Report

Gawler River Stormwater Management Plan

Gawler River Floodplain Management Authority

5 December 2024

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ACKNOWLEDGEMENT OF COUNTRY

The Board and employees of Water Technology acknowledge and respect the Aboriginal and Torres Strait Islander Peoples as the Traditional Custodians of Country throughout Australia. We specifically acknowledge the Traditional Custodians of the land on which our offices reside and where we undertake our work.

We respect the knowledge, skills and lived experiences of Aboriginal and Torres Strait Islander Peoples, who we continue to learn from and collaborate with. We also extend our respect to all First Nations Peoples, their cultures and to their Elders, past and present.

Artwork by Maurice Goolagong 2023.

This piece was commissioned by Water Technology and visualises the important connections we have to water, and the cultural significance of journeys taken by traditional custodians of our land to meeting places, where communities connect with each other around waterways.

The symbolism in the artwork includes:

- *Seven circles representing each of the States and Territories in Australia where we do our work*
- *Blue dots between each circle representing the waterways that connect us*
- *The animals that rely on healthy waterways for their home*
- *Black and white dots representing all the different communities that we visit in our work*
- *Hands that are for the people we help on our journey*

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1 INTRODUCTION

1.1 Intent of the Plan

The aim of Stormwater Management Plans (SMPs) is to develop and implement a coordinated and multi-objective approach to stormwater management in the area being considered. This allows for consistent management that addresses existing problems and identifies opportunities for providing a range of benefits through multi-objective planning. SMPs investigate ways to alleviate existing stormwater and flooding problems and provides flood protection for public and private assets. They also aim to assess flood mitigation options and investigate opportunities for stormwater reuse without compromising flow management or flood mitigation infrastructure. SMPs also explore opportunities for environmental enhancement in the design of stormwater infrastructure. Environmental enhancement may be in the form of improved water quality or increased biodiversity or amenity.

This SMP is in relation to the Gawler River system which comprises the North Para and South Para Rivers which join at Gawler to form the Gawler River.

The Project Steering Group (see Section 1.3.1), in consultation with the Stormwater Management Authority (SMA), agreed that the development of the Gawler River SMP:

> "*would be confined to the lower reaches of the Gawler River downstream of the confluence with the North and South Para Rivers to its discharge into Gulf of St Vincent, and bank to bank of the channel*"
>
> and
>
> "*focus primarily on riverine flooding aspects and would draw upon existing work and complementary projects for additional catchment related information"*

This explains why there are differences within the Gawler River SMP compared to what might otherwise be contained in a "typical" SMP under the SMA Guidelines (2007).

However, the SMP does reference the broader catchment and other SMPs developed in the region, including:

- **The *draft* Gawler and Surrounds Stormwater Management Plan** (Tonkin, 2021, draft) which covers the urbanised areas of Gawler and the rural and semi-rural areas of Gawler Belt, Gawler East, Evanston Park and Bibaringa. Also included are the currently undeveloped areas of Sandy Creek, Kalbeeba and Concordia.
- **The Stormwater Management Plan for Two Wells** (AWE, 2017) which aligns with the 30-year growth boundary area. Two Wells is a regional hub located on the Northern Adelaide Plains approximately 38km north of Adelaide. The Light River is situated to the north of Two Wells and the Gawler River is to the south.
- **The *draft* Smith Creek Catchment Stormwater Management Plan** (Water Technology, 2022, draft) which covers a catchment area of approximately 174 km^2 of which the majority is in the Town of Playford and a small amount is in the Town of Gawler. The upper reaches of Smith Creek emanate from near One Tree Hill and finally discharge into Gulf St Vincent.
- **The Angle Vale North Stormwater Management Plan** (Southfront, 2018) covers the growth area which is bounded by the Gawler River to the north, Riverbanks Road to the east, the existing Angle Vale township to the south and Chivell Road to the west. This SMP was not developed in accordance with the SMA Guidelines but for the purposes of land development.

The area covered by these SMPs is shown on Figure 1-1.

In addition, significant urban developments occurring within the catchment area often have their own SMPs and initiatives that are being implemented as developments progress. Examples include:

- **Riverlea Park** is a 40,000-population development that sits on the southern side of the Gawler River, immediately west of Port Wakefield Road.
- **Liberty Estate** is located to the northwest of the existing Two Wells urban area and is currently under development. Numerous stormwater and flood management plans have been written for the stages of the development.
- **Concordia Growth Area** is commencing investigations covering an area of 950 Ha with a potential 10,000 dwellings and 30,000 residents. The development of this area has not been considered in any of the modelling undertaken for this SMP.

Further background context to the development of the Gawler River SMP is included in the sections below.

1.2 Legislative Context

The *Local Government (Stormwater Management) Amendment Act 2007* came into operation on 1st July 2007. This established the SMA and new financing and governance arrangements for stormwater management and flood mitigation throughout South Australia.

The SMA implements the Stormwater Management Agreement and operates as the planning, prioritising and funding body in accordance with the Agreement. The SMA is charged with:

- Working with Councils to facilitate and coordinate catchment stormwater management planning;
- Allocation of State funding to projects in coordination with Council and other sources of financing; and
- Facilitating cooperative action by all relevant public authorities in the planning, construction and maintenance of stormwater management works.

The process and content by which SMPs are developed have been formalised by the State Government via the SMA in a guideline entitled Stormwater Management Planning Guidelines (2007). This SMP has been prepared in accordance with the Guidelines and addresses issues of flood management, water quality, water harvesting and environmental enhancement associated with the management of stormwater.

South Australia's legislative framework provides a number of other legislative and policy tools to address water management, ranging from state-wide legislation to regional and local policy, including:

- Local Government Act 1999 (which requires local government to form long term strategic and asset management plans)
- Environment Protection Act 1993 and associated policies (including the Water Quality Policy)
- Environment Protection and Biodiversity Conservation Act 1999
- Landscape South Australia Act 2019 and associated Landscape Plans and Water Affecting Activities Control Policy (noting works undertaken as part of stormwater management may potentially require a Water Affecting Activity permit to be approved prior to works commencing)
- Water Allocation Plans (WAP) (Adelaide Plains and the Western Mount Lofty Ranges (WMLR) Prescribed Water Resources Area)
- Planning, Development and Infrastructure Act 2016 and the associated Planning and Design Code
- Native Title Act (South Australia) 1994
- National Water Quality Management Strategy 2000
- Emergency Management Act 2004 and the associated Flood Hazard Plan

One of the key mechanisms for achieving the desired outcomes of integrated water management is to ensure that the objectives of the SMP meet and contribute to other State and National natural resource management policies and strategies. These strategies in turn assist in the implementation of the desired water management outcomes for townships and catchments. The relevant legislation, policies and plans have been considered during the development of this SMP.

1.3 Development of the SMP

1.3.1 Project Steering Group and Technical Steering Group

The Gawler River (including the upstream tributaries) flows through six Local Government Areas (Adelaide Plains Council, Adelaide Hills Council, Barossa Council, City of Playford, Light Regional Council, Town of Gawler) and is also at the boundary of two Landscape Boards (Green Adelaide and Northern and Yorke) (see Figure 1-2). There are therefore numerous stakeholders who share responsibility and interest in the management of the Gawler River system.

The Gawler River Floodplain Management Authority (GRFMA) was formed in 2002 and they have taken the lead role in the development of this SMP in partnership with its Constituent Councils, the SMA, the Green Adelaide Board, the Northern and Yorke Landscape Board and the Department for Environment and Water (DEW). Representatives of these organisations formed the Project Steering Group.

The Project Steering Group were involved in the development of the brief for the SMP and also defined the desired outcomes of the SMP.

Following the engagement of Water Technology to develop the SMP, a Technical Steering Group managed the oversight of the project and the co-ordination with complementary projects.

1.3.2 Funding of the Plan Development

The development of this SMP has received funding from the GRFMA, Green Adelaide and the SMA.

1.3.3 Consultation

A broad range of consultation has been undertaken in the development of this SMP due to the range of organisations that have an interest and impact on the management of the Gawler River system and the number of communities of which the Gawler River flows through and has an impact upon. A summary of the stakeholder engagement and consultation undertaken specifically for this SMP and how the feedback has been included in this SMP is included in Appendix A.

Consultation and engagement with First Nations Peoples has been undertaken through a complementary project (see Section 1.3.5). This pragmatic approach was taken to ensure that First Nations engagement was done in a coordinated way across all related projects to ensure efficiency and consistency and to avoid consultation fatigue. A summary of the consultation and engagement undertaken is included in Appendix A.

Consultation has also been undertaken in the development of the associated and complimentary SMPs in the area and in the development of mitigation works for the catchment area. Details of that engagement is included in the relevant SMP documents.

This draft SMP has been distributed for community consultation prior to being finalised.

Ongoing consultation and engagement with key organisations and communities is expected as this SMP is implemented.

1.3.4 Investigations Commissioned as Part of this SMP

A range of investigations were commissioned as part of the development of this SMP. Key points from these works have been included where relevant throughout the document and the complete reports are included in the Appendices for further reference:

- Risks to marine habitats in the Port Gawler region from stormwater flows by SARDI (Appendix B)
- Ecological inputs to the Gawler River Stormwater Management Plan by Lance Lloyd (Appendix C)
- A helicopter survey to provide updated LiDAR information to allow flexible mesh modelling

1.3.5 Complementary Projects

Over the course of the development of the Gawler River SMP there were a range of complementary projects being undertaken in parallel. These projects have helped to inform the outcomes of the SMP with information sharing and similar stakeholder groups. These projects have included:

- Short Term Projects – led by the Department for Environment and Water in collaboration with Councils
- The Business Case for flood mitigation of the Gawler River - led by the Department for Environment and Water
- Gawler River UNHaRMED Mitigation Project (GRUMP) - led by the University of Adelaide and initiated to support the GRFMA and other relevant stakeholders to develop potential pathways for integrated flood management for the Gawler River catchment area

Short Term Projects

The Government of South Australia allocated funding towards works that would contribute to improving flood management of the Gawler River. The funding formed part of the State Government's economic stimulus package and included:

- Hillier fire rehabilitation works:
  - A December 2019 bushfire impacted approximately a 1km stretch of the Gawler River in Hillier
  - Debris was removed from the Gawler River and surrounds to prevent blockage of the flow of water or movement downstream
  - Revegetation and maintenance was also undertaken and is now being managed by the Town of Gawler
- Carmelo and Park Roads drain in the City of Playford:
  - A new drainage system will be built by Council, with the first stage to include drainage along Park Road
- Improved flood forecasting and warning:
  - Retain, upgrade and add new water resources monitoring stations in the catchment
  - Optimise monitoring network for end-user requirements
  - Trial new technology to better monitor and measure high flows
- River survey, levee repair and vegetation management:
  - Improve the Gawler River's capacity to carry water by removing woody weeds
  - Condition rate existing levees, reconstruct levees to an appropriate standard, develop a process for undertaking works on private land and inform the ongoing process for levee improvements on private land

Key components of these projects were to:

- Build relationships with landholders along the Gawler River to provide access for river and levee bank restoration works to proceed and to build a foundation for establishing access arrangements for ongoing operation and maintenance to be put in place for subsequent works.
- Commence engagement with First Nations Peoples to ensure their cultural views are incorporated into the design and delivery of the Gawler River flood mitigation and management initiatives, including these projects and the Business Case.

Business Case Overview

A business case is a critical tool for developing options and attracting investment longer-term. This is being developed following the Infrastructure SA Assurance Framework.

The business case has been undertaken to:

- Assess in detail the options proposed through rigorous application of social, environmental, financial and economic criteria
- Demonstrate the viability and value of the options assessed
- Recommend an option for implementation
- Propose an integrated approach to funding
- Suggest a preferred delivery and procurement approach

The outcomes from this process have been integrated into the Gawler River SMP to ensure consistency and alignment.

GRUMP Overview

The University of Adelaide and the Research Institute for Knowledge Systems, supported and funded by the Bushfire and Natural Hazard Cooperative Research Centre (CRC), has been developing a Unified Natural Hazard Risk Mitigation Exploratory Decision Support System (UNHaRMED).

UNHaRMED is a decision support system designed to explore how to manage risk into the future in an integrated and dynamic fashion, considering different drivers and options impacting on future risk. Its development has been supported by the inputs of many stakeholders around Australia, including South Australian State Government officials (including DEW, SASES, DPTI), and LGA SA, shaping what the tool should be able to do and what it should look like.

The integrated assessment includes direct and indirect economic impacts of a range of mitigation strategies against alternative scenarios. These results can be used to develop adaptation pathways considering how the performance of actions changes with time, and how options perform in portfolios.

Gawler River UNHaRMED Mitigation Project (GRUMP) was initiated to trial the approach and support the GRFMA and other relevant stakeholders to develop potential pathways for integrated flood management for the Gawler River catchment (University of Adelaide, 2022).

Scenarios were developed to explore plausible pathways into the future and important considerations in this pathways approach included:

- Protection of current assets, and avoiding damage to new developments;
- Protection against minor and major floods;
- Protection under a range of climate scenarios and socio-economic futures; and

- Selection of options that are effective in reducing risk and perform well on other social, economic and environmental indicators representing additional objectives in the river basin.

The impact assessment modelling of individual options as well as combinations of options, showed that a combination of options with immediate effectiveness in protecting existing assets, and the ability to avoid future risk due to new developments, would be desirable.

The findings showed that:

- Indirect costs are significant;
- Implementing a combination of options over time is the best strategy;
- It is important to consider how risk changes into the future; and
- Considering a range of socio-economic scenarios is essential.

1.4 Outline of the Plan

The SMP contains the following sections:

- Section 2 provides a description of the catchment including a summary of the uniqueness of the Gawler River.
- Section 3 provides a summary of the challenges facing the Gawler River and its associated catchment and the opportunities identified to address these challenges.
- Section 4 provides a series of catchment specific objectives that have been developed in consultation with stakeholders and also referencing objectives in related SMPs.
- Section 5 provides an overview of the modelling that has been undertaken to further inform the needs and opportunities to meet the defined objectives.
- Section 6 provides a series of potential management strategies designed to achieve the objectives set out in Section 4.
- Section 7 summarises the estimated costs of the potential strategies and identifies the funding opportunities and potential cost sharing arrangements to undertake the works.
- Section 8 provides a summary of the assessment of the potential strategies against a set of criteria to prioritise the proposed management strategies.
- Section 9 provides a summary of the priorities and timeframes for the high priority actions.
- Section 10 provides a range of additional recommendations for further investigation based on the work undertaken to develop this SMP.
- Section 11 provides the broad range of references that have been utilised to provide the inputs to this SMP.

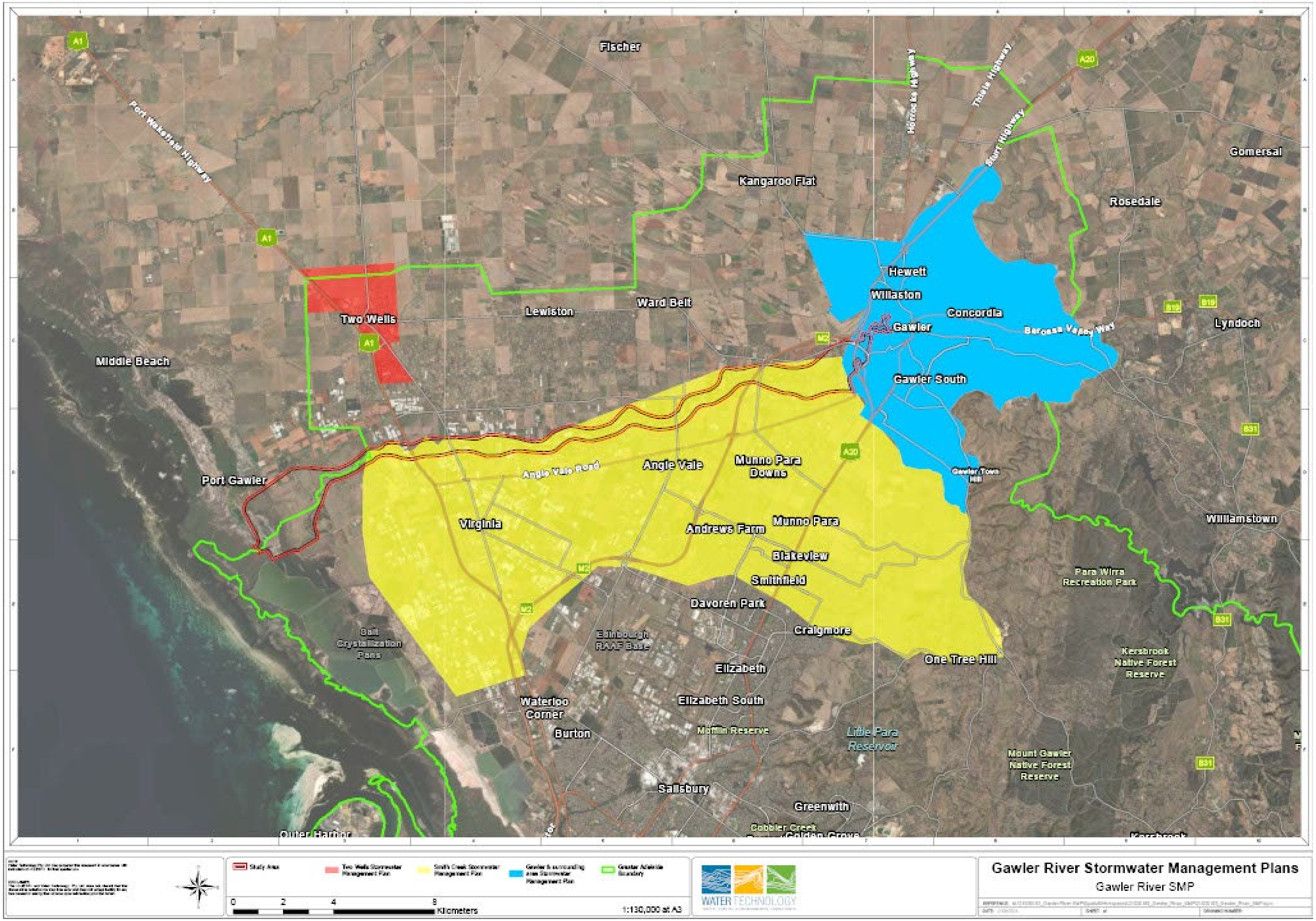

Figure 1-1 Stormwater Management Plans

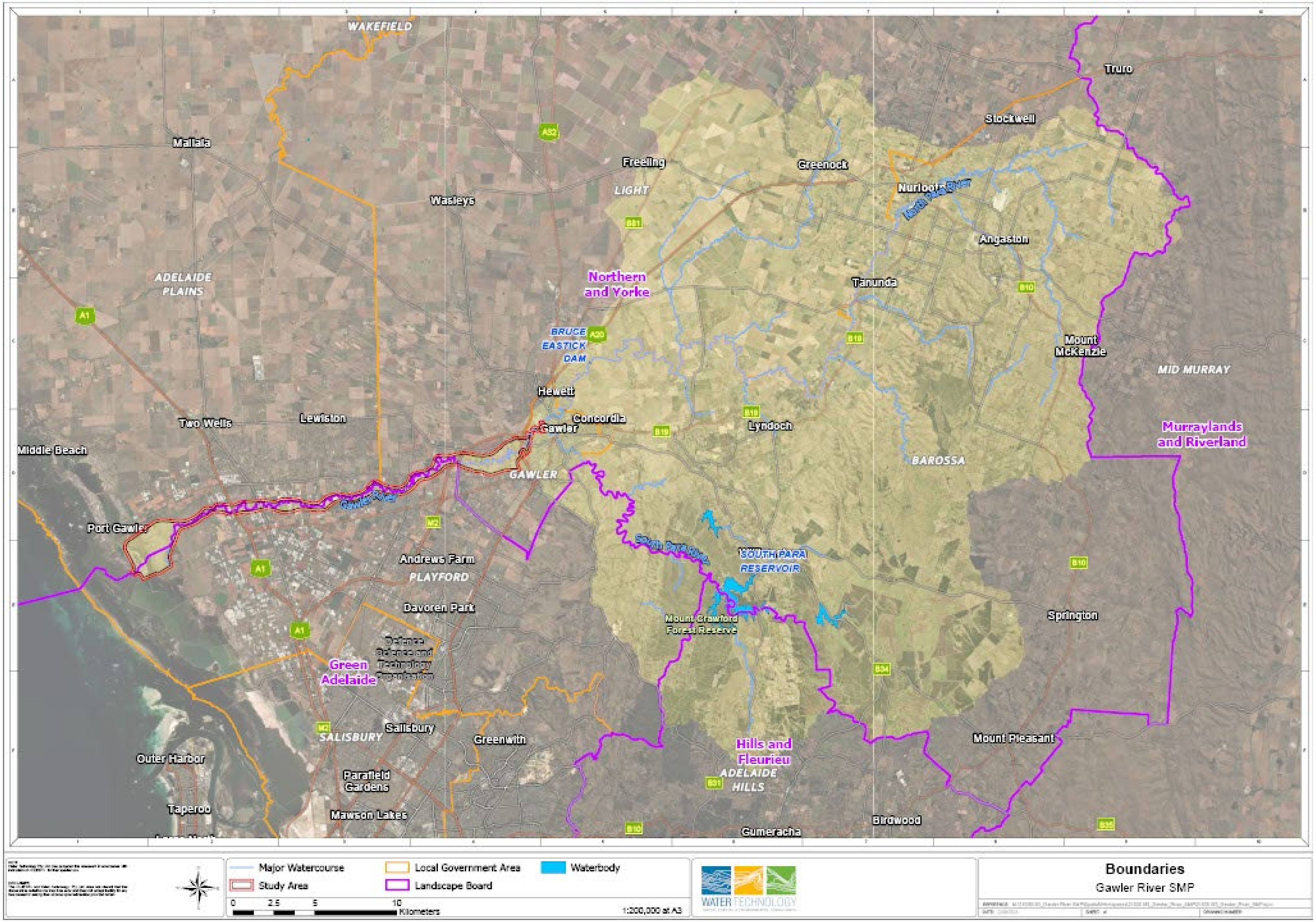

Figure 1-2 Boundaries Overview

2 CATCHMENT DESCRIPTION

2.1 Introduction

Information regarding the Gawler River catchment is summarised below. Further information can be found in the State of the Catchment report (Water Technology, 2024) (that was completed as part of the development of this SMP) or in the material that is referenced.

2.2 Catchment

2.2.1 Overview

The Gawler River system is an episodic river system situated approximately 50 km to the north of Adelaide in South Australia. The catchment covers an area in excess of 1,050 km^2 and consists of three main rivers and their associated tributaries including:

- The North Para River which flows through the Barossa Valley, with a catchment area of approximately 711 km^2
- The South Para River which forms part of Adelaide's water supply with a catchment area of 339 km^2
- The Gawler River which begins at the junction of the North and South Para Rivers in the town of Gawler and flows across the Northern Adelaide Plains and discharges into St Vincent's Gulf at Port Gawler

Figure 2-1 and Figure 2-2 show the Gawler River catchment.

Important features of the Gawler River include:

- The Gawler River itself is only 30 kilometres in length.
- The Gawler River is a perched river system and there are few natural drainage lines flowing into the River beyond Gawler. This is a natural phenomenon of a perched river system. The Gawler River therefore receives very little inflow from the land through which it flows downstream of Gawler.
- The capacity of the lower Gawler River is very small in comparison to the large catchment that feeds it. The channel capacity of the Gawler River decreases as it moves downstream.

The Gawler River is prescribed as part of the Western Mount Lofty Ranges Prescribed Water Resources Area.

In addition, the Light River is situated to the north of Two Wells and the Gawler River is to the South. The main river systems which are situated in and/or located near Two Wells are the Gawler River and Salt Creek. Whilst remote from the township, floodwaters from the Light River could also encroach on the township during a large flood event on the Light River. Salt Creek is a natural, highly ephemeral stream that runs along the eastern and southern side of Two Wells. This stream receives some runoff from the township but its primary hydrological function is to transfer flood waters from upstream catchments to the east, past Two Wells, and out to the sea.

Whilst the Gawler River is presently not regarded as a receiving water of Smith Creek, there are some sections of the river where stormwater inflows from small, localised areas neighbouring the river, either presently occur or are likely to in the future.

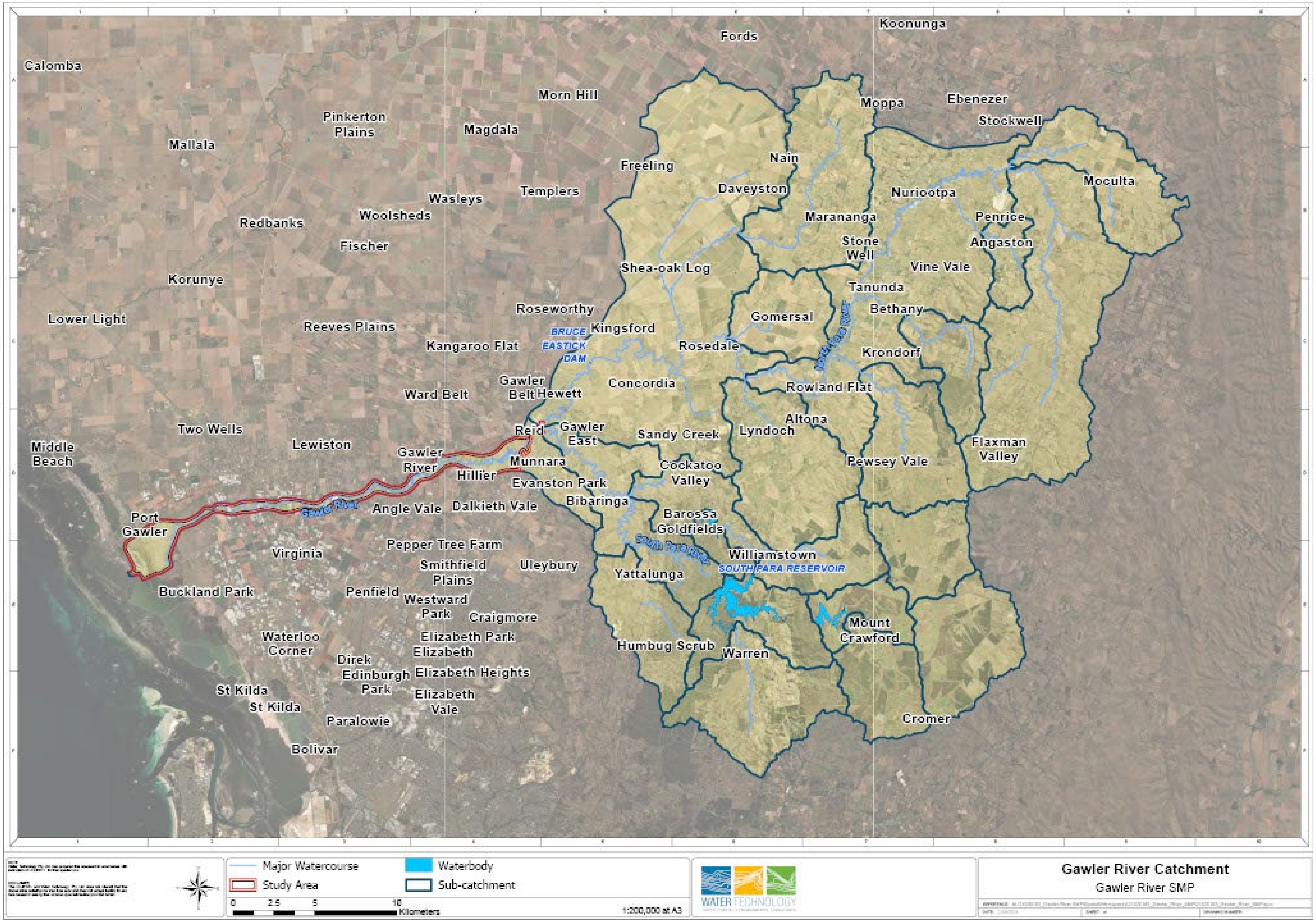

Figure 2-1 Gawler River Catchment

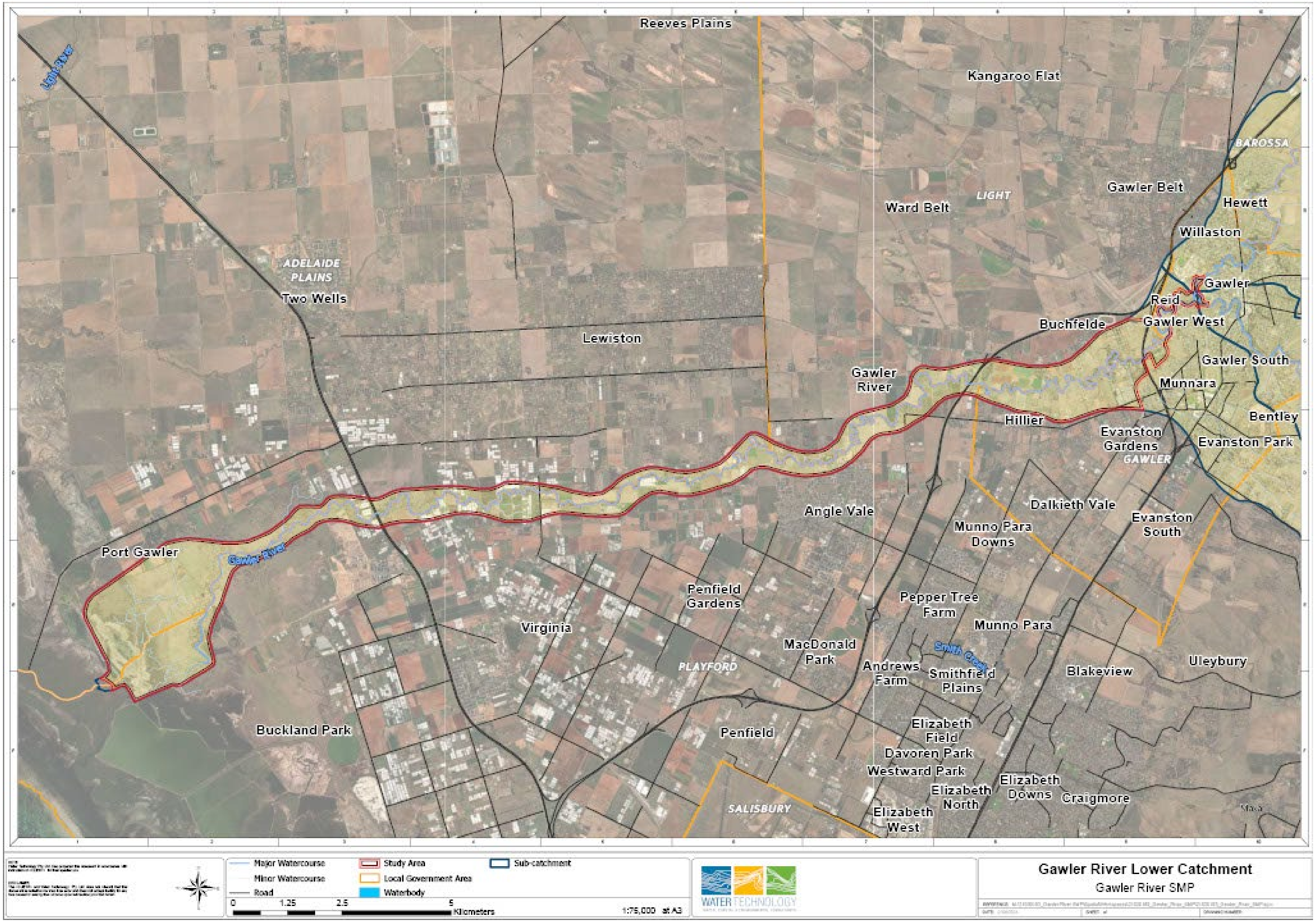

Figure 2-2 Gawler River Lower Catchment

2.2.2 Land Use

Land use varies considerably throughout the Gawler River catchment (Figure 2-3). Land use has also changed significantly over time. The upper catchments of the North and South Para Rivers have mixed uses and includes the townships and vineyards of the Barossa Valley, dryland farming areas, grazing and forests.

Land uses surrounding the Gawler River are characterised by horticulture and agriculture, but there are also substantial areas of urbanisation. The floodplain has been cleared and used for intensive farming for more than 100 years. Large land users include open ground and enclosed horticulture (including the Virginia Horticultural area).

Major communities alongside the Gawler River, or within the 1% AEP floodplain, include Town of Gawler, Angle Vale, Virginia, Two Wells, Lewiston and Middle Beach. These urbanised areas are also expanding significantly as part of the 30-year growth strategy for Adelaide. These include Riverlea, Liberty and Concordia.

2.2.3 Topography

At approximately 600 m above sea level, the upper catchment of the Gawler River includes some of the most elevated hill country in the Greater Adelaide area. The Gawler River itself starts at Gawler Township, at around 50 m above sea level.

The general topographical fall of the land in the Two Wells area is from the north east to the south west with a general grade of <1 %. There is a ridge running through the Two Wells township.

Various topographic datasets are available across the Gawler River catchment, including LiDAR and feature surveys (Figure 2-4).

2.3 Soils

The distribution of soils across the area was determined from data contained in the Department for Environment and Water (DEW) Soils Database and information contained in other relevant SMPs.

The hills of the eastern section of the area are characterised by loam over clay on rock (type D1) with patches of loam over red clay (type D2) along some of the larger tributaries. The predominant soil type in the western sections of the area is hard loam sands over red clay (type D5). The soils of the Gawler Belt region are typically shallow loams over red clay on calcrete (type B6). The soils along the North Para River and South Para River are predominantly classified as shallow soil on rock (type L1).

Along the Gawler River the soils are deep loams (type M1 and M2). The soils within the urban area have not been classified, but it is likely that they reflect the characteristics of the soils in the surrounding area.

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

The eastern end of the Gawler River floodplain is approximately 50% loam over clay and 50% calcareous loam, with the western end being predominantly loam over clay.

Site specific geotechnical investigations are recommended to be undertaken during the detailed design phase for any proposed works.

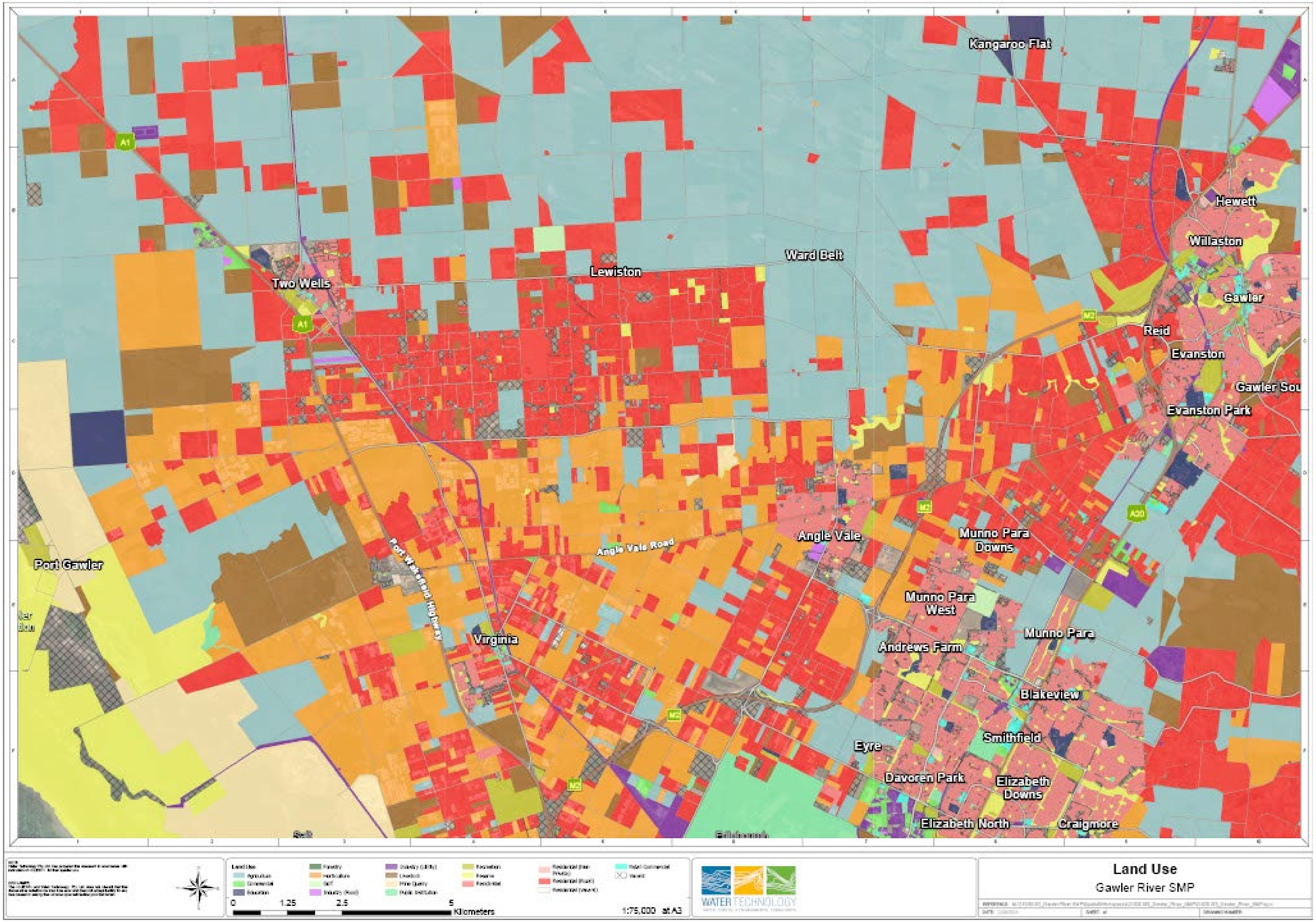

Figure 2-3 Land Use

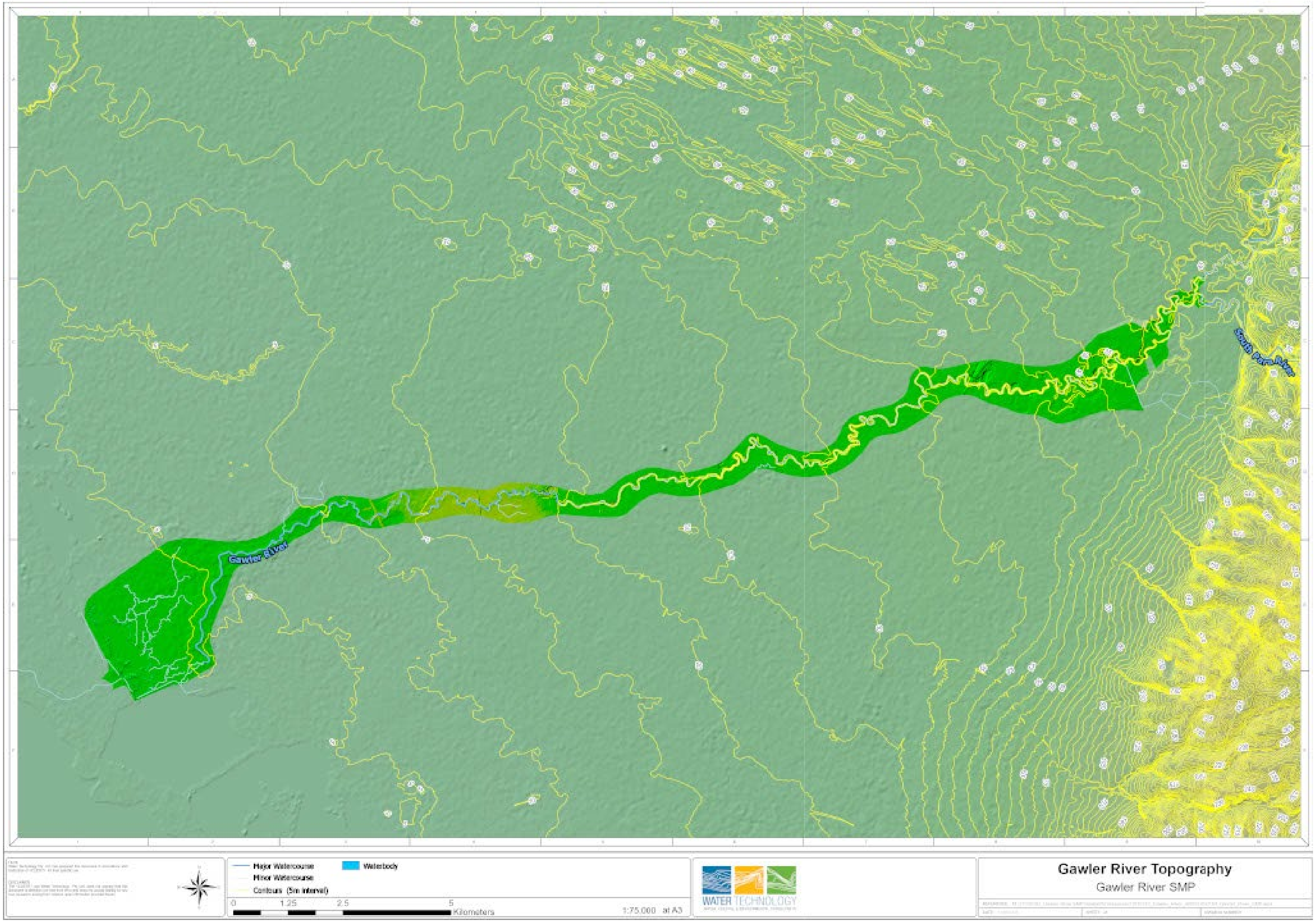

Figure 2-4 Topography

2.4 Hydrology

2.4.1 Climate

The area generally has Mediterranean climate characteristics with hot, dry summers and mild wet winters. Rainfall varies throughout the catchment. The long-term mean annual rainfall information is based on information provided by the Bureau of Meteorology (BOM) and is summarised in Table 2-1 for a range of stations (Figure 2-9). Mean monthly rainfall trends are shown in Figure 2-5.

Table 2-1 Weather Stations in the Catchment Area

Station ID	Station Name	Year Opened	Still Open	Elevation (m)	Mean Annual Rainfall (mm)
023028	Two Wells SA	1881	Yes	11	401.9
023111	Gawler River (Heaslip Road)	1990	Yes	30	413.8
023107	Gawler SA	2003	Yes	40	381.4
023122	Roseworthy AWS	1997	Yes	65	385.4
023318	Tanunda	1868	Yes	249	545.8

Source: www.bom.gov.au/climate/data

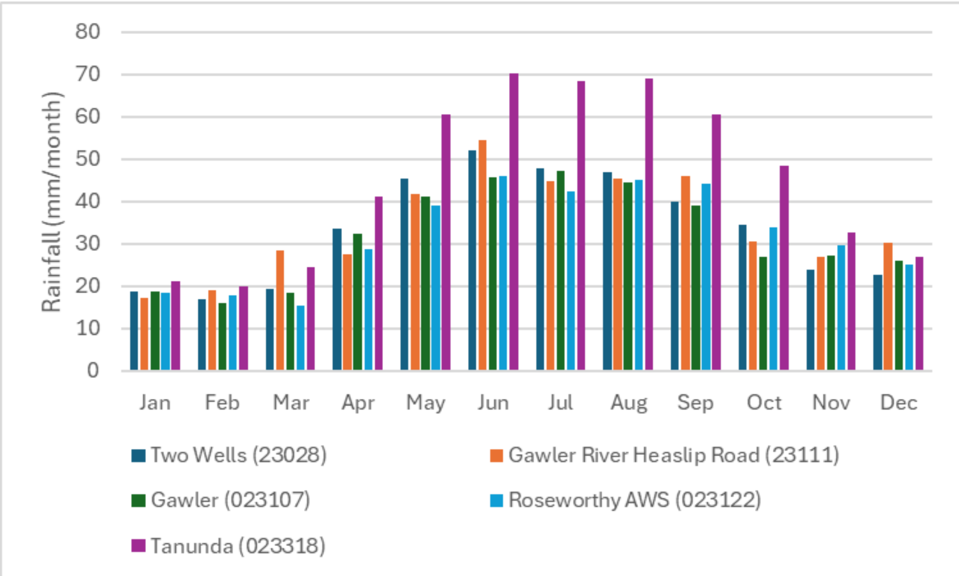

Figure 2-5 Mean Monthly Rainfall for Various Weather Stations within the Catchment Area

Infrequent and intense summer rainfall events have been known in the catchment. Significant floods have occurred because of these summer rainstorms (see Section 2.4.4). Highest recorded monthly rainfall for various weather stations within the catchment area is shown in Figure 2-6.

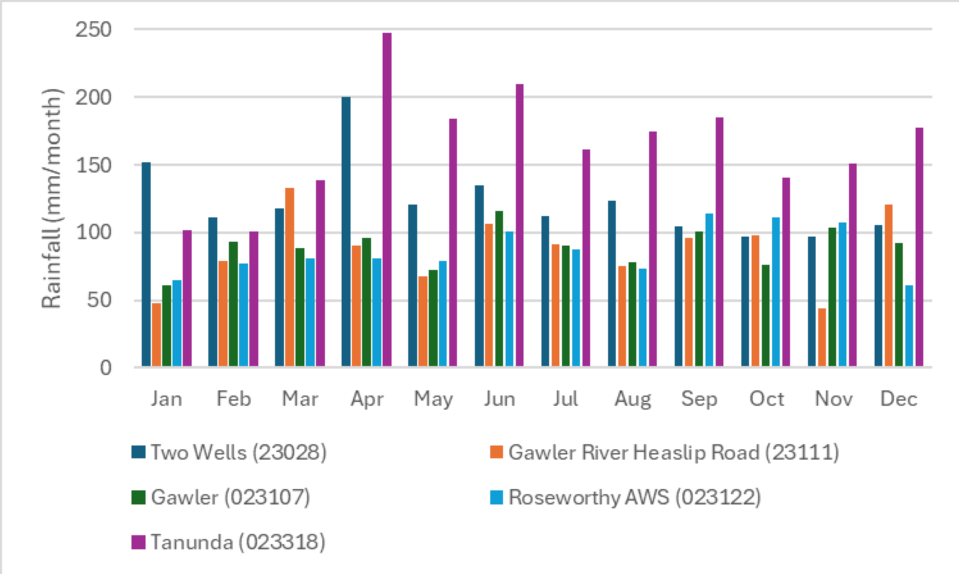

Figure 2-6 Highest Recorded Monthly Rainfall for Various Weather Stations within the Catchment Area

2.4.2 Stream Flow Measurements

There are several surface water monitoring stations within the Gawler River catchment area as summarised in Table 2-2 and shown in Figure 2-9.

Table 2-2 Surface Water Monitoring Stations in the Gawler River Catchment

Station ID	Station Name	Status	Catchment Area (km^2)	Elevation (m)	Data Available
A5050502	North Para River at Yaldara	Active	375.7	135.49	Discharge (1943 – 2024) Water Level (1943 – 2024)
A5051016	North Para River 800m DS Turretfield Flood Control	Closed	NA	56.24	Discharge (2014 – 2020) Water Level (2014 – 2020)
A5050503	South Para River 2.6km SE Gawler PO	Active	324.1	50.46	Discharge (1968 – 2024) Water Level (1968 – 2024)
A5050505	Gawler River at Gawler Junction	Inactive	1069.1	38.15	Discharge (1969 – 2004) Water Level (1969 – 2004)
A5050513	Gawler River at Heaslip Road	Inactive	NA	30	Discharge (1995 – 2007) Water Level (1995 – 2007)
A5050510	Gawler River at Virginia Park	Active	1,170	12	Discharge (1972 – 2024) Water Level (1972 – 2024)

Source: Water Data SA (www.water.data.sa.gov.au)

Examples of the discharge and water level data for a range of the monitoring stations is shown in Figure 2-7 and Figure 2-8.

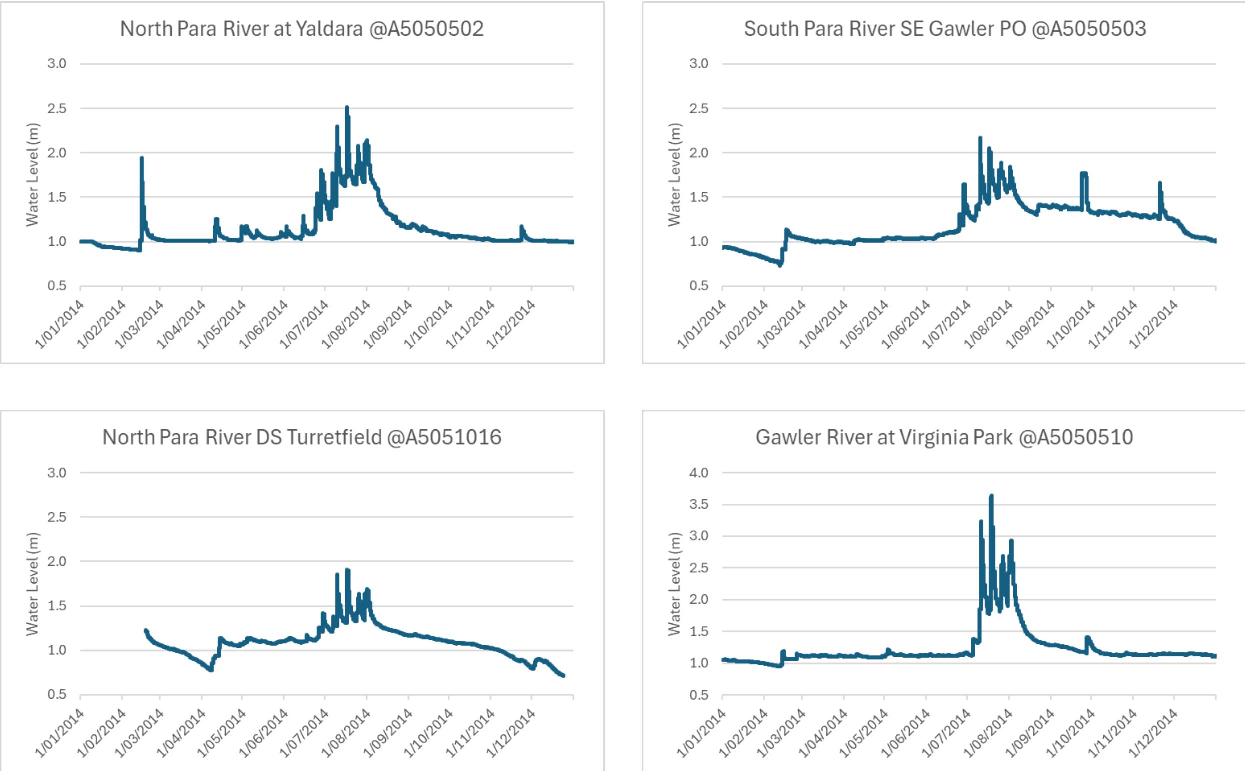

Figure 2-7 Water Levels at Various Gauging Stations for 2014

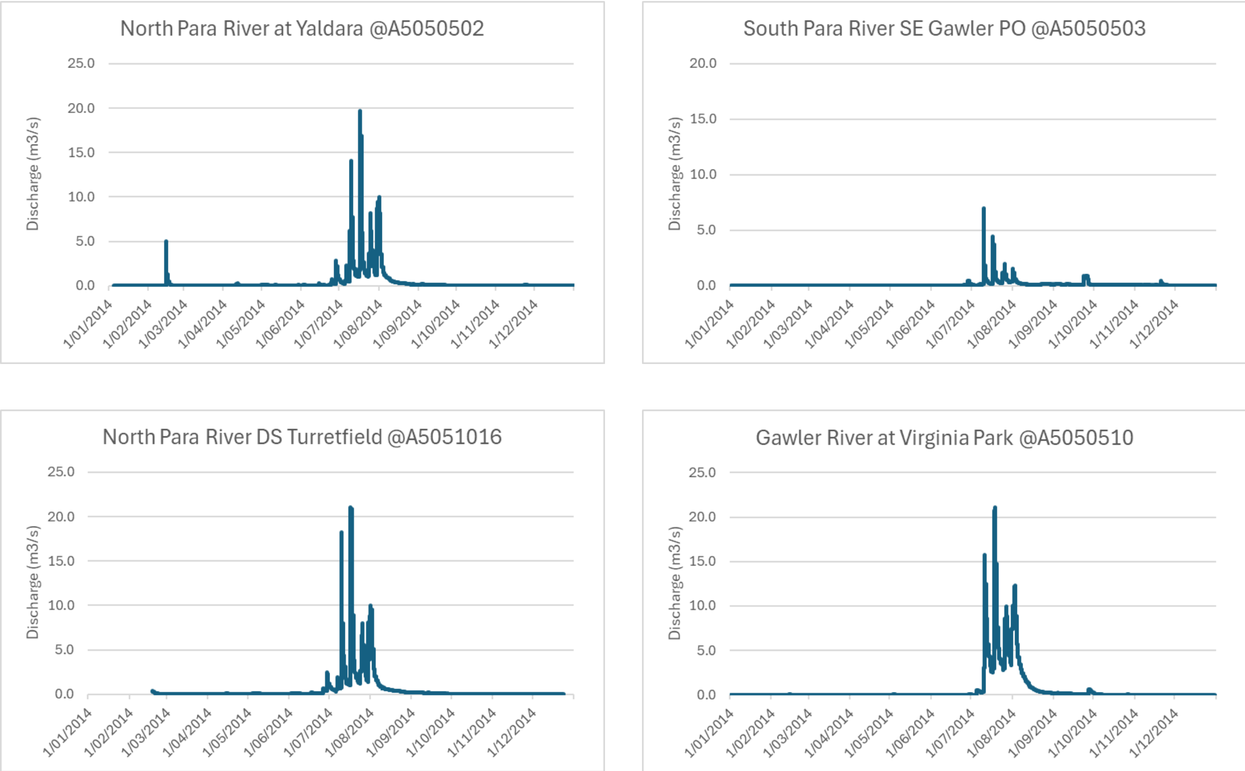

Figure 2-8 Discharge Levels at Various Gauging Stations for 2014

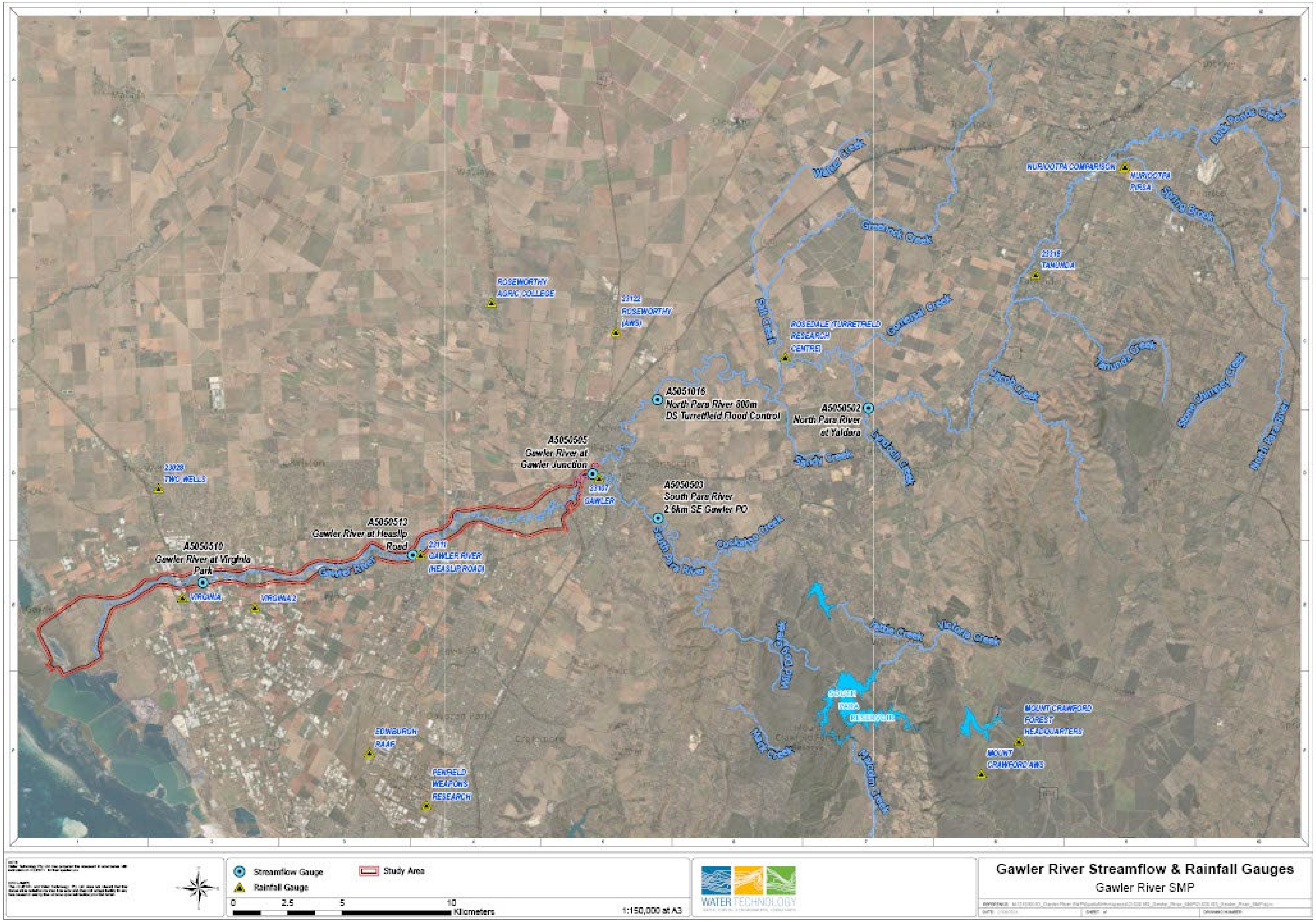

Figure 2-9 Streamflow and Rainfall Gauges

2.4.3 Flow Characteristics

The original flow regime of the Gawler River system has been severely modified by the effects of land clearance, farm dam development and the construction of storages (including the South Para, Warren and Barossa Reservoirs – see Section 2.8).

Natural flow conditions (prior to upstream reservoirs being constructed) would have varied from no flow and base flows to large flooding events.

The Gawler River system now exhibits highly variable flow characteristics. Flowing water is a prominent feature of the Gawler River catchment in both Autumn and Spring.

The Gawler River is therefore classified as an extensively modified creek system. Total volumes, durations, frequencies and seasonality of flows have all been affected.

Stormwater from the Gawler Township and surrounds discharges into the Gawler River at over 50 locations, either directly or via tributaries (Tonkin, 2021, draft).

2.4.4 Previous Flood Events

The Gawler River and its floodplain are subject to flooding to various degrees when the Gawler River overflows. Floods in the Gawler River are driven by flows from the upstream rural catchments of both the North Para and the South Para Rivers.

Flooding has been recorded many times since settlement, one of the largest being in 1889. Major flooding from the Gawler River has occurred in 14 years over the last 150 years or on average once every ten years. There have also been many instances where floods have caused the closure of major roads such as the Port Wakefield Highway.

Three flood events, occurring in 1992, 2005 and 2016, had an overall estimated cost in excess of $120 million, which are described below.

1992 Flood

Multiple floods occurred between September and December 1992 causing over $12 million in damages. The largest of these occurred in October and whilst only having a 1 in 40-year ARI it still caused over $10 million in damage. The reduced channel capacity is why so much damage can occur from even "modest" flood flow rates such as those which occurred in 1992.

2005 Flood

A flood with a peak flow estimated at 200 m^3/s at Gawler Junction (estimated 1 in 20-year ARI flood) occurred on 8th and 9th November 2005 following heavy rains in the catchment. 7 properties including 2 houses were flooded in Gawler and following a breach in the southern flood protection levee near Bakers Road, extensive flooding occurred in the Virginia area with 220 properties including 30 houses flooded. The damage bill was $61 million.

2016 Flood

The rainfall covered an extensive area across the North and South Para catchments with falls from the period of specific interest (midday 28th September 2016 through to midday on the 4th October 2016 from a rainfall perspective) ranging typically between 100 to 140 mm in the higher topographic areas of the North and South Para, whilst in the areas of lower relief areas (but still mainly in the North and South Para catchments) rainfalls were typically between 60 to 90 mm during this six day period.

Most sites recorded two main periods of rainfall, one towards the beginning of this period and second towards the later part of the period with around a day of little rain in between.

Whilst the rainfall intensities would not appear to be particularly excessive, these rainfalls fell on an already wet catchment which is likely to have contributed to higher flows than might have otherwise been expected from the observed rainfalls.

Approximately 250 private properties (along with state and local government infrastructure) were severely affected by the flooding, and there was extensive loss of horticultural production. The event caused an estimated $51 million of damage to agriculture and more than $20 million of damage to local government infrastructure in the Gawler River floodplain.

An independent review of this flood event found that further mitigation activities are necessary to reduce the flood risk for the Gawler River region.

2.4.5 Water for the Environment

The natural flow regime in the South Para River has been heavily impacted by the construction of dams and other water supply infrastructure. Diversions from the river have reduced flows downstream of the South Para Reservoir by up to 90% and have extended the duration and frequency of periods of no flows. This has impacted on the downstream receiving environment of the Gawler River and the coastal outlet at Gulf St Vincent.

Water for the environment is used to describe both Environmental Water Requirements (EWRs) and Environmental Water Provisions (EWPs). EWRs are a description of the water regimes needed to maintain ecological values of water dependent ecosystems at a low level of risk.

The Western Mount Lofty Ranges (WMLR) WAP (AMLR NRMB, 2013) includes formal arrangements for EWPs in the South Para River downstream of the South Para Reservoir. The WAP outlines that SA Water will supply up to 16.5 GL/yr for environmental flow purposes from its reservoirs to maintain watercourses across the plains at an acceptable level of risk.

An environmental flow valve has been installed at the Barossa Diversion Weir for the release of environmental flows and can deliver a maximum flow rate of 7.3 ML/day. All environmental flow components with a discharge rate greater than the capacity of the environmental flow valve are delivered over the weir as a controlled spill (SA Water, 2019).

The flows released by the Gawler River to the coastal environment are understood to be of particular importance for fish migration, life cycle and habitat. The Adelaide International Bird Sanctuary is also a water-dependent ecosystem of particular interest when considering the Gawler River flow regime.

A summary of the EWRs for the Gawler River for different outcomes is summarised in Table 2-3.

Table 2-3 Environmental Water Requirements of the Gawler River

Flow Band	Peak Flow (m^3/s)	Daily Flow (ML)	Average Frequency	Duration (Time)	Importance	Seasonality
Pool connection	6 – 10	420 – 700	Once every 3 years as a minimum but every year is more beneficial	Minimum 2 – 3 months	Water quality for pools. Riffle habitat available. Recharge for aquifers. Freshwater shrimp migration. Fish reproduction and migration.	Autumn and Spring for fish migration
Mid-flow	10	350	Yearly	Minimum 2 – 3 months	Connection and recharge to Buckland Park. Sediment transport.	Winter to Spring
Bank-full	< 300	20,300	Once every 10 – 20 years	Hours	Sediment and organic matter transport. Channel maintenance.	N/A
Over-bank	300 +	20,300+	Once every 10 – 20 years	Hours	Floodplain maintenance and organic inputs to channel.	N/A

Source: NABCWMB (2000) in Lloyd (2021)

2.5 Hydrogeology

The groundwater resources of the prescribed wells areas of the Adelaide Plains are found in several aquifers. Across the flats of the Adelaide Plains there are two main aquifer systems: the shallow Quaternary aquifers and the deeper, confined Tertiary aquifers. The thin Quaternary aquifers are designated Q1 to Q6, in order of increasing depth, and are generally used for stock or domestic purposes. The high salinity of the Quaternary aquifers generally limits their value for extraction.

Below the Quaternary aquifers lie a series of Tertiary aquifers comprising sedimentary layers of sand, gravel and limestone. These deep aquifers are the largest and most important groundwater resource in the Adelaide Plains and, as with the Quaternary aquifers, they are numbered with increasing depth below the ground's surface. The T1 and T2 aquifers are used to support irrigated horticulture, industry and the watering of recreational areas. Below these productive upper Tertiary aquifers, the T3 and T4 aquifers, contain much more saline water.

The T1 aquifer has a maximum thickness of about 120 metres just north of the Para Fault near Adelaide Airport and gradually thins and pinches out around the Gawler River in the north of the Adelaide Plains. The direction of regional groundwater flow in the T1 is from the Adelaide Hills towards Gulf St Vincent. In the Northern Adelaide Plains Prescribed Wells Area, the water within the T1 aquifer is generally of good quality, with salinity of less than 1,500 mg/L. However, salinities of nearly 3,000 mg/L have been measured in some areas.

The T2 aquifer extends across all of the Adelaide Plains Sub-basin and is separated from the overlying T1 aquifer by a confining layer of clay. As with the T1 aquifer, the thickness of the T2 aquifer is greatest just north of the Para Fault at about 80 metres and thins in a northerly direction to 20 metres near Gawler. Most extractions from this aquifer occur in the Northern Adelaide Plains Prescribed Wells Area. Salinity levels in the T2 aquifer are characterised by reasonably stable trends.

Fractured rock aquifers are primarily found in the Mount Lofty Ranges part of the Adelaide Plains.

2.6 Ecological Communities

Riparian vegetation condition varies widely throughout the Gawler River catchment. Some areas of the river system still have healthy riparian vegetation, although such areas are often limited in size and isolated from each other.

The river channel downstream of the township of Gawler is dominated by River Redgum (*Eucalyptus camaldulensis*) and Black Box (*E. largiflorens*). The river channel is also dominated by reeds and sedges (*Phragmites, Typha, Juncus, Isolepis, Schoenoplectus*).

Two of South Australia's 14 threatened ecological communities (listed under the Environment Protection and Biodiversity Conservation Act 1999) occur within the Gawler River Floodplain, which are:

- Peppermint Box (*Eucalyptus odorata*) Grassy Woodland of South Australia, and
- Iron-grass Natural Temperate Grassland of South Australia.

The coastal area where the Gawler River discharges, supports large tracts of saltmarsh and beach that are attractive to migratory and resident shorebirds, hosting significant numbers of the total East Asian – Australasian Flyway populations of some species over summer.

Two key artificial environments, the Dry Creek Saltfields and Buckland Park Lake, enhance the overall value of the area by providing diversity of habitat, and specifically for shorebirds, protected high-tide roosting and supplementary feeding areas.

The native fish species of the Gawler River are included in Table 2-4. Four main non-native fish species have been identified in the Gawler River environment including the predacious redfin and the invasive Eastern Gambusia as well as the two carp species (European carp and goldfish, as well as their hybrids).

Table 2-4 Native Fish Species of the Gawler River

Category	Scientific Name	Common Name
Freshwater	*Galaxias olidus*	Mountain Galaxias
	Retropinna semoni	Australian Smelt
Estuary Opportunist (Freshwater)	*Philypnodon grandiceps*	Flatheaded Gudgeon
	Philypnodon macrostomus	Dwarf Flatheaded Gudgeon
Estuary Dependent (Freshwater)	*Galaxias brevipinnis*	Climbing Galaxias
	Galaxias maculatus	Common Galaxias
	Pseudaphritis urvillii	Congolli
Estuary Resident	*Pseudogobius olorum*	Bluespot Goby
	Arenigobius bifrenatus	Bridled Goby
	Atherinosoma microstoma	Smallmouth Hardyhead
Estuary Dependent (Marine)	*Geotria australis*	Pouched Lamprey
	Mugil cephalus	Sea Mullet
	Aldrichetta forsteri	Yellow-eye Mullet
	Liza argentea	Flat-tail mullet

Source: Lloyd (2021)

2.7 Cultural Heritage

Rivers have long since been an important meeting place and are rich in Aboriginal culture and heritage. The Gawler River catchment is particularly special as it holds the meeting place of three nations: Kaurna, Ngadjuri and Peramangk. People still eat and drink out of the rivers in the catchment, live and work along them and pass on storylines to their children and grandchildren next to them.

Gawler is generally regarded as what would have been an excellent area for First Nations Peoples to occupy. The fertile soil and the rivers meandering through the region would have provided exceptional food and water resources.

The Gawler area was previously known as 'Kaleeya' which is a Kaurna name for the area. 'Para' remains a Kaurna name for what is now known as the North, South and Little Para Rivers. The word 'Para' is derived from the Kaurna word, 'pari', meaning 'water'.

Previous to the European 'discovery' of the Gawler River on 23 November 1838, it was known by the local Indigenous people as 'Moole Yerke Perre'.

Cultural heritage sites are therefore likely to exist alongside and potentially within the Gawler River channel.

Several Cultural Heritage Surveys have been undertaken along the Gawler River prior to rehabilitation and revegetation works. Alluvial soils in the Gawler region have been identified as having a medium-high potential to contain buried Aboriginal sites. The Central Archive is a record of all previously recorded Aboriginal sites within South Australia.

2.8 Infrastructure

2.8.1 Dams

The South Para Reservoir is located on the South Para River about 30 km upstream of its confluence with the North Para River. The primary purpose of the reservoir is for water supply. The South Para Reservoir is the second largest reservoir in South Australia and the principal reservoir of the South Para River system. The reservoir took almost a decade to construct, between 1949 and 1958. The reservoir's large capacity of around 45 GL and its location in the catchment area mean that it only ever fills completely once in every five years. Water from South Para flows to Barossa Reservoir and is owned and operated by SA Water.

The Bruce Eastick North Para River Flood Mitigation Dam was constructed within the North Para River about 9km north-east of the Township of Gawler, between October 2006 and December 2007. The 28-metre-high dam with a storage volume of 9.5GL was designed as a dry detention basin to provide attenuation during flooding events, up to and including the 1% AEP flood event. The dam attenuates river flows by temporarily storing floodwater, restricting flows past the dam through a single low-level outlet pipe (LLOP) and twin high-level outlet pipes (HLOP's) before overtopping the crest of the main dam and ultimately the higher secondary spillway. The subsequent reduction in the peak river flood flows provides an increased level of flood protection to the downstream Township of Gawler, and rural areas further downriver. The dam is only operated during flooding events. The dam is owned and operated by the GRFMA.

Modifications to the South Para dam wall and spillway to provide flood mitigation were completed in 2012.

It is understood there has been one significant flood since construction of the Bruce Eastick North Para River Flood Mitigation Dam and that flood was in 2016 where anecdotally the flood reached within approximately 500mm of the crest of the primary spillway. The outlets all operated, however, the secondary spillway did not.

The hydrology in the catchment is regularly reviewed and updated with more data, knowledge and improved tools available. A review during the time of the construction of the Bruce Eastick North Para River Flood Mitigation Dam found that the impact of the dam on peak flows at the Gawler Junction would most likely be less than the original design expectation.

Works on the South Para Reservoir and construction of the Bruce Eastick North Para River Flood Mitigation Dam have been estimated to reduce the extent of flooding in the Gawler township for a 2% AEP event whilst eliminating major flooding for events around the 5% AEP and less. This compares with the design expectation that the Bruce Eastick North Para River Flood Mitigation Dam would fill and overflow only for the 1 in 100-year ARI (1% AEP) and larger events.

2.8.2 Stormwater

Information on the existing stormwater infrastructure has been sourced from the SMPs that the various areas relate to. A plan showing existing stormwater infrastructure is shown in Figure 2-10.

Gawler and Surrounds

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

The Gawler Belt rural-living area has minimal formal drainage and primarily relies on small open channels and a few detention basins to manage stormwater. The Concordia area is served by existing creek lines and some formal structures under roadways. Similarly, the eastern rural living area of Kalbeeba has little to no formal drainage, relying on existing creek lines and short culverts beneath roadways.

There are stormwater detention basins scattered throughout the area to reduce peak flow rates. To a lesser extent there are water quality treatment devices in the form of sediment basins, wetlands and gross pollutant traps, to improve stormwater quality discharging to the receiving waterways.

Two Wells

Two Wells has no formalised minor (underground piped drains) drainage system, with virtually all urban stormwater runoff directed along the roads via kerb and gutter systems. This is changing however with the new developments being constructed.

Smith Creek

The developed areas in the east of the Smith Creek catchment are drained primarily by a formalised underground drainage network of pits and pipes. The developed areas within the west of the catchment are primarily drained by roadside swales and formal underground drainage in places. The formal drainage systems in developed areas discharge to Smith Creek via outfalls or drainage swales.

Whilst the spatial location of these assets is well established, their age and condition are less clearly defined. The City of Playford is progressively acquiring the information on the condition of its assets through its ongoing infrastructure asset management planning processes.

Angle Vale North

Stormwater runoff generated within the existing Angle Vale North Precinct is currently conveyed by a network of underground drains to detention storages. These detention storages are serviced by one of three existing trunk outfall drains along Broster Road, Heaslip Road and Chivell Road discharging into the Gawler River.

There are also three submersible pump stations within the precinct which service trapped low points in Stevens Drive, the detention basin at the intersection of Fradd Road and Harradine Court, and the detention basin at the Fantasia Drive land division.

2.8.3 Levees

There has been substantial infrastructure development along the Gawler River floodplain and therefore many of the lower sections of the Gawler River have seen the construction of large flood embankments (or levees), which are often two to three metres higher than the natural floodplain level (Figure 2-11 and Table 2-5). Levees are intended to protect public and private infrastructure. The Gawler River has a number of levee banks which increase the capacity of the main channel before flood flows reach a level that they are able to overtop the levees.

In many places these are naturally formed levees of river silt deposits (a feature of perched river systems) but have been re-engineered in places by past and present landholders as well as Councils.

Tonkin Consulting undertook a condition assessment of the levees along the southern bank of the Gawler River between Heaslip Road, Angle Vale and Old Port Wakefield Road, Virginia. These levees have been found to need maintenance in places with numerous breaches.

The Department for Environment and Water have also commenced a pilot project on levee repair on private land along the Gawler River. The aim was to condition rate existing levees, reconstruct levees to an appropriate standard, develop a process for undertaking works on private land and inform the ongoing process for levee improvements on private land (see Section 1.3.5).

Levees will be reconstructed to achieve a 0.5% AEP level of protection in the Angle Vale residential growth area. This is being reviewed through the City of Playford Levee bank framework that aims to maximises the strategic benefit of levees and develop maintenance guidelines. Levees are also planned to be constructed in the Two Wells area.

Table 2-5 Approximate Length of Existing Levees by Local Government Area

Local Government Area	Approximate Length of Existing Levees (Based on 2021 LiDAR)
Adelaide Plains Council	122 km
City of Playford	85 km
Light Regional Council	9 km
Town of Gawler	4 km

2.8.4 Transport

Significant major transport infrastructure is located within the Gawler River catchment area including:

- The Port Wakefield Highway
- The Northern Expressway (NEXY) which crosses the Smith Creek Floodplain
- Angle Vale Road
- The Adelaide to Port August Railway Line

These transport and freight routes need to be considered when assessing flood risk and also for consideration in emergency response planning.

The roads identified are owned and operated by the Department for Infrastructure and Transport and the rail line is managed by the ARTC.

These are vital transport and freight routes and if they are closed or damaged due to flooding this can have a significant impact on communities and the economy.

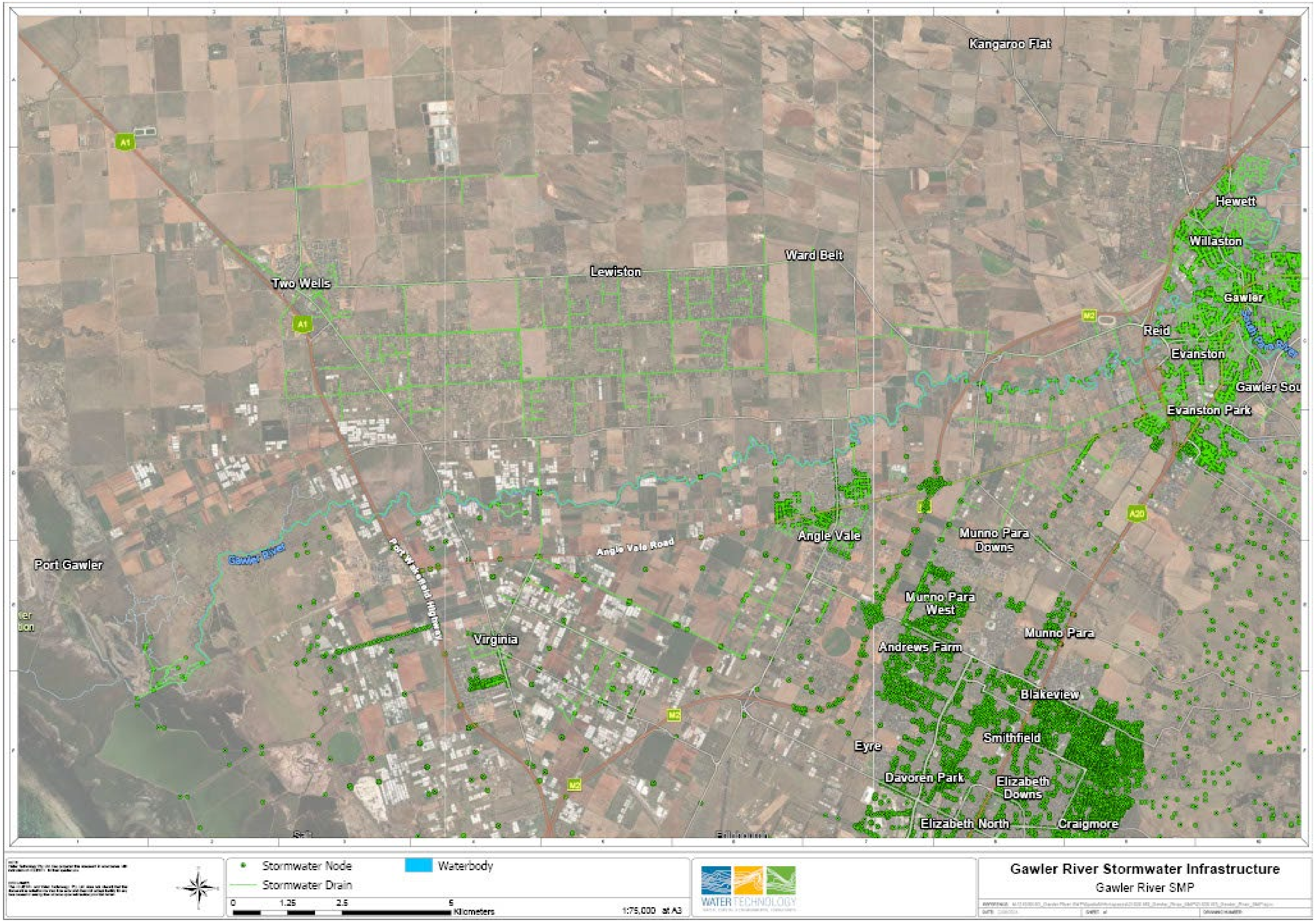

Figure 2-10 Stormwater Infrastructure

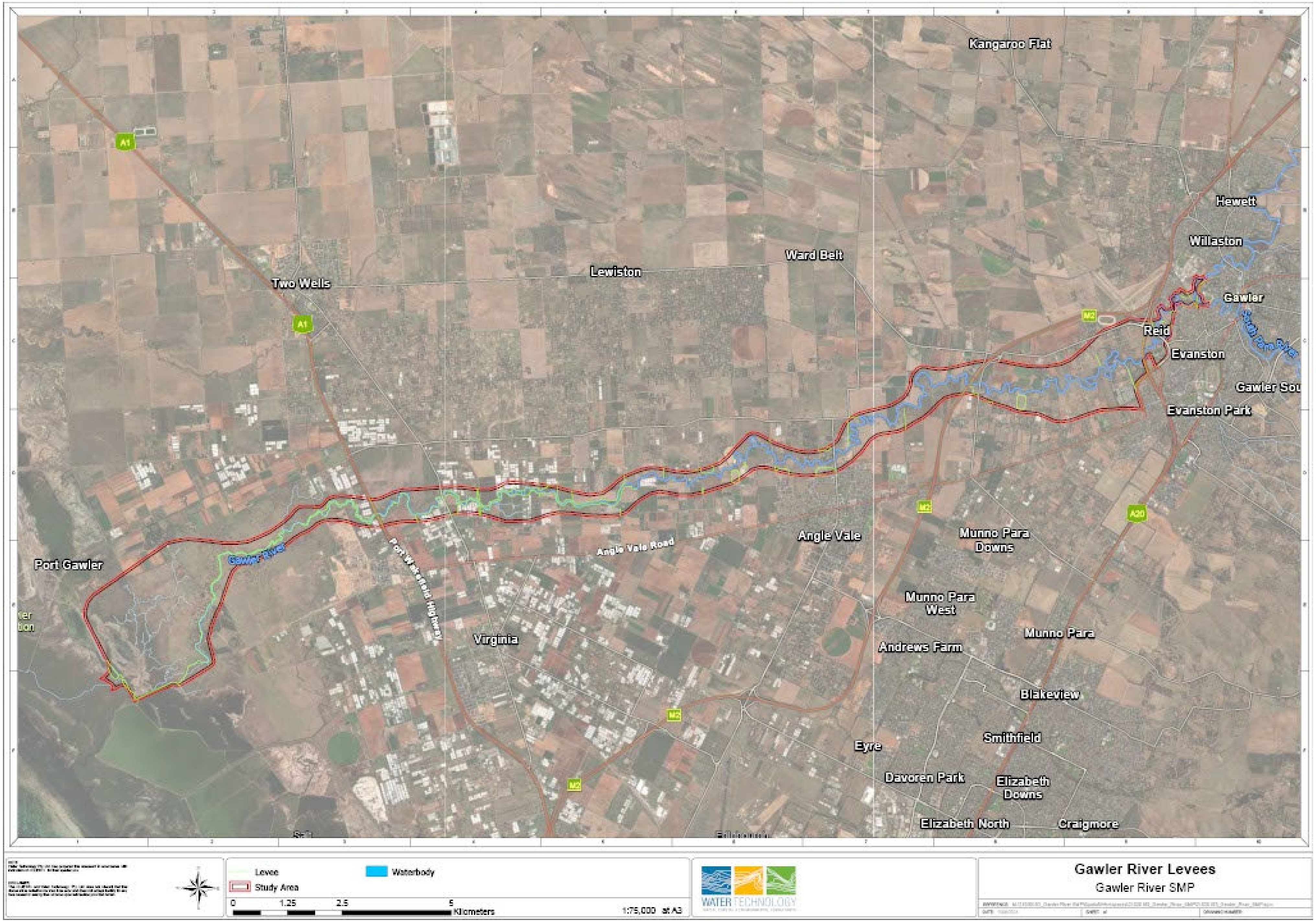

Figure 2-11 Levees in the Gawler River Catchment

2.9 Water Quality

The water quality of the Gawler River system is generally considered to be poor due to human disturbance of the catchment area.

The primary pollutants in runoff from the urbanised areas include gross pollutants, sediment, dissolved pollutants and pathogens while the pollutants from the agricultural and horticultural areas generally include nutrients and pathogens.

The closest available water quality data for the Gawler River is at the Virginia monitoring station (A5050510). The data covers the period March 2012 to March 2017 and included 52 water quality readings over this period. Comparison of the recorded data with the ANZECC guidelines showed:

- Total phosphorus (TP) readings ranged from 15 µg/L to 1,590 µg/L with 75% of the readings exceeding the ANZECC guideline value (100 µg/L) for ‘slightly disturbed’ ecosystems in lowland rivers in south-central Australia.
- Nitrates (NOx) show levels exceeding the ANZECC guideline value of 100 µg/L for 77% of the samples, with recorded values ranging from 3 µg/L to 8,380 µg.

2.10 Receiving Waters

The Gawler River discharges into the Gulf St Vincent at Port Gawler, which is located at the northern end of the Barker Inlet.

The area in the immediate vicinity of the Gawler River outfall predominantly comprises mangroves with some saltmarsh, while in the broader area dense seagrass occurs sub-tidally. The mangrove, saltmarsh and seagrass habitats of the region support a range of fauna including important fisheries species, threatened shore birds and a population of bottlenose dolphins.

The Gawler River outlet discharges near several areas of environmental significance. These are important biodiversity areas in need of protection from poor water quality, sediment transport and changes in hydrological regimes associated with development. These areas include:

- Barker Inlet
- St. Kilda Aquatic Reserve
- Port Gawler Conservation Park
- Adelaide Dolphin Sanctuary
- Large areas of mangroves (Avicennia Closed Forest)
- Adelaide International Bird Sanctuary National Park (RAMSAR listed)

Two key artificial environments, the Dry Creek Saltfields and Buckland Park Lake, enhance the overall value of the area by providing diversity of habitat, and specifically for shorebirds, protected high-tide roosting and supplementary feeding areas.

A 2013 study by the South Australian Environment Protection Authority (EPA) rated the health of the aquatic ecosystems within the South Para River in Gawler as “poor”, with extended dry conditions and “evidence of human disturbance and nutrient enrichment”. There are widespread introduced weeds in the riparian zone.

A similar study undertaken in 2008 for the Gawler River at Gawler rated the condition of the river as “very poor”. It was noted that the ecosystem was in a severely degraded condition with major changes to both the animal and plant life, and that there was a significant breakdown in the way the ecosystem functions because of human impact. The study concluded that the impacts of urban stormwater, runoff from agricultural areas and drought had contributed to the highly disturbed condition of the River.

2.11 Water Resource Availability

Various water resources are available within the Gawler River catchment including:

- Groundwater, mainly from the T2 aquifer, which led to the development of the important horticultural industry in the Virginia area
- Treated wastewater from Bolivar DAFF Plant and the NAIS plant which has also led to further and more sustainable horticultural activity
- Mains water supply is provided by SA Water
- Stormwater is a resource that is increasingly being harvested for use within the catchment area.

A limiting factor for further development (both industrial, agricultural and housing) is the availability of the water resources and the price that they can be supplied at.

Existing and proposed schemes for Water Harvesting and Reuse are contained in the sections below, as described in other relevant SMPs.

2.11.1 Gawler Water Reuse Scheme

Bunyip Water Pty Ltd was formed to build and operate a harvesting and reuse scheme. The Bunyip Water Scheme harvests water from the Gawler River and delivers at least 800 ML/year to Seppeltsfield in the Barossa. It will also supply up to 50 ML/year for the irrigation of parks and schools in the Hewett region.

The scheme is currently in the process of acquiring authorisation to harvest up to 1,600 ML/year from the Gawler River for flows above the environmental water requirements. Water is currently stored in dams, but a managed aquifer recharge (MAR) trial has indicated that MAR is something that is likely to be viable but still requires additional risk assessments to be completed.

2.11.2 Gawler Urban Growth Areas

A harvesting and reuse scheme is proposed for the Gawler Southern Urban Growth Areas. The scheme would include a number of wetlands and basins, bores, pumps and storage tanks. Water is proposed to be used for irrigation of reserves and for irrigation at the local schools including Trinity College.

2.11.3 City of Playford Stormwater Harvesting Schemes

The City of Playford owns several stormwater harvesting schemes operating along Smith Creek. An outline of the schemes is provided in Table 2-6.

Table 2-6 Stormwater Harvesting Schemes in the City of Playford

Scheme Location	Details
Andrews Farm (Davoren Road, Andrews Farm)	The Andrews Farm scheme was constructed in 1993 and incorporated into a new urban development. The scheme operates with two T2 aquifer wells each with a maximum yield of around 28 L/s. In addition to wetland treatment, the water is passed though mechanical and media filtration prior to injection. The water is used for irrigation.
Munno Para (Curtis Road, Munno Para)	The Munno Para MAR scheme was constructed in 2008–09 and incorporated into a new urban development. The scheme operates with three high-yielding wells between 115–130 m deep with open-hole completions in the T2 aquifer. The scheme sources its water from an offtake from Smith Creek running under Curtis Road. Water treatment is via a wetland.
Stebonheath-Curtis (Corner of Stebonheath Road and Curtis Road, Munno Para West)	This scheme was constructed in 2012. It is located one kilometre north-west of the Munno Para schemes, and it shares most of the same features including the water source and target aquifer. It has two wells that are 120 m deep completed open-hole. Water treatment is by a 2.6 ha wetland.
NEXY Basin (Short Road, Penfield)	The NEXY (Northern Expressway) Basin MAR scheme was constructed in 2015. The water is not directly pumped from the scheme into the Playford alternative water main, but rather the water volume is transferred from the injection site and withdrawn from the T1 aquifer at Andrews Farm. The scheme sources water from Smith Creek, but at a location much further downstream from the other Playford schemes. Water that enters the basins in pumped into the storage and following a short detention period (e.g. 1 or 2 days) is then treated through mechanical filtration and media filtration. The scheme has three 126 m deep wells with open-hole completions in the T2 aquifer from 93 m depth. Well yields in this area can be very high and yields vary between 30 and 60 L/s.

3 PROBLEMS AND OPPORTUNITIES

3.1 Introduction

The problems and opportunities identified within this section are based on:

- The results of flood modelling;
- Survey of the Gawler River;
- Assessment of risks to the receiving environment (SARDI, 2023);
- Consultation; and
- Review of previous studies and programs of works.

3.2 Problems

3.2.1 River Capacity

The capacity of the Gawler River channel falls from east to west. Previous assessments of channel capacity of the Gawler River have shown that the capacity steadily decreases from Gawler to the Gulf. For example (AWE, 2008):

- Between Wingate Road and Pederick Road, the river's capacity is between 250-350 m^3/s.
- Between Baker Road and Old Port Wakefield Road the river's capacity is in the order of 80-100 m^3/s.

Whilst the limited capacity of the lower Gawler River is largely a natural characteristic, the gradual accumulation of sediment and increasing density of weed species including exotic trees has further compromised the capacity of the river.

3.2.2 Land Ownership

There are challenges regarding much of the relevant land around the Gawler River, Light River, Templers Creek and Salt Creek as they are located on, or flow through, private land. Therefore, there is a crossover of responsibilities for the maintenance and clearance of channels to enable river flows and the accumulation of debris and native regrowth. In addition, there is also important infrastructure such as levees located on the private land with no formal guidance on maintenance or inspections to ensure integrity of this important infrastructure.

3.2.3 Waterway Stability

Many assessments of the Gawler River channel have identified that a significant amount of the water course is incised and in poor condition. Bank instability results in an ongoing supply of sediment into the water course.

The bank and other stability issues are primarily driven by the increase in runoff frequency, intensities, and volumes as a result of upstream land clearance and urbanisation. Local land management also has a role to play but, that is a secondary factor to the overarching change in catchment hydrology that has occurred due to changes in upstream land use.

Detailed assessment of waterway stability of the Gawler River is challenging due to the length of the watercourse and access difficulties due to private ownership in many sections of the River. A helicopter survey was undertaken to obtain additional LiDAR information in 2021. The footage obtained was reviewed to determine if it could be utilised to assess waterway condition and health. However, the vegetation cover was too dense to see the majority of the bed and banks and in addition the water in the River also obscured the view. The conclusion is that on ground assessment of the river condition is needed.

A watercourse assessment was undertaken along 31 km of watercourse including Smith Creek and parts of its tributaries during the development of the Smith Creek SMP.

The survey highlighted that much of the watercourses associated with the study area are incised and in poor condition. Bank stability being the main issue, resulting in the ongoing supply of sediment into the watercourse. These bank and other stability issues are primarily being driven by the increase in runoff frequency, intensities and volumes as a result of upstream land clearance and urbanisation. Local land management also has a role to play but, that is a secondary factor to the overarching change in catchment hydrology that has occurred as a result of changes in upstream land use.

3.2.4 Ecological Threats

The following threats facing biodiversity and natural processes in the Gawler River include:

- Alteration of stream flows (from instream structures, floodplain changes and catchment alterations; irrigation storages);
- Dam construction affecting flooding, water temperatures and life cycles of fauna and plants;
- Loss of habitat area;
- Loss of habitat diversity;
- Instream barriers to fish passage;
- Loss of riparian (riverside) vegetation;
- Siltation;
- Contaminants (insecticides and weedicides) from agricultural & forestry practices;
- Non-native flora and fauna species posing threat to native species; and
- Increased nutrient loads from agricultural fertilisers.

3.2.5 Water Quality Impact

Water quality is important for all aquatic fauna and flora and many of the ecological threats listed above arise from poor water quality. The Gawler River is saline, carrying heavy sediment loads and very high nutrient levels. Further development of the catchment and floodplain could have further impacts on the water quality of the Gawler River.

3.2.6 Levee Integrity

The levee system has inconsistent integrity and geometry.

Existing levees are mostly in very poor condition because they were either not constructed to an appropriate standard and/or have not been maintained. There is a risk of existing levees failing which could result in flooding.

3.2.7 Shared Responsibilities

Fragmented responsibility for floodplain management is a challenge for the ability to plan and implement effective and holistic responses to the issues within the catchment.

3.2.8 Flood Prone Areas

During high rainfall events, flood waters breach the banks of the Gawler, North Para and South Para Rivers, causing damage to crops, residential properties, infrastructure services and vital transport networks. There are also land areas that are not able to be developed due to flood risk.

3.2.9 Climate Change

The Intergovernmental Panel on Climate Change (IPCC) has concluded that 'it is now certain' that the climate is changing (IPCC 1990). The projections of the general impact of climate change includes:

- Warmer conditions including an increase in mean daily air temperature and mean sea water temperature
- Increase in the number of severe fire danger days, extreme heat days and days in drought
- A projected decrease in average annual rainfall, but a projected increase in the intensity of extreme rainfall events
- A median rise in sea levels

The projected changes to the current climate will impact the management of water resources within the Gawler River catchment – it will reduce the volumes of runoff available for reuse, impact water quality and may increase the frequency and severity of flooding.

3.2.10 Demand for Water Supplies

There is a high demand in the area for additional water supplies for economic and urban development.

3.2.11 Speed of Change

Due to the high inertia of the building stock, infrastructure and high-value agriculture, data reflecting the current status is important for modelling future risk exposures. Improved initial (present-day) data, especially on the value and location of buildings and agricultural practices, would improve the accuracy of results, as could improved damage values for road infrastructure. The pace of change within the catchment and the range of works ongoing makes it challenging to have information that is current to base assessments on.

3.3 Opportunities

For each of the problems, or challenges, identified in the previous section, there are opportunities for improvement that will result in social, environmental and economic benefits.

These opportunities include, but are not limited to:

- Watercourse rehabilitation for water quality and ecological benefits
- Encourage and develop programs to remove and replace non-native and pest flora and fauna species from within the water courses and the catchment
- Encourage primary industries (aquaculture) to move away from Redfin and utilise native species
- Community awareness raising regarding the impacts that activities can have on the health of the watercourses and water dependent ecosystems and the benefit of the floodplain
- Inform private land holders the importance of levees through education and extension of the levee pilot program to promote the integrity of levees on private land
- Flood mitigation and management measures which will enable further development and also reduce the risks of social and economic impacts of floods

- Improve fish migration by removal or modification (providing fish passage) of weirs and instream blockages
- Provide environmental flows, including flow to the sea, over an extended period late autumn to spring at least once every three years but preferably each year
- Increase catchment vegetation cover to reduce sediment runoff
- Provide opportunities for education and training regarding best practice horticultural and agricultural practices to reduce water quality impacts on the receiving water bodies
- Encouragement of Water Sensitive Urban Design (WSUD) measures throughout the urbanised areas to improve water detention, water retention, runoff water quality, habitat creation and amenity
- Utilise stormwater to help improve the amenity and recreational value of areas through the creation of green spaces (including linear trails to provide biodiversity corridors)
- The use of the Bruce Eastick North Para River Flood Mitigation Dam and the South Para Reservoir as alternate water resources for nearby regions

4 STORMWATER MANAGEMENT OBJECTIVES

4.1 Introduction

Stormwater management objectives are aspirational and are established to guide the selection of management strategies that will help achieve these objectives over a set period of time. The key issues to be addressed in the development of any plan for the management of stormwater runoff from an urban catchment include:

- Flooding
- Water quality
- Water use
- Environmental protection and enhancement
- Asset management

The process for developing these objectives, and the specific objectives themselves are summarised below.

4.2 Development Process

Stormwater management objectives for the Gawler River were developed through:

- Summarising the problems and opportunities in the catchment area (see Section 3)
- Consultation and discussions with the Project Steering Group, the Technical Steering Group and community focus group about the problems and opportunities in the catchment
  - The main concerns raised during extensive consultation as part of this SMP were focussed on the need to maintain high levels of service for agricultural areas, and to identify alternative and multiple purpose infrastructure for stormwater management. There was also a desire to improve the amenity of the Gawler River catchment.
- Reviewing relevant policies and plans (including existing SMPs within the catchment area)

4.3 Objectives

The overarching objective is to protect and enhance the Gawler River catchment from social, environmental and economic perspectives.

The key areas to be addressed for the management of stormwater runoff from the catchment include flooding, water quality, water use, environment protection and enhancement and asset management.

These areas are discussed below with specific objectives provided in Table 4-1.

4.3.1 Flooding

The regional flooding perspective is the main focus of the Gawler River SMP as described in Section 1.1. The predominant flooding risk is caused by riverine flooding, as opposed to localised nuisance stormwater flooding.

There has been consideration of what an acceptable level of protection of the community is from both the private and public assets perspective. This involves not just protecting habitable buildings from inundation, but also primary production land.

Minimising flood hazard to the community is also considered.

The specific flood mitigation objectives are dependent on the service level determined for the particular location within the catchment and the particular land use type. However, in general, the principles for flood mitigation include:

- Provide and maintain an adequate degree of flood protection to existing and future development
- Provide and maintain an adequate degree of flood protection to rural (including primary production) land
- Manage flood waters to minimise the risks and potential for damage from flooding
- Minimise the impact development has on flooding
- Increase awareness of flood risk and preparedness for a flood event by individuals, businesses, industry and government

4.3.2 Water Quality

There is limited water quality data within the catchment, however, it is acknowledged that there are significant opportunities for improvement. The water quality objectives that are commonly agreed upon include:

- Improve water quality to meet the requirements for protection of the receiving environment(s) and downstream water users
- Minimise the impact development has on water quality

4.3.3 Water Use

In a water constrained environment with significant development pressure, the imperative is on assessing and identifying the best use of the available water resources there are, that do not have a detrimental impact on the environment. The commonly agreed objective is to:

- Maximise the use of stormwater runoff for beneficial purposes while ensuring sufficient water is maintained in creeks and rivers for environmental and cultural purposes

4.3.4 Environment Protection and Enhancement

There are many opportunities for environment protection and enhancement within the catchment and opportunistic projects will be essential that can provide multiple benefits including:

- Manage stormwater runoff in a manner that protects and enhances biodiversity and the natural environment. In association with this, land used for stormwater management purposes should be developed, where possible, to facilitate recreation use and to enhance amenity
- Manage the catchment to improve the condition of receiving environments
- Maximise opportunities for sustainable and integrated water management solutions
- Increase awareness of the value of the floodplain and the natural environment for current and future generations

4.3.5 Asset Management

The number of flooding and stormwater related assets is increasing throughout the catchment and the diversity of their ownership, service level, inspection frequency and replacement frequency is also increasing. The complexity of this area will continue as more private developments are completed; therefore, asset management is an important area for agreement of next steps:

- Improve the management of stormwater and flood mitigation infrastructure, including ownership, responsibilities and maintenance, to ensure that they remain effective
- Maximise opportunities for partnerships to invest in and manage infrastructure, including natural systems

Table 4-1 Stormwater Management Objectives for the Gawler River SMP

Area	Objective	Measure
Flooding	Protect habitable buildings from inundation	1% AEP modelled protection for habitable floor levels with 300mm freeboard where this is practically and financially achievable
	Protect primary production land from inundation	5% AEP protection for primary production land with zero freeboard, where this practically and financially achievable
	Minimise flood hazard to the community	Improved community awareness of flood risks and response procedures (measured through community surveys)
		All roads are trafficable for 1 in 5 ARI, depth no greater than 300mm in 1 in 100 ARI event (see flood hazard curves in Figure 4-1)
		No increase in peak flows as a result of development
		Planning controls effectively utilised to avoid development in high hazard areas
Water quality	Improve the water quality of stormwater discharges to the receiving environments (Creeks, Rivers and Coast)	Pollution reduction targets to be met for new developments: - Total phosphorous 60% - Total nitrogen 45% - Suspended sediment 80% - Gross pollutants 90%
Water Use	Increase the beneficial usage of stormwater	Volume of stormwater that is reused
		Number of passive irrigation systems that are implemented
		Number of new developments that encourage the installation of rainwater tanks
Environment Protection and Enhancement	Retain and enhance the habitat quality of the existing natural watercourses in the area	Length of waterway restoration works undertaken
		Measures in place to ensure that environmental water requirements of the receiving water bodies are able to be met and sustained
	Maximise the community use and benefit derived from stormwater management infrastructure, including opportunities for biodiversity, water quality, amenity and environmental enhancement	Number of stormwater management solutions implemented that provide broader environment protection and enhancement benefits
		Number of education and awareness sessions undertaken
Asset management	Clear identification of asset ownership and maintenance	Agreement in place on levee ownership and responsibility for maintenance
	Effective and sustainable long-term management of stormwater infrastructure, including asset renewal	Asset management strategies and plans in place

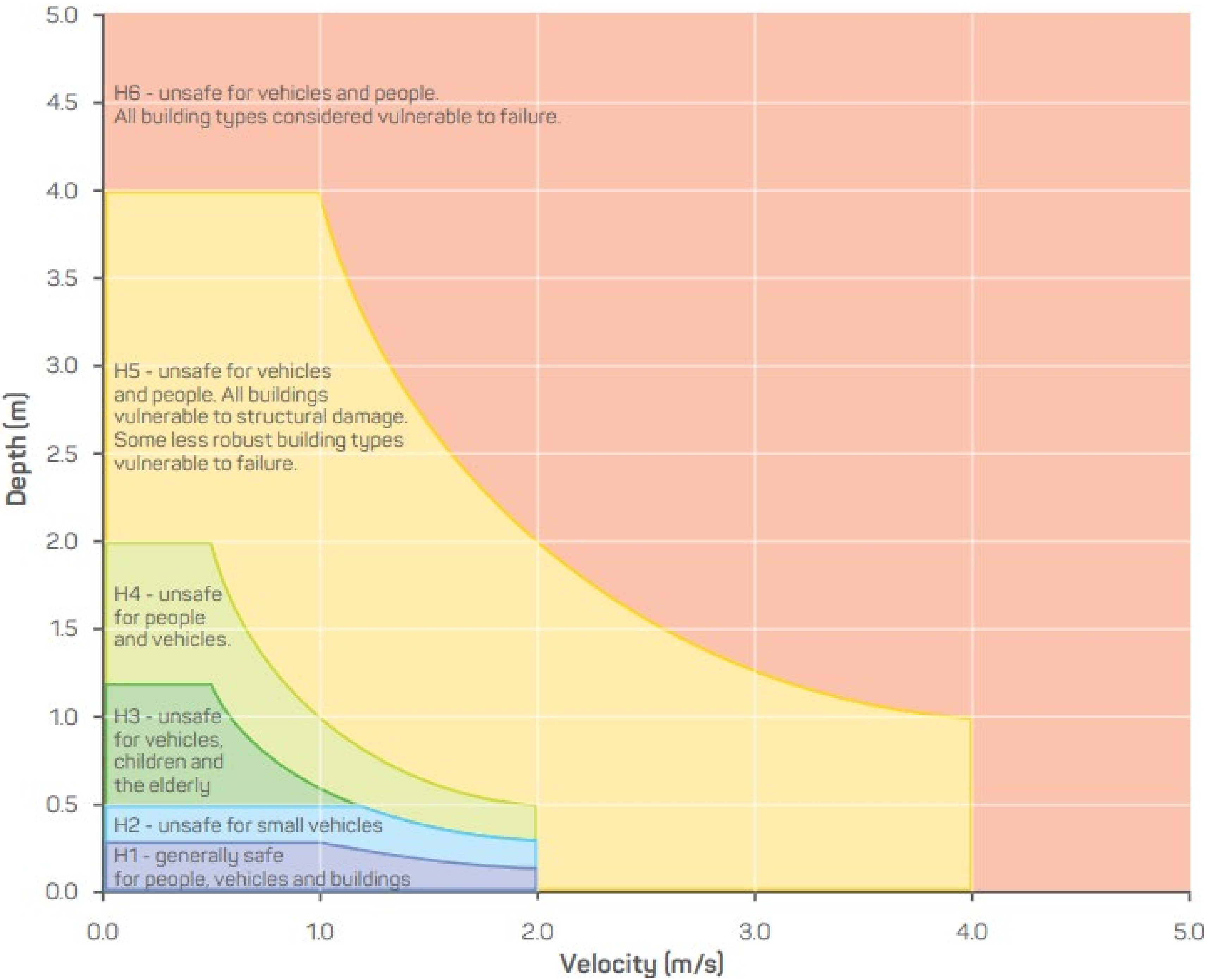

Figure 4-1 Flood Hazard Curves. Source: Smith et al (2014)

5 MODELLING

5.1 Introduction

A significant amount of modelling has been undertaken across the Gawler River catchment over many years. A summary of the modelling that has been used to help define the appropriate management strategies to meet the objectives is contained in the sections below. Some of this modelling has been undertaken as part of the development of this SMP, other modelling has been undertaken as part of the development of other SMPs and some modelling was undertaken for different purposes (such as the complementary projects listed in Section 1.3.5 and historical projects such as development of the Adelaide Coastal Waters Water Quality Improvement Plan).

The focus of the modelling also varies across the different SMPs which can be summarised as:

- Gawler River SMP modelling (this SMP) focuses on riverine flooding across the Gawler River catchment downstream of Gawler
- Gawler and Surrounds SMP focusses on urban stormwater and rural overland flow modelling and water quality modelling regarding the stormwater. This SMP does not consider riverine flooding
- Angle Vale North SMP focusses on urban stormwater
- Two Wells SMP considers both urban stormwater and riverine flooding
- Smith Creek SMP has a focus on riverine flooding but does consider urban development as well

5.2 Regional Flooding

Modelling flood depth and velocity can be used to identify areas of risk. To assess the impacts of regional flooding and the impact that mitigation options may have on the regional flooding impacts, hydrological and hydraulic modelling was undertaken for the Gawler River which is summarised below.

This is in addition to extensive modelling that has been undertaken in the catchment area previously which has covered the Gawler River, the Light River and Smith Creek.

A summary of the historical modelling that has been undertaken by Water Technology for the Gawler River is included in Appendix D.

5.2.1 Hydrological Modelling Overview

Following an extensive review of river gauge monitoring data and Flood Frequency Analysis (FFA), the previously used RRR model, developed in 2007 and updated in 2014 was utilised unchanged. The decision to not transition the model to utilise 2019 IFDs and temporal patterns was made as the model has been calibrated to FFA peak flows and volumes (which remain unchanged). Details of this review is contained in the State of the Catchment report (Water Technology, 2024).

The model was used to derive future climate hydrographs by increasing rainfall intensity. The total storm event rainfall was increased by 5% per degree of warming, resulting in a 18% increase in rainfall intensity.

The 24-hour duration event was adopted for modelling, as per previously. This duration event was found to best replicate the peak flood flow and volumes across the catchment.

Additional sensitivity testing of the peak flow and volume in the hydraulic model would determine the extent to which changes in hydrology may impact flood extents from the Gawler River.

5.2.2 Hydraulic Modelling Overview

The 2D hydraulic model (MikeFlood) developed in 2008 as part of the Gawler River Floodplain Mapping study has been maintained and updated since then. The model has undergone significant calibration to historic events, including to the 2016 flood event. The model boundary and included structures are shown in Figure 5-1.

The model underwent further updates as part of this SMP with the following elements:

- Revised LiDAR, flown in 2021, and covering approximately half of the model area.
- ARTC Gawler River rail bridge updated based on *As Constructed* drawings.
- Existing levee banks updated to 2021 levels (based on the LiDAR).
- Modified from fixed grid to flexible mesh, allowing finer resolution within flow paths.

Hydraulic roughness was applied as per planning zones, this assumes current development plans are fully developed.

Limitations and key assumptions of the model include:

- Outdated LiDAR is utilised in approximately half of the model area (typically south of Gawler River). The resolution is acceptable for modelling; however, recent urban developments may not be captured, including storages.
- The model includes inflows at the North and South Para, upstream of Gawler township. This excludes stormwater downstream of these inflows, including any overland flows that potentially cross into the catchment.
- The stormwater drainage networks within towns have not been represented in the model and are assumed to be at capacity.
- The modelled upstream limit of the North Para is approximately 600 m upstream of the Bruce Eastick Flood Mitigation Dam. The model cannot be used to accurately estimate upstream impacts of modelled changes to the dam, including mitigation options to raise the crest level. In addition to impacts that propagate upstream, such as raised levels, there may also be large, localised flood depths at the dam crest. The proximity of the model boundary introduces uncertainty at these depths, and at larger events results in ‘glass-walling’ where the modelled flow is unrealistically hitting an artificial model boundary. To avoid this, the Dam has been (and continues to be) represented within the hydrologic model as a storage, with downstream flows applied to the hydraulic model.
- Any modifications to bridges or major culverts since the time of survey may not have been captured in the model.
- Levees are assumed to be maintained in good condition. Levee levels are assumed to be maintained at their point of survey with the ability to check the impact of a gap or reduction in level, as well as to identify key levees that have a large impact on flow.
- Levees built since 2021 are not included in the model.

Previously developed hydrology was considered appropriate to use and calibration parameters were kept. The calibration and validation of the model is documented in the State of the Catchment report (Water Technology, 2024).

Since the completion of the modelling for this SMP, there have been amendments made to the model that include the representation of the Northern Expressway Basin (refer to Appendix D). There were some challenges with this area of the model as it is against the model boundary, which was at the limit of the LiDAR.

A recommendation has been included to review this component of the model and determine how the outputs can be validated.

Climate change was modelled for the year 2090 for Representative Concentration Pathway (RCP) 8.5 for the base case with 1% AEP. An 18% increase in rainfall intensity was applied, based on Australian Rainfall and Runoff interim climate change guidelines, using +3.4ºC increase.

5.2.3 Drainage Performance

Riverine flow paths and flood levels through towns have been determined through the hydraulic modelling for 10%, 5%, 2%, 1% and 0.5% AEP, and can be used to identify areas of pooling or where drainage is needed.

Major drainage assets, including culverts and bridges, are included within the model and their performance at passing design flows can be readily evaluated. The Gawler River itself is not impeded by these structures. Across the modelled catchment, many roads are overtopped in flood events, with road structures typically flowing at capacity.

5.2.4 Flood Impacts

Modelled flood impacts are typically related to flow behaviour at or around the levee system. Particularly in the lower half of the catchment, these levees control areas of inundation and levels at which breakouts occur. As the capacity of the channel decreases toward the river outlet, flows break out in multiple locations.

The existing conditions 1% AEP peak flood depths are shown in Figure 5-2. The mapping of the outputs from the other scenarios for the base case are included in Appendix E.

These results show that in a 1% AEP event, Gawler River flows are typically contained to the floodplain upstream of the Northern Expressway. Beyond this, they breakout to the north, through Lewiston toward Two Wells. There is no single point at which this breakout occurs, rather it is the result of overtopping multiple levees at multiple locations. From Two Wells, this flow enters Salt Creek where it is once more contained.

On the southern side of Gawler River, similar breakouts occur above levee crests.

Flows also notably cross Angle Vale Road to Virginia. Again, this occurs in multiple locations. Once flows are south of Angle Vale Road they continue westwards across Port Wakefield Road, and do not return to the main river channel.

Port Wakefield Road is cut in multiple locations by flood either side of the Gawler River, with the Salt Creek crossing causing the highest overtopping depth. Emergency planning should consider the closure of sections of this road.

Within Gawler township, flooding is expected in Gawler West and selected properties near the river, however, most flow is generally limited to the main river and surrounding floodplain. Multiple roads are identified as overtopped, and parks and reserves beside the river are inundated.

The flood modelling also showed a breakout upstream of the Northern Expressway which impacts land to the south, most notably the Angle Vale Growth area.

The flood mapping outputs for the 1% AEP climate change scenario for the base case is shown in Figure 5-3 and additional scenarios are contained in Appendix E.

The impacts of flooding in terms of damages were estimated for the base case flood event using GIS data based on the flood maps generated from the flood modelling and is summarised in Table 5-1. The flood damages assessment process accommodates the large areas of open rural land and high value horticultural crops in the Gawler River catchment.

Table 5-1 Summary of Estimated Damages Based on the Flood Modelling Undertaken

	Total properties impacted (no.)	Residential and commercial properties impacted (no.)	Length of road impacted (km)	Area of farmland† impacted (km^2)
1AEP Base Case	2,802	1,545	162	62.6

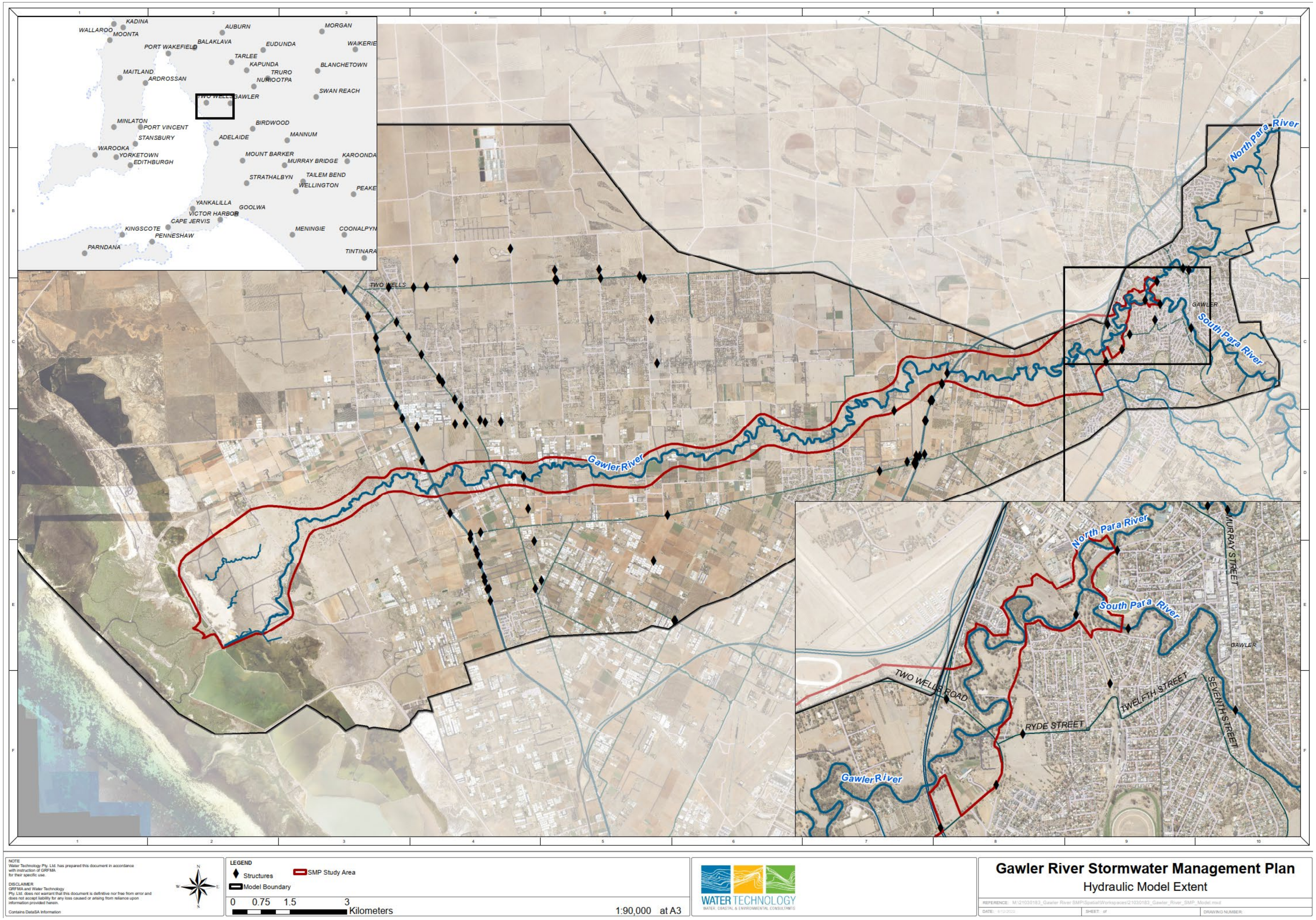

Figure 5-1 Hydraulic Model Extent Showing Modelled Structures

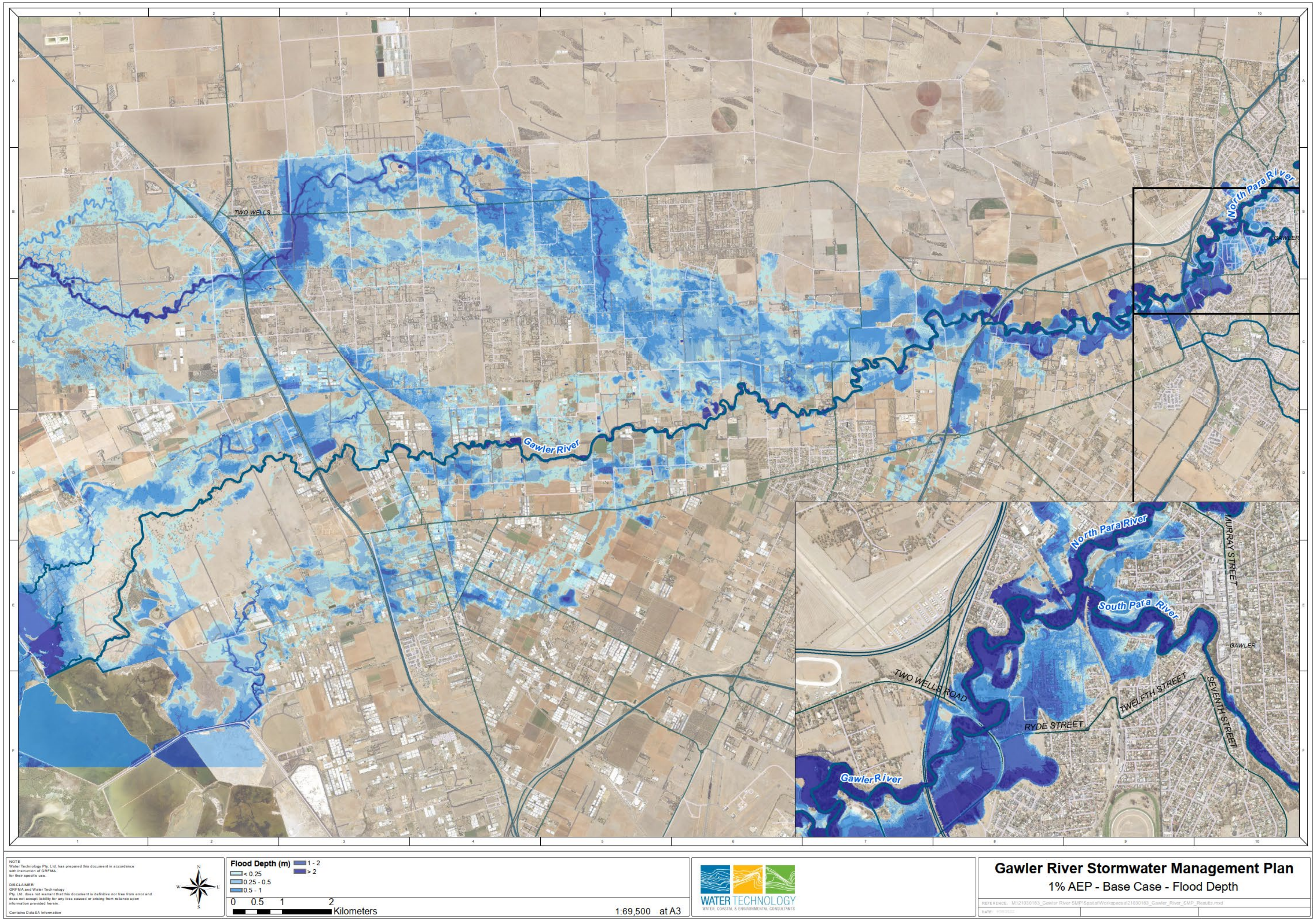

Figure 5-2 1% AEP Base Case Peak Flood Depth

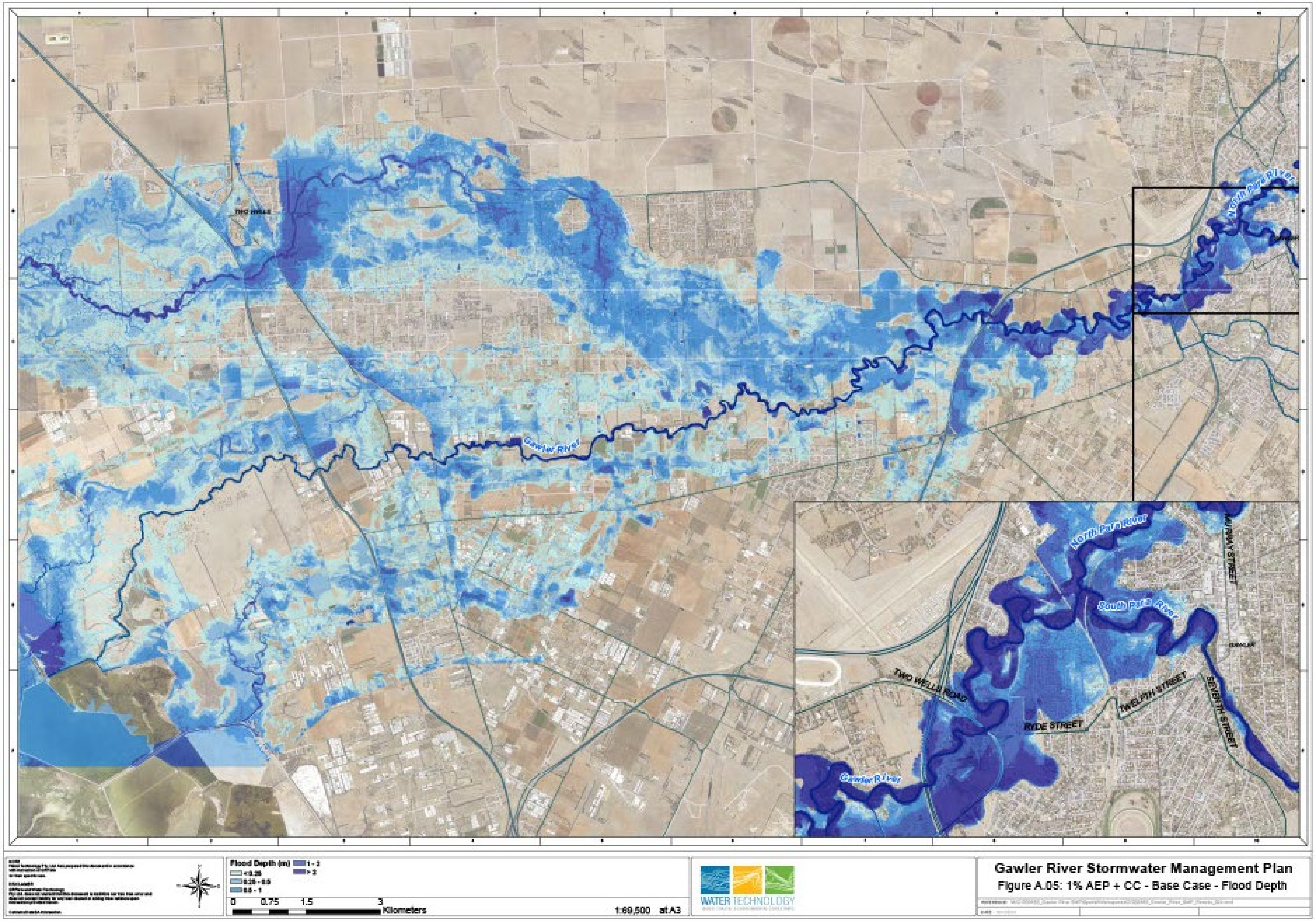

Figure 5-3 1% AEP and Climate Change – Peak Flood Depth

5.2.5 Structural Failure Impacts

There are a number of structures already constructed for flood mitigation throughout the catchment including the Bruce Eastick North Para Flood Mitigation Dam and levees. The failure of these structures, due to construction or maintenance, could have severe consequences in the catchment.

Therefore, an assessment of the dam failure and consequences for the Bruce Eastick North Para Flood Mitigation Dam was undertaken at the current height (30.1m) of the dam (HARC, 2019). The dambreak modelling completed for this project used a two-dimensional hydraulic model (TUFLOW) to determine the depth, velocity and extent of inundation for a range of dam failure and extreme flood scenarios downstream of the Dam.

The hydrological analysis indicates that the primary spillway is engaged at a 1 in 50 AEP event and the Dam Crest Flood (DCF) is approximately 1 in 2000 AEP. The outflow Probable Maximum Flood (PMF) was estimated to be 8720 m^3/s.

The scenarios modelled included:

- 1 in 50 AEP (primary spillway engaged)
- Dam Crest Flood (DCF) with and without failure (secondary spillway engaged)
- Probable Maximum Flood (PMF) with and without failure

Consequences of dam failure were estimated for each of these scenarios including:

- The total and incremental potential loss of life
- Economic damages
- The impacts of dam failure upon the natural environment, society and the dam owners business

The consequences were used to determine the flood consequence categories for the dam according to the guidance in ANCOLD (2012). The consequence category was determined to be “High B” and this then informed the current inspection regime.

5.2.6 Flood Damages Economic Assessment

The economic assessment of flood damages can allocate costs into two primary categories – tangible and intangible. Tangible damages can then be further separated into direct and indirect costs. Figure 5-4 illustrates the general damage categorisation process.

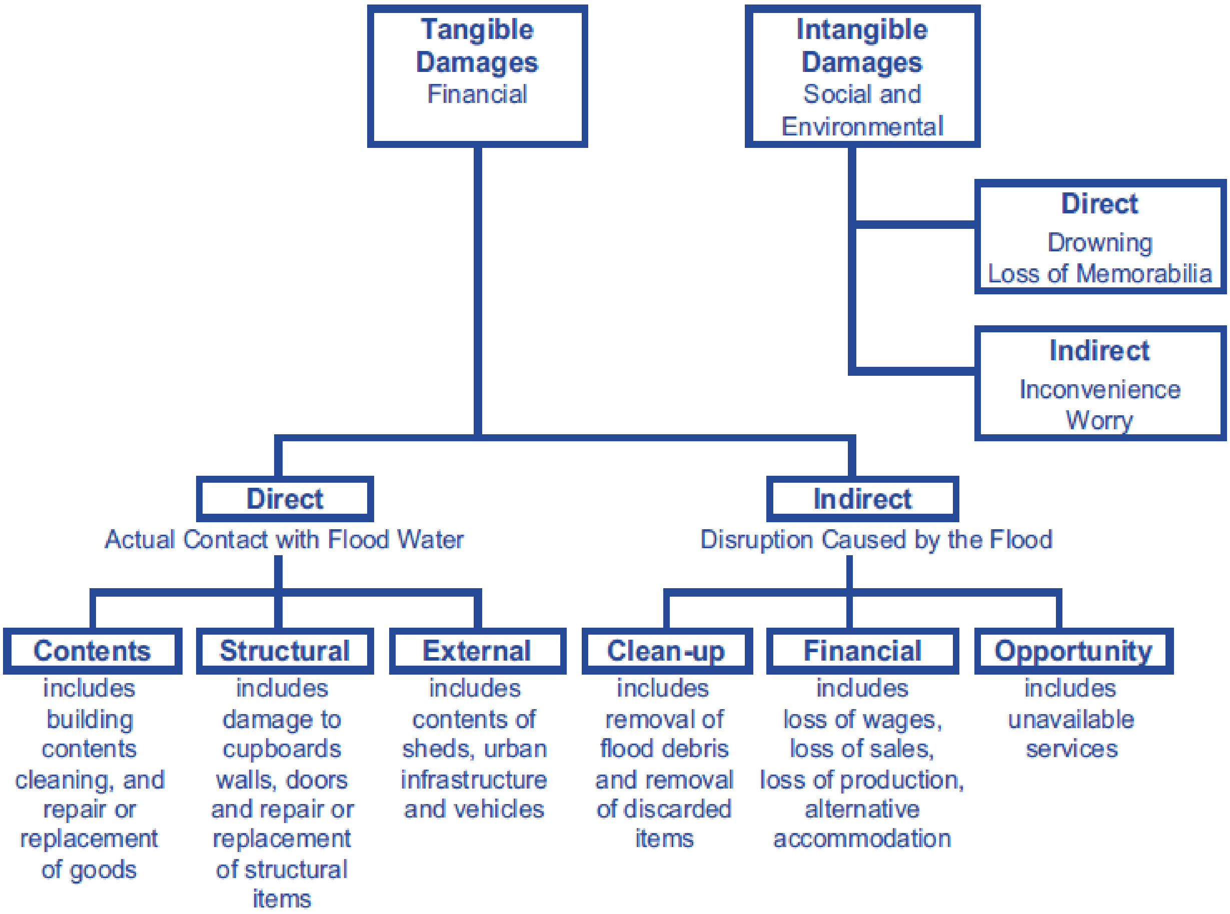

Figure 5-4 Flood Damages Categorisation Process

Source: Commonwealth of Australia (2012)

Direct tangible losses are the losses that arise from the destruction of, or damage to, a physical asset. This includes losses as a result of damage to residential, commercial, or industrial buildings, including:

- Private or public buildings;
- Crops that are to be harvested for commercial sale and hence have a commercial value (whether or not they are naturally occurring);
- Private or public infrastructure such as roads, railway lines, telecommunications, pipelines, electricity generation and distribution systems;
- Vehicles and plant (e.g., mobile farm machinery);
- Livestock; and
- The contents of buildings (e.g. furniture and fittings, retail stock, machinery and goods used for production of a commercial product).

Indirect tangible losses are costs incurred as a consequence of the event occurring but are not related directly to the physical damage that has occurred. These costs include such things as:

- Marginal cost incurred by emergency service organisations in responding to the flood;
- Equivalent cost of volunteers' time in assisting with the response effort;

- Costs incurred by landholders in cleaning up after the flood, including their time;
- Emergency assistance grants given to people to help them deal with urgent issues (e.g., alternative temporary accommodation, replacing a fridge, fixing damaged windows); and
- Disruption to business.

Intangible losses include all those items that cannot be categorised as a direct or indirect tangible loss.

These costs include:

- Loss of life;
- Costs associated with personal injury;
- Increased medical costs / reduced life expectancy associated with increases in levels of sickness in a community following a disaster including stress related illnesses;
- Disruption to households;
- Loss of private memorabilia;
- Loss of heritage values; and
- Loss of items / features of cultural significance.

Outputs have been sourced from an update of the Gawler River UNHaRMED Mitigation Project (GRUMP) and the DEW Business Case Assessment (see Section 1.3.5). Table 5-2 summarises the various economic considerations and impacts included in the assessment.

Table 5-2 Identification of Economic Considerations and Impacts

Aspect	Consideration of Impact
Reductions in Average Annual Damages (AAD)	Benefit arising from reductions in average annual damages, i.e. the expected direct damage per year (AAD) accounting for inundation under a range of flood frequencies. This includes damages to capital stock (residential, commercial, industrial and agricultural properties, crops and infrastructure) (Source: GRUMP 2022, Integrated Assessment of Flood Mitigation Options)
Reductions in Average Annual Output Loss (AAOL)	Benefits arising from reductions in average annual output loss (AAOL), i.e. indirect damages due to productivity losses associated with direct damage to capital loss) (Source: GRUMP 2022, Integrated Assessment of Flood Mitigation Options)
Land Value increases for protected land	Benefits arising from increases in land value. Following flood mitigation, the unit area land value ($/m2) for each type of land use that is currently flood-affected would more closely reflect the value of nearby land that is currently not flood affected. Note this does not consider the value of capital improvements. (Note: Australian Transport and Planning Guidelines, 2021, recognises the land value uplift benefits attributable to new transport initiatives pp 19 and 40)
Increased water security	Benefits arising from the redirection of water detained in Bruce Eastick Dam for irrigation reuse
Reductions in contents damages	Benefits arising from reductions in the estimated value of contents in residential buildings damaged from flood events. The contents of commercial and government buildings were not included in this assessment due to a lack of data. (Source: Geoscience Australia)

Aspect	Consideration of Impact
Reductions in machinery and equipment damages	Benefits arising from reductions in estimated average annual damages to farm machinery and equipment.
Reductions in Gross Value Added (GVA) at risk	Benefits arising from reductions in the gross value added (GVA) at risk. This is based on the change in the proportion of employment land that would be impacted by flood following mitigation. For most of the structural options this is assessed under 1% AEP and 0.5% AEP flood events.
Land value increases for potential rezoned land	Benefits arising from land value uplift that would result from rezoning protected land to a higher value use.
Value of development uplift from new developments on protected land	Benefits arising from development uplift that would result from redeveloping land to a higher use (in this case, residential). A similar approach could be taken to assess the value of developing land for higher value agricultural/ horticultural use. (Note: Australian Transport and Planning Guidelines, 2021, recognises higher value land use benefits attributable to transport initiatives pp 19 and 40)
Environmental impacts	Dis-benefits to ecosystem function and native vegetation coverage

The outcomes of the economic assessment to help inform the options assessment is included in Table 5-3. Note that these are the short-listed options used for the options assessment process (outlined in Section 8) which are:

- Option 1: Bruce Eastick Dam Raise
- Option 1A: Bruce Eastick Dam Raise and Water Security
- Option 2: Northern Floodway
- Option 3: Township Levees
- Option 4: Flood Awareness Campaign
- Option 5: Dam Raise and Northern Floodway
- Option 6: Dam Raise and Planning Controls
- Option 7: Dam Raise and Township Levees and Planning Controls
- Option 8: Dam Raise and Flood Awareness Campaign and Planning Controls

Table 5-3 Summary of CBA from Gawler River Flood Management Business Case

Assessment Approach	Impacts	Value Uplift (PV$ m)								
		Option 1	Option 1a	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8
Inclusion in CBA	Reductions in AAD	250	250	22	-7	0	257	323	262	323
	Reductions in AAOL	78	78	45	-28	0	95	117	84	117
	Reduction in loss of residential contents	0	0	0	0	6	0	0	2	2
	Increased water security	0	<1	0	0	0	0	0	0	0
	Residual asset value	13	13	0	0	0	13	13	13	13
Inclusion in quantitative economic assessment	Land value uplift for protected land	305	305	<1	0	0	309	305	305	305
	Reductions in GVA at risk	129	129	2	-1	0	156	223	131	129
	Land value increases for potential rezoned land	26	26	0	0	0	7	91	26	91
	Value of potential development uplift from new developments	62	62	0	0	0	45	223	62	223

Source: Gawler River Flood Management Business Case (DEW, 2022)

5.3 Stormwater Drainage

5.3.1 Introduction

Modelling has been undertaken to assess the level of performance of stormwater drainage infrastructure for the SMPs related to the Gawler River catchment. A summary is contained in Table 5-4 and the outcomes are summarised below.

5.3.2 Gawler and Surrounds

Based on the hydraulic modelling undertaken for the Gawler and Surrounds SMP, a number of areas were identified as being flood prone including:

- Greening Drive (Evanston South) – trapped stormwater along Greening Drive causes flooding up to 0.6m deep in the 1% AEP flood event
- Railway Crescent / Przibilla Drive (Evanston) – trapped low-spot adjacent to the Gawler Bypass and experiences significant flooding in the 1% AEP event
- First Street (Gawler South) – trapped low spot adjacent to the Gawler Racecourse with significant inundation during the 1% AEP event
- Jarvis Street and Brooks Avenue (Willaston) – trapped low spots with flooding during 20% AEP events
- Jane Street and Davies Street – known locations of frequent flooding during 20% AEP events

Modelling of the effect of increased development in the catchment area (a 6.4% increase in impervious area) resulted in a 12% increase in average annual flows.

5.3.3 Smith Creek

For the 1% AEP event there were numerous breakouts identified across the Smith Creek floodplain. Three main flow paths have been identified. The results show several major flow paths across the floodplain that become well defined above the 5% AEP event. Numerous other flow paths were also identified, particularly across the floodplain to the west of the Northern Expressway. One major flow path closely follows the alignment of the Smith Creek channel from Heaslip Road through to the Port Wakefield Road. There is also a major flow path at Petherton Road where flood water would exceed the channel capacity and would spill southwards into the neighbouring catchment and adjoining Salisbury Council area.

The flood hazard mapping indicated that for the 1% AEP flood, whilst the flood extent is large, much of it is rated as being of low or moderate flood hazard due to shallow depths and low velocities resulting from the broad, flat floodplain. High and extreme hazard ratings were generally only observed within major open channels or formal detention basins, such as the NEXY detention basin near Heaslip Road and where water would back up behind flow control structures such as arterial roads and railway embankments.

The modelling incorporating the growth areas did indicate that there is an increase in floodplain extent, but this is typically minor except with respect to trunk drainage infrastructure along roadways e.g. Heaslip Road from Angle Vale. Whilst the increase in physical extent for the 5% AEP flood is typically less than for the 1% AEP flood, the impacts are proportionally more significant for the smaller events.

Table 5-4 Modelling Undertaken to Assess Stormwater Drainage Infrastructure

Project	Modelling Details	
Gawler and Surrounds SMP (Tonkin, 2021, draft)	Hydrological Modelling	Determine runoff from local urban catchments and external rural catchments to provide inputs to the hydraulic model. Time-Area method applied to create hydrographs for each sub-catchment. Runoff-routing models were developed to produce inflow hydrographs at the boundary of the hydraulic model. Three different catchment development scenarios were used: (i) existing development scenario, (ii) future development scenario (50-year time horizon) and (iii) future development scenario with flood mitigation measures. Inundation due to riverine flooding in the Gawler, North Para or South Para Rivers has not been included in the hydrological (or hydraulic) modelling.
Gawler and Surrounds SMP (Tonkin, 2021, draft)	2D Hydraulic Modelling using TUFLOW modelling platform	Using 2015 LiDAR. Outputs provide an estimate of areas subject to flooding. Five different flood events were modelled in 2D: 20%, 5%, 1% and 0.2% AEP. For each flood event a number of different storm durations were modelled between 30 minutes and 24 hours. Three different scenarios were modelled: (i) Existing infrastructure with existing development levels, (ii) existing infrastructure combined with predicted long-term development levels and (iii) existing infrastructure with proposed modifications and upgrades combined with predicted long-term development levels. To validate the results the peak recorded flow rate in key drains was compared with the theoretical capacity of the drains.
Gawler and Surrounds SMP (Tonkin, 2021, draft)	1D Hydraulic Modelling using DRAINS	Developed for the urban catchment.

Project	Modelling Details	
Smith Creek SMP (Water Technology, 2022, draft)	DRAINS modelling platform	The *Smith Creek Floodplain and Flood Hazard Study (Water Technology 2017)* carried out a full hydrological and hydraulic model of the Smith Creek catchment using the latest terrain survey and flood modelling techniques in order to provide current information on the flood risks within the study area. The following scenarios were considered: - Current Development (1% AEP only); - Ultimate Development (current Development Plan); and - Ultimate Development and 30 Year Growth Area
Two Wells SMP (AWE 2017)	DRAINS modelling platform used to undertake the hydrological / hydraulic modelling and analysis of the area	ARIs selected were 1, 2, 5, 10, 20, 50 and 100 years with storm durations ranging between 5 minutes and 6 hours. Three infill development scenarios were also undertaken (5%, 10% and 60% increase in catchment imperviousness). Modelling of the urban growth area was also undertaken to determine pre-development runoff rates and then post development runoff rates with no mitigation. Calibrated using anecdotal evidence from Council staff. Identification of existing drainage deficiencies where safe depths of stormwater across overland paths could not be achieved

Project	Modelling Details	
Angle Vale North SMP (Southfront, 2018)	DRAINS modelling platform	Design rainfall from the 2016 update of Australian Rainfall and Runoff. Two development scenarios were undertaken: - Full development of the growth area precinct with the existing level of development in the Angle Vale township - Full development of the growth area precinct with a future 'ultimate' level of development in the Angle Vale township (corresponding to the anticipated future subdivision of 50% of existing allotments) This modelling was undertaken to: - Establish pre-development peak flow rates for the 1:5 year and 1:100-year events - Perform initial infrastructure sizing and development/performance assessment of the preliminary stormwater drainage strategy for the growth areas; - Perform assessments of the existing stormwater drainage system in the Angle Vale township and scoping of trunk drainage upgrades for the 'ultimate' development scenario; and - Establish hydrographs for inputs into the floodplain mapping software.

Project	Modelling Details	
Angle Vale North SMP (Southfront, 2018)	TUFLOW (and ESTRY) was used to undertake hydraulic floodplain modelling	Floodplain mapping was performed to demonstrate the effectiveness of the proposed stormwater management strategy for the growth areas, and to assess the performance of the existing stormwater drainage system and proposed upgrades within the Angle Vale township. Floodplain modelling has been undertaken for minor (5-year ARI) and major (100-year ARI) design rainfall events. Floodplain mapping was undertaken for the following scenarios: - Existing development and existing stormwater drainage infrastructure in the Angle Vale township, plus the fully developed Growth Areas with the regional drainage strategy in place; - Ultimate development and existing stormwater drainage infrastructure in the Angle Vale township, plus the fully developed Growth Areas with the regional drainage strategy in place; and - Ultimate development and upgraded stormwater drainage infrastructure in the Angle Vale township, plus the fully developed Growth Areas with the regional drainage strategy in place.

5.3.4 Two Wells

Based on the hydrological modelling undertaken, stormwater drainage deficiencies were identified where the safe flow and/or the safe depth of stormwater across the overland flow paths (i.e. roads) were exceeded for AEPs of 18.13% (ARIs of 5 years) or less.

The required road drainage (flood protection standard) includes a 2.5m trafficable lane width in the 18.13% AEP (5-year ARI) event, and no more than 300mm depth in the 1% AEP (1 in 100 ARI) event. This standard of road drainage is achieved in the newly developed areas. Exceptions are limited to the older areas of Two Wells including:

- Old Port Wakefield Road:
  - South eastern end – a frequency of 63.2% AEP (1 year ARI) was estimated for exceeding both safe depth and flow rate
  - North west of Elizabeth St intersection – a frequency of 18.13% AEP (5-year ARI) was estimated for exceeding both safe depth and flow rate
  - Intersection with Brooks Rd – the model showed water collecting on the road shoulders – a frequency of 18.13% AEP (5-year ARI) was estimated for exceeding both safe depth and flow rate
- Two Wells – Gawler Road:
  - West of the intersection with Drew St – a frequency of 18.13% AEP (5-year ARI) was estimated for exceeding both safe depth and flow rate
  - Old Port Wakefield Road Intersection – a frequency of 18.13% AEP (5-year ARI) was estimated for exceeding both safe depth and flow rate
- Chapman Street (to the north east of the William St intersection) – water ponding on the verge of the southern side of Chapman Street with safe depth and flow rate exceeded for 18.13% AEP (5-year ARI)

The existing Two Wells township has a significant capacity for infill development. However, a comparison of the drainage standards for safe flow and safe depth conducted for the various infill development scenarios showed a noted impact on the hydrology of the catchment. For the infill of the town to continue proper procedures and planning need to be in place now to reduce the occurrence of future drainage issues and deficiencies in the stormwater system.

5.3.5 Angle Vale North

The 0.2 EY (5-year ARI) floodplain map shows that stormwater runoff is comfortably contained within the proposed channels and detention storages. Peak water depths observed for the 0.2 EY (5-year ARI) event are between 0.5-1.5 m.

The 1% AEP (100-year ARI) floodplain map shows the precinct stormwater strategy functioning as desired. Stormwater runoff is conveyed via the open channels to one of the detention storages with water depths varying within the respective storages.

During the 1% AEP (100-year ARI) the effects of the tailwater in the Gawler River are observed most prominently in the longer duration storm events.

The 0.2 EY (5-year ARI) 'ultimate' development floodplain map shows shallow flooding mainly contained to the road network throughout the existing township.

The 1% AEP (100-year ARI) 'ultimate' development floodplain map shows inundation of private property in a number of areas throughout the existing Angle Vale township. Inundation of private property is generally shown to occur in the areas of older housing stock, in the vicinity of Angle Vale Road, Edmonds Road, Chivell Road and Stevens Drive. In newer developments (i.e. Varacalli Way, Fantasia Drive, Bressington Drive and Elm Drive) the 1% AEP (100-year ARI) overland flows are generally contained within the road networks and/or detention basins with little intrusion into private property.

5.4 Water Quality

5.4.1 Introduction

A range of water quality modelling has been undertaken across the whole of the Gawler River catchment for the Adelaide Coastal Waters Study, the Adelaide Coastal Waters Water Quality Improvement Plan and more recently in parts of the Gawler River catchment for the development of SMPs which is summarised in Table 5-5.

MUSIC modelling simulates patterns of pollutant generation for urban areas. The MUSIC model is a simplistic model of flows and pollutant loads and is a useful tool for modelling relative changes to flows and water quality. It is therefore considered suitable for application to the water quality improvement modelling as part of the development of SMPs.

5.4.2 Catchment Scale

Rouse et al. (2016) carried out catchment-scale hydrological and water quality modelling including the Gawler River catchment. Rouse et al. (2016) demonstrated that over 13% of the Total Suspended Solids loading to the Adelaide coastline is provided by the Gawler River. The Gawler River had the finest particles (mean particle size 39 mM) of the rivers assessed, which might be a consequence of a gentler topography and prevalence of horticultural land-use, in comparison to the Torrens and Onkaparinga, which receive inputs from rivers draining the Mount Lofty Ranges. Total annual pollutant constituent loading is driven by larger events, especially in late winter, and mean annual loadings are much higher in wet years. Figure 5-5 shows the modelled mean annual Total Suspended Solids loadings for the Gawler River sub-catchments.

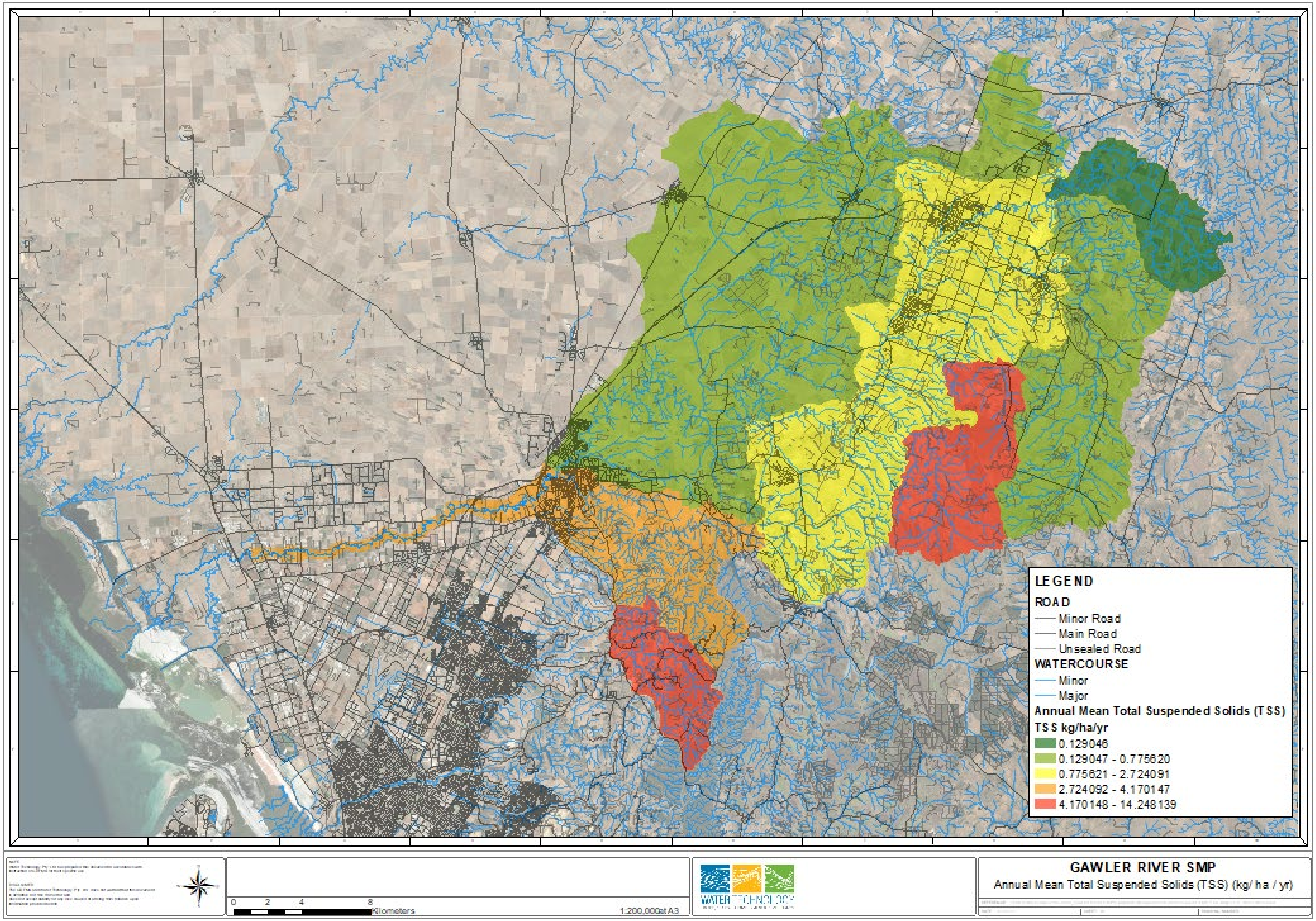

Figure 5-5 Modelled Mean Annual Total Suspended Solids Loading for the Gawler River Sub catchments (Rouse et al. 2016)

Table 5-5 Water Quality Modelling Undertaken in the Gawler River Catchment

Project	Modelling Details		Outcomes
Gawler and Surrounds SMP (Tonkin, 2021, draft)	MUSIC modelling to quantify current stormwater quality	7 sub-catchments Existing GPTs and detention basins included	
Gawler and Surrounds SMP (Tonkin, 2021, draft)	MUSIC modelling to quantify future stormwater quality	The impervious area was increased by 119ha (from 33.3% to 39.7%) to reflect the predicted development in the area Estimates of pollutant loads for long-term climate change scenario are not provided due to limitations with MUSIC	The modelling suggests that development within the catchment will increase flows, with a resultant increase in the annual pollutant loads
Smith Creek Catchment SMP (Water Technology, 2022, draft)	MUSIC modelling to quantify current stormwater quality	The default pollutant generation parameters in the MUSIC model were used for all sub-catchments.	
Two Wells SMP (AWE 2017)	MUSIC modelling to quantify stormwater volumes and qualities	8 sub-catchments Daily time series for rainfall and evaporation for Two Wells Run for a 50-year time sequence	A biofiltration system or wetland treatment system at the end of each sub-catchment was considered to be the most effective (from a treatment and cost perspective)

5.4.3 Gawler and Surrounds

The MUSIC modelling undertaken for the Gawler and Surrounds SMP demonstrated that under a long-term scenario, in an average year, the area may discharge over 330 tonnes of suspended solids, 49 tonnes of gross pollutants, 5 tonnes of nitrogen and 0.7 tonnes of phosphorus into the receiving waters downstream of the catchment. The modelling showed the generation and discharge of pollutants is broadly distributed, with no obvious 'hot spots'.

Table 5-6 Gawler and Surrounds Water Quality Modelling - Loads

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

Source: Tonkin (2021) (draft)

Table 5-7 Gawler and Surrounds Water Quality Modelling Base Case Outputs - Concentrations

	Mean
Average Daily Flow (m3/s)	0.07
Total Suspended Solids (mg/L)	37.90
Total Phosphorus (mg/L)	0.16
Total Nitrogen (mg/L)	1.54

Source: Tonkin (2021) (draft)

5.4.4 Smith Creek

Estimates of the stormwater runoff mean annual loads at 25 reporting nodes, and discharges to sea and the Gawler River were derived using an eWater MUSIC model representing sub-catchments within the Smith Creek Catchment area.

The target exceedance concentration for TN and TP are achieved 5% of the time compared with the 95% target at both the mid- and end-of-catchment sites. The TSS target concentration is achieved more frequently than the TN and TP targets in both the mid- (45%) an end-of (15%) catchment sites, but still fail to meet the 95% target frequency. The TSS target is achieved less frequently in the lower catchment most likely due to high TSS loads associated with agricultural land uses in western part of the Smith Creek catchment.

Key water quality issues identified in the catchment include:

- Herbicides and pesticides from residential runoff may risk non-compliance for injection of harvested runoff leading to reduced yield.
- Ongoing issues with turbidity and sediment load due to construction associated with development within the catchment.
- Agricultural runoff contributing to high nutrient loads in the western reaches of Smith Creek.

Further details can be found in the Smith Creek SMP report.

5.4.5 Two Wells

A range of alternative approaches and configurations were considered in the development of the Two Wells SMP to identify and investigate water quality improvement strategies. Two approaches were considered most appropriate for either retrofitting water treatment systems for the existing township or for adoption in newly developed areas. The two approaches presented involve either an end of pipe approach using wetland systems or by utilising biofiltration systems.

Indicative treatment areas for each of the catchments modelled were provided in the SMP that would meet the desired water quality targets for TSS, TP and TN (Table 5-8).

Table 5-8 General Guidance on Water Quality Treatment Area Required to Meet Pollutant Removal Targets for Two Wells

Catchment Area (Ha)	Indicative Treatment Area Required (Ha)
5	0.1
15	0.3
40	0.8
100	2.0

5.5 Reuse Opportunities

5.5.1 Introduction

Reuse opportunities have been explored as a part of the development of SMPs. The water balance modelling undertaken and a summary of the outcomes is contained in Table 5-9 and summarised below.

Table 5-9 Reuse Opportunities Modelling

Project	Modelling Details		Outcomes
Smith Creek SMP (Water Technology, 2022)	Water balance modelling	Stormwater volumes from the MUSIC modelling were utilised	Estimated to be an increase in runoff, despite the reduction in rainfall. This result is driven by the increase in imperviousness of the catchment due to Greenfields, and infill development.
Two Wells SMP (AWE 2017)	Water balance modelling	Stormwater volumes from the MUSIC modelling were utilised Assessment of irrigation opportunities	
Two Wells SMP (AWE 2017)	Irrigation of public open space model	Used to calculate the monthly irrigation requirement for the potential open spaces within Two Wells	

5.5.2 Gawler and Surrounds

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

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

Two potential locations for additional regional harvesting schemes were identified in the Gawler and Surrounds SMP (Tonkin, 2021, draft): the Gawler Racecourse and adjacent to the Clifford Road Drain.

Review of the WMLR WAP determined that the contributing catchments and the racecourse are within the surface water management zone (SWMZ) LC26 of the WAP. SWMZ L26 has a catchment wide water allocation allowance of 95 ML/yr and the surface water resources within the zone are currently fully allocated. Harvesting would therefore be limited to capture of flows from 'new urban land use development' (with a maximum volume equivalent to the difference between post and pre development runoff).

The Clifford Road Drain is outside of the managed water resource area, however, as it is immediately downstream. Harvesting from this drain would be subject to review and approval from the Landscape Board.

5.5.3 Smith Creek

There have been many studies undertaken to investigate the stormwater harvesting potential of the Smith Creek catchment including:

- Urban Stormwater Harvesting Options Study (Walbridge & Gilbert, 2009)
- Northern Adelaide Plains Water Stocktake study (Goyder Institute, 2015) recommending a downward revision of previous design harvest volume estimations
- Northern Urban Catchments: Stormwater Yield Review study (Aqueon, 2016) which assessed the reliability of flows in the stormwater harvesting systems within the Smith Creek and adjacent catchments and analysed previous predictions for available flow records and harvesting performance.

Reasons for the revisions in the available flow predictions for Smith Creek Catchment include:

- Previously unquantified losses by infiltration are occurring in the unlined stormwater drains.
- Poor water quality associated with sedimentation due to ongoing building development and intense rainfall events has interrupted harvesting inflows for longer than anticipated.
- Loss of harvest efficiency due to delaying recharge after an inflow event.
- Cessation of recharge over summer where frequent/rapid changes between recharge and extraction are not feasible to capture summer flows.

The Smith Creek SMP estimated the total annual volume that could be reliably supplied by the Smith Creek schemes, taking into account the mean available flow volumes, treatment train efficiency and storage duration and recovery efficiency of the aquifer. The projections to 2050 of urban development and subsequent increase of impervious surfaces, result in the predicted large increase in urban run-off of 30%, and the maximum harvest potential will not be fully realised until this catchment is mature i.e. between 2040 and 2050. There is expected to be an increase in the available volumes for harvest due to the urbanisation of the catchment, despite allowing for an expected decrease in total annual rainfall.

5.5.4 Two Wells

A water balance assessment was undertaken to assess the potential for stormwater reuse across the Two Wells catchment for the development of the Two Wells SMP. The area for consideration in the water balance is approximately 538 ha.

The stormwater volumes generated as part of the MUSIC modelling process were used for the water balance assessment. In the first instance it was envisaged that water would be used for irrigation of public open space. It was further assumed for the analysis that the reuse system would comprise a wetland treatment system along with Managed Aquifer Recharge (MAR) to provide storage capacity.

An assessment of irrigation opportunities within Two Wells was undertaken to determine potential uses for the treated stormwater and open space areas totalling approximately 143 Ha were identified.

The water balance anticipates that approximately 1016 ML/year will be generated as stormwater runoff with approximately 356 ML/yr spilling from the system. Approximately 19 ML/yr would be used to top up the wetland and 132 ML/year of stored groundwater being used for irrigation.

The water balance demonstrated sufficient stormwater (when land is fully developed) can be provided to sustain the identified open space areas whilst also ensuring that the wetlands are kept at or above the minimum volume requirements.

Modelling of rainwater tank use, assuming the tanks were the sole source of water supply for households, was found to provide a significant benefit in terms harvesting. This scenario was modelled for a fully developed Two Wells and the 30-year Growth Area and was found to reduce runoff volumes by 370 ML or approximately 37%.

6 MANAGEMENT STRATEGIES

6.1 Introduction

A set of proposed management strategies have been developed on the basis of the stormwater management objectives, technical investigations, feedback received from the Project Steering Group and through the consultation process.

Strategies for the management of stormwater within the catchment need to consider the environmental flow requirements of the receiving water bodies. Strategies should aim to generate flow regimes that mimic pre-development patterns as closely as practicable.

6.2 Non-Structural Management Strategies

A range of non-structural management strategies have been identified that could achieve the objectives outlined in Section 4.3.

Non-structural measures can be low cost and typically can be implemented over much shorter timeframes. They could be initiated almost immediately and thereby provide an improved risk profile in the interim period whilst the structural measures are being developed and arrangements being made for funding.

6.2.1 Planning Controls

Planning controls can help to avoid impacts of new developments based on the knowledge that exists and to learn from lessons of the past.

The Planning and Design Code was implemented in South Australia to ensure a consistent approach is applied within all Local Government areas. The Planning and Design Code will also contain Flood Hazard Overlays based on riverine and surface water flooding within 5%, 1% and 0.2% Annual Exceedance Probability (AEP).

The Planning and Design Code ensures development avoids natural hazard (flood prone) areas, and where it is not possible to avoid the natural hazard area, mitigates risks to people and property to an acceptable or tolerable level.

To avoid significant increases in runoff and therefore increased flood hazard, increases in pollutant loads and impacts on receiving water bodies, Councils should consider the following for new developments if the opportunity arises:

- Limit development within areas categorised as high and medium flood hazard risk
- Limit post-development peak discharge rates to pre-development discharge rates or specify an acceptable level of runoff (considering the 20% AEP and 1% AEP floods) through on-site detention and retention measures
- On-site (or off-site) detention and retention measures consider water quality improvement, water reuse, biodiversity, visual amenity and community integration where possible

6.2.2 Flood Preparedness

Flood preparedness is a cost-effective non-structural means of reducing damages because of a flood. Flood preparedness programs in this context are considered in four phases:

1. Awareness
2. Warning
3. Response (including access)

4. Recovery

Education and Awareness

A flood awareness program for people in the catchment areas is an important aspect of reducing the risk of flood damage. A community awareness program, which assists the community in being better prepared and able to respond to flood risks and events, is recommended.

A program may include awareness activities such as informing the community through discussions with individual households, the Council's newsletters, public presentations, articles in local media, information included on Council's website, and information about a flood emergency kit.

A coordinated education program is one means of ensuring this information is effectively disseminated. The development of such programs is essential for ensuring that landholders can take full advantage of flood warnings.

Detailed floodplain mapping of the catchments is available and could be made available to the communities so that they are aware of where flooding may occur.

Businesses, residents and landowners can be encouraged to develop flood action plans to reduce damages during a flood.

Understanding of the risk profiles of the community is beneficial in development of education and awareness programs which can then help inform the appropriate response mechanisms. This risk profiling needs to be updated regularly as the population within the communities change over time.

For example, there are new communities moving into the Angle Vale area that need to be made aware of the flood risk.

Flood Forecasting and Flood Warning Systems

Research has demonstrated that flood warning can substantially reduce the damage costs associated with flooding. Generally, the greater the warning time, and the more prepared the community are then the greater the savings may be.

The Emergency Services, State Government entities (DEW) and local Councils are all involved in the Northern Adelaide and Barossa Zone Emergency Management Committees (ZEMC) and all have an interest and historical involvement in Gawler River Flood Response and Planning.

Whilst the response time for the local drainage catchments is relatively short, if the community were forewarned of the potential for a flood, the magnitude of the social and economic damages could be reduced significantly.

Warning of flooding provides the community and emergency services time to enact response measures such as placing sandbags around flood prone areas or moving valuable portable property out of flood areas. The potential reduction in flood damages when more than 12 hours of warning is provided, as opposed to less than two hours, can range from 20% up to 50% depending on the relative experience of the community in dealing with flooding (DNRE, 2000). Similar to education and awareness, these potential reductions are significant compared to the structural measures.

Given the relatively short response time of the local catchments (typically 1-2 hours) the only opportunity to provide a meaningful warning time would be to issue a flood warning before a rainfall event occurs. The reliability of such warnings (if based on predicted rainfall) could result in complacency within the community if the warnings are issued too frequently without actual flood events occurring. Flood warnings are therefore not recommended for the local catchments.

Longer response times exist in the Gawler Belt area, as well as areas flooded by the Gawler, North Para and South Para Rivers. Given the possibility for greater flood warning times, a significant reduction in flood damages can be achieved. There is a well-established flood warning system for the Gawler River (Commonwealth of Australia (Bureau of Meteorology), 2020), which also includes warnings for the North and South Para Rivers.

A project has been underway through DEW to upgrade existing monitoring stations and include additional monitoring stations to help improve the flood forecast and warning system (see Section 1.3.5).

Work is also being completed by the SES in conjunction with DEW to pilot a flash flood forecasting capability. This approach uses forecast rainfall and antecedent catchment conditions. For the larger catchments in the catchment area, use of such an approach may be viable if the pilot is successful.

Response

The response phase is highly influenced by the experience (or knowledge) that people have of the likely behaviour and nature of a flood event. There are a range of actions people can do with their property before and during a flood that can substantially reduce the damage costs.

The response of emergency services during a flood is also a key factor in reducing flood damages and threats to public safety. Integrated disaster response plans are an important means for helping to ensure emergency services can effectively respond. The regular review of these plans and the conduct of “dry run” flood response exercises can be effective ways of ensuring emergency response staff and volunteers are aware of the issues, hazards, and opportunities that might be presented to them during a real flood event.

Providing safe effective access to flood prone areas is important to reduce the risk to residents and emergency workers. Effective access means a high-level exit route that remains trafficable for sufficient time to evacuate the population at risk. The levels of damage and disruption caused by a flood are also influenced by the difficulty of evacuating flood-affected people and property.

Emergency response plans are important to develop and regularly review to ensure that key actions are included e.g. that ford crossings are closed as they are very dangerous to try to cross during a flood.

Recovery

The recovery phase post flood is critical to reducing social disruption and long-lasting health issues associated with trauma (and in extreme cases disease) as well as ensuring communities can get back to “normal” as soon as possible and thereby contain the overall damage costs.

6.2.3 Education and Awareness

In addition to education and awareness regarding flood risk and emergency planning, an education and awareness program would be beneficial to implement across the catchment which could cover topics such as:

- The beneficial role of floodplains
- Sustainable approaches in agriculture (including irrigation management, runoff management, fertilizer application)
- Sustainable water management approaches including lot, precinct and catchment-based Water Sensitive Urban Design solutions
- Planting and caring of native vegetation for enhanced biodiversity and amenity benefits

6.2.4 Monitoring Programs

There is limited information available regarding the current water quality of the creeks and river systems that form the Gawler River Catchment. A water quality monitoring program could be implemented to help measure progress towards the water quality targets and also target the areas most needed for improvement.

6.2.5 Asset Management and Maintenance

Stormwater drainage forms a considerable financial asset for Councils. Some of the existing drainage infrastructure was constructed over 30 years ago. Careful asset management will allow for future planning to determine the timeline for replacement of assets.

An increased implementation of WSUD solutions necessitates a higher degree of maintenance to ensure optimum water volume and quality improvement performance is obtained. However, WSUD assets can offset this by providing a more wholistic range of benefits.

Maintenance activities would include:

- Regular inspection
- Weed and sediment management
- Structural competence and condition assessment
- Maintaining an asset register including condition and remaining asset life

Flood related assets such as levees also need to be managed and maintained to ensure they are able to provide the level of flood protection necessary. Significant work is required in this area to ascertain who should own and be responsible for the levee assets in particular when a significant amount of the levees are located on private land.

6.3 Structural Management Strategies

A range of structural management strategies have been proposed based on the technical review of previous studies, flood modelling undertaken for the development of this SMP and also modelling undertaken for the development of other relevant SMPs. These strategies are outlined below and assessed further in the Sections that follow.

6.3.1 Regional Flooding Related

Flooding of the Northern Adelaide Plains associated with the Gawler River is a significant constraint for further development within the region (both north and south of the river) and an ongoing risk to existing development.

A range of structural measures which would be expected to improve the risk of regional flooding are summarised in Table 6-1.

A number of these options, due to their structural nature, have risks involved if the structures fail as a result of poor construction or maintenance or inspection. The risk and consequences of failure is something to be considered in the assessment of the options, especially as the implementation of the solution would result in additional development and potentially in close proximity to the floodplain or the structure.

Table 6-1 Regional Flooding Related Structural Management Strategies

Strategy	Description
Channel Widening	Widening to keep water within the existing channel system whilst minimising the need for further raising of levees.
Detention downstream of Gawler township	30,000 ML storage to reduce peak flow to 160 m^3/s near Hillier A retarding basin downstream of Gawler would be constructed by excavating a large area of the floodplain to provide additional floodplain storage. Given the very flat terrain, the area required to install an effective retarding basin would be substantial, potentially covering an area of around 10 km^2.
Enlarge Bruce Eastick Dam	Raise dam wall height by 10 m.
Northern Floodway and Levee Improvements	A northern floodway from Old Port Wakefield Road to the Port Wakefield Highway and then extending further west of the Port Wakefield Highway.
Southern Floodway and Levee Improvements	A southern floodway formed by raising Angle Vale Road (along with some additional smaller unsealed roads) to form a flood levee to prevent flood waters pushing south of Angle Vale Road.
Channel Desilting with New Outlet	Removing accumulated silt from the bed of the river without undertaking major changes to the riverbanks.
Replacement of Existing Levees	Assess the existing levees and determine if they need to be repaired or replaced to deliver intended level of service for flood protection.
New Strategic Levees – Gawler	Height – typically up to 600 mm Length – 4.7 km
New Strategic Levees – Virginia	Height – typically up to 500 mm Length – 3.4 km, 2.6 km
Strategic Levees – Two Wells	Height – varies up to 2 m Length – 2.4 km

The proposed structural flooding mitigation measures were modelled and the outputs are included in Appendix E. Based on this modelling and mapping work, an assessment of the estimated damages was undertaken as summarised in Table 6-2.

Table 6-2 Estimated Flood Damages for the Mitigation Options Compared with the Base Case

	Total properties impacted* (no.)	Residential and commercial properties impacted (no.)	Length of road impacted (km)	Area of farmland† impacted (km^2)
1AEP Base Case	2,802	1,545	162	62.6
1AEP Strategic Levees	2,517	1,305	155	62.0
1AEP Northern Floodway	2,777	1,531	159	61.9
1AEP Southern Floodway	2,786	1,539	161	62.5
1AEP Dam Extension	660	119	30	25.9
2AEP Base Case	2,170	1,089	128	54.2
2AEP Strategic Levees	1,841	815	121	53.5
2AEP Northern Floodway	2,172	1,088	126	53.6
2AEP Southern Floodway	2,161	1,080	126	54.1
2AEP Dam Extension	644	114	29	25.2

6.3.2 Local Drainage Related

General recommendations across the related SMPs about structural options to manage local stormwater related issues include:

- Monitor and confirm the modelled drainage deficiencies within the existing townships that were not verified with existing anecdotal information (before any structural works are undertaken)
- Implement Water Sensitive Urban Design (WSUD) measures to help reduce the impact on the drainage infrastructure for infill development and for development of the growth areas
- Determine areas that have a high erosion potential. In these areas, peak flow rates and velocities should not be increased and works to protect streams (such as planting, regrading of batters and erosion protection) should be considered as part of future developments.

Strategies for managing the stormwater deficiencies for the existing townships and catchments of Gawler, Two Wells, Smith Creek and Angle Vale are discussed in their relevant SMPs. The highest priority works, as identified through their own assessment process, are summarised in Section 9. The remaining actions can be found in the specific SMPs.

6.3.3 Water Quality Improvement

The relative contribution of stormwater within the Gawler River catchment to flows and pollutant loadings at the point at which the Gawler River discharges into the Gulf of St Vincent is relatively small. For context, the Gawler SMP covers an area of approximately 7,300 ha, while the area of the Gawler River catchment upstream of Gawler is approximately 100,700 ha. Given the size of the upstream catchment, it is considered that the ability of actions within the SMPs area to influence water quality at the mouth of the river would be small.

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

Water quality improvement measures considered for the range of existing SMPs include the construction of wetland or biofiltration systems for both existing developed areas and for areas that are likely to be developed in the future.

A focus for the Councils is the growth areas to ensure quality of runoff from the significant new developments proposed are managed effectively and in a way which provides multi benefits to the community whilst minimising the ongoing costs of maintenance.

The implementation of these measures will also provide opportunities to enhance public open space, raise the profile of stormwater quality within the community and increase local biodiversity.

6.3.4 Environment Protection and Enhancement

Many opportunities exist within the Gawler River Catchment for providing community amenity or recreation opportunities, as well as increasing biodiversity within stormwater management reserve areas. Riparian surveys have also highlighted the condition of many of the watercourses and the opportunity for rehabilitation to improve environmental outcomes.

The Smith Creek SMP has specifically highlighted options including:

- An upgrade and rehabilitation of Smith Creek that could increase biodiversity and habitat creation through utilisation of local species and in addition could incorporate enhanced connectivity with open spaces through development of walking / cycling paths
- The Playford Town Park masterplan provides possible space for additional storage near the Stebonheath-Curtis wetlands
- There is an opportunity to enhance the trail between Main North Road and Craigmore High School. There are areas of remnant vegetation in this area which Council help to protect through biodiversity enhancement work this area. Wayfinding signage could direct pedestrians to Munno Para shops and City Soccer Club. Additional opportunities for a skate park and wider linkages to Smith Creek Trail & Munno Para Wetland could be explored
- The rehabilitation of the swale along Davoren Road and John Hartley school frontage provides an opportunity for water related education activities linked to school curriculum. This would also provide a link to the Kaurna healing garden

6.3.5 Stormwater Harvesting and Use

Consideration of reuse options needs to be in the context of the existing schemes, environmental water requirements and limitations imposed by Water Allocation Plans (WAPs) and Prescribed Wells Areas.

The catchment area is largely within the bounds of the Western Mount Lofty Ranges WAP. DEW have advised that all the available water allocations have been allocated and therefore the opportunities for any new large-scale water harvesting schemes is small.

However, Councils do aim to maximise the harvest and use of stormwater and the opportunity has been explored through the development of other relevant SMPs – either from a township perspective or a new development perspective.

Based on the MUSIC modelling outcomes and some water balance assessments options have been considered that include wetland treatment systems and Managed Aquifer Recharge (MAR) to provide storage capacity.

Several opportunities were identified in the development of the relevant SMPs to optimise and augment the existing stormwater harvesting schemes before trying to establish new schemes including:

- Prioritising catchment sediment management practices
- Investigate options for diversion of poor-quality water from the storages
- Determine if additional water quality and flow monitoring would support operation of the schemes.

7 COSTS AND FUNDING OPPORTUNITIES

7.1 Introduction

A broad range of management strategies have been identified to meet the objectives of the SMP. To enable the initiatives to be prioritised, high level cost estimates have been undertaken. A discussion around the costs and funding opportunities is contained in the sections below.

7.2 Cost Estimates

Cost estimates have been prepared for the purposes of comparison of the preferred management strategies.

The cost estimates provide a magnitude of scale and are outlined in this SMP (and the associated relevant SMPs) to conceptualise the costs involved in each of the options being considered.

The cost estimates have also been produced by different organisations, using different assumptions and at different points in time.

The cost estimates will therefore need to be further refined as the options get closer to implementation and more information becomes available.

The cost estimates for the high priority mitigation and management strategies are included in Section 9.

7.3 Funding Mechanism

The Gawler River Floodplain Management Authority Charter (adopted 28 January 2020) makes provision for funding of major projects, including how the GRFMA might recover costs / contributions from constituent Councils. In the case of the SMP, the GRFMA would initiate actions in accordance with clause 11.7 (see below).

The GRFMA has developed a separate cost share model to identify potential Council contributions based on factors including: (i) Future costs avoided, (ii) Water inflow, (iii) Waterway length and (iv) Ability to pay.

7.4 Funding Opportunities

There are a range of funding opportunities for the actions identified in SMPs including from Local, State and Federal Governments.

Councils could implement a special levee on development, such that the upfront capital expenditure is recouped over time, as upstream development proceeds. Developers could also contribute towards water management measures if their on-site works do not meet the predetermined targets.

Stormwater management projects within catchments that have an area greater than 40 ha and are part of an SMA endorsed SMP are eligible for SMA funding. The SMA typically prioritises funding towards schemes that provide a wide range of benefits including water quality and reuse.

The Northern and Yorke Landscape Board and Green Adelaide Board may provide funding that can be used to help support measures that will benefit natural resources management including actions which improve the quality of water within the area or that will facilitate an increase in stormwater reuse. The Boards could potentially help to co-fund some of the recommended works as part of the SMP or provide in kind support.

The Commonwealth government also offers grants at various times for the purpose of flood disaster planning and relief such as the Disaster Ready Fund (DRF). The DRF is the Australian Government's initiative for disaster resilience and risk reduction. The Australian Government is providing up to one billion dollars through the DRF. The funding runs over five years from 1 July 2023. The funding supports projects that address the physical and social impacts of disasters on our communities that can be caused by climate change and other natural hazards.

11. FINANCIAL CONTRIBUTIONS TO THE AUTHORITY

11.1 The contributions of the Constituent Councils shall be based on the percentage shares for capital works, maintenance of assets of the Authority and operational costs of the Authority in accordance with Schedule 1.

Where the capital and/or maintenance cost exceeds $1 Million in any given year, Clause 11.7 shall apply.

11.2 The Authority will be responsible to provide the Constituent Councils with sufficient information for each of them to ascertain the level of and understand the reasons behind the funding required each financial year. This will be achieved via the business plan and the annual budget.

11.3 The Authority will determine annually the funds required by the Authority to enable it to function. The Constituent Councils shall contribute the funds requested by the Authority, in the annual budget and approved by the Constituent Councils, and any additional funds that are required for the continuing function of the Authority and approved by the Constituent Council. The Authority must provide full details regarding the need for additional funds to the Constituent Councils.

11.4 The annual contribution will be paid by each Constituent Council in advance by six monthly instalments.

11.5 Additional contributions (of any) will be paid by each Constituent Council in the manner and at the time determined by the Authority.

11.6 The Authority is accountable to each Constituent Council to ensure that the Authority functions in accordance with its business plan and approved budgets.

11.7 The Authority may enter into separate funding arrangements with Constituent Councils and with any State or Federal Government or their agencies in respect of any project undertaken or to be undertaken by or on behalf of the Authority.

11.8 Where a Constituent Council or Constituent Councils enter into an agreement with the Authority under Clauses 3.2 and 3.3 of this Charter the subscriptions payable under that agreement shall be additional to the subscriptions payable under this Clause.

Source: Gawler River Floodplain Management Authority Charter, adopted 28 January 2020

8 DECISION-MAKING METHODOLOGY

8.1 Process Overview

The Gawler River SMP has adopted the option assessment process and outcomes of the DEW Business Case project (see Section 1.3.5) to ensure consistency. That project had its own governance structure but included the key stakeholders responsible for this SMP.

The process utilised to assess the possible options for prioritisation and inclusion in the SMP has followed a multi-criteria analysis approach including:

- Problem definition
- Identification of objectives
- Identification of options
- Definition of criteria
- Assessment of the options against the criteria

The process and outcomes described below only consider the flood mitigation options. The assessment process and outcomes for the other mitigation options is contained in each of the relevant SMPs.

It should be note that the SMA Guidelines recommend that the highest priorities are for works and measures that reduce flood hazard and protect life and property.

8.2 Problem Definition

Step 1 of the decision-making process is to define the problem or opportunity.

In the context of this SMP it has been to define and assess measures that reduce flood hazard and protect property and life. During a high rainfall event, flood waters breach the banks of the Gawler, North Para and South Para Rivers, causing damage to crops, residential properties and infrastructure services.

The other relevant SMPs undertook a more holistic view of the options for stormwater management within the catchment area.

8.3 Identification of Objectives

Step 2 of the decision-making process is to define objectives that the options need to be able to achieve.

High level and broad stormwater management objectives for the catchment area are defined in Section 4.

Specific objectives that the options should achieve through the decision-making process include:

- Change physical flooding characteristics for business and residents in the impacted region
- Deliver solutions for which the flooding consequences are acceptable to all users in the flood impacted area
- Deliver integrated solutions that achieve multiple water management outcomes
- Increase awareness of flood risk and preparedness for a flood event by individuals, businesses, industry and government

The benefits of achieving these objectives include:

- Reduced physical damages, economic losses, and disruption to assets and people in the flood impacted area

- Increased economic growth and development
- Timely, effective, coordinated and well- maintained flood management responses
- Increased community confidence and resilience

8.4 Identification of Options

The options considered in the MCA for this SMP are for works and measures that reduce flood hazard and protect life and property. Given that each option outlined in Section 6 has a different benefit profile for the targeted area, impact over time, and impact across different flood frequencies, a combination of options was considered to be necessary to provide the best outcome for protecting current assets, mitigating future risk, and ensuring equitable distribution of benefits.

A short list of the options presented in Section 6 has been developed through extensive consultation with the key stakeholders and is consistent with other programs of work that have been undertaken in parallel to the development of this SMP.

The options include:

- Option 1: Bruce Eastick Dam Raise
- Option 1A: Bruce Eastick Dam Raise and Water Security
- Option 2: Northern Floodway
- Option 3: Township Levees
- Option 4: Flood Awareness Campaign
- Option 5: Dam Raise and Northern Floodway
- Option 6: Dam Raise and Planning Controls
- Option 7: Dam Raise and Township Levees and Planning Controls
- Option 8: Dam Raise and Flood Awareness Campaign and Planning Controls

These options all assume that the existing levees have been assessed and have been repaired or replaced as needed.

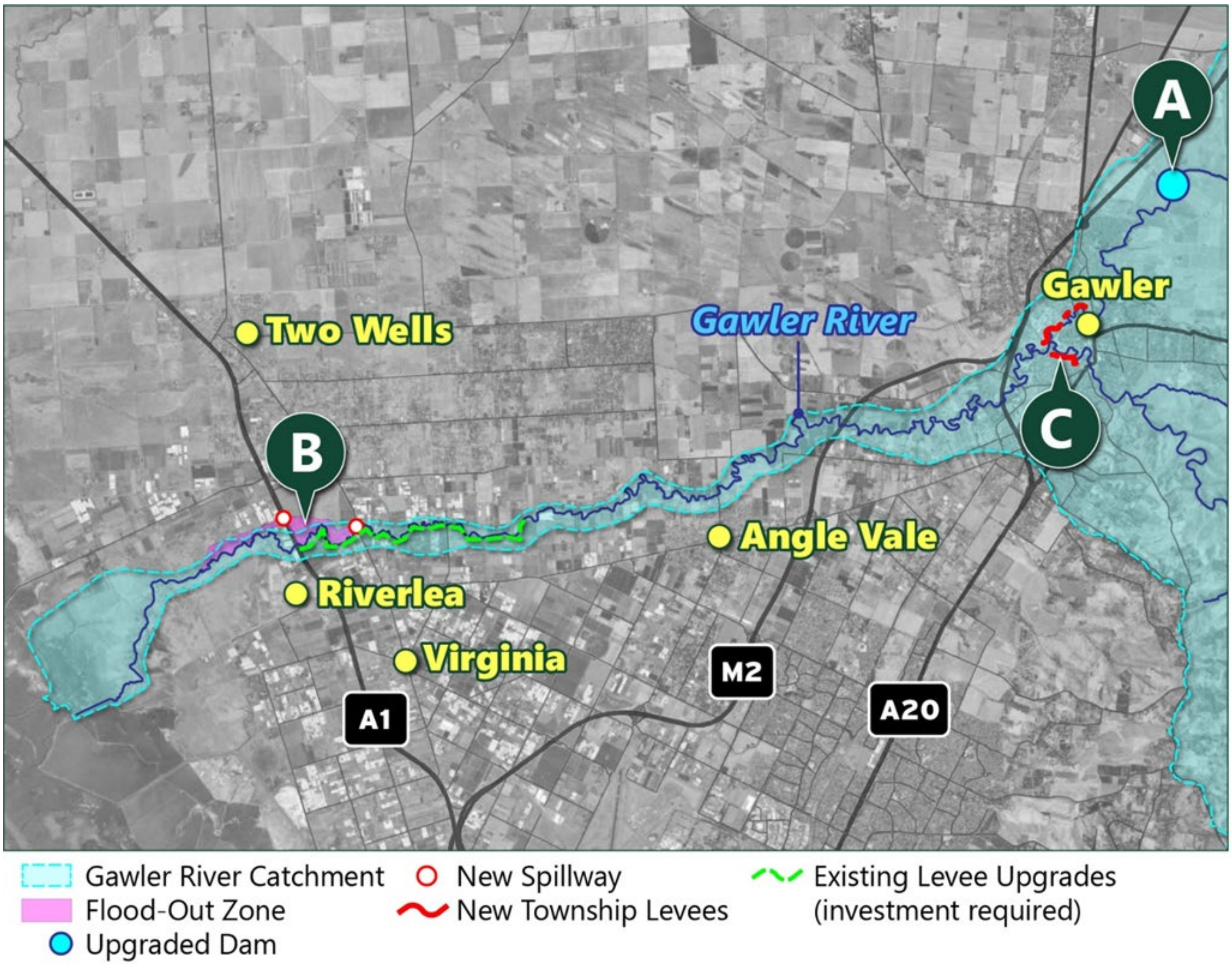

Figure 8-1 Flood Mitigation Options Considered in MCA

8.5 Definition of Criteria

The criteria were developed to ensure a range of factors could be considered in the assessment of the options including the economic, environmental, social, and cultural values.

A summary of the criteria is contained in Table 8-1. A weighting can be applied to the criteria to indicate preference or importance of that criteria. Weightings have been determined by the Project Steering Group on a 1 (low importance) to 5 (high importance) which are also contained in Table 8-1.

Table 8-1 Criteria for Prioritisation of the Potential Management Strategies

Criteria	Metric	Weighting
Economic Merits / BCR	Comparison of the economic benefits against the capital and ongoing costs	5
Impact to Properties / Reduction in Flood Risk	Reduction in number of residential properties & Greenhouse structures flooded over floor in 1% AEP Event	5
Feasibility of Construction	Potential design, implementation and operational challenges and constraints. Risk can increase with implementation timeframe	4
Adaptability to Change for Long Term Feasibility	Eg. adapt to Climate change and increase in population density	4
Impact on Emergency Services	Change in demand on emergency services (SES, Police, Ambulance, Fire, RFS, Council etc)	3
Flood Risk Reduction to Government Services & Assets / Disruption to Critical Facilities	Disruption / damages to critical Government Services and facilities (Includes Rail & Road)	3
Economic Opportunities from Flood Mitigation	Mitigation option derives better land use outcomes (value of potential development uplift from new developments on protected land)	4
Social Disruption	Closure of or restricted access to community facilities (including recreation)	2
Social Equity	The implementation of some FRM measures may benefit particular groups in the community while disadvantaging, or at least not benefiting, others	3
Environmental	Impacts or benefits to the environment	2
Indigenous Cultural Heritage	Impacts to Indigenous cultural heritage	4
Construction Cost	Capital costs and funding sources available	3
Maintenance Cost	Maintenance funding source	4
Ability to Effectively Address Implementation Risks	Can the risks identified be easily resolved	3

8.6 Assessment of Options Against the Criteria

The range of management strategies for flood mitigation outlined in Section 8.4 have been assessed against the criteria to enable the priorities to be established using the scoring guidance contained in Table 8-2 and the weightings contained in Table 8-1.

An assessment of the options has been undertaken to determine their ranking and priorities during a workshop with members of the Project Steering Group. The higher score indicates that the option performs better on those criteria.

Table 8-2 Scoring Guidance

Criteria	Metric	-3	-2	-1	0	1	2	3
Economic metrics / BCR	Comparison of the economic benefits against the capital and ongoing costs	BC < 0.1	BC 0.1 – 0.5	BC 0.5 – 0.9	BC = 1 (or NA)	BC 1.0 to 1.4	BC 1.4 to 1.7	BC < 1.7
Impact to properties / reduction in flood risk	Reduction in number of residential properties & greenhouse structures flooded over floor in 1% AEP event	> 5 adversely affected	1 – 5 adversely affected	0 benefitted	1 – 10 benefitted	10 – 100 benefitted	100 to 250 benefitted	> 250 benefitted
Feasibility of construction	Potential design, implementation and operational challenges and constraints. Risk can increase with implementation timeframe	Major constraints and uncertainties which may render the option unfeasible	Constraints or uncertainties which may significantly increase costs or timeframes	Constraints or uncertainties which may increase costs or timeframes moderately	NA	Constraints that can be overcome with moderate investment of time and resources	Constraints that can be overcome easily	No constraints or uncertainties
Adaptability to change for long term feasibility	E.g adapt to climate change and increase in population on density	Measure is designed for 2024 and can't be modified	Measure is designed for 2024 and difficult to be modified	Measure is designed for 2024 and can be modified	Measure is designed for 2050 CC	Measure is designed for 2050 CC and can be modified	Measure is designed for 2090 CC	Measure is designed for 2090 CC and can be modified
Construction cost	Capital costs and funding sources available	>$50M capital cost and no access to funding	>$50M capital cost and 33% funding	>$50M capital cost and 66% funding	NA	<$50M capital cost 33% funded	<$50M capital cost 66% funded	<$50M capital cost 100% funded
Maintenance cost	Maintenance funding source	>$200K maintenance costs and Councils to foot 100% of maintenance cost	$200K maintenance costs and Councils to foot 100% of maintenance cost	<$200K maintenance costs and Councils to foot 100% of maintenance cost	NA	<$200K maintenance costs and Councils to foot 66% of maintenance cost	<$200K maintenance costs and Councils to foot 33% of maintenance cost	Negligible Maintenance Costs
Economic opportunities from flood mitigation	Mitigation option derives better land use outcomes (Value of potential development uplift from new developments on protected land)	N/A	N/A	Negative change to potential development uplift	No change	$1 - $50M potential development uplift	$51 - $150M potential development uplift	$150M potential development uplift

Criteria	Metric	-3	-2	-1	0	1	2	3
Impact on emergency services	Change in demand on emergency services (SES, Police, Ambulance, Fire, RFS, Council etc).	Major disbenefit	Moderate disbenefit	Minor disbenefit	Neutral	Minor benefit	Moderate benefit	Major benefit / increasing benefit over time
Flood risk reduction to Govt services & assets	Disruption/Damages to critical Government Services and facilities (Includes Rail & Road)	Period of in-operation possibly increased in minor events	Period of in-operation possibly increased in events <10% AEP	Period of in-operation possible increased in events <5% AEP and minimal damages to government assets	No Change	Period of in-operation reduced in events <10% AEP	Period of in-operation reduced in events <5% AEP and minimal damages to government assets	Prevents disruption of critical facility altogether
Social disruption	Closure of or restricted access to community facilities (including recreation)	Normal access significantly reduced or facilities disrupted for > 5 days	Normal access routes moderately reduced or facilities disrupted for 2-4 days	No Change to access but facilities disrupted for up to 12 hours	No Change	Reduces duration of access disruption or facility disruption by up to 12 hours	Reduces duration of access disruption or facility disruption by 2-4 days	Prevents disruption of access or facility altogether
Social equity	The implementation of some FRM measures may benefit particular groups in the community while disadvantaging, or at least not benefitting, others	Benefits a few while disadvantaging others	Benefits some while disadvantaging others	Benefits most while disadvantaging others	Benefit Neutral	Benefits a few with no adverse effects to others	Benefits some with no adverse effects to others	Benefits everyone with no adverse effects
Environmental	Impacts or benefits to Environment	Likely broad-scale vegetation/habitat impacts	Likely isolated vegetation/habitat impacts	Removal of isolated trees, minor landscaping.	Neutral	Planting of isolated trees, minor landscaping	Likely isolated vegetation/habitat benefits	Likely broad-scale vegetation/habitat benefits
Cultural heritage	Impacts to Indigenous Cultural Heritage	Likely impact on State, National or Aboriginal Heritage Item	Likely impact on local heritage item	Likely impact on contributory item within a heritage conservation area	No impact	Reduced impact on contributory item within a heritage conservation area	Reduced impact on local heritage item	Reduced impact and benefit on State, National or Aboriginal Heritage item

Table 8-3 Weighted Evaluation of Options

Criteria	Option 1	Option 1A	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8
Economic metrics / BCR	15	10	-5	-15	-5	5	15	10	15
Impact to properties / reduction in flood risk	15	15	5	5	0	15	15	10	15
Feasibility of construction	-4	-4	4	-8	8	-4	-4	15	-4
Adaptability to change for long term feasibility	-4	-4	-4	-4	12	-4	0	-4	4
Construction cost	-3	-3	-3	-4	9	-3	-3	-4	-3
Maintenance cost	-8	-8	-4	-4	8	-8	-8	-3	-8
Economic opportunities from flood mitigation	8	8	0	0	0	4	12	-8	12
Impact on emergency services	6	6	-3	3	0	0	6	8	6
Flood risk reduction to Govt services & assets	6	6	3	3	0	6	6	6	6
Social disruption	4	4	2	2	0	4	4	6	4
Social equity	6	6	0	-6	9	6	6	4	9
Environmental	0	0	0	-2	0	4	4	0	0
Cultural heritage	-4	-4	0	0	0	-4	-4	-4	-4
Ability to effectively address implementation risk	-3	-3	-3	-3	3	-3	-3	-3	-3
Total	**34**	**29**	**-8**	**-32**	**44**	**18**	**46**	**23**	**49**

Table 8-4 Summary of Output of MCA Options Analysis

Option #	Option Name	Weighted assessment ranking
8	**Dam Raise and Flood Awareness Campaign and Planning Controls**	**1**
6	Dam Raise and Planning Controls	2
4	Flood Awareness Campaign	3
1	Bruce Eastick Dam Raise	4
1A	Bruce Eastick Dam Raise and Water Security	5
7	Dam Raise and Township Levees and Planning Controls	6
5	Dam Raise and Northern Floodway	7
2	Northern Floodway	8
3	Township Levees	9

The results show that the option that includes the combination of raising the Bruce Eastick Flood Mitigation Dam, flood awareness and planning controls (option 8) is the preferred option based on the criteria utilised.

Key observations from the assessment of the options include:

- All options leave a residual flood risk
- Options including infrastructure and planning controls address current and future risk reduction
- Raising community awareness about flood risk will tackle any complacency that infrastructure will provide total flood mitigation
- Infrastructure options have an environmental impact on habitats including coastal shrublands, samphire, and eucalyptus – the 10m dam raise option less so than the floodway
- The 10m dam wall raise options consistently measure better on costs and benefits than other options
- The 'planning controls' scenario assumes the 0.5% AEP modelled flood extent to apply stronger planning controls
- All options assume complementary catchment management is occurring in the upstream catchment to manage river condition and stormwater runoff
- Any option considering the dam can also consider increased water security for an extra cost

9 PRIORITIES, TIMEFRAMES, RESPONSIBILITIES AND RISKS

9.1 Introduction

This SMP (and the associated SMPs) provide a framework for the management of stormwater within the Gawler River catchment area. The Project Steering Group and Technical Steering Group which has overseen the development of this SMP comprises representatives of key stakeholder organisations that have responsibility for implementing the SMP.

This SMP is owned by the GRFMA, however, achieving the SMP objectives is a collective and continual effort that will be an ongoing process by all the relevant stakeholder organisations.

Based on the outcomes of the options assessment, the works have been prioritised in the context of this SMP. High priority and complementary priorities contained in associated SMPs have also been included in the sections below. As this SMP only covers a small portion of each of the Council areas, the works also need to be assessed against other stormwater related needs in other parts of the Council area and in other SMPs.

A number of the priority management strategies identified require considerable expenditure and will need to be staged over a number of years to enable budgeting for the works to fit in with other Council and Government priorities.

At the time of implementation of the recommended actions, consideration should be given to whether the activity has the potential to have adverse impacts on water resources and the ecosystems that depend on them, as well as other water users. These water resources include watercourses, lakes or dams, floodplains, groundwater, springs, wetlands, waterholes and catchment landscapes. Management of Water Affecting Activities (WAA) is essential to maintaining water quality, minimising impacts on other water users and protecting our natural systems and water-dependent ecosystems. A WAA permit may be needed and information on these can be obtained from Landscape SA.

9.2 Regional Flood Mitigation Works

The multi-criteria analysis revealed that no stand-alone initiative would provide the best outcome for protecting current assets, mitigating future risk, and ensuring equitable distribution of benefits. The largest reduction in flood risk is realised by works associated with a combination of structural and non-structural mitigation measures that are outlined below.

9.2.1 Upgrade of Existing Levees

The existing levees are in poor condition and in need of an upgrade to ensure that they are serviceable in the time of a flood. Ongoing maintenance is also required.

Objectives: Flooding and Asset Management

Responsibility: Gawler River Floodplain Management Authority

Timeframe: Ongoing

Estimated Cost: $30,500,000 capital + $152,000 per year ongoing

9.2.2 Expansion of Bruce Eastick Flood Mitigation Dam

Raising of the Bruce Eastick Flood Mitigation Dam was the preferred flood mitigation option as a result of the options assessment described in Section 8.

Objective: Flooding

Responsibility: Gawler River Floodplain Management Authority

Timeframe: 3 – 7 years

Estimated Cost: $195,000,000 capital + $107,000 per year ongoing

9.2.3 Education and Awareness

Having a water literate and flood informed community will enable proactive action to reduce flood impacts and reduce people's distress and anxiety about flood. Opportunities exist particularly with the changing and diverse community in the impacted region.

A public education programme that raises awareness of flood risk and provides information to individuals and businesses that guides their response to floods can reduce flood damages.

The benefit is increased community confidence and resilience.

DEW is the lead on the community flood awareness and preparedness campaign, with GRFMA an active partner assisting in development and delivery of program resources.

Objectives: Flooding and Environment Protection and Enhancement

Responsibility: DEW

Timeframe: Ongoing

Estimated Cost: $517,000 upfront + ongoing costs to be determined

9.2.4 Flood Warning System

A flood warning system includes having appropriate water monitoring infrastructure and data, forecasting capabilities, understanding of flood impact, flood warning generation and communication. This option does not mitigate the flood, but it can reduce the flood impact as people are enabled to respond proactively. Successful reduction of flood damages using flood warnings is dependent on the communities' ability to act on warnings (i.e. awareness and response).

This action would follow on from the work and trials already undertaken as described in Section 1.3.5.

Objective: Flooding

Responsibility: Department for Environment and Water

Timeframe: Ongoing

Estimated Cost: To be determined

9.2.5 Land Use Planning and Planning Controls

Reducing the flood damage potential to new assets on the floodplain can be achieved by planning and building in a manner that considers stormwater and flood management. There is also the potential to prevent new assets causing increased flood impacts on existing properties. Land use and planning controls could address different requirements for different kinds of development (e.g. hospitals) and for critical infrastructure (e.g. power and telecommunications).

Planning controls are managed by the Planning and Design Code with standardised policies across South Australia. Councils can request an amendment to the Code.

Objectives: Flooding, Water Quality, Stormwater Harvesting and Use, Environment Protection and Enhancement and Asset Management

Responsibility: Department of Housing and Urban Development

Timeframe: Ongoing

Estimated Cost: $0

9.3 Localised Flood Mitigation Works

Based on the modelling undertaken, the feedback through the consultation process and the options assessment, a broad range of structural works have been proposed that would result in the reduction of localised flooding issues and more effective stormwater management. The high priority mitigation measures are summarised below as were contained in their respective SMPs.

It should be noted that eligibility of funding from the SMA for localised flood mitigation works needs to meet a 40 Ha catchment criteria.

9.3.1 Gawler and Surrounds

Gawler Racecourse Flood Control Basin and Wetland

Mitigation measures have been identified to alleviate flooding within First Street including upgrade of the First Street drainage network to then discharge into a detention basin in the middle of the Gawler Racecourse.

Review of aerial imagery confirms that there is adequate space to combine the flood basin with a wetland. The water quality modelling suggests that the wetland could provide significant reduction in the quantities of pollutants discharged into the receiving waters.

Objective: Flooding, Water Quality Improvement and Water Reuse

Responsibility: Town of Gawler

Timeframe: Seven years

Estimated Cost: $5,550,000 (capital) + $89,000 (annual)

Trinity College Creek Upgrades, Evanston Oval Parallel Pipe and Tingara Road Flood Control Basin

These three proposed strategies collectively reduce flooding by reducing peak flows (due to the flood control basin) and providing increased capacity to convey stormwater under the Gawler Bypass (via the Trinity College and under Evanston Oval upgrades). While the reduction in AAD is relatively small compared to some of the other projects, the low capital costs of these results in the most favourable benefit cost ratio (0.68) of all of the strategies considered within the Gawler and Surrounds SMP.

These strategies have limited water quality benefits; however, a small retention basin could be incorporated into the flood control basin which could act as a sediment trap. It could also incorporate a low flow swale. Riparian plantings as part of the Trinity College creek upgrades could also have water quality benefits and prevent bank erosion.

Objective: Flooding

Responsibility: Town of Gawler

Timeframe: Four years

Estimated Cost: $1,335,000 (capital) + $12,000 (annual)

Corey Street Basin Outlet Optimisation

Optimisation of the Corey Street basin outlet provides a reasonable level of flood protection and maximises the attenuation of floods by the Corey Street basin. It should be possible to easily retrofit the optimised outlet to the entrance of the existing outlet. The additional attenuation provided by the optimised outlet will be most impactful during events with smaller volumes of total rainfall.

The optimised outlet could be designed to capture and retain runoff from very frequent events which could then be infiltrated rather than discharged to receiving waters.

Objective: Flooding

Responsibility: Town of Gawler

Timeframe: One year

Estimated Cost: $20,000 (capital)

9.3.2 Smith Creek

Catchment 19 Basin

A new 340 ML detention basin at the outlet of Catchment 19 in the Smith Creek headwaters within the Hills Face zone in One Tree Hill would help to alleviate flooding from the foothills and assist in avoiding cross catchment flows into the Adams Creek catchment near Petherton Road and avoid a small catchment overflow near Uley Road. The basin would require a 140 m wide dam wall with 19 m maximum height from the stream invert. The outlet structure would have the equivalent capacity of a 750mm diameter pipe. The basin would provide approximately 9 m^3/s peak flow attenuation.

Objective: Flooding

Responsibility: City of Playford and Town of Gawler

Timeframe: One year

Estimated Cost: $11.1M

Smith Creek West Channel Upgrade

The Smith Creek channel from Petherton Road (east of NEXY) to Beagle Hole Road (west of NEXY) currently cannot meet the desired level of service for conveyance of a 5% AEP nor a 1% AEP flood flow. Works are proposed to upgrade the capacity of the channel,

Objective: Flooding

Responsibility: City of Playford and Town of Gawler

Timeframe: One – five years

Estimated Cost: $26.6M

NEXY Basin Upgrade

The NEXY basin is located adjacent Smith Creek west of NEXY and east of Short Road. The basin was formed as a borrow pit during the construction of NEXY. Recently, flows in Smith Creek have been diverted through the basin via a low flow channel to enable harvesting in the turkey nested storage basin adjacent Short Road. The area west of the NEXY is subject to a high flood risk. This is mostly as a result of the very limited channel capacity of Smith Creek downstream of the expressway. In addition, there is very limited (effectively no) ability to reduce the inflow rates to the detention basin from works upstream.

In combination with the Smith Creek Upgrade (channel widening) downstream of NEXY basin, it is proposed to bring the NEXY basin on-line with Smith Creek and to raise the basin rim to 21 mAHD. This will increase the capacity of the basin from 250 ML at present to 600 ML in total.

Objective: Flooding

Responsibility: City of Playford and Town of Gawler

Timeframe: One year

Estimated Cost: $1.5M

Milne Road Drainage Upgrade

The Milne Road Channel at Evanston has been a source of concern with respect to its flood conveyance capacity and general condition for some time. The area of concern extends from near Gordon Road within the Town of Gawler southwards toward Dalkeith Road, and then beyond into the City of Playford to the Northern Golf Course area downstream of Fradd Road. The channel is predominantly a natural open channel with significant weed growth and also includes sections of culverts throughout the reach. The catchment which contributes to the Milne Road Channel is a combination of urban residential development and rural land use from the foothills and is approximately 350ha.

The proposed work involves widening the Milne Road Drainage system, including enlarging culverts at driveway crossovers and road crossings.

Objective: Flooding

Responsibility: City of Playford and Town of Gawler

Timeframe: One year

Estimated Cost: $3.1M

9.3.3 Two Wells

Chapman Street Spoon Drain

Further investigation was recommended to develop an understanding of the drainage infrastructure connected to the Chapman Street spoon drain to review if the drainage issues are related to sediment build up and vegetation growth.

Objective: Flooding

Responsibility: Adelaide Plains Council

Timeframe: One year

Estimated Cost: $0

Verification of Potential Drainage Deficiencies

A number of potential drainage deficiencies within the existing township were identified through the modelling process. It is possible that the deficiencies identified may be as a result of overestimates of inundation due to inherent limitations in the modelling approach. It was recommended that Council monitor these areas during storm events to gather more anecdotal information on the performance of drainage infrastructure in these areas.

Objective: Flooding

Responsibility: Adelaide Plains Council

Timeframe: One year

Estimated Cost: $0

Infill Development

infill development within the existing township areas could have a significant impact on the Two Wells drainage system if not well managed. The introduction of best practice WSUD procedures as standard across the region can provide comprehensive solutions for the reduction of runoff generation and the attenuation of peak flows.

Responsibility: Adelaide Plains Council

Timeframe: Ongoing

Estimated Cost: $0

9.3.4 Angle Vale North

A range of stormwater drainage upgrades for flood mitigation have been recommended in the Angle Vale North SMP however costs and timeframes are not available in the SMP document, therefore, these are presented in a different format:

- A new trunk drain in Angle Vale Road, from Chivell Road to Heaslip Road, with drain sizes ranging from 750 mm to 1200 mm diameter. The underground drain capacity shall be greater than the 0.2 EY (5-year ARI) in order to limit the overflows along Angle Vale Road in major storm events;
- The new Angle Vale Road trunk drain will facilitate a gravity connection to the existing Fradd Road / Harradine Court detention basin;
- A new lateral drainage system along Short Road and Higgins Road, ranging in size from 450 mm to 600 mm diameter;
- An increase to the Stevens Drive pump rate to a nominal 35 L/s which will maximise the use of the existing 150 mm diameter rising main;
- Upgrades to the road reserves along key transport routes (eg. Angle Vale Road, Heaslip Road, Chivell Road) to include kerbed road carriageways and swales (as required) to contain overland flows in the 1% AEP (100-year ARI) event; and
- Lateral connections to the existing Harris Road trunk drain and provision for controlled overflow from this system to the high flow path in the Chivell Road sub-precinct.

9.4 Water Quality Improvement

Large improvements in water quality can be achieved throughout the Gawler River catchment, however, significant coverage of retrofitted WSUD measures across the already developed Council areas would be required to achieve the targeted water quality objectives, as the opportunities for the implementation of large-scale water quality improvement measures has been found to be limited.

The priority is therefore placed on:

- Smaller scale WSUD infrastructure, such as raingardens, swales, permeable paving and tree pits
- Installation of gross pollutant traps where appropriate
- Erosion control
- Measures put in place for new developments in the 30-year growth areas

Specific water quality improvement projects did not rate highly in the assessment of the options in the various SMP document due to the high cost of installation and maintenance.

9.5 Water Reuse

Stormwater reuse, and integrated water management, is desirable when it can be achieved cost-effectively. The WAP currently limits the viability of implementing large scale water harvesting schemes, therefore, no large-scale water reuse schemes have been given a high priority rating in any of the associated SMPs.

WSUD measures are, however, recommended and rated as a high priority in each of the SMPs including more localised and property scale solutions such as infiltration systems and rainwater tanks.

9.5.1 Optimisation of Existing Harvesting Schemes

Several opportunities were identified in the development of the relevant SMPs to optimise and augment the existing stormwater harvesting schemes before trying to establish new schemes including:

- Prioritising catchment sediment management practices
- Investigate options for diversion of poor-quality water from the storages
- Determine if additional water quality and flow monitoring would support operation of the schemes.

Objective: Water Quality, Water Reuse and Environment Protection and Enhancement

Responsibility: All Councils

Timeframe: Ongoing

Estimated Cost: $20,000 per year

9.5.2 Infiltration Systems

Installation of WSUD infrastructure such as raingardens, permeable paving and tree pits will allow stormwater to infiltrate into the soil. It can help to passively irrigate street trees and other landscaped areas. Such systems should become a component of all new road reconstruction projects.

The infiltration systems will also provide a significant water quality benefit if there is enough of them throughout the catchment.

Passive irrigation of vegetation can help to improve the health of the vegetation. This therefore improves amenity, habitat and can offset heat island effects.

Objective: Water Quality, Water Reuse and Environment Protection and Enhancement

Responsibility: All Councils

Timeframe: Ongoing

Estimated Cost: $100,000 per year (capital)

9.5.3 Rainwater Tanks

Encouraging and subsidising the installation of residential rainwater tanks will help to increase the volume of water harvested and reused at the allotment scale. The tanks would also have the potential to reduce downstream flooding, particularly during smaller events; 5 kL tanks are recommended.

Objective: Water Use

Responsibility: All Councils

Timeframe: Ongoing

Estimated Cost: $50,000 per year

9.6 Environmental Protection and Enhancement

Managing erosion issues along natural watercourses and actively restoring riparian habitat will assist in meeting the objectives proposed. The rollout of WSUD features will also assist in minimising changes to the existing hydrological regime. Many opportunities exist for environmental protection and enhancement within the Gawler River catchment for many benefits including biodiversity and amenity and cooling purposes.

9.6.1 Education and Awareness

An ongoing community education and awareness program could support the environmental protection and enhancement of the Gawler River catchment area. The program could contain a wide variety of topics including the value of the river system to Water Sensitive Urban Design measures for households and businesses.

Objective: Environmental Protection and Enhancement

Responsibility: All Councils

Timeframe: Ongoing

Estimated Cost: $50,000 per year

9.6.2 Riparian Habitat Restoration and Erosion Management

Many of the riparian habitats within the Gawler River catchment have low ecological value due to human activities that have led to invasive species and erosion. The restoration of the creek lines through weed removal and introduction of native species will provide for additional native habitat and provide an environment that is not as susceptible to erosion. These works would also look to minimise erosion risk. Furthermore, these works improve both water quality and slow flow rates which further enhances ecological values. The works would also improve amenity.

Objectives: Water Quality and Environmental Protection and Enhancement

Responsibility: All Councils (with Landscape Boards and DEW)

Timeframe: Ongoing

Estimated Cost: $100,000 per year

9.7 Asset Management

There are several strategies that the Councils can implement to manage their stormwater assets effectively including:

- Development and maintenance of an asset condition database
- Development and undertaking of an asset inspection program
- Development and undertaking of an asset replacement program

The strategies are focused towards ensuring early identification of deteriorated assets to enable proper planning of their replacement. Setting aside funds to implement the strategies will assist the Councils' long-term management of their assets.

There are also specific actions in this area around asset ownership, asset responsibility, agreed levels of service and therefore agreed levels of maintenance. This is particularly important for flood mitigation infrastructure (including levees) but also where investment is placed in natural systems which require ongoing maintenance.

Responsibility: All Councils

Timeframe: Ongoing

Estimated Cost: $100,000 per year

9.8 Risks

There are a range of risks related to the high priority management strategies that have been outlined in this section of the SMP which include:

- Risks related to stakeholder support for proposed option/s
- Risks related to a funding and delivery model for what's recommended
- Risks related to planning policies not getting implemented to the full extent as modelled
- Risks related to the dam and levee consequence category
- Risks related to the impacts if the flood control measures are not implemented or maintained

10 RECOMMENDATIONS AND FURTHER WORK

10.1 Recommendations

There has been a large volume of work and investigations undertaken in the Gawler River Catchment over many years. Meanwhile, development continues and the climatic conditions are changing. There is the need to remain vigilant to ensure that development continues in a way that does not exacerbate flood risk and opportunities are taken to provide other benefits such as enhancing the environment and maximising reuse potential. There are many high priority recommendations contained within this SMP and linked to other relevant SMPs that if implemented will achieve the objectives of the SMP.

The main findings and recommendations from the development of the Gawler River SMP are:

- The flood risk remains and the recommended approach to mitigate that flood risk is to repair / reinstate the existing levees (and ensure ongoing maintenance) and raise the height of the Bruce Eastick Flood Mitigation Dam
- Revisit and determine the most effective way forward regarding the complicated land ownership and responsibility arrangements along the length of the Gawler River including the channel itself and the associated levee banks
- The communities are continually changing within the catchment area and there are many opportunities (and needs) for ongoing community education and awareness programs covering many topics including flooding, climate change, benefits of river systems and opportunities to be involved in the protection and enhancement of the local environment

10.2 Further Work

In addition to the priorities outlined in Section 9 and 10.1, a range of recommendations are included in this section for further work based upon the consultation undertaken and the previous studies reviewed:

- Detailed water quality assessments are undertaken within the Gawler River catchment and the Gawler River itself including regular monitoring to better understand the current water quality issues and measure improvements when initiatives are implemented
- Traditional Custodians be included in the implementation of mitigation options, the implementation of improvement works and the development of future strategies for the area
- Cultural water requirements be included in strategies and options implemented
- Cultural heritage survey(s) should be undertaken before any on ground works commence
- Ongoing bank inspection, rehabilitation and maintenance be undertaken for the Gawler River, including identification and prioritisation of the works to be undertaken
- Prior to setting the stormwater management requirements for areas of new development, the condition of tributaries and outfalls downstream of any proposed areas of development be inspected. Where erosion is of concern, measures should be put in place to limit volumes, peak flows and stormwater velocities from the development and improve bank stability
- Floor level surveys of properties identified as flood prone be undertaken in order to inform detailed design of infrastructure upgrades
- Utilise the helicopter survey to evaluate and map tree health along the Gawler River
- Undertake community awareness programs for the protection and enhancement of the Gawler River
- Look for opportunities to promote linking/connecting the community to the Rivers and Creeks within the catchment area

- Determine specific environmental water requirements (quantity and quality) for the coastal receiving water environments of the Gawler River e.g. provide environmental flows with flow to the sea over an extended period late autumn to spring at least once every three years but preferably each year
- Determine the risk profiles of the people and businesses and transport routes within the flood hazard zone(s) (and for them to be revisited on a regular basis)
- Define the acceptable or tolerable risk of natural hazards including flooding
- Upstream modelling be undertaken to test the assumptions of the Bruce Eastick Flood Mitigation Dam as a storage structure in the models utilised for the regional flood assessments
- Upstream catchments be further explored and information obtained to help inform the management of the Gawler River
- On ground validation of the hydraulic modelling be undertaken through field observations during flood events
- Determine performance level targets for the Gawler River catchment that the mitigation options outcomes can be measured against
- Further assessment of the impact of climate change on the catchment including a detailed assessment of the impact of predicated Sea Level rise on the outfall of the Gawler River
- Further discuss and assess the potential arrangements and associated options for levee ownership and maintenance
- A method of recording progress of this SMP and other associated SMPs as work is completed
- The plan be regularly revisited and revised as more information and data is obtained following the recommendations above

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ABBREVIATIONS

AAD	Average annual damages
AEP	Annual exceedance probability
ARI	Average recurrence interval
ASR	Aquifer storage and recovery
DEW	Department for Environment and Water
DIT	Department for Infrastructure and Transport
EPA	Environment Protection Authority
EWP	Environmental water provisions
EWR	Environmental water requirements
EY	Exceedances per year
GPT	Gross pollutant trap
GRFMA	Gawler River Floodplain Management Authority
GWRS	Gawler Water Reuse Scheme
IPCC	Intergovernmental Panel on Climate Change
MAR	Managed aquifer recharge
SES	State Emergency Service
SMA	Stormwater Management Authority
SMP	Stormwater management plan
SS	Suspended solids
TN	Total nitrogen
TP	Total phosphorus
WAA	Water affecting activities
WAP	Water allocation plan
WMLR	Western Mount Lofty Ranges
WSUD	Water sensitive urban design
ZEMC	Zone Emergency Management Committees

GLOSSARY

Annual Exceedance Probability	Annual Exceedance Probability (AEP) refers to the probability of a flood event occurring in any year, expressed as a percentage. For example, a large flood which may be calculated to have a 1% chance to occur in any one year, is described as 1% AEP. A 1% AEP flood event is equivalent to a 100-year ARI event.
Aquifer	An underground layer of rock or sediment that holds water and allows water to percolate through.
Average Recurrence Interval	Flood risk is often described in terms of Average Recurrence Interval (ARI). This is the number of years on average, within which a given flood will be equalled or exceeded. A 100-year ARI flood will be equalled or exceeded once in 100 years on average. It has a 1% probability of occurring in any given year. Due to the random nature of floods, however, a 100-year flood need not occur in every 100 years and conversely, several floods which exceed the 100-year flood could occur within any one period of 100 years. The ARI of an event is *approximately* equivalent to the inverse of the AEP.
Average Annual Damage	Depending on its size (or severity), each flood will cause a different amount of damage to a flood prone area. Large floods will cause more damage than small floods. The average annual damage is the average damage per year that would occur in a particular area from flooding over a very long period. In many years there may be no damage, in some years there will be minor damage (caused by small, relatively frequent flood events) and in some years there will be major damage (caused by large, rare flood events). Average annual damage provides the basis for comparing the economic effectiveness of different management measures against floods of all sizes, i.e., their ability to reduce the AAD.
Catchment	The surface area of land that collects and drains water into a river or other waterway. Catchments can include both rural and urban areas
Flood control (or mitigation) dam	A reservoir connected to a waterway that provides a temporary storage for floodwaters, potentially reducing or delaying the likelihood or magnitude of downstream flooding.
Flood damage	"Flood damage" is the tangible and intangible costs of flooding. Tangible costs are quantified in monetary terms (e.g., damage to goods and possessions, loss of income or services in the flood

	aftermath). Intangible damages represent the increased levels of physical, emotional, and mental health problems suffered by flood affected people and attributed to a flooding episode. Intangible damages are difficult to quantify in monetary terms.
Flood hazard	Potential loss of life, injury and economic loss caused by future flood events. The degree of hazard varies with the severity of flooding and is affected by flood behaviour (extent, depth, velocity, duration, and rate of rise of floodwaters), topography, population at risk and emergency management.
Floodplain	Land adjacent to a waterway, subject to occasional flooding (up to and including the probable maximum flood). Floodplains can be narrow, steep, wide and/or flat, and can extend several kilometres from the waterway
Groundwater	Water occurring naturally below ground level or water pumped, diverted and released into a well for storage underground
Hydrogeology	The study of groundwater, which includes its occurrence, recharge and discharge processes and the properties of aquifers
Managed Aquifer Recharge (or draining or discharging):	The intentional draining or discharging of water to aquifers for subsequent recovery and use or for environmental benefit
Riverine flooding (Fluvial flooding)	Riverine flooding happens when rivers break their banks and water covers the surrounding land. It is mostly caused by heavy rainfall, but can also be caused by king tides, storm surge, snowmelt, and dam releases.
Stormwater Management Authority	A statutory authority which operates as a body for the planning, prioritisation and funding of stormwater management initiatives and it implements the Agreement on Stormwater Management between the State of South Australia and the Local Government Association of South Australia
Surface water flooding (pluvial flooding)	Surface water flooding happens when rainwater does not drain away through the normal drainage systems or soak into the ground, but lies on or flows over the ground instead
Water allocation plan	A plan prepared under Part 4 Division 2 of the Landscape Act

The table below lists the probability terminology used for the 2016 design rainfalls and shows in bold the standard EY and AEP values for which design rainfalls are available. Generally, EY terminology is used for Very Frequent design rainfalls used in Water Sensitive Urban Design sizing, AEP (%) terminology is used for Frequent and Infrequent design rainfalls, and AEP (1 in x) terminology is used for Rare design rainfalls (major floods).

Australian Rainfall and Runoff terminology

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI	Uses in Engineering Design
Very frequent	**12**				
	6	99.75	1.002	0.17	Water sensitive urban design
	4	98.17	1.02	0.25	
	3	95.02	1.05	0.33	
	2	86.47	1.16	0.50	
	1	**63.2**	1.58	1.00	
Frequent	0.69	**50.00**	2	1.44	Stormwater/pit and pipe design
	0.5	39.35	2.54	2.00	
	0.22	**20.00**	5	4.48	
	0.2	18.13	5.52	5.00	
Infrequent	0.11	**10.00**	10.00	9.49	Floodplain management and waterway design
	0.05	**5.00**	20	20.0	
	0.02	**2.00**	50	50.0	
	0.01	**1.00**	**100**	100	
Rare	0.005	0.50	**200**	200	
	0.002	0.20	**500**	500	
	0.001	0.10	**1000**	1000	
Extremely Rare	0.0005	0.05	**2000**	2000	Design of high-consequence infrastructure (eg major dams)
	0.0002	0.02	5000	5000	
			↓		
Extreme			PMP		

https://arr.ga.gov.au/arr-guideline