SMP study area. The high-level assessment (EMS, 2017) looked at the terrestrial and aquatic habitats of the tributary watercourses of the North and South Para Rivers (refer Appendix A). The assessment was based on a single walk over of the watercourses, noting:

- Existing erosion of the bed and/or banks.
- Stock crossing points.
- Areas of woody weeds or weed species of national significance. Any obstructions to flow.
- Areas of remnant or significant indigenous vegetation to be protected.

3.6.1 Habitat assessment

The assessment found that the tributaries within the study area are highly modified. While it is acknowledged that sections of valuable flora and fauna exist, based on the walk over it was identified that there is little natural habitat remaining—mainly as a result of clearing, urban development and grazing. Small sections of habitat with high environmental value were identified in some tributaries near where they joined with the North Para River.

In the lower reaches of Tributary 1 (refer Figure 3.10 for location of tributaries), some mature *Eucalyptus camaldulensis* were identified with some minor regeneration. EMS noted that some replanting had been undertaken and that there is "much scope for habitat enhancement". Some aquatic pool habitat was also noted in the upper sections of Tributary 1. This tributary drains into the North Para River.

Tributary 6, which is within the Gawler East growth area, has a spring fed permanent pool and drains into the South Para River. The spring fed flows provide a linear waterlogged area, supporting a number of aquatic species.

Any strategies relating to the management of stormwater within the SMP study area must be cognisant of these areas of environmental value. It should also be noted that the assessment was undertaken at a high level and that some valuable fauna and flora species were not picked up by the study.

3.6.2 Erosion potential

The assessment of soil erosion risk was based on a desktop analysis using published methods for South Australia. The modelled soil erosion risk was determined based on the two key factors that influence water-induced erosion of soil – the slope of the land and the inherent erodibility of the soil, as defined and mapped by previous studies.

The resultant classifications for the tributaries within the SMP study area is shown in Figure 3.10 which is an extract from the EMS report.

It can be seen that a number of the tributaries are classified as having a 'moderate' or 'high' erosion potential. Stormwater management strategies must take into account the areas identified as having 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.

The erosion risk of tributaries within the urban areas has not been classified. Observations within the study area have identified existing erosion within the urban section of the study area (an example of this is shown in Figure 3.11). It is recommended that 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.

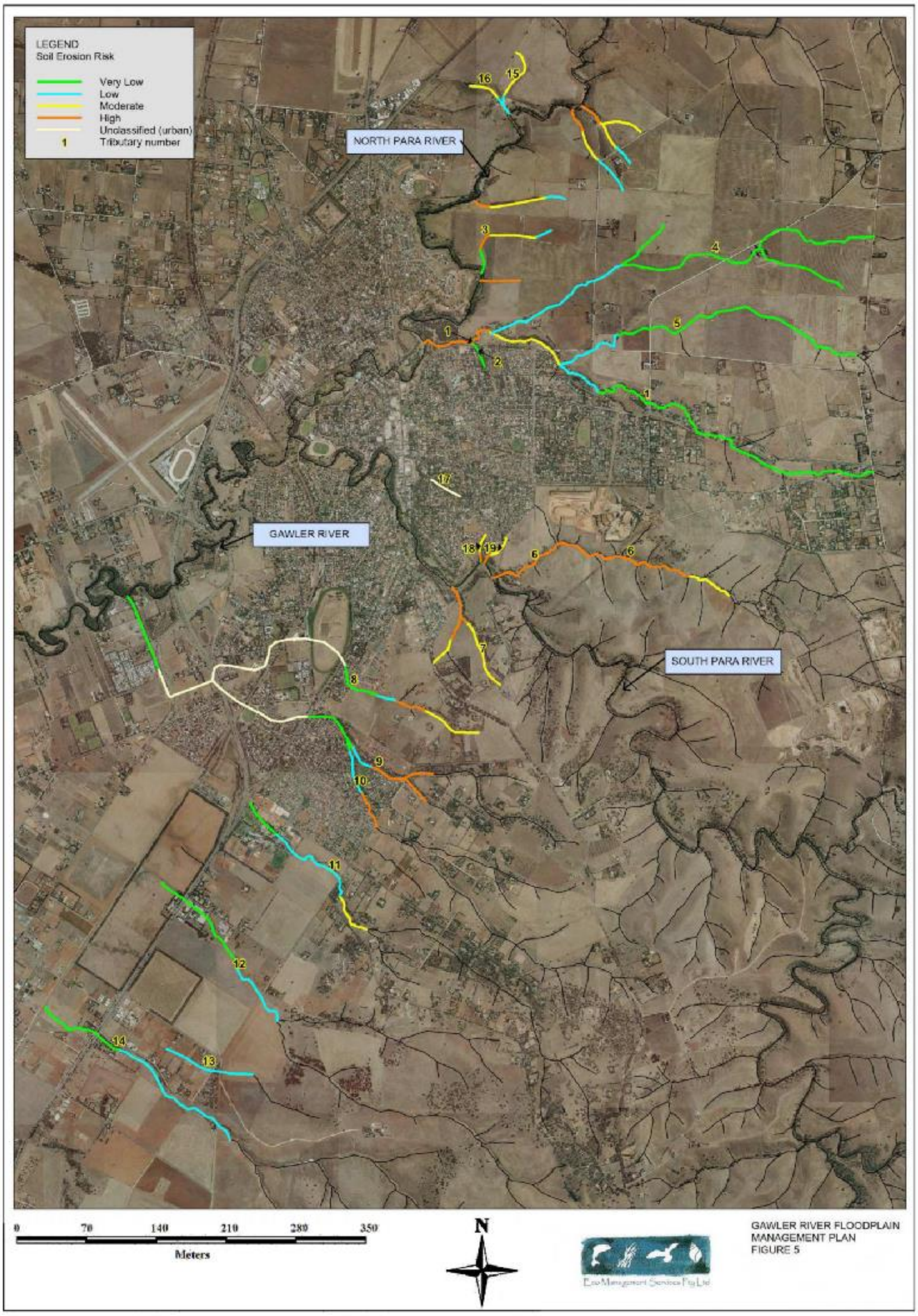


Figure 3.10 Erosion risk of tributaries within the SMP study area (extracted from EMS, 2017)

Figure 3.11 Erosion at a stormwater outfall along the South Para River (left) and on a tributary within the urban area of Gawler

3.7 Water reuse

Consideration of reuse options needs to be in the context of the existing schemes, environmental water requirements and limitations imposed by the WMLR WAP.

A summary of the existing water reuse schemes is provided in the following sections.

3.7.1 Gawler Water Reuse Scheme

The Gawler Water Reuse Scheme (GWRS) presented a concept for a broad-scale water harvesting and reuse scheme for the Gawler and Surrounds area. The original scheme aimed to supply up to 6 GL per year for irrigation and industrial purposes. The scheme incorporated water harvesting from within the Gawler township and the Gawler River, managed aquifer recharge and an extensive distribution network. The original GWRS did not eventuate due to insufficient demand for the non-potable water.

Bunyip Water Pty Ltd has been formed to build and operate a revised version of the GWRS. In 2016, the Bunyip Water harvesting and reuse scheme was completed. The Bunyip Water scheme harvests water from the Gawler River and targets to deliver 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. It is understood that the annual supply volumes are limited by the flows available for diversion. Additional demand exists, should additional flows above the environmental flow threshold be available for harvest.

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.

3.7.2 Gawler Urban Growth Areas

A harvesting and reuse scheme is proposed for the Gawler Southern Urban Growth Areas, which is located just outside the bounds of the SMP study area, but which may represent an opportunity for harvesting and reuse of water from the study area.

Process diagrams for the Devine subdivision (by Wallbridge and Gilbert) show that the recycled water network includes a number of wetlands and basins, new bores at Karbeethan, a site adjacent to Coventry Road and pumps and storage tanks. Water is proposed to be used for irrigation of Karbeethan Reserve, to pump wetlands and as irrigation water for local schools including Trinity College. The scheme is generally consistent with that identified in the Evanston Stormwater Strategy (Ecological Engineering, 2007).

There is currently an injection and extraction bore at Karbeethan Reserve. Gawler Council commissioned a study into water supply options for the supply of additional non-potable water for the Gawler Southern Urban Growth Areas. The bore at Karbeethan was found to be low yielding and suitable for supply only.

The study (KBR, 2018) recommended that the growth area should be supplied with a 'climate independent' water supply with the preferred option being connection to the Water Reticulation Systems Virginia (WRSV) network.

The feasibility of securing additional groundwater resources was discussed in the study and it was identified that as it is a prescribed resource, additional entitlements would need to be sought on the market. This would likely take a number of years as the volume of water traded each year is low. Additionally, there are conditions set out in the WAP that must be satisfied for a transfer to be approved (KBR, 2018).

3.7.3 Regional harvesting schemes

Stormwater harvesting schemes require large areas of open space in close proximity to yields and demands. On this basis, two potential locations for additional regional harvesting schemes have been identified – the Gawler Racecourse and adjacent to the Clifford Road Drain at the downstream end of the study area.

Previous testing has confirmed the capability of MAR in the Evanston area with bore yields of 15 to 20 L/s. Previous studies have determined that MAR at the racecourse was not viable due to high salinity levels associated with the shallow Quaternary aquifer in which the existing bore is completed. Similarly, the existing bore at Karbeethan Reserve has been deemed not suitable for managed aquifer injection due to poor yields (KBR, 2018).

Review of the WMLR WAP determined that the contributing catchments and the racecourse are within surface water management zone (SWMZ) LC26 of the WAP. SMMZ LC26 has a catchment wide water allocation allowance of 95 ML/year. The Department for Environment and Water (DEW) has indicated that the surface water resources in the zone are 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 DEW advised that harvesting from this drain would be subject to review and approval from the Landscape Board.

3.7.4 Impacts of climate change

Climate change is likely to impact the volumes, and quality, of water available for harvest and reuse. Reduced rainfall will result in lower runoff volumes, while higher evaporation rates will increase storage losses.

The MUSIC modelling of the long term development scenario shows that the end of the century climate projections results in a 27% reduction in runoff from the study area at the downstream receiving node (refer Figure 2.6). While increases in development will initially result in increased runoff, it is estimated that by the middle of the century, the impacts of reduced rainfall will more than offset this increased runoff. The MUSIC modelling is based on scaled rainfall and evaporation time series. The modelling does not capture the likely changes to rainfall patterns. With a trend towards higher rainfall intensities, it is likely that the reduction in harvestable volume will be less, with the higher flows exceeding the harvesting capacity of the facility. Increased rainfall intensities, combined with higher temperatures, may also lead to greater concentrations of pollutants which may impact the suitability of water for the intended reuse purposes.

4 Stormwater management objectives

4.1 Stormwater management goals

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

Arising from these issues, broad goals for management of urban stormwater runoff can be developed and are commonly identified as follows:

Goal 1: Flood Management

- Provide and maintain an adequate degree of flood protection to existing and future development.

Goal 2: Water Quality Improvement

- Improve water quality to meet the requirements for protection of the receiving environment and downstream water users.

Goal 3: Water Use

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

Goal 4: Environmental Protection and Enhancement

- Manage stormwater runoff in a manner that protects and enhances biodiversity and the natural environment. In association with this goal, land used for stormwater management purposes should be developed, where possible, to facilitate recreation use and to enhance amenity.

Goal 5: Asset Management

- That stormwater assets are managed in a sustainable manner and are provided with adequate maintenance such that they are able to operate as originally intended.

The development of an SMP for the Gawler and Surrounds area has required that these broad goals be further refined to identify catchment specific management objectives. These specific objectives have enabled targeted management strategies to be identified and assessed.

4.2 Catchment specific objectives

Development of catchment specific objectives for management of runoff from the Gawler and Surrounds SMP area has been carried out with reference to the principles contained in the document 'Stormwater Management Planning Guidelines' prepared by the Stormwater Management Authority (2007).

The catchment specific objectives that have been developed by Tonkin are consistent with the directions for management of stormwater promoted by the guidelines and are consistent with industry best practice. Development of the objectives was undertaken following consultation with the Steering Committee in the initial consultation phase. The Steering Committee has endorsed the objectives.

4.2.1 Flood management

Drainage within the study area is comprised of three main systems.

The urbanised areas of the catchment predominantly contain inlet pits that are interconnected via an underground drainage network. This underground drainage system is there to prevent nuisance flooding of roadways resulting from relatively frequent storm events, while surface flow paths such as roads and reserves are there to carry excess runoff during more substantial storm events. The combined capacity of the underground and surface drainage system should be sufficient to carry the peak flow produced by a 1% AEP event. A design standard of between 2 and 5 years is generally adopted for the underground system.

The underground systems predominantly discharge into natural watercourses which form the second main system in the study area. Based on the flood modelling results these are typically able to carry significant flows and should be able to safely convey 1% AEP flows.

The final systems are shallow surface sheet flows that are predominantly located within the western portion of the study area. In this area there is little formal drainage infrastructure and the depth and direction of flows is governed by the existing topography and the build up by the road network.

Based on the background outlined above the following objectives have been set.

Objective 1.1

- Where economically and practically viable, protect all properties from inundation in a 1% AEP event. A lower standard of flood protection may be adopted where physical and economic constraints limit the ability to achieve a 1% AEP level of protection.

Objective 1.2

- Provide an underground drainage system with a minimum capacity sufficient to convey a 39.35% AEP (equivalent to 2-year ARI) flow, but where possible provide a 20% AEP standard.

Objective 1.3

- Provide a trunk drainage system (typically open channels) with a minimum capacity sufficient to carry a 1% AEP flow.

Objective 1.4

- Ensure that new development does not increase the degree of flood risk to other properties for all events up to a 1% AEP.

Objective 1.5

- Increase the public awareness of flood risk so that they are better able to respond to flood events and reduce flood damages.

Objective 1.6

- Include consideration of possible future climates in all future works.

4.2.2 Water quality improvement

The North Para and South Para Rivers flow through the Gawler and Surrounds SMP study area, merging within the township of Gawler to form the Gawler River. Stormwater from the SMP study area discharges into the North Para River, South Para River and Gawler River, either directly or via tributaries.

The catchment specific objectives for water quality improvement within the receiving waters are listed below. They are based on best practice, understanding of the catchments, the current health of the receiving waters and known key pressures within the study area.

Objective 2.1

- Manage the quantity of gross pollutants discharging into the South Para, North Para and Gawler Rivers such that they meet the 90% recommended reduction in average annual load as specified by the SA Government water sensitive urban design policy (Government of South Australia, 2013).

Objective 2.2

- Minimise the quantity of sediment exported from the catchment such that it meets the 80% recommended reduction in average annual load as specified by the SA Government water sensitive urban design policy.

Objective 2.3

- Minimise the quantity of nutrients (total phosphorus) exported from the catchment such that runoff meets the recommended 60% reduction in average annual load as specified by the SA Government water sensitive urban design policy.

Objective 2.4

- Minimise the quantity of nutrients (total nitrogen) exported from the catchment such that runoff meets the recommended 45% reduction in average annual load as specified by the SA Government water sensitive urban design policy.

Objective 2.5

- Minimise the increase in average annual runoff from redevelopment such that patterns of runoff more closely mimic pre-development conditions.

4.2.3 Water reuse

As outlined in Section 3.7.1, the main water harvesting scheme in the Study Area is operated by Bunyip Water with water harvested from the Gawler River.

The aquifers in the area are potentially suitable for MAR. Testing has confirmed the capability of aquifer recharge in the Evanston area with bore yields of 15 to 20 L/s. A bore on the Gawler horse racing track just to the north has a yield of 10 L/s and will be tested to assess its capacity as a MAR facility.

There is currently an injection and extraction bore at Karbeethan Reserve and Gawler Council have commissioned a study into water supply options for the supply of additional non-potable water for the Gawler Southern Urban Growth Areas.

The catchment specific objectives for water reuse are listed below. Consideration of reuse options will be in the context of the existing schemes and limitations imposed by the requirements of the WMLR WAP.

Objective 3.1

- Encourage on-site use of stormwater runoff to minimise discharges to the downstream stormwater system.

Objective 3.2

- Within the limitations imposed by the WMLR WAP maximise the capture and re-use of stormwater runoff.

4.2.4 Environmental protection and enhancement

The environmental conditions of the existing watercourses within the catchment have been assessed by Eco Management Services (refer Appendix A). The EMS report concluded that "all tributaries have been highly modified, with little of the original natural habitat remaining, mainly through vegetation clearance, urban development, and grazing". Most of the watercourses are within pasture areas with introduced understory species. The remaining vegetation consists of some scattered native shrubs, trees and grasses. The EMS report found that there are important remnant vegetation areas which have ecological and conservation significance, particularly for native grasses. It is acknowledged that the SMP was not able to assess all tributaries in the study area.

Over the last ten years a range of works aimed at improving the environmental values of the watercourses within the study area have been undertaken by various agencies and stakeholder groups. These works include environmental flow trials in the South Para River, improving the biodiversity of the terrestrial and aquatic habitats by exotic species removal and planting of native species.

The objectives described in the following sections are cognisant of the environmental value of the receiving waters and are consistent with the works that have been undertaken. They are aimed at realising opportunities for environmental and biodiversity enhancements.

Objective 4.1

- Where new stormwater management facilities are constructed on existing open space, maximise the community use and benefit derived from the facility and ensure that opportunities for biodiversity, water quality, amenity and environmental enhancement are realised.

Objective 4.2

- Retain and enhance the habitat quality of the existing natural watercourses in the study area.

Objective 4.3

- Attempt to mimic the pre-development hydrological regime of the watercourses in the study area.

4.2.5 Asset management

Stormwater drainage forms a considerable financial asset for the three Councils within the study area, particularly for the Town of Gawler. Considering that a large portion of the existing drainage infrastructure was constructed over 30 years ago, some degree of structural degradation is likely. Degraded infrastructure will reduce the ability of the drainage system to act as per its original design intent.

Without careful planning, structural failure of existing infrastructure may necessitate immediate and expensive rectification. Careful asset management will allow for future planning to determine the timeline for replacement of assets.

An increased implementation of water sensitive urban design (WSUD) necessitates a higher degree of maintenance, compared to traditional pits and pipes, to ensure that optimum water quality improvement performance is obtained from WSUD assets. However, WSUD assets offset this by providing a more wholistic range of benefits.

Based on the above, the following general objectives have therefore been set:

Objective 5.1

- Have up to date information on the age and condition of existing drainage infrastructure.

Objective 5.2

- Plan for the strategic replacement of infrastructure nearing the end of its design life, with a particular focus on major assets such as trunk drainage systems.

Objective 5.3

- All stormwater infrastructure including WSUD schemes are to be maintained in accordance with maintenance management plans.

5 Management strategies

5.1 Flood management

Flood models were developed for three scenarios:

- existing levels of development;
- estimated long-term development within the catchment; and
- estimated long-term development within the catchment with selected structural flood management strategies included.

These flood models were used to identify opportunities for structural flood management strategies, with a particular focus on making a material change in addressing the key flood prone areas described in Section 3.2. The identified flood management strategies were investigated to assess their impact on the extent and severity of flood inundation. Figure 5.1 shows the location of the investigated management strategies.

Figure 5.13, Figure 5.14 and Figure 5.15 (pages 70, 71 and 72 respectively) each show the modelled flood inundation for the 1% AEP event (based on the long-term development scenario) with and without structural flood management strategies. The difference in flood inundation depth as a result of the various management strategies is also shown.

Flood inundation and hazard maps of all scenarios are presented in Appendix F.

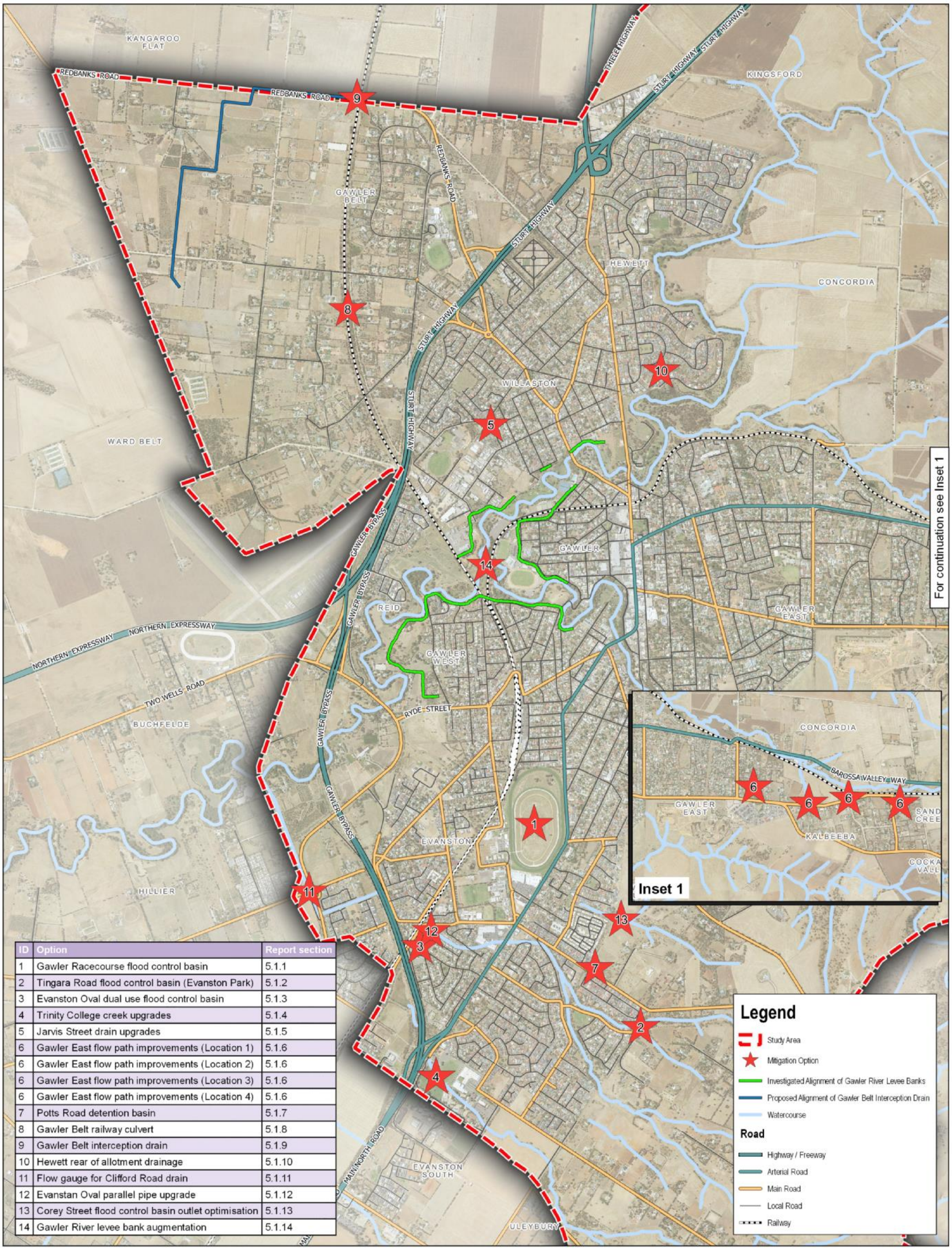
5.1.1 Gawler Racecourse flood control basin

Mitigation measures have been identified to alleviate the flooding within First Street (as described in Section 3.2.3). The flooding at this location is caused by two mechanisms: insufficient capacity of the pipe system passing beneath the Gawler Racecourse which drains the trapped low-spot where flooding occurs; and insufficient capacity of the Sheriff Street drain which conveys flows to the low spot.

It is proposed that the First Street drainage network be upgraded with approximately 200 m of DN1200 reinforced concrete pipe (RCP) to increase outflow capacity from the low spot. Allowing these flows to be conveyed un-detained may result in increased flooding downstream of the racecourse. As such, it is also proposed that a detention basin be used to control the flow rates discharged downstream. There is considerable open space within the centre of the racecourse which could be utilised to provide effective flood storage. Consideration will need to be given to the findings of the *Town of Gawler Biodiversity Management Plan* (McGregor and Durant, 2018) which proposed priority conservation of native grasses within the grounds of the racecourse.

To alleviate the loading from the Adelaide Road and Main North Road drainage systems, it is proposed that these systems are also diverted into the basin. The footprint of the proposed basin and the sections of upgraded pipe networks associated with this option are shown in Figure 5.2.

It is estimated that a 35,000 m^3 basin would be sufficient to detain the volume of runoff that is directed into it, while limiting the discharge flow rate so that it does not exceed the capacity of the downstream drainage system. Ideally the basin would be split into a flood control portion for large flood events and a water quality portion to provide treatment to smaller frequent storm flows. If more than 35,000 m^3 of storage can be provided it may be possible to reduce outflows and further relieve flooded areas downstream in Evanston.



ID	Option	Report section
1	Gawler Racecourse flood control basin	5.1.1
2	Tingara Road flood control basin (Evanston Park)	5.1.2
3	Evanston Oval dual use flood control basin	5.1.3
4	Trinity College creek upgrades	5.1.4
5	Jarvis Street drain upgrades	5.1.5
6	Gawler East flow path improvements (Location 1)	5.1.6
6	Gawler East flow path improvements (Location 2)	5.1.6
6	Gawler East flow path improvements (Location 3)	5.1.6
6	Gawler East flow path improvements (Location 4)	5.1.6
7	Potts Road detention basin	5.1.7
8	Gawler Belt railway culvert	5.1.8
9	Gawler Belt interception drain	5.1.9
10	Hewett rear of allotment drainage	5.1.10
11	Flow gauge for Clifford Road drain	5.1.11
12	Evanstan Oval parallel pipe upgrade	5.1.12
13	Corey Street flood control basin outlet optimisation	5.1.13
14	Gawler River levee bank augmentation	5.1.14

250 0 250 500 750 m

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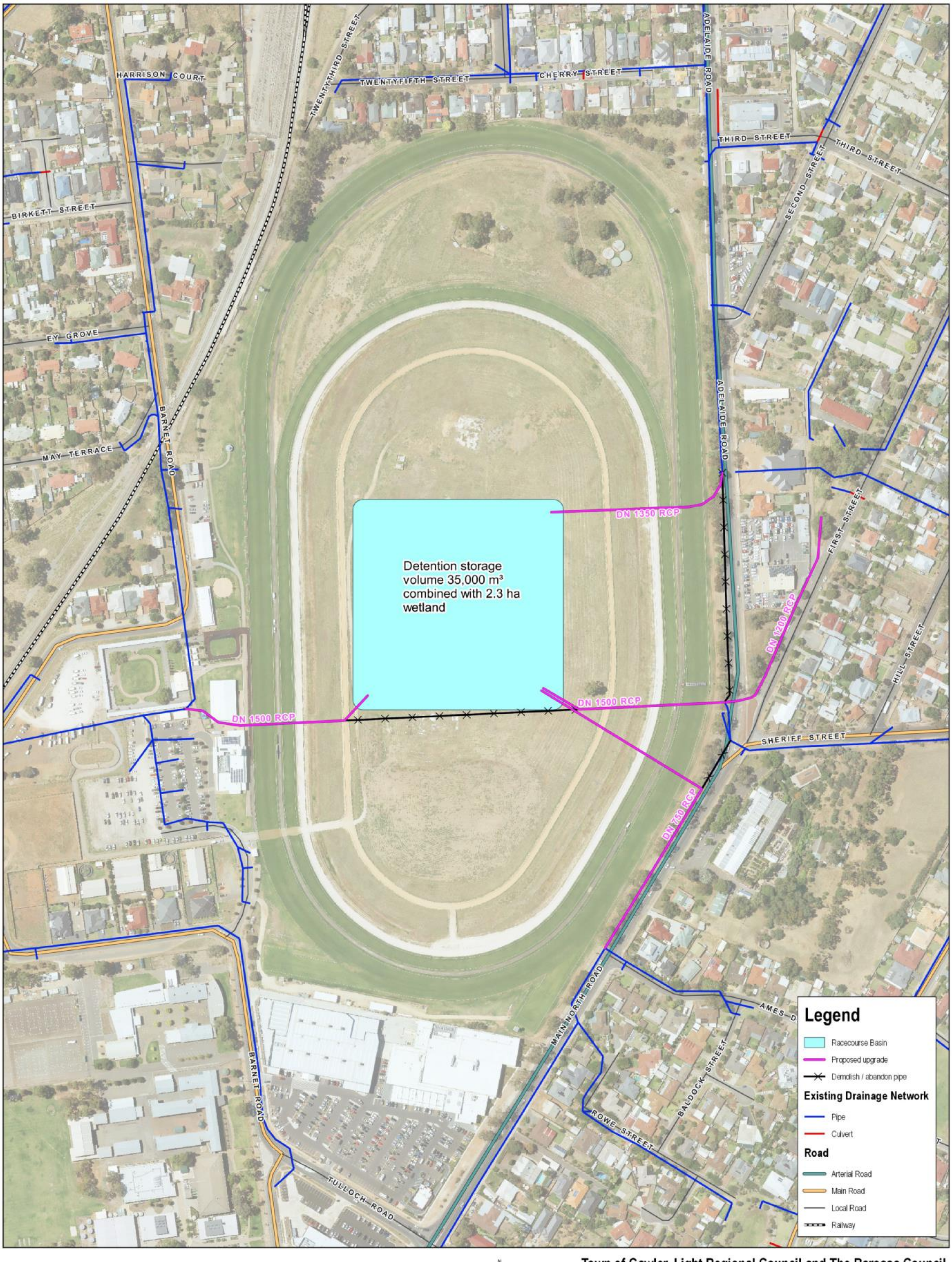
Town of Gawler, Light Regional Council and The Barossa Council

LOCATION OF INVESTIGATED STRUCTURAL FLOOD MANAGEMENT STRATEGIES

Figure 5.1



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Town of Gawler, Light Regional Council and The Barossa Council

GAWLER RACECOURSE FLOOD CONTROL BASIN

Figure 5.2

Figure 5.13 demonstrates the improvements to flooding in First Street as a result of the pipe and basin upgrade. However, upstream of First Street, properties between Mount Terrace and First Street are still subjected to flooding in the 1% AEP event. This is due to stormwater that cannot be conveyed to the First Street low spot by the local stormwater system. The standards mapping of the existing drainage infrastructure estimated that the Sheriff Street drain lacks the capacity to convey the 20% AEP event (refer Figure 2.5). The primary restriction in conveyance appears to be the drain in Sheriff Street.

It may be possible to address the relatively shallow residual flooding by upgrading the Sheriff Street drainage system to have the capacity to convey runoff from the 1% AEP event. However, the 1% AEP underground drainage standard is a higher standard than targeted by this SMP. Therefore, Council will need to consider whether the large expense associated with upgrading of the Sheriff Street drainage system to a 1% AEP standard is merited.

5.1.2 Tingara Road flood control basin (Evanston Park)

A basin at Tingara Road would act to detain flow in the same manner as the existing basins in the area. A review of the digital elevation model suggests that an 8 metre deep basin is likely the maximum possible volume that could be achieved at this site. A concept design for the flood control basin is shown in Figure 5.4.

Modelling was undertaken to determine the minimum possible outflow from the basin in the 1% AEP event without engaging the basin spillway. The modelling demonstrated that a peak 1% AEP inflow of 7 m^3/s could be reduced to 3 m^3/s. Further optimisation of the basin outlet could provide some additional reduction of the peak outflows during more frequent events. Not only does the basin reduce the peak flows, but the timing of the peak outflow from the basin is delayed by about an hour which reduces the coincidence of peak flows within the urban catchments. Consequently, the downstream peak flows are reduced and more flows are contained within the main channel. This provides a noticeable reduction in the flooding around the Evanston Oval and Railway Crescent areas.

A preliminary assessment of the potential environmental impacts of the flood control basin was undertaken. It was considered that construction of the dam would result in a moderate loss of habitat upstream of the basin embankment, noting that the riparian habitat is already degraded. The downstream channel is small and highly modified with virtually no aquatic habitat. The resulting flow regime would not negatively impact the downstream habitat. During design development, consideration should be given to ensuring continuity of low-flow events, as this will benefit the remnant riparian species. More extensive evaluation of the environmental impacts will be necessary during detailed development of this option.

No assessment of the services relocation works required to accommodate this option has been undertaken, however there is potential for the costs to be significant.

5.1.3 Evanston Oval dual use flood control basin

A dual-use flood control basin was considered at Evanston Oval adjacent Dawson Road. This basin was proposed to use the Evanston Oval to detain floodwater spilling from the drainage channel east of the oval. The basin is proposed to activate only during rare flood events (1% AEP or greater) whilst remaining in active use as an oval when not required for flood control. The basin would act to temporarily store floodwater during the flood events, slowly releasing water back into the drainage system at a controlled rate. This would act to prevent runoff from spilling over the railway line and causing inundation of buildings along Dyson Street and Railway Crescent.

A concept design of the basin was developed considering the existing surface elevation of the oval and surrounding areas. Modelling found that the basin provided only a minimal benefit to flood mitigation during the 1% AEP event. The timing of runoff within the upstream catchments is such that the limited storage capacity of the basin is full by the time the main flood peak, which is generated by the large rural catchments upstream of the urban areas, arrives. The basin is therefore unable to significantly attenuate the peak flow rate, with little to no reduction in the downstream flooding. It has therefore not been given further consideration as a mitigation option as part of this SMP.

5.1.4 Trinity College creek upgrades

The large culvert beneath the Gawler Bypass is estimated to have the capacity to convey flows of over 8 m3/s. The DRAINS modelling suggests that the culvert should have ample capacity to convey the flows arriving from the upstream catchment. The modelled flooding is a result of insufficient capacity within the channel through Trinity College. The proposed solution therefore involves containing the flood waters within the channel and directing it via the existing culvert into the existing large detention basins on the western side of the Gawler Bypass. This will require works along the channel between the school chapel and the culvert entrance; marked as A and B respectively in Figure 5.5.

At the upstream end of the channel section, near Site A, the existing culvert does not have the capacity to convey the 1% AEP peak flow. Works would need to upgrade the culvert or alternatively earthworks could create a defined flow path to ensure bypass flows are contained within the channel. This would prevent floodwater escaping the channel and flowing over the oval to the north.

Midway between Site A and Site B, a number of crossings would need to be given a similar treatment, such that low flows flow through a culvert and high flows are contained within the channel.

Channel works would be required for roughly 175 m of channel upstream of Site B to increase the channel capacity and contain the 1% AEP flow. It is estimated that a 1.0 m deep trapezoidal channel with 1V:4H side slopes and 2.1 m base width would provide the required capacity.

Modelling demonstrated that flow through the main culvert could be increased to approximately 6 m^3/s in the 1% AEP event. Although inundation of Greening Drive still occurs, floodwater does not flow along Main North Road. Consequently, there is less floodwater directed towards the flood prone areas in Evanston, such as Railway Crescent and Evanston Oval.

Environmental and amenity impacts

The shallow grassed channel that runs through Trinity College is currently lined with mostly planted red gums, some within the channel (refer Figure 5.3) and one which would be regulated. These trees are considered an important amenity feature and provide shade for students in the summer. The proposed channel works would probably require the removal of trees, subject to getting the necessary approvals. It is likely that as a part of the works riparian vegetation is established and that the channel is landscaped to provide long term benefits such as habitation creation, erosion protection, shade and some water quality treatment.

5.1.5 Jarvis Street drain upgrades

Significant flooding occurs along Jarvis Street and at Brooks Avenue in the 1% AEP event (refer Section 3.2.4). There are no opportunities to detain the floodwaters in the local catchment that drains towards Jarvis Street and Brooks Avenue. Further, due to the topography of the catchment—with a number of trapped low spots—it is not possible to convey excess floodwater using overland flow paths. Therefore, the only possible structural flood control strategy is upgrade of the underground drainage network. Given the significant capital costs of upgrades, it is not proposed that the underground drainage network be upgraded to provide a 1% AEP standard. Instead, a reduced level of protection targeting a 5% AEP level of protection is recommended for the main trunk drain. This would alleviate flooding of the trapped low spots where no other flow path is available. For lateral feeder systems a 20% AEP standard is recommended in line with Objective 1.2.

Two possible upgrade options were considered. The first option replaces the existing trunk network and follows the existing alignment. The second option involves a flow split at the intersection of Jarvis Street and Paxton Road. The second upgrade option allows a shorter distance of replacement for new pipes and at a lower cost. Figure 5.6 shows the layout of the shorter option.

Figure 5.3 Red gums along and within existing creek line

Both options would mitigate flooding within the 5% AEP event for the dwellings in Brooks Avenue and Jarvis Street. Flooding in the 1% AEP event is reduced but not eliminated.

When undertaking preliminary and detailed design of these works, Council should also consider whether the drain system from McGonigal Drive should be upgraded. The drain standards assessment (refer Figure 2.5) indicates this system is particularly limited in capacity near the intersection with Holmes Street.

5.1.6 Gawler East flow path improvements

Formal drainage corridors within the rural residential area bounded by Sunnydale Avenue and Kalbeeba Road have not been established and as a result nuisance flooding occurs within private properties. Flow paths within this area are therefore unpredictable and pose regular nuisance flooding to local properties, particularly under long term conditions where runoff is expected to increase due to future development.

There are four main locations of concern; these include:

1. downstream of the Easton Drive wetlands
2. downstream of John Schultz Court
3. downstream of Lucks Road
4. downstream of Bischoff Road.

These four locations are shown in Figure 5.7.

At some locations along these flow paths a review of aerial imagery identified drainage infrastructure that was not included within the Council GIS databases and hence was not included in the modelling. As the size of the infrastructure appears to be relatively small the resultant impacts on the results of the flood mapping will be minimal. It is recommended that Council identify and capture details of the drainage infrastructure within this area.

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Town of Gawler, Light Regional Council and The Barossa Council

TINGARA ROAD FLOOD CONTROL BASIN

Figure 5.4

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Data Acknowledgement:
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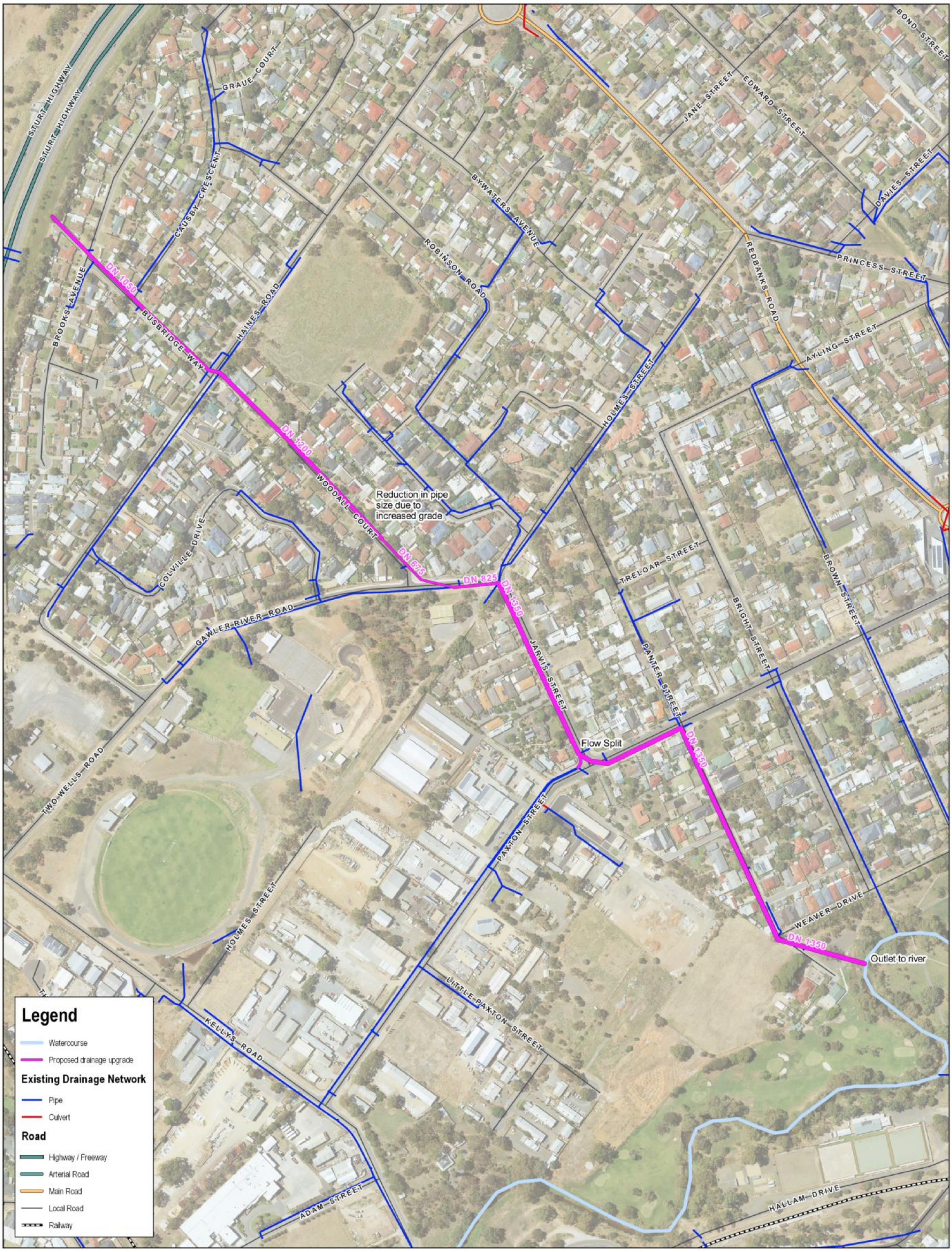
Town of Gawler, Light Regional Council and The Barossa Council

PROPOSED TRINITY COLLEGE CREEK UPGRADES

Figure 5.5



50 0 50 100 150 m

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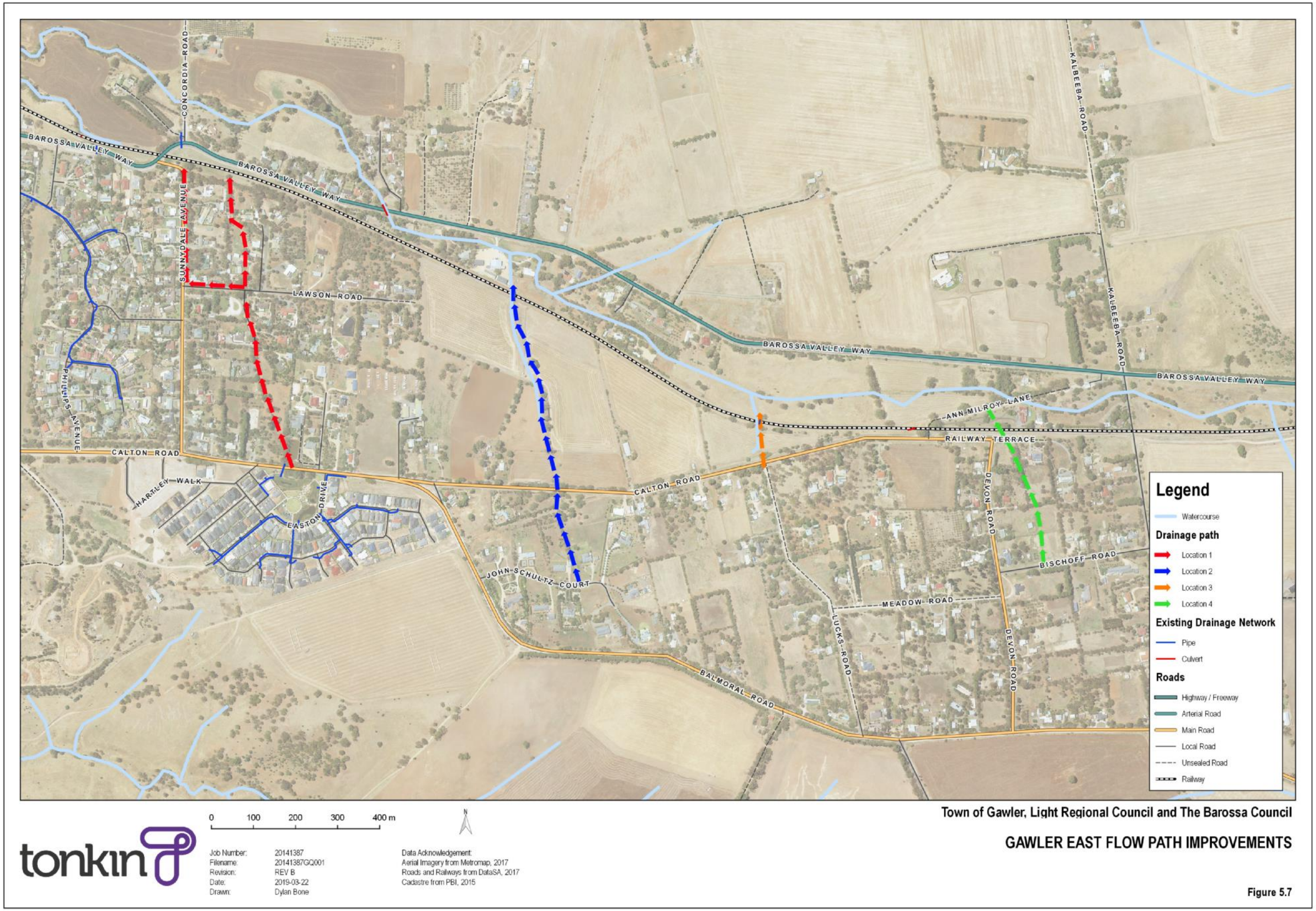
JARVIS STREET UPGRADES

Figure 5.6


CONCORDIA ROAD
BAROSSA VALLEY WAY
SUNNYDALE AVENUE
LAWSON ROAD
PHILLIPS AVENUE
CALTON ROAD
HARTLEY WALK
EASTON DRIVE
JOHN SCHULTZ COURT
BALMORAL ROAD
LUCKS ROAD
MEADOW ROAD
DEVON ROAD
BISCHOFF ROAD
RAILWAY TERRACE
ANN MILROY LANE
KALBEEBA ROAD
Legend
Watercourse
Drainage path
Location 1
Location 2
Location 3
Location 4
Existing Drainage Network
Pipe
Culvert
Roads
Highway / Freeway
Arterial Road
Main Road
Local Road
Unsealed Road
Railway
0 100 200 300 400 m
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Town of Gawler, Light Regional Council and The Barossa Council
GAWLER EAST FLOW PATH IMPROVEMENTS
Figure 5.7

Subject to further design development, additional WSUD features could be incorporated into the works that are proposed below.

Location 1

Discharge from the Easton Drive wetlands moves in a northerly direction towards Hameister Court via a natural channel that passes through downstream properties which have some capacity for detention. Review of the modelled results shows that this channel has the capacity to contain the 1% AEP flows and therefore requires no upgrades.

Flows conveyed by Hameister Court then overtop Lawson Road and disperse and encroach on downstream properties. While there is a channel that runs through these properties and another that runs along the eastern side of Sunnydale Road, the modelling suggests that both of these channels do not have sufficient capacity to contain 1% AEP flows.

It is estimated that channel upgrade works would be required over a distance of approximately 275 m along the channel that runs through private property downstream of Lawson Road. It is estimated that a grass lined trapezoidal channel profile with 1V:3H side slopes, 1.5 m base width and 0.7 m depth would provide a sufficient capacity to convey the 1% AEP flows.

In order to prevent frequent floods from passing through properties downstream of Lawson Road, works would be required to connect pits on Hameister Court and Lawson Road to a pipe that has sufficient capacity to convey the 20% AEP flow underground, in a westerly direction along Lawson Road (approximately 150 m), to the swale that runs along the eastern side of Sunnydale Road. It is estimated that a DN375 pipe would suffice.

Channel works would also be required for a length of approximately 285 m along the eastern side of Sunnydale Road to increase the channel capacity to contain the 20% AEP flow. It is estimated that a grass lined trapezoidal channel profile with 1V:3H side slopes, 0.5 m base width and 0.5 m depth would suffice. As part of these works, short lengths of culverts would be required to convey flows under driveway crossings.

Location 2

Flows filling the sag point within John Schultz Court eventually spill to a downstream property and move in a northerly direction towards Calton Road. The flow width across this path is approximately 50 m. Works would be required to contain the 1% AEP flow within a drainage easement that runs for roughly 230 m along property boundaries. It is estimated that a grass lined trapezoidal channel profile with 1V:3H side slopes, 1.0 m base width and 0.5 m depth would suffice.

Once flows reach Calton Road there appears to be a culvert passing flows under the road. The culvert would need to be upgraded, or an additional culvert provided in parallel, to provide a 1% AEP capacity to prevent flows from ponding within upstream properties.

There is a channel downstream of Calton Road which conveys flows in a northerly direction towards the railway line. Review of the modelled results indicates that this channel has sufficient capacity to contain the 1% AEP flow. It is therefore likely that no channel works are required along this path.

Review of the modelled results shows that the existing DN450 pipe that conveys flows under the railway line does not have sufficient capacity to convey the 1% AEP flow, causing flows to spill along the southern side of the railway line. Works would be required to upgrade this pipe to provide a 1% AEP capacity.

Location 3

Based on surface contours it is predicted that overland flows upstream (south) of Calton Road would flow alongside Lucks Road towards small pipes that convey flows in a northerly direction under Calton

Road. Flows then move in a northerly direction via a natural low point until reaching the railway line where a DN375 pipe conveys flows under the railway line.

Channel works would be required in order to contain the 1% AEP flow within a formalised channel between Calton Road and the railway line. It is estimated that a 0.5 m deep grass lined trapezoidal channel profile with 1V:3H side slopes and a 2.5 m base width would have sufficient capacity.

Review of the modelled results indicates that the DN375 pipe under the railway line does not have sufficient capacity to convey the 1% AEP flow, with flows ponding on the southern side of the railway line until the railway is overtopped. Works would be required to upgrade this pipe, or to provide another in parallel, to achieve a 1% AEP capacity.

Location 4

Flows moving towards the low point along Bischoff Road appear to pass under the road via an existing culvert. This culvert requires a 1% AEP capacity to prevent significant ponding on the upstream (southern) side of the road in a 1% AEP event.

Flows then continue to flow in a northerly direction through downstream properties towards a low point on Railway Terrace where flows pond on the southern side before overtopping the road and spilling to culverts that pass under the adjacent walkway and railway line. The flow width through these properties ranges from 20 to 50 m.

Channel works would be required for a length of approximately 280 m along the flow path between Bischoff Road and Railway Terrace to provide a channel with sufficient capacity to contain the 1% AEP flows. It is estimated that a 0.5 m deep grass lined trapezoidal channel with 1V:3H side slopes and a 2.0 m base width would be sufficient. This channel would need to be extended downstream of Railway Terrace in order to confine the 1% AEP flow to a smaller flow width. Works would also need to provide a culvert under Railway Terrace to convey the 1% AEP flow thereby preventing ponding within upstream properties.

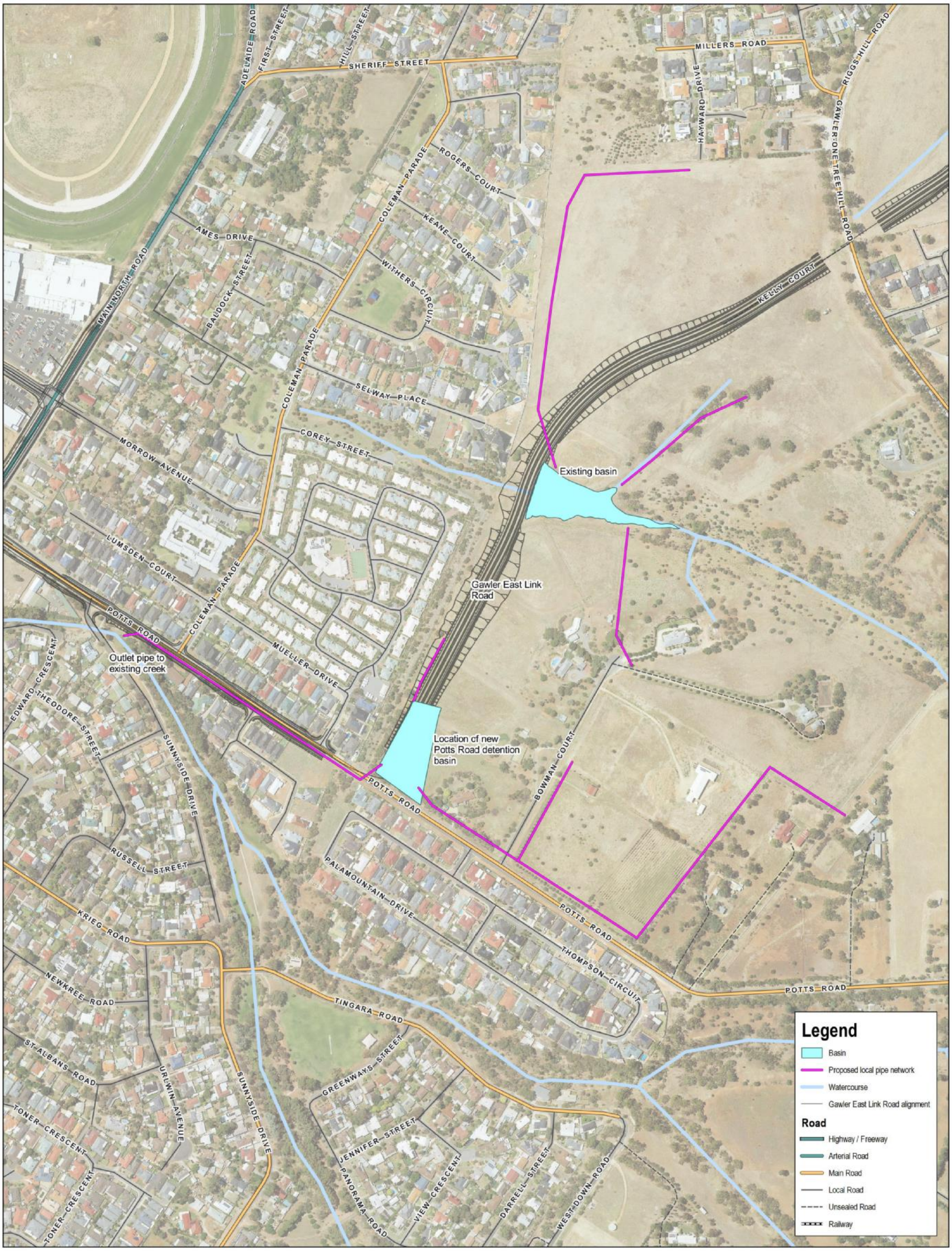
5.1.7 Potts Road detention basin

The area bounded by Potts Road and the Gawler One–Tree Hill Road is currently used for semi-rural living but has recently been zoned for future medium to high density residential development. The *Gawler East Stormwater Infrastructure Study* (Tonkin Consulting, 2016) examined the management of water quality and quantity impacts resulting from the transition in land use. The *Gawler East Stormwater Infrastructure Study* identified that increased runoff from catchments along Potts Road would cause an increased likelihood of flooding downstream of Mueller Drive. Consequently, it was recommended that a detention basin of 7,500 m^3 be implemented to control runoff from future development.

The Potts Road detention basin is proposed to provide 7,500 m^3 of storage to limit outflow to the pre-development 1% AEP flowrate (0.3 m^3/s). The proposed configuration will need to discharge into the Potts Road underground drain constructed as a part of the Gawler East Link Road project. The basin would be reliant on the road network and drainage system of the developed land delivering runoff to the basin during a 1% AEP event.

Modelling of this option (prior to the construction of the Gawler East Link Road) has shown that the construction of the basin would prevent significant sheet flow cascading through properties along Mueller Drive and would reduce the volume of flow reaching detention basins along Coleman Parade. Additionally, the Potts Road basin reduces the volume of runoff causing flooding in First Avenue. Figure 5.13 illustrates the reduction in flooding that results from the Potts Road basin.

It was recommended that the detention basin be located near the southwest corner of the developable land, however, since the release of the *Gawler East Stormwater Infrastructure Study*, DIT have completed construction of the Gawler East Link Road (GELR) (refer Figure 5.8).



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POTTS ROAD DETENTION BASIN

Figure 5.8

The completed design of the GELR conflicts with the location initially proposed for the Potts Road basin. It is expected that the basin will now need to be located slightly further east of that shown in Figure 5.8.

5.1.8 Gawler Belt railway culvert

There is a low point along the Gawler to Kapunda railway line, approximately 250 m south of the intersection with Parkers Road. At this location, the railway embankment acts as a barrier to floodwater moving west, causing deep ponding on the eastern (upstream) side of the railway line. In a 1% AEP event the ponding significantly encroaches on adjacent properties (refer Figure 5.15).

In a 1% AEP event there is approximately 1.5 m^3/s of floodwater that arrives in the low-spot due to overtopping of Parkers Road whilst an additional 0.22 m^3/s arrives from the upstream catchment to the east.

To reduce the amount of ponding on the eastern side of the railway line, a culvert with the capacity to convey a 1% AEP flow under the railway line was considered. It is estimated that the pipe would need to be in the order of a DN900. Installation of a culvert under the railway line will increase the amount of floodwater moving in a westerly direction towards the natural depression on the western side of Clancy Road. The floodwater would travel through private properties between Clancy Road and the railway. It would be necessary to establish a formalised open drain (and easement) sufficient to convey the 1% AEP peak flow downstream of the railway culvert to safely convey floodwater through to Clancy Road.

The set of considered works are shown in Figure 5.9. These works have the potential to slightly increase the downstream flood risk for rural living properties. During public consultation of the SMP, several landowners raised concerns about exacerbation of existing poor drainage conditions. As such this option is not recommended.

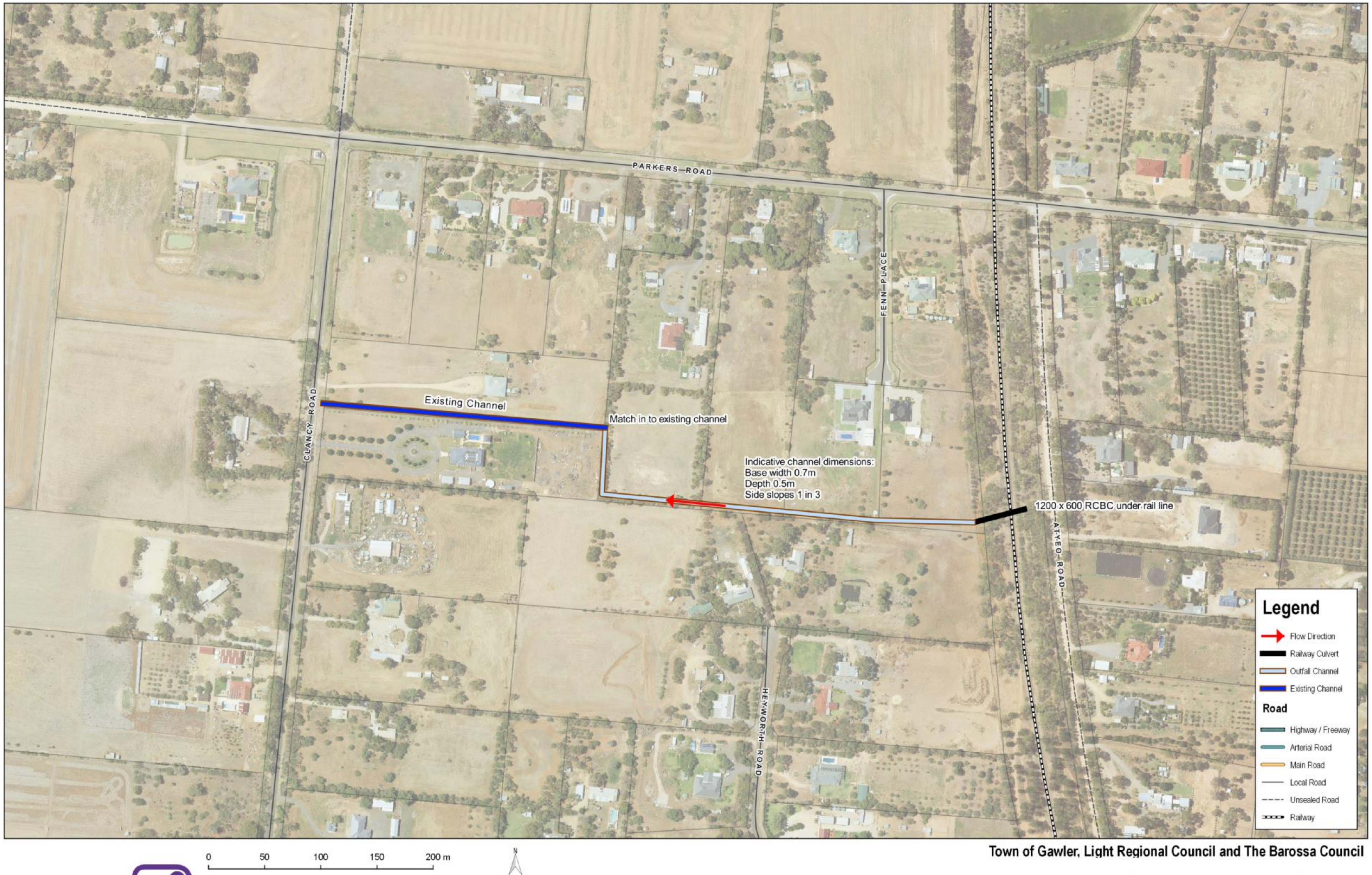
5.1.9 Gawler Belt interception drain

The Gawler Belt area is affected by extensive, but relatively shallow, flooding in events rarer than the 5% AEP event. Flooding is predominantly a result of runoff originating from the catchment area north of Redbanks Road. There is little formal drainage in the area. A formalised open channel was investigated as a means of mitigating the predicted flooding. An open channel system that could intercept floodwater from the Roseworthy area and convey it to the large low spot south of Parkers Road in a contained and controlled manner was investigated.

Due to the rural land-use of the area, it was determined that a 5% AEP standard of protection would represent a good balance between cost of construction and the reduction in damages offset by the works. Two alignments were considered for the open channel. The first is a longer path following property boundaries and avoiding driveway and road crossings as much as possible. The second is a shorter, more direct, path but involves numerous road and driveway crossings. The second alignment whilst shorter was determined to have a higher capital cost due to the number and size of the culvert crossings that would be required. The longer alignment is shown in Figure 5.10.

The estimated flow rate for the 5% AEP event is 14 m^3/s. Depending on the slope of the natural surface, the required channel base width would be between 10 and 16 metres. Three road crossings and one railway crossing would also be required.

The investigated open channel results in a substantially reduced extent of flooding during the 20% and 5% AEP events, mostly eliminating flooding from the areas upstream of the Parkers Road low spot. During the 1% AEP event, the area of land subject to shallow flooding is reduced by about half. During the 20% AEP event, more water reaches the Parkers Road low spot compared to the existing conditions because of the more efficient flow path created by the channel. The floodwater that arrives at the low spot during the 20% AEP event does not encroach on existing dwellings, however, the increased frequency of inundation would likely be perceived as making flooding worse.



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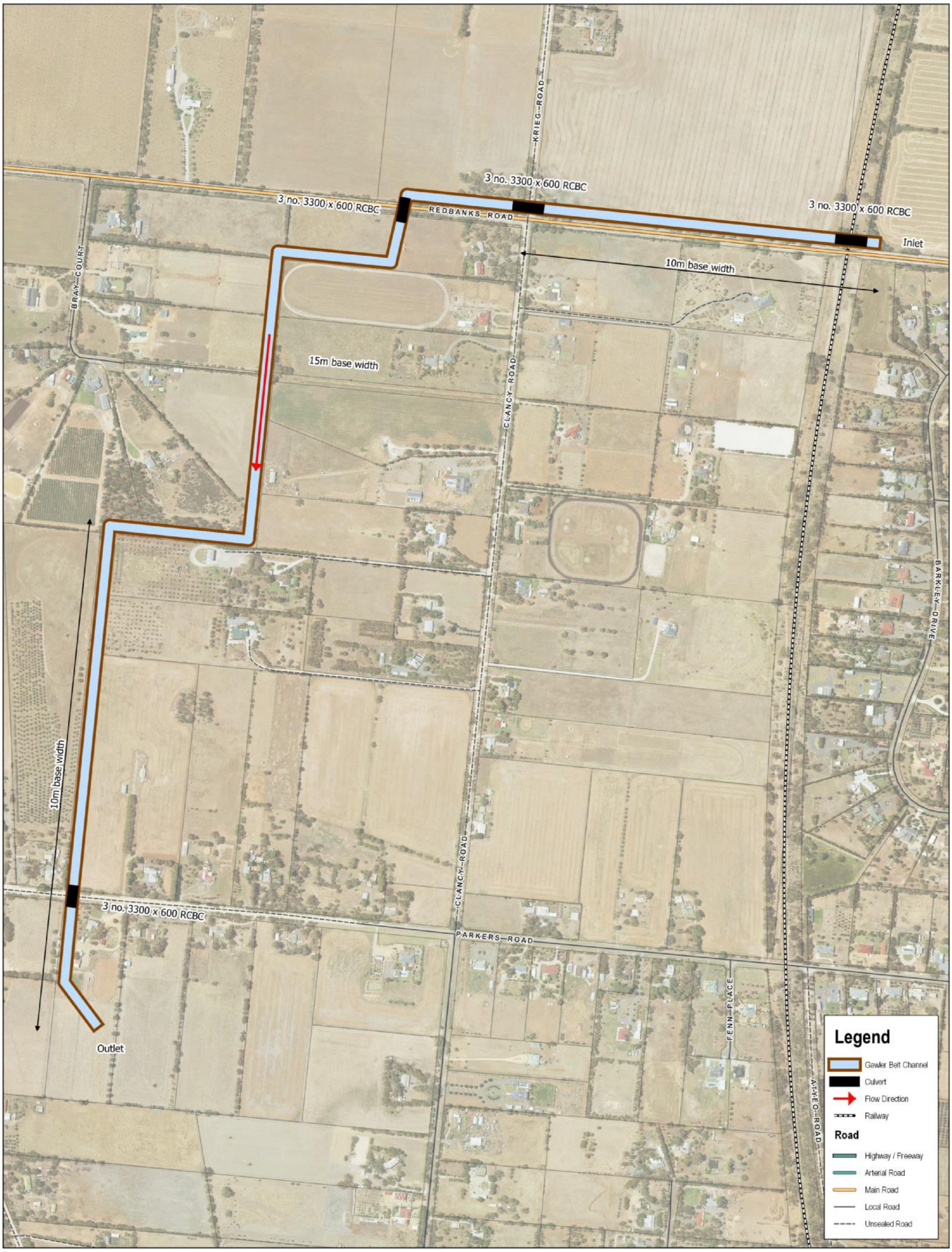
GAWLER BELT RAILWAY CULVERT

Figure 5.9



100 0 100 200 300 m

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Town of Gawler, Light Regional Council and The Barossa Council

GAWLER BELT INTERCEPTION DRAIN PREFERRED ALIGNMENT

Figure 5.10

During the community consultation of the SMP, several landowners raised strong concerns about the works being very intrusive to their land holdings, potentially increasing flooding at the downstream end and potentially costing significantly more than had been estimated. Based on these strong concerns it was agreed during the consultation meeting that this option be not recommended.

During the consultation meeting a number of alternatives to reduce flooding in the Gawler Belt region were proposed. These were to drain flows along the rail line, to intercept the water within a basin further upstream and to provide a new gravity outlet drain to the flood prone area, south of Parkers Road. A brief assessment of these options is presented below.

Railway channel

This option would involve constructing a channel along the alignment of the Roseworthy railway and connecting to the Gawler River. This option was investigated assuming that the 1% AEP event peak flow from Roseworthy area would be directed along the channel; the peak flow is 23.5 m^3/s. To achieve stable channel sides, a ratio of 1:2 (V:H) side slope was assumed. Flow depth was limited to a depth of 2.0 m for safety and constructability concerns. There is approximately 20 m fall over 3.8 km between Redbanks Road and the Gawler River floodplain. The natural topography along the alignment descends from Redbanks Road to approximately 50 mAHD before rising slightly to 55 mAHD near the Sturt Highway, and then rapidly descending into the river floodplain. Consequently, the last 1.4 km of the drain would need to be cut through the rising terrain. The deepest portion of cut would be approximately 10.4 m deep; with the adopted side slopes the channel would be 46 m wide. Due to the magnitude of these proportions a channel along the railway corridor is not considered feasible.

Upstream detention

Consideration was given to detaining the runoff from the Roseworthy catchment as a means of flood mitigation for the Gawler Belt area. A single basin collecting all runoff from a 24-hour 1% AEP rainfall event was investigated. It was assumed that the basin would be located adjacent the intersection of the Roseworthy Railway and Redbanks Road

The total volume arriving at the basin during a 24-hour 1% AEP rainfall event is 400 ML. If no excavation of existing terrain is undertaken, it is estimated that a full basin would occupy a footprint of approximately 14 ha. The embankment required to contain the runoff would be up to 8.5 m high.

If it is assumed that excavation will be undertaken, it is estimated that a full basin would occupy a footprint of approximately 10 ha and be up to 4.0 m deep.

Neither alternative is considered feasible due to the costs associated with construction and land acquisition. Consequently, this option was not investigated further. However, if a large basin is constructed in the area, based on Council requirements for planned development in Roseworthy (refer Section 3.2.6) it may be possible for Council to make a contribution to enlarge the basin further, such that future flood risk is improved compared to existing conditions.

Outfall drain from low spot

Consideration was given to providing a formal outfall for stormwater trapped in the large low spot south of Parkers Road, Gawler Belt. Options to discharge floodwater into the Gawler River were explored. Due to the topography of the area between the low spot and the Gawler River no viable route for an outfall drain was found that did not require prohibitively expensive lengthy and deep excavation. A pumped outfall could also be an alternative, but the large pump rate and long length of large diameter rising main required to make a material reduction to flood risk would again be prohibitively expensive.

Residual risk

It is noted that there are no structural mitigation measures proposed to address flooding within the Gawler Belt area, and hence there is a significant residual flood risk. Consideration should be given to whether acquisition of properties within the large low spot is required. As a minimum, targeted education for the flood prone landholders should be provided.

Recently (in the last few years) the Gawler Belt Area has been prohibited from further subdivision due to the Environment and Food Production Area (EFPA). As such there will not be any further increase to density so there should be no increase in risk. All land division applications prior to the EFPA coming into place over the past 5 years, and prior to that to a lesser degree, have been assessed with the flooding issues in mind and precautions such as prescribed building envelopes and private diversion swales put in place to limit risk to any new buildings within the existing allotments. In this way, the Light Regional Council has already enacted what the SMP is recommending with regard to management of development through planning regulations (refer Section 5.1.17).

5.1.10 Hewett rear of allotment drainage

The residential suburb of Hewett is very steep with rear of allotment drains used in a number of areas to allow properties that grade away from the road to have a stormwater connection point. However, for some large allotments that front onto Explorer Parade and Oakland Circuit, there is no rear of allotment drain. While it is understood that the roof areas drain to the adjacent street via sealed systems, there are large paved and garden areas that drain to the rear of the properties causing nuisance flooding issues within adjacent private properties. Subject to additional design development and site survey, a new section of rear of allotment drain to serve 34 to 42 Oaklands Circuit and 43 Explorer Parade is likely to alleviate this problem. The rear of allotment drain could connect into the existing Council drain in River View Drive.

The extent of the drain is shown in Figure 5.11. The drain will need to be located within a Council-owned and maintained 3 m wide easement.

5.1.11 Flow gauge for Clifford Road drain

The well-defined shape of the Clifford Road outfall drain coupled with its location at the bottom of a large urban catchment make the outfall drain ideally suited for flow measurement. Flow gauges play an important role in the development and calibration of hydrologic and hydraulic flood models. Knowledge gained from calibrated models helps reduce the uncertainty of predictions and can provide greater confidence in the functionality of proposed solutions. Other benefits of flow measurement include the ability to inform the development of water balance and catchment yield models for the investigation of water harvesting potential.

The Hillier Road bridge offers a suitable location for installation of a flow level meter. A beam sensor could be mounted onto the existing bridge structure to detect the water surface elevation beneath the bridge. Due to the well-defined shape of the drain, creation of a rating table would be a relatively simple process.

The flow gauge should be supported by a pluviometer to record rainfall intensity over the catchment. Estimation of rainfall within the catchment may be problematic as the two existing rain gauges in Gawler only offer daily rainfall measurements which are of limited use for calibration of flood models. Ideally, rainfall estimates at 10-minute intervals or less are required to achieve good replication of observed rainfall events (Ochoa-Rodriguez et al., 2015).

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HEWETT REAR OF ALLOTMENT DRAIN

Figure 5.11

5.1.12 Evanston Oval parallel pipe upgrade

The open channel upstream of Evanston Oval has capacity to convey approximately 12.5 m^3/s, however, the existing pipe system beneath the oval only conveys approximately 9 m^3/s. This leads to floodwater spilling from the channel across the oval, over the railway and into properties along Railway Crescent. The addition of a parallel pipe to provide the necessary capacity to prevent flooding of the oval and surrounding properties was investigated.

In the long-term scenario it was assumed that other upstream measures proposed by the SMP have been installed. This assumption results in the peak flow arriving at the oval being reduced to approximately 9.5 m^3/s. While this is only 0.5 m^3/s more than the capacity of the existing drain a significant amount of head is required to drive 9 m^3/s through the drain, which results in upstream flooding. Installation of a DN1050 pipe parallel to the existing DN1650 results in full conveyance of the flood peak under the oval, thereby preventing flooding. If the other flood mitigation measures are not implemented upstream it will be necessary to review the required dimensions for the parallel pipe upgrade.

It should be noted that incorporating detention storage at the oval has been investigated but was not found to be effective (refer Section 5.1.3).

The location of the parallel pipe is shown in Figure 5.12.

5.1.13 Corey Street flood control basin outlet optimisation

The Corey Street flood control basin is designed to mitigate rare floods (between 1% and 0.2% AEP) which generally have large volumes of runoff. Consequently, the main outlet of the basin is sized to prevent stormwater from activating the spillway in rare floods. This has the effect of underutilising the storage volume of the basin during more frequent flood events (where the discharge from the basin need not be as large as that for rare events to avoid activating the spillway).

Careful design of an outlet structure that limits discharge from the basin in frequent flood events, but maintains the discharge required for rare flood events, would ensure that the basin's storage volume is more fully utilised in frequent flood events. This could potentially reduce flooding issues in the Coleman Parade and Sheriff Street drainage systems and may allow for water quality treatment opportunities within the basin.

5.1.14 Gawler River levee bank augmentation

A 4.8 km network of additional or augmented levees within five different sections along the North Para, South Para and Gawler River has been proposed as a potential flood mitigation measure. A concept design of the levee banks has been prepared as part of this SMP with the design summary information contained within a separate report (refer Appendix C). The levee height has been set to provide 300 mm freeboard above the modelled 1% AEP flood level.

10 0 10 20 30 m

Town of Gawler, Light Regional Council and The Barossa Council

EVANSTON OVAL PARALLEL PIPE UPGRADE

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Figure 5.12

The concept design work identified a number of issues associated with the proposed levee works which included the following issues:

- Very limited space to construct a levee at a number of locations. The only viable alternative in these locations is to have a vertical wall.
- The levee crosses a number of thoroughfares including roads, car park entrances and rail lines. At these locations (at least seven in total) a temporary levee would be needed to be erected by emergency services during a flood event to ensure the integrity of the levee is maintained at these locations.
- The levee is in private property for much of its length and would require significant community consultation.
- There are numerous significant trees along the proposed alignment. An augmented and/or new levee would either need the removal of a number of these trees or require a vertical levee.
- The levee may hinder pedestrian movements in some areas.
- A vertical levee in some locations could potentially reduce amenity, particularly within residential areas such as along Paterson Terrace, Nixon Terrace and Victoria Terrace.
- To ensure the long-term integrity of the levee, regular monitoring would be required, along with maintenance, as required. This task is complicated by the levee being located in private property at a number of locations.

Based on the above list of issues, the construction of the levee bank is not recommended. Regardless, management of flooding from the Gawler River (not covered by this SMP), as well as the management of levees, is the responsibility of the Gawler River Floodplain Management Authority.

5.1.15 Review of low-standard drainage systems

Based on the drainage standard assessment (Section 2.3.1), low-standard drainage systems should be targeted for review and upgrades proposed where review finds the standard of protection can be cost-effectively improved.

It is recommended that the Town of Gawler and Light Regional Council undertake further investigations to assess the drainage upgrade works required to provide a 20% AEP standard for the following drainage systems (as a minimum):

Town of Gawler

- Coleman Parade (between Mueller Drive and Corey Street)
- Penrith Avenue (between Gosford Street and the system outlet)
- Reid Street (between Finniss Street and Whitelaw Terrace)
- Sheriff Street (between Mount Terrace and Adelaide Road)
- Sunnyside Drive (between Williams Street and the system outlet)

Light Regional Council

- Murray Road (between Perseverance Place and the system outlet)

5.1.16 Non-structural flood mitigation measures

Education and awareness

Detailed floodplain mapping of the catchment is available. To meet Objective 1.5, this information should be made widely available to the community so that they understand where flooding is likely to occur. Awareness of flood risk can allow the community to better manage their risk and reduce flood damages. This awareness could be achieved via letters and brochures, circulating floods maps publicly (for example, via the internet) and having information available at public places such as libraries and

Council offices. Businesses and residents can be encouraged to develop flood action plans to reduce damages during a flood; for example, by changing the manner in which valuable items are stored.

A targeted education program for the flood prone land holders within the Gawler Belt area should be undertaken.

Flood warning and flood forecasting

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.

Work is being completed by the State Emergency Service (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 study area use of such an approach may be viable if the pilot is successful. Use of such a system is likely to have a medium to long-term timeline and require local water level monitoring in the catchment of concern. The SES/DEW approach is likely to be the most cost-effective approach to flood warning. Council should continue to engage with the SES.

5.1.17 Review of strategic plans, infrastructure schemes and requirements for new development areas

Jensen Plus were engaged to review the strategic plans, asset plans and development plans of the four councils within the SMP study areas (Gawler, Barossa, Light and Playford) to identify changes to these policies that could result in improved management of stormwater.

There is broad policy coverage for a range of stormwater management issues across these strategic and statutory plans. The review focussed principally on the level of controls available within the planning system. Whilst there is good policy coverage addressing issues of stormwater harvesting opportunities and water quality, the review identified a number of non-structural stormwater management measures that could be implemented; these are outlined below.

Use of mapping outputs from the SMP

GIS-based flood modelling data for the study area has been generated as part of the SMP. There is also available floodplain mapping for the Gawler River, North Para River and South Para River. This information should be utilised in the planning of new developments to ensure that new development has adequate flood protection (Objective 1.1). It is recommended that this should include ensuring existing overland flood flow paths are retained and that floor levels of tenements are set above the predicted level of the 1% AEP flood (including appropriate freeboard).

Councils should utilise ePlanning and the SA Planning Portal to regularly and quickly update the extent of floodplain areas shown in the Planning and Design Code (as overlay) when revised modelling is undertaken or as mitigation measures are implemented. This will allow all flood data from numerous investigations to be accessed from a single location.

Planning for climate change

The latest climate change science predicts an increase in rainfall intensity of extreme events. This will result in increased peak flows and may lead to changes in the extent and severity of inundation during flood events.

Council will be able to understand some of the potential impacts of climate change by assessing the climate change floodplain map undertaken as part of this study (refer Section 5.1.18). This knowledge can then be used to plan stormwater management strategies that are robust despite the changing climate (Objective 1.6).

Consistent strategic plans

The councils should continue to work collaboratively to:

- Ensure that stormwater management goals, objectives, strategies and actions within strategic documents recognise the need for cross boundary management of stormwater and flood risk.
- Within the areas identified as flood prone, and new urban growth areas, each council should adopt the agreed assumptions around potential imperviousness (high, medium, low) to inform policy, modelling and mitigation strategies.

Changes to the Development Plan/Planning and Design Code

Development Plans are soon to be replaced with a new Planning and Design Code. The structure and format of the new codes are not yet known. The following strategies provide some recommended changes to existing planning policy to provide consistent treatment of development within flood prone areas across the study area.

The four councils should collaboratively develop a suite of more detailed flood risk and stormwater management design responses and techniques for inclusion within the Development Plan to better guide assessment and responses about achieving existing SAPPL policy objectives. These techniques should be informed by the measures that have worked and not worked in previous development schemes and scenarios and should be broad enough to cater for catchment (land division) scale through to site (renewal) scale design responses. This can also then be easily transferable to (and potentially inform) the imminent Planning and Design Code.

The Development Plans should be updated to include the following requirements:

1. In areas identified as having a medium to high potential for an increase in impervious area (refer Development Potential report in Appendix D), for new development and areas where the capacity of the downstream stormwater infrastructure is limited (be it greenfield, brownfield, infill or commercial / town centre), the policies should mandate on-site detention measures for discharge from all new developments.
2. The requirements should be to limit post-development peak discharge rates to pre-development discharge rates (Objective 1.4).
3. Where it is not practicable to limit discharges to pre-development levels. (for example, if the site of development is currently largely pervious), the policy should specify an acceptable level of runoff. The measures should consider the 20% AEP and 1% AEP floods. Example policy wording would be:

All new buildings and building extensions of 40 square metres or more in floor area in flood prone areas should incorporate sufficient on-site stormwater detention/retention to limit the rate of stormwater runoff from the subject land so that pre-development flows are not exceeded:

a. within residential zones

i. 20% AEP flood event (runoff coefficient 0.25)

ii. 1% AEP flood event (runoff coefficient 0.45)

b. within non-residential urban zones

i. 20% AEP flood event (runoff coefficient 0.65)

ii. 1% AEP flood event (runoff coefficient 0.85).

4. The Development Plans should provide consistent guidance on maximum site coverage and levels of fill above the existing natural surface.
5. The Development Plans should be changed to apply consistent fencing treatments and development setback distances from creek lines and flow paths, including cross-council and cross-owner lines. Setback distances should be watercourse specific, depending on its size and geometry.
6. The Development Plans should be changed to mandate that development within areas categorised as high and medium flood hazard risk areas demonstrates safe access routes to higher ground for major flood events.
7. Development controls should be reviewed with the aim of providing greater policy flexibility within development zones and policy areas so that integration of community facilities (such as local parks, playgrounds and outdoor recreation spaces) with stormwater management flow paths, basins, wetlands and recycling areas can, subject to safety, orientation and structural requirements, be achieved.

Council should undertake spot checks to ensure that development complies with the development approval requirements.

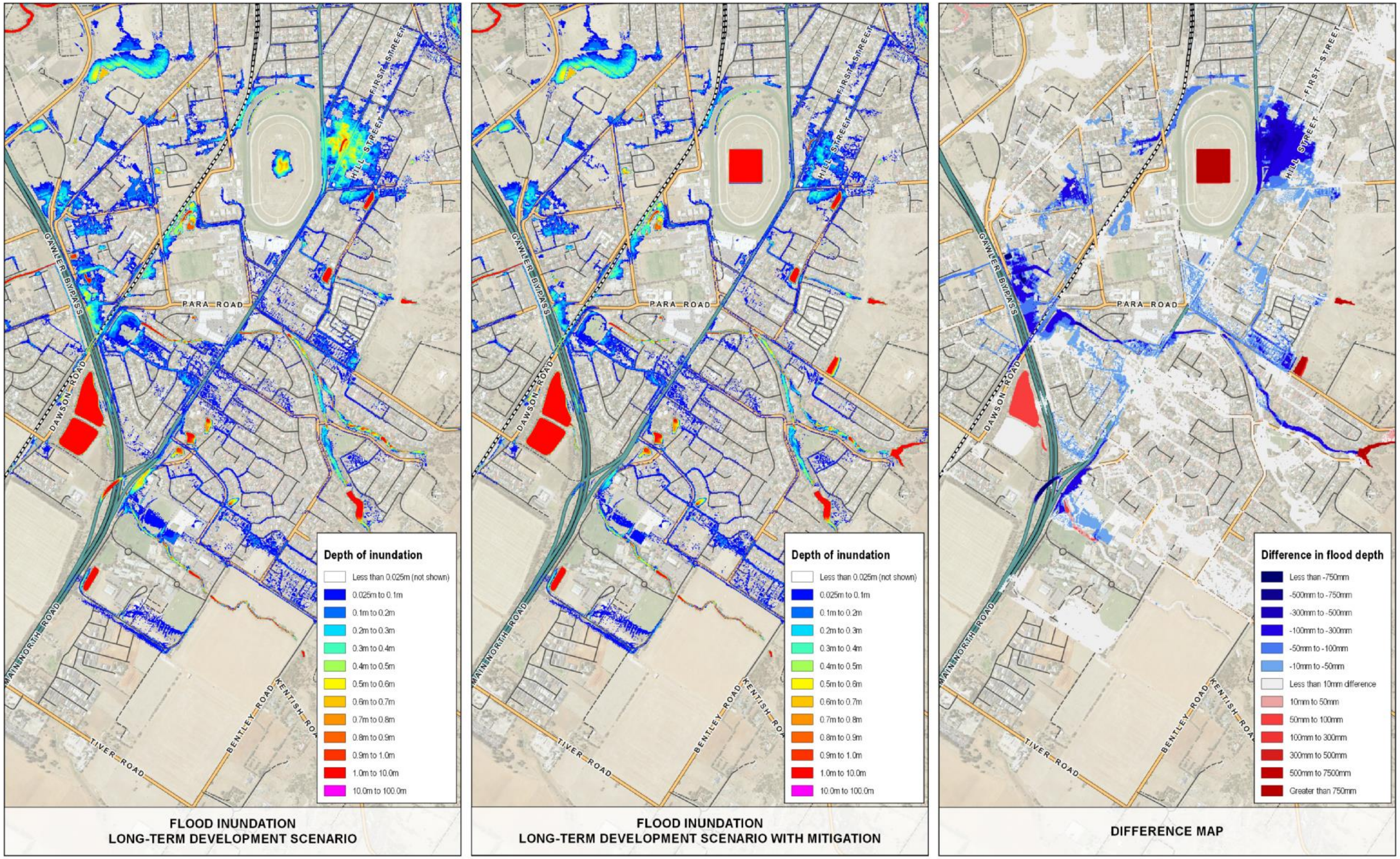
Infrastructure Schemes

While it may be challenging to implement, the councils should continue to liaise with DIT in relation to establishing requirements for a Basic Infrastructure Scheme for regional stormwater management specifically for identified greenfield growth area locations as notified by the Councils (noting that downstream impacts and mitigation measures may cross Council borders). The scheme would potentially detail:

- the nature and intended scope of the stormwater management infrastructure
- the development triggers that generate the need for the stormwater infrastructure
- proposed designated growth areas needing future infrastructure
- proposed timing or staging of scheme elements
- an assessment of the costs and benefits and proposed scheme funding arrangements
- contributions arrangements to spread costs of infrastructure to all those who benefit
- basic infrastructure or assets which may be transferred to councils when the scheme is completed.

5.1.18 Potential impacts of changing climate

Review of the climate projections for the study region shows that under a high emissions scenario (RCP 8.5) rainfall intensity will increase by 7.8% by mid-century (2050). An assessment of the potential impacts of a changing climate has been made by increasing the rainfall by 7.8% and re-running the flood model for the long-term development scenario with mitigation.



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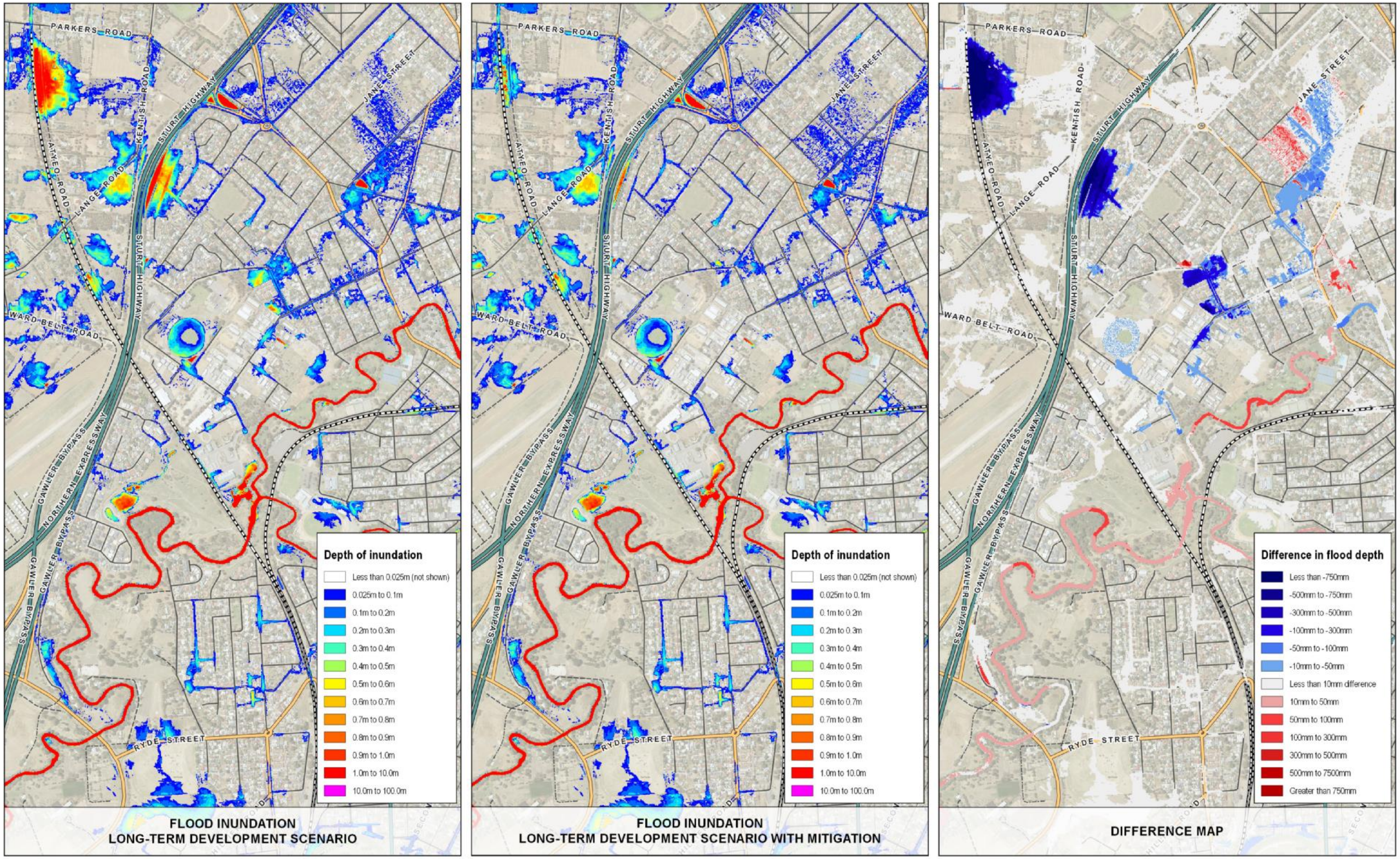
MITIGATION MODELLING DIFFERENCE MAP FOR 1% AEP (SOUTHERN AREA)

(on-site detention not included)

Figure 5.13



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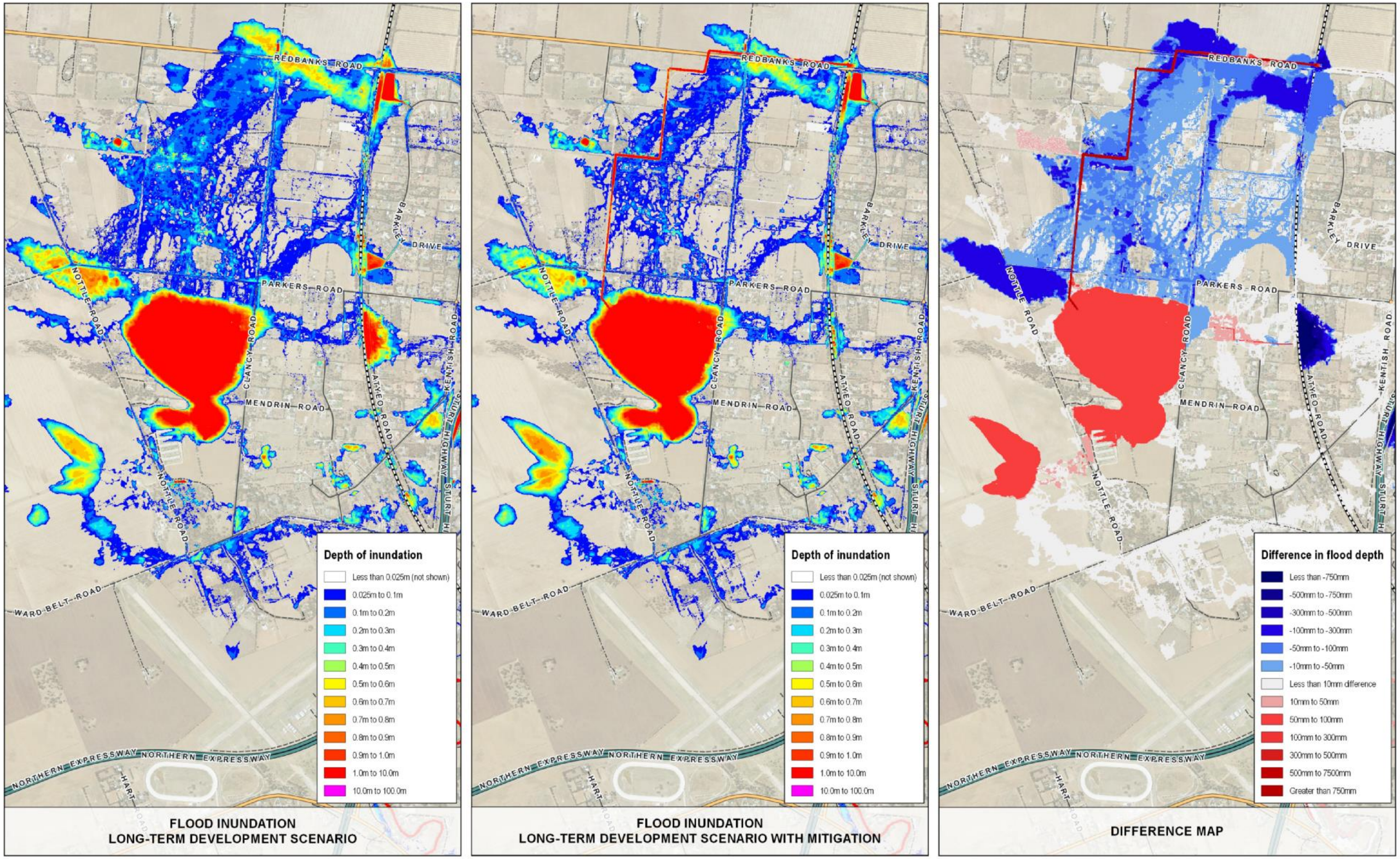
MITIGATION MODELLING DIFFERENCE MAP FOR 1% AEP (EASTERN AREA)

(on-site detention not included)

Figure 5.14



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MITIGATION MODELLING DIFFERENCE MAP FOR 1% AEP (GAWLER BELT AREA)

(on-site detention not included)

Figure 5.15

Unsurprisingly the depth of flooding is increased as a result of the higher rainfall intensity. Generally, the largest increases in flood depth occur in low spots within the study area. It appears that the steep catchments are not sensitive (i.e. flood depth changes by less than 25 mm) to the increase in rainfall modelled. However, due to the increased volume of runoff, low spots fill to higher levels. In some cases, this impacts the performance of proposed mitigation strategies.

For example, the flooding of First Street is adversely impacted by the additional volume of runoff if no changes are made to the proposed Gawler Racecourse basin strategy. Flood depths are up to 150 mm to 180 mm deeper as a result. This increase could be addressed by using larger pipe sizes to drain the additional volume generated by climate change.

Each mitigation strategy will be affected by climate change differently and the Councils are advised to undertake investigations to understand the changes as they proceed with detailed design of each options or as a part of a broader climate change adaptation strategy.

5.2 Water quality improvement strategies – areas of existing development

The following sections detail the proposed strategies for improving the water quality of the runoff from the developed areas of the catchment. The stated water quality objectives for the study area reflect the South Australia state-wide targets which target the following reductions in average annual loads:

- Gross Pollutants – 90%
- Sediments – 80%
- Total Phosphorus – 60%
- Total Nitrogen – 45%

Water sensitive urban design (WSUD) requires the "integration of a range of practices in a defined program" (ARQ, 2006). The hierarchy for the implementation of measures is as follows:

1. Retention and restoration measures which focus on retaining and restoring natural channels, wetlands and riparian vegetation
2. Source control via non-structural measures which aim to change human behaviours (such as education)
3. Source control via structural measures
4. In-system measures.

Given the heavily developed nature of the study area and the distributed nature of the outfalls to the receiving area, the opportunities for the large schemes that can treat a significant portion of the study area are limited. Opportunities for water quality improvement within the existing developed areas of the catchment are therefore largely limited to the retrofitting of the system to incorporate in-system measures.

5.2.1 New gross pollutant traps

A number of gross pollutant traps (GPTs) and trash racks exist within the study area. The MUSIC modelling shows that these, along with a number of existing small basins and wetlands, remove 61% of gross pollutants that are generated within the study area (assuming the ultimate state of development), with a residual gross pollutant load of 44 tonnes.

The installation of additional GPTs is recommended to further reduce the residual load of gross pollutants that are discharged to the receiving waters (Objective 2.1). Seven priority locations for the installation of new GPTs were identified based on a review of the results from water quality modelling. All locations are on outlets which are estimated to produce more than two tons of gross pollutants per year. Installation of GPTs in these locations, as listed in Table 5.1, is therefore considered to represent best value for money.

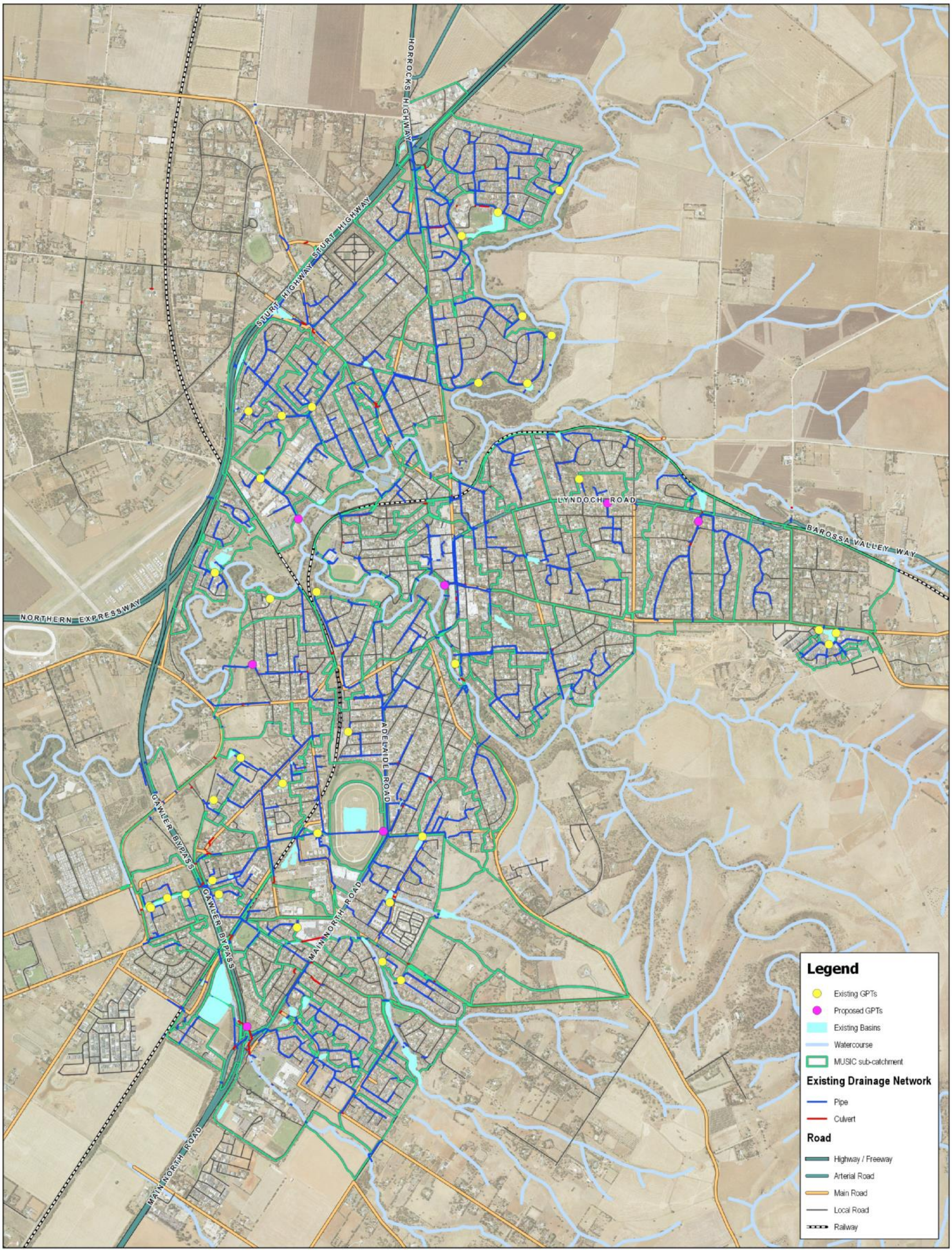
The locations of the proposed additional GPTs are shown in Figure 5.16. Actual placement of each GPT would be subject to further design development which would need to consider issues such as access for maintenance and hydraulic losses that the GPT would introduce into the underground drainage network. Council should also consider the installation of GPTs on any drainage system outlets that drain predominantly commercial or industrial precincts.

The theoretical maximum removal of gross pollutants, as listed in Table 5.1, is based on high-flow GPT units (consistent with those already installed within the study area) with all pipe flows being directed to the GPT. The assumed pollutant removal efficiencies are based on manufacturer's specifications. The actual reduction in gross pollutants achieved will be dependent on the GPT model selected for each location and maximum treatable flow rate.

Table 5.1 Priority locations for the installation of GPTs

	Location	Maximum GP removal* (kg/year)	Indicative pipe size
GPT1	Immediately upstream of racecourse	4185	1500
GPT2	At the outfall from the commercial centre near the junction of Walker Place and Whitelaw Terrace	2590	1200
GPT3	At outlet into North Para River near the southern end of Kellys Road	6800	1200
GPT4	Downstream of Trinity College (east of bypass)	4060	2400×1500
GPT5	Penrith Avenue (prior to discharge into Gawler River)	2780	750
GPT6	Northern end of Hemaford Grove	2380	750
GPT7	Lyndoch Road, near junction with Ellis Street	2250	525

* Based on 100% of flows in pipe going through the GPT, with 99% removal of GP as per typical manufacturer's specification



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PRIORITY LOCATIONS FOR THE INSTALLATION OF NEW GPTS

Figure 5.16

While the primary purpose of GPTs is to remove gross pollutants and coarse sediments, they may also provide a reduction in total suspended solids (TSS) (Objective 2.2) and nutrients (TP and TN) (Objective 2.3). Specifications provided by manufacturers, and underpinned by laboratory testing, suggest that GPTs may remove up to 80% of TSS and 30% of TP and TN. Independent field trials of GPTs suggest that the actual treatment efficiencies of GPTs is heavily influenced by operations and maintenance practices. If organic matter is allowed to accumulate in the wet sump of a GPT, anaerobic decomposition can occur resulting in the release of highly bio-available forms of nutrients into downstream water ways (DPLG, 2010).

During detailed design, it is recommended that the suitability and treatment performance of the units are assessed along with a consideration for safe access for routine maintenance.

5.2.2 Racecourse wetland

The construction of a wetland for water treatment will reduce the loads of sediments (Objective 2.2) and nutrients (Objective 2.3) discharged to receiving waters. Construction of a wetland requires a large amount of relatively flat open space in close proximity to a source of water. Review of the Gawler SMP study area identified the racecourse as a potential site for a wetland. Not only is there a suitable open space, there is also a large stormwater drain that runs beneath the site.

The flood control basin described in Section 5.1.1 could have a separate portion for a wetland and a separate portion of the basin for the temporary storage of flood waters (likely in the form of grassed basin), or the wetland could be part of the flood detention area, tolerating infrequent periodic inundation.

The key design requirements of the wetland are:

- Adequate residence time for various physico-chemical processes (principally sedimentation) and biological processes to occur.
- Shallow areas for the establishment of emergent macrophytes (plus attached algae), which accelerate sedimentation, remove large amounts of the finer sediment fractions which otherwise remain in suspension, and oxygenate sediments with increased pollutant retention.
- Able to mimic natural seasonal hydrological patterns with regards to periods of inundation and exposure to meet the ecological requirements of biota, in order to have a sustainable water quality improvement performance and a diverse ecosystem. This produces a system that meets other objectives of amenity and biodiversity and provides a system which is not a source of nuisance insects.

Being floodplain features, wetlands will not be significantly impacted by flood inundation, but this depends on duration and frequency. Prolonged inundation will drown emergent flora. Hours to days of inundation should not be an issue. The frequency of flood inundation should be as close to typical floodplain inundation patterns as practical to allow the flora to flourish.

The MUSIC model was run to understand the potential water quality improvement that could be achieved through the construction of a wetland on the southern section of the racecourse.

Assuming an area of 2.3 ha, an extended detention depth of 0.5 m and a notional detention time of 48 hours, the modelling indicates that the wetland could provide significant water quality improvement. The potential water quality improvement that could be achieved by the wetland is summarised in Table 5.2, based on the treatment of the upstream local catchment. Further improvements could be possible if a biofiltration system is incorporated into the wetland system. This could be investigated as a part of additional design development of the scheme.

Detailed design should also consider the findings of the *Town of Gawler Biodiversity Management Plan* (McGregor and Durant, 2018) which proposed priority conservation of native grasses within the grounds of the racecourse.

Table 5.2 Modelled treatment effectiveness of the racecourse wetland

	Inflow	Outflow	% reduction
Flow (ML/yr)	323	276	14.6
Total Suspended Solids (kg/yr)	74,800	11,700	84.4
Total Phosphorus (kg/yr)	124	34.8	72
Total Nitrogen (kg/yr)	691	355	48.5
Gross Pollutants (kg/yr)	13,500	8.48	99.9

5.2.3 Raingardens

Raingardens are typically shallow, planted depressions that can provide water quality improvement benefits via biofiltration mechanisms. Raingardens may be implemented at a range of scales from individual residential blocks up to the treatment of whole of catchment flows. Raingardens can reduce the quantity of sediment and nutrients exported to receiving waters (Objective 2.2 and Objective 2.3).

Opportunities for streetscape raingardens have been considered to provide improved stormwater quality runoff within the Gawler and Surrounds SMP area. Typically constructed within verges or roads, streetscape raingardens receive gutter flows via gaps in the kerbing. Flows are then allowed to pond and infiltrate. A high-level overflow may be provided to discharge flows exceeding the storage capacity of the raingarden into the underground drainage network. Depending on the local soil conditions, raingardens may also include a slotted pipe to collect filtered flows and discharge them into the underground drainage network.

Raingardens can be retrofitted into existing roads and offer a range of benefits in addition to improved water quality, including improved aesthetics, increased green space and cooler urban environment. They can also be integrated into traffic calming measures.

A typical layout for a streetscape raingarden is illustrated in Figure 5.17.

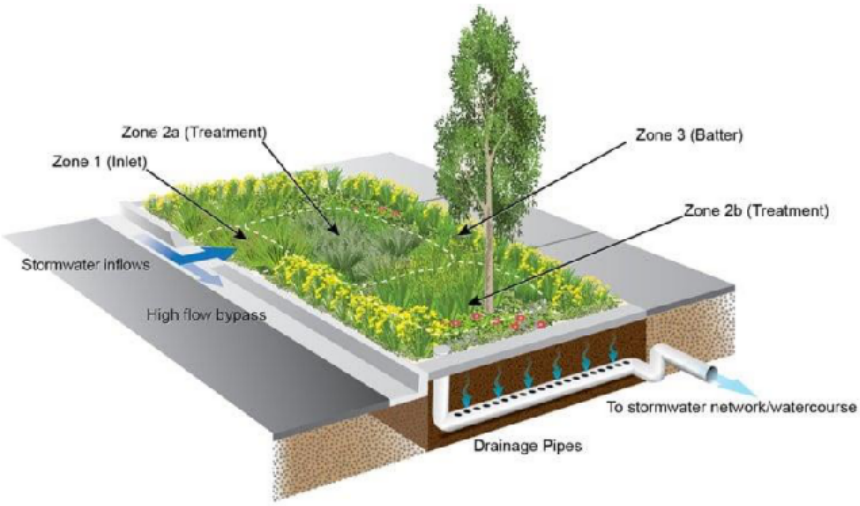


Figure 5.17 Typical layout of a raingarden (Water Sensitive SA)

The site characteristics required for the construction of a streetscape raingarden in a developed area include:

- relatively flat grades
- sufficient space

DesignFlow (2016) determined that the required area of a raingarden to achieve the State Government's stormwater treatment targets can be approximated as 0.7% of the impervious area of the contributing catchment. Raingardens of a smaller size will still provide some water quality treatment.

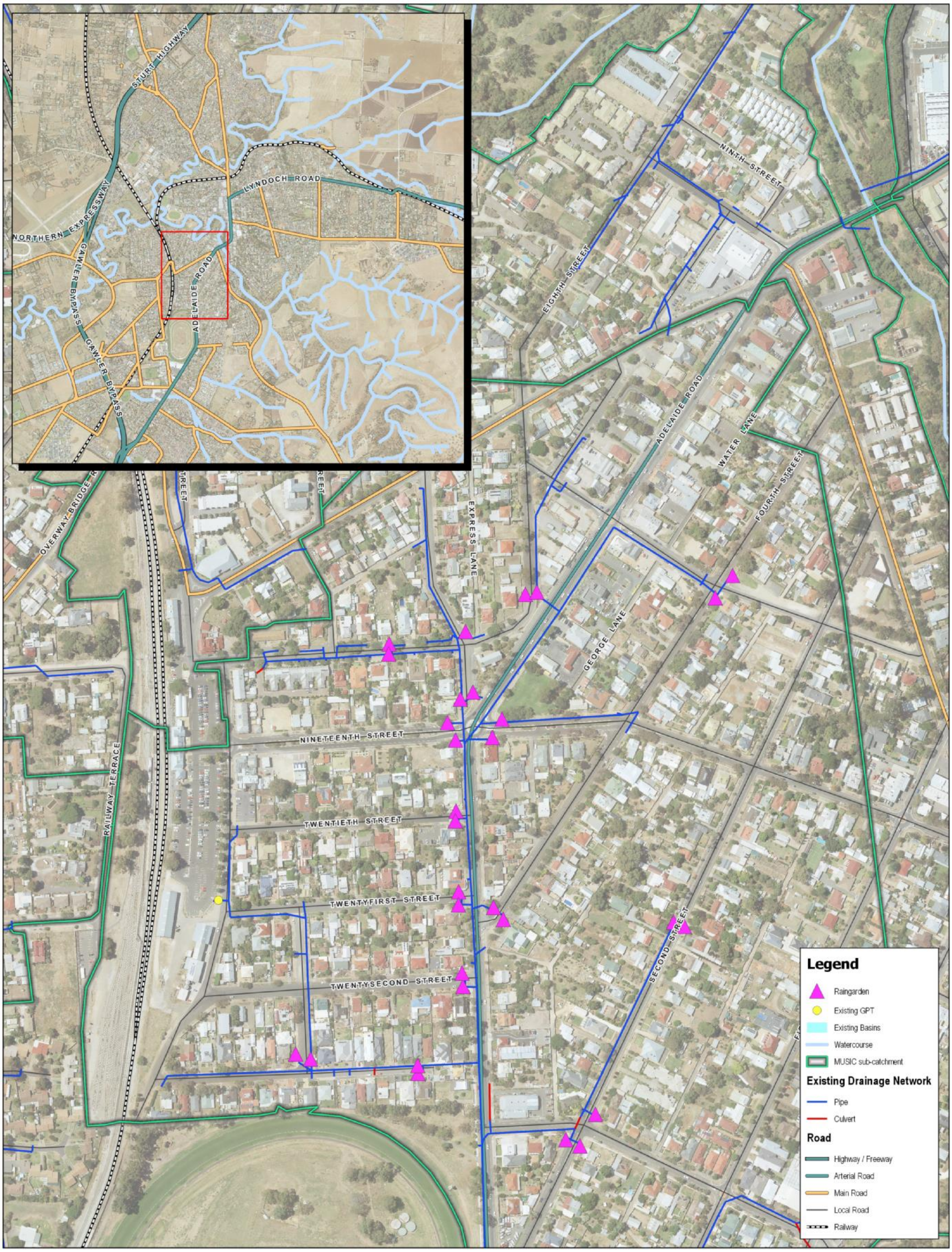
To test the potential effectiveness of streetscape raingardens within the Gawler SMP area, a suitable test catchment was identified. Catchment 89, which is centred around Adelaide Road north of the racecourse was identified on the basis of its relatively flat topography, wide road reserves and the presence of an existing underground stormwater network. Thirty-one potential locations for the construction of raingardens within Catchment 89 were identified and are shown on Figure 5.18. Note that the locations have primarily been selected on the basis of the presence of existing stormwater pits. During the detailed design phase, it will be necessary to consider additional site constraints, including:

- Traffic considerations (sight distances, turning circles etc.)
- Impacts arising from the loss of parking spaces
- Property access
- Impacts on existing trees.

The upstream catchment has an impervious area of 24 ha. Based on the work of DesignFlow, a total raingarden area of approximately 1750 m^2 would be required to provide the targeted water quality improvement performance.

The associated water quality improvement effectiveness of the raingardens was assessed using a lumped approach with a single bioretention node at the downstream extent of the catchment in the MUSIC model. The modelling assumed a total raingarden area of 1750 m^2, with 0.15 m ponding depth. The filter media was assumed to have a total area of 1500 m^2 with a depth of 0.5 m. The base of the raingarden was assumed to be unlined and vegetated with effective nutrient removal plants. The modelled treatment effectiveness of the raingardens is summarised in Table 5.3. It can be seen that the construction of 1750 m^2 of raingardens within the catchment results in a significant reduction in pollutants from the catchment.

While the modelling has focussed on a single catchment, raingardens and other WSUD measures could be implemented into other catchments in the flatter parts of the study area. The level of water quality improvement achieved will be dependent on the size of the raingarden relative to the upstream catchment. It is recommended that in the future, all of the councils within the study area consider opportunities for incorporating raingardens and other WSUD elements (discussed further in following sections) into planned capital works.



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POTENTIAL RAINGARDEN LOCATIONS IN GAWLER SOUTH

Figure 5.18

Table 5.3 Modelled treatment effectiveness of raingardens for Catchment 89

	Inflow	Outflow	% reduction
Flow (ML/yr)	90.3	32.2	64.4
Total Suspended Solids (kg/yr)	18,600	2,990	83.9
Total Phosphorus (kg/yr)	38.5	8.77	77.2
Total Nitrogen (kg/yr)	186	60.6	67.4
Gross Pollutants (kg/yr)	4,040	195	95.2

5.2.4 Other small-scale potential water quality improvement measures

In addition to the raingardens described above, there are a number of other small-scale water sensitive urban design measures which could be considered for implementation within the study area. The measures, some of which are described below, could be implemented as stand-alone projects or incorporated into other capital works projects.

5.2.4.1 Modifications to existing detention basins

There are a number of grass lined detention basins within the study area. There may be an opportunity to provide stormwater quality improvement within these basins by constructing vegetated low flow channels and/or lowering the invert of the basins to provide a wetland within the detention basins. Other small-scale opportunities that may be considered where space exists include the construction of bioretention swales and basins.

5.2.4.2 Permeable paving

Permeable paving, also known as porous paving, is a load bearing pavement structure which can be used on trafficable surfaces including roads with low traffic volumes, carparks and pedestrian areas. It is best suited to areas that are relatively flat (DPLG, 2010).

Permeable paving typically comprises a permeable surface layer overlying an aggregate storage layer and provides many runoff management benefits including:

- Reduction in peak discharges and volumes.
- Increased groundwater recharge.
- Water quality improvement as a result of infiltration.

5.2.4.3 Tree pits

Tree pits typically involve the construction of an opening in the kerb to divert low gutter flows into infiltration pits behind the kerb. The primary objective of the pits is to provide passive irrigation for street trees, with associated amenity and cooling benefits. However, the pits also provide a reduction in stormwater volumes and pollutant loads discharged to receiving environments.

5.2.5 Whole of catchment water quality improvement

A MUSIC model incorporating the racecourse wetland, 31 proposed raingardens (Catchment 89) and priority GPTs, as described in this section (in addition to the existing devices), was run to understand the overall reduction in pollutant loads being discharged into the receiving waters from the developed portions of the study area. The modelled reduction in loads is summarised in Table 5.4. Concordia and the Gawler East growth area (undeveloped) have been excluded from the model; water quality management for these areas is discussed in Section 5.3.

Table 5.4 Modelled whole of catchment water quality improvement

	Sources	Residual load	% reduction	% Target reduction
Flow (ML/yr)	2,310	2,200	4.9	
Total Suspended Solids (kg/yr)	456,000	258,000	43.4	80
Total Phosphorus (kg/yr)	938	650	31.0	60
Total Nitrogen (kg/yr)	4,830	4,140	14.3	45
Gross Pollutants (kg/yr)	93,600	22,700	75.7	90

5.2.6 WSUD in the backyard

It is recommended that council encourage 'WSUD in the backyard' both for existing residences, but more importantly for in-fill development. Examples of measures could include rainwater tanks (with effective reuse), permeable paving and small-scale raingardens. Potential benefits that could be achieved by a WSUD in the backyard approach include reduced peak flows and runoff volumes (Objective 2.4) and improved water quality (Objective 2.1, Objective 2.2 and Objective 2.3).

Implementation of WSUD in the backyard will require community buy-in. It will require a community awareness and education campaign.

Water Sensitive SA has teamed up with the Living Smart program to deliver "WSUD in your home and backyard training for the community" (refer Figure 5.19). Further details can be found on their website at:

http://www.watersensitivesa.com/new-community-webpages-wsud-in-your-home-backyard/

Figure 5.19 The home page for WSUD in your home and backyard (Water Sensitive SA)

5.3 Water quality improvement strategies in areas of future development

There are two main growth areas within the SMP study area: Concordia and the Gawler East growth area. High level stormwater management plans, incorporating WSUD elements, have previously been prepared for both areas. The relevant documents are:

- Concordia Urban Framework Plan (author unknown, report is not publicly available).
- Gawler East Stormwater Infrastructure Study (Tonkin Consulting, 2016).

The requirement for new developments to satisfy the state-wide water quality targets should be enforced for all new developments.

5.3.1 Concordia

The Concordia Urban Framework Plan proposed the following approach to incorporate WSUD into the proposed Concordia development:

- Incorporate natural catchment features into the development through the preservation of areas with high biodiversity and habitat value (Objective 4.2).
- Provision of naturally vegetated low flow swales through areas of existing significant trees (Objective 4.2).
- Adopting a landscape design approach that aims to enhance existing environmental values while adding to create new habitat opportunities through restoration and revegetation (Objective 4.1).
- The integration of the above features into passive recreation uses.
- Avoiding the direct connection of untreated stormwater drainage systems into receiving waters (Objective 2.1, Objective 2.2, and Objective 2.3).
- Management of velocities to 1–2 m/s to prevent waterway erosion (Objective 4.2).
- Addition of retention and detention basins to limit stormwater outflow and peak flow rates.
- Using the treatment train approach to stormwater quality management through the inclusion of:
  - Gross pollutant traps at major outlets (Objective 2.1)
  - Vegetated swales incorporating pool and riffle sequences where possible (Objective 2.2 and Objective 2.3).

The strategy for incorporating WSUD features into the Concordia development has been developed at a master-planning level. As stages of the development progress towards detailed design, Council should work with developers to ensure that the designs are consistent with the development-wide strategy. The design of WSUD infrastructure should consider upstream and downstream catchments. Council should insist that MUSIC modelling be undertaken to demonstrate that the proposed strategy can meet the targeted pollutant reductions.

In addition to meeting the water quality improvement targets, the management of flow velocities to prevent bed erosion will be important for the Concordia development, particularly for catchments discharging into tributaries identified as having a moderate to high erosion potential. The recommended approach within these areas includes:

- Works (such as regrading, rock protection and planting) to repair and stabilise the riverbed and banks in areas of existing erosion.
- Rock riffles and bands of vegetation in-stream to reduce velocities.

An area in the lower reaches of Tributary 1, prior to discharge into the North Para River, has been identified as having scope for improvement of the riparian habitat. Some planting has already been undertaken and it is recommended that weed control and planting of native species be undertaken along this tributary to further enhance the habitat that is there.

5.3.2 Gawler East growth area

Tonkin Consulting developed a stormwater infrastructure plan for the Gawler East growth area (2016). The plan included a strategy for the management of the quality of runoff from the areas. The study notes that:

"Virtually the entire Gawler East area is steep with surface grades typically in the range of 5-15%. This limits the opportunity for water quality improvement measures as systems such as shallow wetland and biofiltration systems typically require flatter grades. The existing gullies in the study area are currently poorly vegetated and typically comprise scattered native trees growing over exotic invasive species and grasses. Uncontrolled development of the upstream catchments will result in a significant increase in both the frequency and volume of runoff. This increase in flows has the potential to increase erosion along the existing gullies and would need to be managed."

Where possible wetland ponds and detention basins have been proposed at the downstream end of the catchments in locations where there are well formed gullies that would facilitate the construction of a basin across the gully within private property, upstream and offline of the receiving watercourse.

In-stream works within larger gullies should consider the planting of riparian vegetation and weed control. The creation of ephemeral ponds may help to retain runoff, provide aquatic habitat and reduce the effective bed grades, thereby reducing velocities. The proposed instream works for the Gawler East area are summarised in Figure 5.20. Depending on the stream gradient, macrophyte plantings may not be sufficient for managing erosion, and constructed measures, such as rock chutes or drop structures, may be required.

In addition to in-stream works, incorporation of a range of WSUD features is recommended within the developments. As the layouts of the proposed developments are not known, these features are not shown on Figure 5.20. GPTs should be installed at the downstream end of each land division, prior to discharge into the watercourses. In addition, biofiltration systems should be incorporated within the land division to encourage on-site infiltration (and thereby reduce the frequency and volume of discharge) and improve water quality. Wetlands, bioretention basins and grassed swales should also be accommodated. WSUD features within developments are preferred over in-stream works, as this minimises the modification of the natural environment.

5.4 Water reuse strategy

The possibilities for the establishment of regional stormwater harvesting schemes were considered during the development of the SMP. The proposed wetland within the racecourse and land adjacent to the Clifford Road drain were identified as potential locations on the basis that they have sufficient open space alongside a source of water.

The catchments contributing flows to the racecourse are within surface water management zone (SWMZ) LC26 of the Western Mount Lofty Ranges WAP. There is a SWMZ wide water allocation allowance of 95 ML/year which is currently fully allocated. In addition to this, there is the provision to harvest water from "new urban land use development" (with a maximum volume equivalent to the difference between post- and pre-development runoff). Given the capped allocations combined with the likely capital costs associated with the construction of a reuse scheme, it is considered unlikely that a managed aquifer recharge (MAR) scheme at the racecourse would be economically viable. Consideration of water harvesting at the racecourse has therefore not been considered further.

The Clifford Road Drain is immediately downstream of the prescribed surface water area. DEW advised that any extractions from this drain would be subject to review by the Landscape Board.

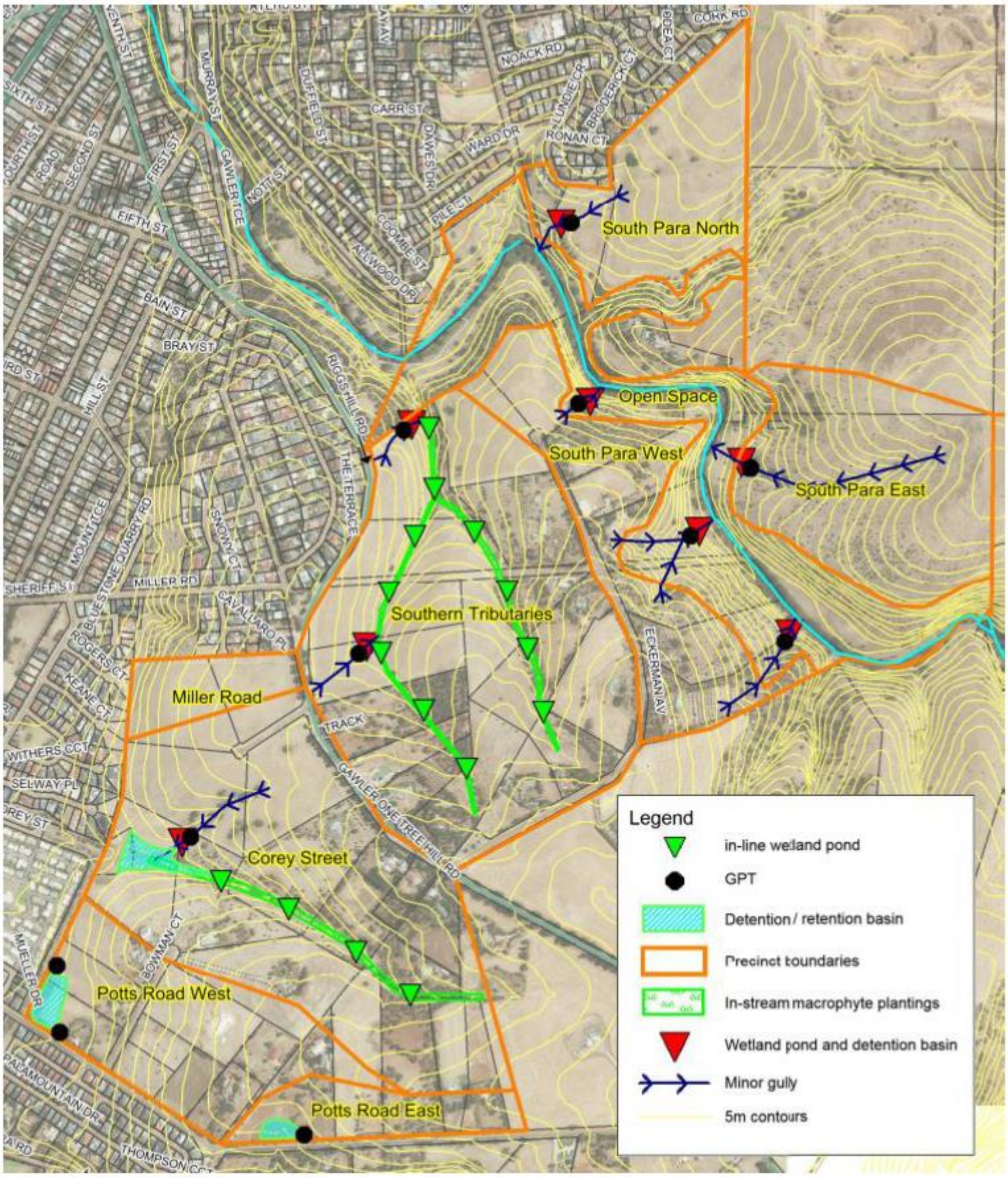


Figure 5.20 In stream water quality improvement works for the Gawler East growth area

A study (KBR, 2018) into options for the supply of non-potable water to wetlands in the Gawler Urban Growth Areas identified harvesting from the Dawson Road detention basin as a potential supply, although noted that the catchment upstream is largely undeveloped and hence the expected yields would be small.

Should the cap on harvestable volumes change, then development of a regional scale reuse facility should be considered. Any scheme would still need to be considered in the context of the existing schemes, notably Bunyip Water.

It is understood that the Town of Gawler will be undertaking a water reuse study in the future to identify suitable areas for harvesting and injection of treated water with the aim of producing an integrated water reuse strategy.

5.4.1 Large rainwater tanks

Rainwater tanks are a recommended strategy to encourage the on-site reuse of stormwater runoff (Objective 3.1).

In areas of new development Council should encourage (potentially via financial subsidisation) the installation of rainwater tanks which, at a minimum, are plumbed into the hot water service and toilet. The volumes of reuse achieved will be dependent on the area of roof plumbed into the rainwater tank, the size of the tank, and the daily water demands for rainwater.

Yield curves showing indicative annual yields for rainwater tanks of various sizes in the Gawler region (assuming a connected roof area of 150 m²) are shown in Figure 5.21. Assuming an average daily demand of 200 L, the curves show that yields may range from 35 kL/year for a 1 kL tank to 65 kL/year for a 20 kL/year. Based on review of the yield curves it is recommended that new dwellings should incorporate a tank with a minimum size 5 kL. A smaller size may be more appropriate if the connected roof area is smaller.

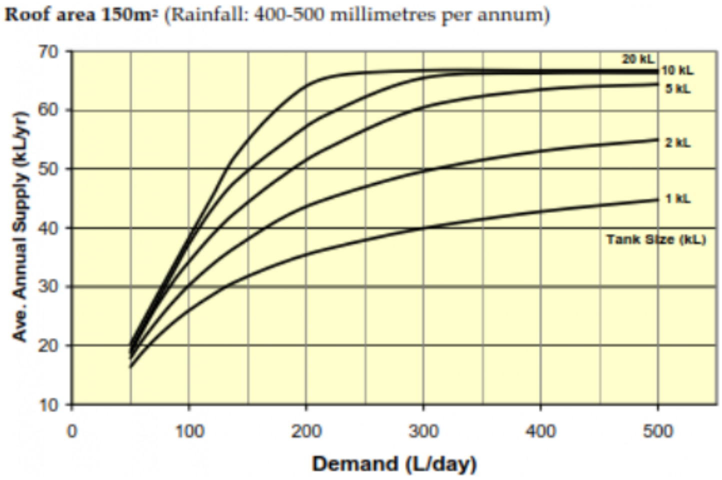


Figure 5.21 Rainwater yield curve for Gawler (150 m² roof area) (DPLG, 2010).

5.4.2 Infiltration systems

A range of passive infiltration systems will facilitate water to recharge into the shallow groundwater system close to the location where the runoff was first generated. Systems that would help to meet this goal include:

- Raingardens (refer Section 5.2.3 for more details) that can allow for soakage of runoff that is diverted into the raingarden.
- Permeable paving (refer Section 5.2.4.2) can be incorporated into road reconstruction projects to encourage infiltration. They can be particularly effective if they are connected into small basins that can act to increase the volume of the storage area that can be used for passive infiltration.
- Tree pits (refer Section 5.2.4.3 for more details) that can help to increase the amount of moisture reaching the root zone of trees. This can enhance tree health and therefore has the added benefit of improving amenity.

Given the clay / clay on rock soil types within the study area, any infiltration is likely to be relatively slow and infiltration will only typically be to a shallow depth.

5.5 Strategies for environmental protection and enhancement

The recommended strategies for achieving the SMP objectives relating to environmental protection and enhancement are summarised in the following sections. The strategies are consistent with the conservation objectives stated in Council's development plan.

It is understood that in recent years the Town of Gawler has undertaken several projects aimed at improving the health of Gawler's river system. The Gawler Urban Rivers Masterplan (SMEC, 2013) included a number of recommendations relating to conservation planning, revegetation and weed removal. The recommended actions (summarised below) complement the majority of the objectives of the SMP. It is recommended that Council audit the proposed actions and, where still relevant, adopt the recommended actions and include them within Council's relevant strategic and asset planning systems.

- Conservation areas maintained by different local groups should be identified.
- All existing information regarding weed control, revegetation and other environment protection works should be consolidated.
- A Best Practice Operating Procedure should be developed in consultation with the Northern and Yorke Landscape Board (NYLB).
- A consultative process should be developed and implemented, so that conservation programs can be undertaken in an integrated manner, and so that Council and relevant community groups can communicate with regards to their respective priorities and objectives for each site.
- Planting and revegetation areas should be consistent and protected. New planting areas should be protected from unauthorised access and grazing with fencing or tree guards and plastic sleeves. Fenced planting areas will also enable easy detection of revegetated areas in large reserves.
- Public awareness should be made to revegetated areas along with signage to inform the significance of the planted community to enable public interest and to follow up on the planting progress. Such awareness and protection will indicate a well-managed area to deter unauthorised access and vandalism.
- Planting of non-indigenous plants should be discouraged wherever possible or practicable.
- A weed management strategy should be established for the river corridors
- Programs to discourage planting of garden plants which can spread from gardens to the river corridors should be put in place. Particular focus on major new development areas should be a priority. Such programs can complement programs to encourage planting of suitable local natives in gardens.

The Town of Gawler Biodiversity Management Plan (McGregor and Durant, 2018) has recently been completed. Any actions aimed at environmental protection and enhancement within the SMP area should be consistent with the recommendations of the biodiversity management plan. The biodiversity management plan made 33 broad recommendations. The main areas that are common between the SMP and the biodiversity management plan (BMP) are:

- Restoration of riparian habitat and weed management which is also likely to improve water quality by reducing erosion risk and encouraging infiltration (BMP recommendations 14, 15, 17, 25, 27, 28, and 30).
- Improving habitat diversity within reserve areas that will be used for stormwater management purposes (BMP recommendations 3 and 4).
- Management of roadside verge areas which will reduce the amount of sediment being washed into the stormwater system and increase biodiversity (BMP recommendations 6, 7, 8, 9, and 10).
- Prevent fragmentation of habitat (BMP recommendation 20).

- Water sensitive urban design to minimise changes to the hydrological regime (BMP recommendation 23).
- Improving biodiversity at the Gawler Racecourse (BMP recommendation 31).

5.5.1 Utilisation of open space

The establishment of wetlands, raingardens, swales or detention systems provides an opportunity to increase biodiversity, improve amenity, education and recreation facilities, offers habitat for fauna, and improves water quality treatment. These opportunities should be considered when implementing the wetlands, raingardens, swales and basins identified within this report (Objective 4.1).

The strategic use of open space for stormwater management has the potential to secure the long-term use of an area as useable open space. The key opportunity for this strategy is in association with the wetland proposed for the Gawler Racecourse, which could be an opportunity to connect with the local community.

Large developments adjacent to watercourse corridors should look to include accessible open space adjacent to watercourse corridors as this could potentially increase the value and useability of these areas.

5.5.2 Riparian habitat restoration

The EMS report (Appendix A) summarises the findings of the environmental assessment of selected watercourses within the study area. It identified a number of opportunities for environmental enhancement through planting of native species and weed control. The report identified that the majority of watercourses have been greatly altered by stock grazing, vegetation clearance, weed invasion and planting of non-indigenous species. Given the low habitat value that the riparian areas have, there is significant scope for improvement. Improved riparian vegetation will also act to enhance water quality and slow flow rate values which both reduces the risk of erosion within the watercourses and increases habitat and recruitment opportunities.

Riparian habitat restoration is a key strategy recommended for the management of stormwater impacts for the Gawler East and Concordia growth areas (Objective 4.2). This is consistent with a number of recommendations from the Town of Gawler Biodiversity Management Plan.

Riparian habitat restoration should be done in a strategic manner that is consistent with the recommendations of the Gawler Urban Rivers Master Plan and the outcomes of the Town of Gawler Biodiversity Management Plan.

5.5.3 Erosion protection

For watercourses identified as having moderate to high erosion potential (either by EMS's assessment or site observations, refer Appendix A for locations) the recommended strategy includes:

- limiting the peak flows and the velocities of flows from areas of new development.
- reducing flow velocities via in-stream works such as the creation of ephemeral pools and the planning of instream vegetation as incorporated into the strategy for the Gawler East growth area.

In areas where erosion already exists the erosion needs be stabilised prior to any upstream development occurring, as this would further exacerbate the existing problem. The stabilisation works could include a range of tasks to improve the bed, floodplain or bank stability such as regrading, planting with indigenous riparian species, and where necessary hard edge works.

5.5.4 Ecosystem protection in rural tributaries in areas of future development

In addition to the riparian habitat restoration and erosion protection measures identified above, it is recommended that within areas of future development (i.e. Concordia and the Gawler East growth area), protection of ecosystems within rural tributaries be required as a condition of development. This can be stipulated within Council's development plan as part of any updates to the plan.

5.6 Asset management

5.6.1 Assess condition of existing infrastructure

Detailed inspections of existing infrastructure, including CCTV and physical inspection by qualified people, will enable an informed estimation of the residual design life for key components of the drainage system to be made (Objective 5.1). For underground drainage infrastructure priority should be given to inspecting drains that have at least two or three of the characteristics described in Table 5.5 (drain characteristics not listed in any specific order).

Table 5.5 Criteria defining CCTV inspection priority

Drain Characteristic	Discussion
Large drain size (larger than 750 mm diameter)	Large drains comprise the highest value component of Council's drainage assets and the unplanned replacement of a section of large drain would have a large impact on Council's financial resources.
Old drain	The older the drain the more likely that it will be nearing the end of its design life.
Prominent location	Some drains are located in prominent locations such as the centre of a commercial area or within an arterial road. Should these drains fail it would result in major traffic disruptions (if the area were no longer trafficable) and the potential for flood damages is highest.
Box culverts	Historically, box culverts have failed well before their expected design life which increases the need to understand their current condition.

Based on the outcomes of these investigations, future works can be prioritised to ensure that the drainage system is replaced prior to the end of its design life (Objective 5.2). If replacement works are deemed necessary, a hydrological and hydraulic assessment of the system should be made to determine if the replacement system should be enlarged to meet the drainage standard objectives outlined within Section 4.

Money should be set aside to initially prioritise which drains should be inspected and then recurring funding should be made available to undertake CCTV inspections of the drainage assets.

The Town of Gawler is also protected, in places, via existing levee banks that reduce flooding from the Gawler, North Para and South Para Rivers. Levee banks are often located within private property and therefore not under the direct control of Council. The condition of the levee banks should be inspected within the next twelve months (high priority) and then at least every five years to ensure any remedial works are undertaken, as required, to ensure their integrity during a flood event.

There are a number of flood control dams within the catchment, with some being relatively significant in scale. During large flood events, a significant volume of water is detained behind the embankments. Embankment failure could result in catastrophic flood damages, that could include the loss of life.

Similar to the recommendations for levee banks, periodic inspection of these embankments is required to ensure that there is no risk of their failure during a flood event.

The significant flows carried by watercourses in the Gawler and Surrounds SMP area can alter the course of the flows. This change in river delineation can occur gradually and sometimes very rapidly and thus proximity of watercourses to assets such as footpaths, buildings and roads all need to be monitored to ensure that erosion is noted, repaired and rehabilitated as appropriate and in a timely manner.

5.6.2 Develop an asset maintenance plan

A number of recommendations of this SMP include infrastructure that will require regular maintenance to ensure that it will continue to function as intended. It is recommended that Council develop a maintenance plan (Objective 5.3) to cover the long-term management of the Council's drainage assets, particularly the assets that have a relatively high maintenance frequency. The plan would need to include the following key parameters:

- the location and description of the asset
- the likely frequency (or event trigger such as a heavy rainfall event) that maintenance will be required
- the type of maintenance that will be required (e.g. removal of silt, weeding, etc.).

Council will also need to allow for adequate resourcing and budgets to maintain the additional infrastructure that may be constructed as part of the implementation of the recommendations of this SMP.

6 Costs and funding opportunities

6.1 Cost estimates

This section provides a summary of the costs required to implement a number of the strategies that have been outlined within Section 5 of the report and includes, for completeness, some strategies that are not recommended by this SMP. The cost estimates include a 15% allowance for preliminaries, a 20% contingency, as well as GST (10%). The accuracy of the cost estimates for capital works is limited by them being based on concept designs only. However, they are able to provide an order of magnitude of cost. Further accuracy in the cost estimates could be determined as a part of further design development. A more detailed breakdown of the costs is provided in Appendix E which also lists the assumptions that have been made. Where information is readily available, estimates of annual maintenance costs have also been provided. One of the key assumptions is that no allowances have been made for service relocation costs, which would need to be refined as part of further design development.

6.1.1 Gawler Racecourse flood control basin

A major expense associated with the construction of the basin within the Gawler Racecourse is upgrading and extending the pipe network, which includes concrete pipes, junction boxes and headwalls. The wetland component of the basin, which is expected to occupy 80% of the basin footprint, is also a significant cost with an estimated rate of $750,000 per hectare. The costs are summarised in Table 6.1.

Table 6.1 Construction cost estimate for Gawler Racecourse flood control basin

Item	Cost
Preliminaries	$550,000
Detention basin earthworks	$875,000
Wetland	$1,725,000
Pipe network	$1,060,000
Contingency	$840,000
GST	$505,000
TOTAL	**$5,550,000**

6.1.2 Tingara Road flood control basin (Evanston Park)

The two main cost components relating to the flood control basin are the diversion pipe and the construction of the embankment, as shown in Table 6.2. An allowance for land acquisition, based on a rate of $30/m^2$, has also been included.

Table 6.2 Construction cost estimate for Tingara Road flood control basin

Item	Cost
Preliminaries	$70,000
Stormwater drainage	$270,000

Item	Cost
Earthworks	$90,000
Land acquisition	$80,000
Miscellaneous	$30,000
Contingency	$110,000
GST	$65,000
TOTAL	**$710,000**

6.1.3 Trinity College creek upgrades

The channel and culvert upgrades at Trinity College are relatively minor works compared to some of the other projects that have been costed in this section. The cost estimate outlined in Table 6.3 includes allowances for widening of the channel (earthworks), as well as culvert replacements, which comprise the largest portion of the estimate. No allowance for land acquisition has been made, however, easements within Trinity College would be required to accommodate the works.

Table 6.3 Construction cost estimate for Trinity College creek upgrades

Item	Cost
Preliminaries	$40,000
Channel earthworks	$35,000
Culvert upgrades	$215,000
Miscellaneous	$10,000
Contingency	$60,000
GST	$35,000
TOTAL	**$390,000**

6.1.4 Jarvis Street drain upgrades

The cost of this strategy, summarised in Table 6.4, is based on the cost of removing the existing pipe network within the Jarvis Street catchment and upgrading the pipe sizes. An allowance for deep excavation has also been included.

Table 6.4 Construction cost estimate for Jarvis Street drain upgrades

Item	Cost
Preliminaries	$335,000
Stormwater drainage	$2,200,000
Miscellaneous	$30,000
Contingency	$515,000

Item	Cost
GST	$310,000
TOTAL	**$3,390,000**

6.1.5 Gawler East flow path improvements

In addition to the earthworks required to formalise the Gawler East channels, land acquisition will be required to provide drainage easements. It is assumed that the easements will extend to a width 0.5 m either side of the channels. The largest expense associated with the formalised channels is the stormwater drainage infrastructure (pipes and culverts) required to convey the flows beneath existing roads. The cost estimate is shown in Table 6.5.

Table 6.5 Construction cost estimate for Gawler East flow path improvements

Item	Cost
Preliminaries	$250,000
Pipes and culverts	$250,000
Channel earthworks	$100,000
Land acquisition	$170,000
Contingency	$120,000
GST	$72,000
TOTAL	**$795,000**

6.1.6 Potts Road detention basin

As with the Gawler Racecourse basin, the largest cost element for the Evanston Park detention basins is the pipe network. At least 2 km of new pipe is required to capture and direct runoff to the existing Corey Street local basin and the new Potts Road basin, the cost of which is summarised in Table 6.6.

Table 6.6 Construction cost estimate for Potts Road detention basin

Item	Cost
Preliminaries	$245,000
Basin earthworks	$370,000
Pipe network	$1,040,000
Wetland ponds and plantings	$230,000
Contingency	$375,000
GST	$225,000
TOTAL	**$2,480,000**

6.1.7 Gawler Belt railway culvert

This option is relatively inexpensive as few elements are required. A single culvert is required below the railway line. Runoff from the culvert would be discharged into a new outfall channel, the costs of which include excavation works as well as land acquisition. A summary of the cost estimate is provided in Table 6.7.

Table 6.7 Construction cost estimate for Gawler Belt railway culvert

Item	Cost
Preliminaries	$25,000
Rail culvert	$75,000
Outfall channel	$75,000
Miscellaneous	$5,000
Contingency	$35,000
GST	$20,000
TOTAL	**$235,000**

6.1.8 Gawler Belt interception drain

This strategy requires a large volume of earthworks to form the new channel, in addition to new culverts to allow the runoff to pass beneath several roads. The investigated channel alignment passes through multiple private properties over a length of approximately 2.8 km; significant land acquisition is required, as shown in Table 6.8.

Table 6.8 Construction cost estimate for Gawler Belt interception drain

Item	Cost
Preliminaries	$535,000
Channel earthworks	$1,225,000
Culverts and headwalls	$660,000
Land acquisition	$1,680,000
Contingency	$820,000
GST	$490,000
TOTAL	**$5,410,000**

6.1.9 Hewett rear of allotment drainage

It is recommended that a rear of allotment drainage system is constructed within a number of the properties along Explorer Parade and Oakland Circuit, Hewett. This will require the installation of uPVC pipes, as well as the formation of a drainage easement within the property boundaries. The costs associated with this measure are summarised in Table 6.9.

Table 6.9 Construction cost estimate for Hewett rear of allotment drainage

Item	Cost
Preliminaries	$20,000
Stormwater drainage	$65,000
Concrete grated inlet pits	$20,000
Drainage easement	$50,000
Contingency	$30,000
GST	$20,000
TOTAL	**$200,000**

6.1.10 Evanston Oval parallel pipe upgrade

The duplication of the existing pipe through Evanston Oval is likely to be a relatively straightforward exercise. The cost estimate shown in Table 6.10 includes the supply and installation of a new pipe, as well as the associated junction boxes and headwalls.

Table 6.10 Construction cost estimate for Evanston Oval parallel pipe upgrade

Item	Cost
Preliminaries	$25,000
Stormwater drainage	$150,000
Miscellaneous	$10,000
Contingency	$35,000
GST	$20,000
TOTAL	**$235,000**

6.1.11 Gross pollutant traps

Gross pollutant traps (GPTs) have been identified as a water quality improvement strategy. The costs associated with the addition of 7 new GPTs is summarised in Table 6.11. The devices have been sized based on the size of the contributing upstream catchment.

Table 6.11 Construction cost estimate for GPTs

Item	Cost
Preliminaries	$135,000
Gross pollutant traps	$750,000
Excavation works	$140,000
Contingency	$205,000
GST	$123,000
TOTAL	**$1,350,000**
GPT annual maintenance	$35,000/yr

6.1.12 Raingardens

The costs associated with construction of fifteen new streetscape raingardens, used to improve water quality, are shown in Table 6.12.

Table 6.12 Construction cost estimate for raingardens

Item	Cost
Preliminaries	$45,000
Raingardens	$300,000
Contingency	$70,000
GST	$40,000
TOTAL	**$455,000**
Raingarden annual maintenance	$4,500/yr

6.1.13 Education and awareness – WSUD in the backyard

A program to raise community awareness about WSUD in the backyard will require staff and personnel time and effort to promote. The expenses incurred may include preparation of materials, articles in the Bunyip and Messenger, community presentations and liaison with developers. It is estimated that the cost of this be $20,000 in the first year, with ongoing costs of $10,000.

Education of the local and development community should be included in Council's developer agreements to reduce the reliance on Council to provide the education program. This would be at no direct cost to Council.

6.1.14 Education and awareness – flood mapping

A program to publicise the floodplain mapping to the general community would require staff or personnel time and effort to promote, preparation of materials, advertising costs and also the cost of a mail out to affected land holders. As for WSUD in the backyard, following an initial cost of $20,000 in the first year, an annual allowance of $10,000 should be budgeted for this campaign,

6.1.15 Rainwater tank subsidies

A budget of $50,000 per year would allow subsidies to be provided for new rainwater tanks, at an indicative rate of $2,000 per tank (i.e. 25 tanks per year).

6.1.16 In-creek works

An annual budget in the order of $100,000 would allow in-creek works to be undertaken to rehabilitate the watercourses in the Gawler area. A rolling program of works based on priority should be developed to identify suitable locations of planting, weeding and bank works, as required.

6.1.17 Corey Street flood control basin outlet optimisation

An allowance of $50,000 has been allocated for this strategy.

6.1.18 Clifford Road flow gauge

A flow gauge within the Clifford Road outfall drain is proposed. A concrete channel with a fixed cross-section would be sufficient to detect normal flow with no backwater effects. Installation of gauging data will be required (such as a sensor attached to the existing bridge to detect flow depth). The estimated cost of these works would be $15,000 with an ongoing monitoring cost of $1,000 per year.

6.1.19 Climate change flood modelling

A budget allowance of approximately $20,000 would cover the costs associated with undertaking a more rigorous assessment in relation to the potential impacts of climate change on flooding.

6.1.20 Asset condition assessment

An amount of $20,000 per year would allow for periodic CCTV inspection of key drainage assets within the catchment that would allow for a good ongoing understanding of the condition of existing stormwater assets. A further $10,000 per year is required for physical inspection of assets, such as watercourses, levees and flood control dams.

6.1.21 Infiltration systems

An annual budget in the order of $50,000-$100,000 would allow permeable pavements and tree pits to be periodically rolled out across the study area.

6.1.22 Localised drainage upgrades

A budget allowance of $50,000 per year would allow small-scale drainage upgrade works, such as a new lateral drainage system or upgrades to existing systems, to be undertaken. In the first instance, these works may include the review and upgrade of the low-standard drainage systems summarised in Section 5.1.15.

6.2 Funding opportunities

6.2.1 Stormwater Management Authority

The main stormwater related funding opportunity is with the Stormwater Management Authority (SMA). Stormwater management projects within catchments that have an area greater than 40 ha and are part of an 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 re-use. An assessment of the eligibility of the projects outlined above for SMA funding is provided in Table 6.13.

6.2.2 Landscape Boards

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 study 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.

6.2.3 Developer contribution

Some of the works, such as the Potts Road detention basin, are downstream of new areas of development. While these works would potentially have to initially be funded by Council, the Council 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 quality improvement measures if their on-site works do not meet the predetermined targets.

6.3 Cost sharing framework

The strategies described within this SMP can be used to manage runoff from numerous catchments across each of the four Council areas (Town of Gawler, City of Playford, Light Regional Council and The Barossa Council). On this basis, a cost sharing framework has been prepared in order to allocate the costs of each of the major management strategies to the relevant Council(s). The costs allocated to each Council are summarised in Table 6.13 and are based on the contributing catchment areas.

Table 6.13 Capital works cost sharing opportunities

Management strategy	Town of Gawler	City of Playford	Light Regional Council	The Barossa Council	SMA Eligibility (>40 ha)
Gawler Racecourse flood control basin	$5,550,000				Yes
Tingara Road flood control basin (Evanston Park)	$135,000	$575,000			Yes
Trinity College creek upgrades	$390,000				Yes
Jarvis Street drain upgrades	$3,390,000				Yes
Gawler East flow path improvements	$120,000			$675,000	No
Potts Road detention basin*	$2,480,000				Yes
Gawler Belt railway culvert			$235,000#		No
Gawler Belt interception drain			$5,410,000#		Yes

Management strategy	Town of Gawler	City of Playford	Light Regional Council	The Barossa Council	SMA Eligibility (>40 ha)
Hewett rear of allotment drainage			$200,000		No
Evanston Oval parallel pipe upgrade	$235,000				Yes
TOTAL	**$12,300,000**	**$575,000**	**$200,000^**	**$675,000**	

* These works are potentially able to be recouped through a developer contribution as upstream development proceeds

These works are not recommended strategies as a part of this SMP

^ Excludes strategies that are not recommended

7 Flood damages and economic assessment

7.1 Flood damages assessment

The flood damages assessment follows the Rapid Appraisal Method (RAM) developed by the Victorian Department of Natural Resources and Environment (DNRE, 2000). This approach allows for a rapid and consistent evaluation of the flood management strategies in a cost-benefit analysis framework. The simplicity of the RAM process (compared to other methods) allows for easy reproduction in future.

The flood damages were derived from the results of the two-dimensional (2D) hydraulic modelling, detailed within the *Hydraulic Modelling Summary Report* which is provided in Appendix B. Flood depth and flood hazard maps are presented in Appendix F. The assessment is based on flooding generated within the study area and does not consider flooding from the North Para River, South Para River or Gawler River (which are not covered by the SMP, but have been investigated by AWE (2016)).

The flood damages assessment was performed for each of the modelled scenarios, as follows:

- Existing: existing infrastructure combined with existing development levels.
- Long term: existing infrastructure combined with predicted long-term development levels (with no on-site detention).
- Flood management strategies: existing infrastructure with proposed mitigation options (outlined in Section 5.1) combined with predicted long-term development levels (with no on-site detention).

The proposed modifications and upgrades of the existing drainage system included in the modelling of the management strategies included:

- Gawler Racecourse flood control basin
- Tingara Road flood control basin (Evanston Park)
- Trinity College creek upgrades
- Jarvis Street drain upgrades
- Potts Road detention basin
- Evanston Oval parallel pipe upgrade.

Additionally, recent drainage upgrade works constructed within Willaston were included in the flood management strategies model. On-site detention is not included in any of the development scenarios.

7.1.1 Data pre-processing

The RAM relies primarily on GIS datasets, including cadastral information such as allotment boundaries, land use types and property valuations. All of this information needs to be pre-processed and validated prior to performing the damages assessment.

The following sections detail the process that was adopted for preparing the GIS datasets for input into the damages assessment calculator.

Assigning damage potential categories

A damage potential category was assigned to each allotment within the cadastral dataset based on the land use type – an attribute that was already assigned by Council. The damage potential category describes the type of property within an allotment and the relative potential for damage occurring during flooding of that allotment. The adopted strategy addresses damages to residential properties differently to other property types. The flood damage categories that were used include low, medium, high and residential. The general process for assigning damage categories to the allotments is summarised in Table 7.1.

Table 7.1 Allocation of damage potential categories

Property type	Damage potential category
Residential	Residential
Retail	High
Industrial	High
Public reserves	Low
Education institutions	Medium
Public utilities	Medium
Recreation areas	Low
Agricultural	Low

There were a large number of allotments that did not have land use types. Aerial imagery was used to assign appropriate land use types to these allotments.

The assigned damage potential categories were visually assessed and validated through comparison with aerial imagery. The final damage potential category allocation is shown in Figure 7.1.

Property valuations

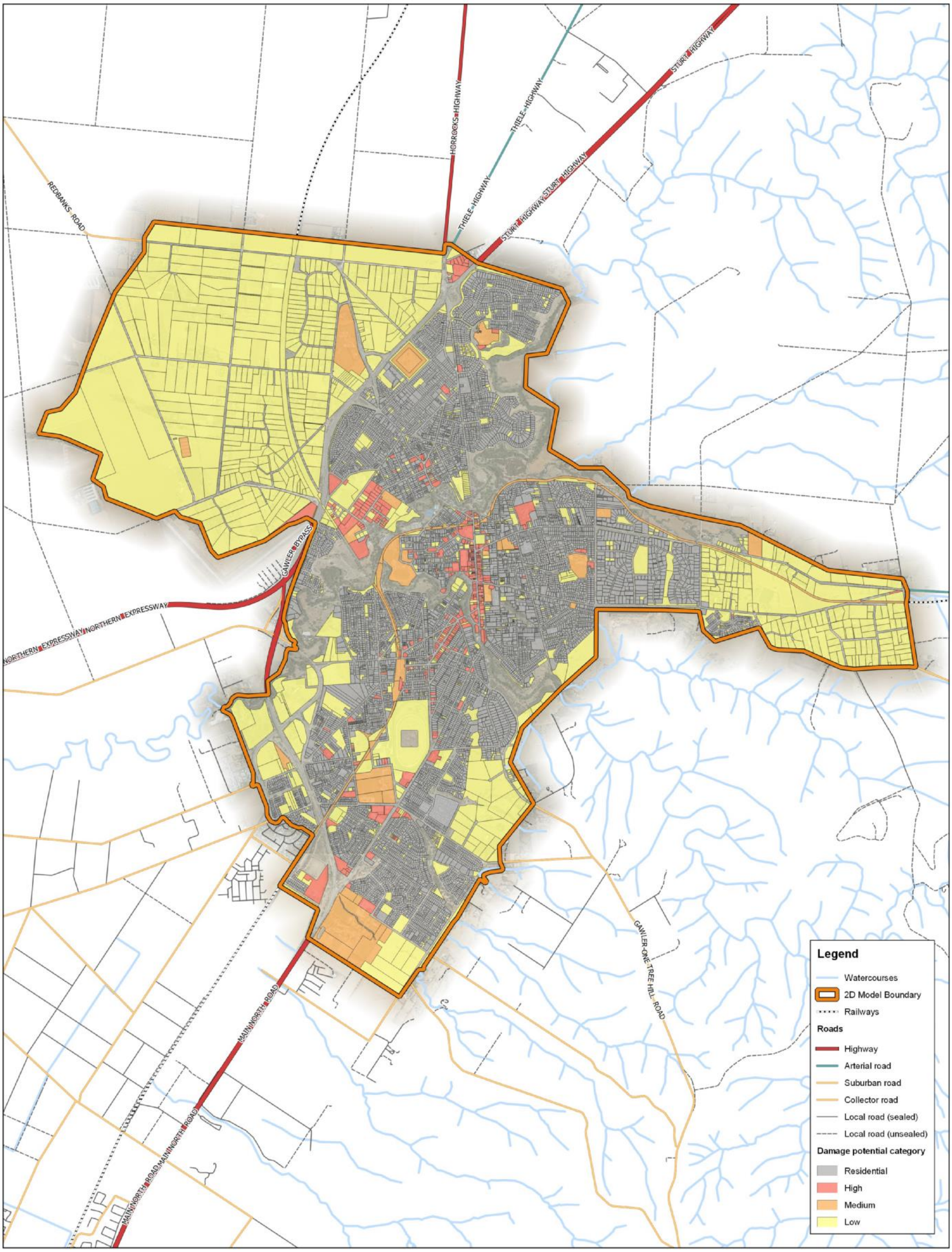
The RAM only requires valuation data for residential allotments. The majority of property valuations were provided by Council. However, for the relevant allotments that were not valued, the following values were adopted:

- $535,000 for rural residential allotments within the Barossa region
- $285,000 for all urban residential allotments.

EXCLUSION OF ALLOTMENTS

A number of allotments were excluded from the damages assessment for the following reasons:

- multi-storey properties: only the ground level properties of a multi-storey complex were included. Properties above ground level were excluded, as including them would result in double (or more) the damage costs when, in reality, flood levels would need to be above 2 m to affect these properties.
- small areas: there were a significant number of parcels with areas less than 50 m². These areas predominantly included individual car parks and strata titles. If left in the dataset, they would have contributed a large residential damage when, in reality, minimal property damage would occur.
- unaffected areas: there were a number of large parcels with flooding that had very minimal amounts of infrastructure that would be impacted by flooding. This includes allotments that contain natural watercourses, drainage easements, or large vacant/rural parcels. If these parcels were retained, they would generate large flood damage costs when, in reality, very little damage would occur.
- bodies of water: any areas that are supposed to have large depths of water, such as detention basins, were excluded.
- roads: there are usually no roads included in cadastral data, so any that were included were excluded.



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Job Number: 20141387
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Revision: B
Date: 2019-03-25
Drawn: DB

Data Acknowledgement:
Aerial imagery provided by and used with permission of Council

Town of Gawler, Light Regional Council and Barossa Council

DAMAGE POTENTIAL CATEGORIES

Figure 7.1

7.1.2 Calculations

The total damage costs incurred at an allotment following a specific flood event were split into two types as follows:

- direct damage: damages resulting from the direct impact of flood waters, including physical or functional damage.
- indirect damage: consisting of any loss in revenue caused by the effects (direct damage) of flooding.

Calculation procedures for both damage types are detailed in the following sections.

Direct damages

Calculations for the direct damage costs were separated into the following three groups:

- residential allotments
- non-residential allotments with an area less than 1,000 m^2
- non-residential allotments with an area greater than or equal to 1,000 m^2.

Residential allotments

Residential allotments were only considered damaged if the flood depth at the centroid of the allotment exceeded 100 mm. This assumes that the finished floor level (FFL) of all residential dwellings is 100 mm above ground level.

The damage at each allotment was calculated using the following equation.

$$FD = \$30{,}000 + \$30{,}000\left(d\frac{CV}{CV_{ave}}\right)$$

Where,

$FD = Flood\ damage$

$d = flood\ damage$

$CV = property\ valuation$

$CV_{ave} = average\ residential\ property$

The base flood damage value for residential allotments ($30,000) and the factor used for the property value component ($30,000) are based on work conducted by Tonkin Consulting in 2008 and have been adjusted for inflation to get the present (2018) value. The past work estimated this value from reviewing several flood damage assessments that were undertaken in Adelaide.

An additional $500 worth of damage was added to residential allotments if more than 10% of the allotment area was inundated by waters greater than 100 mm deep. This was to account for damage caused by the high velocities of flood water passing through allotments on steep sloping land.

Small non-residential allotments

Non-residential allotments with an area less than 1,000 m^2 were considered damaged if the flood depth at the centroid of the allotment was greater than 100 mm, assuming that the FFL of the buildings are 100 mm above ground level.

If the allotment was considered damaged, then the damage was calculated using a flat rate based on the damage category of the allotment. The adopted flat rates for each of the damage categories are summarised in Table 7.2.

Table 7.2 Damage flat rate for small non-residential allotments

Damage potential category	Flat rate per damaged allotment
Low	$4,000
Medium	$32,000
High	$80,000

Large non-residential allotments

Damages for non-residential allotments with an area greater than or equal to 1,000 m² were calculated based on the flooded area within the allotment. The flooded area within an allotment was taken as the area where flood depths were greater than 100 mm. The flooded area was multiplied by a unit rate to calculate the direct damage within that allotment.

The adopted damage rates are shown in Table 7.3

Table 7.3 Damage unit rate for large non-residential allotments

Damage potential category	Damage per square meterage of flooded area
Low	$5
Medium	$40
High	$100

Note that the unit rate for 'low' category allotments within the Gawler Belt region was reduced to $0.25 per square meterage of flooded area. This is to account for the fact that the Gawler Belt region predominantly consists of rural land that is likely to incur minimal damage when flooding occurs.

Indirect damages

The indirect damages were calculated as a percentage of the direct damage. Indirect damages include the emergency response to flood, as well as the disruption to normal and commercial activities which occur subsequent to the direct damage of physical assets, such as to the disruption of employment and commerce. The adopted percentages are summarised in Table 7.4.

Table 7.4 Indirect damage factors

Damage potential category	Indirect factor (%)
Residential	15
Low	15
Medium	60
High	60

The indirect damage for medium to high category allotments was estimated to be 60% of the direct damage, as there is likely to be a high disruption to services, transport and commerce (Kates, 1965; URS, 2005). The indirect damages for residential and low category allotments was estimated to be 15% of the direct damages due to the lower disruption potential.

Conversion to actual damages

The direct and indirect damages are not equivalent to realised damages due to mitigating factors such as the community's preparedness to flooding. Given the rapid response time of the urban catchments, a potential to actual conversion of 0.9 has been adopted for all urban areas. Due to the delayed response time of the rural catchments, a potential to actual conversion factor of 0.8 was adopted for rural areas. These values are based on Table 3.5 of the *Rapid Appraisal Method for Floodplain Management* report (DNRE, 2000).

Exclusions

The following damages have not been accounted for:

- damage to roads or vehicles
- economic costs due to injury or loss of life, stress or other intangible damages.

These damages cannot be easily assessed as part of a cadastral-based assessment and have therefore not been included. However, they can be a significant component of the total damage caused by flooding and while they cannot be compared in dollar terms, they can be found to be more important than tangible losses (Queensland Government, 2002).

7.1.3 Results

The flood damages were grouped using the following zones (shown on Figure 7.2):

- **Zone 1:** Gawler Belt region (zone area 9.8 km^2)
- **Zone 2:** Hewett catchment draining to the North Para River (2.4 km^2)
- **Zone 3:** Willaston catchment draining to the North Para River (3.3 km^2)
- **Zone 4:** the portion of Gawler East and Gawler draining to the South Para River (2.3 km^2)
- **Zone 5:** the portion of Gawler East that drains to the North Para River (3.1 km^2)
- **Zone 6:** Barossa Council region (2.5 km^2)
- **Zone 7**: southern portion draining directly to the Gawler and South Para rivers (3.1 km^2)
- **Zone 8**: southern portion draining south towards the Doudney Avenue reserve (3.5 km^2)
- **Zone 9:** southern portion draining north towards the Doudney Avenue reserve (3.2 km^2).

Actual flood damages

The actual flood damages for each of the modelled scenarios are summarised in Table 7.5 and are shown in Figure 7.3. The 0.2% AEP results are not shown on Figure 7.3 for the purpose of clarity. A more detailed breakdown of the actual damages for each of the modelled scenarios is provided in Appendix G. The data in Appendix G includes a breakup of the number of properties that register as damaged based on the aforementioned criteria, as well as the actual damages for each of the modelled scenarios.

In the smaller events (20% and 5% AEP) a large portion of the allotments which incur damages (roughly 40 to 60%) are low category rural properties, most of which are in the Gawler Belt area. Most allotments within the urban areas do not experience flooding during these smaller events as flows are either conveyed within the underground drainage system or contained within the road reserve. The rural areas have minimal underground drainage infrastructure and most of the roads do not have a kerb and gutter system to contain flows within the road reserve. This results in flows through private properties.

While most of the properties that incur damages are classified as "low damage potential", the portion of the actual damages that results from the flooding of these properties is relatively low. This reflects the fact that these allotments comprise large open areas that allow flows to move through the property without causing significant damage to dwellings. The majority of actual damages result from the flooding of "high damage potential" and residential category allotments which have a greater economic risk associated with flooding.

In the larger events (1% and 0.2% AEP) a significant number of the damaged allotments, as well as a significant portion of the damages, result from the flooding of residential allotments, particularly within Zones 8 and 9. This results from the flows exceeding the capacity of the formal (minor and major) flow paths, causing the flooding of private property. Some of the key locations where extensive flooding results in damages to groups of residential properties include:

- allotments bounded by Sheriff Street, Adelaide Road, Third Street and Mount Terrace, Gawler South
- allotments bounded by Railway Crescent, Przibilla Drive, Hillier Road and Para Road, Evanston
- allotments fronting Brooks Avenue, Willaston
- allotments along Davies Street, Princess Street and Holmes Street, Willaston.

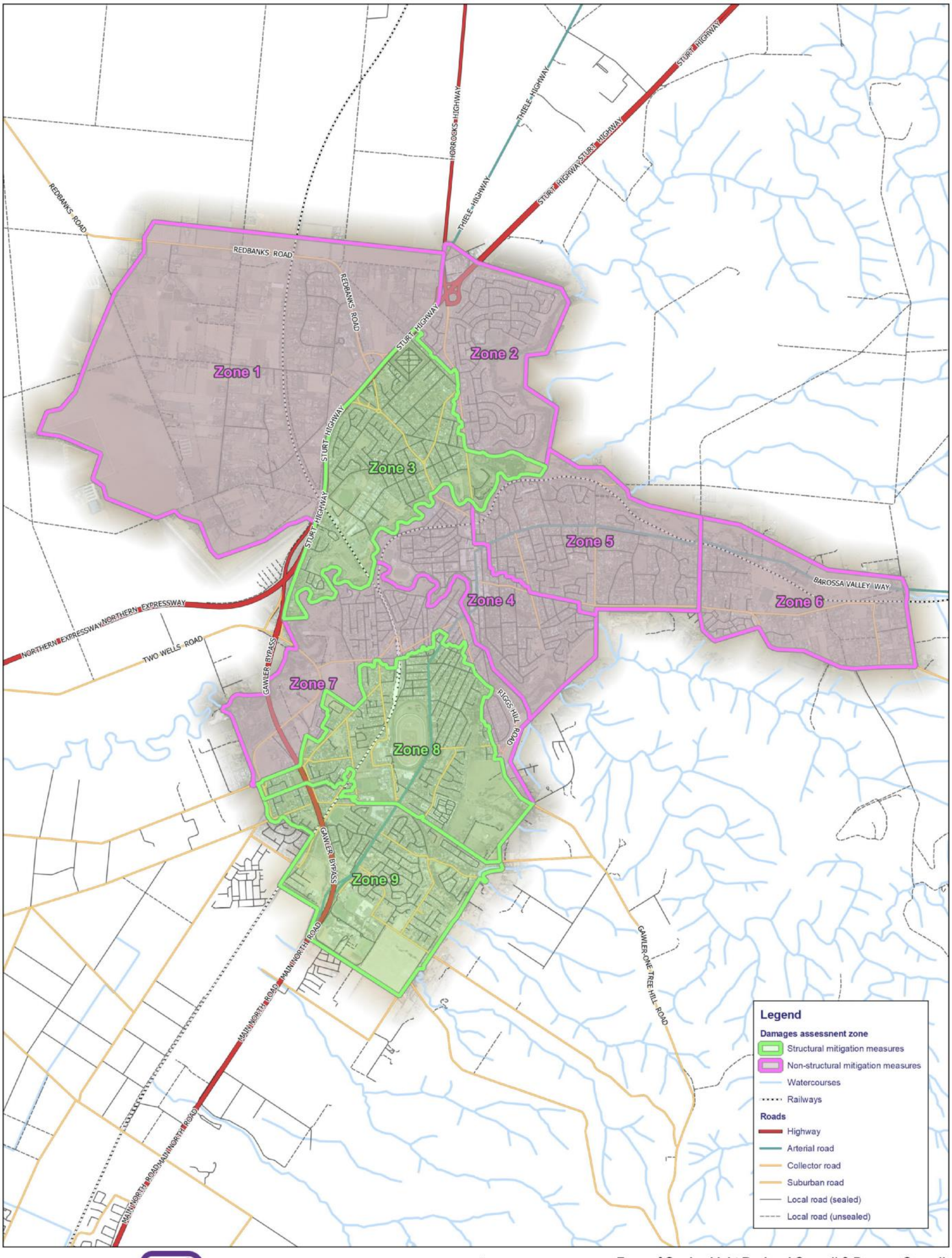
The largest flood damages occur within Zones 3, 8 and 9. Most of these damages can be significantly reduced (by up to 50% in a 1% AEP event) through the implementation of the proposed flood management strategies described in Section 5.1.

No structural mitigation measures are proposed for zones 1, 2, 4, 5, 6 and 7. Non-structural measures are proposed to reduce damages in these areas, however, so as not to overestimate the benefits realised from non-structural mitigation measures (which cannot be quantified), only structural measures have been included in the flood modelling. Hence, zones without structural measures show no reduction in damages.

Table 7.5 Actual flood damages in million dollars

Zone	Scenario	Annual Exceedance Probability			
		20%	5%	1%	0.2%
Zone 1 (Non-structural mitigation measures)	Existing	$ 0.28	$ 0.85	$ 1.71	$ 3.29
	Long term	$ 0.29	$ 0.90	$ 1.79	$ 3.29
	Management strategies	$ 0.29	$ 0.90	$ 1.79	$ 3.29
Zone 2 (Non-structural mitigation measures)	Existing	$ 0.04	$ 0.11	$ 0.39	$ 0.99
	Long term	$ 0.10	$ 0.18	$ 0.45	$ 1.01
	Management strategies	$ 0.10	$ 0.18	$ 0.45	$ 1.01
Zone 3 (Structural mitigation measures)	Existing	$ 0.33	$ 0.57	$ 1.97	$ 10.39
	Long term	$ 0.50	$ 0.91	$ 2.85	$ 11.41
	Management strategies	$ 0.32	$ 0.54	$ 1.42	$ 6.37
Zone 4 (Non-structural mitigation measures)	Existing	$ 0.41	$ 0.71	$ 1.34	$ 6.33
	Long term	$ 0.43	$ 0.74	$ 1.44	$ 6.37
	Management strategies	$ 0.43	$ 0.74	$ 1.44	$ 6.37
Zone 5	Existing	$ 0.14	$ 0.20	$ 0.54	$ 2.42

Zone	Scenario	Annual Exceedance Probability			
		20%	5%	1%	0.2%
(Non-structural mitigation measures)	Long term	$ 0.16	$ 0.28	$ 0.71	$ 2.50
	Management strategies	$ 0.16	$ 0.28	$ 0.71	$ 2.50
Zone 6 (Non-structural mitigation measures)	Existing	$ 0.13	$ 0.29	$ 0.55	$ 0.91
	Long term	$ 0.14	$ 0.30	$ 0.57	$ 0.91
	Management strategies	$ 0.14	$ 0.30	$ 0.57	$ 0.91
Zone 7 (Non-structural mitigation measures)	Existing	$ 0.09	$ 0.13	$ 0.37	$ 2.35
	Long term	$ 0.12	$ 0.18	$ 0.47	$ 2.46
	Management strategies	$ 0.12	$ 0.18	$ 0.47	$ 2.34
Zone 8 (Structural mitigation measures)	Existing	$ 0.13	$ 0.37	$ 1.85	$ 15.31
	Long term	$ 0.51	$ 1.42	$ 4.75	$ 16.01
	Management strategies	$ 0.21	$ 1.08	$ 2.01	$ 11.73
Zone 9 (Structural mitigation measures)	Existing	$ 0.36	$ 0.89	$ 2.15	$ 13.41
	Long term	$ 0.44	$ 1.09	$ 2.52	$ 13.51
	Management strategies	$ 0.44	$ 0.91	$ 1.51	$ 10.37
TOTALS	**Existing**	**$ 1.90**	**$ 4.12**	**$ 10.86**	**$ 55.41**
	Long term	**$ 2.68**	**$ 6.00**	**$ 15.55**	**$ 57.47**
	Management strategies	**$ 2.20**	**$ 5.11**	**$ 10.37**	**$ 44.89**



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Job Number: 20141387
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Data Acknowledgement:
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Town of Gawler, Light Regional Council & Barossa Council

GAWLER AND SURROUNDS STORMWATER MANAGEMENT PLAN
Damages assessment zones

Figure 7.2

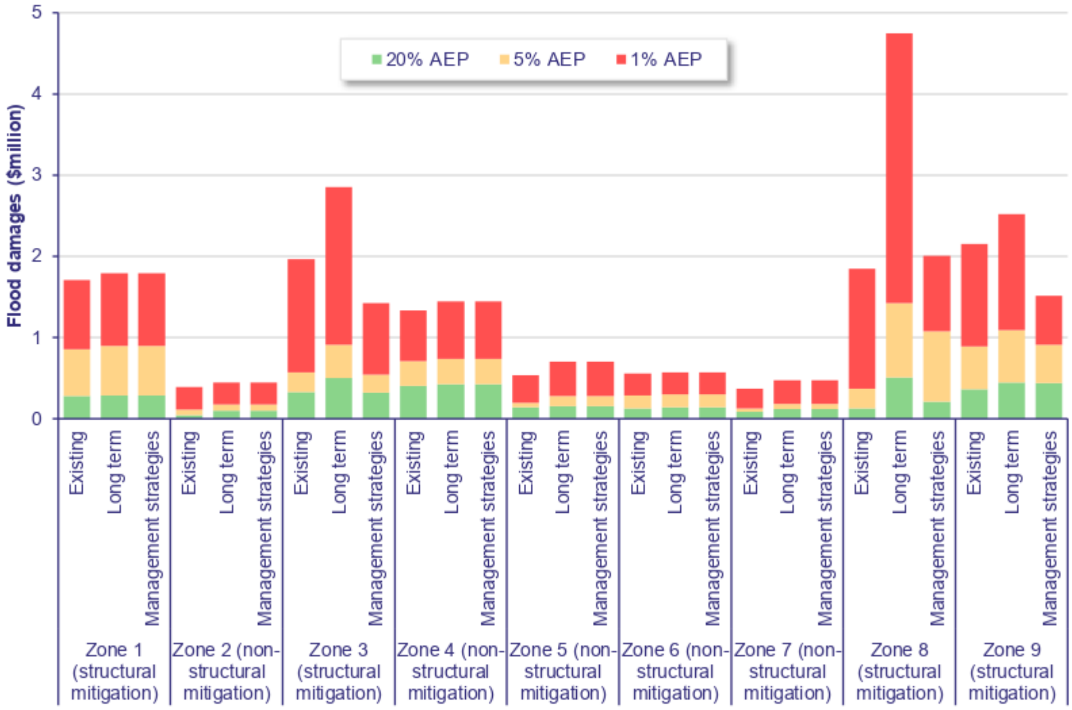

Figure 7.3 Breakdown of the actual flood damages

Annual Average Damages

The annual average damage (AAD) provides an estimate of the annual average expenditure for resolving flood related damages over a long period of time. It balances small, frequent flood damages against rare, but significant flood damages and provides a convenient way to assess the effectiveness of different floodplain management measures. It is a probability-weighted mean of the actual flood damages and is equivalent to the area beneath the damage-probability curve. The damage-probability curves for each of the modelled scenarios are shown in Figure 7.4.

For the purpose of calculating the AAD it has been assumed that the underground drainage network is capable of conveying flows generated by events with an AEP of 39.35% and greater. This means that there are no (or minimal) damages resulting from these events. They are therefore excluded from the assessment of AAD. The AADs for the modelled scenarios are summarised in Table 7.6.

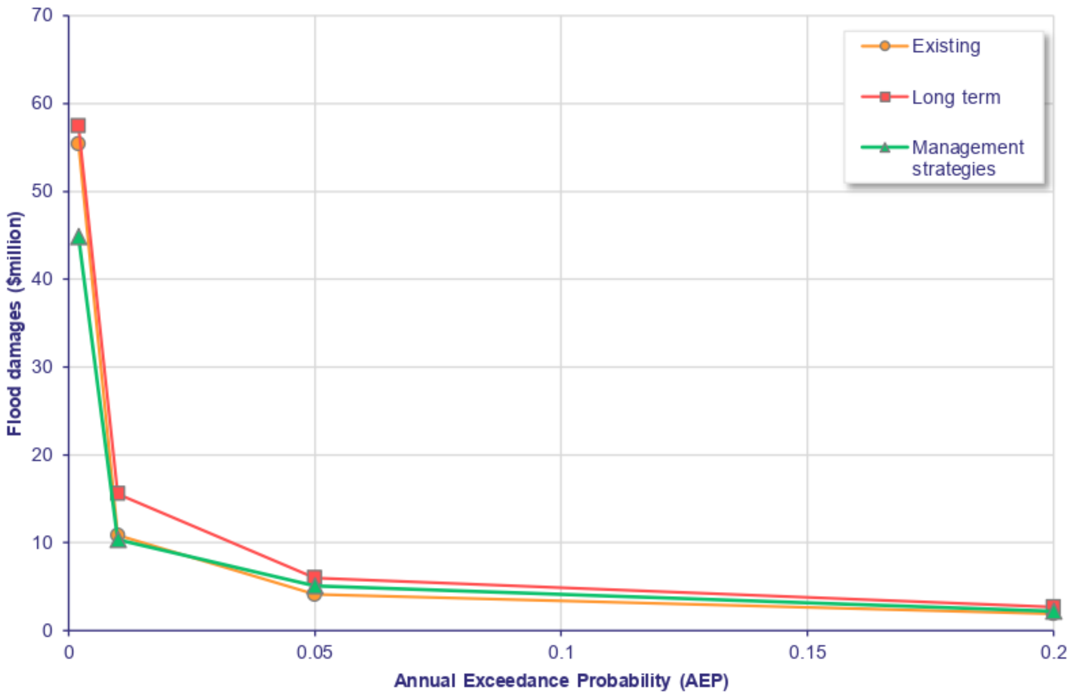

Figure 7.4 Damage-probability curve

7.2 Economic assessment

An economic assessment has been undertaken for a number of the flood management strategies described in Section 5.1. The benefit has been quantified based on the resultant reduction in annual average damage (AAD) for the long-term development scenario with and without the flood management strategies.

As a single hydraulic model was used to assess all of the flood management strategies, it was difficult to assess the reduction in flooding and associated damages for each of the distinct management strategies. Instead the economic assessment was undertaken for each zone. The allocation of the modelled flood management strategies between the zones is summarised in Table 7.7.

Table 7.6 Annual average damages

Zone	Existing	Long term	Management strategies
1	$ 183,000	$ 191,000	$ 191,000
2	$ 32,000	$ 49,000	$ 48,000
3	$ 200,000	$ 287,000	$ 167,000
4	$ 195,000	$ 203,000	$ 203,000
5	$ 65,000	$ 80,000	$ 80,000
6	$ 66,000	$ 70,000	$ 70,000
7	$ 46,000	$ 59,000	$ 58,000
8	$ 163,000	$ 401,000	$ 234,000
9	$ 252,000	$ 294,000	$ 240,000
Total	**$ 1,202,000**	**$ 1,634,000**	**$ 1,291,000**

Table 7.7 Grouping of management strategies for the economic assessment

Zone	Management strategies
1	None
2	None
3	Jarvis Street drainage upgrades, Willaston drainage upgrades
4	None
5	None
6	None
7	None
8	Gawler racecourse flood control basin, Potts Road detention basin
9	Evanston Park flood control basin, Trinity College creek upgrades and the parallel pipe upgrade under Evanston Park

The costs (capital and ongoing) of the flood management strategies and the modelled reductions in AAD for each zone are summarised in Table 7.8. The overall reduction in AAD is $343,000 which represents a 21% reduction in the total AAD of $1.63 million for the study area. The percentage reduction in AAD for each zone is 18% for zone 9 and 42% for zones 3 and 8. The greatest reduction in actual AAD occurs in zone 8, with a $167,000 reduction.

The capital costs associated with each of the flood management strategies have been taken from Section 6.1 but have excluded components specifically related to water quality improvement. Some of the strategies will have ongoing maintenance costs. These ongoing costs have been estimated using costing information that is available within the appendices of the MUSIC User Manual (eWater, 2009).

Table 7.8 Summary of costs

Zone	Capital cost ($million)	Annual maintenance cost ($)	Reduction in AAD ($)	Reduction in AAD (%)
3	4.3	0	120,000	42
8	6.3	108,000	167,000	42
9	1.3	12,000	54,000	18
All	**12.0**	**120,000**	**341,000**	**21**

The economic assessment, which is summarised in Table 7.9, has been based on a discount rate of 4.5% across a 50-year time horizon. The assessment assumes the following:

- Net Present Value (NPV): the difference between the present value of cash inflows and the present value of cash outflows over the 50-year period. The zone having the highest NPV would have the greatest long-term benefit.
- Benefit-Cost Ratio (BCR): ratio between the NPV of the benefits and the NPV of the costs. A ratio greater than 1 indicates a project of which the benefits outweigh the costs. The higher the benefit cost ratio, the greater the value of the investment.
- Internal Rate of Return (IRR): the rate at which all cash flow needs to be discounted at to achieve a NPV of zero. The higher the value the more attractive the project.

Table 7.9 Economic assessment

Zone	Internal Rate of Return (%)	Net Present Value ($million)	Benefit-Cost Ratio
3	1.4	-2.0	0.55
8	-2.6	-5.0	0.39
9	1.9	-0.5	0.68
All	**-0.3**	**-12.5**	**0.47**

While all of the strategies show a significant reduction in the AAD, all of them have a negative NPV with a BCR less than 1, suggesting that the costs outweigh the benefits. This analysis is based on monetized benefits only and does not include consideration of other benefits (such as social, environmental) that may be realised by the project.

The outcomes of the economic analysis suggest that the flood management strategies within Zone 9, which include the Evanston Park flood control basin and the creek upgrade works within Trinity College, provide the best value in economic terms. These works have the highest BCR which is a result of low costs and a relatively large reduction in AAD.

8 Optimised decision-making methodology

8.1 Background

"Optimised Decision Making Guidelines (ODMG): A sustainable approach to managing infrastructure" was developed by the New Zealand National Asset Management Steering Group in 2004. The guidelines were developed to *"...allow the application of the very best management techniques and practices to ensure that the decisions made on maintaining, renewing and investing in new assets are both optimal and sustainable"*.

The ODMG are particularly suited to the solving of a single problem or opportunity with a number of worked examples given within the guidelines such as:

- Footpath renewal
- Wastewater treatment plant upgrade
- Road realignment
- Stormwater flooding at a particular location

The development of this SMP has required the selection of solution(s) to identified problem(s) from a range of available solutions. The ODMG process has been applied as a tool to support the decision-making process, considering a range of objectives.

8.2 Process overview

The process to implement the ODMG is flexible, and in the application of the preparation of this SMP has been implemented according to a four-step process as described below.

Step 1 – Define the problem or opportunity

The definitions are generally concise, well defined and typically relate to a particular problem (such as a flooding hotspot) or desire to achieve a particular objective (such as a catchment water harvesting target).

Step 2 – Identify potential options to manage the problem or opportunity

This step requires the broad identification of all possible solutions. Alongside these, a list of non-negotiable criteria ('deal breakers' such as performance standards and use of valuable open space) would apply, some of which may emerge in response to the nature of the solutions put forward. The options list is then subsequently cut down to a shortlist of potential options according to these criteria.

Step 3 – Multi-criteria analysis of the potential options

The options are evaluated against a range of criteria that may include economic, environmental and social considerations. Each option is scored against each of the criteria which are given a weighting based on their relative importance.

Step 4 – Identify the optimal solution

This step generally involves selecting a solution that obtains the highest score in the evaluation process.

8.3 Multi-criteria analysis

Step 1 of the process has been to define the problem or opportunity. In the context of this SMP it has been to set up a framework for the holistic management of stormwater within the study area.

Options for the management of stormwater within the study area have been developed as part of the SMP (step 2 of the ODMG). As part of optimising the selection of strategies for implementation, a multi-criteria analysis has been undertaken. The analysis assesses each option against six main evaluation criteria. A number of sub-criteria within each area have also been established. Each of these is described in more detail below.

8.3.1 Flood protection of development

A number of areas throughout the Gawler and Surrounds SMP area have been identified as being flood prone. The weighting assigned to this criterion is related to the likely improvement in flood risk in at least one of the known flood prone areas.

Given that the modelling has shown a number of relatively significant flood prone areas, and that flooding is a key consideration of the SMP, the weighting for this criterion is relatively high.

8.3.2 Runoff quality and impact on receiving environment

This criterion has been further divided into four sub-criteria. These criteria can be modelled within MUSIC.

Little runoff from the study area would make its way out to the ocean as it will infiltrate into the bed of the Gawler River, except during winter when there would be significant dilution from the large rural upstream catchment. The main impact is to improve aquatic habitat within the Gawler River, which is ephemeral. During summer, the main contribution of flow into Gawler River is from the study area due to its developed nature. The water quality weightings have therefore been given a moderate weighting.

Reduction in gross pollutants

The reduction in gross pollutants is compared against acceptable quantities entering the Para or Gawler Rivers. A desirable target would be to significantly reduce gross pollutants entering the downstream river system. A 90% reduction target is selected as in accordance with SA Government water sensitive urban design policy.

Reduction in suspended solids

The reduction in suspended solids is compared against current quantities entering the Para or Gawler Rivers. A desirable target would be to reduce suspended solids below current levels, with the aspirational target of an 80% reduction.

Reduction in nitrogen

The reduction in nitrogen is compared against current quantities entering the Para or Gawler Rivers. A desirable target would be to limit nitrogen to the below current levels, with an aspirational target of 45% across the area.

Reduction in phosphorus

The reduction in phosphorus is compared against acceptable quantities entering the Para or Gawler Rivers. A desirable target would be to limit phosphorus to the below current levels, with an aspirational target of a 60% reduction across the area.

8.3.3 Beneficial use of stormwater

The study area is largely within the bounds of the Western Mount Lofty Ranges WAP. DEW have advised that all of the available water allocations have been allocated and therefore the opportunities for any new large-scale water harvesting schemes is small. On this basis, the beneficial use of stormwater has been assigned a relatively low weighting.

Direct infiltration

The passive infiltration of surface water into the underlying shallow aquifer and the irrigation of vegetated areas such that downstream flows mimic the predevelopment flow regime.

Storage and reuse

This involves aquifer storage and recovery (ASR) into deep aquifers. A target for reuse would be for the ASR to provide a noticeable reduction in mains water usage under a normal (non-drought) operational scenario.

8.3.4 Social values

Given the heavily urbanised nature of a large portion of the study area, this criterion has been given a moderate rating.

Improved visual amenity

This criterion would include removal of concrete and paved areas and replacement with landscaped areas and the general improvement of amenity by constructing landscaped drainage elements (such as wetlands, WSUD). Nuisance flooding can result in spreading of unsightly debris and result in minor erosion. WSUD features also have the potential to improve visual amenity if they result in improved vegetative health through increased infiltration via tree pits or permeable paving.

Improved public safety

This would be related to issues such as reducing fast flowing waters and reducing dangerous flood risk.

Additional useful open space

This could include improving the functionality and the services available within an area of open space that is currently unavailable for public use.

Disruption during construction

The implementation of some items of new infrastructure may result in disruption to the public. This could include physical displacement and traffic disruptions during construction.

8.3.5 Habitat and biodiversity

This criterion has been given a moderate rating, which is considered a balance between the aspirational targets of environmental protection and enhancement and the current, highly modified nature of the watercourse within the study area.

Habitat creation

Some stormwater related works have the potential to create new areas of habitat. This would predominantly be within regional scale facilities such as wetlands and basins.

Increased biodiversity

Regional scale stormwater facilities may be able to provide increased biodiversity in the area by providing new types of habitat.

8.3.6 Capital and maintenance cost

The affordability of management strategies is considered critical and hence this criterion has been assigned a relatively high weighting.

Capital cost

The capital cost criteria relates to the upfront capital cost of the proposed works. This would be compared against what could reasonably be afforded by Council and the sources of financial support that may be available for each strategy.

ECONOMIC VIABILITY

The economic viability compares the capital cost of the works to the benefits derived from less flood damages to enable the derivation of a benefit to cost ratio. Due to the inability to quantify the benefits, the economic viability of non-structural works has been made qualitatively.

RECURRING/MAINTENANCE COST

Once established most new infrastructure will require some form of maintenance therefore representing ongoing costs for Council. Consideration of ongoing costs is important when considering the affordability of the works.

8.4 Criteria

Following consultation with the Steering Committee the weightings shown in Table 8.1 were applied to the main assessment criteria. Table 8.2 shows the weightings that have been applied to each of the sub-criteria.

Table 8.1 Weighting of main criteria

Criteria	Weighting
Flood protection of development	25
Runoff quality and impact on receiving environment	20
Beneficial use of stormwater	10
Social values	10
Environmental benefit	10
Capital cost, maintenance cost and economic viability	25
TOTAL	100

Table 8.2 Weighting of sub-criteria

Criteria	Sub-Weighting
Flood protection of development	
Improved flood protection	100
Runoff quality and impact on receiving environment	
Reduction in gross pollutants	25
Reduction in suspended solids	25
Reduction in nitrogen	25
Reduction in phosphorus	25
Beneficial use of stormwater	
Storage and reuse	60

Criteria	Sub-Weighting
Direct infiltration	40
Social values	
Improved visual amenity	35
Improved public safety	20
Additional useful open space	35
Disruption during construction	10
Habitat and biodiversity	
Habitat creation	70
Increased biodiversity	30
Capital and maintenance cost	
Capital cost	45
Economic viability	45
Maintenance cost	10

Each option was given a rating against each criterion. The ratings used for each criterion ranged from 0 through to 4. More information as to how each criteria was rated is provided in Table 8.3.

Table 8.3 Criterion weighting guide

Rating	Capital, economic viability and maintenance cost
0	Significant costs incurred. Major Council expenditure. Would require significant forward financial planning. Benefit/cost ratio significantly lower than other options and below 1.0.
1	Large costs incurred. Large Council expenditure. Likely to require changes to Council financial planning. Benefit/cost ratio moderately lower than other options
2	Moderate cost option. Likely to be accommodated based on existing Council budgets. Benefit/cost ratio similar to other options
3	Low cost option. Benefit/cost ratio moderately higher than other options
4	Insignificant cost option. Benefit/cost ratio significantly higher than other options and above 1.0.

Table 8.3 Criterion weighting guide (continued)

Rating	Flood protection of development
0	No improvement to existing flood risk
1	Low level of improvement to flood risk
2	Moderate improvement to flood risk
3	Large improvement to flood risk. Flood protection during 10%–2% AEP event
4	Large improvement to flood risk. Flood protection during 1% AEP event, the maximum level that can reasonably be expected.

Rating	Runoff quality and impact on receiving environment
0	No improvement in water quality
1	Low level of improvement in downstream water quality
2	Moderate improvement in downstream water quality
3	Large improvement in downstream water quality
4	Significant improvement in downstream water quality. Maximum level of improvement that could reasonably be achieved.

Rating	Environmental benefit
0	No environmental benefit
1	Low level of environmental benefit
2	Moderate environmental benefit
3	Large environmental benefit
4	Significant environmental benefit. Maximum level of improvement that could reasonably be achieved.

Table 8.3 Criterion weighting guide (continued)

Rating	Social values
0	No improvement in social values
1	Low level of improvement in social values
2	Moderate improvement in social values
3	Large improvement in social values
4	Significant improvement in social values. Maximum level of improvement that could reasonably be achieved.

Rating	Beneficial use of stormwater
0	No beneficial use of stormwater
1	Low level of beneficial use of stormwater
2	Moderate beneficial use of stormwater
3	Large beneficial use of stormwater
4	Significant beneficial use of stormwater. Maximum level of improvement that could reasonably be achieved.

8.5 Assessment of benefits through implementation of the multi-criteria assessment

Each of the main stormwater management strategies has been assessed using the multi-criteria analysis framework described above. A summary of the resultant ratings (out of a maximum possible score of 100) is provided in Table 8.4. A full breakdown of the analysis is contained within Appendix I.

Table 8.4 Summary of multi-criteria assessment

Works Description	Flood protection	Runoff quality	Beneficial use	Social values	Environ-mental benefit	Economics	Total score
Gawler Racecourse basin	18.8	16.2	4.0	5.0	7.5	2.8	54.3
Tingara Road basin	18.8	5.0	1.0	2.4	0	10.3	37.4
Trinity College	18.8	1.3	1.0	3.9	2.5	9.7	37.1
Jarvis Street	25	0	0	1.0	0	8.1	34.1

Works Description	Flood protection	Runoff quality	Beneficial use	Social values	Environ-mental benefit	Economics	Total score
Gawler East drainage paths	18.8	5.0	1.0	1.6	2.5	4.1	32.9
Potts Road basin	25	10	1	3.8	2.5	6.3	48.5
Gawler Belt rail culverts	18.8	0	1.0	2.0	0	6.9	30.6
Gawler Belt channel	18.8	5	1.0	3.5	1.8	0.6	30.6
Evanston Oval dual pipe	18.8	0	0	1.5	0	10.9	31.2
Hewett rear of allotment drain	18.8	0	0	1.0	0	10.3	30.1
Targeted riparian remediation	0	6.3	1.0	5.6	10	9.7	32.6
GPTs on outlets	0	8.9	0	1.9	0.8	5.6	17.0
Subsidised large rain tanks	6.3	5.0	4.5	1.3	0	12.5	29.5
Raingardens in selected areas	6.3	13.8	3.0	3.1	2.5	11.3	39.9
Localised drainage upgrades	12.5	0	0	1.5	0	13.1	27.1
Utilise flood plain mapping data for new developments	19	0	0	2.4	0	23.8	44.9
Education and awareness	13	5.0	2.5	1.0	2.5	20.9	44.4
Infiltration systems	6.3	8.8	4.0	1.4	0.8	11.9	33.0

Works Description	Flood protection	Runoff quality	Beneficial use	Social values	Environ-mental benefit	Economics	Total score
Corey Street basin outlet optimisation	12.5	1.3	1.0	2.0	0	21.6	38.3

9 Priorities, timeframes, consultation and responsibilities

9.1 Priorities for flood mitigation works

As part of the ODMG methodology a multi-criteria analysis was used to assess the proposed stormwater management strategies against a range of criteria including reduction in flood risk, water reuse and water quality improvements (refer Section 8.5).

The largest reduction in flood risk (based on reduced annual average damage) is realised by works associated with the Gawler Racecourse basin and the Jarvis Street drain.

Some options, such as the Gawler Racecourse flood control basin and wetland, provide benefits in addition to flood mitigation (such as water quality improvement) and therefore score well within the MCA framework. Other options, such as the Jarvis Street drain upgrades, score poorly as they do not offer additional benefits and/or have high capital costs.

Due to the conceptual nature of the proposed works, a safety in design review has not been undertaken for each project as a part of this SMP. A safety in design review would need to be undertaken should any of the concepts be developed further. Some consideration with safety in design has been included, such as recommending appropriately flat batter banks and that safe access would be needed for siting GPTs.

Based on the outcomes of the MCA assessment, the proposed works have been prioritised and listed in decreasing priority in the following sections. This determination of the 'optimal' solution represents the final stage in the ODMG process. A summary of the options is shown in Table 9.1.

The works have been prioritised in the context of this SMP. As the SMP only covers a small portion of the Light Regional Council and Barossa Council, the works in those council areas need to be assessed against other stormwater related works in other parts of the council area.

9.1.1 Priority F1 (high priority): Gawler Racecourse flood control basin and wetland

Flood reduction benefits

The works proposed within the Gawler Racecourse, including associated upstream pipe upgrade works (refer Section 5.1.1 for details) provide fairly significant flood reduction within the residential areas to the east of the basin (shown on Figure 5.13). The reduction in AAD in Zone 8 is the largest in the study area. This reduction is predominantly due to the works associated with the Gawler Racecourse flood control basin.

Water quality improvement

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 a significant reduction in the quantities of pollutants discharged into the receiving waters (refer Section 5.2.2).

Other benefits or impacts

The wetland has the potential to not only improve the visual amenity of the area but could also create additional habitat for local fauna. The wetland may also act to reduce the frequency and volume of runoff that enters the Gawler River thereby more closely mimicking the pre-development hydrological regime.

9.1.2 Priority F2 (high priority): Trinity College creek upgrades, Evanston Oval parallel pipe and Tingara Road flood control basin

Flood reduction benefits

These three strategies collectively reduce flooding by reducing peak flows (due to the flood control basin, refer Section 5.1.2) and providing increased capacity to convey stormwater under the Gawler Bypass (via the Trinity College and under Evanston Oval upgrades, refer sections 5.1.4 and 0 respectively). The combined reduction in flooding associated with these works is shown on Figure 5.13. 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 study area.

All three projects collectively work to reduce flooding in the area and it is recommended that they all be built. The following order of works is recommended based on ease of construction:

- Evanston Oval dual pipe
- Trinity College upgrades
- Evanston Park flood control dam.

Water quality benefits

These schemes 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 to treat low flows. Riparian plantings as part of the Trinity College creek upgrades could also have water quality benefits and prevent bank erosion.

Other benefits or impacts

The works within Trinity College may require the removal of a number of large trees along the creek which currently provide shade to students. This impact could potentially be managed through alternative measures to bank widening, such as shallow flood walls or steep landscaped channel batters (for example, use of gabion baskets), provided student safety is carefully considered. If the final works are well landscaped, they could improve the amenity and functionality of the area in the long term.

9.1.3 Priority F3 (high priority): Utilise flood mapping data for new development

Flood reduction benefits

The floodplain mapping data should be incorporated into the various Councils' GIS systems so that any developments within potentially flood prone areas are flagged for further review to ensure that appropriate controls are implemented, such as floor level controls or retention of overland flood flow paths.

As part of the new planning system, the Planning and Design Code includes flood hazard overlays. If Council has not already done so, hazard mapping should be provided to Planning and Land Use Services.

9.1.4 Priority F4 (high priority): Education and awareness

Flood reduction benefits

For a relatively modest investment, 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. Increased public awareness of flooding allows a more effective response to flooding and has been demonstrated to result in lower damages.

Education and awareness of WSUD in the backyard schemes should also be prioritised.

9.1.5 Priority F5 (high priority): Corey Street basin outlet optimisation

Flood reduction benefits

For a relatively modest investment, 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.

Water quality benefits

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.

9.1.6 Priority F6 (medium priority): Jarvis Street drain upgrade and Willaston drainage upgrade

Flood reduction benefits

The Jarvis Street and Willaston drainage upgrades (refer Section 5.1.5 for details) reduce the deep flooding in the vicinity of Brooks Avenue (refer Figure 5.14), with an associated large reduction in the AAD. The works include both the Jarvis Street drain upgrade and the upgrade to the Willaston drainage system, which Council have recently finished constructing.

Water quality benefits

The works have no water quality benefits, however a GPT could be incorporated within the system, prior to discharge into the North Para River.

Other Benefits or Impacts

The capital costs for the project are significant due to the length of drain required. This results in a fairly poor benefit cost ratio, although this could be improved if a lower standard of protection were adopted. During construction there would be local traffic management impacts as the alignment follows local roads.

9.1.7 Priority F7 (medium priority): Gawler East flow path improvements

Flood reduction benefits

Formalising the Gawler East flow path (refer Section 5.1.6 for details) would prevent the nuisance flooding that occurs across a number of private properties.

Water quality benefits

The open channels proposed through the area would still be vegetated and would provide for some vegetative filtering of flows that pass along them.

Other benefits or impacts

The flow paths would be within Council easements which would allow for maintenance, with minimal impact to the general public.

9.1.8 Priority F8 (medium priority): Hewett rear of allotment drainage

Flood reduction benefits

The rear of allotment drain (refer Section 5.1.10 for details) will prevent nuisance flooding due to runoff from the higher properties sheeting water through the adjacent private properties during large rainfall events.

Other benefits or impacts

Nuisance flooding across property boundaries is not legally allowed and the new drain would reduce the chance of any potential future disputes from arising.

9.1.9 Priority F9 (medium priority): Update floodplain mapping to include climate change

Flood reduction benefits

Flood maps that incorporate considerations for a variety of climate change scenarios could be used to assess if additional measures are required when planning for new development. They can be used to assess risks associated with a reduced level of service provided by critical infrastructure. Knowledge of the impacts of climate change could also be used to test the sensitivity of the proposed flood management measures to changes in climate.

Consideration of climate change will help to develop stormwater management strategies that are robust despite a changing climate. Flood mapping for a single climate change scenario has been undertaken as part of the SMP development. Refer Appendix F for the 1% AEP flood depth map with long-term development, mitigation and 2050 climate change (RCP 8.5).

9.1.10 Priority F10 (medium priority): Updates to strategic plans, infrastructure schemes and requirements for new development areas

Changes to the strategic plans, asset plans and development plans could result in improved management of stormwater, as described in Section 5.1.17, particularly for future growth areas such as Concordia and the Gawler East growth area. Councils should work collaboratively to consider:

- Consistent strategic plans
- Changes to the Development Plan / Planning and Design Code
- Infrastructure schemes.

Updates to the relevant plans are not exclusively for flood mitigation purposes, and should also incorporate requirements for water reuse, water quality, environmental protection and enhancement, and asset management, where relevant.

9.1.11 Priority F11 (low priority, ongoing): Localised drainage upgrades

Flood reduction benefits

Drainage upgrade work would predominantly help to reduce nuisance flooding caused by excessive gutter flow widths and insufficient inlet capacities.

9.1.12 Priority F12 (low priority): Clifford Road drain flow gauge

Flood Reduction Benefits

The gauge would allow for better calibration of a large portion of the study area which would reduce the level of uncertainty within the flood modelling.

9.1.13 Priority F13 (low priority): Flood warning system

Flood Reduction Benefits

If the community are forewarned of the potential for a flood, the magnitude of the social and economic damages could be reduced significantly.

9.1.14 Priority F14 (undetermined priority): Potts Road detention basin

Flood reduction benefits

The main driver for the Potts Road detention basin is to provide a regional scale detention basin to facilitate development upstream of the basin (refer Section 5.1.7 for details). Until development starts to proceed in the upstream catchment, there is little need for the basin.

However, it is recommended that planning and negotiations commence to confirm the land requirements. The design of the detention basin has been complicated by the new Gawler East Link Road passing through the area.

Water quality benefits

The basin could have retention storage at the base which would act as a sedimentation basin. GPTs on the inlets into the basin will provide preliminary treatment which will remove gross pollutants, coarse sediments and free oils. If retention storage could be accommodated within the basin, it would also help to reduce the frequency and volume of flows generated by the upstream catchment.

Other benefits or impacts

A well landscaped basin will have the potential to improve the amenity of the area and could potentially become useful open space.

9.1.15 Priority F15 (not recommended): Gawler Belt railway culvert

During public consultation, several landowners raised concerns about exacerbation of existing poor drainage conditions. For these reasons, this option is not recommended.

Flood reduction benefits

The Gawler Belt railway culvert (refer Section 5.1.8 for details) results in a significant reduction in flood depth east of the railway line (refer Figure 5.15).

Water quality benefits

While the primary objective of the works is flood reduction, the channel downstream of the rail culverts would provide some vegetative filtering of flows and, given its flat longitudinal grade, would facilitate infiltration along the channel. A small step up in the invert of the culvert would also provide upstream retention such that during most events stormwater is still able to infiltrate upstream of the rail culverts.

Other benefits or impacts

Several private landholders would need to be approached to obtain easements over their land.

9.1.16 Priority F16 (not recommended): Gawler Belt interception drain

During public consultation, several landowners raised concerns about this mitigation strategy. Consequently, this option is not recommended.

Flood reduction benefits

The interception drain provides a large reduction in flooding in the 5% AEP event, but only moderate improvements in the 1% AEP event (refer Figure 5.15). Given the widespread nature of flooding and the low value assigned to damages in the Gawler Belt area (due to it being a rural living area) the reduction in AAD is relatively minor.

Water quality benefits

The channel could provide some vegetative filtering of flows and, given its flat longitudinal grade, may facilitate infiltration along the channel.

Other benefits or impacts

The interception channel would create a physical barrier that blocks access across it which would be problematic for some properties.

There may also be difficulties in obtaining land from all affected landowners. The significant capital costs and limited flood reduction benefits mean that the works have the lowest benefit cost ratio of all the mitigation strategies assessed by the SMP.

9.2 Priorities for water reuse

9.2.1 Priority R1 (high priority, ongoing): Infiltration systems – raingardens, permeable paving, tree pits

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 required component of all new road reconstruction projects.

Water quality benefits

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

Other benefits or impacts

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

9.2.2 Priority R2 (medium priority, ongoing): Subsidising large rainwater tanks

Subsidising the installation of residential rainwater tanks larger than the legislated minimum size (refer Section 5.4.1) 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.

9.3 Priorities for water quality

9.3.1 Priority Q1 (high priority, ongoing): Raingardens

In selected areas where there are wide road reserves and relatively flat topography, raingardens should be retrofitted into the existing street network (refer Section 5.2.3 for details). These works should become a required component as a part of any planned roadworks (such as the installation of traffic calming devices and road reconstruction projects). Due to the nature of the study area with areas of steep topography and limited open space the opportunities for the implementation of large scale WSUD infrastructure, such as wetlands, are limited. Therefore, the importance of smaller scale WSUD infrastructure, such as raingardens, is increased.

Raingardens provide improved water quality and facilitate infiltration of small flow events and reductions in nuisance flooding. They provide improved aesthetics and will help to counteract urban heat island effects.

9.3.2 Priority Q2 (high priority, ongoing): Infiltration systems

Installation of infrastructure such as 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. These systems should become a required component of all new road reconstruction projects.

9.3.3 Priority Q3 (medium priority): Gross pollutant traps on outlets

GPTs have been identified as one of the key elements to improve water quality in a number of the locations within the developed areas of the catchment (refer Section 5.2.1 for details).

9.3.4 Priority Q4 (medium priority, ongoing): WSUD in the backyard

Council should work with Water Sensitive SA to promote the concept of WSUD in the backyard. Activities may include the preparation of information materials and periodic publicity to encourage residents to take action at a domestic scale which will improve water quality.

9.4 Priorities for environmental protection and enhancement

9.4.1 Priority E1 (medium priority): Riparian habitat restoration and erosion management

Assessment of the riparian habitats within the study area determined that they mainly 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 (refer Section 5.5.2). These works would also look to minimise erosion risk (refer Section 5.5.3). Furthermore, these works improve both water quality and slow flow rates which further enhances ecological values. The works would also improve amenity.

9.5 Priorities for asset management

9.5.1 Priority A1 (medium priority): Asset inspection program

The CCTV inspection component of the program should be prioritised based on asset age and significance. Once a good asset condition data base has been established the inspection program can focus on infrastructure nearing the end of its service life, so that the assets can be replaced before they fail.

Physical inspections of other assets, such as basins and levee banks, should also be undertaken. Priority should be given to assets where failure could result in significant damages or reductions in water quality.

9.6 Timeframes

A number of the priority stormwater 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 priorities. Table 9.2 presents a 10-year capital works plan to implement the recommendations within this report. The plan is based on a total expenditure of approximately $1.2M per year (comprised of $0.8M from Council and $0.4M from the SMA). Priorities F1, F2 and F6 are all potentially eligible for SMA funding. If the works did not secure SMA funding, it would delay the implementation of the capital works program.

Table 9.1 Summary of priorities

						Flood Mitigation Benefit		Water Harvesting Benefit		Water Quality Benefit		Other Benefits	
Priority	Project/ Activity Title	Objectives Targeted	Capital Cost ($)[1]	SMA / NYLB Funding eligible	Recurrent Cost ($ / annum)	Measure used?	Quantification or Description of Benefit	Measure used?	Quantification or Description of Benefit	Rating	Qualitative Description of Benefit	Rating	Qualitative Description of Benefit
						(D) – AAD Reduction (P) – Properties Affected (Q) – Qualitative		(V) Volumetric (Q) Qualitative		(H) – High (M) – Med (L) – Low		(H) – High (M) – Med (L) – Low	
F1 (High)	Gawler Racecourse Flood Control Basin and Wetland	1.1, 2.2, 2.3, 2.4, 4.1	$5,550,000	Y	$89,000	D	$167,000 (combined with Potts Road basin)	Q	Potential for some harvesting, but unlikely to be economically viable	H	Wetland will provide for large quality improvements	H	Visual amenity and habitat creation
F2 (High)	Tingara Road Basin	1.1	$710,000	Y	Minimal	D	$54,000 (combined with Evanston Oval parallel pipe and Trinity College creek upgrades)	-	-	L	Potential for retention storage to provide sediment capture	L	Improved public safety.
F2 (High)	Evanston Oval parallel pipe	1.1, 1.2	$235,000	Y	Minimal	D	$54,000 (combined with Tingara Road and Trinity College creek upgrades)	-	-	L	No benefits	L	Improved public safety
F2 (High)	Trinity College creek upgrades	1.1	$390,000	Y	$12,000	D	$54,000 (combined with Tingara Road basin and Evanston Oval pipe)	-	-	L	Some filtering of water along channel	L	Improved visual amenity and habitat creation
F3 (High)	Utilise flood mapping data for new development	1.1, 1.4	N/A	-	-	Q	Ensure that new development has a high level of flood protection	-	-	L	No direct improvement	L	Improved public safety
F4 (High)	Education and awareness	1.1, 1.5	$70,000	-	$10,000	Q	Likely to lower flood damages	-	-	M	Public better understand the implications of their actions on the receiving waters	M	Public can better respond to flooding. Better community resilience to flooding.
F5 (High)	Corey Street flood control basin outlet optimisation	1.1, 4.1	$20,000	Y	Minimal	Q	Reduced downstream flooding by retaining more water behind basin	-	-	L	Potential for retention storage to be incorporated into base of basin allowing for sedimentation	L	Improved public safety
Q1/R1 (High)	Raingardens	2.2, 2.3, 2.4, 2.5	$455,000 (15 raingardens)	N	$35,000 (15 raingardens)	Q	Minor improvement to flooding	Q	Able to infiltrate water close to the source and assist with passive irrigation of street trees	H	Large benefits if are constructed in sufficient numbers	M	Can improve amenity, reduce heat island impacts.
Q2 (High)	Infiltration systems (permeable paving, tree pits)	2.2, 2.3, 2.4	Variable (allow $100,000)	N	Variable (allow $50,000-$100,000 per year for roll out)	Q	Minor improvement to flooding	Q	Able to infiltrate water close to the source and assist with passive irrigation of street trees	M	Large benefits if are constructed in sufficient numbers across the catchment	M	Can improve amenity, reduce heat island impacts.
F6 (Medium)	Jarvis Street drainage upgrade	1.2	$3,390,000	P	Minimal	D	$120,000 (in conjunction with Willaston drainage upgrades – already constructed)	-	-	L	Minimal. GPT can be installed at a later date to improve water quality.	L	Improved public safety
F7 (Medium)	Gawler East flow path improvements	4.1	$795,000	N	$15,000	Q	Reduces nuisance flooding to properties along the various flow paths	-	-	L	Infiltration and vegetative filtering	M	Facilitates easy council maintenance access to flow paths. Less nuisance flooding.
F8 (Medium)	Hewett rear of allotment drainage	1.2	$200,000	N	Minimal	P	Reduces nuisance flooding for about 6 properties.	-	-	L	No direct improvement	L	Avoids legal disputes in future
Q3 (Medium)	Gross pollutant traps	2.1	$1,350,000 (7 large GPTs)	P	$35,000 (7 large GPTs)	Q	No benefit	-	-	M	Removal of gross pollutants and sediment	L	Improved amenity with less gross pollutants washed downstream of GPT.
F9 (Medium)	Update floodplain mapping to include climate change	1.6	$20,000	-	-	Q	Helps to assess risk and develop measures			L	No direct improvement	L	Improve public safety
A1 (Medium)	Asset inspections	5.1, 5.2, 5.3	N/A		$30,000	Q	Potentially significant improvement if an asset is identified for remediation/replacement before it fails	-	-	M	Inspections can ensure WSUD assets are performing as originally intended	L	Improve public safely. Proactively identify issues, rather than responding after the problem has occurred

Priority	Project/ Activity Title	Objectives Targeted	Capital Cost ($)[1]	SMA / NYLB Funding eligible	Recurrent Cost ($ / annum)	Flood Mitigation Benefit Measure used? (D) – AAD Reduction (P) – Properties Affected (Q) – Qualitative	Quantification or Description of Benefit	Water Harvesting Benefit Measure used? (V) Volumetric (Q) Qualitative	Quantification or Description of Benefit	Water Quality Benefit Rating (H) – High (M) – Med (L) – Low	Qualitative Description of Benefit	Other Benefits Rating (H) – High (M) – Med (L) – Low	Qualitative Description of Benefit
E1 (Medium)	Riparian habitat restoration	4.2, 4.3	$100,000		$100,000	Q	Appropriate managed watercourses will ensure they are not choked by weeds and reduces erosion risk	-	-	M	Vegetative filtering of water can be enhanced.	M	Improved amenity, habitat and biodiversity
Q4 (Medium)	WSUD in backyard	2.1, 2.2, 2.3, 2.4, 3.1, 3.2	$20,000	N	$10,000	Q	Minor reduction in the amount of runoff generated by a site	-	-	M	Infiltration and vegetative filtering. Large benefits if constructed in sufficient numbers.	M	Visual amenity.
R2 (Medium)	Rainwater tank subsidies	2.5, 3.1, 3.2	Low	N	$50,000	Q	Additional retention of water within the catchment will provide a small improvement in downstream flood risk	Q	Varies on size of roof area, tank size and demand	L	Prevents cleaner roof water intermixing with other less clean stormwater runoff	L	Reduces mains demand.
F10 (Medium)	Consistent strategic plans, changes to development plans, infrastructure schemes	1.1, 1.4, 2.5, 3.1, 3.2, 4.3	Not costed	N	Not costed	Q	Flood mitigation achieved through policy requirements	-	Not quantified	-	Not quantified	L	Consistency in management of stormwater within the catchment across Council boundaries
F11 (Low)	Localised drainage upgrades	1.2	Varied	N	Variable (allow $50,000 per year)	P	Reduce nuisance flooding	-	-	L	No direct improvement, but GPT could be installed on new pipes	L	Improved safety with less nuisance flooding
F12 (Low)	Clifford Road drain flow gauge	-	$15,000	N	$1,000	Q	Allow for better calibration of study area	-	-	L	No direct improvement	L	Improved accuracy of flood predictions.
F13 (Low)	Flood warning system	1.5	Unspecified	N	Unspecified	Q	Provide for a reduction in flood damages by giving people time to prepare for flooding	-	-	L	People may have the opportunity to reduce at source pollutant loads	M	Less intangible flood losses if people are able to prepare for flooding
F14 (Undetermined)	Potts Road detention basin	1.1	$2,480,000	N	$19,000	Q	$167,000 (combined with Gawler Racecourse Flood Basin)	-	-	M	Reduce pollutant loads	M	Can provide amenity and local habitat.
F15 (Not recommended)	Gawler Belt railway culvert	-	$235,000	Y	$11,000	D	$33,000 (in conjunction with Gawler Belt interception drain)	-	-	L	Infiltration and vegetative filtering along channel	L	Improved public safety
F16 (Not recommended)	Gawler Belt interception drain	-	$5,410,000	Y	$37,000	D/P	$33,000 (in conjunction with Gawler Belt railway culvert)	Q	Infiltration along the unlined channel.	L	Infiltration and vegetative filtering	L	Increased safety and amenity
Not recommended	Gawler River levee bank augmentation	-	Not costed	Y	Not costed	Q	Prevent flooding of properties due to break out of the Gawler and Para Rivers	-	-	L	No benefits	L	Improved safety

1: Estimates of capital cost do not allow for costs associated with relocation of services

Table 9.2 10-year capital works plan (values in millions)

Priority	Works	21/ 22	22/ 23	23/ 24	24/ 25	25/ 26	26/ 27	27/ 28	28/ 29	29/30	30/31
F1	Gawler racecourse basin *	0.4	0.4	0.4	0.4	0.4	0.4	0.4			
F2	Trinity College*, Evanston Oval dual pipe*, Evanston basin*								0.4	0.3	
F3, F10	Development controls		0.2								
F4	Flood/WSUD education program	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
F5	Corey Street basin optimisation	0.05									
F6	Jarvis Street drain upgrade*									0.1	0.48
Q1	Raingardens	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Q2	Infiltration systems	0.1		0.1		0.1		0.1		0.1	
E1	Riparian creek works	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
F11	Localised drainage upgrades	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
R2	Large rainwater tanks	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
F9	Climate change flood mapping		0.02								
A1	CCTV inspections	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Q3	GPTs on outlets			0.2			0.2			0.2	
Q4	WSUD in backyard	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	SMA funding#	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.48
Total		**1.39**	**1.43**	**1.51**	**1.21**	**1.31**	**1.41**	**1.31**	**1.21**	**1.51**	**1.37**

* SMA funding eligible.

SMA funding cannot be guaranteed and would be subject to a successful application.

9.7 Responsibilities

The Gawler and Surrounds SMP provides a framework for the management of stormwater within the study area. The Steering Group which has overseen the development of the SMP comprises representatives of key stakeholder organizations that have responsibility for implementing the plan. These includes the Town of Gawler, Light Regional Council and the Barossa Council and representatives of the SMA. However, the primary organisation that will be responsible for the implementation of most of the recommendations contained within the plan will be the Town of Gawler.

Management of flooding from the Gawler River (not covered by the SMP), as well as the management of levees, is the responsibility of the Gawler River Floodplain Management Authority.

The highest priority strategy within the Light Regional Council area is Strategy F8 (Hewett rear-of-allotment drains).

The highest priority capital works for the Barossa Council is the Gawler East flow path improvements (Strategy F7).

All councils will also be required to play an important role in implementing the study and ongoing works related to strategies F3, F4, E1, R1, A1, Q1, Q2 and Q4.

The *Landscape South Australia Act 2019* has replaced the *Natural Resources Management Act 2004*. The area covered by the Gawler and Surrounds SMP now predominantly lies within the Northern and Yorke Landscape Board region, but the southernmost tip of the SMP area falls within the Green Adelaide region.

Each of these Boards has developed a Water Affecting Activities Control Policy that describes the relevant regulatory documents containing the principles that apply to works undertaken at locations across the Landscape regions. Under the policies, works undertaken as part of stormwater management may potentially require a water affecting activity permit to be approved prior to works commencing.

Based on the total cost of all of the works, and assuming a total budget of $1.0 million per year, it is estimated that it would take at least 14 years to complete the implementation of all recommended works.

9.8 Achievement of SMP objectives

This section reviews the level to which the proposed SMP objectives are attained by the priorities set out in the preceding sections. It should be noted that achieving the SMP objectives is a collective and continual effort that must be sustained by all three Councils.

9.8.1 Flood management

The SMP has proposed many management strategies that reduce flooding within the catchment. The management strategies target the most pronounced areas of flooding and are effective in reducing flood damages across the catchment. There are areas that the proposed strategies do not address. However, these areas can be successfully investigated in the future using the detailed flood model produced for the SMP. It should be noted that the implementation of non-structural measures will help to reduce flood damages in these areas as well.

9.8.2 Stormwater quality

The SMP has demonstrated that large improvements in water quality can be achieved throughout the catchment. However, the water quality improvement objectives listed in Section 4.2.2 cannot be met, even if all recommended actions are completed.

Significant coverage of retrofitted WSUD measures across the council areas would be required to achieve the targeted water quality objectives.

9.8.3 Stormwater harvesting and reuse

Stormwater reuse is desirable when it can be achieved cost-effectively. The SMP has found that the financial return of large schemes within the study area is minimal to none. The WAP limits the viability of implementing large scale water harvesting schemes. Widespread rollout of WSUD measures will help to encourage infiltration of stormwater close to its source. Additionally, the continued rollout of large rainwater tanks that are plumbed into houses will help to increase the volume of stormwater harvested in the study area.

9.8.4 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.

9.8.5 Asset management

The SMP presents several strategies that the Councils can implement to manage their stormwater assets effectively. 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.

9.8.6 Summary of objectives

An assessment of whether or not the SMP objectives are achieved is provided in Table 9.3. The priorities that contribute to the achievement of an objective are also listed.

Table 9.3 Attainment of objectives

Objective	Achieved	Priority	Discussion
Flood management			
Objective 1.1	Partial (1% AEP level of flood protection achieved in some areas)	F1, F2, F3, F4, F5, F10, F14	The SMP addresses the most pronounced areas of flooding. Residual areas of flooding are shown in the flood maps. Achieving a 1% AEP standard of protection across the entire SMP area is an aspirational target that could be worked towards over a long timeframe. Significant structural upgrades of drainage infrastructure across the entire catchment would be required to achieve this target. This would not be economically viable for Council across the 10-year planning horizon. Further investigation of additional strategies to provide a 1% AEP standard of protection across the remainder of the catchment will be required once the works within the 10-year capital works plan (Table 9.2) have been implemented.
Objective 1.2	Partial (39.35% AEP pipe standard achieved in some areas)	F2, F8, F6, F11	Local drainage upgrades have been identified, however significant upgrades across the entire SMP area would be required to achieve at least a 39.35% AEP standard for the underground network throughout the whole catchment. As above, this is not economically viable in the short term; works to provide this drainage standard should be identified beyond the 10-year planning horizon.