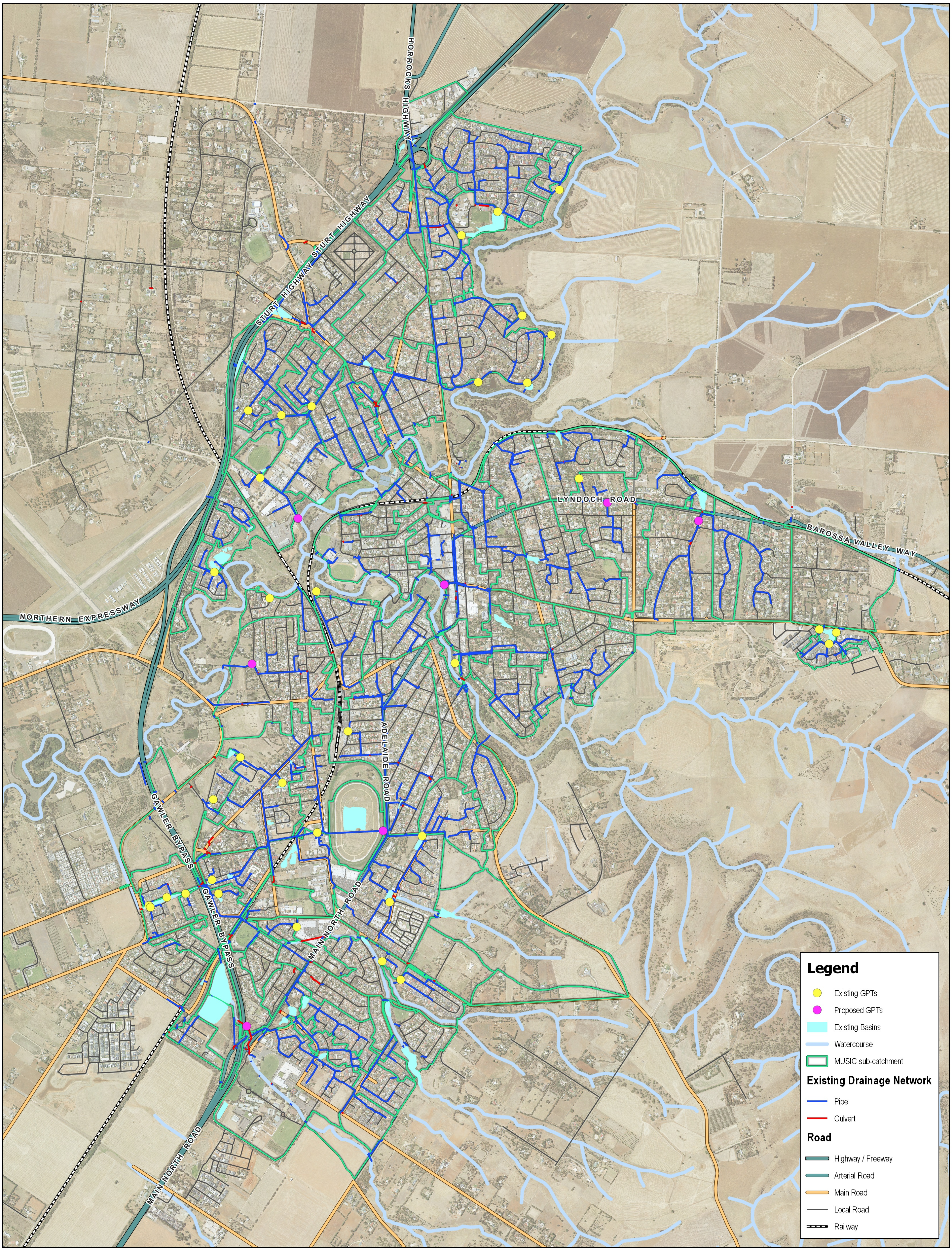

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Town of Gawler, Light Regional Council and The Barossa Council

PRIORITY LOCATIONS FOR THE INSTALLATION OF NEW GPTS

Figure 5.16

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

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 relative 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 1500 mm pipe that runs under the site.

The 2.3 ha basin 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.
- Areas of shallows 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 flood plain 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 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 is a biofiltration system is incorporated into the wetland system. This could be investigated as a part of additional design development of the scheme.

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 bio filtration 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 improve 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/outlet 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.

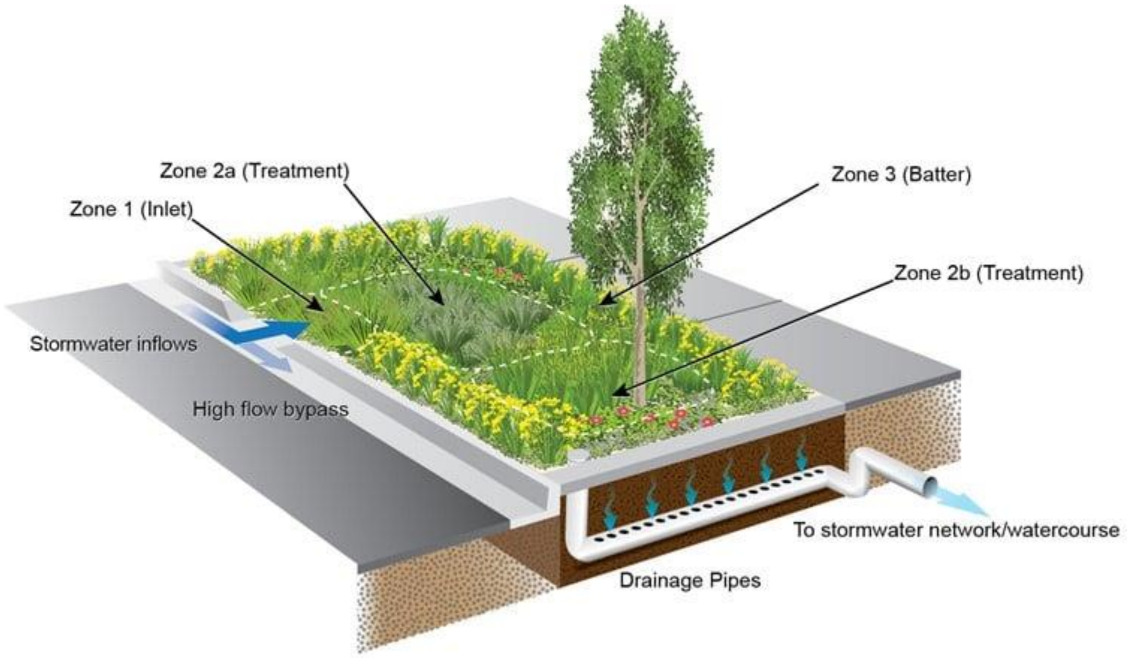


Figure 5.17 Typical layout of a raingarden (Water Sensitive SA)

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.

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

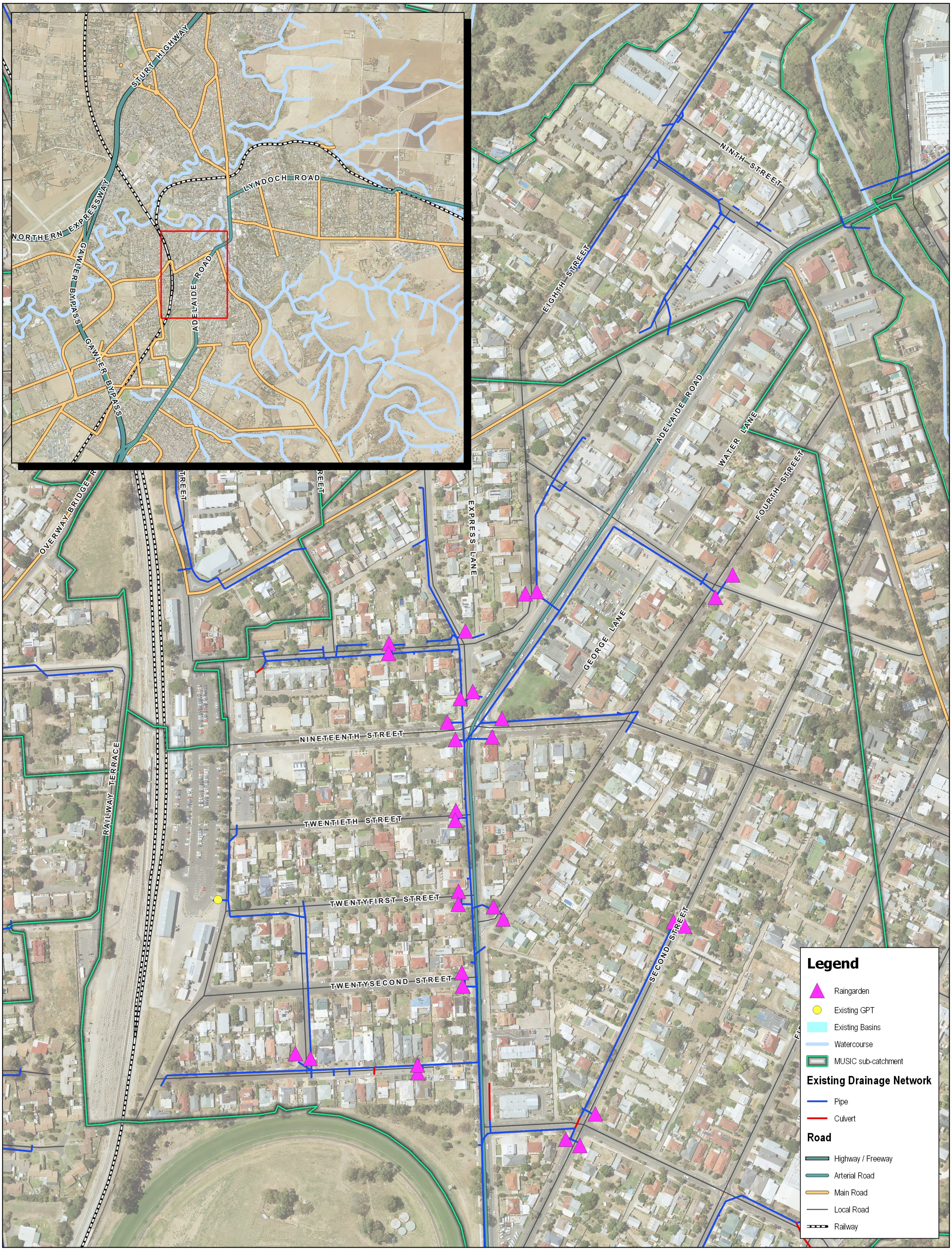
- relatively flat grades
- sufficient space

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 race course 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.



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POTENTIAL RAINGARDEN LOCATIONS IN GAWLER SOUTH

Figure 5.18

The associated water quality improvement effectiveness of the raingardens was assessed using a lumped approach with a single bio retention 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 of 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.

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 of 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 all of the racecourse wetland, proposed raingardens and priority GPTs, as described in this section (in addition to the existing devices) to understand the overall reduction in pollutant loads being discharged into the receiving waters. The modelled reduction in loads is summarised in Table 5.4.

Table 5.4 Modelled whole of catchment water quality improvement

	Reduced load	% reduction	% Target reduction
Flow (ML/yr)	130	4.9	
Total Suspended Solids (t/yr)	236	43.4	80
Total Phosphorus (kg/yr)	334	31.0	60
Total Nitrogen (kg/yr)	790	14.3	45
Gross Pollutants (t/yr)	85.6	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 your 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/

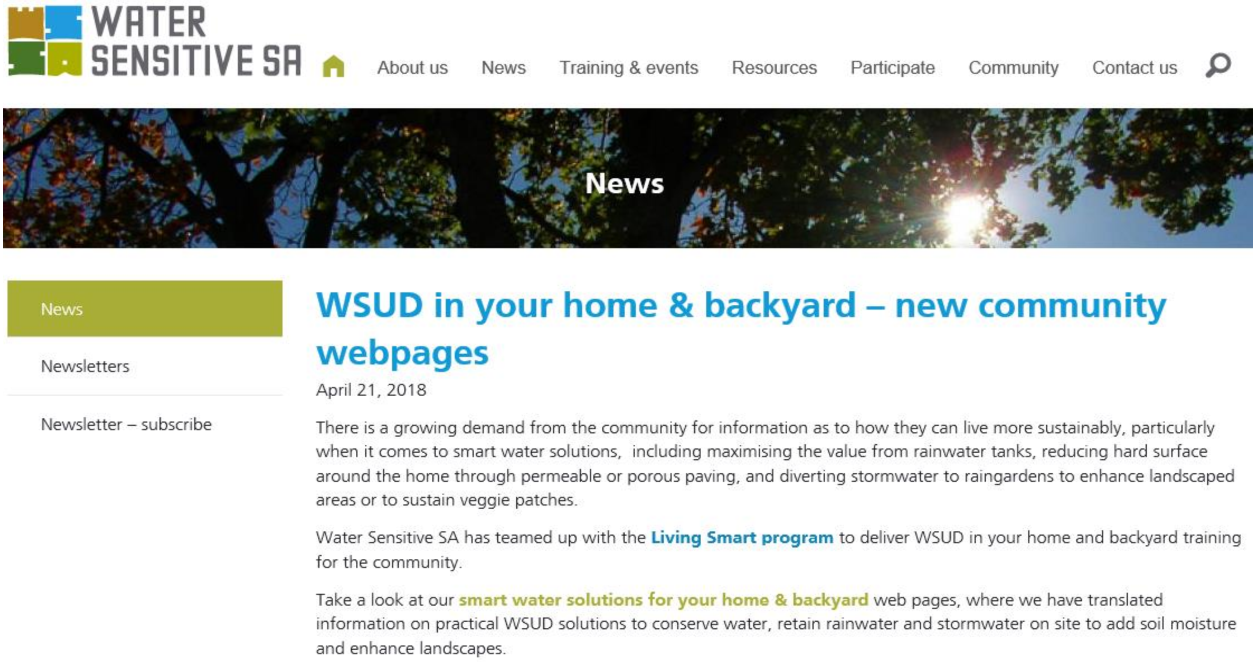


Figure 5.19 The home page for WSUD in your home and backyard (Water Sensitive SA)

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)
- Gawler East Stormwater Infrastructure Study (Tonkin Consulting, 2016).

5.3.1 Concordia

The proposed approach for the incorporation of WSUD into the Concordia development is as follows:

- Incorporation of natural catchment features into the development through the preservation of areas of high habitat and biodiversity (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 prevent bed erosion to 1-2 m/s (Objective 4.2)
- Addition of retention and detention basins to limit stormwater outflows and thus limit flow rates.
- Using the treatment train approach to stormwater 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 Masterplan 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 must 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 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 river bed 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 improving 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 of 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 off line from the receiving watercourse.

In-stream works recommended within larger gullies include the planting of riparian vegetation and weed control. The creation of ephemeral ponds is recommended as the shallow pools would help to retain flows, would 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.

In addition to the 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, bio-filtration 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, bio retention basins and grassed swales should also be accommodated.

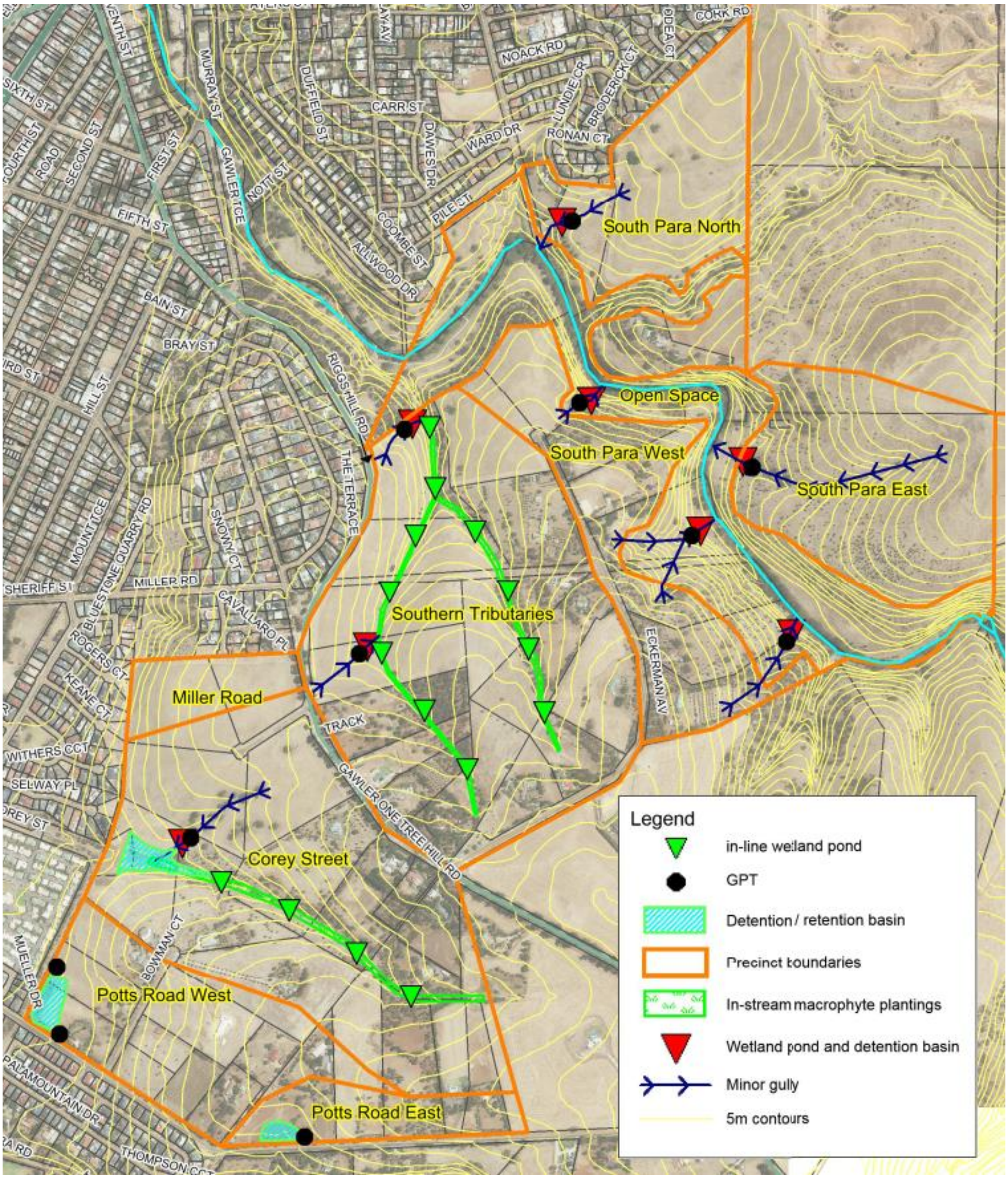


Figure 5.20 In stream water quality improvement works for the Gawler East Growth Area

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 NRM board.

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 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 rain water.

Yield curves showing indicative annual yields for rainwater tanks of various sizes in the Gawler region (assuming a connected roof area of 150 m^2) 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.

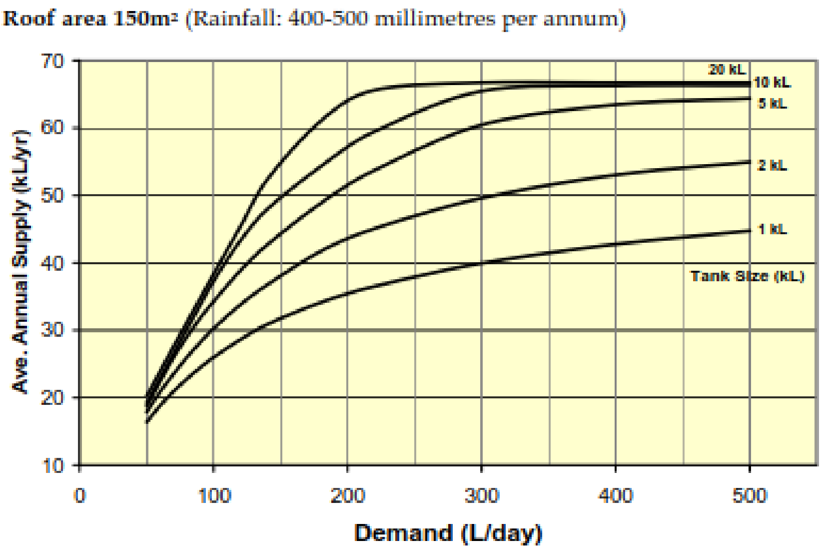


Figure 5.21 Rainwater yield curve for Gawler (150 m^2 roof area) (DPLG, 2010).

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:

- Rain gardens (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) 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.

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 included them into 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 AMLRNRM.
- 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, J. Durant , M. 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 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 will is also likely to improve water quality by reducing erosion risk and encouraging infiltration (BMP recommendations 14, 15, 17, 25, 27, 28, 30)
- Improving habitat diversity within reserve areas that will be used for stormwater management purposes (BMP recommendation 3, 4)
- Management of road side verge areas which will reduce the amount of sediment being washed into the stormwater system and increase biodiversity (BMP recommendation 6, 7, 8, 9, 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 wetland, rain gardens, swales or detention systems provide an opportunity to increase biodiversity, improved amenity, education and recreation facilities as well as provision of habitat for fauna and water quality treatment. These opportunities should be considered when implementing the wetlands, rain gardens, 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 to include accessible open spaces provide an opportunity especially along watercourse corridors for both maintenance and community access.

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 and 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.

5.6 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 was 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 due to 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 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 foot paths, buildings and roads all need to be monitored to ensure that erosions 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 plan 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. It would need to include the following key areas:

- 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. The cost estimates include a 15% allowance for preliminaries, a 20% contingency, as well as GST (10%). 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 wetland and 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, 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 (Evaston 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
Earthworks	$90,000
Land acquisition	$80,000
Miscellaneous	$30,000

Item	Cost
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 relative 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.

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
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 and wetland

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 to be provided below the railway line. Runoff from the culvert will 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 a number of road crossings. As the channel alignment passes through private property for a length of more than 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

Construction of fifteen new streetscape raingardens, used to improve water quality. The cost of these raingardens is shown in Table 6.12 below.

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 flood plain 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. A one off budget of $50,000 should be allowed 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 (e.g. 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 is required for physical inspection of assets, such as watercourses, levees and flood control dams.

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 prioritise 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 Adelaide & Mount Lofty Ranges Natural Resources Management

The Adelaide & Mount Lofty Ranges Natural Resources Management department 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. NRM 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 make a contribution 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 is summarised in Table 6.13 and is 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
Hewett rear of allotment drainage			$200,000		No
Evanston Oval parallel pipe upgrade	$235,000				Yes
TOTAL	**$12,300,000**	**$575,000**	**$5,845,000**	**$675,000**	

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

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 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,
- Gawler Belt railway culvert,
- Gawler Belt interception drain, and
- 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

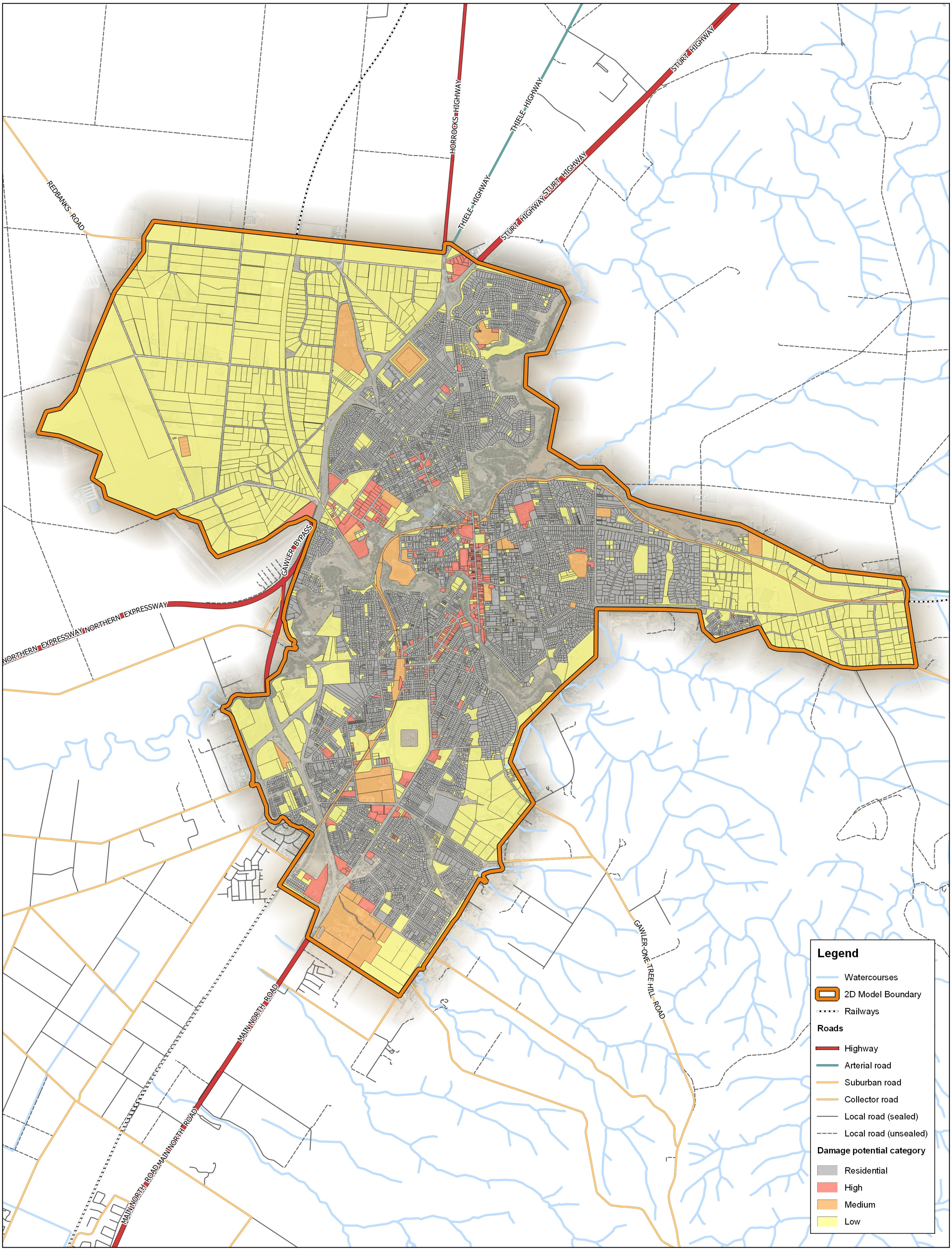
The RAM only requires valuation data for residential allotments. The majority of property valuations were provided by Council. However, for the relevant allotments that were not valued, the following values were adopted:

- $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 m^2. 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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Town of Gawler, Light Regional Council and Barossa Council

DAMAGE POTENTIAL CATEGORIES

tonkin

Job Number: 20141387
Filename: 20141387GQ071A
Revision: B
Date: 2019-03-25
Drawn: DB

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

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 m^2 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 if flooding were to occur.

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.

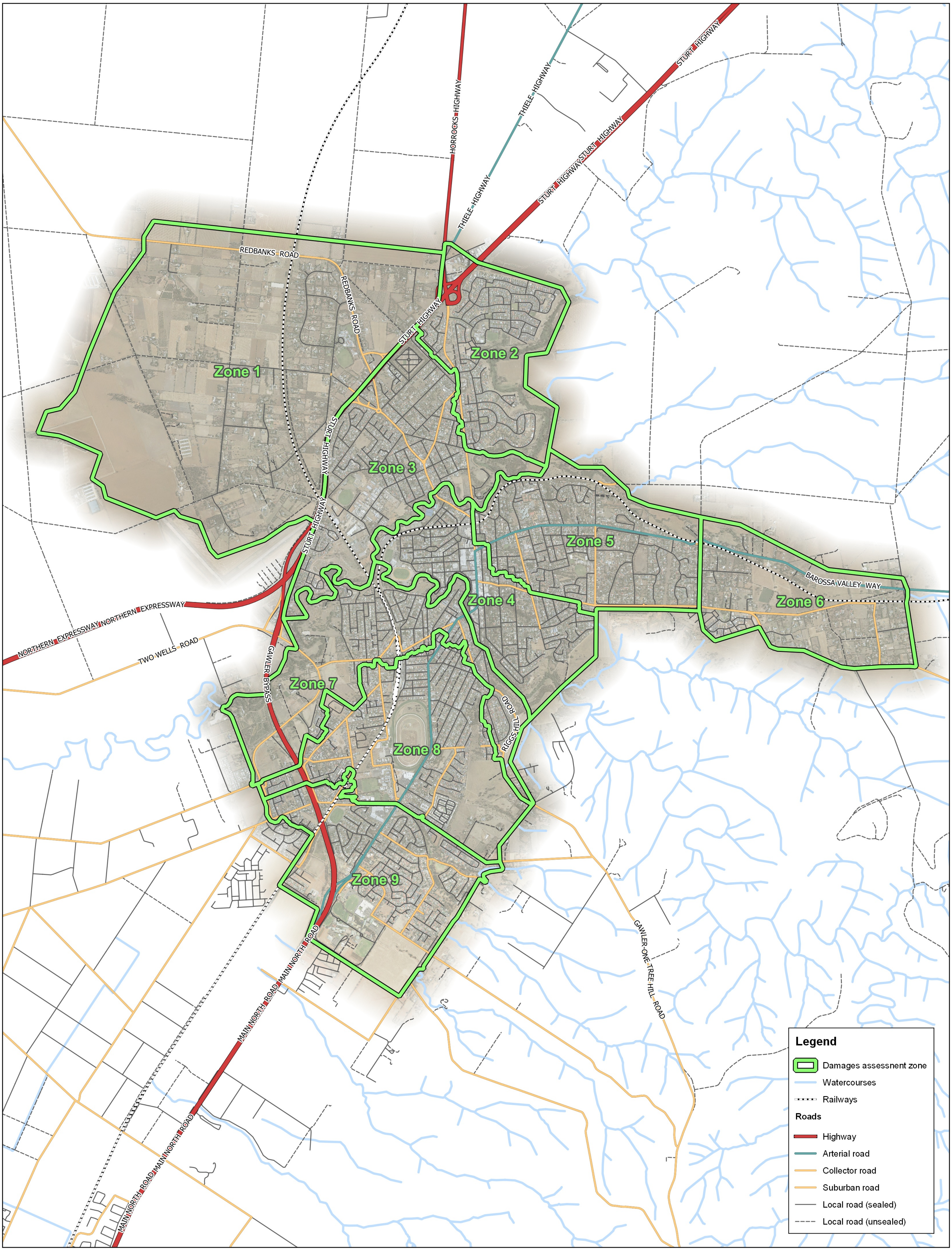
The largest flood damages occur within zones 3, 8 and 9. Most of these damages can be significantly reduced (by up to 50% in a 1% AEP event) through the implementation of the proposed flood management strategies described in Section 5.1.

No structural mitigation measures are proposed for zones 2, 4, 5, 6 and 7. Non-structural measures are proposed to reduce damages in these areas, however, only structural measures have been included in the flood modelling (e.g. on-site detention is not modelled). Hence, some 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	Existing	$ 0.28	$ 0.85	$ 1.71	$ 3.29
	Long term	$ 0.29	$ 0.90	$ 1.79	$ 3.29
	Management strategies	$ 0.28	$ 0.62	$ 1.61	$ 3.10
Zone 2	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	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	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
	Long term	$ 0.16	$ 0.28	$ 0.71	$ 2.50
	Management strategies	$ 0.16	$ 0.28	$ 0.71	$ 2.50
Zone 6	Existing	$ 0.13	$ 0.29	$ 0.55	$ 0.91

Zone	Scenario	Annual Exceedance Probability			
		20%	5%	1%	0.2%
	Long term	$ 0.14	$ 0.30	$ 0.57	$ 0.91
	Management strategies	$ 0.14	$ 0.30	$ 0.57	$ 0.91
Zone 7	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	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	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	**$ 2.19**	**$ 4.83**	**$ 10.19**	**$ 44.69**



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Town of Gawler, Light Regional Council and Barossa Council

DAMAGES ASSESSMENT ZONES

Job Number:	20141387
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Revision:	B
Date:	2019-03-25
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Data Acknowledgement:
Aerial imagery provided by and used with permission of Council

Figure 7.2

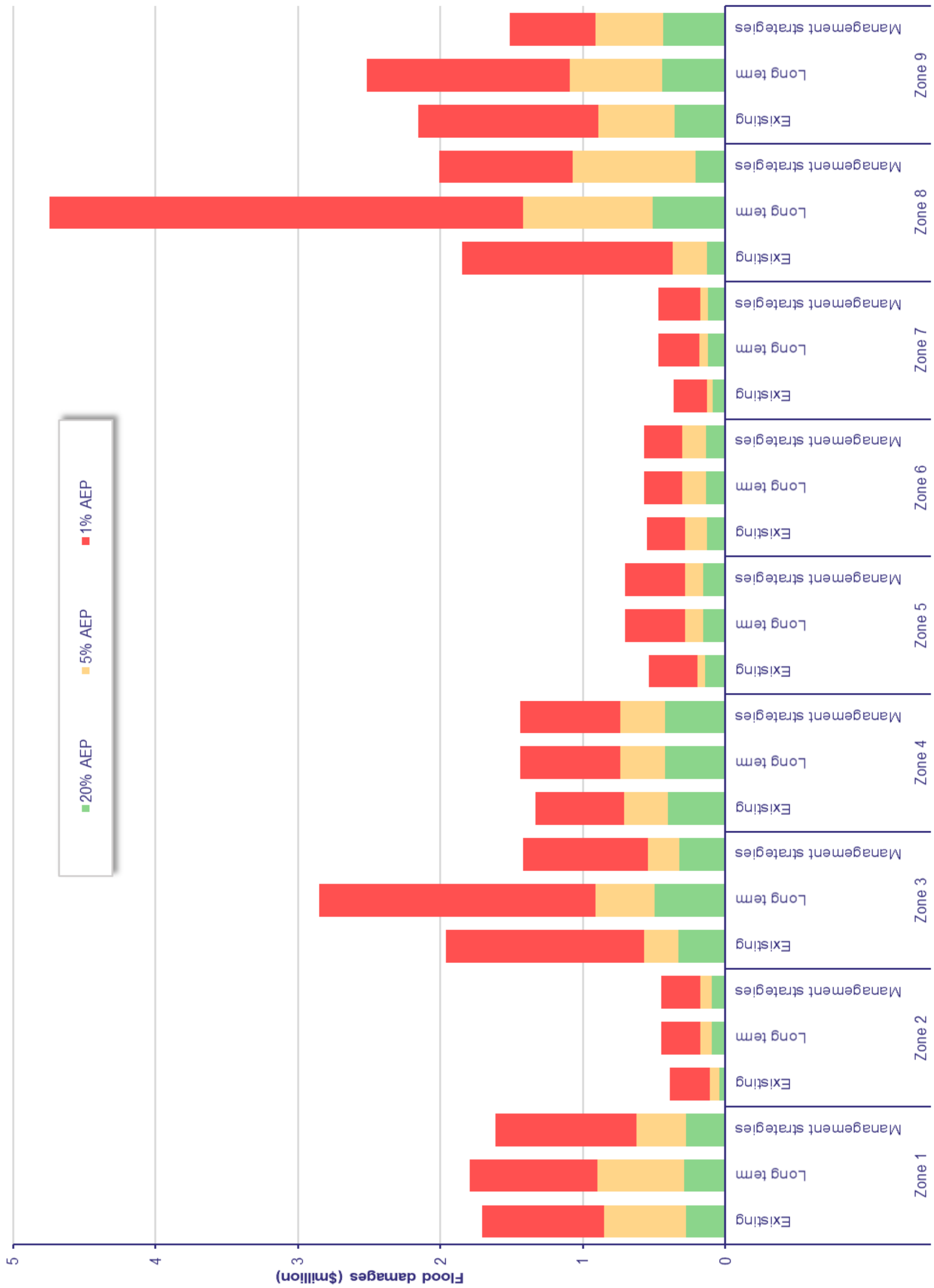

Figure 7.3 Breakdown of the actual flood damages

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 purposed 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.

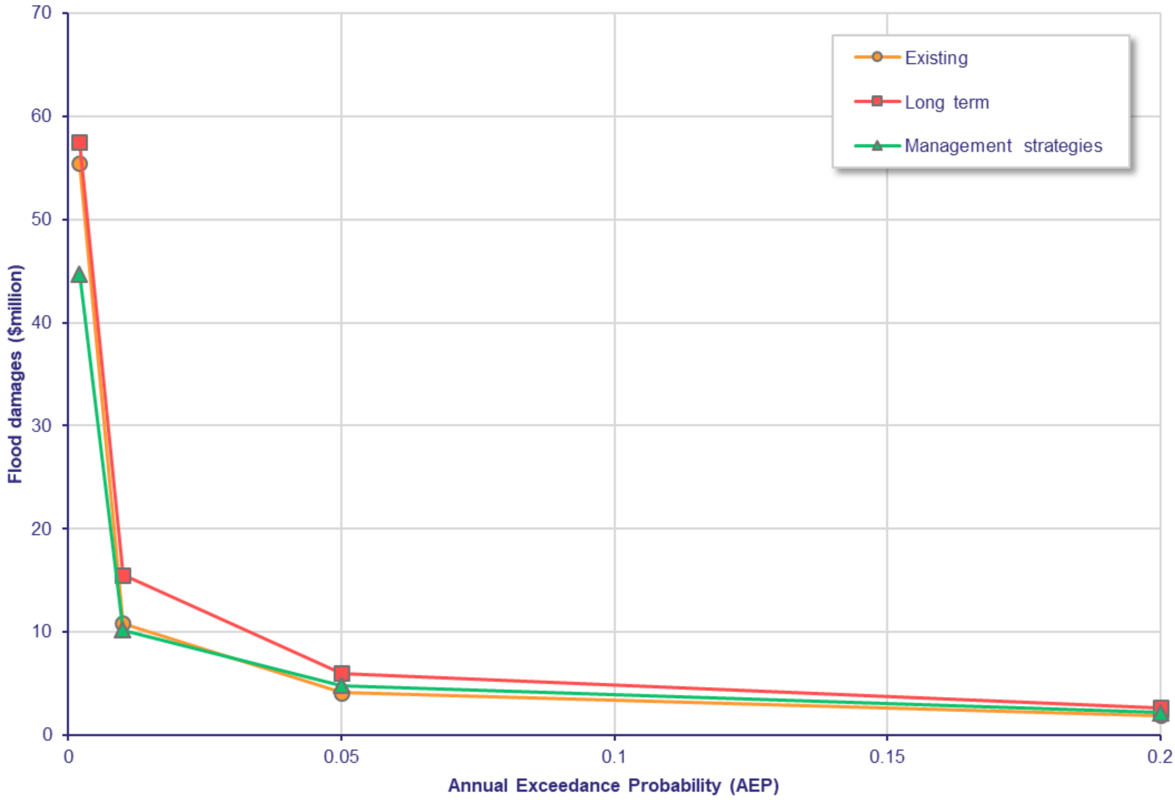

Figure 7.4 Damage-probability curve

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) based on modelling of 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 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	$ 158,000
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**	**$ 1,258,000**

Table 7.7 Grouping of management strategies for the economic assessment

Zone	Management strategies
1	Gawler Belt railway culvert, Gawler Belt interception drain
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 reduction in AAD for each zone are summarised in Table 7.8. The overall reduction in AAD is $374,000 which represents a 23% reduction in the total AAD of $1.63 million for the study area. The percentage reduction in AAD for each zone ranges from 17% for zone 1 to 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 for 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 (%)
1	5.7	49,000	33,000	17
3	4.3	0	120,000	42
8	6.3	53,000	167,000	42
9	1.3	12,000	54,000	18
All	**19.4**	**135,000**	**374,000**	**23**

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
1	n/a[1]	-6.0	0.10
3	1.4	-2.0	0.55
8	-0.4	-4.0	0.45
9	1.9	-0.5	0.68
All	**-1.1**	**-12.5**	**0.37**

[1] The annual maintenance cost is larger than the annual benefit, therefore, there is no discount rate that will achieve a NPV equal to zero.

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 (social, environmental etc) that may be realised by the project.

The outcomes of the economic analysis suggest that the flood management strategies within Zone 9, which includes the Evanston Park flood control basin and the creek upgrade works within Trinity College, provide the best value on 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 Stormwater Management Plan 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, in the preparation of this Stormwater Management Plan.

8.2 Process overview

The process to implement the ODMG is flexible, and in the application to the preparation of this Stormwater Management Plan 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 subdivided 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 (wetlands, WSUD etc.). 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 following weightings 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

Criteria	Sub-Weighting
Beneficial Use of Stormwater	
Storage and Reuse	60
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 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
Tigara 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 includes, 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 5.1.12 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 of all of the strategies considered within the study area (of 0.68).

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 have 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 (e.g. use of gabion baskets), provided student safety in 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 development 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.

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.

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) reduces 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 was adopted. During construction there would be local traffic management impacts as the alignment follows local roads.

9.1.7 Priority F7 (medium priority): Gawler Belt railway culvert

Flood reduction benefits

The Gawler Belt railway culvert (refer Section 5.1.8 for details) results in a significant reduction in flooding that occurs to the 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 set up in the invert of the culvert would also provide upstream retention such that during the majority of events water is still able to infiltrate upstream of the rail culverts.

Other benefits or impacts

A number of private landholders would need to be consulted to obtain easements over their land.

9.1.8 Priority F8 (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 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 easy maintenance, with minimal impact to the general public.

9.1.9 Priority F9 (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.

9.1.10 Priority F10 (medium priority): Update flood plain 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 reduce 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 and can provide.

Consideration of climate change will help to develop stormwater management strategies that are robust despite a changing climate.

9.1.11 Priority F11 Ongoing Works (low priority): Localised drainage upgrades

Flood reduction benefits

These works would predominantly help to reduce nuisance flooding as a result of excessive gutter flow widths, and insufficient inlet capacities.

9.1.12 Priority F12 (low priority): Gawler Belt interception drain

Flood reduction benefits

The interception drain results 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 relatively widespread and relatively low rate of 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 would provide some vegetative filtering of flows and, given its flat longitudinal grade, would facilitate some infiltration along the channel.

Other benefits or impacts

The channel has the potential to create a natural barrier for access across it and would require negotiation with a number of private landowners. The significant capital costs and limited flood reduction benefits mean that the works have the lowest benefit cost ratio of all of the strategies that have been assessed.

There is the potential that the channel will convey stormwater into the large depression area to the south of Parkers Road. This could slightly increase flood levels in the depression area.

9.1.13 Priority F13 (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.

9.1.14 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 recently proposed Gawler East Link Road going 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.

9.2 Priorities for water reuse

9.2.1 Infiltration Systems R1 Ongoing (High Priority) 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 Ongoing (Medium Priority): Subsidising large rain tanks

Subsidising residents to install rain 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 Ongoing (High Priority): 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 road works (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 in 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 Ongoing (High Priority) 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 system 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 Ongoing (Medium Priority): WSUD in 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). Further these works improve both water quality and slow flow rates which further enhance ecological values. They 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, such that the assets can be replaced before they fail.

Physical inspections of other assets, such as basins, levee banks etc. 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

Priority	Project/ Activity Title	Capital Cost ($)	SMA / NRMB Funding eligible	Recurrent Cost ($ / annum)	Flood Mitigation Benefit		Water Harvesting Benefit		Water Quality Benefit		Other Benefits	
					Measure used? (D) – AAD Reduction (P) – Properties Affected (Q) – Qualitative	Quantification or Description of Benefit	Measure used? (V) Volumetric (Q) Qualitative	Quantification or Description of Benefit	Rating (H) – High (M) – Med (L) – Low	Qualitative Description of Benefit	Rating (H) – High (M) – Med (L) – Low	Qualitative Description of Benefit
High	Gawler Race Course Flood Control Basin and Wetland	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
High	Tingara Road Basin	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.
High	Evanston Oval parallel pipe	235,000	Y	Minimal	D	$54,000 (combined with Tingara Road and Trinity College creek upgrades)	-	-	L	No benefits	L	Improved public safety
High	Trinity College creek upgrades	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
High	Utilise flood mapping data for new development	N/A	-	-	Q	Ensure that new development has a high level of flood protection	-	-	L	No direct improvement	L	Improved public safety
High	Corey Street flood control basin outlet optimisation	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
High	Education and awareness	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.
High	Raingardens	30,000 each	N	300 pa per raingarden	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.
High	Infiltration systems (permeable paving, tree pits)	Variable	N	Variable	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.
Medium	Jarvis Street drainage upgrade	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
Medium	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
Medium	Gawler East flow path improvements	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.
Medium	Hewett rear of allotment drainage	200,000	N	Minimal	P	Reduces nuisance flooding for about 6 properties.	-	-	L	No direct improvement	L	Avoids legal disputes in future
Medium	Gross pollutant traps	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.

Priority	Project/ Activity Title	Capital Cost ($)	SMA / NRMB Funding eligible	Recurrent Cost ($ / annum)	Flood Mitigation Benefit Measure used? (D) – AAD Reduction (P) – Properties Affected (Q) – Qualitative	Flood Mitigation Benefit Quantification or Description of Benefit	Water Harvesting Benefit Measure used? (V) Volumetric (Q) Qualitative	Water Harvesting Benefit Quantification or Description of Benefit	Water Quality Benefit Rating (H) – High (M) – Med (L) – Low	Water Quality Benefit Qualitative Description of Benefit	Other Benefits Rating (H) – High (M) – Med (L) – Low	Other Benefits Qualitative Description of Benefit
Medium	Update floodplain mapping to include climate change	20,000	-	-	Q	Helps to assess risk and develop measures			L	No direct improvement	L	Improve public safety
Medium	Asset inspections	20,000		10,000	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
Medium	Riparian habitat restoration	100,000		100,000 per year	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
Medium	WSUD in backyard	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.
Medium	Rainwater tank subsidies	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.
Low	Localised drainage upgrades	Varied	N	-	P	Reduce nuisance flooding	-	-	L	No direct improvement, but GPT could be installed on new pipes	L	Improved safety with less nuisance flooding
Low	Flood warning system	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
Low	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
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.
Undetermined	Potts Road detention basin	2,480,000	N	19,000	Q	$167,000 (combined with Gawler Race Course Flood Basin)	-	-	M	Reduce pollutant loads	M	Can provide amenity and local habitat.
Undetermined	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

Table 9.2 10-year Capital Works Plan (values in millions)

Priority	Works	19/ 20	20/ 21	21/ 22	22/ 23	23/ 24	24/ 25	25/ 26	26/ 27	27/ 28	28/ 29
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	Development controls		0.2								
F4	Flood education program	0.05									
F5	Corey Street basin optimisation	0.05									
F6	Jarvis Street drain upgrade*									0.1	0.48
Q1	Raingardens		0.08		0.08		0.08		0.08		0.08
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
R1	Large rain tanks	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
F10	Climate change flood mapping		0.02								
A1	CCTV inspections	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
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	0.4
Total		**1.19**	**1.28**	**1.28**	**1.06**	**1.08**	**1.26**	**1.08**	**1.06**	**1.28**	**1.14**

- * 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 Stormwater Management Plan comprises representatives of key stakeholder organizations that have responsibility for implementing the Stormwater Management 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.

The highest priority works within the Light Regional Council area is Strategy F7 (Gawler Belt railway culvert). The highest priority capital works for the Barossa Council is the Gawler East flow path improvements (Strategy F8).

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.

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 20 years to complete the implementation of all recommended works.

9.8 Attainment of SMP objectives

This section reviews the level to which the proposed SMP objective 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 improvement in water quality can be achieved throughout the catchment. However, large improvements in water quality in keeping with the objectives will not be realised until the Councils are able to achieve significant coverage of retrofitted WSUD measures in existing areas.

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

9.9 Consultation

Consultation in relation to the SMP has been thorough. It has included the following:

- Communication with key stakeholders.
- Communication with and feedback from the Project steering group (representatives from Town of Gawler, Light Regional Council, Barossa Council, Stormwater Management Authority, and the Adelaide & Mt Lofty Ranges Natural Resources Management Board)
- Elected members from the Town of Gawler, Light Regional Council and Barossa Council

Consultation with the general community is still to be undertaken for the final draft SMP prior to endorsement by the SMA.

Additional detail of the consultation undertaken to date is contained within Appendix H.

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