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Northern Areas Council

Gladstone Stormwater Management Plan

Draft Report



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Gladstone Stormwater Management Plan

Draft Report

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Executive Summary

This Stormwater Management Plan for Gladstone has been prepared for Northern Areas Council. The preparation of the plan has been jointly funded by Northern Areas Council and the Stormwater Management Authority.

This document contains:

- A summary of collated information covering a range of factors relevant to the management of stormwater in the town;
- The identification of flood impacts highlighting performance deficiencies ranging from major flooding hotspots to nuisance ponding;
- A review of the quality of stormwater runoff leaving the town;
- Findings from the community consultation and objectives and targets for managing stormwater within the town;
- Potential management strategies that may be used to meet the objectives and targets;
- Estimated costs and benefits associated with each of the strategies; and
- A clear definition of the priorities, responsibilities and timeframe for implementation of the Stormwater Management Plan.

The study area for this Stormwater Management Plan is approximately 650 hectares in size, and contains the town of Gladstone, sections of the Yangya Creek and Rocky River channels, as well as several smaller watercourses. The study area is not defined by a single contributing catchment, but instead by major watercourses surrounding and through the town and numerous catchments within the town. The study area is wholly located within the jurisdiction of Northern Areas Council.

The topography of the study area varies, with higher elevations to the north and east of the town. Yangya Creek flows through Gladstone from the north, leaving the study area to the south, while Rocky River skirts around the town to the southwest. The town generally grades from north to south, with runoff flowing overland towards the Rocky River. The railway corridor separates the Yangya Creek from the western part of town.

Key issues identified by this Stormwater Management Plan include:

- A range of drainage system performance deficiencies including trapped ponding, insufficient drainage infrastructure and property inundation;
- Limited stormwater quality improvement measures have been implemented across the town to date;
- Future development, largely consisting of greenfield development, will exacerbate flood risk and decrease the quality of water entering the receiving waters; and
- The potential for climate change, in the form of higher intensity rainfall, to increase flood risk within the town.

A set of objectives specific to this Stormwater Management Plan was developed, addressing:

- Providing an acceptable level of flood protection for public and private assets;
- Improving the quality of runoff to the receiving waters;
- Finding opportunities for the beneficial use of stormwater;
- Planning for new developments to provide open space and maximise the onsite retention of stormwater runoff;
- The sustainable asset management of stormwater infrastructure;
- Improving the condition of receiving watercourses; and
- Effective communication and consultation with stakeholders, businesses and the community.

The Stormwater Management Plan recommends a range of structural and non-structural stormwater management responses, which have been summarised in the table below. These measures have been developed with a view to maximising the level of flood protection that can be achieved within practical constraints. In accordance with the objectives and targets, an absolute target of achieving no above floor inundation of properties in the 5% AEP storm was adopted, with an aspirational target to provide a 1% AEP standard.

The proposed flood mitigation strategies include new and upgraded underground drainage systems and various earthworks, all aimed at reducing surface ponding and property inundation in major storm events. Flood damage estimates and structural cost estimates have been developed to evaluate the economic feasibility of the proposed flood mitigation measures. The total cost of implementing the various flood mitigation measures is estimated to be $4.6m.

Water quality improvement measures have also been recommended in this Stormwater Management Plan, including bioretention basins, streetscape raingardens and gross pollutant traps. The total cost of implementing the proposed Water Sensitive Urban Design (WSUD) strategy is estimated to be $6.2m, with an annual maintenance cost of $256,000.

Water quality modelling has shown that the proposed WSUD strategy outlined in this plan would achieve the adopted water quality improvement targets. The opportunity for further measures also exists at the street level, such as raingardens being incorporated into road reconstructions, and on private property.

A Multi-Criteria Analysis (MCA) was developed to enable relative priorities to be assigned to all proposed stormwater management responses, taking into account financial, environmental and social factors. A consolidated list of the prioritised measures is presented in the table below, which also provides capital cost estimates and highlights the actions that are potentially eligible for Stormwater Management Authority funding.

Priority	Project Description	Benefits	Capital Cost	Potentially Eligible for SMA Funding
Very High	Yangya Creek Flood Protection	Flood mitigation	$1,410,000	✓
Very High	Flood Warning Systems	Water quality improvement, amenity improvement	-	✓
Very High	SES Community FloodSafe Program	Flood mitigation, information and knowledge	-	✓
High	Port Street, Bondowie Street Drainage	Flood mitigation, drainage service	$1,360,000	
High	High Street Bioretention Basin	Water quality improvement, amenity improvement	$220,000	
High	Council's Emergency Management Plan	Flood mitigation, information and knowledge, administration efficiency	-	
Moderate	Centre Street Drain and Flood Levee	Flood mitigation, drainage service	$930,000	
Moderate	Streetscape Raingardens	Water quality improvement	$5,700,000	
Moderate	Rezoning Flood-prone Land	Flood mitigation, information and knowledge	-	
Moderate	New Building Floor Levels	Flood mitigation	-	
Low	Mill Street, Port Street Drainage	Flood mitigation, drainage service	$910,000	
Low	Gross Pollutant Traps	Water quality improvement	$320,000	
Low	Rainwater Tanks and Allotment Level Reuse	Stormwater reuse, water quality improvement, information and knowledge	-	
Low	Ongoing Maintenance and Monitoring of Council Assets	Flood mitigation, drainage service, information and knowledge, administration efficiency	-	
Low	Education and Promotion of WSUD Measures	Stormwater reuse, water quality improvement, ecological improvement, information and knowledge	-	
Low	Development Controls – Beneficial Use of Stormwater	Stormwater reuse, water quality improvement	-	

1 Introduction

This Stormwater Management Plan (SMP) for the township of Gladstone has been prepared for the Northern Areas Council in accordance with the requirements of the brief. The preparation of the plan has been jointly funded by the Northern Areas Council (Council) and the Stormwater Management Authority (SMA).

The Plan will provide an overview of the existing catchments and issues relating to current stormwater management in the township of Gladstone. It also provides an overview of the opportunities to improve stormwater management to both address flood protection and the sustainable management of this resource and the environment.
This Plan has been developed primarily in consultation with Council staff, with external stakeholders from relevant State Government Authorities providing technical guidance regarding the objectives, targets and preferred management responses.

This progress report provides background on the township in the form of a baseline assessment, describing the current state and condition of the catchment and establishing a baseline against which the effectiveness of stormwater management options can be assessed. This report also summarises the proposed approach to identifying and managing stormwater risk and issues.

2 Baseline Assessment

2.1 Introduction

A baseline assessment of the township of Gladstone has been undertaken. This assessment describes the current state of the township and its catchments, establishing a baseline against which the effectiveness of future stormwater management options can be assessed. The following sections describe the elements included in the baseline assessment.

2.2 Administrative Boundaries

A Stormwater Management Plan boundary, forming the study area, has been prepared, and can be seen in Figure 2.1 below.

The study area is wholly contained within the Northern Areas Council local government area. The relevant Landscape SA board for the study area is the Northern and Yorke region, and the study area falls under the Southern and South-Western Flatlands (East) National Resource Management sub cluster.

2.3 Topography, Land Use, Geology and Soils

2.3.1 Major Catchments

The study area contains two major watercourses flowing through and around the town from the north to the southwest, being Rocky River and Yangya Creek. There are also two smaller, unnamed tributaries of the Yangya Creek which flow from the east of Gladstone. Rocky River is offset from the town to the west, however Yangya Creek flows directly through it from north to south along the railway line. Major catchment boundaries for these watercourses were delineated using regional topographic data obtained from the ELVIS online spatial data service developed and maintained by Geoscience Australia.

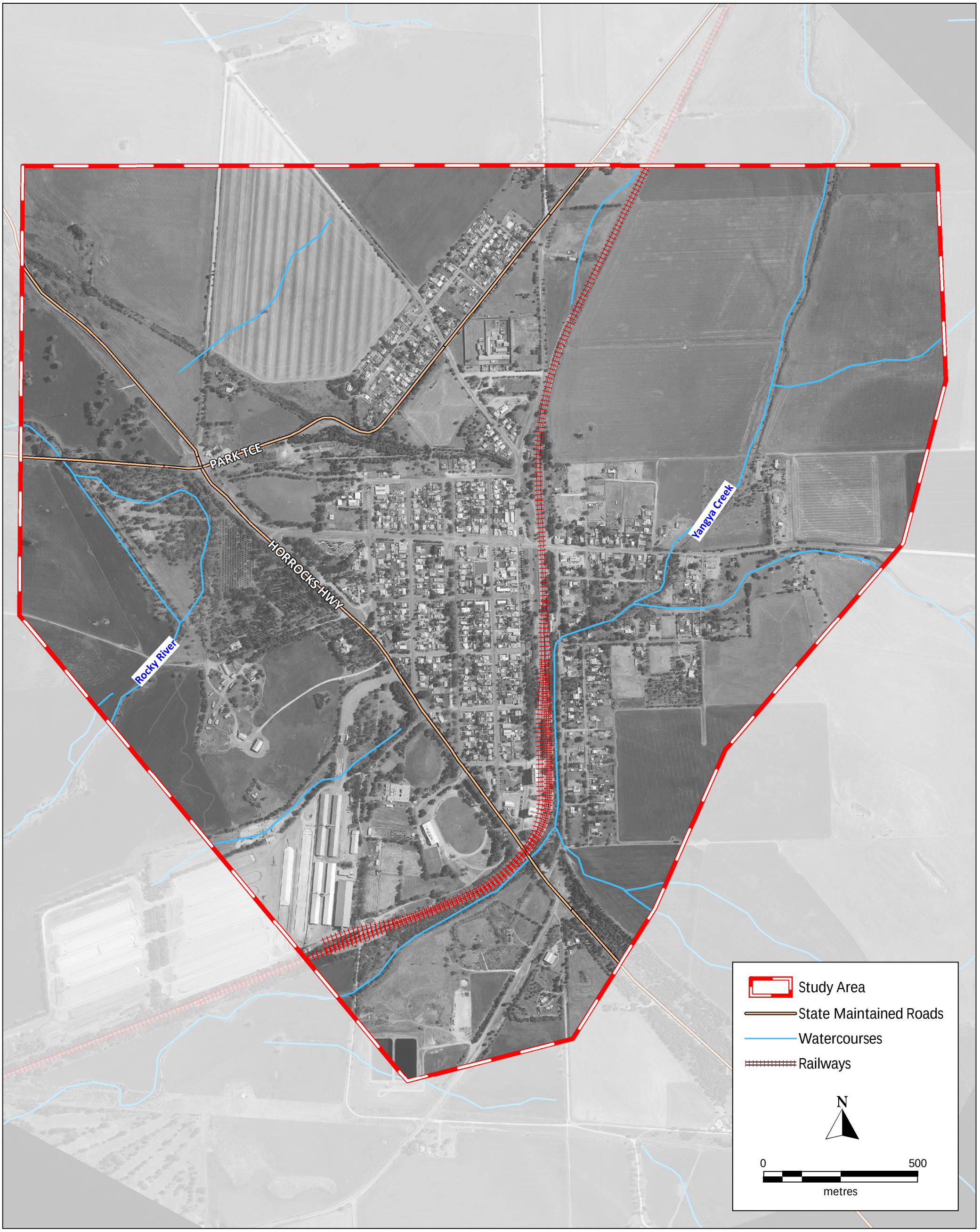
In general, the upstream catchments are rural in nature with extensive agricultural land usage and minimal development. The Rocky River catchment contains the towns of Laura, Wirrabara, Appila and Tarcowie.

The very large Rocky River catchment is characterised by hilly, steep terrain upstream in the catchment with grades upwards of 3%, and by flatter terrain further downstream with grades of under 0.2% closer to Gladstone. Pine Creek upstream in the catchment is a key tributary of Rocky River. The catchment extends north into the District Council of Mount Remarkable and the District Council of Orroroo Carrieton.

The Yangya Creek catchment similarly has steep upper reaches with grades in excess of 3%, and flattens slightly as the creek reaches Gladstone with a longitudinal gradient of 0.6%. Pisant Creek upstream in the catchment is a key tributary of Yangya Creek.

The two smaller, tributary catchments are hillier, with main channel gradients of between 1 and 2%.

A summary of catchment sizes is presented in Table 2.1, and the catchment extents are shown in Figure 2.2.



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Data Sources:
Northern Areas Council (Aerial Photography)
Data SA (State Maintained Roads, Railways, Watercourses)

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FIGURE 2.1 - STUDY AREA

Table 2.1 Catchment Size Information

Catchment	Area (km²)
Rocky River	982
Yangya Creek	102
Tributary 1	19
Tributary 2	3

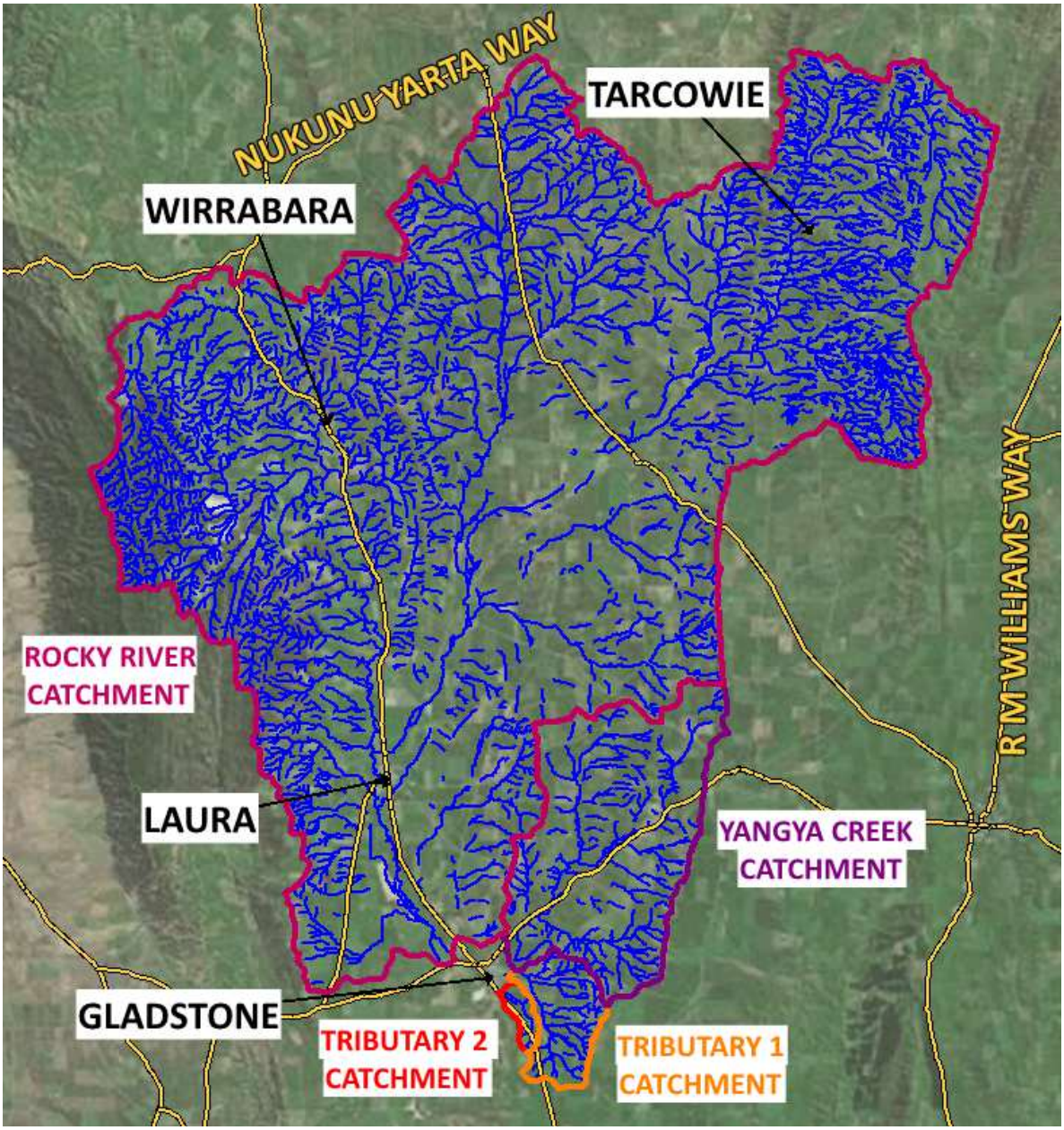


Figure 2.2 Major Catchment Boundaries

2.3.2 Topography

A Digital Terrain Model (DTM) of the Gladstone township has been provided by Council for this SMP. The DTM was generated from a Light Detection And Ranging (LiDAR) point data capture of nine regional South Australian townships undertaken between October 2021 and November 2021. The LiDAR has a spacing of approximately 14.2 to 15.6 points per square metre, and a reported vertical accuracy of +/- 0.06 m (95% confidence interval). The DTM is shown in Figure 2.3 below.

Regions of higher elevation can be seen to the north and east, separating the watercourses flowing towards Gladstone. Rocky River can be seen to the west of the study area, and is lower lying than the town. Yangya Creek cuts through the town, running alongside the railway line to the east before crossing under Horrocks Highway. The township is shown to grade generally from north to south, with water running overland towards Yangya Creek.

2.3.3 Land Use

Land use throughout the study area has been sourced from the Valuer General's Generalized Land Use Dataset (2021). This GIS layer is based on actual land use rather than zoning, and within the study area can be broken down as follows:

- 66 ha of Residential, 17 ha of Rural Residential, 24 ha of Vacant Residential and 1 ha of Nonprivate Residential;
- 317 ha of Agriculture and 2 ha of Food Industry;
- 26 ha of Utility/Industry;
- 26 ha of Commercial and 4 ha of Retail Commercial;
- 12 ha of Public Institution and 13 ha of Education;
- 28 ha of Recreation and 4 ha of Reserve; and
- 10 ha of Vacant.

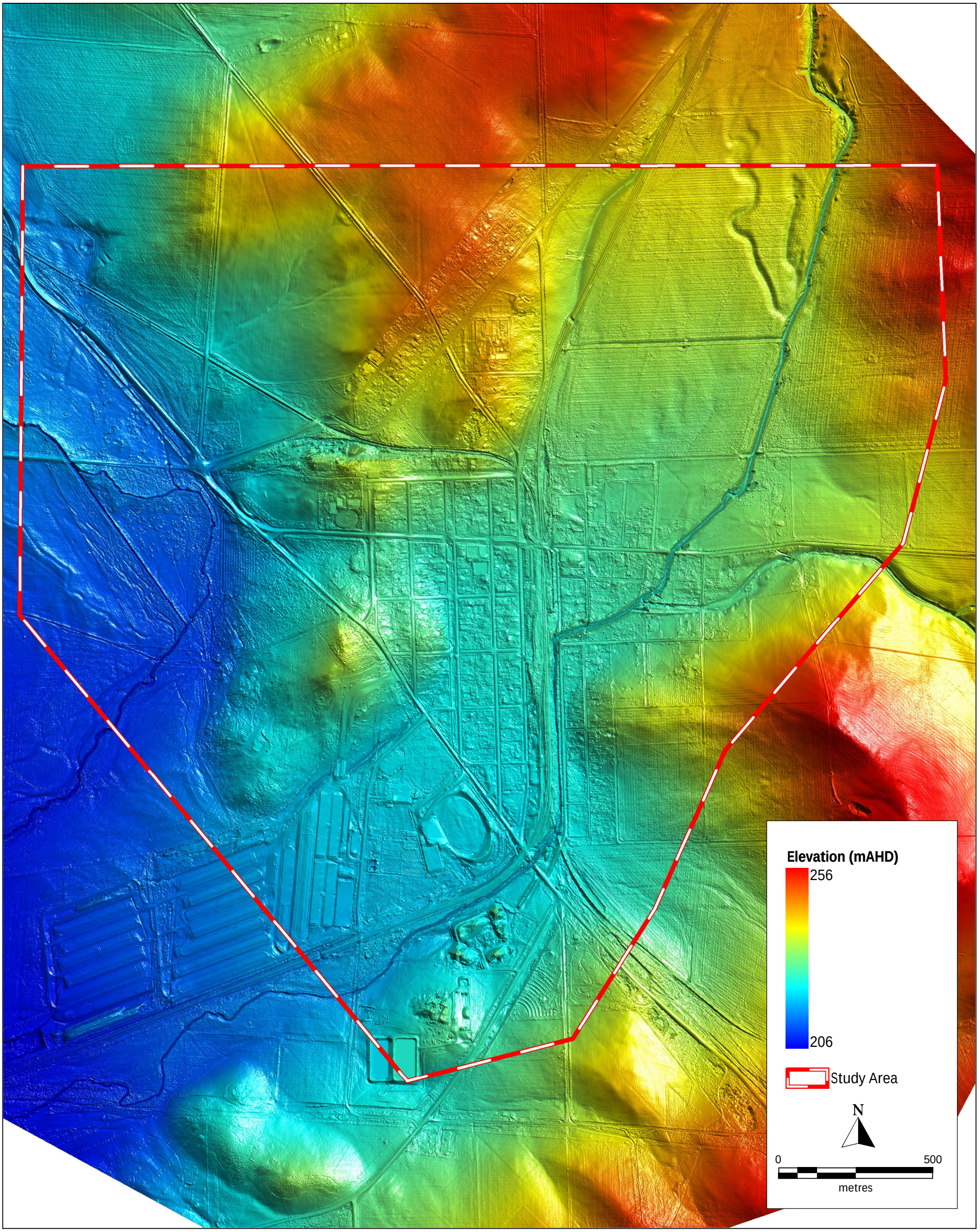
Land use within the study area can be seen in Figure 2.4.

2.3.4 Geology and Soils

Geological information throughout the study area and upstream catchments has been sourced from the South Australian Resources Information Gateway (SARIG) website developed by the Department for Energy and Mining. This dataset provides stratigraphic information throughout the state and was used to gain an understanding of the geology of the region.

The dataset indicates that the township of Gladstone is located on a mixture of geological layers including quaternary alluvial/fluvial sediments, miocene-pliocene unit 1, Mintaro shale, Saddleworth Formation and holocene alluvial/fluvial sediments. The Rocky River catchment is primarily comprised of quaternary alluvial/fluvial sediments and Saddleworth formation, the Yangya Creek catchment largely consists of Woolshed flat shale and quaternary alluvial/fluvial sediments while the two unnamed watercourse catchments are generally made up of quaternary alluvial/fluvial sediments, Saddleworth formation and Mintaro shale.

We are not aware of any existing literature which investigates the feasibility of aquifer storage and recharge schemes within the Gladstone study area.



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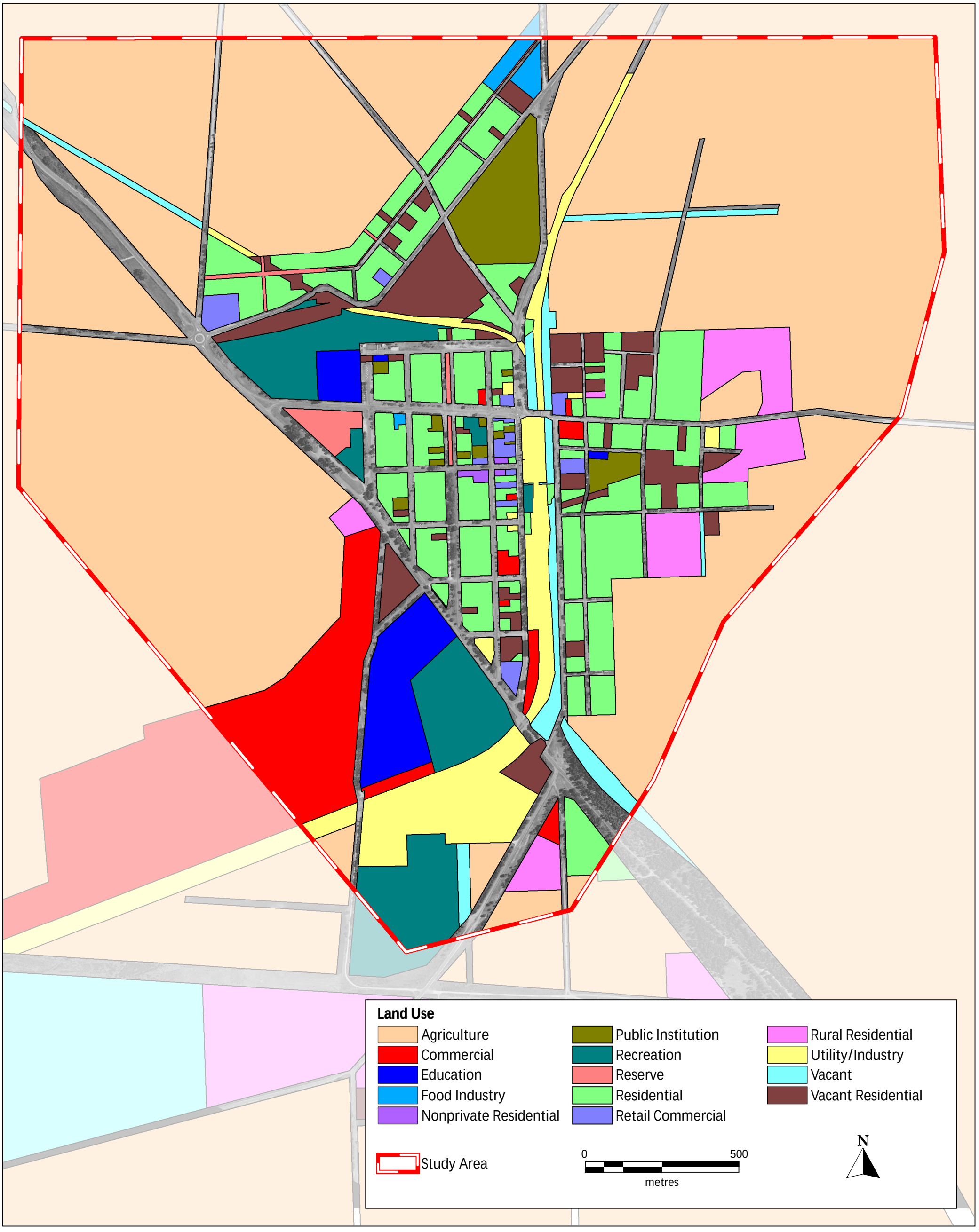
Data Sources:
Southfront (Study Area)
Northern Areas Council (DTM)

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FIGURE 2.3 - TOPOGRAPHY



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Data Sources:
Southfront (SMP Study Area)
Data SA (Generalised Land Use)

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FIGURE 2.4 - LAND USE

2.4 Climate and Hydrology

2.4.1 Rainfall and Temperature Analysis

Daily rainfall data from the Bureau of Meteorology rainfall gauge in Gladstone (Station 21021) was obtained from the Bureau of Meteorology weather station directory online service, for the years 1878-2022. The mean annual rainfall in Gladstone was found to be 416 mm.

Statistical analysis of the annual rainfall variation is also provided by the Bureau of Meteorology, which reports variations from the annual mean as summarised in Table 2.2 and Figure 2.5, which show monthly deviations from the annual mean and illustrate monthly trends.

Table 2.2 Rainfall Data for Gladstone (Station 21021)

Statistic [Year of Occurrence]	Annual Rainfall (mm)	% Difference to Mean
Mean	416.2	-
Lowest [1967]	201.0	-52%
5th percentile	257.6	-38%
10th percentile	297.4	-29%
Median	406.9	-2.2%
90th percentile	540.4	+30%
95th percentile	598.9	+44%
Highest [1974]	782.6	+88%

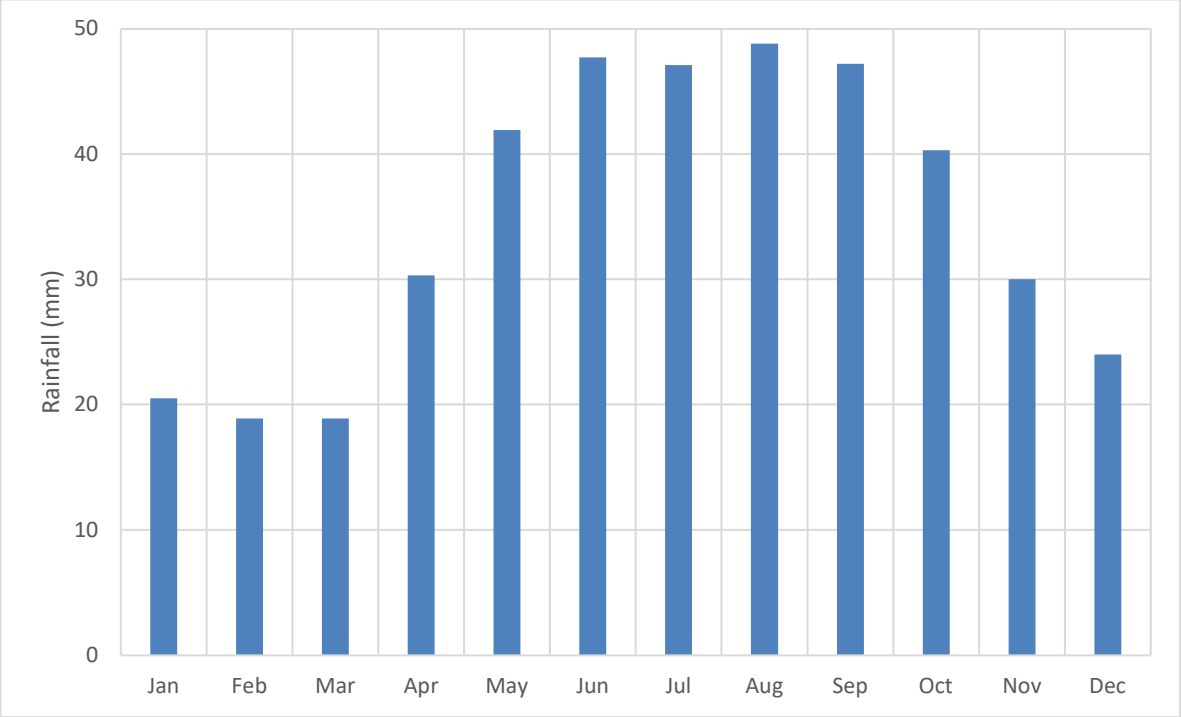


Figure 2.5 Gladstone Mean Monthly Rainfall

Historic daily maximum temperature information from 1900 to 2022 at Gladstone was acquired from the SILO website managed by the Queensland Government. This data was analysed and the average maximum temperature for each month was determined. Daily evaporation data for

the same time period was also obtained from the SILO website, and analysed to find average monthly evaporation. The two are shown in Figure 2.6 below.

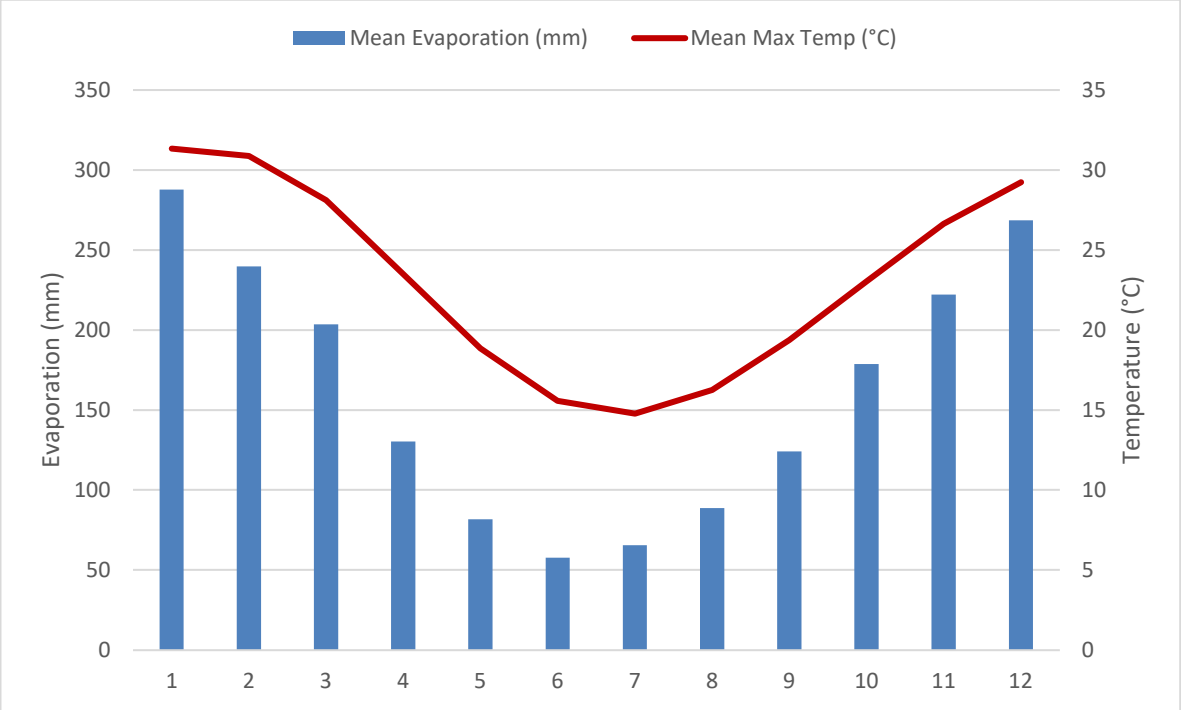


Figure 2.6 Gladstone Monthly Evaporation and Temperature

Figure 2.6 above shows that evaporation and maximum temperature are strongly correlated as would be expected.

2.4.2 Design Rainfalls

Design rainfall Intensity-Frequency-Duration (IFD) data has been prepared for Gladstone utilising the Australian Rainfall and Runoff 2019 (ARR 2019) online procedure provided by the Bureau of Meteorology. This data is presented in Table 2.3 for the relevant Annual Exceedance Probabilities.

Table 2.3 IFD Design Rainfall Intensities (mm/hr)

Duration	Annual Exceedance Probability (AEP)					
	18.2%	10%	5%	2%	1%	0.2%
1 min	120	145	175	217	253	329
2 min	104	127	154	192	226	298
3 min	93.8	114	138	172	202	265
4 min	85.8	104	125	156	183	239
5 min	79.2	96.0	115	144	168	219
10 min	58.8	71.1	85.3	106	123	160
15 min	47.7	57.7	69.3	86.2	100	130

Duration	Annual Exceedance Probability (AEP)					
	18.2%	10%	5%	2%	1%	0.2%
30 min	31.8	38.6	46.4	57.8	67.4	87.6
1 hour	20.4	24.7	29.8	37.1	43.3	56.5
2 hour	12.8	15.5	18.6	23.1	26.9	35.1
3 hour	9.75	11.7	14.0	17.3	20.2	26.2
6 hour	6.09	7.25	8.60	10.6	12.2	15.7
12 hour	3.79	4.48	5.29	6.45	7.40	9.52
24 hour	2.33	2.75	3.24	3.94	4.51	5.85
48 hour	1.39	1.65	1.95	2.38	2.73	3.67
72 hour	1.01	1.20	1.43	1.74	2.01	2.72

2.4.3 Impact of Climate Change

Climate change leads to changes in the frequency, intensity, spatial extent, duration and timing of extreme weather and climate events. Within a stormwater management context, potential future changes in rainfall patterns are of particular interest, as these result in changes to levels of flood protection, stormwater drainage performance and the availability of stormwater for harvesting and reuse.

ARR 2019 provides an approach for addressing the risks posed by climate change in projects and decisions that involve estimation of design flood characteristics. It draws on the most recent climate science, particularly the release of the Intergovernmental Panel on Climate Change (IPCC) *Fifth Assessment Report* (IPCC, 2014) as well as *Guide to Climate Projections for Risk Assessment and Planning in South Australia* (Department for Environment and Water, 2022).

The procedure relies on the Climate Futures web tool developed by the CSIRO where projected changes from Global Climate Models (GCMs) can be explored for fourteen 20-year periods based on four Representative Concentration Pathways (RCPs) for greenhouse gas and aerosol concentrations that were used to drive the GCMs. The pathways are provided by regional Natural Resource Management (NRM) clusters (divided into 11 regions nationally), with the Gladstone study area falling within the Southern and South-Western Flatlands (East) region.

ARR 2019 recommends the use of RCPs 4.5 and 8.5 (low and high concentration pathways, respectively) for rainfall intensity impact assessment. Further details can be found at the Australian Climate Futures website (https://www.climatechangeinaustralia.gov.au).

For this study, the designated climate planning horizon is the year 2050. Using the web tool, Table 2.4 indicates the IPCC GCM consensus for rising temperatures as a result of rising greenhouse gas emissions for high and low scenarios for the region.

Table 2.4 GCM Predicted Changes to Annual Mean Surface Temperature (2050)

RCP Scenario	GCM Consensus	Projected Annual Mean Surface Temperature Change (°C)
4.5	Warmer (45 of 46)	+ 0.5 to + 1.5
8.5	Warmer (27 of 48), Hotter (21 of 48)	+ 0.5 to + 1.5 + 1.5 to + 3.0

ARR 2019 recommends using the temperature midpoint of the projected annual mean surface temperature change to calculate adjustments to the projected rainfall intensity using the following equation:

$$I_p = I_{ARR} \times 1.05^{T_m}$$

Where I_p is the projected rainfall intensity, I_{ARR} is the design rainfall intensity for current climate conditions, 1.05 is the assumed temperature scaling based on the approximately exponential relationship between temperature and humidity, and T_m is the temperature at the midpoint of the selected class interval.

As the models could not come to a consensus for both RCP scenarios, the temperature midpoint of the wider interval +0.5 to +3.0 °C (1.75 °C) was used. Therefore, $I_p = I_{ARR}$ x 1.09 (i.e. a 9% intensity increase for 2050). The Intensity-Frequency-Duration data is shown in Table 2.5 with this climate change factor applied. The modelling of proposed drainage infrastructure will utilise these rainfall intensities.

Table 2.5 IFD Design Rainfall Intensities (mm/hr) with Climate Change Factor (2050)

Duration	Annual Exceedance Probability (AEP)					
	18.2%	10%	5%	2%	1%	0.2%
1 min	131	158	191	237	276	359
2 min	113	138	168	209	246	325
3 min	102	124	150	187	220	289
4 min	93.5	113	136	170	199	261
5 min	86.3	105	125	157	183	239
10 min	64.1	77.5	93.0	116	134	174
15 min	52.0	62.9	75.5	94.0	109	142
30 min	34.7	42.1	50.6	63.0	73.5	95.5
1 hour	22.2	26.9	32.5	40.4	47.2	61.6
2 hour	14.0	16.9	20.3	25.2	29.3	38.3
3 hour	10.6	12.8	15.3	18.9	22.0	28.6
6 hour	6.64	7.90	9.37	11.6	13.3	17.1
12 hour	4.13	4.88	5.77	7.03	8.07	10.4

Duration	Annual Exceedance Probability (AEP)					
	18.2%	10%	5%	2%	1%	0.2%
24 hour	2.54	3.00	3.53	4.29	4.92	6.38
48 hour	1.52	1.80	2.13	2.59	2.98	4.00
72 hour	1.10	1.31	1.56	1.90	2.19	2.96

The Climate Futures web tool also showed that annual rainfall is predicted to decrease within the Southern and South Western Flatlands (East) National Resources Management Sub Cluster. GCM consensus results for RCP scenarios 4.5 and 8.5 are shown in Table 2.6.

Table 2.6 GCM Predicted Changes to Annual Rainfall (2050)

RCP Scenario	GCM Consensus Rainfall	Projected Annual Rainfall Change (%)
4.5	Drier (29 of 68) Little Change (28 of 68)	-15 to -5 -5 to +5
8.5	Drier (25 of 70) Little Change (27 of 70)	-15 to -5 -5 to +5

As can be seen, GCM consensus for both RCP scenarios indicates annual rainfall becoming 'drier' or having 'little change' by the year 2050. Taking the midpoint of the wider range (-15% to +5%), an average annual rainfall reduction of 5% by 2050 is predicted.

The impact of climate change on soil moisture, particularly within the study area, is unclear. However, it is expected that soil moisture will decrease as temperature increases, which is forecasted over the planning horizon for this Stormwater Management Plan.

2.4.4 Hydrology of the Study Area

As discussed in Section 2.3.1, the township of Gladstone is situated near a number of watercourses, including the Rocky River, Yangya creek and two smaller, unnamed watercourses. Rocky River flows towards Gladstone from the northwest, crossing beneath Wilkins Highway and coming close to Horrocks Highway before turning southwest away from Gladstone. Yangya Creek approaches Gladstone from the northeast, crossing under Bondowie Street where it meets with the larger of the two unnamed watercourses, before crossing beneath Port Street and flowing to the south along the eastern side of the railway line. It is then joined by the smaller of the two unnamed watercourses, before flowing under Horrocks Highway and leaving the study area to the southwest where it flows into Rocky River.

2.4.5 History of Flooding and Drought in Gladstone

As summarised in *Gladstone Flood Protection Study* (GHD, 2004), Gladstone has experienced major flood events in 1890, 1893, 1904, 1909, 1910, 1921, 1934 and 1941, with significant flooding also occurring in April 2000. In addition, *Floods in South Australia (1836-2005)* (Bureau of Meteorology, 2006) documents flooding of varying severity in Gladstone in 1877, 1883, 1884, 1888, 1914, 1946, 1978 and 2000. The frequency with which flooding has historically occurred within Gladstone speaks to the stormwater management challenges facing the town, with a

significant watercourse running directly through the town. The figures below show historic photographs of flooding in Gladstone.



Figure 2.7 1910 Flood at Booyoolee Hotel (Source: State Library of South Australia)



Figure 2.8 1910 Flood, looking south along Gladstone St (Enhanced and Colourised, Source: Gladstone SA History Pics Info Community Notices Facebook Page)



Figure 2.9 1910 Flood alongside Railway Line showing Overtopping



Figure 2.10 2016 Flood along Wilkins Hwy (Source: Gladstone SA History Pics Info Community Notices Facebook Page)

Figure 2.10 above appears to confirm comments by Cr Kathy Webb during a site visit on 12 October 2022 that previous flooding events have cut off Gladstone, with major roads out of the town flooded and impassable.

In 1975, a flood mitigation scheme was implemented by the State and Federal Governments with the support of landowners across the catchment, involving the establishment of contour

banking to reduce the flow of water into Yangya Creek. In total 1,400 hectares was contoured. Although an ultimate area of 7,000 hectares was scoped for contouring, it is unclear whether any additional contouring was done.

Following the completion of the *Gladstone Flood Protection Study* (GHD, 2004), a raised bund and channel north of Bondowie Street were constructed, diverting flows through the railway culvert to the east and into Yangya Creek north of the town.

While Gladstone has experienced many periods of intense rainfall, it has also experienced a number of droughts, including the following:

- The Federation drought (1895 to 1902);
- The 1914 to 1915 drought;
- The World War II drought (1937 to 1945);
- The 1965 to 1968 drought;
- The 1982 to 1983 drought;
- The Millenium drought (1997 to 2009); and
- The 2017 to 2019 drought.

2.4.6 Available Hydrometric Data

The Water Data SA website, operated by the Department for Environment and Water, was accessed to determine the availability of hydrometric data within the study area. No flow gauges were found within either the Rocky River catchment or the Yangya Creek catchment, with the nearest gauge being on the Rocky River downstream of Gladstone, southeast of Crystal Brook. Similarly, there was no data available for the drainage networks within the study area.

2.4.7 Surface Water and Groundwater Interaction

We are not aware of any studies or information investigating the interaction between surface water and groundwater in Gladstone. However publicly available drillhole log information from the WaterConnect website suggests that the groundwater table is in excess of 7 m deep, and is therefore considered unlikely to meaningfully impact surface water from a stormwater management perspective. More broadly, the *Rocky River Catchment Water Resources Assessment* (Department of Water, Land and Biodiversity Conservation, 2005) estimated for the entire catchment an annual groundwater recharge of 2,500-24,000 ML.

2.5 Stormwater and Flood Infrastructure

2.5.1 Existing Infrastructure

Northern Areas Council maintains records of existing stormwater infrastructure, which have been provided for this Stormwater Management Plan. This information is in the form of a GIS point layer containing asset data, and a separate excel spreadsheet of stormwater asset data.

Using the supplied GIS data, together with aerial photography, the DTM and information gained on a site visit, stormwater pit and stormwater pipe layers were created. Figure 2.11 below provides an overview of the location and extent of existing stormwater infrastructure within the study area. A summary profile of existing infrastructure is provided in Table 2.7.

Table 2.7 Existing Stormwater Infrastructure

Asset Class	Description	Quantity
Pipe	150mm dia 225mm dia 300mm dia 375mm dia 450mm dia 1500mm dia Unknown dia	78 m 310 m 207 m 160 m 282 m 53 m 39 m
Box Culvert	Size varying	502 m
Node	Side Entry Pit Headwall Grated Inlet Pit Flap Gate	1 57 3 1
Levee	N/A	706 m

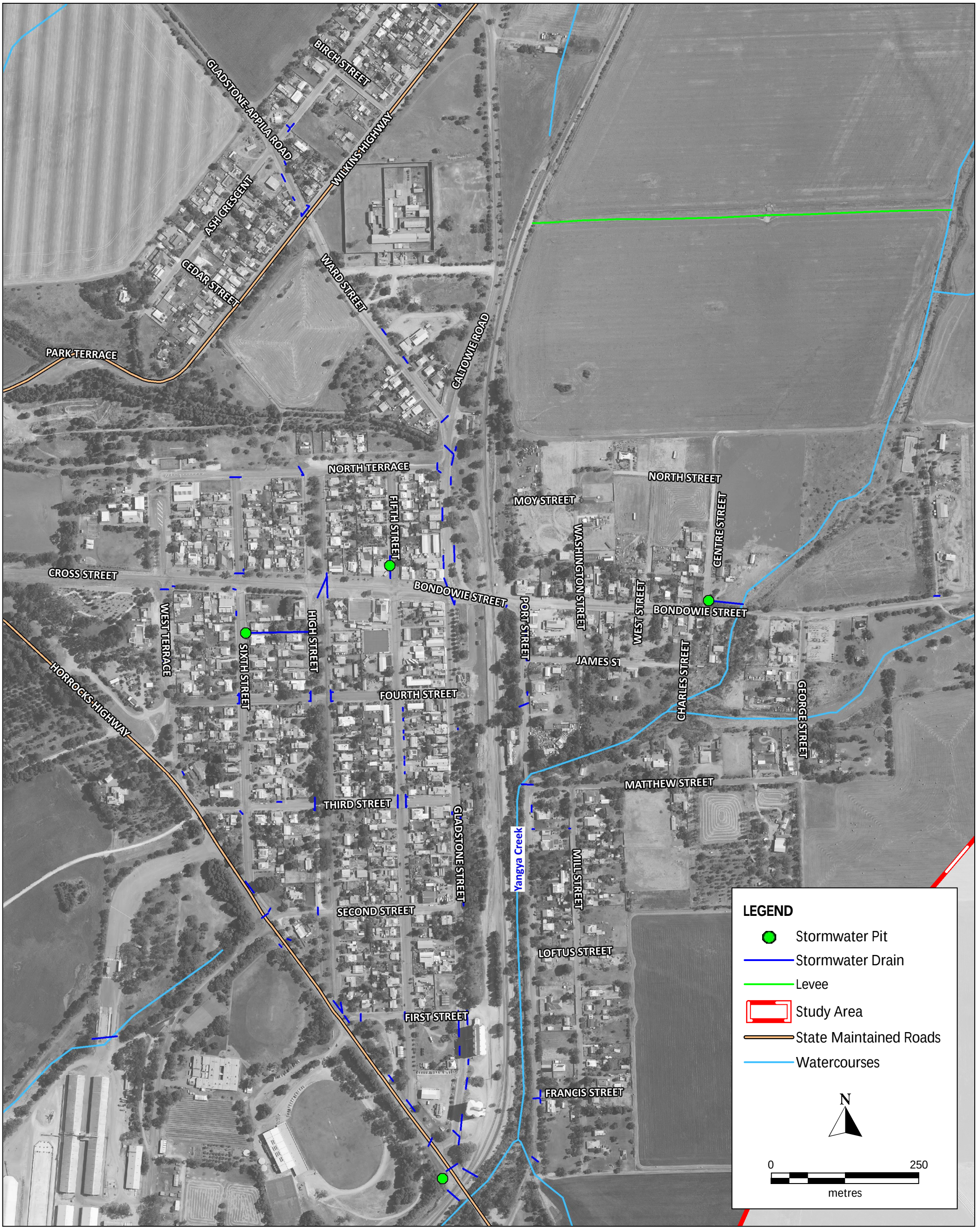
2.5.2 Stormwater Asset Age and Condition

Council's GIS and spreadsheet stormwater asset databases contain condition information, however as discussed these are not linked to spatially accurate pit and pipe objects, and therefore it is difficult to map asset condition. The two databases do not list asset age, however the spreadsheet lists a date of expiry.

2.5.3 Stormwater Asset Management Planning

Council are in the process of developing a Stormwater Asset Management Plan (personal communication David McKinley, October 2022), which will be used to guide the planning and maintenance of Council's stormwater assets. Other relevant processes and plans include:

- *Stormwater Management Planning Guidelines* (Stormwater Management Authority, 2007);
- *Asset Management Policy* (Northern Areas Council, 2022); and
- *Long Term Financial Plan 2021-22 to 2030-31* (Northern Areas Council, 2021).



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Data Sources:
Northern Areas Council (Aerial Photography, Stormwater Assets)
Data SA (Roads, Watercourses)

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FIGURE 2.10 - STORMWATER INFRASTRUCTURE

2.5.4 Actual and Desired Level of Service

The existing level of service provided by stormwater infrastructure has previously been investigated in *Gladstone Flood Protection Study* (GHD, 2004). These studies identified problem areas, namely surrounding the Yangya Creek channel along Port Street, with the existing main creek found to have limited capacity. The study found that in a 1% AEP flood event, water overtops the western bank due to the constriction of the channel at Bondowie Street Bridge and the increased creek roughness downstream of the bridge due to uncontrolled vegetation growth within the channel.

From discussions with Council staff, it is assumed that there are no formalised level of service requirements for stormwater management within the study area. Rather, priorities involve protecting the town from major flooding and managing more frequent nuisance ponding. Key level of service targets for this study will be selected through discussions with Council staff.

It appears that the full study area flows untreated towards Rocky River. As with flood protection, we are unaware of defined water quality targets set by Council.

2.6 Environmental Values

2.6.1 Water Quality

The quality of water within the study area is of great importance. The primary downstream receiving waters is Rocky River, and therefore it is important that appropriate consideration is given to pollutants in runoff leaving the study area. Additionally, the quality of stormwater will impact the feasibility of potential stormwater harvesting and reuse schemes. *Water sensitive urban design – Creating more liveable and water sensitive cities in South Australia* (Department of Environment, Water and Natural Resources, 2013) provides WSUD performance targets for South Australia, which will be benchmarked against in this report.

Typical stormwater pollutants include:

- Total suspended solids (TSS), commonly clay, gravel, sand and silt, but also including algae and decomposing organic material;
- Total phosphorus (TP), with common sources including sewage, intensive livestock industries, soil, fertilisers and detergents;
- Total nitrogen (TN), with common sources including food processing industries, sewage, intensive livestock industries, soil and fertilisers; and
- Gross pollutants, typically including rubbish, plant debris and coarse sediment.

We are not aware of any pollutant base load or concentration information specific to the study area, however it is expected these would be comparable to those for catchments primarily comprised of agricultural and grazing land use.

The presence of total suspended solids in watercourses can result in cloudier water, affecting the oxygen levels within the water and potentially harming animals and plants living within it, as well as humans if the water is consumed. High levels of total phosphorus and total nitrogen often cause blue-green algal blooms, which can produce harmful toxins to humans through contact or consumption. Gross pollutants such as litter can be harmful to receiving waters if not screened, with animals potentially consuming plastics or other rubbish.

Australian Guidelines for Water Recycling: Stormwater Harvesting and Reuse (Natural Resource Management Ministerial Council, 2009) recommends including stormwater treatment to minimise operational risks. Operational risks include gross pollutants blocking pipes or damaging pumps and organic matter resulting in reduced oxygen levels, potentially creating odours and releasing pollutants from sediments.

2.6.2 Threatened/Sensitive Ecological Communities

It is important to consider the impact of stormwater runoff on the downstream environment. *A River Management Plan for the Broughton Catchment* (Department of Water, Land and Biodiversity Conservation, 2004) describes the water dependent ecosystems and processes throughout the Broughton River Catchment, of which the Rocky River is a major tributary.

The Rocky River channel downstream of Gladstone is characterised by a wide channel and extensive reedbeds containing common reed and bulrush. Upstream of the confluence with Yangya Creek, the vegetation reflects that of an open forest of river red gums. The in-stream vegetation is also less dense, consisting of a more diverse range of species, but still predominantly consists of bulrush and common reed. A wide range of macro-invertebrates were found within the downstream receiving waters, including worms, amphipods, midge larva and springtails. Fish species identified in Rocky River include blue spot goby, eastern gambusia and goldfish.

2.6.3 Watercourse Assessment

The Rocky River vegetation downstream of the study area was found in *A River Management Plan for the Broughton Catchment* (Department of Water, Land and Biodiversity Conservation, 2004) to consist of exotic annual grasses with scattered trees and shrubs, with extensive reedbeds in the channel. Upstream of Gladstone, Rocky River vegetation transitions to an open forest of river red gums. Along all reaches of the Rocky River, the understorey vegetation has been modified due to the impact of grazing and clearing, with most areas lacking shrub species. The channel condition was found to be fair, with generally good bank stability observed. Stream structures were classified as high or medium stability.

Yangya Creek was surveyed as a predominantly dry channel with areas of permanent baseflow which provide important habitats. Woodlands of native pines and Broughton willow were observed along Yanga Creek. In the lower reaches stream vegetation mainly consists of annual exotic grasses. Exotic trees, including pines and peppertrees, can be found along the creek through Gladstone. Further upstream, a high groundwater table results in aquatic plants and reedbeds in the channel, as discussed in Section 2.4.7. The creek channel is well defined, with moderate to good bank stability observed.

In a site visit undertaken on 12 October 2022, Yangya Creek was inspected at the Bondowie Street and Port Street crossings. At the crossing of Bondowie Street, there was sparse vegetation in the channel immediately upstream, however on the downstream side there was substantial vegetation throughout the channel, including bushes, shrubs and many large trees. Similar vegetation was observed along the channel further downstream at Port Street. Although vegetated channels comes with a range of benefits such as amenity, water quality and habitat for wildlife, they also result in increased roughness, reducing the flow capacity and increasing flood risk. Figure 2.12 and Figure 2.13 show photographs of the channel in these locations.



Figure 2.12 Yangya Creek Crossing at Bondowie Street



Figure 2.13 Yangya Creek Crossing at Port Street

2.6.4 Areas of Environmental Importance

The Rocky River channel and surrounding floodplain downstream of Gladstone was identified in *A River Management Plan for the Broughton Catchment* (Department of Water, Land and Biodiversity Conservation, 2004) as an important riverine ecosystem. The lower reaches of the Rocky River comprise extensive reedbeds and sedgelands, sparse trees and shrubs and permanent pool environments. Further downstream the surrounding habitat consists of river red gum open forest and permanent pool environments. In-stream habitats and aquatic habitats, as well as a range of native vegetation were identified. These elements result in increased amenity, higher recreational value and improved environmental health.

2.6.5 Environmental Flows

A River Management Plan for the Broughton Catchment (Department of Water, Land and Biodiversity Conservation, 2004) also assessed the environmental flow regimes and requirements for the different watercourses within the greater Broughton River catchment, including Rocky River. The ecological communities outlined previously all have varying environmental flow requirements, for example river red gums in the floodplain are dependent on infrequent overbank flows, while macro-invertebrates require various flow regimes ranging from no flow to mid-bank flows. Table 2.8 below describes the environmental flow requirements for Rocky River in the vicinity of the study area. The Broughton River Catchment Plan did not determine environmental flow requirements for Yangya Creek.

Table 2.8 Rocky River Environmental Flow Requirements (Department of Water, Land and Biodiversity Conservation, 2004)

Flow Band	Key Functions	Frequency (every X years)
Groundwater table – Riverbed wetted, pools filled	Maintain aquatic habitat Maintain macrophytes	1
Mid flow – Low flow channel filled	Increase aquatic habitat Connectivity between pools Migration of macro-invertebrates Development and recruitment of fish Connectivity to downstream areas	1 to 3
High-bankfull flow – Three-quarter bankfull to bankfull flows	Maintain water quality Maintain riparian vegetation Trigger for fish breeding Migration of macro-invertebrates and fish Channel maintenance Transport sediment/organic matter Removal of fines (riffles)	1 to 5
Overbank flow – Overbank flows into floodplain	Floodplain inundation River red gum establishment Nutrient and organic matter transport	5 to 20

	Create aquatic habitat Connect floodplain to in-stream zone Scouring of pools Channel maintenance Sediment transport	

Any activity which will modify the frequency, timing, seasonality or water quality of the natural flow regime can have a large impact on the downstream, often sensitive ecological communities. Additionally, on-line farm dams, which were found to be very common upstream in the Rocky River catchment, can significantly affect the natural flow regime, detaining low flows and restricting the volume of water entering the downstream channel.

The increased level of imperviousness associated with development has had a significant impact on the natural flow regime. Hard surfaces result in larger, more frequent runoff compared to pervious surfaces such as that of the natural catchment, and also reduce the response time for a catchment.

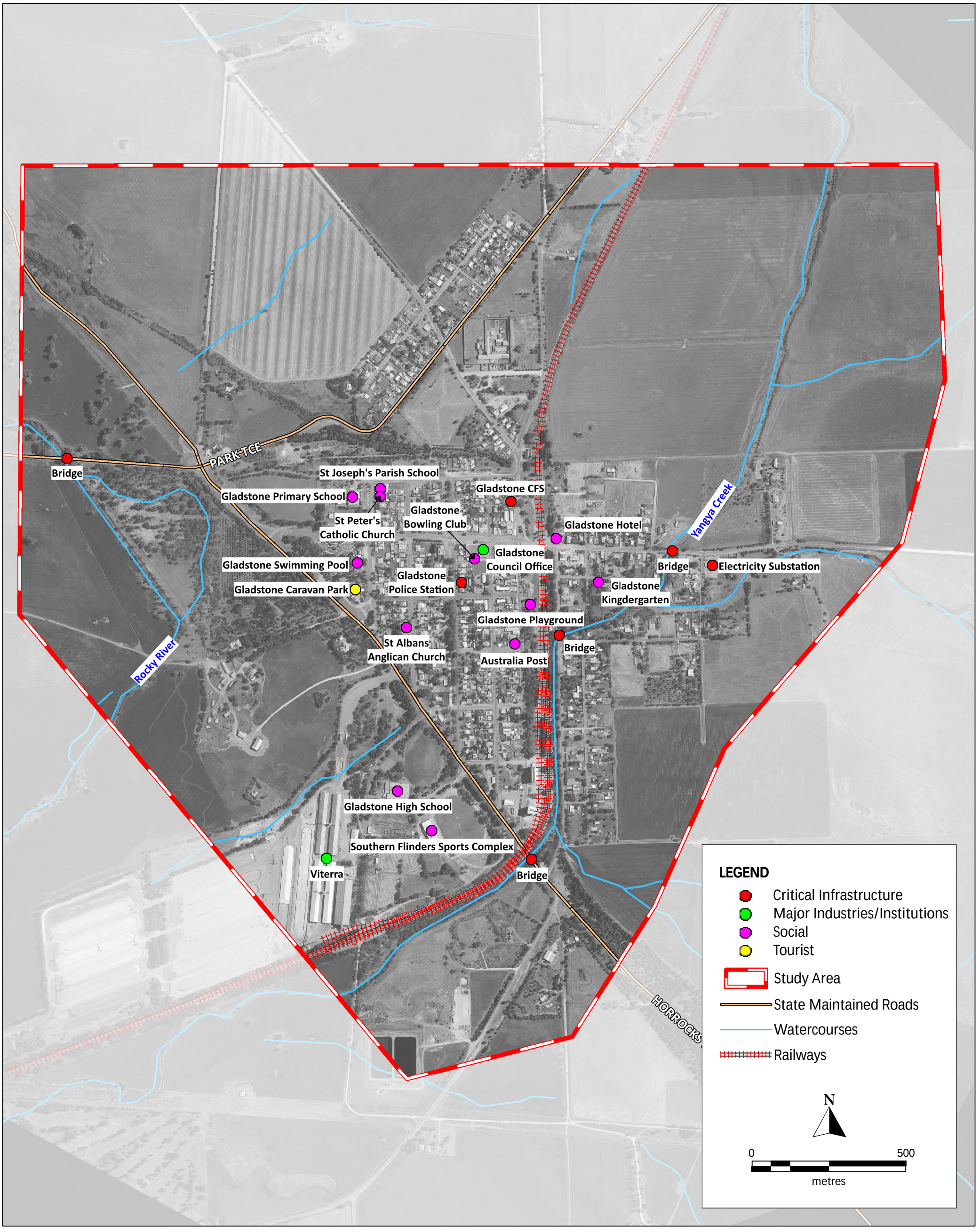
2.7 Social, Socio-Economic and Cultural Values

A map has been prepared summarising locations within the study area of social, socio-economic and cultural importance, and is shown in Figure 2.14. This includes major industries and institutions, critical infrastructure, tourist, trade and social facilities and routes. Gladstone has three State Heritage Places, being the former Gladstone Gaol, Bank SA (originally Savings Bank of SA) Building and the former National Australia Bank Gladstone Branch.

The Northern Areas Council is located within Ngadjuri and Nukunu land.

2.8 Development Policy

A map showing the planning and design code zones within the study area has been prepared, and is shown in Figure 2.15. As can be seen, within the 'Neighbourhood' zone there remains a reasonable amount of vacant land. Vacant lots within this region can be considered potential sites of future development, and are mainly located north of Bondowie Street to the east of the railway line. This confirms information provided by Cr Kathy Webb during a site visit on 12 October 2022, who flagged this region as a key area of development potential in Gladstone.



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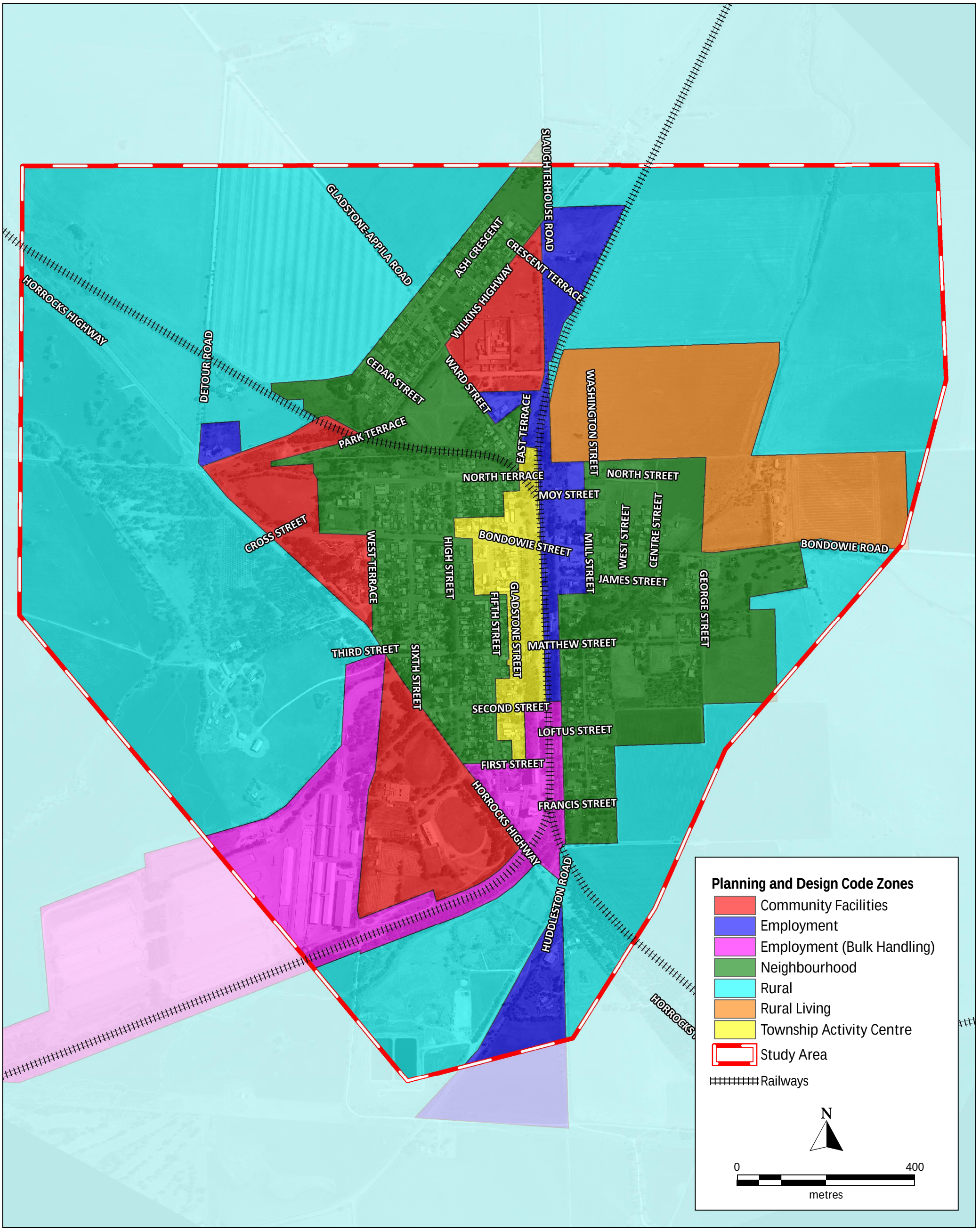
Data Sources:
Northern Areas Council (Aerial Photography)
Southfront (Locations of Interest)
Data SA (State Maintained Roads, Railways, Watercourses)

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FIGURE 2.13 - SOCIAL, SOCIO-ECONOMIC AND CULTURAL VALUES



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Data Sources:
Northern Areas Council (Aerial Photography)
Southfront (SMP Study Area)
Data SA (Planning and Design Code Zones, Roads, Railways)

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FIGURE 2.14 - PLANNING AND DESIGN CODE ZONES

3 Identification of Stormwater Risks and Issues

3.1 General

Stormwater modelling of the study area has been undertaken, including hydrologic, hydraulic and water quality modelling. Details regarding the development of these models and their key results are provided in *Gladstone Stormwater Management Plan Modelling Report* (Southfront, 2025). The results from these models have been used to identify risks and issues relating to stormwater within the township.

3.2 Model Scenarios

The hydrological and hydraulic modelling undertaken consider three scenarios, which are described below:

- Scenario A: Current stormwater infrastructure, current development and current climate;
- Scenario B: Current stormwater infrastructure, future development and future climate to the year 2050; and
- Scenario C: Proposed stormwater infrastructure, future development and future climate to the year 2050.

The range of storm frequencies modelled includes the 18% Annual Exceedance Probability (AEP), 10% AEP, 5% AEP, 2% AEP, 1% AEP and 0.2% AEP events.

The water quality modelling considered four scenarios as follows:

- Scenario 1: Existing development with no WSUD infrastructure;
- Scenario 2: Future development with no WSUD infrastructure;
- Scenario 3: Future development with existing WSUD infrastructure; and
- Scenario 4: Future development with existing and proposed WSUD infrastructure.

The climate data used was the Northern and Yorke climate template, as recommended in *South Australian MUSIC Guidelines* (Water Sensitive South Australia, 2021). This data was captured in Roseworthy between 2001 and 2010, during which time the mean annual rainfall was 404 mm. No climate change assumption has been applied in any scenario in line with the specifications of the brief.

3.3 Stormwater Infrastructure Hydraulic Performance

3.3.1 Background

The hydraulic performance of the stormwater network has been modelled across the required range of events and scenarios listed above. The development of the hydrological and hydraulic models has been documented in *Gladstone Stormwater Management Plan Modelling Report* (Southfront, 2025). The list of deficiencies considered includes over floor flooding (discussed in Section 3.5), high or extreme flood hazard, low freeboard or upwelling in the minor network, stormwater inlet capacity and excessive gutter flow depths or flow widths.

3.3.2 High/Extreme Flood Hazard

Flood hazard is defined by the Australian Institute for Disaster Resilience's Flood Hazard Guideline 7-3 (AIDR, 2017) as a relationship between water depth and velocity. This definition breaks hazard into 6 categories, ranging from lower hazard at H1 through to maximum hazard at H6, as shown in Figure 3.1 below.

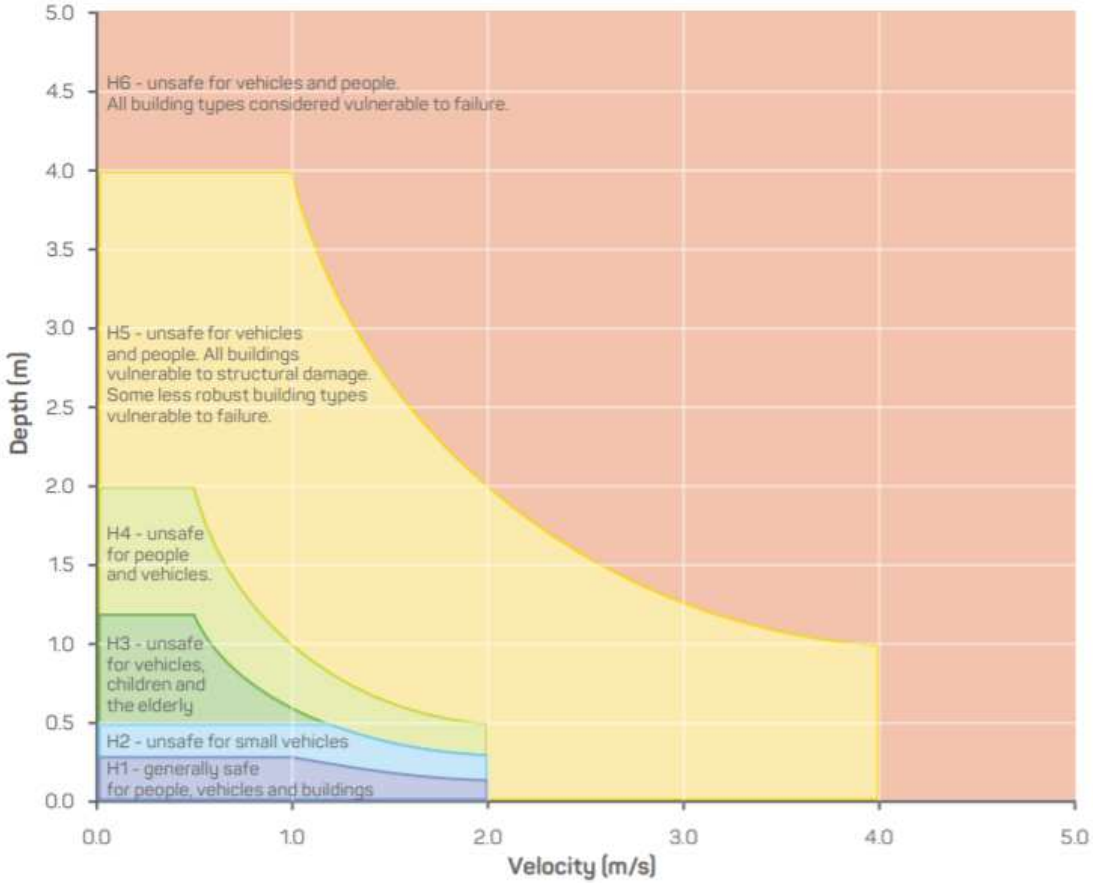


Figure 3.1 Flood Hazard Classification

For this assessment, high flood hazard is defined as category H3 or H4, while extreme flood hazard is defined as category H5 or H6. High and extreme flood hazard within the major watercourses has been ignored for this assessment, and instead flood hazard on roads and through developed land has been considered.

3.3.3 Low Freeboard and Upwelling

The results of the hydraulic modelling have been inspected to determine the maximum HGL level experienced at each stormwater inlet for each AEP. These levels were compared with the node surface level and the level 150 mm below the surface, and when these were exceeded the pit was considered to have upwelled or had insufficient freeboard respectively.

3.3.4 Stormwater Inlet Capacity

An assessment of inlet capacity was undertaken for the stormwater pits in the study area. The capture capacity of each pit was calculated with reference to *SA Road Stormwater Drainage Inlets: Hydraulic Study* (Urban Water Resources Centre). This study examined the performance of the most common stormwater drainage inlets used throughout South Australia, and produced curves relating approach flow with capture flow. Curves for standard side entry pits

have been taken from the City of Charles Sturt pits, while curves for double side entry pits were taken from the City of West Torrens pits.

The peak flow rate approaching each stormwater pit in the 18% AEP storm event was compared with the calculated pit capture capacity, highlighting locations where stormwater pits are undersized relative to their contributing catchment.

3.3.5 Gutter Flow Depth and Flow Width

An assessment was undertaken to determine excessive gutter flow depths and widths in the 18% AEP flood based on flood mapping results. Excessive gutter flow depths have been defined as flooding greater than 100 mm deep in the 18% AEP flood, while excessive gutter flow widths have been defined as flooding greater than 2.5 m wide in the 18% AEP flood.

3.3.6 Hydraulic Performance Assessment

Table 3.1 below presents the various identified stormwater issues in an impact register, providing an ID and a location, describing the type of deficiency, listing the AEP at which the deficiency occurs and providing any additional comments.

Table 3.1 Scenario A Flood Impact Register

ID	Location	Type of Deficiency	AEP Occurring	Comment
1	Wilkins Highway	High/Extreme Flood Hazard	18% AEP/ 10% AEP	Channel spills across road
2	George Street	High/Extreme Flood Hazard	18% AEP/ 5% AEP	Channel spills across road
3	Properties along Port Street and Mill Street next to James Street	High Flood Hazard	5% AEP	Yangya Creek channel spills
4	Properties on George Street adjacent to channel	High Flood Hazard	5% AEP	Adjacent channel spills
5	Properties surrounding intersection of Mill Street and Matthew Street	High Flood Hazard	5% AEP	Yangya Creek channel spills
6	Properties along Port Street and Mill Street south of Loftus Street	High Flood Hazard	5% AEP	Yangya Creek channel spills
7	Horrocks Highway	High/Extreme Flood Hazard	5% AEP/ 1% AEP	Channel spills across road
8	Properties between Port Street and George Street north of Matthew Street	High Flood Hazard	2% AEP	Yangya Creek channel spills

ID	Location	Type of Deficiency	AEP Occurring	Comment
9	Industrial properties along West Terrace	High Flood Hazard	2% AEP	Yangya Creek channel spills
10	Properties between High Street, Second Street and Horrocks Highway	High Flood Hazard	2% AEP	Water spills from High Street through properties
11	Intersection of Third Street and High Street	High/Extreme Flood Hazard	2% AEP/ 1% AEP	Water within central verge spills over Third Street
12	Fourth Street near Gladstone Street	High/Extreme Flood Hazard	2% AEP/ 1% AEP	Water spilling across railway floods road
		Gutter Flow Depth/Width	18% AEP	
13	Gladstone Street from Fourth Street to Second Street	High/Extreme Flood Hazard	2% AEP	Water spilling across railway floods road
		Gutter Flow Depth/Width	18% AEP	
14	Horrocks Highway east of Fifth Street	High/Extreme Flood Hazard	1% AEP/ 0.2% AEP	Water spilling across road
15	Properties between Gladstone Street and High Street south of Fourth Street	High Flood Hazard	1% AEP	Water spilling across railway floods properties
16	Along Fourth Street and High Street	High / Extreme Flood Hazard	1% AEP/ 0.2% AEP	Water spilling across railway floods road
		Gutter Flow Depth/Width	18% AEP	
17	Intersection of Horrocks Highway and High Street	High / Extreme Flood Hazard	1% AEP/ 0.2% AEP	Flooding across Horrocks Highway
18	Properties along Bondowie Street between Washington Street and Centre Street	High Flood Hazard	0.2% AEP	Yangya Creek channel overflows upstream of Gladstone
19	Corner of First Street and Fifth Street	High Flood Hazard	0.2% AEP	Property inundation surrounding this intersection
20	Along Fifth Street	Extreme Flood Hazard	0.2% AEP	Flooding along road
		Gutter Flow Depth/ Width	18% AEP	

ID	Location	Type of Deficiency	AEP Occurring	Comment
21	Properties on corner of High Street and Third Street	High Flood Hazard	0.2% AEP	Property inundation surrounding this intersection
22	Gladstone High School	High Flood Hazard	0.2% AEP	
23	Stormwater Inlet on Centre Street	Low Freeboard /Upwelling	5% AEP	
		Inlet Capacity	18% AEP	
24	Stormwater Inlet on Fifth Street near Cross Street	Low Freeboard	18% AEP	
		Inlet Capacity	18% AEP	
25	Around Stormwater Inlet on Sixth Street	Low Freeboard	18% AEP	
		Inlet Capacity	18% AEP	
		Gutter Flow Depth/Width	18% AEP	
26	Washington Street	Gutter Flow Depth/Width	18% AEP	
27	Bondowie Street between Washington Street and West Street	Gutter Flow Depth/Width	18% AEP	
28	Mill Street south of Bondowie Street	Gutter Flow Depth/Width	18% AEP	
29	James Street between Port Street and Mill Street	Gutter Flow Depth/Width	18% AEP	
30	Matthew Street near Mill Street	Gutter Flow Depth/Width	18% AEP	
31	Port Street south of James Street	Gutter Flow Depth/Width	18% AEP	
32	Cross Street between Sixth Street and High Street	Gutter Flow Width	18% AEP	

The various identified stormwater deficiencies are also presented in Figure 3.2. Locations of high or extreme hazard were mostly commonly found where the Yangya Creek channel spilled. There was limited flood hazard through buildings in low AEP floods, starting with minor inundation along Port Street in the 10% AEP flood. Flood hazard through properties west of the railway line was low in floods smaller than the 2% AEP, where the railway was overtopped. While there were only three identified stormwater inlets, low freeboard was observed at each in events ranging from the 18% to the 5% AEP. Inlet Capacity was an issue at all stormwater inlets, and excessive gutter flows were experienced throughout the study area.

The Scenario A flood impact register was then updated to reflect the flooding observed in Scenario B, and is presented in Table 3.2 below and shown in Figure 3.2.

Table 3.2 Scenario B Flood Impact Register

ID	Location	Type of Deficiency	AEP Occurring	Comment
1	Wilkins Highway	High/Extreme Flood Hazard	18% AEP/ 10% AEP	Channel spills across road
2	George Street	Extreme Flood Hazard	18% AEP	Channel spills across road
3	Properties along Port Street and Mill Street next to James Street	High Flood Hazard	5% AEP	Yangya Creek channel spills
4	Properties on George Street adjacent to channel	High Flood Hazard	10% AEP	Adjacent channel spills
5	Properties surrounding intersection of Mill Street and Matthew Street	High Flood Hazard	10% AEP	Yangya Creek channel spills
6	Properties along Port Street and Mill Street south of Loftus Street	High Flood Hazard	10% AEP	Yangya Creek channel spills
7	Horrocks Highway	High/Extreme Flood Hazard	5% AEP/ 2% AEP	Channel spills across road
8	Properties between Port Street and George Street north of Matthew Street	High Flood Hazard	5% AEP	Yangya Creek channel spills
9	Industrial properties along West Terrace	High Flood Hazard	5% AEP	Yangya Creek channel spills
10	Properties between High Street, Second Street and Horrocks Highway	High Flood Hazard	2% AEP	Water spills from High Street through properties
11	Intersection of Third Street and High Street	Extreme Flood Hazard	2% AEP	Water within central verge spills over Third Street
12	Fourth Street near Gladstone Street	Extreme Flood Hazard	2% AEP	Water spilling across railway floods road
		Gutter Flow Depth/Width	18% AEP	

ID	Location	Type of Deficiency	AEP Occurring	Comment
13	Gladstone Street from Fourth Street to Second Street	Extreme Flood Hazard	2% AEP	Water spilling across railway floods road
		Gutter Flow Depth/Width	18% AEP	
14	Horrocks Highway east of Fifth Street	High/Extreme Flood Hazard	2% AEP/ 1% AEP	Water spilling across road
15	Properties between Gladstone Street and High Street south of Fourth Street	High Flood Hazard	2% AEP	Water spilling across railway floods properties
16	Along Fourth Street and High Street	High / Extreme Flood Hazard	2% AEP/ 1% AEP	Water spilling across railway floods road
		Gutter Flow Depth/Width	18% AEP	
17	Intersection of Horrocks Highway and High Street	High / Extreme Flood Hazard	2% AEP/ 1% AEP	Flooding across Horrocks Highway
18	Properties along Bondowie Street between Washington Street and Centre Street	High Flood Hazard	1% AEP	Yangya Creek channel overflows upstream of Gladstone
19	Corner of First Street and Fifth Street	High Flood Hazard	0.2% AEP	Property inundation surrounding this intersection
20	Along Fifth Street	High / Extreme Flood Hazard	1% AEP/ 0.2% AEP	Flooding along road
		Gutter Flow Depth/Width	18% AEP	
21	Properties on corner of High Street and Third Street	High Flood Hazard	0.2% AEP	Property inundation surrounding this intersection
22	Gladstone High School	High Flood Hazard	0.2% AEP	
23	Stormwater Inlet on Centre Street	Low Freeboard /Upwelling	10% AEP/ 5% AEP	
		Inlet Capacity	18% AEP	
24	Stormwater Inlet on Fifth Street near Cross Street	Low Freeboard	18% AEP	
		Inlet Capacity		
25		Low Freeboard	18% AEP	

ID	Location	Type of Deficiency	AEP Occurring	Comment
	Around Stormwater Inlet on Sixth Street	Inlet Capacity	18% AEP	
		Gutter Flow Depth/Width	18% AEP	
26	Washington Street	Gutter Flow Depth/Width	18% AEP	
27	Bondowie Street between Washington Street and West Street	Gutter Flow Depth/Width	18% AEP	
28	Mill Street south of Bondowie Street	Gutter Flow Depth/Width	18% AEP	
29	James Street between Port Street and Mill Street	Gutter Flow Depth/Width	18% AEP	
30	Matthew Street near Mill Street	Gutter Flow Depth/Width	18% AEP	
31	Port Street south of James Street	Gutter Flow Depth/Width	18% AEP	
32	Cross Street between Sixth Street and High Street	Gutter Flow Width	18% AEP	

The table demonstrates the impact of climate change and development on flooding throughout the township. Several locations with identified high or extreme hazard in Scenario A occur in a more frequent storm event in Scenario B, demonstrating the impact of the increased flow in Yangya Creek due to climate change.

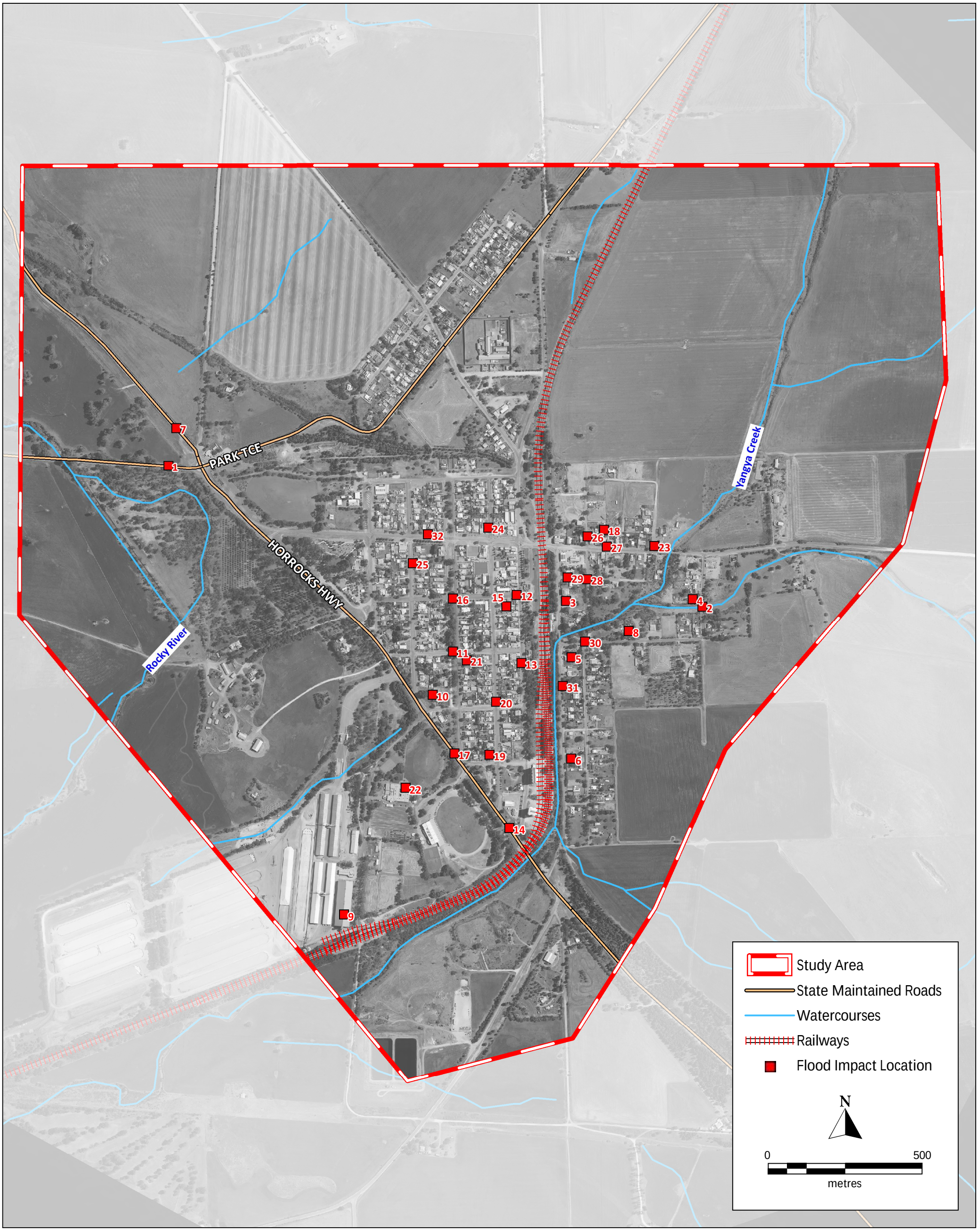
3.3.7 Watercourse Peak Flows

Peak flow rates at key locations along Yangya Creek have been determined for the 18% AEP and 1% AEP flood events, for both Scenario A and Scenario B, and are presented in Table 3.3 below. These locations have also been marked on the 18% AEP and 1% AEP flood maps alongside critical duration information.

Table 3.3 Peak Watercourse Flow Rates (m^3/s)

Watercourse	Location	Scenario A		Scenario B	
		18% AEP	1% AEP	18% AEP	1% AEP
Yangya Creek	Bondowie Street Bridge	19.0	98.0[1]	27.2	102.8[1]
Yangya Creek	Port Street Bridge	20.9	38.3[1]	29.9	39.4[1]
Yangya Creek	Horrocks Highway Bridge	22.6	87.3	28.2	88.9
Yangya Creek	Spill across Railway	0	45.4	0	68.2

[1]The Yangya Creek channel breaks its banks prior to Port Street, as seen on the flood maps.



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Data Sources:
Southfront (Flood Impacts)
Northern Areas Council (Aerial Photography)
Data SA (State Maintained Roads, Watercourses)

NORTHERN AREAS COUNCIL

GLADSTONE STORMWATER MANAGEMENT PLAN

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FIGURE 3.2 - FLOOD IMPACTS LOCATION MAP

3.4 Flood Impacts and Characteristics

Flood and hazard maps for the required scenarios and AEPs have been prepared and are attached in Appendix B and Appendix C for Scenario A and in Appendix D and Appendix E for Scenario B. The flood and hazard maps have been reviewed to determine a range of flood impacts and characteristics within the study area. These maps highlight areas where life and property may be in danger in a given flood, and show key vulnerabilities throughout the study area. General commentary on key flow pathways, high risk locations and other relevant points has been provided for Scenario A for the range of AEP events. It should be noted that surveyed floor levels were unavailable, and therefore it was uncertain if individual dwellings were inundated.

18% AEP Flood Event

Flooding in the 18% AEP flood is largely contained to the major watercourses and channels around and through the township. There is shallow inundation of private property in a number of locations, including north of Bondowie Street, between James Street and Matthew Street, between Gladstone Street and High Street and between Port Street and Mill Street. There is a narrow, shallow overland flow pathway through Gladstone High School. All identified critical infrastructure is outside of the floodplain.

There is flooding deeper than 500 mm for over 210 m of the Wilkins Highway to the west of Gladstone, restricting access.

10% AEP Flood Event

Flooding throughout the study area in the 10% AEP flood is generally similar to the 18% AEP flood, however in some locations the extent of property inundation has drastically increased. The extent of property flooding has increased along Port Street from James Street to Francis Street, with widespread inundation in excess of 250 mm as the Yangya Creek capacity is exceeded and the channel spills. The flow pathway through Gladstone High School has widened, and there is additional flooding deeper than 100 mm. All identified critical infrastructure is outside of the floodplain.

Flooding along Wilkins Highway reached almost 1 m deep, with ponding along the road deeper than 500 mm deep for over 240 m. Along Horrocks Highway north of Wilkins Highway water reached over 100 mm deep and along Port Street varied from shallow to over 500 mm deep.

5% AEP Flood Event

In the 5% AEP flood event, behaviour is again similar to smaller events, but with increased depths through previously identified flooding hotspots. Water spills across the railway line, but is largely kept to the rail reserve and does not flood the town. The extent of inundation surrounding the Yangya Creek channel between Bondowie Street and Horrocks Highway has increased substantially, with several areas of private property inundation to depths of over 500 mm, primarily along Port Street. The flow pathway through Gladstone High School has widened, with even more flooding deeper than 100 mm. All identified critical infrastructure is outside of the floodplain.

Flooding along Wilkins Highway exceeds 1 m deep, with over 260 m of the road inundated deeper than 500 mm. Along Horrocks Highway north of Wilkins Highway depths reached over 250 mm and depths along most of Port Street are in excess of 500 mm. Shallow flooding across Horrocks Highway was observed between Fifth Street and Gladstone Street.

2% AEP Flood Event

Compared to smaller flood events, the flood behaviour in the 2% AEP flood has changed significantly, with the flooding again overtopping the railway line and causing widespread flooding throughout the township. To the east of the railway line, the extent of flooding has significantly increased, with widespread areas along Port Street, Mill Street and Matthew Street flooded to depths of over 500 mm, reaching upwards of 1 m at worst.

Water spills across the railway line to depths of over 250 mm, causing widespread flooding of up to 500 mm deep through private property between Gladstone Street and High Street to the south of Fourth Street. Further downstream, there is flooding of over 100 mm at Gladstone High School, continuing further southwest and affecting the industrial properties north of the railway line. There is shallow flooding at both the CFS building and the police station, and shallow flooding in the corner of the power station at the intersection of George Street and Bondowie Street.

Flooding reached over 1.5m deep along Wilkins Highway, with over 270 m flooded deeper than 500 mm. Along Horrocks Highway north of Wilkins Highway depths exceeded 500 mm, and were over 1 m deep along Port Street between James Street and Francis Street. Along Horrocks Highway from Gladstone Street to High Street there is shallow flooding of up to 250 mm.

1% AEP Flood Event

The overall flood behaviour in the 1% AEP flood is similar to that of the 2% AEP flood, but with increased flood depth and extent. Along the Yangya Creek channel between Bondowie Street and Port Street almost every house is flooded, with depths exceeding 1 m in some locations. Along Port Street between Matthew Street and Francis Street there is widespread property flooding of over 1 m in depth. North of Bondowie Street properties are flooded over 500 mm deep.

Water spills across the railway line causing widespread flooding through private property. Water depths of over 500 mm were observed in various locations between Gladstone Street and High Street, and between High Street and Horrocks Highway. There is over 250 mm deep flooding throughout most of Gladstone High School, and flooding of over 500 mm deep through the industrial land downstream. The majority of the police station is inundated, with depths reaching over 250 mm. Shallow flooding was observed at the CFS building and the power station.

There is widespread flooding over 1.5m deep along Wilkins Highway, with over 280 m flooded deeper than 500 mm. There is flooding over 500 mm deep along Horrocks Highway north of Wilkins Highway and over 1 m deep along Port Street. Within Gladstone there is flooding over 250 mm deep across Horrocks Highway over 500 mm deep along Gladstone Street and Fourth Street. Flood depths exceed 1 m for most of Port Street.

0.2% AEP Flood Event

Again the flood behaviour in the 0.2% AEP flood is similar to the smaller floods, but with large increases to flood depth and extent. The floodplain on the eastern side of the railway line between Bondowie Street and Matthew Street is significant, with widespread flooding of over 500 mm through private property with significant regions of over 1 m deep flooding. Properties along Port Street are flooded over 1 m deep, with small regions nearing 1.5 m deep. Many properties along Washington Street, West Street and Centre Street are flooded over 500 mm deep, with far more inundated over 250 mm deep.

Water spills across the railway line at a depth of up to 500 mm, resulting in a deep, wide flow pathway through the town, across Horrocks Highway back into the Yangya Creek channel. Every property within the rectangle bounded by Fourth Street, High Street, Gladstone Street and Horrocks Highway is flooded to a depth of at least 250 mm, with depths reaching 1 m at worst. Properties between Fourth Street and Bondowie Street along High Street, Fifth Street and Gladstone Street are also flooded, with water reaching over 500 mm deep.

Gladstone High School is completely flooded, with maximum depths reaching over 500 mm. The nearby industrial land is also totally inundated, with depths ranging from shallow to over 1 m. The Gladstone police station is fully flooded up to 500 mm deep, there is shallow flooding at the CFS building and widespread shallow flooding of under 250 mm deep across the power station.

Wilkins Highway is flooded to depths of over 1.5m, with over 310 m deeper than 500 mm. Horrocks Highway north of Wilkins Highway is flooded over 1 m deep and along Port Street depths reach almost 1.5 m. Bondowie Street is flooded over 500 mm deep between Washington Street and West Street, while parts of Gladstone Street, Fourth Street, Fifth Street, High Street and Third Street are all flooded over 500 mm deep. Flooding over Horrocks Highway within the town exceeds depths of 500 mm.

Impact of Climate Change and Future Development
In general, climate change and future development have increased the flood risk facing Gladstone. Increased rainfall associated with climate change has resulted in significantly larger flows in both Yangya Creek and Rocky River, exacerbating the extent of flooding observed across all AEPs. Future development has had a comparatively smaller impact on flooding, with the impacts centralised on the township.

The water level to the east of the railway line was of critical importance, as exceeding the railway line results in significant flooding through the town to the west. Table 3.4 below summarises the freeboard observed across the range of AEPs and scenarios.

Table 3.4 Freeboard to Railway Line

Annual Exceedance Probability	Freeboard (mm)	
	Scenario A	Scenario B
18%	220	210
10%	160	Railway Line Exceeded
5%	Railway Line Exceeded	Railway Line Exceeded
2%	Railway Line Exceeded	Railway Line Exceeded
1%	Railway Line Exceeded	Railway Line Exceeded
0.2%	Railway Line Exceeded	Railway Line Exceeded

3.5 Flood Damages

3.5.1 Background

Estimates of flood damages provide important information that can be used to prioritise flood mitigation works. Flood damages are typically split into the following categories:

- Direct tangible damages, which includes material damage caused by the flood;
- Indirect tangible damages, which mostly consists of damages caused by disruptions due to the flood;
- Direct intangible damages, which considers direct damages that cannot be objectively quantified; and
- Indirect intangible damages, which considers indirect damages that cannot be objectively quantified.

Estimating intangible damages is difficult, and minimal guidance is available for these categories, and therefore they have not been included. However, similar studies have noted that these damages may match or even exceed the tangible damage cost. Flood damages have been calculated for all modelled scenarios across all modelled AEPs.

The adopted methodology also does not consider the following items:

- Damage to public infrastructure
- Damage to crops and stock losses
- Damage to vehicles

3.5.2 Evaluation Approach

Direct tangible flood damages have been estimated with reference to the Investment Framework For the Economics of Water Sensitive Cities (INFFEWS) Value Tool, developed by the Cooperative Research Centre for Water Sensitive Cities (CRCWSC). The INFFEWS is a package of tools and documents for economic analysis of urban water and green infrastructure projects. The INFFEWS Value Tool is designed to assist users to estimate non-market values for the benefits arising from these projects.

INFFEWS provides stage-damage curves for a range of residential and commercial buildings which have been used to estimate flood damages. These curves were developed for the *Brisbane River Strategic Floodplain Management Plan* (State of Queensland, 2018) in 2018, and are based on a survey undertaken to determine stage-damage curves for properties affected by the Brisbane River flooding in late 2010 to early 2011. The stage-damage curves have been adjusted to account for inflation since the development of the curves.

As the stage-damage curves used were developed for the *Brisbane River Strategic Floodplain Management Plan*, this means they are based on properties in and around Brisbane. To account for this, the curves have been adjusted to suit Gladstone based on information from *Rawlinsons Australian Construction Handbook* (Rawlinsons, 2022). This document provides costs for various building types in the major cities, and regional index maps which provide an expected increase in cost associated with distance from the major city. The stage-damage curves from INFFEWS were scaled by the difference in costs between Brisbane and Adelaide, and then increased by 10% according to the regional index.

Indirect tangible damages have been estimated as 15% of the direct tangible damages for residential buildings, and 55% of the direct tangible damages for commercial and industrial buildings, in line with recommendations of *INFFEWS Value Tool: Guidelines (Version 4)* (Iftekhar, Gunawardena, Fogarty, Pannell, & Rogers, 2022).

Residential Properties

Residential stage-damage curves are provided for three building sizes, small (<140 m²), medium (140-210 m²) and large (>210 m²). To determine an appropriate building size to use, an analysis of residential building sizes was undertaken. The sample-sub areas developed to determine subcatchment runoff coefficients for the DRAINS model were used, as these were considered representative of urban development in the study area. Building sizes within the sub-areas were determined, as summarised in Table 3.5.

Table 3.5 Residential Building Size Analysis

Sample Sub-Area	Average Building Size (m²)
North Terrace / Fifth Street	266.5
Fourth Street / Sixth Street	201.3
Matthew Street / Port Street	265.2

As can be seen, two of the three sub-areas had an average residential building size of over 210 m², with the third being at the upper end of the range classified as 'medium'. Therefore, direct tangible flood damages for residential properties were calculated using the stage-damage curves for 'large' residential properties, as this was considered a suitable representation of the residential properties throughout the study area.

For each building size, stage-damage curves are provided for six different house types:

- Fully detached single storey (slab on the ground);
- Fully detached single storey (on stumps);
- Fully detached single storey (highset);
- Fully detached double storey;
- Multi-unit single storey; and
- Multi-unit double storey.

Given the lack of available house type information, all residential properties were assumed to be fully detached single storey houses with a slab on the ground. This is broadly consistent with site visit observations during the project.

For residential properties, INFFEWS provides three separate stage-damage curves, representing internal damage, structural damage and external damage. Internal damage refers to the damage to the contents of the main building of a property, and includes furniture, appliances and other internal contents. Structural damage refers to the damage sustained by the fabric of a building, and includes foundations, floors, walls, doors and permanently fixed objects such as cupboard and benches. External damage refers to damage to objects outside of the main building such as cars, fences, gardens and sheds.

The total residential damage to each property was determined by summing the values of the three curves at the corresponding flood depth range as determined in the TUFLOW model. The flood depth used for each property has been taken at the location of the dwelling. For allotments with no building, no flood damage has been calculated as the curves primarily consider structural damage associated with a building. Where a curve did not have a damage value for a required flood depth, it has been linearly interpolated from the surrounding values. Table 3.6 below shows the adopted residential stage-damage curve.

Table 3.6 Residential Stage-Damage Curve

Flood Depth Range (m)	Flood Damage Cost
0-0.15	0
0.15-0.25	$94,895
0.25-0.5	$212,876
0.5-1.0	$285,720
1.0-1.5	$314,260
1.5-2.5	$374,673
2.5-5.0	$388,780

The flood damage curves provided by INFFEWS start at floor level, and therefore when an assumed 150 mm slab height is factored in, the curves show no damage for the first 150 mm. The curves show that flooding of just 100 mm above the floor can have a substantial cost, with damage increasing to almost $400,000 for flooding over 2.5 m deep.

Commercial Buildings

Stage-damage curves for commercial buildings are provided for three building sizes, small (<186 m²), medium (186-650 m²) and large (>650 m²). Given the lack of building footprint information, it has been assumed that all commercial buildings are 'medium' in size due to the wide range of building sizes that would fit into this category.

For each building size, stage-damage curves have been provided for five 'value classes', which classify the relative value of the type of business being flooded. These are summarised in Table 3.7 below.

Table 3.7 Commercial Building Value Classes

Value Class	Example Businesses
VC1 (Very Low)	Florists, Garden Centres, Vehicle Sales Areas, Schools, Churches
VC2 (Low)	Offices, Cafes, Restaurants, Service Stations, Pubs, Clubs
VC3 (Medium)	Chemists, Musical Instruments, Printing, Clothing
VC4 (High)	Bottle Shops, Cameras
VC5 (Very High)	Pharmaceuticals, Electronics

For the purposes of flood damage estimation, it has been assumed that all commercial buildings are Value Class 2 (Low). This was considered a reasonable assumptions as the majority of commercial businesses could be considered either Value Class 1 or Value Class 2. The adopted commercial stage-damage curve is shown in Table 3.8 below.

Table 3.8 Commercial Stage-Damage Curve

Flood Depth Range (m)	Flood Damage Cost
0-0.1	$54,682
0.1-0.15	$74,547

0.15-0.25	$116,988
0.25-0.5	$168,860
0.5-1.0	$270,857
1.0-1.5	$346,836
1.5-2.5	$407,868
2.5-5.0	$438,097

Unlike residential properties, the stage-damage curve for commercial properties shows significant costs even for flooding below 150 mm, as it is assumed the floor level for these properties is at ground level. Compared to the residential stage-damage curves, the damage for commercial flooding is much greater at smaller depths, lower at moderate depths and greater at higher depths.

Industrial Buildings

The INFFEWS Value Tool does not provide stage-damage curves for industrial properties, and therefore the curves used for commercial properties have been used to calculate industrial property damages. This is consistent with the *Brisbane River Strategic Floodplain Management Plan* (State of Queensland, 2018) where the stage-damage curves were originally developed. Like commercial properties, all industrial properties were assumed to be 'medium' size, and Value Class 2 (Low).

Limitations of Approach

The adopted approach comes with several limitations which affect the accuracy of the results, however it has been successfully adopted in previous flood studies. Key limitations of the method are discussed below.

A single damage curve has been adopted for each of residential, commercial and industrial building types. Not all properties are the same, and these curves attempt to represent the average property of each type. It is likely that a more in-depth, nuanced investigations to develop multiple curves based on property size and value would provide more accurate results.

All commercial buildings have been assumed to be of the same value class. As discussed, the value class describes the relative value of a commercial building, and there is quite a substantial difference between the lower and higher classes. Value Class 2 was adopted for all commercial buildings as this value class was thought to best represent the typical commercial buildings in the study area, however a more thorough investigation would likely result in more accurate damages.

The damage estimates prepared with this approach consider only structural damage to buildings and their surroundings, and not damages to public assets such as roads and open space features. This has the effect of producing lower benefit-cost ratios than would be determined if these assets were monetised. However research on determining flood damages for public assets is comparatively underdeveloped, with INFFEWS providing no guidance in this area, and therefore this approach was considered suitable.

The adopted damage curves for this study are based on curves developed for Brisbane that have been scaled according to property prices in Adelaide, factored to account for the distance from Adelaide and finally factored once more to adjust the curves to the current year. In reality, the

damage curves for a property in Gladstone would be significantly different to those for a property in Brisbane, and this has not been accounted for with the adopted approach. However there is minimal guidance available for calculating flood damages, and the adopted methodology was considered the best available information at the time of the study.

3.5.3 Scenario A Flood Damages

Number of Properties Affected

Flood levels within each property were determined from the flood grids produced by the TUFLOW model, and these have been used to determine the number of affected properties in Scenario A. In this instance, an affected property is defined as a property with any depth of water at the location of the building. Table 3.9 below summarises the total number of properties affected by each stage-damage curve range for all modelled AEPs.

Table 3.9 Scenario A Inundated Properties by Flood Depth

Flood Depth Range (m)	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
0-0.1	27	37	56	42	24	18
0.1-0.15	2	7	4	25	11	12
0.15-0.25	0	5	12	64	51	4
0.25-0.5	1	4	16	33	80	75
0.5-1.0	0	0	4	28	34	89
1.0-1.5	0	0	0	0	2	22
1.5-2.5	0	0	0	0	0	0
2.5-5.0	0	0	0	0	0	0
Total	30	53	92	192	202	220

The table demonstrates the increase in affected properties between AEP events, with the most substantial increase occurring between the 5% AEP and the 2% AEP floods, coinciding with the railway line being overtopped. Property flooding reaches a maximum of 500 mm deep until the 5% AEP flood, reaching a maximum depth of over 1 m in the 1% AEP and 0.2% AEP floods.

Table 3.10 below categorises the affected properties by land use, being residential, commercial and industrial.

Table 3.10 Scenario A Inundated Properties by Land Use

Land Use	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
Residential	28	45	78	151	157	163
Commercial	2	8	12	37	40	48
Industrial	0	0	2	4	5	9
Total	30	53	92	192	202	220

Residential land use makes up the vast majority of affected property, followed by commercial and finally industrial.

Direct Tangible Flood Damages
Direct tangible flood damages for Scenario A have been estimated. The flood level determined for each property was compared with the appropriate stage-damage curve to determine a damage cost for each property, and these have been summed across the study area. Table 3.11 below shows the resulting flood damage by land use as well as the total flood damage for the range of modelled AEPs.

Table 3.11 Scenario A Direct Tangible Flood Damages

Land Use	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
Residential	$0.2m	$1.2m	$4.8m	$16.9m	$25.5m	$37.1m
Commercial	$0.1m	$0.5m	$1.2m	$4.6m	$5.9m	$10.0m
Industrial	$0.0m	$0.0m	$0.1m	$0.5m	$0.7m	$1.6m
Total	$0.3m	$1.8m	$6.1m	$22.1m	$32.0m	$48.6m

Although many residential properties were considered flood-affected in the 18% AEP event, because for most of these the water depth was below 150 mm this has resulted in a relatively low direct tangible flood damage. Damages can be seen to increase gradually with increasing AEP as would be expected, with larger increases in residential damage in the 2% AEP and rarer floods as the railway is overtopped.

Indirect Tangible Flood Damages
As discussed, INFFEWS recommends indirect tangible flood damages of 15% for residential buildings and 55% for commercial and industrial buildings. This results in the total tangible flood damages summarised in Table 3.12.

Table 3.12 Scenario A Total Tangible Flood Damages

Land Use	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
Residential	$0.2m	$1.4m	$5.5m	$19.5m	$29.3m	$42.6m
Commercial	$0.2m	$0.8m	$1.9m	$7.2m	$9.1m	$15.5m
Industrial	$0.0m	$0.0m	$0.2m	$0.7m	$1.1m	$2.4m
Total	$0.4m	$2.2m	$7.5m	$27.4m	$39.5m	$60.6m

Average Annual Damages
An average annual damage value, representing the damage that would occur in any given year if flood damages from all AEPs were spread out equally over time, was calculated for the study area, giving a value of $1,755,123.

3.5.4 Scenario B Flood Damages

Number of Properties Affected
Flood levels within each property were determined from the flood grids produced by the TUFLOW model, and these have been used to determine the number of affected properties in

Scenario B. Table 3.13 below summarises the total number of properties affected by each stage-damage curve range for all modelled AEPs.

Table 3.13 Scenario B Inundated Properties by Flood Depth

Flood Depth Range (m)	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
0-0.1	38	40	80	27	23	21
0.1-0.15	3	5	34	21	6	6
0.15-0.25	3	7	21	48	29	10
0.25-0.5	2	17	14	71	105	58
0.5-1.0	0	1	18	29	38	106
1.0-1.5	0	0	0	2	8	24
1.5-2.5	0	0	0	0	0	0
2.5-5.0	0	0	0	0	0	0
Total	46	70	167	198	209	225
Change from Scenario A	+53.3%	+32.1%	+81.5%	+3.1%	+3.5%	+2.3%

Unlike in Scenario A, the number of inundated properties increased most significantly between the 10% AEP and 5% AEP flood events, with future development and climate change causing the railway line to be overtopped in the 5% AEP flood event. From the 18% AEP to the 5% AEP floods there were substantial increases in the number of affected properties, while in the 2% AEP and rarer floods this increase was very limited. However, in these significant flood events the distribution was changed in that more properties were within the deeper flood ranges.

Table 3.14 below categorises the affected properties by land use.

Table 3.14 Scenario B Inundated Properties by Land Use

Land Use	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
Residential	40	59	135	155	157	168
Commercial	6	11	28	38	45	48
Industrial	0	0	4	5	7	9
Total	46	70	167	198	209	225

The distribution of land use in the affected properties was found to be very similar to that of Scenario A.

Direct Tangible Flood Damages

Direct tangible flood damages for Scenario B have been estimated. The flood level determined for each property was compared with the appropriate stage-damage curve to determine a damage cost for each property, and these have been summed across the study area. Table 3.15

below shows the resulting flood damage by land use as well as the total flood damage for the range of modelled AEPs.

Table 3.15 Scenario B Direct Tangible Flood Damages

Land Use	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
Residential	$0.7m	$4.0m	$8.5m	$22.4m	$30.2m	$38.8m
Commercial	$0.3m	$1.0m	$2.6m	$5.5m	$7.2m	$10.5m
Industrial	$0.0m	$0.0m	$0.3m	$0.7m	$0.8m	$1.7m
Total	$1.0m	$5.0m	$11.4m	$28.6m	$38.2m	$51.0m

Compared to Scenario A, flood damage has increased in all modelled AEPs, with the most significant increases coming from the 18% AEP, 10% AEP and 5% AEP floods. This is due to the additional flow in Yangya Creek as a result of climate change and future development affecting more properties in these events.

Indirect Tangible Flood Damages

As discussed, INFFEWS recommends indirect tangible flood damages of 15% for residential buildings and 55% for commercial and industrial buildings. This results in the total tangible flood damages summarised in Table 3.16.

Table 3.16 Scenario B Total Tangible Flood Damages

Land Use	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
Residential	$0.8m	$4.7m	$9.8m	$25.8m	$34.7m	$44.7m
Commercial	$0.5m	$1.5m	$4.1m	$8.5m	$11.1m	$16.3m
Industrial	$0.0m	$0.0m	$0.4m	$1.1m	$1.3m	$2.6m
Total	$1.3m	$6.2m	$14.3m	$35.3m	$47.1m	$63.5m

Average Annual Damages

The resulting average annual damages value was found to be $2,610,345, which is a 49% increase from the Scenario A value.

3.6 Water Quality Performance

3.6.1 Background

Details of the water quality modelling work undertaken for this assessment, including software selection, determination of key input parameters and model configuration, are provided in the modelling report. Key results from the water quality modelling are presented below for the required locations across the range of required water quality scenarios.

3.6.2 Scenario 1 Water Quality Modelling

Scenario 1 consists of existing development with no WSUD infrastructure. A summary of the average annual pollutant loads and stormwater runoff generated by the urban catchment in Scenario 1 is provided in Table 3.17 below.

Table 3.17 Scenario 1 Urban Catchment Pollutant Loads

Parameter	Pollutant Load
Flow (ML/yr)	95.9
Total Suspended Solids (kg/yr)	15,100
Total Phosphorous (kg/yr)	33.6
Total Nitrogen (kg/yr)	261
Gross Pollutants (kg/yr)	1,620

3.6.3 Scenario 2 Water Quality Modelling

Scenario 2 consists of future development with no WSUD infrastructure. Table 3.18 provides the annual pollutant loads generated by the urban catchment for Scenario 2.

Table 3.18 Scenario 2 Urban Catchment Pollutant Loads

Parameter	Pollutant Load
Flow (ML/yr)	107
Total Suspended Solids (kg/yr)	16,900
Total Phosphorous (kg/yr)	37.9
Total Nitrogen (kg/yr)	292
Gross Pollutants (kg/yr)	2,440

3.6.4 Scenario 3 Water Quality Modelling

Scenario 3 consists of future development with existing WSUD infrastructure. Table 3.19 provides the annual pollutant loads generated by the urban catchment for Scenario 3.

Table 3.19 Scenario 3 Urban Catchment Pollutant Loads

Parameter	Pollutant Load
Flow (ML/yr)	96.2
Total Suspended Solids (kg/yr)	13,000
Total Phosphorous (kg/yr)	31.8
Total Nitrogen (kg/yr)	249
Gross Pollutants (kg/yr)	1,260

3.7 Risk Assessment

The flood impacts registers presented in Section 3.3 have been expanded to form risk registers. Risk registers have been prepared for Scenario A and Scenario B, identifying the flooding hotspots which are most affected by future development and climate change.

In the preparation of the risk registers, a risk classification framework has been developed with reference to Council's Risk Management Plan, which considers the following categories:

- General
- Flooding

- Health & Safety
- Cost
- Environmental
- Social/Stakeholder

Traditionally risk is defined as a combination of likelihood and consequence. However, given that likelihood and consequence are inherently related for flooding, with less frequent events having a larger impact than more frequent events, it was necessary to define risk in relation to consequence. Table 3.20 below shows the adopted relationship between consequence and risk, with the full risk consequence matrix including definitions provided in Appendix A.

Table 3.20 Adopted Consequence Risk Relationship

Consequence Level	Risk Definition
1 Insignificant	Low
2 Minor	Moderate
3 Moderate	High
4 Major	Extreme
5 Catastrophic	Extreme

The flood impact registers developed in Section 3.3 have been expanded upon to consider the type of risks and the level of consequence associated with each flood hotspot, and are attached below as Table 3.21 for Scenario A and Table 3.22 for Scenario B. The consequence level adopted represents the greatest impact experienced across the various risk categories.

Table 3.21 - Scenario A Flood Risk Register

ID	Location	Type of Deficiency	1% AEP Impact Details	Risk Category	Consequence	Risk
1	Wilkins Highway	High/Extreme Flood Hazard	Flooding over 1500mm deep across major road	Flooding, Health & Safety	4	Extreme
2	George Street	High/Extreme Flood Hazard	Flooding over 1000mm deep across the road	Flooding, Health & Safety	3	High
3	Properties along Port Street and Mill Street next to James Street	High Flood Hazard	Properties flooded over 500mm deep, with some over 1000mm	Flooding, Health & Safety, Social/Stakeholder	4	Extreme
4	Properties on George Street adjacent to channel	High Flood Hazard	Properties flooded over 500mm deep	Flooding, Health & Safety, Social/Stakeholder	3	High
5	Properties surrounding intersection of Mill Street and Matthew Street	High Flood Hazard	Many properties flooded over 500mm deep, with some over 1000mm	Flooding, Health & Safety, Social/Stakeholder	4	Extreme
6	Properties along Port Street and Mill Street south of Loftus Street	High Flood Hazard	Properties flooded over 500mm deep, with some over 1000mm	Flooding, Health & Safety, Social/Stakeholder	4	Extreme
7	Horrocks Highway	High/Extreme Flood Hazard	Flooding over 500 mm deep across major road	Flooding, Health & Safety	3	High
8	Properties between Port Street and George Street north of Matthew Street	High Flood Hazard	Properties flooded over 500mm deep	Flooding, Health & Safety, Social/Stakeholder	3	High
9	Industrial properties along West Terrace	High Flood Hazard	Properties flooded over 250mm deep, with some over 500mm	Flooding, Health & Safety, Social/Stakeholder	3	High
10	Properties between High Street, Second Street and Horrocks Highway	High Flood Hazard	Properties flooded over 250mm deep, with some over 500 mm	Flooding, Health & Safety, Social/Stakeholder	3	High
11	Intersection of Third Street and High Street	High/Extreme Flood Hazard	Flooding over 500mm deep across the road	Flooding, Health & Safety	2	Moderate
12	Fourth Street near Gladstone Street	High/Extreme Flood Hazard, Gutter Flow Depth/Width	Flooding over 500mm deep across the road	Flooding, Health & Safety	2	Moderate
13	Gladstone Street from Fourth Street to Second Street	High/Extreme Flood Hazard, Gutter Flow Depth/Width	Widespread flooding over 250mm deep across the road, reaching 500mm at	Flooding, Health & Safety	2	Moderate
14	Horrocks Highway east of Fifth Street	High/Extreme Flood Hazard	Flooding over 250mm deep across the major road	Flooding, Health & Safety	1	Low
15	Properties between Gladstone Street and High Street south of Fourth Street	High Flood Hazard	Many properties flooded over 250mm deep, with some over 500 mm	Flooding, Health & Safety, Social/Stakeholder	3	High
16	Along Fourth Street and High Street	High/Extreme Flood Hazard, Gutter Flow Depth/Width	Widespread flooding over 250mm deep across the road, reaching 500mm at times	Flooding, Health & Safety	2	Moderate
17	Intersection of Horrocks Highway and High Street	High/Extreme Flood Hazard	Flooding over 250 mm deep across the major road	Flooding, Health & Safety	2	Moderate
18	Properties along Bondowie Street between Washington Street and Centre Street	High Flood Hazard	Many properties flooded over 250mm deep, with some over 500 mm	Flooding, Health & Safety, Social/Stakeholder	3	High
19	Corner of First Street and Fifth Street	High Flood Hazard	Many properties flooded over 250mm deep	Flooding, Health & Safety, Social/Stakeholder	3	High

20	Along Fifth Street	Extreme Flood Hazard, Gutter Flow Depth/Width	Flooding over 250mm deep along the road	Flooding, Health & Safety	1	Low
21	Properties on corner of High Street and Third Street	High Flood Hazard	Many properties flooded over 250mm deep	Flooding, Health & Safety, Social/Stakeholder	3	High
22	Gladstone High School	High Flood Hazard	School flooded over 250mm deep	Flooding, Health & Safety, Social/Stakeholder	3	High
23	Stormwater Inlet on Centre Street	Low Freeboard /Upwelling, Inlet Capacity	Flooding over 250 mm deep along the road	Flooding	1	Low
24	Stormwater Inlet on Fifth Street near Cross Street	Low Freeboard, Inlet Capacity	Shallow flooding along road	Flooding	1	Low
25	Around Stormwater Inlet on Sixth Street	Low Freeboard, Inlet Capacity, Gutter Flow Depth/Width	Shallow flooding on both sides of the road, through properties	Flooding	2	Moderate
26	Washington Street	Gutter Flow Depth/Width	Flooding over 250 mm deep along the road	Flooding	1	Low
27	Bondowie Street between Washington Street and West Street	Gutter Flow Depth/Width	Flooding over 250 mm deep along the road	Flooding	1	Low
28	Mill Street south of Bondowie Street	Gutter Flow Depth/Width	Flooding over 500 mm deep along the road	Flooding	2	Moderate
29	James Street between Port Street and Mill Street	Gutter Flow Depth/Width	Flooding over 500 mm deep along the road	Flooding	2	Moderate
30	Matthew Street near Mill Street	Gutter Flow Depth/Width	Flooding over 500 mm deep along the road	Flooding	2	Moderate
31	Port Street south of James Street	Gutter Flow Depth/Width	Flooding over 1 m deep along the road	Flooding	3	High
32	Cross Street between Sixth Street and High Street	Gutter Flow Width	Shallow flooding along road	Flooding	1	Low
33	Receiving waters	Water quality of town runoff	Risk of ecological harm	Environmental, Social/Stakeholder, Reputational/Political	2	Moderate

Table 3.22 - Scenario B Flood Risk Register

ID	Location	Type of Deficiency	1% AEP Impact Details	Risk Category	Consequence	Risk
1	Wilkins Highway	High/Extreme Flood Hazard	Flooding over 1500mm deep across major road	Flooding, Health & Safety	4	Extreme
2	George Street	Extreme Flood Hazard	Flooding over 1000mm deep across the road	Flooding, Health & Safety	3	High
3	Properties along Port Street and Mill Street next to James Street	High Flood Hazard	Properties flooded over 500mm deep, with some over 1000mm	Flooding, Health & Safety, Social/Stakeholder	4	Extreme
4	Properties on George Street adjacent to channel	High Flood Hazard	Properties flooded over 500mm deep	Flooding, Health & Safety, Social/Stakeholder	3	High
5	Properties surrounding intersection of Mill Street and Matthew Street	High Flood Hazard	Many properties flooded over 500mm deep, with some over 1000mm	Flooding, Health & Safety, Social/Stakeholder	4	Extreme
6	Properties along Port Street and Mill Street south of Loftus Street	High Flood Hazard	Properties flooded over 500mm deep, with some over 1000mm	Flooding, Health & Safety, Social/Stakeholder	4	Extreme
7	Horrocks Highway	High/Extreme Flood Hazard	Flooding over 1000 mm deep across major road	Flooding, Health & Safety	4	Extreme
8	Properties between Port Street and George Street north of Matthew Street	High Flood Hazard	Properties flooded over 500mm deep	Flooding, Health & Safety, Social/Stakeholder	3	High
9	Industrial properties along West Terrace	High Flood Hazard	Properties flooded over 250mm deep, with some over 1000mm	Flooding, Health & Safety, Social/Stakeholder	3	High
10	Properties between High Street, Second Street and Horrocks Highway	High Flood Hazard	Properties flooded over 500mm deep	Flooding, Health & Safety, Social/Stakeholder	3	High
11	Intersection of Third Street and High Street	Extreme Flood Hazard	Flooding over 500mm deep across the road	Flooding, Health & Safety	2	Moderate
12	Fourth Street near Gladstone Street	Extreme Flood Hazard, Gutter Flow Depth/Width	Flooding over 500mm deep across the road	Flooding, Health & Safety	2	Moderate
13	Gladstone Street from Fourth Street to Second Street	Extreme Flood Hazard, Gutter Flow Depth/Width	Flooding over 500mm deep across the road	Flooding, Health & Safety	2	Moderate
14	Horrocks Highway east of Fifth Street	High/Extreme Flood Hazard	Flooding over 500mm deep across the major road	Flooding, Health & Safety	3	High
15	Properties between Gladstone Street and High Street south of Fourth Street	High Flood Hazard	Many properties flooded over 250mm deep, with some over 500 mm	Flooding, Health & Safety, Social/Stakeholder	3	High
16	Along Fourth Street and High Street	High / Extreme Flood Hazard, Gutter Flow Depth/Width	Flooding over 500mm deep across the road	Flooding, Health & Safety	2	Moderate
17	Intersection of Horrocks Highway and High Street	High/Extreme Flood Hazard	Flooding over 250 mm deep across the major road	Flooding, Health & Safety	2	Moderate
18	Properties along Bondowie Street between Washington Street and Centre Street	High Flood Hazard	Many properties flooded over 500 mm deep	Flooding, Health & Safety, Social/Stakeholder	4	Extreme
19	Corner of First Street and Fifth Street	High Flood Hazard	Many properties flooded over 250mm deep	Flooding, Health & Safety, Social/Stakeholder	3	High

20	Along Fifth Street	High / Extreme Flood Hazard, Gutter Flow Depth/Width	Flooding over 250mm deep along the road	Flooding, Health & Safety	1	Low
21	Properties on corner of High Street and Third Street	High Flood Hazard	Many properties flooded over 250mm deep	Flooding, Health & Safety, Social/Stakeholder	3	High
22	Gladstone High School	High Flood Hazard	School flooded over 250mm deep	Flooding, Health & Safety, Social/Stakeholder	3	High
23	Stormwater Inlet on Centre Street	Low Freeboard /Upwelling, Inlet Capacity	Flooding over 500 mm deep along the road	Flooding	2	Moderate
24	Stormwater Inlet on Fifth Street near Cross Street	Low Freeboard, Inlet Capacity	Shallow flooding along road	Flooding	1	Low
25	Around Stormwater Inlet on Sixth Street	Low Freeboard, Inlet Capacity, Gutter Flow Depth/Width	Shallow flooding on both sides of the road, through properties	Flooding	2	Moderate
26	Washington Street	Gutter Flow Depth/Width	Flooding over 250 mm deep along the road	Flooding	1	Low
27	Bondowie Street between Washington Street and West Street	Gutter Flow Depth/Width	Flooding over 500 mm deep along the road	Flooding	2	Moderate
28	Mill Street south of Bondowie Street	Gutter Flow Depth/Width	Flooding over 1 m deep along the road	Flooding	3	High
29	James Street between Port Street and Mill Street	Gutter Flow Depth/Width	Flooding over 1 m deep along the road	Flooding	3	High
30	Matthew Street near Mill Street	Gutter Flow Depth/Width	Flooding over 1 m deep along the road	Flooding	3	High
31	Port Street south of James Street	Gutter Flow Depth/Width	Flooding over 1 m deep along the road	Flooding	3	High
32	Cross Street between Sixth Street and High Street	Gutter Flow Width	Shallow flooding along road	Flooding	1	Low
33	Receiving waters	Water quality of town runoff	Risk of ecological harm	Environmental, Social/Stakeholder, Reputational/Political	2	Moderate

4 Stormwater Management Objectives and Targets

4.1 Introduction

The stormwater management objectives and targets adopted for this Stormwater Management Plan have been developed with reference to the recommendations of several government departments including the Stormwater Management Authority, the Department for Environment and Water and the Northern and Yorke Landscape Board. While documents from these entities formed the basis of the objectives and targets, they have been adjusted based on the community values determined during community consultation, ensuring they are relevant to the local context.

4.2 Stormwater Management Authority Guidelines

When developing a catchment-based Stormwater Management Plan, it is required to identify specific and measurable objectives and targets that are relevant to the local context. The *Stormwater Management Planning Guidelines* (Stormwater Management Authority, 2007) stipulates that:

As a minimum, the objectives are to set goals for:

- *An acceptable level of protection of the community and both private and public assets from flooding;*
- *Management of the quality of runoff and effect on the receiving waters, both terrestrial and marine where relevant;*
- *Extent of beneficial use of stormwater runoff;*
- *Desirable end-state values for watercourses and riparian ecosystems;*
- *Desirable planning outcomes associated with new development, open space, recreation and amenity; and*
- *Sustainable management of stormwater infrastructure, including maintenance.*

The objectives and targets developed for this SMP will address the above criteria, and be classified as either absolute or aspirational, with the performance requirement tailored to suit the local context and community expectations.

4.3 Northern and Yorke Landscape Plan

The *Northern and Yorke Landscape Plan 2021-26* (Northern and Yorke Landscape Board, 2021) was developed in partnership with the community and key stakeholders following extensive consultation undertaken over a ten year time frame. The plan seeks to inspire, educate and work with the community to sustainably manage natural resources in the region.

The plan has identified 5 priorities to address over the 5 year period ending in 2026, being communities, biodiversity, water management, sustainable agriculture and pest plant and animal control. The priorities most relevant to the management of stormwater are biodiversity and water management, with the key focus area summarised in Table 4.1.

Table 4.1 Northern and Yorke Landscape Plan Priorities

Priority	Focus Areas
Biodiversity	Coordinate programs to improve climate change resilience and adaptive capacity. Improve ecosystems through conservation and restoration.
Water management	Sustainably manage the region's prescribed water resources. Protect and rehabilitate watercourses and wetlands. Promote the sustainable use of water for environmental, cultural, social and industry outcomes.

The above priorities have been considered in the development of the SMP objectives and targets, ensuring the outcomes of the plan align with the goals of the Northern and Yorke Landscape Board.

The plan also references *Conservation Action Planning Summary: Mid North Agricultural Districts* (Berkinshaw & McGregor, 2016), which lists objectives for the conservation of assets in the Mid North Agricultural Districts. Those relating to the management of stormwater are summarised in Table 4.2 below.

Table 4.2 Mid North Agricultural Districts Conservation Objectives

Asset	Objective
Rivers, Creeks and Waterhole Assets	By 2030, critical threats to high priority river reaches are strategically managed and abated across all catchments to maintain and improve condition. By 2030, maintain viable populations and sustainable habitat for native fish species (Common Galaxias, Blue Spot Goby) in priority subcatchments.

These objectives relating to rivers, creeks and watercourses have been considered during the development of objectives and targets for the SMP.

4.4 State Government WSUD Guidelines

Several documents have been published which provide guidance for water quality improvements and water sensitive urban design principles in new development. The document *Water sensitive urban design – creating more liveable and water sensitive cities in South Australia* sets out the South Australian Government's position on WSUD in a local context, provides State-wide WSUD 'targets' for new developments and details the role that Government will play in collaboration with other stakeholders to maximise the use of WSUD approaches (Department of Environment, Water and Natural Resources, 2013). Table 4.3 below summarises these across the range of principles.

Table 4.3 State-wide WSUD Performance Principles

Principle	Performance Target
Water Conservation	Demonstrated compliance with South Australian residential building requirements for water efficiency. Non-residential: evidence demonstrating reasonable effort in promoting water efficient techniques in commercial, industrial and other non-residential urban settings. Irrigated open spaces: evidence demonstrating reasonable effort in promoting best practice irrigation management in outdoor irrigated open spaces.
Runoff Quality	The state-wide performance target in this report for improving runoff quality is to achieve the following minimum reductions in total pollutant load, compared with that in untreated stormwater runoff, from the developed part of the site: • Total suspended solids: 80% • Total phosphorus: 60% • Total nitrogen: 45% • Gross pollutants: 90%
Runoff Quantity	**For waterway protection:** Manage the rate of runoff discharged from the site so that it does not exceed the pre-urban development 1 year average recurrence interval (ARI) peak flow. **For flood management:** For development and other relevant infrastructure that will drain runoff to an existing publicly managed drainage system or to a drainage system such as a creek or watercourse on privately-owned land: • The capacity of the existing drainage system is not exceeded; and • There is no increase in the 5 year ARI peak flow and no increase in flood risk for the 100 year ARI peak flow, compared to existing conditions.
Integrated Design	Evidence that relevant stakeholders are engaged at appropriate stages of planning, designing, constructing and managing WSUD measures so as to maximise the potential for WSUD to contribute to 'green infrastructure' and other relevant State, regional, and local objectives.

The WSUD performance principles are recommendations only, meaning there is no legal obligation to meet the requirements, however they will form the basis for the objectives and targets of the SMP.

4.5 Community Consultation

4.5.1 Background

Following the completion of Stage 4 of the Stormwater Management Plan with the State of the Catchment report, a preliminary round of community consultation was held. The purpose of this consultation was to seek feedback from the community on the baseline assessment and the identified stormwater risks and issues, and to determine community values regarding stormwater management within the town.

4.5.2 Consultation Process

Consultation on the first four stages of the Stormwater Management Plan took place in September and October 2023. Consultation activities undertaken include:

- A presentation to Council elected members on the 5th of September 2023 outlining the work undertaken to date on the Stormwater Management Plan and identifying the areas of elevated flood risk; and
- Open house sessions held in Laura, Gladstone and Spalding on the 24th of October 2023.

At the open house sessions, members of the public were invited to come along and discuss any aspect of the stormwater management plan, provide details of stormwater issues and have conversations with Southfront and Council staff. The sessions were promoted on the Council website and social media accounts 2 weeks prior.

Staff from Council and Southfront were present at all open house sessions. Posters were displayed providing information about the State of the Catchment report including an explanation of the purpose of an SMP, the tasks required, the study area and topography, 1% AEP flood maps and identified flood impacts.

Online and paper feedback forms were developed and made available at the open house sessions and on the Council website, allowing respondents to describe their priorities for the management of stormwater and provide details of any stormwater issues they are aware of.

4.5.3 Community Consultation Feedback

In total over 20 people and one Council Elected Member attended the open house drop in sessions across the three towns. The following feedback was provided informally by session attendees (i.e. verbally to staff, not via a feedback form):

- A landowner on Matthew Street reported flooding through their front yard and a paddock to the side of their property;
- There were concerns about the maintenance of the pumping system underneath the railway line at the southern end of town;
- Photos (seen below as Figure 4.1 and Figure 4.2) were provided showing blockage of the Rocky River channel upstream of Gladstone caused by an accumulation of branches, tree trunks and roots, with concerns over the impact of the blockage on the floodplain; and
- Concerns were expressed over the unsightliness of the rock-lined detention basin on the corner of High Street and Cross Street, with residents having been promised it would be landscaped and would continuously flow to the southern end of High Street. There were also concerns about its safety, with comments on the lack of guard rails.



Figure 4.1 Blockage of Rocky River Viewed from Channel Bed



Figure 4.2 Blockage of Rocky River Viewed from the Bank

In addition, four online feedback forms and twelve paper feedback forms were submitted. Within the forms, respondents were asked to rank the importance of a range of factors, including major flooding, nuisance flooding, water quality, stormwater capture/reuse and climate change. Table 4.4 below summarises the responses across the online and paper feedback forms, which have also been attached to this report in Appendix B.

Table 4.4 Community Response Form Summary

Factor	Number of Responses				
	1 (High Priority)	2	3	4	5 (Low Priority)
Major flooding	12	0	2	1	1
Nuisance flooding	6	5	2	1	2
Water quality	4	1	6	3	2
Stormwater capture and reuse	6	1	5	3	1
Climate change	3	1	1	6	4

The highest priority issue for the community was major flooding, followed by nuisance flooding and stormwater capture and reuse, with water quality and climate change being perceived as lower priorities.

In addition to the rankings above, respondents were asked to provide details of any stormwater related concerns, local flooding problems or ways in which they thought stormwater should be managed within the town. These comments are summarised below.

- Requests for the Yangya Creek to be cleared of vegetation;
- Problems occur in regards to the blockages in the Rocky River through Booyoolee, which divert the water out of the creek in various locations, changing the true flow of water;
- Concerns about the visual amenity of the catchment area at the intersection of Cross Street and High Street;
- The floodway along High Street is sufficient in size and currently acts as a good watering source for the trees and grass along this area; and
- Concerns that the stormwater harvesting currently in place will be impacted by any changes.

The community feedback summarised above has been considered in the development of the objectives and targets for the Stormwater Management Plan, as discussed below.

4.6 Stormwater Management Plan Objectives and Targets

Having considered the range of guidelines from the various government bodies and the outcomes from the community consultation, a set of objectives and targets was formulated addressing a range of factors, as summarised in Table 4.5 below.

Table 4.5 SMP Objectives and Targets

ID	Objective		Target	Absolute (Abs) or Aspirational (Asp)
1	**Provide an acceptable level of flood protection for the community and both private and public assets**	a	No above floor inundation of dwellings in a 1% AEP flood event.	Asp
		b	Where appropriate, no above floor inundation of dwellings in a 5% AEP flood event. In some locations, the cost of flood proofing would likely exceed the value of property being protected, and therefore non-structural measures may need to be considered.	Abs
		c	Safe vehicle access (maximum hazard class H1) along major evacuation routes in a 1% AEP flood event.	Asp
		d	Council provide flood risk information to the community and assist with the creation of flood action plans.	Abs
		e	Effective emergency management arrangements are in place and engage all relevant agencies, staff and affected communities.	Abs
2	**Manage the quality of runoff and its effect on receiving waters**	a	Compared to untreated runoff, achieve the following pollutant reductions: • Total suspended solids: 80% • Total phosphorus: 60% • Total nitrogen: 45% • Gross pollutants: 90%	Asp
		b	Educate the community on the importance of water quality within the receiving waters.	Abs
3	**Make beneficial use of stormwater**	a	Opportunities to increase use of recycled stormwater are to be identified and investigated where viable.	Asp
		b	Where possible Council will strive for new developments to retain peak flows to pre-development levels.	Asp
4	**Planning for new developments provides for open space, recreation and amenity**	a	Identify planning and design policies and procedures to be implemented by Council, where they have authority to do so, that could contribute to effectively manage development to minimise the impact of flooding on new and existing development.	Asp
		b	Identify design principles for Council to implement, where they have the authority to do so, which promote integrated planning, design and management of stormwater systems to maximise the potential to achieve multiple outcomes for water management in new development, as well as redevelopment, retrofits, upgrades and extensions.	Asp
		c	Identify design principles for Council to champion which provide for protection and enhancement of natural features and systems where possible, and	Asp

			increase biodiversity, stormwater treatment and passive reuse.	
5	**Improve the condition of receiving watercourses**	a	All new and upgraded stormwater outlets discharging to receiving watercourses are to be designed to control silt deposits and discharging velocities, and mitigate any adverse effects to the physical conditions of the immediate receiving environment.	Abs
6	**Sustainable asset management of stormwater infrastructure**	a	All stormwater assets are identified and recorded in an asset management system and/or asset management plan.	Asp
		b	All proposed stormwater infrastructure is to be designed with consideration of the likely impacts of climate change.	Abs
7	**Effective communication and consultation with catchment stakeholders, businesses and community members**	a	Effectively engage with the community on stormwater management issues and proposed strategies including WSUD and stormwater reuse opportunities where possible.	Abs
		b	Raise awareness to enable businesses and the community to respond efficiently to extreme weather flood warnings.	Abs
		c	Identify opportunities for partnerships with the community and government bodies in the development and implementation of strategies.	Abs

5 Stormwater Management Responses

5.1 Structural Management Measures

Having investigated the stormwater performance of the Study Area, management responses have been developed to meet the stormwater management objectives and targets discussed in Section 4. These are designed to address stormwater management issues identified through the development of this plan.

5.1.1 Flood Mitigation Strategies

Flood mitigation strategies are outlined in this section. These strategies have been developed with a view to maximising the level of flood protection that can be achieved within practical constraints. All flood mitigation strategies have been developed using the hydrology from Scenario B, which incorporates future development and climate change.

In accordance with the Plan's objectives outlined in Section 4, these strategies have aspired to achieve no above floor inundation of properties for all events up to and including the 1% AEP storm. An absolute target of achieving no above floor inundation in the 5% AEP storm was adopted, however it is likely that in some locations, the cost of providing flood immunity would far exceed the value of the property being protected. In these situations, non-structural measures could also be considered.

Each of the proposed works packages has been assigned a project ID which corresponds to the project location. Flood depth and hazard maps have been prepared for each AEP event to demonstrate the performance of the flood mitigation strategies, and are presented in Appendix G and Appendix H. Figure 5.6 below provides a side by side comparison of the pre-mitigation and post-mitigation scenarios in the 5% AEP flood event, demonstrating the impact of the strategies.

The recommended mitigation strategies have been developed holistically considering the stormwater performance of the entire Study Area. While some of the strategies have primarily localised impacts, others also reduce the demand on separate areas. The upgrades should be viewed collectively as a strategic solution to various identified stormwater issues.

Budget cost estimates have also been prepared for the proposed flood mitigation works and are included in Appendix I. The are exclusive of GST and include allowances of:

- 10% for design;
- 5% for modification to existing services;
- 15% for construction preliminaries; and
- 20% for contingencies on construction.

Note that these allowances have at times been adjusted to reflect the location of the works. These cost estimates are based upon historical cost information and experience, and do not allow for latent or market conditions (i.e. competition, escalation).

The potential cost of soil remediation and/or disposal of contaminated material has not been considered in preparing these cost estimates. Council may elect to undertake environmental testing of project sites during the design development phase to assist in managing this risk.

D1: Yangya Creek Flood Protection

The strategy to reduce flooding associated with Yangya Creek consists of multiple components. The recommended components significantly reduce flooding throughout large parts of Gladstone on both sides of the Yangya Creek in a wide range of storm events. The upgrades prevent spill across the railway line in up to a 5% AEP flood event, and significantly reduce both the depth and extent of inundation on the eastern side of the railway line where there are many residential properties and businesses.

The Yangya Creek upgrades outlined below were found to reduce the flooding along the Horrocks Highway at the southern edge of town. This is a major road that could be used to evacuate the town in an emergency, and is completely covered with water between Fifth Street and Gladstone Street in a 5% AEP flood, with high flood hazard throughout the northern lane. The upgrades were found to reduce the flooding, keeping part of the road clear of ponding and to a maximum flood hazard class of H1, which is safe for vehicles. This is a significant outcome, as a Councillor flagged that previous flood events have cut off vehicle access in and out of Gladstone, as discussed in Section 2.4.5.

Due to the topographical challenges facing the town and the large flow rates associated with the Yangya Creek, it was considered impractical to achieve a 5% AEP flood standard across Gladstone. Instead, the measures significantly reduce flooding in large parts of the town, however some low-lying properties are still significantly impacted.

The strategies outlined below could be constructed in stages if funding is not available to implement them all together. Strategies D1-A and D1-B together will significantly reduce flood risk facing Gladstone even without strategies D1-C and D1-D being constructed, and this will be more pronounced in events smaller than the 5% AEP flood. For the 5% AEP flood and rarer events, strategies D1-C and D1-D not being in place will have more of an impact.

D1-A: Clearing Vegetation from Yanga Creek

The Yangya Creek channel through Gladstone is overrun with thick vegetation, reducing the flow capacity of the creek and exacerbating flood risk in the surrounding areas. It is recommended that the creek channel between Bondowie Street and Horrocks Highway is substantially cleared of vegetation, as this will free up capacity in the channel for conveying flood flows. Suitable vegetation should be planted on the channel banks, increasing their stability and preventing erosion.

Guidance for the removal of vegetation from a watercourse is available in *Current recommended practice – Removal of vegetation from a watercourse, lake or floodplain* (Northern and Yorke Landscape Board, 2021). This document provides information for the Northern and Yorke Landscape Board Area on vegetation removal methods, timing of works, which species are declared pest plants and describes the legal obligations involved including whether a water affecting activity permit will be required. Guidance is also available under the Water Affecting Activities Best Operating Procedures agreement between Council and the Northern and Yorke Landscape Board. Through discussions with Council staff in October 2024, it is understood that Council are currently working to remove vegetation along the creek.

In the community consultation undertaken for this assignment, a resident recommended that Yangya creek was cleared of vegetation, and another highlighted watercourse blockages as being an issue more generally for Gladstone. This aligns with the findings of *Gladstone Flood*

Protection Study (GHD, 2004), which concluded that the removal of vegetation had the wholehearted approval of the community.

It is important that the creek is regularly cleared of vegetation to ensure that the benefits are retained over an extended period of time. The cost will also be reduced if trees are removed before becoming fully established. The impact of the clearing is most significant in major flood events, which are infrequent in nature, stressing the importance of regular maintenance. For the purposes of cost estimation, it has been assumed that ongoing creek clearing would be required every 5 years, at an estimated cost of $50,000, resulting in an annual maintenance cost of $10,000.

D1-B: Widening the Yangya Creek Channel

The Yangya Creek channel through Gladstone is quite narrow, and has a flow capacity far below the flow rate entering the channel. It is recommended that the creek channel is widened from the Port Street bridge to just upstream of the Horrocks Highway bridge where the existing channel widens. A trapezoidal channel is recommended to increase the storage available and reduce flooding of the surrounding areas. A minimum channel base width of 10 m and side slopes of 1V:2H are recommended to maximise the space available in the corridor between the railway and Port Street.

The aim with this recommendation is to make the best use of the space available along the creek, and alongside the vegetation removal to increase the hydraulic capacity of the channel. Figure 5.1 compares the existing Yangya Creek cross section with the proposed cross section, looking downstream.

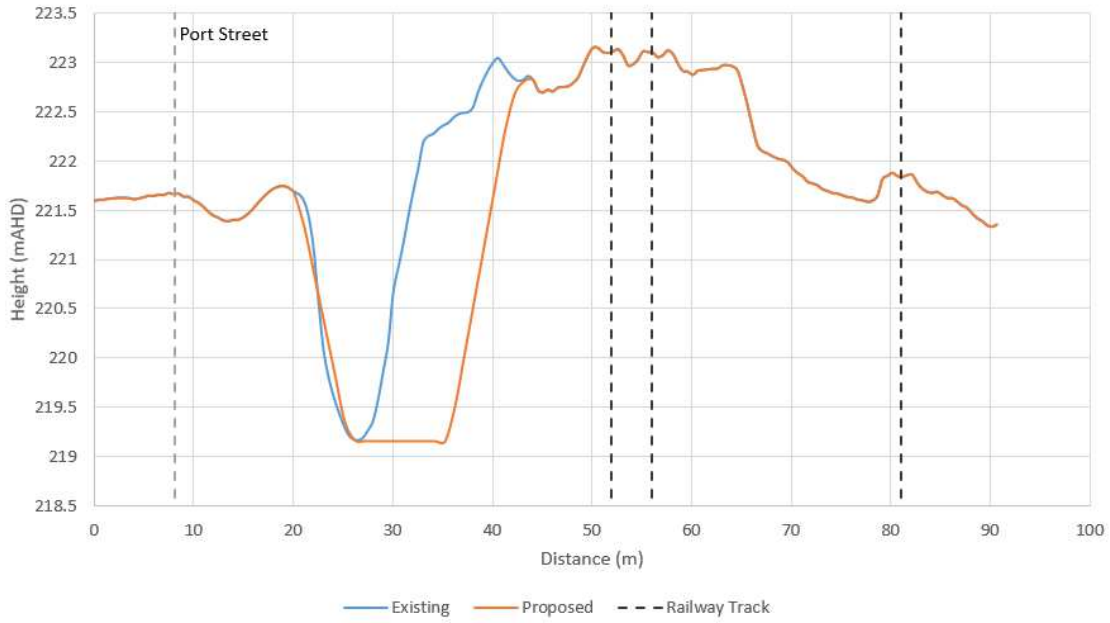


Figure 5.1 Existing vs Proposed Yangya Creek Cross Section

The existing Yangya Creek cross-section is varied along its length, however the section used for the above figure can be considered representative of the typical shape. The increase in flow area is evident from the figure, with a much wider base matching into the existing levels either side of the channel. Importantly, all proposed earthworks occurs in the corridor between Port Street and the railway tracks. While side slopes of 1V:2H are steeper than a channel would

ideally have, there is limited space available, and the existing channel also has side slopes of approximately 1V:2H, as illustrated by the similar slope of the channel sides in Figure 5.1.

For the purposes of cost estimation, this measure has been combined with the clearing of vegetation recommended in D1-A. Undertaking these works in conjunction will significantly reduce the overall cost of works when compared to undertaking the works separately.

D1-C: Closing the Railway Underpass

A pedestrian underpass connects Gladstone Street with Port Street underneath the railway. In major flood events, this underpass was found to convey significant volumes of water beneath the railway line towards Gladstone Street where it causes widespread inundation.

It is recommended that this underpass be closed, preventing water from flowing underneath the railway to the western part of Gladstone. It is understood that a mural was recently painted along the length of the underpass. If the underpass is considered to be of value to the community, a flood door could be installed in lieu of permanently closing it. Flood doors are engineered to withstand the force of flood waters, and can be retrofitted to existing structures. By installing a flood door, pedestrian access through the underpass can be maintained outside of major events, however procedures would need to be put in place to ensure the door is closed ahead of forecasted heavy rainfall in the Yangya Creek catchment.

D1-D: Constructing Levees along Yangya Creek

The results of the flood modelling suggest that in a 5% AEP flood event, water breaks out of the Yangya Creek upstream of Bondowie Street, and also between Bondowie Street and Mill Street. It is recommended that two levees are constructed along the western bank of the creek, the first upstream of Bondowie Street with a length of approximately 250 m and the second from Charles Street to Mill Street with a length of approximately 330 m. Levee heights ranging from 0.5 m to 0.8 m north of Bondowie Street and ranging from 0.5 m to 1.1 m between Charles Street and Mill Street were found sufficient to provide 300 mm freeboard to the 5% AEP flood.

The proposed alignment of the two levees is shown in Figure 5.2 below. Although efforts were made to avoid having levees in private land, ultimately this was unavoidable due to the narrow width of the creek and the close proximity of the surrounding properties. Council would need to meet with the affected landowners before progressing this option further.

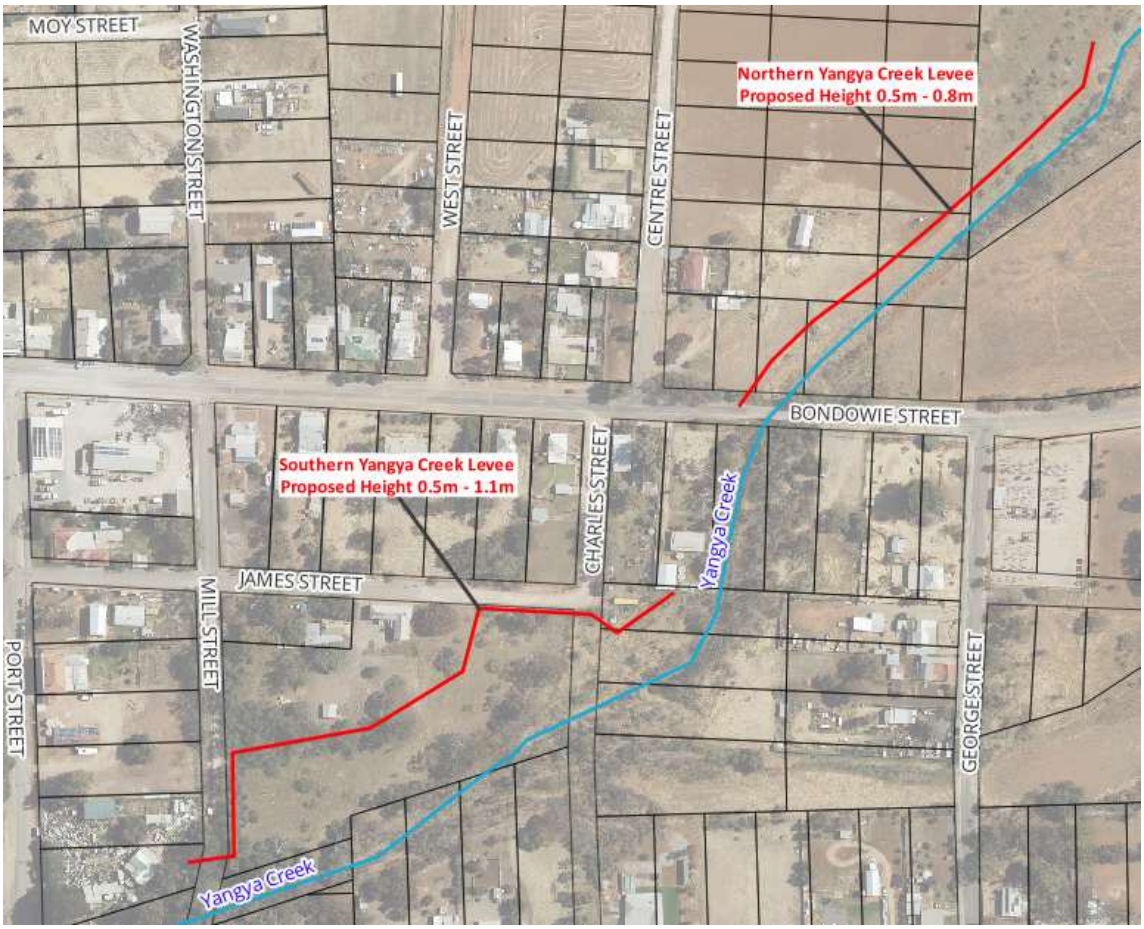


Figure 5.2 Proposed Yangya Creek Levees

D2: Centre Street Drain and Flood Levee

Bondowie street between the railway line and Yangya Creek was found to be a flood hotspot. Water from the catchments to the north flows towards Bondowie Street, inundating many properties along Washington Street, West Street and Centre Street.

It is recommended to construct a 400 m long levee north of North Street at the boundary between residential allotments and rural land. The levee height is to vary generally between 0.5 m and 1 m along its length depending on adjacent surface and flood levels. A stormwater inlet north of the levee is to connect to a 450 mm diameter drain down Centre Street. Some minor earthworks is also required on the upstream side of the levee to prevent water from being trapped in lows alongside the levee.

An existing stormwater inlet on Centre Street just north of Bondowie Street, and a connecting 375 mm diameter drain flowing into Yangya Creek are to be removed. Several new stormwater inlets in this location will intercept runoff from the local catchment and connect to the Centre Street drain, which is to transition to a 600 mm diameter pipe. The system then follows Bondowie Street to the east before connecting into the Yangya Creek south of the Bondowie Streer bridge. A flap gate on the outlet pipe will be required to prevent high water levels in the Yangya Creek from causing upwelling at the stormwater inlets along Centre Street.

The upgrades were found to prevent overland flows from the rural catchments to the north in up to a 5% AEP flood event. A 450 mm diameter pipe beneath the levee was determined to be sufficient to allow this accumulation of water to drain following a flood event. There is some

shallow ponding along Centre Street surrounding the proposed stormwater inlets, however this remains on the road and does not impact the surrounding properties.

This upgrade has been designed holistically under the assumption that the upgrades listed in strategy D1 have also been implemented. If this were not the case, flooding from the Yangya Creek would reduce the effectiveness of this strategy in longer duration storms.

Figure 5.3 below provides an overview of the components involved in the flood strategy.

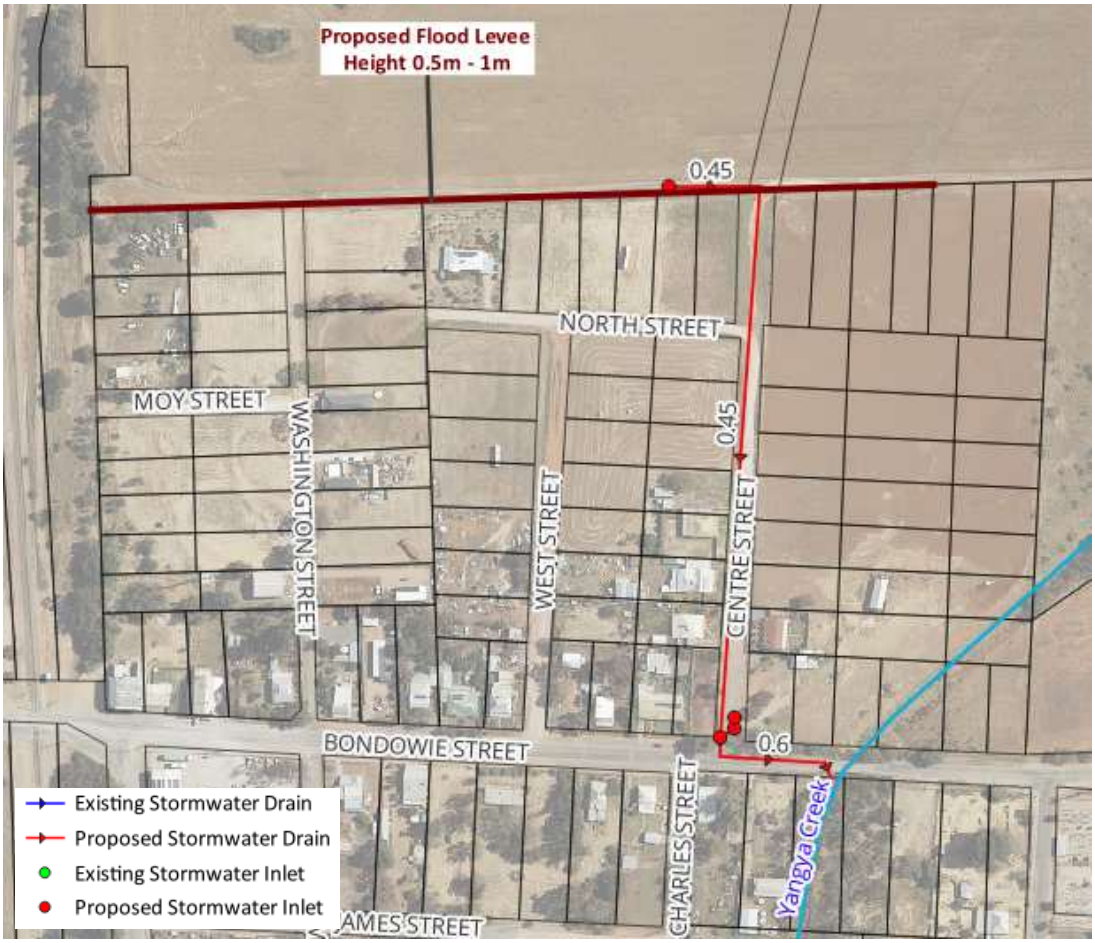


Figure 5.3 Flood Mitigation Strategy D2 Overview

D3: Port Street, Bondowie Street Drainage

Flood maps identify significant flooding along Port Street and Bondowie Street. Both of these streets contain low points with either minimal existing stormwater infrastructure or none at all. Flows from the local catchments reach these trapped areas, where ponding occurs leading to widespread overland flow and property inundation.

It is recommended to construct a new stormwater network starting in Bondowie Street at West Street, running west to Mill Street, south to James Street and west to Port Street before turning south towards a new outlet in Yangya Creek just downstream of the Port Street bridge. A flap gate would be required on the outlet to prevent upwelling along Port Street during times of elevated water level in Yangya Creek. A main drain size ranging from 600 mm in Bondowie Street to 1050 mm at the outlet was found to provide a 5% AEP flood standard to all properties surrounding the drain. Some ponding remains along several of the roads, but this is of the lowest flood hazard category and is unlikely to pose a risk to people or vehicles.

It should be noted that if the upgrades listed in strategy D1 have not been constructed, this strategy will be far less effective during long duration storms where the water level in the Yangya Creek is elevated. However in shorter durations storms which are critical, strategy D1 not having been constructed will have little impact.

By removing ponding on Bondowie Street, this upgrade creates a safer evacuation route out of town, to the east along Bondowie Street. As discussed, it has been commented that previous flood events have completely cut off Gladstone, so creating another safe evacuation route is highly beneficial to the town.

There is potential for this upgrade to be constructed in stages, in order to account for limitations in Council's budget and resourcing. However as the majority of the flooding mitigated by this strategy is centred around Bondowie Street, constructing just the downstream section of the drain will not provide much benefit until the full strategy is built.

Figure 5.4 shows the proposed drain alignment and sizes.

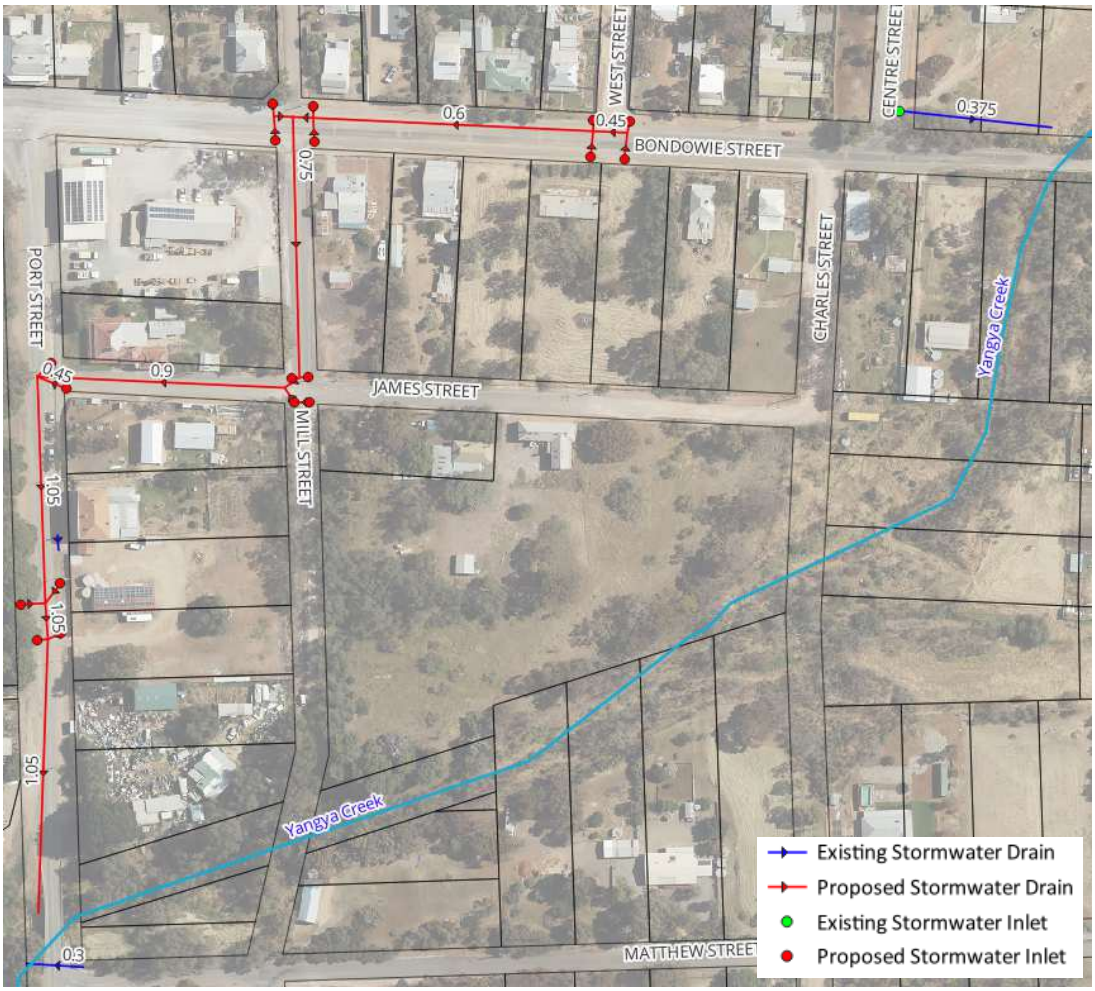


Figure 5.4 Flood Mitigation Strategy D3 Overview

D4 – Mill Street, Port Street Drainage

The scenario B flood maps indicate significant flooding surrounding Mill Street and Port Street due to spill from large catchments to the east and southeast. It is recommended that a levee is constructed, protecting the properties on Mill Street and Port Street from a major flow pathway and diverting flows around residential land. A levee height ranging from 0.5 m to 1.2 m is recommended depending on adjacent surface and flood levels. Minor localised works may be required to ensure there are no trapped depressions where water will pond alongside the levee.

The existing culvert under Port Street is a single 450 mm diameter pipe, which is drastically undersized relative to approximately 325 hectare contributing catchment. Twin 3000 mm by 1200 mm box culverts were found to be adequate in up to a 5% AEP flood event to convey flows from the upstream watercourse through to Yangya Creek and limit the depth of ponding on the eastern side of Port Street to a level that does not threaten properties.

It is recommended that this culvert is upgraded alongside earthworks on both sides of Port Street to lower the invert levels. This would require removing vegetation on both sides of the road prior to conducting the excavation, which could be done alongside the removal of vegetation from Yangya Creek recommended in upgrade D1-A. This upgrade would also require constructing a levee through privately owned land, which would require discussions with affected landowners.

Thought was given to lowering the section of Port Street between Horrocks Highway and Francis Street, allowing it to act as a floodway during flood events. However this would remove a key evacuation route for the vulnerable eastern side of Gladstone, and would require lowering the road by over one metre, and therefore was not considered suitable.

The upgrades were found to prevent flows from the upstream catchments from spilling through properties in a 5% AEP flood event. Figure 5.5 shows the extent of the works.



Figure 5.5 Flood Mitigation Strategy D4 Overview

The improvements provided by the various upgrade strategies in the 5% AEP flood event are demonstrated in Figure 5.6 below, highlighting the significant reduction in flood depth and extent achieved in the areas surrounding Yangya Creek. While the widening of the Yangya Creek alongside Port Street can be seen in the figure, the removal of vegetation between Bondowie Street and Horrocks Highway is not, but is an essential part of the strategy.

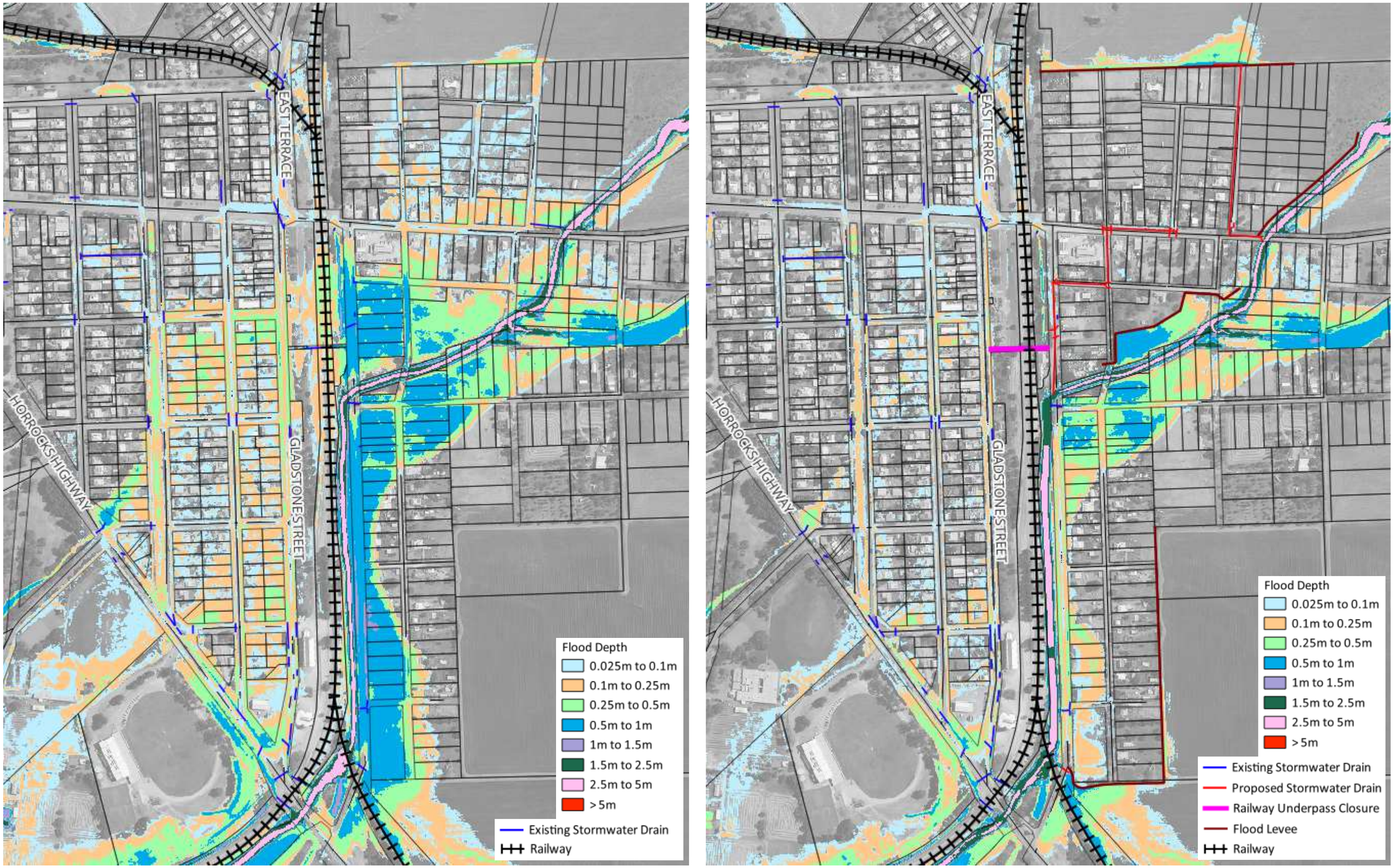


Figure 5.6 Gladstone Pre-Mitigation (Left) and Post-Mitigation (Right) 5% AEP Flood Maps

5.1.2 Flood Mitigation Benefits

The benefits associated with the reduction in flooding due to the construction of the recommended structural mitigation strategies have been assessed. This assessment considers the number of affected properties as well as the expected damages in flood events of varying frequency, and the average annual damages value.

Number of Properties Affected

Flood levels at the centroid of each property were determined from the flood grids produced by the TUFLOW model, and these levels have been used to determine the number of affected properties in Scenario C. Table 5.1 below summarises the total number of properties affected by each stage-damage curve range for all modelled AEPs.

Table 5.1 Scenario C Affected Properties by Flood Depth

Flood Depth Range (m)	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
0-0.1	28	39	45	59	63	27
0.1-0.15	3	1	5	13	37	8
0.15-0.25	0	3	9	9	40	26
0.25-0.5	1	1	4	18	32	99
0.5-1.0	0	0	4	13	21	54
1.0-1.5	0	0	0	0	2	9
1.5-2.5	0	0	0	0	0	0
2.5-5.0	0	0	0	0	0	0
Total	32	44	67	112	195	223
Change from Scenario B	-30.4%	-37.1%	-60.0%	-43.4%	-6.7%	-0.9%

The table demonstrates the significant reductions in flood extent and depth provided by the proposed upgrades. The moderate reductions in the 18% and 10% AEP floods is reflective of the difficulty in flood proofing Gladstone, with some properties found to be extremely vulnerable and economically infeasible to protect. The significant improvement in the 5% AEP (and to a lesser extent the 2% AEP event) is primarily due to the upgrades to the capacity of the Yangya Creek and cutting off the railway underpass, which together prevent flows in Yangya Creek from crossing to the western part of town in up to a 5% AEP flood.

Though the strategies have been designed for the 5% AEP event, there are still significant improvements in larger events. There is a significant improvement to flood protection in the 2% AEP event, and diminishing improvements as the storm events get rarer and the flood mitigation strategies are completely overwhelmed.

Table 5.2 below breaks down the number of affected properties by land use type for each modelled AEP flood event.

Table 5.2 Scenario C Affected Properties by Land Use

Land Use	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
Residential	29	38	57	94	149	166
Commercial	3	6	10	17	41	48
Industrial	0	0	0	1	5	9
Total	32	44	67	112	195	223

The distribution of affected properties has slightly changed as a result of the upgrades, which primarily focussed on protecting residential dwellings. However the upgrades result in reductions in the number of affected properties across all land use types.

Direct Tangible Flood Damages

Direct tangible flood damages have been estimated for Scenario C, which considers future development and climate change, in conjunction with the proposed strategies. The flood level determined for each property was compared with the appropriate stage-damage curve to determine a damage cost for each property. Table 5.3 shows the resulting direct tangible flood damages by land use as well as the total flood damage for each modelled AEP.

Table 5.3 Scenario C Direct Tangible Flood Damages

Land Use	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
Residential	$0.2m	$0.4m	$2.8m	$7.3m	$14.2m	$32.0m
Commercial	$0.2m	$0.4m	$0.7m	$1.6m	$4.2m	$8.0m
Industrial	$0.0m	$0.0m	$0.0m	$0.1m	$0.4m	$1.3m
Total	$0.4m	$0.8m	$3.4m	$9.0m	$18.8m	$41.2m

Indirect Tangible Flood Damages

INFFEWS recommends considering indirect tangible flood damages of 15% for residential buildings and 55% for commercial and industrial buildings. Applying these factors results in the total tangible flood damages summarised in Table 5.4.

Table 5.4 Scenario C Total Tangible Flood Damages

Land Use	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
Residential	$0.2m	$0.5m	$3.2m	$8.4m	$16.4m	$36.8m
Commercial	$0.3m	$0.6m	$1.0m	$2.5m	$6.5m	$12.4m
Industrial	$0.0m	$0.0m	$0.0m	$0.1m	$0.6m	$2.0m
Total	$0.5m	$1.1m	$4.2m	$11.0m	$23.5m	$51.1m

Table 5.5 below demonstrates the improvements provided by the recommended flood mitigation strategies across the range of modelled AEPs.

Table 5.5 Reduction in Flood Damages Due to Flood Mitigation Strategies

Model Scenario	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
Scenario B (Future)	$1.3m	$6.2m	$14.3m	$35.3m	$47.1m	$63.5m
Scenario C (Future/Upgrades)	$0.5m	$1.1m	$4.2m	$11.0m	$23.5m	$51.1m
Change in Flood Damages	-$0.8m **(-61.5%)**	-$5.1m **(-82.3%)**	-$10.1m **(-70.6%)**	-$24.3m **(-68.8%)**	-$23.6m **(-50.1%)**	-$12.4m **(-19.5%)**

The table demonstrates the significant reduction in property inundation achieved through the recommended flood mitigation strategies. Compared to the reductions in the number of affected properties in Table 5.1, the damages reductions are far more significant. Although not every property is fully protected by the strategies, for many the depth of inundation is significantly smaller, resulting in a lower damages estimate. The reductions were found to be most substantial in events up to and including the 2% AEP event, however there was also a significant reduction in the 1% AEP event and a modest reduction in the 0.2% AEP event.

Average Annual Damages

The resulting average annual damages value was found to be $1,011,385, which is a $1,598,960 reduction from the Scenario B value. The substantial reduction of flood damages in events up to the 2% AEP has significantly diminished the average annual damages value, which is weighted more heavily towards frequent events.

5.1.3 Water Sensitive Urban Design Strategies

A Water Sensitive Urban Design (WSUD) strategy has been developed for the town. The recommended measures will improve the quality of stormwater entering the receiving waters and, where possible, enable stormwater harvesting and reuse. The measures aim to achieve the aspirational water quality improvement targets outlined in Section 4, being an 80% reduction in TSS, a 60% reduction in TP, a 45% reduction in TN and a 90% reduction in gross pollutants.

The proposed measures have been modelled within MUSIC to allow for preliminary sizing of components and budget cost estimation. The Scenario 3 MUSIC model, considering future development and existing WSUD infrastructure, has been used as the basis for the upgrades. In addition to the identified measures, it is expected that further WSUD opportunities will be explored over time, particularly alongside land developments and road reconstruction works.

The WSUD measures considered are described in detail in the sections below. Many of the strategies are interconnected with the flood mitigation strategies discussed in Section 5.1.1. Each of the proposed works packages has been assigned a project ID which corresponds to the project location. As with the flood mitigation strategies, budget cost estimates have been prepared for the proposed works and are included in Appendix J.

WQ1: High Street Bioretention Basin
Bioretention basins are engineered depressions designed to detain and treat stormwater runoff. Following rainfall events, stormwater runoff pools in the basin and infiltrates through a prescribed soil media surface, removing sediment and nutrients from the water. Pollutants are retained in the system through enhanced sedimentation, fine filtration and biological uptake in the vegetation. An example of a bioretention basin is shown in Figure 5.7 below.



Figure 5.7 Bioretention Basin (Water Sensitive SA)

A bioretention component is recommended within the detention basin within the central median of High Street just south of Cross Street. As discussed in Section 4.5.3, this basin is considered unsightly by the residents, being rock lined and overgrown with weeds. It is recommended that this basin be reworked to allow it to provide treatment for runoff while also enhancing its visual amenity.

The basin is to be lined and include a submerged zone that will provide moisture storage to support the vegetation during prolonged periods without rainfall. The filter area size was determined using the MUSIC model, ensuring that water leaving the bioretention node achieves a suitable water quality improvement. A filter area of 500 m² and an extended detention depth of 0.3 metres are recommended. Other parameters have been adopted in line with *South Australian MUSIC Guidelines* (Water Sensitive South Australia, 2021). Including a stormwater harvesting scheme alongside the basin was considered, however due to the constrained space within the reserve between the two roads, this was ruled out.

Figure 5.8 below shows the location of the proposed bioretention component.

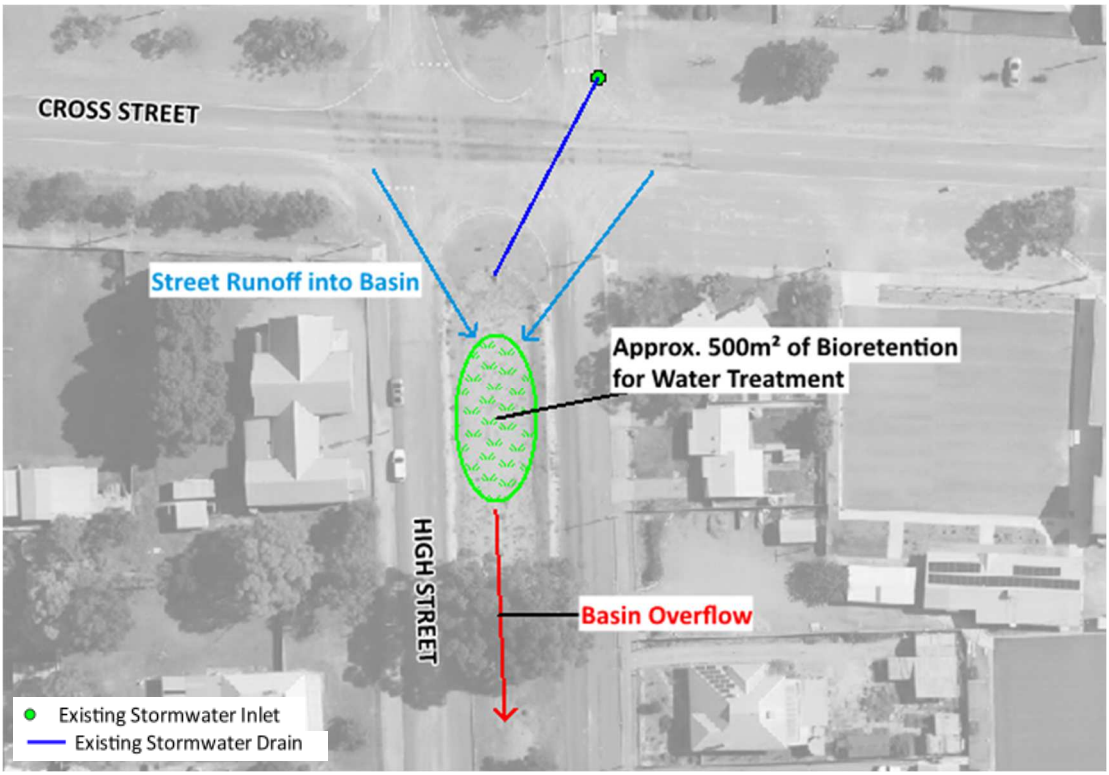


Figure 5.8 WSUD Strategy WQ1 Overview

WQ2: Streetscape Raingardens

Raingardens are garden beds that use carefully selected native plants and soil to capture and biologically treat stormwater runoff from roofs and roads. Water ponds on the surface of the raingarden, where it soaks through the filter media, leaving sediments and rubbish behind. The plant roots in the soil absorb the nutrients in the stormwater, resulting in cleaner water leaving the raingarden. An example of a raingarden is shown in Figure 5.9.



Figure 5.9 Raingarden During a Rain Event (Resilient East)

It is essential that raingardens are properly maintained in order to ensure they function as intended over a long period of time. This involves promoting healthy vegetation, removing excess collected sediments, ensuring the surface can drain freely and removing any material blocking hydraulic structures. A schematic view of a raingarden is shown in Figure 5.10.

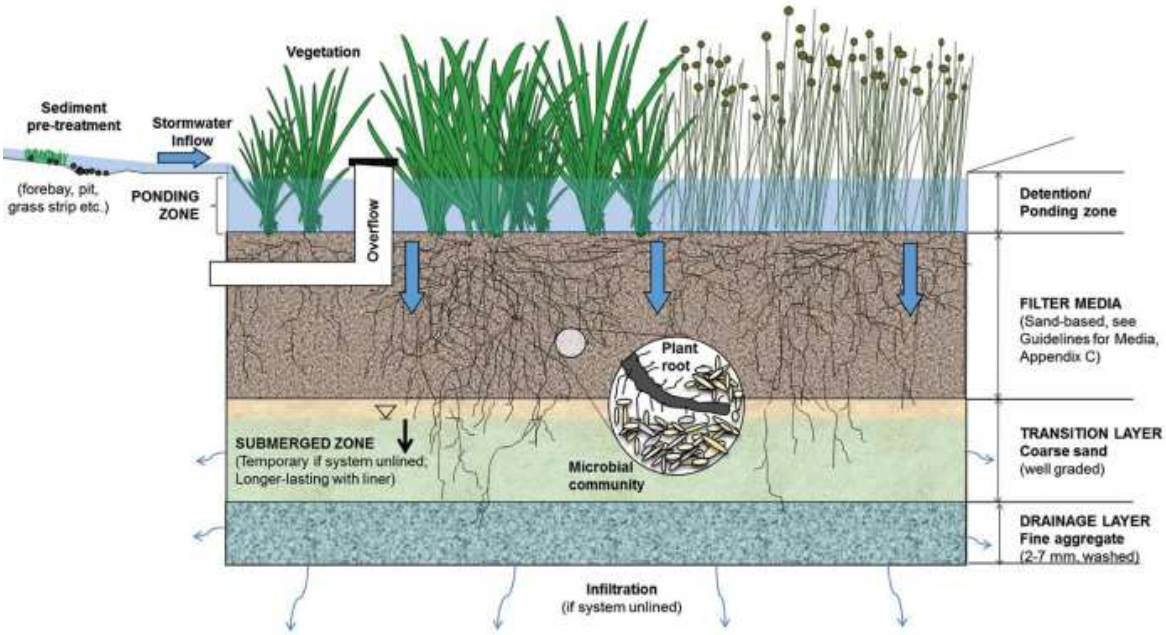


Figure 5.10 Typical Raingarden Composition

Within the MUSIC model, a 15 m² bioretention system has been assumed for each raingarden. Adopted MUSIC modelling parameters for the proposed streetscape bioretention systems are listed in Table 5.6.

Table 5.6 Adopted Raingarden System Properties

Parameter	Adopted Value
Filter Area (m²)	15
Extended Detention Depth (m)	0.15
High Flow Bypass (L/s)	125
Filter Depth (m)	0.5

Raingardens are proposed where new stormwater inlets are recommended along Bondowie Street, James Street, Port Street and Centre Street. As there was no suitable open space to support a large bioretention system to treat runoff from the streets west of Yangya Creek, streetscape raingardens are recommended.

In urban areas such as this with no underground stormwater pipes, raingardens can be constructed with an overflow weir in the kerb. These modified raingardens allow for bioretention treatment of runoff in locations without formalised drainage networks. Figure 5.11 shows an example of a streetscape raingarden with an overflow weir.



Figure 5.11 Raingarden with Overflow Weir in Kerb (Water Sensitive SA)

Overflow weir raingardens are proposed along several streets which have currently have kerbs to simplify their installation. This includes Sixth Street, High Street, Fifth Street and Gladstone Street, which are all wide and can support raingardens without significantly restricting the movement of vehicles. These raingardens have been modelled with the same properties as in Table 5.6, but with an extended detention depth of 0.1 m and without an underdrain to reflect the lowered kerb height and the lack of drainage network present.

Besides where a flood mitigation strategy is recommended, raingardens have not been proposed in locations without a standard kerb, such as along Ash Crescent in the northern section of town and several roads to the east of Yangya Creek, as this would significantly increase the cost of installing raingardens. The potential for downstream systems such as bioretention basins to treat these untreated areas exists, but considering the high number of outflow points around the town this was not considered to be economical.

The figures below provide an overview of the proposed raingarden locations, noting that these will need to be refined during detailed design.



Figure 5.12 Proposed Port/James/Bondowie Street Raingardens

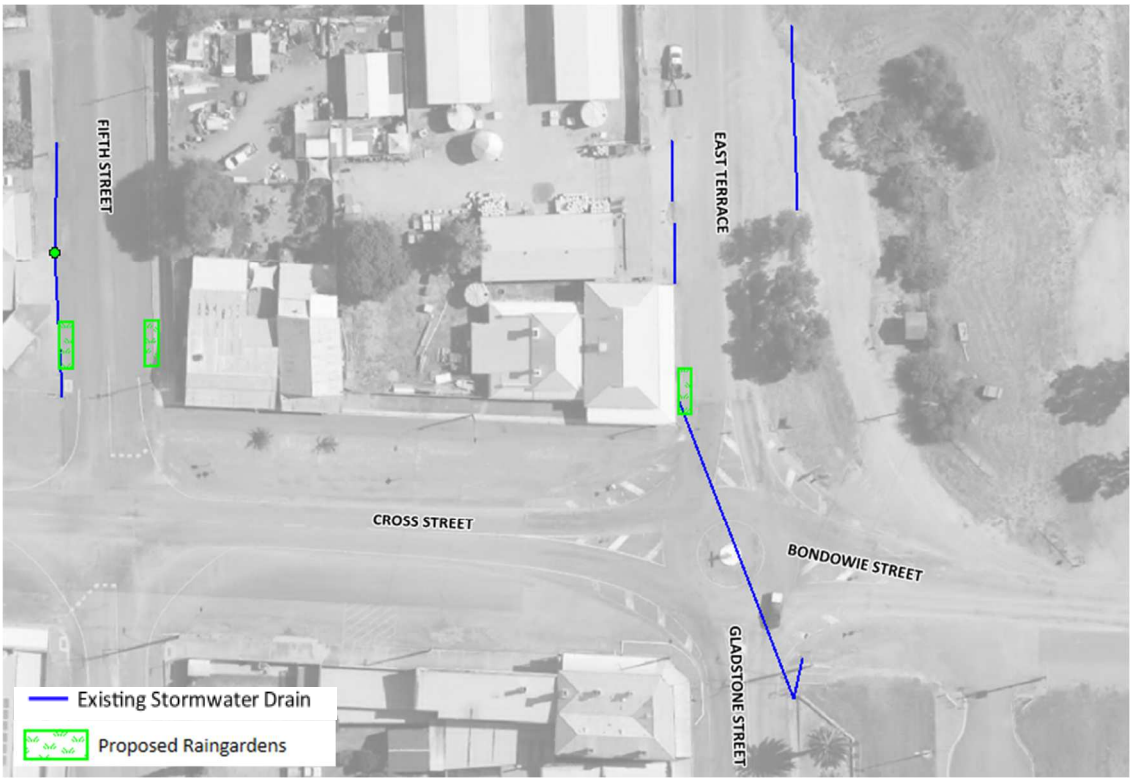


Figure 5.13 Proposed Cross Street Raingardens



Figure 5.14 Proposed Fourth Street Raingardens

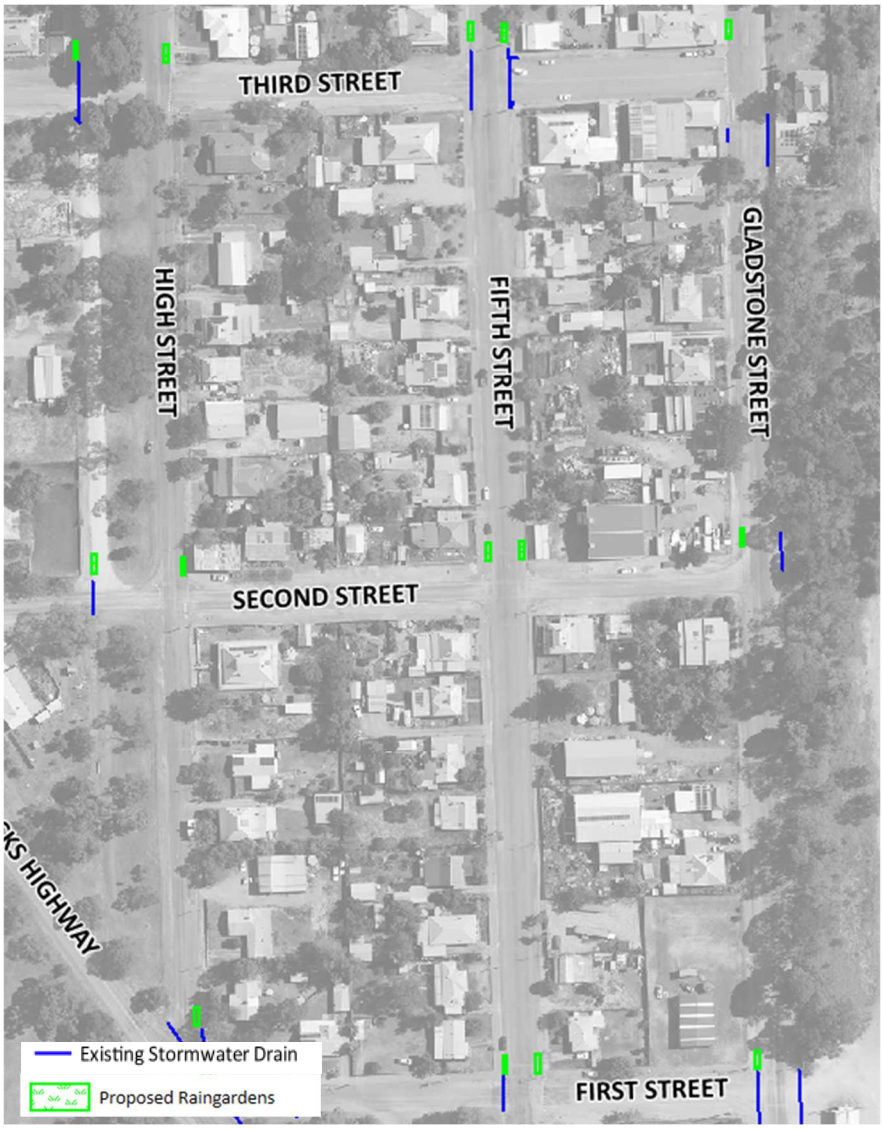


Figure 5.15 Proposed First/Second/Third Street Raingardens

WQ3: Gross Pollutant Traps

Gross pollutant traps (GPTs) are primary treatment devices that are designed to remove anthropogenic waste, organic matter and coarse sediment from stormwater flows. There are many different proprietary makes and models of GPT, ranging from below ground 'wet sump' devices to above ground trash racks and capture nets on pipe outlets.

The parameters adopted in MUSIC for GPTs have been based on Civilmart Cleansall GPTs. Following the guidance of *South Australian MUSIC Guidelines* (Water Sensitive South Australia, 2021), all GPTs are assumed to only provide effective reductions in gross pollutants and total suspended solids, and have assumed to result in no reduction in total phosphorus and total nitrogen loads.

For all new outlets to the watercourses in and around the town, it is recommended for a gross pollutant trap to be included. This includes the new drain in Centre Street to Yangya Creek (strategy D2) and the new drain in Bondowie Street and Port Street to Yangya Creek (strategy D3). Velocity dissipation measures should also be implemented at any new outlet structure to minimise erosion of the channel.

Depending on the system being installed and the details surrounding its installation, Council may need to apply for a water affecting permit from the Northern and Yorke Landscape Board prior to installing gross pollutant traps. Council should refer to their Water Affecting Activities Best Practice Operating Procedure agreement with the Board when determining if a permit will be required for the works.

WQ4: Rainwater Tanks and Allotment Level Reuse

It has been assumed that for each new house, a 10 kL rainwater tank will be used to irrigate the garden, as discussed in *Gladstone Stormwater Management Plan Modelling Report* (Southfront, 2025). This is considered to be a conservative approach, as aerial photography shows the majority of houses in Gladstone contain at least one large rainwater tank.

Further to rainwater tanks, it is recommended Council explore the addition of other allotment scale reuse practises as part of its development approval process. This includes encouraging passive irrigation of gardens, such as use of buffer strips, infiltration systems, pervious pavement and green roofs. These elements will reduce the use of potable water for irrigation, reduce the overall volume of stormwater runoff to receiving environments, provide additional opportunities for greening and cooling of the catchment and potentially assist with flood mitigation measures by limiting allotment runoff volumes.

Stormwater Harvesting and Reuse

Due to the limited availability of large open space within Gladstone, the opportunities to implement large-scale stormwater harvesting are considered limited. While there are some moderately sized reserves and grassed median strips, the majority of these house significant trees. It is understood that Council operates a CWMS scheme in Gladstone, treating wastewater from the town in ponds on Huddleston Road to be used for irrigating various Council owned land and recreational surfaces. Therefore there is likely to be a reduced demand for harvested stormwater in Gladstone.

Aquifer Storage and Recovery

As discussed in Section 2.3.4, no study investigating the feasibility of aquifer storage and recovery for Gladstone was identified through the baseline assessment. It is recommended that a consultant be engaged to undertake an ASR feasibility study should Council wish to consider a scheme in Gladstone.

5.1.5 Scenario 4 Water Quality Modelling

The Scenario 3 MUSIC model was modified, incorporating the various WSUD features described above. The lumped catchments adopted for the previous scenarios have been split to allow treatment measures to be implemented inside of these catchments. The results of the Scenario 4 MUSIC model are compared with the untreated runoff pollutant loads determined in Scenario 2 for the total urban catchment in Table 5.7.

Table 5.7 Total Urban Catchment Water Quality Improvement

Parameter	Sources	Residual Load	Reduction	Aspirational Target
Flow (ML/yr)	107	90.5	15%	N/A
Total Suspended Solids (kg/yr)	16,900	7,510	56%	80%
Total Phosphorus (kg/yr)	37.9	22.7	40%	60%
Total Nitrogen (kg/yr)	292	194	34%	45%
Gross Pollutants (kg/yr)	2,440	363	85%	90%

The results reflect the performance of a strategy which exhausts the obvious WSUD measures, considering the topography of the catchment and the limited large-scale open space available. To extend the strategy further and achieve the aspirational water quality improvement targets would likely require a decentralised approach comprising individual, small-scale WSUD elements. This may include additional measures at the street level (such as WSUD infrastructure incorporated into road reconstructions) and at the site level (such as rainwater tanks and other site-based measures incorporated into new developments.

Assuming a raingarden size of 15 m², a total of 349 raingardens are recommended across the urban catchment in order to achieve the aspirational pollutant reduction targets. The number of raingardens required is very high due to the lower performance associated with overflow weir raingardens, and the size of some of the catchments. Depending on the width of the road, larger 30 m² raingardens may be suitable, which would halve the number of raingardens required and be more space and cost efficient. The number of 15 m² overflow weir raingardens that should be implemented within each region can be seen in Figure 5.16. Values in the figure account for the other proposed WSUD assets such as standard raingardens and GPTs.

This number is aspirational, and is an indication of what is required to achieve the targets, however may not be achievable within Council's budget. In catchments without suitable locations for raingardens, the use of WSUD measures such as bioretention basins, grassed swales, buffers, tree pits or other treatment measures will significantly reduce the number of raingardens required. Standard raingardens with an underdrain, constructed alongside underground stormwater drainage, would also reduce the number of overflow weir raingardens required.

Table 5.8 below demonstrates the water quality improvement provided by the additional raingardens in combination with the proposed WSUD strategy.

Table 5.8 Aspirational WSUD Strategy Total Urban Catchment Improvement

Parameter	Sources	Residual Load	Reduction	Aspirational Target
Flow (ML/yr)	107	82.7	23%	N/A
Total Suspended Solids (kg/yr)	16,900	3,060	82%	80%
Total Phosphorus (kg/yr)	37.9	14.2	63%	60%
Total Nitrogen (kg/yr)	292	154	47%	45%
Gross Pollutants (kg/yr)	2,440	0	100%	90%

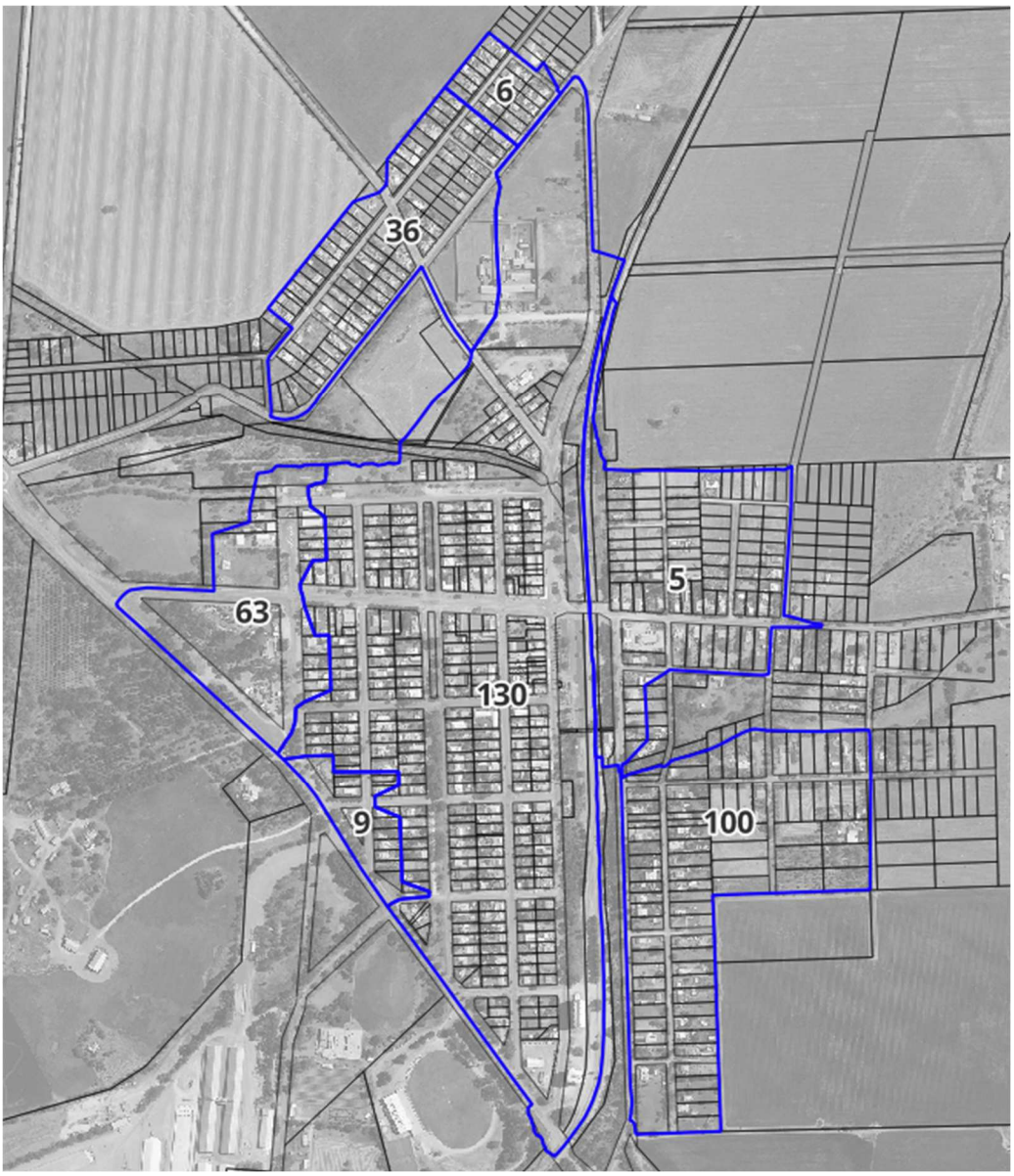


Figure 5.16 Number of Raingardens Required to Meet Aspirational Targets

5.2 Non-structural Measures

To complement the proposed structural options, a number of non-structural options are also recommended. Non-structural options are typically low cost (relative to structural measures) and hence are extremely cost effective with respect to the benefits that they provide.

N1: Flood Warning Systems
It is recommended that Council implement flood warning systems for the major watercourses of Yangya Creek and Rocky River upstream of the town. These catchments are very large in size and have long critical durations ranging from 12 hours to 48 hours, meaning that with the appropriate warning systems in place there will be time to alert the community ahead of a major flood event.

National Arrangements for Flood Forecasting and Warning (Bureau of Meteorology, 2018) provides a summary of how flood forecasting and warning services are arranged nationally. This document discusses various funding programs available at national and state/territory levels, which can include flood warning investments. Arrangements vary across jurisdictions and can involve a shared contribution between Council and the government. Opportunities for one-off funding are also available either following a significant flood event or a major review exercise.

Having flood gauges on the upstream catchments will also provide a better understanding of the flow patterns and volumes for these large watercourses, for which there is currently no flow data available. Over time, this will enable more accurate estimates of peak flow to be produced, therefore giving a better understanding of flood risk within the town.

N2: Rezoning Flood-prone Land
Council should consider rezoning vacant land that is currently shown to be inundated in up to a 1% AEP flood event, or where considered necessary for the storage of stormwater. It is also recommended that Council obtains easements over all proposed levees for long-term access and maintenance.

N3: SES Community FloodSafe Program
The State Emergency Service (SES) deliver their FloodSafe and StormSafe programs in schools and the community, to help build community resilience and understanding about flood risk. Community FloodSafe is a partnership between local Councils and State and Federal governments. The FloodSafe program uses existing SES volunteers, as well as new community volunteers with good presentation skills, to reach into communities to raise awareness in flood-prone areas. Initiatives include articles in Council newsletters, street corner meetings, community group meetings, internet sites, brochures and school education.

The volunteers talk to community groups, local residents, businesses and schools about what they can do to reduce the risk of flood damage and improve the resilience of their community if a flood should occur. FloodSafe volunteers typically address communities on:

- Local risks and historic flooding in the area;
- Having a flood plan to reduce the risk to business equipment, stock and staff;
- Protecting family and property;
- Understanding BOM Flood Watch and flood warnings;
- Having a home emergency kit; and
- How to call for SES response.

Since its inception in 2009, many metropolitan and regional South Australian councils have joined the FloodSafe program. Council may also elect to make the floodplain mapping of the town available via their website, along with advice to residents on measures they can take to reduce their flood risk and steps to preparing a Personal Flood Action Plan.

N4: Council's Emergency Management Plan
It is recommended that Council develop an Emergency Management Plan, with the purpose of collectively developing skills which provide the community with:

- Knowledge of the emergency risks that exist in the local area;
- Information to support the role that each member of the community can have in an emergency;
- A platform to connect with each other and Council before, during and after an emergency; and
- The ability to support each other to become resilient in an emergency event or disaster.

N5: New Building Floor Levels
It is recommended that Council ensure all new development has a floor level that provides at least 300 mm freeboard to the 1% AEP floodplain. This will mean that over time, the level of flood risk affecting properties will gradually decrease as new development occurs.

N6: Ongoing Maintenance and Monitoring of Council Assets
It is recommended that Council develop a Stormwater Asset Management Plan. The goal of such a plan is to ensure processes are in place for the required maintenance, monitoring and capital renewal of Council assets and to ensure it is done in a financially sustainably way. It is also recommended that Council develop a record of all of their stormwater assets in GIS form, and continually update this with any new infrastructure as it is constructed. It may also be worthwhile for Council to reconcile any drainage easements through private property.

N7: Education and Promotion of WSUD Measures
It is recommended that Council seek to increase uptake of WSUD measures on private property through community education and promotion of WSUD demonstration sites. Council staff and volunteers should seek to educate businesses, community groups, schools and local residents about options for managing the stormwater runoff generated from their property in an environmentally responsible manner. Suitable WSUD measures may include permeable paving, rainwater tanks, raingardens and soakage systems. These could be promoted through Council newsletters, street corner meetings, community group meetings, website and social median updates, brochures and school education.

N8: Development Controls – Beneficial Use of Stormwater
It is recommended that Council seek to increase uptake of WSUD measures on private property through community education and promotion of WSUD demonstration sites. Council staff and volunteers should seek to educate businesses, community groups, schools and residents about options for managing the stormwater runoff generated from their property in an environmentally responsible manner. Suitable WSUD measures may include permeable paving, rainwater tanks, raingardens and soakage systems. These could be promoted through Council newsletters, street corner meetings, community group meetings, website and social media updates, brochures and school education.

5.3 Risk Reduction Assessment

The flood risk assessment undertaken for Scenario A and Scenario B in Section 3.7 has been reviewed and updated following the modelling of the recommended stormwater management responses. The updated risk register is shown in Table 5.11.

Table 5.9 below summarises the identified risk ratings for Scenario B and Scenario C.

Table 5.9 Distribution of Risk Ratings across Model Scenarios

Model Scenario	Low Risk	Moderate Risk	High Risk	Extreme Risk
Scenario B	4	9	14	6
Scenario C	5	15	8	5

The table shows the risk reduction provided by the stormwater management measures. It should be noted that many of the high and extreme risk locations are associated with flooding across roads outside of the town, and were not targeted by flood mitigation strategies.

5.4 Social and Political Capital Requirements

The level of 'social and political capital' that would be required to implement each of the proposed management responses has been investigated. A rating system has been developed to define the levels of social and political capital, as presented in Table 5.10 below.

Table 5.10 Definitions of Social and Political Capital Levels

Rating	Structural Measure	Non-Structural Measure
Low	Small, simple works being undertaken in low-traffic areas such as local roads, undeveloped reserves or vacant land.	Simple to implement measure unlikely to require behavioural change.
Medium	Moderately sized works being undertaken outside of areas of social, economic or environmental importance.	Moderately complicated measure requiring behavioural change.
High	Complex, expensive or sensitive works requiring land acquisition, or being centred around areas of social, economic or environmental importance.	Complex measure requiring policy changes, significant behavioural change or significant financial investment.

A rating has been assigned for each management response, and these have been incorporated into the summary table provided in the following section.

5.5 Overview of Stormwater Management Responses

The full range of recommended management responses, including those targeting flooding and water quality as well as non-structural measures, have been combined into a single overview table, summarising the key information relating to each. The table presents the management responses in a way which allows for easy comparison of the merits of each option, and is shown in Table 5.12 below.

Table 5.11 - Scenario C Flood Risk Register

ID	Location	Type of Deficiency	1% AEP Impact Details	Risk Category	Consequence	Risk
1	Wilkins Highway	High/Extreme Flood Hazard	Flooding over 1500mm deep across major road	Flooding, Health & Safety	4	Extreme
2	George Street	Extreme Flood Hazard	Flooding over 1000mm deep across the road	Flooding, Health & Safety	3	High
3	Properties along Port Street and Mill Street next to James Street	High Flood Hazard	Properties flooded over 500mm deep	Flooding, Health & Safety, Social/Stakeholder	4	Extreme
4	Properties on George Street adjacent to channel	High Flood Hazard	Properties flooded over 500mm deep	Flooding, Health & Safety, Social/Stakeholder	3	High
5	Properties surrounding intersection of Mill Street and Matthew Street	High Flood Hazard	Many properties flooded over 500mm deep, with some over 1000mm	Flooding, Health & Safety, Social/Stakeholder	4	Extreme
6	Properties along Port Street and Mill Street south of Loftus Street	High Flood Hazard	Properties flooded over 500mm deep	Flooding, Health & Safety, Social/Stakeholder	4	Extreme
7	Horrocks Highway	High/Extreme Flood Hazard	Flooding over 1000 mm deep across major road	Flooding, Health & Safety	4	Extreme
8	Properties between Port Street and George Street north of Matthew Street	High Flood Hazard	Properties flooded over 500mm deep	Flooding, Health & Safety, Social/Stakeholder	3	High
9	Industrial properties along West Terrace	High Flood Hazard	Properties flooded over 250mm deep	Flooding, Health & Safety, Social/Stakeholder	2	Moderate
10	Properties between High Street, Second Street and Horrocks Highway	High Flood Hazard	Properties flooded up to 250mm deep	Flooding, Health & Safety, Social/Stakeholder	2	Moderate
11	Intersection of Third Street and High Street	High Flood Hazard	Flooding over 250mm deep across the road	Flooding, Health & Safety	2	Moderate
12	Fourth Street near Gladstone Street	High Flood Hazard, Gutter Flow Depth/Width	Flooding over 250mm deep across the road	Flooding, Health & Safety	2	Moderate
13	Gladstone Street from Fourth Street to Second Street	High Flood Hazard, Gutter Flow Depth/Width	Flooding over 250mm deep across the road	Flooding, Health & Safety	2	Moderate
14	Horrocks Highway east of Fifth Street	High/Extreme Flood Hazard	Flooding over 250mm deep across the major road	Flooding, Health & Safety	2	Moderate
15	Properties between Gladstone Street and High Street south of Fourth Street	High Flood Hazard	Many properties flooded over 100mm deep, with some over 250 mm	Flooding, Health & Safety, Social/Stakeholder	2	Moderate
16	Along Fourth Street and High Street	Gutter Flow Depth/Width	Flooding over 100mm deep across the road	Flooding, Health & Safety	1	Low
17	Intersection of Horrocks Highway and High Street	High/Extreme Flood Hazard	Flooding over 250 mm deep across the major road	Flooding, Health & Safety	2	Moderate
18	Properties along Bondowie Street between Washington Street and Centre Street	High Flood Hazard	Many properties flooded over 250 mm deep	Flooding, Health & Safety, Social/Stakeholder	3	High
19	Corner of First Street and Fifth Street	High Flood Hazard	Many properties flooded over 100mm deep	Flooding, Health & Safety, Social/Stakeholder	2	Moderate
20	Along Fifth Street	Gutter Flow Depth/Width	Flooding over 250mm deep along the road	Flooding, Health & Safety	1	Low

21	Properties on corner of High Street and Third Street	High Flood Hazard	Many properties flooded over 100mm deep	Flooding, Health & Safety, Social/Stakeholder	2	Moderate
22	Gladstone High School	High Flood Hazard	School flooded over 100mm deep	Flooding, Health & Safety, Social/Stakeholder	2	Moderate
23	Stormwater Inlet on Centre Street	Low Freeboard /Upwelling, Inlet Capacity	Flooding over 250 mm deep along the road	Flooding	2	Moderate
24	Stormwater Inlet on Fifth Street near Cross Street	Low Freeboard, Inlet Capacity	Shallow flooding along road	Flooding	1	Low
25	Around Stormwater Inlet on Sixth Street	Low Freeboard, Inlet Capacity, Gutter Flow Depth/Width	Shallow flooding on both sides of the road, through properties	Flooding	2	Moderate
26	Washington Street	Gutter Flow Depth/Width	Flooding over 100 mm deep along the road	Flooding	1	Low
27	Bondowie Street between Washington Street and West Street	Gutter Flow Depth/Width	Flooding over 250 mm deep along the road	Flooding	2	Moderate
28	Mill Street south of Bondowie Street	Gutter Flow Depth/Width	Flooding over 500 mm deep along the road	Flooding	3	High
29	James Street between Port Street and Mill Street	Gutter Flow Depth/Width	Flooding over 500 mm deep along the road	Flooding	3	High
30	Matthew Street near Mill Street	Gutter Flow Depth/Width	Flooding over 1 m deep along the road	Flooding	3	High
31	Port Street south of James Street	Gutter Flow Depth/Width	Flooding over 500 mm deep along the road	Flooding	3	High
32	Cross Street between Sixth Street and High Street	Gutter Flow Width	Shallow flooding along road	Flooding	1	Low
33	Receiving waters	Water quality of town runoff	Risk of ecological harm	Environmental, Social/Stakeholder, Reputational/Political	2	Moderate

Table 5.12 - Summary of Stormwater Management Responses

ID	Description	Objectives Addressed	Structural?	Type of Action	Benefit Provided	Capital Cost	Estimated Annual Operating Cost	Social/Political Capital Required	Stakeholder Responsible for Funding/Implementing	Post-measure Residual Risk
D1	Yangya Creek Flood Protection	1,6	Yes	Works, land acquisition	Flood mitigation	$1,410,000	$10,000	High	Northern Areas Council	Moderate
D2	Centre Street Drain and Flood Levee	1,6	Yes	Works, land acquisition	Flood mitigation, drainage service	$930,000	-	High	Northern Areas Council	Low
D3	Port Street, Bondowie Street Drainage	1,6	Yes	Works	Flood mitigation, drainage service	$1,360,000	-	High	Northern Areas Council	Low
D4	Mill Street, Port Street Drainage	1,6	Yes	Works, land acquisition	Flood mitigation, drainage service	$910,000	-	High	Northern Areas Council	Moderate
WQ1	High Street Bioretention Basin	2,6	Yes	Works, integrated program, amenity improvement	Water quality improvement, amenity improvement	$220,000	$8,000	Low	Northern Areas Council	N/A
WQ2	Streetscape Raingardens	2,6	Yes	Works, integrated program	Water quality improvement	$5,700,000	$244,300	High	Northern Areas Council	N/A
WQ3	Gross Pollutant Traps	2,5,6	Yes	Works, integrated program	Water quality improvement	$320,000	$4,000	Medium	Northern Areas Council	N/A
WQ4	Rainwater Tanks and Allotment Level Reuse	2,3,4,6,7	No	Community education program	Stormwater reuse, water quality improvement, information and knowledge	N/A	N/A	Medium	Northern Areas Council	N/A
N1	Flood Warning Systems	1,7	No	Policy change	Flood mitigation, information and knowledge, administration efficiency	N/A	N/A	High	Northern Areas Council, State/Federal Governments	N/A
N2	Rezoning Flood-prone Land	4,7	No	Policy change, community education program	Flood mitigation, information and knowledge	N/A	N/A	High	Northern Areas Council	N/A
N3	SES Community FloodSafe Program	7	No	Community education program	Flood mitigation, information and knowledge	N/A	N/A	Medium	Northern Areas Council, State Emergency Service	N/A
N4	Council's Emergency Management Plan	1,7	No	Investigation, policy change	Flood mitigation, information and knowledge, administration efficiency	N/A	N/A	Medium	Northern Areas Council	N/A
N5	New Building Floor Levels	4,7	No	Policy change	Flood mitigation	N/A	N/A	Medium	Northern Areas Council, Developers	N/A
N6	Ongoing Maintenance and Monitoring of Council Assets	6	No	Policy change	Flood mitigation, drainage service, information and knowledge, administration efficiency	N/A	N/A	High	Northern Areas Council	N/A
N7	Education and Promotion of WSUD Measures	2,4,7	No	Community education program	Stormwater reuse, water quality improvement, ecological improvement, information and knowledge	N/A	N/A	Medium	Northern Areas Council, Businesses, Organisations, Communities	N/A
N8	Development Controls – Beneficial Use of Stormwater	3,4,7	No	Policy change	Stormwater reuse, water quality improvement	N/A	N/A	Medium	Northern Areas Council, Businesses, Organisations, Communities	N/A

5.6 Prioritisation of Management Responses

The recommendations outlined in this Stormwater Management Plan will require implementation to be scheduled over many years, in order to be accommodated sustainably within the Northern Areas Council's budget and the budgets of other potential funding partners.

Each of the actions within the SMP has been assigned one of five priority levels, each of which have an associated time frame:

- Very High (0-2 years);
- High (2-5 years);
- Moderate (5-10 years);
- Low (10-20 years); and
- Very Low (20-30 years).

A Multi-Criteria Analysis (MCA) approach has been followed to assign priorities to all proposed stormwater management responses. This approach allows relative priorities to be assigned to all recommended structural works, taking into account financial, environmental and social factors. The criteria and weightings adopted have been developed with consideration of the stormwater management objectives and targets developed for this SMP, which were developed following discussions with key stakeholders.

A diverse range of stormwater management strategies have been recommended in this plan to cater to the unique requirements of the town. Having regard to the diversity of these strategies and the need for a flexible and optimal decision making framework for this plan, a separate MCA approach has been developed for the flood mitigation strategies and for the water sensitive urban design strategies.

The two MCA approaches are linked through the inclusion of a criterion that recognises flood mitigation projects that are required as a precursor to the implementation of WSUD actions. Consolidation of scores from the two MCA approaches has also been undertaken to inform the prioritisation of works and reinforce the value of achieving multiple objectives for stormwater management projects in the town.

The priority rating of responses is flexible and likely to change over time. It is anticipated that certain responses will be 'brought forward', particularly when opportunities for external grant funding arise. A number of flood mitigation projects eligible for funding from the Stormwater Management Authority have been identified. It is recommended that Northern Areas Council liaise with the Stormwater Management Authority to identify a time frame for the delivery of these projects that meets the forward budget limitations of both parties.

The SMP brief asks for a reasonable and credible estimate of the benefit provided by each response, quantified where possible. Considering the nature of flooding in the town, with urban runoff being the dominant flooding mechanism in the more frequent events and major watercourses governing flooding in the rarer events, this was not considered possible. As the strategies have been developed holistically looking at both urban and rural flooding mechanisms, no single strategy can be attributed all of the flood reduction achieved in a given area across the range of modelled AEPs. The overall benefit provided by the entire strategy is described in Section 5.1.2.

In lieu of considering the economic benefit of each individual strategy, alternative metrics have been adopted to assess the benefit provided by each. This includes a metric looking at residual nuisance flooding along roads in minor storm events and a metric looking at the reduction in major flood risk in rare storm events. These are qualitative, and have been assessed by comparing the pre-mitigation and post-mitigation flood maps for a range of storm events.

It should be noted that the non-structural measures are not included within the assessment as they do not necessarily fit within the MCA criteria.

5.6.1 Flood Mitigation Strategies Multi-Criteria Analysis

The criteria and weightings used in the MCA to prioritise the flood mitigation strategies are summarised in Table 5.13.

Table 5.13 Flood Mitigation Strategies MCA Performance Matrix

Criterion	Weighting	Performance Score				
		5	4	3	2	1
Capital Cost	20	<$100k	$100-500k	$500k-1m	$1m-2m	>$2m
Reduced Street Drainage Nuisance	20	Very High	High	Moderate	Low	Very Low
Reduced Major Flooding Risk	30	Very High	High	Moderate	Low	Very Low
Precursor to WSUD Strategy	10	Multi-objective WSUD	-	Water Quality Only	-	None
Community Buy-In	20	Very High	High	Moderate	Low	Very Low
Total	100					

Performance values used in the assessment of proposed stormwater management responses have been defined as follows:

- Capital Cost

Reference has been made to the construction cost estimates outlined in this plan to determine this value. Projects with a greater capital cost are assigned lower scores than projects with a smaller capital cost.

- Reduced Street Drainage Nuisance

This value was assigned based on judgement of the improvements demonstrated by the 18% AEP floodplain mapping of the flood mitigation strategies. Projects that limit property and roadway ponding in the vicinity to a depth of less than 0.1 metres were assigned the highest value, with progressively lower values assigned where the residual impact was larger.

- Reduced Major Flooding Risk

This value was assigned based on judgement of the improvements demonstrated by the 5% AEP and rarer floodplain mapping of the flood mitigation strategies. This criterion has been assigned

a higher weighting due to the significant social, financial and environmental impacts associated with major flooding.

➢ Precursor to WSUD Strategy

Several of the recommended flood mitigation strategies are required as a precursor to, or directly facilitate, the implementation of a water sensitive urban design strategy. Projects that facilitate multi-objective WSUD outcomes have been assigned higher values than projects that provide only water quality improvement (e.g. gross pollutant traps). This criterion has been assigned a lower weighting as WSUD strategies are considered separately.

➢ Community Buy-In

All projects were assigned a default maximum rating for this criteria, then revised down for projects that require acquisition of land or easements through private property, and for projects that impact the existing use of public open space. Projects which address issues raised in the community consultation have been assigned higher ratings. Projects that negatively impact existing sites of high recreational value or that support organised sport were assigned the lowest ratings.

Performance values input into the MCA can be found in Appendix J.

Weighted scores for each stormwater management response have been determined using the above MCA framework, and are presented in Table 5.14 from highest to lowest. Note that each strategy can achieve a maximum score of 5 and a minimum score of 1.

Table 5.14 Flood Mitigation Strategies MCA Results

Strategy ID	Description	Weighted Score
D1	Yangya Creek Flood Protection	3.0
D3	Port Street, Bondowie Street Drainage	2.8
D2	Centre Street Drain and Flood Levee	2.4
D4	Mill Street, Port Street Drainage	2.3

5.6.2 WSUD Strategies MCA Performance Matrix

The criteria and weightings used in the MCA to prioritise the WSUD strategies are summarised in Table 5.15.

Table 5.15 WSUD Strategies MCA Performance Matrix

Criterion	Weighting	Performance Score				
		5	4	3	2	1
Capital Cost	20	<$50k	$50-250k	$250-500k	$500k-1m	>$1.0m
Annual Maintenance Cost	20	<$5k	$5-10k	$10-15k	$15-20k	>$20k
Pollutant (TSS) Reduction (average annual load)	20	>5 tonnes	2-5 tonnes	1-2 tonnes	0.5-1 tonnes	<0.5 tonnes
Stormwater Capture and Reuse	20	Capture and Reuse	-	Capture Only	-	None
Community Buy-In	20	Very High	High	Moderate	Low	Very Low
Total	100					

Performance values used in the assessment of proposed stormwater management responses have been defined as follows:

- Capital Cost

Reference has been made to the construction cost estimates outlined in this plan to determine this value. Projects with a greater capital cost are assigned lower scores than projects with a smaller capital cost.

- Maintenance Cost

Values were assigned based on maintenance cost estimates from historical experience and industry sources.

- Pollutant (TSS) Reduction

Projects have been assigned a value that is reflective of their expected pollutant removal performance, as defined by the average annual load reduction of total suspended solids reported by the MUSIC model.

- Stormwater Capture and Reuse

Several of the recommended WSUD strategies result in the capture and/or reuse of stormwater. Projects that facilitate stormwater capture and reuse have been assigned higher performance scores than projects that facilitate stormwater capture only.

- Community Buy-In

All projects were assigned a default maximum rating for this criteria, then being revised down for projects that require acquisition of land or easements through private property, and for

projects that impact the existing use of public open space. Projects that impact existing sites of high recreational value or that support organised sport were assigned the lowest ratings.

Performance values input into the MCA can be found in Appendix J.

Weighted scores for each stormwater management response have been determined using the above MCA framework, and are presented in Table 5.16 from highest to lowest. Note that each strategy can achieve a maximum score of 5 and a minimum score of 1.

Table 5.16 WSUD Strategies MCA Results

Strategy ID	Description	Weighted Score
WQ1	High Street Bioretention Basin	3.4
WQ3	Gross Pollutant Traps	3.2
WQ2	Streetscape Raingardens	2.8

5.6.3 Implementation Plan

An implementation plan for the recommended responses is presented in Table 5.17. This table describes the additional work and investigations that would be required to implement any given response, suggests an implementation time frame based on the MCA analysis, and details the responsible party and any funding sources available.

5.6.4 Responsibilities for Implementation and Funding Opportunities

Northern Areas Council is responsible for the implementation of all actions identified within this Stormwater Management Plan. It is expected that Council will continue to liaise with relevant State Government departments and agencies to satisfy a variety of regulatory requirements.

There may be opportunities to secure funding from the Northern and Yorke Landscape Board and the Department of Environment and Water, particularly for water quality improvement works. The South Australian Environment Protection Authority also occasionally provide grants for Water Sensitive Urban Design projects, such as the Rain Garden 500 program in 2016.

Actions that are potentially eligible for Stormwater Management Authority funding (typically co-funding on a 50/50 basis with Local Government for projects with a contributing catchment area greater than 40 hectares) have been highlighted. Note that the authority has the discretion to contribute more or less than 50% of the cost of certain works and may elect to contribute to the cost of works where the contributing catchment area is less than 40 hectares, provided those works form part of an approved Stormwater Management Plan.

Projects not eligible for funding from the Stormwater Management Authority may still be eligible for other external funding opportunities, such as the National Flood Mitigation Infrastructure Program. This program, established by the National Emergency Management Agency, delivered $100 million across 2020-21 and 2021-22 to state and territory governments for the construction or improvement of flood mitigation infrastructure.

5.6.5 Monitoring Implementation Plan Progress

It is recommended that a structured approach is taken to programming in the proposed strategies and actions in this Stormwater Management Plan. Following the endorsement of the Plan, it is recommended Council review their capital works plan to schedule in the strategies recommended alongside previously identified projects.

It is recommended that Council consolidate and continually update their stormwater GIS layers as new infrastructure is constructed. This will not only ensure that the best available information is recorded for future use, but will also enable Council to effectively plan for the long-term management of their stormwater assets from maintenance to renewal. It is also recommended that where strategies will require ongoing maintenance, such as cleaning GPTs and replacing raingarden filter layer material, Council factor this into their budgeting and planning to ensure these assets continue to perform as designed into the future.

It is recommended that Council develop a strategy for reporting progress on the implementation of recommended strategies to key stakeholders including the local community. This will ensure the community remains informed about flood mitigation and water quality improvement works being undertaken by Council, and can be seen as an opportunity to educate the community on the benefits of these types of works. This could include articles on the Council website, updates in the Council newsletter or posts on Council's social media accounts.

Table 5.17 - Stormwater Management Response Implementation Plan

ID	Description	Further Investigation Required?	Land Acquisition Required?	Planning or Policy Changes Required?	Potential Approvals/ Licences Required	Priority	Nominated Time Frame	Responsible Authority	Potential Funding Sources
D1	Yangya Creek Flood Protection	Yes	Yes	No	Water Affecting Activity Permit	Very High	0-2 years	Northern Areas Council	Stormwater Management Authority
D2	Centre Street Drain and Flood Levee	Yes	Yes	No	Water Affecting Activity Permit	Moderate	5-10 years	Northern Areas Council	
D3	Port Street, Bondowie Street Drainage	Yes	No	No	Water Affecting Activity Permit	High	2-5 years	Northern Areas Council	
D4	Mill Street, Port Street Drainage	Yes	Yes	No	Water Affecting Activity Permit	Low	10-20 years	Northern Areas Council	Stormwater Management Authority
WQ1	High Street Bioretention Basin	Yes	No	No		High	2-5 years	Northern Areas Council	
WQ2	Streetscape Raingardens	Yes	No	No		Moderate	5-10 years	Northern Areas Council	
WQ3	Gross Pollutant Traps	Yes	No	No	Water Affecting Activity Permit	Low	10-20 years	Northern Areas Council	
WQ4	Rainwater Tanks and Allotment Level Reuse	N/A	N/A	Yes		Low	10-20 years	Northern Areas Council	
N1	Flood Warning Systems	N/A	N/A	Yes		Very High	0-2 years	Northern Areas Council	Stormwater Management Authority, Federal/State Government
N2	Rezoning Flood-prone Land	N/A	N/A	Yes		Moderate	5-10 years	Northern Areas Council	
N3	SES Community FloodSafe Program	N/A	N/A	Yes		Very High	0-2 years	Northern Areas Council, State Emergency Service	Stormwater Management Authority
N4	Council's Emergency Management Plan	N/A	N/A	Yes		High	2-5 years	Northern Areas Council	
N5	New Building Floor Levels	N/A	N/A	Yes		Moderate	5-10 years	Northern Areas Council	
N6	Ongoing Maintenance and Monitoring of Council Assets	N/A	N/A	Yes		Low	10-20 years	Northern Areas Council	
N7	Education and Promotion of WSUD Measures	N/A	N/A	Yes		Low	10-20 years	Northern Areas Council	Stormwater Management Authority
N8	Development Controls – Beneficial Use of Stormwater	N/A	N/A	Yes		Low	10-20 years	Northern Areas Council	Stormwater Management Authority

5.7 Review of SMP Objectives and Targets

Table 5.18 below provides an assessment of the degree to which each of the identified Stormwater Management Plan objectives and targets have been met by the recommended management measures.

Table 5.18 Assessment of SMP Objectives and Targets

Objective /Target	Achieved?	Discussion
Provide an acceptable level of flood protection for the community and both public and private assets		
1a	Partially	The flood mitigation measures were found to reduce the number of dwellings facing above-floor inundation in a 1% AEP flood from 180 to 95 (a 47% reduction). This target was aspirational, and the flood mitigation measures were developed targeting the 5% AEP flood event.
1b	Partially	The flood mitigation measures were found to reduce the number of dwellings facing above-floor inundation in a 5% AEP flood from 53 to 17 (a 68% reduction). The cost of providing complete flood immunity would likely exceed the value of property being protected, so a practical solution which provides a reasonable improvement has been adopted. Non-structural management measures have been recommended which if implemented will reduce the risk to the community.
1c	Partially	The maximum flood hazard along Bondowie Street in a 1% AEP flood has significantly reduced from extreme (H5) to moderate (H2) due to the proposed measures. Flood hazard throughout Gladstone west of Yangya Creek has significantly reduced, allowing safe access to Caltowie Road. Some houses east of Yangya Creek will not have a safe evacuation route in a 1% AEP flood.
1d	Yes	Council have throughout the project communicated with the community to describe the flood risk racing the town. The recommended FloodSafe program run by SES will enable the community to be prepared for a flood.
1e	Yes	The recommendations of this SMP include for Council to develop a Community Emergency Management Plan.
Manage the quality of runoff and its effects on receiving waters		
2a	Yes	The proposed water quality improvement strategy meets the aspirational pollutant reduction targets.
2b	Yes	The plan recommends for the education and promotion of WSUD measures throughout the wider community.
Make beneficial use of stormwater		
3a	Yes	Opportunities to implement a harvesting scheme within Gladstone were investigated, this was found not to be viable due to the limited available open space receiving town runoff.
3b	Yes	It has been recommended for Council to promote the use of WSUD measures to reduce the stormwater runoff leaving development sites.

Objective /Target	Achieved?	Discussion
Planning for new developments provides for open space, recreation and amenity		
4a	Yes	This SMP recommends strategies to enforce development control for new development floor levels.
4b	Yes	A campaign to educate the community about the benefits of WSUD infrastructure is recommended as part of this SMP.
4c	Yes	Development controls to improve opportunities to beneficially reuse stormwater have been recommended through this SMP.
Improve the condition of receiving waters		
5a	Yes	All proposed stormwater drains with outlets to the river have gross pollutant traps and scour protection recommended.
Sustainable asset management of stormwater infrastructure		
6a	Yes	A recommendation of this SMP is for Council to develop a Stormwater Asset Management Plan, and develop a GIS database for their stormwater infrastructure.
6b	Yes	All proposed structural management measures have been designed against future development and climate change.
Effective communication and consultation with catchment stakeholders, businesses and community members		
7a	Yes	Through the development of this SMP the community were consulted on the stormwater risks facing the town.
7b	Yes	The SMP recommends the development of a flood warning system, and the SES FloodSafe program recommended will help prepare the community for a potential flood event.
7c	Yes	The stormwater management responses summary table and implementation plan suggest external agencies such as the Stormwater Management Authority that Council may be able to partner with in the development of management measures.

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Appendix A

Flood Risk Consequence Matrix



Flood Risk Consequence Matrix

Consequence						
Level	**General**	**Flooding**	**Health & Safety**	**Cost**	**Environmental**	**Social/Stakeholder**
1 Insignificant	Undetectable or below guidelines, no disruption to normal operation, no increase in normal operation costs	Nuisance road ponding in the 18% AEP flood, negligible property inundation in the 1% AEP flood	Insignificant impact to health & safety	Insignificant loss of assets and resources and insignificant impact on budget	Insignificant impact to the environment & negligible effect on customers	Insignificant damage to Council and stakeholder perception/confidence
2 Minor	Some manageable operation disruption, some increase in operating costs	Shallow road ponding in the 18% AEP flood, properties inundated up to 250mm deep in the 1% AEP flood	Minor impact to health & safety resulting in no injuries	Loss of assets and resources, <5% deviation from program budget	Breach of a control system causing minor environmental impact, minor effect on customers	Minor negative perception and short-term damage to an insignificant audience
3 Moderate	Significant modification to normal operation but manageable, operation costs increased, increased monitoring	Properties inundated over 250mm deep, trafficability of roads limited in the 1% AEP flood	Moderate impact to health & safety resulting in minor injuries requiring medical assistance	Moderate loss of assets and resources, 5% deviation from program budget resulting in limiting project scope	Intermittent non-compliance with regulations causing moderate impacts to the environment, moderate effect on customers	Moderate negative perception and short-term damage to a specific audience in Council or stakeholder agencies
4 Major	Systems significantly compromised and abnormal operation if at all, high level of monitoring required	Many properties inundated over 500mm deep, roads inundated over 1m deep in the 1% AEP flood	Major impacts to health & safety resulting in serious injury and hospitalisation	Major loss of assets and resources, 15% deviation from program budget, resulting in possible closure of the project	Failure to comply with regulations & causing major environmental hard resulting in temporary shutdown of the project, adverse effect on customers	Negative Council and stakeholder perception and short-term damage to Council and stakeholder confidence
5 Catastrophic	Major impact, complete failure of systems, risk to public health & environment	Widespread property inundation over 1m deep, emergency services infrastructure impacted, road access completely cut off in 1% AEP flood	Significant impact to health & safety resulting in death	Significant loss of assets and resources, 30% deviation from program budget, resulting in closure of the project	Sustained non-compliance to regulation & causing significant impact to the environment causing project closure	Significant impact to Council and stakeholder perception and long-term damage to Council and stakeholder confidence

Appendix B

Community Consultation Responses



Laura, Gladstone, Georgetown and Spalding
Stormwater Management Plans

Community Response Form

This feedback form should be read in conjunction with the summary brochure and State of the Catchment reports which explain the work undertaken to date on the Stormwater Management Plans.

1 Which of the following describes your interest in the Stormwater Management Plans? Please tick all that apply.

- ☑ Local resident
- ☑ Interest or experience of flooding
- ☑ Interest in local environment
- ☑ Interest in improving water quality
- ☑ Interest in water conservation and/or stormwater harvesting and reuse
- ☐ Other (please specify) .....

2 Please score the following stormwater management considerations from 1 to 5, with 1 being the highest priority in your opinion and 5 being the lowest.

	1	2	3	4	5
Major flooding	✓				
Nuisance flooding		✓			
Water quality			✓		
Stormwater capture and reuse			✓		
Climate change				✓	

3 Are there any specific stormwater related issues or concerns you would like to see the Stormwater Management Plans address? For example a specific local flooding problem or any ways in which you think stormwater should be managed within the towns? Please explain your response.

- CENTRE OF TOWN HAS VERY POOR ABILITY TO CLEAR STORM WATER.
- SIGNIFICANT EVENTS ARE NOT ABLE TO BE CONTROLLED. ESPECIALLY NORTH OF TOWN (DIVERSION)
- CATCH AND RELEASE IN TOWN DAM APPEARS INADEQUATE. TOWN DAM DOES NOT HOLD WATER AND NEED CLEANING OF SILT SO THAT IT COULD BE USED ON THE OVAL.

Laura, Gladstone, Georgetown and Spalding
Stormwater Management Plans

Community Response Form

4 Do you have any other comments to make?

OUR PROPERTY (20 ACRES) SW OF TOWN DOES NOT ADD MUCH TO THE STORM WATER IN TOWN. HOWEVER THE NATURAL WATER COARSE CROSSES BLOGAN RD. THIS IS REPAIRED ANNUALLY. I WOULD SUGGEST A CULVERT UNDER THE ROAD AT THE CROSSING POINT.

5 To help us understand who participated in the consultation please provide the following details:

Name: .....

Street name .....

Suburb GEORGETOWN .....

If you are open to being contacted regarding your response, please provide your phone number and/or email address.

Phone: ... .

Email: ... .

Thank you for taking the time to complete the feedback form. Your feedback is invaluable and will be considered in developing the Stormwater Management Plans.

Submissions should be completed by 30 October, 2023. Please return this feedback form to one of the following:

- Northern Areas Council, PO Box 120, 94 Ayr Street Jamestown, SA 5491
- Gladstone District Office, 14 Fifth Street Gladstone, SA 5473
- Spalding District Office, 11 Main Street Spalding, SA 5454
- Via email to admin@nacouncil.sa.gov.au

Laura, Gladstone, Georgetown and Spalding
Stormwater Management Plans

Community Response Form

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1 Which of the following describes your interest in the Stormwater Management Plans? Please tick all that apply.

- ☑ Local resident
- ☑ Interest or experience of flooding
- ☐ Interest in local environment
- ☐ Interest in improving water quality
- ☑ Interest in water conservation and/or stormwater harvesting and reuse
- ☐ Other (please specify) .....

2 Please score the following stormwater management considerations from 1 to 5, with 1 being the highest priority in your opinion and 5 being the lowest.

	1	2	3	4	5
Major flooding	1				
Nuisance flooding	1				
Water quality					
Stormwater capture and reuse	1				
Climate change					

3 Are there any specific stormwater related issues or concerns you would like to see the Stormwater Management Plans address? For example a specific local flooding problem or any ways in which you think stormwater should be managed within the towns? Please explain your response.

- Ensuring that the stormwater harvesting in gladstone currently in place is not impacted by any changes made, eg. The harvesting point at the railway line.
- Problems occur in regards to the blockages in the Rocky River through Boyodee, which divert the water out of the creek in various locations, changing the true flow of water.

Laura, Gladstone, Georgetown and Spalding
Stormwater Management Plans

Community Response Form

4 Do you have any other comments to make?

- I believe these blockages need to be considered and attended to in regards to the plan.

- The floodway along high street does not need to be made larger as it currently acts as a good watering source for the trees and grass along this area in its current ways.

5 To help us understand who participated in the consultation please provide the following details:

Name: ...

Street name: .

Suburb ... Gladstone SA 5473

If you are open to being contacted regarding your response, please provide your phone number and/or email address.

Phone: .....

Email: .....

Thank you for taking the time to complete the feedback form. Your feedback is invaluable and will be considered in developing the Stormwater Management Plans.

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Laura, Gladstone, Georgetown and Spalding Stormwater Management Plans

Community Response Form

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1 Which of the following describes your interest in the Stormwater Management Plans? Please tick all that apply.

- ☑ Local resident
- ☑ Interest or experience of flooding
- ☑ Interest in local environment
- ☐ Interest in improving water quality
- ☐ Interest in water conservation and/or stormwater harvesting and reuse
- ☐ Other (please specify) .....

2 Please score the following stormwater management considerations from 1 to 5, with 1 being the highest priority in your opinion and 5 being the lowest.

	1	2	3	4	5
Major flooding	✓				
Nuisance flooding			✓		
Water quality			✓		
Stormwater capture and reuse			✓		
Climate change ?					

3 Are there any specific stormwater related issues or concerns you would like to see the Stormwater Management Plans address? For example a specific local flooding problem or any ways in which you think stormwater should be managed within the towns? Please explain your response.

Pisant Creek clearing a
Port Broughton will be Good

Laura, Gladstone, Georgetown and Spalding Stormwater Management Plans

Community Response Form

4 Do you have any other comments to make?

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5 To help us understand who participated in the consultation please provide the following details:

Name: ....

Street name: ....

Suburb .....

If you are open to being contacted regarding your response, please provide your phone number and/or email address.

Phone: ....

Email: ....

Thank you for taking the time to complete the feedback form. Your feedback is invaluable and will be considered in developing the Stormwater Management Plans.

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Laura, Gladstone, Georgetown and Spalding
Stormwater Management Plans

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1 Which of the following describes your interest in the Stormwater Management Plans? Please tick all that apply.

- ☑ Local resident
- ☑ Interest or experience of flooding
- ☑ Interest in local environment
- ☑ Interest in improving water quality
- ☑ Interest in water conservation and/or stormwater harvesting and reuse
- ☑ Other (please specify) Work being done to help improve the look of our town.

2 Please score the following stormwater management considerations from 1 to 5, with 1 being the highest priority in your opinion and 5 being the lowest.

	1	2	3	4	5
Major flooding	✓				
Nuisance flooding	✓				
Water quality	✓				
Stormwater capture and reuse	✓				–
Climate change	✓				–

3 Are there any specific stormwater related issues or concerns you would like to see the Stormwater Management Plans address? For example a specific local flooding problem or any ways in which you think stormwater should be managed within the towns? Please explain your response.

The corner of Cross St + High St dam catchment area has become a continual eyesaw in the centre of our town + visitors to our town plus locals have to drive past it. The project wasn't ever completed as the water has no clear channel to follow down High St + doesn't get harvested for re-use. It is also a safety hazard with no protective guard rails – only flimsy posts which are continually knocked over.

Laura, Gladstone, Georgetown and Spalding Stormwater Management Plans

Community Response Form

4 Do you have any other comments to make?

Before the project began we were assured that the catchment area would be landscaped but we only have weeds left to grow to a metre or more & only sprayed when we complain. Then they are left to rot down naturally & it's not a very welcoming sight in any town.

5 To help us understand who participated in the consultation please provide the following details:

Name: .....

Street name: .....

Suburb ..... Gladstone 5473. .....

If you are open to being contacted regarding your response, please provide your phone number and/or email address.

Phone: .....

Email: .....

Thank you for taking the time to complete the feedback form. Your feedback is invaluable and will be considered in developing the Stormwater Management Plans.

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Laura, Gladstone, Georgetown and Spalding
Stormwater Management Plans

Community Response Form

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- ☑ Local resident
- ☐ Interest or experience of flooding
- ☐ Interest in local environment
- ☐ Interest in improving water quality
- ☐ Interest in water conservation and/or stormwater harvesting and reuse
- ☐ Other (please specify) .....

2 Please score the following stormwater management considerations from 1 to 5, with 1 being the highest priority in your opinion and 5 being the lowest.

	1	2	3	4	5
Major flooding	✓				
Nuisance flooding	✓				
Water quality				✓	
Stormwater capture and reuse				✓	
Climate change				✓	

3 Are there any specific stormwater related issues or concerns you would like to see the Stormwater Management Plans address? For example a specific local flooding problem or any ways in which you think stormwater should be managed within the towns? Please explain your response.

1) Supporting the call for urgent attention to the flood water problem adjacent my sister's property at 24 West Tce Laura
2) PTO

Laura, Gladstone, Georgetown and Spalding
Stormwater Management Plans

Community Response Form

4 Do you have any other comments to make?

2) The spoondrain adjacent my property needs replacing. It has lifted at joins & is consistantly silted up, which when we have heavy rainfall spreads stormwater into my property

5 To help us understand who participated in the consultation please provide the following details:

Name: ...

Street name: .

Suburb ..... Laura 5480

If you are open to being contacted regarding your response, please provide your phone number and/or email address.

Phone: ....

Email: .....

Thank you for taking the time to complete the feedback form. Your feedback is invaluable and will be considered in developing the Stormwater Management Plans.

Submissions should be completed by 30 October, 2023. Please return this feedback form to one of the following:

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Laura, Gladstone, Georgetown and Spalding
Stormwater Management Plans

Community Response Form

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1 Which of the following describes your interest in the Stormwater Management Plans? Please tick all that apply.

- ☑ Local resident
- ☑ Interest or experience of flooding
- ☐ Interest in local environment
- ☑ Interest in improving water quality
- ☑ Interest in water conservation and/or stormwater harvesting and reuse
- ☑ Other (please specify) toilet sewage/sewers in small towns without systems + drainage/recycling water - better facilities for recycle of garden water.

2 Please score the following stormwater management considerations from 1 to 5, with 1 being the highest priority in your opinion and 5 being the lowest. (Probably more a Gov issue)

	1	2	3	4	5
Major flooding				4	
Nuisance flooding					5
Water quality			3		
Stormwater capture and reuse		2			
Climate change	1				

3 Are there any specific stormwater related issues or concerns you would like to see the Stormwater Management Plans address? For example a specific local flooding problem or any ways in which you think stormwater should be managed within the towns? Please explain your response.

1) Big rains, storms + flooding - All this lovely water is wasted - it just flows out to the rivers + ends up at the sea. Last November there was enough rain to fill all our tanks but it all went out + down the Broughton River. - 2) The rivers need to be cleared of reeds which are blocking up the flow of water.

Laura, Gladstone, Georgetown and Spalding
Stormwater Management Plans

Community Response Form

4 Do you have any other comments to make?

I think the Government should give more grants to Regional towns to support more people to be able to afford 1) Solar 2) Sewage recycle systems 3) Rain Water tanks — This would also help with climate change.

5 To help us understand who participated in the consultation please provide the following details:

Name: ..

Street name: ..

Suburb ..... Spalding 5454

If you are open to being contacted regarding your response, please provide your phone number and/or email address.

Phone: .....

Email: .....

Thank you for taking the time to complete the feedback form. Your feedback is invaluable and will be considered in developing the Stormwater Management Plans.

Submissions should be completed by 30th October, 2023. Please return this feedback form to one of the following:

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Laura, Gladstone, Georgetown and Spalding
Stormwater Management Plans

Community Response Form

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- ☑ Local resident
- ☐ Interest or experience of flooding
- ☑ Interest in local environment
- ☑ Interest in improving water quality
- ☑ Interest in water conservation and/or stormwater harvesting and reuse
- ☐ Other (please specify) .....

2 Please score the following stormwater management considerations from 1 to 5, with 1 being the highest priority in your opinion and 5 being the lowest.

	1	2	3	4	5
Major flooding	1				
Nuisance flooding			1		
Water quality	1				
Stormwater capture and reuse	1				
Climate change				1	

3 Are there any specific stormwater related issues or concerns you would like to see the Stormwater Management Plans address? For example a specific local flooding problem or any ways in which you think stormwater should be managed within the towns? Please explain your response.

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Laura, Gladstone, Georgetown and Spalding
Stormwater Management Plans

Community Response Form

4 Do you have any other comments to make?

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5 To help us understand who participated in the consultation please provide the following details:

Name: .....

Street name: .... Spalding phone rings twenty

Suburb times (because of scammers) leave a message and we'll get back to you

If you are open to being contacted regarding your response, please provide your phone number and/or email address.

Phone: .....

Email: .....

Thank you for taking the time to complete the feedback form. Your feedback is invaluable and will be considered in developing the Stormwater Management Plans.

Submissions should be completed by 30th October, 2023. Please return this feedback form to one of the following:

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Laura, Gladstone, Georgetown and Spalding Stormwater Management Plans

Community Response Form

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1 Which of the following describes your interest in the Stormwater Management Plans? Please tick all that apply.

- ☑ Local resident
- ☑ Interest or experience of flooding
- ☐ Interest in local environment
- ☐ Interest in improving water quality
- ☐ Interest in water conservation and/or stormwater harvesting and reuse
- ☐ Other (please specify) .....

2 Please score the following stormwater management considerations from 1 to 5, with 1 being the highest priority in your opinion and 5 being the lowest.

	1	2	3	4	5
Major flooding	✓				
Nuisance flooding	✓				
Water quality	✓				
Stormwater capture and reuse	✓				
Climate change					✓

3 Are there any specific stormwater related issues or concerns you would like to see the Stormwater Management Plans address? For example a specific local flooding problem or any ways in which you think stormwater should be managed within the towns? Please explain your response.

would like to see proper storm water drainage in the main Street to stop the water flowing through the main st (spalding)

Laura, Gladstone, Georgetown and Spalding Stormwater Management Plans

Community Response Form

4 Do you have any other comments to make?

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5 To help us understand who participated in the consultation please provide the following details:

Name: .. ..

Street name: ....

Suburb ..... Spalding .....

If you are open to being contacted regarding your response, please provide your phone number and/or email address.

Phone: .. ..

Email: ... .

Thank you for taking the time to complete the feedback form. Your feedback is invaluable and will be considered in developing the Stormwater Management Plans.

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Laura, Gladstone, Georgetown and Spalding
Stormwater Management Plans

Community Response Form

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1 Which of the following describes your interest in the Stormwater Management Plans? Please tick all that apply.

- ☑ Local resident
- ☐ Interest or experience of flooding
- ☐ Interest in local environment
- ☐ Interest in improving water quality
- ☐ Interest in water conservation and/or stormwater harvesting and reuse
- ☑ Other (please specify) BECAUSE I WAS TOLD FRESHWATER CREEK COULD FLOOD MY INSURANCE WENT FROM $130 TO $821 PER MONTH

2 Please score the following stormwater management considerations from 1 to 5, with 1 being the highest priority in your opinion and 5 being the lowest.

	1	2	3	4	5
Major flooding					✓
Nuisance flooding					✓
Water quality			✓		
Stormwater capture and reuse					✓
Climate change	✓				

3 Are there any specific stormwater related issues or concerns you would like to see the Stormwater Management Plans address? For example a specific local flooding problem or any ways in which you think stormwater should be managed within the towns? Please explain your response.

FROM THE BOTTOM OF FRESHWATER CREEK IT WOULD HAVE TO RAISE 30 MTRS TO FLOOD OUR HOUSE ACCORDING TO OLD LOCALS IT HASN'T FLOODED IN 100 YEARS PLEASE EXPLAIN?

Laura, Gladstone, Georgetown and Spalding Stormwater Management Plans

Community Response Form

4 Do you have any other comments to make?

REFER TO N° 3.

5 To help us understand who participated in the consultation please provide the following details:

Name: .....

Street name: .....

Suburb SPALDING 5454

If you are open to being contacted regarding your response, please provide your phone number and/or email address.

Phone: .....

Email: .....

Thank you for taking the time to complete the feedback form. Your feedback is invaluable and will be considered in developing the Stormwater Management Plans.

Submissions should be completed by 30th October, 2023. Please return this feedback form to one of the following:

- Northern Areas Council, PO Box 120, 94 Ayr Street Jamestown, SA 5491
- Gladstone District Office, 14 Fifth Street Gladstone, SA 5473
- Spalding District Office, 11 Main Street Spalding, SA 5454
- Via email to admin@nacouncil.sa.gov.au

Laura, Gladstone, Georgetown and Spalding
Stormwater Management Plans

Community Response Form

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1 Which of the following describes your interest in the Stormwater Management Plans? Please tick all that apply.

- ☑ Local resident
- ☐ Interest or experience of flooding
- ☐ Interest in local environment
- ☐ Interest in improving water quality
- ☐ Interest in water conservation and/or stormwater harvesting and reuse
- ☐ Other (please specify) .....

2 Please score the following stormwater management considerations from 1 to 5, with 1 being the highest priority in your opinion and 5 being the lowest.

	1	2	3	4	5
Major flooding			✓		
Nuisance flooding		✓			
Water quality			✓		
Stormwater capture and reuse			✓		
Climate change		✓			

3 Are there any specific stormwater related issues or concerns you would like to see the Stormwater Management Plans address? For example a specific local flooding problem or any ways in which you think stormwater should be managed within the towns? Please explain your response.

I'M NOT SURE IF ITS POSSIBLE TO RE-LOOK AT FLOOD MANAGEMENT PLAN, FOR THE MAIN CBD AREA OF THE TOWN OF SPALDING - IT STILL FLOODS BAD EVEN AFTER 1 (1 HOUR) EVENT, AS HAPPENED LAST NOV. 2022 - MAYBE A SECOND DIVERSION CHANNEL (NOT SO BIG AS THE FIRST)

Laura, Gladstone, Georgetown and Spalding Stormwater Management Plans

Community Response Form

4 Do you have any other comments to make?

MAIN ST (AND TOWN) FLOODING IN TOWN OF SPALDING, EVEN AFTER A 1 HOUR EVENT. (I KNOW ITS HEAVY RAIN IN THAT HOUR, BUT STILL!

5 To help us understand who participated in the consultation please provide the following details:

Name: .....

Street name: .....

Suburb SPALDING SA 5454

If you are open to being contacted regarding your response, please provide your phone number and/or email address.

Phone: .. ..

Email: .....

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Stormwater Management Plans

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- ☑ Interest in local environment
- ☑ Interest in improving water quality
- ☑ Interest in water conservation and/or stormwater harvesting and reuse
- ☐ Other (please specify) .....

2 Please score the following stormwater management considerations from 1 to 5, with 1 being the highest priority in your opinion and 5 being the lowest.

	1	2	3	4	5
Major flooding	✓				
Nuisance flooding	✓				
Water quality	✓				
Stormwater capture and reuse	✓				
Climate change				✓	

3 Are there any specific stormwater related issues or concerns you would like to see the Stormwater Management Plans address? For example a specific local flooding problem or any ways in which you think stormwater should be managed within the towns? Please explain your response.

.....

.....

.....

.....

.....

Laura, Gladstone, Georgetown and Spalding Stormwater Management Plans

Community Response Form

4 Do you have any other comments to make?

We need stormwater pipes (drains).

5 To help us understand who participated in the consultation please provide the following details:

Name: ..

Street name: .....

Suburb ..... Spalding

If you are open to being contacted regarding your response, please provide your phone number and/or email address.

Phone: ...

Email: ....

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Laura, Gladstone, Georgetown and Spalding Stormwater Management Plans

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- ☑ Interest or experience of flooding
- ☐ Interest in local environment
- ☐ Interest in improving water quality
- ☐ Interest in water conservation and/or stormwater harvesting and reuse
- ☐ Other (please specify) .....

2 Please score the following stormwater management considerations from 1 to 5, with 1 being the highest priority in your opinion and 5 being the lowest.

	1	2	3	4	5
Major flooding	1				
Nuisance flooding		2			
Water quality					5
Stormwater capture and reuse			3		
Climate change				4	

3 Are there any specific stormwater related issues or concerns you would like to see the Stormwater Management Plans address? For example a specific local flooding problem or any ways in which you think stormwater should be managed within the towns? Please explain your response.

Main street from shop to Burra turn.
Maintenance program.
Wider channel to run water away quicker at
South End of town.

Laura, Gladstone, Georgetown and Spalding
Stormwater Management Plans

Community Response Form

4 Do you have any other comments to make?

Outside of our yard getting flooded I have some ideas but no-one wants to know, whether they are simple or more complex ones.
After last flooding footpath not fixed, still gravel etc in gutters (street sweeping did not remove)
Culvert Bridge never maintained - full of weeds + debris

5 To help us understand who participated in the consultation please provide the following details:

Name: .....

Street name: .....

Suburb .....Spalding.....

If you are open to being contacted regarding your response, please provide your phone number and/or email address.

Phone: .....

Email: .....

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- [ ] Interest in local environment
- [ ] Interest in improving water quality
- [ ] Interest in water conservation and/or stormwater harvesting and reuse
- [ ] Other

Please score the following stormwater management considerations from 1 to 5, with 1 being the highest priority in your opinion and 5 being the lowest.

Major flooding

○ 1 ○ 2 ◉ 3 ○ 4 ○ 5

Nuisance flooding

○ 1 ○ 2 ○ 3 ◉ 4 ○ 5

Water quality

○ 1 ○ 2 ○ 3 ◉ 4 ○ 5

Stormwater capture and reuse

○ 1 ○ 2 ○ 3 ◉ 4 ○ 5

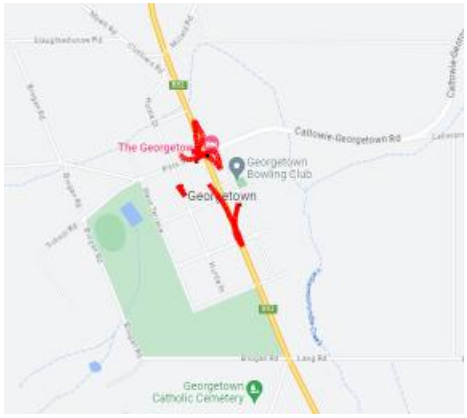
Climate change

○ 1 ○ 2 ○ 3 ◉ 4 ○ 5

Please select the town you are a resident of:

- ○ Laura
- ○ Gladstone
- ◉ Georgetown
- ○ Spalding
- ○ Other

Please mark on the map any locations where you have noticed a flooding or stormwater issue.



Clear drawing

Please provide details of any issues you recorded.

Poorly designed guttering lower than drains that can not drain. Inadequate drainage for moderate rainfall at Pitts/Fisher st corner leading to the corner flooding.

Are there any specific stormwater related issues or concerns you would like to see the Stormwater Management Plans address? For example a specific local flooding problem or any ways in which you think stormwater should be managed within the towns? Please explain your response.

Greater consideration to what happens with heavy rainfall, and multiple opportunity for water to escape when drains block

Do you have any other comments to make?

To help us understand who participated in the consultation please provide the following details:

Name

Street Name

Suburb

georgetown

If you are open to being contacted regarding your response, please provide your phone number and/or email address.

Phone Number

Email Address

Laura, Gladstone, Georgetown and Spalding Stormwater Management Plans

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- [ ] Interest or experience of flooding
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- [ ] Other

Please score the following stormwater management considerations from 1 to 5, with 1 being the highest priority in your opinion and 5 being the lowest.

Major flooding

(●) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5

Nuisance flooding

( ) 1 (●) 2 ( ) 3 ( ) 4 ( ) 5

Water quality

( ) 1 ( ) 2 (●) 3 ( ) 4 ( ) 5

Stormwater capture and reuse

( ) 1 ( ) 2 ( ) 3 (●) 4 ( ) 5

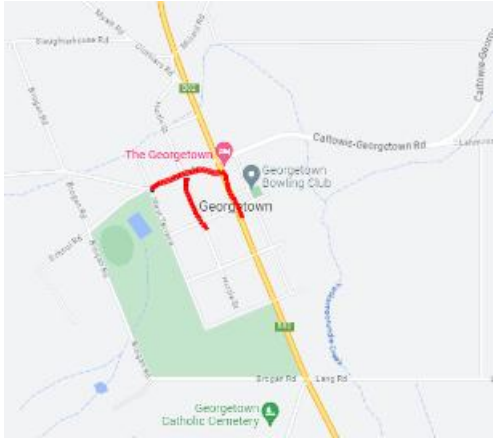
Climate change

( ) 1 ( ) 2 ( ) 3 ( ) 4 (●) 5

Please select the town you are a resident of:

- ( ) Laura
- ( ) Gladstone
- (●) Georgetown
- ( ) Spalding
- ( ) Other

Please mark on the map any locations where you have noticed a flooding or stormwater issue.



Clear drawing

Please provide details of any issues you recorded.

Flooding and large volumes of water from the carport behind the community hall, flood Fisher Street and drag dirt from the carpark

blocking drains.

Are there any specific stormwater related issues or concerns you would like to see the Stormwater Management Plans address? For example a specific local flooding problem or any ways in which you think stormwater should be managed within the towns? Please explain your response.

The gutters on hurtle Street both sides and fisher street western side need replacing. The damaged gutters contribute to standing water and flooding.

Do you have any other comments to make?

To help us understand who participated in the consultation please provide the following details:

Name

Street Name

Suburb

Georgetown

If you are open to being contacted regarding your response, please provide your phone number and/or email address.

Phone Number

Email Address

Laura, Gladstone, Georgetown and Spalding Stormwater Management Plans

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Which of the following describes your interest in the Stormwater Management Plans? Please tick all that apply. *

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- [ ] Interest or experience of flooding
- [ ] Interest in local environment
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- [ ] Other

Please score the following stormwater management considerations from 1 to 5, with 1 being the highest priority in your opinion and 5 being the lowest.

Major flooding

(●) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5

Nuisance flooding

(●) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5

Water quality

( ) 1 (●) 2 ( ) 3 ( ) 4 ( ) 5

Stormwater capture and reuse

(●) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5

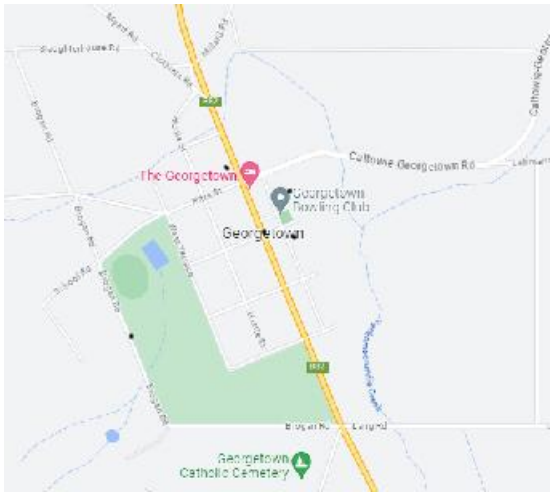
Climate change

( ) 1 ( ) 2 (●) 3 ( ) 4 ( ) 5

Please select the town you are a resident of:

- ( ) Laura
- ( ) Gladstone
- (●) Georgetown
- ( ) Spalding
- ( ) Other

Please mark on the map any locations where you have noticed a flooding or stormwater issue.



Clear drawing

Please provide details of any issues you recorded.

Bowls Club entrance is flooded during heavy down pours.
Brogan Road has water flowing over it following a heavy downpour and is following a natural water course.
Parts of Fisher Street has water almost to the gutters and takes a long time to recede.

Are there any specific stormwater related issues or concerns you would like to see the Stormwater Management Plans address? For example a specific local flooding problem or any ways in which you think stormwater should be managed within the towns? Please explain your response.

Do you have any other comments to make?

No

To help us understand who participated in the consultation please provide the following details:

Name

Street Name

Suburb

Georgetown

If you are open to being contacted regarding your response, please provide your phone number and/or email address.

Phone Number

Email Address

Laura, Gladstone, Georgetown and Spalding Stormwater Management Plans

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- [ ] Interest or experience of flooding
- [ ] Interest in local environment
- [ ] Interest in improving water quality
- [ ] Interest in water conservation and/or stormwater harvesting and reuse
- [ ] Other

Please score the following stormwater management considerations from 1 to 5, with 1 being the highest priority in your opinion and 5 being the lowest.

Major flooding

- (●) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5

Nuisance flooding

- ( ) 1 (●) 2 ( ) 3 ( ) 4 ( ) 5

Water quality

- ( ) 1 ( ) 2 ( ) 3 (●) 4 ( ) 5

Stormwater capture and reuse

- ( ) 1 ( ) 2 (●) 3 ( ) 4 ( ) 5

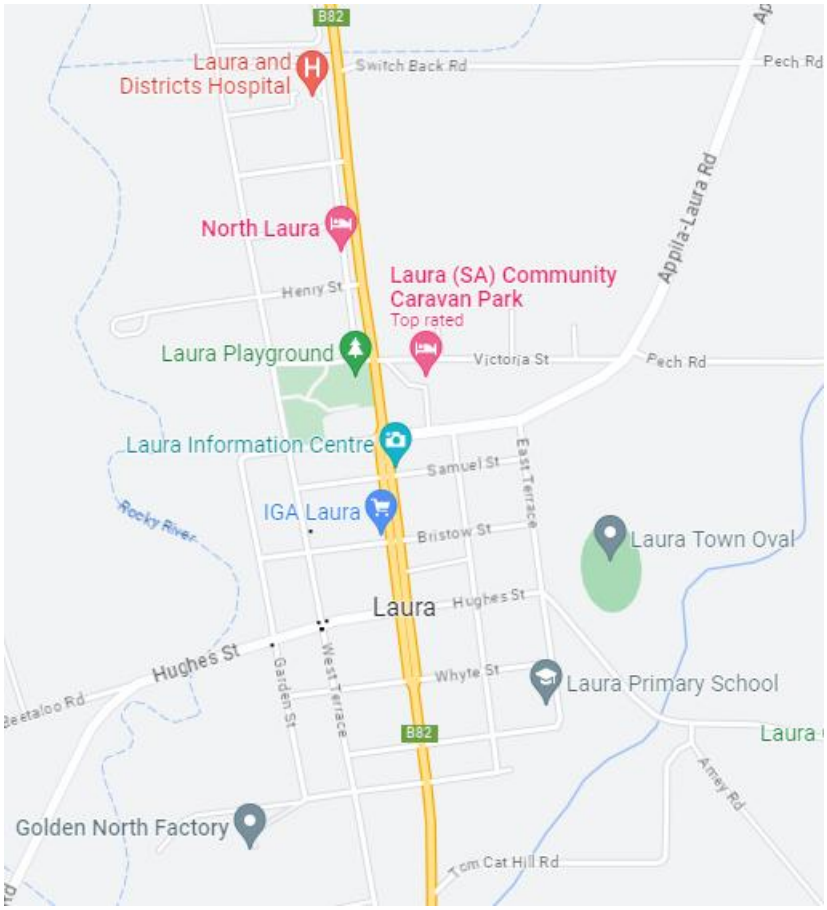
Climate change

- ( ) 1 ( ) 2 ( ) 3 ( ) 4 (●) 5

Please select the town you are a resident of:

- (●) Laura
- ( ) Gladstone
- ( ) Georgetown
- ( ) Spalding
- ( ) Other

Please mark on the map any locations where you have noticed a flooding or stormwater issue.



Clear drawing

Please provide details of any issues you recorded.

Water fails to flow on West Terrace due to their being no proper drains. Any drop of leaves/branches/seeds will clog the "gutter"and cause the water to back up. Their needs to be a proper delving of the drains each year to ensure that there is aproper channel which allows the water to run.

The intersection of Hughes Street and West Terrace has large puddles on t least three corners when it rains. Whic is compounded by both heavy and light traffic cutting the corners and creating large potholes, which then fill with water. There needs to be either traffic management systems put in place to prevent corner cutting or the road surface needs ot be extended and strengthened to prevent heavy traffic from tearing up the unprotected surface. Water flows from both West Terrace and Highes Street into this intersection so it may be necessary to have drainage along Hughes Street into the Rocky River.

Are there any specific stormwater related issues or concerns you would like to see the Stormwater Management Plans address? For example a specific local flooding problem or any ways in which you think stormwater should be managed within the towns? Please explain your response.

As above

Do you have any other comments to make?

To help us understand who participated in the consultation please provide the following details:

Name

Street Name

Suburb

Laura

If you are open to being contacted regarding your response, please provide your phone number and/or email address.

Phone Number

Email Address

Appendix C

Scenario A Flood Mapping



Appendix D

Scenario A Flood Hazard Mapping



Appendix E

Scenario B Flood Mapping



Appendix F

Scenario B Flood Hazard Mapping



Appendix G

Scenario C Flood Mapping



Appendix H

Scenario C Flood Hazard Mapping



Appendix I

Cost Estimates



Indicative Construction Cost Estimate

Project	Gladstone SMP
Job Number	22035
Title	Clearing Vegetation from Yangya Creek (D1-A) and Widening the Yangya Creek Channel (D1-B)
Estimator	QB
Reviewer	DJ
Date	9-Jan-25

Item	Description	Unit	Quantity		Rate		Total
Civil and Drainage Works	Hire 20t excavator + operator	day	30	$	1,500.00	$	45,000.00
	Hire wood chipper + operator	day	30	$	1,500.00	$	45,000.00
	Hire 8t tipper truck + operator	day	30	$	1,300.00	$	39,000.00
	Disposal of excavated material	item	1	$	150,000.00	$	150,000.00
	Traffic controller	day	60	$	400.00	$	24,000.00
	Works to stabilise creek banks	item	1	$	100,000.00	$	100,000.00
	Grass re-seeding and establishment of new vegetation	m^2	30000	$	5.00	$	150,000.00
	Subtotal					**$**	**553,000.00**
Overheads and Contingencies	Preliminaries	item	1		15%	$	82,950.00
	Design	item	1		10%	$	55,300.00
	Services modifications	item	1		0%	$	-
	Contingencies on construction	item	1		20%	$	138,250.00
	Grand Total					**$**	**829,500.00**

Notes

All figures are exclusive of GST (10%)

Cost estimates prepared by Southfront are based upon historical cost information and experience, and do not allow for latent or market conditions (ie. competition, escalation). Southfront recommend that a professional quantity surveyor be engaged if assurance of cost and project budget estimates allowing for these factors is required.

Indicative Construction Cost Estimate

Project	Gladstone SMP
Job Number	22035
Title	Closing the Railway Underpass (D1-C)
Estimator	QB
Reviewer	DJ
Date	16-Jan-25

Item	Description	Unit	Quantity	Rate	Total
Civil and Drainage Works	Supply and install flood door to fit underpass	item	1	$ 30,000.00	$ 30,000.00
	Subtotal				**$ 30,000.00**
Overheads and Contingencies	Preliminaries	item	1	15%	$ 4,500.00
	Design	item	1	10%	$ 3,000.00
	Services modifications	item	1	5%	$ 1,500.00
	Contingencies on construction	item	1	20%	$ 7,800.00
	Grand Total				**$ 46,800.00**

Notes

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Indicative Construction Cost Estimate

Project	Gladstone SMP
Job Number	22035
Title	Constructing Levees along Yangya Creek (D1-D)
Estimator	QB
Reviewer	DJ
Date	10-Jan-25

Item	Description	Unit	Quantity		Rate		Total
Civil and Drainage Works	Excavate to remove top soil average 150mm deep	m^3	620	$	5.00	$	3,100.00
	Imported sand filling, deposited, spread and levelled and compacted to 90%	m^3	1750	$	85.00	$	148,750.00
	Import clay for levee bank core, spread and levelled and compacted to 90%	m^3	1170	$	100.00	$	117,000.00
	Shape levee bank	m^2	4100	$	5.00	$	20,500.00
	150mm thick top soil spread, raked and levelled	m^2	4100	$	10.00	$	41,000.00
	Grass re-seeding and establishment of new vegetation	m^2	4100	$	5.00	$	20,500.00
	Subtotal					**$**	**350,850.00**
Overheads and Contingencies	Preliminaries	item	1		15%	$	52,627.50
	Design	item	1		10%	$	35,085.00
	Services modifications	item	1		0%	$	-
	Contingencies on construction	item	1		20%	$	87,712.50
	Grand Total					**$**	**526,275.00**

Notes

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Indicative Construction Cost Estimate

Project	Gladstone SMP
Job Number	22035
Title	Centre Street Drain and Flood Levee (D2)
Estimator	QB
Reviewer	DJ
Date	10-Jan-25

Item	Description	Unit	Quantity	Rate	Total
Civil and Drainage Works	Supply, lay, backfill and reinstate 600 mm diameter RCP	m	83	$ 790.00	$ 65,570.00
	Supply, lay, backfill and reinstate 525 mm diameter RCP	m	9	$ 690.00	$ 6,210.00
	Supply, lay, backfill and reinstate 450 mm diameter RCP	m	347	$ 590.00	$ 204,730.00
	Supply and install 900 x 900mm junction box	item	6	$ 3,865.00	$ 23,190.00
	Supply and install double side entry pit	item	4	$ 4,500.00	$ 18,000.00
	Remove and dispose of existing small pit	item	1	$ 260.00	$ 260.00
	Excavate to remove top soil average 150mm deep	m^3	465	$ 5.00	$ 2,325.00
	Imported sand filling, deposited, spread and levelled and compacted to 90%	m^3	1320	$ 85.00	$ 112,200.00
	Import clay for levee bank core, spread and levelled and compacted to 90%	m^3	880	$ 100.00	$ 88,000.00
	Shape levee bank	m^2	3080	$ 5.00	$ 15,400.00
	150mm thick top soil spread, raked and levelled	m^2	3080	$ 10.00	$ 30,800.00
	Grass re-seeding and establishment of new vegetation	m^2	3080	$ 5.00	$ 15,400.00
	Rock scour protection	m^2	8	$ 195.00	$ 1,560.00
	Geofab liner	m^2	8	$ 75.00	$ 600.00
	Supply and install flap valve to support 600 mm diameter pipe	item	1	$ 15,000.00	$ 15,000.00
	Subtotal				**$ 599,245.00**
Overheads and Contingencies	Preliminaries	item	1	15%	$ 89,886.75
	Design	item	1	10%	$ 59,924.50
	Services modifications	item	1	5%	$ 29,962.25
	Contingencies on construction	item	1	20%	$ 155,803.70
	Grand Total				**$ 934,822.20**

Notes

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Indicative Construction Cost Estimate

Project	Gladstone SMP
Job Number	22035
Title	Port Street, Bondowie Street Drainage (D3)
Estimator	QB
Reviewer	DJ
Date	10-Jan-25

Item	Description	Unit	Quantity	Rate	Total
Civil and Drainage Works	Supply, lay, backfill and reinstate 1050 mm diameter RCP	m	196	$ 1,560.00	$ 305,760.00
	Supply, lay, backfill and reinstate 900 mm diameter RCP	m	97	$ 1,270.00	$ 123,190.00
	Supply, lay, backfill and reinstate 750 mm diameter RCP	m	103	$ 940.00	$ 96,820.00
	Supply, lay, backfill and reinstate 600 mm diameter RCP	m	102	$ 790.00	$ 80,580.00
	Supply, lay, backfill and reinstate 525 mm diameter RCP	m	5	$ 690.00	$ 3,450.00
	Supply, lay, backfill and reinstate 450 mm diameter RCP	m	75	$ 590.00	$ 44,250.00
	Supply, lay, backfill and reinstate 375 mm diameter RCP	m	61	$ 490.00	$ 29,890.00
	Supply and install double side entry pit	item	19	$ 4,500.00	$ 85,500.00
	Supply and install 1500 x 1200mm junction box	item	3	$ 8,370.00	$ 25,110.00
	Supply and install 1200 x 1200mm junction box	item	4	$ 6,440.00	$ 25,760.00
	Supply and install 900 x 900mm junction box	item	4	$ 3,865.00	$ 15,460.00
	Remove and dispose of existing small diameter RCP	m	16	$ 65.00	$ 1,040.00
	Rock scour protection	m^2	8	$ 195.00	$ 1,560.00
	Geofab liner	m^2	8	$ 75.00	$ 600.00
	Supply and install flap valve to support 1050 mm diameter pipe	item	1	$ 30,000.00	$ 30,000.00
	Subtotal				**$ 868,970.00**
Overheads and Contingencies	Preliminaries	item	1	15%	$ 130,345.50
	Design	item	1	10%	$ 86,897.00
	Services modifications	item	1	5%	$ 43,448.50
	Contingencies on construction	item	1	20%	$ 225,932.20
	Grand Total				**$ 1,355,593.20**

Notes

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Indicative Construction Cost Estimate

Project	Gladstone SMP
Job Number	22035
Title	Mill Street, Port Street Drainage Upgrades (D4)
Estimator	QB
Reviewer	DJ
Date	10-Jan-25

Item	Description	Unit	Quantity		Rate		Total
Civil and Drainage Works	Supply, lay, backfill and resinstate 3000mm x 1200mm box culvert	m	32	$	5,000.00	$	160,000.00
	Remove and dispose of existing small headwall	item	2	$	5,000.00	$	10,000.00
	Remove and dispose of existing small diameter RCP	m	16	$	65.00	$	1,040.00
	Headwall approach excavation and shaping	m^3	80	$	25.00	$	2,000.00
	Supply and install large headwall (box culvert)	item	2	$	15,000.00	$	30,000.00
	Excavate to remove top soil average 150mm deep	m^3	670	$	5.00	$	3,350.00
	Imported sand filling, deposited, spread and levelled and compacted to 90%	m^3	1905	$	85.00	$	161,925.00
	Import clay for levee bank core, spread and levelled and compacted to 90%	m^3	1270	$	100.00	$	127,000.00
	Shape levee bank	m^2	4450	$	5.00	$	22,250.00
	150mm thick top soil spread, raked and levelled	m^2	4450	$	10.00	$	44,500.00
	Grass re-seeding and establishment of new vegetation	m^2	4450	$	5.00	$	22,250.00
	Subtotal					**$**	**584,315.00**
Overheads and Contingencies	Preliminaries	item	1		15%	$	87,647.25
	Design	item	1		10%	$	58,431.50
	Services modifications	item	1		5%	$	29,215.75
	Contingencies on construction	item	1		20%	$	151,921.90
	Grand Total					**$**	**911,531.40**

Notes

All figures are exclusive of GST (10%)

Cost estimates prepared by Southfront are based upon historical cost information and experience, and do not allow for latent or market conditions (ie. competition, escalation). Southfront recommend that a professional quantity surveyor be engaged if assurance of cost and project budget estimates allowing for these factors is required.

Indicative Construction Cost Estimate

Project	Gladstone SMP
Job Number	22035
Title	High Street Bioretention Basin (WQ1)
Estimator	QB
Reviewer	DJ
Date	14-Jan-25

Item	Description	Unit	Quantity		Rate		Total
Civil and Drainage Works	Basin excavation and shaping	m^3	100	$	95.00	$	9,500.00
	Grass re-seeding and establishment of new vegetation	m^2	500	$	5.00	$	2,500.00
	HDPE liner	m^2	500	$	95.00	$	47,500.00
	Perforated PVC pipe	m	110	$	90.00	$	9,900.00
	Filter media	m^3	250	$	115.00	$	28,750.00
	Screenings and transition layer	m^3	50	$	90.00	$	4,500.00
	Submerged zone	m^3	250	$	115.00	$	28,750.00
	Plantings and temporary irrigation	m^2	500	$	25.00	$	12,500.00
	Subtotal					**$**	**143,900.00**
Overheads and Contingencies	Preliminaries	item	1		15%	$	21,585.00
	Design	item	1		10%	$	14,390.00
	Services modifications	item	1		5%	$	7,195.00
	Contingencies on construction	item	1		20%	$	37,414.00
	Grand Total					**$**	**224,484.00**

Notes

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Indicative Construction Cost Estimate

Project	Gladstone SMP
Job Number	22035
Title	Overflow Weir Raingardens (WQ2)
Estimator	QB
Reviewer	DJ
Date	14-Jan-25

Item	Description	Unit	Quantity		Rate		Total
Civil and Drainage Works	Excavation (cut to disposal of Waste Fill)	m^3	20	$	120.00	$	2,400.00
	HDPE liner	m^2	30	$	95.00	$	2,850.00
	Filter media	m^3	7.5	$	115.00	$	862.50
	Screenings and transition layer	m^3	1.5	$	90.00	$	135.00
	Submerged zone	m^3	7.5	$	115.00	$	862.50
	Rock scour protection	m^2	3	$	195.00	$	585.00
	150mm high barrier kerb (or similar concrete edging)	m	20	$	120.00	$	2,400.00
	Plantings and temporary irrigation	m^2	15	$	25.00	$	375.00
	Subtotal					**$**	**10,470.00**
Overheads and Contingencies	Preliminaries	item	1		15%	$	1,570.50
	Design	item	1		10%	$	1,047.00
	Services modifications	item	1		5%	$	523.50
	Contingencies on construction	item	1		20%	$	2,722.20
	Total					**$**	**16,333.20**
	Number of Raingardens						**349**
	Grand Total					**$**	**5,700,286.80**

Notes

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Indicative Construction Cost Estimate

Project	Gladstone SMP
Job Number	22035
Title	D2 Gross Pollutant Trap (WQ3)
Estimator	QB
Reviewer	DJ
Date	14-Jan-25

Item	Description	Unit	Quantity		Rate		Total
Civil and Drainage Works	Supply and install Ecosol GPT 4450 (max pipe diameter 600mm)	item	1	$	59,400.00	$	59,400.00
	Subtotal					**$**	**59,400.00**
Overheads and Contingencies	Preliminaries	item	1		15%	$	8,910.00
	Design	item	1		10%	$	5,940.00
	Services modifications	item	1		5%	$	2,970.00
	Contingencies on construction	item	1		20%	$	15,444.00
	Grand Total					**$**	**92,664.00**

Notes

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Indicative Construction Cost Estimate

Project	Gladstone SMP
Job Number	22035
Title	D3 Gross Pollutant Trap (WQ3)
Estimator	QB
Reviewer	DJ
Date	14-Jan-25

Item	Description	Unit	Quantity		Rate		Total
Civil and Drainage Works	Supply and install Ecosol GPT 4750 (max pipe diameter 1050mm)	item	1	$	148,500.00	$	148,500.00
	Subtotal					**$**	**148,500.00**
Overheads and Contingencies	Preliminaries	item	1		15%	$	22,275.00
	Design	item	1		10%	$	14,850.00
	Services modifications	item	1		5%	$	7,425.00
	Contingencies on construction	item	1		20%	$	38,610.00
	Grand Total					**$**	**231,660.00**

Notes

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Cost estimates prepared by Southfront are based upon historical cost information and experience, and do not allow for latent or market conditions (ie. competition, escalation). Southfront recommend that a professional quantity surveyor be engaged if assurance of cost and project budget estimates allowing for these factors is required.

Appendix J

MCA Scores



Flood Mitigation Strategies MCA

Project ID	Project Description	Criteria					Score
		Capital Cost	Reduced Street Drainage Nuisance	Reduced Major Flooding Risk	Precursor to WSUD Strategy	Community Buy-In	
		20%	20%	30%	10%	20%	
D1	Yangya Creek Flood Protection	2	1	5	1	4	3.0
D2	Centre Street Drain and Flood Levee	3	3	1	3	3	2.4
D3	Port Street, Bondowie Street Drainage	2	4	1	3	5	2.8
D4	Mill Street, Port Street Drainage	3	2	2	1	3	2.3

Water Sensitive Urban Design Strategies MCA

Project ID	Project Description	Criteria					Score
		Capital Cost	Annual Maintenance Cost	Pollutant (TSS) Reduction	Stormwater Capture and Reuse	Community Buy-In	
		20%	20%	20%	20%	20%	
WQ1	High Street Bioretention Basin	3	4	2	3	5	3.4
WQ2	Streetscape Raingardens	1	1	5	3	4	2.8
WQ3	Gross Pollutant Traps	3	5	2	1	5	3.2