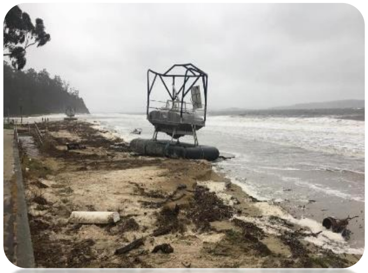
KINGBOROUGH COUNCIL

Stormwater System Management Plan

Report

March 2020

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REV	**DESCRIPTION**	**AUTHOR**	**REVIEWER**	**PROJECT MANAGER**	**APPROVER / PROJECT DIRECTOR**	**DATE**
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Rev 2	Final Client Issue	Mark Page	Karl Umlauff	Mark Page	Mark Page	3 March 2020
Signatures		M Page	K. Umlauff	M Page	M Page	

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1. INTRODUCTION AND BACKGROUND

1.1 Overview

Engeny Water Management (Engeny) has been engaged to prepare the Kingborough Stormwater System Management Plan (SSMP) on behalf of Kingborough Council (hereafter referred to as Council or KC). The purpose of this document is to assist in addressing the requirements of the Urban Drainage Act 2013 (the Act) and will form the basis for future studies or investigation relating to stormwater quantity management. The specific requirements of the Act are outlined as follows:

- A council must develop a stormwater system management plan for the urban area of its municipality within 6 years after the day on which this Act commences.
- A stormwater system management plan is to specify:
  - Plans for the management of any assets used for the delivery of a stormwater service.
  - The level of risk from flooding for each urban stormwater catchment in the public stormwater system; and
  - Any other matters prescribed in the regulations or that the council considers appropriate.

The SSMP has been prepared based on the following guidance:

- Stormwater System Management Planning: A Guide for Local Government in Tasmania (LGAT, 2016).
- Tasmanian Subdivision Guidelines (LGAT, 2013).
- State Stormwater Strategy (EPA, 2010).
- WSUD Engineering procedures for stormwater management in Tasmania (EPA, 2012).
- Kingborough Interim Planning Scheme (KC, 2015).
- Derwent Estuary Program (DEP, 2019).

1.2 Stormwater Management Objectives

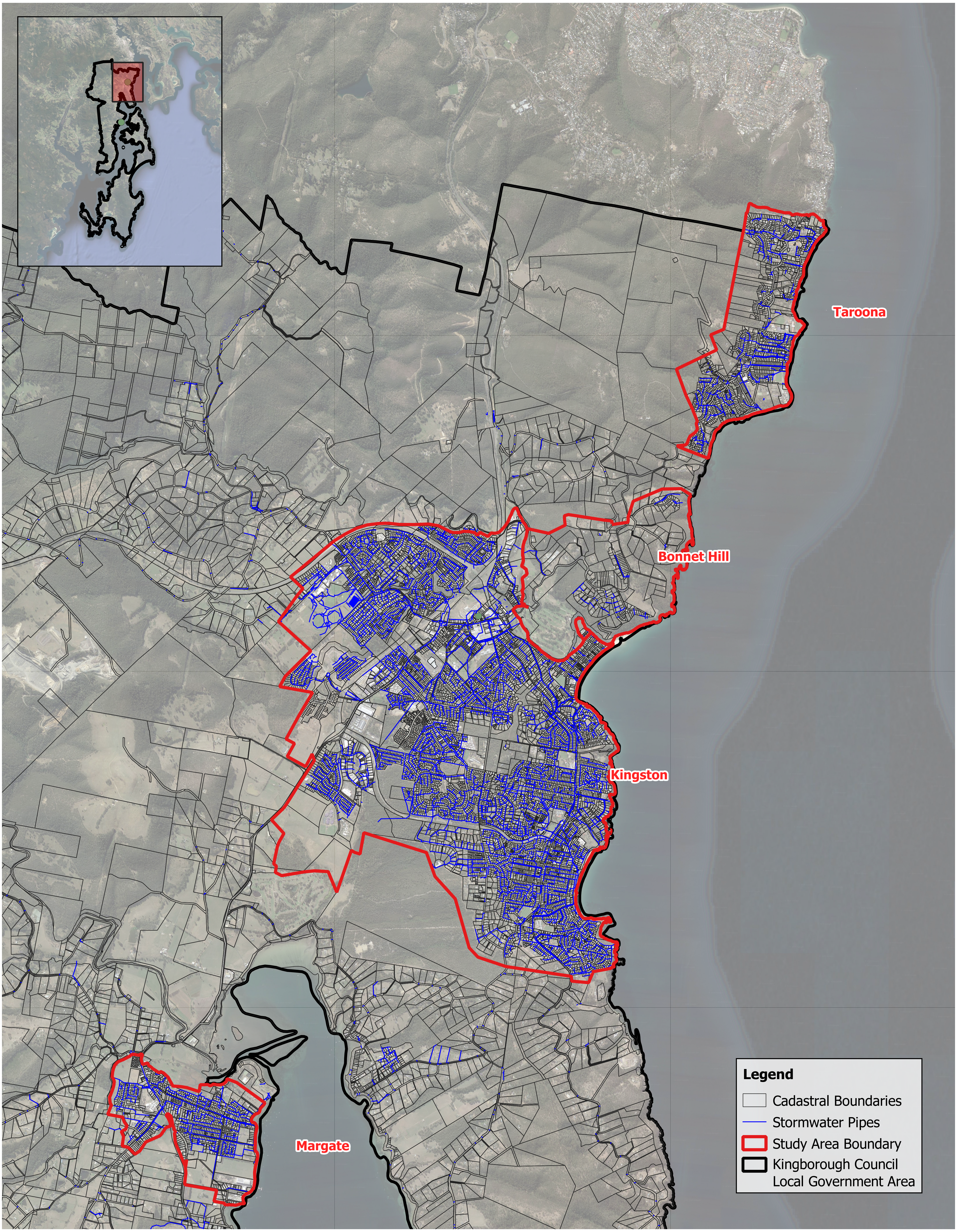
The objectives of this study were to:

- Fulfil the requirements of the Urban Drainage Act 2013.
- Assess overall drainage deficiencies in the municipal area.

- Highlight key drainage issue areas (flood risk hotspots).
- Provide high level recommendations to improve drainage deficiencies.
- Provide recommendations for further studies.

1.3 Study Area

The SSMP addresses the stormwater systems of the urban areas within its municipality. Urban areas of the municipality were defined based on the presence of stormwater infrastructure (systems) and clusters of population. The urban areas of Taroona, Bonnet Hill, Kingston, Blackmans Bay, Margate, Electrona, Snug, Conningham and Kettering were included in the SSMP and are shown in Figure 1.1.



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ENGENY WATER MANAGEMENT

Kingborough

0 500 1000 1500 2000 m

Scale in metres (1:40000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Australia Geodetic Datum
Vertical Datum: Australia Geodetic Datum
Grid: Australian Map Grid, Zone 56

Kingborough Council
Stormwater System Management Plan

Figure 1.1 -Study Area
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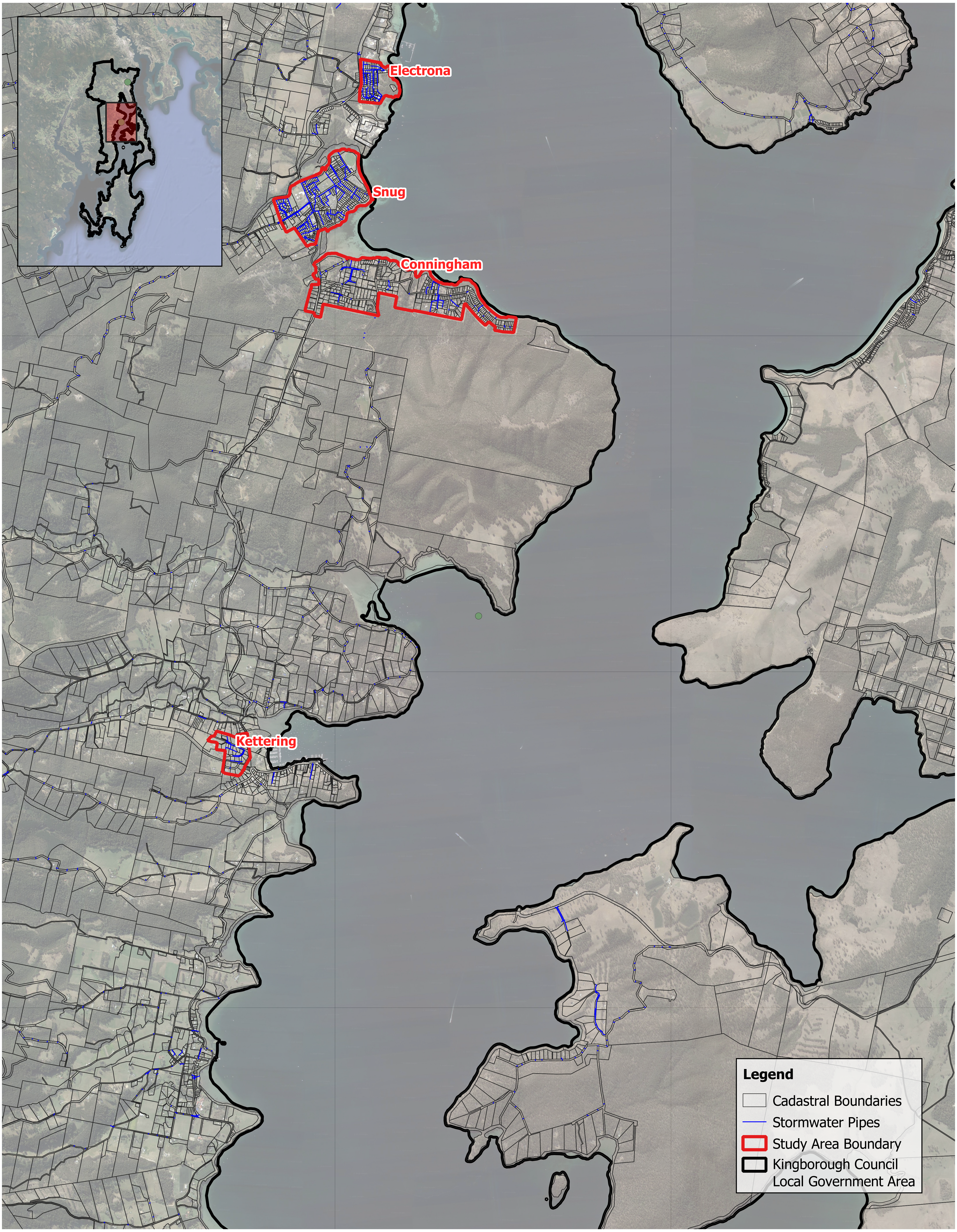
Date: 21/1/2020



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Kingborough Council
Stormwater System Management Plan

Figure 1.1 -Study Area
Sheet 2 of 2

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2. PROJECT INPUT DATA

2.1.1 Site Visit

A site inspection was undertaken as part of the project inception in order to:

- Inspect known drainage issue locations.
- Inspect street scale drainage features not captured within the GIS data (such as typical pit dimensions).
- Assess potential for hydraulic structure blockage.
- Familiarise the project team with the building types in the study area.
- Familiarise the project team with the recent land development changes in land use since the capture of digital data.

2.1.2 Aerial Photography

Aerial imagery from Land Information Systems Tasmania (LIST) and Google Earth were used for the study.

2.1.3 Topography

Digital Elevation Models (DEMs) covering most of the study area were generated from the following sources:

- Mt Wellington and the Derwent 2010 LiDAR capture.
- Greater Hobart 2013 LiDAR capture.

The LiDAR data is incomplete for Kettering and therefore, coarser Shuttle Radar Topographic Mission (SRTM) data was used for the missing areas. This was considered appropriate given that the stormwater system within Kettering is not extensive.

2.1.4 Drainage Network

Information regarding the stormwater drainage network in GIS format was supplied by Council. A review of the data was undertaken as described in Section 4.1.

As constructed or design drawings of the following recent developments were also provided including:

- Spring Farm Estate.
- Whitewater Park.

The stormwater data was found to be incomplete where approximately 60% of pipe invert levels were missing and approximately 1% of pipe dimensions were missing. A data gap filling process (refer Section 4.1.1) was adopted for the drainage capacity assessment, however for future drainage analysis and design, survey should be undertaken for assets with missing details given the uncertainty associated with data gap filling assumptions. Overall, the location of GIS stormwater assets was found to be of reasonable accuracy.

2.1.5 Current Stormwater Standards and Policies

The Kingborough Interim Planning Scheme does not include a specific policy or code relating to stormwater management, other than the Stormwater Drain Blockage Policy (12 November 2018). The commonly adopted stormwater drainage standard is the Tasmanian Subdivision Guidelines (2013), however there does not appear to be any formal Council requirement for the Tasmanian Subdivision Guidelines to be adopted.

As such, Council does not appear to have a formal planning instrument to manage the design and implementation of stormwater infrastructure within the Kingborough Council local government area.

2.1.6 Other Studies

Other studies utilised in this study include:

- Kingston Beach Flood Study (KC, 2016).
- State of the Derwent Estuary 2010-2015 (DEP, 2015).
- State of the Derwent Report Card 2018 (DEP, 2018).
- Stormwater and Rivulet Monitoring Report 2010-2011 (DEP, 2011).

3. CATCHMENT DESCRIPTION

The stormwater catchments within the study area are generally steep and ultimately discharge to the Derwent Estuary. Given the density of property development within the urban areas and the overall lack of formalised overland flow management, there are several locations where stormwater impacts are affected by the capacity of the pipe network. As such, the inlet capacity of entry pits is critical to ensure that the existing pipe network is flowing at full capacity. The existing piped drainage network was found to generally consist of the following:

- Approximately 9500 pipes (excluding subsoil drains).
- Approximately 4400 manholes.
- Approximately 3700 entry pits.
- Approximately 5000 house connections.

The majority of the urban population resides in Kingston (including Blackmans Bay). The land use in accordance with the Kingborough Interim Planning Scheme for over 50% of the Kingston study area is ‘General Residential’. Residential areas in Bonnet Hill, Conningham, Electrona, Kettering, Margate, Snug and Taroona are of lower density and zoned ‘Low Density Residential’, ‘Rural Living’ or ‘Environmental Living’.

Approximately 180 mm of rainfall was recorded at the Kingston Greenhill rain gauge (094222) over 24 hours during the May 2018 storm event. This event resulted in widespread flood damage through the Kingborough Municipality. An example of damage to Channel Court caused by flood debris is shown in Figure 3.1.

Figure 3.1 Flood Debris at the Channel Count Shopping Centre (ABC, 2018)

4. DRAINAGE CAPACITY ASSESSMENT

4.1 Overview

An assessment of the piped drainage capacity has been undertaken. Computational modelling was not undertaken as a part of this assessment and further investigation is required to confirm the drainage issues and inform the design of drainage improvement measures.

4.1.1 Data Gap Filling

A review of Council's pit and pipe data was undertaken. Although the data was found to be incomplete, it was deemed sufficient for the purposes of this study. However, a gap filling process was required prior to the drainage assessment. A description of the data issues and adopted gap filling assumptions are summarised in Table 4.1Pit and Pipe Data- Gap Filling .

The gap filling process was largely automated. This process is suitable for this project and a reasonable outcome was achieved. For future investigations, a manual data review will be required.

Table 4.1 Pit and Pipe Data- Gap Filling

Data Issue	Gap Filling Assumption
Approximately 1% of pipe diameters/dimensions missing	The missing pipe diameters/dimensions were filled based on the following hierarchy of information: 1. Key missing dimensions (major structures) were supplied by Council upon further data request. 2. Where upstream or downstream pipe sizes were known, the same size was assumed. 3. Where there are no upstream or downstream pipe sizes, a pipe size based on a similar drainage catchment was assumed.
Approximately 60% of pipe invert levels missing	Pipe slopes were calculated based on the topographic slope where invert levels were unavailable or unrealistic.
Pit inlet and manhole invert levels not available	Pit inlet and manhole invert levels assumed to be the lowest invert level of the connecting pipes.
Pit inlet and manhole dimensions not available	Typical pit inlet dimensions were assumed based on site observations, discussions with Council and measurement of detailed aerial photography.
Unrealistic invert levels (e.g. pit and pipe invert	Unrealistic invert levels were manually rectified based as follows:

Data Issue	Gap Filling Assumption
levels 100 m above the surface)	1. Where the invert levels were approximately 10 or 100 times higher or lower than surrounding levels, it was assumed that this is a data entry error (e.g. 178 m AHD intended to be 17.8 m AHD) 2. Otherwise, invert levels were calculated based on 600 mm cover above the top of the largest connecting pipe.

4.2 Pipe Capacity Assessment

4.2.1 Methodology

The piped drainage capacity has been assessed as follows:

1. Peak flows for the 39% AEP (2 year ARI), 5% AEP (20 year ARI) and 1% AEP (100 year ARI) were calculated as follows:
    a. The Rational Method was used to calculate peak flows for eleven (11) catchments of different areas (1900 m^2 to 182 ha).
    b. A catchment area and peak flow regression equation was determined based on the Rational Method calculations.
    c. A catchment area was calculated for each pipe and a peak flow was determined based on the regression equation.
2. Piped drainage capacities were calculated as follows:
    a. The Manning's equation was used to calculate pipe capacities based on pipe slopes and diameters.
    b. The orifice equation was used to calculate pipe capacities based on pipe diameters.
    c. Given the steep slopes in the catchment, pipes capacities can be inlet controlled. The lesser of the Manning's equation and orifice equation calculated capacities was adopted as the pipe capacity.
3. The design event peak flows were compared to the drainage capacities for each pipe.

Details of the assessment are described in Section 4.2.2 to 4.2.5 below and pipe capacity assessment maps for the study area are provided in Appendix A.

4.2.2 Rational Method

The Rational Method was used to calculate peak flows for eleven (11) catchments of different areas (1900 m^2 to 182 ha). The time of concentration was calculated based on 7 minutes standard time of concentration and travel time through the piped drainage system.

The travel time through the piped drainage system was calculated based on Manning's equation for velocity through the pipes. The runoff coefficient (C) was calculated based on a C10 values and frequency factors from Book 4 of Australian Rainfall and Runoff (Engineers Australia, 1987).

4.2.3 Catchment Areas

The process to calculate the catchment area for each pipe was undertaken as follows:

- The piped drainage system was 'burned' into the DEM as a stream network. The burn depth for each pipe was the pipe diameter + 1.5 m.
- The burned DEM was hydrologically corrected using a sink filling algorithm (Wang & Liu, 2006).
- The catchment area was calculated for every cell in the hydrologically corrected DEM using the Deterministic 8 algorithm (O'Callaghan and Mark, 1984).
- The catchment area at the middle of the pipe was adopted as the catchment area for each pipe.
- The calculated catchment areas were manually checked for eleven (11) catchments of different sizes and suitable validation was achieved.

4.2.4 Capacity Assessment

The lesser of the capacities calculated by the Manning's equation and orifice equation was adopted as the pipe capacity as described in the equation below.

$$Pipe\ Capacity = \min\left(\frac{1}{n} A R^{\frac{2}{3}} \sqrt{S}, C_d A \sqrt{2gh}\right)$$

Where n= Manning's coefficient = 0.013, A= Area, R= Hydraulic Radius, S= Slope,

C_d=Coefficient of Discharge, g= gravity, h= head level

4.2.5 Results

Although this methodology allows for a municipality wide assessment, it is an indicative and broad scale assessment only. Key observations from the assessment results included:

- Approximately 3000 out of 9500 pipes (32% of pipes) have less than 39 % AEP (2 year ARI) capacity.
- Approximately 5000 out of 9500 pipes (53% of pipes) have less than 5% AEP (20 year ARI) capacity.

4.3 Pit Capacity Assessment

Based on a desktop review, discussions with Council and observations from the site inspection, insufficient pit capacity is considered to be a relatively common and key drainage issue. The insufficient pit capacity is generally related to an inappropriate inlet size and configuration. Many pits lintels are less than 1.5 m long with a small or absent grate (e.g. side entry only). Given the steep flow paths in the study area (often >5%), the intended flows are likely to bypass many pits in the catchment.

Figure 4.1 Example of Potentially Ineffective Side Entry Pit on Harris Court, Kingston

Another observation was that many inlet pits were less than 500 mm deep. Given the steep flow paths in the study area this may result in flow surcharge. An example is shown in Figure 4.2.

Figure 4.2 Example of Potentially Insufficient Pit Depth

4.4 Blockage Potential Assessment

Approximately 2700 out of 9500 pipes (28% of pipes) within the study area are 225 mm or less in diameter, 1100 of which are on public land. Guidance from the Tasmanian Subdivision Guidelines (LGAT, 2013) suggests a minimum pipe diameter of 300 mm for road drainage. In Queensland, the minimum pipe diameter adopted by most councils is 375 mm based on guidance from the Queensland Urban Drainage Manual (QUDM) (refer QUDM Section 7.8.3). QUDM does allow for 300 mm RCPs in some circumstances subject to hydraulic analysis. The minimum pipe size is enforced by councils through a stormwater code or policy which is contained within the planning scheme.

Given the debris loads observed in post-flood photos (e.g. May 2018), pipe sizes of 225 mm diameter or less are prone to blockage and therefore a minimum pipe size should be adopted for future stormwater planning and design. KC will need to consider the planning mechanism to enforce design criteria, however a stormwater code is commonly used in Queensland and other states.

5. OVERLAND FLOW PATH ASSESSMENT

An overland flow path assessment has been undertaken to assist in defining flood risk hotspots. This included the development of a TUFLOW direct rainfall model of the entire study area (except for Kettering where detailed topographic data was incomplete). This modelling is preliminary only and should not be used for any purpose other than providing a high-level indication of overland flow paths. Further detailed modelling and investigation is required prior to the design of any mitigation measures. The overland flow path mapping is provided in Appendix B.

5.1 Model Development

The Kingborough SSMP study area has been modelled using a 2D direct rainfall approach. Rainfall hyetographs were applied directly to the model topography and both the hydrology and hydraulics analysis were resolved in the same model. The TUFLOW modelling software was adopted for the study. TUFLOW has been successfully applied for similar projects in Tasmania and across Australia.

5.1.1 Rainfall and Infiltration

The 1% AEP 30 minute storm was selected for the overland flow path assessment. The catchments are generally steep and urbanised and affected by flash flooding. Therefore, the 30 minute storm was selected as a representative storm. Neither critical duration analyses nor temporal pattern analyses have been undertaken.

The Australian Rainfall and Runoff (ARR) 2019 rainfall depth was adopted and sourced from the Bureau of Meteorology (BoM) online Intensity-Frequency-Duration (IFD) tool. Areal reduction factors were not applied. The Zone 1 temporal pattern from ARR 1987 based on the Average Variability Method (Pilgrim and Cordery, 1975) was adopted. The adoption of the ARR 1987 AVM temporal pattern is appropriate for the purpose of this assessment. ARR 2019 specified three approaches to design event analysis, which includes the simple event approach. The simple approach to modelling simulations involves application of a single temporal pattern per storm event AEP and duration combination. Both the ARR 2019 and ARR 1987 guidelines recommend the use of temporal patterns that were developed using the Average Variability Method (AVM) for simple event analysis, which is considered appropriate for the purpose of this study.

No infiltration was modelled as a conservative assumption. It is noted that climate change has not been considered in the assessment. It is advised that climate change be considered in accordance with latest guidance for more detailed planning and design.

5.1.2 Topography, Model Extent and Cell Size

The adopted base topography in the model was based on Digital Elevation Models (DEMs) generated from:

- Mt Wellington and the Derwent 2010 LiDAR capture.
- Greater Hobart 2013 LiDAR capture.

No modifications were made to the base topography. The model extent captures the entire study area and upstream drainage catchments (not including creek or rivulet catchments). A cell size of 4 m was adopted to represent key flow paths while maintaining practical simulation time.

5.1.3 Hydraulic Structures

Surface hydraulic infrastructure such as detention basins and drainage channels that were captured in the LiDAR topography have been included within the model. Bridges and road overpasses have been represented within the model as openings (i.e. no bridge deck or piers). However, sub-surface infrastructure such as culvert, pits and pipes have not been modelled. This is appropriate for the purpose of this study, which was to determine indicative overland flow paths. Culverts and bridges should be represented in flood studies and subsurface drainage infrastructure should also be included in more detailed drainage studies.

5.1.4 Boundary Conditions

The rainfall hyetographs were applied directly to the model topography and therefore flow accumulation was resolved within the hydraulic model itself. A constant water level of 0 m AHD has been applied at the model downstream boundaries, which allows for a free outfall condition and a suitable assessment of overland flow generated by local catchment runoff.

5.2 Results

A filtering process was also been undertaken to improve the legibility of the overland flow path results. The filtering criteria was as follows:

- Exclude flood depth velocity products <0.02 m^2/s.
- Exclude flood depths <0.05 m.
- Exclude ponds <500 m^2 in area.

Mapping of the overland flow path results are provided in Appendix B.

The results have been mapped according to the General Flood Hazard Curves (Smith et. al., 2014). This classification has been determined based on the vulnerability and is also described in Figure 5.1.

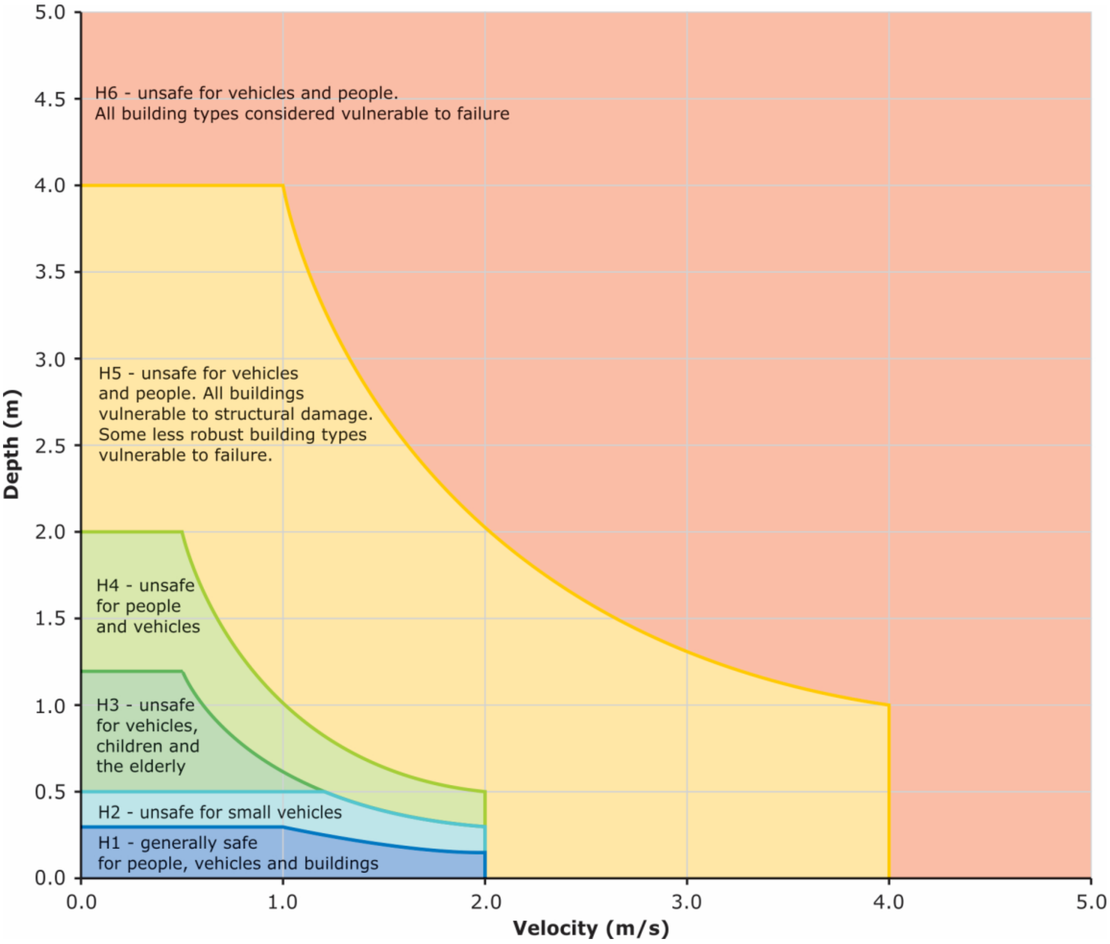

Figure 5.1 Flood Hazard Curves

5.3 Limitations

Hydraulic modelling limitations include:

- Rain on grid application within TUFLOW based on 1% AEP 30 minute storm only. No hydrologic validation.
- No inclusion of 1d network (i.e. bridges stormwater pits and pipes, etc.)
- Limited modification of the 2d domain (based on LiDAR data).

- Obstructions such as buildings have not been specifically represented within the model and therefore overland flow is shown through shopping centres (i.e. Channel Court Shopping Centre and Kingston Plaza) which may not reflect reality.

6. DRAINAGE ISSUES

6.1 General Drainage Issues

Based on the site inspections, discussions with Council, the drainage assessment and the overland flow path assessment, the following general drainage issues were observed within the study area:

- Many inlet pits were less than 500 mm deep. Given the steep flow paths in the study area, this may result in flow surcharge.
- Insufficient pit sizes resulting in insufficient flow capture. A number of inlet pits had lintels with ineffective or no grates, and lintels were estimated to be only 600 mm long.
- Overland flow paths within private properties are not maintained and are even built over or obstructed in many cases due to no provision of easements or drainage reserves. This is not in accordance with the Tasmanian Subdivision Guideline, which requires that provision should be made to allow stormwater flow up to a 100 year ARI storm to flow overland without undue inundation to any properties.
- Significant drainage infrastructure (approximately 40% of pipes) located on private property without the provision of easements.
- Many of the observed drainage issues are considered to relate to the lack of a formal planning instrument for stormwater management.

Section 7.2.1 outlines the recommendation to ensure these drainage issues do not continue to occur.

6.2 Key 'Hotspot' Areas

Flood risk 'hotspots' were generally defined as clusters of two or more buildings affected by H2 flood hazard or worse, based on the overland flow path assessment, with the following exceptions:

- Where buildings are only affected by local ponding, not by a major flow path. This has been excluded.
- Where buildings are affected by creek, rivulet, river or coastal flooding.

The defined hotspots are for indicative purposes only and based on a preliminary assessment, therefore may not reflect the actual flood risk to properties. For example, buildings have not been specifically represented within the model and therefore an overland flow path is shown through shopping centres (i.e. Channel Court Shopping Centre and Kingston Plaza) and buildings which may not reflect reality. For the purpose of this high-level study, commercial premises were conservatively assumed to be potentially affected where a major flow path was observed, however further investigation and hydraulic assessment is required to confirm the flood risk to commercial properties.

Additionally, it is understood that several properties (mainly along Stirling Drive and Hillside Drive in Blackmans Bay) suffered flooding and severe scouring due to surcharge from the stormwater network during the May 2018 event. Flooding due to stormwater network deficiencies may not be captured in this study, however more detailed studies should include stormwater network modelling to provide a more accurate assessment of surface and subsurface flow behaviour.

The identified hotspots were delineated based on being part of the same flow path or potentially being affected by the same infrastructure. The flood risk hotspots are mapped in Appendix C and summarised in Table 6.1.

Table 6.1 Preliminary Hotspots (Number of Buildings in each Hazard Classification)

<table>
<tr><th colspan="2">Hotspot</th><th>H1</th><th>H2</th><th>H3</th><th>H4</th><th>H5</th><th>H6</th></tr>
<tr><td>1</td><td>Belhaven Avenue (Taroona)</td><td></td><td>2</td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>Norwood Avenue (Taroona)</td><td>5</td><td>1</td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>Seaview Avenue (Taroona)</td><td>1</td><td>1</td><td>1</td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>Summerleas Road (Kingston)</td><td>3</td><td>1</td><td></td><td></td><td></td><td></td></tr>
<tr><td>5</td><td>Ferguson Court (Kingston)</td><td>2</td><td>4</td><td></td><td></td><td></td><td></td></tr>
<tr><td>6</td><td>Harris Court (Kingston)</td><td>3</td><td>4</td><td></td><td>2</td><td></td><td></td></tr>
<tr><td>7</td><td>Sherburd Street (Kingston)</td><td>2</td><td></td><td></td><td>1</td><td></td><td></td></tr>
<tr><td>8*</td><td>Channel Court Shopping Centre (Kingston)</td><td colspan="5" rowspan="3">Key Commercial Area affected by up to H5 hazard</td><td></td></tr>
<tr><td>9*</td><td>Coles Kingston Plaza (Kingston)</td><td></td></tr>
<tr><td>10*</td><td>Kingston Gateway Plaza (Kingston)</td><td></td></tr>
<tr><td>11</td><td>James Avenue (Kingston Beach)</td><td>2</td><td>1</td><td></td><td></td><td></td><td></td></tr>
<tr><td>12</td><td>Ewing Avenue (Kingston Beach)</td><td>5</td><td>10</td><td></td><td></td><td>1</td><td></td></tr>
<tr><td>13</td><td>Beach Road (Kingston Beach)</td><td>7</td><td>2</td><td></td><td></td><td></td><td></td></tr>
<tr><td>14</td><td>Saffron Drive (Kingston)</td><td>3</td><td>2</td><td></td><td></td><td></td><td></td></tr>
</table>

	Hotspot	H1	H2	H3	H4	H5	H6
15	Algona Road (Kingston)		2	2			
16	Hiern Road (Blackmans Bay)	5	2				
17	Powell Avenue (Blackmans Bay)			1			
18	Blowhole Road (Blackmans Bay)		5				
19	Roslyn to Pearsall Avenue (Blackmans Bay)	14	16	5	3		
20	Sunny Avenue (Blackmans Bay)	11	3				
21	Pearsall Avenue to Wells Parade (Blackmans Bay)	3		2		1	
22	Ocean Esplanade A (Blackmans Bay)			1	4	1	
23	Ocean Esplanade B (Blackmans Bay)	3	4	2	1		
24	Woodlands Drive to Roslyn Avenue (Blackmans Bay)	4	2		1		
25	Roslyn Avenue to View Street (Blackmans Bay)	3	2				
26	View Street to Hazell Street (Blackmans Bay)	3	3				
27	Hazell Street to Wells Parade (Blackmans Bay)	7	3				
28	Illawarra Road (Blackmans Bay)	4	3				
29	Coral Place (Blackmans Bay)	2	2	1			
30	Suncoast Road (Blackmans Bay)	1	4	1	2		
31	Homebush Court (Margate)	1	1				
32	Conningham A (Conningham)		1				
33	Conningham B (Conningham)	1	2	1			

**Shopping centres have been conservatively assumed to be potentially affected for the purpose of this high-level assessment.*

7. STORMWATER MANAGEMENT OPPORTUNITIES

Managing stormwater and any associated flood risk is important to improve community resilience to flooding and limiting flood risk growth which may occur from increased development and changes to climate. Achieving effective management within the Kingborough Council LGA should involve encouraging or promoting the:

- Inclusion of stormwater management outcomes in policies, planning instruments and forward plans.
- Management of existing, future and residual flood risk for the local community using a range of suitable measures.
- Engagement with, and active participation of, the local community in managing the flood risks they face.
- Identification, assessment and implementation of feasible, practical and effective options to treat intolerable risks to the existing community, considering their social, environmental and economic benefits and costs, and their sustainability.

Generally, flood risk management opportunities are broadly separated into three (3) categories; property modification measures, response modification measures and flood behaviour modification measures. However, for the purpose of the SSMP, stormwater and flood risk management measures have been described as follows:

- Structural management measures.
- Planning and development management measures.
- Emergency management measures.
- Community and catchment management measures.

Effective strategies often include a combination of measures rather than focusing only on the most favoured measure.

7.1 Structural Management Measures

Structural management options have been identified for prioritised hotspots as part of this study, however other hotspots and mitigation options may also be considered and assessed as part of future studies. A review of these hotspots and identification of potential others should also be considered and assessed as part of future studies, including assessment of the feasibility and cost-benefit ratio of these options.

The prioritised hotspots were determined based on an assessment of number of properties affected by the flood hazard. A hazard score was derived for each hotspot based on the sum product of the number of properties and the hazard classification (e.g. H3 =3). The prioritised hotspots consist of the hotspots with the ten (10) worst scores summarised in Table 7.1.

It is noted that the worst hotspots are generally located within the Kingston CBD catchment or the Blackmans Bay catchment. Key commercial areas were given an arbitrary and conservative score of 100 and whilst premises within the shopping centres may not have been inundated in the 2018 event, the high score will ensure that flood risks and mitigation options are further assessed as part of future studies.

Table 7.1 Prioritised Flood Risk Hotspots (based on Hazard Score)

	Hotspot	H1	H2	H3	H4	H5	H6	Hazard Score
8	Channel Court Shopping Centre (Kingston)	Key Commercial Areas**						100
9*	Coles Kingston Plaza (Kingston)							100
10*	Kingston Gateway Plaza (Kingston)							100
19	Roslyn to Pearsall Avenue (Blackmans Bay)	14	16	5	3			73
12	Ewing Avenue (Kingston Beach)	5	10			1		30
22	Ocean Esplanade A (Blackmans Bay)			1	4	1		24
23	Ocean Esplanade B (Blackmans Bay)	3	4	2	1			21
30	Suncoast Road (Blackmans Bay)	1	4	1	2			20
6	Harris Court (Kingston)	3	4		2			19
20	Sunny Avenue (Blackmans Bay)	11	3					17

* Although preliminary overland flow mapping indicates that Kingston Plaza floods, feedback to Council from business owners suggests that little to no flooding was experienced during the May 2018 event. As such, actual flood risk may be much less than indicated.

**Key commercial areas were given an arbitrary score of 100 which is intentionally conservative for the purposes of this assessment.

7.1.1 Structural Management Options for Prioritised Hotspots

Six key potential structural management measures have been identified to improve flooding issues at the prioritised hotspots. These were considered to be the most viable structural measures and are summarised in Table 7.2 and mapped in Appendix D. These options are indicative only and are only provided for consideration in future studies. Mitigation measures for other hotspots should also be reviewed in future studies.

Table 7.2 Potential Structural Management Measures - Prioritised Hotspots

	Mitigation Measure	Relevant Hotspots	Additional Considerations
KIN1	1. Construct embankment along disturbed pedestrian path upstream of existing basins/wetlands or within the Sherburd Street road reserve to create a detention basin (upstream storage). There is an existing walking track on the school property that could potentially be raised to form an embankment to attenuate flows. 2. Additionally, the two small existing basins/wetlands located immediately upstream of 12 and 14 Sherburd Street could be rectified or upgraded to marginally increase detention storage and improve their functionality. 3. Increase pit capacity upstream of the Channel Court Shopping Centre	7, 8, 9 and 10	Mitigation Measure 1 will increase flood levels within the Kingston Primary School property due to the creation of flood storage/detention. Further investigation will need to account for the safety of students and the general public as well as any potential compromise of school use. The embankment height to be further investigated with consideration of these matters. The adequacy of the existing inlet pits on Freeman Street should be investigated as part of a more detailed study (incl. hydraulic modelling) to determine whether upgrading the inlet pits will provide any benefit.
KIN2	Upgrade pit and pipe network from Ferguson Court down Harris Court and outlet in gully downstream	6	This may increase flooding downstream and should only be proposed in conjunction with or following consideration of downstream options
KIN3	Upgrade pit and pipe network from Roslyn Ave down James Ave to outlet	11 and 12	
BLB1	Upgrade pits at sags on Roslyn Avenue and construct pipe down Pearsall avenue to outlet	19, 20, 21, 22 and 23	
BLB2	Upgrade pits at sags on Roslyn Ave, View Street- and Hazell Street and construct pipe to outlet	25, 26, 27 and 23	
BLB3	Construct detention basin within park. Upgrade pit and pipe system from Coral Place down Suncoast Drive	30	

7.1.2 Structural Management Options for All Hotspots

Potential structural management measures have been identified to improve flooding issues at the remainder of the flood risk hotspots (refer to Appendix C). The options are summarised in Table 7.3. These options are indicative only and are only provided for consideration in future studies. It is noted that no feasible structural management options were identified for some hotspots, this is primarily as a result of flow paths and stormwater infrastructure being located within private property.

Table 7.3 Potential Management Options - All Hotspots

Hotspot		Potential Management Option
1	Belhaven Avenue (Taroona)	Re-profile verge and driveways to increase capacity in the road sag
2	Norwood Avenue (Taroona)	Re-profile verge and driveways to increase capacity in the road sag
3	Seaview Avenue (Taroona)	Construct diversion bund or channel behind 31-43 Seaview Avenue
4	Summerleas Road (Kingston)	Upgrade 100m of pipe from Willowbend road to downstream gully
5	Ferguson Court (Kingston)	No feasible structural management option identified
6	Harris Court (Kingston)	Refer to KIN2 in Table 7.2.
7	Sherburd Street (Kingston)	Refer to KIN1 in Table 7.2, and/or Upgrade/rectify existing stormwater basins (Lot 1 on GQQ92), and/or Increase pit capacity upstream of the Channel Court Shopping Centre
8	Channel Court Shopping Centre (Kingston)	
9	Coles Kingston Plaza (Kingston)	Refer to KIN1 in Table 7.2, and/or Upgrade 300 m of pipe from Channel Court Shopping Centre to Whitewater Creek (including pit upgrades)
10	Kingston Gateway Plaza (Kingston)	
11	James Avenue (Kingston Beach)	Refer to KIN3 in Table 7.2. An alternative option to upgrade the existing drainage network along James Lane was also considered and should be investigated as part of a future study
12	Ewing Avenue (Kingston Beach)	
13	Beach Road (Kingston Beach)	Upgrade road profile (Kerb or verge raise) for 500m from Roslyn Avenue north to Browns River
14	Saffron Drive (Kingston)	Upgrade 300 m of pipe down Thornbill Street to downstream gully (including pit upgrades)

Hotspot		Potential Management Option
15	Algona Road (Kingston)	Construct diversion bund on the eastern end of the site, however impacts to adjacent properties should be considered.
16	Hiern Road (Blackmans Bay)	No feasible structural management option identified in SSMP
17	Powell Avenue (Blackmans Bay)	Reprofile local topography to avoid ponding behind Powell Road (on affected property)
18	Blowhole Road (Blackmans Bay)	Upgrade road profile (Kerb or verge raise) for 300m from the intersection of Talone Road and Blowhole Road down to gully
19	Roslyn to Pearsall Avenue (Blackmans Bay)	Refer to BLB1 in Table 7.2.
20	Sunny Avenue (Blackmans Bay)	
21	Pearsall Avenue to Wells Parade (Blackmans Bay)	
22	Ocean Esplanade A (Blackmans Bay)	
23	Ocean Esplanade B (Blackmans Bay)	
24	Woodlands Drive to Roslyn Avenue (Blackmans Bay)	No feasible structural management option identified
25	Roslyn Avenue to View Street (Blackmans Bay)	Refer to BLB2 in Table 7.2.
26	View Street to Hazell Street (Blackmans Bay)	
27	Hazell Street to Wells Parade (Blackmans Bay)	
28	Illawarra Road (Blackmans Bay)	Upgrade 250 m of pipe from intersection of Illawarra Road and Illawarra Court down to Blackmans Bay (including pit upgrades). This measure should be reviewed with consideration of the recently upgraded stormwater system on Illawarra Road.
29	Coral Place (Blackmans Bay)	No feasible structural management option identified in SSMP

Hotspot		Potential Management Option
30	Suncoast Road (Blackmans Bay)	Refer to BLB3 in Table 7.2.
31	Homebush Court (Margate)	Re-profile verge and driveways to increase capacity in the road sag
32	Conningham A (Conningham)	Reprofile local drainage to avoid flooding of buildings (on affected properties)
33	Conningham B (Conningham)	Reprofile local drainage to avoid flooding of buildings (on affected properties)

7.2 Planning and Development Management Measures

7.2.1 Adopt a Stormwater Management Policy

Stormwater systems for new development should be designed in accordance with the Tasmanian Subdivision Guidelines (LGAT, 2013) or a Kingborough Council Stormwater Code. Improving the design of new stormwater systems is significantly more cost effective than rectifying poorly designed stormwater systems. The Tasmanian Subdivision Guidelines (LGAT, 2013) provides guidance on stormwater design in Tasmania, however it is also advised that Council consider adopting a stormwater management guideline/code or policy to support the planning scheme in managing future development.

Based on the drainage issues identified in the existing stormwater system, the key design considerations are as follows:

- Ensure provision of overland flow paths for major events to ensure that provision is made to allow stormwater flow up to a 100 year ARI storm to flow overland without undue inundation to any properties.
- Ensure minimum pipe sizes, pit sizes and pit depths. Based on the specified minimum pipe size of 300 mm from the Tasmanian Subdivision Guidelines, 300 mm would be considered appropriate.
- Ensure pipes are located on public property or within dedicated easements. This should be enforced for future development. High risk uncontrolled overland flow through existing private properties should be identified and considered for voluntary or compulsory easement acquisition. More detailed investigation and hydraulic modelling is likely to be required to enable this determination.
- Ensure that stormwater drainage design considers pit head loss reduction (i.e. benching) where required and additional design considerations to prevent manhole lids from popping for systems with steep hydraulic grades.

Council should consider developing a stormwater code that can refer to the Tasmanian Subdivision Guidelines or Kingborough Council specific requirements with consideration for best stormwater management practice including reference to QUDM and other industry leading guidelines. Additionally, a review of development assessment considerations relating to stormwater management should also be undertaken.

Additionally, Council should ensure that stormwater headwork charges are spent on addressing issues identified in the SSMP and more detailed stormwater related studies or projects.

7.2.2 Utilise Overland Flow Path Mapping as a Development Trigger

A preliminary overland flow path assessment has been undertaken as part of this study (refer to Section 4 and Appendix B). With further refinement, the outputs can be utilised as a trigger to identify development that may be subject to overland flow and trigger the requirement to manage overland flow accordingly. For example, if a proposed development involves building or earthworks within the development trigger, a detailed overland flow path assessment (i.e. hydrologic and hydraulic analysis) may be required to quantify the extent of overland flow and determine appropriate measures and development layouts to manage overland flow accordingly.

7.3 Emergency Management Measures

7.3.1 Prepare Flood Emergency Management Plans (FEMP)

Flood Emergency Management Plans (FEMP) address evacuation, emergency access, flood warning and preparedness. A FEMP for the Channel Court shopping centre may be of particular value given recent flood damages in May 2018. The FEMP would serve to assist shopping centre management, its tenants and customers to reduce the impacts from flooding.

7.3.2 Provide Flood Risk Information to Emergency Management Agencies (e.g. State Emergency Service)

Flood risk information collected and analysed by Council as part of this study and as part of future studies can be used to assist emergency management agencies. It is also advised that the viability of flash flood warning be further investigated as part of the catchment resilience project for Kingston.

7.4 Community/ Catchment Management Measures

7.4.1 Consider Making Stormwater and Flooding Information Publicly Available

A requirement of the Urban Drainage Act 2013 is for Council to maintain publicly available maps showing all public stormwater systems. Integrating the Council GIS system with interactive online mapping can ensure that information is consistent and up to date. Additionally, available flood mapping (i.e. flood risk and/or overland flow) should also be made available at key Council locations including the Civil Centre for hard copy inspection.

7.4.2 Provide Email Address for the Community to Submit Photos and Videos of Storm Events

The accuracy of flood models is generally limited by the availability of historical flood data. An email address for the community to submit photos and videos of storm events or any other information can assist in any future flood risk investigations. This could be ongoing or only used for the collection of event specific information following a flood event.

7.4.3 Undertake Detailed Flood Risk Management Studies

It is understood that Council has commenced projects developing resilience programs for the Kingston CBD catchment and the Blackmans Bay catchment. This is a positive measure taken by Council and it is recommended that relevant information from the SSMP is transferred to these studies (e.g. potential management measures), however the limitation of the SSMP should be clearly understood.

7.4.4 Develop a Community Awareness Program

Increased community education and awareness can better facilitate response in a flood event and flood risk in general. A community awareness program is recommended following the completion of the catchment resilience programs for Kingston and Blackmans Bay. The community awareness program can serve to increase flood risk awareness as well as promote the mitigation measures proposed to reduce risk. Details of the program such as the program objectives, target audience, method/s of engagement and communication, and information to be disseminated is to be further considered by Council following the completion of the catchment resilience programs.

8. COST ESTIMATES

8.1 Methodology and Assumptions

For the purpose of prioritising structural mitigation options, high level indicative cost estimates have been undertaken for the potential structural management options outlined in Table 7.3. As no concept design or hydrologic/hydraulic modelling has been undertaken, quantities have been broadly estimated based on approximate lengths and volumes only. Given the inaccuracy of the cost estimates, they have been broadly categorised and are presented in Table 8.1.

Table 8.1 Costing Approach

Cost Category	Criteria	Cost Score
Low	Cost estimate <$1,000,000	1
Medium	$5,000,000>Cost estimate >$1,000,000	2
High	Cost estimate >$5,000,000	3
N/A	No mitigation option identified	4

It is noted that these cost estimates are for prioritisation purposes only and should not be used for budgeting purposes. Structural measures should be assessed and reprioritised as part of more detailed projects.

8.2 Cost Score

The cost score determined for each hotspot is presented in Table 9.2.

9. PRIORITISATION

9.1 Methodology

A higher order prioritisation has been undertaken for the identified hotspots. The prioritisation has been based on a high-level evaluation of flood risk and the associated indicative infrastructure cost to mitigate the identified flood risk. Flood risk has been determined based on the flood hazard score which was derived for each hotspot based on the sum product of the number of properties and the hazard classification (e.g. H3 =3).

It is advised that the hotspots, risks and mitigation costs be reviewed and further assessed as part of more detailed studies in the future.

9.2 Prioritisation

The overall prioritisation results are presented in Table 9.2, however the top five (5) ranked mitigation options are presented in Table 9.1.

Table 9.1 Top 5 Ranked Mitigation Options

Rank	Location	Hazard Score	Cost Score	Prioritisation Score
1	Hotspots 19 to 23 – Roslyn Ave, Pearsall Ave and Ocean Esp	149	2	75
2	Hotspots 7 and 8 – Channel Court Shopping Centre and Sherburd St	106	2	53
3*	Hotspots 9 and 10 – Kingston Gateway Plaza and Coles Kingston Plaza	100	2	50
4	Hotspots 11 and 12 – James Ave and Ewing Ave	34	2	17
5	Hotspots 25, 26 and 27 – Roslyn Ave to Wells Pde	29	2	15

* Although preliminary overland flow mapping indicates that Kingston Plaza floods, feedback to Council from business owners suggests that little to no flooding was experienced during the May 2018 event. As such, actual flood risk may be much less than indicated.

Table 9.2 Prioritisation Outcome

		Multiplier												
		1	2	3	4	5	6							
Hotspot	Location	H1	H2	H3	H4	H5	H6	Hazard Score	Potential Management Option	Hazard Score	Cost Score	Prioritisation Score= Hazard/Cost	Rank	Rank (ordinal)
1	Belhaven Avenue (Taroona)		2					4	Re-profile verge and driveways to increase capacity in the road sag	4	1	4	11=	16
2	Norwood Avenue (Taroona)	5	1					7	Re-profile verge and driveways to increase capacity in the road sag	7	1	7	8=	10
3	Seaview Avenue (Taroona)	1	1	1				6	Construct diversion bund or channel behind 31-43 Seaview Avenue	6	1	6	9=	12
4	Summerleas Road (Kingston)	3	1					5	Upgrade 100m of pipe from Willowbend road to downstream gully	5	2	3	12=	19
5	Ferguson Court (Kingston)	2	4					10	No feasible structural management option identified	10	4	3	12=	18
6	Harris Court (Kingston)	3	4		2			19	Refer to KIN2 in Table 7.2	19	2	10	6=	7
7	Sherburd Street (Kingston)	2			1			6	Refer to KIN1 in Table 7.2, and/or Upgrade/rectify existing stormwater basins (Lot 1 on GQQ92), and/or Increase pit capacity upstream of the Channel Court Shopping Centre	106	2	53	2	3
8	Channel Court Shopping Centre (Kingston)							100						
9	Coles Kingston Plaza (Kingston)							100	Refer to KIN1 in Table 7.2, and/or Upgrade 300 m of pipe from Channel Court Shopping Centre to Whitewater Creek (including pit upgrades)	100	2	50	3	1
10	Kingston Gateway Plaza (Kingston)							100						
11	James Avenue (Kingston Beach)	2	1					4	Refer to KIN3 in Table 7.2	34	2	17	4	4
12	Ewing Avenue (Kingston Beach)	5	10			1		30						
13	Beach Road (Kingston Beach)	7	2					11	Upgrade road profile (Kerb or verge raise) for 500m from Roslyn Avenue north to Browns River	11	2	6	9=	11
14	Saffron Drive (Kingston)	3	2					7	Upgrade 300 m of pipe down Thornbill Street to downstream gully (including pit upgrades)	7	2	4	11=	15
15	Algona Road (Kingston)		2	2				10	Construct diversion bund on the eastern end of the site	10	1	10	6=	8
16	Hiern Road (Blackmans Bay)	5	2					9	No feasible structural management option identified in SSMP	9	4	2	13=	22
17	Powell Avenue (Blackmans Bay)			1				3	Reprofile local topography to avoid ponding behind Powell Road (on affected property)	3	1	3	12=	20
18	Blowhole Road (Blackmans Bay)		5					10	Upgrade road profile (Kerb or verge raise) for 300m from the intersection of Talone Road and Blowhole Road down to gully	10	2	5	10=	13
19	Roslyn to Pearsall Avenue (Blackmans Bay)	14	16	5	3			73	Refer to BLB1 in Table 7.2	149	2	75	1	2
20	Sunny Avenue (Blackmans Bay)	11	3					17						
21	Pearsall Avenue to Wells Parade (Blackmans Bay)	3		2		1		14						
22	Ocean Esplanade A (Blackmans Bay)			1	4	1		24						
23	Ocean Esplanade B (Blackmans Bay)	3	4	2	1			21						
24	Woodlands Drive to Roslyn Avenue (Blackmans Bay)	4	2		1			12	No feasible structural management option identified	12	4	3	12=	17
25	Roslyn Avenue to View Street (Blackmans Bay)	3	2					7	Refer to BLB2 in Table 7.2	29	2	15	5	5
26	View Street to Hazell Street (Blackmans Bay)	3	3					9						
27	Hazell Street to Wells Parade (Blackmans Bay)	7	3					13						

		Multiplier												
		1	2	3	4	5	6							
Hotspot	Location	H1	H2	H3	H4	H5	H6	Hazard Score	Potential Management Option	Hazard Score	Cost Score	Prioritisation Score= Hazard/Cost	Rank	Rank (ordinal)
28	Illawarra Road (Blackmans Bay)	4	3					10	Upgrade 250 m of pipe from intersection of Illawarra Road and Illawarra Court down to Blackmans Bay (including pit upgrades)	10	2	5	10=	14
29	Coral Place (Blackmans Bay)	2	2	1				9	No feasible structural management option identified in SSMP	9	4	2	13=	23
30	Suncoast Road (Blackmans Bay)	1	4	1	2			20	Refer to BLB3 in Table 7.2	20	2	10	6=	6
31	Homebush Court (Margate)	1	1					3	Re-profile verge and driveways to increase capacity in the road sag	3	1	3	12=	21
32	Conningham A (Conningham)		1					2	Reprofile local drainage to avoid flooding of buildings (on affected properties)	2	1	2	13=	24
33	Conningham B (Conningham)	1	2	1				8	Reprofile local drainage to avoid flooding of buildings (on affected properties)	8	1	8	7	9

10. SUMMARY

The Kingborough SSMP has included a high-level drainage capacity analysis, overland flow analysis and the identification and prioritisation of potential management options for the identified flooding hotspots. A summary of study outcomes is provided as follows:

- Some overland flow paths within private properties were not maintained and were built over or obstructed in many cases due to no provision of easements or drainage reserves. This is not in accordance with the Tasmanian Subdivision Guideline that requires provision should be made to allow stormwater flow up to a 100 year ARI storm to flow overland without undue inundation to any properties.

- The capacity of the piped drainage network was generally limited by the capacity of inlet pits. Many pit lintel lengths were estimated to be approximately 600 mm with a small or absent grate (e.g. side entry only) and were less than 500 mm deep. Given the steep flow paths in the study area (often >5%), the intended flows are likely to bypass many pits in the catchment or surcharge from the pits at or near pipe full capacity.

- The pipe capacity assessment determined that approximately 3000 out of 9500 pipes (32% of pipes) have less than 39 % AEP (2 year ARI) capacity and approximately 5000 out of 9500 pipes (53% of pipes) have less than 5% AEP (20 year ARI) capacity.

- The majority of flooding hotspots were identified to experience H2 (Unsafe for small vehicles) flood hazard or worse.

- Three flooding hotspots were identified where multiple buildings experience H5 (Unsafe for vehicles, children and the elderly) flood hazard.

- Potential management options were considered for the 33 identified hotspots that were then prioritised based on a high-level evaluation of flood risk and the associated indicative infrastructure cost to mitigate the identified flood risk.

- The 5 highest ranked structural mitigation options were for hotspots at Kingston Gateway Plaza and Coles Kingston Plaza, Roslyn Avenue and Pearsall Avenue, Channel Court Shopping Centre and Sherburd Street, James Avenue ad Ewing Avenue, and Blowhole Road.

- Many of the observed drainage issues are considered to relate to the lack of a formal planning instrument for stormwater management.

- In addition to structural mitigation measures, planning and development control, emergency management, and community and catchment management measures have also been identified.

A summary of key actions are provided in Table 10.1.

Table 10.1 Summary of Key Actions from SSMP

Action/Strategy	Scope	Priority	Timeline
Overland flow mapping	Utilise preliminary overland flow path mapping from the SSM as development trigger for overland flow management. More detailed overland flow path modelling to be undertaken.	High	FY 2020/2021 for development trigger (overland flow mapping to be endorsed by Council simultaneously with the SSMP report). Detailed modelling: possibly FY 2021/2022 (pending budget allocations)
Stormwater management policy	Develop a stormwater management policy to support the planning scheme in managing future development. A review of development assessment considerations relating to stormwater management should also be undertaken.	High	FY 2020/2021
Review structural mitigation measures	Undertake detailed flood risk management studies and review the structural mitigation measures identified in the SSMP. Outcome should include updated list of prioritised measures.	High	FY 2021/2022 (pending budget allocations)
Provide flood risk information to emergency management agencies	Provide preliminary overland flow mapping to emergency management agencies (i.e. State Emergency Services) to inform emergency management planning and response.	Medium	FY 2020/2021 (information should be provided as soon as practicable after the SSMP report has been endorsed by Council)
Community awareness program	Develop a community awareness program following the completion of the catchment resilience programs for Kingston and Blackmans Bay. The community awareness program should serve to increase flood risk awareness as well as promote the mitigation measures proposed to reduce risk.	Medium	FY 2020/2021 (the awareness programs needs to be submitted and endorsed by Council prior to engagement with the community)

11. RECOMMENDATIONS

The Kingborough SSMP recommendations are that Council:

- Considers and further investigates the identified mitigation measures:
  - Structural Management Options
  - Adopt Stormwater Management Policy
  - Utilise Overland Flow Path Mapping as a Development Trigger
  - Prepare Flood Emergency Management Plans
  - Provide Flood Risk Information to Emergency Management Agencies
  - Consider Making Stormwater and Flooding Information Publicly Available
  - Provide Email Address for the Community to Submit Photos and Videos of Storm Events
  - Undertake Detailed Flood Risk Management Studies
  - Develop a Community Awareness Program
- Ensures that the Catchment Resilience Program considers and builds upon the outcomes from the Kingborough SSMP including a more detailed investigation of key hotspots to quantify flood risks and determine suitable mitigation options.
- Develops a stormwater management policy or guideline to support the planning scheme for the purpose of improving the current stormwater management outcomes.
- Enforces the desired stormwater management requirements for the benefit of both council and the community.
- Utilises the overland flow mapping to inform development assessment.
- Adopts the key SSMP actions outlined in Table 10.1.

The Kingborough SSMP has been undertaken based on a high-level determination of flooding hotspots, mitigation options, cost estimation and prioritisation. As such, the limitations of this assessment should be considered when using information obtained from the Kingborough SSMP.

12. QUALIFICATIONS

a. In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

b. Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

c. Engeny reserves the right to review and amend any aspect of the works performed including any opinions and recommendations from the works included or referred to in the works if:

   (i) Additional sources of information not presently available (for whatever reason) are provided or become known to Engeny; or

   (ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.

d. Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the works, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works. All limitations of liability shall apply for the benefit of the employees, agents and representatives of Engeny to the same extent that they apply for the benefit of Engeny.

e. This document is for the use of the party to whom it is addressed and for no other persons. No responsibility is accepted to any third party for the whole or part of the contents of this report.

f. If any claim or demand is made by any person against Engeny on the basis of detriment sustained or alleged to have been sustained as a result of reliance upon the report or information therein, Engeny will rely upon this provision as a defence to any such claim or demand.

g. This report does not provide legal advice.