Alexandrina Council

Ashbourne Stormwater Assessment



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Ashbourne Stormwater Assessment

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1 Introduction

1.1 Background

Southfront was engaged by Alexandrina Council to prepare a high level stormwater assessment regarding ongoing surface water and flood management issues in Ashbourne. This assessment will review all existing documentation, anecdotal evidence and physical catchment features to develop a flood and stormwater mitigation strategy roadmap to work towards resolving the issues outlined below.

Anecdotally, residents in Ashbourne have been repeatedly affected by both locally generated overland stormwater flows and flood flows from Bull Creek breaking its banks, with major events occurring in 2010, 2016 and most recently in 2022. Several houses in the town are known to have had stormwater/flood waters enter or very nearly enter their respective premises during the previous storm events.

A flood and stormwater assessment of the township was undertaken in 2011 by Australian Water Environments (*Bull Creek Ashbourne Stormwater and Flood Study, ref: 11091, V4, 30/05/2011).* That report analysed and modelled both the local stormwater catchments and Bull Creek itself, corroborating much of the anecdotal information. A number of flood mitigation strategies were recommended within the report, of which some have since been implemented.

An update to the flood study was warranted, given recent updates to hydrologic processes in the most recent version of *Australian Rainfall and Runoff* (2019), updates to *Bureau of Meteorology* rainfall data (2016) and improvements in two-dimensional modelling techniques. Updated modelling will inform the proposed flood mitigation options in Section 4.

A brief description of the catchment features and details of known flood/stormwater issues are outlined in the following sections.

1.2 Local Catchment Features

Details of the local catchment area were obtained from regional contour data, aerial drone survey (see Section 1.4) as well as engineering survey of Bull Creek Road, Kirkham Road and portions of the creek supplied by Council.

The local catchment areas which contribute flows are shown in Figure 1.1 below. As per the figure, the Ashbourne township is located on the southern banks of Bull Creek, at the base of the steep creek valley. The catchment area extends into the slopes south of the town, with a total area of approximately 1.2 km^2. Runoff from the catchment is directed straight into the swale and drainage system of Bull Creek Road, with eventual discharge into the creek.

Drainage infrastructure in Bull Creek Road was supplied by Council (via GIS database) and engineering survey. Drainage infrastructure within Bull Creek Road is made up of roadside swales and underground stormwater drainage which direct the majority of surface flows towards Kirkham Road at the south-west corner of town. The Bull Creek Road swale (on the southern side of the road) is intercepted by several driveway crossovers, most of which are generally 225 to 300mm in diameter. No swale or drainage system of note exists on the northern side of Bull Creek Road, with any stormwater that overtops the road likely to spill directly into properties on the northern side.

The majority of stormwater runoff from the town is directed into the paddock on the northern side of Kirkham Road. This area is shown to be low-lying and anecdotally ponds behind the road. A stormwater pipe under Kirkham Road directs water into a Council-owned drainage easement on the southern side of Kirkham Road (a recommendation from the 2011 AWE report). These flows are directed through the rear of approximately five properties to Christina Street. This is known to cause ongoing nuisance to the residents neighbouring the flow path.

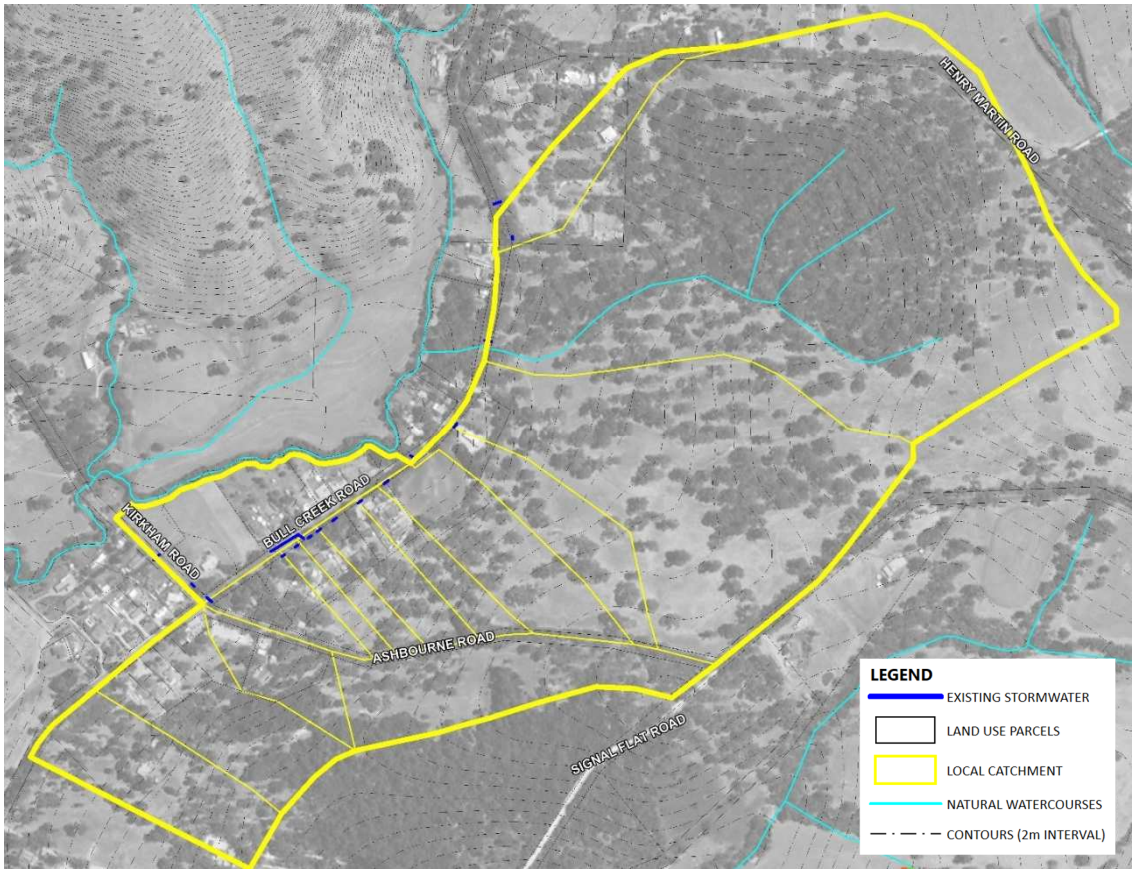


Figure 1.1 Local Catchment Areas

1.3 Bull Creek Catchment Features

The creek itself has been heavily modified over the years. A levee has been constructed on the southern side of the creek to protect residential development in the town. As per anecdotal and modelling information, the levee has been shown to be insufficient during the recent flood events.

The aerial survey (see Section 1.4) shows how the creek becomes perched as it meanders through Ashbourne, with the true low point of the valley at Kirkham Road centred between the creek channel itself and Bull Creek Road. This means that any flows that break out of the creek are unable to re-enter until much further downstream.

The Bull Creek catchment to Ashbourne is 42.42 square kilometres in size and almost entirely rural in nature. A figure of the catchment area is shown in Figure 2.1.

1.4 Aerial Survey Capture

Aerial survey of the study area was captured in February 2024 by Adelaide Drone Hire and covered the creek, floodplain and surrounding valley slopes of the town. The drone LiDAR was used to generate a Digital Terrain Model (DTM), as shown in the figure below.

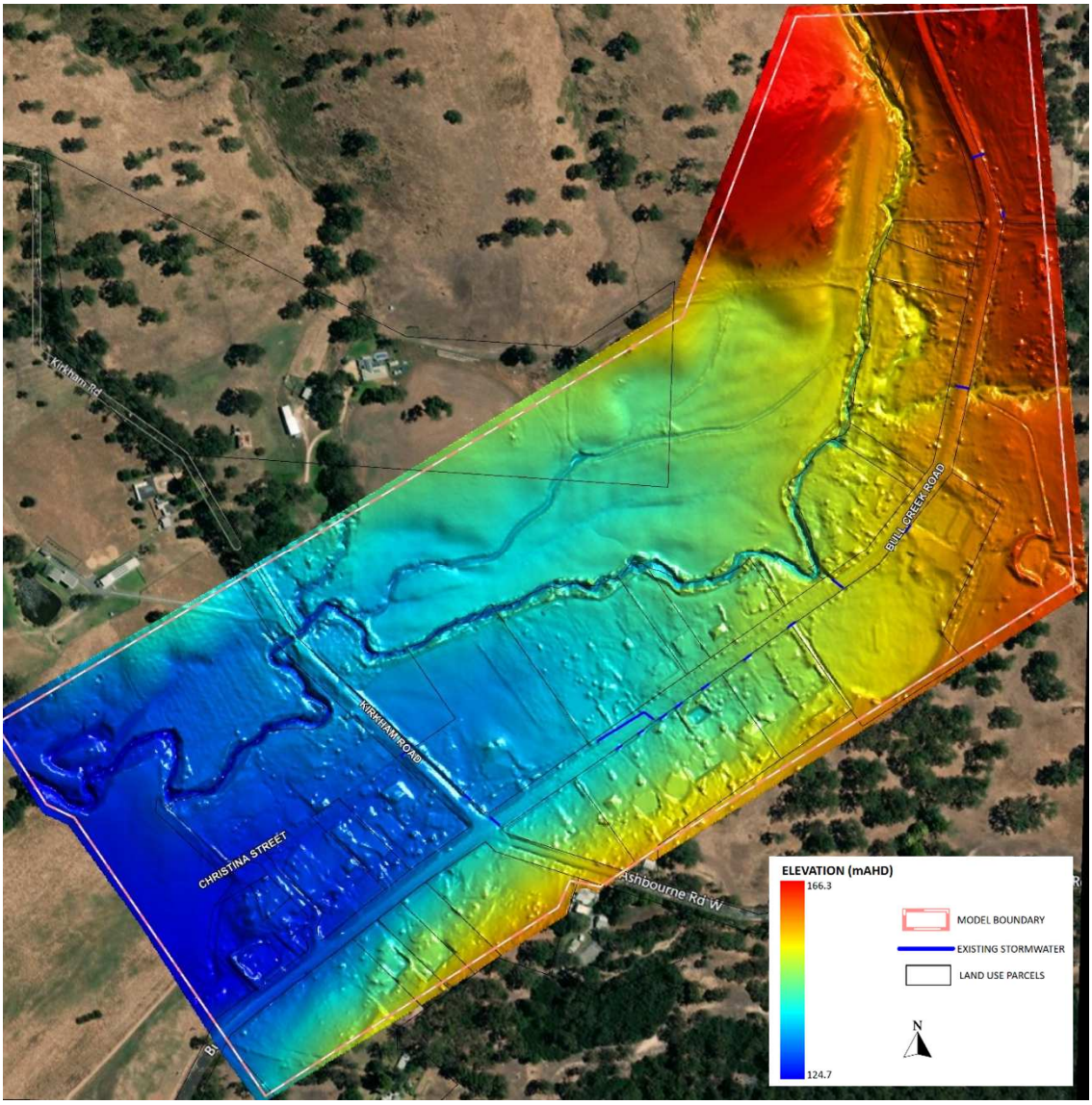


Figure 1.2 Digital Elevation Model (Aerial Survey)

1.5 Known Issues

A site visit was conducted in October 2023 with Southfront and Council staff to inspect the area and meet with several residents. Issues identified from the site visit are summarised below:

- Property at 1330 Bull Creek Road has experienced flood inundation damage during recent events. Damage mainly caused by overland flows originating from Bull Creek Road entering property from south and east (via neighbours' front yard).
- 1330 Bull Creek Road also impacted by breakout from creek over the levee system, approaching property from north.

- First breakout over Bull Creek Road occurs in the vicinity of the cross-culvert near where the creek dog-legs close to the road (adjacent to 1298 Bull Creek Road).
- Local catchment flows have been known to overtop Bull Creek Road and pass under the dwelling at 1298 Bull Creek Road.
- Flows have been known to build up behind Kirkham Road and pond in paddock on northern side.
- Kirkham Road was overtopped in the 2022 flood event, came close to entering properties on the southern side of the road.
- The existing drainage easement adjacent to 13 Kirkham Road is always soggy during winter and a nuisance to residents.

2 Hydrological Modelling

2.1 Local Catchment Modelling

2.1.1 Software Selection

Hydrological modelling of the local catchments in Ashbourne was undertaken using DRAINS. DRAINS computer modelling software is an industry standard tool used for the hydrological and hydraulic analysis of stormwater drainage systems. Hydrological parameters used within the model are outlined in the sections below. The catchment areas modelled within DRAINS are shown in Figure 1.1 above, and range from less than 1 to 47 hectares in size.

2.1.2 Hydrological Loss Parameters

Surface runoff is produced by rainfall excess which occurs at the ground surface when the rainfall intensity exceeds the infiltration capacity. The 'initial loss' and 'continuing loss' (IL/CL) model is a widely accepted method of estimating hydrological losses, whereby no runoff is assumed to occur until a given initial loss capacity has been exceeded (regardless of the rainfall rate), and continuing loss occurs at a constant rate thereafter.

Loss values for this region were obtained from Australian Rainfall and Runoff (ARR) DataHub online tool. It is noted that ARR losses are recommended for use in rural catchments only, unless in cases where the impervious area drops below 5% of the total Indirectly Connected Area (ARR 2019, Book 5). Local Ashbourne catchments are characterised by large rural residential blocks with significant pervious area surrounding relatively small dwellings. As such DataHub IL/CL values were adopted for this study and are as follows:

- Initial Loss: 26 mm
- Continuing Loss: 4.5 mm/hr

Times of concentration were selected based on a combination of Bransby-Williams equation for flow time within channels and Friend's equation for overland sheet-flow travel time.

The DRAINS model was executed for the 5%, 2% and 1% AEP storms and hydrographs were extracted for modelling of the local catchments within the hydraulic model, as per Section 3.

2.2 Rural Catchment Modelling

2.2.1 Software Selection

Hydrological modelling of the Bull Creek watercourse catchment was undertaken using the streamflow routing software RORB. The catchment does not have flow gauges, and therefore the RORB model was developed in line with guidance in *Australian Rainfall and Runoff* (ARR) 2019 and with reference to previous flood modelling undertaken for a previous flood study (AWE 2011).

RORB is a "general runoff and streamflow routing program used to calculate flood hydrographs from rainfall and other channel inputs. It subtracts losses from rainfall to produce rainfall-excess and routes this through catchment storage to produce runoff hydrographs at any location. It can also be used to design retarding basins and to route floods through channel networks." (Laurenson et al, 2010).

The sections below describe how the required model inputs were obtained, explain the structure of the model, and describe the process by which peak flows were estimated and benchmarked against regional estimates.

2.2.2 Model Structure

The RORB model was created using the MiRORB tool, which allows RORB models to be created within the MapInfo GIS environment. The catchment area was delineated by publicly available surface elevation data. Nodes were placed at subarea centroids and at the junction of any two watercourses. Nodes were then connected by RORB reaches, each representing the length of the watercourse between nodes. The catchment was assumed to be fully pervious. The model structure and catchment extent is shown in the figure below.

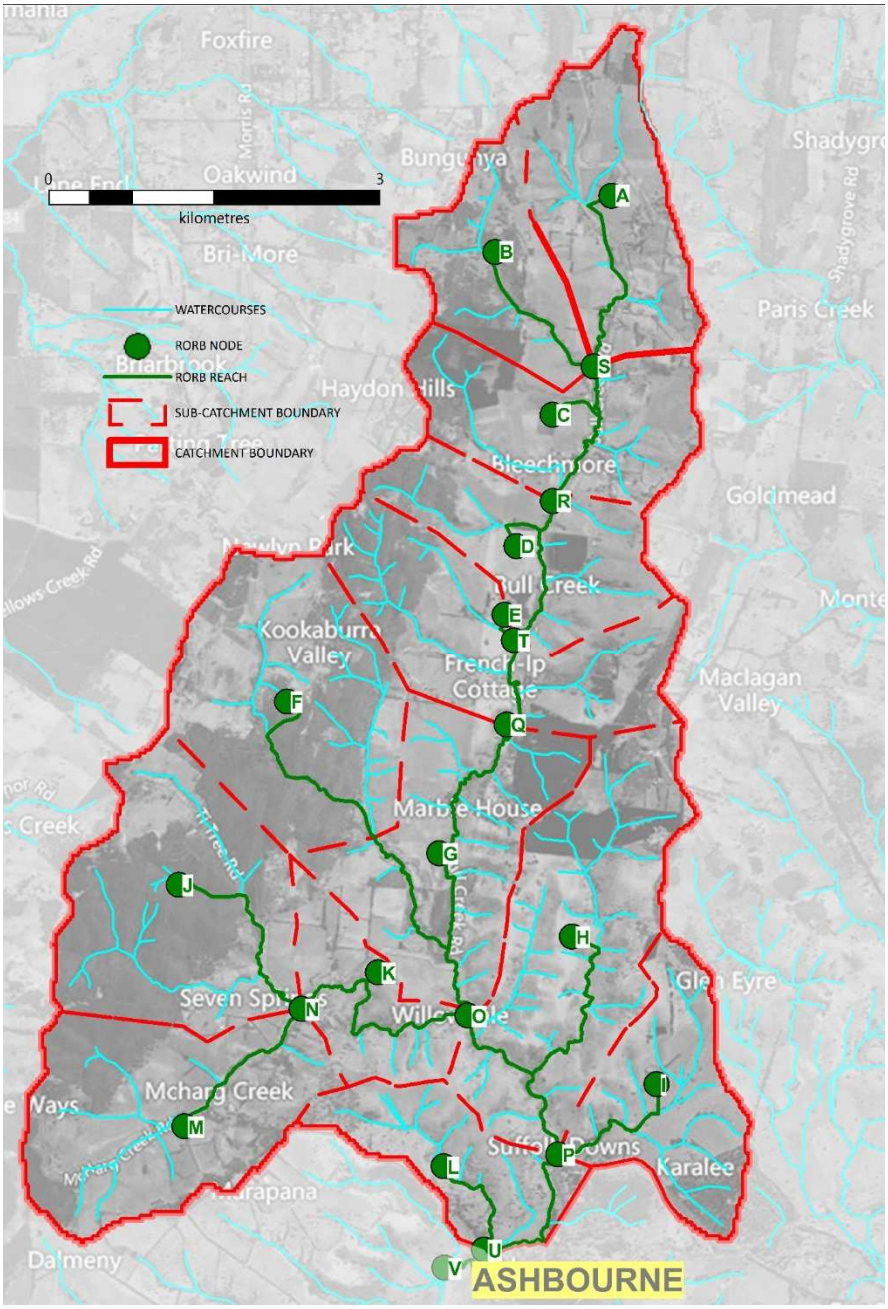


Figure 2.1 Bull Creek RORB model structure and catchment area to Ashbourne.

2.2.3 Model Parameters

The model parameters used in RORB are 'K_c' and 'm'. The parameter m is a dimensionless exponent used as a measure of a catchment's nonlinearity, and K_c is a dimensionless coefficient related to the storage within a catchment. The values used for K_c and m influence the size, shape and profile of an outlet hydrograph and are dependent on catchment features and stream lengths. The value of K_c is very dependent on the value of m and is the principal parameter used in RORB to calibrate the model. An m value of 0.8 is suggested in ARR 2019.

ARR 2019 recommends K_c be determined using the following equation, suitable for catchments smaller than 100 km² in the south-east region (Zone 6) of South Australia.

$$K_c = 0.60A^{0.67}$$

where A is the catchment area in km².

Table 2.1 shows the parameters adopted for each catchment, based on the above formula. The recommended m value of 0.8 has been used.

Table 2.1 Adopted RORB Model Parameters

Catchment	Area (km²)	K_c	m
Bull Creek	42.42	7.39	0.8

2.2.1 Model Losses

ARR 2019 recommends the IL/CL model as the most suitable for design flood estimation for rural catchments. ARR 2019 notes that most Australian studies of losses at catchment scale have found that both IL and CL do not vary with AEP. ARR 2019 therefore recommends that the IL and CL values used be kept the same for all AEPs unless there is specific evidence to suggest that there is a systematic variation of loss with AEP (ARR Book 5, Section 3.7.1).

The IL/CL model was adopted as the loss model to be used within RORB, and a single set of losses was used for all AEPs within the catchment model. The values for these parameters were obtained from the ARR Data Hub online service using the centroid of the Bull Creek catchment, the parameters are summarised in Table 2.2.

Table 2.2 ARR 2019 Recommended Loss Values

Catchment	Initial Loss (mm)	Continuing Loss (mm/h)
Bull Creek	26	4.5

2.2.2 Design Rainfall

Design rainfall values were obtained from the Data Hub online service provided by Australian Rainfall and Runoff. These were obtained for the centroid of the catchment, as well as temporal patterns specific to the Murray Basin sub-cluster. Point temporal patterns were utilised, in accordance with ARR 2019 Book 2 Section 5.9.1 which recommends the use of point temporal patterns for catchments smaller than 75 km².

2.2.3 Peak Flow Estimation

With the determined parameters, the RORB model was run as a Monte Carlo simulation using 100 runs over each rainfall interval and rainfall distribution discretised into 50 intervals across the range of AEPs and durations between 10 minutes and 48 hours.
Several alternate peak flow estimation methods were used, being a range of regional regressions developed for various parts of South Australia, allowing for comparison with the results of the RORB models.

The Regional Flood Frequency Estimation (RFFE) Model 2021 published by Australian Rainfall and Runoff was also used to estimate peak flows for the catchment. RFFE is a data-driven approach, in which the flood characteristics from a set of gauged catchments are transferred to ungauged catchments to produce peak flow estimates. The RFFE model is useful in that local rainfall and losses are used, but there are several key limitations.

The Eusuff High (1995) and Kemp Onkaparinga (Kemp 2003) peak flow estimates were generated using regression equations developed for the Mount Lofty Ranges. These regressions relate catchment area to peak flow, and therefore do not consider local factors such as losses and rainfall. Table 2.3 below show the peak flows calculated from the RORB model and the alternate methods for the Bull Creek catchment.

The previous flood study undertaken by AWE in 2011 was also used to compare peak flows over the different AEPs. Since that time, several changes to the industry standard approach to regional flood estimation has occurred. The AWE flood adopted the Eusuff (High) regression method.

Table 2.3 Bull Creek Catchment Peak Flow Summary (m^3/s)

AEP	RORB	RFFE	Eusuff (High)	Kemp (Onkaparinga)	RORB (Tonkin 1985)
5%	33.84	17.88	42.1	55.2	47.8
2%	54.90	24.68	50.2	74.94	73.3
1%	72.17	30.08	58.6	93.25	95.9

As presented above, RORB results are slightly higher than Eusuff (high) but lower than the Kemp Onkaparinga regression and Tonkin (1985) study. RFFE in this case is an outlier, likely due to inclusion of several catchments with differing characteristics to that of Bull Creek.

The design peak flows for the Bull Creek catchment are presented in Table 2.4 below alongside the corresponding storm duration and temporal pattern selected as the design storm.

Table 2.4 Bull Creek RORB Design Peak Flows (m^3/s)

AEP	Peak Flow (m^3/s)	Storm Duration	Depth	Temporal Pattern	Initial Loss Factor
5%	33.53	12 hour	71.3	12	1.53
2%	53.09	12 hour	85.5	28	0.35
1%	72.79	12 hour	100.1	29	0.49

Hydrographs for the design peak flows above were extracted from the RORB model for each AEP and applied to the hydraulic TUFLOW model, as described in following section.

It should be noted that, at this stage, climate change factors were not applied to the hydrologic modelling. It is recommended that a climate change sensitivity assessment (various climatic/emission scenarios and projections) be undertaken during design development of flood mitigation infrastructure to understand the full impact of how this would impact the performance of existing and proposed scenarios.

3 Hydraulic Modelling

3.1 Model Selection

Flood modelling was undertaken to determine the likely extent and behaviour of floodwaters generated from both the local and rural catchments upstream of Ashbourne. This was then used as the basis to determine appropriate flood mitigation measures to reduce the impact of high rainfall events.

Hydraulic flood modelling was undertaken using TUFLOW. TUFLOW (Two-dimensional Unsteady FLOW) is a computer program which is specifically orientated towards establishing flow and inundation patterns in rivers, floodplains and urban areas where the flow behaviour is essentially 2 dimensional (2D) in nature and cannot be represented using a 1D model. Model parameters and outcomes are described below.

3.2 TUFLOW Model Parameters

3.2.1 Model Extent

The area covered by the hydraulic model is centred on the residential areas of Ashbourne including Bull Creek and surrounding floodplain. The model covers an area of approximately 53 hectares.

3.2.2 2D Cell Size

Determining an appropriate 2D cell size to be used by TUFLOW requires a compromise between the accuracy of modelling necessary to sufficiently reproduce the hydraulic behaviour of the floodplain as well as limitations in computing power and processing time. A 1 metre cell size was chosen for the TUFLOW model as this size was found sufficient to define the major flow paths, creek channel and levee embankments within the study area.

3.2.3 Topography

Digital Elevation Model (DEM) was generated using the aerial drone survey (obtained by Adelaide Drone Hire in February 2024). This data was used to assign elevations to individual cells within the '2D domain' of the TUFLOW model. These elevations are assigned at the cell centres, corners and mid-sides to enable interaction with surrounding cells.

3.2.4 Bed Resistance Parameters

The bed resistance is an essential element used to define the flow and hence the water depth at any location within the 2D model domain. The bed resistance values represent Manning's Roughness Coefficient ('n' values) for various surface types within the study area.

3.2.5 Boundary Conditions

As part of the modelling, consideration was given to the boundary conditions within 2D domain at the edges of the model. The boundary condition adopted in the 2D domain was a 'HQ' (stage-discharge) type boundary with a water surface slope of 1.2%. The purpose of this approach was to allow water to 'disappear' once flood flows reached the model boundaries and ensure that results in the floodplain were not affected at model edges.

3.2.6 Inflows

The inflow hydrographs were derived from DRAINS and RORB modelling as per Section 2. The hydrographs for each storm event were applied as surface inflows in the 2D domain of the model area. This approach ensured that the entire inflow hydrograph for each catchment was applied to the model.

3.3 Surface Water Assessment – Existing Scenario

Flood maps for the 1% AEP event are presented in Appendix A. The maps show flooding depths and extents overlaid with aerial photography and key stormwater infrastructure.

Modelling results are validated by much of the anecdotal and historical evidence supplied by Council and Ashbourne residents described in Section 1.5. Flows from the local catchments are shown to overwhelm the swale on the southern side of Bull Creek before spilling over the road and into surrounding properties.

The model indicates stormwater flows from the local catchments eventually make their way to the northern side of the Kirkham Road, where they overtop the road and spill through several properties in an uncontrolled manner towards Christina Street. It should be noted that the critical storm durations for local catchments in the 1% AEP event is between 3 and 6 hours.

Flows from the creek are shown to spill over the existing levee at multiple locations. Breakouts are shown to mainly affect properties at the southern end of town which are in the low-lying areas of the valley. Analysis of flood timing indicates that much of the flows from the local catchments will pass through the system prior to that of the creek flows, resulting in misalignment of peak flows. It shows a number of these properties can be impacted initially by locally generated flows flows, only to be inundated again hours later by the creek in the same storm event.

The farmers' dam in the north-eastern end of the study area is shown to overtop, with flows spilling towards the town oval, affecting properties at the northern end of town.

It should be noted the flood maps presented do not represent past or historical flood events and are used for analysis and baseline comparison purposes only.

A number of flood mitigation options were considered to resolve flooding in Ashbourne. They are described in detail in the following section.

4 Flood Mitigation Strategies

Flood mitigation strategies from both locally generated stormwater and Bull Creek flows are outlined below. Each option was developed to provide minimum 1% AEP (1 in 100 year) flood protection standard to existing development in the town. Any future development in Ashbourne would need to refer to the flood model maps such that adequate protection measures can be applied. The flood mitigation options are described in detail below.

Flood mitigation strategies were inserted into the model to assess their performance and provide an indication of required extent and characteristics of each element. Proposed strategy flood maps are presented in Appendix B. All proposed upgrades are shown and labelled on the flood maps attached.

It should be noted that the area in the vicinity of Bull Creek Road and Kirkham Road intersection was assumed to be developed in the flood mitigation strategies. It is assumed this area was filled above existing flood levels and is unavailable for flood storage/conveyance. This area is indicated on the flood maps.

4.1 Bull Creek Flood Levee Upgrade

An upgrade of the Bull Creek flood levee (southern bank) is recommended from approximately 1312 Bull Creek Road to the southern end of town. Modelling indicates the existing levee is adequate along much of its length, however certain segments will require raising to provide a 1% AEP standard. The existing levee would generally need to be raised by up to 300 – 400mm in some locations on the northern side of Kirkham Road.

A new earthen levee is required on the southern side of Kirkham Road, along the Bull Creek embankment, where modelling indicates upstream levee upgrades will increase flood levels in this section of creek (as the floodplain through the town would no longer be engaged). Modelling shows the levee on the southern side of Kirkham Road would vary is size from 300mm high, up to 1 metre. It is expected the levee would form an earthen bank with gentle side slopes such that banks could be vegetated, mowed and maintained easily by both residents and Council.

The levee would also need to be continued over Kirkham Road itself to remain effective. An assessment of required levee levels indicates that Kirkham Road could be lifted such that it achieves the required flood protection levels while also maintaining trafficability to the other side of the creek.

4.2 Creek Overland Flow Bypass Channels

High-flow bypass channels are recommended at two locations along the creek alignment to take advantage of floodplain features on the northern side of the creek to assist in lowering flood levels in the main creek channel. The upstream high-flow bypass is located north of the town, where it is recommended a levee on the northern side of the creek channel be removed to allow earlier engagement of a historical flow channel through the paddock. This is effective at lowering 1% AEP flood levels downstream by up to 400mm and reduces the required levee bank upgrade level at its northern end by up to 100mm. It is expected the high-flow bypass channel would only be engaged in large rainfall events and allow for continued cropping and access to the paddock. The bypass channel excavation would be required for approximately 150 metres into the paddock from the creek channel.

The second location is immediately downstream of Kirkham Road bridge. Similar to the northern section, this will take advantage of historical flow patterns through the floodplain on the northern side of the creek and be effective at reducing flood levels in the main creek channel. The extent of both flow bypass channels are shown on the flood maps.

4.3 Bull Creek Road Drainage Upgrade

Both modelling and anecdotal evidence indicate that once the capacity of the existing swale on the southern side of Bull Creek Road is exceeded, flows will overtop the road and enter properties either side of the road. As such an upgrade of the Bull Creek Road drainage system is recommended.

Three drainage alignment options were considered as part of the Bull Creek drain upgrade. Each upgrade starts at the Town Oval and connects to the existing roadside swale in Bull Creek Road to divert flows from into the proposed drain. The three alignments are described below. Each of the options were modelled within the 2D hydraulic flood model and are shown in Appendix B.

4.3.1 Option 1: Bull Creek Road to Kirkham Road Paddock

This option considers a new drain in Bull Creek Road from the town oval to Kirkham Road, discharging into the creek channel. The pipe is to discharge into the creek on the southern side of Kirkham Road as flood levels are significantly lower on that side of the road in the 1% AEP event. A 'non-return' flap gate is required on the pipe outlet as 1% AEP flows will exceed existing surface levels behind the proposed flood levee. For this option a flood storage in the paddock on the northern side of Kirkham Road is required to store and retain locally generated flows until flood levels in the creek recede and allow for the main outlet drain to be activated.

The size of the drain would range from 675 mm diameter to 1050 mm diameter.

4.3.2 Option 2: Bull Creek Road to southern paddock

This option considers the new Bull Creek Road drain from the Town Oval through to the southern end of town, discharging into the paddock south of Christina Street. A new outlet (with non-return flap gate) at Kirkham Road into the creek is also required for this option to manage locally generated flows on the northern side of Kirkham Road (behind the levee). No flood detention basin is required for this option as the majority of local catchment flows are diverted to the south of town.

A flood retention basin and flow spreader would be required for this option where the new drain discharges into the southern paddock. This is to prevent concentrated flows from the new drain causing scour and damages to the receiving paddock, south of town.

The size of the drain would range from 675 mm diameter to 1200 mm diameter.

4.3.3 Option 3: Bull Creek Road to southern paddock via Kirkham Road

This option, like Option 2, considers a new Bull Creek Road drain from Town Oval to the southern paddock. However, the drain alignment follows the existing flow path, from Kirkham Road through the rear of several properties to Christina Street before discharging into the southern paddock. A channel excavation would be required for the pipe to daylight south of

Christina Street, with flows to be diverted into a flood retention/flow spreader basin in the southern paddock.

An easement through the properties between Kirkham Road and Christina would be required. Drainage construction would require removal of all structures (sheds, rainwater tanks, gardens, etc) within the drainage path. The size of the drain would range from 675 mm diameter to 1200 mm diameter.

A summary of the pros and cons for each option is listed in the table below.

Table 4.1 Bull Creek Road Drainage Options – Pros and Cons

Option	Pros	Cons
Option 1 - Bull Creek Road to Kirkham Road Paddock	Cheapest option, least amount of road works, hard engineering solutions	Requires flood storage in paddock and new outlet into Bull Creek
	Provides 1% AEP flood protection standard	Required acquisition and excavation of paddock on northern side of Kirkham Road
	Least roadworks, community disturbance	All minor/frequent flows from local catchments will continue to pass through Kirkham Road (though redirected to creek/basin)
Option 2 - Bull Creek Road to southern paddock	Provides 1% AEP flood protection standard	Most expensive option, most amount of roadwork, pipework
	Requires least amount of land acquisition or new easements	Requires new outlet into Bull Creek
	Operation of Bull Creek Road drainage independent of creek flood levels	Requires flood retention and flow spreader, potential issues at new drain outlet south of Christina Street (frequent, concentrated flows)
Option 3 - Bull Creek Road to southern paddock via Kirkham Road	No new outlet into Bull Creek, operation of drain independent of creek flood levels	Major community disturbance, new easements through private property
	Not as expensive as Option 2	Requires flood retention and flow spreader, potential issues at new drain outlet south of Christina Street (frequent, concentrated flows)
	Provides 1% AEP flood protection standard	

4.4 Farm Dam Spillway Upgrade

The farm dam east of the town oval has a large upstream rural catchment area which, in large rainfall events, generates significant runoff. Modelling indicates that when the farm dam spills, the flow path leads directly into properties at the north of the town oval. As such, it is recommended the farm dam spillway be upgraded to accommodate flows up to the 1% AEP, directing them to the existing natural channel to the north.

Modelling indicates this would resolve much of the flooding issues at the northern end of town (in conjunction with the Bull Creek Road drainage upgrade). As additional flows are directed

north, however, this will require upgrade of the existing Bull Creek Road culvert crossing. This is described below.

4.5 Bull Creek Road culvert upgrade (or flood detention)

Upgrade of the Bull Creek Road culvert (north of farm dam) is required to accommodate additional flows from the spillway upgrade. It is estimated the culvert would need to be 1800mm in diameter, or twin 1200mm pipes.

Alternatively, a new embankment on the upstream side of the culvert could detain flows, negating the need for a costly culvert upgrade. Modelling shows this, with the flow creek bypass works, will result in lower flood levels throughout the northern end of town in the 1% AEP event.

4.6 Roadside Swales

Minor upgrades to roadside swales on Ashbourne Road and Bull Creek Road are also recommended to manage locally generated flows in order to direct them into proposed drainage infrastructure. The swale locations are shown on the flood maps in Appendix B.

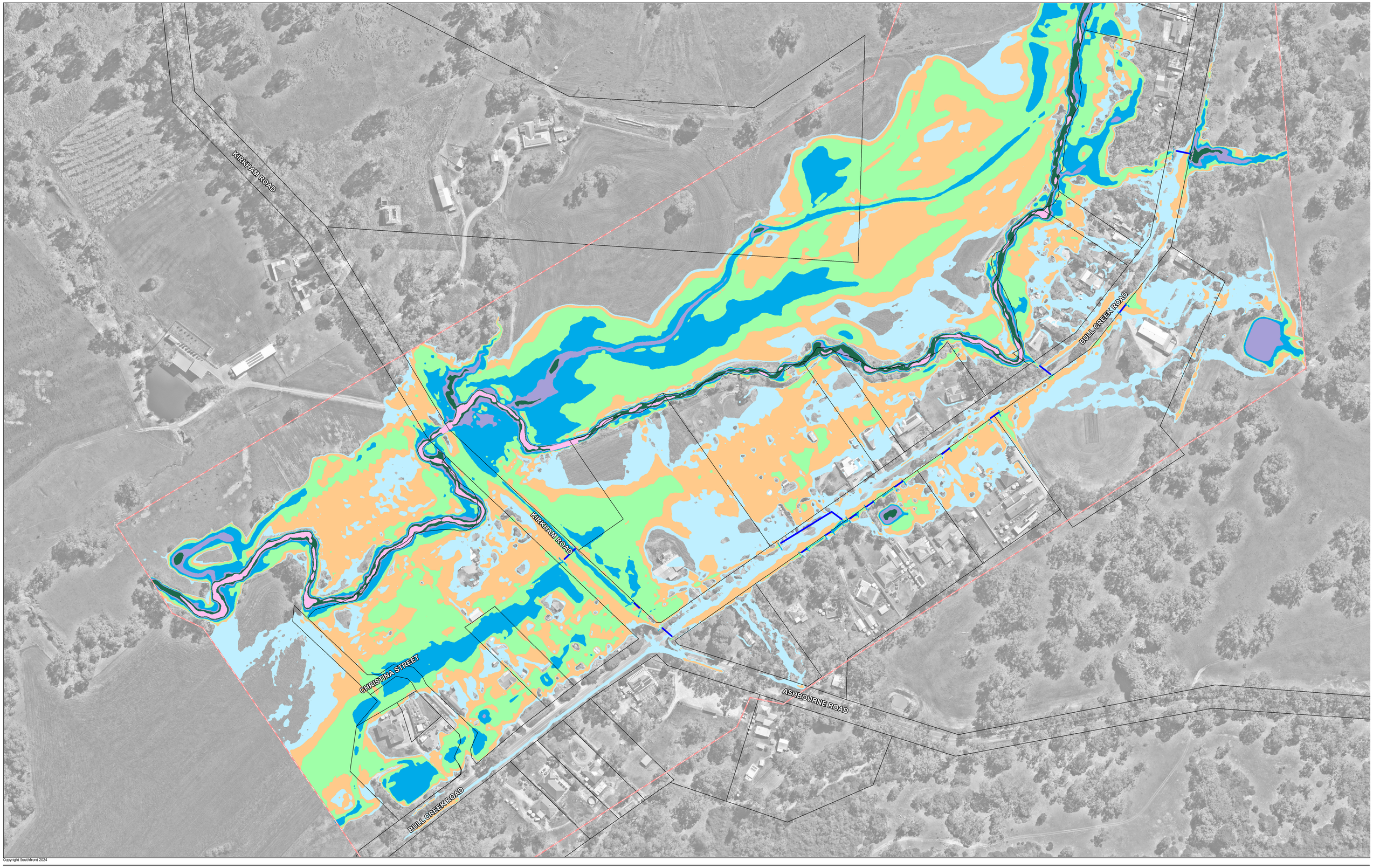
4.7 Bull Creek Vegetation Maintenance

It is recommended large trees of exotic species be cleared from the creek channel over time. Heavy vegetation reduces the capacity of the creek channel and therefore the effectiveness of the creek to convey flows. Council should place creek clearing and levee inspection into their annual maintenance programme to ensure ongoing monitoring and performance of the creek and levee banks.

Appendix A

Existing Scenario Flood Mapping





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Data Sources:
Data SA (Roads, Land Use)
Southfront (Flood strategies)
Near Map: Aerial Photograph

LEGEND

- EXISTING STORMWATER
- MODEL BOUNDARY
- LAND USE PARCELS

FLOOD DEPTH CONTOUR BAND

- 0.025 - 0.1 m
- 0.1 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1.0 m
- 1.0 - 1.5 m
- 1.5 - 2.5 m
- 2.5 - 5.0 m
- >5.0 m

N

0 0.1
kilometres
Scale 1:1,500

southfront

ALEXANDRINA COUNCIL

ASHBOURNE STORMWATER ASSESSMENT

EXISTING SCENARIO 1% AEP FLOOD MAP

Appendix B

Flood Mitigation Strategies

Options 1, 2 & 3



HIGH -LEVEL OVERFLOW PATH TO
REDUCE DOWNSTREAM FLOOD LEVELS

BULL CREEK CULVERT UPGRADE

RAISED SECTION OF KIRKHAM ROAD
TO MATCH LEVEE LEVELS

HIGH-LEVEL OVERLAND FLOW PATH

FLOOD LEVEE UPGRADE

FARM DAM SPILLWAY UPGRADE

NEW FLOOD LEVEE DOWNSTREAM OF KIRKHAM ROAD

NEW FLOOD DETENTION BASIN IN PADDOCK

EXISTING SWALE AND DRIVEWAY CROSSOVERS

NEW OUTLET TO CREEK

NEW PIPE IN BULL CREEK RD TO KIRKHAM RD

POSSIBLE FUTURE RESIDENTIAL SUBDIVISION
(FILLING ABOVE FLOOD LEVEL REQUIRED)

FORMALISE ROADSIDE SWALES

FORMALISE ROADSIDE SWALE ON NORTHERN SIDE
OF BULL CREEK ROAD

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Data Sources:
Data SA (Roads, Land Use)
Southfront (Flood strategies)
Near Map: Aerial Photograph

LEGEND

- EXISTING STORMWATER
- LAND USE PARCELS
- AB_Opt1_Rev2
- PIPE UPGRADE
- CHANNEL/SWALE UPGRADE
- LEVEE UPGRADE
- DETENTION BASIN FOOTPRINT
- MODEL BOUNDARY

FLOOD DEPTH CONTOUR BAND

- 0.025 - 0.1 m
- 0.1 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1.0 m
- 1.0 - 1.5 m
- 1.5 - 2.5 m
- 2.5 - 5.0 m
- >5.0 m

N

0 0.1
kilometres
Scale 1:1,500

ALEXANDRINA COUNCIL

ASHBOURNE STORMWATER ASSESSMENT

PROPOSED STRATEGIES - OPTION 1
1% AEP FLOOD MAP

CREEK OVERFLOW PATH TO
REDUCE FLOOD LEVELS DOWNSTREAM

BULL CREEK CULVERT UPGRADE

RAISED SECTION OF KIRKHAM ROAD
TO MATCH LEVEE LEVELS

CREEK OVERLAND FLOW FORMAISED

FLOOD LEVEE UPGRADE

FARM DAM SPILLWAY UPGRADE

NEW OUTLET TO CREEK

NEW FLOOD LEVEE DOWNSTREAM OF KIRKHAM ROAD

NEW KIRKHAM RD SWALE TO NEW OUTLET

SWALE AND DRIVEWAY CROSSOVERS

NEW PIPE IN BULL CREEK RD TO SOUTH OF TOWN

POSSIBLE FUTURE RESIDENTIAL SUBDIVISION
(FILLING ABOVE FLOOD LEVEL REQUIRED)

FORMALISE ROADSIDE SWALE

FLOOD DETENTION AND FLOW SPREADER

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Data Sources:
Data SA (Roads, Land Use)
Southfront (Flood strategies)
Near Map: Aerial Photograph

LEGEND

- EXISTING STORMWATER
- LAND USE PARCELS
- AB_Opt1_Rev2
- PIPE UPGRADE
- CHANNEL/SWALE UPGRADE
- LEVEE UPGRADE
- DETENTION BASIN FOOTPRINT
- MODEL BOUNDARY

FLOOD DEPTH CONTOUR BAND

- 0.025 - 0.1 m
- 0.1 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1.0 m
- 1.0 - 1.5 m
- 1.5 - 2.5 m
- 2.5 - 5.0 m
- >5.0 m

N

0 0.1
kilometres
Scale 1:1,500

southfront

ALEXANDRINA COUNCIL

ASHBOURNE STORMWATER ASSESSMENT

PROPOSED STRATEGIES - OPTION 2
1% AEP FLOOD MAP

CREEK OVERFLOW PATH TO
REDUCE FLOOD LEVELS DOWNSTREAM

BULL CREEK CULVERT UPGRADE

RAISED SECTION OF KIRKHAM ROAD
TO MATCH LEVEE LEVELS

CREEK OVERLAND FLOW FORMAISED

FLOOD LEVEE UPGRADE

FARM DAM SPILLWAY UPGRADE

NEW FLOOD LEVEE DOWNSTREAM OF KIRKHAM ROAD

NEW KIRKHAM RD SWALE TO EASEMENT

SWALE AND DRIVEWAY CROSSOVER

NEW PIPE IN BULL CREEK RD TO CHRISTINA ST

FORMALISE ROADSIDE SWALE

POSSIBLE FUTURE RESIDENTIAL SUBDIVISION
(FILLING ABOVE FLOOD LEVEL REQUIRED)

OUTLET CHANNEL TO DETENTION/FLOW SPREADER

EASEMENT FROM KIRKHAM RD TO CHRISTINA ST

FLOOD DETENTION AND FLOW SPREADER

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Data Sources:
Data SA (Roads, Land Use)
Southfront (Flood strategies)
Near Map: Aerial Photograph

LEGEND

- EXISTING STORMWATER
- LAND USE PARCELS
- AB_Opt1_Rev2
- PIPE UPGRADE
- CHANNEL/SWALE UPGRADE
- LEVEE UPGRADE
- DETENTION BASIN FOOTPRINT
- MODEL BOUNDARY

FLOOD DEPTH CONTOUR BAND

- 0.025 - 0.1 m
- 0.1 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1.0 m
- 1.0 - 1.5 m
- 1.5 - 2.5 m
- 2.5 - 5.0 m
- >5.0 m

N

0 0.1
kilometres
Scale 1:1,500

southfront

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ASHBOURNE STORMWATER ASSESSMENT

PROPOSED STRATEGIES - OPTION 3
1% AEP FLOOD MAP