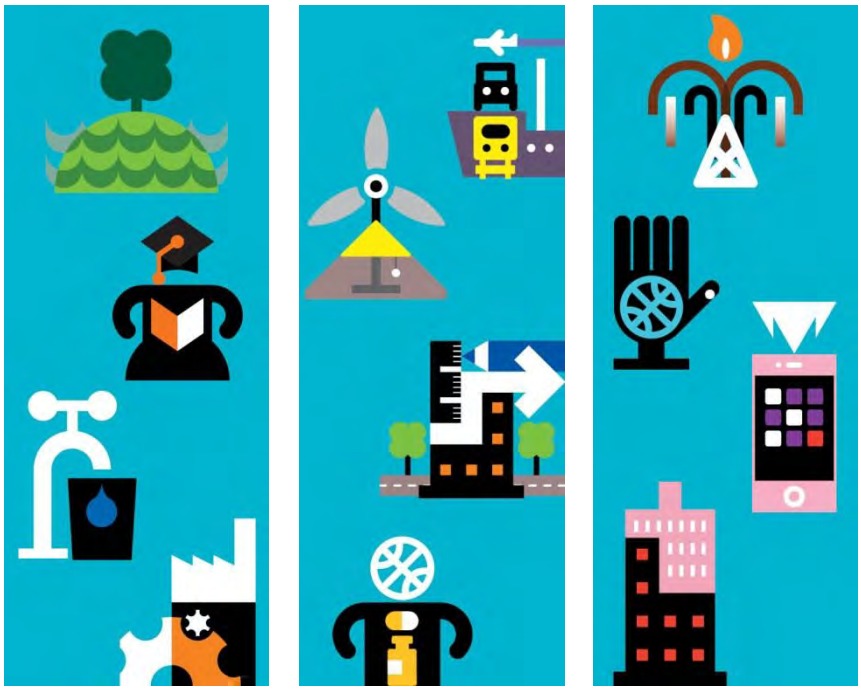


Banksia Priority Precinct

Desktop Literature Review
Flooding and Drainage

October 2016

NSW Department of Planning and Environment

Mott MacDonald

Banksia Priority Precinct

Desktop Literature Review
Flooding and Drainage

October 2016

NSW Department of Planning and Environment

Mott MacDonald, L10, 383 Kent Street, Sydney NSW 2000, Australia
PO Box Q1678, QVB Sydney NSW 1230, Australia
T +61 (0)2 9098 6800 F +61 (0)2 9098 6801 W www.mottmac.com

Issue and revision record

Revision	Date	Originator	Checker	Approver	Description
A	21.08.2015	N. Franklin, J. Taylor	G. Lee	C. Avis	Draft
B	27.08.2015	N. Franklin, J. Taylor	G. Lee	C. Avis	Final
C	01.09.2015	N. Franklin, J. Taylor	G. Lee	C. Avis	Final
D	02.10.2015	N. Franklin, J. Taylor	G. Lee	C. Avis	Final
E	13.10.2015	N. Franklin, J. Taylor	G. Lee	C. Avis	Final
F	13.10.2016	N. Franklin, J. Taylor	G. Lee	C. Avis	Minor Amendments
G	28.10.2016	G.Lee	G. Lee	C. Avis	Minor Updates

Contents

Figures

1 Introduction

1.1 Purpose of This Document

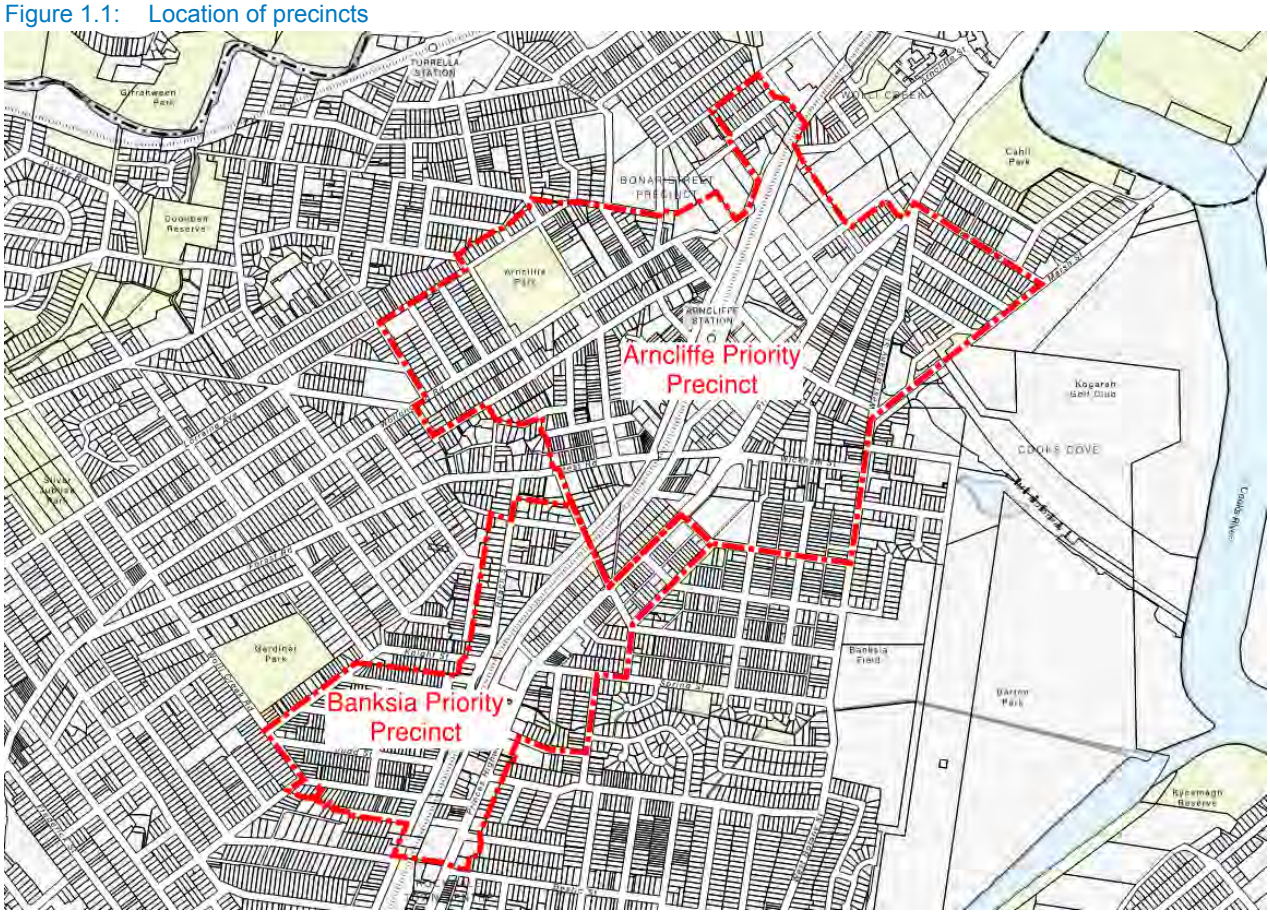
Mott MacDonald has undertaken an assessment for the New South Wales Department of Planning and Environment on the existing flooding and stormwater drainage conditions in and around the Arncliffe and Banksia Priority Precincts.

This document focuses on the Banksia Priority Precinct and is an interim report which describes the existing flood studies, opportunities and constraints pertaining to drainage, and initial recommendations for the precinct proposal.

1.2 Site Location

The Arncliffe and Banksia Priority Precincts are located in Sydney's south, approximately 10-12km from the Sydney CBD. They occupy an area along the Princes Highway Corridor extending from Wolli Creek to Rockdale Town Centre and Banksia and Arncliffe Train Stations. The Precincts are located within the Rockdale City Council Local Government Area. See Figure 1.1 for the precinct locations.

Figure 1.1: Location of precincts



355324/NSW/SYD/3/E 13 October 2015
P:\Sydney\Projects\35xxxx\355324\04 Working\02 Documents\Civil\Document 2 - Lit Review Separate Reports\02 Banksia Report\355324 161013 Banksia Flood & Drainage Review_Rev G.docx

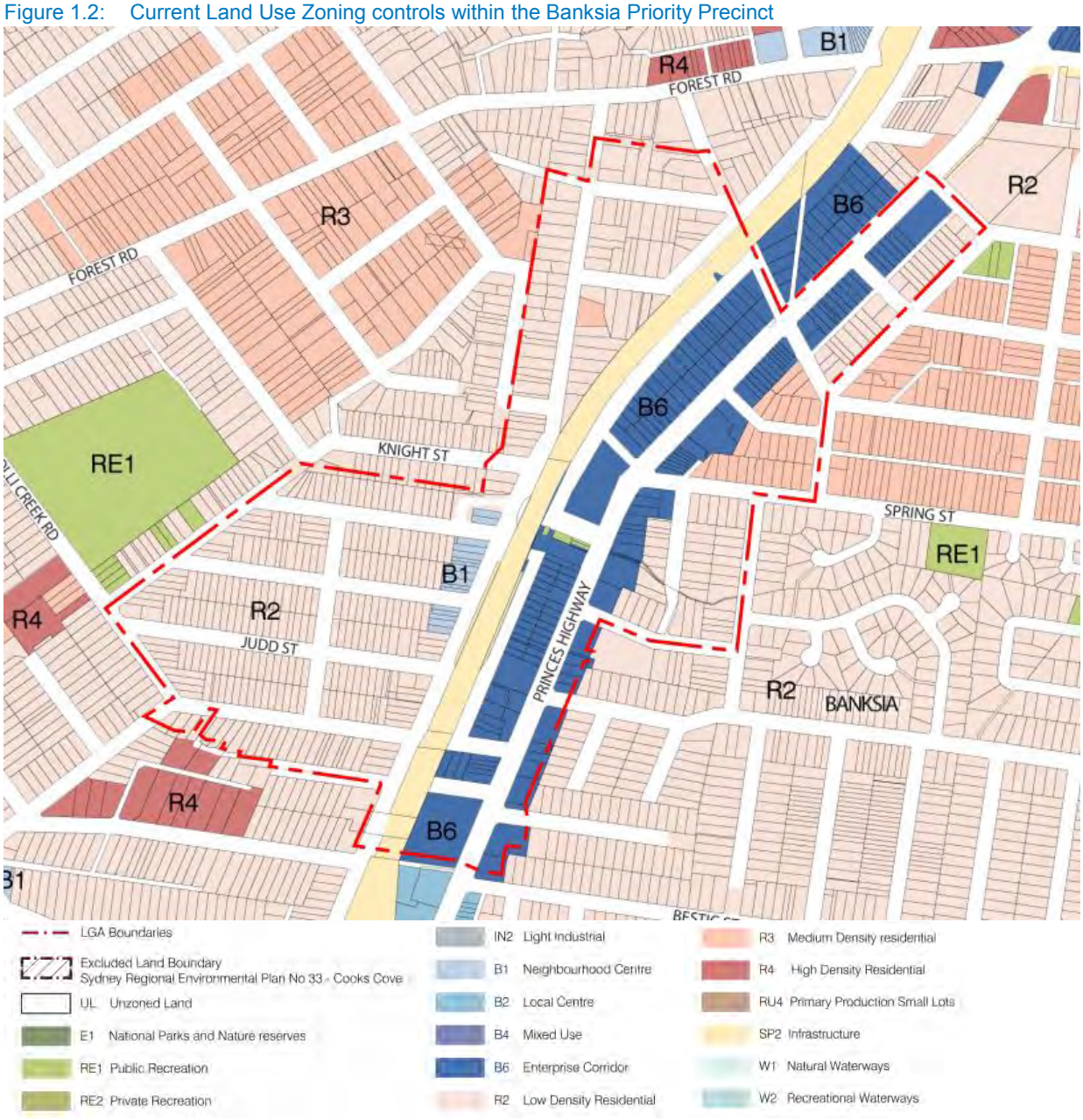
The location of the Arncliffe and Banksia Priority Precincts along the Princes Highway defines them as a key gateway along the main north / southern route through Sydney. The Precincts are well serviced by public transport, being centrally located around Arncliffe and Banksia Train Stations. From these stations, ready access to Central Station and the wider Sydney Train network can be achieved. The Banksia Priority Precinct forms the southern portion of the overall Precincts bordering Gardiner Park and encompassing Banksia Station and the surrounding residential and mixed use property.

1.3 Precinct Description

The Arncliffe and Banksia Priority Precincts have been identified by the NSW Government in conjunction with Rockdale City Council as key precincts for development. The precincts comprise a total area of approximately 200ha.

The current land use zoning controls in the Banksia Priority Precinct is shown in Figure 1.2. From the figure it can be seen that the majority of land use zoning within the precincts is predominantly low density residential with some large and small pockets of medium and high density residential respectively. Moderate areas of mixed use zoning around Arncliffe Station and a small zoning of Neighbourhood Centre adjacent Banksia Station are present.

Figure 1.2: Current Land Use Zoning controls within the Banksia Priority Precinct

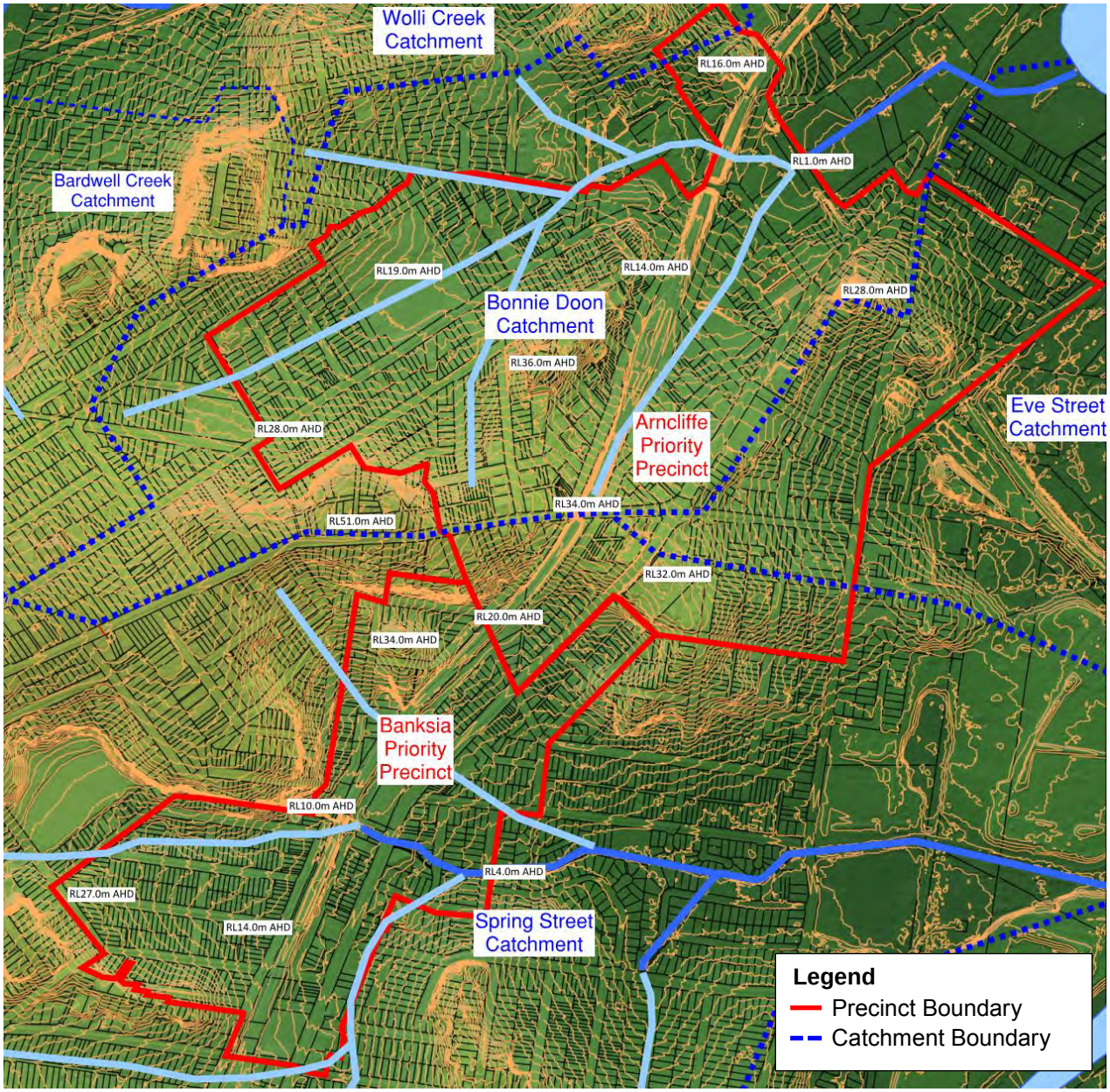


Source: *Arncliffe and Banksia Urban Activation Precinct Background and Initial analysis, Architectus Group/ Gallagher Studio*

The topography of the combined precincts and surrounding areas is generally undulating in a north-south direction, with some fall towards the east and the Cooks River. A crest, generally along Forest Road, west of the rail line forms a ridge line, and defines the two dominant catchments housing the precincts; being the Bonnie Doon Catchment, which holds the majority of the Arncliffe Priority Precinct, and the Spring Street Catchment which holds all of the Banksia Priority Precinct, as well as a small portion of the Arncliffe Priority Precinct. The Arncliffe Priority Precinct touches on the Wolli Creek Catchment boundary to the north. A fourth catchment to the east, the Eve Street Catchment holds the remaining portion of the Arncliffe Priority Precinct. Figure 1.3 shows the precinct locations in relation to these catchments.

The Bonnie Doon Catchment has two main flow paths. The northern flow path starts at the vicinity of the intersection of Lorraine Avenue and East Street which is external to the Arncliffe Priority Precinct boundary. From here it traverses Arncliffe Park with a number of flows contributing along the way. It then runs beneath the rail line at the Wollongong Rd/ Allen St underpass. The southern tributary generally starts at Arncliffe station, on the eastern side of the rail line and runs largely parallel to it, deviating to the east and converging with the northern tributary around the location of the existing Rockdale Mazda and Ford Service Centres (the intersection of Allen and Argyle Streets) to form the Bonnie Doon Channel. The channel then continues along the alignment of the Princes Hwy, traverses the northern section of Cahill Park and joins the Cooks River.

Figure 1.3: Topography, Catchments and Creek Lines



Source:
- *Catchment Boundaries: Rockdale Technical Specification, Stormwater Management*
- *Topography and Cadastre: Rockdale Council GIS data*
- *Creek Lines: Gallagher Studios/Architectus Group*

The Spring St Catchment covers a larger area than the Bonnie Doon Catchment, though a number of sub-catchments do not impact the precincts directly. There are two main tributaries through the Banksia Priority Precinct. The northern tributary, which also accommodates the small portion of the Arncliffe Priority Precinct, starts generally along Mount St, external the Banksia Priority Precinct boundary, crossing Roach Street and passing beneath the rail line where it deviates south, to join the Spring Canal, around the intersection of Chestnut Dr and Short St. The southern tributary generally starts at Oswell St, again outside of the Banksia Priority Precinct boundary, crosses the southernmost tip of Gardiner Park, continuing to Subway Road where it passes beneath the rail line and becomes the Spring Canal at confluence with the northern tributary. A small sub-catchment in the south of the Banksia Priority Precinct collects flows from generally Judd and Kimpton Streets and conveys them beneath the rail line at Kimpton St and again converging at the start of the Spring Canal. The Spring Canal joins Muddy Creek which then joins The Cook River.

The Eve Street Catchment is relatively low lying along the Cooks River consisting primarily of the Eve Street Wetland, Kogarah Golf Course and Cahill Park and has capacity issues with the drainage network. There are no clearly defined drainage channels, though the area of the Arncliffe Priority Precinct lying within the Eve Street Catchment is generally split around the intersection of West Botany Street and Marsh Street and falls north to Cahill Park and south to the Eve Street Wetland.

1.4 Proposed Works

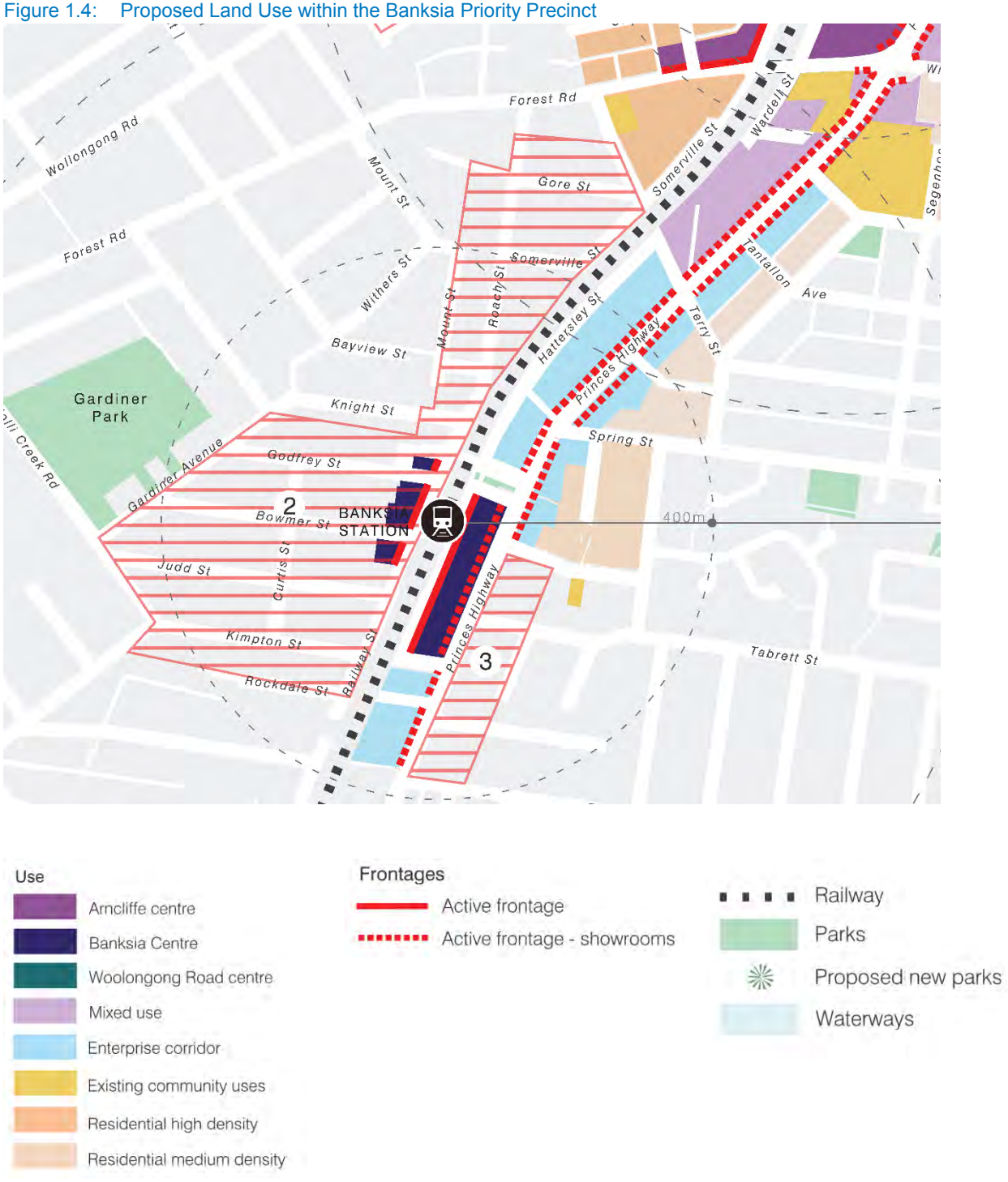
The Arncliffe and Banksia Priority Precincts will be a vibrant and well planned town centre around Arncliffe and Banksia train stations. The new centre will include more restaurants and cafes, open spaces and parks, and more residencies.

The existing retail areas of Banksia and Arncliffe will extend east across the railway. There will be a greater local centre focus around Arncliffe Park, joining the existing areas of shops and the potential for new local facilities around Gardiner Park providing an improved focus and entry to the park.

The Princes Highway corridor will continue to focus on large-format commercial uses at ground floor with the potential for some residential uses above and set back from the street.

Proposed development will include an increased building height and potential site consolidation. Increasing building height will provide opportunities for offices and residential units. The greatest increase in building density in the Banksia Priority Precinct will be along the Princes Highway Corridor.

Figure 1.4: Proposed Land Use within the Banksia Priority Precinct



Source: APP Corporation

Figure 1.5: Proposed Building Heights within the Banksia Priority Precinct

Source: *APP Corporation*

1.5 Applicable Standards and Guidelines

Local Government Area (LGA) controls:

- Rockdale City Council's *Rockdale Technical Specification, Stormwater Management*, adopted 4 May 2011, effective 5 December 2011;
- Rockdale City Council's *Rockdale Development Control Plan 2011*, Amendment number 2 dated 5/6/2013, effective 20/6/2013;
- *Rockdale Local Environmental Plan 2011*, version 8 January 2015;

State-wide (NSW) controls:

- *Environmental Planning and Assessment Act 1979 No 203*, version 5 March 2015;

2 Historical Studies

2.1 List of Studies

- *Spring Street Drain, Muddy Creek and Scarborough Ponds Drainage Catchments 2D Flood Study Review*, BMT WBM Pty Ltd, In-Progress
- *Gardiner Park Detention Basin, investigation and concept design*, Cardno NSW/ACT, 2010
- *Spring Street Drain - Piped Drainage and Overland Flow Analysis*, Brown Consulting, Ref. X04184-01E, October 2007;
  - *Spring Street Drain - Piped Drainage and Overland Flow Analysis - Supplementary Report*, Brown Consulting, Ref. X04184-02C, October 2007;
- *Floodplain Management Study, Spring Street Drain, Muddy Creek and Scarborough Ponds*, Final Report (*Volume 1 – Report* and *Volume 2 – Appendices*),Willing & Partners, Ref. 3808, January 2000;

2.2 Supplementary Data

- GIS Data provided by Rockdale City Council;

3 Banksia Priority Precinct

3.1 Summary of Historical Studies

3.1.1 Spring Street Drain, Muddy Creek and Scarborough Ponds Drainage Catchments 2D Flood Study Review, BMT WBM Pty Ltd, In-Progress

BMT WBM Pty Ltd is currently undertaking a 2D flood study of the above identified catchments. Limited information has been provided for review, with the investigation anticipated to be finalised later this year. Council has provided provisional results for design (1% AEP, CSD) run for the Spring Street Catchment around Banksia shown in Figure 3.1 below.

Figure 3.1: Spring Street Drain, Muddy Creek and Scarborough Ponds Drainage Catchments 2D Flood Study Review, BMT WBM Pty Ltd, In-Progress

Source: BMT WBM Pty Ltd

From the above figure it can be seen that there is considerable ponding, averaging one metre along Railway Street, against the rail corridor, with depths reaching four metres at the underpass from Godfrey Street. A number of overland flow paths are evident including through properties from Gardiner Avenue to

the Subway Road underpass, along the Princes Highway generally from Bestic Street to Tabrett Street then to Short Street crossing Banksia Avenue before discharging to the Spring Street Channe and generally from Rockdale Mazda on Hattersley Street, crossing the Princes Highway and onto Spring Street at Marinea Street. Most depths are observed to be half a metre or less, with some isolated areas reaching one metre. It is important to note that these findings are preliminary and are subject to further study and as such should not be relied upon. When finalised, the study will provide further guidance on Flood Risk Planning.

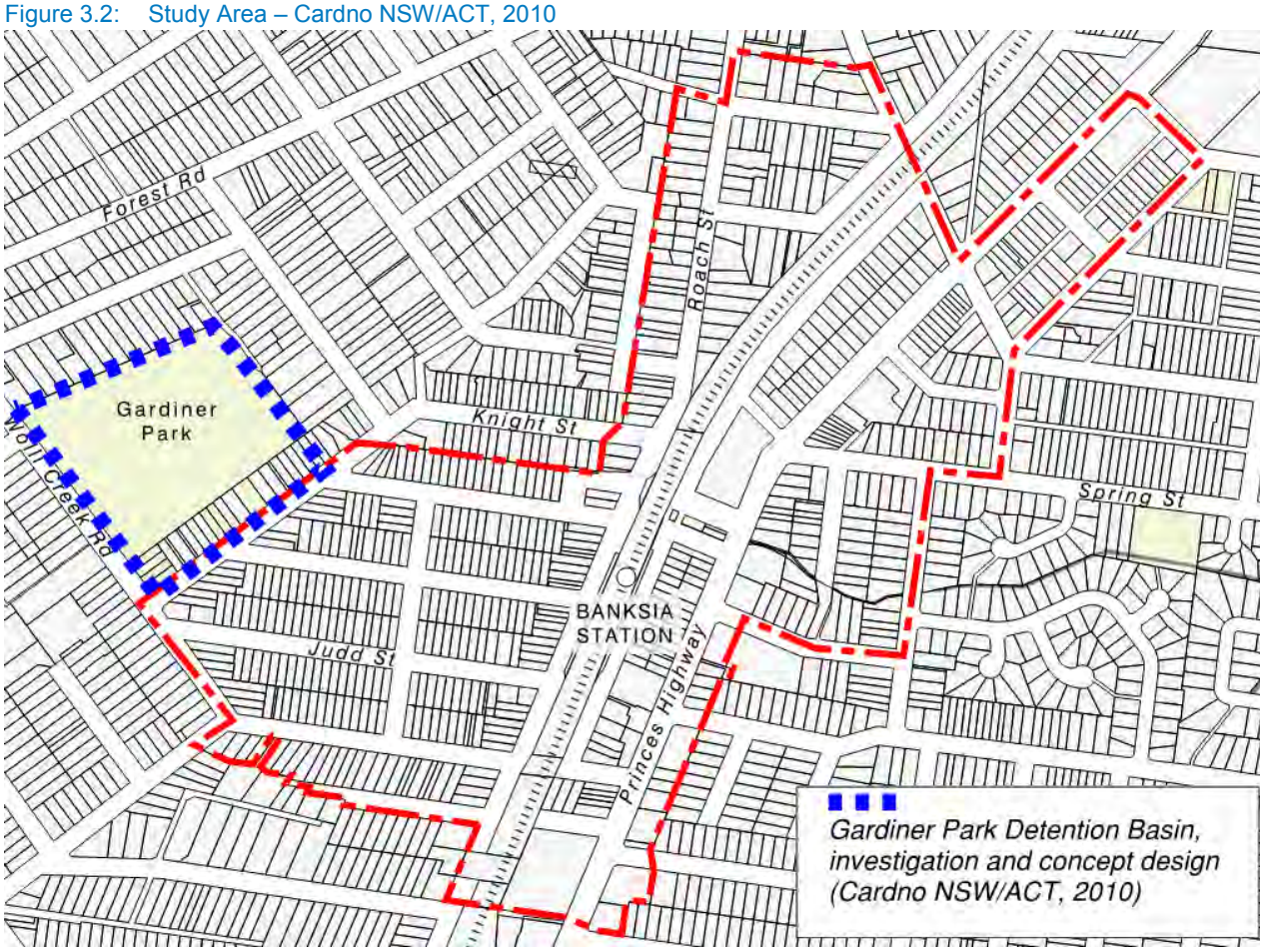
3.1.2 Gardiner Park Detention Basin, investigation and concept design (Cardno NSW/ACT, 2010)

Following from findings and recommendations in previous investigations, Cardno NSW/ ACT was engaged by Rockdale City Council to prepare detention basin options utilising the existing Gardiner Park. Six preliminary options were prepared and costed, which were reviewed by Council along with a heritage consultant. It was decided by Council at this point that the excessive cost was outside of its capability to fund, noting the benefit/ cost ratio of the flood risk was reduced. The heritage consultant provided initial advice indicating that the works would have potentially significant impacts to the park.

It was agreed to terminate the engagement with Cardno NSW/ACT due to the excessive cost of the options, as furthering the designs would provide no benefit.

Council has outlined potential for exploring alternative options including a below ground tank, or alternative locations/ configurations for above ground detention within the park.

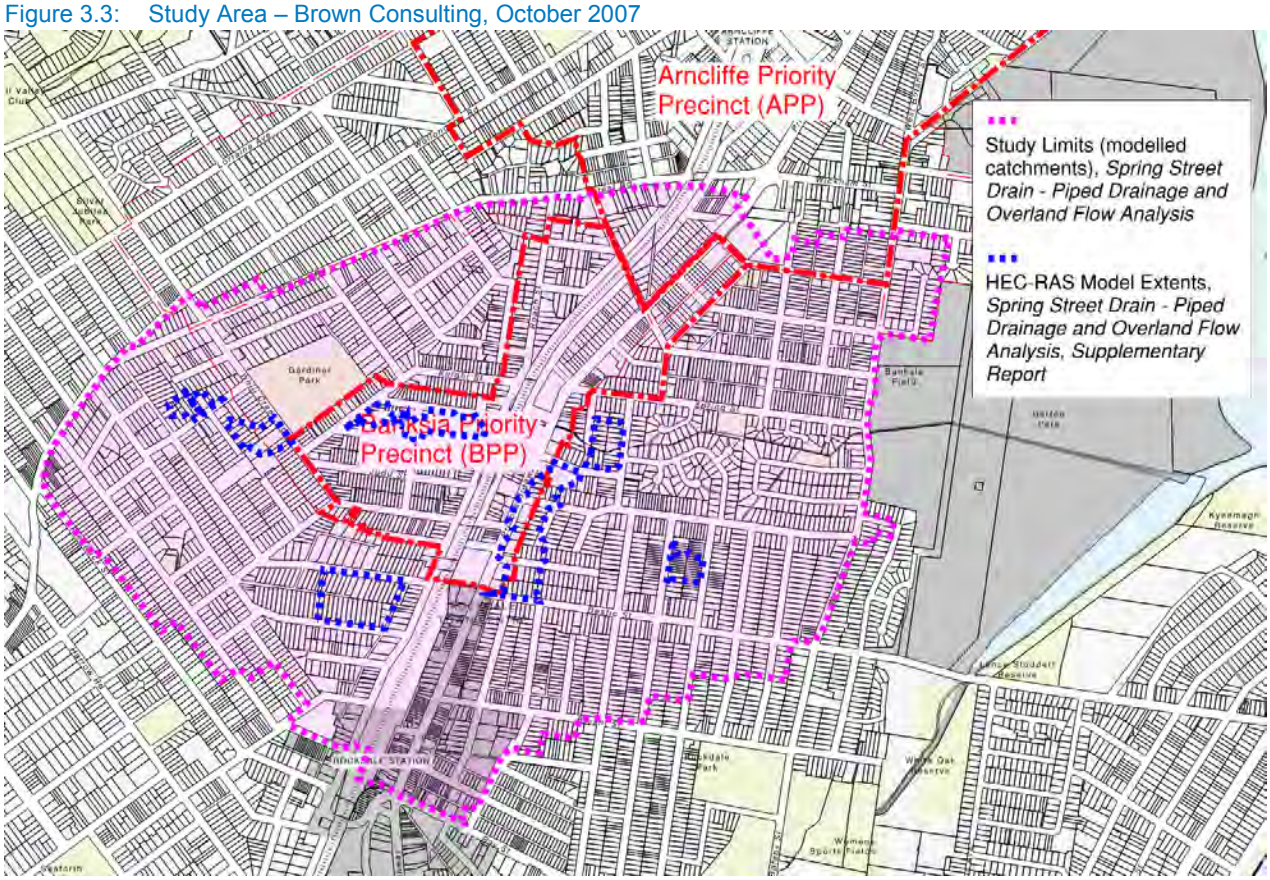
Figure 3.2: Study Area – Cardno NSW/ACT, 2010



3.1.3 Spring Street Drain – Pipe Drainage and Overland Flow Analysis (Brown Consulting, October 2007)

The *Spring Street Drain Piped Drainage and Overland Flow Analysis* (SSD2007) assessed existing flood behaviour in the Spring Street Catchment area as part of the first stage of the NSW Government's Flood Policy process. Information for the study was sourced from Rockdale City Council including GIS data, survey and historical records. The study area encompasses the entire Banksia Priority Precinct, with detailed modelling undertaken in key areas; see Figure 3.3.

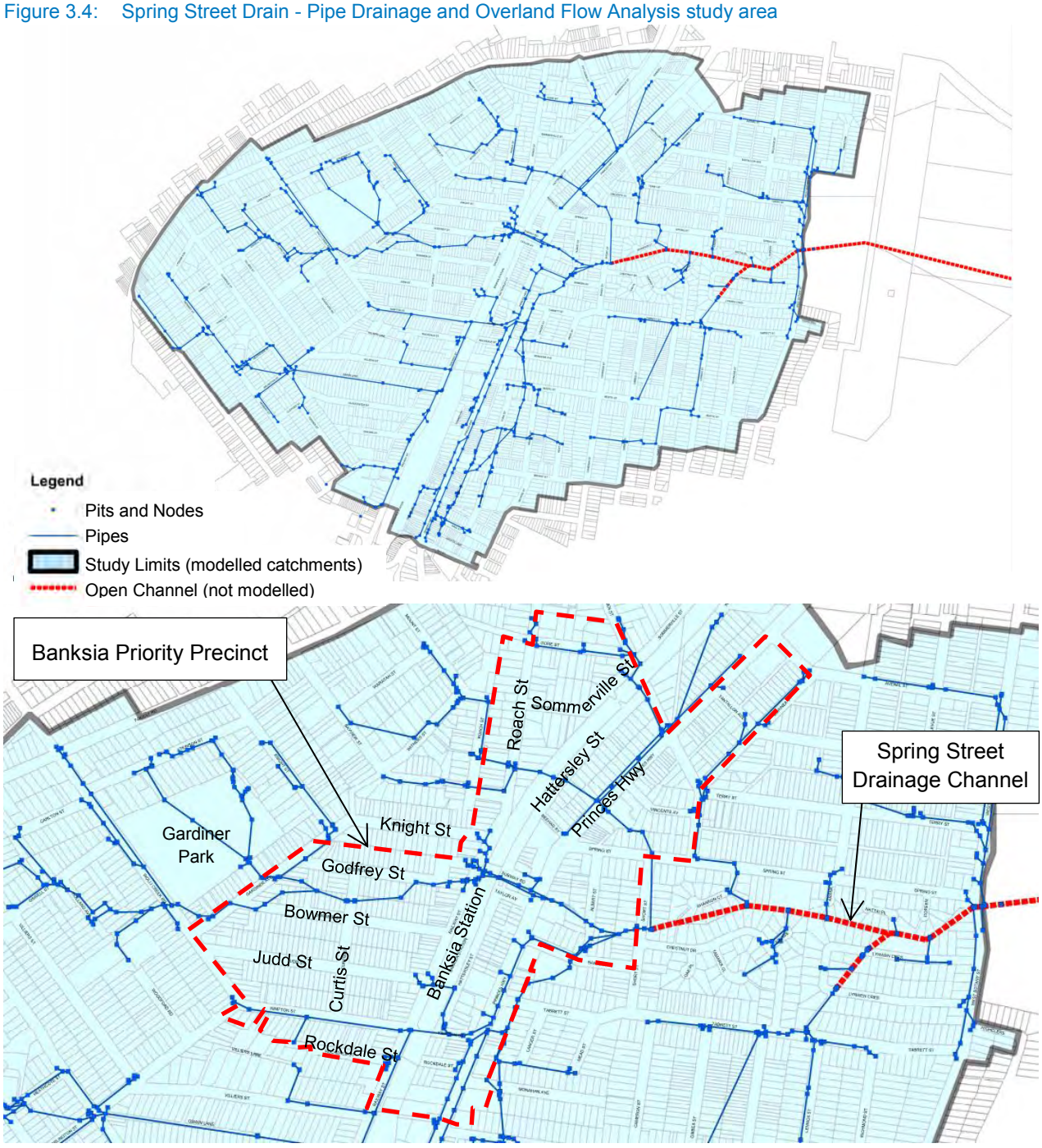
Figure 3.3: Study Area – Brown Consulting, October 2007



Source: *Spring Street Drain – Pipe Drainage and Overland Flow Analysis* (October 2007)

The Spring Street Drainage Catchment covers an area of 224 hectares draining eastwards to an outlet at West Botany Street, within the suburbs of Rockdale, Banksia, Arncliffe and Bexley. Stormwater ultimately drains to Botany Bay via Muddy Creek, see Figure 3.4.

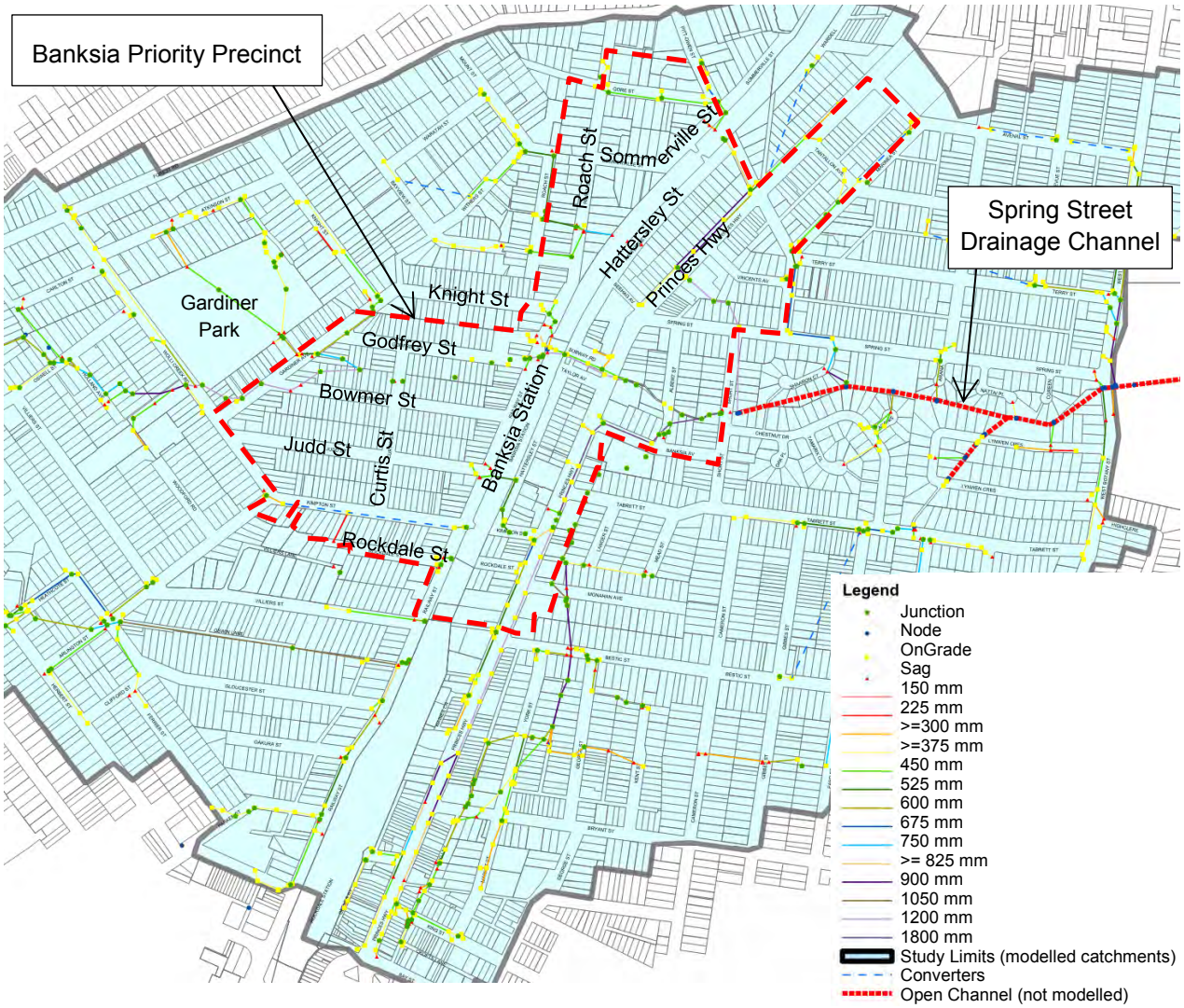
Figure 3.4: Spring Street Drain - Pipe Drainage and Overland Flow Analysis study area



Source: Spring Street Drain – Pipe Drainage and Overland Flow Analysis (October 2007)

The aim of the SSD2007 study was to identify and assess the properties affected by overland flows within the catchment using the DRAINS and HEC-RAS computer models. The study investigated the sub-catchments draining to the channel and not the channel itself. The modelled drainage networks are shown in Figure 3.5

Figure 3.5: Pit and Pipe Network



Source: Spring Street Drain – Pipe Drainage and Overland Flow Analysis (October 2007)

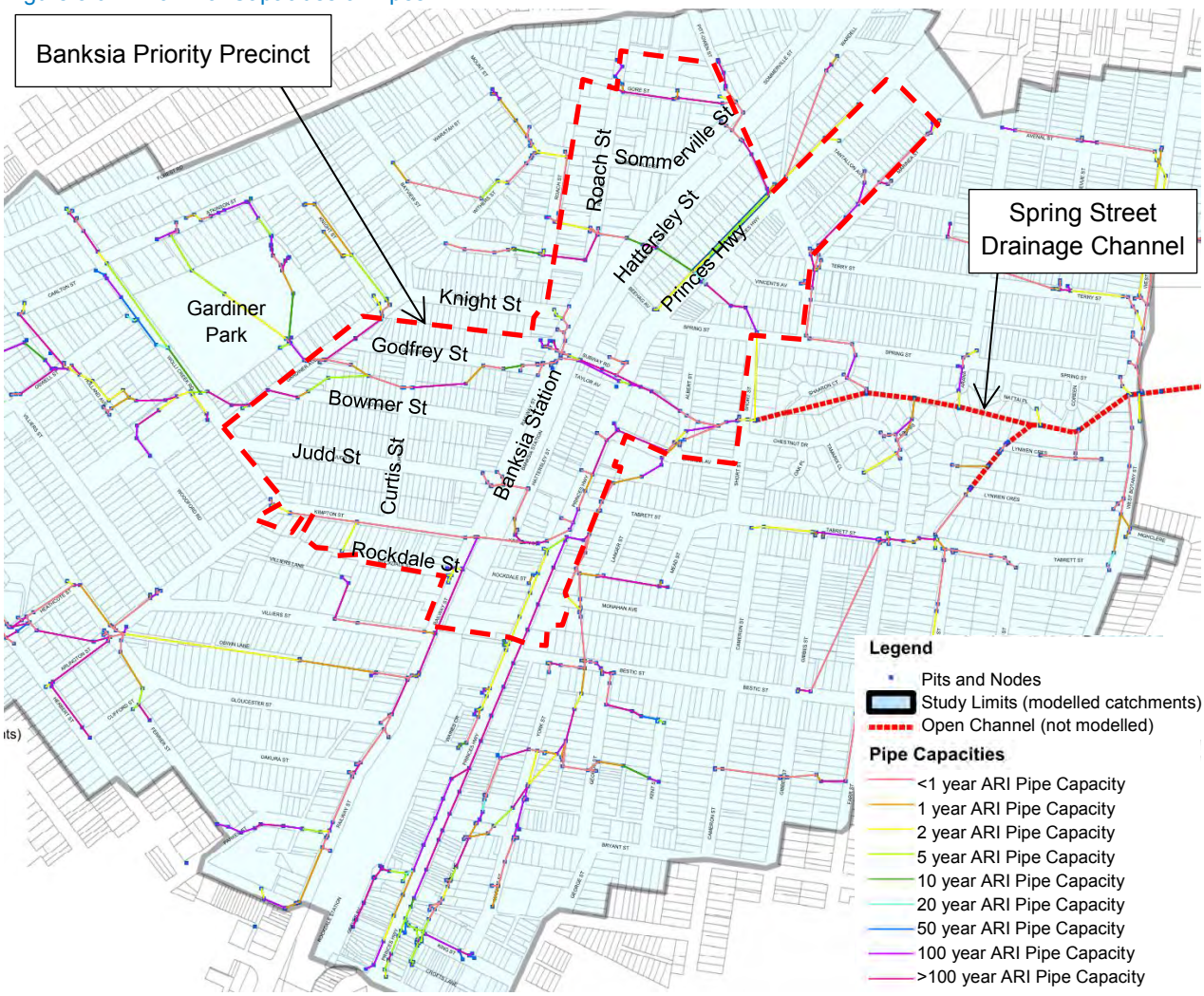
The results of the SSD2007 study show that the effectiveness of the pipelines is constrained by the flood levels in Spring Street Drain (affected by backwater from Muddy Creek). Most of the outlets from the pipeline are below the mainstream flood level, so that the piped system capacities are limited by the low hydraulic head that is available.

Due to the low conveyance of flow within the pipelines, a significant amount of flow is conveyed overland. In the steeper areas to the west of the railway line, there are significant surface flows through properties.

In the flat areas of the catchment this results in significant problems where localised drainage depressions have been filled in and properties built over them. Pipelines located in the areas are generally undersized for the runoff generated from heavily developed sub-catchments.

The assumed capacity of pipes, according to the average recurrence interval of the storm flows they can carry is shown in Figure 3.6.

Figure 3.6: Nominal Capacities of Pipes



Source: Spring Street Drain – Pipe Drainage and Overland Flow Analysis (October 2007)

Overall, the analysis indicates that there is a significant amount of overland flow within the catchment, partly due to the constraint of capacity within pipelines resulting from the diameters and also the backwater effect from the Spring Street Drain.

The study states that the primary items of concern are:

- Trapped low points resulting in flow being conveyed directly through private property (in many cases houses are located across the main drainage depressions of the catchment),
- Sag points, such as in roadways, where flow ponds before flow can escape via alternative means or is delayed until capacity is available within the pipe system,
- Conveyance of significant flow rates along roadways which may inundate some properties and affect traffic flow.
- Mainstream flood affected properties (Note not assessed in the SSD2007 report).

Significant overland flow affects areas along Railway Street, Subway Road, Princes Highway, Bestic Street, Monahan Avenue, Tabrett Street, Banksia Avenue, Albert Street, Short Street, Spring Street and West Botany Street.

The report states that as a result of pipe upgrades at upstream locations within the private properties, the overland flows through the downstream properties would be increased. It is noted that overland flows through the properties downstream to Albert Street are increased following the upstream pipe upgrades compared to the existing overland flows. This is due primarily to the improved conveyance of flows from the upstream sub-catchments to the downstream areas. Downstream impacts need to be defined for works considered for implementation. Additional works may be required to prevent adverse effects resulting to other properties.

The SSD2007 report highlights three areas of concern that are within our study area:

- Gardiner Avenue to Godfrey Street
- Bestic Street to Banksia Avenue
- Holland Avenue to Wolli Creek Road

3.1.3.1 Gardiner Avenue to Godfrey Street

A major depression in the area west of the railway line is located between Gardiner Avenue and Godfrey Street. The lowpoint is located at the rear of houses and crosses the lowpoint in Curtis Street. A box culvert 1.2m x 1.35m is used to drain the significant catchment that discharges to this area. The study shows that the velocity-depth product indicates a high provisional hazard for the 20 year ARI event.

3.1.3.2 Bestic Street to Banksia Avenue

A high point is located in the catchment adjacent to Cameron Street in a north-south direction containing the flows to the depression to the east of the Princes Highway. Flows, both from local catchments and from the western side of the railway line, are then conveyed via pipelines and overland to the Spring Street drainage channel. The depression conveys the flows across several streets and through private property, both residential and commercial/industrial.

The depth of flow for the 100 year ARI flow at the roadways crossed by the depression varies from about 0.3m to 1.5m with corresponding provisional hazards of low and high. The flow characteristics within the private property are similar.

The wall at the rear of 9 Banksia Avenue is indicated as a significant impediment to flow. If the flow through the walls was unconstrained, a major backup of flow is indicated as occurring due to the buildings fronting Tabrett Street.

The modelling of the flows between Monahan Avenue and Tabrett Street indicates that the flow is not confined within properties in the depression, but also inundates a section of the Princes Highway in the 20 year ARI event.

3.1.3.3 Holland Avenue to Wolli Creek Road

A trapped lowpoint is located near number 14 Holland Avenue resulting in flows discharging through private property towards Wolli Creek Road. Flows are conveyed through properties facing Holland Avenue then along the footpath near to and the driveway of apartments at 32-34 Wolli Creek Road. The depth of flow in the 100 year ARI event is up to 1.22m in the driveway of number 32-34 Wolli Creek Road and has a velocity-depth provisional hazard rating of low to high.

3.1.4 Floodplain Management Study – Spring Street Drain, Muddy Creek and Scarborough Ponds (January 2000)

The Floodplain Management Study defines the nature and extent of the flood hazard in the Spring Street Drain, Muddy Creek and Scarborough Ponds catchments. It also identifies and assesses strategies and measures aimed at reducing the impact of flooding on both existing and future development, and measures to prevent future development from making flooding worse.

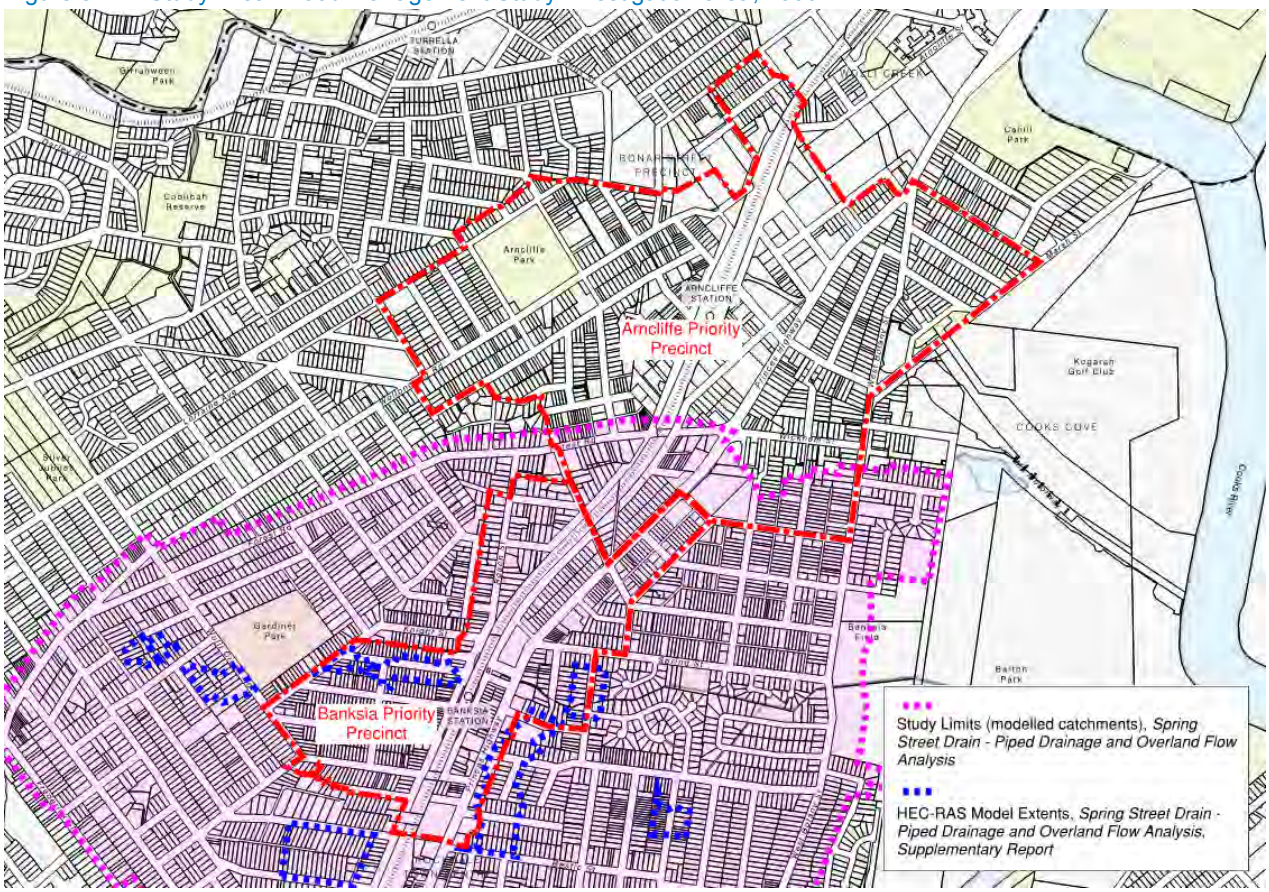
Using computer modelling and data from previous flood events the study determines a significant amount of existing development is located on the floodplain. Relocation of this development is not feasible on either economic or social grounds. The placing of excessive restrictions on development or redevelopment in the floodplain is also not desirable as it would restrict economic activity in an important part of the urban area. The Floodplain Management Study investigation area can be seen in Figure 3.7

The study provides a list ‘structural measures’ and ‘non-structural measures’ which may be beneficial at mitigating the impact of flooding in the three catchments. The study examines every measure in detail and determines how each specific measure may be useful towards mitigating flood issues in each particular catchment. The Spring Street Drain catchment is the only catchment relevant to this Mott Macdonald Literature Review and therefore the mitigation measures relevant to that catchment are investigated further.

The Floodplain Management Study determines that the structural measures suited to the problem areas in the Banksia Priority Precinct are:

- Detention basins
- Pipe and drainage pit amplification
- Overland flow path improvements
- Channel and bridge improvement works (in the Spring Drain open channel downstream of the Banksia Priority Precinct)
- Flood proofing

Figure 3.7: Study Area -Flood Management Study investigation area, 2000



3.1.4.1 Detention Basins

Detention basins can be used to reduce peak discharges downstream of the basin. This can produce a reduction in peak flood levels, if no channel improvements are carried out, or alternatively can reduce the size and cost of the channel and bridge improvements needed to carry a given design flow.

The study determines that Gardiner Park represents the only practicable site for a significant detention basin in the Spring Street Drain catchment.

3.1.4.2 Pipe and Drainage Pit Upgrades

The study identified a number of locations where pipe and drainage pit upgrades were required. Specifically within the Banksia Priority Precinct these locations are:

- Oswin Lane
- Gardiner Park to Banksia Subway
- Beehag Avenue and Banksia Subway to Short Street
- Short street to York street

3.1.4.3 Overland Flow Paths

The study determined that a number of private properties will be subject to significant overland flows if the capacity of the existing pit and pipe drainage system is exceeded. Council design standards state that the drainage system in such areas should be upgraded to a 5% AEP. Alternatively if an adequate overland flow path is provided, the pipe drainage system need only be designed for a 10% AEP. Therefore, consideration was given to upgrading overland flow paths in conjunction with pipe upgrading. Three overland flow paths were identified in the Banksia Priority Precinct:

Overland Flow Path Bestic Street to Tabrett Street

The overland flow path from Bestic Street to Tabrett St continues through the back yards of four properties before it reaches a drainage easement at the rear of properties fronting Princes Highway. Easements would need to be obtained through these properties in any case to allow pipe upgrading. The overland flow path can be improved by replacing solid fences with open types that permit water to flow through, and by removing obstructions along the flow path. Alternative overland flow paths are impractical due to the existing ground and road levels.

Overland Flow Path, Princes Highway to Spring Street

Upgrading of this overland flow path would be very difficult because it crosses diagonally across properties and under buildings. An alternative route for gutter and overland flow runs south along the Princes Highway and then along Spring Street. Therefore, upgrading of the overland flow path was not considered necessary.

Overland Flow Path, Gardiner Avenue to Railway Street

Flows generated in the upper reaches of the catchment, particularly Gardiner Park begin to converge and pond at a natural low-point within the park at the heritage wall. Flows build and overtop the wall into adjacent properties and through to Gardiner Avenue, generally between Bowmer and Godfrey Streets. An overland flow path is formed and travels east through most properties, in some capacity towards Curtis Street, remaining between Bowmer and Godfrey Streets. From here it travels diagonally across properties as it heads towards Godfrey Street and onto Subway Road. Easements would need to be obtained through these properties in any case to allow pipe upgrading. The overland flow path can be improved by replacing

solid fences with open types that permit water to flow through, and by removing obstructions near the back fences.

3.1.4.4 Channel and Bridge Improvements

The existing concrete channel could be widened on the south side, between West Botany Street and the outlet to Muddy Creek. To gain the hydraulic benefit from this work it is also recommended that the bridge at West Botany Street be amplified. The Spring Street open channel is outside the Banksia Priority Precinct area however upgrading the channel may be beneficial to the precinct.

3.1.4.5 Flood proofing

The study determines that flood proofing of residential buildings may be a viable option where the depth of flooding is shallow, say less than 300mm. This could involve sandbagging of doorways by residents or emergency service personnel. Alternatively and depending on the individual site, it may be possible to erect or modify the bottom section of the boundary fence so as to exclude floodwaters.

Flood proofing by filling is also possible during redevelopment. Care would have to be taken to ensure that an 'island' is not created which could make emergency access or evacuation difficult.

3.1.4.6 Non-Structural Measures

Non-structural measures that may be beneficial to the Banksia Priority Precinct include:

- Rezoning controls
- Development controls
- Building controls
- On-site detention (OSD) policy
- Dividing fences policy
- House raising
- Voluntary purchase
- Flood proofing
- Flood warning
- Emergency response plan
- Public education

3.2 Key Issues to be Addressed in Planning for the Banksia Priority Precinct

3.2.1 Existing Flood Affected Land within the Proposed Precinct

The key flood affected areas identified in the Banksia Priority Precinct are:

- Gardiner Avenue to the Subway Station underpass;
- Railway Street adjacent Banksia Station;
- Bestic Street to Short Street; and

- Areas west of the rail line, in the vicinity of Roach and Mount Streets.

These areas generally don't exceed half a metre with some pockets reaching one metre. Council currently use the Floodplain Management Study (Willing & Partners, January 2000) to assess flood risk within the Precinct. Only two areas are identified as having flood risk, being low risk flood ways. These are:

- Gardiner Avenue to the Subway Station underpass; and
- Bestic Street to Short Street.

Refer to Appendix A for maps illustrating the above.

As the areas are already developed, future planning controls should be implemented to further minimise or at least maintain the low risk category as new developments take place. These controls are outlined in Section 3.3.3.

3.2.2 Existing Flow Restrictions

3.2.2.1 Piped/ Formed

- The flood levels in the Spring Street Drain dramatically reduce the effectiveness of the pipelines from the Banksia Catchment. Limited hydraulic head is available due to the mainstream flood level being higher than most pipeline outlets.
- Major sag located between Gardiner Avenue and Godfrey Street. Runoff discharges through 750mm and 1200mm diameter pipelines, the overland at the rear of the houses. A 1.2m x 1.35m box culvert is used to drain the area,
- High point located in the catchment adjacent to Cameron Street containing the flows to the depression to the east of the Princes Highway. In the 20 year ARI event, the flow is not confined within properties in the depression but also inundates a section of the Princess Highway.
- Trapped sag point located near number 14 Holland Avenue resulting in flows discharging through private property towards Wolli Creek Road.
- Pit and pipe drainage system from Gardiner Park and surrounding streets through Gardiner/ Godfrey Street to Railway Street which in various areas is undersized for frequent rainfall events, resulting in surcharge during events greater than 2 year ARI.
- Over capacity pipes in the 1 year ARI at the intersection of Godfrey Street and Railway Street, between Roach Street and Hattersley Street and vat the intersection of Somerville Street and Pitt Street.

3.2.2.2 Overland

- Illawarra railway line which is raised above the surrounding surface levels;
- The wall at the rear of 9 Banksia Avenue is indicated as a significant impediment to flow;
- If flow through the aforementioned wall was unconstrained, a major backup of flow would occur due to the buildings fronting Tabrett Street.

3.3 Recommendations and Opportunities

3.3.1 Further Studies and/or Modelling

The following is suggested for further investigation on the basis of the historical reports:

- Flood data collection – the reports note that the availability of data from historical floods is limited. It is recommended that comprehensive data be collected for all future events. Council have advised that as part of the BMT WBM work currently being undertaken, flood information from recent events is being collected for the purposes of model calibration in the adjacent Muddy Creek catchment.
- Further detailed modelling of flows in the following areas:
  - Adjacent to Gardiner Park, at the limits of the Spring Street modelling (Willing & Partners 2000).
  - In the vicinity of Subway Road and the areas east of the Illawarra railway line.
- Progression of the TUFLOW modelling and associated reporting currently being undertaken by BMT WBM due for completion in late 2015.

3.3.2 Remedial Works/Design Recommendations

3.3.2.1 Detention Basin

The Spring Street Drain, Muddy Creek and Scarborough Ponds Floodplain Management Study determined that a detention basin is a feasible option for reducing peak discharges downstream during a period of prolonged rainfall.

Leading on from this, Council had decided to engage Cardno NSW/ ACT to prepare detention options within the park. Six options were developed and priced, though due to excessive costs and heritage implications it was decided that a detention basin in Gardiner Park was not a viable option to reduce the flood hazard in the catchment. As such, the designs were never progressed further.

Council has not ruled out providing a detention basin in Gardiner Park, though have outlined that alternative options would need to be investigated, including but not limited to a below ground tank, or as above ground though in a location which does not impact the heritage aspects of the park. Council has also noted that they are investigating the use of synthetic sport field surfaces with Gardiner Park being a potential site for future playing fields. The issue being that the use of the playing field for above ground detention may be prohibitive should synthetic surfaces be used.

3.3.2.2 Pipe and Overland Flows Upgrades

The reports note that areas of the existing pit and pipe network are undersized, with some pipe capacities being less than the 1 year ARI (Brown Consulting 2007). As such, upgrades are recommended by the reports to some areas of the pit and pipe network, in particular through the properties in the vicinity of Bowmer Street and Godfrey Street.

It is noted that due to the highly developed nature of the precinct, upgrades to the existing piped drainage network may be cost prohibitive as the existing drainage line in areas passes through multiple properties. It is suggested that a parallel upgrade within the road may be more appropriate than upsizing pipes in the current alignment, if feasible. However it is also noted that any pipe upgrades in the precinct may increase the efficiency of flows to downstream areas, potentially exacerbating flooding adjacent the Spring Street channel. As such it is recommended that any pipe upgrades be assessed in conjunction with the option of a detention basin to assist in attenuating flows. Any works undertaken within the precinct would need to prove that there is not adverse impact on flooding within downstream properties.

The reports also suggest the provision of defined overland flow paths. However flows are noted to be relatively significant and as such may be difficult to contain within a single controlled flow path. Again, due to the highly developed nature of the precinct, this option may be limited as the primary flow path through the Banksia Priority Precinct passes through several existing properties. It may be preferable to relocate the sag to align with the road however this is likely to require widespread filling which may adversely affect flood storage in the precinct, as is not likely to be feasible unless the entire block of affected properties can be redeveloped simultaneously. Any minor works to improve piped/overland flows would be assessed within individual Development Approval (DA) applications, with the DA required to prove that flooding is not being worsened elsewhere by the development.

From the previous studies and investigations undertaken by Council, a number of remedial items have been identified with some subsequently actioned. The below table highlights these options whether physical works or controls implemented as part of the draft FRMS+P in order of priority:

Table 3.1: Summary of Remedial Options

Source of Option	Remedial Options	Comments from Studies where applicable	Status as confirmed by Rockdale City Council	Estimated Construction Cost
Priority 1 Items			Priority numbers are as provided by Rockdale City Council	
Floodplain Management Study – Spring Street Drain, Muddy Creek and Scarborough Ponds (January 2000)	Gardiner Park detention basin	Explore option of above ground detention basin within park.	Preliminary design options undertaken. Above ground detention option in Gardiner Park abandoned at this stage primarily due to costs outweighing benefit of flood mitigation. May look to below ground tank or alternative location options in future.	$3.3 million* to $6.6 million* depending on option.
Floodplain Management Study – Spring Street Drain, Muddy Creek and Scarborough Ponds (January 2000)	Overland flow path upgrades – Gardiner Park to Banksia Subway	Re-grading of road surfaces, kerb and gutter, landscaping or regarding private property, replacement of solid fences. As above, effect on downstream flooding to be further assessed.	Being implemented via flood related development controls for overland flow assessment, however reassessment of risk is a focus of the in-progress flood study review	By Developers as part of any future development.
Council Advice	Broaden OSD	-	OSD policy was restructured in 2007 to include single dwellings	-
Council Advice	Flood Planning Levels	-	Flood planning levels have been applied under the Development Control Plans and Local Environmental Plans	-
Council Advice	Flood Awareness	-	A flood education program and flood safe guide was undertaken and prepared between 2011 and 2013	-
Council Advice	Flood Warning and Emergency Response	-	The State Emergency Services are responsible for developing and implementing a flood warning system and emergency response plan.	-

Source of Option	Remedial Options	Comments from Studies where applicable	Status as confirmed by Rockdale City Council	Estimated Construction Cost
Priority 2 Items				
Floodplain Management Study – Spring Street Drain, Muddy Creek and Scarborough Ponds (January 2000)	Pipe and drainage pit upgrades – York Street to Short Street	Notes that drainage improvements may lead to increased downstream flooding due to a reduction in storage, to be assessed further.	Upgrade works at Bestic Street completed, Council undertaking further works in vicinity of York Street and Bryant Street with further plans for York St drainage improvements, Development at Banksia Ave improved capacity through site.	Upgrade works largely complete.
Floodplain Management Study – Spring Street Drain, Muddy Creek and Scarborough Ponds (January 2000)	House Raising/ Flood proofing of residential buildings by possibly erecting or modifying the bottom section of the boundary fence so as to exclude floodwaters	Relates to properties along the channel (not applicable for Banksia Priority Precinct). Study notes impact on flood levels.	No active program, new development to comply with Flood Planning Levels	By Developers as part of any future development.
Floodplain Management Study – Spring Street Drain, Muddy Creek and Scarborough Ponds (January 2000)	Pipe and drainage pit upgrades – Beehag Avenue and Banksia Subway to Short Street	Notes that drainage improvements may lead to increased downstream flooding due to a reduction in storage, to be assessed further.	No active works, due to constraints by existing buildings and mixed ownership of assets i.e. Sydney Trains own culvert through railway	By Developers as part of any future development.
Floodplain Management Study – Spring Street Drain, Muddy Creek and Scarborough Ponds (January 2000)	Pipe and drainage pit upgrades – Gardiner Park to Banksia Subway	Notes that drainage improvements may lead to increased downstream flooding due to a reduction in storage, to be assessed further.	No active works, due to constraints by existing buildings/private land ownership	By Developers as part of any future development.
Priority 3 Items				
Floodplain Management Study – Spring Street Drain, Muddy Creek and Scarborough Ponds (January 2000)	Overland flow path upgrades – York St to Short St	Re-grading of road surfaces, kerb and gutter, landscaping or regarding private property, replacement of solid fences. As above, effect on downstream flooding to be further assessed.	Being implemented via flood related development controls for overland flow assessment, however reassessment of risk is a focus of the in-progress flood study review	By Developers as part of any future development.

Source of Option	Remedial Options	Comments from Studies where applicable	Status as confirmed by Rockdale City Council	Estimated Construction Cost
Floodplain Management Study – Spring Street Drain, Muddy Creek and Scarborough Ponds (January 2000)	Widen Spring Canal between West Botany Street and Muddy Creek & amplify the bridge at West Botany Street	Indicative cost provided for channel amplification upstream of West Botany Street.	No action pending the Cooks Cove Development	$2,360,000*
Floodplain Management Study – Spring Street Drain, Muddy Creek and Scarborough Ponds (January 2000)	Flood proofing of residential buildings by possibly erecting or modifying the bottom section of the boundary fence so as to exclude floodwaters	Relates to properties along the channel (not applicable for Banksia Priority Precinct). Study notes impact on flood levels.	Properties and flood ways assessed at DA stage. New developments would need to comply with Flood Planning Levels	By Developers as part of any future development.

*All costs have been adjusted to the latest 2014 data on Building Price Index (BPI) figures given in the Australian Construction Handbook, Rawlinsons 2015 (Prices rounded up to nearest $10,000 where appropriate). BPI is based on historical data and is intended as a guide to the effect on building costs brought about by periodic variations in the rates of labour and materials as well as reflecting the cost effect of building activity and resource availability (i.e. market competition) at any time.

It is noted that the remainder of the studies discussed are generally part of the first stage of the NSW Government's Flood Policy process and as such only assess the existing situation and do not provide recommendations.

3.3.3 Planning Controls

Rockdale City Council currently adopts flood hazard categories for development and roads based on information from the *Floodplain Management Study, Spring Street Drain, Muddy Creek and Scarborough Ponds, Final Report (Volume 1 – Report and Volume 2 – Appendices* (Willing & Partners, Ref. 3808, January 2000) which classifies the catchment into Flood Management Areas. These areas are traced on Figure A02 in Appendix A for information and will need to be applied to the future land use strategy for the Banksia Priority Precinct. There may be opportunities for improvement and reduction of flood hazard category with the implementation of works listed in Table 3.1.

Lands are classified as either Low, Medium or High hazard for a flood equivalent to the Flood Standard (in this case the 1% flood). The classification is a qualitative assessment based on several factors including (but not limited to) depth and velocity of floodwaters, rate of rise, and evacuation difficulties.

Low Hazard is typically within the floodplain (i.e. the extent of the probable maximum flood) but generally above the 100 year flood and suitable for most land uses. Although a risk of flood damages exists, appropriate planning and building controls can minimise the risk to an acceptable level.
Medium Hazard generally indicates land below the 100 year flood where a significant risk of flood damage exists and where there may be some evacuation difficulties, but these damages can be minimised by applying appropriate development controls.
High Hazard areas indicate potential high flood damages, risk to life, evacuation issues or where

development would significantly and adversely affect flood behaviour in the catchment. Development is usually restricted in areas classified as High Hazard.

Rockdale City Council is currently in the process of consolidating planning controls for the Local Government Area through the preparation of a City Wide Floodplain Risk Management Study and Plan which is currently in draft format. Council's draft policy is yet to be finalised and will supersede any land hazard categories or planning controls presented within this report.

Preliminary planning controls are suggested in Section 4, on the basis of Council's existing flood management policies as well as the draft Floodplain Risk Management Study/Plan that is currently being developed by Rockdale City Council. It should be noted that the draft policy has not yet been publically exhibited, however it collates Council's existing policies that are in effect and was deemed useful in understanding appropriate controls.

4 Recommendations

4.1 Summary of Planning Controls in accordance with Rockdale City Council's Draft Floodplain Risk Management Study and Plan

The following presents a summary of some of the key appropriate planning controls for various hazard classifications. Rockdale City Council's draft policy is yet to be finalised and will supersede any planning controls presented within this report.

4.1.1 Development on Land with Flood Depths >100mm or Medium to High Hydraulic Hazard

Suggested planning controls for proposed future development for areas of the proposed priority precinct identified as being affected by the existing 1% AEP flood extents (illustrated in Appendix A), with depths greater than 100mm and/or which are classified by the existing flood reports as medium to high hydraulic hazard, are as follows:

- Minimum Planning Level for non-habitable floors at 100 year ARI flood level.
- Minimum Planning Level for habitable floors at 100 year flood level plus 500mm freeboard.
- All structures to have flood compatible building components and methods below the Planning Level or the 100 year ARI, whichever is greater.
- Engineer to certify that the structure can withstand forces of floodwater, debris and buoyancy up to and including the 100 year ARI plus 500mm freeboard.
- Engineer to certify that the development will not have adverse flood effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood conveyance; and (iii) the cumulative impact of multiple potential developments in the floodplain.
- Minimum surface level of open car parking spaces, garages or carports shall no lower than the 100 year ARI. Notwithstanding, where enclosed car parking is provided all openings to the car parking area shall be protected from inundation from floods up to the 100 year ARI plus 500mm freeboard.
- Residential:
  - A flood evacuation strategy for the development that provides reliable access for pedestrians or vehicles is required from within the building, commencing at a minimum level equal to the lowest habitable floor level to an area of refuge above the PMF. Such a refuge may comprise a minimum of 20% of the gross floor area of the development or such other area which is demonstrated as capable of accommodating the likely occupants of the development for the period of the flood. An engineer's report may be required.
  - The flood evacuation strategy for the development must be consistent with any flood evacuation plan, or local plan or similar strategy if adopted by Council.
  - Provide a Site Flood Management Plan that demonstrates how the required flood evacuation strategy will be implemented, including initiation of procedures and on-going emergency management procedures during and after the flood event. The Plan should include procedures to maintain flood emergency procedure awareness as owners, residents or occupants change through time.
  - Provide a *Site Flood Management Plan* that demonstrates the procedures for the management of contents such as valuable articles and equipment or potentially hazardous materials stored below

the prescribed floor level. The Plan should include procedures to maintain flood emergency procedure awareness as owners, residents or occupants change through time.

- Commercial and Industrial:
  - A *Business FloodSafe Plan* is required that demonstrates the required evacuation provisions including the evacuation facilities, initiation of evacuation procedures, and on-going emergency management procedures during and after the flood event. The Plan should include procedures to maintain flood emergency procedure awareness as owners, residents or occupants change through time.
  - The flood evacuation strategy for the development must be consistent with any flood evacuation plan, or local plan or similar strategy if adopted by Council.
  - Provide a *Business FloodSafe Plan* that demonstrates the procedures for the management of contents such as valuable articles and equipment or potentially hazardous materials stored below the prescribed floor level. The Plan must include procedures to maintain flood emergency procedure awareness as owners, residents or occupants change through time.

4.1.2 Development on Land with Low Hydraulic Hazard

For additional areas within the precinct affected by 1% AEP flood extents where the hydraulic hazard is classified as low, preliminary suggested flood controls are as follows:

- Minimum Planning Level for non-habitable floors at 100 year ARI flood level.
- Minimum Planning Level for habitable floors at 100 year flood level plus 500mm freeboard.
- All structures to have flood compatible building components and methods below the Planning Level or the 100 year ARI, whichever is greater.
- Engineer to certify that the structure can withstand forces of floodwater, debris and buoyancy up to and including the 100 year ARI plus 500mm freeboard.
- Commercial and Industrial:
  - Engineer to certify that the development will not increase flood effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood conveyance; and (iii) the cumulative impact of multiple potential developments in the floodplain.
- Minimum surface level of open car parking spaces, garages or carports shall no lower than the 100 year ARI. Notwithstanding, where enclosed car parking is provided all openings to the car parking area shall be protected from inundation from floods up to the 100 year ARI plus 500mm freeboard.
- Commercial and Industrial:
  - A Business FloodSafe Plan is required that demonstrates the required evacuation provisions including the evacuation facilities, initiation of evacuation procedures, and on-going emergency management procedures during and after the flood event. The Plan should include procedures to maintain flood emergency procedure awareness as owners, residents or occupants change through time.
  - The flood evacuation strategy for the development must be consistent with any flood evacuation plan, or local plan or similar strategy if adopted by Council.
  - Provide a *Business FloodSafe Plan* that demonstrates the procedures for the management of contents such as valuable articles and equipment or potentially hazardous materials stored below

the prescribed floor level. The Plan must include procedures to maintain flood emergency procedure awareness as owners, residents or occupants change through time.

4.1.3 Development on Land with Flood Depths <100mm and Low Hydraulic Hazard

It is noted that some areas affected by 1% AEP flood extents are classified as low hydraulic hazard and depths are less than 100mm, generally within the roads. These would generally be considered gutter flows and as such a Minimum Floor Planning level of 200mm above surrounding ground level would be considered more appropriate than a freeboard above "flood level".

4.1.4 **Land shown as "Flood Planning Area" in the Rockdale LEP 2011**

Controls applied by the LEP which specifies a 500mm freeboard to "flood planning level" for properties identified by the flood affected land map, as well as *"other land at or below the flood planning level"*, would still apply as legislatively required.

4.1.5 General Controls

The following additional controls would be applicable to development within the Banksia Priority Precinct on the basis of Rockdale City Council's existing policies:

- Stormwater Management
  - Filling of land up to the 100 year ARI flood level (or flood storage area) is not permitted.
  - Filling of land between the 100 year ARI flood level and the PMF level (or in flood fringe) is discouraged however will be considered if proven it does not adversely impact flood behaviour.
  - Pipes shall be designed to convey the 5 minute, 20 year ARI design rainfall of 204mm/hr.
- Overland Flow
  - The water level of surface flow routes and ponding sag pits designed to cater for the 100 year ARI flow shall be at least 100mm below the floor level of any adjacent building.
  - Maximum ponding depths permitted are 200mm for parking and driveways; 600mm for courtyards, grass and landscape.
  - Adjacent floor levels are to have 300mm freeboard to overland flow level. In cases where the 100 year flow can be contained within the piped system, habitable floor levels are to be a minimum of 200mm above finished ground level.
  - Design standard is the 100 year ARI although a viable escape route is required to PMF.
- On Site Detention
  - Permissible site discharge (PSD) and OSD volume rates for the 50 year ARI event are specified in Section 6.2 of Council's *Rockdale Technical Specification, Stormwater Management* (2011).
  - Permissible site discharge (PSD) and OSD volume rates for the 2 year ARI event are specified in Section 6.3 of Council's *Rockdale Technical Specification, Stormwater Management* (2011).
- Groundwater
  - Areas identified by Map B.1 of Council's *Rockdale Technical Specification, Stormwater Management* (2011) are situation in a Groundwater Protection Zone, refer Figure 4.1.

Figure 4.1: *Groundwater Protection Zone (Indicative Location of Absorption Areas and Low Absorption Areas)*

Source: Appendix B Map B.1, *Rockdale Technical Specification, Stormwater Management* (Rockdale City Council 2011)

- Flooding Freeboard – refer sections 4.1 to 4.1.4 inclusive.
- Low Level Properties
  - Appendix D of Council's *Rockdale Technical Specification, Stormwater Management* (2011) outlines the drainage policy for properties which fall away from the street which cannot be gravity drained to Council's stormwater pit and pipe network in the street.
- Climate Change
  - Council have indicated that for the Banksia and Arncliffe area, the projected increase in average daily rainfall due to climate change is as follows:
    - +11.36% by years 2060-79
    - +1.40% by years 2020-39
  - Increase in rainfall due to climate change will need to be considered as part of the DA application for future developments on a site by site basis.

Appendices

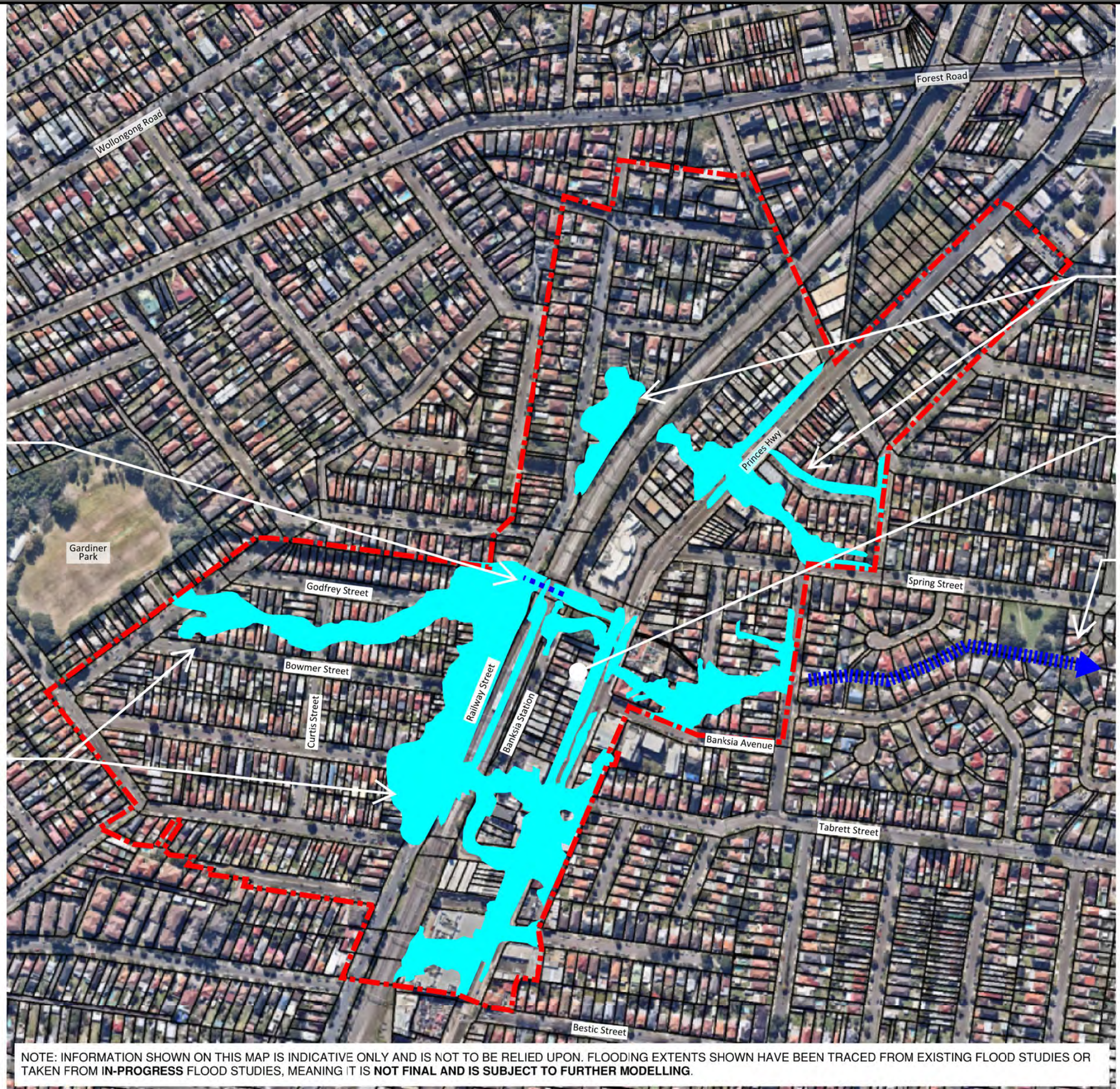
Appendix A. Plans

Legend

Indicative Flood Extents - 1% AEP

Existing Subway Road underpass

Indicative 100yr ARI Flood Extents generally greater than 100mm depth based on in-progress Spring Street Drain, Muddy Creek and Scarborough Ponds Drainage Catchments 2D Flood Study Review, BMT WBM Pty Ltd.



Indicative 100yr ARI Flood Extents generally greater than 100mm depth based on in-progress Spring Street Drain, Muddy Creek and Scarborough Ponds Drainage Catchments 2D Flood Study Review, BMT WBM Pty Ltd.

Progression of the TUFLOW modelling and associated reporting currently being undertaken by BMT WBM due for completion in late 2015 to provide more detail of flooding constraints in Banksia Precinct

Flows continue to existing concrete channel.

NOTE: INFORMATION SHOWN ON THIS MAP IS INDICATIVE ONLY AND IS NOT TO BE RELIED UPON. FLOODING EXTENTS SHOWN HAVE BEEN TRACED FROM EXISTING FLOOD STUDIES OR TAKEN FROM **IN-PROGRESS** FLOOD STUDIES, MEANING IT IS **NOT FINAL AND IS SUBJECT TO FURTHER MODELLING**.

Mott MacDonald

Map is Not to Scale

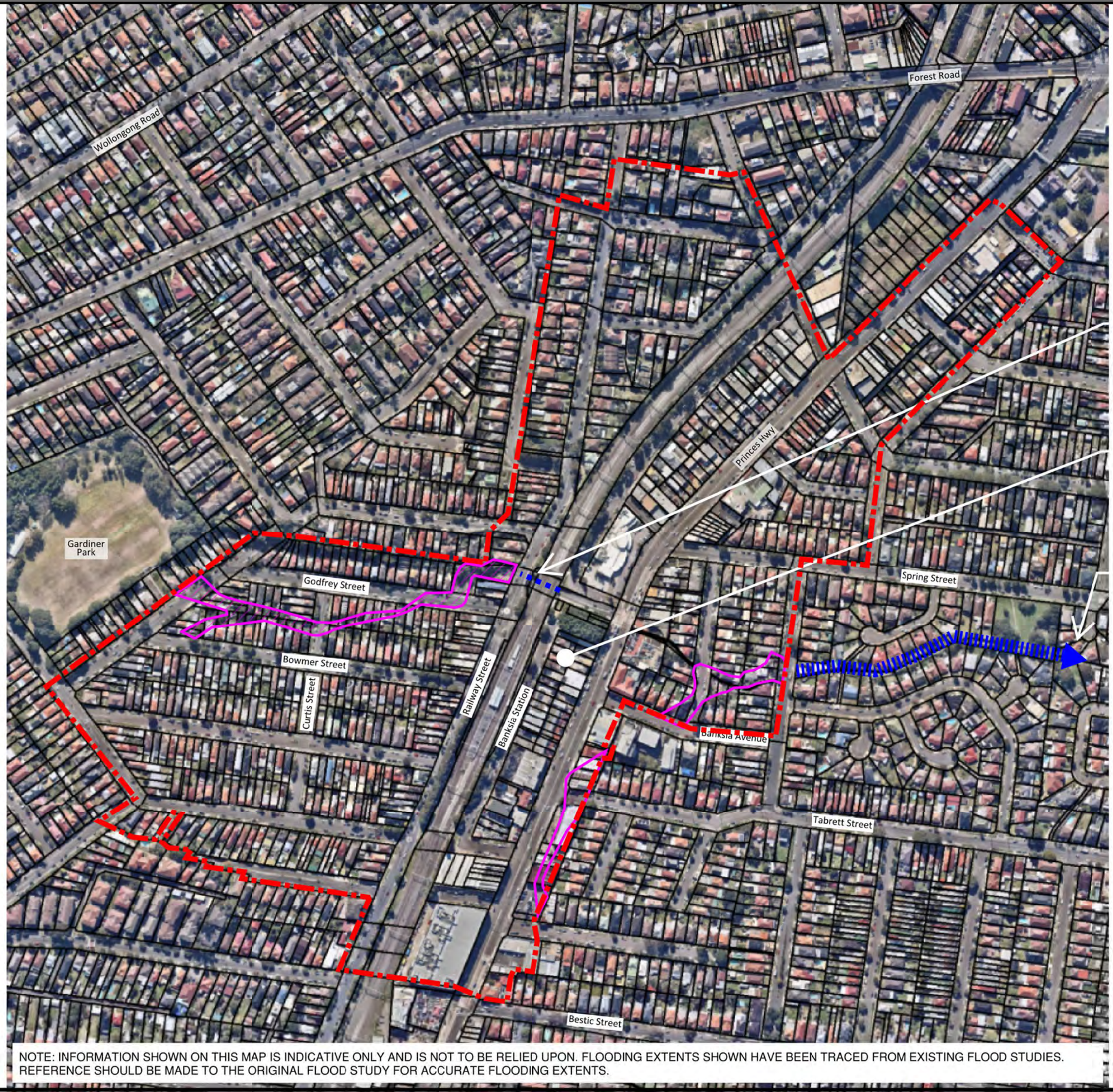
Banksia Priority Precincts
Desktop Literature Review
Flooding and Drainage

Figure A01
Existing Indicative Flood Extents

Legend

Hazard Classification Areas (Willing & Partners, January 2000)

Low Hazard



Existing Subway Road underpass

Progression of the TUFLOW modelling and associated reporting currently being undertaken by BMT WBM due for completion in late 2015 to provide more detail of flooding constraints in Banksia Precinct

Flows continue to existing concrete channel.

Note:
Hazard data sourced from Floodplain Management Study, Spring Street Drain, Muddy Creek and Scarborough Ponds (Willing & Partners, January 2000). Rockdale City Council currently use this document to asses flooding in the area.

Hazard classification shown is for the 1% flood level as per Table 3 of the above study. In an Extreme flood some areas may become an Extremely Hazardous Floodway.

NOTE: INFORMATION SHOWN ON THIS MAP IS INDICATIVE ONLY AND IS NOT TO BE RELIED UPON. FLOODING EXTENTS SHOWN HAVE BEEN TRACED FROM EXISTING FLOOD STUDIES. REFERENCE SHOULD BE MADE TO THE ORIGINAL FLOOD STUDY FOR ACCURATE FLOODING EXTENTS.

Mott MacDonald

Map is Not to Scale

Banksia Priority Precincts
Desktop Literature Review
Flooding and Drainage

Figure A02
Existing Indicative Flood Hazard