FIGURE 25
BAYSIDE WEST FRMS&P: MUDDY CREEK PROPERTY DATABASE

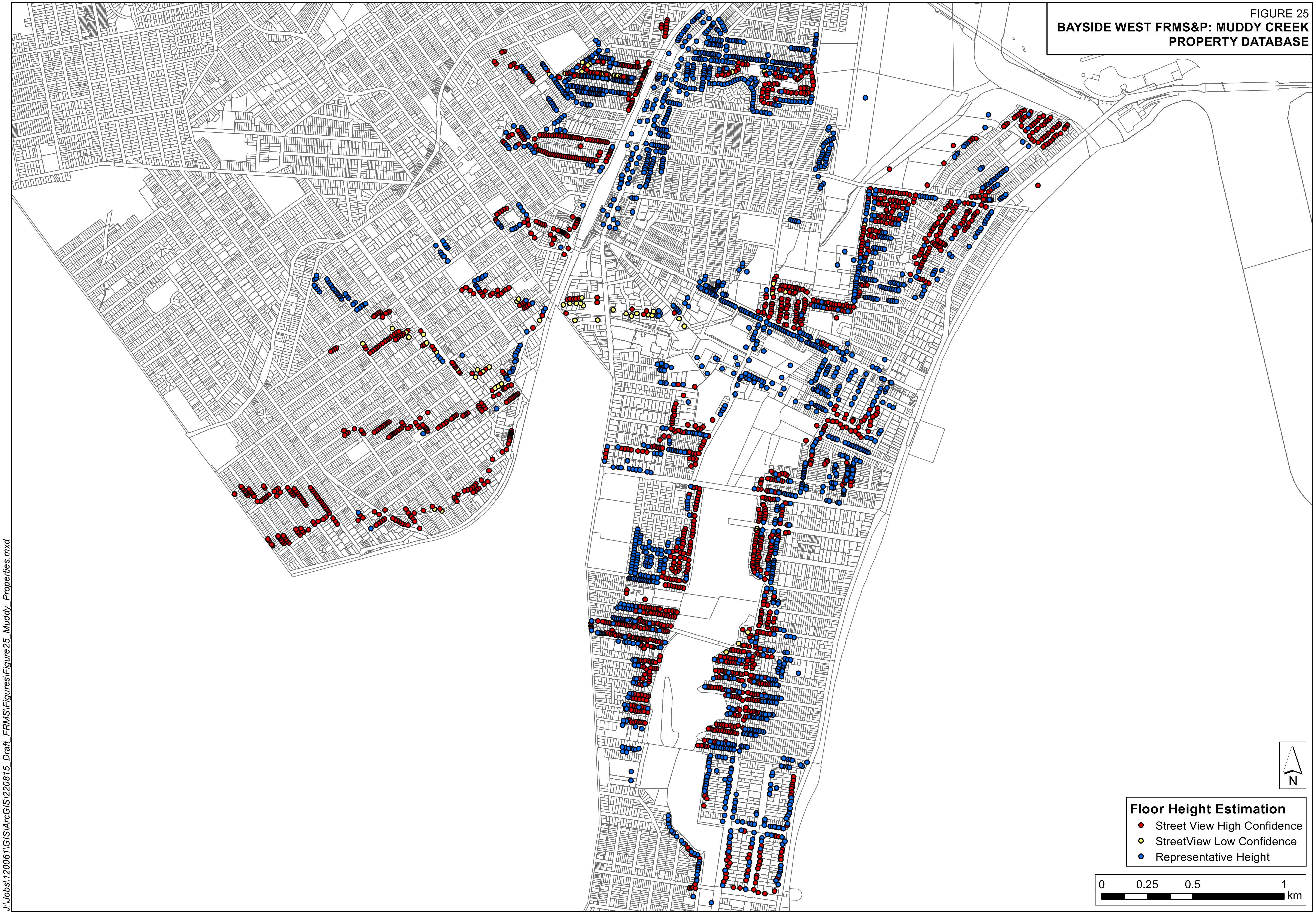

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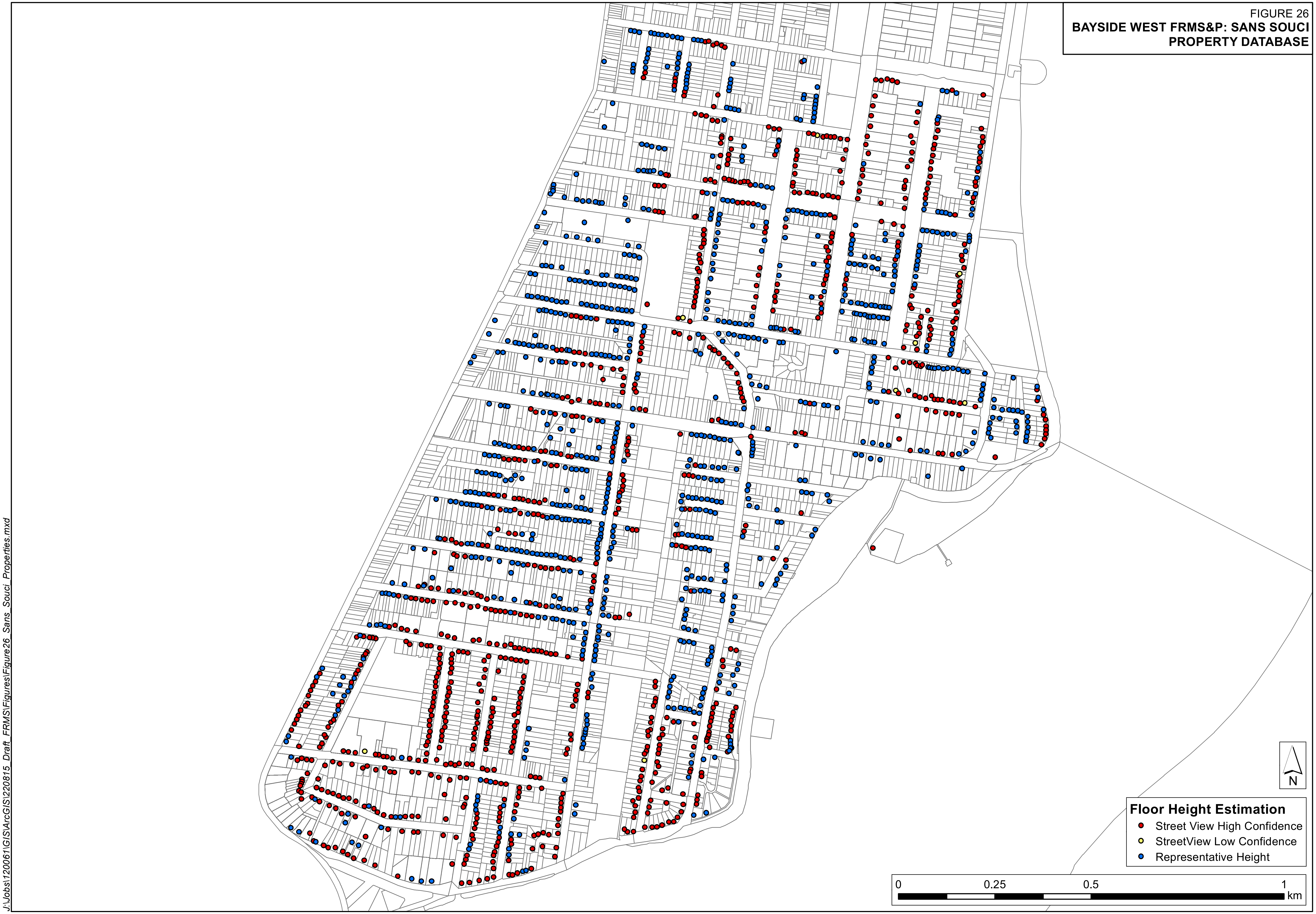
FIGURE 26

BAYSIDE WEST FRMS&P: SANS SOUCI PROPERTY DATABASE



J:\Jobs\120061\GIS\ArcGIS\220815_Draft_FRMS\Figures\Figure26_Sans_Souci_Properties.mxd

FIGURE 27
BAYSIDE WEST FRMS&P: BARDWELL CREEK
FIRST EVENT FLOOD ABOVE FLOOR

J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure27_Bardwell_First_Event_Flooded_Above_Floor.mxd

FIGURE 28
BAYSIDE WEST FRMS&P: BONNIE DOON
FIRST EVENT FLOODED ABOVE FLOOR

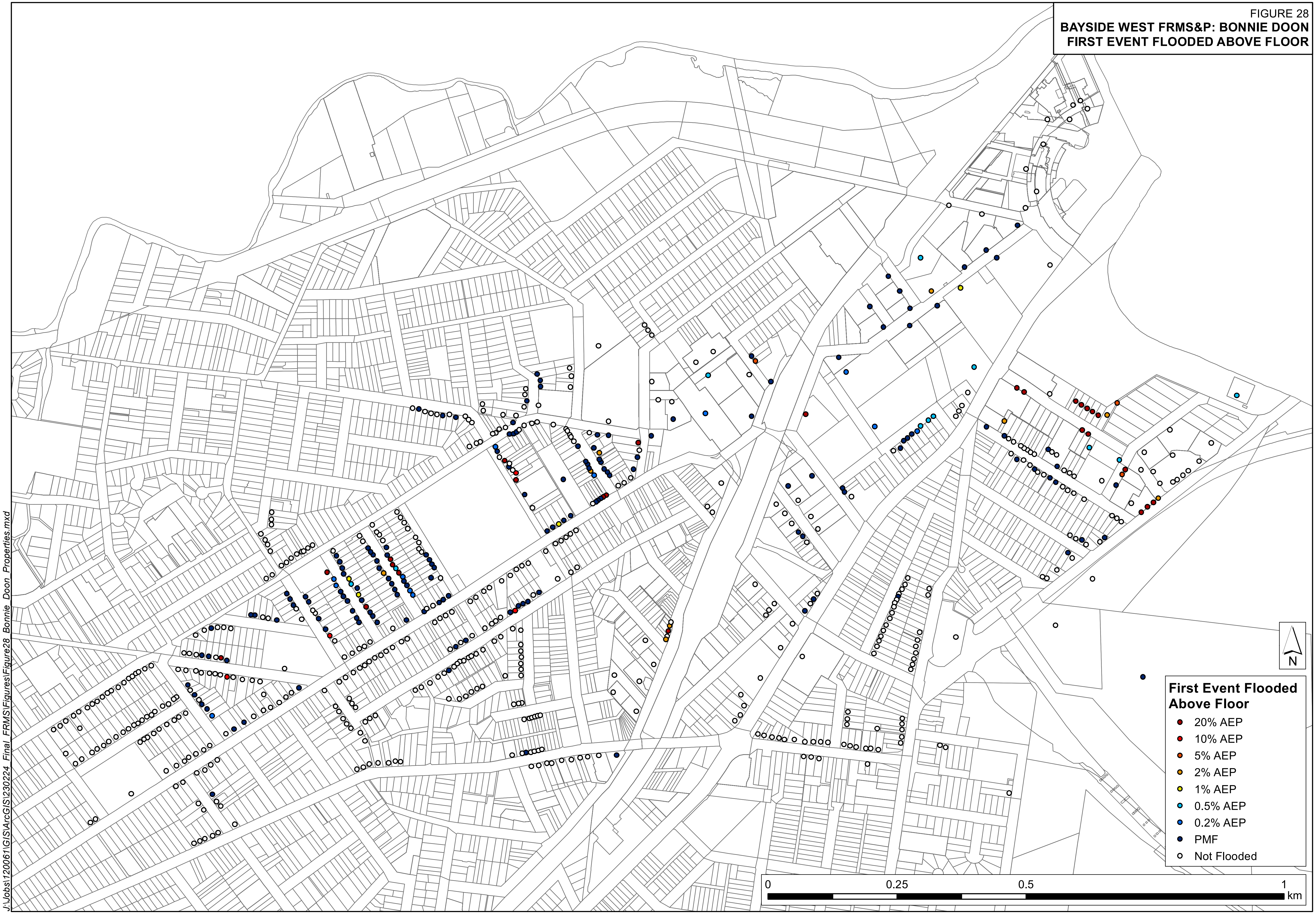
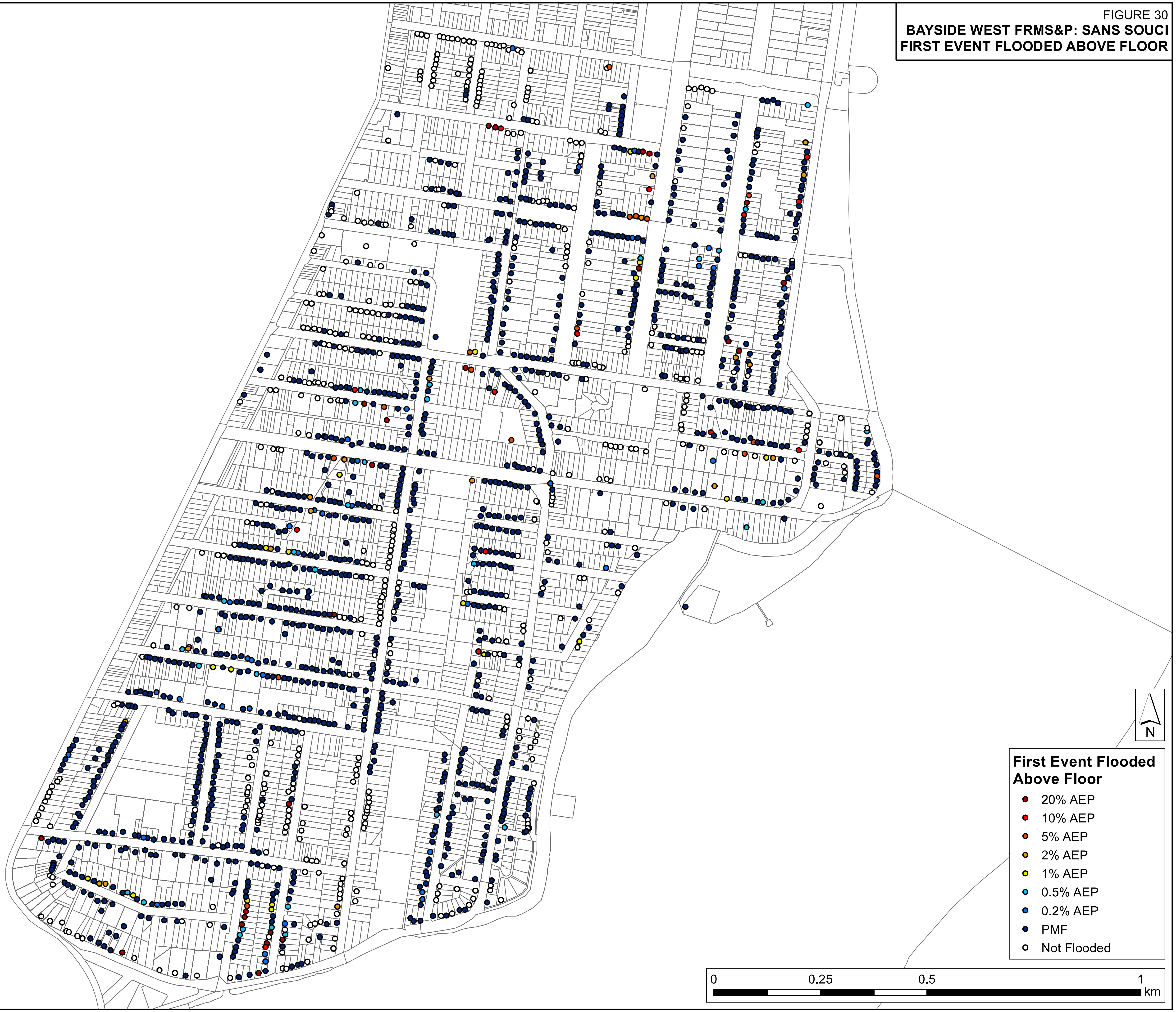


FIGURE 29
BAYSIDE WEST FRMS&P: MUDDY CREEK
FIRST EVENT FLOODED ABOVE FLOOR

J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure29_Muddy_Properties_First_Event_Flooded_Above_Floor_Level.mxd

FIGURE 30
BAYSIDE WEST FRMS&P: SANS SOUCI
FIRST EVENT FLOODED ABOVE FLOOR



J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure30_Sans_Souci_Properties_First_Event_Flooded_Above_Floor.mxd

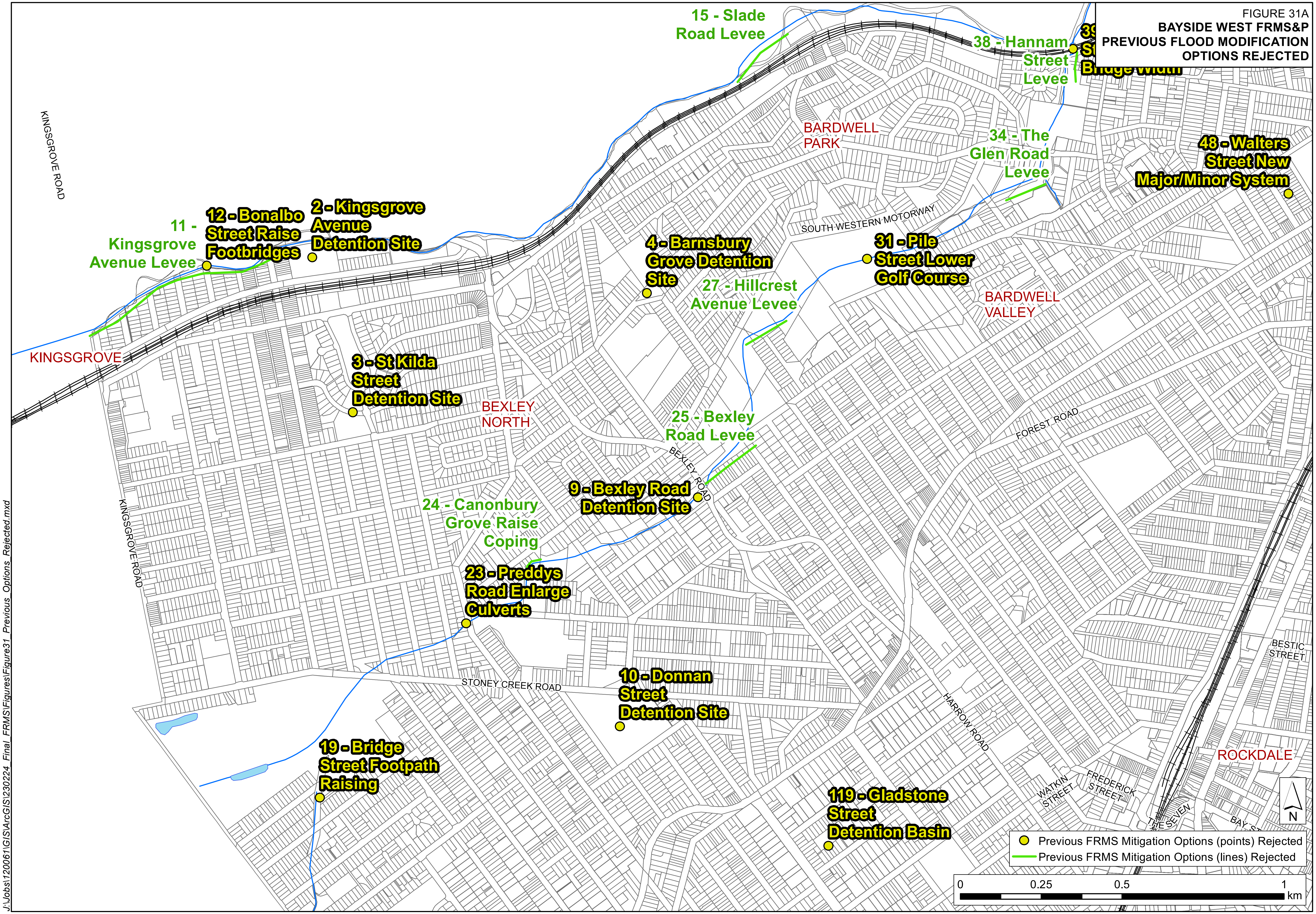


FIGURE 31A
BAYSIDE WEST FRMS&P
PREVIOUS FLOOD MODIFICATION OPTIONS REJECTED

J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure31_Previous_Options_Rejected.mxd

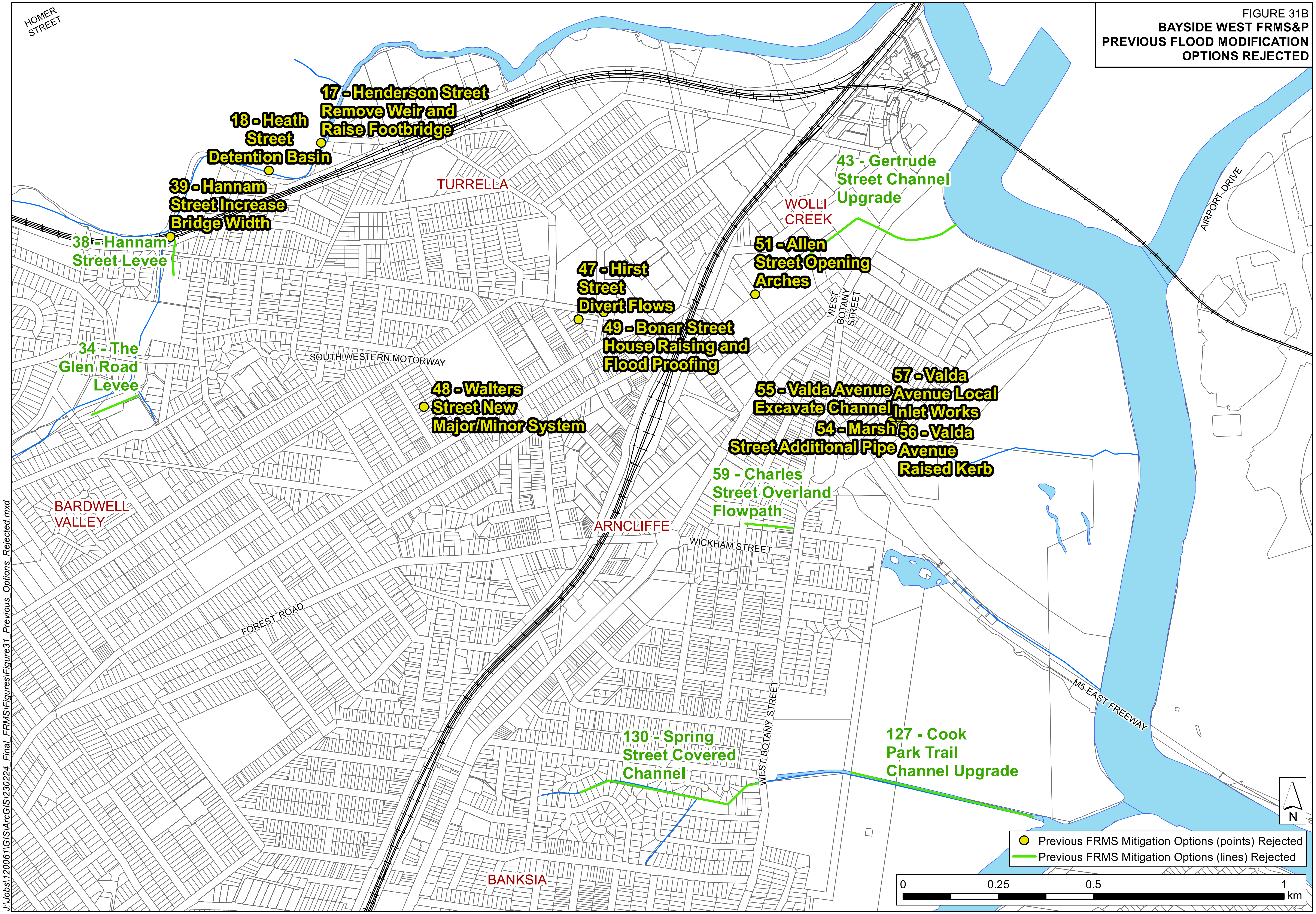
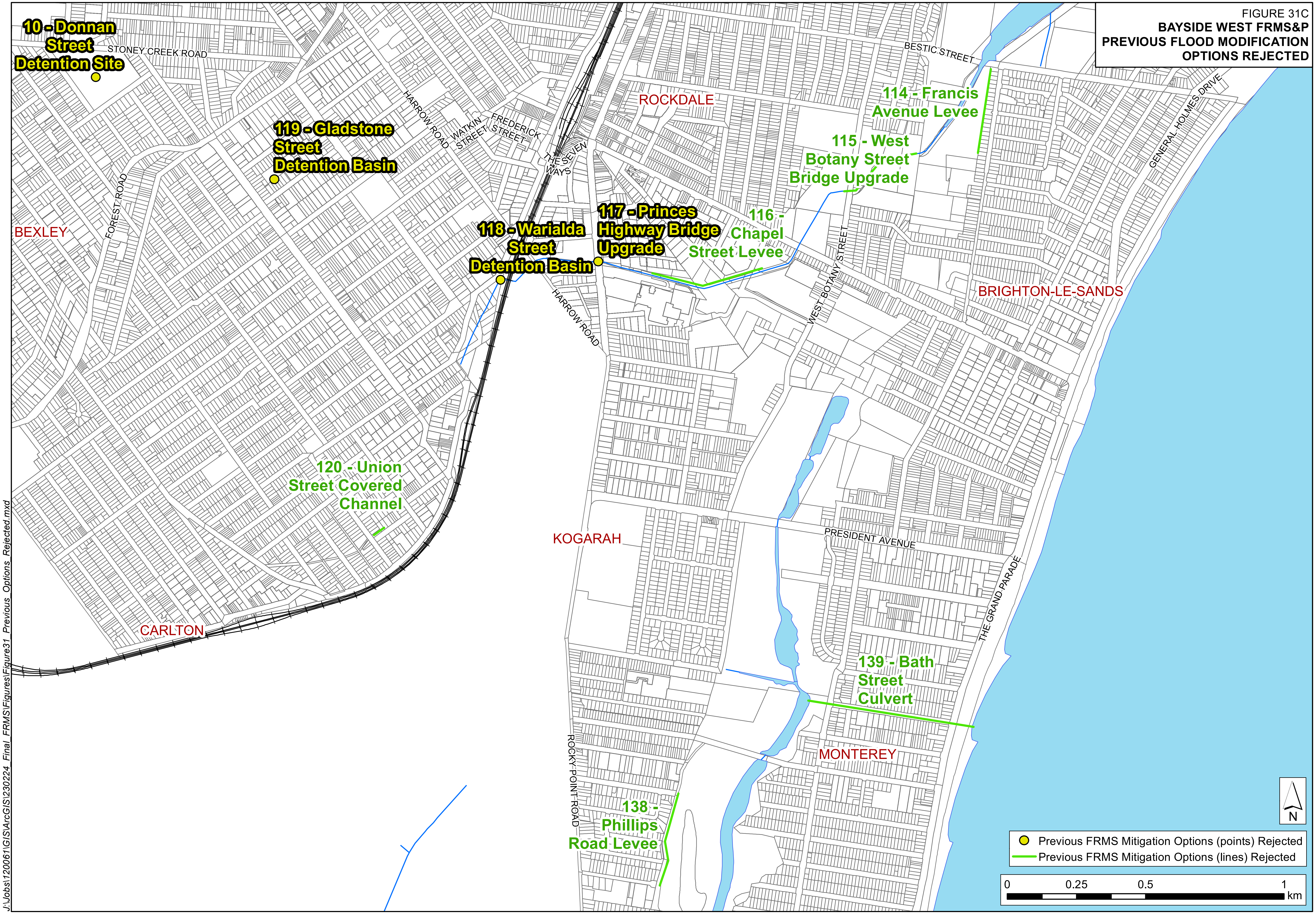


FIGURE 31B
BAYSIDE WEST FRMS&P
PREVIOUS FLOOD MODIFICATION
OPTIONS REJECTED
HOMER STREET
17 - Henderson Street Remove Weir and Raise Footbridge
18 - Heath Street Detention Basin
39 - Hannam Street Increase Bridge Width
38 - Hannam Street Levee
34 - The Glen Road Levee
TURRELLA
WOLLI CREEK
43 - Gertrude Street Channel Upgrade
51 - Allen Street Opening Arches
47 - Hirst Street Divert Flows
49 - Bonar Street House Raising and Flood Proofing
48 - Walters Street New Major/Minor System
SOUTH WESTERN MOTORWAY
WEST BOTANY STREET
57 - Valda Avenue Local Inlet Works
55 - Valda Avenue Excavate Channel
54 - Marsh Street Additional Pipe
56 - Valda Avenue Raised Kerb
59 - Charles Street Overland Flowpath
AIRPORT DRIVE
BARDWELL VALLEY
ARNCLIFFE
WICKHAM STREET
FOREST ROAD
M5 EAST FREEWAY
130 - Spring Street Covered Channel
127 - Cook Park Trail Channel Upgrade
BANKSIA
Previous FRMS Mitigation Options (points) Rejected
Previous FRMS Mitigation Options (lines) Rejected
0
0.25
0.5
1
km
N
J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure31_Previous_Options_Rejected.mxd

FIGURE 31C
BAYSIDE WEST FRMS&P
PREVIOUS FLOOD MODIFICATION OPTIONS REJECTED



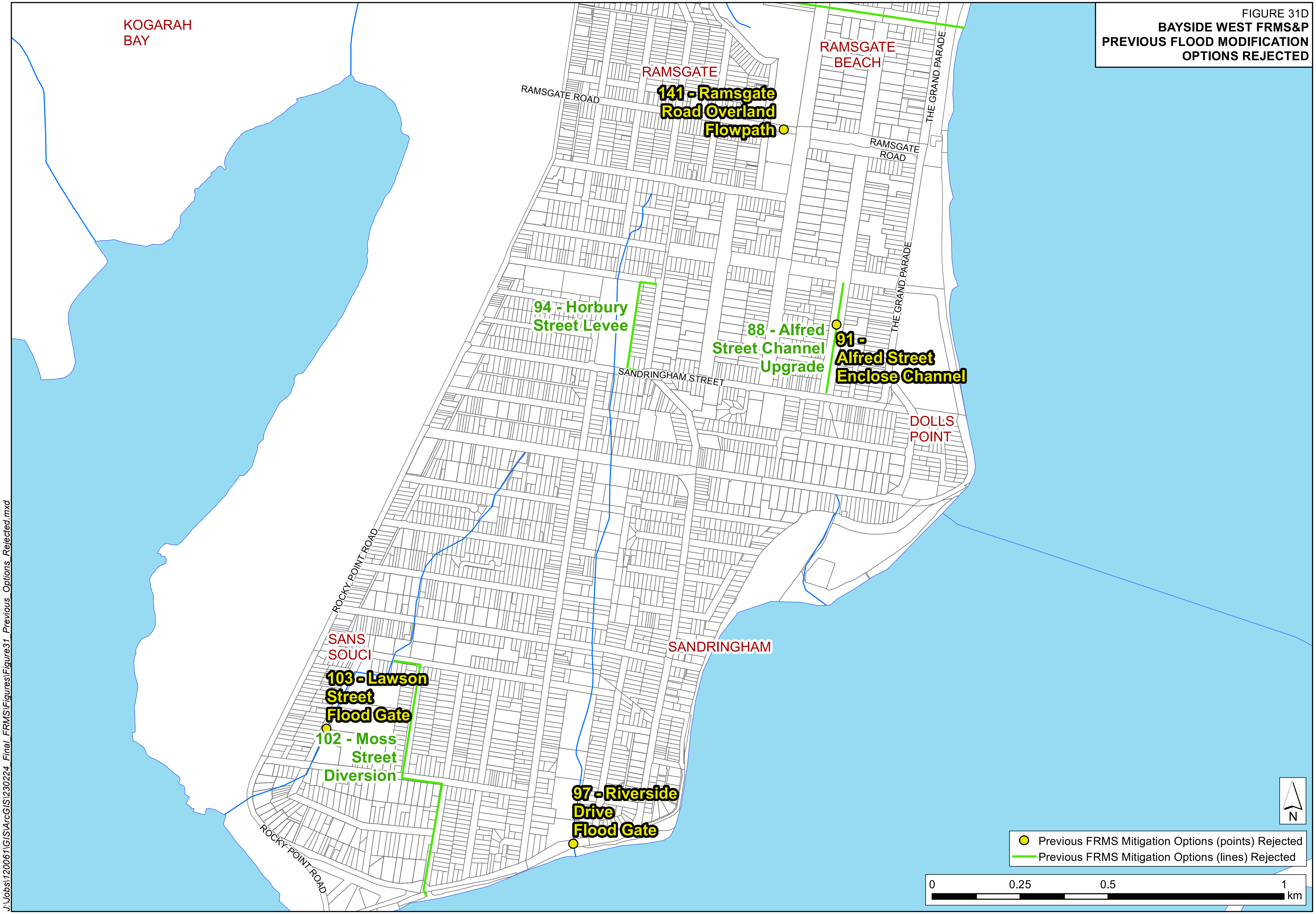
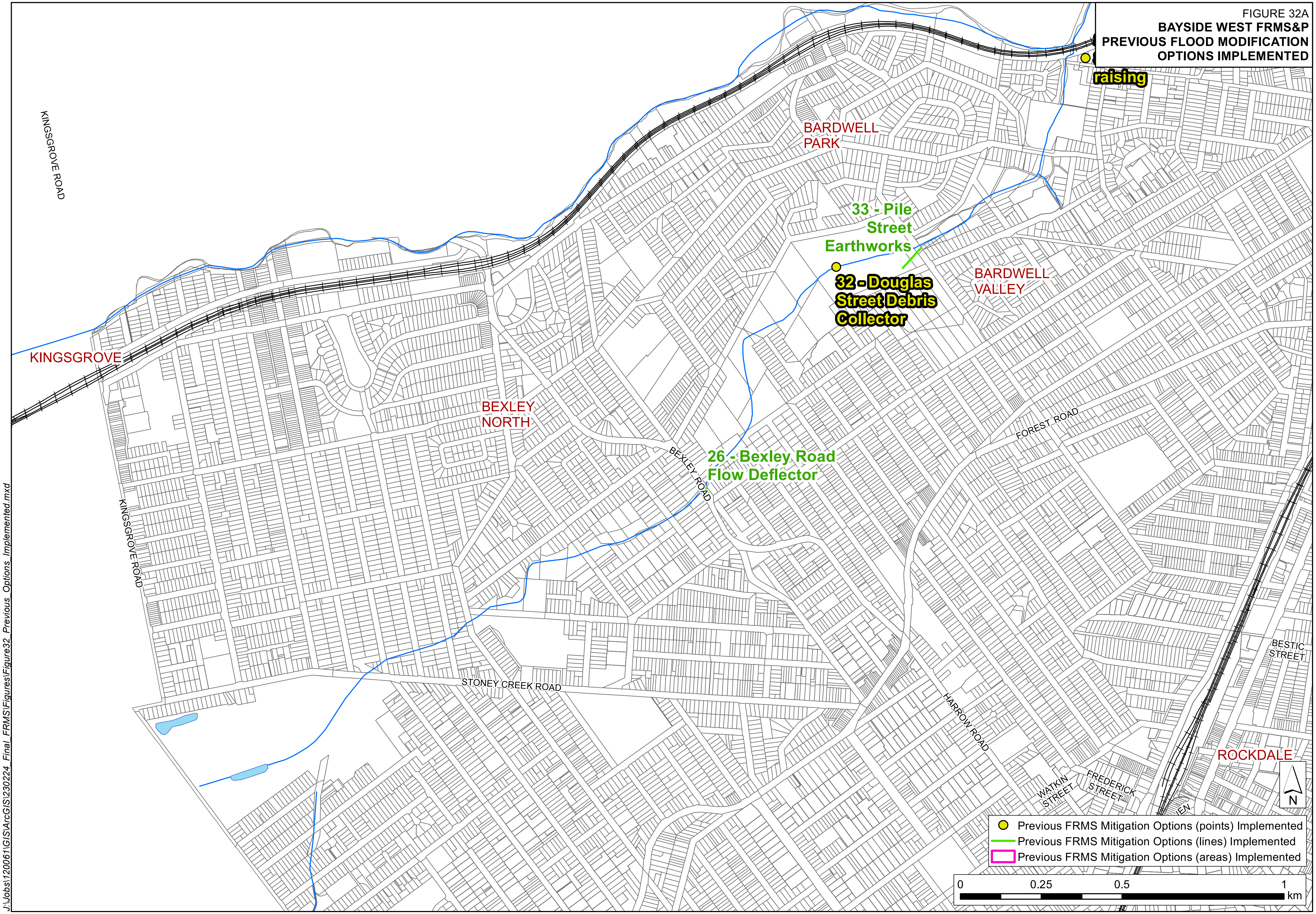


FIGURE 31D
BAYSIDE WEST FRMS&P
PREVIOUS FLOOD MODIFICATION
OPTIONS REJECTED
KOGARAH
BAY
RAMSGATE
RAMSGATE
BEACH
RAMSGATE ROAD
RAMSGATE
ROAD
THE GRAND PARADE
THE GRAND PARADE
141 - Ramsgate
Road Overland
Flowpath
94 - Horbury
Street Levee
88 - Alfred
Street Channel
Upgrade
91 -
Alfred Street
Enclose Channel
SANDRINGHAM STREET
DOLLS
POINT
ROCKY POINT ROAD
SANS
SOUCI
SANDRINGHAM
103 - Lawson
Street
Flood Gate
102 - Moss
Street
Diversion
97 - Riverside
Drive
Flood Gate
ROCKY POINT ROAD
N
Previous FRMS Mitigation Options (points) Rejected
Previous FRMS Mitigation Options (lines) Rejected
0
0.25
0.5
1
km
J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure31_Previous_Options_Rejected.mxd

FIGURE 32A
BAYSIDE WEST FRMS&P
PREVIOUS FLOOD MODIFICATION OPTIONS IMPLEMENTED



J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure32_Previous_Options_Implemented.mxd

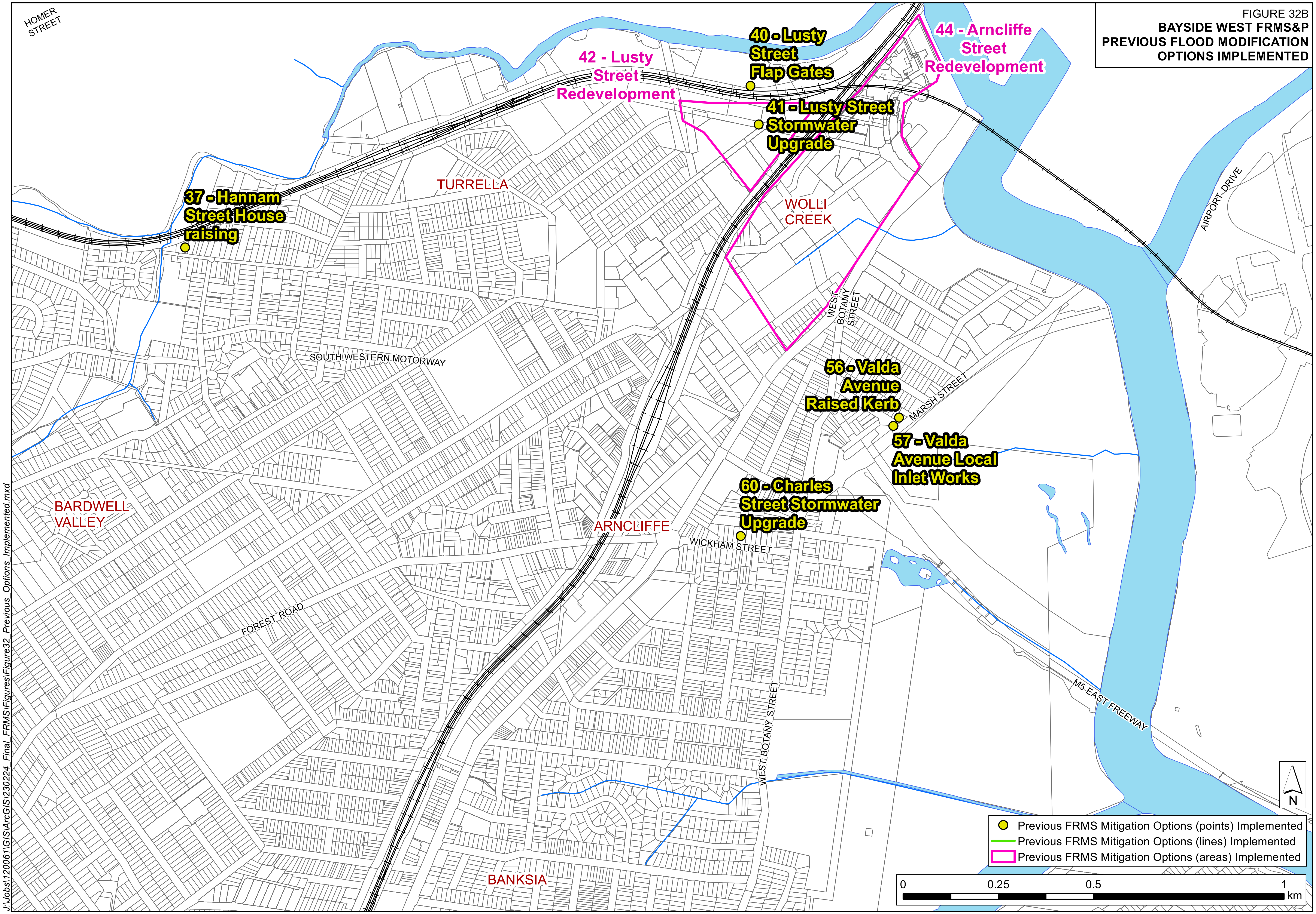
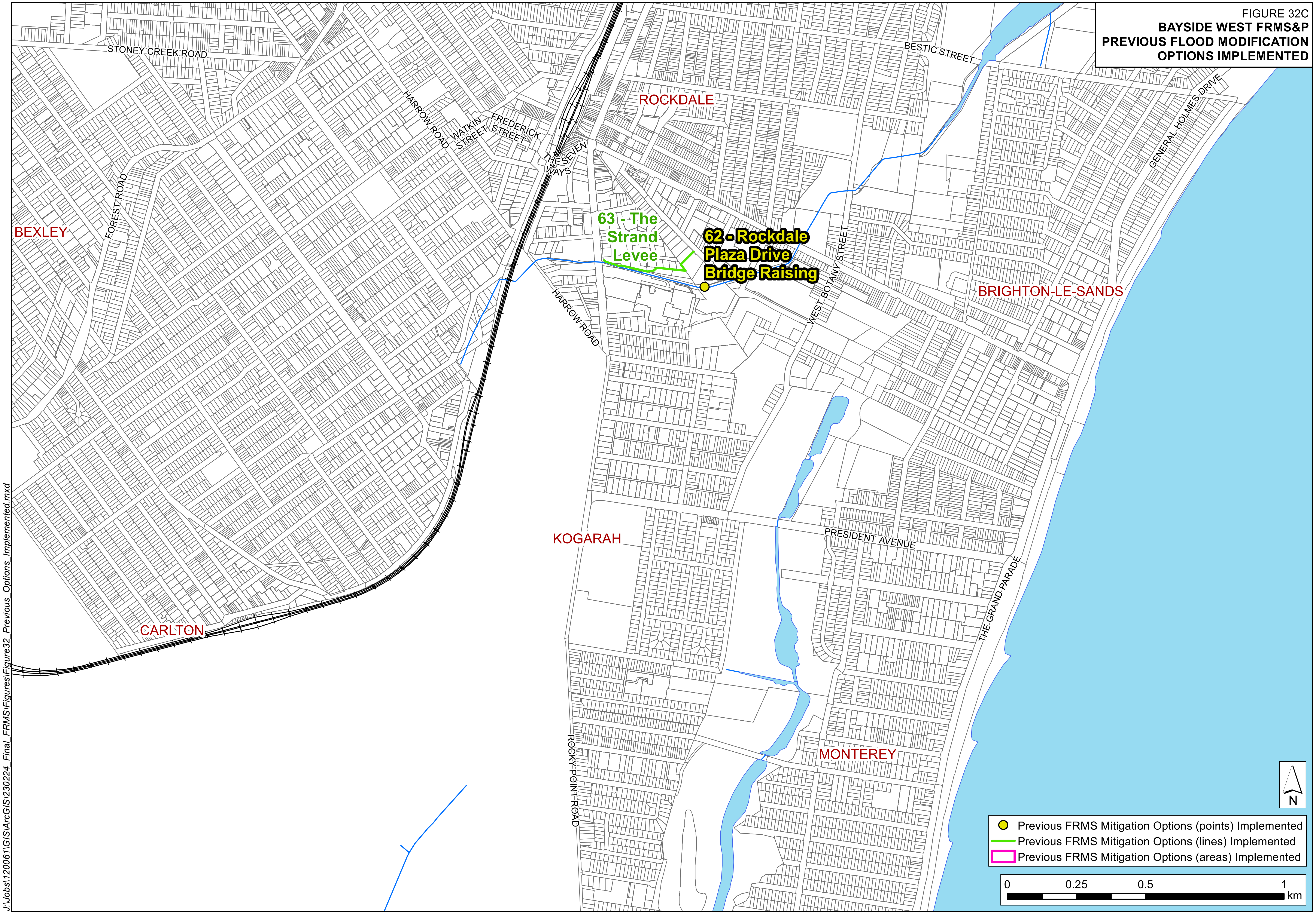


FIGURE 32B
BAYSIDE WEST FRMS&P
PREVIOUS FLOOD MODIFICATION
OPTIONS IMPLEMENTED
HOMER STREET
40 - Lusty Street Flap Gates
42 - Lusty Street Redevelopment
44 - Arncliffe Street Redevelopment
41 - Lusty Street Stormwater Upgrade
37 - Hannam Street House raising
TURRELLA
WOLLI CREEK
AIRPORT DRIVE
WEST BOTANY STREET
SOUTH WESTERN MOTORWAY
56 - Valda Avenue Raised Kerb
MARSH STREET
57 - Valda Avenue Local Inlet Works
60 - Charles Street Stormwater Upgrade
BARDWELL VALLEY
ARNCLIFFE
WICKHAM STREET
FOREST ROAD
M5 EAST FREEWAY
WEST BOTANY STREET
BANKSIA
N
Previous FRMS Mitigation Options (points) Implemented
Previous FRMS Mitigation Options (lines) Implemented
Previous FRMS Mitigation Options (areas) Implemented
0
0.25
0.5
1
km
J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure32_Previous_Options_Implemented.mxd

FIGURE 32C
BAYSIDE WEST FRMS&P
PREVIOUS FLOOD MODIFICATION OPTIONS IMPLEMENTED



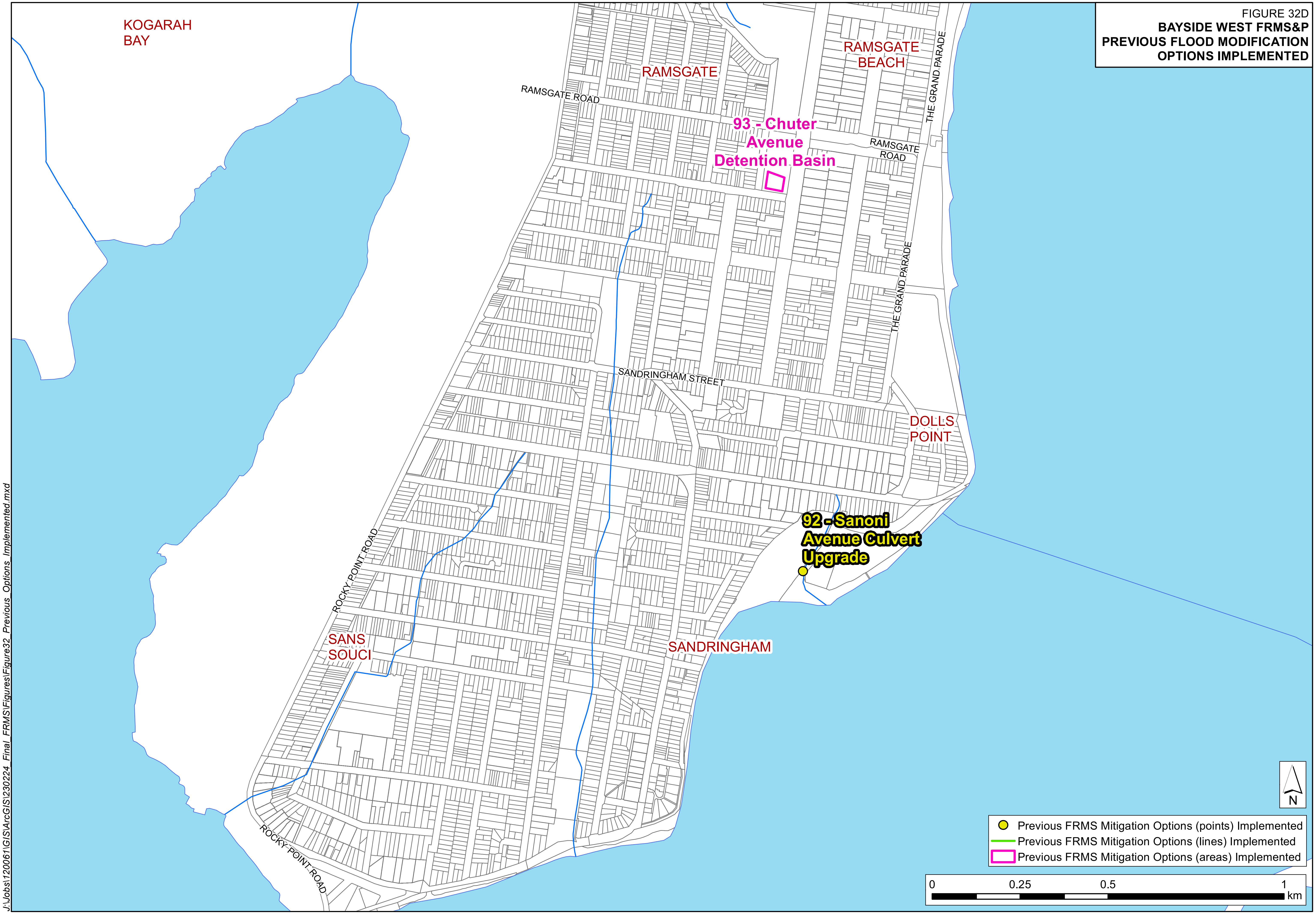
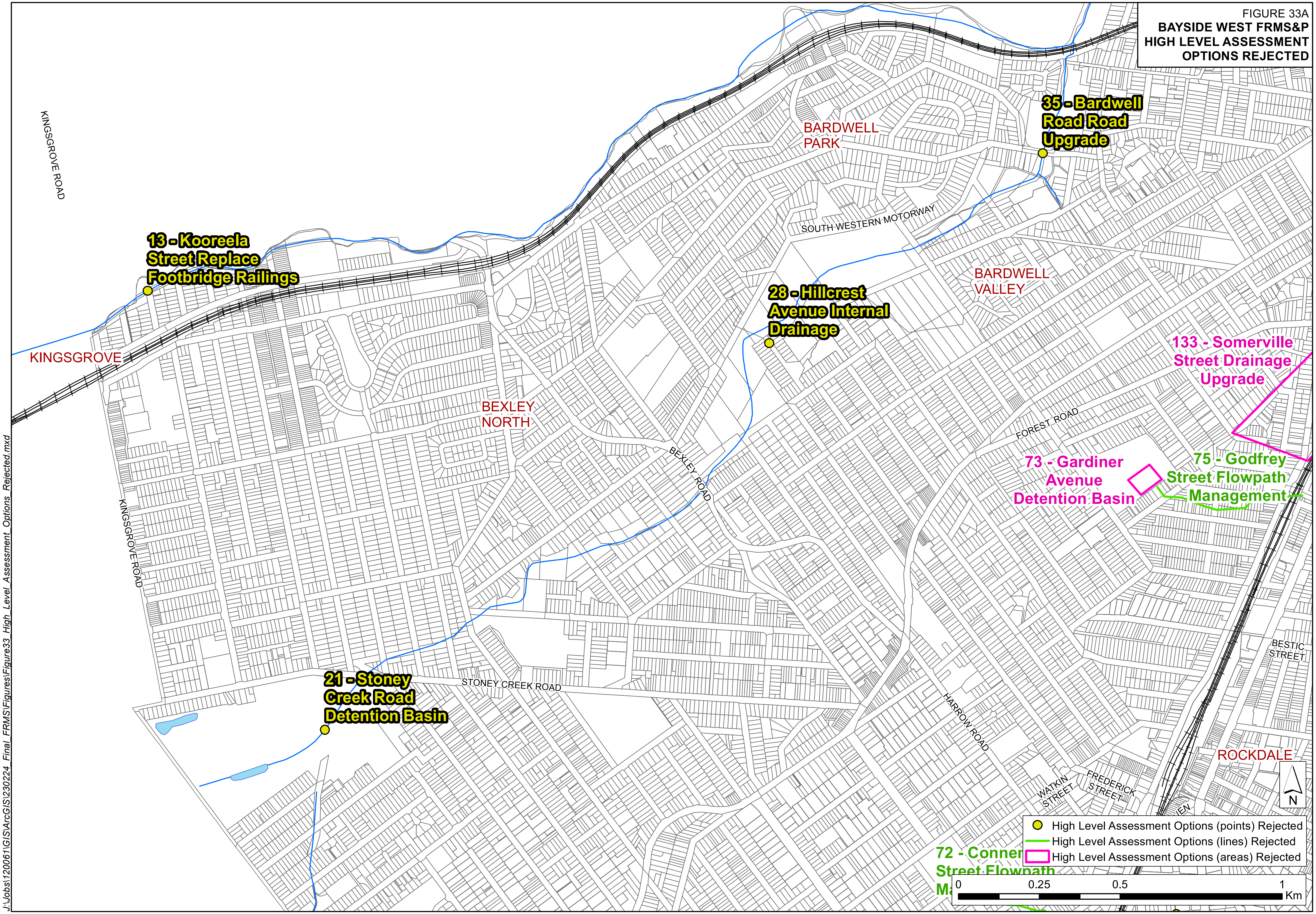


FIGURE 32D
BAYSIDE WEST FRMS&P
PREVIOUS FLOOD MODIFICATION
OPTIONS IMPLEMENTED
KOGARAH BAY
RAMSGATE
RAMSGATE BEACH
RAMSGATE ROAD
THE GRAND PARADE
93 - Chuter Avenue Detention Basin
SANDRINGHAM STREET
DOLLS POINT
92 - Sanoni Avenue Culvert Upgrade
ROCKY POINT ROAD
SANS SOUCI
SANDRINGHAM
N
Previous FRMS Mitigation Options (points) Implemented
Previous FRMS Mitigation Options (lines) Implemented
Previous FRMS Mitigation Options (areas) Implemented
0
0.25
0.5
1
km
J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure32_Previous_Options_Implemented.mxd

FIGURE 33A
BAYSIDE WEST FRMS&P
HIGH LEVEL ASSESSMENT
OPTIONS REJECTED



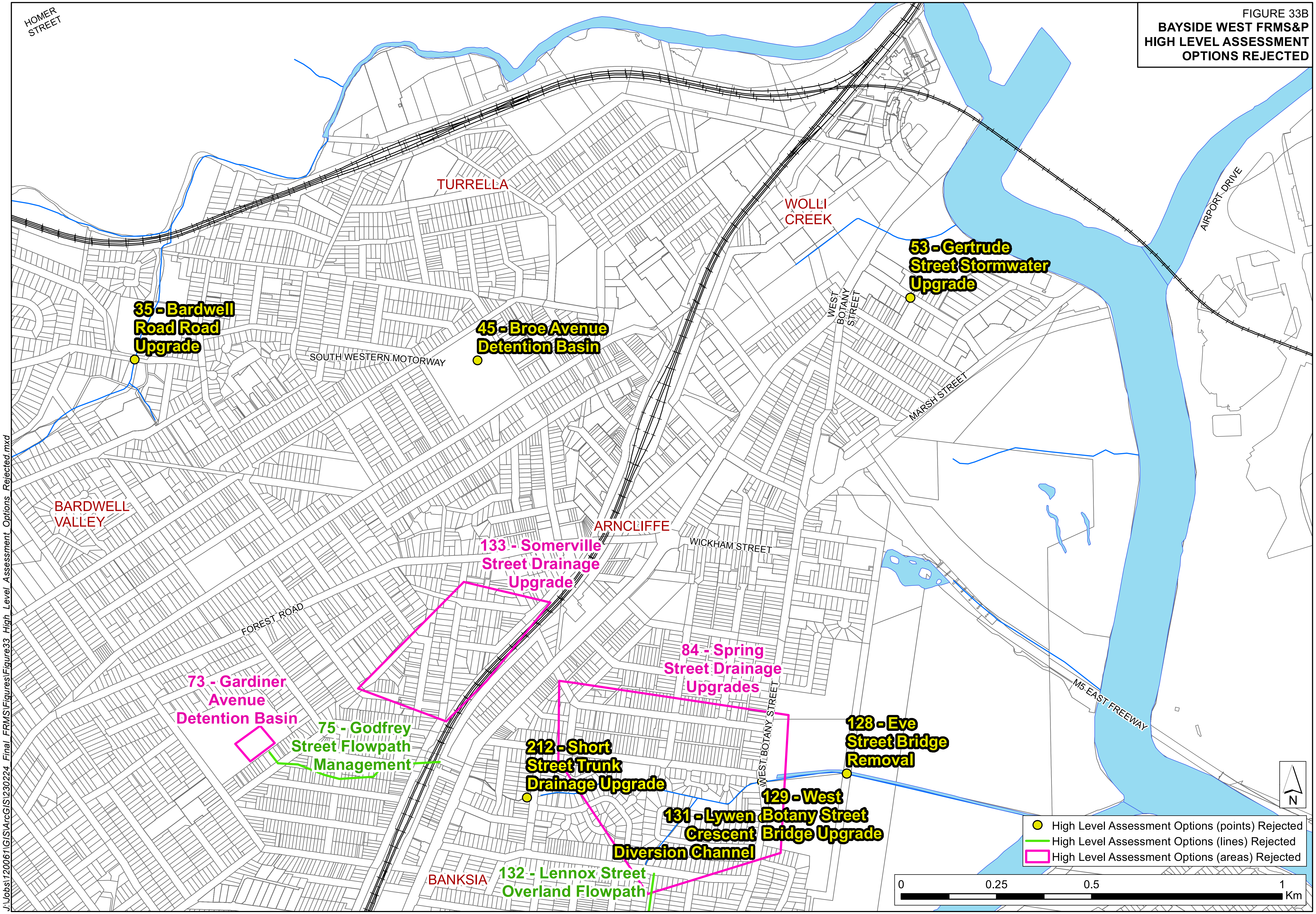


FIGURE 33B
BAYSIDE WEST FRMS&P
HIGH LEVEL ASSESSMENT
OPTIONS REJECTED
HOMER STREET
TURRELLA
WOLLI CREEK
AIRPORT DRIVE
53 - Gertrude Street Stormwater Upgrade
35 - Bardwell Road Road Upgrade
45 - Broe Avenue Detention Basin
SOUTH WESTERN MOTORWAY
WEST BOTANY STREET
MARSH STREET
BARDWELL VALLEY
ARNCLIFFE
WICKHAM STREET
133 - Somerville Street Drainage Upgrade
FOREST ROAD
84 - Spring Street Drainage Upgrades
73 - Gardiner Avenue Detention Basin
75 - Godfrey Street Flowpath Management
212 - Short Street Trunk Drainage Upgrade
128 - Eve Street Bridge Removal
M5 EAST FREEWAY
129 - West Botany Street Bridge Upgrade
131 - Lywen Crescent Diversion Channel
BANKSIA
132 - Lennox Street Overland Flowpath
N
High Level Assessment Options (points) Rejected
High Level Assessment Options (lines) Rejected
High Level Assessment Options (areas) Rejected
0
0.25
0.5
1
Km
J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure33_High_Level_Assessment_Options_Rejected.mxd

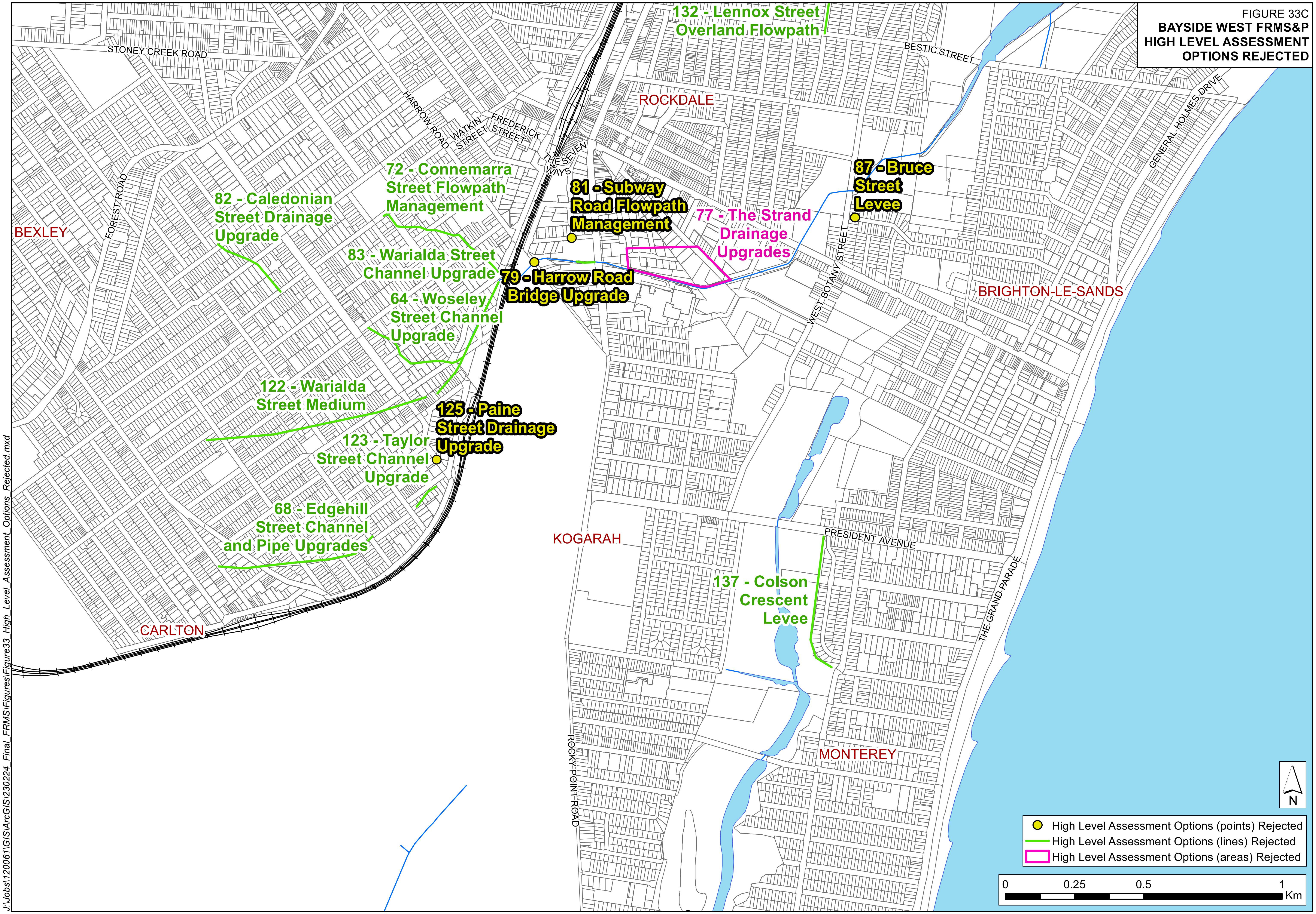
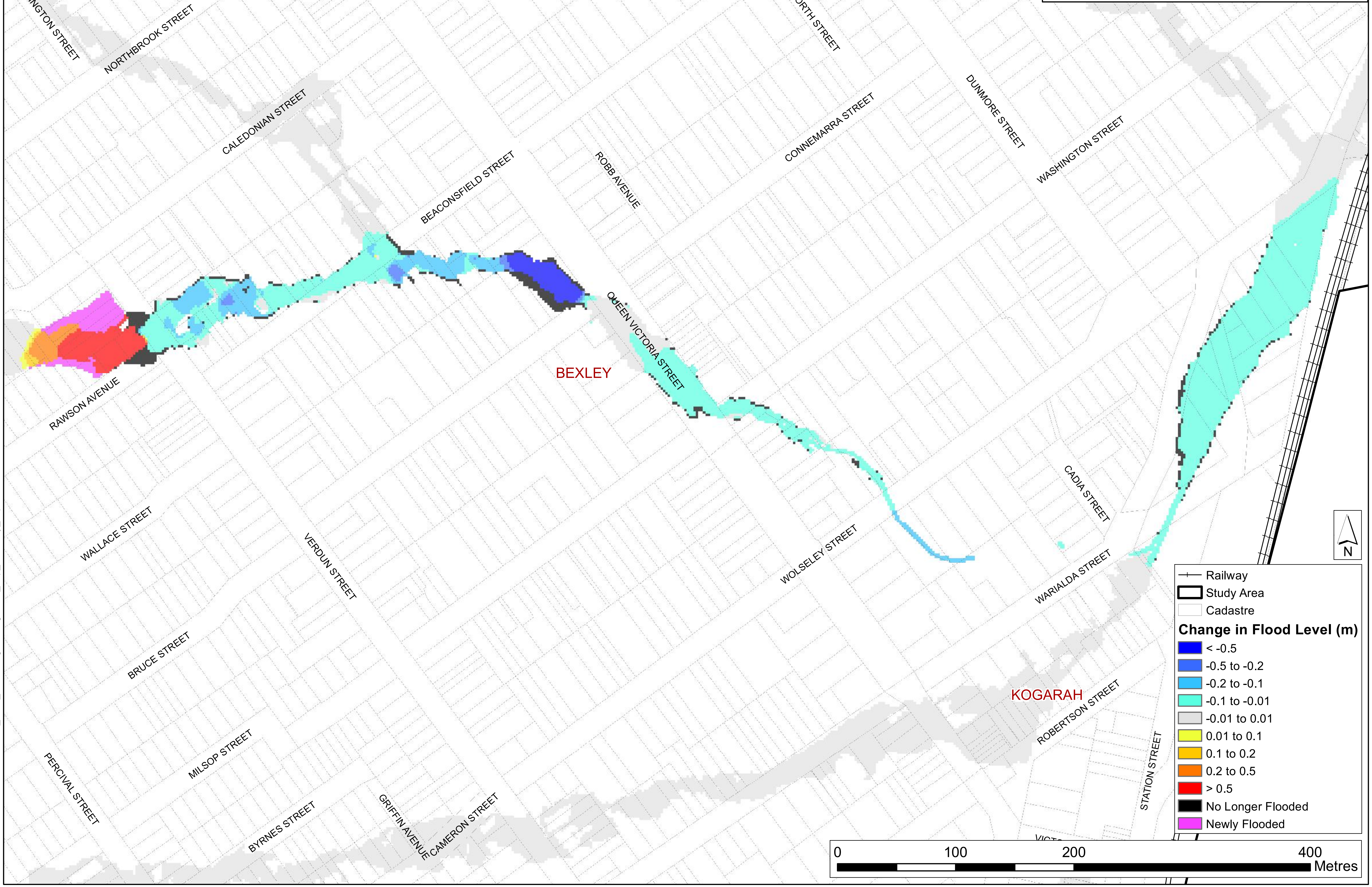


FIGURE 33C
BAYSIDE WEST FRMS&P
HIGH LEVEL ASSESSMENT
OPTIONS REJECTED
132 - Lennox Street Overland Flowpath
72 - Connemarra Street Flowpath Management
82 - Caledonian Street Drainage Upgrade
81 - Subway Road Flowpath Management
77 - The Strand Drainage Upgrades
87 - Bruce Street Levee
83 - Warialda Street Channel Upgrade
79 - Harrow Road Bridge Upgrade
64 - Woseley Street Channel Upgrade
122 - Warialda Street Medium
125 - Paine Street Drainage Upgrade
123 - Taylor Street Channel Upgrade
68 - Edgehill Street Channel and Pipe Upgrades
137 - Colson Crescent Levee
STONEY CREEK ROAD
BESTIC STREET
HARROW ROAD
WATKIN STREET
FREDERICK STREET
THE SEVEN WAYS
FOREST ROAD
WEST BOTANY STREET
GENERAL HOLMES DRIVE
PRESIDENT AVENUE
THE GRAND PARADE
ROCKY POINT ROAD
ROCKDALE
BEXLEY
BRIGHTON-LE-SANDS
KOGARAH
CARLTON
MONTEREY
N
High Level Assessment Options (points) Rejected
High Level Assessment Options (lines) Rejected
High Level Assessment Options (areas) Rejected
0
0.25
0.5
1
Km
J:\Jobs\120061\GIS\ArcGIS\S1230224_Final_FRMS\Figures\Figure33_High_Level_Assessment_Options_Rejected.mxd


FIGURE 33D
BAYSIDE WEST FRMS&P
HIGH LEVEL ASSESSMENT
OPTIONS REJECTED
KOGARAH BAY
RAMSGATE
RAMSGATE BEACH
RAMSGATE ROAD
THE GRAND PARADE
SANDRINGHAM STREET
DOLLS POINT
SANDRINGHAM
ROCKY POINT ROAD
86 - The Grand Parade Tidal Gate Upgrade
99 - Minton Avenue Overland Flowpath
95 - Russell Avenue Culvert Upgrade
89 - Russell Avenue Flood Gate
100 - Primrose Avenue Overland Flowpath
144 - Catchment Wide Drainage Upgrade
96 - Ida Street Culvert Upgrade
101 - Lawson Street Channel Upgrade
106 - Rocky Point Road Overland Flowpath
High Level Assessment Options (points) Rejected
High Level Assessment Options (lines) Rejected
High Level Assessment Options (areas) Rejected
0
0.25
0.5
1
Km
N
J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure33_High_Level_Assessment_Options_Rejected.mxd

FIGURE 34
BAYSIDE WEST FRMS&P: MUDDY CREEK
DOMINEY RESERVE DETENTION BASIN
5% AEP EVENT CHANGE IN PEAK FLOOD LEVEL



J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure34_05p_Dominey_Impact.mxd

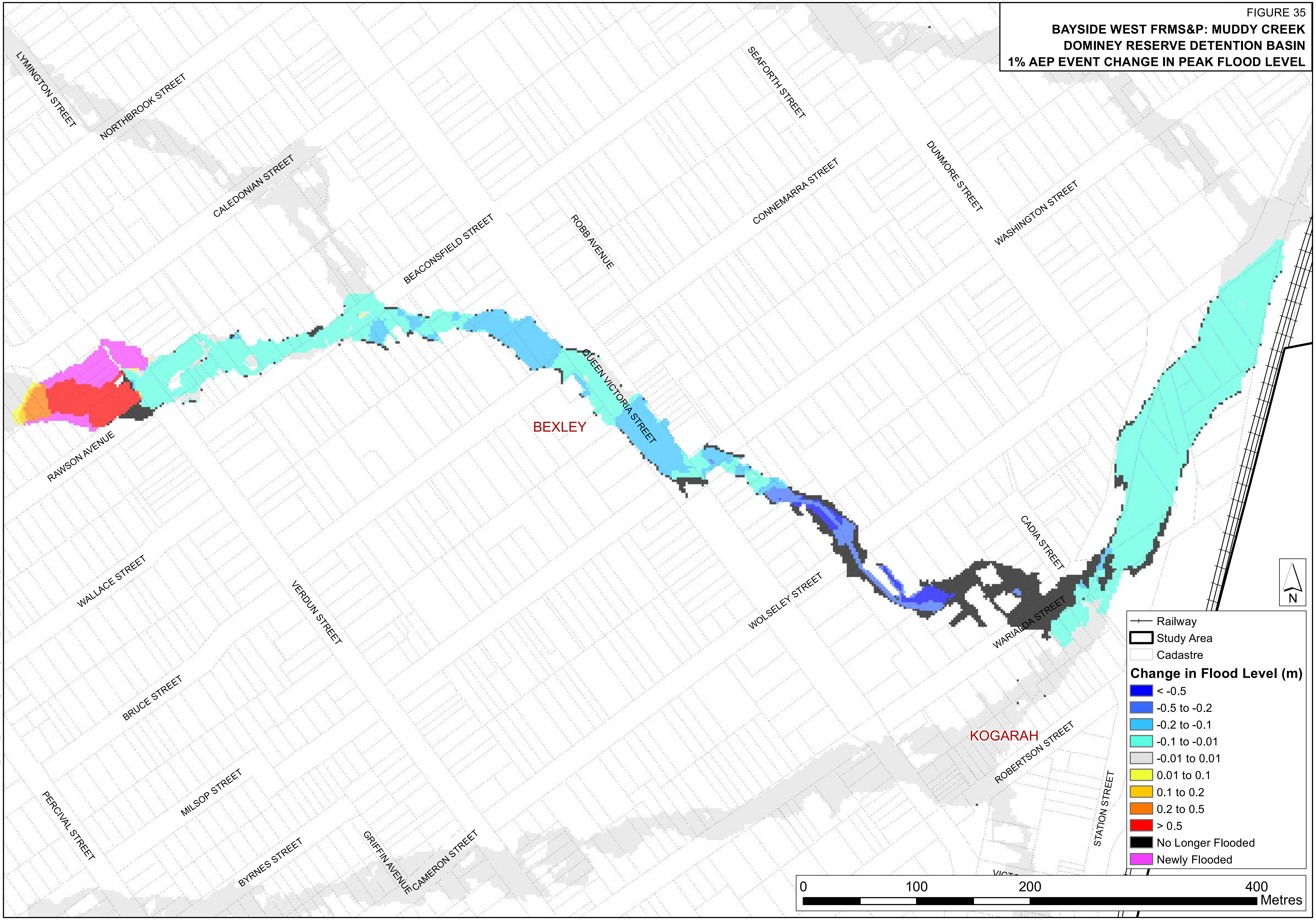


FIGURE 35
BAYSIDE WEST FRMS&P: MUDDY CREEK
DOMINEY RESERVE DETENTION BASIN
1% AEP EVENT CHANGE IN PEAK FLOOD LEVEL
LYMINGTON STREET
NORTHBROOK STREET
CALEDONIAN STREET
BEACONSFIELD STREET
ROBB AVENUE
SEAFORTH STREET
CONNEMARRA STREET
DUNMORE STREET
WASHINGTON STREET
QUEEN VICTORIA STREET
BEXLEY
RAWSON AVENUE
WALLACE STREET
VERDUN STREET
WOLSELEY STREET
CADIA STREET
WARIALDA STREET
BRUCE STREET
KOGARAH
ROBERTSON STREET
MILSOP STREET
PERCIVAL STREET
BYRNES STREET
GRIFFIN AVENUE
CAMERON STREET
STATION STREET
N
Railway
Study Area
Cadastre
Change in Flood Level (m)
< -0.5
-0.5 to -0.2
-0.2 to -0.1
-0.1 to -0.01
-0.01 to 0.01
0.01 to 0.1
0.1 to 0.2
0.2 to 0.5
> 0.5
No Longer Flooded
Newly Flooded
0
100
200
400
Metres
J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure35_05p_Dominey_Impact.mxd

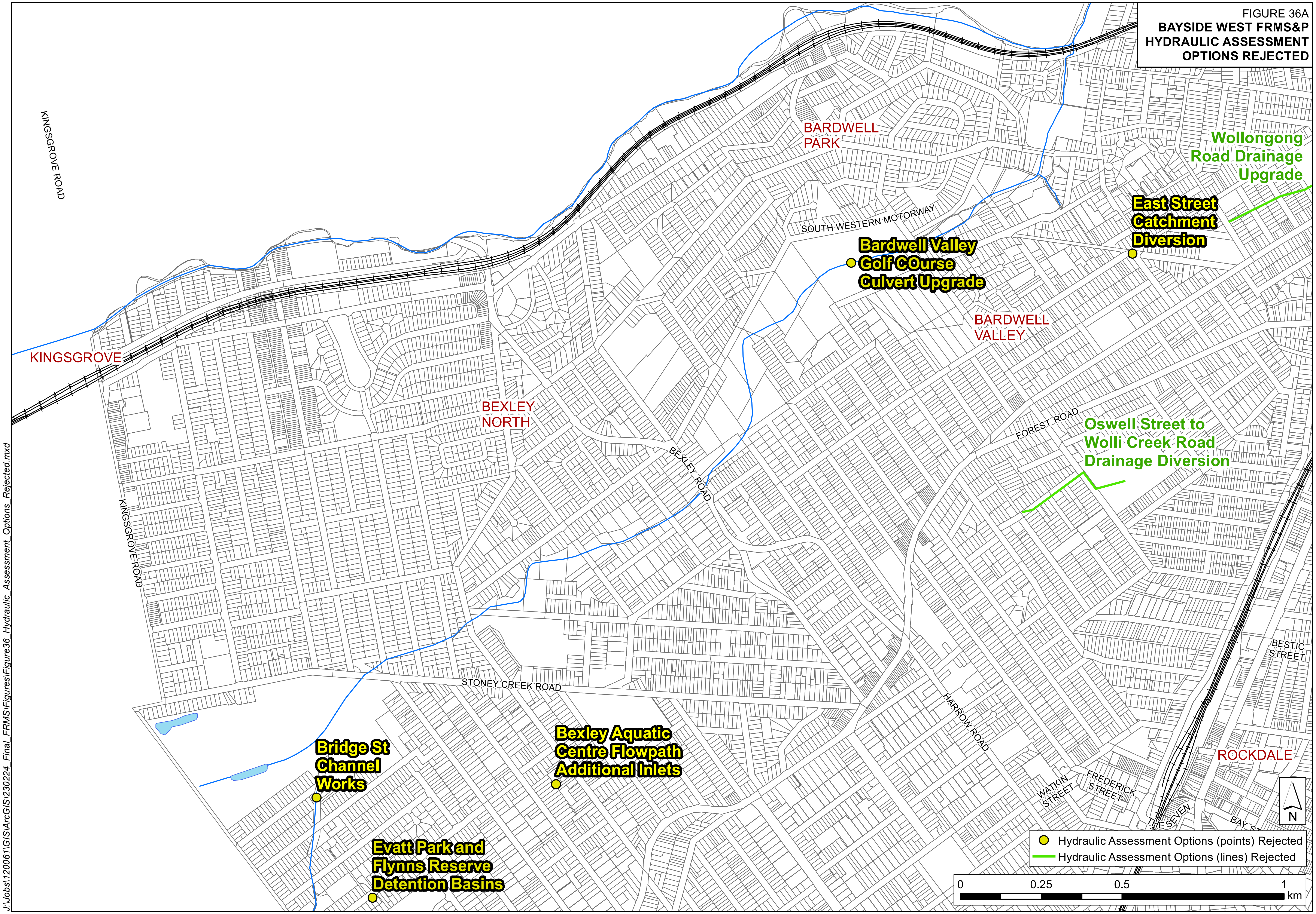
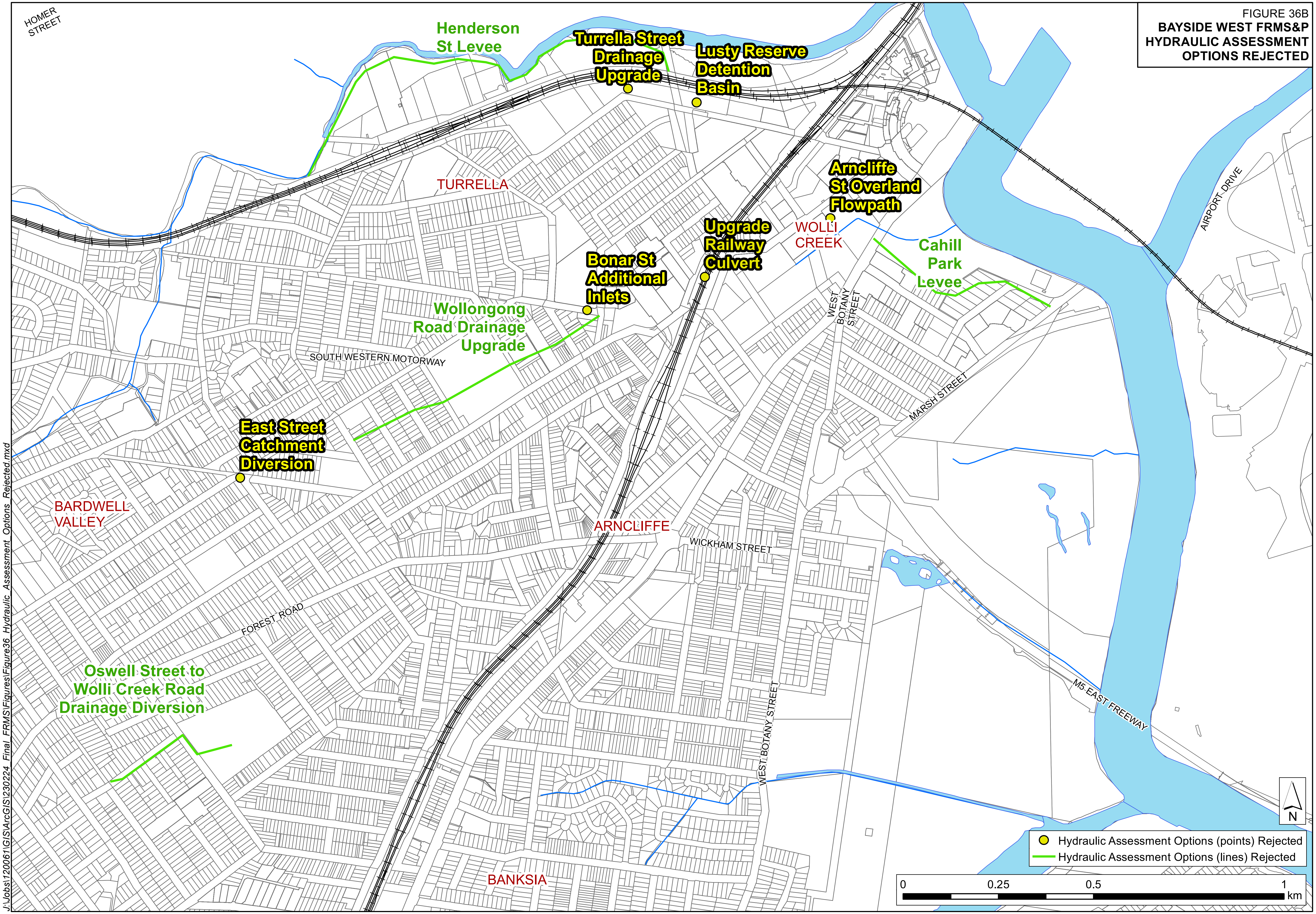
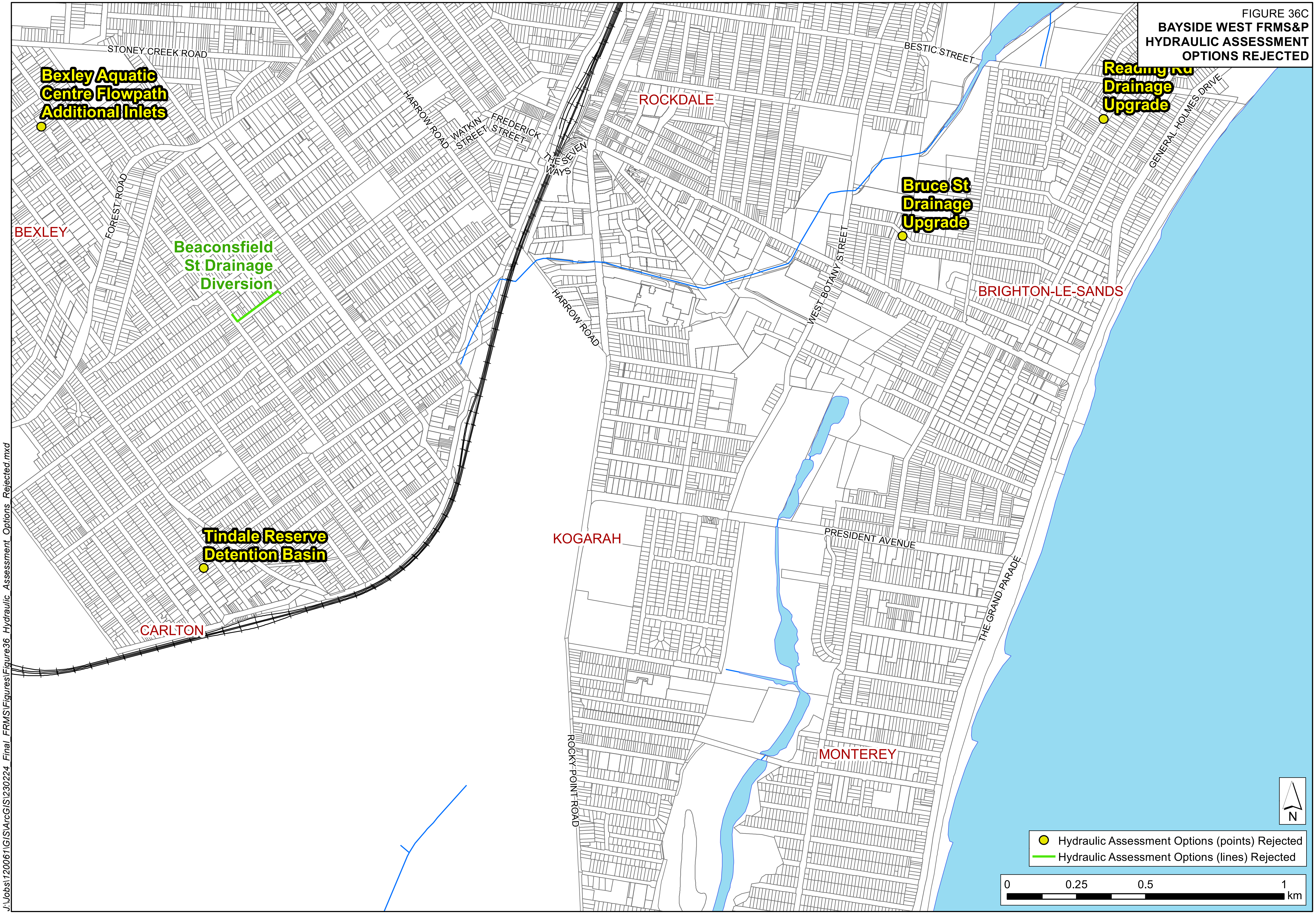


FIGURE 36A
BAYSIDE WEST FRMS&P
HYDRAULIC ASSESSMENT
OPTIONS REJECTED
KINGSGROVE ROAD
BARDWELL
PARK
Wollongong
Road Drainage
Upgrade
East Street
Catchment
Diversion
SOUTH WESTERN MOTORWAY
Bardwell Valley
Golf COurse
Culvert Upgrade
BARDWELL
VALLEY
KINGSGROVE
BEXLEY
NORTH
FOREST ROAD
Oswell Street to
Wolli Creek Road
Drainage Diversion
BEXLEY ROAD
KINGSGROVE ROAD
STONEY CREEK ROAD
HARROW ROAD
BESTIC
STREET
Bexley Aquatic
Centre Flowpath
Additional Inlets
Bridge St
Channel
Works
ROCKDALE
WATKIN
STREET
FREDERICK
STREET
THE SEVEN
N
Hydraulic Assessment Options (points) Rejected
Hydraulic Assessment Options (lines) Rejected
Evatt Park and
Flynns Reserve
Detention Basins
0
0.25
0.5
1
km
J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure36_Hydraulic_Assessment_Options_Rejected.mxd

FIGURE 36B
BAYSIDE WEST FRMS&P
HYDRAULIC ASSESSMENT
OPTIONS REJECTED



J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure36_Hydraulic_Assessment_Options_Rejected.mxd



J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure36_Hydraulic_Assessment_Options_Rejected.mxd

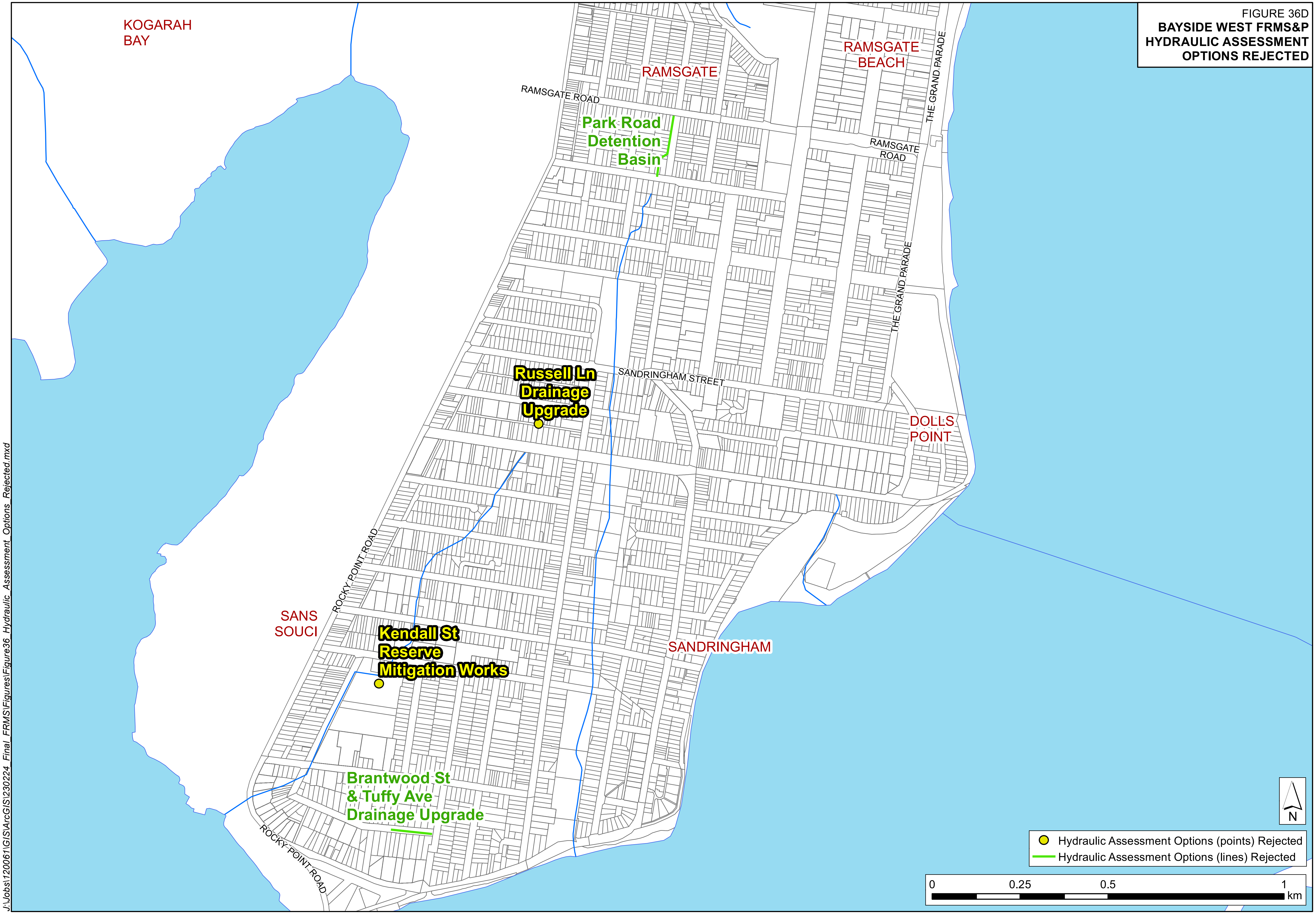


FIGURE 36D
BAYSIDE WEST FRMS&P
HYDRAULIC ASSESSMENT
OPTIONS REJECTED
KOGARAH BAY
RAMSGATE
RAMSGATE BEACH
RAMSGATE ROAD
THE GRAND PARADE
Park Road Detention Basin
Russell Ln Drainage Upgrade
SANDRINGHAM STREET
DOLLS POINT
ROCKY POINT ROAD
SANS SOUCI
Kendall St Reserve Mitigation Works
SANDRINGHAM
Brantwood St & Tuffy Ave Drainage Upgrade
N
Hydraulic Assessment Options (points) Rejected
Hydraulic Assessment Options (lines) Rejected
0
0.25
0.5
1
km
J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure36_Hydraulic_Assessment_Options_Rejected.mxd

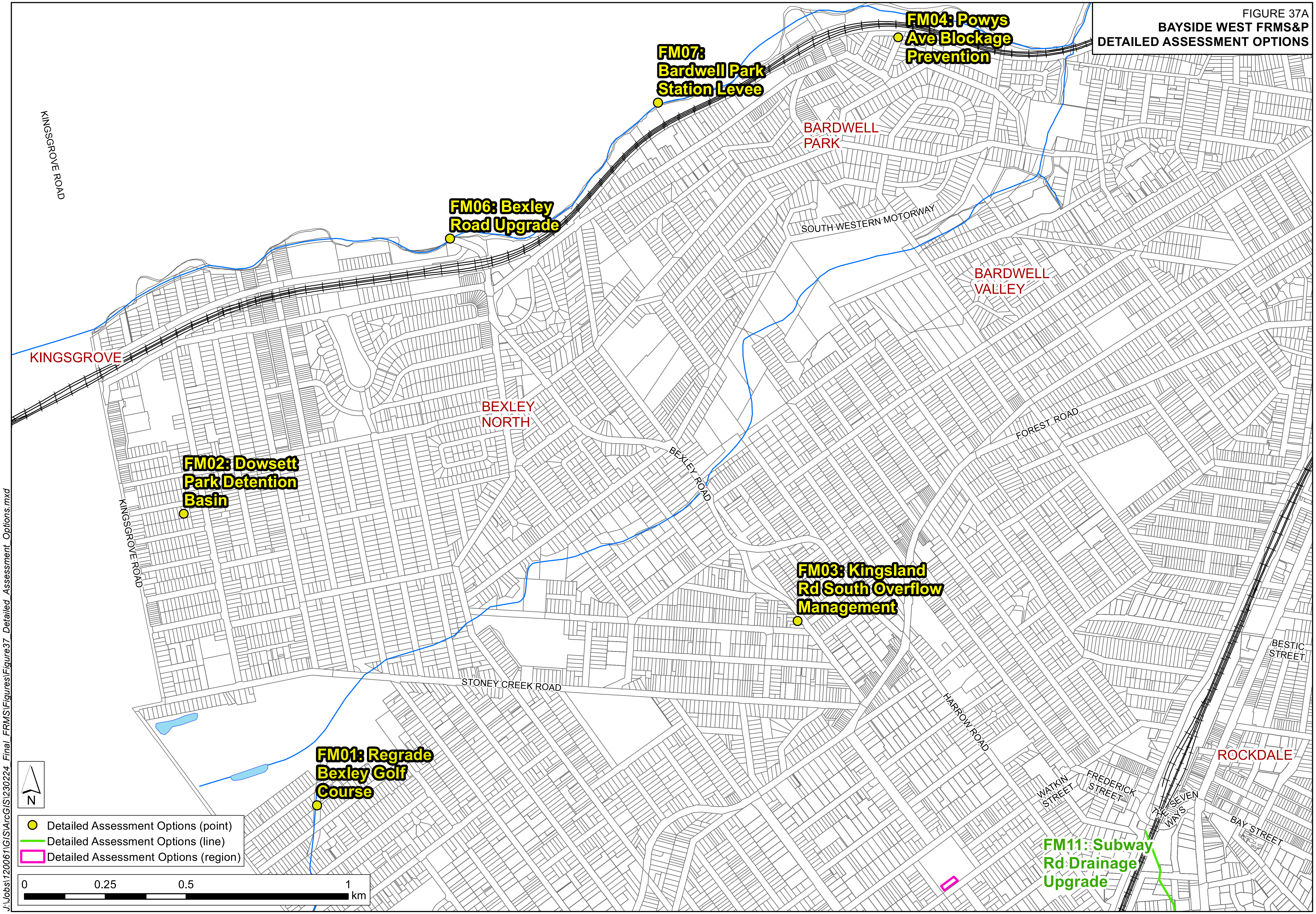


FIGURE 37A
BAYSIDE WEST FRMS&P
DETAILED ASSESSMENT OPTIONS
FM04: Powys Ave Blockage Prevention
FM07: Bardwell Park Station Levee
FM06: Bexley Road Upgrade
FM02: Dowsett Park Detention Basin
FM03: Kingsland Rd South Overflow Management
FM01: Regrade Bexley Golf Course
FM11: Subway Rd Drainage Upgrade
KINGSGROVE ROAD
KINGSGROVE
BARDWELL PARK
BARDWELL VALLEY
BEXLEY NORTH
ROCKDALE
SOUTH WESTERN MOTORWAY
FOREST ROAD
BEXLEY ROAD
STONEY CREEK ROAD
HARROW ROAD
BESTIC STREET
WATKIN STREET
FREDERICK STREET
THE SEVEN WAYS
BAY STREET
N
Detailed Assessment Options (point)
Detailed Assessment Options (line)
Detailed Assessment Options (region)
0
0.25
0.5
1
km
J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure37_Detailed_Assessment_Options.mxd

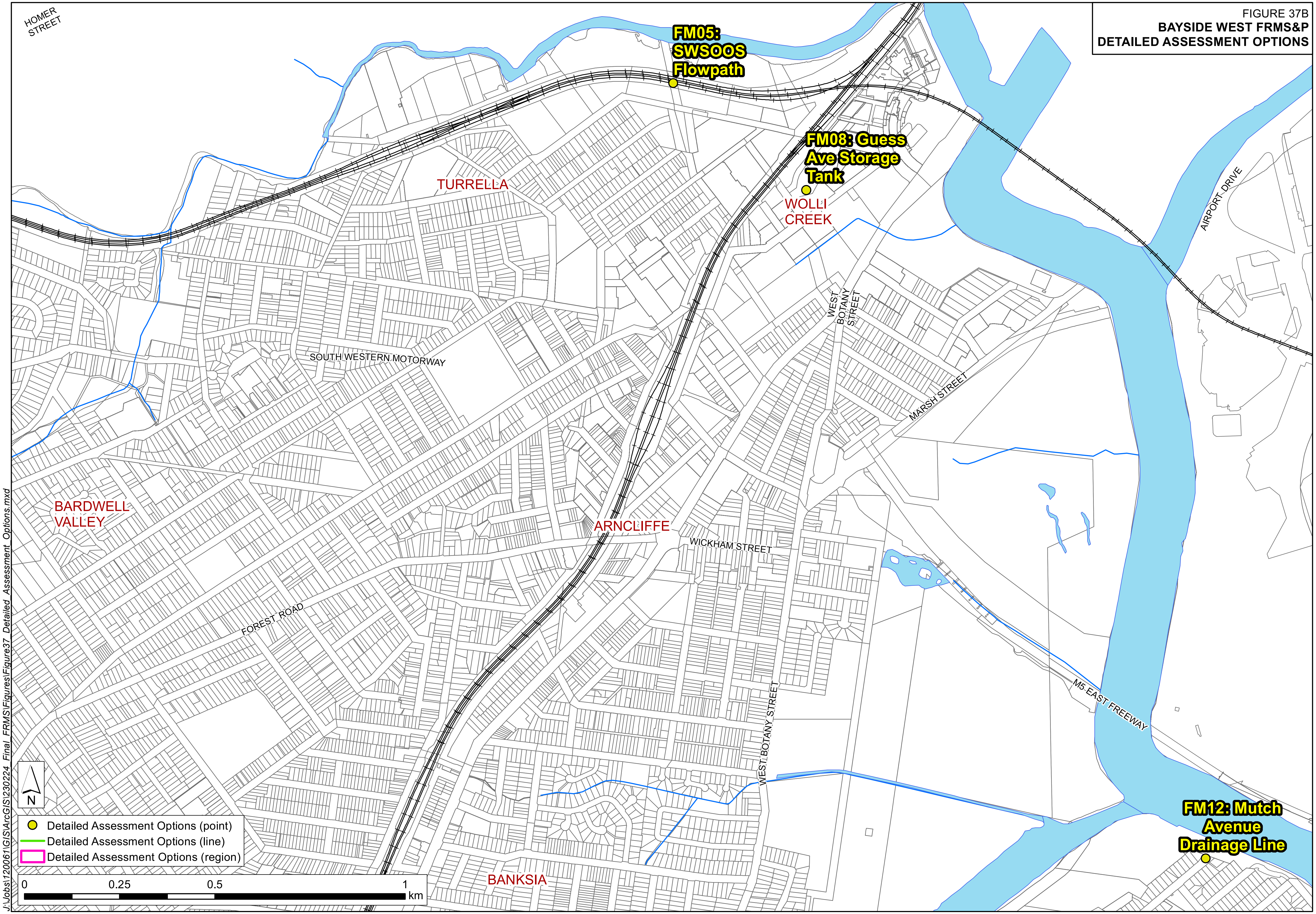


FIGURE 37B
BAYSIDE WEST FRMS&P
DETAILED ASSESSMENT OPTIONS
FM05: SWSOOS Flowpath
FM08: Guess Ave Storage Tank
FM12: Mutch Avenue Drainage Line
HOMER STREET
TURRELLA
WOLLI CREEK
AIRPORT DRIVE
WEST BOTANY STREET
SOUTH WESTERN MOTORWAY
MARSH STREET
BARDWELL VALLEY
ARNCLIFFE
WICKHAM STREET
FOREST ROAD
M5 EAST FREEWAY
WEST BOTANY STREET
BANKSIA
N
Detailed Assessment Options (point)
Detailed Assessment Options (line)
Detailed Assessment Options (region)
0
0.25
0.5
1
km
J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure37_Detailed_Assessment_Options.mxd

FIGURE 37C
BAYSIDE WEST FRMS&P
DETAILED ASSESSMENT OPTIONS

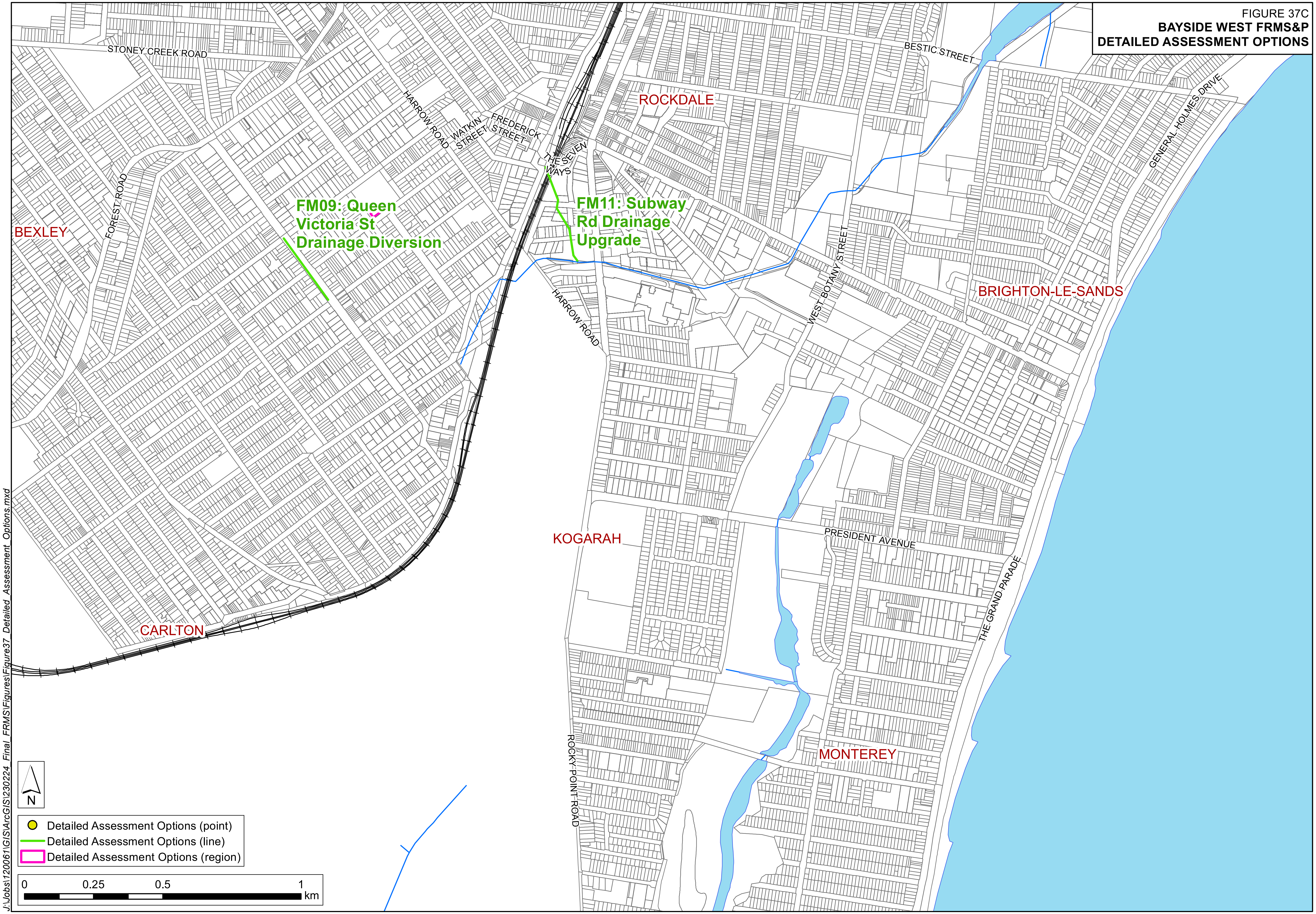
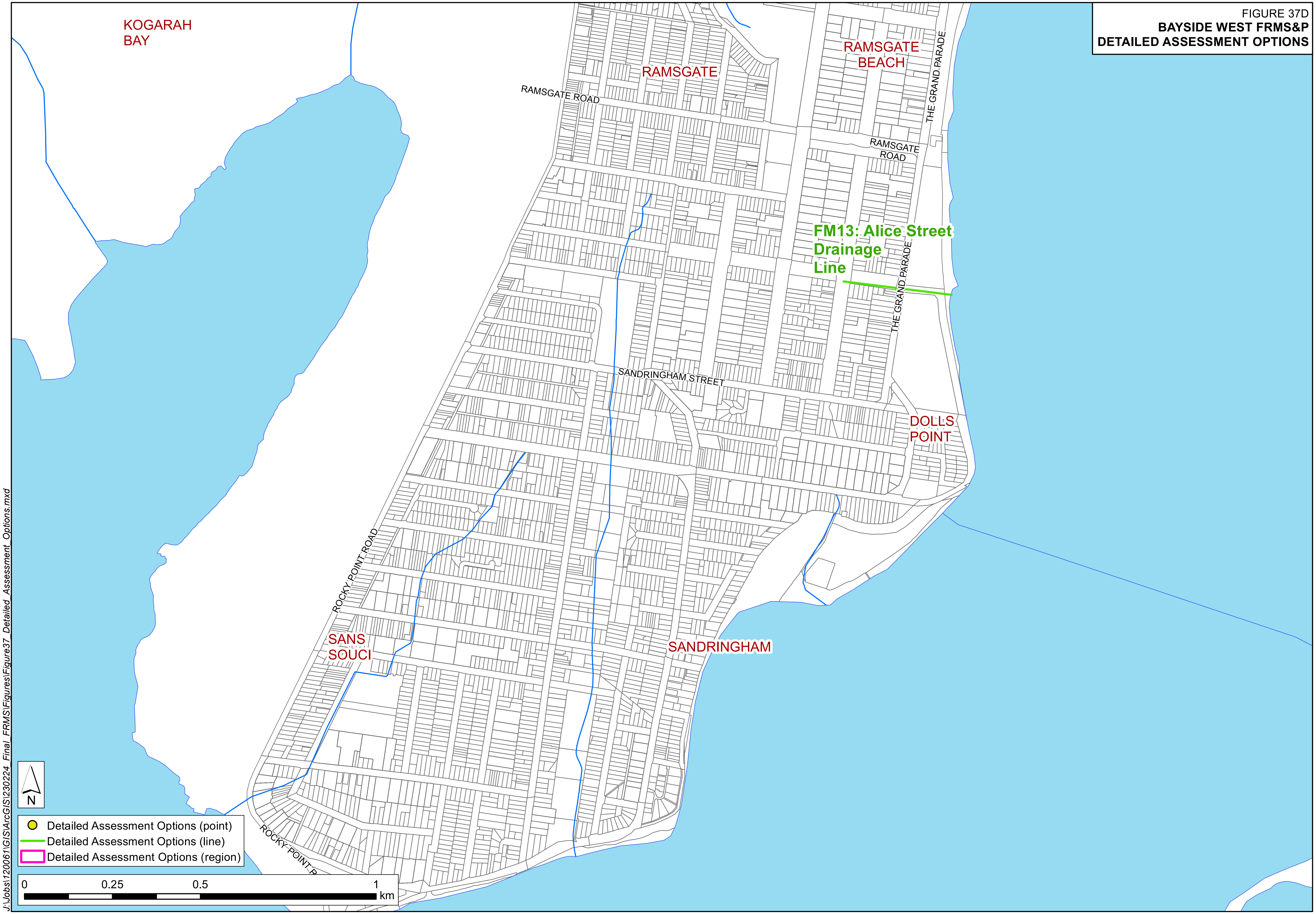
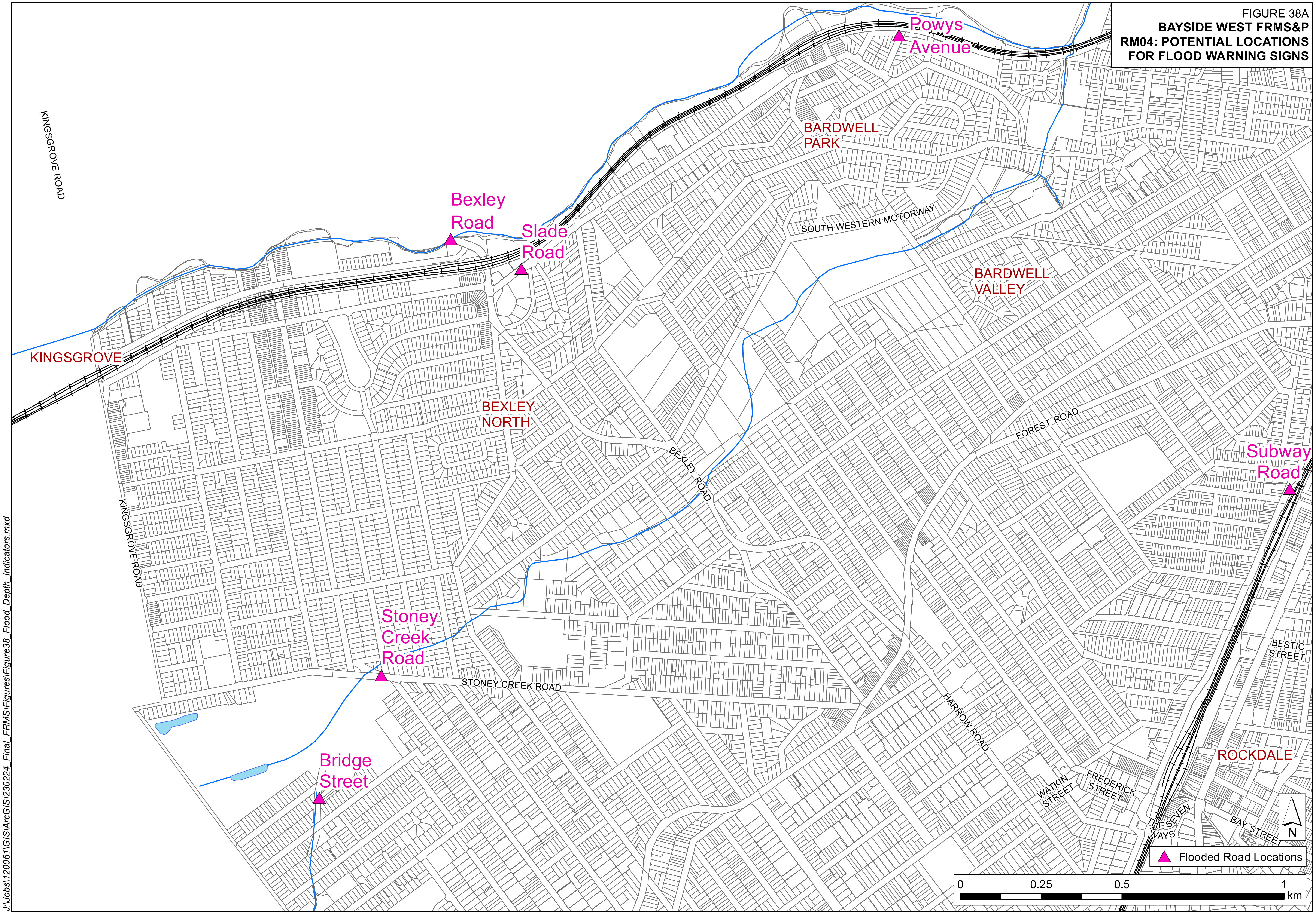


FIGURE 37D
BAYSIDE WEST FRMS&P
DETAILED ASSESSMENT OPTIONS



J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure37_Detailed_Assessment_Options.mxd

FIGURE 38A
BAYSIDE WEST FRMS&P
RM04: POTENTIAL LOCATIONS FOR FLOOD WARNING SIGNS



J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure38_Flood_Depth_Indicators.mxd

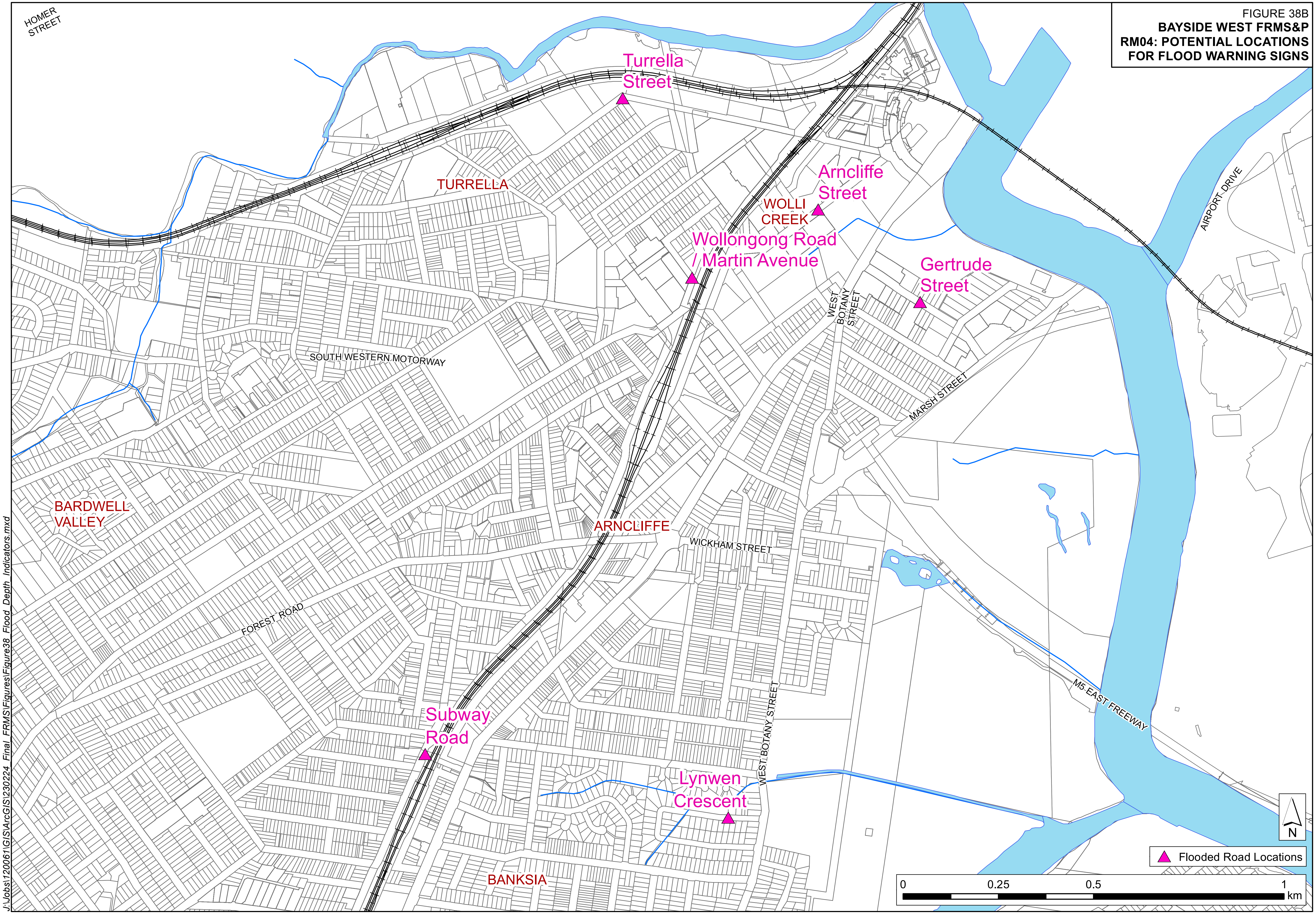


FIGURE 38B
BAYSIDE WEST FRMS&P
RM04: POTENTIAL LOCATIONS FOR FLOOD WARNING SIGNS

J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure38_Flood_Depth_Indicators.mxd

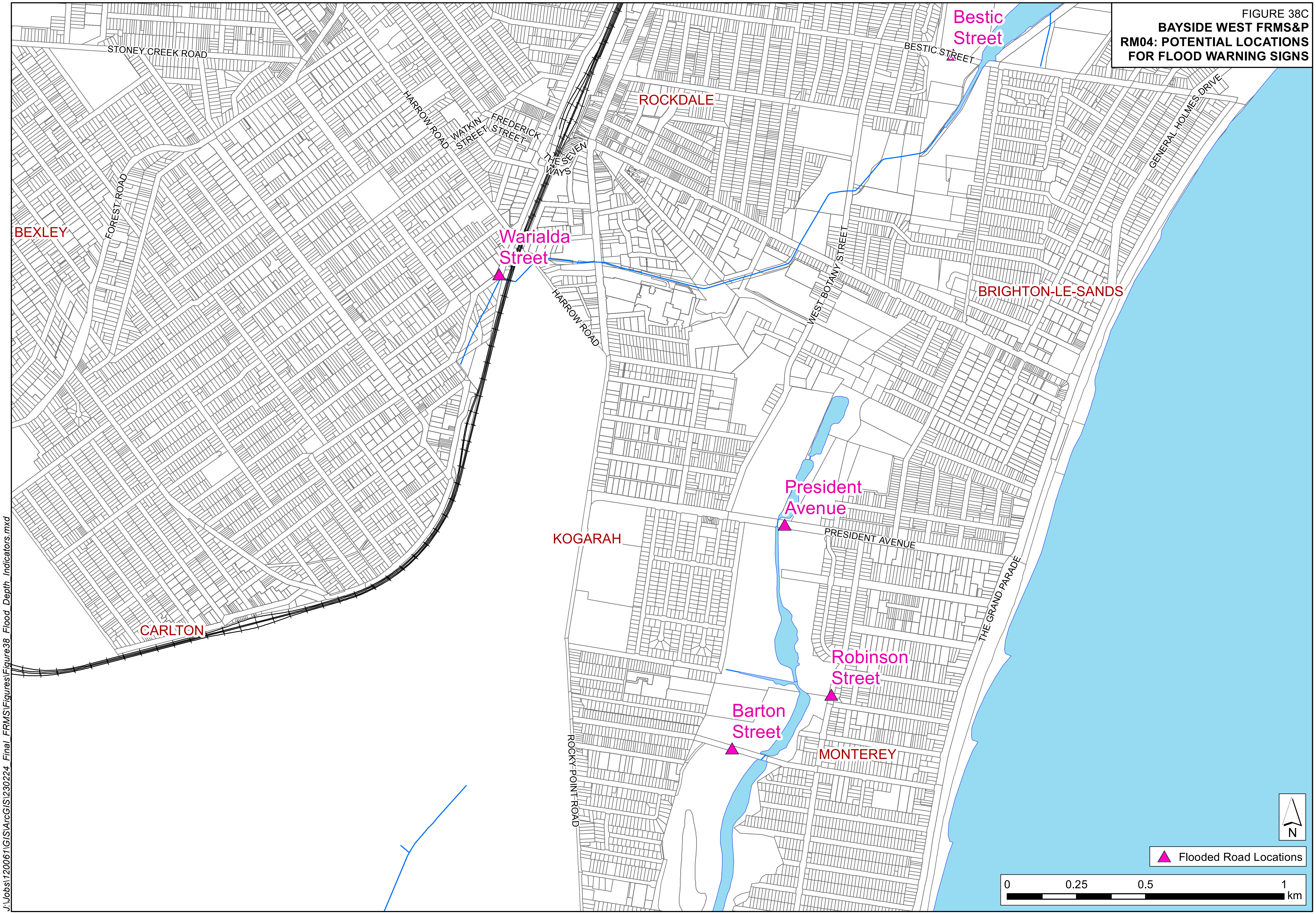


FIGURE 38C
BAYSIDE WEST FRMS&P
RM04: POTENTIAL LOCATIONS
FOR FLOOD WARNING SIGNS
Bestic Street
Warialda Street
President Avenue
Robinson Street
Barton Street
STONEY CREEK ROAD
BESTIC STREET
ROCKDALE
HARROW ROAD
WATKIN STREET
FREDERICK STREET
THE SEVEN WAYS
GENERAL HOLMES DRIVE
BEXLEY
FOREST ROAD
WEST BOTANY STREET
BRIGHTON-LE-SANDS
PRESIDENT AVENUE
KOGARAH
THE GRAND PARADE
CARLTON
ROCKY POINT ROAD
MONTEREY
N
Flooded Road Locations
0 0.25 0.5 1 km
J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure38_Flood_Depth_Indicators.mxd

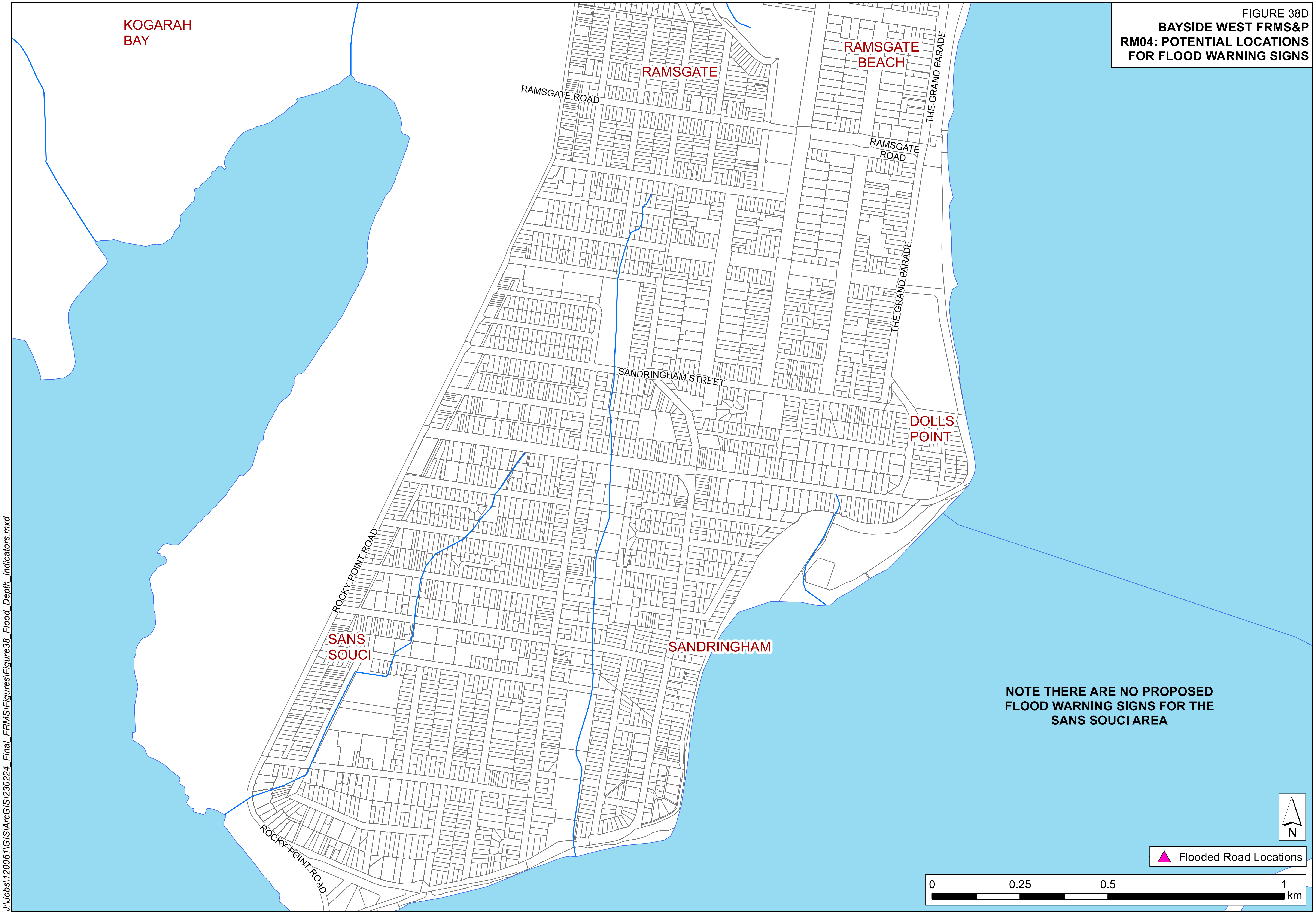


FIGURE 38D
BAYSIDE WEST FRMS&P
RM04: POTENTIAL LOCATIONS FOR FLOOD WARNING SIGNS

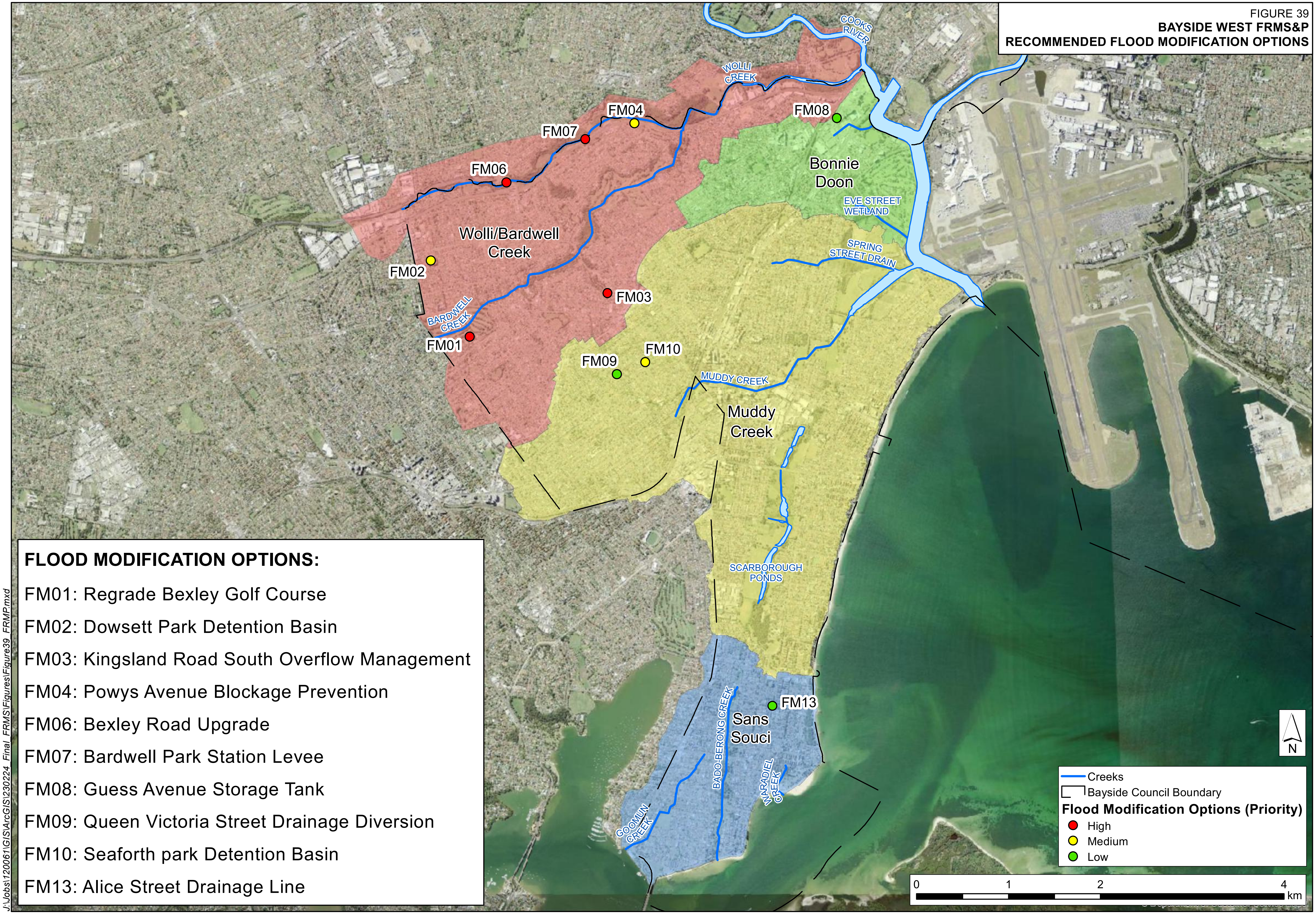


FIGURE 39
BAYSIDE WEST FRMS&P
RECOMMENDED FLOOD MODIFICATION OPTIONS

J:\Jobs\120061\GIS\ArcGIS\230224_Final_FRMS\Figures\Figure39_FRMP.mxd

ATTACHMENT A: ARR 2019 Datahub Metadata

Attachment A

Australian Rainfall & Runoff Data Hub - Results

Input Data

Longitude	151.134
Latitude	-33.956
Selected Regions (clear)	
River Region	show
ARF Parameters	show
Storm Losses	show
Temporal Patterns	show
Areal Temporal Patterns	show
BOM IFDs	show
Median Preburst Depths and Ratios	show
10% Preburst Depths	show
25% Preburst Depths	show
75% Preburst Depths	show
90% Preburst Depths	show
Interim Climate Change Factors	show
Probability Neutral Burst Initial Loss (./nsw_specific)	show

Data

River Region

Division	South East Coast (NSW)
River Number	13
River Name	Sydney Coast-Georges River

Layer Info

Time Accessed	01 April 2021 10:22AM
Version	2016_v1

ARF Parameters

A R F = M i n { 1 , [1 – a (A r e a b – c log 10 D u r a t i o n) D u r a t i o n – d + e A r e a f D u r a t i o n g (0.3 + log 10 A E P) + h 10 i A r e a D u r a t i o n 1440 (0.3 + log 10 A E P)] }

Zone	a	b	c	d	e	f	g	h	i
SE Coast	0.06	0.361	0.0	0.317	8.11e-05	0.651	0.0	0.0	0.0

Short Duration ARF

A R F = M i n [1 , 1 – 0.287 (A r e a 0.265 – 0.439 log 10 (D u r a t i o n)) . D u r a t i o n – 0.36 + 2.26 x 10 – 3 x A r e a 0.226 . D u r a t i o n 0.125 (0.3 + log 10 (A E P)) + 0.0141 x A r e a 0.213 x 10 – 0.021 (D u r a t i o n – 180) 2 1440 (0.3 + log 10 (A E P))]

Layer Info

Time Accessed	01 April 2021 10:22AM
Version	2016_v1

Storm Losses

Note: Burst Loss = Storm Loss - Preburst

Note: These losses are only for rural use and are **NOT FOR DIRECT USE** in urban areas

Note: As this point is in NSW the advice provided on losses and pre-burst on the NSW Specific Tab of the ARR Data Hub (./nsw_specific) is to be considered. In NSW losses are derived considering a hierarchy of approaches depending on the available loss information. The continuing storm loss information from the ARR Datahub provided below should only be used where relevant under the loss hierarchy (level 5) and where used is to be multiplied by the factor of 0.4.

ID	8818.0
Storm Initial Losses (mm)	32.0
Storm Continuing Losses (mm/h)	2.1

Layer Info

Time Accessed	01 April 2021 10:22AM
Version	2016_v1

Temporal Patterns | Download (.zip) (static/temporal_patterns/TP/ECsouth.zip)

code	ECsouth
Label	East Coast South

Layer Info

Time Accessed	01 April 2021 10:22AM
Version	2016_v2

Areal Temporal Patterns | Download (.zip) (./static/temporal_patterns/Areal/Areal_ECsouth.zip)

code	ECsouth
arealabel	East Coast South

Layer Info

Time Accessed	01 April 2021 10:22AM
Version	2016_v2

BOM IFDs

Click here (http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016&coordinate_type=dd&latitude=-33.955793&longitude=151.134058&sdmin=true&sdhr=true&sdday
to obtain the IFD depths for catchment centroid from the BoM website

Layer Info

Time Accessed	01 April 2021 10:22AM

Median Preburst Depths and Ratios

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	7.5 (0.244)	4.8 (0.120)	3.0 (0.064)	1.2 (0.023)	2.1 (0.035)	2.8 (0.042)
90 (1.5)	10.4 (0.293)	7.4 (0.160)	5.4 (0.101)	3.4 (0.057)	2.3 (0.033)	1.5 (0.019)
120 (2.0)	10.6 (0.270)	8.2 (0.160)	6.5 (0.110)	5.0 (0.074)	3.2 (0.041)	1.9 (0.022)
180 (3.0)	8.0 (0.176)	6.8 (0.114)	6.0 (0.086)	5.2 (0.066)	4.6 (0.050)	4.2 (0.041)
360 (6.0)	7.8 (0.130)	12.4 (0.156)	15.4 (0.165)	18.2 (0.171)	13.8 (0.110)	10.5 (0.075)
720 (12.0)	3.7 (0.047)	9.7 (0.089)	13.7 (0.106)	17.5 (0.117)	20.0 (0.113)	22.0 (0.110)
1080 (18.0)	3.5 (0.037)	10.1 (0.077)	14.5 (0.092)	18.7 (0.102)	22.8 (0.105)	25.9 (0.106)
1440 (24.0)	1.9 (0.018)	6.6 (0.044)	9.7 (0.054)	12.7 (0.061)	17.1 (0.069)	20.4 (0.072)
2160 (36.0)	0.3 (0.002)	2.4 (0.014)	3.8 (0.018)	5.1 (0.021)	5.2 (0.017)	5.2 (0.015)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	1.6 (0.005)	2.7 (0.007)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	01 April 2021 10:22AM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

10% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
90 (1.5)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	01 April 2021 10:22AM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

25% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
90 (1.5)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.5 (0.002)	1.0 (0.004)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.1 (0.000)	0.2 (0.001)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	01 April 2021 10:22AM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

75% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	46.8 (1.520)	34.2 (0.856)	25.8 (0.560)	17.8 (0.342)	24.1 (0.402)	28.8 (0.436)
90 (1.5)	41.1 (1.157)	41.6 (0.902)	41.8 (0.786)	42.1 (0.699)	30.6 (0.440)	22.0 (0.287)
120 (2.0)	45.9 (1.164)	42.5 (0.832)	40.3 (0.681)	38.2 (0.569)	35.5 (0.457)	33.5 (0.390)
180 (3.0)	42.0 (0.918)	43.2 (0.726)	44.1 (0.637)	44.9 (0.569)	47.9 (0.522)	50.2 (0.493)
360 (6.0)	46.0 (0.766)	54.7 (0.688)	60.5 (0.649)	66.0 (0.617)	70.5 (0.561)	73.9 (0.526)
720 (12.0)	28.2 (0.351)	37.9 (0.348)	44.3 (0.343)	50.5 (0.337)	60.9 (0.343)	68.7 (0.344)
1080 (18.0)	33.6 (0.352)	42.6 (0.325)	48.6 (0.310)	54.4 (0.298)	66.7 (0.307)	76.0 (0.310)
1440 (24.0)	22.1 (0.206)	33.0 (0.221)	40.2 (0.225)	47.1 (0.226)	54.6 (0.219)	60.3 (0.214)
2160 (36.0)	12.4 (0.099)	22.7 (0.128)	29.5 (0.139)	36.1 (0.145)	38.6 (0.130)	40.5 (0.121)
2880 (48.0)	1.9 (0.014)	6.6 (0.034)	9.7 (0.041)	12.7 (0.046)	24.0 (0.072)	32.5 (0.087)
4320 (72.0)	0.0 (0.000)	0.7 (0.003)	1.1 (0.004)	1.5 (0.005)	14.1 (0.038)	23.4 (0.056)

Layer Info

Time Accessed	01 April 2021 10:22AM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

90% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	112.8 (3.663)	89.5 (2.241)	74.0 (1.606)	59.2 (1.136)	69.5 (1.159)	77.3 (1.170)
90 (1.5)	106.0 (2.982)	125.7 (2.730)	138.8 (2.607)	151.3 (2.511)	106.4 (1.528)	72.8 (0.947)
120 (2.0)	84.6 (2.149)	106.5 (2.085)	121.0 (2.046)	134.9 (2.011)	129.1 (1.660)	124.7 (1.449)
180 (3.0)	82.9 (1.814)	106.8 (1.792)	122.6 (1.771)	137.7 (1.748)	123.8 (1.350)	113.3 (1.113)
360 (6.0)	75.8 (1.263)	89.2 (1.122)	98.0 (1.051)	106.5 (0.995)	128.4 (1.022)	144.9 (1.032)
720 (12.0)	60.1 (0.748)	80.9 (0.743)	94.7 (0.733)	108.0 (0.721)	111.9 (0.630)	114.9 (0.576)
1080 (18.0)	74.2 (0.778)	87.4 (0.666)	96.1 (0.614)	104.5 (0.573)	127.3 (0.585)	144.4 (0.589)
1440 (24.0)	45.0 (0.419)	63.5 (0.425)	75.8 (0.424)	87.6 (0.420)	115.2 (0.461)	135.9 (0.482)
2160 (36.0)	36.9 (0.294)	49.1 (0.278)	57.1 (0.269)	64.9 (0.261)	87.0 (0.292)	103.7 (0.308)
2880 (48.0)	17.3 (0.124)	35.3 (0.180)	47.3 (0.200)	58.7 (0.212)	81.0 (0.244)	97.6 (0.261)
4320 (72.0)	6.2 (0.040)	15.0 (0.067)	20.8 (0.077)	26.3 (0.084)	52.0 (0.139)	71.2 (0.169)

Layer Info

Time Accessed	01 April 2021 10:22AM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

Interim Climate Change Factors

	RCP 4.5	RCP6	**RCP 8.5**
2030	**0.869 (4.3%)**	0.783 (3.9%)	**0.983 (4.9%)**
2040	**1.057 (5.3%)**	1.014 (5.1%)	**1.349 (6.8%)**
2050	**1.272 (6.4%)**	1.236 (6.2%)	**1.773 (9.0%)**
2060	**1.488 (7.5%)**	1.458 (7.4%)	**2.237 (11.5%)**
2070	**1.676 (8.5%)**	1.691 (8.6%)	**2.722 (14.2%)**
2080	**1.810 (9.2%)**	1.944 (9.9%)	**3.209 (16.9%)**
2090	**1.862 (9.5%)**	2.227 (11.5%)	**3.679 (19.7%)**

Layer Info

Time Accessed	01 April 2021 10:22AM
Version	2019_v1
Note	ARR recommends the use of RCP4.5 and RCP 8.5 values. These have been updated to the values that can be found on the climate change in Australia website.

Probability Neutral Burst Initial Loss

min (h)\AEP(%)	50.0	20.0	10.0	5.0	2.0	1.0
60 (1.0)	15.5	8.9	9.0	9.9	8.6	5.9
90 (1.5)	15.2	8.8	8.9	8.8	8.5	7.3
120 (2.0)	15.0	9.0	9.7	9.1	8.6	6.3
180 (3.0)	16.1	10.1	10.8	9.9	10.0	6.3
360 (6.0)	16.5	10.7	11.2	10.1	9.8	5.0
720 (12.0)	20.7	14.9	14.3	13.4	12.0	5.5
1080 (18.0)	20.2	15.6	15.0	13.2	14.0	3.5
1440 (24.0)	23.5	18.2	17.5	15.5	15.6	6.6
2160 (36.0)	27.2	22.0	21.3	19.6	18.8	7.9
2880 (48.0)	32.0	27.1	25.6	27.4	20.7	8.7
4320 (72.0)	35.2	30.7	30.0	32.7	24.9	16.5

Layer Info

Time Accessed	01 April 2021 10:22AM
Version	2018_v1
Note	As this point is in NSW the advice provided on losses and pre-burst on the NSW Specific Tab of the ARR Data Hub (./nsw_specific) is to be considered. In NSW losses are derived considering a hierarchy of approaches depending on the available loss information. Probability neutral burst initial loss values for NSW are to be used in place of the standard initial loss and pre-burst as per the losses hierarchy.

Download TXT (downloads/727ee105-e404-4f99-9432-43ed973b00dd.txt)

Download JSON (downloads/3deab5e0-ebbf-490a-b3be-efcfbc675ac6.json)

Download PDF ()

APPENDIX A. GLOSSARY OF TERMS

Appendix A

Taken from the Floodplain Development Manual (April 2005 edition)

acid sulfate soils	Are sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid. More detailed explanation and definition can be found in the NSW Government Acid Sulfate Soil Manual published by Acid Sulfate Soil Management Advisory Committee.
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m^3/s or larger event occurring in any one year (see ARI).
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	The long term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
caravan and moveable home parks	Caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the LG Act.
catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
consent authority	The Council, government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the Council, however legislation or an EPI may specify a Minister or public authority (other than a Council), or the Director General of DIPNR, as having the function to determine an application.
development	Is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act). **infill development:** refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. **new development:** refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power. **redevelopment:** refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large

scale. Redevelopment generally does not require either rezoning or major extensions to urban services.

disaster plan (DISPLAN) A step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.

discharge The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).

ecologically sustainable development (ESD) Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the Local Government Act 1993. The use of sustainability and sustainable in this manual relate to ESD.

effective warning time The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.

emergency management A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.

flash flooding Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.

flood Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.

flood awareness Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.

flood education Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves an their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.

flood fringe areas The remaining area of flood prone land after floodway and flood storage areas have been defined.

flood liable land Is synonymous with flood prone land (i.e. land susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land covers the whole of the floodplain, not just that part below the flood planning level (see flood planning area).

flood mitigation standard The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.

floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
floodplain risk management options	The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammetic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.
flood planning area	The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the Aflood liable land@ concept in the 1986 Manual.
Flood Planning Levels (FPLs)	FPL=s are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the Astandard flood event@ in the 1986 manual.
flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
flood prone land	Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land.
flood readiness	Flood readiness is an ability to react within the effective warning time.
flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. **existing flood risk:** the risk a community is exposed to as a result of its location on the floodplain. **future flood risk:** the risk a community may be exposed to as a result of new development on the floodplain. **continuing flood risk:** the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence,

it is necessary to investigate a range of flood sizes before defining flood storage areas.

floodway areas Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flows, or a significant increase in flood levels.

freeboard Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.

habitable room **in a residential situation:** a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom.

in an industrial or commercial situation: an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.

hazard A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in the Manual.

hydraulics Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.

hydrograph A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.

hydrology Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.

local overland flooding Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.

local drainage Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.

mainstream flooding Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.

major drainage Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purpose of this manual major drainage involves:

- the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or

- water depths generally in excess of 0.3 m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or

- major overland flow paths through developed areas outside of defined drainage reserves; and/or

- the potential to affect a number of buildings along the major flow path.

mathematical/computer models The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.

merit approach The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State=s rivers and floodplains.

The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into Council plans, policy and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local floodplain risk management policy and EPIs.

minor, moderate and major flooding Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood:

minor flooding: causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded.

moderate flooding: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered.

major flooding: appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.

modification measures Measures that modify either the flood, the property or the response to flooding. Examples are indicated in Table 2.1 with further discussion in the Manual.

peak discharge The maximum discharge occurring during a flood event.

Probable Maximum Flood (PMF) The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.

Probable Maximum Precipitation (PMP) The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.

probability A statistical measure of the expected chance of flooding (see AEP).

risk Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.

runoff The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.

stage Equivalent to Awater level@. Both are measured with reference to a specified datum.

stage hydrograph A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.

survey plan A plan prepared by a registered surveyor.

water surface profile A graph showing the flood stage at any given location along a watercourse at a particular time.

wind fetch The horizontal distance in the direction of wind over which wind waves are generated.

APPENDIX B. DRAINS MODEL UPDATE MEMO

Appendix B

Memorandum

TO:	Pulak Saha & Debbie Fransen
FROM:	Rhys Hardwick Jones
DATE:	18 November 2021
SUBJECT:	DRAINS Model Updates
PROJECT:	Consolidated Bayside West FRMS/P
PROJECT NUMBER:	120061

1. INTRODUCTION

This memorandum outlines the DRAINS model updates that have been undertaken as a component of the Bayside West Floodplain Risk Management Study and Plan (FRMS/P). Bayside Council (Council) requested that the existing DRAINS models be updated and extended for the Bayside West study area. WMAwater understands that the primary use for the DRAINS modelling will be as a supplementary tool for Council's stormwater team, for investigation of stormwater capacity and possible local drainage upgrades and localised design work, rather than requiring interrogation or running of the more accurate (but time consuming) TUFLOW model for such tasks. The DRAINS modelling will be simpler and less accurate than the detailed TUFLOW 2D hydraulic modelling, but can be useful for in-house Council design of minor drainage upgrades. This memorandum outlines the work undertaken for these DRAINS models.

2. SCOPE OF WORK

The following scope of work was agreed with Council:

1. Review existing DRAINS models
2. Extend DRAINS models where required
3. Develop new DRAINS models where required

The aim of this package of work is to provide Council with working DRAINS models that can be run in recent versions of the program. These models would contain consistent model parameters (where appropriate) and cover the entire Bayside West study area. The models would be used to assess localised drainage upgrades and hence having georeferenced models would be beneficial.

3. EXISTING DRAINS MODELS

3.1. Available Models

The following catchments were covered by DRAINS models were provided by Council (with the assumed most up-to-date model noted):

- Wolli Creek (wolli_100run_Modified20120116.drn)
- Southern Bardwell Creek (Southern Bardwell Final_output_100yr.drn)

- Northern Bardwell Creek (NBardPipedDrainage2.drn)
- Bonnie Doon (101014_DRAINS_Bonnie_Doon.drn)
- Upper Muddy Creek (Upper-Muddy-Creek_mudnew_2013run.drn)
- Lower Muddy Creek (Lower Muddy Creek DRAINS Dec 2002.drn)
- Spring Street Drain (SPRINGST22B REVISED 201704 output 100yr 2hr.drn)
- Scarborough Ponds (Scarborough Ponds DRAINS with PMP overflows Apr 2004-2018.drn)
- Sans Souci 1 - Waradiel Creek (SS1.drn)
- Sans Souci 2 - Bado-berong Creek (SS2_Ext.drn)

The extent of these models, as well as areas of the Bayside West study area not covered by any models is shown in Figure 1.

3.2. Model Parameters

The parameters adopted by the existing DRAINS models varies between models. Key hydrologic parameters and hydraulic parameters are outlined in Table **1** and Table **2**, respectively.

Table 1: Summary of key hydrology parameters for existing DRAINS models

Model	Hydrology	Impervious Storage (mm)	Supplementary Storage (mm)	Pervious Storage (mm)	Soil Type	Antecedent Moisture Condition	Catchment Data Type[1]	Time of Concentration (minutes) & Delay Coefficient[2]
Wolli Creek	ILSAX ARR1987	0.5	0	2	2	4	Abbreviated	varies / 0 / varies
Northern Bardwell Creek	ILSAX ARR1987	0.5	0	2	2	4	Abbreviated	varies / 0 / varies
Southern Bardwell Creek	ILSAX ARR1987	0.5	0.5	2	2	4	Abbreviated	varies / 0 / varies
Bonnie Doon	ILSAX ARR1987	1	1	5	Specific Soil Parameters	3	Detailed	2 / 0 / 2 0.015 / 0.03 / 0.03
Upper Muddy Creek	ILSAX ARR1987	0.5	0	2	2	4	Abbreviated	varies / 0 / varies
Lower Muddy Creek	ILSAX ARR1987	0.5	0.5	2	3	4	Detailed	1.5 / 1 / 2 0.015 / 0.01 / 0.025
Spring Street Drain	ILSAX ARR1987	0.5	0.5	2	3	4	Detailed	1.5 / 1 / varies 0.018 / 0.018 / 0.17
Scarborough Ponds	ILSAX ARR1987	0.5	0.5	2	2	4	Detailed	1.5 / 1 / 2 0.015 / 0.01 / 0.025
Sans Souci 1	ILSAX ARR1987	1	3	9	3	3	Abbreviated	2 / 0 / 5
Sans Souci 2	ILSAX ARR1987	1	3	9	3	3	Abbreviated	2 / 0 / 5

1 Abbreviated data simply uses an impervious/supplementary/pervious area within a subcatchment with a time of concentration specified
Detailed data uses an impervious/supplementary/pervious area within a subcatchment with a time, flowpath length, flowpath slope and delay coefficient specified

2 Abbreviated data is time of concentration (mins) for impervious/supplementary/pervious areas
Detailed data is additional time (mins) for impervious/supplementary/pervious areas and delay coefficient for impervious/supplementary/pervious areas

Table 2: Summary of key hydraulic parameters for existing DRAINS models

Model	Pipe Friction	Pipe Roughness[1]	Pit Family[2]	Sag Pit Blockage	On-Grade pit Blockage	Overland Flow Type[3]	Tailwater Condition
Wolli Creek	Colebrook-White	0.3	Specific inlet parameters	0.4	0.15	n/a	Atmosphere
Northern Bardwell Creek	Colebrook-White	0.3	Specific inlet parameters	0.4	0.15	n/a	Constant Water Level
Southern Bardwell Creek	Colebrook-White	0.3	Sutherland - 3% crossfall, all slopes	0.4	0.15	Dummy (road low point overtopping)	Atmosphere
Bonnie Doon	Mannings	0.015	Hornsby Council Inlets (KI+grate), 3% crossfall, all grades	0	0	8 m wide road (half section)	Atmosphere
Spring Street Drain	Colebrook-White	0.3	Sutherland KI+grate, all slopes, clogged <= 3 m, Hornsby Council Relationships >3 m	0.24	0.15	8 m wide road	Atmosphere
Upper Muddy Creek	Mannings	0.015	Specific inlet parameters	0.4	0.15	n/a	Constant Water Level
Lower Muddy Creek	Colebrook-White	0.3	Sutherland KI+grate, all slopes, clogged	0.24	0.15	8 m wide road	Atmosphere
Scarborough Ponds	Colebrook-White	0.3	Sutherland KI+grate, all slopes, clogged	0.24	0.15	8 m / 13 m wide road	Atmosphere
Sans Souci 1	Mannings	0.015	Specific inlet parameters	0.5	0.2	n/a	Atmosphere
Sans Souci 2	Mannings	0.015	Specific inlet parameters	0.5	0.2	n/a	Atmosphere

1 Units consistent with the pipe friction method adopted

2 Typical pit family type adopted in the model – there may be some pits with a different type

3 Typical overland flow cross section type – there may be some pits with a different type. If 'NA' is specified, this is because an earlier version of DRAINS did not require a cross section, but just specified a fixed overland flow time (which is still required)

4. DRAINS MODEL UPDATES

4.1. Global Model Updates

Several model updates were made to all existing models. These were made to improve the consistency between models. These include the following:

- Georeferencing of the models using GDA94 MGA56 projection. This helps locate the model in the real world.
- Inclusion of a background that enables identification of locations within the DRAINS model. A DXF background was created for the DRAINS models that consists of the cadastral boundaries and road names within the Bayside West study area. This background was applied to all DRAINS models. The background appears in the correct location in the model due to the georeferencing that was undertaken (item 1).
- Adoption of standard hydraulic parameters including:
  - Pipe friction approach to Mannings;
  - Pipe roughness to 0.015; and
  - Blockage factors of 50% for sag pits and 20% for on-grade pits
- Adoption of a single IFD using ARR 1987. This was sourced from the Bureau of Meteorology for a point within the catchment that was considered to be representative of the entire Bayside West study area (33.95°S, 151.15°E). The following ARR 1987 coefficients were adopted for all models:

Rainfall Intensity (mm/hr)	2 year ARI	50 year ARI	IFD Parameters	
1 hour	39.7	84.0	**G**	0
12 hour	7.98	15.6	**F2**	4.95
72 hour	2.48	4.95	**F50**	15.95

  Storm durations from 5 minutes to 2 hours were imported into each model, for the 1 year ARI to 100 year ARI events. An antecedent moisture condition of 4 was adopted for all storms, representing 75-100 mm of rainfall in the 5 days prior to the storm burst (for soil types 2 and 3).
- Running of all models in a recent version of DRAINS (2020.061). In order to run the old models in the more recent versions of DRAINS, several features required updating:
  - Adoption of updated pit blockage procedures
  - Adoption of updated overflow route procedures
  - Adjustment of some model parameters due to new checks that DRAINS implements, including extending short pipes (to ensure the length > 3 x diameter/height) and adjusting pipe and channel invert levels where the incoming pipe/channel invert level is lower than the outgoing pipe/channel invert level at a particular pit or node.
- Split models: It was originally envisaged that the DRAINS models would be consolidated into one large DRAINS model for Bayside West. This was not considered feasible due to the following reasons:
  - Makes it more difficult to find a particular pipe
  - Run time would be significantly extended. This is particularly of interest if multiple Annual Exceedance Probabilities (AEPs) and durations are to be run. If Australian Rainfall and Runoff (ARR) 2019 is implemented at a later date, the run time will increase by a factor

of 10 (for the ensemble of temporal patterns required). Larger models require significant computational resources and time to run

Having smaller models makes it much easier to find a pipe of interest and undertake multiple model runs (for example design iterations) quickly. The Bayside West study area was split into 19 separate DRAINS model areas, as shown in Figure 2.

The following elements were retained from the existing models, assuming that these were catchment-specific:

- Hydrologic model parameters (impervious storage, supplementary storage, pervious storage and soil type)
- Catchment representation (catchment data type, fraction impervious / supplementary / pervious, time of concentration, delay coefficient, flow path details, etc.)
- Pit family and pit types (except for those old style pits where inlet parameters are specified and these are no longer supported in the latest versions of DRAINS)

4.2. Individual Model Updates

4.2.1. Wolli Creek Model

In addition to the global model updates specified in Section 4.1, the following updates were made for the Wolli Creek DRAINS model:

- Illudas pits (no longer supported) replaced with Sutherland KI+grate pits for all slopes. Kerb inlet size was assumed to be 1.2 m.
- Remaining pits that utilise inlet parameters (no longer supported) were replaced with Sutherland KI+grate pits for all slopes. Kerb inlet sizes were estimated based on inlet parameter values.
- Add maximum ponding depth for sag pits based on ponding volume.
- Change dummy pipes of type “Wolli Creek Circular” to a minimum of 100 mm diameter (were previously 10 mm).
- Add in overflow route cross sections, adopting an “8m wide road” with 1% bed slope.
- Adjustment of the starting elevation of the stage-storage curve of Basin 10A.020 to match incoming pipe invert levels.

The Wolli Creek DRAINS model was also extended. A small drainage network that discharges to Wolli Creek at the north eastern extent of the catchment was previously missing (as shown in Figure 1). Details of the development of these areas where DRAINS models do not exist is contained in Section 5.

4.2.2. Northern Bardwell Creek Model

In addition to the global model updates specified in Section 4.1, the following updates were made for the Northern Bardwell Creek DRAINS model:

- Illudas pits (no longer supported) replaced with unrestricted sag pits with a ponding volume of 100 m^3.
- Remaining pits that utilise inlet parameters (no longer supported) were replaced with Sutherland KI+grate pits for all slopes. Kerb inlet sizes were estimated based on inlet parameter values.
- Change the minimum overflow travel time from 0.01 to 0.1 minutes.

- Change pipe P236.05 to be directed to pit 234.20 instead of 236.20

4.2.3. Southern Bardwell Creek Model

In addition to the global model updates specified in Section 4.1, the following updates were made for the Southern Bardwell Creek DRAINS model:

- Ponding volume updated to the minimum allowed (0.25 m^3) for some junction pits.
- Change dummy pipes of type "Bardwell" to a minimum of 100 mm diameter (were previously 10 mm).
- The Lite version of DRAINS can only handle one connection to an outlet node, and hence additional outlet nodes were added so each drainage line outlets to a single node.

4.2.4. Bonnie Doon Model

The only updates that the (Upper) Bonnie Doon model required are outlined in Section 4.1. The (Upper) Bonnie Doon DRAINS model was extended. The drainage network downstream of the railway was not included in the existing model. There are three main drainage lines that cross the railway and these all discharge into the top of the Bonnie Doon open channel. The model was extended to the top of the open channel to simulate flow through the entire stormwater network to the open channel. This area is shown in Figure 1. Details of the development of these areas where DRAINS models do not exist is contained in Section 5.

4.2.5. Upper Muddy Creek Model

The Upper Muddy Creek model was unable to be georeferenced. There was no simple translation or scaling of coordinates that could align the stormwater network to its geographical location. Moreover, the network appeared to be incomplete, as it was difficult to find the correct pipes to align with the GIS stormwater network provided by Council. Due to these issues, and the fact that the remaining Upper Muddy Creek catchment area either side of this model needed to be developed, it was considered appropriate to develop new DRAINS models for the entire Upper Muddy Creek catchment. Hence, this model was made redundant. This is shown in Figure 1.

4.2.6. Lower Muddy Creek Model

In addition to the global model updates specified in Section 4.1, the following updates were made for the Lower Muddy Creek DRAINS model:

- Revised the 'unrestricted entry' and 'Special – Subway Rd' pit inlet curves in the pit database to comply with new DRAINS version requirements.
- Revised the 'dummy' pipe database to be a minimum of 100 mm in diameter (was previously smaller).
- Adjustment of the starting elevation of the stage-storage curve of Basin bRock3.10 to match incoming pipe invert levels.
- The Lite version of DRAINS can only handle one connection to an outlet node, and hence additional outlet nodes were added so each drainage line outlets to a single node.

4.2.7. Scarborough Ponds Model

In addition to the global model updates specified in Section 4.1, the following updates were made for the Scarborough Ponds DRAINS model:

- Two channels were changed to not be 'roofed' to run in recent versions of DRAINS
- Adjustment of the starting elevation of the stage-storage curve of BasinSunb, BasinLach and BasinBota basins to match incoming pipe invert levels.

The Scarborough Ponds DRAINS model was also extended. A small drainage network at the southern extent of the model that discharges into the ponds was previously missing (as shown in Figure 1). Details of the development of these area where DRAINS models do not exist is contained in Section 5.

4.2.8. Sans Souci 1 Model

In addition to the global model updates specified in Section 4.1, the following updates were made for the Sans Souci 1 DRAINS model:

- Pits that utilise inlet parameters (no longer supported) were replaced with Sutherland KI+grate pits for all slopes. Kerb inlet sizes were estimated based on inlet parameter values.
- Add in overflow route cross sections, adopting a "Half Road" with 1% bed slope (adopted from Scarborough Ponds DRAINS model).

4.2.9. Sans Souci 2 Model

In addition to the global model updates specified in Section 4.1, the following updates were made for the Sans Souci 2 DRAINS model:

- Pits that utilise inlet parameters (no longer supported) were replaced with Sutherland KI+grate pits for all slopes. Kerb inlet sizes were estimated based on inlet parameter values.
- Add in overflow route cross sections, adopting a "Half Road" with 1% bed slope (adopted from Scarborough Ponds DRAINS model).

5. NEW AND EXTENDED DRAINS MODELS

5.1. Stormwater network

The stormwater network adopted for the new and extended DRAINS models were taken from the stormwater network provided by Council. This was provided in the form of a GIS layer (Stormwater_Pit.shp and Stormwater_Pipe.shp). This data was supplemented with data from the existing TUFLOW models that cover the Bayside West study area. The following data was used:

- Pipe or box culvert size. Where this data was missing, the relevant TUFLOW pipe layers were searched to try and determine pipe sizes. Where pipe sizes could not be filled, upstream and downstream sizes were searched to try and match these sizes. Where this was not possible, a dummy pipe diameter of 999 mm was adopted, or box culvert size of 999 mm x 999 mm.

- Number of pipes. Where this data was missing, the relevant TUFLOW pipe layers were searched to try and determine the number of pipes. Where this was missing it was assumed a single pipe exists.
- Upstream and downstream invert levels. At pit junctions, the lowest invert of incoming and outgoing pipes was adopted to remove mismatching of inverts at pit junctions which can cause instabilities in DRAINS. Where these were missing, the relevant TUFLOW pipe layers were searched to try and determine invert levels. Where invert levels could not be filled, the surface level (derived from available LiDAR data) was used allowing for 0.6 m cover.
- Pits were assumed to be from the 'Sutherland KI+grate, all slopes, clogged' pit family, with a 1.2 m lintel opening where pit inlet sizes could not be inspected from the stormwater GIS layer. Pits were assumed to be 'On-grade' type.

The same checks and adjustments were made to the stormwater network as outlined in Section 4.1 in order to correctly run in DRAINS, including pipe lengths being greater than 3 times the pipe diameter and adding the pit and pipe database adopted into the model.

5.2. Subcatchment delineation

Subcatchments to each pit inlet were delineated using GIS techniques. The latest available LiDAR information was used and re-sampled into a 5 m DEM to provide a smoother surface. The terrain was 'hydrologically treated' to fill sinks and provide continuous flow paths through the catchment. Hydrologic algorithms were then applied to calculate flow direction and flow accumulation grids. These grids were used to derive a dense stream network. Pit inlet locations were then snapped to this stream network and the upstream catchment area was calculated to these points. These subcatchments were further 'cleaned' and processed to obtain a subcatchment network. The GIS layer for these subcatchments is provided. The area of these subcatchment polygons was used in the DRAINS model.

Subcatchment land use was adopted based on typical values for existing models, or estimated for new models based on aerial imagery. Typical slopes were also inspected from the available LiDAR data. A summary of the adopted subcatchment parameters for each new or extended model can be seen in Table 3.

Table 3: Summary of subcatchment parameters for new and extended DRAINS models

Area	Model ID	Status (Hydrology)[1]	Subcatchment Landuse			Slope[2]
			% Paved	% Supplementary	% Grassed	
Wolli Creek[3]	3	Extended				
- Low Relief			70	0	30	0.3%
- High Relief			70	0	30	5%
Upper Bonnie Doon	8	Extended	65	5	30	4%
Lower Bonnie Doon[3]	9	New (Upper Bonnie Doon)				
- Marsh St			100	0	0	0.5%
- Low Relief			60	10	30	0.5%
- High Relief			60	10	30	5%
Upper Muddy Creek	10, 11	New (Lower Muddy Creek)	60	10	30	3%

Area	Model ID	Status (Hydrology)[1]	Subcatchment Landuse			Slope[2]
			% Paved	% Supplementary	% Grassed	
Scarborough Ponds	16	Extended	60	10	30	1%
Sans Souci 3	19	New (Sans Souci 1 & 2)	60	10	30	0.5%

1 Extended DRAINS models adopt the same hydrology model as the existing model. New models adopt a hydrology model from a nearby DRAINS model (hydrology parameters outlined in Table 1).
2 Slope adopted for the calculation of time of concentration and for overflow route slope
3 These models were split into different areas for the application of certain parameters, typically due to some areas having high relief (steep slopes) and low relief (flat areas).

Abbreviated subcatchment data was used for these areas, consisting of the following:

- Subcatchment area, derived from the GIS layer as described above. Area was calculated in hectares and rounded to 3 significant figures.
- Land use percentages applied as outlined in Table 3.
- Time of concentration for grassed areas calculated based on catchment area using the Bransby-Williams formula (as described in Australian Rainfall and Runoff 1987). The formula is as follows:

$$t_c = \frac{58L}{A^{0.1}S_e^{0.2}}$$

Where: t_c is the time of concentration (mins)
S_e is the equal area slope of the main stream (m/km)
L is the length of the main stream (km)
A is the area of the catchment (km^2)

The length of the main stream was assumed to be related to the subcatchment area as follows (as outlined in the WBNM Theory Manual):

$$L = A^{0.57}$$

The slope of the subcatchment was assumed based on the values in Table 3.

- Time of concentration for paved areas assumed to be 2/3 of the time of concentration for paved areas.
- Time of concentration (additional time) for supplementary areas was assumed to be 0 minutes.

5.3. Overflow Routes

Overflow routes from pits were assumed to follow the outlet pipe from the pit. The length of the overflow routes was assumed to be the same as the outlet pipe it followed. Overflow routes were assigned an indicative “8m wide road” cross section that would simulate gutter flow. It was also assumed that none of the downstream catchment area contributed to flow on the overflow route. The slope of the overflow route was adopted from the typical catchment slope, as outlined in Table 3.

5.4. Outlets

The stormwater network was assumed to freely discharge to the atmosphere at the downstream invert level of the pipe where the network discharges into a creek, open channel or Botany Bay. No open channels were included in the new and extended DRAINS models.

6. LIMITATIONS

It is intended that these DRAINS models be used for testing of minor stormwater upgrades and indicative stormwater capacity assessments. In particular the following should be noted:

- The models adopt ARR 1987. It is understood that for the Bayside West catchment, the adoption of ARR 2019 generally results in lower runoff primarily due to the following:
    - Lower IFD's: ARR 2019 IFD's are up to 30% lower than ARR 1987 IFD's. For example, the ARR 2019 1% AEP 1 hour rainfall intensity is 28% lower than the ARR 1987 1% AEP 1 hour rainfall intensity. The magnitude of the ARR 2019 1% AEP 1 hour storm is equivalent to the ARR 1987 5% AEP 1 hour storm.
    - Temporal patterns: ARR 2019 requires an ensemble of temporal patterns to be run, with the adopted pattern for any particular duration being the one that produces peak flows just above the mean of the ensemble for a particular location in the catchment. It is known that the single temporal pattern adopted using the ARR 1987 methodology typically produces higher peak flows due to the temporal distribution of rainfall.

  In this case, the adoption of ARR 1987 simplifies the number of runs that need to be undertaken to obtain a quick assessment. ARR 1987 will generate higher flows than ARR 2019, however, different ARI's will provide different magnitudes of rainfall events that will still be beneficial in assessing stormwater capacity and upgrades.
- Coincident tailwater conditions in channels, creeks and the ocean has not been considered. It is assumed that all stormwater networks discharge 'freely to the atmosphere'. If any results need to consider tailwater effects, a static water level at outlet nodes can be applied (for pipe calculations). Further information for overflow routes is provided below.
- The models are designed to be run in 'Lite' mode. This mode does not require a premium license and applies a simplified approach to calculating overflow routes. It does not consider backwater effects along these routes or unsteady flow conditions. If detailed information of overland flow paths is required, it is recommended that the relevant TUFLOW model be utilised.
- All errors and several warnings have been rectified in both existing and new models. There are, however, several warnings that still exist, which include:
    - Warning that the upstream pit's spill level is below the receiving pit's surface or spill level for some overflow routes. Due to the way DRAINS computes flows along these overflow routes, they will be 'carrying water uphill', as the warning message (both prior to running and at the completion of a simulation) suggests.
    - Warning about the spill level for some basins being below the receiving pit's spill level. As described above, this can 'carry water uphill'.
    - Warning about some of the pit types adopting an infinite capacity. These pits were retained from the existing DRAINS models and were not modified.

- Warning about maximum water levels exceeding the maximum elevation specified in some basins. The basin schematisation was not modified from the existing DRAINS models.

The models have been updated or developed based on the best available information from Council, however, there are likely to be data gaps that have been filled based on broad assumptions. For every localised assessment that is to be undertaken, it is recommended that the existing stormwater line both upstream and downstream of the section of interest is reviewed. This includes a review of:

- Catchment areas and parameters
- Pipe sizes
- Pit parameters (size, type, blockage, etc.)
- Invert levels
- Overflow routes

These should be checked to ensure the modelled stormwater network is reasonable and accurate based on available information. In particular, a number of assumptions have been made in updating or developing new DRAINS models (as outlined in this document) that may need to be reviewed for a site-specific assessment. It is likely that similar assumptions were made when the existing DRAINS models were also developed. For example, a review of a particular stormwater line may reveal an adverse grade on a pipe due to inaccurate invert levels that may need to be corrected prior to assessing upgrade works. This sort of review is warranted particularly for catchment-wide models such as these DRAINS models.

FIGURES

FIGURE 1
EXISTING DRAINS MODEL EXTENT

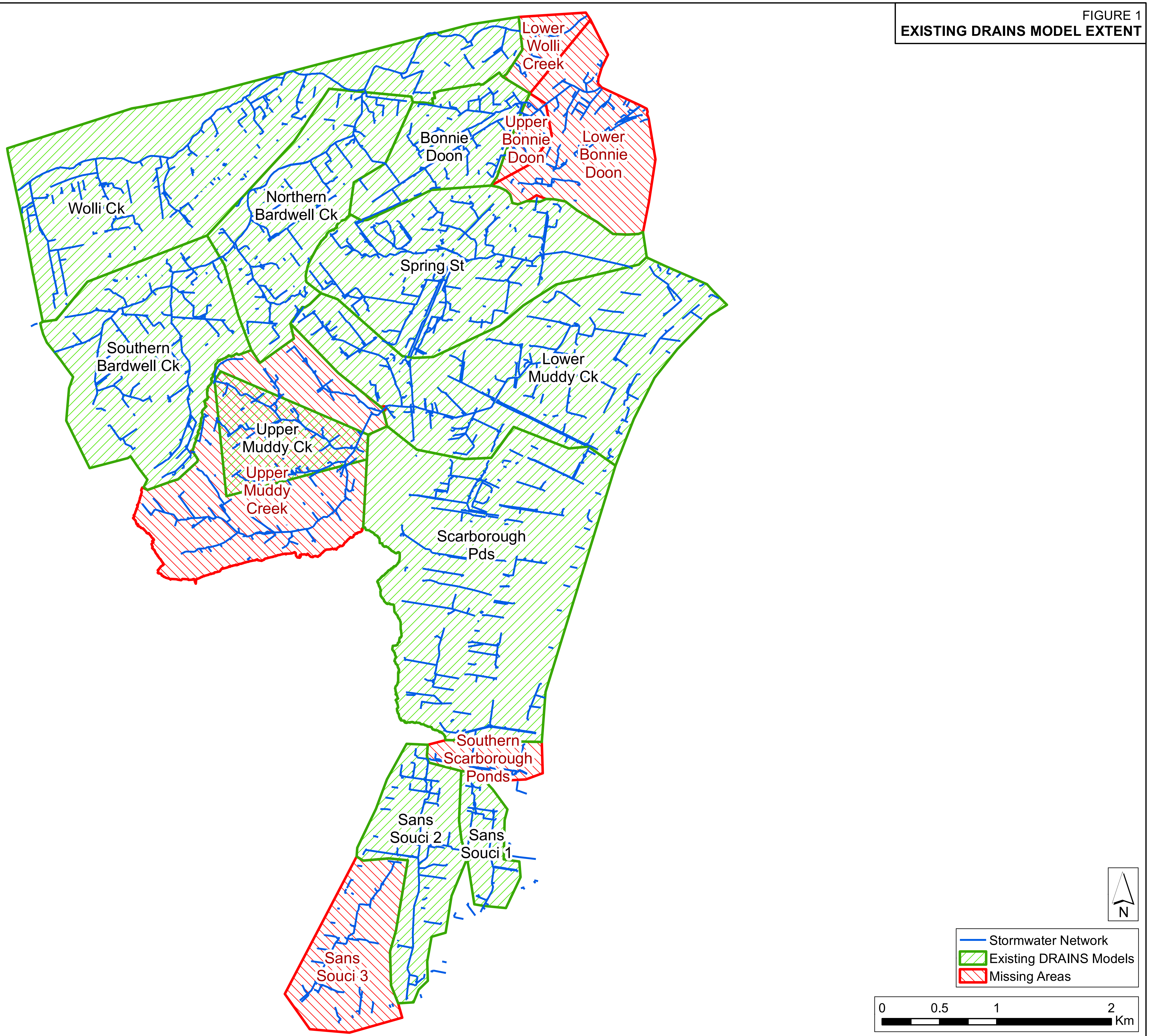


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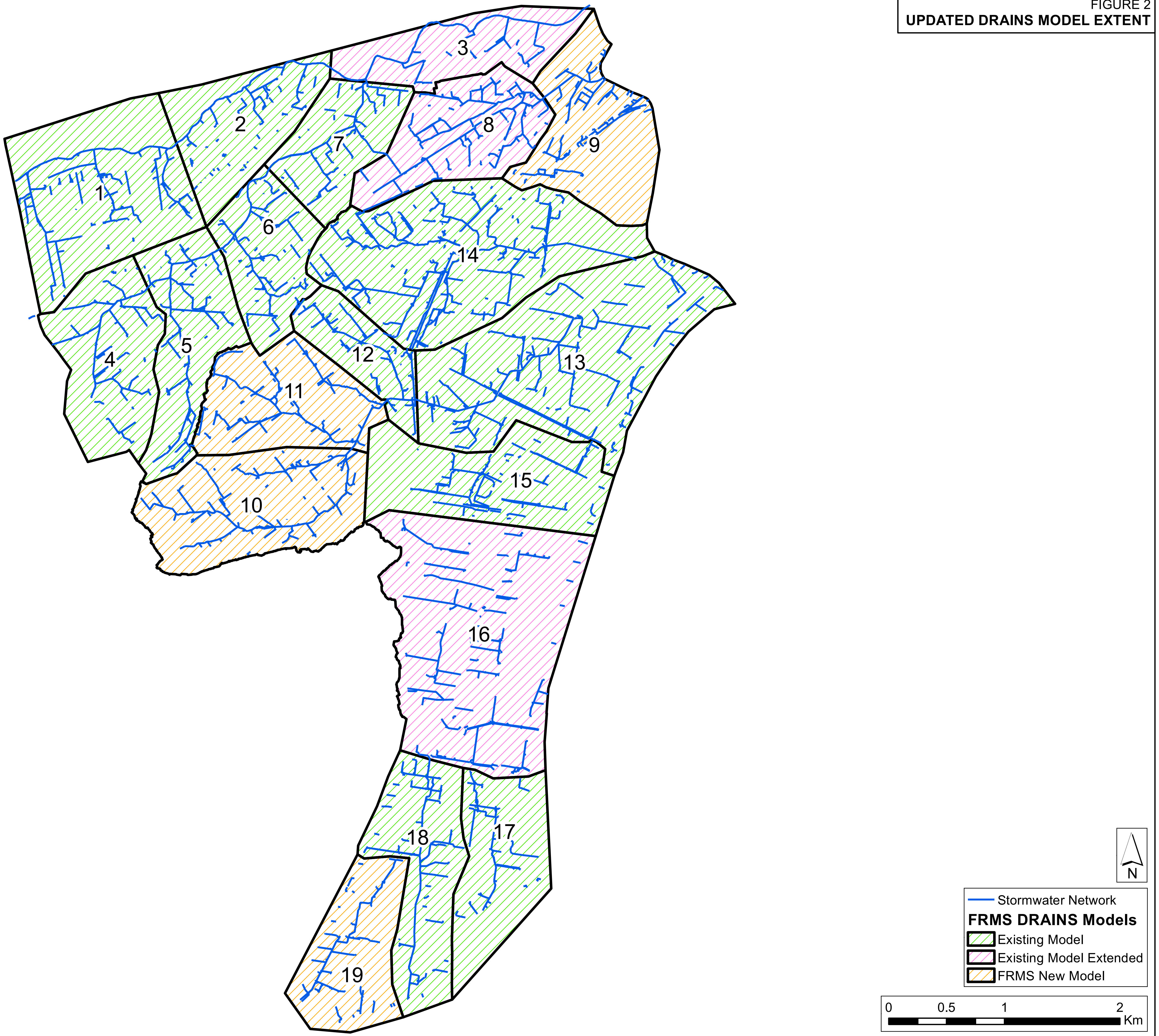
FIGURE 2
UPDATED DRAINS MODEL EXTENT



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APPENDIX C. BARDWELL CREEK DESIGN FLOOD MAPPING

Appendix C

FIGURE C1

BAYSIDE WEST FRMS&P: BARDWELL CREEK
PEAK FLOOD DEPTH AND LEVEL
20% AEP EVENT

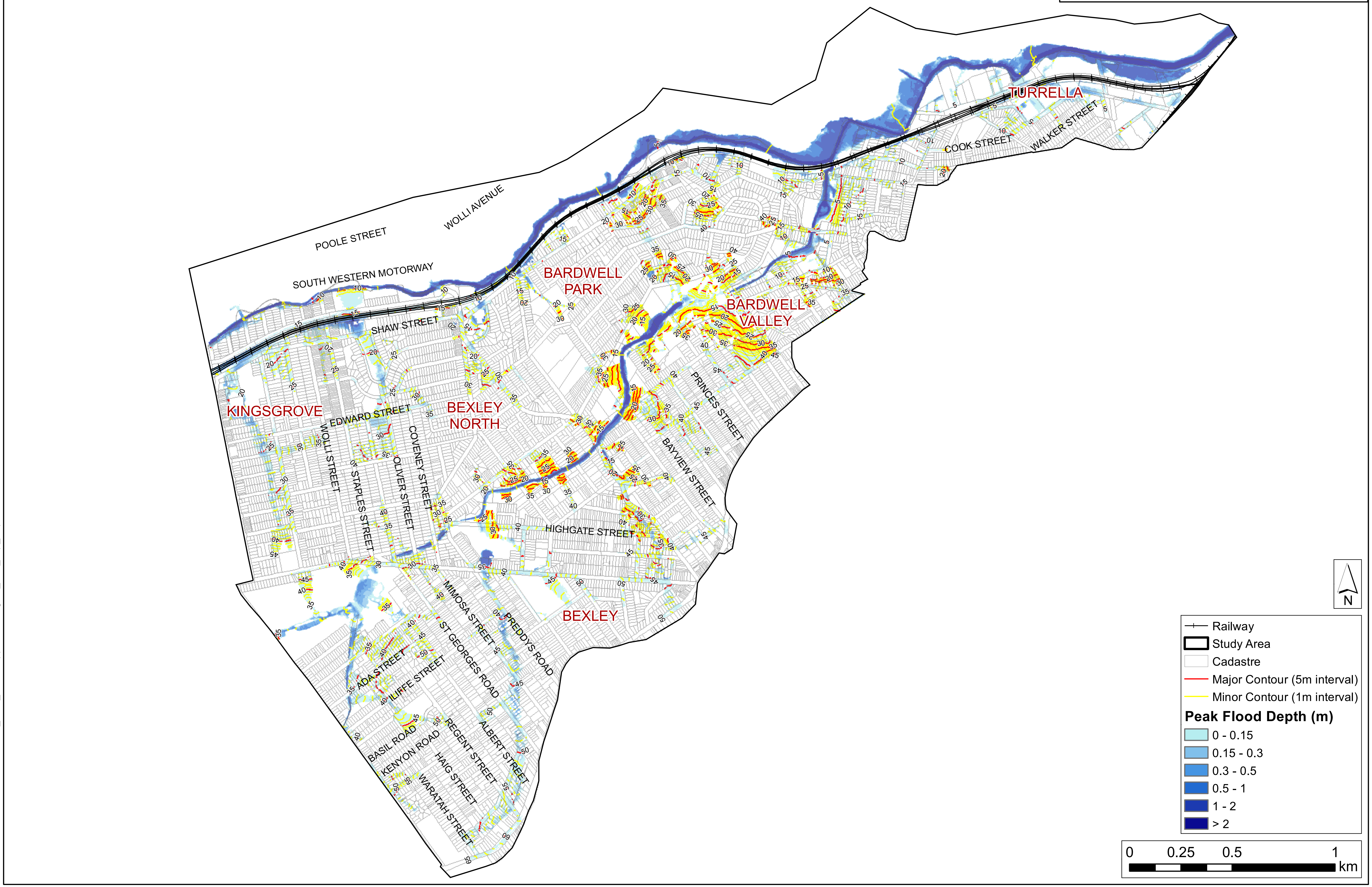

FIGURE C2

BAYSIDE WEST FRMS&P: BARDWELL CREEK
PEAK FLOOD DEPTH AND LEVEL
10% AEP EVENT

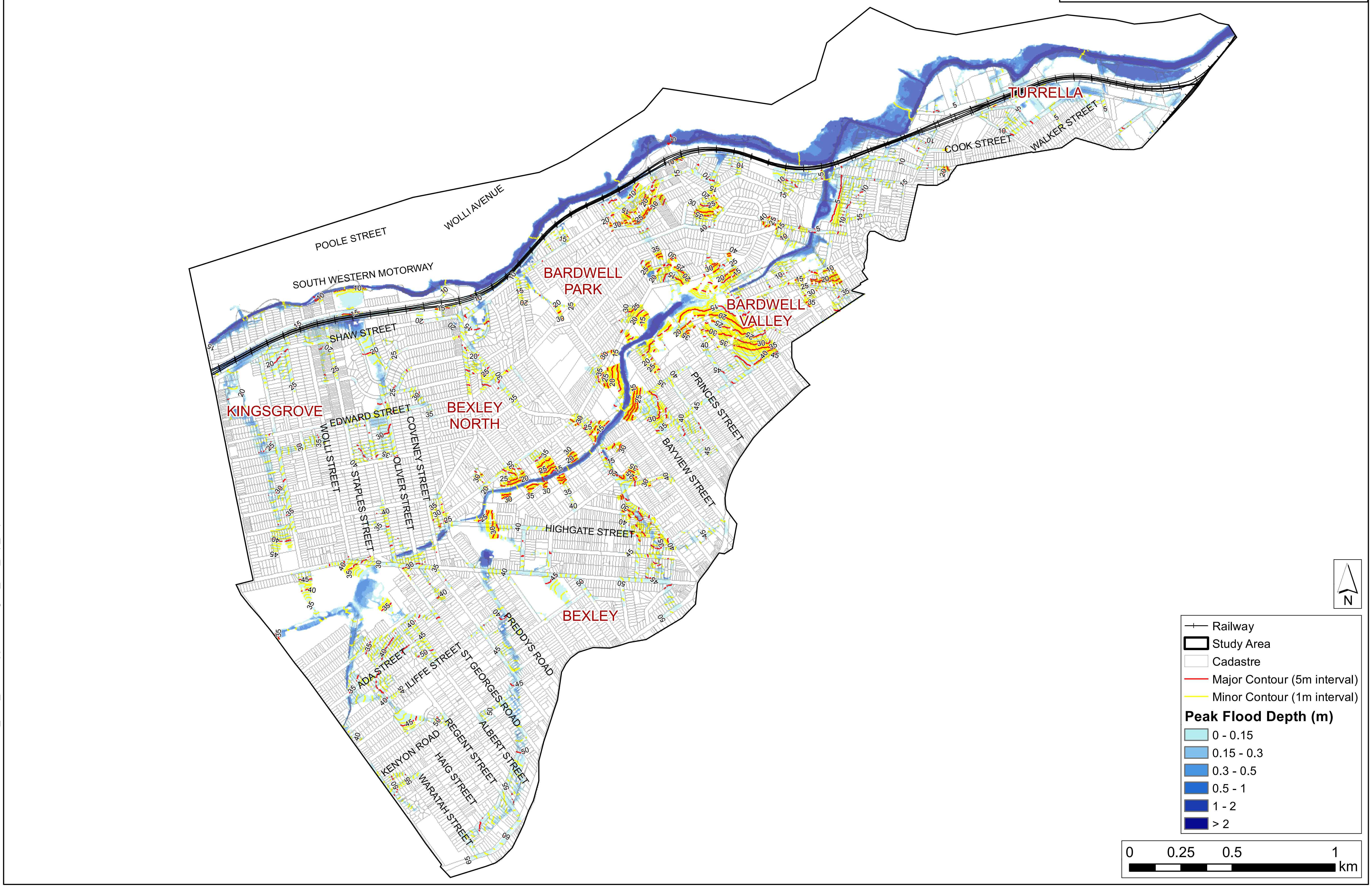

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FIGURE C3

BAYSIDE WEST FRMS&P: BARDWELL CREEK
PEAK FLOOD DEPTH AND LEVEL
5% AEP EVENT

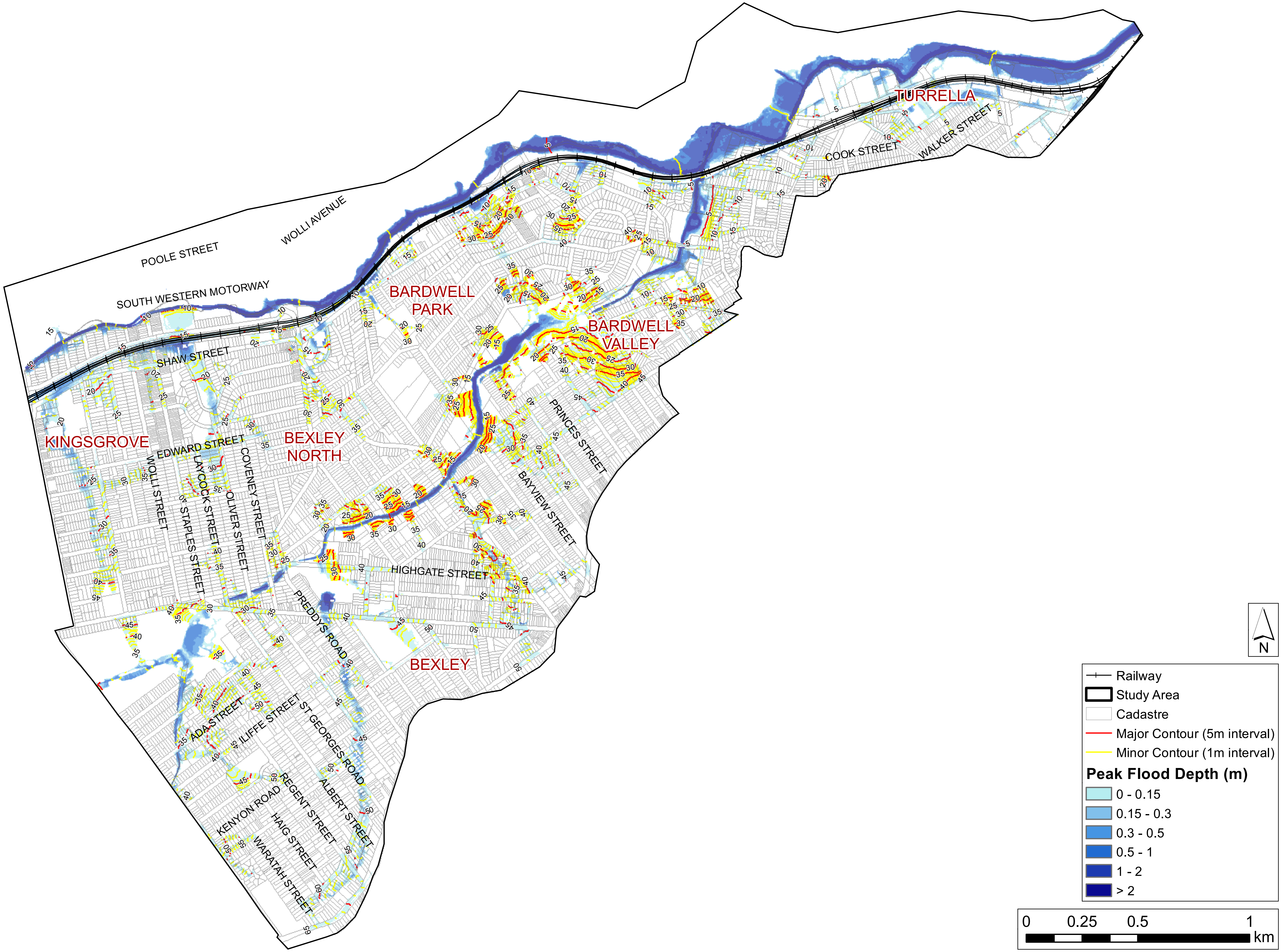

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FIGURE C4
BAYSIDE WEST FRMS&P: BARDWELL CREEK
PEAK FLOOD DEPTH AND LEVEL
2% AEP EVENT

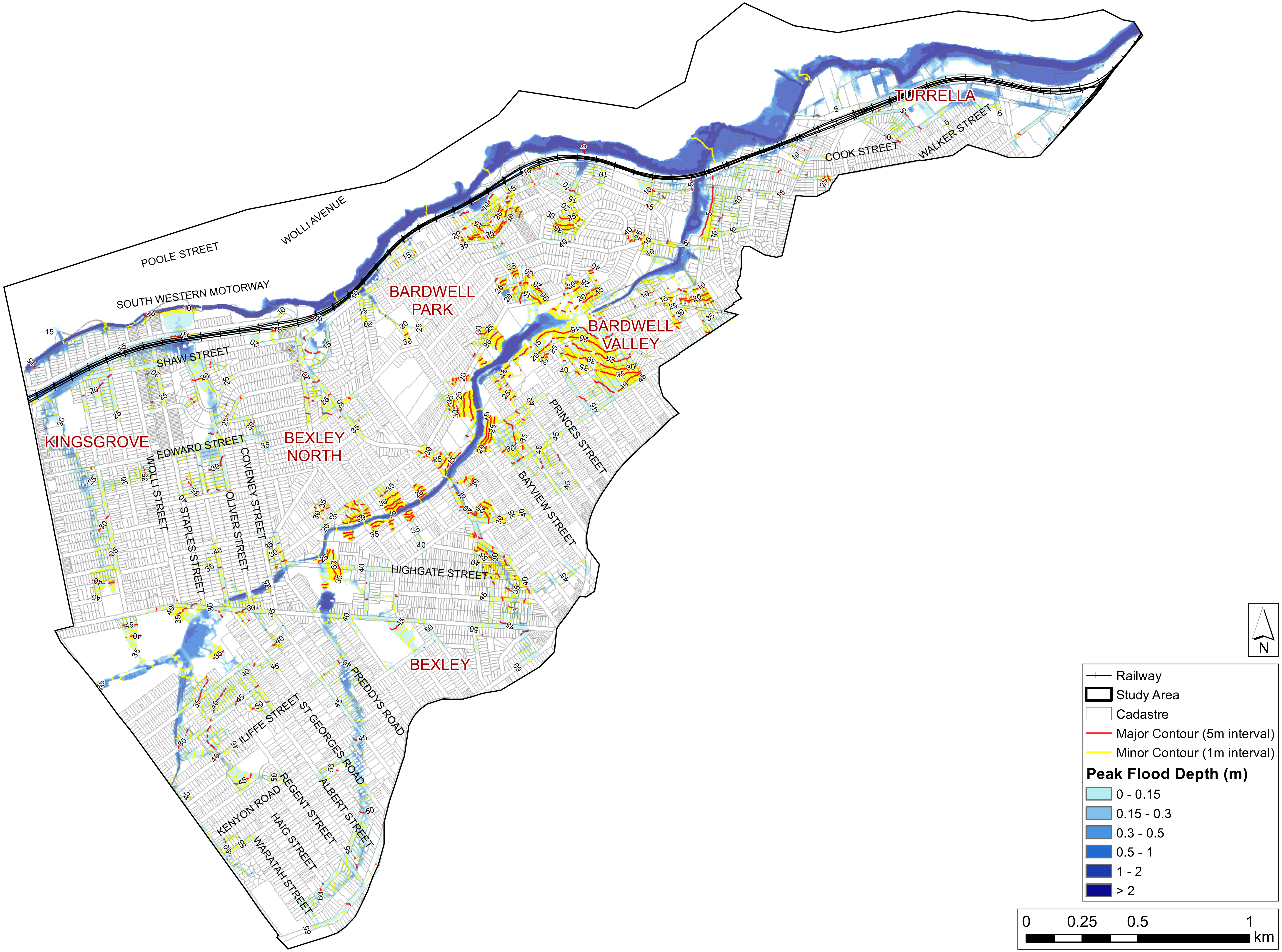

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FIGURE C5

BAYSIDE WEST FRMS&P: BARDWELL CREEK
PEAK FLOOD DEPTH AND LEVEL
1% AEP EVENT

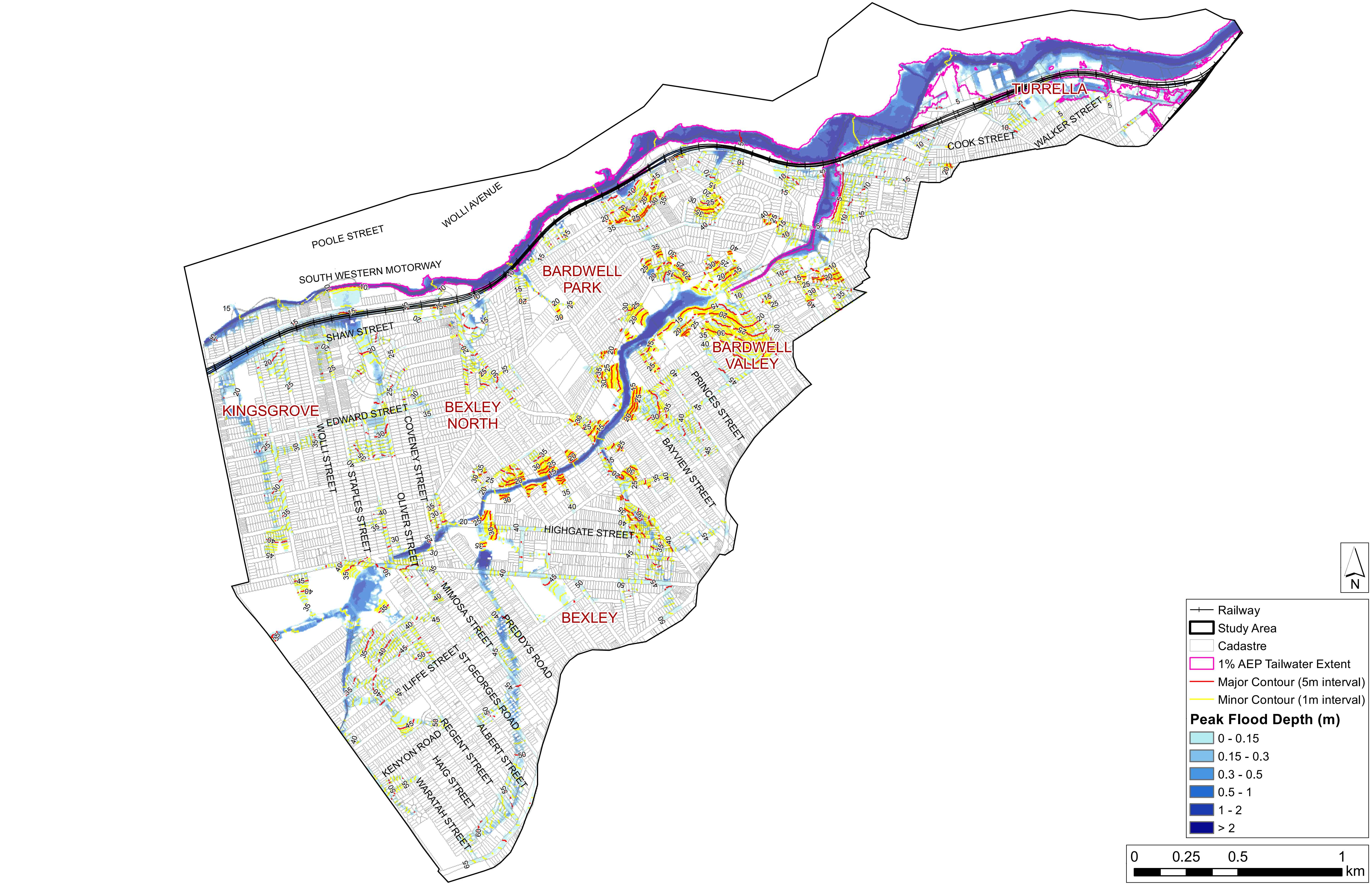

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FIGURE C6

BAYSIDE WEST FRMS&P: BARDWELL CREEK PEAK FLOOD DEPTH AND LEVEL 0.5% AEP EVENT

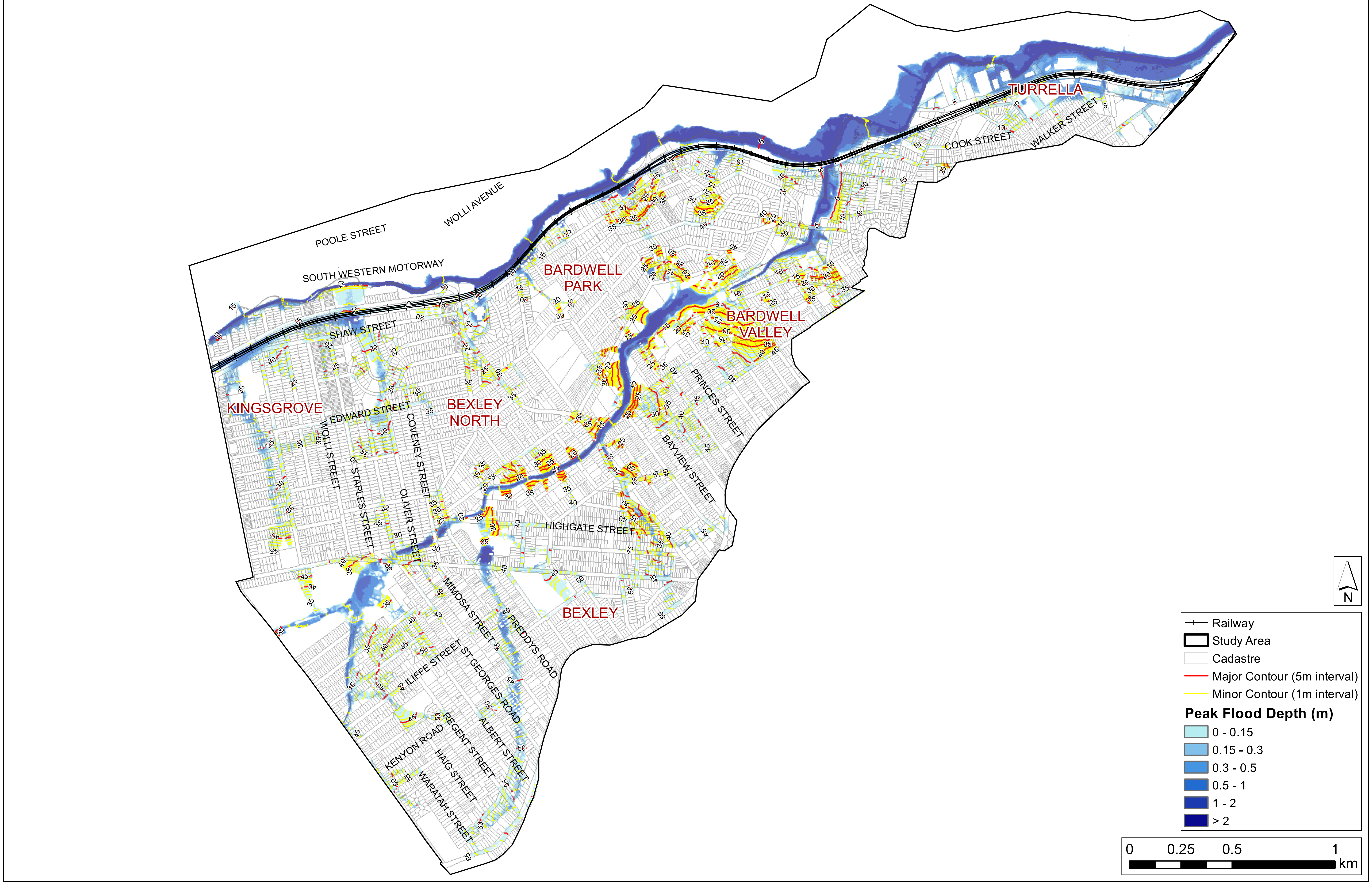

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FIGURE C7

BAYSIDE WEST FRMS&P: BARDWELL CREEK
PEAK FLOOD DEPTH AND LEVEL
0.2% AEP EVENT

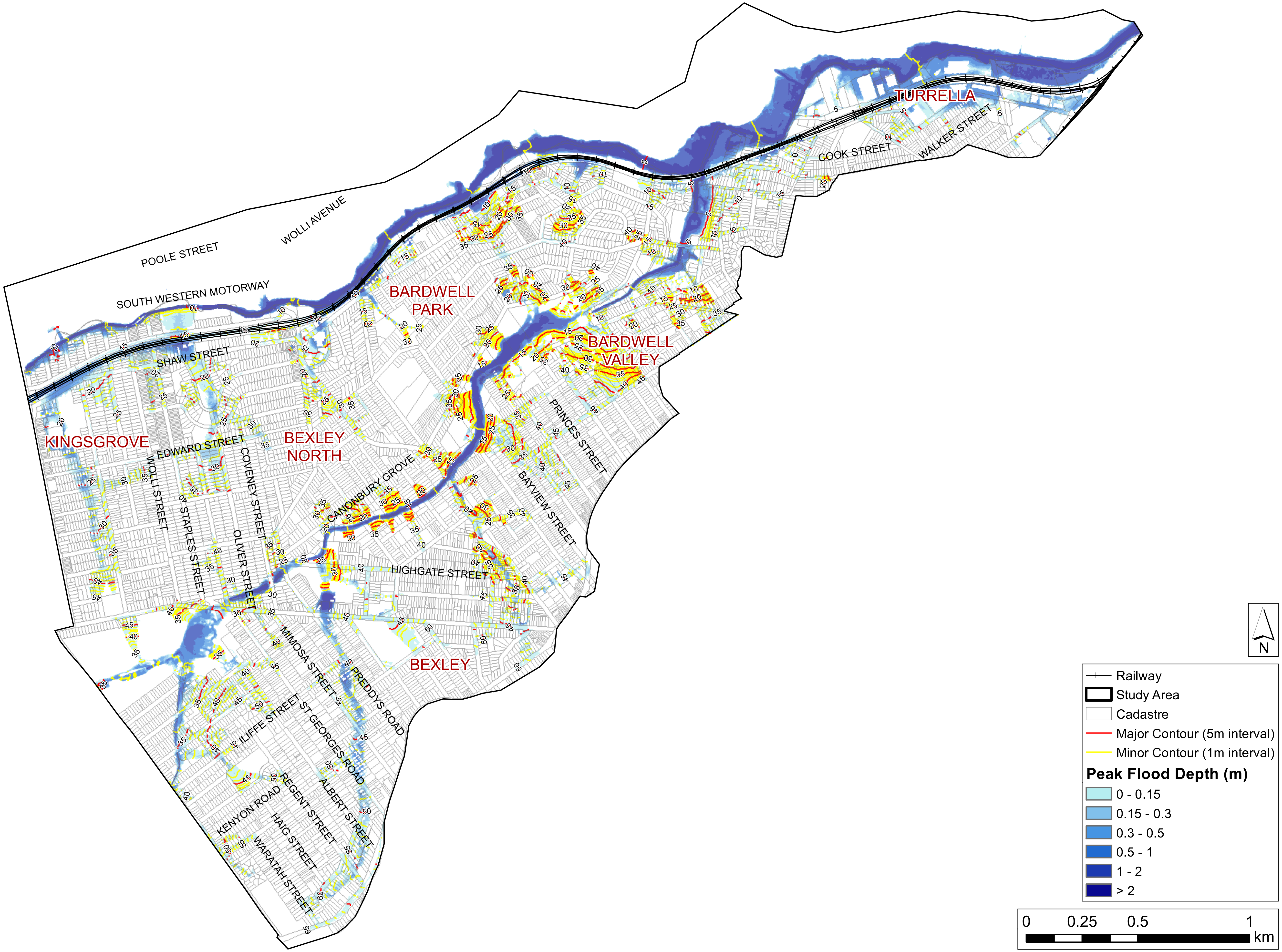

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FIGURE C8

BAYSIDE WEST FRMS&P: BARDWELL CREEK
PEAK FLOOD DEPTH AND LEVEL
PMF EVENT

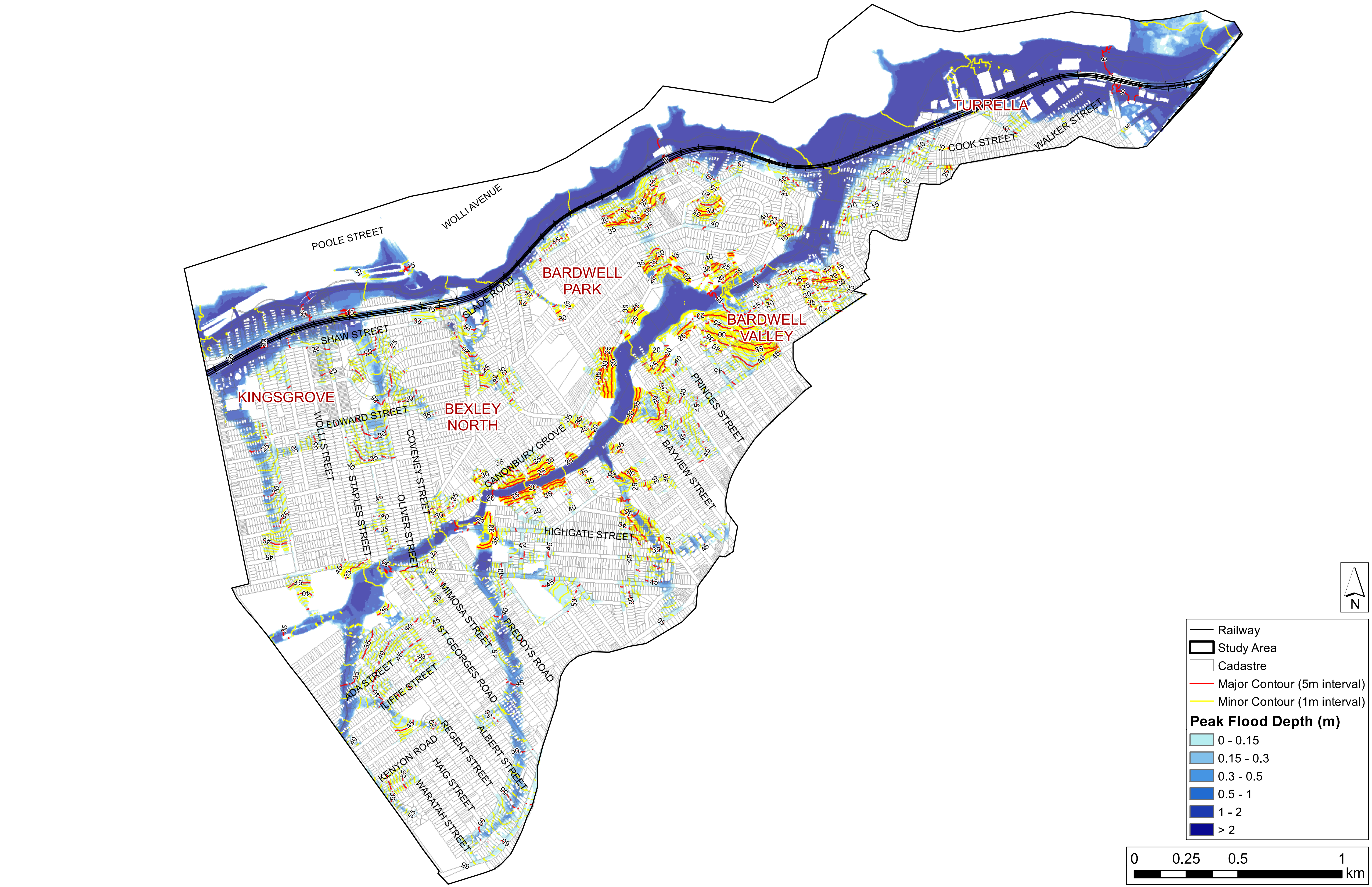

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FIGURE C9

BAYSIDE WEST FRMS&P: BARDWELL CREEK
PEAK VELOCITY
20% AEP EVENT

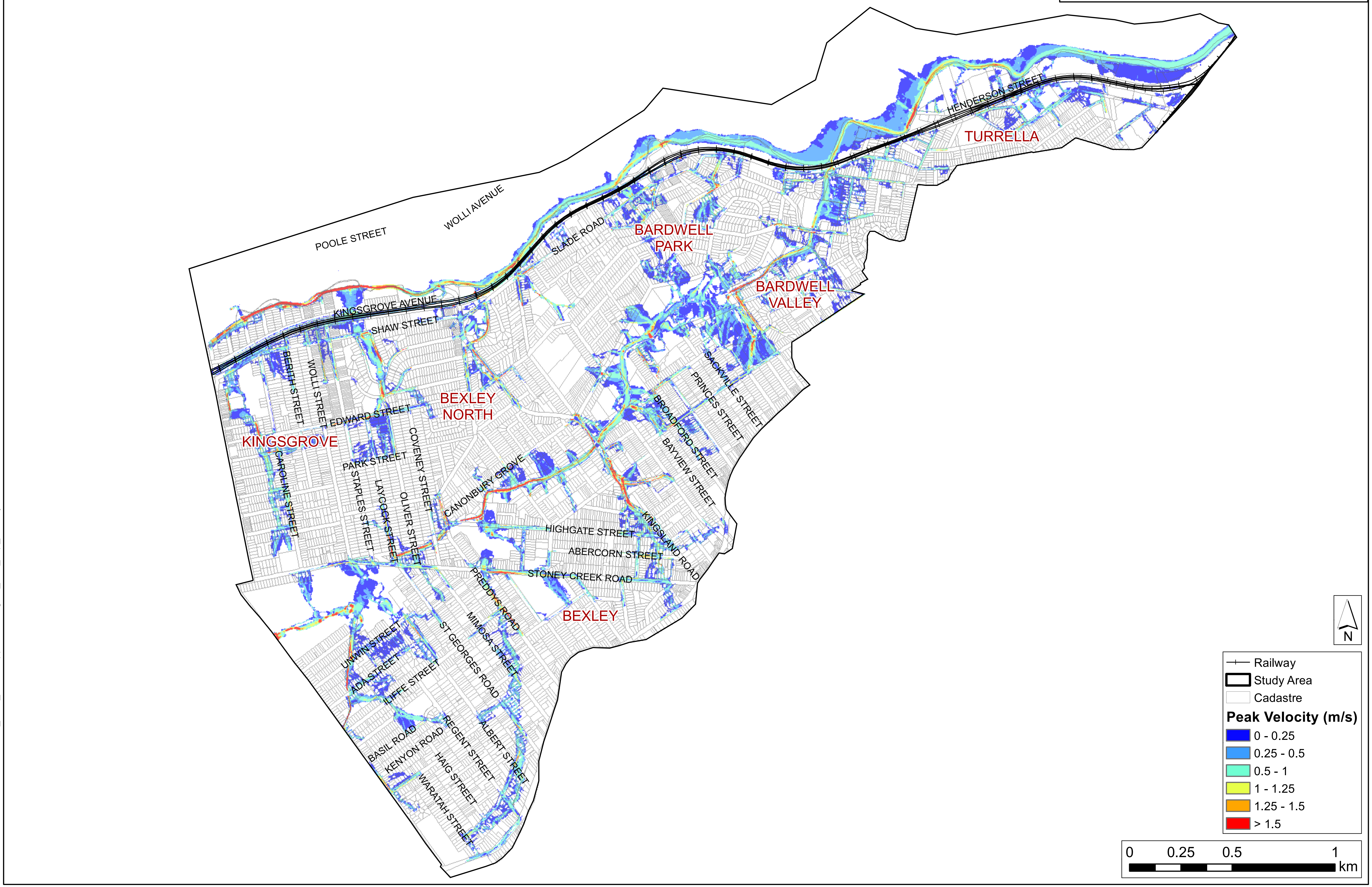

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FIGURE C10

BAYSIDE WEST FRMS&P: BARDWELL CREEK
PEAK VELOCITY
10% AEP EVENT

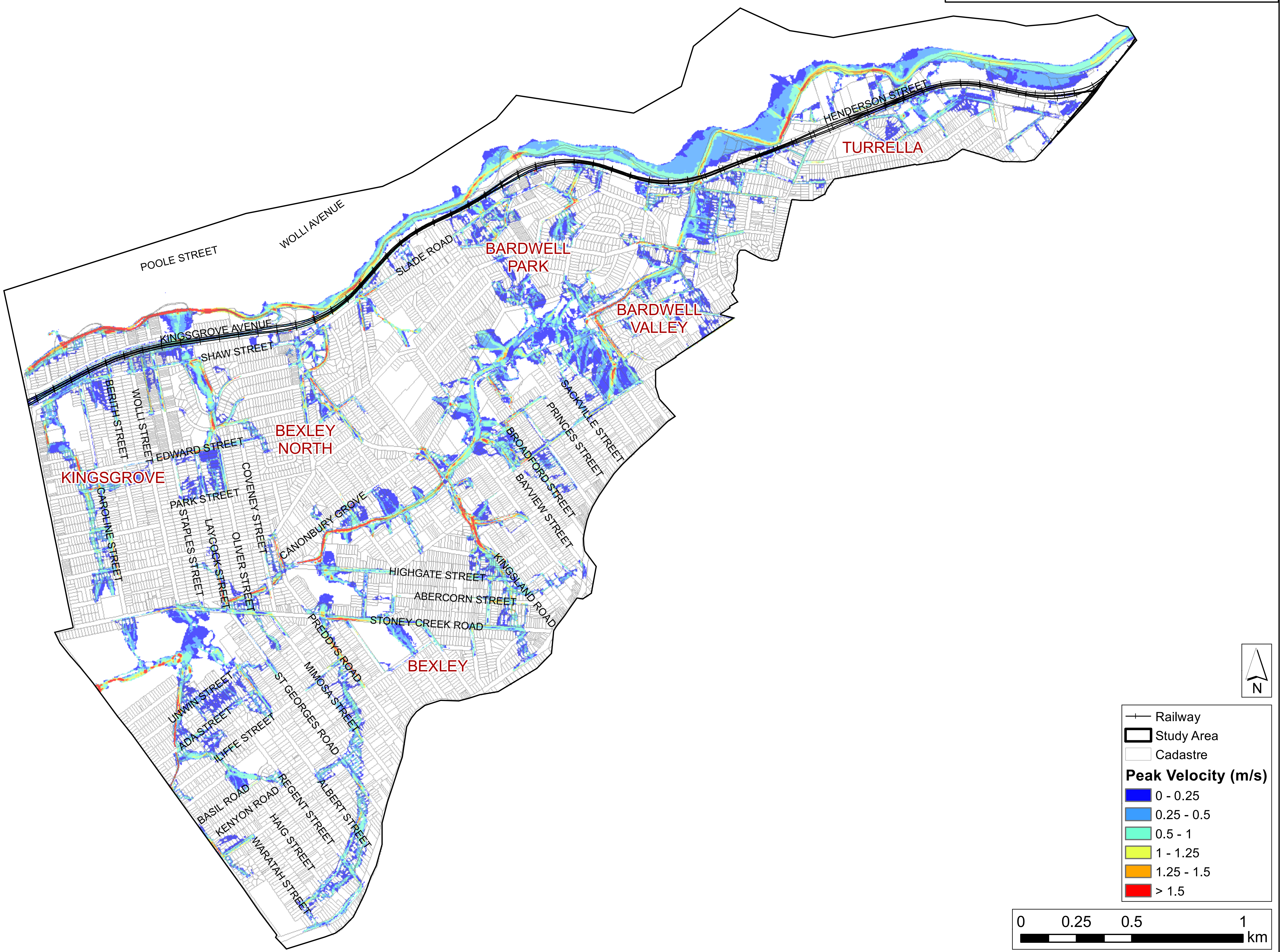

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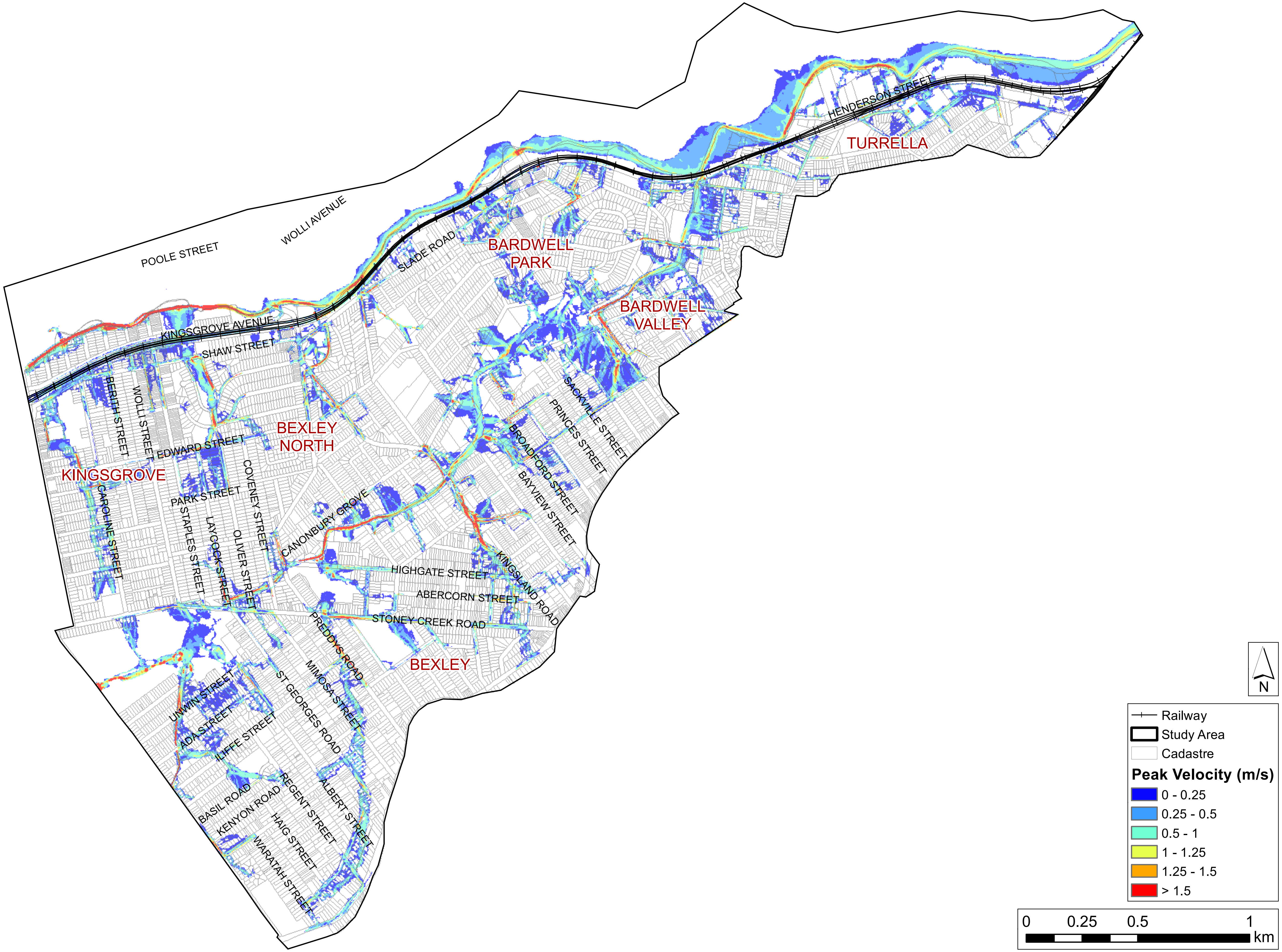
FIGURE C11

BAYSIDE WEST FRMS&P: BARDWELL CREEK
PEAK VELOCITY
5% AEP EVENT



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