A

Appendix A – Groundwater Memorandum

Memorandum

Memorandum

To:	Melbourne Water	**Date:**	13 August 2025
From:	Water4Good	**Our Ref:**	3551531_286 - Memorandum
Copy:			
Subject:	Croskell Precinct Structure Plan (PSP) Proposed Drainage Strategy – Groundwater Data Summary		
Doc #	3551531_286-Croskell PSP Proposed Drainage Strategy – Groundwater Data Summary		

Melbourne Water (MW) has commissioned Water4Good (W4G) to undertake a geotechnical investigation as part of the Croskell Precinct Structure Plan (PSP) Proposed Drainage Strategy Project (the Project). This memo provides a summary of the groundwater levels recorded during this investigation.

The Croskell PSP area is located within the suburbs of Cranbourne East and Clyde North and is bounded by Thompsons Road in the north, Berwick-Cranbourne Road in the east, Narre Warren Road in the west and Linsell Boulevard in addition to a number of residential streets in the south.

As part of the preliminary investigations for the project a total of 23 boreholes were drilled at the project site, during two site investigation programs. Drilling undertaken as part the initial site investigation program occurred across two periods, the first between 28 February and 2 March 2023, the second between 3 April and 6 April 2023. An additional investigation occurred between 26 August and 27 August 2024 with a total of 2 additional boreholes (boreholes BH23 and BH24) drilled at the project site.

In total the investigation included:

- 14 boreholes drilled to a depth of 3m.
- 9 boreholes drilled to a depth of 6m, including the installation of a groundwater monitoring well with a flush mounted gatic cover.

Results of the geotechnical site investigations have been provided in the following reports:

- W4G Report: ‘3551531_286-Croskell PSP Proposed Drainage Strategy Geotechnical Site Report’.
- W4G Report: ‘3551531_286-Croskell PSP Proposed Drainage Strategy Geotechnical Site Report Additional Investigation’.

These reports should be read in conjunction with this memorandum.

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Figure 1, attached, shows the location of the completed boreholes. Borehole locations were recorded using a handheld GPS to an approximate horizontal accuracy of +/- 5 m. Borehole elevations were not recorded.

Prior to installing groundwater monitoring wells, a bore construction license was obtained from Southern Rural Water. After installation, groundwater levels at the installed monitoring wells were measured using a handheld dip meter on 6 April 2023. Further measurements were then taken on a monthly basis between August 2024 and July 2025 as part of a twelve-month groundwater monitoring program. These measurements are summarised in Table 1. The highest groundwater level recorded at each location has been highlighted. Note that as the relative level of the boreholes were not surveyed, they have been estimated based on a projection to a topographic surface.

During the twelve-month groundwater monitoring program, access limitations and changing site conditions impacted the ability to collect measurements at all well locations. Where a reading in Table 1 is listed as not measured, this is indicative of the well not being accessed for groundwater monitoring for that month.

Memorandum

Table 1 Groundwater levels measured in wells.

	Borehole / Well ID	BH03	BH06	BH10	BH16	BH13	BH19	BH21	BH23	BH24
	Estimated Collar RL*	36.50	36.70	40.80	31.10	33.10	32.20	31.80	43.10	29.60
Groundwater Depth (mRL AHD)	**6th April 2023**	36.05	35.17	40.20	29.06	31.12	29.64	29.50	Not yet drilled	Not yet drilled
	27th August 2024	Well location flooded	Not measured	Not measured	Not measured	29.13	29.14	30.23	GNE^	25.15
	9th September 2024	Well location flooded	Not measured	40.67	Not measured	31.14	29.04	30.26	Not measured	27.43
	14th October 2024	Not measured	35.78	40.56	Not measured	Not measured	Not measured	Not measured	GNE	Not measured
	11th November 2024	Not measured	35.74	39.74	Not measured	Not measured	Not measured	Not measured	GNE	27.47
	9th December 2024	Not measured	35.76	40.36	29.20	Not measured	29.24	Not measured	GNE	27.65
	20th January 2025	Not measured	35.41	39.91	29.04	Not measured	29.27	Not measured	GNE	27.52
	10th February 2025	Not measured	35.08	39.52	28.92	Not measured	29.19	Not measured	GNE	27.34
	20th March 2025	Not measured	34.86	39.41	28.74	Not measured	29.14	Not measured	GNE	27.1
	17th April 2025	Not measured	34.72	39.48	28.61	Not measured	29.07	Not measured	GNE	27.05
	15th May 2025	Not measured	34.88	39.58	28.61	Not measured	28.98	Not measured	GNE	26.97
	12th June 2025	Not measured	34.93	39.63	28.54	Not measured	28.89	Not measured	38.44	26.94
	9th July 2025	Not measured	35.07	39.82	28.49	Not measured	28.82	Not measured	38.28	26.91

*RLs for boreholes were not surveyed and are estimated based on projection onto topographic surface.

^Groundwater not encountered



NOTE
W4G has prepared this document in accordance with instruction of Melbourne Water for their specific use.

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N W E S

0 125 250 500 Meters

1:8,500 at A3

Water 4good

Croskell PSP Proposed Drainage Strategy

Figure 1: Borehole Location Plan

REFERENCE: C:\Users\AUJE507134\WSP O365\AU-WKG - Geospatial - AIS - Projects\PS200634_Croskell_PSP\Mxd\PS200634_Croskell_PSP_2024_v1_no_design.mxd

DATE: 5/02/2025 SHEET: 1 of 1 DRAWING NUMBER: 3551531_286-1

B

Appendix B – Pre-development hydrological modelling

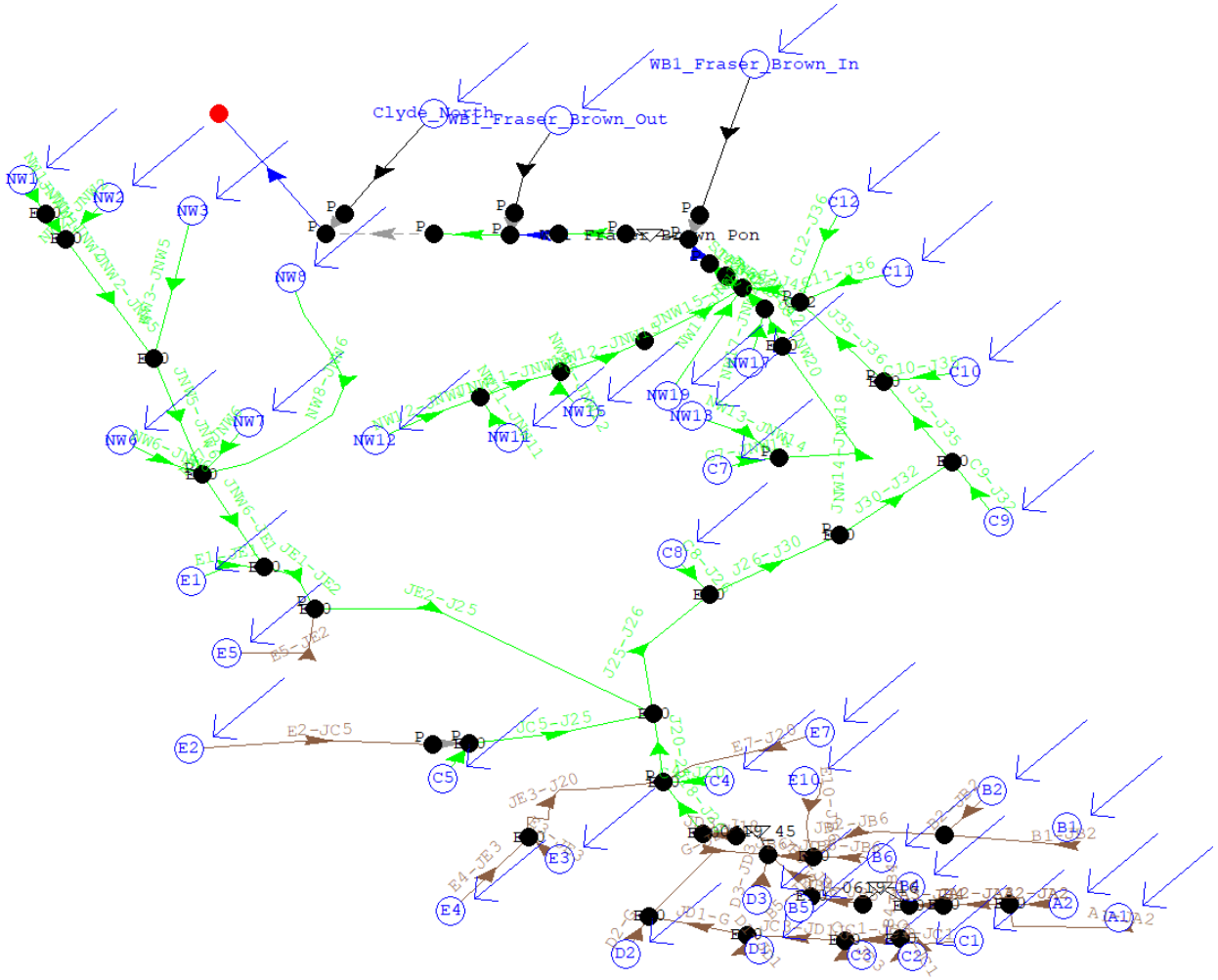


Figure B - 1: West pre-development RORB model layout

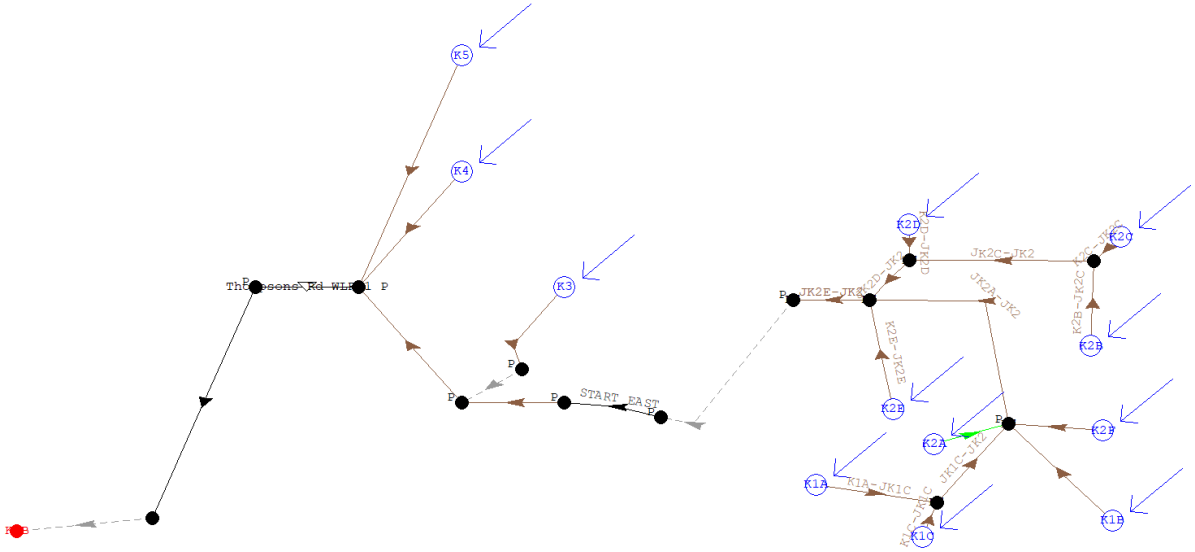


Figure B - 2: East pre-development (historical) RORB model layout

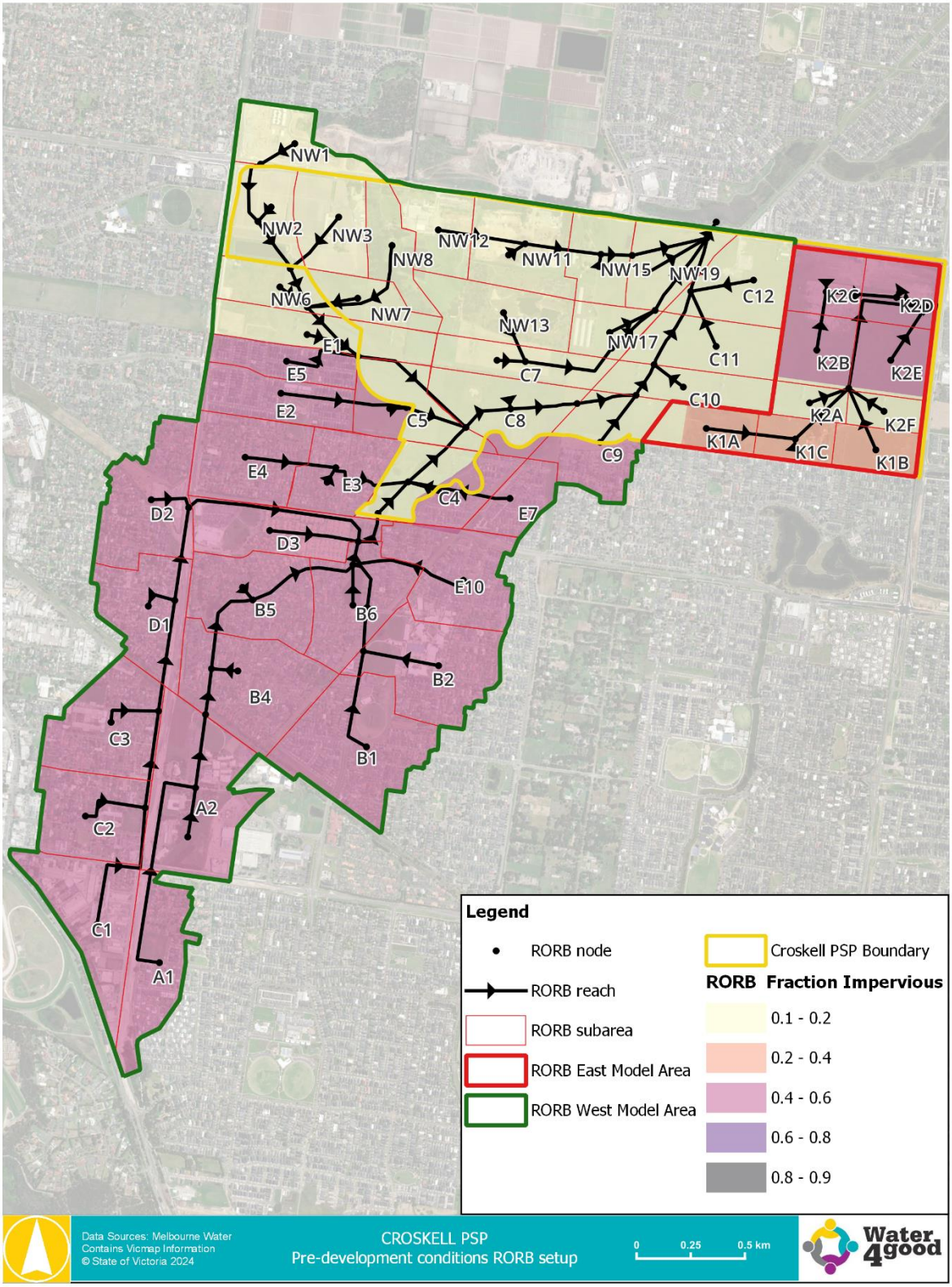


Figure B - 3: Pre-development RORB model setup map

Pre-development RORB results

Table B - 1: RORB west model pre-development peak flow rates (1% AEP with climate condition)

Node	Event	Duration (min)	Duration (text)	Adopted TP Q	Adopted TP
Water Main Crossing	1% AEP year 2100 SSP2 - 4.5	360	6 hours	31.51	6135
WB1_in	1% AEP Year 2100 SSP2 4-5	20	20 min	44.23	5844
WB1_Out	1% AEP Year 2100 SSP2 4-5	20	20 min	25.14	5844
WB1_Fraser_Brown_Out	1% AEP Year 2100 SSP2 4-5	360	6 hours	31.56	6135
WB1_Fraser_Brown_In	1% AEP Year 2100 SSP2 4-5	30	30 min	42.17	5907
WB1 Fraser Brown Pon	1% AEP Year 2100 SSP2 4-5	360	6 hours	29.13	6133
WB1 Fraser Brown Pon	1% AEP Year 2100 SSP2 4-5	360	6 hours	29.13	6133
THOMPSONS ROAD	1% AEP Year 2100 SSP2 4-5	270	4.50 hours	25.65	6102
SBRB2_match	1% AEP Year 2100 SSP2 4-5	270	4.50 hours	25.74	6102
NW13/C7	1% AEP Year 2100 SSP2 4-5	60	1 hour	4.33	5967
E2/C5	1% AEP Year 2100 SSP2 4-5	30	30 min	6.06	5906
E1/E5	1% AEP Year 2100 SSP2 4-5	270	4.50 hours	3.83	6102
Croskell_WLRB3_inflow	1% AEP Year 2100 SSP2 4-5	90	1.50 hour	30.18	6002
Croskell water main cross N	1% AEP Year 2100 SSP2 4-5	180	3 hours	23.64	6062
Croskell Water Main Cross S	1% AEP Year 2100 SSP2 4-5	120	2 hours	26.46	6036
Croskell VDP main cross	1% AEP Year 2100 SSP2 4-5	120	2 hours	25.26	6028
Croskell VDP Cable W	1% AEP Year 2100 SSP2 4-5	90	1.50 hour	4.9	6003
Clyde_sub	1% AEP Year 2100 SSP2 4-5	20	20 min	22.2	5840
Clyde_North	1% AEP Year 2100 SSP2 4-5	360	6 hours	35.96	6131
0619_45	1% AEP Year 2100 SSP2 4-5	90	1.50 hour	31.39	6003
0619-16	1% AEP Year 2100 SSP2 4-5	45	45 min	13.01	5942

Table B - 2: RORB east model pre-development peak flow

Node	Event	Duration (min)	Duration (text)	Adopted TP Q	Adopted TP
Thompsons Rd WLRB1 P	1% AEP-2.5-MMM-CC	540	9 hours	5.24	6167
Thompsons Rd WLRB1 Outlet	1% AEP-2.5-MMM-CC	540	9 hours	5.24	6167
K3	1% AEP-2.5-MMM-CC	30	30 min	20.9	5795
K2	1% AEP-2.5-MMM-CC	30	30 min	15.02	5906
Croskell VDP Cable EAST	1% AEP-2.5-MMM-CC	25	25 min	8.39	5781
Croskell B-C Road example	1% AEP-2.5-MMM-CC	20	20 min	15.02	5844
Croskell B-C Rd swale ex roa	1% AEP-2.5-MMM-CC	30	30 min	15.06	5906
Croskel Berwick Cranbourne R	1% AEP-2.5-MMM-CC	30	30 min	15.06	5906

C

Appendix C – Post-development hydrological modelling

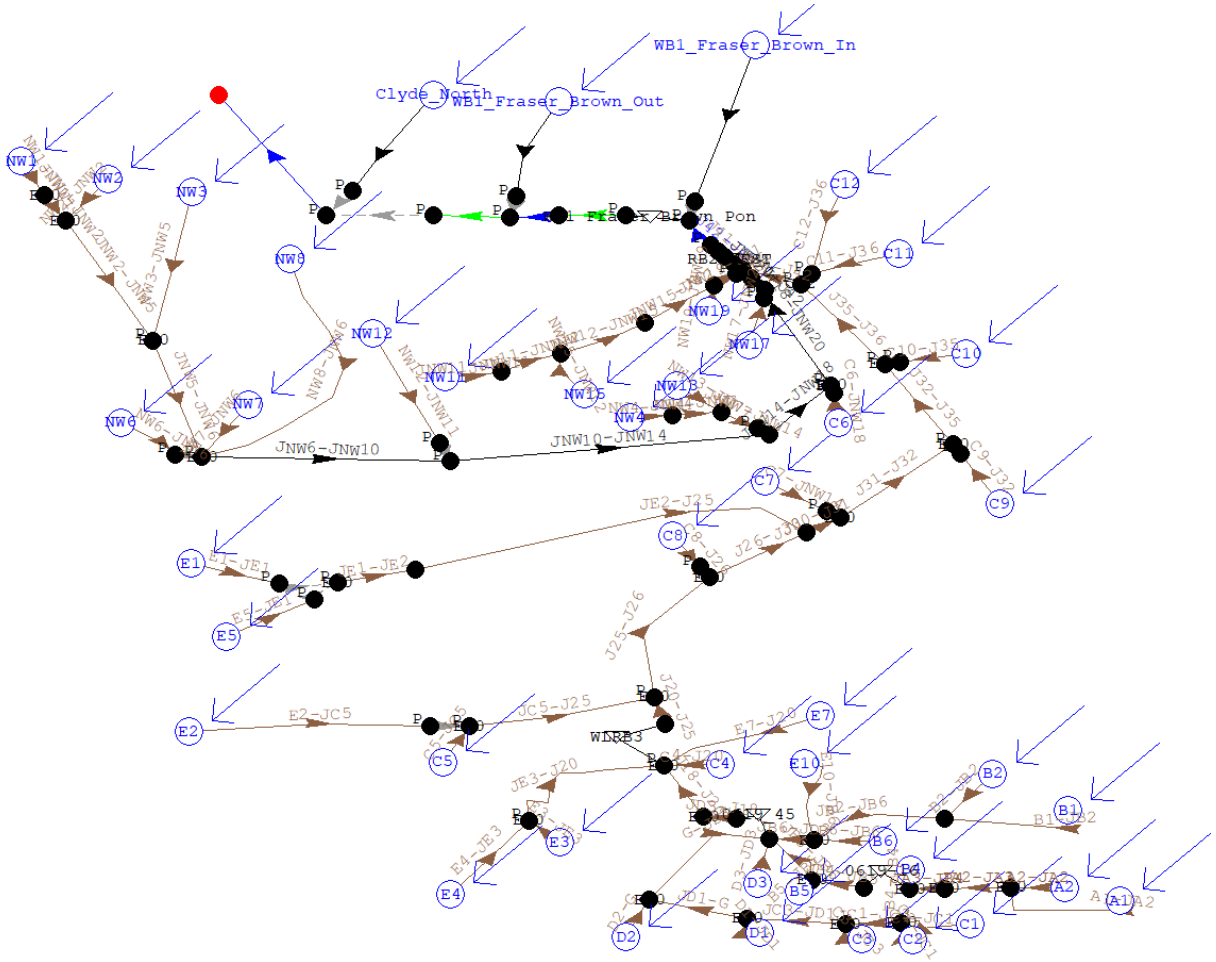


Figure C - 1: West post-development RORB model layout

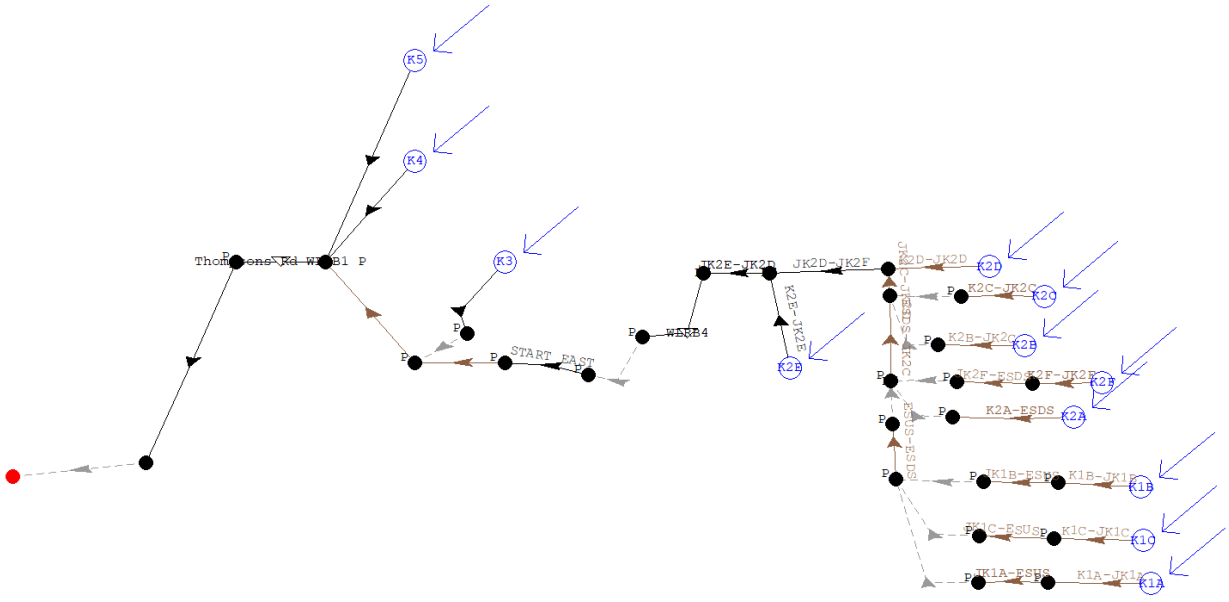


Figure C - 2: East post-development RORB model layout

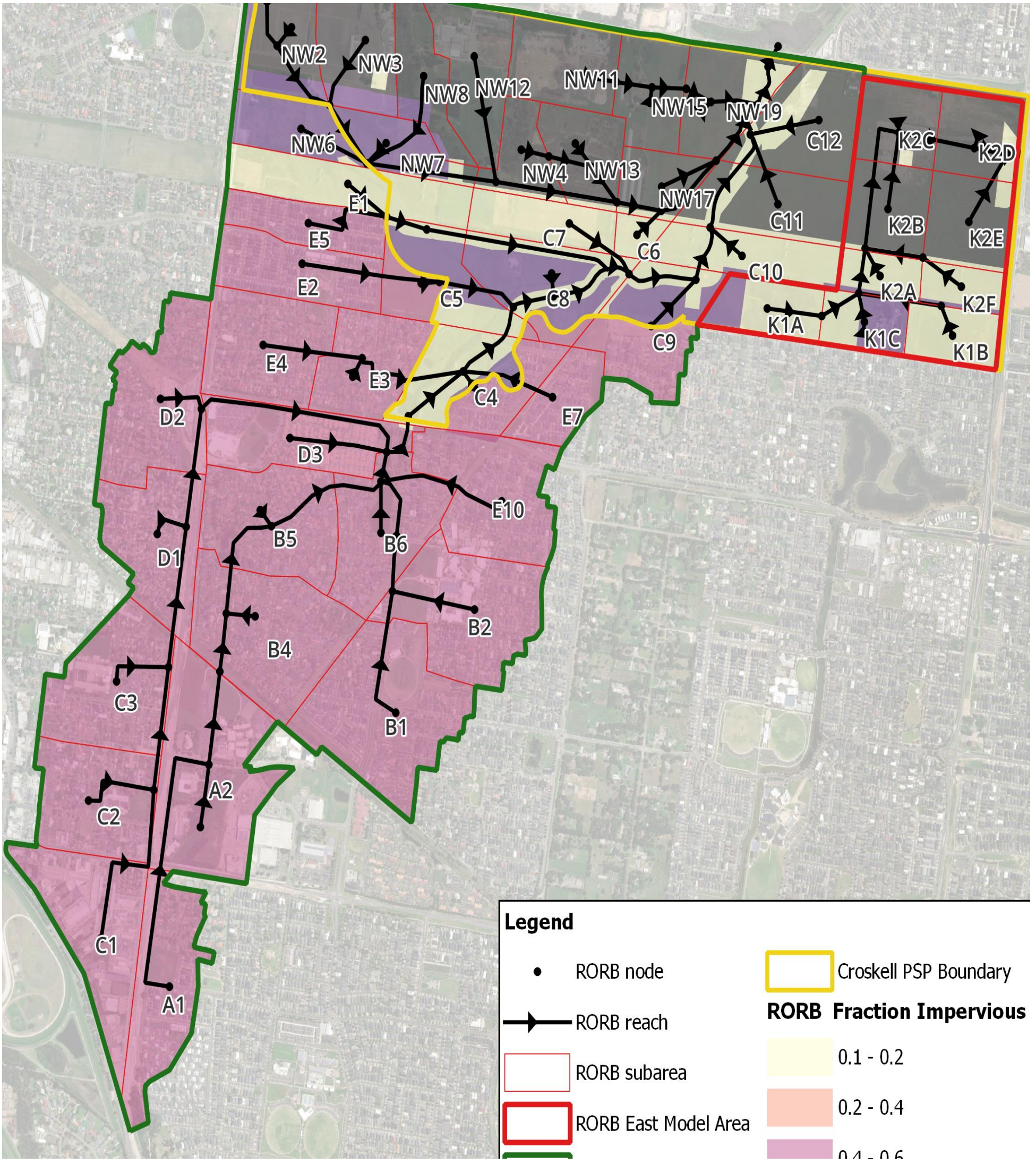


Figure C - 3: Post-development RORB model setup map

Post-development RORB results

Table C - 1: RORB west model post-development peak flow rates (1% AEP with climate change)

Node	Event	Duration (min)	Duration (text)	Adopted TP Q	Adopted TP
0619-16	1% AEP Year 2100 SSP2 4-5	45	45 min	13.44	5942
0619_45	1% AEP Year 2100 SSP2 4-5	90	1.50 hour	31.53	6003
C10DS	1% AEP Year 2100 SSP2 4-5	25	25 min	3.11	5781
C11/C12	1% AEP Year 2100 SSP2 4-5	20	20 min	8.68	5842
C6_pipe	1% AEP Year 2100 SSP2 4-5	45	45 min	0.6	5942
C7DS	1% AEP Year 2100 SSP2 4-5	60	1 hour	1.74	5969
C8DS	1% AEP Year 2100 SSP2 4-5	20	20 min	7.04	5842
C9DS	1% AEP Year 2100 SSP2 4-5	20	20 min	5.45	5842
Clyde_North	1% AEP Year 2100 SSP2 4-5	120	2 hours	37.6	6033
Clyde_sub	1% AEP Year 2100 SSP2 4-5	20	20 min	22.2	5845
Croskell VDP Cable W	1% AEP Year 2100 SSP2 4-5	30	30 min	15.83	5910
Croskell VDP main cross	1% AEP Year 2100 SSP2 4-5	540	9 hours	12.18	6163
Croskell Water Main Cross S	1% AEP Year 2100 SSP2 4-5	540	9 hours	11.52	6167
Croskell water main cross N	1% AEP Year 2100 SSP2 4-5	540	9 hours	14.32	6168
Croskell waterway 2	1% AEP Year 2100 SSP2 4-5	90	1.50 hour	32.06	6002
DSC6	1% AEP Year 2100 SSP2 4-5	30	30 min	20.49	5910
DSNW3	1% AEP Year 2100 SSP2 4-5	20	20 min	10.97	5847
E1	1% AEP Year 2100 SSP2 4-5	45	45 min	3.55	5942
E1/E5	1% AEP Year 2100 SSP2 4-5	45	45 min	5.55	5942
E2	1% AEP Year 2100 SSP2 4-5	30	30 min	2.47	5795
E2/C5	1% AEP Year 2100 SSP2 4-5	20	20 min	8.08	5841
E3&E4	1% AEP Year 2100 SSP2 4-5	20	20 min	9.7	5841
E5	1% AEP Year 2100 SSP2 4-5	30	30 min	2.05	5906
NW11/15/19	1% AEP Year 2100 SSP2 4-5	20	20 min	11.3	5844
NW12DS	1% AEP Year 2100 SSP2 4-5	30	30 min	17.7	5907
NW12_pipe	1% AEP Year 2100 SSP2 4-5	20	20 min	4.44	5842
NW13DS	1% AEP Year 2100 SSP2 4-5	30	30 min	20.27	5910
NW13_pipe	1% AEP Year 2100 SSP2 4-5	20	20 min	5.54	5841
NW17DS	1% AEP Year 2100 SSP2 4-5	30	30 min	20.98	5907
NW17_pipe	1% AEP Year 2100 SSP2 4-5	20	20 min	2.42	5842
NW6DS	1% AEP Year 2100 SSP2 4-5	30	30 min	2.28	5907
NW_PIPE	1% AEP Year 2100 SSP2 4-5	30	30 min	20.57	5910
RB2 WEST	1% AEP Year 2100 SSP2 4-5	90	1.50 hour	20.61	6002
THOMPSONS ROAD	1% AEP Year 2100 SSP2 4-5	90	1.50 hour	20.51	6002
WB1 Fraser Brown Pon	1% AEP Year 2100 SSP2 4-5	90	1.50 hour	31.61	5995
WB1 Fraser Brown Pon	1% AEP Year 2100 SSP2 4-5	90	1.50 hour	31.61	5995
WB1_Fraser_Brown_In	1% AEP Year 2100 SSP2 4-5	30	30 min	46.2	5906
WB1_Fraser_Brown_Out	1% AEP Year 2100 SSP2 4-5	120	2 hours	33.88	6030
WB1_Out	1% AEP Year 2100 SSP2 4-5	20	20 min	25.13	5844
WB1_in	1% AEP Year 2100 SSP2 4-5	20	20 min	44.18	5844
WLRB3	1% AEP Year 2100 SSP2 4-5	270	4.50 hours	9.53	6063
Water Main Crossing	1% AEP Year 2100 SSP2 4-5	120	2 hours	32.49	6036

Table C - 2: RORB east model post-development peak flow rates (1% AEP with climate change)

Node	Event	Duration (min)	Duration (text)	Average Q (m3/s)	Median Q	Adopted TP Q	Adopted TP
WLRB4	1% AEP Year 2100 SSP2 4-5	180	3 hours	2.39	2.41	2.39	6065
Thompsons Rd WLRB1 P	1% AEP Year 2100 SSP2 4-5	720	12 hours	3.64	3.67	3.61	6196
Thompsons Rd WLRB1 Outlet	1% AEP Year 2100 SSP2 4-5	720	12 hours	3.64	3.67	3.61	6196
K3	1% AEP Year 2100 SSP2 4-5	10	10 min	20.39	20.41	20.46	5774
K2F	1% AEP Year 2100 SSP2 4-5	60	1 hour	0.92	0.89	0.94	5969
K2C	1% AEP Year 2100 SSP2 4-5	10	10 min	5.65	5.62	5.84	5774
K2B	1% AEP Year 2100 SSP2 4-5	20	20 min	4.07	4.14	4.14	5842
K2A	1% AEP Year 2100 SSP2 4-5	25	25 min	1.5	1.47	1.51	5809
K2	1% AEP Year 2100 SSP2 4-5	180	3 hours	2.4	2.41	2.4	6065
K1C	1% AEP Year 2100 SSP2 4-5	20	20 min	3	2.94	3	5841
K1B	1% AEP Year 2100 SSP2 4-5	45	45 min	1.57	1.53	1.63	5942

Node	Event	Duration (min)	Duration (text)	Average Q (m3/s)	Median Q	Adopted TP Q	Adopted TP
K1A	1% AEP Year 2100 SSP2 4-5	20	20 min	2.94	2.95	2.92	5841
ESUS	1% AEP Year 2100 SSP2 4-5	20	20 min	6.52	6.82	6.53	5840
ESDS(BeforeCrossing)	1% AEP Year 2100 SSP2 4-5	30	30 min	5.65	5.52	5.71	5907
ESDS(AfterCrossing)	1% AEP Year 2100 SSP2 4-5	30	30 min	7.59	7.4	7.79	5906
Croskell B-C Road example	1% AEP Year 2100 SSP2 4-5	10	10 min	20.38	20.4	20.35	5771
Croskell B-C Rd swale ex roa	1% AEP Year 2100 SSP2 4-5	180	3 hours	2.39	2.41	2.39	6065
Croskel Berwick Cranbourne R	1% AEP Year 2100 SSP2 4-5	180	3 hours	2.39	2.41	2.39	6065

D

Appendix D – MUSIC Contributing Catchments

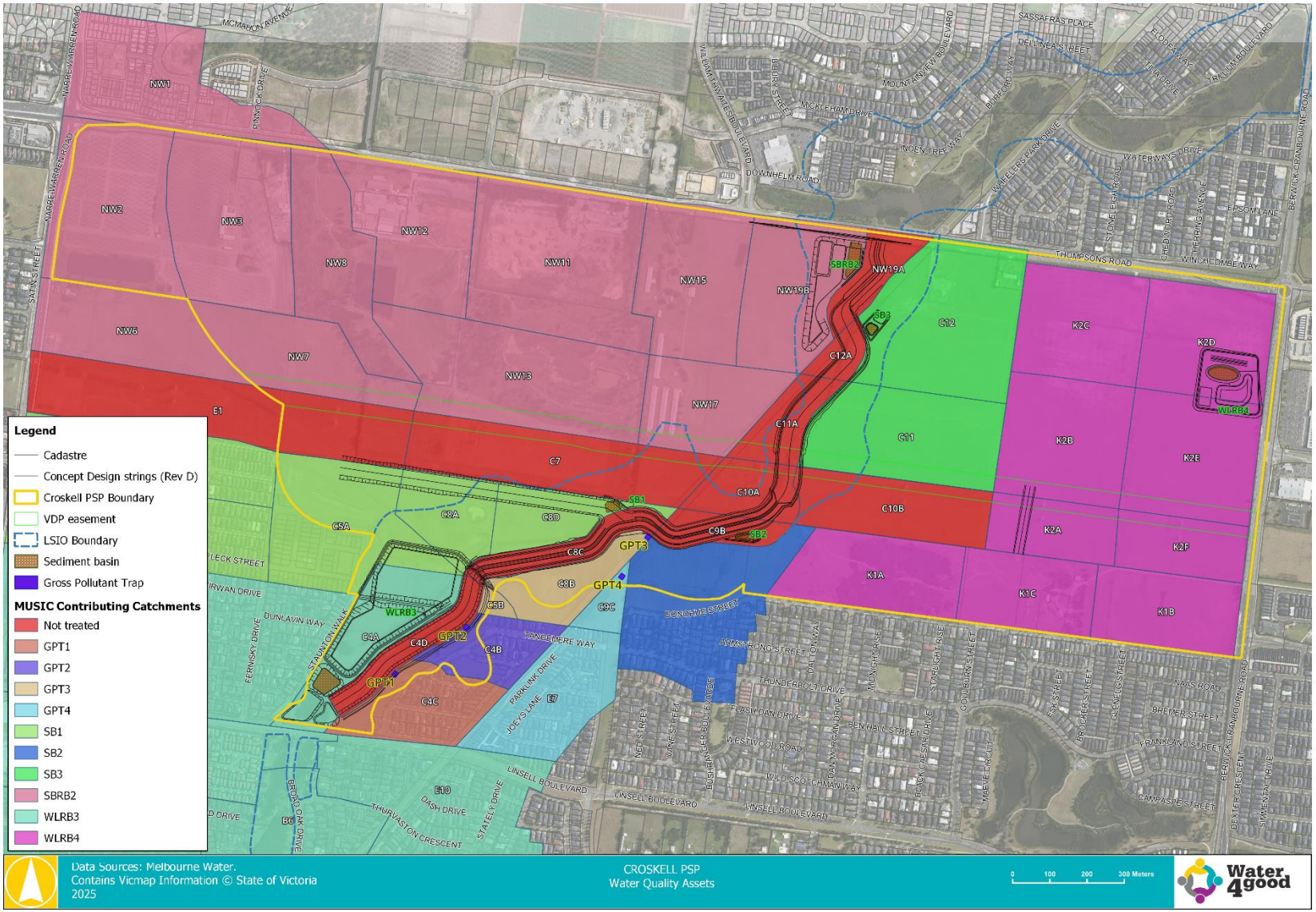


Figure D - 1: Croskell PSP MUSIC catchment map

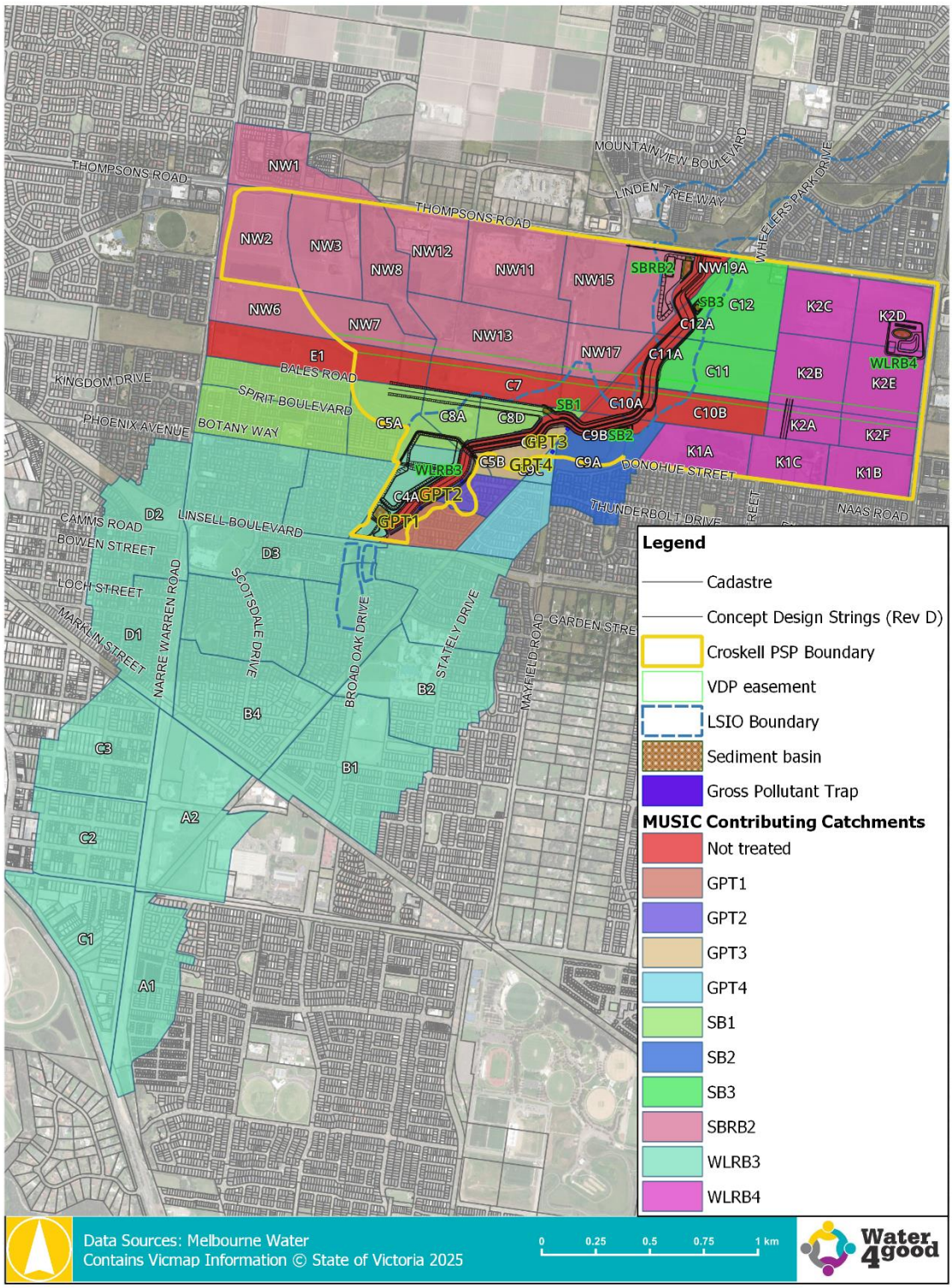


Figure D - 2: Croskell PSP MUSIC catchment map showing external catchment

E

Appendix E – Sediment basin sizing

Description:

This section shows the sediment pond size estimates used for MUSIC trials in the Croskell PSP Drainage Scheme.

Approach: The sediment ponds are sized using the Fair and Geyer equation. The turbulence parameter based on the hydraulic efficiency, which depends on the shape of the sediment pond. The main parameters utilized are listed in the tables below.

Calculations:

Table E - 1: Scenario 1 - Sediment ponds are empty

Scenario 1	Units	SB1	SB2	SB3	SBRB 2	WLRB3 sed pond	WLRB4 sed pond
Standalone sed pond?		Yes	Yes	Yes	Yes	No	No
Contributing Area	ha	47.41	14.37	27.68	148.63	380.60	77.75
Fraction of target Sediment to be removed	R	0.95	0.95	0.95	0.95	0.95	0.95
Turbulence Parameter	n	1.12	1.12	1.12	1.35	1.12	1.35
Settling velocity of particle	Vs (m/s)	0.01	0.01	0.01	0.01	0.01	0.01
Peak Flow 3 Months ARI (sediment pond high flow bypass)	Q (m3/s)	0.57	0.40	0.56	2.29	2.98	1.33
Extended Detention Depth	de (meters)	0.35	0.35	0.35	0.35	0.35	0.35
Permanent Pool Depth	dp (0.5 to 1.5 meters)	1.50	1.50	1.50	1.50	1.50	1.50
Depth below permanent pool	d (0.5 to 1.0 meters)	1.00	1.00	1.00	1.00	1.00	1.00
Total depth (m)	de+dp	1.85	1.85	1.85	1.85	1.85	1.85
MUSIC Surface Area adopted	m2	762.9	397.0	547.4	1932.4	3047.34	1431.8

Table E - 2: Scenario 2 - Sedimentation ponds are full

Scenario 2	Units	SB1	SB2	SB3	SBRB2	WLRB3 sed pond	WLRB4 sed pond
Fraction of target Sediment to be removed	R	0.95	0.95	0.95	0.95	0.95	0.95
Turbulence Parameter	n	1.12	1.12	1.12	1.35	1.12	1.35
Settling velocity of particle	Vs (m/s)	0.01	0.01	0.01	0.01	0.01	0.01
Peak Flow 3 Months ARI	Q (m3/s)	0.57	0.40	0.56	2.29	2.98	1.35
Extended Detention Depth	De (meters)	0.35	0.35	0.35	0.35	0.35	0.35
Permanent Pool Depth	dp (0.5 to 1.5 meters)	0.50	0.50	0.50	0.50	0.50	0.50
Depth below permanent pool	d (0.5 to 1.0 meters)	0.50	0.50	0.50	0.50	0.50	0.50
Total depth	de+dp (meters)	0.85	0.85	0.85	0.85	0.85	0.85
Area	A (m2)	780.58	544.14	749.63	2295.90	4175.99	1331.29

Table E - 3: Sediment ponds' minimum storage required

	Units	SB1	SB2	SB3	SBRB2	WLRB3 sed pond	WLRB4 sed pond
Fraction of target sediment	R	0.95	0.95	0.95	0.95	0.95	0.95
Sediment Loading Rate (m3/ha/yr)	Lo	2.00	2.00	2.00	2.00	1.00 – upstream external catchments* 2.00 -Croskell PSP	2.00
Cleanout frequency	Fr (1 in X years)	5.00	5.00	5.00	5.00	5.00	5.00
Volume of storage required between base and 0.5m below NWL	St (m3)	450.43	136.49	262.93	1411.94	2092.36	738.59
Drying area	m2	900.86	272.97	525.86	2823.88	4184.71	1477.17

* To account for sediment removal from existing assets upstream of Linsell Blv.

F

Appendix F – 2025 TUFLOW modelling approach

F.1 Overview

This appendix documents the modelling approach applied to the 2025 TUFLOW modelling of the Croskell PSP precinct. The TUFLOW model conducted an assessment of the flood behaviour across the Croskell PSP precinct and the area downstream of the precinct, for both pre- and post- development scenarios and considered the climate change effects under ARRv4.2 SSP2-4.5 conditions. The concept drainage strategy Rev D (September 2025) designed assets were assessed in TUFLOW to verify their effectiveness in managing flood risks for the 1% AEP (with climate change) event. The following sections describe the approach used in the TUFLOW modelling.

F.1.1 Model development

Catchment characteristics

Information on the site locality is located in Item 4 of this report. Croskell PSP drainage strategy includes a combination of major drainage assets, designed to retard 1% AEP (with climate change) post-development flows to 1% AEP (with climate change) pre-development, considering the latest ARR2019 climate change design guidelines (version 4.2). The major drainage assets included in the 2025 TUFLOW model are:

- SBRB2: Sediment basin and retarding basin 2
- WLRB3: Wetland retarding basin 3
- WLRB4: Wetland retarding basin 4
- Ti-Tree Creek main waterway
- Western Swale
- Eastern swale
- Northwest catchment pipe diversion
- Sediment ponds: Sediment basin 1 (SB1), sediment basin 2 (SB2) and sediment basin 3 (SB3)

Topography data

The topography data representing the study area was derived from the Optimised Design Rev C (Feb 2025) 12D model, which exported a .dem format file generated using the Lidar and the designed values for the major assets. It should be noted that the 12D model does not include modifications made to the Ti-Tree Creek waterway in March 2025 to accommodate relocation of Ausnet towers within the transmission easement.

The underlying model topography was predominantly sampled from the high-resolution surveyed LiDAR. Three sources of topography data were utilised in this study, these are:

- 20171128_Melbourne_LiDAR_Merged_Extended.asc: base DEM.
- 20220428_SVY20220404_TRIANGLES_TIN.12da: updated survey DTM.
- CroskellPSP_Design_Surface.dem: topography updated with Concept Drainage Strategy Rev. D.

Modelling methodology

TUFLOW files developed by Cardno in 2019 for the Ti Tree Creek flood mapping project were supplied to Water4Good and used as a base model for the development of the pre- and post-development scenarios.

The modelling undertaken to assess a catchment's flood behaviour used TUFLOW software for both the hydrologic and hydraulic model. The hydrologic modelling component was included within the hydraulic model by adopting inflows using 2d_sa (for both the pre and post-development scenarios) and 2d_sa _ALL features (only for the pre-development scenario). Additionally, inflows were applied to the northwest pipe diversion (1d_nwk_L) feature through 1d_bc (QT) points layer applied at the pits' locations at the inlet of each pipe segment of the 1% AEP (with climate change) pipe diversion.

For the purpose of this study, two TUFLOW models were developed utilising the Heavily Parallelised Computing (HPC) engine (release 2025.0.2 iDP-w64): one model to represent pre-development and another for post-development flood behaviour assessment.

Design constraints

The key design constraints for the 2025 TUFLOW model are:

- Freeboard within the Ti Tee Creek waterway should be 300mm along the Croskell PSP precinct.
- Floor level of Pump station located nearby WLRB3 Retarding basin development area: As built drawing '*SP839-P00079-C-019 Rev 2'* produced for South East Water mentions that the permanent generator with concrete pad sits approximately "300mm above the 1% AEP flood level of 37.99mAHD". Therefore, ensuring the WLRB3 flood level doesn't not exceed 37.99mAHD is desirable to guarantee sufficient freeboard for the generator.
- According to the '*Eastleigh Stage 1&2 Interim Drainage Strategy',* there is a development proposal for a 66.6 ha site. The proposed development is bordered to the west by Narre Warren Road, to the north by vacant land / paddocks, to the south by existing residential estates and a waterway, and to the east by vacant land (downstream landowner - Melbourne Water easement, where WLRB3 is planned to be constructed). From that strategy document, it was found that the lowest finished surface level being proposed is 39.08mAHD at Lot 117. The finished surface level is considered a constraint for the Croskell PSP design, with reference to the WLRB3 peak flood elevation.
- SBRB2 outlet capacity will be lower than the existing culvert capacity at Thompsons Road existing culvert (5 No. 1800 mm (W) x 1500 mm (H) barrels with approximately 31m^3/s total capacity). A detailed outlet structure would be required at functional design.

Design assumptions

The following design assumptions were implemented in the 2025 TUFLOW modelling for the pre- and post-development scenarios:

- The TUFLOW model extent covers areas upstream of Linsell Boulevard and immediately downstream of Croskell PSP precinct boundary, at Thompsons and Berwick-Cranbourne Roads.
- Downstream of Croskell PSP precinct, the model set-up is the same between pre and post-development scenarios. The majority of council pipes downstream of Croskell PSP were not included as they didn't influence the TUFLOW models' results.
- Tailwater level of 26.08 mAHD at Berwick Cranbourne Road outlet pipe was applied. It is equivalent to the upstream obvert of this existing culvert.
- Within the Croskell PSP precinct, in the pre-development TUFLOW model, the hydraulic parameters are derived from Cardno (2019) TUFLOW model.

The assumptions below were adopted only for the post-development scenario:

- Total inflows from contributing catchments (routed via the RORB model) were applied directly on the drainage assets (retarding basins, Ti-Tree Creek waterway and western swale). For the northwest diversion pipe, inflows were applied through 1d_bc (QT) points layer at pits' locations at the inlet of each pipe segment. It is assumed all inflows are being captured by the diversion pipe, with no flow surcharges and the storage capacity of the pits is not modelled in TUFLOW.
- The northwest pipe diversion inverts were estimated based on '1% AEP DIVERSION PIPE LONGITUDINAL SECTION (MEG250-07-DW-CV-SKH-3201 Rev 0)' drawing.
- Initial water level was applied within the retarding basins' areas for SBRB2, WLRB3 and WLRB4 to account for the extended detention depth (EDD) of 350mm as the base level of the designed topography (.dem file) represents the normal water level (NWL) of the retarding basins.
- 2d_zsh features are used between basin ponds within the retarding basins to facilitate simplified passage of flows.

- Approximately 10 meters upstream and 10 meters downstream the VDP cable, within the waterway, a Mannings coefficient value of 0.02 was adopted, as this section of the waterway is proposed to be a concreted lined channel.
- Eastern swale was not modelled as this asset is designed for approximately 20%AEP with climate change design capacity.
- The spillway of WLRB3 is not represented in the design DEM. Instead, an embankment height of 38.0 mAHD has been adopted for the concept design in the 2025 TUFLOW model, which represents a freeboard of approximately 540 mm (peak water level = 37.46 mAHD). The freeboard may be reduced to 300mm in the functional design stage and simulated accordingly in the TUFLOW model.

F.1.2 Hydrological modelling approach

Overview

Water4Good developed four RORB models (two for the Western catchments and two for the Eastern catchments) for the purposes of modelling the Croskell PSP pre- and post-development conditions. The Eastern RORB models present two drainage outfalls, one at Berwick-Cranbourne Road (within PSP) and one at Thompsons Road culvert outfall downstream of Thompsons Rd WLRB1 (downstream of PSP). The West RORB model has only the Thompsons Road culvert outfall (within Croskell PSP).

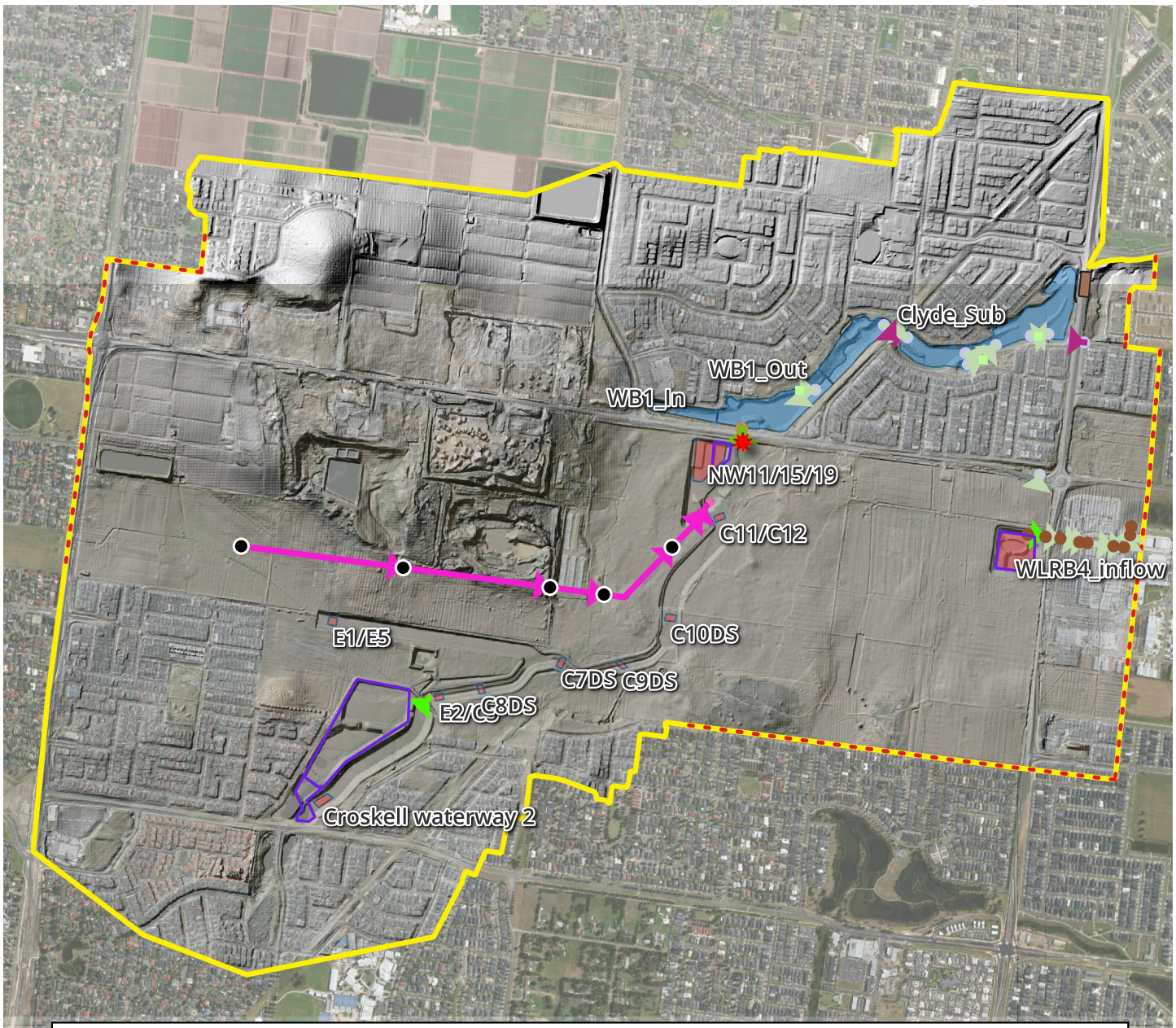
Simulations were performed using ARR2019 v4.2 for the 1% AEP 2100 SSP 2-4.5 climate change scenario. The hydrological parameters and design requirements (including climate change) used in the pre- and post-development RORB models are described in the following sections. Outputs from the RORB models were applied in the TUFLOW pre- and post-development scenarios as inflows.

Inflows applied in the pre- and post-development TUFLOW model

The inflows applied in the pre- and post-development TUFLOW model were obtained from outputs from RORB itself (excess files) and RORB runs using the StormInjector's software (ts1 files).

- The local external catchment runoff (2d_sa) was incorporated into the TUFLOW model downstream of the existing Thompsons Road culvert.
- In the pre-development scenario, RORB excess .csv files were used inside the Croskell PSP precinct as 2d_sa ALL, to represent overland flow routing over the existing topography. StormInjector.ts1 files were also used to account for inflows from catchments upstream Croskell PSP.
  In the post-development scenario, the inflows source is only .ts1 files applied through 2d_sa, distributing routed flows inside the major drainage assets, as a conservative approach to confirm if those assets have sufficient storage. For details on the application of inflows see: Figure F -1.

Figure F - 1: Croskell PSP post-development TUFLOW model setup.



Legend

- 1D Boundary Conditions - QT
- 1D Boundary Conditions - HT
- 1D Network - Thompsons Rd Culvert Weir
- 1D IWL Existing underground Culvert
- 1D Network - Existing Council Pits - R
- 1D Network Nodes - Croskell PSP Pits
- 2d_bc Boundary Condition - HQ
- 2D IWL Retarding Basins
- 2d_sa - Existing Inflows Downstream (RORB prints in labels)
- 2d_sa - Post-development inflows (RORB prints in labels)
- 2d_code
- 1D Network - Retarding Basins Outlet Pipes
  - RCP
  - RCBC
- 1D Network - Northwest Diversion Pipe
  - RCP
- 1D Network - Existing Council Pipes
  - RCP
  - RCBC

Data Sources: Melbourne Water
Contains Vicmap Information
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CROSKELL PSP
Post-development TUFOW model setup

0 0.25 0.5 km

Water 4good

Hydrological parameters

The Intensity–Frequency–Duration (IFD) design rainfalls and temporal patterns (TPs) were derived from ARR 2019 Data Hub parameters using the coordinates of Croskell PSP (38.08159°S, 145.33029°E). The Climate change factors considered the projections for 2100 SSP2 4.5 from the ARR2019 Data Hub (version 4.2). Table F - 1 presents the climate change factors applied to the IFDs.

The climate change factors for initial losses and continuing losses were 1.1 and 1.22, respectively. Table F - 3 shows the hydrological model parameters adopted for the pre- and post-development scenarios in StormInjector.

Table F - 2: Climate change factors (Rainfall factors) for 2100 SSP2 - 4.5

Duration	ARR2019 SSP2-4.5 climate change factors
<1 hour	1.41
1.5 Hours	1.37
2 Hours	1.35
3 Hours	1.32
4.5 Hours	1.29
6 Hours	1.27
9 Hours	1.25
12 Hours	1.24
18 Hours	1.22
>24 Hours	1.21

Table F - 3: StormInjector hydrological model parameters

Parameter	Value
IL (pervious)	25 mm/h
CL (pervious)	2.5 mm/h
ARFs	As per ARR2019 Data Hub
IFD	As per ARR2019 Data Hub
Burst initial loss	Global initial Loss minus Median Pre-burst depths
Climate change condition	Year 2100 1% Annual Exceedance Probability (AEP)
Climate change factor	As per ARR2019 SSP2-4.5 climate change factors, (climate change factors for IFDs are presented in Table F - 2

It is important to note that even though Croskell PSP is located within the loss region 3, it was preferred to use the median pre burst values rather than the ARR recommended 75th percentile pre-burst values for that region, as requested by Melbourne Water.

Table F - 4 shows the hydrological parameters for each scenario used in RORB. The Kc/dav ration remain the same as used in the previous RORB modelling TITRULT15Dec21.cat, TITRULT12.catg, and an earlier Neil Craigie model version 9). The dav value was obtained considering the length of the East RORB model up to WLRB1 and the length of the West RORB model up to Thompsons Road.

Initial loss and continuing loss factors were recommended by Melbourne Water based on parameters calibrated to a nearby gauged catchment and a sensitivity test on hydrological parameters, as per MEG250-07-TD-OT-REP-0004 Rev. 0 – WATER4GOOD Report. Table F - 5 shows the losses derived from StormInjector for 1%AEP (with climate change) that were used in the RORB models runs.

Table F - 4: RORB hydrological model parameters

	Parameters	
RORB Models	Dav	Kc
Pre-development West	3.02	6.04
Pre-development East	1.20	2.40
Post-development West	2.95	5.90
Post-development East	1.20	2.40

Table F - 5: Losses adjusted (based on the pre-burst values and StormInjector IL-normalisation formula) to 1% AEP (with climate change) applied to RORB run

Duration minutes	IL	CL
25	26.08	3.07
30	26.08	
45	26.08	
60	26.08	
90	25.31	
120	25.86	
180	24.54	
270	23.22	
360	21.9	
720	21.57	

Areal Reduction Factors (ARF) were applied as per ARR 2019 guidelines (As was outlined in Water4Good (February 2025) MEG250-07-TD-OT-REP-0005 Rev. C – WATER4GOOD Report.). The Intensity–Frequency–Duration (IFD) design rainfalls and temporal patterns (TPs) were derived from ARR 2019 Data Hub parameters using the coordinates of Croskell PSP (38.08159°S, 145.33029°E). ARR 2019 temporal patterns derived for the Southern Slopes (mainland) region have been adopted for this study.

F.1.3 Hydraulic modelling approach

Model domain

The establishment of the TUFLOW model domain was undertaken using a combination of the available topographical information and aerial photography. The model domain aimed at achieving optimal representation of the flood-prone area, encapsulating the entire upstream catchment and area immediately downstream of the site. A 3 m grid cell size resolution was adopted, providing sufficient resolution of modelled results while maintaining model run time efficiency.

Hydraulic Structures

The 1d_nwk culvert data applied in the TUFLOW model includes:

- Existing drainage:
  - WLRB4 culvert: Modelled as per as constructed drawing (Melbourne Water Ti-Tree Creek, Section 111. City of Casey. 1790 Thompsons Road, Clyde North Detail Plan. Drawing No. 0619/111/03).
  - Council's pipes and pits downstream Croskell PSP boundary were imported from Melbourne Water regional TUFLOW model for Ti-Tree Creek (Cardno, 2020), with the exception of a 1d_nkw line

'C_WPD' that comprises 6 No. 3000 mm (W) x 1200 mm (H) culverts, which was added to replace a bridge in the Cardno (2019) model.

- Outlet culverts of the retarding basins: contained information on culverts' size and number used in the RORB models, with the exception of SBRB2 asset, which uses the existing Thompsons Road culvert as an outlet control:
  - For SBRB2, the existing drainage referred to as 'Thompsons Road culvert' works as the outlet structure for the retarding basin. As constructed, the Thompsons Road culvert has approximately 31m^3/s total capacity. This configuration was applied to the TUFLOW pre-development scenario.
  - In the post-development scenario, the Thompsons Road culvert was sized using the HY8 software to meet the outflow rate capacity of 25.62 m^3/s simulated for the retarding basin in the RORB model. The Thompsons Road culvert, acting as the retarding basin outlet for up to a 1%AEP (with climate change) event, was represented as 1 No. 1500 (W) x 600 mm (H) barrel and 3 No. 1800 mm (W) x 1500 mm (H).

Standard entrance and exit loss coefficients of 0.5 and 1.0, respectively, were adopted as recommended by the TUFLOW software manual. Similarly, height and width contraction coefficients of 0.6 and 0.9 were adopted for Reinforced Concrete Box Culvert (RCBC) culverts respectively, and 1.0 for the width contraction coefficients in Reinforced Concrete Pipe (RCP) culverts connected to the retarding basins. No blockage was adopted for hydraulic cross drainage structures.

Hydraulic Roughness

Hydraulic roughness represents flow resistance offered by various surface materials. In the context of the TUFLOW model, hydraulic roughness is spatially distributed to describe the variability in flow resistance across the modelled extent.

In the pre-development and post-development TUFLOW models, the various surface types and Manning's 'n' roughness zones across the model extent were adopted as per the original model from Cardno (2019). In the post-development scenario, an additional material layer was created to represent the land use for this scenario within the Croskell PSP precinct. The applied Manning's 'n' values per roughness type were based on the Flood Mapping guidelines and technical specifications (Melbourne Water 2023) and are summarised in Table F - 6.

Table F - 6: Adopted Manning's 'n' Values from Flood Mapping guidelines and technical specifications (Melbourne Water 2023).

Manning's 'n'	Materials description
0.3	Residential – urban footprints (higher density)
0.1	Residential – rural (lower density)
0.1	Residential – urban (higher density) (remainder)
0.05	Residential – rural (lower density) (remainder)
0.5	Building
0.3	Industrial
0.3	Commercial
0.04	Open Pervious Areas | Minimal Grassed Vegetation
0.06	Open Pervious Areas | Moderate Shrubbed Vegetation
0.1	Open Pervious Areas | Thick Treed Vegetation
0.03	Waterways / Channels | Minimal Vegetation
0.06	Waterways / Channels | Moderate Vegetation
0.05	Constructed waterway
0.022	Carparks / Driveways
0.02	Lakes | No Emergent Vegetation
0.06	Wetlands | Emergent Vegetation
0.05	Gravelled Surface | Rural Road
0.015	Artificial Turf / Handstand Sporting Surface
0.015	Culvert
0.05	Agriculture / Farmland
0.02	Paved Roads

Boundary conditions

A fixed water level boundary condition (HT boundary) was introduced downstream of the proposed WLRB4 to account for tail water effects from an established wetland in Collision Road D.S. (known as WLRB1). A head-flow boundary (HQ boundary) was adopted where flow exits the 2D domain elsewhere (i.e. overland flow paths out of the study area), based on the slope of the underlying topography.

F.1.4 Design event modelling

A range of storm events were simulated through the combined hydrologic and hydraulic TUFLOW model to assess the project's hydraulic modelling objectives. This section details the derivation of design rainfall data and outlines the design storm selection methodology.

Rainfall Depth

The design rainfall depths were derived from the Bureau of Meteorology (BoM) 2016 IFDs (extracted from the ARR Data Hub). The design rainfall estimates were adjusted considering the latest Intergovernmental Panel on Climate Change (IPCC) temperature projections based on the medium Shared Socioeconomic Pathways (SSP2-4.5) for the 2100 year, as mentioned in item F.1.2 in 'Hydrological parameters'.

Selection of critical durations

Croskell PSP critical durations were selected based on the critical storms for the major drainage assets (waterways, retarding basins and swales) in the RORB models for the post-development scenario. The print statement locations for those major assets represented in the post-development RORB models for the West and Eastern catchments were matched with print statements at similar locations in the pre-development RORB models. The critical storms for the pre-development scenario were selected from the pre-development RORB models simulations based off these similar locations with the post-development RORB models. However, due to the differences in reaches configuration between the pre-development and post-development RORB models, some print statements could not be matched, including:

- The Waterway (at water main cross in the southern area of Croskell PSP) asset: For this print statement, there was no storm event assigned in the pre-development TUFLOW model as in the West pre-development RORB model, there was no possible equivalence to be made with the West post-development RORB model print ('Croskell Water Main Cross S').
- The Western Swale asset: even though there was not an equivalent print statement between the pre-development and post-development west RORB models, the storm event in the pre-development TUFLOW scenario were assumed the same as the post-development, because the subareas' fraction imperviousness and areas contributing to that asset haven't changed between the pre- and post-development west RORB models.

The representative critical durations and temporal patterns for the 1% AEP (with climate change) event which were selected from the RORB model simulations are summarised in Table F - 7. The selected durations and TPs were simulated in the 2025 TUFLOW models.

Table F - 7: Selected critical durations and temporal patterns used in TUFLOW modelling runs

	Pre-development (1AEP with climate change)			Post-development (1AEP with climate change)		
Drainage design asset	**RORB print**	**Duration (min)**	**TP**	**RORB print**	**Duration (min)**	**TP**
Eastern swale	Croskell VDP Cable EAST	25	5781	ESDS(After Crossing)	30	5906
WLRB4	Croskell Berwick Cranbourne R	30	5906	WLRB4	180	6065
Western Swale (1)	N/A	45	5942	E1/E5	45	5942
WLRB3	Croskell_WLRB3_inflow	90	6002	WLRB3	270	6063
Waterway (at VDP main cross)	Croskell VDP main cross	120	6028	Croskell VDP main cross	540	6163
Waterway (at water main cross in the southern area of Croskell PSP) (2)	N/A	N/A	N/A	Croskell Water main cross S	540	6167
Waterway (at water main cross in the northern area of Croskell PSP)	Croskell VDP water main cross N	180	6062	Croskell water main cross N	540	6168
SBRB2	SBRB2_match	270	6102	RB2 WEST	90	6002
Water main crossing	Water main crossing	360	6135	Water main crossing	120	6036
Downstream of Croskell PSP (Clyde North)	Clyde_North	360	6131	Clyde_North	120	6033
WLRB1 (3)	N/A	720	6196	Thompsons Rd WLRB1 P	720	6196

1. Applied same critical duration and TP as the post-development RORB models for the "E1/E5" print because subareas contributing to the western swale remained equivalent in both pre and post-development RORB models.

2. No print statement in the pre-development RORB model equivalent to the post-development RORB model.

3. In the pre-development and post-development scenarios, the critical duration for the WLRB1 asset was taken from the previously submitted RORB model (TITR16-Croskell-post-dev-with-mit-RevB.catg) at the print node ‘Thompsons Rd WLRB1 Outlet’.

A total of 17 storm events were simulated for the pre-development scenario and the same events were simulated in the post-development scenario, with the exception of the 6 hours TP 6135 storm. The reason for the omission of this storm event in the post-development scenario, is due to the print statements for 'Croskell VDP main cross', 'Croskell Water cross S' and 'Croskell water main cross N' resulting in the selection of TP6135 as the temporal pattern for the 6-hour duration which results in the WLRB3 spilling in the RORB

model. While the 6 hours TP 6135 aligns with the selection methodology, it represents one of the more extreme outcomes among the 10 temporal patterns assessed. Notably from the box plot results, 6 or 7 of these TPs do not result in basin spilling, indicating that spilling is not the expected outcome for WLRB3. Since all TPs are considered to have equal likelihood of occurrence, the dominance of non-spilling scenarios suggests that the basin is resilient under most temporal distributions.

The temporal pattern (TP) selection in StormInjector was configured to use the “closest to mean with bias to above mean” method, which is typically a conservative approach. The bias toward the mean in the selection method, while conservative, can become overly influenced by outlier cases like the 6hours TP 6135. These outliers artificially elevate the mean, making it less representative of the broader distribution of results. As a result, the adopted TP may not reflect the most probable or realistic scenario. To maintain a balance between conservatism and realism, the next highest TP selected in Storminjector that does not result in WLRB3 spilling has been selected for analysis on the 2025 TUFLOW model. This approach avoids the influence from atypical scenarios that are not representative of the majority of outcomes for the optimized design of WLRB3.

G

Appendix G – Constructed Waterway Freeboard

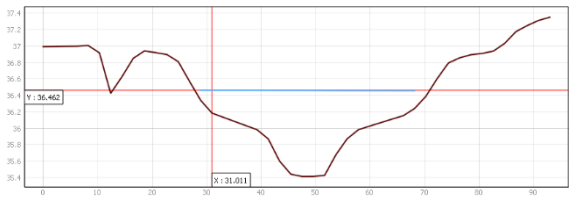
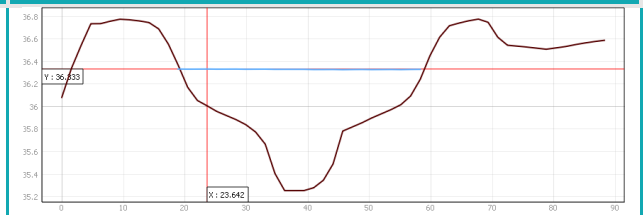
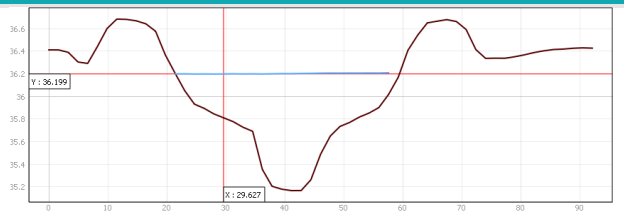
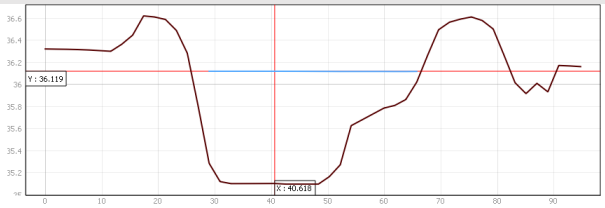
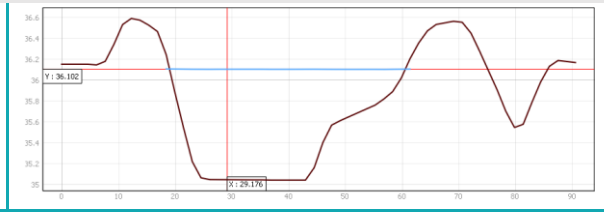
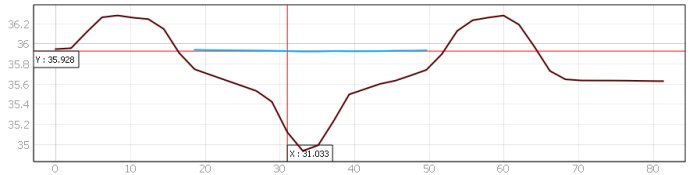
Profile 01 (Ti-Tree Creek at WLRB3 outlet)	Profile 02 (Ti-Tree Creek downstream WLRB3)	Profile 03 (Ti-Tree Creek downstream WLRB3)
		
Profile 04 (Ti-Tree Creek upstream western swale)	**Profile 05 (Ti-Tree Creek downstream western swale)**	**Profile 06 (Ti-Tree Creek at Water main crossing South – pipe track)**
		

Figure G - 1: Ti Tree Creek waterway profiles showing channel design section and 1%AEP + CC peak flood level.

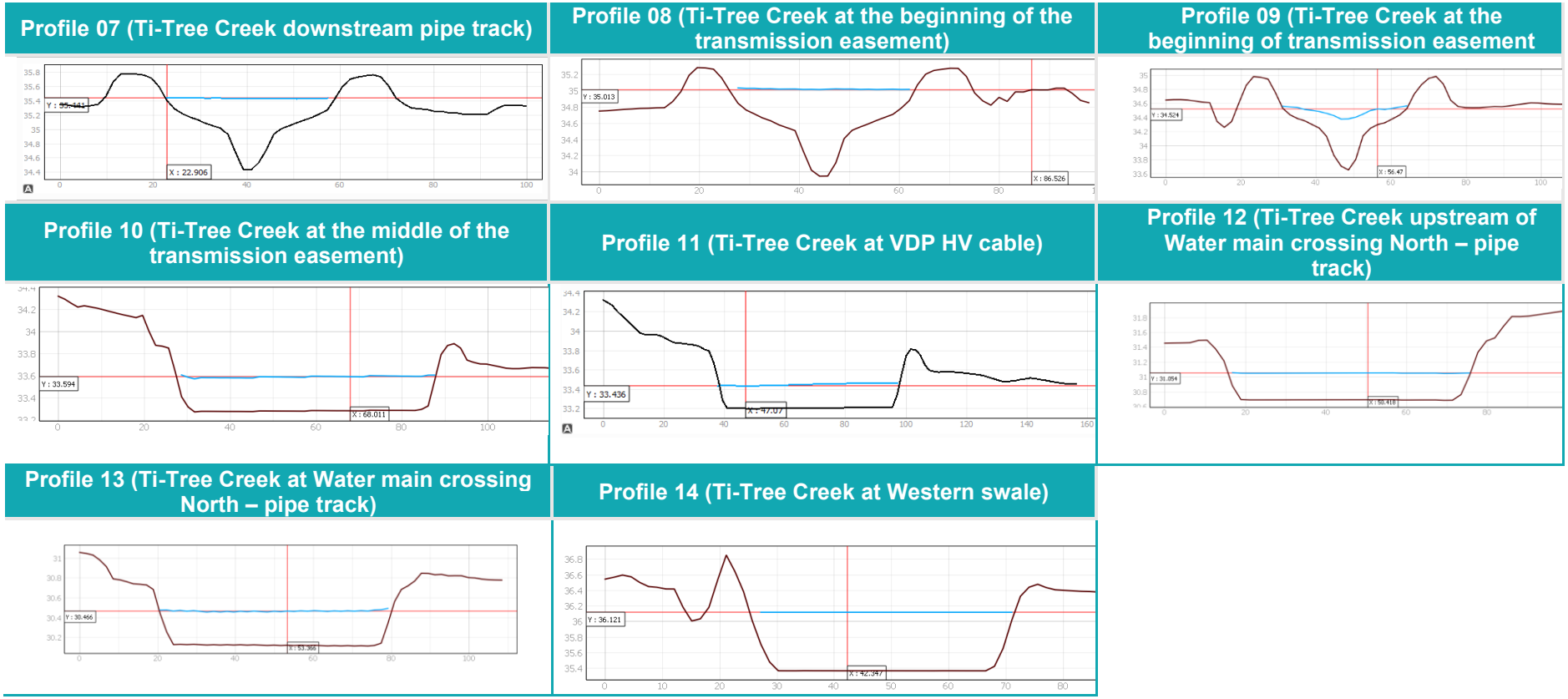


Figure G - 2: Ti Tree Creek waterway profiles showing channel design section and 1%AEP + CC peak flood level.