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Flagstone City-Masterplan

Flooding Assessment

721743/032/R1V6



Prepared for
Peet Flagstone City Pty Ltd

5 September 2014

Contact Information

Cardno (QLD) Pty Ltd
ABN 57 051 074 992

Level 11 Green Square North Tower
515 St Paul's Terrace
Fortitude Valley QLD 4006
Locked Bag 4006 Fortitude Valley

Telephone: 07 3369 9822
Facsimile: 07 3369 9722
International: +61 7 3369 9822

cardno@cardno.com.au.
www.cardno.com.au.

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Table of Contents

1	Introduction	1
2	Existing Site and Proposed Development	2
2.1	Existing Site Description	2
2.2	Proposed Masterplan Description	2
3	Data	3
4	Hydrologic Assessment	4
4.1	Methodology	4
4.1.1	Critical Duration Analysis	4
4.2	Model Assumptions	5
4.3	Model Calibration	5
5	Hydraulic Assessment	7
5.1	Methodology	7
5.2	Model Setup	7
5.2.1	Model Topography	7
5.2.2	Inflows	8
5.2.3	Tailwater Conditions	8
5.2.4	Roughness Values	8
5.2.5	Structures	8
5.2.6	Proposed Mitigation Measures	9
5.3	Hydraulic Model Results	11
6	Consideration of Logan City Council Temporary Local Planning Instrument (TLPI)	13
7	Conclusion	16
8	Qualifications	17
9	References	18

Tables

Table 4-1	Adopted Fraction Impervious Values	5
Table 4-2	Predicted Peak Flows, Rational vs RORB, 100 Year Event	5
Table 4-3	Predicted Peak Flows, Runoff Routing Model Comparison, 100 Year Event	6
Table 4-4	Adopted WBNM Initial and Continual Loss Parameters	6
Table 5-1	Existing Structures - Bridges	8
Table 5-2	Existing Structures - Culverts	9
Table 5-3	Proposed Structures	10
Table 5-4	Proposed Detention Basins	11
Table 5-5	100 Year ARI Predicted Peak Flood Levels	12
Table 6-1	Specific Outcomes and Probable Solutions for the Flooding and Inundation Area	13

Figures

- Figure 1 Site Location
- Figure 2 WBNM Model – Pre-Development Catchment Layout
- Figure 3 WBNM – Post-Development Model Topography and Boundary Locations
- Figure 4 TUFLOW Model – Pre-Development Model Topography
- Figure 5 TUFLOW Model – Post-Development Model Topography and Proposed Mitigation Structures

Reference Drawings

Flagstone Structural Plan-DWG 110056-262-Structure_OPT2L DWG # 110056-263-3 Dated 01 July 2014

Appendices

- Appendix A WBNM Catchment Details
- Appendix B Pre-Development Flooding Conditions (TUFLOW Results)
- Appendix C Post-Development Flooding Conditions (TUFLOW Results)
- Appendix D Post-Development Predicted Impacts (TUFLOW Results)
- Appendix E Post-Development Predicted Impacts (TUFLOW Detailed Results)
- Appendix F Pre & Post-Development Hydrographs

1 Introduction

This flooding assessment report has been prepared by Cardno (Water Resources and Coastal), specialist hydrologic and hydraulic consultants, for Peet Flagstone City Pty Ltd to investigate the hydrologic and hydraulic requirements for the overall Masterplan of the Flagstone City development, located in Logan City Council (LCC) under the Economic Development Queensland (EDQ). This report has been prepared as a supporting document to inform the identification and allocation of stormwater infrastructure for all future development of Flagstone City.

The Flagstone City masterplan comprises of five context plan areas identified as Context Areas 1 to 5 as shown on Figure 1. The current structure plan layout has been provided by RPS and is included in the reference section of this report.

The management of the water quantity and site flooding is proposed to be addressed as a Masterplan solution. This Masterplan solution presents an integrated approach to the flooding to provide the most cost effective solution both in terms of construction and on-going maintenance. This report provides the details of the flood management strategy and the analysis to justify its implementation.

2 Existing Site and Proposed Development

2.1 Existing Site Description

The overall site is approximately 1500ha in area. It is located in an area bounded by the existing Brisbane to Sydney Railway to the east and forested property to the west. The Real Property description is

- Lot 1 on RP35155
- Lot 2 on RP47120
- Lot 4 on RP45728
- Lot 5 on S312569
- Lot 9 on S312569
- Lot 10 on SL6002
- Lot 873 on SP166448
- Lot 875 on SP146552
- Lot 907 on RP819216
- Lot 908 on RP819216
- Lot 910 on RP857850
- Lot 911 on RP857870
- Lot 988 on CP857841
- Lot 989 on RP854074

Parish of Mclean, County Stanley. The site currently does not have a street address but is located off Homestead Road, which connects to Teviot Road, Jimboomba.

The site is currently cleared rural land with vegetation maintained along the creeks and gullies that traverse the site. The site drains into Flagstone and Sandy Creeks, or tributaries of these creek systems. Within the site the elevations range from approximately 32.1m AHD to 170.9m AHD, with a predominate direction of flow in an easterly direction prior to discharging under the existing railway.

An aerial of the current site condition is presented on Figure 1.

2.2 Proposed Masterplan Description

Flagstone City is proposed to be a large master planned mix use development consisting of:

- Residential dwellings;
- Super allotments;
- Mixed use lots;
- Town Centre;
- Schools;
- Parks (including Regional, district and local facilities); and
- Open Space.

The current structure plan layout and staging plan has been provided by RPS and is included in the reference section of this report.

3 Data

The assessments detailed in this report are based on the following data:

- Aerial LiDAR survey data obtained from the Department of Environment and Heritage Protection (DEHP);
- 1:25,000 topographic map ('Undullah'), produced by the Queensland Department of Mapping and Surveying (SUNMAP);
- Stage 14 Site layout provided by Saunders Havill Group Drawing No 6601 P 04 PP F dated 29/10/2012;
- Stage 14 detail design TIN provided in 12d format from Sedgmen Yeats, as detailed on Drawing No YC0434-C1-204 and YC0434-C1-205;
- Stage 15 site layout provided on Cardno Drawing Nos 7506/01/26-102 B, 7214/58/07-105 C, 7214/58/08-105 C, 7214/58/02-103 4, and 7214/58/11-103 F ; and
- Cardno report titled, '*Flagstone Stages 14A, 14B, 15A, 15B, 15C and 15D, Hydraulic Analysis*' dated November 2009 (ref 3503-62).

4 Hydrologic Assessment

A hydrologic assessment has been undertaken to quantify both the pre- and post-development runoff characteristics of the local tributaries. The results of the hydrologic model was used for input into the hydraulic model (TUFLOW).

4.1 Methodology

A detailed hydrologic analysis was undertaken using the Watershed Bounded Network Model (WBNM) 2007 Version 104. WBNM is a non-linear runoff routing software package produced by the University of Wollongong in New South Wales. WBNM has been used in accordance with Council's 'Logan Planning Scheme' (2011), 'Queensland Urban Drainage Manual' (2008) and 'Australian Rainfall and Runoff' (1999), and reference to the Urban Land Development Authority (ULDA) 'Greater Flagstone Urban Development Area Development Scheme' (2011) and ULDA Guideline 15.

The hydrologic model set up includes the full catchment for Sandy Creek, Flagstone Creek and several unnamed tributaries to Teviot Road, Jimboomba. The catchment has a total area of approximately 54km².

Catchment extents were mapped from the Undullah 1:25,000 topographic map, produced by the Queensland Department of Lands. Sub-catchment boundaries within the site were determined from 5m contours sourced from aerial survey of the area. The WBNM model layout and sub-catchment boundaries for the pre- and post-development (Master Plan) scenarios are shown on Figure 2.

The hydrologic modelling considers the following scenarios:

- **Existing – Calibration (Case EU02d):** This scenario assumes catchments within the site extents as well as the catchments to the west of the Brisbane to Sydney Railway line, in their existing state and remaining catchments external to the site in a developed state. Ultimate land uses were derived from Council's Planning Scheme and existing land uses via satellite imagery from Google Earth (2012). For this scenario, initial loss of 15mm and continuous loss of 2.5mm/hr were adopted for all the catchments external to the site, For the subject site itself (cleared scenario), initial loss of 5mm and continuous loss of 2.5mm/hr were adopted. Figure 2 shows the existing/pre-development catchment layout.
- **Pre-Development (Case EU02e):** This scenario assumes the same catchments and land uses as per the Existing Case. However, initial loss of 15mm was adopted for site areas to model pre-clearing (ie. forested) as recommended by EDQ consultant Jacobs (formerly SKM). Figure 2 shows the pre-development catchment layout; and
- **Post-Development (Case DU03e):** This scenario assumes the same catchment and land uses as per the Pre-Development Case for areas external to the site. While for the subject site, the fraction impervious factors were applied based on the proposed densities. Figure 2 shows the post-development catchment layout. The proposed site densities are shown on in the reference section of the report. The site densities for Stage 14 are shown in the Saunders Havill Group Drawing No 6601 P 04 PP F dated 29/10/2012. The reference drawing showing the site densities for Stage 15 is Cardno Drawing Nos 7506/01/26-102 B, 7214/58/07-105 C, 7214/58/08-105 C, 7214/58/02-103 4, and 7214/58/11-103 F.

4.1.1 Critical Duration Analysis

A hydrologic modelling was undertaken to determine the critical storm durations across the model area. The modelling showed that the 60minute, 180minute, 270 minute and 360minute storms were found to be the critical storms across the model area. Therefore, the final hydrologic and hydraulic analyses have been undertaken for those storm events.

4.2 Model Assumptions

The WBNM model assumes land uses as per Logan City Council Planning Scheme Map and aerial photography. The adopted fraction impervious value for each land use is listed in Table 4-1. The fraction impervious values were adopted from Logan City Council's *'Draft Interim Standards for Stormwater, Overland Flow and Flood Plain Management'* (August 2010).

In accordance with the Draft Interim Standards, with a lot density of approximately 10 lots/ha the proposed Stage 14 development falls under the 'Residential 600' category generally giving a fraction impervious of 60%. Considering that the bulk of the lots within Stage 14 are generally less than 600 square meters, Cardno adopted a conservative measure for the fraction impervious value for the proposed Stage 14 development as shown in Table 4-1 below. Details of the existing and developed catchments are provided in Appendix A.

Table 4-1 Adopted Fraction Impervious Values

Land Use	Fraction Impervious
Forest	0%
External Urban	60%
Conservation	0%
Park Area	2%
Open Space	20%
Residential Low Density	50%
Residential Medium Density	60%
Residential Stage 14	70%
Residential High Density	85%
Schools	70%
Commercial/Town Centre	90%

4.3 Model Calibration

The hydrologic modelling for Flagstone was originally completed in RORB. This previous RORB model is detailed in the Cardno report titled, *'Flagstone Stages 14A, 14B, 15A, 15B, 15C and 15D, Hydraulic Analysis'* dated November 2009 (ref 3503-62). The RORB model used regional relationships for South East Queensland as described in AR&R (1987).

The 2009 RORB modelling adopted initial loss of 0mm and continuous loss of 2.5mm/hr. The current WBNM modelling adopted initial loss of 15mm and continuous loss of 2.5mm/hr. Therefore, in order to compare the two models, the initial and continuous loss parameters in RORB have been modified to match the current WBNM model.

The peak flow rate in Sandy Creek from the RORB model was compared to a Rational Method assessment as presented in Table 4-2. For the analysis of the peak flood levels in Sandy Creek, the higher peak flow rates obtained from the runoff routing model were conservatively adopted for use.

Table 4-2 Predicted Peak Flows, Rational vs RORB, 100 Year Event

Method		Peak Flow Rate (m ³ /s)
Rational	Weeks	77.3
	McMahon and Muller	91.5
RORB – Runoff Routing		88.7

For the design event modelling the RORB model was transferred into WBNM to better assess the relative impact of development. As WBNM does not have a regional lag value and in lieu of stream gauge data, the WBNM model was calibrated to the original RORB model.

A comparison between the RORB and WBNM 100 year event peak flows are presented in Table 4-3. Results show a reasonable calibration between the two models was achieved, with WBNM peak flows higher than the RORB model and thus more conservative.

Table 4-3 Predicted Peak Flows, Runoff Routing Model Comparison, 100 Year Event

Location (RORB / WBNM)	RORB Model – Existing		WBNM Model – Existing		Difference (%)
	Peak (m ³ /s)	Critical Duration (min)	Peak (m ³ /s)	Critical Duration (min)	
Rail Line / RP3	85.8	270	91.9	270	7%
Southern Tributary / SC11	88.7	270	92.5	270	4%
Northern Tributary / E2	10.6	120	11.1	60	5%

Based on the calibration, the initial and continuing losses adopted for the Existing Case WBNM model are shown in Table 4-4. A catchment lag of $m = 2.45$ was adopted for all ARI events.

Table 4-4 Adopted WBNM Initial and Continual Loss Parameters

ARI (Years)	Pervious		Impervious	
	Initial Loss (mm)	Continuing Loss (mm/hr)	Initial Loss (mm)	Continuing Loss (mm/hr)
100	15	2.5	0	0

5 Hydraulic Assessment

Hydraulic analysis has been performed to determine peak flood levels through the site and to ensure development on the site will remain flood free and not adversely impact on other properties external to the site in accordance with the appropriate design standards.

5.1 Methodology

A two dimensional (2D) model has been setup of the site and surrounds with a grid size of 10m. The model extent is shown on Figure 3. The hydraulic assessment of the site has been undertaken using the TUFLOW (Build 2011-09-AF), a linked one-dimensional/two-dimensional (1D/2D) hydraulic model.

The following scenarios have been considered:

- **Pre-Development Case** (Case E21e): The pre-development topography modelled is shown on Figure 3. The model uses the pre-development hydrologic flows as detailed in Section 4 which assumes the site undeveloped, and ultimate development external to the site. The downstream roughness was also modified to reflect the assumptions in Cardno's 2009 report.
- **Post-Development Master Plan** (Case M32e): This scenario is based on the pre-development case and includes the developed site. This case includes the Sandy Creek road crossing allowing Sandy Creek to drain under Parkside Drive and the inclusion of Stage 14 and 15 works. The post-development topography modelled is shown on Figure 5. The model uses the post-development hydrologic flows as detailed in Section 4.

5.2 Model Setup

5.2.1 Model Topography

The digital terrain model (DTM) of the study site for the Stage 14 and 15 assessment was setup based on the following data sources:

- ALS (Airborne laser scanning) data obtained from the Department of Environment and Heritage Protection (DEHP).
- Bulk earthworks layout plan for stage 15C and 15A, part of the pre developed area, designed by Cardno. The levels of lots 1514, 1515, 1516, 1502, 1503 and 1501 have been updated with the levels from the plan. The plan can be found under the Reference drawings section of this report.
- Detailed design TIN from Sedgmen Yeats for Stage 14 as shown on Drawing No YC0434-C1-204 and YC0434-C1-205

The extent of the TUFLOW study area is shown in Figure 3. A grid with a spacing of 10 metres (i.e. ground levels being represented every 10 metres) was adopted. From a review of the culvert blockage assessment it was determined that the definition of the creek and downstream had not been modelled with sufficient detail.

The modelling for both the pre and post-development scenarios was updated to include additional detail of the creek invert and subsequent 2D modelling of this invert. This generally caused a local lowering of the flood levels through downstream of the site.

5.2.2 Inflows

The discharge hydrographs from the WBNM model has been used as inflow to the TUFLOW model. The hydraulic analysis was conducted with design inflows for the 1 to 100 year ARI events, for the 60minute, 180minute, 270minute, and 360minute storms. The reference drawing showing the increased density incorporated into modelling is the Saunders Havill Group Drawing No 6601 P 04 PP F dated 29/10/2012. Hydrologic analysis is detailed in Section 4. The location of the inflow points in the TUFLOW model are shown in Figure 3 and the same inflow points has been used in the Pre-development and Post-development case.

5.2.3 Tailwater Conditions

A normal depth corresponding to a slope of 1.0% (approximate slope of the creek invert at this location) was assumed as the tail water condition occurring at the eastern boundary of the model. Considering the distance between the tailwater location and the site this assumption is considered appropriate.

5.2.4 Roughness Values

The Manning's n roughness values for the study area were derived from aerial photographs. The pre-development case was modelled as forested areas outside already developed areas with a Manning's n value of 0.15. The developed areas in the pre-development case were modelled as residential areas with a Manning's n value of 0.15 and as cleared land with a Manning's n value of 0.05.

For the reach between the railway and the confluence of Sandy Creek a lower roughness values of 0.05 has been adopted for the river bed and 0.08 for the river banks. These roughness values were based on site inspection and calibration and validation of the hydraulic model documented in the Cardno report - *Flagstone Stages 14A, 14B, 15A, 15B, 15C & 15D Hydraulic Analysis* (ref 3503/62).

Based on Council's request of 27 May 2013, the hydraulic roughness of the creek bed and banks of Sandy Creek downstream of the railway was increased from a Manning's n value of 0.05 to a value of 0.08.

Although the areas within the site change in land use, these are not inundated and therefore the Manning's n value was not changed pre- and post-development.

5.2.5 Structures

The existing structures are based on information obtained from Queensland Rail and Logan City Council. Table 5-1 and Table 5-2 outlines the existing bridge spans and culvert openings for the various roads across the floodplain.

Table 5-1 Existing Structures - Bridges

Description	Bridge Type	Details
Railway crossing – Tributary of sandy creek	-	Obvert level 41.1m AHD
Railway crossing – Sandy creek	-	Obvert level 39m AHD
Railway crossing – Flagstone Creek	-	Obvert level 39m AHD
Teviot Road bridge	Three span bridge	Obvert level 23.64m AHD

Table 5-2 Existing Structures - Culverts

Description	Culvert Type	Details
Culv_Homest	RCBC	4 / 3.6 x 2.7m, length 15m
Culv_Home2	RCP	3 / 1.5 m, length 17m
Culv_BUSHRD	RCP	2 / 1.8m , length 15m
Culv_SandP	RCBC	3 / 3.6 x 3.3m, length 15m
Riv Oak Culv	RCBC	5 / 3.6 x 3.6m, length 20m
Culv_N1	RCP	2 / 1.8m, length 30m
QR_B	RCP	1 / 1.5m, length 10m
QR_C	RCP	1 / 1.5m, length 10m
QR_D	RCP	1 / 1.5m, length 10m
QR_E	RCP	1 / 1.05m, length 10m

5.2.6 Proposed Mitigation Measures

Several mitigation measures have been proposed within the subject site to mitigate the impact of the development on peak flow rates, duration and flood levels external to the site.

The details of the proposed mitigation measures (road crossings and detention basins) are provided in Table 5-3 and Table 5-4. The locations of the proposed structures are shown in Figure 5. The culverts were modelled as one dimensional links, connected to the two dimensional domain.

Table 5-3 Proposed Structures

Structure ID	Culvert Type		Road Level (mAHD)
	Minor Flow Pipe	Major Flow Pipe	
1	900mm RCP, USIL 48.97 mAHD, DSIL 48.7 mAHD	5@1050mm RCPs, USIL 50.5 mAHD, DSIL 50.5 mAHD	52.4
2*	1050mm RCP, USIL 46.15 mAHD, DSIL 46.1 mAHD	5@1050mm RCPs, USIL 47.6 mAHD, DSIL 47.6 mAHD	48.9
3*	1050mm RCP, USIL 44.66 mAHD, DSIL 44.59 mAHD	5@ 1200mm x 1200mm RCBCs, USIL 45.8 mAHD, DSIL 45.8 mAHD	47.5
4	750mm RCP, USIL 52.297 mAHD, DSIL 52.165 mAHD	2@1050mm RCPs, USIL 53.25 mAHD, DSIL 53.25 mAHD	54.9
5	750mm RCP, USIL 54.247 mAHD, DSIL 54.205 mAHD	2@ 1200mm x 1200mm RCBCs, USIL 55.2 mAHD, DSIL 55.2 mAHD	56.3
6	900mm RCP, USIL 46.9 mAHD, DSIL 46.8 mAHD	2@1350mm RCPs, USIL 48.55 mAHD, DSIL 48.55 mAHD	50.5
7	900mm RCP, USIL 41.673 mAHD, DSIL 41.493 mAHD	2@1350mm RCPs, USIL 43.15 mAHD, DSIL 43.15 mAHD	45.1
8	1800mm RCP, USIL 50.65 mAHD, DSIL 50.52 mAHD	n/a	53.1
9	2100mm RCP, USIL 37.11 mAHD, DSIL 36.96 mAHD	n/a	40.4
10	2@1500mm RCPs, USIL 57.06 mAHD, DSIL 56.94 mAHD	n/a	59.8
11	5@ 2700mm x 2400mm RCBCs, USIL 39.73 mAHD, DSIL 39.431 mAHD	n/a	43.75
12	5@ 2700mm x 2400mm RCBCs, USIL 35.62 mAHD, DSIL 35.45 mAHD	n/a	39.2
13	2@2100mm RCP, USIL 60.8 mAHD, DSIL 60.6 mAHD	n/a	63.5
14	2@2100mm RCP, USIL 53.43 mAHD, DSIL 53.05 mAHD	n/a	56.3
15	5@ 2400mm x 2400mm RCBCs, USIL 52.45 mAHD, DSIL 52.2 mAHD	n/a	55.82
16	5@ 2700mm x 2400mm RCBCs, USIL 35 mAHD, DSIL 34.87 mAHD	n/a	39.99
17	1050mm RCPs, USIL 40.47 mAHD, DSIL 39.92 mAHD	n/a	42.8
18*	1050mm RCPs, USIL 44.5 mAHD, DSIL 44.4 mAHD	n/a	46.4
19	2500mm x 3000mm RCBC, USIL 30.2mAHD,DSIL30.125mAHD 2@1500mm x2500mm RCBCs, USIL 31.7mAHD,DSIL31.63mAHD and 3300mm x 3000mm RCBC, USIL 30.2mAHD,DSIL 30.13 mAHD	n/a	34.53

* indicated proposed bund

Table 5-4 Proposed Detention Basins

Detention ID	Outlet Structures		Road Level (mAHD)
	Minor Flow Pipe	Major Flow Pipe	
Bas1	750mm RCP, USIL 48.63mAHD, DSIL 48.43mAHD and 750mm RCP, USIL 48.84mAHD, DSIL 48.54mAHD	7m wide weir having crest level of 49.7mAHD And 7m wide weir having crest level of 49.9mAHD	n/a
Bas2	1200mm RCPs, USIL 42.32 mAHD, DSIL 42.085 mAHD	n/a	44.5
Bas3	120mm RCP, USIL 41mAHD, DSIL 40.79Mahd	6m wide weir having crest level of 42.0mAHD	n/a

5.3 Hydraulic Model Results

Maps of post-developed peak flood levels and impacts are shown in Appendix C and D, respectively. Table 5-5 below presents the 100 year ARI pre- and post-development predicted peak flood levels and impacts for key locations within the model extent (refer Appendix B figures for reporting point locations). The Tables in Appendix E and F show the predicted peak flood levels, peak flows and impacts for all the relevant reporting nodes for the 100 Year ARI event. In Appendix F pre and post-developed hydrographs upstream and downstream of the site can be found for the 100 Year ARI event.

Table 5-5 100 Year ARI Predicted Peak Flood Levels

Reporting Node ID	Peak Flood Level (mAHD)		Impact (m)
	Pre-Developed	Post-Developed	
H_SDYCK_DS3_CH9400	24.46	24.41	-0.04
H_SDYCK_DS3_CH8900	25.91	25.88	-0.04
H_SDYCK_DS2_CH7500	29.59	29.52	-0.07
H_SDYCK_CH7000	31.26	31.20	-0.06
H_SDYCK_US1_CH6400	33.11	32.93	-0.18
H_SDYCK_DS1_CH6250	34.12	34.03	-0.10
H_SCBRIDGE_DS_CH5550	36.29	36.17	-0.12
H_SDYCK_BRIDGE1_US_CH5200	37.67	37.57	-0.11
H_SDYCK_CH4200	41.19	41.13	-0.07
H_SDYCK_CH2650_Trib1	59.70	60.18	0.48
H_SDYCK_CH2650_Trib2	57.40	57.57	0.17
H_FSTCK_CH10800	21.74	21.73	-0.02
H_FSTCK_CH10200	23.20	23.18	-0.02
H_FSTCK_CH9700	24.38	24.37	-0.01
H_FSTCK_CH9100	26.07	26.07	-0.01
H_FSTCK_CH8500	28.52	28.52	-0.01
H_FSTCK_CH7500	32.83	32.78	-0.05
H_FSTCK_CH7300_trib1	41.88	42.54	0.66
H_FSTCK_CH7300_trib2	40.70	40.58	-0.12
H_FSTCK_CH6900	36.33	36.26	-0.07
H_FSTCK_CH6700	37.12	37.03	-0.09
H_FSTCK_CH6350	39.19	39.31	0.12
H_FSTCK_CH6250	39.83	40.20	0.37
H_FSTCK_CH5100	45.65	45.62	-0.02
H_FSTCK_CH3800_Trib1	54.37	55.27	0.90
H_FSTCK_CH3800_Trib2	53.51	53.58	0.07
H_FSTCK_CH3350	54.54	54.53	-0.01
H_FSTCK_CH3200	55.67	56.02	0.34
H_FSTCK_CH2800	57.77	57.81	0.04
H_FSTCK_CH2000	61.22	61.23	0.01
H_FSTCH_CH10650_TEVRD_US	22.18	22.16	-0.02

With the current proposed Flagstone City Masterplan, the site external impacts downstream of the site are found to be minimal for the 100 Year ARI event. The proposed culvert under Parkside Drive (see Figure 5) causes impacts upstream of the site but the impacts become negligible when reaching the railway crossing of the Sydney – Brisbane Railway.

6 Consideration of Logan City Council Temporary Local Planning Instrument (TLPI)

Following the January 2011 floods Logan City Council (ICC) implemented their Temporary Local Planning Instrument (30 March 2011). This provides recommendations for flood management. The intent of the flood management for the Flagstone City development has been to comply with the principles and intent of this TLPI, with some minor exceptions.

Overall the proposed development has adopted the practice of maintaining all future development outside the main floodplain. This will maintain the flood storage within the catchment and river system, whilst also maintaining the ecological characteristics of the creeks and significant tributaries.

A change from the TLPI recommendations has been to utilise on-line flood attenuation devices. The mitigation is achieved by providing restricted openings at the Parkside Drive road crossing. There is no additional excavation of the floodplain. This strategy causes a localised raising of flood levels upstream of the crossing with the benefit of reduced flood levels external to and downstream of the site. These localised increases do not significantly change the flood extent, are contained within the overall Flagstone area, and critically are still outside of the development footprint.

The compliance of the development to Table 3 of the TLPI is provided in Table 6-1.

Table 6-1 Specific Outcomes and Probable Solutions for the Flooding and Inundation Area

TLPI Specific Outcomes	Compliance to TLPI
Risk to people and premises	
O1 Development results in— (a) no increase in the number of people at risk from flooding; (b) no increase in the number of people that need evacuation; (c) no increase in the number of premises or significant infrastructure at risk from flooding; (d) existing flood warning times being maintained or increased; and (e) no adverse effect on the ability of traffic to use evacuation routes. Note: Division 4, Table 4 provides guidelines for satisfying this specific outcome.	Compliant.
O2 A building is located on premises that is above the flood level of the defined flood event.	Compliant
O3 The floor level of a habitable room in a building has a finished floor level which is a minimum of 500 millimetres above the flood level of the defined flood event where— (a) the building is used for a residential purpose; or (b) the building— i. is used for a non-residential purpose; and ii. is intended to be occupied during, or in the aftermath of a defined flood event.	Compliant
O4 A lot of 2000m ² or less is located above the flood level of the defined flood event.	Compliant

Column 1 Specific Outcomes	Column 2 Probable Solutions
O5 A lot greater than 2000m ² provides a development envelope area on the premises that is above the flood level of the defined flood event.	Not Applicable- lots will be above flood level
O6 Public safety and the environment are not adversely affected by the detrimental impacts of floodwater on hazardous materials manufactured or stored in bulk. Note: Division 4, Table 4 provides guidelines for satisfying this specific outcome	Compliant.
O7 A material change of use for a car park or car park associated with a development is only located below the flood level of the defined flood event where there is no increase in risk to— (a) pedestrian and vehicular safety; and (b) land. Note: Division 4, Table 4 provides guidelines for satisfying this specific outcome.	Compliant
O8 Community infrastructure and essential services infrastructure are able to function effectively during and immediately after flood events. Note: Division 4, Table 4 provides guidelines for satisfying this specific outcome.	Compliant. Community and essential services infrastructure will be set at levels necessary to ensure that they function effectively during and immediately after flood events.
Flood storage and discharge capacity	
O9 An existing flood flow path is protected and maintained without adversely affecting adjoining premises.	The creeks and their significant tributaries that drain through the site are protected. Minor gullies within urban areas will be replaced with piped and overland flow drainage networks as necessary to maintain conveyance.
O10 The natural conveyance of flood waters and the natural overland flow path is protected and maintained. Note: Division 4, Table 4 provides guidelines for satisfying this specific outcome	The creeks and their significant tributaries that drain through the site are protected
O11 Development does not— (a) cause cumulative flood damage; (b) cause ponding of flood water; or (c) adversely affect the flood discharge capacity. Note: Division 4, Table 4 provides guidelines for satisfying this specific outcome.	Compliant.
O12 The loss of flood plain storage is compensated with compensatory storage or excavation that— (a) is of equal volume, creating a balance of cut to fill; (b) is free draining; (c) is located within the premises; (d) does not adversely affect the hydraulic capacity of the flood channel or flood plain; (e) is provided to the corresponding level; and (f) is solely for the purpose of compensatory excavation and storage.	The development will not cause a loss in floodplain storage.
O13 Development relative to the pre-developed state both within and outside of the premises does not change the following flood characteristics for a flood event with a flood level up to and including the defined flood event— (a) peak flow; (b) the flow of any part of the hydrograph before the peak;	Compliant.

Column 1 Specific Outcomes	Column 2 Probable Solutions
(c) flood flow velocity or level of flooding; or (d) the hydrograph time to peak. Note: Division 4, Table 4 provides guidelines for satisfying this specific outcome.	
Extent or severity of flooding or flood risk	
O14 Earthworks are carried out above the defined limit equivalent to the flood level of the 10 year average recurrence interval local flood event.	Compliant.
O15 Stormwater quality treatment devices are located— (a) above the flood level of the 20 year average recurrence interval local flood event; and (b) above the flood level of the 50 year average recurrence interval regional flood event.	Compliant
O16 Stormwater quantity treatment devices are located— (a) above the flood level of the 50 year average recurrence interval local flood event; and (b) above the flood level of the 50 year average recurrence interval regional flood event.	It is proposed to use online storage to ameliorate the impact of development on runoff.
Access	
O17 Development provides access to a road which is— (a) above the flood level of the defined flood event; or (b) below the flood level of the defined flood event where the road— i. has a low flood hazard; ii. remains serviceable and trafficable having regard to the likely traffic densities and loads until another road access to the development may be restored; and iii. connects to a road which is above the flood level of the defined flood event that provides access to the road network. Note: Division 4, Table 4 provides guidelines for satisfying this specific outcome.	Compliant
O18 Development provides that the access area to a building or a fill area upon which a building is to be constructed is classified as a low flood hazard in the defined flood event. Note: Division 4, Table 4 provides guidelines for satisfying this specific outcome.	Compliant.

7 Conclusion

The above sections provide details of overall hydrologic and hydraulic models developed over the Flagstone City area. These models have been used to assess the flood impact from Flagstone City Masterplan demonstrating discernible adverse flood impacts downstream of the site due to mitigation of flows by the proposed Culverts and detention basins within the site. Furthermore upstream flood impacts in Sandy creek were found to be negligible at the Brisbane to Sydney Railway crossing.

8 Qualifications

This report has been prepared by Cardno specifically for Peet Limited and specifically to provide advice on Stormwater Management Planning for Flagstone Masterplan development at Teviot Road, Jimboomba.

The Real Property description of the development site includes The Real Property description is Lot 1 on RP35155, Lot 2 on RP47120, Lot 4 on RP45728, Lot 5 on S312569, Lot 9 on S312569, Lot 10 on SL6002, Lot 873 on SP166448, Lot 875 on SP146552, Lot 907 on RP819216, Lot 908 on RP819216, Lot 910 on RP857850, Lot 911 on RP857870, Lot 988 on CP857841 Lot 989 on RP854074 Parish of Mclean, County Stanley.

Our analysis and overall approach has been specifically catered for the particular requirements of Peet Limited, and may not be applicable beyond this scope. For this reason any other third parties are not authorised to utilise this report without further input and advice from Cardno.

Cardno has relied on the following information provided by others:

- Aerial LiDAR survey data obtained from the Department of Environment and Heritage Protection (DEHP);
- 1:25,000 topographic map ('Undullah'), produced by the Queensland Department of Mapping and Surveying (SUNMAP);
- Site layouts provided by RPS;
- Rainfall Data from the Greenbank Thompson Road station obtained from the Bureau of Meteorology; and
- Cardno report titled, '*Flagstone Stages 14A, 14B, 15A, 15B, 15C and 15D, Hydraulic Analysis*' dated November 2009 (ref 3503-62).

The accuracy of the report is dependent upon the accuracy of this information.

While Cardno's report accurately assesses peak flows from design storms, it is an ungauged catchment; consequently future observed flows may vary from that predicted.

9 References

Cardno, November 2009, '*Flagstone Stages 14A, 14B, 15A, 15B, 15C and 15D, Hydraulic Analysis*' (ref 3503-62).

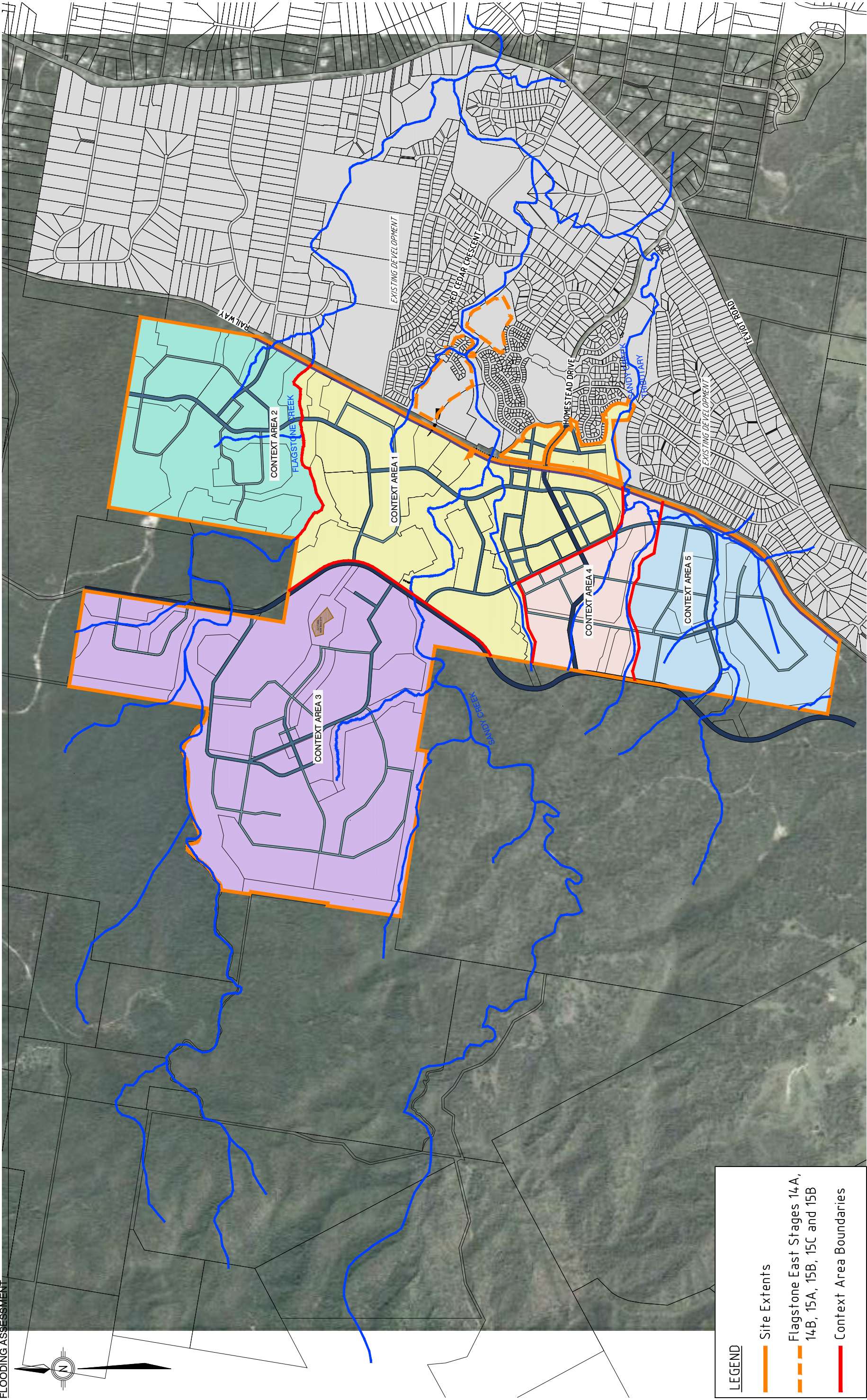
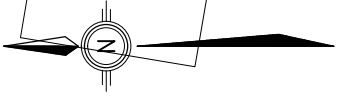
Department of Natural Resources and Water, 2008, *Queensland Urban Drainage Manual*

Logan City Council, 2010, '*Draft Interim Standards for Stormwater, Overland Flow and Flood Plain Management*'

Logan City Council, 2012, '*Temporary Local Planning Instrument No. 1 (Logan Interim Flood Response) 2011*'

FIGURES

- Figure 1 Site Location
- Figure 2 WBNM Model – Pre-Development Catchment Layout
- Figure 3 WBNM – Post-Development Model Topography and Boundary Locations
- Figure 4 TUFLOW Model – Pre-Development Model Topography
- Figure 5 TUFLOW Model – Post-Development Model Topography and Proposed Mitigation Structures



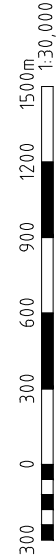
LEGEND

Site Extents

Flagstone East Stages 14A,
14B, 15A, 15B, 15C and 15B

Context Area Boundaries

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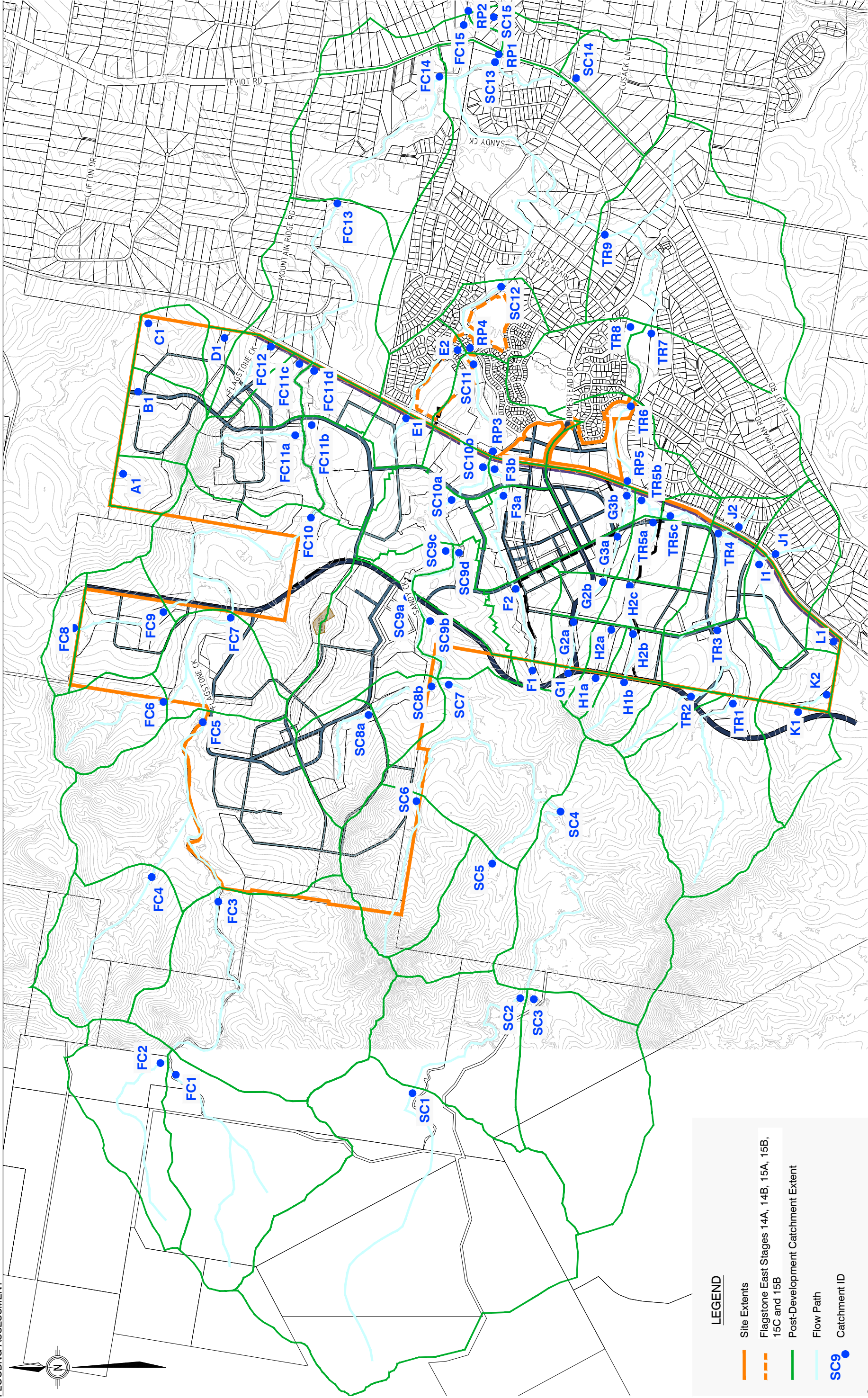
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FIGURE 1

SITE LOCATION AND LAYOUT PLAN



FIGURE 2
WBNM MODEL - PRE-DEVELOPMENT CATCHMENT LAYOUT



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Rev: Orig. Date: AUGUST 2014

Peet Flagstone City Pty Ltd
CAD File: C:\Users\pflagstone\Documents\Flagstone\Fig 2 and 3 - WBNM Pre and Post Dev.dwg
XREF's: Existing Contours, 110056-262-STRUCTURE_00721_01.dwg, X-Road and Creek Labels

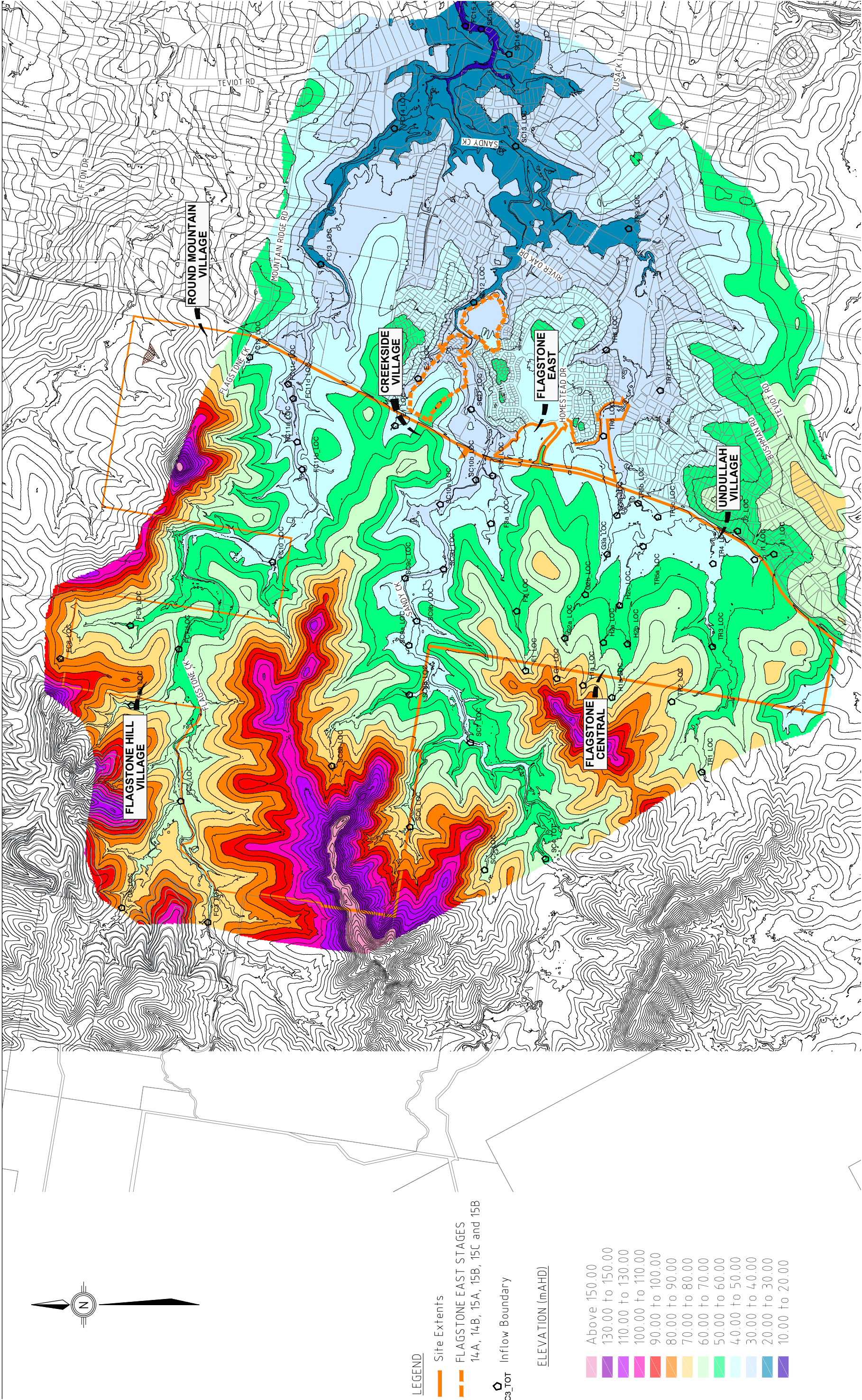
Project No.: 7217/43

PRINT DATE: 05 September, 2014 - 12:44pm

Scale 1:30,000 (A3)

FIGURE 3

WBNM MODEL - MASTERPLAN POST-DEVELOPMENT CATCHMENT LAYOUT

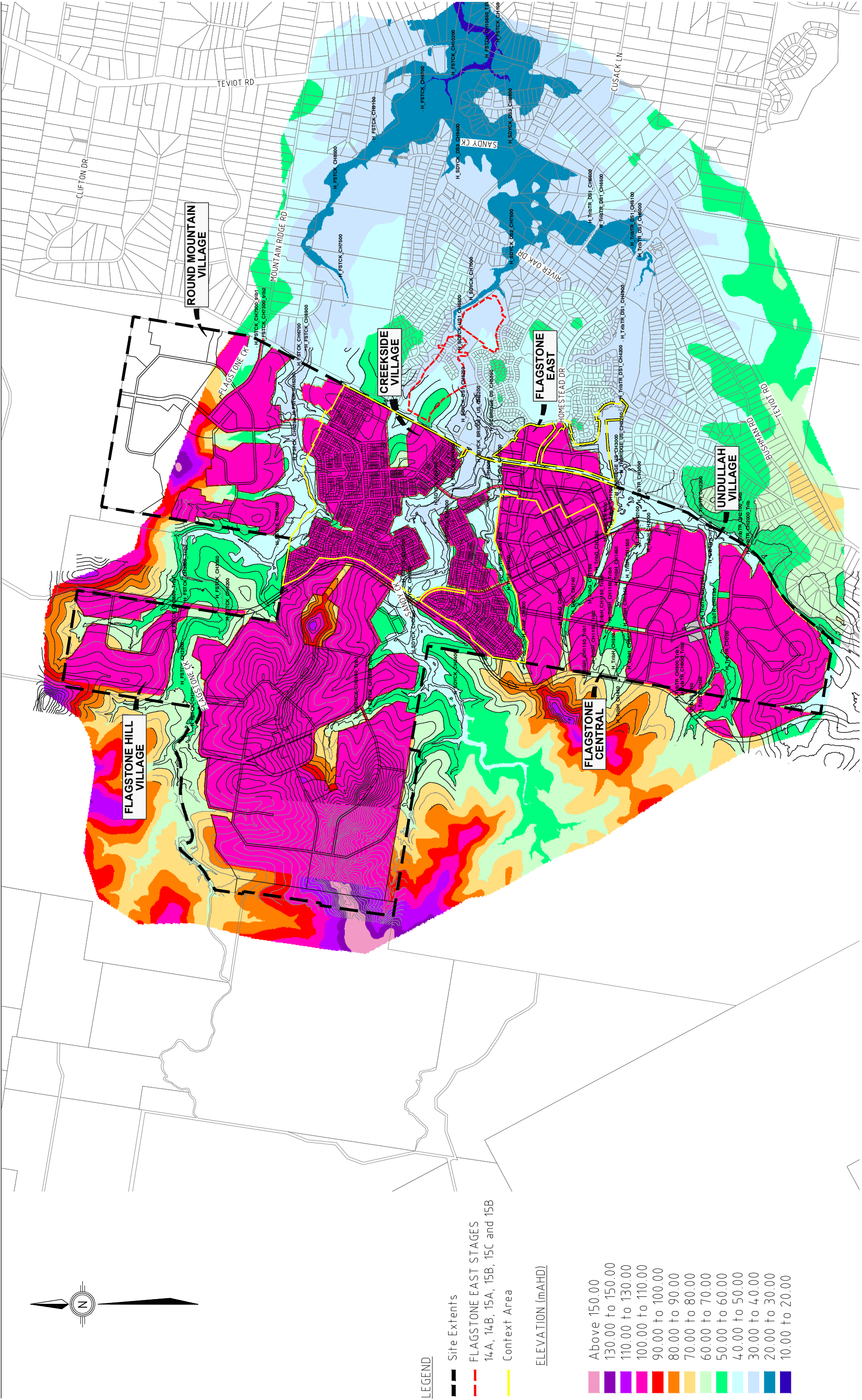


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Rev: Orig. Date: August 2014

Peat Flagstone City Pty Ltd
Cardno (Qld) Pty Ltd
XREF's: Existing Contours, 110056-73 and 110056-85 combined, Inflow points, Topo_EXG_E1B_10m, X-Read and Creek labels



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Rev: Orig. Date: August 2014
Peet Flagstone City Pty Ltd
CADREF's: Max_WSL_Flagst_EXG_100Y_DEPTH_EXG_100Y_EXG_110056-85 moved, 110056-85-Proposal-WIP 020812, X-Road and Creek labels



Scale 1:30000 (A3)
FIGURE 5

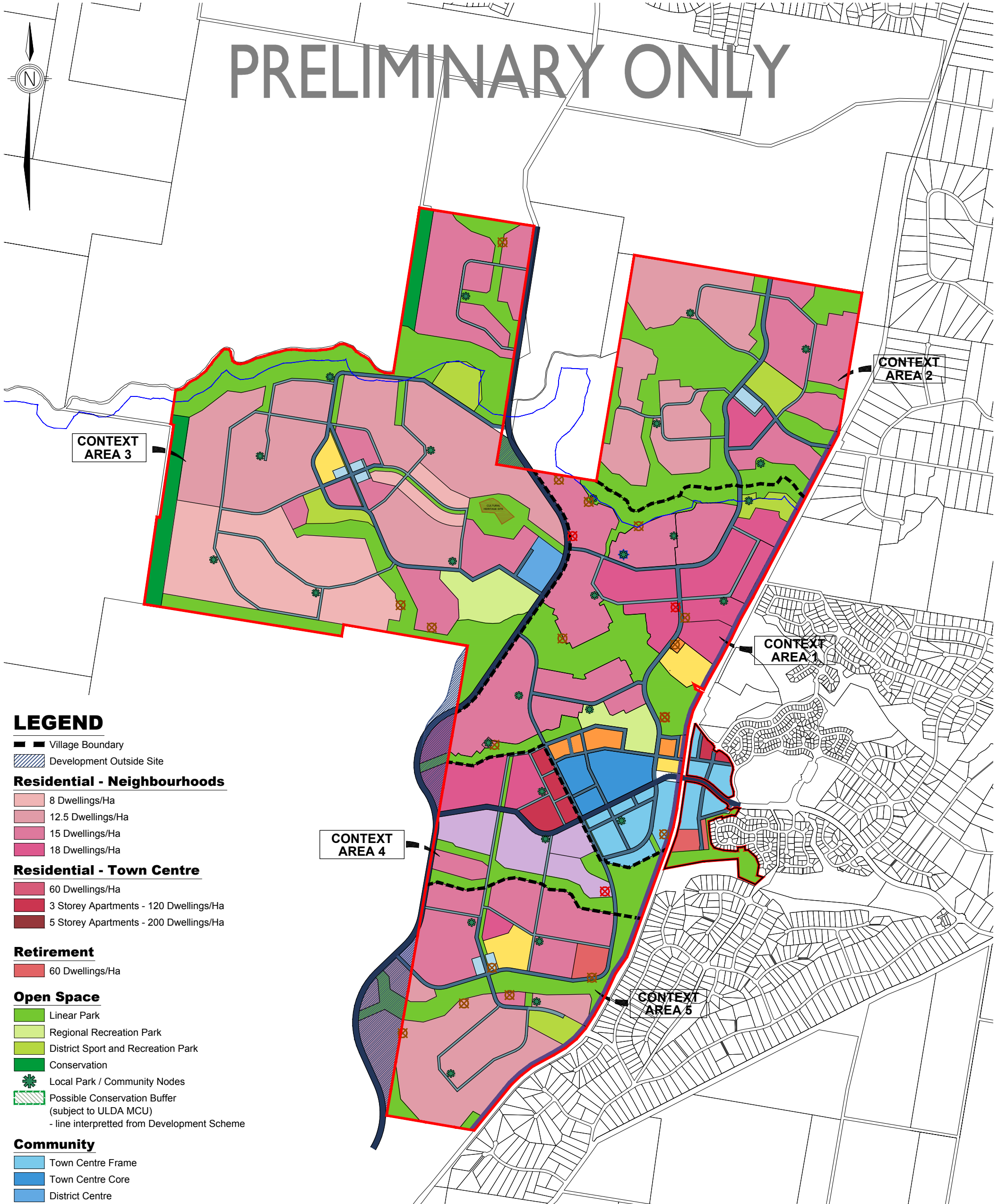
TUFLOW Model - Post-Development Model Topography and Reporting Points

Project No.: 7217/43
PRINT DATE: 05 September, 2014 - 12:49pm

Flagstone City-Masterplan

REFERENCE DRAWINGS

PRELIMINARY ONLY



LEGEND

— Village Boundary

Development Outside Site

Residential - Neighbourhoods

8 Dwellings/Ha

12.5 Dwellings/Ha

15 Dwellings/Ha

18 Dwellings/Ha

Residential - Town Centre

60 Dwellings/Ha

3 Storey Apartments - 120 Dwellings/Ha

5 Storey Apartments - 200 Dwellings/Ha

Retirement

60 Dwellings/Ha

Open Space

Linear Park

Regional Recreation Park

District Sport and Recreation Park

Conservation

Local Park / Community Nodes

Possible Conservation Buffer
(subject to ULDA MCU)
- line interpreted from Development Scheme

Community

Town Centre Frame

Town Centre Core

District Centre

Village (Neighbourhood) Centre

Mixed Use (Residential & Commercial)

Employment

Education

Heritage Sites

Burial Site

Test Pit Location

Surface Collection Location

Test Trench Location

Road Hierarchy

North-South Arterial (40m Wide)

Village Connector Roads (24 - 26m Wide)

Neighbourhood Streets (18.5 - 21m Wide)

Private or Public Streets (18m Wide)

Rail

Potential Land Dedication –
Salisbury to Beaudesert Rail Corridor
Note: Refer condition 15 DEV2012/209

Note:

All dimensions and areas are approximate only, and are subject to survey and Council approval.

Dimensions have been rounded to the nearest 0.1 metres.

Areas have been rounded down to the nearest 5m².

The boundaries shown on this plan should not be used for final detailed engineers design.

Source Information:

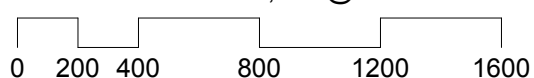
Site boundaries: Registered Survey Plans.

Adjoining information: DCDB.

Heritage Information: Jagera Daran



SCALE 1 : 25,000 @ A3

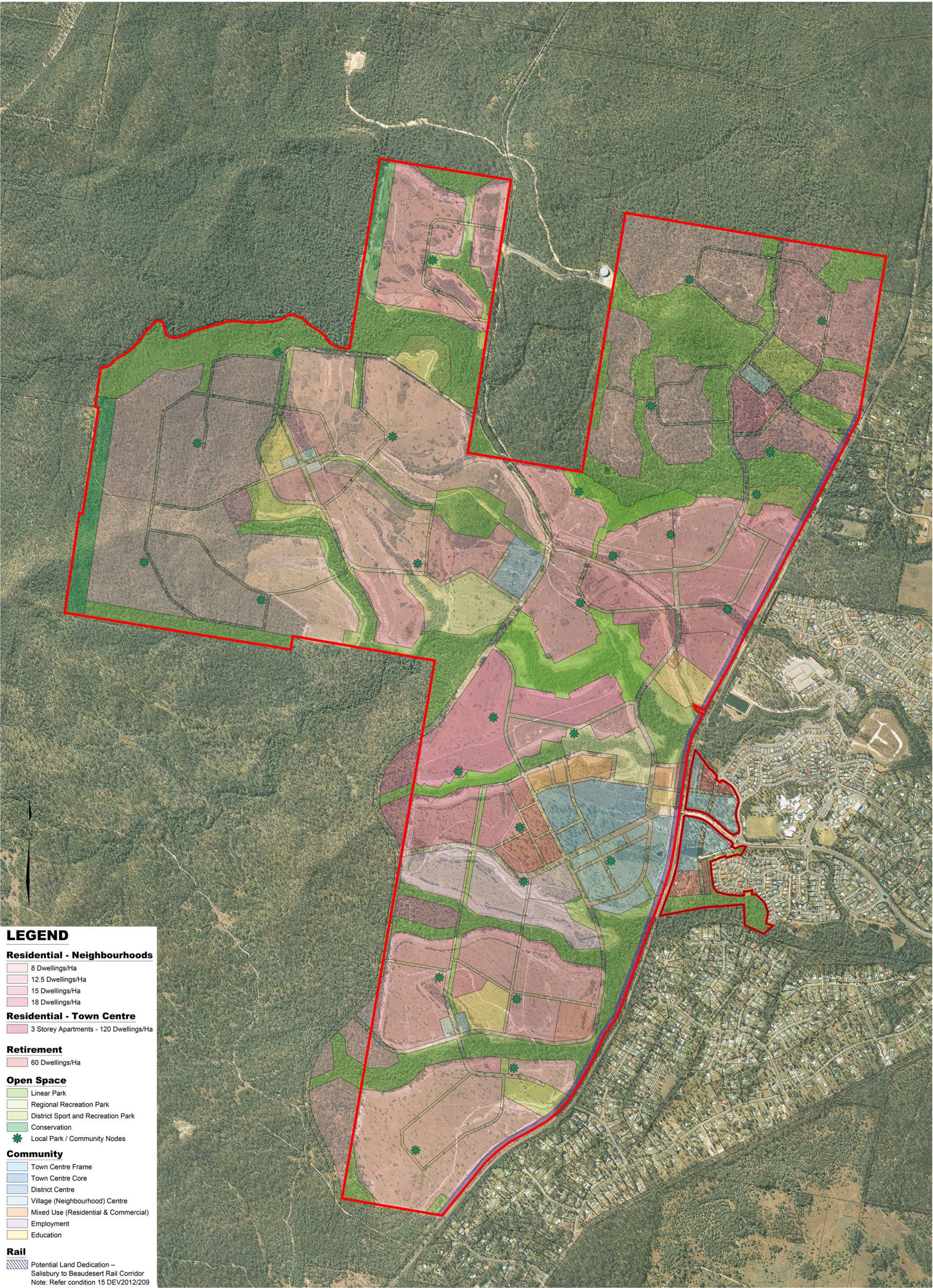


STRUCTURE PLAN - OPTION 2L

FLAGSTONE

DATE : 01 July 2014

DWG NAME : 110056-262-STRUCTURE_OPT2L DWG # 110056-262-3



LEGEND

Residential - Neighbourhoods

- 8 Dwellings/Ha
- 12.5 Dwellings/Ha
- 15 Dwellings/Ha
- 18 Dwellings/Ha

Residential - Town Centre

- 3 Storey Apartments - 120 Dwellings/Ha

Retirement

- 60 Dwellings/Ha

Open Space

- Linear Park
- Regional Recreation Park
- District Sport and Recreation Park
- Conservation
- Local Park / Community Nodes

Community

- Town Centre Frame
- Town Centre Core
- District Centre
- Village (Neighbourhood) Centre
- Mixed Use (Residential & Commercial)
- Employment
- Education

Rail

- Potential Land Dedication – Salisbury to Beaudesert Rail Corridor
Note: Refer condition 15 DEV2012/209

Flagstone City-Masterplan

APPENDIX

A

WBNM Catchment Details

Pre-Development (Case EU04a) – Catchment Areas (ha)				
Catchment Name	Forest	External Urban	Total Area	Overall Catchment Fraction Impervious
A1	24.62		24.62	0%
B1	42.22		42.22	0%
C1	35.03		35.03	0%
D1	11.25		11.25	0%
E1	19.99		19.99	0%
E2	12.35	26.18	38.53	41%
F1	7.10		7.10	0%
F2	39.95		39.95	0%
F3	47.08		47.08	0%
G1	5.31		5.31	0%
G2	27.79		27.79	0%
G3	33.87		33.87	0%
G4	25.84		25.84	0%
H1	31.02		31.02	0%
H2	36.48		36.48	0%
I1	32.73		32.73	0%
J1		45.95	45.95	60%
J2		15.43	15.43	60%
K1	42.67		42.67	0%
K2	22.59		22.59	0%
L1	6.04		6.04	0%
TR1	137.87		137.87	0%
TR2	20.78		20.78	0%
TR3	59.02		59.02	0%
TR4	26.59		26.59	0%
TR5	56.09	5.38	61.47	5%
TR6	18.95	49.23	68.18	43%
TR7		132.48	132.48	60%
TR8		62.72	62.72	60%
TR9		244.80	244.80	60%
FC1	174.37		174.37	0%
FC2	102.29		102.29	0%
FC3	281.95		281.95	0%
FC4	116.92		116.92	0%
FC5	268.34		268.34	0%
FC6	58.97		58.97	0%
FC7	74.20		74.20	0%
FC8	21.23		21.23	0%

Pre-Development (Case EU04a) – Catchment Areas (ha)				
Catchment Name	Forest	External Urban	Total Area	Overall Catchment Fraction Impervious
FC9	64.52		64.52	0%
FC10	167.14		167.14	0%
FC11	169.02		169.02	0%
FC12	24.48		24.48	0%
FC13		135.99	135.99	60%
FC14		144.34	144.34	60%
FC15		36.02	36.02	60%
SC1	464.95		464.95	0%
SC2	129.00		129.00	0%
SC3	167.16		167.16	0%
SC4	236.71		236.71	0%
SC5	69.24		69.24	0%
SC6	103.98		103.98	0%
SC7	157.43		157.43	0%
SC8	88.52		88.52	0%
SC9	154.44		154.44	0%
SC10	86.96		86.96	0%
SC11	13.14	45.50	58.64	47%
SC12	11.44	32.90	44.34	45%
SC13		322.82	322.82	60%
SC14		60.76	60.76	60%
SC15		27.18	27.18	60%
Totals	4029.65	1387.68	5417.3	

Post-Development (Case DU03b) – Catchment Areas (ha)												
Catchment	Forest	External Urban	Conservation	Park Area	Open Space	Residential Low Density	Residential Med Density	Residential High Density	Schools	Commercial / Town Centre	Total Area	Catchment Fraction Impervious
A1				5.67			18.95				24.62	46%
B1				11.51			30.71				42.22	44%
C1	5.34			7.06			22.63				35.03	39%
D1				4.60			6.65				11.25	35%
E1							22.18				22.18	60%
E2		38.53									38.53	60%
F1	7.10										7.1	0%
F2				5.41			19.96	5.41		4.75	35.53	59%
F3a				12.88			13.71	1.17		24.09	51.85	60%
F3b				3.19					1.36	5.63	10.18	59%
G1	5.31										5.31	0%
G2a							8.25			5.08	13.33	71%
G2b				0.89			2.31	2.31		10.09	15.6	73%
G3a				2.10						13.74	15.84	78%
G3b				4.92						27.3	32.22	76%
H1a	7.91										7.91	0%
H1b	23.11										23.11	0%
H2a				2.38			2.81			4.72	9.91	60%
H2b				3.03			12.68				15.71	48%
H2c				3.38			16.86		1.76	1.44	23.44	56%
I1				4.37			28.36				32.73	52%
J1		45.95									45.95	60%
J2		15.43									15.43	60%
K1	42.67										42.67	0%

Post-Development (Case DU03b) – Catchment Areas (ha)												
Catchment	Forest	External Urban	Conservation	Park Area	Open Space	Residential Low Density	Residential Med Density	Residential High Density	Schools	Commercial / Town Centre	Total Area	Catchment Fraction Impervious
K2				2.99			19.60				22.59	52%
L1				0.83			5.21				6.04	52%
TR1	137.87										137.87	0%
TR2	20.78										20.78	0%
TR3				8.21			39.13			0.78	48.12	50%
TR4				11.02			17.75		5.33	3.38	37.48	46%
TR5a				4.78			21.14			8.13	34.05	59%
TR5b			4.56								4.56	0%
TR5c		5.40	4.87								10.27	32%
TR6	7.58	41.47	7.98				5.17			5.98	68.18	49%
TR7		132.48									132.48	60%
TR8		62.72									62.72	60%
TR9		244.80									244.8	60%
FC1	174.37										174.37	0%
FC2	102.29										102.29	0%
FC3	274.04		4.95			2.96					281.95	1%
FC4	116.92										116.92	0%
FC5	118.79		5.80	32.29			105.98		4.08	1.4	268.34	26%
FC6	50.81		8.42								59.23	0%
FC7	3.37		32.31				39.24				74.92	31%
FC8	21.23										21.23	0%
FC9	12.74			10.97			39.84				63.55	38%
FC10	78			22.64			77.09				177.73	26%
FC11a				39.9			26.61	3.95		0.21	70.67	28%

Post-Development (Case DU03b) – Catchment Areas (ha)												
Catchment	Forest	External Urban	Conservation	Park Area	Open Space	Residential Low Density	Residential Med Density	Residential High Density	Schools	Commercial / Town Centre	Total Area	Catchment Fraction Impervious
FC11b				15.18			26.31	4.0			45.49	42%
FC11c				7.71			8.23	2.0			17.94	37%
FC11d				11.50				12.81			24.31	45%
FC12				9.77			12.46	0.83		1.42	24.48	39%
FC13		135.99									135.99	60%
FC14		144.34									144.34	60%
FC15		36.02									36.02	60%
SC1	464.95										464.95	0%
SC2	129.00										129	0%
SC3	167.16										167.16	0%
SC4	236.71										236.71	0%
SC5	69.24										69.24	0%
SC6	50.84		4.85	8.28		40.01					103.98	19%
SC7	147.53			3.18		6.72					157.43	2%
SC8a				13.99		33.83	7.58			0.12	55.11	39%
SC8b	5.94			6.63		14.57	6.0				33.41	33%
SC9a	0.94			29.11		31.27	21.3			6.75	89.37	39%
SC9b	13.79			11.35			6.57				28.05	14%
SC9c				5.72			9.61				15.33	38%
SC9d				7.01			24.42				31.43	47%
SC10a				15.05			37.35				52.4	43%
SC10b				7.79			7.42		6.78	0.6	22.59	43%
SC11		49.64		0.15						8.85	58.64	64%
SC12		44.34									44.34	60%

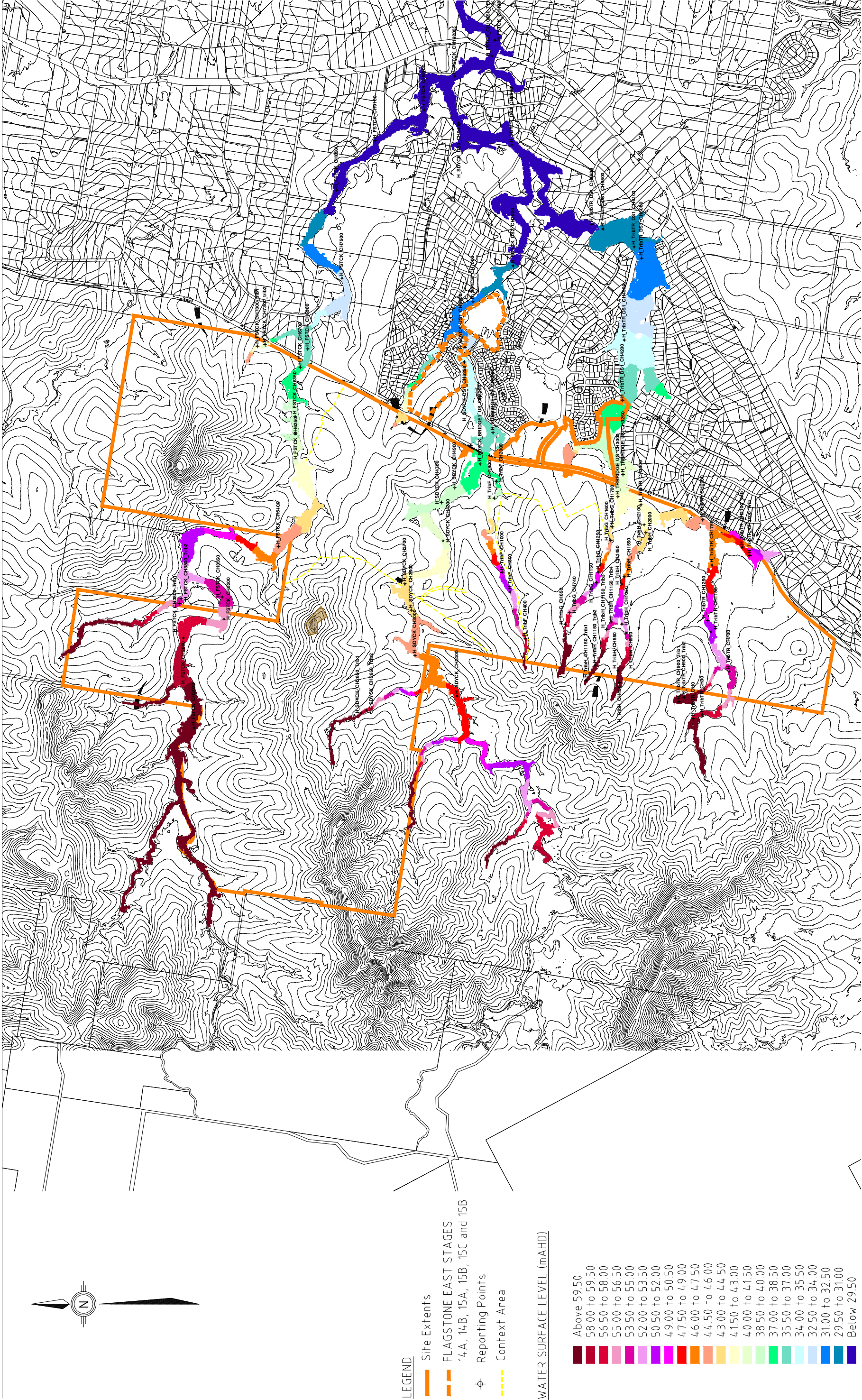
Post-Development (Case DU03b) – Catchment Areas (ha)												
Catchment	Forest	External Urban	Conservation	Park Area	Open Space	Residential Low Density	Residential Med Density	Residential High Density	Schools	Commercial / Town Centre	Total Area	Catchment Fraction Impervious
SC13		322.82									322.82	60%
SC14		60.76									60.76	60%
SC15		27.18									27.18	60%
Total Areas	2501.93	1407.22	369.47	14.09	24.66	111.49	767.57	32.29	26.96	161.62	5417.3	

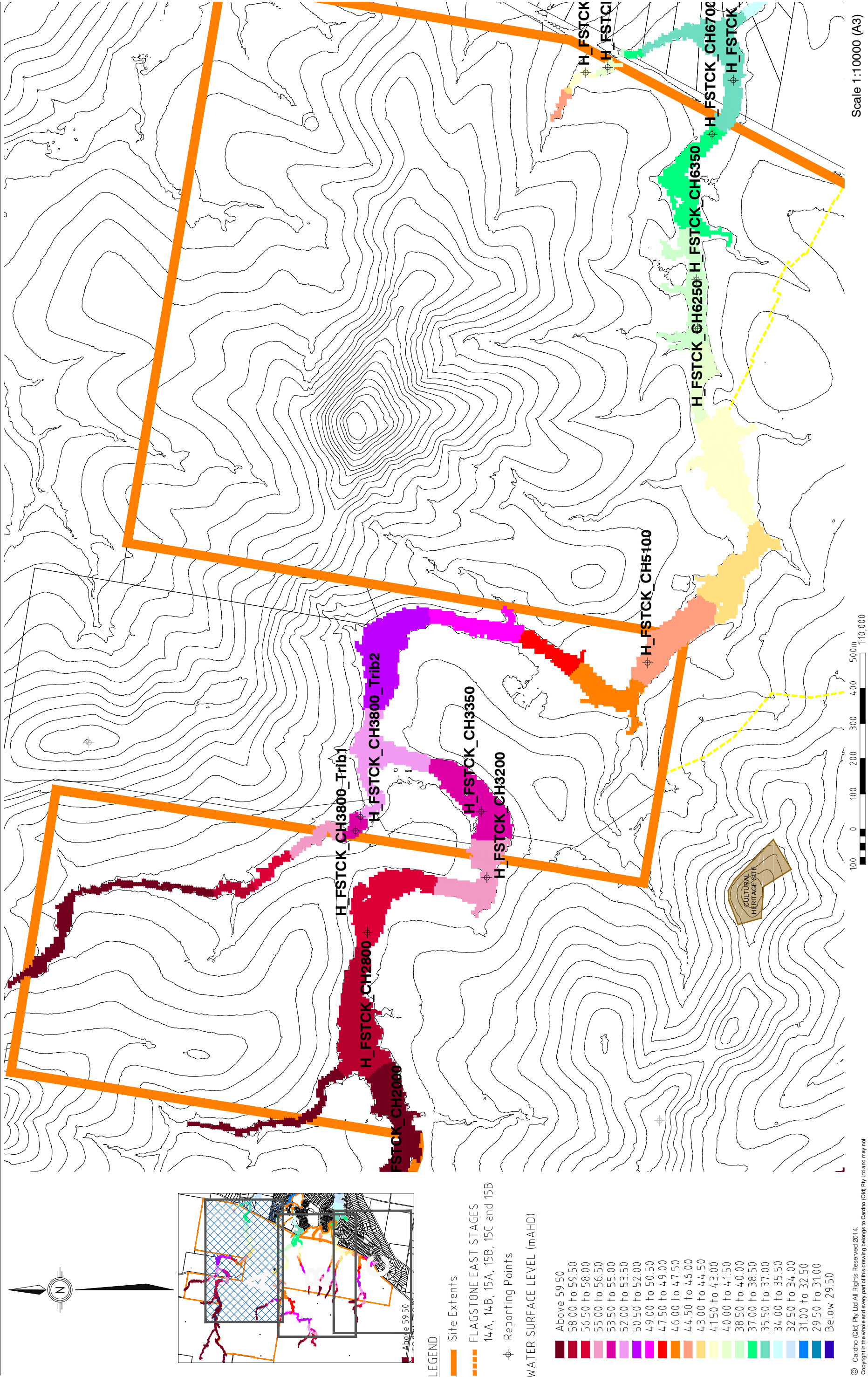
Flagstone City-Masterplan

APPENDIX

B

Pre-Development Flooding Conditions (TUFLOW Results)





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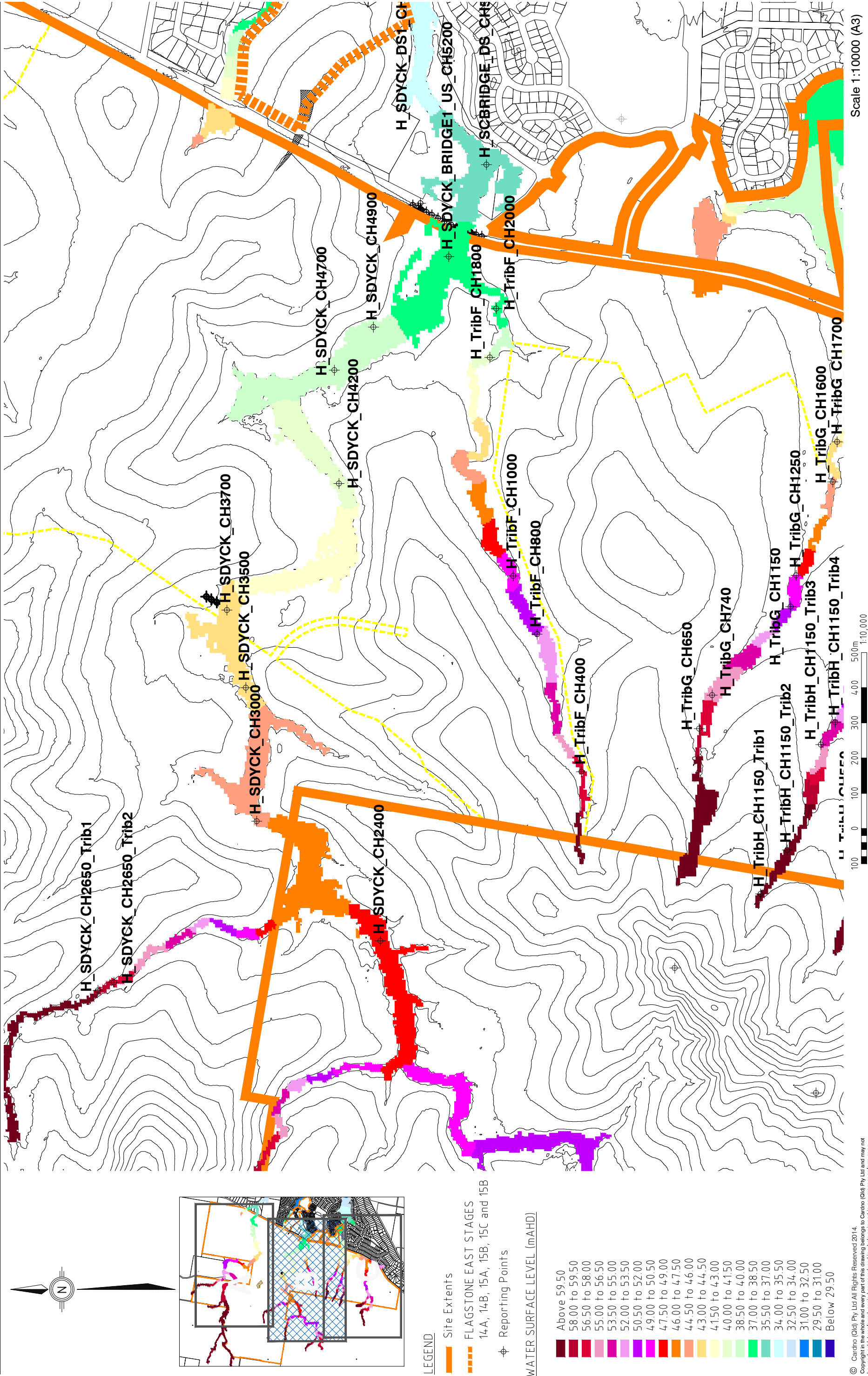
Rev: Orig. Date: 5 September 2014

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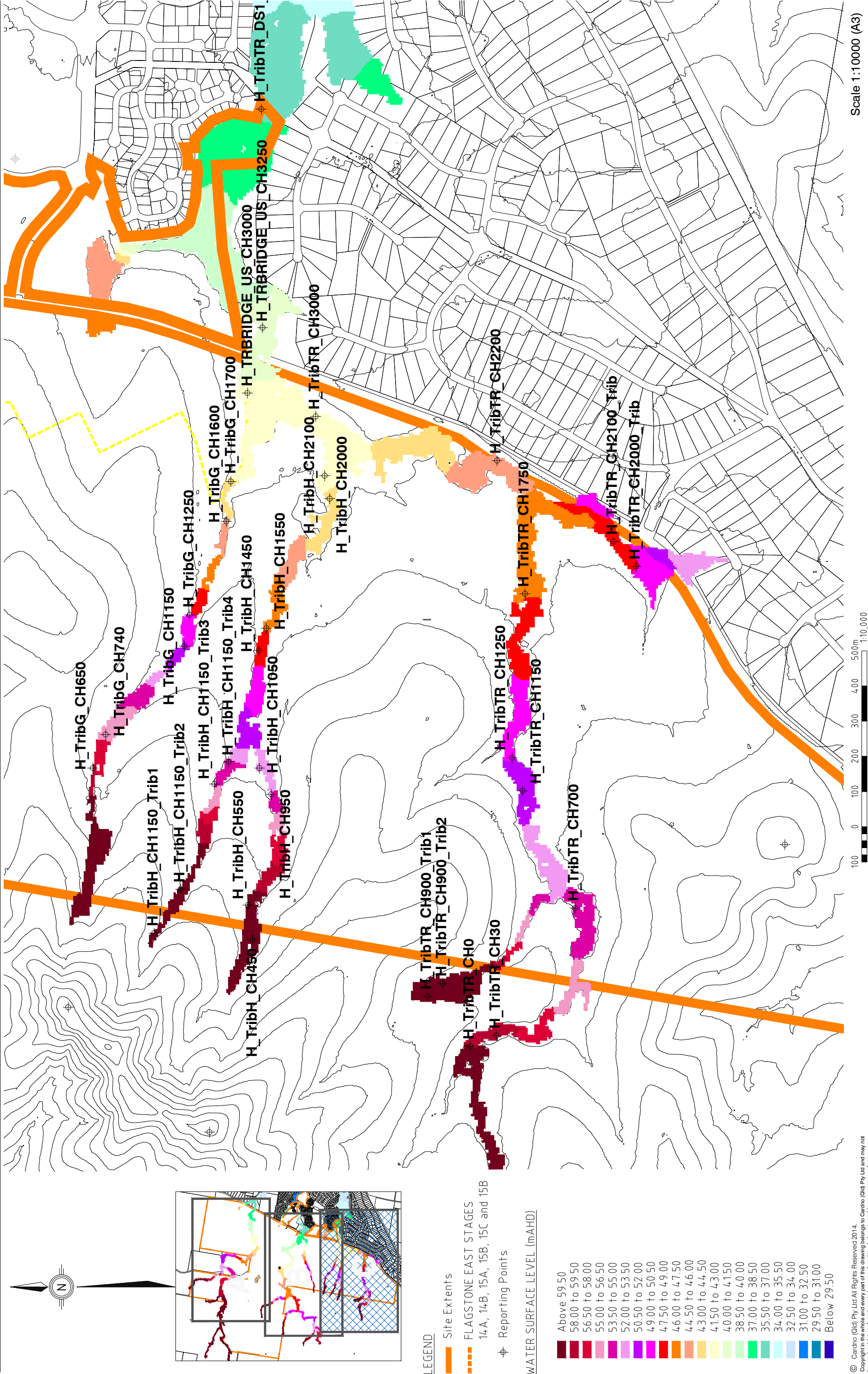
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Project No.: 7217/43

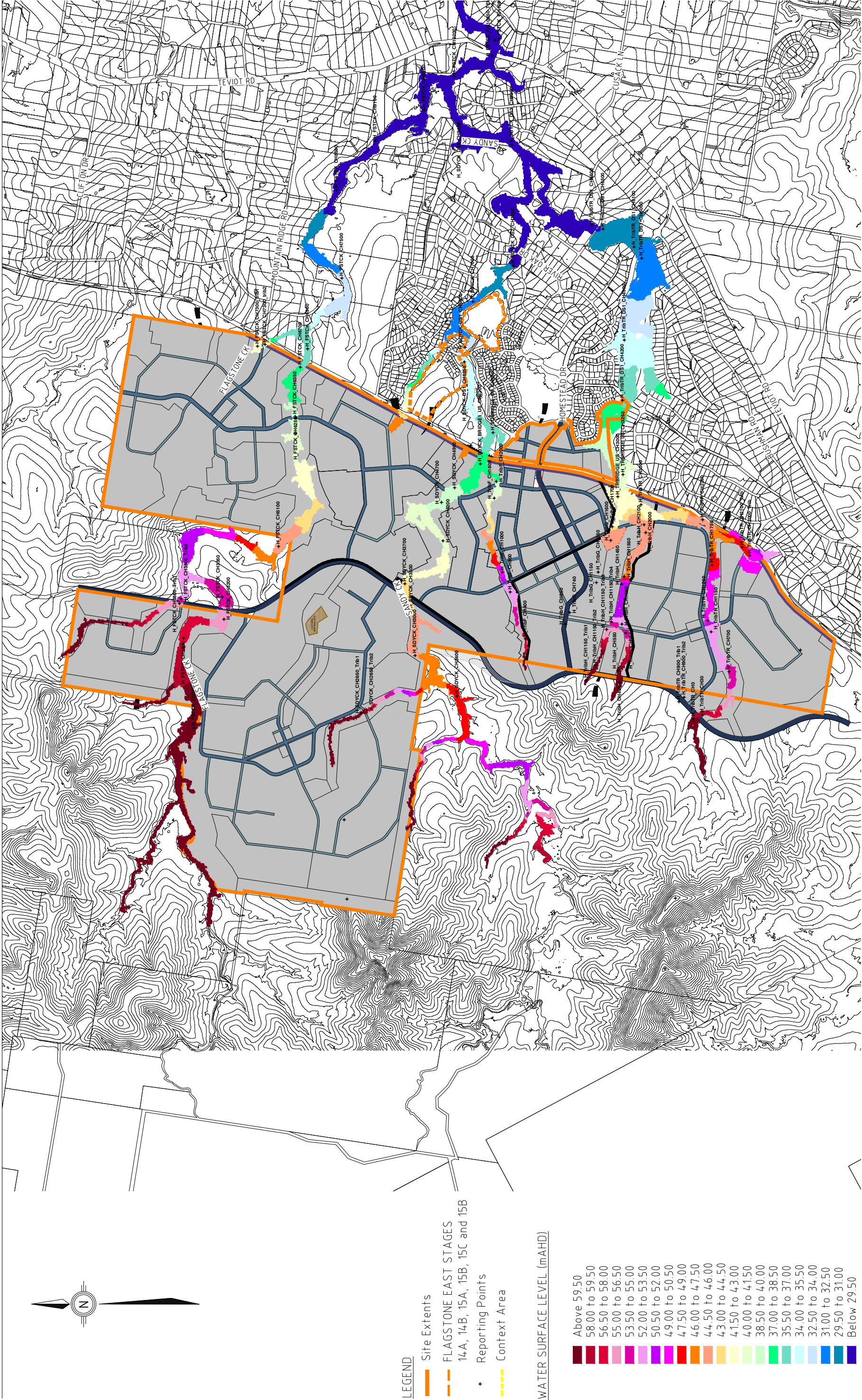
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Flagstone City-Masterplan

APPENDIX

C

Post-Development Flooding Conditions
(TUFLOW Results)



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XREF's: Existing Contours, WSL_Reporting points, All_Points_moved, E2toUlow_Results, 10056-262-STRUCTURE_DPT2L_grey, X-Road and Creek labels

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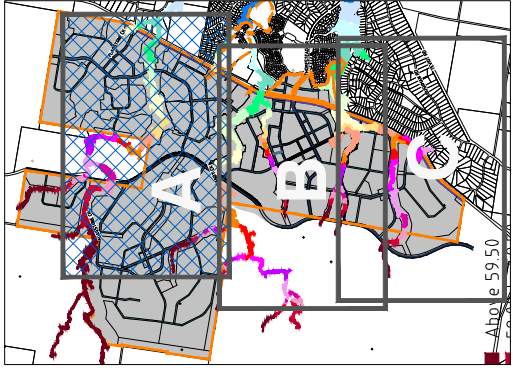
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FIGURE C1

100 Year ARI - Post-Development Case M32e - Peak Water Surface Levels

Project No.: 7217/43

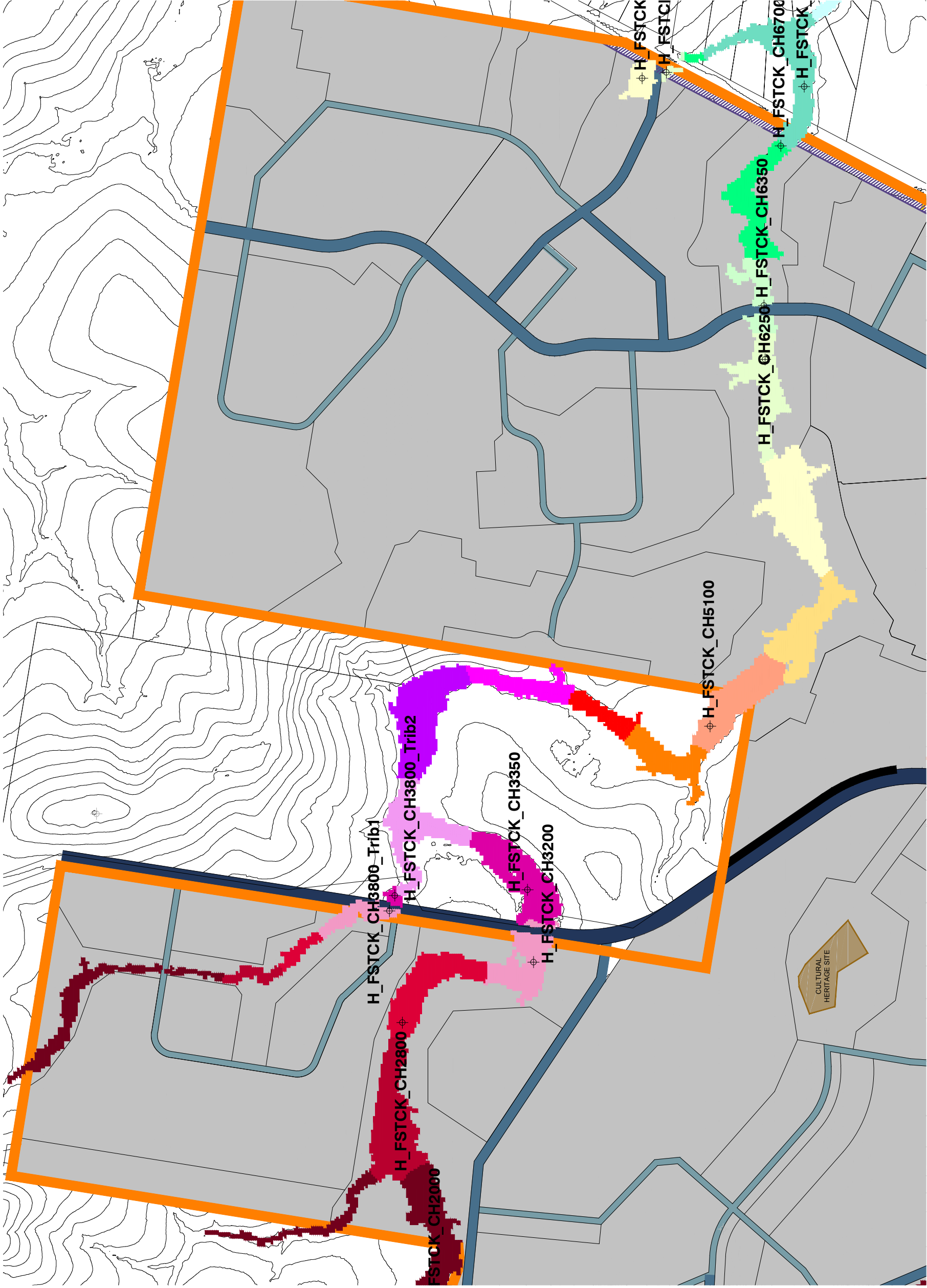
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LEGEND

- Site Extents
- FLAGSTONE EAST STAGES
14A, 14B, 15A, 15B, 15C and 15B
- Reporting Points

WATER SURFACE LEVEL (mAHD)



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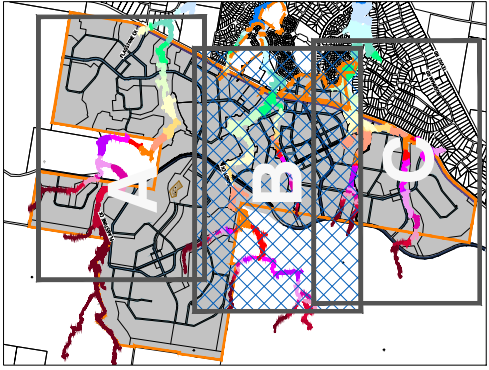
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FIGURE C1.1 (A)
100 Year ARI - Post-Development Case M32e - Peak Water Surface Levels

Project No.: 7217/43

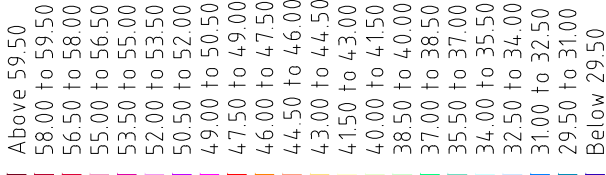
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LEGEND

- Site Extents
- FLAGSTONE EAST STAGES
14A, 14B, 15A, 15B, 15C and 15B
- Reporting Points

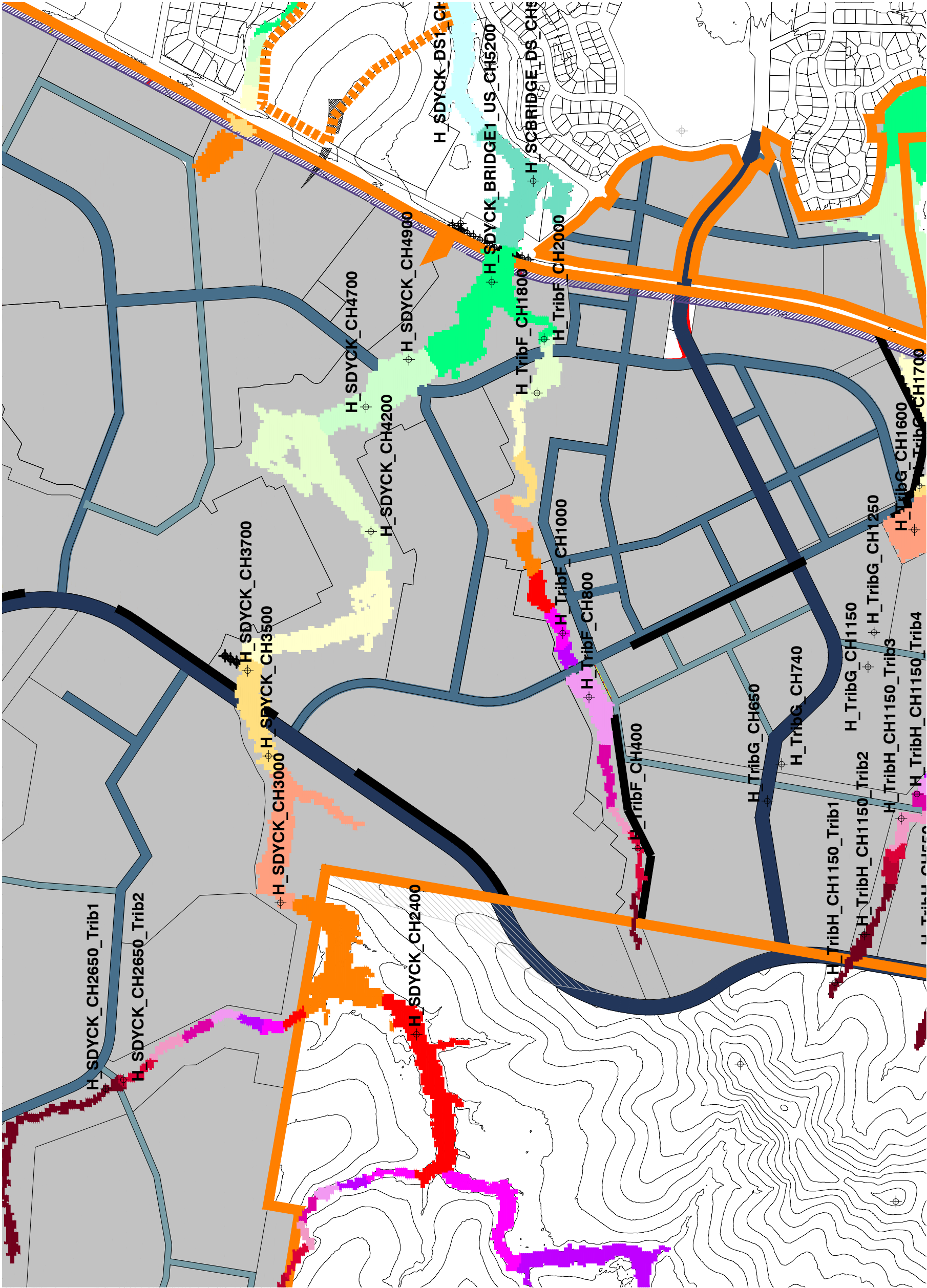
WATER SURFACE LEVEL (mAHD)



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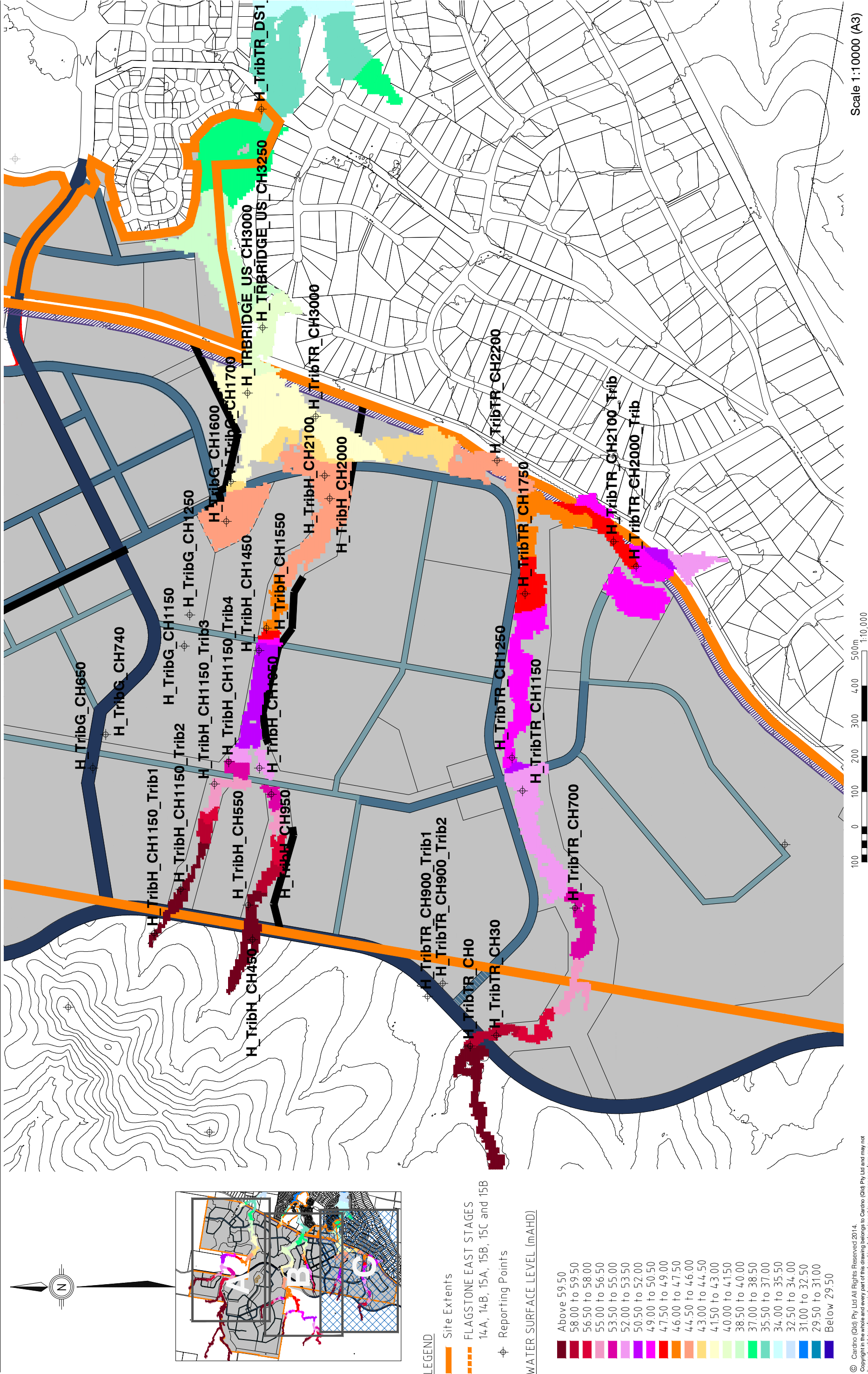
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FIGURE C1.1 (B)

100 Year ARI - Post-Development Case M32e - Peak Water Surface Levels

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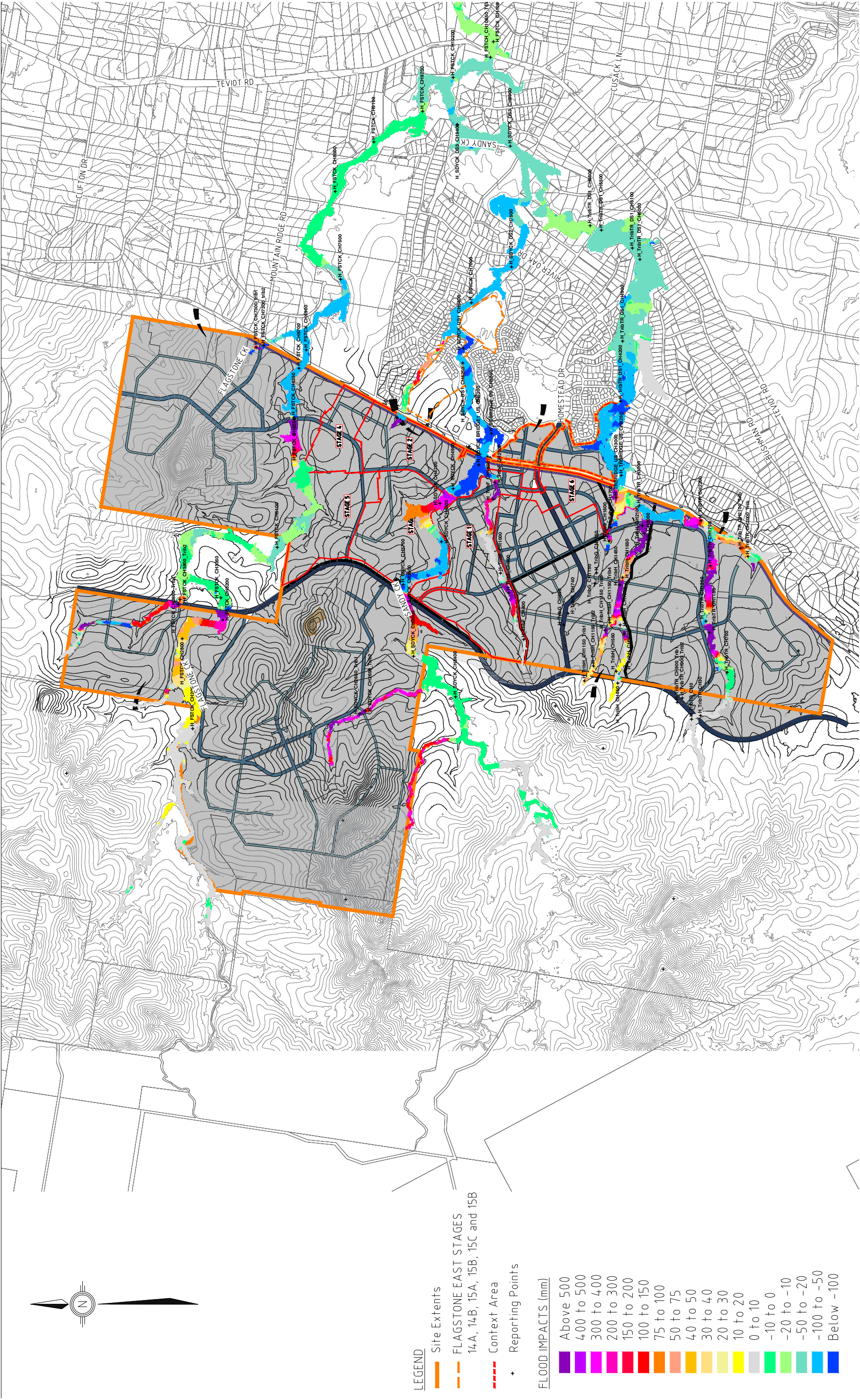
FIGURE C1.1 (C)
100 Year ARI - Post-Development Case M32e - Peak Water Surface Levels

Flagstone City-Masterplan

APPENDIX

D

Post-Development Predicted Impacts (TUFLOW Results)



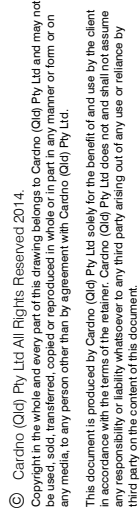
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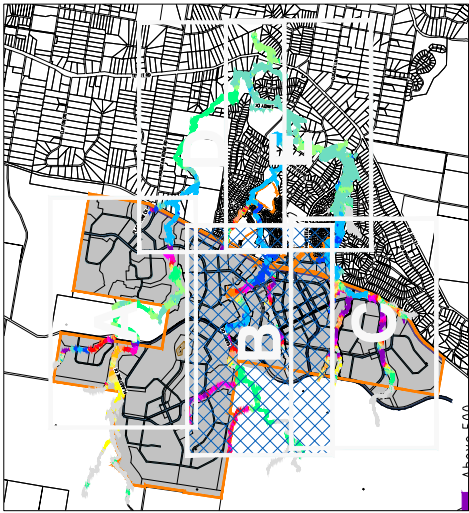


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FIGURE D1.1 (A)

100 Year ARI - Post-Development (Master Plan) case M32e - Flood Impacts

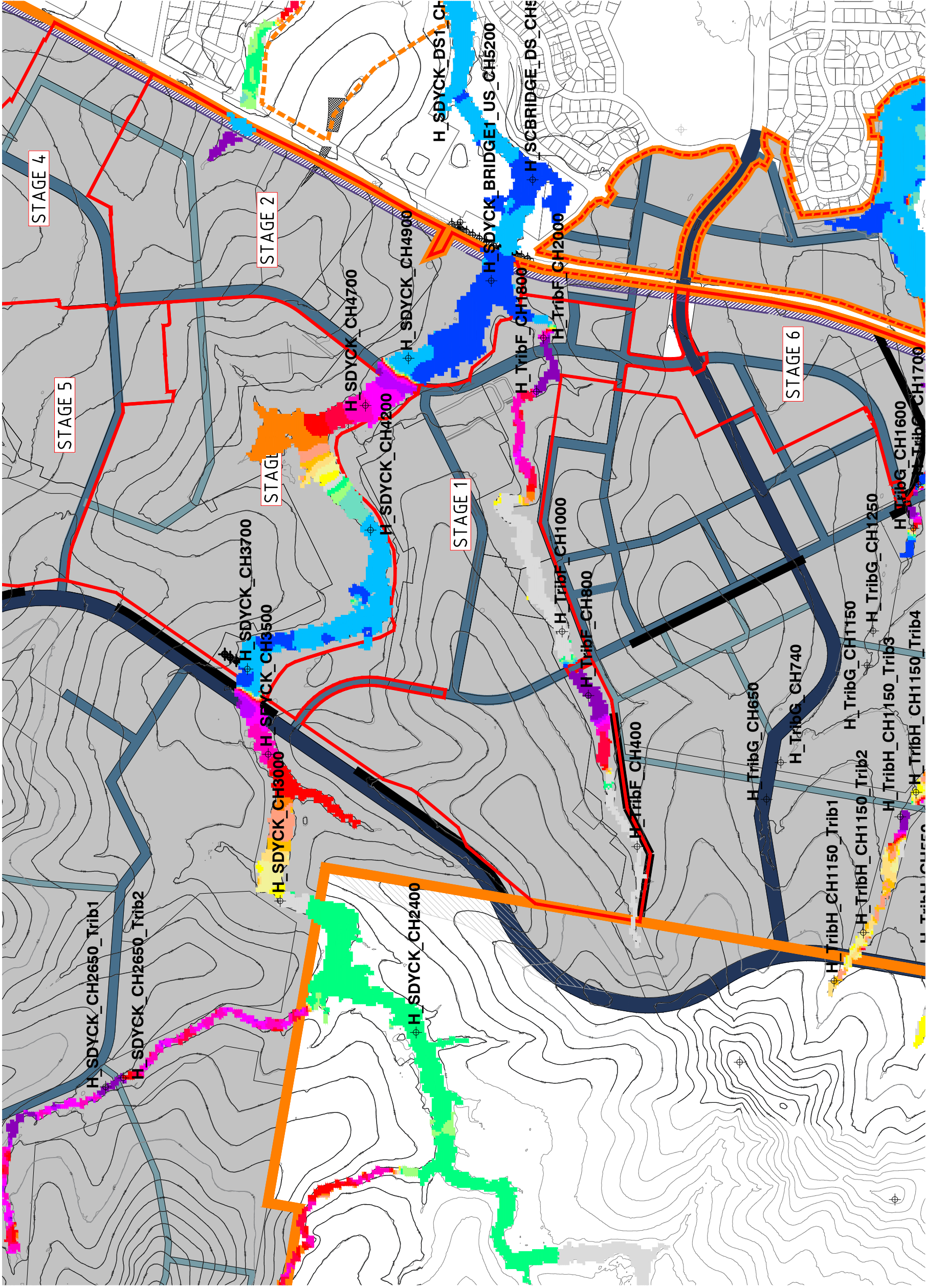
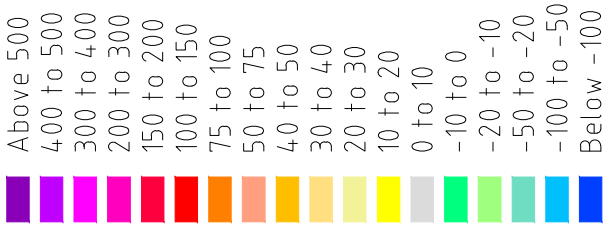


LEGEND

- Site Extents
- FLAGSTONE EAST STAGES
14A, 14B, 15A, 15B, 15C and 15B
- Context Area

Reporting Points

FLOOD IMPACTS (mm)



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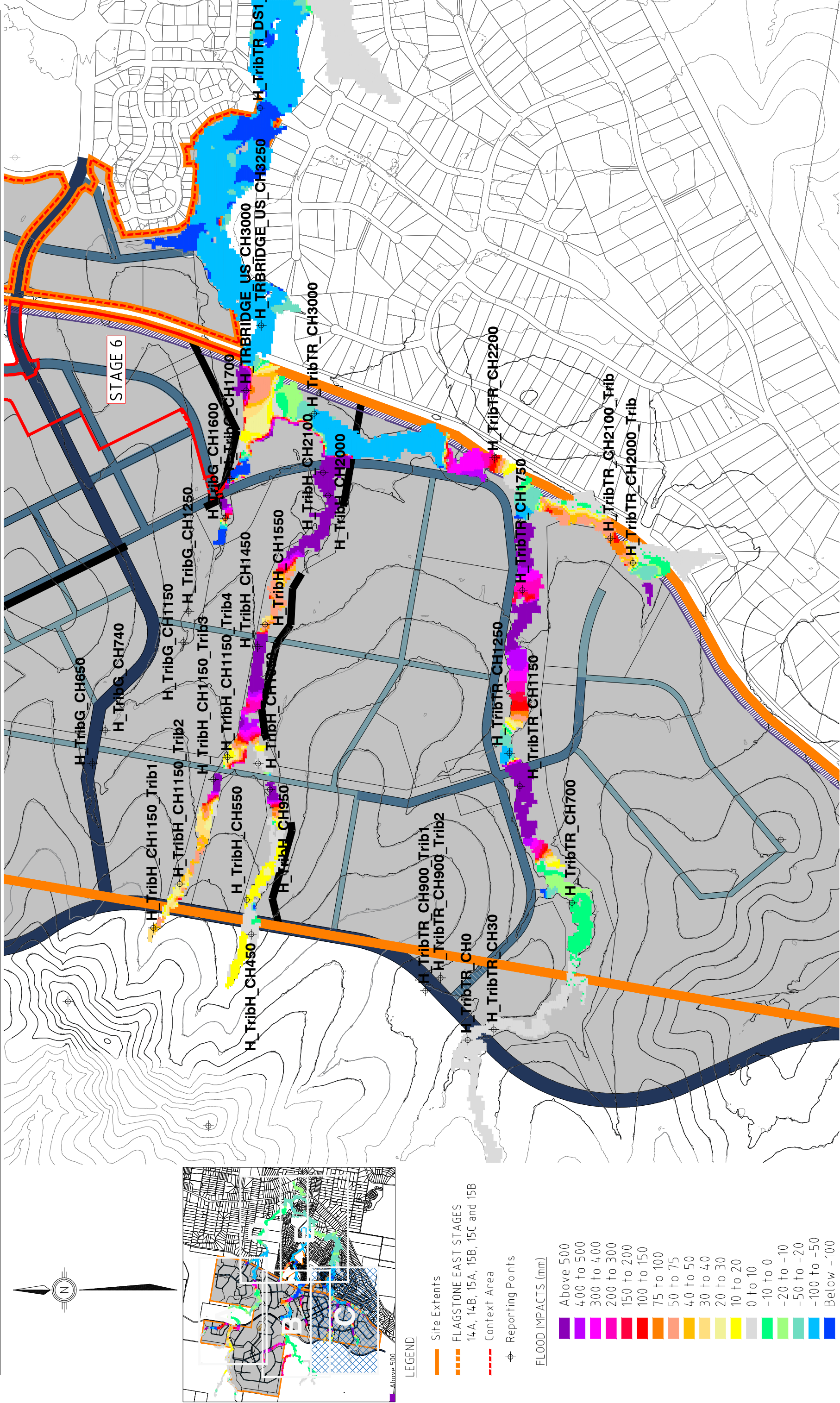
Project No.: 7217/43

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FIGURE D1.1 (B)

100 Year ARI - Post-Development (Master Plan) case M32e - Flood Impacts



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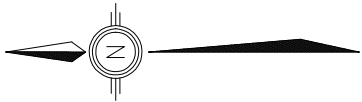
Rev: Orig. Date: 5 September 2014

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Project No.: 7217/43

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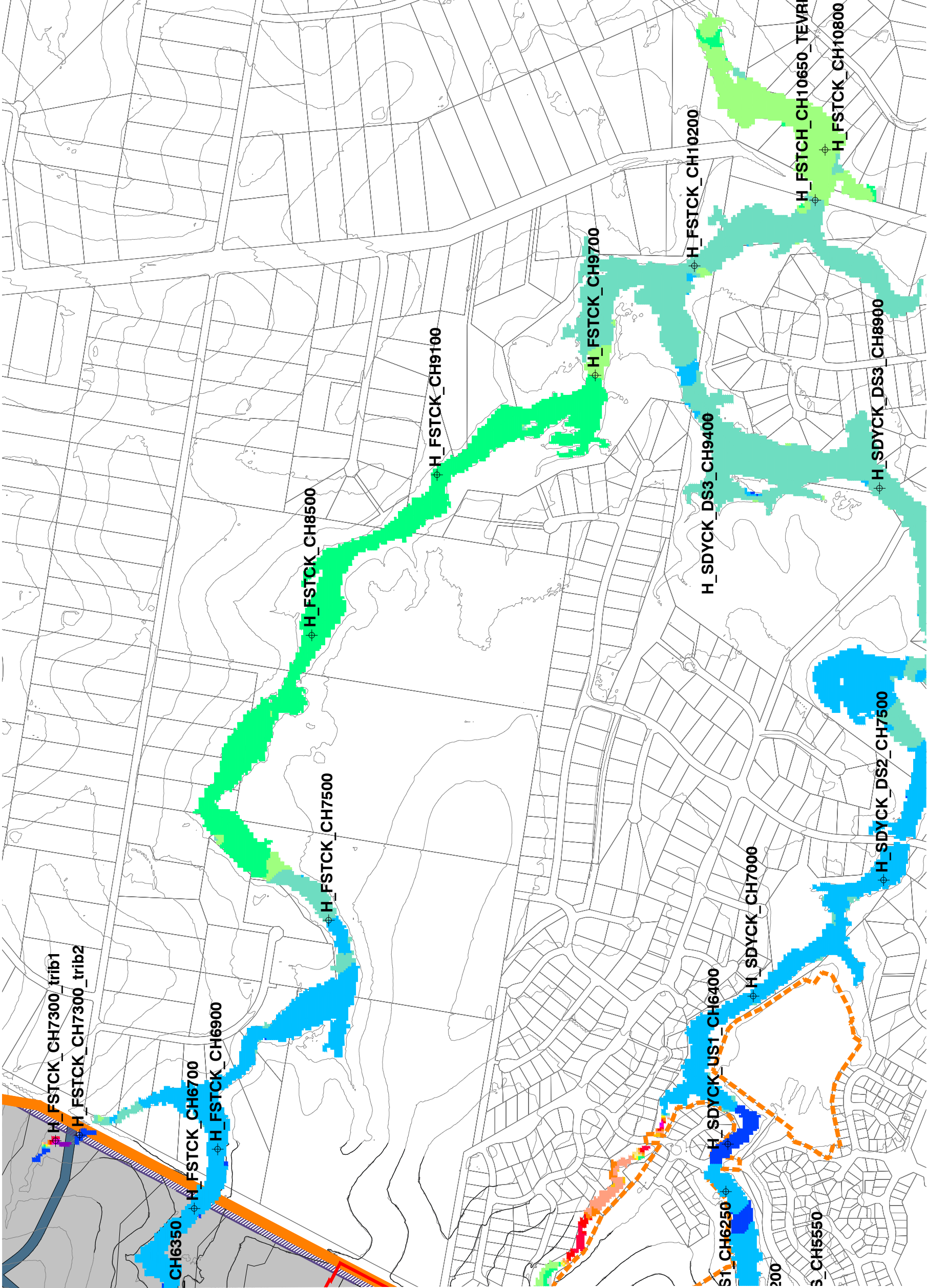
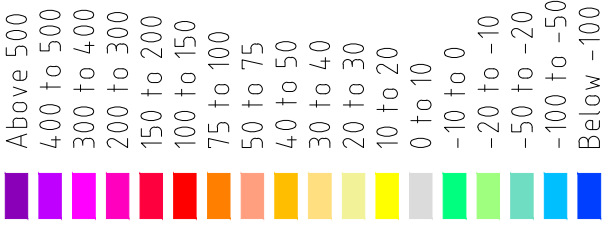


LEGEND

- Site Extents
- FLAGSTONE EAST STAGES
14A, 14B, 15A, 15B, 15C and 15B

Reporting Points

FLOOD IMPACTS (mm)



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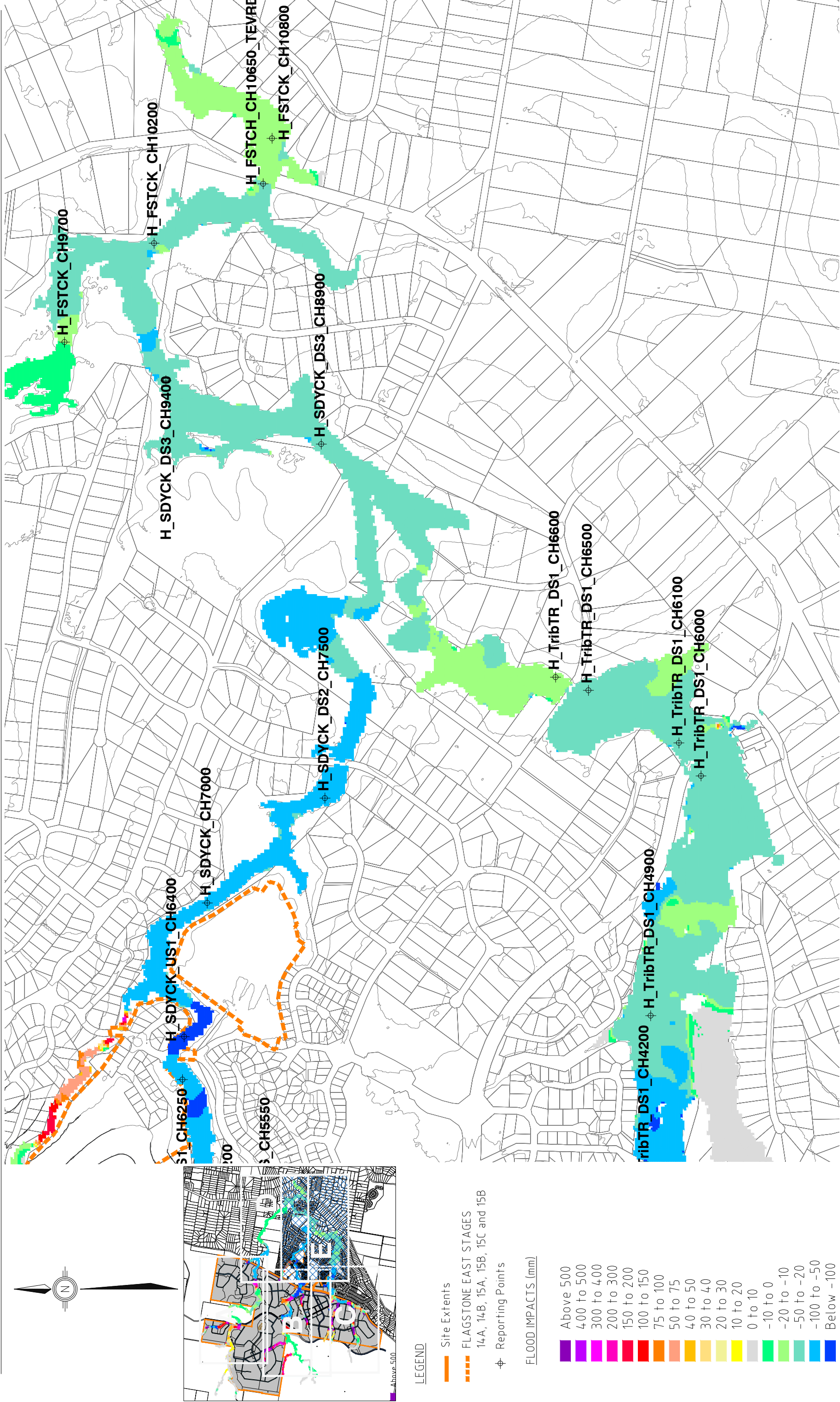
Project No.: 7217/43

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FIGURE D1.1 (D)

100 Year ARI - Post-Development (Master Plan) case M32e - Flood Impacts



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Flagstone City-Masterplan

APPENDIX

E

Post-Development Predicted Impacts (TUFLOW
Detailed Results)

Reporting Points	Peak Flood Level (mAHD)		Impact (m)
	Existing Case (E21e)	Developed Case (M32e)	
H_TRBRIDGE_US_CH3250	40.55	40.49	-0.06
H_TRBRIDGE_US_CH3000	41.53	42.59	1.07
H_TribTR_DS1_CH6600	28.95	28.93	-0.02
H_TribTR_DS1_CH6500	29.55	29.52	-0.03
H_TribTR_DS1_CH6100	30.70	30.66	-0.03
H_TribTR_DS1_CH6000	31.28	31.23	-0.04
H_TribTR_DS1_CH4900	34.42	34.39	-0.03
H_TribTR_DS1_CH4200	36.87	36.77	-0.10
H_TribTR_CH3000	42.36	42.31	-0.05
H_TribTR_CH2200	45.23	45.40	0.17
H_TribTR_CH2100_Trib	48.10	48.17	0.07
H_TribTR_CH2000_Trib	48.94	48.98	0.03
H_TribTR_CH1750	47.45	47.65	0.20
H_TribTR_CH1250	50.47	50.41	-0.06
H_TribTR_CH1150	51.02	52.63	1.61
H_TribTR_CH900_Trib1	65.76	65.71	-0.05
H_TribTR_CH900_Trib2	62.75	62.43	-0.32
H_TribTR_CH700	53.81	53.80	-0.01
H_TribTR_CH30	58.93	58.93	0.00
H_TribTR_CH0	59.51	59.51	0.00
H_SDYCK_DS3_CH9400	24.46	24.41	-0.04
H_SDYCK_DS3_CH8900	25.91	25.88	-0.04
H_SDYCK_DS2_CH7500	29.59	29.52	-0.07
H_SDYCK_CH7000	31.26	31.20	-0.06
H_SDYCK_CH4200	41.19	41.13	-0.07
H_SDYCK_CH2650_Trib1	59.70	60.18	0.48
H_SDYCK_CH2650_Trib2	57.40	57.57	0.17
H_FSTCK_CH10800	21.74	21.73	-0.02
H_FSTCK_CH10200	23.20	23.18	-0.02
H_FSTCK_CH9700	24.38	24.37	-0.01
H_FSTCK_CH9100	26.07	26.07	-0.01
H_FSTCK_CH8500	28.52	28.52	-0.01
H_FSTCK_CH7300_trib1	41.88	42.54	0.66
H_FSTCK_CH7300_trib2	40.70	40.58	-0.12
H_FSTCK_CH3800_Trib1	54.37	55.27	0.90
H_FSTCK_CH3800_Trib2	53.51	53.58	0.07

Flagstone City-Masterplan

APPENDIX

F

Pre & Post-Development Hydrographs

Location*	100 Year ARI Peak Flood Level (mAHD)		Impact (m)
	Existing Case (E21e)	Developed Case (M32e)	
H_TribTR_DS1_CH6000	31.28	31.23	-0.04
H_TribTR_DS1_CH6100	30.70	30.66	-0.03
H_TRBRIDGE_US_CH3000	41.53	42.59	1.07
H_SDYCK_BRIDGE1_US_CH5200	37.67	37.57	-0.11
H_FSTCK_CH6700	37.12	37.03	-0.09
H_FSTCK_CH7300_trib2	40.70	40.58	-0.12
H_FSTCH_CH10650_TEVRD_US	22.18	22.16	-0.02
H_TribTR_DS1_CH6500	29.55	29.52	-0.03
H_TribTR_DS1_CH6500	29.55	29.52	-0.03
H_TribTR_DS1_CH6600	28.95	28.93	-0.02
H_SDYCK_DS1_CH6250	34.12	34.03	-0.10
H_SDYCK_DS2_CH7500	29.59	29.52	-0.07
H_FSTCK_CH10800	21.74	21.73	-0.02
H_TRBRIDGE_US_CH3250	40.55	40.49	-0.06
H_FSTCK_CH6900	36.33	36.26	-0.07
H_SDYCK_US1_CH6400	33.11	32.93	-0.18
H_FSTCK_CH8500	28.52	28.52	-0.01
H_TribTR_DS1_CH4900	34.42	34.39	-0.03
H_TribTR_DS1_CH4200	36.87	36.77	-0.10
H_SDYCK_CH7000	31.26	31.20	-0.06
H_SDYCK_DS3_CH8900	25.91	25.88	-0.04
H_FSTCK_CH9700	24.38	24.37	-0.01
H_FSTCK_CH9100	26.07	26.07	-0.01
H_SDYCK_DS3_CH9400	24.46	24.41	-0.04
H_FSTCK_CH10200	23.20	23.18	-0.02
H_Poinciana Dr RP2	34.65	34.65	0.00
H_Poinciana Dr RP1	34.53	34.53	0.00
H_Poinciana Dr RP3	36.81	36.81	0.00
H_Poinciana Dr RP4	35.15	35.15	0.00
H_FSTCK_CH7500	32.83	32.78	-0.05

*refer to Figure G.1 for locations

Location*	100 Year ARI Peak Flow (m ³ /s)		Impact (m ³ /s)
	Existing Case (E21e)	Developed Case (M32e)	
Q_SDYCK_DS2_CH7500	99.7	95.0	-4.7
Q_SDYCK_BRIDGE1_US_CH5300	97.6	89.7	-7.9
Q_SCBRIDGE_DS_CH5450	97.5	89.8	-7.7
Q_TribTr_BridgeUS_CH3100	48.2	44.5	-3.7
Q_TribTr_BridgeDS_CH3190	48.0	44.4	-3.7
Q_SDYCK_CH6700_Trib	3.2	0.0	-3.2
Q_FSTCH_CH10650_TEVRD_US	265.7	262.3	-3.3
Q_SDYCK_DS3_CH9400	171.8	168.2	-3.6
Q_TribTR_DS1_CH6600	66.2	64.8	-1.4
Q_TribTR_DS1_CH4200	54.0	47.2	-6.7
Q_TribTR_DS1_CH4900	63.7	59.3	-4.4
Q_FSTCK_CH9700	96.8	96.7	-0.1
Q_SDYCK_DS3_CH8900	172.6	169.0	-3.6
Q_FSTCK_CH10200	267.3	263.4	-3.9
Q_FSTCH_CH11000_TEVRD_DS	268.5	265.7	-2.8
Q_SDYCK_DS1_CH6200	97.5	91.4	-6.1
Q_Poinciana Dr	0.0	0.0	0.0
Q_SDYCK_US1_CH6400	97.9	92.2	-5.7
Q_SDYCK_CH7000	100.0	95.4	-4.6
Q_FSTCK_CH7500	92.3	88.5	-3.8

*refer to Figure G.2 for locations

Figure G.1

Flagstone City

Water Level Reporting Points



LEGEND

● Reporting Points

Scale: 1:30,000



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Level 11, North Tower, 515 St Pauls Terrace
Locked Bag 4006, Fortitude Valley QLD 4006
Tel: 07 3369 9822 Fax: 07 3369 9722

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SHEET

A4

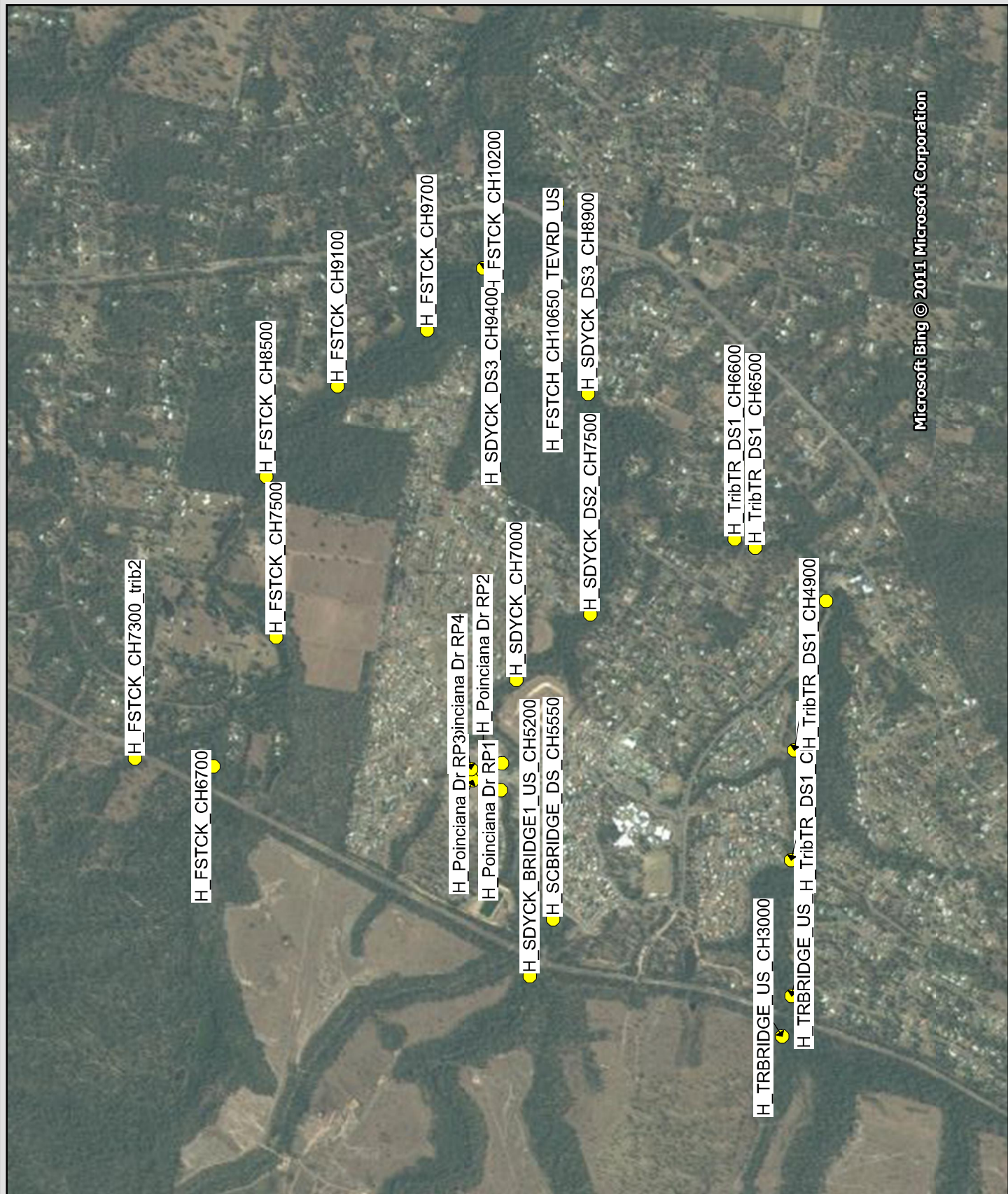
Project No:

Date: _____

Revision Number:	
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Designed by:

Client Name:



Flow Reporting Lines



LEGEND

Reporting Lines

0 300 600
Metres
Scale: 1:30,000



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Project No:

Date:

Revision Number:

Designed by:

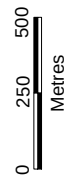
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**Flagstone City
Time Series
Water Level
Reporting Point**



LEGEND

● Reporting Points



Scale: 1:25,000



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Locked Bag 4006, Fortitude Valley QLD 4006
Tel: 07 3369 9822 Fax: 07 3369 9722

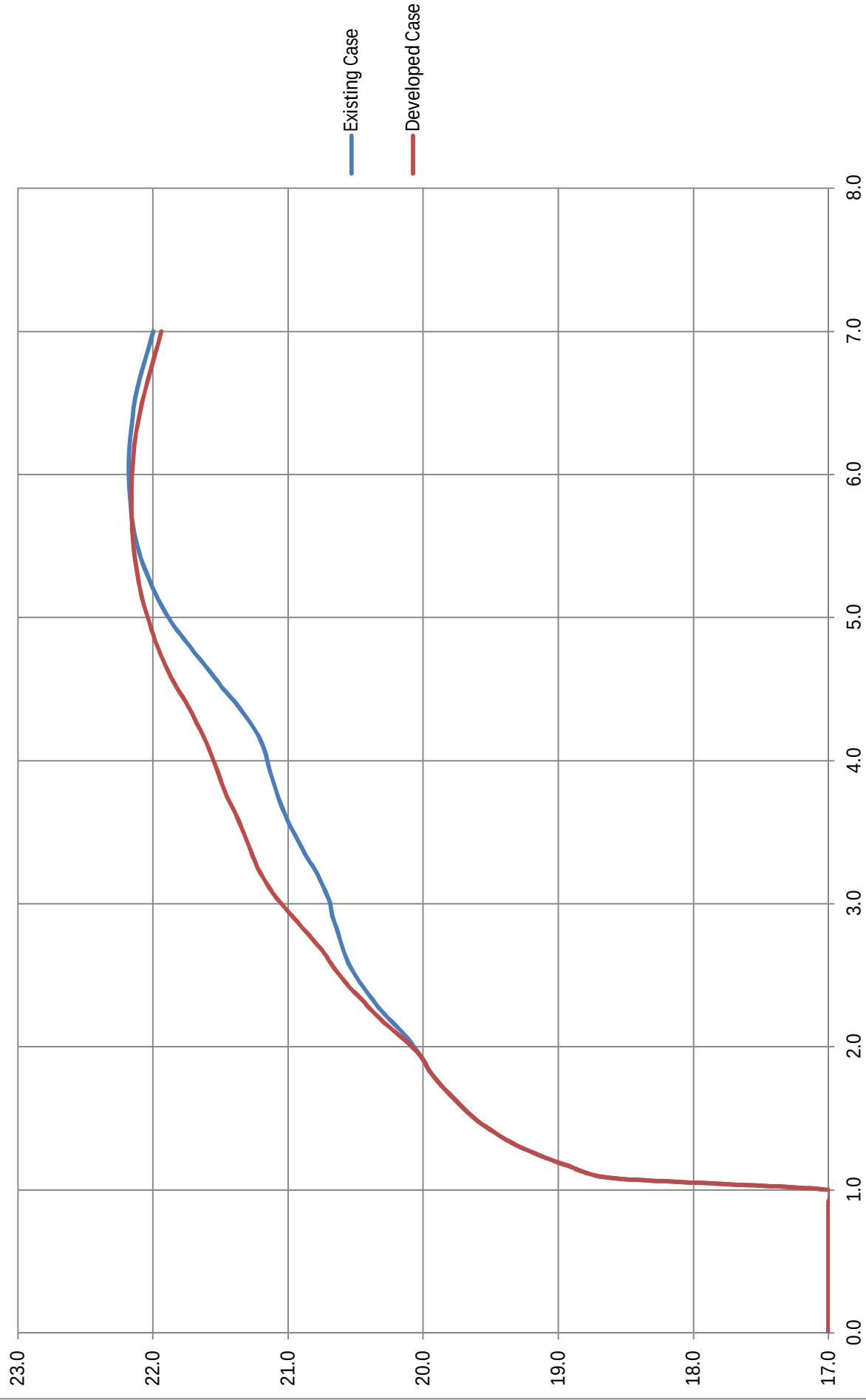
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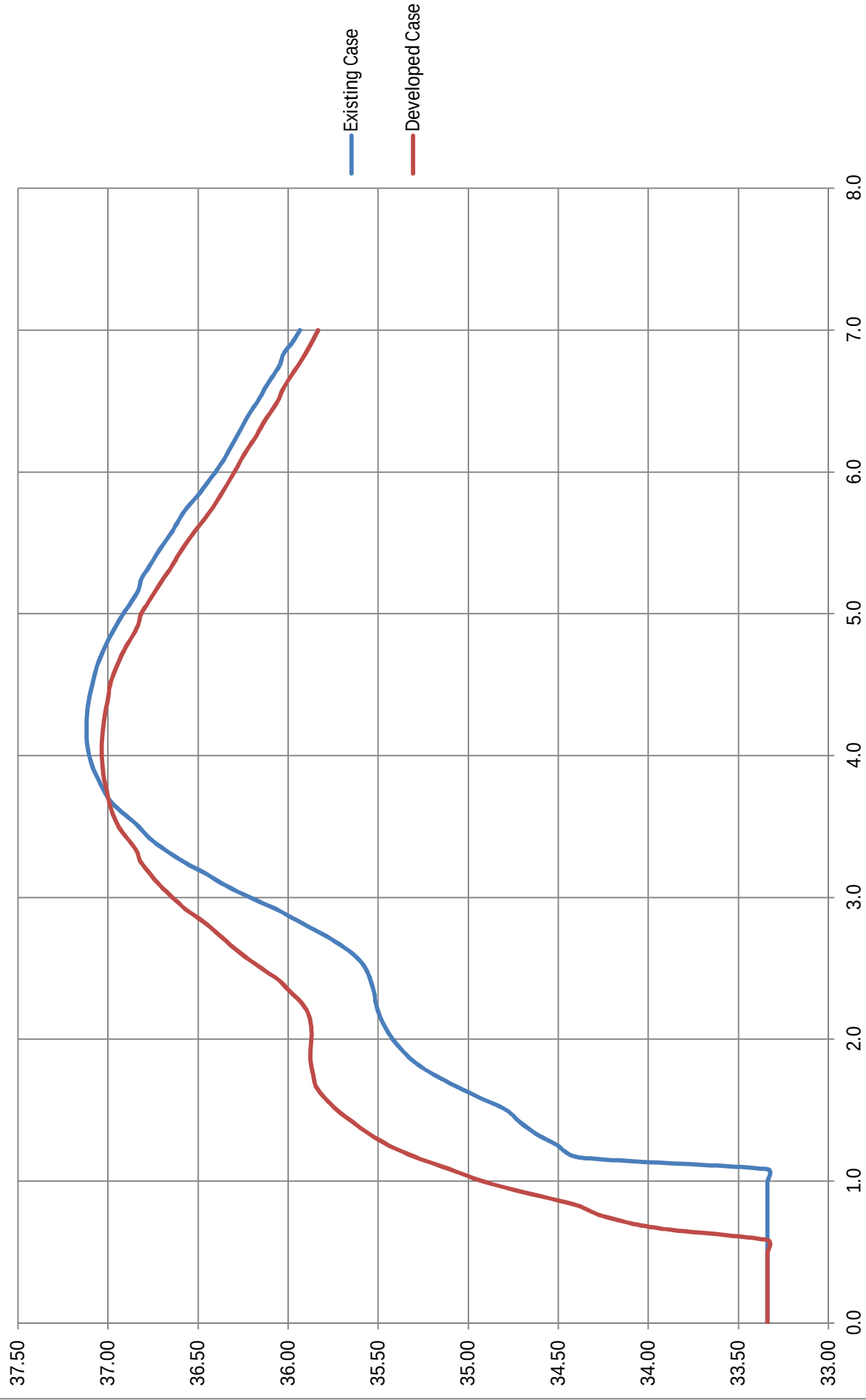
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Revision Number:	
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Client Name:	

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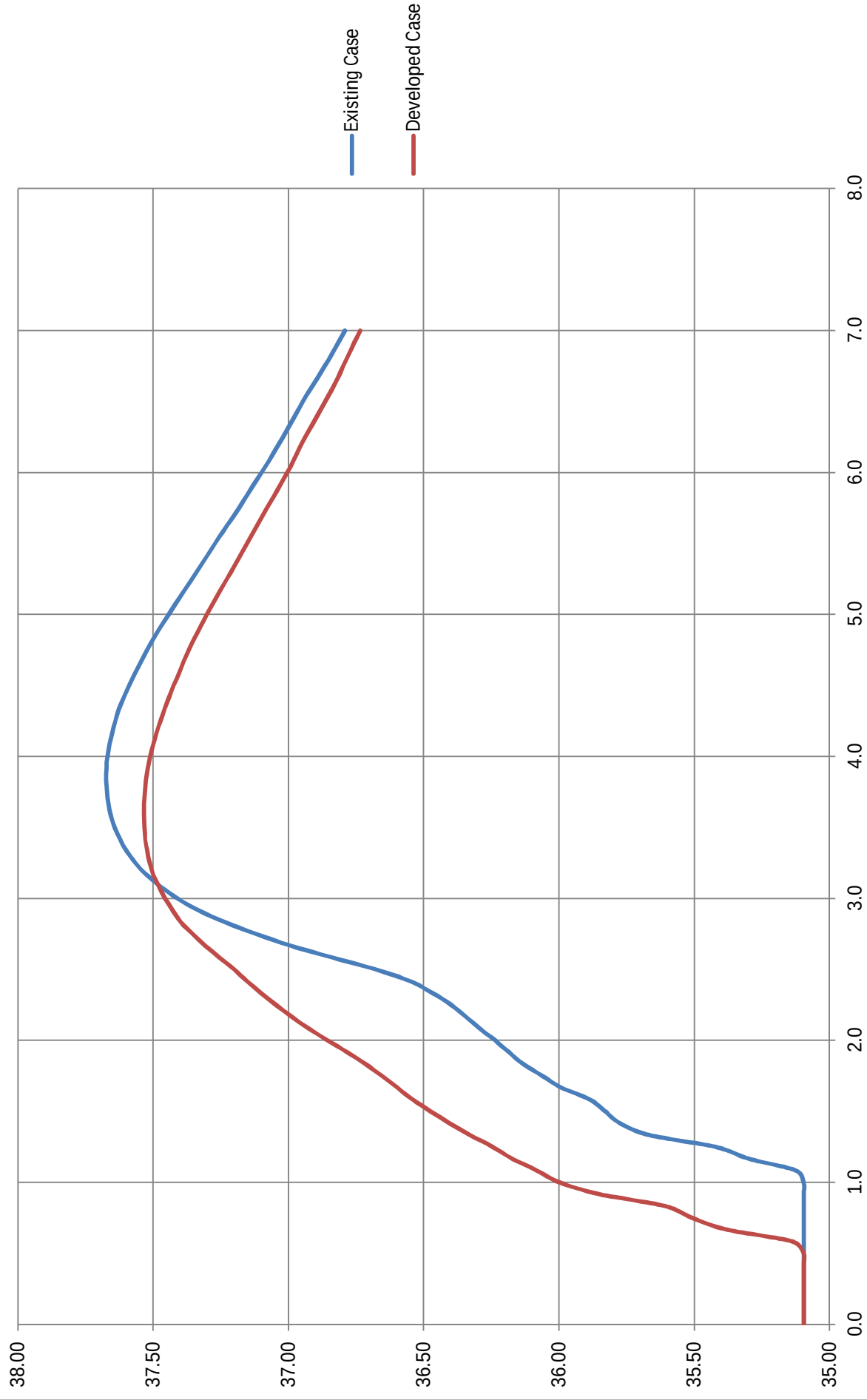
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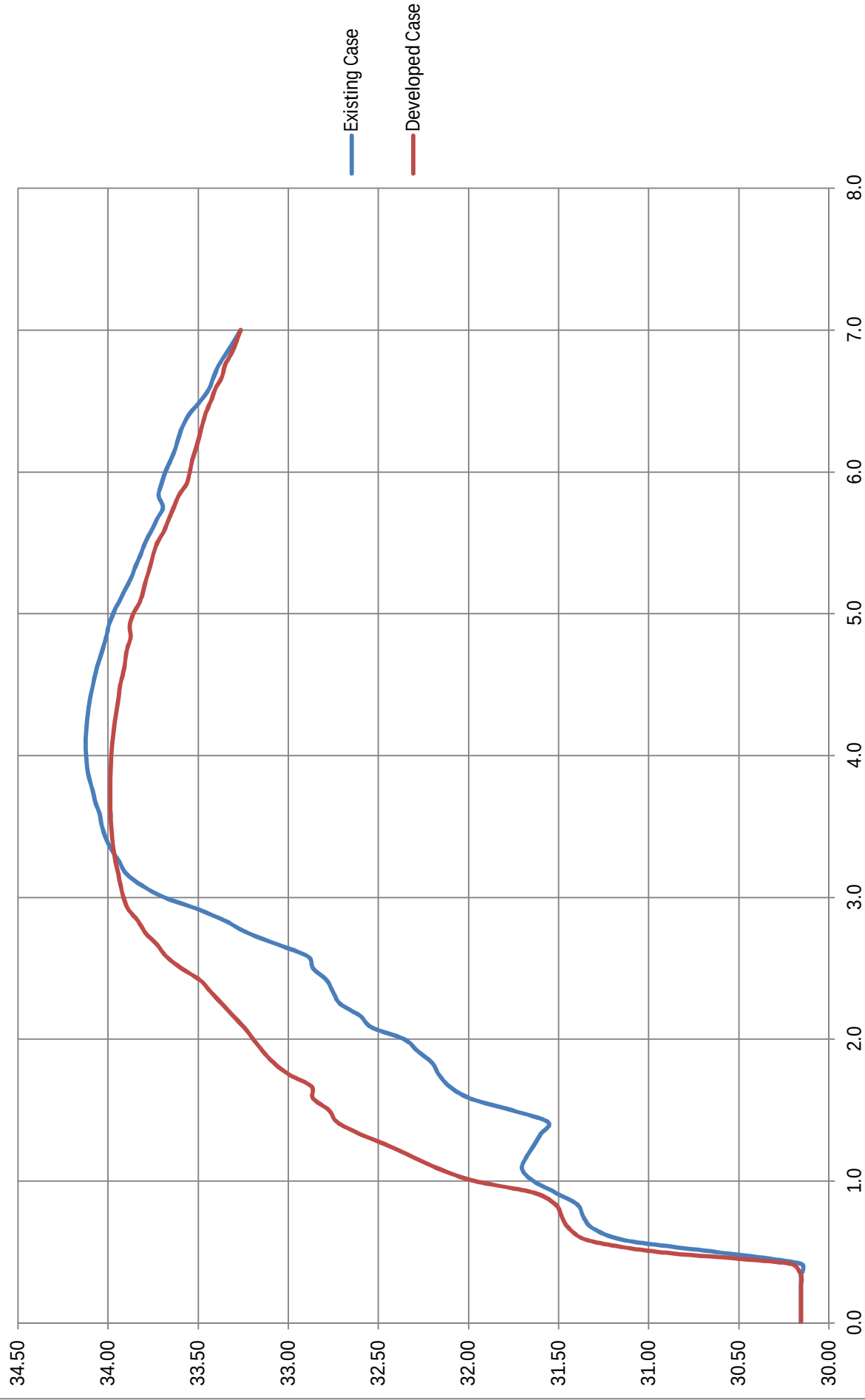
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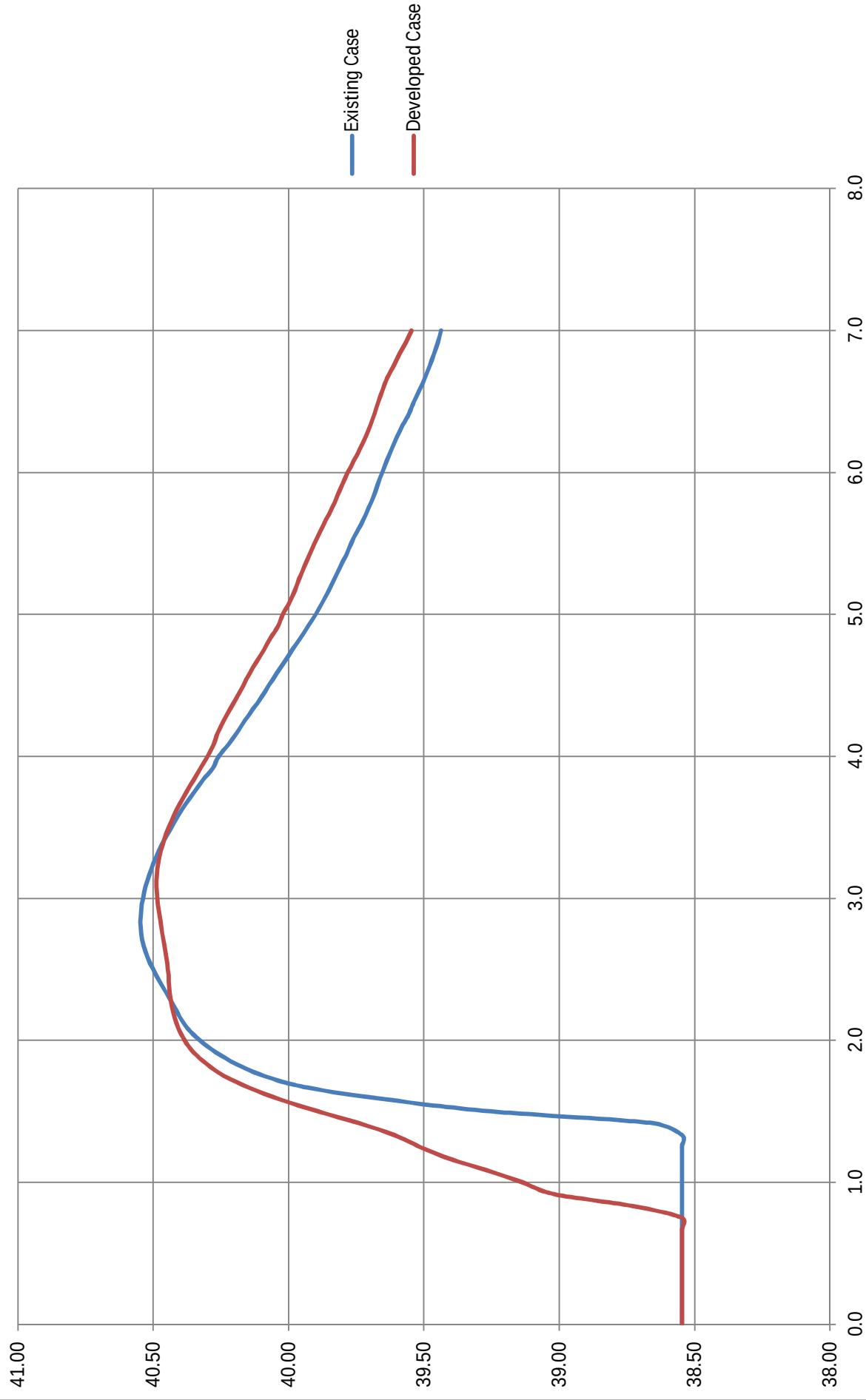
Time Series of Q100 180min Water Level - SDYCK_BRIDGE1_US_CH5200



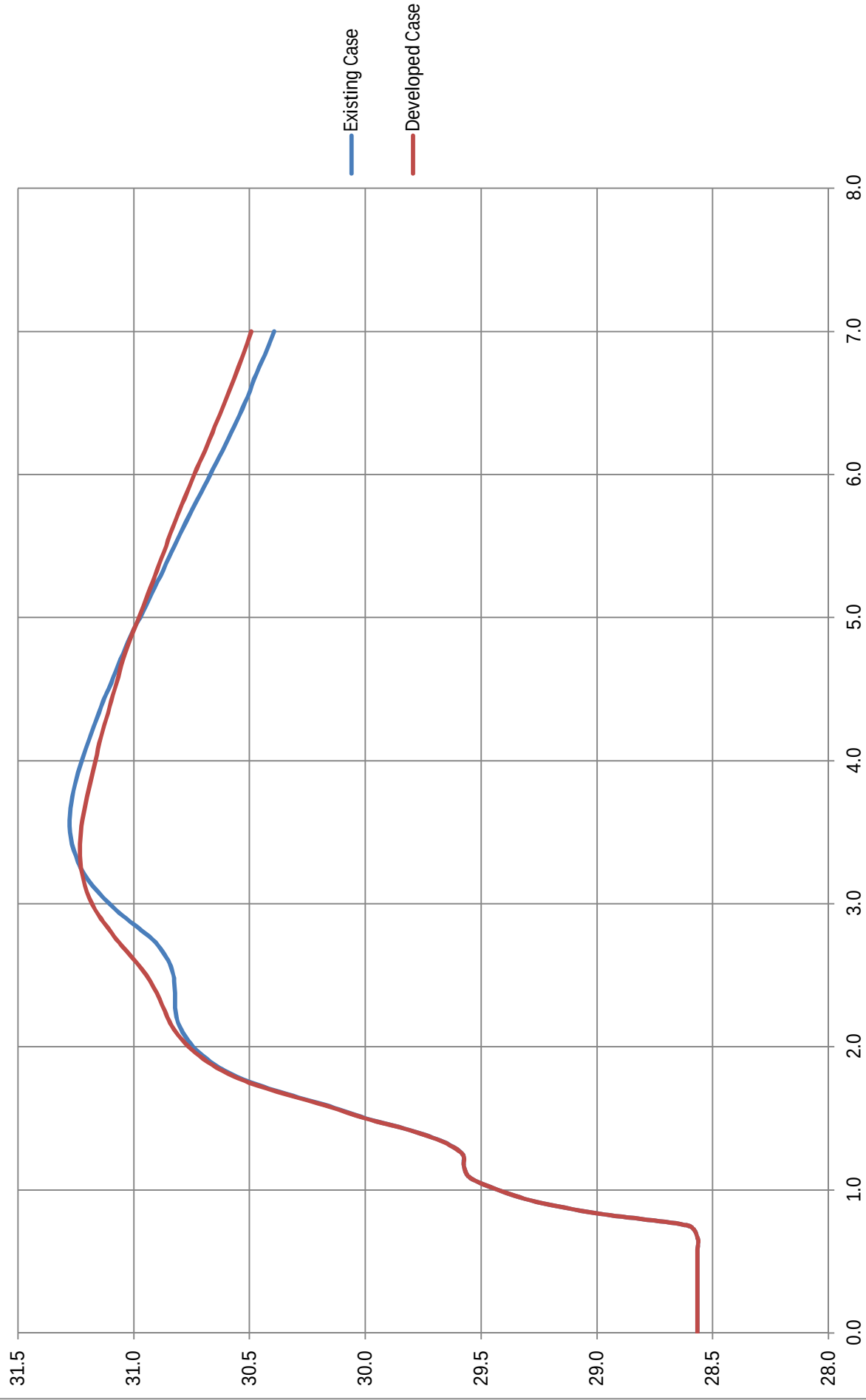
Time Series of Q100 180min Water Level - SDYCK_DS1_CH6250



Time Series of Q100 180min Water Level - TRBRIDGE_US_CH3250



Time Series of Q100 180min Water Level - TribTR_DS1_CH6000



Time Series of Q100 270min Water Level - TribTR_DS1_CH6500

