Appendix 16
Hydrological and Hydraulic Flood Modelling

DHI Water and Environment

September 2008



Warner Industrial Park
Preferred Project Report Concept Plan and Project Application

Precinct 14 WEZ

Sparks Rd and Hue Hue Rd
Warnervale
May 2009

80
TERRACE
TOWER
GROUP

Warner Business Park Pty Ltd
Part of the Terrace Tower Group

Peter Andrews + Associates Pty Ltd
architecture planning urban design

By email

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Date: 16/09/2008

Re: Warner Industrial Park – Precinct 14

Introduction /Background

The NSW Department of Planning has requested additional information on the impacts of climate change on flooding issues for the Warner Industrial Park – Precinct 14. The request specifies that *'The adequacy of the design of the stormwater management system, development footprint and proposed freeboard must be assessed in the context of climate-change induced increases in the frequency of storms and floods'*.

DHI Water and Environment was engaged by Trehy Ingold Neate (TIN) on behalf of Warner Business Park Pty Ltd to carry out hydrological and hydraulic flood modelling to provide data to address the above requirements of the Department of Planning in considering the impacts of climate change on flood levels for the above titled development.

This report presents the flood levels across the development site as assessed for the existing 1% AEP event and the increased rainfall intensities, based on the current NSW Department of Environment and Climate Change (DECC) guidelines for assessing the effects of climate change on flooding. The rainfall intensities that have been simulated for climate change represent increases of 10%, 20% and 30% above the existing 1% AEP event.

Methodology

The assessment of impacts of climate change for flooding at the site has been carried out through sensitivity tests of increased rainfall intensity over current estimates for the 1% AEP storm event. Following DECC guidelines, the assessment has been undertaken with the increased rainfall intensities of 10%, 20% and 30% for the 1% AEP. Two storm durations of 2 hours and 9 hours have been simulated in line with the previously assessed critical storm duration for the site and the maximum water level from the two durations calculated.

The study has been undertaken using existing hydrological (RORB) and hydraulic (MIKE 11) models of the Buttonderry Creek and Precinct 14, which had been used in previous flood modelling of the proposed Warner Industrial Park.

The broad approach for this assessment was as follows:

- Re-establishment of the RORB hydrological model to simulate catchment runoff for the 1% AEP event;
- Hydrological model simulations to generate runoff for 10%, 20% and 30% increases in rainfall intensity above the existing 1% AEP;
- Re-establishment of the existing MIKE 11 hydraulic model from archives;

- MIKE 11 hydraulic model simulations using runoff hydrographs from the RORB simulations for the increased rainfall intensities; and
- Analysis of model results and presentation of flood level for the increased rainfall intensities.

Hydrological Modelling

The RORB hydrological model inclusive of the Buttonderry Creek and Mountain Road Tributary catchments provides the input flows to the MIKE 11 flood model. The RORB model was originally developed for the "Buttonderry Creek Flood Investigation" study in 1997 by Paterson Consultants and was later revised in 2005 for the "Buttonderry Creek Flood Study - Precincts 11, 13 and 14" by Matrix Plus Consulting[1]. The revised hydrological model included changes or updates in loss parameters, impervious areas, model layout and catchment boundaries, hydrograph locations, design rainfall intensities and peak flows.

The 1997 RORB model files were provided to DHI by Wyong Shire Council (WSC) for use in this study, together with the Matrix Consulting report on the 2005 flood study, which described the changes and updates to the 1997 model. The 2005 RORB model was not provided to DHI and it was necessary to update the 1997 model to reproduce the results of the 2005 model for use in this study. A complicating factor was that the model files provided by WSC did not contain rainfall information for the 1% AEP, only details of the physical catchment parameters.

The 1997 RORB model was first updated with the information contained in the report on the 2005 model. Rainfall distributions for the 1% AEP for 2 hour and 9 hour events were then generated in compliance with the approach recommended in Australian Rainfall and Runoff[2] to provide the same total rainfall as documented in the 2005 flood study report and the RORB model run for these events. Further adjustment and fine-tuning of the RORB model parameters was required in order to achieve a satisfactory match with the previously published catchment runoff hydrographs (See Tables A1 and A2 in Attachment A).

Verification of the predicted runoff values for the updated model was confirmed by applying the new runoff hydrographs to the existing MIKE 11 model and comparing the peak water level results with those from the previous studies for the 1% AEP. A satisfactory match between the predicted flood levels was achieved using the new runoff hydrographs (see Tables A3 and A4 in Attachment A).

Using the re-established RORB hydrological model, runoff hydrographs were generated for the climate change scenarios as represented by 10%, 20% and 30% increases in rainfall intensity above the existing 1% AEP. The rainfall intensities applied are summarised in Table 1.

Table 1: 1% AEP and increased rainfall intensities

Duration	**Rainfall Intensity (mm/hour)**			
	1% AEP	**10% increase**	**20% increase**	**30% increase**
2 hours	53.40	58.74	64.08	69.42
9 hours	23.00	25.30	27.60	29.90

Runoff hydrographs for the above rainfall intensities were generated for both 2 and 9 hour rainfall durations and then used as input in the MIKE 11 hydraulic model simulations, which are described below.

Hydraulic Model Simulations

The existing MIKE 11 hydraulic model for the Warner Industrial Park has been retrieved from DHI archives and the model re-established for this study. The hydraulic modelling has been conducted with the following conditions:

[1] Buttonderry Creek Flood Study – Precincts 11, 13, 14 , Final Report (Version 2 Final), Matrix Plus Consulting, 2005.
[2] Australian Rainfall and Runoff. Volume 1. A Guide to Flood Estimation. The Institution of Engineers, Australia, 2001.

- Value of Manning's 'n' 0.060 for all catchments;
- Option C for Catchment F2 with industrial land to the east (as per DHI report dated 14 Sept 2007);
- 20m wide bridge on Catchment B1 (as per DHI report dated 2 May 2007); and
- Additional flood storage at the South-East corner of Precinct 14, adjacent to the Freeway embankment with the aim of minimizing the flood levels along the channel F2 (as per DHI report dated 14 Sept 2007).

A total of eight hydraulic model simulations have been carried out in MIKE 11 using the runoff hydrographs from the re-established RORB hydrological model. Four scenarios, comprising the 1% AEP rainfall and the 10%, 20% and 30% increases in rainfall, have each been simulated for 2 hour and 9 hour duration storms. The results from these simulations have been presented below in Tables 2 and 3. The maximum flood levels in the tables have been calculated as the maximum values at each cross-section location from the 2 hour and 9 hour storms for the F2 channel and Buttonderry Creek (B1). The locations of the cross-sections are shown in Figure 1, which presents an extract of the MIKE 11 network for F2 channel and Buttonderry Creek (B1).

Table 2 Predicted Maximum Flood Levels along F2 Channel

Model Location	**Peak Flood Level (m AHD)**			
	1% AEP Base case	**1% AEP + 10% (increase over base case)**	**1% AEP + 20% (increase over base case)**	**1% AEP + 30% (increase over base case)**
F2 0.00	25.24	25.27 (0.03)	25.29 (0.05)	25.31 (0.07)
F2 90.00	24.79	24.82 (0.03)	24.85 (0.06)	24.88 (0.09)
F2 140.00	24.42	24.48 (0.06)	24.54 (0.12)	24.59 (0.17)
F2 210.00	24.10	24.16 (0.06)	24.22 (0.12)	24.27 (0.17)
F2 280.00	23.57	23.62 (0.06)	23.68 (0.11)	23.73 (0.16)
F2 350.00	22.99	23.04 (0.06)	23.10 (0.12)	23.15 (0.17)
F2 420.00	22.43	22.49 (0.06)	22.55 (0.12)	22.60 (0.17)
F2 490.00	21.85	21.91 (0.06)	21.96 (0.12)	22.02 (0.17)
F2 560.00	21.23	21.29 (0.06)	21.35 (0.12)	21.40 (0.17)
F2 630.00	20.63	20.69 (0.06)	20.75 (0.12)	20.80 (0.17)
F2 700.00	20.07	20.13 (0.06)	20.19 (0.12)	20.24 (0.17)
F2 770.00	19.72	19.78 (0.06)	19.84 (0.12)	20.02 (0.30)
F2 840.00	19.41	19.51 (0.10)	19.79 (0.38)	20.01 (0.60)
F2 910.00	19.09	19.50 (0.40)	19.79 (0.69)	20.01 (0.91)
F2 980.00	19.09	19.50 (0.41)	19.79 (0.70)	20.01 (0.92)
F2 1050.00	19.09	19.50 (0.41)	19.79 (0.70)	20.01 (0.92)

Table 3 Predicted Maximum Flood Levels along Buttonderry Creek (B1 Channel)

Model Location	Flood Level (mAHD)			
	1% AEP (base case)	1% AEP + 10% (increase over base case)	1% AEP + 20% (increase over base case)	1% AEP + 30% (increase over base case)
B1 -373.00	24.16	24.23 (0.07)	24.30 (0.15)	24.37 (0.21)
B1 -323.00	23.99	24.06 (0.07)	24.12 (0.13)	24.19 (0.20)
B1 -273.00	23.69	23.75 (0.06)	23.81 (0.12)	23.87 (0.17)
B1 -223.00	23.37	23.42 (0.06)	23.48 (0.11)	23.53 (0.17)
B1 -173.00	23.20	23.25 (0.05)	23.30 (0.10)	23.35 (0.15)
B1 -123.00	23.10	23.15 (0.05)	23.20 (0.10)	23.25 (0.15)
B1 -73.00	23.07	23.12 (0.05)	23.16 (0.10)	23.21 (0.14)
B1 -53.00	23.06	23.11 (0.05)	23.15 (0.09)	23.20 (0.14)
B1 -43.00	23.06	23.10 (0.05)	23.15 (0.09)	23.19 (0.14)
B1 -28.00	22.54	22.62 (0.09)	22.70 (0.16)	22.76 (0.22)
B1 0.00	22.33	22.42 (0.08)	22.49 (0.16)	22.55 (0.22)
B1 70.00	21.46	21.54 (0.09)	21.63 (0.17)	21.70 (0.24)
B1 140.00	20.87	20.94 (0.07)	21.01 (0.13)	21.07 (0.19)
B1 210.00	20.76	20.83 (0.07)	20.89 (0.13)	20.95 (0.19)
B1 280.00	20.52	20.58 (0.06)	20.64 (0.12)	20.70 (0.18)
B1 310.00	20.36	20.44 (0.08)	20.51 (0.15)	20.58 (0.22)
B1 350.00	20.33	20.41 (0.08)	20.48 (0.15)	20.56 (0.23)
B1 372.00	20.24	20.31 (0.07)	20.39 (0.15)	20.46 (0.22)
B1 420.00	20.16	20.24 (0.08)	20.32 (0.15)	20.39 (0.23)
B1 490.00	20.00	20.08 (0.08)	20.16 (0.16)	20.25 (0.26)
B1 560.00	19.71	19.81 (0.10)	19.93 (0.22)	20.10 (0.39)
B1 630.00	19.66	19.76 (0.10)	19.90 (0.23)	20.08 (0.41)
B1 670.00	19.66	19.77 (0.10)	19.90 (0.23)	20.08 (0.41)
B1 700.00	19.66	19.76 (0.10)	19.90 (0.23)	20.08 (0.41)
B1 730.00	19.66	19.76 (0.10)	19.90 (0.23)	20.08 (0.41)
B1 745.00	19.66	19.76 (0.10)	19.90 (0.23)	20.08 (0.41)

The results in Table 2 show that the flood levels at the downstream end of F2 channel are particularly sensitive to the increases in rainfall intensity. Changes in peak water levels in this area are more susceptible to changes in rainfall intensity due to the propensity for further connectivity and flow interactions between the Buttonderry Creek channel and the F2 channel at higher channel flow rates. . This increased flow exchange is caused by higher water levels in Buttonderry Creek compared to the F2 channel. As catchment runoff increases the excess flow water in the F2 channel which is unable to pass under the freeway due to insufficient culvert capacity, causes flood levels to increase. This effect is most noticeable for the 30% increase in rainfall which has the greater difference between the catchment runoff flows and the capacity of the culvert, which is only just sufficient to pass the base 1% AEP flow.

The modelling also predicts that water levels resulting from the increased rainfall intensities will exceed the top bank level in several locations. In these locations, the model provides a conservative estimate of water levels since MIKE 11 estimates peak flood level by extrapolating the available cross section attributes as previously provided by TIN. The degree of conservatism is not likely to be significant, but it is not possible to quantify without modifying the cross-sections and re-running the model, which is beyond the scope of this study.

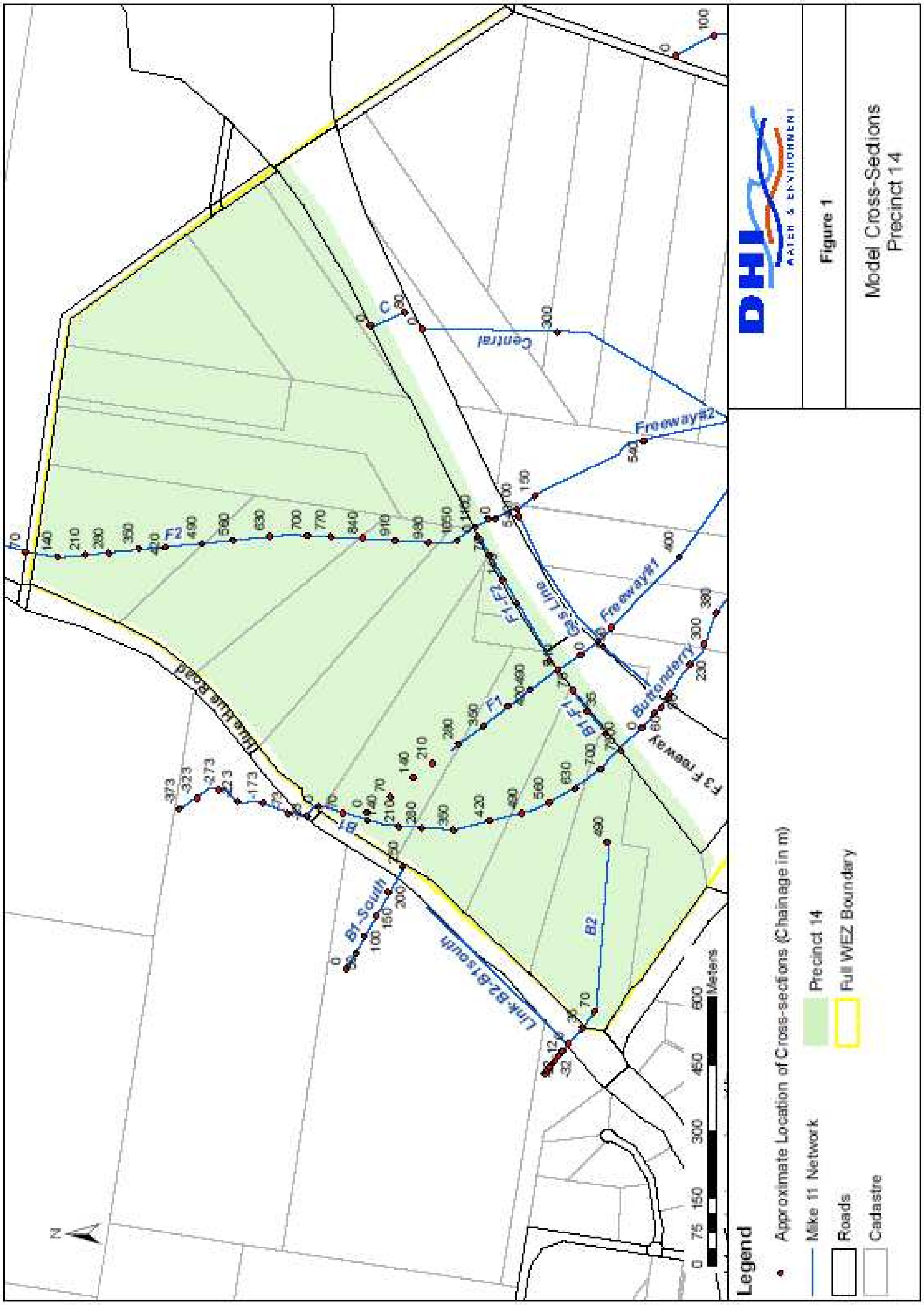
The modelling predicts that velocities at the downstream end of F2 channel decrease as the water level increases. At the peak water level of 20.01m the velocities are predicted to be less than 0.1 m/s adjacent to the freeway for the 1% AEP plus 30% rainfall scenario.

We trust the above report provides you with sufficient information. If you require further please do not hesitate to contact the undersigned.

Yours sincerely,
DHI Water and Environment Pty Ltd

Craig Allery
Principal Engineer

Verified by: Grantley Smith
Date: 29 September 2008


Legend
Approximate Location of Cross-sections (Chainage in m)
Mike 11 Network
Roads
Cadastre
Precinct 14
Full WEZ Boundary
Meters
DHI
Figure 1
Model Cross-Sections
Precinct 14
Hue Hue Road
F3 Freeway
Gas Line
Central
Freeway#1
Freeway#2
Buttonderry
Link-B2-B1south
B1-South

Attachment A

Table A1: Comparison of Runoff Peaks from Previous and New RORB Models (100 Year 2 Hour)

Hydrograph Identifier	Description	Peak Runoff (m^3/s)		Error (%)
		Previous Model	New Model	
B1	Buttonderry Creek at Hue Hue Road (RORB subcatchments 1-4, 5a)	63.440	63.384	0.09
B2	B2 Catchment Tributary at Hue Hue Road (RORB subcatchment 6a)	6.540	6.524	0.24
F2	Freeway 2 Tributary at Hue Hue Road (RORB subcatchment 8)	30.920	30.831	0.29
5b	RORB subcatchment 5b	13.310	13.251	0.44
6b	RORB subcatchment 6b	10.200	10.252	0.51
9a	RORB subcatchment 9a	15.680	15.597	0.53
9b	RORB subcatchment 9b	11.920	11.918	0.02
i2	RORB subcatchment 7	28.310	28.287	0.08
i4	RORB subcatchment 10	28.310	28.289	0.07
i5	RORB subcatchment 11	11.440	11.430	0.09
i6	RORB subcatchment 12	14.540	14.535	0.03
i7	RORB subcatchment 13	11.430	11.410	0.17

Table A2: Comparison of Runoff Peaks from Previous and New RORB Models (100 Year 9 Hour)

Hydrograph Identifier	Description	Peak Runoff (m^3/s)		Error (%)
		Previous Model	New Model	
B1	Buttonderry Creek at Hue Hue Road (RORB subcatchments 1-4, 5a)	67.690	67.505	0.27
B2	B2 Catchment Tributary at Hue Hue Road (RORB subcatchment 6a)	2.393	2.368	1.04
F2	Freeway 2 Tributary at Hue Hue Road (RORB subcatchment 8)	17.300	17.053	1.43
5b	RORB subcatchment 5b	6.774	6.727	0.69
6b	RORB subcatchment 6b	5.301	5.255	0.86
9a	RORB subcatchment 9a	10.160	10.150	0.10
9b	RORB subcatchment 9b	6.679	6.590	1.33
i2	RORB subcatchment 7	9.988	9.968	0.20
i4	RORB subcatchment 10	18.350	18.220	0.71
i5	RORB subcatchment 11	8.946	8.912	0.38
i6	RORB subcatchment 12	11.160	11.161	0.01
i7	RORB subcatchment 13	5.961	5.960	0.02

Table A3: Comparison of Simulated Water Levels using Runoff from Previous and New RORB Model (100 Year 2 Hour)

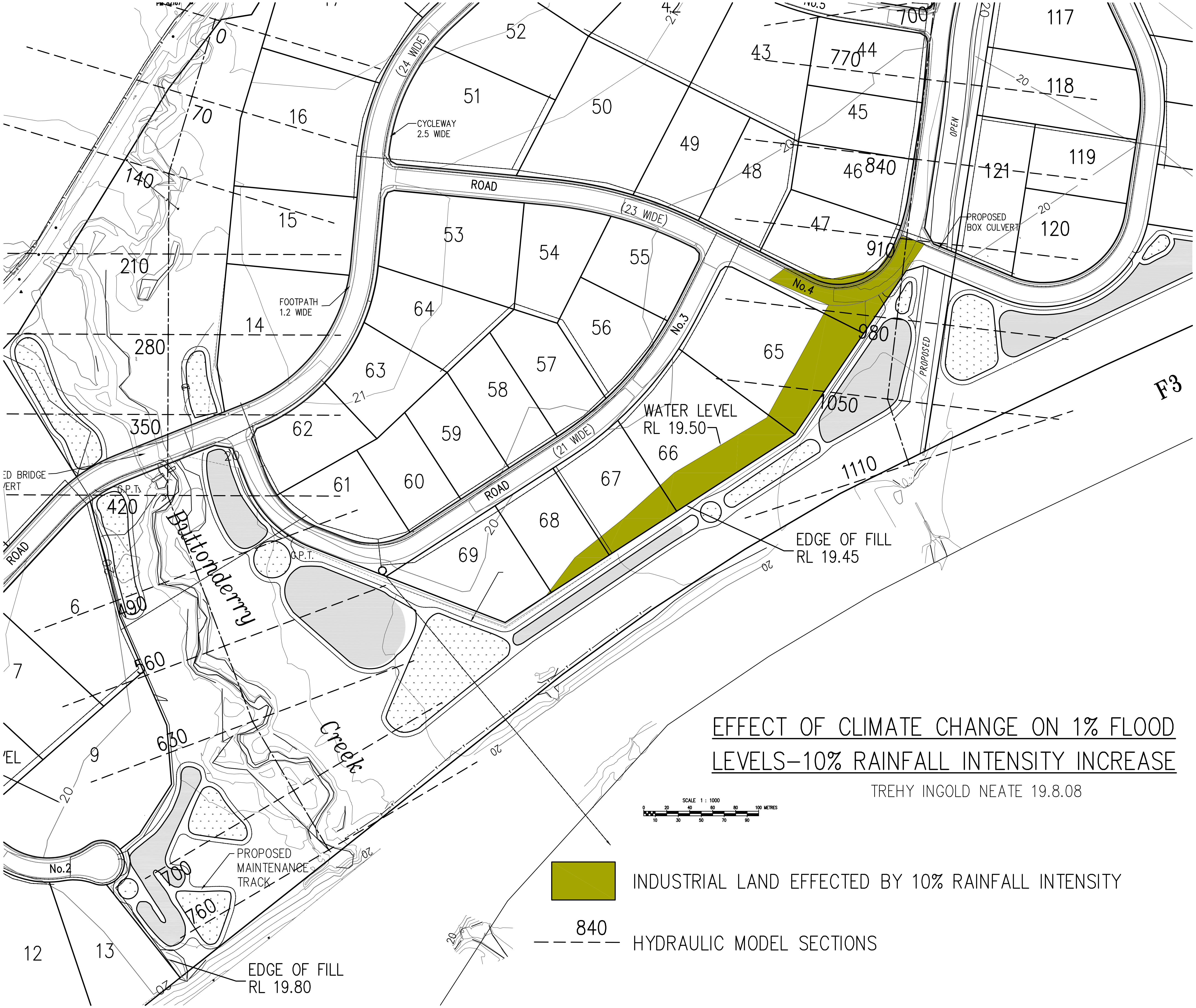
Model Location	Maximum Water Level (mAHD)		Difference (m)
	Previous Model	New Model	
F2 0.00	25.240	25.240	0.000
F2 90.00	24.790	24.791	0.001
F2 140.00	24.416	24.417	0.001
F2 210.00	24.100	24.101	0.001
F2 280.00	23.566	23.567	0.001
F2 350.00	22.984	22.985	0.001
F2 420.00	22.428	22.429	0.001
F2 490.00	21.848	21.848	0.000
F2 560.00	21.230	21.231	0.001
F2 630.00	20.627	20.627	0.000
F2 700.00	20.069	20.070	0.001
F2 770.00	19.714	19.715	0.001
F2 840.00	19.407	19.409	0.002
F2 910.00	18.891	18.894	0.003
F2 980.00	18.712	18.724	0.012
F2 1050.00	18.702	18.715	0.013

Table A4: Comparison of Simulated Water Levels using Runoff from Previous and New RORB Model (100 Year 9 Hour)

Model Location	Maximum Water Level (mAHD)		Difference (m)
	Previous Model	New Model	
F2 0.00	25.118	25.115	-0.003
F2 90.00	24.669	24.667	-0.002
F2 140.00	24.126	24.120	-0.006
F2 210.00	23.841	23.836	-0.005
F2 280.00	23.314	23.309	-0.005
F2 350.00	22.727	22.722	-0.005
F2 420.00	22.171	22.165	-0.006
F2 490.00	21.595	21.589	-0.006
F2 560.00	20.975	20.970	-0.005
F2 630.00	20.366	20.361	-0.005
F2 700.00	19.795	19.789	-0.006
F2 770.00	19.428	19.421	-0.007
F2 840.00	19.156	19.150	-0.006
F2 910.00	19.077	19.093	0.016
F2 980.00	19.072	19.090	0.018
F2 1050.00	19.072	19.089	0.017

EFFECT OF CLIMATE CHANGE ON 1% FLOOD LEVELS–10% RAINFALL INTENSITY INCREASE

TREHY INGOLD NEATE 19.8.08

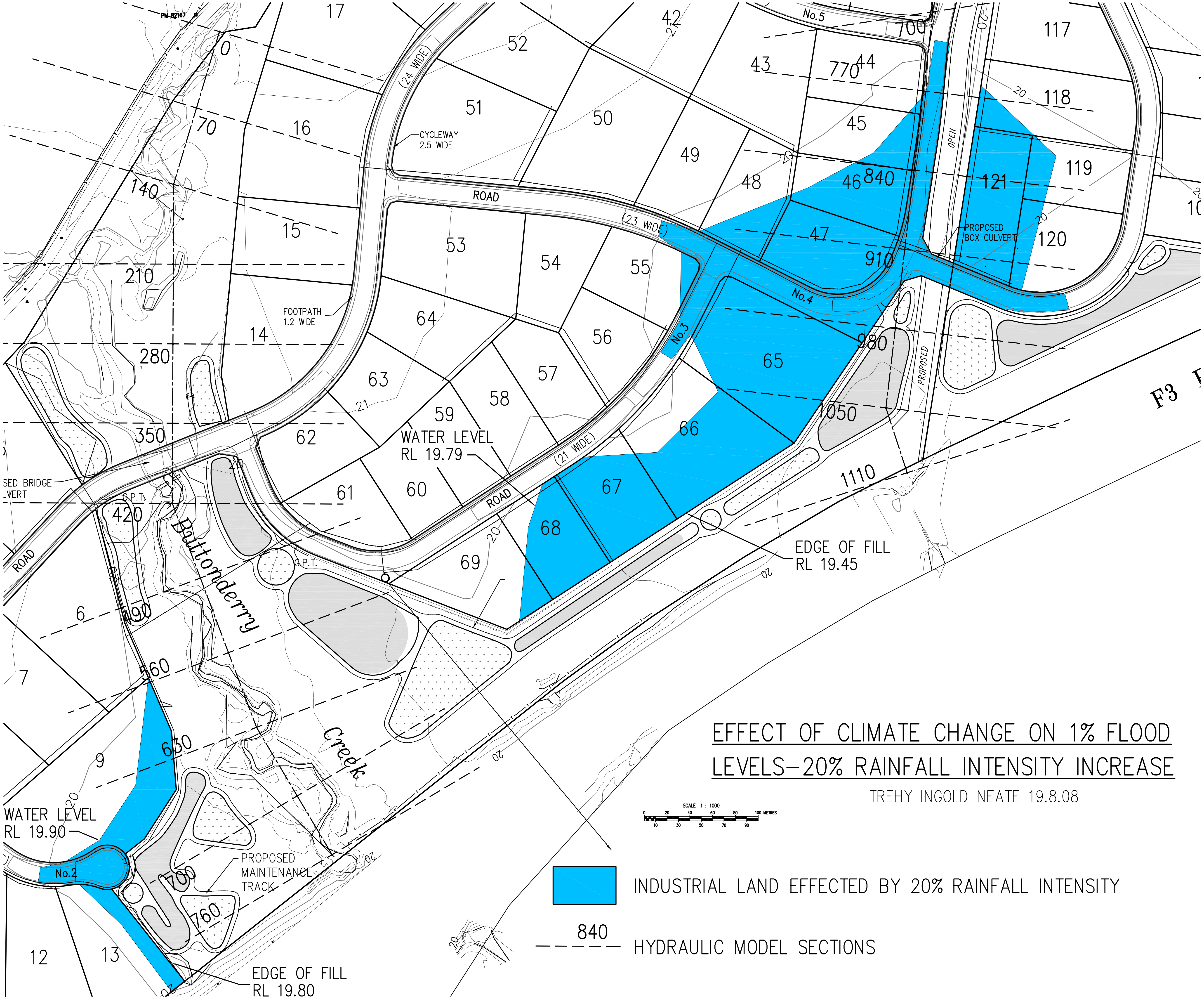


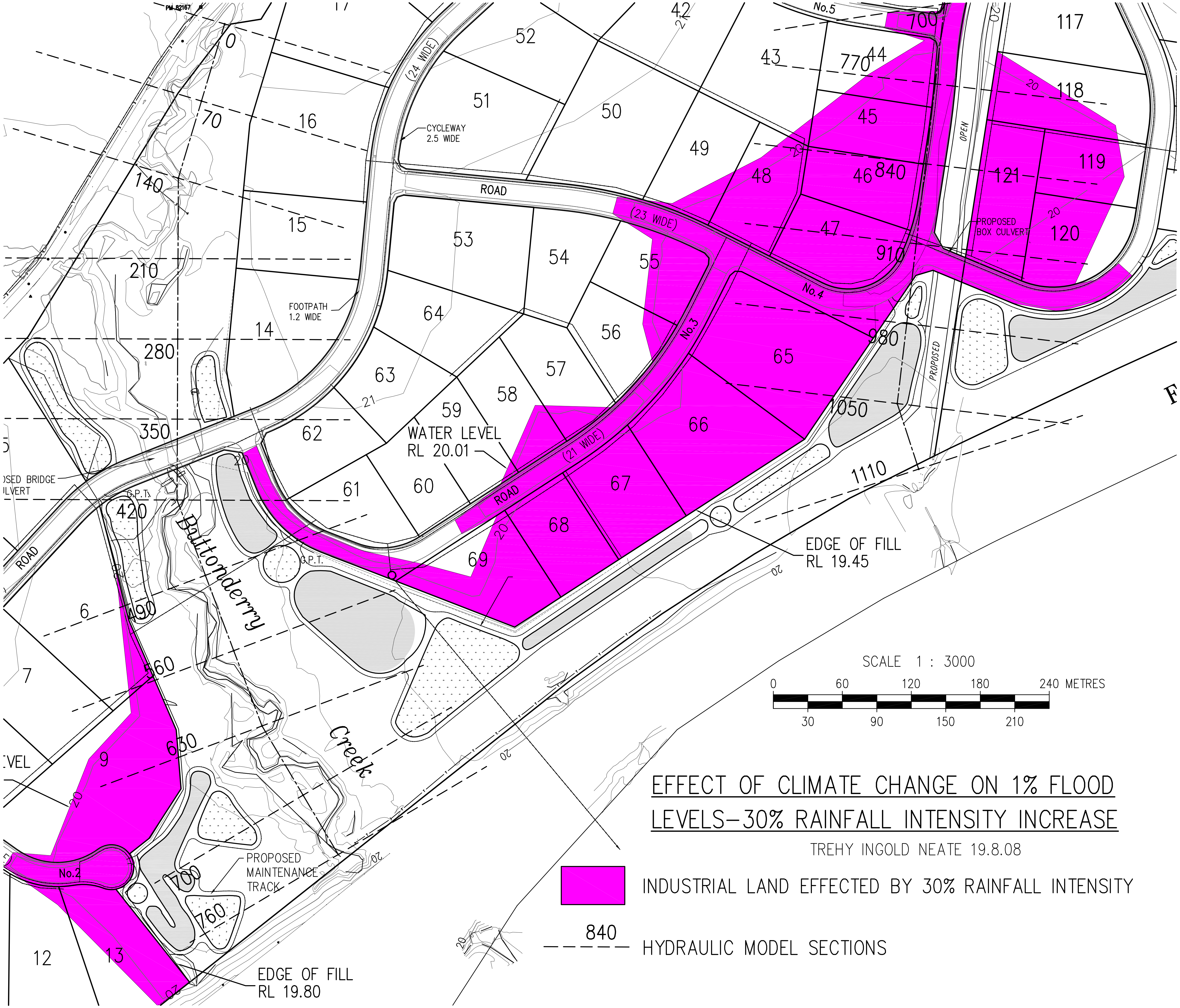
INDUSTRIAL LAND EFFECTED BY 10% RAINFALL INTENSITY

840 — HYDRAULIC MODEL SECTIONS

EFFECT OF CLIMATE CHANGE ON 1% FLOOD LEVELS–20% RAINFALL INTENSITY INCREASE

TREHY INGOLD NEATE 19.8.08




EFFECT OF CLIMATE CHANGE ON 1% FLOOD LEVELS–30% RAINFALL INTENSITY INCREASE
TREHY INGOLD NEATE 19.8.08
INDUSTRIAL LAND EFFECTED BY 30% RAINFALL INTENSITY
840 HYDRAULIC MODEL SECTIONS
SCALE 1 : 3000
0 30 60 90 120 150 180 210 240 METRES
EDGE OF FILL RL 19.45
EDGE OF FILL RL 19.80
WATER LEVEL RL 20.01
Buttonderry Creek
PROPOSED MAINTENANCE TRACK
PROPOSED BOX CULVERT
PROPOSED OPEN
CYCLEWAY 2.5 WIDE
FOOTPATH 1.2 WIDE
ROAD (24 WIDE)
ROAD (23 WIDE)
ROAD (21 WIDE)
No.2
No.3
No.4
No.5
G.P.T.
ROAD