

Warren Smith & Partners
1st Floor, 123 Clarence Street
SYDNEY NSW 2000

Job No. AR269.020

Attn: Mr Michael Cahalane

20 December 2016

Re: Proposed Subdivision of 12 Frederick Street, St Leonards

Dear Sir,

This report sets out the findings of an investigation that has been undertaken by Lyall & Associates (**L&A**) to assess patterns of overland flow in the vicinity of No. 12 Frederick Street, St Leonards (**Property**), being Lot 1 in DP 591747.

1. Site Description

Figure 1 shows that the Property is bounded by Westbourne Street to its south, Reserve Road to its west, Frederick Street to its north and existing commercial development to its east. **Figure 1** also shows the proposed subdivision of the Property into two lots, denoted Proposed Lot 1 and Proposed Lot 2.

The Property comprises an existing multi-storey factory building containing eleven units on the ground floor accessible by the Frederick Street Entrance and two units on the roof top accessible by the Upper and Lower Reserve Road Entrances. The finished floor levels of the ground floor units range between RL 75.81 m AHD and RL 77.03 m AHD.

The survey plan provided by the Applicant (refer copy contained in **Annexure A**) shows that there is about a 20 m fall in levels internal to the Property along the Reserve Road and Westbourne Road frontages.

Reserve Road falls at a grade of about seven per cent from an elevation of about RL 97.80 m AHD at a location approximately 45 m north of its intersection with Westbourne Street to about RL 80.60 m AHD at its intersection with Frederick Street.

Frederick Street also falls at a grade of about seven per cent from an elevation of about RL 80.60 m AHD at its intersection with Reserve Road to about RL 75.10 m AHD adjacent to the northern boundary of the Property. A sag point is located in Frederick Street approximately 50 m to the east of the Property and has an elevation of about RL 74.20 m AHD.

Westbourne Street falls at a slightly steeper grade of approximately nine per cent from an elevation of about RL 97.60 m AHD at its intersection with Reserve Road to about RL 92.55 m AHD adjacent to the eastern boundary of the Property.

2. Existing Drainage System

Figure 1 shows the extent of the catchments that contribute to flow in the existing piped drainage system that controls surface runoff discharging to the roads which border the Property, while **Figure 2** shows the key features of the existing piped drainage system in the immediate vicinity of the Property.

Runoff from the 2.7 ha and 0.3 ha catchments that contribute to flow on the western and eastern sides of Reserve Road, respectively is controlled by a 525 mm diameter pipe that runs in an easterly direction toward the sag point in Frederick Street, while runoff from the 0.2 ha catchment that lies to the south of the Property is controlled by an existing piped drainage system (the dimensions of which are unknown) that runs in an easterly direction along Westbourne Street.

Runoff that cannot enter the existing piped drainage system will be conveyed around the Property in the adjacent road reserves which act as overland flow paths. Plates contained in **Annexure B** show the key features of these overland flow paths in the immediate vicinity of the Property.

3. Assessment of Drainage Patterns – Present Day Conditions

3.1 Development of Hydrologic and Hydraulic Models

A hydrologic (DRAINS) model that was developed as part of a previous Local Government Area (LGA) wide screening study that was undertaken by L&A on behalf of WCC in 2009 was used as the starting point for defining patterns of overland flow in the vicinity of the Property.

The structure of the DRAINS model was updated to incorporate additional sub-catchments (refer **Figure 1**), the outlets of which corresponded with the location of existing stormwater inlet pits. The surface roughness applied to each sub-catchment was also updated to reflect the findings of more recent studies that have been undertaken in the LGA.

Details of the existing piped drainage system in Reserve Road and Frederick Street were incorporated into the DRAINS model. Council's stormwater asset database was used to determine pipe dimensions, while the ground survey data provided by the Applicant were used to determine pipe invert levels where available. Pit types were defined by visual inspection.

The DRAINS model was used to assess the capacity of the existing piped drainage system and determine the magnitude of surcharge flow for design storms with Average Recurrence Intervals (ARI's) of 5, 20 and 100 years¹.

The HEC-RAS modelling software was used to assess the depth at which stormwater which surcharges the existing piped drainage system will be conveyed in the roads that border the Property. **Figure 2** shows the layout of the three HEC-RAS models which were developed as part of the present investigation (denoted the "**Westbourne Street, Reserve Road East and Reserve Road West HEC-RAS Models**").

The **Reserve Road West HEC-RAS Model** comprises ten cross sections which are located along the western side of Reserve Road, noting that overland flow in the western kerbline of Reserve Road at its intersection with Frederick Street will continue in a northerly direction toward the intersection of Campbell Street and Reserve Road.

¹ Note that the DRAINS model does not incorporate pit and pipe data in Westbourne Street as there is no existing piped drainage system in this area.

The **Reserve Road East HEC-RAS Model** comprises ten cross sections along Reserve Road and four cross sections along Frederick Street. Overland flow in the eastern kerbline of Reserve Road will turn into Frederick Street where it will discharge in an easterly direction toward the sag point which is located about 50 m to the east of the Property.

The **Westbourne Street HEC-RAS Model** was developed to confirm if runoff generated from the adjacent 0.2 ha catchment will be contained within the road reserve.

3.2 Hydraulic Model Results

Annexure C contains a tabulated set of results for the **Reserve Road West HEC-RAS Model**, as well as cross sections showing depths of overland flow along the western side of Reserve Road. The key findings of the investigation in relation to flow along the western side of Reserve Road were as follows:

- There is a reduction in flow downstream of cross section *RR_W_7* as the overland flow in the western kerbline is intercepted by the existing piped drainage system immediately upstream of cross section *RR_W_6*.
- The peak 100 year ARI flow of 0.92 m³/s at cross section *RR_W_1* is confined to the western side of Reserve Road.
- Overland flow will not overtop the crown of the road and contribute to flow along the eastern side of Reserve Road.

Annexure D contains a tabulated set of results for the **Reserve Road East HEC-RAS Model**, as well as cross sections showing depths of overland flow along the eastern side of Reserve Road and the southern side of Frederick Street. The key findings of the investigation in relation to flow along the eastern side of Reserve Road and the southern side of Frederick Street were as follows:

- As the overland flow does not surcharge the western side of Reserve Road for storm events up to 100 year ARI, flow along the eastern kerbline of Reserve Road is generated entirely by the 0.3 ha catchment shown on **Figure 1**.
- The majority of flow along the eastern kerbline of Reserve Road is intercepted by the existing piped drainage system immediately downstream of cross section *RR_E_1*. Flow along the southern kerbline of Frederick Street is therefore relatively minor in nature.
- Flow overtops the crown of the road in a 100 year ARI storm event, contributing to flow on the western side of Reserve Road adjacent to cross section *RR_E_1*².
- Depths of overland flow along the eastern kerbline of Reserve Road are not sufficient to surcharge the road reserve adjacent to the Property.

Annexure E contains a tabulated set of results for the **Westbourne Street HEC-RAS Model**, as well as cross sections showing depths of overland flow along the southern side of Westbourne Street. The key finding regarding flow along the southern side of Westbourne Street is that depths of overland flow are not sufficient to result in surcharge of the road reserve.

² The **Reserve Road West HEC-RAS model** was rerun assuming the 0.13 m³/s from the eastern side of Reserve Road contributes to the total flow in the western side of the road. Even with the additional flow (i.e. total flow of 1.05 m³/s at cross section *RR_W_1*), depths of overland flow along the western kerbline of Reserve Road are not sufficient to result in surcharge of the road reserve during a 100 year ARI storm event.

Figure 3 shows the computed 100 year ARI hydraulic grade line along the existing piped drainage system where it runs between Pits 1 to 5 (refer **Figure 2** for location of pits). By inspection of **Figure 3**, the existing piped drainage system is not surcharged by a 100 year ARI storm event. This is principally due to the capacity of the existing inlet pits limiting the rate at which surface runoff can enter the piped drainage system.

4. Concluding Remark

Hydrologic and hydraulic modelling undertaken as part of the present investigation has demonstrated that overland flow will be contained within the road reserve and therefore not discharge to the Property for storms with ARI's up to 100 years.

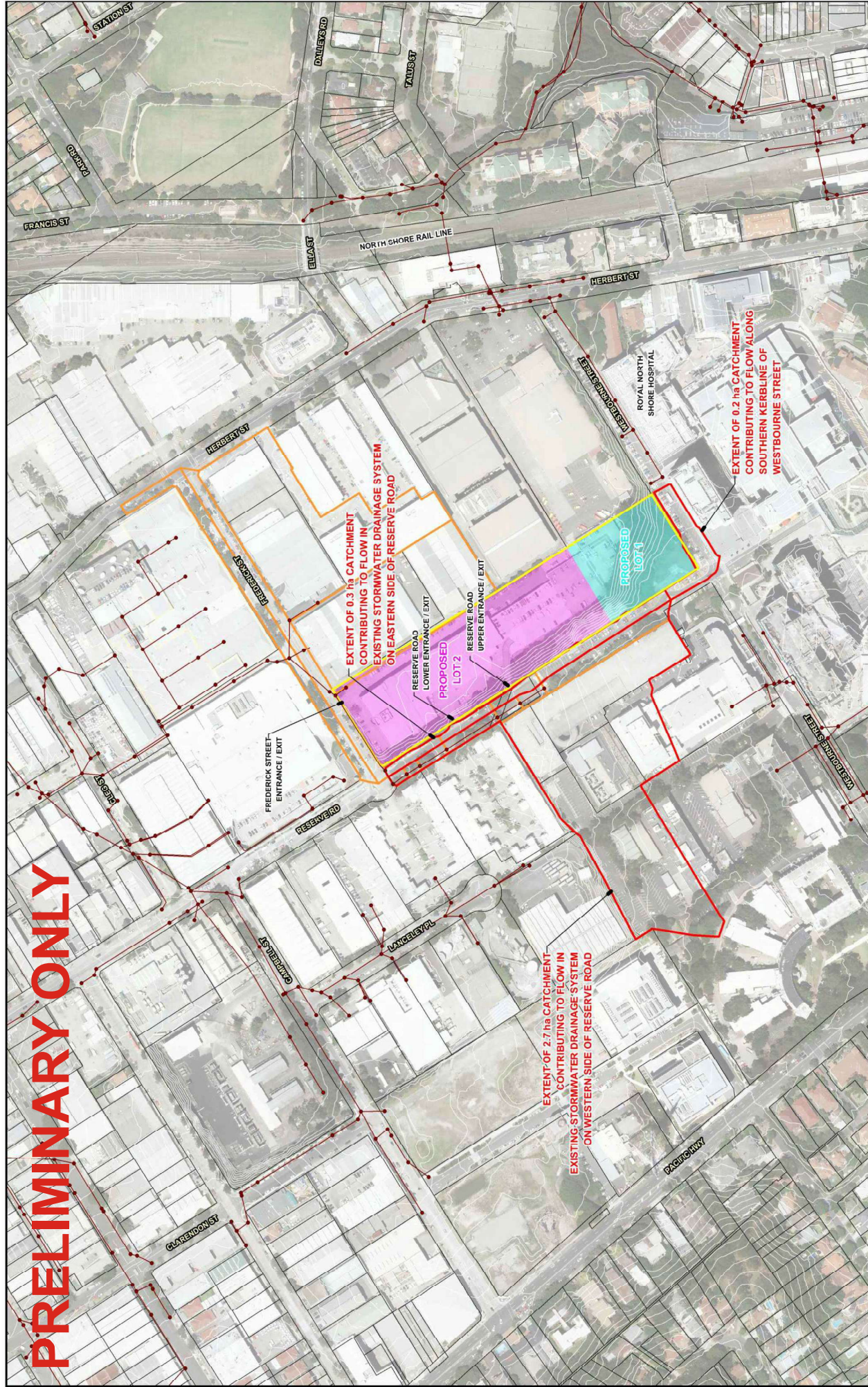
We trust that the findings presented in this letter report will assist you in obtaining an approval for the proposed subdivision. Please do not hesitate to contact the undersigned should you require any further advice in relation to the above assessment.

Yours faithfully

Lyall & Associates Consulting Water Engineers

Scott Button
Principal

PRELIMINARY ONLY



LEGEND

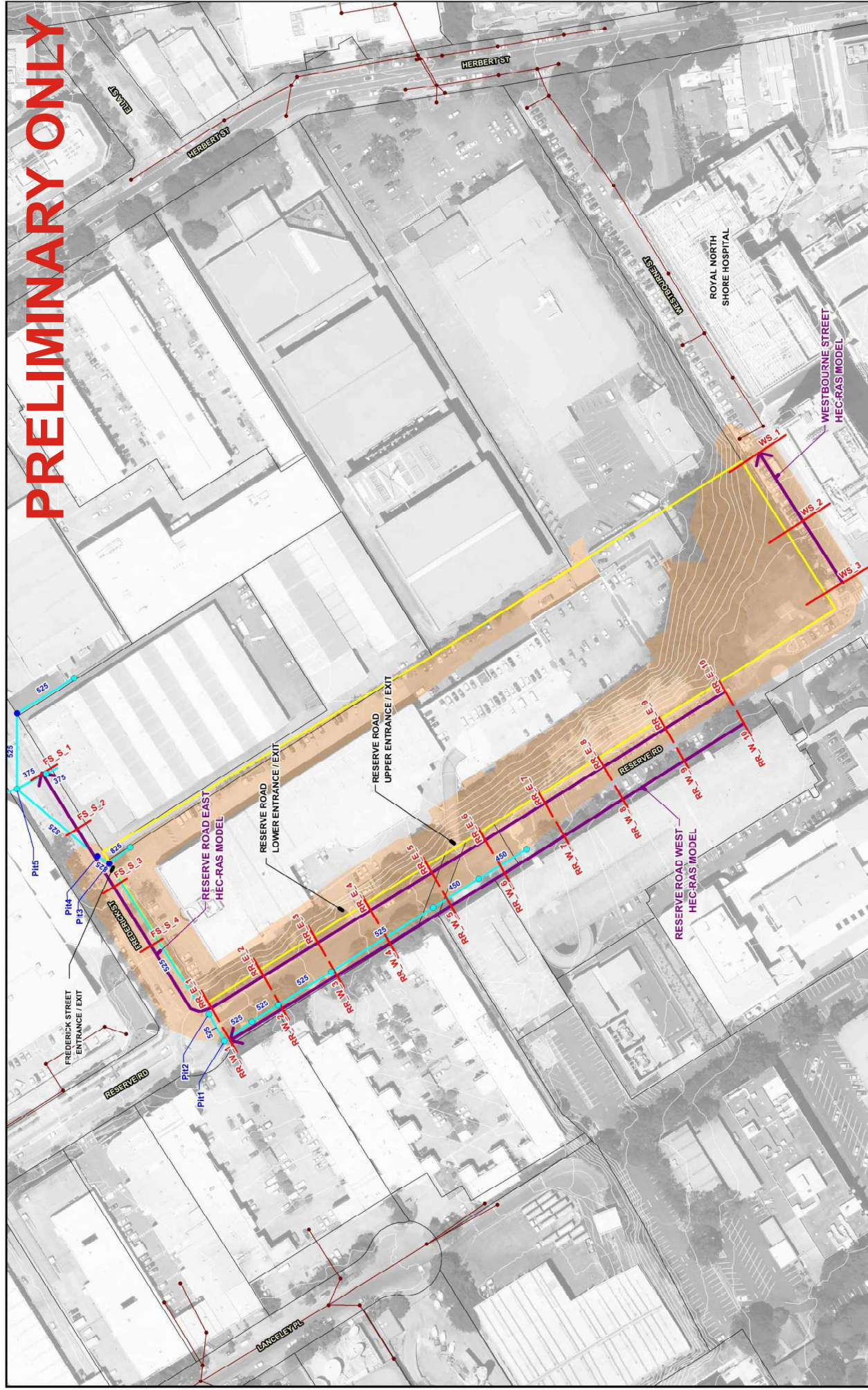
- Sub-catchment Boundary
- Catchment Boundary
- Property Boundary
- Existing Stormwater Drainage Network

12 FREDERICK STREET, ST LEONARDS
FLOODING ASSESSMENT

Figure 1

CATCHMENT PLAN AND EXISTING STORMWATER DRAINAGE SYSTEM

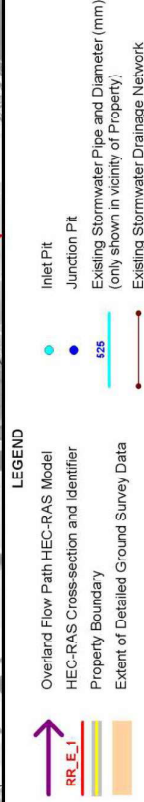
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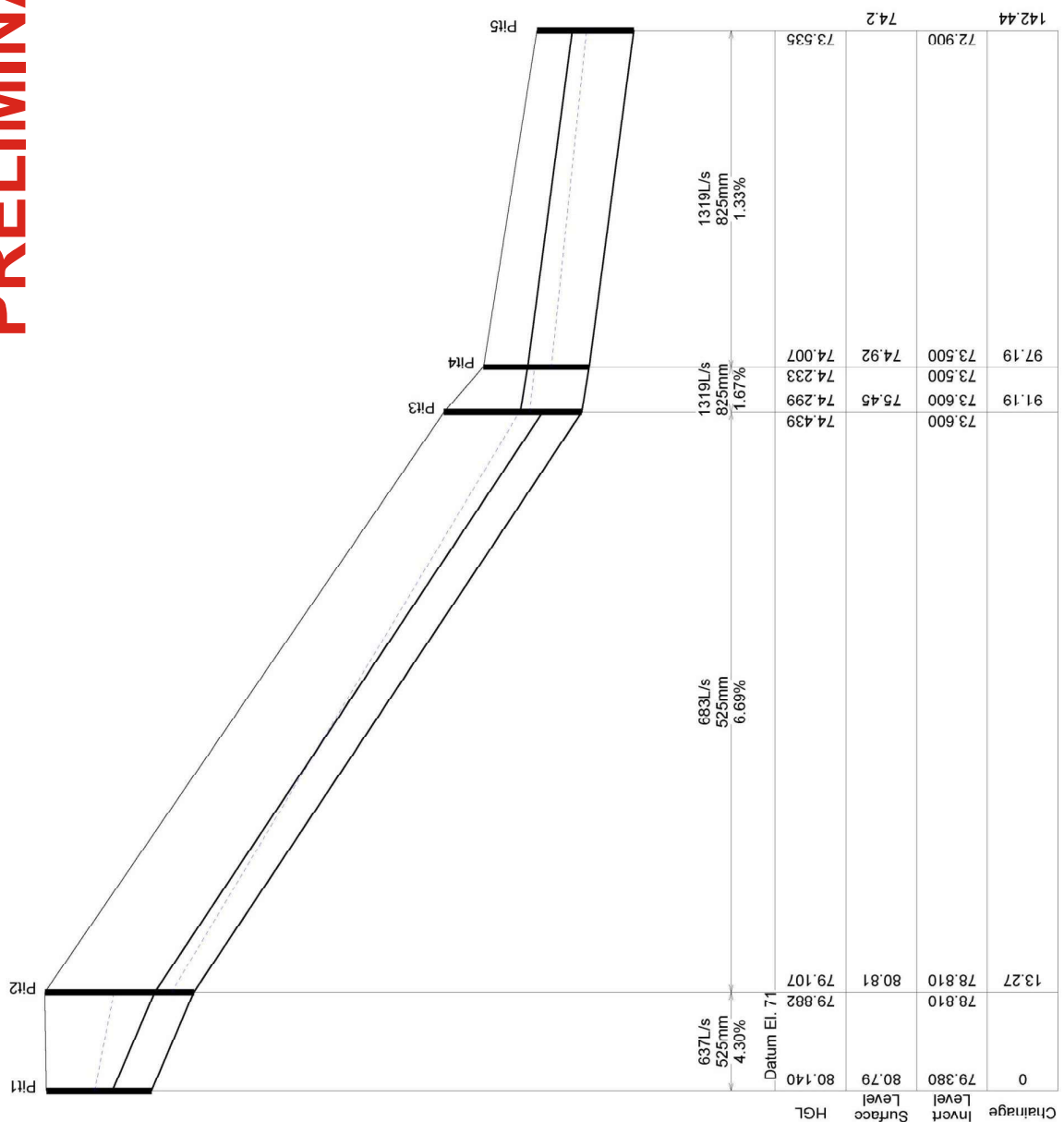
12 FREDERICK STREET, ST LEONARDS
FLOODING ASSESSMENT

Figure 2

HYDROLOG C AND HYDRAULIC MODEL LAYOUT



PRELIMINARY ONLY

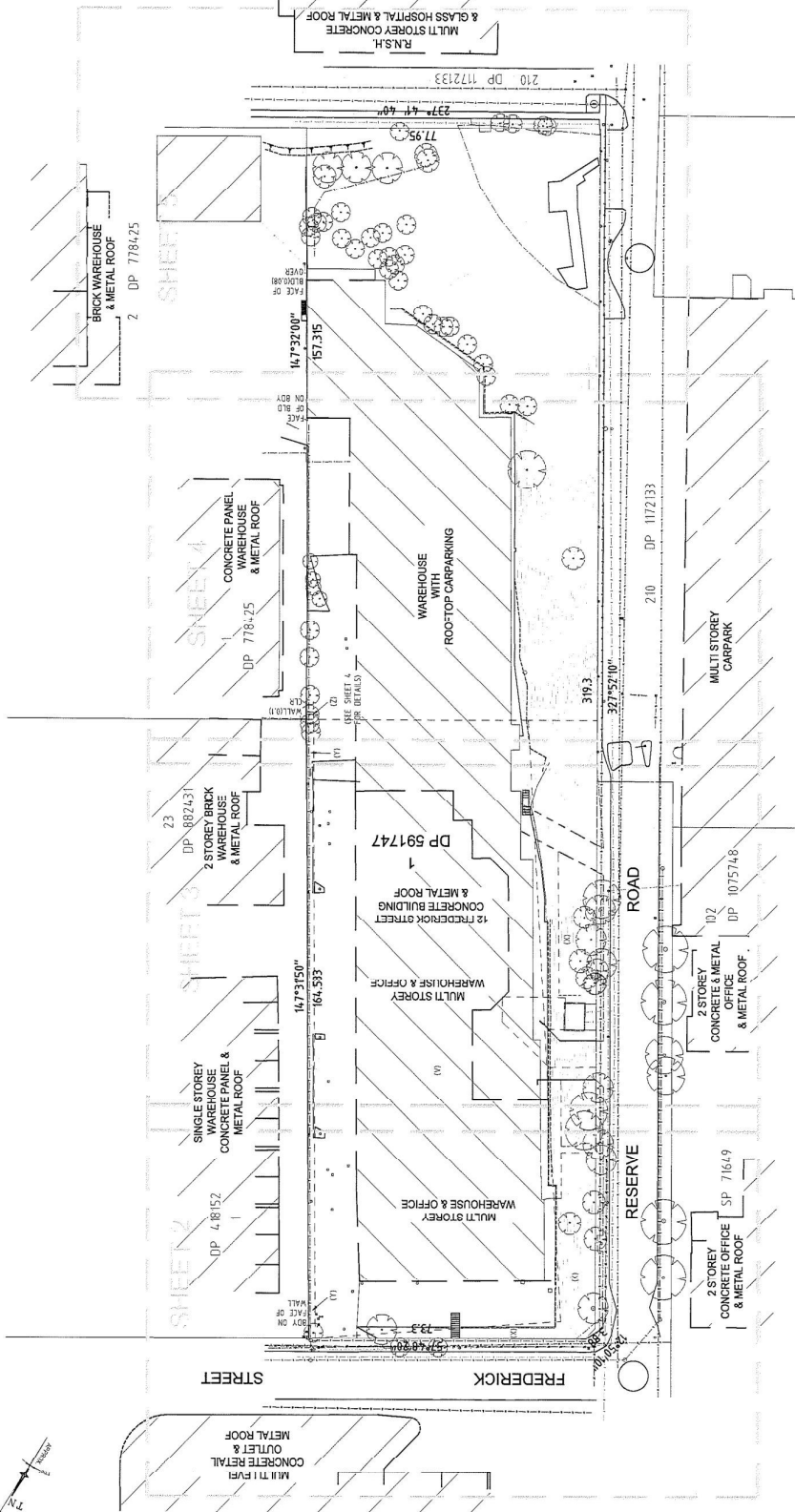
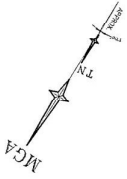


NOTE:
Where available details of the existing stormwater drainage system have been taken from detailed ground survey provided by the Applicant (refer Annexure A for copy).



ANNEXURE A

SURVEY PLAN



- NOTES
1. THE BOUNDARIES HAVE NOT BEEN MARKED
 2. ALL AREAS AND DIMENSIONS HAVE BEEN COMPILED FROM PLANS MADE AVAILABLE BY THE CLIENT
 3. ORIGIN OF LEVELS IN A.M.D. IS TAKEN FROM 55088990 RL 76445 (A.M.D.) IN HERBERT STREET
 4. CONTOURS ARE INDICATIVE ONLY. ONLY SPOT LEVELS SHOULD BE USED FOR CALCULATIONS OF QUANTITIES WITH CAUTION
 5. KERNEL LEVELS ARE TO THE TOP OF KERB UNLESS SHOWN OTHERWISE
 6. NO INVESTIGATION OF UNDERGROUND SERVICES HAS BEEN MADE. SERVICES HAVE BEEN PLOTTED FROM RELEVANT AUTHORITIES INFORMATION AND HAVE NOT BEEN SURVEYED. ALL RELEVANT AUTHORITIES SHOULD BE NOTIFIED PRIOR TO ANY EXCAVATION ON OR NEAR THE SITE
 7. 8/477 DEMOTES TREE SPREAD OF 8m, TRUNK DIAMETER OF 0.4m & APPROX HEIGHT OF 7m
 8. 8/477 DEMOTES TREE SPREAD OF 8m, TRUNK DIAMETER OF 0.4m & APPROX HEIGHT OF 7m
 9. 8/477 DEMOTES TREE SPREAD OF 8m, TRUNK DIAMETER OF 0.4m & APPROX HEIGHT OF 7m
 10. 8/477 DEMOTES TREE SPREAD OF 8m, TRUNK DIAMETER OF 0.4m & APPROX HEIGHT OF 7m
 11. 8/477 DEMOTES TREE SPREAD OF 8m, TRUNK DIAMETER OF 0.4m & APPROX HEIGHT OF 7m
 12. 8/477 DEMOTES TREE SPREAD OF 8m, TRUNK DIAMETER OF 0.4m & APPROX HEIGHT OF 7m

EASEMENTS

- (N) - EASEMENT (DP 1075748) & N 542580
(O) - EASEMENT FOR BRAMAGE (DP 591747 & N 542580)
(Y) - EASEMENT FOR BRAMAGE (DP 591747 & N 542580)
(Z) - EASEMENT FOR BRAMAGE (DP 591747)



REFER TO NOTES AND LEGEND

Revision	Date	Description
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2	00/00/00	
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THIS IS THE PLAN REFERRED TO IN THE LETTER DATED: 00/00/00

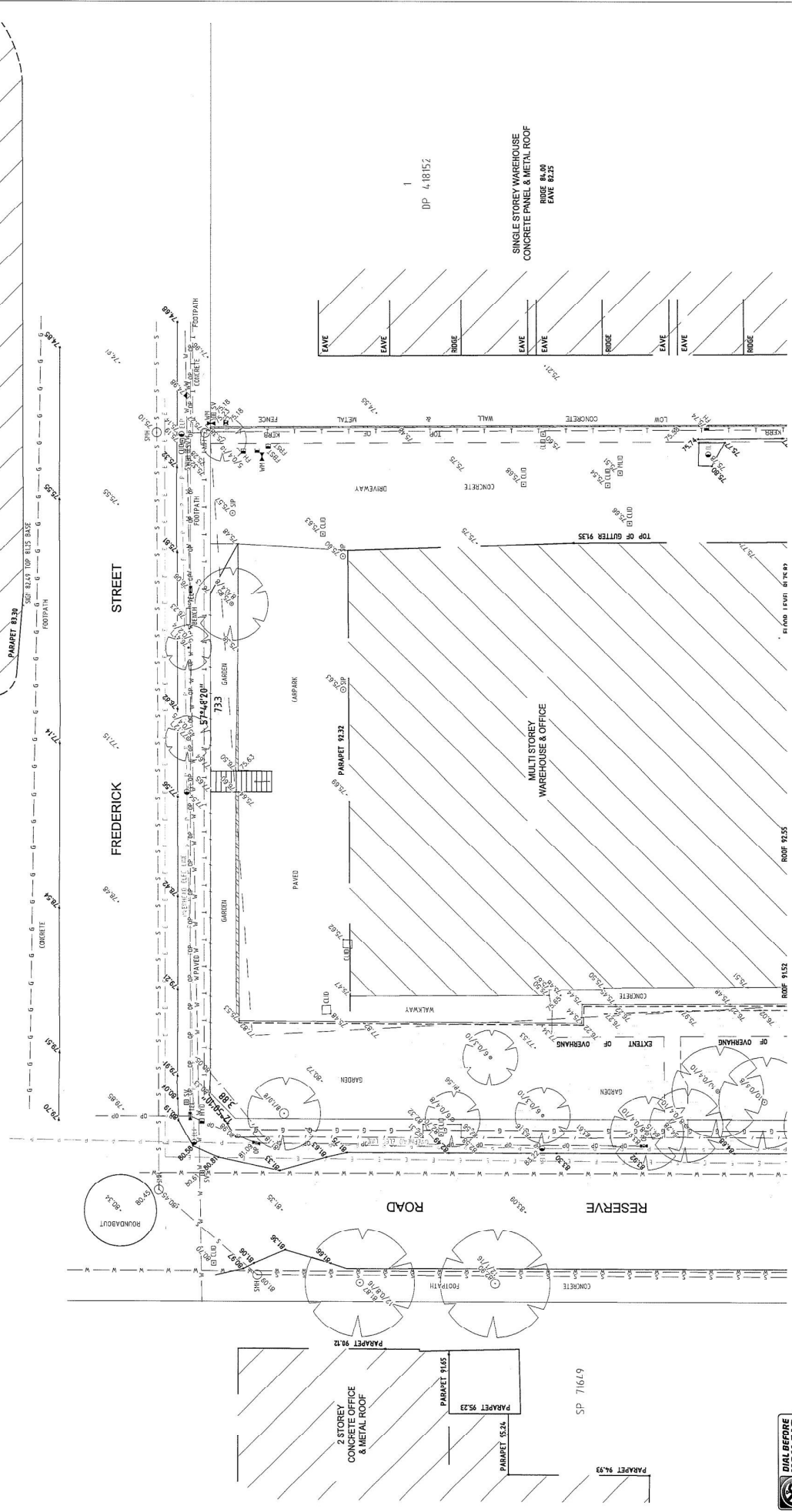
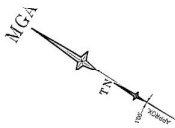


Site 1, Level 1
Gordon NSW 2072
P 1300 887 000
F 02 9497 150

Client: DEBUS PROPERTY GROUP
Drawing No: 247810
KNOWN AS 12 FREDERICK STREET ST LEONARDS

Project number: 4224307 - UN
Scale: 1:500 @ A1
SHEET: 1 OF 7 SHEETS

Author: WILLOUGHBY
Reference number: 4224307 - UN
Scale: 1:500 @ A1
SHEET: 1 OF 7 SHEETS



REFER TO NOTES AND LEGEND



SEE SHEET 1 FOR NOTES AND LEGEND

Revision	Date	Description
D	03/09/15	00
C	03/09/15	00
A	03/09/15	00

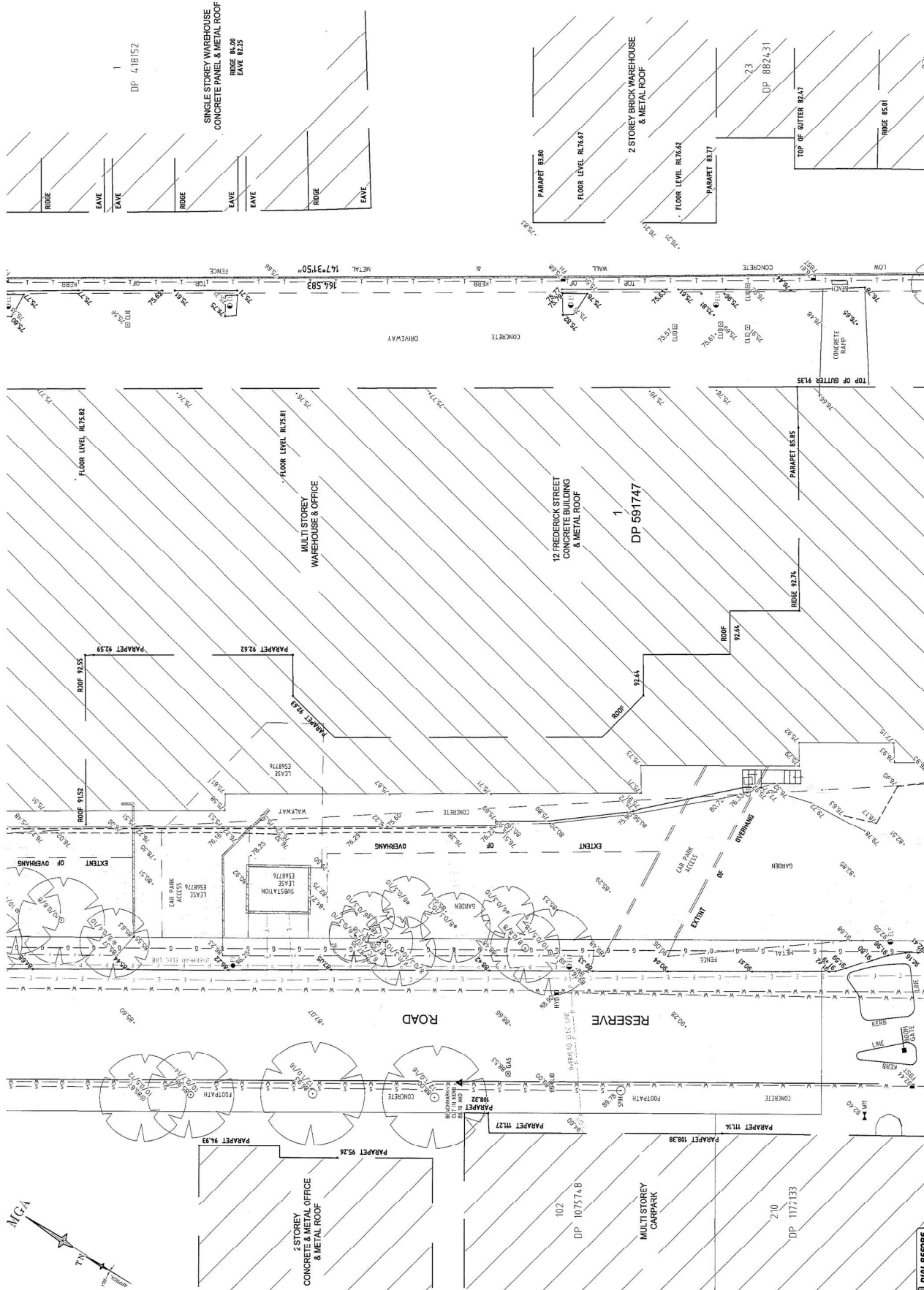
THIS IS THE PLAN REFERRED TO IN THE CONTRACT



Site 1, Level 1
Gordon NSW 2072
Gordon NSW 2072
F 03 9397 7000

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Drawing title: PLAN OF DETAIL AND LEVELS OVER LOT 1 IN DP591747
KNOWN AS 12 FREDERICK STREET ST LEONARDS

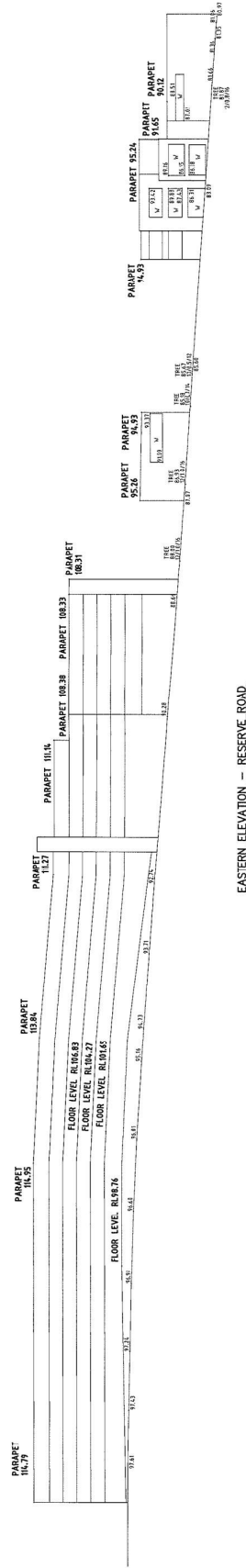
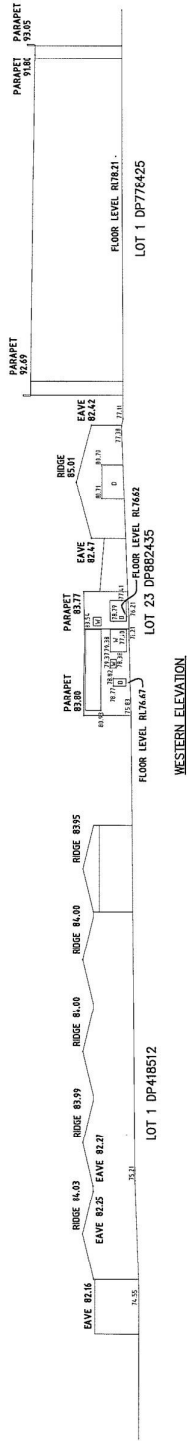
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Project number: 1200 @A1
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Date of survey: 30/08/15
Project number: 1200 @A1
Scale: 1:200
Date of survey: 30/08/15



SEE SHEET 1 FOR NOTES AND LEGEND

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SEE SHEET 1 FOR NOTES AND LEGEND

Revision	Date	Description	Reference
D	02/02/2015		00
C	02/02/2015		00
B	02/02/2015		00
A	02/02/2015	Initial draft plan completed	00

THIS IS THE PLAN REFERRED TO IN THE BUILDING ACT 2007



THE CLIENT
8000 Pacific Highway
Gordon NSW 2072
Gordon NSW 2072
LOCKLEY
Registered Surveyor NSW
F 02 9497 1200

Client: DEXUS PROPERTY GROUP

Project number: 4224301

Scale: 1:200

Sheet number: 6 OF 7 SHEET

Project name: 4224301 - UNTOUCHED_A3

ANNEXURE B

PLATES SHOWING KEY FEATURES OF OVERLAND FLOW PATHS



Plate 1: Looking north (downstream) along eastern side of the Reserve Road from cross section *RR_E_9*.



Plate 2: Looking north (downstream) along the western side of Reserve Road from cross section *RR_W_7*.



Plate 3: Looking north (downstream) along the eastern side of Reserve Road from cross section *RR_E_7*.



Plate 4: Looking east (downstream) along the southern side of Frederick Street from its intersection with Reserve Road.

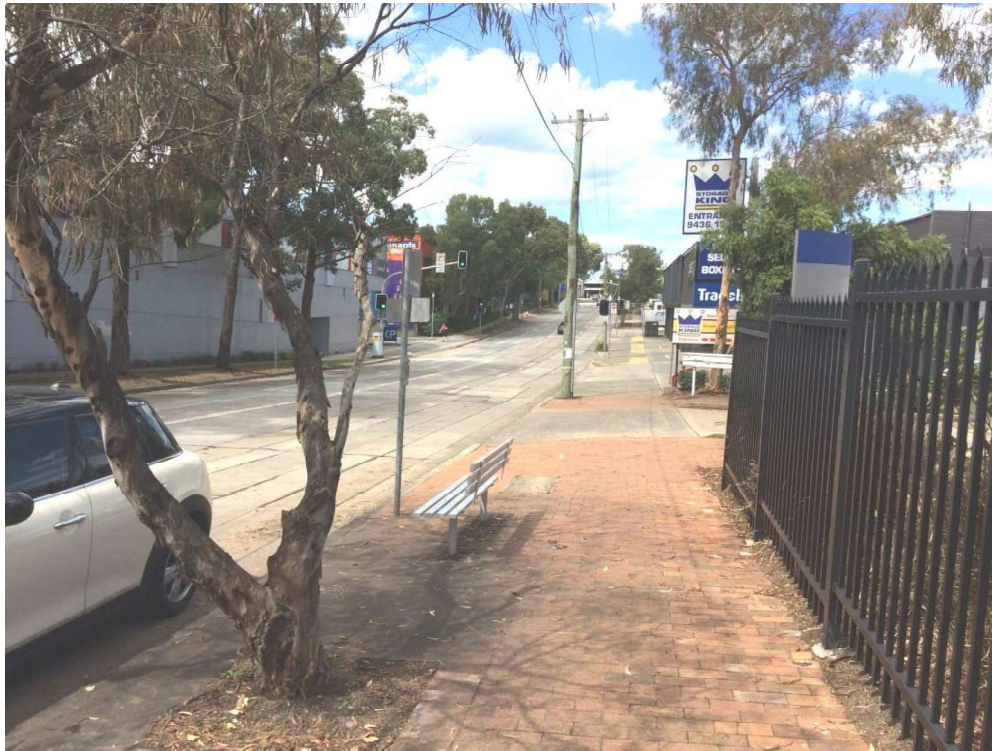


Plate 5: Looking east (downstream) from the Frederick Street Entrance/Exit towards the sag point in Frederick Street.



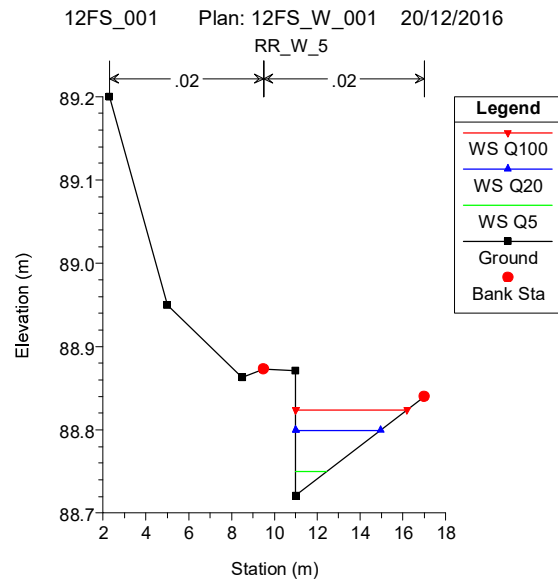
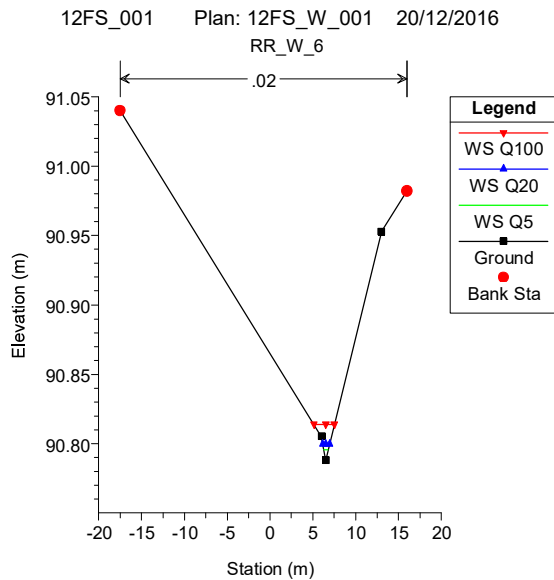
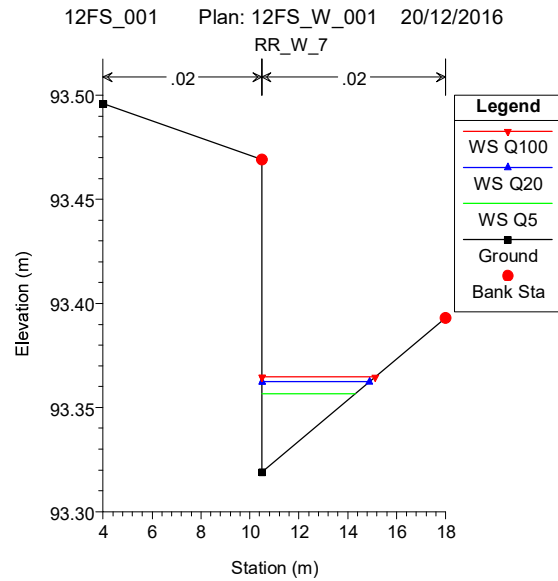
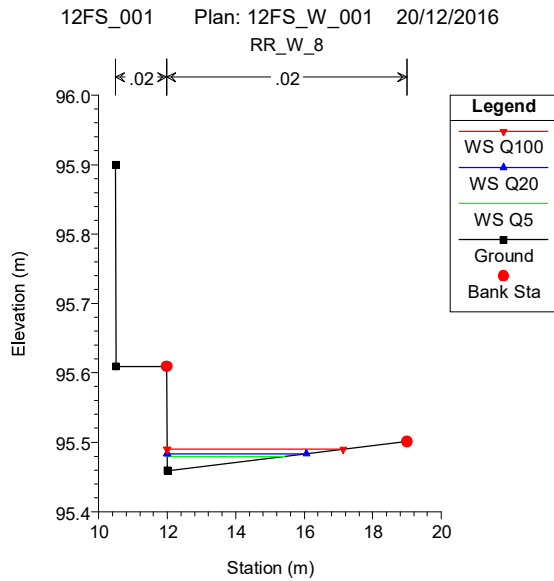
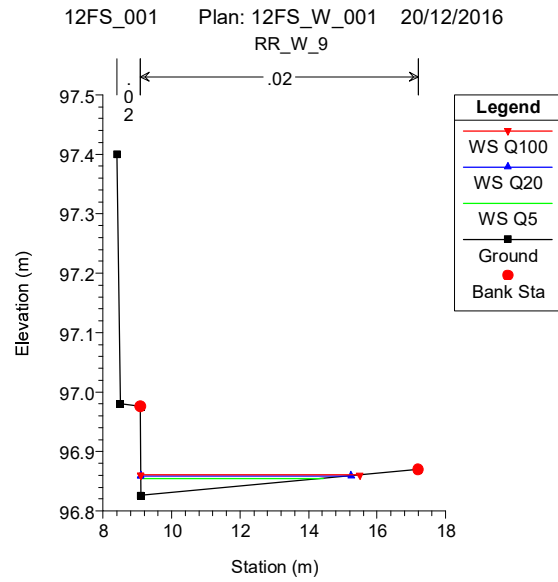
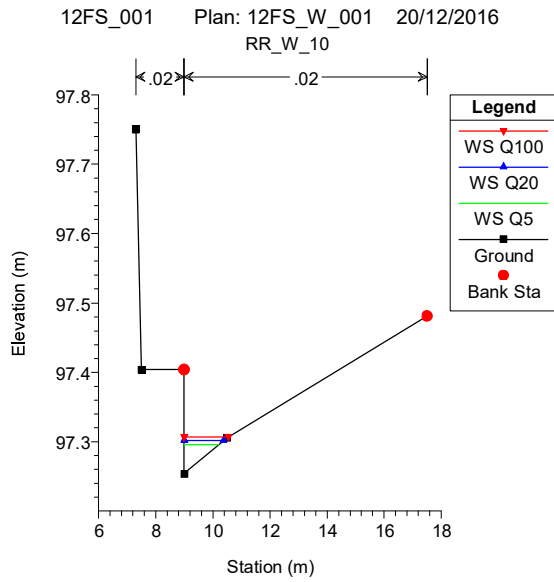
Plate 6: Looking east (downstream) along Westbourne Street from its intersection with Reserve Road.

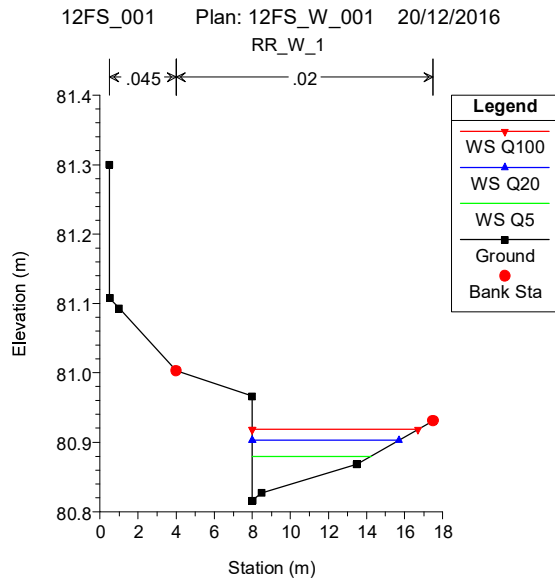
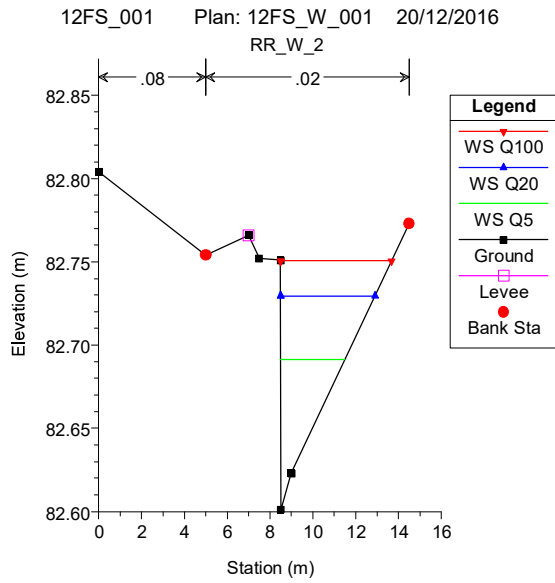
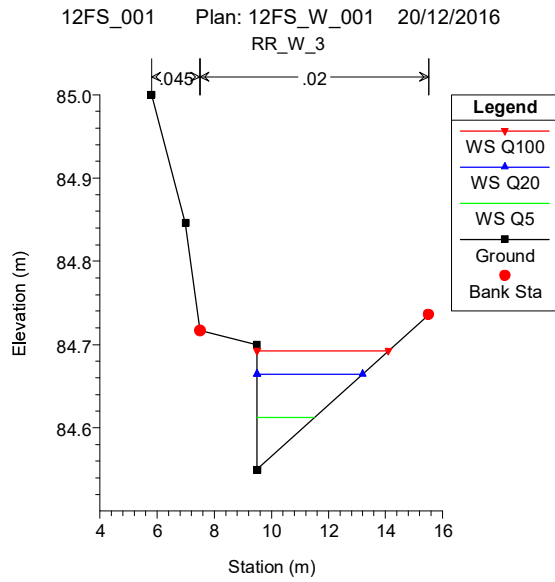
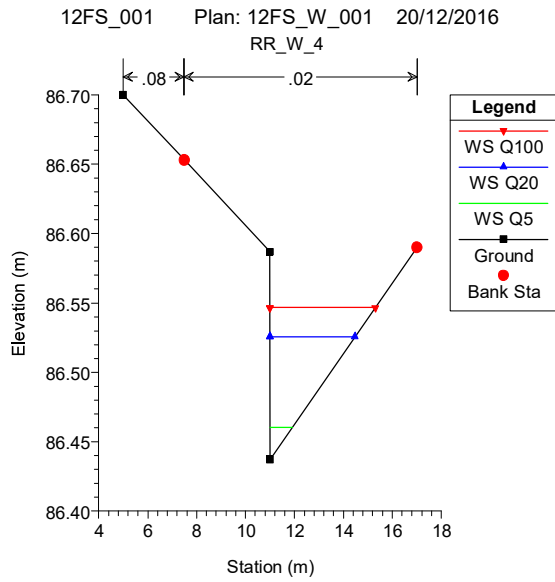
ANNEXURE C

RESERVE ROAD WEST HEC-RAS MODEL RESULTS

HEC-RAS Plan: 12FS_W River: 12FS Reach: Reserve_Rd

Cross-section	Profile	Gutter Level	Max. Water Surface Elevation	Peak Flow	Flow Velocity
		(m AHD)	(m AHD)	(m³/s)	(m/s)
RR_W_10	5 year ARI	97.25	97.3	0.01	0.52
	20 year ARI	97.25	97.3	0.02	0.57
	100 year ARI	97.25	97.31	0.03	0.61
RR_W_9	5 year ARI	96.83	96.86	0.03	0.34
	20 year ARI	96.83	96.86	0.04	0.37
	100 year ARI	96.83	96.86	0.05	0.46
RR_W_8	5 year ARI	95.46	95.48	0.04	1.09
	20 year ARI	95.46	95.48	0.06	1.15
	100 year ARI	95.46	95.49	0.08	0.96
RR_W_7	5 year ARI	93.32	93.36	0.05	0.72
	20 year ARI	93.32	93.36	0.08	0.8
	100 year ARI	93.32	93.36	0.1	0.96
RR_W_6	5 year ARI	90.79	90.8	0.01	4.05
	20 year ARI	90.79	90.8	0.02	3.57
	100 year ARI	90.79	90.81	0.04	1.43
RR_W_5	5 year ARI	88.72	88.75	0.01	0.57
	20 year ARI	88.72	88.8	0.25	1.6
	100 year ARI	88.72	88.82	0.47	1.76
RR_W_4	5 year ARI	86.44	86.46	0.01	1.11
	20 year ARI	86.44	86.53	0.25	1.62
	100 year ARI	86.44	86.55	0.47	2
RR_W_3	5 year ARI	84.55	84.61	0.08	1.2
	20 year ARI	84.55	84.66	0.4	1.88
	100 year ARI	84.55	84.69	0.69	2.11
RR_W_2	5 year ARI	82.6	82.69	0.2	1.56
	20 year ARI	82.6	82.73	0.54	2.01
	100 year ARI	82.6	82.76	0.84	2.04
RR_W_1	5 year ARI	80.82	80.88	0.25	1.29
	20 year ARI	80.82	80.9	0.6	1.7
	100 year ARI	80.82	80.92	0.92	1.86



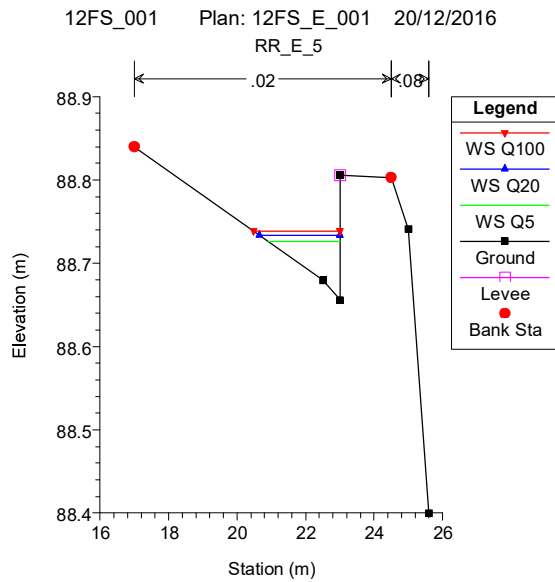
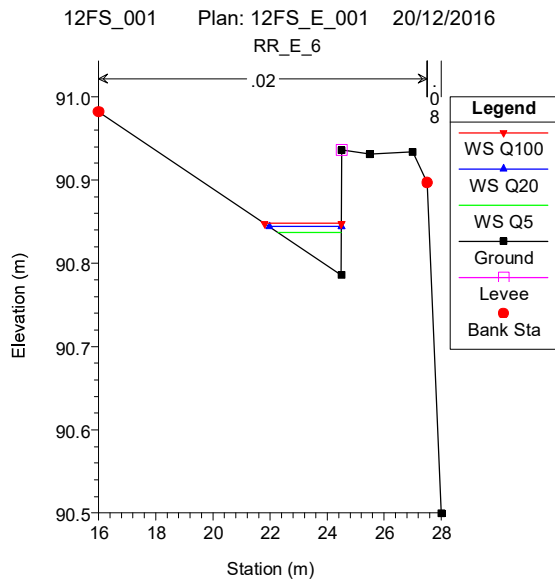
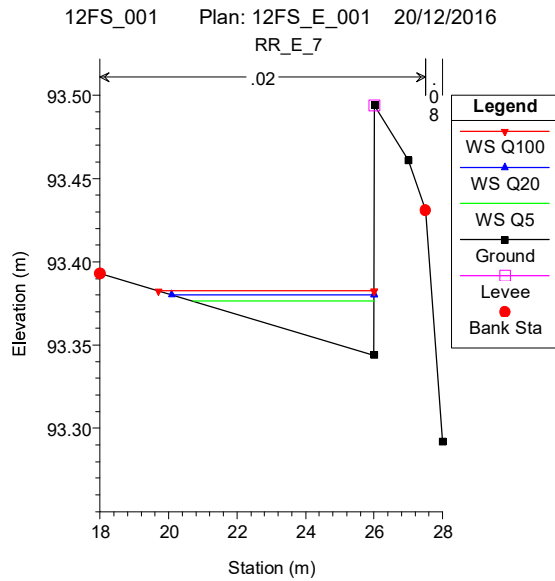
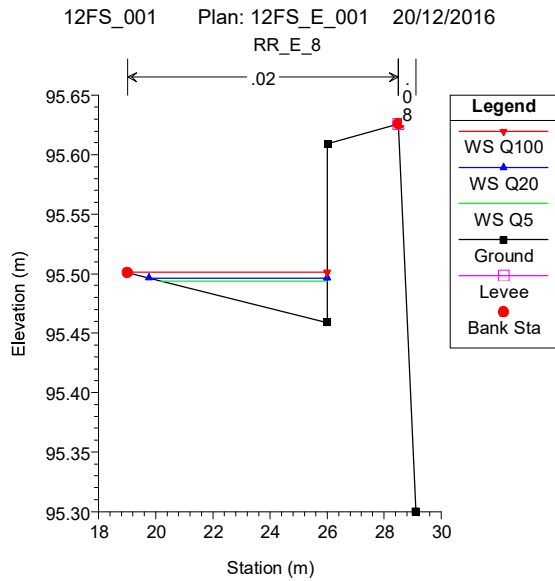
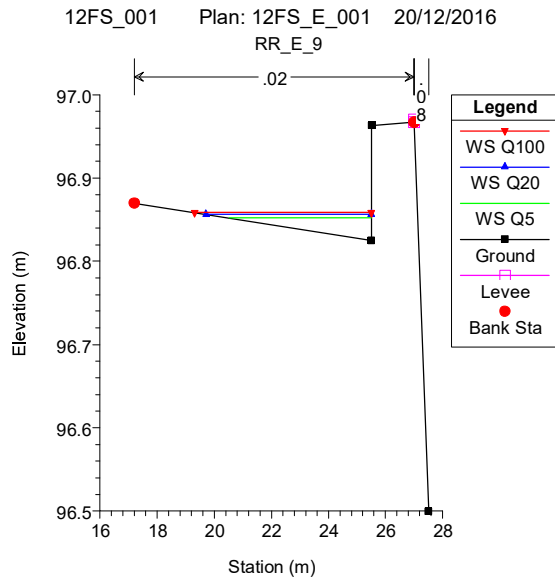
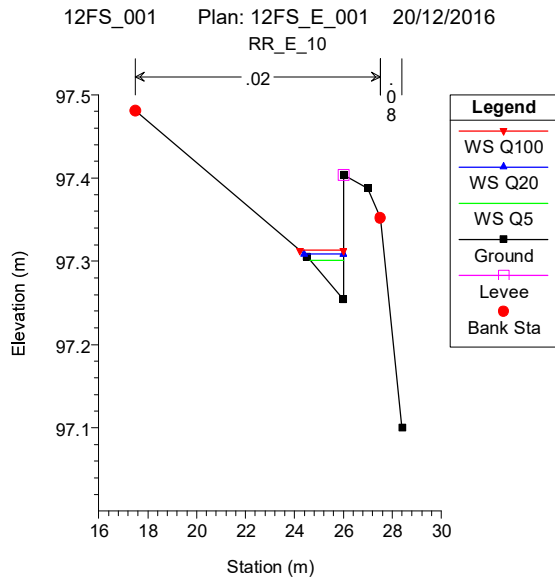


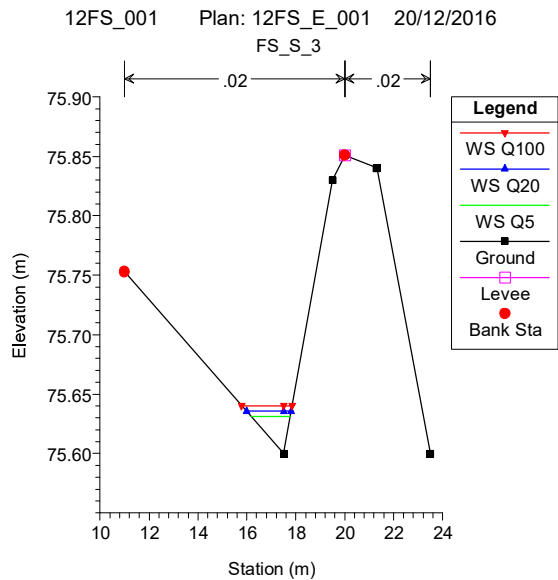
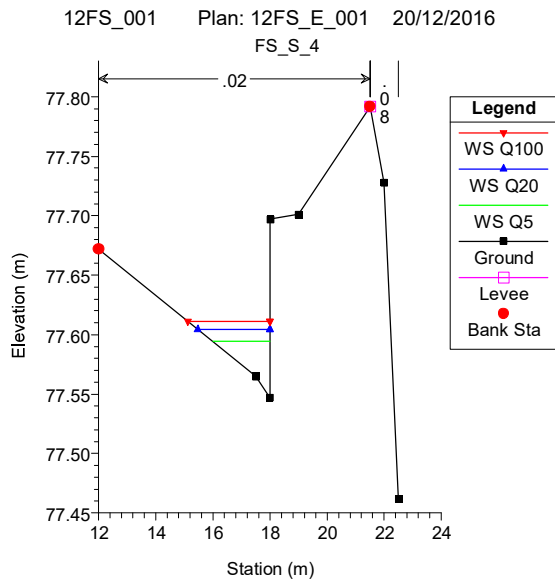
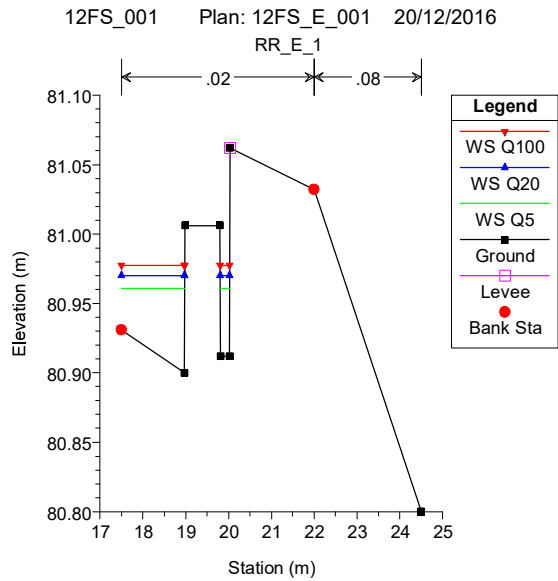
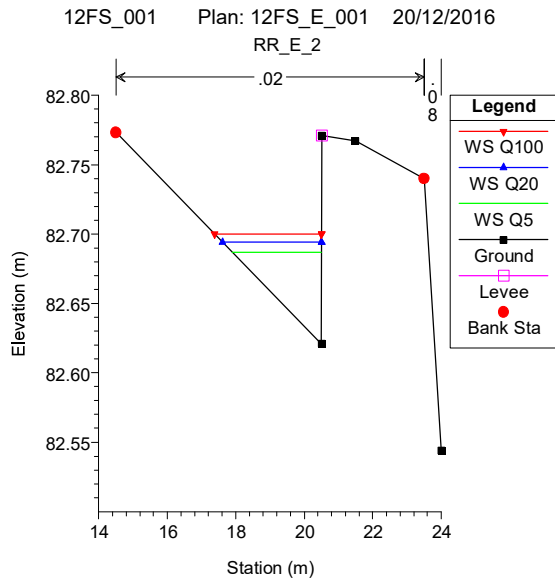
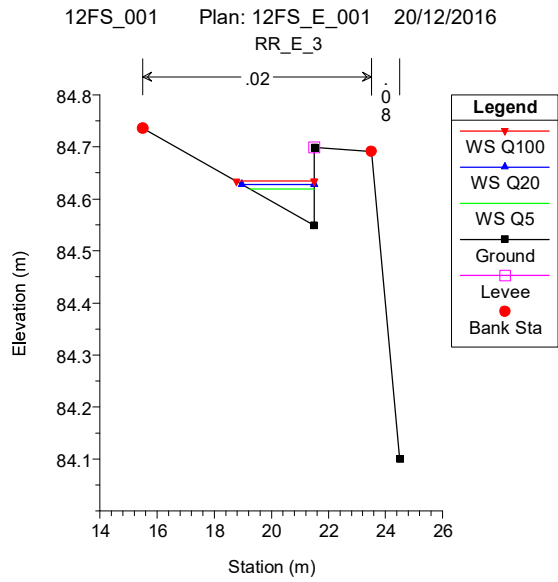
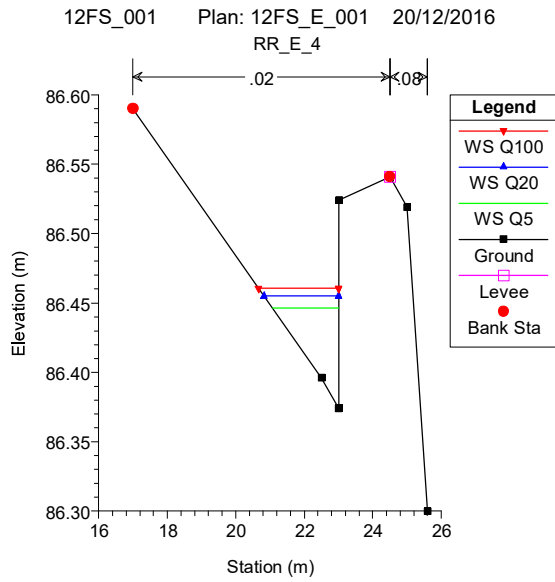
ANNEXURE D

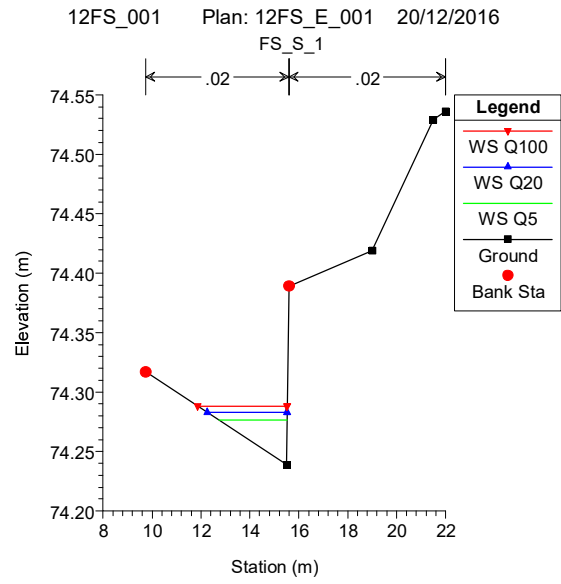
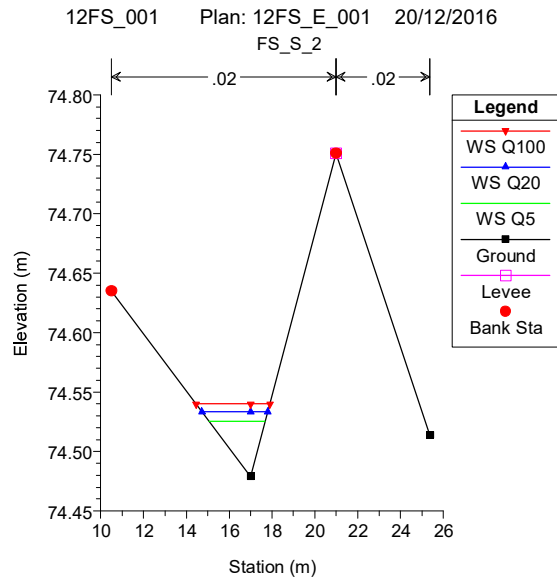
RESERVE ROAD EAST HEC-RAS MODEL RESULTS

HEC-RAS Plan: 12FS_E River: 12FS Reach: Reserve_Rd

Cross-section	Profile	Gutter Level	Max. Water Surface Elevation	Peak Flow	Flow Velocity
		(m AHD)	(m AHD)	(m³/s)	(m/s)
RR_E_10	5 year ARI	97.25	97.3	0.01	0.4
	20 year ARI	97.25	97.31	0.02	0.41
	100 year ARI	97.25	97.31	0.02	0.44
RR_E_9	5 year ARI	96.82	96.85	0.03	0.39
	20 year ARI	96.82	96.86	0.04	0.4
	100 year ARI	96.82	96.86	0.04	0.41
RR_E_8	5 year ARI	95.46	95.49	0.04	0.38
	20 year ARI	95.46	95.5	0.05	0.45
	100 year ARI	95.46	95.5	0.06	0.44
RR_E_7	5 year ARI	93.34	93.38	0.05	0.61
	20 year ARI	93.34	93.38	0.07	0.66
	100 year ARI	93.34	93.38	0.09	0.71
RR_E_6	5 year ARI	90.79	90.84	0.05	0.9
	20 year ARI	90.79	90.84	0.07	0.96
	100 year ARI	90.79	90.85	0.09	1.03
RR_E_5	5 year ARI	88.66	88.73	0.07	1.02
	20 year ARI	88.66	88.73	0.09	1.1
	100 year ARI	88.66	88.74	0.11	1.16
RR_E_4	5 year ARI	86.37	86.45	0.07	1
	20 year ARI	86.37	86.45	0.09	1.07
	100 year ARI	86.37	86.46	0.11	1.13
RR_E_3	5 year ARI	84.55	84.62	0.08	1.02
	20 year ARI	84.55	84.63	0.11	1.09
	100 year ARI	84.55	84.63	0.13	1.15
RR_E_2	5 year ARI	82.62	82.69	0.08	0.95
	20 year ARI	82.62	82.69	0.11	1.03
	100 year ARI	82.62	82.7	0.13	1.08
RR_E_1	5 year ARI	80.9	80.96	0.08	1.05
	20 year ARI	80.9	80.97	0.11	1.18
	100 year ARI	80.9	80.98	0.13	1.26
FS_S_4	5 year ARI	77.55	77.59	0.02	0.48
	20 year ARI	77.55	77.6	0.03	0.48
	100 year ARI	77.55	77.61	0.04	0.5
FS_S_3	5 year ARI	75.6	75.63	0.02	0.79
	20 year ARI	75.6	75.64	0.03	0.95
	100 year ARI	75.6	75.64	0.04	1
FS_S_2	5 year ARI	74.48	74.53	0.02	0.33
	20 year ARI	74.48	74.53	0.03	0.37
	100 year ARI	74.48	74.54	0.04	0.4
FS_S_1	5 year ARI	74.24	74.28	0.02	0.38
	20 year ARI	74.24	74.28	0.03	0.43
	100 year ARI	74.24	74.29	0.04	0.46





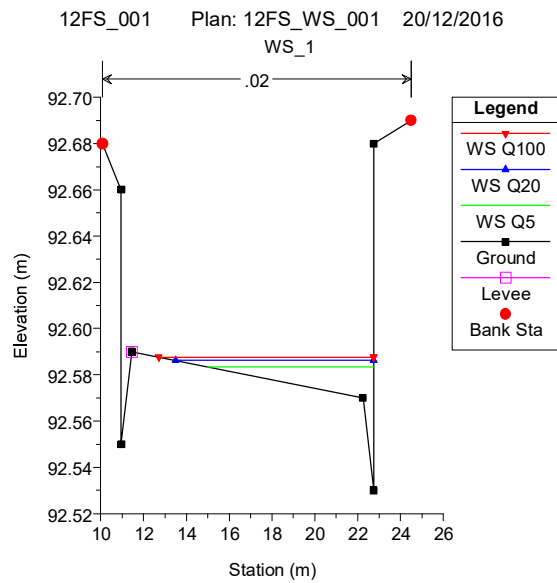
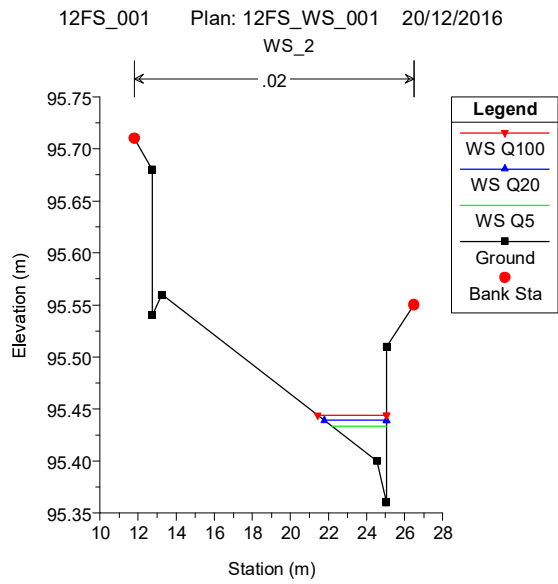
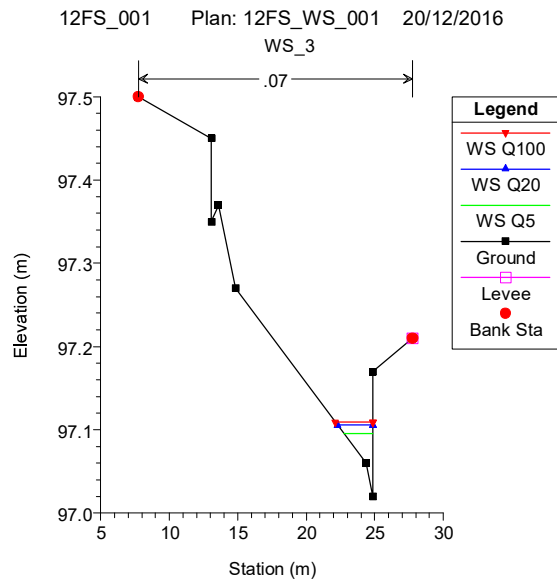


ANNEXURE E

WESTBOURNE STREET HEC-RAS MODEL RESULTS

HEC-RAS Plan: 12FS_WS River: Westbourne St Reach: Westbourne_St

Cross-section	Profile	Gutter Level	Max. Water Surface Elevation	Peak Flow	Flow Velocity
		(m AHD)	(m AHD)	(m³/s)	(m/s)
WS_3	5 year ARI	97.02	97.1	0.03	0.53
	20 year ARI	97.02	97.11	0.04	0.52
	100 year ARI	97.02	97.11	0.05	0.58
WS_2	5 year ARI	95.36	95.43	0.05	0.7
	20 year ARI	95.36	95.44	0.06	0.78
	100 year ARI	95.36	95.44	0.08	0.81
WS_1	5 year ARI	92.53	92.58	0.07	1.01
	20 year ARI	92.53	92.59	0.09	1.04
	100 year ARI	92.53	92.59	0.12	1.12



SCHEDULE 3 – MUSIC RESULTS

Receiving Node

8/06/2017 11:42:08 AM

Treatment Train Effectiveness

	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	Gross Pollutants (kg/yr)
Sources	7.41	1.39E3	2.78	16.9	180
Residual Load	7.41	278	0.708	8.50	6.71
% Reduction	0.0	80.0	74.6	49.7	96.3