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 years[1].

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 m^3/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 m^3/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 m^3/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

CLEG ST
CLARENDON ST
CAMPBELL ST
LANCELEY PL
RESERVE RD
FREDERICK ST
HERBERT ST
FRANCIS ST
PARK RD
STATION ST
ELLA ST
DALLEYS RD
TALUS ST
NORTH SHORE RAIL LINE
WESTBOURNE STREET
PACIFIC HWY
ROYAL NORTH SHORE HOSPITAL

FREDERICK STREET ENTRANCE / EXIT

EXTENT OF 0.3 ha CATCHMENT CONTRIBUTING TO FLOW IN EXISTING STORMWATER DRAINAGE SYSTEM ON EASTERN SIDE OF RESERVE ROAD

RESERVE ROAD LOWER ENTRANCE / EXIT

PROPOSED LOT 2

RESERVE ROAD UPPER ENTRANCE / EXIT

EXTENT OF 2.7 ha CATCHMENT CONTRIBUTING TO FLOW IN EXISTING STORMWATER DRAINAGE SYSTEM ON WESTERN SIDE OF RESERVE ROAD

PROPOSED LOT 1

EXTENT OF 0.2 ha CATCHMENT CONTRIBUTING TO FLOW ALONG SOUTHERN KERBLINE OF WESTBOURNE STREET

N

30 0 30 60 90 m

Scale: 1:3,000

LEGEND

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

Lyall & Associates

12 FREDERICK STREET, ST LEONARDS
FLOODING ASSESSMENT

Figure 1

CATCHMENT PLAN AND EXISTING STORMWATER DRAINAGE SYSTEM

PRELIMINARY ONLY

FREDERICK STREET ENTRANCE / EXIT

RESERVE ROAD EAST HEC-RAS MODEL

RESERVE ROAD LOWER ENTRANCE / EXIT

RESERVE ROAD UPPER ENTRANCE / EXIT

RESERVE ROAD WEST HEC-RAS MODEL

WESTBOURNE STREET HEC-RAS MODEL

ROYAL NORTH SHORE HOSPITAL

RESERVE RD

FREDERICK ST

LANGELEY PL

ELLA ST

HERBERT ST

WESTBOURNE ST

Pit1 Pit2 Pit3 Pit4 Pit5

RR_W_1 RR_W_2 RR_W_3 RR_W_4 RR_W_5 RR_W_6 RR_W_7 RR_W_8 RR_W_9 RR_W_10

RR_E_1 RR_E_2 RR_E_3 RR_E_4 RR_E_5 RR_E_6 RR_E_7 RR_E_8 RR_E_9 RR_E_10

FS_S_1 FS_S_2 FS_S_3 FS_S_4

WS_1 WS_2 WS_3

525 450 375 825

N

15 0 15 30 45 m

Scale: 1:1,500

LEGEND

- Overland Flow Path HEC-RAS Model
- RR_E_1 HEC-RAS Cross-section and Identifier
- Property Boundary
- Extent of Detailed Ground Survey Data
- Inlet Pit
- Junction Pit
- 525 Existing Stormwater Pipe and Diameter (mm) (only shown in vicinity of Property)
- Existing Stormwater Drainage Network

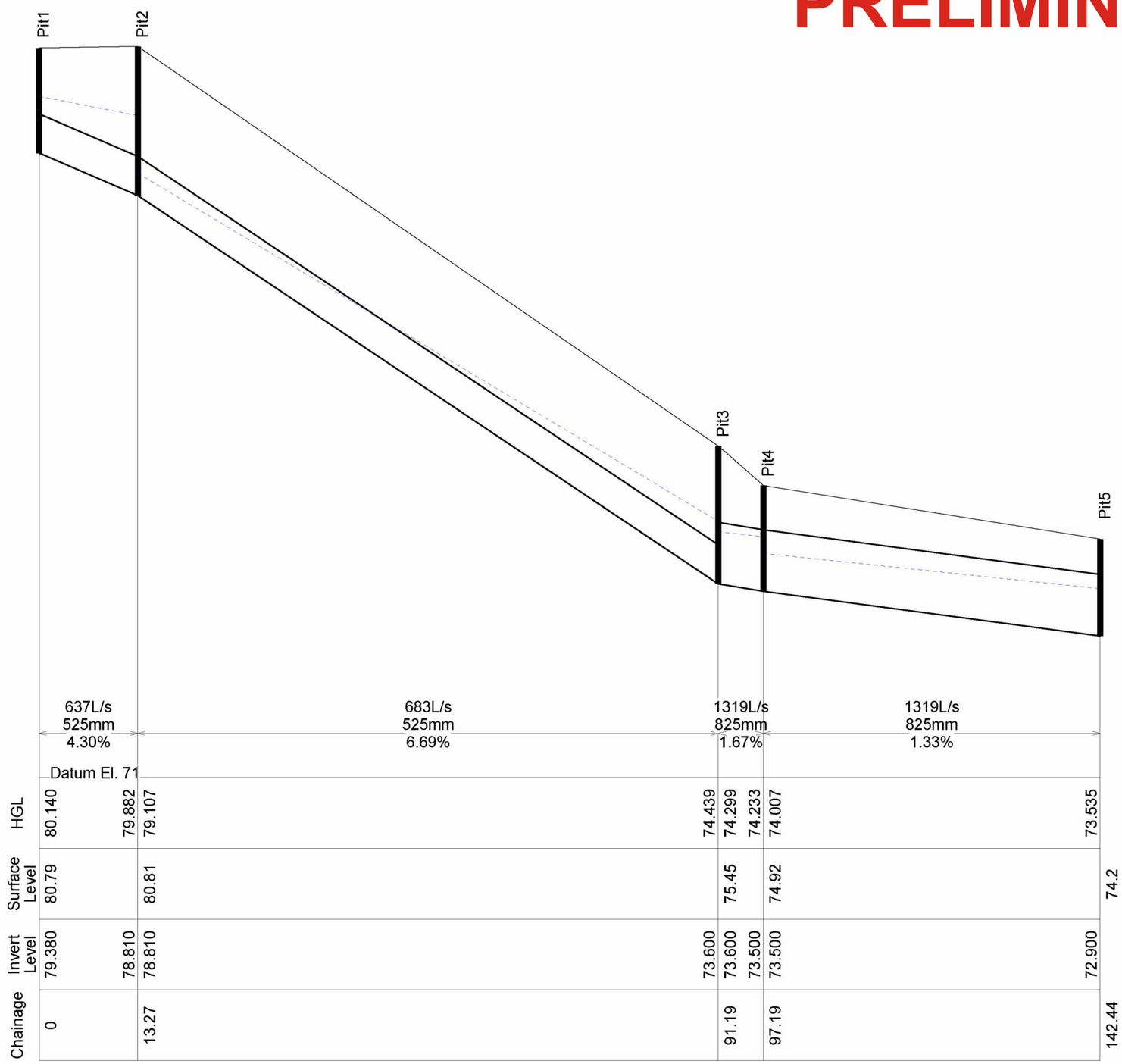
Lyall & Associates

12 FREDERICK STREET, ST LEONARDS
FLOODING ASSESSMENT

Figure 2

HYDROLOGIC AND HYDRAULIC MODEL LAYOUT

PRELIMINARY ONLY



12 FREDERICK STREET, ST LEONARDS
FLOODING ASSESSMENT

Figure 3

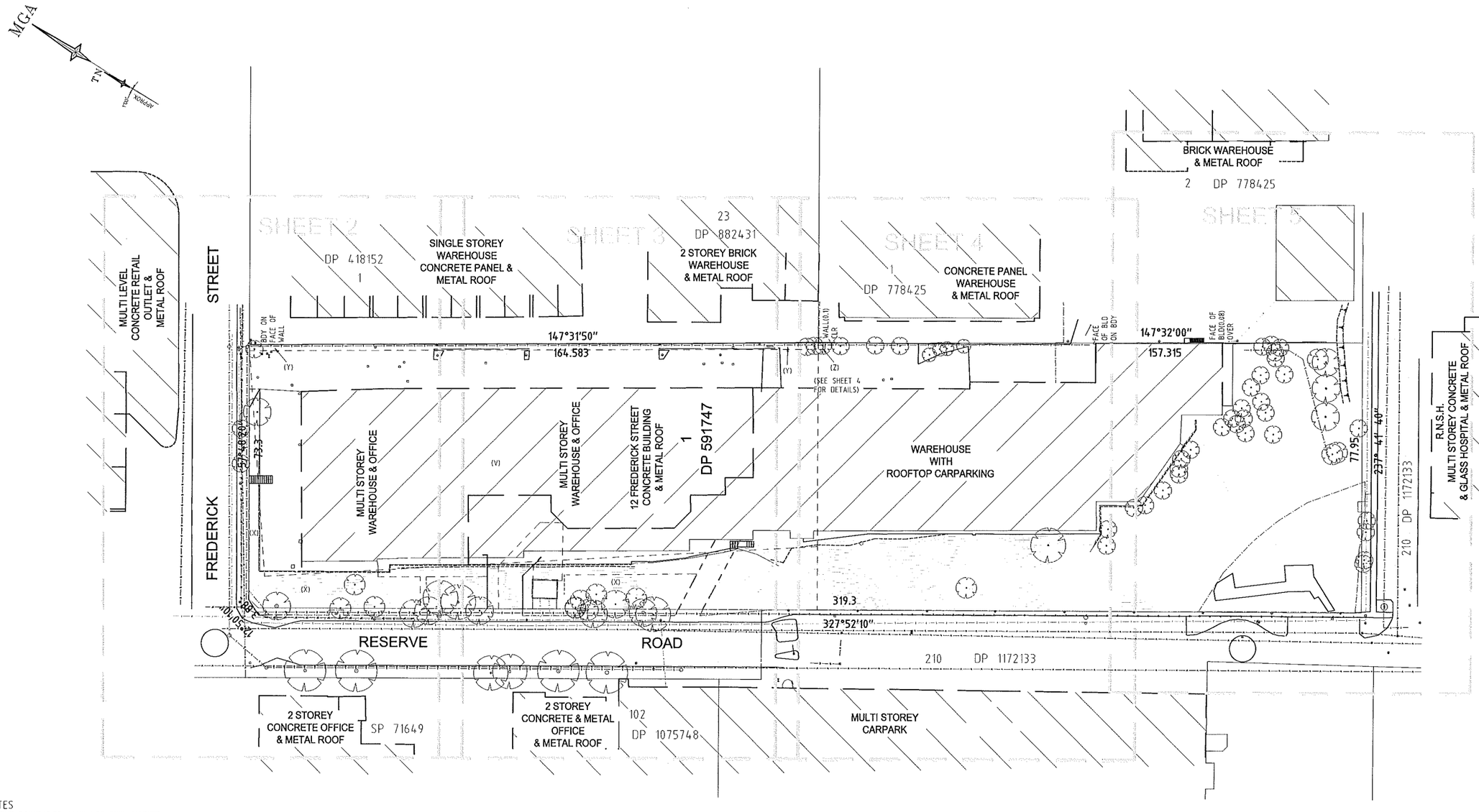
HYDRAULIC GRADE LINE
100 YEAR ARI

Lyall & Associates

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



LEGEND

BENCH MARK	▲
OPTUS PIT	OP
TELSTRA PILLAR	TP
COMMS PIT	COM
TELSTRA PIT	TEL
ELECTRIC LIGHT POLE	ELP
ELECTRIC LIGHT BOLLARD	LB
ELECTRICITY PIT	EPIT
ELECTRICITY BOX	EL
POWER POLE	PP
SERVICE PIT	PIT
PIT WITH CONCRETE LID	CLID
PIT WITH METAL LID	MLID
TRAFFIC LIGHT	TL
STREET SIGN	SS
BOLLARD	BOL
ROAD TRAFFIC AUTHORITY	RTA
GRATED INLET PIT	GIP
KERB INLET PIT	KIP
SEWER INSPECTION POINT	SIP
SEWER MANHOLE	SMH
STOP VALVE	SV
HYDRANT	HYD
FIRE HYDRANT	FH
FIRE SERVICE	FBST
WATER METER	WM
WATER VALVE	WV
GAS VALVE	GM
GAS VALVE	GAS
VEHICLE CROSSING	(VC)
PRAM CROSSING	(PC)
WINDOW	W
DOOR	D
HEAD/SILL	H/S
GAS (DBYD)	G
TELSTRA (DBYD)	T
WATER (DBYD)	W
STORMWATER (DBYD)	
SEWER (DBYD)	S
ELECTRICITY (OVERHEAD)	P
ELECTRICITY (U'GROUND) (DBYD)	E
NATIONAL BROADBAND NETWORK (DBYD)	NBN
GAS (DETECTED)	G(D)
TELSTRA (DETECTED)	T(D)
OPTICAL FIBRE (DETECTED)	OF(D)
WATER (DETECTED)	W(D)
STORMWATER (DETECTED)	
SEWER (DETECTED)	S(D)
ELECTRICITY (DETECTED)	E(D)
UNKNOWN SERVICE (DETECTED)	U(D)

NOTES

1. THE BOUNDARIES HAVE NOT BEEN MARKED
2. ALL AREAS AND DIMENSIONS HAVE BEEN COMPILED FROM PLANS MADE AVAILABLE BY THE OFFICE of LAND & PROPERTY INFORMATION (NSW) AND ARE SUBJECT TO FINAL SURVEY
3. ORIGIN OF LEVELS ON A.H.D. IS TAKEN FROM **SSM38990** R.L. **76.645** (A.H.D.) IN HERBERT STREET
4. CONTOUR INTERVAL **0.5m**
5. CONTOURS ARE INDICATIVE ONLY. ONLY SPOT LEVELS SHOULD BE USED FOR CALCULATIONS OF QUANTITIES WITH CAUTION
6. ONLY SPOT LEVELS SHOULD BE USED FOR CALCULATIONS OF QUANTITIES WITH CAUTION
7. KERB LEVELS ARE TO THE TOP OF KERB UNLESS SHOWN OTHERWISE
8. FLOOR LEVELS SHOWN ARE THRESHOLD LEVELS. NO INVESTIGATION OF INTERNAL FLOOR LEVELS HAS BEEN UNDERTAKEN
9. 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
10. 8/.477 DENOTES TREE SPREAD OF 8m, TRUNK DIAMETER OF 0.4m & APPROX HEIGHT OF 7m
11. SHOWS APPROXIMATE POSITION OF ROAD LINEMARKING AND IS INDICATIVE ONLY
12. BEARINGS SHOWN ARE MGA (MAP GRID OF AUSTRALIA) ADD APPROX. 1°00' FOR TRUE NORTH

EASEMENTS

(V) - COVENANT (DP 591747 & H 542568)
(X) - EASEMENT FOR SUPPORT (DP 591747 & H 542567)
(Y) - EASEMENT FOR DRAINAGE (DP 591747 & H 542568)
(Z) - EASEMENT FOR DRAINAGE (DP 591747)

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Registered Surveyor NSW

LOCKLEY
Registered Surveyors NSW
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Suite 1, Level 1
810 Pacific Highway
Gordon NSW 2072
Locked Bag 5
Gordon NSW 2072
P 1300 587 000
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Client DEXUS PROPERTY GROUP

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

datum	AHD	project number	42243DT - UNTOUCHED_A3
site Area	2.478ha	scale	1:600 @A1
		date of survey	30/08/15
LGA	WILLOUGHBY	SHEET	1 OF 7 SHEETS | 1

MGA

TN

APPROX. 10°

EAVE 83.09
RIDGE 87.36
RIDGE 83.47
RIDGE 87.36
RIDGE 83.41
RIDGE 87.38
RIDGE 87.40

MULTI LEVEL
CONCRETE RETAIL
OUTLET &
METAL ROOF

PARAPET 83.30

SIGN 82.49 TOP 81.25 BASE

CONCRETE FOOTPATH

FREDERICK STREET

ROUNDABOUT

OVERHEAD ELEC LINE

BENCH

FOOTPATH

CONCRETE FOOTPATH

57°48'20"
73.3

72°50'10"
3.88

GARDEN

PAVED

CARPARK

SIP

FENCE

KERB

2 STOREY
CONCRETE OFFICE
& METAL ROOF

PARAPET 90.12

PARAPET 91.65

PARAPET 95.23

PARAPET 95.24

PARAPET 94.93

SP 71649

FOOTPATH

CONCRETE

ROAD

RESERVE

GARDEN

WALKWAY

EXTENT OF OVERHANG

EXTENT OF OVERHANG

CONCRETE

PARAPET 92.32

MULTI STOREY
WAREHOUSE & OFFICE

TOP OF GUTTER 91.35

ROOF 91.52

ROOF 92.55

FLOOR LEVEL 81.75 82

DRIVEWAY

CONCRETE

TOP OF WALL

METAL

CONCRETE

LOW

KERB

1
DP 418152

SINGLE STOREY WAREHOUSE
CONCRETE PANEL & METAL ROOF

RIDGE 84.00
EAVE 82.25

EAVE
EAVE
RIDGE
EAVE
EAVE
RIDGE
EAVE
EAVE
RIDGE

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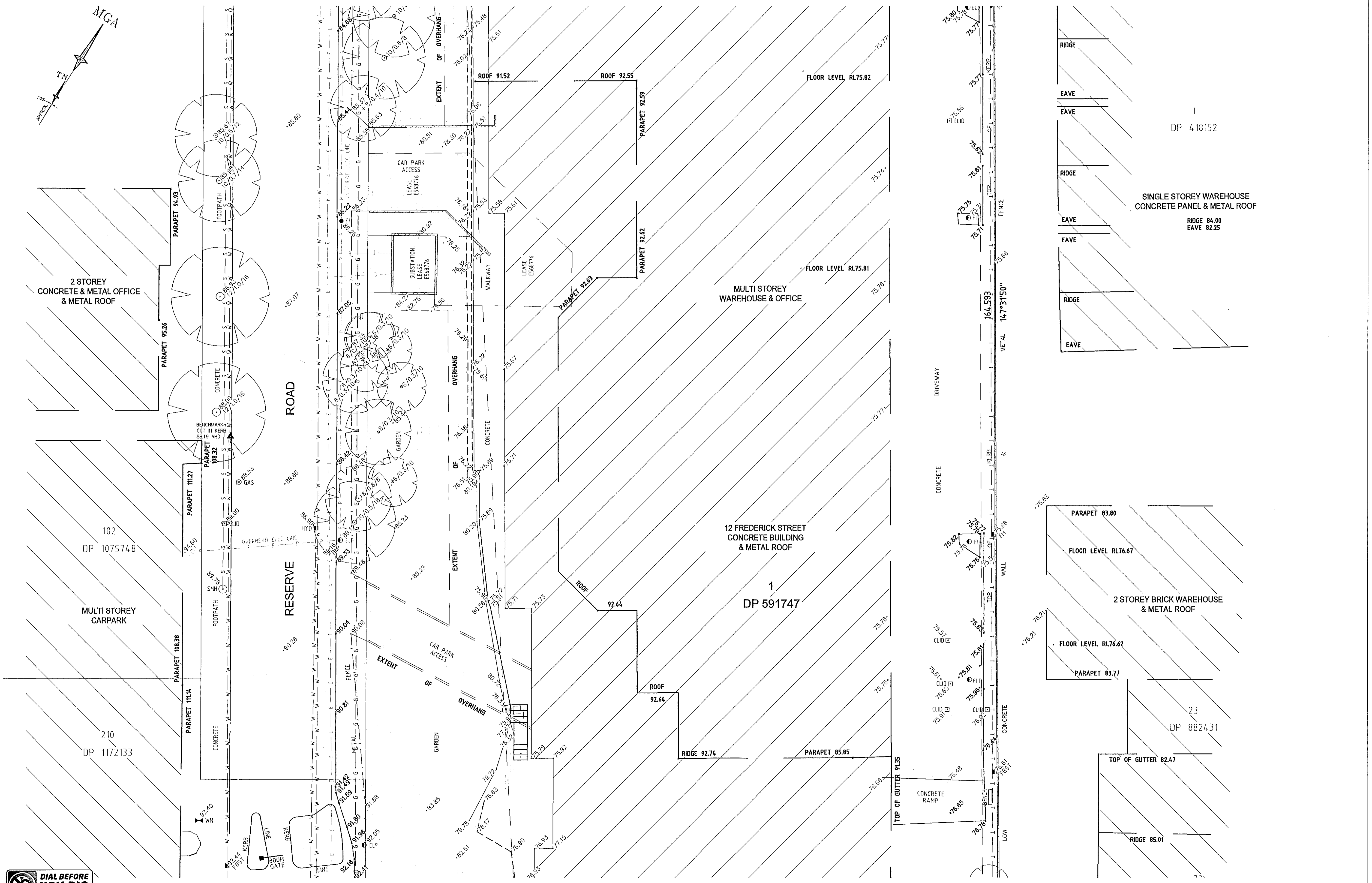
WILLOUGHBY	2 OF 7 SHEETS	2



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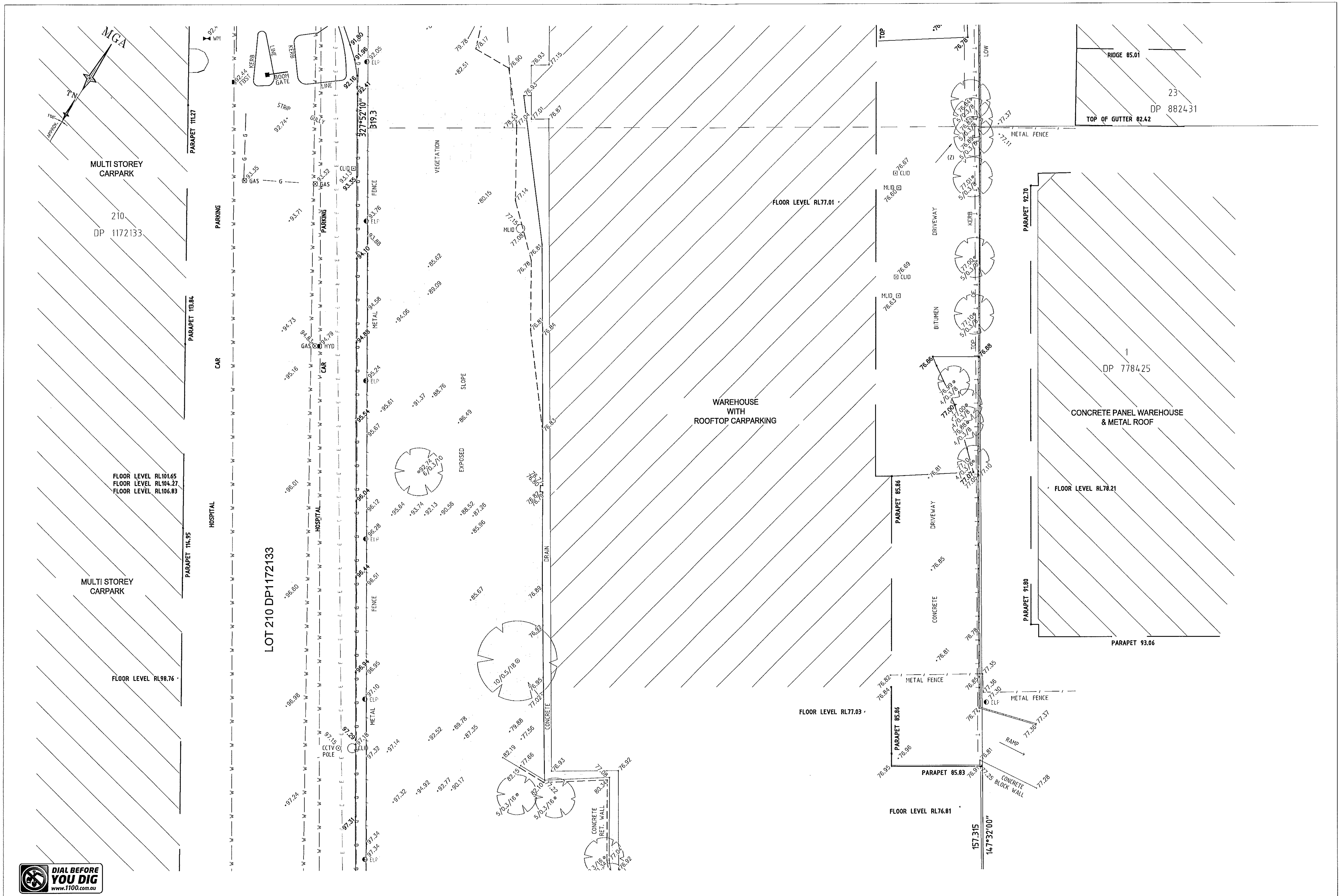
Client DEXUS PROPERTY GROUP

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

datum AHD | project number - | reference number 42243DT - UNTOUCHED_A3

site Area 2.478ha | scale 1:200 @A1 | date of survey 30/08/15

LGA WILLOUGHBY | SHEET 3 OF 7 SHEETS | 3



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project number: -
reference number: 42243DT - UNTOUCHED_A3
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scale: 1:200 @A1
date of survey: 30/08/15
LGA: WILLOUGHBY
SHEET 4 OF 7 SHEETS
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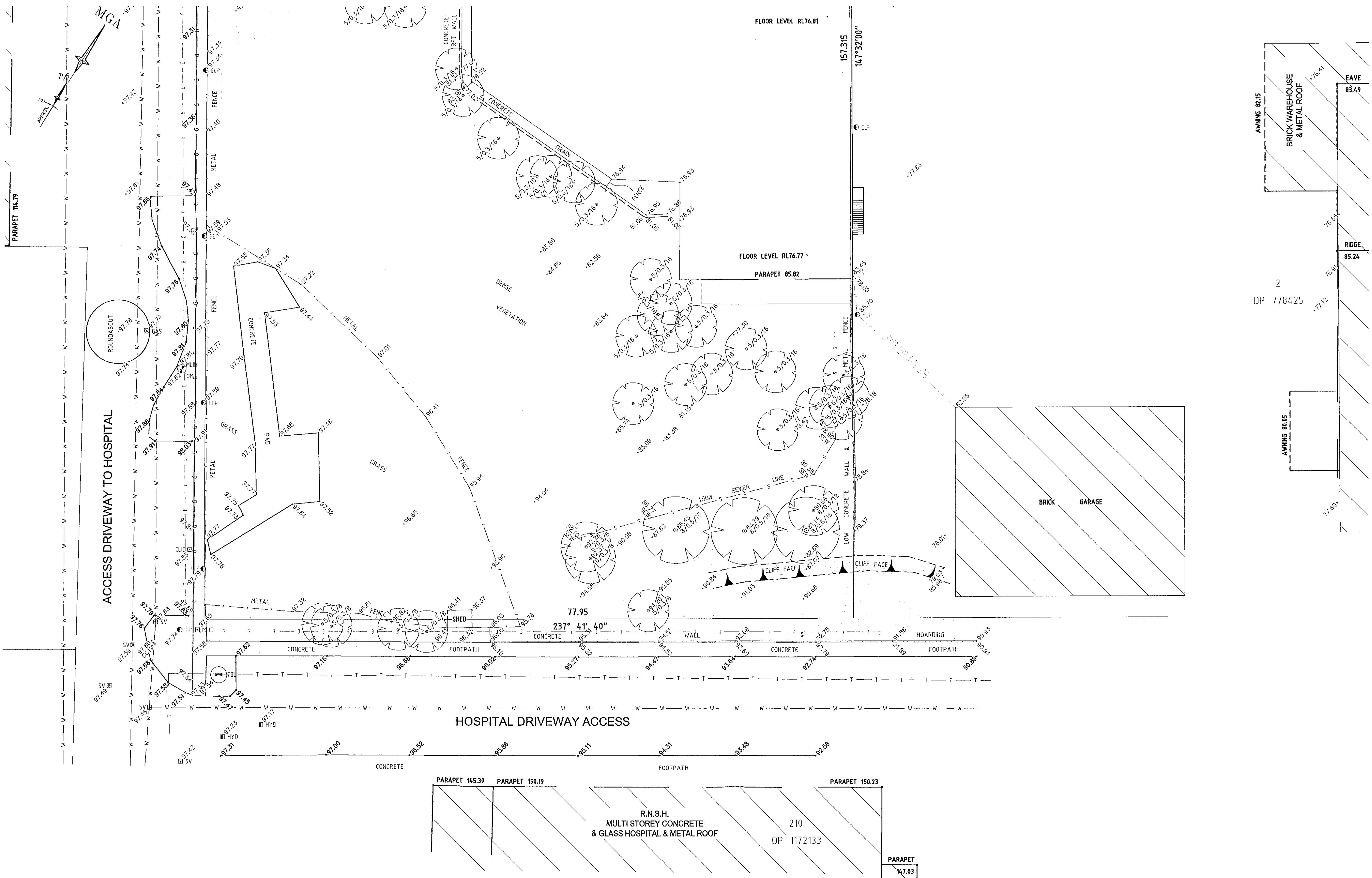

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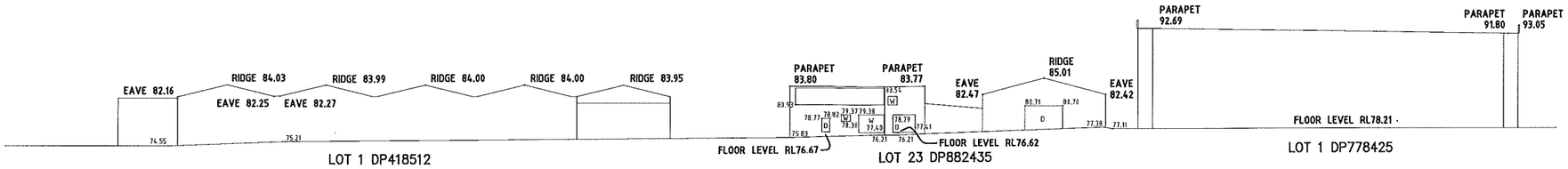
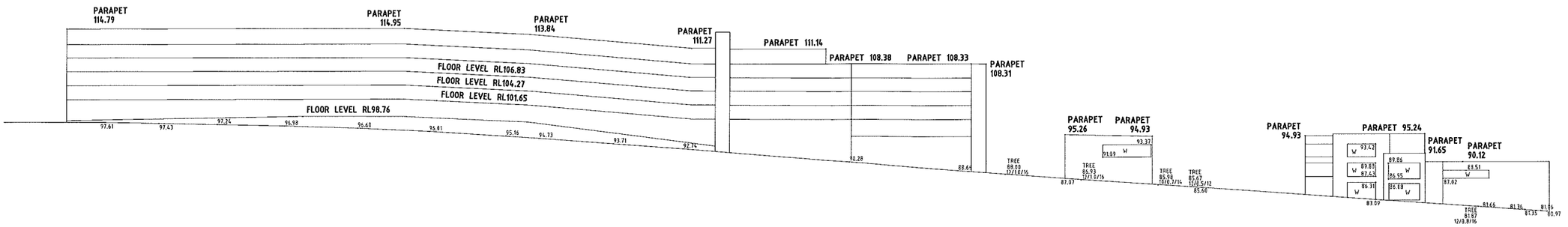


WESTERN ELEVATION



EASTERN ELEVATION – RESERVE ROAD

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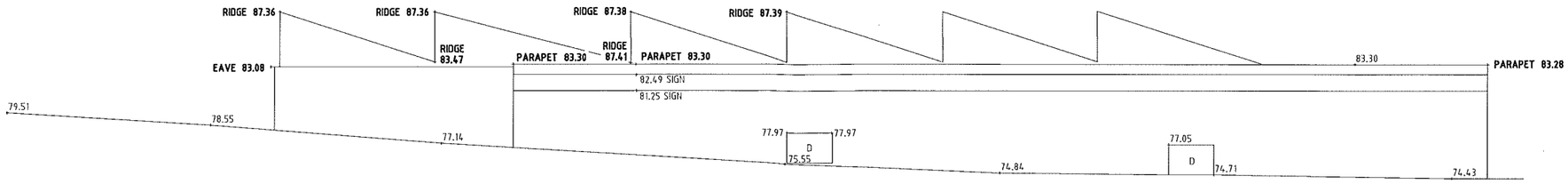
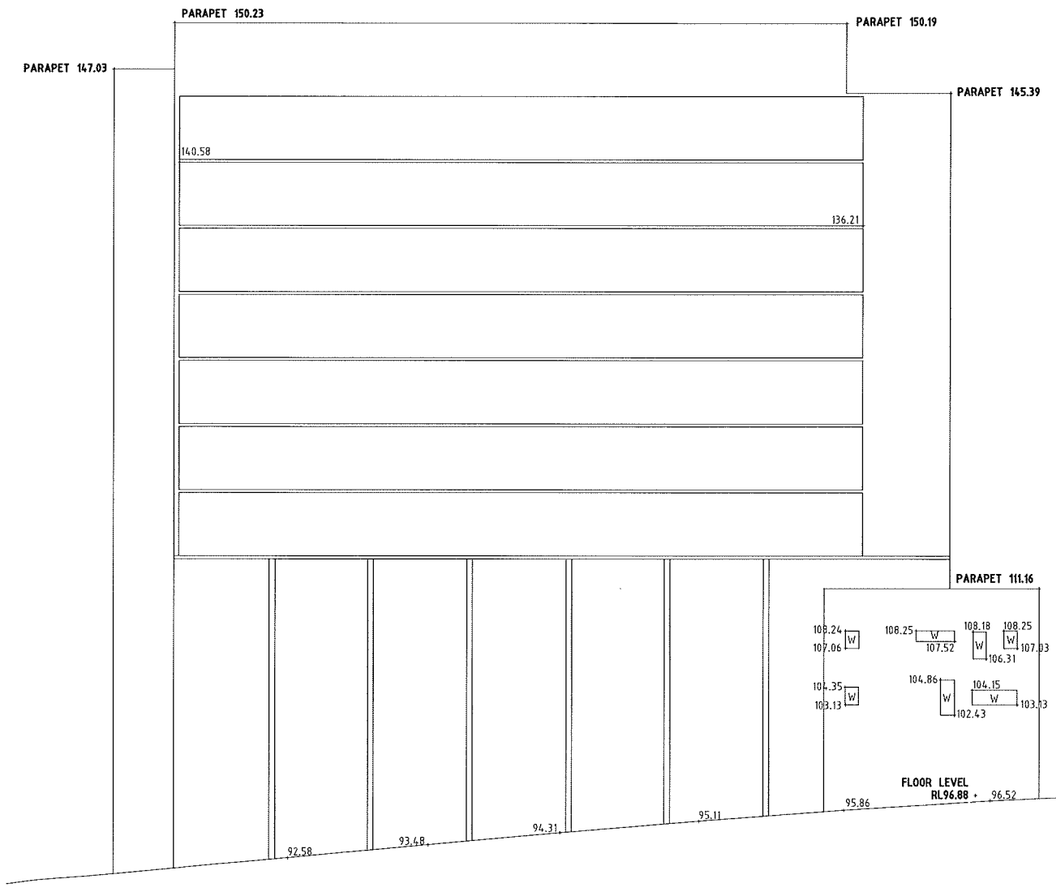


NORTHERN ELEVATION – FREDERICK STREET

WESTERN ELEVATION (2) – LOT 2 DP778425



SOUTHERN ELEVATION – WESTBOURNE STREET

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B	00/00/00	-	00
A	03/08/15	Initial draft plan completed	00

THIS IS THE PLAN REFERRED TO IN MY LETTER DATED:

.....
Registered Surveyor NSW

LTS LOCKLEY
Registered Surveyors NSW
www.lts.com.au
Suite 1, Level 1
810 Pacific Highway
Gordon NSW 2072
Locked Bag 5
Gordon NSW 2072
P 1300 587 000
F 02 9499 7760

Client DEXUS PROPERTY GROUP
Drawing title
PLAN OF DETAIL AND LEVELS OVER LOT 1 IN DP591747
KNOWN AS 12 FREDERICK STREET ST LEONARDS

datum AHD
site Area 2.478ha
LGA WILLOUGHBY
project number -
scale 1:200 @A1
SHEET 7 OF 7 SHEETS
reference number 42243DT - UNTOUCHED_A3
date of survey 30/08/15
7

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

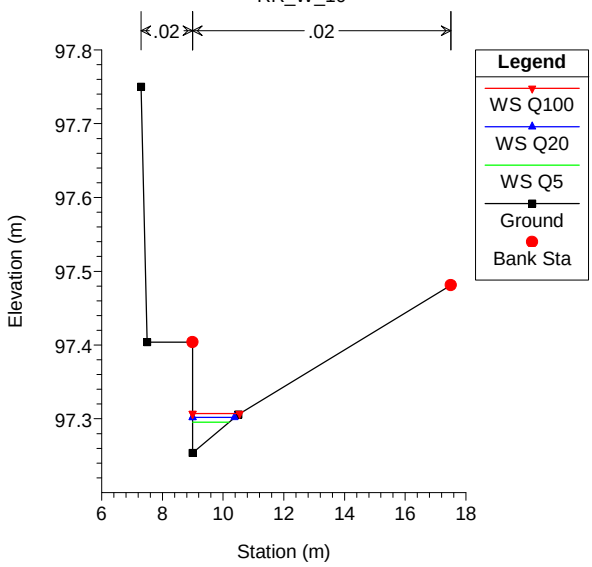
RESERVE ROAD WEST HEC-RAS MODEL RESULTS

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)	(m^3/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

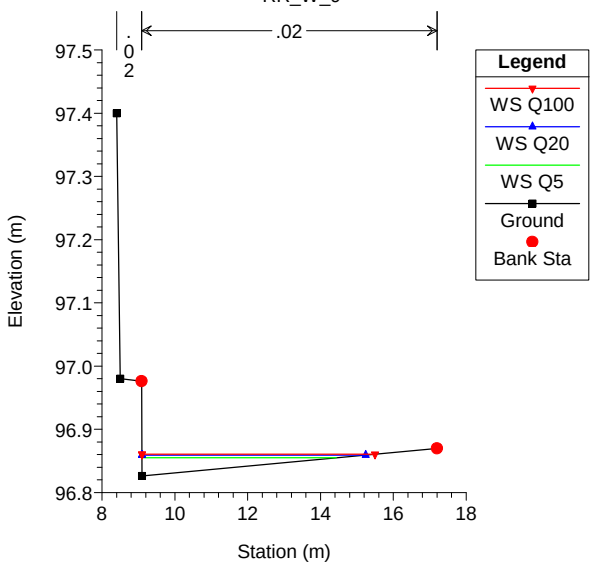
12FS_001 Plan: 12FS_W_001 20/12/2016

RR_W_10



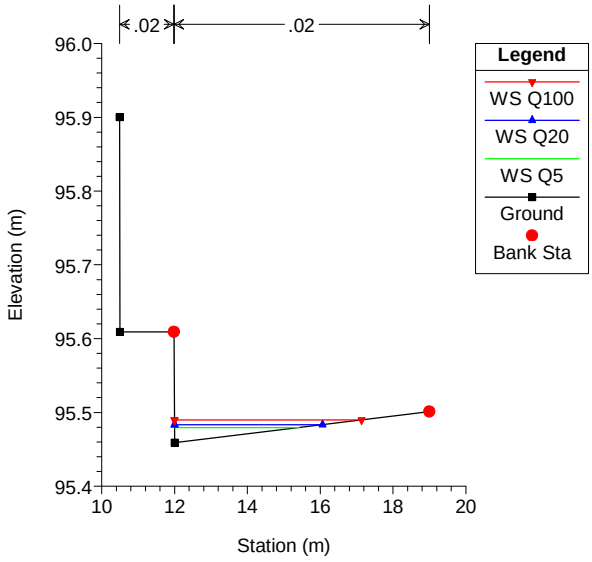
12FS_001 Plan: 12FS_W_001 20/12/2016

RR_W_9



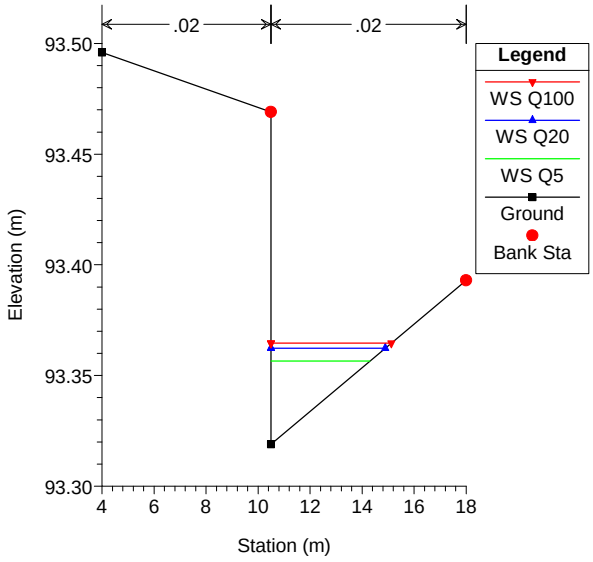
12FS_001 Plan: 12FS_W_001 20/12/2016

RR_W_8



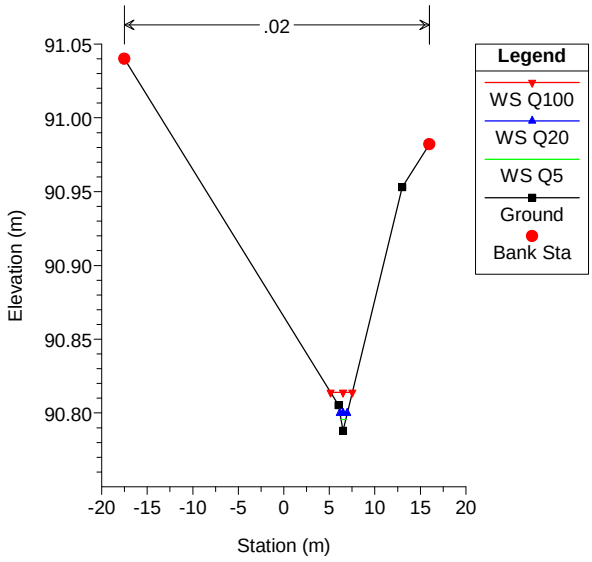
12FS_001 Plan: 12FS_W_001 20/12/2016

RR_W_7



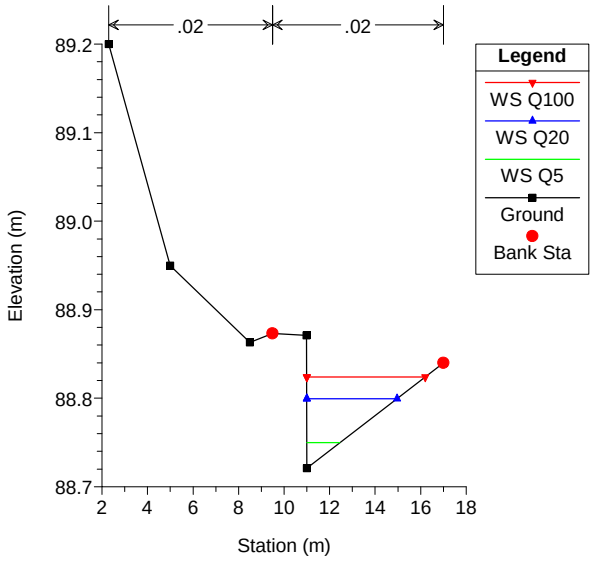
12FS_001 Plan: 12FS_W_001 20/12/2016

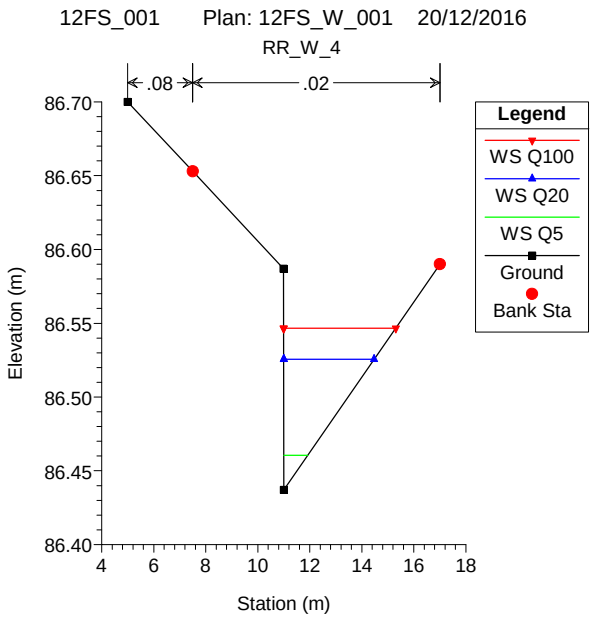
RR_W_6

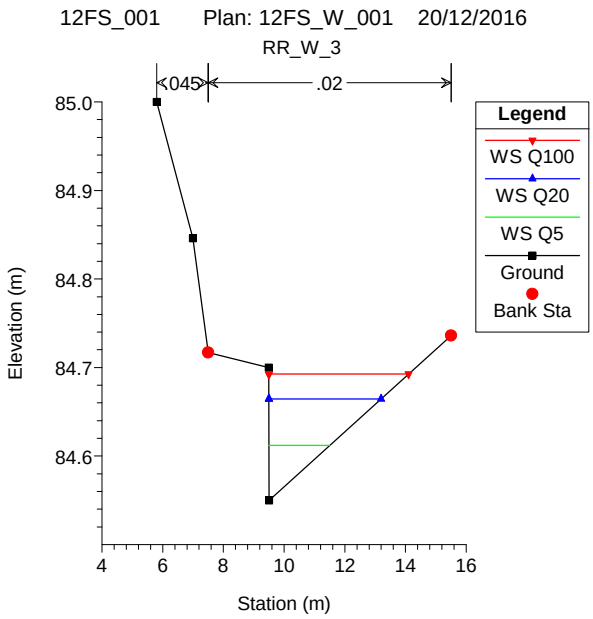


12FS_001 Plan: 12FS_W_001 20/12/2016

RR_W_5




12FS_001 Plan: 12FS_W_001 20/12/2016
RR_W_4
.08
.02
Elevation (m)
Station (m)
Legend
WS Q100
WS Q20
WS Q5
Ground
Bank Sta


12FS_001 Plan: 12FS_W_001 20/12/2016
RR_W_3
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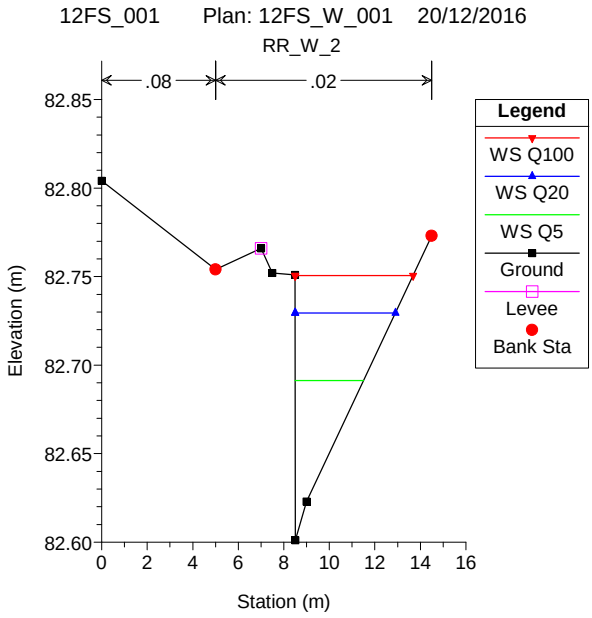
.02
Elevation (m)
Station (m)
Legend
WS Q100
WS Q20
WS Q5
Ground
Bank Sta


12FS_001 Plan: 12FS_W_001 20/12/2016
RR_W_2
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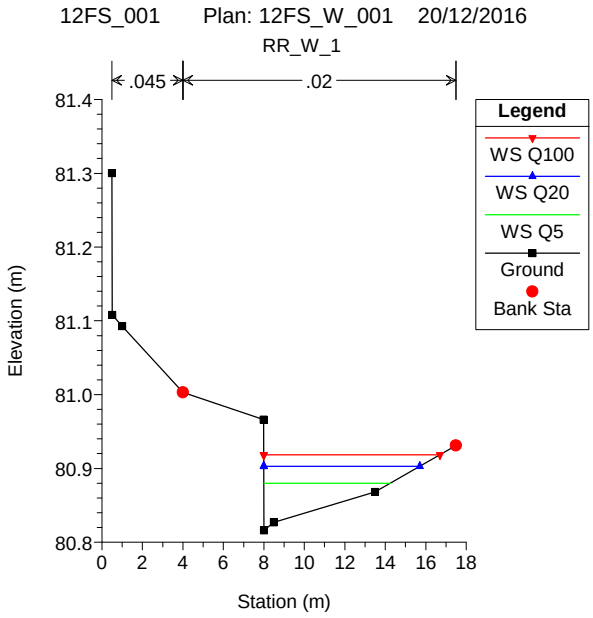
.02
Elevation (m)
Station (m)
Legend
WS Q100
WS Q20
WS Q5
Ground
Levee
Bank Sta


12FS_001 Plan: 12FS_W_001 20/12/2016
RR_W_1
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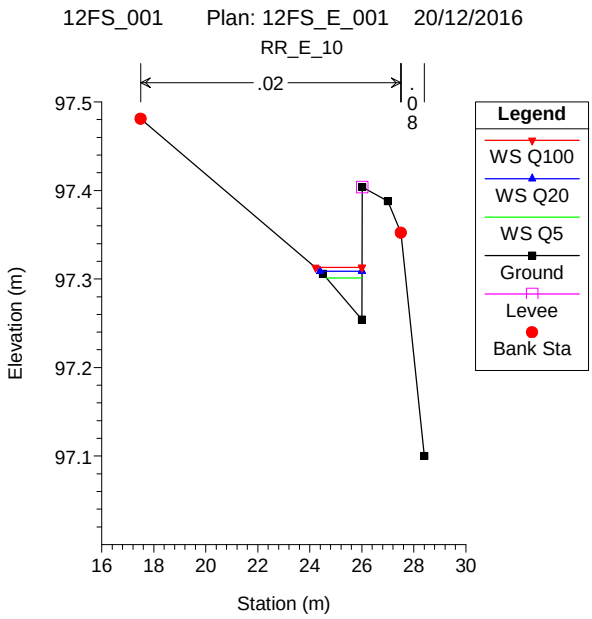
.02
Elevation (m)
Station (m)
Legend
WS Q100
WS Q20
WS Q5
Ground
Bank Sta

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)	(m^3/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


12FS_001 Plan: 12FS_E_001 20/12/2016
RR_E_10
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Legend
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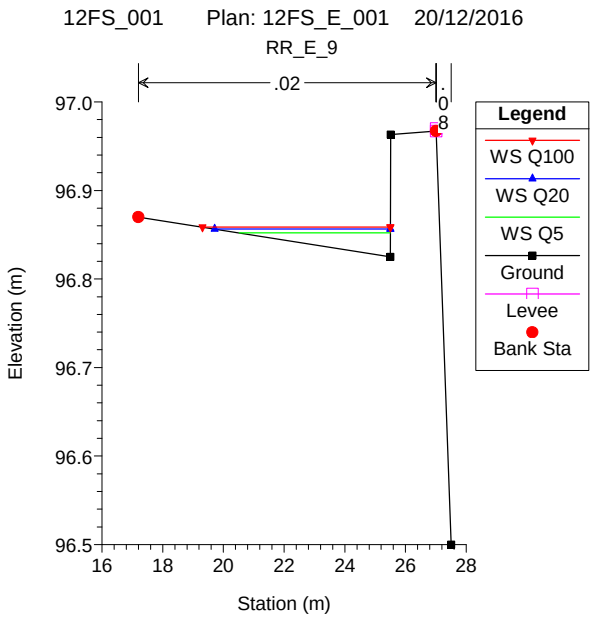
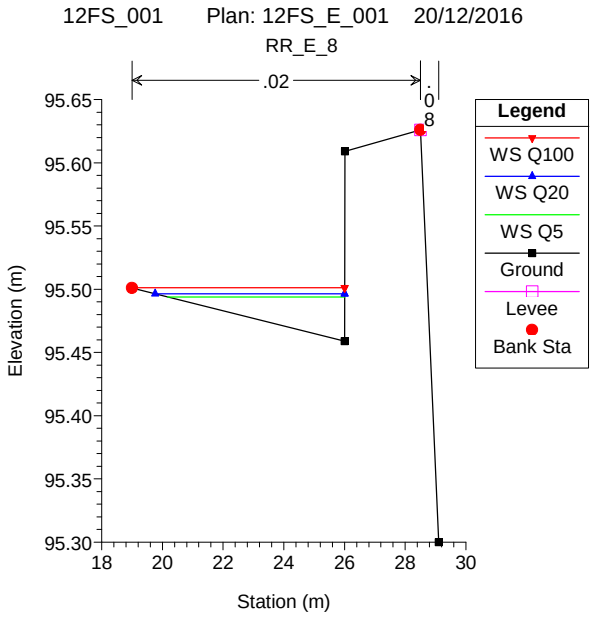
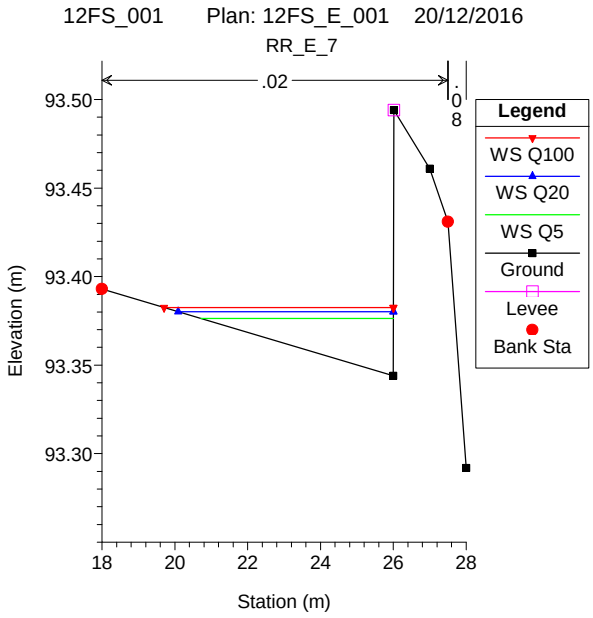
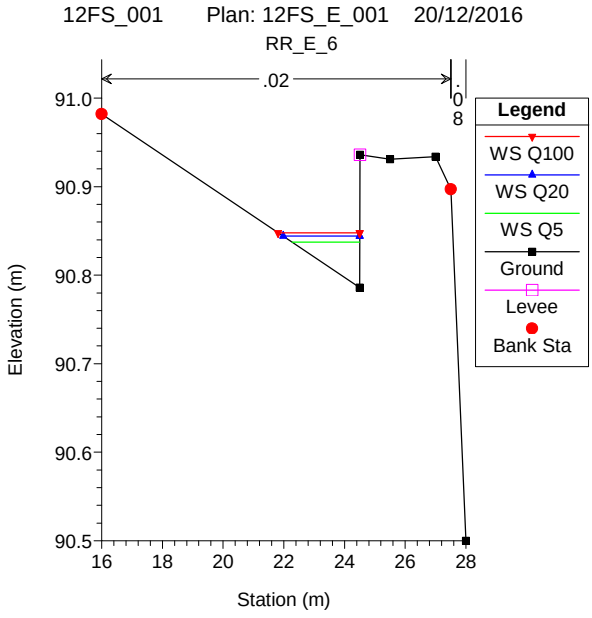
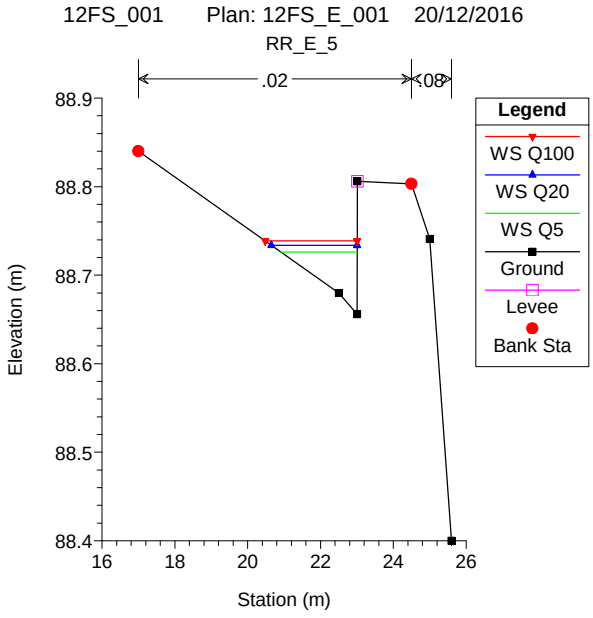
WS Q20
WS Q5
Ground
Levee
Bank Sta
Elevation (m)
Station (m)


12FS_001 Plan: 12FS_E_001 20/12/2016
RR_E_9
.02
.08
Legend
WS Q100
WS Q20
WS Q5
Ground
Levee
Bank Sta
Elevation (m)
Station (m)


12FS_001 Plan: 12FS_E_001 20/12/2016
RR_E_8
.02
.08
Legend
WS Q100
WS Q20
WS Q5
Ground
Levee
Bank Sta
Elevation (m)
Station (m)


12FS_001 Plan: 12FS_E_001 20/12/2016
RR_E_7
.02
.08
Legend
WS Q100
WS Q20
WS Q5
Ground
Levee
Bank Sta
Elevation (m)
Station (m)


12FS_001 Plan: 12FS_E_001 20/12/2016
RR_E_6
.02
.08
Legend
WS Q100
WS Q20
WS Q5
Ground
Levee
Bank Sta
Elevation (m)
Station (m)


12FS_001 Plan: 12FS_E_001 20/12/2016
RR_E_5
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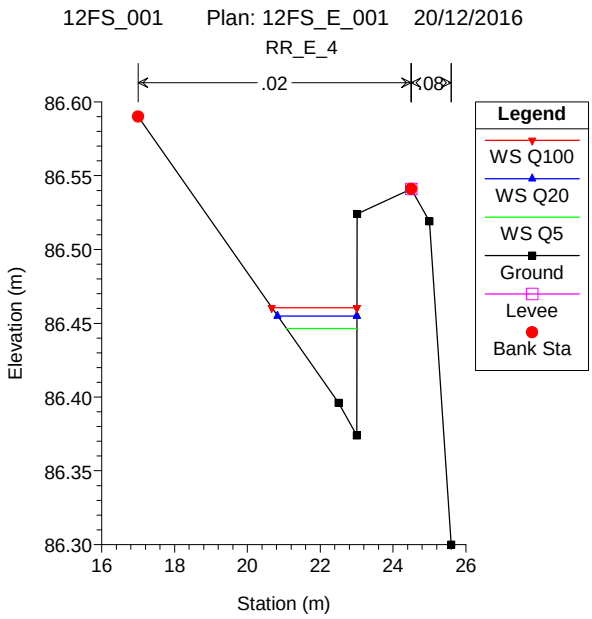
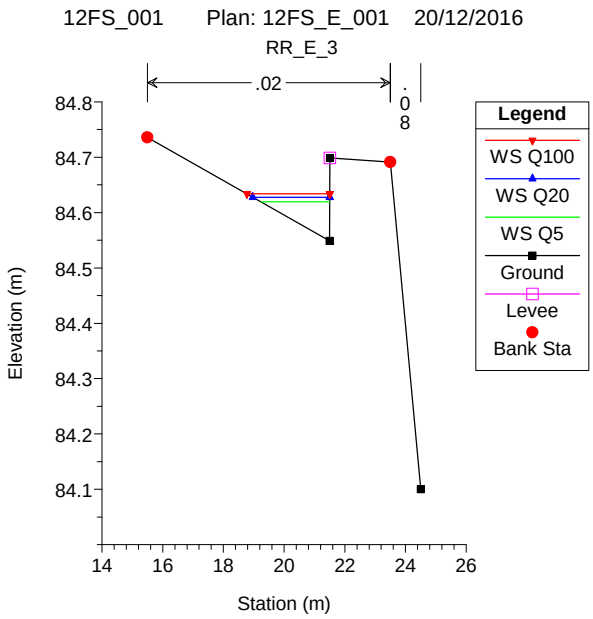
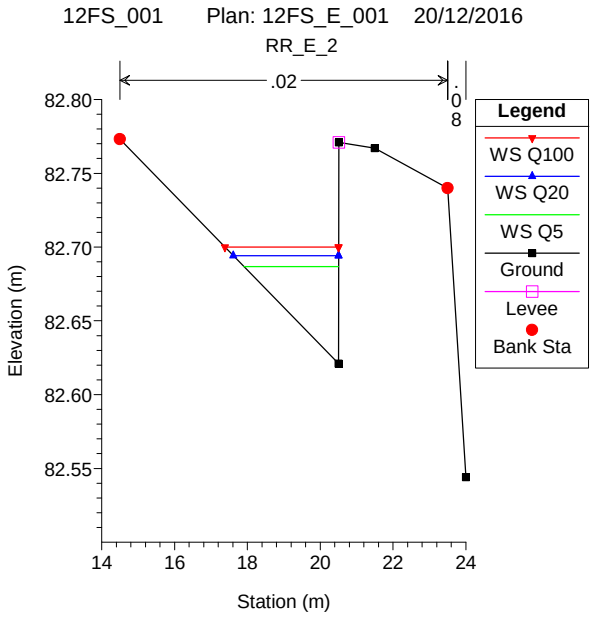
.08
Legend
WS Q100
WS Q20
WS Q5
Ground
Levee
Bank Sta
Elevation (m)
Station (m)


12FS_001 Plan: 12FS_E_001 20/12/2016
RR_E_4
.02
.08
Elevation (m)
Station (m)
Legend
WS Q100
WS Q20
WS Q5
Ground
Levee
Bank Sta


12FS_001 Plan: 12FS_E_001 20/12/2016
RR_E_3
.02
.08
Elevation (m)
Station (m)
Legend
WS Q100
WS Q20
WS Q5
Ground
Levee
Bank Sta


12FS_001 Plan: 12FS_E_001 20/12/2016
RR_E_2
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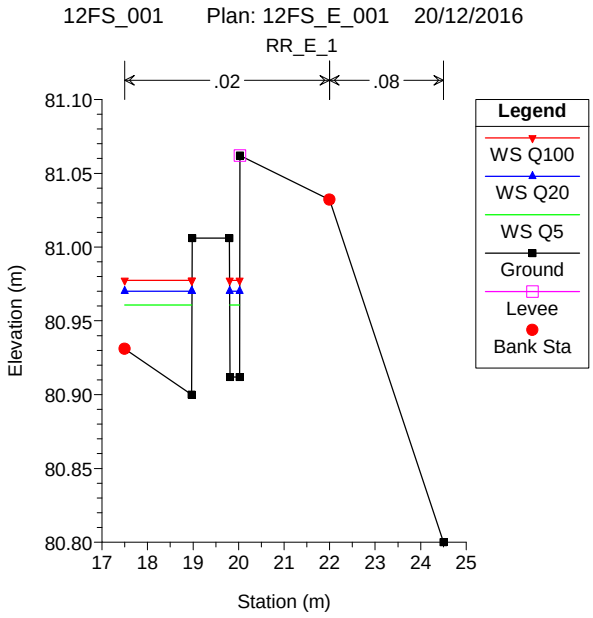
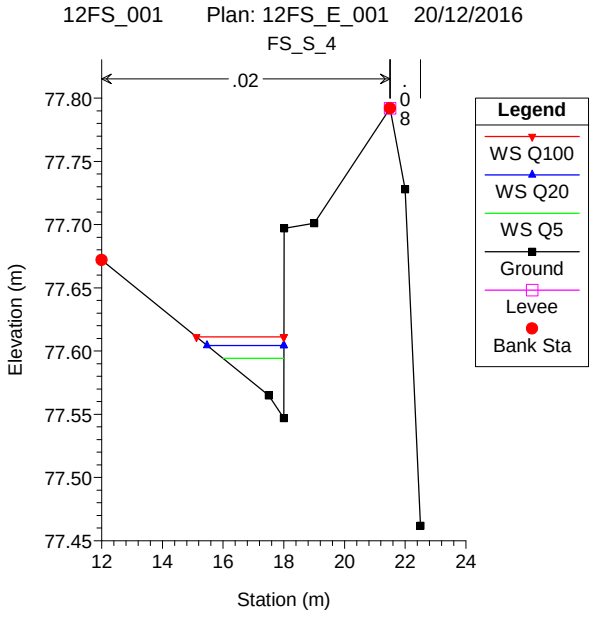
.08
Elevation (m)
Station (m)
Legend
WS Q100
WS Q20
WS Q5
Ground
Levee
Bank Sta


12FS_001 Plan: 12FS_E_001 20/12/2016
RR_E_1
.02
.08
Elevation (m)
Station (m)
Legend
WS Q100
WS Q20
WS Q5
Ground
Levee
Bank Sta


12FS_001 Plan: 12FS_E_001 20/12/2016
FS_S_4
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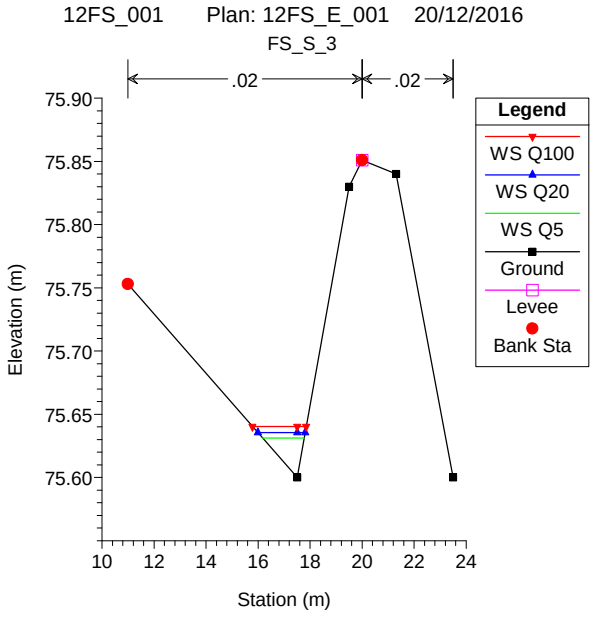
Elevation (m)
Station (m)
Legend
WS Q100
WS Q20
WS Q5
Ground
Levee
Bank Sta


12FS_001 Plan: 12FS_E_001 20/12/2016
FS_S_3
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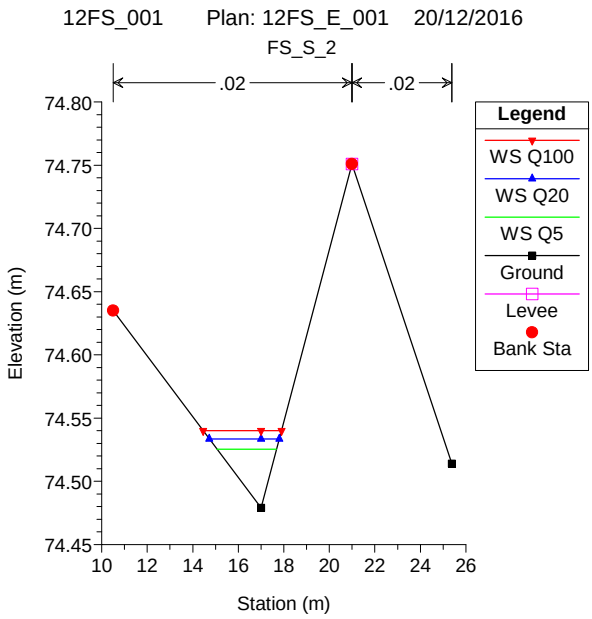
Elevation (m)
Station (m)
Legend
WS Q100
WS Q20
WS Q5
Ground
Levee
Bank Sta


12FS_001 Plan: 12FS_E_001 20/12/2016
FS_S_2
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.02
Legend
WS Q100
WS Q20
WS Q5
Ground
Levee
Bank Sta
Elevation (m)
Station (m)
74.80
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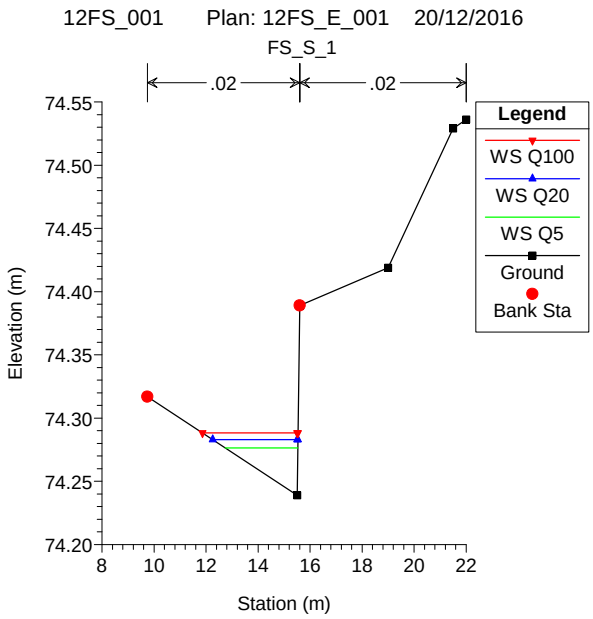
22
24
26

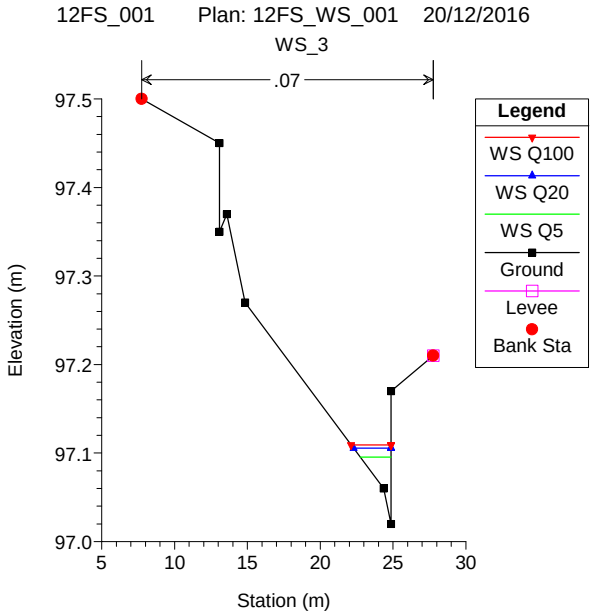

12FS_001 Plan: 12FS_E_001 20/12/2016
FS_S_1
.02
.02
Legend
WS Q100
WS Q20
WS Q5
Ground
Bank Sta
Elevation (m)
Station (m)
74.55
74.50
74.45
74.40
74.35
74.30
74.25
74.20
8
10
12
14
16
18
20
22

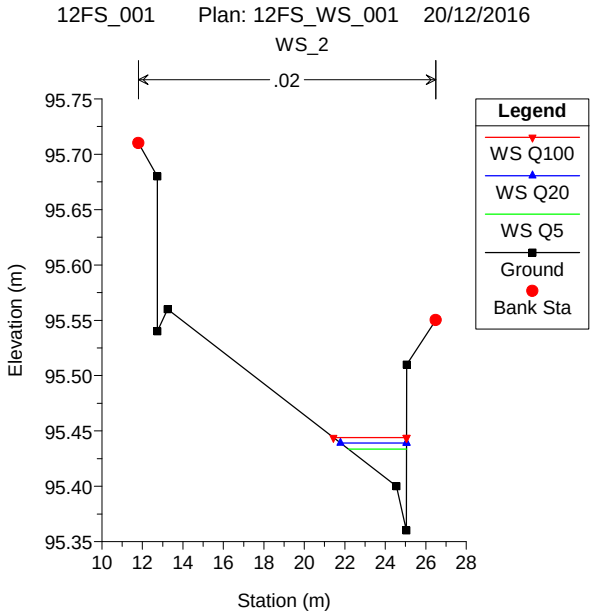
ANNEXURE E

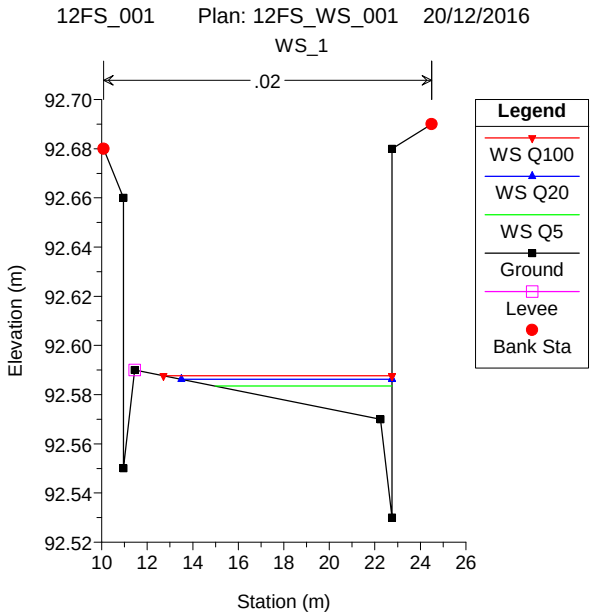
WESTBOURNE STREET HEC-RAS MODEL RESULTS

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)	(m^3/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


12FS_001 Plan: 12FS_WS_001 20/12/2016
WS_3
.07
Elevation (m)
Station (m)
Legend
WS Q100
WS Q20
WS Q5
Ground
Levee
Bank Sta


12FS_001 Plan: 12FS_WS_001 20/12/2016
WS_2
.02
Elevation (m)
Station (m)
Legend
WS Q100
WS Q20
WS Q5
Ground
Bank Sta


12FS_001 Plan: 12FS_WS_001 20/12/2016
WS_1
.02
Elevation (m)
Station (m)
Legend
WS Q100
WS Q20
WS Q5
Ground
Levee
Bank Sta