OAKS MEWS APARTMENTS

BOWEN HILLS, QLD

Stormwater Management Plan

Document History

Revision	Prepared By	Signature:	RPEQ No.	Date
P1	Lachlan Nunn	Lach N	09863	03/12/2019

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY.

This document has been prepared in order to communicate the fundamental design changes required to the site's existing Storm Water Drainage design. The changes to the existing SW design are required to mitigate flood ingress that has occurred numerous times over the last few years into the basement as a result of damaged inground pipework and blocked discharge headwall. During high rainfall events and/or high tide events, back pressure is being applied the inground drainage which is resulting in water backing up and percolating up through basement pits and the slab joints.

The new storm water management plan is designed to remove up to 90% of the site's SW loading from the existing SW inground infrastructure to a new drainage system that running high level within the Basement and out to a new head wall within Breakfast (Enoggera) Creek.

The new drainage systems will be a combination of both Conventional Traditional Drainage Systems with retention and Siphonic Roof Drainage Systems.

2.0 INTRODUCTION

2.1 THE PROJECT

Oaks Mews Apartments
141 Campbell Street
Bowen Hills QLD 4006

Syfon Systems were approached by The Body Corporate for The Mews Bowen Hills in May 2018 to investigate the Site's existing storm water conditions and provide an alternative drainage solution to overcome the site's current water ingress issues that had frequently occurred within the Basement causing extensive damage to the building's assets and occupant's property.

A "Water Inundation Investigation – Stage 2" report (Dated: November 2017) by Lambert & Rehbein Civil Consulting firm (refer to Appredix C) was provided to Syfon Systems which documents that;

"water ingress occurred firstly when the roofwater system failed, whereby the system could not drain to the existing Council pipe due to the raised levels in the pipe Enoggera Creek. This caused backup pressure in the roofwater system which subsequently resulted in the top slabs of the stormwater manholes lifting off the main chamber of the manhole. This in turn allowed water under the slab from both the roofwater system and potentially backwater from the Council pipe. The excess water under the slab then caused the basement drainage system to be overloaded."

Syfon Systems provided a remedial works drainage solution that captures up to 90% of the sites drainage to a new headwall via new high level Basement drainage pipework systems.

Syfon Systems have been engaged to undertake the works from our design and hence seeking approval from the EDQ for the proposed new drainage solution.

2.2 COMPETENCY

Syfon Systems are Specialist Roof Drainage Engineers with extensive experience in Siphonic roof drainage systems & rain water harvesting, especially in high rainfall areas. Commencing business is 1992, and having worked extensively with European Siphonic and conventional systems, the company now employs over 200 staff throughout Australia & Asia. We have fully staffed offices in Melbourne, Brisbane, Perth, & Kuala Lumpur, and permanent Construction Teams across Australia & Asia.

The "Syfon System" siphonic system was developed in conjunction with the CSIRO (refer appendix B) and Dr Simon Beecham of the University of Technology, Sydney (UTS). This included development, design, fabrication and testing of the Siphonic inlet to verify operational parameters, development and verification of the Design Software for the system.
Having been acquired been the publicly listed EVZ in 2004, Syfon Systems are the recognized leader of the Asean Siphonic Industry.

Adam Bellgrove is the Managing Director of Syfon Systems and has extensive experience in all aspects of Plumbing works and 20 years experience in the management of Siphonic Drainage.

Lachlan Nunn is the Design Manager and has 20 years detailed experience in Siphonic Drainage. Lachlan has further qualifications as B.E. (Civil) and Chartered Professional Engineer and Registered Building Practitioner with a broad design and construction experience.

Chris Blake is the Operation Manager at Syfon Systems with the qualification of a Bachelor of Mechanical Engineering Degree and 14 years in detailed design and practical work face experience in Siphonic Drainage.

In other words we feel that we are appropriately qualified to undertake the design and installation of these remedial Storm Water Drainage works, from both an engineering and practical perspective.

3.0 EXISTING CONDITIONS

3.1 Existing Site's Storm Water Design

As detailed in figure 1.0, the entire site's stormwater is conventionally drained via a network of inground pipework below the basement carpark and discharges into the Counsel's SW pit on the north-west side of the property. This pit is also fed by upstream curb side road drainage. There is a Ø900 Counsel SW outlet pipe that runs inground to a headwall within Breakfast Creek.

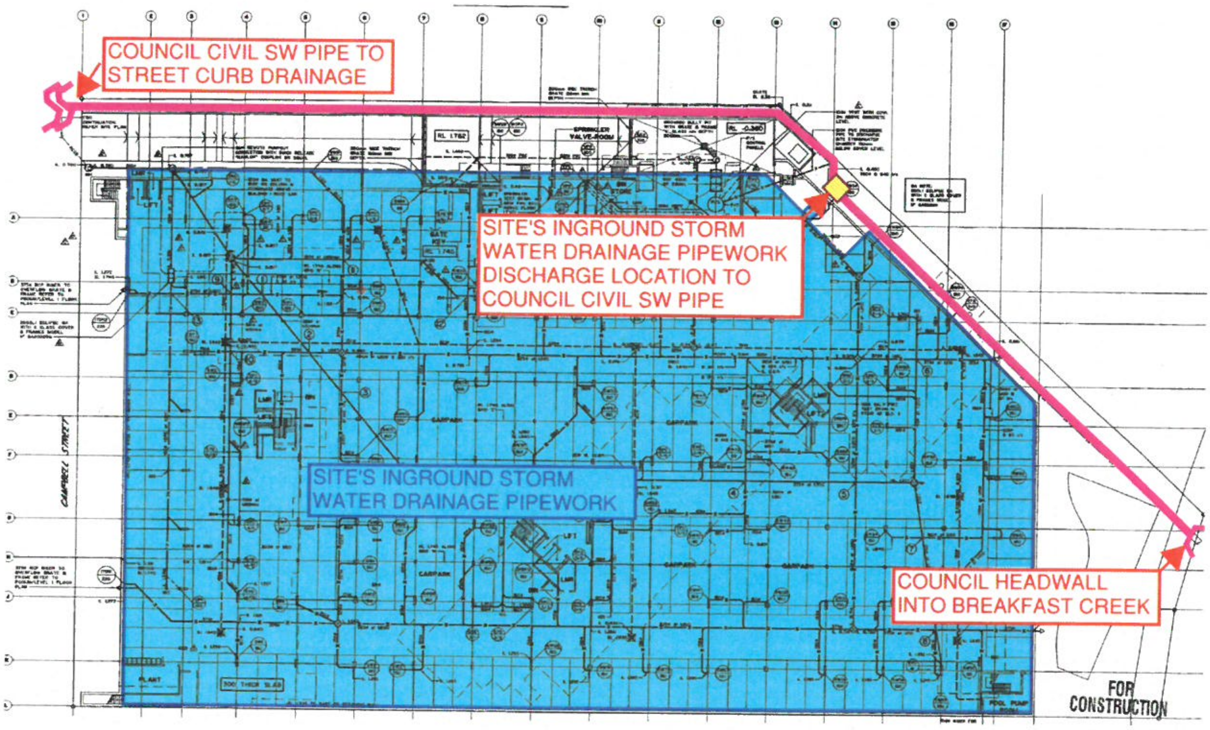


Figure 1.0 – Site Drainage Discharge Plan

3.2 Existing Storm Water Drainage Condition

As detailed within the Lambert & Rehbein November 2017 Investigation Report (refer to appendix 1) a number of basement slab areas were excavated and documented the findings of numerous inground SW pipes were damaged.

Syfon Systems investigation found that the existing Council headwall was 90-95% blocked with Mangroves which would have significantly contributed to the site inground pipework backing up and flooding the basement.

4.0 PROPOSED NEW DRAINAGE SOLUTION

The new stormwater drainage solution will divert above 90% of the site existing stormwater drainage away from the compromised existing inground system to a new piped high level basement system that will discharge directly into the Breakfast Creek via a new headwall.

The new drainage solution consists of a network of new Syfonic Roof Drainage Systems that drains the upper roof's of the 5x Apartments as well as a Conventional Drainage Detention System that drains the Podium deck and low level roofs. Refer to figure 2.0.

Both the Syfonic and Convention Detention Systems connect into a new Ø560 Stormwater Pit and Inground that discharges into the Breakfast Creek via a new headwall.

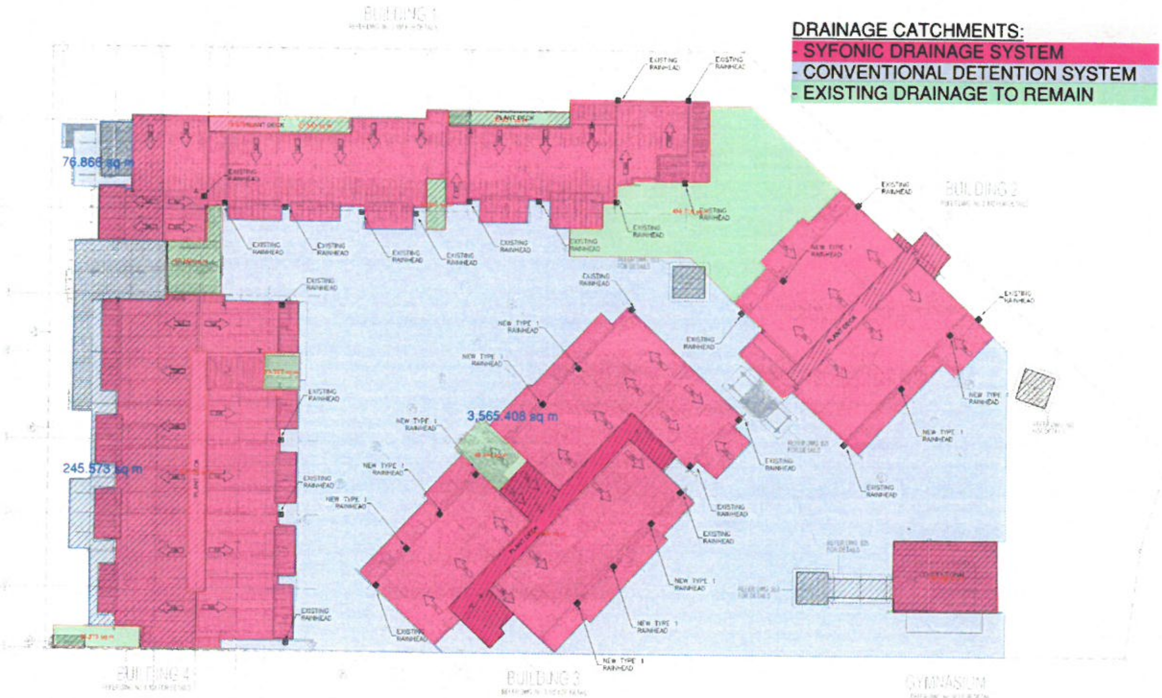


Figure 2.0 – SITE PROPOSED DRAINAGE PLAN

4.1 NEW CONVENTIONAL DETENTION SYSTEM

Refer to Appendix A, for the Basement Detention Drainage Shop Drawing.

The Detention System has an effective storage capacity of 67.0m3 and designed with a restricted orifice discharge flow up to 25l/s into the new Ø560 discharge pipe. The effective detention volume and restricted discharge flowrate caters for drainage of a Q100yr (5min duration) Rainfall Event for the podium and low level roof areas.

The Podium is over 90% soft landscaped and therefore a designed run off coefficient of 0.7 has been incorporated within the Detention System drainage calculations.

The storage capacity of the detention systems is achieved via large bore pipework within the Basement Carpark and below the Pool Undercroft. The existing SW Podium outlet will simply be diverted into the new Detention System within the Basement Carpark.

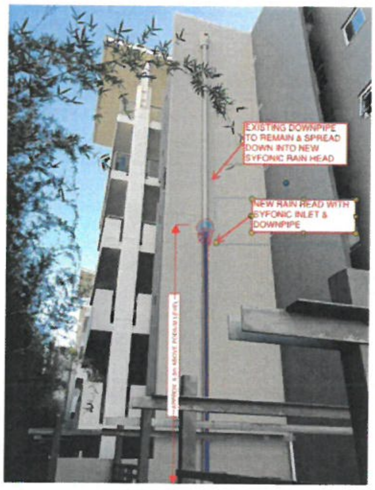
4.2 NEW SYFONIC ROOF DRAINAGE SYSTEMS

Refer to Appendix B, for the Syfonic Roof Drainage Shop Drawings.

The Syfonic Roof Drainage Systems have been designed to cater for a Q100yr (5min Duration) Rainfall Event to pickup the sites high level Building's drainage. The above ground level Syfonic Drainage collects into a series of main horizontal syfonic pipes that run high level within the Basement Carpark to the north-east corner of the site where all Syfonic pipework discharges into the new Ø560 pit that feeds into the river.

Syfonic Inlets will either be retrofit installed directly into the existing gutters at there low points or a new syfonic rainhead will be installed below the existing conventional drainage rainhead and pipe. Refer to the figure 3.0 below.

TYPE 1: RAINHEAD – BALCONY ACCESS
NOT TO SCALE



TYPE 2: RAINHEAD – EXTERNAL WALL
NOT TO SCALE

Figure 3.0 – SYFONIC INLET & RAINHEAD

4.3 NEW CREEK DISCHARGE PIPE & HEADWALL

It is the design intention of this remedial works drainage proposal to direct all of the site's new stormwater drainage to a new Ø560 pit and inground pipe and discharge this separately into the Breakfast Creek via a new stone pitched headwall. (Refer to Appendix C for Headwall Details)

The maximum Q100yr discharge flowrate into the Creek is 431l/s. The discharge velocity of this flowrate in a Ø560 pipe (1:200 fall) is 1.999m/s. This is below the 2m/s flowrate velocity as detailed within the BCC standards of requiring additional scouring protection.

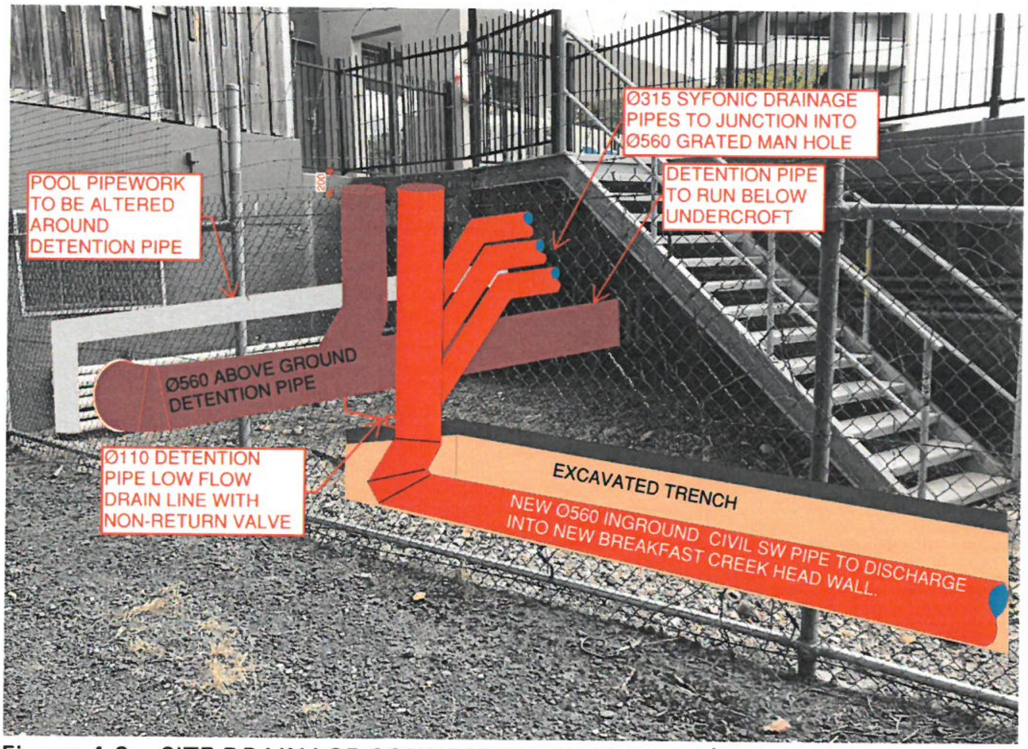


Figure 4.0 – SITE DRAINAGE CONNECTION INTO NEW Ø560 CIVIL PIPE

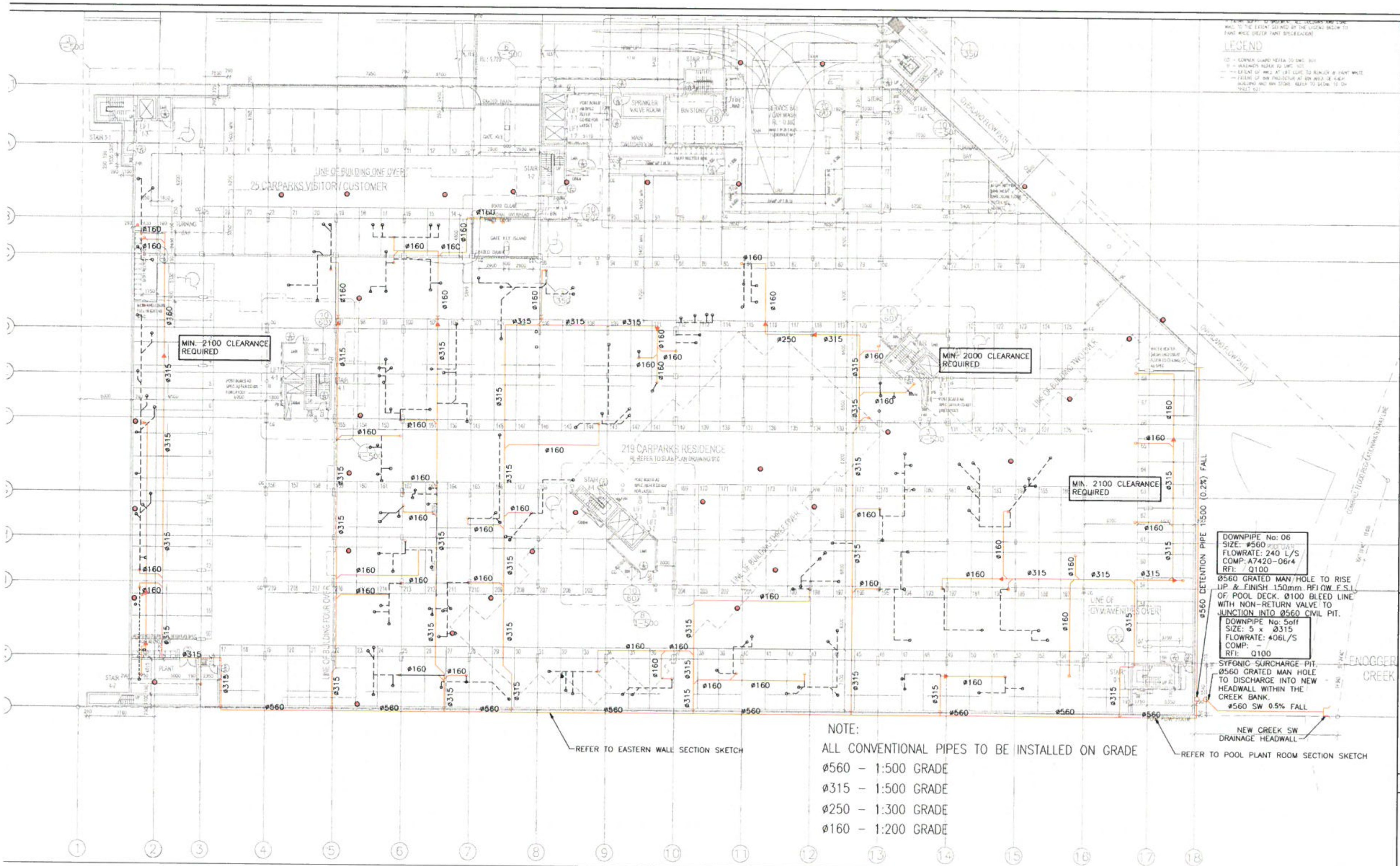
Figure 5.0 – LOCATION OF NEW CREEK SW DISCHARGE POINT

APPENDIX A

NEW CONVENTIONAL DRAINAGE

DETENTION SYSTEM

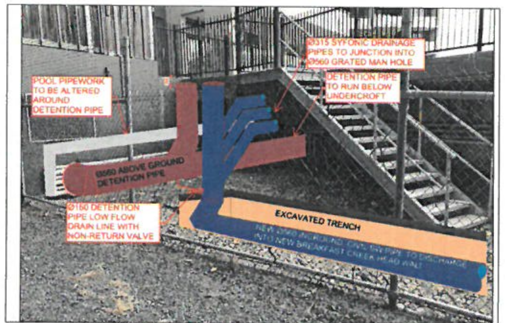
BASEMENT SHOP DRAWING



NOTE:
ALL CONVENTIONAL PIPES TO BE INSTALLED ON GRADE
Ø560 – 1:500 GRADE
Ø315 – 1:500 GRADE
Ø250 – 1:300 GRADE
Ø160 – 1:200 GRADE

BASEMENT EASTERN WALL SECTION SKETCH

POOL PLANT ROOM SECTION SKETCH



EXTERNAL DETENTION PIPE SKETCH

——— STAGE 1 CONVENTIONAL PIPEWORK

– – – – EXISTING STORMWATER PIPEWORK

PIPE WEIGHTS

PIPE DIAM.ø	WEIGHT (kg/m) WHEN FULL OF WATER & RAILED
ø50	4.0
ø56	5.0
ø63	5.5
ø75	7.0
ø90	9.0
ø110	12.0
ø125	15.0
ø160	23.0
ø200	35.0
ø250	53.0
ø315	82.0

PIPE CLIP SPACINGS

DIAMETER	CENTRES
50	500
56 – 63	600
75	750
90 – 110	1000
125	1200
160	1500
200 – 315	2000

DESIGN RAINFALL INTENSITY:
Q_{100} (5 min.) = 306 mm/HR
Q_{20} (5 min.) = N/A mm/HR

SYFON SYSTEMS LEGEND

- ø315 — SYFONIC HDPE PIPEWORK WITH PIPE O.D.
- ø315 — SYFONIC HDPE OVERFLOW PIPEWORK WITH PIPE O.D.
- ø315 — SYFONIC HDPE UNDER GROUND PIPEWORK
- SYFONIC DOWNPIPE TO BELOW (T/B)
- SYFONIC DOWNPIPE WITH 45° BRANCH LINE
- SYFONIC DOWNPIPE FROM ABOVE (F/A)
- VERTICAL STEP DOWN IN PIPE LEVEL
- 2 x 45° STEP DOWN IN PIPE LEVEL
- REDUCER/ENLARGER IN PIPE
- SYFONIC STANDARD PRIMARY INLET & TAILPIPE
- SYFONIC STANDARD O/F INLET & TAILPIPE
- CONVENTIONAL OVERFLOW OUTLET BY OTHERS (U.N.O.)
- CONVENTIONAL DOWNPIPE & SPREADER BY OTHERS (U.N.O.)
- ø75:(ø56/ø63) SIZE OF INLET : (TAILPIPE (VERTICAL)/ TAILPIPE (HORIZONTAL))
- T.O.P. TOP OF PIPE REDUCED LEVEL
- FEJ FLAT EXPANSION JOINT WITH NOMINAL 1 IN 200 FALL TO INLETS

No.	Date	Amendment.	Drawn	Checked
D	15.11.19	For Approval	T.T.	C.B.
C	04.06.19	For Approval	C.B.	L.N.
B	28.03.19	For Approval	SFS	L.N.
A	25.02.19	For Coordination	SFS	L.N.

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PROJECT
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BOWEN HILLS
QLD

DRAWING
STORMWATER
BASEMENT PLAN – STAGE 1

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Dwg No. SYF 01 | Rev. D

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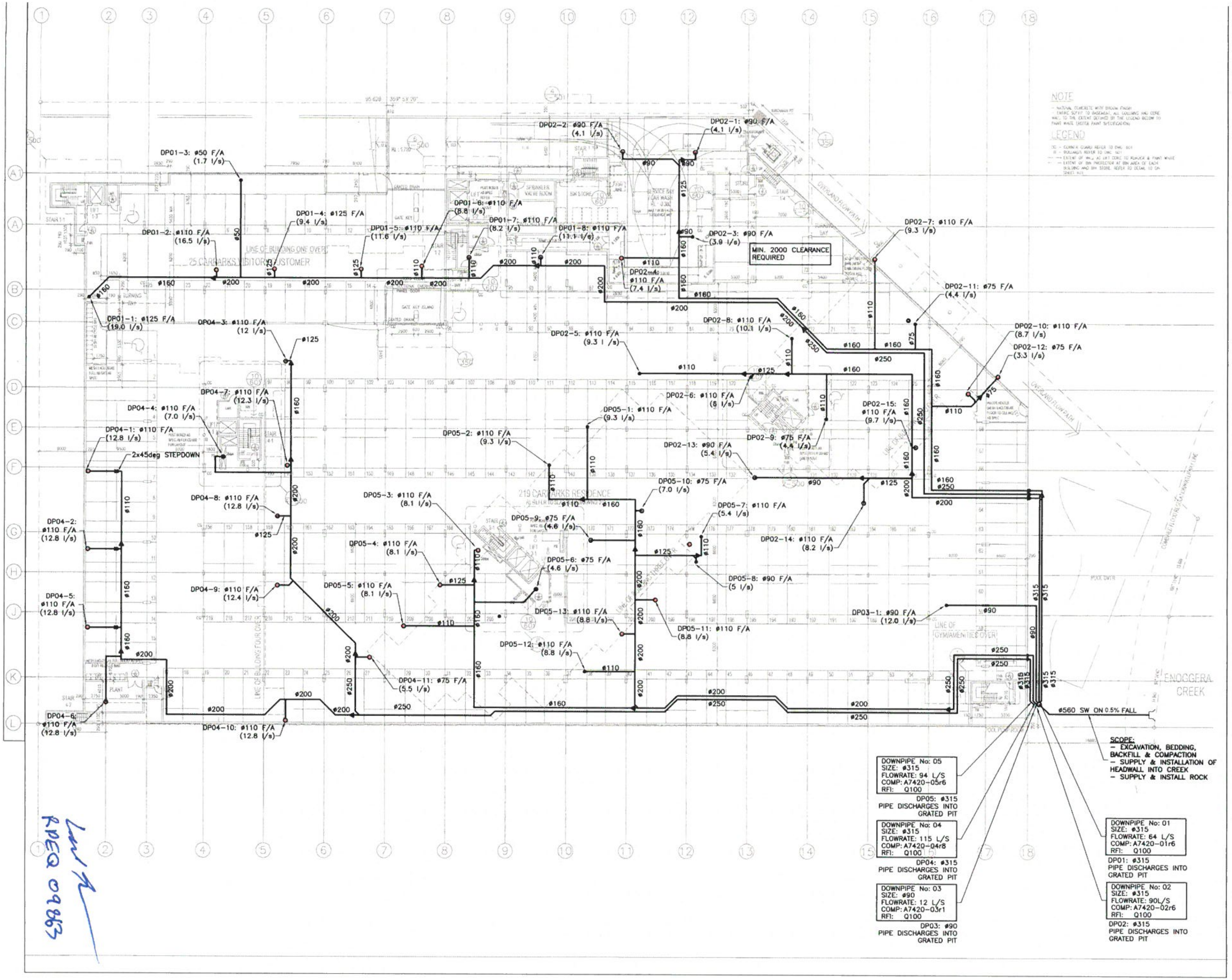
APPENDIX B

NEW SYFONIC ROOF DRAINAGE

SHOP DRAWINGS



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PIPE WEIGHTS

PIPE DIAM.ø	WEIGHT (kg/m) WHEN FULL OF WATER & RAILED
ø50	4.0
ø56	5.0
ø63	5.5
ø75	7.0
ø90	9.0
ø110	12.0
ø125	15.0
ø160	23.0
ø200	35.0
ø250	53.0
ø315	82.0

PIPE CLIP SPACINGS

DIAMETER	CENTRES
50	500
56 - 63	600
75	750
90 - 110	1000
125	1200
160	1500
200 - 315	2000

DESIGN RAINFALL INTENSITY:
Q_{100} (5 min.) = 306 mm/HR
Q_{20} (5 min.) = N/A mm/HR

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- ø315 — SYFONIC HDPE PIPEWORK WITH PIPE O.D.
- ø315 — SYFONIC HDPE OVERFLOW PIPEWORK WITH PIPE O.D.
- ø315 — SYFONIC HDPE UNDER GROUND PIPEWORK
- SYFONIC DOWNPIPE TO BELOW (T/B)
- SYFONIC DOWNPIPE WITH 45° BRANCH LINE
- SYFONIC DOWNPIPE FROM ABOVE (F/A)
- VERTICAL STEP DOWN IN PIPE LEVEL
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DRAWING
SYFONIC DRAINAGE
BASEMENT PLAN - STAGE 2

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1:100 @ A0 = 1:200 @ A2
1:200 @ A0 = 1:400 @ A2
1:500 @ A0 = 1:1000 @ A2
1:250 @ A0 = 1:500 @ A2

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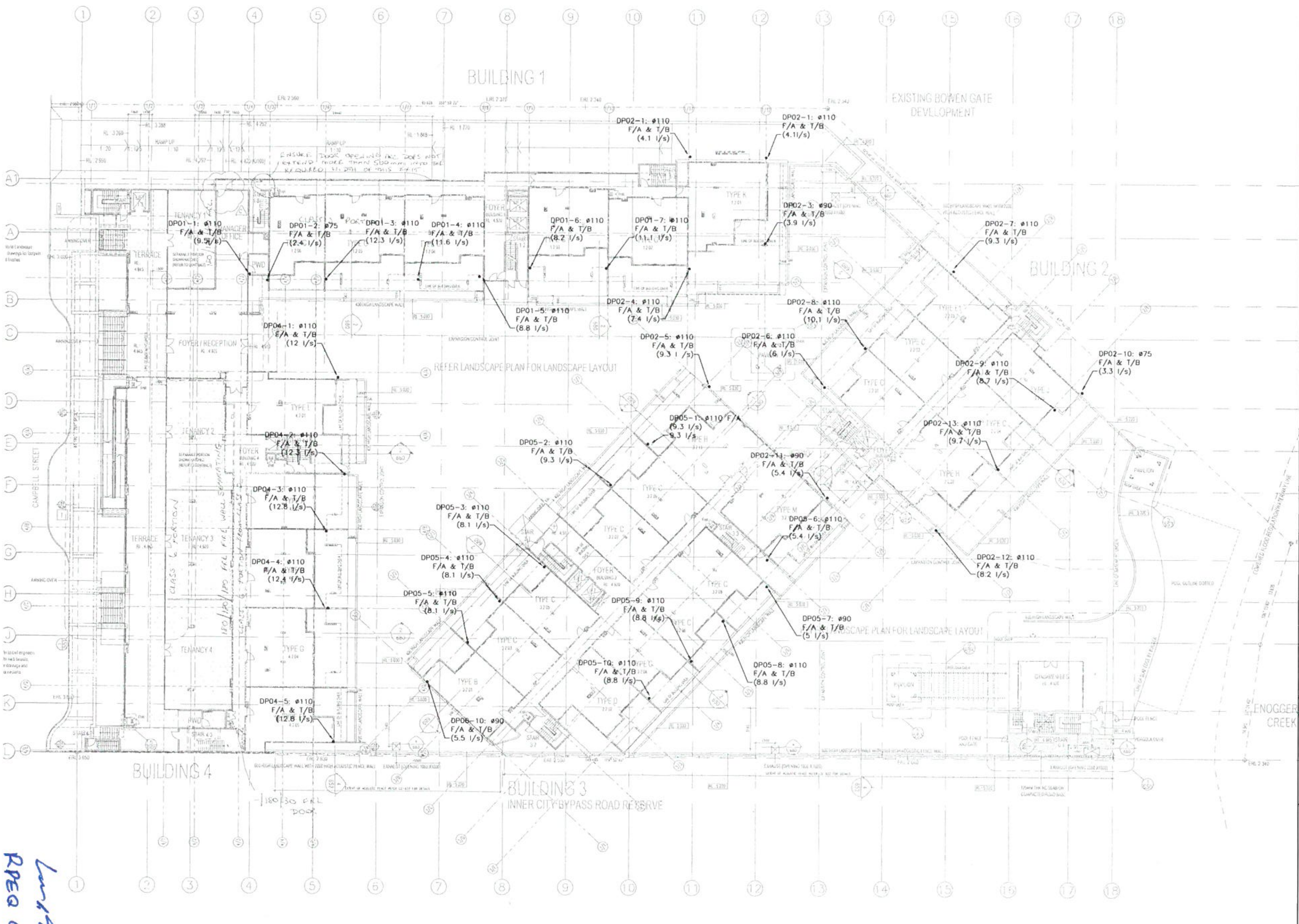

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- T.O.P. — TOP OF PIPE REDUCED LEVEL
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No.	Date	Amendment.	Drawn	Checked
A	30.09.19	For Coordination	SFS	L.N.

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PROJECT

THE MEWS APARTMENTS
BOWEN HILLS
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DRAWING

SYFONIC DRAINAGE
LEVEL 1 PLAN - STAGE 2

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0 1 2 3 4 5m / 0 2 4 6 8 10m — 1:100 @ A0 = 1:200 @ A2; 1:200 @ A0 = 1:400 @ A2

0 5 10 15 20 25m / 0 5 10m — 1:500 @ A0 = 1:1000 @ A2; 1:250 @ A0 = 1:500 @ A2

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Job No.	A7420				

NOTE: ALL DOWNPIPE LOCATIONS TO BE CONFIRMED ON SITE

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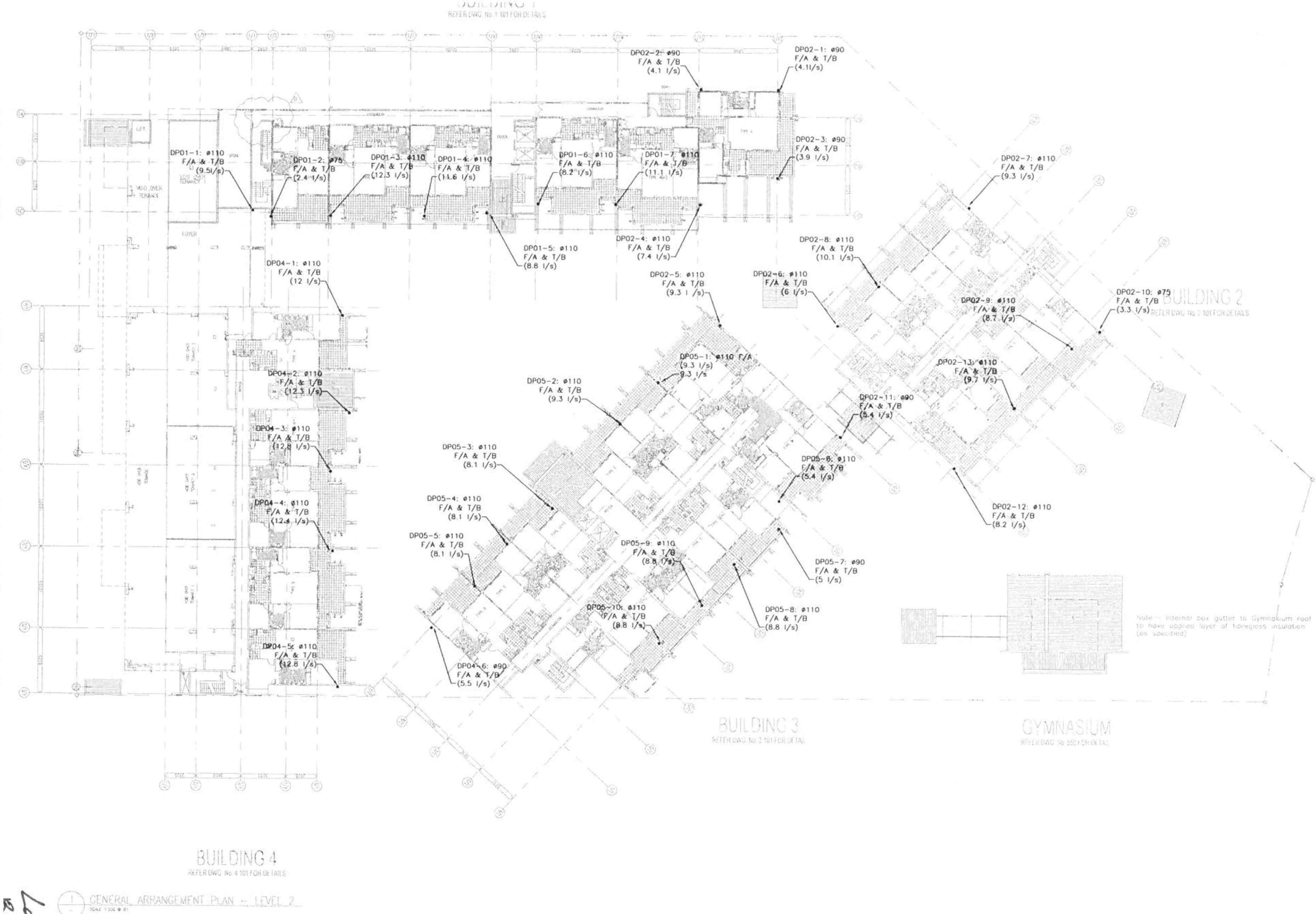

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New Zealand

PROJECT
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SYFONIC DRAINAGE
LEVEL 2 PLAN - STAGE 2

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0 5 10m — 1:250 @ A0 = 1:500 @ A2

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Date	30/09/2019	Checked	L.N.	SYF 04	A
Job No.	A7420				

Lach Z
R DEQ 09863

NOTE: ALL DOWNPIPE LOCATIONS TO BE CONFIRMED ON SITE

PIPE WEIGHTS

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ø110	12.0
ø125	15.0
ø160	23.0
ø200	35.0
ø250	53.0
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PROJECT

THE MEWS APARTMENTS
BOWEN HILLS
QLD

DRAWING

SYFONIC DRAINAGE
LEVEL 3 PLAN – STAGE 2

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Date	30/09/2019	Checked	L.N.	SYF 05	A
Job No.	A7420				

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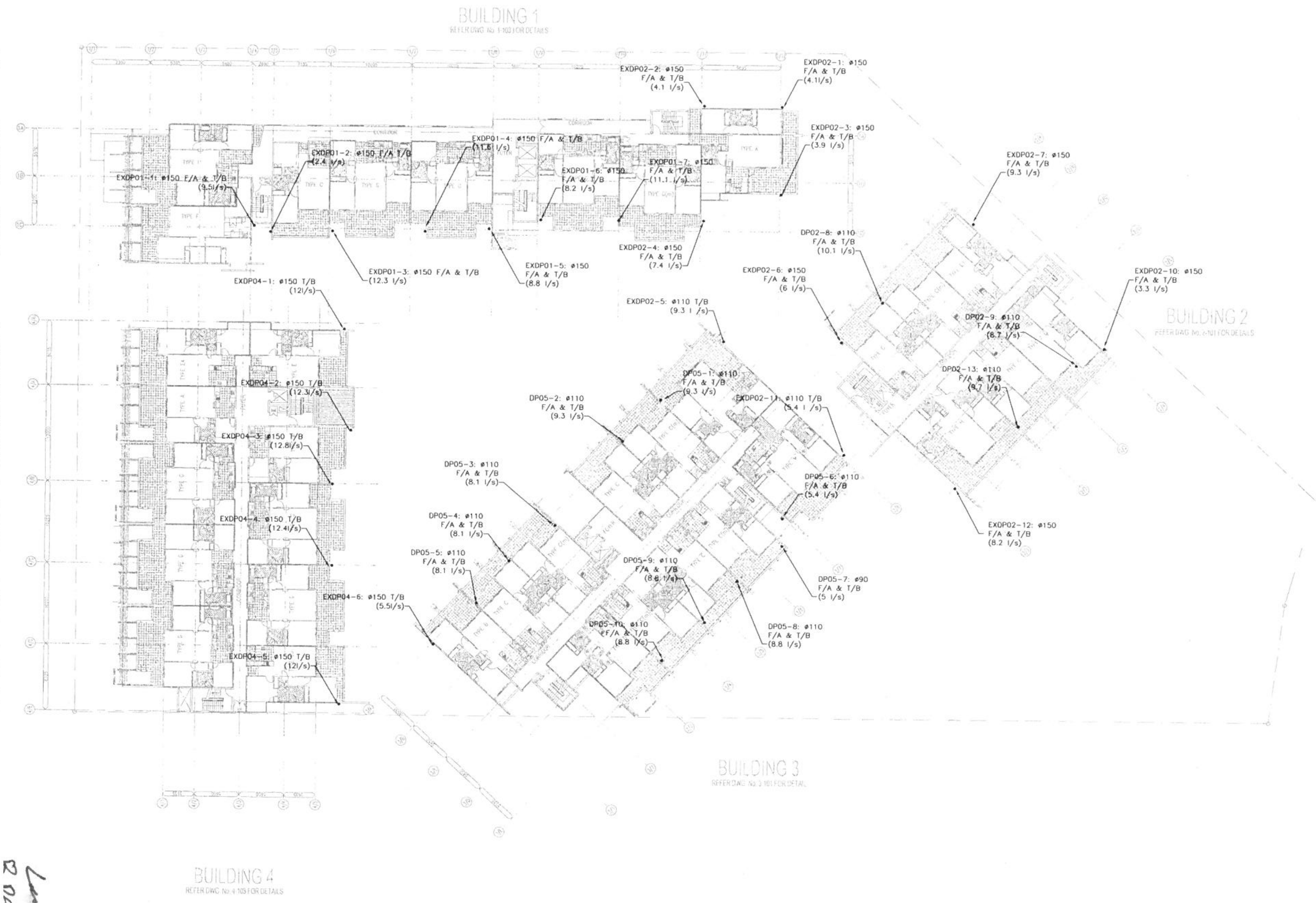

1 GENERAL ARRANGEMENT PLAN - LEVEL 4 & 5

Last 9/L
R REQ-09983

NOTE: ALL DOWNPIPE LOCATIONS
TO BE CONFIRMED ON SITE

PIPE WEIGHTS

PIPE DIAM.ø	WEIGHT (kg/m) WHEN FULL OF WATER & RAILED
ø50	4.0
ø56	5.0
ø63	5.5
ø75	7.0
ø90	9.0
ø110	12.0
ø125	15.0
ø160	23.0
ø200	35.0
ø250	53.0
ø315	82.0

PIPE CLIP SPACINGS

DIAMETER	CENTRES
50	500
56 - 63	600
75	750
90 - 110	1000
125	1200
160	1500
200 - 315	2000

DESIGN RAINFALL INTENSITY:
Q_{100} (5 min.) = 306 mm/HR
Q_{20} (5 min.) = N/A mm/HR

SYFON SYSTEMS LEGEND

- ø315 — SYFONIC HDPE PIPEWORK WITH PIPE O.D.
- ø315 — SYFONIC HDPE OVERFLOW PIPEWORK WITH PIPE O.D.
- ø315 — SYFONIC HDPE UNDER GROUND PIPEWORK
- SYFONIC DOWNPIPE TO BELOW (T/B)
- SYFONIC DOWNPIPE WITH 45° BRANCH LINE
- SYFONIC DOWNPIPE FROM ABOVE (F/A)
- VERTICAL STEP DOWN IN PIPE LEVEL
- 2 x 45° STEP DOWN IN PIPE LEVEL
- REDUCER/ENLARGER IN PIPE
- S.I. — SYFONIC STANDARD PRIMARY INLET & TAILPIPE
- O.F.I. — SYFONIC STANDARD O/F INLET & TAILPIPE
- CONVENTIONAL OVERFLOW OUTLET BY OTHERS (U.N.O.)
- CONVENTIONAL DOWNPIPE & SPREADER BY OTHERS (U.N.O.)
- ø75:(ø56/ø63) — SIZE OF INLET : (TAILPIPE (VERTICAL)/ TAILPIPE (HORIZONTAL))
- T.O.P. — TOP OF PIPE REDUCED LEVEL
- FE — FLAT EXPANSION JOINT WITH NOMINAL 1 IN 200 FALL TO INLETS

No.	Date	Amendment.	Drawn	Checked
A	30.09.19	For Coordination	SFS	L.N.

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New Zealand

PROJECT
THE MEWS APARTMENTS
BOWEN HILLS
QLD

DRAWING
SYFONIC DRAINAGE
LEVEL 4/5 PLAN - STAGE 2

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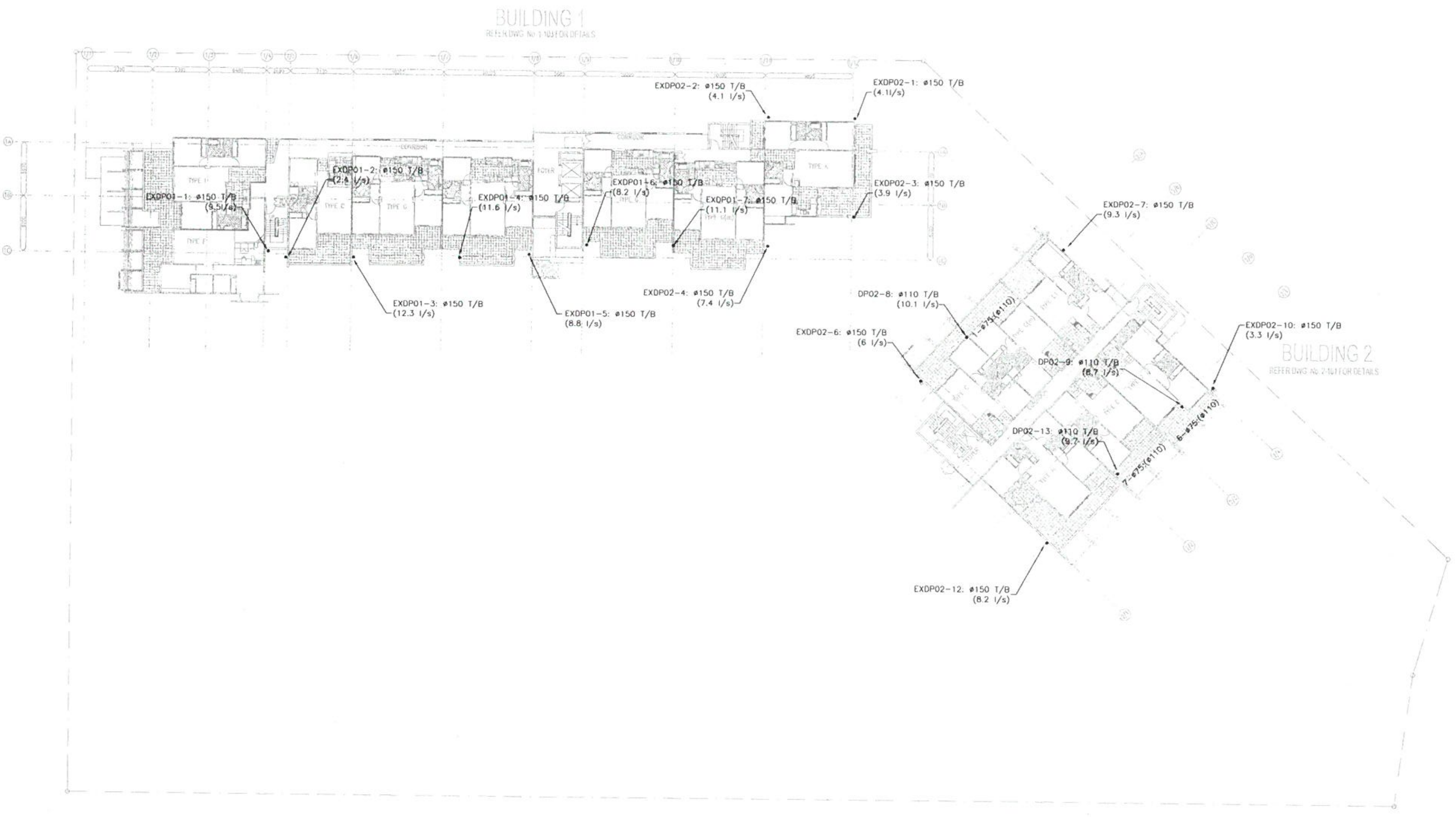
0 1 2 3 4 5m / 0 2 4 6 8 10m — 1:100 @ A0 = 1:200 @ A2; 1:200 @ A0 = 1:400 @ A2
0 5 10 15 20 25m / 0 5 10m — 1:500 @ A0 = 1:1000 @ A2; 1:250 @ A0 = 1:500 @ A2

Scale	1:200 @ B1	Drawn	SFS	Dwg No.	Rev.
Date	30/09/2019	Checked	L.N.	SYF 06	A
Job No.	A7420				



1 GENERAL ARRANGEMENT PLAN - LEVEL 6

NOTE: ALL DOWNPIPE LOCATIONS TO BE CONFIRMED ON SITE

Lead R
RPEQ: 09863

PIPE WEIGHTS

PIPE DIAM.ø	WEIGHT (kg/m) WHEN FULL OF WATER & RAILED
ø50	4.0
ø56	5.0
ø63	5.5
ø75	7.0
ø90	9.0
ø110	12.0
ø125	15.0
ø160	23.0
ø200	35.0
ø250	53.0
ø315	82.0

PIPE CLIP SPACINGS

DIAMETER	CENTRES
50	500
56 - 63	600
75	750
90 - 110	1000
125	1200
160	1500
200 - 315	2000

DESIGN RAINFALL INTENSITY:
Q_{100} (5 min.) = 306 mm/HR
Q_{20} (5 min.) = N/A mm/HR

SYFON SYSTEMS LEGEND

ø315	SYFONIC HDPE PIPEWORK WITH PIPE O.D.
ø315	SYFONIC HDPE OVERFLOW PIPEWORK WITH PIPE O.D.
ø315	SYFONIC HDPE UNDER GROUND PIPEWORK
	SYFONIC DOWNPIPE TO BELOW (T/B)
	SYFONIC DOWNPIPE WITH 45° BRANCH LINE
	SYFONIC DOWNPIPE FROM ABOVE (F/A)
	VERTICAL STEP DOWN IN PIPE LEVEL
	2 x 45° STEP DOWN IN PIPE LEVEL
	REDUCER/ENLARGER IN PIPE
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	CONVENTIONAL OVERFLOW OUTLET BY OTHERS (U.N.O.)
	CONVENTIONAL DOWNPIPE & SPREADER BY OTHERS (U.N.O.)
ø75(ø56/ø63)	SIZE OF INLET : (TAILPIPE (VERTICAL)/ TAILPIPE (HORIZONTAL))
T.O.P.	TOP OF PIPE REDUCED LEVEL
FEJ	FLAT EXPANSION JOINT WITH NOMINAL 1 IN 200 FALL TO INLETS

No.	Date	Amendment.	Drawn	Checked
A	30.09.19	For Coordination	SFS	L.N.

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PROJECT
THE MEWS APARTMENTS
BOWEN HILLS
QLD

DRAWING
SYFONIC DRAINAGE
LEVEL 6 PLAN - STAGE 2

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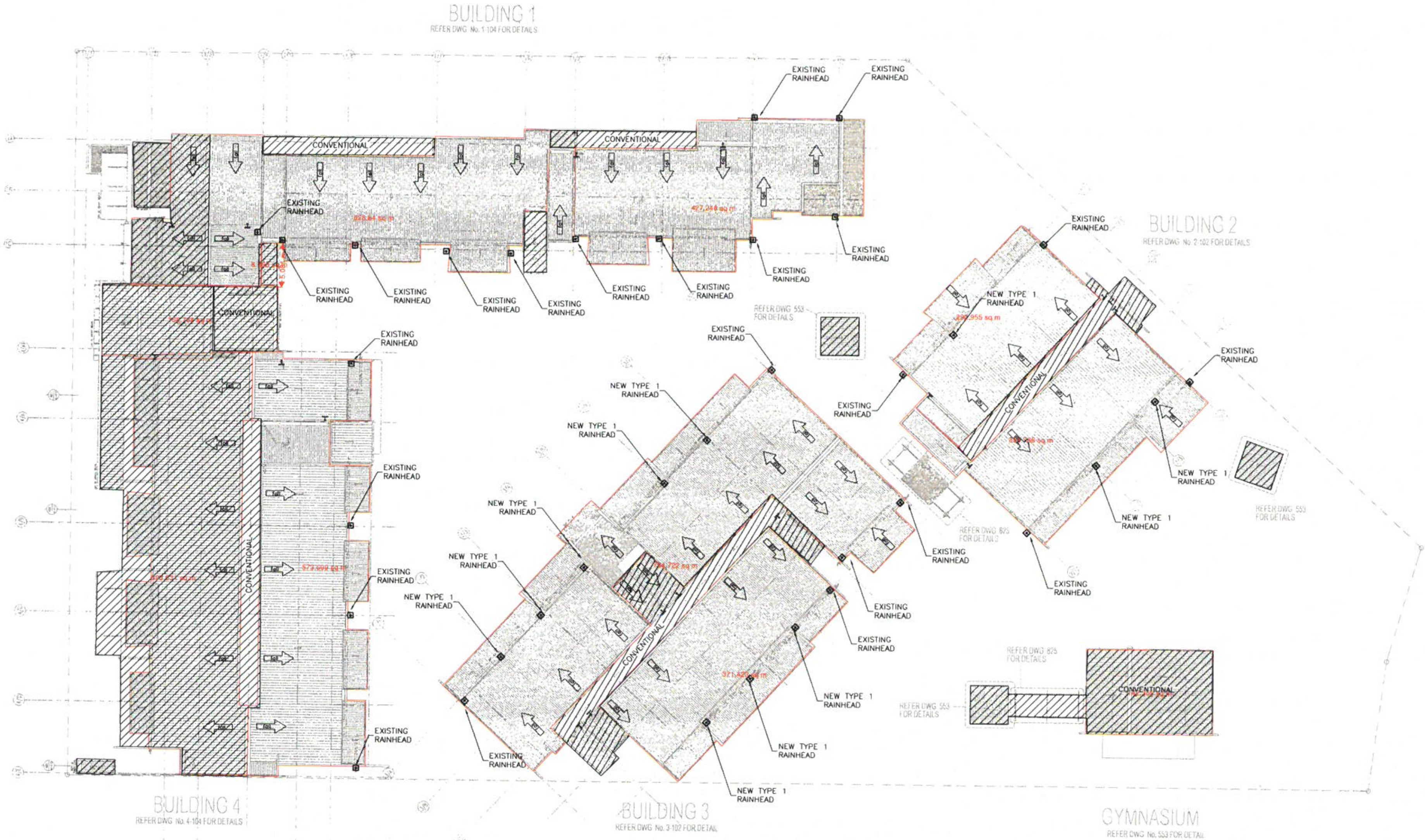
0 1 2 3 4 5m — 1:100 @ A0 = 1:200 @ A2
0 2 4 6 8 10m — 1:200 @ A0 = 1:400 @ A2
0 5 10 15 20 25m — 1:500 @ A0 = 1:1000 @ A2
0 5 10m — 1:250 @ A0 = 1:500 @ A2

Scale	1:200 @ B1	Drawn	SFS	Dwg No.	Rev.
Date	30/09/2019	Checked	L.N.	SYF 07	A
Job No.	A7420				



PIPE DIAM.ø	WEIGHT (kg/m) WHEN FULL OF WATER & RAILED
ø50	4.0
ø56	5.0
ø63	5.5
ø75	7.0
ø90	9.0
ø110	12.0
ø125	15.0
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ø200	35.0
ø250	53.0
ø315	82.0

PIPE WEIGHTS

DIAMETER	CENTRES
50	500
56 - 63	600
75	750
90 - 110	1000
125	1200
160	1500
200 - 315	2000

PIPE CLIP SPACINGS

DESIGN RAINFALL INTENSITY:

Q_{100} (5 min.) = 306 mm/HR

Q_{20} (5 min.) = N/A mm/HR

SYFON SYSTEMS LEGEND

ø315	SYFONIC HDPE PIPEWORK WITH PIPE O.D.
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	SYFONIC DOWNPIPE FROM ABOVE (F/A)
	VERTICAL STEP DOWN IN PIPE LEVEL
	2 x 45° STEP DOWN IN PIPE LEVEL
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	SYFONIC STANDARD O/F INLET & TAILPIPE
	CONVENTIONAL OVERFLOW OUTLET BY OTHERS (U.N.O.)
	CONVENTIONAL DOWNPIPE & SPREADER BY OTHERS (U.N.O.)
ø75 (ø56/ø63)	SIZE OF INLET : (TAILPIPE (VERTICAL)/ TAILPIPE (HORIZONTAL))
T.O.P.	TOP OF PIPE REDUCED LEVEL
FEJ	FLAT EXPANSION JOINT WITH NOMINAL 1 IN 200 FALL TO INLETS

No.	Date	Amendment.	Drawn	Checked
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PROJECT

THE MEWS APARTMENTS
BOWEN HILLS
QLD

DRAWING

SYFONIC DRAINAGE
ROOF PLAN - STAGE 2

Contractors shall verify all dimensions on site before commencing any work or making any shop drawings.
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0 1 2 3 4 5m — 1:100 @ A0 = 1:200 @ A2
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0 5 10 15 20 25m — 1:500 @ A0 = 1:1000 @ A2
0 5 10m — 1:250 @ A0 = 1:500 @ A2

Scale	1:200 @ B1	Drawn	SFS	Dwg No.	Rev.
Date	30/09/2019	Checked	L.N.	SYF 08	A
Job No.	A7420				

TYPE 1: RAINHEAD - BALCONY ACCESS

NOT TO SCALE

TYPE 2: RAINHEAD - EXTERNAL WALL

NOT TO SCALE

RPEQ: 09863

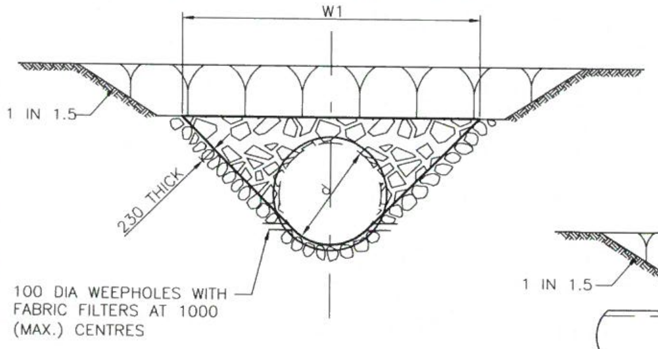
APPENDIX C

BRISBANE CITY COUNCIL STANDARD DRAWING

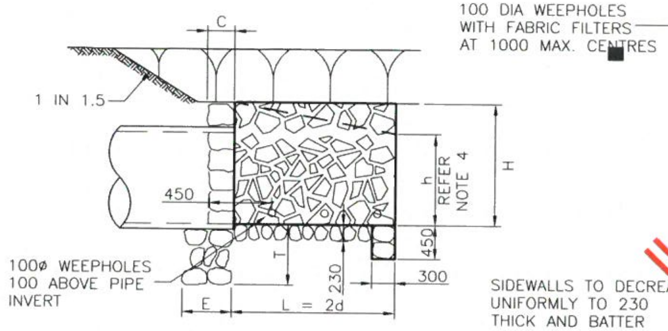
CREEK HEAD WALL

INLETS AND OUTLETS (STONEPITCHED)

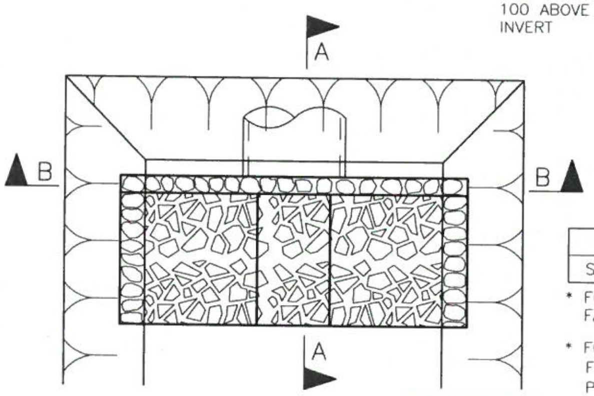
STORMWATER DRAINS



SECTION B–B

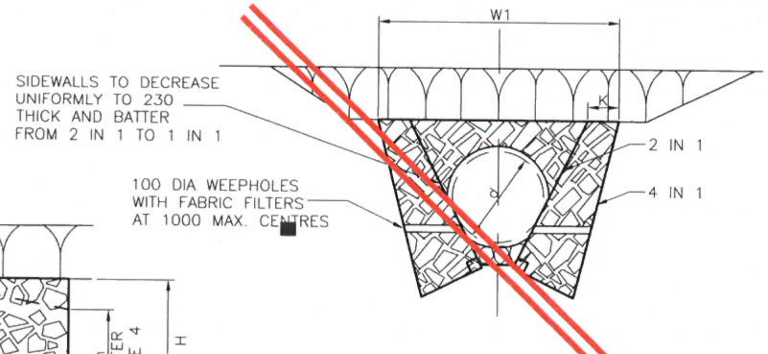


SECTION A–A

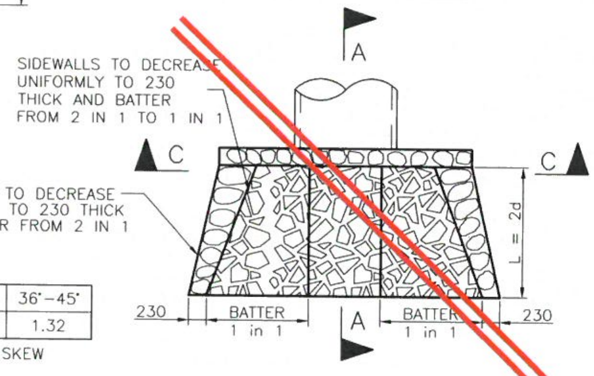


TYPE A PLAN

PROPOSED HEAD WALL



SECTION C–C



TYPE B PLAN

PIPE SKEW	5°–15°	16°–25°	26°–35°	36°–45°
SKEW FACTOR	1.02	1.07	1.16	1.32

* FOR SKEWED PIPES – MULTIPLY W1 BY THE SKEW FACTOR.

* FOR MULTIPLE PIPES – INCREASE W1 BY DIMENSION 'X' FOR EACH ADDITIONAL PIPE ('X' BEING THE DISTANCE FROM PIPE ℄ TO PIPE ℄).

MULTIPLE\SKEW PIPES

DIMENSION	PIPE DIAMETER 'd'													
	300	375	450	525	600	675	750	900	1050	1200	1350	1500	1650	1800
W1*	1095	1285	1485	1820	2015	2200	2550	2720	3300	3685	4065	4450	4810	5175
C	150	150	150	230	230	230	300	300	300	300	300	300	300	300
E	450	450	450	450	450	450	600	600	600	600	600	600	600	600
H	485	565	650	800	885	960	1120	1275	1435	1595	1755	1905	2065	2215
T	450	450	450	450	450	600	600	600	600	600	600	600	600	600
'X'	510	595	685	765	850	935	1015	1180	1345	1510	1675	1835	2000	2165

DIMENSIONS

TYPE A INLET FOR d = 300 TO 1200

TYPE A OUTLET FOR d = 300 TO 1800

DIMENSION	PIPE DIMENSION 'd'			
	1350	1500	1650	1800
W1*	2960	3200	3755	4000
B	760	840	915	990
C	300	300	300	300
E	600	600	600	600
H	1755	1905	2065	2220
T	450	450	450	450
K	300	300	450	450
X	1675	1835	2000	2165

DIMENSIONS

TYPE B INLET AND OUTLET

FOR d = 1350 TO 1800

NOTES:

1. DESIGN ALLOWABLE BEARING PRESSURE 75 KPa. WHERE THIS BEARING PRESSURE CANNOT BE OBTAINED, THE SUPERINTENDENT MAY DIRECT THAT A WIDER FOOTING BE USED.
2. UNREINFORCED CONCRETE CLASS 20 MPa/20. REINFORCED CONCRETE CLASS 32 MPa/20. CONCRETE COVER TO 50 UNLESS SHOWN OTHERWISE.
3. IN TIDAL AREAS WHERE MESH REINFORCEMENT IS SPECIFIED, CONCRETE IS TO BE SULPHATE RESISTANT GRADE S40.
4. IN EMBANKMENT SITUATIONS, THE HEIGHT OF THE WING WALL AT THE TOE SHOULD BE REDUCED TO "h" SO THAT THE SLOPE OF THE TOP OF THE WING WALL EQUALS THE ADJACENT EMBANKMENT BATTER. (REFER TO PROJECT DRAWINGS FOR VALUE OF "h").
5. SEE PROJECT DRAWINGS FOR THE FOLLOWING: NUMBER AND DIAMETER OF PIPES; SKEW ANGLES OF PIPES, IF APPLICABLE; INVERT LEVELS OF PIPES; HEIGHT OF WING WALL "h" AT TOE IF APPLICABLE.
6. FOR QUANTITIES REFER BSD–8104.
7. SCOUR PROTECTION IS GENERALLY REQUIRED DOWNSTREAM OF THE APRON UNDER ANY ONE OF THE FOLLOWING CONDITIONS:
   - AVERAGE OUTLET VELOCITY EXCEEDS THE NON–EROSIVE VELOCITY.
   - AVERAGE OUTLET VELOCITY EXCEEDS 2m/s.
   - OUTLET JET IS EXPECTED TO STRIKE AN UNPROTECTED CHANNEL BANK WITHIN A DISTANCE OF 10 TIMES THE PIPE DIAMETER.
8. BED SCOUR MAY BE CONTROLLED BY THE FOLLOWING METHODS:
   - REDUCING THE OUTLET VELOCITY BY INSTALLING AN EXPANSION CHAMBER.
   - INSTALLING AN ENERGY DISSIPATOR.
   - ARMOURING THE BED WITH ROCK, USUALLY OVER A MAXIMUM DISTANCE OF 8 TIMES THE PIPE DIAMETER.
9. PREFERRED POSITIONING OF STORMWATER PIPE OUTLET:
   - SETBACK FOR MORE THAN A DISTANCE OF 3 TIMES THE BANK HEIGHT MEASURED FROM THE TOE OF THE WATERCOURSE BANK.
   - FOR 'NARROW' RECEIVING WATERCOURSE, ANGLE THE OUTLET PIPE IN THE DIRECTION OF THE MAIN FLOW. AN APPROACH ANGLE IN THE RANGE OF 45° TO 60° MEASURED FROM THE BANK IS RECOMMENDED.
   - LIMIT THE MAXIMUM HEIGHT BETWEEN THE OUTLET INVERT AND THE RECIEVING CHANNEL INVERT OR EXPECTED WATER LEVEL TO $0.247/d^{0.5}$ WHERE d IS THE OUTLET PIPE DIAMETER IN METRES.
10. WHERE DIRECTED, INSTALL 1200 HIGH FENCE ALONG HEADWALL AND WINGWALLS:
    - FOR 1000–1500 DROP HEIGHT, PROVIDE GALVANISED TUBULAR HANDRAIL IN ACCORDANCE WITH BSD–7001, GALVANISED WELD MESH FENCING IN ACCORDANCE WITH BSD–7002 OR PEDESTRIAN SAFETY FENCING IN ACCORDANCE WITH BSD–7003.
    - FOR >1500 DROP HEIGHT, PROVIDE POWDER COATED STEEL FENCING (HUNTER ROD TOP OR APPROVED EQUIVALENT) INSTALLED USING VANDAL PROOF FIXINGS. DESIGN TO RESIST A MINIMUM STATIC LOAD OF 1.5 kN/m AS PER CLAUSE 3.6 OF AS 1170–2002.
11. USE OF EQUIVALENT PRECAST PRODUCTS IS PERMITTED.
12. DIMENSIONS IN MILLIMETRES (U.N.O.).

ISSUE	AMENDMENT	DRAWN DATE	CHK'D DATE	APPR'D DATE
A	ORIGINAL ISSUE	OCT '13	OCT '13	OCT '13

DRAWING AUTHORISED FOR PUBLICATION
Publish
ASSET ENGINEERING MANAGER
STRATEGIC ASSET MANAGEMENT
DESIGN APPROVED
Publish
PRINCIPAL ASSET OFFICER
ROADS & DRAINAGE

DESIGN	Std Dwgs WG	DATE	OCT '13
DRAWN	CPO - P&D	DATE	OCT '13
CHECKED		DATE	OCT '13
DRAWING FILENAME	BSD-8102.dwg		
ASSOCIATED PLANS	SUPERSEDES UMS-342		

BRISBANE CITY

BRISBANE CITY COUNCIL STANDARD DRAWING

INLETS AND OUTLETS (STONEPITCHED) STORMWATER DRAINS

SCALE: NOT TO SCALE
DWG No.: BSD–8102
ORIGINAL SIZE: A3
REVISION: A

APPENDIX D

"WATER INUNDATION INVESTIGATION – STAGE 2 REPORT

LAMBERT & REHBEIN CIVIL CONSULTANTS

DATED: NOV 2017

LAMBERT & REHBEIN
ENGINEERS • MANAGERS • SCIENTISTS

DATE 10 November 2017

CONTACT ANDREW PEZZUTTI

Water Inundation Investigation - Stage 2
For the Mews Bowen Hills Body Corporate CTS 33016

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APPENDIX E

PHOTOS OF RAIN EVENT

APPENDIX F

BRW HYDRAULICS REPORT

APPENDIX G

SELECTED STUCTURAL ENGINEERING DRAWINGS

Document Control Page

Revision	Date	Description	Author	Signature	Verifier	Signature	Approver	Signature
A	28/04/17	Draft	AP/AR		AR		AP	
B	10/11/17	Final	AP/AR		AR		AP	

1.0 INTRODUCTION

Lambert & Rehbein have been commissioned by The Body Corporate for The Mews Bowen Hills CTS 33016 to undertake Stage 2 - water inundation investigations of flooding issues in the basement of the Mews building located at 141 Campbell Street, Bowen Hills.

Previously, we have undertaken Stage 1 - preliminary investigations of the water inundation and flooding of the basement carpark levels and provided preliminary advice and recommendations in our letter dated 9th October 2015.

The scope for the Stage 2 of the proposed investigations is to gain a better understanding of the issues and to assist in determining potential solutions. This investigation included the following investigations:

a) Invasive under-slab investigation of the basement slab on ground at selected locations;

b) Investigation of the condition of selected PVC pipe junctions just above and below the basement slab on ground;

c) Investigation of the sub-floor roof-water and the basement drainage systems;

d) A partial review of the sewerage network (pipe damage);

e) Supervision of removal of unsuitable material and slab reconstruction in areas where the investigation occurred;

f) Investigation of the roof-water drainage system;

g) A general review of the podium layout, surfaces and finishes; and

h) A review of construction issue structural engineering drawings obtained by the hydraulics consultant.

2.0 UNDER SLAB INVESTIGATIONS

The Stage 1 investigations recommended the following further works be undertaken:

- Invasive investigation at nominally four (4) locations is undertaken to determine the sub-surface soil profile under the basement slab – particularly where the slab has heaved. This will allow us to determine the cause of the issue and the view the resultant damage;
- Inspection of manhole structures located on the Roofwater & Podium drainage system to check if they are still water tight or have suffered damage allowing leakage; and
- Undertake pipe camera investigations of the sealed pipe system to check for joint integrity and any breakages;

A summary of the actual works undertaken on site during the works are is summarised below.

2.1 UNDERSLAB INVESTIGATION

General

Based on reviews of the available documentation, observed defects and cost limitations and following a site inspection and meeting with the contractor, five (5) locations were selected for and invasive investigation. This work included saw-cutting and removal of the existing basement slab on ground and some subgrade material. The five (5) locations selected for the investigation are identified on the Slab Investigation Locations plan attached in Appendix A.

In general, at each location the slab had heaved and there was a void evident below the concrete slab. The depth of this void varied between 100 and 200mm below the underside of the slab. The slab appeared to have been originally constructed on top of an approximately 200mm thick drainage layer consisting of 20mm aggregate stone laid over a geofabric material.

The slab depth varied considerably between 75mm and 250mm thick with the average slab thickness being around 100mm. A review of the structural engineering documentation confirmed that the slab was designed to be 100mm thick, constructed on a waterproof membrane/geofabric/150mm drainage gravel layer/geofabric with 75mm diameter agi lines on an 8.0m grid. This profile has been adopted to manage sub-surface water ingress – this may or may not have been noted during the soils investigation. The profile adopted is used to manage water in tidal zones as a method of managing water ingress (flooding) above slab level. For this system to work the stormwater outfall must be free-draining or pumped away from the basement and the water ingress rate from the sub-surface soil profile must be less than the capacity of the pipe network under the slab. An extract of the relevant parts of the structural drawings are included below to indicate the design intent.

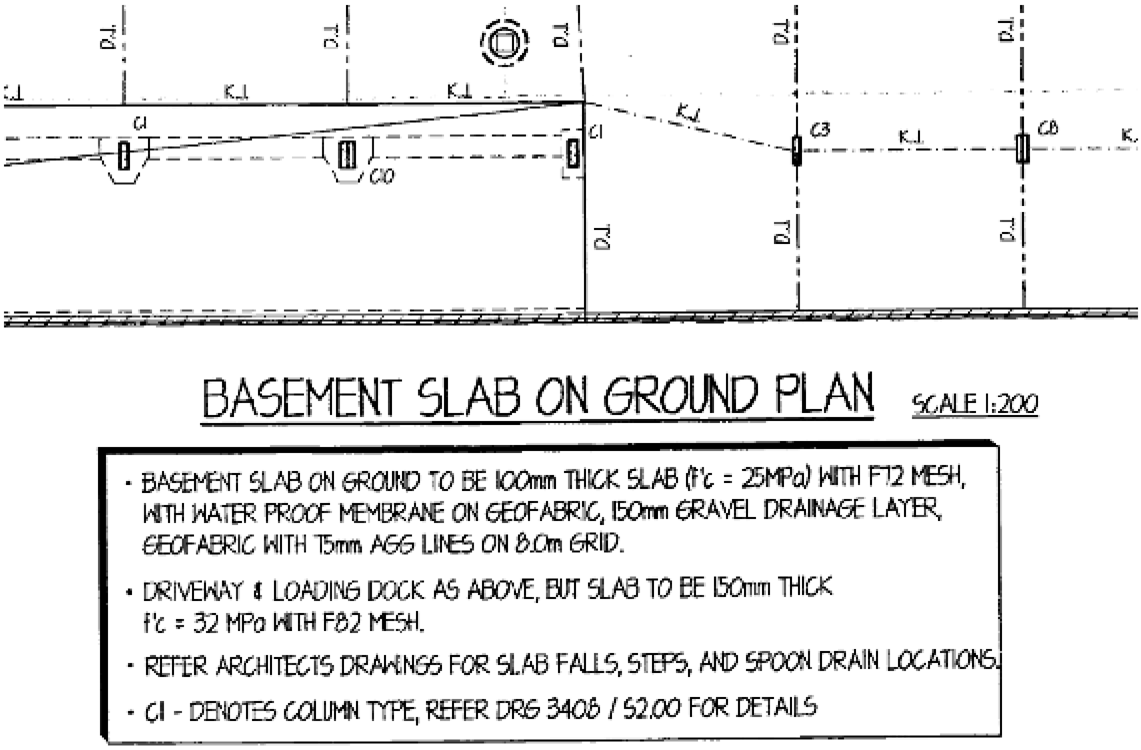


Figure 1 – Extract of the Basement Slab Plan showing the slab and subsurface design

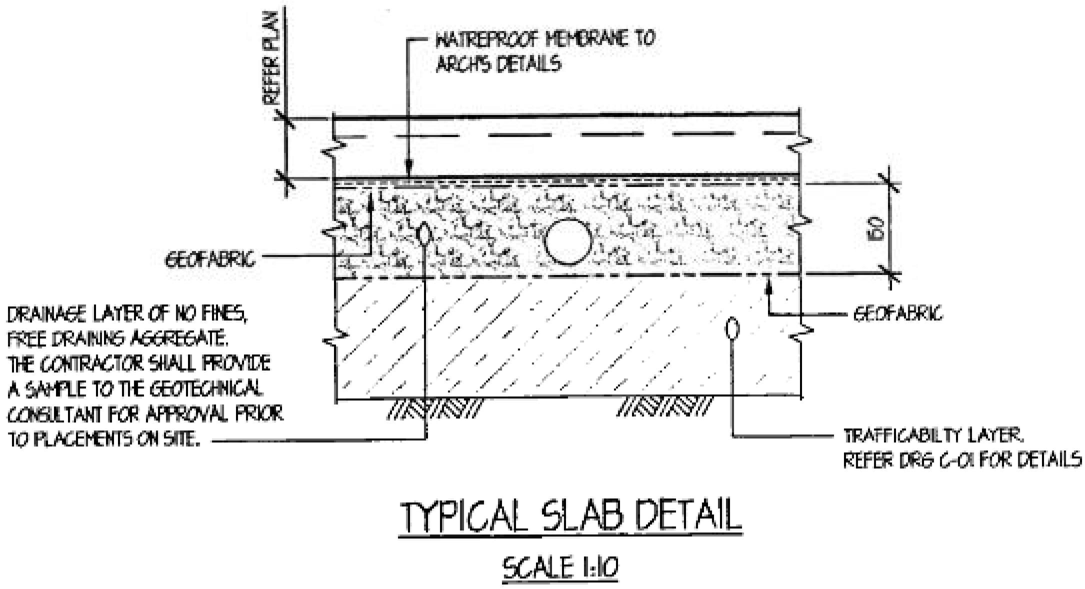


Figure 2 – Extract of the Basement Slab Plan showing the slab/subsurface detail

Observations made at each location are described below and are shown in photographs included in Appendix B.

Location 1

- There was a void under slab;
- Once the slab section was removed the surrounding slab areas dropped as the slab was 'caught up on the column'; and
- We noted that the slab thickness varied considerably and that the slab was cast on plastic on a gravel layer with a geofabric layer underneath – we did not observe any geofabric layer under the slab as nominated in the design.

Location 2

- There was a void under slab;
- The 150mm diameter sewer pipe at this location was not broken; and
- We noted that the slab was cast on plastic on a sandy gravel layer with a geofabric layer underneath – we did not observe any geofabric layer under the slab as nominated in the design and the gravel was contaminated.

Location 3

- There was a void under slab;
- The 150mm diameter roof-water pipe at this location was broken at a joint under the slab;
- We noted that the slab was cast on plastic on a sandy gravel layer with a geofabric layer underneath – we did not observe any geofabric layer under the slab as nominated in the design and the gravel was contaminated;
- The broken pipe was repaired prior to repouring the slab; and
- Once the slab was removed the surrounding slab dropped. Some further saw cutting and slab removal was required to allow the slab to drop around the column and minimise steps at existing slab joints.

Location 4

- There was a void under slab;
- The 150mm diameter roof-water pipe at this location was broken at a joint under the slab
- We noted that the slab was cast on plastic on a sandy gravel layer with a geofabric layer underneath – we did not observe any geofabric layer under the slab as nominated in the design and the gravel was contaminated; and
- The broken pipe was repaired prior to repouring the slab.

Location 5

- There was a void under slab;
- The 150mm diameter roof-water pipe at this location was not broken.
- The saddle joint of the 150mm diameter roof-water pipe to the 525mm diameter pipe was secure;
- Once the slab was removed the surrounding slab dropped;
- We noted that the slab was cast on plastic on a sandy gravel layer with a geofabric layer underneath – we did not observe any geofabric layer under the slab as nominated in the design and the gravel was contaminated; and
- During the slab removal, the existing downpipe was damaged and needed to be repaired.

2.2 MANHOLE STRUCTURES

A visual inspection of the manholes located on the 'sealed' roof-water system indicated that the aspro slabs (top lid slab of a manhole) remained on top of and sealed to the top of the manhole chamber. No evidence of leakage from these chambers was present. The issue with these types of manholes is that they can tolerate no vertical movement of the lid as they are not structurally connected and would be susceptible to opening up if the basement slab was to lift. In the past these pits had clearly failed and they were repaired. It is our belief that these manhole chambers should have been constructed as cast-insitu pits with an insitu lid that is structurally connected – they are more robust and would not allow water to enter the subgrade when subjected to large flows and hydrostatic pressure. Refer to the photographs in Appendix C.

We also inspected the grated inlet pit structures on the basement drainage system and noted that multiple 75mm diameter agi drain outlets were provided at the top of these structures as per the note in the legend on the Basement Plan Hydraulic Services by Christopher Contracting. The size and spacing of these pipes is important to the success of a system sub-floor drainage system and requires detailed assessment of water inflows, soil permeability and drainage capacity.

2.3 CCTV OF PIPES

Based on the findings of the under-slab investigations and manhole inspections it is unlikely that CCTV of the sub-floor roof-water drainage pipe system is warranted at this stage. It is evident that there are breakages in the pipe network and this supports a proposal to redirect roof-water to a level above the basement slab. A system such as this will result in the existing pipe network becoming redundant, removing the need to remove large sections of slab and repair joints on a system that is unable to cope with stormwater and roof-water flows. If it was decided to maintain the existing sub floor roof-water piped system then the CCTV would be necessary to identify breakage locations for rectification along with a major upgrade of the roof-water storage and pumping system.

2.4 OTHER OBSERVATIONS

The lids for the grated stormwater pit - Ecosol pollutant device and pump well located in the loading dock area which are associated with the basement drainage system were removed for inspection and maintenance as requested by the building management. All these pits were full of water and it was evident that the pumps had not been working for some time.

At an inspection on the 22 March 2017 the building management had arranged for electricians to undertake maintenance of the stormwater pumps and they were temporarily fixed. The pumps commenced emptying the grated pit and Ecosol unit. As the pits emptied we then observed water entering the pits from around the outside of the pipe penetrations through the pit walls. This observation confirms that that there is water in the trenches and surrounding ground – which is expected. The water ingress confirms the difficulties faced in attempting drain an unsealed basement that is below fluctuating groundwater and tidal levels. Refer to photographs in Appendix D.

During our inspection on 23 March 2017 the stormwater pumps were not running and the ground water ingress into these structures had stopped. It is likely that the water will return when tidal and rain events occur – the rate of water ingress being proportional to the permeability of the sub-surface soils and drainage system. We note that the electricians stated that there was a float switch issue with the pumps and this would need to be fixed for the pumps to operate on a regular basis.

During the course of our investigation, a reasonably large rain event occurred on the 30 March 2017. We visited the site at approximately 7.00am on the morning of the rain event and at that stage there was no major ingress of water in the basement or loading dock. At a further visit at approximately 11.00am on 30 March 2017, water was entering the basement and loading dock.

Within the main basement area water was observed percolating out at various locations as noted below:

- The seals and bolt holes of the bolt down lids located on the roof-water system manholes;
- The joints in the basement slab and between columns and the basement slab. This was more predominant at the northern end of the basement.;
- Around the roof-water pipes where they penetrated the basement slab and out of the adjoining joints between the column and the slab;
- At joints in the roof-water pipes above slab level; and
- Through joints in the podium slab over

The basement drainage system appeared to be working as water was entering the pits via the grated inlets and the subsoil drains and appeared to be draining away. It was noted that the basement drainage pumps were not operational at the time when they were required to. We observed a temporary pump was installed in the loading dock area and that it was pumping water from the grated pit located within the driveway of the loading dock area and part of the basement drainage system via hose out to Campbell Street. Clearly the subsurface drainage layer was full of water during this event as we noted that water in the loading dock was:

- Percolating out of joints in the slab;
- Percolating out of the trench grate across the driveway;
- Running out from behind the building wall;
- Spouting out of the block retaining wall located on the site's western boundary

Please refer to photographs in Appendix E

3.0 DISCUSSION

Based on our investigations it is evident that water has been entering the under-slab drainage layer located under the basement slab and loading dock via roof-water pipe fractures. There is also groundwater relating to tidal fluctuations and water from adjacent ground surfaces that makes its way into this sub-floor layer. The failure of the roof-water drainage system and under-slab drainage system to accommodate large rainfall events and large tidal water ingress both separately and simultaneously is considered to be the primary cause for heaving of the basement slabs. The ingress of large volumes of water has caused cavitation and slab heave and further damage to the roof-water pipes that intersect the slab when basement slab heave occurred. This conclusion supports the findings of our preliminary assessment in the Stage 1 investigation as shown in italics below:

- *'water ingress occurred firstly when the roofwater system failed, whereby the system could not drain to the existing Council pipe due to the raised levels in the pipe Enoggera Creek. This caused backup pressure in the roofwater system which subsequently resulted in the top slabs of the stormwater manholes lifting off the main chamber of the manhole. This in turn allowed water under the slab from both the roofwater system and potentially backwater from the Council pipe. The excess water under the slab then caused the basement drainage system to be overloaded'.*

3.1 30 MARCH 2017 - RAIN EVENT

During the rain event on the 30 March 2017 it was evident that the roof-water system was backing up and the under-slab gravel drainage layer was placed under a head of water causing water to percolate out of the sealed lids of the pits. This failure confirms that the system could not drain to the existing Council pipe due to raised water levels in this pipe and Enoggera Creek. The backed-up water and the roof-water would then be discharging under the slab through the broken roof-water pipes as evidenced in our under-slab investigations.

3.2 UNDER-SLAB DRAINAGE LAYER

The volume and rate of water ingress into the gravel drainage layer from the roof-water system due to pipe breakage and stormwater pit failure would not have been considered in the design of the under-slab drainage system. The roof-water pipe network was designed as closed pipe network, that could withstand pressure, but not slab heave. The sub-floor drainage layer may have been able to cater for ground water inflows if the system could free drain or if the water could be pumped away.

We observed that the pump system had failed and we understand that the system has not been operational in some rain events due to power failure. We also have determined that the tidal levels in the nearby creek prevent water within the under-slab drainage layer from draining away.

When large rain events coincide with high tides this causes water to back-up in stormwater pipe network and into the sub-floor drainage layer. This issue when coupled with the roof-water ingress creates volume changes that cause slab heave when the pressure exceeds the capacity of the slab joints to handle water inflows. The result of these coincidental failures is flooding of the loading dock and water percolating up thorough the basement slab when the sub-floor drainage layer is under pressure. Eventually, when creek levels drop the water drains away – pumps assist in the removal of water from the sub-floor drainage layer, however the capacity of these pumps must exceed the volume of water coming in – a difficult requirement if the water inflows include unlimited tidal water inflows that occur during high tides.

We have determined that, during storm and large rainfall events, the sub-floor drainage system is required to accommodate a range of water sources and issues that include:

- Roof water under head that surcharges the gravel and void space under the slab;
- Drainage pits that are not watertight or capable of withstanding several metres of head of water;
- Inadequate or non-existent drainage outfall because pumps are either undersized, broken or without power; and
- A drowned outlet that does not permit water to drain away when the tide is high in the nearby creek; and
- A large rate of water ingress into the sub-floor drainage layer that connects to external areas and the creek.

These issues, in combination or isolation, prevent roof-water and groundwater from being drained away, filling up the sub-floor drainage gravel and voids, eventually flooding the loading dock and basement.

It is likely that a series of concrete cut-off walls will be required on the northern face of the site to reduce the permeability of the soils adjacent to the creek in order to reduce the tidal flows/groundwater ingress into the sub-floor drainage gravel layer within the building.

3.3 SLAB HEAVE

The basement slab has been constructed as a slab on ground, with a sub-floor drainage layer. The slab has not been designed to resist hydrostatic uplift and has regularly spaced joints. When water ingress into the sub-floor drainage layer exceeds the outfall capacity, the drainage layer fills up with water and eventually water percolates thorough the joints and penetrations in the slab and through drainage pits. If the rate of water inflow is significant, the slab will heave as observed at this site.

A hydrostatic raft slab, correctly design and constructed, with tanking to the underside of the slab and basement walls to prevent water ingress would resist water inflows into the basement. This type of slab is significantly thicker and is either fully reinforced or prestressed. The slab would be structurally connected to the columns and walls and pile caps to prevent it lifting under water pressure. For this system to be effective all pits and penetrations are required to be fully sealed.

3.4 ROOF-WATER DRAINAGE SYSTEM

The roof-water pipe network was designed as closed pipe network that could withstand pressure up to 3m above basement level. The failure of this system occurred when the slab heaved and the pipe sections were broken under the slab, surcharging the space with significant quantities of water during large rainfall events. The roof-water drainage system is discussed further in Section 4 and Appendix F.

3.5 ROOF-WATER REDIRECTION

As the failed roof-water system is considered to be the source of a major volume of water under the basement slab we believe that it is appropriate to remove the source, thereby reducing the pressure on the sub-floor drainage system to cater with rain event drainage.

We do not consider that the repair of the current roof-water system is appropriate as the repairs would include significant effort and costs in identifying and repairing the issues. All sections of pipe that are broken would need to be replaced and sealed which also requires slab removal and replacement. Logging and identifying these issues would be difficult in the first instance. The system once repaired would be likely to fail again.

To remove the risk of further breakage of the pipes and resultant flooding of the basement the roof-water pipes should be redirected so that they are not located under the basement slab. This would involve re-routing the roof-water pipes so that they are above the basement slab and under the podium slab and at upper levels of the building. This option improves maintenance significantly. Roof-water overflow can be incorporated into this system at locations that are external to the building - if blockages occur or the creek and Council pipe outlet water levels are elevated the water can surcharge and be managed without risk of water entering the basement.

Treatment of the existing under slab roof-water system and its connection to the Council pipe will be required to address backwater inflows. The connection to the Council pipe should be fully sealed to reduce the inflows and it will be necessary to address areas where the roof-water pipe network intersects the external under-slab system. There are many issues to address that include management of groundwater inflows and the existing pipe network that need to be addressed in a detailed design.

If the roof-water redirection occurs there is still potential for water ingress into the basement through the cracks and joints in the basement slabs due to elevated groundwater levels associated with the adjacent creek. Accordingly, an appropriately designed and fully managed and operational pump system would need to be installed in the loading dock to manage groundwater ingress on the site. This may include larger / multiple pumps and diesel generator backup power supply.

4.0 ROOFWATER REDIRECTION INVESTIGATIONS

Lambert & Rehbein engaged hydraulics consultant BRW Hydraulics Pty Ltd to assist to investigate the possibility of reconstructing the existing roof-water system currently located under the basement slab to be above the basement slab.

A copy of their report, "Audit and Proposed Rectification of Roofwater Issues at the Mews Residential Complex" dated the 27th October 2017 is included in Appendix F.

In summary, the report demonstrates that conceptually the redirection of the existing roof-water system to be located above the basement slab is possible. This could be achieved via:

- redirection of pipes at higher levels along the external façade of the building;
- redirection of pipes along the walls of the basement; and
- where the above cannot be achieved via a redirection of pipes to above ground tanks with pumps located within the basement.

There are a number of items associated with this proposal that will need consideration by the Body Corporate, including:

- Building aesthetics,
- Disruption to commercial and residential tenancies;
- Location of tanks in the basement may require loss of carparks; and
- Costs

It is important to note that the BRW proposal is conceptual only and further detailed investigations and design will be necessary to further assess and implement their proposals.

5.0 OPINION OF POSSIBLE COSTS

In order to assist the Body Corporate to make an assessment of the viability of proceeding with rectification works, we have prepared and opinion of possible construction costs – these costs will vary depending on the outcome of a detailed design and contractor's inputs.

1. Redirection of Roofwater System (refer BRW Report) $1,120,750.00
2. Improvement of loading dock pump system, cast insitu pump wells and installation of backflow prevention $ 150,000.00

We note that these are high level opinions of possible construction costs only and are subject to further investigations including geotechnical investigations, detail survey, building inspections, invasive investigations and detailed design.

In view of the above Lambert & Rehbein (SEQ) Pty Ltd accepts no responsibility for any person or corporation who may use or rely on this opinion of possible construction costs. The opinion of possible construction costs should only be used as a guide with final detailed cost estimates only being available following completion and approval of the engineering design.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSION

Lambert & Rehbein were commissioned by The Body Corporate for The Mews Bowen Hills CTS 33016 to undertake Stage 2 water inundation investigations of flooding issues in the basement of the Mews building located at 141 Campbell Street, Bowen Hills.

The scope for the Stage 2 of the proposed investigations is to gain a better understanding of the issues and to assist in determining potential solutions.

The following key findings of our investigations are noted below:

- Voids were found under the basement slab;
- The sub-floor roof-water drainage system has failed breaking the pipes and forcing roof-water under the basement slab;
- The ingress of large volumes of water has caused cavitation and slab heave and further damage to the roof-water pipes that intersect the slab when basement slab heave occurred.
- During rainfall events, the water level in the Council piped stormwater system and the adjoining Enoggera Creek is preventing discharge of the roof-water system. This causes water to back up into the sub-floor drainage layer;
- Groundwater ingress into the loading dock was observed;
- The basement drainage pumps were not operating correctly, resulting in no outlet being available for the basement drainage system flows nor the increased water volume provided by the roof-water system;
- It is evident that water has been entering the under-slab drainage layer located under the basement slab and loading dock via roof-water pipe fractures. There is also groundwater relating to tidal fluctuations and water from adjacent ground surfaces that makes its way into this sub-floor layer. The failure of the roof-water drainage system and under-slab drainage system to accommodate large rainfall events and large tidal water ingress both separately and simultaneously is considered to be the primary cause for heaving of the basement slabs and flooding of the basement.

- The repair of the current sub-floor roof-water system is not considered to be appropriate due to the significant effort and costs to identify and repair the issues;
- The existing sub floor roof-water system should be redirected so that they are not located under the basement slab;
- Water Technologies, in their report dated 8 October 2015 nominated that the Enoggera Creek tidal levels range from RL -0.5 to RL +1.5. Flood levels of around RL 2.8 were observed in May 2015. The Q100 flood level in the area is currently RL 4.32;
- As a minimum, the loading dock slab which is located at around 1.9m below high tide level, should have been constructed as fully tanked raft and wall system with fully sealed pump wells that are designed to accommodate the groundwater inflows, creek inflows, floodwater ingress, and ramp and basement surface water;
- If flooding of the basement was to be avoided, the basement slab which is located at RL 1.75 should have been designed and constructed as a tanked, hydrostatic raft slab with perimeter walls that are fully tanked to above flood levels.

6.2 RECOMMENDATIONS

Based on our investigations we make the following recommendations for potential improvements to the current flooding situation at The Mews:

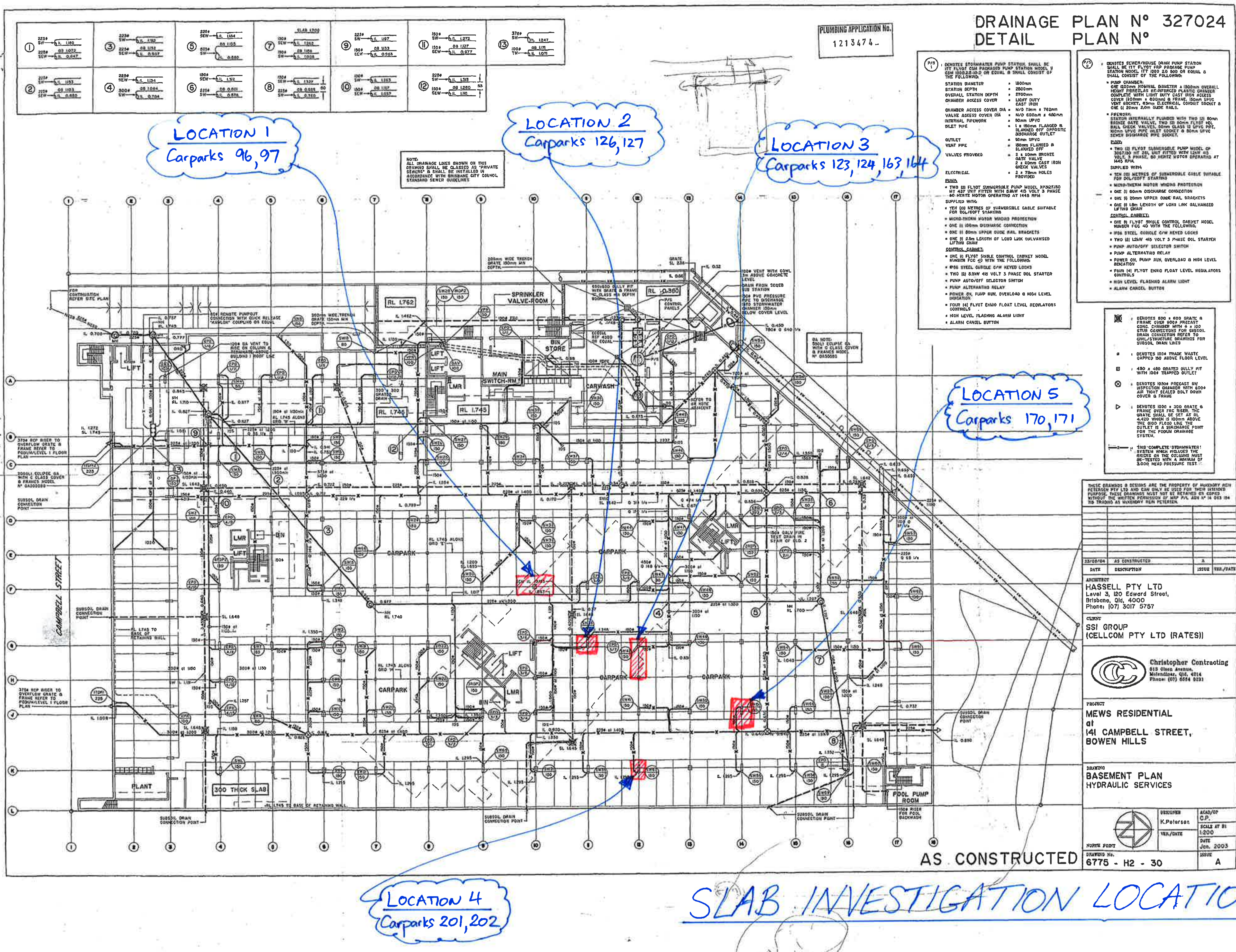
- Immediately repair and maintain the existing basement drainage pumps located in the loading dock so that the effects of rainfall events are reduced – it should be noted that large rainfall events will continue to result in basement flooding and slab heave;
- Undertake detailed design to arrive at a solution that redirects the roof-water pipes so that they are not located under the basement slab. The would be in general accordance with the conceptual proposal detailed in the BRW Hydraulics Pty Ltd report “Audit and Proposed Rectification of Roofwater Issues at the Mews Residential Complex” dated the 27th October 2017;
- Improve the basement drainage pump system located in the loading dock – this will include insitu pump wells, larger pumps and a diesel generator backup power. This will not prevent the loading dock from flooding but it will reduce the frequency of basement flooding;

- Provide backflow prevention by blocking the existing connection between the sub-floor roof-water system and the Council stormwater pipe that outfalls to the creek;
- Provide cut-off walls external to the basement walls on the northern side of the site adjacent to creek to reduce groundwater inflows into the sub-floor drainage system.

Once the Body Corporate has reviewed this report we would be available to meet to discuss this matter and our recommendation to proceed with further detailed investigations and detailed design.

APPENDIX A

SLAB INVESTIGATION LOCATIONS



SLAB INVESTIGATION LOCATIONS

LAMBERT & REHBEIN
ENGINEERS • MANAGERS • SCIENTISTS

APPENDIX B

PHOTOS OF UNDERSLAB

Location 1

Photo 1 – Void under slab

Photo 2 – Void under slab

Photo 3 – General photo of excavation with void, drainage layer and geofabric visible

Photo 4 – Drainage Layer Material under slab

Location 2

Photo 5 - Existing sewer pipe not broken

Location 3

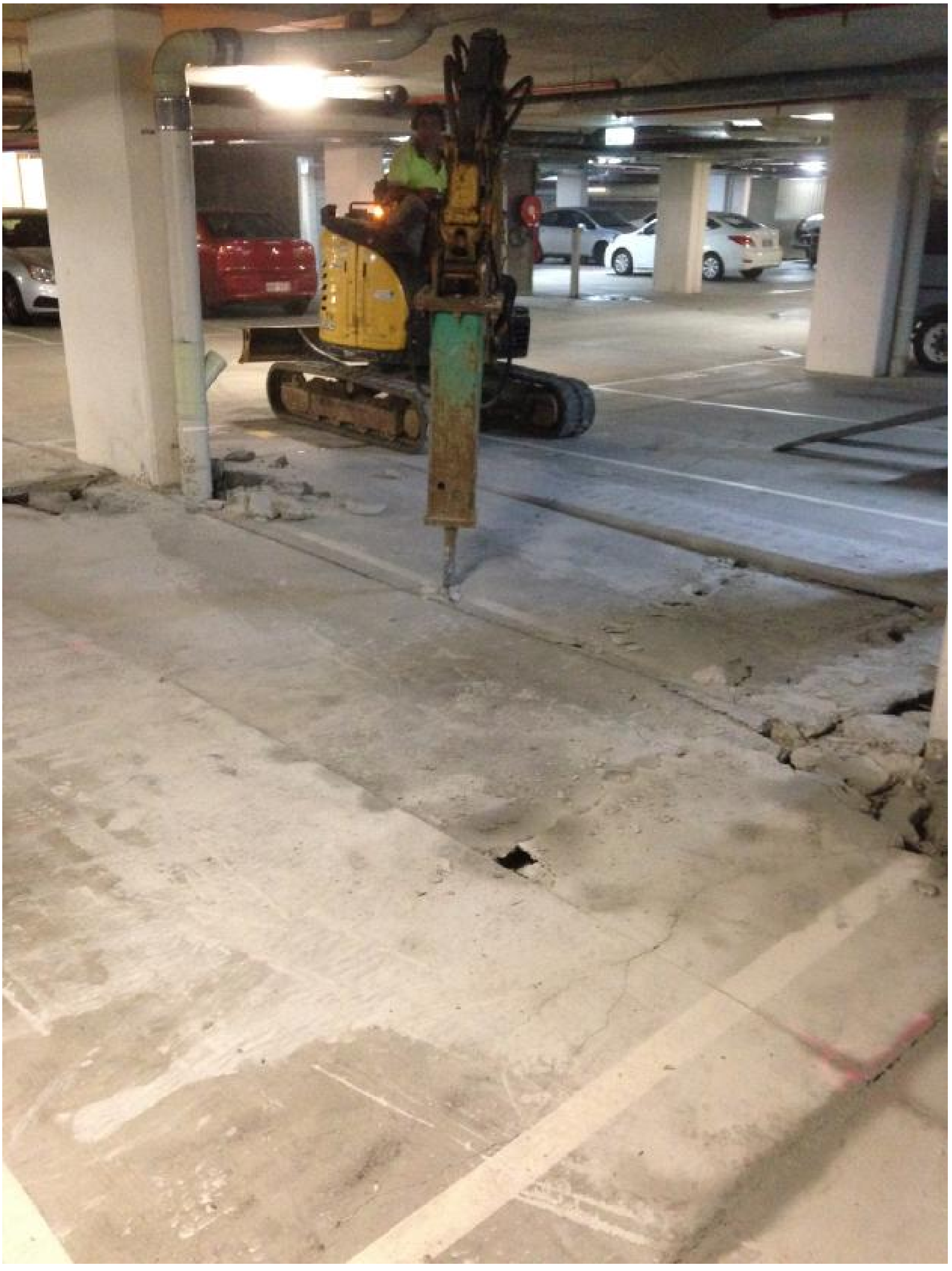


Photo 6 – Existing slab being removed

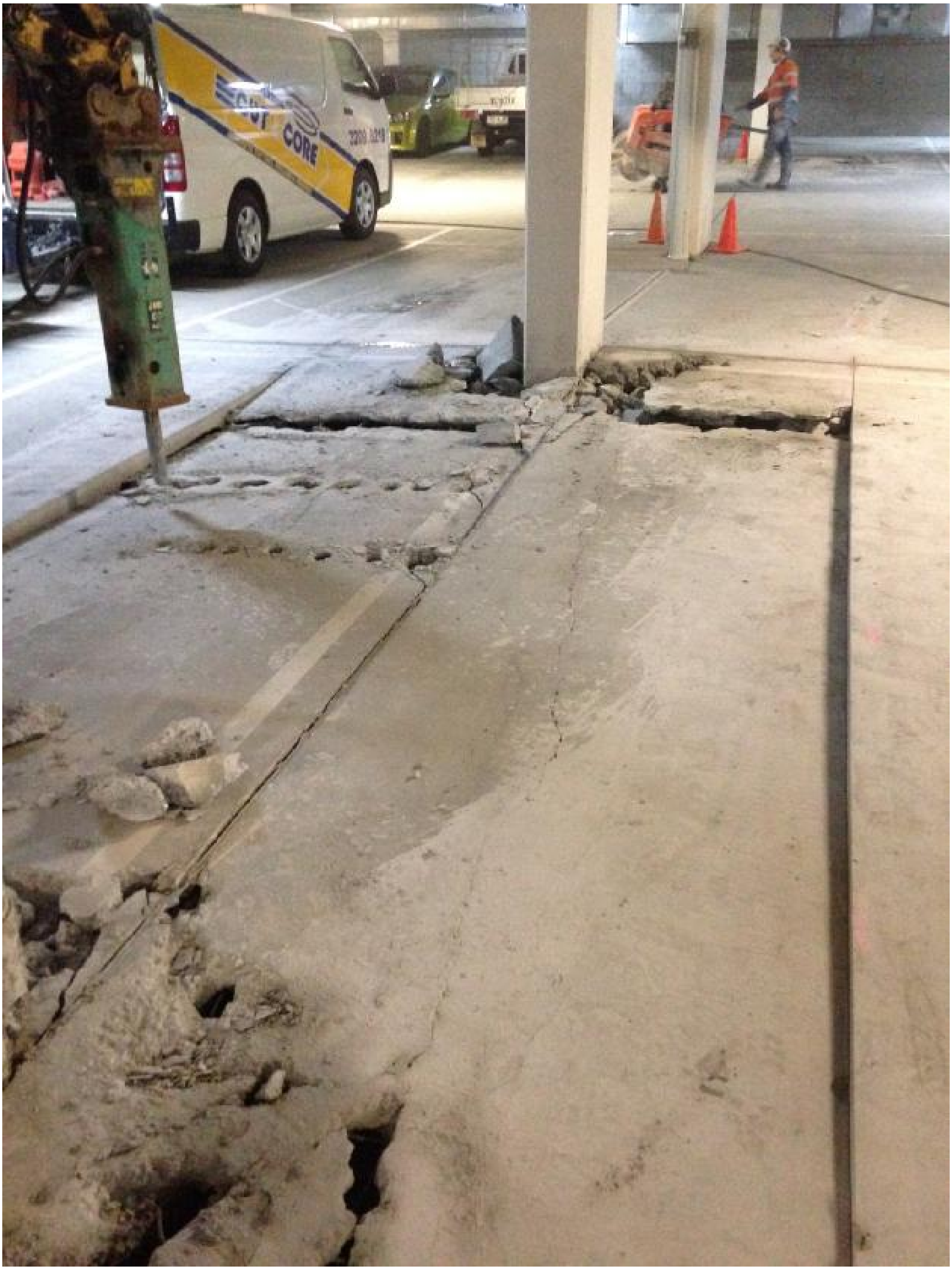


Photo 7 – Existing slab being removed

Photo 8 – Void under slab. Slab thickness only approximately 80mm thick

Photo 9 – Void under slab approximately 200mm deep

Photo 10 – Void under slab

Photo 11 - Void under

Photo 12 - Broken roofwater pipe

Photo 13 – Repair undertaken to broken roofwater pipe

Location 4

Photo 14 – Void under slab

Photo 15 – Void under slab

Photo 16 – Depth of void 100mm

Photo 17 – Void under slab

Photo 18 – Cracked roofwater pipe wide shot

Photo 19 – Close up of broken roofwater pipe

Location 5

Photo 20 – 150mm roofwater saddle joint to 525mm diameter pipe

APPENDIX C

PHOTOS OF MANHOLES

Photo 1 - Manhole on sealed roof water system. Aspro Slab still connected and sealed to main chamber

Photo 2 – Manhole on sealed roof water system. Aspro Slab still connected and sealed to main chamber

Photo 3 – Grated Inlet Pit on basement drainage system – 50mm ag drain from under slab drainage layer can be seen

APPENDIX D

PHOTOS OF BASEMENT DRAINAGE INFILTRATION

Photo 1 - Ground water entering around pipe penetration in basement drainage manhole located in loading dock

Photo 2 – Ground water entering around pipe penetration in the Ecosol Unit on basement drainage system located in loading dock

Photo 3 – Pit on basement drainage line located upstream of pumps in loading dock. Full of water due to non-operation of pumps

APPENDIX E

PHOTOS OF RAIN EVENT

Photo 1 – Leakage through joints in podium slab into basement during rain event

Photo 2 - Temporary pump located in loading dock during rain event

Photo 3 – Discharge to loading dock area from under basement slab

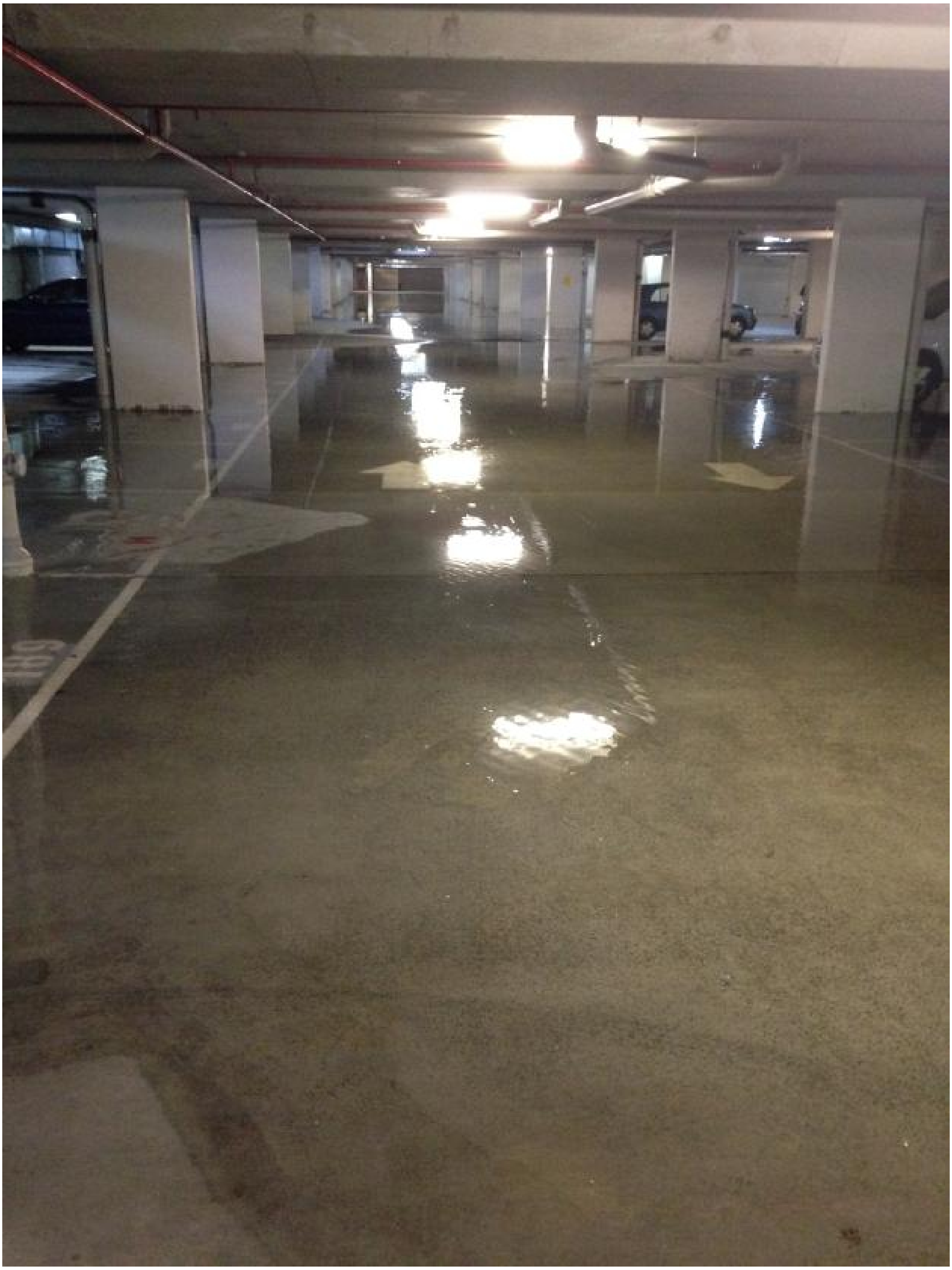


Photo 4 – Flooding of basement during rain event

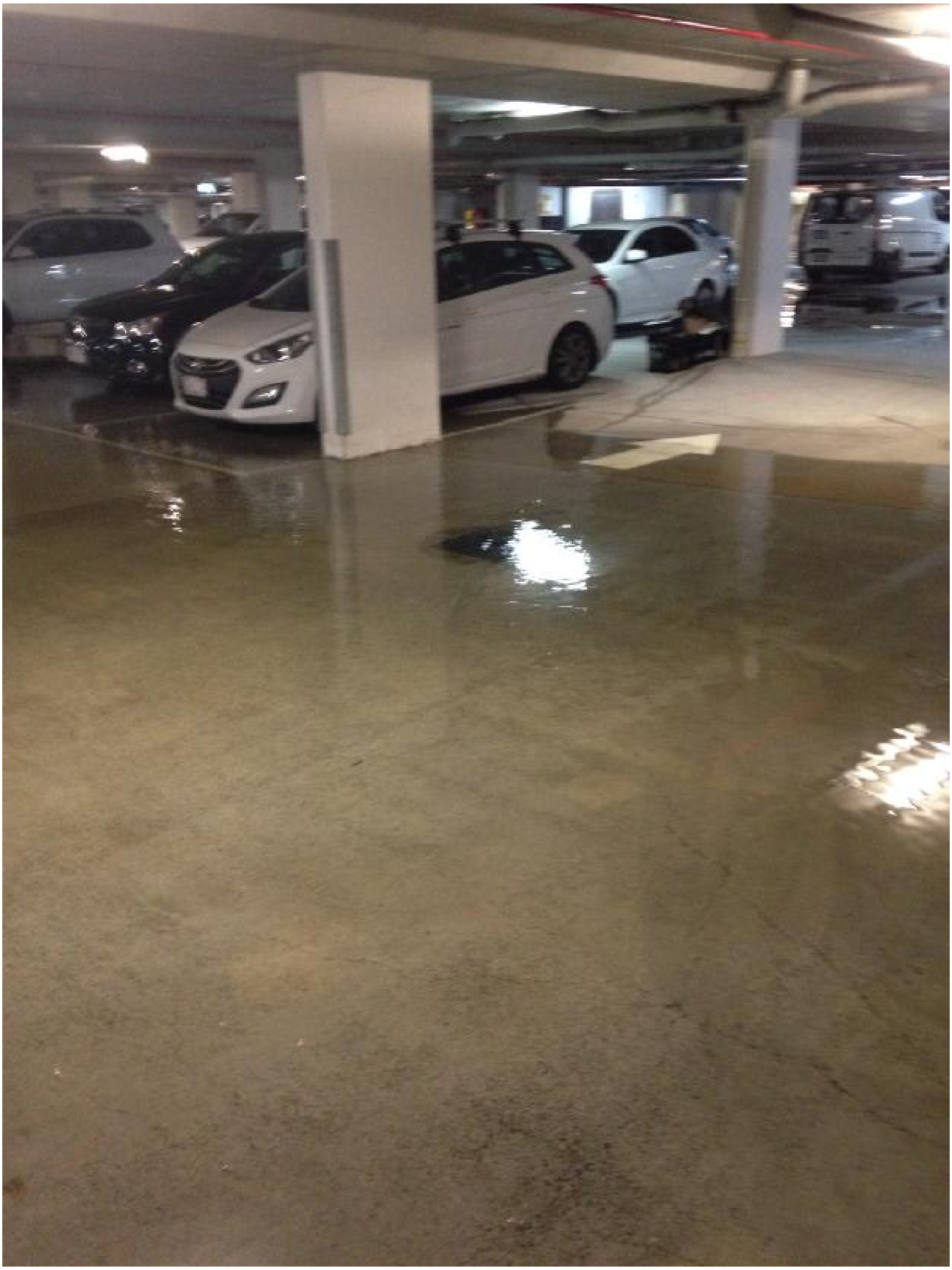


Photo 5 - Flooding of basement during rain event

APPENDIX F

BRW HYDRAULICS REPORT