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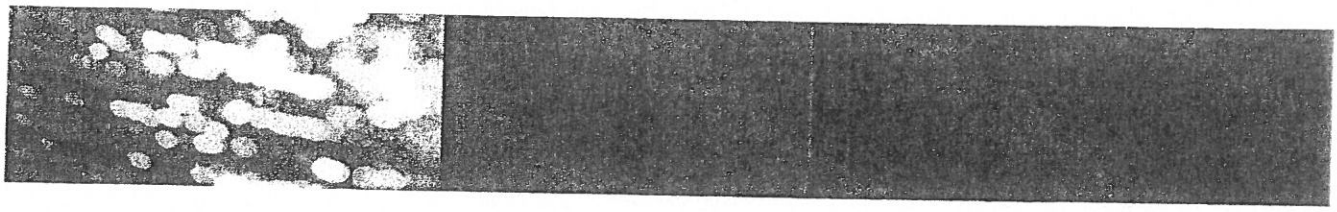

LOTS 2 ON RP615695 AND 80 ON RP604102, GRACEMERE

Flood Study

ROCKHAMPTON REGIONAL COUNCIL
These plans are approved subject to the current conditions of approval associated with Development Permit No. D-220-2009
Dated 3/18/2010

27 November 2009
Job No. R1039-06

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Document Control

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1	25 January 2008	Carlos Gonzalez	CG	Martin Giles	MG
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3	27 November 2009	Michael Della	MD	Martin Giles	MG

LOTS 2 ON RP615695 AND 80 ON RP604102, GRACEMERE FLOOD STUDY

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1. INTRODUCTION

It is proposed to develop two sites, one is located at the intersection of Capricorn Street and Middle Road and the second one is adjacent to Douglas Street, Gracemere. The development sites comprise Lot 2 on RP615695 and Lot 80 on RP604102, Gracemere, Shire of Fitzroy. The location of the proposed development sites is shown on Figure 1.

Gracemere Creek and a small unnamed tributary of Gracemere Creek drain through the proposed development sites, joining further downstream of the property adjacent to Capricorn Street. A flood study has been completed to determine the 100 year Average Recurrence Interval (ARI) flood levels along the creeks traversing the site. This report details the analysis undertaken and the results obtained.

The peak flow rate and flood levels produced by the 100 year ARI event for existing site conditions were calculated to determine current flooding conditions within the tributary. Channel works and associated filling needed to improve flooding conditions within the site were then determined.

The present study was completed with reference to the *Capricorn Municipal Stormwater Drainage Design Guidelines* and the *Queensland Urban Design Manual* (QUDM).

Peak flow rates and flood levels along Gracemere Creek were sourced from a previous hydraulic report completed by Cardno in September 2007 (*Industrial Estate, Somerset Road, Gracemere Hydraulic Report)* to determine the impact of an adjacent industrial estate (located in Lot 9 on P4030) on flood levels along Gracemere Creek.

2. SITE AND CATCHMENT DESCRIPTION

2.1 Site Description

The proposed development site has an approximate total area of 12.0 hectares, comprising Lot 2 on RP615695 and Lot 80 on RP604012, Gracemere, Shire of Fitzroy. The location of the site is shown on Figure 1.

The proposed development involves dividing the sites to provide commercial lots. Currently, the sites are mostly undeveloped and comprise rural residential land. Lot 2 on RP615695 is directly bounded to the north and east by Capricorn Street, to the south by Middle Road and to the west by Lot 80 on RP604012.

The sites consist of flat terrain with a maximum ground elevation of 19.1 mAHD at the eastern corner of Lot 2 on RP615695 (downstream of the corner of Capricorn Street and Middle Road) and of 19.25 at the upstream boundary of Lot 80 on RP604012. The minimum ground elevation within Lot 2 on RP615695 is approximately 16.3 m at the northern boundary of the site (just upstream of Capricorn Street). Slopes within the site are approximately 0.2 to 0.5 percent. For Lot 80 on RP604012 the minimum ground elevation is approximately 17.0 m at the northern boundary of the site (just upstream of Lot 2 on RP615695).

Gracemere Creek crosses the central part of both sites flowing in a northerly direction. An unnamed tributary of Gracemere Creek crosses the eastern corner of Lot 2 on RP615695 flowing from south to north, ultimately merging with Gracemere Creek further downstream of the site.

2.2 Catchment Description

The catchment of Gracemere Creek extends approximately 15 kilometres upstream of the intersection with Capricorn Street covering an area of 3260 hectares. The catchment for the unnamed tributary extends approximately 2.3 kilometres upstream of the intersection with Middle Road covering an approximate area of 137 hectares. Figure 2 presents the catchment plan considered in this study.

The catchment of the tributary comprises a large, mostly rural residential area that includes part of the residential precinct of the Town of Gracemere. The catchment comprises the land enclosed between Clifton Street (south of the site), Capricorn Street and the ridges located to the west and east of the town of Gracemere (refer to Figure 2).

The land uses considered in this study were based on Zoning Map A8 of the Fitzroy Shire Council Planning Scheme. Due to the small percentage of catchment area covered by the site (less than 0.3 %), the increase in catchment fraction impervious due to the proposed development is considered negligible.

3. HYDROLOGY

3.1 General

The Rational Method was used to determine the peak flow rates corresponding to the 100 year ARI event throughout the sites.

3.2 Rainfall Intensities

Rainfall intensities for Rockhampton were utilised in this study, they were calculated using AUS-IFD following the procedures described in Chapter 2 of *Australian Rainfall and Runoff*, 1987, Volume 1 (AR&R 1987). The rainfall intensities, average regional skewness (G) and Geographical factors (F_2 and F_{50}) used in the study are listed in Table 1.

Table 1 Rainfall Intensities and Geographical Parameters for Rockhampton, Qld.

Storm Duration	2 yr ARI (mm/h)	50yr ARI (mm/h)	Regional Parameters	
1 hr	44.9	85.0	G	0.22
12 hr	8.9	17.9	F_2	4.22
72 hr	2.6	6.1	F_{50}	17.70

3.3 Runoff Coefficients

In the present study, only the developed scenario of the catchment was analysed. This scenario considered the imperviousness of the catchment based on the different levels of development likely to occur throughout the catchment in the immediate future. Consequently, an ultimate level of development was assumed in accordance with Map A8 of the Fitzroy Shire Council Planning Scheme by considering the catchment as a predominantly rural residential area.

A fraction impervious of 0.2 was assumed for the entire catchment of the tributary. The 10 year, 1 hour rainfall intensity for the site is 64 mm/h. Therefore, based on the *Queensland Urban Drainage Manual* (QUDM, 1992), the 10 year runoff coefficient (C_{10}) for rural residential areas is 0.65. The corresponding 100 year runoff coefficient for the catchment is 0.78.

For the Gracemere Creek catchment, a fraction impervious value of 0.5 was adopted for the developed area, which occupies about 450 hectares of the catchment. The fraction impervious value for the remainder of the catchment was set at zero. Based on Table 5.05.1 of QUDM, a runoff coefficient of 0.61 was derived for the 10 year event, providing a 100 year event runoff coefficient of 0.73.

3.4 Times of concentration

The time of concentration of the catchment was calculated using the Rational Method as recommended in the *Queensland Urban Drainage Manual.*

For these predominantly rural catchment areas, the times of concentration were calculated using the Bransby-Williams Equation (QUDM Eq. 5.05.3A).

$$t_c = \frac{92.7L}{A^{0.1} \cdot S^{0.2}} = \frac{92.7(2.3)}{(136.9)^{0.1} \cdot (6.45)^{0.2}} = 90 \quad \text{min}$$

where t_c is the time of concentration in minutes, L is the length of the flow path in Kilometres, A is the catchment Area in hectares and S is the equal area slope of the stream flow path. The resulting time of concentration for the tributary catchment was 90 minutes.

A time of concentration of 8.3 hours was obtained for the Gracemere Creek catchment. The 100 year rainfall intensity applicable to this time of concentration is 26.8 mm/hr.

3.5 Peak Flows

The 100 year ARI flow rate for Gracemere creek and the tributary traversing the sites were calculated at the northern boundary of the site (outlet point). The rational method parameters and calculated peak flow rates are summarized in Table 2. The calculated flows were applied to a HECRAS model to obtain the 100 year ARI flood levels within the tributary (refer to Section 4).

Table 2 100 year ARI event Peak Flow Rate

Catchment	Area (ha)	Runoff Coefficient		t_c (min)	100 Year ARI Event	
		C_{10}	C_{100}		Rainfall Intensity (mm/h)	Peak Flow (m^3/s)
Unnamed Tributary	136.9	0.65	0.78	90.0	78.0	23.1
Gracemere Creek	3260	0.61	0.73	498	26.9	177.0*

Note: *Flow rates sourced from (*Industrial Estate, Somerset Road, Gracemere Hydraulic Report)*

4. HYDRAULIC MODEL

HEC-RAS is a one-dimensional hydraulic model used to perform hydraulic calculations for natural and constructed waterways.

4.1 Gracemere Creek

A HEC-RAS model of Gracemere Creek was previously set up using surveyed cross-sections spaced at approximately 50m through the sites and downstream of Capricorn Street as shown in Figure 3. The survey data used had a contour interval of 0.25m.

A Manning's n value of 0.10 was assumed for the channel area in each cross section, representing dense brush. A Manning's n value of 0.04 was assumed for the floodplain areas, representing short grass.

Normal depth was assumed at the downstream end of the hydraulic model. This depth was determined by calculating the slope between the most downstream cross sections, which was evaluated to be 0.3 percent. Despite their negligible capacity, the three 375mm RCP culverts and the road profile of Capricorn Street were included in the model.

Previous HEC-RAS results showed that most of the western area of the proposed development sites will be inundated by 100 year ARI flood levels within Gracemere Creek. They also showed that filling conducted in the adjacent site will increase flood levels in the areas of the subject site adjacent to the right bank of the creek.

In the present study, the previously developed HEC-RAS model was modified to determine the filling and excavation works required to improve flooding conditions within the sites. Cross sections 5 to 21 were updated to represent the proposed filling and excavation works. It is required to excavate the areas adjacent to the Gracemere Creek to provide 100 year ARI flood immunity to the sites.

Between cross sections 5 and 13, a 75 metre wide area within the site on the south-eastern side of Gracemere Creek should be excavated to a level of 17.0 mAHD. Similarly, the area adjacent to the western bank of Gracemere Creek between cross sections 13 and 14 should be excavated to a level of 16.5 mAHD. Lastly, the area adjacent to the eastern bank of the creek between cross sections 16 and 19 should be excavated to a level of 16.7 mAHD (refer to Figure 4 to locate the proposed cut and fill areas).

The obtained results are compared in Table 3 with current flood 100 year ARI flood levels along Gracemere Creek. The current extent of inundation for Gracemere corresponding to the 100 year ARI event is shown on Figure 3.

Table 3 Gracemere Creek Flood Levels - 'As Constructed' and Fill and Excavate Cases

Cross Section	100 Year ARI Flood Level		Afflux (mm)
	2007 'as constructed' case (mAHD)	2008 Proposed Filling and Excavation case (mAHD)	
21	19.32	19.11	-210
20	19.16	18.70	-480
19	19.03	18.55	-500
18	18.90	18.52	-410
17	18.83	18.50	-360
16	18.78	18.49	-320
15	18.67	18.47	-240
14	18.48	18.37	-150
13	18.25	18.30	-10
12	18.19	18.26	-10
11	18.09	18.10	-20
10	17.96	17.96	0
9	17.86	17.86	0
8	17.80	17.78	-20
7	17.76	17.73	-30
6	17.67	17.65	-20
5	17.52	17.51	-10
4	17.45	17.44	-10
3	17.28	17.28	0
2	17.06	17.06	0
1	16.83	16.83	0

Note: Refer to Figure 3 for the location of cross sections

Based on results presented in Table 3 it can be seen that that flood levels corresponding to the developed conditions of the central part of both sites (fill and excavate scenario) are lower than those modelled under the existing conditions. This is due to the improved channel capacity and conveyance achieved with the proposed excavated works. Note that this analysis assumed that the areas of both sites adjacent to Gracemere Creek will be filled above the 100 year level.

4.2 Unnamed Tributary

A HEC-RAS model of the tributary was also developed to calculate current flooding conditions within the eastern corner of Lot 2 on RP615695. Channel works and associated filling needed to improve flooding conditions within the site were then determined.

The tributary was represented by eleven cross sections derived from 0.25 metre spaced contour data. The model was limited to the reaches contained within the site (refer to Figure 3).

The calculated flow rates presented in Table 2 were entered into the cross sections representing the inlet (cross sections 14 and 11). The model was analysed as a subcritical flow regime. Tailwater levels were set at the downstream end of the model based on the normal depth occurring for the natural slope (1 percent).

Based on visual inspection of the gullies, the Manning's n roughness values for all its cross sections were set at 0.05 (grass and scattered shrubs) for the main channel and overbank areas.

The flood levels calculated for the 100 year ARI storm for the tributary are summarised in Table 4. The current extent of inundation for the tributary corresponding to the 100 year ARI event is shown on Figure 3.

Table 4 100 Year ARI Flood Levels within Tributary – Existing Case

Cross section	Flood Levels (m AHD)
11 (crest of Middle Road)	18.65
10	18.58
9	18.34
8	18.18
7	17.96
6	17.81
5	17.76
4	17.75
3	17.69
2	17.61
1	17.56

Note: Refer to Figure 3 for the location of cross sections

Results showed in Table 4 show that most of the area of the proposed development site will be inundated by 100 year ARI flood levels within the tributary.

For the proposed development, the tributary crossing the eastern corner of the site will be replaced with a man made channel to confine the flow and consequently reduce the inundation area (refer to Figure 4 for channel location). The site will also be filled to match the 100 year inundation level to provide flood immunity for the dwellings to be located on site. Flood levels for the proposed post development conditions of the site are also shown in Table 4.

A 2 metre deep trapezoidal channel with batter slopes of 1v:4h will be adopted. The channel base is 7 metres wide and the channel top 23 metres wide. The proposed channel has a bed slope of 0.2 percent. The channel invert level at the downstream end of the channel is 16.15 metres. A 30 metre wide transition covering the first 15 metres of the channel (just downstream of Middle Road) will direct runoff into the main 23 metre wide channel. A roughness of 0.05 (corresponding to grass cover with limited shrubs) was applied to all sections within the model.

The resulting flood levels for the post development scenario of the site (including the proposed channel) are listed in Table 5.

Table 5 Tributary Flood Levels –Developed (with channel) Case

Cross section	Invert level (m AHD)	100 Year ARI Flood Level Developed case (with channel) (m AHD)	Freeboard (mm)
11 (crest of Middle Road)	17.67	18.54	--
10	16.75	18.49	280
9	16.69	18.44	300
8	16.61	18.36	300
7	16.54	18.28	300
6	16.46	18.20	310
5	16.38	18.12	320
4	16.3	18.03	320
3	16.23	17.94	340
2	16.15	17.85	350

Note: Refer to Figure 3 for the location of cross sections

Based on results presented in Table 5 it can be seen that the adopted channel and fill configuration contains the 100 year flood without breaking the banks of the channel and a minimum of 300 mm freeboard is achieved along the entire length of the channel. A sketch of the proposed fill and excavation scenario of the site is shown in Figure 4. It should be noted that the analysis assumed that site will be filled to above the 100 year level.

5. CONCLUSION

A flood study has been conducted to determine the flood levels applicable to the 100 year ARI storm event for the development on Lot 2 on RP615695 and Lot 80 on RP604102, Gracemere, Shire of Fitzroy.

Based on calculated flood levels, it can be concluded that most of the site areas are prone to flooding in occurrence of the 100 year ARI storm event. The proposed developments will need to undertake filling and compensatory works to improve flooding conditions within the sites.

To reduce the extent of inundation within the sites, it is proposed to undertake fill and cut compensatory works along the areas adjacent to the banks of Gracemere creek and to replace the existing tributary crossing the eastern corner of the site with a man made channel.

Hydraulic modelling with HEC-RAS of proposed works on both creeks traversing the site has shown that:

- **Gracemere Creek**

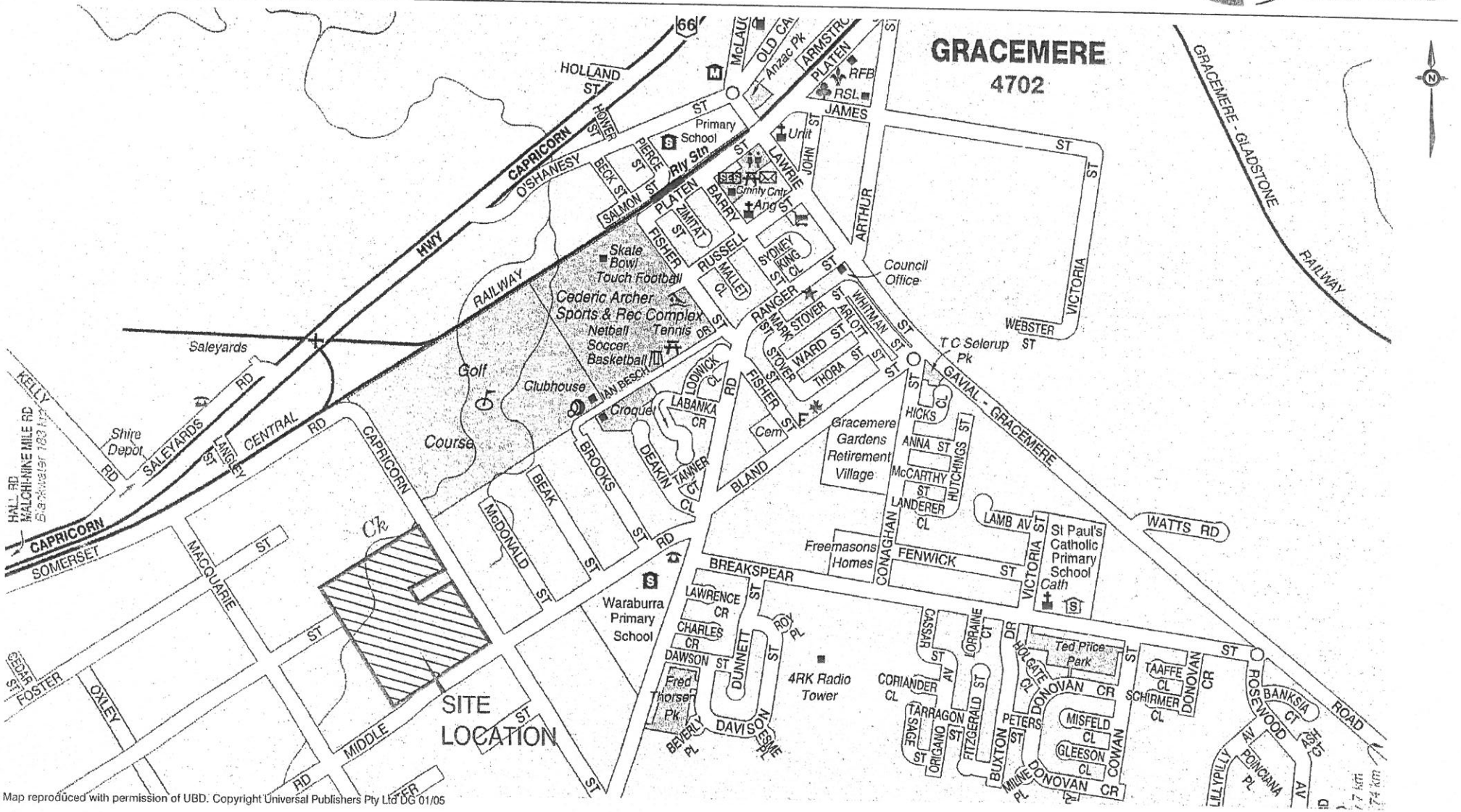
The flood levels corresponding to the developed conditions of the central part of the site (fill and excavate scenario) are lower than those obtained under the existing conditions. This is due to the improved channel capacity and conveyance achieved with the excavated works. To provide flood immunity for the site in the 100 year ARI flood event, a 75 metre wide area within the site on the south-eastern side of Gracemere Creek (between cross sections 5 and 13) is proposed to be excavated to a level of 17.0 mAHD. Similarly, the area adjacent to the western bank of the creek (between cross sections 13 and 14) is proposed to be excavated to a level of 16.5 mAHD. Finally, the area adjacent to the eastern bank of the creek between cross sections 16 and 19 is proposed to be excavated to a level of 16.7 mAHD. The remaining areas of both sites need to be filled to above the 100 year level.

- **Tributary**

The adopted channel and fill configuration contains the 100 year flood without breaking the banks of the channel and a minimum of 300 mm freeboard is achieved along the entire length of the channel. It can be noted that the analysis assumed that the eastern corner of Lot 2 on RP615695 will be filled to above the 100 year level.

FIGURES

Cardno



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N.T.S.

FIGURE 1
SITE LOCALITY PLAN

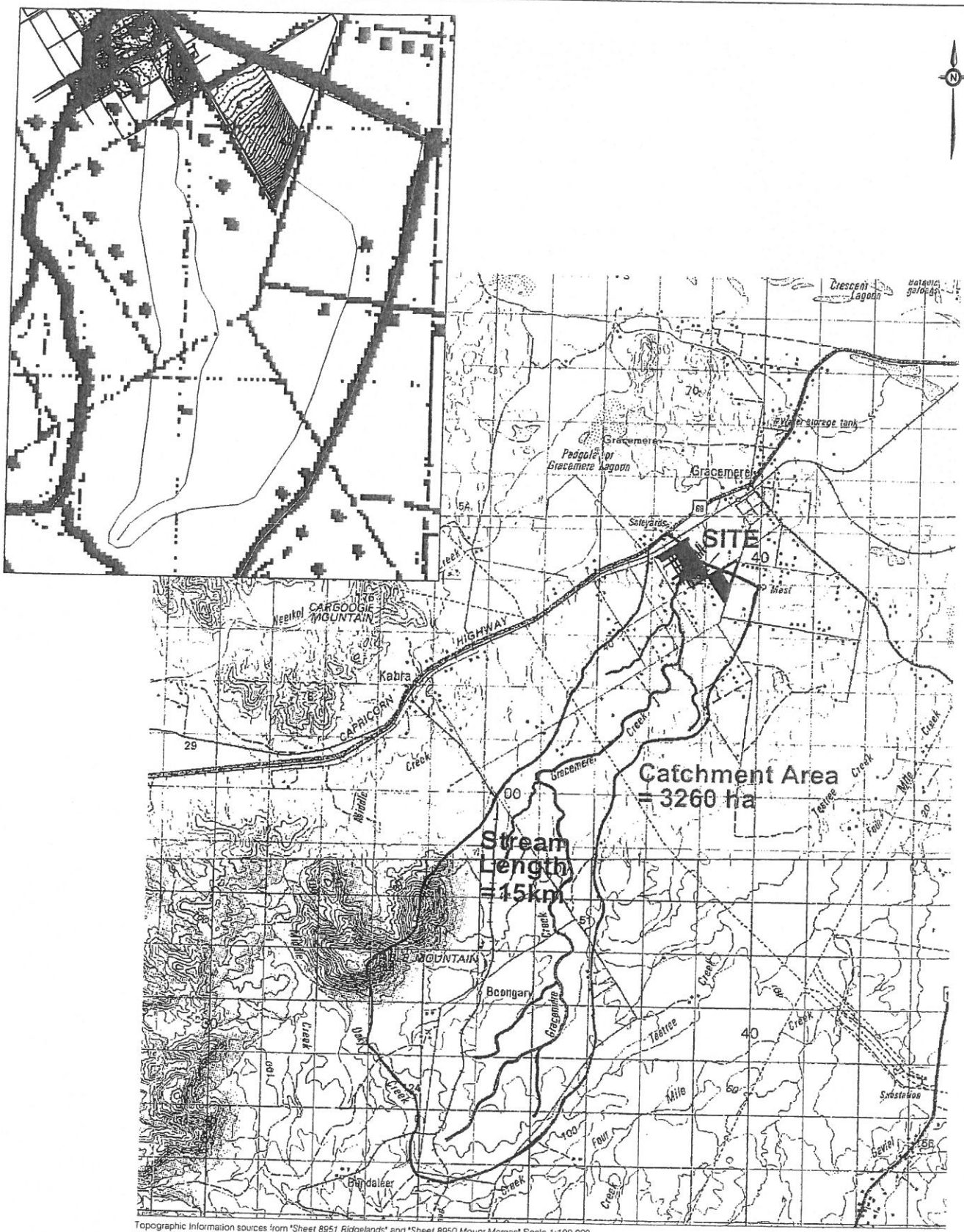
Rev: Orig Date: 25 January 2008

Project No.: R1039/06

Czislowski Holdings

CAD FILE: J:\R1039-06\acad\Flood Study\Figure 1 - Site Locality Plan.dwg

PRINT DATE: 04 February, 2008 - 10:05am



Topographic Information sources from *'Sheet 8951 Ridgelands'* and *'Sheet 8950 Mount Morgan'* Scale 1:100 000, Division of National Mapping (NATMAP), 1983.

Scale 1:100 000 (A4)

FIGURE 2
CATCHMENT PLAN

Rev: Orig Date: 25 January 2008

Project No.: R1039/06

Czislowski Holdings

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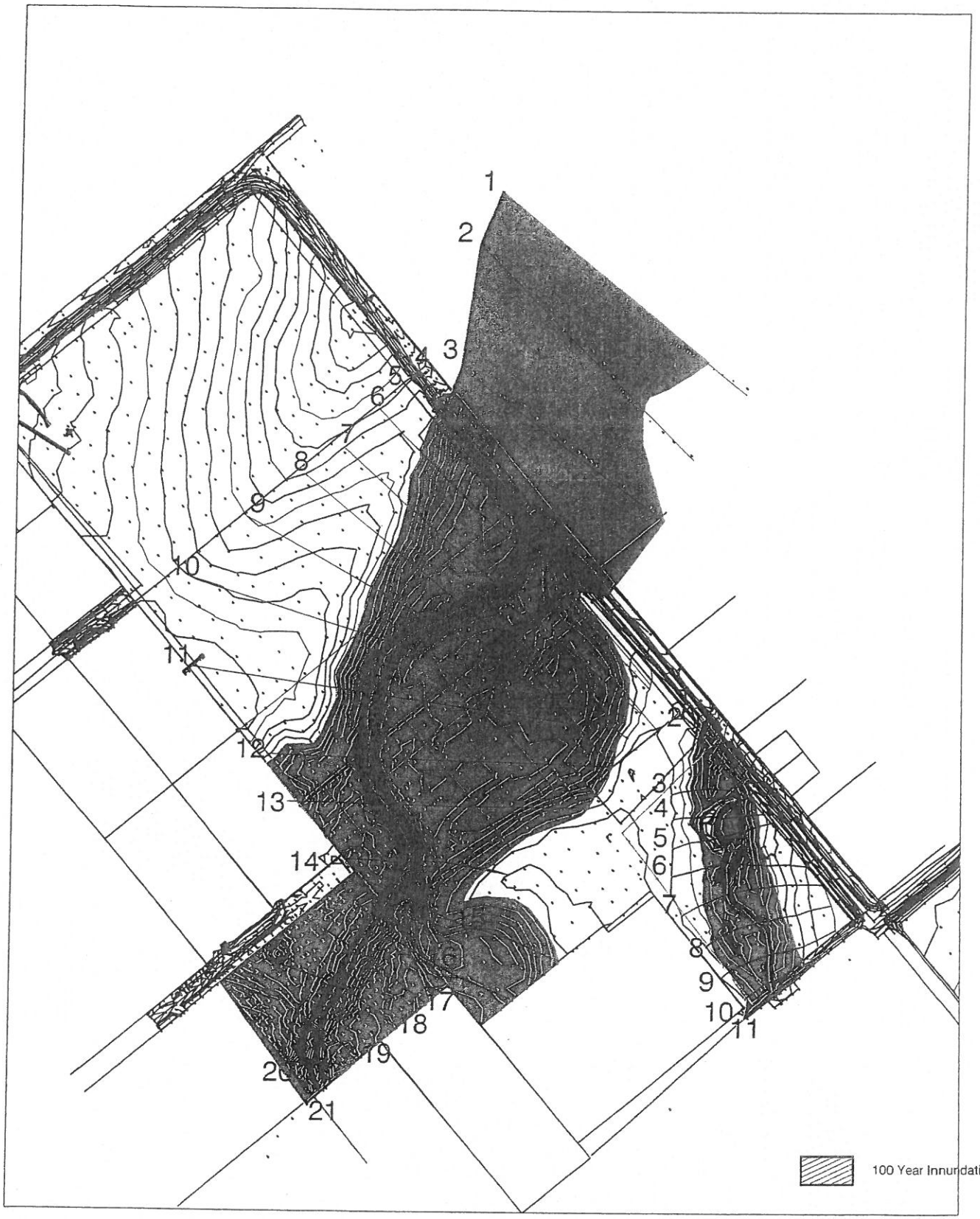
XREFs:

PRINT DATE: 04 February, 2008 - 10:06am



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Scale 1:3500 (A3)

FIGURE 3
100 YEAR INNUNDATION

Project No.: R1039/06

PRINT DATE: 04 February, 2009 - 10:07am

Rev: Orig. Date: 25 January 2008

Czislowski Holdings

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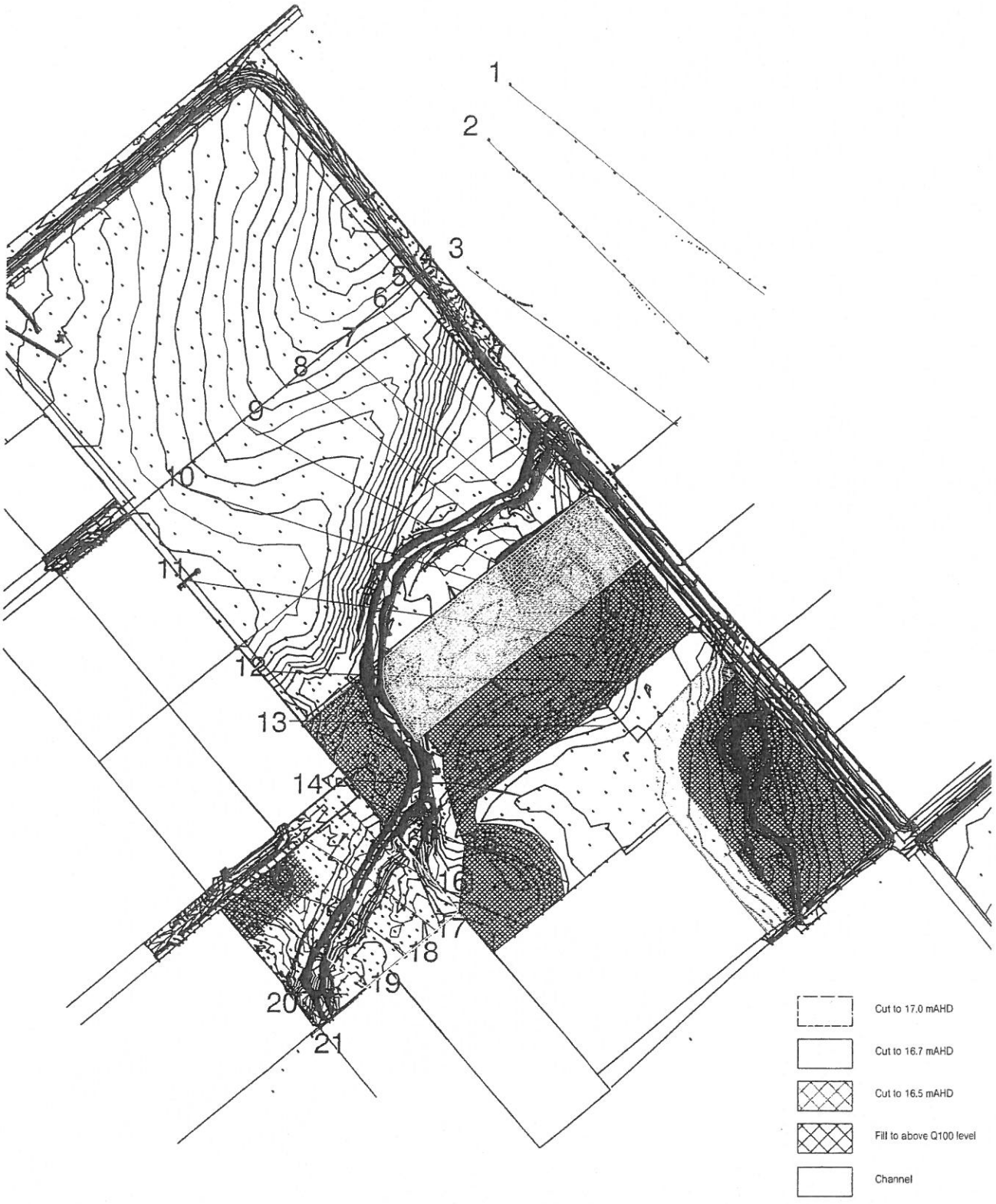

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FIGURE 4

PROPOSED FILL AND EXCAVATION WORKS

Rev: Orig. Date: 27 November 2009

Project No.: R1039/06

Czislowski Holdings

CAD FILE: J:\R1039-06\cad\Flood Study\Figure 4 - Proposed fill and excavation works_v1.dwg
XREFs:

PRINT DATE: 27 November, 2009 - 2:15pm

STAGE 1

SHEET 1 OF 2 SHEETS

IMPORTANT NOTE

This plan was prepared for Czislowski Holdings for the sole purpose of accompanying a reconfiguration of a lot application to the Fitzroy Shire Council and should not be used for any other purpose. The number of lots, areas and dimensions are subject to survey and approval by all relevant authorities. This plan should not be used for any financial dealings involving the land. This note is an integral part of this plan.

ROCKHAMPTON REGIONAL COUNCIL
AMENDED PLANS APPROVED
27 April 2016
DATE

These plans are approved subject to the current conditions of approval associated with

Development Permit No. D/230-2009 Dated 31/8/10

Vert Datum : AHD
Hor.Datum : Cadastral RP615695
Contour interval : 500mm, 1m index
Co-Ord. System : Assumed

INDUSTRIAL ESTATE
LOT 1 ON RP615695
LOT 82 ON RP604012
STAGES land 3–5

CAPRICORN SURVEY GROUP
ABN 46 082 818 818
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Facsimile (07) 4922 2745
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RICHARD FORD
AUTHORISED FOR ISSUE
DATE 01/03/2016

CZISLOWSKI HOLDINGS PTY LTD
21 LOT INDUSTRIAL SUBDIVISION
CAPRICORN STREET
GRACEMERE

SCALE 1:1250 AT A2 SIZE

DRAWING NUMBER 4663A-PRO REVISION D

DRAINAGE EASEMENT

DRAINAGE RESERVE

CAPRICORN STREET

DOUGLAS STREET

MIDDLE ROAD

42 — 8.01 ha — 3.82 ha — 41 — 1.88 ha — 7120 m² — 2 RP610518

79 RP604012 — 78 RP604012 — 81 RP604012 — 5 SP223829 — 2 SP163917 — 1 RP613228 — 2 RP613228 — 1 RP618098 — 2 RP618098 — 3 RP618098 — 4 RP618098 — 3 RP612534

STAGE 1	Subdivision 2 Lots (Lots 41&42 and Drainage Reserves)
STAGE 3	Subdivision 4 Lots (Lots 12–15)
STAGE 4	Subdivision 11 Lots (Lots 16–20,28–31)
STAGE 5	Subdivision 7 Lots (Lots 21–27)

Scale 1:1250 – Lengths are in Metres.

10 0 20 40 60 80 100 120 140

STAGES 3–5

SHEET 2 OF 2 SHEETS

ROCKHAMPTON REGIONAL COUNCIL
AMENDED PLANS APPROVED
27 April 2016
DATE

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Development Permit No D/230-2009 Dated 31/8/10

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Vert Datum : AHD
Hor.Datum : Cadastral RP615695
Contour Interval : 500mm, 1m Index
Co-Ord. System : Assumed

INDUSTRIAL ESTATE
LOT 6 ON SP223829
STAGES 1 and 3–5

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RICHARD FORD
AUTHORISED FOR ISSUE DATE 01/03/2016

CZISLOWSKI HOLDINGS PTY LTD
21 LOT INDUSTRIAL SUBDIVISION
CAPRICORN STREET
GRACEMERE

SCALE 1:1250 AT A2 SIZE

DRAWING NUMBER 4663A-PR0 REVISION D

CAPRICORN STREET
ROAD B (20m Road Reserve)
ROAD C (20m Road Reserve)
DRAINAGE RESERVE
DRAINAGE EASEMENT 'A' & 'B' on LOT 42
DOUGLAS STREET
MIDDLE ROAD
12 m² 1730
13 m² 2040
14 m² 2050
15 m² 2210
16 m² 1200
17 m² 1200
18 m² 1200
19 m² 1460
20 m² 1920
21 2170 m²
22 3.98 ha
23 m² 1300
24 m² 1320
25 m² 1370
26 m² 1370
27 m² 1380
28 m² 1480
29 m² 1640
30 m² 1190
31 m² 1150
41
9 P4010
79 RP604012
78 RP604012
81 RP604012
5 SP223829
2 SP163917
2 RP613228
1 RP613228
2 RP618098
1 RP618098
3 RP618098
4 RP618098
3 RP612534
2 RP610518

Scale 1:1250 – Lengths are in Metres.
10 0 20 40 60 80 100 120 140

STAGE 1	Subdivision 2 Lots (Lots 41&42 and Drainage Reserves)
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