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Project: Rockhampton Local Catchments Flood Study

Thozets Creek Hydrologic and Hydraulic Modelling Report

Reference: 231721

Prepared for: Rockhampton Regional Council

Revision: 2

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1 Introduction

1.1 Study background

The Fitzroy River Flood Study provided Rockhampton Regional Council with a suite of Fitzroy River related flood information for use in development and emergency planning. The flood study report also recommended that Council's flood database should be further developed to include local catchment flood information. The Local Creeks Catchment Flood Study was undertaken to address this recommendation and provide flood information for many of Rockhampton's developed areas on the north-eastern side of the Fitzroy River.

The Local Creeks Catchment Flood Study also addresses recommendation 2.4 of the Queensland Floods Commission of Inquiry Final Report which states that *"a recent flood study should be available for use in floodplain management for every urban area in Queensland. Where no recent study exists, one should be initiated."* It is also the first step in addressing recommendation 2.12, that *"Councils in floodplain areas should, resources allowing, develop comprehensive floodplain management plans that accord as closely as practicable with best practice principles."*

The outputs from the Local Creek Catchments Flood Study provide input to Council's new planning scheme and will assist with development planning. The outputs will also be used to assist with Council's emergency planning and provide an understanding of flood affected areas under a range of flood events.

1.2 Study area

The six local catchments identified for this study are located on the north-eastern side of the Fitzroy River and all discharge directly to the river. The location of the Local Creek Catchments study area and the extents of the catchments contributing to flows in this area are presented in Figure 2 and Figure 3. These catchments all contain existing development or are earmarked for future development. This includes:

- Ramsay Creek
- Limestone Creek
- Splitters Creek
- Moores Creek
- Frenchmans Creek
- Thozets Creek

This report focuses upon the Thozets Creek catchment.

1.3 Thozets Creek model area

The Thozets Creek catchment consists of largely residential development in the middle and lower reaches and undeveloped land in the upper reaches. Floodwaters breakout from Frenchmans Creek into Thozets Creek in the lower reaches, therefore the hydraulic characteristics of these two catchments cannot be considered in isolation. The lower reaches are also affected by Fitzroy River flooding. Two XP-RAFTS hydrologic models were prepared covering the catchments to Lakes Creek Road. A single TUFLOW hydraulic model was prepared from Cascade Close at the upstream end on Frenchmans Creek and the Holt Street road reserve at the upstream end on Thozets Creek to Lakes Creek Road and the railway at the downstream end.

1.4 Study objectives

The key objectives of the study are:

- Development of comprehensive computer-based hydrologic and hydraulic models of the study area and its contributing catchments
- Calibration of the models to available data from the 2013 Australia Day Long Weekend flood event
- Determination and documentation of flood levels, inundation extents, velocities, depths and hazards across the study area for the nominated design events
- Identification of critical infrastructure and emergency facilities for which safe operation may be disrupted by flood events
- Identification of flood events that may isolate parts of the community and assessment of periods of isolation and emergency evacuation routes consistent with the Queensland Evacuation Guidelines (August 2011)
- Preparation of detailed maps and GIS layers for inclusion in Council’s databases
- Detailed reporting of all elements of the project and its outcomes
- Input to Council’s emergency and development planning information databases

The work undertaken to achieve the above objectives is documented in the following report.

2 Study data

The data collected for use in this study is detailed in the following sections.

2.1 Previous studies

No previous study data was available.

2.2 Topographic data

Rockhampton Regional Council (RRC) and the Department of Environment and Resource Management (DERM) commissioned LiDAR survey of a large part of the Gladstone and Rockhampton region which was flown in June 2009. This data was provided to Aurecon as 1 m grid Digital Elevation Model (DEM) (xyz) tiles over the eastern part of the Mt Archer National Park area. This data has a vertical accuracy of ± 0.15 m and a horizontal accuracy of ± 0.30 m.

SunWater commissioned LiDAR survey of a large portion of the lower Fitzroy River catchment in 2010. This data was provided to Aurecon as 1 m grid DEM (xyz) tiles over almost the entire study area.

The extent of each dataset and the areas over which each dataset was adopted is presented in Figure 4. The Sunwater data was adopted where it was available, with the RRC/DERM data used in all other areas.

The raw LiDAR data was converted into a GIS-based DEM using the following process:

- Both raw data sets were triangulated using the 12D civil design software and exported in a GIS compatible format
- The 12D exports were then imported into the GIS MapInfo package as DEMs
- Both DEMs were then spliced together to create an overall DEM of the local creek catchments

2.3 Aerial photography

Two aerial images were provided to cover the catchments and study area. A detailed 10 cm aerial image (captured in June 2010) was provided covering almost the entire hydraulic modelling area and a 50 cm aerial image (captured in July/September 2010) was provided covering the entire catchment area. This aerial photography was used to identify and confirm topographic and vegetative characteristics of the study area.

2.4 Historical flood data

Historical data from the Australia Day Long Weekend 2013 flood event was collected for use in the model calibration process. This data included:

- Pluviograph (1 minute interval) rainfall data from the Rockhampton Aero rainfall gauge
- Pluviograph (30 minute interval) rainfall data recorded by a property owner on Serocold Street in the Moores Creek catchment
- Daily rainfall totals for a number of other rainfall gauges in the region
- Three GIS survey datasets of flood observations during the event
  - Doorknock survey information – Information gathered after the event via a doorknock survey of residents with some level of exposure to the flood event. The information consists primarily of residents observations, most of which give a description of where the flood waters reached on either the residents own property or at a nearby location
  - Extra survey points – Additional information provided by residents either from memory or photographs
  - Event pickups – Points surveyed at either debris edges or debris top elevations
- Photographs showing flood levels and extents during the event

2.5 Hydraulic structure data

Available Design or As-Constructed data for hydraulic structures beneath the Central Railway Line and state controlled roads was sourced from Queensland Rail/QR National and the Department of Transport and Main Roads (TMR). Information for Council owned structures was sourced from Council in the form of GIS information from Council's GIS database.

The structure data was supplemented with measurements collected during the site visit, as discussed in Section 2.7.

2.6 GIS data

Council provided digital cadastral boundary data in GIS format for use in the study. GIS information for major roadways, emergency facilities and other critical infrastructure was not provided for this study; therefore the information provided for the Fitzroy River Flood study was used. This information was previously provided to Aurecon on 17 May 2010.

These datasets were used to help interrogate model outputs and were also used in the flood mapping phase of the project.

2.7 Site inspection

A site inspection was carried out on 28 and 29 August 2012 and was used to capture and check structure details, hydraulic roughness parameters and catchment details for input to the modelling. Structure details for many of the hydraulic structures were measured during this site visit.

3 Hydrologic model development

A RAFTS hydrologic model was developed for the Thozets Creek catchment. This software is a runoff-routing model which is used to simulate catchment and channel routing behaviour in response to rainfall. It has been developed for use and application in both urban and rural catchments and includes the ability to model natural and artificial storages as well as channel and river storage throughout the catchment. The model accounts for catchment and channel characteristics including slopes, impervious areas and roughnesses.

The following section discusses the model development process, rainfall inputs and parameters. Figure 5 presents the hydrologic model layout. The adopted model parameters are provided in Appendix B.

3.1 Model layout

3.1.1 Sub-catchment delineation and slope

Sub-catchments were defined using a GIS interface based on the available topographic data discussed in Section 2.2. Twelve sub-catchments were delineated within the Thozets Creek catchment, with the areas of each sub-catchment being derived from interrogation of the GIS discretisation.

Catchment slopes were also determined based on the available topographic data with the equal area slope method being used to calculate the adopted values.

3.1.2 Impervious area and PerN

The land use within the catchment is a mixture of rural and various types of development (eg residential, industrial). Areas were assigned a percentage impervious related to their land use type. The overall percentage impervious for each sub-catchment was calculated based upon the proportional contribution of rural, residential, industrial and vegetated areas.

Similar to the impervious percentages, the RAFTS roughness parameters (PerN) were assigned a value relating to their land use. Residential areas were assigned a lower PerN coefficient than rural areas to reflect smoother ground conditions in line with industry standard values. The overall value for each sub-catchment was calculated based on the proportional contribution of both developed and undeveloped areas.

3.1.3 Catchment links

The catchment flowpath links were defined using lag links. Lag times were calculated using the slope and length of the flowpath, with adopted average stream velocities of 2.5 m/s, 1.7 m/s and 1.0 m/s chosen for the upper, mid and lower catchments respectively. A coarse hydraulic model was setup to cross-check these velocities which were also confirmed with additional Manning's calculations.

The selected values were further verified by calculating 'peak-to-peak' travel times looking at the propagation of the discharge hydrographs through the hydraulic model. The celerity (speed) of the flood wave was established for varying topographic conditions and was observed to correlate well to the adopted stream velocities.

3.2 Rainfall data

A summary of the rainfall data used for the different events is provided in Sections 3.2.1 to 3.2.5.

3.2.1 Calibration event

Initially, a comparison of the daily rainfall totals across a number of rainfall gauges in the region was carried out. These totals are presented in Table 1 and show that in all locations the heaviest rain fell on the 25 January 2013; however the amount of rainfall varied across the region.

Table 1 | Daily rainfall totals across the region (mm)

Date	Rocky Aero	Broadmeadows	Hedlow Airfield	Belmont CSIRO	Serocold St
24/1/13	118	161	108	40	183
25/1/13	349	478	205	252	449
26/1/13	23.2	130	No Data	101	68

From the above analysis it was decided that the Serocold Street rainfall data would be the most representative data for use in the calibration process. It is the most central to the calibration area and shows similar rainfall patterns to the nearby gauges, therefore it is considered reliable. This data was applied to the RAFTS model to produce calibration event hydrographs for input to the hydraulic model.

No initial rainfall losses were applied in the calibration event, as there was rainfall which occurred prior to the event timing which has been analysed above. Continuing losses were applied as discussed in Section 3.2.5.

3.2.2 Design events

The RAFTS model was run for the 2, 5, 10, 20, 50, and 100 year ARI events using standard Australian Rainfall and Runoff temporal patterns and IFD parameters. The 15, 30, 45, 60, 90, 120, 180, 270 and 360 minute events were simulated. Rainfall intensities for the modelled events are presented in Table 2. These intensities are based upon a mid-catchment IFD curve which averages the higher upper catchment intensities with the lower intensities from the downstream end of the catchment.

Table 2 | Design event rainfall intensities

Event Duration (mins)	Rainfall Intensities (mm/h)					
	2yr ARI	5yr ARI	10yr ARI	20yr ARI	50yr ARI	100yr ARI
15	89.8	117.3	133.4	155.9	186.5	210.7
30	64.6	84.1	95.4	111.3	132.9	150.0
45	52.3	68.0	77.0	89.7	107.0	120.6
60	44.8	58.0	65.7	76.5	91.1	102.7
90	34.8	45.2	51.3	59.8	71.3	80.4
120	29.0	37.8	42.9	50.0	59.7	67.4
180	22.4	29.0	33.2	38.8	46.4	52.4
270	17.2	22.5	25.7	30.0	36.0	40.7
360	14.3	18.8	21.4	25.0	30.0	34.0

3.2.3 Extreme events

The hydrologic analysis considered three extreme events, being the 200 and 500 year ARI events and the Probable Maximum Precipitation (PMP) event. The 15, 30, 45, 60, 90, 120, 180, 270 and 360 minute storms were simulated for the 200 and 500 year ARI events and the PMP analysis also included the 150, 240 and 300 minute storms (as per standard PMP methodology).

The 200 and 500 year ARI design rainfall intensities were calculated using both the AR&R and CRC-FORGE approaches. It was found that the rainfall intensities calculated using the CRC-FORGE approach were marginally higher than those determined using the AR&R guidelines (approximately +9% to +13%). Accordingly the CRC_FORGE rainfall intensities were adopted for use in the RAFTS hydrologic model. Table 3 summarises the rainfall intensities for the 200 and 500 year ARI storm events.

The Probable Maximum Precipitation was determined using the Generalised Short Duration Method (GSDM). This approach is outlined in *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method* (Bureau of Meteorology, 2003). This approach is suitable for the Thozets Creek catchment as it is less than 1,000 km^2 in total area and its critical storm duration is less than six hours. Table 3 shows the PMP rainfall intensities for the Thozets Creek catchment. These intensities are specific to this catchment as they are directly related to the catchment area.

Table 3 | Extreme event rainfall intensities

Event Duration (mins)	Rainfall Intensities (mm/h)		
	200yr ARI	500yr ARI	PMP
15	271.5	317.5	800
30	193.4	226.1	580
45	155.1	180.7	493
60	132.5	154.9	440
90	103.2	120.4	373
120	86.1	100.7	325
150	-	-	288
180	67.2	78.6	263

Event Duration (mins)	Rainfall Intensities (mm/h)		
	200yr ARI	500yr ARI	PMP
240	-	-	225
270	52.0	60.8	-
300	-	-	198
360	43.5	50.8	175

3.2.4 Climate change events

Climate change scenarios were tested within the Thozets Creek hydrologic model as per the recommendations outlined in:

- *Increasing Queensland's resilience to inland flooding in a changing climate: Final report on the Inland Flooding Study* (Office of Climate Change – Queensland Department of Environment and Resource Management, Queensland Department of Infrastructure and Planning and Local Government Association of Queensland, 2010) which predicts a 5% increase in rainfall intensity for each degree of global warming and an increase in temperatures of 4 degrees Celsius by 2100 (hence an increase in rainfall intensities of +20% by 2100)
- *Guidelines for Preparing a Climate Change Impact Statement (CCIS)* (Queensland Office of Climate Change, Environmental Protection Agency, 2008) which predict an increase in cyclonic rainfall intensity of +20 to +30% by 2050

Accordingly, the effects of climate change were assessed by increasing the 100, 200 and 500 year ARI rainfall intensities (as shown in Table 2 and Table 3) in the hydrologic model by +20% and +30%. The discharge hydrographs for both scenarios were then incorporated into the hydraulic model.

3.2.5 Rainfall losses

The initial and continuing loss method was used to represent rainfall losses in the design, extreme and climate change events. The adopted loss values for pervious and impervious areas are presented in Table 4. Based on the impervious percentage of each sub-catchment, a weighted average was calculated to provide an initial and continuing loss specific to each sub-catchment.

Table 4 | Adopted loss values for 2 year and 5 year ARI events

	Initial Loss* (mm)	Continuing Loss (mm/hr)
2 and 5 year ARI – Pervious Areas	15	2.5
10 year ARI – Pervious Areas	10	2.5
20 year ARI – Pervious Areas	5	2.5
>20 year ARI – Pervious Areas	0	2.5
All events – Impervious Areas	0	0

3.3 Verification

As no calibration data was available to confirm the results of the hydrologic model separately to those of the hydraulic model, the Rational Method was used to cross-check the outputs of the RAFTS hydrologic model and ensure the design discharges were of the correct order of magnitude for the 5 and 100 year ARI events. It is acknowledged that the Rational Method offers a less robust estimate of the design discharge and should not be relied upon as a definitive approach. The Rational Method is only recommended for use in catchments with areas of up to 500 ha for urban catchments and 2500 ha for rural catchments. It is empirical in nature and has been found to be unreliable in some catchment shapes, such as long thin catchments.

In the upcoming release of Australian Rainfall and Runoff the Rational Method will no longer be the recommended approach for determining discharges in ungauged catchments; therefore it was only used to provide an order of magnitude comparison.

In addition to Rational Method checks, verification of the assumed flood velocities used to calculate the RAFTS lag times was carried out using a coarse hydraulic model.

3.4 Sensitivity analysis

A sensitivity analysis of three key hydrologic parameters/coefficients was conducted to establish the effect that these parameters/coefficients have on the predicted peak discharge for the 5 and 100 year ARI events. This involved varying:

- Bx, the storage coefficient multiplication factor by ±10%
- PerN, the subcatchment roughness coefficient by ±20%
- The adopted channel link velocities by ±20%

4 Hydraulic model development

In order to compute and predict the hydraulic behaviour of Thozets Creek a hydraulic model was developed as part of the flood study. The TUFLOW two-dimensional hydraulic modelling package was used for this assessment. TUFLOW models free surface flow situations in which stratification can be neglected. TUFLOW simulates water level variations and flows in response to a variety of forcing functions in floodplains, lakes, estuaries, bays and coastal areas. The water levels and flows are resolved on a rectangular grid covering the area of interest when provided with bathymetry (topography), bed resistance coefficients, wind field, hydrographic boundary conditions etc.

TUFLOW also includes the capacity to incorporate one-dimensional elements which are hydraulically linked to the two-dimensional floodplain, such as culverts. The one-dimensional modelling package within TUFLOW is called ESTRY.

The following sections discuss the model development process and parameterisation. The model layout is presented in Figure 6.

4.1 Model grid

A 5 m grid spacing was adopted for the following reasons:

- A 5 m grid provided detailed resolution throughout the study area and sufficient detail to represent key features such as roadways and drainage channels
- A 5 m grid provided a reasonable balance between resolution and model run times
- A 5 m grid was consistent with modelling undertaken for other local catchments within the Rockhampton Region
- Smaller grid sizes would have compromised the accuracy of the models as the shallow water equations on which the hydraulic model is based are no longer valid once the depth of the water is greater than the cell size

4.2 Topography

A 2 m grid Digital Terrain Model (DTM) was developed from the LiDAR data described in Section 2.2. The model topographies were based upon this DTM. Topographic modifiers were included where necessary to ensure a continuous drainage path occurred and LiDAR triangulations across the channel were removed.

4.3 Land use type

The aerial photography was used to define the land use type across the model, as presented in Figure 7. The Manning's roughness values presented in Table 5 were applied for the specified land use types.

Table 5 | Manning's n roughness values

Land Use Type	Manning's n
High Density Residential	0.150
Low Density Residential	0.090
Industrial	0.150
Medium Density Vegetation	0.070
Low Density Vegetation	0.050
Channel	0.045
Rough Channel	0.065
Riparian Corridor	0.070
Maintained Grass	0.030
Road Reserve	0.030

4.4 Hydraulic structures

The hydraulic structure details were sourced from available data. The modelled culverts and their details are presented in Table 6 and the modelled bridges and their associated details are presented in Table 6. The structure locations are presented on the model layout plan (Figure 6).

Table 6 | Modelled culvert structures

Culvert ID	Culvert Location	Dimensions (mm)	Upstream Invert Level (m AHD)	Downstream Invert Level (m AHD)
THO_ROC_01	Rockina Road	2 / 900 RCP	23.90	23.75
THO_ROC_02	Rockina Road	3/ 3100*1200 RCBC	12.03	11.95
THO_XXX_01		2 / 900 RCP	19.30	19.35
THO_PAT_01	Patterson Avenue	3 / 600 RCP	16.10	15.98
THO_LAK_01	Lakes Creek Road	3 / 1500 RCP	2.82	2.73
THO_LAK_02	Thozets Creek Road	3 / 1500 RCP	3.19	2.99
THO_LAK_03	Lakes Creek Road	3 / 1500 RCP	2.62	2.46

Table 7 | Modelled bridge structures

Bridge ID	Bridge Location	Dimensions (m)
THO_YEP_01	Yeppoon Branch Railway	15/5.0m Span Bridge

4.5 Boundary conditions

The RAFTS model outputs were applied as inflows into the TUFLOW model. Total inflows from catchments upstream of the hydraulic model extents were applied at the upstream model boundary and local inflows from areas within the TUFLOW model were applied throughout the model.

The Mean High Water Spring level (2.66 m AHD) was applied as the downstream boundary condition for the design event simulations of 2 through 20 year ARI events.

The Highest Astronomical Tide level (3.9 m AHD) was applied as the downstream boundary condition for the design event simulations greater than 20 year ARI event.

The Highest Astronomical Tide level plus 0.8 m (4.7 m AHD) was applied as the downstream boundary condition for the climate change design event simulations.

4.6 Calibration, design and extreme event modelling

The same model was used for the calibration, design and extreme events.

4.7 Sensitivity analysis

Sensitivity analysis was undertaken to assess the effect that the following key parameters have on the 5 and 100 year ARI model predictions:

- Manning's roughness (±10%)
- Structure blockage (50 & 100%)
- Tailwater level (Fitzroy River 5yr ARI level)

5 Calibration and verification results

5.1 Hydrologic model calibration

No calibration data exists to calibrate the hydrologic model. There is anecdotal evidence which suggests that the highest peak of the 2013 Australia Day Long Weekend event occurred on 25 January. The RAFTS model results for this event were reviewed and showed that the model with a Storage Coefficient Multiplication Factor (Bx) = 1 produced the highest peak on 24 January. With Bx = 1.25 the highest peak occurred on 25 January, which more closely matches anecdotal evidence from the event; therefore a value of Bx = 1.25 was adopted for the modelling.

5.2 Hydrologic model verification

5.2.1 Rational Method comparisons

The Rational Method was used to check the predicted peak discharges from the RAFTS model at a number of key locations (typically upstream boundary locations). This was carried out for the 5 and 100 year ARI events only.

For each catchment the time of concentration was modelled using the Bransby Williams equation, the Modified Friends equation or Urban catchment methods. An appropriate method was selected based upon the predominant land use type in the catchment. Bransby Williams and Modified Friends equation are both used in rural catchments, with the Modified Friends equation taking better account of the channel characteristics.

Three locations were selected for Rational Method comparisons within the Thozets Creek catchment. These catchment locations can be found on Figure 5. Location THO-7 represents a large rural catchment. DUM-2 is the entire Thozets Creek Catchment. THO-12 represents the downstream subcatchment within the Little Thozets Creek catchment. Table 8 presents the Rational Method parameters and Table 9 presents the results.

Table 9 shows that the Rational Method is both over and under-predicting the peak discharges when compared to the RAFTS model predictions. Given the known limitations with the Rational Method, this was considered an acceptable verification of the hydrologic model predictions.

Table 8 | Rational Method parameters

Location	Catchment Area (ha)	Stream Length (km)	Stream Slope (%)	Adopted Method	Time of Concentration (mins)	Equivalent Velocity (m/s)
THO-7	245	3.4	7.1	Modified Friends	38	1.5
DUM-2 (THO-11+THO-12)	445	5.3	3.6	Modified Friends	81	1.1
THO-12	58	1.4	2.3	Urban	9	1.5

Table 9 | Rational Method results

Location	5yr ARI Modelled Peak Discharge (m^3/s)	5yr ARI Rational Method Peak Discharge (m^3/s)	5yr ARI Difference (%)	100yr ARI Modelled Peak Discharge (m^3/s)	100yr ARI Rational Method Peak Discharge (m^3/s)	100yr ARI Difference (%)
THO-7	25	34	25	66	76	13
DUM-2 (THO-11+THO-12)	40	41	1	90	92	2
THO-12	22	18	-22	43	41	-6

5.2.2 Stream velocity checks

The RAFTS model catchment flowpath links were defined using lag links. Lag times were calculated using the slope and length of the flowpath, with adopted average stream velocities of 2.5 m/s, 1.7 m/s and 1.0 m/s chosen for the upper, mid and lower catchments respectively.

A coarse hydraulic model was setup to cross-check these velocities. The selected values were verified by calculating travel times of the discharge hydrographs through the hydraulic model. The speed of the flood wave propagation was established for varying topographic conditions and was observed to correlate well to the adopted stream velocities.

5.3 Calibration dataset

A single calibration dataset was developed from the GIS data identified in Section 2.4. Varying levels of reliability and accuracy were assigned to the different types of data. Where the data contained a location and elevation, a smaller tolerance level was assigned. Where the data contained observations only, the observation had to be interpreted and a larger tolerance level was assigned. The adopted calibration tolerances are presented in Table 10. Whilst these general tolerances were adopted, there are numerous locations where two nearby calibration points give conflicting data, therefore general trends in the calibration were relied upon more heavily than the calibration at individual locations.

Table 10 | Adopted calibration dataset tolerances

Data Source	Adopted Tolerance	Explanation of Reliability and Accuracy	Example
Debris Edge with elevation	+/-0.3m	High level of accuracy for data point	-
Debris Top Centre or water mark with elevation	+0.3m/-0.5m	Same as Debris Edge except momentum can push debris higher onto an obstruction, therefore the elevation can be overestimated	-
Elevation interpreted from an observation at a specified location	+/-0.5m	Interpretation of DEM elevation and potential water surface elevation was required at the specified location	Highest point came to fence line at the back of the house (back pool fence)
Elevation interpreted from an observation within a general area	+/-0.7m	Same as above except the DEM elevation within a region can vary and therefore an increased level of tolerance was adopted	Water was nowhere near house but at front and rear of property

5.4 Hydraulic model calibration

5.4.1 Calibration process

In order to review the accuracy of the modelling outputs for Thozets Creek, the RAFTS model flows from the 2013 Australia Day Long Weekend event were run though the hydraulic model. The results were compared to the surveyed GIS data and the models were modified until a good match was made across the catchment. These modifications were primarily based around the adopted land use definitions.

The average difference and the absolute average difference were used to assess whether a good match occurred between the recorded and calculated values. The average difference is the average of all differences between recorded and predicted values. This value can be affected by positive and negative numbers and can appear quite small even when large positive and negative differences occur. The absolute average difference is the average of all the absolute differences (essentially the negative values are treated as positive values). This removes the influence of positive and negative values and gives a better indication of whether or not large differences occur between recorded and calculated values.

The following modifications were made during calibration of the Frenchmans/Thozets Creeks model:

- The delineation of roughness polygons was enhanced
- Roughness values were modified to better match localised ground cover types evident in site photos
- Varying roughness values were used throughout the channel
- The final adopted land use types are those presented in Table 5
- A 50% blockage factor was applied to the Rockonia Road culvert crossing on Thozets Creek

5.4.2 Calibration results

The calibration of the Frenchmans/Thozets Creeks model generally matches well with the recorded datasets and falls within the adopted tolerances (as shown in Figure 7). The average difference between recorded and modelled values is 0.05 m and the absolute average difference between these values is 0.35 m. The average tolerance is 0.52 m which shows that the calibration is generally well within tolerance limits.

Upstream of Rigarlsford Park the calibration values are both above and below the adopted tolerances within a localised area. Upstream and downstream of this location the calibration is within the adopted tolerances, therefore this location was identified as a localised anomaly and no further changes were made to the model.

5.5 Peer review

A peer review of the hydrologic and hydraulic assessment was carried out by BMT WBM to provide further verification of the adopted methodology and processes which are documented in this report.

6 Design and extreme event results

This section of the report presents the hydraulic modelling results. It provides information relating to the flood mapping, design discharges, critical durations and flood depths for the complete range of design and extreme event magnitudes. It also presents the results of the critical infrastructure assessment and the climate change analyses.

6.1 Mapping

The TUFLOW model results were analysed and a series of maps (Figure 8 to Figure 25) were developed to present the results for each modelled return period. Three sets of maps were produced to display:

- Inundation extents with peak water surface levels and velocity vectors – these maps present 0.5 m contours of the peak water surface levels, as well as peak velocities displayed as arrows. The velocity arrows show the direction of the flow and are scaled to represent the magnitude of the flow (ie larger arrows mean faster flow)
- Peak depths – the maps present peak depth contours in 0.5 m bands up to a depth of 5 m, with the lower band separated into two bands covering 0 to 0.3 m and 0.3 to 0.5 m
- Hazard maps – hazard is a function of flood depth and flood velocity and is related to safety of the flood waters. The peak low, medium, high and extreme hazard contours presented in these maps are based upon the recommendations in *Floodplain Management in Australia Best Practice Principles and Guidelines* produced by the Standing Committee on Agriculture and Resource Management (SCARM) (2000). Image 1 is an extract from the guidelines and presents the adopted hazard category relationship

Further to these three sets of maps, a single map showing a comparison of the inundation extents for the 2, 5, 10, 20, 50 and 100 year ARI design events has also been produced (Figure 35).

The mapping information has all been provided to Council in GIS format.

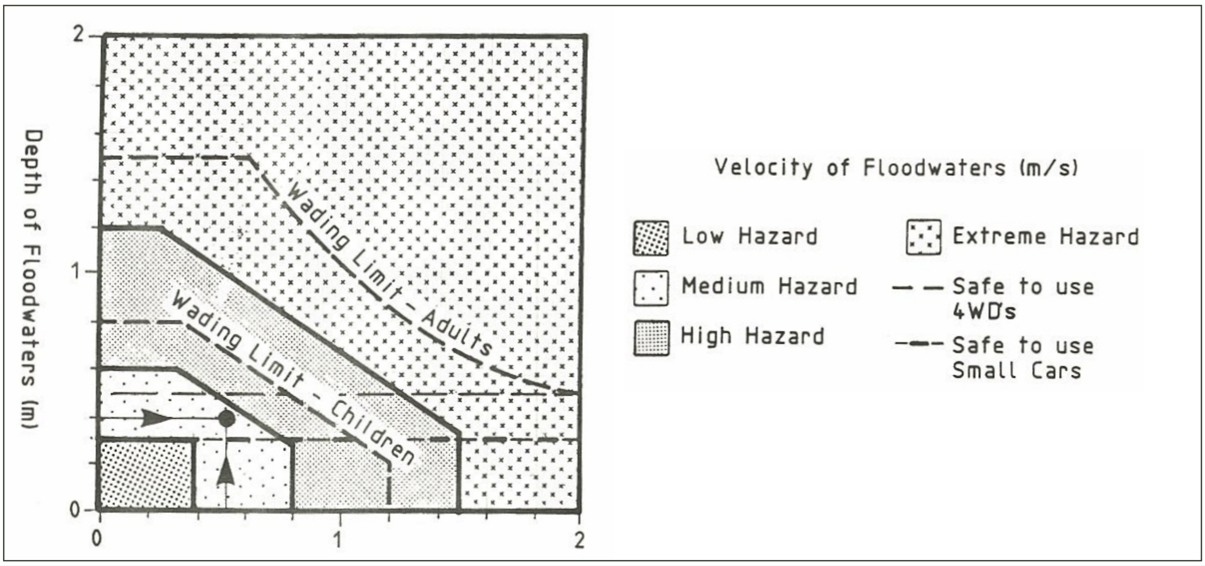

Image 1 | Hazard categories

6.2 Design event discharges

Peak modelled discharges (from the TUFLOW model) at locations of major road and rail crossings and other key locations are presented in Table 11 and the associated critical durations are presented in Table 12. The critical duration along the main channel varies from the 60 minute event in the upper reaches to the 120 minute event at the outlet. Runoff occurs more rapidly from smaller areas; therefore as the catchment area increases the critical duration increases.

Appendix C contains information regarding peak discharges and critical durations at additional locations throughout the model area and Appendix D contains flow hydrographs for the critical duration event at each location.

Peak modelled discharges are not presented for the extreme events. Breakouts between tributaries and channels become more common in the extreme events and the reporting of flows for individual crossings becomes difficult.

Table 11 | Design event peak discharges at key locations

Location	Peak Discharge (m^3/s)					
	2yr	5yr	10yr	20yr	50yr	100yr
Thozet Road (Total)	0.0	0.0	0.0	2.0*	12.1*	20.9*
Lakes Creek Road (Total incl Little Thozet Creek)	41.8	60.3*	73.0*	87.3*	103.6*	119.5*
Yeppoon Branch Railway (Bridge)	24.7	39.7	50.3	66.5	84.2	100.8

** Indicates that road is inundated*

Table 12 | Design event critical durations at key locations

Location	Critical Duration (mins)					
	2yr	5yr	10yr	20yr	50yr	100yr
Thozet Road (Total)	N/A	N/A	N/A	120	90	90
Lakes Creek Road (Total incl Little Thozet Creek)	120	120	120	120	90	90
Yeppoon Branch Railway (Bridge)	90	120	120	120	90	90

6.3 Design event results

The results presented in Figure 8 to Figure 25 show that Thozets Creek catchment consists of largely residential development in the middle and lower reaches and in these areas properties are affected by inundation. Areas that are an inundated include:

- In the 2 year ARI event
  - Properties along Stack Street, Rhodes Street, Pilkington Street, Stenhouse Street and Rose Street
  - A property on Patterson Avenue
- In the 5 year ARI event
  - Properties along Rockonia Road, Blanchfield Street, Bryant Street, Thozets Road and Joiner Street
- In the 10 Year ARI Event
  - A property at Mason Street

Some key points to note are:

- For the inundation identified above:
  - The areas identified as being inundated for each ARI include those areas identified for smaller events
  - The discussion has focussed on areas where buildings are shown in the aerial image
  - Properties identified as being inundated may only be partially inundated and may not be inundated at the location of building
  - The discussion does not take into account building floor levels, which may be above the inundation levels
- Critical durations in this catchment are relatively short duration events when compared with a Fitzroy River flood event. Along the main creek channel the critical durations range between:
  - Ninety minutes and two hours in the downstream reaches
  - One and two hours in the middle reaches
  - One hour and ninety minutes in the upper reaches
  - In Little Thozets Creek the critical durations are typically between one hour and ninety minutes

6.4 Extreme event results

Extreme events are assessed as a requirement of State Planning Policy 1/03 and also Council's Planning Policy. These policies require community infrastructure such as emergency facilities, hospitals and key services (eg power) to be located above extreme flood levels. The PMF is assessed to define the extent of the floodplain.

The results for the 200 and 500 year ARI and the PMF events are presented in Figure 26 to Figure 34. These results are presented in the same format (three sets of maps) as the design event results. A comparison of the 100, 200 and 500 year ARI and PMF inundation extents is shown in Figure 36.

These maps show that in the 200 and 500 year ARI events inundation occurs in the following additional areas:

- Properties along Osullivan Street
- Additional properties along Rose Street

The results presented in Figure 32 to Figure 34 show that much of the area in the vicinity of the creek becomes inundated in the PMF event.

6.5 Hydraulic category mapping

Hydraulic category mapping has been carried out in accordance with the Planning Scheme requirements. This mapping defines the areas of floodway, flood storage and flood fringe and is consistent with that carried out for the Fitzroy River. The hydraulic category map is based upon the 100 year ARI event and is presented in Figure 37.

Floodways are areas which convey a significant portion of flood flows and which would cause significant adverse impacts if they were to be blocked. Flood storage areas are those in which temporary storage of floodwaters occurs during a flood event and which could potentially cause increases in flood levels/discharges in other areas of the floodplain if filled. All other areas are considered flood fringe.

The following criteria were used to define the hydraulic categories:

- Floodway
  - Velocity-depth product ≥ 0.5 m^2/s or
  - Velocity ≥ 1 m/s
- Flood storage
  - Velocity-depth product ≤ 0.5 m^2/s and
  - Depth ≥ 0.5 m
- Flood fringe
  - Velocity-depth product ≤ 0.5 m^2/s and
  - Depth ≤ 0.5 m

A number of manual overrides to the above definitions were also required across the floodplain, including:

- Removal of isolated zones/areas within categories – eg if a small area of flood storage was completely surrounded by a large area of floodway the flood storage was redefined as floodway and vice versa
- Removal of small sections of categories – any location in which the category area was less than 0.1 Ha was integrated into the nearby category

6.6 Climate change

Two Climate Change scenarios were assessed:

- Climate Change Scenario 1: 20% increase in rainfall intensity and 0.8 m increase in tailwater level for the 100, 200 & 500 year ARI events
- Climate Change Scenario 2: 30% increase in rainfall intensity and 0.8 m increase in tailwater level for the 100, 200 & 500 year ARI events

The results of this assessment are presented in the following sections.

6.6.1 Scenario 1

The impacts of Climate Change Scenario 1 are presented in Figure 38 to Figure 41. These figures show throughout most of the hydraulic model the flow is mainly contained within the channel and the water elevations increase between +0.05 m to +0.25 m, and reaching +0.40 m in the higher regions. These impacts are similar for the 100, 200 and 500 year ARI events.

For the 100 year ARI Scenario 1 case, the inundation extents are similar to the Existing Case 200 year ARI event throughout much of the model area. The 200 year ARI Scenario 1 inundation extents are and the Existing Case 500 year ARI extents.

Thozets Creek Catchment is highly developed and in the Existing Case the majority of flow is contained within defined channels. These channels have been designed to convey Existing Case flows, not Climate Change Scenario flows; therefore Climate Change flows tend to lead to larger inundation extents as flows are no longer contained within the channels. For areas with defined channels there is a noticeable increase in inundation extent for each climate change scenario.

6.6.2 Scenario 2

The increases in peak water levels and inundation extents resulting from Climate Change Scenario 2 are presented in Figure 42 to Figure 45. These figures show that the increase in peak water level is typically +0.1 to +0.4 m throughout much of the model area. Peak water levels in Scenario 2 are approximately +0.06 m higher than those for Scenario 1.

The 100 year ARI Scenario 2 results show that inundation extents are similar to but slightly smaller than the Existing Case 500 year ARI extents. The 200 year ARI Scenario 2 inundation extents are slightly larger than the Existing Case 500 year ARI extents.

As per Scenario 1, an increase in inundation extent is noticed throughout the model due to the issue of defined channels not being designed to convey Climate Change flows.

6.6.3 Inundation extent comparisons

Comparisons of the 100, 200 and 500 year inundation extents for Climate Change Scenario 1 and Climate Change Scenario 2 are presented in Figure 41 and Figure 45 respectively.

Comparisons of the inundation extents for the Existing Case, Climate Change Scenario 1 and Climate Change Scenario 2 are presented for the 100, 200 and 500 year ARI events respectively in Figure 46, Figure 47 and Figure 48.

6.7 Critical infrastructure assessment

A list of critical infrastructure and the design event at which it is likely to be inundated has been prepared and included in Appendix E. This includes the following infrastructure:

- Emergency services facilities (eg ambulance, police, fire, coast guard, airstrip, hospital)
- Significant facilities for evacuation (eg child care, education, retirement, nursing care, media)
- Key water and sewerage infrastructure
- Roads/bridges

7 Sensitivity testing

This section presents the results of the hydrologic and hydraulic model sensitivity testing.

7.1 Hydrologic model sensitivity testing

A sensitivity analysis of key RAFTS parameters (Bx, PerN and the adopted channel velocities) was conducted to establish the effect that these parameters/coefficients have on the predicted peak discharge for the 5 and 100yr ARI events. This was done to provide an understanding of the primary influences to model and catchment behaviour, the findings of which are discussed in the following sections. The three locations at which sensitivity checks were undertaken were chosen to match those used for the Rational Method checks.

7.1.1 Storage coefficient, Bx

Bx is the storage coefficient multiplication factor and is used to modify the calculated storage time delay coefficient. This value was both increased and decreased by 10%.

Table 13 summarises the results of this sensitivity analysis and shows that flow increases with a decrease in Bx and vice versa. The average change of flow for an increase in Bx is 5%. If Bx is deceased by 10% the average flow increases by 5%. This indicates that the model response is not linear in comparison to the change in Bx value and the sensitivity is less than the absolute change in Bx value.

Table 13 | Hydrologic model sensitivity results – Bx sensitivity

ARI (yrs)	Modified Parameter	Location	Sensitivity Model Peak Discharge (m^3/s)	Base Model Peak Discharge (m^3/s)	Difference (%)
5yr	Bx +10%	1 (THO-7)	23	25	-8%
		2 (DUM-2)	38	40	-5%
		3 (CON-1)	7	8	-13%
	Bx -10%	1 (THO-7)	27	25	8%
		2 (DUM-2)	42	40	5%
		3 (CON-1)	8	8	0%

ARI (yrs)	Modified Parameter	Location	Sensitivity Model Peak Discharge (m^3/s)	Base Model Peak Discharge (m^3/s)	Difference (%)
100yr	Bx +10%	1 (THO-7)	73	77	-5%
		2 (DUM-2)	96	99	-3%
		3 (CON-1)	19	20	-5%
	Bx -10%	1 (THO-7)	83	77	8%
		2 (DUM-2)	104	99	5%
		3 (CON-1)	21	20	5%

7.1.2 Sub-catchment roughness coefficient, PerN

PerN is an empirical parameter that is used to take pervious and impervious sub-catchment roughness into account. It is incorporated as an average Manning's n representation of sub-catchment roughness. This parameter was increased and decreased by 20% and the results are tabulated in Table 14.

The effects of the PerN coefficients were not of a linear nature, with reduced PerN values having an average impact of +10% and the increased PerN values having an average impact of -9%. The maximum change in discharge was 15%.

Table 14 | Hydrologic model sensitivity results – PerN sensitivity

ARI (yrs)	Modified Parameter	Location	Sensitivity Model Peak Discharge (m^3/s)	Base Model Peak Discharge (m^3/s)	Difference (%)
5yr	PerN +20%	1 (THO-7)	22	25	-12%
		2 (DUM-2)	37	40	-8%
		3 (CON-1)	7	8	-13%
	PerN -20%	1 (THO-7)	29	25	16%
		2 (DUM-2)	43	40	8%
		3 (CON-1)	8	8	0%
100yr	PerN +20%	1 (THO-7)	69	77	-10%
		2 (DUM-2)	93	99	-6%
		3 (CON-1)	19	20	-5%
	PerN -20%	1 (THO-7)	88	77	14%
		2 (DUM-2)	107	99	8%
		3 (CON-1)	22	20	10%

7.1.3 Channel link velocities

Adopted channel link velocities were also tested for sensitivity. The chosen velocity is used in conjunction with the length of the channel to estimate the lag time from one node to the next. The channel velocity was increased and decreased by 20% and the results are shown in Table 15.

The average change in discharge observed due to a 20% variation in channel velocity was 2% (absolute). An increase in velocity was observed to correspond with an increase in discharge and vice versa.

Table 15 | Hydrologic model sensitivity results – link velocity sensitivity

ARI (yrs)	Modified Parameter	Location	Sensitivity Model Peak Discharge (m^3/s)	Base Model Peak Discharge (m^3/s)	Difference (%)
5yr	Lag Link Velocity +20%	1 (THO-7)	25	25	0%
		2 (DUM-2)	41	40	3%
		3 (CON-1)	8	8	0%
	Lag Link Velocity -20%	1 (THO-7)	24	25	-4%
		2 (DUM-2)	39	40	-3%
		3 (CON-1)	7	8	-13%
100yr	Lag Link Velocity +20%	1 (THO-7)	79	77	3%
		2 (DUM-2)	106	99	7%
		3 (CON-1)	20	20	0%
	Lag Link Velocity -20%	1 (THO-7)	75	77	-3%
		2 (DUM-2)	96	99	-3%
		3 (CON-1)	20	20	0%

7.1.4 Summary of sensitivity analysis results

Overall, the sensitivity testing of the hydrologic models shows that changing the Bx storage coefficient has a minimal effect on the predicted peak discharge. The impacts of varying PerN and the lag link velocity are of a smaller magnitude than the corresponding parameter change. These tests show that the model is not particularly sensitive to any of the adopted model parameters which provides confidence that the predicted peak discharge hydrographs are suitable for use in the Thozets Creek flood study.

7.2 Hydraulic model sensitivity testing

A number of sensitivity tests were conducted using the Thozets Creek TUFLOW model to assess the effects these parameters/coefficients have on the predicted model results. This was undertaken to provide an understanding of the primary influences on model and catchment behaviour. These sensitivity checks were carried out for the 5 and 100 year ARI events and are summarised in the following bullet points:

- Varied Manning's n roughness coefficients (± 10%)
- 50% structure blockage
- 100% structure blockage
- Tailwater level set to 5 year ARI Fitzroy River flood level

The structure blockage values were applied to culverts and to bridge handrails. No blockage was applied to the waterway areas beneath the bridge decks as it was assumed that bridge openings are large enough to pass most debris and are not likely to become blocked.

A discussion of the sensitivity test results is provided below. No mapping of the sensitivity testing has been included in this report.

7.2.1 Manning's n roughness coefficient

The results of the Manning's n roughness coefficient sensitivity testing show that the impacts are different for the 5 and the 100 year ARI events. When Manning's n value is reduced by 10% in the 5 year ARI event, the water surface levels in the upper catchment decrease by an average of -0.02 m with a maximum of -0.45 m. The flow distributions between the main channel and the breakout upstream of Rockonia Road are modified and reductions in water level (up to -0.02 m) are seen along the breakout flowpath, while the man channel water surface levels are seen to increase by up to +0.08m. When the Mannings n value is reduced by 10% in the 100 year ARI event, water surface levels in the upper catchment reduce by an average of -0.02 m. Downstream of Rockonia Road, the overbank water surface levels reduce by an average of -0.01 m while the main channel water surface levels reduce by an average of -0.02 m.

When the Manning's n is increased by 10% in the 5 year ARI event it has the opposite effect to decrease in values. Downstream of Rockonia Road, the overbank water surface levels increase by +0.01 m to +0.02 m. When the Manning's n value is increased by +10% in the 100 year ARI event, water surface levels above Gable Street increase by about +0.05 m and in the lower reaches they increase by +0.01 m to +0.04 m. The sensitivity of the model to the Manning's roughness value is not considered significant and these potential impacts to peak water levels are within typical freeboard allowances.

7.2.2 Structure blockage

In the 50% blockage case, impacts along the main channel occur in the middle and upper reaches. Peak water levels increase upstream of Rockina Road by 0.15 to 0.30 m and Paterson Avenue by 0.02 m to 0.07 m. For the 100% blockage case water levels upstream of Rockina Road increase by +0.3 to +0.7 m and Paterson Avenue increase in the range of 0.05 m to 0.10 m.

Thozets Creek is highly developed in the lower and middle parts of the catchment and the increases in peak water levels throughout have the potential to impact upon a number of properties. Regular cleaning and maintenance of these culverts may reduce potential blockage impacts.

7.2.3 Tailwater level

The tailwater sensitivity analysis was undertaken for the 100 year ARI local catchment event with a coincident 5 year ARI Fitzroy River tailwater level. The model results were compared to the results using MHWS as the tailwater level. These results showed that using the 5 year ARI tailwater raises peak water levels within the downstream reach of the model; however the areas in which this change occurs are wholly contained within the flood extent created by 100 year ARI Fitzroy River flooding. This means that the selection of model tailwater will have no impact upon the planning conditions which are applied in the downstream reaches of the creek.

8 Conclusions

Detailed RAFTS hydrologic and TUFLOW hydraulic models of Thozets Creek were developed. Mapping and GIS layers of existing flood conditions were prepared as key outputs from the study. These maps include flood levels, inundation extents, velocities, depths and hazard across the study area for the 2, 5, 10, 20, 50 and 100 year ARI design events and the 200 and 500 year ARI and PMF extreme events. These models were calibrated to the 2013 Australia Day Long Weekend event to ensure that a good representation of actual flood behaviour was achieved. In addition these models were peer reviewed to provide further confidence that they were consistent with standard industry practices.

The Thozets Creek catchment consists of largely residential development in the middle and lower reaches and undeveloped land in the upper reaches. Floodwaters breakout from Frenchmans Creek into Thozets Creek in the lower reaches therefore it was necessary to model both catchments in a single hydraulic model.

Floodwaters for the 2 to 100 year events are mainly contained within the channel and areas adjacent to the channel. The results presented in this report show that properties adjacent to the channel are inundated under the 2 to 100 year ARI events. It is possible that application of the floodplain management process, including flood risk and mitigation options assessment, could reduce the potential impacts of flooding.

Analysis of the extreme events showed that flow patterns are similar to the 100 year ARI event, with wider inundation extents resulting from the increased flows. For extreme events floodwaters are predicted to break out from the main channel in a number of locations. Under the PMF event much of the area in the vicinity of the creek is subject to flood inundation.

Climate change analysis showed that, with increased rainfall intensities, the 100 year ARI event magnitude increases and becomes similar to the Existing Case 200 year ARI event.

Hydraulic category mapping of the catchment was prepared for input to Council's Planning Scheme, with areas prone to flooding in the 100 year ARI event being categorised into floodway, flood storage or flood fringe areas. An assessment of critical infrastructure at risk of flooding was also undertaken to provide information for emergency planning and response.

9 Explanatory notes and disclaimers

9.1 General notes

- This report and the associated mapping were developed to represent creek flooding in the developed/developable areas in Thozets Creek. Flooding continues beyond the upstream extents. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made
- The levels of flood risk presented in this report and on the associated mapping are based upon ground surface elevations. The level of risk of above floor flooding has not been assessed as part of this study. The risk of above floor flooding will be reduced from that shown on the mapping, depending upon how high each individual property is above the ground level
- The topographic data used in preparation of the hydraulic model and this report was based upon the best information available as at September 2012 and relied upon LiDAR survey captured in 2009 and 2010. No bathymetric data was included
- The results presented in this report are based upon model results from the Thozets Creek RAFTS and TUFLOW models as at March 2014
- Information presented in this report is indicative only and may vary, depending upon the level of catchment and floodplain development. Filling of land or excavation and levelling may alter the ground levels locally at any time, whilst errors may also occur from place to place in the local ground elevation data from which the models have been developed
- The hydraulic modelling presented in this report was based upon a 5 m grid hydraulic model. This model resolution may not be representative of features such as small, local drainage channels
- Flood hazard assessments have been based upon consideration of flood depths and velocities only. No consideration of evacuation times has been included

9.2 Important things you should know about this report

9.2.1 Exclusive use

- This report has been prepared by Aurecon at the request of Rockhampton Regional Council ("Client") exclusively for the use of its Client
- The basis of Aurecon's engagement by the Client is that Aurecon's liability, whether under the law of contract, tort, statute, equity or otherwise, is limited as set out in the terms of the engagement

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- It is not possible to make a proper assessment of this report without a clear understanding of the terms of engagement under which the report has been prepared, including the scope of the instructions and directions given to and the assumptions made by the consultant who has prepared the report
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- The report is also based on information provided to Aurecon by other parties. Although the providers of the information have not warranted the accuracy of the data and have waived liability in respect of its use, Aurecon's report is provided strictly on the basis that the information that has been provided is accurate, complete and adequate
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9.2.5 Legal documents etc

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If the reader should become aware of any inaccuracy in or change to any of the facts, findings or assumptions made either in Aurecon's report or elsewhere, the reader should inform Aurecon so that it can assess its significance and review its comments and recommendations.

Appendices

Appendix A
List of figures

This mapping was developed to represent flooding in the Frenchmans & Thozets Creeks catchment. Flooding extends upstream of the limits shown but has not been mapped as part of this study. No consideration of flooding in areas of piped urban stormwater drainage has been made.

The levels of flood risk presented on this mapping are based upon ground surface elevations. The level of risk of above floor flooding has not been assessed as part of this study. The risk of above floor flooding will be reduced from that shown on the mapping, depending upon how high each individual property is above the ground level.

The topographic data used in preparation of the hydraulic model and this mapping was based upon the best information available as at September 2012 and relied upon LiDAR survey captured in 2009 and 2010. No bathymetric data was included.

The results presented in this mapping are based upon model results from the Local Creek Catchments - Frenchmans & Thozets Creeks Flood Study RAFTS and TUFLOW models.

Information presented in this mapping is indicative only and may vary depending upon the level of catchment and floodplain development. Cutting, filling and levelling of land associated with new or upgraded developments may alter the ground levels locally at any time, and depending on the time that such works have been carried out, they may not have been captured in original LiDAR survey. Errors may also occur from place to place in the local ground elevation data from which the models have been developed.

The hydraulic model results presented in this mapping are based upon 5m grid hydraulic models. This model resolution may not be representative of features such as small, local drainage channels.

All level information presented in this mapping is expressed in metres AHD.

Flood hazard assessments have been based upon consideration of flood depths and velocities only. No consideration of evacuation times has been included.

These maps were produced to accompany the Frenchmans & Thozets Creek Flood Study Report. Detailed information regarding the model setup and modelling methodology is available in this report.

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Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

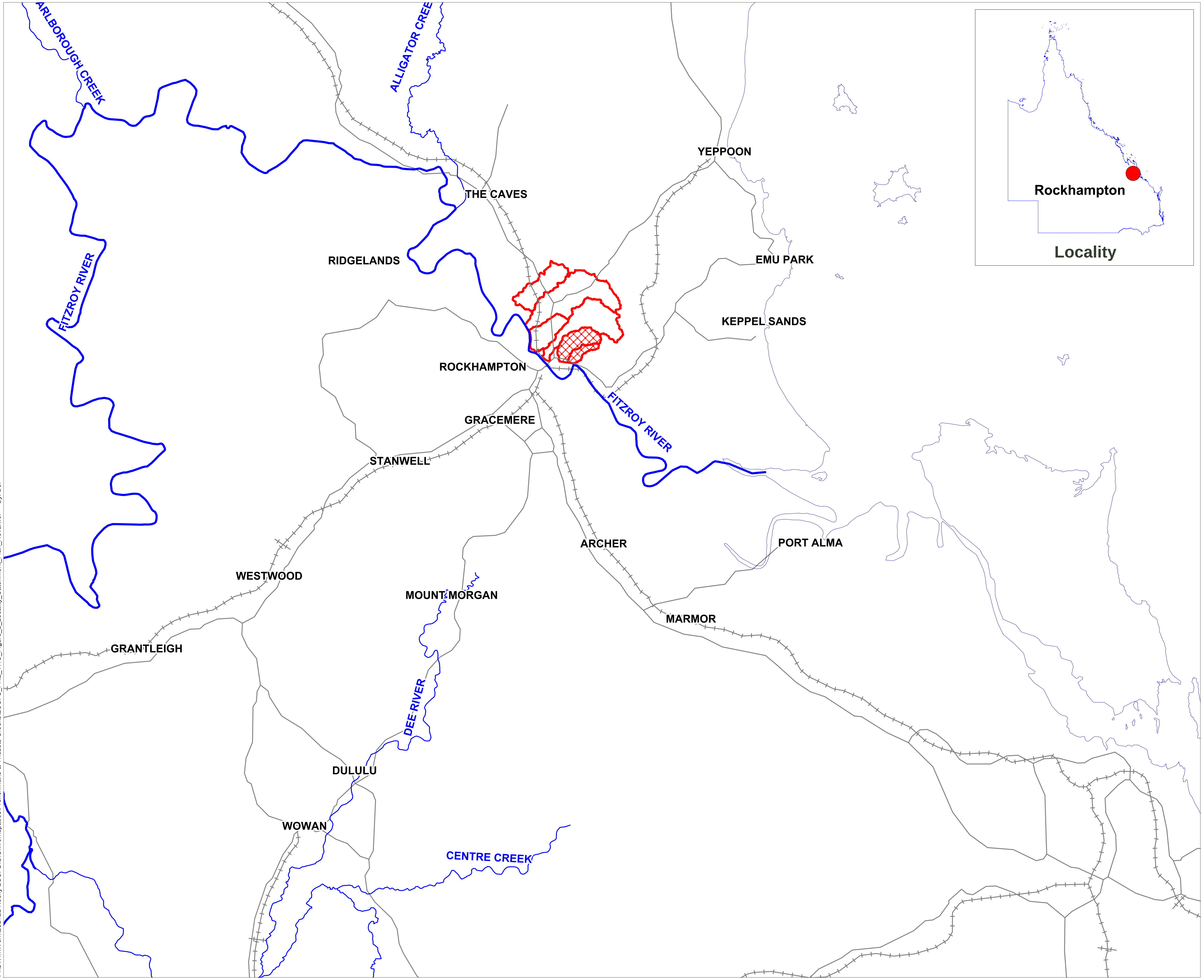
Legend

Notes:

Date: 29/05/2014 **Version: 2**

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 1: Explanatory Notes and Disclaimers



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Legend

- Local Creek Catchments
- Frenchmans & Thozets Creeks Catchment
- Coastline
- Fitzroy River
- Major Waterways
- Railways
- Main Roads

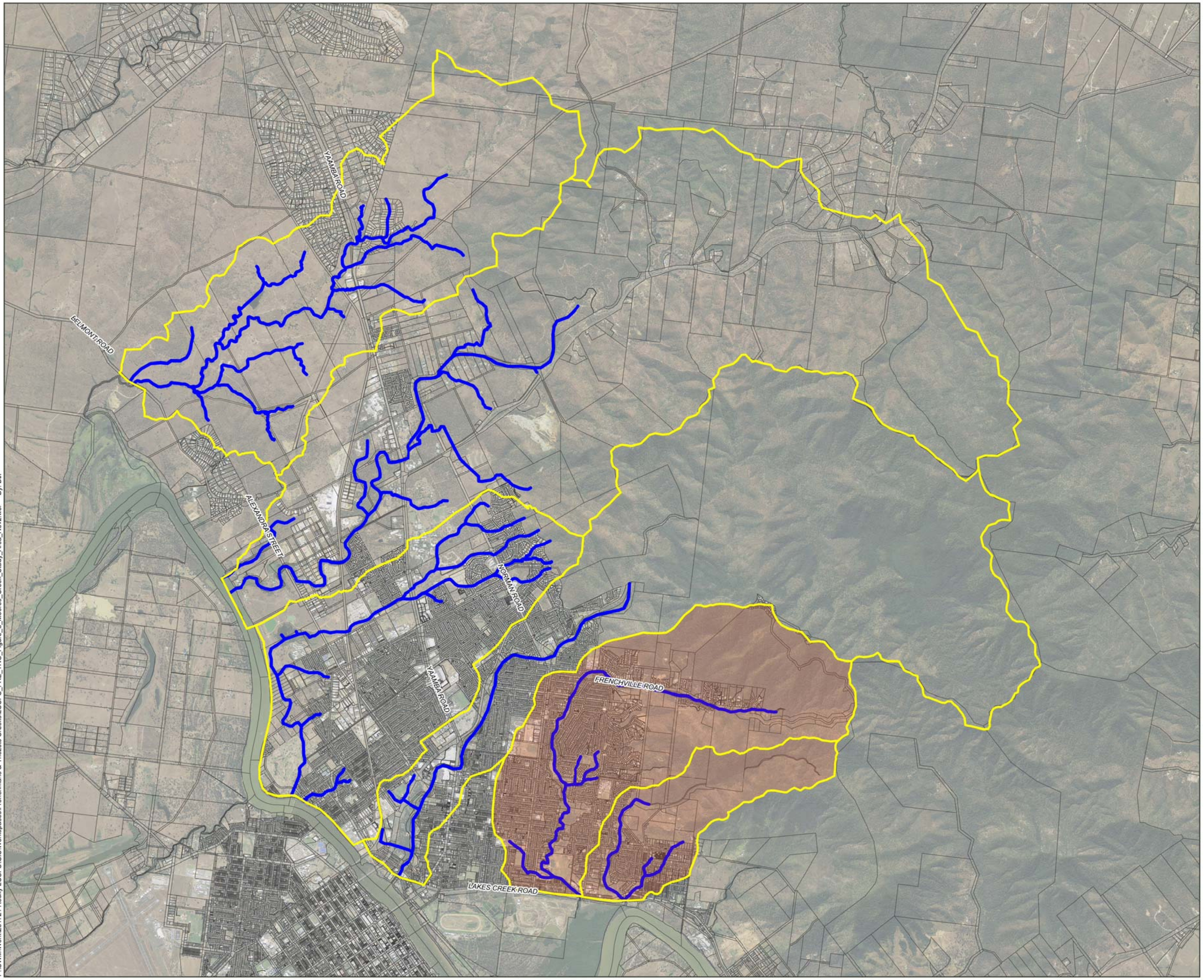
Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.

Date: 29/05/2014 **Version: 2**

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 2: Locality and Catchment Plan



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Attorney-General's Department

Queensland Government

Legend

- Cadastre
- Frechmans & Thozets Creeks Catchments
- Local Creek Catchments
- Modelled Flow Paths

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.

P:\SWM\Work\231721 Rocky LCCFS\GIS\Workspaces\Frenchmans & Thozets Creeks\LCCFS_FRE_THO_Figure_3_Moores_Creek_Study_Area_Rev2.wor By: DJF

Date: 29/05/2014

Version: 2

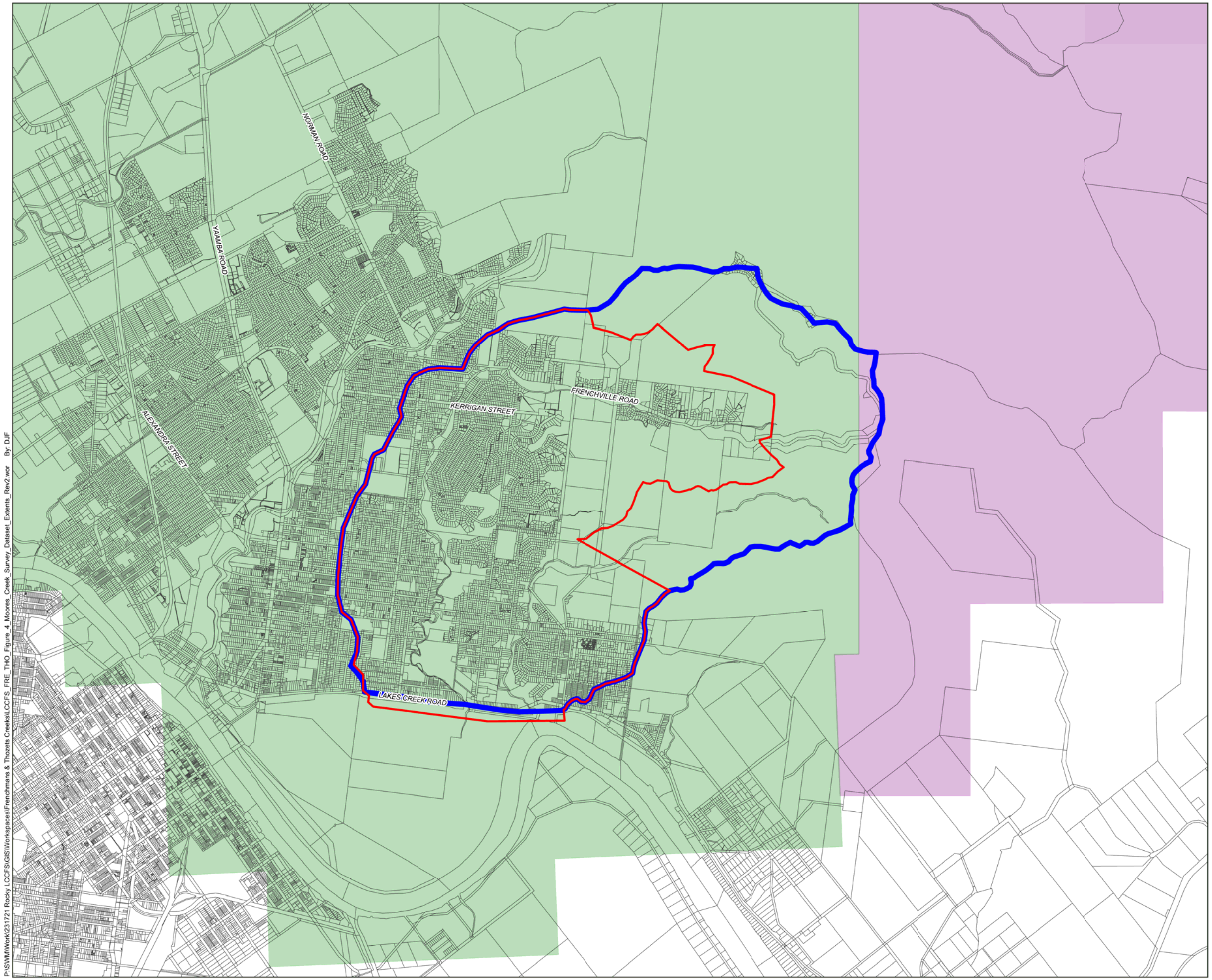
0 3000 (m)

Scale 1:60 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 3: Study Area



Legend

- Cadastre
- TUFLOW Model Extents
- Rafts Model Extents
- SunWater 2010 LiDAR Data Extents
- Rockhampton Regional Council 2009 LiDAR Data Extents

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.

Date: 29/05/2014 **Version: 2**

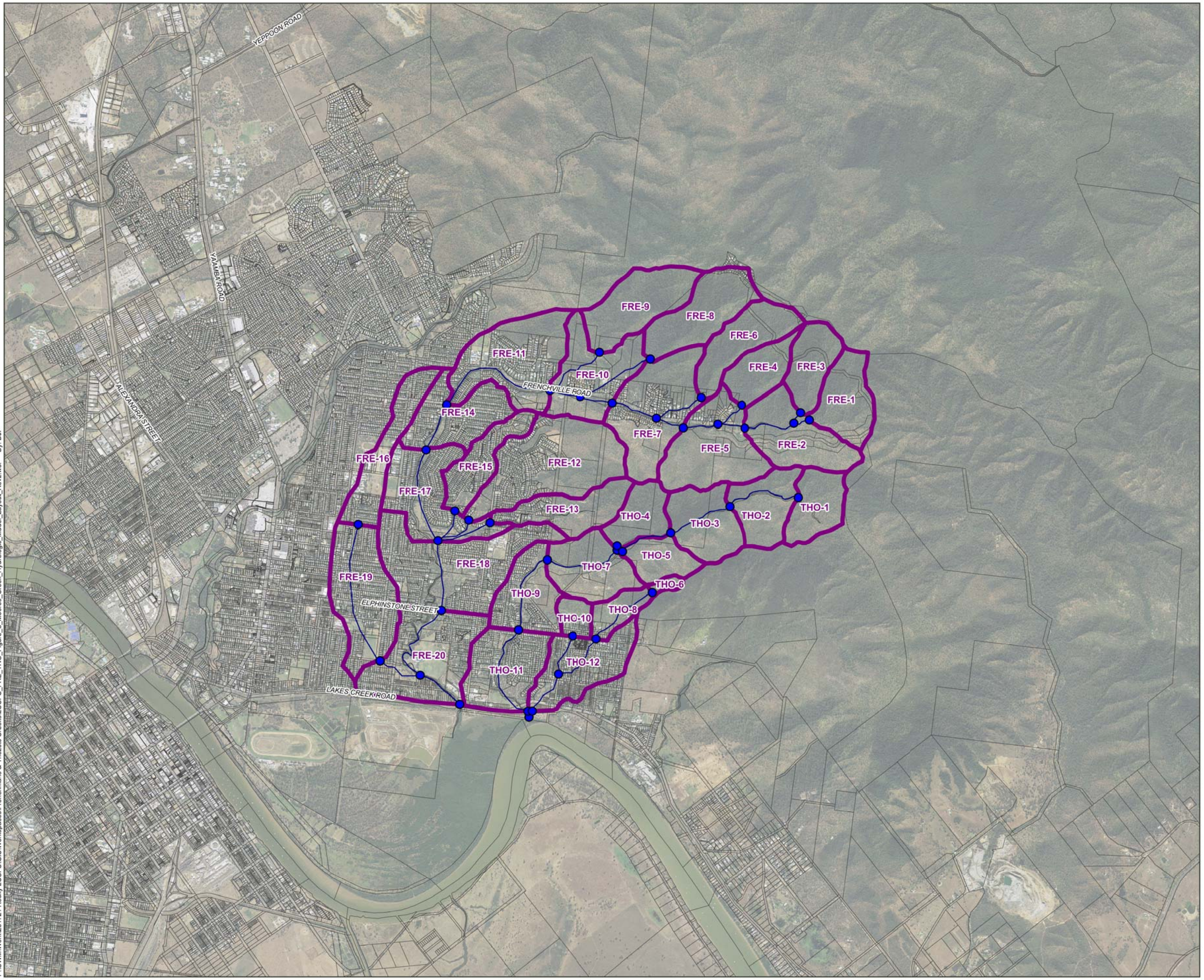
0 2000 (m)

Scale 1:40 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 4: Survey Data Extents



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Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

Sub-Catchments

Node

Link

Cadastre

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.

Date: 29/05/2014 **Version: 2**

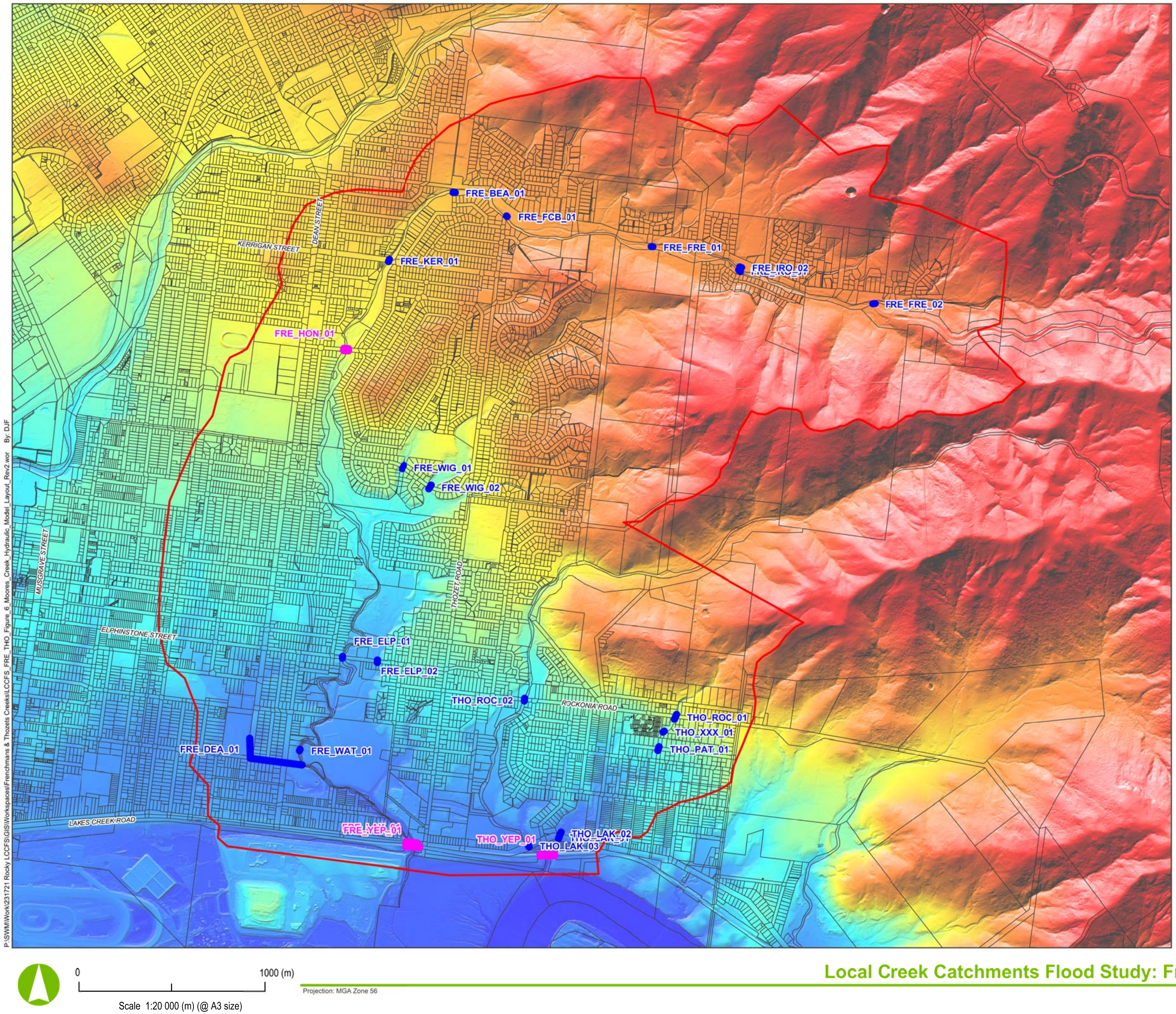
0 2000 (m)

Scale 1:40 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 5: Hydrologic Model Layout



Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- TUFLOW Model Boundary
- Culvert
- Bridge
- Cadastre

Elevation (m AHD)
200.0
50.0
30.0
15.0
0.0

Notes:

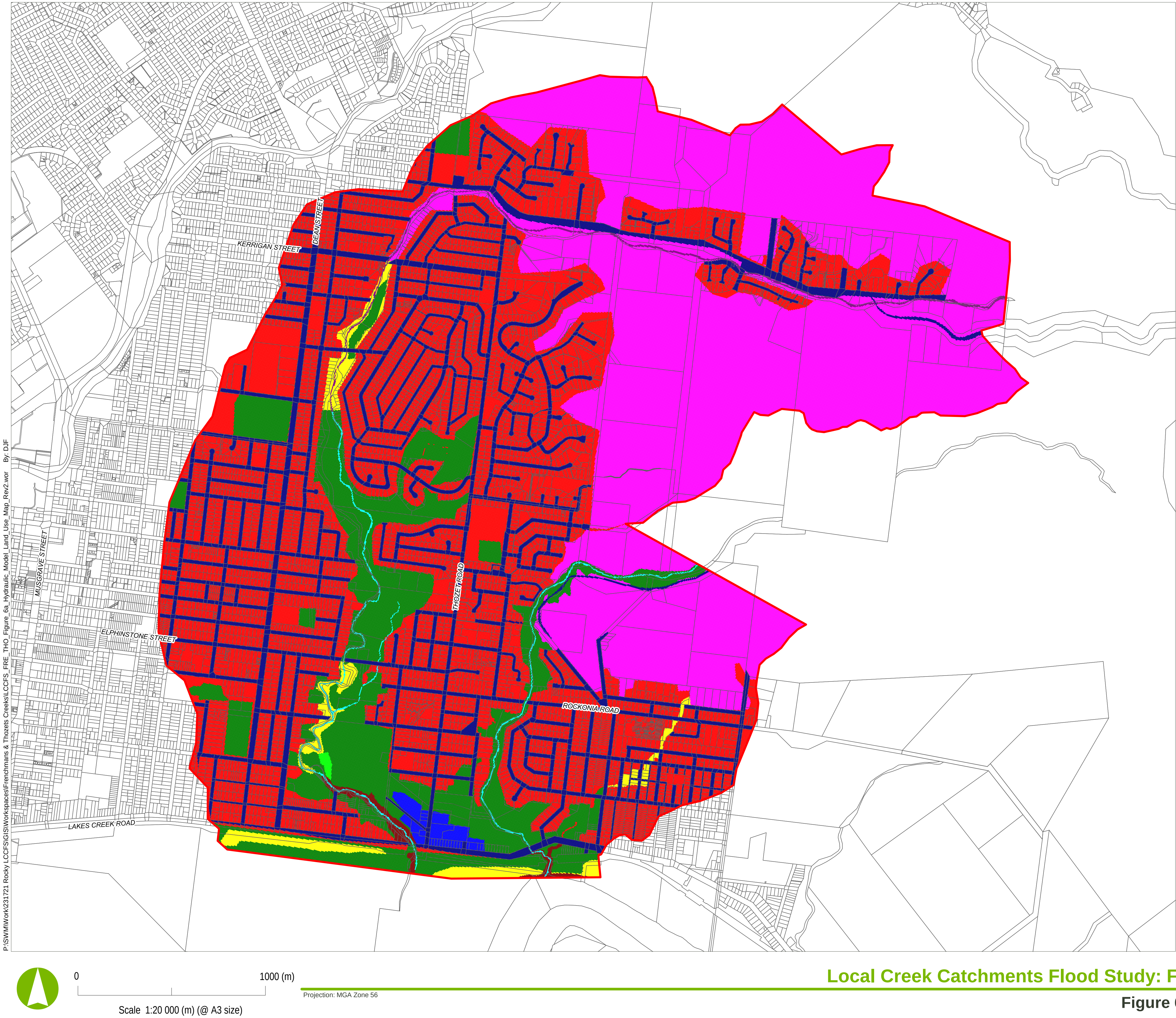
1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.

Date: 29/05/2014 Version: 2

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 6: Hydraulic Model Layout



Legend

- Cadastre
- TUFLOW Model Extents
- 0.150 (High Density Residential)
- 0.090 (Low Density Residential)
- 0.150 (Industrial)
- 0.070 (Medium Dense Vegetation)
- 0.050 (Low Density Vegetation)
- 0.045 (Channel)
- 0.070 (Riparian Corridor)
- 0.030 (Maintained Grass)
- 0.030 (Road Reserve)
- 0.065 (Rough Channel)

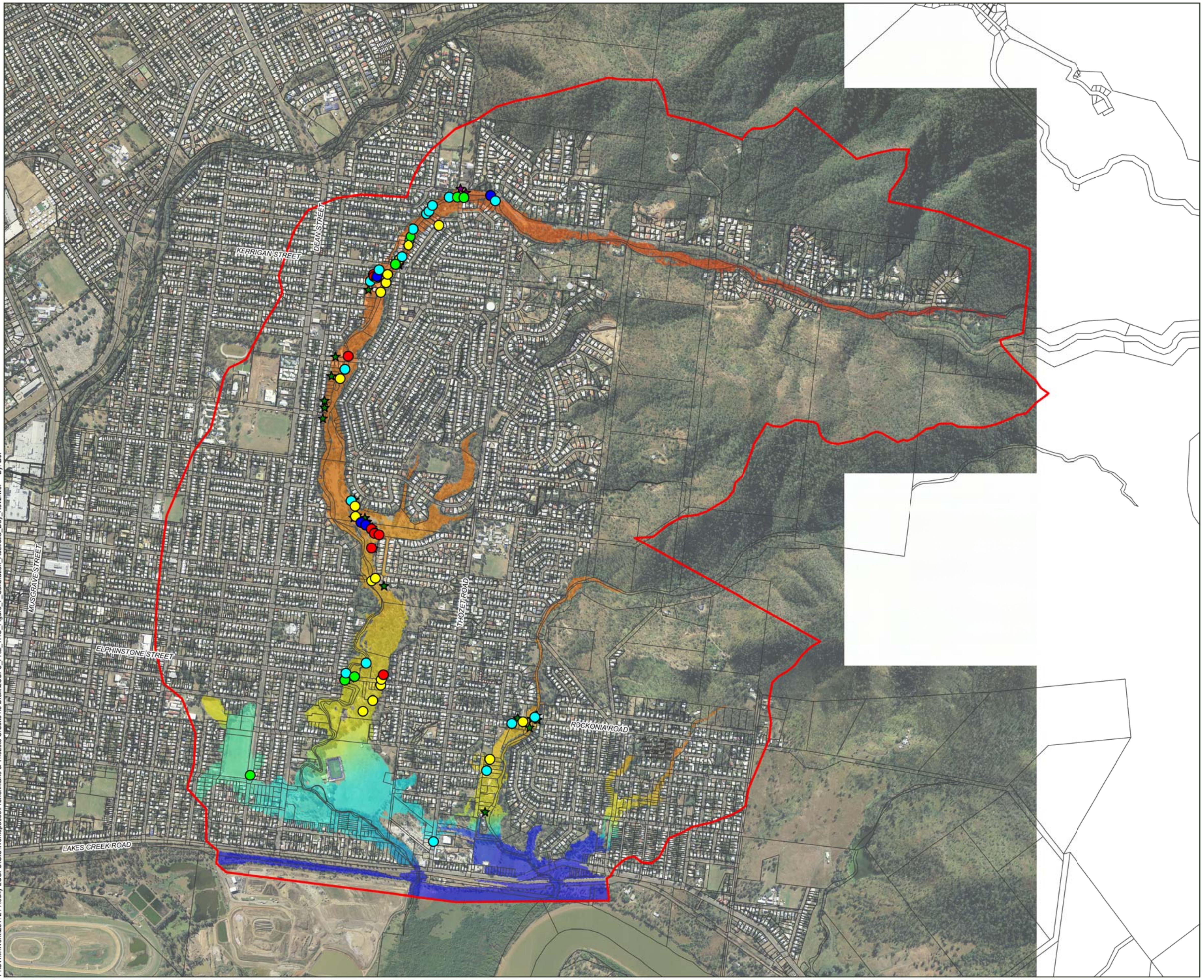
Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.

Date: 29/05/2014 **Version: 2**

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 6a: Hydraulic Model Land Use Map



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Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

TUFLOW Model Boundary

Cadastre

Modelled Vs Recorded Differences

- Within Tolerance
- Within Tolerance - Low
- Within Tolerance - High
- Outside Tolerance - Too Low
- Outside Tolerance - Too High
- No Value - N/A

Inundation Extent

- Verification
- Calibration

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent 5 year ARI flood event on the Fitzroy River.

Date: 29/05/2014 Version: 2

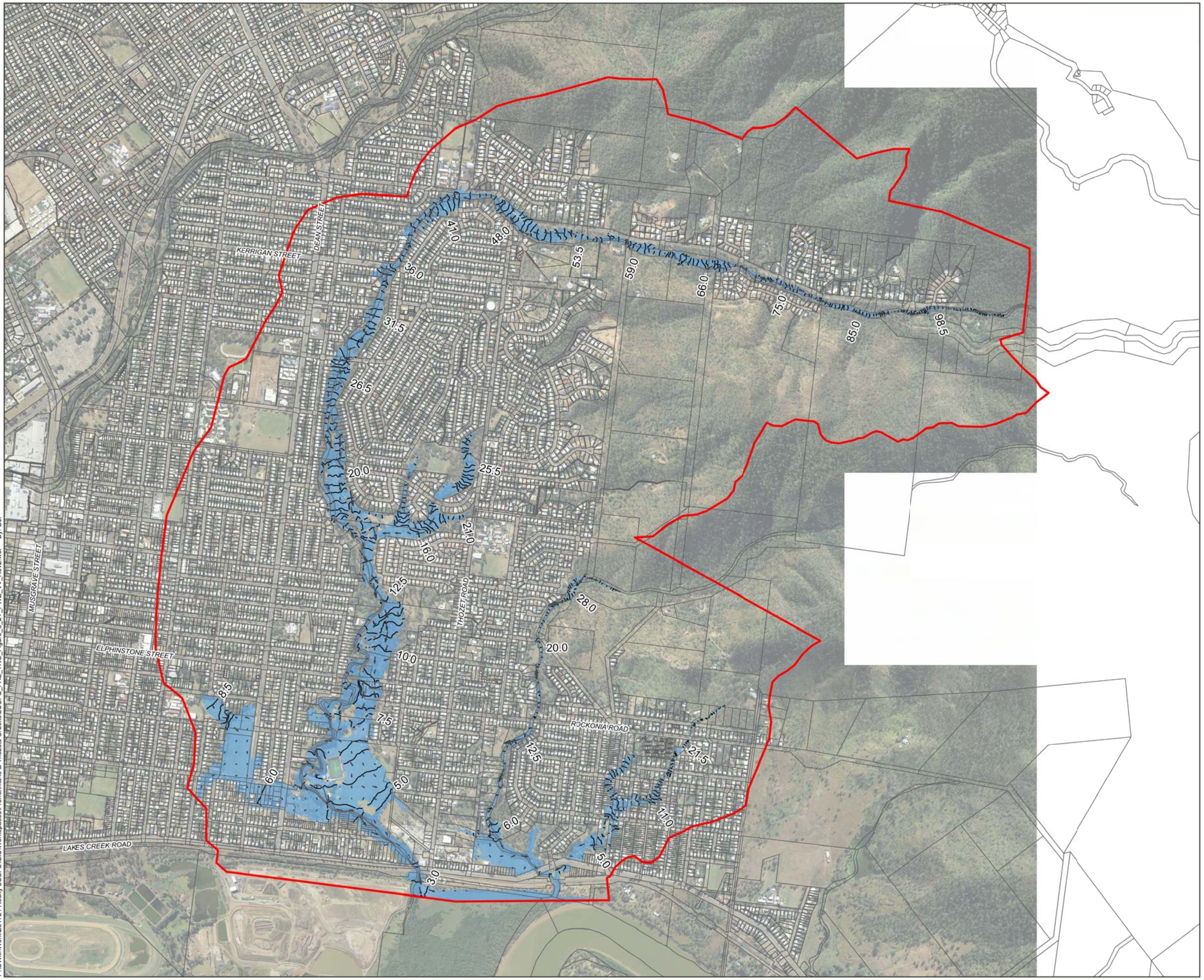
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 7: Calibration to 2013 Australia Day Long Weekend Event



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Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents

Inundation Extents

0.5m (AHD) Peak Water Surface Elevation Contour

Velocity Vector
- represents velocity at time of peak water level
- reference vector = 3 m/s

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

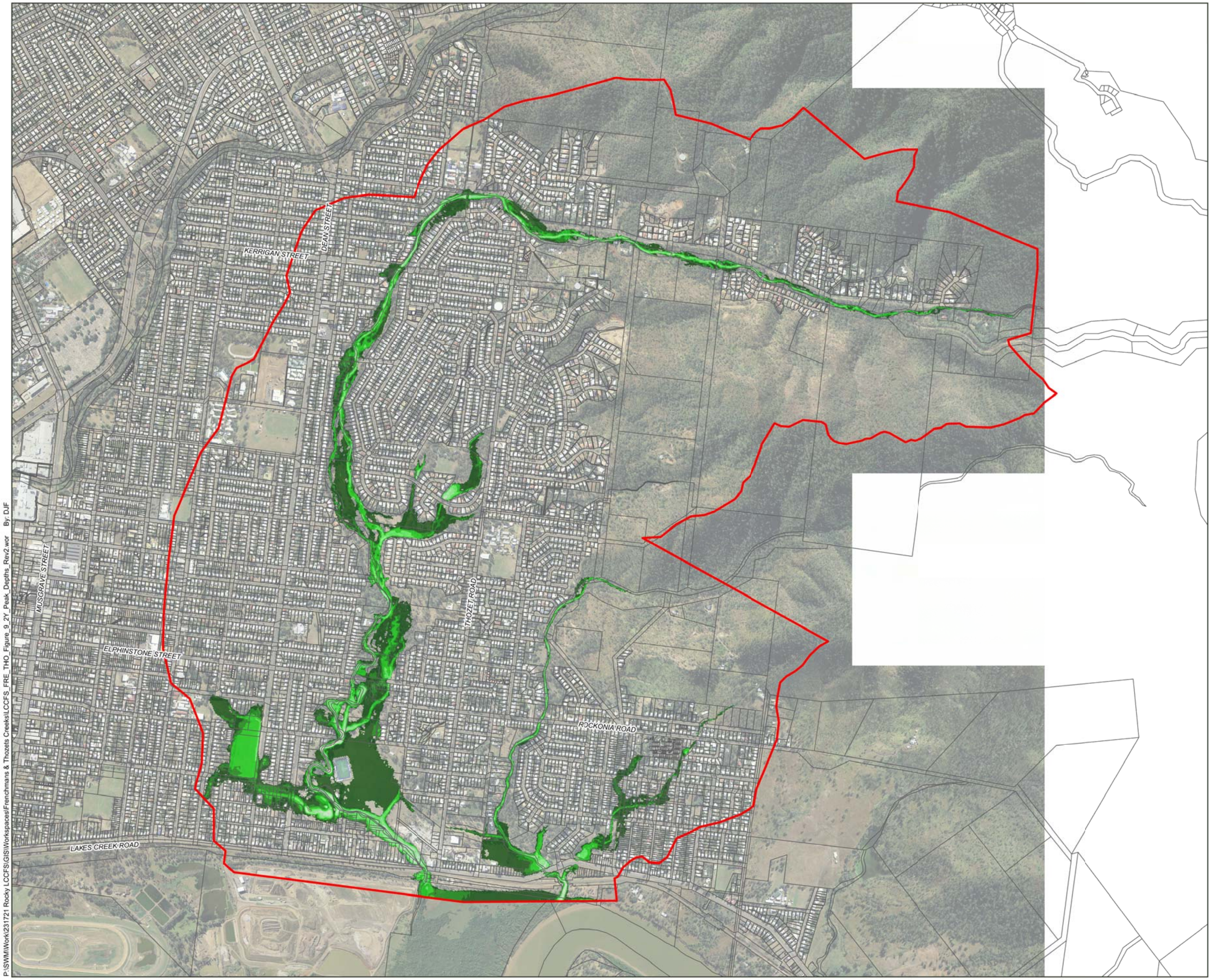
Date: 29/05/2014 **Version: 2**

0 1000 (m)
Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 8: Existing Conditions - 2 Year ARI Inundation Extents, Peak Water Surface Elevations and Velocities



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Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents

Depth (m)

0.0 to 0.3	2.5 to 3.0
0.3 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014

Version: 2

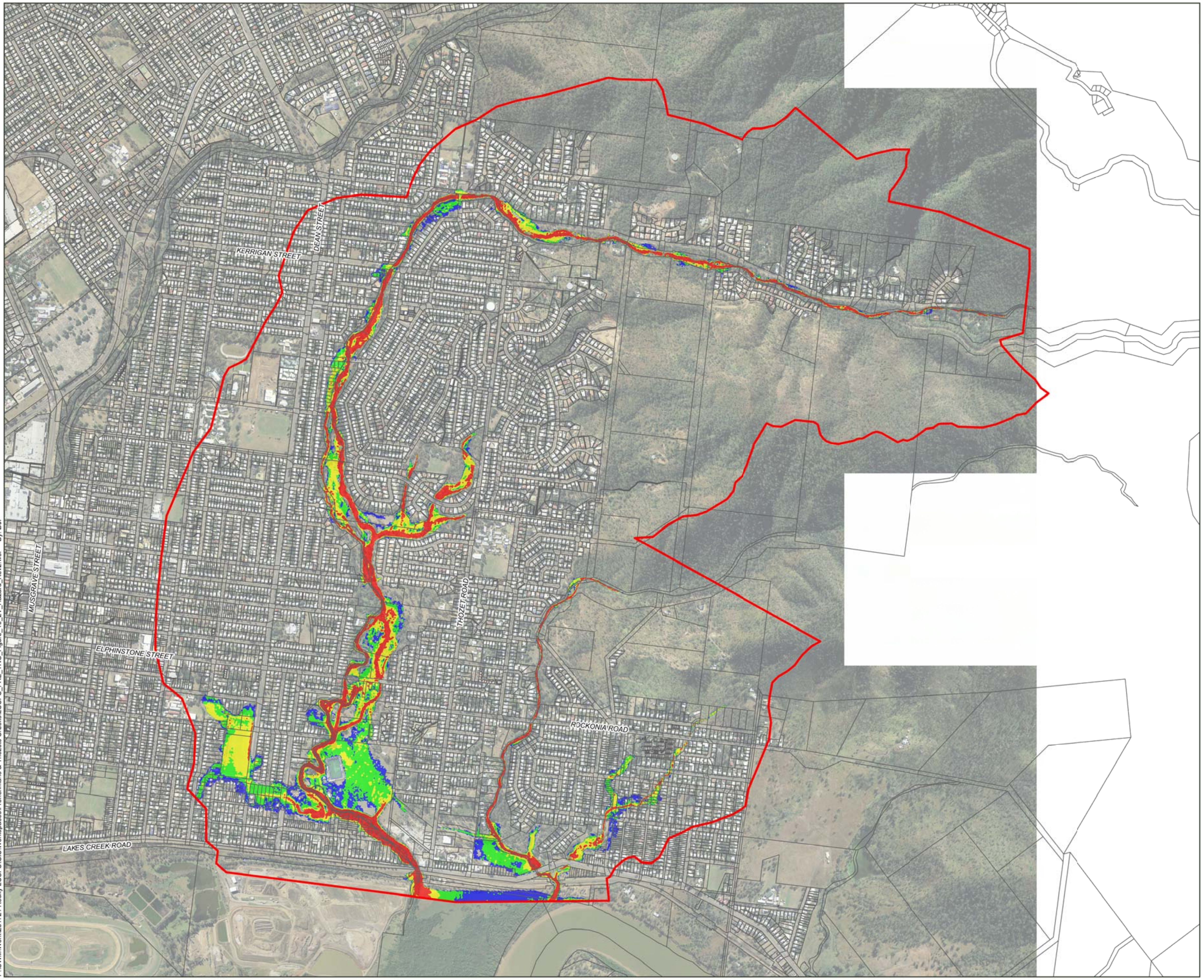
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 9: Existing Conditions - 2 Year ARI Peak Depths



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Rockhampton Regional Council

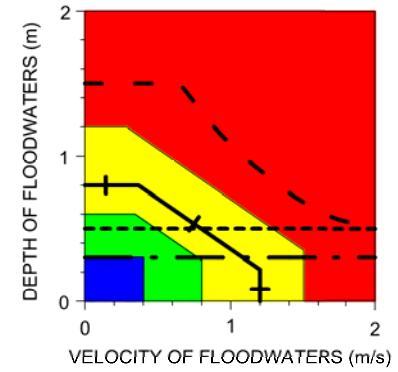
Australian Government
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents



Hazard Categories

Low

High

Medium

Extreme

Hazard Thresholds

Wading Limit - Children

Safe to Use Small Cars

Wading Limit - Adults

Safe to Use 4WDs

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014

Version: 2

0

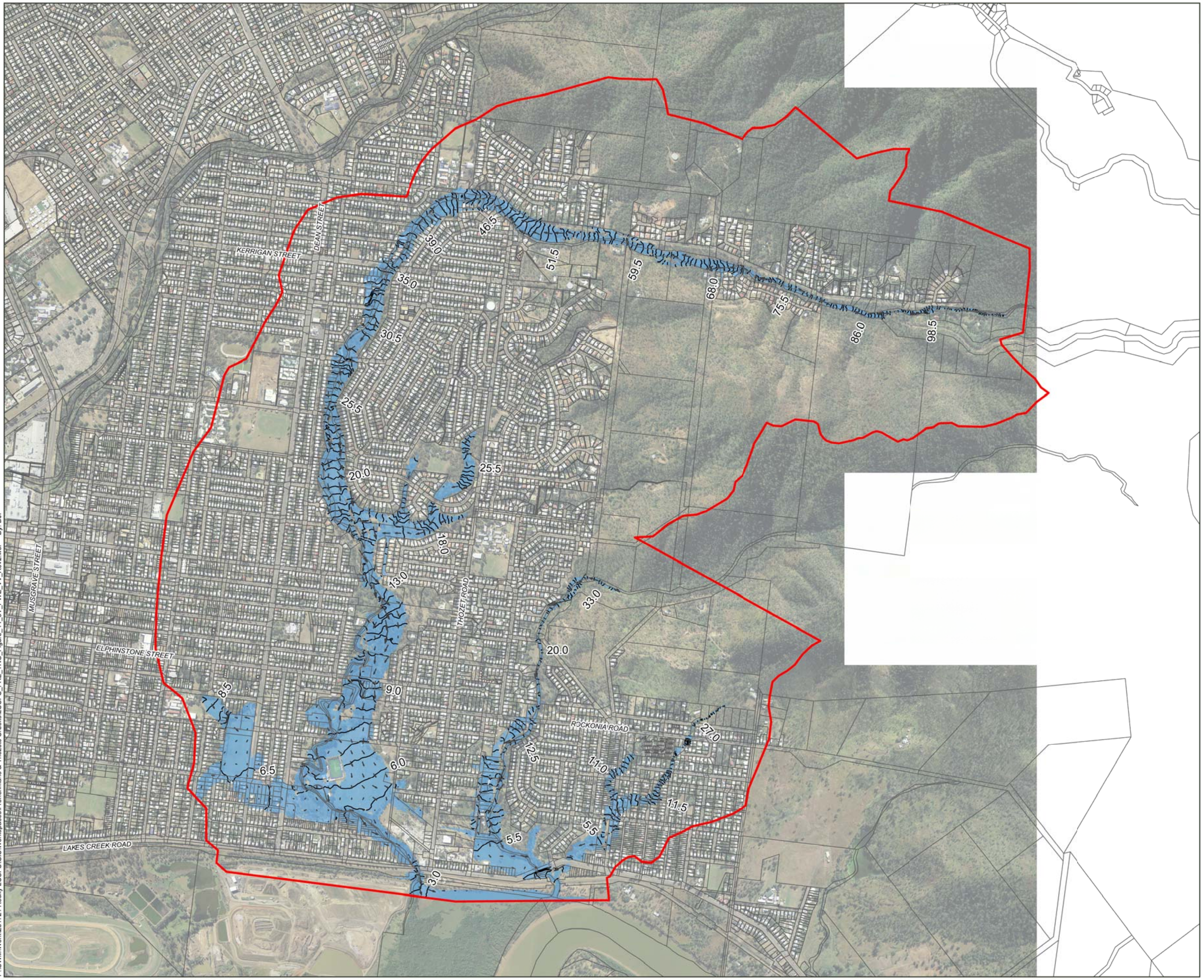
1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 10: Existing Conditions - 2 Year ARI Peak Hazard



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Rockhampton Regional Council

Australian Government Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- Inundation Extents
- 0.5m (AHD) Peak Water Surface Elevation Contour
- Velocity Vector
  - represents velocity at time of peak water level
  - reference vector = 3 m/s

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014 Version: 2

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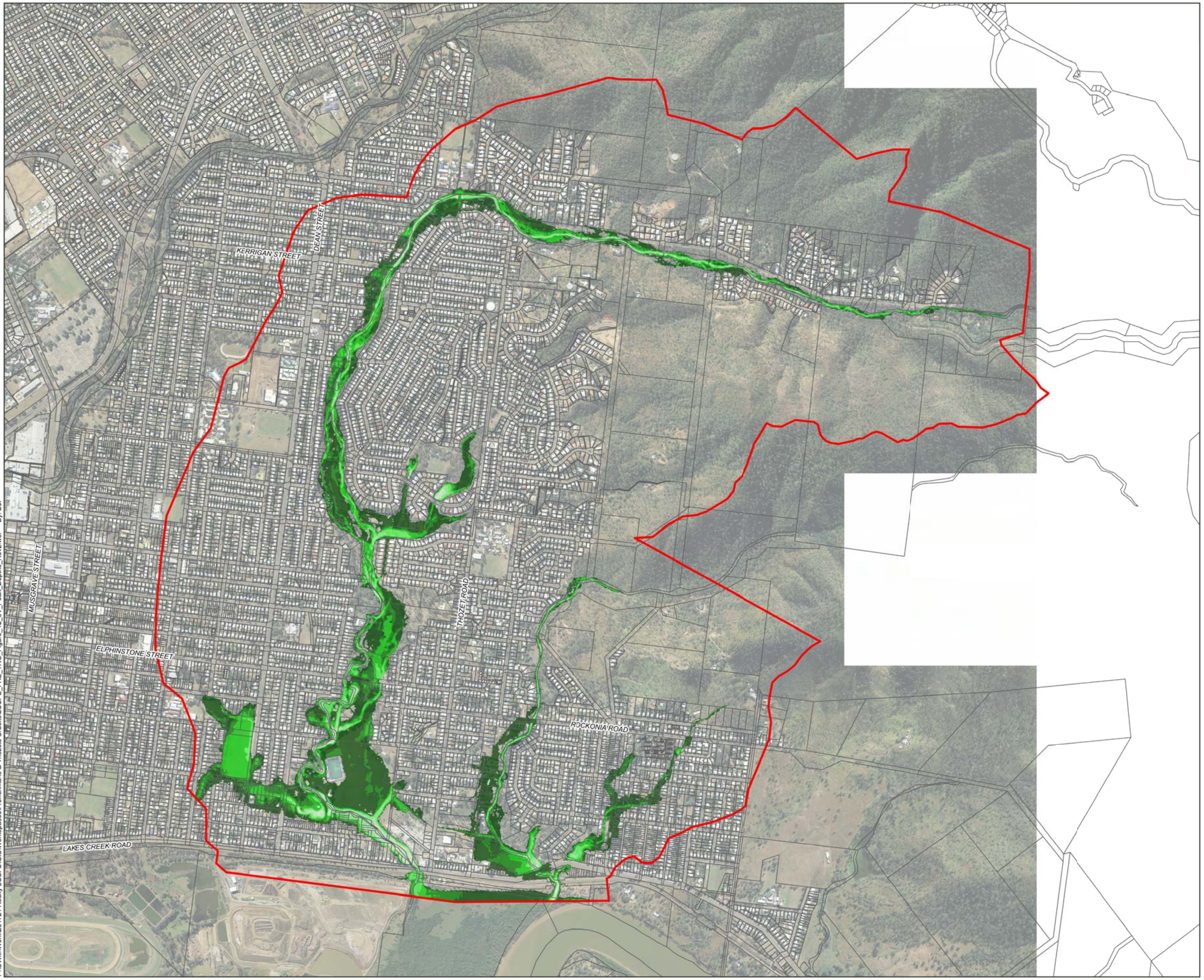
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 11: Existing Conditions - 5 Year ARI Inundation Extents, Peak Water Surface Elevations and Velocities



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Rockhampton Regional Council

Australian Government Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents

Depth (m)

0.0 to 0.3	2.5 to 3.0
0.3 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

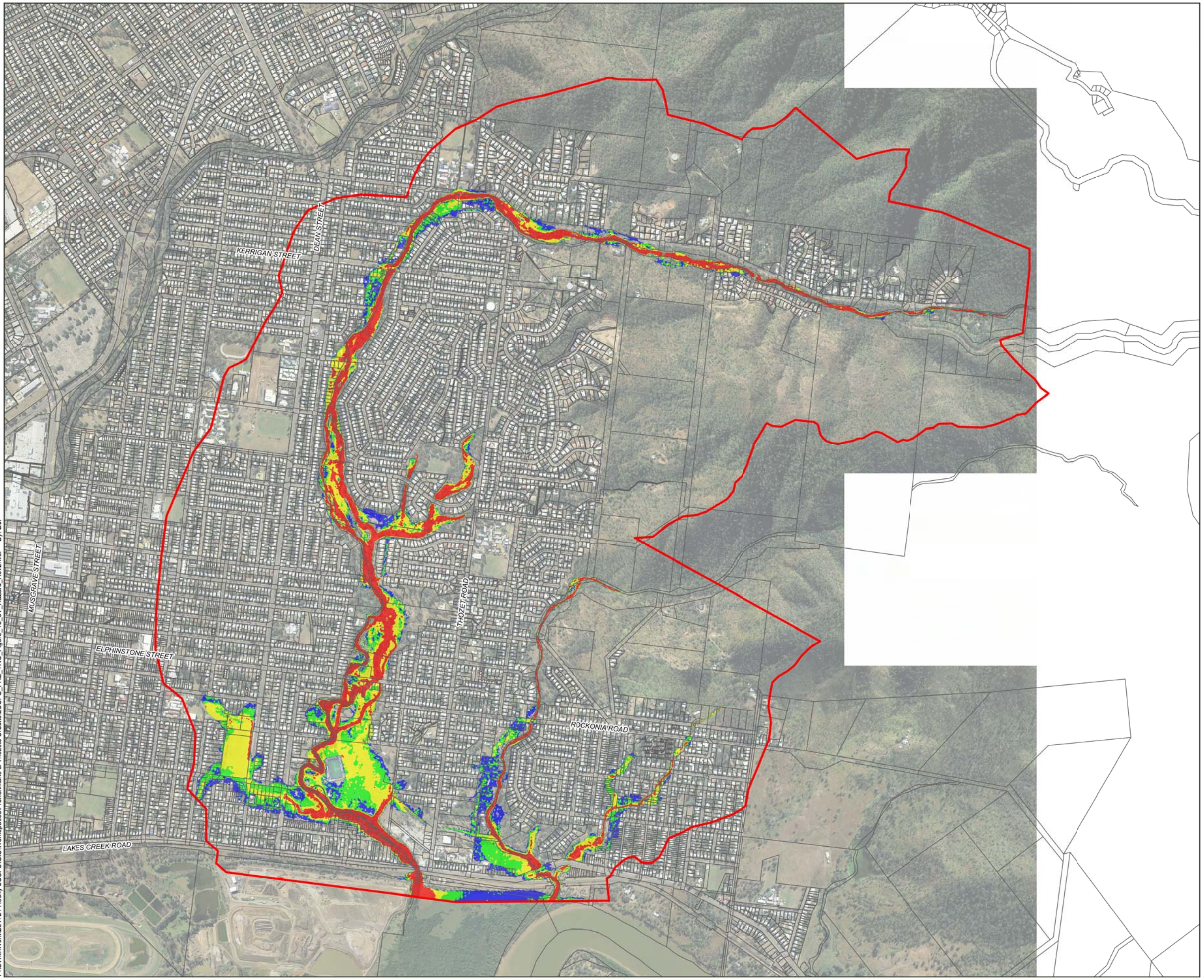
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 12: Existing Conditions - 5 Year ARI Peak Depths



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Rockhampton Regional Council

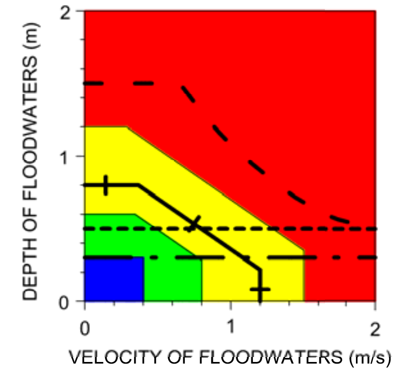
Australian Government Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents



Hazard Categories

Low

High

Medium

Extreme

Hazard Thresholds

Wading Limit - Children

Safe to Use Small Cars

Wading Limit - Adults

Safe to Use 4WDs

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014

Version: 2

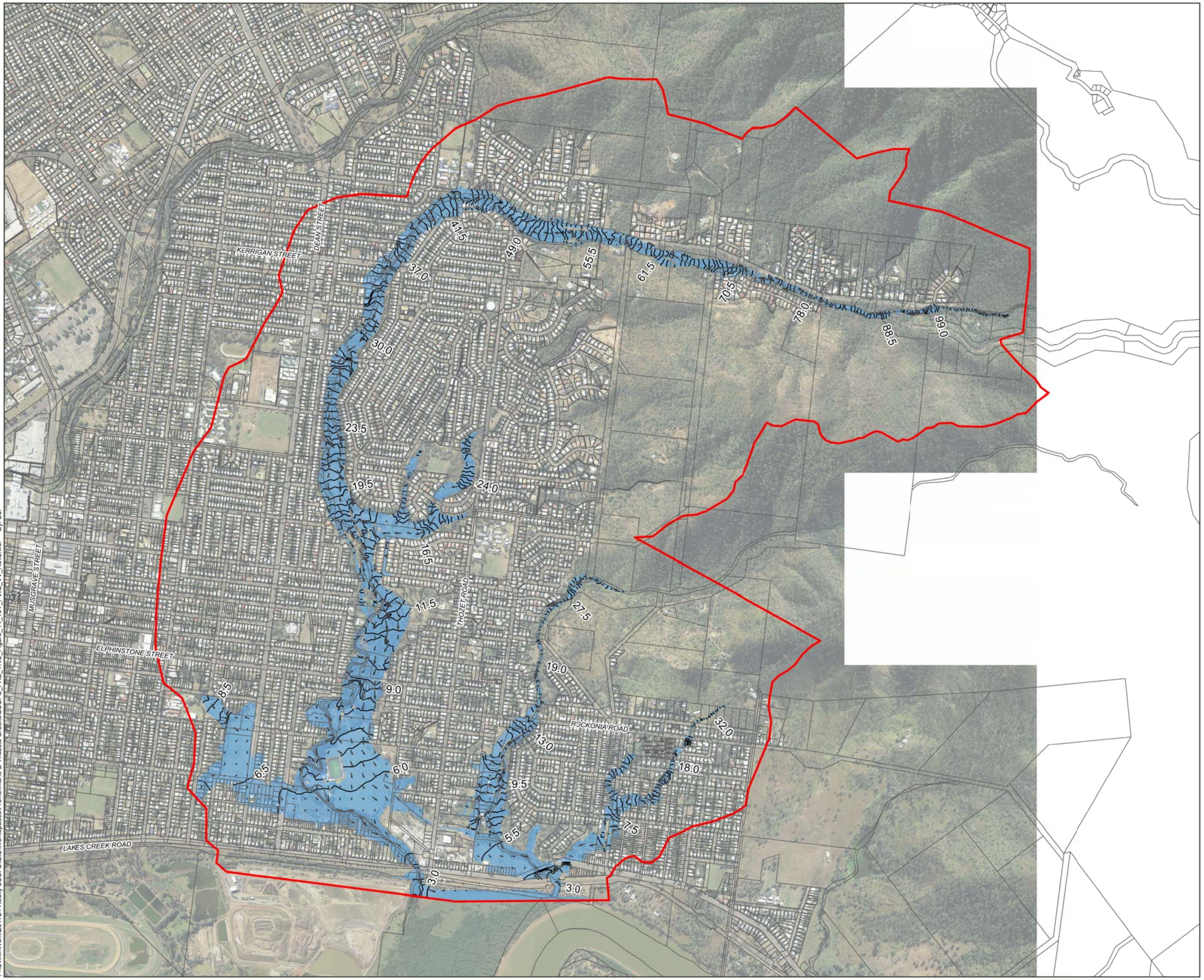
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 13: Existing Conditions - 5 Year ARI Peak Hazard



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Rockhampton Regional Council

Australian Government Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- Inundation Extents
- 0.5m (AHD) Peak Water Surface Elevation Contour
- Velocity Vector
  - represents velocity at time of peak water level
  - reference vector = 3 m/s

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014 **Version:** 2

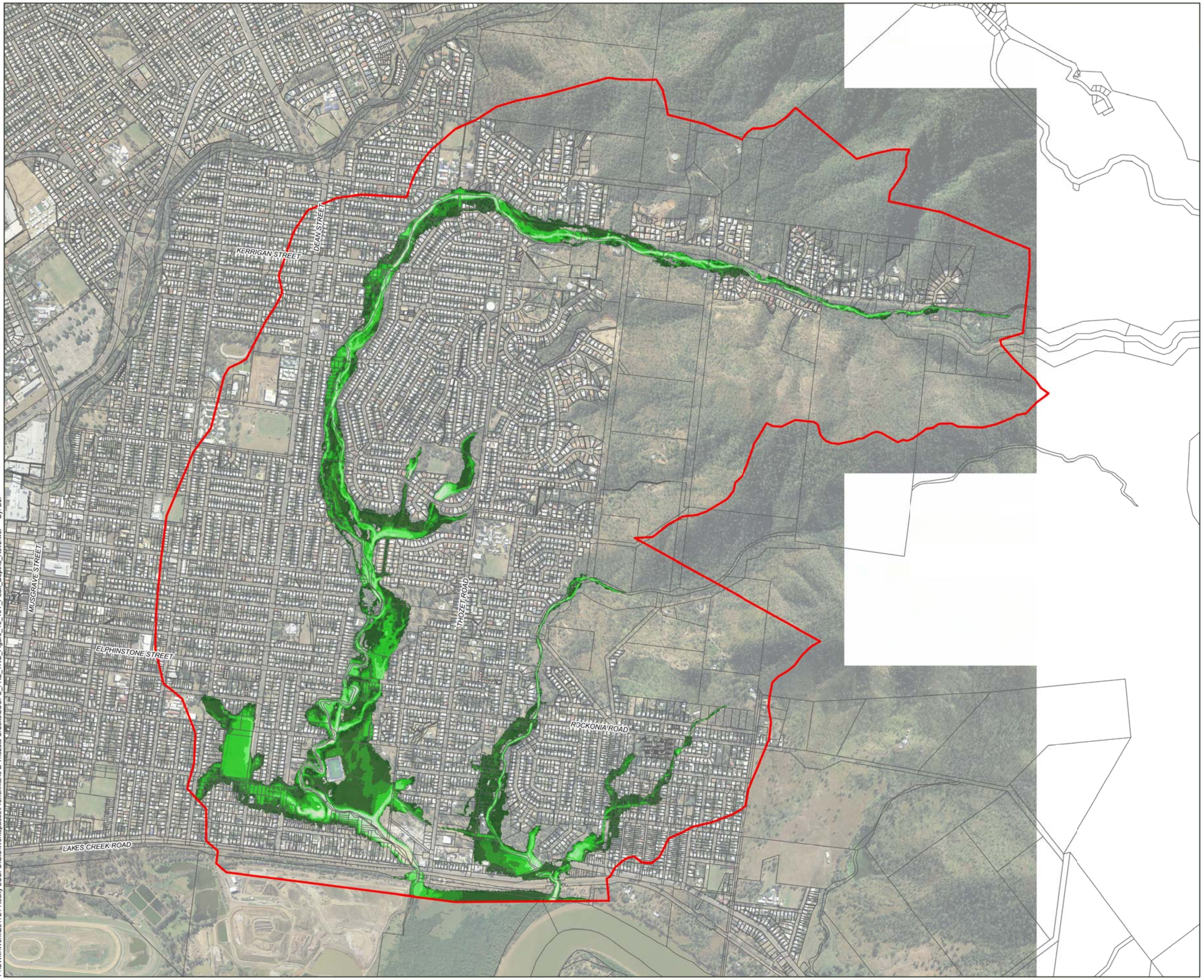
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 14: Existing Conditions - 10 Year ARI Inundation Extents, Peak Water Surface Elevations and Velocities



aurecon

Rockhampton Regional Council

Australian Government Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents

Depth (m)

- 0.0 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014 Version: 2

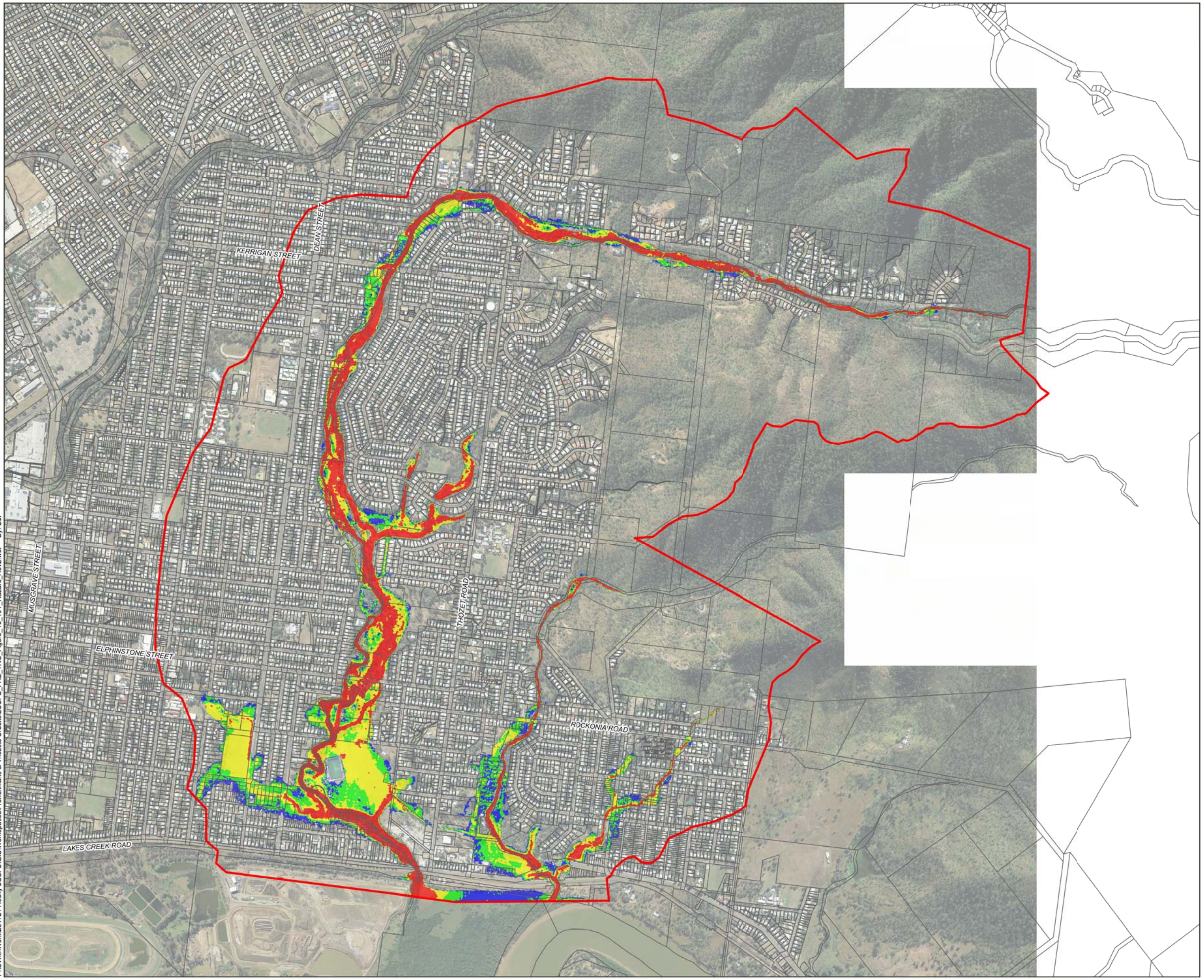
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

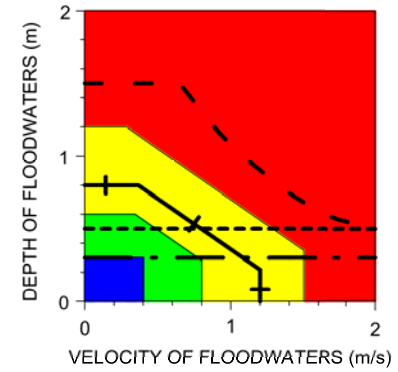
Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 15: Existing Conditions - 10 Year ARI Peak Depths



Legend

Cadastre
TUFLOW Model Extents



Hazard Categories

Low
High
Medium
Extreme

Hazard Thresholds

Wading Limit - Children
Safe to Use Small Cars
Wading Limit - Adults
Safe to Use 4WDs

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014 Version: 2

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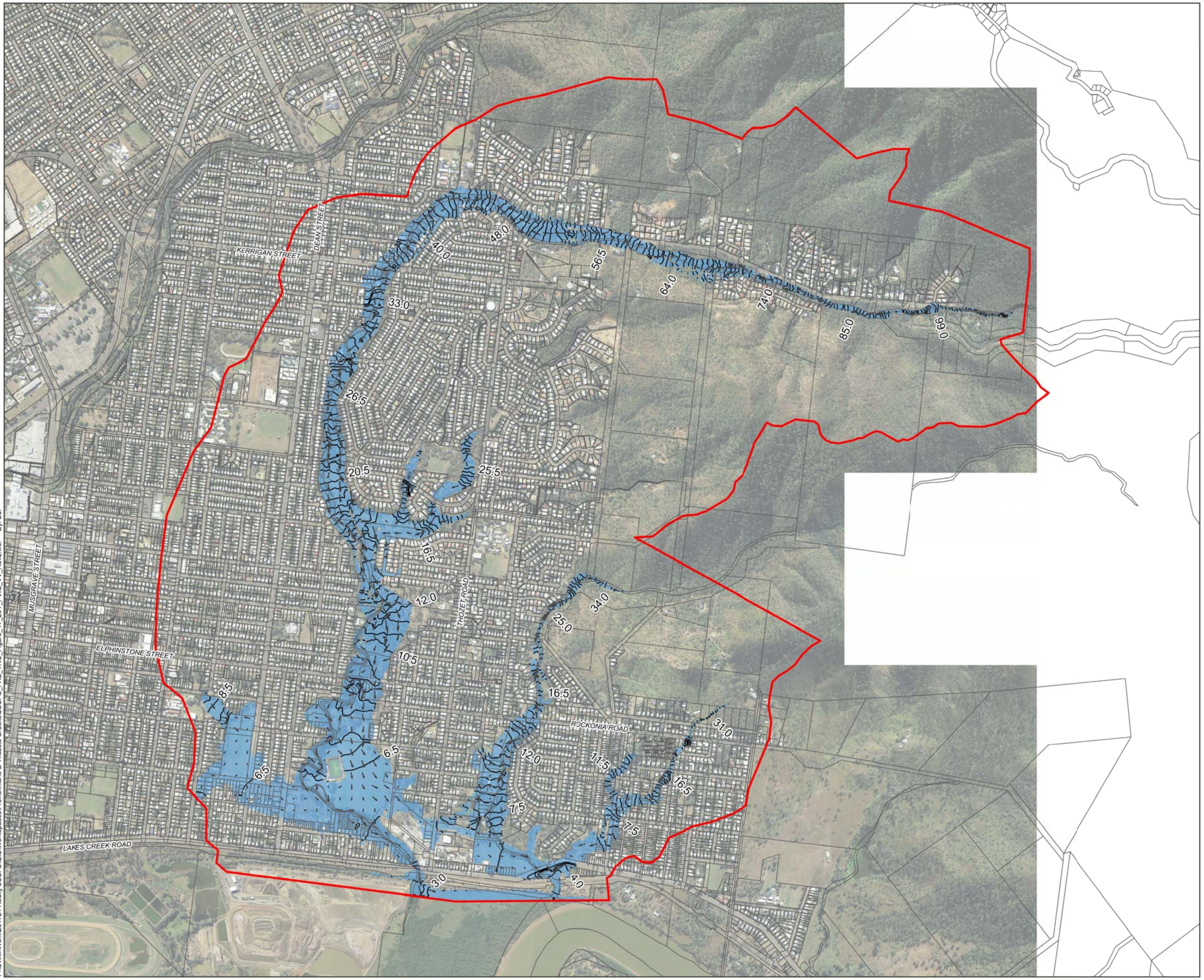
0 1000 (m)
Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 16: Existing Conditions - 10 Year ARI Peak Hazard



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Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents

Inundation Extents

Velocity Vector
- represents velocity at time of peak water level
- reference vector = 3 m/s

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

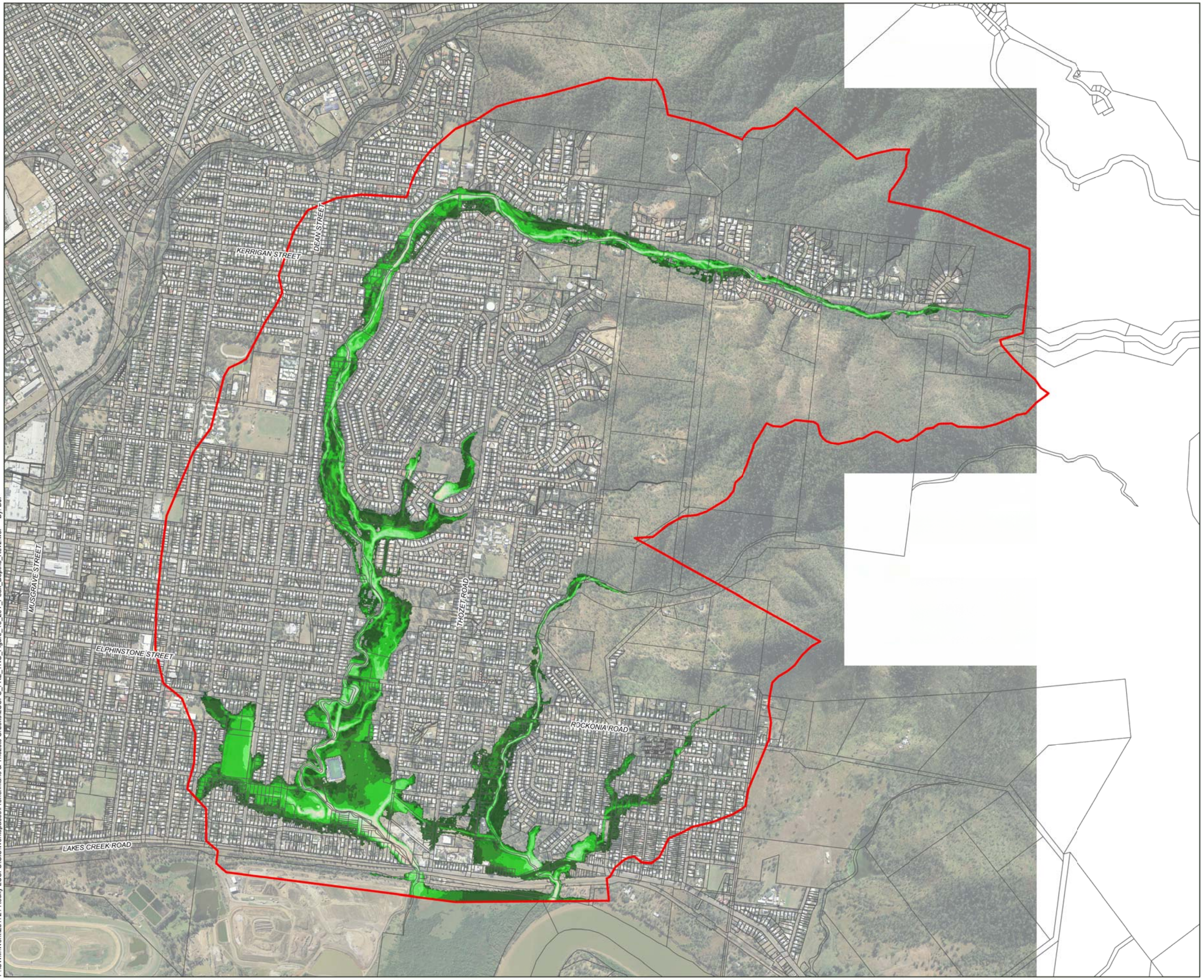
Date: 29/05/2014 Version: 2

0 1000 (m)
Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 17: Existing Conditions - 20 Year ARI Inundation Extents, Peak Water Surface Elevations and Velocities



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aurecon

Rockhampton Regional Council

Australian Government Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents

Depth (m)

0.0 to 0.3	2.5 to 3.0
0.3 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014 Version: 2

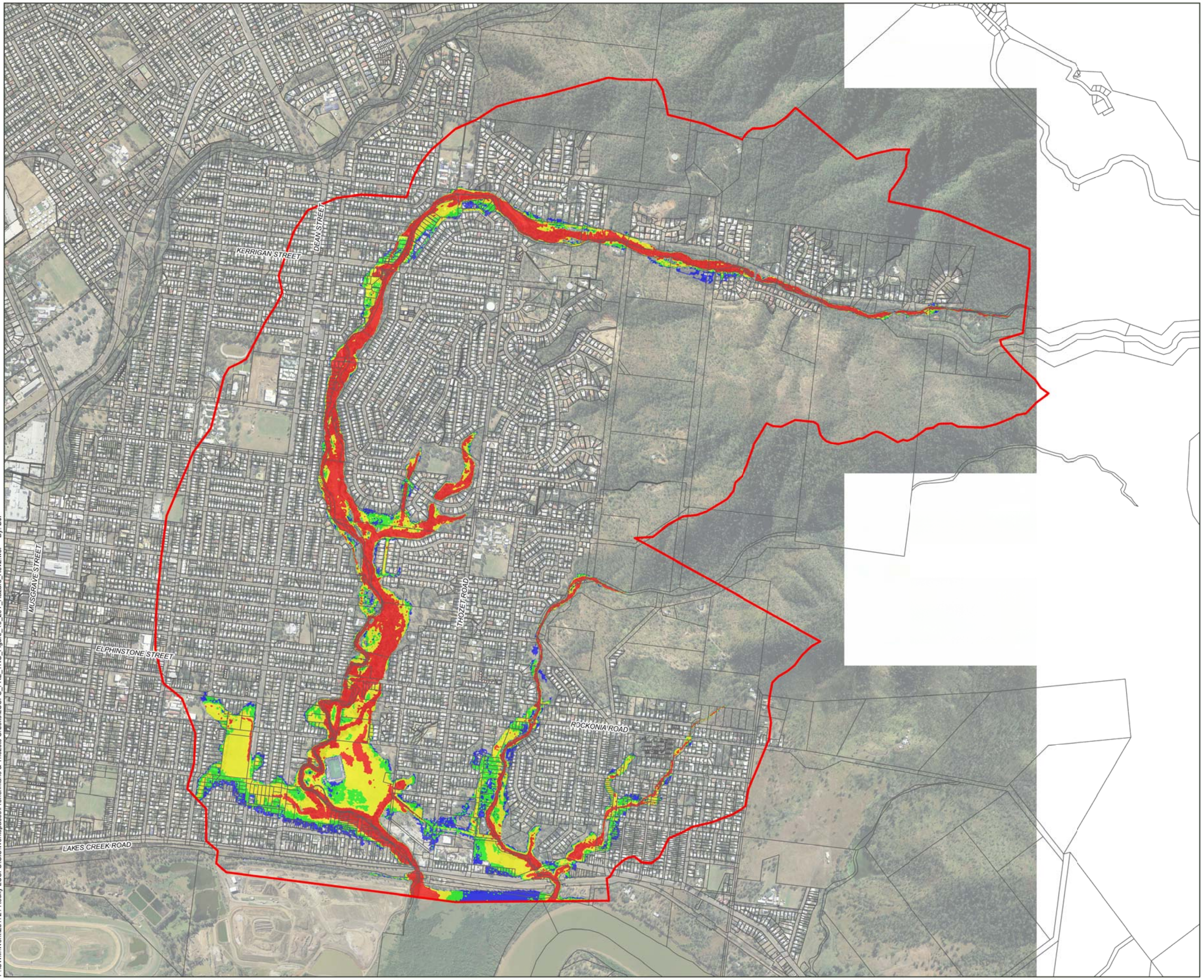
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 18: Existing Conditions - 20 Year ARI Peak Depths



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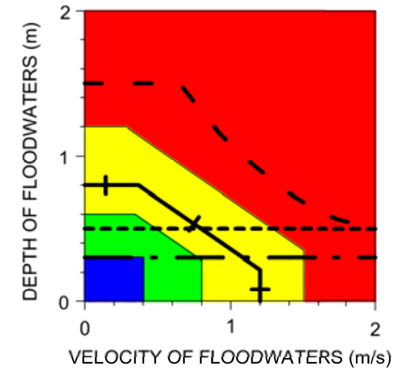
Queensland Government

Legend

Cadastre

TUFLOW Model Extents



Hazard Categories

Low

High

Medium

Extreme

Hazard Thresholds

Wading Limit - Children

Safe to Use Small Cars

Wading Limit - Adults

Safe to Use 4WDs

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014

Version: 2

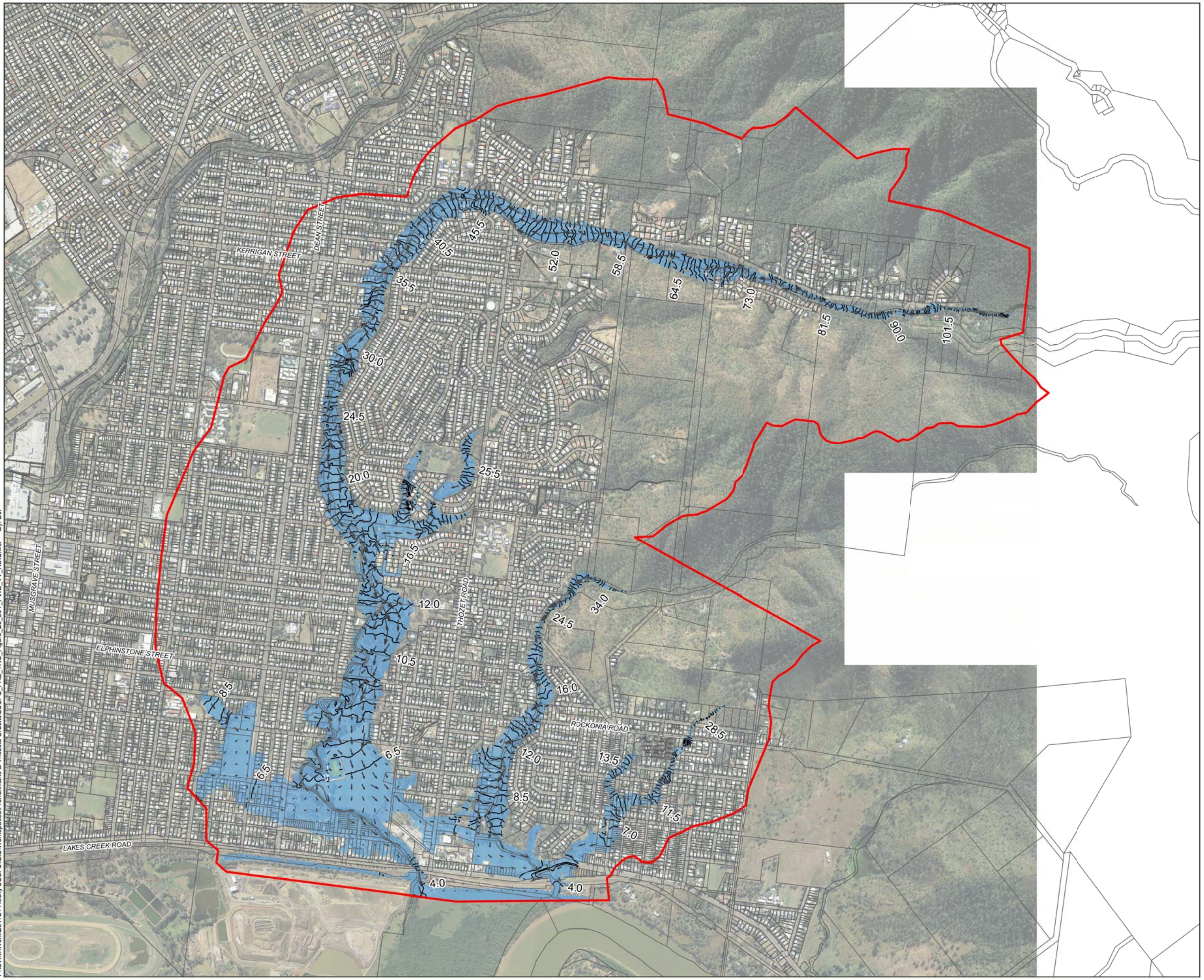
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 19: Existing Conditions - 20 Year ARI Peak Hazard



P:\SWM\Work\231721 Rocky LCCFS\GIS\Workspaces\Frenchmans & Thozets Creeks\LCCFS_FRE_THO_Figure_20_50Y_PWE_VV_Rev2.wor By: DJF

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Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents

Inundation Extents

0.5m (AHD) Peak Water Surface Elevation Contour

Velocity Vector
- represents velocity at time of peak water level
- reference vector = 3 m/s

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

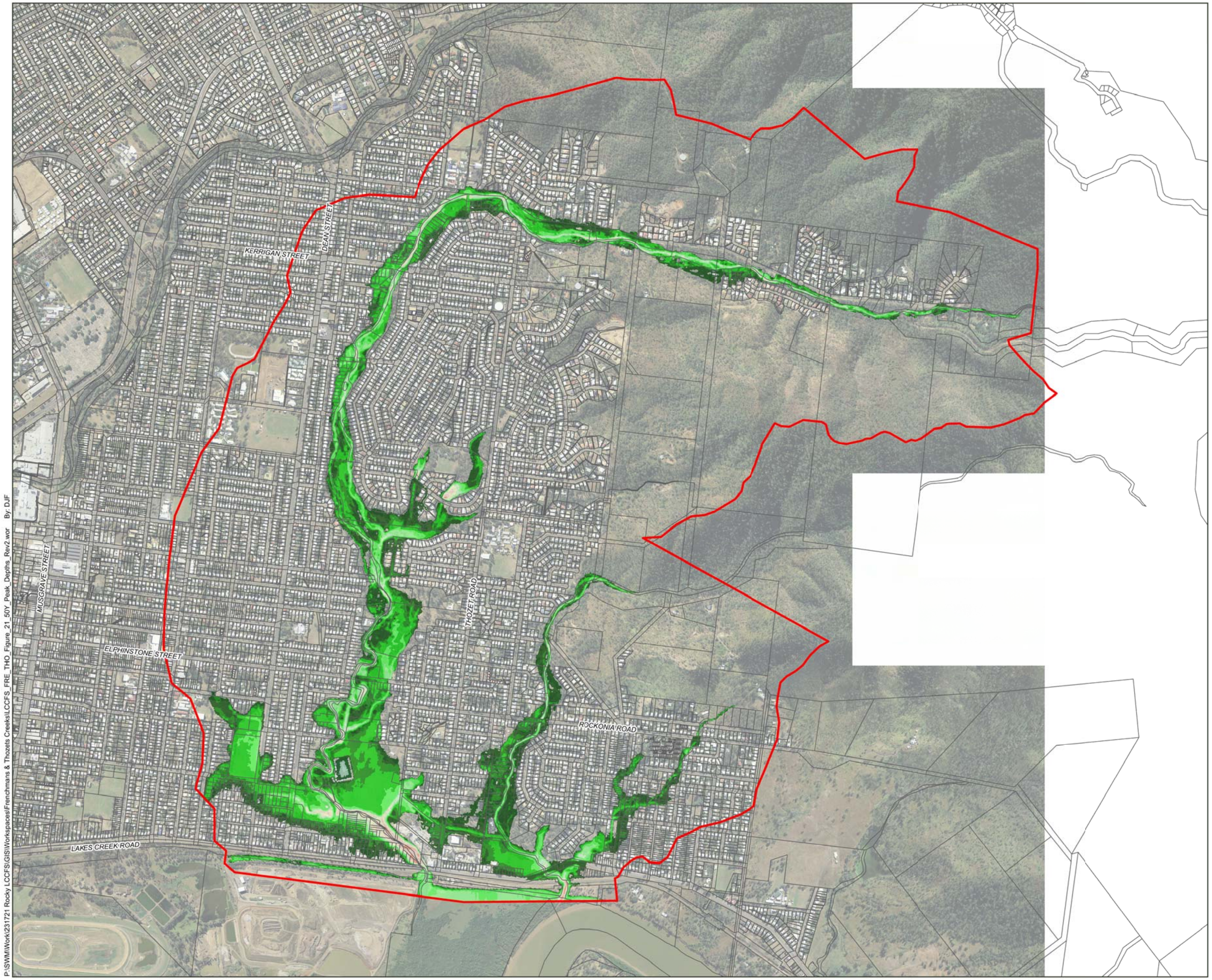
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 20: Existing Conditions - 50 Year ARI Inundation Extents, Peak Water Surface Elevations and Velocities



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Rockhampton Regional Council

Australian Government Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents

Depth (m)

0.0 to 0.3	2.5 to 3.0
0.3 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 Version: 2

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 21: Existing Conditions - 50 Year ARI Peak Depths

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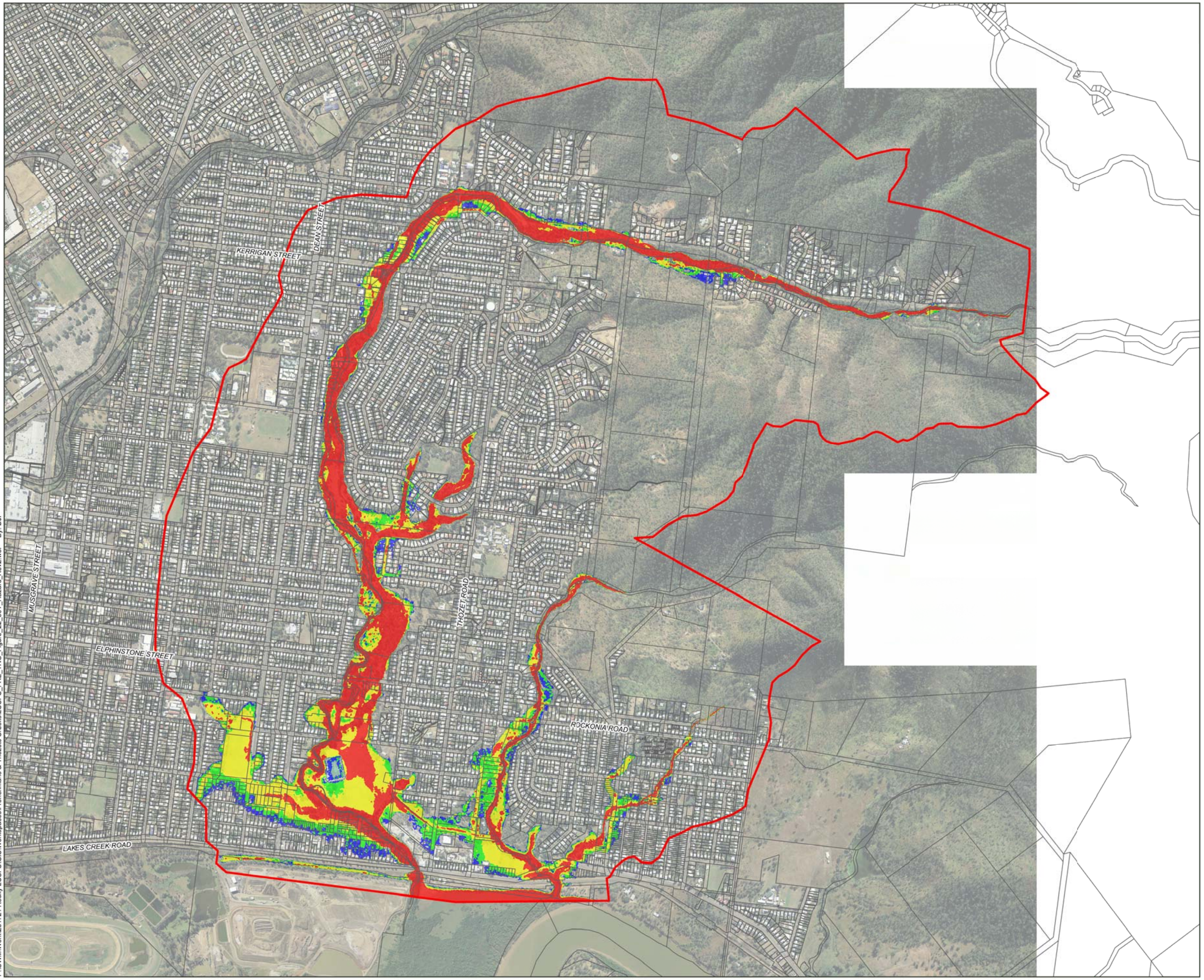

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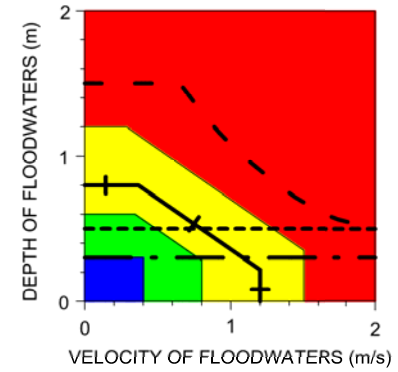
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents



Hazard Categories

Low
High
Medium
Extreme

Hazard Thresholds

Wading Limit - Children
Safe to Use Small Cars
Wading Limit - Adults
Safe to Use 4WDs

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014

Version: 2

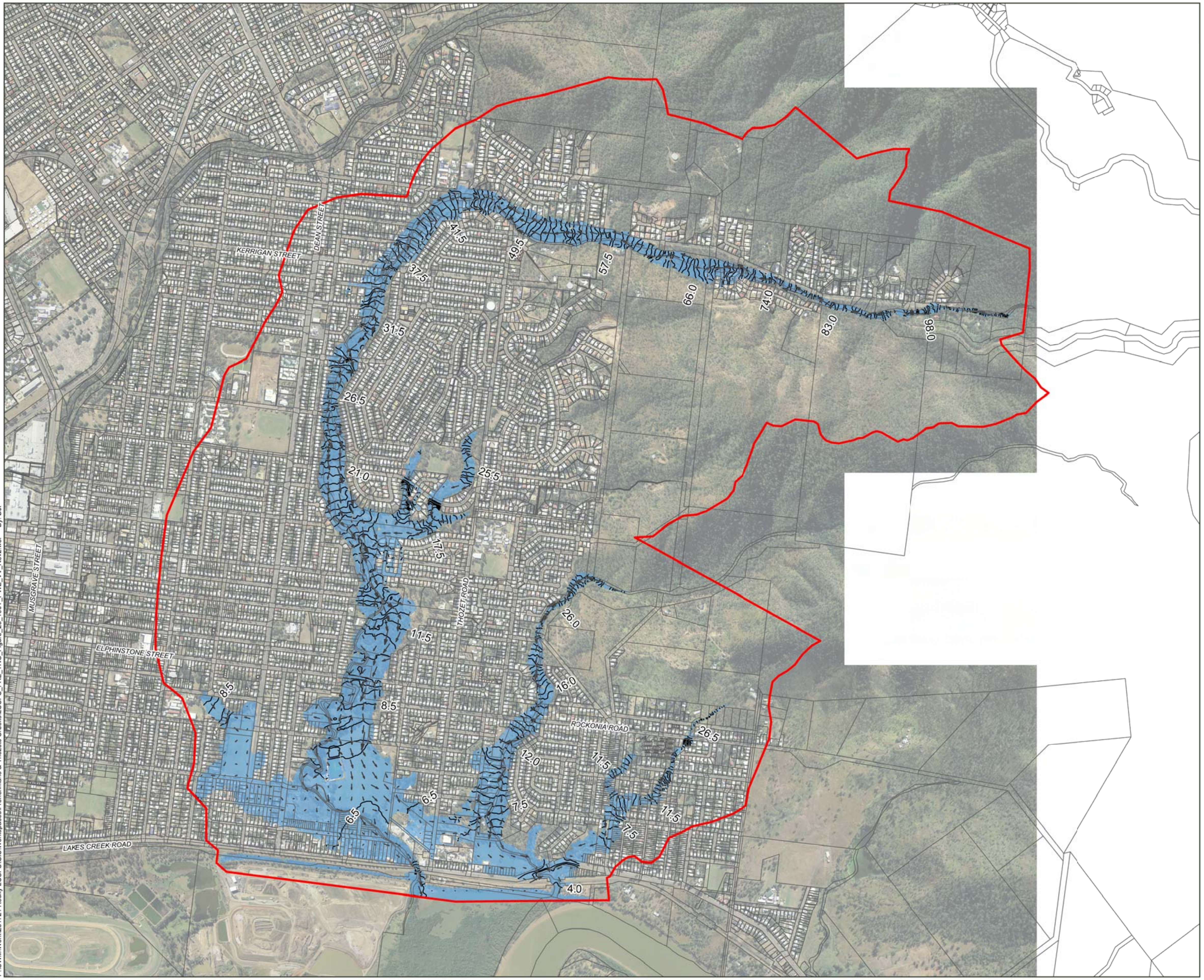
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 22: Existing Conditions - 50 Year ARI Peak Hazard



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Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- Inundation Extents
- 0.5m (AHD) Peak Water Surface Elevation Contour
- Velocity Vector
  - represents velocity at time of peak water level
  - reference vector = 3 m/s

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 Version: 2

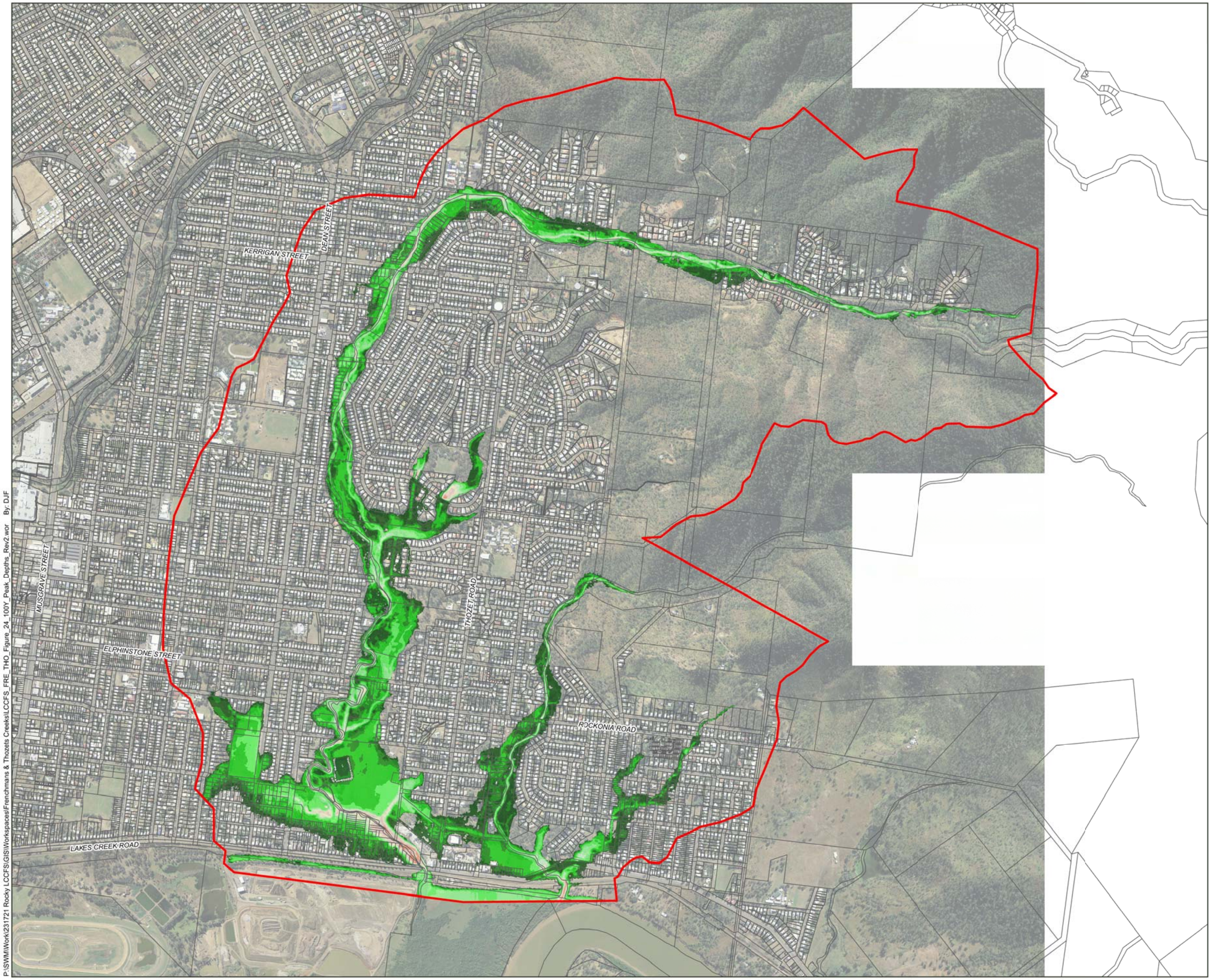
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 23: Existing Conditions - 100 Year ARI Inundation Extents, Peak Water Surface Elevations and Velocities



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Rockhampton Regional Council

Australian Government Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents

Depth (m)

0.0 to 0.3	2.5 to 3.0
0.3 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
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4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 24: Existing Conditions - 100 Year ARI Peak Depths

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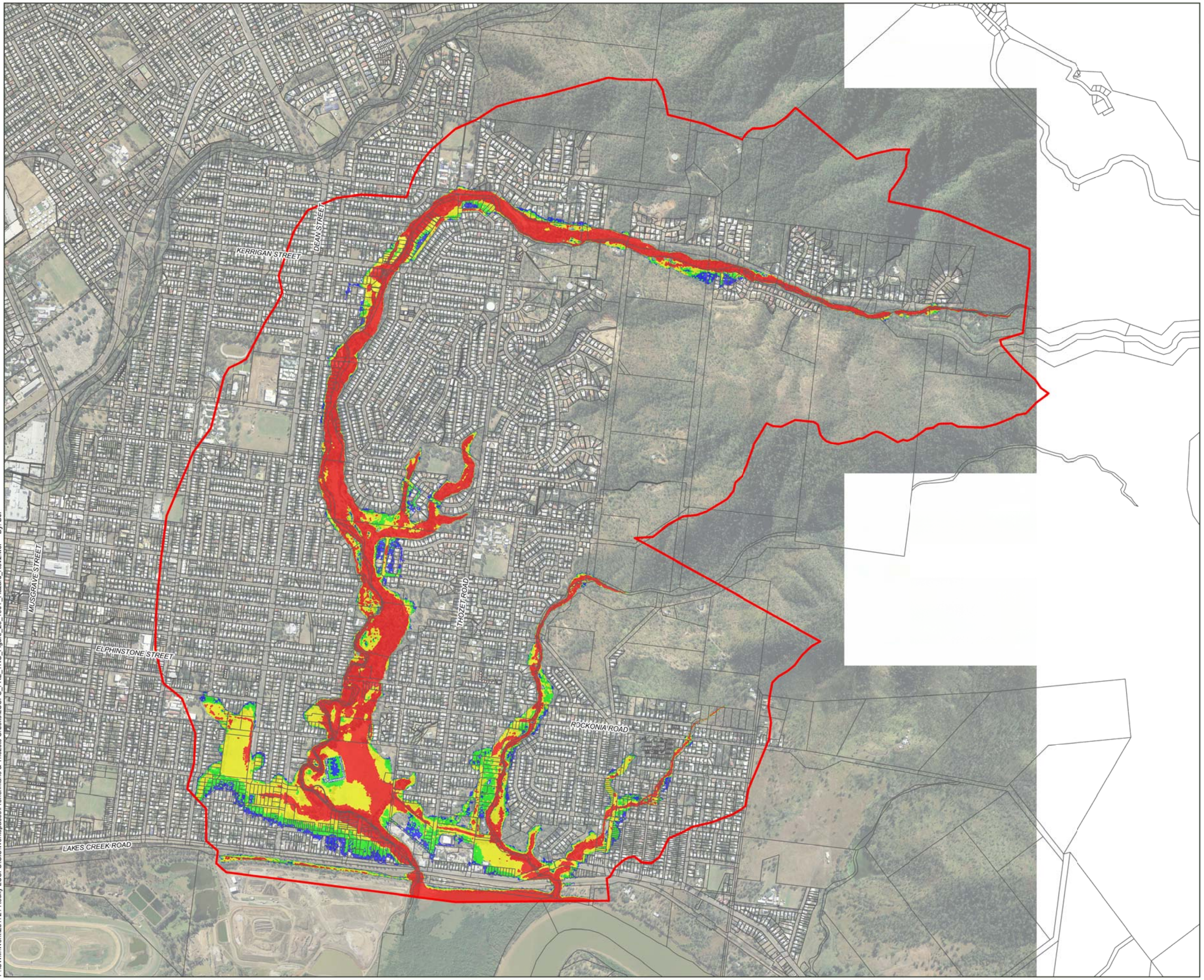

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Rockhampton Regional Council

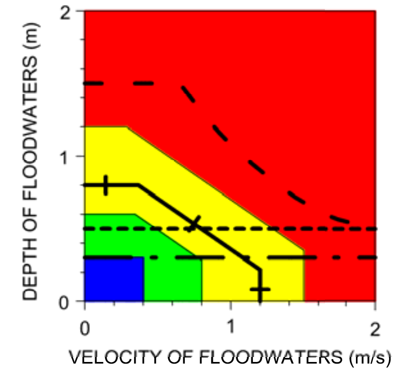
Australian Government
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents



Hazard Categories

Low

High

Medium

Extreme

Hazard Thresholds

Wading Limit - Children

Safe to Use Small Cars

Wading Limit - Adults

Safe to Use 4WDs

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
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4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
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6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014

Version: 2

0

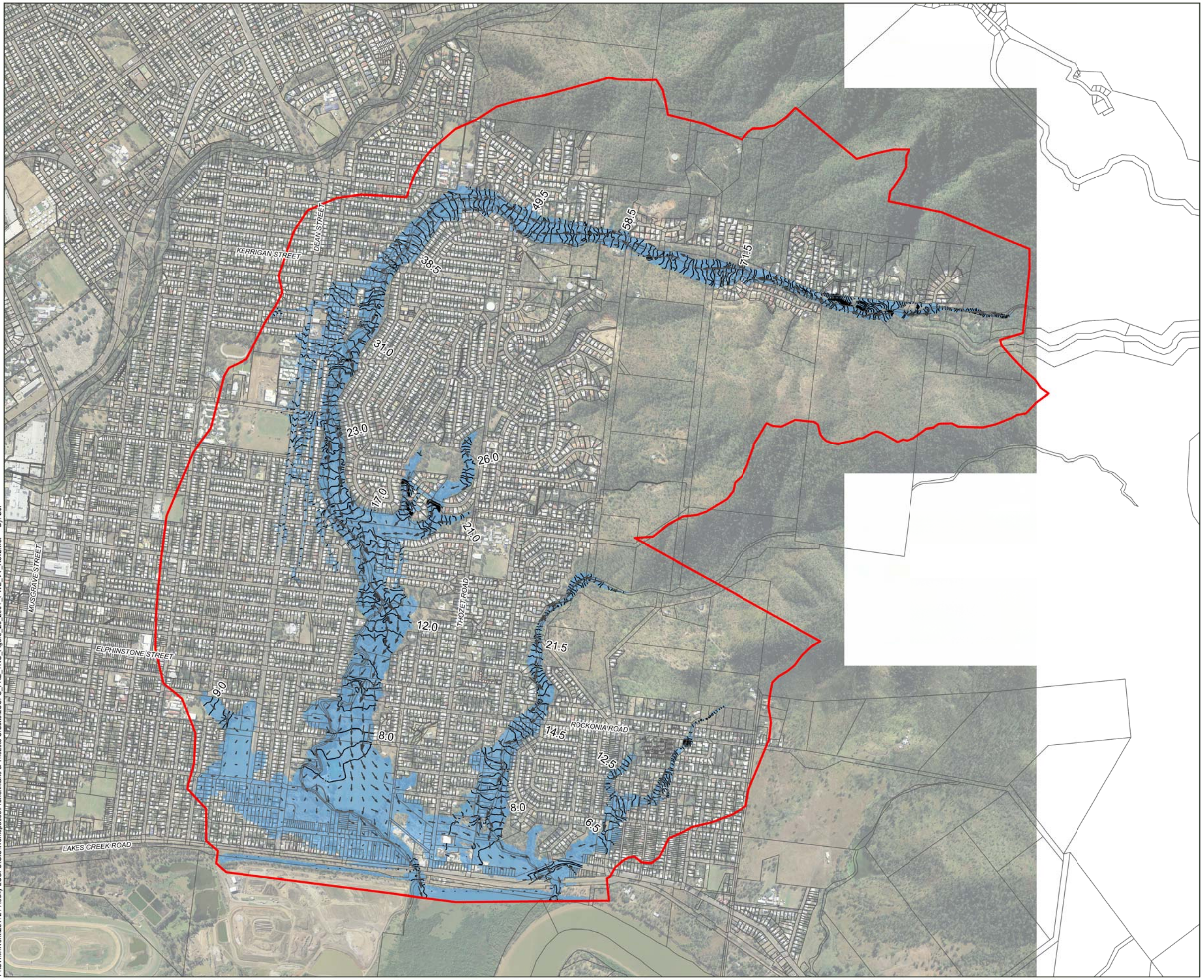
1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 25: Existing Conditions - 100 Year ARI Peak Hazard



P:\SWM\Work\231721 Rocky LCCFS\GIS\Workspaces\Frenchmans & Thozets Creeks\LCCFS_FRE_THO_Figure_26_200Y_PWE_VV_Rev2.wor By: DJF

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Rockhampton Regional Council

Australian Government Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- Inundation Extents
- 0.5m (AHD) Peak Water Surface Elevation Contour
- Velocity Vector
  - represents velocity at time of peak water level
  - reference vector = 3 m/s

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
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3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
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6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 Version: 2

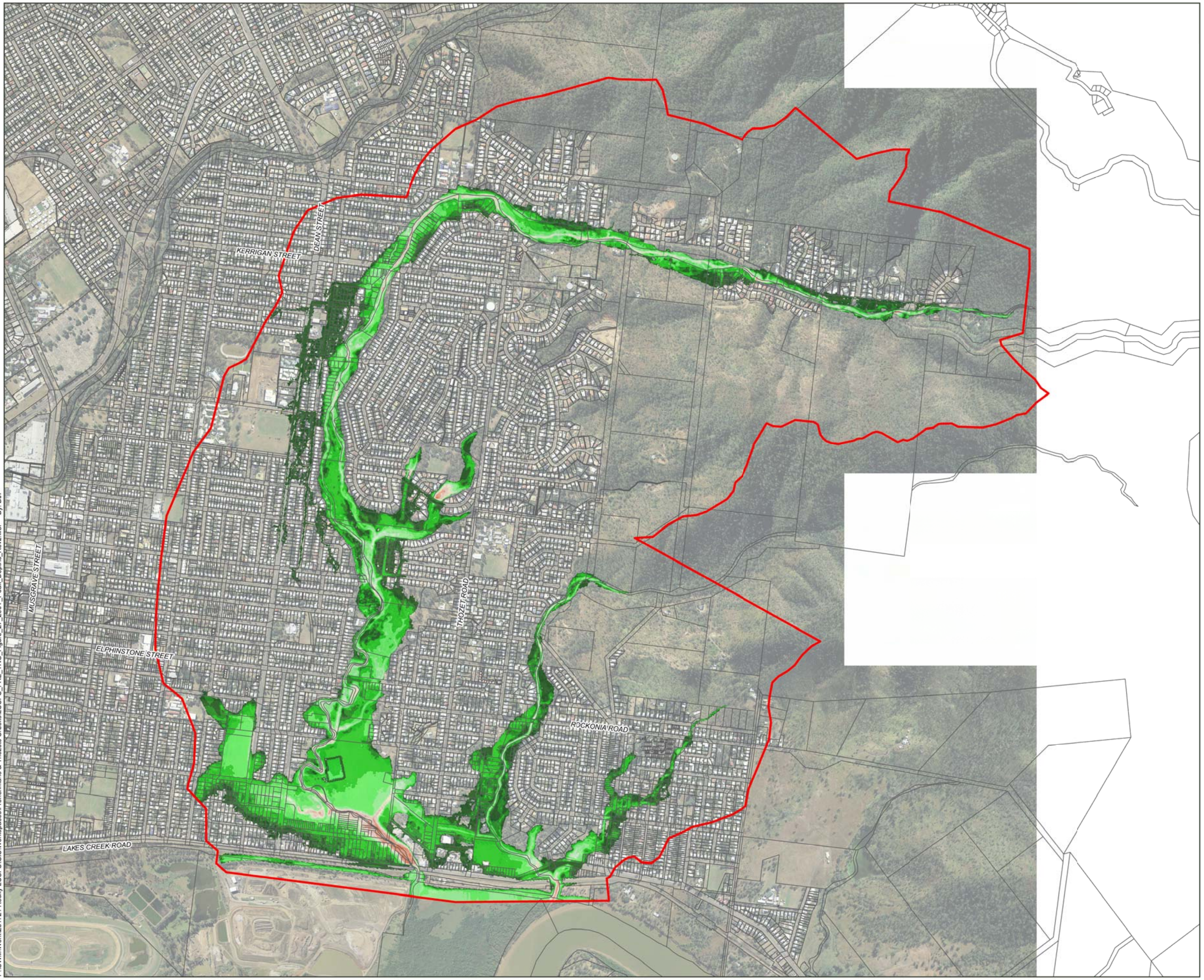
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 26: Existing Conditions - 200 Year ARI Inundation Extents, Peak Water Surface Elevations and Velocities



Rockhampton Regional Council

Australian Government Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents

Depth (m)

- 0.0 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
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3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 27: Existing Conditions - 200 Year ARI Peak Depths

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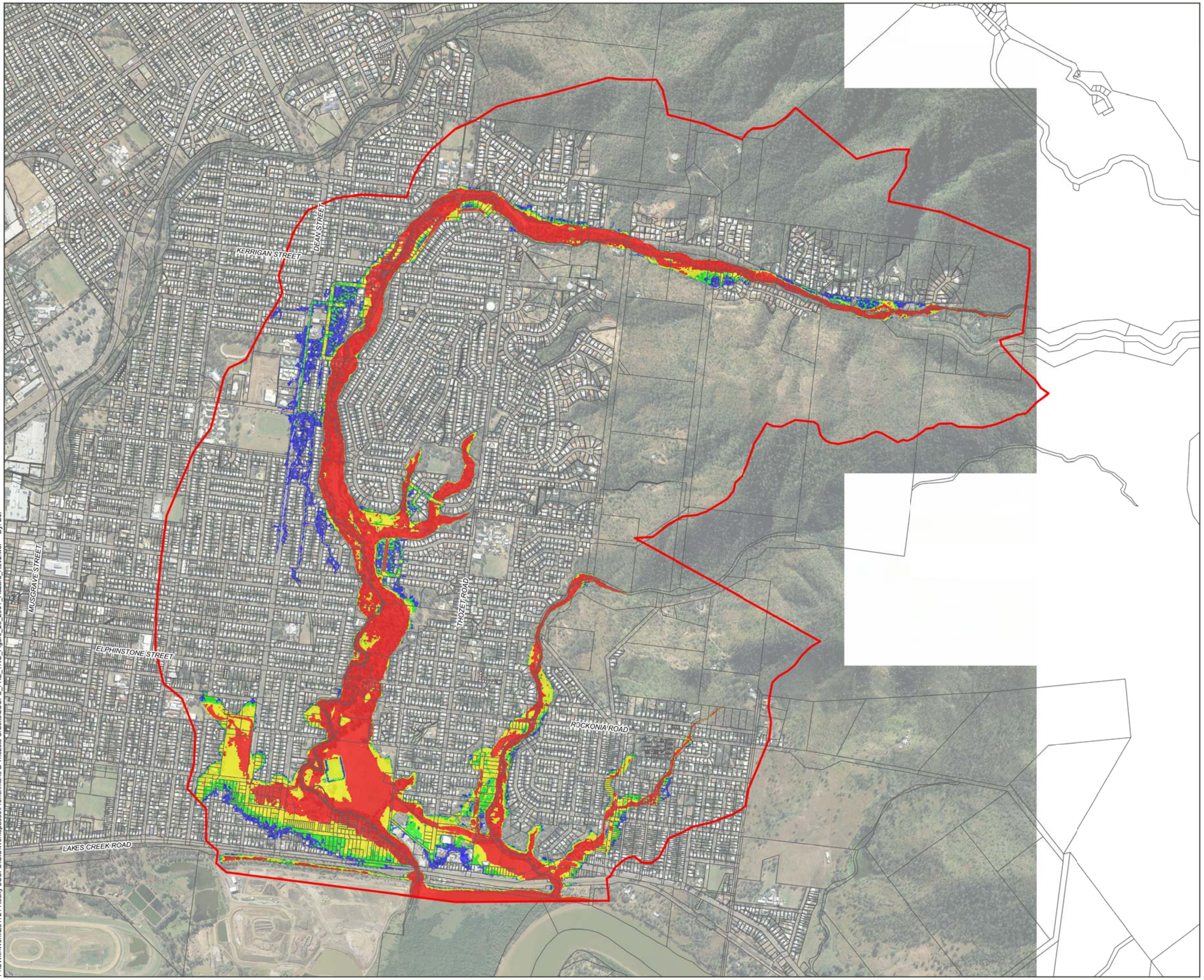
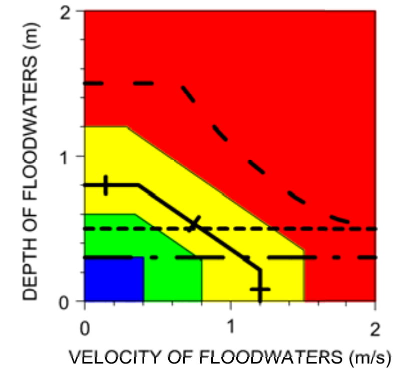
Queensland Government



Legend

Cadastre

TUFLOW Model Extents



Hazard Categories

Low

Medium

High

Extreme

Hazard Thresholds

Wading Limit - Children

Wading Limit - Adults

Safe to Use Small Cars

Safe to Use 4WDs

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 Version: 2

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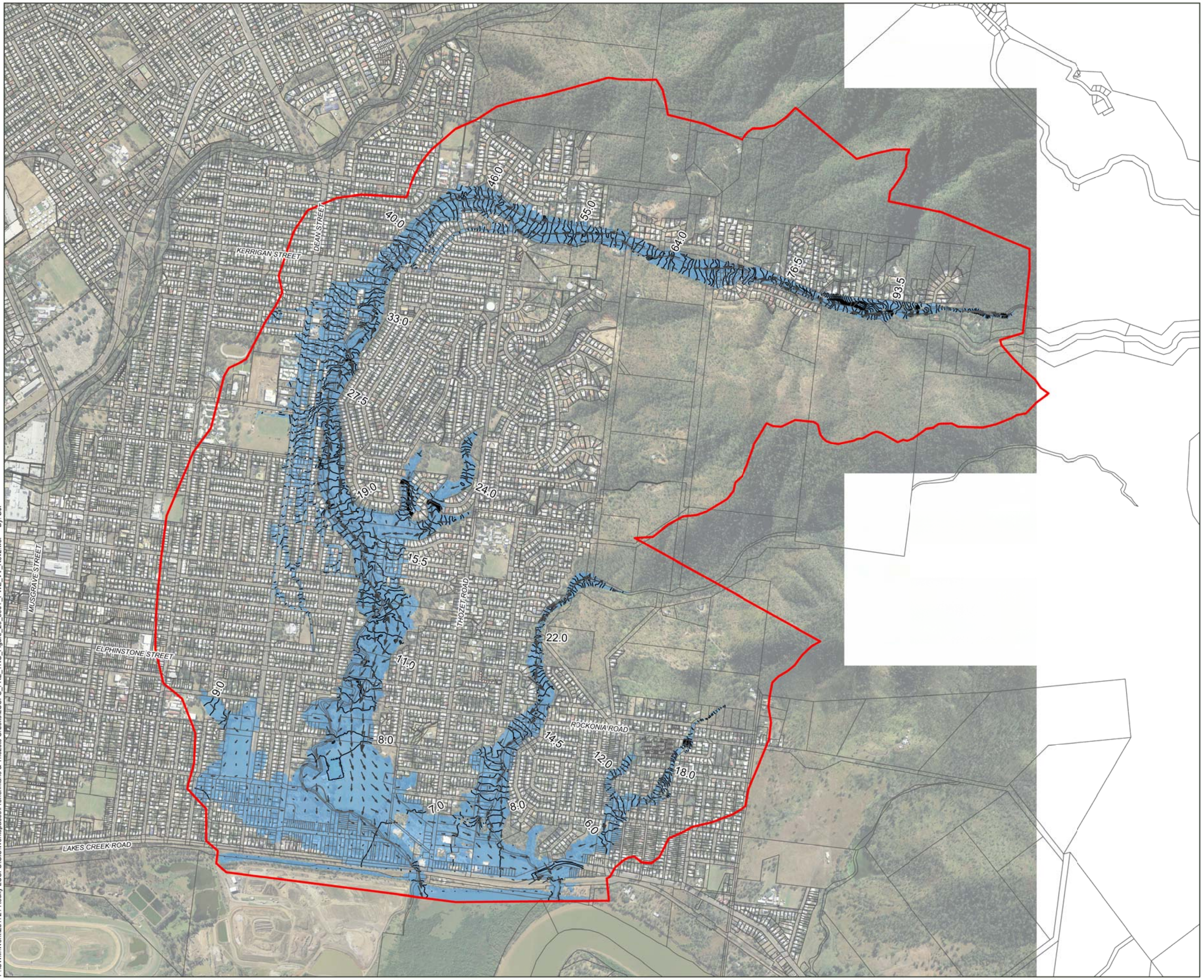
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 28: Existing Conditions - 200 Year ARI Peak Hazard



P:\SWM\Work\231721 Rocky LCCFS\GIS\Workspaces\Frenchmans & Thozets Creeks\LCCFS_FRE_THO_Figure_29_500Y_PWE_VV_Rev2.wor By: DJF

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Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- Inundation Extents
- 0.5m (AHD) Peak Water Surface Elevation Contour
- Velocity Vector
  - represents velocity at time of peak water level
  - reference vector = 3 m/s

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

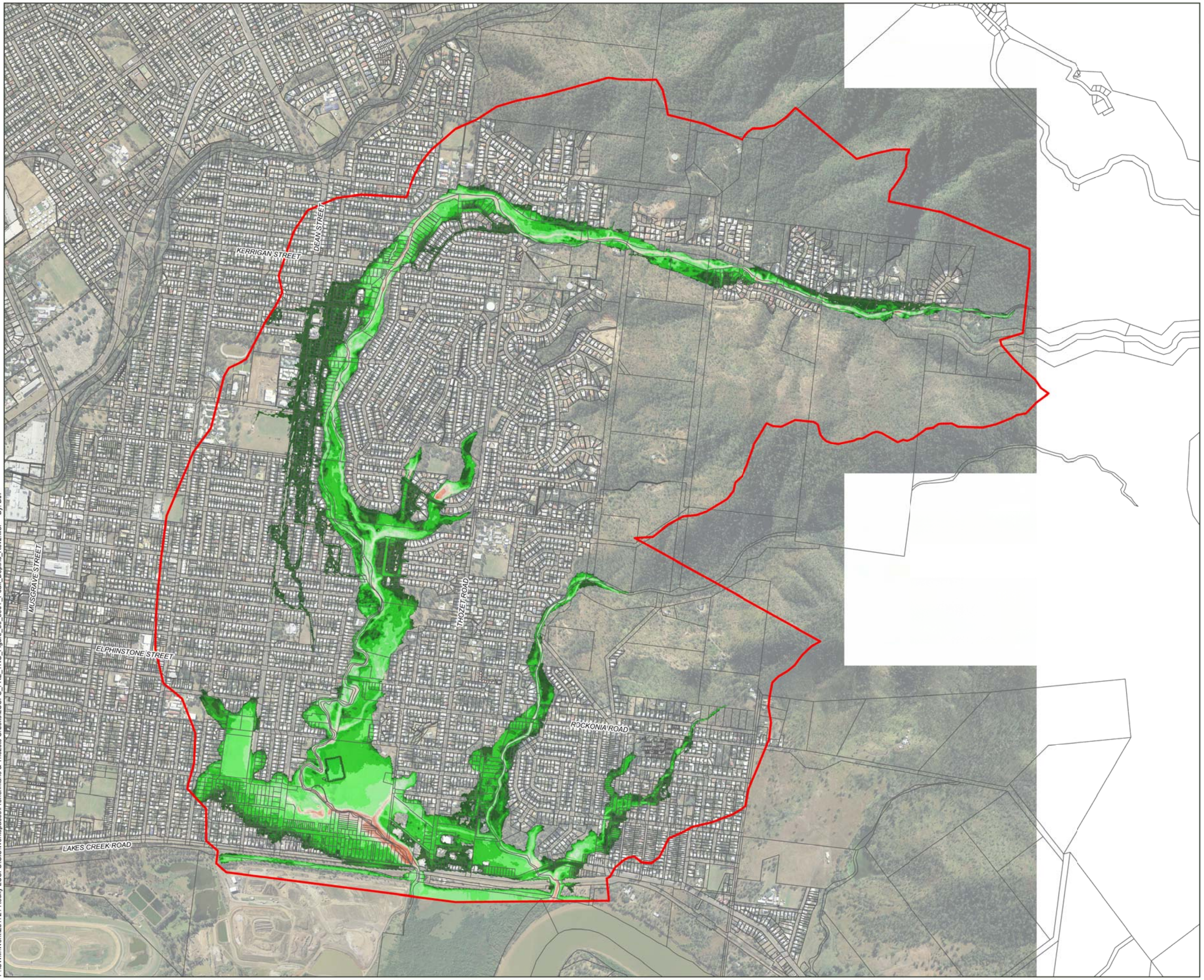
Date: 29/05/2014 **Version: 2**

0 1000 (m)
Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 29: Existing Conditions - 500 Year ARI Inundation Extents, Peak Water Surface Elevations and Velocities



P:\SWM\Work\231721 Rocky LCCFS\GIS\Workspaces\Frenchmans & Thozets Creeks\LCCFS_FRE_THO_Figure_30_500Y_Peak_Depths_Rev2.wor By: DJF

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Rockhampton Regional Council

Australian Government Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents

Depth (m)

0.0 to 0.3	2.5 to 3.0
0.3 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 Version: 2

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 30: Existing Conditions - 500 Year ARI Peak Depths

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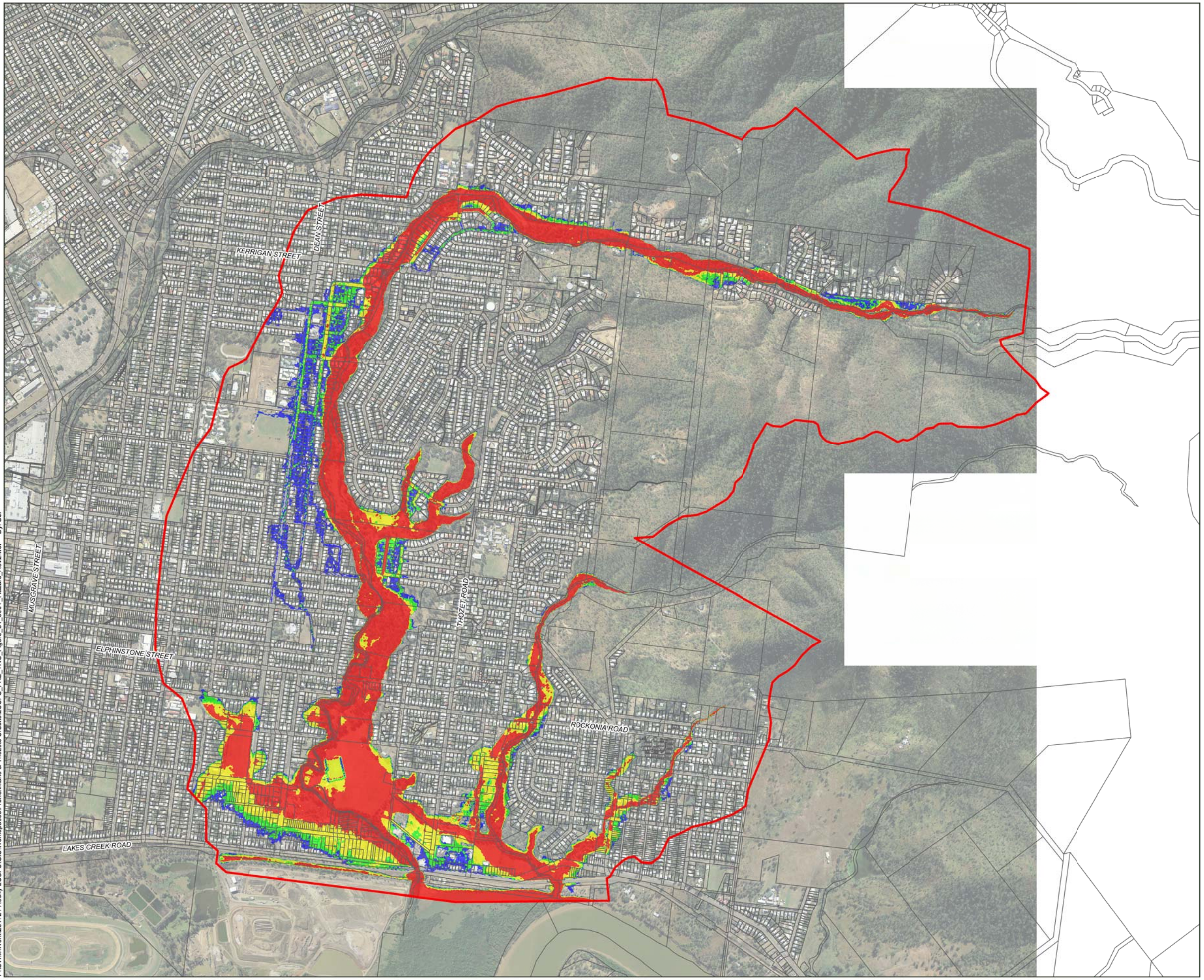
Australian Government Attorney-General's Department

Queensland Government

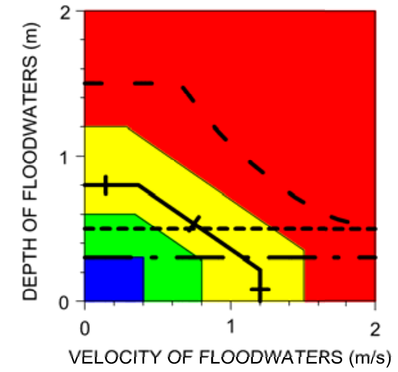


P:\SWMWork\231721 Rocky LCCFS\GIS\Workspaces\Frenchmans & Thozets Creeks\LCCFS_FRE_THO_Figure_31_500Y_Hazard_Rev2.wor By: DJF

Legend

Cadastre

TUFLOW Model Extents



Hazard Categories

Low

High

Medium

Extreme

Hazard Thresholds

Wading Limit - Children

Safe to Use Small Cars

Wading Limit - Adults

Safe to Use 4WDs

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014

Version: 2

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 31: Existing Conditions - 500 Year ARI Peak Hazard

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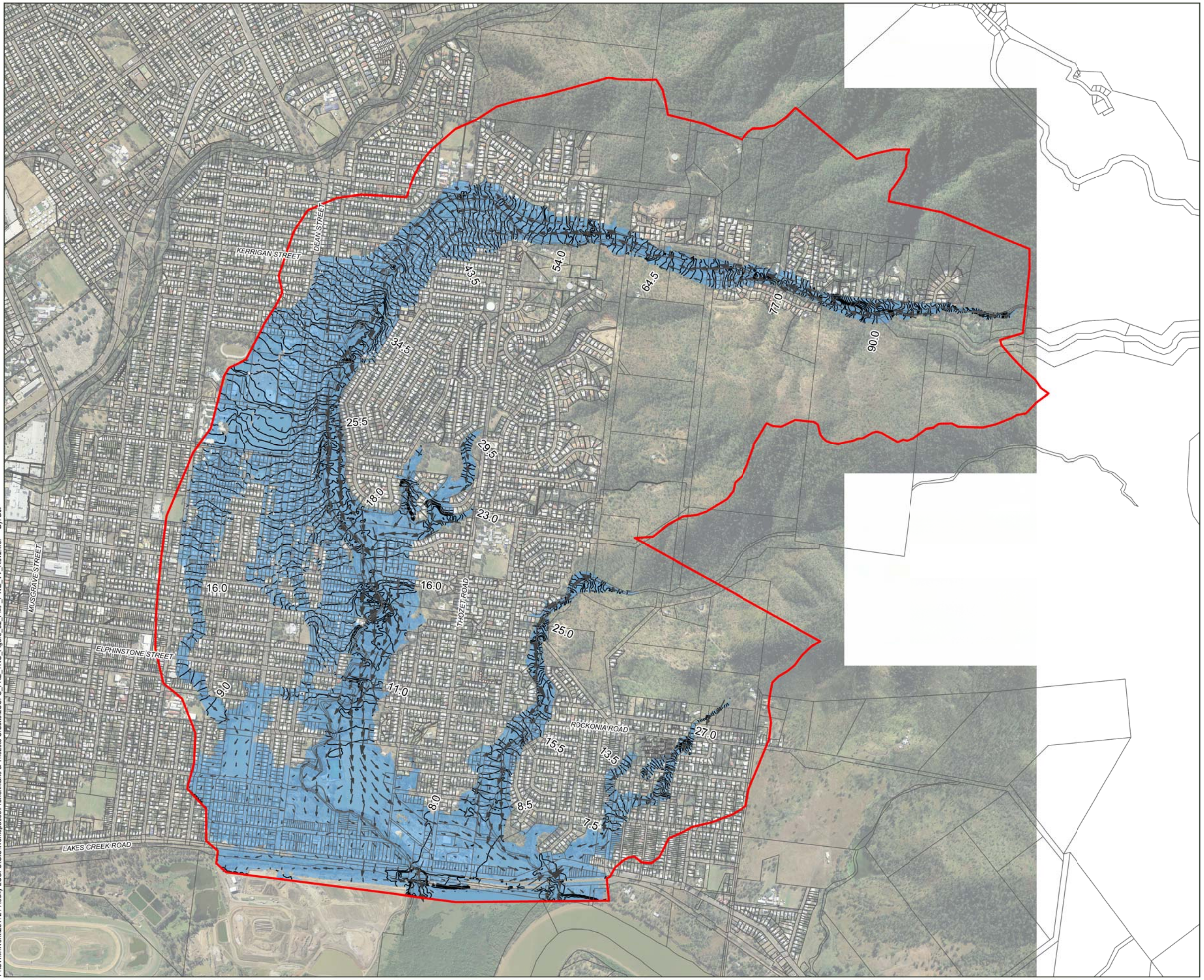
Queensland Government



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Legend

- Cadastre
- TUFLOW Model Extents
- Inundation Extents
- 0.5m (AHD) Peak Water Surface Elevation Contour
- Velocity Vector
  - represents velocity at time of peak water level
  - reference vector = 3 m/s

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
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3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.
7. The flood inundation extent associated with the Probable Maximum Flood (PMF) event does not account for inter-catchment flow.

Date: 29/05/2014 **Version: 2**

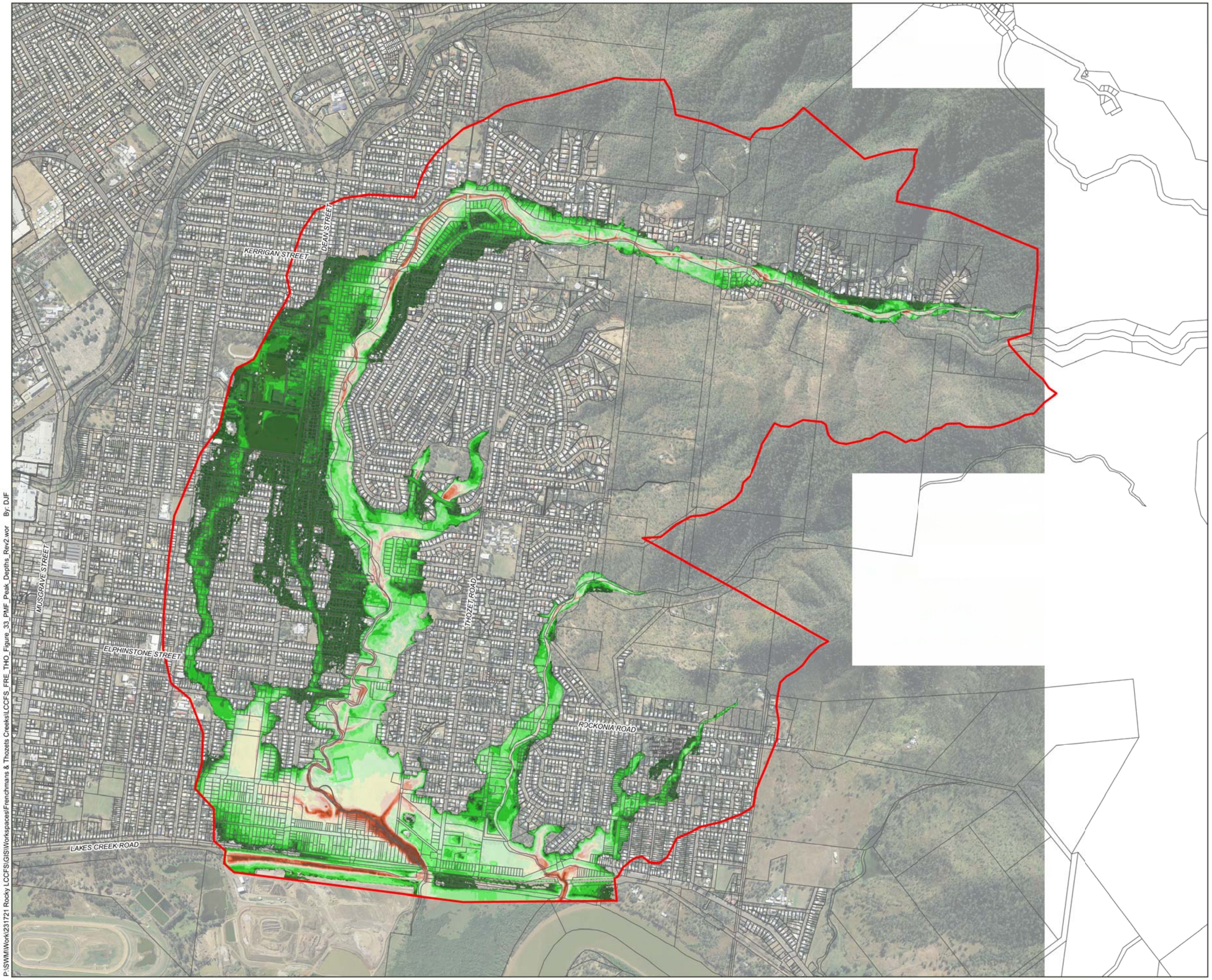
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 32: Existing Conditions - PMF Inundation Extents, Peak Water Surface Elevations and Velocities



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Australian Government Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents

Depth (m)

0.0 to 0.3	2.5 to 3.0
0.3 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
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3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.
7. The flood inundation extent associated with the Probable Maximum Flood (PMF) event does not account for inter-catchment flow.

Date: 29/05/2014 **Version: 2**

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 33: Existing Conditions - PMF Peak Depths

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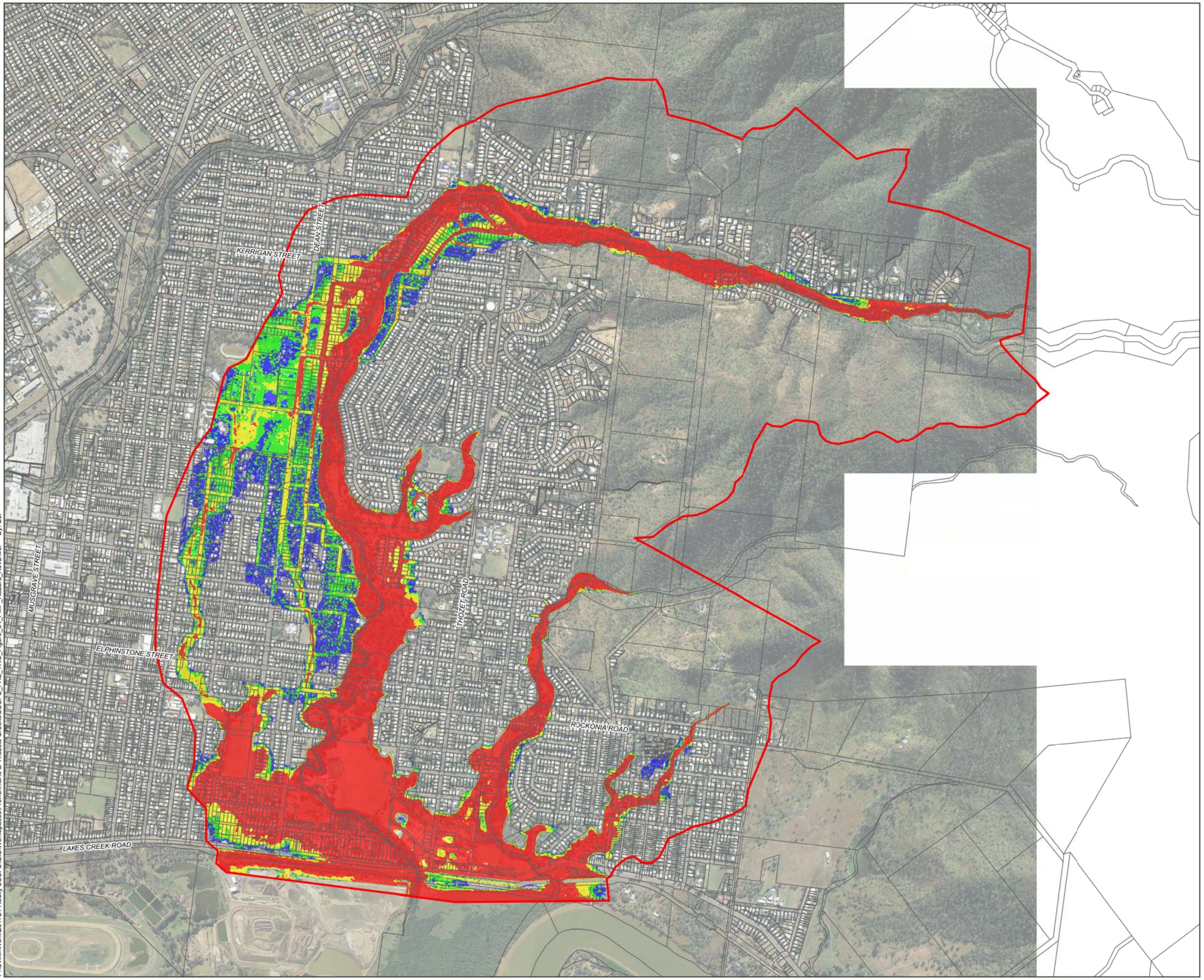
Queensland Government



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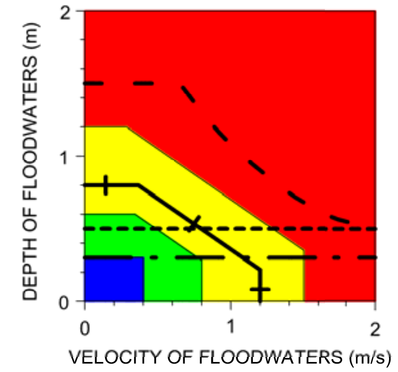
Legend

Cadastre

TUFLOW Model Extents



Hazard Categories

Low

High

Medium

Extreme

Hazard Thresholds

Wading Limit - Children

Safe to Use Small Cars

Wading Limit - Adults

Safe to Use 4WDs

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
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3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.
7. The flood inundation extent associated with the Probable Maximum Flood (PMF) event does not account for inter-catchment flow.

Date: 29/05/2014

Version: 2

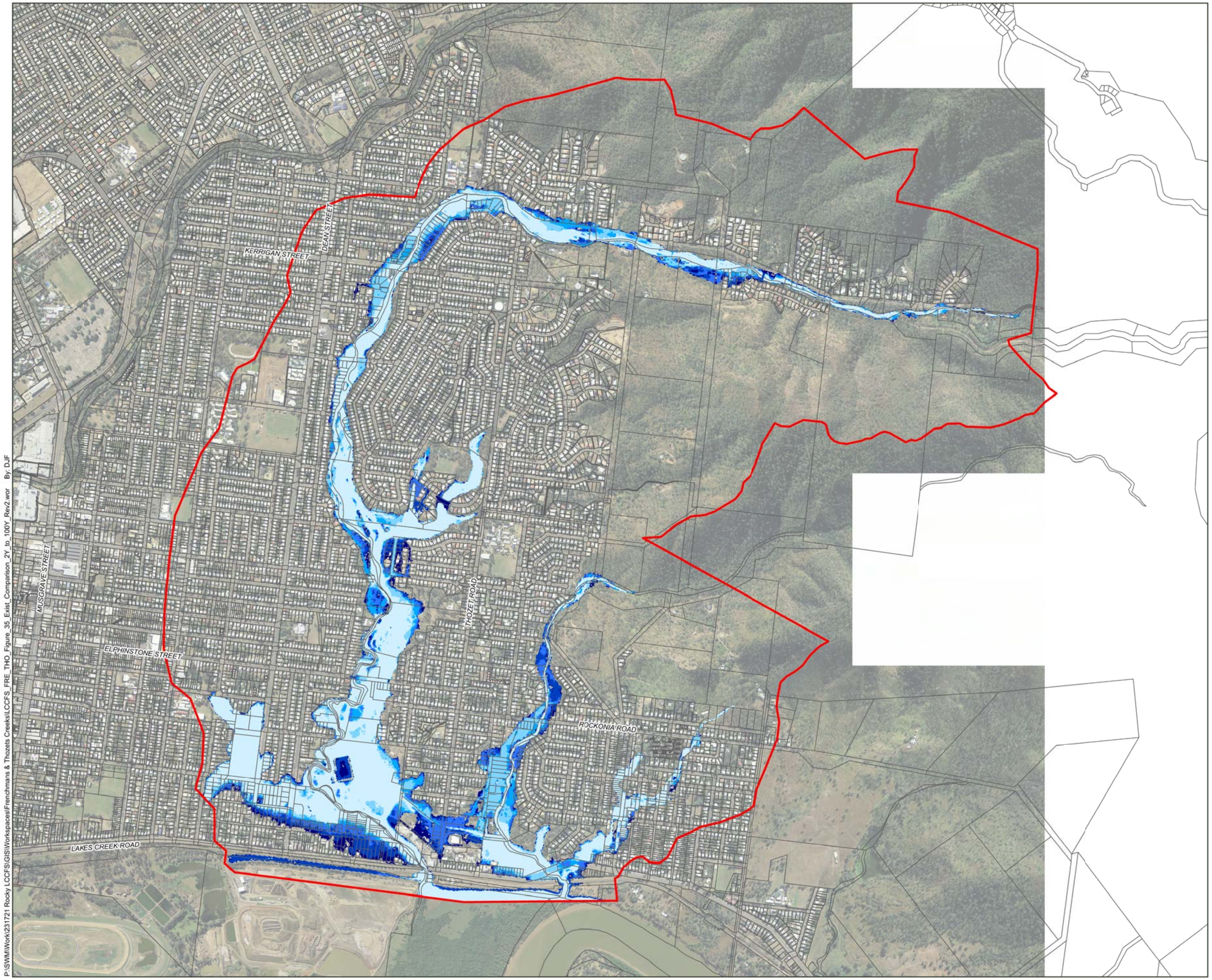
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 34: Existing Conditions - PMF Peak Hazard



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Australian Government Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- 2 Year ARI Inundation Extent
- 5 Year ARI Inundation Extent
- 10 Year ARI Inundation Extent
- 20 Year ARI Inundation Extent
- 50 Year ARI Inundation Extent
- 100 Year ARI Inudation Extent

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 Version: 2

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 35: Existing Conditions - Inundation Extent Comparison - 2 to 100 Year ARI

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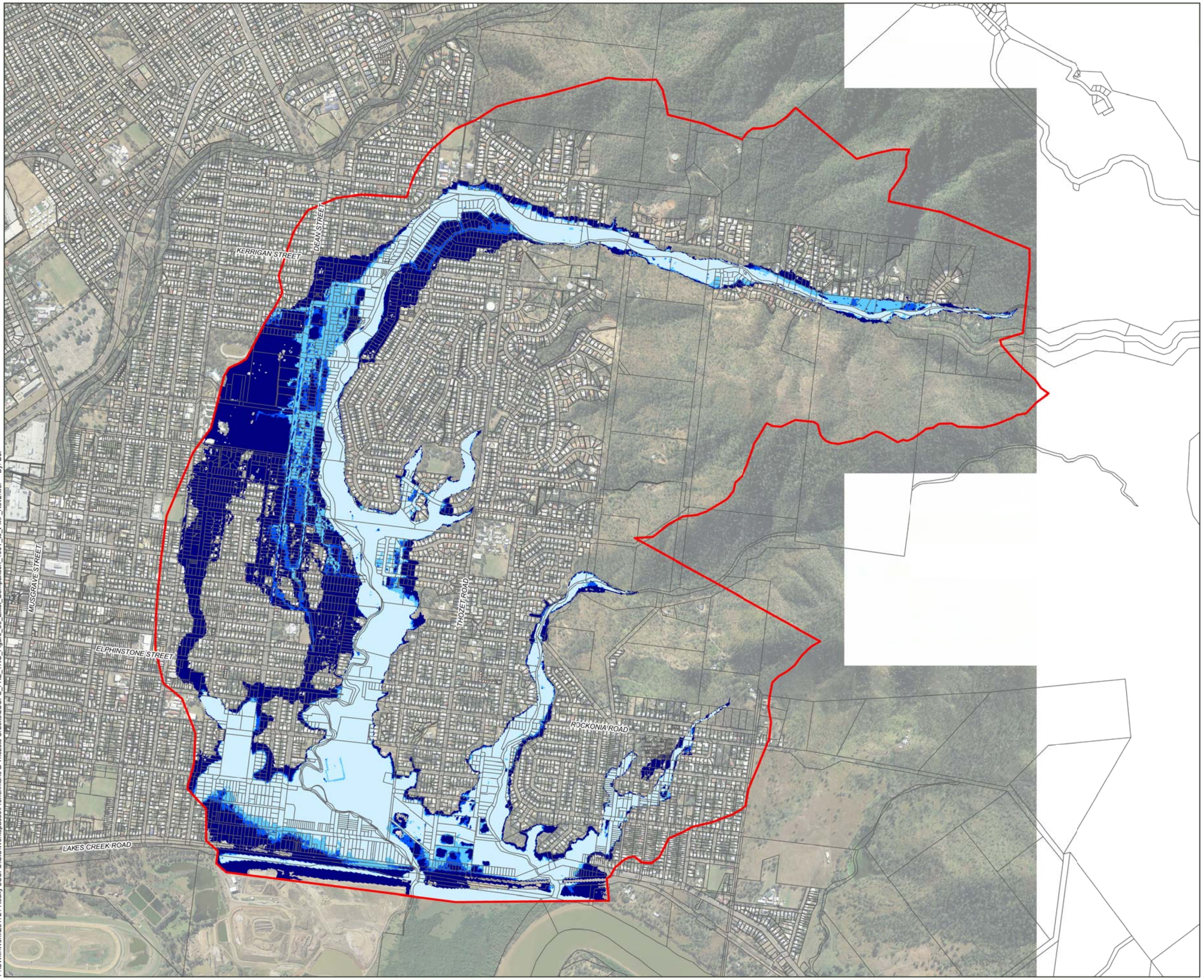

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Legend

- Cadastre
- TUFLOW Model Extents
- 100 Year ARI Inundation Extent
- 200 Year ARI Inundation Extent
- 500 Year ARI Inundation Extent
- PMF Inundation Extent

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.
7. The flood inundation extent associated with the Probable Maximum Flood (PMF) event does not account for inter-catchment flow.

Date: 29/05/2014 Version: 2

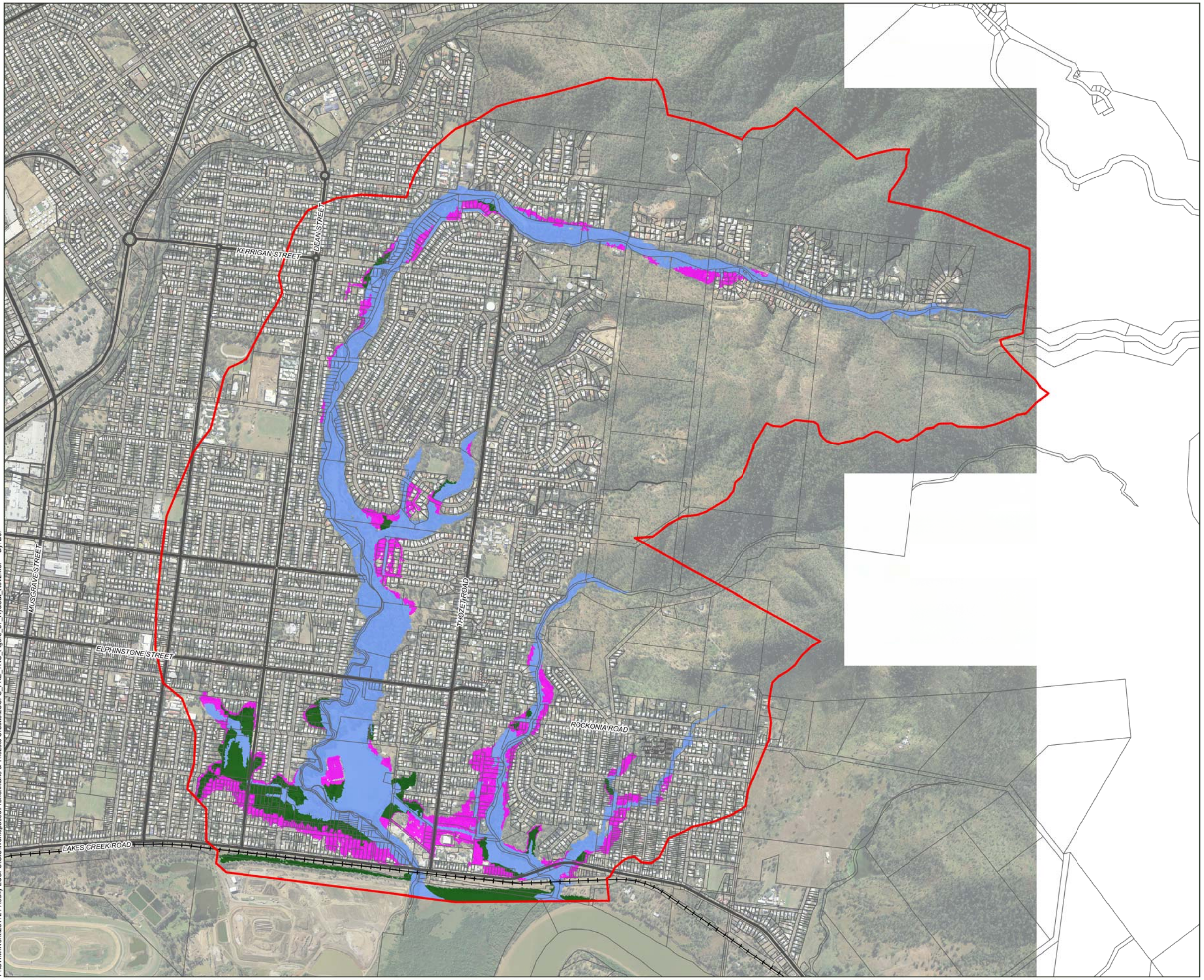
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 36: Existing Conditions - Inundation Extent Comparison - 100 Year ARI to PMF



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Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- Major Road
- Railway Line

Hydraulic Category

- Floodway
- Flood Storage
- Flood Fringe

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 Version: 2

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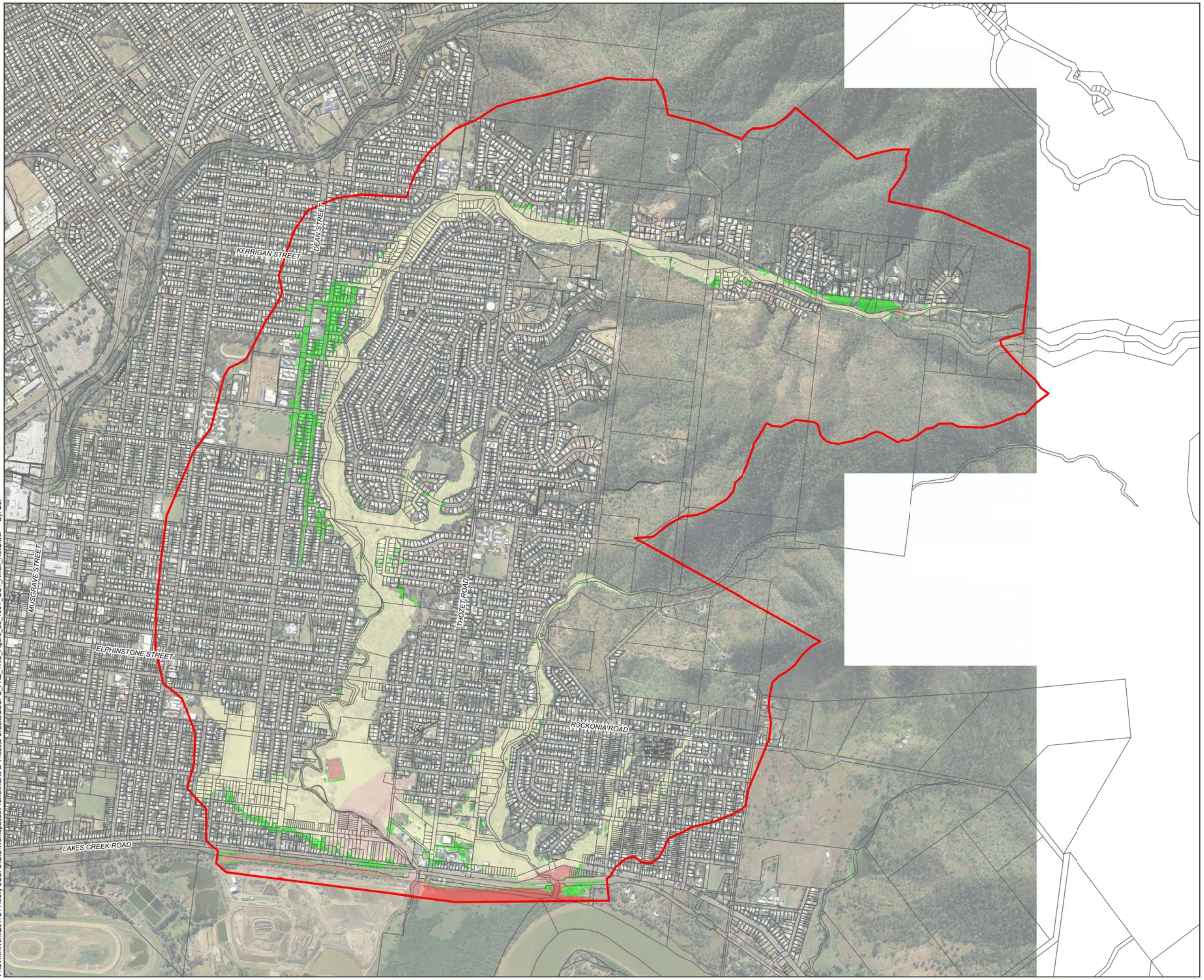
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 37: Hydraulic Categories



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Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents

Afflux (m)

- 0.00 to 0.25
- 0.25 to 0.50
- 0.50 to 0.75
- 0.75 to 1.00
- 1.00 to 1.50
- >1.5

Was Dry Now Wet

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The inundation extents associated with climate change scenarios are based on a tailwater condition that assumes a concurrent Highest Astronomical Tidel level plus 0.8m on the Fitzroy River.

Date: 29/05/2014

Version: 2

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 38: Climate Change Conditions - Scenario 1 (+20%) Increase in 100 Year ARI Peak Water Levels

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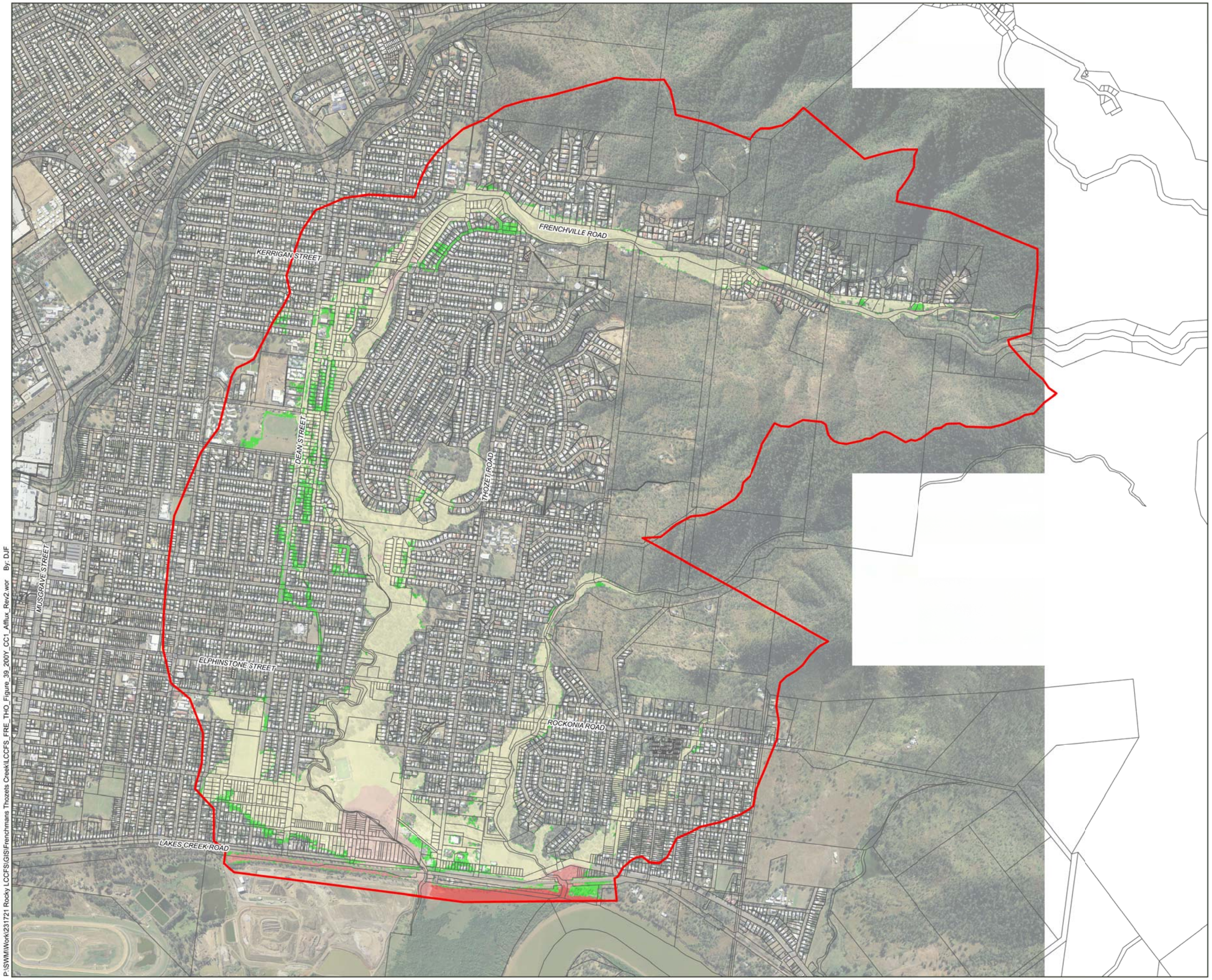

Legend

- Cadastre
- TUFLOW Model Extents

Afflux (m)

- 0.00 to 0.25
- 0.25 to 0.50
- 0.50 to 0.75
- 0.75 to 1.00
- 1.00 to 1.50
- >1.5
- Was Dry Now Wet

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
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3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
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5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The inundation extents associated with climate change scenarios are based on a tailwater condition that assumes a concurrent Highest Astronomical Tidel level plus 0.8m on the Fitzroy River.

Date: 29/05/2014 Version: 2

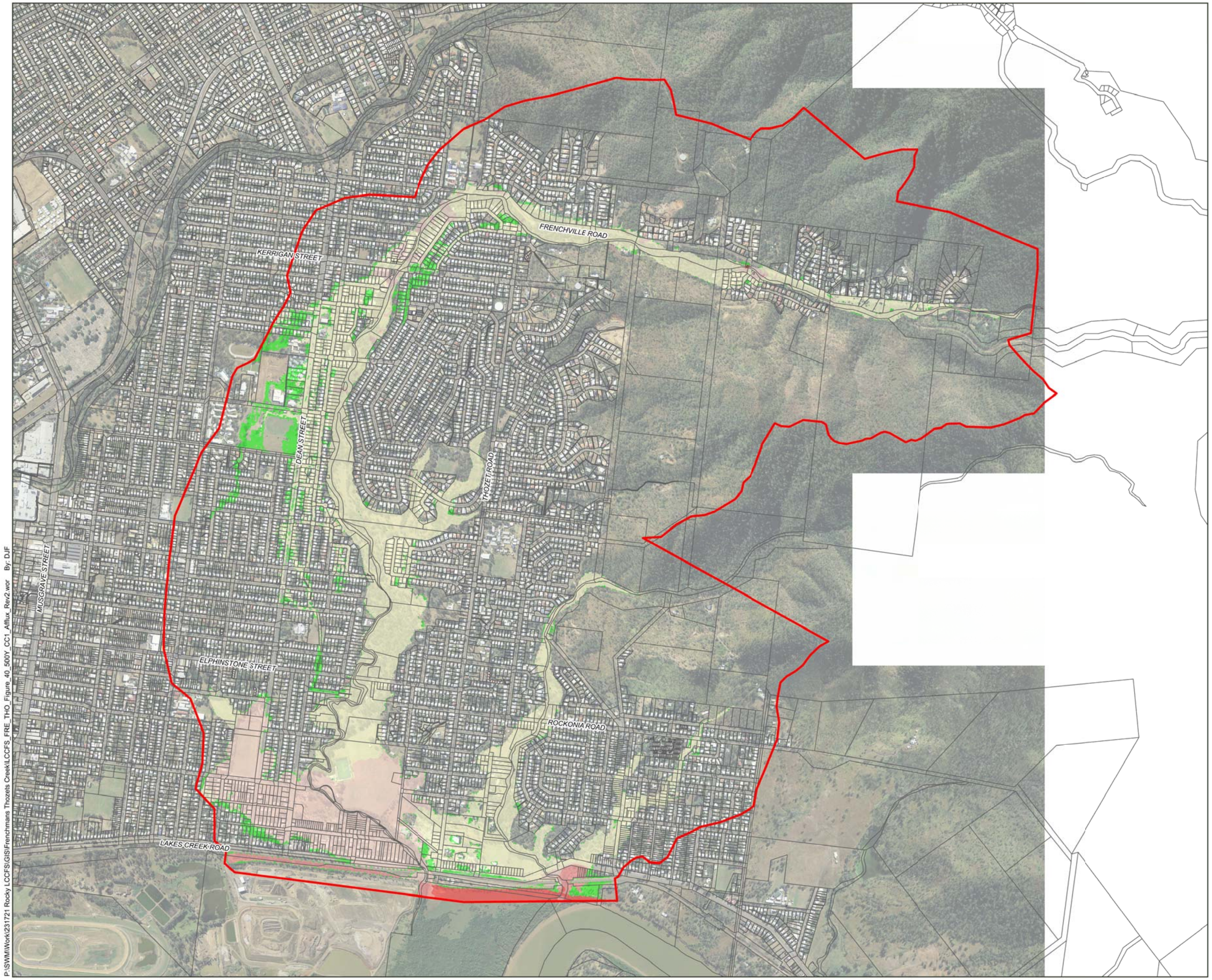
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 39: Climate Change Conditions - Scenario 1 (+20%) Increase in 200 Year ARI Peak Water Levels



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Queensland Government

Legend

Cadastre

TUFLOW Model Extents

Afflux (m)

- 0.00 to 0.25
- 0.25 to 0.50
- 0.50 to 0.75
- 0.75 to 1.00
- 1.00 to 1.50
- >1.5

Was Dry Now Wet

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
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3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The inundation extents associated with climate change scenarios are based on a tailwater condition that assumes a concurrent Highest Astronomical Tidel level plus 0.8m on the Fitzroy River.

Date: 29/05/2014 Version: 2

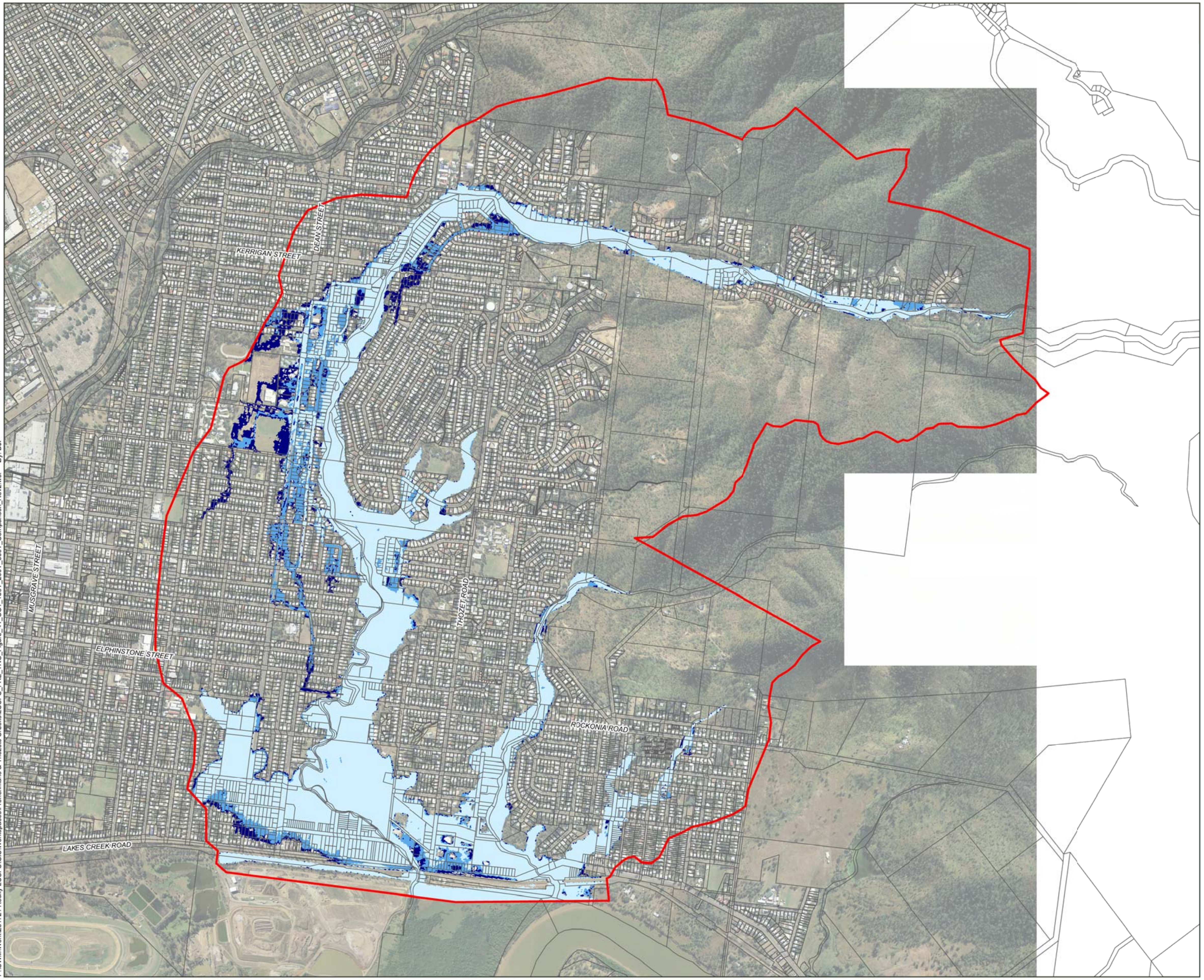
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 40: Climate Change Conditions - Scenario 1 (+20%) Increase in 500 Year ARI Peak Water Levels



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Attorney-General's Department

Queensland Government

Legend

	Cadastre
	TUFLOW Model Extents
	100 Year ARI + Climate Change (20%) Event Inundation Extents
	200 Year ARI + Climate Change (20%) Event Inundation Extents
	500 Year ARI + Climate Change (20%) Event Inundation Extents

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
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3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The inundation extents associated with climate change scenarios are based on a tailwater condition that assumes a concurrent Highest Astronomical Tidel level plus 0.8m on the Fitzroy River.

Date: 29/05/2014 Version: 2

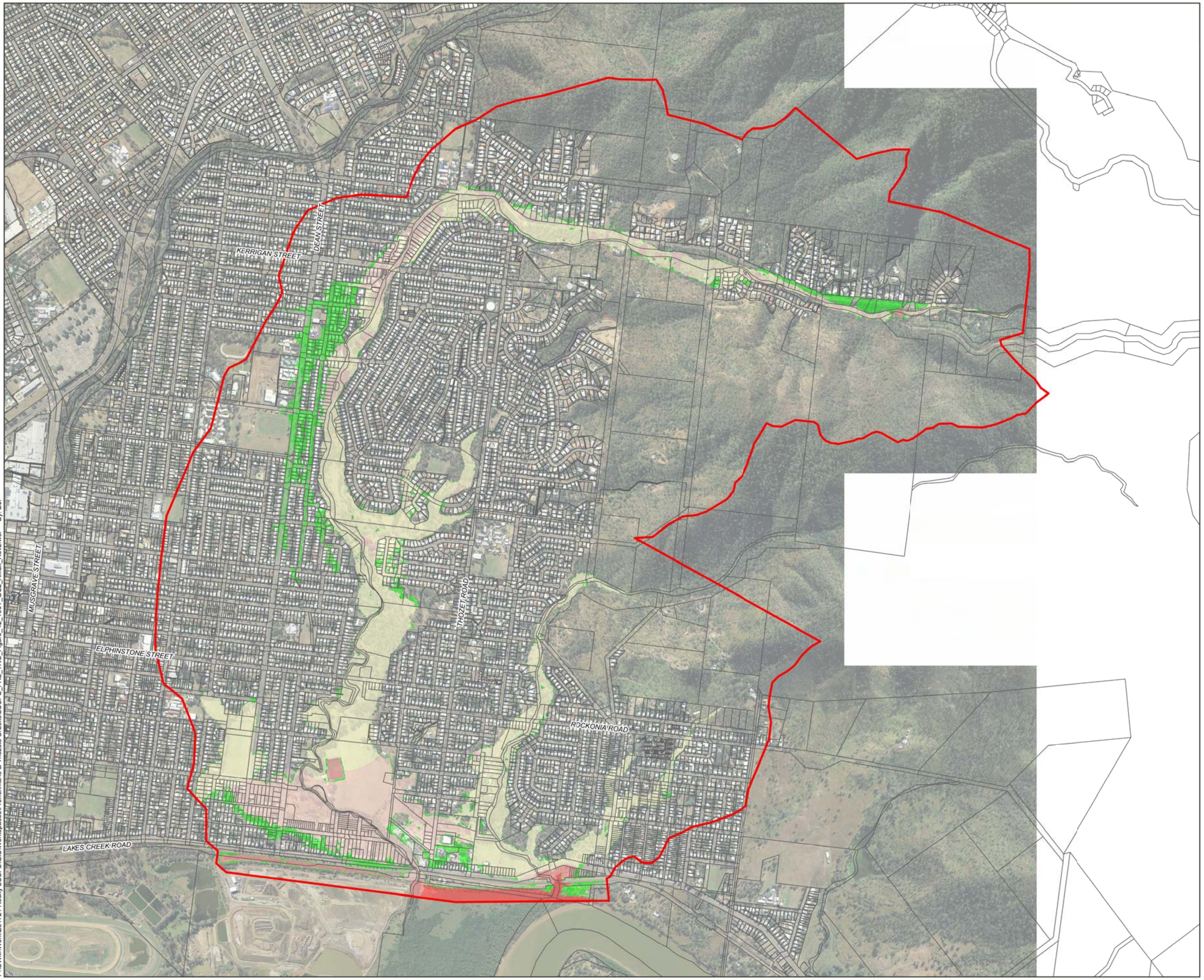
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 41: Climate Change Conditions - Inundation Extent Comparison - Scenario 1 (+20%) - 100, 200 & 500 Year ARI



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Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents

Afflux (m)

- 0.00 to 0.25
- 0.25 to 0.50
- 0.50 to 0.75
- 0.75 to 1.00
- 1.00 to 1.50
- >1.5
- Was Dry Now Wet

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
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5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The inundation extents associated with climate change scenarios are based on a tailwater condition that assumes a concurrent Highest Astronomical Tidel level plus 0.8m on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

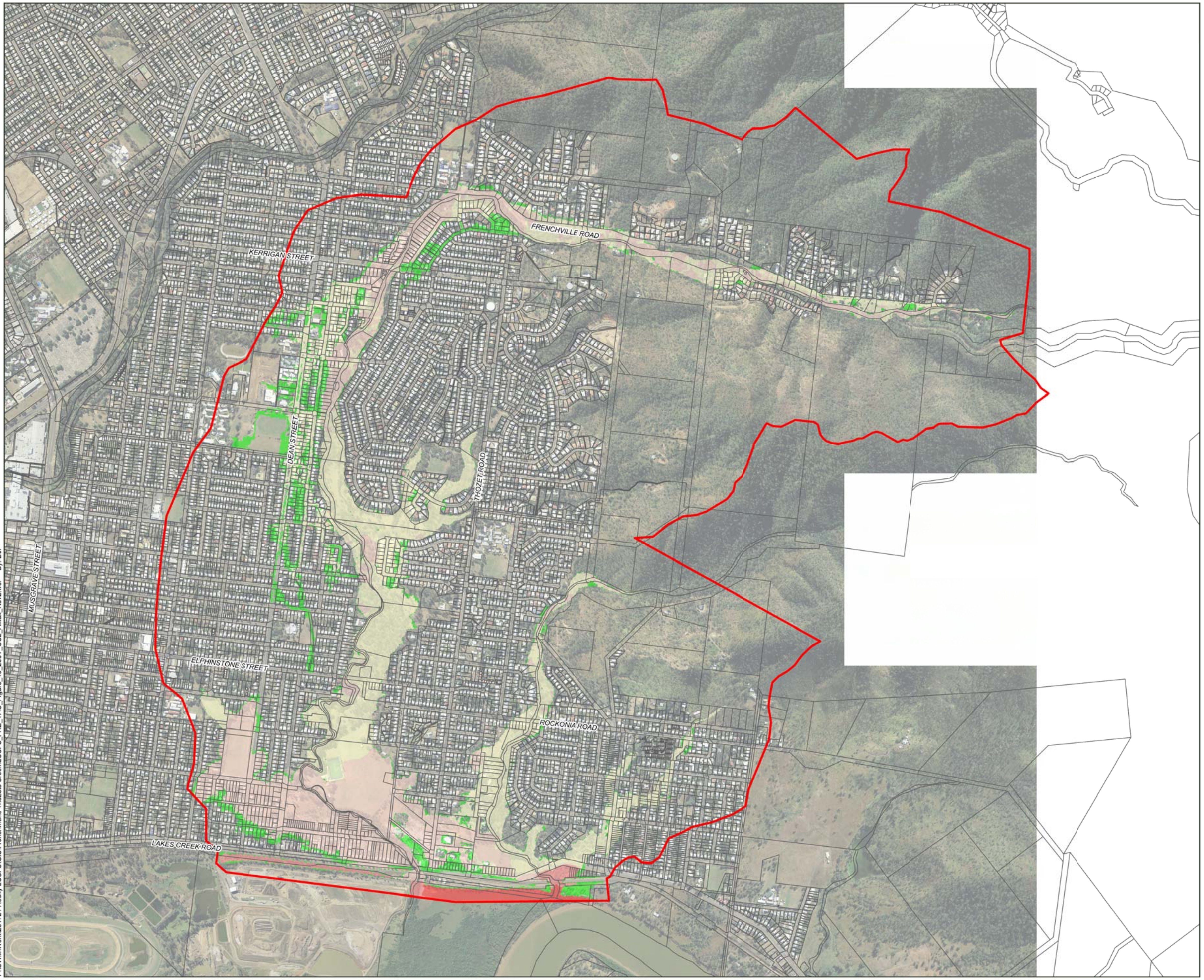
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 42: Climate Change Conditions - Scenario 2 (+30%) Increase in 100 Year ARI Peak Water Levels



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Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents

Afflux (m)

- 0.00 to 0.25
- 0.25 to 0.50
- 0.50 to 0.75
- 0.75 to 1.00
- 1.00 to 1.50
- >1.5

Was Dry Now Wet

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The inundation extents associated with climate change scenarios are based on a tailwater condition that assumes a concurrent Highest Astronomical Tidel level plus 0.8m on the Fitzroy River.

Date: 29/05/2014 Version: 2

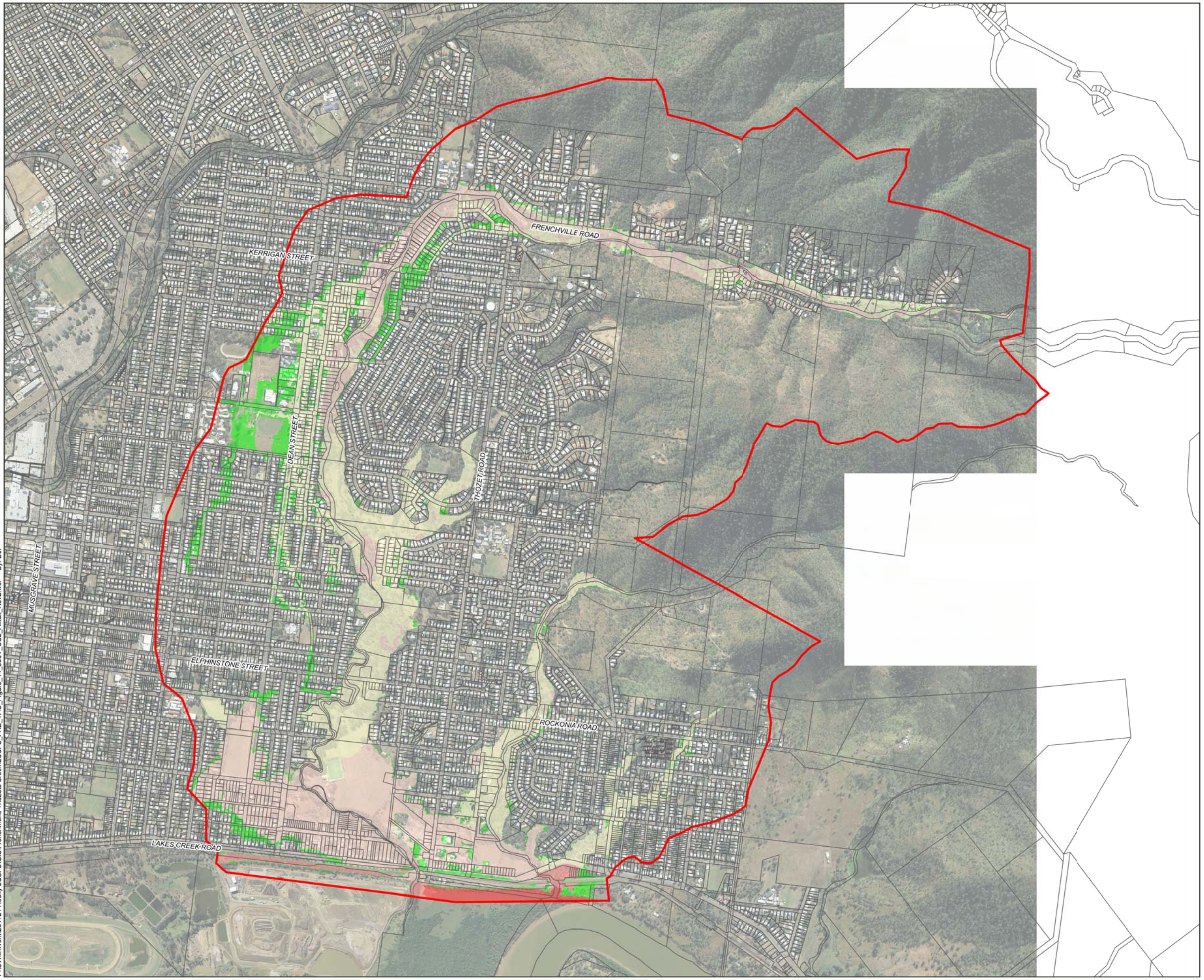
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 43: Climate Change Conditions - Scenario 2 (+30%) Increase in 200 Year ARI Peak Water Levels



P:\SWM\Work\231721 Rocky LCCFS\GIS\Frenchmans Thozets Creek\LCCFS_FRE_THO_Figure_44_500Y_CC2_Afflux_Rev2.wor By: DJF

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents

Afflux (m)

- 0.00 to 0.25
- 0.25 to 0.50
- 0.50 to 0.75
- 0.75 to 1.00
- 1.00 to 1.50
- >1.5

Was Dry Now Wet

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Frenchmans & Thozets Creeks TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The inundation extents associated with climate change scenarios are based on a tailwater condition that assumes a concurrent Highest Astronomical Tidel level plus 0.8m on the Fitzroy River.

Date: 29/05/2014 Version: 2

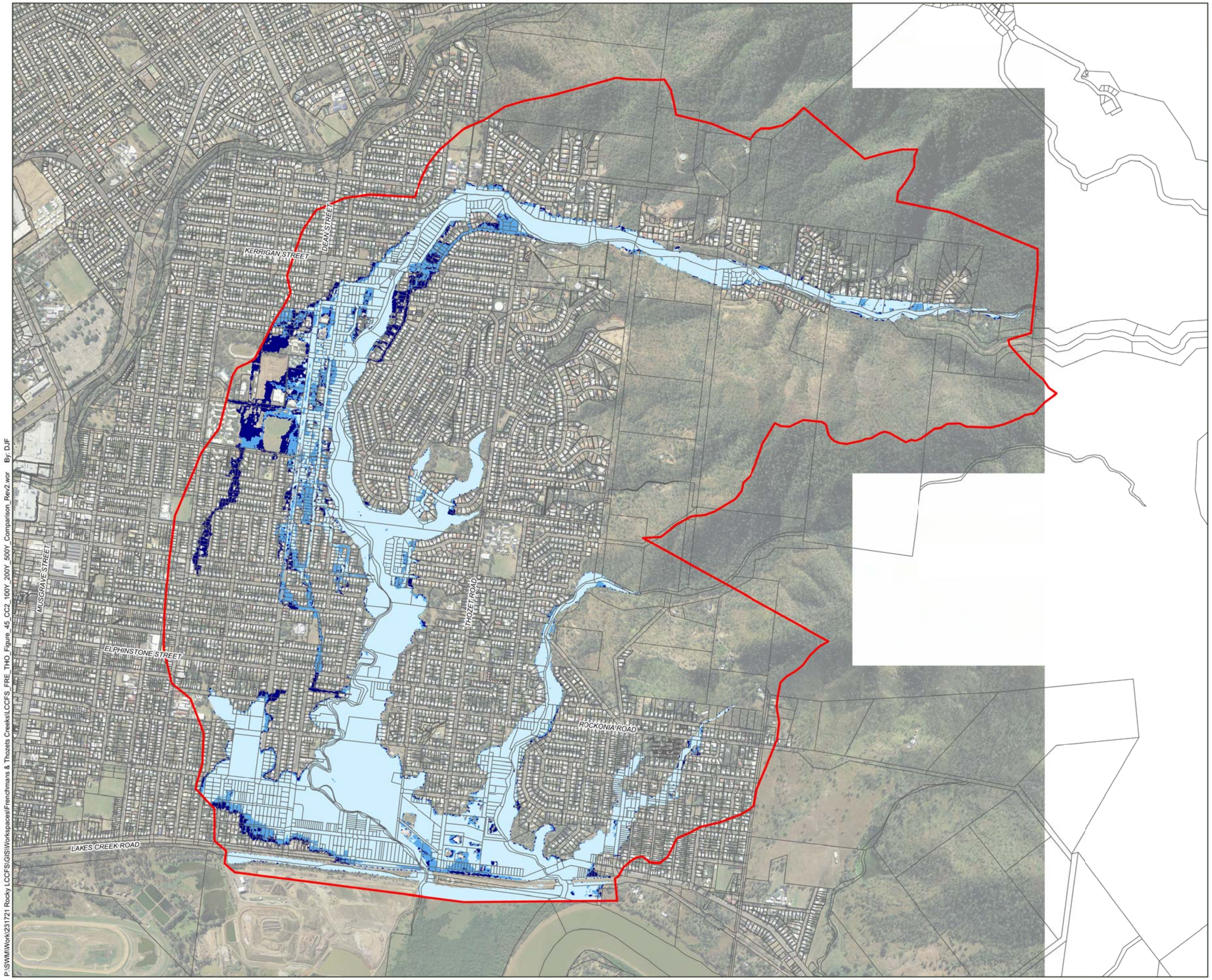
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 44: Climate Change Conditions - Scenario 2 (+30%) Increase in 500 Year ARI Peak Water Levels



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Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents

100 Year ARI + Climate Change (30%) Event Inundation Extents

200 Year ARI + Climate Change (30%) Event Inundation Extents

500 Year ARI + Climate Change (30%) Event Inundation Extents

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
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Date: 29/05/2014 Version: 2

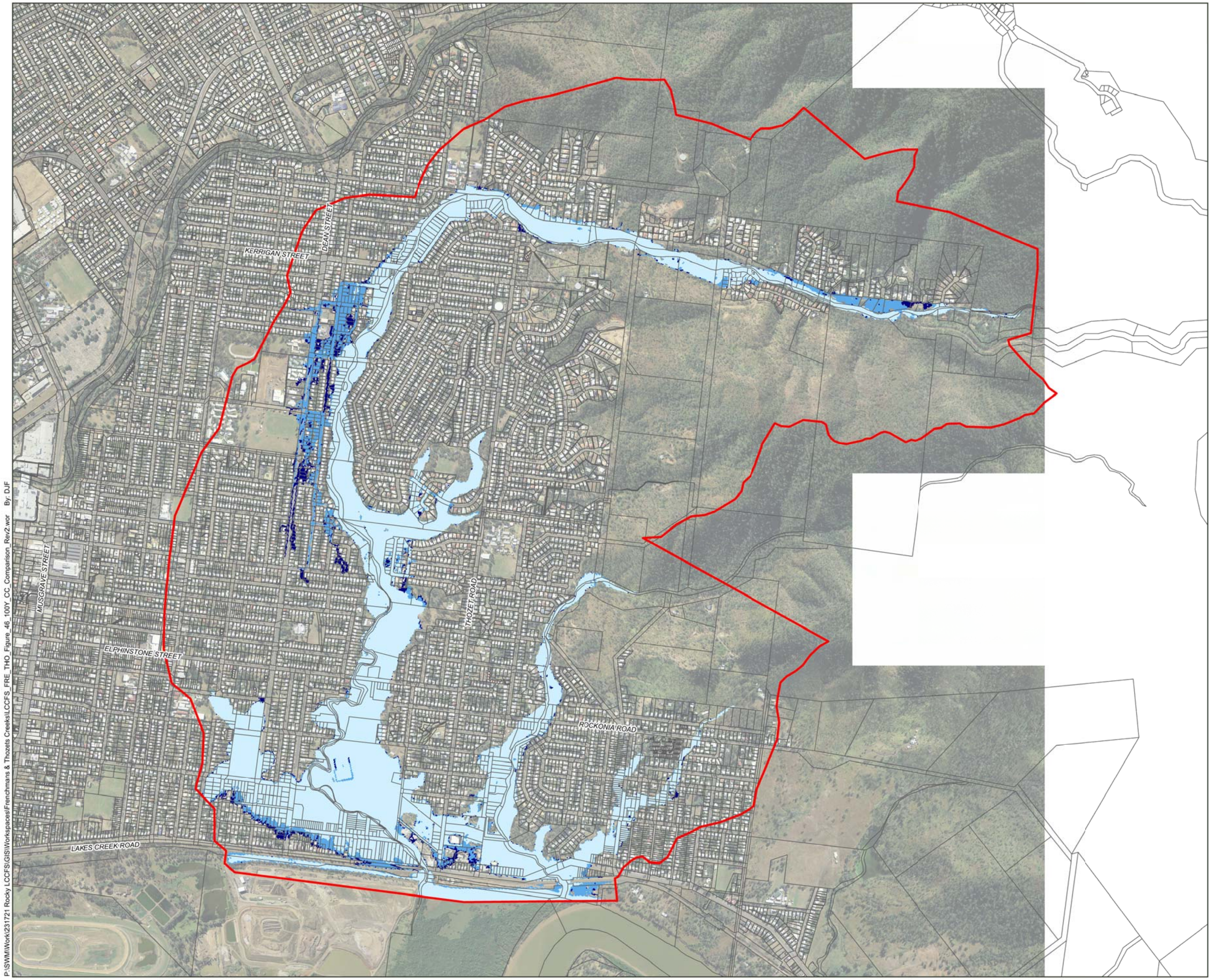
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 45: Climate Change Conditions - Inundation Extent Comparison - Scenario 2 (+30%) - 100, 200 & 500 Year ARI



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Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- 100 Year ARI Event Inundation Extents
- 100 Year ARI + Climate Change (20%) Event Inundation Extents
- 100 Year ARI + Climate Change (30%) Event Inundation Extents

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
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6. The inundation extents associated with climate change scenarios are based on a tailwater condition that assumes a concurrent Highest Astronomical Tidel level plus 0.8m on the Fitzroy River.

Date: 29/05/2014 Version: 2

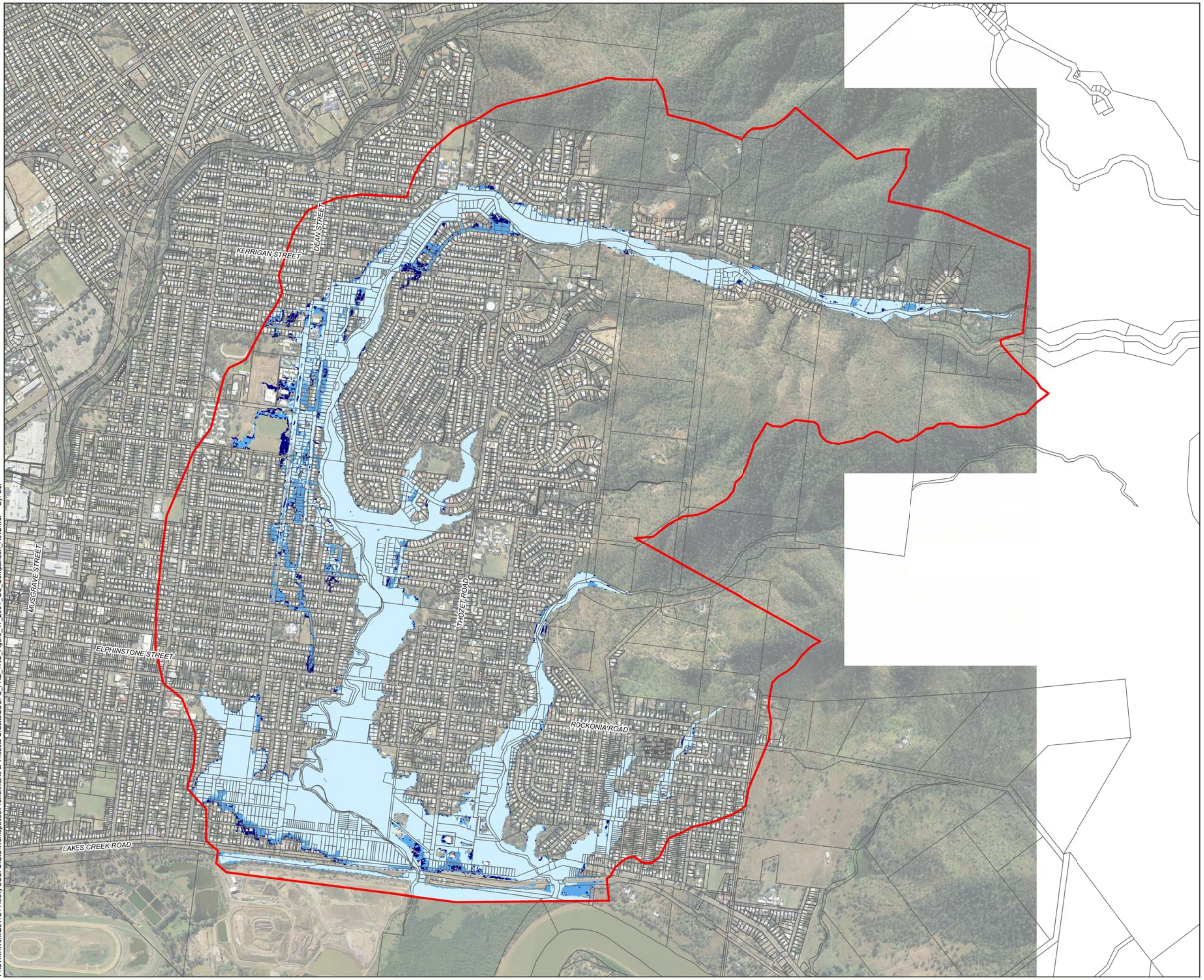
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 46: Climate Change Conditions - Inundation Extent Comparison - 100 Year ARI



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Legend

- Cadastre
- TUFLOW Model Extents
- 200 Year ARI Event Inundation Extents
- 200 Year ARI + Climate Change (20%) Event Inundation Extents
- 200 Year ARI + Climate Change (30%) Event Inundation Extents

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
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Date: 29/05/2014 Version: 2

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 47: Climate Change Conditions - Inundation Extent Comparison - 200 Year ARI

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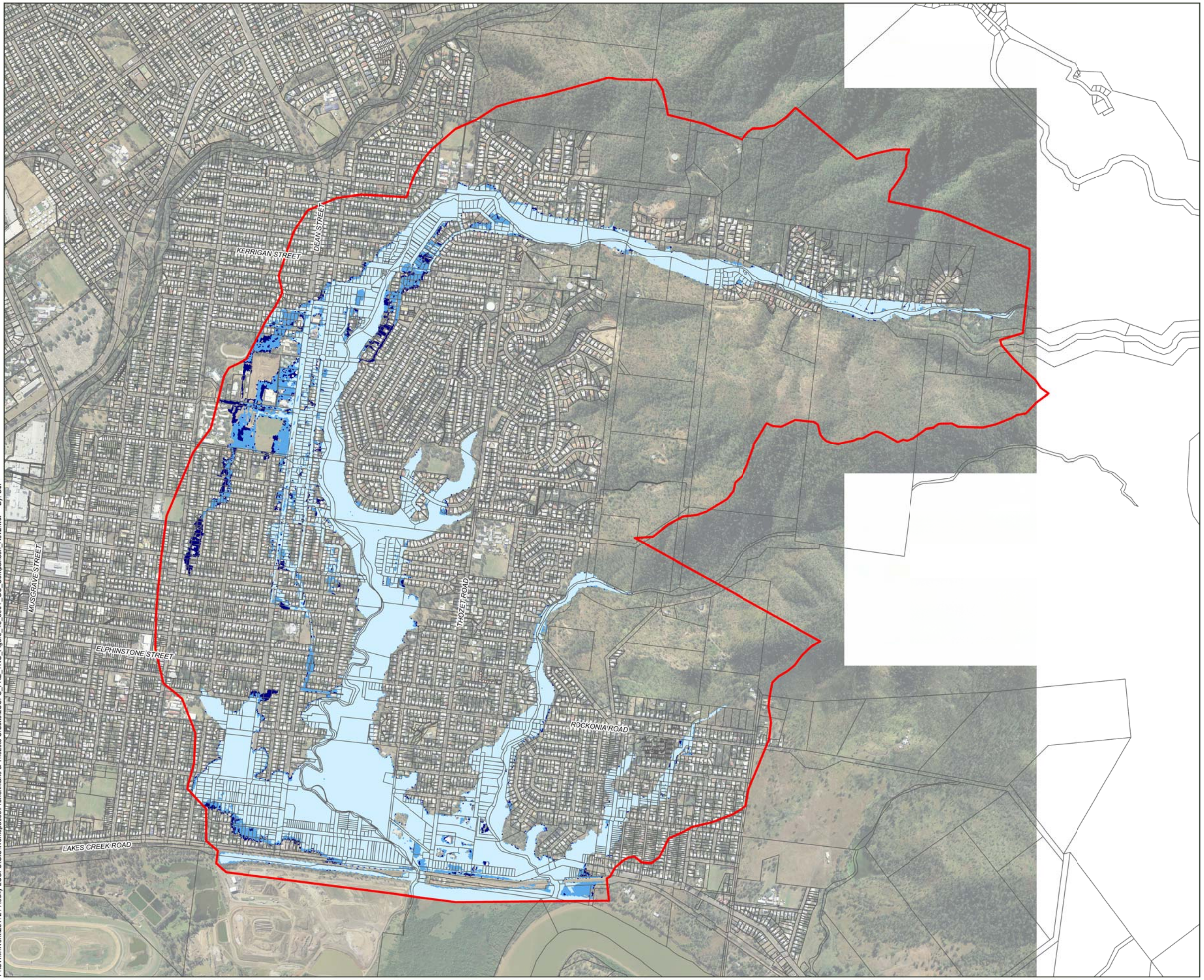

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Legend

- Cadastre
- TUFLOW Model Extents
- 500 Year ARI Event Inundation Extents
- 500 Year ARI + Climate Change (20%) Event Inundation Extents
- 500 Year ARI + Climate Change (30%) Event Inundation Extents

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks Figure 1 so as to understand the important limitations and conditions on such use.
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Date: 29/05/2014 Version: 2

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Frenchmans & Thozets Creeks

Figure 48: Climate Change Conditions - Inundation Extent Comparison - 500 Year ARI

Appendix B
RAFTS model parameters

Sub-catchment parameters

Sub-Catchment ID	Area (ha)	Slope (%)	% Impervious	Roughness (PerN)
THO-1	36.8	19.4	0.0	0.088
THO-2	43.9	16.8	0.0	0.093
THO-3	49.4	14.7	0.0	0.092
THO-4	31.3	20.6	0.9	0.100
THO-5	27.7	11.9	0.7	0.074
THO-6	4.2	14.6	0.0	0.072
THO-7	51.7	7.3	0.7	0.081
THO-8	19.5	10.6	11.8	0.064
THO-9	48.3	2.4	45.0	0.049
THO-10	13.4	21.1	31.7	0.055
THO-11	61.9	2.3	59.3	0.043
THO-12	57.9	2.3	69.8	0.035

Link parameters

Link ID	Length (m)	Adopted Velocity (m/s)	Lag Time (mins)
Link_CON-1A	446	1.7	4
Link_CON-1B	601	1.7	6
Link_DUM-1A	607	2.5	4
Link_THO-11	1102	1	18
Link_THO-12	504	1	8
Link_THO-2	822	2.5	5
Link_THO-3	689	2.5	5
Link_THO-7	808	2.5	5
Link_THO-8	799	2.5	5
Link_THO-9	874	1.7	9

Appendix C
TUFLOW model peak discharges

Design event peak discharges

Results Type	Location	Peak Discharge (m^3/s)					
		2yr	5yr	10yr	20yr	50yr	100yr
1d Culverts	THO_ROC_01	3.1	3.6*	3.7*	3.9*	4.0*	4.1*
	THO_ROC_02	20.9	27.2*	28.3*	29.2*	30.8*	31.0*
	THO_XXX_01	2.4	2.6	3.0	3.3	3.6	3.7
	THO_PAT_01	2.3*	2.5*	2.6*	2.7*	2.7*	2.8*
	THO_LAK_01	11.9	14.9	17.6*	18.9*	19.2*	19.3*
	THO_LAK_02	9.5	9.5	9.6	9.7	9.6	9.6
	THO_LAK_03	18.7	20.6*	21.0*	21.0*	20.1*	20.1*
2d Lines	Stenhouse Street	9.9*	14.1*	17.3*	23.1*	29.1*	33.2*
	Thozet Road	0.0#	0.0#	0.0#	2.0*	12.1*	20.9*
	Yeppoon Branch Railway	24.7	39.7	50.3	66.5	84.2	100.8
Total	Rockina Road East	3.1	4.6*	6.0*	7.8*	9.6*	11.0*
	Rockina Road West	20.9	30.4*	37.8*	53.7*	65.1*	75.4*
	Patterson Avenue	5.3*	7.9*	9.7*	12.6*	15.6*	18.2*
	Lakes Creek Road (incl Little Thozet Ck)	41.8	60.3*	73.0*	87.3*	103.6*	119.5*

** Indicates that road is inundated*
 # Zero flow as breakout between catchments does not inundate Thozet Road in this event

Design event critical durations

Results Type	Location	Critical Duration (mins)					
		2yr	5yr	10yr	20yr	50yr	100yr
1d Culverts	THO_ROC_01	90	90	60	60	60	60
	THO_ROC_02	90	120	120	60	45	90
	THO_XXX_01	45	90	60	60	60	60
	THO_PAT_01	60	90	90	60	60	60
	THO_LAK_01	60	60	60	60	60	60
	THO_LAK_02	60	45	60	60	45	45
	THO_LAK_03	120	120	90	180	45	90
2d Lines	Stenhouse Street	60	60	90	60	60	60
	Thozet Road	N/A	N/A	N/A	120	90	90
	Yeppoon Branch Railway	90	120	120	120	90	90
Total	Rockina Road East	90	90	60	60	60	60
	Rockina Road West	90	120	90	120	60	60
	Patterson Avenue	90	90	60	60	60	60
	Lakes Creek Road (incl Little Thozet Ck)	120	120	120	120	90	90

Appendix D
Discharge hydrographs at key locations

When reviewing the discharge hydrographs, some points to note are:

- In some locations the critical duration varies for different magnitude events. For example, at Lakes Creek Road Total, the 120 minute duration is critical for the 5 to 20 year ARI events and the 90 minute duration is critical for the 2, 50 and 100 year ARI events. For this reason the shape of the 5 to 20 year ARI hydrographs at this location are different to that of the hydrographs for the other events
- Where there are culverts, some graphs of the model results show a sharp change in the discharges. This occurs when the flow regime in the culvert changes, such as when the culvert inlet or outlet becomes submerged. Whilst discharge results show significant changes at these locations, the modelled peak water levels do not change

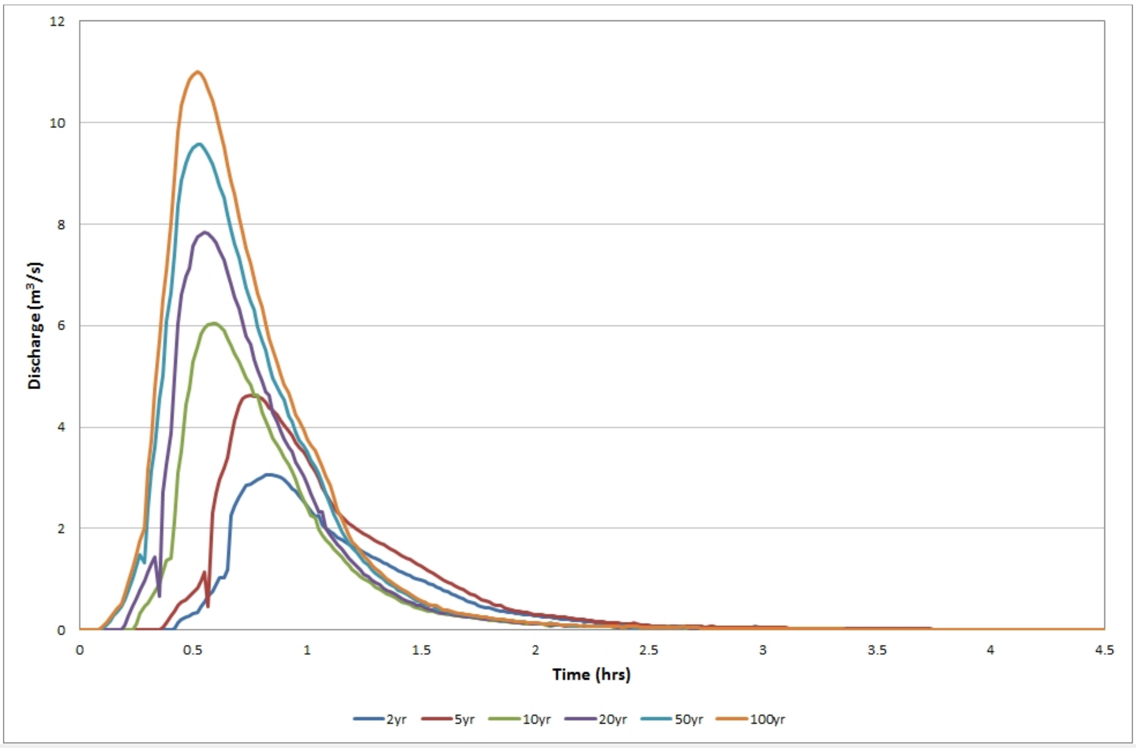

Image 2 | Design Event Discharge Hydrographs – Rockina Road East

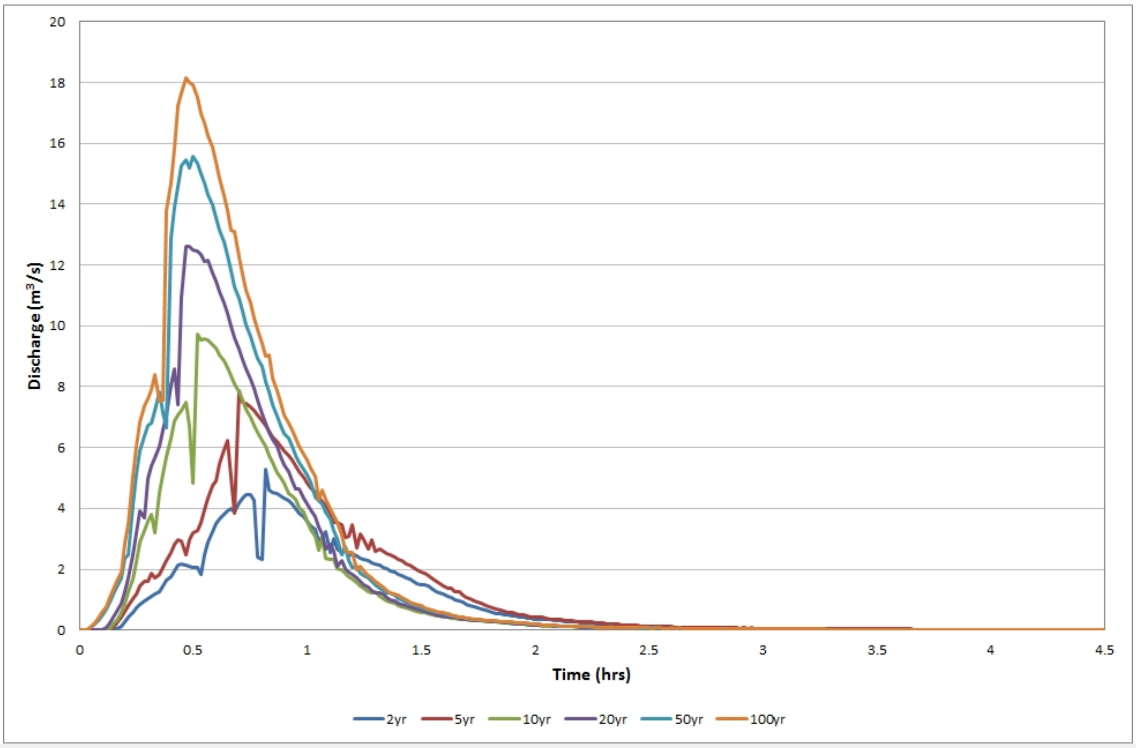

Image 3 | Design Event Discharge Hydrographs – Patterson Avenue

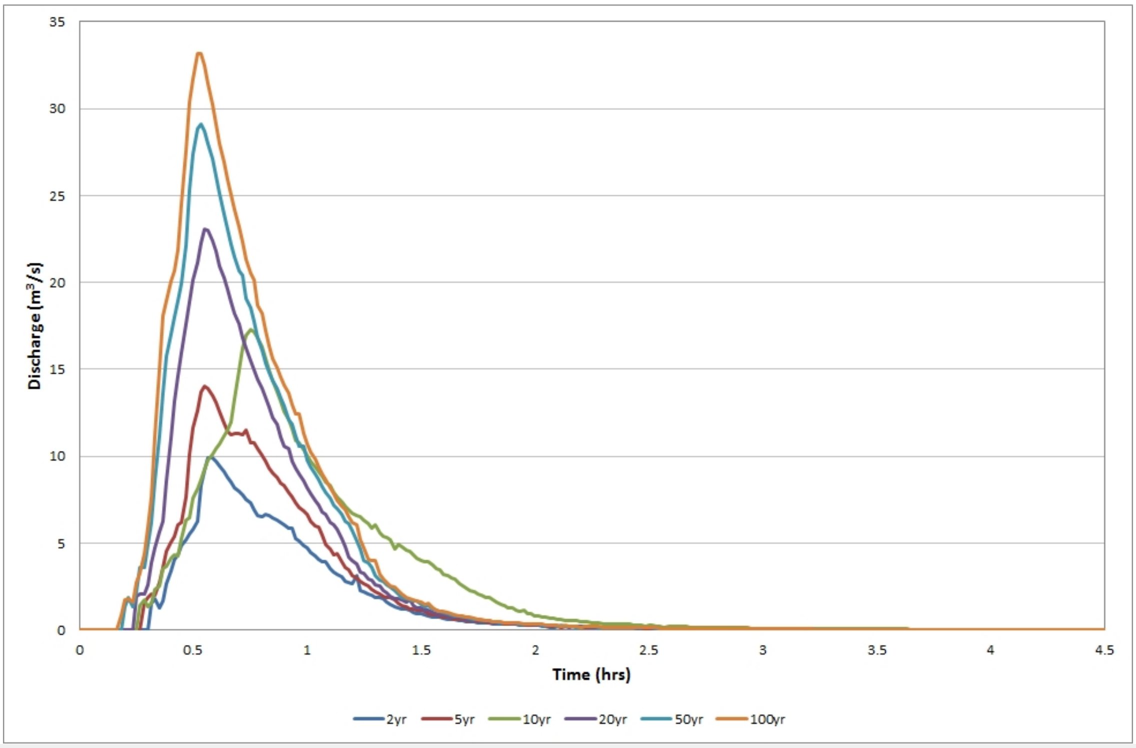

Image 4 | Design Event Discharge Hydrographs – Stenhouse Street

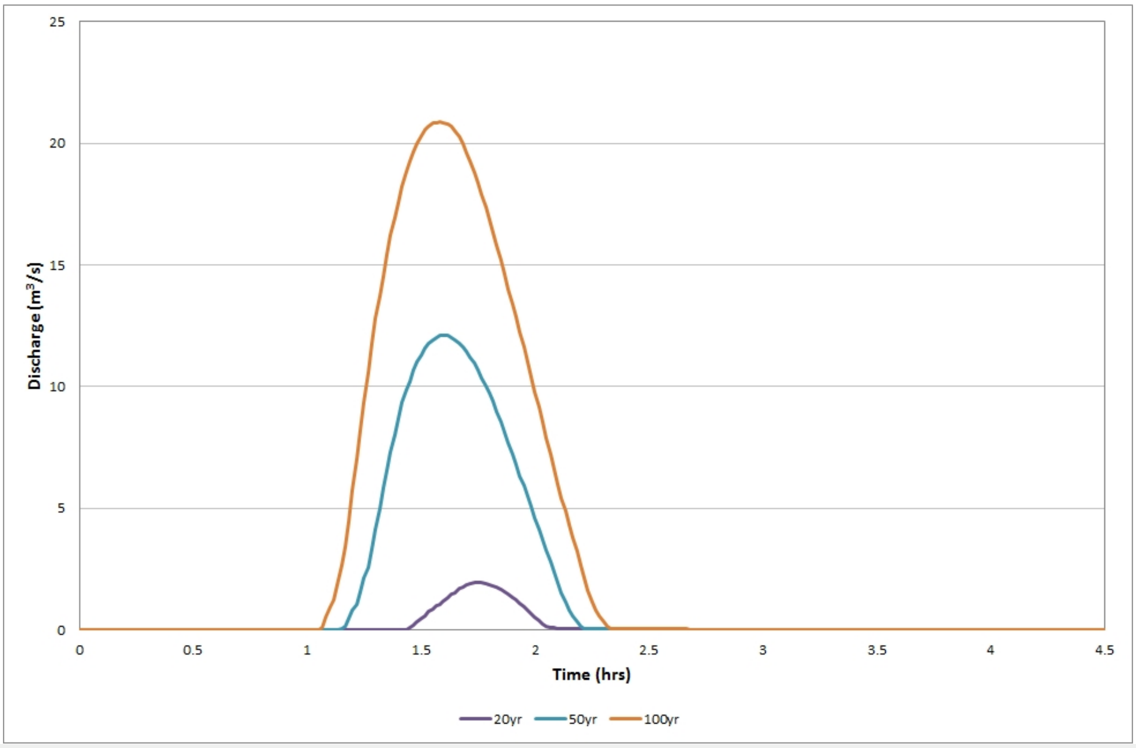

Image 6 | Design Event Discharge Hydrographs – Thozet Road

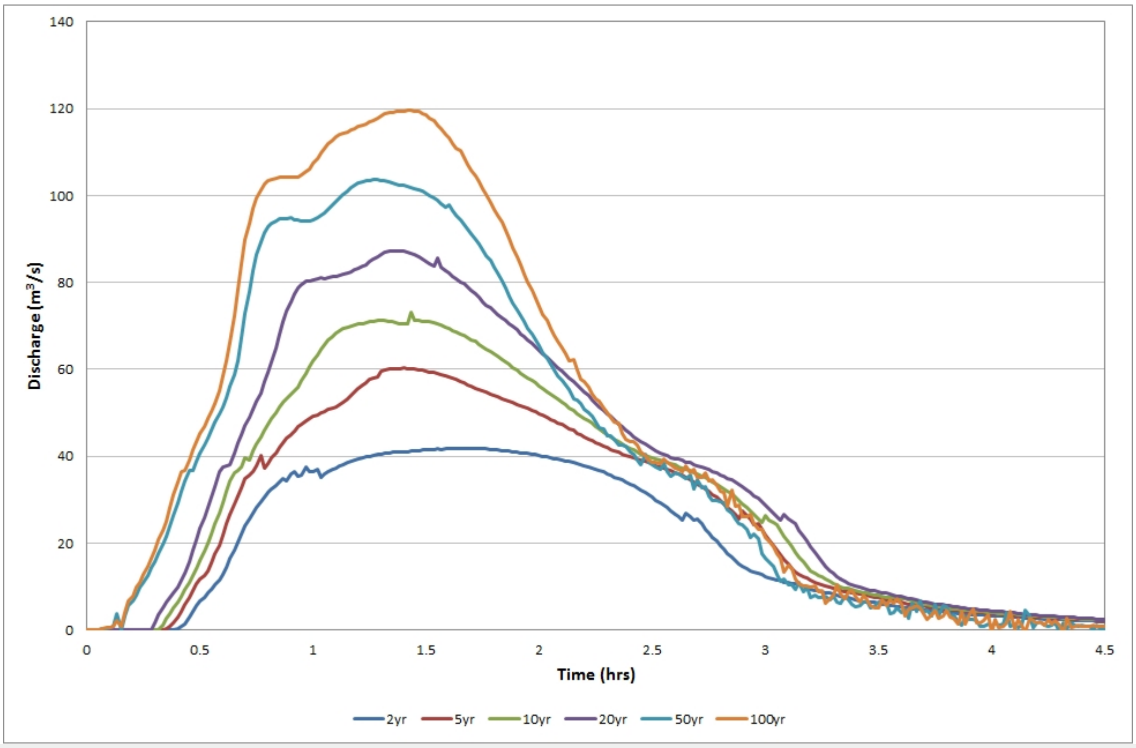

Image 7 | Design Event Discharge Hydrographs – Lakes Creek Road

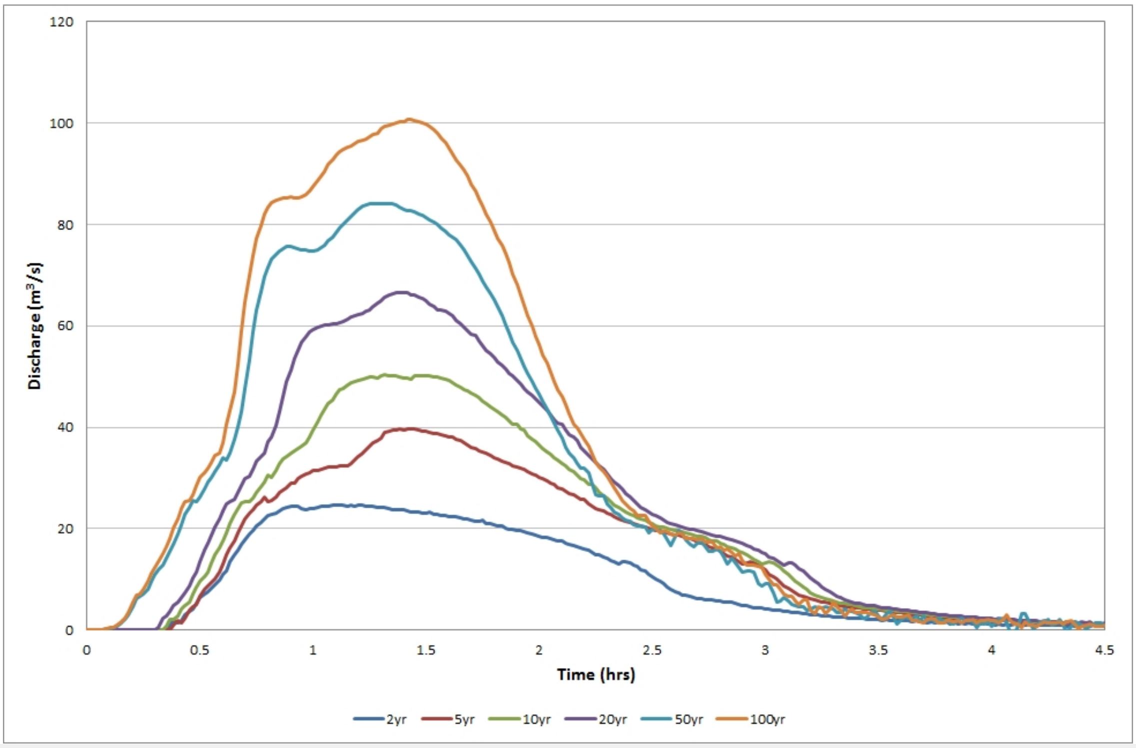

Image 8 | Design Event Discharge Hydrographs – Yeppoon Branch Railway

Appendix E
Critical infrastructure inundation assessment

Roads and rail

ARI at which Road Becomes Inundated (not Closure Level)	Road/Street Name *	Suburb	Road/Street Section Inundated in PMF Event	Location where Road/Street First Becomes Inundated
2y-5y	Lakes Creek Road	Koongal	Model boundary near Ellis Street to catchment boundary at Stack Street	Near Dee Street
10y-20y	Thozet Road	Koongal	Grubb Street to downstream model boundary	Between Williams Street and Grubb Street
500y-PMF	Yeppoon Branch Railway	Koongal	Model boundary near Ellis Street to catchment boundary at Stack Street	Between Thozet Road and Yeppoon Branch Railway Bridge

** Based upon major roads information supplied by Council*

Water and sewerage infrastructure

ARI at which Infrastructure Becomes Inundated*	Infrastructure Type	Suburb	Name/Location
There is no inundated critical water and sewerage infrastructure within the Thozets Creek catchment			

** ARI was determined based upon the location of the water/sewerage point object, as provided in GIS. It may not be representative of the facility as a whole.*

Critical infrastructure, emergency facilities and possible evacuation shelters

Approx ARI at which Building Location Starts to Become Inundated*	ARI at which Property Starts to Become Inundated	Infrastructure Type	Address	Suburb	Name
There is no inundated critical infrastructure, emergency facilities or possible evacuation shelters within the Thozets Creek catchment					

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