

Flinders Precinct 1: **Flood Impact Assessment**

April 2017

**PLANS AND DOCUMENTS
referred to in the PDA
DEVELOPMENT APPROVAL**

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Flinders Precinct 1: Flood Impact Assessment

Prepared for: Pacific International Development Corporation Pty Ltd

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Synopsis: Flood impact assessment for Precinct 1 of the Flinders Master Planned Community with the inclusion of the proposed lakes. This plan has been prepared in response to the Terms of Reference from Economic Development Queensland (EDQ) and to augment the successful planning, design, implementation and management of the proposed lakes.		

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1 Introduction

1.1 Background

The Flinders Master Planned Community (hereafter referred to as Flinders) is a 4,000 hectare landholding being developed by the Pacific International Development Corporation. Flinders is located in Undullah, south west of Logan City as shown in Figure 1-1.

Flinders includes an approximately 1,000 hectare area known as Precinct 1, which is located within the Greater Flagstone Priority Development Area (GFPDA). Precinct 1 is proposed to ultimately accommodate approximately 18,000 residents in 7,280 dwellings.

The remainder of the Flinders site (which is to the west of Precinct 1), is referred to as the 'Balance Land'. The overall project will result in approximately 20,000 dwellings with 50,000 residents. Proposed land uses are further described in Section 2.4.

Previous planning completed with respect to the Flinders development assumed that the watercourses within the development would be retained. Detailed flood modelling was completed (refer Section 1.4) in support of this solution to demonstrate that the development could proceed without causing unacceptable flood impacts.

Subsequent to the completion of the reports, the Master Plan was revised to include lakes as focal points of the development. The Master Plan envisages an upper lake upstream of a larger lower lake within Precinct 1.

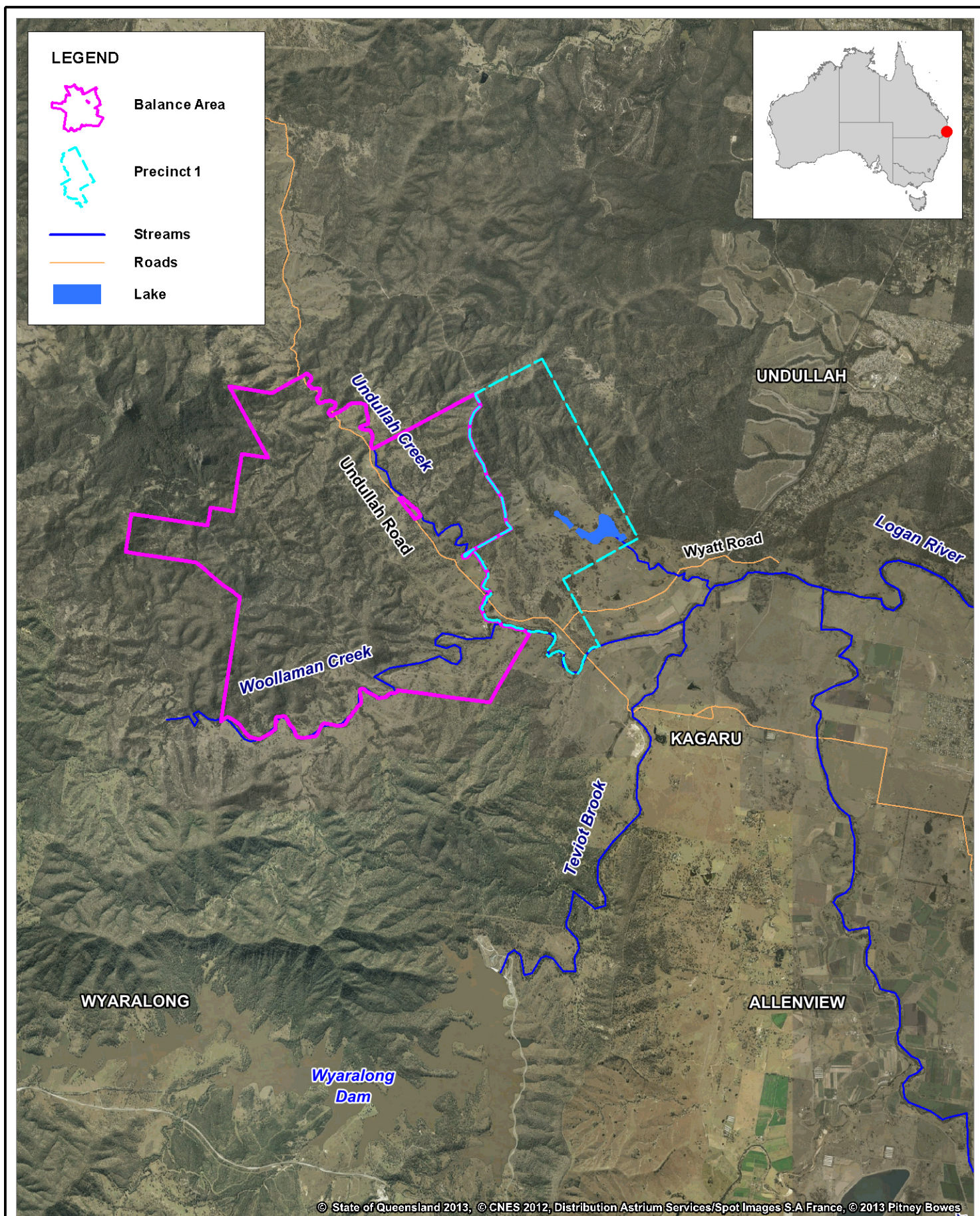
It is proposed that the lakes will be integrated into Precinct 1 to enhance amenity for the benefit of the local community and to provide recreational opportunities for future residents. As the lakes are yet to be formally named, for the purposes of this report the lakes are referred to as the upper and lower lakes. The lakes will be located in the south-east corner of Precinct 1 at the headwaters of an unnamed creek.

The lower lake is expected to be "U-shaped" in response to topography. As the lakes and most of their catchment are located within Precinct 1 (refer to Section 2.3 for further description of site topography and drainage), discussion about the 'site' in this report hereafter refers to Precinct 1. The exception to this is where reference is made to the broader 'Flinders site' which includes the entire development.

1.2 General Lake Description

The lakes are to be constructed in the lowest area of Precinct 1 as shown in Figure 2-4. The lakes will be formed by constructing dams across the watercourse upstream of the southern Precinct 1 boundary. The areas of the upper and lower lakes are expected to be approximately 3.8 hectares and 22.3 hectares respectively, with an average typical water depth of the order of 4 metres.

It is anticipated that the lakes will be predominantly open water with mostly fringing vegetation and some 'hard edge' treatments, including (for example boardwalks) and rock walls. Boat ramps, jetties, pontoons, canoe launching facilities and other community facilities are also likely to be integrated adjacent to the lakes to augment recreational values.



Title:
Location of Site

Figure:
1-1

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Existing Case Flood Model Results

1.3 Report Objective

The primary objectives of the investigation were as follows:

- 1) Develop a new flood model to represent existing case conditions;
- 2) Revise the existing case model to reflect the proposed development and lakes; and
- 3) Quantify the impacts on flooding as a result of the proposed development and confirm that the development will not adversely impact on flooding external to the site.

The investigation was completed in order to update the previous modelling and to address the flooding component of the Terms of Reference issued by DSDIP on 22 July 2014, as repeated below.

'To change the original approval, it will be necessary to update the Gilbert and Sutherland Report Conceptual Flood Assessment, Flinders Grove, Undullah, Queensland (March 2011) to reflect the proposed waterbody.'

The embankment at the downstream end of the waterbody is likely to be substantial. A consideration of issues and risk associated with the embankment will be required, identifying the studies (for example Dam Failure Impact Assessment) that will be required as part of a subsequent IMP-OSS/application processes to confirm the number of Persons at Risk and embankment design criteria.'

A detailed response to the Terms of Reference is provided in Section 5 of this report.

This report deals with the main tributary draining through Precinct 1. For the western part of Precinct 1 that drains to Undullah Creek and Woollaman Creek, the 2011 Gilbert and Sutherland report remains valid.

1.4 Reference Reports

This report has been produced based on the previous work outlined in the following reports:

BMT WBM, 2017, "Flinders Precinct 1: Lake Concept Management Plan", BMT WBM;

G&S, 2011, "Conceptual Flood Assessment Flinders Grove Undullah, Queensland", Gilbert and Sutherland Pty Ltd, document ref no: 10511 FLD AJF1F.docx (hereafter referred to as the G&S 2011 report); and

G&S, 2012, "Flood Assessment Flinders Neighbourhood 1 North and Neighbourhood 3 Undullah, Queensland", Gilbert and Sutherland Pty Ltd, document ref no: 10767 RAF1F.docx (hereafter referred to as the G&S 2012 report).

2 Flinders Site Description

2.1 Preamble

This section provides an overview of the Flinders site, including a description of existing land uses, topography, drainage and soils.

2.2 Site Location and Existing Use

The site is located in Undullah, south west of Logan City as shown in Figure 1-1. Undullah is a locality divided between the Logan City and the Scenic Rim Regional Council, although Precinct 1 is located wholly within the boundaries of Logan City. The Balance Land is predominantly located within the boundaries of Logan City, with a small section located within the boundaries of the Scenic Rim Regional Council. Precinct 1 is located within the Greater Flagstone Priority Development Area, one of a number of such areas defined by the State Government to achieve accelerated development with a focus on economic growth.

The existing Flinders site comprises large tracts of land being actively grazed by cattle. The agricultural land use is confined by the steeper topography of the Teviot Range, which is the upper catchment for the Flinders site. The upper catchment is undeveloped and features open forest woodlands.

Photos showing existing conditions of Precinct 1 are provided in Figure 2-1 below.

2.3 Topography, Drainage and Soils

With a ridgeline separating the majority of Precinct 1 from the Balance Land, Flinders is characterised by two separate catchments. Precinct 1 features steep, densely-wooded terrain to the north including peaks of the Teviot Range (also referred to as the Flinders Peak Group) up to 320m Australian High Datum (AHD). The precinct drains towards the south where topography becomes flatter towards its lowest point of approximately 25 m AHD.

The Balance Land also features steep, forested land in its upper catchment with peaks of the Teviot Range up to approximately 355 metres AHD. The Balance Land drains predominantly to the east towards its lowest point which is approximately 35 metres AHD. A digital elevation model (DEM) showing the topography of the existing Flinders site is shown in Figure 2-3.

The Flinders site is located within the Logan River Drainage Basin. Two major creeks drain the Balance Land including Undullah Creek which flows from north to south through the Flinders site and Woollaman Creek, which joins Undullah Creek along the southern boundary of the Flinders site.

Teviot Brook flows from Wyaralong Dam in a north easterly direction past the south east corner of Precinct 1. Woollaman Creek flows into Teviot Brook approximately 1.4 kilometres downstream of the site and then flows into the Logan River a further 3.2 kilometres downstream of the confluence of these two waterways. The ultimate receiving environment for the Flinders site is southern Moreton Bay.

Precinct 1 drains to the south-east via an unnamed tributary to its junction with Teviot Brook approximately 1.3 kilometres downstream of the site boundary and also downstream of the junction between Woollaman Creek and Teviot Brook.

Existing Case Flood Model Results

The Flinders site features highly dispersive soils and many of the drainage corridors across the site are deeply eroded in the upper catchment, erosion is often down to sandstone bedrock while in the lower catchment creek bed erosion is down to granite bedrock. Eroded material covers the base of the drainage paths and creeks.

Other notable drainage features include a large weir structure which currently limits flows in Undullah Creek and a series of farm dams located across the Flinders site. The key drainage features of the existing Flinders site are shown in Figure 2-2.

The integration of the lakes will require the construction of a dam across the unnamed watercourses that drain through Precinct 1. The undeveloped catchment draining to the proposed lakes is approximately 557 hectares, the majority of which is located wholly within Precinct 1, apart from an area in the upper catchment of approximately 51 hectares that is located north east of the site. The location of the lakes and their contributing catchments are presented in Figure 2-4.



Figure 2-1 Photos of Precinct 1



Examples of eroded drainage paths in the upper to mid catchments



Examples of deposition and suspension of eroded material in mid catchment (L) and lower catchment (R) waterways

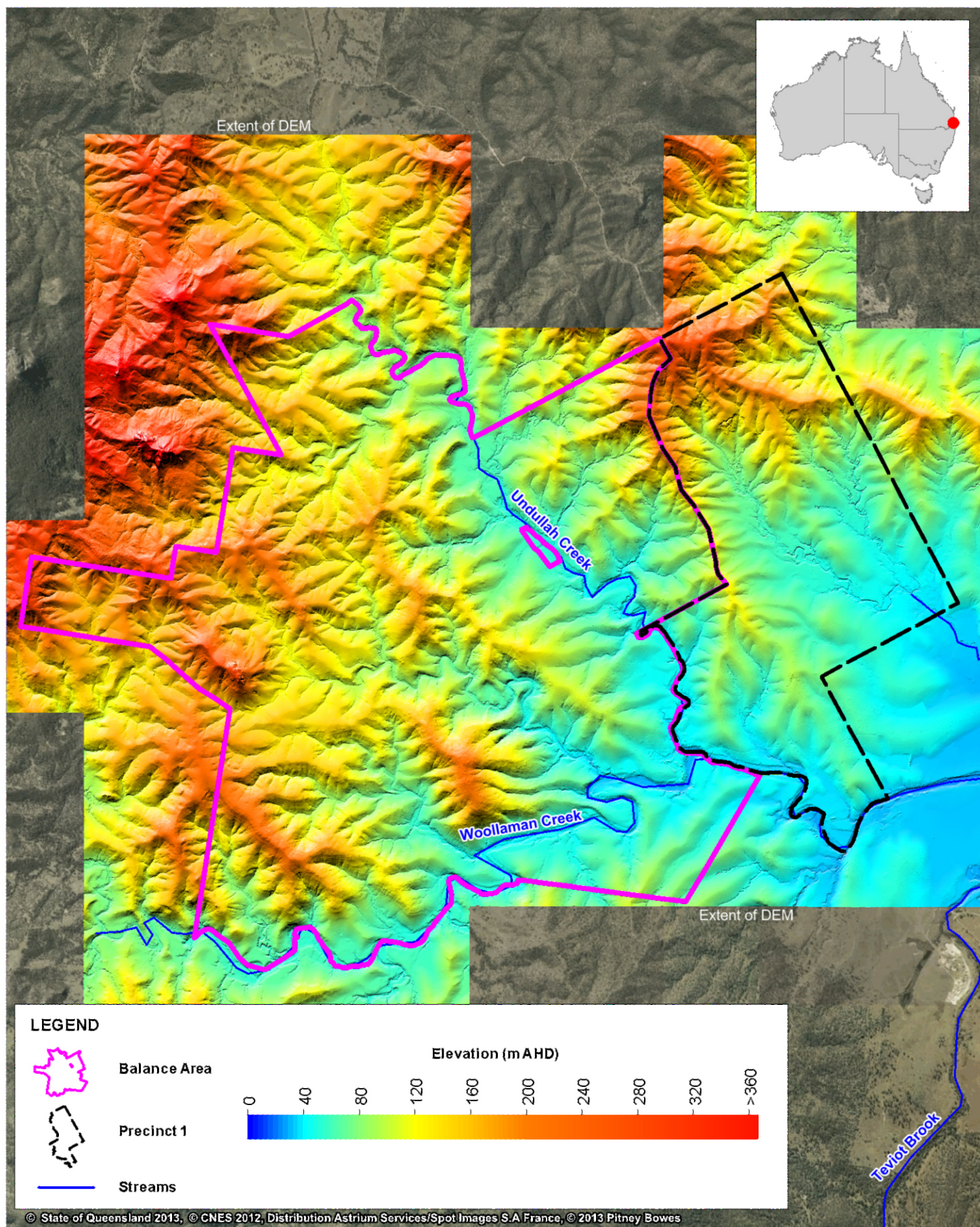


Examples of exposed sandstone bedrock in the upper catchment (L) and exposed granite bedrock in the lower catchment (R)



Example of farm dam (L) and the Undullah Creek weir (R)

Figure 2-2 Photos Showing Key Drainage Features of the Flinders Site



Title:
Digital Elevation Model Showing Existing Topography

Figure:

2-3

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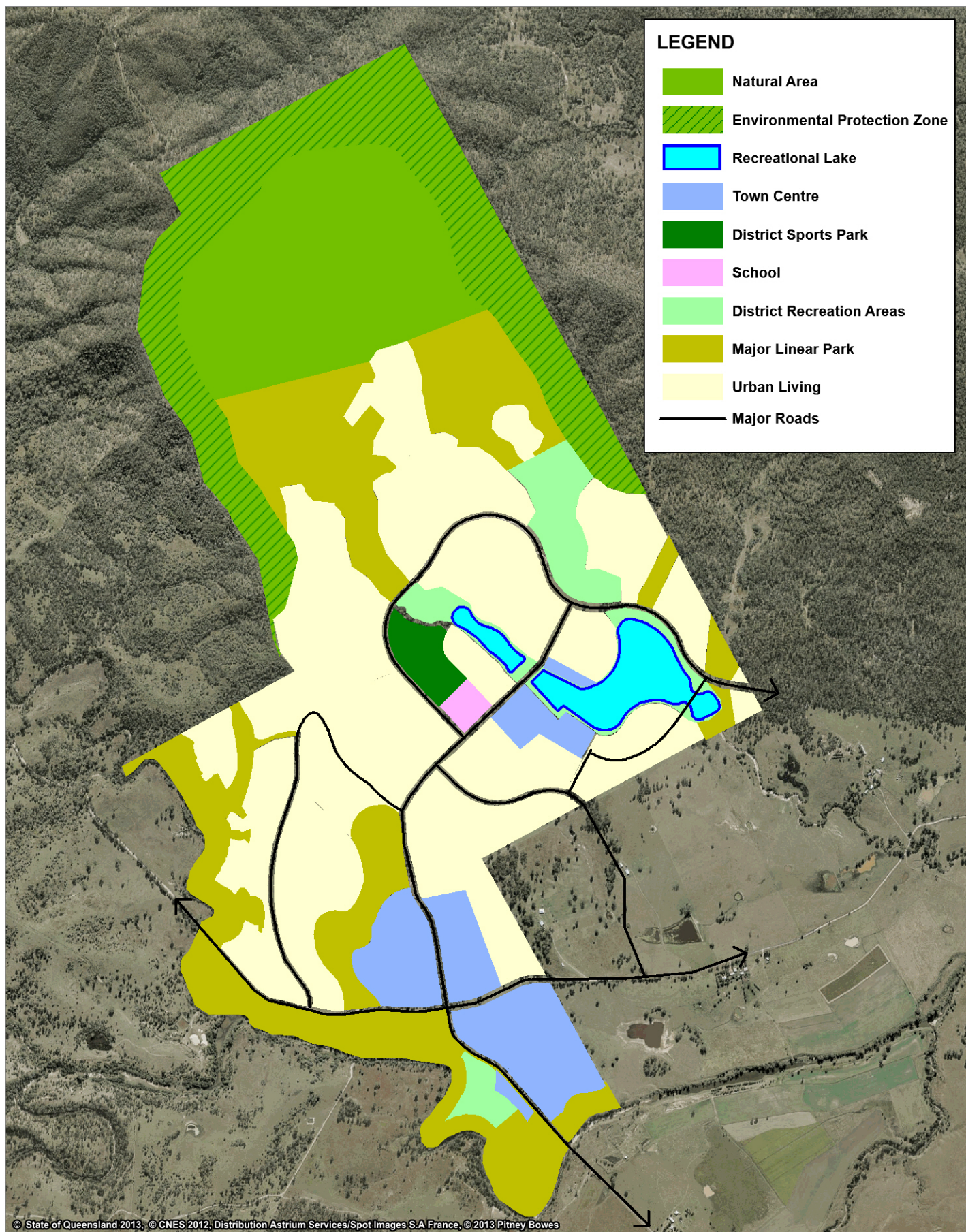
Existing Case Flood Model Results

2.4 Proposed Land Use

A proposed land use plan has been developed for Precinct 1 and conceptually for the Balance Land as part of a Section 242 Material Change of Use (MCU) application to Logan City Council. The land use plan for Precinct 1 is shown on Figure 2-4, and proposed land uses for Precinct 1 include:

- community use areas;
- conservation areas;
- environmental protection zones;
- neighbourhood centre;
- neighbourhood residential;
- recreation sports;
- riparian corridors; and
- town centre.

The watercourses draining to the lakes are expected to be surrounded by recreation/sports land uses with the neighbourhood centre and a community use area also fronting the lakes. Two open space 'spines' will provide the primary pathway for stormwater to drain into the lakes. It is expected a series of smaller such spines may also be identified during subsequent planning and design exercises.



Title:
Precinct 1 Proposed Land Use Plan

Figure:
2-4

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3 Hydrological Model Setup

3.1 Preamble

Hydrologic models were constructed for both the existing site, and the site including the proposed development. The non-linear runoff routing WBNM software package (WBNM2003 v1.03) was used to create the models. Runoff hydrographs calculated by the models were input to the hydraulic model of the site (refer Section 4).

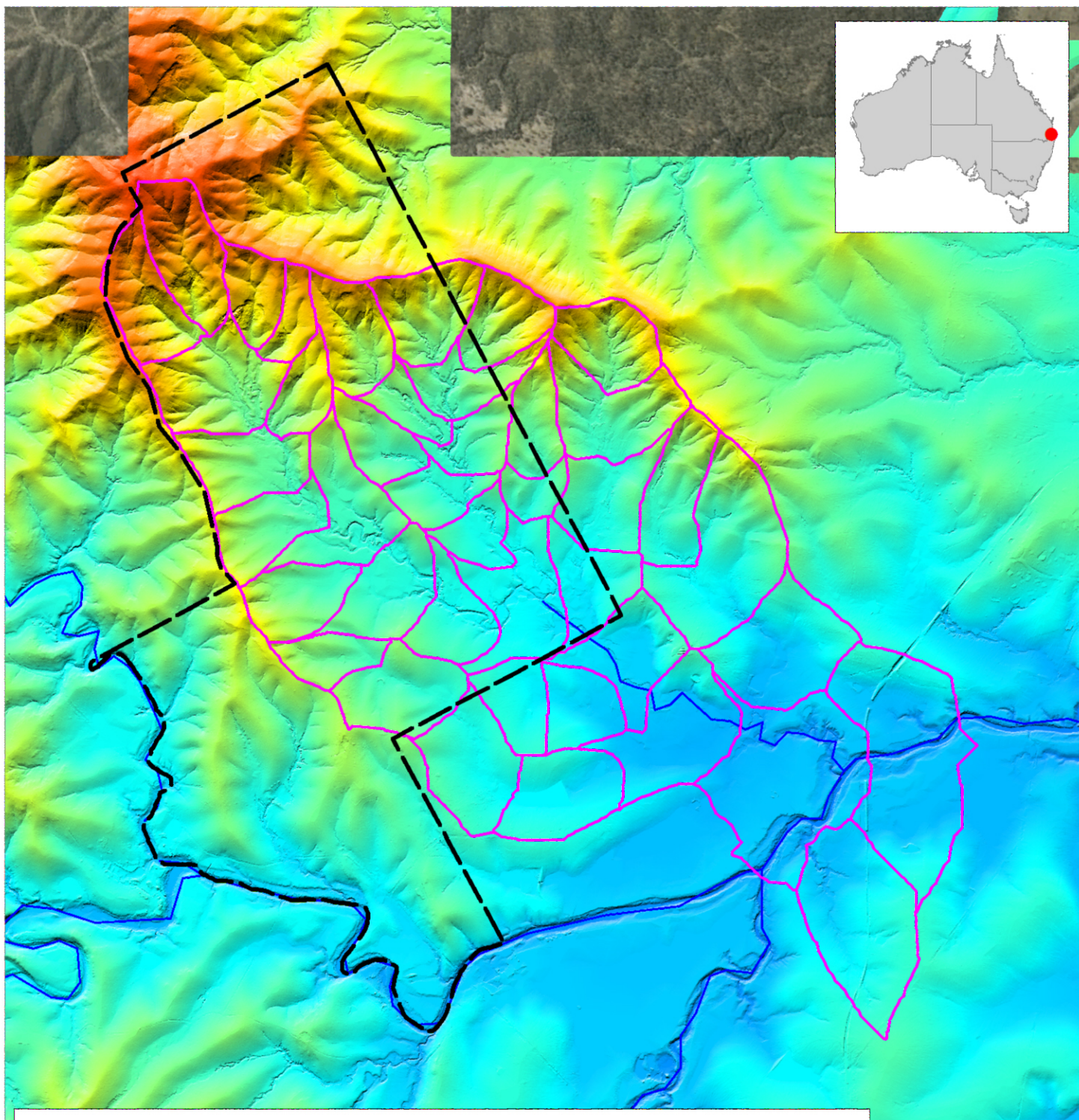
The hydrological models were based on models previously developed by Gilbert and Sutherland (as detailed in the G&S 2011 and G&S 2012 reports), with updates made as appropriate to the development layout and proposed land uses to reflect the current Master Plan for the development.

For the existing case hydrology it was assumed that the area to the east of the site is un-developed and that appropriate measures will be put in place to ensure that development of the area does not result in an increase in discharge into the Flinders development area.

3.2 Existing Case Hydrologic Model Setup

3.2.1 Sub-catchment Delineation

To represent the hydrologic behaviour of the site in its existing condition, 42 sub-catchments were created using the CatchmentSIM software package and are presented on Figure 3-1.



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Sub-Catchments

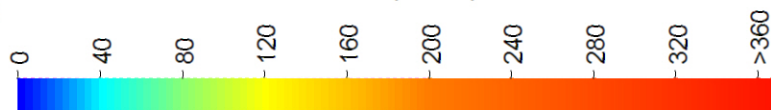


Precinct 1



Streams

Elevation (m AHD)



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Title:

Exisiting Site Hydrologic Sub-Catchments Layout

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3-1

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Existing Case Flood Model Results

3.2.2 Land Use Fraction Impervious

Catchment land use was determined for the existing site based on aerial photography and site inspection. Appropriate fraction impervious areas were then defined for each use based on Table 4.5.1 of the *Queensland Urban Drainage Manual* (QUDM, 2013). The fraction impervious values adopted for each landuse are listed in Table 3-1.

The resultant fraction impervious values adopted for each sub-catchment are presented in Table 3-2.

Table 3-1 Landuse Impervious %

Landuse	Impervious %
Urban Residential	75%
Commercial and Community Centres	90%
Dense Vegetation	0%
Light Vegetation	0%
Open Space / Grass	0%
Standing Waterbodies	100%
Roads – Pavement	90%
Exposed Creek Channel Bed	0%
Rock for Scour Protection	100%

Table 3-2 Existing Site Sub-Catchment Properties

Sub-catchment ID	Area (ha)	Impervious %	Sub-catchment ID	Area (ha)	Impervious %
10-a	24.9	0	2-c	31.1	0
11-a	19.6	0	2-d	26.4	0
12-a	19.0	0	2-e	35.1	0
12-b	10.6	0	2-f	29.9	0
13-a	27.7	0	2-g	23.5	0
13-b	37.4	0	2-h	38.7	0
13-c	29.0	0	2-i	25.1	0
14-a	15.8	0	2-j	31.7	0
14-b	32.8	0	2-k	45.8	0
14-c	36.9	0	3-a	30.6	0
14-d	33.3	0	4-a	18.4	0
15-a	20.4	0	5-a	12.9	0
15-b	21.9	0	6-a	16.7	0
16-a	31.3	0	7-a	26.1	0
16-b	63.2	0	8-a	28.0	0
16-c	46.5	0	8-b	12.4	0
18-a	64.7	0	8-c	17.6	0
1-b	80.8	0	8-d	16.6	0
1-c	86.3	0	8-e	15.7	0
2-a	35.0	0	9-a	29.9	0
2-b	40.8	0	9-b	20.8	0

Existing Case Flood Model Results

3.2.3 Stream Lag

A catchment stream lag of 1.0 was used for the existing case WBNM model to represent the natural channel flow. However, it should be noted the stream lag has no direct effect on the hydraulic model as runoff from each sub-catchment was directly applied to the TUFLOW hydraulic model.

The stream lag parameter was used to ensure peak flows obtained from the WBNM model were reasonable. The stream lag parameter used for the analysis is detailed in Section 3.2.5 while the verification analysis undertaken is described in Section 3.2.6.

3.2.4 Rainfall Parameters

The rainfall parameters used in the WBNM model were extracted from AR&R (1987) for the Undullah area. The parameters are presented in Table 3-3 and an Intensity Frequency chart is presented in Figure 3-2.

Table 3-3 Rainfall Data

Parameter	Value
ARR Zone	3
2 Year ARI 1 hour	44.02
2 Year ARI 12 hour	6.76
2 Year ARI 72 hour	1.87
50 Year ARI 1 hour	81.41
50 Year ARI 12 hour	12.23
50 Year ARI 72 hour	3.86
Skew Coefficient	0.19
Geographical Factor F2	4.39
Geographical Factor F50	17.08

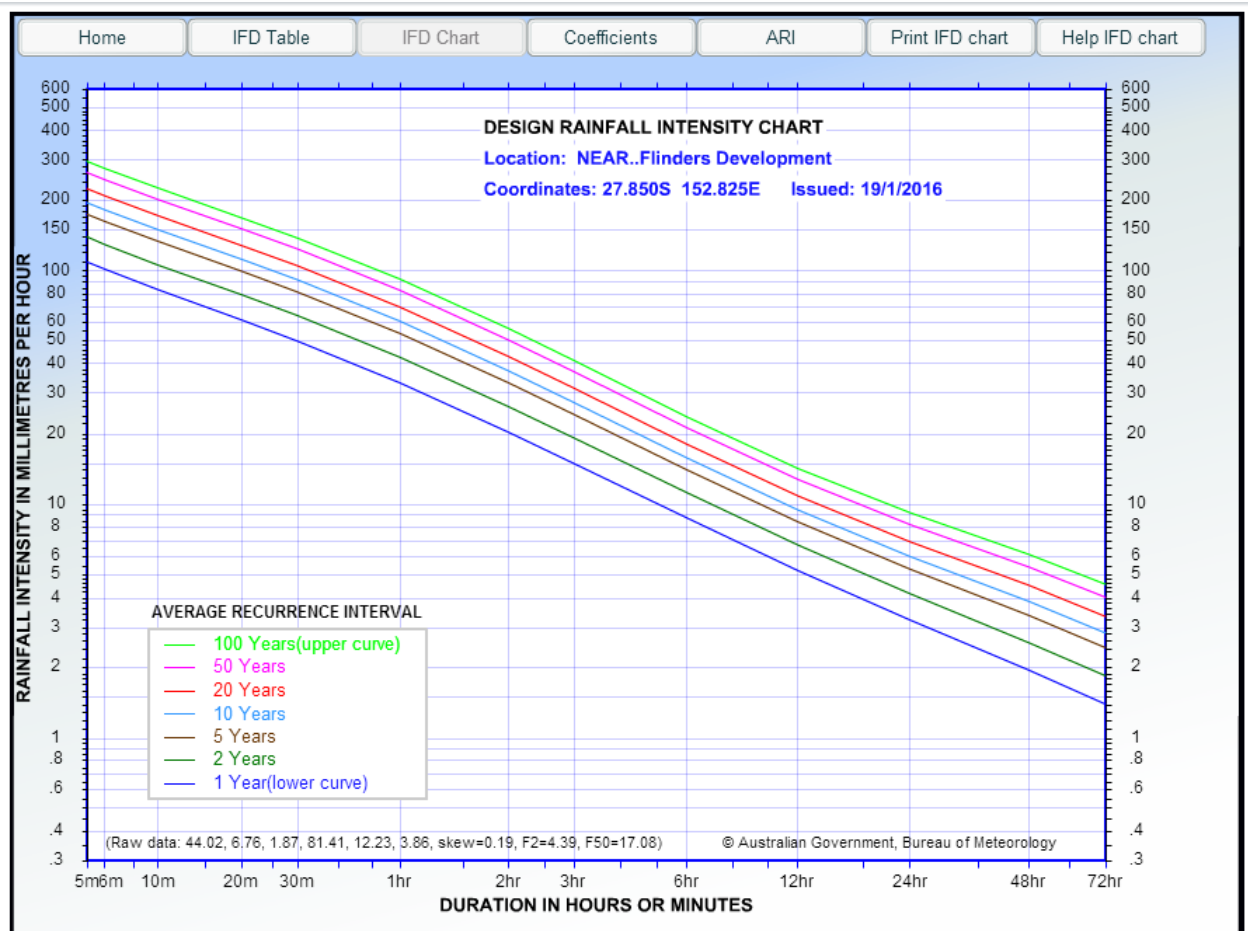


Figure 3-2 Design Rainfall IFD Chart

3.2.5 Hydrologic Parameters

The hydrologic parameters adopted in the WBNM model are presented in Table 3-4. These parameters are based on the previous flood modelling undertaken for the site by Gilbert and Sutherland, as presented in Table 3.1.1 of the G&S 2012 report). For the G&S 2012 report a lag parameter value of 1.6 was adopted based on the recommended values for WBNM models (refer Section 4.1 of the G&S 2012 model). Based on a review of the peak flow rates obtained using this value (refer Section 3.2.6), the lag parameter was considered to be reasonable.

It can be noted that an initial loss of 15 mm was adopted for pervious areas for all events in accordance with the recommendation of the SKM review of the previous G&S flood report, as documented in the G&S letter dated 4 February 2012.

Table 3-4 Sub-Catchment Hydrologic Parameters

Parameter	Design Storm ARI						
	1	2	5	10	20	50	100
Initial Loss (Pervious) (mm)	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Initial Loss (Impervious) (mm)	0.5						
Continuing Loss (Pervious) (mm)	1.5						
Lag Parm C	1.6						
Impervious Lag Factor	0.1						

Existing Case Flood Model Results

3.2.6 Rational Method Verification

Due to the absence of a stream gauge on the watercourses that drain through the site, it was not possible to calibrate the hydrologic models to historic flood events.

In lieu of stream gauge data, recourse was made to the Rational Method to confirm that the peak flows calculated by the hydrologic model were reasonable. For the Rational Method assessment, which was completed in accordance with the procedures nominated in Section 4 of QUDM, parameters presented in Table 3-5 were adopted for the total site catchment. The resultant peak flows for a range of events are presented in Table 3-7.

Table 3-6 lists the peak flows obtained from the WBNM model for a range of events and a range of storm durations for each event. With reference to Table 3-6, storm durations of between two and three hours produce peak flow conditions at the downstream boundary of the catchment.

Table 3-5 Rational Method Parameters

Parameter	Value	Notes
Catchment Area	1,310 ha	
Fraction Impervious	0%	
Length of Flow Path from Catchment Divide	7 km	
Time of Concentration	201 min	From Bransby-Williams' Equation
Runoff Coefficient (C_{10})	0.70	G+S soil assessment indicated that the soils show a very low permeability.

Table 3-6 Existing Case WBNM Peak Discharge

Event Duration	Design Storm Average Recurrence Interval						
	1	2	5	10	20	50	100
10min	0.0	1.1	4.4	6.8	10.4	15.7	20.1
20min	2.8	7.4	14.2	18.7	25.1	34.8	42.6
30min	6.4	12.9	22.2	28.3	37.2	49.9	60.3
1 Hour	15.5	25.9	40.9	50.7	64.7	84.4	100.6
2 Hours	21.5	34.3	52.1	63.6	79.7	101.8	119.8
3 Hours	24.0	37.2	55.0	66.1	81.5	101.3	117.7
6 Hours	22.8	33.7	47.9	56.7	69.0	82.3	94.8

Note: ARI Peak Discharge highlighted in grey.

A comparison of the peak flow predicted using the Rational Method and that calculated by the WBNM model is presented in Table 3-7.

Existing Case Flood Model Results**Table 3-7 Rational Method Comparison**

ARI (Years)	Rational Method	WBNM	% Difference
100	122.4	119.8	-2%
50	102.6	101.8	-1%
20	80.3	81.5	+1%
10	58.6	66.1	+13%
5	50.9	55.0	+8%
2	39.0	37.2	-5%
1	28.6	24.0	-16%

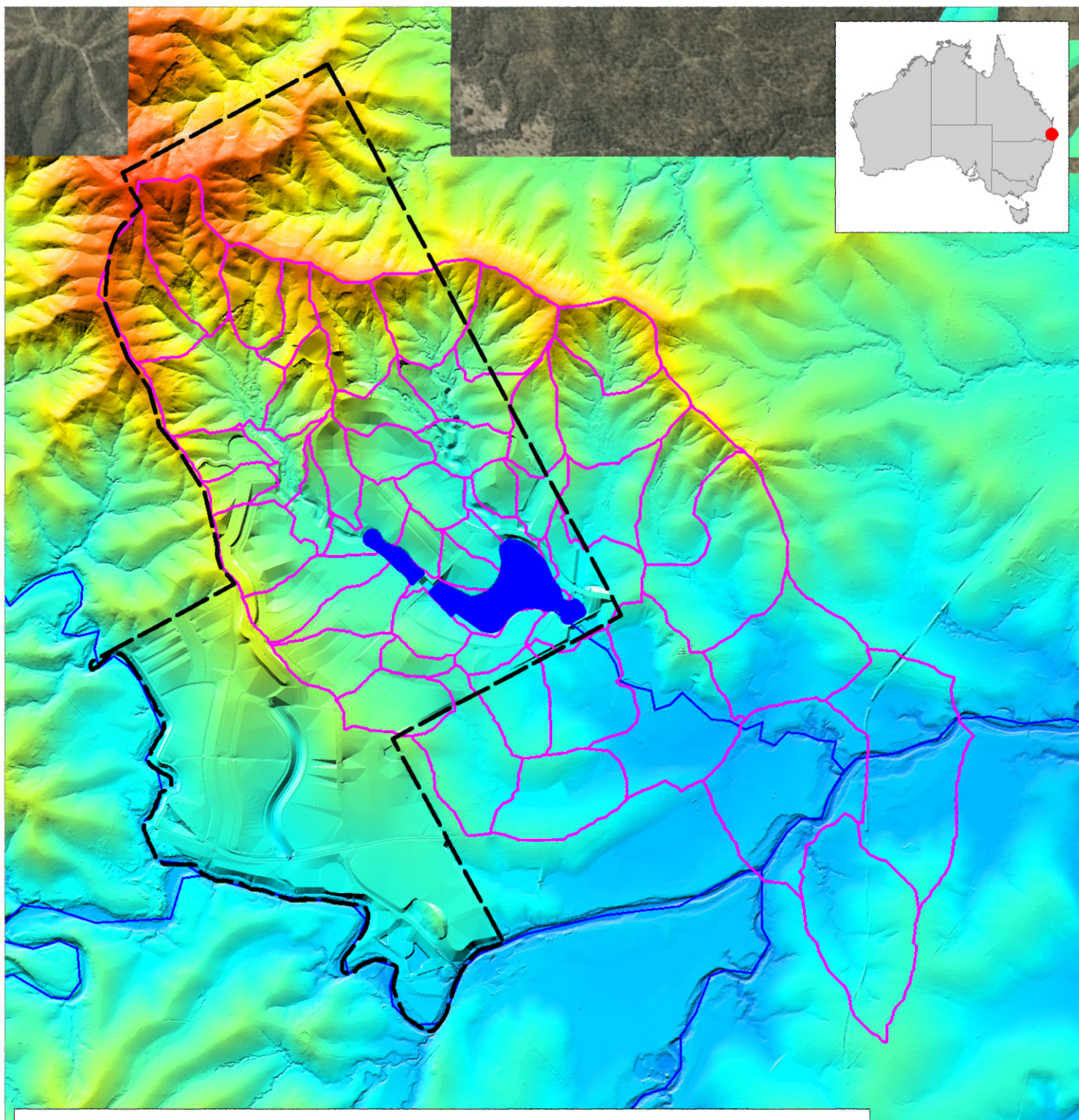
Based on the results presented in Table 3-7 above, it is considered that a good correlation exists between the WBNM model and the Rational Method and that therefore the model can be used with confidence to define runoff hydrographs for use in the hydraulic model.

3.3 Developed Case Hydrologic Model Setup

To reflect the developed case, the existing case hydrologic model was updated to reflect the proposed terrain and land use changes associated with the development. Information regarding the developed case terrain was provided by the civil engineering consultants for the project, Mortons Urban Solutions.

3.3.1 Developed Case Sub-catchment Delineation

For the site in its developed condition, 48 sub-catchments were created using the CatchmentSIM software package. The resultant catchments are presented on Figure 3-3.



LEGEND



Sub-catchments



Precinct 1



Streams

Elevation (m AHD)



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Title:
Developed Site Hydrologic Sub-Catchment Layout

Figure:

3-3

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Existing Case Flood Model Results

3.3.2 Developed Case Land Use Fraction Impervious

Based the development plan presented in Figure 2-4, and the land usage fraction impervious values presented in Table 3-1, the fraction impervious for each of the developed case subcatchments was determined. The resultant subcatchment properties are presented in Table 3-8.

Table 3-8 Developed Site Sub-Catchment Properties

Sub-catchment ID	Area (ha)	Impervious %	Sub-catchment ID	Area (ha)	Impervious %
10-a	12.2	69.8	26-c	25.2	0.0
11-a	27.7	12.0	27-a	21.8	6.4
11-b	15.8	46.8	28-a	21.4	44.2
11-c	13.5	30.7	28-b	37.0	3.5
12-a	30.3	0.1	28-c	33.8	5.1
12-b	21.3	11.4	29-a	36.0	0.0
13-a	29.7	0.0	29-b	61.8	3.2
14-a	13.2	63.4	29-c	51.8	5.4
15-a	22.7	62.1	2-a	35.7	0.0
16-a	17.5	69.8	2-b	38.7	0.0
17-a	19.3	74.8	2-c	11.4	25.9
17-b	6.3	77.0	2-d	10.6	45.8
17-c	10.8	57.7	2-e	16.4	46.4
18-a	18.7	6.6	2-f	30.0	100
18-b	10.1	33.2	2-g	33.3	18.0
19-a	7.6	60.0	2-h	32.9	0.1
1-b	78.5	1.8	2-i	63.4	2.2
1-c	82.6	0.5	31-a	65.0	0.0
20-a	12.4	56.7	3-a	31.1	0.0
21-a	8.2	61.9	4-a	19.4	0.0
22-a	13.8	63.0	5-a	12.5	6.2
23-a	7.8	51.9	6-a	18.1	18.9
24-a	9.1	55.3	7-a	12.2	25.3
25-a	2.2	62.6	8-a	9.4	40.7
26-a	26.8	0.0	9-a	25.6	68.8
26-b	38.4	0.0			

3.4 Probable Maximum Flood

To allow the impact of an extreme event to be assessed, the WBNM hydrological model was also used to estimate inflows during the Probable Maximum Flood (PMF) for the developed site.

Hydrologic inputs to the WBNM model for the PMF estimation were based on the methodology outlined in the Bureau of Meteorology's (BOM, 2003) "*Estimation of Probable Maximum Precipitation in Australia: Generalized Short-Duration Method*".

A summary of the hydrologic inputs are presented in Table 3-9. The resultant total design rainfalls for each PMF duration are presented in Table 3-10.

Table 3-9 PMF Hydrologic Inputs

Parameter	PMF Design Storm
Initial Loss (Pervious) (mm)	0.0
Initial Loss (Impervious) (mm)	0.0
Continuing Loss (Pervious) (mm)	0.0
Lag Parm C	1.6
Impervious Lag Factor	0.1
Terrain Category (R and S)	R = 1.0, S = 0.0
Elevation Adjustment Factor (EAF)	1.0
Moisture Adjustment Factor (MAF)	0.83

Table 3-10 PMF Design Rainfall

Event Duration (min)	Total Design Rainfall (mm)
20	203
30	256
60	386
120	571
180	689
360	923

4 Hydraulic Assessment

4.1 Preamble

This section provides a description of the hydraulic assessment of the site, including the setup of the dynamic surface and sub-surface TUFLOW 1D/2D hydraulic model, and a discussion of the results.

4.2 Existing Case Hydraulic Model Setup

4.2.1 Model Extent and Topography

The TUFLOW model created for this assessment covers an area of 1,310 ha. The 2D domain for the model was derived from a 12d terrain model of the existing area.

To provide a sufficient level of resolution, a 5 metre grid cell size was used in the 2D domain. The existing case catchment extent and topography was previously presented in Figure 3-1.

4.2.2 Roughness

A roughness map representing the Manning 'n' roughness coefficients was adopted based on previous flood studies for the site (G&S 2012 report) which in turn had been derived from a review of aerial photography and site inspections. As part of the current investigation, the adopted roughness values were reviewed and found to be consistent with ARR Project 15, *Two Dimensional Modelling of Urban and Rural Floodplains* (AR&R, 2012).

Given this, the adopted roughness values presented in Table 4-1 were considered appropriate for use.

Table 4-1 Roughness Values

Landuse	Manning's Roughness
Urban Residential	0.20
Commercial and Community Centres	0.20
Dense Vegetation	0.08
Light Vegetation	0.06
Open Space / Grass	0.05
Standing Waterbodies	0.02
Roads – Pavement	0.02
Exposed Creek Channel Bed	0.035
Rock for Scour Protection	0.022

4.2.3 Boundary Conditions

The tailwater level adopted for the hydraulic model was based on the previous flood study for the development (G&S, 2012). The G&S 2012 report used a tailwater condition of 33.02m AHD to represent the combined influence of regional flooding from the Teviot Brook and the Logan River catchments (refer Section 5.2.2 of G&S 2012 report).

Existing Case Flood Model Results

4.3 Developed Case Hydraulic Model Setup

4.3.1 Model Extent and Topography

To assess the proposed redevelopment of the site, the existing case model 2d domain, as described above, was updated to reflect the proposed terrain and land usage changes associated with the development and the lakes (refer Section 3.3), as shown in , Figure 2-4 and Figure 3-3.

4.3.2 Roughness

The roughness values adopted for the existing case were adjusted to reflect the development layout as outlined in Figure 2-4.

4.3.3 Culvert Network

A 1D domain was used to represent the primary culvert network within the proposed development. The culvert network was based on the preliminary landuse layout, and is limited to only the major waterway crossings within the development. The proposed culvert sizes used in the hydraulic model are presented in Table 4-2. The indicative culvert locations are presented in Figure 4-1.

Further refinement and optimisation of the network will be required as part of detailed design.

Table 4-2 Proposed Culverts

Culvert ID	Quantity	Size (mm)	Type
C1	1	2400x1800	RCBC
C3	3	1800x2100	RCBC
C4	3	3000x2400	RCBC
C6	3	2400x1800	RCBC
C7	2	1500x1500	RCBC

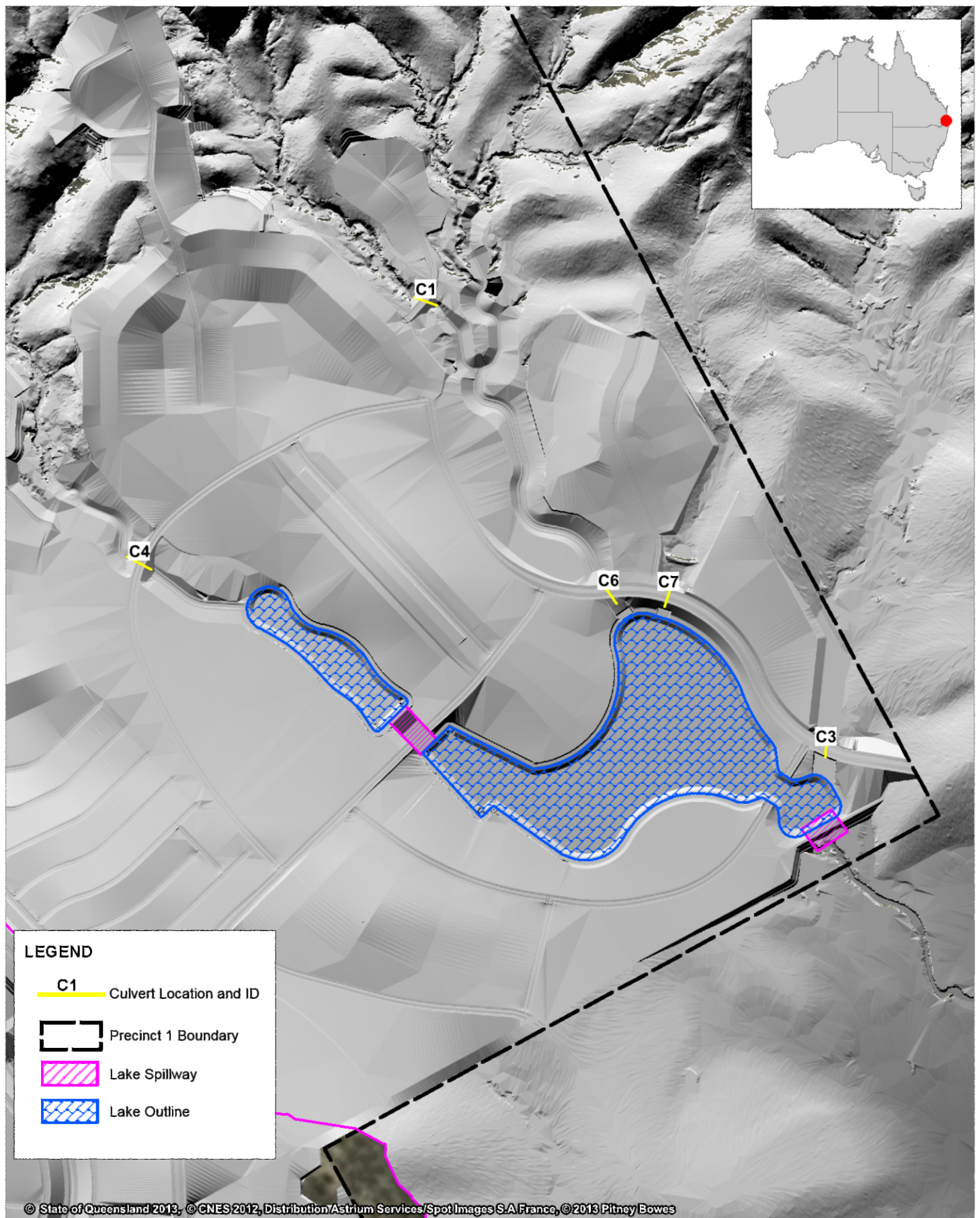
4.3.4 Lake Outlets

Discharge from the upper lake to the lower lake and from the lower lake will be controlled by spillways on the dams that will form the downstream boundary of each lake. The width of each spillway needs to be sufficiently narrow to provide for the ponding of water in the lakes to attenuate the peak flow and ensure that the peak flow discharged from the lower lake does not increase compared to the existing situation. The spillways also have to be sufficiently wide to ensure that the peak water level in the lakes (both for major and extreme events) does not result in too great a difference between the standing water level in the lakes and the adopted minimum development level for roads and houses.

As part of the investigation, a number of spillway widths were trialled. It was determined that a spillway width of 70 metres for the lower lake outlet provided the required amelioration of development impacts on peak flows while also providing peak flood levels in the lake that were manageable. For the upper lake spillway, it was found that a spillway width of 50 metres resulted in similar depths of flooding as the lower lake. It is envisaged that the spillway widths will be further considered as part of detailed design.

Existing Case Flood Model Results**4.3.5 Boundary Conditions**

The same boundary conditions to those used in the existing case model were applied to the developed case model. For the developed case model, the lakes were assumed to be at full capacity (upper lake level 50 mAHD and lower lake level 40m AHD) at the commencement of each design storm event.



Title:
Developed Site Culvert Locations

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4-1

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Existing Case Flood Model Results

4.4 Results

4.4.1 Existing Case

Design floods with Average Recurrence Intervals (ARI) ranging from 1 year to 100 years inclusive were simulated using the hydraulic model. For each event a range of storm durations was considered, with the envelope of peak levels and flows used for the preparation of flood mapping.

Appendix A provides detailed results by way of mapped peak water levels and depths for the existing site for the full range of flood events.

Figure 4-2 and Figure 4-3 show the existing peak 100 year flood levels and depths respectively.

A summary of the modelled peak discharges for the existing case are presented in Table 4-3.

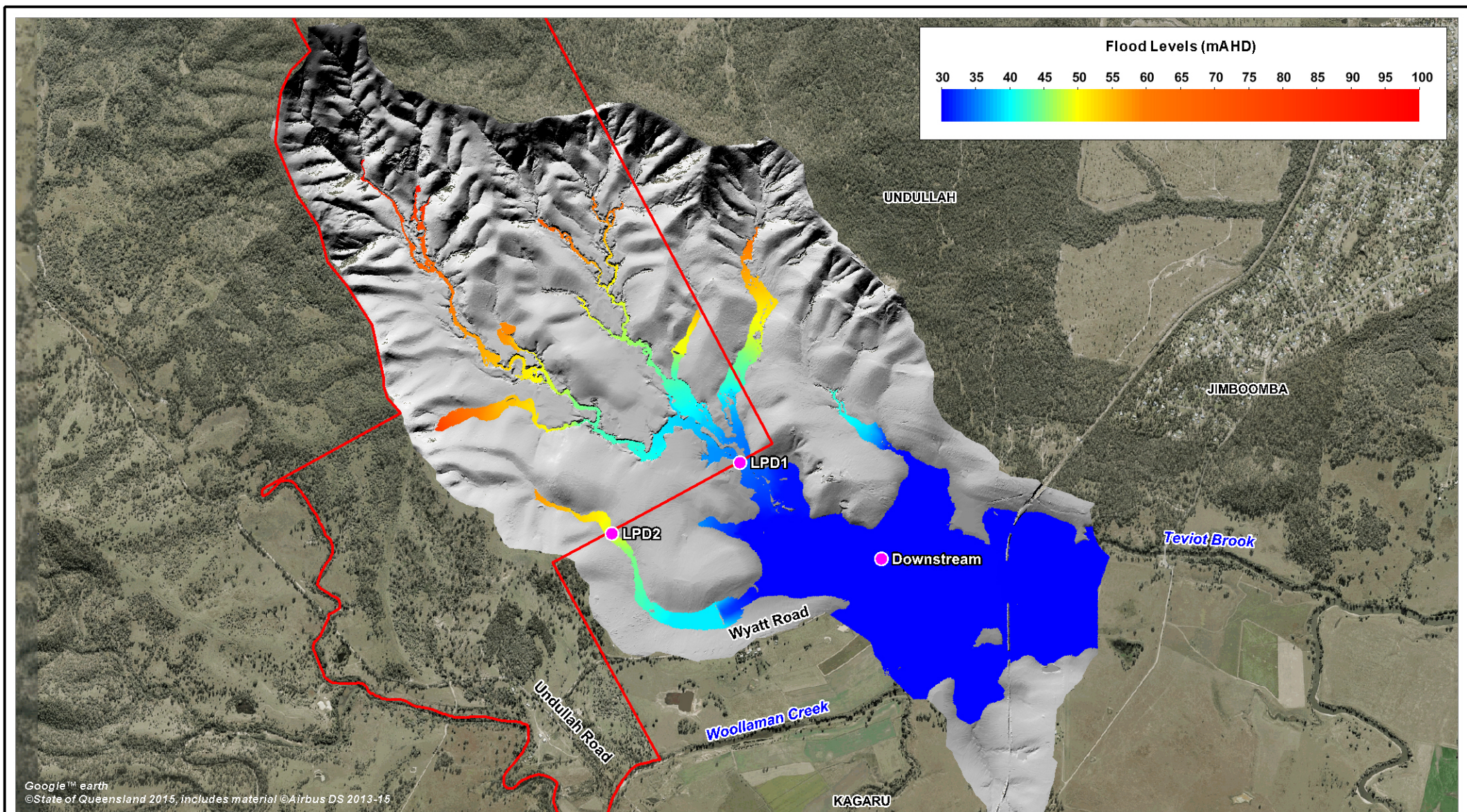
Table 4-3 Existing Peak Discharge

Reporting Point	Design Storm Average Recurrence Interval (y)						
	1	2	5	10	20	50	100
LPD1 Peak Discharge (m ³ /s)	23.4	36.6	52.7	62.3	75.4	97.7	116.3
LPD2 Peak Discharge (m ³ /s)	2.6	4.0	5.9	7.1	8.6	10.0	11.1

Peak flood levels for the site and surrounds at specific reporting points around the site, for the full range of design storms, are presented in Table 4-4. The reporting point locations are shown in Figure 4-2.

Table 4-4 Existing Peak Water Levels

Reporting Point	Design Storm Average Recurrence Interval (y)						
	1	2	5	10	20	50	100
LPD1 Peak Water Level (mAHD)	34.28	34.61	35.14	35.42	35.59	36.04	36.12
LPD2 Peak Water Level (mAHD)	48.16	48.18	48.20	48.22	48.23	48.25	48.26
Downstream Peak Water Level (mAHD)	33.02	33.02	33.02	33.03	33.04	33.04	33.04



LEGEND

- Reporting Points
- Precinct Boundary

Title:

Existing Case ARI 100 Year Peak Flood Levels

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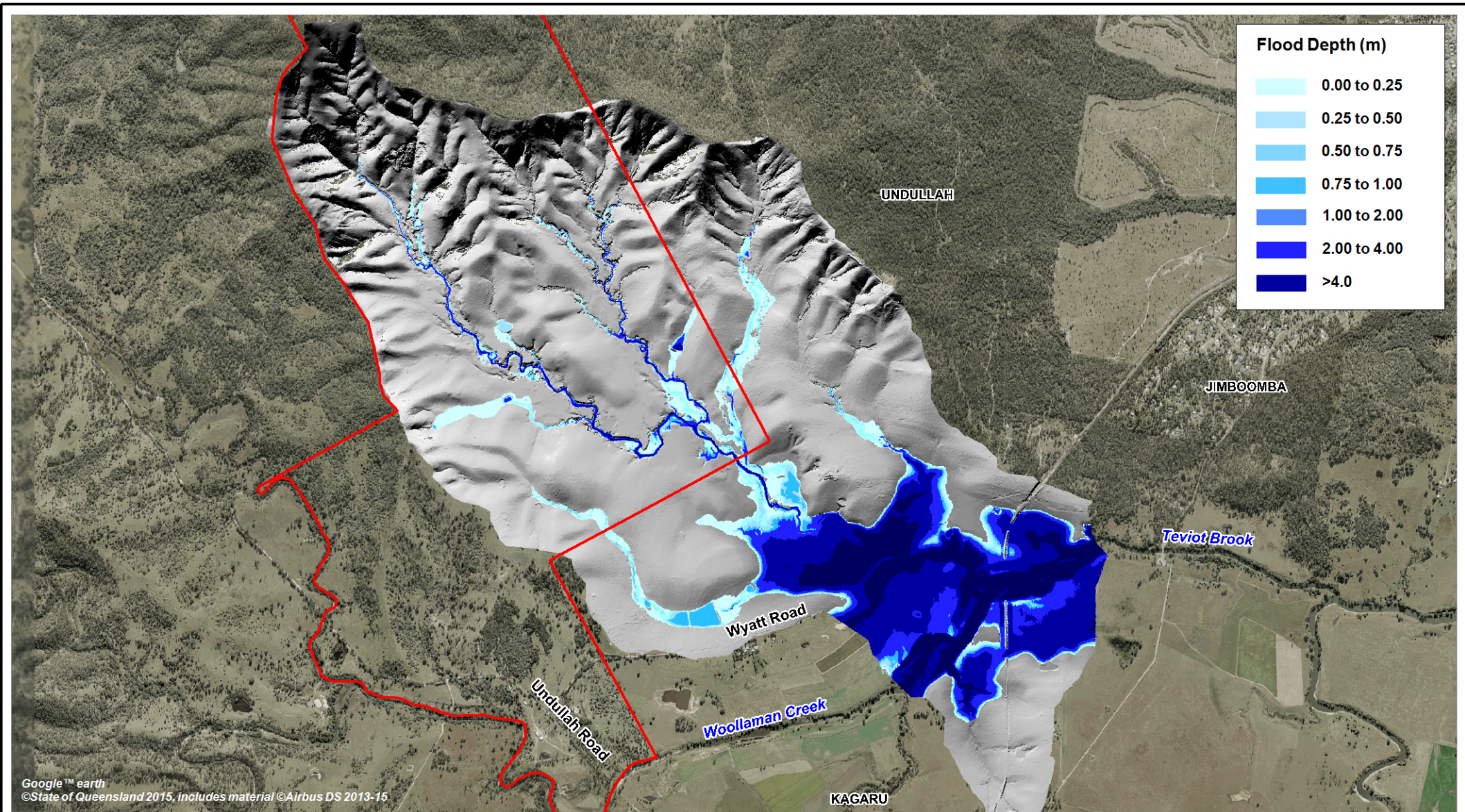
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LEGEND

Precinct Boundary

Title:

Existing Case ARI 100 Year Peak Flood Depths

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Existing Case Flood Model Results

4.4.2 Developed Case

Appendix B contains detailed results for the developed site case by way of mapped flood impacts, peak water levels and depths.

A summary of the modelled peak discharges for the developed case are presented in Table 4-5.

Table 4-5 Developed Peak Discharge

Reporting Point	Design Storm Average Recurrence Interval (y)						
	1	2	5	10	20	50	100
LPD1 Peak Discharge (m ³ /s)	13.0	19.5	32.2	40.8	56.3	73.5	85.7
LPD2 Peak Discharge (m ³ /s)	2.2	3.1	4.3	5.0	6.0	7.0	8.0

Peak flood levels for the site and surrounds, for the full range of design storms, at specific reporting points for the developed case around the site are presented in Table 4-6. With reference to Table 4-6, the 100 year ARI event results in a depth of flooding 0.8 metres above the nominal standing water level of 40 mAHD.

Table 4-6 Developed Peak Water Levels

Reporting Point	Design Storm Average Recurrence Interval (y)						
	1	2	5	10	20	50	100
Upper Lake Centre (mAHD)	50.29	50.38	50.51	50.58	50.68	50.79	50.87
Lower Lake Centre (mAHD)	40.29	40.37	40.48	40.56	40.64	40.74	40.81
LPD1 (mAHD)	33.97	34.15	34.52	34.80	35.20	35.62	35.69
LPD2 (mAHD)	48.15	48.16	48.18	48.19	48.20	48.21	48.22
Downstream (mAHD)	33.02	33.02	33.02	33.03	33.03	33.03	33.03

Table 4-7 provides a summary of flood impacts at each reporting point.

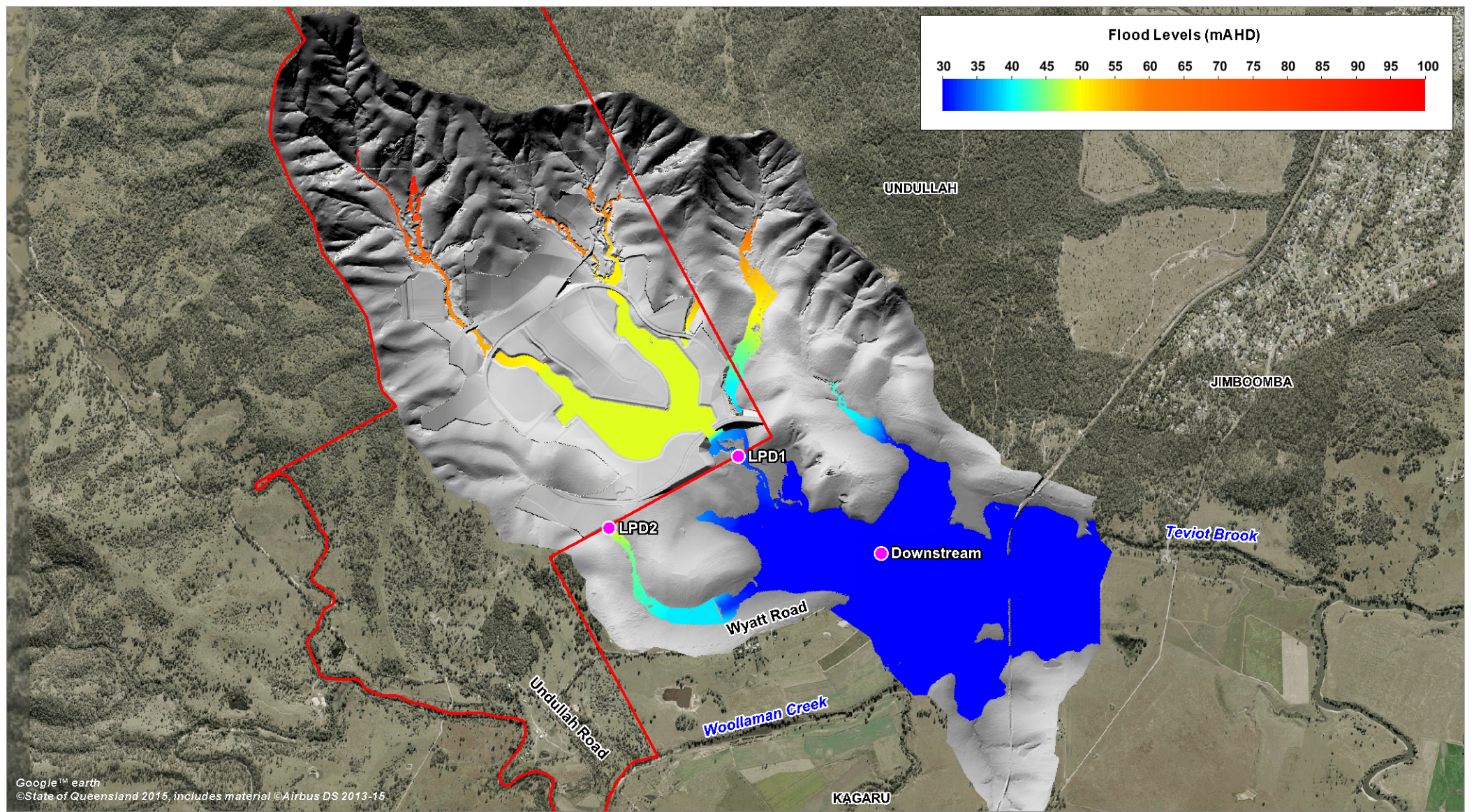
Table 4-7 Peak Water Level Impacts

Reporting Point	Design Storm ARI						
	1	2	5	10	20	50	100
LPD1 (m)	-0.31	-0.46	-0.62	-0.62	-0.39	-0.42	-0.43
LPD2 (m)	-0.01	-0.01	-0.02	-0.03	-0.03	-0.04	-0.04
Downstream (m)	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01

Figure 4-4, Figure 4-5, and Figure 4-6 present the peak 100 year ARI flood levels, depths and hazard (velocity x depth) respectively for the developed case.

Predicted flood impacts for the 100 year flood event are presented in Figure 4-7.

In summary, the flood impact results for the proposed overall site development demonstrate that that no adverse impacts resulting in actionable damage are predicted to occur for the range of ARI flood events. The lakes provide sufficient attenuation to allow a reduction in level to be achieved.



LEGEND

- Reporting Points
- Precinct Boundary

Title:

Developed Case ARI 100 Year Peak Flood Levels

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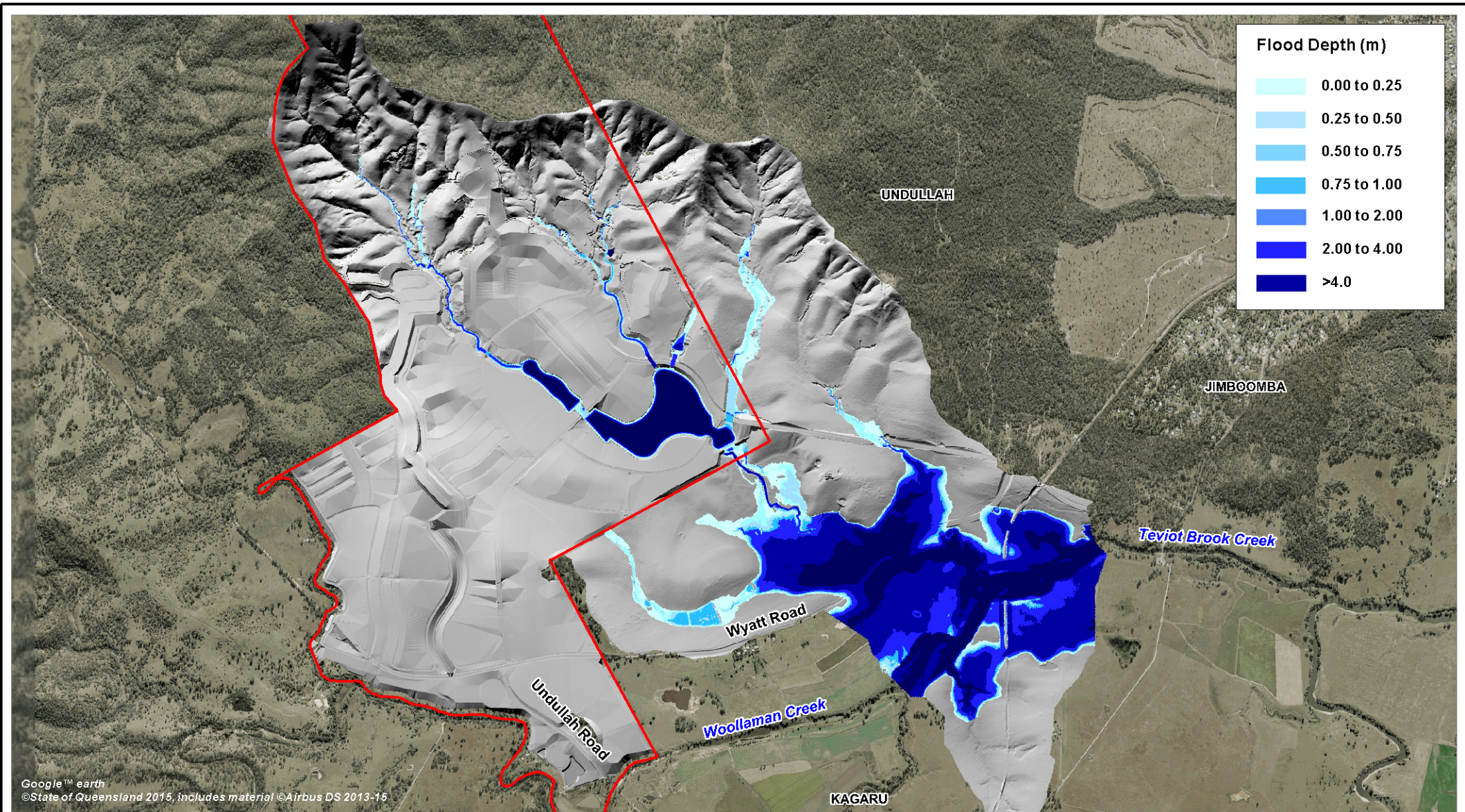
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Precinct Boundary

Title:

Developed Case ARI 100 Year Peak Flood Depths

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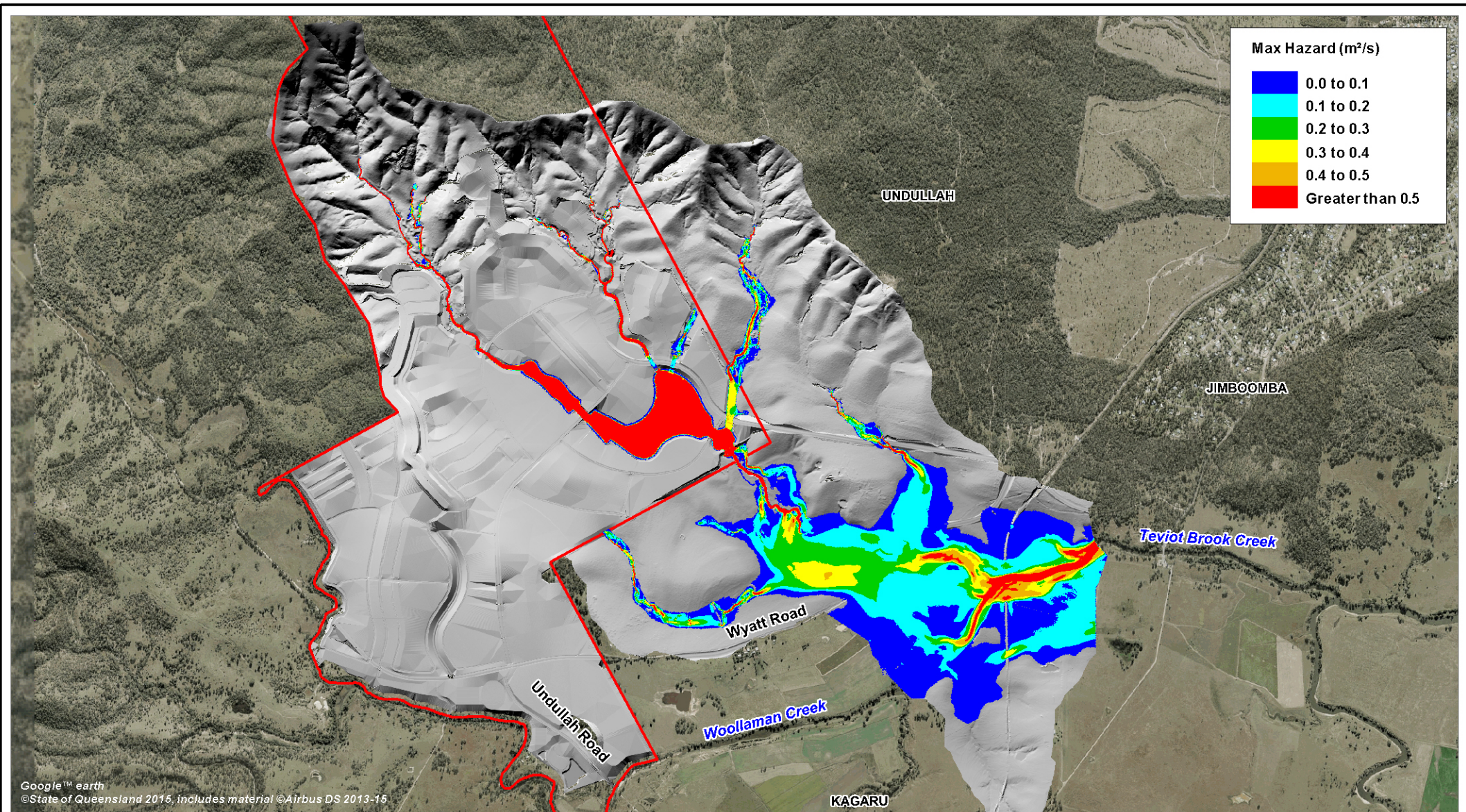
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LEGEND

Precinct Boundary

Title:

Developed Case ARI 100 Year Peak Flood Hazard

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4-6

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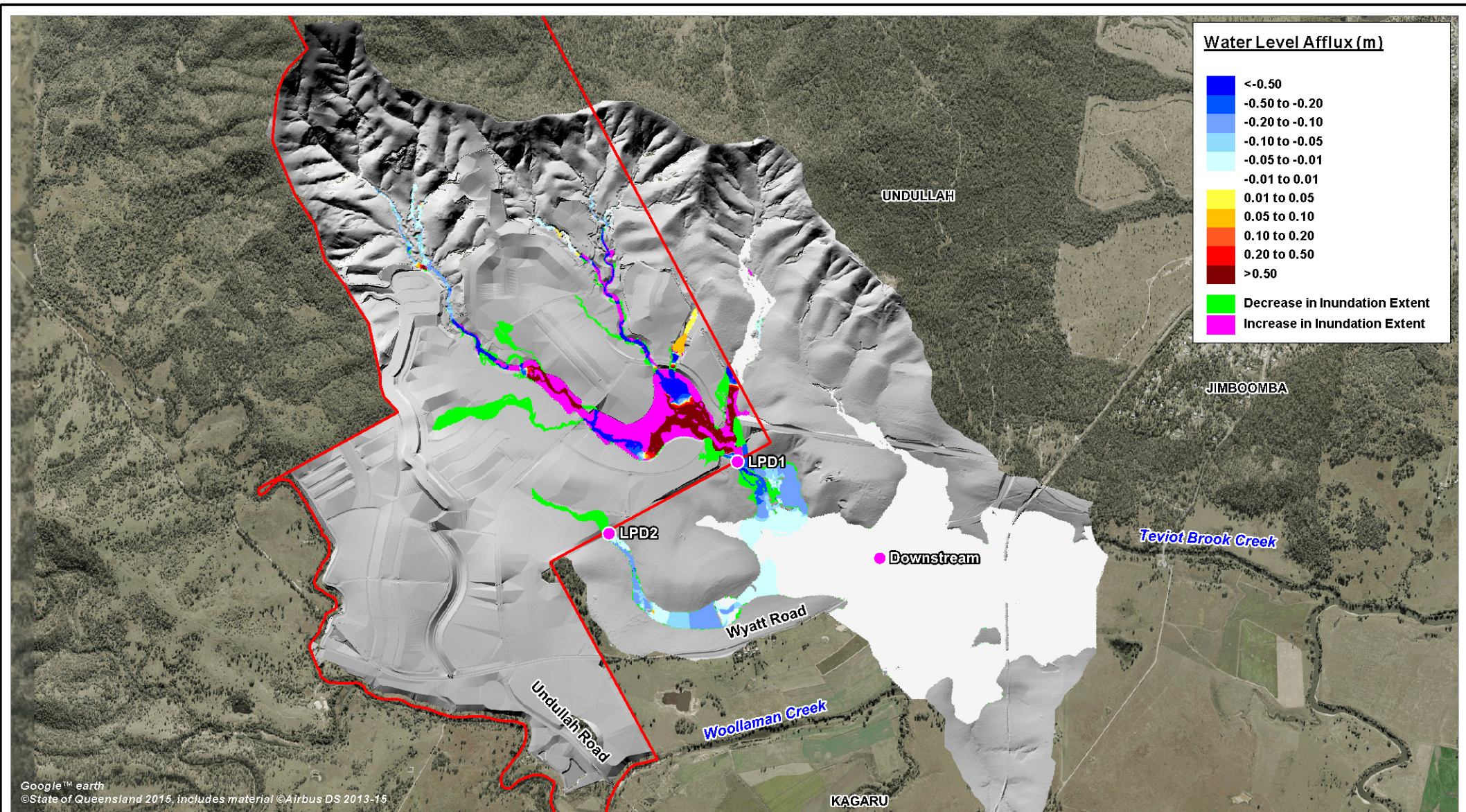
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LEGEND

- Reporting Points
- Precinct Boundary

Title:

Developed Case ARI 100 Year Peak Flood Impact

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Existing Case Flood Model Results

4.4.3 PMF Results

To provide an understanding of likely conditions during an extreme flood event, modelling of the Probable Maximum Flood (PMF) was completed. Appendix C contains detailed PMF results for the developed site case by way of mapped peak water levels and depths.

A summary of the modelled peak discharges for the developed case PMF event are presented in Table 4-8.

Table 4-8 Developed Case PMF Peak Discharge

Reporting Point	Peak Discharge (m ³ /s)
LPD1	626
LPD2	27.3

Peak flood levels for the site and surrounds, for the developed case PMF event at specific reporting points, are presented in Table 4-9. With reference to Table 4-9, the PMF event produces depths of flooding 2.29 metres and 2.89 metres above the standing water level in the upper and lower lakes respectively. Given the severity of the event, the resultant depth is considered reasonable. The depth of flooding during the PMF event will be reviewed as part of detailed design of the spillway.

Table 4-9 Developed Case PMF Peak Water Level

Reporting Point	Peak Water Level (mAHD)
Upper Lake Centre	52.29
Lower Lake Centre	42.89
LPD1	37.72
LPD2	48.36
Downstream	33.19

5 Terms of Reference and Conclusion

5.1 Response to Terms of Reference

As noted in Section 1.3, the investigation detailed in this report was completed in order to update the previous modelling and to address the flooding component of the Terms of Reference issued by DSDIP on 22 July 2014.

A response to each of the points relating to flooding in the Terms of Reference is provided below,

1. ***'To change the original approval, it will be necessary to update the Gilbert and Sutherland Report Conceptual Flood Assessment, Flinders Grove, Undullah, Queensland (March 2011) to reflect the proposed waterbody.'***

This report presents the results of the modelling completed with respect to the revised Master Plan for the development, which incorporates lakes as a focal point of the development. Where appropriate, elements of the previous modelling were retained following detailed review to confirm their appropriateness for the new model. The updated model has demonstrated that the storage afforded by the lakes will allow the impact of development on discharge from the site to be fully ameliorated for a range of design events up to and including the 100 year average recurrence interval event.

The modelling provides a basis for the detailed design of the development in the future.

2. ***'The embankment at the downstream end of the waterbody is likely to be substantial. A consideration of issues and risk associated with the embankment will be required, identifying the studies (for example Dam Failure Impact Assessment) that will be required as part of a subsequent IMP-OSS/application processes to confirm the number of Persons at Risk and embankment design criteria.'***

According to Section 341(1) of the *Water Supply (Safety and Reliability) Act 2008* (current at 21 August 2015, hereafter referred to as the Act):

'A dam is, or a proposed dam after its construction will be, a referable dam if—

- (a) a failure impact assessment of the dam, or the proposed dam, is required to be carried out under this part; and***
- (b) the assessment states the dam has, or the proposed dam after its construction will have, a category 1 or category 2 failure impact rating; and***
- (c) the chief executive has, under section 349, accepted the assessment.'***

Under Section 343 (1) of the Act, ***'A person who proposes to construct a dam must have the dam failure impact assessed if the dam, after its construction, will be—***

- (a) more than 10m in height and have a storage capacity of more than 1500ML; or***
- (b) more than 10m in height and have a storage capacity of more than 750ML and a catchment area that is more than 3 times its maximum surface area at full supply level.'***

Based on the above criteria, at least one of the dams will be more than 10 metres in height and therefore require the completion of a dam failure impact assessment in accordance with the Department of Energy and Water Supply publication *Guidelines for Failure Impact*

Existing Case Flood Model Results

Assessment of Water Dams (2012 or later version current at the time the assessment is undertaken).

As noted in Section 2.2 of the guidelines:

‘A failure impact assessment of a water storage dam is the process used under the Act to determine the number of people whose safety could be at risk should a dam fail (population at risk). The results of the assessment are used to determine:

- whether a dam is referable and
- the failure impact rating of a dam’

Section 2.3 of the guidelines notes that:

‘A failure impact rating is a measure of the population at risk should a dam fail. There are two categories:

- Category 1— between two to 100 people at risk by the dam failing. All category 1 dams are referable dams under the Act.
- Category 2— more than 100 people at risk by the dam failing.

All category 2 dams are referable dams under the Act. If less than two people are at risk by the dam failing then the dam is not given a failure impact rating and is not referable under the Act.’

Although the failure impact assessment is yet to be completed, based on an initial review of existing development downstream of the site it is expected that the failure impact rating will at least be Category 1 and possibly Category 2. The dams are therefore expected to be referable dams.

The following studies and approvals are proposed for the next phase of works:

1. Gain approval for the referable dams. This will involve the preparation of the following for each dam:
 - Dam Safety Management Program;
 - Emergency Action Plan; and
 - Demonstrate that the spillway has an adequate flood carrying capacity.
2. Dam Failure Impact Assessment

The following guidelines are relevant in this regard at the time of preparation of the report:

- Department of Energy and Water Supply, 2016. *Guidelines on Acceptable Flood Capacity for Water Dams*. January.
- Department of Natural Resources and Mines, 2002. *Queensland Dam Safety Management Guidelines*, February.
- Department of Energy and Water Supply, 2013. *Emergency Action Planning for Referable Dams*, Provisional, June.
- *Guidelines for Failure Impact Assessment of Water Dams* (2012)

Existing Case Flood Model Results

It is noted that the guidelines associated with the design and operation of dams are routinely updated and it will be necessary to complete the design of the dams based on the versions of the guidelines current at the time the design is undertaken.

5.2 Conclusion

A detailed flood investigation has been undertaken with respect to Precinct 1 of the proposed Flinders Master Planned Community. The investigation updates previous modelling that was undertaken prior to the inclusion of the lakes and primarily deals with the section of Precinct 1 draining to the lakes.

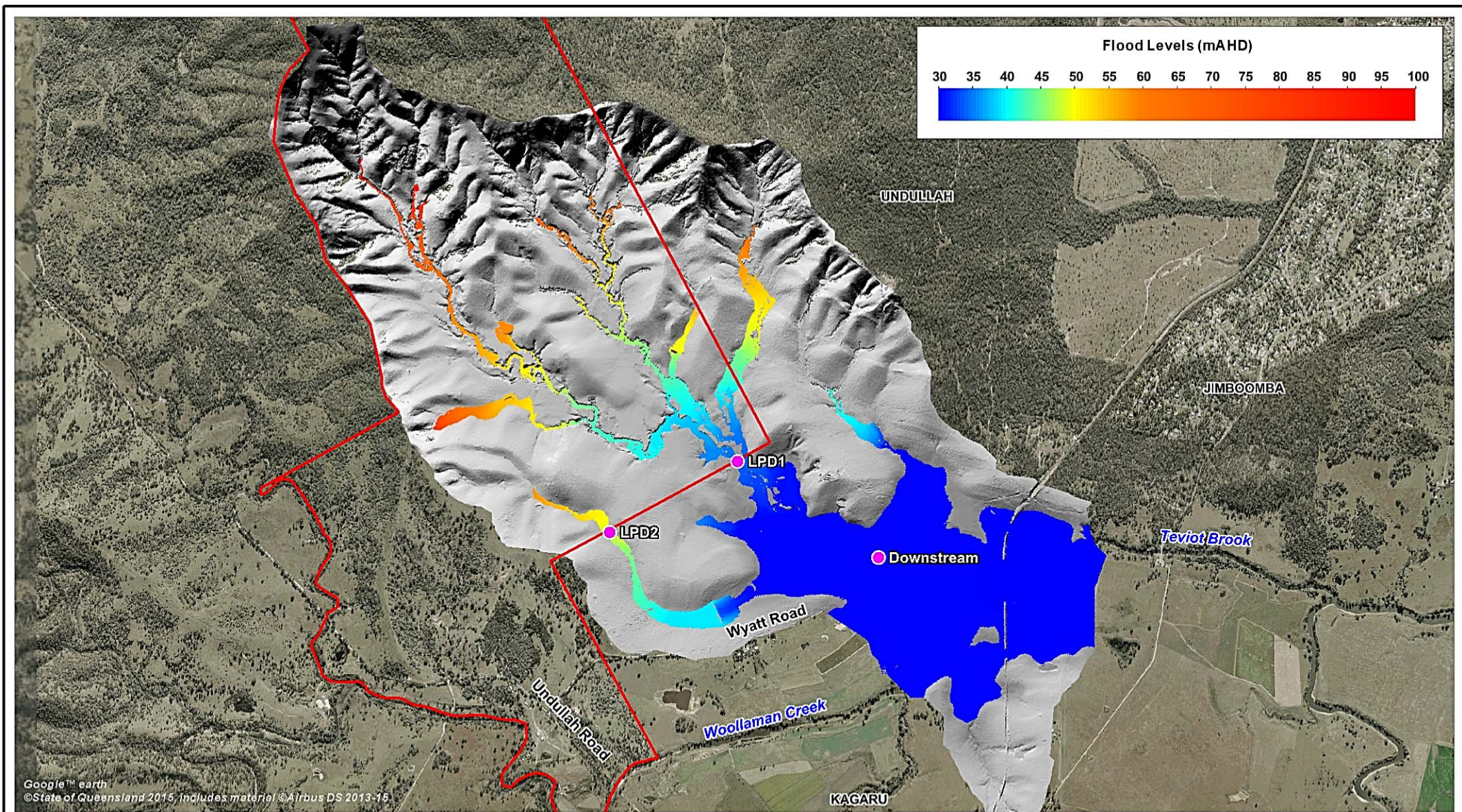
For the remainder of Precinct 1 (i.e. the western part of Precinct 1) that drains to Undullah Creek and Woollaman Creek, the 2011 Gilbert and Sutherland report *Conceptual Flood Assessment Flinders Grove Undullah, Queensland* remains valid.

Based on the results of the investigations outlined in this report it is considered that, subject to suitable detailed design, the site can be developed without causing an increase in flood level or flow downstream of the site.

6 References

- Engineers Australia, 2012, "*Australian Rainfall & Runoff, Revision Project 15: Two Dimensional Modelling in Urban and Rural Floodplains*", Australian Rainfall and Runoff, Engineers Australia – Water Engineering
- Bureau of Meteorology, 2003, "*The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method*", Commonwealth Bureau of Meteorology
- BMT WBM, 2017, "*Flinders Precinct 1: Lake Concept Management Plan*"
- Department of Energy and Water Supply, 2013. *Queensland Urban Drainage Manual*, Third Edition 2013- provisional.
- G&S, 2011a, "*Conceptual Flood Assessment Flinders Grove Undullah, Queensland*", Gilbert and Sutherland Pty Ltd, document ref no: 10511 FLD AJF1F.docx
- G&S, 2011b, "*Preliminary Soil assessment Proposed Flinders Subdivision, Undullah, Queensland*", Gilbert and Sutherland Pty Ltd, document ref no: 10510 SSA RGLH1F.docx
- G&S, 2012, "*Flood Assessment Flinders Neighbourhood 1 North and Neighbourhood 3 Undullah, Queensland*", Gilbert and Sutherland Pty Ltd, document ref no: 10767 RAF1F.docx
- Jordan P, Nathan R, Mittiga L, Taylor B, 2005, *Growth curves and temporal patterns of short duration design storms for extreme events.*, Australian Journal of Water Resources Vol 9, No 1

Appendix A Existing Case Flood Model Results



LEGEND

- Reporting Points
- Precinct Boundary

Title:

Existing Case ARI 50 Year Peak Flood Levels

Figure:

A-1

Rev:

A

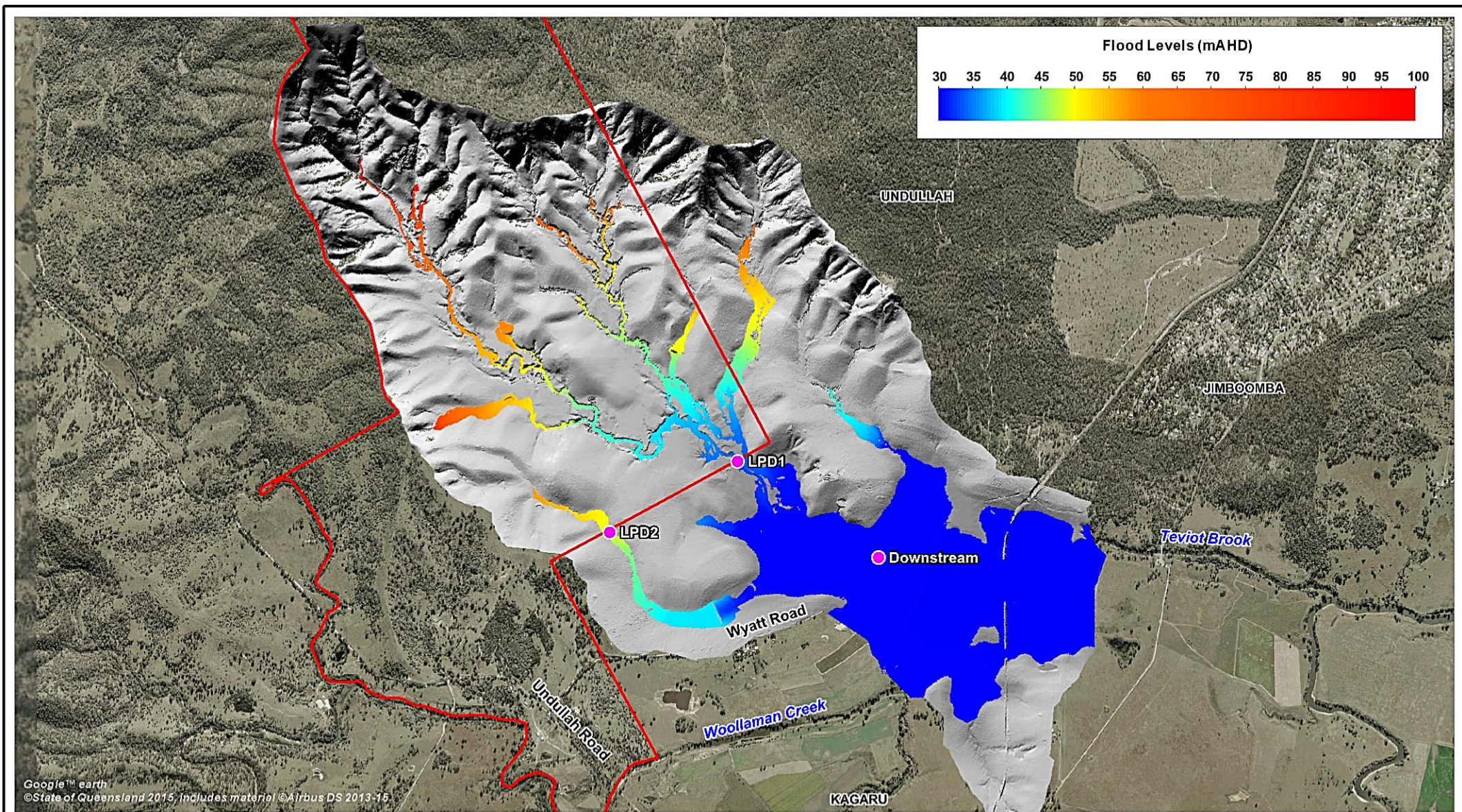
BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.



0 0.5 1km
Approx. Scale



Filepath : I:\B21415_I_JLB Flinders Project NC\DRG\Flood Mapping\FLD_013_160224_ARI 50 Year Peak Flood Levels_Existing Case.wor



LEGEND

- Reporting Points
- Precinct Boundary

Title:

Existing Case ARI 20 Year Peak Flood Levels

Figure:

A-2

Rev:

A

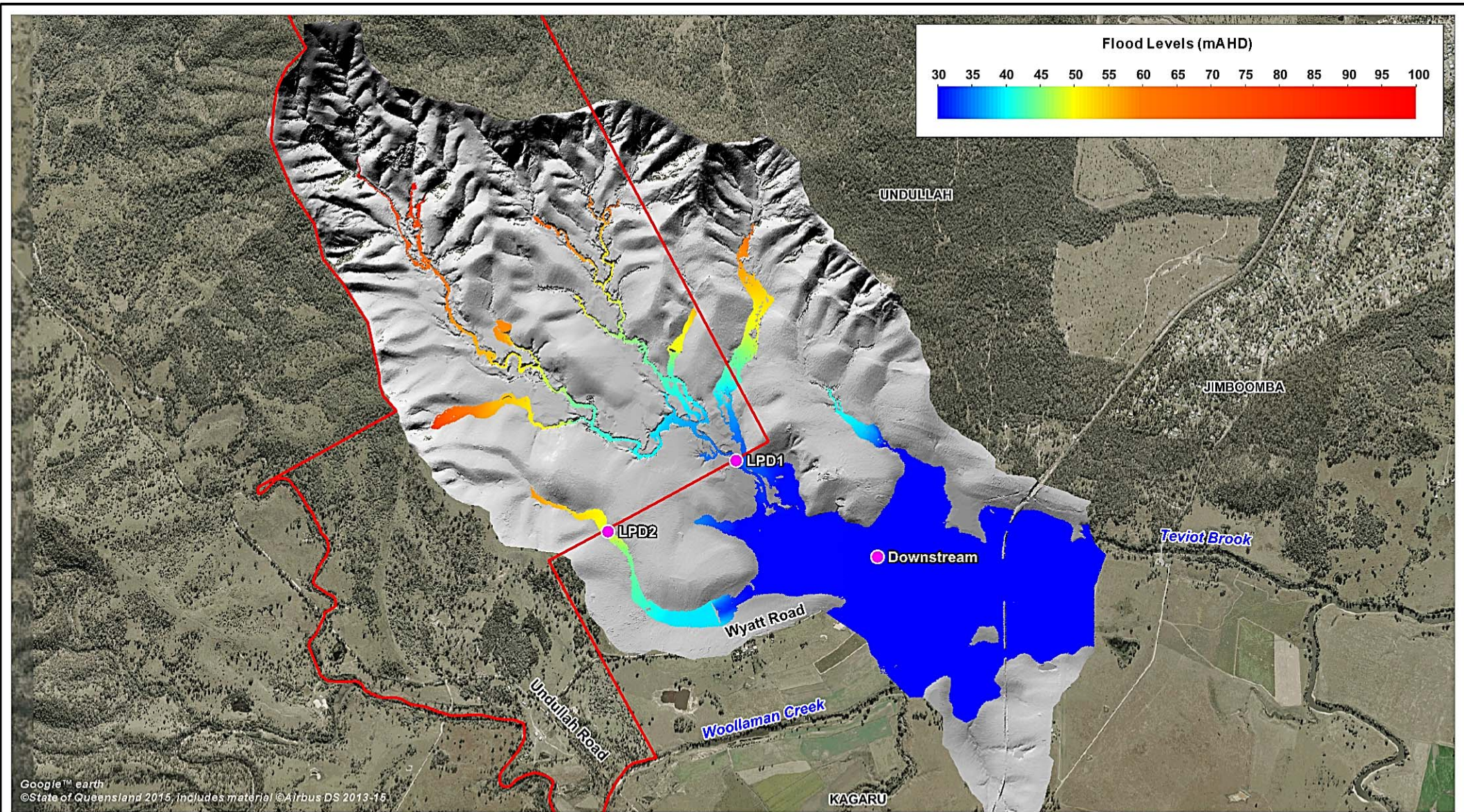
BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.



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Approx. Scale



Filepath : I:\B21415_I_JLB Flinders Project NC\DRG\Flood Mapping\FLD_014_160224_ARI 20 Year Peak Flood Levels_Existing Case.wor



LEGEND

- Reporting Points
- Precinct Boundary

Title:

Existing Case ARI 10 Year Peak Flood Levels

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Approx. Scale

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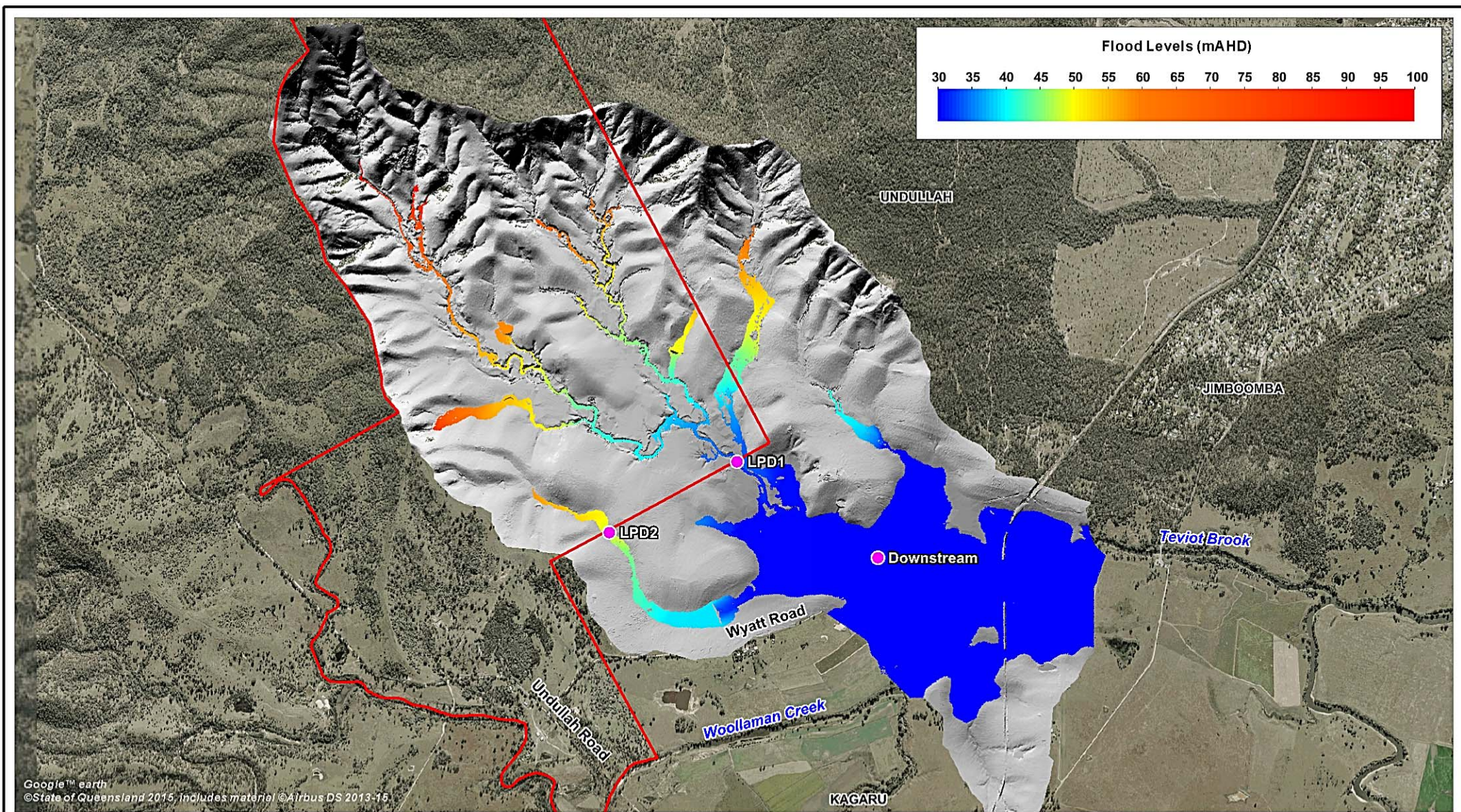
A-3

Rev:

A



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LEGEND

- Reporting Points
- Precinct Boundary

Title:

Existing Case ARI 5 Year Peak Flood Levels

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Approx. Scale

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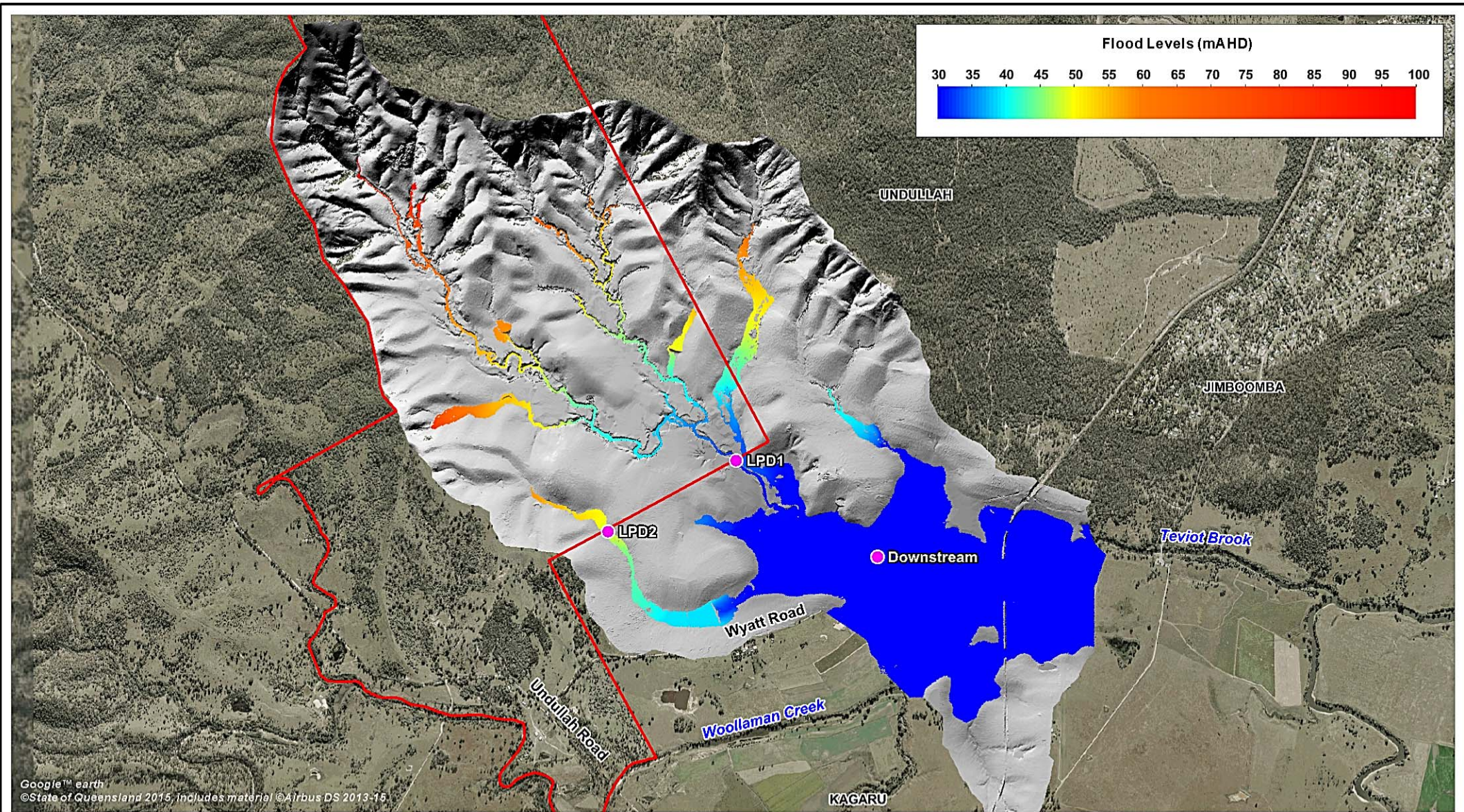
A-4

Rev:

A



Filepath : I:\B21415_I_JLB Flinders Project NC\DRG\Flood Mapping\FLD_016_160224_ARI 5 Year Peak Flood Levels_Existing Case.wor



LEGEND

- Reporting Points
- Precinct Boundary

Title:

Existing Case ARI 2 Year Peak Flood Levels

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Approx. Scale

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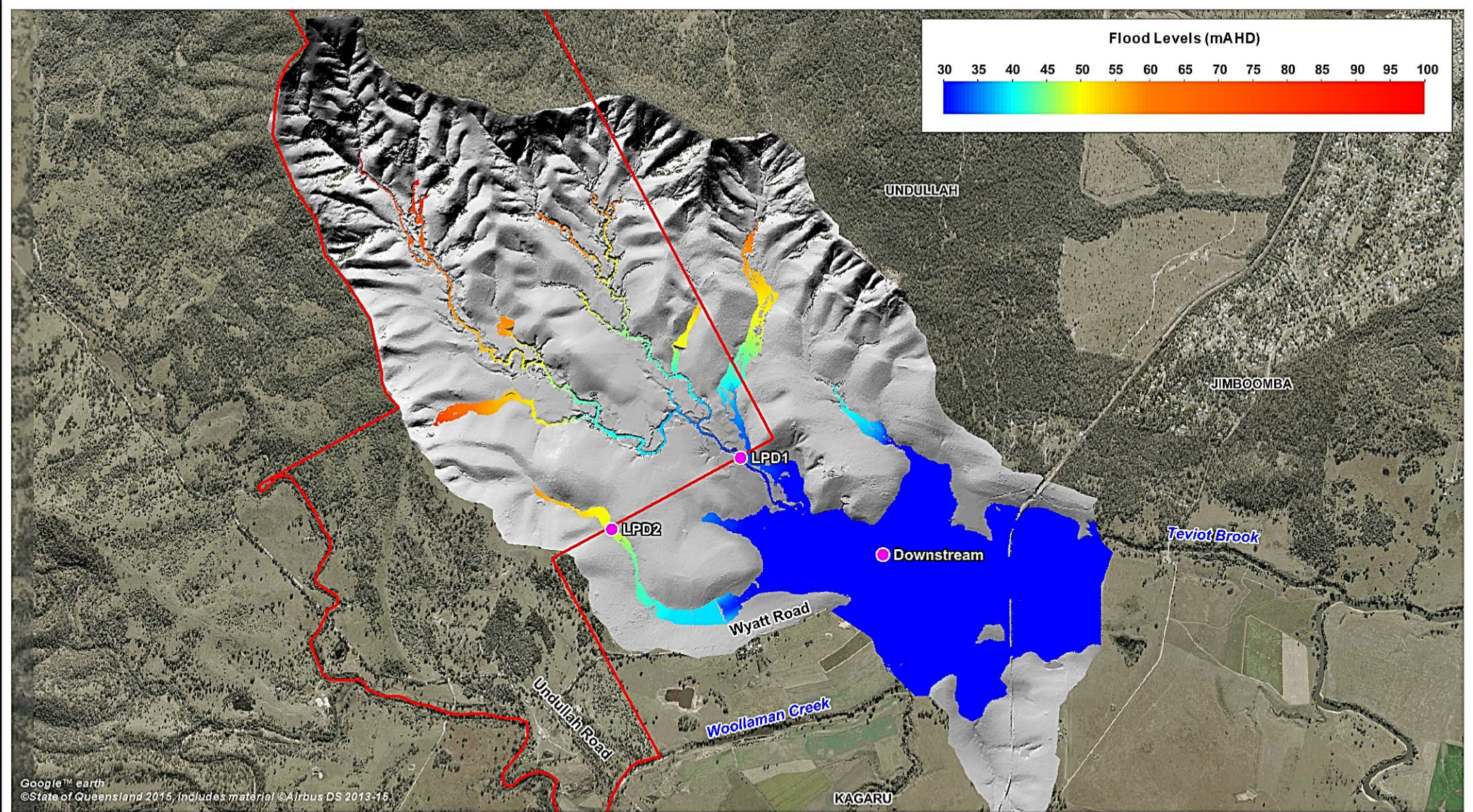
A-5

Rev:

A



Filepath : I:\B21415_I_JLB Flinders Project NC\DRG\Flood Mapping\FLD_017_160224_ARI 2 Year Peak Flood Levels_Existing Case.wor



LEGEND

- Reporting Points
- Precinct Boundary

Title:

Existing Case ARI 1 Year Peak Flood Levels

Figure:

A-6

Rev:

A

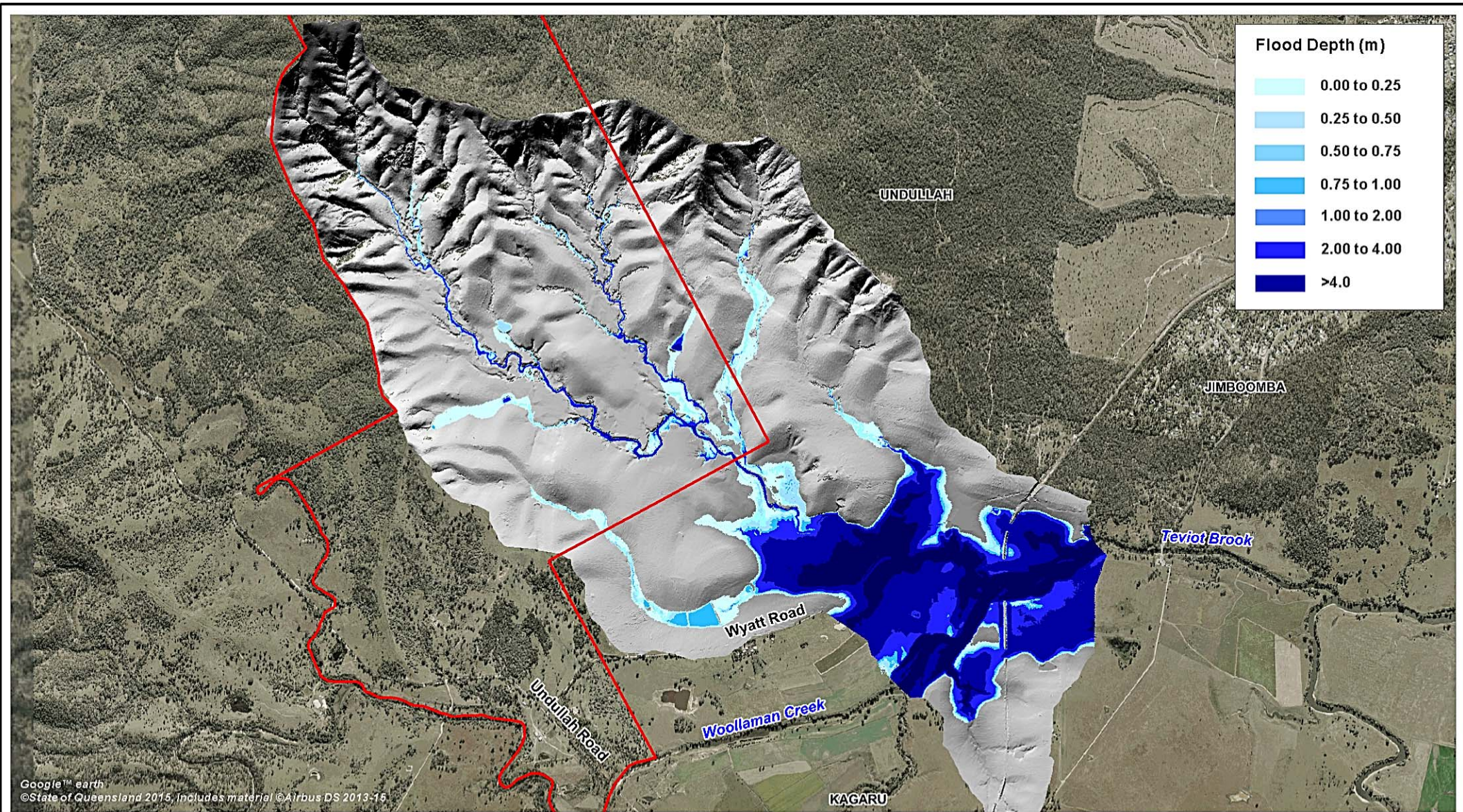
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Approx. Scale



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LEGEND

 Precinct Boundary

Title:

Existing Case ARI 50 Year Peak Flood Depths

Figure:

A-7

Rev:

A

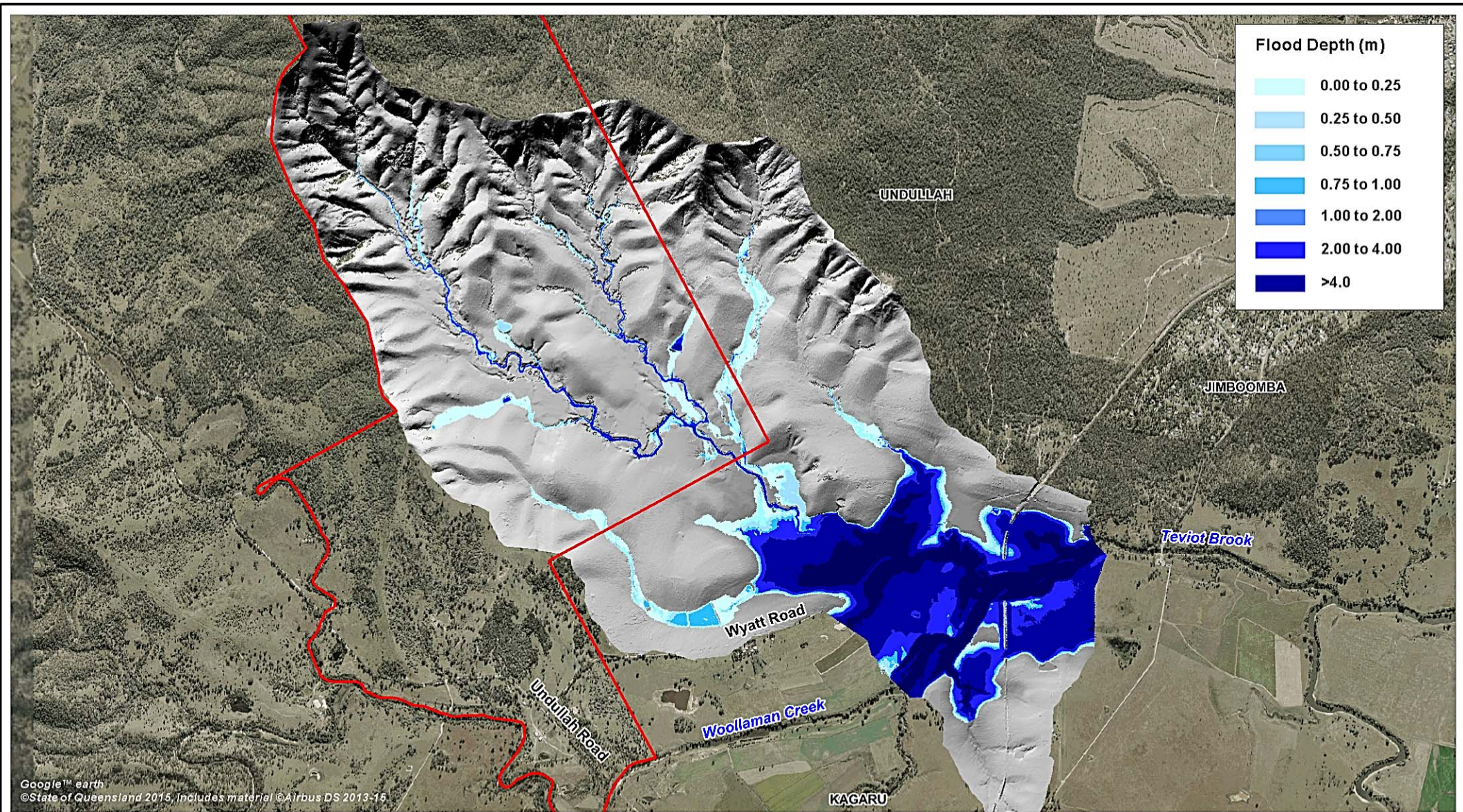
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Approx. Scale



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LEGEND

 Precinct Boundary

Title:

Existing Case ARI 20 Year Peak Flood Depths

Figure:

A-8

Rev:

A

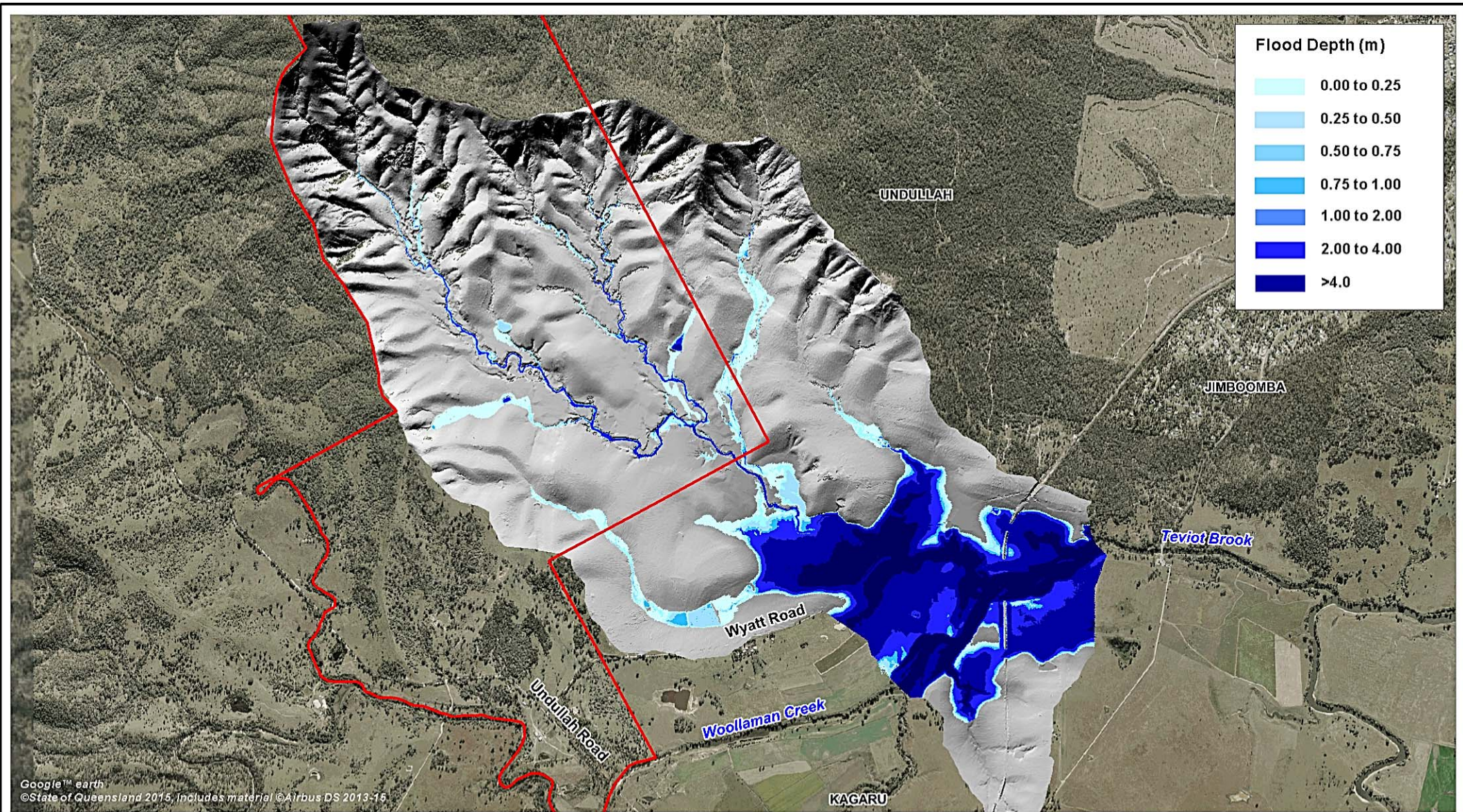
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Approx. Scale



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LEGEND

 Precinct Boundary

Title:

Existing Case ARI 10 Year Peak Flood Depths

Figure:

A-9

Rev:

A

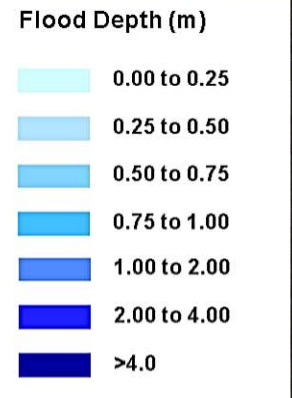
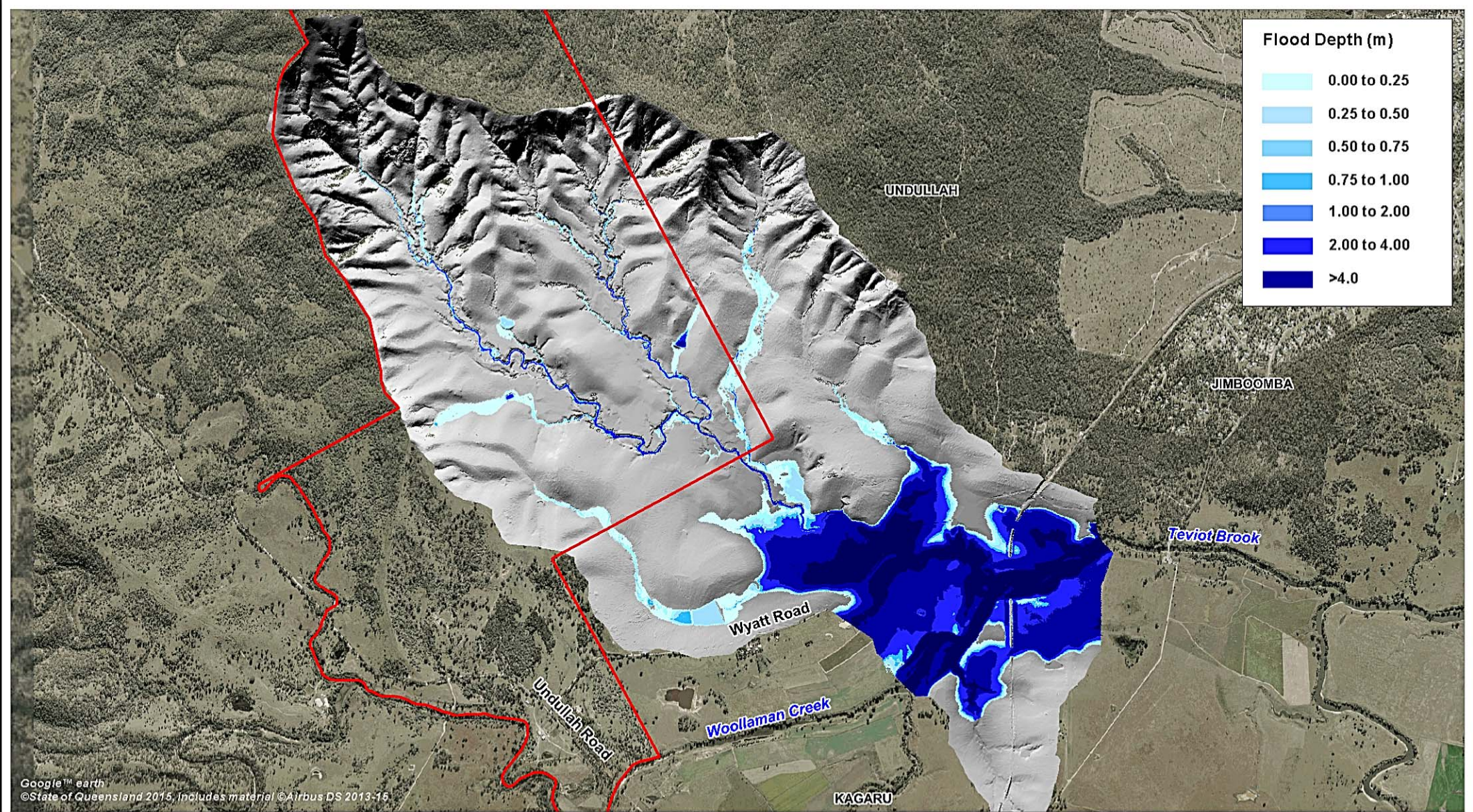
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Approx. Scale



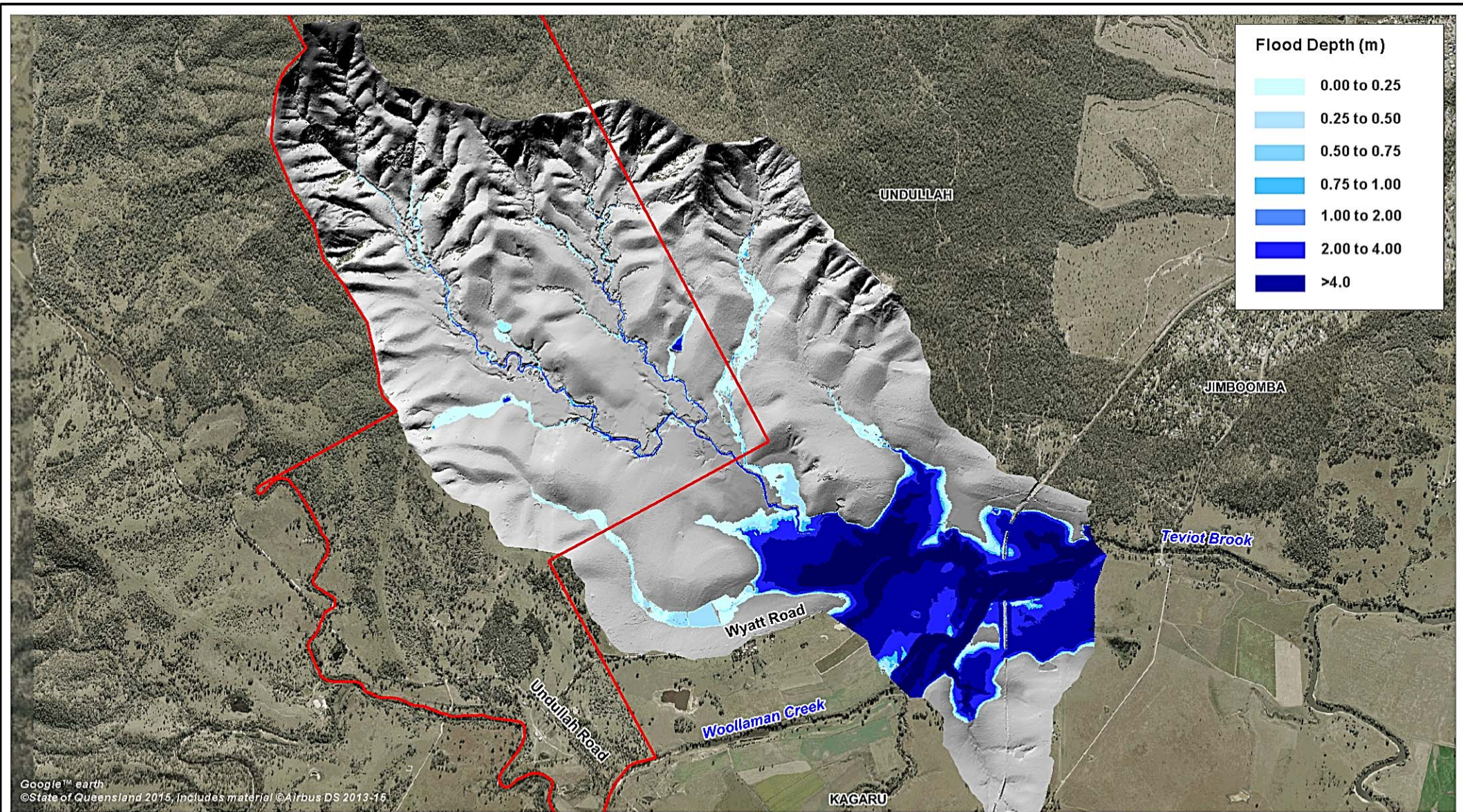
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LEGEND  Precinct Boundary	Title: Existing Case ARI 5 Year Peak Flood Depths	Figure: A-10	Rev: A
	BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.  0 0.5 1km Approx. Scale	 www.bmtwbm.com.au	

Filepath : I:\B21415_I_JLB Flinders Project NC\DRG\Flood Mapping\FLD_022_160224_ARI 5 Year Peak Flood Depth_Existing Case.wor



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LEGEND

 Precinct Boundary

Title:

Existing Case ARI 2 Year Peak Flood Depths

Figure:

A-11

Rev:

A

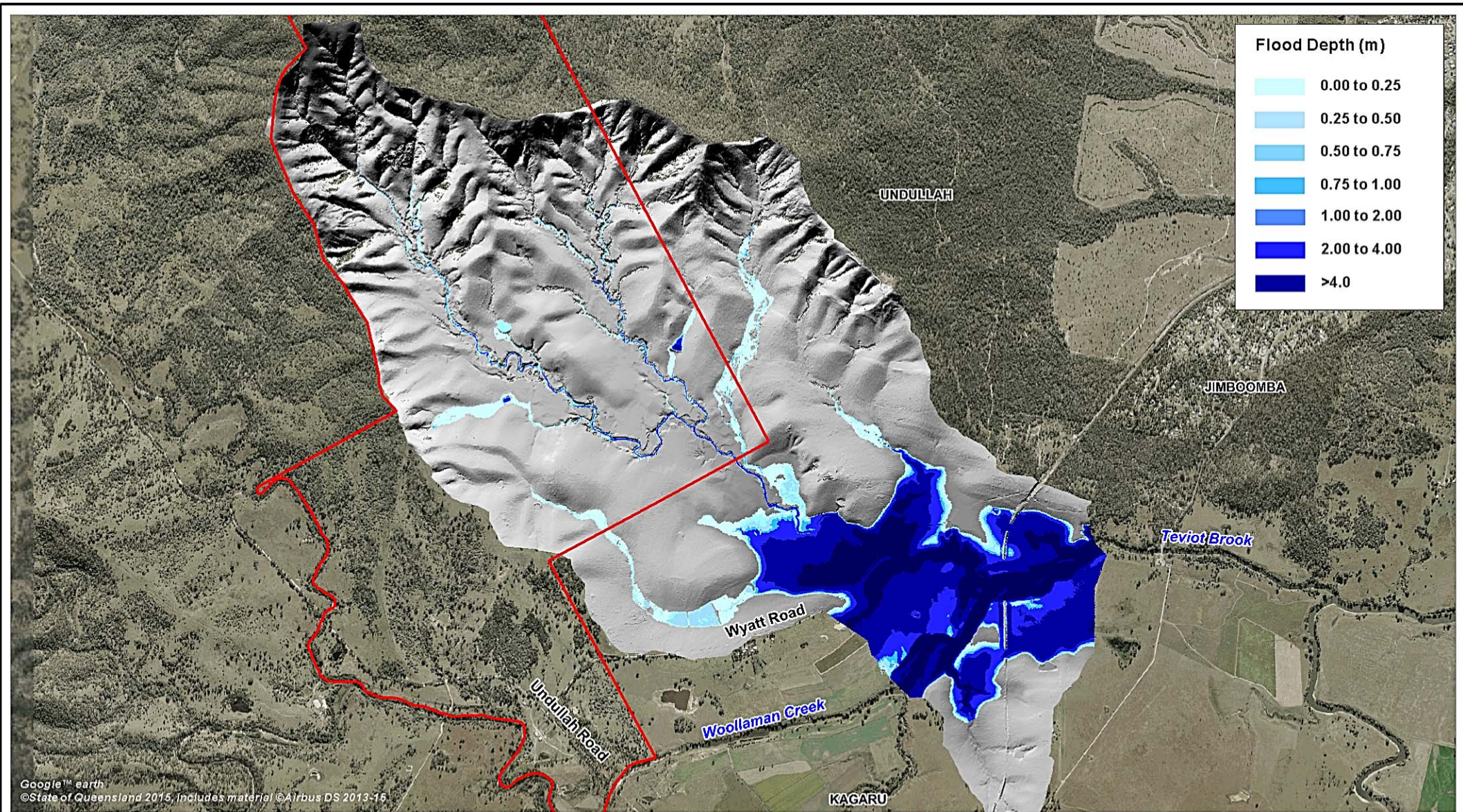
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Approx. Scale



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LEGEND

 Precinct Boundary

Title:

Existing Case ARI 1 Year Peak Flood Depths

Figure:

A-12

Rev:

A

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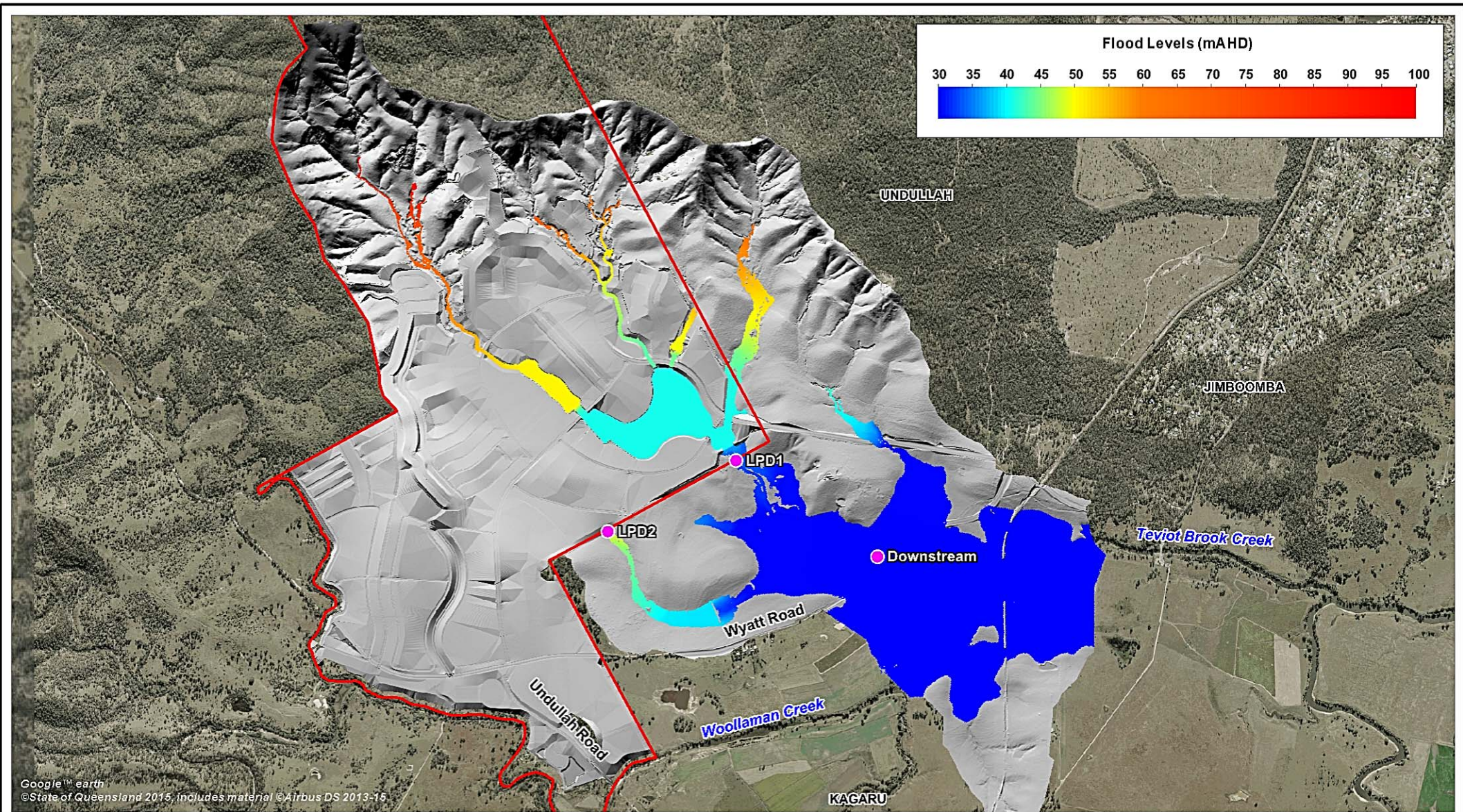


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Approx. Scale



Filepath : I:\B21415_I_JLB Flinders Project NC\DRG\Flood Mapping\FLD_024_160224_ARI 1 Year Peak Flood Depth_Existing Case.wor

Appendix B Developed Case Flood Model Results



LEGEND

- Reporting Points
- Precinct Boundary

Title:

Developed Case ARI 50 Year Peak Flood Levels

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0 0.5 1km
Approx. Scale

Figure:

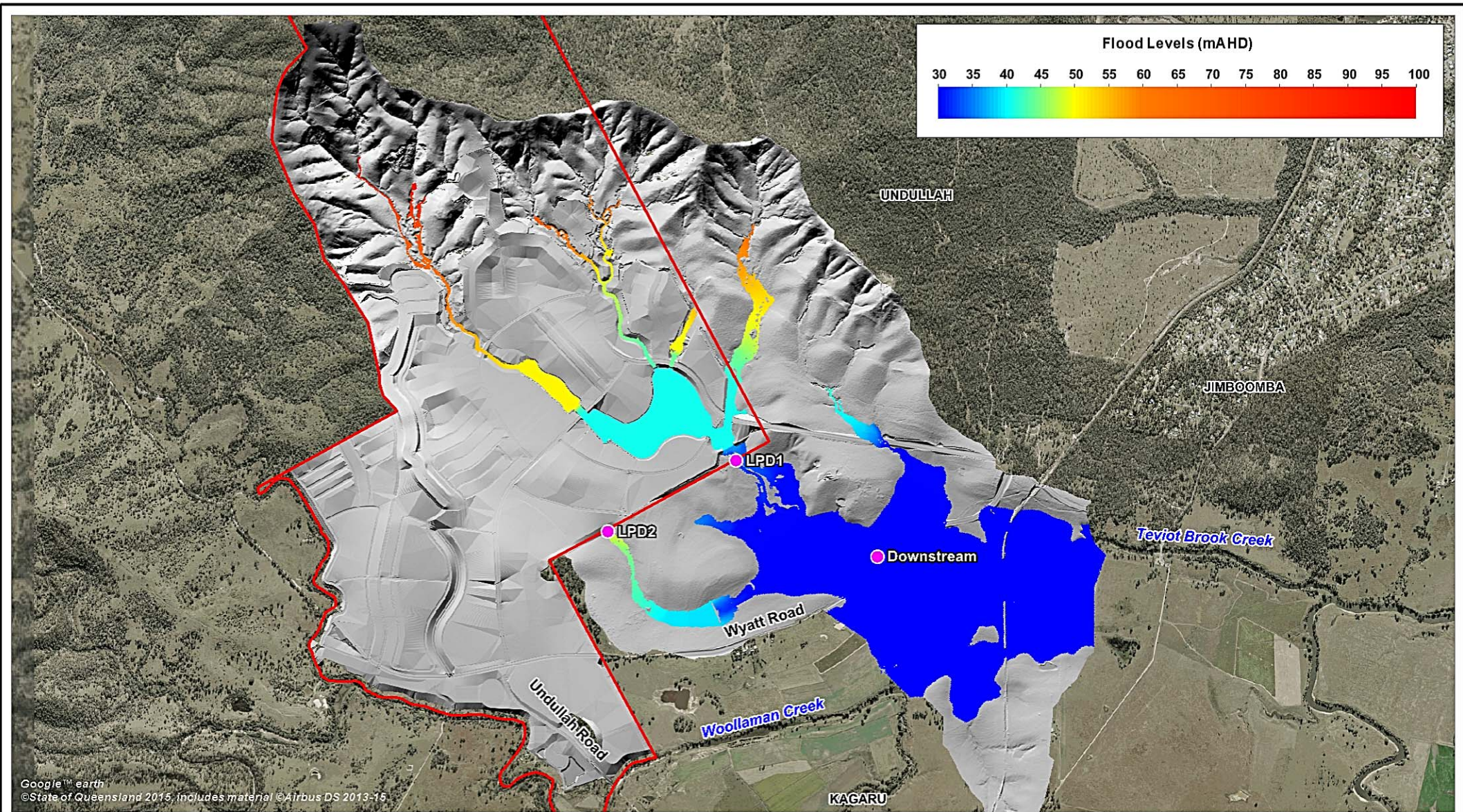
B-1

Rev:

A



Filepath: I:\B21415_I_JLB Flinders Project NC\DRG\Flood Mapping\FLD_025_160224_ARI 50 Year Peak Flood Levels_Developed Case.wor



LEGEND

- Reporting Points
- Precinct Boundary

Title:

Developed Case ARI 20 Year Peak Flood Levels

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Approx. Scale

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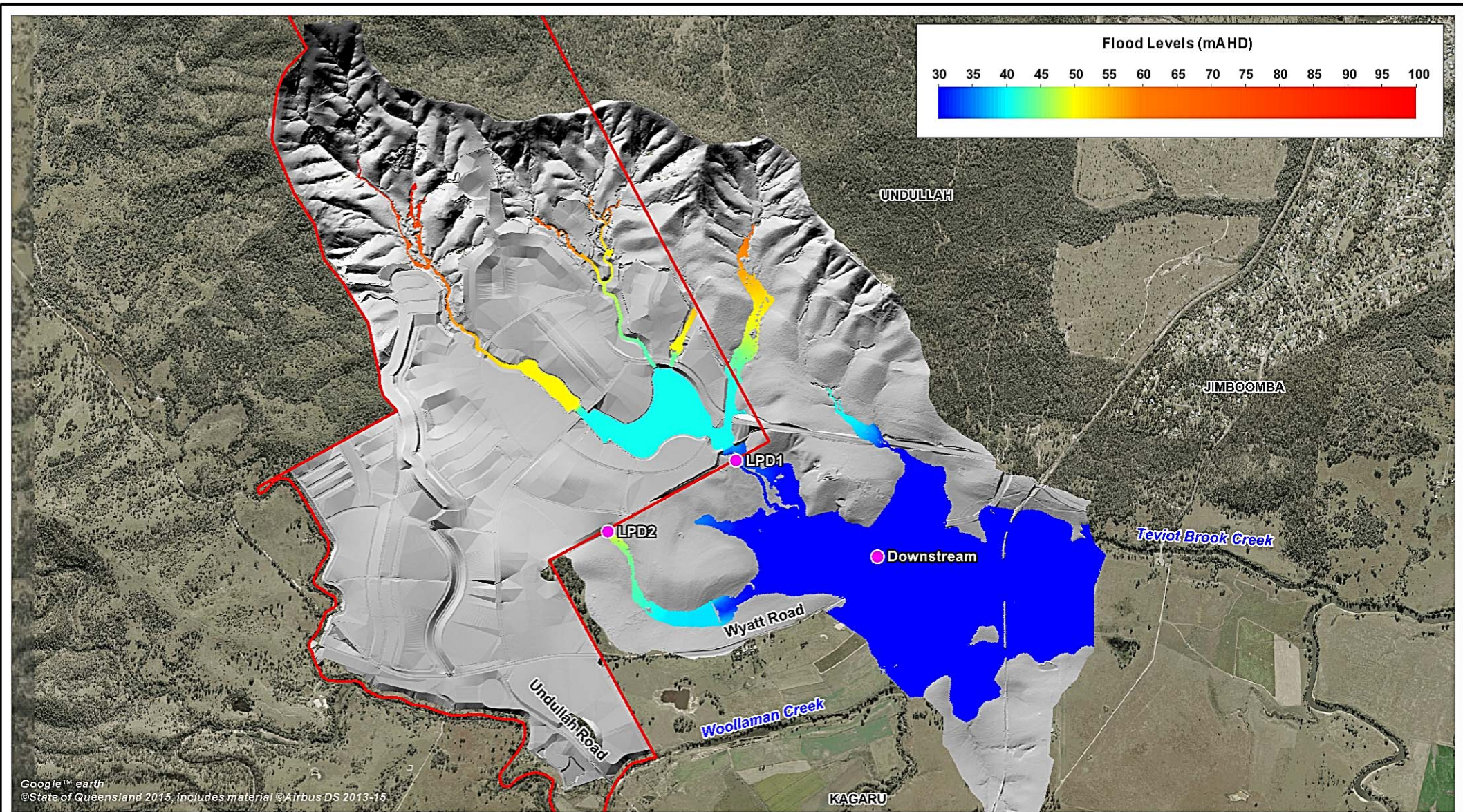
B-2

Rev:

A



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LEGEND

- Reporting Points
- Precinct Boundary

Title:

Developed Case ARI 10 Year Peak Flood Levels

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0 0.5 1km
Approx. Scale

Figure:

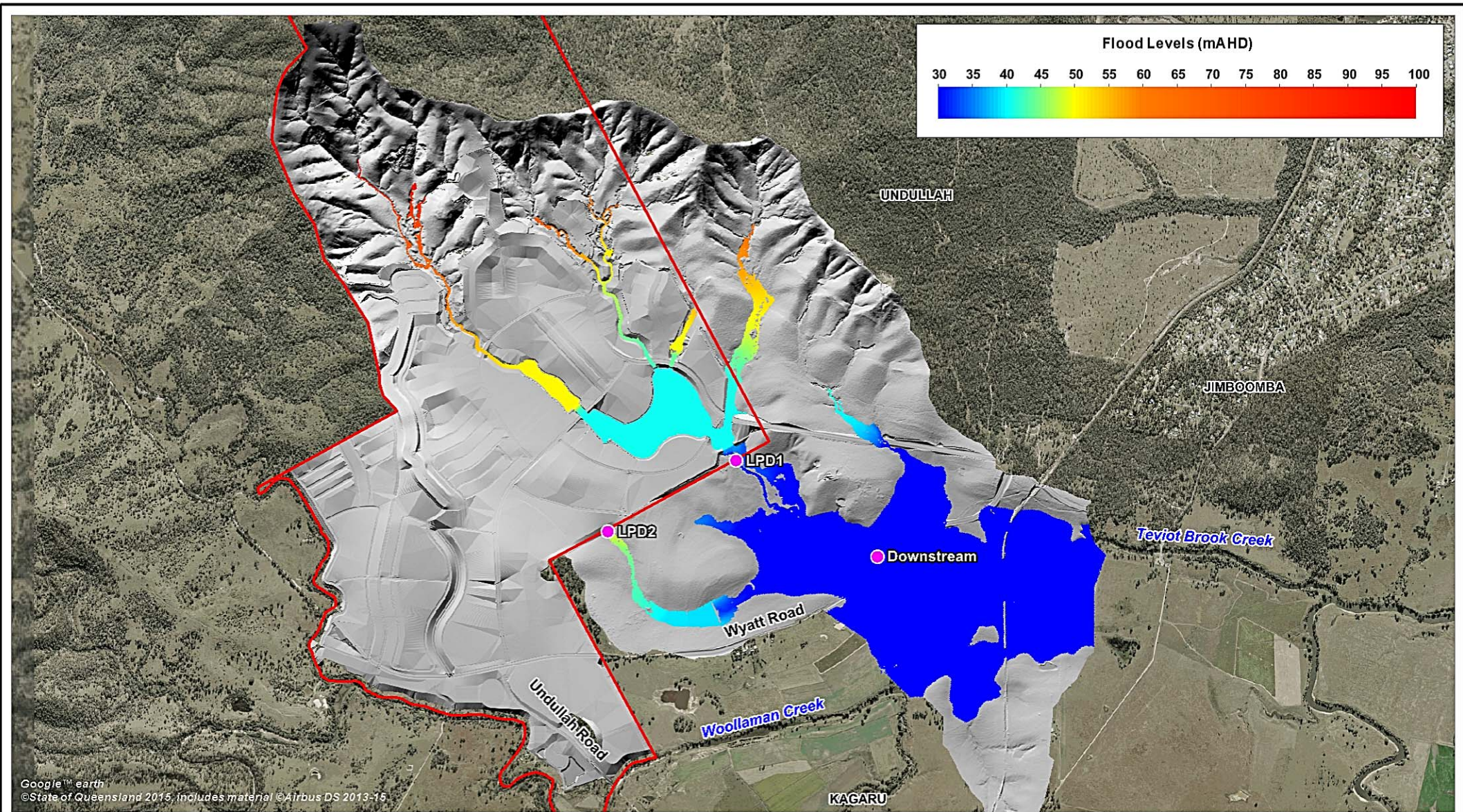
B-3

Rev:

A



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LEGEND

- Reporting Points
- Precinct Boundary

Title:

Developed Case ARI 5 Year Peak Flood Levels

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0 0.5 1km
Approx. Scale

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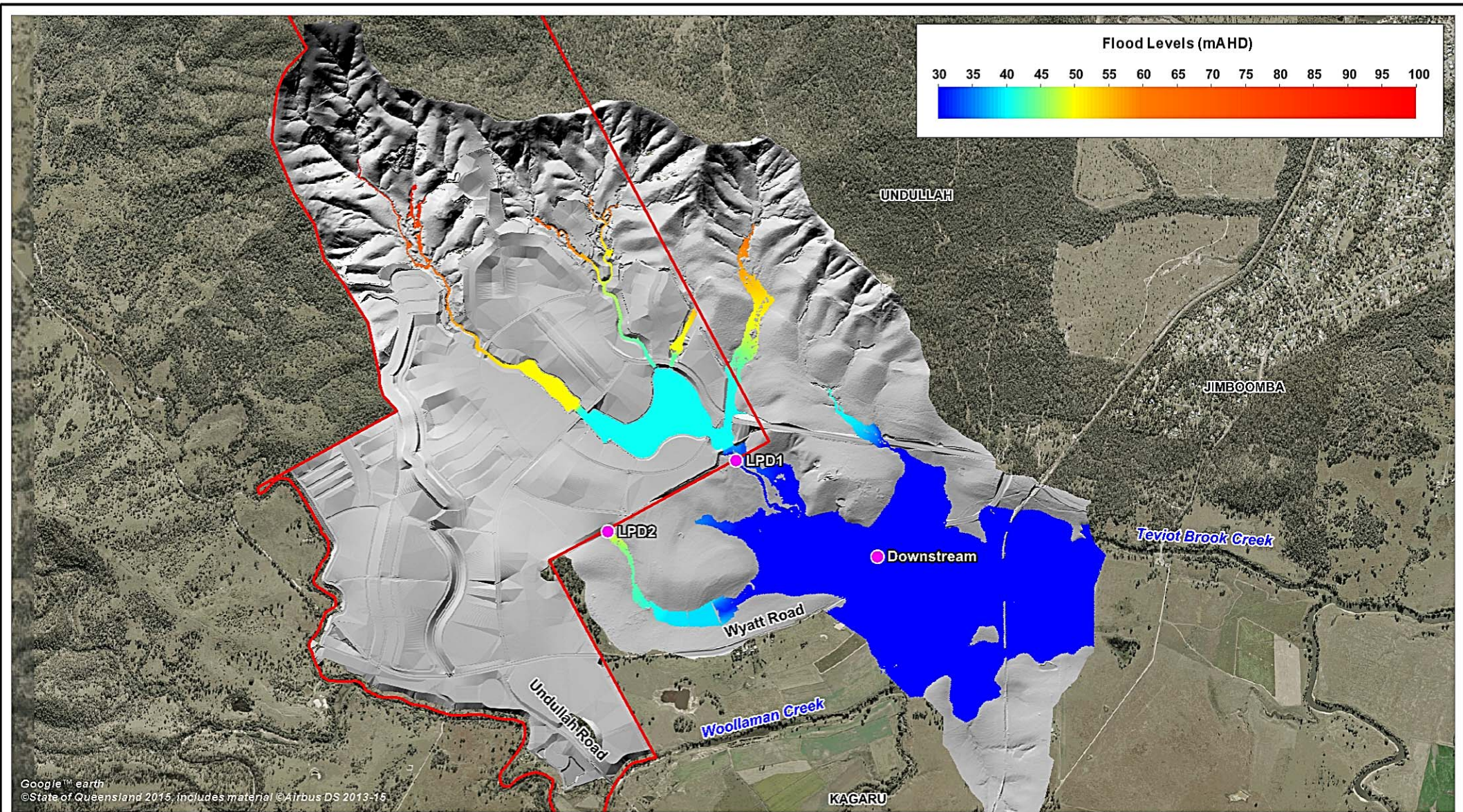
B-4

Rev:

A



Filepath: I:\B21415_I_JLB Flinders Project NC\DRG\Flood Mapping\FLD_028_160224_ARI 5 Year Peak Flood Levels_Developed Case.wor



LEGEND

- Reporting Points
- Precinct Boundary

Title:

Developed Case ARI 2 Year Peak Flood Levels

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0 0.5 1km
Approx. Scale

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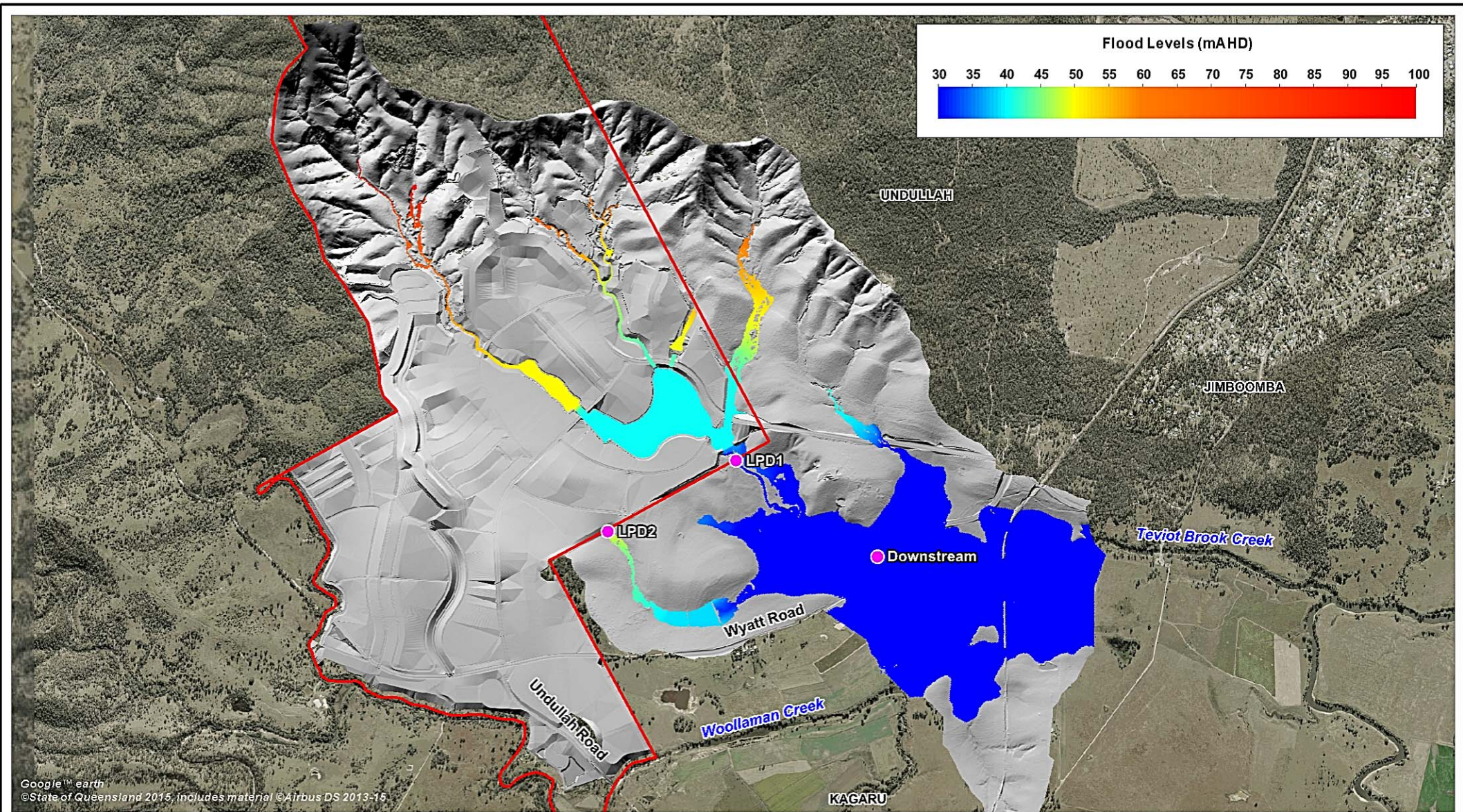
B-5

Rev:

A



Filepath: I:\B21415_I_JLB Flinders Project NC\DRG\Flood Mapping\FLD_029_160224_ARI 2 Year Peak Flood Levels_Developed Case.wor



LEGEND

- Reporting Points
- Precinct Boundary

Title:

Developed Case ARI 1 Year Peak Flood Levels

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Approx. Scale

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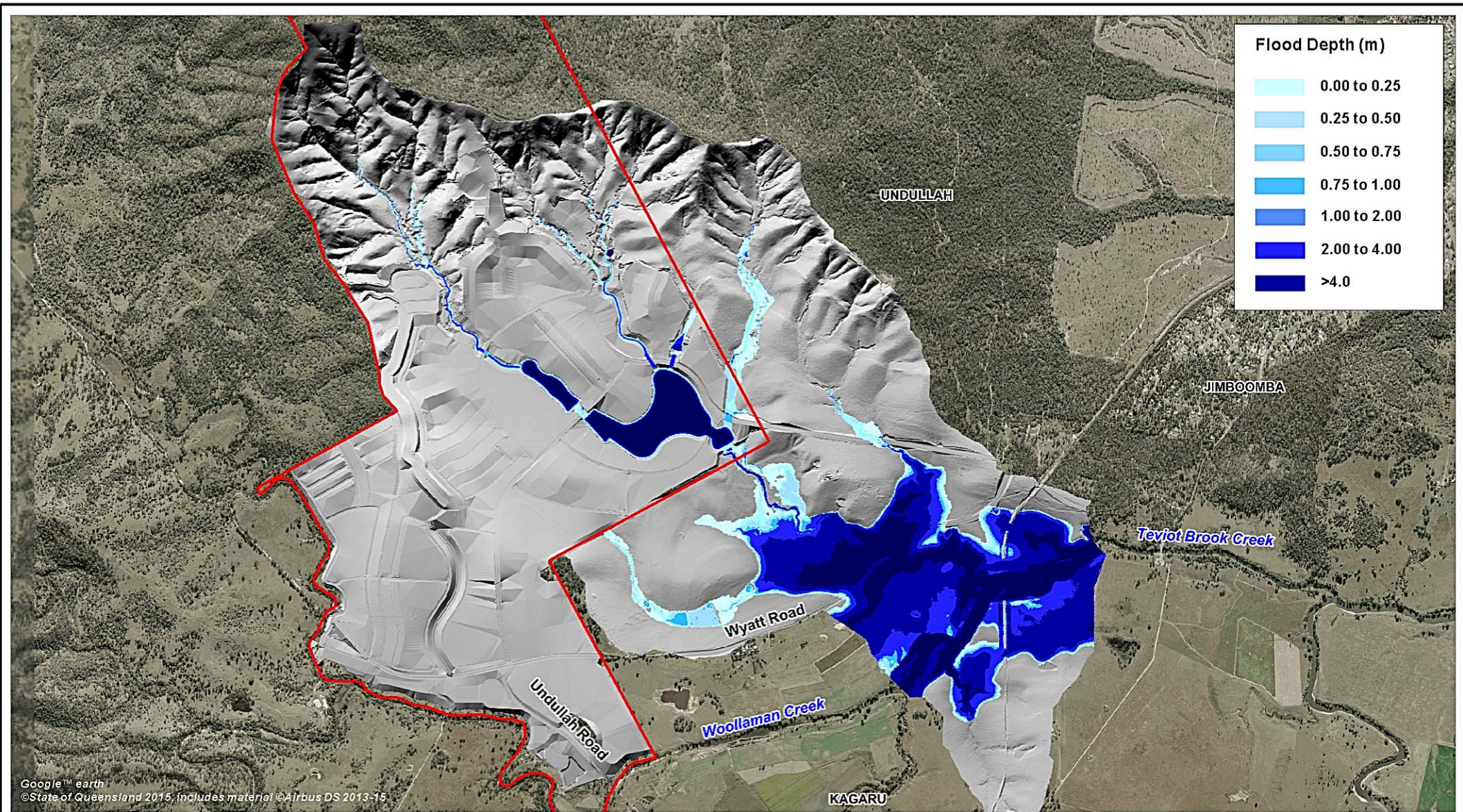
B-6

Rev:

A



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LEGEND

 Precinct Boundary

Title:

Developed Case ARI 50 Year Peak Flood Depths

Figure:

B-7

Rev:

A

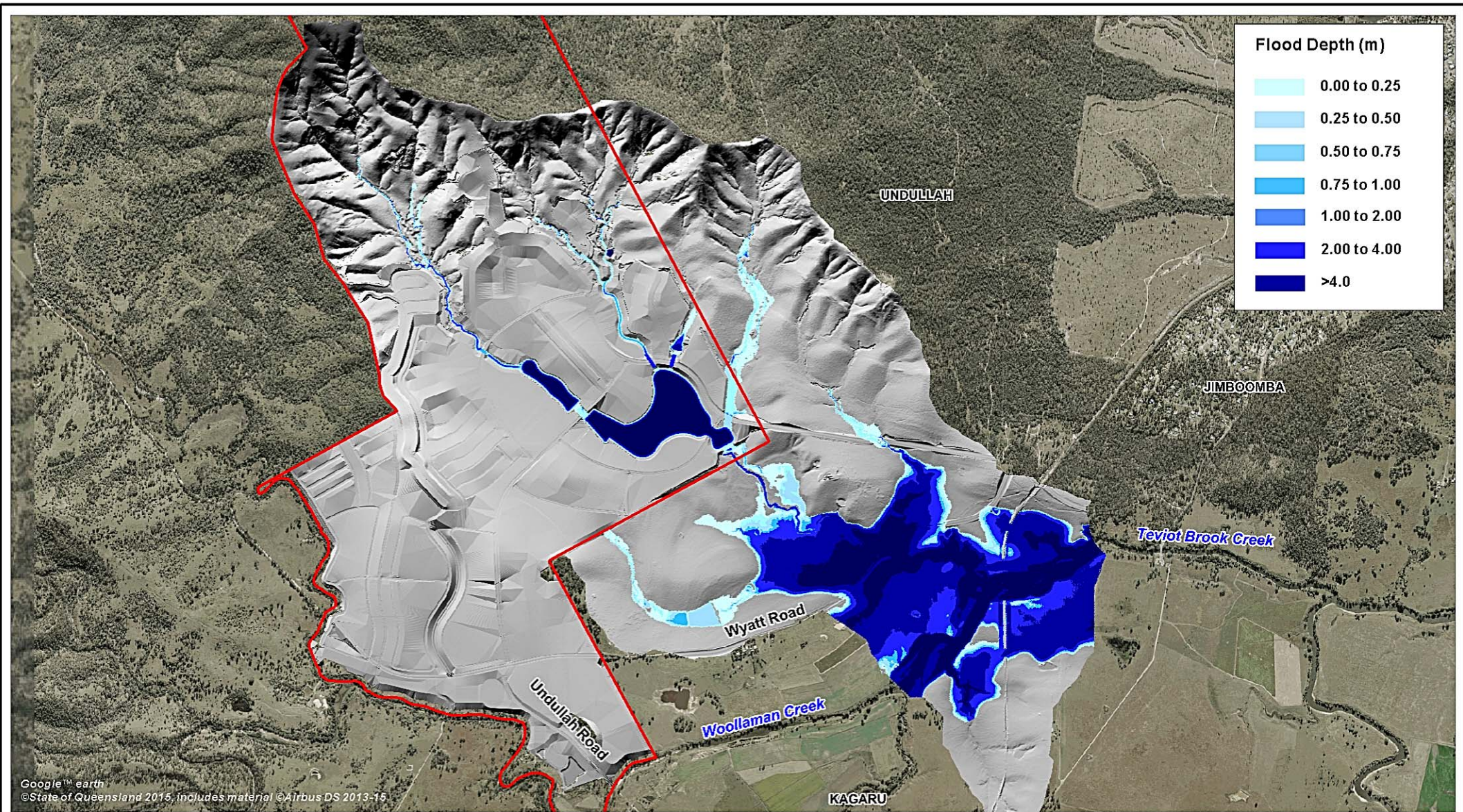
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Approx. Scale



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LEGEND

 Precinct Boundary

Title:

Developed Case ARI 20 Year Peak Flood Depths

Figure:

B-8

Rev:

A

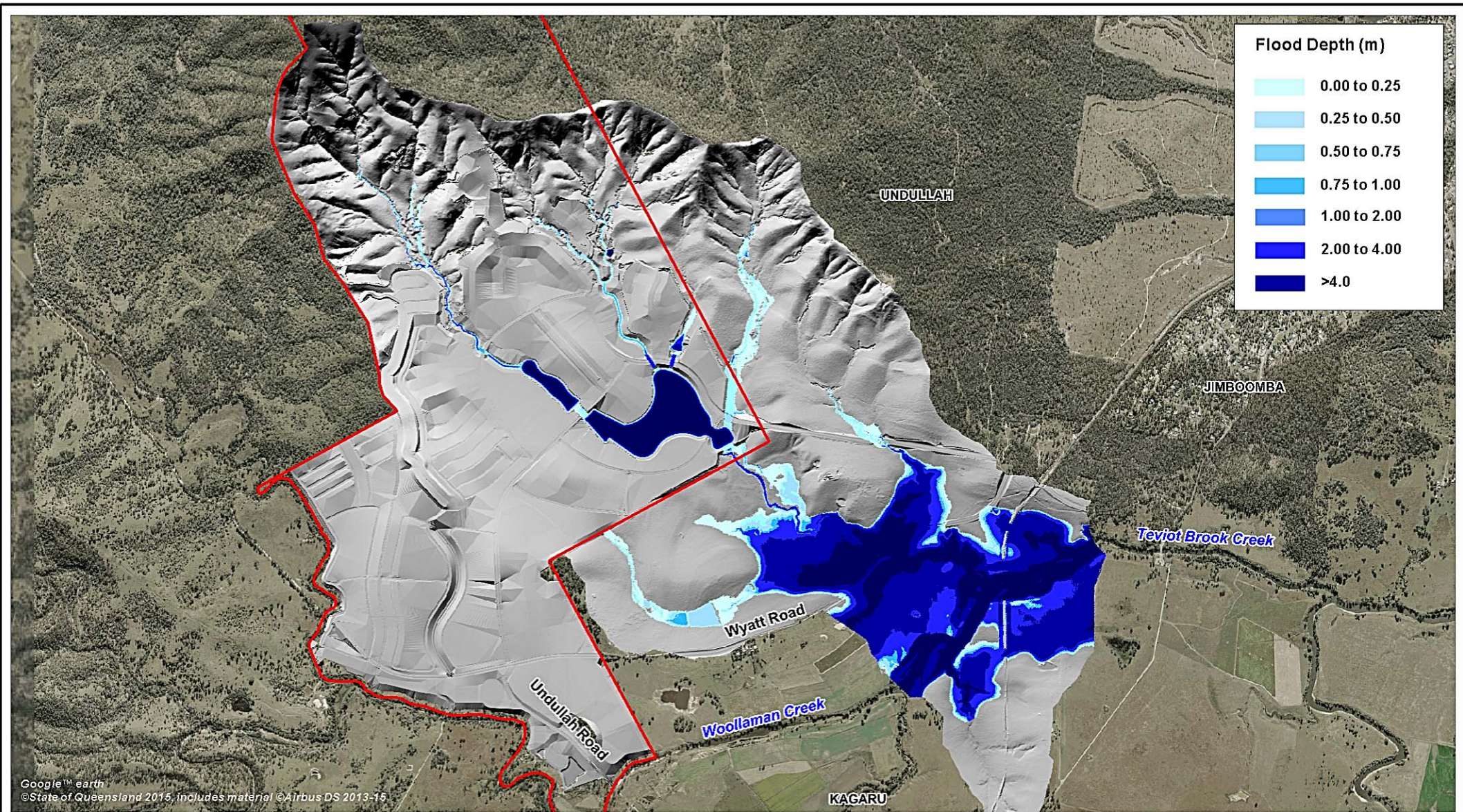
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Approx. Scale



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LEGEND

 Precinct Boundary

Title:

Developed Case ARI 10 Year Peak Flood Depths

Figure:

B-9

Rev:

A

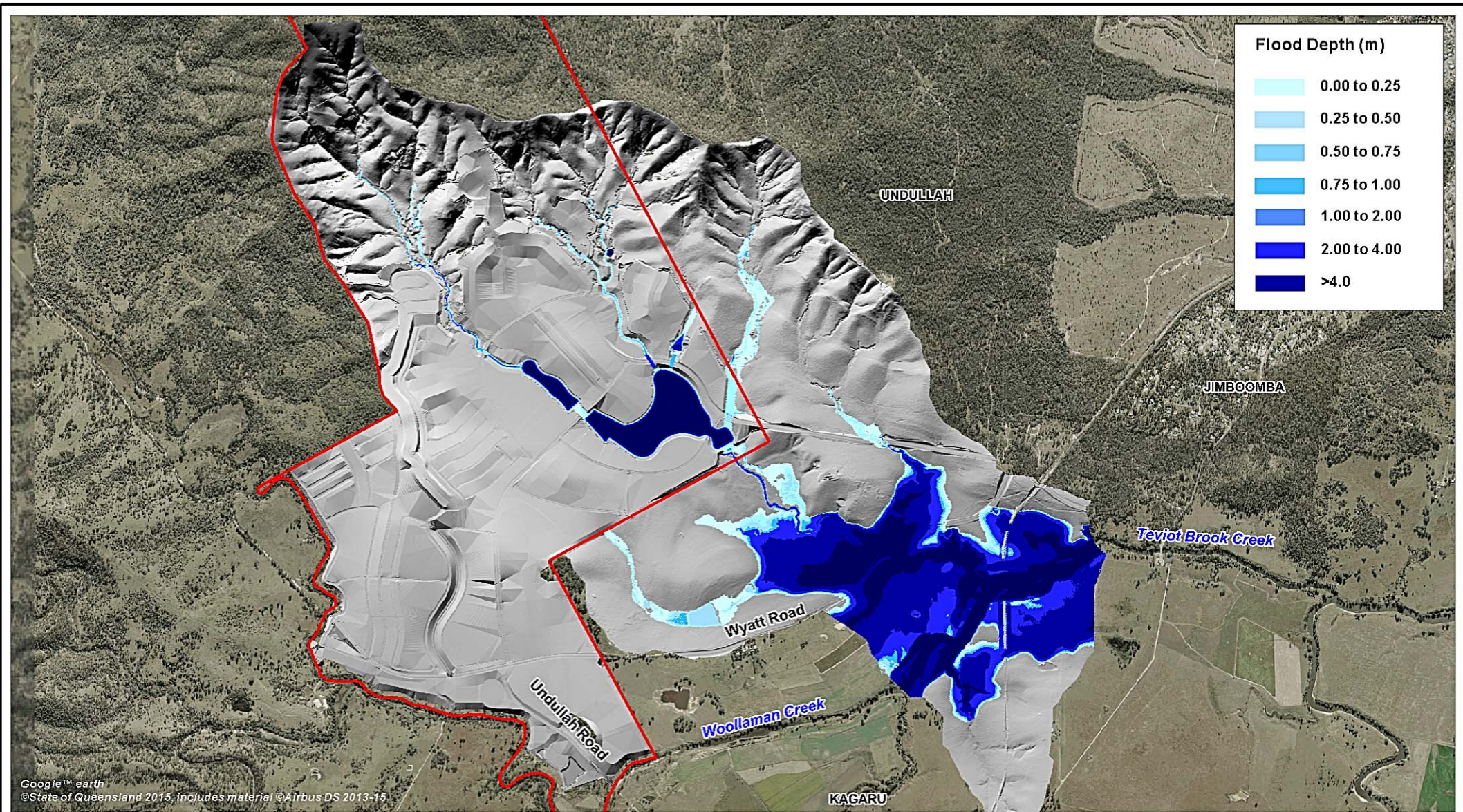
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Approx. Scale



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LEGEND

 Precinct Boundary

Title:

Developed Case ARI 5 Year Peak Flood Depths

Figure:

B-10

Rev:

A

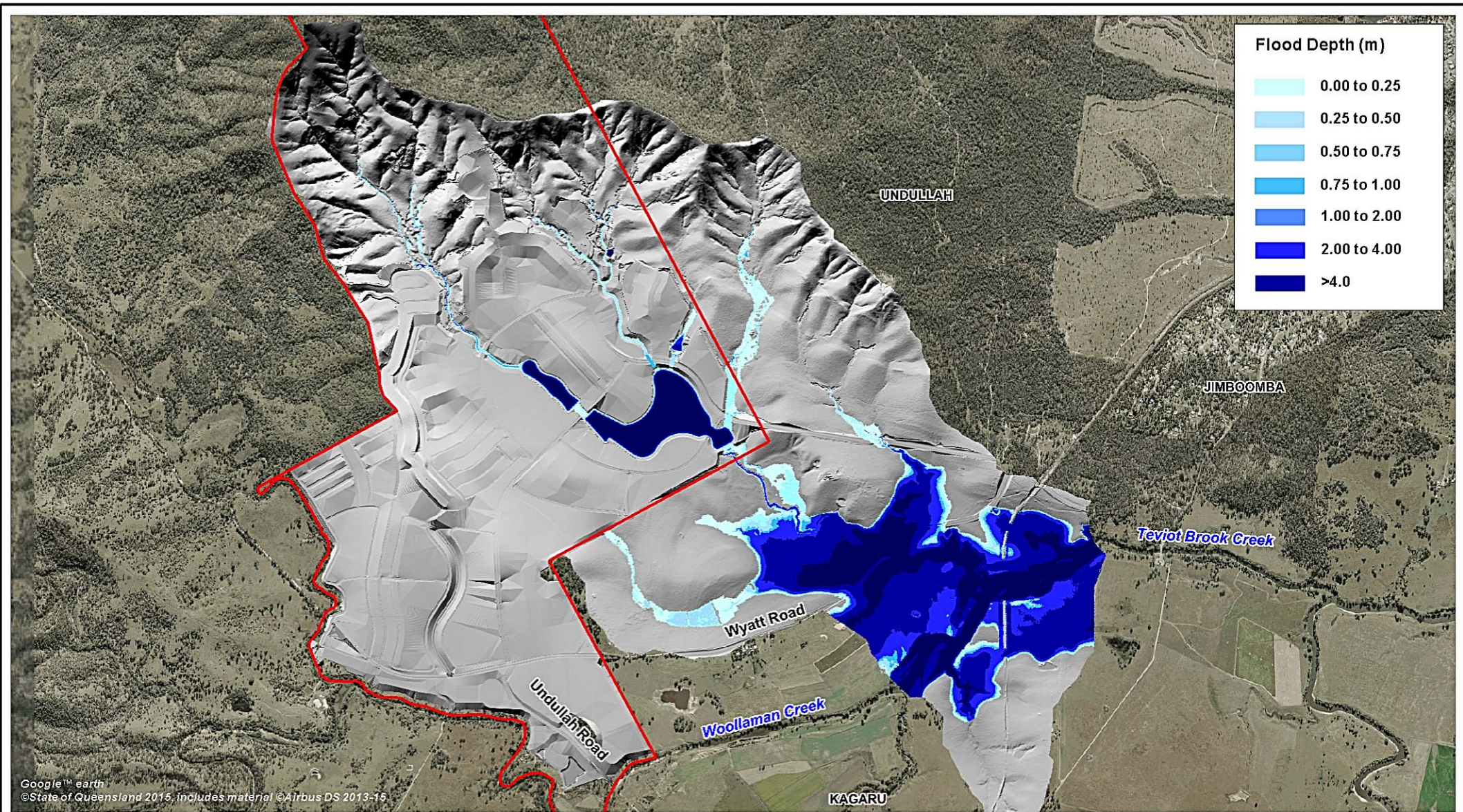
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Approx. Scale



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LEGEND

 Precinct Boundary

Title:

Developed Case ARI 2 Year Peak Flood Depths

Figure:

B-11

Rev:

A

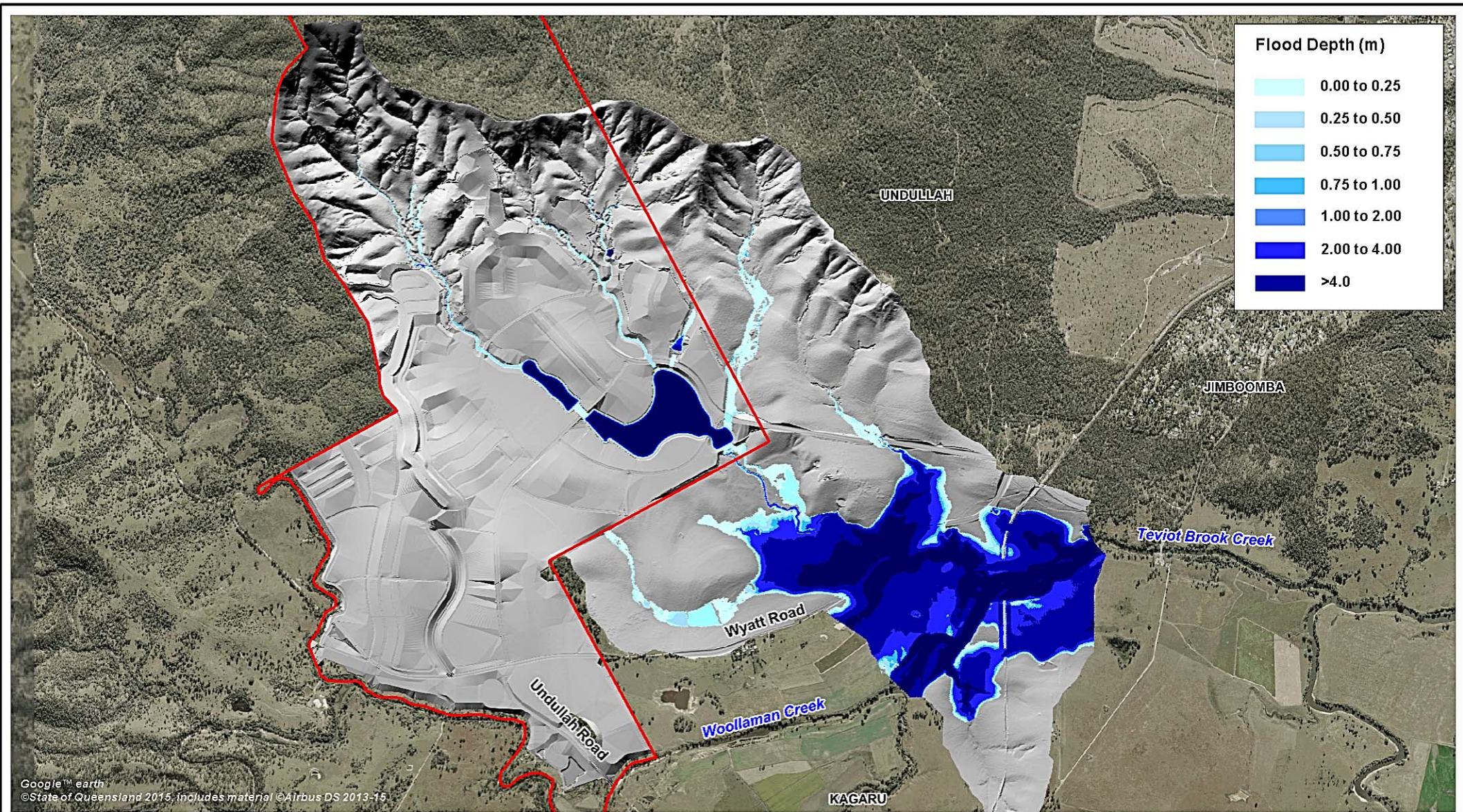
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Approx. Scale



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LEGEND

 Precinct Boundary

Title:

Developed Case ARI 1 Year Peak Flood Depths

Figure:

B-12

Rev:

A

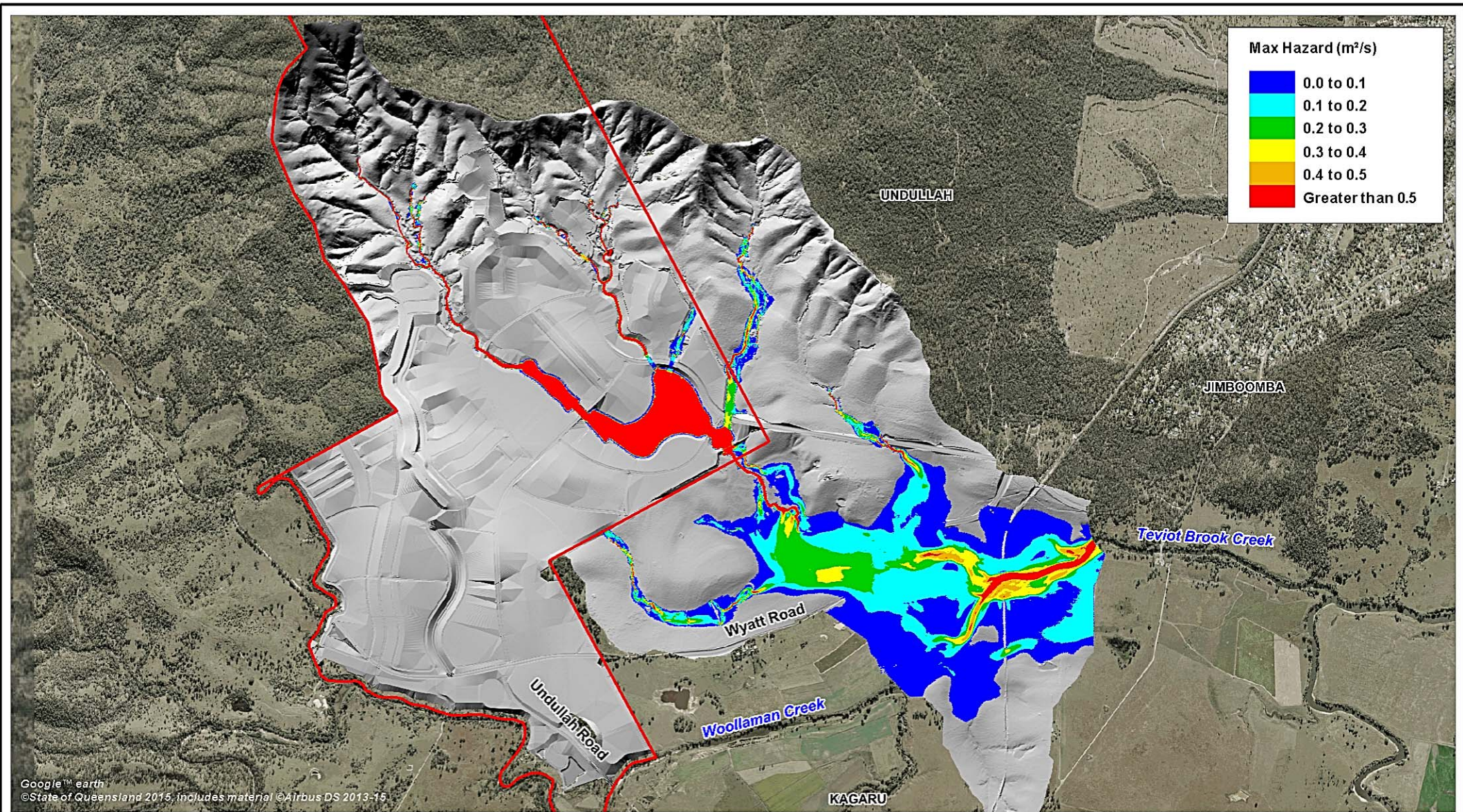
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Approx. Scale



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LEGEND

 Precinct Boundary

Title:

Developed Case ARI 50 Year Peak Flood Hazard

Figure:

B-13

Rev:

A

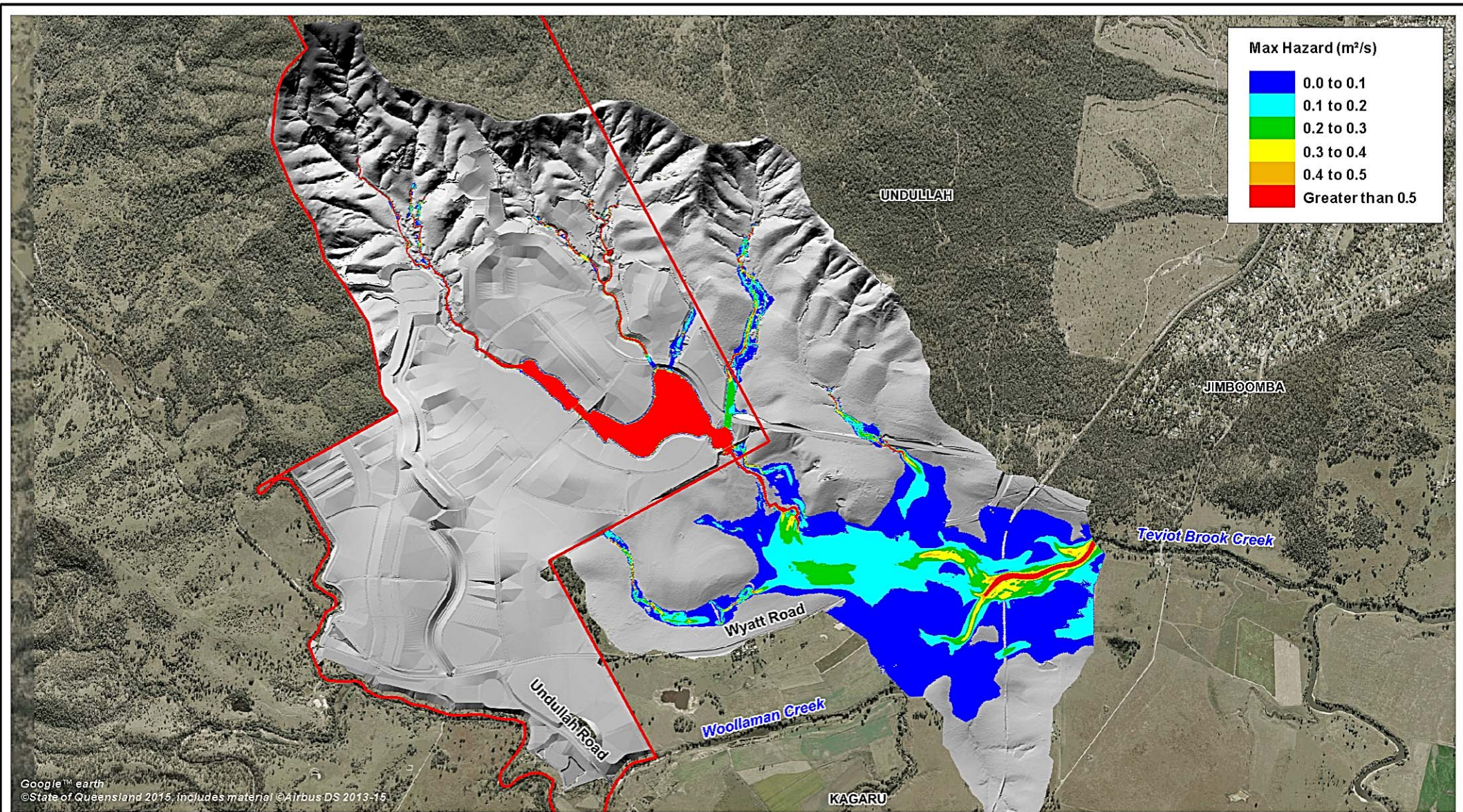
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Approx. Scale



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LEGEND

 Precinct Boundary

Title:

Developed Case ARI 20 Year Peak Flood Hazard

Figure:

B-14

Rev:

A

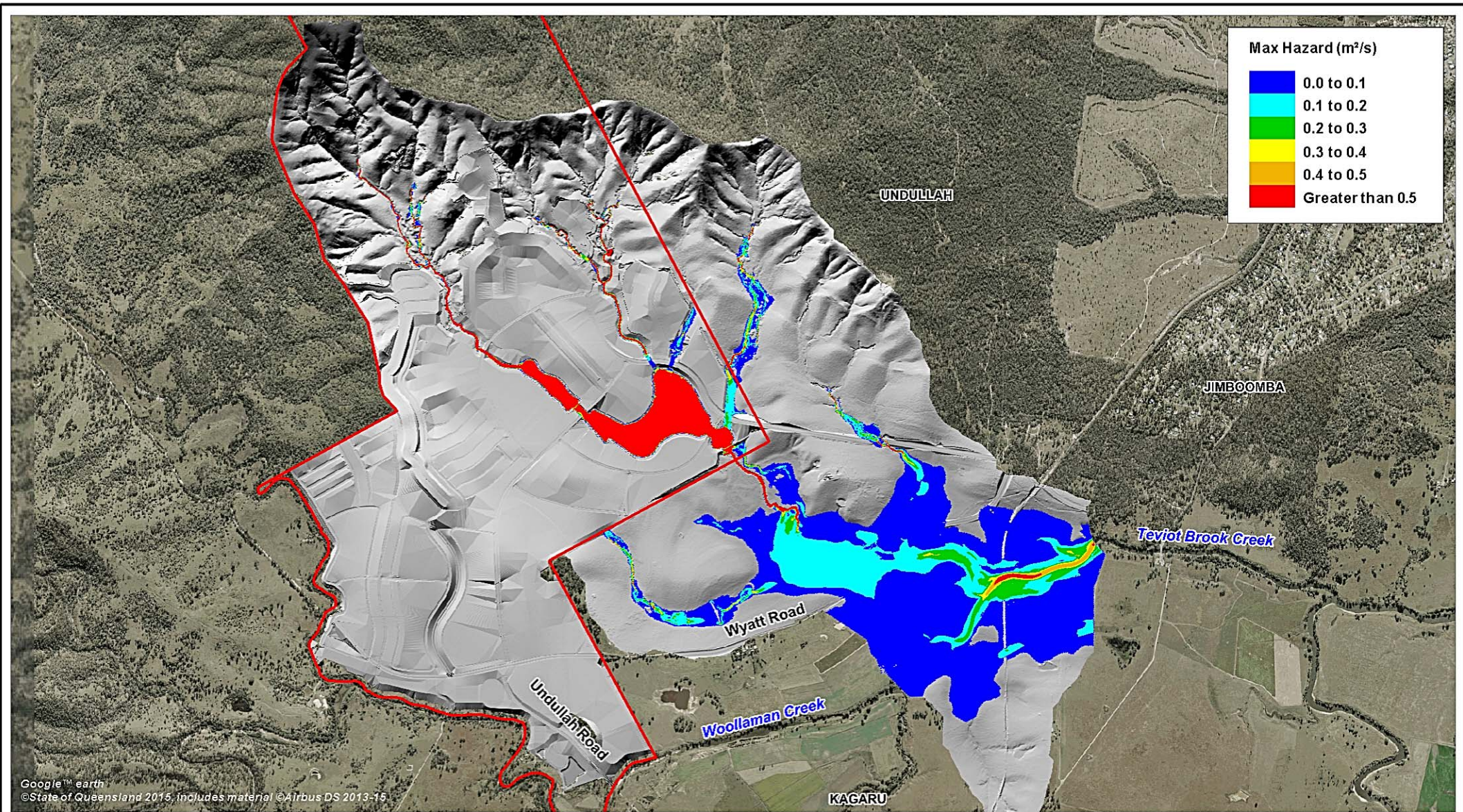
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LEGEND

 Precinct Boundary

Title:

Developed Case ARI 10 Year Peak Flood Hazard

Figure:

B-15

Rev:

A

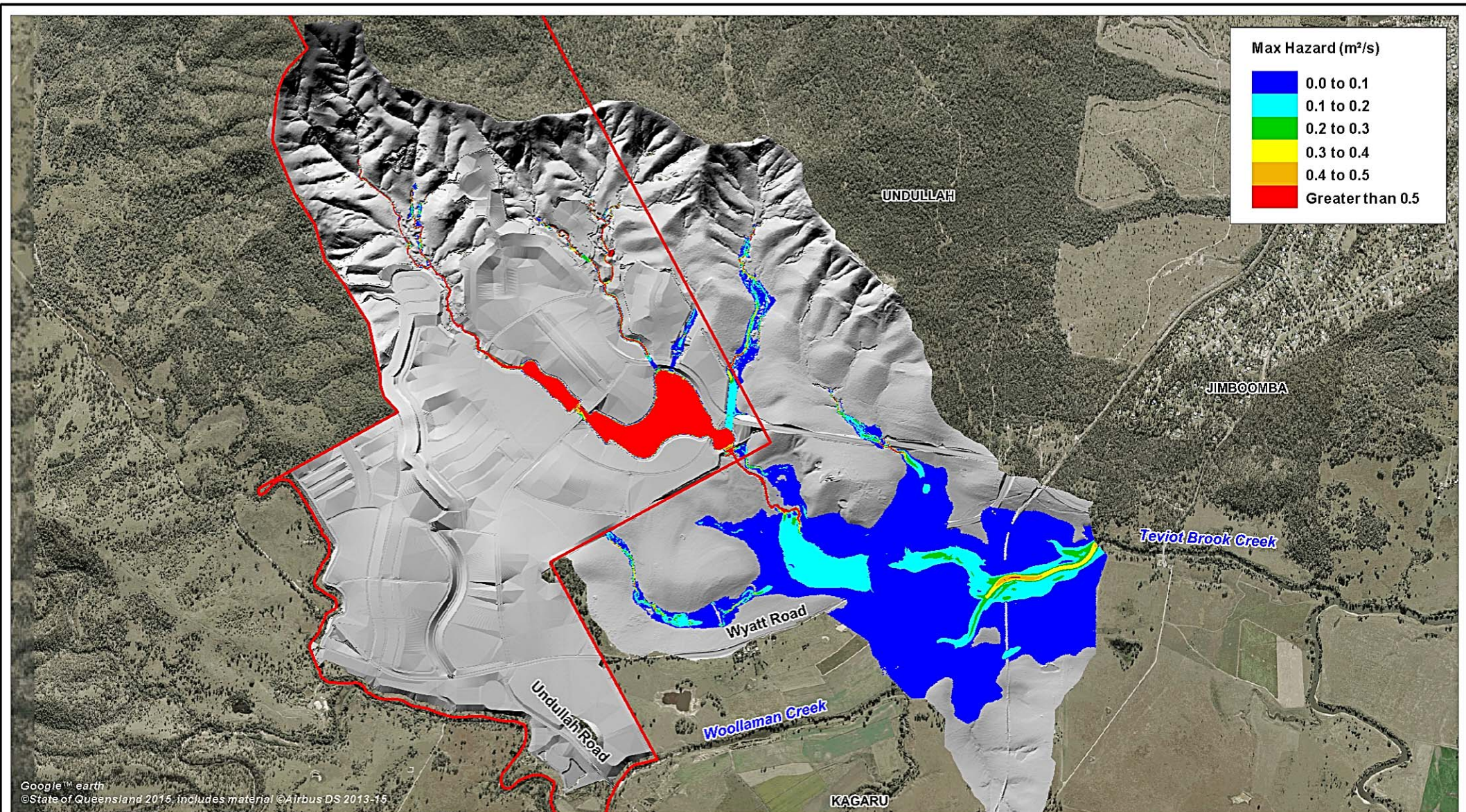
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Approx. Scale



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LEGEND

 Precinct Boundary

Title:

Developed Case ARI 5 Year Peak Flood Hazard

Figure:

B-16

Rev:

A

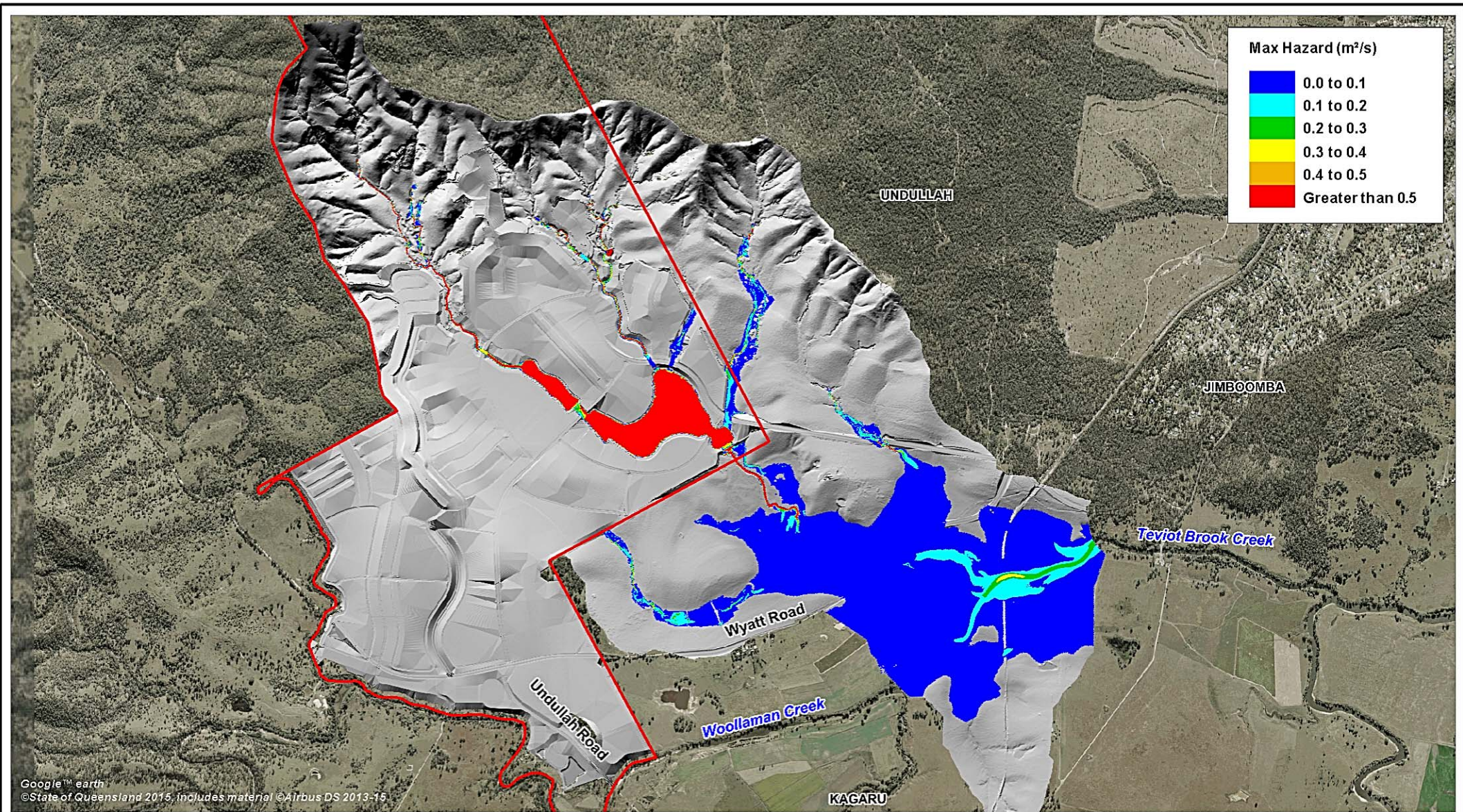
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0 0.5 1km
Approx. Scale



Filepath: I:\B21415_I_JLB Flinders Project NC\DRG\Flood Mapping\FLD_040_160224_ARI 5 Year Peak Flood Hazard_Developed Case.wor



LEGEND

 Precinct Boundary

Title:

Developed Case ARI 2 Year Peak Flood Hazard

Figure:

B-17

Rev:

A

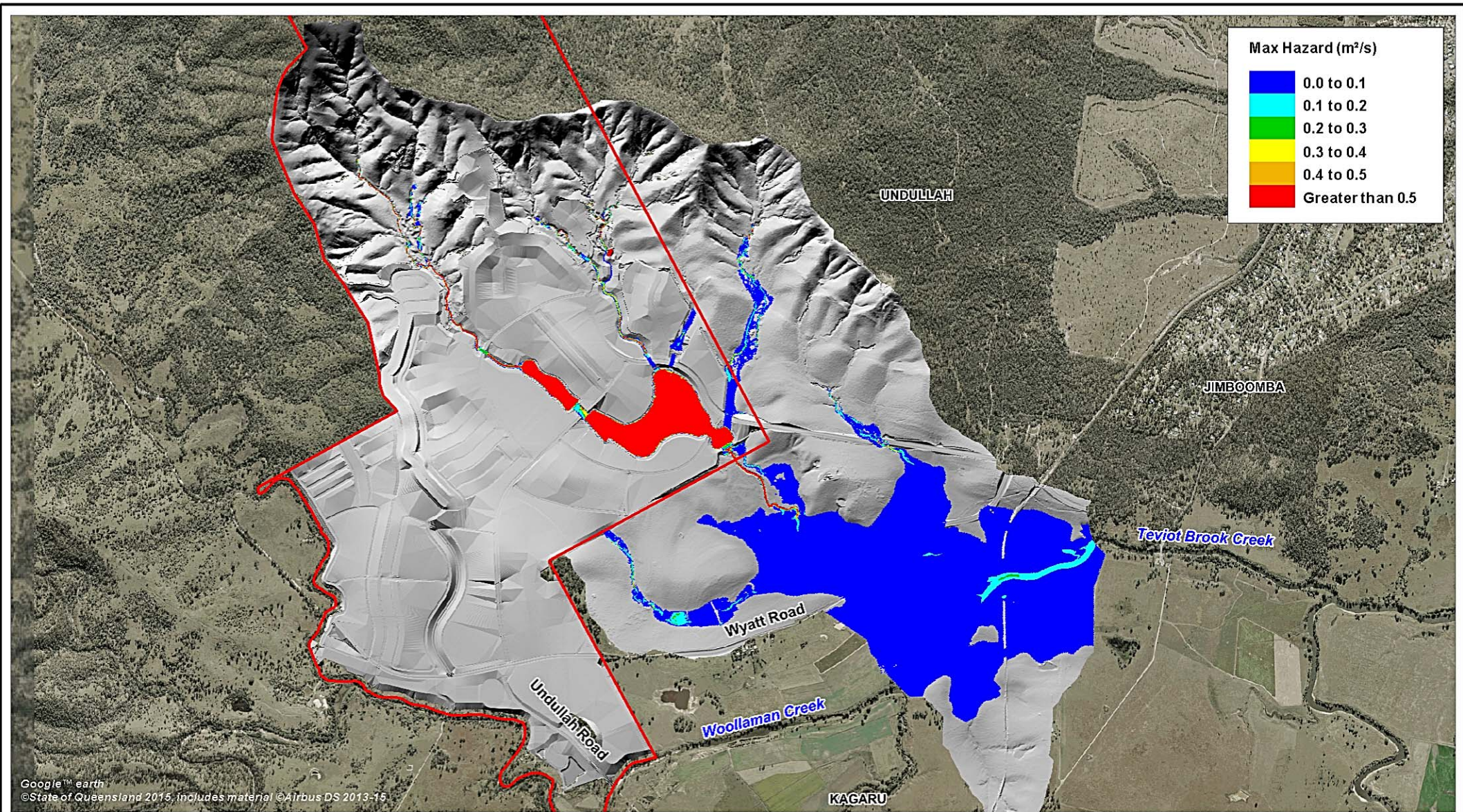
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0 0.5 1km
Approx. Scale



Filepath: I:\B21415_I_JLB Flinders Project NC\DRG\Flood Mapping\FLD_041_160224_ARI 2 Year Peak Flood Hazard_Developed Case.wor



LEGEND

Precinct Boundary

Title:

Developed Case ARI 1 Year Peak Flood Hazard

Figure:

B-18

Rev:

A

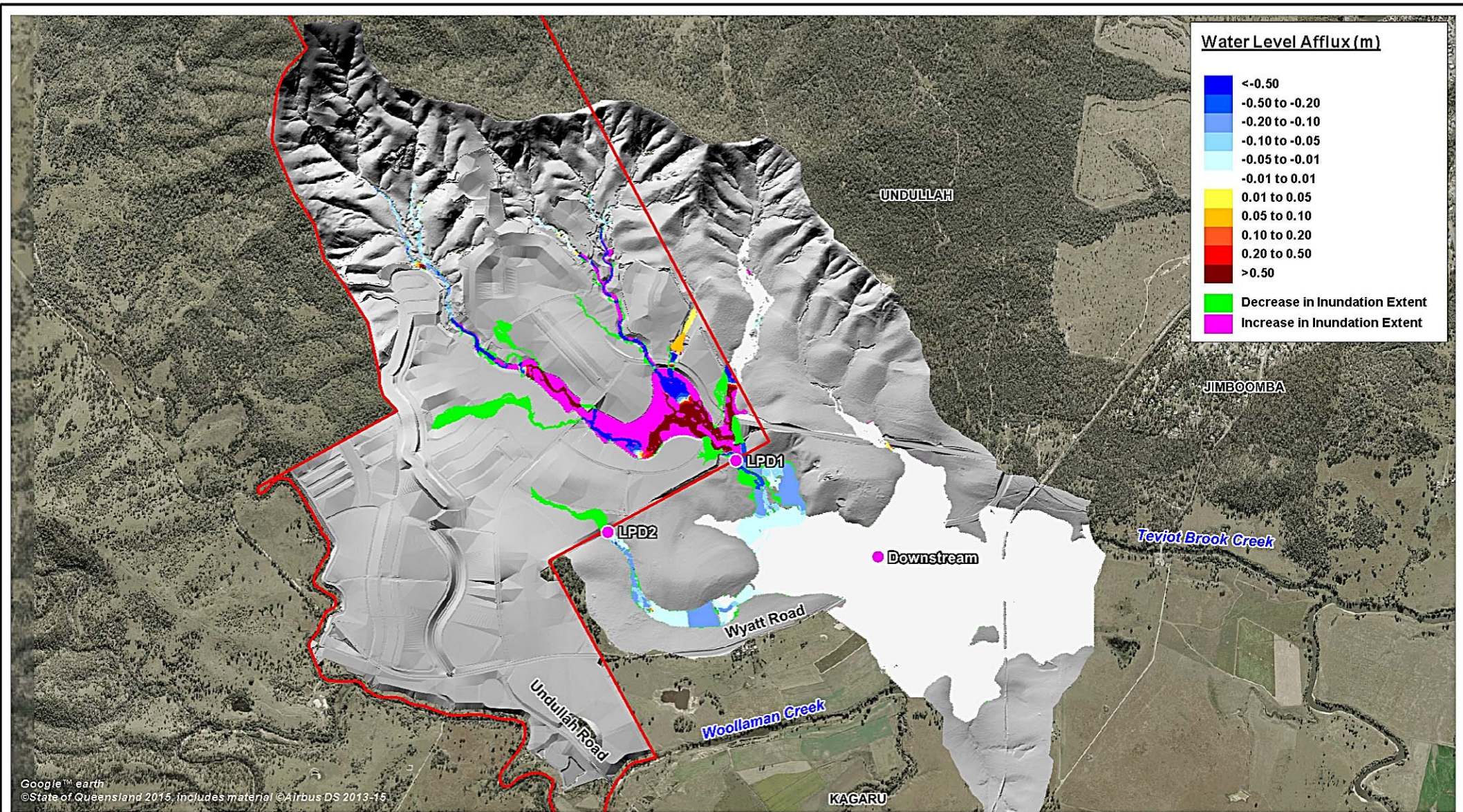
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0 0.5 1km
Approx. Scale



Filepath: I:\B21415_I_JLB Flinders Project NC\DRG\Flood Mapping\FLD_042_160224_ARI 1 Year Peak Flood Hazard_Developed Case.wor



LEGEND

- Reporting Points
- Precinct Boundary

Title:

Developed Case ARI 50 Year Peak Flood Impact

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0 0.5 1km
Approx. Scale

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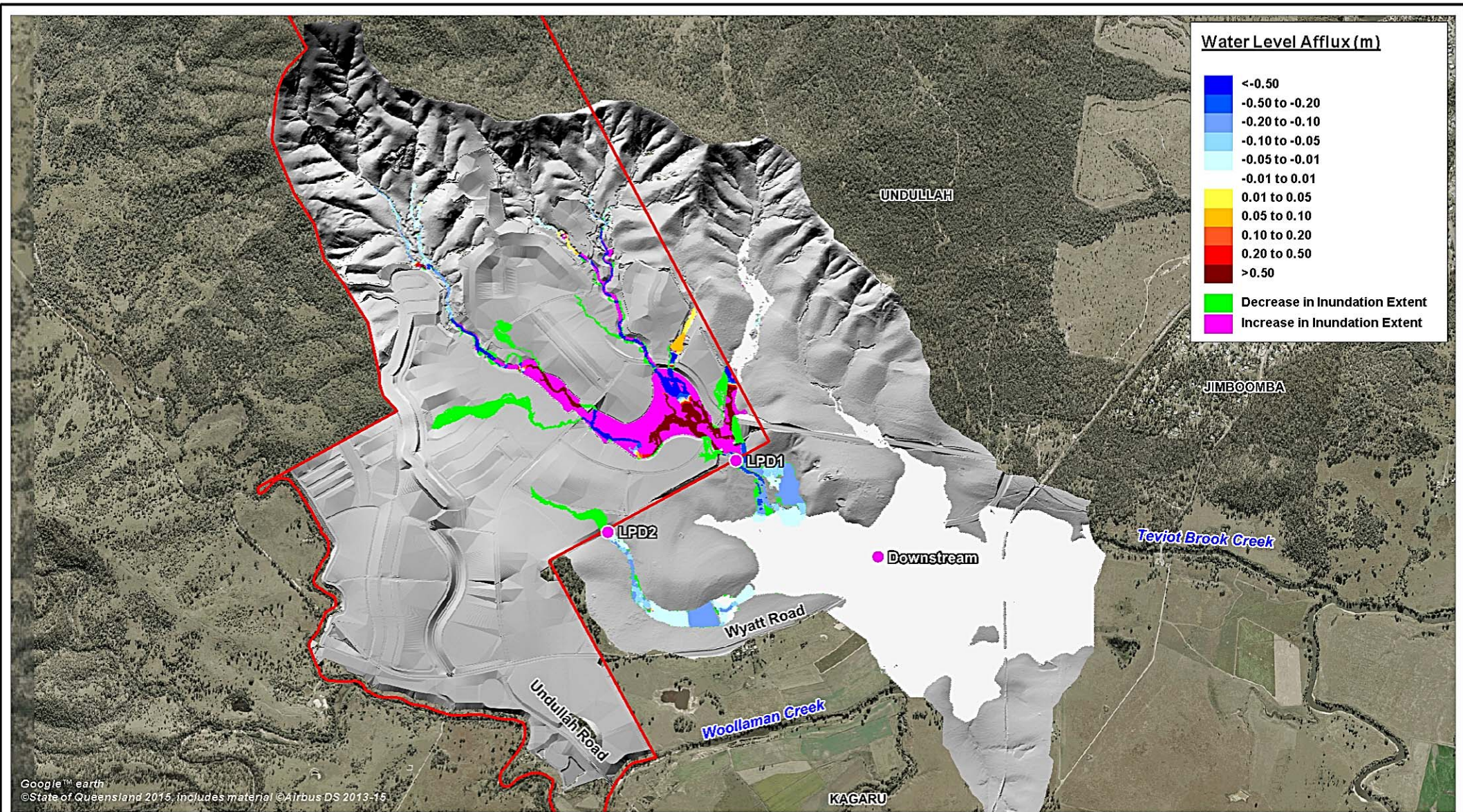
B-19

Rev:

A



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LEGEND

- Reporting Points
- Precinct Boundary

Title:

Developed Case ARI 20 Year Peak Flood Impact

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Approx. Scale

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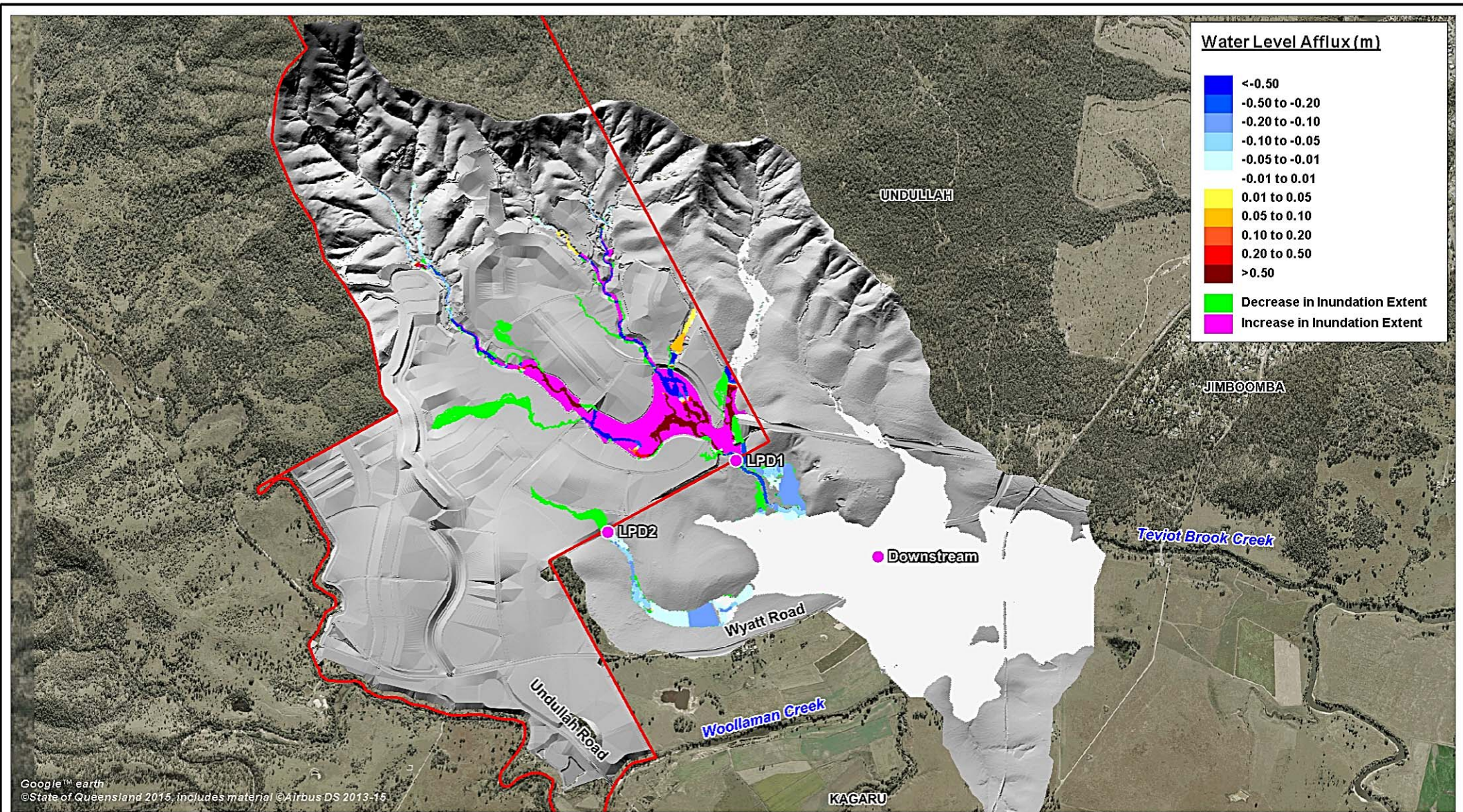
B-20

Rev:

A



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LEGEND

- Reporting Points
- Precinct Boundary

Title:

Developed Case ARI 10 Year Peak Flood Impact

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0 0.5 1km
Approx. Scale

Figure:

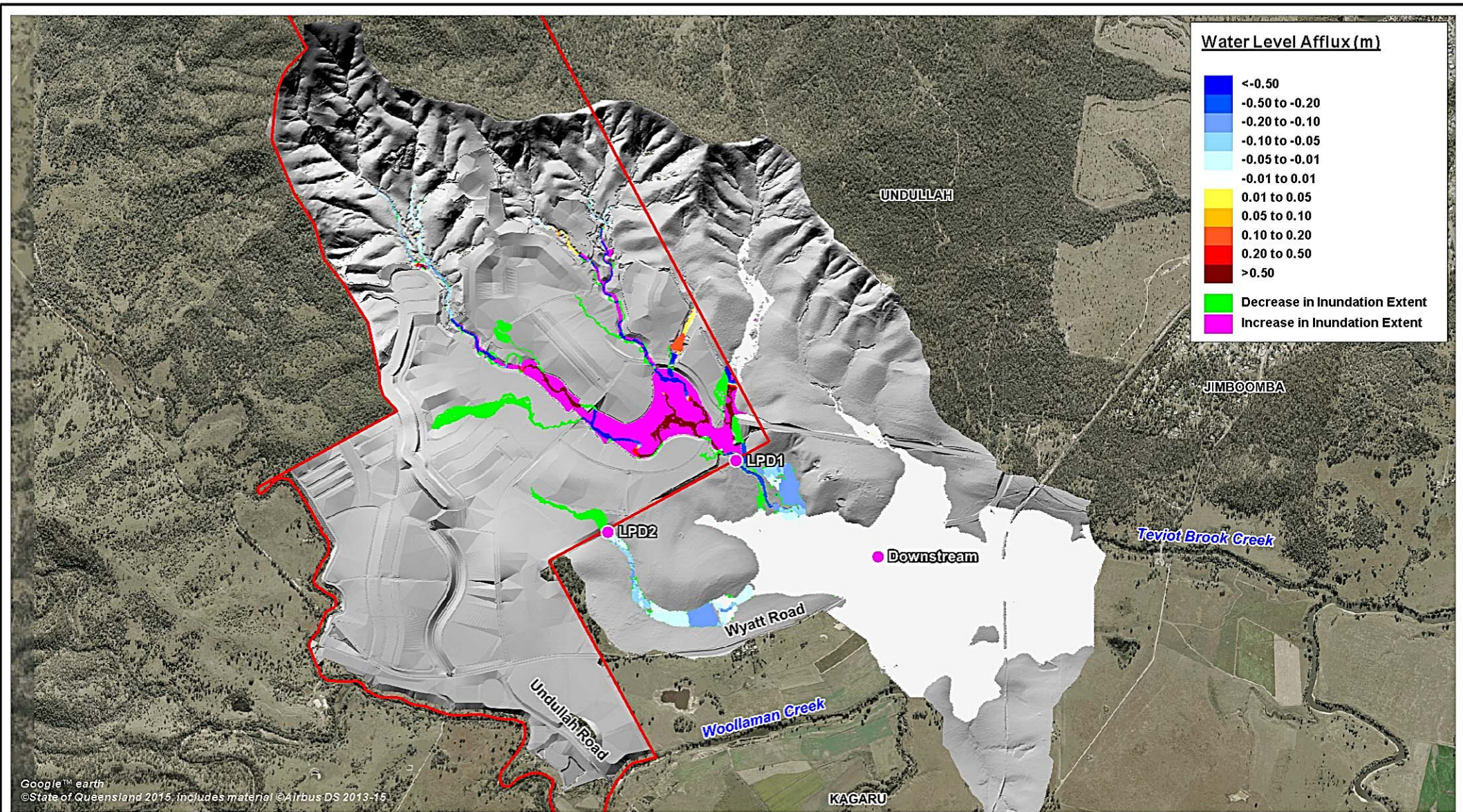
B-21

Rev:

A



Filepath: I:\B21415_I_JLB Flinders Project NC\DRG\Flood Mapping\FLD_045_160224_ARI 10 Year Peak Flood Impact_Developed Case.wor



LEGEND

- Reporting Points
- Precinct Boundary

Title:

Developed Case ARI 5 Year Peak Flood Impact

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0 0.5 1km
Approx. Scale

Figure:

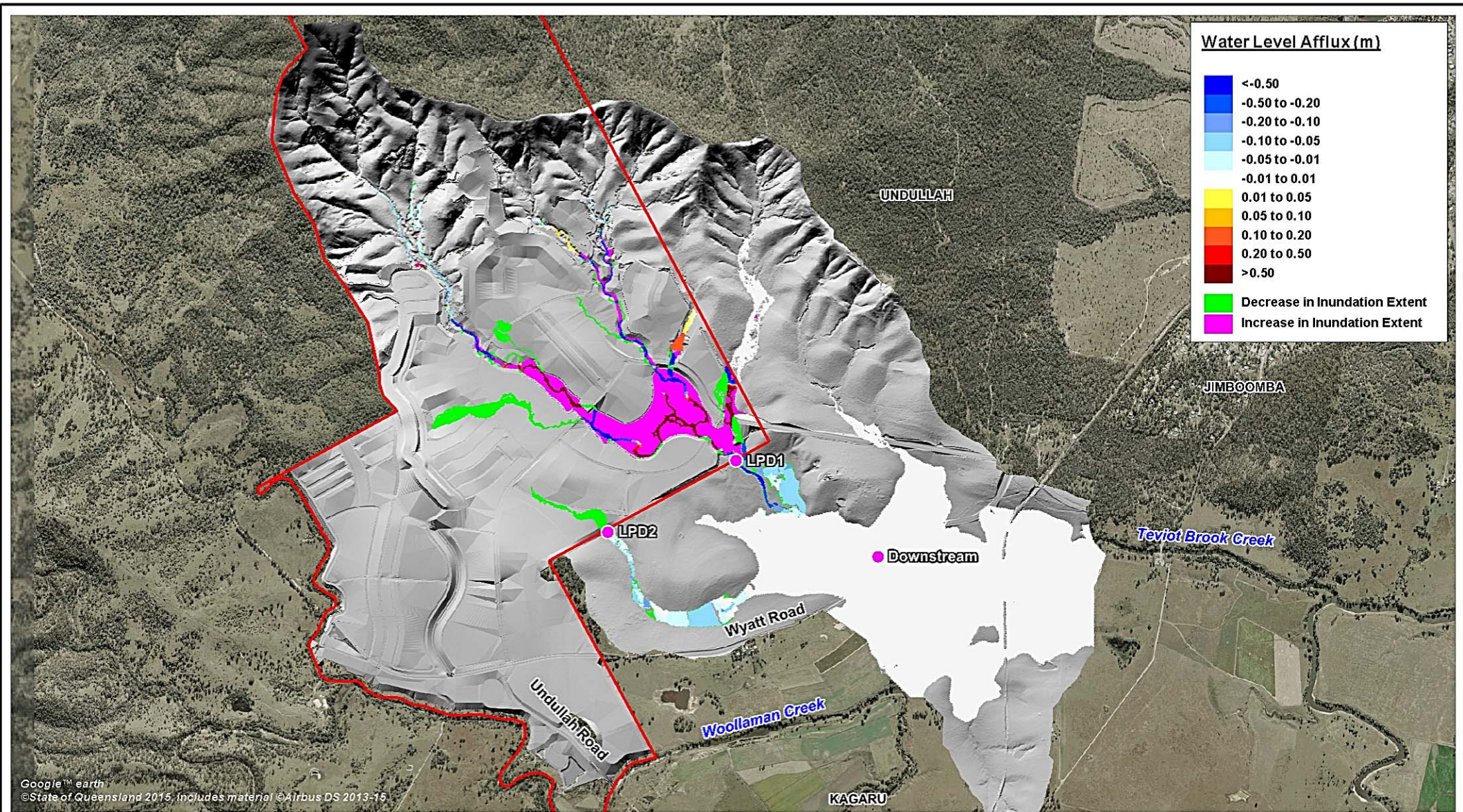
B-22

Rev:

A



Filepath: I:\B21415_I_JLB Flinders Project NC\DRG\Flood Mapping\FLD_046_160224_ARI 5 Year Peak Flood Impact_Developed Case.wor



LEGEND

- Reporting Points
- Precinct Boundary

Title:

Developed Case ARI 2 Year Peak Flood Impact

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Approx. Scale

Figure:

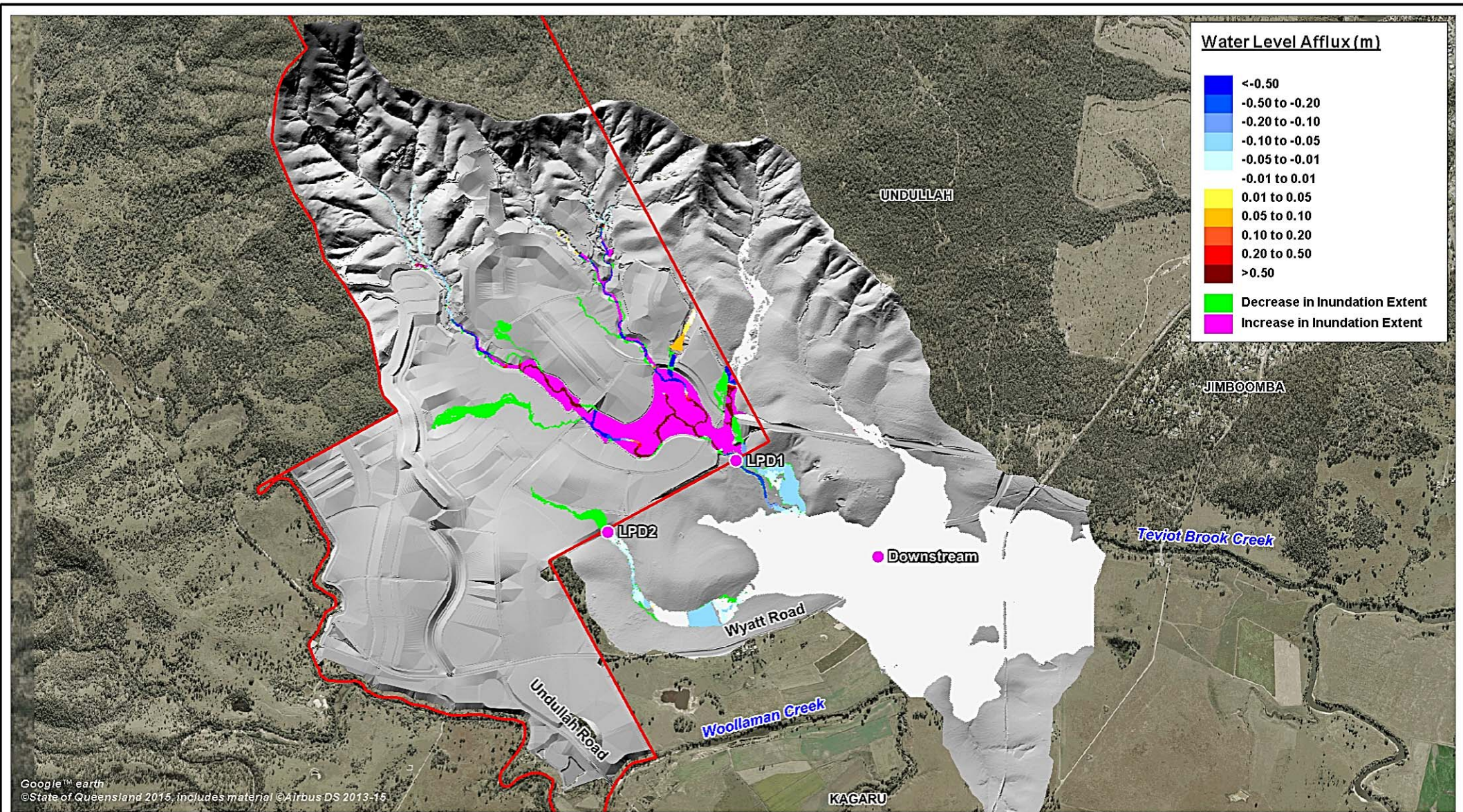
B-23

Rev:

A



Filepath: I:\B21415_I_JLB Flinders Project NC\DRG\Flood Mapping\FLD_047_160224_ARI 2 Year Peak Flood Impact_Developed Case.wor



LEGEND

- Reporting Points
- Precinct Boundary

Title:

Developed Case ARI 1 Year Peak Flood Impact

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0 0.5 1km
Approx. Scale

Figure:

B-24

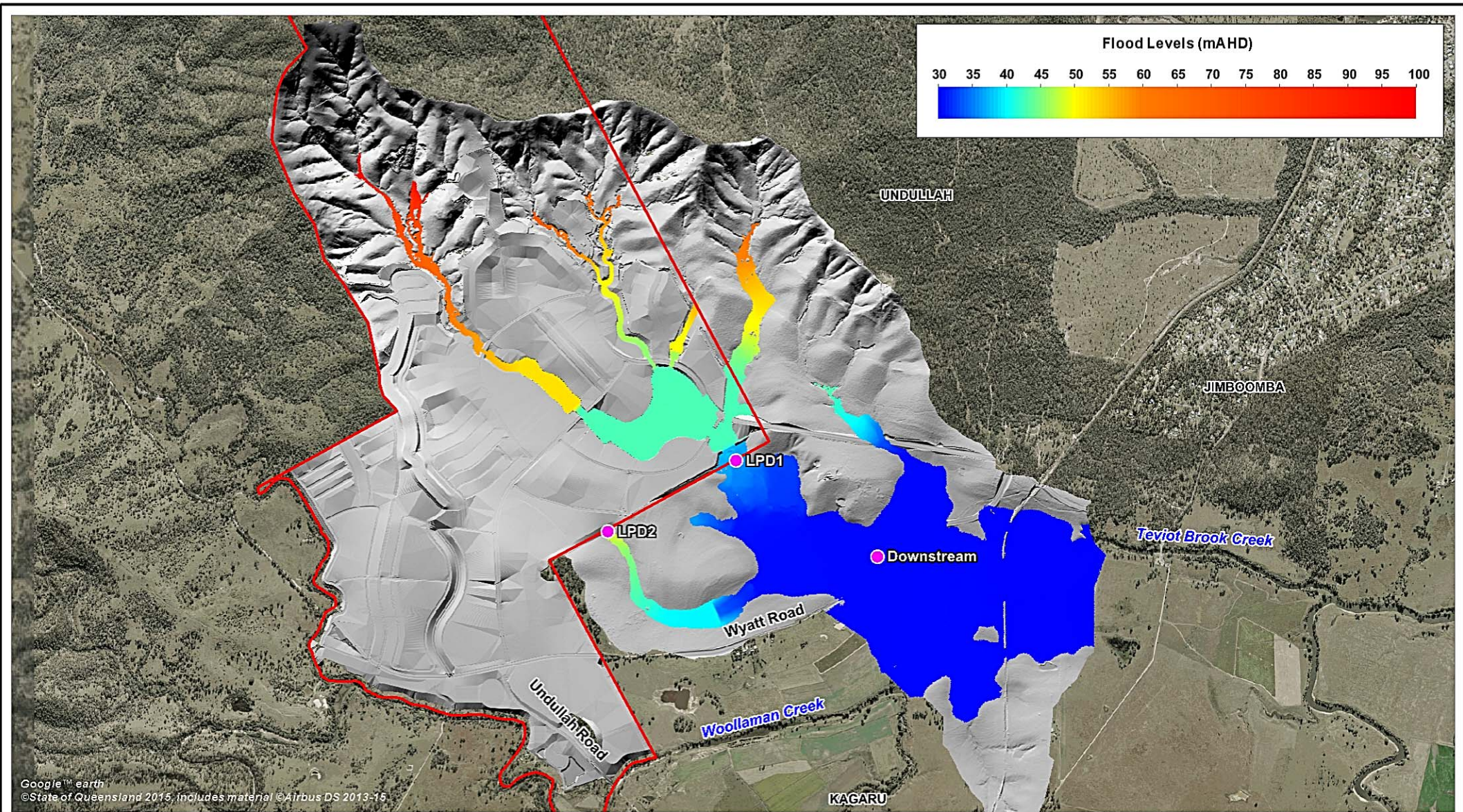
Rev:

A



Filepath: I:\B21415_I_JLB Flinders Project NC\DRG\Flood Mapping\FLD_048_160224_ARI 1 Year Peak Flood Impact_Developed Case.wor

Appendix C Developed Case PMF Flood Model Results



LEGEND

- Reporting Points
- Precinct Boundary

Title:

Developed Case PMF Peak Flood Levels

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0 0.5 1km
Approx. Scale

Figure:

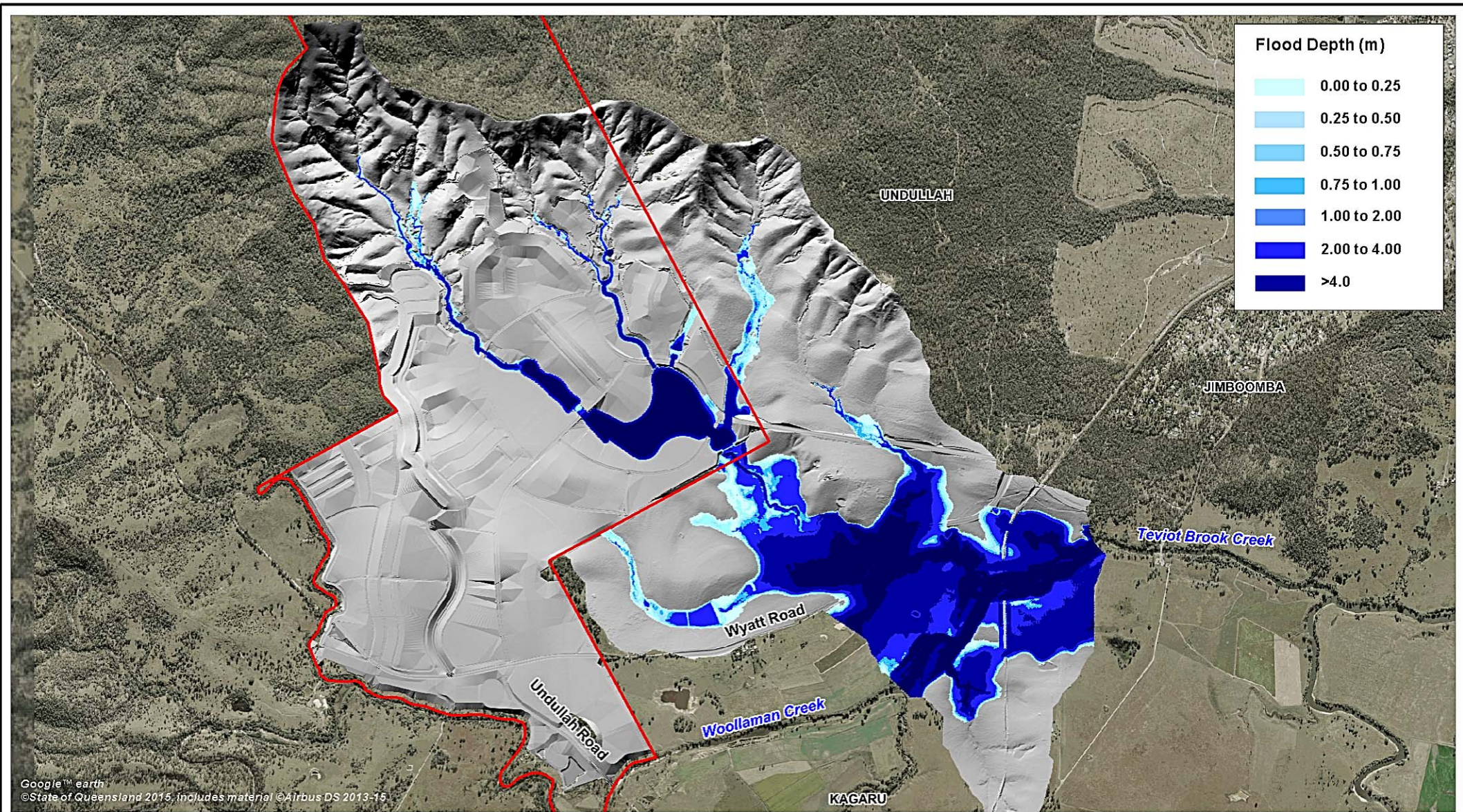
C-1

Rev:

A



Filepath: I:\B21415_I_JLB Flinders Project NC\DRG\Flood Mapping\FLD_049_160224_PMF Peak Flood Levels_Developed Case.wor



LEGEND

 Precinct Boundary

Title:

Developed Case PMF Peak Flood Depths

Figure:

C-2

Rev:

A

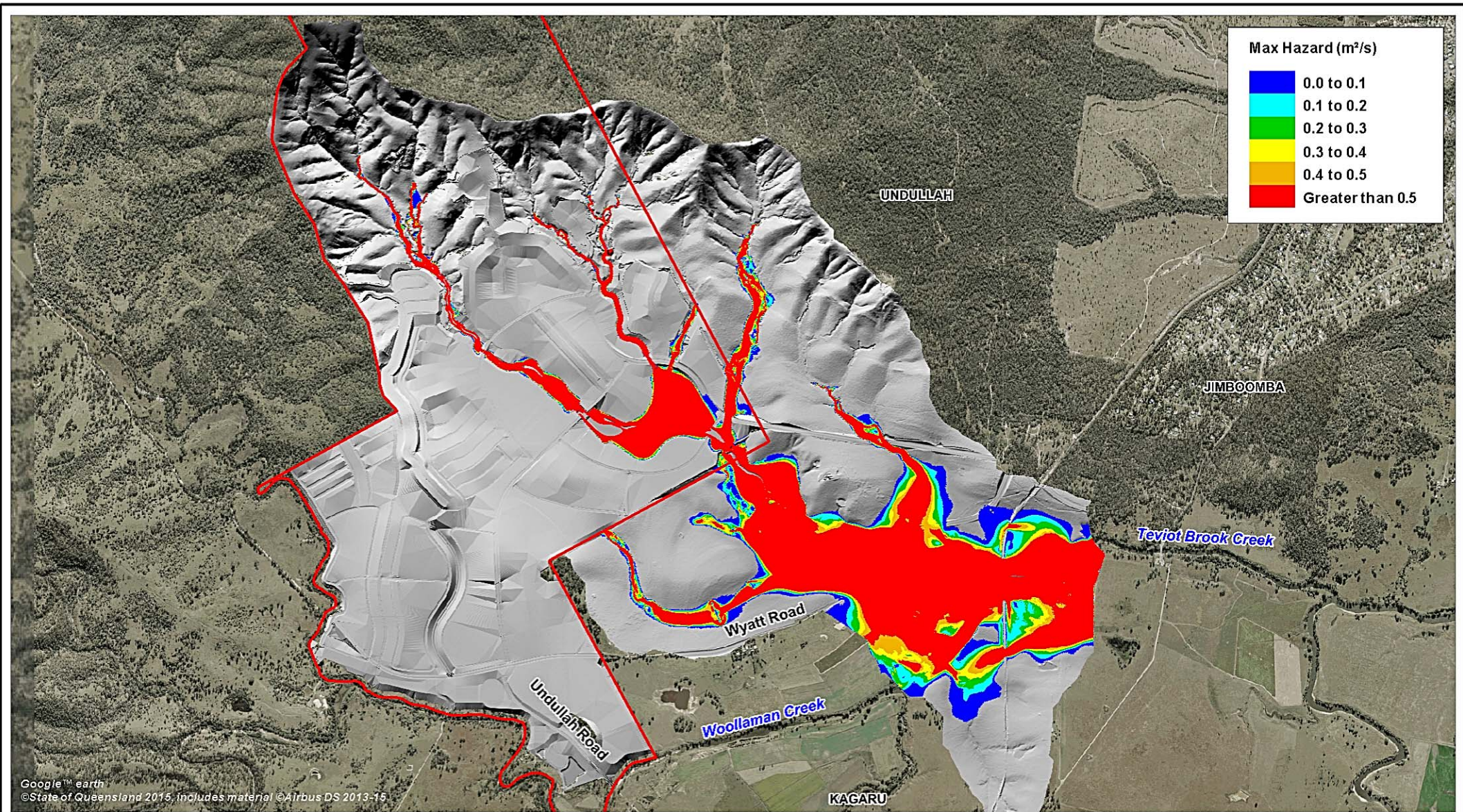
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0 0.5 1km
Approx. Scale



Filepath: I:\B21415_I_JLB Flinders Project NC\DRG\Flood Mapping\FLD_050_160224_PMF Peak Flood Depth_Developed Case.wor



LEGEND

Precinct Boundary

Title:

Developed Case PMF Peak Flood Hazard

Figure:

C-3

Rev:

A

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0 0.5 1km
Approx. Scale



Filepath: I:\B21415_I_JLB Flinders Project NC\DRG\Flood Mapping\FLD_051_160224_PMF Peak Flood Hazard_Developed Case.wor



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