WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

HYDRAULIC ASSESSMENT – PROPOSED MULTI UNIT DEVELOPMENT AT 303 LOGAN RESERVE ROAD, LOGAN RESERVE

February 2016

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1. INTRODUCTION AND BACKGROUND

1.1 Introduction

Water Technology P/L (WT) have been commissioned by Lambert & Rehbein P/L (L&R) on behalf of Vic Land Holding Pty Ltd to undertake a flood assessment for a proposed development located on Logan Reserve Road, Logan Reserve. The property is located at 303 - 309 Logan Reserve Road (real property description Lot 2 RP165534), Logan Reserve between School Road and Bayes Road (refer Figure 1-1), and is located within the Logan City Council (LCC) local government area. The subject site is located on a tributary to what is understood to be the southern branch as Schmidts Creek. Schmidts Creek itself flows to the Logan River approximately 2.5km downstream of the site.

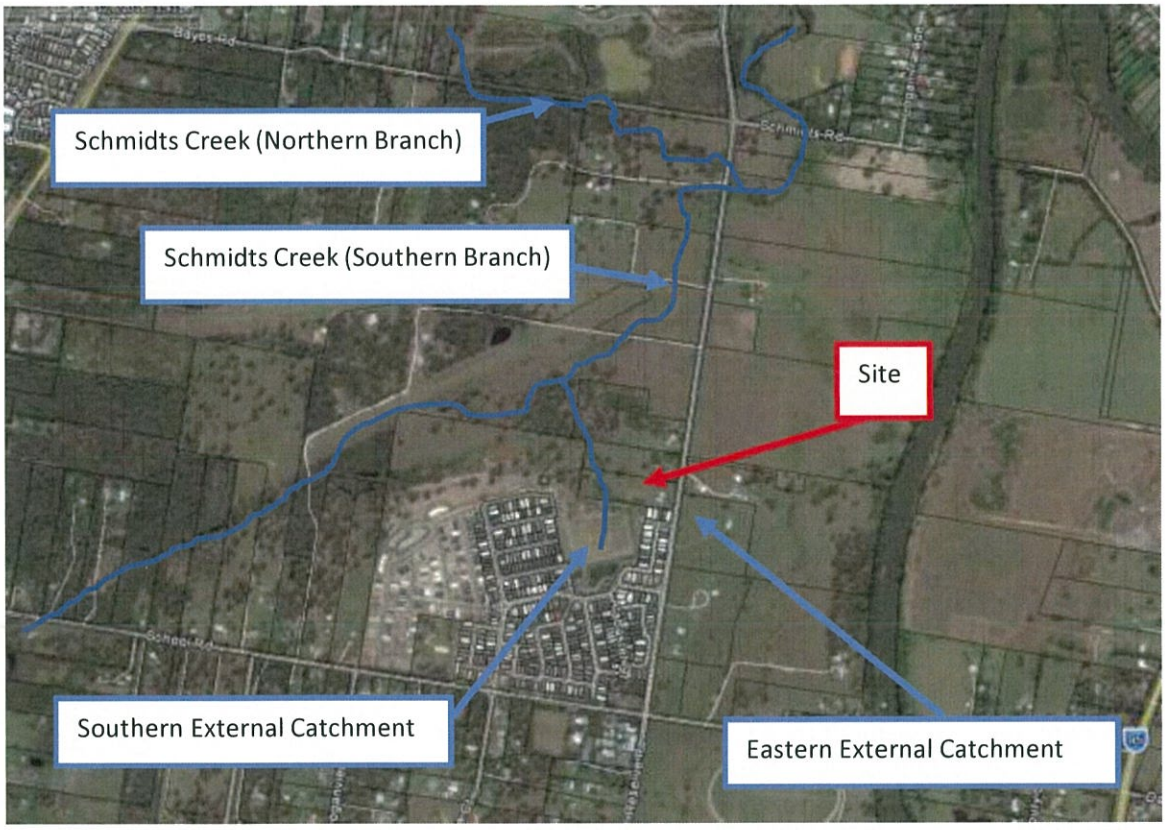

Figure 1-1 Site Locality (Source – Google Earth)

1.2 Scope of Works

This report has been prepared to document the flood assessment works undertaken at the site for the purposes of a proposed development application made to Council. The flood assessments completed at the site and as documented in this report includes assessments of catchment hydrology in addition with hydraulic assessments relating to regional, local and stormwater flooding. This report has been prepared for the purposes of demonstrating a compliant development outcome in relation to Council's planning scheme and codes.

This report has been prepared specifically to address flooding at the site and does not include an assessment of other matters relating to the development, including stormwater quality or civil aspects which are addressed by others. Reference is also made to the civil engineering drawings and associated reporting prepared by Lambert & Rehbein Consulting Engineers which form part of the documentation prepared in support of the development application.

1.3 Site Description and Proposed Development

The subject property is located at 303 - 309 Logan Reserve Road (real property description Lot 2 RP165534) and is currently subjected to flooding from a number of sources. Specifically, this includes flooding from the following mechanisms: -

- Regional flooding relating to a Logan River flood event;
- Local flooding relating to the Schmidt's Creek system; and
- Stormwater flooding relating to the external drainage catchment located to the east of Logan Reserve Road.

The waterway to the rear of the property is a tributary of what is understood to be the southern Branch of Schmidt's Creek. Other than floodwaters from the Logan River backwatering up the tributary, the waterway is also subject to local flooding from an external local catchment extending to the south of the site. This external catchment includes a sports field associated with the adjacent development which is understood to act as a detention basin for flows from the upstream development. Water in the sports field is detained by an embankment with an opening approximately 6m in width.

There is a small channel that traverses approximately through the middle of the site which drains a small external catchment located to the west of Logan Reserve Road. Water enters the channel via existing stormwater pits located on western side of Logan Reserve Road.

Within the site itself, there is also an existing farm dam located to the rear of the site. The existing dam is approximately 0.1ha and is proposed to be removed as part of the development. There is also a further farm dam located downstream and within the adjacent property to the north and is also of similar size.

The site in its present form is used for rural residential purposes and is essentially vacant open land and is grassed. There is an existing residential dwelling with several ancillary structures (i.e. sheds, etc). The proposed development includes a multi-unit development comprising a mixture of 2, 3 and 4 bedroom unit dwellings serviced by an internal road linking to Logan Reserve Road. A total of 31 individual unit dwellings are proposed. The existing channel through the site will be converted to a piped stormwater drainage system, which also links to the existing drainage on Logan Reserve Road. A plan of the proposed development is included in Appendix A.

1.4 Planning Scheme and Overlays

Development of the site will be assessed under the provisions of the Logan City Planning Scheme 2015 - Version 1.1 (LCPS 2015) which came into effect on the 15th May 2015. Planning information for the site has been accessed via Council's online mapping which is illustrated in Figure 1-2.

The site is subjected to existing flood overlay mapping under the Council scheme. The existing mapping is understood to relate to regional Logan River flooding and represents the dominant flood constraint at the site. A flood level certificate for the site has also been obtained from Logan City Council and is included in Figure 1-3. Council's Defined Flood Level (DFL) at the site is 13.17m AHD.

As discussed previously, the site is also subjected to flooding from both local flooding as well as stormwater flooding from the external area located to the east of the site. Flooding at the site therefore represents a key constraint to the proposed development and accordingly will necessitate further assessment in respect to the development proposal. This report has been prepared to document the flood related works completed at the site and is intended to provide supporting information to a development application to be lodged with Council.

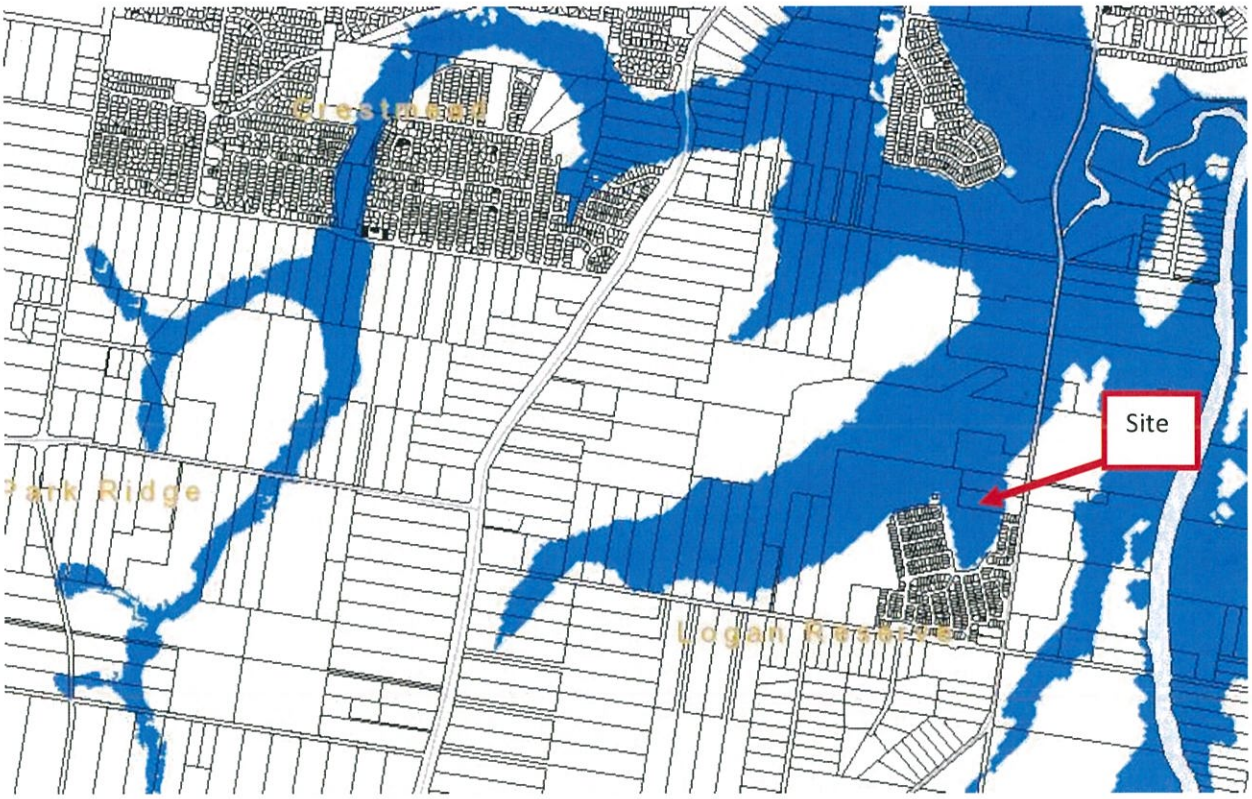

Figure 1-2 Logan City Council Site Overlay Mapping (Source – LCC Online Mapping)

18 November 2015

150 Wembley Road
Logan Central QLD 4114
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COPY

Dear Sir/Madam

APPLICATION FOR PROPERTY INFORMATION - FLOODING
LOCATED AT: 303-309 LOGAN RESERVE ROAD, LOGAN RESERVE
PROPERTY DESCRIPTION: LOT 2 RP 165534

Thank you for your enquiry requesting information on the above property. Investigation shows that the property is identified as being at risk of flooding in a 1% AEP (Annual Exceedance Probability) flood event.

Table 1: Defined Flood Level for Property

Defined Flood Event	Flood level (m) (AHD)
1% AEP	13.17

The defined flood level in Table 1 has been compiled from the best available information presently available to Council and is in accordance with the Logan Planning Scheme 2015, version 1.1, Part 8 Overlays – 8.2.5 Flood hazard overlay code, which commenced on 18 May 2015.

Council is required by State legislation to provide flood information based on a 1% AEP flood event. This event has a one percent (1 in 100) chance of being equalled or exceeded in any given year. The 1% AEP event is also commonly described as a '100 year Average Recurrence Interval' (100 year ARI) event. This is generally the standard used in the assessment of development applications and emergency management throughout South-East Queensland.

Please be aware, the flood levels and maps do not necessarily indicate flooding of properties in past events.

Changes to the topography and condition of the local creeks and waterways may alter the effects of flooding. In addition, further technical studies may be carried out in the future which may affect the advice provided in this letter. Consequently, there is no warranty given to the accuracy of this information.

Furthermore, you are advised that a development application under the **"Sustainable Planning Act 2009"** for development within the flooding area must also provide details in accordance with the provision of Council's local planning instruments and local laws. A copy of Council's policy, local planning instruments and local laws relevant to the advice are available from Council's Administration Centre or visit www.logan.qld.gov.au.

NOTE: Flood searches are valid for a period of six (6) months from date of issue.

If you have any further enquiries on this matter or require clarification, please do not hesitate to contact Council's Flood Management Officer, Ms Nardine Bird, on (07) 3412 5282.

Yours faithfully

Khairul Alam
River & Catchment Engineering Program Leader
(on behalf of Chris Rose, Chief Executive Officer)

Figure 1-3 Flood Level Certificate (Source – Logan City Council)

2. CATCHMENT HYDROLOGY

2.1 Overview

Hydrology for the regional flooding relating to Logan River flooding was informed using Council's modelling which was sourced and licensed through Council for this study. The regional model included the lower Logan River catchment area and represented a trimmed down model prepared by Council using the larger Logan and Albert River floodplain model. The trimmed model included inflows associated with the regional catchment within the specific area of interest and was undertaken using XP-RAFTS software. For the subject site, Council's regional model only included one lumped sub-catchment within the XP-RAFTS model to represent the southern branch of the Schmidts Creek catchment. In the context of the specific local catchment hydrology for the site, the regional model was considered overly coarse to otherwise inform design flows at the subject site and the flows associated with the local tributary of Schmidts Creek.

Owing to the presence of the various flood characteristics at the site represented by regional, local and stormwater drainage sources, and the coarse nature of Council's existing hydrology model, a detailed hydrological model was prepared as part of this assessment and to otherwise inform design flow estimates at the subject site. A single hydrological model has been prepared to include both the local tributary associated with the Schmidt's Creek catchment (n.b. located to the west of the site) and the stormwater drainage catchment associated with the subject development and external catchment to Logan Reserve Road (n.b. located to the east of the proposed development). Further details on the development of the local hydrological model is described in the following sections of this report.

2.2 Regional XP-RAFTS Model

As noted above, Council's regional hydrological model of the greater Logan and Albert River system was undertaken using the XP-RAFTS software. The model utilised non-spilt pervious and impervious sub-catchments and has approximately 96 sub-catchments in the model extents provides to Water Technology as part of this study.

In the vicinity of the subject site, Council's model utilises one sub-catchment (i.e. named LR013). This one sub-catchment was used to represent the flows from the local catchment and included in the regional floodplain model for the Logan and Albert River systems. There is a significant difference in catchment timings of peak flows at the site between the regional versus local catchment models. Specifically, the timing of the regional flooding peak downstream of the site (i.e. location JLR013) to the peak of the local catchment is over two days apart. As such, separate assessments are required for local flooding compared to the regional flooding at the site which has been considered and assessed as part of this study.

2.3 Local Hydrological Model

The local hydrologic model was developed by Water Technology for the purposes of this study and was subject to calibration and verification against a number of methods. The model extends to include the full extent of the southern branch of the Schmidts Creek catchment to the existing culverts under Logan Reserve Road at the confluence point of the southern and northern branches. The model also extends to include the associated stormwater catchment and proposed development located to the east of Logan Reserve Road. The local model was prepared using WBNM software and includes some 14 sub-catchments. The extent of the model and associated sub-catchment breakdown is presented in Figure 2-1.

The WBNM software is an event based hydrologic model which calculates flood hydrographs from storm rainfall hyetographs. It is a commercially available software package for works of this nature and represents an industry standard hydrological model that is capable of modelling natural, part urban and fully urban catchments. The WBNM model uses routing parameters, area, lag parameters, urbanisation and rainfall to determine hydrographs. Further details pertaining to the WBNM model setup are presented in the following sections of this report.

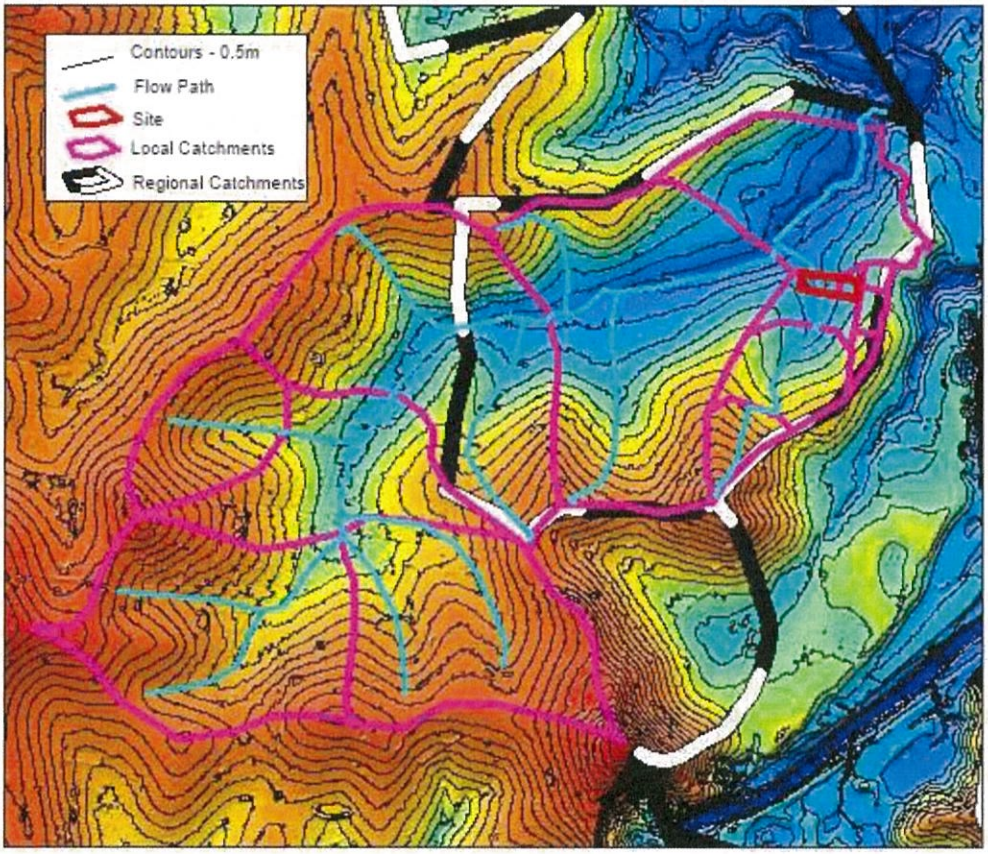

Figure 2-1 Catchment Layouts for the Regional, Local and Eastern Stormwater Catchments

2.3.1 Topographical Data

The topographic data used for the WBNM model has been sourced from the Queensland Department of Natural Resources and Mines (DNRM). This data is understood to have been collected in circa 2008. The topographical data includes LiDAR data based on a 5m grid size and has been sourced to cover the full extent of the Schmidt Creek catchment including the subject site as well as the eastern stormwater catchment. The LiDAR data was used to prepare a Digital Elevation Model (DEM), from which 1m contours were generated and used to delineate the catchment and to sub-divide the catchment into a number of sub-catchments for representation in the WBNM hydrological model.

The subject site is located on a smaller tributary of the southern branch of the Schmidts Creek catchment, which itself discharges to Schmidts Creek and ultimately into the Logan River. The WBNM model developed for the purposes of this study has included all localised catchments and tributary systems, along with the immediate stormwater catchment area to the east of the development. The hydrological modelling prepared, including sub-catchment and tributary representations are sufficient

to assess the local flows reporting to the site and to inform the hydraulic analysis. Figure 2-1 previously illustrates the WBNM local model sub-catchments and extents and also includes the XP-RAFTS sub-catchment sourced from Council's regional model. The following summarises the catchment characteristics at the site: -

- The total catchment area to the catchment outlet to Logan Reserve Road is approximately 627 hectares.
- The WBNM model includes some 14 separate sub-catchments.
- WBNM model parameters have been based on physical conditions informed from the catchment characteristics as well as published guidance on WBNM model parameters. This includes catchment area, and routing and lag parameters, etc.
- Catchment landuse as described in Section 2.3.2 below.

2.3.2 Catchment Land Use and Model Scenarios

A number of different model scenarios were prepared for the local catchment WBNM hydrology model to otherwise inform the flood assessment works completed as part of this study. The model scenarios included consideration of the following catchment conditions: -

- Existing Case WBNM Model – This includes all external catchment areas to the site being represented in the current (existing) conditions. This scenario reflects what is currently present on the ground. The WBNM modelling completed under this scenario has additionally included an assessment of pre and post development of the subject site itself; and
- Ultimate Case WBNM Model – This includes all external catchment areas to the site being developed in an ultimate condition in accordance with Council's strategic plan. This scenario is reflective of the long term catchment conditions and development occurring in accordance with the strategic plan and excludes any detention facilities. Accordingly, this scenario represents a worst case condition for catchment flows. The WBNM modelling completed under this scenario has additionally included an assessment of pre and post development of the subject site itself.

2.3.3 Catchment Land Use

The existing catchment landuse conditions have been informed using the current aerial imagery of the site (i.e. Google Earth). The current catchment conditions comprise primarily rural residential development. However, the external catchment immediately to the south of the site does include higher density residential development. For the purposes of this assessment and for conservatism, a constant fraction imperviousness of 0.1 has been applied for all sub-catchment areas for the existing case WBNM model.

For the ultimate case WBNM model, land use was determined in accordance with Council's strategic land use plan outlined in the Logan City Planning Scheme extracted from Council's interactive mapping system (refer Figure 2-2). We understand that this represents the latest and current strategic plan for the land use zones represented throughout the catchment. Each of the sub-catchments in the WBNM model was determined based on the planning scheme zone classifications, with the overall percentage imperviousness for each sub-catchment prepared based on an area averaged basis. Fraction imperviousness's adopted for each of the respective land use zone classifications are summarised in Table 2-1 and have been determined having regard to the guidance provided in the planning scheme as well as the recommendations outlined in the Queensland Urban Drainage Manual (QUDM) (NRW, 2007).

Table 2-1 Adopted Land Use Categories

Land Use	Fraction Impervious
Low Density Residential	0.6
Medium Density Residential	0.7
Local Centre	0.9
Road	0.9
Community (Schools)	0.4
Emerging Community	0.6
Sports and Recreation	0

For the ultimate case WBNM model, the overall average fraction imperviousness of the Schmidts Creek local catchment above Logan Reserve Road was determined to be 65% based on the above land use zones.

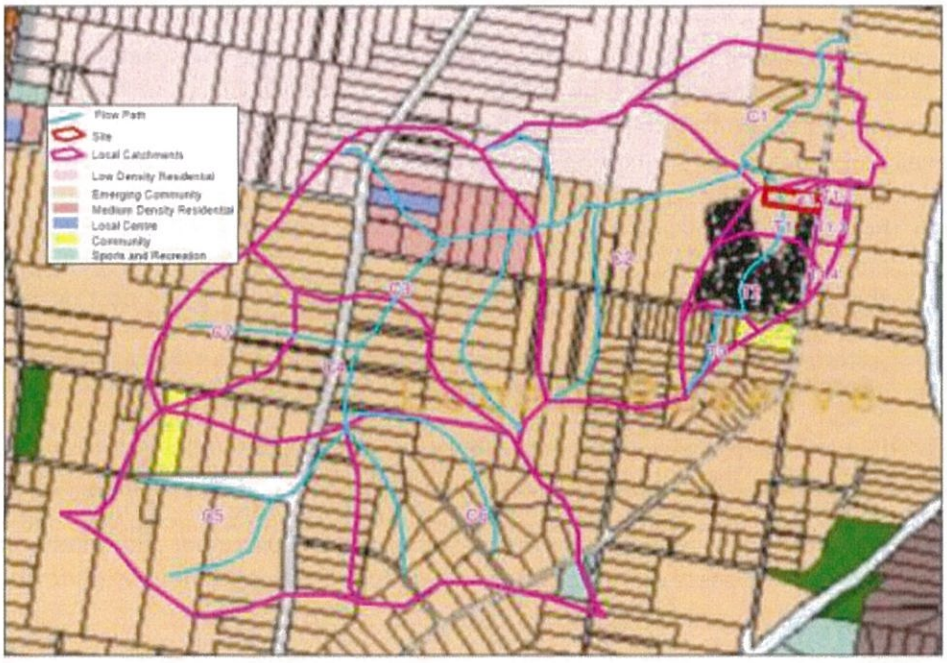

Figure 2-2 Land use Zone for the Catchment (Source - Logan City Planning Scheme 2015)

2.3.4 Design Rainfall IFD

Design rainfall within the WBNM model have been based on an Intensity-Frequency-Duration (IFD) curve taken at the approximate centroid of the southern branch of the Schmidts Creek catchment. The design rainfall IFD parameter sets have been based on the Bureau of Meteorology (BoM) IFD generation tool using the AR&R 1987 intensities and temporal patterns. Table 2-2 summarises the design rainfall IFD parameters used for the WBNM model.

Table 2-2 Rainfall IFD Parameters

Parameter	Value
IFD Location	Logan Reserve
2 Year 1 Hour Intensity	47.2
2 Year 12 Hour Intensity	8.7
2 Year 72 Hour Intensity	2.8
50 Year 1 Hour Intensity	82.9
50 Year 12 Hour Intensity	16.9
50 Year 72 Hour Intensity	5.5
Skew	0.12
F2	4.4
F5	17.2
Latitude	-27.73
Longitude	153.10

2.3.5 WBNM Model Parameters

An initial and continuing rainfall loss model was adopted in the WBNM model. The rainfall losses are within the recommended design rainfall losses outlined in Australian Rainfall and Runoff in IEAust (1998) and vary with the Annual Exceedance Probability (AEP). The rainfall loss parameters applied to the WBNM model are summarised in Table 2-3.

Table 2-3 Rainfall Losses for Different Annual Exceedance Probabilities

Annual Exceedance Probability	Pervious Initial Loss (mm/hr)	Pervious Continuing Loss (mm/hr)	Impervious Initial Loss (mm/hr)
39% AEP – 19% AEP	22	2.5	0.5
10% AEP – 5% AEP	17	2.5	0.5
2% AEP – 1% AEP	12	2.5	0.5

Different lag parameters have been applied in the WBNM model for different parts of the catchment due to the change in catchment characteristics. All lag parameters and stream lag factors applied in the WBNM model are in accordance with guideline values including those recommenced by Ball et al (2011). Moreover, the southern branch catchment of Schmidts Creek is largely undeveloped in its current condition and was therefore assumed to remain largely unaltered from the present condition and in accordance with Logan City Councils Planning Scheme (2015). The waterways will largely be maintained in a natural condition and the stream lag factors applied in the model are conservative compared to recommendations for natural channels.

Table 2-4 WBNM Lag Parameters

Catchments	Pervious Lag Factor	Impervious Lag Factor	Stream Lag Factor
C7 to C1	1.4	0.1	0.6
T3 to T1	1.5	0.1	0.65
T1.4 to T1.1	1.75	0.1	0.9

The WBNM parameters and subsequently design flow estimates were also subject to model calibration and validation processes having regard to a number of catchment discharge estimation techniques. Model calibration and validation is discussed and detailed separately below.

2.3.6 Discharge Estimation and Hydrological Methods

Introduction

Various hydrological methods are available for estimation of catchment discharges. The various methods have been assessed and investigated as part of this study to confirm the magnitude of the 1% AEP design flow estimate for the purposes of this analysis. Of specific interest is the 1% AEP flow for the southern branch of the Schmidt Creek catchment being the design flow of specific interest in respect to the proposed development. The various methods considered as well as the results are discussed separately below.

Rational Method

The Rational Method is currently the primary simplified hydrologic estimation technique for Queensland. It is recommended that the application of the Rational Method be limited to rural catchments with a catchment area less than 25 km^2 and for urban catchments less than 5 km^2 in area (NRW, 2007). The catchment area to Logan Reserve Road culverts and the subject site (area of 6.3 km^2) is larger than the recommended limit. However, the rational method does provide one such discharge estimation method that is available in this respect. Rational methods have also been undertaken on smaller areas of the catchment which lie within the recommended limits and as such is therefore an applicable flow estimation method in this instance.

The time of concentration for the catchment has been assessed using a combination of an overland flow time component as well as channel flow along the main catchment tributary. The channel flow component was based on a Stream Velocity Method using an averaged channel velocity based on a 1D HEC-RAS model, as well as averaged velocities obtained from the 2D TUFLOW model prepared for this study. As such, channel velocities were determined based on the physical characteristics of the waterway and are therefore representative of actual flow velocity and travel times at the site.

The estimate of a coefficient of discharge (C) is required for the Rational Method to adequately represent factors influencing peak catchment discharge such as infiltration and other losses. The C_{10} values as outlined in Table 4.05.3 (a) and 4.05.3 (b) of QUDM were adopted for use in this assessment based on the associated fraction impervious values as determined from Council's strategic plan. A fraction impervious C_{10} value of 0.81 was adopted for the catchment to the Logan Reserve Road Culverts.

Table 2-5 summarises the Rational Method parameters. The 1% AEP design flow was estimated to be 147.3 m^3/s at Logan Reserve Road and 18.3 m^3/s for the southern tributary in which the site is located.

Table 2-5 1% AEP Rational Method Parameters and Peak Discharges (Ultimate Catchment Conditions)

Parameter	Overall Catchment	Southern Branch Tributary	Southern Branch Middle	Small Eastern Catchment
Sub-Catchment Name	C1	T1	C3	T1.1
Area (ha)	627.2	45.5	401.0	7.2
C_{10}	0.81	0.81	0.81	0.80
Overland Flow Time (mins)	57.9	10.11	47.8	5.0
Flowpath Length (m)	4867	1084	2884	452
Av. Channel Velocity (m/s)	1.4	1.5	1.5	1.5
Time of Concentration (mins)	71.4	27.2	47.8	18.6
Rainfall Intensity (1% AEP event)	87.4	148.5	110.1	177.9
1% AEP Peak Discharge (m^3/s)	147.3	18.3	118.8	3.4

The Australian Regional Flood Frequency Method (ARFF)

The Australian Regional Flood Frequency Model (ARFF) (IEAust, 2012) has been considered as part of this study. The ARFF is recommended for use on rural catchments between 20 and 1000 km^2 (IEAust, 2012). For comparison, the Schmidt Creek southern branch catchment area is 6.3km^2. While the subject catchment does not fit within the area recommendations of the ARFF model, the method is however applicable for overall discharge estimation for comparison purposes. The ARFF was used to check the flood magnitude estimates for the southern branch catchment outlet. The ARFF estimate for the 1% AEP AEP event was 177 m^3/s, with 5% and 95% confidence limits of 77m^3/s and 401m^3/s respectively.

Local Flood Frequency Analysis

Where adequate historical data is available, an at-site flood frequency analysis is generally considered the best available approach to estimate design flood magnitudes. Where adequate historical data is unavailable (which is generally the usual situation), it is necessary to use either catchment simulation techniques (sometimes referred to as rainfall runoff based techniques such as a WBNM model) or regional transformation techniques (sometimes referred to as Regional Flood Methods) in order to generate information about the flood characteristics of the catchment. The advantages and disadvantages of the FFA approach are best described by Kuczera and Franks (2005) as follows: -

"Flood peaks are the product of a complex joint probability process involving the interaction of many random variables associated with the rainfall event, antecedent conditions and rainfall-runoff transformation. Peak flood records represent the integrated response of the storm event with the catchment. They provide a direct measure of flood exceedance probabilities. As a result flood frequency analysis is less susceptible to bias, possibly large, that can affect alternative methods based on design rainfall".

There is no stream gauging information available on Schmidts Creek or any associated tributary systems. There were two existing stream gauging stations to the site which had similar characteristics to the site and were located at Oxley Creek at New Beith (DNRM gauge ID 143033A) and Ithaca Creek at Jason Street (DRNM gauge ID 143028A). Both gauges are located within the Brisbane Basin and are approximately 15km to the west and 33km to the north of the subject site respectively. The only other available stream gauges to the site were associated with either regulated waterways or significantly larger catchment systems, both of which being unlikely to provide representative catchment gaugings on which to compare flow estimates at the site. A summary of the gauges details are summarised in

Table 2-6.

Table 2-6 Gauge Details for FFA and Catchment Transposition

Gauge Number and Description	Catchment Area (km^2)	Record Length
143033A – Oxley Creek at New Beith	60	October 1976 to Current (approximately 39 year of record)
143028A – Ithaca Creek at Jason Street	10	September 1972 to Current (approximately 43 years of record)

For the purposes of this study, a check on the design flow estimates has been made using a Flood Frequency Analysis (FFA) of the Oxley Creek and Ithaca Creek stream gauge history and using catchment transposition techniques. Transposing ARI discharge estimates from gauged to ungauged locations/catchments needs to account for the following processes: -

- Spatial variation in catchment characteristics and climate;
- Variation in catchment areas;
- Spatial variation of rainfall.

That is, assuming that catchment characteristics and climate are similar: -

- Larger catchments will produce larger discharges (for a given ARI) than smaller catchments, due to the larger catchment area;
- There will be greater spatial variation in rainfall across larger catchments - the so-called areal reduction factor. That is, for a small catchment, a given rainfall event is likely to fall over the entire catchment area with the percentage of the catchment receiving rainfall decreasing with increasing catchment area. This tends to introduce non-linearity in the catchment area – discharge relationship.

There is very little available methodology for transposing discharges between catchments in Queensland. The only applicable method is provided in Grayson et al. (1996): -

$$\frac{Q_C}{Q_G} = \left(\frac{A_C}{A_G}\right)^{0.7}$$

Where:

Q = Discharge (m3/s)
A = Area (hectares)
C = ungauged catchment
G = gauged catchment

The following transposition methodology was undertaken for this study: -

- A FFA was prepared at the Ithaca Creek and Oxley Creek gauges. The FFA has utilised the FLIKE FFA procedures as outlined in the current ARR Revision project.
- The results of the FFA has been transposed to be applicable for the southern branch of Schmidts Creek at the Logan Reserve Road culverts based on the Grayson et al (1996) methodology outlined above.

The 1% AEP design flow estimate for the Schmidts Creek catchment at the Logan Reserve Road culverts using the transposition method outlined by Grayson et al (1996) was 85.7m^3/s for Oxley Creek and 98.2m^3/s for Ithaca Creek.

Regional Equations

Palmen and Weeks (2009) developed regression equations relating discharge to catchment area based upon rural catchments with areas of less than 1,000 km^2. The study was based upon 289 Queensland catchments. Equations were provided for the 2, 5, 10, 20, 50 and 100 year ARI discharges. As an example, the equation for the estimate of the 100 year ARI is outlined below: -

$$Q_{100} = 10^{[0.847+(0.644 \cdot \log_{10}(Area))+(0.899 \cdot \log_{10}(i72h50y))]}$$

Where: -
Q100 = 100 year ARI discharge (m^3/s);
Area = catchment area (km^2); and
i72h50y = the design rainfall intensity for the 72 hour, 50 year ARI (mm/h) storm.

The application of this equation to the Schmidt Creek catchment is applicable in this instance given the nature of the catchment and overall catchment area of 6.3 km^2 to the junction with Logan Reserve Road. As such, estimates of the 1% AEP discharge at specific locations within the Schmidt Creek southern branch catchment were found to be 107.7m^3/s.

2.3.7 Summary and Discussion

A summary of the 1% AEP design flow estimates at the outlet of the southern branch of the Schmidt Creek catchment using the various hydrologic methods outlined previously are summarised in Table 2-7.

Table 2-7 1% AEP Discharge Estimate Summary (Ultimate Catchment Development)

Method	Discharge (m^3/s)
ARRF	177
Rational Method	147
FFA Transposition - Grayson et al. (1996) Transposition – Ithaca Creek	98
FFA Transposition - Grayson et al. (1996) Transposition – Oxley Creek	86
Palmen and Weeks Equation	108
Design Rainfall - WBNM - 0IL, 0CL	150
Design Rainfall - WBNM - 12IL, 2.5CL	141

It is expected that the flow estimates derived using the FFA estimates and transposed to the catchment will likely represent a lower bound estimate given: -

- The circa 40 year period of available stream flow record at the sites for the FFA. A greater degree of certainty in the FFA estimates can only be achieved with a longer period of record and FFA estimates can be dramatically affected by available periods of record;
- Likely substantial variations and differences in rainfall intensities and spatial variation. Note that Oxley Creek and Ithaca Creek are located closer to mountain ranges and Oxley Creek is located further inland; and
- Different levels of catchment development.

The Rational Method is currently the primary simplified hydrologic estimation technique for Queensland. It is recommended that the application of the Rational Method be limited to rural catchments with a catchment area less than 25 km^2 and for urban catchments less than 5 km^2 in area (QUDM, 2008). The Schmidt Creek catchment (6.27km^2) is slightly outside this limit but can still be considered a reasonable method for calibration (and especially where the upper reaches of the catchment fit within the area guidelines). The rational method was found to compare favourably to the design flow estimates using the WBNM model.

The ARFF estimate is understood to be derived and based on FFA results that considers discharges up to approximately 2010. With the sparsity of locally based stream gauges generally in the area, it is not clear what the ARFF estimate has been based on in this example. However, again it can be considered to be an appropriate method for flow comparison. The ARRF estimate was found to be higher than that prepared using all other methods and could be considered the upper band to the estimate due to the number of gauges located in the Logan River catchment. As the Logan River is much greater in area compared to the local catchment, a greater spatial variation is expected in the ARFF estimate. None the less, the ARFF estimate was found to be within a general range compared to other methods.

The Palmen and Weeks equation is also based on rural catchments and could be considered a lower bound estimate when considering catchment urbanisation.

The design rainfall technique was found to provide reasonable estimates for the 1% AEP event when compared to the rational method and using rainfall losses parameters that were within recommended guidance as outlined Australian Rainfall and Runoff in IEAust (1998). The design rainfall technique is considered to be appropriate in this instance.

Considering all of the hydrological methods outlined and based on the range of results obtained, the design flood discharge estimates adopted for this study have considered the design rainfall techniques using the WBNM model. The results from the WBNM model were also found to be similar to other methods considered as part of this study including the Rational Method estimates.

2.4 WBNM Design Flow Analysis

2.4.1 Existing Case Design Flows

As mentioned previously, an assessment of peak flows has been prepared using the WBNM model based on the existing (current) catchment conditions both with and without the proposed urbanisation of the subject site. Peak design flow estimates for a range of design events were assessed using the WBNM model and a 60 minute storm event was found to be critical at the subject site. A summary of the peak flows are presented in Table 2-8 and the flow reporting locations are illustrated in Figure 2-2. Peak flow estimates for the existing case scenario have been adopted for the hydraulic model which is outlined separately in Section 3 of this report.

Table 2-8 WBNM Peak Flow Summary (Existing Landuse Scenario)

Annual Exceedance Probability	Ultimate Land Use Case	WBNM Catchment			
		C1	T1	T1.12	T2
18% AEP (1 in 5yr)	Existing Case	34.0	5.0	1.0	3.1
	Developed Case	34.0	5.0	1.0	3.1
	Change	0	0	0	0
10% AEP (1 in 10yr)	Existing Case	47.7	6.9	1.4	4.4
	Developed Case	47.7	6.9	1.4	4.4
	Change	0	0	0	0
2 % AEP (1 in 50yr)	Existing Case	81.8	11.1	2.2	7.0
	Developed Case	81.8	11.1	2.2	7.0
	Change	0	0	0	0
1 % AEP (1 in 100yr)	Existing Case	95.0	12.8	2.5	8.1
	Developed Case	95.0	12.8	2.5	8.1
	Change	0	0	0	0

2.4.2 Ultimate Case Design Flows

The WBNM model developed for this study has been analysed using the ultimate land use scenarios and based on a 60 minute storm duration which was assessed to be the critical duration at the site. Peak design flow estimates for a range of design events and WBNM catchment reporting locations are summarised in Table 2-9 and the flow reporting locations are illustrated in Figure 2-2. Peak flow estimates for the ultimate case scenario have been adopted for the hydraulic model which is outlined separately in Section 3 of this report.

Table 2-9 WBNM Peak Flow Summary (Ultimate Landuse Scenario)

Annual Exceedance Probability	Ultimate Land Use Case	WBNM Catchment			
		C1	T1	T1.12	T2
18% AEP (1 in 5yr)	Existing Case	69.6	9.5	1.7	7.1
	Developed Case	69.6	9.5	1.7	7.1
	Change	0	0	0	0
10% AEP (1 in 10yr)	Existing Case	84.1	11.4	2.0	8.4
	Developed Case	84.1	11.4	2.1	8.4
	Change	0	0	0.1	0
2 % AEP (1 in 50yr)	Existing Case	123.9	16.1	2.8	11.5
	Developed Case	124.0	16.0	2.9	11.5
	Change	0.1	-0.1	0.1	0
1 % AEP (1 in 100yr)	Existing Case	141.3	18.1	3.1	12.9
	Developed Case	141.3	18.1	3.2	12.9
	Change	0	0	0.1	0

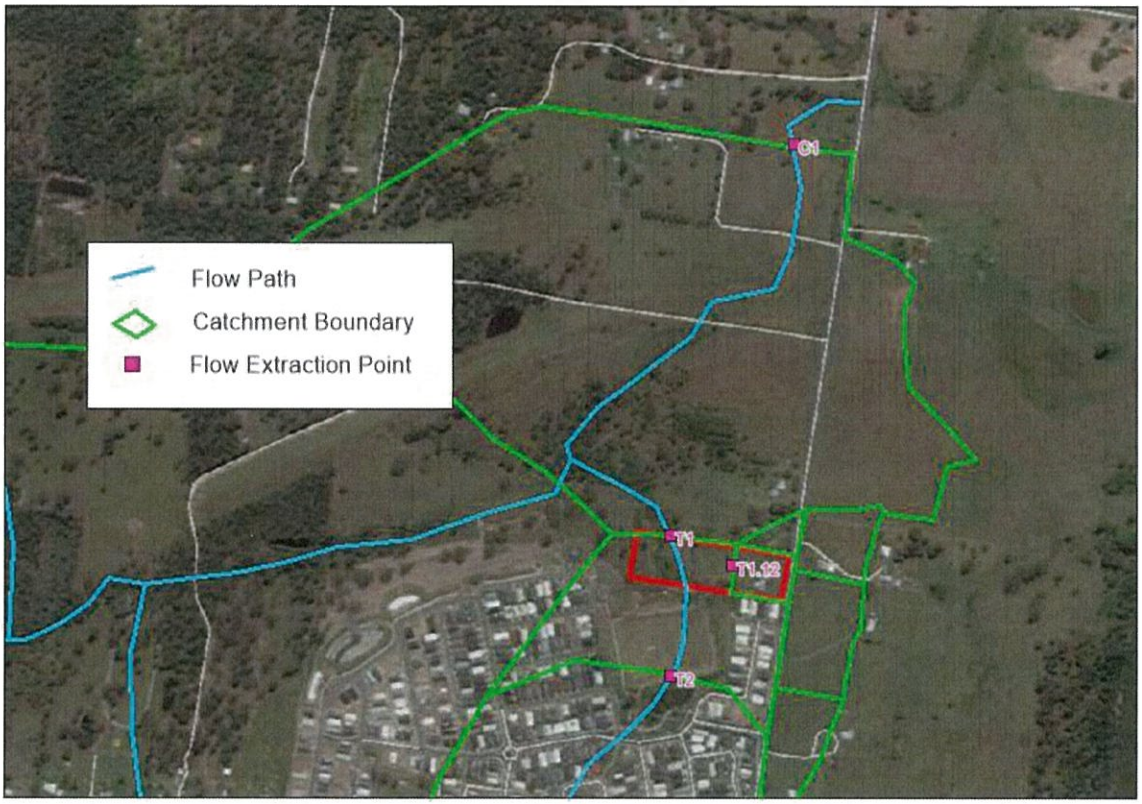

Figure 2-3 WBNM Flow Reporting Locations

2.4.3 Non-Worsening in Flows

In order to demonstrate non-worsening in flows, hydrographs for the peak 1% AEP design events have been extracted at the downstream property boundary using the WBNM model for both the existing and ultimate scenarios which also include pre and post development of the site. The hydrographs include the following: -

- Existing case hydrographs – Refer Figure 2-4; and
- Ultimate case hydrographs – Refer Figure 2-5.

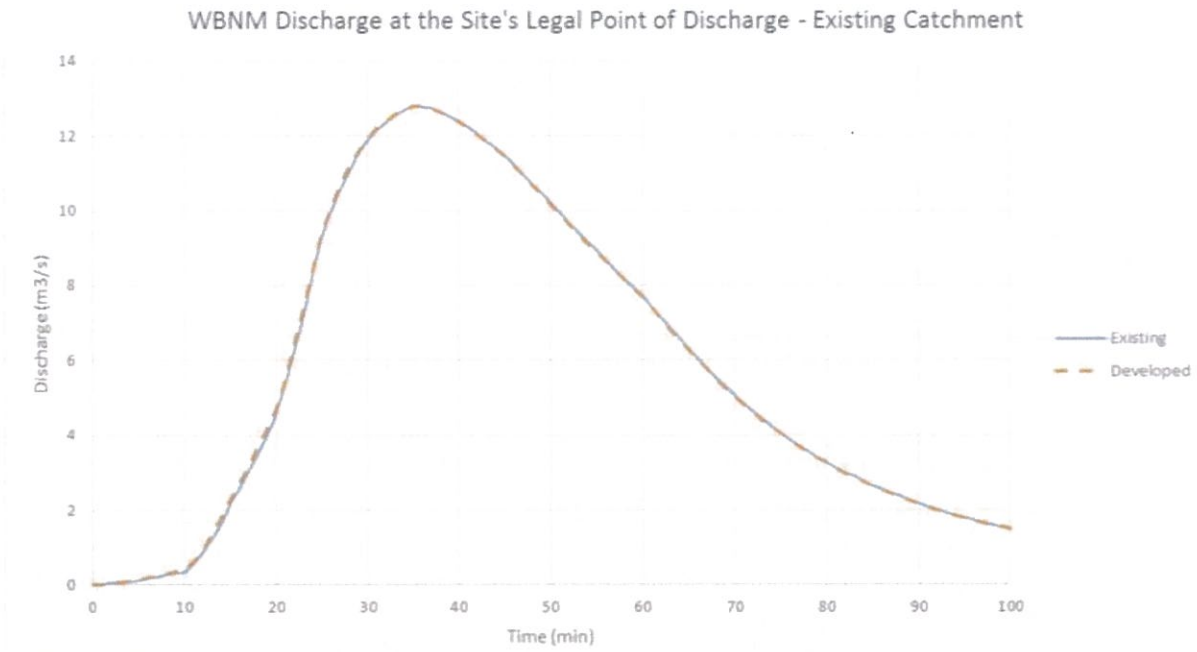

Figure 2-4 Existing Case 1% AEP Hydrograph

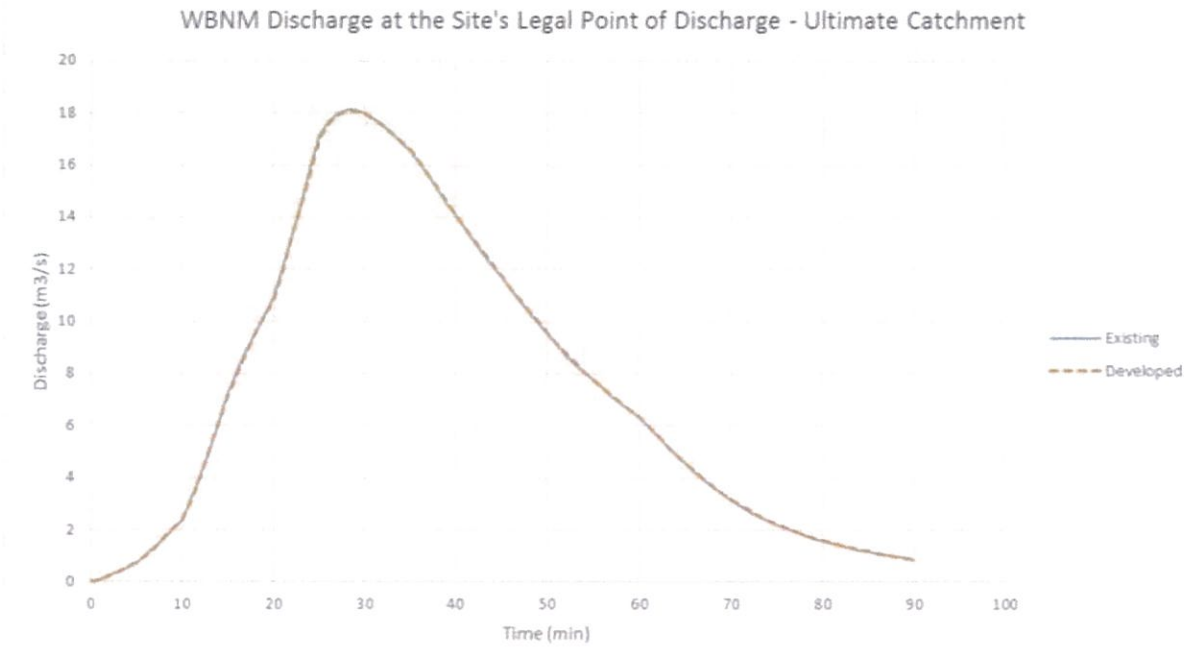

Figure 2-5 Ultimate Case 1% AEP Hydrograph

The following comments are made in respect to the hydrograph comparisons presented above: -

- No increase in peak discharge was found to occur to the downstream property on Lot 1 RP160429 in either the existing or ultimate catchment landuse conditions. This result occurred despite development of the subject site and no on-site detention being included in the proposed development; and
- This result occurs owing to both the timing of the hydrographs at the site as well as peak flows being dominated by the proportionally larger external catchment areas to the site which includes both the stormwater catchment located to the east of the site as well as the larger external catchment to the south of the site. The peak discharge from the site occurs quicker and is much lower in magnitude in comparison to the peak flows from the external catchments which ultimately dominate the overall peak flow at the downstream site boundary.

On the basis of the results of the WBNM model and hydrograph comparisons, there is no worsening in flows to the downstream property. Accordingly, no on-site detention is being proposed as part of the development. Non-worsening provisions at the site have also been assessed using the hydraulic model and this is discussed in further detail in Section 3 of this report.

3. HYDRAULICS

3.1 Regional Logan River Hydraulic Model

3.1.1 Overview

Council's regional flood model for the Logan and Albert River floodplain has been sourced from Council for the purposes of this assessment. The Council model includes a TUFLOW 1D-2D linked hydraulic model which extends from Logan Reserve to near Carbrook some 26km downstream. The model employs a 20m grid and covers approximately 106 square kilometres. The model provided by Council represents a trimmed version of the full Logan and Albert River flood model. The regional Council model was used to assess the proposed development in respect to flooding associated with a regional Logan River flood event.

3.1.2 Model Layout and Boundary Locations

The trimmed Council model is approximately 16,500m x 10,500m in area, with a cell size of 20m. There are two external inflow boundaries for Scrubby Creek and the Logan River respectively. The model also includes some 14 internal boundaries representing local inflows. The model layout is illustrated in Figure 3-1.

3.1.3 Regional Model Scenarios

Council's regional model was analysed for the following scenarios: -

- Existing case. This represents the pre-developed condition of the subject site (current site arrangements) and represents a re-analysis of Council's existing flood model; and
- Developed case. This includes the proposed development of the site. Specifically, proposed earthworks representing filling of the development along with compensatory earthworks to the rear of the property have been included in the model based on the developed case civil design earthworks profiles which were provided by the civil engineer.

The regional model was assessed based on the 1% AEP design flood event and using the same 24hr critical storm duration as reflected in Council's supplied model.

3.1.4 Results

The results of the regional flood assessment have been presented in terms of peak water levels and flood impacts prepared as the difference in water level between the pre and post development scenarios. The results are presented in a series of GIS maps included in Appendix B of this report. The following summarises the results of the regional flood assessment: -

1. There is no increase in flood levels in the 1% AEP regional flood event as a result of development of the site. This has occurred primarily due to a compensatory earthworks condition being maintained at the site such that development filling has been offset by compensatory earthworks to the rear of the site (refer separate discussion below);
2. The peak 1% AEP water surface level associated with a regional flood event at the site was found to be RL13.17m AHD. This level is consistent with Council's flood level certificate sourced as part of this study. An assessment of building floor level immunity is presented separately in this report; and
3. All compensatory earthworks proposed at the site are located to a level higher than the regional 10% AEP design flood event.

The outcome of the regional flood assessment demonstrates non-worsening in flood conditions as a result of the proposed development. As such, the development provides and acceptable outcome in respect to regional flooding considerations.

3.1.5 Compensatory Earthworks

The rear section of the site is subject to flooding under the regional flood event. Filling within the rear section of the site is proposed in order to provide a larger development outcome. As this filling includes areas that are subject to flooding under Council's regional flood overlay, compensatory earthworks will be required at the site.

The proposed civil earthworks at the site have been determined by Lambert & Rehbein Consulting Engineers. Earthwork quantities are summarised on the cut and fill earthworks plans and this is understood to include a net earthworks cut at the site. We also note the following in relation to the compensatory earthworks: -

- All compensatory earthworks proposed at the site are located on the subject site only;
- All compensatory earthworks are free draining in nature; and
- No earthworks are proposed to below the 10% AEP regional flood event (refer Appendix mapping in Appendix B).

The proposed earthworks at the site are therefore understood to provide an acceptable solution in this regard.

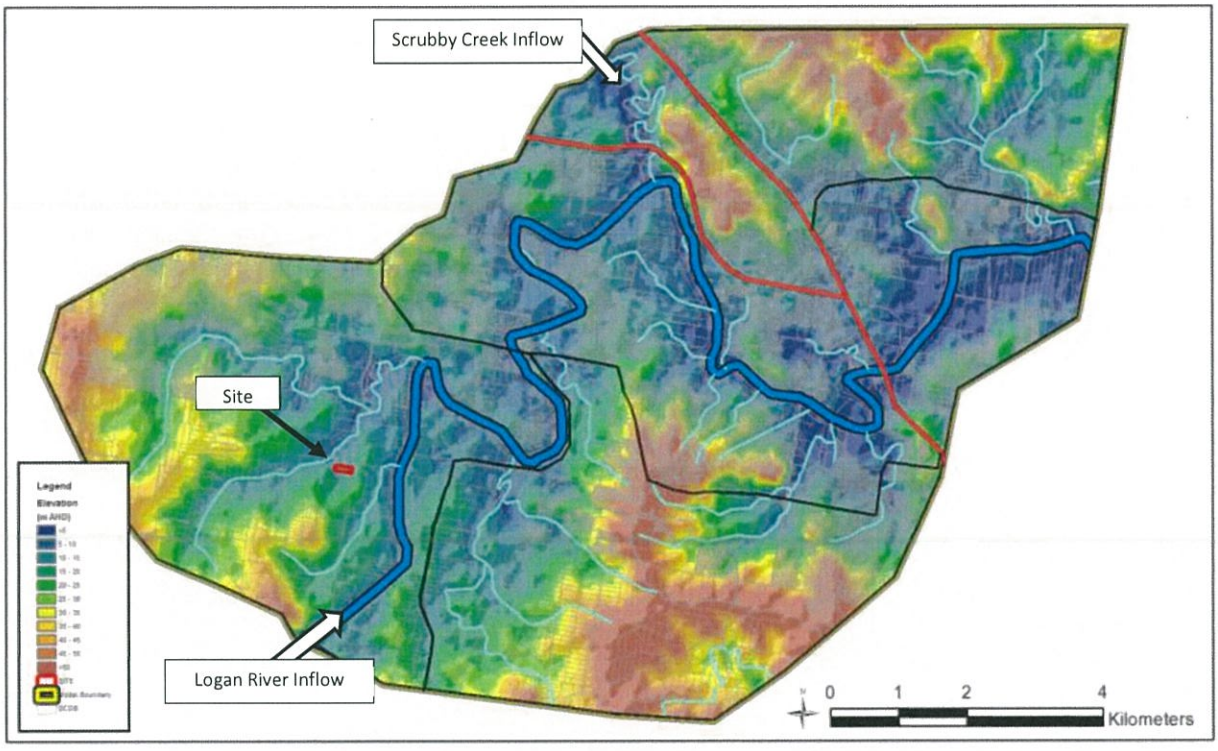

Figure 3-1 TUFLOW Model Layout of Trimmed Logan River Hydraulic Model (Source – Logan City Council, 2015)

3.2 Local Catchment Hydraulic Model

3.2.1 Overview

A 2-dimensional TUFLOW 1D-2D model of the local Schmidts Creek system down to Logan Reserve Road was developed as part of this study. The hydraulic model additionally included the stormwater catchment to the east of the development as well as the subject site itself. The 2.8km by 1.8km model employed a 5m grid resolution with local catchment inflows for a range of flood magnitudes to assess the flood characteristics associated with the proposed development.

3.2.2 Model Layout and Boundary Locations

The model is approximately 2800m x 1800m in area, with a cell size of 5m. The model layout is shown in Figure 3-2. Model boundaries included a mixture of boundary inflows as well as a series of source inflows applied throughout the model domain. In all cases, model inflows were taken from the WBNM hydrological model as described in previous sections of this report.

3.2.3 Model Topography

The model topography was created using 5m LiDAR sourced from the QLD Department of Natural Resources and Mines (DNRM). The existing model topography is illustrated in Figure 3-2. Within the area of the subject site, the LiDAR topography was replaced with detailed survey information which covered the greater site and included the frontage to Logan Reserve Road. The detailed survey provides more accurate topographical representation compared to the LiDAR and was used in preference in the TUFLOW model.

The hydraulic assessment has been undertaken based on two (2) scenarios as follows: -

1. Existing case topography. This represents current conditions and prior to any development; and
2. Developed case scenario, representing the proposed development and associated compensatory earthworks.

The assessment of the developed case scenario has utilised a modified topographical condition which is reflective of the proposed development of the site. A design TIN representing the proposed earthworks at the site was incorporated into the hydraulic model to represent the proposed development. The major changes in site earthworks which have been reflected in the developed case scenario includes: -

- Development filling associated with the proposed development itself; and
- Compensatory earthworks to the rear portion (western portion) of the site (as discussed and outlined previously).

Changes were also made to hydraulic structures and stormwater piping arrangements in the developed case and are detailed separately below.

3.2.4 Hydraulic Structures and Stormwater Drainage

The only hydraulic structures represented at the site included the stormwater cross drainage culverts under Logan Reserve Road immediately to the east of the site. The existing stormwater drainage arrangements were included in the TUFLOW model as a 1D element coupled to the 2D domain. The culverts included 2 No. 1.2m x 0.3m RCBC culverts, with the invert levels informed from the detailed survey.

For the developed case site conditions, additional stormwater drainage is proposed and this is includes: -

- An internal stormwater drainage system to the development itself. This system functions to capture frequent flows associated with the development. The internal drainage discharges to the south western corner of the site and to the proposed bio-retention basin; and
- A separate dedicated stormwater system to capture flows from the external eastern catchment upstream of Logan Reserve Road which is conveyed through the development and to the southern tributary to the rear of the site. This dedicated system comprises the following arrangements: -
    - Logan Reserve Road – replacement of the existing RCBC culverts with 2 No. 1050mm RCPs (upstream IL = 14.0m AHD and downstream IL = 13.8m AHD);
    - Internal stormwater pipe through development to include 1 No. 1200mm RCP (upstream IL = 13.8m AHD and downstream IL = 10.5m AHD); and
    - Localised earthworks in the table drain on the eastern side of Logan Reserve Road to facilitate longitudinal drainage to the new culvert.

Reference is made to the civil design drawings prepared by Lambert & Rehbein Consulting Engineers for further details on the proposed drainage arrangements. The proposed stormwater drainage arrangement as outlined above have been included in the developed case TUFLOW model as a series of 1D elements coupled to the 2D domain.

It is noted that the final arrangements for the stormwater drainage at the site, including the proposed upgrade of culverts under Logan Reserve Road will be finalised as part of the future operational works application.

3.2.5 Hydraulic Roughness

Manning's 'n' roughness coefficients were assigned to various land uses within the model. The roughness category was based on Google Maps aerial photography captured in October 2015. A map of adopted roughness values and their Manning's 'n' values are shown in Figure 3-3.

3.2.6 Tailwater

A normal depth tailwater condition has been applied in the model. This is appropriate for consideration of a local flood event which is separate to regional flooding considerations. As noted previously in this report, there is a significant difference in storm duration for local versus regional flooding and as such adopting a normal depth tailwater boundary condition for the assessment of local flooding is appropriate.

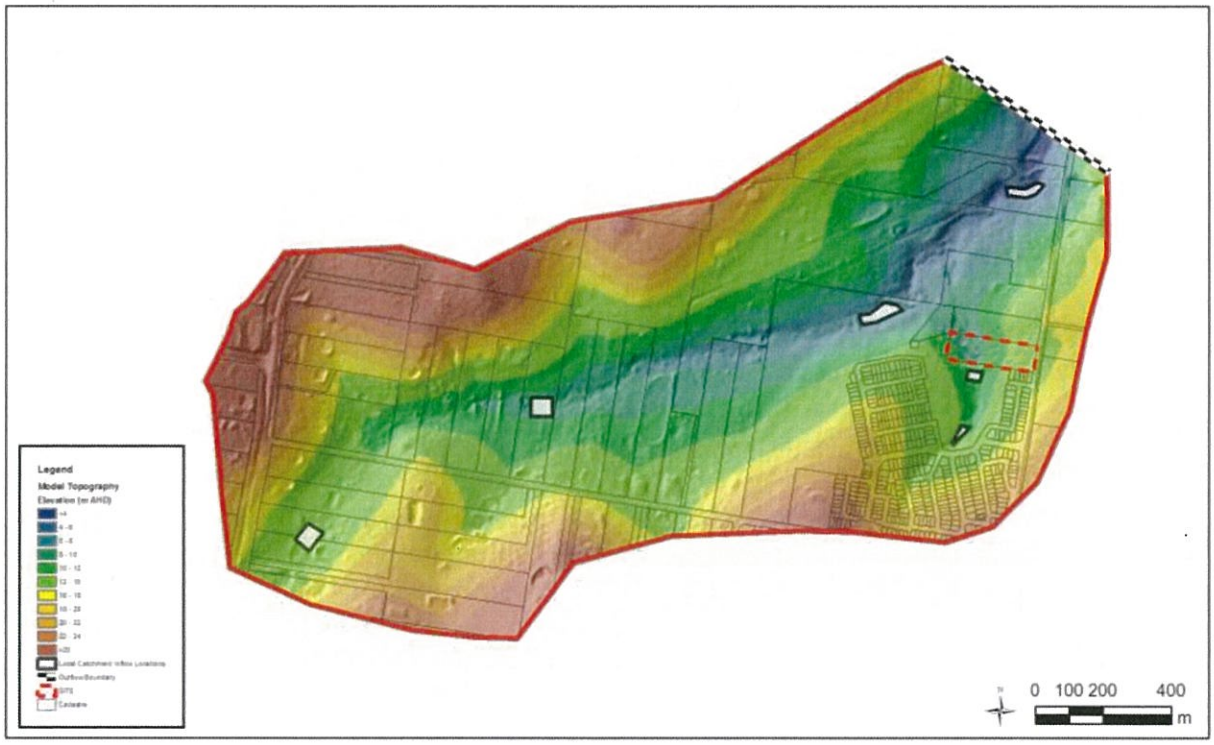

Figure 3-2 TUFLOW Model Layout of Local Hydraulic Model

Figure 3-3 TUFLOW Model Hydraulic Roughness

3.2.7 Model Scenarios and Design Events Analysed

A number of different hydraulic model scenarios were prepared for the local flood assessment. The model scenarios included consideration of the following catchment conditions: -

- Existing Case (pre and post site development) – The hydraulic model included design flows for all external catchment areas being represented of the current (existing) catchment conditions. Two (2) separate hydraulic models were prepared to represent the site in both the pre and post development conditions; and
- Ultimate Case (pre and post site development) – The hydraulic model included design flows for all external catchment areas being represented of ultimate catchment development conditions in accordance with Council's strategic plan. Again, two (2) separate hydraulic models were prepared to represent the site in both the pre and post development conditions.

The TUFLOW model has been used to assess flood characteristics in and around the site for the above model scenarios for each of the 1%, 2%, 10% and 39% AEP design events.

3.2.8 Existing Case Scenario Model Results

The results of the existing case local flood assessment (existing external catchment flows) have been presented in terms of peak water levels and depth maps for each of the 1%, 2%, 10% and 39% AEP design events. The results are presented in a series of GIS maps included in Appendix C of this report.

The following provides a brief summary of the results: -

- The 1% AEP event associated with the tributary to the south of the site was found to be outside the proposed development footprint. The proposed development does not project into the conveyance area associated with the southern tributary and by default there will be no fundamental change is flood characteristics for this tributary;
- Logan Reserve Road was found to be flood free in the 1% AEP design flood event;
- Flood levels in the eastern area of the property are dominated by flooding from the external eastern catchment (stormwater flooding) as opposed to regional flooding from the Logan River;
- In the post development case, the extent of flooding upstream from Logan Reserve Road has reduced by virtue of the upgrade cross drainage to the road; and
- The proposed development is flood free and is located to above the 1% AEP flood level.

3.2.9 Developed Case Scenario Model Results

The results of the developed case local flood assessment (ultimate external catchment flows) have been presented in terms of peak water levels and depth maps for each of the 1%, 2%, 10% and 39% AEP design events. The results are presented in a series of GIS maps included in Appendix D of this report.

The following provides a brief summary of the results: -

Pre-Developed Condition

- The 1% AEP event associated with the tributary to the south of the site was found to be outside the proposed development footprint. The proposed development does not project into the conveyance area associated with the southern tributary and by default there will be no fundamental change is flood characteristics for this tributary;
- Logan Reserve Road was found to be subject to inundation in both the 1% and 2% AEP flood events. The road was immune in the 10% AEP event;
- Importantly, the existing and since built development located immediately south of the site was also found to be subject to inundation in the 1% and 2% AEP events. This included approximately 5 property lots which experience inundation and occurs as a result of flows

breaking across Logan Reserve Road and flowing in a southerly direction through the properties. The breakout flow and inundation to these lots was not found to occur in the 10% AEP event.

Developed Condition

- The 1% AEP event associated with the tributary to the south of the site was found to be outside the proposed development footprint. The proposed development does not project into the conveyance area associated with the southern tributary and by default there will be no fundamental change is flood characteristics for this tributary;
- With the proposed upgrade to the culverts under Logan Reserve Road, the road was found to be immune in the 1% AEP event. This represents a significant improvement compared to the pre-developed case;
- Significantly, the existing and since built development located immediately south of the site was found to be no longer subject to inundation in either the 1% and 2% AEP events. The upgrade of Logan Reserve Road and dedicated stormwater system through the development has significantly aiding in preventing break-out flows flowing in a southerly direction through the properties.

3.2.10 Flood Impact Assessment

Flood impact assessments have been assessed for the proposed development under the following two (2) scenarios: -

- Existing Case (pre and post site development) – The hydraulic model included design flows for all external catchment areas being represented of the current (existing) catchment conditions; and
- Ultimate Case (pre and post site development) – The hydraulic model included design flows for all external catchment areas being represented of ultimate catchment development conditions in accordance with Council's strategic plan.

Flood impact assessments have been prepared for the proposed development as the difference between water levels in the pre versus post development conditions for each of the above scenarios. The results for the flood impact assessment are presented in a series of GIS maps included in Appendix E and F respectively for the existing flow and ultimate flow scenarios. The following provides a brief summary of the results: -

Existing Catchment Flow Scenario

- Flooding upstream of Logan Reserve Road has been significantly improved, with flood levels being reduced by in-excess of 200mm in the 1% AEP event. Logan Reserve Road is flood immune in the 1% AEP event under this scenario and as such the decrease in flooding does not impact road immunity of trafficability outcomes.
- Large areas within the site that were previously subject to inundation and now dry by virtue of the proposed site filling.
- Apart from a very localised area of higher water levels to the rear of the site (which are limited to the subject site itself), there are no adverse impacts extending to any other areas either upstream of downstream from the site in any of the design events analysed.
- There has been a marginal lowering in water levels to the downstream property in the 1% AEP and 2% AEP design flood events. Water levels have been decreased by approximately 10mm.
- The compensatory earthworks to the rear portion of the site has assisted in minimising off-site impacts.

Ultimate Catchment Flow Scenario

- Flooding upstream of Logan Reserve Road has been significantly improved, with flood levels being reduced by in-excess of 200mm in the 1% AEP event. This has resulted in Logan Reserve Road being flood immune in the 1% AEP event and is a significant improvement compared to the existing case;
- Flooding to the existing properties immediately to the south of the site is now prevented from occurring as a direct result of the proposed development and associated stormwater upgrade. These areas were previously subject to inundation and are now dry;
- Large areas within the site that were previously subject to inundation and now dry by virtue of the proposed site filling;
- Apart from a very localised area of higher water levels to the rear of the site (which are limited to the subject site itself), there are no adverse impacts extending to any other areas either upstream of downstream from the site in any of the design events analysed. While there has been a localised increase in flow to the rear section of the property by virtue of the stormwater diversion from Logan Reserve Road, this has been offset by the compensatory earthworks within the same area that still results in no adverse impact.

The results of the hydraulic analysis and flood impact assessment outlined above demonstrate that a non-worsening condition is maintained from the proposed development under either catchment flow scenario (i.e. existing landuse and ultimate landuse). This result has been obtained despite no on-site detention provisions being proposed as part of the development. Even with the exclusion of any on-site detention provisions at the site, there is no increase in water level to the downstream property as a result of the proposed development.

3.2.11 Building and Lot Flood Immunity Provisions

An assessment has been made in relation to minimum lot levels and finished floor levels for the proposed development. This assessment has been undertaken based on the ultimate catchment landuse conditions which represents the highest flows from the catchment. The ultimate catchment flows additionally exclude any provision for on-site detention within the catchment. The following summary is provided: -

1. Council's regional 1% AEP is RL13.17m AHD and represents the Defined Flood Level (DFL) at the site. In accordance with the flood overlay code: -
    a. The entire development area must be located to above the DFE; and
    b. Minimum building floor levels must be 500mm above the DFE (i.e. RL13.67m AHD).
2. The development complies with the above requirements as: -
    a. The minimum lot level at the site is RL13.7m AHD at the rear of Lot 16 and is above the DFE + 500mm;
    b. All developable areas are located to above the DFE; and
    c. The minimum finished floor level at the site is RL14.17m AHD and is above the minimum requirements stated in the flood overlay code.
3. The local stormwater catchment associated with the eastern external catchment to the development has also been considered in respect to minimum building floor level requirements. The maximum 1% AEP water surface level at the site occurs adjacent to Lot 24 associated with the internal drainage system and is RL14.35m AHD. This level is higher than the DFL and reflects the higher hydraulic grade line associated with flows from the external catchment. Note that this level is based on ultimate catchment development of the external catchment in accordance with Council's strategic plan and in the absence of on-site detention.
4. The development complies with minimum lot and finished floor levels based on consideration of local stormwater provisions as: -
    a. The minimum lot levels at the site are located to above the 1% AEP flood level based on the external stormwater catchment; and

b. The finished floor level associated with Lots 4, 5, 6 and 24 is RL14.65m AHD and provides 300mm freeboard. Floor level provisions for all other lots were found to be acceptable given there is no flooding estimated to occur internally through the development in a 1% AEP external stormwater catchment flood event (i.e. owing to the provision of the internal stormwater drainage system for the development).

3.2.12 Road Trafficability and Flood Immunity Provisions

In the existing landuse catchment flow scenario, Logan Reserve Road is afforded with flood immunity to the 15 AEP design event. This condition will not change as a result of the downstream development as the road immunity is a function of the magnitude of the external catchment flows.

In the ultimate landuse catchment flow scenario, Logan Reserve Road only has flood immunity to the 10% AEP event and is inundated by both the 1% and 2% AEP events. As a result of the proposed upgrade to the culvert under Logan Reserve Road and associated stormwater drainage system through the development, there have been significant improvements in flood immunity and road trafficability of Logan Reserve Road. Specifically, Logan Reserve Road will now maintain flood immunity to all events up to and including the 1% AEP flood event under the ultimate catchment flow scenario.

Regardless of the catchment landuse condition assessed, there will be no restrictions or limitations in respect to site access and trafficability provisions in servicing the proposed development from Logan Reserve Road.

3.3 On-site Detention Provisions

An assessment of on-site detention requirements for the proposed development is not required given that it has been demonstrated both hydrologically and hydraulically that a non-worsening condition will be maintained for discharge to the downstream property. While it is acknowledged that there is an increase in the fraction impervious from development which will result in an increase in flows to the immediate rear area of the site, this does not translate to a corresponding increase on the downstream property as: -

- Any localised increases in peak flows from the development are discharged to the large rear balance area of the site. This area will remain undeveloped and assists in mitigating any increase in flow locally from the development while also providing a sufficient area for flow dissipation associated with the stormwater system. Note also that this area is also subject to compensatory earthworks and therefore provides a beneficial outcome in respect to mitigation and offsetting any localised increases in flooding associated with the development; and
- The location of the proposed development is such that it lies in the lower catchment reaches of both the eastern stormwater catchment as well as the larger southern tributary external catchment. The magnitude of flows in the area of the subject development and the associated catchment timings dominate flows leaving the site boundary. In this context, flows from the development itself no not contribute to any increase in flooding to the downstream properties.

Given the results outlined above, the proposed development will maintain non-worsening conditions external to the site and this can be achieved without the inclusion of on-site detention as part of the development.

As a further note, there will be no change to the future development potential of the downstream properties as a result of this development. It is also acknowledged that these properties already have limited development potential owing to the existing Council flood overlay mapping affecting the lots which is associated with both regional and local flooding considerations. Development of the subject site will have no bearing on the future use of these downstream properties.

3.4 Legal Point of Discharge

All discharge from the subject property currently flows to the rear of the site and combines with an existing tributary associated with the external catchment to the south of the site before discharging to the adjacent property to the north. The flow and discharge patterns as a result of the proposed development maintain this current discharge arrangement and are not fundamentally altered as a result of the development. The overall extent of flooding to the neighbouring property has not been fundamentally altered as a result of the development. The flood impact assessment has also shown there to be no-worsening in flooding to the neighbouring property.

In respect to the external stormwater catchment to the east of the site, the development provides a formalised flowpath for discharge and this includes an internal stormwater system through the site. Formalisation of this flowpath including creation of associated drainage easements in Council's favour will provide a legal point of discharge for flows originating from both Logan Reserve Road as well as the upstream external catchment areas. This will facilitate and enhance future development potential of these external catchment areas as well as the associated private freehold lots.

For the above reasons, it is contended that the site is provided with a lawful point of discharge in accordance with the QUDM provisions of Section 3.02.

4. FLOOD HAZARD OVERLAY CODE RESPONSES

An assessment of development compliance relating to the flood hazard overlay code requirements against Section 8.2.5 of the Logan City Planning Scheme 2015 has been completed as part of this assessment. Responses to the Criteria for Assessment are outlined in Table 4-1 below.

Table 4-1 Flood Overlay Code Assessment Summary

Performance outcomes	Acceptable outcomes	Project Outcomes
For self-assessable and assessable development		
Risk to people and premises		
P01 A building floor level of a habitable room has adequate allowance for the hydraulic gradient above the main floodway.	**A01** A building has a finished habitable floor level a minimum of 500mm above the defined flood event.	Acceptable solution provided. All building floor levels are a minimum of 500mm above the regional and local DFE.
P02 Development must not increase the level of risk of injury to life or risk of damage to property or adversely affect flood evacuation procedures.	**A02** Development: (a) does not result in any of the following: (i) an increase in the number of people at risk from flooding up to and including the defined flood event; or (ii) an increase in the number of people that need evacuation up to and including the defined flood event; or (iii) an increase in the number of premises or infrastructure at risk from flooding up to and including the defined flood event; or (iv) existing flood warning times being reduced for flood events up to and including the defined flood event; or (v) an adverse impact on the ability of traffic to use evacuation routes or unreasonably increase traffic volumes on evacuation routes; or (b) is located entirely within a development envelope area approved by	Acceptable solution provided. Development is not subject to unacceptable flood risk or increases flood risk at the site. Development is proposing an improved flood outcome relating to access from Logan Reserve Road.
For assessable development		
Risk to people and premises		

P03 Development provides a development envelope area that is above the flood level during the defined flood event.	**A03** Development provides a development envelope area above the flood level during the defined flood event with a minimum size and dimension specified in Table 8.2.5.3.2–Development envelope area.	Acceptable solution provided. The development footprint is located to above the DFE.
P04 Public safety and the environment are not adversely affected by floodwater by: (a) locating a Medium impact industry or High impact industry to be able to function safely during and immediately after flood events; (b) safely storing hazardous materials.	**A04** Development: (a) for a Medium impact industry or High impact industry is above the flood level specified in column 2 of Table 8.2.5.3.3—Minimum flood levels; (b) involving the storage, sale or use of hazardous materials is located above the flood level during the defined flood event.	Not applicable – Development is not proposing industrial development or storage of hazardous materials.
P05 A car park other than a Parking station is only located below the flood level during the defined flood event where there is no increase in risk to: (a) pedestrian and vehicular safety; (b) a building or other structure. Note—Section 4.1–Guidelines for satisfying flood hazard overlay code in planning scheme policy 5–Infrastructure provides guidance to achieve this outcome.	**A05** No acceptable outcome provided.	Acceptable solution provided. All car parking is located above the DFE. Development is also proposing an improved flood outcome relating to access from Logan Reserve Road.
P06 Development for any of the uses identified in column 1 of Table 8.2.5.3.3—Minimum flood levels, are able to function effectively during and immediately after flood events. Note—Compliance with this performance outcome is to be demonstrated by a flood study report prepared in accordance with section 2.5.1 of planning scheme policy 5–Infrastructure Note—Section 4.1–Guidelines for satisfying flood hazard overlay of planning scheme policy 5–Infrastructure provides	**A06** Development for any of the uses identified in column 1 of Table 8.2.5.3.3—Minimum flood levels is located above the flood level specified in column 2 of Table 8.2.5.3.3—Minimum flood levels.	Acceptable solution provided. The development footprint is located to above the DFE.

guidance to achieve this outcome.		
Flood storage and discharge capacity		
P07 An existing floodway is protected and maintained to ensure there are no losses of conveyance capacity of waterways and storage so as not to adversely affect other premises, infrastructure and the environment. Note—Compliance with this performance outcome is to be demonstrated by a flood study report prepared in accordance with section 2.5.1 of planning scheme policy 5–Infrastructure Note—Section 4.1–Guidelines for satisfying flood hazard overlay of planning scheme policy 5–Infrastructure provides guidance to achieve this outcome.	**A07** No acceptable outcome provided.	Acceptable solution provided. Compensatory earthworks are proposed at the site to maintain flood storage and conveyance characteristics. Flood impact assessment demonstrates no adverse impact to external properties or existing infrastructure. An improved flood outcome has been provided for Logan Reserve Road.
P08 The natural conveyance of flood waters and natural overland flow paths are protected and maintained without adversely affecting adjoining premises. Note—Section 4.1–Guidelines for satisfying flood hazard overlay of planning scheme policy 5—Infrastructure provides guidance to achieve this outcome.	**A08** No acceptable outcome provided.	Acceptable solution provided. Compensatory earthworks are proposed at the site to maintain flood storage and conveyance characteristics.
P09 Development (or development in combination with other development) for all flood events up to and including the defined flood event does not do any of the following: (a) cause or have the potential to cause damage; or (b) cause ponding of flood water; or (c) adversely affect the flood discharge capacity of the floodplain; or (d) decrease the flood resilience of properties and infrastructure; or (e) cause a cumulative increase in flood levels external to the premises.	**A09** No acceptable outcome provided.	Acceptable solution provided. Compensatory earthworks are proposed at the site to maintain flood storage and conveyance characteristics. Flood impact assessment demonstrates no adverse impact to external properties or existing infrastructure. The proposed development provides a beneficial outcome to existing development located to the south of the site. An improved flood outcome has also been provided for Logan Reserve Road which will benefit access for the local area.

Note—Compliance with this performance outcome is to be demonstrated by a flood study report prepared in accordance with section 2.5.1 of planning scheme policy 5–Infrastructure Note—Section 4.1–Guidelines for satisfying flood hazard overlay of planning scheme policy 5–Infrastructure provides guidance to achieve this outcome.		
P010 Any loss of floodplain storage is compensated with compensatory storage or excavation that: (a) is of equal volume, creating a balance of cut to fill; (b) is free draining; (c) is located within the premises; (d) does not adversely affect the hydraulic conveyance capacity of the flood channel or floodplain; (e) is provided to the corresponding flood level; (f) is landscaped to provide visual amenity and erosion control; (g) is solely for the purpose of compensatory storage. Note—Compliance with this performance outcome is to be demonstrated by a flood study report prepared in accordance with section 2.5.1 of planning scheme policy 5–Infrastructure Note—Section 4.1–Guidelines for satisfying flood hazard overlay of planning scheme policy 5–Infrastructure provides guidance to achieve this outcome.	**A010** No acceptable outcome provided.	Acceptable solution provided. Compensatory earthworks are proposed at the site to maintain flood storage and conveyance characteristics. Compensatory earthworks are: • Located within a backwater area and fully contained within the subject site; • In an area where the flow velocity is negligible; • Will not adversely impact on hydraulic conveyance and storage provisions. • Is free draining. • Is provided to the corresponding flood level. • Is proposed solely for flood storage. • Is located to above the 10% AEP regional flood level.
P011 Development does not adversely change the following flood characteristics for all flood events up to and including the defined flood event: (a) peak flow; (b) flow of any part of the flood before the peak; (c) flood flow velocity; (d) level of flooding; (e) flood time to peak.	**A011** No acceptable outcome provided.	Acceptable solution provided. Compensatory earthworks are proposed at the site to maintain flood storage and conveyance characteristics. Flood impact assessment demonstrates no adverse impact to external properties or existing infrastructure. The proposed development provides a beneficial outcome to existing development located to the south of the site. An improved flood outcome has also been provided for

Note—Compliance with this performance outcome is to be demonstrated by a flood study report prepared in accordance with section 2.5.1 of planning scheme policy 5–Infrastructure Note—Section 4.1–Guidelines for satisfying flood hazard overlay of planning scheme policy 5–Infrastructure provides guidance to achieve this outcome.		Logan Reserve Road which will benefit access for the local area.
P012 A stormwater quality improvement device is located to retain existing flood plain storage capacity and ensure functionality of the stormwater quality improvement device.	**A012** A stormwater quality improvement high flow outlet device is located: (a) above the five percent AEP flood event caused by local flooding; (b) above the two percent AEP flood event caused by regional flooding.	Acceptable solution provided. Refer engineering report prepared by Lambert & Rehbein Consulting Engineers.
P013 A stormwater quantity management device is located to retain existing flood plain storage capacity and ensure functionality of the stormwater quantity management device.	**A013** A stormwater quantity management high flow outlet device is located above the two percent AEP flood event.	Acceptable solution provided. No stormwater detention facility is proposed as part of the development.
Filling and excavation		
P014 Filling and excavation is carried out above the flood level of the 10 percent AEP event to protect in stream and banks of a waterway and wetland. Note—Section 4.1–Guidelines for satisfying flood hazard overlay code in planning scheme policy 5–Infrastructure provides guidance to achieve this outcome.	**A014.1** Earthworks are limited to areas where: (a) flooding is predominately due to backflow; (b) the peak depth average velocity is less than the maximum permissible velocity for considerable bare earth channels (typically 0.5m/sec) in accordance with Table 9.0.5.3 of the Queensland Urban Drainage Manual; (c) the cut/fill batter is not steeper than 1V:4H and the exposed earth surface is landscaped with erosion resistant vegetation cover.	Acceptable solution provided. Compensatory earthworks are proposed at the site to maintain flood storage and conveyance characteristics. Compensatory earthworks are: • Located within a backwater area and fully contained within the subject site; • In an area where the flow velocity is negligible; • Will not adversely impact on hydraulic conveyance and storage provisions. • Is free draining. • Is provided to the corresponding flood level. • Is proposed solely for flood storage. • Is located to above the 10% AEP regional flood level.
	A014.2	Acceptable solution provided. Refer engineering report prepared by

	A filling and excavation plan is provided in accordance with section 2.2.2 of planning scheme policy 5–Infrastructure.	Lambert & Rehbein Consulting Engineers.
Access		
P015 Development provides vehicular access to a road network that is sufficient to enable safe access and egress. Note—Section 4.1–Guidelines for satisfying flood hazard overlay code in planning scheme policy 5–Infrastructure provides guidance to achieve this outcome.	**A015** Development provides vehicular access to a road that is: (a) above the flood level during the defined flood event; or (b) below the flood level during the defined flood event where the road: (i) has a low flood hazard; (ii) remains trafficable until another road access to the development becomes trafficable; (iii) directly connects to a road that is above the defined flood event that provides access to the road network.	Acceptable solution provided. Flood free access to the site is proposed to above the DFE.
P016 Development provides an access area to a building or fill area on which a building is to be constructed where the access is located on land classified as a low flood hazard in the defined flood event.	**A016** Development provides access to a building or fill area that has: (a) a maximum depth of inundation of 300 mm during all flood events up to and including the defined flood event; (b) a maximum distance of inundation of 200 metres during all flood events up to and including the defined flood event; (c) a depth multiplied velocity product of less than or equal to 0.4m2/s. Note—Velocity in flood waters is measured as the average velocity over a column of water.	Acceptable solution provided. Internal access to the development is maintained in the DFE.

5. CONCLUSION

Water Technology P/L (WT) have been commissioned by Lambert & Rehbein P/L (L&R) on behalf of Vic Land Holding Pty Ltd to undertake a flood assessment for a proposed development located on Logan Reserve Road, Logan Reserve. The property is located at 303 - 309 Logan Reserve Road (real property description Lot 2 RP165534) and is located within the Logan City Council (LCC) local government area.

The site in its present form is used for rural residential purposes and is essentially vacant open land and is grassed. There is an existing residential dwelling with several ancillary structures (i.e. sheds, etc). The proposed development includes a multi-unit development comprising a mixture of 2, 3 and 4 bedroom unit dwellings serviced by an internal road linking to Logan Reserve Road. A total of 31 individual unit dwellings are proposed. The existing channel through the site will be converted to a piped stormwater drainage system, which also links to the existing drainage on Logan Reserve Road.

A WBNM hydrological model has been prepared for the purposes of estimating catchment discharges for a range of design events and catchment landuse conditions. A number of hydrological methods have been used in the validation of the model flows. Comparison of design flow estimates using a number of methods has shown the WBNM flow estimates to be appropriate and reasonable.

A hydraulic analysis of flooding at the site has been undertaken using a 1D/2D TUFLOW model. The TUFLOW model has been used to estimate flood levels, extents, depths and flow velocities in and around the subject site based on the local flooding characteristics at the site. Additionally, Council's regional flood model has also been used to assess the development based on a large Logan River flood event.

The following brief summary is provided in relation to the results of this assessment: -

- The modelling has demonstrated that there is no requirement to provide on-site detention as part of the proposed development as there is no increase in peak flows leaving the site.
- There is no worsening in flooding as a result of the development to the extent that there would not be any actionable nuisance in either of the existing or ultimate landuse scenarios.
- The development is provided with minimum building and pad levels that will satisfy minimum development levels.
- Flood free evacuation routes are available to the development via Logan Reserve Road based on the 1% AEP design flood event.
- The site is provided with a lawful point of discharge in accordance with the QUDM provisions of Section 3.02.
- Acceptable solutions are provided for the development against Council's flood hazard overlay code.

The proposed development also provides a general benefit in respect to flood inundation in the local area when considering an ultimate catchment flow condition, and this includes: -

- Improved inundation outcomes to existing residential development located immediately to the south of the development. Previously, these properties would be subject to inundation in the 1% and 2% AEP design flood events under ultimate catchment flows;
- Improved road access and trafficability outcomes for Logan Reserve Road. As a result of the development, Logan Reserve Road will now maintain flood immunity for all events up to the 1% AEP event.

On the basis of the above, it is believed that Logan City Council should support the proposed development of the site located at 303 - 309 Logan Reserve Road (real property description Lot 2 RP165534).

6. REFERENCES

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2. Boyd, M.J. and Bodhinayake, N.D. (2006). WBNM runoff routing parameters for South and Eastern Australia. Institution of Engineers Australia, Journal of Water Resources, 10(1), pp. 35-48.
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5. IEAust (1998), *Australian Rainfall and Runoff, A Guide to Flood Estimation, Volume 1 and 2,* Editor in Chief DH Pilgrim, Institution of Engineers.
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7. Grayson R.B., Argent R.M., Nathan R.J., McMahon T.A. and Mein R.G. (1996), *Hydrological Recipes, Estimation Techniques in Australian Hydrology*, Cooperative Research Centre for Catchment Hydrology.
8. Kuczera G. and Franks S. (2005), Chapter 2 – At-Site Flood Frequency Analysis, Australian Rainfall and Runoff Revision, Draft November 2005, School of Engineering, University of Newcastle.
9. NRW (2007), *Queensland Urban Drainage Manual*, Volume 1, Second Edition, Natural Resources and Water, Queensland Government.
10. Palmen L.B. and Weeks W.D. (2009), *Regional Flood Frequency for Queensland using the Quantile Regression Technique*, Proceedings of H2O 09: 32nd Hydrology and Water Resources Symposium, Newcastle, Engineers Australia.

APPENDIX A PROPOSED PLAN OF DEVELOPMENT

SITE AREA: 20,200$_M^2$

AMOUNT OF NEW UNITS PROPOSED:	31
PRIVATE ALLOCATED UNIT PARKING:	49
PRIVATE ALLOCATED VISITOR PARKING:	14
MAXIMUM HEIGHT OF BUILDINGS :	9.5$_M$

COMMUNAL OPEN SPACE
12164.74$_m^2$

PRIVATE OPEN SPACE
MIN. 25 SQM / UNIT

FLOOD LINE

2 BED UNIT QTY: 13

3 BED UNIT QTY: 15

4 BED UNIT QTY: 3

Nominated Bioretention basin

Landscape- garden

Timber lapped
and capped fencing
1800mm high

Driveway to garage

Bin location

0 5 10 15 20

SITE LAYOUT

Clients _____

Builders _____

Suarez drafting & design
T 041 995 0884
E tim@suarezdesign.com.au

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NOTES

WET AREAS TO COMPLY WITH PART 3.8.1 OF BCA
WC DOORS TO COMPLY WITH PART 3.8.3.3 OF BCA
SETDOWN GARAGE SLABS 85mm AND ALL EXTERNAL CONCRETE SLABS OR PAVING 75mm BELOW WEEPHOLES
DOWNPIPES, HWS & SIMILAR 25mm CLEAR OF PART 'B'
DIMENSIONS TO TAKE PRECEDENCE OVER SCALE IF LINSURE ASK.

JOB ADDRESS	LOT 2 303-309 LOGAN RESERVE RD LOGAN RESERVE
DRAWING DESCRIPTION	MULTI-UNIT DEVELOPMENT PROPOSAL
CLIENT PARTICULARS	

revision					
DRAWN	RSU	JOB No.	15-132	DESIGN	SUAREZ
DATE	11/01/2016	SCALE	1:500 ON A3	SHEET	1
wind					

APPENDIX B REGIONAL FLOOD MODEL RESULTS

Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 01/02/2016

Logan Reserve Flood Assessment - Developed Case (Existing Catchment)
Regional Flood Impact - 2% AEP 60min

2016-02-01T16:16:15

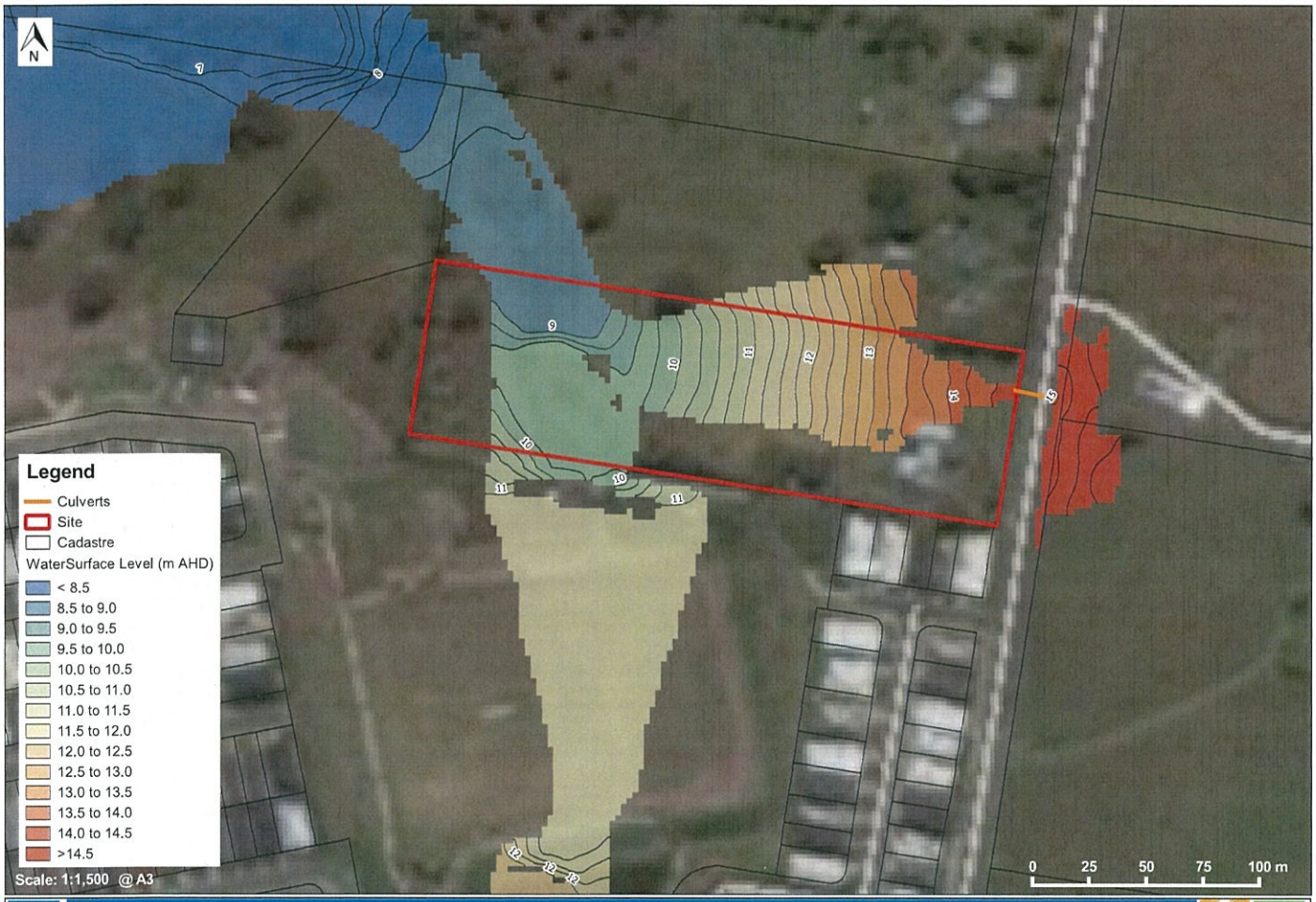

N
Legend
Development Fill Area
Site
Cadastre
Flood Extent (Exg) - 1% AEP
Flood Extent (Dev) - 1% AEP
Afflux (m)
< -0.200
-0.200 to -0.100
-0.100 to -0.050
-0.050 to -0.025
-0.025 to -0.010
-0.010 to -0.001
-0.001 to 0.001
0.001 to 0.010
0.010 to 0.025
0.025 to 0.050
0.050 to 0.100
0.100 to 0.200
> 0.200
Scale: 1:1,500 @ A3
0 25 50 75 100 m
Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 01/02/2016
Logan Reserve Flood Assessment - Developed Case (Existing Catchment)
Regional Flood Impact - 1% AEP 60min
2016-02-01T16:15:25

APPENDIX C EXISTING LANDUSE CASE GIS MAPS

Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 01/02/2016

Logan Reserve Flood Assessment - Existing Case (Existing Catchment)
Peak Flood Depth - 18% AEP 60min

2016-02-01T14:37:50


N
Legend
Culverts
Site
Cadastre
WaterSurface Level (m AHD)
< 8.5
8.5 to 9.0
9.0 to 9.5
9.5 to 10.0
10.0 to 10.5
10.5 to 11.0
11.0 to 11.5
11.5 to 12.0
12.0 to 12.5
12.5 to 13.0
13.0 to 13.5
13.5 to 14.0
14.0 to 14.5
>14.5
Scale: 1:1,500 @ A3
0 25 50 75 100 m
Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 01/02/2016
Logan Reserve Flood Assessment - Existing Case (Existing Catchment)
Peak Water Surface Level - 18% AEP 60min
2016-02-01T14:30:44

Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 01/02/2016

Logan Reserve Flood Assessment - Existing Case (Existing Catchment)
Peak Flood Depth - 10% AEP 60min

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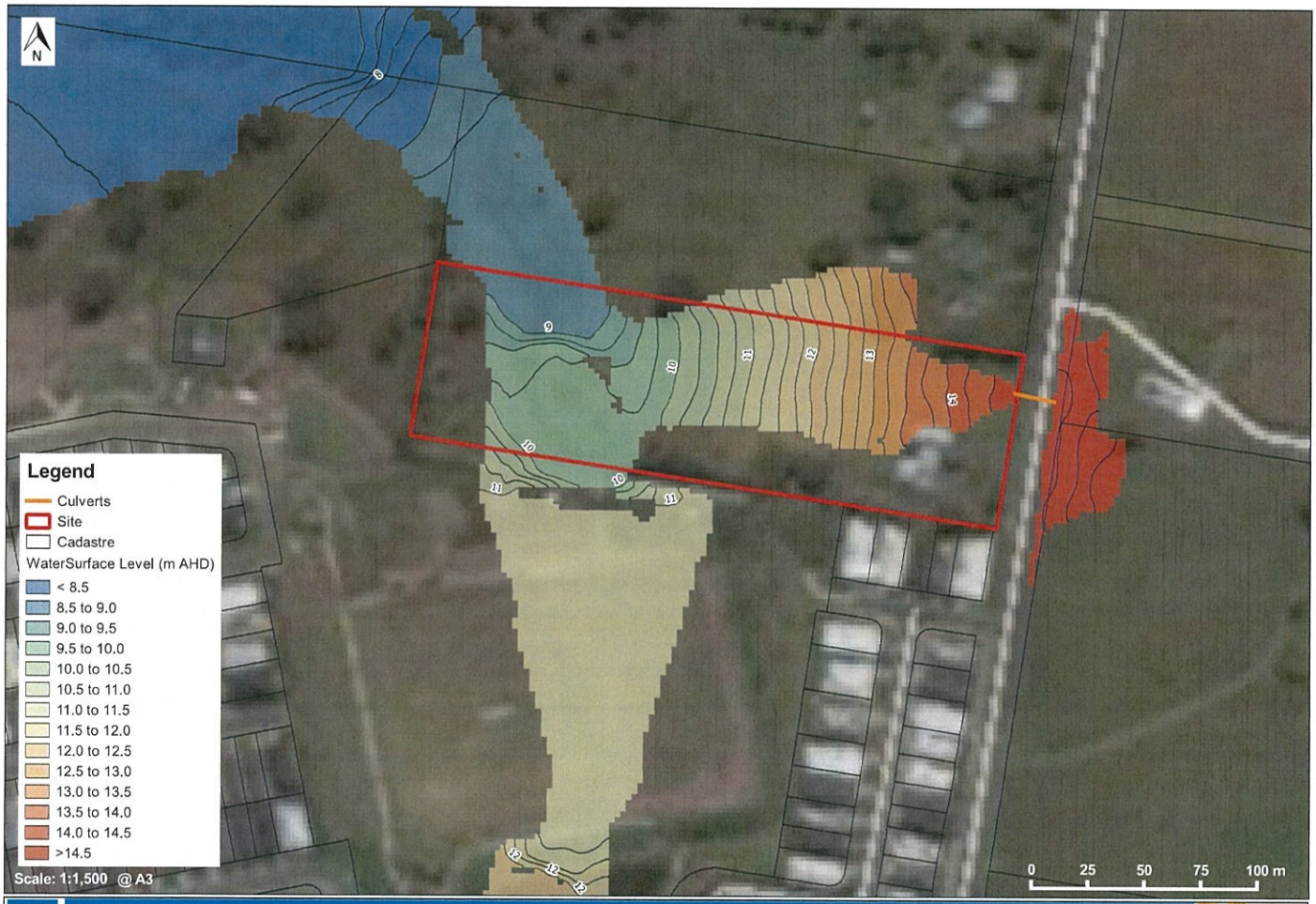
N
Legend
Culverts
Site
Cadastre
WaterSurface Level (m AHD)
< 8.5
8.5 to 9.0
9.0 to 9.5
9.5 to 10.0
10.0 to 10.5
10.5 to 11.0
11.0 to 11.5
11.5 to 12.0
12.0 to 12.5
12.5 to 13.0
13.0 to 13.5
13.5 to 14.0
14.0 to 14.5
>14.5
Scale: 1:1,500 @ A3
0 25 50 75 100 m
Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 01/02/2016
Logan Reserve Flood Assessment - Existing Case (Existing Catchment)
Peak Water Surface Level - 10% AEP 60min
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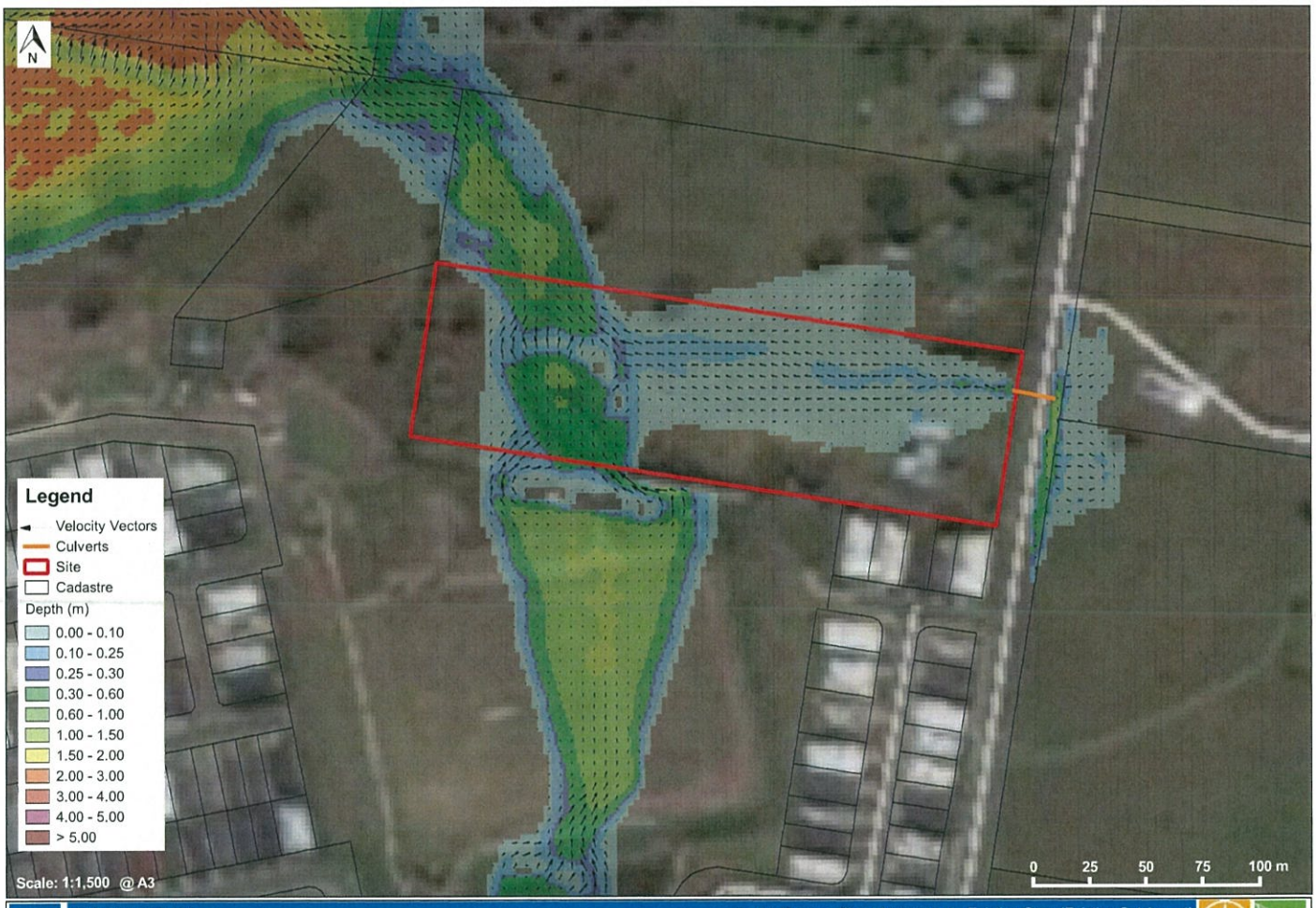

Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 01/02/2016

Logan Reserve Flood Assessment - Existing Case (Existing Catchment)
Peak Flood Depth - 2% AEP 60min

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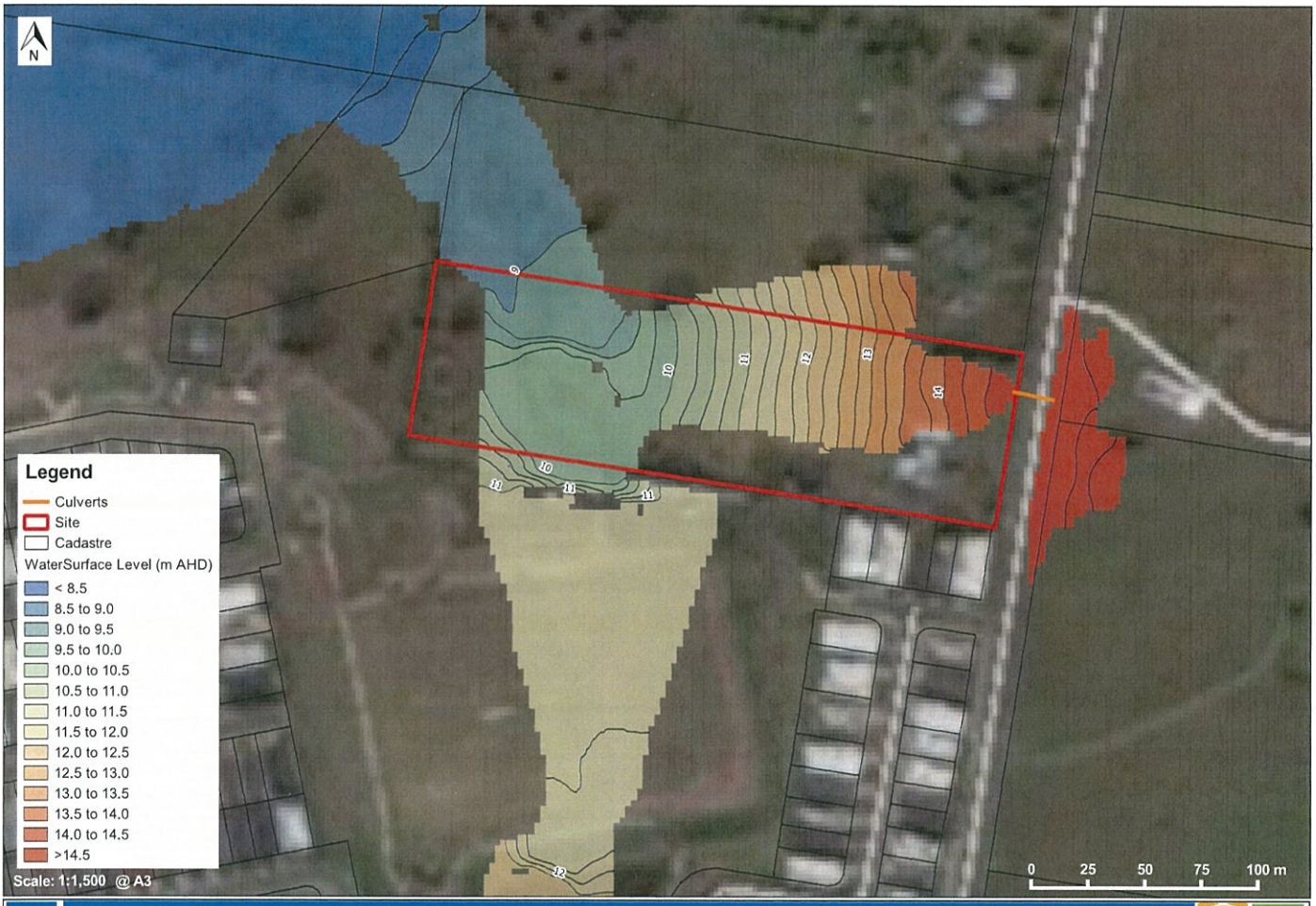
N
Legend
Culverts
Site
Cadastre
WaterSurface Level (m AHD)
< 8.5
8.5 to 9.0
9.0 to 9.5
9.5 to 10.0
10.0 to 10.5
10.5 to 11.0
11.0 to 11.5
11.5 to 12.0
12.0 to 12.5
12.5 to 13.0
13.0 to 13.5
13.5 to 14.0
14.0 to 14.5
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Map Coordinates: GDA 1994
Water Technology Pty Ltd
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Peak Water Surface Level - 2% AEP 60min
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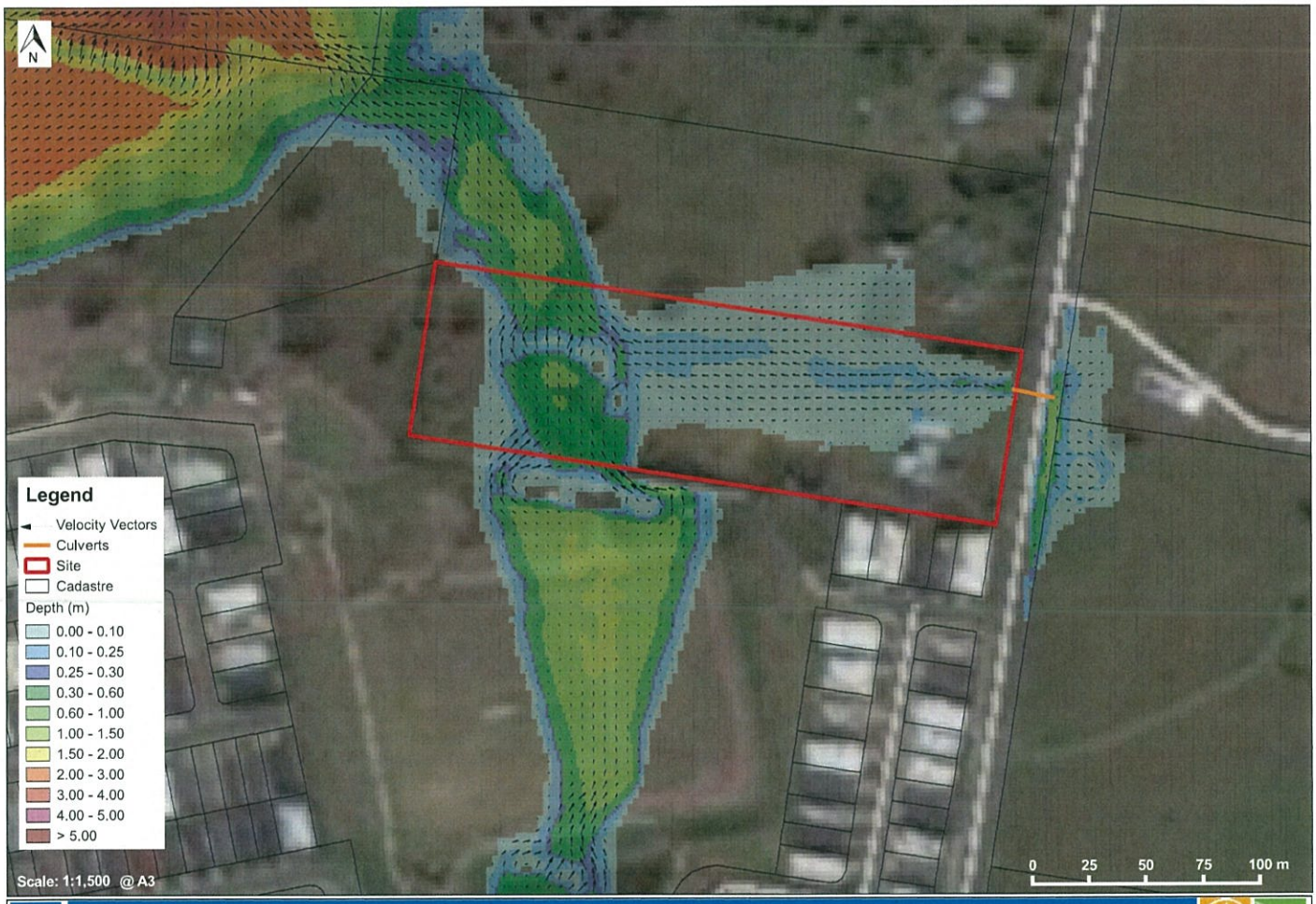

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Water Technology Pty Ltd
Date: 01/02/2016

Logan Reserve Flood Assessment - Existing Case (Existing Catchment)
Peak Flood Depth - 1% AEP 60min

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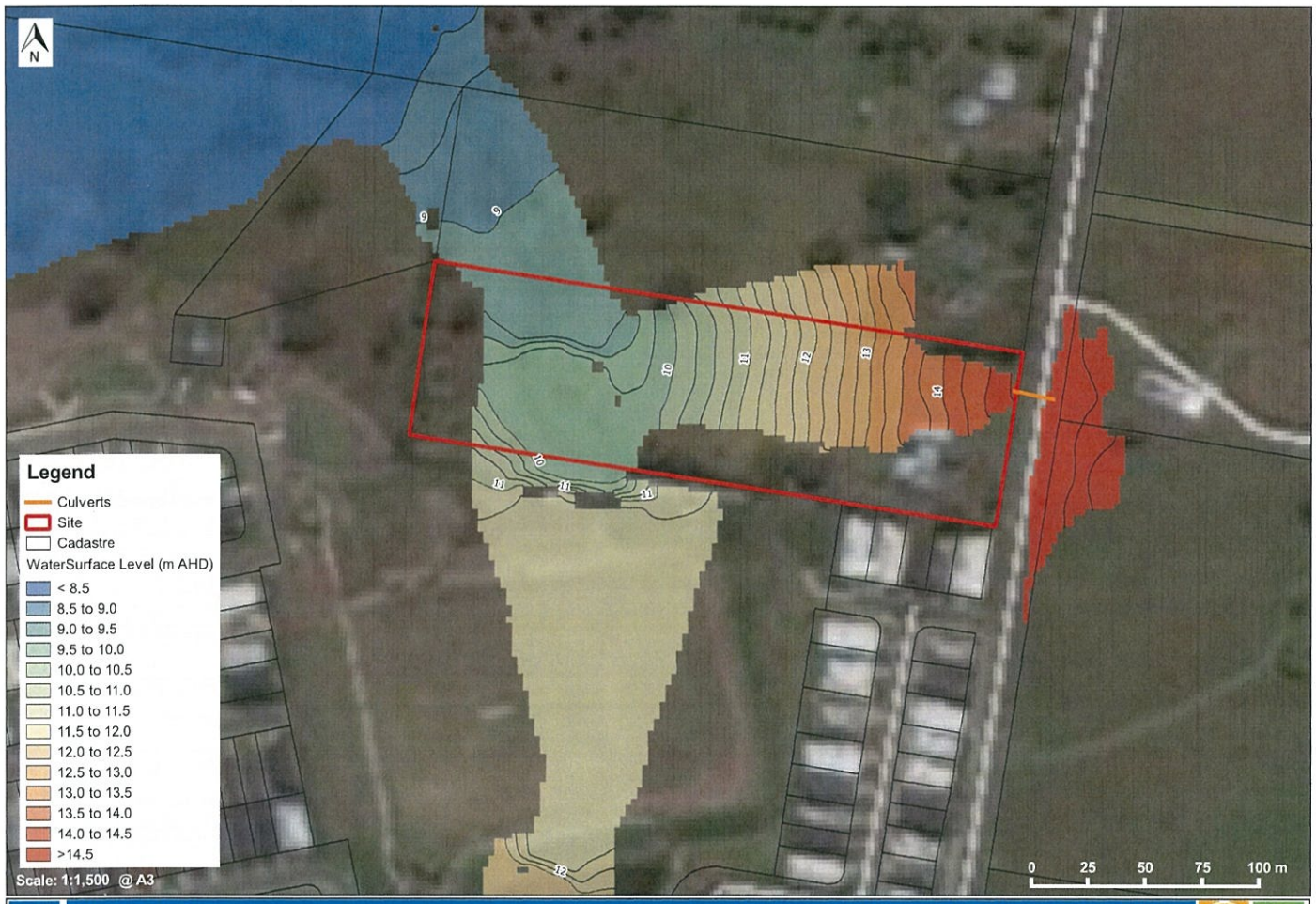
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Legend
Culverts
Site
Cadastre
WaterSurface Level (m AHD)
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10.0 to 10.5
10.5 to 11.0
11.0 to 11.5
11.5 to 12.0
12.0 to 12.5
12.5 to 13.0
13.0 to 13.5
13.5 to 14.0
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>14.5
Scale: 1:1,500 @ A3
0 25 50 75 100 m
Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 01/02/2016
Logan Reserve Flood Assessment - Existing Case (Existing Catchment)
Peak Water Surface Level - 1% AEP 60min
2016-02-01T14:33:32

Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 01/02/2016

Logan Reserve Flood Assessment - Developed Case (Existing Catchment)
Peak Flood Depth - 18% AEP 60min

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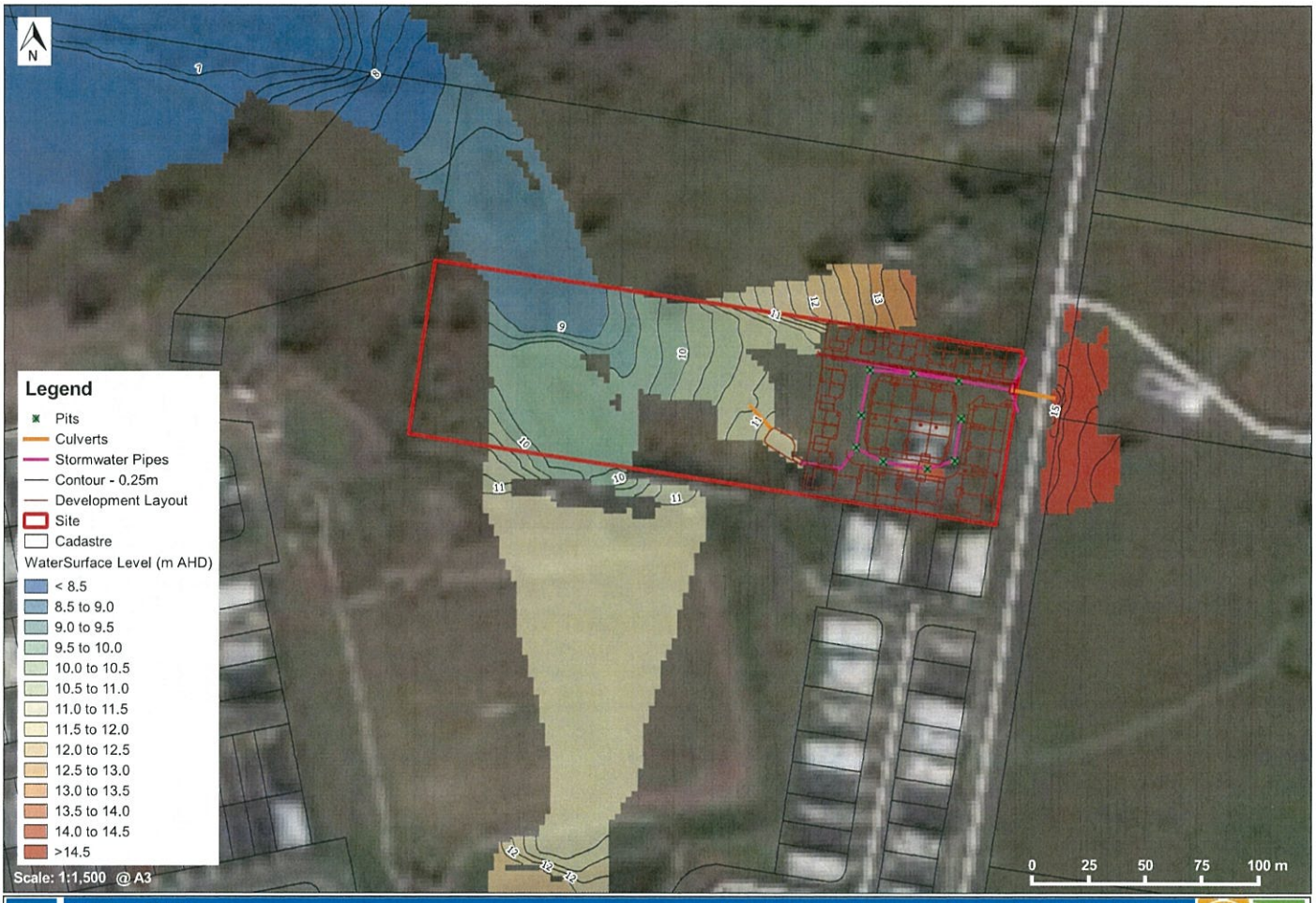
N
Legend
Pits
Culverts
Stormwater Pipes
Contour - 0.25m
Development Layout
Site
Cadastre
WaterSurface Level (m AHD)
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8.5 to 9.0
9.0 to 9.5
9.5 to 10.0
10.0 to 10.5
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11.0 to 11.5
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12.5 to 13.0
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>14.5
Scale: 1:1,500 @ A3
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Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 01/02/2016
Logan Reserve Flood Assessment - Developed Case (Existing Catchment)
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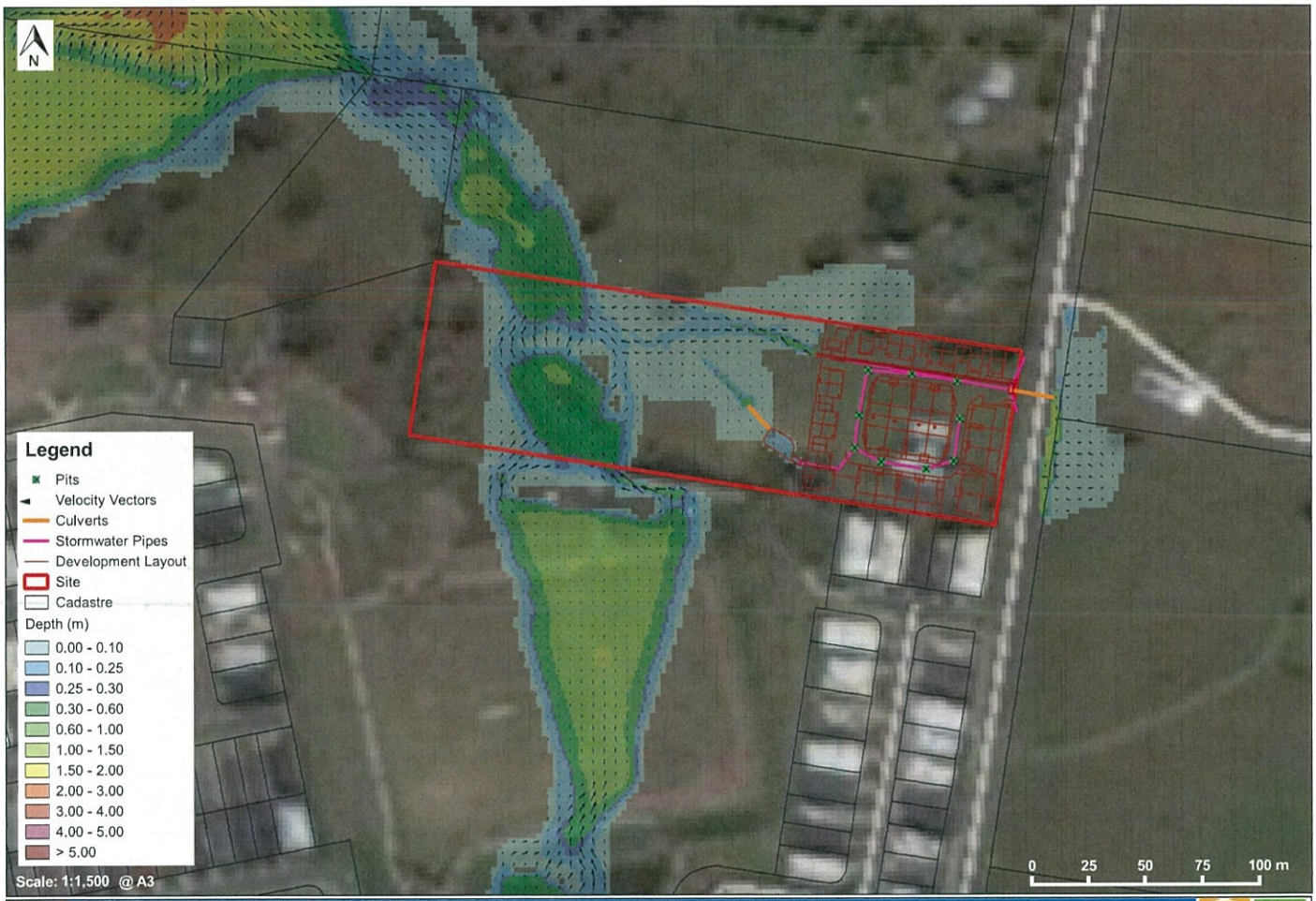

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Water Technology Pty Ltd
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Logan Reserve Flood Assessment - Developed Case (Existing Catchment)
Peak Flood Depth - 10% AEP 60min

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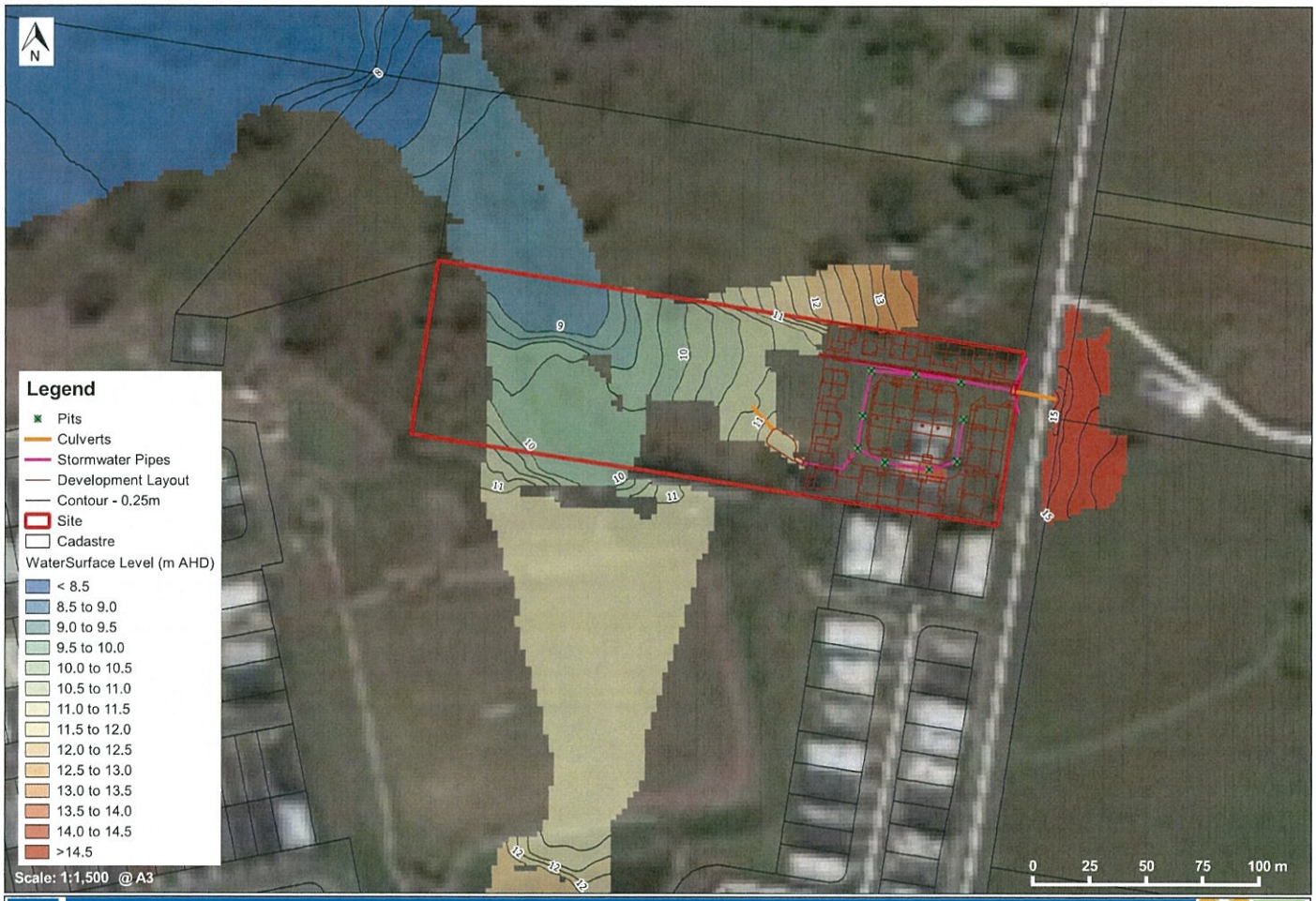
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Legend
Pits
Culverts
Stormwater Pipes
Development Layout
Contour - 0.25m
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Cadastre
WaterSurface Level (m AHD)
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8.5 to 9.0
9.0 to 9.5
9.5 to 10.0
10.0 to 10.5
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11.0 to 11.5
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14.0 to 14.5
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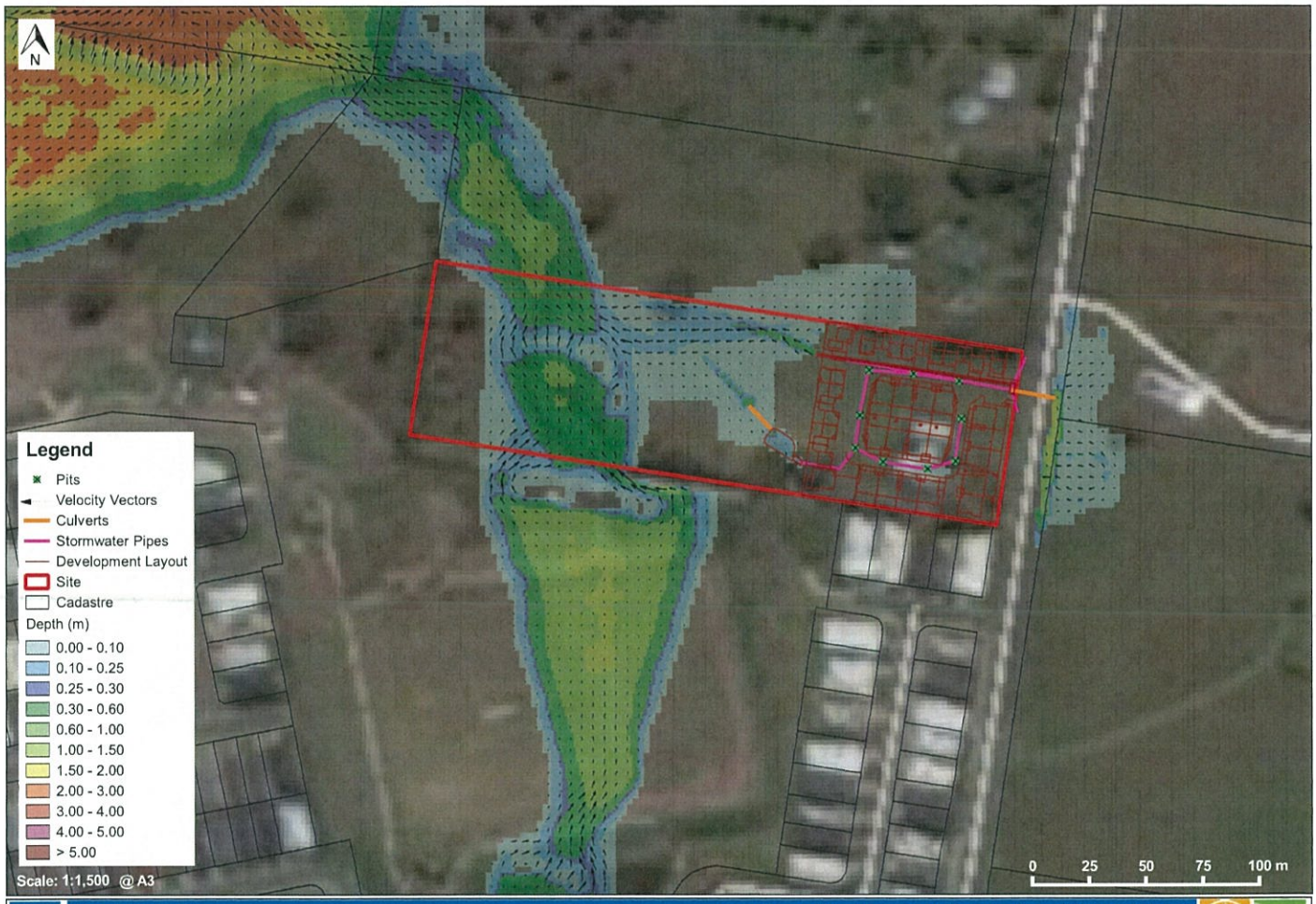
Water Technology Pty Ltd
Date: 01/02/2016
Logan Reserve Flood Assessment - Developed Case (Existing Catchment)
Peak Water Surface Level - 10% AEP 60min



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Water Technology Pty Ltd
Date: 01/02/2016

Logan Reserve Flood Assessment - Developed Case (Existing Catchment)
Peak Flood Depth - 2% AEP 60min

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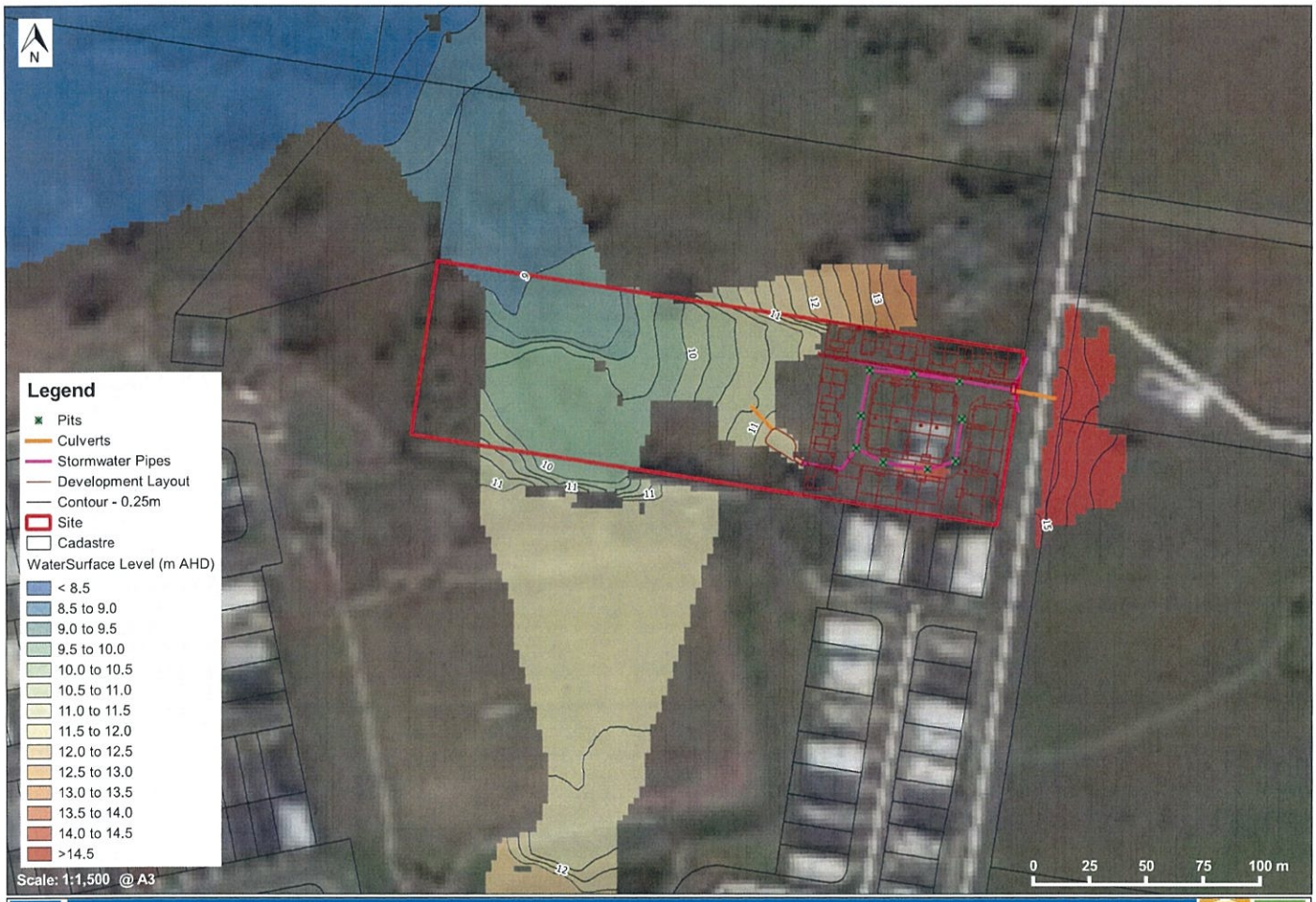
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Legend
Pits
Culverts
Stormwater Pipes
Development Layout
Contour - 0.25m
Site
Cadastre
WaterSurface Level (m AHD)
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8.5 to 9.0
9.0 to 9.5
9.5 to 10.0
10.0 to 10.5
10.5 to 11.0
11.0 to 11.5
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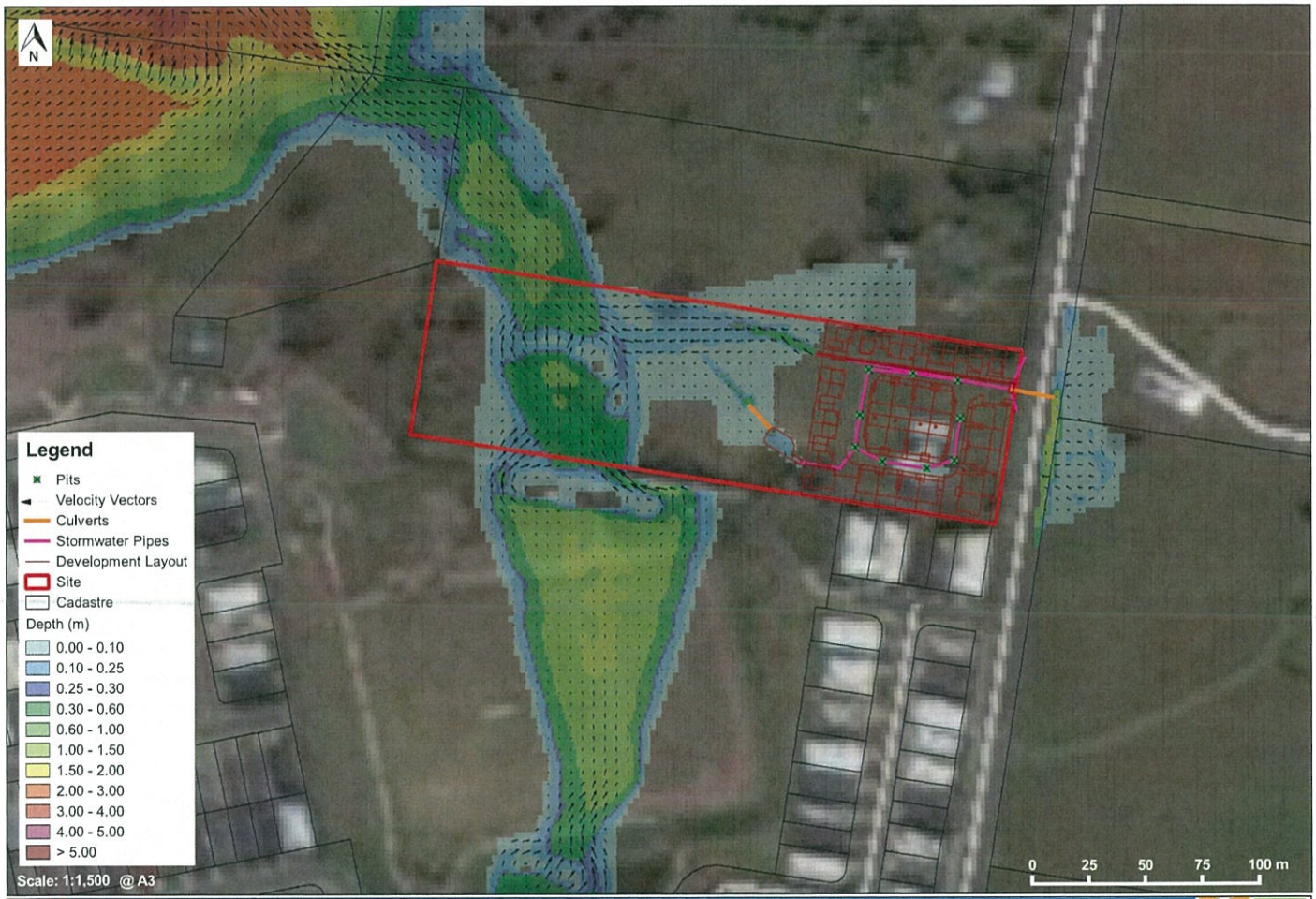
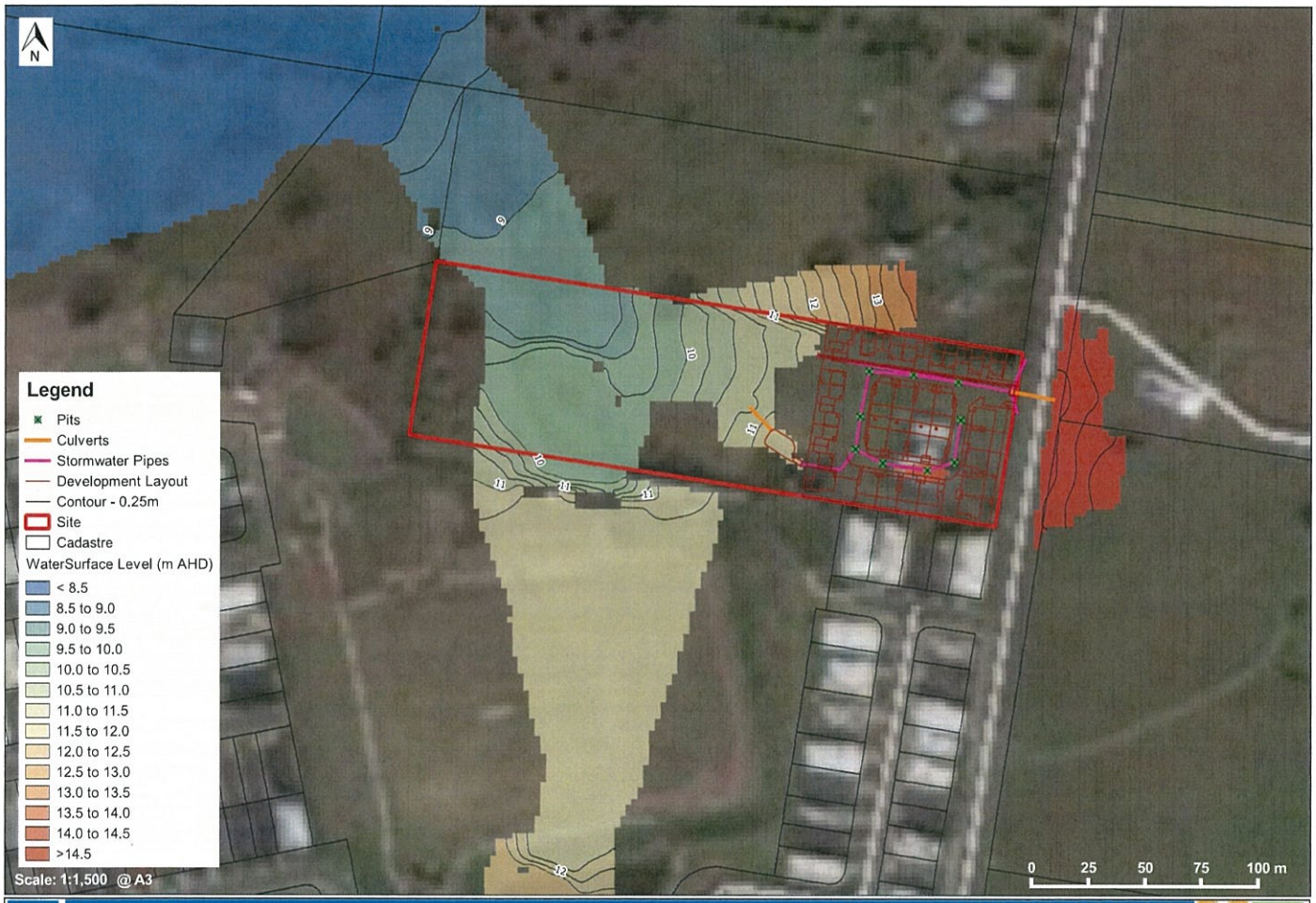
14.0 to 14.5
>14.5
Scale: 1:1,500 @ A3
0 25 50 75 100 m
Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 01/02/2016
Logan Reserve Flood Assessment - Developed Case (Existing Catchment)
Peak Water Surface Level - 2% AEP 60min
2016-02-01T14:41:06



Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 01/02/2016

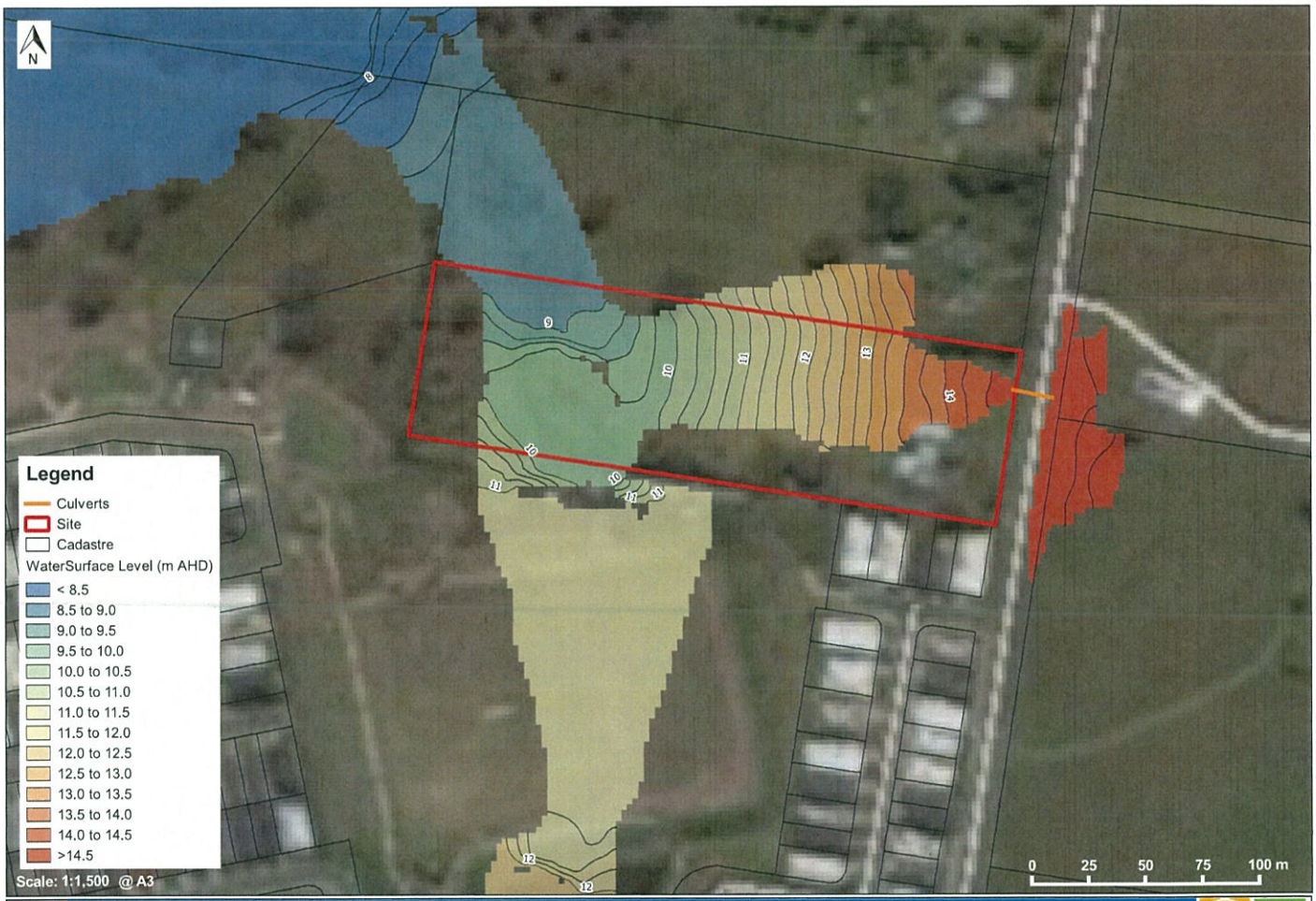
Logan Reserve Flood Assessment - Developed Case (Existing Catchment)
Peak Flood Depth - 1% AEP 60min

2016-02-01T14:31:08


N
Legend
Pits
Culverts
Stormwater Pipes
Development Layout
Contour - 0.25m
Site
Cadastre
WaterSurface Level (m AHD)
< 8.5
8.5 to 9.0
9.0 to 9.5
9.5 to 10.0
10.0 to 10.5
10.5 to 11.0
11.0 to 11.5
11.5 to 12.0
12.0 to 12.5
12.5 to 13.0
13.0 to 13.5
13.5 to 14.0
14.0 to 14.5
>14.5
Scale: 1:1,500 @ A3
0 25 50 75 100 m
Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 01/02/2016
Logan Reserve Flood Assessment - Developed Case (Existing Catchment)
Peak Water Surface Level - 1% AEP 60min
2016-02-01T14:51:55

APPENDIX D ULTIMATE LANDUSE CASE GIS MAPS

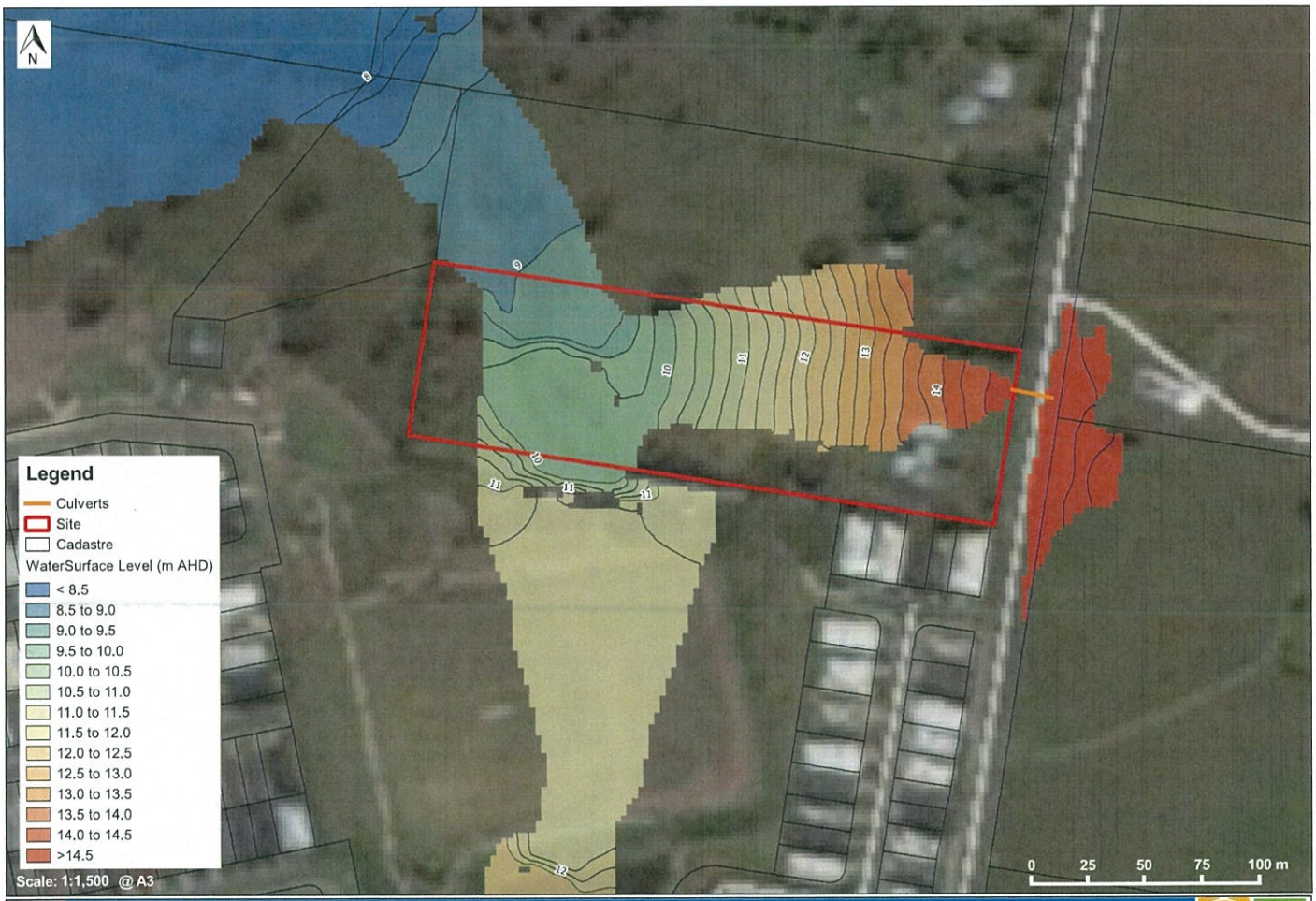

N
Legend
Velocity Vectors
Culverts
Site
Cadastre
Depth (m)
0.00 - 0.10
0.10 - 0.25
0.25 - 0.30
0.30 - 0.60
0.60 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 3.00
3.00 - 4.00
4.00 - 5.00
> 5.00
Scale: 1:1,500 @ A3
0 25 50 75 100 m
Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 29/01/2016
Logan Reserve Flood Assessment - Existing Case
Peak Flood Depth - 18% AEP 60min
2016-01-29T13:52:14


N
Legend
Culverts
Site
Cadastre
WaterSurface Level (m AHD)
< 8.5
8.5 to 9.0
9.0 to 9.5
9.5 to 10.0
10.0 to 10.5
10.5 to 11.0
11.0 to 11.5
11.5 to 12.0
12.0 to 12.5
12.5 to 13.0
13.0 to 13.5
13.5 to 14.0
14.0 to 14.5
>14.5
Scale: 1:1,500 @ A3
0 25 50 75 100 m
Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 29/01/2016
Logan Reserve Flood Assessment - Existing Case
Peak Water Surface Level - 18% AEP 60min
2016-01-29T13:51:42

Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 29/01/2016

Logan Reserve Flood Assessment - Existing Case
Peak Flood Depth - 10% AEP 60min

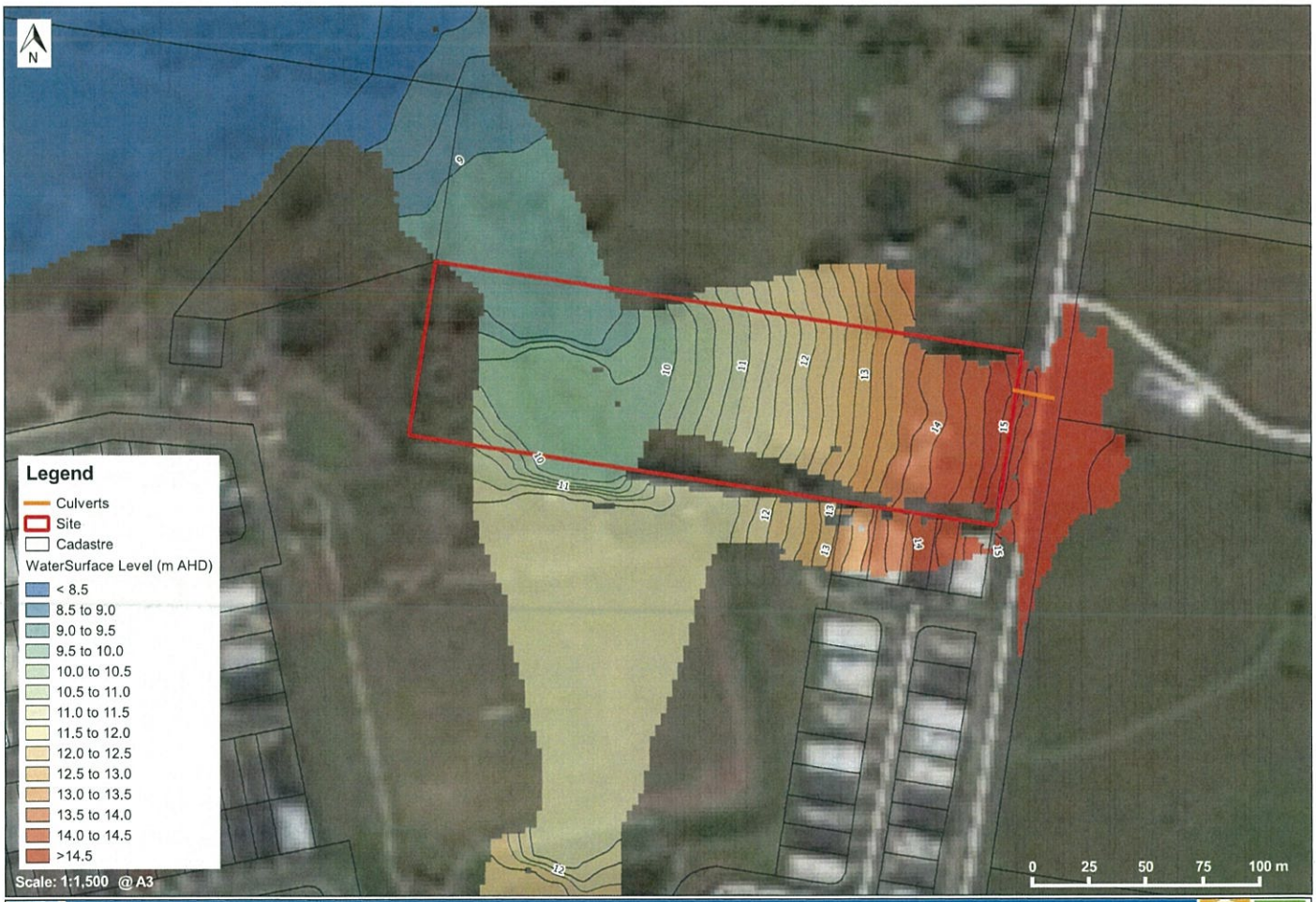
2016-01-29T10:50:16


N
Legend
Culverts
Site
Cadastre
WaterSurface Level (m AHD)
< 8.5
8.5 to 9.0
9.0 to 9.5
9.5 to 10.0
10.0 to 10.5
10.5 to 11.0
11.0 to 11.5
11.5 to 12.0
12.0 to 12.5
12.5 to 13.0
13.0 to 13.5
13.5 to 14.0
14.0 to 14.5
>14.5
Scale: 1:1,500 @ A3
0 25 50 75 100 m
Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 29/01/2016
Logan Reserve Flood Assessment - Existing Case
Peak Water Surface Level - 10% AEP 60min
2016-01-29113:49:28

Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 29/01/2016

Logan Reserve Flood Assessment - Existing Case
Peak Flood Depth - 2% AEP 60min

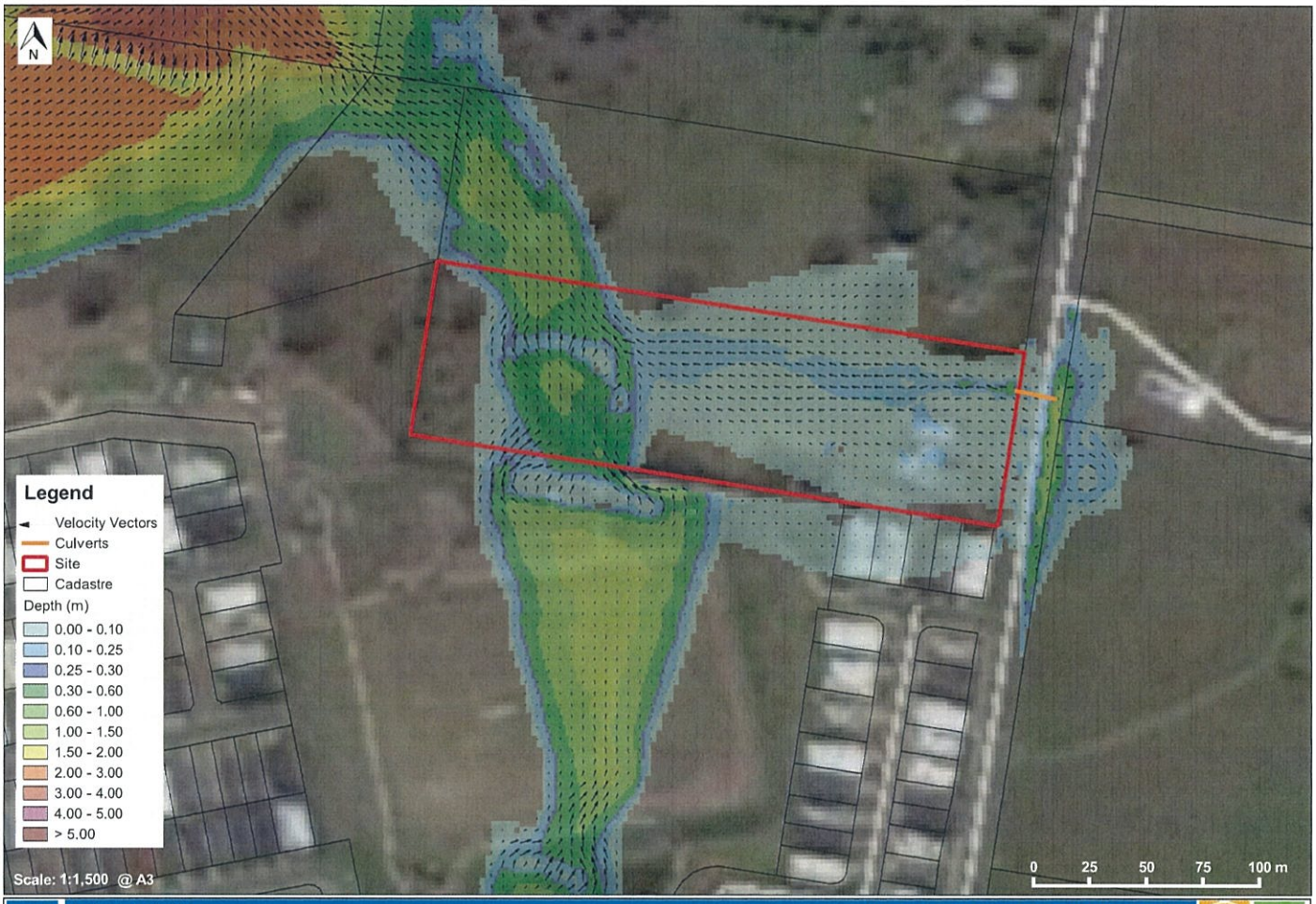
2016-01-29T12:22:10



Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 29/01/2016

Logan Reserve Flood Assessment - Existing Case
Peak Water Surface Level - 2% AEP 60min

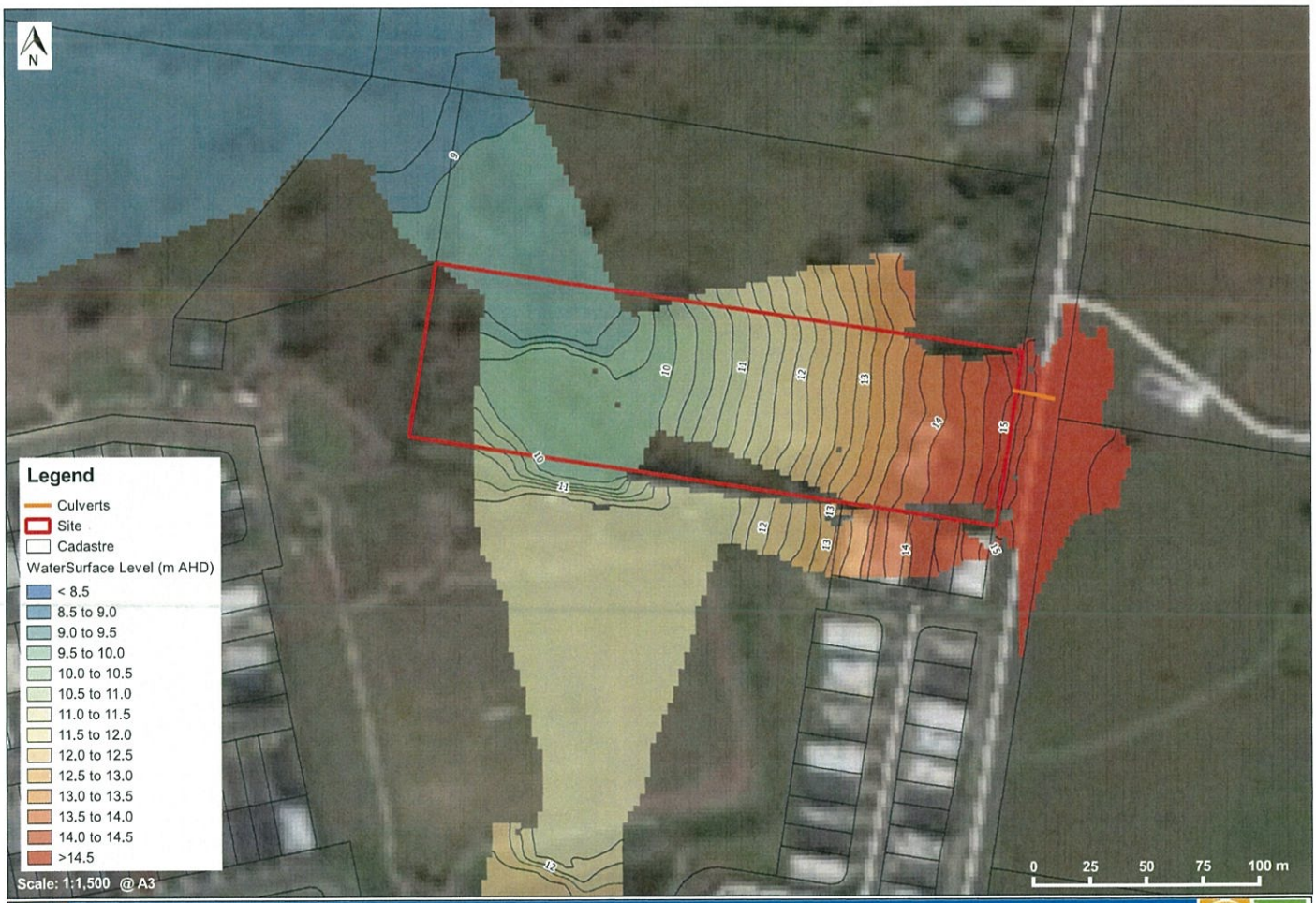
2016-01-29T13:48:30



Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 29/01/2016

Logan Reserve Flood Assessment - Existing Case
Peak Flood Depth - 1% AEP 60min

2016-01-29T10:46:02



Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 29/01/2016

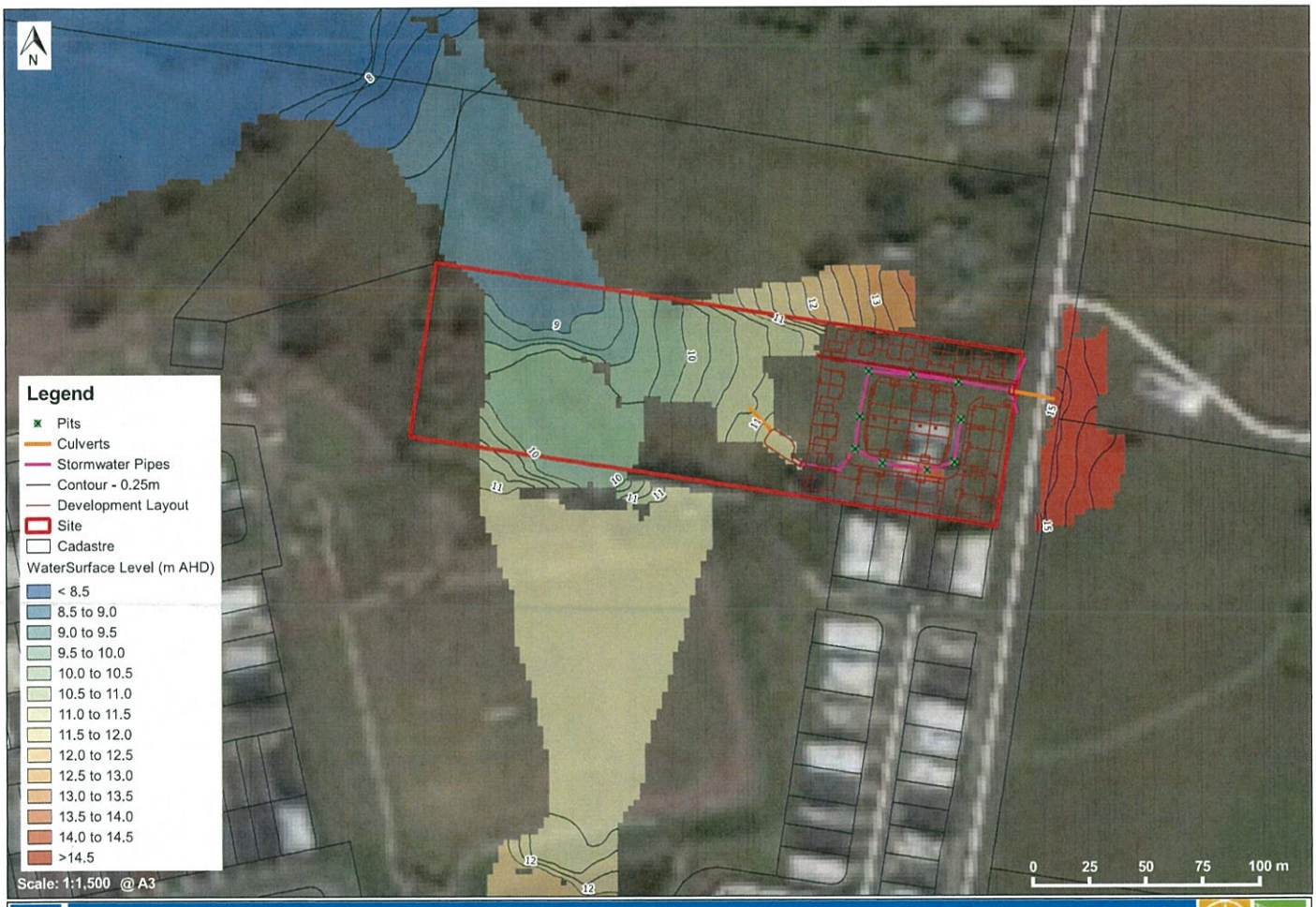
Logan Reserve Flood Assessment - Existing Case
Peak Water Surface Level - 1% AEP 60min

2016-01-29T13:47:39

Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 29/01/2016

Logan Reserve Flood Assessment - Developed Case
Peak Flood Depth - 18% AEP 60min

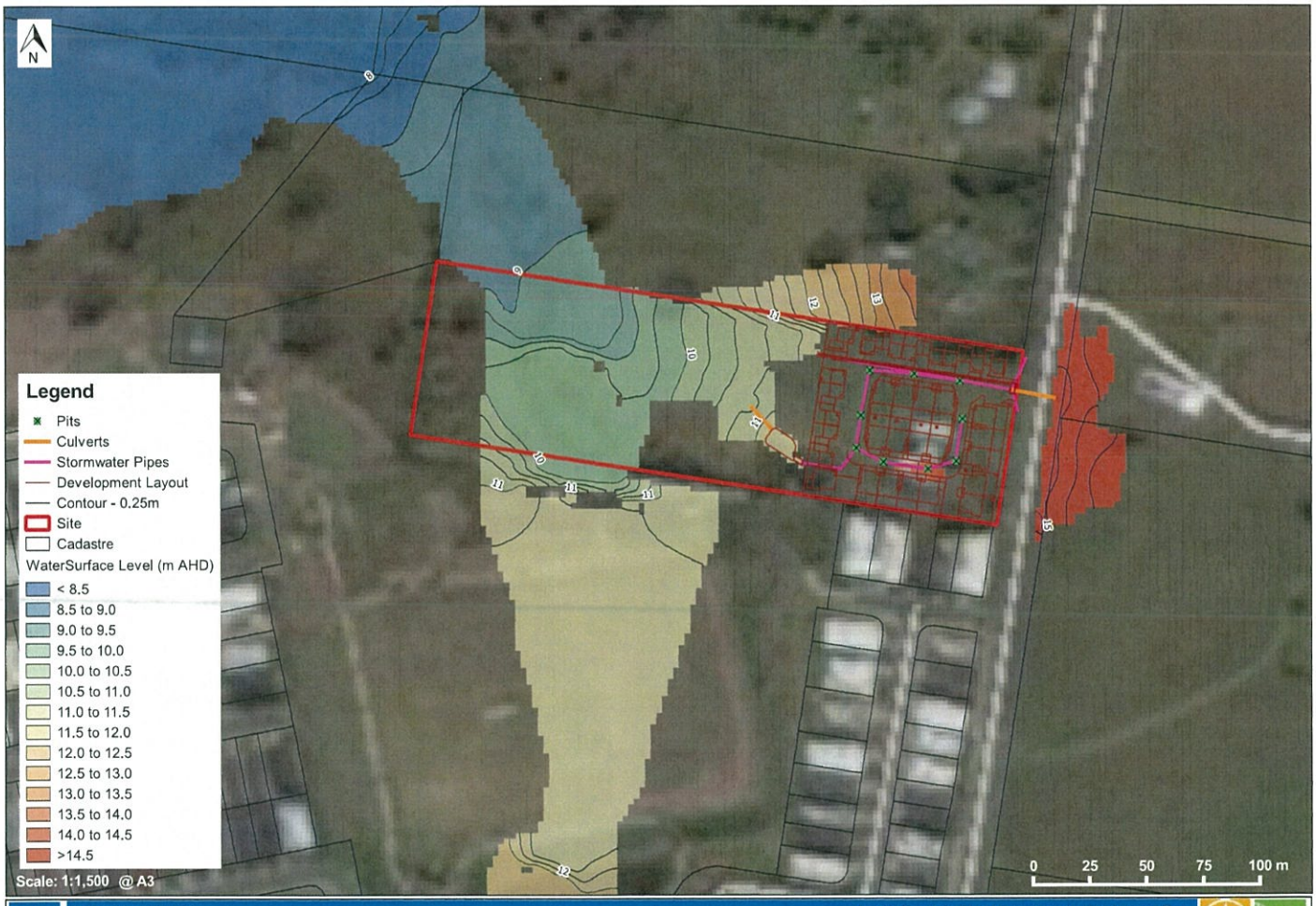
2016-01-29T13:53:22

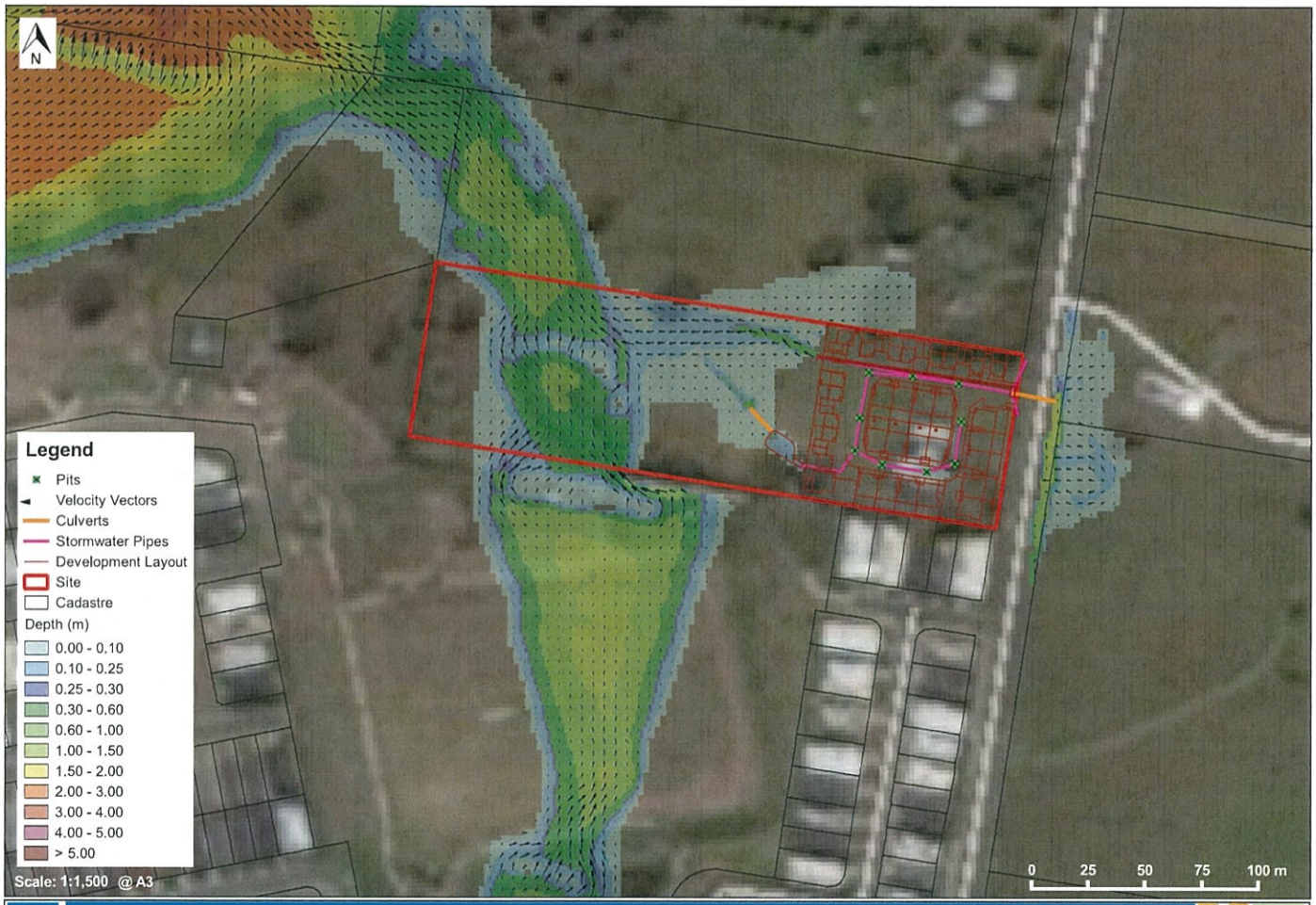

N
Legend
Pits
Culverts
Stormwater Pipes
Contour - 0.25m
Development Layout
Site
Cadastre
WaterSurface Level (m AHD)
< 8.5
8.5 to 9.0
9.0 to 9.5
9.5 to 10.0
10.0 to 10.5
10.5 to 11.0
11.0 to 11.5
11.5 to 12.0
12.0 to 12.5
12.5 to 13.0
13.0 to 13.5
13.5 to 14.0
14.0 to 14.5
>14.5
Scale: 1:1,500 @ A3
0 25 50 75 100 m
Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 29/01/2016
Logan Reserve Flood Assessment - Developed Case
Peak Water Surface Level - 18% AEP 60min
2016-01-29T13:52:46

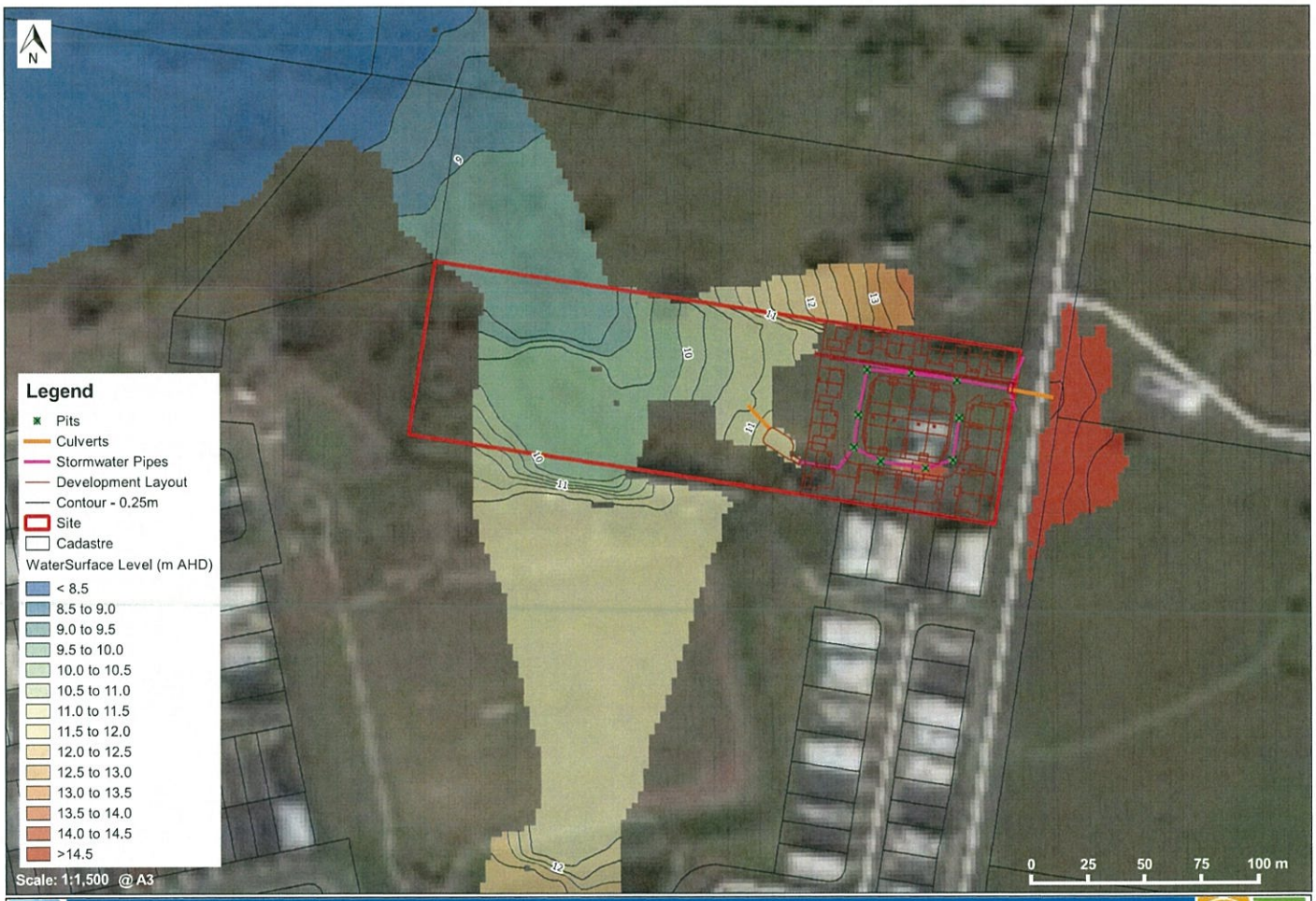
Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 29/01/2016

Logan Reserve Flood Assessment - Developed Case
Peak Flood Depth - 10% AEP 60min

2016-01-29T12:41:20


N
Legend
Pits
Culverts
Stormwater Pipes
Development Layout
Contour - 0.25m
Site
Cadastre
WaterSurface Level (m AHD)
< 8.5
8.5 to 9.0
9.0 to 9.5
9.5 to 10.0
10.0 to 10.5
10.5 to 11.0
11.0 to 11.5
11.5 to 12.0
12.0 to 12.5
12.5 to 13.0
13.0 to 13.5
13.5 to 14.0
14.0 to 14.5
>14.5
Scale: 1:1,500 @ A3
0 25 50 75 100 m
Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 29/01/2016
Logan Reserve Flood Assessment - Developed Case
Peak Water Surface Level - 10% AEP 60min
2016-01-29T13:30:28

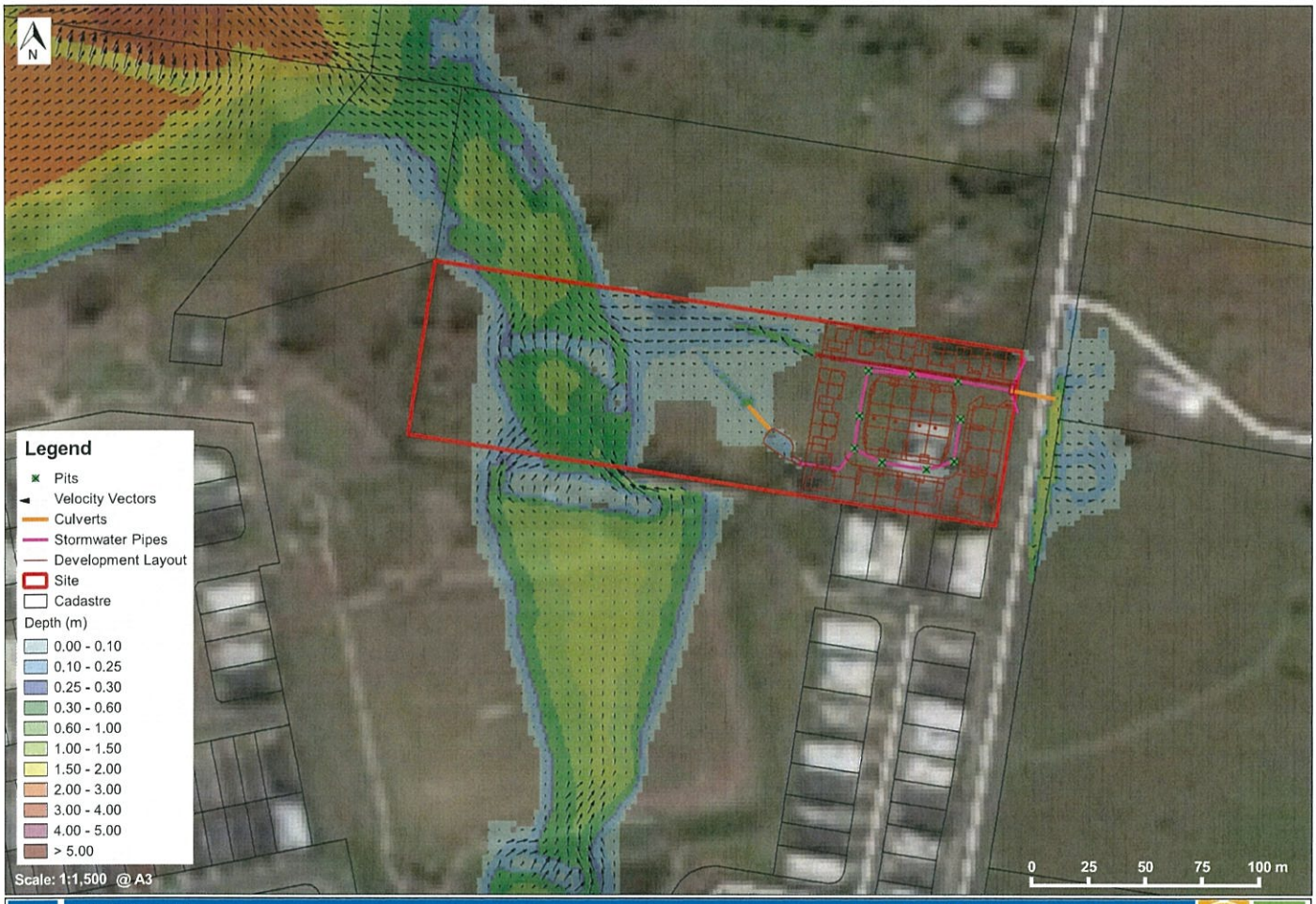

N
Legend
Pits
Velocity Vectors
Culverts
Stormwater Pipes
Development Layout
Site
Cadastre
Depth (m)
0.00 - 0.10
0.10 - 0.25
0.25 - 0.30
0.30 - 0.60
0.60 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 3.00
3.00 - 4.00
4.00 - 5.00
> 5.00
Scale: 1:1,500 @ A3
0 25 50 75 100 m
Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 29/01/2016
Logan Reserve Flood Assessment - Developed Case
Peak Flood Depth - 2% AEP 60min
2016-01-29 13:40:02



Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 29/01/2016

Logan Reserve Flood Assessment - Developed Case
Peak Water Surface Level - 2% AEP 60min

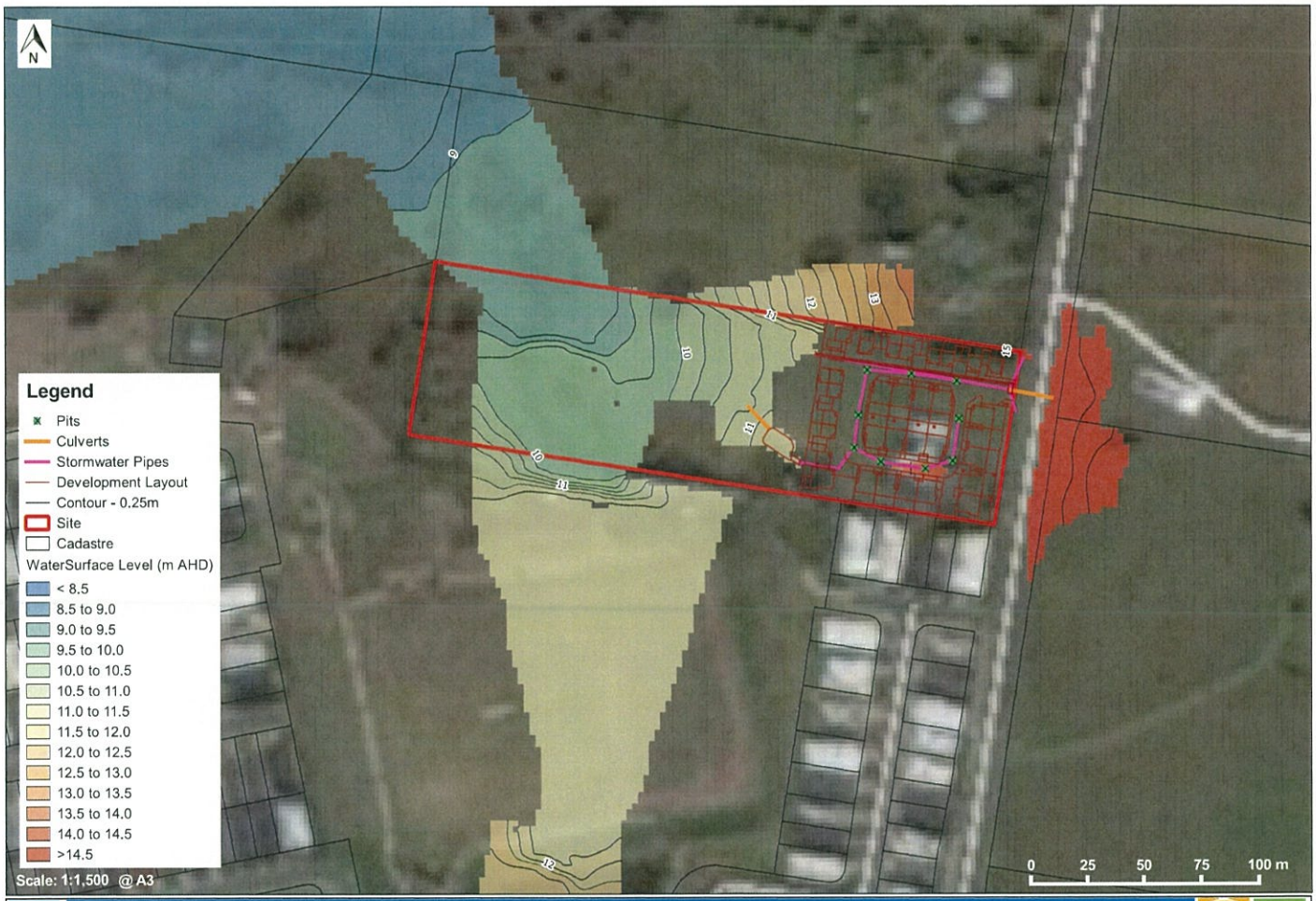
2016-01-29T13:29:46



Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 29/01/2016

Logan Reserve Flood Assessment - Developed Case
Peak Flood Depth - 1% AEP 60min

2016-01-29T13:39:00


N
Legend
Pits
Culverts
Stormwater Pipes
Development Layout
Contour - 0.25m
Site
Cadastre
WaterSurface Level (m AHD)
< 8.5
8.5 to 9.0
9.0 to 9.5
9.5 to 10.0
10.0 to 10.5
10.5 to 11.0
11.0 to 11.5
11.5 to 12.0
12.0 to 12.5
12.5 to 13.0
13.0 to 13.5
13.5 to 14.0
14.0 to 14.5
>14.5
Scale: 1:1,500 @ A3
0 25 50 75 100 m
Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 29/01/2016
Logan Reserve Flood Assessment - Developed Case
Peak Water Surface Level - 1% AEP 60min

APPENDIX E EXISTING CASE FLOOD IMPACT GIS MAPS

Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 01/02/2016

Logan Reserve Flood Assessment - Developed Case (Existing Catchment)
Flood Impact - 18% AEP 60min

2016-02-01T14:34:22

Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 01/02/2016

Logan Reserve Flood Assessment - Developed Case (Existing Catchment)
Flood Impact - 10% AEP 60min

2016-02-01T14:25:52

Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 01/02/2016

Logan Reserve Flood Assessment - Developed Case (Existing Catchment)
Flood Impact - 2% AEP 60min

2016-02-01T14:39:38

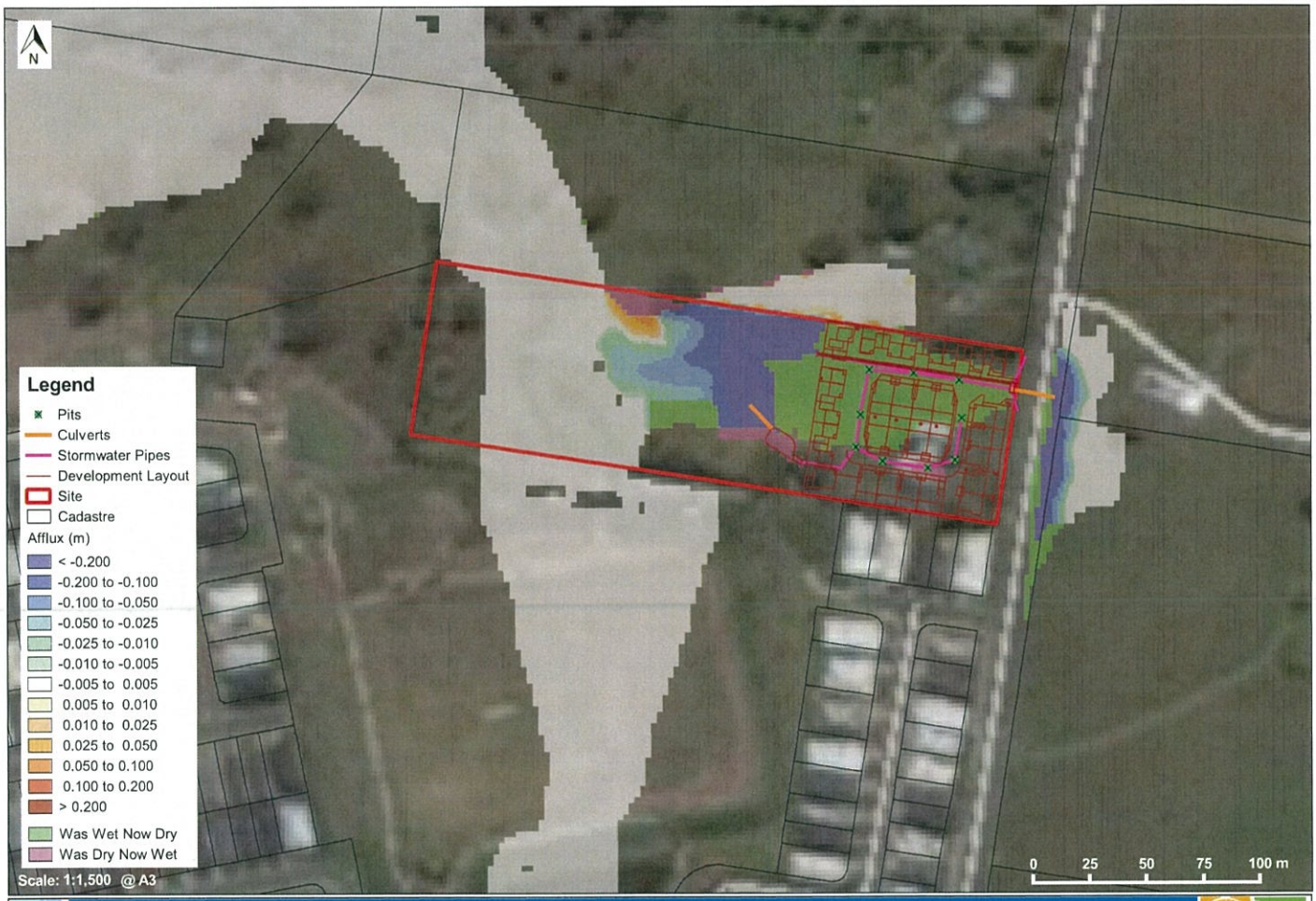
Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 01/02/2016

Logan Reserve Flood Assessment - Developed Case (Existing Catchment)
Flood Impact - 1% AEP 60min

2016-02-01T14:30:30

APPENDIX F DEVELOPMENT IMPACT GIS MAPS


N
Legend
Pits
Culverts
Stormwater Pipes
Development Layout
Site
Cadastre
Afflux (m)
< -0.200
-0.200 to -0.100
-0.100 to -0.050
-0.050 to -0.025
-0.025 to -0.010
-0.010 to -0.005
-0.005 to 0.005
0.005 to 0.010
0.010 to 0.025
0.025 to 0.050
0.050 to 0.100
0.100 to 0.200
> 0.200
Was Wet Now Dry
Was Dry Now Wet
Scale: 1:1,500 @ A3
0 25 50 75 100 m
Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 29/01/2016
Logan Reserve Flood Assessment
Flood Impact - 18% AEP 60min
2016-01-29T13:53:52



Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 29/01/2016

Logan Reserve Flood Assessment
Flood Impact - 10% AEP 60min

2016-01-29113:36:09

Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 29/01/2016

Logan Reserve Flood Assessment
Flood Impact - 2% AEP 60min

2016-01-29T13:35:17


N
Legend
Pits
Culverts
Stormwater Pipes
Development Layout
Site
Cadastre
Afflux (m)
< -0.200
-0.200 to -0.100
-0.100 to -0.050
-0.050 to -0.025
-0.025 to -0.010
-0.010 to -0.005
-0.005 to 0.005
0.005 to 0.010
0.010 to 0.025
0.025 to 0.050
0.050 to 0.100
0.100 to 0.200
> 0.200
Was Wet Now Dry
Was Dry Now Wet
Scale: 1:1,500 @ A3
0 25 50 75 100 m
Map Coordinates: GDA 1994
Water Technology Pty Ltd
Date: 29/01/2016
Logan Reserve Flood Assessment
Flood Impact - 1% AEP 60min
2016-01-29T13:34:25