# Flood Risk Assessment

## 200 Aldington Industrial Estate

NW30034

Prepared for
Fife Kemps Creek Pty Limited

15 October 2020

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Shaping the Future

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# Executive Summary

This report has been prepared to inform a State Significant Development Application (SSDA) for the staged development of the Fife Kemps Creek (FKC) properties at Lots 20-23 and Lots 30-32 Aldington Road in Kemps Creek.

The purpose of this report is to provide a high-level understanding of the opportunities and constraints of the site due to flooding and to inform the development of a stormwater strategy/management plan for the 200 Aldington Industrial Estate based on an assessment of flooding under benchmark (pre-development) conditions.

Detailed flood modelling to assess the impacts of the proposed 200 Aldington Estate is described in the companion Flood Impact Assessment report (refer Cardno, 2020).

## Hydrology

Hydrological modelling of the South Creek catchment was undertaken at the catchment scale using XP-RAFTS.

A comparison of the 2008/2016/2019 GHD/Oakdale South/Oakdale West assessments with other studies highlighted significant differences in the peak flow estimates. Comparisons of the catchment area to the Sydney Water Pipeline and the catchment boundaries and the peak flows led to a re-discretisation of the upper Ropes Creek catchment in the 2008/2016/2019 GHD/Oakdale South/Oakdale West model and a review of the adopted levels of imperviousness as well as the partitioning of the site based on the local subcatchments under existing conditions.

An assessment of the sensitivity of 100 yr ARI peak runoff to storm burst rainfall losses, model parameter values and version of ARR was undertaken in order to identify the benchmark conditions for this study.

These cases which were reviewed and/or assessed were:

- The 2008/2016/2019 GHD/Oakdale South/Oakdale West model (GHD, 2008: Cardno, 2016,2019) (Case 1)
- The 2015 Ropes Creek model (Worley Parsons, 2015) (Case 2)
- The Southern Link Road model (Lyall & Associates, 2020) (Case 3)

The re-discretised GHD model (this study) for three scenarios:

- ARR1987 IDF + Rainfall losses and roughness values and BX value from GHD, 2008; Cardno, 2016b, 2019 (Case 4)
- ARR1987 + Rainfall losses and model parameter from Worley Parsons, 2015 (Case 5)
- ARR2019 + ARR2019 rainfall losses + and roughness values and BX value from GHD, 2008; Cardno, 2016b, 2019 (Case 6)

It was concluded that:

(i) The 100 yr ARI peak flows under Case 4 are far closer to the Worley Parsons (Case 2) peak flows than the previous Oakdale South/Oakdale West/GHD (Case 1) estimates;

(ii) A change in the critical storm burst duration to 9 hours with the1.5 hour and 2 hour peak flows being not too much lower (under ARR1987);

(iii) The adoption of ARR2019 would reduce the critical storm burst duration to 6 hours and would further reduce the 1% AEP peak flows.

For assessment purposes, Case 4 was adopted for the assessment of the benchmark conditions.

## Hydraulics

The assessment of the flooding in Ropes Creek was undertaken using a TUFLOW model of the upper Ropes Creek floodplain. An assessment of the sensitivity of 100 yr ARI flood levels under pre-development conditions was undertaken in order to identify the benchmark conditions for this study. The cases which were reviewed and/or assessed included:

- The 2008 GHD model of Existing Conditions (GHD, 2008)
- The 2015 Ropes Creek model (Worley Parsons, 2015)
- The 2016 GHD model with Oakdale South (Cardno, 2016)
- The 2019 GHD model with Oakdale South and Oakdale West (Cardno, 2019)
- The 2008 GHD model of Existing Conditions with revised hydrology (this study) (Case E1)
- The 2019 GHD model with Oakdale South and Oakdale West and revised hydrology (this study) (Case E2)

The following was concluded from these results:

(i) The 2015 Worley Parsons 100 yr ARI flood levels under Existing Conditions are significantly lower than the 2008 GHD 100 yr ARI flood levels under Existing Conditions (0.2 m – 0.73 m lower);

(ii) The revised 100 yr ARI flood levels under Existing Conditions (this study – Case E1) are significantly lower than the 2008 GHD 100 yr ARI flood levels under Existing Conditions (0.1 m – 0.39 m lower) but remain higher than 2015 Worley Parsons 100 yr ARI flood levels under Existing Conditions (0.14 – 0.36 m higher)

(iii) While the impact of Oakdale South and Oakdale West under revised Existing Conditions (this study - Case E2) in comparison to 2019 GHD model with Oakdale South and Oakdale West are increases of up to 0.21 m this is in an area where the 2019 lowered the 100 yr ARI flood level by 0.19 m – consequently the net effect is a flood levels which is the same as under Case E1;

(iv) The incremental impacts of Oakdale South and Oakdale West under revised Existing Conditions (this study - Case E2) in comparison to revised Existing Conditions are increases of up to 0.05 m (but in locations where the revised flows have lowered the 100 yr ARI flood level);

Based on this comparative assessment, Case E2, which incorporates Oakdale South and Oakdale West which is currently under construction, was adopted as the benchmark conditions.

The TUFLOW floodplain model was run for the critical storm burst durations for the 2 yr ARI, 5 yr ARI, 100 yr ARI and PMF events under Benchmark Conditions. Flood levels and extent, depths, velocities and hazards under Benchmark Conditions are plotted for each of these events.

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# 1 Introduction

## 1.1 Purpose of this Report

This report has been prepared to inform a State Significant Development Application (SSDA) for the staged development of the Fife Kemps Creek (FKC) property at Lots 20-23 and Lots 30-32 Aldington Road in Kemps Creek.

The purpose of this report is to provide a high-level understanding of the opportunities and constraints of the site due to flooding and to inform the development of a stormwater strategy/management plan for the 200 Aldington Industrial Estate based on an assessment of flooding under Pre-development conditions.

This report supports an Environmental Impact Statement (EIS) prepared in respect of the proposal and should be read in conjunction with the EIS, Civil Infrastructure report and development plans submitted with the SSDA.

## 1.2 Location

The site address is known as 106 – 142 (Lots 30-32) and 144 – 228 (Lots 20-23) Aldington Road, Kemps Creek.

The location of the site is indicated in **Figure 1**.

## 1.3 Planning Context

In September 2020 the Department of Planning and Environment released the Western Sydney Aerotropolis Plan which applies to the land comprising the Aerotropolis which contains 10 precincts, six of which will be the focus of initial precinct planning. One of the initial precincts is the Mamre Road Precinct which includes the site of the proposed 200 Aldington Industrial Estate.

As stated, in part, in the Plan:

> *6.4.2 Floodplain management*
>
> *The NSW Government's Flood Prone Land Policy aims to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone land. The NSW Floodplain Development Manual (2005) guides the process of floodplain risk management. Floodplain risk management studies and plans identify and prioritise ways to reduce risk of damage from flooding.*
>
> *… The Blue–Green Infrastructure Framework provides an ideal opportunity to accommodate and manage overland flow through innovative stormwater retention strategies without unnecessarily sterilising land.*
>
> *… Flood management infrastructure and planning should account for climate change and the reforestation of the Blue–Green Infrastructure Framework as part of the landscape- led approach. Reforestation will be planned so as to not impede flood management.*
>
> *… Precinct planning will need to consider floodplain risk management measures such as safe evacuation routes, cut and fill and development issues for the entire floodplain. Development controls will apply to land within the 1 in 100-year flood area in line with each Council's relevant policy.*

There are also various planning instruments and development controls that are applicable to development located in the Penrith Local Government Area (LGA). These were identified by Jacobs, 2016, in part, as follows.

### 1.3.1 Penrith Local Environmental Plan 2010

The first stage of the Penrith Local Environmental Plan 2010 was published in 2010 and applied to Penrith's rural and industrial areas and St Marys Town Centre. The second stage of the Penrith LEP was published on 28 January 2015 and came into effect on 25 February 2015 to set planning controls for much of the areas not covered by Stage 1 of Penrith Local Environmental Plan 2010, including the City's residential and commercial areas.

The Penrith Local Environmental Plan (LEP) zones the land within the Penrith LGA and imposes standards to control development, or implements a state or local policy outcome. Clause 7.2 'Flood Planning' in the Penrith LEP provides the details of items which the consent authority must satisfy themselves of before providing development consent. The clause applies to all land at or below the flood planning level (100 year average recurrence interval (ARI) event plus 0.5m freeboard). The LEP aims to ensure that the development:

- *Is compatible with the flood hazard of the land*
- *Is not likely to adversely affect flood behaviour, flow distributions or velocities resulting in detrimental increases in the potential flood affectation of other development or properties or the environment (including stability of waterways and riparian vegetation)*
- *Is not likely to adversely affect the safe and effective evacuation of the land and the surrounding area*
- *Is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding*
- *Manages the risk to life from flood*

The LEP also includes Flood Planning Land Maps defining the Flood Planning Area (FPA) (see below). It is noted that while Council's Flood Planning Area extends both into the Lots 31 & 32, Aldington Road that this area is not connected across the boundary between Lots 31 and 32. Development of Lots 31 and 32, Aldington Road as part of the 200 Aldington Industrial Estate would be occurring on flood prone lands for the purpose of the SEPP (WSEA).

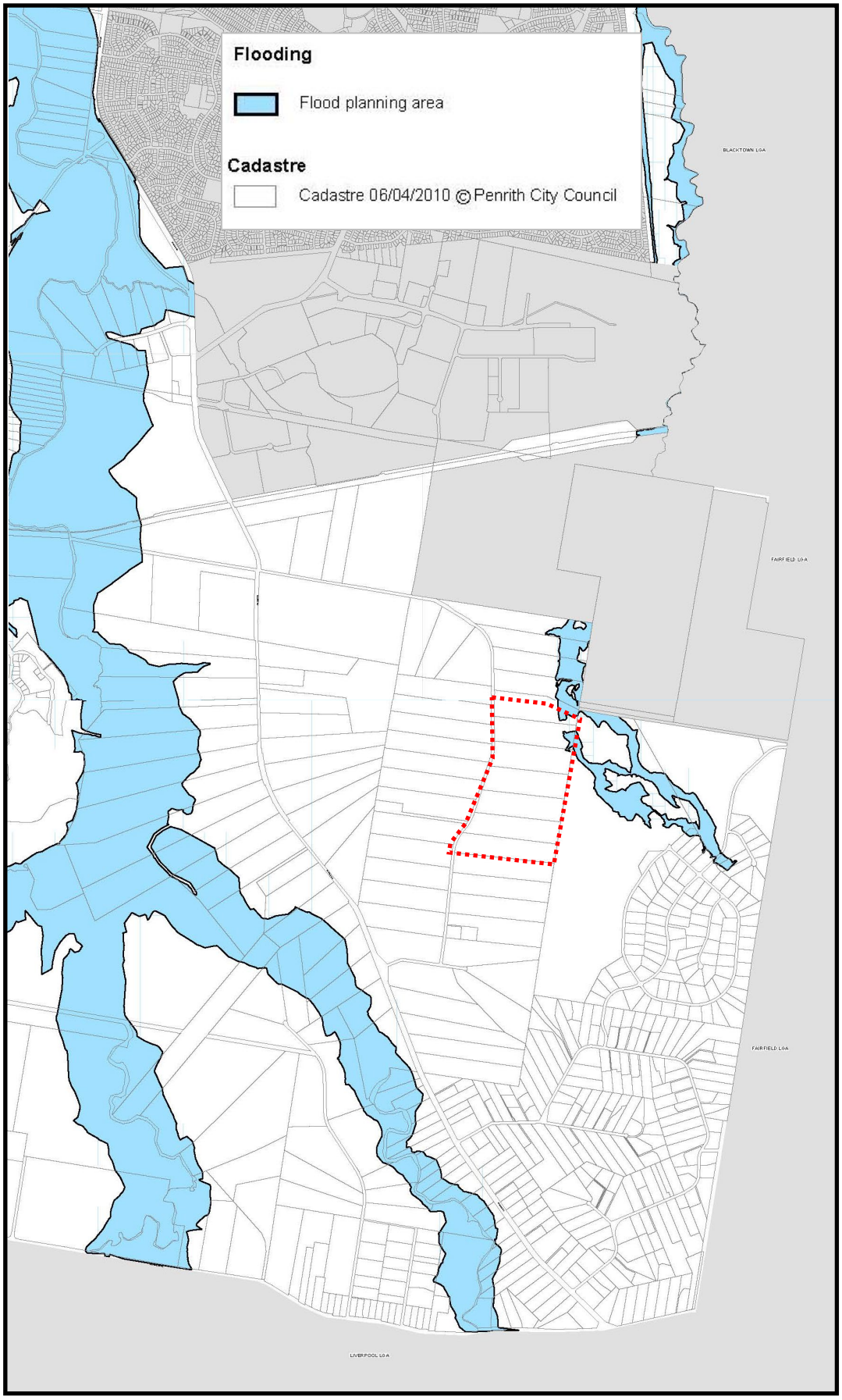
### 1.3.2 Penrith Development Control Plan 2014

Chapter C3 Water Management of the Penrith Development Control Plan (DCP) 2014 outlines the flooding constraints on developments in Chapter 3.5.

As stated in Chapter 3.5:

> *The LEP contains provisions for development on land at or below the flood planning level, defined in the LEP as the level of a 1:100 Average Recurrence Interval (ARI) (1% AEP (100 year ARI)) flood event plus 0.5m freeboard.*
>
> *The 1% AEP (100 year ARI) flood event is a tool for broadly assessing the suitability of land for development. It is not an assessment of flood risk, nor does reference to the 1% AEP (100 year ARI) flood event mean that properties and development above this level are not subject to flood risk.*
> *….*

*Significant areas of Penrith are affected by the Probable Maximum Flood (PMF) and in some cases this will need to be considered in determining flood hazard.*



**Penrith LEP 2010 Flood Planning Area**

*….*

*13 Overland Flow Flooding*

*a) Council has undertaken a Penrith Overland Flow Flood 'Overview' Study. Consideration must be given to the impact on any overland flow path. Generally, Council will not support development obstructing overland flow paths. Development is required to demonstrate that any overland flow is maintained for the 1% AEP (100 year ARI) overland flow. A merit based approach will be taken when assessing development applications that affect the overland flow.*

*b) Council's Stormwater Drainage Specification for Building Developments provides information on the details required in the preparation of an overland flow study.*

*15 Rezoning of Land*

*a) Council will not support the rezoning of any land located in a floodway or high hazard area.*

*b) Council will generally not support the rezoning of rural land situated below the 1% AEP (100 year ARI) flood where the development of that land may require or permit the erection of buildings or works even if the surface of the land can be raised to a level above the 1% AEP (100 year ARI) flood by means of filling.*

*c) Where land below the flood planning level is currently zoned to permit urban development, Council will generally not support the rezoning of land to permit a higher economic use or an increase in the density of development.*

### 1.3.3 State Environmental Planning Policy (Western Sydney Employment Area) 2009

The Mamre Road Precinct (MRP) was rezoned on 12 June 2020.

The State Environmental Planning Policy (Western Sydney Employment Area) 2009 (SEPP (WSEA)) was amended and the Mamre Road Structure Plan was introduced.

The aims of the SEPP (WSEA) are set out in Part 1 Preliminary as follows:

***3 Aims of Policy***

*(1) This Policy aims to protect and enhance the land to which this Policy applies (the **Western Sydney Employment Area**) for employment purposes.*

*(2) The particular aims of this Policy are as follows—*

*(a) to promote economic development and the creation of employment in the Western Sydney Employment Area by providing for development including major warehousing, distribution, freight transport, industrial, high technology and research facilities,*

*(b) to provide for the co-ordinated planning and development of land in the*

*Western Sydney Employment Area,*

*(c) to rezone land for employment, environmental conservation or recreation purposes,*

*(d) to improve certainty and regulatory efficiency by providing a consistent planning regime for future development and infrastructure provision in the Western Sydney Employment Area,*

*(e) to ensure that development occurs in a logical, environmentally sensitive and cost-effective manner and only after a development control plan (including specific development controls) has been prepared for the land concerned,*

*(f) to conserve and rehabilitate areas that have a high biodiversity or heritage or cultural value, in particular areas of remnant vegetation.*

The relevant primary considerations are set out in Part 6 Miscellaneous provisions as follows.

***33 Infrastructure development and use of existing buildings of the Crown***

***33I Development on flood prone land***

*(1) This clause applies to development requiring consent that is carried out on flood prone land.*

*(2) Consent is not to be granted to the carrying out of development to which this clause applies unless the consent authority has taken into consideration whether or not*

*(a) the development will adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and*

*(b) the development will alter flow distributions and velocities to the detriment of other properties or the environment of the floodplain, and*

*(c) the development will enable safe occupation of the flood prone land, and*

*(d) the development will detrimentally affect the floodplain environment or cause avoidable erosion, siltation, salinity, destruction of riparian vegetation or a reduction in the stability of the riverbank/watercourse, and*

*(e) the development will be likely to result in unsustainable social and economic costs to the flood affected community or general community, as a consequence of flooding, and*

*(f) the development is compatible with the flow conveyance function of the floodway, and*

*(g) the development is compatible with the flood hazard, and*

*(h) in the case of development consisting of the excavation or filling of land, the development—*

*(i) will detrimentally affect the existing drainage patterns and soil stability in the locality, and*

*(ii) will adversely impact or alter flood behaviour.*

***Note.*** *Clause 33H contains other matters that the consent authority must consider before granting development consent for earthworks.*

### 1.3.4 Draft Mamre Road Precinct DCP 2020

As stated in the Mamre Road Precinct Finalisation Study dated June 2020:

> *The Department is preparing a Development Control Plan (DCP) in consultation with Council to provide detailed design controls for development in the precinct. Until a DCP is finalised, Clause 18 of the WSEA SEPP applies to any DA. It requires a DCP to be prepared and applicable to a site. It is anticipated a draft DCP will be exhibited in the second half of 2020.*

Given that the draft Mamre Road Precinct DCP has not yet been exhibited it is expected that the Western Sydney Aerotropolis DCP 2020 – Phase 1 gives an indication of the flooding considerations which are likely to be included in the draft Mamre Road Precinct DCP. These are overviewed in **Section 1.3.5**.

### 1.3.5 Western Sydney Aerotropolis DCP 2020 – Phase 1

As stated in the Western Sydney Aerotropolis DCP 2020 dated September 2020:

> *This Phase 1 DCP identifies the precinct planning principles, objectives and performance outcomes to allow precinct planning to progress.*
>
> *The Phase 2 DCP will be released once precinct planning for the initial precincts within the Western Sydney Aerotropolis (Aerotropolis) is finalised. The Phase 2 DCP will identify:*
>
> - *additional performance outcomes including specific precinct outcomes;*
> - *acceptable solutions for all performance outcomes; and*
> - *the objectives, performance outcomes and acceptable solutions for all development and subdivision types that are envisaged within the Aerotropolis (which have not been considered under this Phase 1 DCP).*

This DCP was adopted by the Minister for Planning and Public Spaces on 4 September 2020 and comes into force on 1 October 2020.

Section 4.2 Flooding of the Western Sydney Aerotropolis DCP 2020 - Phase 1 details the following performance outcomes for flooding:

> ***4.2 Flooding***
>
> *4.2.1 Objectives*
>
> *a) Minimise the flood risk to life and property.*
>
> *b) Ensure development does not adversely impact flood functions.*
>
> *c) Provide protection of the natural environment.*
>
> *d) Floodplains are to be used for amenity and recreation opportunities as well as flood function, where appropriate.*

*4.2.2 Performance Outcomes*

*PO1 Ensure the siting and layout of development responds to flooding affectation and maintains personal safety at all times. The site layout and ultimate footprint of the development should be compatible with the flood risk. This includes applying subdivision design for greater resilience to flooding.*

*PO2 Manage the passage of floodwaters through the floodplain.*

*PO3 Avoid intensification and new development on land subject to the 1 in 100-year flood event.*

*PO4 Fill should not reduce the capacity of the floodplain.*

*PO5 Fill should remain stable and not be affected by erosion and scour.*

*PO6 Development must not change the flood characteristics of the area, and is to consider cumulative impacts of development, outside the site including:*

*a) loss of flood storage;*
*b) loss of or changes to flood flow paths;*
*c) acceleration or obstruction of flood flows;*
*d) increase in the depth, duration or velocity of flood waters; or*
*e) any reduction in flood warning times elsewhere on the floodplain.*

*PO7 Prevent intensification of inappropriate use of land within high flood risk areas or floodways.*

*PO8 Ensure development is sited to enable vehicular egress in the event of a flood.*

*PO9 Ensure public safety and the environment are not adversely affected by the detrimental impacts of floodwater on hazardous materials manufactured or stored in bulk.*

*PO10 Ensure essential services infrastructure within a site (including electricity, gas, water supply, wastewater and telecommunications) maintains its function during and immediately after flood events.*

*PO11 Development must be designed and constructed so that it remains structurally sound for the life of the development, considering the flood events likely to impact the structure, foundations/footing system and external walls. Development must be designed to prevent flotation, collapse or permanent lateral movement (as per ASCE24-14).*

*PO12 Flooding and drainage characteristics upstream or downstream of the site are not worsened by development, including any proposed works on natural creeks. The development is to also avoid significant adverse effects on the floodplain environment that would cause erosion, siltation, destruction of riparian vegetation or a reduction in the stability of the river bank/watercourse.*

*PO13 Fencing must be designed and constructed so that it does not impede and/or direct the flow of floodwaters, add debris to floodwaters or increase flood affectation on surrounding land.*

*PO14 Development is to be in accordance with NSW Governments Flood Prone Land Policy and Floodplain Development Manual.*

*PO15 Post-development flows that enter or are conveyed across the Pipelines corridor must be equal to or less than the pre-development flows for each storm event up to and including 1% AEP event.*

### 1.3.6 NSW Flood Risk Management Framework

As described by Jacobs, 2016:

**NSW FRM Policy and Guidelines**

The NSW Flood Prone Land Policy as produced within Section 1.1 of the Floodplain Development Manual (FDM 2005) is consistent with that first introduced in 1984, which places the primary responsibility for implementation on local councils. Penrith City Council has adopted the principles and recommendations in the 2005 FDM and applied them to the plans and policies they have implemented.

The primary objective of the NSW Flood Prone Land Policy recognises the following two important facts:

- flood prone land is a valuable resource that should not be sterilised by unnecessarily precluding its development; and
- if all development applications and proposals for rezoning of flood prone land are assessed according to rigid and prescriptive criteria, some appropriate proposals may be unreasonably disallowed or restricted, and equally, quite inappropriate proposals may be approved.

The primary objective is as follows:

> "*To reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible.*"

The flood study for South Creek was completed in 2015 and Penrith City Council is currently finalising the South Creek Floodplain Risk Management Study and Plan. A Draft South Creek Floodplain Risk Management Study and Plan, was placed on public exhibition by Council from Thursday 31 October to Thursday 28 November 2019.

**2007 Flood Planning Guideline**

On January 31, 2007 the NSW Planning Minister announced a new guideline for development control on floodplains (the "Flood Planning Guideline"). An overview of the new Guideline and associated changes to the Environmental Planning and Assessment Act, 1979 (EPA Act) and Environmental Planning and Assessment Regulation 2000 (Regulation) was issued by the Department of Planning in a Circular dated January 31, 2007 (Reference PS 07-003). The Flood Planning Guideline issued by the Minister in effect relates to a package of directions and changes to the EPA Act, Regulation and the FDM.

This Flood Planning Guideline provides an amendment to the Manual. The Guideline confirms that unless there are "exceptional circumstances", Councils are to adopt the 100 year ARI flood as the flood planning level (FPL) for residential development, with the exception of some sensitive forms of residential development such as seniors living housing. The Guideline does provide that controls on residential development above the 100 year ARI flood may be imposed subject to an "exceptional circumstance" justification being agreed to by the Department of Natural Resources (now the Office of Environment and Heritage - OEH) and the Department of Planning (now the Department of Planning and Environment) prior to the exhibition of a Draft LEP or Draft DCP.

The "Guideline on Development Controls on Low Flood Risk Areas – Floodplain Development Manual" defines Standards for Flood Controls for Residential Development. Whilst the flood used to define the residential FPL is a decision of Council, FDM highlights that FPLs for typical residential development would generally be based on the 100 year ARI flood plus an appropriate freeboard (typically 0.5m). Penrith City Council has adopted these recommendations provided in the guideline.

**State Environmental Planning Policies**

A State Environmental Planning Policy (SEPP) is a planning document prepared in accordance with the EPA Act by the NSW Department of Planning and Environment and eventually approved by the Minister, which deals with matters of significance for environmental planning for the State. Clause 1.19 of the Codes SEPP has been amended so that land identified as 'flood control lot' is no longer excluded from the application of the General Housing Code.

Instead, specified development and development standards have been added to the General Housing Code for development on low hazard flood control lots. The development standards have been designed to ensure that complying development is not allowed on high hazard or high risk flood control lots including floodways, flood storage areas, a flowpath or areas identified in local flood plans as high hazard or high risk.

**Section 117 Directions**

Ministerial directions pursuant to Section 117(2) of the EPA Act specify matters which local councils must take into consideration in the preparation of LEPs. Direction 4.3, as currently applies, deals specifically with flood [liable] prone land and has the following two objectives:

*"(a) To ensure that the development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual, 2005.*

*(b) To ensure that the provisions of an LEP on flood prone land is commensurate with flood hazard and includes consideration of the potential flood impacts both on and off the subject land".*

The Direction applies to all councils that contain flood prone land when an LEP proposes to "*create, remove or alter a zone or provision that affects flood prone land*." In such cases, the Direction requires draft LEPs to ensure the following:

*(4) A planning proposal must include provisions that give effect to and are consistent with the NSW Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas).*

*(5) A planning proposal must not rezone land within the flood planning areas from Special Use, Special Purpose, Recreation, Rural or Environmental Protection Zones to a Residential, Business, Industrial, Special Use or Special Purpose Zone.*

*(6) A planning proposal must not contain provisions that apply to the flood planning areas which:*

- *a. permit development in floodway areas,*
- *b. permit development that will result in significant flood impacts to other properties,*
- *c. permit a significant increase in the development of that land,*
- *d. are likely to result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services, or*

*e. permit development to be carried out without development consent except for the purposes of agriculture (not including dams, drainage canals, levees, buildings or structures in floodways or high hazard areas), roads or exempt development.*

*(7) A planning proposal must not impose flood related development controls above the residential flood planning level for residential development on land, unless a relevant planning authority provides adequate justification for those controls to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).*

*(8) For the purposes of a planning proposal, a relevant planning authority must not determine a flood planning level that is inconsistent with the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas) unless a relevant planning authority provides adequate justification for the proposed departure from that Manual to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).*

**2020 Flood Prone Land Package**

As advised on the DPIE website (https://www.planning.nsw.gov.au/Policy-and-Legislation/Managing-risk-in-land-use-planning/Flooding):

*The Department has been working to update the Flood Prone Land Package which provides advice to councils on considering flooding in land use planning and consists of:*

- *a proposed amendment to schedule 4, section 7A of the Environmental Planning and Assessment Regulation 2000*
- *a revised planning circular*
- *a revised local planning direction regarding flooding issued under section 9.1 of the Environmental Planning and Assessment Act 1979*
- *revised Local Environmental Plan flood clauses*
- *a new guideline: Considering Flooding in Land Use Planning (2020).*

The updated Flood Prone Land Package was on exhibition until **25 June 2020.**

## 1.4 Approach

Previous assessments of flooding and flood risk management in the Ropes Creek catchment have been reported in the:

- 1991 South Creek Floodplain Risk Management Study (Willing & Partners, 1991)
- 2006 Penrith Overland Flow Flood "Overview Study" (Cardno Lawson Treloar, 2006)
- 2008 Ropes Creek Flood Study (GHD, 2008)
- 2015 Updated South Creek Flood Study (Worley Parsons, 2015)
- 2016 Oakdale South Industrial Estate Flood Impact Assessment (Cardno, 2016)
- 2019 Draft South Creek Floodplain Risk Management Study and Plan (Worley Parsons, 2019)
- 2019 Oakdale West Industrial Estate Flood Impact Assessment (Cardno, 2019)
- 2020 Southern Link Road Flooding and Drainage Investigation (Lyall & Associates, 2020)

The approach adopted to the hydrological and hydraulic assessments is outlined as follows.

### 1.4.1 Hydrology

ARR1987

In 2008 GHD undertook hydrological and hydraulic modelling of the upper Ropes Creek catchment including the overall Oakdale development. Hydrological modelling was undertaken at the catchment and development scale. Results for the catchment hydrological modelling were not included in the 2008 report.

After some adjustments, the 2008 GHD hydrological model was adopted for flow estimation purposes for the 2016 Oakdale South Estate and 2019 Oakdale West Estate flood impact assessments. The subcatchment boundaries under Existing Conditions in the vicinity of the Oakdale South and Oakdale West Estates were updated to define in greater detail the local runoff from a number of subcatchments. These models were based on ARR1987 IFD.

The hydrological model assembled by Worley Parsons in 2015 was based on ARR1987 IFD. The 2015 study also identified the critical storm burst duration for Ropes Creek to be 36 hours. While any future development would be expected to have an adverse impact of peak flows in short duration storm bursts it is likely that any future development will have minimal or nil adverse or beneficial impact on peak flows in a 36 hour storm due to the duration of the storm and timing effects due to runoff from impervious areas occurring more rapidly than runoff from pervious areas.

A comparison of the 2008/2016/2019 GHD/Oakdale South/Oakdale West assessments with other studies highlighted significant differences in the peak flow estimates. Comparisons of the catchment area to the Sydney Water Pipeline and the catchment boundaries and the peak flows led to a re-discretisation of the upper Ropes Creek catchment in the 2008/2016/2019 GHD/Oakdale South/Oakdale West model and a review of the adopted levels of imperviousness and the partitioning of the site based on the local subcatchments under existing conditions.

ARR2019

An additional sensitivity assessment was undertaken using ARR2019 IFD and burst losses. The revised hydrological model was run to generate inflows for the floodplain model.

### 1.4.2 Hydraulics

The assessment of the impact or otherwise of the 200 Aldington Industrial Estate on the Ropes Creek floodplain was undertaken using a the 2008/2016/2019 GHD/Oakdale South/Oakdale West TUFLOW model of the upper Ropes Creek floodplain. This model was modified to represent a number of development concepts and to assess the impact of the preferred development layout.

## 1.5 Terminology

Book 1, Chapter 2, Section 2.2.5. Adopted Terminology in Australian Rainfall & Runoff, 2016 describes the adopted terminology as follows:

> *To achieve the desired clarity of meaning, technical correctness, practicality and acceptability, the National Committee on Water Engineering has decided to adopt the terms shown in Figure 1.2.1 and the suggested frequency indicators.*

| Frequency Descriptor | EY | AEP (%) | AEP (1 in x) | ARI |
|---|---|---|---|---|
| Very Frequent | 12 | | | |
| | 6 | 99.75 | 1.002 | 0.17 |
| | 4 | 98.17 | 1.02 | 0.25 |
| | 3 | 95.02 | 1.05 | 0.33 |
| | 2 | 86.47 | 1.16 | 0.5 |
| | 1 | 63.21 | 1.58 | 1 |
| Frequent | 0.69 | 50 | 2 | 1.44 |
| | 0.5 | 39.35 | 2.54 | 2 |
| | 0.22 | 20 | 5 | 4.48 |
| | 0.2 | 18.13 | 5.52 | 5 |
| | 0.11 | 10 | 10 | 9.49 |
| Rare | 0.05 | 5 | 20 | 20 |
| | 0.02 | 2 | 50 | 50 |
| | 0.01 | 1 | 100 | 100 |
| Very Rare | 0.005 | 0.5 | 200 | 200 |
| | 0.002 | 0.2 | 500 | 500 |
| | 0.001 | 0.1 | 1000 | 1000 |
| | 0.0005 | 0.05 | 2000 | 2000 |
| Extreme | 0.0002 | 0.02 | 5000 | 5000 |
| | | | ↓ | |
| | | | PMP/ PMPDF | |

*Figure 1.2.1. Australian Rainfall and Runoff Preferred Terminology*

*Navy outline indicates preferred terminology. Shading indicates acceptable terminology which is depends on the typical use. For example in floodplain management 0.5% AEP might be used while in dam design this event would be described as a 1 in 200 AEP.*

*As shown in the third column of Figure 1.2.1, the term Annual Exceedance Probability (AEP) expresses the probability of an event being equalled or exceeded in any year in percentage terms, for example, the 1% AEP design flood discharge. There will be situations where the use of percentage probability is not practicable; extreme flood probabilities associated with dam spillways are one example of a situation where percentage probability is not appropriate. In these cases, it is recommended that the probability be expressed as 1 in X AEP where 100/X would be the equivalent percentage probability.*

*For events more frequent than 50% AEP, expressing frequency in terms of annual exceedance probability is not meaningful and misleading, as probability is constrained to a maximum value of 1.0 or 100%. Furthermore, where strong seasonality is experienced, a recurrence interval approach would also be misleading. An example of strong seasonality is where the rainfall occurs predominately during the Summer or Winter period and as a consequence flood flows are more likely to occur during that period.*

*Accordingly, when strong seasonality exists, calculating a design flood flow with a 3 month recurrence interval is of limited value as the expectation of the time period between occurrences will not be consistent throughout the year. For example, a flow with the magnitude of a 3 month recurrence interval would be expected to occur or be exceeded 4 times a year; however, in situations where there is strong seasonality in the rainfall, all of the occurrences are likely to occur in the dominant season.*

*Consequently, events more frequent than 50% AEP should be expressed as X Exceedances per Year (EY). For example, 2 EY is equivalent to a design event with a 6 month recurrence interval when there is no seasonality in flood occurrence*

The terminology adopted herein depends on the edition of Australian Rainfall and Runoff provide the IFD data. In the case of assessments based on ARR1987 the ARI terminology was adopted design floods. In the case of assessments based on ARR2019 the AEP terminology was adopted design floods.

# 2 Previous Studies

Previous assessments of flooding and flood risk management in the Ropes Creek catchment have been reported in:

- 1991 South Creek Floodplain Risk Management Study (Willing & Partners, 1991)
- 2006 Penrith Overland Flow Flood "Overview Study" (Cardno Lawson Treloar, 2006)
- 2008 Ropes Creek Flood Study (GHD, 2008)
- 2015 Updated South Creek Flood Study (Worley Parsons, 2015)
- 2016 Oakdale South Industrial Estate Flood Impact Assessment (Cardno, 2016)
- 2019 Draft South Creek Floodplain Risk Management Study and Plan (Worley Parsons, 2019)
- 2019 Oakdale West Industrial Estate Flood Impact Assessment (Cardno, 2019)
- 2020 Southern Link Road Flooding and Drainage Investigation (Lyall & Associates, 2020)

These studies are overviewed in **Appendix B.**

# 3 Hydrology

Hydrological modelling of the South Creek catchment was undertaken at the catchment scale using XP-RAFTS.

A comparison of the 2008/2016/2019 GHD/Oakdale South/Oakdale West assessments with other studies highlighted significant differences in the peak flow estimates. Comparisons of the catchment area to the Sydney Water Pipeline and the catchment boundaries and the peak flows led to a re-discretisation of the upper Ropes Creek catchment in the 2008/2016/2019 GHD/Oakdale South/Oakdale West model and a review of the adopted levels of imperviousness as well as the partitioning of the site based on the local subcatchments under existing conditions.

The subcatchment boundaries in the upper Ropes Creek catchment adopted in the revised XP-RAFTS model are plotted in **Figure 2**. The local subcatchment boundaries within the site are plotted in **Figure 3**.

The revised hydrological model run to generate inflows for the floodplain model.

## 3.1 Initial Sensitivity Assessment

An assessment of the sensitivity of 100 yr ARI peak runoff to storm burst rainfall losses, model parameter values and version of ARR was undertaken in order to identify the benchmark conditions for this study.

These cases which were reviewed and/or assessed were:

- The 2008/2016/2019 GHD/Oakdale South/Oakdale West model (GHD, 2008; Cardno, 2016,2019) (Case 1)
- The 2015 Ropes Creek model (Worley Parsons, 2015) (Case 2)
- The Southern Link Road model (Lyall & Associates, 2020) (Case 3)

The re-discretised GHD model (this study) for three scenarios:

- ARR1987 IDF + Rainfall losses and roughness values and BX value from GHD, 2008: Cardno, 2016,2019 (Case 4)
- ARR1987 + Rainfall losses and model parameter from Worley Parsons, 2015 (Case 5)
- ARR2019 + ARR2019 rainfall losses + and roughness values and BX value from GHD, 2008: Cardno, 2016,2019 (Case 6)

The storm burst rainfall losses, model parameter values and version of ARR used for each assessment are summarised in **Table 1**.

The peak flows were estimated for 100 yr ARI storm burst durations from 30 minutes to 36 hours. The 100 yr ARI peak flows estimated at the Sydney Water Pipeline and just north of the NE corner of the 200 Aldington Industrial Estate site are summarised in **Tables 2** and **3** respectively.

There are significant differences between the peak flows the 2008/2016/2019 GHD/Oakdale South/Oakdale West models (Case 1) and the 2015 Worley Parsons model (Case 2). This was attributed to the 2008 GHD study adopting conservative imperviousness values for the upper catchment which appear to represent a future development condition with more intense development than currently exists.

**Table 1 Rainfall Losses and Model Parameter Values for Various Studies**

| Case | Catchment Area (ha) | ARR Edition | Rainfall Losses | | | | Catchment Roughness | | BX |
|---|---|---|---|---|---|---|---|---|---|
| | | | Pervious | | Impervious | | Pervious | Impervious | |
| | | | IL(mm) | CL (mm/h) | IL(mm) | CL (mm/h) | | | |
| 1 | 1795 | 1987 | 15 | 2 | 2.5 | 0 | 0.025 | 0.06 | 1.0 |
| 2 | 1683 | 1987 | 32.6 | 0.94 | 1 | 0 | 0.025 | 0.025 | 1.3 |
| 3 | *NR* | 1987 | 15 | 2.5 | 2 | 0 | *NR* | *NR* | 0.8 |
| 4 | 1710 | 1987 | 15 | 2 | 2.5 | 0 | 0.025 | 0.06 | 1.0 |
| 5 | 1710 | 1987 | 32.6 | 0.94 | 1 | 0 | 0.025 | 0.025 | 1.3 |
| 6 | 1710 | 2019 | PNIBL | 2.3 | 2.5 | 0 | 0.025 | 0.06 | 1.0 |

*NR = Not Reported* *PNIBL = Probability Neutral Initial Burst Losses obtained from the ARR Data Hub*

**Table 2 100 yr ARI Peak Flows ($m^3/s$) at Sydney Water Pipeline**

| Case | Burst Duration (hrs) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0.5 | 1 | 1.5 | 2 | 3 | 6 | 9 | 12 | 36 |
| 1 | 197.2 | 203.3 | 207.7 | 205.2 | 158.0 | 128.6 | 138.3 | 124.9 | 107.8 |
| 2 | 8.7 | 23.9 | 36.0 | 46.2 | 61.3 | 78.1 | 98.3 | 95.8 | 98.2 |
| 4 | 64.4 | 81.9 | 97.6 | 97.7 | 84.1 | 83.1 | 104.7 | 95.5 | 94.9 |
| 5 | 55.8 | 76.7 | 93.3 | 94.9 | 83.1 | 92.9 | 123.5 | 104.1 | 111.0 |
| 6 | - | 80.2 | 83.3 | 85.0 | 83.6 | 91.8 | 84.7 | 88.1 | 68.2 |

**Table 3 100 yr ARI Peak Flows ($m^3/s$) just north of the NE Corner of 200 Aldington Industrial Estate**

| Case | Burst Duration (hrs) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0.5 | 1 | 1.5 | 2 | 3 | 6 | 9 | 12 | 36 |
| 1 | 189.7 | 189.9 | 192.1 | 188.6 | 142.3 | 109.7 | 115.8 | 106.3 | 88.2 |
| 2 | 6.7 | 18.6 | 28.0 | 36.1 | 48.4 | 63.0 | 79.2 | 77.0 | 78.8 |
| 4 | 57.4 | 70.2 | 82.0 | 80.0 | 65.8 | 68.2 | 84.1 | 78.7 | 76.4 |
| 5 | 51.7 | 66.9 | 78.4 | 77.0 | 69.1 | 77.1 | 101.7 | 88.3 | 90.0 |
| 6 | - | 68.2 | 68.3 | 69.5 | 68.9 | 74.9 | 68.4 | 72.6 | 53.3 |

Comparisons of the catchment area to the Sydney Water Pipeline and the catchment boundaries and the peak flows led to a re-discretisation of the upper Ropes Creek catchment in the 2008/2016/2019 GHD/Oakdale South/Oakdale West model and a review of the adopted levels of imperviousness and the partitioning of the site based on the local subcatchments under existing conditions (Case 4).

The sensitivity of the revised hydrological model to the 2015 Worley Parsons storm burst rainfall losses, model parameter values and ARR1987 IFD was tested in Case 5.

The sensitivity of the revised hydrological model to ARR2019 IFD and rainfall loss values was tested in Case 6.

It was concluded that:

(i) The 100 yr ARI peak flows under Case 4 are far closer to the Worley Parsons (Case 2) peak flows than the previous Oakdale South/Oakdale West/GHD (Case 1) estimates;

(ii) A change in the critical storm burst duration to 9 hours with the1.5 hour and 2 hour peak flows being not too much lower (under ARR1987);

(iii) The adoption of ARR2019 would reduce the critical storm burst duration to 6 hours and would further reduce the 1% AEP peak flows.

## 3.2 Hydrological Modelling

For assessment purposes, Case 4 was adopted for the assessment of the benchmark conditions.

Design rainfall and storm burst patterns were obtained from ARR1987 for 2 yr ARI, 20 yr ARI and 100 yr ARI events.

The PMP depths were generated using the procedures built into XP-RAFTS which estimate PMP depths in accordance with in The Estimation of Probable Maximum Precipitation in Australia: Generalised Short – Duration Method (Bureau of Meteorology, 2003) and as adopted in the 2008/2016/2019 GHD/Oakdale South/Oakdale West models.

For the 2 yr ARI, 20 yr ARI and 100 yr ARI events the adopted pervious area initial rainfall loss = 15 mm and continuing rainfall loss = 2.0 mm/h while for impervious areas an initial loss = 2.5 mm and continuing rainfall loss = 2.0 mm/h was adopted.

For the PMF the adopted rainfall losses were an initial loss = 1 mm and a continuing loss = 0 mm/h.

The revised hydrological model run to generate inflows for the floodplain model.

# 4 Flooding Assessment

The assessment of the impact or otherwise of development on the Ropes Creek floodplain was undertaken using a TUFLOW model of the upper Ropes Creek floodplain.

The model extent covers those portions of the subject site draining to Ropes Creek.

The roughness zones for the floodplain are mapped in **Figure 4**.

Inflows to the TUFLOW model were exported from the hydrological model and input at the locations of the subcatchment outlets (nodes).

## 4.1 Pre-Development (Existing) Conditions

An assessment of the sensitivity of 100 yr ARI flood levels under pre-development conditions was undertaken in order to identify the benchmark conditions for this study. The cases which were reviewed and/or assessed were the:

- 2008 GHD model of Existing Conditions (GHD, 2008)
- 2015 Ropes Creek model (Worley Parsons, 2015)
- 2016 GHD model with Oakdale South (Cardno, 2016)
- 2019 GHD model with Oakdale South and Oakdale West (Cardno, 2019)
- 2008 GHD model of Existing Conditions with revised hydrology (this study) (Case E1)
- 2019 GHD model of Oakdale South, Oakdale West and revised hydrology (this study) (Case E2)

**Table 4** summarises the 100 yr ARI flood levels extracted at 11 reference locations (0, 1, 2, 3, …10) identified in **Figure 21** for each of the cases identified above.

The following was concluded from these results:

(i) The 2015 Worley Parsons 100 yr ARI flood levels under Existing Conditions are significantly lower than the 2008 GHD 100 yr ARI flood levels under Existing Conditions (0.2 m – 0.73 m lower);

(ii) The revised 100 yr ARI flood levels under Existing Conditions (this study – Case E1) are significantly lower than the 2008 GHD 100 yr ARI flood levels under Existing Conditions (0.1 m – 0.39 m lower) but remain higher than 2015 Worley Parsons 100 yr ARI flood levels under Existing Conditions (0.14 – 0.36 m higher)

(iii) While the impact of Oakdale South and Oakdale West under revised Existing Conditions (this study - Case E2) in comparison to 2019 GHD model with Oakdale South and Oakdale West are increases of up to 0.21 m this is in an area where the 2019 lowered the 100 yr ARI flood level by 0.19 m – consequently the net effect is a flood levels which is the same as under Case E1;

(iv) The incremental impacts of Oakdale South and Oakdale West under revised Existing Conditions (this study - Case E2) in comparison to revised Existing Conditions are increases of up to 0.05 m (but in locations where the revised flows have lowered the 100 yr ARI flood level).

Based on this comparative assessment, Case E2, which incorporates Oakdale South and Oakdale West Industrial Estates which are currently under construction, was adopted as the benchmark conditions.

**Table 4 Comparison of 100 yr ARI Flood Levels at Reference Locations**

| Reference Location | Existing (2008 GHD) (mAHD) (a) | Existing (2015 Worley Parsons) (mAHD) (b) | Flood Level Difference (cm) (b) - (a) | Oakdale South + Oakdale West (Cardno, 2019) (mAHD) (c) | Flood Level Difference (cm) (c) - (a) | Revised Existing (E1) (mAHD) (f) | Flood Level Difference (cm) (f) - (a) | Flood Level Difference (cm) (f) - (b) | Revised Oakdale South + Oakdale West (E2) (mAHD) (g) | Flood Level Difference (cm) (g) - (c) | Flood Level Difference (cm) (g) - (f) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 64.61 | 64.41 | -20 | 64.56 | -5 | 64.30 | -31 | -11 | 64.30 | -26 | 0 |
| 1 | 64.05 | 63.80 | -25 | 63.86 | -19 | 64.07 | 2 | 27 | 64.07 | 21 | 0 |
| 2 | 64.01 | 63.68 | -33 | 63.85 | -16 | 63.91 | -10 | 23 | 63.91 | 6 | 0 |
| 3 | 63.90 | 63.64 | -26 | 63.79 | -11 | 63.83 | -7 | 19 | 63.83 | 4 | 0 |
| 4 | 63.12 | 62.47 | -65 | 62.84 | -28 | 62.75 | -37 | 28 | 62.76 | -8 | 1 |
| 5 | 63.10 | 62.37 | -73 | 62.82 | -28 | 62.73 | -37 | 36 | 62.74 | -8 | 1 |
| 6 | 62.02 | 61.41 | -61 | 61.84 | -18 | 61.63 | -39 | 22 | 61.65 | -19 | 2 |
| 7 | 60.26 | 60.00 | -26 | 60.25 | -1 | 60.14 | -12 | 14 | 60.16 | -9 | 2 |
| 8 | 57.67 | 57.27 | -40 | 57.66 | -1 | 57.48 | -19 | 21 | 57.53 | -13 | 5 |
| 9 | 56.68 | 56.26 | -42 | 56.72 | 4 | 56.57 | -11 | 31 | 56.62 | -10 | 5 |
| 10 | 54.52 | 54.24 | -28 | 54.51 | -1 | 54.40 | -12 | 16 | 54.41 | -10 | 1 |

## 4.2 Benchmark Conditions

The TUFLOW floodplain model was run for the critical storm burst durations for the 2 yr ARI, 5 yr ARI, 100 yr ARI and PMF events under Benchmark Conditions.

### 4.2.1 2 yr ARI

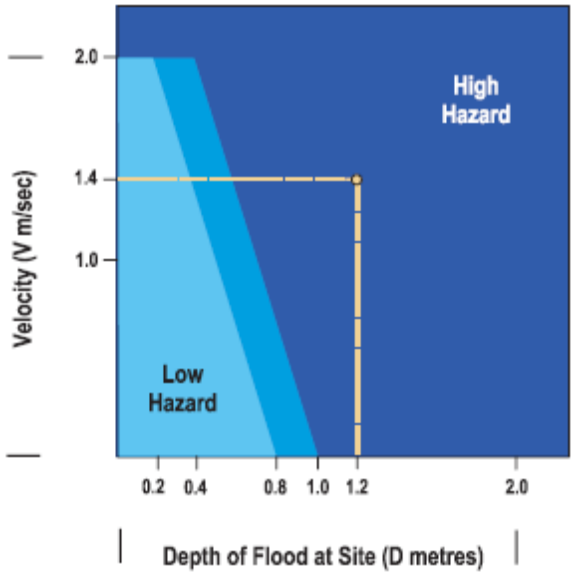
The estimated 2 year ARI flood levels and extent, depths and velocities under Benchmark Conditions are plotted in **Figures 5, 6** and **7** respectively.

Experience from studies of floods throughout NSW and elsewhere has allowed authorities to develop methods of assessing the hazard to life and property on floodplains. This experience has been used in developing the NSW Floodplain Development Manual to provide guidelines for managing this hazard. These guidelines are shown schematically below.

To use the diagram, it is necessary to know the average depth and velocity of floodwaters at a given location. If the product of depth and velocity exceeds a critical value (as shown below), the flood flow will create a high hazard to life and property.

There will probably be danger to persons caught in the floodwaters, and possible structural damage. Evacuation of persons would be difficult. By contrast, in low hazard areas people and their possessions can be evacuated safely by trucks. Between the two categories a transition zone is defined in which the degree of hazard is dependent on site conditions and the nature of the proposed development.

This calculation leads to a provisional hazard rating. The provisional hazard rating may be modified by consideration of effective flood warning times, the rate of rise of floodwaters, duration of flooding and ease or otherwise of evacuation in times of flood. The estimated 2 year ARI provisional flood hazard under Benchmark Conditions are plotted in **Figure 8**.




Provisional Hazard Categories (after Figure L2, NSW Government, 2005)

### 4.2.2 20 yr ARI

The estimated 20 year ARI flood levels and extent, depths, velocities and hazards under Benchmark Conditions are plotted in **Figures 9, 10, 11** and **12** respectively.

### 4.2.3 100 yr ARI

The estimated 100 year ARI flood levels and extent, depths, velocities and hazards under Benchmark Conditions are plotted in **Figures 13, 14, 15** and **16** respectively.

### 4.2.4 PMF

The estimated PMF flood levels and extent, depths, velocities and hazards under Benchmark Conditions are plotted in **Figures 17, 18, 19** and **20** respectively.

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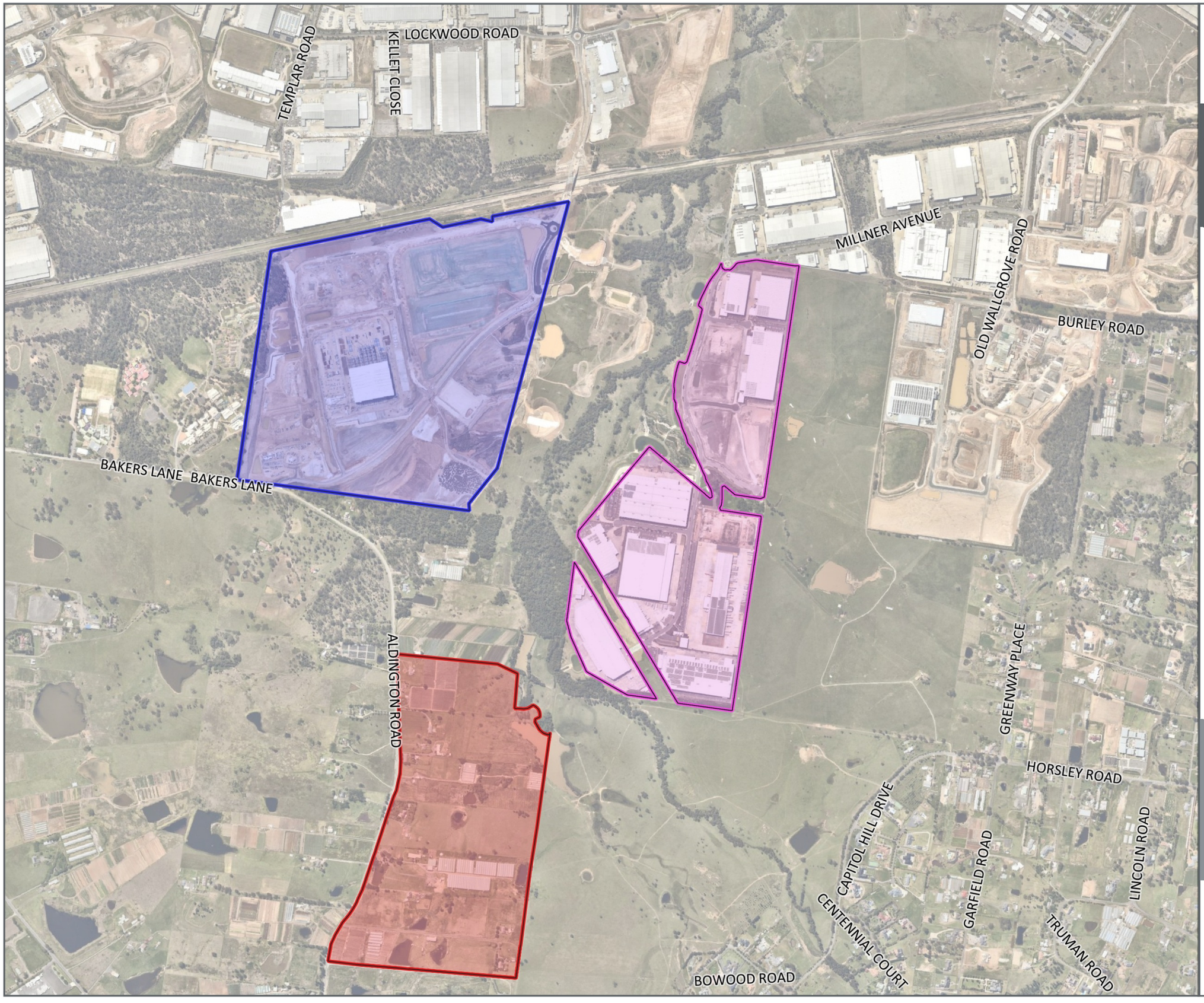
# APPENDIX A
## FIGURES

Cardno
Shaping the Future

# Fife Kemps Creek Pty Limited

## 200 Aldington Industrial Estate

**Benchmark**
**Location of 200 Aldington Industrial Estate**




**Legend**

- Oakdale_West
- Oakdale_South
- 200 Aldington

**FIGURE 1**

**1:14000 Scale at A3**

0 100 200 300 400 500 m

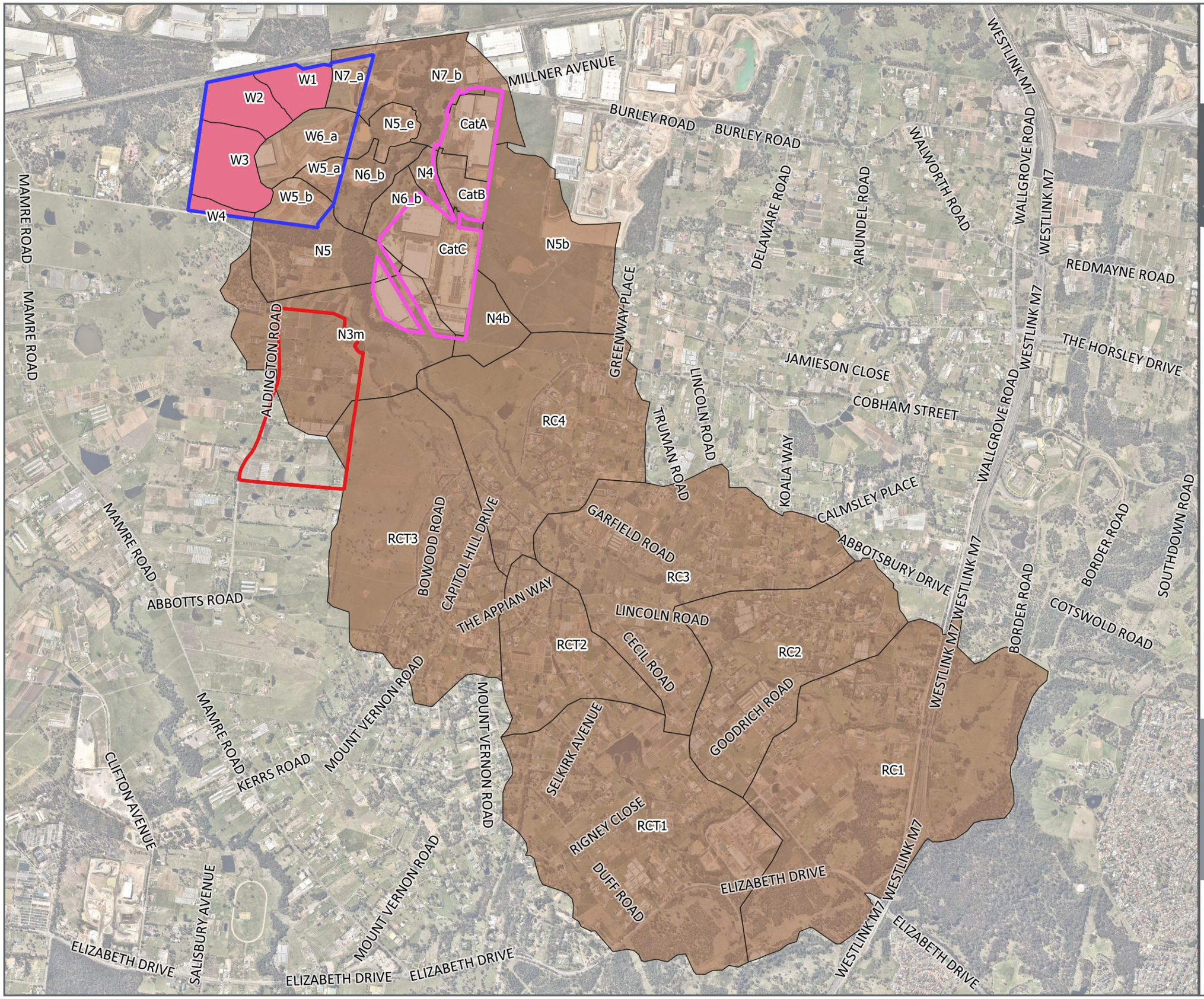
Cardno

Map Produced by St Leonards Water (AWE)
Date: 2020-10-15| Project: XXXXXXXX
Coordinate System: MGA Zone 56
Map: FKC Figures.qgz

# Fife Kemps Creek Pty Limited

## 200 Aldington Industrial Estate

**Benchmark Subcatchment Boundaries in XPRAFTS model**




**Legend**

- Oakdale_West_Study_Area
- Oakdale_South_Study_Area
- 200 Aldington_Study_Area
- Subcatchment Boundaries West
- Subcatchment Boundaries

**FIGURE 2**

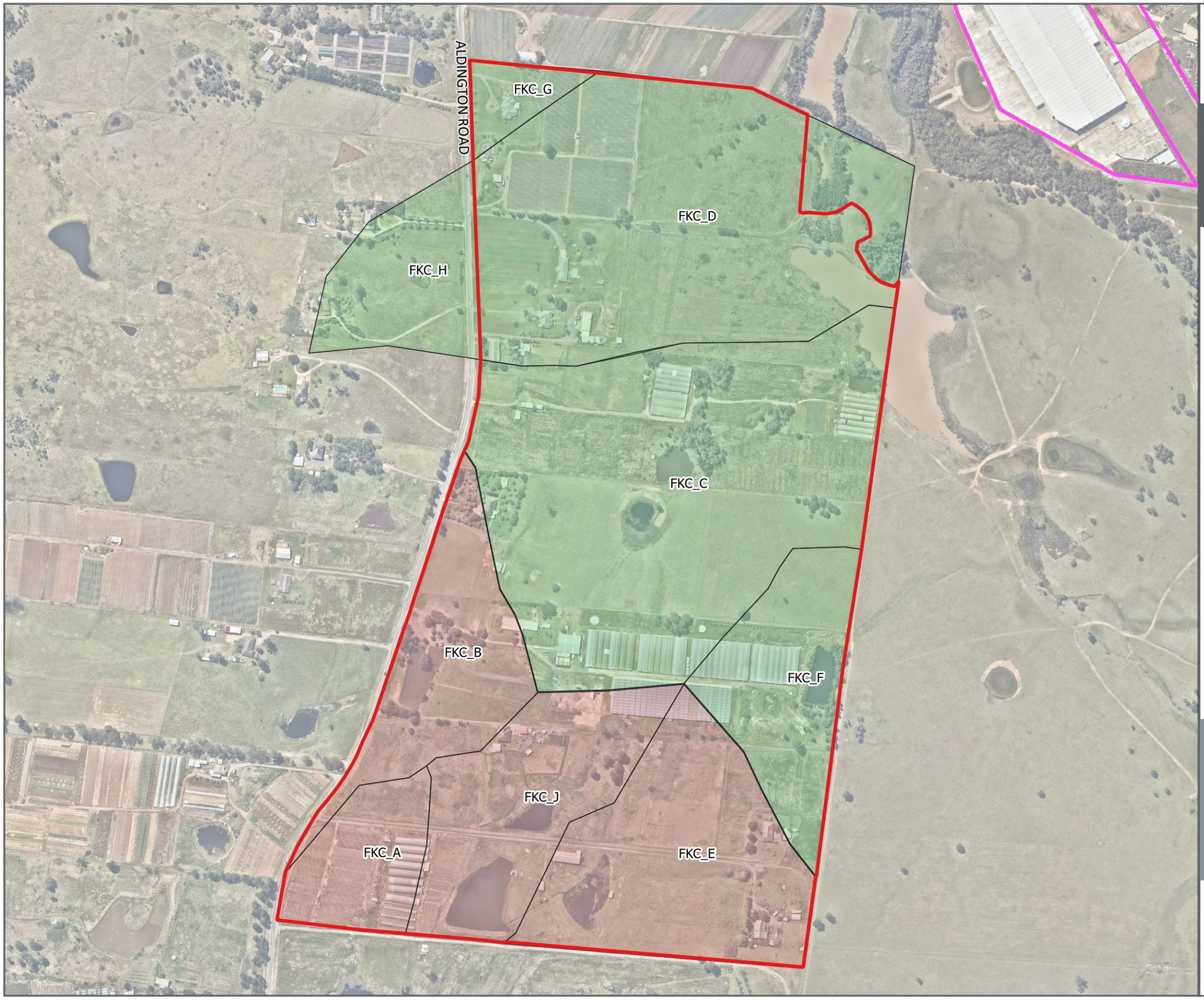
**1:25000 Scale at A3**

0 200 400 600 800 1000 m

N

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2020-10-15| Project: XXXXXXXX
Coordinate System: MGA Zone 56
Map: FKC Figures.qgz




# Fife Kemps Creek Pty Limited

## 200 Aldington Industrial Estate

**Benchmark**
**Local Subcatchment Boundaries**

**Legend**

- 200 Aldington_Study_Area
- Local Subcatchments draining to Ropes Creek
- Local Subcatchments draining to Kemps Creek

**FIGURE 3**

**1:5000** **Scale at A3**

0 50 100 150 200 250 m

N

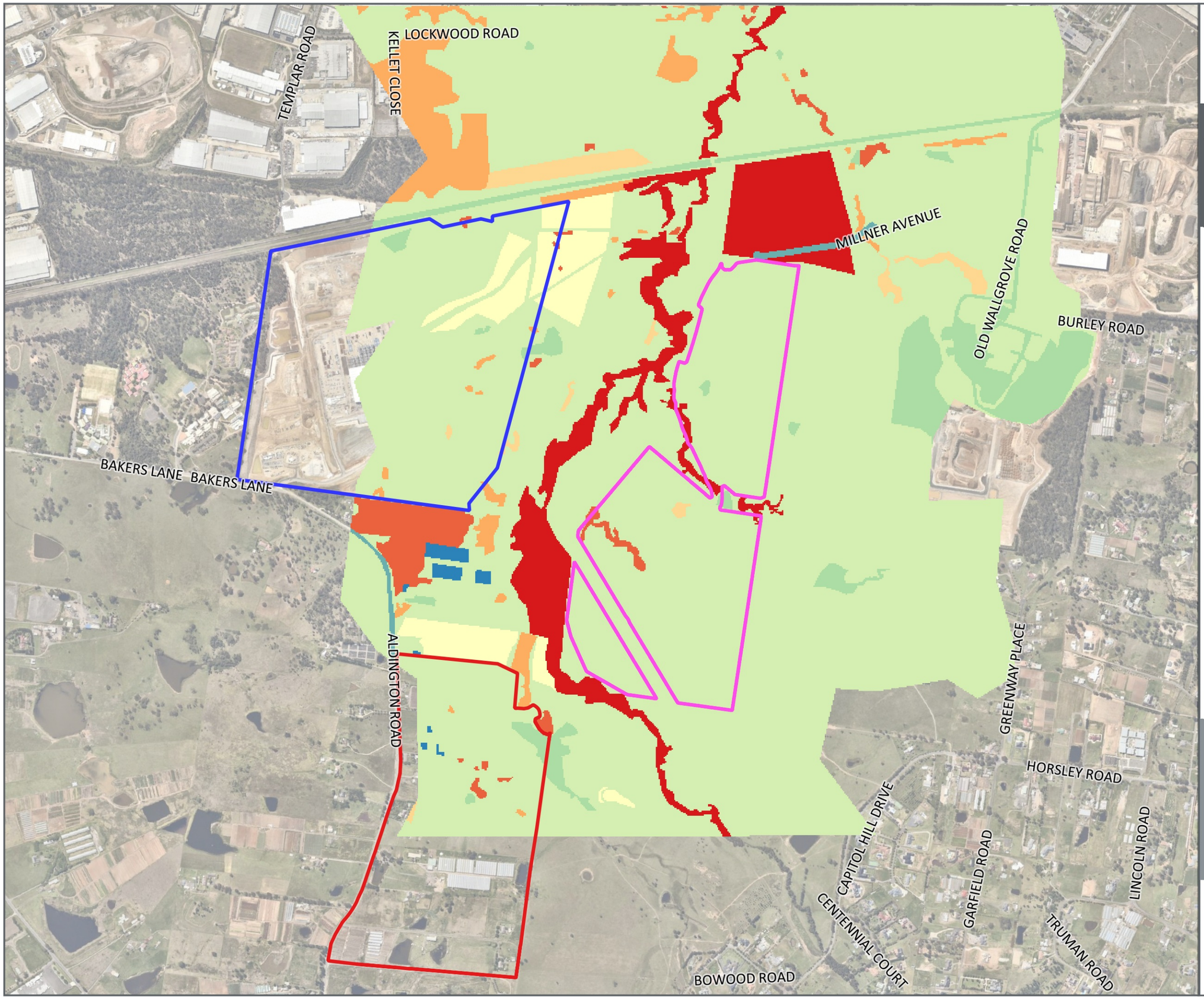
Cardno

Map Produced by St Leonards Water (AWE)
Date: 2020-10-15| Project: XXXXXXXX
Coordinate System: MGA Zone 56
Map: FKC Figures.qgz

# Fife Kemps Creek Pty Limited

## 200 Aldington Industrial Estate

**Benchmark**
**Adopted Roughness Zones**




**Legend**

- Oakdale_West_Study_Area
- Oakdale_South_Study_Area
- 200 Aldington_Study_Area

Roughness Zones

- n=0.12
- n=0.10
- n=0.08
- n=0.05
- n=0.035
- n=0.03
- n=0.022
- n=0.017
- n=4

**FIGURE 4**

**1:14000 Scale at A3**

0 100 200 300 400 500 m

N

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2020-10-15| Project: XXXXXXXX
Coordinate System: MGA Zone 56
Map: FKC Figures.qgz

# Fife Kemps Creek Pty Limited

## 200 Aldington Industrial Estate

**Benchmark**
**2 yr ARI Flood Extents and Flood Levels**

TEMPLAR ROAD
KELLET CLOSE
LOCKWOOD ROAD
MILLNER AVENUE
OLD WALLGROVE ROAD
BURLEY ROAD
BAKERS LANE
BAKERS LANE
ALDINGTON ROAD
BOWOOD ROAD
CENTENNIAL COURT
CAPITOL HILL DRIVE
GARFIELD ROAD
TRUMAN ROAD
LINCOLN ROAD
HORSLEY ROAD
GREENWAY PLACE

**Legend**

- Oakdale_West_Study_Area
- Oakdale_South_Study_Area
- 200 Aldington_Study_Area

Benchmark 2 yr ARI
Water Level (m)

- <= 56
- 56 - 57
- 57 - 58
- 58 - 59
- 59 - 60
- 60 - 61
- 61 - 62
- 62 - 63
- 63 - 64
- > 64

**FIGURE 5**

**1:14000 Scale at A3**

0 100 200 300 400 500 m

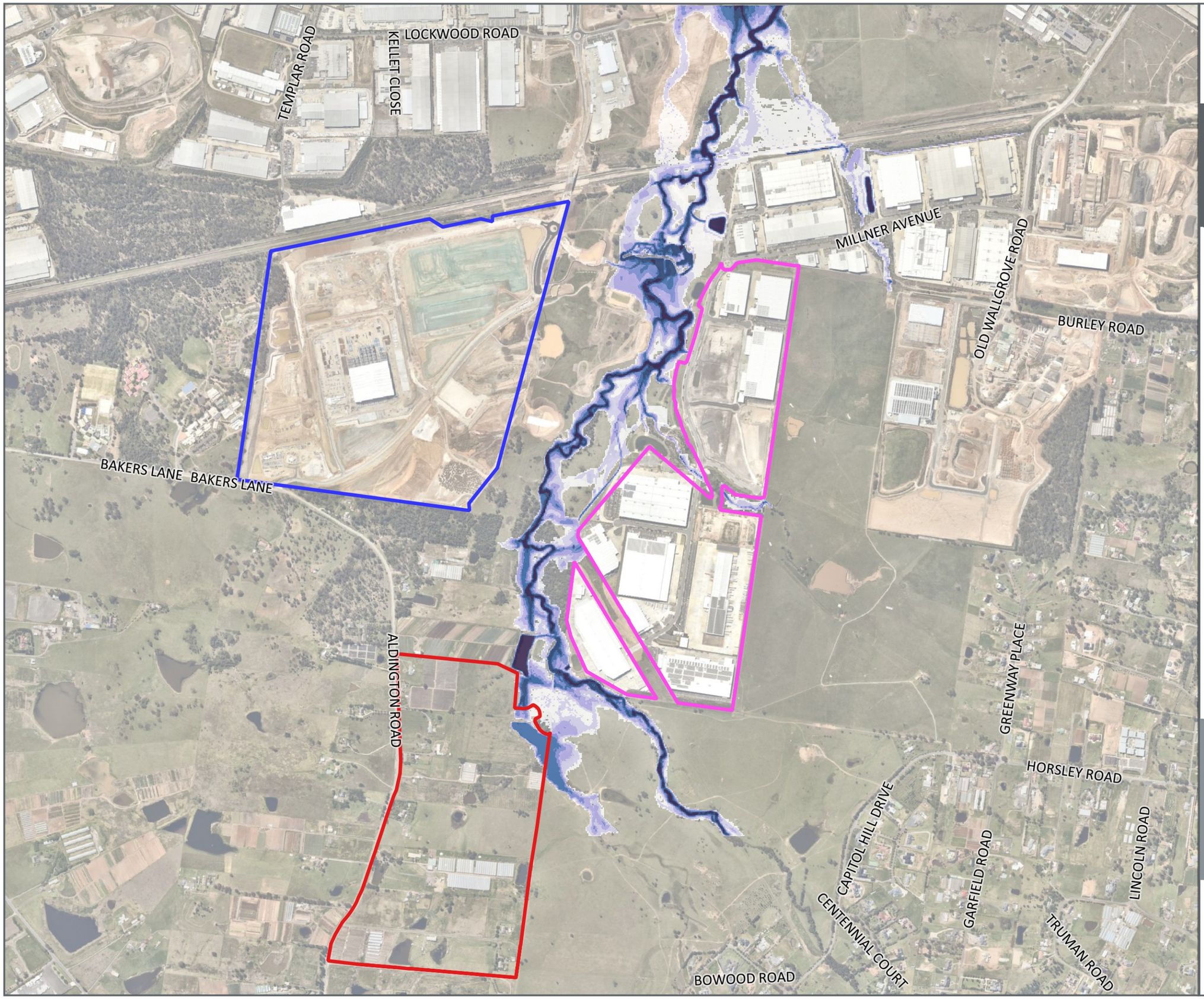
Cardno

Map Produced by St Leonards Water (AWE)
Date: 2020-10-15| Project: XXXXXXXX
Coordinate System: MGA Zone 56
Map: FKC Figures.qgz

# Fife Kemps Creek Pty Limited

## 200 Aldington Industrial Estate

**Benchmark**
**2 yr ARI Depth (m)**




**Legend**

- Oakdale_West_Study_Area
- Oakdale_South_Study_Area
- 200 Aldington_Study_Area

Benchmark 2 yr ARI Depth (m)

- 0.00 to 0.10
- 0.10 to 0.30
- 0.30 to 0.50
- 0.50 to 0.70
- 0.70 to 1.00
- 1.00 to 1.50
- > 1.50

**FIGURE 6**

**1:14000 Scale at A3**

0 100 200 300 400 500 m

N

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2020-10-15| Project: XXXXXXXX
Coordinate System: MGA Zone 56
Map: FKC Figures.qgz