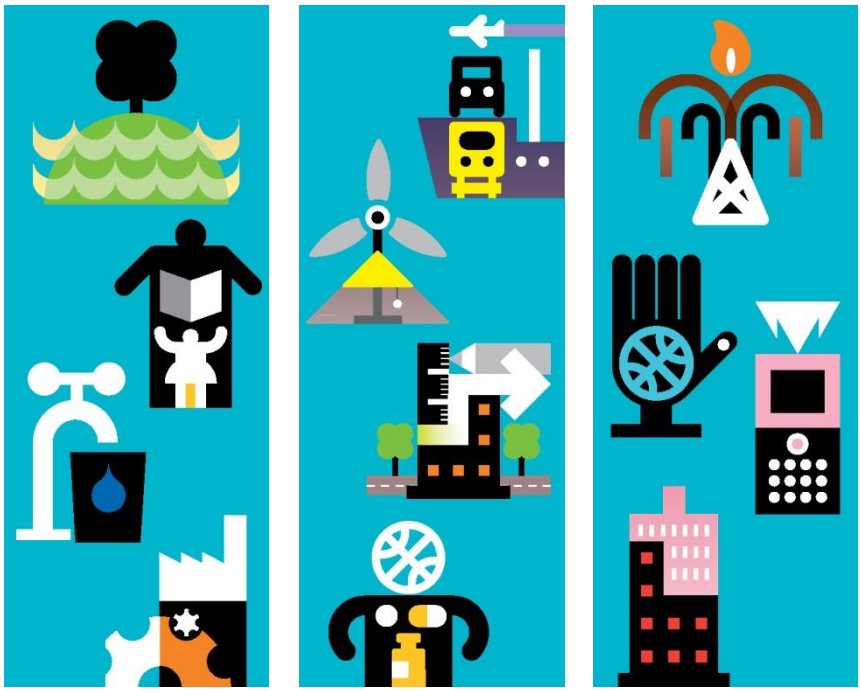

Water Cycle Management Report

Riverstone East

May 2016

NSW Department of Planning & Environment

Mott MacDonald

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Contents

1 Introduction

1.1 Objective of report

This report undertaken by Mott MacDonald (MM) details the procedures used and results obtained from analyses undertaken in developing the water cycle management strategy for the Riverstone East precinct. It supports the master plan by providing engineering input to assist in the development of an Indicative Layout Plan (ILP). The strategy has been developed using an integrated approach to flood risk management and urban design based on water sensitive urban design principles, meeting relevant standards.

1.2 Scope of Work

The purpose of the analyses was to:

- establish a water cycle management strategy based on water sensitive urban design principles;
- provide input into the development of the riparian corridors assessment;
- provide input into the development of the riparian land management and planning controls;
- undertake a hydrologic, hydraulic and water quality assessment of the precinct as an integrated approach to flood risk and water cycle management;
- develop a flood evacuation strategy to assist the State Emergency Services in directing residents of the precinct to during large storm events; and
- undertake concept design and cost analysis of water cycle infrastructure for precinct master planning.

The following analyses have taken into consideration the economical, engineering, environmental and social aspects of the planning proposal under the draft ILP. Particular emphasis has been placed on protecting the environment and enhancing the biodiversity of the receiving water bodies and surrounding environment by implementing water sensitive urban design and best management practices.

The following methodology has been adopted in order to assess the above scope of work:

1. Collate existing site data;
2. Review design controls and requirements;
3. Review previous studies;
4. Undertake hydrologic catchment analysis to compare existing site flows to proposed flows and determine stormwater detention strategies;
5. Undertake hydraulic modelling to assess the impact the proposed development has on surrounding environs and determine appropriate modifications required to minimise the impact on surrounding land, including channel, culvert and detention basin sizing and configuration; and
6. Assess the impact the proposed development has on regional water quality and develop water quality treatment strategies.

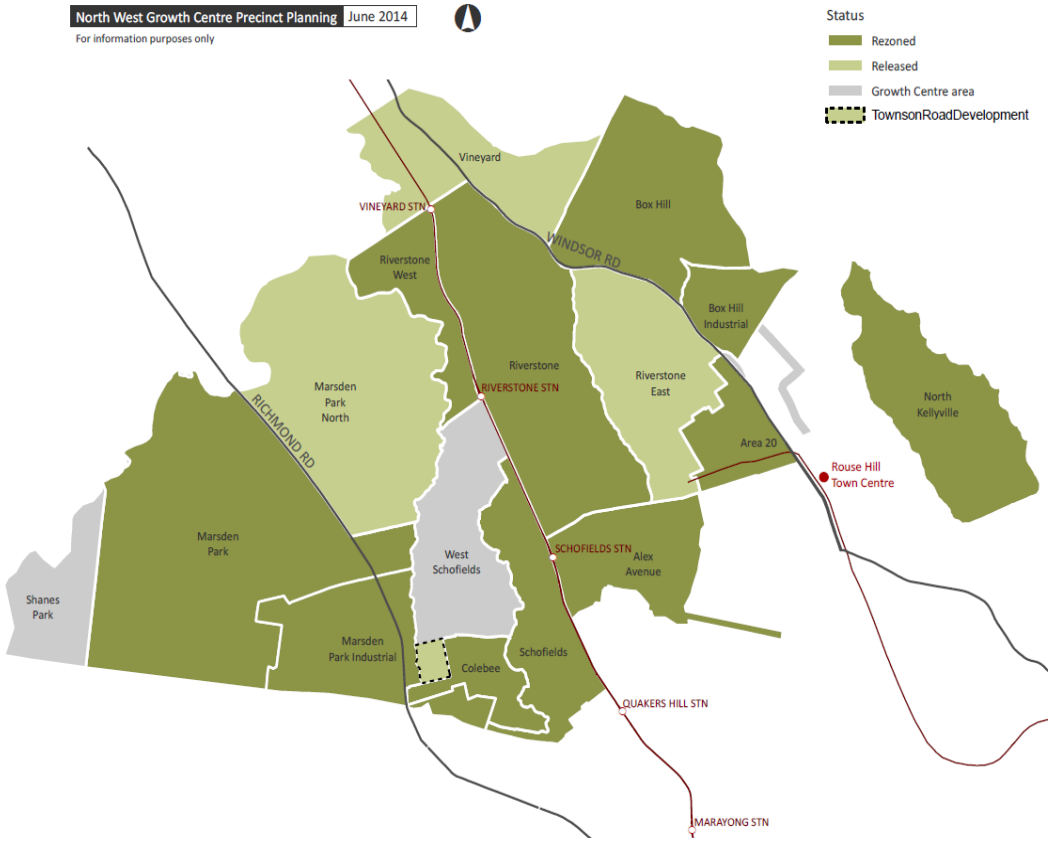
2 The Physical Environment

2.1 The Site

It is expected that by 2036 Sydney will be home to an additional 1.7 million people. Part of the NSW government's plan to meet this need sustainably is the creation of two growth centres in Western Sydney. The North West Growth Centre (NWGC) located within The Hills, Blacktown and Hawkesbury local government areas and The South West Growth Centre (SWGC) located within Liverpool, Camden and Campbelltown local government areas. Combined, these growth centres should provide 181,000 new dwellings for 500,000 people.

Located west-northwest of the CBD, between Quakers Hill and Windsor, the NWGC should provide approximately 70,000 new dwellings for 200,000 people. The growth centre is approximately 10,000 hectares in size and comprised of 16 precincts. The precincts are gradually being rezoned and released for urban development. The overall layout and current re-zoning progress is provided in Figure 2.1.

Figure 2.1: North West Growth Centre Structure Plan, June 2014



Source: NSW Department of Planning and Environment

The NWGC is currently serviced by the Richmond rail line, and two major roads, Richmond and Winsor road. At the south eastern end of the growth centre, the M7 may be readily accessed. In addition, works are underway for the future North West Rail Link (NWRL).The NWRL is proposed to connect to the Richmond line at Vineyard station and run southeast though the Box Hill precinct to the major regional centre, Rouse Hill. From Rouse Hill, the Northwest Rail link is proposed to continue through to Bella Vista, Castle Hill, Macquarie Park and finally, the Chatswood interchange providing easy access to employment.

The Riverstone East precinct is located towards the eastern side of the NWGC and is bounded by Windsor Rd to the north east, First Ponds creek to the west, Schofields Rd to the south and the precinct Area 20 to the south east. The surrounding precincts are Box Hill, Box Hill Industrial, Alex Avenue, Riverstone and Area 20 as shown in Figure 2.1 (above).

Riverstone East is part of the Blacktown Local Government area and is approximately 656 hectares in size. Currently, it is predominately used for rural purposes, although once developed it is intended to provide approximately 5,800 dwellings for 15,000 people. Most of the land to be developed however, 110 hectares have being set aside to become part of Rouse Hill Regional Park and limited development is possible along the riparian corridors which are subject to flooding.

Two major flow paths convey runoff for the precinct, First Ponds Creek and a southern tributary of the Killarney Chain of Ponds; both of which direct flows north, crossing the site boundary through formal drainage structures at Windsor Road.

Figure 2.2: Site Location

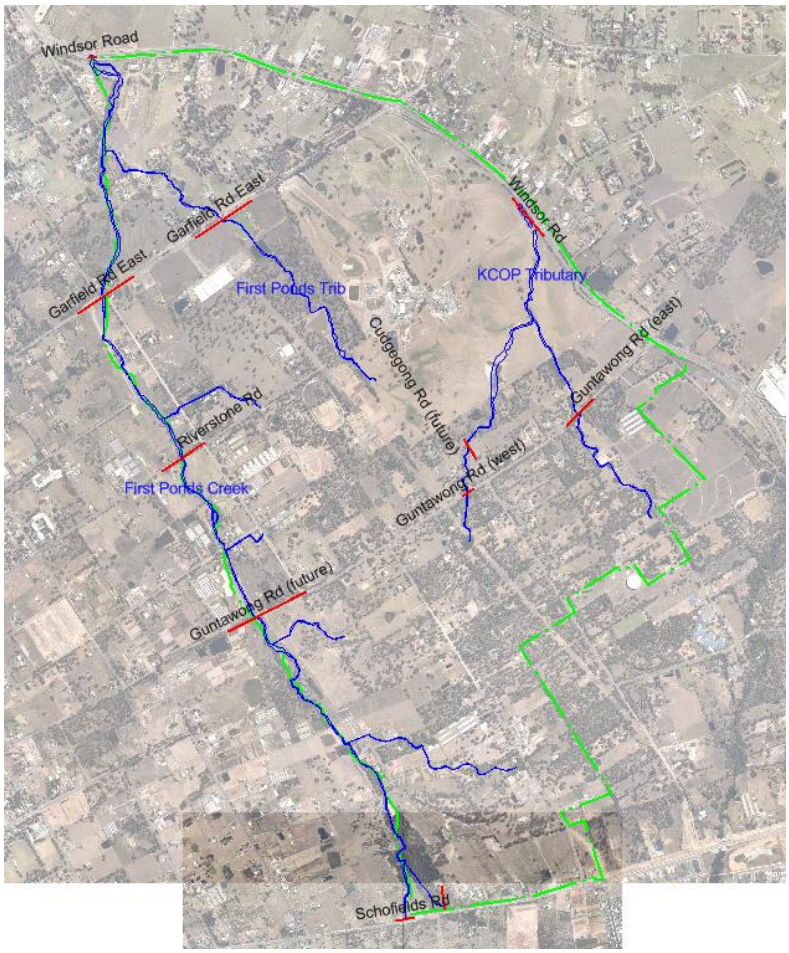
Source: Nearmap

2.2 Data

2.2.1 Topography and Geology

The precinct is located within the South Creek sub-catchment of the Hawkesbury-Nepean River and consists of undulating terrain with elevations ranging from 20-80m AHD. The main ridgeline runs in a north south direction through the centre of the precinct, with the two major natural drainage paths running parallel, First Ponds Creek to the west and the southern tributary of Killarney Chain of Ponds to the east.

Figure 2.3: Existing Creeks



Source: Nearmap base image

2.2.2 Developed Layout – Indicative Layout Plan (ILP)

The ILP has been developed using a holistic approach giving consideration to existing site conditions, environmental, indigenous heritage, non-indigenous heritage and cultural constraints, existing and proposed servicing infrastructure, housing demands, traffic conditions in and around the precinct, approved ILP's of surrounding precincts and costs associated with preparing the site. As part of the Riverstone East precinct, Infrastructure and Development Staging Plans have been prepared. This draft document provides possible locations for future critical services infrastructure and helps determine future land use for the developed scenario.

An additional driver of the indicative layout plan is the arterial road network. A preliminary road hierarchy plan supplied by ARUP has allowed the development of a flood evacuation plan and improved compatibility with water-cycle and flood hazard management principles. According to the road hierarchy plan Garfield Road East will function as the major east-west thoroughfare, with Clarke Street and Tallawong Road identified as future sub-arterial roads for north-south travel. Design of local and collector roads will be guided by the information in this and other preliminary reports, and be documented in the Indicative Layout Plan.

A common objective of the Water Cycle Management Strategy and the Infrastructure and Development Staging Plan is to precede the planning process and feed robust engineering information into planners to enable a considered Indicative Layout Plan.

2.2.3 Rainfall Data

2.2.3.1 Rainfall Records

The water quality analysis required historical rainfall data recorded, by a pluviograph station. The Liverpool (Whitlam Centre) pluviograph recording station which is situated approximately 11km south of the Blacktown LGA is the recommended rainfall data to be used by Council. Historical rainfall records for the area were obtained from the Bureau of Meteorology as follows:

Table 2.1: Liverpool (Whitlam Centre) Base Pluviograph Data

Station No.	Location	Records	Data Interval
067035	Liverpool (Whitlam Centre)	1967 - 1976	6 minute

Source: Bureau of Meteorology

2.2.3.2 Intensity-Frequency-Duration (IFD)

Rainfall intensities were calculated within the XPRAFTS model using the automatic storm generator tool. The tool requires input of the nine raw coefficients which were obtained from the Bureau of Meteorology's IFD calculator, based on the geographical coordinates.

Table 2.2 below provides a summary of the coefficients used.

Table 2.2: Bureau of Meteorology – IFD Coefficients

Intensity (mm/hr)			
50 year 1 hour	58.5	2 year 1 hour	30.05
50 year 1 hour	13.04	2 year 1 hour	6.72
50 year 1 hour	4.57	2 year 1 hour	1.86
Geographic Factors			
f50	15.82	f2	4.3
Location Skew			
0.02			

Source: Bureau of Meteorology

2.3 Additional Information used in the Assessment

2.3.1 Drainage Information

The flooding conditions on the site have potential to become worse under a developed scenario due to increases in impervious areas. A number of existing roads may be directly impacted as a result. Windsor Road, owned by the Roads and Maritime Services (RMS), is an arterial road and a designated flood evacuation route. As such, it is required to maintain service up to and including the 500 year storm event.

Information on existing drainage culverts beneath Windsor Road have been provided by RMS. Where information was not available, including on other roads within the precinct, site inspections were undertaken to measure culvert information, including size, type and approximate length.

2.3.2 Cadastre

Existing cadastre and lot information, along with notable easements including Endeavour Energy and TransGrid overhead transmission line easements were provided by the Department of Planning and Environment. Information was provided in GIS format.

2.3.3 Creek Categories

Information on the existing creek locations and alignments, categories and riparian setbacks was provided by Ecological Australia.

3 Design Controls

3.1 Growth Centres Development Code (October 2006)

This code establishes the process of precinct planning for the growth centres including a framework for the development of the Indicative Layout Plan. This document ensures that the technical analyses necessary to produce specific planning controls are carried out within the context of the formulation of an Indicative Layout Plan so that the appropriate infrastructure will support future development.

3.2 State Environmental Planning Policy (Sydney Region Growth Centres) 2006

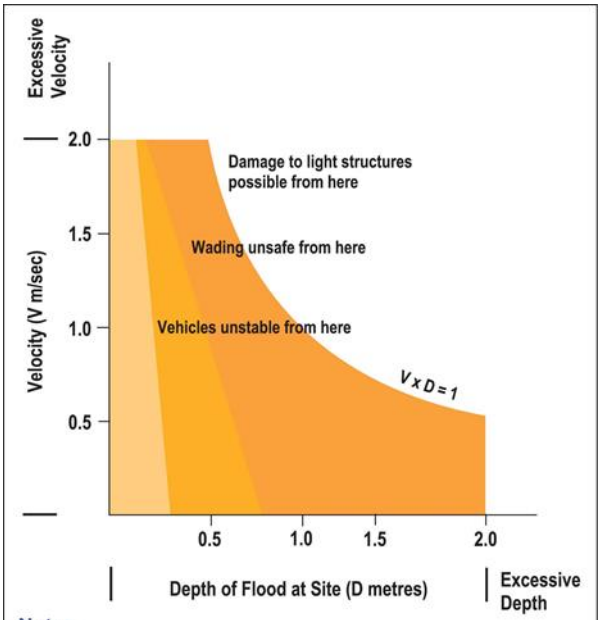
This legislation provides a set of controls on the planning process and on the development of land within the growth centre to ensure that changes to land use can be achieved with positive economic, cultural and ecological effects, improving the amenity of the growth centre area for future development. Of particular relevance to this report, the legislation ensures the availability of effective flood evacuation routes, limits any development with detrimental flood hazard impacts and maintains the overall sustainability of the water cycle.

3.3 NSW Floodplain Development Manual (April 2005)

The NSW Government's *Floodplain Development Manual – the Management of Flood Liable Land (2005)* is concerned with the management of the consequences of flooding as they relate to the human occupation of urban and rural developments. The manual outlines the floodplain risk management process and assigns roles and responsibilities for the various stakeholders.

The manual applies to the development, in particular in Appendix L – *Hydraulic and Hazard Categorisation* for ensuring safe overland flow paths are provided (see Figure L1 below).

Figure 3.1: Velocity Depth Relationships, FDM



Notes

1. At velocities in excess of 2.0 m/s, the stability of foundations and poles can be affected by scour. Also, grass and earth surfaces begin to scour and can become rough and unstable
2. The velocity of floodwaters passing between buildings can produce a hazard, which may not be apparent if only the average velocity is considered. For instance, the velocity of floodwaters in a model test has risen from an average of 1 m/sec to 3 m/sec between houses.
3. Vehicle instability is initially by buoyancy.
4. At floodwater depths in excess of 2.0 meters and even at low velocities, there can be damage to light-framed buildings from water pressure, flotation and debris impact.

Derived from laboratory testing and flood conditions which caused damage.

FIGURE L1 - Velocity & Depth Relationships

Source: NSW *Floodplain Development Manual, 2004 (*Dept. of Infrastructure, Planning & Natural Resources*)*

3.4 Floodplain Risk Management Guideline: Practical Consideration of Climate Change – Department of Environment and Climate Change (2007)

This guideline is designed to be used in addition to the Floodplain Development Manual (2005) and provides recommendations and methodologies for examining flood risk to developments in light of the projected impacts of climate change on sea levels and design rainfall events. The report recommends that sensitivity analysis is undertaken to using 10, 20 and 30% increases to rainfall intensities, with an appropriate level adopted based on the outcomes of this analysis. Previous studies on surrounding precincts in the NWGC have adopted a percentage increase of 15%.

3.5 Stream Classifications for the North West Growth Centre

The NSW Office of Water supplies stream order classification for the identification and management of river ecosystems. The classifications of streams and the associated controls on development activities aim to preserve riparian buffer zones which contribute to the improvement in the health of river ecosystems and the reduction of erosion and potential flooding. Additional information was provided by Ecological Australia.

3.6 Australian Rainfall and Runoff – Volume 1 (2001)

Prepared by the Institution of Engineers, Australia Australian Rainfall and Runoff – *A Guide to Flood Estimation* was written to "provide Australian designers with the best available information on design flood estimation". It contains procedures for estimating stormwater runoff for a range of catchments and rainfall events and design methods for urban stormwater drainage systems.

According to the document, good water management master planning should take into account:

- hydrological and hydraulic processes;
- land capabilities;
- present and future land uses;
- public attitudes and concerns;
- environmental matters;
- costs and finances; and
- legal obligations and other aspects.

3.7 NSW Department of Environment and Heritage

The NSW Department of Environment and Heritage, formerly The Department of Environment and Climate Change (DECC), and the NSW Environment Protection Authority (EPA) has developed a set of guidelines known as the Managing Urban Stormwater (MUS) series. The set of guidelines includes:

- Managing Urban Stormwater: Council Handbook;
- Environmental targets;
- Managing Urban Stormwater: Source Control;
- Managing Urban Stormwater: Soils & Construction; and
- Managing Urban Stormwater: Harvesting and Reuse.

3.7.1 Managing Urban Stormwater: Environmental Targets

The NSW Department of Environment and Climate Change (DECC) encourages the principle of no net deterioration of water quality. Under its former name, the NSWEPA, the DECC published Managing Urban Stormwater: Environmental Targets, outlining recommended environmental targets for stormwater management in new urban developments. These treatment objectives, along with those outlined in Blacktown City Council's engineering guidelines, have been shown in the below table:

Table 3.1: Stormwater Treatment Objectives for New Urban Areas

Pollutant	DECC Treatment Objectives	Blacktown City Council Treatment Objectives
Gross Pollutant	90% retention of the annual average load for particles 0.5mm or less	90% retention of the annual average load for particles 0.5mm or less
Suspended Solids	85% retention of the annual average load	85% retention of the annual average load
Total Phosphorous	65% retention of the annual average load	65% retention of the annual average load
Total Nitrogen	45% retention of the annual average load	45% retention of the annual average load

Source: Managing Urban Stormwater: Environmental Targets; and Blacktown City Council DCP 2006

3.7.2 Managing Urban Stormwater: Source Control

The DECC guide, Managing Urban Stormwater: Source Control recommends the control of stormwater pollution at the source, rather than more traditional "end of line" systems that are unsightly and require high levels of ongoing maintenance. In this document, Water Sensitive Urban Design (WSUD) is described as "minimising the impacts of development on the total water cycle and maximising the multiple benefits of a stormwater system". It lists the main objectives of WSUD as:

- preservation of existing topographic and natural features;
- protection of surface water and groundwater sources;
- integration of public open space with stormwater drainage corridors, maximising public access; and
- passive recreational activities and visual amenity.

The broad principles of WSUD are listed as:

- minimising impervious area;
- minimising use of formal drainage systems (e.g. pipes);
- encouraging infiltration (where appropriate); and
- encouraging stormwater re-use.

3.7.3 Managing Urban Stormwater: Soils and Construction

Managing Urban Stormwater – Soils and Construction (4th edition, March 2004) are guidelines produced by the NSW Department of Housing to help mitigate the impacts of land disturbance activities on landforms and receiving waters by focusing on the removal of suspended solids in stormwater runoff from construction sites.

According to the guide, effective soil and water management during construction involves the following key principles:

- assess the soil and water implications of development at the subdivision or site planning stage (including salinity and acid sulphate soils);
- plan for erosion and sediment control concurrently with engineering design and before the land disturbance begins;
- minimise the area of soil disturbed;
- conserve topsoil for subsequent rehabilitation/revegetation;
- control surface runoff from upstream areas, as well as through the development site;
- rehabilitate disturbed lands as quickly as possible; and
- maintain soil and water management measures appropriately during, and after the construction phase until the disturbed land is fully stabilised.

3.8 Blacktown City Council (BCC) Control Documents

3.8.1 Blacktown City Council DCP 2006

An integral part of the master planning process for developments, the *Blacktown City Council DCP 2006* provides the necessary controls for the redevelopment of the site. Particular water management requirements include:

- compliance with Council's Engineering Design Guide for Development;
- compliance with the demands of the BASIX system; and
- adoption of the principles of WSUD (including a water cycle management plan).

3.8.2 Blacktown City Council Engineering Guide for Development

Council's *Engineering Guide for Development* sets out their requirements for the design of stormwater drainage for urban and rural areas. The Engineering Design Guide outlines the broad objectives of the policy of:

- retention of the natural stormwater system where possible;
- a high level of safety for all users;
- acceptable levels of amenity and protection from the impact of flooding;
- consideration given to the effect of floods greater than the design flood;
- a controlled rate of discharge to reduce downstream flooding impacts;
- protection of the environment from adverse impacts as a result of the development;
- maintenance of and enhancement of the regional water quality;
- sustainability of infrastructure; and
- economy of construction and maintenance.

The policy also provides detailed requirements for the hydrologic and hydraulic design and analyses of the developed water management system including standard calculation factors and drawings.

3.8.3 Blacktown City Council Developer Handbook for Water Sensitive Urban Design

Council's *Developer Handbook for Water Sensitive Urban Design* sets out their requirements for the design of water quality management systems to assist in mitigating the impact of urban development on local waterways within the area. The handbook also provides Council's modelling guidelines for the use of MUSIC modelling software.

3.8.4 Blacktown City Council Growth Centre Precincts DCP 2010

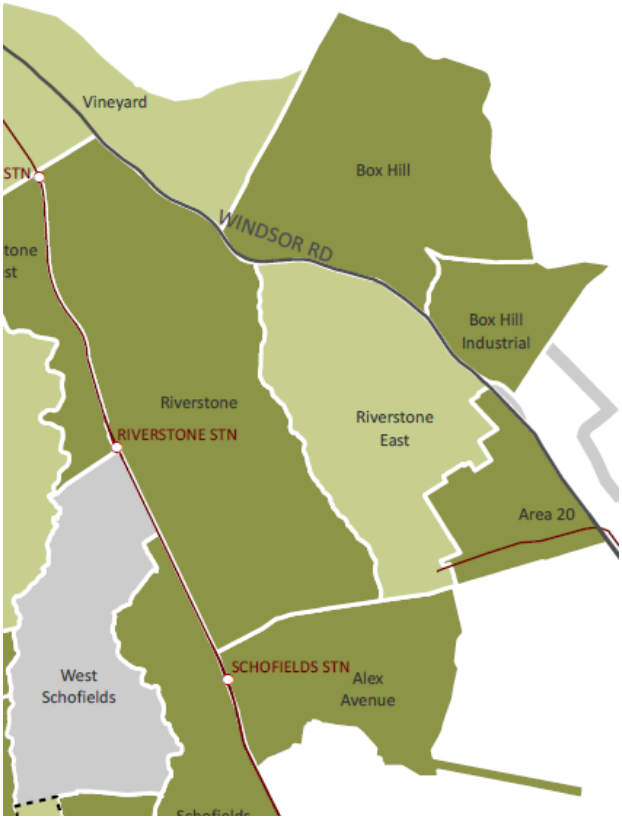
The Department of Planning and Environment's Growth Centre Precincts Development Control Plan sets out their specific controls and design principles for the development of land within the growth centre precincts in addition to the requirements of Council's Engineering Guide for Development.

4 Literature Review

4.1 Water Sensitive Urban Design and Flooding – Riverstone and Alex Avenue Precincts, GHD 2008 and Post Exhibition Report 2010

Riverstone and Alex Avenue precincts lie to the west and south of Riverstone East respectively. The combined size of these precincts is approximately 1600 ha. As seen in Figure 4.1(below), Riverstone East boarders Riverstone along Fist Ponds Creek and Alex Avenue along Schofield Road. Current land use throughout the precincts is predominantly rural with some urban areas in Riverstone.

Figure 4.1: Riverstone East and surrounding precincts



Source: NSW Department of Planning and Environment

In September 2008, GHD prepared a Water Sensitive Urban Design and Flooding (WSUD) report for Riverstone and Alex Avenue. The report was later superseded by the Post Exhibition study in 2010. The 2008 WSUD strategy made a number of proposals for the management of water quality and quantity including: Vegetated swales, detention/bio-retentions basins, public wetlands including a frog habitat, gross pollutant traps and a flood evacuation strategy for PMF inundated areas.

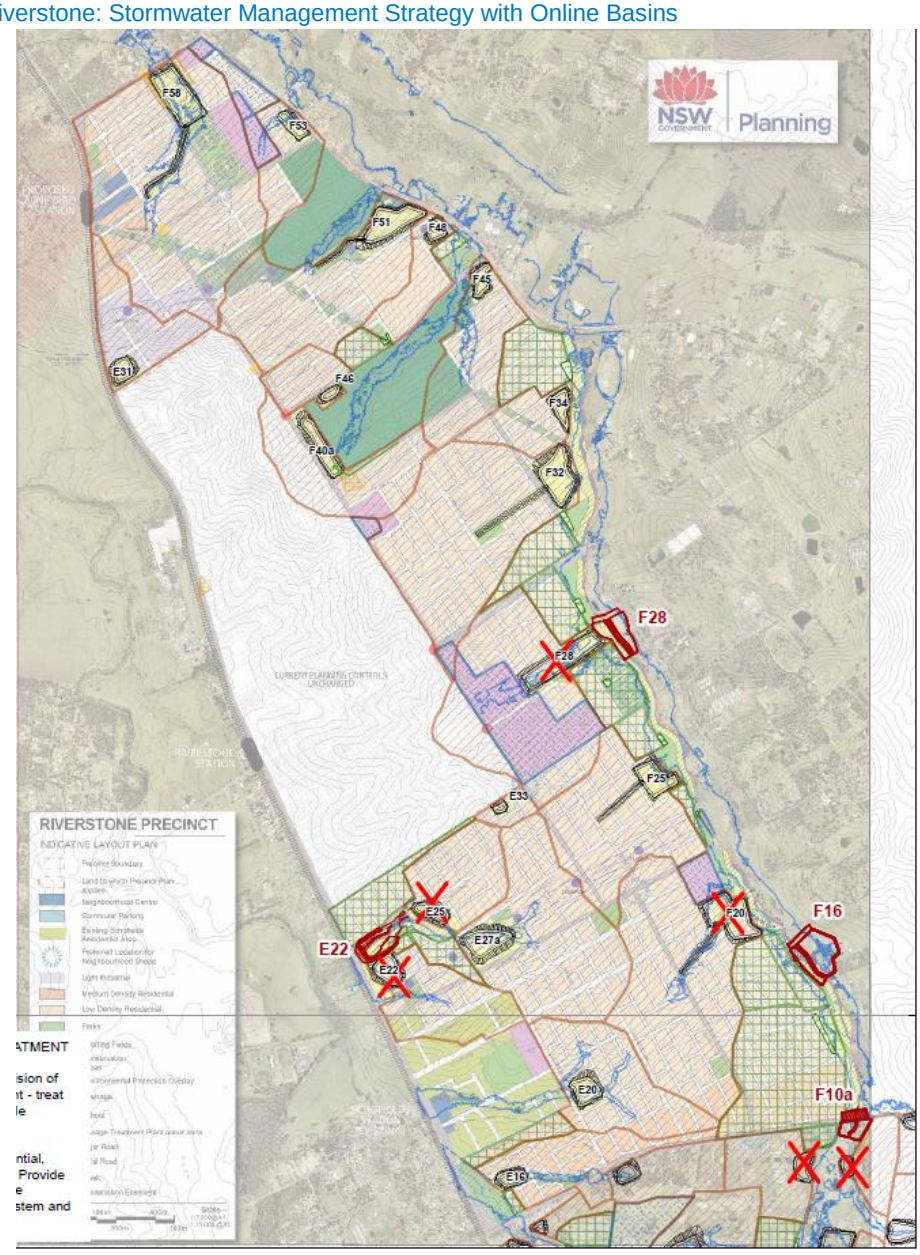
GHD developed a one-dimensional XPRAFTS model of the Riverstone catchment area for the Riverstone and Alex Avenue precincts using Mike 11 software. Annual recurrence intervals of 2, 4, 10, 20 and 100 years with durations of 25 minutes to 9 hours were considered. The area included in this modelling

comprised two distinct catchments, one catchment discharging to Eastern Creek and the other to First Ponds Creek. Water quality modelling was carried out in MUSIC.

An existing scenario was modelled hydraulically by GHD for comparison with a developed scenario which incorporated information from the indicative layout plan (ILP) for the future development of the Riverstone and Alex Avenue precincts. Recommendations were made as to locations and sizing of online and offline basins to attenuate the post development flows back to the flow rates determined in the existing scenario model.

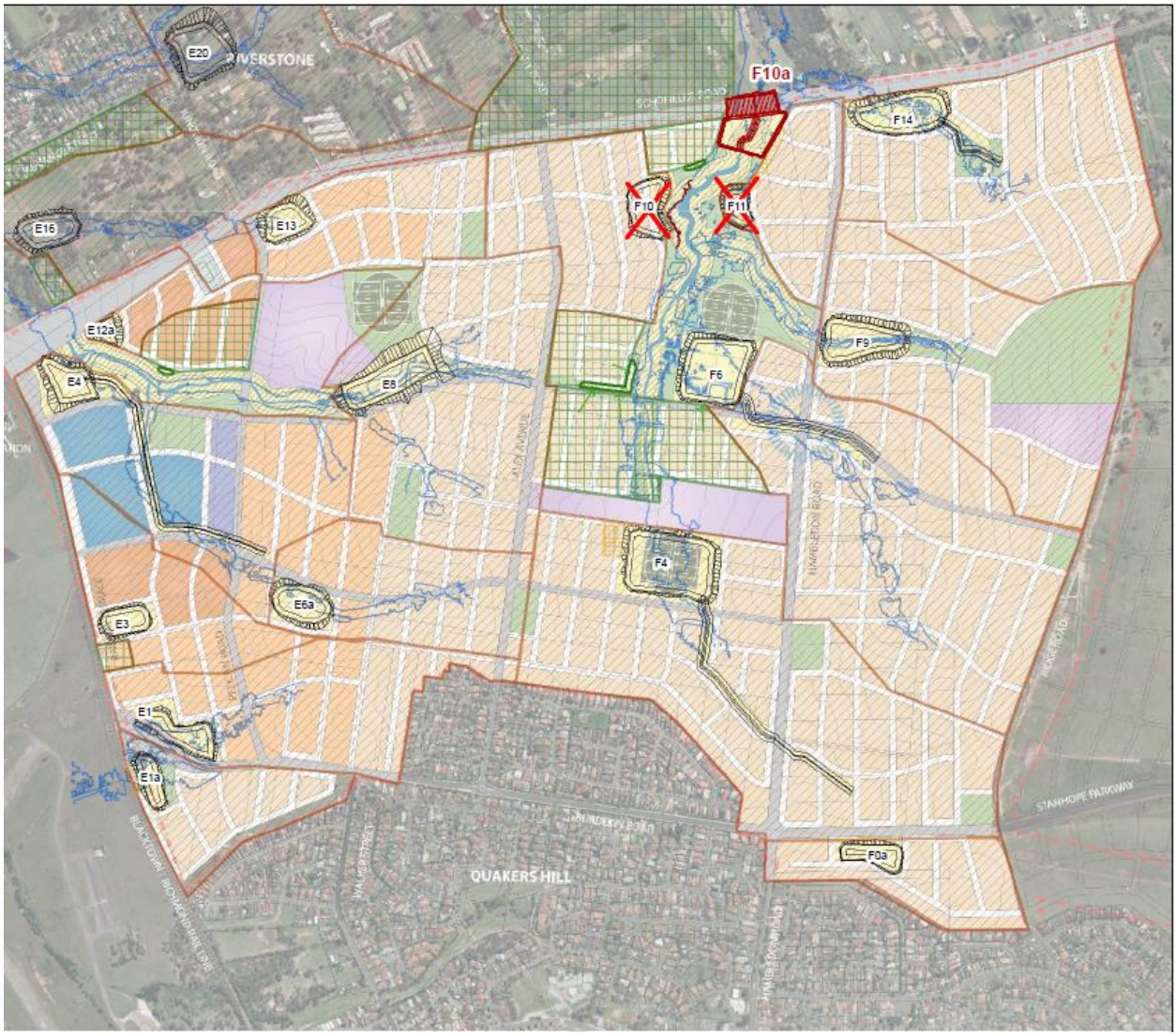
The 2010 GHD post exhibition study reworked the retention and bio-retention basins, altering the flow regime of First Ponds Creek in order to maximise development potential and reduce the number of detention basins as seen in Figure 4.2 and Figure 4.3. An integrated Riverstone/Riverstone East strategy was developed to ensure that the development criteria for both precincts could be satisfied. Due to the high costs of soil disposal the design of the retention basins were also modified to reduce cut volumes by introducing steps into basin designs, bringing significant cost savings to the council.

Figure 4.2: Riverstone: Stormwater Management Strategy with Online Basins



Source: Riverstone Alex Avenue – GHD Draft Post Exhibition Flooding

Figure 4.3: Alex Avenue – Stormwater Management Strategy with Online Basins



Source: Riverstone Alex Avenue – GHD Draft Post Exhibition Flooding

The integrated Riverstone and Riverstone East analysis gave consideration to the Riverstone East development potential and draft basin strategies were developed however these were to be reassessed in more detail during the preparation of the Riverstone East ILP.

The report recommended a series of offline and online detention basins for the precincts. Most importantly four approved online detention basins were proposed, two of which are located online to First Ponds Creek and are designed to accommodate developed flows from both Riverstone and Riverstone East, these proposed online basins may be seen in Figure 4.2 and have been reviewed as part of this (MM) report.

Finally, the potential impacts of climate change were originally not taken into consideration in 2008 report due to the preliminary nature of the study. This short fall was amended in the post exhibition report. The revised storm water quantity management system was subjected to flood modelling with increased rainfalls and flows of 20% and ~25% respectively, future proofing the region.

4.2 Water Cycle Management – Box Hill/Box Hill Industrial Precinct, JWP 2011

The Box Hill and Box Hill Industrial precincts border Riverstone East to the north east along Windsor road as seen in Figure 4.1. The precincts cover an area of 974 hectares including 133 hectares of employment land, 118 of which is industrial. The sites are expected to provide 9,900 new dwellings for 29,700 people. To support the increased population, the precincts will feature a new town centre, 3 villages, new schools, major road upgrades, new pedestrian and cycle ways. On the 5 of April 2013, the Box Hill precincts were rezoned for urban development.

In 2011 J. Wyndham Prince (JWP) produced a Water Cycle Management Plan (WCMP) for the Box Hill and Box Hill Industrial Precincts. The exhibition process received a number of submissions from land owners and government agencies resulting in changes to the Indicative layout plan (ILP). The revised ILP required a revaluation of the WCMP, which was performed by JWP in 2012.

For the 2011 WCMP, JWP developed a one and two-dimensional flood model for the existing and proposed scenarios. Comparison was made between existing and proposed models for the 100 year ARI and PMF depth profile maps. This was done to ensure that flooding was not worsened by development. To manage flooding and water quality the WCMP included 11 detention basins, 21 bio-retention basins, gross pollutant traps and 3kL water tanks on each lot.

In 2012, JWP re-analysed the new developed case for the 100 year ARI 2012 and produced the revised WCMP report. This report detailed a number of amendments to the flow regime of Killarney Chain of Ponds to manage the water cycle and address both quality and quantity targets for the precinct. Most notably, two basins were removed and three others were increased in size to compensate. The report identified areas where filling of the precinct could be achieved to maximise the developable land while addressing flood risk.

The hydrologic and hydraulic modelling discussed in the JWP 2012 report provided flow rates at various points along the Killarney Chain of Ponds and First Ponds Creek. These have been referenced in this report for model calibration and parameter comparison purposes. This has been discussed in greater detail in Section 6.

It is important to note that the developed scenario for the Box Hill/Box Hill Industrial precinct has assumed an undeveloped upstream catchment for the Killarney Chain of Ponds southern tributary. A large portion of the catchment for this tributary is within the Riverstone East precinct (upstream of Windsor Rd). Therefore any changes to the flow regime in the tributary as a result of development in the Riverstone East precinct could not increase the flood levels or flow rates in this tributary. This constraint on the southern tributary flows from the Riverstone East precinct supported the need for flood mitigating works within the precinct.

4.3 Water Cycle Management Strategy & Flood Study – Area 20 Precinct, JWP 2010

In 2010 JWP prepared Water Cycle Management Strategy for the Department of Planning which included a flood study for the Area 20 precinct. Area 20, is 245 ha in size and boarders Riverstone East along the south eastern boundary (Figure 4.1). This boundary is roughly defined by a natural ridge line which also separates the major catchments. A single catchment extends over the majority of Area 20 and drains to Second Ponds Creek.

Continuing from prior work, JWP modified a XPRAFTS model originally created by Jacobs (then Sinclair Knights Merz) to include the Area 20 site. The XPRAFTS output was subsequently used in a 1D, HEC-RAS model to determine the PMF levels. Annual recurrence intervals of 2, 20 and 100 years were considered.

Area 20 lies within a much larger catchment where regional storm water management strategy has been implemented, known as the Rouse Hill Stage 1 Trunk Drainage Strategy. Under this strategy, no additional retention basins should be required. JWP was able to affirm this assumption through their model. However, 13 bio-retention basins were still required for water quality purposes.

A comparison of existing and developed flood models showed that the urbanisation of the precinct would reduce flood levels both for Area 20 and downstream sites. This reduction is due to a decrease in peak flow rates of the urbanised catchment.

Any flows from Area 20 into Riverstone East were not considered by the JWS model, but have been accounted for in the Riverstone East ILP 2014 model. These flows are minor and originate from differences between the precinct boundaries and the major catchment boundaries. The major flows from Area 20 drain through Second Ponds Creek to Smalls creek to Cattai Creek which flows away from the Riverstone East precinct. Thus, the major flows from Area 20 will not have any impact on Riverstone East and the small flows are considered in the Riverstone East ILP 2014 Model. Hydrological Model

The hydrological modelling for the Riverstone East precinct was undertaken using XPRAFTS software to determine the critical flows generated from the contributing catchments. The catchments contributing to the study area were modelled within XPRAFTS to determine the runoff hydrographs to be used as inflows in the 2D terrain flood model. These flows were compared with results extracted from the approved GHD (2010) study for verification of the XPRAFTS modelling.

5 Water Quantity Modelling

The assessment of water quantity was completed through hydrological and hydraulic modelling. Computer based models of the existing and developed catchments were constructed using XPRAFTS. Design storms were applied to these models to give estimates of the 2, 20, 100, 200 and 500 year ARI discharges as well as discharge from the probable maximum precipitation (PMP), which are examined in the following sections. Assessment of these models then allowed the sizing and configuration of proposed detention basins and the documentation of their requirements. Assessment was also undertaken on the existing basin sizes.

5.1 XPRAFTS

XPRAFTS is a runoff routing computer model used for hydrologic and hydraulic analysis of stormwater drainage and conveyance systems. Rainfall, catchment and channel data forms the basis of the model. The catchment and rainfall data generates runoff hydrographs. The channel data models how the runoff flows between catchments to establish the cumulative impacts across the site.

An overall catchment is divided into a network of sub-catchments joined by links. The links represent natural watercourses, artificial channels, or pipes. Rainfall is applied to each sub-catchment. Losses (representing infiltration, interception, etc.) are subtracted from the rainfall and the excess is then converted into an instantaneous flow. This instantaneous flow is then routed through the sub-area storages to develop local sub-catchment hydrographs. Total flow hydrographs at various nodes in the drainage network are calculated by combining local hydrographs. Hydrographs are transported through the drainage network by time lagging or channel routing. Hydrographs may also be routed through the storage basins such as dams or detention basins.

5.1.1 Parameters

As described above, the user data inputs required by XPRAFTS include catchment areas and slopes, pervious and impervious areas, IFD rainfall statistics, hydrological losses and routing times. Guidelines for determining these parameters are provided in the Australian Rainfall and Runoff (I.E Aust, 2001) and are broken up as follows:

5.1.1.1 Slopes

A three-dimensional (3D) surface was produced from aerial survey (LiDAR) data supplied by the Department of Planning and Environment using 3D modelling software. A slope analysis was performed on the 3D surface to determine slope profiles across the precinct. These slopes were used as the basis for the determination of runoff flow paths and catchment areas.

5.1.1.2 Impervious Catchment Areas

For the existing scenario modelling, the areas of roads, pavements and structures were measured off aerial photographs to determine the proportion of each catchment to be treated as impervious. For the developed scenario the values recommended in the BCC Growth Centre Precincts Development Control

Plan 2010 were adopted since these reflect the developed land use as documented in the draft ILP and are Council's preferred parameters.

The North West Rail Link stabling yard has not been considered as developed for either the existing or proposed scenarios. It is expected that the existing scenario would comprise a worst case and any future development would modify flows through detention to have a 'no worse or better' impact on flows. This is explored later in the report for the Alex Avenue Precinct which has a greater potential to influence flows. The findings have been applied to NWRL catchment. Modelling files were not available at the time this report was prepared.

5.1.1.3 Intensity-Frequency-Duration (IFD)

Rainfall determined described in Section 2.2.3.2

5.1.1.4 Rainfall Losses

The loss model used to estimate rainfall excess in the development of design flow hydrographs was the Australian Representative Basins Model (ARBM). Parameters have been adopted from Councils Engineering guideline.

5.1.1.5 Land Use

Aerial photographs provided information on current land use for the modelling of runoff in the existing scenario. The draft Indicative Layout Plan supplied by Cox Richardson was used as the basis for land use in the developed scenario. GIS information on the extent of the existing Rouse Hill Regional Park and the extent of the proposed dedicated green space adjacent was provided by the Department of Planning and Environment.

5.1.1.6 Hydraulic Roughness Parameters

Hydraulic roughness parameters for the catchments were estimated based upon site inspections and discussions with Blacktown City Council, and were applied in accordance with recommendations in AR&R. Manning's values we applied to the model based on the land use of each sub-catchment.

In the existing scenario, a Manning's roughness parameter of 0.04 was adopted for the pervious and 0.025 for the impervious portion component of all 'undeveloped' land,

The proposed scenario adopted the same parameters for the areas of unchanged land use (land remaining undeveloped) and new values were adopted for the land area that is proposed for new land uses. A Manning's roughness parameter of 0.035 was applied to the pervious component while 0.015 was applied to the proposed impervious component, this is to allow for increases in runoff efficiency due to pervious areas being connected by streamlined drainage networks (such as pipes/roads).

5.1.1.7 B-Multiplier

The b-multiplier (b) used in XPRAFTS is the coefficient used to calibrate a model to fit observed rainfall and stream flow data/recorded floods. The existing and proposed models both adopted a default 'b' value of 1.0 and no further calibration was deemed necessary based on comparisons with other approved models (refer section 5.4).

5.1.1.8 Links

Time based lag links were used to route flows through the model. This is described further in section 5.3.

5.2 Existing Scenario

Catchments for the existing scenario were determined through 3-dimensional slope analysis of the surveyed topography as discussed in Section 5.1.1.1. Aerial LiDAR survey provided by Blacktown City Council and information gathered from site visits was used for the analysis of flow paths and catchment boundaries.

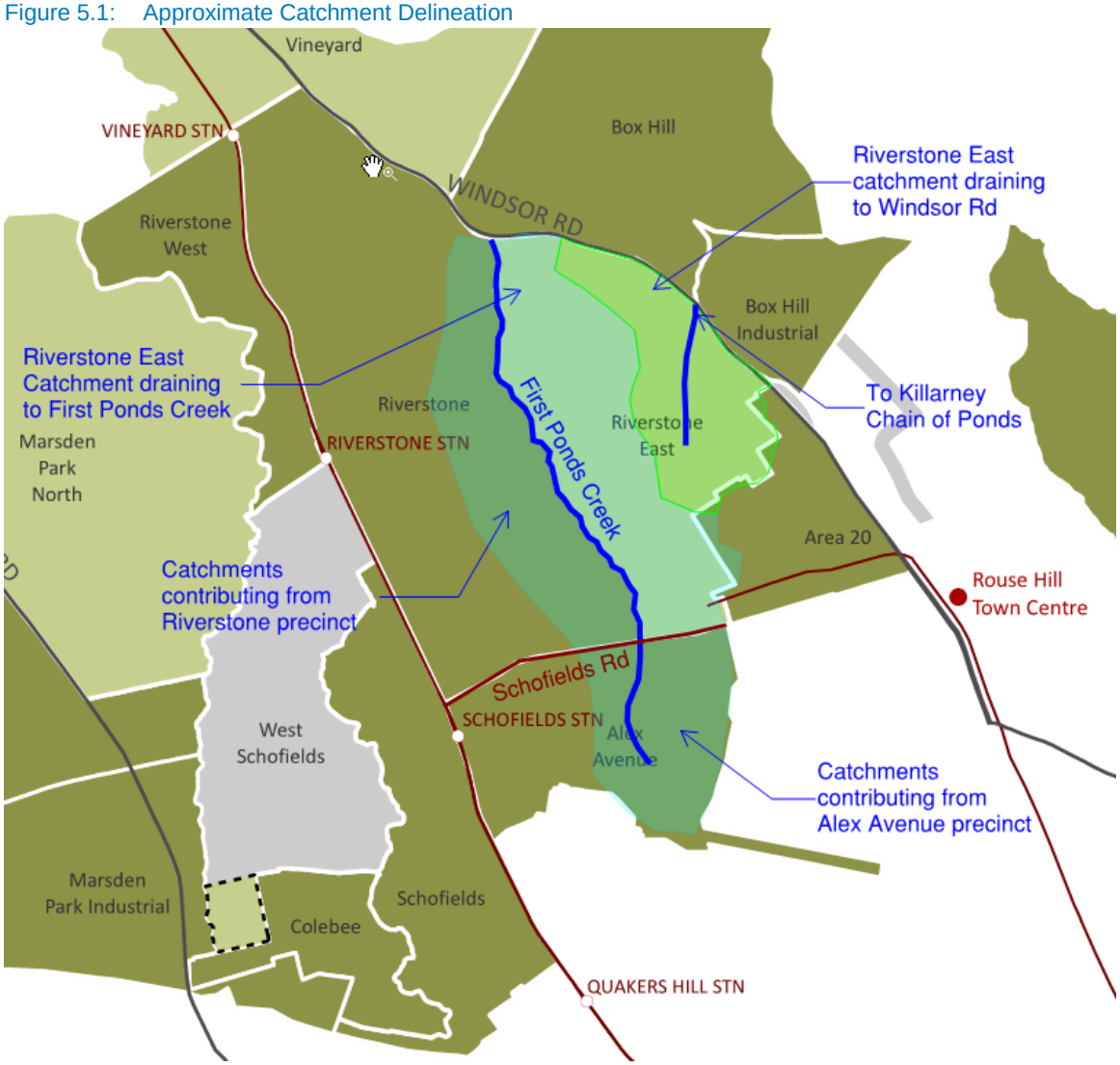
The Riverstone East Precinct is 656 hectares, but also has contributing flows from upstream areas, which give a total catchment size of approximately 1,254 hectares.

As described previously, First Ponds Creek runs from south-west to north-east along the western boundary of the site, conveying runoff from the Riverstone and Alex Avenue growth centre precincts to the Killarney Chain of Ponds. This major water course has a series of smaller tributaries contributing runoff to the major channel, most of which will remain in the post-development scenario. A crest running south to north through the eastern part of the precinct, splits a small portion of the precinct towards Windsor Road to the east. The below figure shows roughly how the catchments within and external to the precinct drain.

The existing Riverstone East catchment has been divided into approximately 80 sub-catchments. These sub-catchments range in size from 2.4 to 32.4 hectares (refer to Appendix B), however generally uniform catchment delineation was adopted. The sub-catchments east of the ridgeline naturally adjoin the Killarney Chain of Ponds system at various points and eventually discharge to a large pond at the northern boundary of the Vineyard precinct. West of the ridgeline, the sub-catchments fall to the west and also find a series of small tributaries that discharge to the main Eastern Creek line.

Modelling results in the following sections of this report will determine the extent of additional detention volumes and other required water cycle control measures to ensure the overall discharge from the post development scenario does not exceed the overall site discharges in the existing scenario at the outlet of the development precinct.

Figure 5.1: Approximate Catchment Delineation



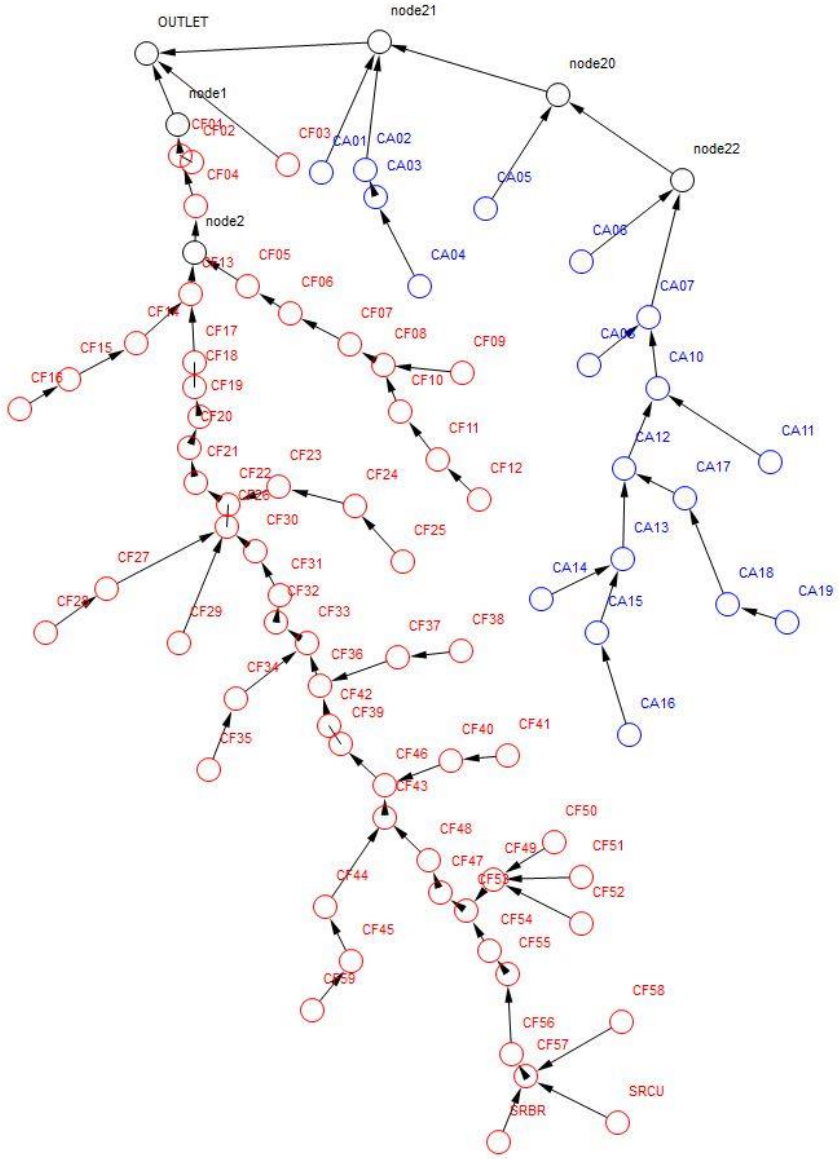
Source: NSW Department of Planning and Environment

Figure 5.2 represents the existing network within XPRAFTS. The division of catchments was based upon the overland flow paths and existing road and drainage networks. Overland flow paths generally match the drainage and riparian corridors specified by the relevant authorities. Refer to the Water Cycle plans in Appendix A For further details including the catchment plan. The catchments coloured in ‘red’ are directly associated with First Ponds Creek and the catchments coloured in ‘blue’ relate specifically to Killarney Chain of Ponds.

As both the Riverstone and Alex Avenue Precincts drain through the Riverstone East Precinct, they have been considered as part of the assessment. The Riverstone model has been rebuilt as part of this study to

verify flows obtained in the GHD model, and confirm online basin sizing. Generally all parameters have been maintained with the exception of manning's roughness parameters. The Alex Avenue precinct has been assessed as an existing 'worst case', as any development would be required to have a no worse or better discharging flow. A sensitivity analysis was undertaken on the Alex Avenue Precinct to determine if any cumulative impacts may occur under a proposed scenario. This is explored later in the report.

Figure 5.2: Existing XPRAFTS Network



Site investigations have confirmed that the existing catchment has a combination of minor and major stormwater infrastructure in place to assist in conveyance of surface flows to their respective outlets.

The pre-developed XPRAFTS model was subsequently formulated by incorporating the following:

- "Catchment Nodes" were used to represent each of the sub-catchments. Here, each node is representative of the catchment and is divided into both pervious and impervious values (Refer Appendix B);
- "Dummy Nodes" were used where two or more existing sub-catchments joined, which allowed both inflow and outflow hydrographs to be assessed.
- "Lag Links" were used as the links between the nodes and were modelled to provide the travel time (in minutes) for the peak flow to travel the length of this reach. The method for determining the lag link times is discussed in Section 5.3 below.

The following additional assumptions/comments are also provided:

- No minor pipe networks have been modelled in the XPRAFTS model;
- External catchments which are directed through the site have been included as part of the assessment. This includes flows from the Riverstone and Alex Avenue Precincts;
- Existing dams are assumed to be full so as not to cause any attenuation of flows. This would result in a worst case existing scenario.

5.3 Model Calibration

To ensure an accurate representation of hydrograph phasing was achieved, TUFLOW was utilised to calibrate the model. In lieu of river gauge data, the procedure for determining the lag times was based on an iterative process which re-rationalised the links based on actual flow velocities generated by the catchment. The methodology is described below (where possible existing models from surrounding precincts were compared);

- Lag times (in minutes) were initially derived from conservative estimates of flow velocities through the active floodway and floodplain. The XPRAFTS model was run with these estimations and the resulting flow hydrographs were then applied to the 2D TUFLOW hydraulic model.
- As TUFLOW determines storm flow runoff characteristics from the physical topography, stream flow velocities were able to be accurately measured along each of the major flow paths. After examining the flow velocities across the precinct, an average velocity of 0.60m/s was adopted for First Ponds Creek & Killarney Chain of Ponds. 0.35m/s was adopted for the First Ponds Creek Tributary.
- The adopted precinct flow velocity (m/s) was then converted to a lag time (in minutes) for each lag link based on the known catchment flow path lengths (m). From this, revised XPRAFTS lag link times were calculated and returned into the model.

5.4 Existing Model Verification

5.4.1 Previous Studies

A comparison between the XPRAFTS hydrologic model results and previous modelling results extracted from the studies discussed in Section 4 was carried out as a validity check on the parameters used for input to the modelling. This comparison also serves to highlight the effect of various assumptions in the modelling parameters on the flow rates and flood levels.

A review against the previously approved studies was undertaken to compare flow rates at various locations across the site with those obtained through this study. A summary of these flow rates has been outlined in the below table, with comparison locations shown in Figure 5.3.

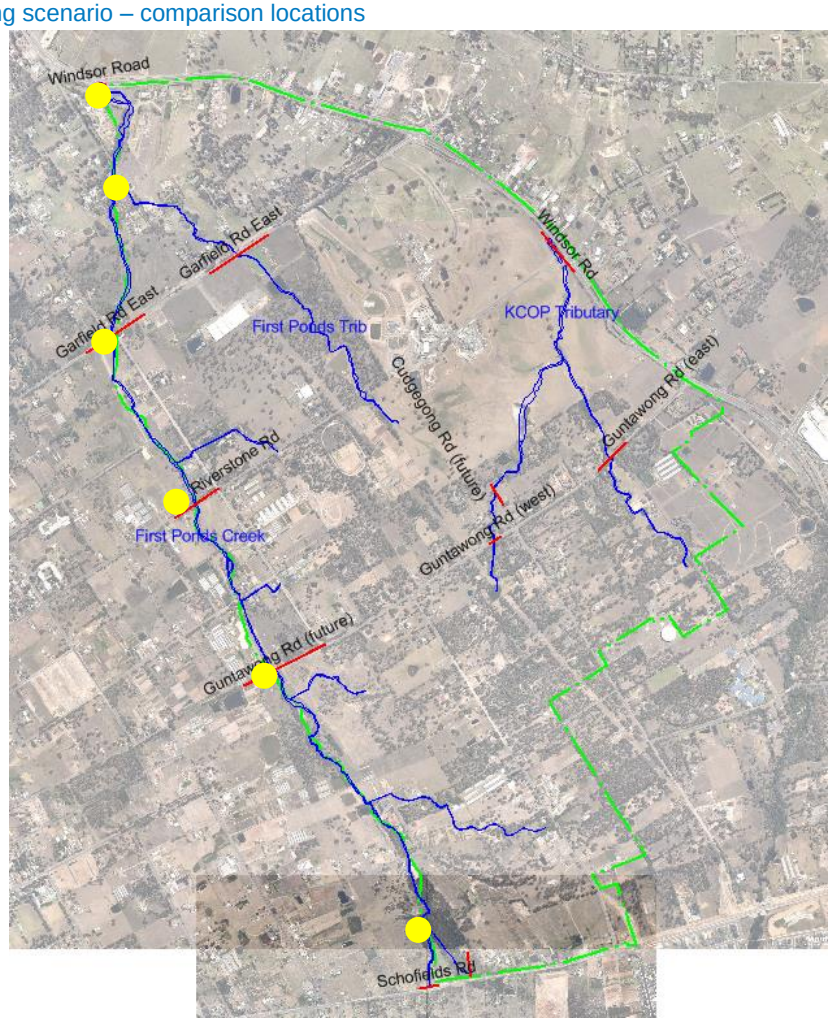
Table 5.1: Hydrological model 100 year flow comparison - Existing Scenario

First Ponds Creek Location	MM XPRAFTS Node	MM flow rate (m^3/second)	JWP flow rate (m^3/second)	GHD flow rate (m^3/second)	PB flow rate (m^3/second)
Schofields Road	CF56	30.98	-	23.36	28.20*
Guntawong Road (future)	CF46	60.72	-	43.3	-
Riverstone Road	CF32	66.48	-		-
Garfield Road East	CF19	71.68	-	59.31	-
Windsor Road (Outlet)	**CF01**	**78.84**	**75.30**	**81.45**	**-**
First Ponds Tributary Location		**MM flow rate (m^3/second)**	**JWP flow rate (m^3/second)**	**GHD flow rate (m^3/second)**	**PB flow rate (m^3/second)**
Confluence of First Ponds Creek and First Ponds Creek Tributary	CF05	11.27	-	11.79	-

Source: Reports on previous modelling supplied by Department of Planning and Environment
*Summary flow representing First Ponds Creek and First Ponds Creek Tributary peak flows.

From the above it can be seen that the flows across the three investigations vary across the site and do approach as much as 40% difference at some locations. It is noted however, that flows at the Windsor Road Outlet are less than 10% in difference, with the Mott MacDonald model being within 5% of each of the previous two. Review of the previous models, indicated that different modelling methods and model parameters were the main reason for these differences, in particular an Initial and continuing loss method was used in the GHD Alex Avenue/Riverstone East Model whereas ARBM parameters were used in the MM model. For this assessment, Mott MacDonald has calculated equal area slopes for each individual catchment and extracted stream flow velocities from the TUFLOW model. This has resulted in the average catchment slopes being higher and the routing links having a lower velocity. The effect on the Mott MacDonald model is that the catchments generate an earlier and higher peak flow, with greater time between nodes whereas the previous models have generally lower and later peak flows from catchments with less time between nodes. This results in variances through the model, though averaging out at the outlet to result in a comparable flow rate.

Figure 5.3: Existing scenario – comparison locations



Source: Nearmap base image

5.4.2 Rational Method

Modelled flow rates were also compared with calculated flow rates determined using the rational method, to validate that they were within the expected range. The rational method is the most widely used empirical technique used for calculating design flow rates within Australia (as recommended in AR&R87). The rational method calculates the peak flow rate corresponding to the particular time of concentration for the catchment. These estimated flow rates are not related to any one specific storm event.

Table 5.2: Catchment peak flow rate 100 year event – Rational Method

First Ponds Creek Location	MM XPRAFTS Node	RAFTS existing flow rate (m^3/s)	Rational method existing flow rate (m^3/s)
Schofields Road	CF56	30.98	24.03
Guntawong Road (future)	CF46	60.72	41.78
Riverstone Road	CF32	66.48	49.96
Garfield Road East	CF19	71.68	60.77
Windsor Road (Outlet)	**CF01**	**78.84**	74.08
First Ponds Tributary Location		**MM flow rate (m^3/second)**	**JWP flow rate (m^3/second)**
Confluence of First Ponds Creek and First Ponds Creek Tributary	CF05	11.27	10.48

From the above it can be seen that the flows across the three investigations; along with the Rational Method check, vary across the site though generally align at the primary outlet with a difference of approximately 5%. Overall, the variances are seen as acceptable and therefore appropriate for use.

5.5 Developed Scenario

Information on the anticipated land use for the precinct was supplied by Cox Richardson. Taking infrastructure requirements into account, preliminary grading of some precinct areas was carried out to allow for the development of the detention strategy, preservation of flood storage, management of hazards, and to improve the overall amenity for increased land use. Based on the revised grading and input from the stormwater management across the precinct, catchment data (slopes, impervious percentage, etc.) representing the developed scenario was input into the XPRAFTS hydrologic model.

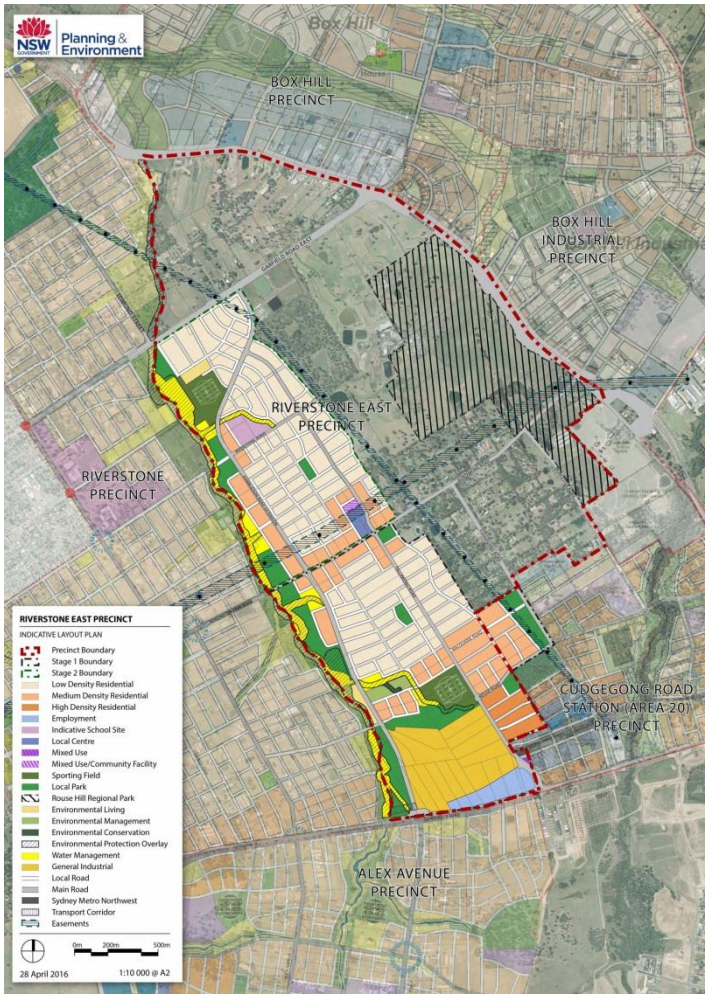
Catchment division in the proposed scenario is similar to the existing though increases the sub-catchments to 82. Water Cycle plans in Appendix A shows the proposed catchment divisions, while Figure 5.5 represents the proposed network in XPRAFTS. Catchment areas, slopes and percentage impervious portions are tabulated in Appendix B.

The post-developed XPRAFTS model was subsequently formulated by incorporating the following:

- “Catchment Nodes” were used to represent each of the 82 sub-catchments. Here, each node is representative of the catchment (either remaining as existing, or adjusted for proposed development) and is divided into both pervious and impervious values (Refer Appendix B);
- “Dummy Nodes” were used where two or more existing sub-catchments joined, which allowed both inflow and outflow hydrographs to be assessed.
- “Lag Links” were used as the links between the nodes and were modelled to provide the travel time (in minutes) for the peak flow to travel the length of this reach.
- “Basins” were used to represent the proposed detention basins utilised to ensure there is no increase to peak flows exiting the overall development, which could potentially have adverse impacts on downstream properties.

Increases to peak flows within the precinct have been addressed through the design of channels and appropriate overland flow routes, to minimise potential flood impacts on surrounding land. This is detailed in the Hydraulics section of the report

Figure 5.4: Riverstone East ILP



Source: Cox Richardson

5.5.1 Proposed Development Assumptions

A number of assumptions have been made in the development of the existing and proposed modelling scenarios for the Riverstone East precinct. They are as follows;

- Areas surrounding the stabling yard are assumed to be industrial/ commercial and are to provide their own on-site detention. As described earlier, the proposed model has accounted for this by adopting the existing parameters (i.e. no proposed development) in these areas.
- Medium/High Density and Commercial areas have been assumed to provide their own water quality and quantity devices in accordance with Council's requirements as such these areas have been included modelled as undeveloped.
- Due to the interdependence between Riverstone and Riverstone East in relation to the basin strategy along First Ponds Creek, the Riverstone precinct has been considered developed. And as such, the following detention basins from the GHD study have been included in the MM model: F16 (Online detention basin); F25; F28 (Online detention basin); F32; and F34
- As Alex Avenue is separated from the Riverstone and Riverstone East Precincts by Schofields Road, it has an independent impact on First Ponds Creek. Meaning, developed flow targets exiting the site beneath Schofields Road would need to be no worse than the existing. As such, Alex Avenue has been modelled under an existing scenario. The below section describes a sensitivity analysis which was undertaken on the Precinct to confirm that modelling it this way was appropriate;
- No increase in impervious area was proposed for the Regional Park as such no detention related specifically to the regional park has been provided. In discussion with Office of Environment and Heritage (OEH) any future works in the park will be offset with local detention and water quality basins provided and managed by OEH separate to this proposal.

5.5.1.1 Alex Avenue Precinct

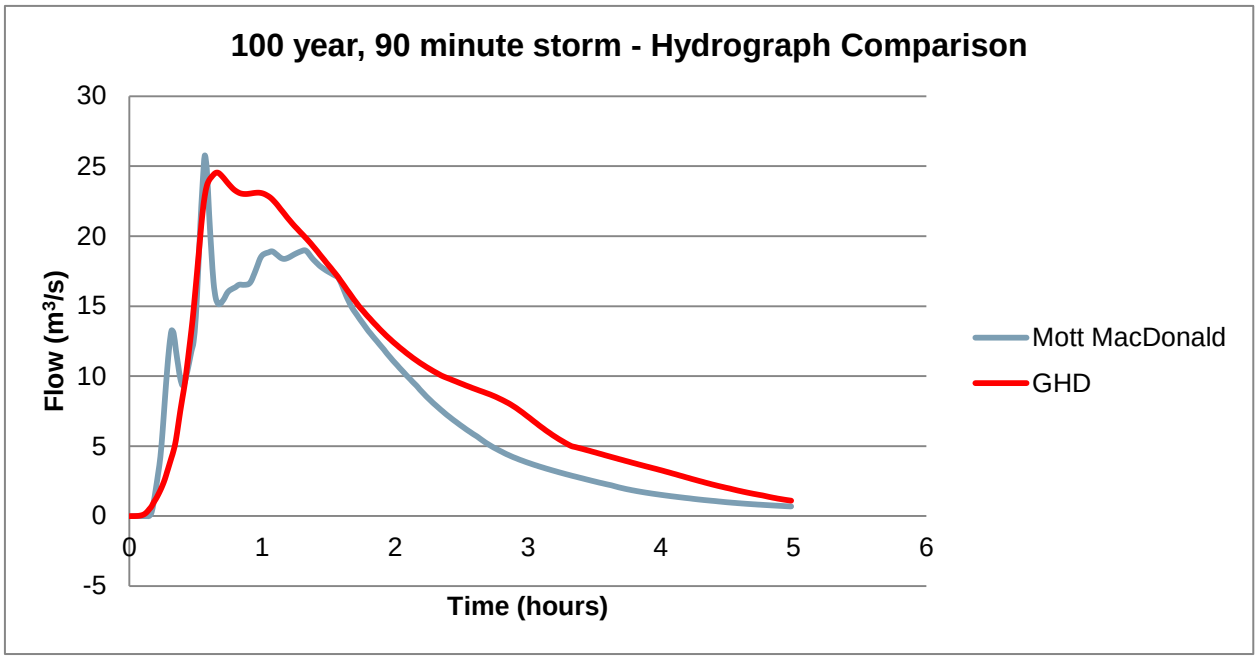
A sensitivity analysis was undertaken to assess any variances between the flows developed in this study for the Alex Avenue Precinct and those from the GHD study prepared as part of the Alex Avenue Precinct Planning process. This study adopted an existing scenario as a worst case, assuming that the proposed would be 'no worse or better'. The below table shows that the changes in the peak flow fluctuate for various storms, noting however, that the overall peak flow from the Mott MacDonald model is greater than the overall peak flow from the GHD model.

Table 5.3: 100 year flow comparison at Schofields Road (m^3/s)

Duration	GHD Existing (a)	GHD Proposed (Post Exhibition) (b)	MM Proposed (Existing Alex Avenue) (c)	Difference (c) – (b)
25	9.94	20.29	24.45	4.16
45	18.69	22.71	19.08	-3.63
60	22.83	23.85	23.47	-0.38
90	24.89	24.53	**26.77**	2.24
120	26.45	**25.68**	23.96	-1.72
180	24.98	22.33	18.29	-4.04
360	27.95	21.70	18.61	-3.09

Keeping the above in mind, there is however potential that a difference in the time to peak could inadvertently cause adverse effects downstream. This could happen by aligning two peak flows from two

separate catchments at a convergence point. This could result in higher flows and a worse scenario in areas than that currently modelled. The below graph shows the hydrograph from the MM prepared Alex Avenue Precinct under existing conditions, against that from the GHD model under developed conditions.



As can be seen there is a slight variation in the time at which the peak flow occurs. To accurately consider the Alex Avenue Precinct under a developed scenario, the flow hydrographs have been exported from the GHD model (node F10a) for all durations and input to the Mott MacDonald model by replacing the 'existing scenario' nodes (SRBR & SRCU).

The below table shows the impact of the GHD modelled proposed flows on the MM modelled Riverstone East Precinct at different locations along First Ponds Creek. The flows generated under the Mott MacDonald existing Alex Avenue Precinct scenario have been provided for comparison.

Table 5.4: 100 year flow comparison – Alex Ave - Existing to Developed – CF01

Storm Duration (min)	MM 'existing' Alex Ave flows	GHD developed Alex Ave hydrograph input	Percentage Change
25	43.60	43.60	0.00%
45	56.03	56.03	0.00%
60	63.39	63.39	0.00%
90	71.02	71.02	0.00%
120	76.12	74.46	-2.18%
180	**78.35**	76.83	-1.94%
360	73.05	**77.00**	5.41%

Table 5.5: 100 year flow comparison – Alex Ave - Existing to Developed – CF46

storm (min)	MM 'existing' Alex Ave flows	GHD developed Alex Ave hydrograph input	Percentage Change
25	40.88	34.39	-18.87%
45	47.33	38.31	-23.54%
60	52.51	44.08	-19.12%
90	57.68	50.66	-13.86%
120	**58.64**	**53.84**	-8.92%
180	48.87	49.25	0.77%
360	43.80	48.64	9.95%

From the above tables it can be seen that the differences in peak flows generally vary across the different duration storms; however they progressively align as the flows traverse the site. Differences in modelling methods, particularly loss method, (GHD adopted *Initial / Continuing Loss* whereas MM adopted *ARBM*) have been observed to greatly impact the resulting flows and could be the reason for these differences. It should be noted that the peak flow across both methods occurs in the MM model adopting an 'existing' Alex Avenue. This is considered a conservative approach.

In light of the above, modelling has been progressed with the Alex Avenue Precinct being maintained under the Mott MacDonald generated existing scenario flows. It is understood that Council are currently exploring options for additional detention storage within Alex Avenue which may affect detention volumes within Riverstone/Riverstone East.

5.6 Management Strategies

5.6.1 Major/Minor System

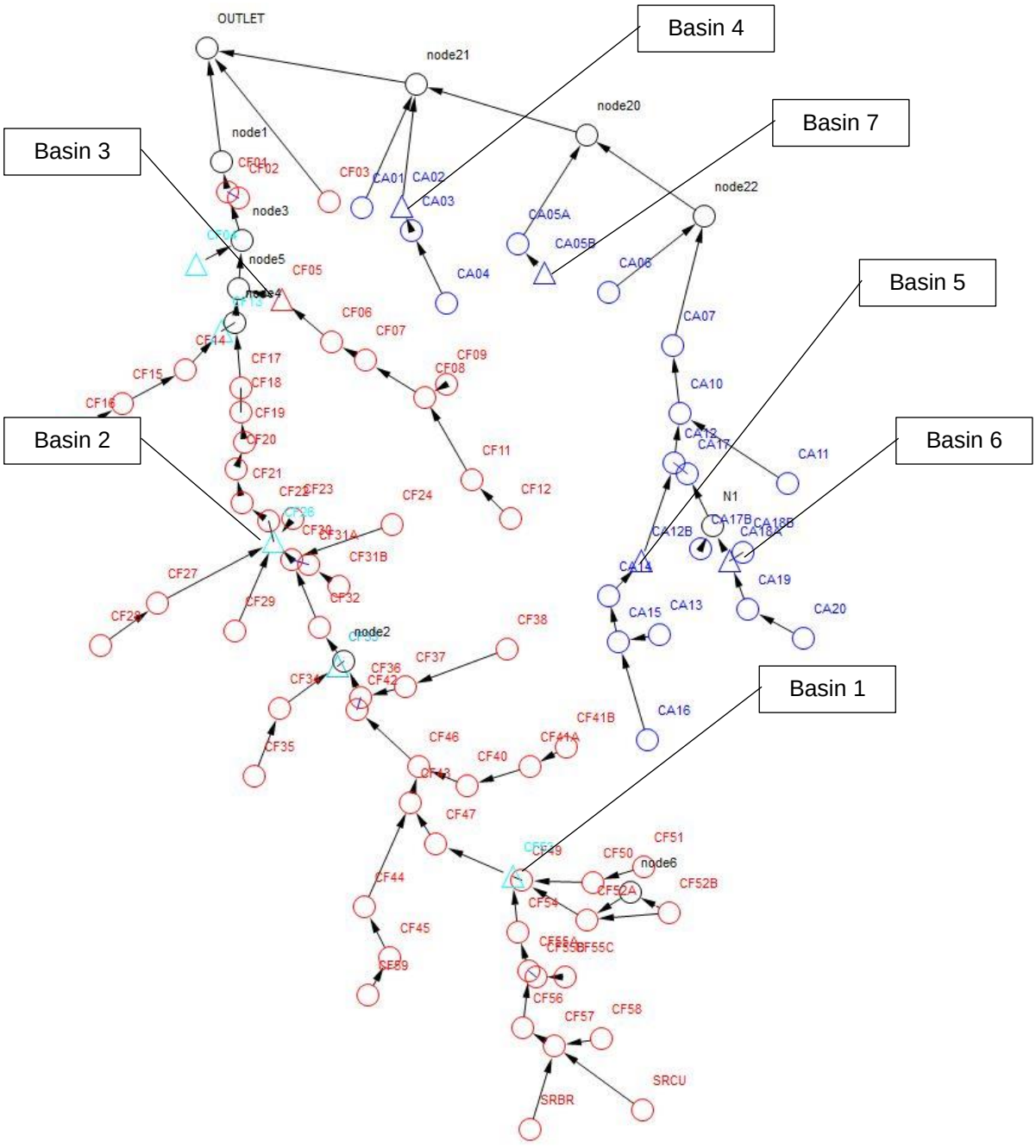
The drainage system to be used in the developed scenario is the major/minor system. The minor system is designed to control nuisance flooding and enable effective stormwater management for the site. Council's standards require that the minor system be designed for a minimum 5 year ARI, but with more stringent requirements on specific areas dependant on land use. For the purpose of a high level assessment minor stormwater pit and pipe networks were not considered in the modelling however consideration was given to sizing of regional drainage elements such as detention basins for the 2yr, 20yr, 100yr, 200yr, 500yr, PMF and Climate Change.

The major drainage system incorporates overland flow routes through developed scenario roads and open spaces and has been assessed against the 100 year ARI design storm event, with general safety and flooding issues being addressed for events in excess of the 100 year ARI storm. The function of Windsor Road was also checked against flooding affectation in the 500 year event due to its role as an emergency evacuation route for the Riverstone, Box Hill, Vineyard and Windsor areas.

5.6.2 Detention Basins

To manage the flood risk impact on downstream properties, detention basins will be constructed for water quantity management. Detention Basins were introduced in the hydrologic modelling for the developed scenario to ensure that during the 2 to 100 year flood events no increase to peak flows is to be experienced. A detention strategy was developed to determine the location, sizing and configuration of detention basins, optimising the flow regime to satisfy the requirements of maximum permitted flows as established through the modelling of the existing scenario.

Figure 5.5: Proposed XPRAFTS Network Including Riverstone East Basins



5.6.2.1 Basin Strategy

Five new basins have been proposed to detain flows and decrease the peak flow rates generated by the proposed Riverstone East development. Two basins online of First Ponds Creek, previously proposed as part of the Riverstone Precinct study have been maintained and remodelled making a total of seven basins. All basins were modelled with a stage-storage relationship and use the default discharge equations within XPRAFTS. Basins 1, 2 and 3 have been designed to maintain the existing first ponds creek within the detention basin for the 2 year bank full flows, the outlet structure is then comprised of a staged weir (rather than a piped outlet) to maintain environmental flows to the creeks. It was noted that there is an identified Aboriginal Heritage area surrounding Basin 1. As much as possible, the basin was located to avoid this area as well as the existing Buddhist Temple.

The design of the proposed basins 4, 5, 6 & 7 incorporates the sizing of the piped outlet to satisfy the minor events pre-post discharge rate. The peak design flow (100 year ARI) is then discharged via a combination of the piped and weir outlets and conveyed along the watercourse downstream.

A shared basin approach has been adopted for Riverstone and Riverstone East with the introduction of two online detention basins (Basins 1 and 2). This strategy was proposed in the GHD study and further refined as part of this study. First Ponds Creek is a 2nd order creek with the strategy receiving approval from the NSW Office of Water (NOW). This assessment has attempted to maintain the approved locations as much as possible as the NOW assessment allowed for incorporation of the Green and Golden Bell frog habitat within Riverstone precinct.

Basin 5 is currently proposed with the Regional Park. Discussions have been made with OEH regarding the location of this basin and where possible the existing dam/unvitiated areas were used. It is understood that this basin will be managed by Council however this is pending further negotiations.

Basin 7 has been designed to maintain the existing culverts under Garfield Rd East, by detaining proposed flows back to the existing flows. This basin also acts to offset the small downstream catchment such that flows are maintained to the culverts beneath Windsor Rd.

The remaining basins 3, 4 and 6 have been provided at the most downstream sections of their respective catchments in order to maximise their efficiency and maintain pre-post flow regimes. Channels and overland flow paths have been proposed to contain flows and minimise flood impacts on surrounding lands. This is detailed in the Hydraulics section of the report.

Table 5.6: Riverstone and Riverstone East Basin Strategy

Basin Servicing Strategy	Riverstone (GHD 2010)	Riverstone East	Comment
Basin 1	X	X	Basin 1 (aka Basin F16 in GHD report) is an online detention basin for First ponds creek which accepts flows from both Riverstone & Riverstone East Preliminary designs were undertaken by GHD in 2010, this has now been updated as part of this study to suit the proposed ILP
Basin 2	X	X	Basin 2 (aka Basin F28 in GHD report) is an online detention basin for First ponds creek which accepts flows from both Riverstone & Riverstone East Preliminary designs were undertaken by GHD in 2010, this has now been updated as part of this study to suit the proposed ILP
Basin 3		X	Services only the proposed Riverstone East Catchment
Basin 4		X	Services only the proposed Riverstone East Catchment
Basin 5		X	Services only the proposed Riverstone East Catchment
Basin 6		X	Services only the proposed Riverstone East Catchment
Basin 7		X	Services only the proposed Riverstone East Catchment
Basin F25	X		Services only the proposed Riverstone Catchment
Basin F32	X		Services only the proposed Riverstone Catchment
Basin F34	x		Services only the proposed Riverstone Catchment

General principals adopted when locating and configuring the basins included the following:

- Locate basins to detain as much of the catchments runoff as possible, thereby minimising the overall number of basins required;
- Avoid existing vegetation where possible;
- Avoid areas that may be retained (such as the existing Buddhist temple and Aboriginal Heritage Sites);
- Provide active storage depth of 1.2m with a maximum depth of 1.5m within storage overbank areas;
- Provide and average batter slopes of 1:6;
- Maintaining a natural creek flow continually through the online basins where possible. This involves constricting the creek flow for minor storm events rather than constructing a low flow culvert/ piped outlet; and
- Staged weir outlet for larger storm events.

5.6.2.2 Online 2nd Order Detention Basins (Basins 1 and 2)

In 2010 the Department of Planning and Environment in collaboration with NSW Office of Water (NOW) undertook a review of the initial detention basin strategy proposed as part of the Riverstone and Alex Avenue rezoning studies. As part of this review process opportunities were explored to improve the efficiency of drainage land in which alternate online detention basins were proposed. The online basins were proposed in very limited circumstances and only where environmental impacts were minimised and development benefits maximised. These basins were referred to as F16 (referred to as Basin 1 in this report) and F28 (referred to as Basin 2 in this report) and located along first ponds creek to provide

common benefit to the Riverstone east and Riverstone precincts. Approval for the online basins was obtained from NOW as part of this review process.

Since this approval more detailed analysis has been undertaken of the basins as part of this Riverstone East study. As such minor adjustments to the initial basin locations have been recommended in this report. The below figures show the adjusted basin locations with reference to the previously (2010) approved 'in principle' basin locations.

Figure 5.6: Adjusted Proposed Basin 1 (red)

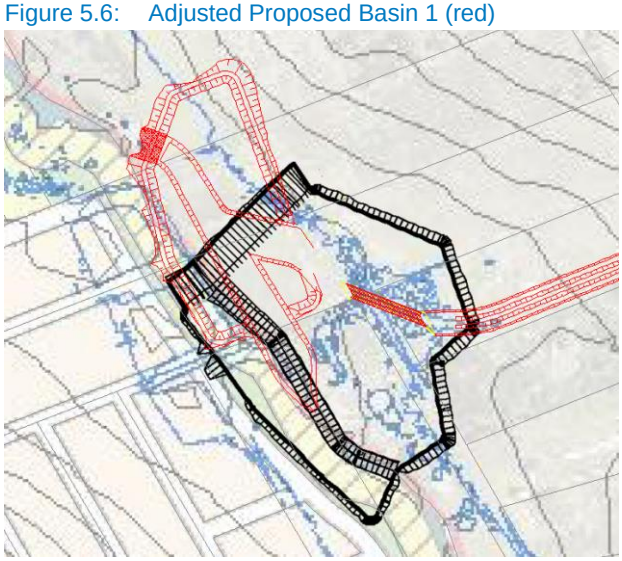
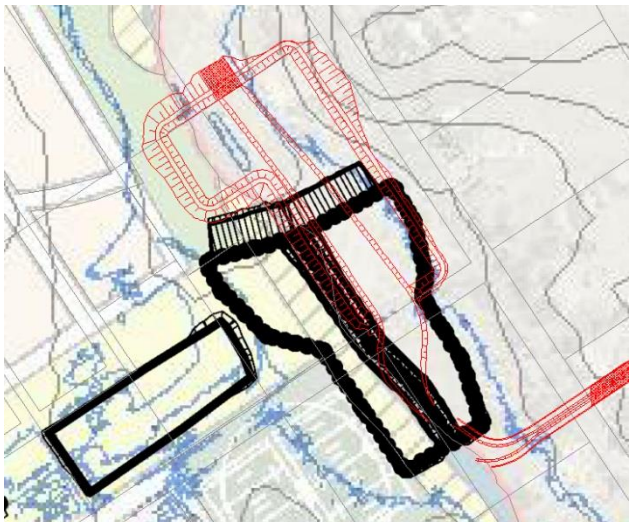


Figure 5.7: Adjusted Proposed Basin 2 (red)

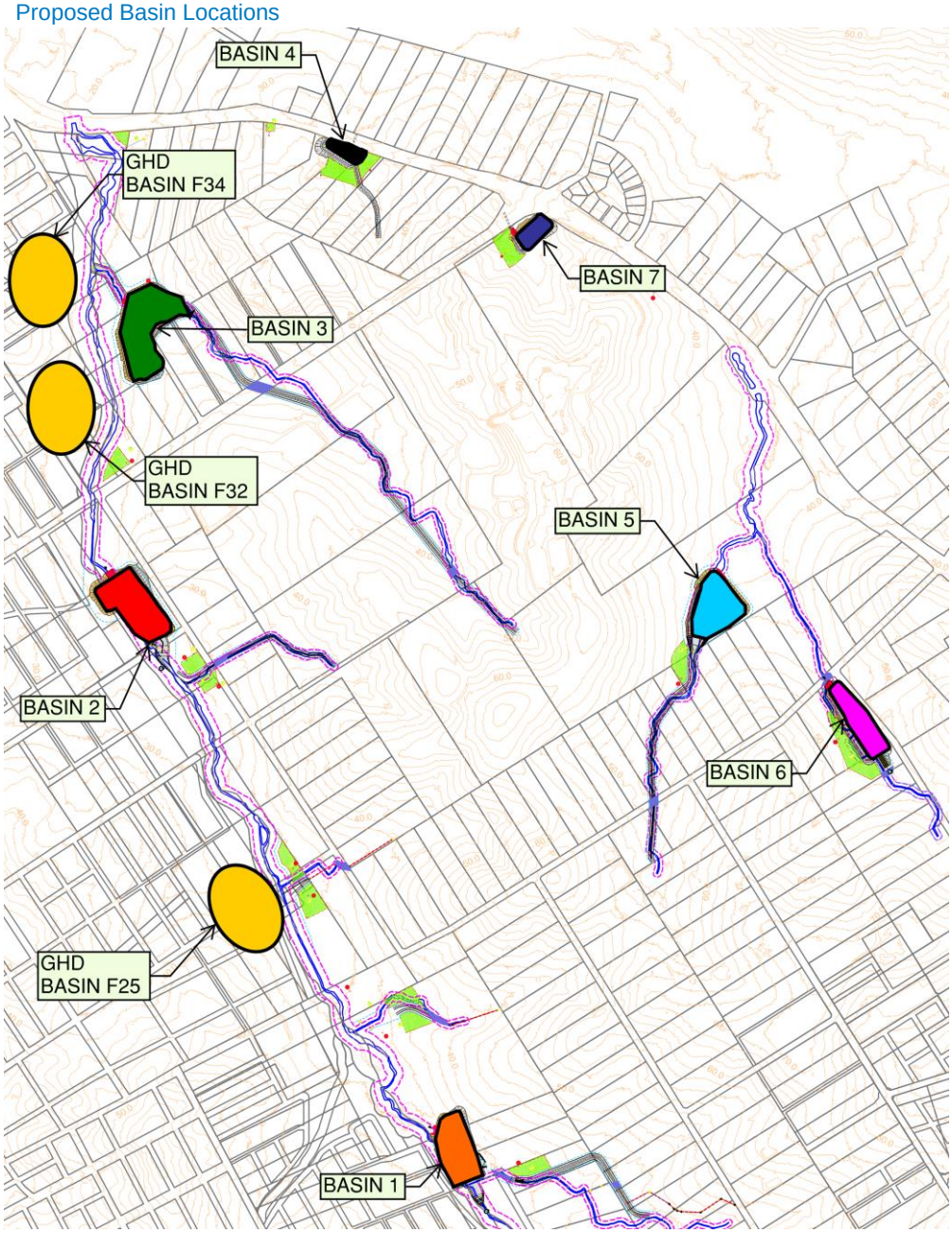


The adjusted basin locations shown above in red have been refined from the original locations in black due to the following factors,

- Proximity to Aboriginal Heritage sites
- Proximity to Existing Buddhist temple
- Environmental constraints
- Location in relations to services and proposed/existing roads
- Minimising land take and earthworks

Whilst the above locations have been slightly amended it is understood that the current NOW approval will still apply given the locations are largely the same and the additional social, environmental and economic benefits.

Figure 5.8: Proposed Basin Locations



The volumes required were refined by manual iteration until results showed that the total flows generated from the post-developed scenario did not exceed those in the pre-developed. A summary of the proposed detention storages for the Riverstone East precinct are shown in the table below. The basin locations are shown in Appendix A.

Table 5.7: Proposed Detention Basins

Basin	Size (m^3)	Average Depth (m)	Type of Basin	Location
1	35,650	1.2	2nd Order Online	First Ponds Creek; west of Macquarie Road
2	33,750	1.2	2nd Order Online	First Ponds Creek; south of Garfield Road East
3	25,750	1.2	1st Order Online	First Ponds Creek Tributary; north of Garfield Road East
4	4,800	1.2	Upstream of Windsor Road to eliminate need to upgrade culverts	Northern most end of site; south of Windsor Road
5	21,400	1.2	1st Order Online	Regional Park; north of Guntawong Road
6	18,500	1.2	1st Order Online	South of Guntawong Road
7	4,800	1.2	1st Order Online	Corner of Garfield Road East and Windsor Road (south side)

5.7 Results

The following sections describe the results of the hydrological model and include discussion on various aspects and parameters of the modelling.

5.7.1 Design Discharges

Urban catchments generally experience higher discharge rates than rural ones due to the increase in impervious areas and the reduction of hydraulic resistance to flow paths. The detention strategy was developed to attenuate design flows such that there would be no increase in flow rates as a result of development from the 2 to 100 year ARI design flood events.

Design discharges were produced for a range of ARIs including the 2, 20, and 100 year ARI events. Storm durations ranging from 25 minutes to 12 hours were modelled for each ARI, using AR&R temporal patterns, in order to identify the peak flow for each sub-catchment node. The design discharges for all of these events are shown in Appendix C. Extended duration storms were simulated for the 6 hour and 12 hour events to analyse any potential secondary peaks.

5.7.2 Comparison of Existing and Post-Developed Flows

The 100-year ARI flows for the post-development scenario are compared with existing conditions in Table 5.8 below. A comparison is drawn between the existing scenario and the developed scenario with and without detention basins for key locations across the precinct. It can be seen that developed peak flows are generally higher than the corresponding flows in the existing case, and that the detention basin strategy is necessary to limit the developed peak flows back to the corresponding existing peak flow rate. Similarly, the peak flow rate results from the 2 year event can be seen in Table 5.9.

Table 5.8: 100 year Existing and Developed peak flow rates (m^3/s)

First Ponds Creek Location	XPRAFTS Node	Existing peak flow (m^3/second)	Developed peak flow* (m^3/second)	Developed peak flow with detention (m^3/second)
Schofields Road	CF56	30.98	32.48	32.48
Guntawong Road (future)	CF46	60.72	66.95	58.63
Riverstone Road	CF32	66.48	72.64	64.39
Garfield Road East	CF19	71.68	77.48	67.55
Windsor Road (Outlet)	**CF01**	**78.84**	**87.48**	**78.35**
First Ponds Tributary Location	**XPRAFTS Node**	**Existing peak flow (m^3/second)**	**Developed peak flow* (m^3/second)**	**Developed peak flow with detention (m^3/second)**
Confluence of First Ponds Creek and First Ponds Creek Tributary	CF05	11.27	22.90	16.61
Killarney COP Tributary Location	**XPRAFTS Node**	**Existing peak flow (m^3/second)**	**Developed peak flow* (m^3/second)**	**Developed peak flow with detention (m^3/second)**
Discharge to Regional Park	CA12	24.04	42.42	24.05
Windsor Road (central)	CA05	3.80	7.57	3.80
Windsor Road (north)	CA02	5.50	8.50	5.44

Table 5.9: 2 year Developed and Existing peak flow rates (m^3/s)

First Ponds Creek Location	XPRAFTS Node	Existing peak flow (m^3/second)	Developed peak flow* (m^3/second)	Developed peak flow with detention (m^3/second)
Schofields Road	CF56	11.67	12.38	12.38
Guntawong Road (future)	CF46	20.56	28.04	17.58
Riverstone Road	CF32	22.10	30.66	21.04
Garfield Road East	CF19	22.91	32.93	18.94
Windsor Road (Outlet)	**CF01**	**25.33**	**38.78**	**25.55***
First Ponds Tributary Location	**XPRAFTS Node**	**Existing peak flow (m^3/second)**	**Developed peak flow* (m^3/second)**	**Developed peak flow with detention (m^3/second)**
Confluence of First Ponds Creek and First Ponds Creek Tributary	CF05	3.21	10.06	3.99
Killarney COP Tributary Location	**XPRAFTS Node**	**Existing peak flow (m^3/second)**	**Developed peak flow* (m^3/second)**	**Developed peak flow with detention (m^3/second)**
Discharge to Regional Park	CA12	5.94	17.87	5.73
Windsor Road (central)	CA05	0.82	3.32	1.06*
Windsor Road (north)	CA02	1.26	4.03	1.92*

*Minor discrepancies between some two year storms however pre-post flows are matched for all ARI greater than 5 year (Councils Minor system drainage requirement). Staged discharged relationship can be adjusted to rectify this at the detailed design stage.

5.7.3 Probable Maximum Flood

The probable maximum flood event has been considered in the assessment to aid in the preparation of a flood evacuation plan. Probable Maximum Precipitation (PMP) was derived using the Bureau of Meteorology's Generalised Short Duration Method (2003). A comparison of rainfall intensities is shown in the below table along with the resulting peak flows for the 100 year event and PMF at the main catchment outlet (node CF01)

Table 5.10: Comparison of 100 year and PMF event at Node CF01 – 2 hour duration

	100yr Intensity (mm/hr)	100yr flow rate (m^3/s)	PMF Intensity (mm/hr)	PMF flow rate (m^3/s)
Existing	43.29	78.84	255	551.86
Proposed	43.29	78.35	255	502.66

Based on the modelling, the peak PMF will be approximately 6 times greater in flows than the peak 100 year event at the outlet to the site. The PMF event is explored further as part of the Hydraulic assessment.

5.7.4 Climate Change Assessment

Recommendations from the former Department of Environment and Climate Change document titled *Practical Consideration of Climate Change,* guide the modelling of flood scenarios to include a "sensitivity check" incorporating data on the projected effects of climate change on sea levels and rainfall intensities. Multiple iterations of flood models can be produced using different climate change affected rainfall intensities. For the purpose of this report however, a sensitivity analysis has been undertaken by applying a 20% increase to rainfall intensity of the peak 100year ARI storm event. It is acknowledged that other precincts in the region have adopted a 15% increase in flows as such the 20% increase is considered acceptable.

Table 5.11 below compares 100 year flow rates for the developed scenario with corresponding flow adopting the increased rainfall intensity above. As is evident, the increase to peak flow at the outlet is proportional to the increase in rainfall intensity. Discussion and 2D modelling of the effect of the increased flows on flood levels are explained in the following section.

Table 5.11: Effects of climate change on 100yr storm – 2 hour duration (at node CF01)

100 year 2 hour storm	Current	+20%
Rainfall Intensity (mm/hr)	43.29	51.95
Peak Flow (m^3/s)	78.35	92.67
Percent Increase to Peak Flow	0%	18.28%

6 Hydraulics

6.1 Introduction

TUFLOW, a one and two-dimensional (1D/2D) hydraulic modelling program has been utilised to perform a detailed assessment of the existing (pre-development) and proposed (post-development) flooding scenarios for the Riverstone East precinct.

The objective of the flood assessment was to determine changes to flooding characteristics resulting from development of the precinct, and examine the performance of the water cycle management strategies discussed in Section 5.6. The flooding characteristics examined in the analysis include water level, depth, velocity and hazard category.

Data supplied by Council, the Department of Planning and Environment and the Bureau of Meteorology was utilised along with information gathered through first hand observations of existing conditions.

6.2 Existing and Proposed Models

6.2.1 TUFLOW Software Package

The *TUFLOW* (2D component) software package computes flow paths by dividing the floodplain into a grid of individual cells. The flow of water between cells is then computed repeatedly at regular time steps by solving two dimensional shallow water equations to estimate the flood spread and flow. As each cell contains information on water levels, flows are routed in the direction that will naturally follow the modelled topography.

ESTRY (1D component) is a separate calculation engine which is incorporated into *TUFLOW* to handle flows through structures which cannot be accurately represented with grid cells. *ESTRY* is a network dynamic flow program suitable for mathematically modelling floods and tides (and/or surges) in a virtually unlimited number of combinations. By including non-linear geometry, *ESTRY* can provide an accurate representation of the way in which channel conveyance and available storage volumes vary with changing water depth. *ESTRY* has been developed in conjunction with *TUFLOW* to resolve complex 1D-2D flows across the floodplain interface.

The flood assessment was modelled using TUFLOW build 2013-12-AB.

6.2.2 Flood Events

Flood events were modelled for the 2, 20, 100, 200, 500 year Average Recurrence Intervals, the Probable Maximum Flood and Climate Change. These events were simulated in both the existing and developed scenarios.

6.2.3 Hydrologic Data

Results of the Hydrological assessment were input into the existing and developed TUFLOW hydraulic models. Flows were extracted JWP's Box Hill/Box Hill Industrial Precincts model for consistency and to sufficiently model tailwater effects. These hydrographs have been applied to the model at specific locations as discussed in section 6.2.5.

As the Riverstone and Riverstone East Precincts are proposed to share 2 basins, the Riverstone Precinct has been modelled as a proposed scenario to appropriately size the detention basins. However, the Alex Avenue Precinct shares no link to the Riverstone East Precinct and has therefore been modelled as existing. While it's acknowledged that surrounding growth centre precincts are in various stages of a similar planning process to Riverstone East, the timing of development across the precincts cannot be assumed with reliability. It is also noted that flows from developed scenarios should be attenuated back to existing scenario flow rates through proper implementation of water sensitive urban design and flood risk management principles. It is also acknowledged that flow volumes and peak flow times may change, however this has been explored previously in the report

6.2.4 Digital Terrain Model

6.2.4.1 Survey data

The topography of the catchments and the creek alignments have been reproduced digitally, based on LiDAR (Light Detection and Ranging) information supplied by Council. A 5m x 5m grid was selected for the Digital Terrain Model (DTM) for use in TUFLOW. This grid resolution is judged appropriate for this model given the scale of the precinct and a general lack of clearly defined creek banks which could potentially demand a finer resolution.

6.2.4.2 Schofields Rd - Stage 2 upgrade works

In the area surrounding the Stage 2 Schofields Road upgrade works at First Ponds Creek, the DTM has been supplemented with the designed surface levels. This incorporates First Ponds Creek re-grading works which will affect flow regimes in the area. Current creek invert levels upstream and downstream of the works have been modified to create a smooth transition to the design surface levels and best represent the flow regime at completion of the works.

6.2.4.3 Developed scenario modifications

For analysis of the developed scenario earthworks have been proposed to amend flow regimes within the upper reaches of streams (stream order 1) and overland flow paths in order to consolidate developable land and maximise the developable value of the precinct. Where small streams are to be re-trained as channels or flow paths as roads, 3D terrain modelling was carried out to create design surface levels applied directly to the DTM.

Where detention basins are proposed for the management of water quantity and quality, the grading of the basins has been created using 3D terrain modelling and applied to the DTM as surface levels. General design principles for the basins are as follows:

- Nominal storage depth of 1.2m
- 1v:6h graded basin walls
- 2 year ARI flow channel cut through the basin.
- Modified v-notch stage-discharge

Overflow structures for the basins have been modelled as one-dimensional structures in ESTRY and discussed in section 6.2.6.

6.2.5 Boundary Conditions

6.2.5.1 Precinct Catchments

The runoff volumes from catchments within the precinct have been determined through the hydrological modelling, and have been applied to the hydraulic model as hydrographs (flow vs time). With this approach the hydraulic model simulates the convergence of sub catchment rainfall at the lower portion of each sub-catchment where it enters more defined overland flow paths or streams. For the developed scenario some of these hydrographs have been directly applied to channel sections within the DTM to simulate the flow within a typical future road cross-section, or the discharge of formal road network drainage infrastructure to open drainage channels.

6.2.5.2 Upstream creek flows

First Ponds Creek crosses the model boundary near Schofields Road with two major flow paths from upstream catchments. The culvert and bridge structures and ground model for the Stage 2 Schofields Rd upgrade works have been incorporated into the hydraulic model to best represent the flow regime exiting these structures. The runoff volumes for the two upstream reaches of First Ponds Creek were calculated in the hydrological analysis discussed in section 5.7. These upstream flows have been applied as hydrographs upstream of the Schofields Rd structures.

Tributaries of Killarney Chain of Ponds enter the model within the Box Hill/Box Hill Industrial Precincts. As discussed in section 6.2.2, calculated flow rates and extracted flow rates from previous models were considered in each of these tributaries. The selected hydrographs were applied across the flood plain at the model boundary allowing TUFLOW to apply the flows to creek sections.

In the developed scenario, tributary flows entering First Ponds Creek from the Riverstone precinct have been input to the model with attenuated hydrographs. These hydrographs reflect flow rates from Riverstone precinct catchments integrating the performance of detention basins upstream of the Riverstone East precinct.

6.2.5.3 Downstream creek flows

The downstream boundary levels are generated by TUFLOW through calculations of localised flood levels through the Killarney Chain of Ponds floodway given pre-determined grades from the digital terrain model.

In the PMF event the precinct experiences backwater flooding from the greater Hawkesbury-Nepean catchment. As such the downstream boundary condition across Killarney Chain of Ponds is configured as a stable water level at the predetermined regional flood level. These levels were supplied by Blacktown City Council.

6.2.5.4 Losses

Losses through evaporation and infiltration to the soil have been applied in the hydrological model for all catchment areas of the precinct. Further infiltration and evaporation has not been incorporated into the hydraulic model as these affects have been accounted for already in the hydrological analysis.

6.2.5.5 Existing Dam structures

Existing dams as surveyed have been examined for the sensitivity of surrounding flooding characteristics to water levels and potential storage volumes. The initial water level of existing dams has been applied to the model conservatively to reduce the risk of over-estimation of dam storage through flood events. This approach is consistent with previous studies of flooding in the area and is in line with best practices.

6.2.6 Hydraulic structures (1D ESTRY component)

Where formal drainage structures are located within the model extents, additional survey information from Blacktown City Council, data from previous models and information from site inspections have been used to generate an accurate one-dimensional hydraulic representation of these structures within the model.

Windsor Road runs the entire length of the downstream boundary of the precinct and forces all flows exiting the precinct through formal drainage structures or to spill across the road surface. Roads and Maritime Services (RMS) cross drainage data for Windsor Road was provided by the Department of Planning and Environment for incorporation into the model as one-dimensional structures.

In discussions with Blacktown City Council, inlet and culvert blockages were considered in the modelling with a 50% blockage factor across all culverts being applied in order to assess overland flow paths. Smaller culverts with a diameter less than or equal to 600mm were omitted from modelling in major events to simulate potential blockages of these structures. In determination of the sizing for drainage structures associated with arterial roads, 50% blockage was allowed for in the design capacity.

6.2.6.1 Detention basin outlet structures

The detention basin outlet structures designed integrally through the hydrological analysis have been incorporated into the TUFLOW model as ESTRY structures. The performance of the basins, as designed, has been replicated in TUFLOW by embedding the structures into the basin walls (within the DTM) creating both the low flow outlet and overflow weir sections. Detention basins pipe outlets were not considered to have a 50% blockage factor applied.

6.2.7 Flood Management Strategies

A range of measures is proposed for the flood cycle management of the Riverstone East precinct. The following strategies were adopted,

- Detention basins have been modelled to assess the impacts of the increase in runoff from the proposed development and to test the efficiency of the basins in relation to geometric design and outlet function with tailwater effects.
- Opportunities have been explored to reduce the extent of flooding within the development thus increasing the developable area. This has generally only been applied where there are existing wide spread shallow flows. This has been achieved with localised filling and channel re-definition.
- Where it is possible to manage surface flows within the street drainage network they have been excluded from the TUFLOW modelling.

6.2.7.1 Creek re-alignment

In the developed scenario, the construction of a road network and associated piped drainage structures will capture rainfall and runoff flows from the upper portions of the precinct catchments. In order to consolidate the proposed development layout and maximise the development potential of the precinct, minor flow paths and streams have been either:

- realigned and channelized (where the existing stream-order of one applies); or
- removed and replaced with formal drainage structures.

Under existing conditions there are sections of First Ponds Creek and First Ponds Creek Tributary that have been significantly altered by agricultural/industrial works such that in some locations there is little to none discernible creek channel. In these areas the existing flooding is quite widespread, this is particularly evident along First Ponds Creek Tributary where there has been significant manipulation to the existing floodplain with farm dams and pastures, here flood depths are generally quite shallow and upgraded creek is proposed to better manage nuisance water and floodwaters. This in turn allows previously shallow flooded areas to be salvaged for development.

Where existing riparian corridors exist these have been maintained and creek embellishment works proposed (these works are only proposed to 1st order streams). The existing classification has been

maintained while the flows have been channelised. The result is a formal drainage channel with riparian offsets, better streamlined for configuration of developable areas.

6.2.7.2 Detention Basins

Detention basins have been designed through the hydrological analysis of the developed scenario to attenuate developed scenario flows back to existing for events ranging from the 2 – 100yr ARI. The performance of these detention basins can be observed in the attenuated flow rates discussed in the results section following and can be observed across the flood maps for 2 to 100year ARI events. The stage vs storage relationships for these facilities have been replicated in the TUFLOW model as discussed in section 6.2.4.3.

6.3 Results

6.3.1 Flood maps for design events

The following TUFLOW output maps are attached to this report as Appendix A:

- 2yr Existing Flood Extents/Depths
- 2yr Proposed Flood Extents/Depths
- 100yr Existing Flood Extents/Depths
- 100yr Proposed Flood Extents/Depths
- 100yr Flood Difference maps from Existing to Proposed
- 100yr Existing Flood FDM Hazard Maps
- 100yr Proposed Flood FDM Hazard Maps
- 100yr Climate Change maps (20% Increase in rainfall intensity)
- 100yr Flood Difference maps from Proposed scenarios with and without climate change
- 500yr Proposed Flood Maps
- PMF Proposed Flood Maps

6.3.2 Existing and developed scenario comparison

Generally, flood mapping indicates that in the developed scenario the flood management strategies achieve their goal of restricting developed flows back to the existing scenario flow rates. As can be seen in the attached flood maps flood hazards are generally not increased across the site, and in most cases are reduced.

For the 100 year event flood water levels were generally reduced or maintained. On average flood levels were reduced by approximately 0-50mm along the length of First Ponds Creek. Localised areas of increase generally occur within the detention basins where they are manageable and velocities are low.

The results are consistent with the hydrologic modelling and there is generally no increased impact on neighbouring properties or downstream of the site. Improvements are also noticed at sites such as the

Lankarama Vihara Buddhist Temple, here existing mainstream flooding from First Ponds Creek and overland flow from surrounding catchments inundated the site. The proposed 1st order creek alignments and the effective placement of Basin 1 have improved flood levels across the site, whilst the site is still not flood free there is no worsening for storms up to and including the 100 year event.

Opportunities were explored to reduce flood extents to minimise nuisance flooding these areas are highlighted in Appendix E. It is expected that trunk piped drainage networks will be provided leading into the creeks.

As a result of the detention basins there is generally no flood worsening for the Windsor Rd culverts and no increased impact for the Regional Park.

6.4 Channel Stabilization Assessment

An assessment has been undertaken to identify areas of potential waterway instability. With increased development the volume of surface runoff is generally increased. This is also coupled with a corresponding increase in velocity related to surface roughness and concentration of flows (to reduce nuisance flooding on minor creeks/waterways). The increased surface runoff and some increased velocities can cause increased risk of erosion in large storm event. To ensure waterways remain stable a shear stress assessment has been undertaken to determine potential areas that may be at risk to erosion.

Different soil types and soil grain sizes respond differently to erosion. Larger grain sizes are generally heavier; such as boulders, and require a larger force to move than compared to a grain of sand. The point at which a soil/gravel particle becomes mobile (causing erosion) is determined by the Critical Shear Stress. The following table provide an indication of the Critical Shear Stress for a given material.

Table 6.1: Critical Shear Stress

Particle classification name	Ranges of particle diameters (mm)	Critical bed shear stress (τc) (N/m2)
Coarse cobble	128 – 256	112 – 223
Fine cobble	64 – 128	53.8 – 112
Very coarse gravel	32 – 64	25.9 – 53.8
Coarse gravel	16 – 32	12.2 – 25.9
Medium gravel	8 – 16	5.7 – 12.2
Fine gravel	4 – 8	2.7 – 5.7
Very fine gravel	2 – 4	1.3 – 2.7
Very coarse sand	1 – 2	0.47 – 1.3
Coarse sand	0.5 – 1	0.27 – 0.47
Medium sand	0.25 – 0.5	0.194 – 0.27
Fine sand	0.125 – 0.25	0.145 – 0.194
Very fine sand	0.0625 – 0.125	0.110 – 0.145
Coarse silt	0.0310 – 0.0625	0.0826 – 0.110

Particle classification name	Ranges of particle diameters (mm)	Critical bed shear stress (τc) (N/m2)
Medium silt	0.0156 – 0.0310	0.0630 – 0.0826
Fine silt	0.0078 – 0.0156	0.0378 – 0.0630

Source: USGS

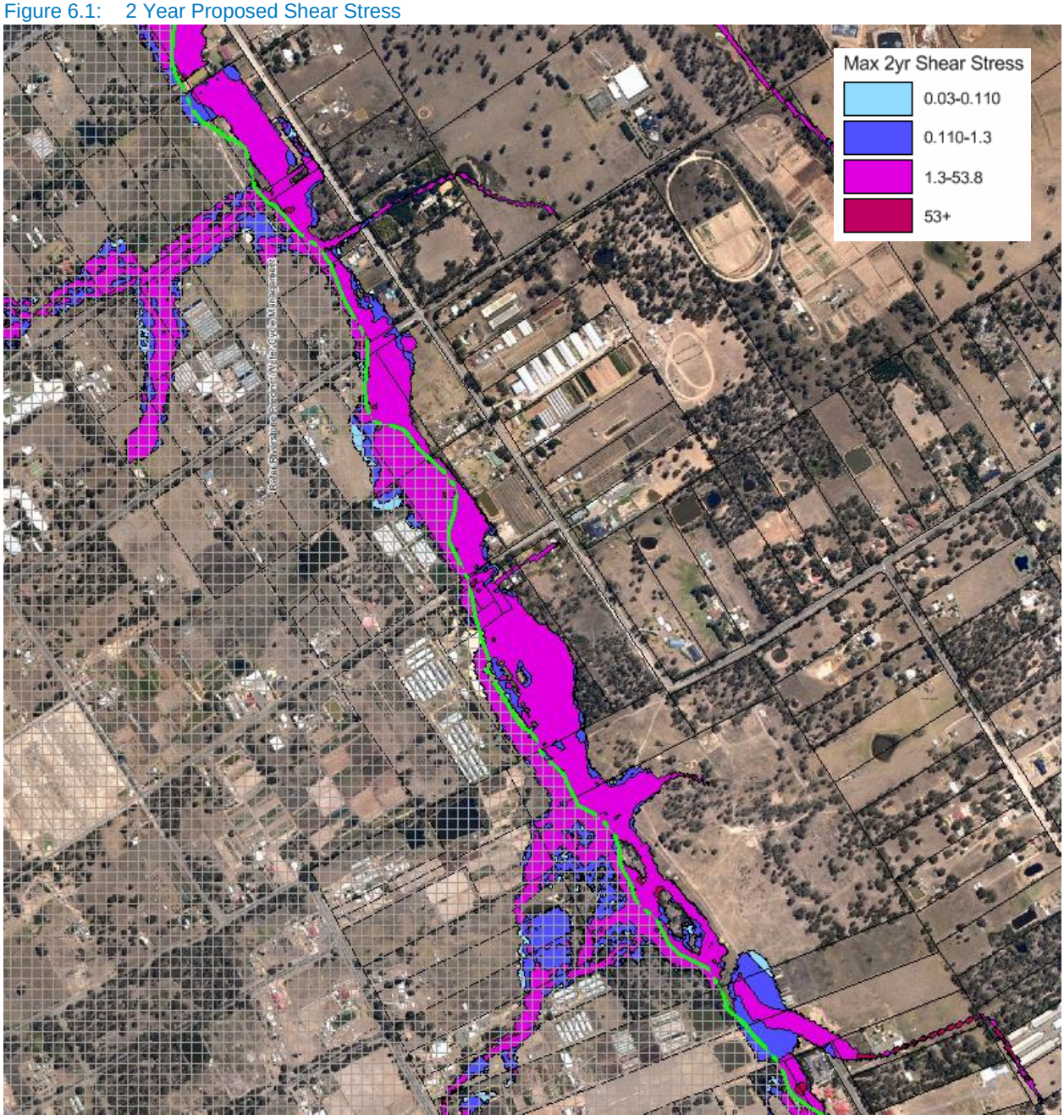
Using the results of the 2year ARI Storm event an analysis was undertaken to categorise the measured shear stresses. The shear stresses have been grouped in the following categories, where a shear stress is recorded in one of these categories then further assessment may be required to confirm the soil type at that location has a higher shear stress than those recorded. If the recorded shear stress is less than the Critical shear stress of that particular soil type then no erosion will occur. If the recorded shear stress is greater than the Critical shear stress of that particular soil type then erosion protection may need to be provided at the detailed design stage. It should be noted that vegetated layers have different shear stress values than those specified below.

Table 6.2: Critical Shear Stress Ranges for General Soil Media

Critical Shear Stress Range	General Material Classification
0.03-0.110	Silt
0.110-1.3	Sand
1.3-53.8	Gravel
53+	Cobbles/Boulders

The flowing figure indicates the expected shear stresses in stages 1 and 2

Figure 6.1: 2 Year Proposed Shear Stress



6.5 Climate Change

As an extension of the climate change assessment undertaken in section 5.7.4 the proposed flow increases were run through the flood model to determine the associated impacts and increases in flood level. As a worst case scenario the 20% rainfall intensity climate change scenario was adopted.

The results of the study indicate that flood level increases are expected in the order of 0-300mm when compared with the proposed development base case. Under a 20% climate change increase scenario flood levels are similar in level to the 200yr event. It is anticipated that the increase in size and cost of detention basins to accommodate this climate change scenario may outweigh the alternate impact of adopting a higher freeboard. As such it is recommended that the proposed detention basins not be upgraded to detain the 20% Climate change scenario but rather the Flood Planning Level be set at 0.5m above the 20% Climate change level as opposed to the traditional flood planning level set at 0.5m above the 100 year event.

6.6 Flood Evacuation Strategy

Extensive and complex operations are required to deal with severe and extreme floods within the precinct and across the wider Hawkesbury-Nepean catchment. This dictates the need for a detailed set of management arrangements for evacuation of flood affected areas.

For flood evacuation planning to be effective in all circumstances, preparation must take into account the worst case floods that could occur. The Peak PMF flood event has been simulated in the proposed flood model for this purpose.

In the PMF event the precinct experiences backwater flooding from the greater Hawkesbury-Nepean catchment which further amplifies the impacts of flooding, particularly on the lower regions of the precinct at the First Ponds Creek/Windsor Road crossing. As Windsor Road is cut off by severe flooding at First Ponds Creek, safe refuge and evacuation can generally be achieved towards the South of the precinct.

The Blacktown City Local Flood Plan (November 2010, a sub-plan of the Blacktown Local Disaster Plan - DISPLAN, March 2008) and subsequent State Emergency Services (SES) flood evacuation plans provide comprehensive guidance for flood response strategies and govern the evacuation procedures of the Riverstone East area. In the event of a significant flood event, the procedures detailed in these plans will be activated and co-ordinated by SES Local Controllers and Blacktown City Council. Affected residents within the precinct will be informed of appropriate evacuation routes and directed to emergency relief centres, potentially located at Guntawong Road and Worcester Road. Further details relating to regional preparedness and emergency response can be found in the Blacktown City Local Flood Plan.

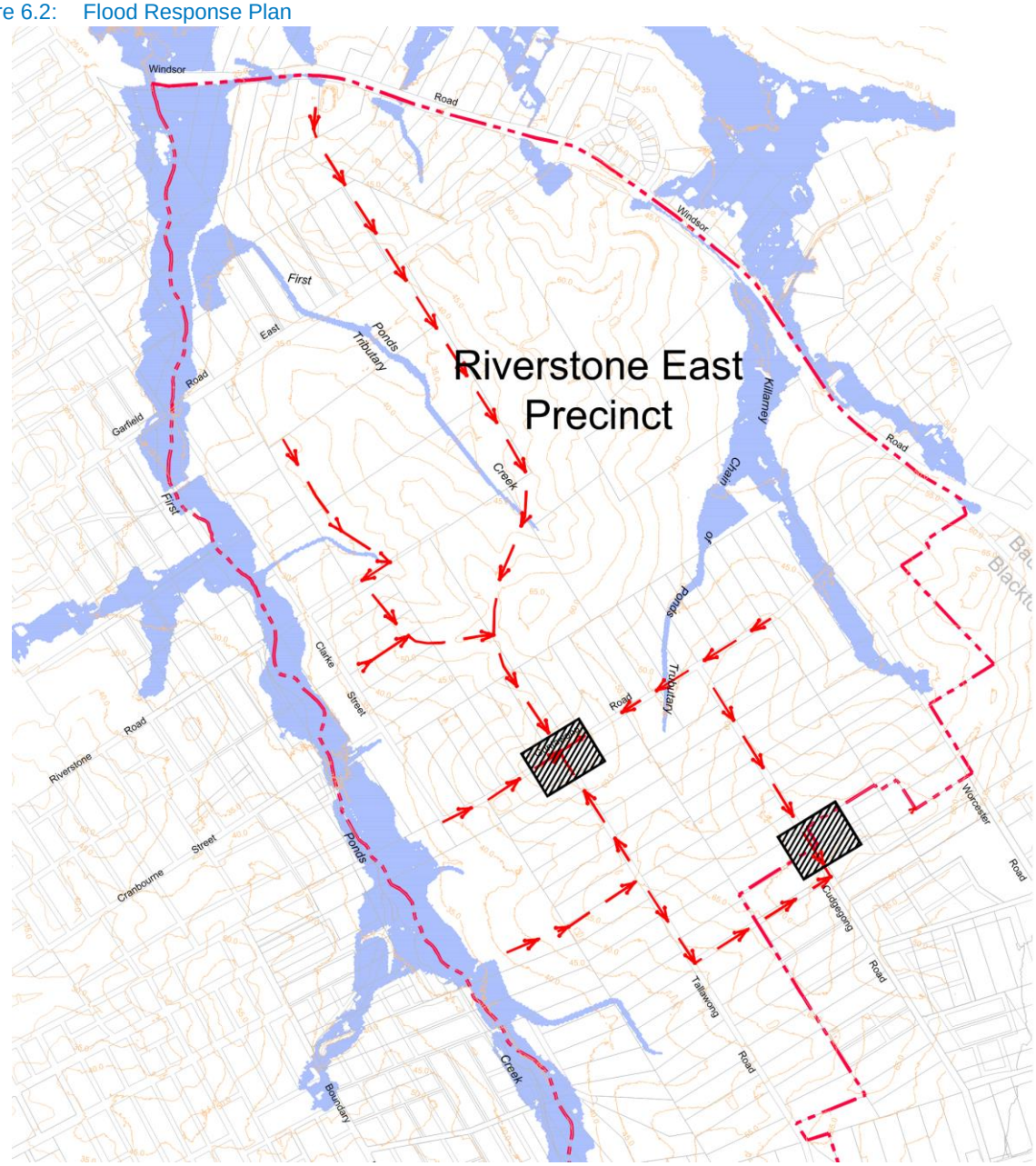
Properties along the fringe that may be affected as flood levels increase during an event will be able to safely evacuate to higher ground within Riverstone East precinct. It is recommended that proposed schools and community facilities in the area act as localised refuge points in times of flooding to reduce the risk of cars travelling along the flood prone Windsor Road. If a person must leave the site via Windsor Road, they

should do so only if the road is free from flood waters. It is recommended that people do not try and cross flood waters in their vehicles and should return to higher ground and follow the procedures of the regional flood evacuation plan.

Whilst clear evacuation strategies are defined for the precinct, significant portions of the district remain unaffected by floodwaters during a PMF event. People should remain in these unaffected areas if possible or seek shelter in the refuge areas designated by the Blacktown City Local Flood Plan, such as the Town Centre or school site/s.

A sample flood evacuation route map is shown below in Figure 6.2 and has also been included in Appendix A (Mott MacDonald Flood Response Plan, drawing MMD-334331-C-DR-RE-XX-0260). The 500 year flood level has been shown on this plan in order to highlight evacuation routes leading up to a potential PMF event.

Figure 6.2: Flood Response Plan



Source: Mott MacDonald

The following text is extracted from the Blacktown City Local Flood Plan;

- The SES will advise the community of the requirements to evacuate. The SES will issue an **Evacuation Warning** when the intent of an SES Operations Controller is to warn the community of the need to prepare for a possible evacuation. The SES will issue an **Evacuation Order** when the intent of

the SES Operations Controller is to instruct a community to immediately evacuate in response to an imminent threat. A guide to the content of evacuation warning and order messages is provided in the Blacktown City Local Flood Plan.

6.7 Comparison of Modelled Results

Developed and existing scenario flow rates across the site determined through the hydraulic analysis were compared with the previous hydraulic models for Box Hill/Box Hill Industrial and Riverstone and Alex Avenue precincts discussed earlier. As indicated in the table below, the maximum 100 year developed scenario flow rate was compared with those from previous modelling for various locations across the precinct.

Table 5.3: Peak Flood Scenarios – Flood Level (m AHD)

Location	100yr Existing	500yr Existing	100yr Proposed	100yr Proposed Climate Change +20%	200yr Proposed	500yr Proposed	PMF Proposed
First Ponds Creek at Guntawong Rd	32.28	32.42	32.21	32.29	32.29	32.35	32.98
First Ponds Creek at Garfield Rd East	25.58	25.81	25.53	25.68	25.67	25.80	27.24
First Ponds Creek at Windsor Rd	22.28	22.96	22.29	22.66	22.61	23.06	26.46
Windsor Rd, Nth of Nelson Rd	35.68	36.22	35.56	36.09	36.05	36.21	36.75
Windsor Rd Nth of Garfield Rd East	34.99	35.10	35.02	35.13	35.12	35.21	35.61
Windsor Rd Culvert, Sth First Ponds Ck	31.68	31.98	31.27	31.44	31.43	31.74	32.15

7 Water Quality Modelling

The stormwater management systems for the precinct shall comply with the requirements of the Growth Centres Commission and Blacktown City Council's Development Control Plan. Council's policy requires improved water quality of the stormwater flow from the developed site prior to discharge into the local stormwater drainage system.

To demonstrate compliance with these objectives, treatment removal loads were analysed from pre to post development scenarios using MUSIC (Model for Urban Stormwater Improvement Conceptualisation) Version 6 software. Model development and results are discussed in detail in the following sections.

7.1 MUSIC Methodology

MUSIC software allows the modeller to assess the effectiveness of the water quality devices proposed. The Model assesses the pollutants generated and compares the effect of the treatment train in removing said pollutants against a 'base' case which assumes no treatment devices. Subsequent reduction percentages are calculated based on the compared results.

These were then compared with the pollutant removal objectives set out in the Blacktown City Council DCP as summarised below (Table 7.1).

Table 7.1: MUSIC Pollutant Reduction Targets

Pollutant	Minimum Removal Rate
Gross Pollutants (GP)	90%
Suspended Solids (TSS)	85%
Nitrogen	45%
Phosphorus	65%

Source: Blacktown City Council DCP, 2006

7.2 Model Parameters

7.2.1 Rainfall Data

In accordance with BCC Council's requirements, a 6-minute-interval was utilised within the model based on the pluviograph data from 067035 Liverpool (1967-1976).

7.2.2 Catchment Analysis

The XPRAFTS model developed for detailed analysis and design of the proposed water management system divided the site into approximately 80 sub-catchments. This level of detail, while required at the design stage for the site hydrologic and hydraulic analyses, is not necessary for the water quality modelling. The MUSIC model uses area alone to predict the performance of stormwater quality management systems and will not produce greatly different results by delineating the catchments to the same level required by XPRAFTS.

The RAFTS sub-catchments were therefore consolidated into approximately 25 sub-catchment areas based on the proposed stormwater quality management system and the given indicative layout plan (ILP).

Figure 7.1: Land Use Plan

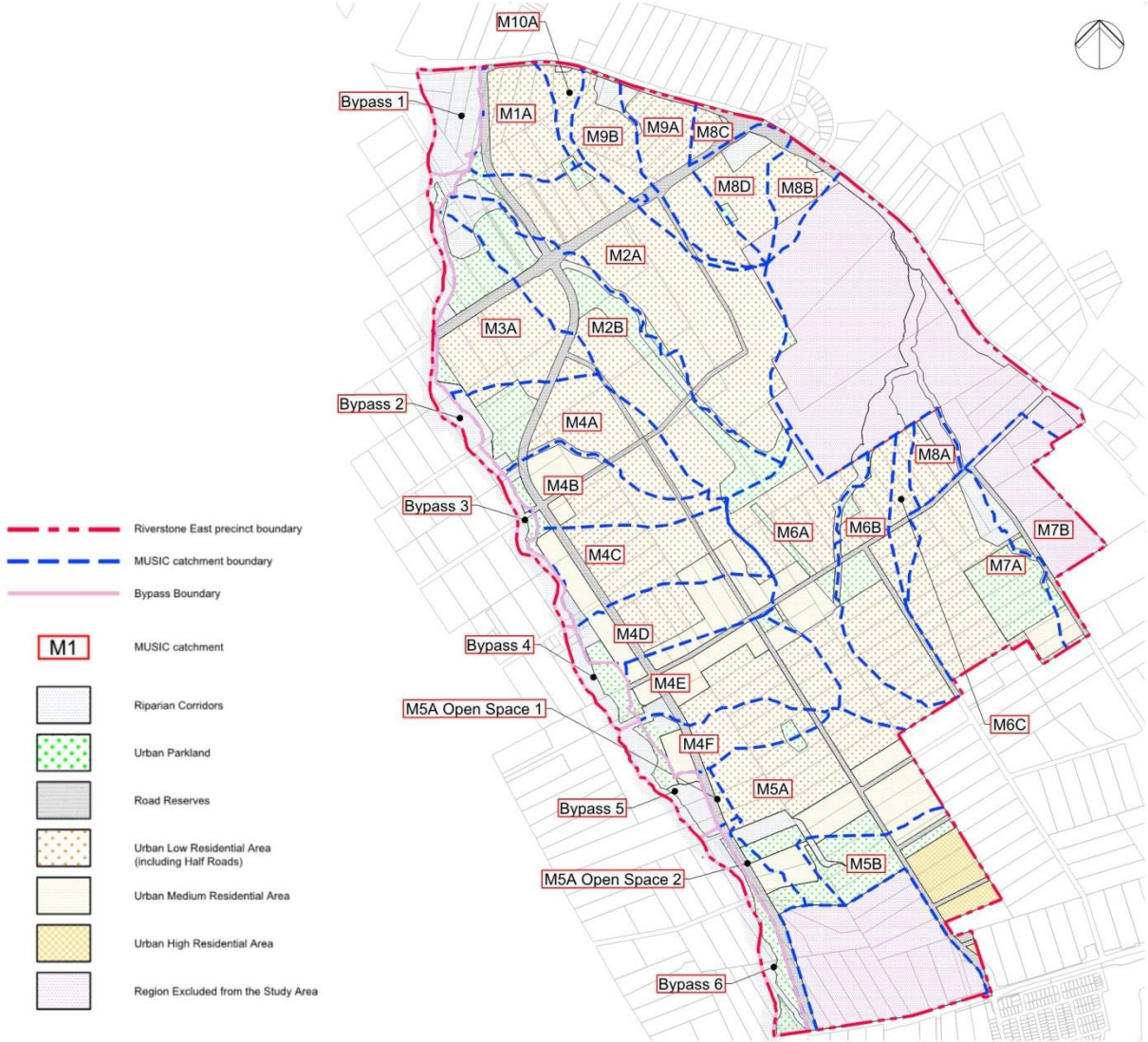


Figure 7.1 above illustrates the different types of land uses across the precinct, with each being responsible for different levels of pollutant production. Each land use identified is listed below and described following:

- Urban low density residential area (Including half road reserve);
- Urban medium density residential area;
- Urban high density residential and commercial area;
- Urban Parkland;
- Rouse Hill Regional Park;
- Major road reserves;
- Riparian corridors; and
- North West Rail Link – train stabling yard.

It should be noted that through consultation with BCC and relevant authorities, only four (4) categories were decided to be analysed in the MUSIC model. These being:

- Urban low density residential area (Including half road reserve);
- Urban Parkland;
- Major road reserves; and
- Riparian corridors.

As such, the commentary describes various assumptions for the relevant land uses adopted to develop the model.

7.2.2.1 Urban Low Density Residential Area (Including Half Road Reserve)

The following assumptions were used to develop the MUSIC model to represent the Urban Low Density Areas (including half road reserve) within the precinct:

- 85% impervious fraction was adopted for the urban residential areas within the catchment in accordance with Blacktown City Council's MUSIC Modelling Guidelines (New Residential Lot including Half Road);
- Average No. Lots per Hectare = 20;
- Average Lot size = 500m^2;
- Average Roof Fraction per Lot = 50%;
- Average Dwelling Area = 75% of Total Catchment Area;
- Average Road Area = 25% of Total Catchment Area;
- 85% impervious fraction was adopted for reserved road areas within residential lots;
- Blacktown City Council's MUSIC Modelling Guidelines (New Residential Lot including Half Road), the sum of total impervious area should follow the equation below:

$$\sum (Impervious\ Area_{Reserved\ Roads} + Impervious\ Area_{Residential\ Residual\ Area} + Roof\ Area) = 85\%$$

Additionally, Council's guidelines stipulate that, the urban residential zones within the precinct are to be further categorised into the following surface types:

- Road Frontage;
- Roof To RWT;
- Roof Bypass;
- Pervious Area; and
- Impervious Area

7.2.2.2 Urban Medium, High Density Residential and Commercial Areas

In consultation with BCC and relevant authorities, it is assumed that appropriate stormwater quality management systems are to be incorporated in urban medium/high density residential and Commercial developments by developers on a case by case basis. The pollutants generated from the abovementioned developments are to be treated to reach pollution removal rates indicated by Council prior to discharge into the public drainage network. It is noted that this approach is consistent with those employed by the surrounding precincts within the Growth Centre. Therefore, urban medium and high density residential areas are to be excluded from the study area.

7.2.2.3 Urban Parkland

The following assumptions were incorporated in the MUSIC model to represent the Urban Parkland within the precinct:

- 15% impervious fraction was adopted for the new urban parkland zones;

7.2.2.4 Rouse Hill Regional Park

Rouse Hill Regional Park is situated in the South-East of Riverstone East precinct. Both Catchment M7 and M8 have been largely taken by the regional park, however, in consultation with BCC, it is agreed that Rouse Hill Regional Park is to be excluded from this study as well as from the MUSIC model for the purposes of water quality analysis.

7.2.2.5 Major Road Reserves

The following methodology and parameters were incorporated in the MUSIC model to represent the major road reserves within the precinct:

- 85% impervious fraction was adopted for the roads;

7.2.2.6 Riparian Corridors

The following methodology and parameters were incorporated in the MUSIC model to represent the Riparian corridor (drainage areas) within the precinct:

- 5% impervious fraction has been adopted;
- It is noted that Blacktown City Council currently do not have approved source nodes for non-urban land uses. As such, in lieu of more detailed data, the rainfall runoff parameters utilised within the model were based on the recommended default values for non-urban areas listed in the Sydney Catchment Authorities NSW Draft MUSIC Modelling Guidelines (2010) for the Riparian zones:

6.2.2.6 North West Rail Link – Train Stabling Yard

As part of the North West Rail Link project, the train stabling yard that situated to the North of Schofield Road is also to be excluded from the study area. It is anticipated that necessary water quality treatment devices are to be incorporated within the development on site to meet the council's target rates.

7.2.3 Adopted Land Uses

Noting the four adopted land uses, Table 7.2 below details the area breakdown per catchment per land use. It is important to note that bypass flows in individual catchments have been grouped for the staged stormwater quality assessment.

Noting previously that Urban Low Density Residential has been broken into five surface types, Table 7.3 breaks down the area further per catchment per surface type.

Table 7.2: Land Use Breakdown per MUSIC Catchment

Catchment	Urban Low Density Residential Area (Ha)	Urban Parkland (Ha)	Major Road Reserves (Ha)	Riparian Corridors (Ha)	Total (Ha)
Bypass 1 (M1A)	0.00	4.834	0.509	3.593	**8.935**
M1A	12.45	0.765	1.715	0.000	**14.930**
Bypass 2 (M2A + M2B + M3A + M4A)	0.00	0.570	0.076	5.521	**6.167**
M2A	45.64	2.461	4.076	2.905	**55.084**
M2B	17.60	14.139	3.085	4.455	**39.279**
M3A	15.37	5.651	2.769	1.748	**25.542**
M4A	16.53	4.649	2.753	2.029	**25.959**
Bypass 3 (M4B + M4C)	0.00	0.457	0.149	2.293	**2.898**
M4B	8.87	0.562	2.006	1.076	**12.512**
M4C	15.44	0.411	1.910	0.883	**18.644**
Bypass 4 (M4D + M4E)	0.00	2.064	0.291	2.498	**4.853**
M4D	6.50	0.833	1.561	0.771	**9.670**
M4E	12.55	0.722	3.053	0.680	**17.001**
Bypass 5 (M4F + M5A)	0.00	2.214	0.006	3.594	**5.813**
M4F	7.97	1.036	0.922	0.779	**10.710**
M5A	18.06	4.460	1.600	2.031	**26.146**
M5A Open Space 1	0.86	0.000	0.829	0.000	**1.684**
M5A Open Space 2	0.17	1.418	3.098	0.089	**4.775**
Bypass 6 (M5B)	0.00	3.997	0.199	3.070	**7.266**
M5B	0.00	7.859	2.826	0.644	**11.330**
M6A	22.25	4.351	0.631	1.350	**28.581**
M6B	19.11	2.683	2.105	0.869	**24.768**
M6C	5.15	0.000	0.200	0.016	**5.369**
M7A	19.94	8.345	0.735	2.786	**31.805**
M7B	0.23	0.705	2.311	1.270	**4.513**
M8A	3.67	0.000	0.000	0.506	**4.173**
M8B	4.82	0.000	0.939	0.159	**5.913**
M8C	1.98	0.000	1.674	0.142	**3.795**
M8D	7.47	0.274	1.342	1.619	**10.707**
M9A	13.70	0.141	1.276	0.540	**15.653**
M9B	10.38	0.000	1.074	1.325	**12.783**
M10A	3.37	0.070	0.277	0.136	**3.856**
Total	**290.07**	**75.671**	**45.997**	**49.376**	**461.114**

Table 7.3: Urban Low Density Residential Area (Including half road reserve) – MUSIC Catchment Breakdown

Catchment	Road Frontage (Ha)	Roof To RWT (Ha)	Roof Bypass (Ha)	Impervious Areas (Ha)	Pervious Areas (Ha)	Total (Ha)
M1A	3.11	2.33	2.33	3.27	1.40	**12.45**
M2A	11.41	8.56	8.56	11.98	5.14	**45.64**
M2B	4.40	3.30	3.30	4.62	1.98	**17.60**
M3A	3.84	2.88	2.88	4.04	1.73	**15.37**
M4A	4.13	3.10	3.10	4.34	1.86	**16.53**
M4B	2.22	1.66	1.66	2.33	1.00	**8.87**
M4C	3.86	2.90	2.90	4.05	1.74	**15.44**
M4D	1.63	1.22	1.22	1.71	0.73	**6.50**
M4E	3.14	2.35	2.35	3.29	1.41	**12.55**
M4F	1.99	4.50	4.50	2.09	0.90	**7.97**
M5A	4.51	3.39	3.39	4.74	2.03	**18.05**
M5A Open Space 1	0.21	0.16	0.16	0.22	0.10	**0.86**
M5A Open Space 2	0.04	0.03	0.03	0.05	0.02	**0.17**
M5B	0.00	0.00	0.00	0.00	0.00	**0.00**
M6A	5.56	4.17	4.17	5.84	2.50	**22.25**
M6B	4.78	3.58	3.58	5.02	2.15	**19.11**
M6C	1.29	0.97	0.97	1.35	0.58	**5.15**
M7A	4.98	3.74	3.74	5.23	2.24	**19.94**
M7B	0.06	0.04	0.04	0.06	0.03	**0.23**
M8A	0.92	0.69	0.69	0.96	0.41	**3.67**
M8B	1.20	0.90	0.90	1.26	0.54	**4.81**
M8C	0.49	0.37	0.37	0.52	0.22	**1.98**
M8D	1.87	1.40	1.40	1.96	0.84	**7.47**
M9A	3.42	2.57	2.57	3.60	1.54	**13.70**
M9B	2.60	1.95	1.95	2.73	1.17	**10.38**
M10A	0.84	0.63	0.63	0.89	0.38	**3.37**
Total	**72.52**	**54.39**	**54.39**	**76.14**	**32.63**	**290.07**

7.2.4 Pollutant Generation

Different land uses are responsible for different levels of pollutant generation. Reflecting on section 7.2.2.1, some land uses can be broken down into a number of specific surfaces which also differ in levels of pollutant generation. A notable example being that Urban Residential can be broken into Road Way, Roof and Landscaped areas as a minimum.

The below tables highlight the different MUSIC node classifications adopted for each Land Use as per Blacktown City Council's WSUD Handbook.

Table 7.4: Urban Low Density Residential – MUSIC Node Classification

Land Use	MUSIC Node	Land-use Category in WSUD Handbook
Roof To RWT	Roof	"Roof Areas"
Roof Bypass	Roof Bypass	'Roof Areas'
Road Frontage	Roads	"Road Areas"
Impervious Areas	Imperv.	"Other Impervious Areas"
Pervious Areas	Perv.	"Pervious Areas"

Table 7.5: Urban Parkland – MUSIC Node Classification

Land Use	MUSIC Node	Land-use Category in WSUD Handbook
Urban Parkland	Park	"Pervious Areas"

Table 7.6: Major Road Reserves – MUSIC Node Classification

Land Use	MUSIC Node	Land-use Category in WSUD Handbook
Major Road Reserves	Road	'Road Areas'

Table 7.7: Riparian Corridors – MUSIC Node Classification

Land Use	MUSIC Node	Land-use Category in WSUD Handbook
Riparian Corridors	Riparian	"Forest"

The WSUD handbook provides different pollutant generation rates for each category which are input into MUSIC to form the basis of the analysis. These have been tabulated below.

Table 7.8: Model input Parameters based on Categories from WSUD Handbook

	Roof Areas	Road Areas	Pervious Areas	Other Impervious Areas	Forest
Impervious Area Rainfall threshold (mm/day)	1.4	1.4	1.4	1.4	1.4
Pervious Area Soil Capacity (mm)	170	170	170	170	210
Pervious Area Initial Storage (% of Capacity)	30	320	30	30	30
Pervious Area Field Capacity (mm)	70	70	70	70	80
Pervious Area Infiltration Capacity Coefficient 'a'	210	210	210	210	175
Pervious Area Infiltration Capacity Coefficient 'b'	4.7	4.7	4.7	4.7	3.1
Groundwater Initial Depth (mm)	10	10	10	10	10
Groundwater Daily Recharge Rate (%)	50	50	50	50	35
Groundwater Daily Base Flow Rate (%)	4	4	4	4	20
Groundwater Daily Seepage Rate (%)	0	0	0	0	0

7.2.5 Treatment Train

In general, stormwater runoff generated within the precinct can be categorized into three (3) main streams:

- Roof or rainwater runoff, which can be captured and reused for internal use (e.g. toilet flushing) or external use (e.g. irrigation);
- Road and pavement (hardstand area) runoff, which can be treated by GPT's or bio-retention devices; and
- Pervious surfaces which capture partial rainwater runoff due to soil storage and infiltration capacity and result in water "lost" to groundwater.

The developed treatment train is as follows:

- Rainwater tanks are to be provided on the developed dwellings (low density) at source treatment and re-use of roof water;
- Gross pollutant traps and trash racks are to capture larger pollutants and sediments before discharge into the watercourse; and
- Bioretention "raingardens" are to provide online treatment for effective removal of finer sediments and nutrients.

The possibility of using tree bays as an at source stormwater bio-retention device has not been considered as part of this proposal. The deviation of low flows from the road gutters into these tree bays would enable the at source water quality treatment of the low flows. This additional treatment would further improve any water quality results obtained during this modelling. The potential for this would be assessed as part of individual evaluation of each stage depending upon site parameters including road networks and grades.

With the rapidly evolving field of Water Sensitive Urban Design any developed measures should be reconsidered at the time of construction to ensure they are still industry best practice and suitable for the development however, at a minimum they should meet the requirements specified in this report.

7.2.5.1 Rainwater Tanks

In developing the MUSIC model for the proposed scenario, it is our understanding that a rainwater (re-use) tank is to be incorporated for each individual lot within the precinct. The tanks will collect the 'clean' roof water from the new dwellings for re-use on site, with overflows directed to the public drainage network.

The following assumptions have been adopted for the rainwater tanks to be included within the precinct:

- 2,000 litre tank per lot;
- Average roof area 250m^2 per lot;
- 50% roof catchment split;
- Internal re-us rate = 0.1 kL/day; and
- External re-use rate = 0.4 kL/m^2/year (distributed as PET - Rain).

It is noted that a more comprehensive assessment of the rainwater tanks will need to be undertaken during the detailed design stage and should also include a BASIX assessment to confirm the above assumptions.

7.2.5.2 Gross Pollutant Traps

It is anticipated that GPTs are to be located at the upstream of individual discharge point prior draining into the watercourses. For catchments where raingardens incorporated in the proposed MUSIC model, GPTs are placed upstream of raingardens to efficiently reduce gross pollutants and suspended solids. Indicative locations of GPTS are as per indicated in the water cycle management drawings set.

Each GPT is sized to treat runoff for a 3-month-ARI event in accordance with general engineering practice.

The expected removal rates that were utilised within the water quality modelling process to represent the GPT units were based on Blacktown City Council's standard rates for a "Vortex" type GPT as shown below:

Table 7.9: GPT MUSIC Input Parameters

Pollutant	Input	Output
Total Suspended Solids (mg/L)	1,000	300
Total Phosphorus (mg/L)	5	3.5
Total Nitrogen (mg/L)	50	50
Gross Pollutants (kg/ML)	15	0

Source: Blacktown City Council

7.2.5.3 Bio-retention "Raingardens"

Bio-retention "Raingardens" are proposed to treat runoff from all catchments within the precinct. "Flow splitting" pits will direct flows up to and including the 1-year ARI runoff to the treatment facilities, while higher flows up to and including the 100-year ARI storm event will bypass the system and drain to a downstream OSD basin / watercourse.

In developing the MUSIC model for the post-developed site, the following assumptions have been made regarding the bio-retention systems:

- Extended detention depth = 0.3m;
- Filter depth = 0.6m;
- Saturated hydraulic conductivity = 125 mm/hr; and
- Orthophosphate Content of Filter Media = 40 mg/kg.

The proposed locations of the Bio-retention "Raingardens" are shown in drawing 0214. Here, basins have been nominated as either an "online" or "offline" system, with consideration given to the location of the system in relation to the riparian zones and flooding regime for each creek.

Table 7.10: Bio-Retention Summary

Catchment	Raingarden	Bio-retention Filter Area (m^2)	Bio-retention Footprint Area (m^2)
M1	M1-A	1,220	1,420
M2	M2-A	5,500	6,880
	M2-B		
M3	M3-A	1,400	3,640
M4	M4-A	1,400	2,990
	M4-B	800	2,440
	M4-C	1,200	4,000
	M4-D	2,000	5,380
	M4-E	1,550	3,840
	M4-F	2,000	3,580
M5	M5-A	8,000	10,050
	M5-B		
M6	M6-A	2,200	4,690
	M6-B	3,000	3,440
	M6-C		
M7	M7-A	3,000	4,470
	M7-B		
M8	M8-A	-	-
	M8-B	-	-
	M8-C	-	-
	M8-D	1,350	5,080
M9	M9-A	4,500	7,580
	M9-B		
M10	M10-A	300	640
Total		39,420	70,120

7.3 Results

Using all previously mentioned input data; a model of the ultimately developed scenario was created which included a proposed treatment train.

Results of the MUSIC analysis indicate that, by including the nominated treatment train, the water quality improvement objectives set out in Blacktown City Council's DCP Part R: WSUD and Integrated Water Cycle Management are achieved for the precinct.

7.3.1.1 Staged Assessment

It is anticipates that development will occur across the site in stages. As such, an assessment of the water quality targets at key catchments has been undertaken to ensure progressive development of the precinct will not have any adverse impacts on the existing watercourses. The below table provides resultant removal rates at a number of key locations.

Table 7.11: First Ponds Creek Staged Results

Downstream of Catchment	Total Suspended Solids (kg/yr)	Total Phosphorus (kg/yr)	Total Nitrogen (kg/yr)	Gross Pollutants (kg/yr)
M5A	97.3	81.7	69.8	100
M5A Open Space 2	88.9	67.4	60.1	100
M5A Open Space 1	82.8	60.5	53.8	94.9
M4F	83.8	62.8	55.2	93.8
M4E	85.4	65.1	55.5	95.4
M4D	85.3	65.8	56	94.4
M4C	85.7	65.7	54.8	95.5
M4B	85.7	65.7	54.4	95.5
M4A	86	65.6	53.6	96.3
M3A	86.1	65.6	53	96.8
M2A	85.6	65.5	52.6	97
M1A	85.3	65	52.9	97.5
OBJECTIVES	**85**	**65**	**45**	**90**

Table 7.12: Killarney Chain of Pons Tributary

Downstream of Catchment	Total Suspended Solids (kg/yr)	Total Phosphorus (kg/yr)	Total Nitrogen (kg/yr)	Gross Pollutants (kg/yr)
M6	90	70.5	57.4	99.8
M6 & M7	88.6	68.3	55.5	99.8
M8B	85.5	63.8	52.3	99.8
M8D	86.4	65	53.2	99.8
M9B	86.4	65.1	54.3	99.7
M10A	86.4	65.1	54.3	99.7
M1A	85.3	65	52.9	97.5
OBJECTIVES	**85**	**65**	**45**	**90**

7.3.1.2 Assessment at Receiving Waterways

Results at the overall receiving node have been assessed against BCC's pollutant removal targets and indicate that the proposed treatment train is efficient in achieving the target removal rates, which are shown below

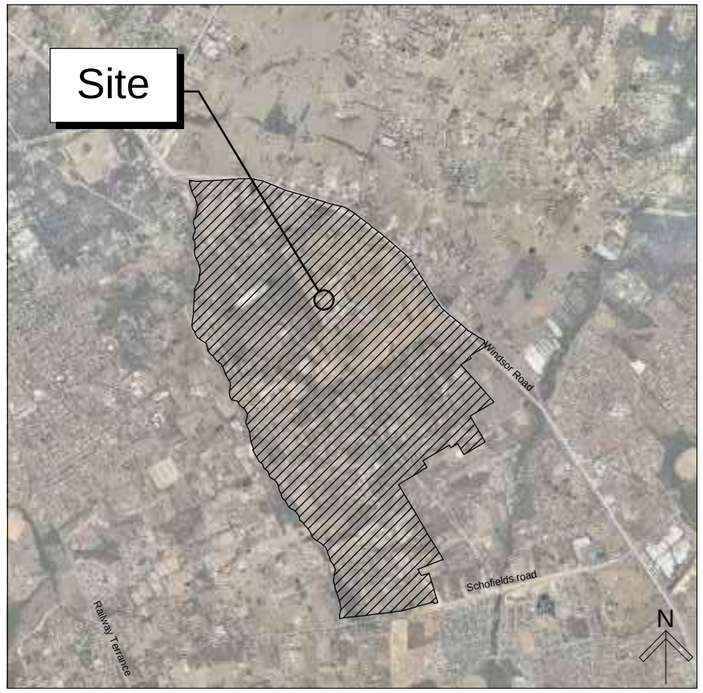
Table 7.13: MUSIC Model Results at Downstream of Riverstone East Precinct

Description	Total Suspended Solids (kg/yr)	Total Phosphorus (kg/yr)	Total Nitrogen (kg/yr)	Gross Pollutants (kg/yr)
Generation	423,000	808	5,380	60,900
Output	61,700	283	2,530	1,530
REDUCTIONS	**85.3**	**65**	**52.9**	**97.5**
OBJECTIVES	**85**	**65**	**45**	**90**

Appendices

Appendix A. Drawings

Riverstone East Precinct Water Cycle Management Plan



Riverstone East

Locality Sketch

Not To Scale

Drawing List	
Drawing Number	Drawing Title
0200	Cover Sheet
0201	Existing Site Plan
0202	Existing Catchment Plan
0203	Existing Catchment Flow Path Plan
0204	Existing Stream Order Plan
0205	TUFLOW Existing Land Use Plan
0206	Existing Flood Extents 100yr ARI
0207	Proposed Catchment Plan
0208	Proposed Catchment Flow Path Plan
0209	Proposed Creek Re-Alignment and Detention Strategy Plan
0210	TUFLOW Proposed Land Use Plan
0211	Proposed Flood Extents 100yr ARI
0212	Proposed Stormwater Major Culvert Crossing
0213	MUSIC Catchment Plan
0214	Proposed Stormwater Treatment Plan
0230	Sections and Details
0240	Basin 1 Plan and Section Sheet
0241	Basin 2 Plan and Section Sheet
0242	Basin 3 Plan and Section Sheet
0243	Basin 4 Plan and Section Sheet
0244	Basin 5 Plan and Section Sheet
0245	Basin 6 Plan and Section Sheet
0246	Basin 7 Plan and Section Sheet
0250	Proposed Channel Plan Channel CF49
0251	Proposed Channel Plan Channel CF40
0252	Proposed Channel Plan Channel CF38 and CF24
0253	Proposed Channel Plan Channel CF05
0255	Proposed Channel Plan Channel CA14
0256	Proposed Channel Plan Channel CA03
0260	Flood Response Plan
0270	Proposed Riparian Corridor Offset Plan

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MM Project No	334311
Dwg No	0200
Revision	P8
Date	11.05.2016
Reason For Issue	Issued for Post Exhibition Amendments

.

Notes

Key to symbols

- Riverstone East precinct boundary
- Surrounding precinct boundary
- LGA boundary
- Existing cadastre

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P8	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P7	19.03.15	MMc	Issued for Exhibition	GL	CJA
P6	27.01.15	AMP	Issued for Exhibition	GL	CJA
P5	16.01.15	AMP	Issued for Exhibition	GL	CJA
P4	28.11.14	ADS	Issued for Draft ILP	GL	-

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Title

Riverstone East Precinct Water Cycle Management Plan

Existing Site Plan

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
1:10000	PRE	P8

Drawing Number
MMD-334311-C-DR-RE-XX-0201

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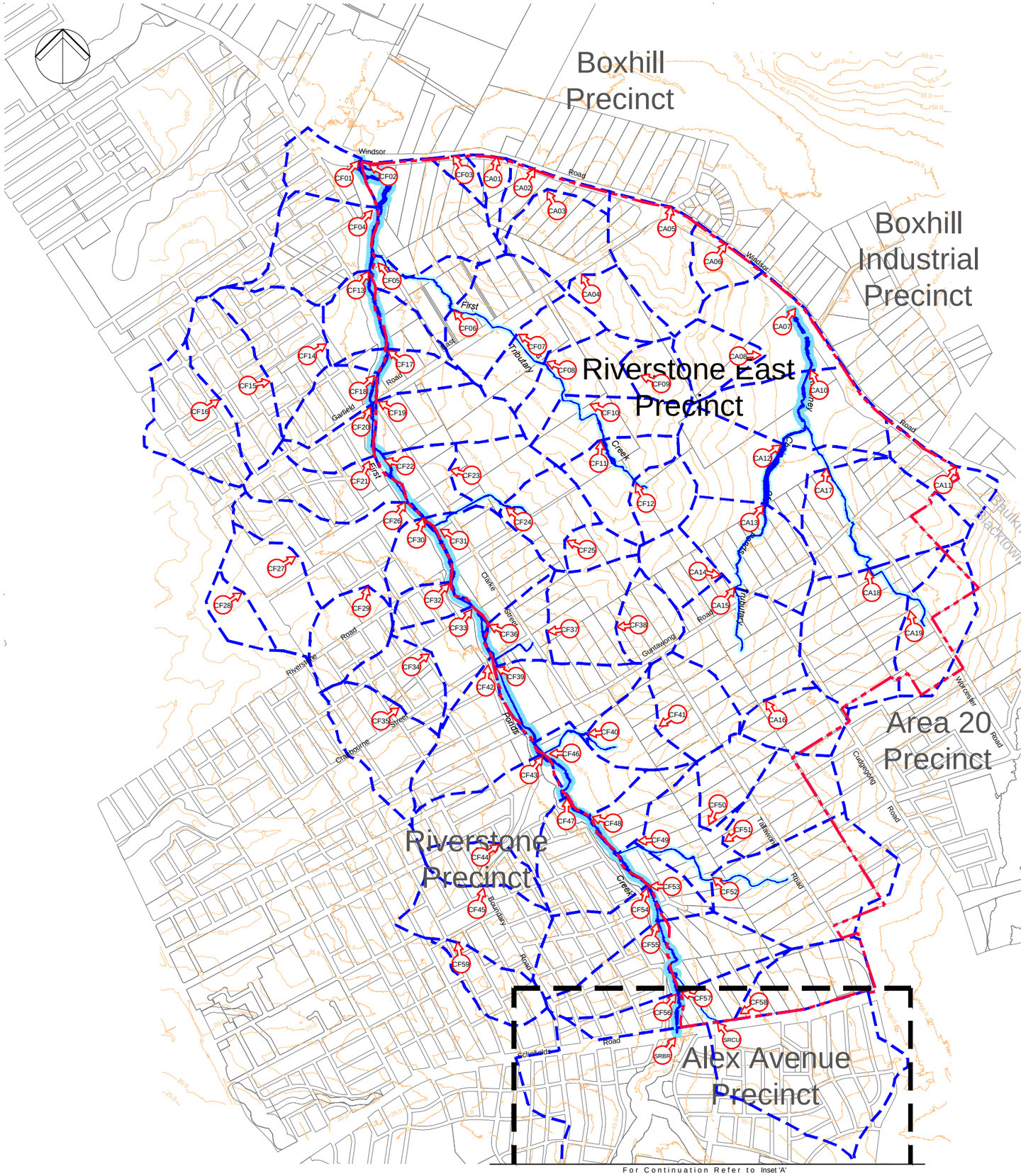
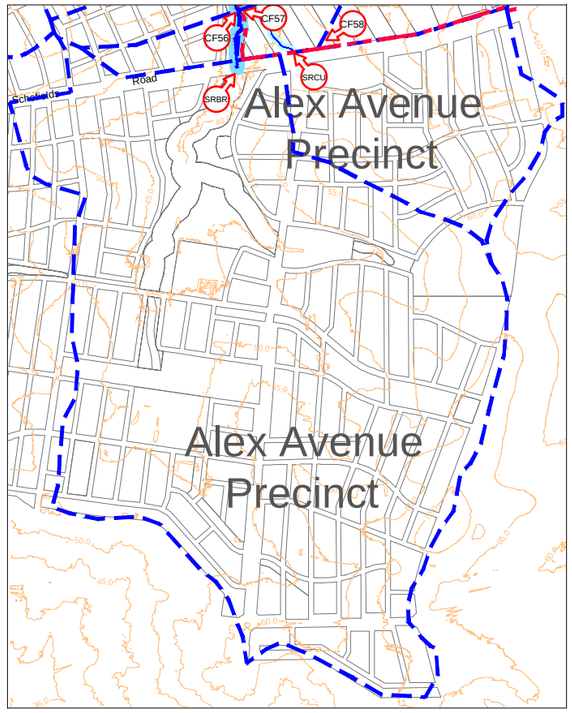
PLAN Scale 1:10000 @ A1

Post Exhibition Amendments





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100 50 0 100 200 300
PLAN Scale 1:10000 @ A1

Post Exhibition Amendments

Notes

Key to symbols

- Riverstone East precinct boundary
- Existing cadastre
- Catchment Boundary
- CFXX Catchment To Pit Node In Drains
- Validated Watercourse
- Riparian Zone - 1st Order Stream
- Riparian Zone - 2nd Order Stream

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P8	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P7	19.03.15	MMc	Issued for Exhibition	GL	CJA
P6	27.01.15	AMP	Issued for Exhibition	GL	CJA
P5	16.01.15	AMP	Issued for Exhibition	GL	CJA
P4	28.11.14	ADS	Issued for Draft ILP	GL	-

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Client
NSW GOVERNMENT Planning & Environment

Title
Riverstone East Precinct
Water Cycle Plan

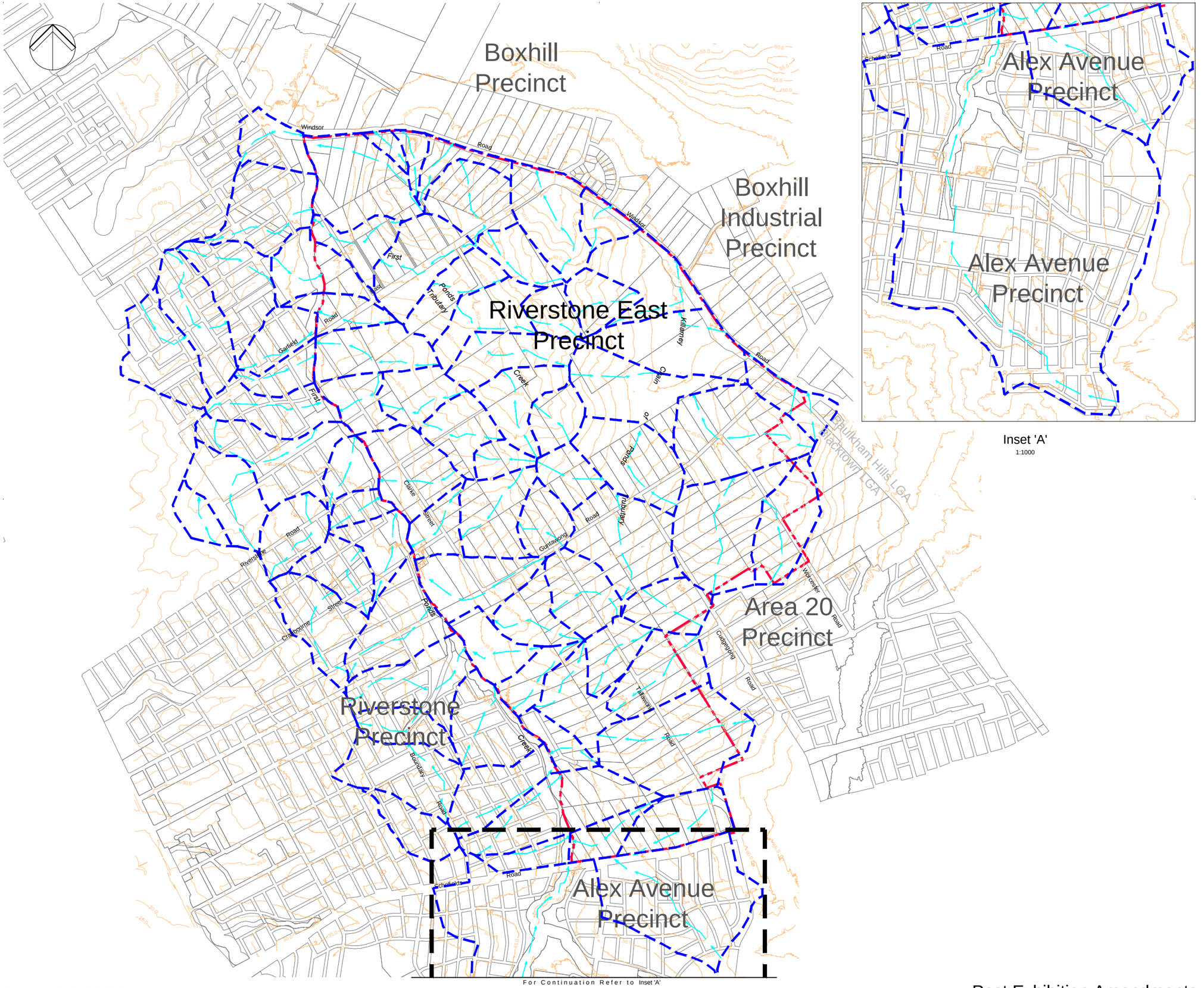
Existing Catchment Plan

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
1:10000	PRE	P8

Drawing Number
MMD-334311-C-DR-RE-XX-0202

P:\Parramatta\Projects\33xxxx\334311\06 CAD\6_4 Working drawings\Civil\Autocad\1_IS_Riverstone East\Drawings\Water Cycle\MMD-334311-C-DR-RE-XX-0202.dwg May 11, 2016 - 5:54PM sin55925



Notes

Key to symbols

- Riverstone East precinct boundary
- Existing cadastre
- Catchment Boundary
- Existing Flow Path

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P8	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P7	19.03.15	MMc	Issued for Exhibition	GL	CJA
P6	27.01.15	AMP	Issued for Exhibition	GL	CJA
P5	16.01.15	AMP	Issued for Exhibition	GL	CJA
P4	28.11.14	ADS	Issued for Draft ILP	GL	-

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NSW GOVERNMENT Planning & Environment

Title

Riverstone East Precinct
Water Cycle Management Plan

Existing Catchment Flow Path Plan

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
1:10000	PRE	P8

Drawing Number
MMD-334311-C-DR-RE-XX-0203

Post Exhibition Amendments

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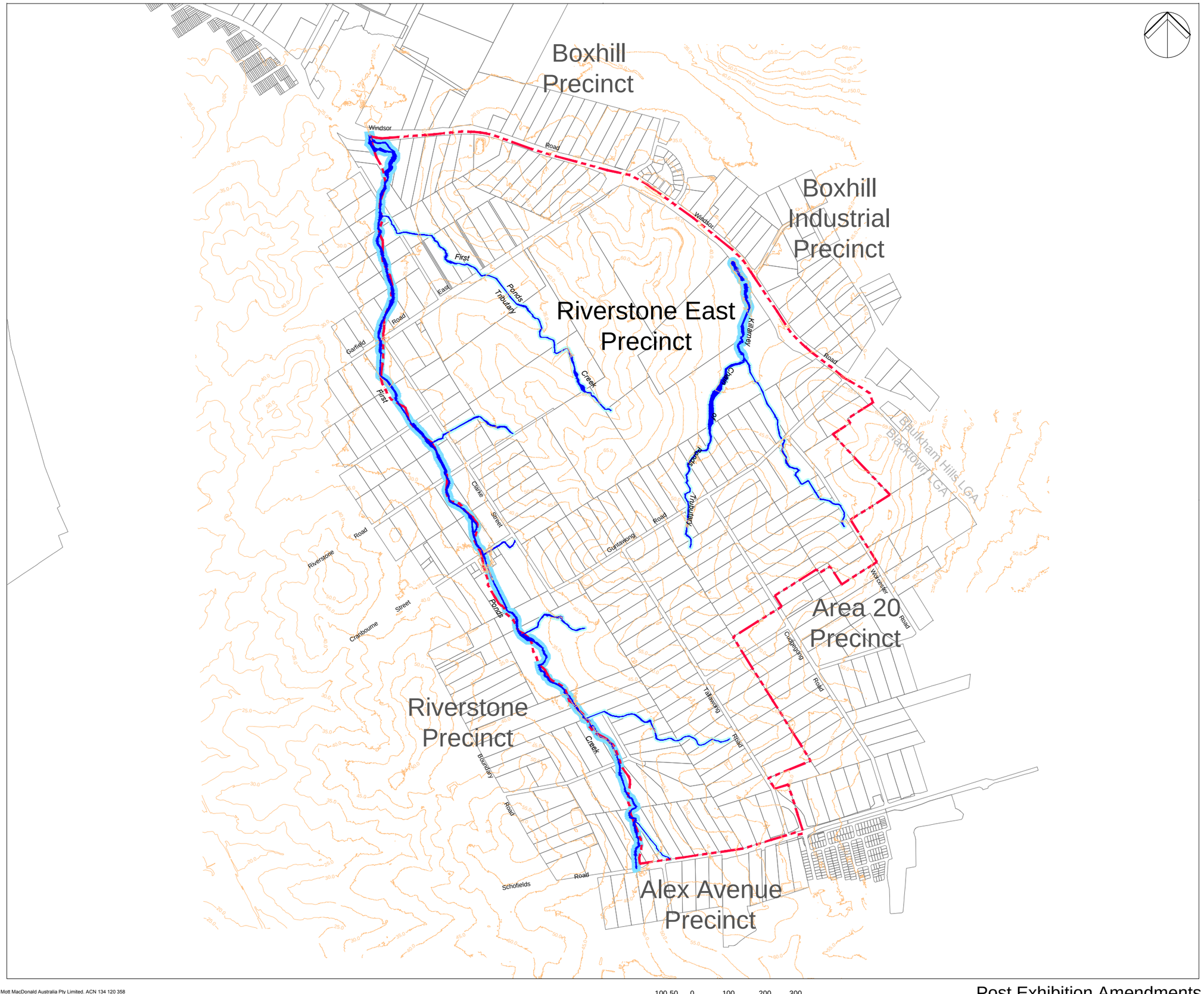

Notes

Creeks Mapped by TBA

Key to symbols

- Riverstone East precinct boundary
- Existing cadastre
- Validated Watercourse
- Riparian Zone - 1st Order Stream
- Riparian Zone - 2nd Order Stream

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P8	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P7	19.03.15	MMc	Issued for Exhibition	GL	CJA
P6	27.01.15	AMP	Issued for Exhibition	GL	CJA
P5	16.01.15	AMP	Issued for Exhibition	GL	CJA
P4	28.11.14	ADS	Issued for Draft ILP	GL	-

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Title

Riverstone East Precinct Water Cycle Management Plan

Existing Stream Order Plan

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
1:10000	PRE	P8

Drawing Number
MMD-334311-C-DR-RE-XX-0204

100 50 0 100 200 300
PLAN Scale 1:10000 @ A1

Post Exhibition Amendments

Notes

Key to symbols

- Riverstone East precinct boundary
- Existing cadastre
- Dense Vegetation - Manning's Value = 0.12
- Light Vegetation - Manning's Value = 0.05
- Water Surface - Manning's Value = 0.035
- Roads - Manning's Value = 0.013

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P7	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P6	19.03.15	MMc	Issued for Exhibition	GL	CJA
P5	27.01.15	AMP	Issued for Exhibition	GL	CJA
P4	16.01.15	AMP	Issued for Exhibition	GL	CJA
P3	28.11.14	ADS	Issued for Draft ILP	GL	-

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NSW GOVERNMENT Planning & Environment

Title

Riverstone East Precinct
Water Cycle Management Plan

TUFLOW Existing Land Use Plan

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
1:10000	PRE	P7

Drawing Number
MMD-334311-C-DR-RE-XX-0205

100 50 0 100 200 300
PLAN Scale 1:10000 @ A1

Post Exhibition Amendments

Notes

Key to symbols

- Riverstone East precinct boundary
- 100yr Flood extents
- 100yr Flood Area

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P7	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P6	19.03.15	MMc	Issued for Exhibition	GL	CJA
P5	27.01.15	AMP	Issued for Exhibition	GL	CJA
P4	16.01.15	AMP	Issued for Exhibition	GL	CJA
P3	28.11.14	ADS	Issued for Draft ILP	GL	-

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NSW GOVERNMENT Planning & Environment

Title

Riverstone East Precinct
Water Cycle Management Plan

Existing Flood Extents
100yr ARI

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
1:10000	PRE	P7

Drawing Number
MMD-334311-C-DR-RE-XX-0206

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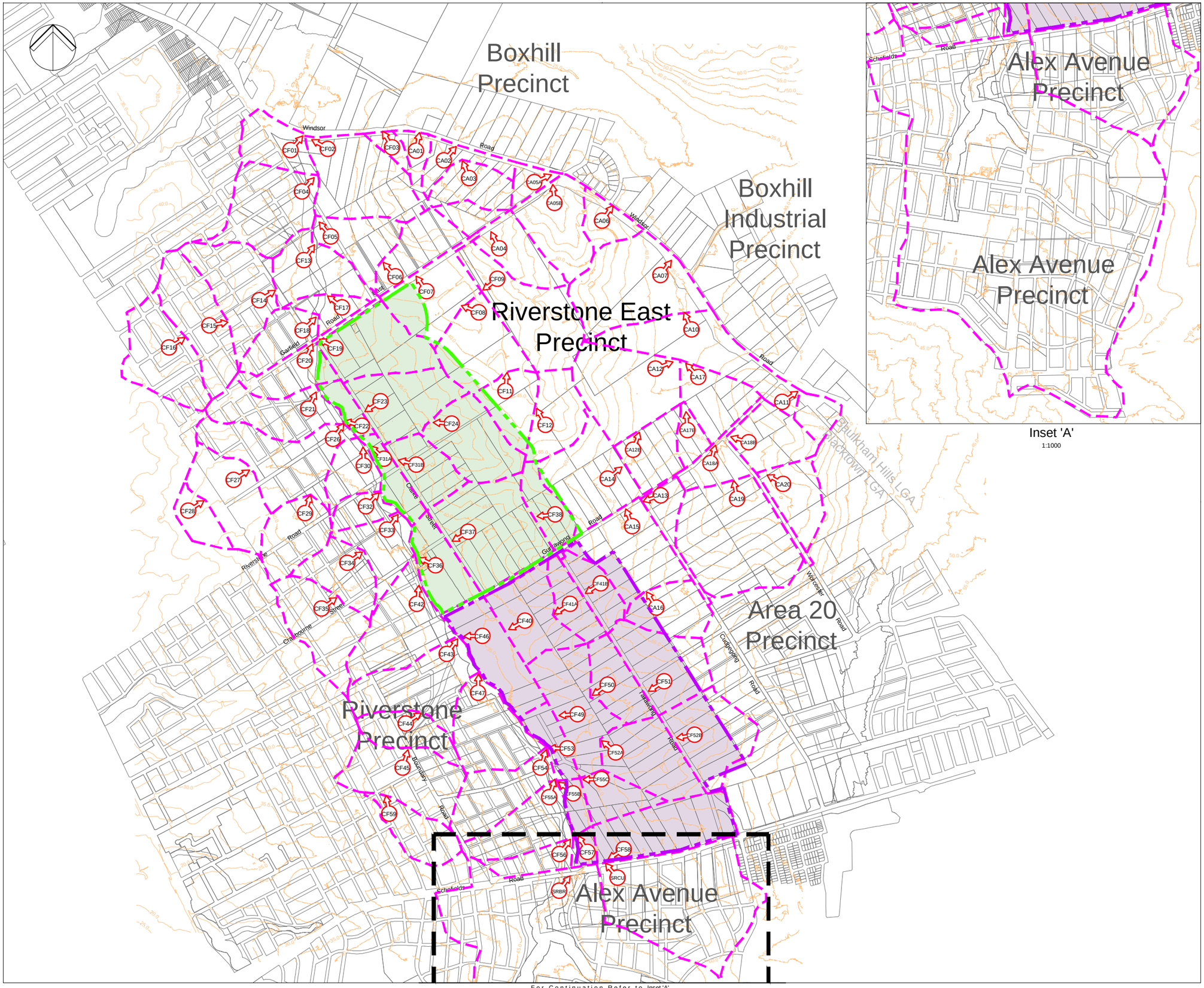
PLAN Scale 1:10000 @ A1

Post Exhibition Amendments



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PLAN Scale 1:10000 @ A1

Post Exhibition Amendments

Notes

Key to symbols

- Riverstone East precinct boundary
- Catchment Boundary
- Stage 1 boundary
- Stage 2 boundary
- CFXX — Catchment To Pit Node In Drains
- Stage 1 Area
- Stage 2 Area

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P8	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P7	19.03.15	MMc	Issued for Exhibition	GL	CJA
P6	27.01.15	AMP	Issued for Exhibition	GL	CJA
P5	16.01.15	AMP	Issued for Exhibition	GL	CJA
P4	28.11.14	ADS	Issued for Draft ILP (Not Issued)	GL	-

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Client
NSW GOVERNMENT Planning & Environment

Title
Riverstone East Precinct
Water Cycle Management Plan

Proposed Catchment Plan

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
1:10000	PRE	P8

Drawing Number
MMD-334311-C-DR-RE-XX-0207

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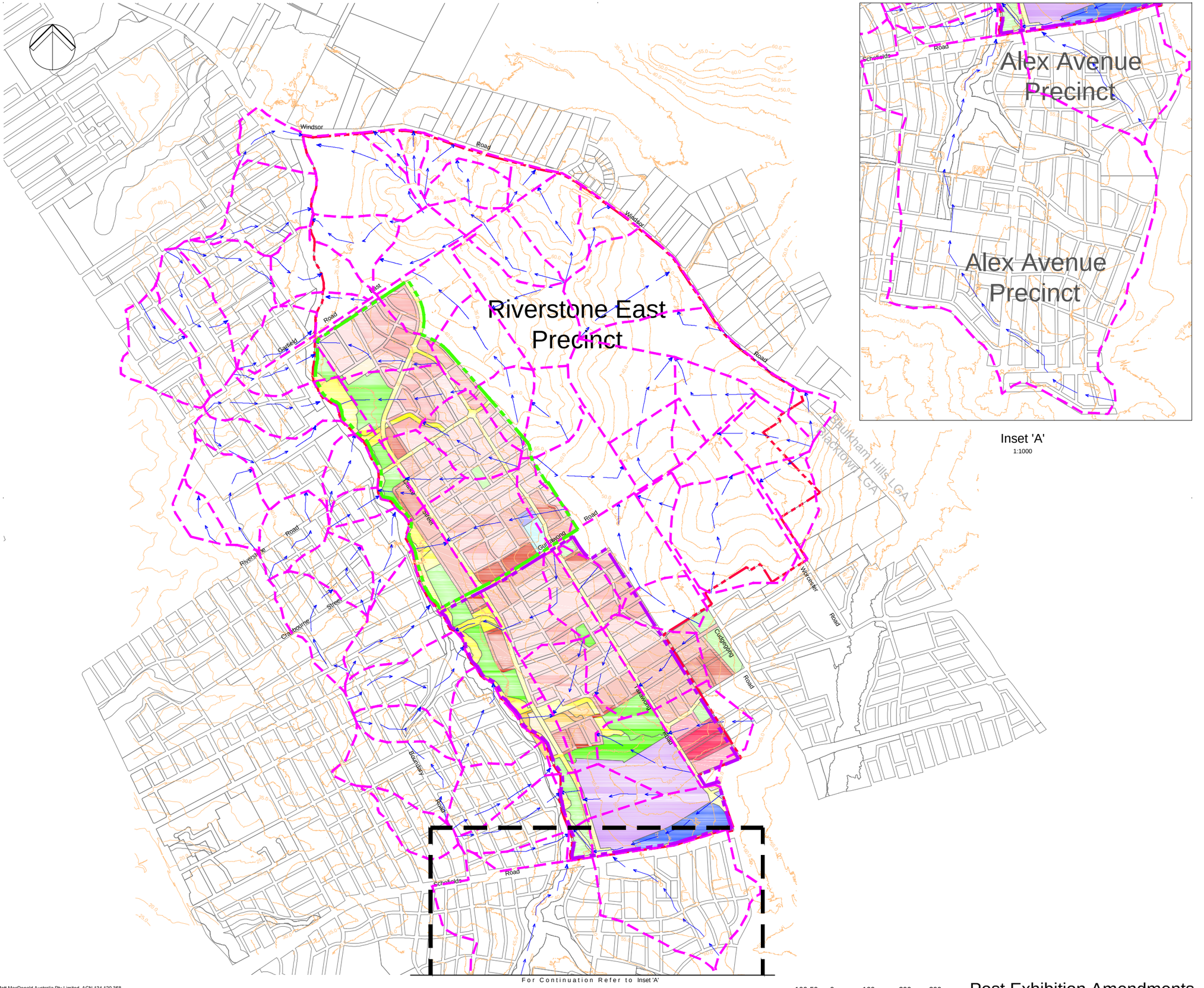

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PLAN Scale 1:10000 @ A1

Post Exhibition Amendments

Notes

Key to symbols

- Riverstone East precinct boundary
- Stage 1 boundary
- Stage 2 boundary
- Existing cadastre
- Catchment Boundary
- Proposed Flow Path

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P8	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P7	19.03.15	MMc	Issued for Exhibition	GL	CJA
P6	27.01.15	AMP	Issued for Exhibition	GL	CJA
P5	16.01.15	AMP	Issued for Exhibition	GL	CJA
P4	28.11.14	ADS	Issued for Draft ILP (Not Issued)	GL	CJA

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Title
Riverstone East Precinct
Water Cycle Management Plan

Proposed Catchment Flow Path Plan

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
1:10000	PRE	P8

Drawing Number
MMD-334311-C-DR-RE-XX-0208

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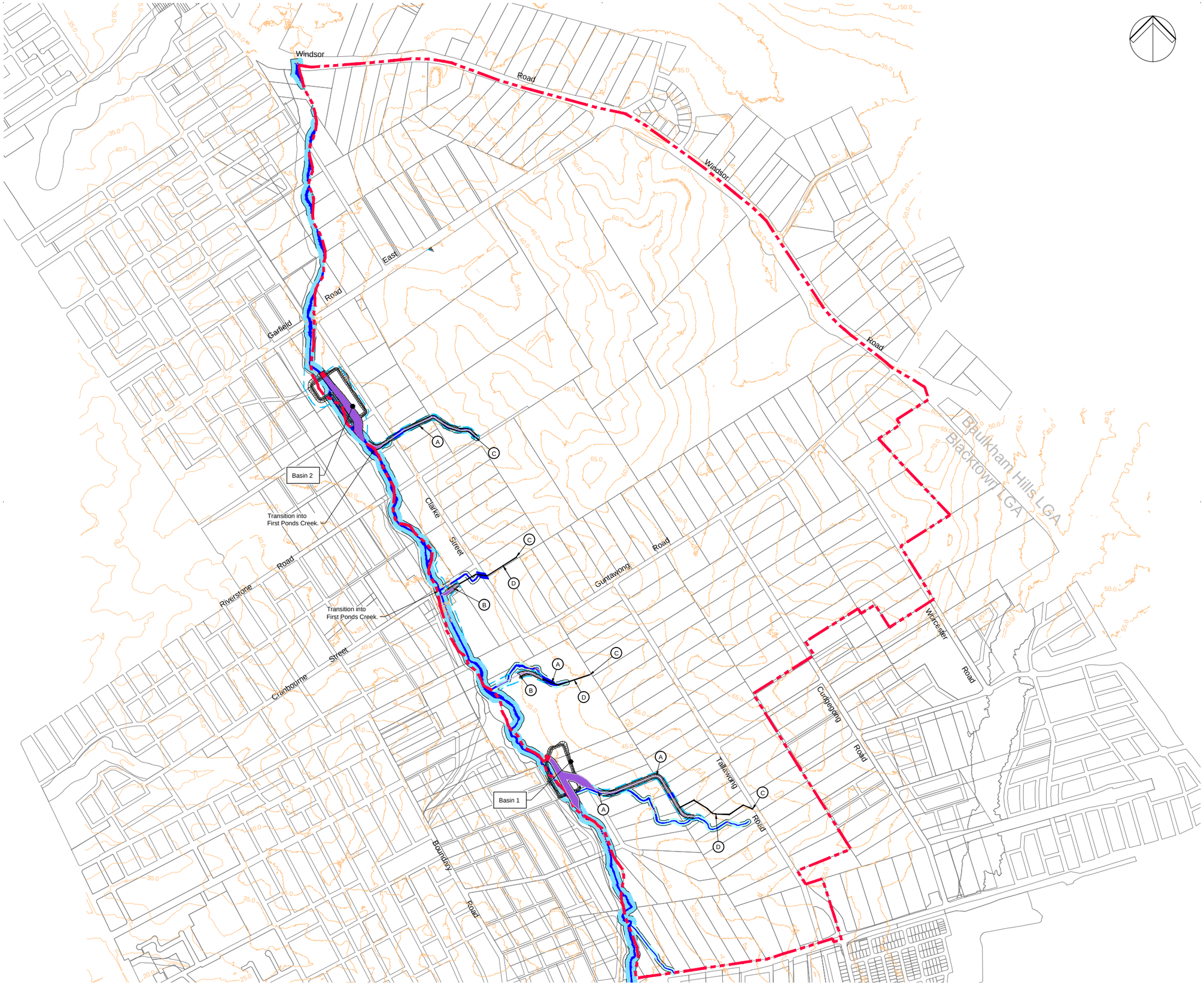

Notes

Key to symbols

- Riverstone East precinct boundary
- Proposed Stage 1 boundary
- Proposed Stage 2 boundary
- Existing cadastre
- Proposed Detention basin
- Proposed Riparian Extents
- Proposed Creeks/Channel
- Proposed Piped Network
- Validated Watercourse
- Riparian Zone - Category 1
- Riparian Zone - Category 2

(A) Provide Re aligned riparian creek channel to contain 100YR proposed flows.

(B) Proposed New drainage channel to contain 100YR proposed flows.

(C) Upstream flows to be converted in road and pipe network.

(D) Existing riparian corridor to be offset and replaced with piped drainage system

Basin Volumes	
Basin	Volume (m³)
1	35650
2	33750
Total	69400

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P8	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P7	19.03.15	MMc	Issued for Exhibition	GL	CJA
P6	27.01.15	AMP	Issued for Exhibition	GL	CJA
P5	16.01.15	AMP	Issued for Exhibition	GL	CJA
P4	28.11.14	ADS	Issued for Draft ILP (Not Issued)	GL	CJA

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NSW GOVERNMENT Planning & Environment

Title

Riverstone East Precinct
Water Cycle Management Plan

Proposed Creek Re-Alignment and Detention Strategy Plan

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
1:8000	PRE	P8

Drawing Number

MMD-334311-C-DR-RE-XX-0209

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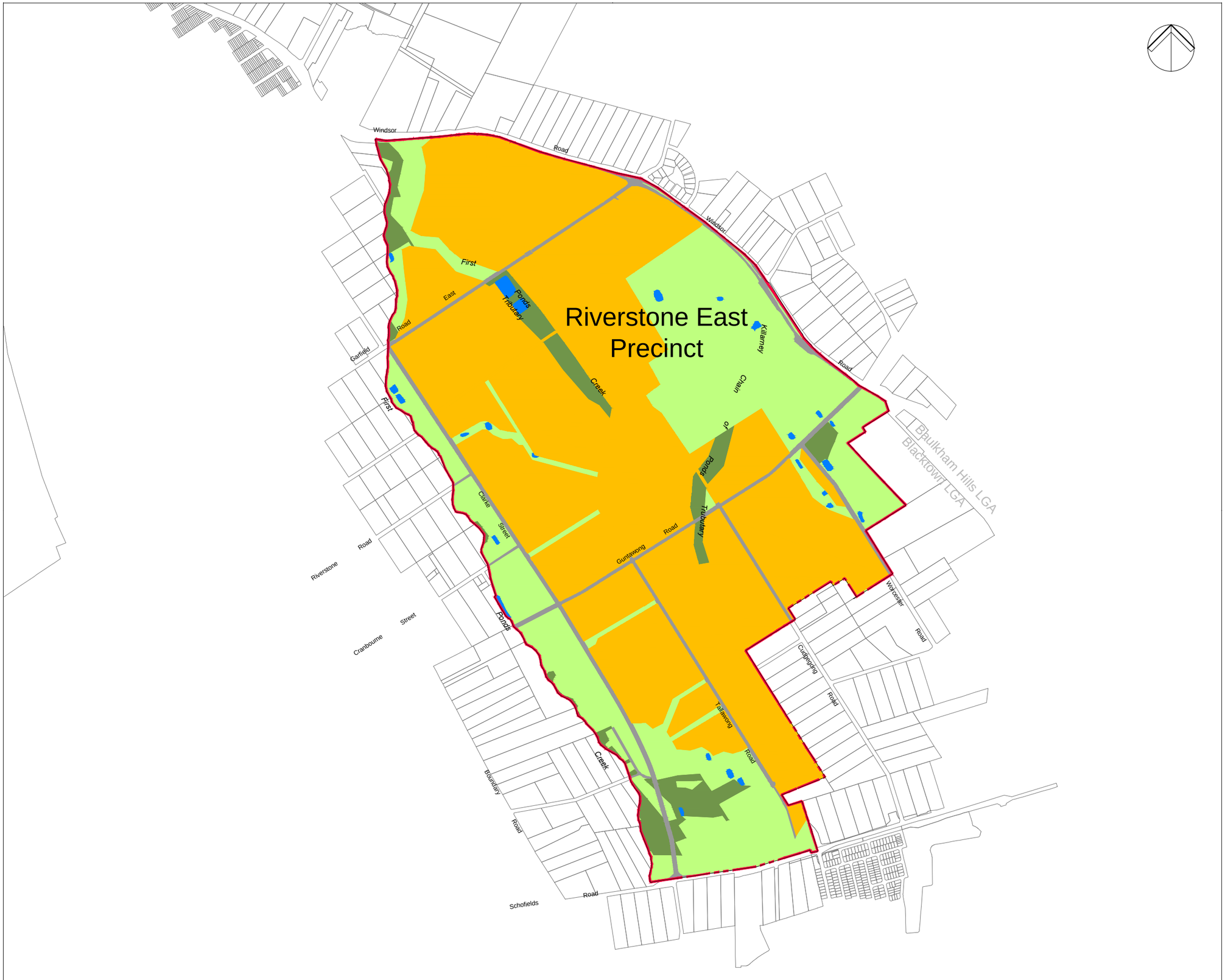
PLAN Scale 1:8000 @ A1

Post Exhibition Amendments



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100 50 0 100 200 300
PLAN Scale 1:10000 @ A1

Post Exhibition Amendments

Notes

Key to symbols

- Riverstone East precinct boundary
- Existing cadastre
- Dense Vegetation - Manning's Value = 0.12
- Light Vegetation - Manning's Value = 0.05
- Water Surface - Manning's Value = 0.035
- Residential - Manning's Value = 0.125
- Roads - Manning's Value = 0.013

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P5	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P4	19.03.15	MMc	Issued for Exhibition	GL	CJA
P3	27.01.15	AMP	Issued for Exhibition	GL	CJA
P2	16.01.15	AMP	Issued for Exhibition	GL	CJA
P1	28.11.14	ADS	Issued for Draft ILP (Not Issued)	GL	-

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Client
NSW GOVERNMENT Planning & Environment

Title
Riverstone East Precinct
Water Cycle Management Plan

TUFLOW Proposed Land Use Plan

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
1:10000	PRE	P5

Drawing Number
MMD-334311-C-DR-RE-XX-0210

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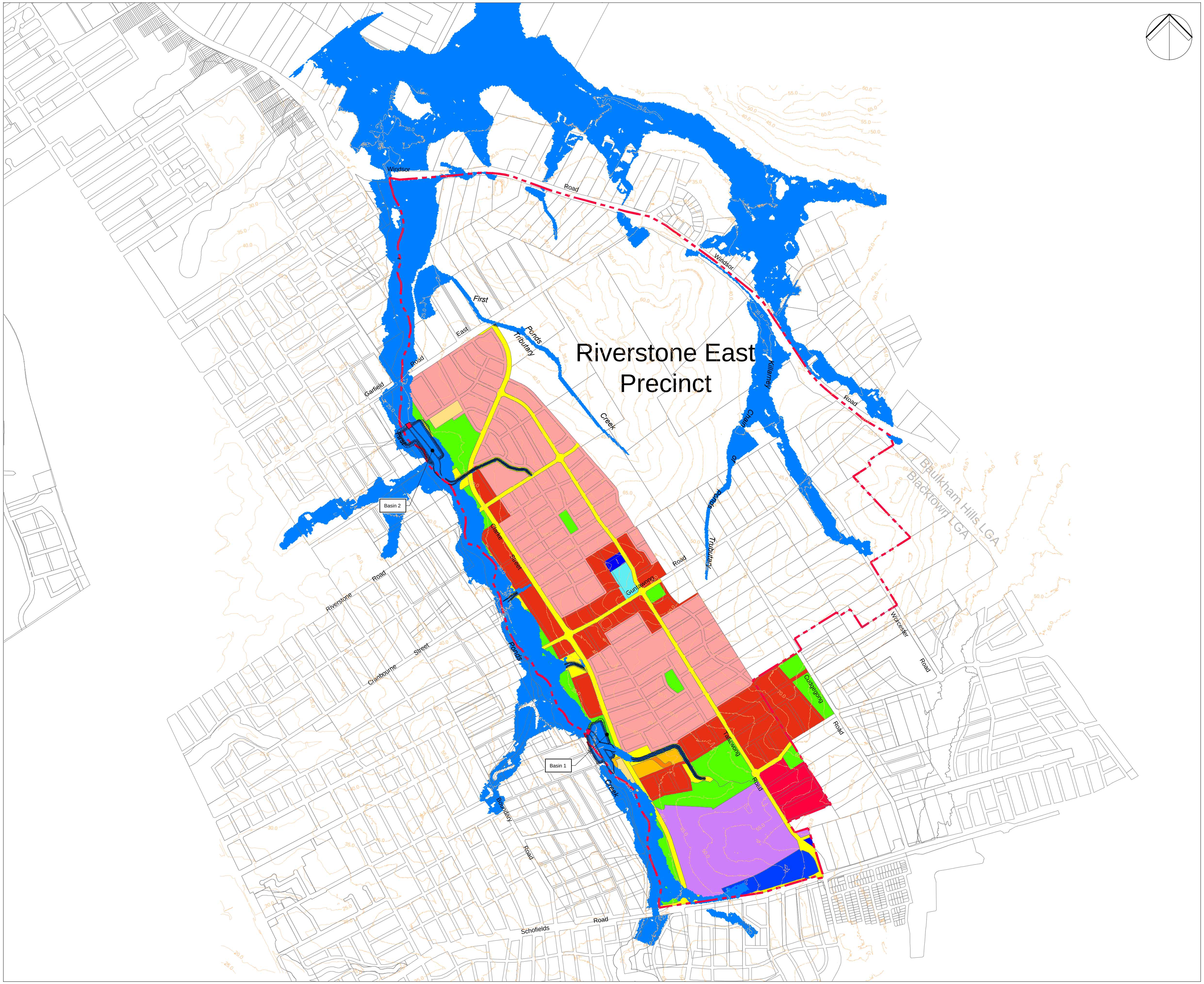

Notes

Key to symbols

- Riverstone East precinct boundary
- Proposed Stage 1 boundary
- Proposed Stage 2 boundary
- Existing cadastre
- Proposed 100year Flood Extents

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P8	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P7	19.03.15	MMc	Issued for Exhibition	GL	CJA
P6	27.01.15	AMP	Issued for Exhibition	GL	CJA
P5	16.01.15	AMP	Issued for Exhibition	GL	CJA
P4	28.11.14	ADS	Issued for Draft ILP (Not Issued)	GL	CJA

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NSW GOVERNMENT Planning & Environment

Title

Riverstone East Precinct
Water Cycle Management Plan

Proposed Flood Extents
100yr ARI

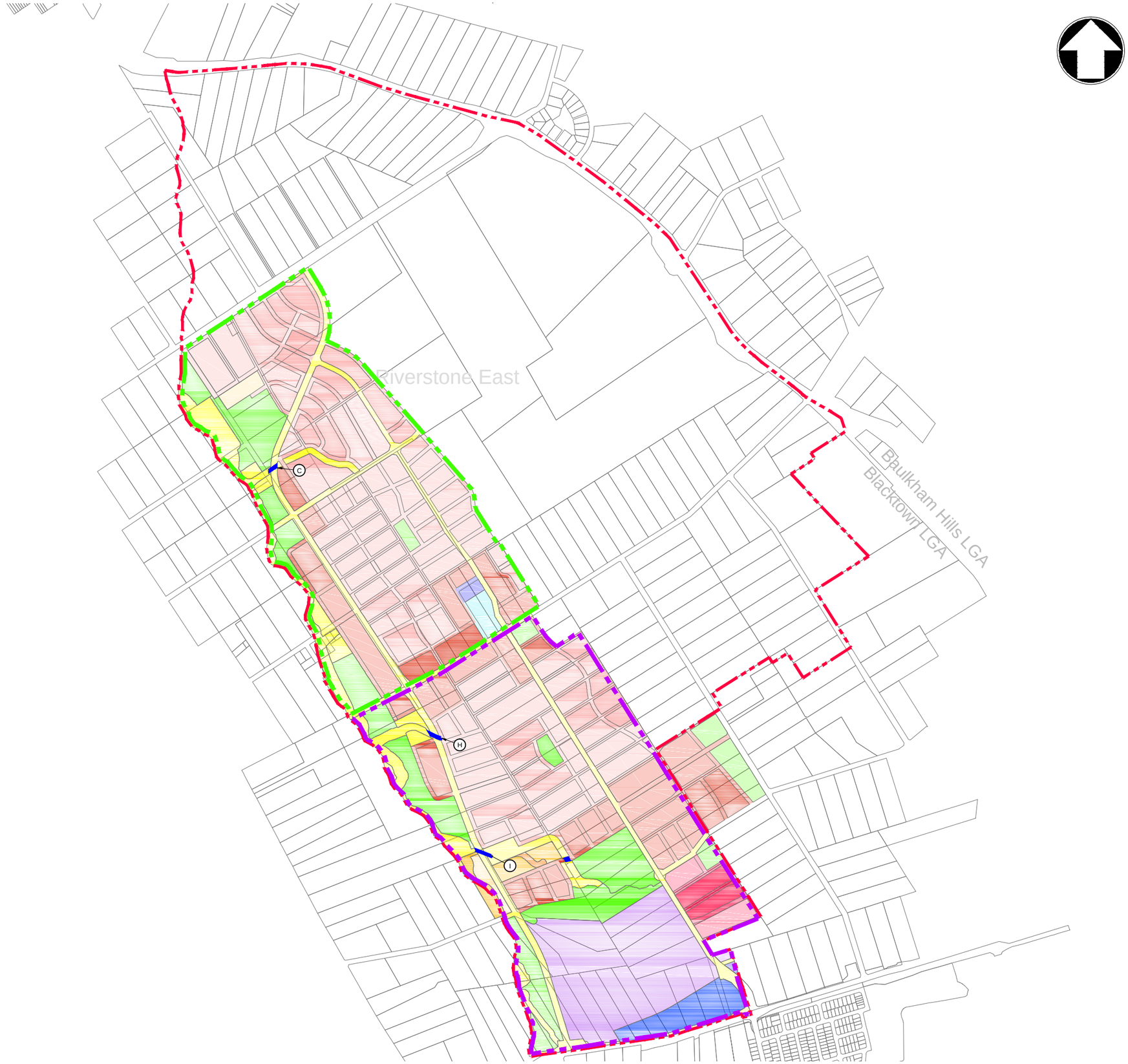
Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
1:10000	PRE	P8

Drawing Number
MMD-334311-C-DR-RE-XX-0211

100 50 0 100 200 300
PLAN Scale 1:10000 @ A1

Post Exhibition Amendments



Notes

Key to symbols

- Riverstone East precinct boundary
- Proposed Stage 1 boundary
- Proposed Stage 2 boundary
- Existing cadastre
- Major culvert crossing
- Detention basin
- (A) Proposed piped location under road

Location	100YR Flow (m3/s)	Pipe/Culvert
C	15.393	3x1800x900
H	10.765	2x2400x900
I	22.386	3x2400x1200

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P5	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P4	19.03.15	MMc	Issued for Exhibition	GL	CJA
P3	27.01.15	AMP	Issued for Exhibition	GL	CJA
P2	16.01.15	AMP	Issued for Exhibition	GL	CJA
P1	28.11.14	ADS	Issued for Draft ILP	GL	-

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NSW GOVERNMENT Planning & Environment

Title

Riverstone East Precinct
Water Cycle Management Plan

Proposed Stormwater Major Culvert Crossing

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
1:8000	PRE	P5

Drawing Number
MMD-334311-C-DR-RE-XX-0212

200 100 0 200 400
PLAN Scale 1:8000 @ A1

Post Exhibition Amendments

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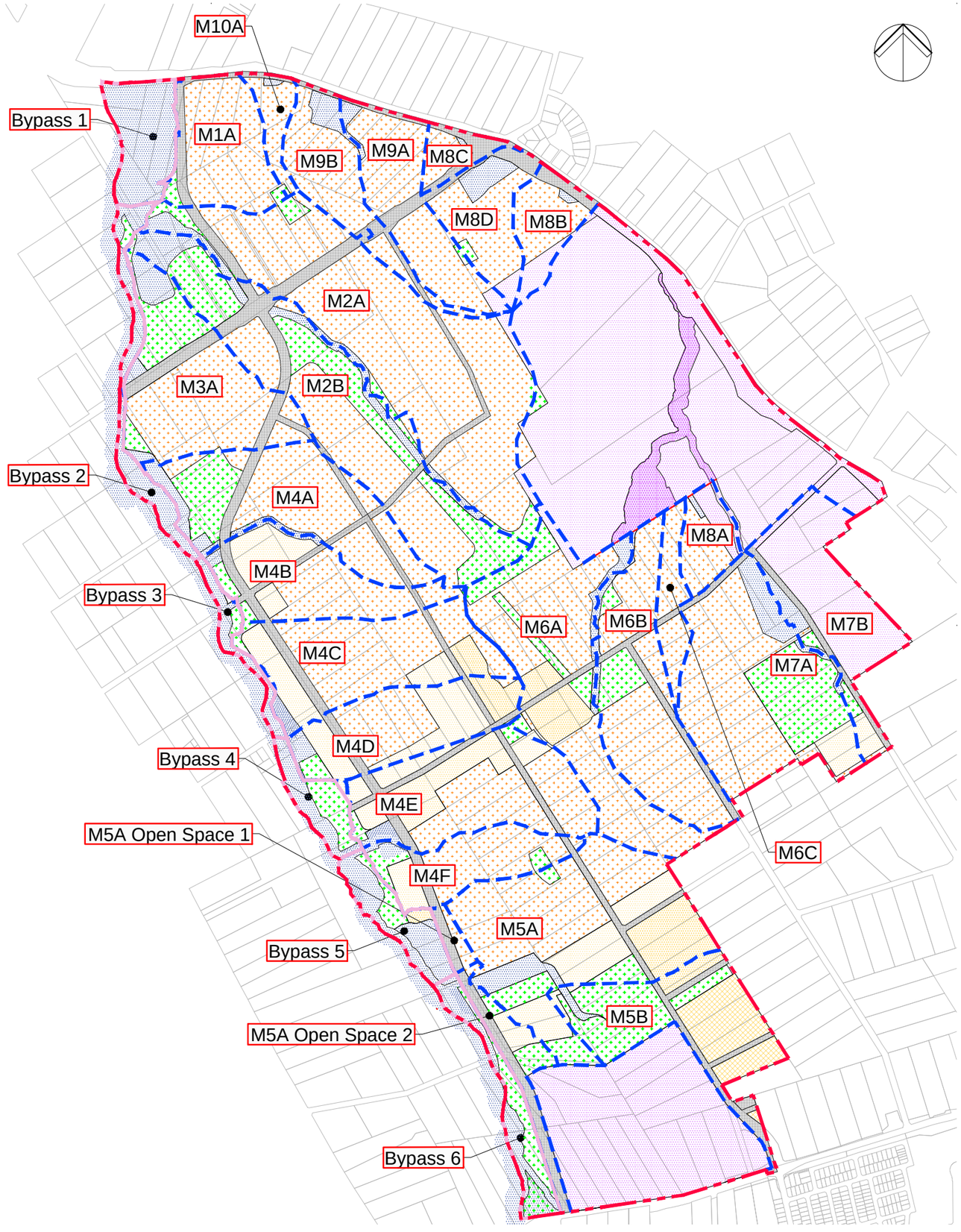
	Area (Ha)				
MUSIC Subcatchment					Total
Bypass 1 (M1A)	0.000	4.834	0.509	3.593	**8.935**
M1A	12.450	0.765	1.715	0.000	**14.930**
Bypass 2 (M2A + M2B + M3A + M4A)	0.000	0.570	0.076	5.521	**6.167**
M2A	45.643	2.461	4.076	2.905	**55.084**
M2B	17.601	14.139	3.085	4.455	**39.279**
M3A	15.374	5.651	2.769	1.748	**25.542**
M4A	16.528	4.649	2.753	2.029	**25.959**
Bypass 3 (M4B + M4C)	0.000	0.457	0.149	2.293	**2.898**
M4B	8.869	0.562	2.006	1.076	**12.512**
M4C	15.440	0.411	1.910	0.883	**18.644**
Bypass 4 (M4D + M4E)	0.000	2.064	0.291	2.498	**4.853**
M4D	6.504	0.833	1.561	0.771	**9.670**
M4E	12.546	0.722	3.053	0.680	**17.001**
Bypass 5 (M4F + M5A)	0.000	2.214	0.006	3.594	**5.813**
M4F	7.974	1.036	0.922	0.779	**10.710**
M5A	18.055	4.460	1.600	2.031	**26.146**
M5A Open Space 1	0.855	0.000	0.829	0.000	**1.684**
M5A Open Space 2	0.171	1.418	3.098	0.089	**4.775**
Bypass 6 (M5B)	0.000	3.997	0.199	3.070	**7.266**
M5B	0.000	7.859	2.826	0.644	**11.330**
M6A	22.248	4.351	0.631	1.350	**28.581**
M6B	19.112	2.683	2.105	0.869	**24.768**
M6C	5.153	0.000	0.200	0.016	**5.369**
M7A	19.939	8.345	0.735	2.786	**31.805**
M7B	0.227	0.705	2.311	1.270	**4.513**
M8A	3.667	0.000	0.000	0.506	**4.173**
M8B	4.815	0.000	0.939	0.159	**5.913**
M8C	1.979	0.000	1.674	0.142	**3.795**
M8D	7.472	0.274	1.342	1.619	**10.707**
M9A	13.696	0.141	1.276	0.540	**15.653**
M9B	10.384	0.000	1.074	1.325	**12.783**
M10A	3.373	0.070	0.277	0.136	**3.856**
Total	**290.071**	**75.671**	**45.997**	**49.376**	**461.114**

*Note: Medium to High Residential Areas will provide their own "WSUD" as such they have been excluded from the study area



200 100 0 200 400

PLAN Scale 1:8000 @ A1

Post Exhibition Amendments

Notes

Key to symbols

- Riverstone East precinct boundary
- MUSIC catchment boundary
- Bypass Boundary
- M1 — MUSIC catchment
- Riparian Corridors
- Urban Parkland
- Road Reserves
- Urban Low Residential Area (including Half Roads)
- Urban Medium Residential Area
- Urban High Residential Area
- Region Excluded from the Study Area

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P9	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P8	11.01.16	MMc	Issued for Exhibition	GL	CJA
P7	19.03.15	MMc	Issued for Exhibition	GL	CJA
P6	27.01.15	AMP	Issued for Exhibition	GL	CJA
P5	16.01.15	AMP	Issued for Exhibition	GL	CJA

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Client: NSW GOVERNMENT Planning & Environment

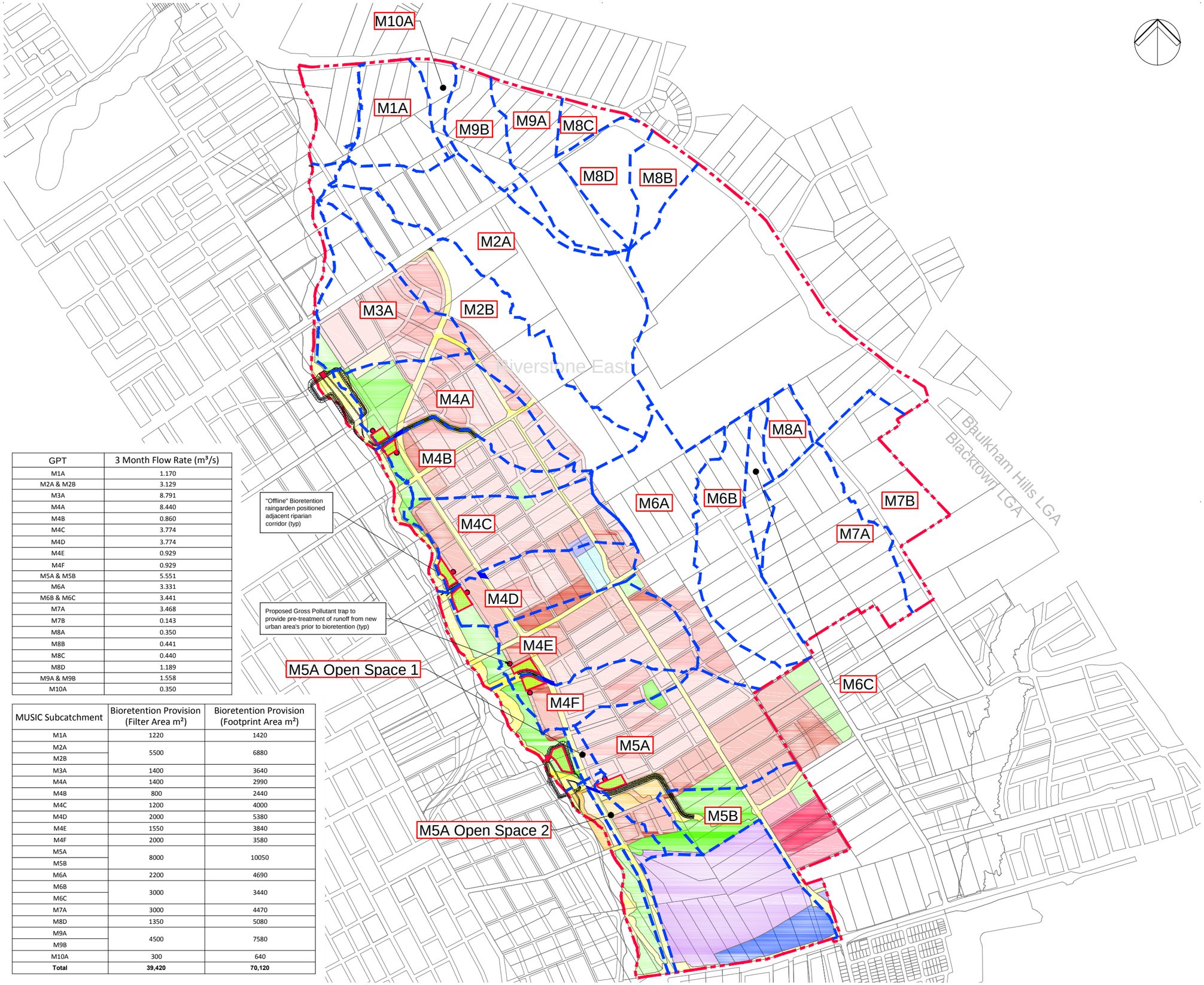
Title

Riverstone East Precinct Water Cycle Management Plan

MUSIC Catchment Plan

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.
Scale at A1	1:8000	Status	PRE	Rev	P9

Drawing Number: MMD-334311-C-DR-RE-XX-0213



GPT	3 Month Flow Rate (m^3/s)
M1A	1.170
M2A & M2B	3.129
M3A	8.791
M4A	8.440
M4B	0.860
M4C	3.774
M4D	3.774
M4E	0.929
M4F	0.929
M5A & M5B	5.551
M6A	3.331
M6B & M6C	3.441
M7A	3.468
M7B	0.143
M8A	0.350
M8B	0.441
M8C	0.440
M8D	1.189
M9A & M9B	1.558
M10A	0.350

MUSIC Subcatchment	Bioretention Provision (Filter Area m^2)	Bioretention Provision (Footprint Area m^2)
M1A	1220	1420
M2A	5500	6880
M2B		
M3A	1400	3640
M4A	1400	2990
M4B	800	2440
M4C	1200	4000
M4D	2000	5380
M4E	1550	3840
M4F	2000	3580
M5A	8000	10050
M5B		
M6A	2200	4690
M6B	3000	3440
M6C		
M7A	3000	4470
M8D	1350	5080
M9A	4500	7580
M9B		
M10A	300	640
Total	**39,420**	**70,120**

200 100 0 200 400
PLAN Scale 1:8000 @ A1

Post Exhibition Amendments

Notes

- GPT locations are indicative and subject to final sitting during detailed design

Key to symbols

- Riverstone East precinct boundary
- Proposed Stage 1 boundary
- Proposed Stage 2 boundary
- Existing cadastre
- Major culvert crossing
- MUSIC catchment boundary
- Detention basin
- M1 — MUSIC catchment
- Gross Pollutant Trap
- Bioretention

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P9	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P8	14.12.15	DRC	Issued for Information	GL	CJA
P7	19.03.15	MMc	Issued for Exhibition	GL	CJA
P6	27.01.15	AMP	Issued for Exhibition	GL	CJA
P5	16.01.15	AMP	Issued for Exhibition	GL	CJA

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Client: NSW Government Planning & Environment

Title
Riverstone East Precinct
Water Cycle Management Plan

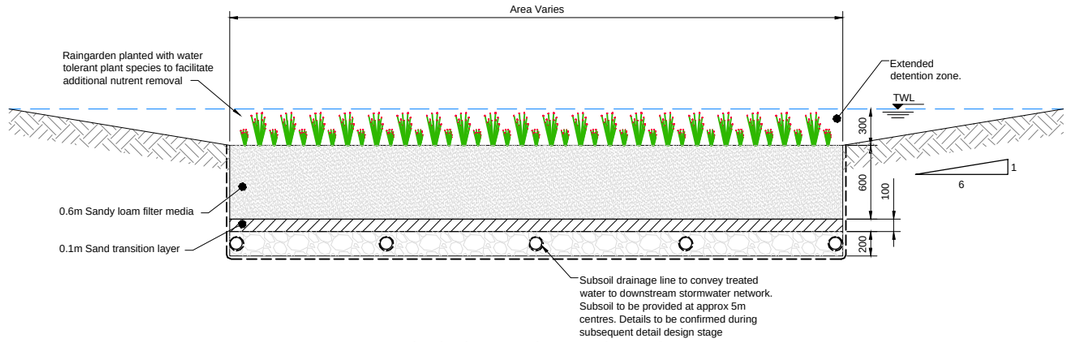
Proposed Stormwater Treatment Plan

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
1:8000	PRE	P9

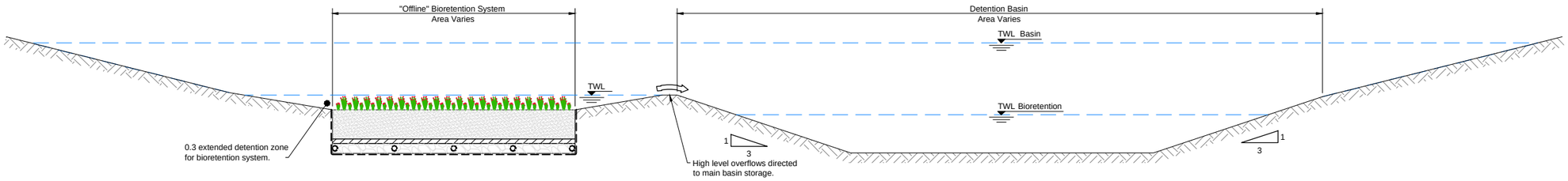
Drawing Number
MMD-334311-C-DR-RE-XX-0214

P:\Parramatta\Projects\33xxxx\334311\06 CAD\6_4 Working drawings\Civil\Autocad\1_IS_Riverstone East\Drawings\Water Cycle\MMD-334311-C-DR-RE-XX-0214.dwg May 11, 2016 - 5:56PM sin55925



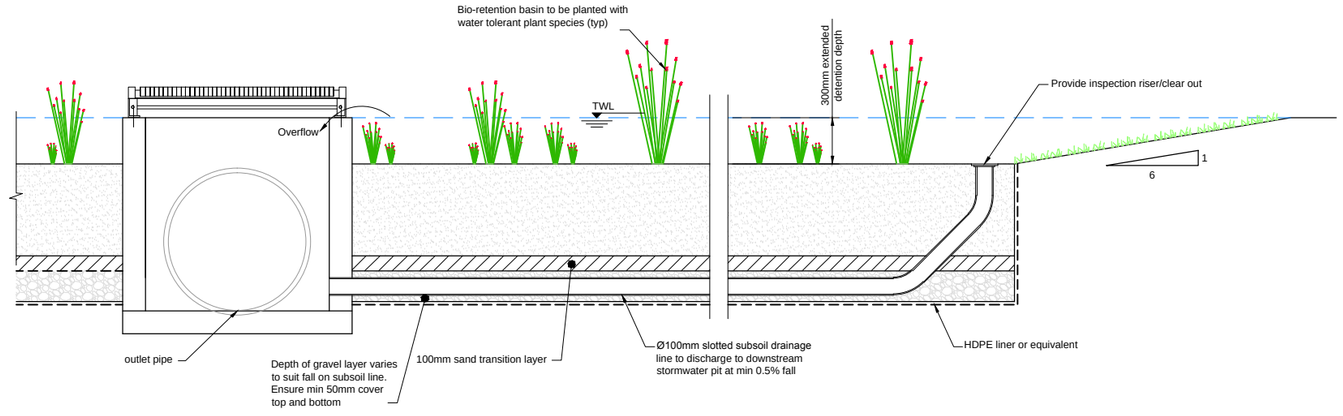
Typical Bioretention "Raingarden" Detail

1:25



Typical Combined Detention/Bioretention Detail

1:50



Typical Bioretention Basin

1:20

0.5 0.25 0 0.5 1.0
PLAN SCALE 1:20 @ A1

0.5 0 1 2 3
PLAN SCALE 1:50 @ A1

Post Exhibition Amendments

Notes

Key to symbols

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P5	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P4	19.03.15	MMc	Issued for Exhibition	GL	CJA
P3	27.01.15	AMP	Issued for Exhibition	GL	CJA
P2	16.01.15	AMP	Issued for Exhibition	GL	CJA
P1	28.11.14	ADS	Issued for Draft ILP (Not Issued)	GL	CJA

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Client

NSW GOVERNMENT Planning & Environment

Title

Riverstone East Precinct
Water Cycle Management Plan

Sections and Details

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
As Shown	PRE	P5

Drawing Number
MMD-334311-C-DR-RE-XX-0230

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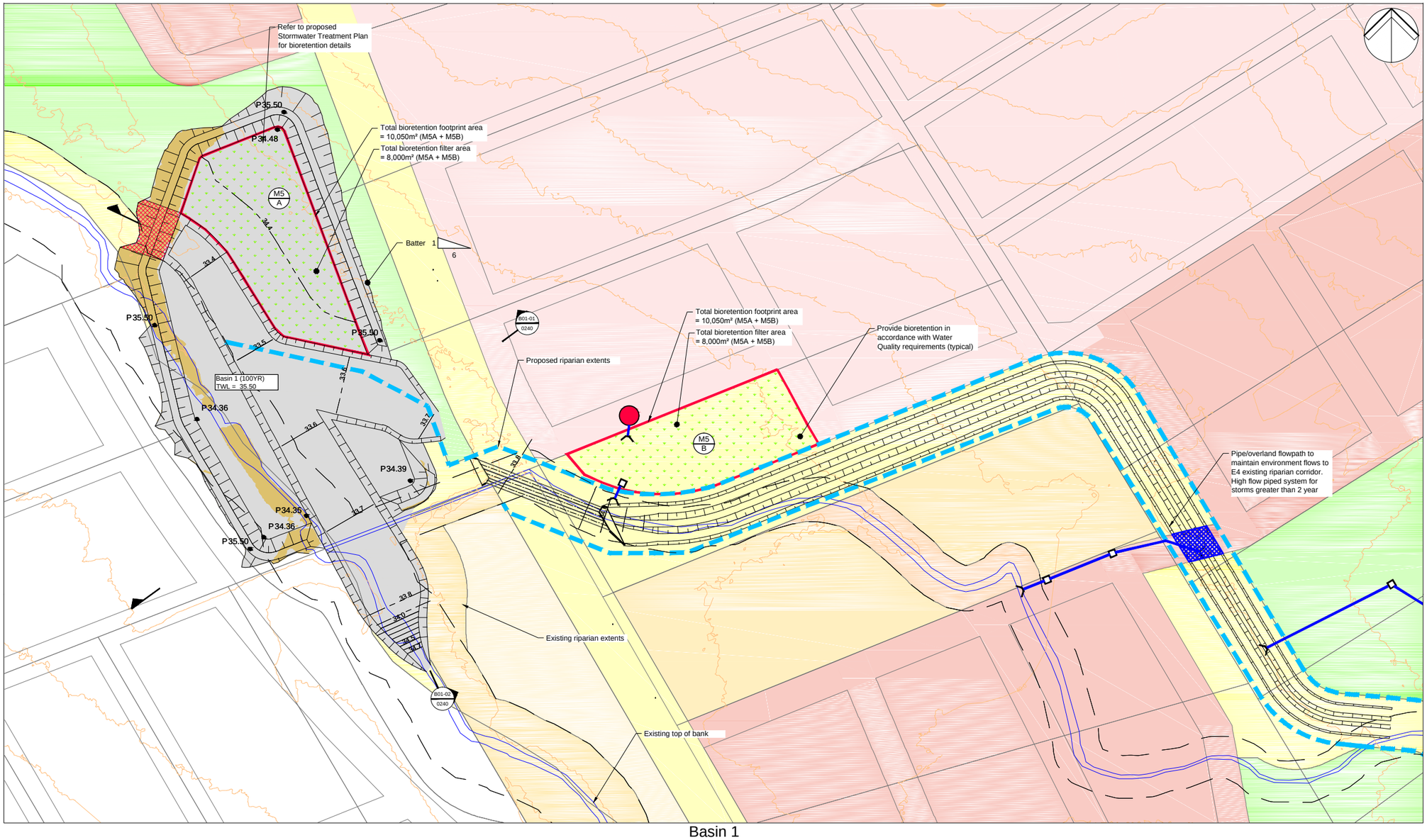
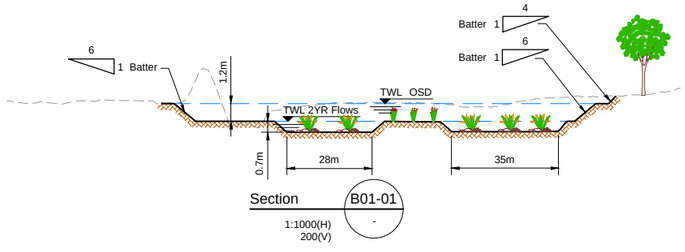


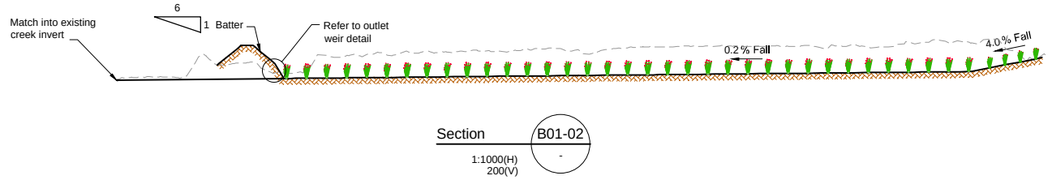
Basin 1

1:1250



Section B01-01

1:1000(H)
200(V)



Section B01-02

1:1000(H)
200(V)

25 0 25 50 75
PLAN Scale 1:1250 @ A1

20 10 0 20 40 60
PLAN Scale 1:1000 @ A1

Post Exhibition Amendments

Notes

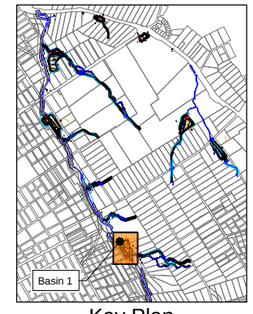
Earthworks Volume

Total cut	-36,590m³
Total fill	+2,015m³
Total balance	-34,575m³

- For basin storage volume refer drawing 0212
- GPT locations are indicative and subject to final sitting during detailed design

Key to symbols

- Existing Riparian Extents
- Proposed Riparian Extents
- Existing Top of Creek Bank
- On-site Detention
- Extent of Cut
- Extent of Fill
- Outlet Weir
- Stormwater crossing (refer drawing 0212)
- Bioretention Footprint
- Provide Piped outlet
- Provide GPT (in accordance with water quality requirements)
- M1 A — Bioretention number



Key Plan

NTS

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P8	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P7	19.03.15	MMc	Issued for Exhibition	GL	CJA
P6	27.01.15	AMP	Issued for Exhibition	GL	CJA
P5	16.01.15	AMP	Issued for Exhibition	GL	CJA
P4	26.11.14	ADS	Issued for Draft ILP (Not Issued)	GL	-

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Title

Riverstone East Precinct
Water Cycle Management Plan

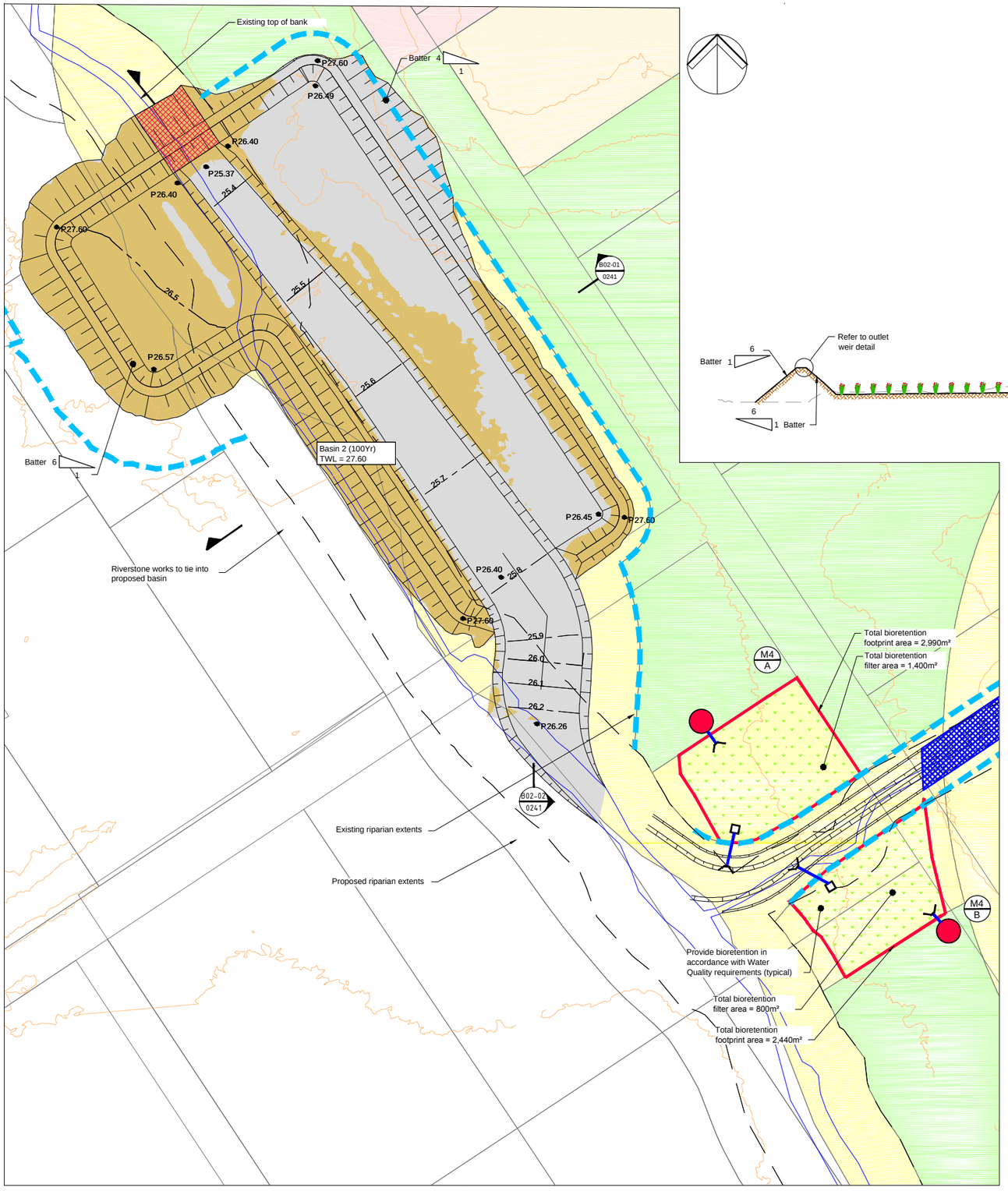
Basin 1
Plan and Section Sheet

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
As Shown	PRE	P8

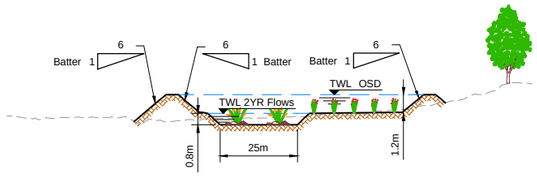
Drawing Number
MMD-334311-C-DR-RE-XX-0240

P:\Parramatta\Projects\33xxxx\334311\06 CAD\6_4 Working drawings\Civil\Autocad\1_IS_Riverstone East\Drawings\Water Cycle\MMD-334311-C-DR-RE-XX-0240.dwg May 11, 2016 - 5:57PM sin55925



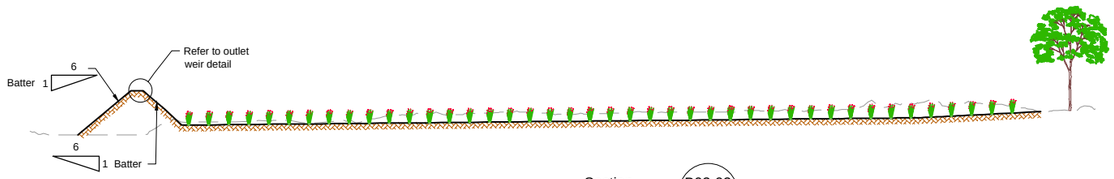
Basin 2

1:1000



Section B02-01

1:1000(H)



Section B02-02

1:1000(H)

200(V)

Notes

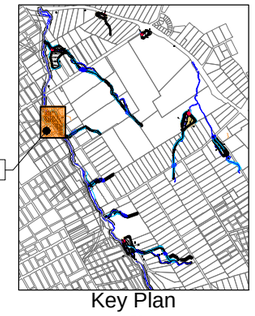
Earthworks Volume

Total cut	-12,293m³
Total fill	+14,392m³
Total balance	+2,099m³

- For basin storage volume refer drawing 0212
- GPT locations are indicative and subject to final sitting during detailed design

Key to symbols

- Existing Riparian Extents
- Proposed Riparian Extents
- Existing Top of Creek Bank
- On-site Detention
- Extent of Cut
- Extent of Fill
- Outlet Weir
- Stormwater crossing (refer drawing 0212)
- Bioretention Footprint
- Provide Piped outlet
- Provide GPT (in accordance with water quality requirements)
- Bioretention number (M1 / A)



Key Plan

NTS

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P8	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P7	19.03.15	MMc	Issued for Exhibition	GL	CJA
P6	27.01.15	AMP	Issued for Exhibition	GL	CJA
P5	16.01.15	AMP	Issued for Exhibition	GL	CJA
P4	26.11.14	ADS	Issued for Draft ILP (Not Issued)	GL	-

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Title

Riverstone East Precinct
Water Cycle Management Plan

Basin 2
Plan and Section Sheet

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
As Shown	PRE	P8

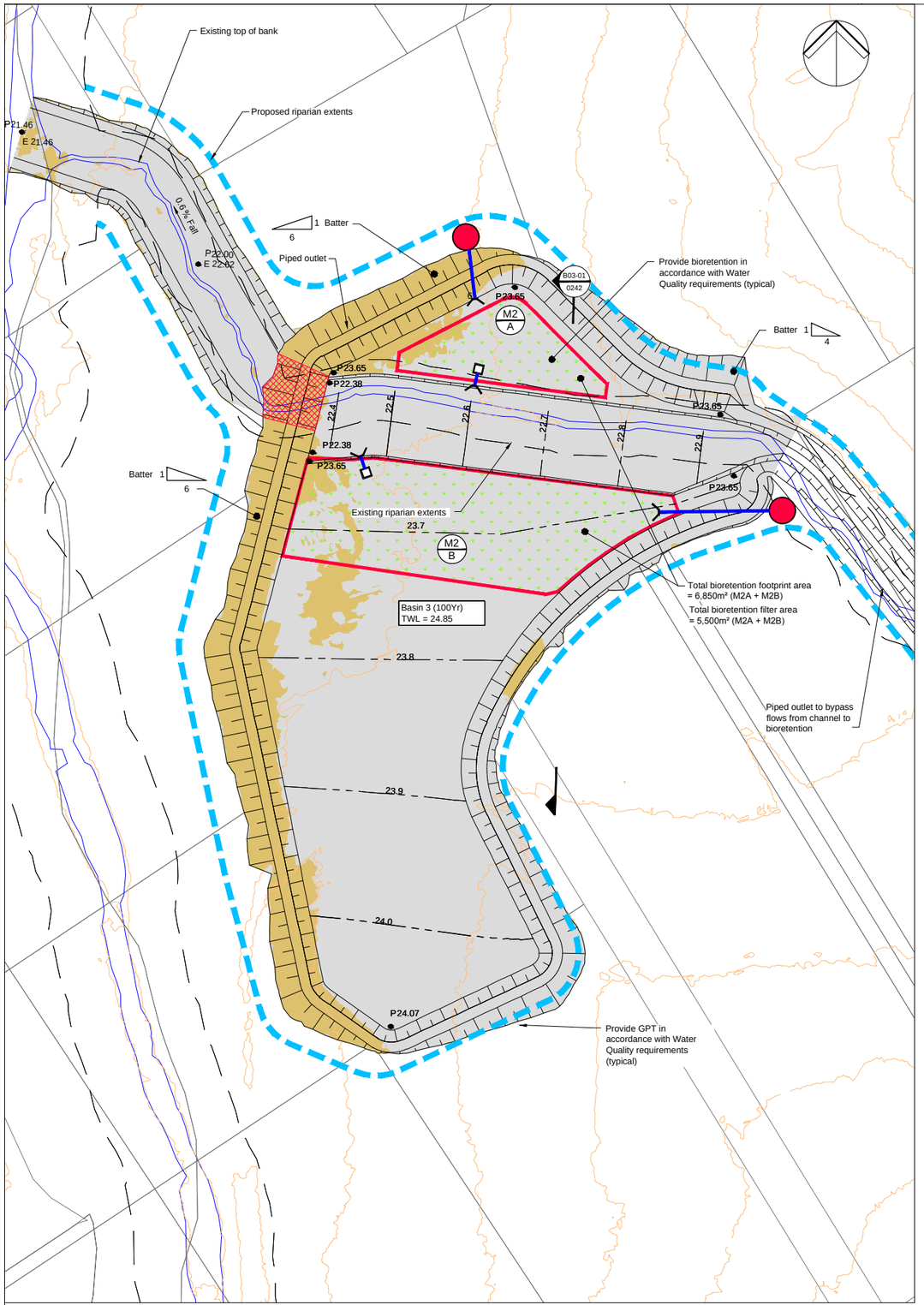
Drawing Number

MMD-334311-C-DR-RE-XX-0241

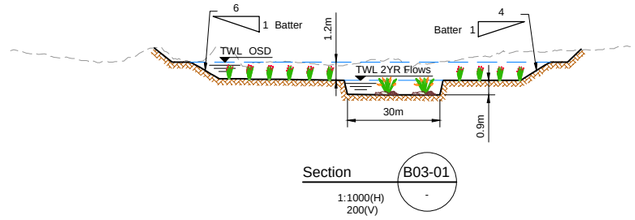
20 10 0 20 40 60
PLAN Scale 1:1000 @ A1

5 4 3 2 1 0 5 10
PLAN Scale 1:200 @ A1

Post Exhibition Amendments



Basin 3
1:1000



Section B03-01
1:1000(H)
200(V)

Notes

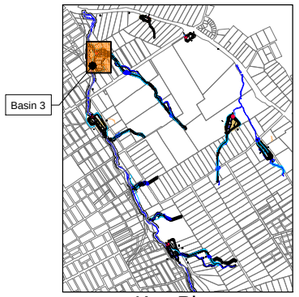
Earthworks Volume

Total cut	-35,091m³
Total fill	+4,978m³
Total balance	-30,113m³

- For basin storage volume refer drawing 0212
- GPT locations are indicative and subject to final sitting during detailed design

Key to symbols

- Existing Riparian Extents
- Proposed Riparian Extents
- Existing Top of Creek Bank
- On-site Detention
- Extent of Cut
- Extent of Fill
- Outlet Weir
- Stormwater crossing (refer drawing 0212)
- Bioretention Footprint
- Provide Piped outlet
- Provide GPT (in accordance with water quality requirements)
- M1 A — Bioretention number



Key Plan
NTS

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P8	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P7	19.03.15	MMc	Issued for Exhibition	GL	CJA
P6	27.01.15	AMP	Issued for Exhibition	GL	CJA
P5	16.01.15	AMP	Issued for Exhibition	GL	CJA
P4	26.11.14	ADS	Issued for Draft ILP (Not Issued)	GL	-

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Client: NSW Government Planning & Environment

Title
Riverstone East Precinct
Water Cycle Management Plan

Basin 3
Plan and Section Sheet

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
As Shown	PRE	P8

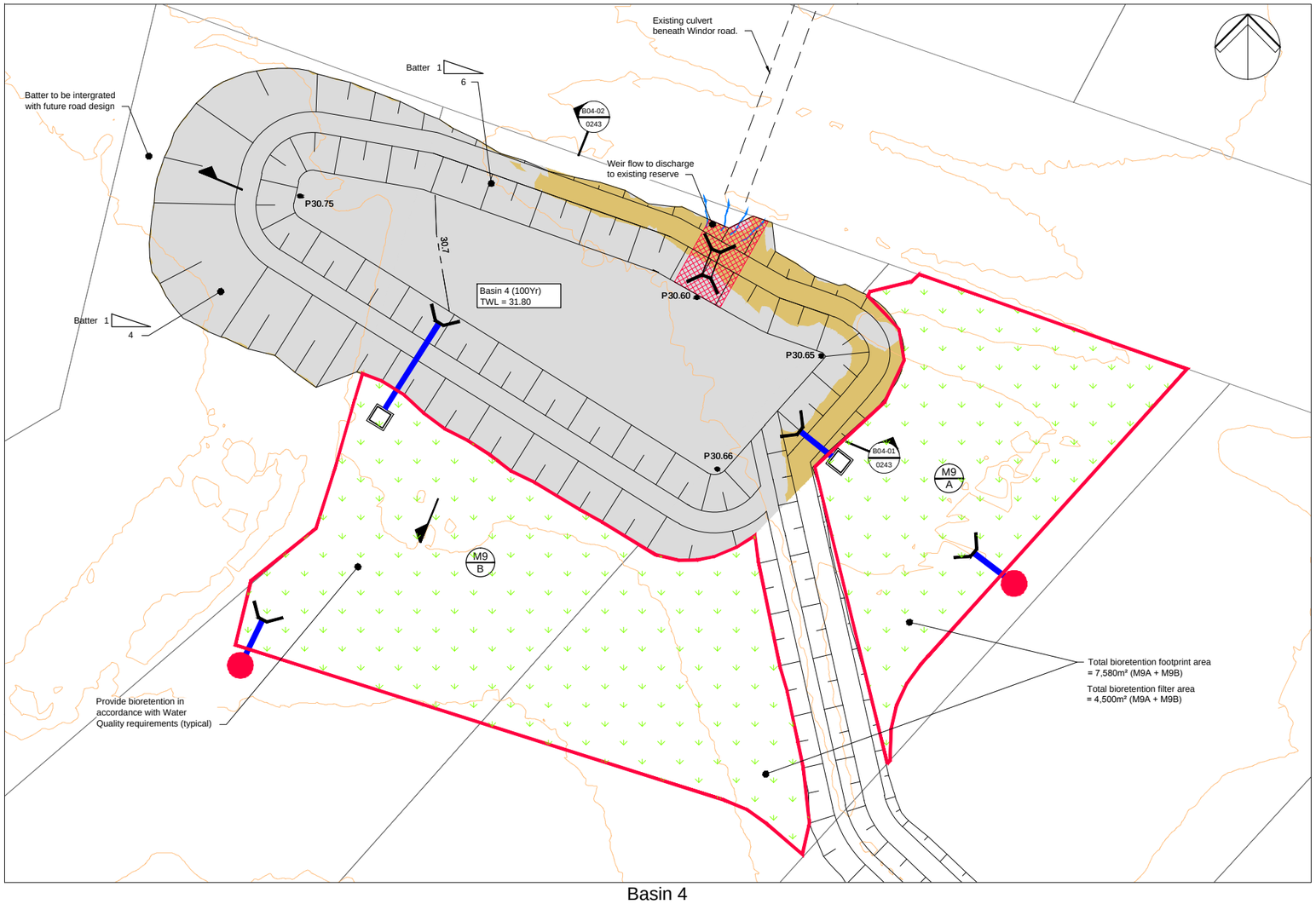
Drawing Number
MMD-334311-C-DR-RE-XX-0242

20 10 0 20 40 60
PLAN Scale 1:1000 @ A1

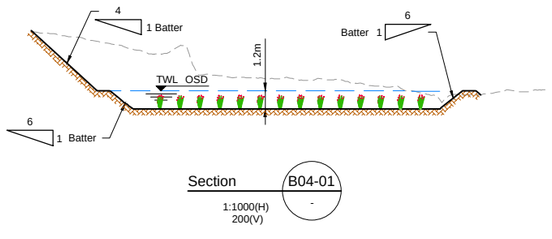
5 4 3 2 1 0 5 10
SECTION Scale 1:200 @ A1

Post Exhibition Amendments

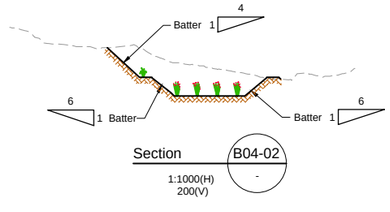
P:\Parramatta\Projects\33xxxx\334311\06 CAD\6_4 Working drawings\Civil\Autocad\1_IS_Riverstone East\Drawings\Water Cycle\MMD-334311-C-DR-RE-XX-0240.dwg May 11, 2016 - 5:58PM sin55925



Basin 4
1:500



Section B04-01
1:1000(H)
200(V)



Section B04-02
1:1000(H)
200(V)

20 10 0 20 40 60
PLAN Scale 1:1000 @ A1

5 4 3 2 1 0 5 10
SECTION Scale 1:200 @ A1

Post Exhibition Amendments

Notes

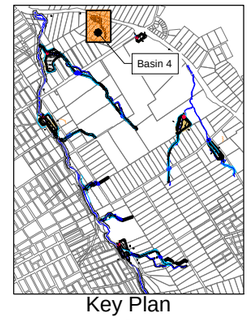
Earthworks Volume

Total cut	-10,835m³
Total fill	+201m³
Total balance	-10,634m³

- For basin storage volume refer drawing 0212
- GPT locations are indicative and subject to final sitting during detailed design

Key to symbols

- Existing Riparian Extents
- Proposed Riparian Extents
- Existing Top of Creek Bank
- On-site Detention
- Extent of Cut
- Extent of Fill
- Outlet Weir
- Stormwater crossing (refer drawing 0212)
- Bioretention Footprint
- Provide Piped outlet
- Provide GPT (in accordance with water quality requirements)
- M1 / A — Bioretention number



Key Plan
NTS

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P8	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P7	19.03.15	MMc	Issued for Exhibition	GL	CJA
P6	27.01.15	AMP	Issued for Exhibition	GL	CJA
P5	16.01.15	AMP	Issued for Exhibition	GL	CJA
P4	26.11.14	ADS	Issued for Draft ILP (Not Issued)	GL	-

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Client
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Title
Riverstone East Precinct
Water Cycle Management Plan

Basin 4
Plan and Section Sheet

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
As Shown	PRE	P8

Drawing Number
MMD-334311-C-DR-RE-XX-0243

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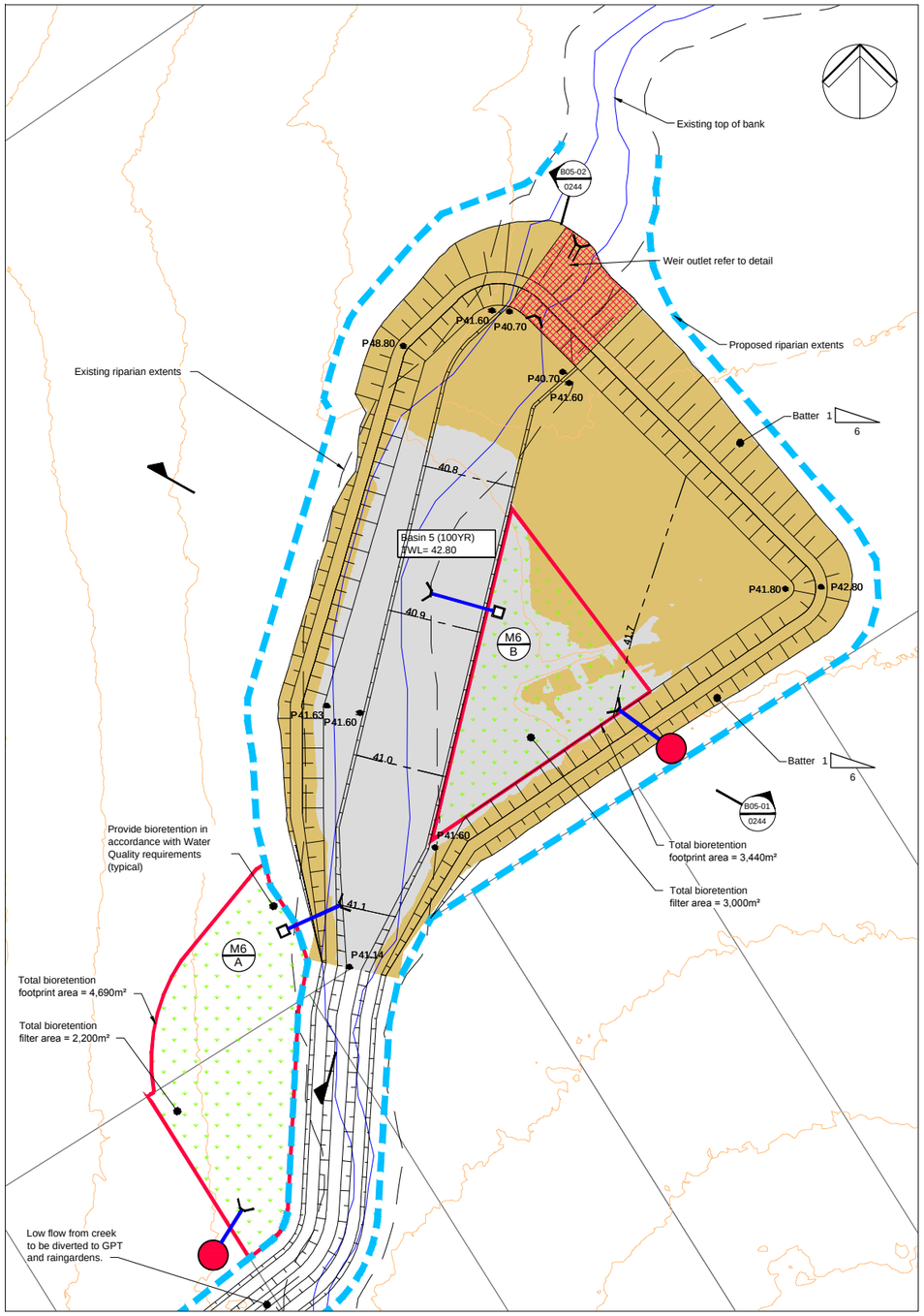
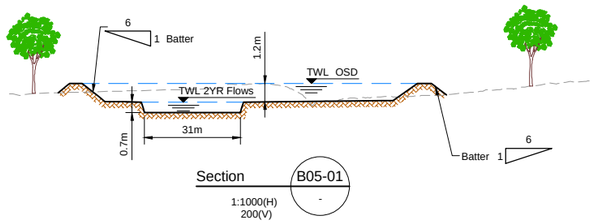


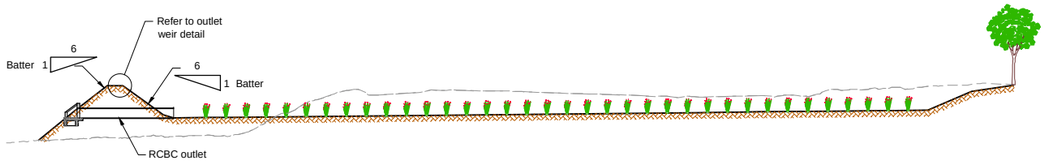
Basin 5

1:1000



Section B05-01

1:1000(H)
200(V)



Section B05-02

1:1000(H)
200(V)

Notes

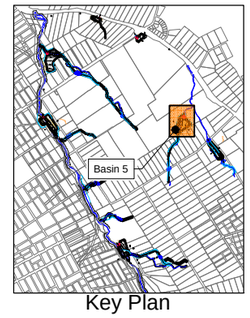
Earthworks Volume

Total cut	-9,512m³
Total fill	+16,904m³
Total balance	+7,392m³

- For basin storage volume refer drawing 0212
- GPT locations are indicative and subject to final sitting during detailed design

Key to symbols

- Existing Riparian Extents
- Proposed Riparian Extents
- Existing Top of Creek Bank
- On-site Detention
- Extent of Cut
- Extent of Fill
- Outlet Weir
- Stormwater crossing (refer drawing 0212)
- Bioretention Footprint
- Provide Piped outlet
- Provide GPT (in accordance with water quality requirements)
- M1 / A — Bioretention number



Key Plan

NTS

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P8	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P7	19.03.15	MMc	Issued for Exhibition	GL	CJA
P6	27.01.15	AMP	Issued for Exhibition	GL	CJA
P5	16.01.15	AMP	Issued for Exhibition	GL	CJA
P4	26.11.14	ADS	Issued for Draft ILP (Not Issued)	GL	-

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NSW GOVERNMENT Planning & Environment

Title

Riverstone East Precinct
Water Cycle Management Plan

Basin 5
Plan and Section Sheet

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
As Shown	PRE	P8

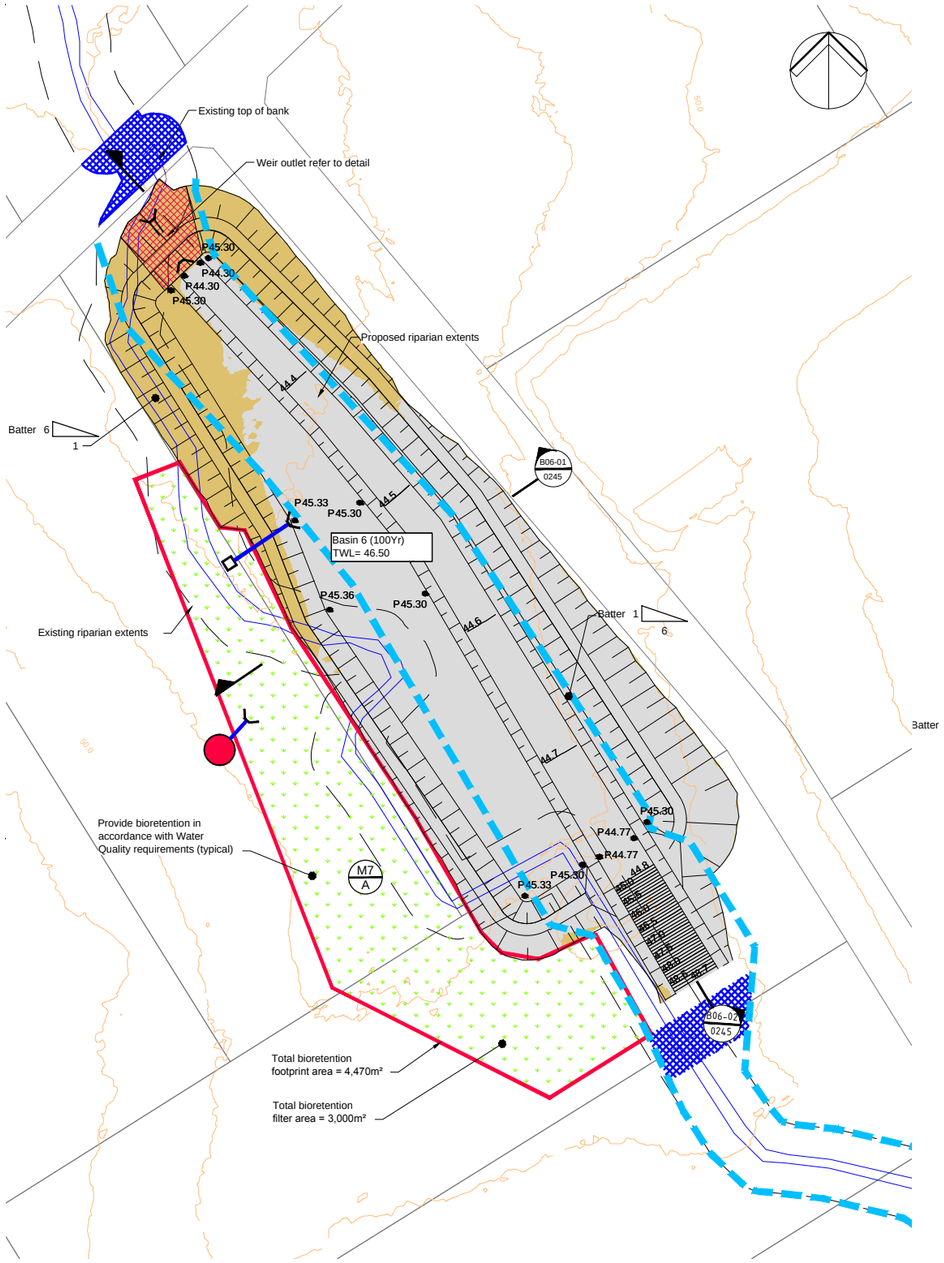
Drawing Number

MMD-334311-C-DR-RE-XX-0244

20 10 0 20 40 60
PLAN Scale 1:1000 @ A1

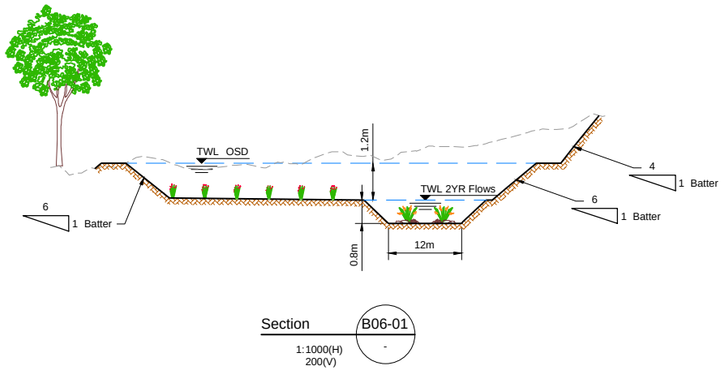
5 4 3 2 1 0 5 10
SECTION Scale 1:200 @ A1

Post Exhibition Amendments



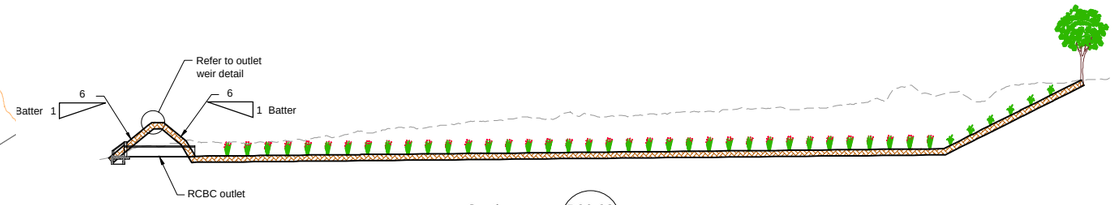
Basin 6

1:1000



Section B06-01

1:1000(H)
200(V)



Section B06-02

1:1000(H)
200(V)

Notes

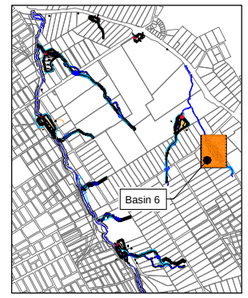
Earthworks Volume

Total cut	-28,135m³
Total fill	+4,255m³
Total balance	-23,880m³

- For basin storage volume refer drawing 0212
- GPT locations are indicative and subject to final sitting during detailed design

Key to symbols

- Existing Riparian Extents
- Proposed Riparian Extents
- Existing Top of Creek Bank
- On-site Detention
- Extent of Cut
- Extent of Fill
- Outlet Weir
- Stormwater crossing (refer drawing 0212)
- Bioretention Footprint
- Provide Piped outlet
- Provide GPT (in accordance with water quality requirements)
- M1 / A — Bioretention number



Key Plan

NTS

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P8	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P7	19.03.15	MMc	Issued for Exhibition	GL	CJA
P6	27.01.15	AMP	Issued for Exhibition	GL	CJA
P5	16.01.15	AMP	Issued for Exhibition	GL	CJA
P4	26.11.14	ADS	Issued for Draft ILP (Not Issued)	GL	-

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Client

NSW GOVERNMENT Planning & Environment

Title

Riverstone East Precinct
Water Cycle Management Plan

Basin 6
Plan and Section Sheet

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
As Shown	PRE	P8

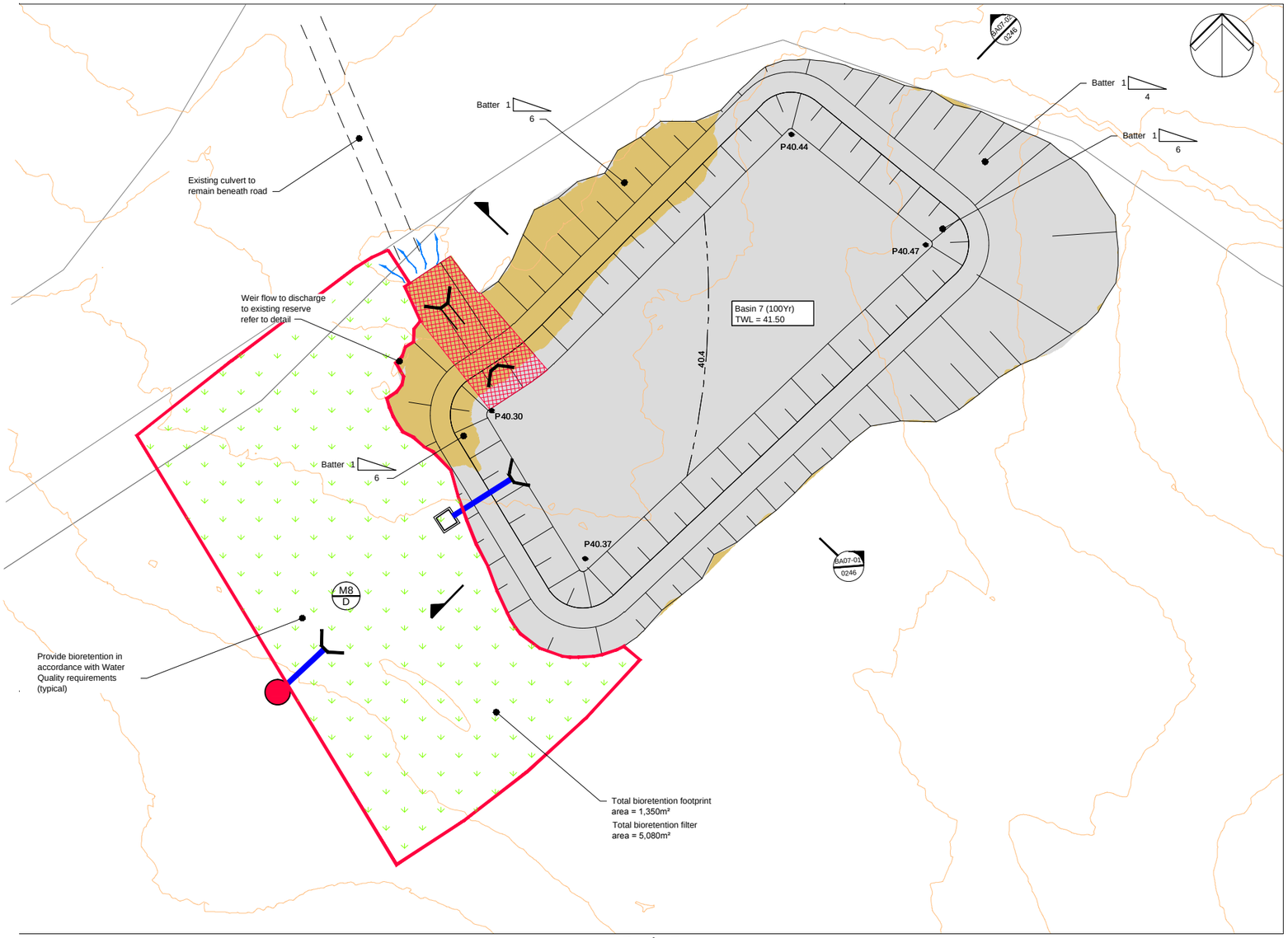
Drawing Number

MMD-334311-C-DR-RE-XX-0245

20 10 0 20 40 60
PLAN Scale 1:1000 @ A1

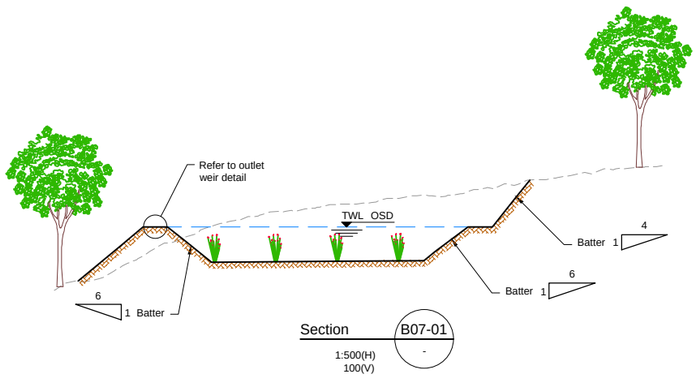
5 4 3 2 1 0 5 10
SECTION Scale 1:200 @ A1

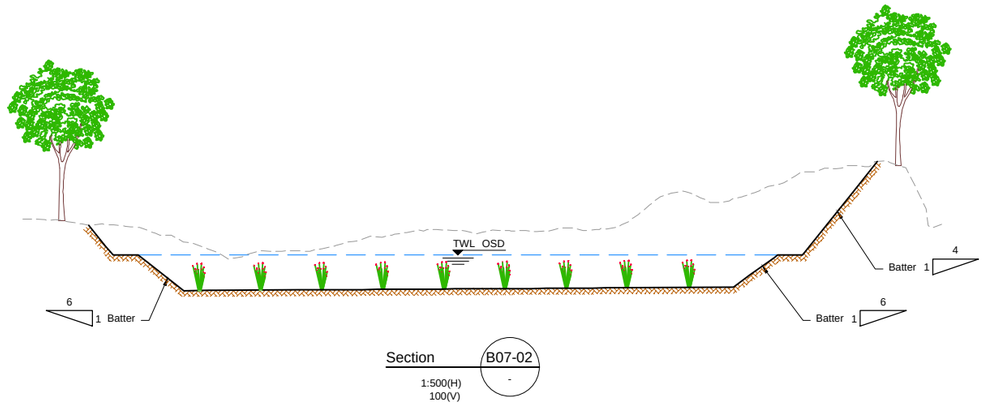
Post Exhibition Amendments



Basin 7

1:500





5 4 3 2 1 0 5 10
SECTION Scale 1:200 @ A1

10 5 0 10 20 30
PLAN Scale 1:500 @ A1

2 1 0 2 4 6
SECTION Scale 1:100 @ A1

Post Exhibition Amendments

Notes

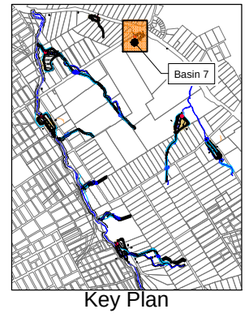
Earthworks Volume

Total cut	-13,580m³
Total fill	+692m³
Total balance	-12,888m³

- For basin storage volume refer drawing 0212
- GPT locations are indicative and subject to final sitting during detailed design

Key to symbols

- Existing Riparian Extents
- Proposed Riparian Extents
- Existing Top of Creek Bank
- On-site Detention
- Extent of Cut
- Extent of Fill
- Outlet Weir
- Stormwater crossing (refer drawing 0212)
- Bioretention Footprint
- Provide Piped outlet
- Provide GPT (in accordance with water quality requirements)
- M1 A — Bioretention number



Key Plan

NTS

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P5	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P4	19.03.15	MMc	Issued for Exhibition	GL	CJA
P3	27.01.15	AMP	Issued for Exhibition	GL	CJA
P2	16.01.15	AMP	Issued for Exhibition	GL	CJA
P1	28.11.14	ADS	Issued for Draft ILP (Not Issued)	GL	-

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NSW GOVERNMENT Planning & Environment

Title

Riverstone East Precinct
Water Cycle Management Plan

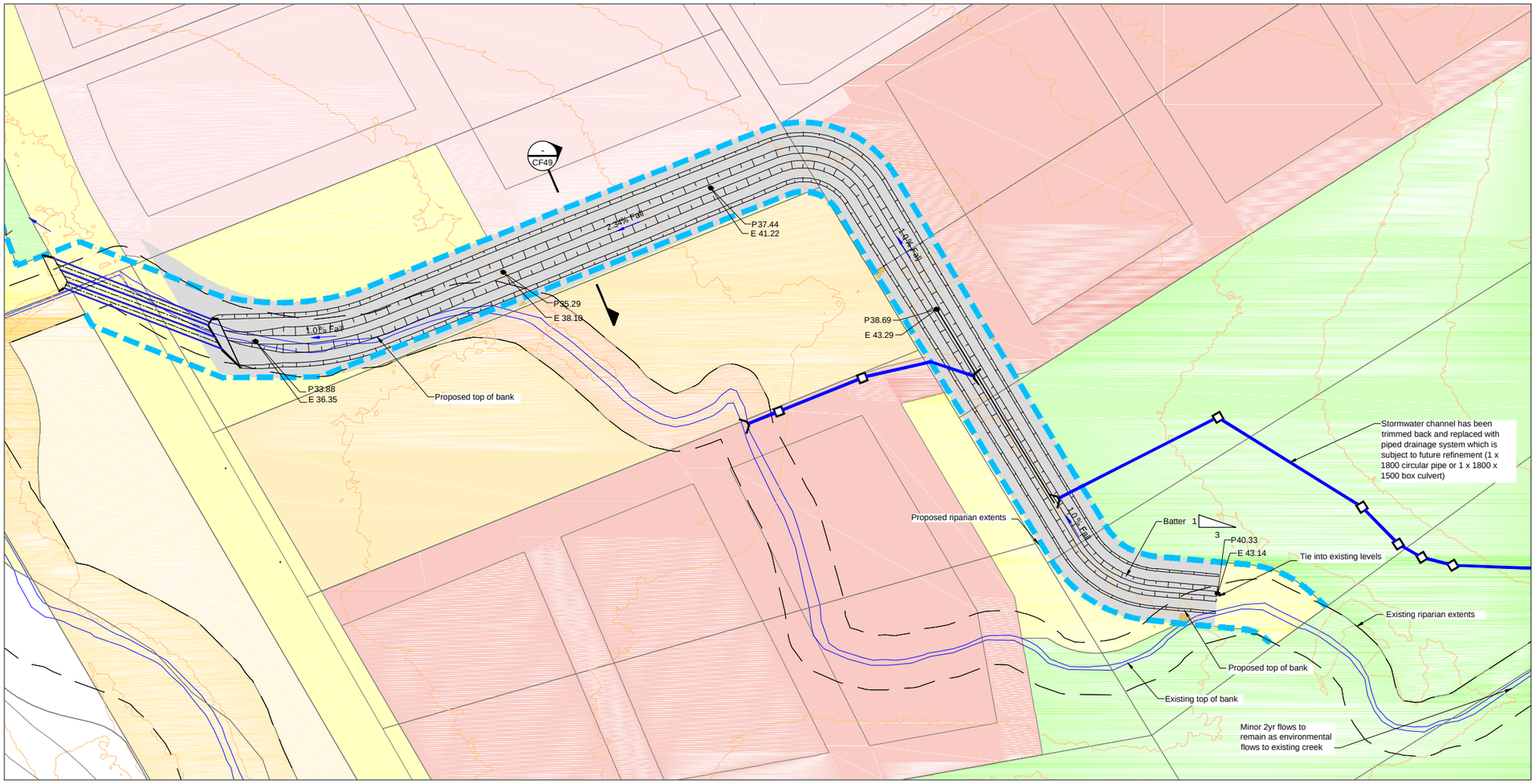
Basin 7
Plan and Section Sheet

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
As Shown	PRE	P5

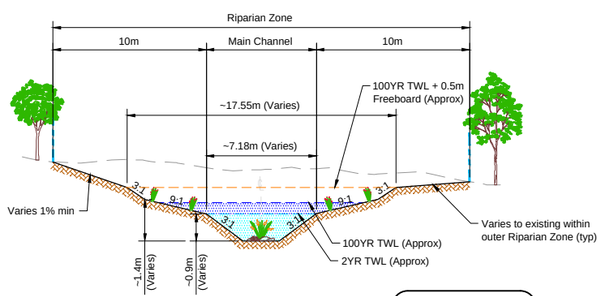
Drawing Number

MMD-334311-C-DR-RE-XX-0246



Channel CF49

1:1000



Channel CF49
Typical Section

1:200(H) 1:100(V)

Refer Water Cycle Report for detailed calculations

Creek channel shown as centralised. How ever creek can meander within overall riparian zone to promote a more 'Natural' appearance.

20 10 0 20 40 60
PLAN Scale 1:1000 @ A1

Post Exhibition Amendments

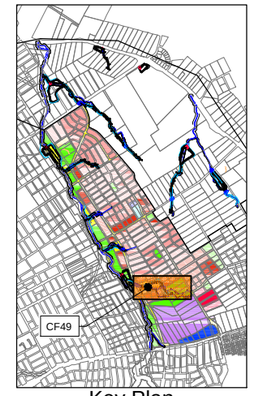
Notes

Earthworks Volume - Channel CF49

Total cut	-30,909m³
Total fill	+4m³
Total balance	-30,905m³

Key to symbols

- Existing Riparian Extents
- Proposed Riparian Extents
- Existing Top of Bank
- 100yr Top of Water Level and Freeboard
- Proposed Channel
- Proposed Pit and pipe network
- Extent of Cut
- Extent of Fill
- Piped culvert crossing (refer drawing 0212)



Key Plan

NTS

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P7	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P6	19.03.15	MMc	Issued for Exhibition	GL	CJA
P5	27.01.15	AMP	Issued for Exhibition	GL	CJA
P4	16.01.15	AMP	Issued for Exhibition	GL	CJA
P3	28.11.14	ADS	Issued for Draft ILP (Not Issued)	GL	-

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NSW GOVERNMENT Planning & Environment

Title

Riverstone East Precinct
Water Cycle Management Plan

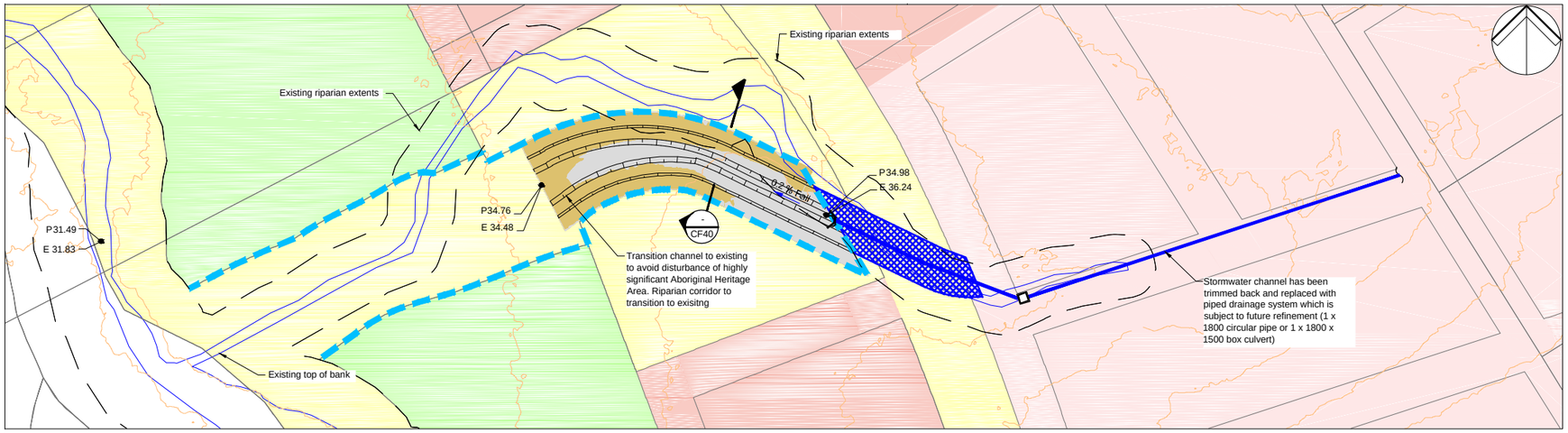
Proposed Channel Plan
Channel CF49

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
As Shown	PRE	P7

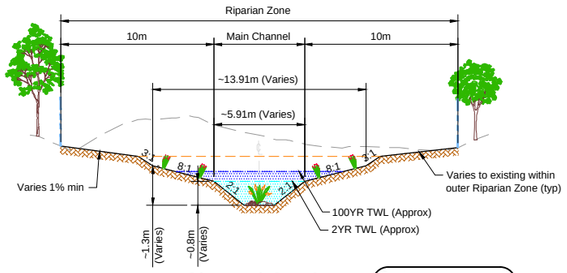
Drawing Number
MMD-334311-C-DR-RE-XX-0250

P:\Parramatta\Projects\33xxxx\334311\06 CAD\6_4 Working drawings\Civil\Autocad\1_IS_Riverstone East\Drawings\Water Cycle\MMD-334311-C-DR-RE-XX-0250.dwg May 11, 2016 - 6:00PM sin55925



Channel CF40

1:1000



Channel CF40 Typical Section

1:200(H) 1:100(V)

Refer Water Cycle Report for detailed calculations

Creek channel shown as centralised. How ever creek can meander within overall riparian zone to promote a more 'Natural' appearance.

20 10 0 20 40 60
PLAN Scale 1:1000 @ A1

Post Exhibition Amendments

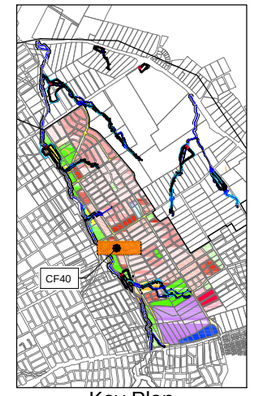
Notes

Earthworks Volume - Channel CF40

Total cut	-600m³
Total fill	+729m³
Total balance	+129m³

Key to symbols

- Existing Riparian Extents
- Proposed Riparian Extents
- Existing Top of Bank
- 100yr Top of Water Level and Freeboard
- Proposed Channel
- Proposed Pit and pipe network
- Extent of Cut
- Extent of Fill
- Piped culvert crossing (refer drawing 0212)



Key Plan

NTS

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P7	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P6	19.03.15	MMc	Issued for Exhibition	GL	CJA
P5	27.01.15	AMP	Issued for Exhibition	GL	CJA
P4	16.01.15	AMP	Issued for Exhibition	GL	CJA
P3	28.11.14	ADS	Issued for Draft ILP (Not Issued)	GL	-

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NSW GOVERNMENT Planning & Environment

Title

Riverstone East Precinct
Water Cycle Management Plan

Proposed Channel Plan
Channel CF40

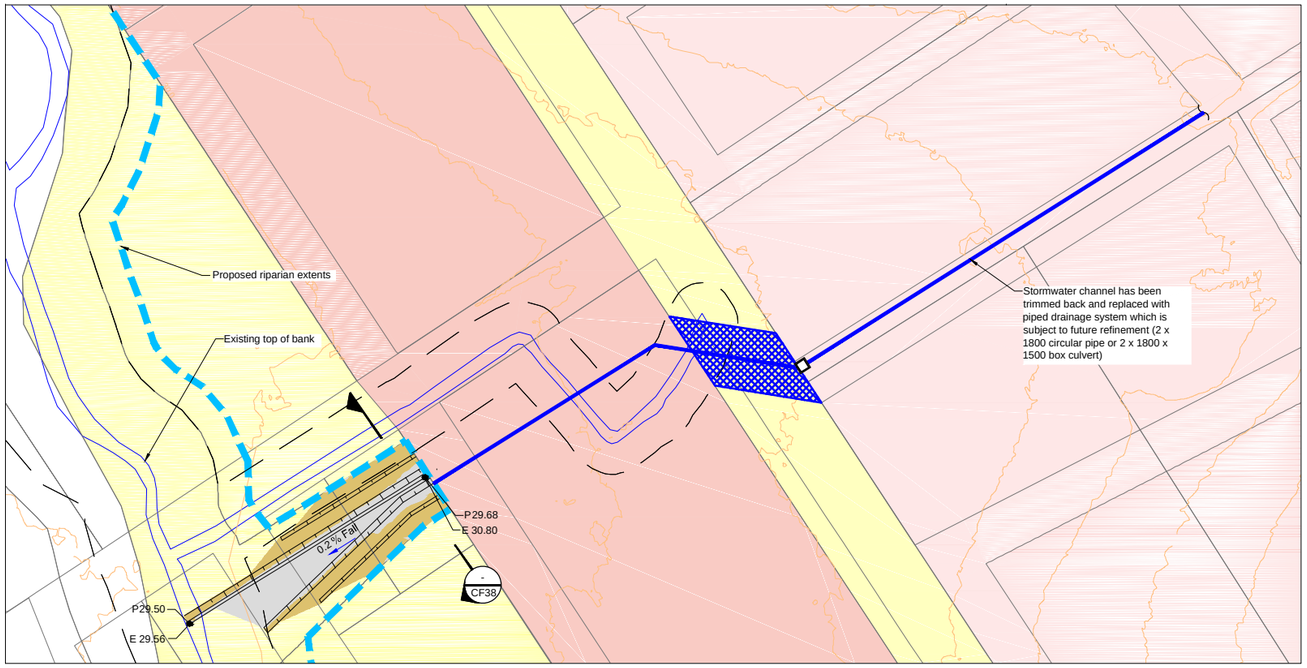
Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
As Shown	PRE	P7

Drawing Number

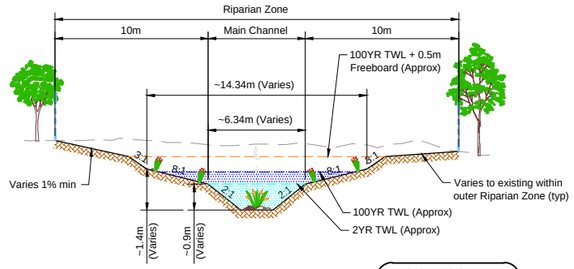
MMD-334311-C-DR-RE-XX-0251

P:\Parramatta\Projects\33xxxx\334311\06 CAD\6_4 Working drawings\Civil\Autocad\1_IS_Riverstone East\Drawings\Water Cycle\MMD-334311-C-DR-RE-XX-0250.dwg May 11, 2016 - 6:00PM sin55925



Channel CF38

1:1000

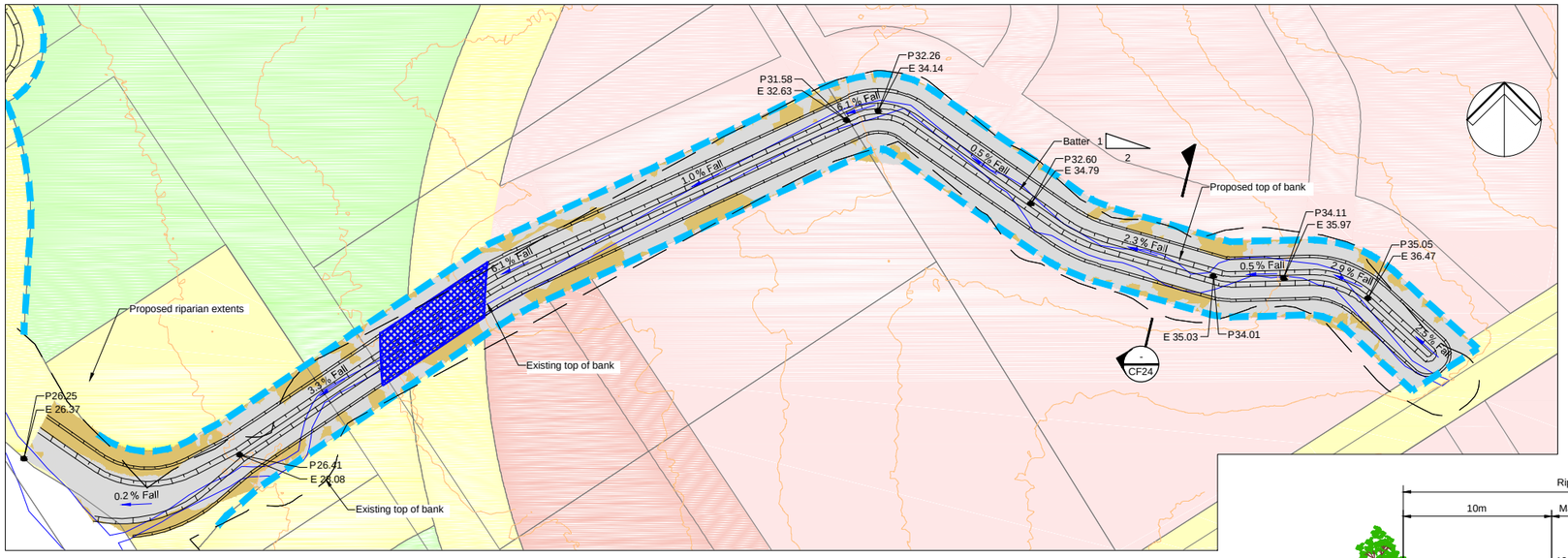


Channel CF38 Typical Section

1:200(H) 1:100(V)

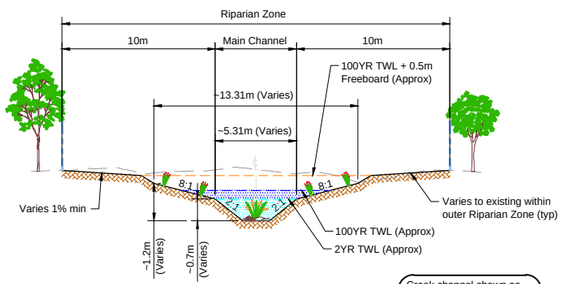
Creek channel shown as centralised. How ever creek can meander within overall riparian zone to promote a more 'Natural' appearance.

Refer Water Cycle Report for detailed calculations



Channel CF24

1:1000



Channel CF24 Typical Section

1:500(H) 1:100(V)

Creek channel shown as centralised. How ever creek can meander within overall riparian zone to promote a more 'Natural' appearance.

Refer Water Cycle Report for detailed calculations

Post Exhibition Amendments

20 10 0 20 40 60
PLAN Scale 1:1000 @ A1

Notes

Earthworks Volume - Channel CF38

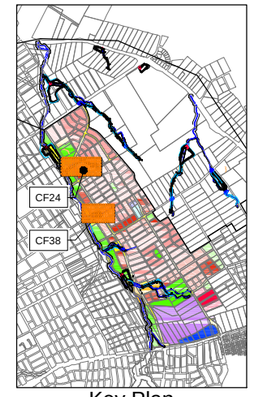
Total cut	-409m³
Total fill	+469m³
Total balance	-60m³

Earthworks Volume - Channel CF24

Total cut	-7,638m³
Total fill	+304m³
Total balance	-7,334m³

Key to symbols

- Existing Riparian Extents
- Proposed Riparian Extents
- Existing Top of Bank
- 100yr Top of Water Level and Freeboard
- Proposed Channel
- Proposed Pit and pipe network
- Extent of Cut
- Extent of Fill
- Piped culvert crossing (refer drawing 0212)



Key Plan

NTS

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P7	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P6	19.03.15	MMc	Issued for Exhibition	GL	CJA
P5	27.01.15	AMP	Issued for Exhibition	GL	CJA
P4	16.01.15	AMP	Issued for Exhibition	GL	CJA
P3	28.11.14	ADS	Issued for Draft ILP (Not Issued)	GL	-

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NSW GOVERNMENT Planning & Environment

Title

Riverstone East Precinct
Water Cycle Management Plan

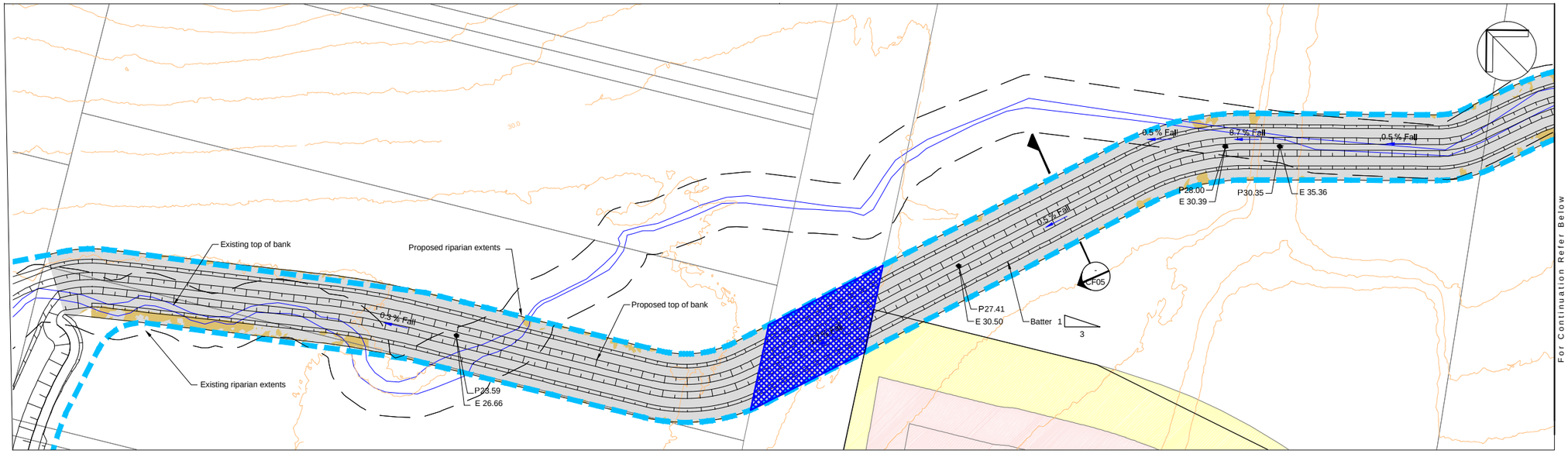
Proposed Channel Plan
Channel CF38 and CF24

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
As Shown	PRE	P7

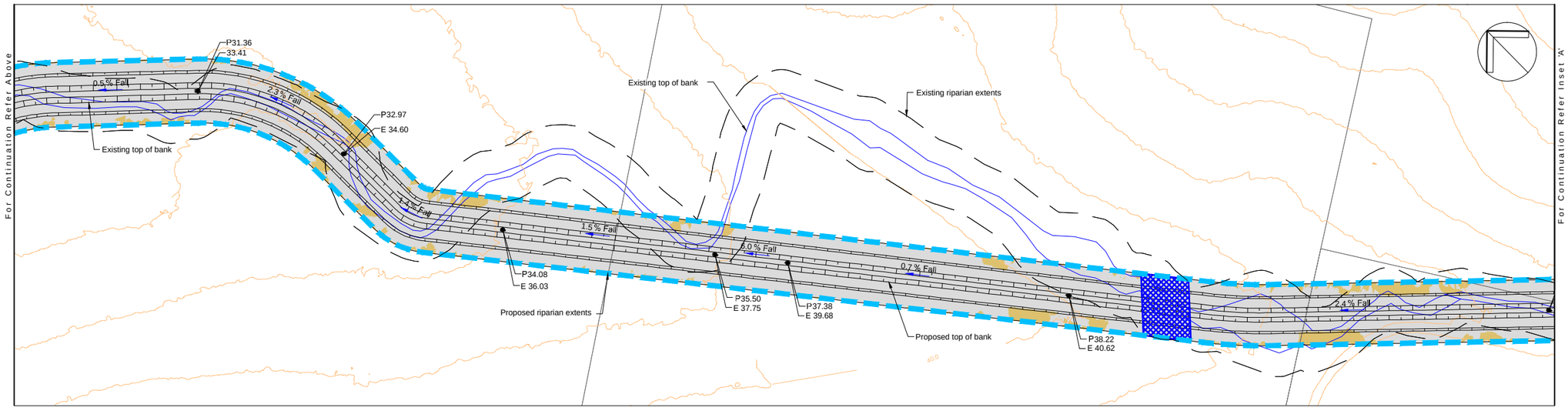
Drawing Number
MMD-334311-C-DR-RE-XX-0252

P:\Parramatta\Projects\33xxxx\334311\06 CAD\6_4 Working drawings\Civil\Autocad\1_IS_Riverstone East\Drawings\Water Cycle\MMD-334311-C-DR-RE-XX-0250.dwg May 11, 2016 - 6:00PM sin55925



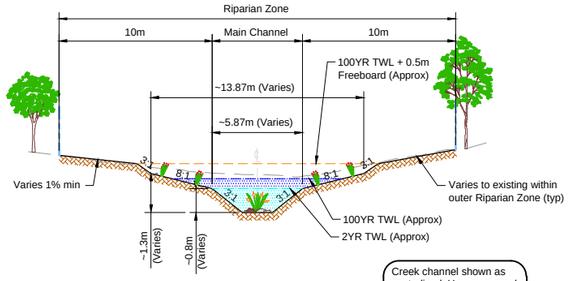
Channel CF05

1:1000



Channel CF05 (Continuation)

1:1000

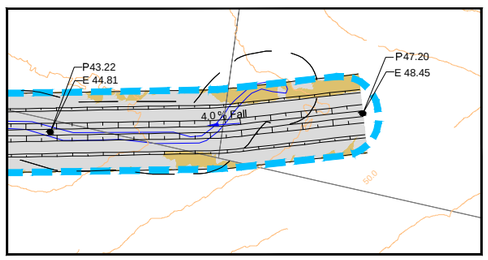


Channel CF05
Typical Section

1:200(H) 1:100(V)

Refer Water Cycle Report
for detailed calculations

Creek channel shown as centralised. How ever creek can meander within overall riparian zone to promote a more 'Natural' appearance.



Inset 'A'

1:1000

20 10 0 20 40 60

PLAN Scale 1:1000 @ A1

Post Exhibition Amendments

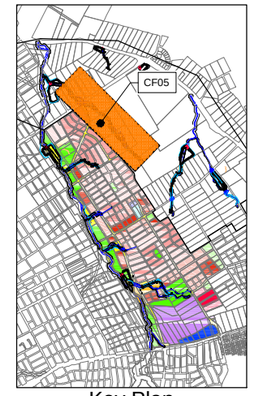
Notes

Earthworks Volume - Channel CF05

Total cut	-39,294m³
Total fill	+153m³
Total balance	-39,141m³

Key to symbols

- Existing Riparian Extents
- Proposed Riparian Extents
- Existing Top of Bank
- 100yr Top of Water Level and Freeboard
- Proposed Channel
- Proposed Pit and pipe network
- Extent of Cut
- Extent of Fill
- Piped culvert crossing (refer drawing 0212)



Key Plan

NTS

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P7	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P6	19.03.15	MMc	Issued for Exhibition	GL	CJA
P5	27.01.15	AMP	Issued for Exhibition	GL	CJA
P4	16.01.15	AMP	Issued for Exhibition	GL	CJA
P3	28.11.14	ADS	Issued for Draft ILP (Not Issued)	GL	-

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Client

NSW GOVERNMENT Planning & Environment

Title

Riverstone East Precinct
Water Cycle Management Plan

Proposed Channel Plan
Channel CF05

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
As Shown	PRE	P7

Drawing Number

MMD-334311-C-DR-RE-XX-0253

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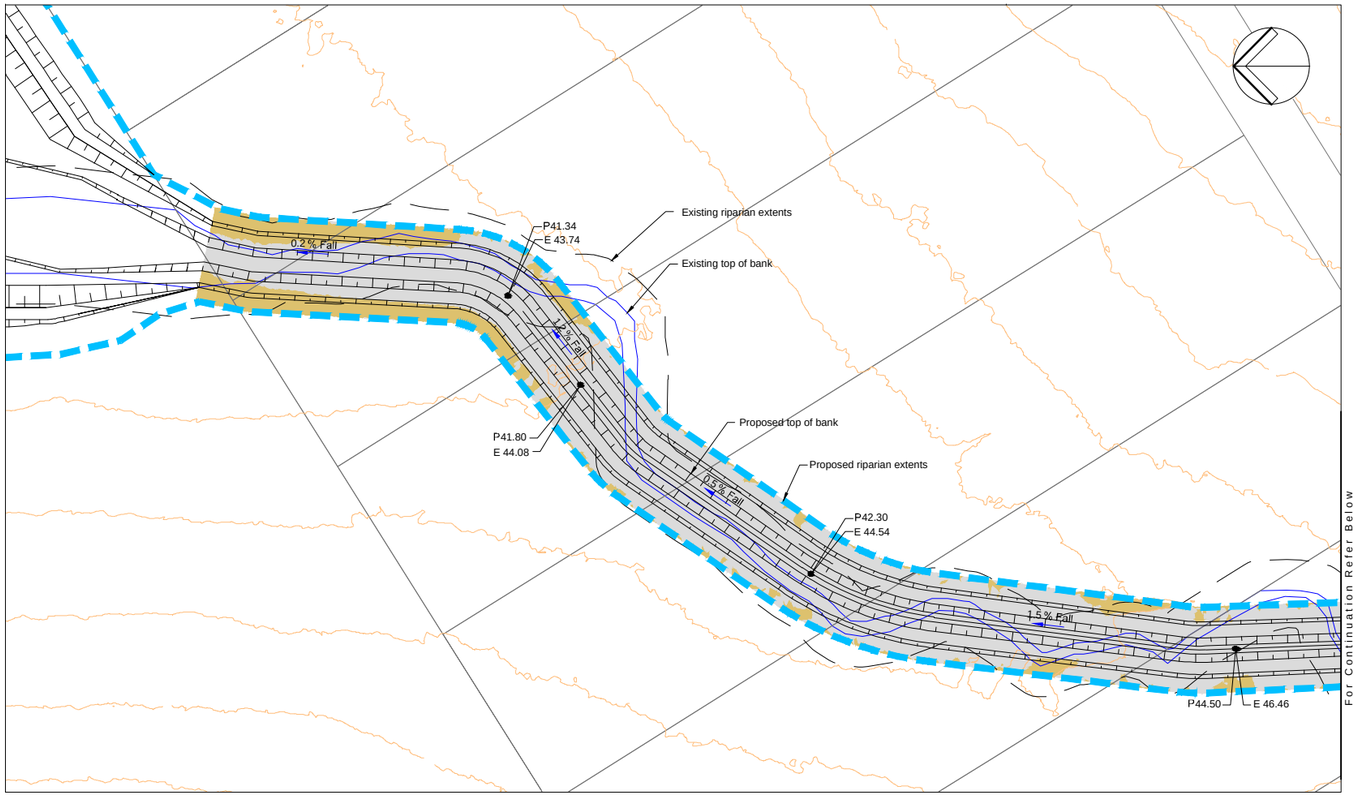
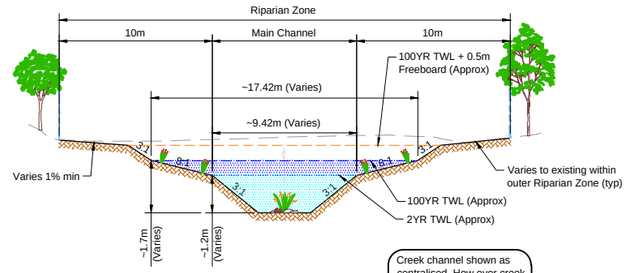


Channel CA14

1:1000

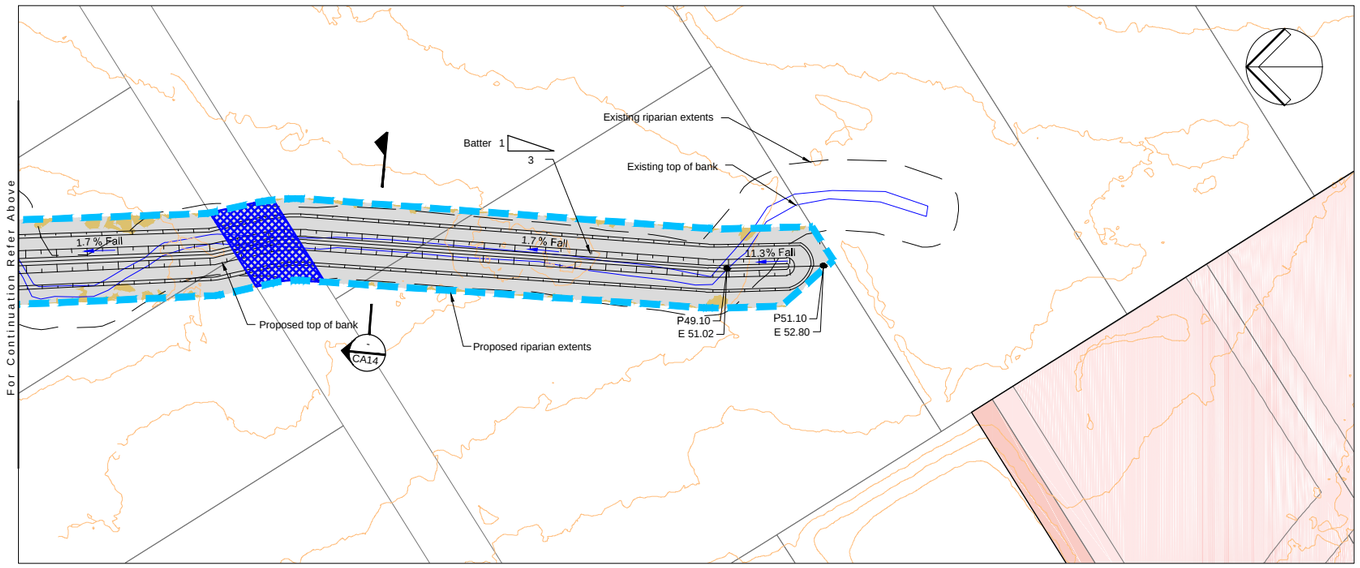


Channel CA14
Typical Section

1:200(H) 1:100(V)

Refer Water Cycle Report
for detailed calculations

Creek channel shown as centralised. How ever creek can meander within overall riparian zone to promote a more 'Natural' appearance.



Channel CA14 (Continuation)

1:1000

20 10 0 20 40 60

PLAN Scale 1:1000 @ A1

Post Exhibition Amendments

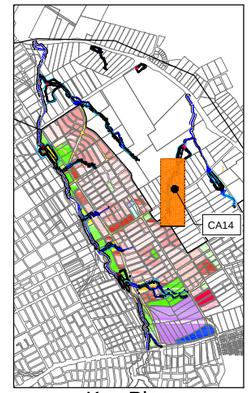
Notes

Earthworks Volume - Channel CA14

Total cut	-17,174m³
Total fill	+408m³
Total balance	-16,766m³

Key to symbols

- Existing Riparian Extents
- Proposed Riparian Extents
- Existing Top of Bank
- 100yr Top of Water Level and Freeboard
- Proposed Channel
- Proposed Pit and pipe network
- Extent of Cut
- Extent of Fill
- Piped culvert crossing (refer drawing 0212)



Key Plan

NTS

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P7	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P6	19.03.15	MMc	Issued for Exhibition	GL	CJA
P5	27.01.15	AMP	Issued for Exhibition	GL	CJA
P4	16.01.15	AMP	Issued for Exhibition	GL	CJA
P3	28.11.14	ADS	Issued for Draft ILP (Not Issued)	GL	-

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Client

NSW GOVERNMENT Planning & Environment

Title

Riverstone East Precinct
Water Cycle Management Plan

Proposed Channel Plan
Channel CA14

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
As Shown	PRE	P7

Drawing Number

MMD-334311-C-DR-RE-XX-0255

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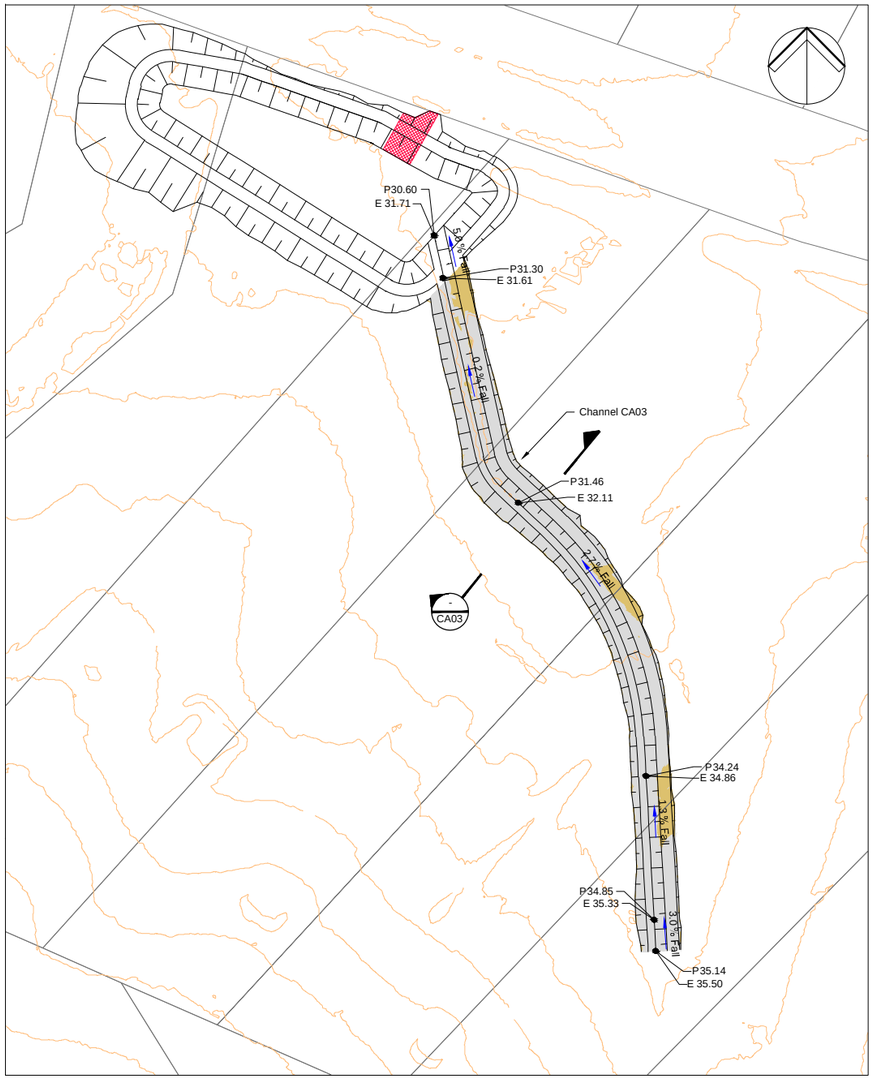
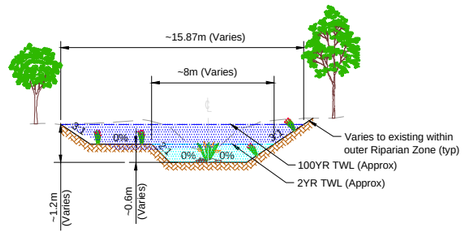


Channel CA03

1:1000



Channel CA03
Typical Section

1:200(H) 1:100(V)

Refer Water Cycle Report for detailed calculations

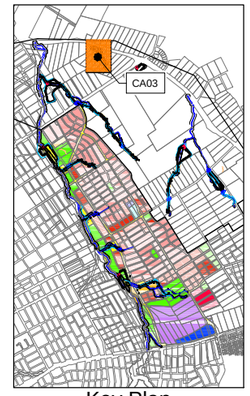
Notes

Earthworks Volume - Channel CA03

Total cut	-1,587m³
Total fill	+69m³
Total balance	-1,518m³

Key to symbols

- Existing Riparian Extents
- Proposed Riparian Extents
- Existing Top of Bank
- 100yr Top of Water Level and Freeboard
- Proposed Channel
- Proposed Pit and pipe network
- Extent of Cut
- Extent of Fill
- Piped culvert crossing (refer drawing 0212)



Key Plan

NTS

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P7	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P6	19.03.15	MMc	Issued for Exhibition	GL	CJA
P5	27.01.15	AMP	Issued for Exhibition	GL	CJA
P4	16.01.15	AMP	Issued for Exhibition	GL	CJA
P3	28.11.14	ADS	Issued for Draft ILP (Not Issued)	GL	-

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Client

NSW GOVERNMENT Planning & Environment

Title

Riverstone East Precinct
Water Cycle Management Plan

Proposed Channel Plan
Channel CA03

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
As Shown	PRE	P7

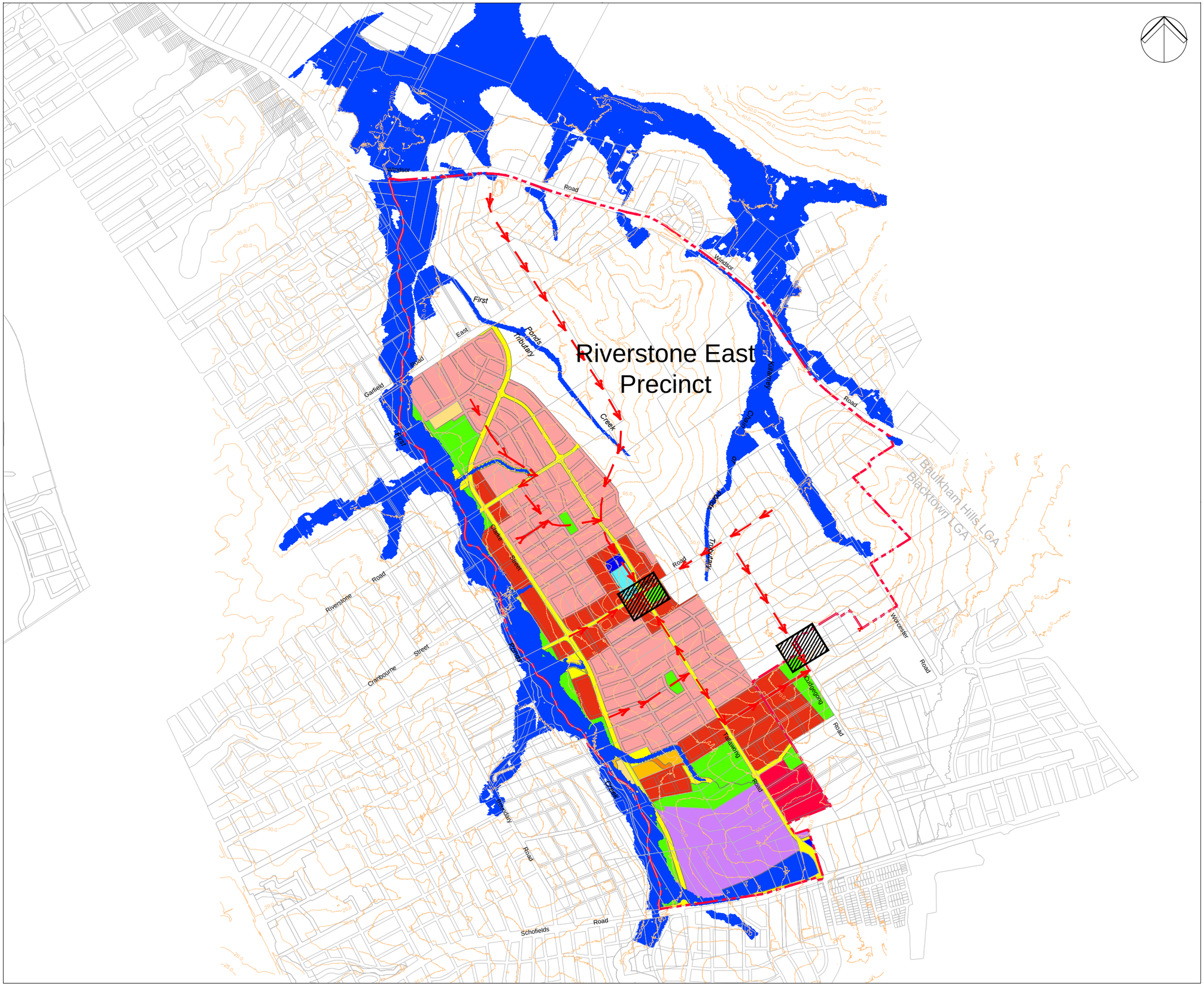
Drawing Number

MMD-334311-C-DR-RE-XX-0256

20 10 0 20 40 60

PLAN Scale 1:1000 @ A1

Post Exhibition Amendments



Notes

Key to symbols

- Riverstone East precinct boundary
- Proposed Stage 1 boundary
- Proposed Stage 2 boundary
- Existing road
- Evacuation Route
- Flood Response Extents
- Point of Refuge

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P6	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA
P5	19.03.15	MMc	Issued for Exhibition	GL	CJA
P4	27.01.15	AMP	Issued for Exhibition	GL	CJA
P3	16.01.15	AMP	Issued for Exhibition	GL	CJA
P2	26.11.14	DW	Issued for Draft ILP	GL	-

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Client

NSW GOVERNMENT Planning & Environment

Title

Riverstone East Precinct
Water Cycle Management Plan

Flood Response Plan

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

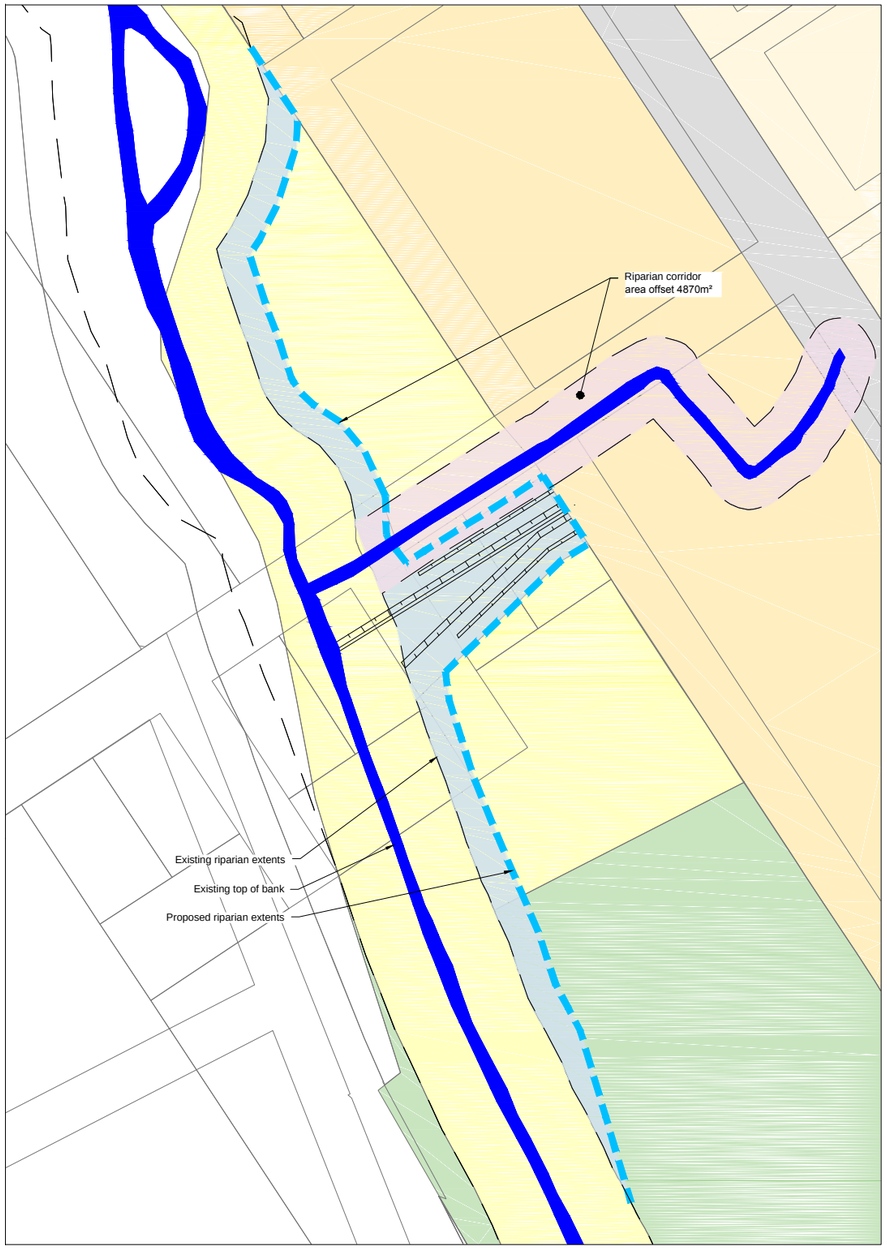
Scale at A1	Status	Rev
1:10000	PRE	P6

Drawing Number
MMD-334311-C-DR-RE-XX-0260

100 50 0 100 200 300
PLAN Scale 1:10000 @ A1

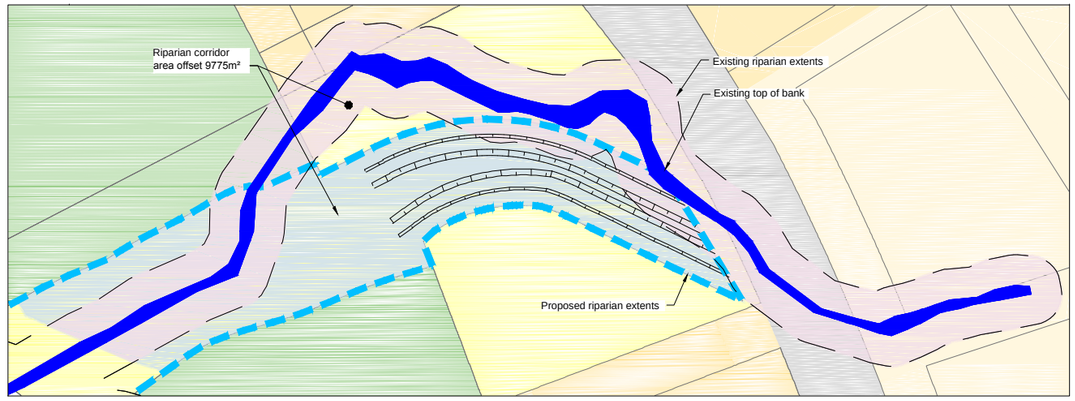
Post Exhibition Amendments

P:\Parramatta\Projects\33xxxx\334311\06 CAD\6_4 Working drawings\Civil\Autocad\1_IS_Riverstone East\Drawings\Water Cycle\MMD-334311-C-DR-RE-XX-0260.dwg May 12, 2016 - 12:06PM sin55925



Riparian Offset Area 1

1:1000



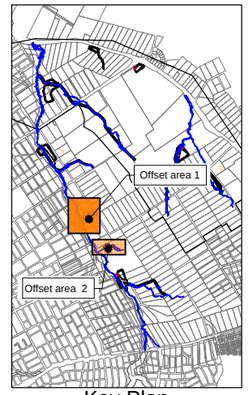
Riparian Offset Area 2

1:1000

Notes

Key to symbols

- Existing Riparian Extents
- Proposed Riparian Extents
- Existing Top of Bank
- Existing Riparian Corridor to be Relocated
- New Relocated Riparian Corridor
- Validated Watercourse



Key Plan

NTS

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	11.05.16	ADS	Issued for Post Exhibition Amendments	GL	CJA

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NSW GOVERNMENT Planning & Environment

Title

Riverstone East Precinct
Water Cycle Management Plan

Proposed Riparian Corridor
Offset Plan

Designed	JT	.	Eng check	GL	.
Drawn	ADS	.	Coordination	GL	.
Dwg check	GC	.	Approved	CJA	.

Scale at A1	Status	Rev
As Shown	PRE	P1

Drawing Number

MMD-334311-C-DR-RE-XX-0270

20 10 0 20 40 60
PLAN Scale 1:1000 @ A1

10 0 25 50 100
PLAN Scale 1:1500 @ A1

Post Exhibition Amendments

Appendix B. RAFTS Model Data

Riverstone Precinct

Existing Catchment Data

Catchment	Total Area [ha]	Percentage Impervious	Impervious Area [ha]	Pervious Area [ha]	Catchment Slope [%]	Pervious Mannings 'n'	Impervious Mannings 'n'
CA01	3.529	5%	0.176	3.353	4.84	0.04	0.025
CA02	6.298	6%	0.378	5.920	5.08	0.04	0.025
CA03	15.124	5%	0.756	14.368	3.27	0.04	0.025
CA04	8.747	5%	0.437	8.310	5.04	0.04	0.025
CA05	18.541	5%	0.927	17.614	5.53	0.04	0.025
CA06	5.994	6%	0.360	5.634	6.61	0.04	0.025
CA07	17.942	5%	0.897	17.045	4.79	0.04	0.025
CA08	8.888	5%	0.444	8.444	6.44	0.04	0.025
CA10	22.056	6%	1.323	20.733	4.19	0.04	0.025
CA11	9.134	6%	0.548	8.586	7.42	0.04	0.025
CA12	22.360	5%	1.118	21.242	5.93	0.04	0.025
CA13	20.215	6%	1.213	19.002	4.77	0.04	0.025
CA14	8.298	6%	0.498	7.800	5.65	0.04	0.025
CA15	24.647	5%	1.232	23.415	3.73	0.04	0.025
CA16	11.017	6%	0.661	10.356	3.36	0.04	0.025
CA17	29.304	5%	1.465	27.839	5.91	0.04	0.025
CA18	28.511	6%	1.711	26.800	5.02	0.04	0.025
CA19	16.465	5%	0.823	15.642	5.17	0.04	0.025
CF01	9.560	27%	2.581	6.979	2.64	0.04	0.025
CF02	23.358	28%	6.540	16.818	4.42	0.04	0.025
CF03	2.414	6%	0.145	2.269	5.08	0.04	0.025
CF04	19.599	28%	5.488	14.111	4.02	0.04	0.025
CF05	9.693	16%	1.551	8.142	5.94	0.04	0.025
CF06	17.718	16%	2.835	14.883	4.52	0.04	0.025
CF07	12.106	16%	1.937	10.169	5.63	0.04	0.025
CF08	13.399	16%	2.144	11.255	3.33	0.04	0.025
CF09	6.703	15%	1.005	5.698	5.48	0.04	0.025
CF10	13.652	16%	2.184	11.468	5.81	0.04	0.025
CF11	13.235	15%	1.985	11.250	6.05	0.04	0.025
CF12	8.168	15%	1.225	6.943	6.26	0.04	0.025
CF13	13.875	26%	3.608	10.268	4.21	0.04	0.025
CF14	18.003	26%	4.681	13.322	4.37	0.04	0.025
CF15	17.692	25%	4.423	13.269	3.64	0.04	0.025
CF16	17.753	25%	4.438	13.315	2.78	0.04	0.025
CF17	7.892	25%	1.973	5.919	4.54	0.04	0.025
CF18	9.436	25%	2.359	7.077	6.83	0.04	0.025
CF19	15.715	26%	4.086	11.629	4.06	0.04	0.025
CF20	7.101	25%	1.775	5.326	6.58	0.04	0.025
CF21	14.261	25%	3.565	10.696	4.82	0.04	0.025
CF22	8.937	36%	3.217	5.720	3.19	0.04	0.025
CF23	10.586	35%	3.705	6.881	4.61	0.04	0.025
CF24	11.419	36%	4.111	7.308	5.69	0.04	0.025
CF25	4.969	35%	1.739	3.230	7.22	0.04	0.025
CF26	21.629	35%	7.570	14.059	4.44	0.04	0.025
CF27	15.441	35%	5.404	10.037	4.46	0.04	0.025
CF28	5.698	35%	1.994	3.704	3.27	0.04	0.025
CF29	12.305	36%	4.430	7.875	4.49	0.04	0.025
CF30	7.751	36%	2.790	4.961	2.64	0.04	0.025
CF31	17.169	35%	6.009	11.160	6.14	0.04	0.025
CF32	4.914	36%	1.769	3.145	4.51	0.04	0.025
CF33	9.943	35%	3.480	6.463	3.77	0.04	0.025
CF34	10.711	36%	3.856	6.855	4.08	0.04	0.025
CF35	17.038	35%	5.963	11.075	4.19	0.04	0.025
CF36	8.166	35%	2.858	5.308	5.98	0.04	0.025
CF37	15.786	35%	5.525	10.261	6.72	0.04	0.025
CF38	8.943	35%	3.130	5.813	8.25	0.04	0.025
CF39	17.140	35%	5.999	11.141	6.3	0.04	0.025
CF40	10.946	35%	3.831	7.115	5.25	0.04	0.025

CF41	13.897	36%	5.003	8.894	5.32	0.04	0.025
CF42	19.066	35%	6.673	12.393	4.63	0.04	0.025
CF43	19.101	30%	5.730	13.371	4.64	0.04	0.025
CF44	9.167	30%	2.750	6.417	6.16	0.04	0.025
CF45	19.116	31%	5.926	13.190	5.86	0.04	0.025
CF46	9.892	25%	2.473	7.419	4.53	0.04	0.025
CF47	16.697	25%	4.174	12.523	5.12	0.04	0.025
CF48	7.395	26%	1.923	5.472	5.04	0.04	0.025
CF49	13.528	25%	3.382	10.146	5.47	0.04	0.025
CF50	9.433	25%	2.358	7.075	5.2	0.04	0.025
CF51	16.625	25%	4.156	12.469	5.4	0.04	0.025
CF52	33.832	25%	8.458	25.374	4.47	0.04	0.025
CF53	6.480	25%	1.620	4.860	4.04	0.04	0.025
CF54	14.500	25%	3.625	10.875	6.17	0.04	0.025
CF55	25.531	26%	6.638	18.893	4.82	0.04	0.025
CF56	5.573	25%	1.393	4.180	4.52	0.04	0.025
CF57	6.995	26%	1.819	5.176	4.18	0.04	0.025
CF58	14.227	26%	3.699	10.528	4.24	0.04	0.025
CF59	9.450	16%	1.512	7.938	3.2	0.04	0.025
SRBR	190.200	18%	34.236	155.964	1.72	0.04	0.025
SRCU	40.900	10%	4.090	36.810	2.04	0.04	0.025

Appendix B - RAFTS Model Data

Riverstone Precinct

Proposed Catchment Data

Catchment	Total Area [ha]	Percentage Impervious	Impervious Area [ha]	Pervious Area [ha]	Catchment Slope [%]	Pervious Mannings 'n'	Impervious Mannings 'n'
CA01	3.941	85%	3.349	0.591	3.93	0.035	0.015
CA02	5.166	100%	5.165	0.001	5.52	0.025	0.015
CA03	12.826	85%	10.902	1.924	2.44	0.035	0.015
CA04	10.353	81%	8.393	1.960	4.75	0.035	0.015
CA05A	3.388	85%	2.880	0.508	6.52	0.035	0.015
CA05B	15.270	75%	11.453	3.817	5.51	0.035	0.015
CA06	6.028	69%	4.153	1.875	6.61	0.035	0.015
CA07	26.846	5%	1.342	25.503	5.81	0.04	0.025
CA10	17.311	5%	0.866	16.445	4.19	0.04	0.025
CA11	9.146	5%	0.457	8.688	7.42	0.04	0.025
CA12	22.634	5%	1.132	21.502	2.77	0.04	0.025
CA12B	10.033	85%	8.528	1.505	1.2	0.035	0.015
CA13	5.581	85%	4.744	0.837	4.57	0.035	0.015
CA14	19.208	85%	16.327	2.881	4.84	0.035	0.015
CA15	19.435	85%	16.520	2.915	2.12	0.035	0.015
CA16	10.543	85%	8.962	1.581	3.36	0.035	0.015
CA17	11.122	5%	0.556	10.566	5.31	0.04	0.025
CA17B	3.816	85%	3.244	0.572	5.9	0.035	0.015
CA18A	9.268	85%	7.878	1.390	5.01	0.035	0.015
CA18B	11.481	5%	0.574	10.907	5	0.035	0.015
CA19	32.428	85%	27.563	4.864	5.02	0.035	0.015
CA20	10.144	5%	0.507	9.637	5.17	0.04	0.025
CF01	9.561	85%	8.127	1.434	2.64	0.035	0.015
CF02	21.891	85%	18.607	3.284	4.42	0.035	0.015
CF03	2.414	85%	2.052	0.362	5.08	0.035	0.015
CF04	19.599	85%	16.659	2.940	4.02	0.035	0.015
CF05	11.043	85%	9.387	1.656	5.94	0.035	0.015
CF06	10.887	85%	9.254	1.633	4.61	0.035	0.015
CF07	15.476	85%	13.155	2.321	1	0.035	0.015
CF08	16.173	85%	13.747	2.426	1.88	0.035	0.015
CF09	21.809	83%	18.079	3.729	6.34	0.035	0.015
CF11	9.537	85%	8.106	1.430	5.95	0.035	0.015
CF12	11.658	85%	9.910	1.749	6.26	0.035	0.015
CF13	13.634	85%	11.589	2.045	4.21	0.035	0.015
CF14	18.002	85%	15.302	2.700	4.37	0.035	0.015
CF15	17.692	85%	15.038	2.654	3.64	0.035	0.015
CF16	17.754	85%	15.091	2.663	2.78	0.035	0.015
CF17	4.816	85%	4.094	0.722	5.03	0.035	0.015
CF18	9.018	85%	7.665	1.353	6.83	0.035	0.015
CF19	16.896	85%	14.362	2.534	4.06	0.035	0.015
CF20	9.903	85%	8.417	1.485	6.58	0.035	0.015
CF21	14.261	85%	12.122	2.139	4.82	0.035	0.015
CF22	3.967	85%	3.372	0.595	2.6	0.035	0.015
CF23	16.515	85%	14.037	2.477	4.37	0.035	0.015
CF24	15.850	85%	13.473	2.378	5.68	0.035	0.015
CF26	21.629	85%	18.385	3.244	4.44	0.035	0.015
CF27	15.441	85%	13.125	2.316	4.46	0.035	0.015
CF28	5.698	85%	4.843	0.855	3.27	0.035	0.015
CF29	12.304	85%	10.459	1.846	4.49	0.035	0.015
CF30	7.750	85%	6.588	1.163	2.64	0.035	0.015
CF31A	6.219	85%	5.286	0.933	4.14	0.035	0.015
CF31B	9.679	85%	8.227	1.452	6.38	0.035	0.015
CF32	4.913	85%	4.176	0.737	4.51	0.035	0.015
CF33	9.943	85%	8.452	1.492	3.77	0.035	0.015
CF34	10.711	85%	9.104	1.607	4.08	0.035	0.015
CF35	17.038	85%	14.482	2.556	4.19	0.035	0.015
CF36	10.986	85%	9.338	1.648	2.05	0.035	0.015
CF37	25.455	85%	21.637	3.818	3.11	0.035	0.015

CF38	7.189	85%	6.111	1.078	6.42	0.035	0.015
CF40	14.511	85%	12.334	2.177	3.74	0.035	0.015
CF41A	6.976	85%	5.929	1.046	7.53	0.035	0.015
CF41B	7.037	85%	5.981	1.055	4.13	0.035	0.015
CF42	19.066	85%	16.206	2.860	4.63	0.035	0.015
CF43	19.101	85%	16.236	2.865	4.64	0.035	0.015
CF44	9.167	85%	7.792	1.375	6.16	0.035	0.015
CF45	19.115	85%	16.248	2.867	5.86	0.035	0.015
CF46	17.134	85%	14.564	2.570	2.13	0.035	0.015
CF47	16.666	85%	14.166	2.500	5.12	0.035	0.015
CF49	17.715	85%	15.058	2.657	5.46	0.035	0.015
CF50	9.882	85%	8.400	1.482	4.38	0.035	0.015
CF51	17.054	85%	14.495	2.558	5.52	0.035	0.015
CF52A	15.741	53%	8.410	7.331	3.89	0.035	0.015
CF52B	17.224	85%	14.641	2.584	4.4	0.035	0.015
CF53	6.049	85%	5.142	0.907	0.82	0.035	0.015
CF54	14.350	85%	12.198	2.153	6.17	0.035	0.015
CF55A	13.350	85%	11.348	2.003	5.02	0.035	0.015
CF55B	3.424	85%	2.910	0.514	3.51	0.035	0.015
CF55C	7.515	25%	1.879	5.636	3.97	0.04	0.025
CF56	5.575	85%	4.739	0.836	4.52	0.035	0.015
CF57	2.397	25%	0.599	1.798	1.26	0.04	0.025
CF58	19.477	25%	4.869	14.608	3.63	0.04	0.025
CF59	9.455	85%	8.037	1.418	3.2	0.035	0.015
SRBR	190.200	18%	34.236	155.964	1.72	0.04	0.025
SRCU	40.900	10%	4.090	36.810	2.04	0.04	0.025

Appendix B - RAFTS Model Data

Appendix C. Peak Flows from XPRAFTS

Riverstone Precinct

Peak Total Flows (m3/S) - Exisitng Scenario

	Average Recurrence Interval (ARI)							
	2yr	5yr	10yr	20r	50yr	100yr	500yr	PMF
CA01	0.214	0.356	0.514	0.674	0.815	0.965	1.539	6.449
CA02	1.257	2.145	2.869	3.783	4.652	5.504	8.932	34.911
CA03	0.993	1.721	2.337	3.074	3.807	4.556	7.417	28.539
CA04	0.443	0.775	1.063	1.415	1.712	2.076	3.339	13.978
CA05	0.824	1.459	1.969	2.637	3.213	3.799	6.499	26.287
CA06	0.374	0.648	0.891	1.192	1.425	1.676	2.656	11.175
CA07	7.056	11.618	15.41	19.606	24.159	28.179	45.04	189.979
CA08	0.501	0.877	1.217	1.575	1.966	2.307	3.671	15.452
CA10	6.59	10.982	14.465	18.445	22.703	26.436	42.384	170.616
CA11	0.561	0.953	1.319	1.747	2.14	2.473	3.907	16.626
CA12	5.94	9.976	13.067	16.819	20.591	24.039	38.589	150.814
CA13	2.406	4.073	5.261	6.757	8.244	9.63	15.923	61.542
CA14	0.447	0.781	1.084	1.422	1.741	2.092	3.325	13.963
CA15	1.267	2.214	3.009	3.98	4.887	5.764	9.547	38.408
CA16	0.431	0.75	1.013	1.354	1.675	2.055	3.41	13.834
CA17	2.903	4.902	6.652	8.771	10.722	12.52	20.341	78.71
CA18	1.843	3.164	4.246	5.685	6.977	8.301	14.251	56.94
CA19	0.735	1.279	1.699	2.35	2.853	3.361	5.758	23.348
CF01	25.33	38.878	46.407	56.837	68.837	78.837	121.421	551.855
CF02	1.976	2.816	3.44	4.254	4.937	5.671	9.31	35.042
CF03	0.164	0.272	0.375	0.514	0.607	0.703	1.117	4.664
CF04	25.26	38.523	46.316	56.733	68.677	78.651	121.164	550.503
CF05	3.205	4.965	6.405	8.049	9.737	11.271	17.515	75.06
CF06	3.168	4.917	6.303	7.909	9.496	10.99	16.981	71.734
CF07	2.86	4.505	5.696	7.19	8.591	9.962	15.444	59.625
CF08	2.525	4.061	5.163	6.449	7.745	8.945	14.023	50.589
CF09	0.473	0.767	1.013	1.322	1.561	1.832	3.043	12.19
CF10	1.786	2.891	3.61	4.523	5.445	6.254	9.818	35.547
CF11	1.276	2.125	2.725	3.435	4.054	4.728	7.473	26
CF12	0.585	0.965	1.256	1.638	1.945	2.277	3.706	15.057
CF13	23.373	34.602	43.054	52.913	63.795	73.142	113.087	488.536
CF14	2.822	4.344	5.468	6.916	8.311	9.726	15.389	56.099
CF15	2.152	3.049	3.836	4.83	5.737	6.676	10.924	42.034
CF16	1.354	1.917	2.319	2.844	3.27	3.75	6.106	22.797
CF17	22.959	33.516	42.341	52.059	62.633	71.809	111.04	468.234
CF18	22.935	33.484	42.305	52.015	62.576	71.746	110.926	467.504
CF19	22.913	33.452	42.269	51.97	62.514	71.678	110.781	466.527
CF20	22.856	33.376	42.163	51.826	62.296	71.429	110.428	463.44
CF21	22.839	33.348	42.131	51.786	62.238	71.364	110.305	462.39
CF22	22.776	33.256	42.011	51.622	61.988	71.077	109.886	458.13
CF23	1.982	2.978	3.698	4.587	5.36	6.153	9.664	32.884
CF24	1.461	2.105	2.609	3.254	3.774	4.354	7.045	25.637
CF25	0.622	0.907	1.162	1.414	1.609	1.837	2.753	10.571
CF26	22.535	32.934	41.313	50.776	60.788	69.704	107.851	443.698
CF27	1.866	2.583	3.115	3.86	4.44	5.134	8.207	30.177
CF28	0.614	0.856	1.033	1.294	1.487	1.708	2.73	10.199
CF29	1.308	1.863	2.261	2.769	3.184	3.641	5.811	21.798
CF30	22.193	32.428	40.028	49.188	58.665	67.316	104.257	425.303
CF31	22.15	32.378	39.9	49.031	58.416	67.031	103.832	423.558
CF32	22.099	32.314	39.627	48.691	57.929	66.479	102.996	419.958

CF33	22.074	32.281	39.545	48.591	57.791	66.313	102.721	418.428
CF34	2.278	3.339	4.08	5.059	5.863	6.781	10.643	39.169
CF35	1.768	2.477	2.98	3.656	4.171	4.822	7.582	28.235
CF36	21.535	31.533	38.281	47.023	55.734	64.01	99.347	400.134
CF37	2.114	3.051	3.796	4.692	5.556	6.394	10.182	36.902
CF38	1.074	1.601	1.988	2.458	2.805	3.21	4.866	18.686
CF39	20.799	30.499	37.056	45.18	53.527	61.384	95.234	378.47
CF40	2.099	3.123	3.841	4.722	5.48	6.31	9.718	35.181
CF41	1.493	2.147	2.622	3.223	3.693	4.289	6.713	25.428
CF42	21.095	30.89	37.497	45.753	54.203	62.172	96.578	384.693
CF43	19.453	28.647	34.924	42.657	50.439	57.909	89.857	352.499
CF44	2.521	3.769	4.722	5.922	6.953	8.015	12.964	47.27
CF45	1.998	2.882	3.595	4.502	5.27	6.103	10.041	36.885
CF46	20.556	30.158	36.665	44.664	52.939	60.722	94.05	372.862
CF47	17.18	25.296	30.881	37.845	44.507	51.23	80.007	311.463
CF48	17.37	25.569	31.194	38.206	44.962	51.735	80.749	315.432
CF49	5.473	8.075	9.909	12.311	14.225	16.378	26.669	94.577
CF50	0.835	1.271	1.573	1.992	2.318	2.68	4.361	16.988
CF51	1.402	2.085	2.601	3.216	3.817	4.425	7.201	27.814
CF52	2.669	3.788	4.598	5.706	6.513	7.475	12.394	46.284
CF53	16.63	24.463	29.92	36.727	43.108	49.672	77.861	300.587
CF54	13.074	18.739	22.654	27.655	32.051	36.896	57.904	237.314
CF55	12.429	17.759	21.496	26.278	30.402	35.076	55.299	227.94
CF56	11.666	15.972	19.181	23.337	26.834	30.982	49.165	209.774
CF57	11.452	15.592	18.509	22.475	25.804	29.789	47.321	205.632
CF58	1.16	1.703	2.104	2.647	3.063	3.571	5.825	22.365
CF59	0.547	0.817	1.078	1.365	1.651	1.933	3.315	12.919
node1	25.33	38.878	46.407	56.837	68.837	78.837	121.421	551.855
node2	25.216	38.28	46.259	56.667	68.558	78.508	120.958	549.268
node20	7.394	12.069	16.191	20.568	25.417	29.588	47.252	207.182
node21	8.05	13.269	17.627	22.324	27.699	32.343	51.137	232
node22	7.111	11.69	15.558	19.806	24.407	28.484	45.525	194.124
OUTLET	29.33	45.077	55.23	68.308	82.981	95.113	144.854	635.675
SRBR	9.368	12.657	14.728	17.537	19.894	22.811	35.642	153.608
SRCU	1.422	2.107	2.635	3.293	4.004	4.793	8.06	38.895

Appendix C - Peak Flows from RAFTS

Riverstone Precinct

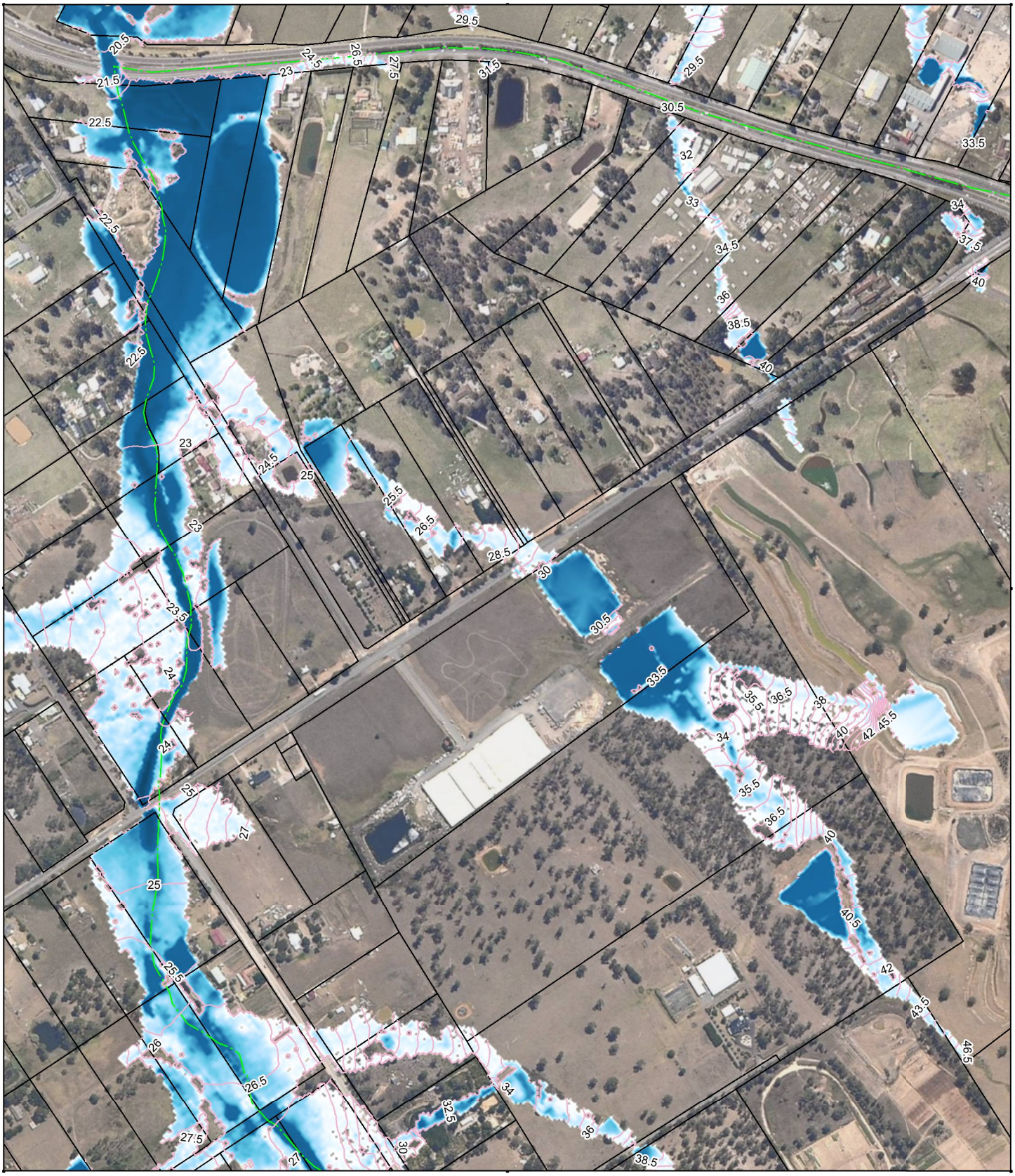
Peak Total Flows (m3/S) - Proposed Scenario

	Average Recurrence Interval (ARI)							
	2yr	5yr	10yr	20r	50yr	100yr	500yr	PMF
CA01	0.908	1.195	1.369	1.608	1.714	1.915	3.125	9.236
CA02	4.026	5.227	5.953	6.907	7.645	8.501	14.347	39.145
CA03	4.026	5.227	5.953	6.907	7.645	8.501	14.347	39.145
CA04	2.279	3.009	3.432	4.001	4.308	4.818	7.994	23.597
CA05A	1.056	1.423	1.627	1.924	2.774	3.795	9.976	33.957
CA05B	3.147	4.144	4.755	5.604	6.105	6.87	11.415	34.357
CA06	1.184	1.604	1.857	2.193	2.42	2.719	4.523	13.628
CA07	7.08	10.071	12.468	16.578	22.625	29.173	68.392	202.857
CA10	6.573	8.932	11.713	15.664	21.169	27.133	64.497	197.912
CA11	0.561	0.954	1.321	1.749	2.143	2.476	4.625	16.644
CA12	5.732	7.549	10.55	14.116	18.986	24.05	57.8	182.585
CA12B	9.042	11.805	13.582	15.825	17.7	19.813	32.656	90.669
CA13	1.293	1.691	1.948	2.272	2.433	2.708	4.447	13.039
CA14	8.646	11.275	12.889	15.005	16.862	18.805	30.774	83.186
CA15	6.963	9.059	10.301	11.95	13.165	14.677	24.161	59.145
CA16	2.424	3.148	3.58	4.16	4.414	4.945	8.144	24.087
CA17	2.04	2.888	4.904	6.83	9.323	11.878	29.999	97.683
CA17B	0.894	1.177	1.371	1.589	1.696	1.895	3.067	9.002
CA18A	9.11	11.944	13.63	16.076	18.04	20.419	34.78	101.881
CA18B	0.607	1.057	1.439	1.925	2.326	2.717	5.387	18.717
CA19	7.489	9.774	11.129	12.968	14.203	15.931	27.158	78.528
CA20	0.503	0.872	1.204	1.609	1.959	2.336	4.554	15.877
CF01	25.545	40.957	48.155	57.617	69.027	78.351	135.923	502.656
CF02	5.014	6.54	7.412	8.613	9.189	10.299	16.86	50.045
CF03	0.581	0.741	0.847	1.006	1.075	1.212	1.954	5.689
CF04	4.491	5.835	6.645	7.695	8.24	9.177	15.021	44.672
CF05	10.055	13.169	15.149	17.789	20.421	22.903	38.637	103.536
CF06	9.843	12.898	14.843	17.438	19.93	22.355	37.709	102.68
CF07	9.457	12.419	14.291	16.792	19.089	21.424	36.223	96
CF08	8.709	11.413	13.128	15.425	17.374	19.496	32.934	94.377
CF09	4.904	6.43	7.343	8.593	9.16	10.268	16.996	50.042
CF11	4.166	5.453	6.211	7.255	8.189	9.18	14.336	41.308
CF12	2.691	3.537	4.043	4.716	5.055	5.684	9.29	27.14
CF13	8.984	11.674	13.288	15.49	17.346	19.362	31.806	82.694
CF14	8.156	10.573	12.031	14.041	15.638	17.473	28.782	81.034
CF15	6.913	8.993	10.226	11.851	13.27	14.839	22.784	68.062
CF16	4.051	5.248	5.993	6.942	7.493	8.33	13.569	39.813
CF17	19.163	33.445	40.106	48.947	59.331	67.561	117.048	442.284
CF18	19.053	33.345	39.992	48.945	59.328	67.557	117.043	442.231
CF19	18.94	33.16	39.78	48.941	59.322	67.551	117.028	442.057
CF20	18.755	32.795	39.771	48.926	59.294	67.518	116.977	440.114
CF21	18.646	32.587	39.768	48.921	59.286	67.506	116.952	439.993
CF22	18.475	32.229	39.759	48.905	59.256	67.471	116.894	437.853
CF23	3.8	4.931	5.609	6.526	6.952	7.796	12.81	37.813
CF24	3.633	4.783	5.45	6.364	6.787	7.597	12.511	36.686
CF26	25.131	33.213	41.129	49.877	60.189	68.42	118.316	439.017
CF27	4.212	5.524	6.293	7.333	7.907	8.886	14.365	43.015
CF28	1.311	1.702	1.955	2.288	2.429	2.709	4.469	13.128
CF29	2.823	3.697	4.216	4.902	5.22	5.855	9.647	28.301
CF30	22.533	31.91	39.59	48.107	57.899	65.793	114.043	418.106

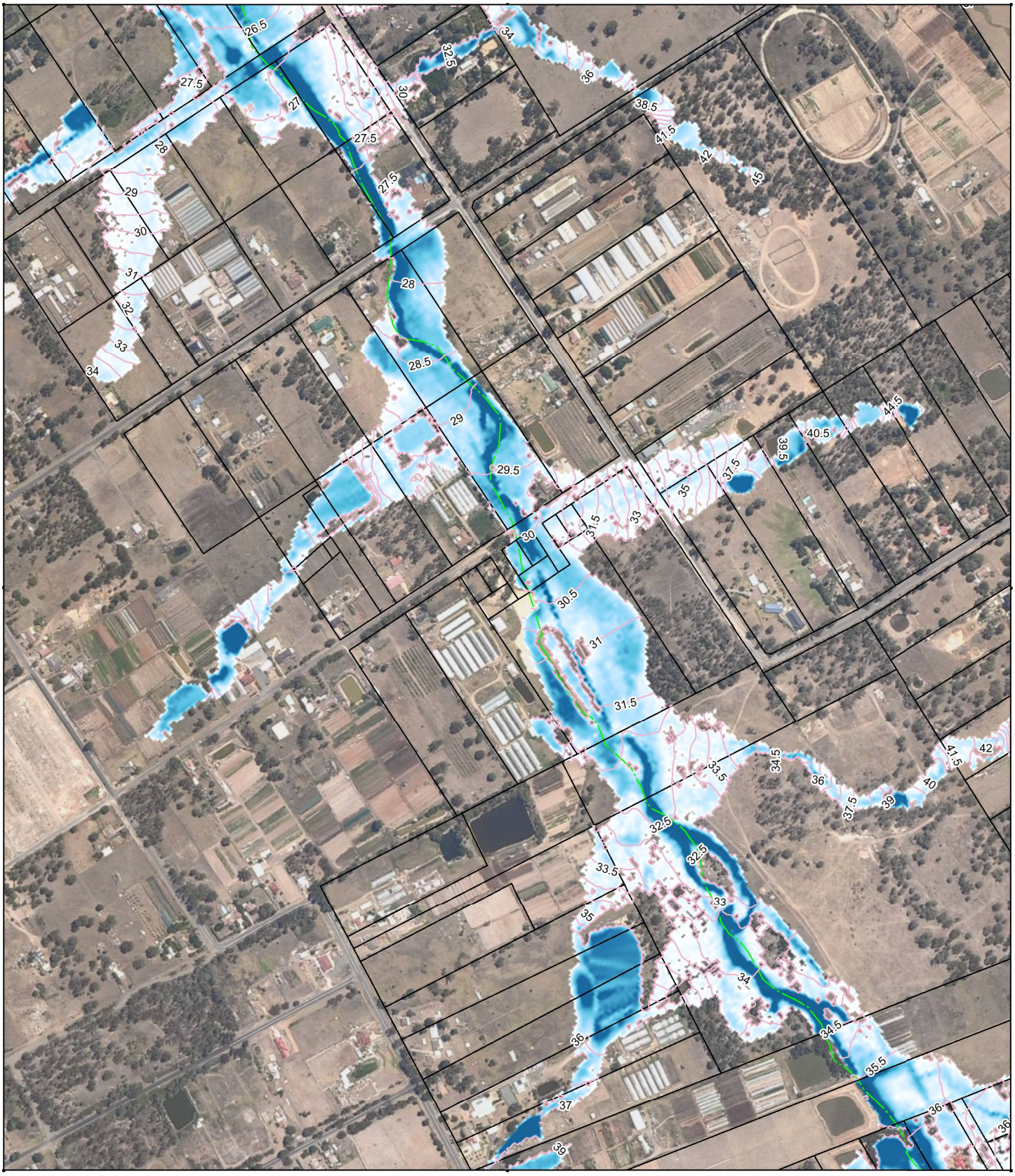
CF31A	2.938	3.79	4.313	5.003	5.638	6.322	10.166	27.704
CF31B	2.262	2.961	3.376	3.933	4.198	4.724	7.753	22.671
CF32	21.037	31.14	38.693	47.165	56.612	64.393	111.709	408.639
CF33	5.78	7.497	8.532	9.928	11.092	12.401	20.445	58.972
CF34	5.343	7.135	8.171	9.475	10.609	11.883	18.452	51.859
CF35	3.919	5.078	5.778	6.71	7.155	8.019	13.158	38.961
CF36	19.652	29.467	36.762	44.887	53.907	61.342	107.344	386.145
CF37	6.67	8.707	9.894	11.488	12.337	13.792	22.12	67.165
CF38	1.69	2.213	2.543	2.956	3.138	3.522	5.837	16.898
CF40	5.128	6.707	7.64	8.847	9.632	10.765	17.32	52.161
CF41A	2.781	3.64	4.154	4.823	5.396	6.06	9.399	27.976
CF41B	1.611	2.124	2.439	2.834	3.007	3.367	5.616	16.323
CF42	18.116	28.385	35.543	43.397	51.978	59.299	103.8	370.397
CF43	16.163	26.015	32.613	40.191	47.834	54.756	96.299	340.631
CF44	6.488	8.332	9.597	11.235	12.474	13.989	23.227	63.434
CF45	5.529	7.226	8.24	9.61	10.451	11.699	19.009	56.459
CF46	17.583	27.694	34.777	42.978	51.312	58.634	102.428	364.924
CF47	14.135	23.506	29.438	36.231	43.039	49.277	87.914	305.721
CF49	9.892	13.052	15.025	17.515	19.919	22.386	37.874	112.197
CF50	5.47	7.049	8.06	9.333	10.406	11.657	18.327	50.15
CF51	3.908	5.132	5.854	6.821	7.274	8.147	13.412	39.348
CF52A	4.736	6.279	7.263	8.541	9.612	10.78	18.342	53.053
CF52B	3.959	5.133	5.853	6.805	7.251	8.123	13.344	39.448
CF53	21.605	29.487	35.362	42.448	48.469	55.089	97.097	303.565
CF54	14.003	19.545	23.288	28.094	32.419	37.312	68.62	237.584
CF55A	13.482	18.841	22.486	27.168	31.21	35.969	66.476	228.086
CF55B	1.146	1.495	1.724	2.05	2.406	2.74	5.007	15.516
CF55C	0.646	0.937	1.197	1.502	1.747	2.039	3.937	12.893
CF56	12.383	17.032	20.334	24.582	28.119	32.479	60.636	210.766
CF57	12.047	16.521	19.748	23.905	27.322	31.589	59.208	206.81
CF58	1.511	2.186	2.678	3.296	3.822	4.479	8.576	27.194
CF59	2.164	2.816	3.213	3.731	3.965	4.437	7.319	21.596
N1	1.818	2.597	4.518	6.199	8.287	10.649	27.611	94.357
node1	25.545	40.957	48.155	57.617	69.027	78.351	135.923	502.656
node2	20.799	31.042	38.583	47.052	56.455	64.226	111.431	407.209
node20	7.935	11.414	13.722	18.039	24.382	31.12	72.143	219.684
node21	9.45	13.198	15.667	20.201	27.007	34.074	76.604	242.127
node22	7.194	10.278	12.677	16.819	22.975	29.575	69.268	205.005
node3	24.994	40.674	47.831	57.235	68.393	77.605	134.686	502.554
node4	21.405	36.332	43.323	52.521	63.06	71.708	123.393	459.33
node5	24.634	40.289	47.431	56.756	67.745	76.891	133.55	501.872
node6	0	0.397	1.117	2.069	2.515	3.387	8.608	34.712
OUTLET	34.254	49.472	59.336	71.074	85.616	96.74	181.315	656.461
SRBR	9.368	12.657	14.728	17.537	19.894	22.811	41.831	153.608
SRCU	1.422	2.107	2.635	3.293	4.004	4.793	9.587	38.895

Appendix C - Peak Flows from RAFTS

Appendix D. Tuflow Results



Title **Riverstone East ILP** **50% AEP Existing Flood** **Flood Level**				Mott MacDonald 200 0 m N W E S	0.00m 0.15m 0.30m 0.45m 2.59m		
Date	**Drawn**	**Checked**	**Approved**	**Scale at A4**	**Drawing Number**	**Status**	**Rev**
06/05/2016	GL	GL	CA	1:8000	RE_EXL_2yr_360m_D	FI	C



Title

Riverstone East ILP
50% AEP Existing Flood
Flood Level

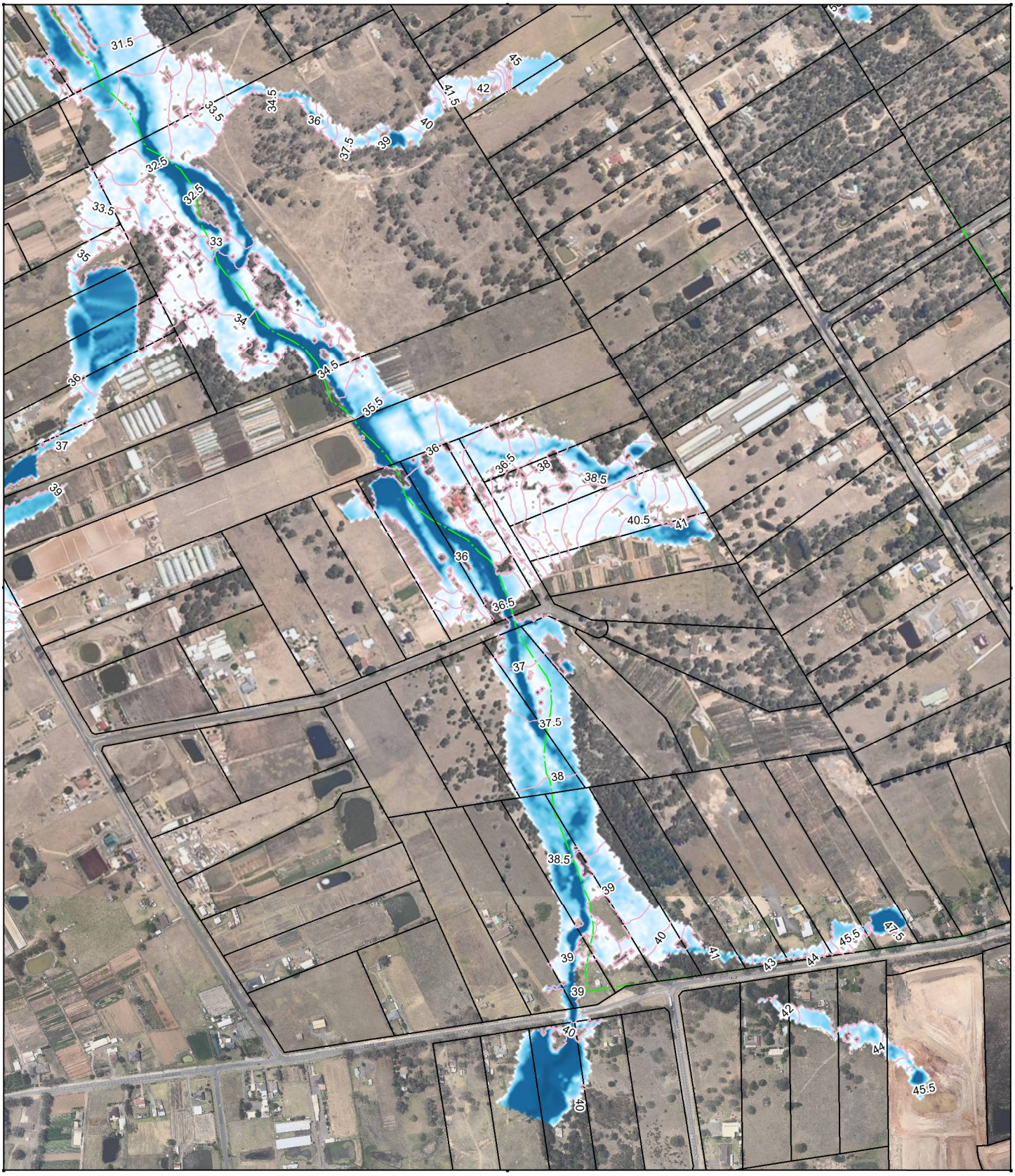
Mott MacDonald

200 0 m

N W E S

- 0.00m
- 0.15m
- 0.30m
- 0.45m
- 2.59m

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_EXL_2yr_360m_D	FI	C



Title

Riverstone East ILP
50% AEP Existing Flood
Flood Level

Mott MacDonald

200 0 m

N W E S

0.00m
0.15m
0.30m
0.45m
2.59m

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_EXL_2yr_360m_D	FI	C

Title

Rivestone East ILP
50% AEP Existing Flood
Flood Level

Mott MacDonald

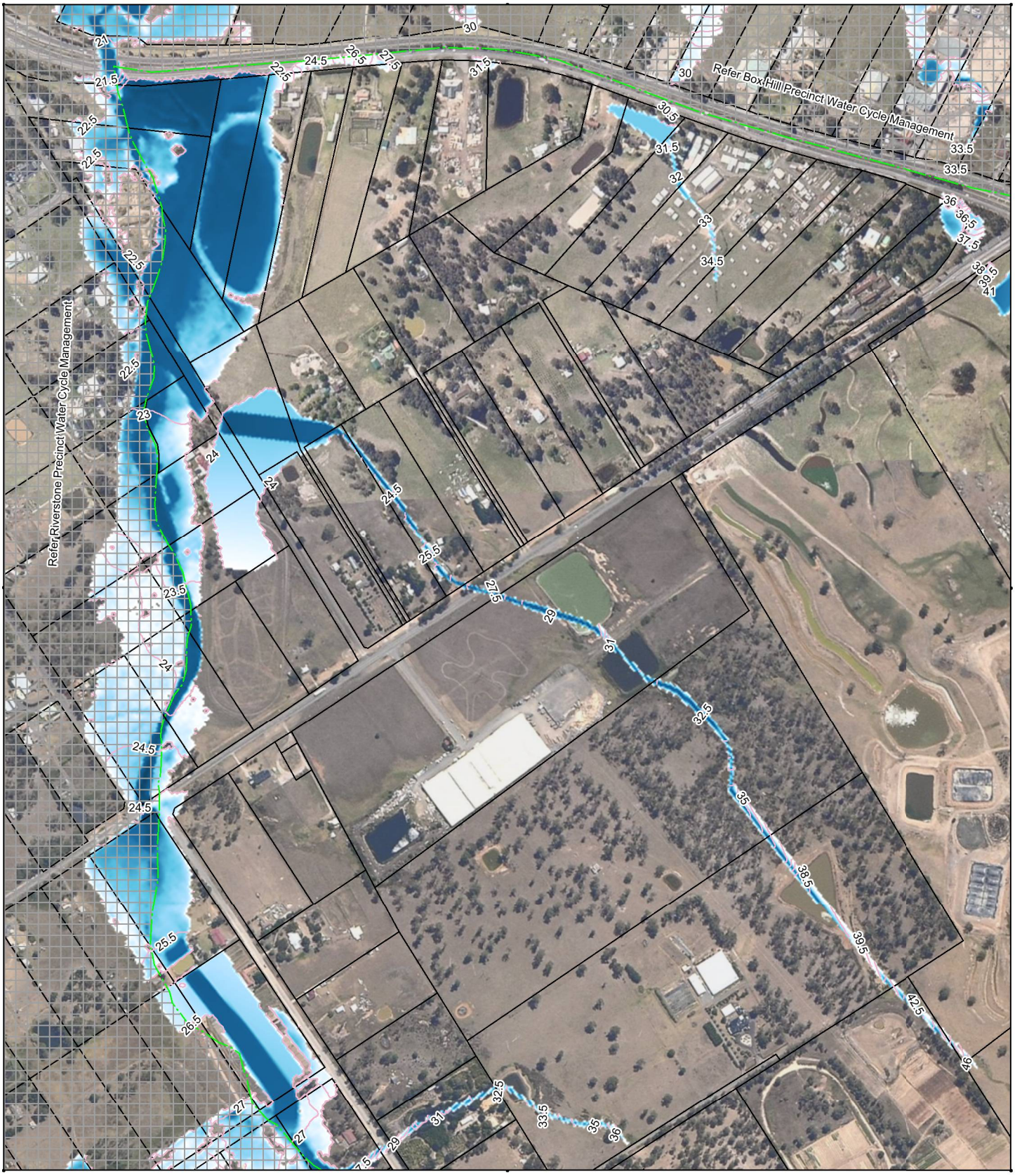
200 0 m

N W E S

0.00m
0.15m
0.30m
0.45m
2.59m

4

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_EXL_2yr_360m_D	FI	C



Title

Riverstone East ILP
50% AEP Proposed Flood
Flood Level

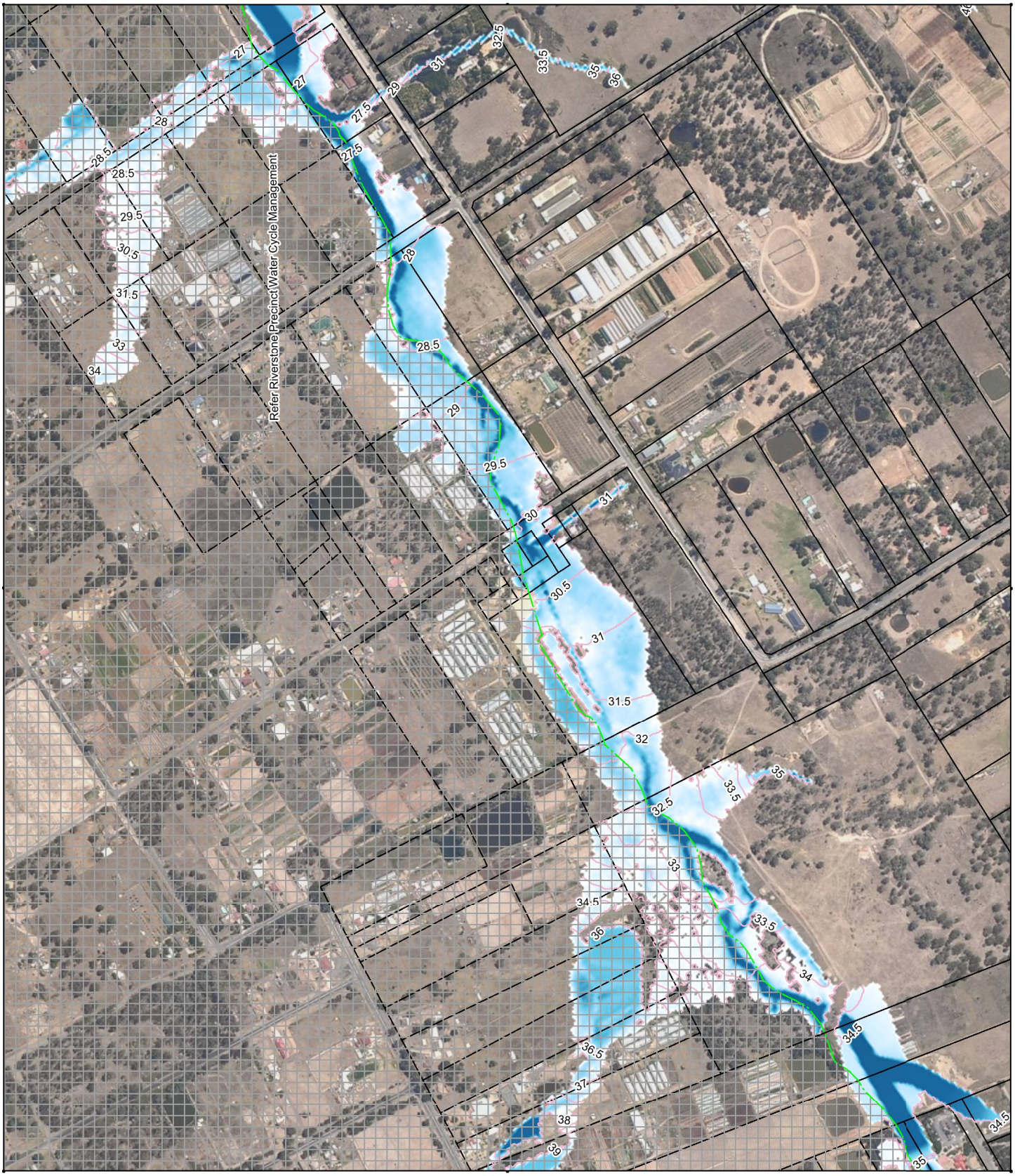
Mott MacDonald

200 0 m

N W E S

0.00m
0.15m
0.30m
0.45m
2.59m

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_2yr_360m_D	FI	C



Title

Riverstone East ILP
50% AEP Proposed Flood
Flood Level

Mott MacDonald

200 0 m

N W E S

0.00m
0.15m
0.30m
0.45m
2.59m

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
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06/05/2016	GL	GL	CA	1:8000	RE_PRL_2yr_360m_D	FI	C

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Rivestone East ILP
50% AEP Proposed Flood Flood Level

Mott MacDonald

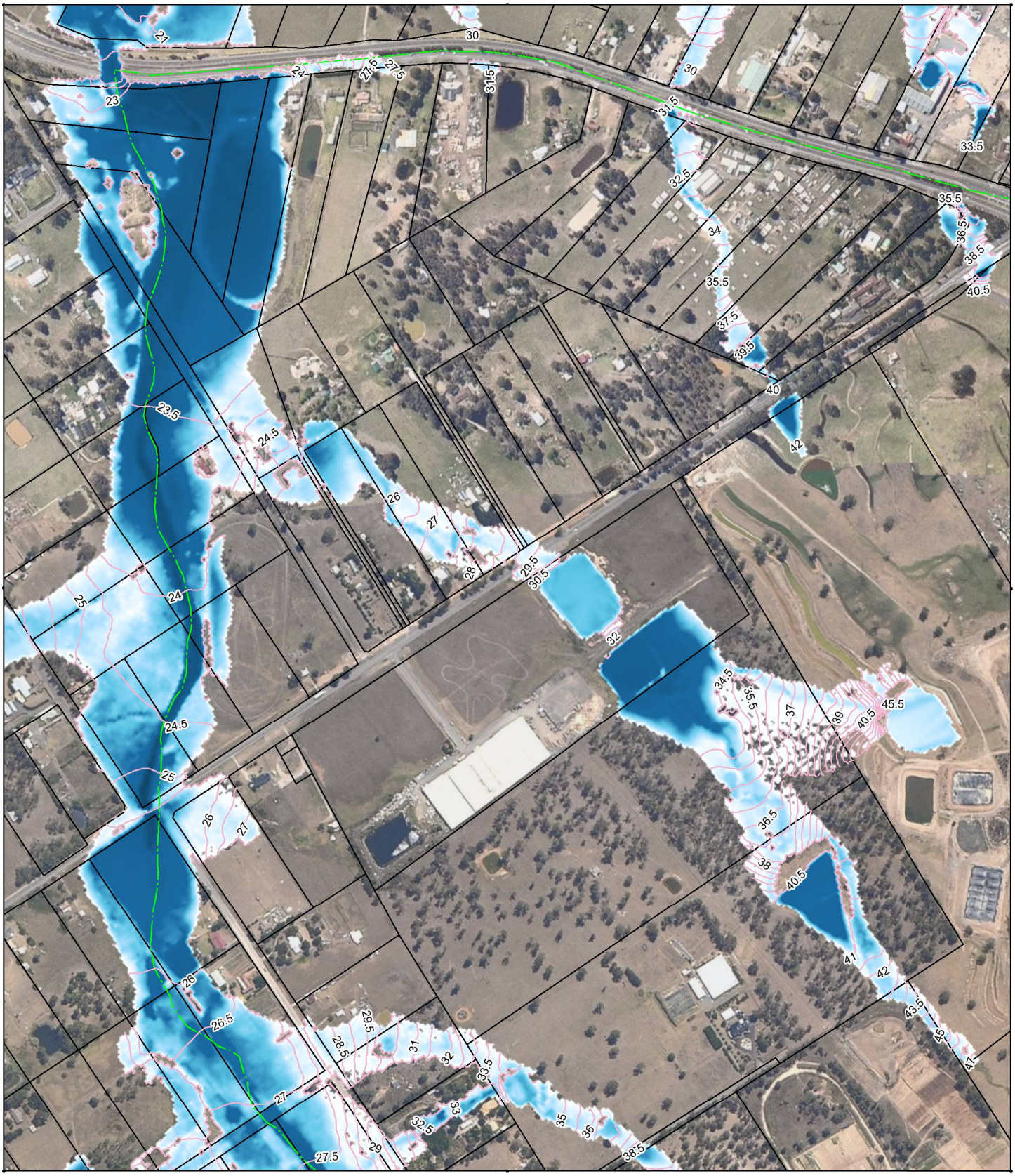
200 0 m

N W E S

0.00m
0.15m
0.30m
0.45m
2.59m

4

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_2yr_360m_D	FI	C



Title

Riverstone East ILP
1% AEP Existing Flood
Flood Depth

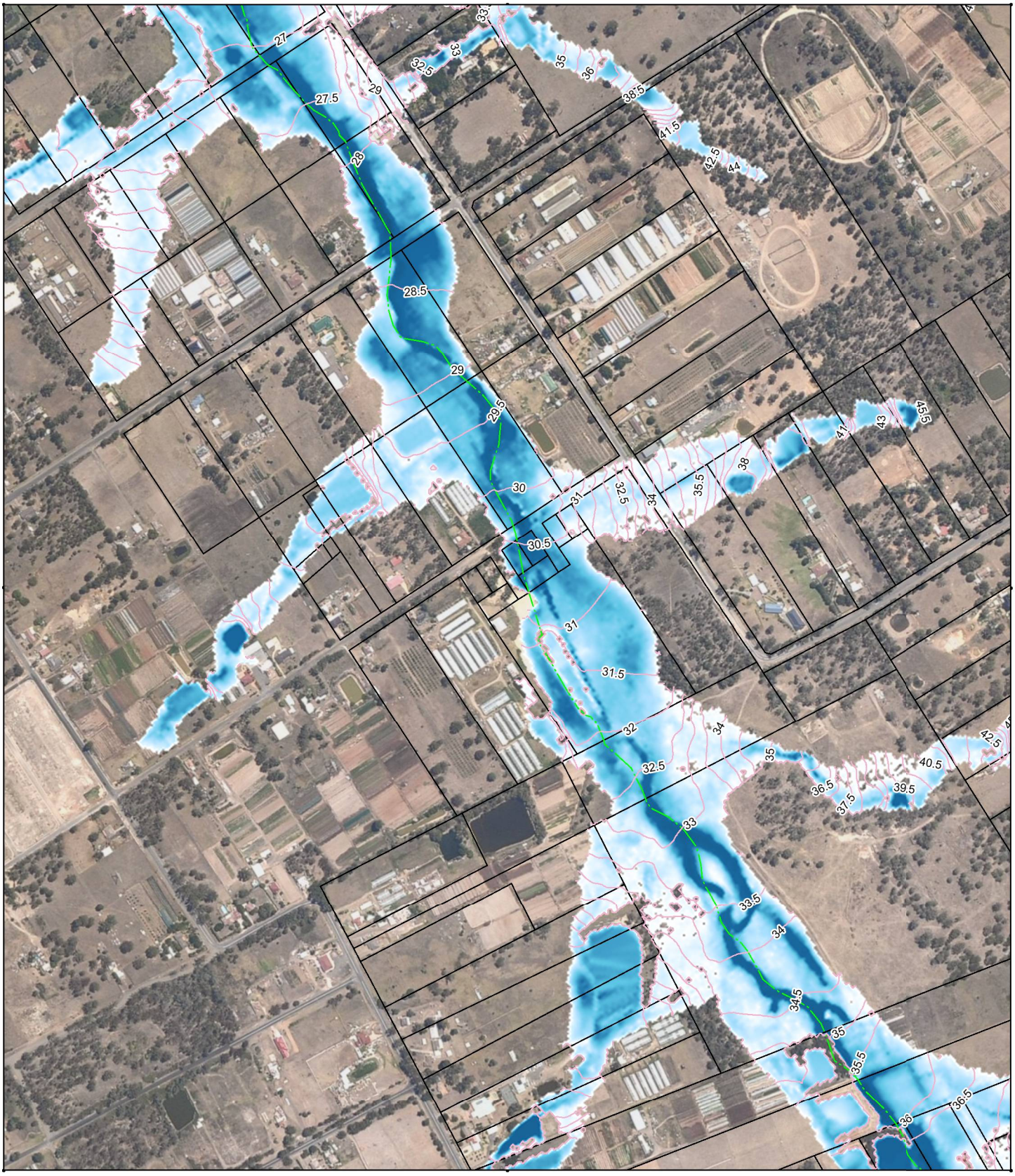
Mott MacDonald

200 0 m

N W E S

0.00m
0.25m
0.50m
0.75m
3.15m

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_EXL_100yr_120m_D	FI	C



Title

Riverstone East ILP
1% AEP Existing Flood
Flood Depth

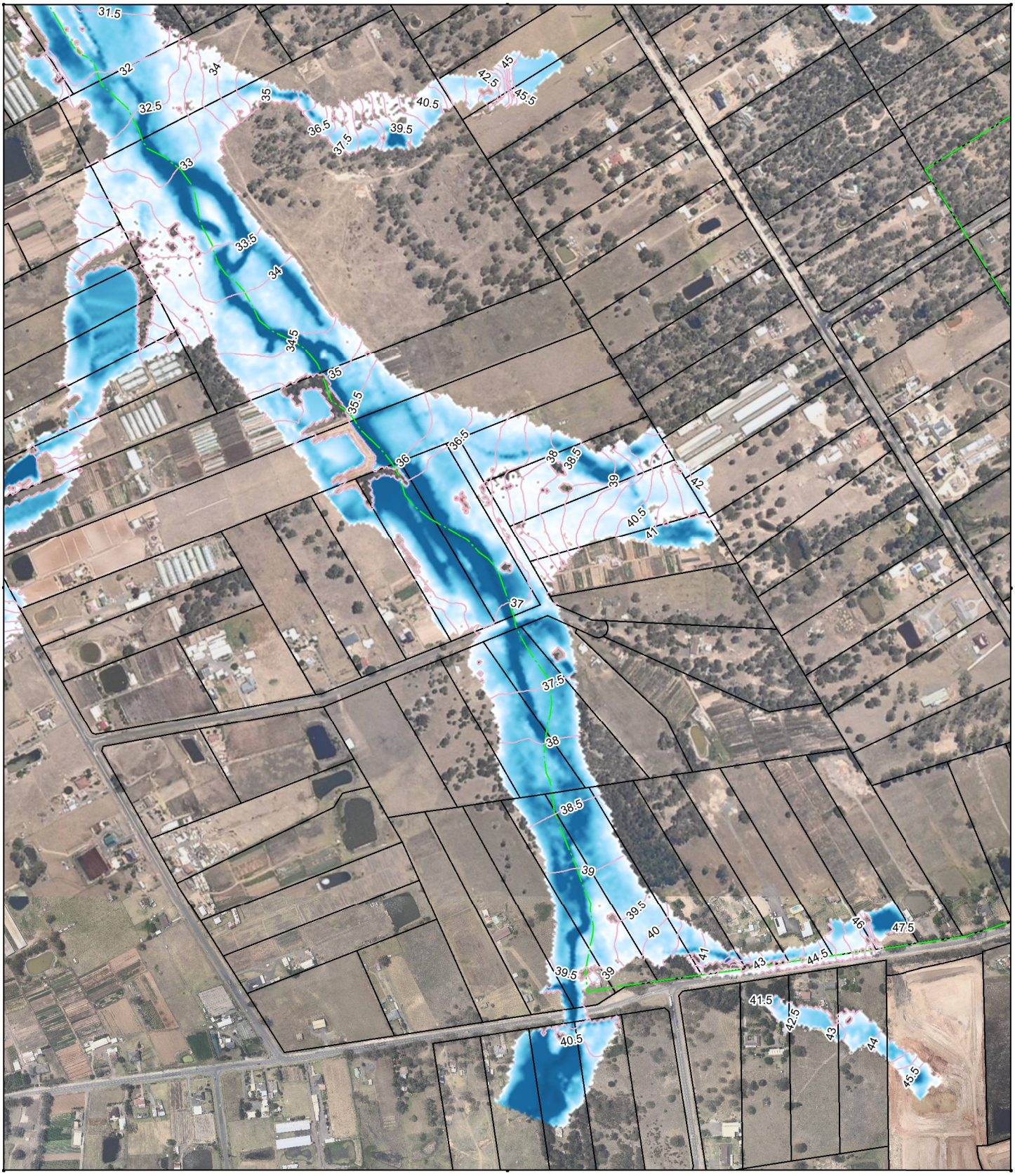
Mott MacDonald

200 0 m

N W E S

0.00m
0.25m
0.50m
0.75m
3.15m

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_EXL_100yr_120m_D	FI	C



Title

Riverstone East ILP
1% AEP Existing Flood
Flood Depth

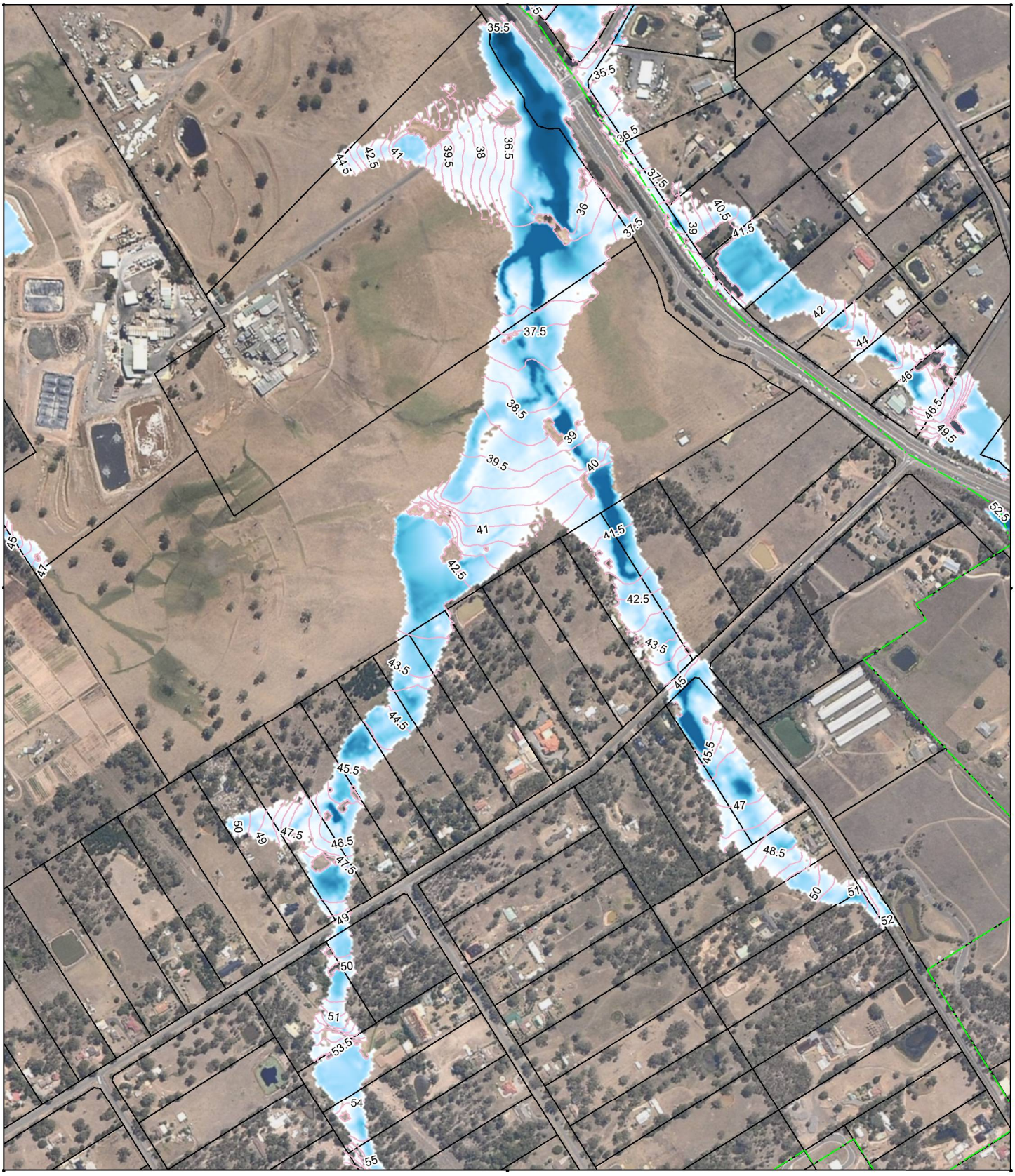
Mott MacDonald

200 0 m

N W E S

- 0.00m
- 0.25m
- 0.50m
- 0.75m
- 3.15m

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_EXL_100yr_120m_D	FI	C

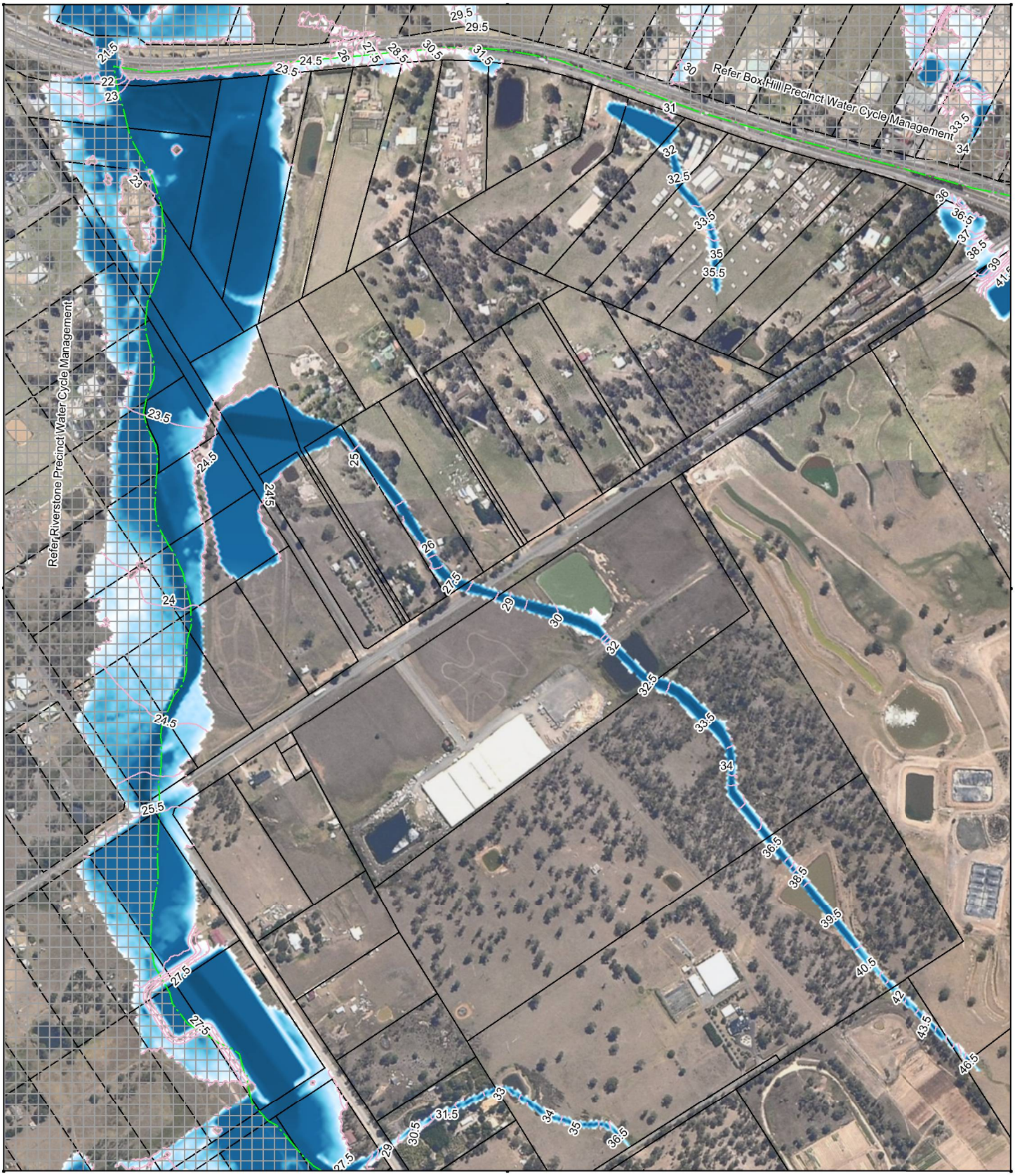


Title

Rivestone East ILP
1% AEP Existing Flood
Flood Depth

Mott MacDonald

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/06/2016	GL	GL	CA	1:8000	RE_EXL_100yr_120m_D	FI	C

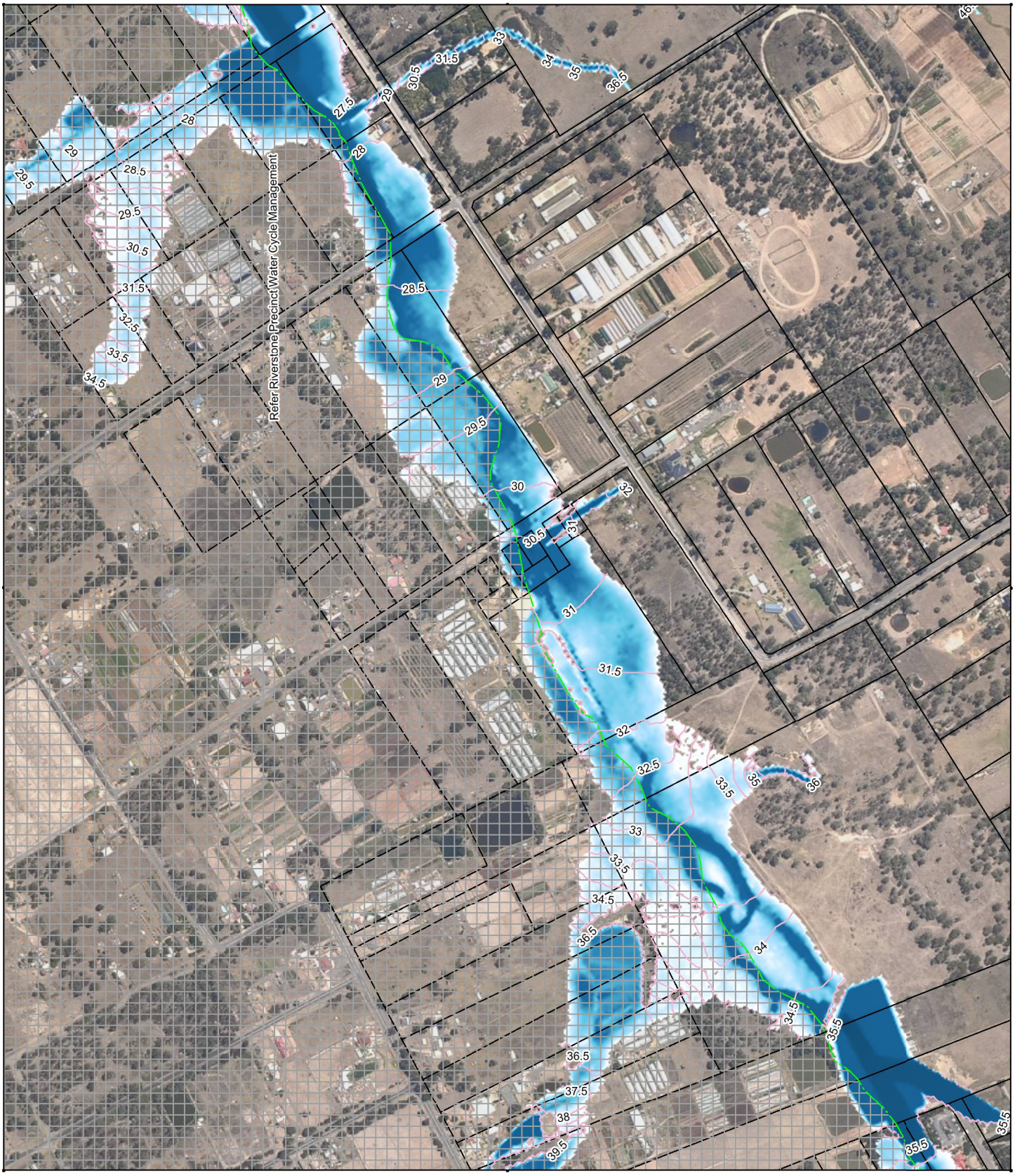


Title

Riverstone East ILP
1% AEP Proposed Flood
Flood Depth

Mott MacDonald

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_100yr_120m_D	FI	C



Title

Riverstone East ILP
1% AEP Proposed Flood
Flood Depth

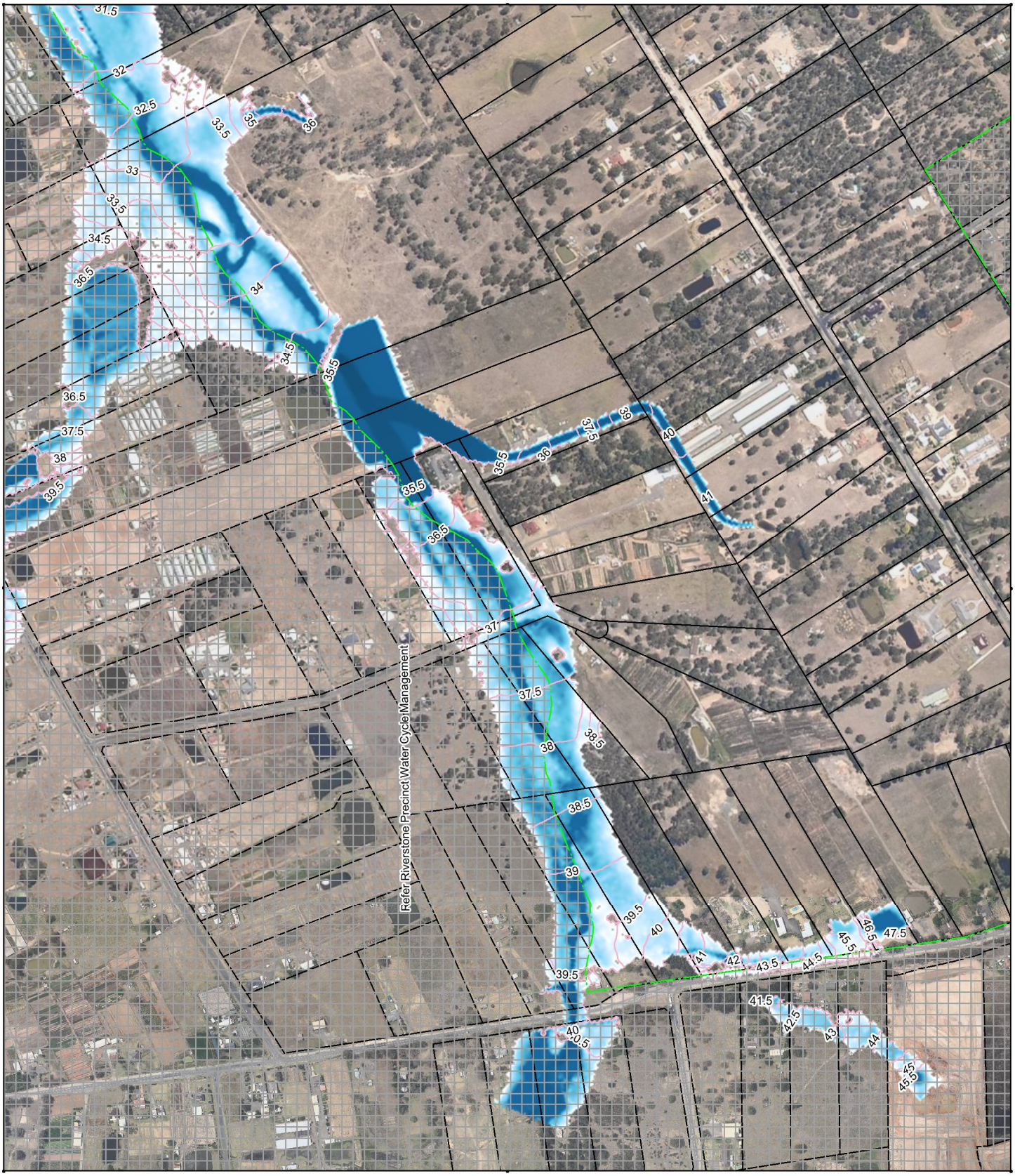
Mott MacDonald

200 0 m

N W E S

0.00m
0.25m
0.50m
0.75m
3.00m

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_100yr_120m_D	FI	C



Title

Riverstone East ILP
1% AEP Proposed Flood
Flood Depth

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_100yr_120m_D	FI	C

Title

Rivestone East ILP
1% AEP Proposed Flood
Flood Depth

Mott MacDonald

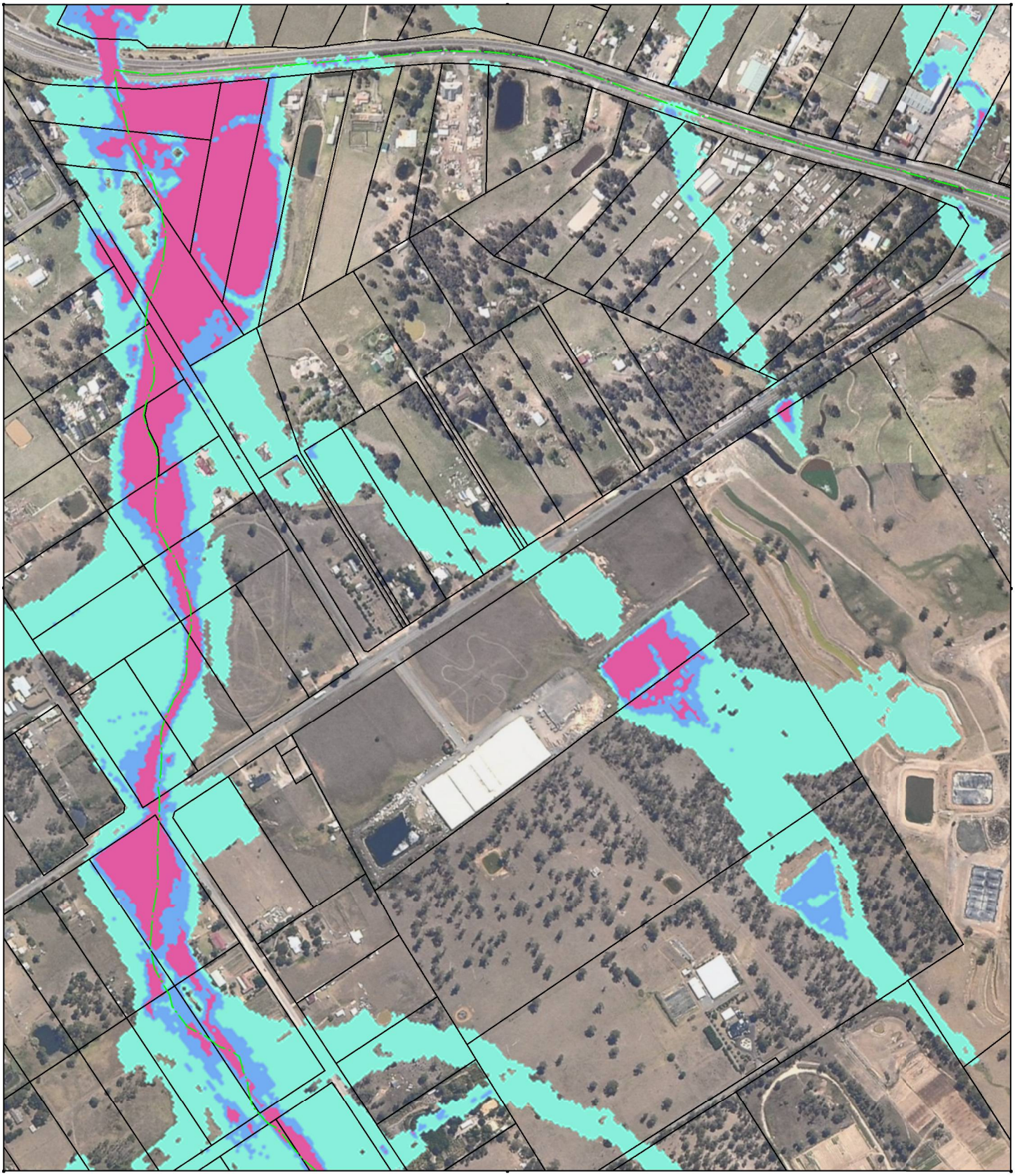
200 0 m

N W E S

0.00m
0.25m
0.50m
0.75m
3.00m

4

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_100yr_120m_D	FI	C

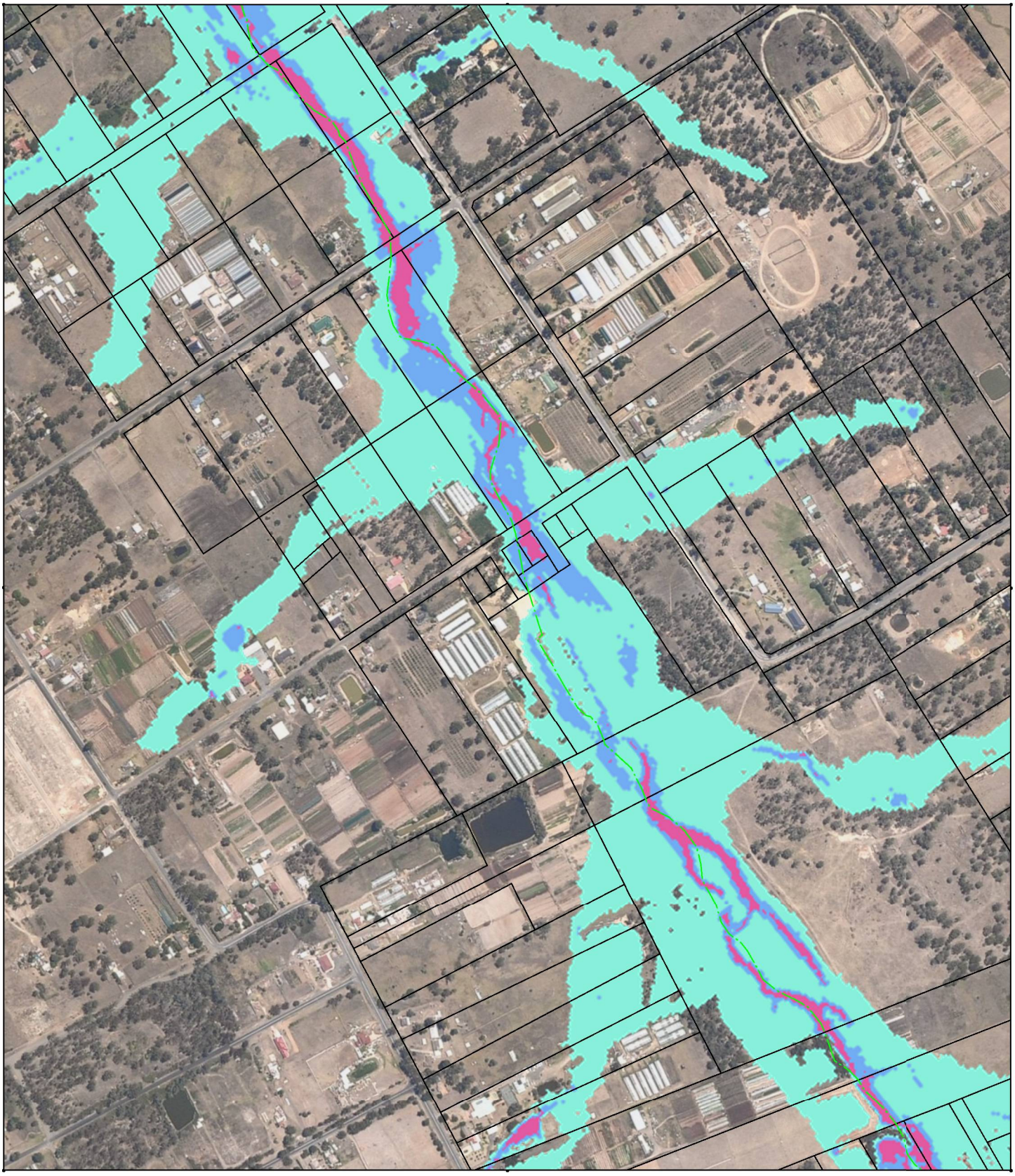


Title

Riverstone East ILP
1% AEP Existing Flood
Flood Hazard (FDM)

Mott MacDonald

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_EXL_100yr_120m_DV	FI	C

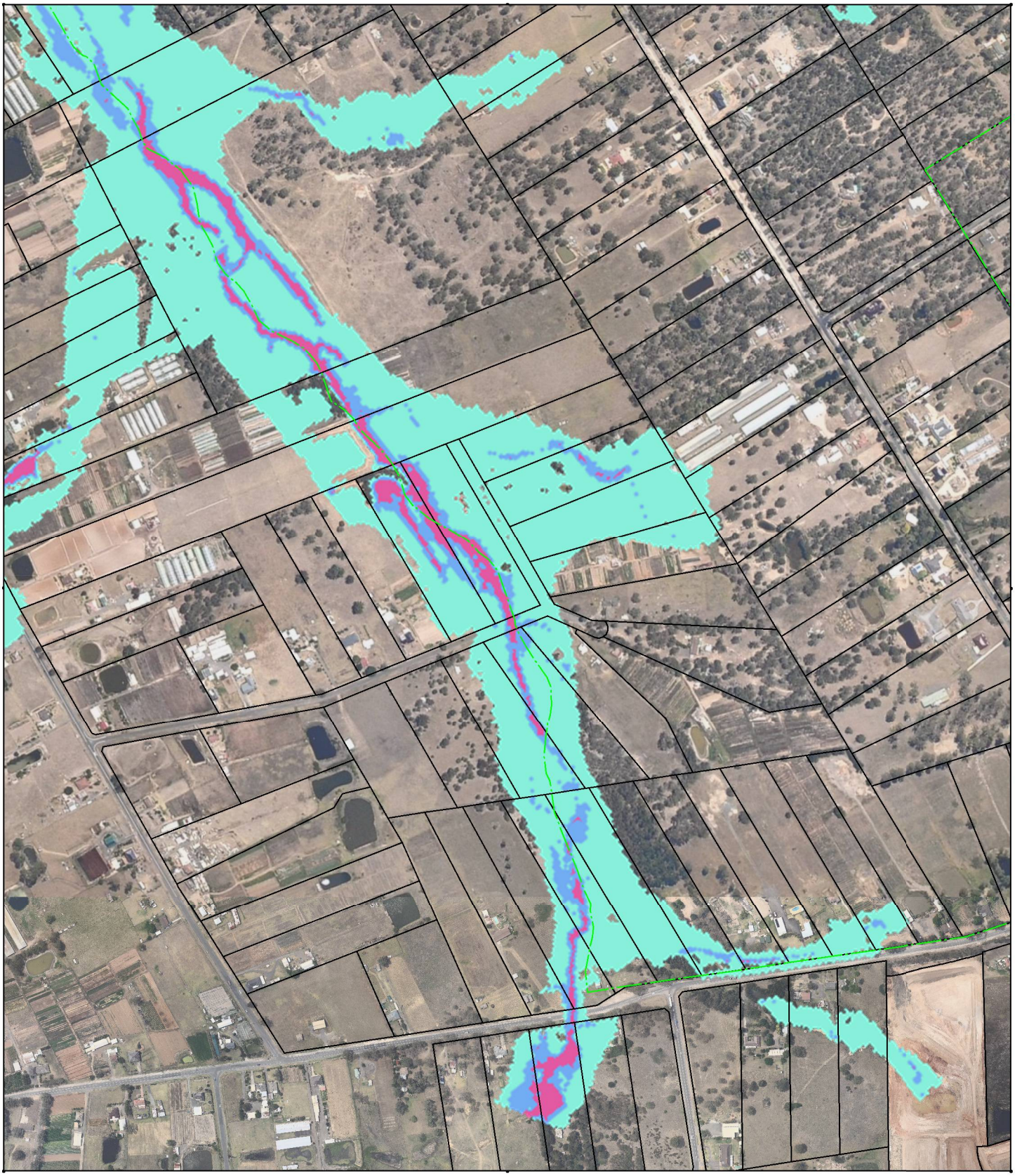


Title

Riverstone East ILP
1% AEP Existing Flood
Flood Hazard (FDM)

Mott MacDonald

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_EXL_100yr_120m_DV	FI	C

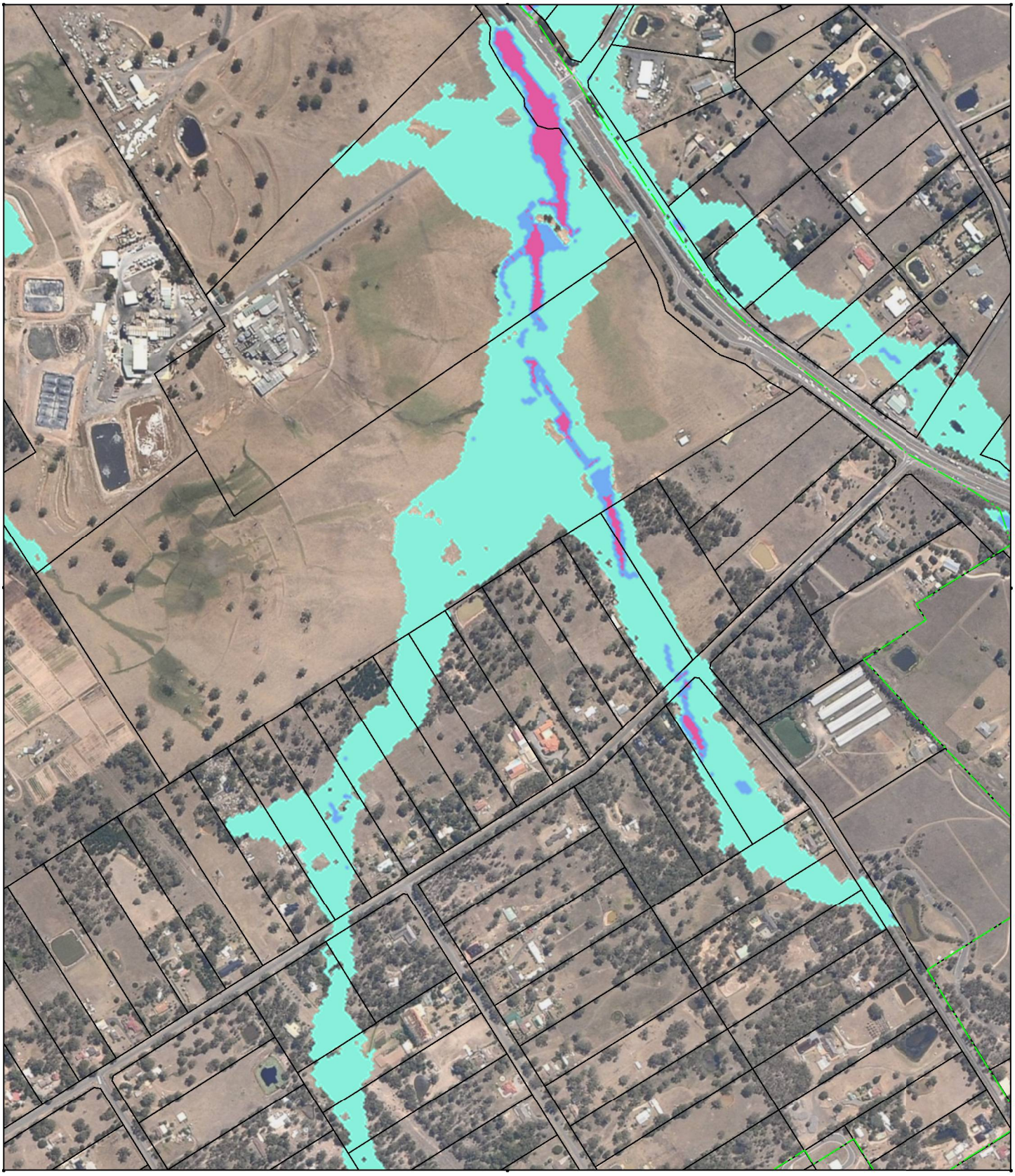


Title

Riverstone East ILP
1% AEP Existing Flood
Flood Hazard (FDM)

Mott MacDonald

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_EXL_100yr_120m_DV	FI	C

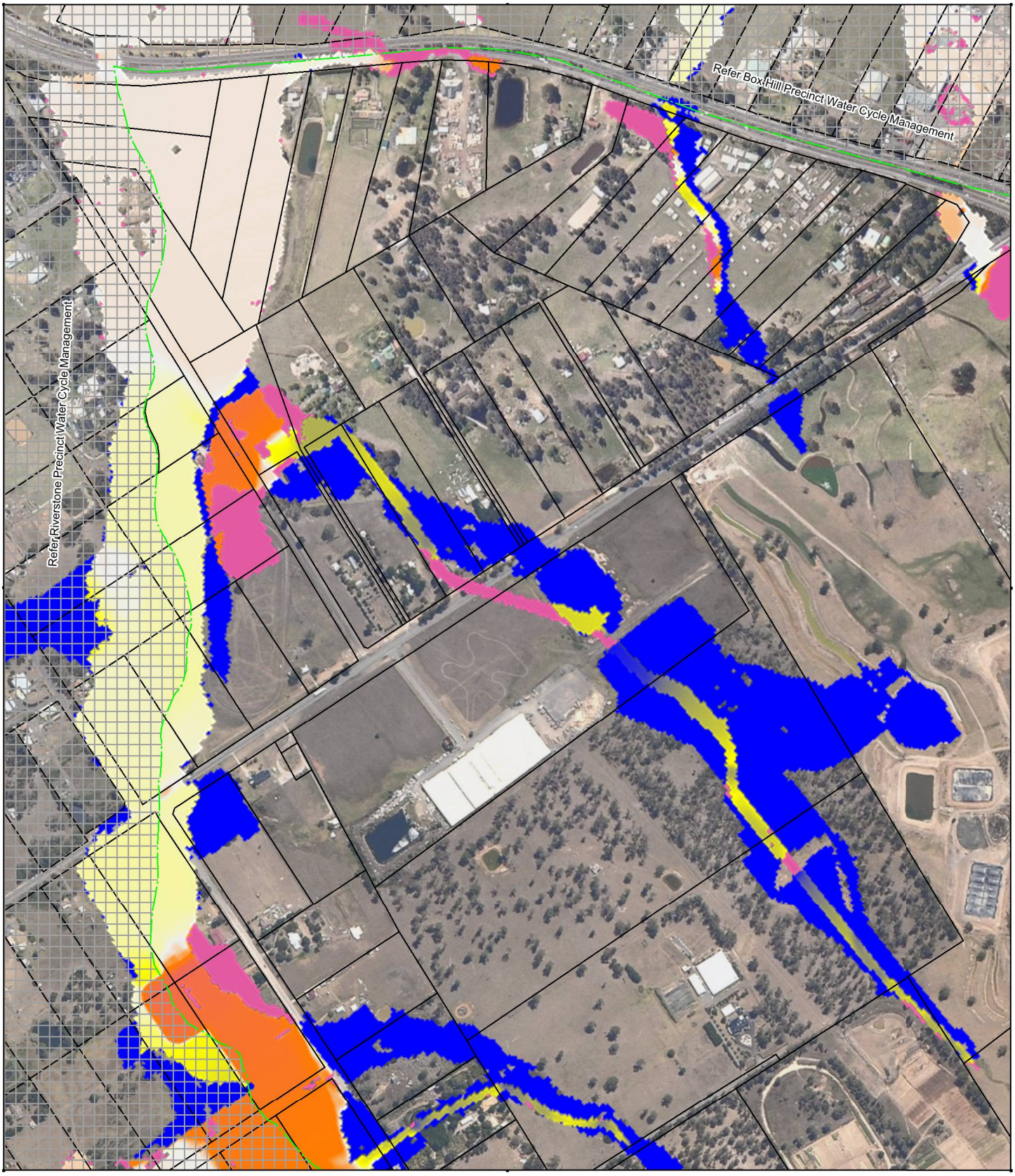


Title

Rivestone East ILP
1% AEP Existing Flood
Flood Hazard (FDM)

Mott MacDonald

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_EXL_100yr_120m_DV	FI	C



Title

Riverstone East ILP
1% AEP Pre-Post
Flood Level Difference

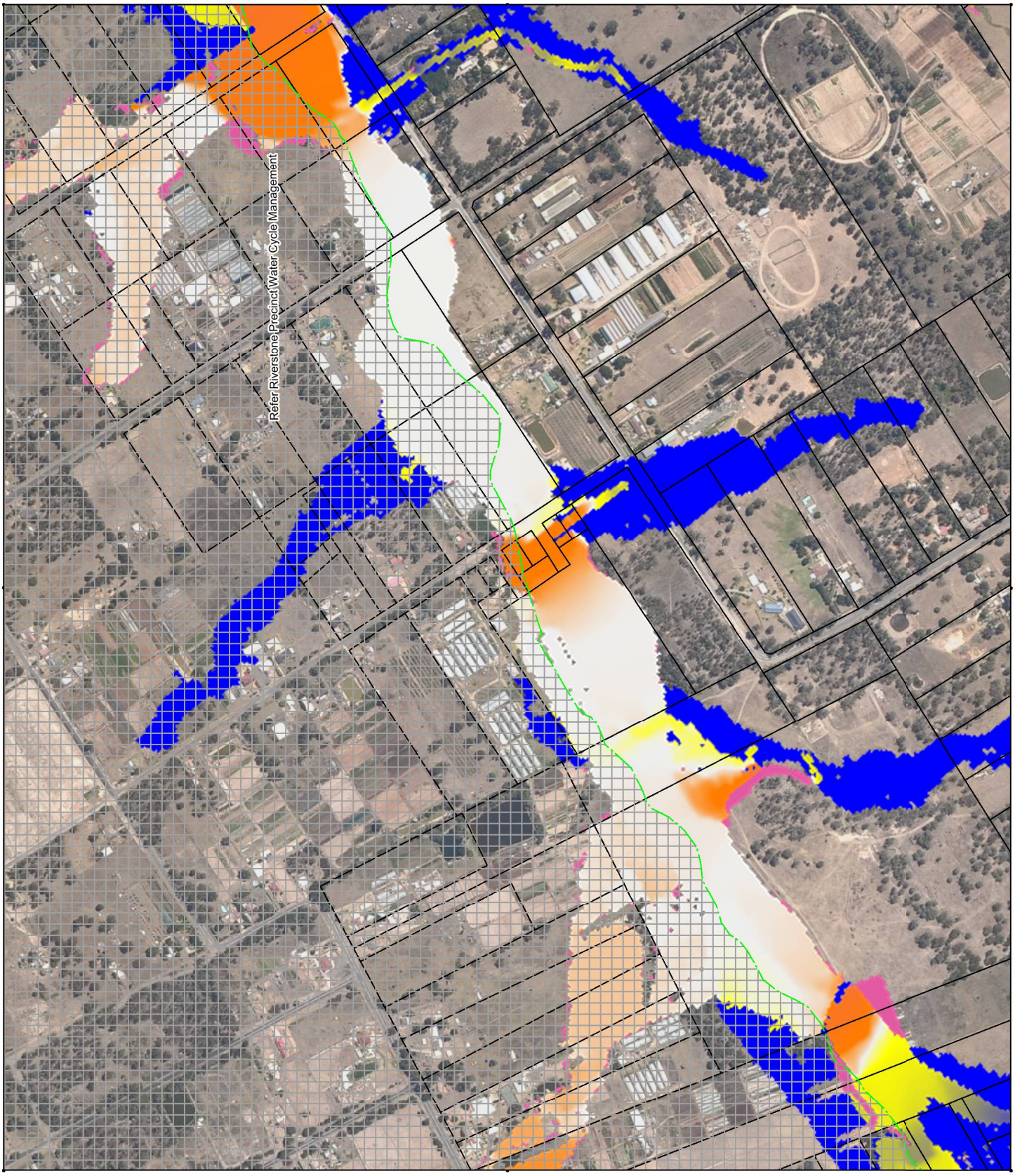
Mott MacDonald

200 0 m

N W E S

- Was Wet
- -0.01m
- 0.00m
- 0.01m
- Was Dry

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_DIF_100yr_120m	FI	C



Title

Riverstone East ILP
1% AEP Pre-Post
Flood Level Difference

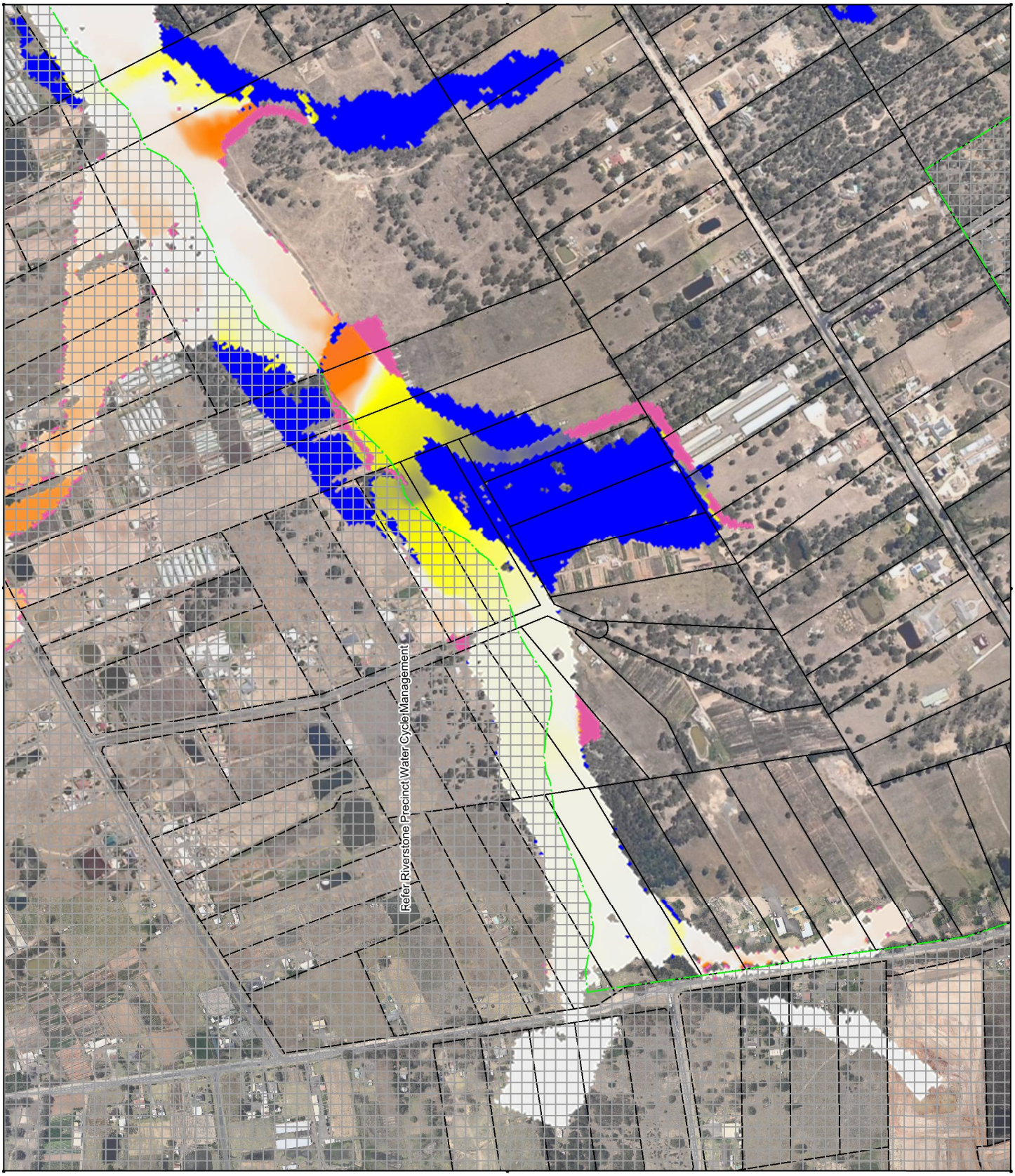
Mott MacDonald

200 0 m

N W E S

Was Wet
-0.01m
0.00m
0.01m
Was Dry

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_DIF_100yr_120m	FI	C



Title

Riverstone East ILP
1% AEP Pre-Post
Flood Level Difference

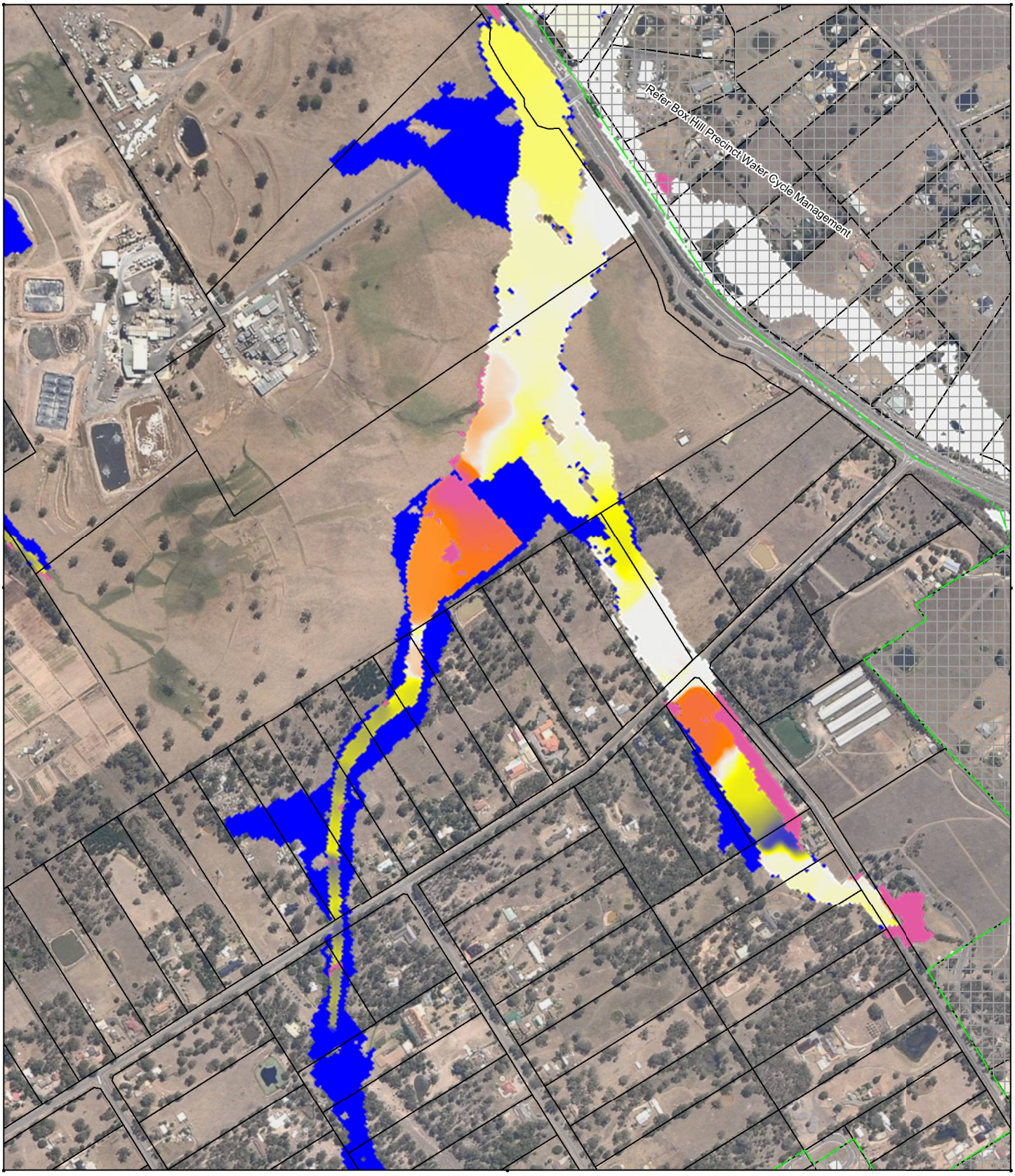
Mott MacDonald

200 0 m

N W E S

- Was Wet
- -0.01m
- 0.00m
- 0.01m
- Was Dry

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_DIF_100yr_120m	FI	C



Title

Rivestone East ILP
1% AEP Pre-Post
Flood Level Difference

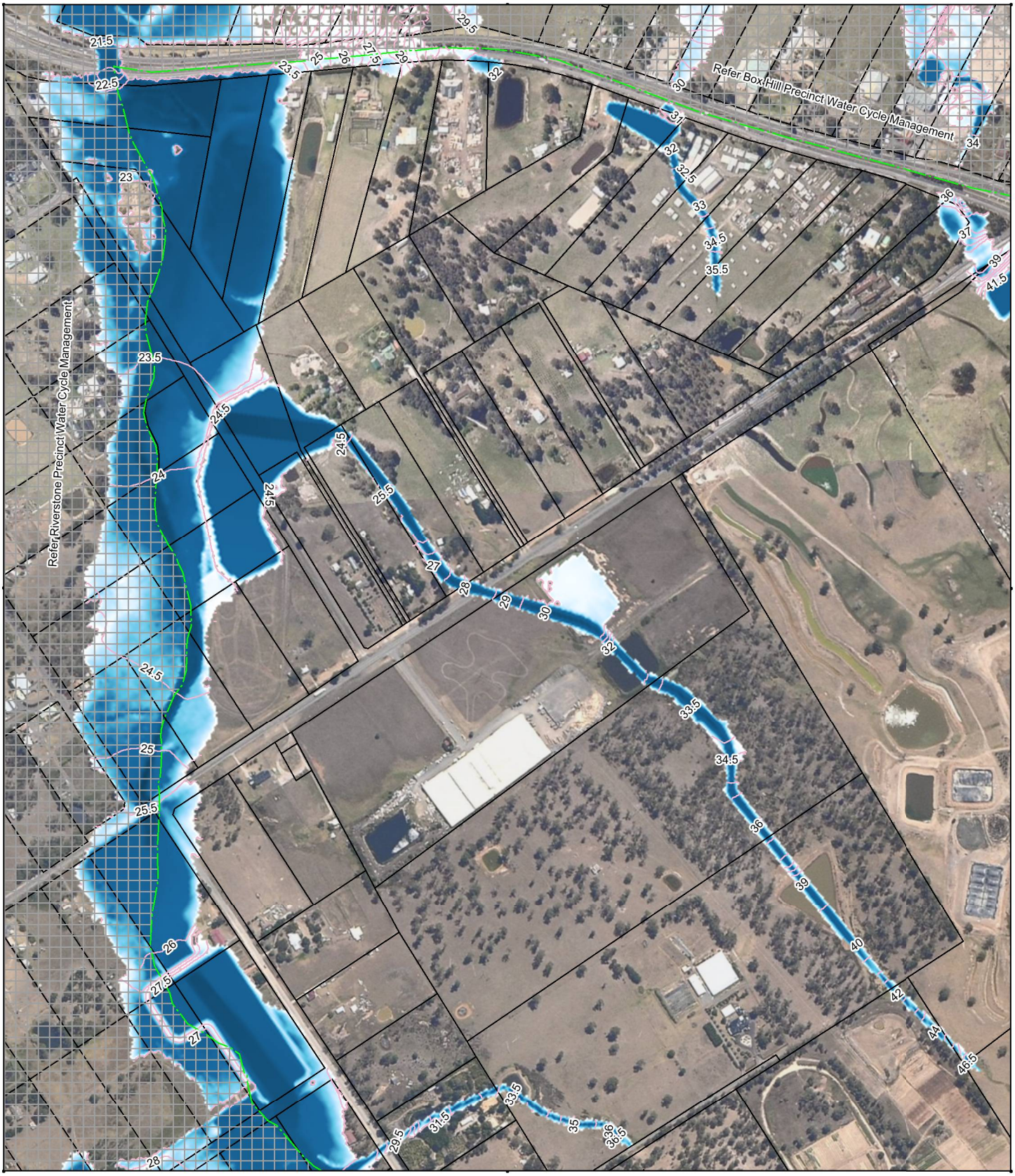
Mott MacDonald

200 0 m

N W E S

Was Wet
-0.01m
0.00m
0.01m
Was Dry

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_DIF_100yr_120m	FI	C



Title

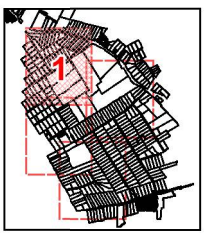
Riverstone East ILP
1% AEP Proposed Flood Depth
Climate Change Scenario 2

Mott MacDonald

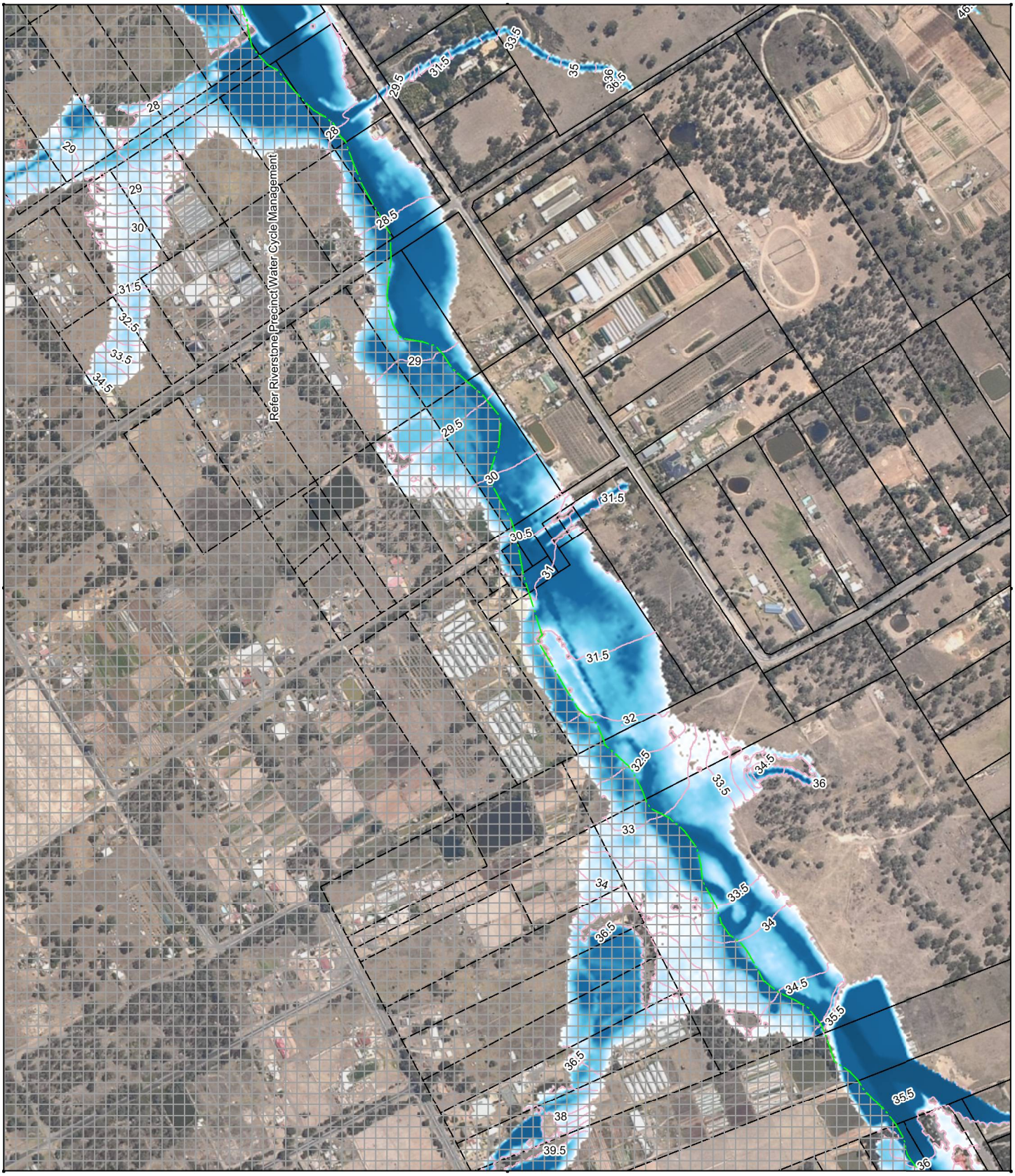
200 0 m

N W E S

0.00m
0.25m
0.50m
0.75m
2.87m



Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_100yrCC2_120m_D	FI	C



Title

Riverstone East ILP
1% AEP Proposed Flood Depth
Climate Change Scenario 2

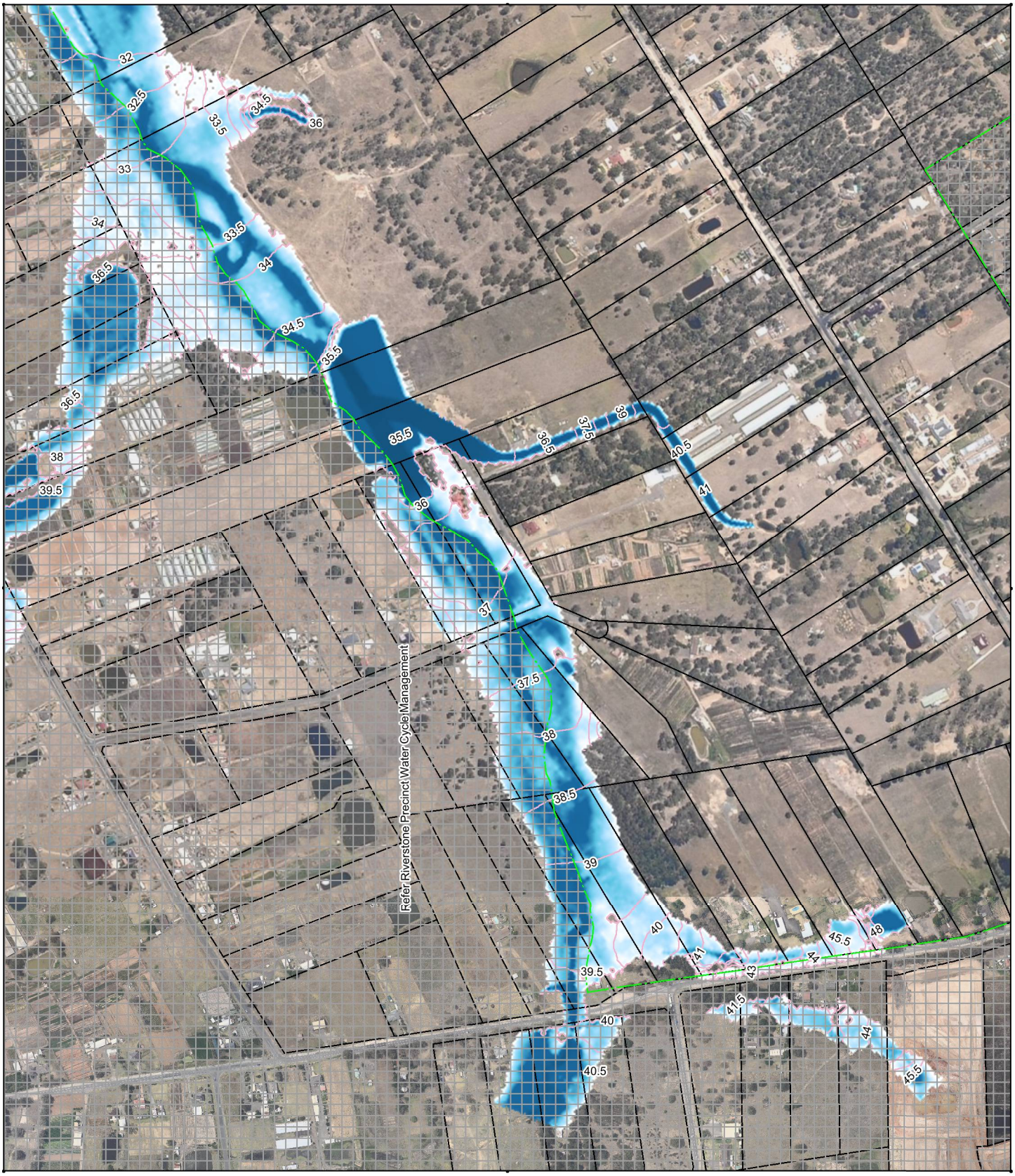
Mott MacDonald

200 0 m

N W E S

0.00m
0.25m
0.50m
0.75m
2.87m

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_100yrCC2_120m_D	FI	C



Title

Riverstone East ILP
1% AEP Proposed Flood Depth
Climate Change Scenario 2

Mott MacDonald

200 0 m

N W E S

0.00m
0.25m
0.50m
0.75m
2.87m

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_100yrCC2_120m_D	FI	C

Title

Rivestone East ILP
1% AEP Proposed Flood Depth
Climate Change Scenario 2

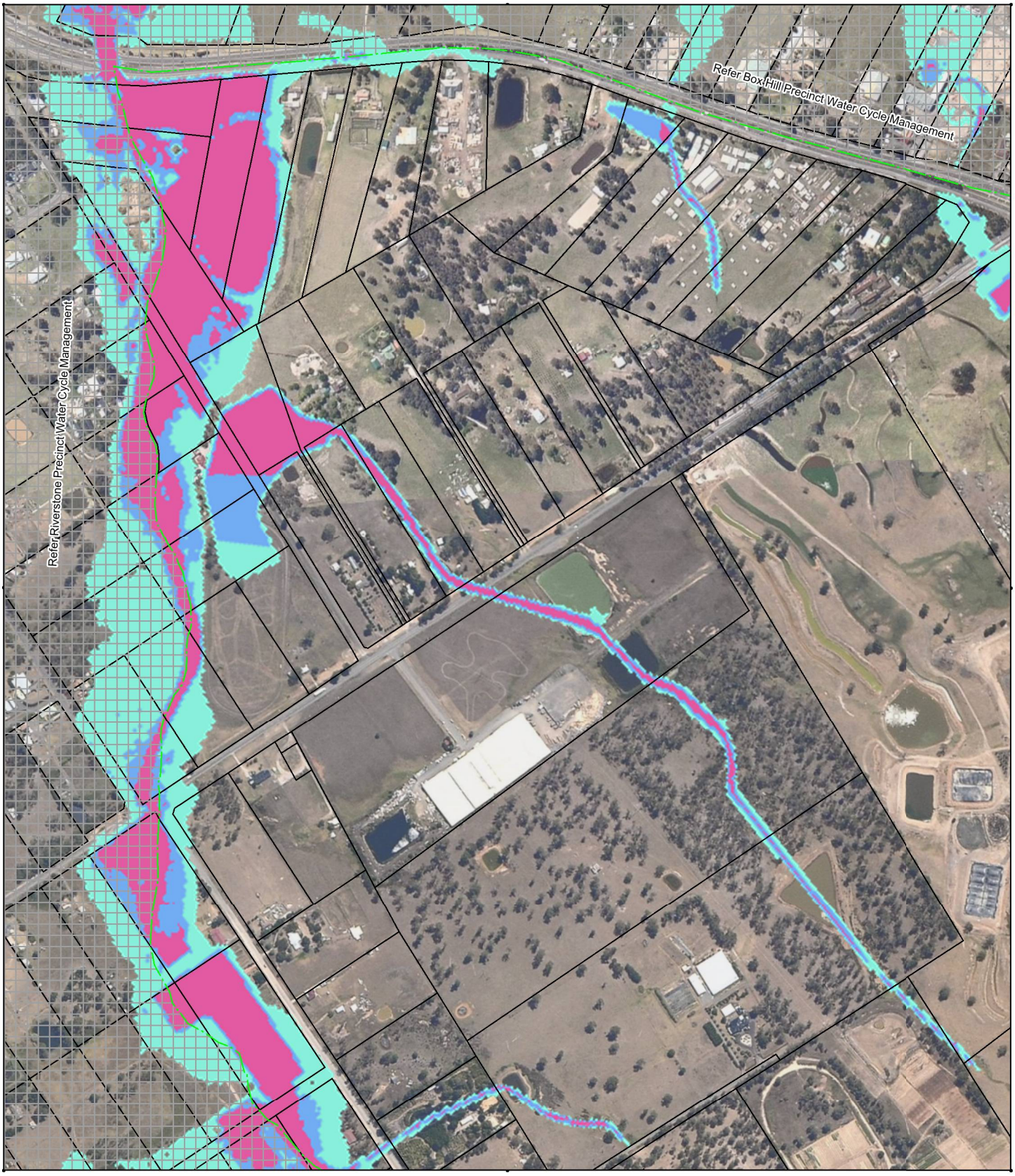
Mott MacDonald

200 0 m

N W E S

0.00m
0.25m
0.50m
0.75m
2.87m

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_100yrCC2_120m_D	FI	C



Title

Riverstone East ILP
1% AEP Proposed Flood
Flood Hazard (FDM)

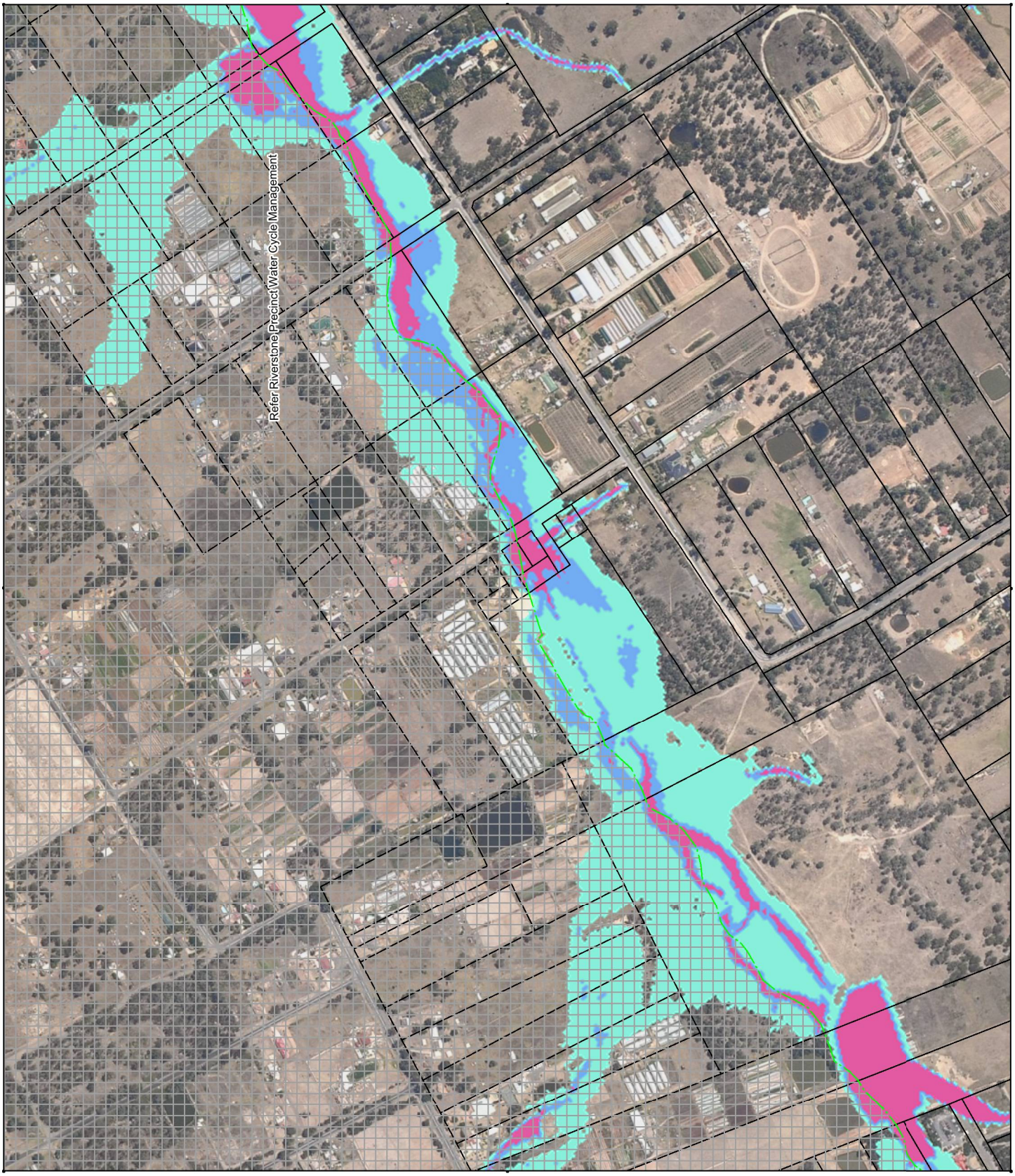
Mott MacDonald

200 0 m

N W E S

Low
Intermediate
High

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_100yr_120m_DV	FI	C



Title

Riverstone East ILP
1% AEP Proposed Flood
Flood Hazard (FDM)

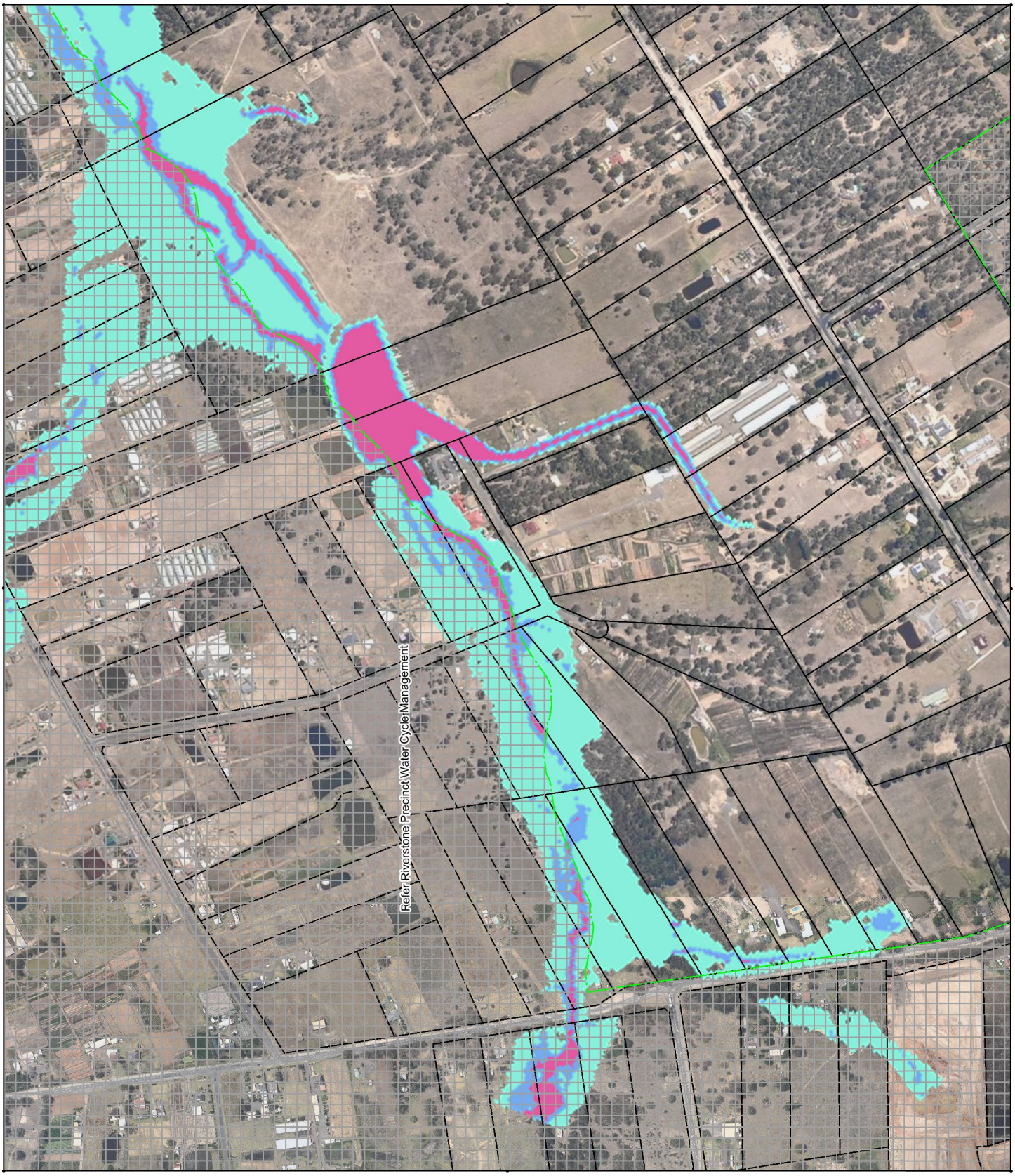
Mott MacDonald

200 0 m

N W E S

Low
Intermediate
High

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_100yr_120m_DV	FI	C



Title

Riverstone East ILP
1% AEP Proposed Flood
Flood Hazard (FDM)

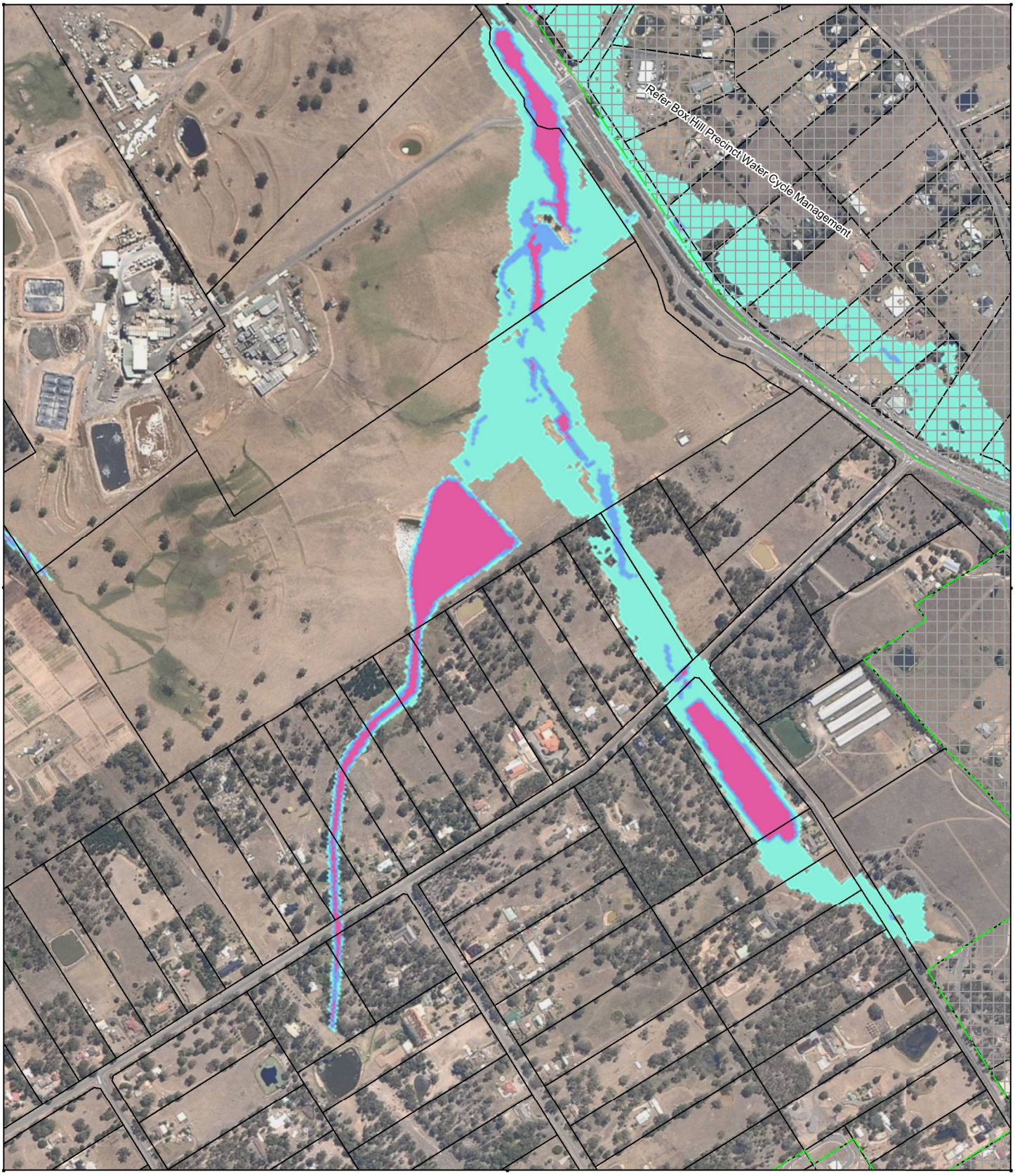
Mott MacDonald

200 0 m

N W E S

Low
Intermediate
High

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_100yr_120m_DV	FI	C



Title

Rivestone East ILP
1% AEP Proposed Flood
Flood Hazard (FDM)

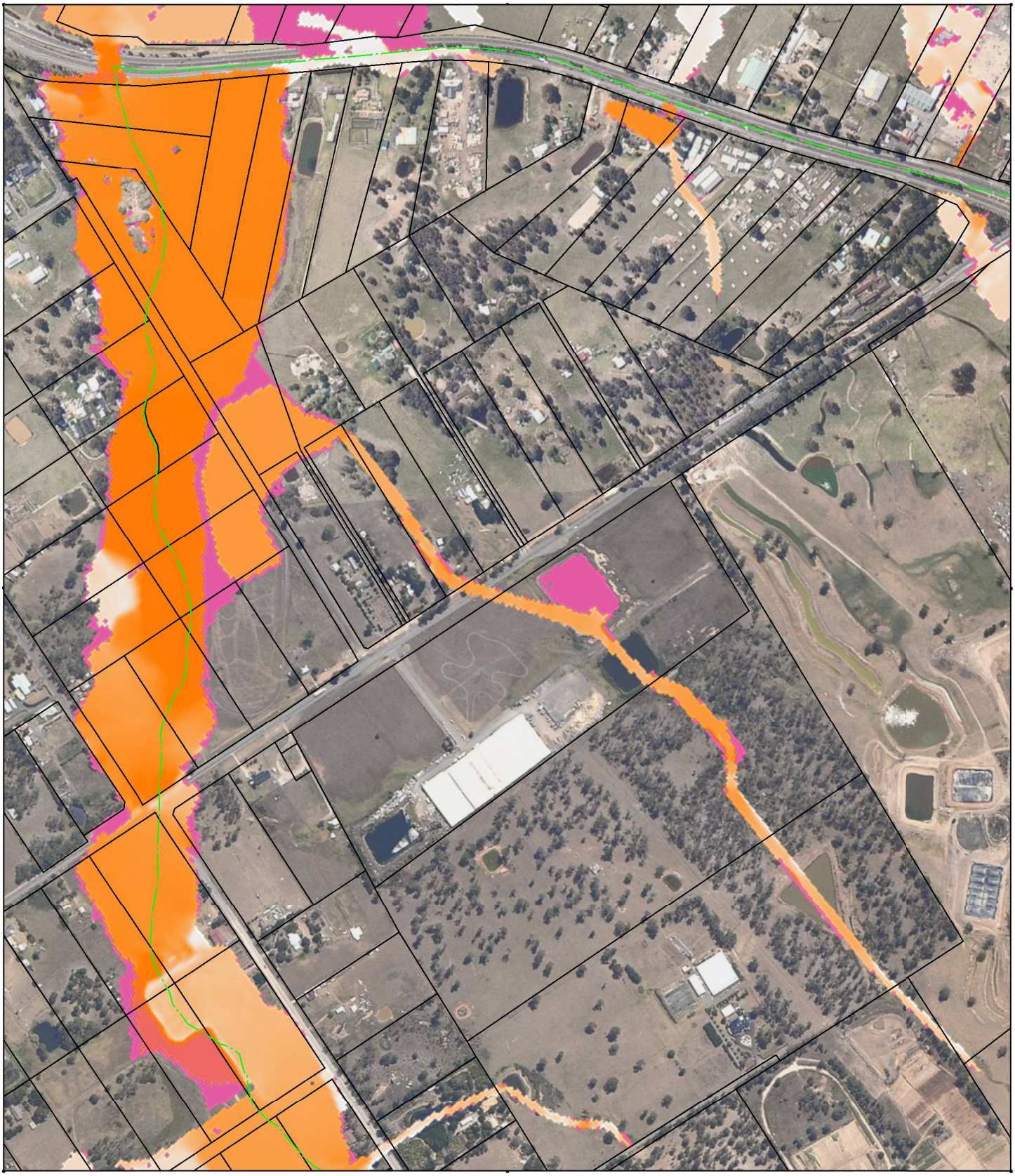
Mott MacDonald

200 0 m

N W E S

Low
Intermediate
High

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_100yr_120m_DV	FI	C

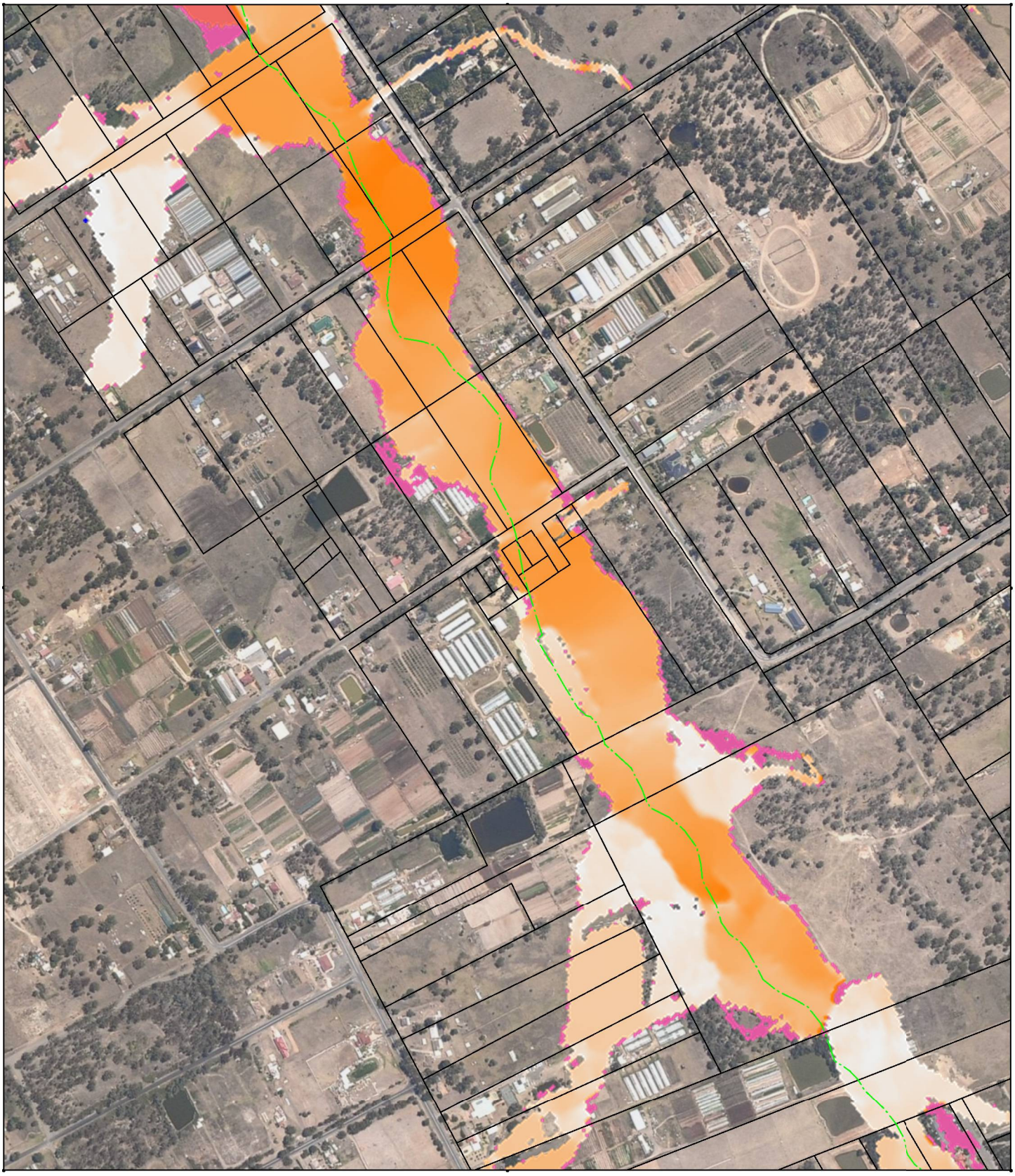


Title

Riverstone East ILP
1% AEP Proposed Depth Diff
Climate Change (+20%) - Proposed

Mott MacDonald

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_DIFCC_100yr_120m	FI	C

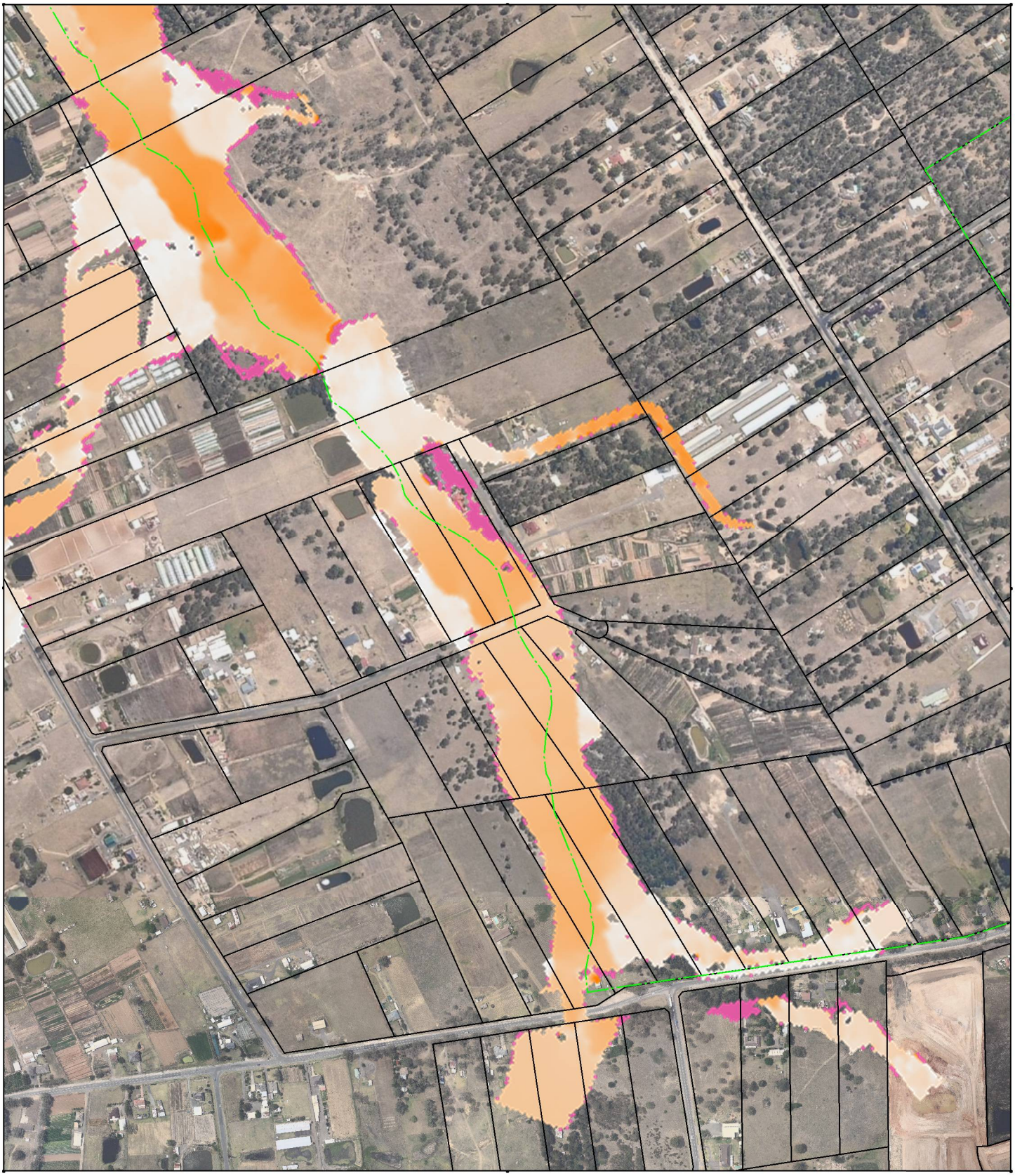


Title

Riverstone East ILP
1% AEP Proposed Depth Diff
Climate Change (+20%) - Proposed

Mott MacDonald

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_DIFCC_100yr_120m	FI	C

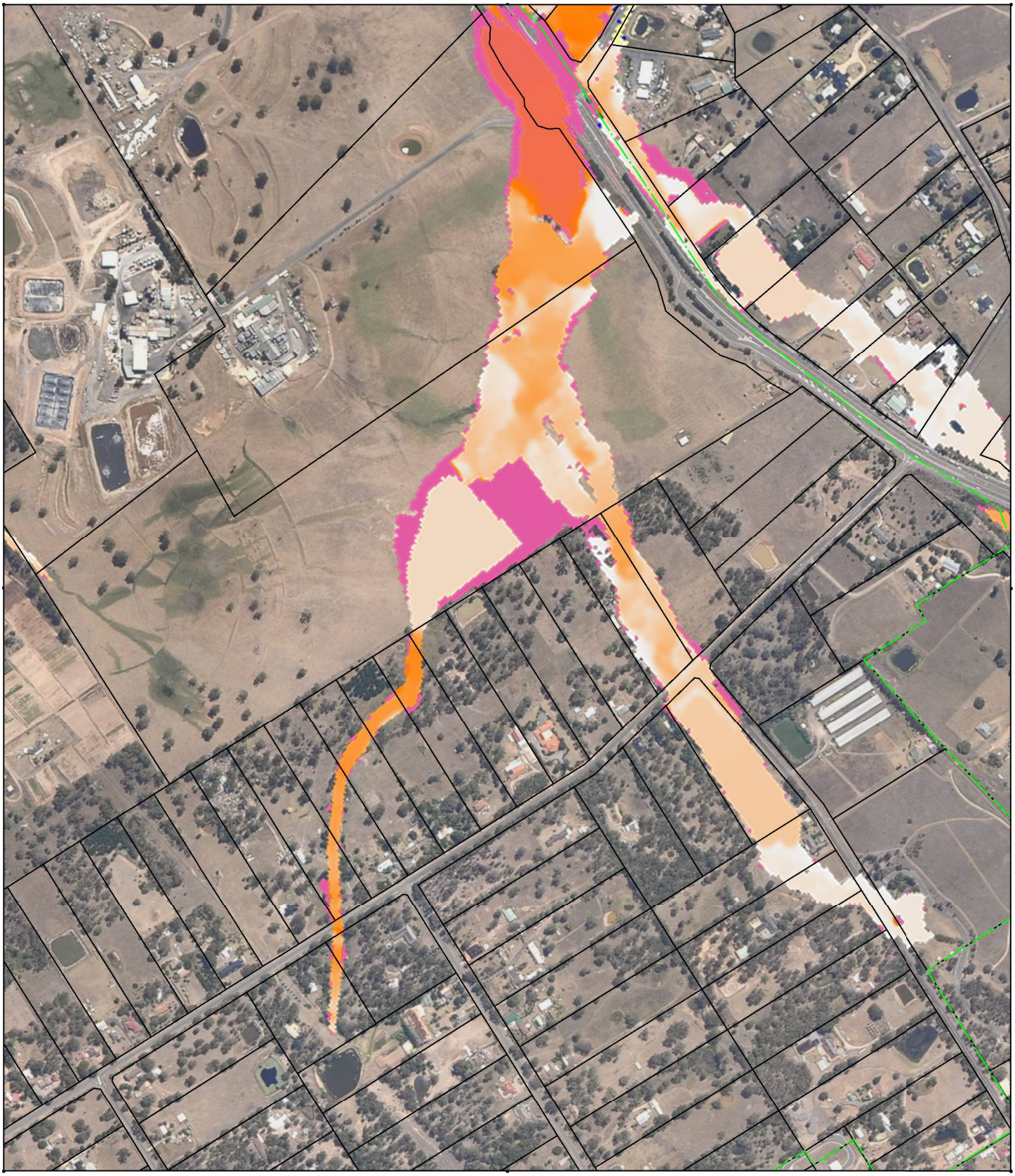


Title

Riverstone East ILP
1% AEP Proposed Depth Diff
Climate Change (+20%) - Proposed

Mott MacDonald

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_DIFCC_100yr_120m	FI	C

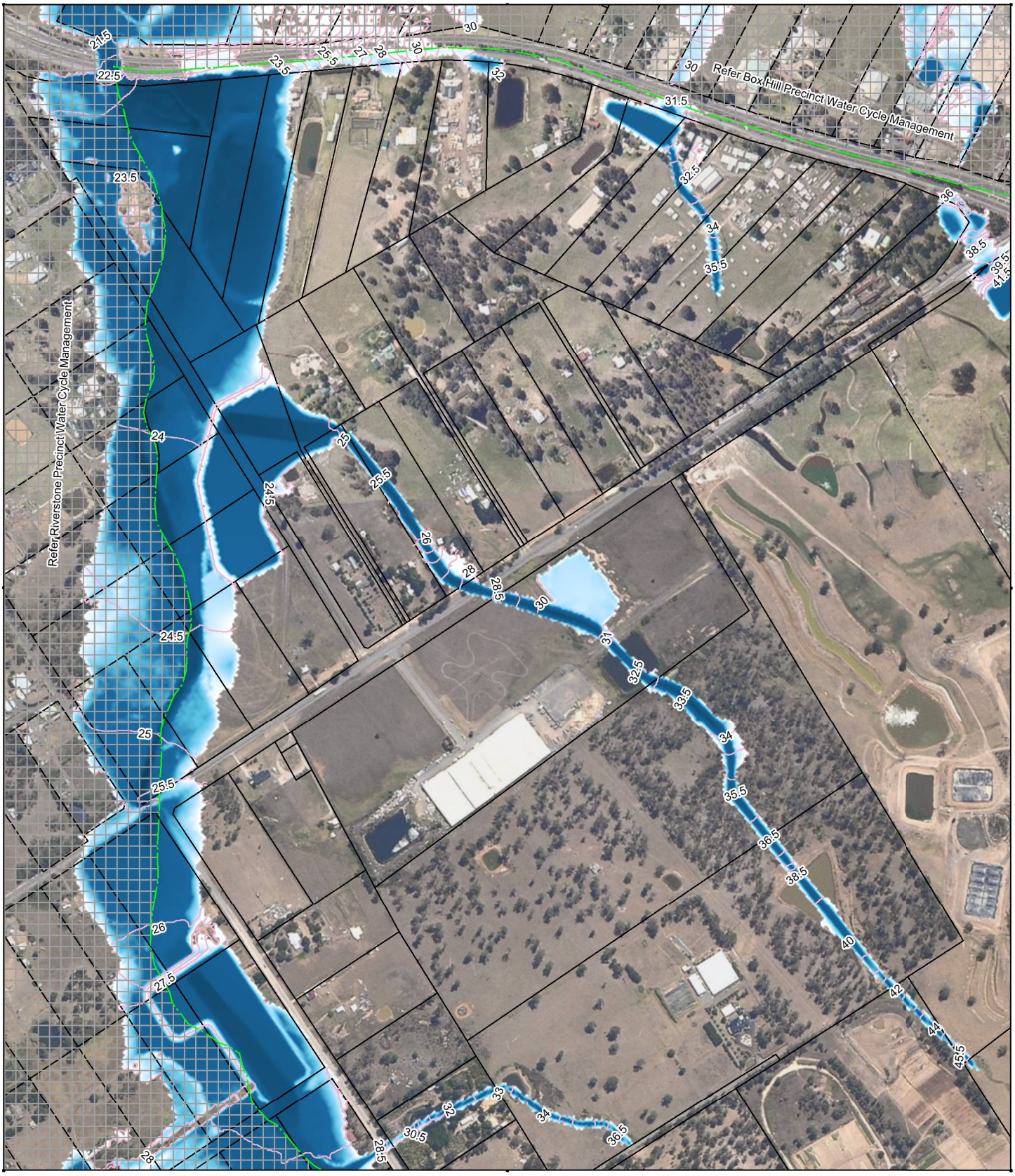


Title

Rivestone East ILP
1% AEP Proposed Depth Diff
Climate Change (+20%) - Proposed

Mott MacDonald

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_DIFCC_100yr_120m	FI	C



Title

Riverstone East ILP
0.2% AEP Proposed Flood Flood Level

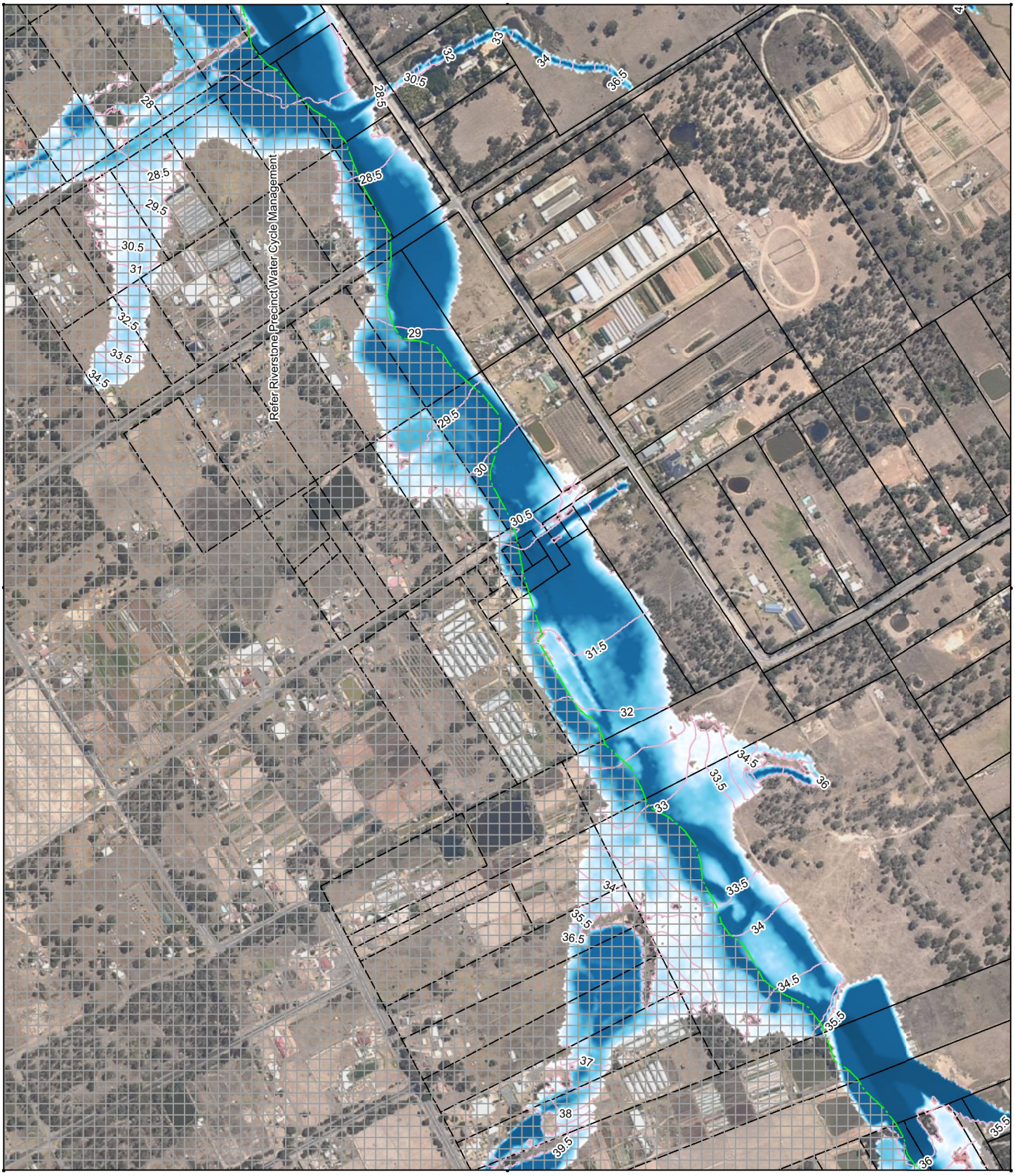
Mott MacDonald

200 0 m

N W E S

- 0.00m
- 0.25m
- 0.50m
- 0.75m
- 3.59m

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_500yr_120m_D	FI	C



Title

Riverstone East ILP
0.2% AEP Proposed Flood Flood Level

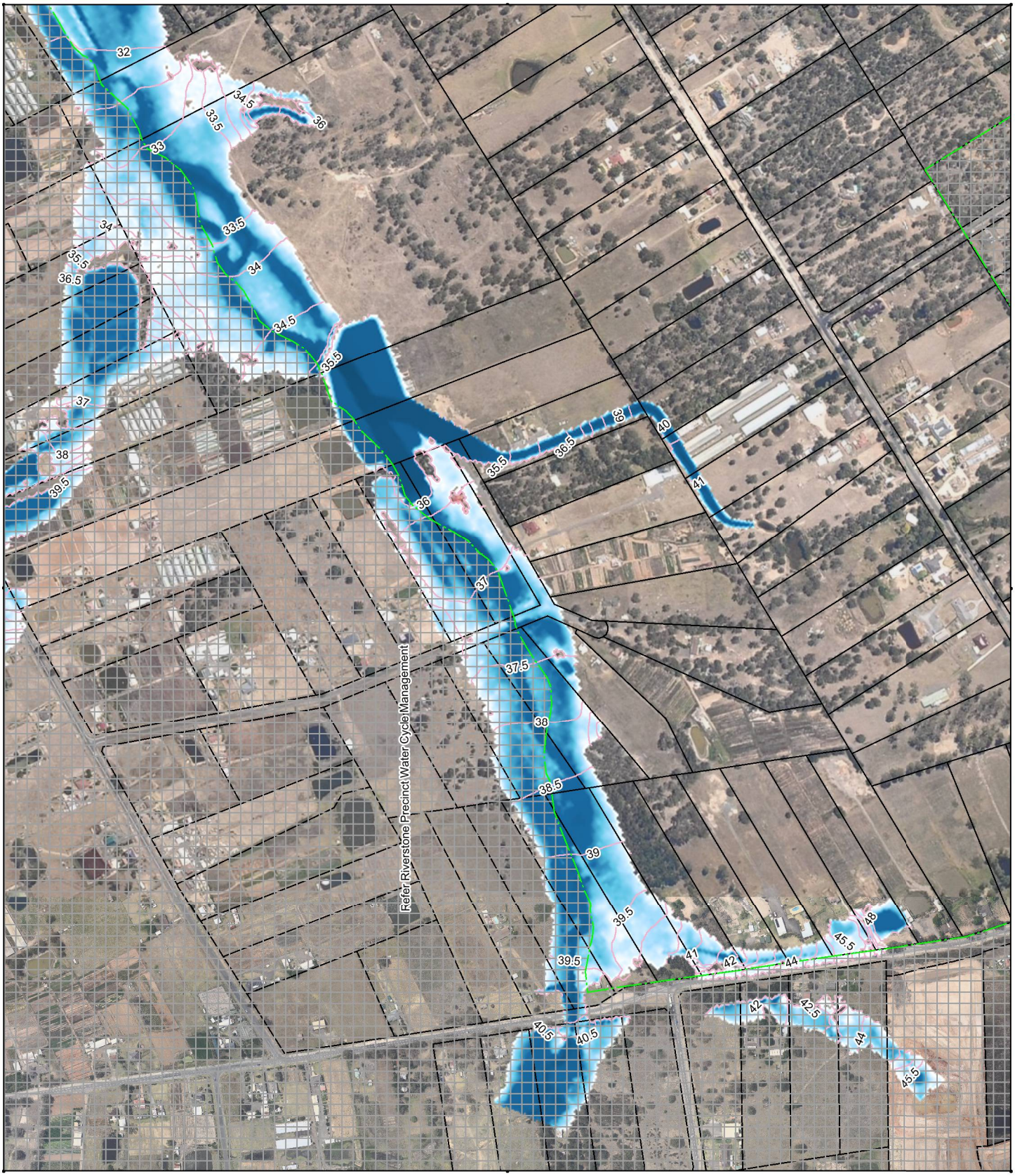
Mott MacDonald

200 0 m

N W E S

0.00m
0.25m
0.50m
0.75m
3.59m

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_500yr_120m_D	FI	C



Title

Riverstone East ILP
0.2% AEP Proposed Flood Flood Level

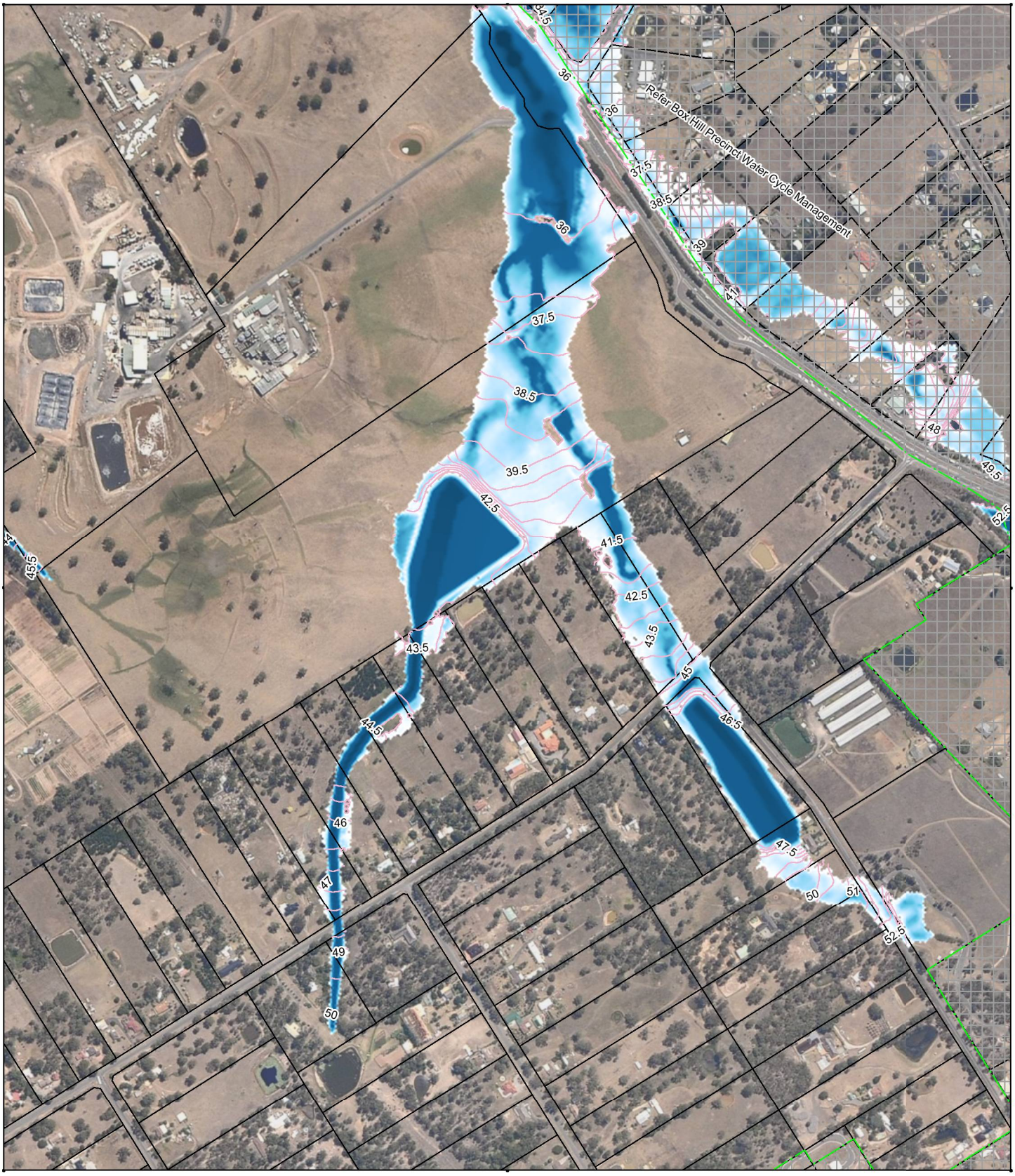
Mott MacDonald

200 0 m

N W E S

0.00m
0.25m
0.50m
0.75m
3.59m

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_500yr_120m_D	FI	C



Title

Rivestone East ILP
0.2% AEP Proposed Flood Flood Level

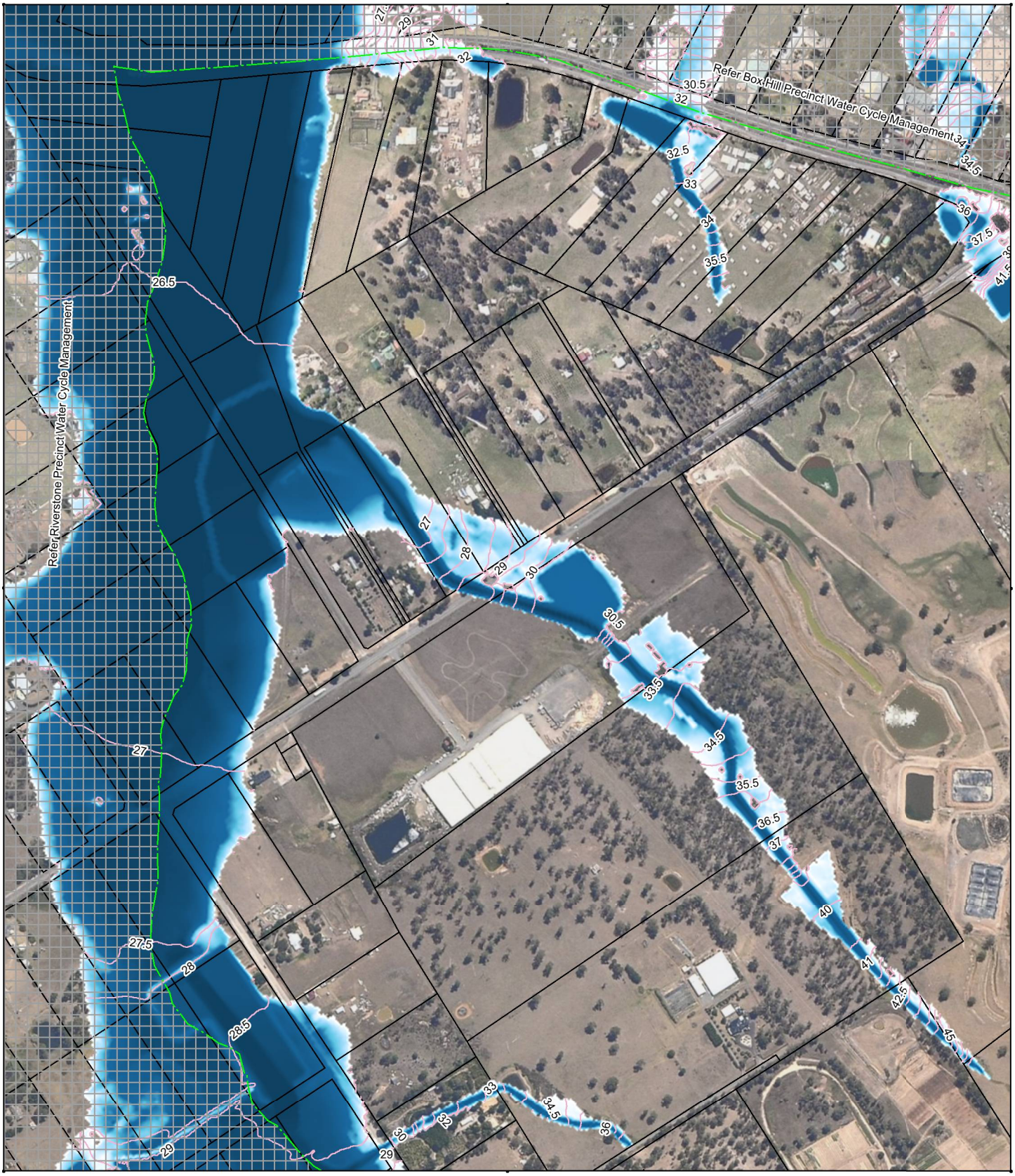
Mott MacDonald

200 0 m

N W E S

0.00m
0.25m
0.50m
0.75m
3.59m

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_500yr_120m_D	FI	C



Title

Riverstone East ILP
PMF Proposed Flood Flood Level

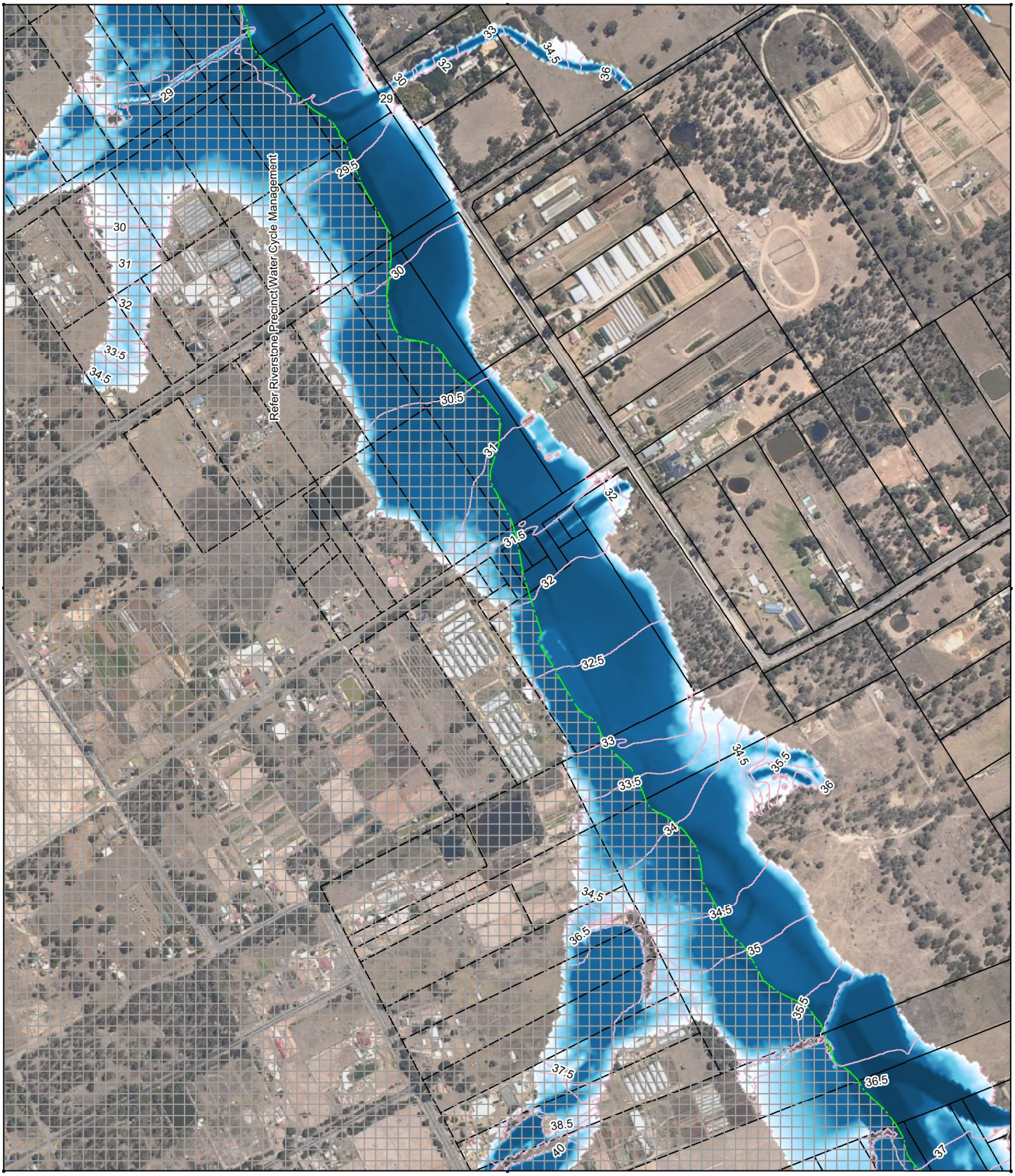
Mott MacDonald

200 0 m

N W E S

0.00m
0.60m
1.20m
1.80m
9.00m

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_PMF_120m_D	FI	C



Title

Riverstone East ILP
PMF Proposed Flood Flood Level

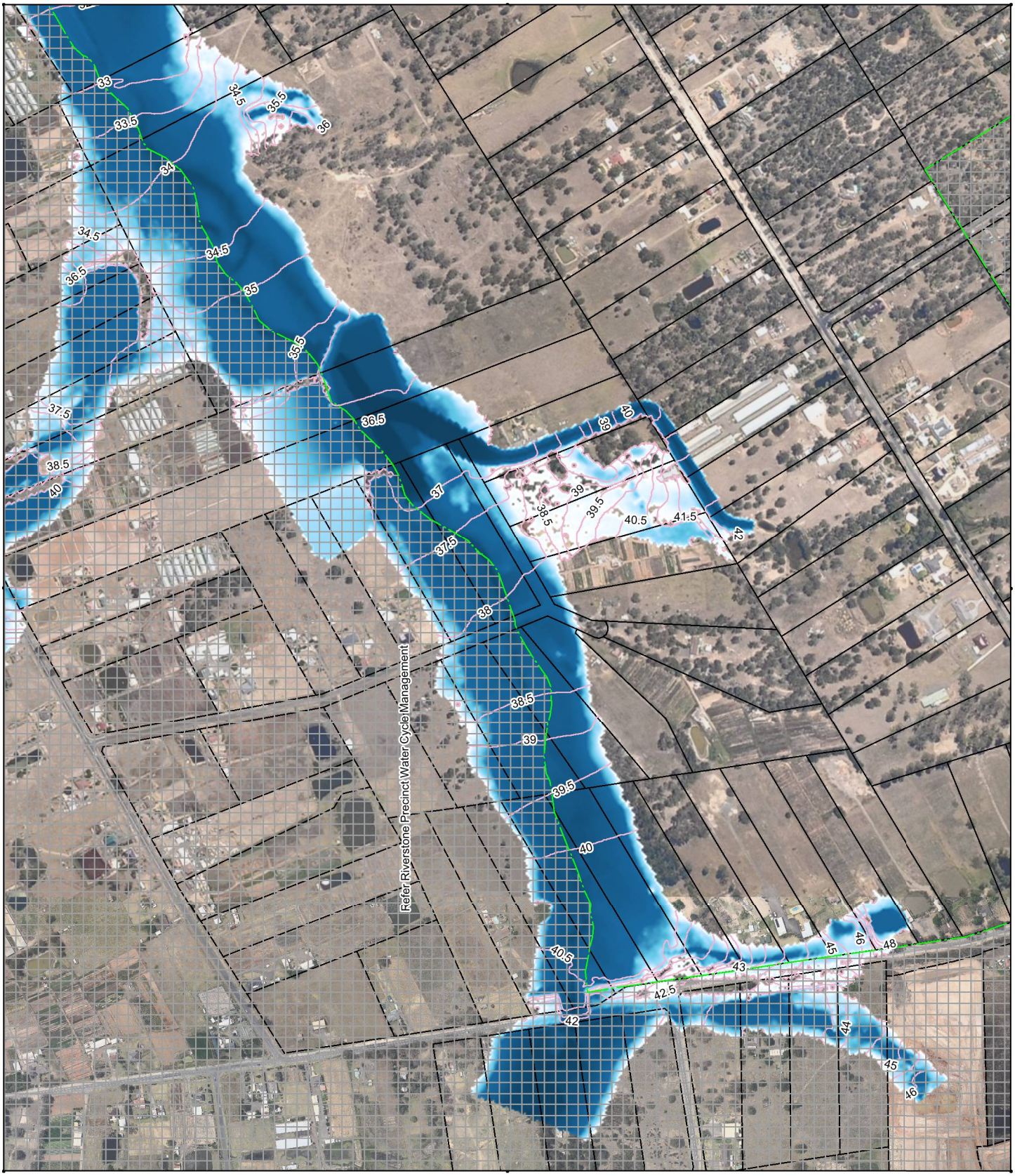
Mott MacDonald

200 0 m

N W E S

0.00m
0.60m
1.20m
1.80m
9.00m

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_PMF_120m_D	FI	C



Title

Riverstone East ILP
PMF Proposed Flood Flood Level

Mott MacDonald

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_PMF_120m_D	FI	C

Title

Rivestone East ILP
PMF Proposed Flood Flood Level

Mott MacDonald

200 0 m

N W E S

- 0.00m
- 0.60m
- 1.20m
- 1.80m
- 9.00m

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
06/05/2016	GL	GL	CA	1:8000	RE_PRL_PMF_120m_D	FI	C

Appendix E. Channel Cross Section Calculations

Riverstone East - Channel Calculations
CROSS-SECTION ANALYSIS
100-YR

X-section: CA15

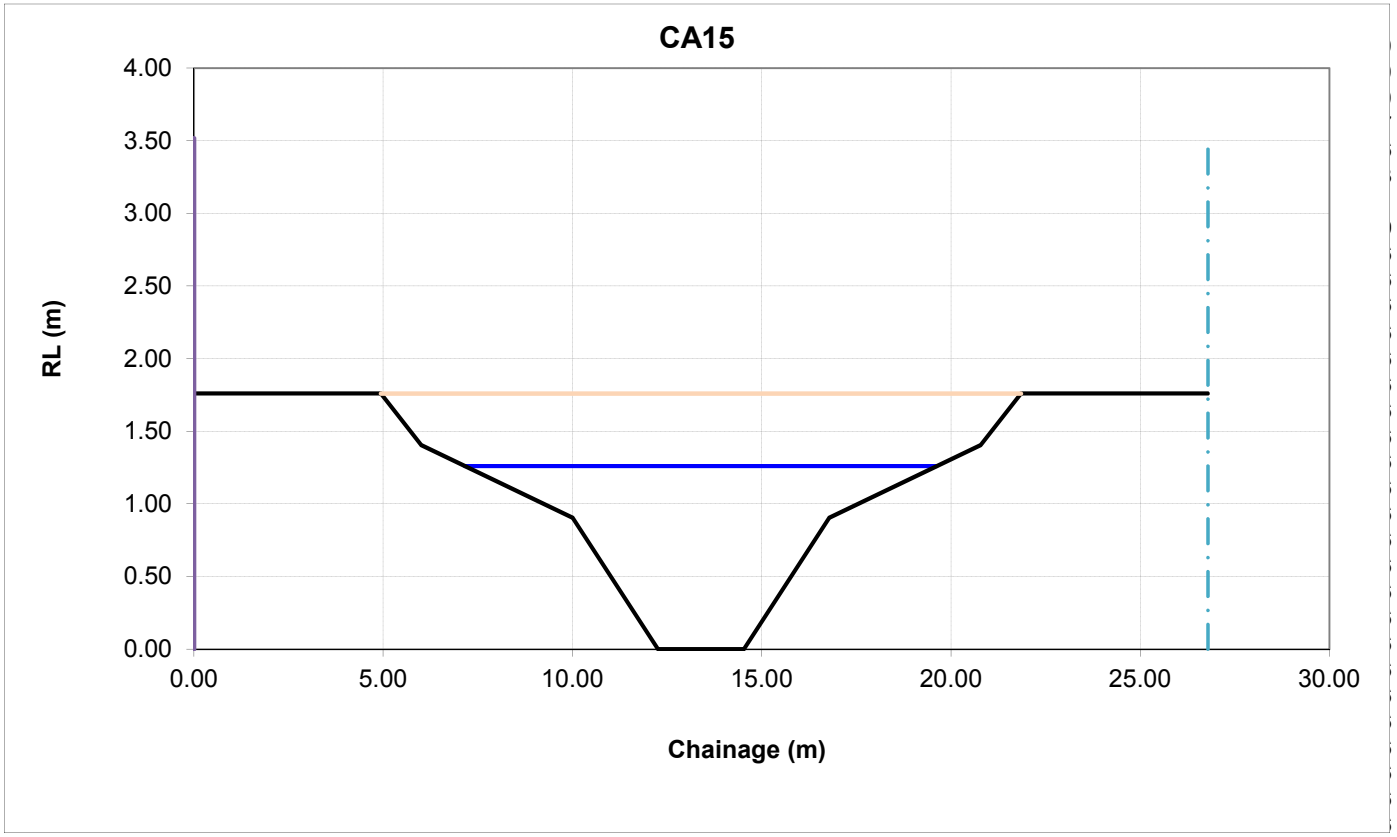
Mott MacDonald

Geometry	
Main Channel (m)	8.52
Riparian (m)	28.52
Slope (m/m)	0.015
Water Level (m)	1.26

Channel Markers	
Left	10.00
Right	16.78

Channel Properties	Area (m^2)	R	n	K	Flow (m^3/s)	Velocity (m/s)
Left Overbank	0.50	0.10	0.050	2.14376	0.26	0.52
Main Channel	6.49	0.83	0.050	114.548	14.03	2.16
Right Overbank	0.50	0.18	0.050	3.14923	0.39	0.77
Total	**7.50**	**0.50**	**0.039**	**119.841**	**14.677**	**1.96**

Chainage (m)	RL (m)	n
0.00	1.76	
4.94	1.76	0.05
6.00	1.40	0.05
10.00	0.90	0.05
12.26	0.00	0.05
13.39	0.00	0.05
14.52	0.00	0.05
16.78	0.90	0.05
20.78	1.40	0.05
21.85	1.76	0.05
26.78	1.76	0.05



Riverstone East - Channel Calculations
CROSS-SECTION ANALYSIS
100-YR

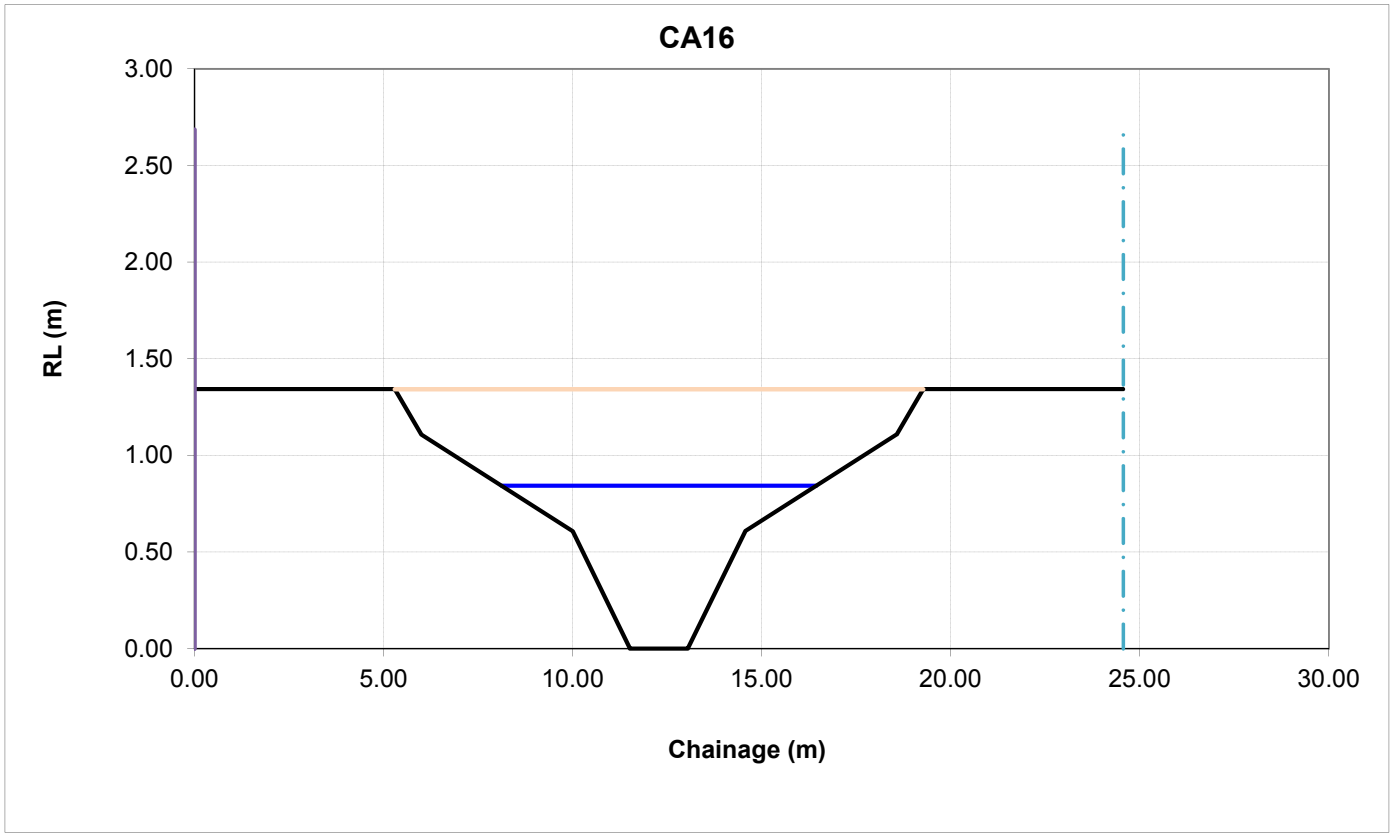
X-section: CA16

Geometry	
Main Channel (m)	7.04
Riparian (m)	27.04
Slope (m/m)	0.015
Water Level (m)	0.84

Channel Markers	
Left	10.00
Right	14.56

Channel Properties	Area (m^2)	R	n	K	Flow (m^3/s)	Velocity (m/s)
Left Overbank	0.22	0.05	0.050	0.56912	0.07	0.32
Main Channel	2.92	0.55	0.050	39.4568	4.83	1.65
Right Overbank	0.22	0.12	0.050	1.04731	0.13	0.58
Total	**3.36**	**0.29**	**0.036**	**41.0732**	**5.030**	**1.50**

Chainage (m)	RL (m)	n
0.00	1.34	
5.30	1.34	0.05
6.00	1.11	0.05
10.00	0.61	0.05
11.52	0.00	0.05
12.28	0.00	0.05
13.04	0.00	0.05
14.56	0.61	0.05
18.56	1.11	0.05
19.27	1.34	0.05
24.56	1.34	0.05



Riverstone East - Channel Calculations
CROSS-SECTION ANALYSIS
100-YR

X-section: CF05

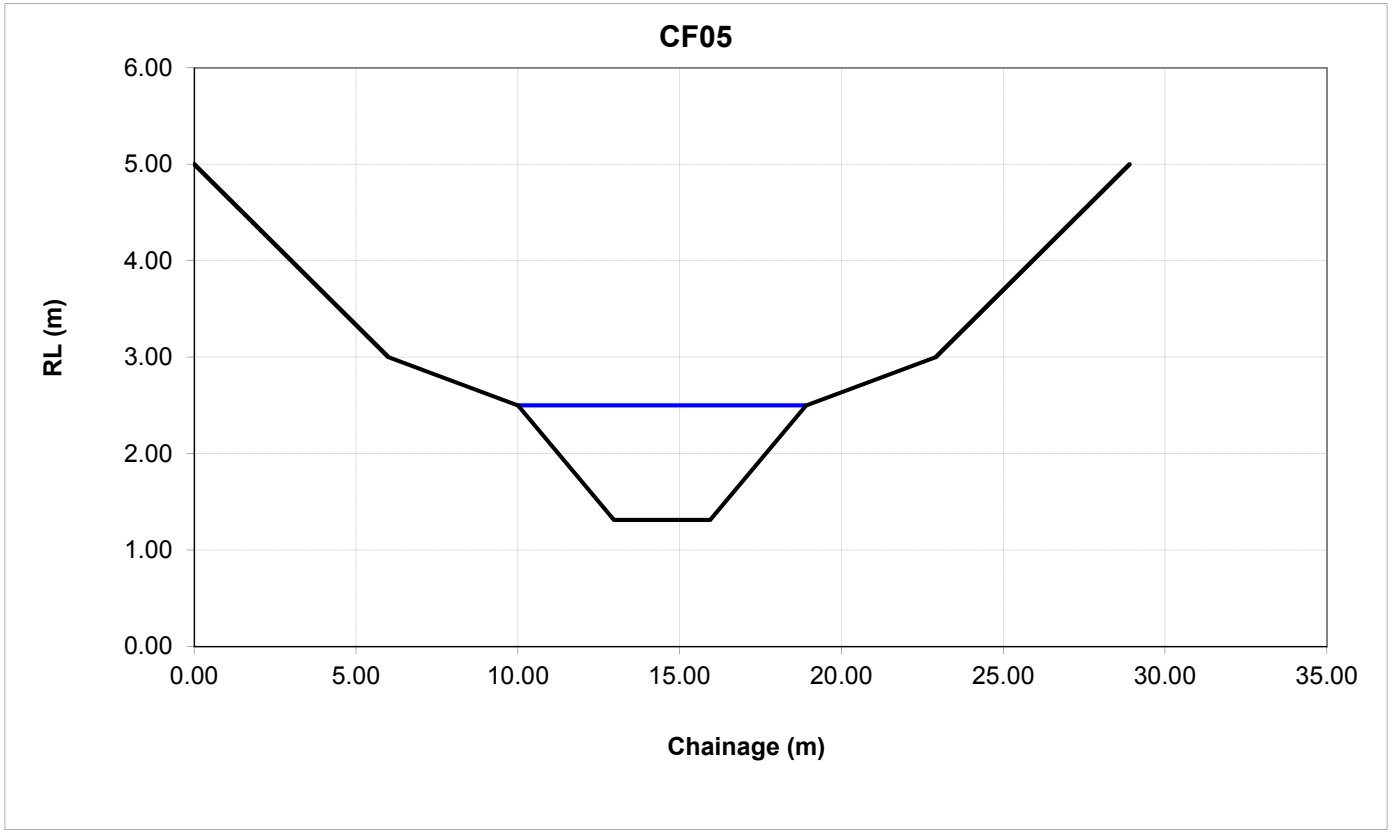
Mott MacDonald

Geometry	
Main Channel (m)	8.90
Riparian (m)	28.90
Slope (m/m)	0.005
Water Level (m)	2.50

Channel Markers	
Left	10.00
Right	18.90

Channel Properties	Area (m^2)	R	n	K	Flow (m^3/s)	Velocity (m/s)
Left Overbank	0.00	0.00	0.000	0	0.00	0.00
Main Channel	7.05	0.75	0.050	116.637	8.25	1.17
Right Overbank	0.00	0.00	0.000	0	0.00	0.00
Total	**7.05**	**0.53**	**0.039**	**116.637**	**8.247**	**1.17**

Chainage (m)	RL (m)	n
0.00	5.00	
6.00	3.00	0.05
10.00	2.50	0.05
12.97	1.31	0.05
14.45	1.31	0.05
15.94	1.31	0.05
18.90	2.50	0.05
22.90	3.00	0.05
28.90	5.00	0.05



Riverstone East - Channel Calculations
CROSS-SECTION ANALYSIS
100-YR

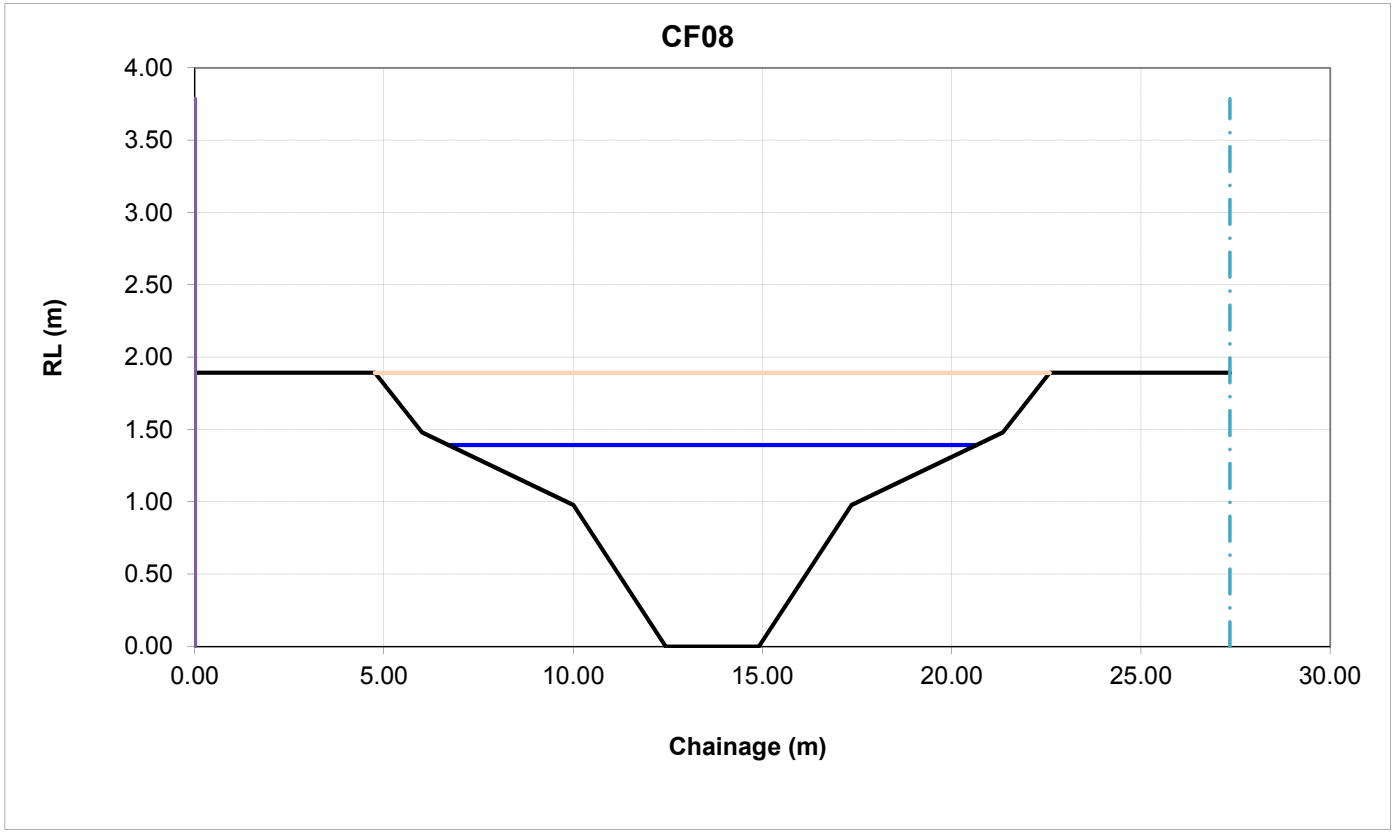
X-section: CF08

Geometry	
Main Channel (m)	8.90
Riparian (m)	28.90
Slope (m/m)	0.01
Water Level (m)	1.39

Channel Markers	
Left	10.00
Right	17.35

Channel Properties	Area (m^2)	R	n	K	Flow (m^3/s)	Velocity (m/s)
Left Overbank	0.68	0.13	0.050	3.49883	0.35	0.51
Main Channel	7.83	0.92	0.050	147.768	14.78	1.89
Right Overbank	0.68	0.20	0.050	4.74769	0.47	0.70
Total	**9.20**	**0.56**	**0.040**	**156.015**	**15.601**	**1.70**

Chainage (m)	RL (m)	n
0.00	1.89	
4.76	1.89	0.05
6.00	1.48	0.05
10.00	0.98	0.05
12.45	0.00	0.05
13.67	0.00	0.05
14.90	0.00	0.05
17.35	0.98	0.05
21.35	1.48	0.05
22.59	1.89	0.05
27.35	1.89	0.05



Riverstone East - Channel Calculations
CROSS-SECTION ANALYSIS
100-YR

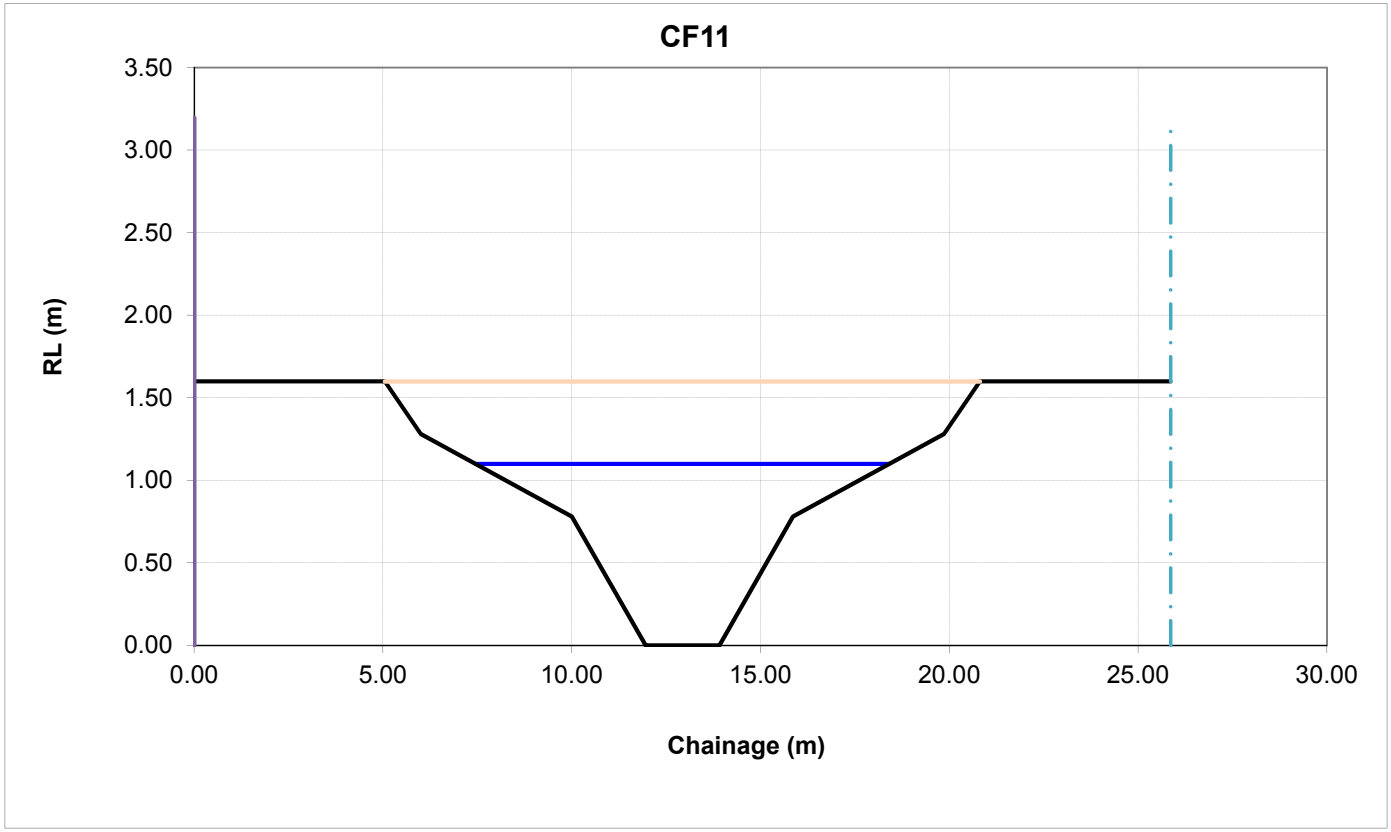
X-section: CF11

Geometry	
Main Channel (m)	7.90
Riparian (m)	27.90
Slope (m/m)	0.01
Water Level (m)	1.10

Channel Markers	
Left	10.00
Right	15.86

Channel Properties	Area (m^2)	R	n	K	Flow (m^3/s)	Velocity (m/s)
Left Overbank	0.40	0.08	0.050	1.50137	0.15	0.37
Main Channel	4.90	0.72	0.050	78.9585	7.90	1.61
Right Overbank	0.40	0.16	0.050	2.33983	0.23	0.58
Total	**5.71**	**0.42**	**0.038**	**82.7997**	**8.280**	**1.45**

Chainage (m)	RL (m)	n
0.00	1.60	
5.05	1.60	0.05
6.00	1.28	0.05
10.00	0.78	0.05
11.95	0.00	0.05
12.93	0.00	0.05
13.90	0.00	0.05
15.86	0.78	0.05
19.86	1.28	0.05
20.81	1.60	0.05
25.86	1.60	0.05



Riverstone East - Channel Calculations
CROSS-SECTION ANALYSIS
100-YR

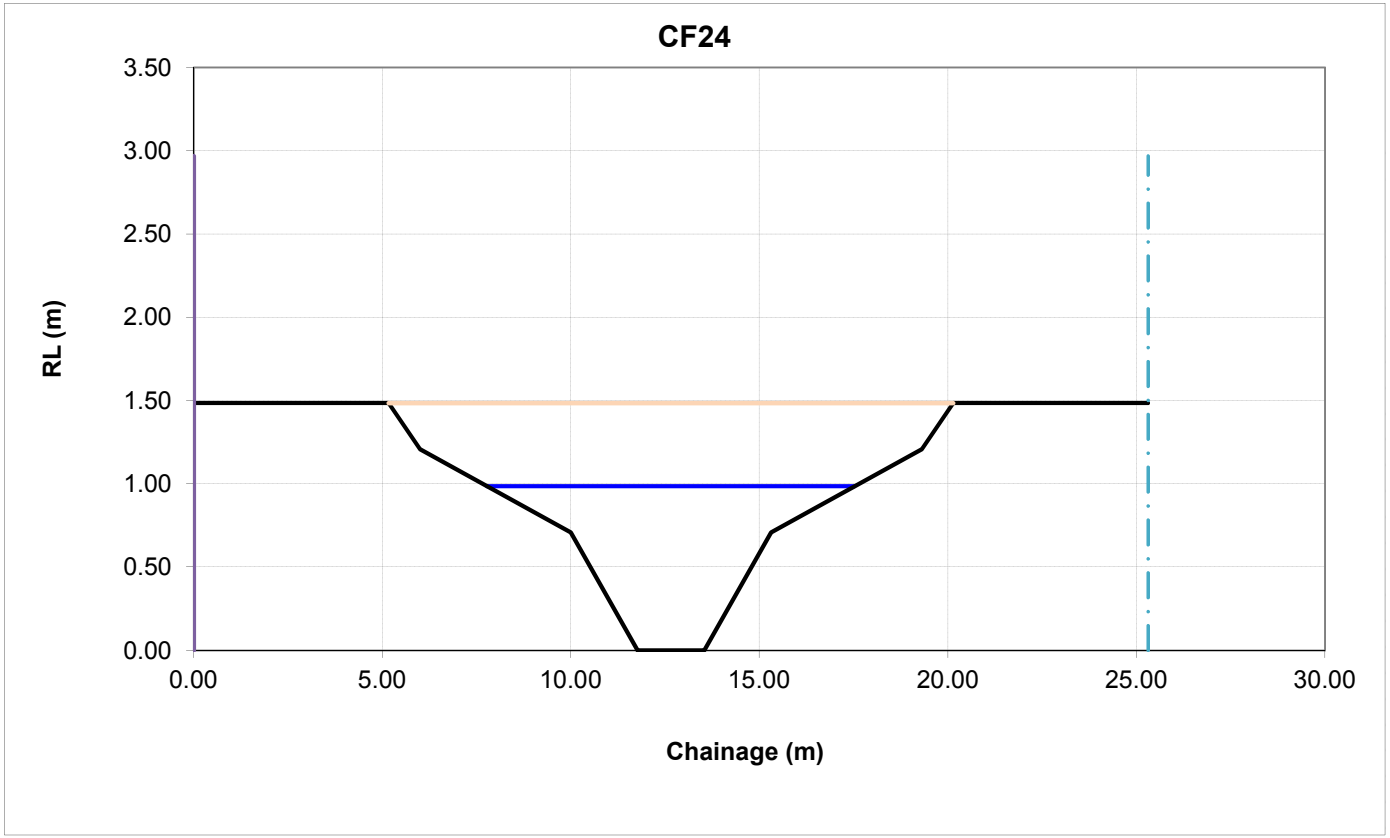
X-section: CF24

Geometry	
Main Channel (m)	7.54
Riparian (m)	27.54
Slope (m/m)	0.015
Water Level (m)	0.98

Channel Markers	
Left	10.00
Right	15.31

Channel Properties	Area (m^2)	R	n	K	Flow (m^3/s)	Velocity (m/s)
Left Overbank	0.31	0.06	0.050	0.97004	0.12	0.39
Main Channel	3.97	0.65	0.050	59.4598	7.28	1.83
Right Overbank	0.31	0.14	0.050	1.6278	0.20	0.65
Total	**4.58**	**0.36**	**0.038**	**62.0577**	**7.600**	**1.66**

Chainage (m)	RL (m)	n
0.00	1.48	
5.17	1.48	0.05
6.00	1.21	0.05
10.00	0.71	0.05
11.77	0.00	0.05
12.65	0.00	0.05
13.54	0.00	0.05
15.31	0.71	0.05
19.31	1.21	0.05
20.14	1.48	0.05
25.31	1.48	0.05



Riverstone East - Channel Calculations
CROSS-SECTION ANALYSIS
100-YR

X-section: CF40

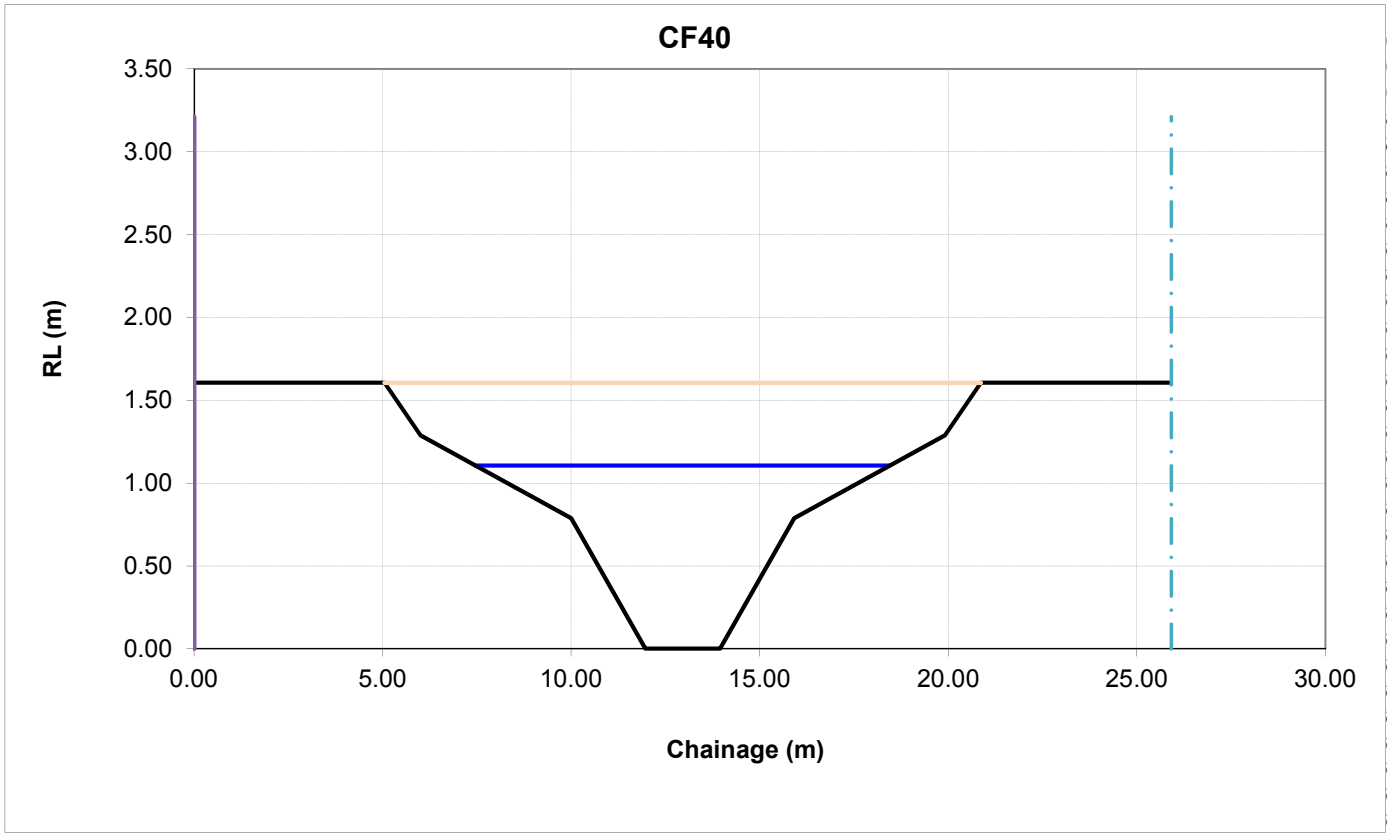
Mott MacDonald

Geometry	
Main Channel (m)	7.94
Riparian (m)	27.94
Slope (m/m)	0.015
Water Level (m)	1.11

Channel Markers	
Left	10.00
Right	15.91

Channel Properties	Area (m^2)	R	n	K	Flow (m^3/s)	Velocity (m/s)
Left Overbank	0.40	0.08	0.050	1.50332	0.18	0.46
Main Channel	4.98	0.73	0.050	80.5529	9.87	1.98
Right Overbank	0.40	0.16	0.050	2.34237	0.29	0.71
Total	**5.78**	**0.42**	**0.038**	**84.3986**	**10.337**	**1.79**

Chainage (m)	RL (m)	n
0.00	1.61	
5.05	1.61	0.05
6.00	1.29	0.05
10.00	0.79	0.05
11.97	0.00	0.05
12.96	0.00	0.05
13.94	0.00	0.05
15.91	0.79	0.05
19.91	1.29	0.05
20.86	1.61	0.05
25.91	1.61	0.05



Riverstone East - Channel Calculations
CROSS-SECTION ANALYSIS
100-YR

X-section: CF49

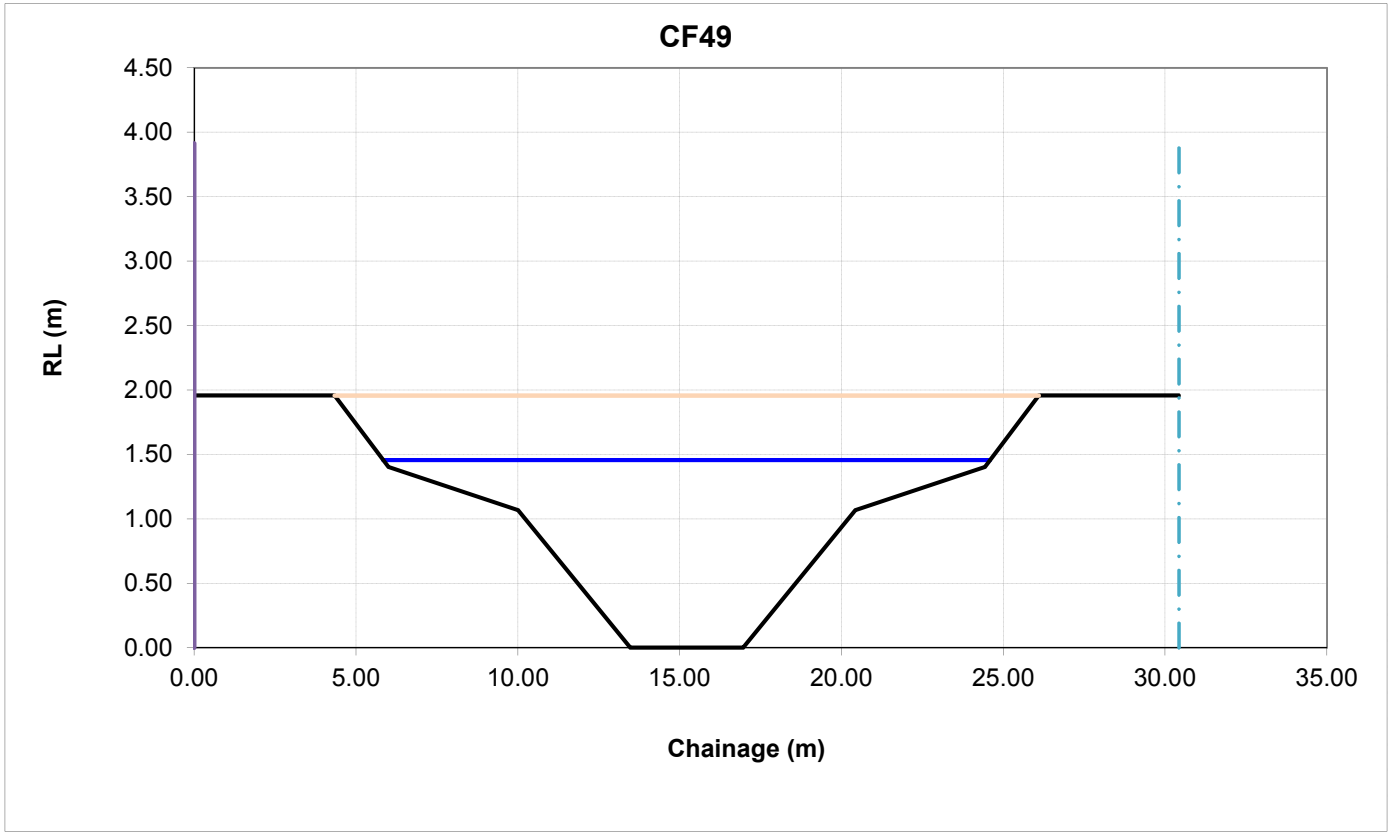
Mott MacDonald

Geometry	
Main Channel (m)	10.95
Riparian (m)	30.95
Slope (m/m)	0.0088
Water Level (m)	1.46

Channel Markers	
Left	10.00
Right	20.43

Channel Properties	Area (m^2)	R	n	K	Flow (m^3/s)	Velocity (m/s)
Left Overbank	0.89	0.09	0.050	3.52632	0.33	0.37
Main Channel	11.47	1.00	0.050	228.803	21.46	1.87
Right Overbank	0.89	0.21	0.050	6.31221	0.59	0.67
Total	**13.25**	**0.53**	**0.036**	**238.642**	**22.387**	**1.69**

Chainage (m)	RL (m)	n
0.00	1.96	
4.34	1.96	0.05
6.00	1.40	0.05
10.00	1.07	0.05
13.48	0.00	0.05
15.21	0.00	0.05
16.95	0.00	0.05
20.43	1.07	0.05
24.43	1.40	0.05
26.09	1.96	0.05
30.43	1.96	0.05



Riverstone East - Channel Calculations
CROSS-SECTION ANALYSIS
100-YR

X-section: CF50

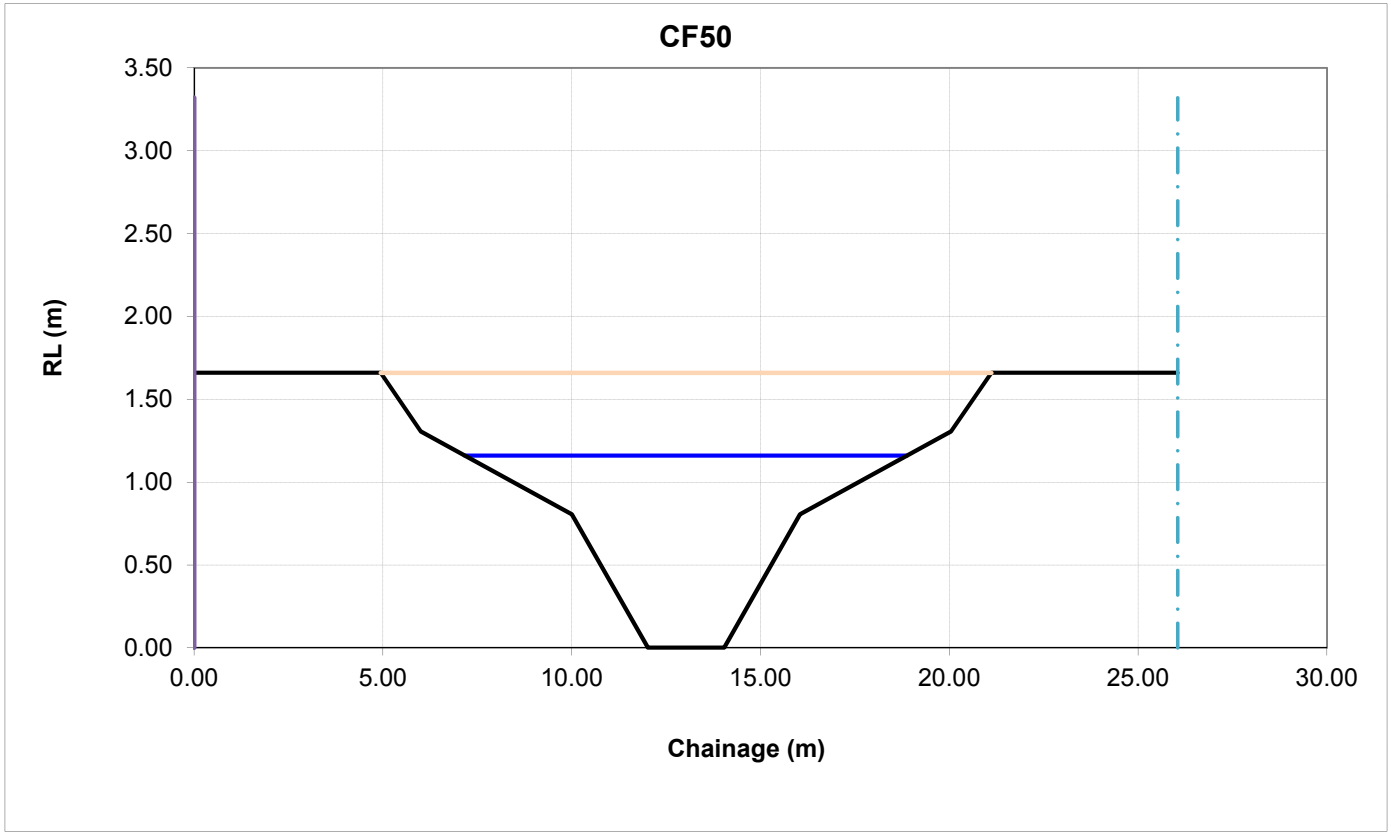
Mott MacDonald

Geometry	
Main Channel (m)	8.03
Riparian (m)	28.03
Slope (m/m)	0.015
Water Level (m)	1.16

Channel Markers	
Left	10.00
Right	16.04

Channel Properties	Area (m^2)	R	n	K	Flow (m^3/s)	Velocity (m/s)
Left Overbank	0.50	0.10	0.050	2.13792	0.26	0.52
Main Channel	5.39	0.76	0.050	89.9251	11.01	2.04
Right Overbank	0.50	0.18	0.050	3.14205	0.38	0.77
Total	**6.39**	**0.45**	**0.039**	**95.2051**	**11.660**	**1.83**

Chainage (m)	RL (m)	n
0.00	1.66	
4.94	1.66	0.05
6.00	1.31	0.05
10.00	0.81	0.05
12.01	0.00	0.05
13.02	0.00	0.05
14.03	0.00	0.05
16.04	0.81	0.05
20.04	1.31	0.05
21.11	1.66	0.05
26.04	1.66	0.05



Riverstone East - Channel Calculations
CROSS-SECTION ANALYSIS
100-YR

X-section: CF52A

Geometry	
Main Channel (m)	8.24
Riparian (m)	28.24
Slope (m/m)	0.015
Water Level (m)	1.11

Channel Markers	
Left	10.00
Right	16.36

Channel Properties	Area (m^2)	R	n	K	Flow (m^3/s)	Velocity (m/s)
Left Overbank	0.28	0.06	0.050	0.84416	0.10	0.37
Main Channel	5.28	0.73	0.050	85.7981	10.51	1.99
Right Overbank	0.28	0.13	0.050	1.45075	0.18	0.63
Total	**5.84**	**0.43**	**0.038**	**88.0931**	**10.789**	**1.85**

Chainage (m)	RL (m)	n
0.00	1.61	
5.21	1.61	0.05
6.00	1.35	0.05
10.00	0.85	0.05
12.12	0.00	0.05
13.18	0.00	0.05
14.24	0.00	0.05
16.36	0.85	0.05
20.36	1.35	0.05
21.16	1.61	0.05
26.36	1.61	0.05