Wood & Grieve Engineers

Flood Risk Management Report

BWC 2/25

Blacktown Workers Sports Club

Site A: Outdoor Sports Facilities – 221 Walters Road, Arndell Park

Site B: Seniors Living Village – 170 Reservoir Road, Arndell Park

Client:	**Paynter Dixon Constructions Pty Ltd** **Level 2, 2 Richardson Place** **NORTH RYDE NSW 2113**
Date:	**21st December 2015**
Version:	A
File Reference	28811-SYD-C-R-FRM
Prepared by:	**Tim Fitzhardinge**

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Revision

Site Address:	170 Reservoir Road, Arndell Park NSW 2148
Real Property Description:	Lot 14 on DP6796, Lot 10 and 11 on DP818679, Lot 14, 16 and 17 on DP 809530 and Lot 200 & 201 on DP880404
Proposed Development:	Sports Club and Facilities
Client:	Paynter Dixon Constructions Pty Ltd
Local Authority	Blacktown City Council
Authority Reference #:	N/A
Wood & Grieve Reference:	28811-SYD-C-R-FRM

Tim Fitzhardinge BE (Civil) & ME (Water)
For and on behalf of
Wood & Grieve Engineers

REVISION	DATE	COMMENT	APPROVED BY
A	21.12.2015	DA Issue	**IH**

Contents

1. Executive Summary

Wood & Grieve Engineers have been commissioned by Paynter Dixon Constructions Pty Ltd to prepare this Flood Study for the proposed development at 170 Reservoir Road, Arndell Park NSW 2148. The site's real property description is Lot 14 on DP6796, Lot 10 and 11 on DP818679, Lot 14, 16 and 17 on DP 809530 and Lot 200 & 201 on DP880404.

Given the integrated nature of the master plan this report has been prepared for all three components needed to facilitate the development:

- *Planning Proposal to include 'recreation facility (outdoor)' on Lot 14 Sec 4 DP6796 and Lot 10 DP818679.*
- *Development Application for the outdoor sports facilities on Lot 14 Sec 4 DP6796 and Lot 10 DP818679.*
- *Site Compatibility Certificate for a Seniors Living Village on Lot 201 DP880404*

This study has assessed the existing flood risks along Bungarribee Creek and existing adjacent major overland flow paths. This study has been prepared to accompany a development application for the site being lodged with Blacktown City Council. This study has been undertaken in accordance with Australian Rainfall and Runoff, the NSW Floodplain Management Manual and Council's Floodplain Management Technical Standard.

Flood maps have been developed and detail the flood extents, flood depths, flood levels for the 100yr and PMF (Probably Maximum Flood) flood events.

1.1 Introduction

The analysis was completed using two-Dimensional (2D) flood modelling. This Flood Risk Management Report also covers the following:

- Review of previous studies
- Catchment and topography analysis
- Hydrology assessment of the catchment
- 2D Hydraulic assessment of the existing Bungarribee Creek, overland flow paths and surrounding areas
- Discussion of hydraulic model limitations
- Flood Evacuation

This flood risk management used the software package XPSWMM to build hydrologic and hydraulic models to develop flood maps. These flood maps are used to demonstrate the hydraulic impacts (if any) of the proposed development. The hydraulic impacts include changing of flood water surface levels, (ie flood depths of water and flood extent).

XPSWMM uses the XP RAFTS engine for the hydrological modelling. The 1D hydraulic model is based on the EPA SWMM engine and the 2D model is based on the Tuflow engine. The 1D hydraulic analysis includes unsteady 1D flow analysis incorporating the full St. Venant Equations. Tuflow is a 2D hydraulic engine that analyses flow and velocity in the x and y direction (known as u and v direction in Tuflow). XPSWMM converts the topographic surface into a mesh with a series of regular symmetric cells. From the flow and velocity values and magnitude, XPSWMM uses this information to approximate flood depth and flood extent.

XPSWMM contains a hydraulic analysis module which is identical to XPSTORM's 1D/2D hydraulic analysis and a sanitary analysis module. XPSWMM models undertaken using only the hydraulic analysis module, are interchangeable with XPSTORM, and thus can be opened and reviewed in XPSTORM.

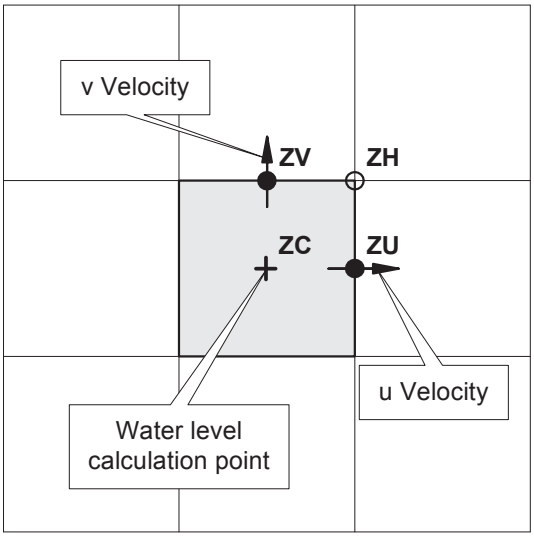


Figure 1 – Tuflow 2D hydraulic theory with topographic mesh, and v and u velocities

2. Existing Conditions

2.1 Property Detail

Address:	170 Reservoir Road, Arndell Park NSW 2148
Real Property Description:	Lot 14 on DP6796, Lot 10 and 11 on DP818679, Lot 14, 16 and 17 on DP 809530 and Lot 200 & 201 on DP880404
Total Site Area:	209,000 m^2 (20.9Ha)

The site is bounded by:

- Reservoir Road to the east,
- Holbecke Road and warehouses to the north,
- Walters Road to the west,
- Penny Place and warehouses to the south

Refer to locality plan in figure 1.

Figure 1. Site Locality Plan

The proposed development will be spilt into two sites (shown in **Figure 2**)

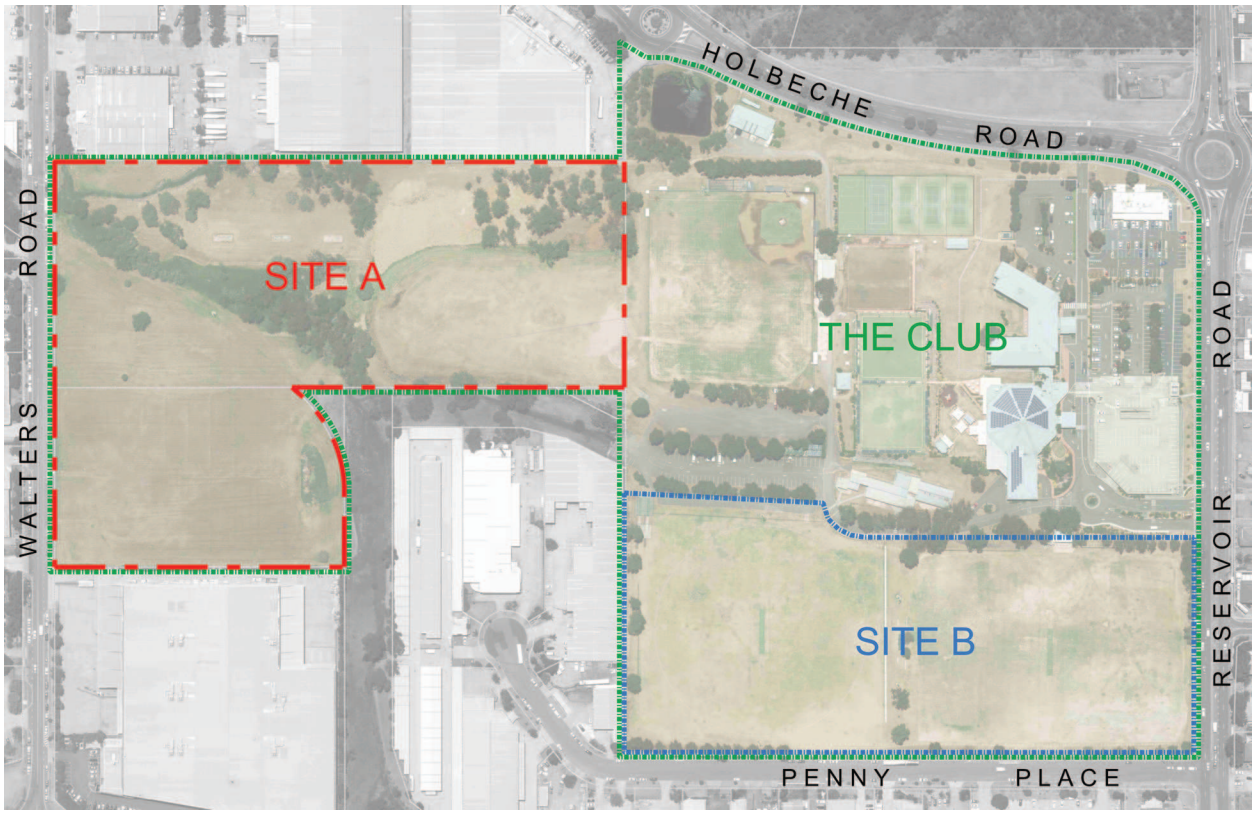


Figure 2. Proposed Site layout showing breakdown

2.2 Existing Site and Topography

The proposed site is located near the upstream end of Bungarribee Creek. The existing site contains Blacktown Workers Sports Club, carparks and access roads, sports fields and greenfield areas. The site falls from east to west. Bungarribee Creek is classified by the Office of Water as a blue line creek.

The eastern upstream catchment flows via overland and pipe to Reservoir Road. It then flows overland flow through the Club entrance access road and southern access road. This eventually flows into Bungarribee Creek.

The northern upstream catchment flows into a landscape swale on the northern side of Holbecke Road, then drains via a box culvert under the road into a basin. The basin discharges via an existing pipe to the overland flow path, flowing into Bungarribee Creek.

The following figure outlines the upstream catchments draining into the site.

Figure 3. Catchment Plan Summary and existing overland flow paths

2.2.1 Site A

The site proposed for the development of Site A is currently split Bungarribee Creek. The creek runs north west across the development site and discharged from the site through a culvert under Walters Road. This creek and its associated riparian zone will be retained following development. As discussed above there are two areas which are to be developed in Site A, split by the creek. These will be referred to as the southern site and northern site.

The southern site currently falls steeply from the south western corner to the creek. There is currently a 10m fall across the site.

The northern site is located on both a raised relatively flat section of the site at RL59.00 which then batters steeply to the creek near the creeks banks and a lower section of the site at RL56.00.

2.2.2 Site B

Site B is located to the south of the main access road through the site and is currently playing fields, the site as a consequence is currently relatively flat. The topography generally falls from east to west from RL65.00 to RL61.00.

The north of the area proposed for seniors living currently sits higher than the main access road through the site. This provides protection in the current situation against overland flow which passes through the site from Reservoir Road to the creek.

2.3 Existing Stormwater Network

Council has an existing trunk stormwater network that runs under the nature strip on the western side of Reservoir Road. These pipes consist of a Φ1650 running north-south and Φ1350 running south-north along Reservoir Road towards the junction at the entrance access road. The pipe network then turns into a Φ2100 running west for approximately 12m. The pipe network then contracts into Φ1650 pipe at a surcharge pit. The pipe network continues to run west as a Φ1650 which eventually discharges into an open natural channel which flows into Bungarribee Creek.

A previous easement survey plan by Lovegrove Oxley & Partners documented Council's trunk stormwater pipes (as described above) sits inside a 2.5m wide easement.

The stormwater information was obtained from Council's GIS database. Refer to figure 2.

Figure 4. Existing Stormwater Network (Source: Blacktown City Council GIS Data)

For Sites A and B currently all stormwater runoff from the existing site are conveyed across the site in an uncontrolled and untreated manner towards the creek and discharge directly into the creek.

2.4 Existing Flooding

Buckton Lysenko had previously undertaken a flood study titled "Flood Study for Industrial Development at Walters Road, Arndell Park" dated 29 November 2004. The study carried out a HEC-RAS (1D hydraulic analysis software) of Bungarribee Creek and upstream natural watercourse and produced 100 year ARI hydraulic results including flood levels and flood extent. The report did not analyse the PMF or any other design rainfall events.

2.5 Proposed Development

2.5.1 Site A – Outdoor Sports Facilities

Site A of the redevelopment is the relocation and upgrade of the existing outdoor sporting facilities on the site. It is proposed that the existing playing fields located south of the sites main access road will be relocated to the existing open spaces within the site adjacent to Walters Road and next to the existing baseball field on the site.

The works include development of four new full sized playing fields, two training pitches and four all weather pitches. In addition to the playing fields two new grandstands with associated vehicle parking will be constructed.

There will be significant bulk earthworks required to prepare the site for the construction of the new development.

The development areas are located up to 10m above the top of the existing creek bank.

2.5.2 Site B – Senior Living Facilities, Sports Facility and Child Care Facility

The development of Site B will include the construction of a new senior living precinct on the existing sports fields. There will also be a new sports facility located to the south of the existing baseball field and a childcare facility to the south of the existing bowling green.

The seniors living precinct will include a basement level under a podium accessed from the main entrance of the site.

Both the seniors living and the child care facilities will be constructed above the levels of the existing access road to help achieve flood planning levels for these buildings.

3. Flood Modelling

3.1 Methodology

The flood model methodology was to consider the best approach of modelling the flood behaviour around our specific site.

Catchment analysis and review of the surrounding topography was then conducted. This involved a combination of site walks and developing a 3D digital topographic surface. A 3D digital topographic surface was built using a combination of detailed survey and aerial laser survey (ALS) was of the immediate and surrounding areas. This surface was also used to identify major overland flow paths and catchment boundaries (as part of the catchment analysis).

Once the catchment boundaries were defined, the flood model was then developed. A hydrologic rainfall runoff model was prepared in XPSWMM (a 1D/2D hydrological and hydraulic modelling software package).

The 1D/2D hydraulic model was setup in XPSWMM. The overflow hydrographs from the hydrological analysis were used as upstream inflow boundary conditions. XPSWMM uses the XP RAFTS engine for the hydrological modelling. The 1D hydraulic model is based on the EPA SWMM engine and the 2D model is based on the Tuflow engine. All hydraulic elements in incorporate the Australian Runoff and Rainfall (AR&R-87) standards.

XPSWMM and AutoCAD civil 3D was also used to generate the flood water level contours, and flood depth contours. AutoCAD, AutoCAD civil 3D and Nearmaps were used to develop the final GIS Flood Maps.

The aerial photography was taken from Nearmaps dated (5th December 2015). Nearmaps is an online aerial map photography provider that provides current aerial photography. They conduct frequent aerial flyovers to update their aerial photography.

Reviewing previous flood assessments conducted on the surrounding areas. This information was then used to compare and benchmark the findings and assumptions in this report.

3.1.1 Data

As previously discussed in section 3.1 the following table summarises the type and origin of data used for flood modelling purposes.

Data	Type	Supplier
Aerial Laser Survey (ALS)	Digital Terrain Survey	Blacktown Council
Site Photography	Aerial Photography	Near Map
GIS Stormwater Pipe	Drainage Details	Blacktown Council
Study Area Boundaries	Catchment Definition	WGE
Stormwater Trunk Drain	Trunk Drain Details	Blacktown Council
Upstream Catchment Inflow	Hydrographs	WGE

Table 1. Model Data

3.1.2 Calibration

The flood model has been calibrated against the previous flood study across the site prepared by Buckton Lysenko Consulting Engineers entitled "Flood Study for Industrial Development at Walters Road, Arndell Park" dated 29th November 2004.

The flood modelling undertaken in the previous report utilised HEC-RAS to assess the 100 year design storm flows through the creek.

The results of the previous flood model are summarised in the table below:

Location	100 Year Water Level	100 Year Flow Velocity
Main – Walters Road Crossing	51.590	2.16
Main – Tributary Intersection	53.562	4.01
Main – Southern Boundary	54.496	2.14
Tributary – Eastern Extent	56.339	0.69

Table 2. Previous Modelling Results

The model was calibrated against these results ensuring that the flows, flood depths and water levels were similar to the previous model.

3.1.3 XPSWMM Model Setup

The following schematic diagram outlines the different XPSWMM model elements:

- 1D channel centreline and cross section and 1D pipes (grey)
- The nodes (red circles) where the 2D upstream boundary conditions were applied
- 2D surface grid (black outline)
- Catchment extents (cyan), following section 2.2
- 1D boundary condition at outfall (magenta)

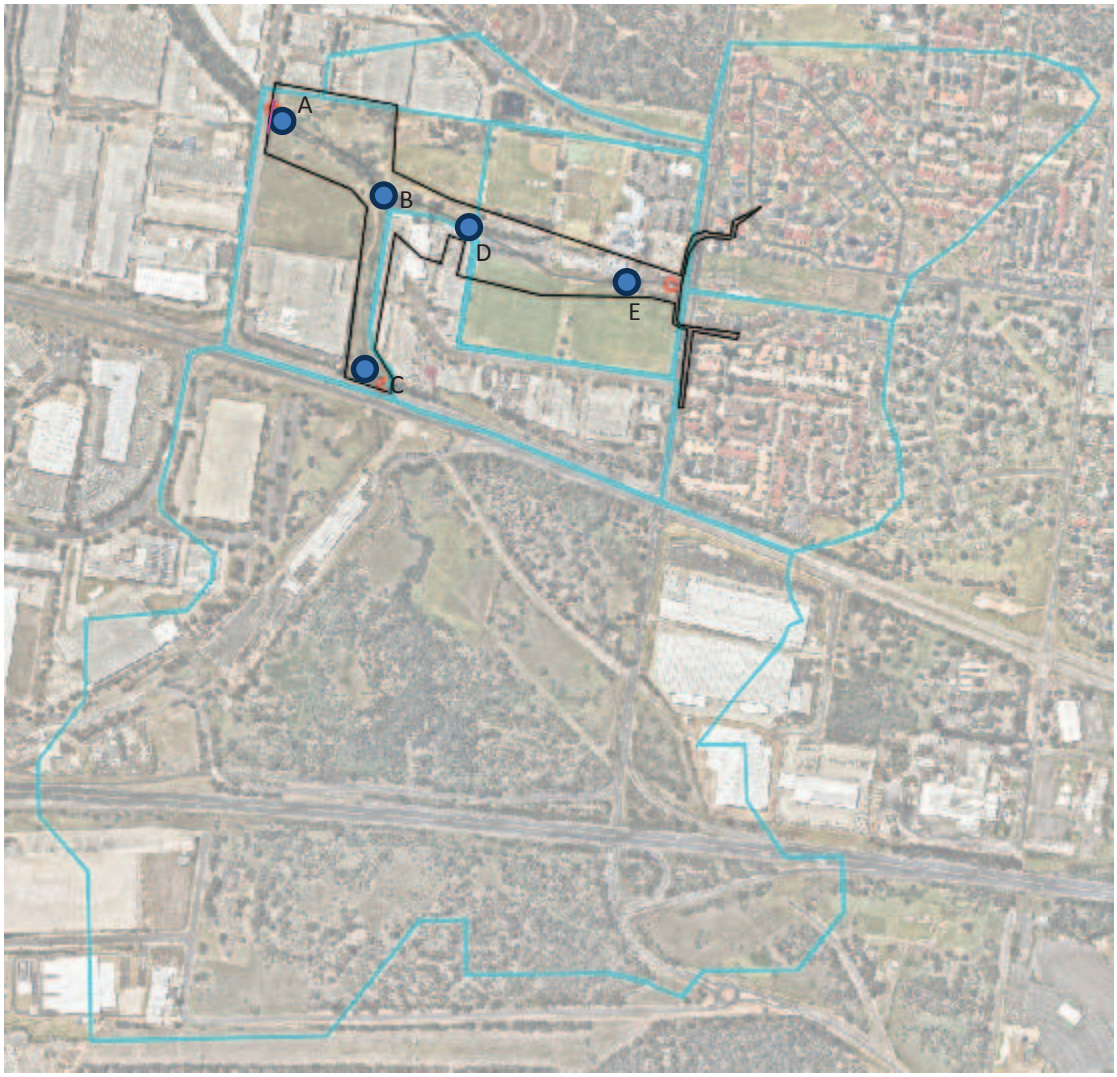


Figure 5. XPSWMM Model Setup

4. Hydrology

4.1 Rainfall Data

Rainfall Intensity Frequency Data (IFD) used in the hydrological model has been obtained using procedures and data provided in AR&R Volumes 1 and 2, which was consequently derived from Blacktown City Council's Engineering Guidelines Manual.

4.2 Peak and Critical Storms

The peak storm is the storm duration that generates the highest flowrate from the catchment. The critical storm is the storm duration that generally produces the largest volume of surface runoff for the catchment resulting in the largest storm events and highest flood levels.

Various storm durations were analysed to determine the peak and critical storm durations for the 100yr and PMF storm events. The following table summaries the peak and critical storm durations for the 100yr and PMF storm events that have been adopted for this study. The peak and critical durations for the existing and proposed scenarios were the same.

Storm Event	Peak Duration	Critical Duration
100yr	90mins	180mins
PMF	15mins	360mins

Table 3. Peak and Critical Storm Summary

4.3 Catchment Definition

As discussed in section 2.2, the Study Area for this development encompasses a 176.1 hectare area within the larger Hawkesbury-Nepean catchment.

The Study Area catchment is bounded by Walter Street at the downstream, and Prospect Nature Reserve (south), St Hedwig Village (north), Parkland Street and Farmingdale Drive (east) at the upstream. Terrain and contour maps within the study area were used to further define catchments affecting the proposed development.

Further to catchment definitions using contour and digital terrain models, a site investigation was carried out to fully determine the catchment extends and characteristics prior to modelling reporting. It was evident from this extension that several catchments would have to be defined further in order to realistically represent overland flows and potential flooding hazards.

4.4 Modelling Assumptions

The following assumptions were made for the hydrology model:

- Major trunk drains only. Minor system not incorporated
- Simplified pit (node) structure. Catchments diverted directly to nodes
- Depression Storage is 3mm
- Loss method was Initial and Continuing Loss

The manning's surface roughness values used to develop the hydrology are the same as the surface roughness values used to develop hydraulic model. Refer to Table 4 for values.

5. Hydraulics

5.1 1D Network

The pipe and pit trunk drainage for the catchment was from created GIS data of existing stormwater networks which was provided by Blacktown City Council.

5.1.1 Assumptions

The following key assumptions were made for preparation of the 1D network:

- Manning's 'n' of 0.016 adopted for existing pipes.
- All energy/pressure loss coefficients at 1D links set as 1.5.
- Manning's roughness for the channel is 0.1
- 33% pipe and pit blockage (pipe sizes between Φ1050mm- Φ1600mm) in accordance with Blacktown City hydraulic modelling requirements. Φ1600 pipes were modelled as

5.1.2 Boundary Conditions

The 1D boundary conditions used in the model are:

Upstream Conditions	Upstream boundary conditions were the inflow hydrographs (flow vs time) applied at the nodes
Downstream Conditions	Downstream boundary conditions were set as the channel base grade (refer explanation below)

Table 5. 1D Boundary Conditions

An additional 1D channel element and node downstream of the Walters Street bridge was added to the model. This enabled the downstream boundary condition or outfall to include the "throttling effect" of the bridge while allowing free flowing downstream of the Walters Street Bridge. The nominated outfall condition applied to the 1D node was set to normal flow conditions.

5.2 2D Network

5.2.1 Model Setups and Assumptions

The following items have been used in the model to develop the 2D Network

- 2D Network Grid Size set as 3.0m
- Time-step is 1 seconds

The time step is 1s which when treated as unitless, is 0.333 the cell size. This is the recommended range outlined in the BMT WBM (2010) "Tuflow User Manual".

Blacktown City Council have advised their preferred manning's surface roughness to be used in flood models and are summarized in the following table.

Surface	Manning's Roughness
Property Lots/Blocks and Heavy Vegetation	0.1
Landscaping and Ovals	0.05
Roads and handstand areas	0.025

Table 4. Manning's Surface Roughness Values

5.3 Modelling Scenarios

This flood study was undertaken to assess the existing flood impacts on the site in order to set the constraints for the proposed development of the site. Modelling of the 100 year and PMF design events has been undertaken to assess the current flood impacts.

6. Flood Assessment

6.1 Hydraulic Results

Existing – Base Case modelling showed results which have been calibrated against the previous study undertaken by Buckton Lysenko Consulting Engineers, providing acceptable tolerances.

Location ID	100 Year Water Levels		100 Year Channel Velocities	
	Previous Report	New Report	Previous Report	New Report
A	51.590	51.260	2.16	2.80
B	53.562	53.503	4.01	1.60
C	54.496	56.762	2.14	1.00
D	56.339	56.912	0.69	2.40

Table 6. Calibration Results

Comparing the two models shows that the flood levels are very comparable. The flow velocities show a larger variance but this is likely to do with the variation between modelling types.

The detailed results taken from the model are summarised below. Floods maps showing the flood levels and flow depths for the 100 year and the PMF design events are included in Appendix A of this report.

Location ID	100 Year ARI Hydraulic Results		PMF Hydraulic Results	
	Water Level (AHD)	Water Depth (m)	Water Level (AHD)	Water Depth (m)
	Existing	Existing	Existing	Existing
A	51.260	1.248	51.770	1.758
B	53.503	0.643	53.723	0.863
C	56.762	0.764	57.151	1.153
D	56.912	0.537	56.995	0.620
E	61.157	0.457	61.187	0.487

Table 7. Existing Scenario Results Comparison

6.2 Modelled Impacts

6.2.1 Site A

The modelling indicates that the 100 year flood waters are generally contained within the extent of the creeks riparian zone. Flood levels vary from FL54.00 at the intersection between the main creek and the tributary running from Reservoir Road and FL51.26 at the Walters Road boundary.

The proposed development of the outdoor sports facilities will be located at a minimum height of RL55.00 which is a meter higher than the 100 year flood levels next to the site.

6.2.2 Site B

The modelling indicates that the 100 year flood waters through Site B are generally contained within the road corridor. Flood levels vary from FL62.00 at the eastern boundary of the site to FL54.00 at the intersection with the main creek channel.

The 100 year flood does not impact on the proposed development of the seniors living village.

Flood planning levels for the seniors living village will be set to ensure the flood waters do not impact on the development and the model will be revisited to ensure that the development does not have any adverse impacts on the existing flood plain.

7. Hydraulic Model Limitations

XPSWMM is based on the Tuflow model which is a 2D hydraulic modelling engine (as described in previous sections). It relies on mass continuity that is water volume into the model equals water volume leaving the model. Mass errors are differences between the water volume into and out of the model. All XPSWMM models will contain small mass errors, and it is ideal to limit the mass errors to ensure a stable and reliable model.

As XPSWMM is a 2D hydraulic package, in areas of supercritical flow, 3D localised effects such as hydraulic jumps and surcharge against obstructions cannot be modelled.

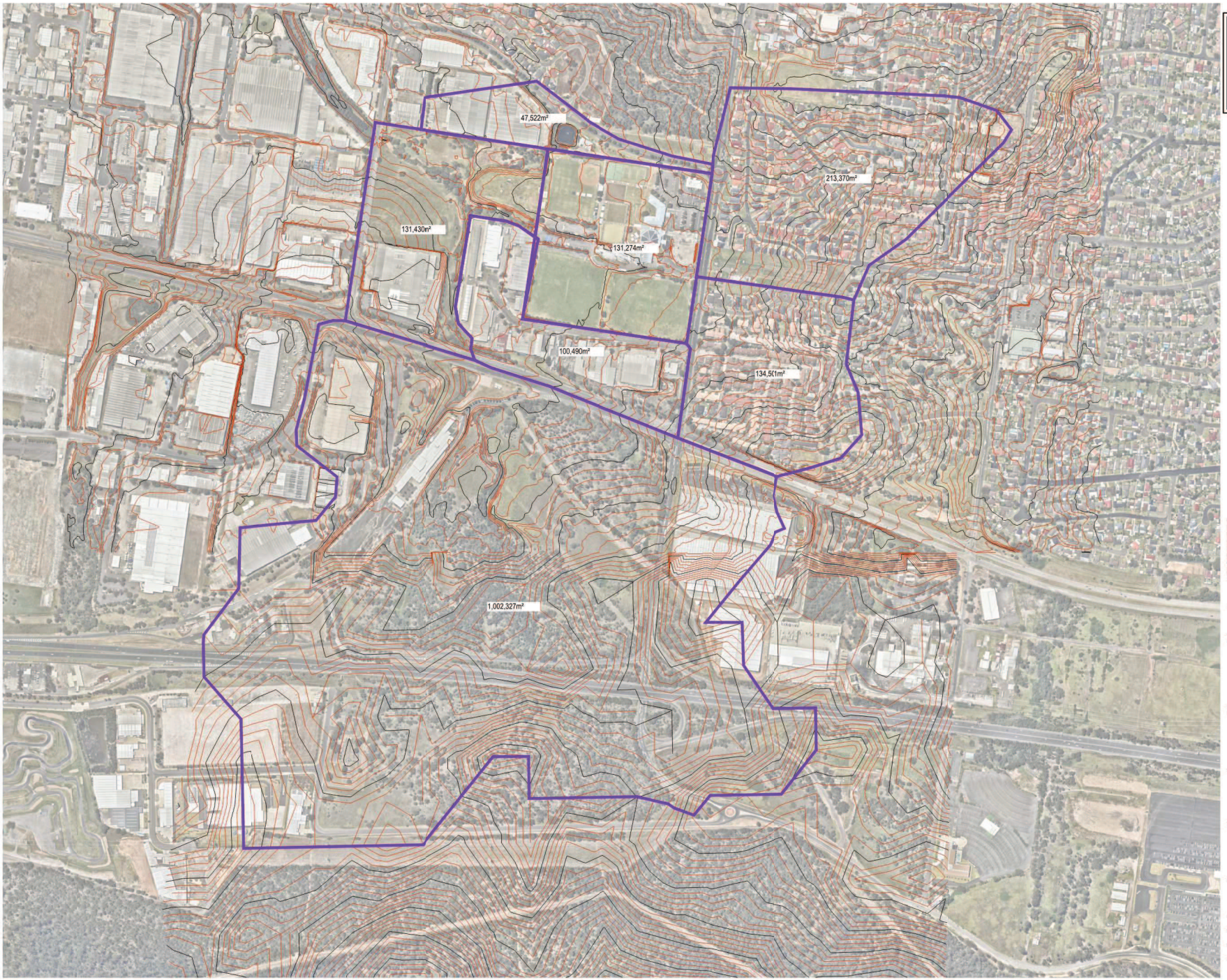
XPSWMM relies on a regular and symmetrical grid to be setup of the surface. 3m cell grid was used in this XPSWMM model. This means that there was only 1 elevation level per cell. Small complex topography may not get captured in a 2D hydraulic model.

To help ensure a stable XPSWMM model, topography should be smooth and elevation changes should be gradual. XPSWMM does not handle well rapid changes in grades and this may cause model instabilities.

Deep flow and trapped low points can also cause model instabilities. The Blacktown Workers Sports Club basement carpark level is an existing trapped low and was excluded from the model for model stability.

Appendix A

Catchment Plan
Flood Maps



LEGEND

131,400m²	DRAINAGE CATCHMENT AREA
	CONTOUR - MAJOR
	CONTOUR - MINOR

REV:	DESCRIPTION	DRAWN	APP'D	DATE
01	ISSUED FOR INFORMATION	CPO	IAH	21.12.15

CLIENT:

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BLACKTOWN WORKERS SPORTS CLUB -
SITE A: OUTDOOR SPORTS FACILITY
SITE B: SENIOR LIVING VILLAGE

TITLE:

CATCHMENT PLAN

PRELIMINARY
NOT FOR CONSTRUCTION

DESIGNED :	TIF	VERIFIED :	/ /
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SCALE :	AS NOTED	APPROVED FOR CONSTRUCTION :	/ /

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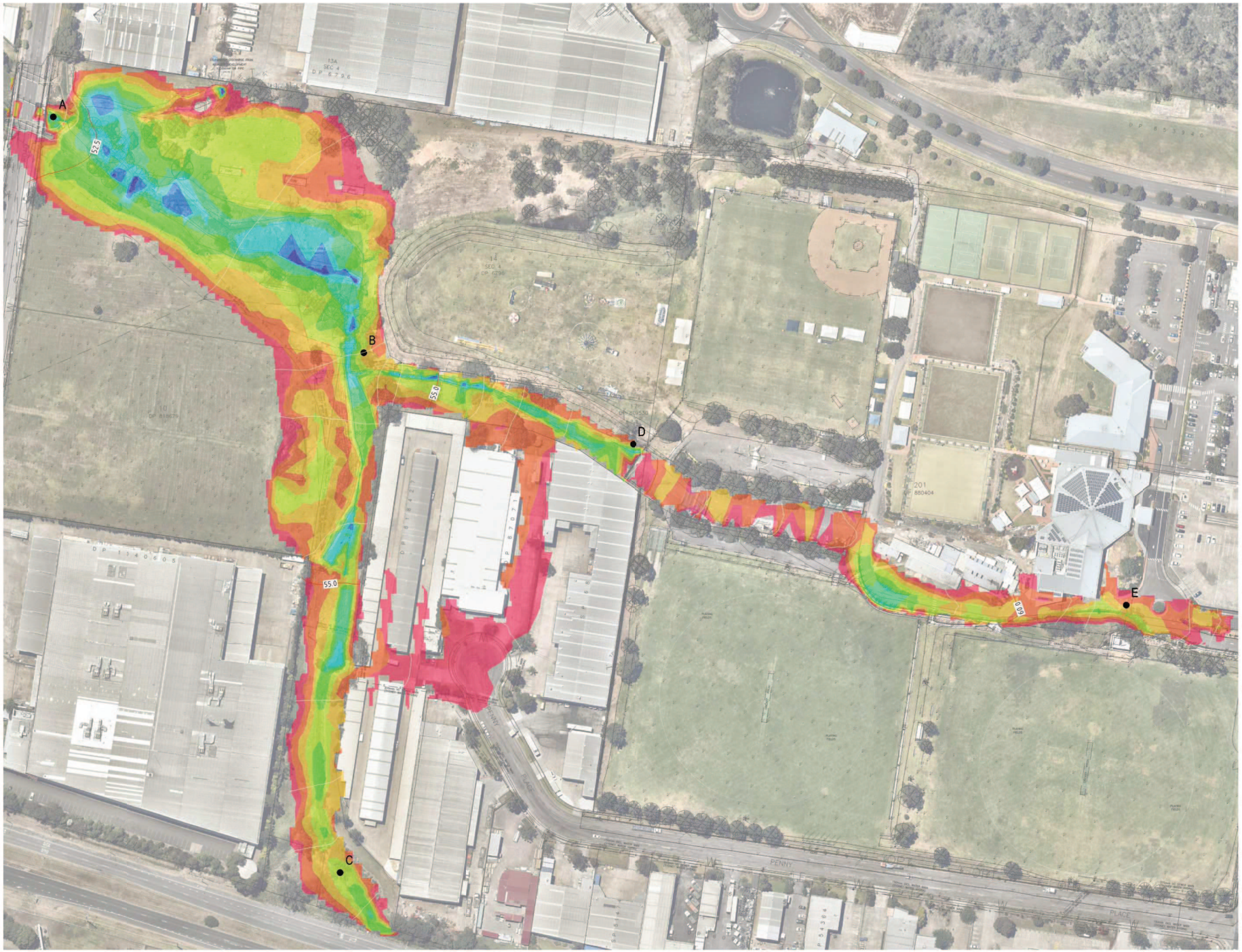

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10		1.850	2.050

REV.	DESCRIPTION	DRAWN	APP'D	DATE
01	ISSUED FOR INFORMATION	CPO	IAH	21.12.12

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BLACKTOWN WORKERS SPORTS CLUB -
SITE A: OUTDOOR SPORTS FACILITY
SITE B: SENIOR LIVING VILLAGE

TITLE:

EXISTING 100YR ARI FLOOD DEPTHS & FWL CONTOURS

PRELIMINARY
NOT FOR CONSTRUCTION

DESIGNED :	TIF	VERIFIED :	/ /
DRAWN :	CP	APPROVED FOR TENDER :	/ /
SCALE :	AS SHOWN	APPROVED FOR CONSTRUCTION :	/ /

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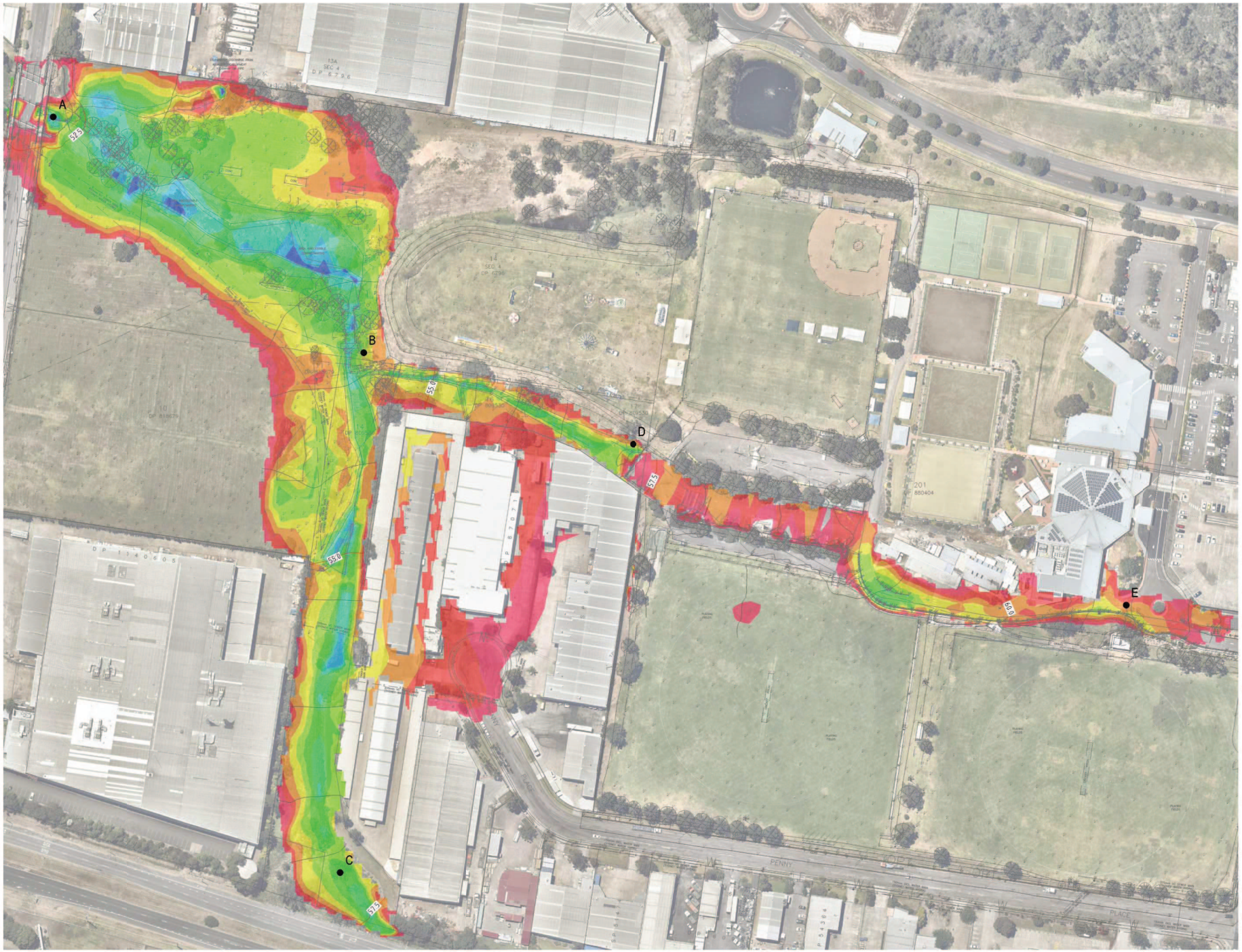

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REV.	DESCRIPTION	DRAWN	APP'D	DATE
01	ISSUED FOR INFORMATION	CPO	IAH	21.12.12

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BLACKTOWN WORKERS SPORTS CLUB -
SITE A: OUTDOOR SPORTS FACILITY
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TITLE:

EXISTING PMF FLOOD DEPTHS & FWL CONTOURS

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DRAWN :	CP	APPROVED FOR TENDER :	/ /
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