SELF-STORAGE SHED DEVELOPMENT

LOT 90 DP1119204

27 ROSS STREET

GOULBURN. NSW. 2580

<u>LOCAL FLOOD & OVERLAND FLOW STUDY</u>

Prepared by SOWDES

7 March 2024

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Local Flood and Overland Flow Study

Introduction

SOWDES has been commissioned by the proponents of a Self-Storage Shed development to be created on a parcel of land identified as 27 Ross Street, Goulburn to undertake a *Local Flood and Overland Flow Study* and to assess the proposed development against the relevant risks associated with the results of the study which are focused on the 10%, 5% and 1% AEP rain events.

Chapter 3.8 'Flood Affected Lands' of the Goulburn Mulwaree Council Development Control Plan provides for specific development controls for development occurring within land that is identified as flood prone or potentially flood prone. The development property is identified as being partially burdened by probable maximum flood (PMF) associated with riverine flooding of the Wollondilly and Mulwaree Rivers, and the overland flow path associated with residential land to the north of the site and therefore a flood risk assessment is required. It is noted that the site is not located within the adopted 'flood planning area' associated with the 1% AEP rain event for riverine flooding, however it is affected by overland flows in event magnitudes greater than the 10% AEP.

In 2022 the Goulburn Mulwaree Council adopted a new Floodplain Risk Management Study which introduced the extents of flood affectation in the probable maximum flood (PMF) rain event and the use of Flood Planning Constraints Categories (FPCC) which relies on a risk matrix table to identify prohibited land uses, permissible land uses with controls, and unrestricted land uses in various categories of risk. The lower southern portion of the development site is located on the fringes of the probable maximum flood extents, and the site is largely affected by areas of flood planning constraints category of FPCC4 with isolated patches of FPCC3 and FPCC2.

The aims and objectives of the local flood and overland flow study report are:

- To demonstrate the existing extent and depths of overland flow, the proposed extent and depths of overland flow in the post-development scenario and identify any adverse impact on downstream properties.
- Prepare a detailed assessment and description of the catchment area which generates overland flow that drains to and through the development property – in particular where the access to and from the development property may be impacted
- establishment of suitable hydrological and hydraulic models to provide a robust assessment of the potential for flooding within the development property
- provide a detailed description of the data sources that form part of the background information within the models including terrain information and post-development regrading of the site.

- Identification of areas within the property and surrounding catchment that may be impacted by the proposed development in the 'design' rain events by undertaking pre-development and post-development comparison modelling.
- Identification and classification of the hydraulic hazard associated with the developed site in the design flood events, and
- Prepare a summary of the findings and the implications (if any) on the proposed development.

It is considered that the proposed development for the establishment of a 40 shed self-storage facility is consistent with the intent of the NSW Flood Prone Land Policy, the NSW Flood Risk Management Manual (2023), and the development controls within Chapter 3.8 'Flood Affected Lands' of the Goulburn Mulwaree Council Development Control Plan.

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7 March 2024

1. DEVELOPMENT PROPOSAL		
#	***DESCRIPTION***	***DETAIL***
1.1	Property details	The development site is an irregular shaped parcel of land – being almost triangular which is identified as Lot 90 DP1119204 and comprises approximately 2,865m²
1.2	Address	27 Ross Street, Goulburn. 2580
1.3	Land zoning	'In1 – General Industrial - Goulburn Mulwaree Council Local Environmental Plan (2009), Land Zone Map 001d and 001G
1.4	Development	The development proposal is for the construction of 40 self-storage sheds to be constructed in two bays with the floor areas vary between 18m² (6 x 3 metres) and 36m² (12 x 3 metres).
1.5		In addition, non-fixed items such a caravans and boats on trailers may be stored along the northern boundary of the site
1.6		The scope of civil works will be limited to providing a uniform surface that essentially mimics the current terrain profile, except that all undulations and hollows will be removed.
1.7		An existing gateway in the lower southern portion of the site will be retained as the sole entry point.
1.8		Existing shrubs and trees along the eastern boundary of the site will be removed and replaced with purpose-designed landscaping.
1.9		The southern portion of the development site below the alignment of the existing property entrance is burdened by the margins of the probable maximum flood associated with flooding of the Mulwaree and Wollondilly Rivers, with the modelled depths of water varying between less than 10mm and 1 metre along the southern boundary.
1.10		The corresponding half of the site is also captured in the Council's recently adopted *Flood Precinct Constraints Category* mapping, with a mix of FPCC2, FPCC3 and FPCC4 areas identified, however it is noted that the site does not fall within the mapped flood planning area presently adopted by the Council.
1.11		In addition to the impacts associated with riverine flooding the site and surrounding area is also moderately affected by mainstream overland flows that are generated in the residential lands within the Bradfordville areas upslope to the north and northwest.
1.12		The focus of the report will be on the mainstream overland flows associated with the 10%, 5%, and 1% AEP 'rare' rain events that burden the site as these are most likely to have a direct and adverse effect, and assessing the impacts on downstream flows in the post-development scenario.

2. EXISTING SITE CONDITIONS

#	*DESCRIPTION*	*DETAIL*
2.1	Access	The development site is accessed from the Ross Street traffic corridor which lies adjacent to the eastern boundary of the holding with a formed layback and access driveway located approximately 20 metres north of the southeast corner.
2.2		The site is located just below the crest of the Ross Street road formation as it crosses the dis-used Goulburn to Crookwell rail line with the old rail corridor adjoining the northwestern boundary.
2.3		The southwestern and southern aspects of the site are bordered by a single industrial holding that has a separate property access off Ross Street approximately 70 metres to the south of the entrance to the development site.
2.4	Slope / topography	The development site has a natural fall from the north toward the south at an average grade of 3.5% (2°), with a cross fall from the northwest toward the southeast, however the slope across the site is relatively uniform apart from some minor undulations and depressions.
2.5		The eastern aspect of the site commencing from the northeast corner and extending down to the entrance gateway sits below the natural surface level of the road reserve and pedestrian footpath located outside the boundary with the depths variations commencing at approximately 900mm and tapering off to zero at the existing gateway.
2.6	Vegetation and ground conditions	The vegetation formations throughout the site are set to a mix of four to five old cypress trees along the eastern boundary, a single and isolated eucalypt tree in the southern quarter, and a blend of grasses and other ground covers throughout the remainder of the land area.
2.7		The site is presently used to store formwork and site safety materials associated with the building and construction industry along with two locked containers and some ancillary items.
2.8		From the existing gateway there is a gravel driveway that extends across to the opposite boundary, and there are a few worn tyre tracks in the centre of the site resulting from accessing the stored materials over time.
2.9	Stormwater drainage	The site is presently not serviced by any form of stormwater drainage infrastructure, the only stormwater drainage system of note is the existing roadside kerb and gutter system at the front of the property which is higher that the natural surface levels inside the site north of the existing entrance gateway.

2.10		There is a transition in surface level differentials south of the existing entrance gateway where the natural surface levels inside the site essentially match the surface levels of the road reserve immediately adjacent.
2.11	Constraints and other considerations	The site is burdened by an easement for overhead power lines that runs parallel but at slightly different offsets from the northwestern boundary - varying in width from 12.80 to 10.60 metres based on survey information provided.
2.12		The average width of the easement within the property is 11.70 metres however the location of the easement restricts the placement of buildings within that zone.
2.13		The northwestern aspect of the site is bordered by the disused Goulburn to Crookwell rail line which is presently grazed by a few privately owned horses, however personal communications with a neighbouring property owner to the west indicates that the rail authority's property management agency do undertake regular inspections and maintenance of the rail corridor.
2.14		The Ross Street road corridor has a formed kerb and gutter system extending from the intersection with Taralga Road to the north and continuing past the frontage of the property to the south, however the section of the road corridor that crosses the old rail corridor does not have a formed kerb and gutter.
2.15		The missing section of kerb and gutter along the section of Ross Street to the immediate north of the development site is largely responsible for the direction of the overland flows that burden the site.
2.16		Typically a road corridor is used as part of the drainage system to convey surface water in the large rain events however with the missing section of kerb and gutter and some landforming to direct water off the road at the upstream end where the existing kerb terminates overland flows from the residential precinct to the north are effectively forced into the development site.

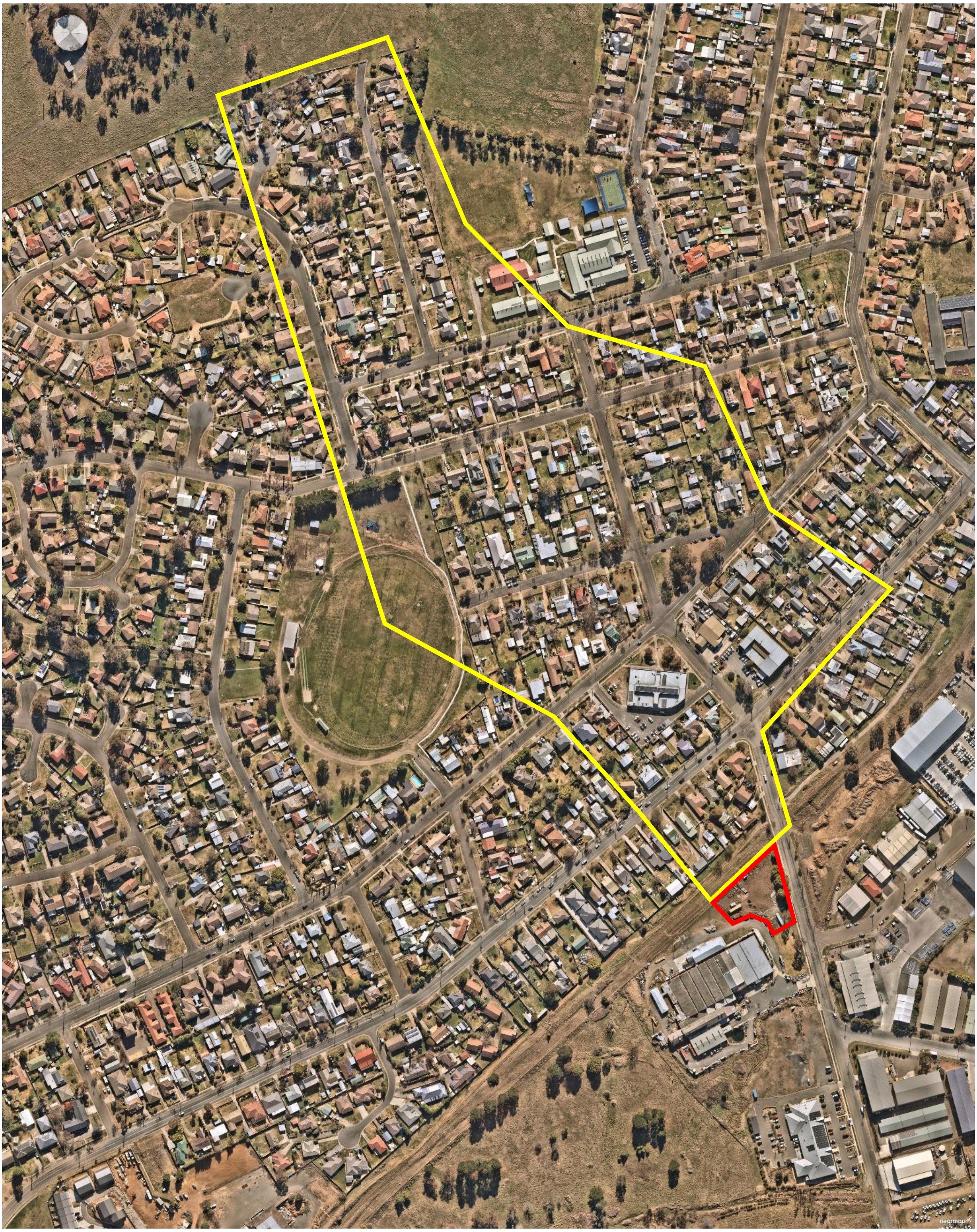


Figure 1. Aerial image of the development site (red) and the contributing catchment area to the north and northwest of approximately 20 hectares (yellow) which generates rainwater and surface water runoff that burdens the site. It is noted that the surface types within the catchment are fairly uniform with low density residential dwellings, roads corridors, and open public spaces. The development site and adjoining lands to the east and south transition into industrial developments.

3. OVERLAND FLOW AND CATCHMENT DETAILS		
#	*DESCRIPTION*	*DETAIL*
3.1	Flood liable lands	A recent flood study of riverine flooding within the Goulburn city area identified that in the probable maximum flood (PMF) rain event the extent of flooding from the Wollondilly River located to the south and possibly in association with the confluence of Mulwaree River to the southwest would over-top the banks and partially inundate the southern portion of the development site below the entrance driveway – along with adjoining lands to the east, south, and southwest.
3.2		Whilst a portion of the development property is located within the extents of the PMF it sits well outside and above the adopted flood planning level for riverine flooding which is equivalent to the 1% AEP level plus a freeboard of 800m.
3.3		There are however the sources of overland flow that emanate from the residential precinct on the northern aspect of the development property and flow across the northwestern boundary that need to be considered.
3.4		For overland flows not directly associated with riverine flooding the Council's Development Control Plan requires that all buildings (habitable or otherwise) have a finished floor level that is above the 1% AEP water levels plus a freeboard of 500mm – where practical and appropriate.
3.5	Catchment details	The catchment area which generates rainwater and surface water runoff that directly affects the boundaries of the development property originates from the north and northwestern aspects and comprises an area of approximately 20 hectares.
3.6		The catchment is made up of a mix of low-density residential dwellings and road networks with areas of open grasslands, managed parks, gardens and sporting fields, and the average slope across the length of the catchment is 3% (26 metres of rise over a distance of 850 metres).
3.7		General rainwater and overland flows which are generated within the contributing catchment and are too large for the existing stormwater drainage system (pit and pipes) to manage are largely moved through the catchment via the road network which lies in the lower areas of the flow path.
3.8		The majority of the road network throughout the catchment area is formed with a 150mm high straight-back kerb and gutter system on each side of the sealed roadway the retains most of the flows within the road reserve.

3.9		There are however several break-out location areas within the catchment where overland flows in the 5% AEP and rarer rain events overtop the kerbs, and in some instances the outflows directly affect adjoining properties.
3.10		Noticeable locations within the catchment where overland flow exceeds the capacity of the kerb and gutter system are the sag points just to the east of the junction of Ross Steet and Record Street, just to the east of the junction of Ross Street and Queen Street, and across the entire junction of Ross Street and Taralga Road.
3.11		Where overland flow breaches the kerb and gutter system it becomes sheet flow across the entire width of the road reserve including footpaths and verges, eventually draining back into the roadway further downstream from the sag point and continuing toward the development site.
3.12		The section of Ross Street to the immediate north of the development site that crosses the dis-used Goulburn to Crookwell rain line does not have any kerb and gutter system, and the terrain either side of the road centreline is formed with a fall away from the roadway to help drain water.
3.13		The missing section of kerb and gutter to the north of the site and the landforming from the roadway directs approximately 60% of the overland flow from the upstream catchment toward the development site.
3.14		The mixed nature of land use types that form the catchment is represented by variable roughness characteristics that affect the flow of water over the surface however the overall elements across the catchment are uniformly distributed hence a Mannings 'N' coefficient value of 0.15 which is a median value for 'low density residential' land use has been adopted in accordance with of Table 6.2.2 of AR&R (2019).
3.15		To determine the bounds of the contributing catchment and the downstream receiving areas and flow paths an initial and larger catchment model of approximately 85 hectares was prepared to help clearly define the areas that did and did not drain toward the development site.
3.16		Throughout the contributing catchment area there is a network of 'pit and pipe' stormwater drainage infrastructure that helps manage runoff in the 'very frequent' and 'frequent' rain events, and possibly up to the lower end of the 'rare' rain events, however for the purposes of the flood risk assessment the stormwater drainage system has not been included as it assumed that the system is full at the commencement of the model.

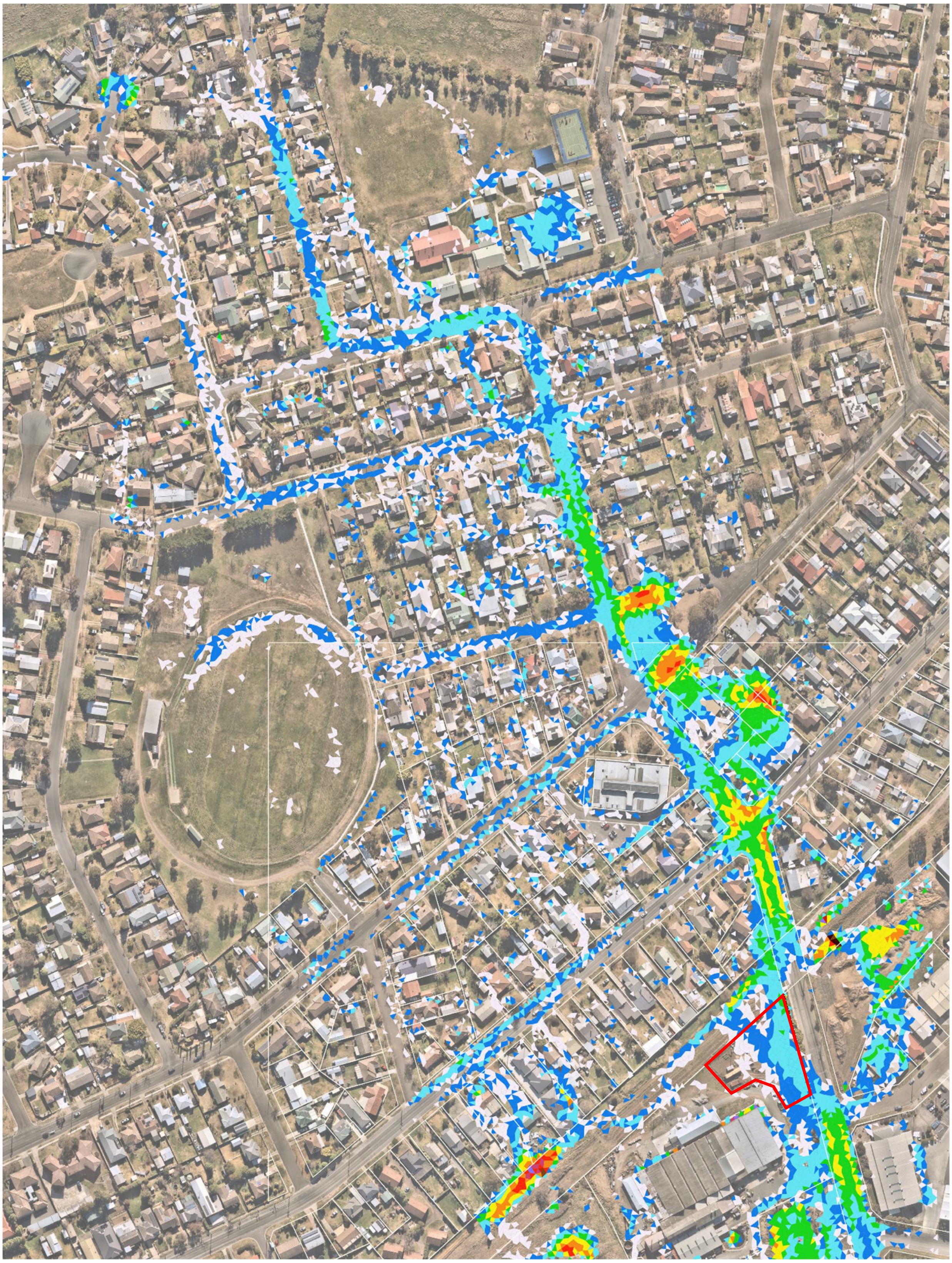


Figure 2. Image from the 1% AEP pre-development model showing the overland flow pathways through the defined catchment area that eventually reach the northern aspect of the development site which is outlined in red. The small area of flow around the residential precinct to the immediate left of the development property which is in the bottom central section of the image does not directly impact the site.

4. OVERLAND FLOW MODELLING RESULTS		
#	***DESCRIPTION***	***DETAIL***
4.1	Details of the flood modelling and parameterisation	To assess the impacts of overland flows and surface water drainage on the proposed development both pre-development and post-development stormwater drainage and overland flow models have been undertaken of the existing site and surrounding catchment area using a combination of LiDAR mapping information and detailed contour survey of the property and adjoining road corridor between the Ross Street / Taralga Road intersection and the intersection of Ross Street with O'Sullivan Place to the south of the site.
4.2		To create a terrain profile for the stormwater drainage and overland flow assessment outside of the detailed property survey LiDAR information was obtained for the development area from the Geoscience Australia '*Elevation and Depth Foundation Spatial Data'* website (ELVIS).
4.3		The defined catchment area and development property is captured within two datasets (Goulburn201906-LID1-AHD_7506152_55_0002_0002 and Goulburn201906-LID1-AHD_7526154_55_0002_0002) which has a grid area of 2km x 2km which was downloaded as 2 metre grid Digital Elevation Model metadata item.
4.4		The primary objective of the modelling is to determine the existing overland flow patterns, water depths, and velocities that affect the development property and to conservatively estimate for the 'design events' – being the 10%, 5% and 1% AEP rain events where the main impacts from external sources are experienced.
4.5		Results from the modelling exercise were also used to help define areas for the placement of stormwater drainage infrastructure throughout the development site.
4.6		Software used to undertake the modelling is the '*InfoWorks ICM Ultimate*' which is licenced, distributed, and supported by Autodesk.
4.7		'*InfoWorks ICM Ultimate*' is a stormwater and flood modelling program incorporating 1D network and 2D scaled mesh operations to perform both above and below ground hydrology and hydraulic simulations.
4.8		The digital elevation model was imported into the software to create a terrain profile which was paired with a georeferenced aerial image of the catchment area for ease of identification, correlation, and result analysis purposes.

4.9		It is noted that in the pre-development and post-development models all water depths less than 10mm have been turned off to help clear the image and to remove multiple areas of isolated and small ponding.
4.10		In accordance with advice from the Goulburn Mulwaree Council's Development Assessment Department the overland flow and flood assessment has adopted the *Australian Rainfall & Runoff 2019* (AR&R2019) modelling guidelines.
4.11		Within the model a direct-rainfall methodology was employed which is deemed suitable to determine overland flow paths, depths, and velocity information for small catchment areas.
4.12		Design parameterisation and rainfall data for the site was obtained directly through the Australian Rainfall & Runoff Data Hub and the Bureau of Meteorology portal and was focused on the 10%, 5%, and 1% AEP rain events as these are generally the critical rain events of interest for assessing stormwater drainage systems and design floor levels.
4.13		As the characteristics of the upstream catchment area is comprised of varied but relatively uniform land uses and surface types associated with 'low density residential dwelling' development a roughness coefficient (Manning's 'n') of 0.15 has been adopted which is in accordance with Table 6.2.2 of the AR&R2019 guidelines.
4.14		Within the Bureau of Meteorology rainfall data an initial rainfall loss of 16mm is adopted however the model does not include an assumption of a continuing loss.
4.15		Within each of the modelled rain events (10%, 5% and 1% AEP) which include an ensemble of 10 different temporal patterns the maximum water level and hydraulic hazard was essentially the same across each of the patterns with just the timing of peak water level varying.
4.16		For analysis purposes the 2-hour storm with temporal pattern #8 run for a 180-minute duration was adopted as this tended to have the largest rainwater inflows, two bursts of rainfall intensity with an irregular burst in the rainfall pattern that continued until the end of the run, and it was possible to observe how long the depths of water remained or completely drained after the peak flows in the rain event.
4.17		The modelled catchment area that drains to the development site covers 38.30 hectares and it is broken down into approximately 61,000 meshing triangles that have an average area of 7.66m², and each 'working' face allows normal flow conditions from one mesh triangle to the next.

4.18		The large modelling area validates the effective upstream catchment that directly burdens the development property (approximately 20 hectares) by identifying other drainage regimes that occur outside, around, and beyond the property, and which therefore can effectively be ignored.
4.19		Within each of the modelling scenarios 'break lines' were created along the edges of the Ross Street roadway to force meshing triangles where the kerb and gutter and/or edge of bitumen is located such that height differentials between the back and top of the kerb and the road surface were clearly identified.
4.20	Pre-development model	The pre-development model comprised a total catchment area of approximately 38.30 hectares which included adjoining upslope properties to the northwest and northeast to gauge the impact of all external sources of surface water runoff that potentially burden the site.
4.21		From the modelling outcomes it is possible to determine that the 'effective' catchment area that directs overland flows into or adjacent to the site covers an area of approximately 20 hectares.
4.22		The results for each of the modelled rain events indicate that the eastern half of the site immediately adjacent to the Ross Street road corridor is affected by depths of water that vary between 50mm and 250mm with the majority of the flow entering the site in the extreme northern corner.
4.23		The flow of surface water from the Ross Street traffic corridor that burdens the site splits into two separate regimes once off the roadway; the first being flows running adjacent to the road corridor and then directly into the northern corner; and the second is a channel of flows that runs along a dirt track on the northern side of the rail corridor for approximately 50 metres before hitting a low point and some of the water then turning at right-angles to cross the rail corridor and enter the site approximately midway along the length of the northwestern boundary.
4.24		The remaining flow of surface water that does not cross into the subject development site continues along the rail corridor track in a southwesterly direction for a short distance and then re-enters the overall surface water considerations which is discussed further in Items 4.32 and 4.33.
4.25		At the peak of the 10% AEP rain event the maximum flow of water across the northwestern boundary is 0.30 m^3/s, the highest flow rate is 0.25 m/s, and the maximum depth of water is 140mm

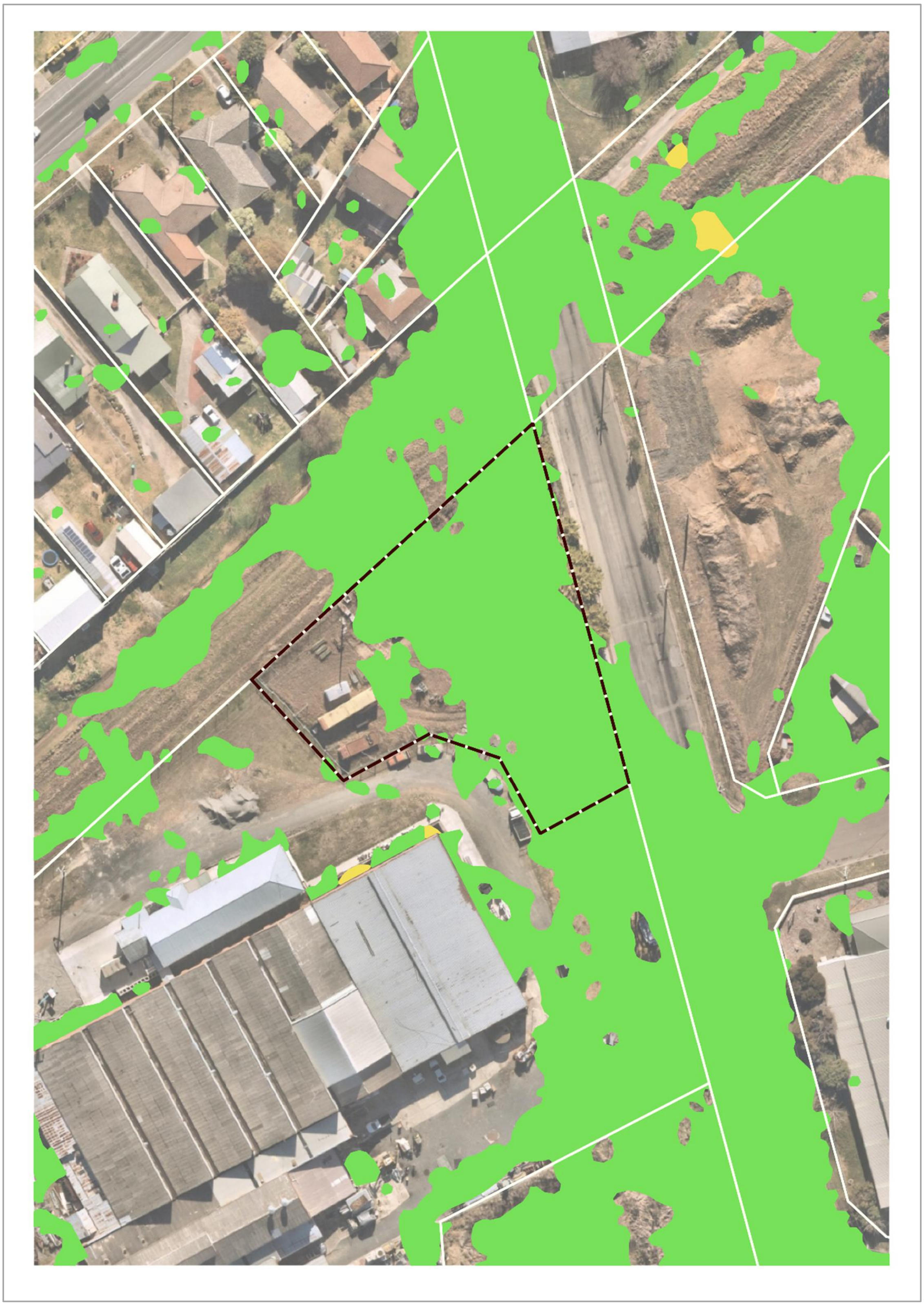
4.26		At the peak of the 5% AEP rain event the maximum flow of water across the northwestern boundary is 0.36 m³/s, the highest flow rate is 0.28 m/s, and the maximum depth of water is 163mm
4.27		At the peak of the 1% AEP rain event the maximum flow of water across the northwestern boundary is 0.78 m³/s, the highest flow rate is 0.37 m/s, and the maximum depth of water is 232mm.
4.28		In the pre-development models the northern corner experiences the deepest and fastest flowing water whilst an area of approximately 350m² in the western portion of the site is not affected by overland flows in any of the design events which is an important consideration for the proposed development.
4.29		Once overland flows have entered the site the flow of water is essentially in a north → south pattern with the general flow exiting along the entire length of the southern boundary and the lower southeast portion all the way back to the property entranceway, however in the 1% AEP event there is also outflows along southwestern aspect of the property boundary.
4.30		Once the overland flows extend beyond the southern boundary of the site it converges with a separate source of overland flows that originate from the industrial lands to the northeast and east on the opposite side of the Ross Street road corridor.
4.31		This eastern source of overland flow travels in a northeast to southwest alignment and the two systems merge at the intersection of Ross Street and O'Sullivan Place where they then flow across and to the south of the industrial land holding that adjoins the subject development site.
4.32		It is observed in the pre-development models the adjoining industrial holding to the immediate southwest is impacted by overland flow that also enters the site from the rail corridor along the northern aspect.
4.33		This source of overland flows is essentially the residual flow of surface water that doesn't enter the subject development site via the secondary flow referenced in Item 4.23 and it tends to be directed toward an existing building within the site with a portion of the surface water eventually flowing around the footprint of the building toward the east and merging with the outflows from the subject development site.
4.34		Within each of the pre-development models it is highlighted that there is significantly deeper pool of water along the northern facing façade of the existing building which is created by an abrupt change in the natural surface levels within that site that is associated with terracing and landforming around the building.

4.35	Site design considerations based on pre-development model findings	The pre-development overland flow models identified that to a reasonable and practical extent there is a need to maintain the existing flow of water through the site such that there is no significant increase in flow patterns or direction in the post-development scenario.
4.36		The pre-development models also provided important data on water depth and flow characteristics such that informed design of the site could be undertaken.
4.37		From the 1% AEP model (being the larger of the rain events) the water depths and flow velocity were used to define the '*flood function'* characteristics of the catchment with the 'flood conveyance', 'flood storage' and 'flood fringe' areas identified.
4.38		Classification of the three separate flood function components is important in determining the likely impact of development in a design flood event – including overland flows, with each of the separate flood function classifications responding differently to changes.
4.39		'Flood conveyance' is defined as those areas where a significant flow of water occurs and are normally associated with natural and man-made channels and are often the areas of deeper flows and/or where the higher velocities occur – changes in topography or development within these areas can cause a significant redistribution of flood flow or cause a significant rise in flood levels.
4.40		'Flood storage' are areas that temporarily store floodwater in a flood event and by doing so attenuate or slow-down the peak water flows and flood levels, and as the main flow of floodwater recede, they slowly release the stored water downstream – filling or removing flood storage areas reduces their ability to attenuate the flood flows and thereby flood flows and levels downstream may significantly increase.
4.41		'Flood fringe' is the remainder of the flood extent and is generally the areas where effects on flood function are not a constraint with development unlikely to significantly alter the flood behaviour.
4.42		Determination of the 'flood function' for overland flow within the 1% AEP model has been undertaken using the criteria prescribed by *Howells et al (2003*) with the flood conveyance (floodway) defined as: **velocity x depth >0.25m/s and velocity >0.25m/s, or velocity >1.0m/s and depth >0.15m** Flood storage is the area outside of the floodway with a depth greater than 500mm, whilst the flood fringe is the area outside the floodway with a depth less than 500mm.

4.43		Using the above the criteria the 1% AEP flood function has been determined for the catchment with a focused view of the development site and surrounding areas displayed in Figure 03 (it is noted that the flood function calculations have been undertaken using water depths that are greater than 25mm).
4.44		From the details in Figure 03 it is observed that the entire site and surrounding area is located within the 'flood fringe' which would suggest that with certain controls 'development' within the subject site will not have a significant effect on flood and overland flow behaviour.
4.45		In each of the design event pre-development models a separate hydraulic hazard or 'flood hazard' has been determined which provides important information on particular characteristics of the flood event that are likely to have an effect or present a risk to people, vehicles, infrastructure, and buildings.
4.46		The hazard classifications are divided into six separate categories based on a combination of flow velocities and water depth thresholds with slower and shallower water representing a lesser risk than the deeper and faster flowing water.
4.47		The hazard categories are defined as 'H1' to 'H6' with areas of 'H1' and 'H2' generally safe for all people, infrastructure, buildings, and vehicles with the exception of 'small vehicles' at category 'H2'.
4.48		Hazard categories 'H3' and 'H4' are generally deemed to be unsafe for all vehicles and people, whilst categories 'H5' and 'H6' are unsafe for essentially all development considerations.
4.49		For each of the design rain events the pre-development site and surrounding areas are classified as 'H1' hazard categories meaning that the site is considered safe for all potential land users and development types – this is particularly important for a vehicle risk assessment with the possibility that egress from the site may be required in a large rain event, although the site should not be used or accessed in such situations.
4.50	Post-development model	To gauge the potential impact of the proposed development on existing overland flows a second 'post-development' model was prepared for each of the design rain events that incorporated the existing external terrain data with the proposed storage sheds which includes assigned floor levels, and the stormwater drainage system to be installed on the northern and eastern aspects of the proposed shed buildings.
4.51		The primary objective of the post-development model was to assess the impacts of the shed placements on the existing overland flow patterns, and to review the proposed shed floor levels against any changes in water depths throughout the site.

4.52		The layout of the shed buildings allows for the continued flow of surface water through the site whilst still exiting along the same sections of the southern boundary as is the case in the pre-development conditions.
4.53		The inclusion of the internal stormwater drainage system removes some of the inflowing water received in the earlier part of the rain events to the southeastern portion of the site where it discharges to the kerb and gutter system in Ross Street.
4.54		The volume of water removed through the 'pit and pipe' system is relatively constant across all design events as the capacity of the pipe system is effectively only designed to convey the flows associated with the 10% AEP event in accordance with Council's engineering standards for commercial / industrial developments.
4.55		The remaining flows of water through the site are predominantly channelled between and around the proposed sheds with only slight changes in water depths where the flows first encounter the footprint of the buildings, but with the natural slope of the site these quickly dissipate and equal the pre-development levels slightly downstream.
4.56		The position of the western shed units provides a slight interception to the flow of water through the central portion of the site, however this is the area of the site where any depths of water are generally less than 50mm in both the pre-development and post-development conditions.
4.57		The effect of the interception is that a small amount of water is passed to the western aspect of the site, and a 'shadow' zone is created immediately downstream and to the south of the building footprint.
4.58		The depth of the water passed to the west of the site continues to be less than 50mm with the exception of a very small section adjacent to the western boundary in the 1% AEP event where the depth of water is between 50mm and 100mm, the bulk of the intercepted water is collected in the pits and pipes that are installed at the front of the building footprint.
4.59		A comparison of the pre-development and post-development models for each of the design events shows that the water levels in each case are essentially identical at the corresponding location which indicates that the net effect of the proposed shed buildings on the flow and depth of water is negligible.
4.60		The post-development results also reaffirm the design finish floor levels for the sheds which are proposed to be approximately 300mm to 400mm above the modelled water levels.

4.61		Not far south of the development the post-development flows essentially revert to the pre-development conditions, although it is noted that the visual representation between the two scenarios is slightly skewed as the meshing process between events is not 100% identical due to the change in site conditions.
4.62		As with the pre-development models, a 'flood hazard' assessment of the post-development conditions has been undertaken which does not show any change in the post-development conditions – the hazard category for each rain event remains as 'H1'.
4.63	Modelling summary and results	The pre-development and post-development modelling results are presented in Figure 04 to Figure 09 of this report with the models collated in order of event magnitude starting from the more frequent rainfall event being the 10% AEP and finishing with the rarer and larger 1% AEP design rain event.
4.64		For each event magnitude a comparison of the pre-development and post-development results for water depths and levels are present on the same page, and this is immediately followed by a comparison of the pre-development and post-development 'flood hazard' for the same event magnitude.
4.65		Comparative images between the pre-development and post-development water depth conditions for two transects through the site located on either side of the long row of sheds where the main flow streams are created are included in Figure 10 and Figure 11.
4.66		The transects show the minor change in water levels relative to the existing surface levels with each design rain event represented by a different line colour.



SELF-STORAGE SHEDS 27 ROSS STREET. GOULBURN. NSW. 2580	
1% AEP PRE-DEVELOPMENT FLOOD FUNCTION (Depth >0.025)	
FIGURE:	03

Site boundary

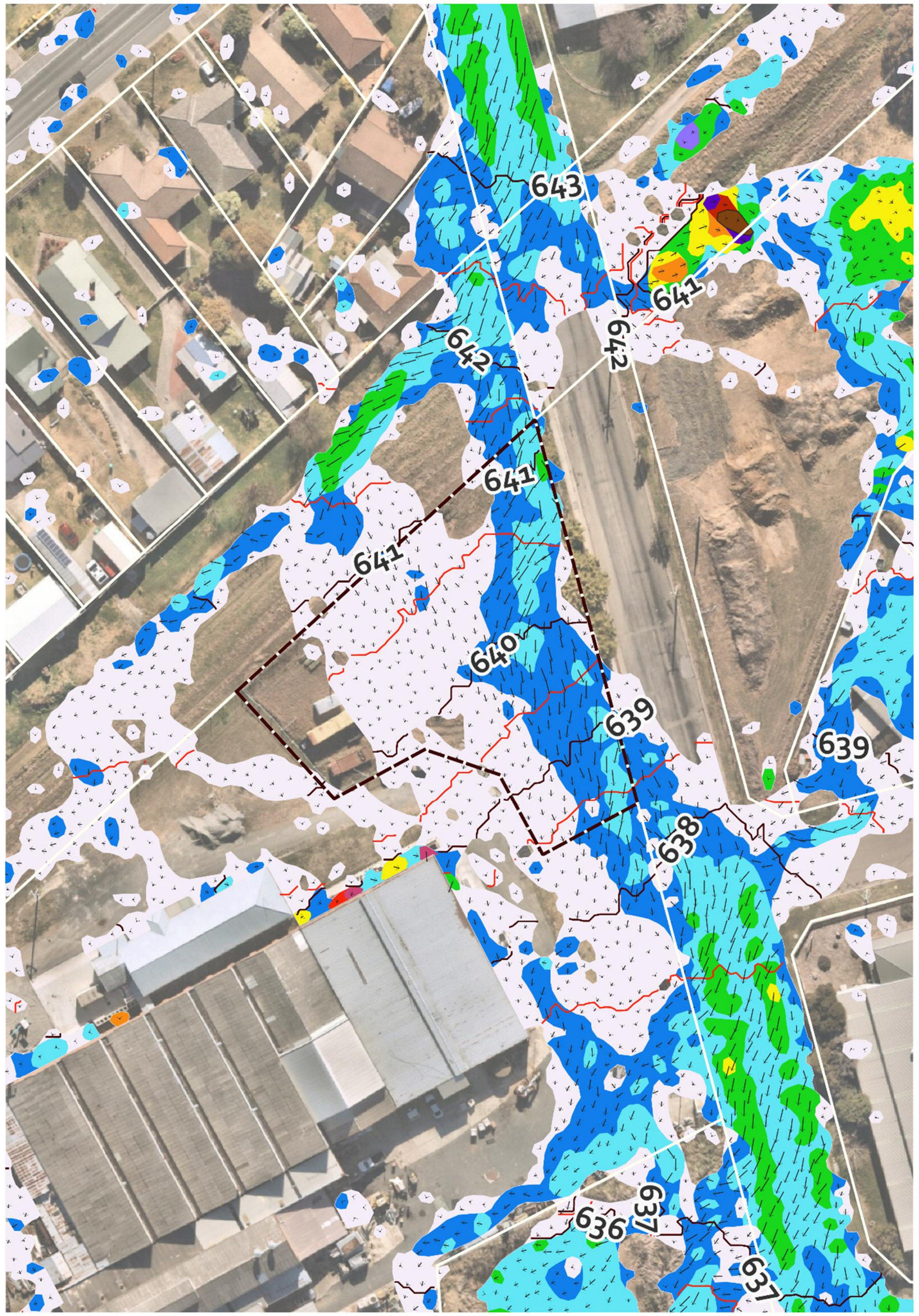
Cadastral boundary

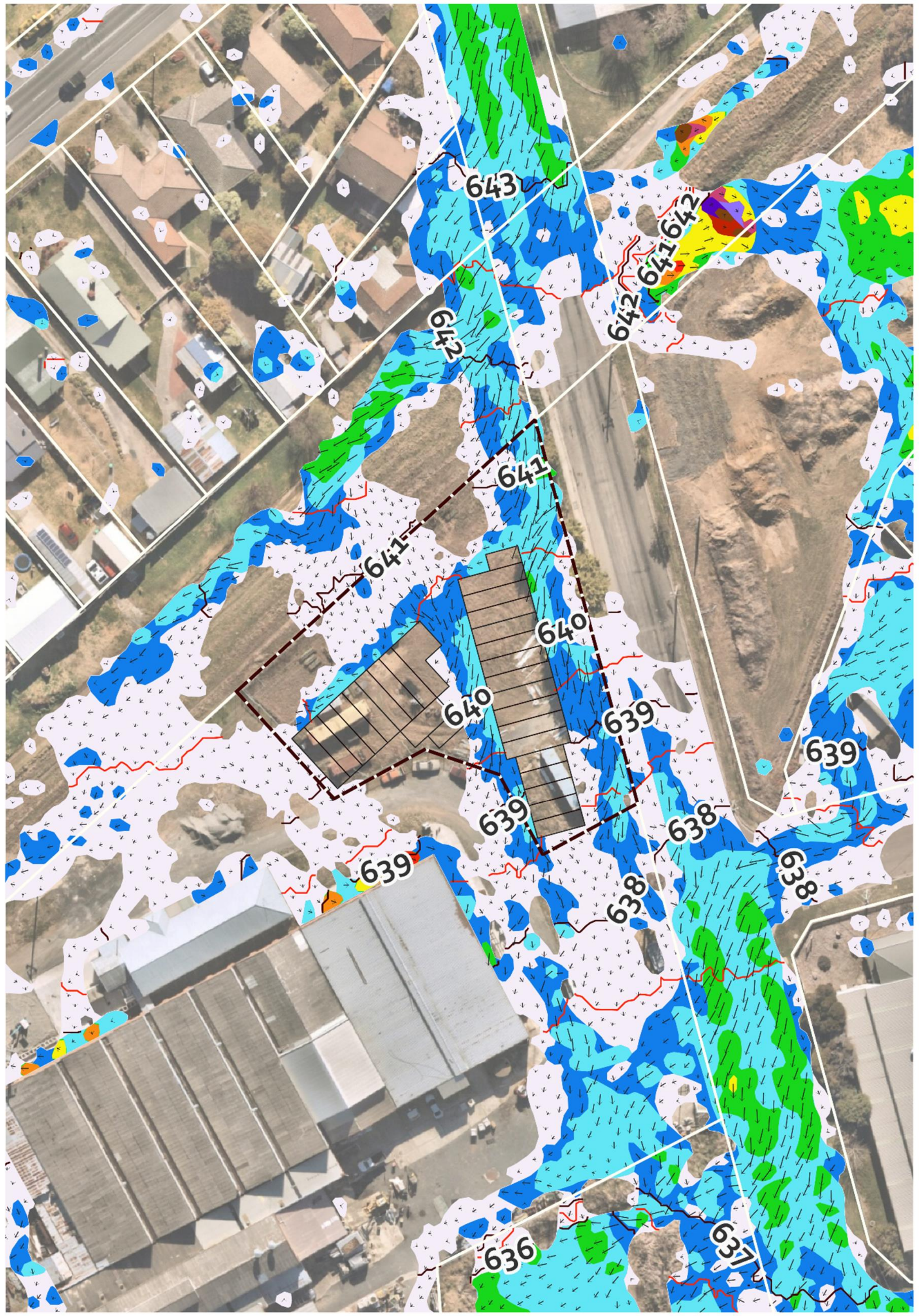
Floodway

Flood Storage

Flood Fringe

SOWDES
PO Box 619
Goulburn. 2580
sowdes@sowdes.com
0428 863 401





SELF-STORAGE SHEDS
27 ROSS STREET
GOULBURN. NSW. 2580

10% AEP
PRE-DEVELOPMENT &
POST DEVELOPMENT
OVERLAND FLOW WATER
DEPTHS & LEVELS

FIGURE: 04

Site boundary

Cadastral boundary

Water Depths (m)

0.00 – 0.050
0.050 – 0.100
0.100 – 0.200
0.200 – 0.300
0.300 – 0.400
0.400 – 0.500
0.500 – 0.600
0.600 – 0.700
0.700 – 0.800
0.800 – 0.900
0.900 – 1.000
> 1.000

Major water level – 1.0m

Minor water level - 0.5m

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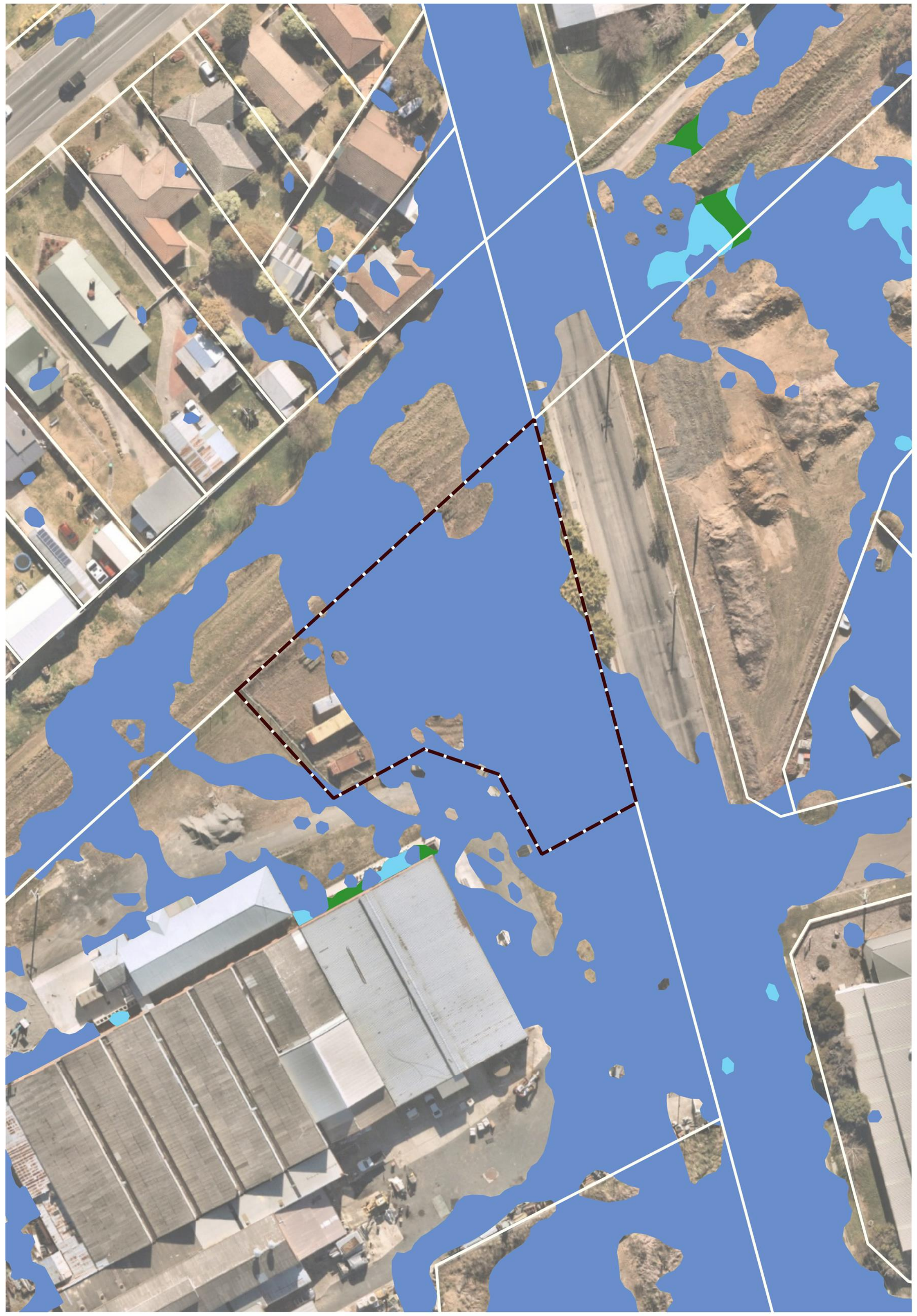

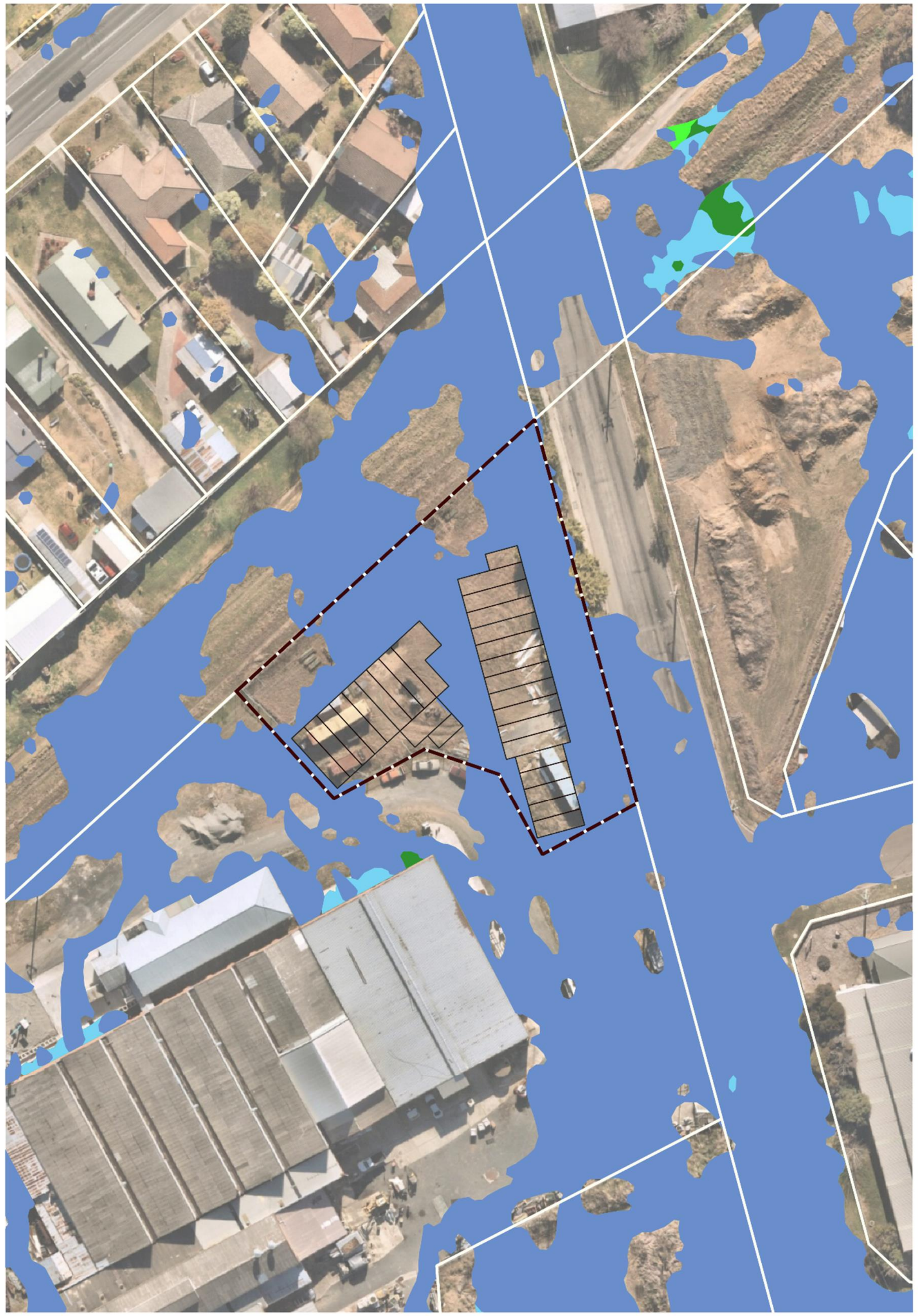

SELF-STORAGE SHEDS
27 ROSS STREET
GOULBURN. NSW. 2580

10% AEP
PRE-DEVELOPMENT &
POST DEVELOPMENT
FLOOD HAZARD
CATEGORY

FIGURE: 05

Site boundary

Cadastral boundary

Hazard Category

H1 (Generally safe for vehicles, people & buildings)

H2 (Unsafe for small vehicles)

H3 (Unsafe for vehicles, children & the elderly)

H4 (Unsafe for vehicles & people)

H5 (Unsafe for vehicles & people. All buildings subject to structural damage)

H6 (Unsafe for vehicles & people. All building types considered vulnerable to failure)

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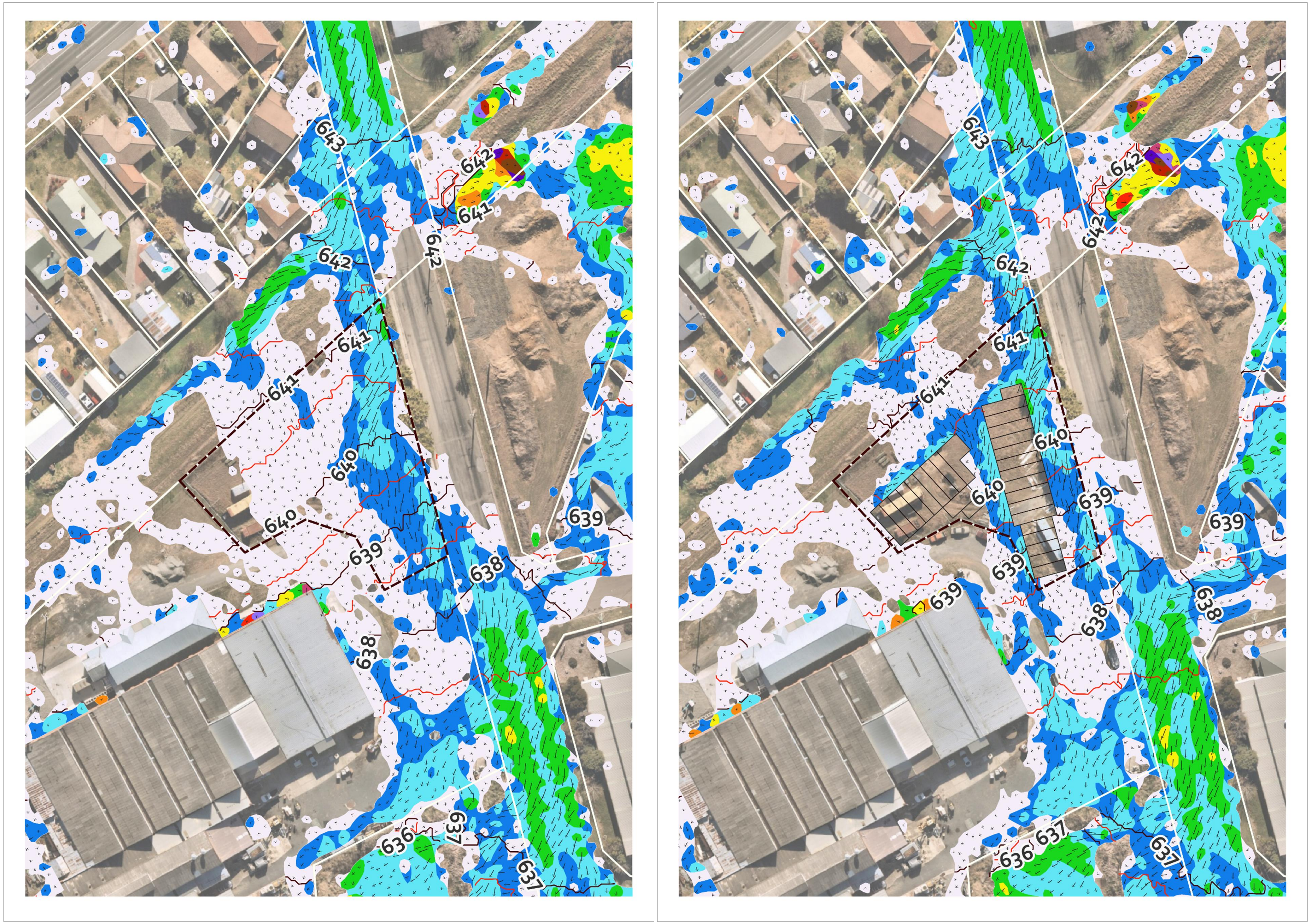

SELF-STORAGE SHEDS
27 ROSS STREET
GOULBURN. NSW. 2580

5% AEP
PRE-DEVELOPMENT &
POST DEVELOPMENT
OVERLAND FLOW WATER
DEPTHS & LEVELS

FIGURE: 06

Site boundary

Cadastral boundary

Water Depths (m)

0.00 – 0.050
0.050 – 0.100
0.100 – 0.200
0.200 – 0.300
0.300 – 0.400
0.400 – 0.500
0.500 – 0.600
0.600 – 0.700
0.700 – 0.800
0.800 – 0.900
0.900 – 1.000
> 1.000

Major water level – 1.0m

Minor water level - 0.5m

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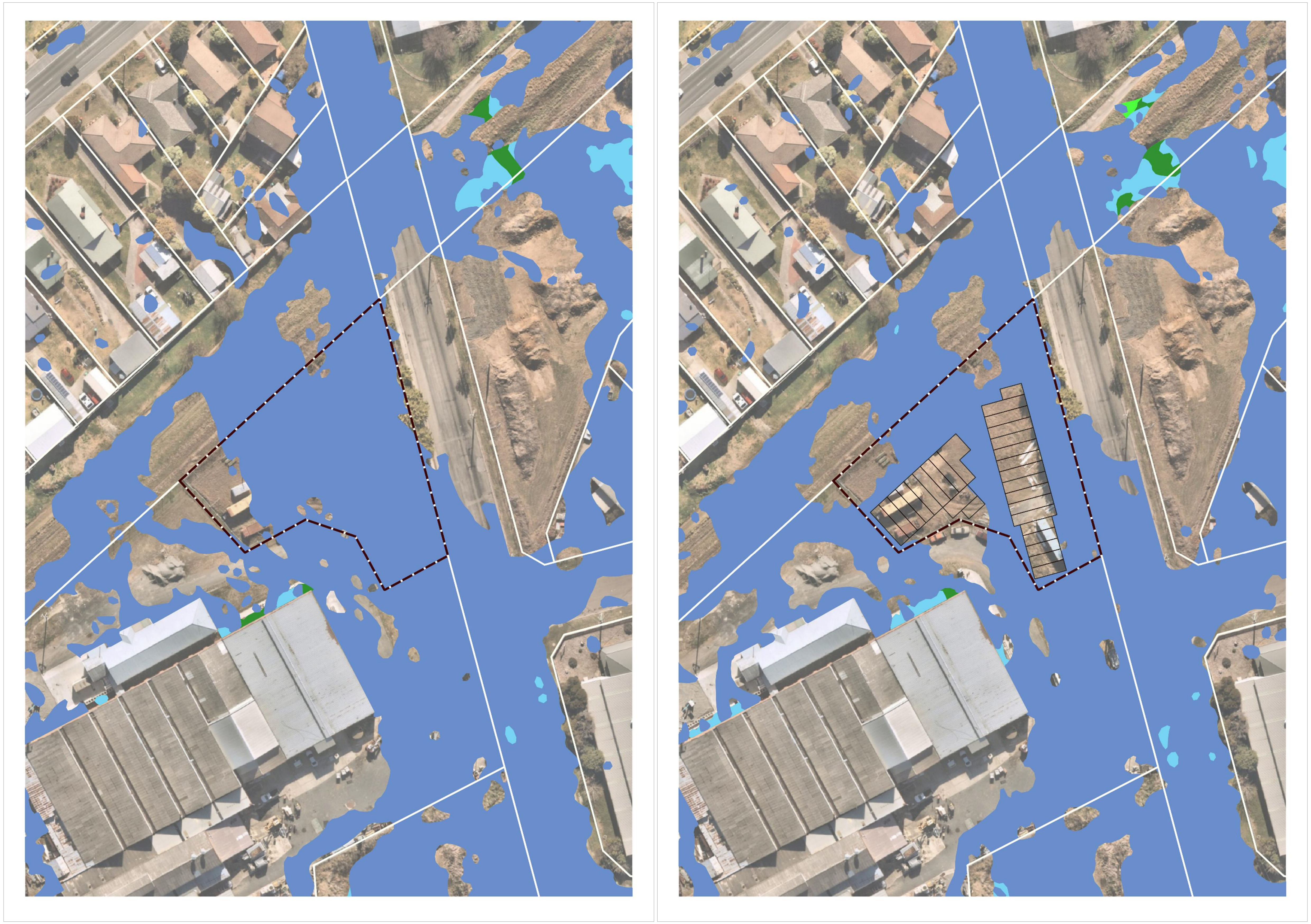

SELF-STORAGE SHEDS
27 ROSS STREET
GOULBURN. NSW. 2580

5% AEP
PRE-DEVELOPMENT &
POST DEVELOPMENT
FLOOD HAZARD
CATEGORY

FIGURE: 07

Site boundary

Cadastral boundary

Hazard Category

H1 (Generally safe for vehicles, people & buildings)

H2 (Unsafe for small vehicles)

H3 (Unsafe for vehicles, children & the elderly)

H4 (Unsafe for vehicles & people)

H5 (Unsafe for vehicles & people. All buildings subject to structural damage)

H6 (Unsafe for vehicles & people. All building types considered vulnerable to failure)

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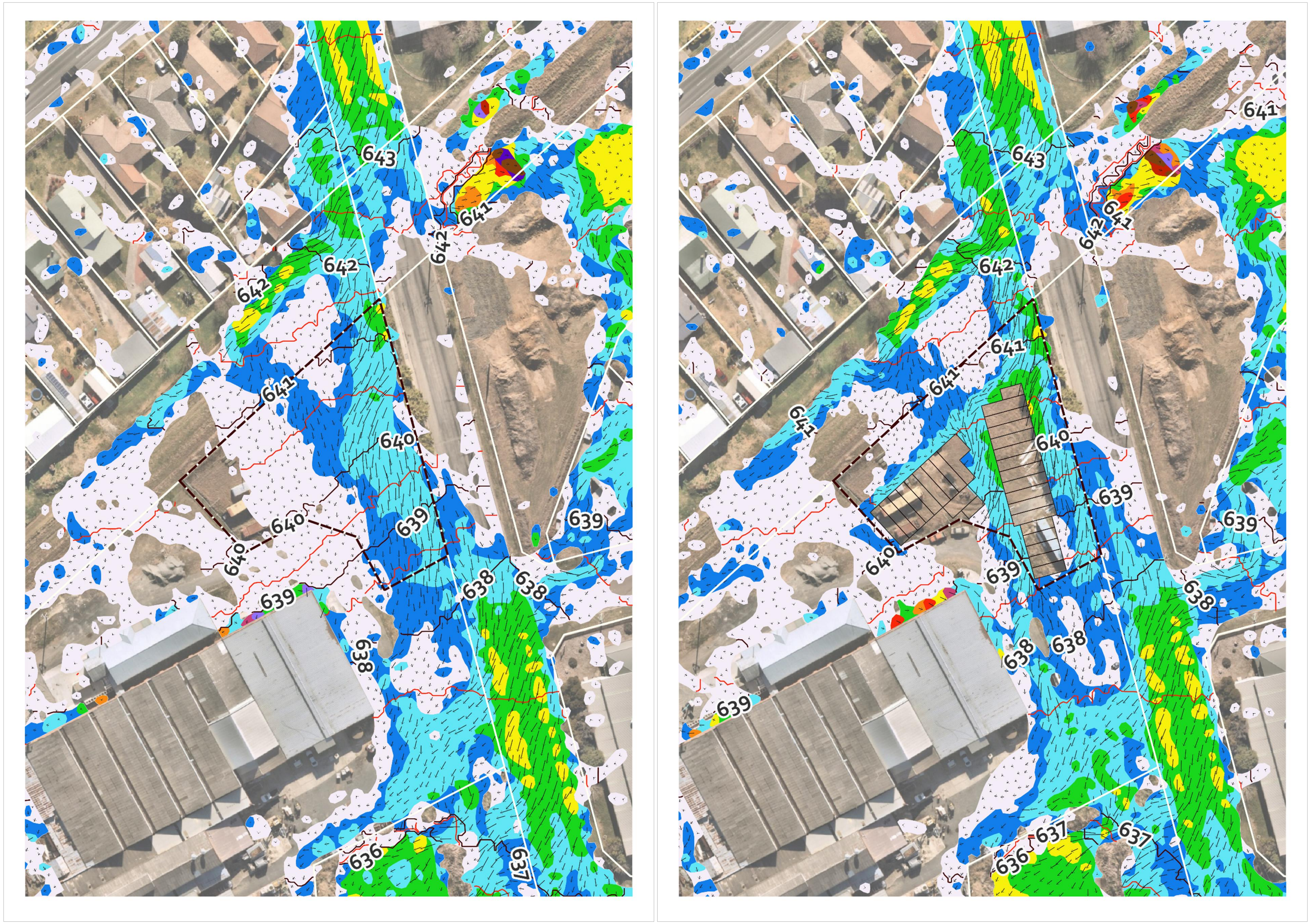

SELF-STORAGE SHEDS
27 ROSS STREET
GOULBURN. NSW. 2580

1% AEP
PRE-DEVELOPMENT &
POST DEVELOPMENT
OVERLAND FLOW WATER
DEPTHS & LEVELS

FIGURE: 08

Site boundary

Cadastral boundary

Water Depths (m)

0.00 – 0.050
0.050 – 0.100
0.100 – 0.200
0.200 – 0.300
0.300 – 0.400
0.400 – 0.500
0.500 – 0.600
0.600 – 0.700
0.700 – 0.800
0.800 – 0.900
0.900 – 1.000
> 1.000

Major water level – 1.0m

Minor water level - 0.5m

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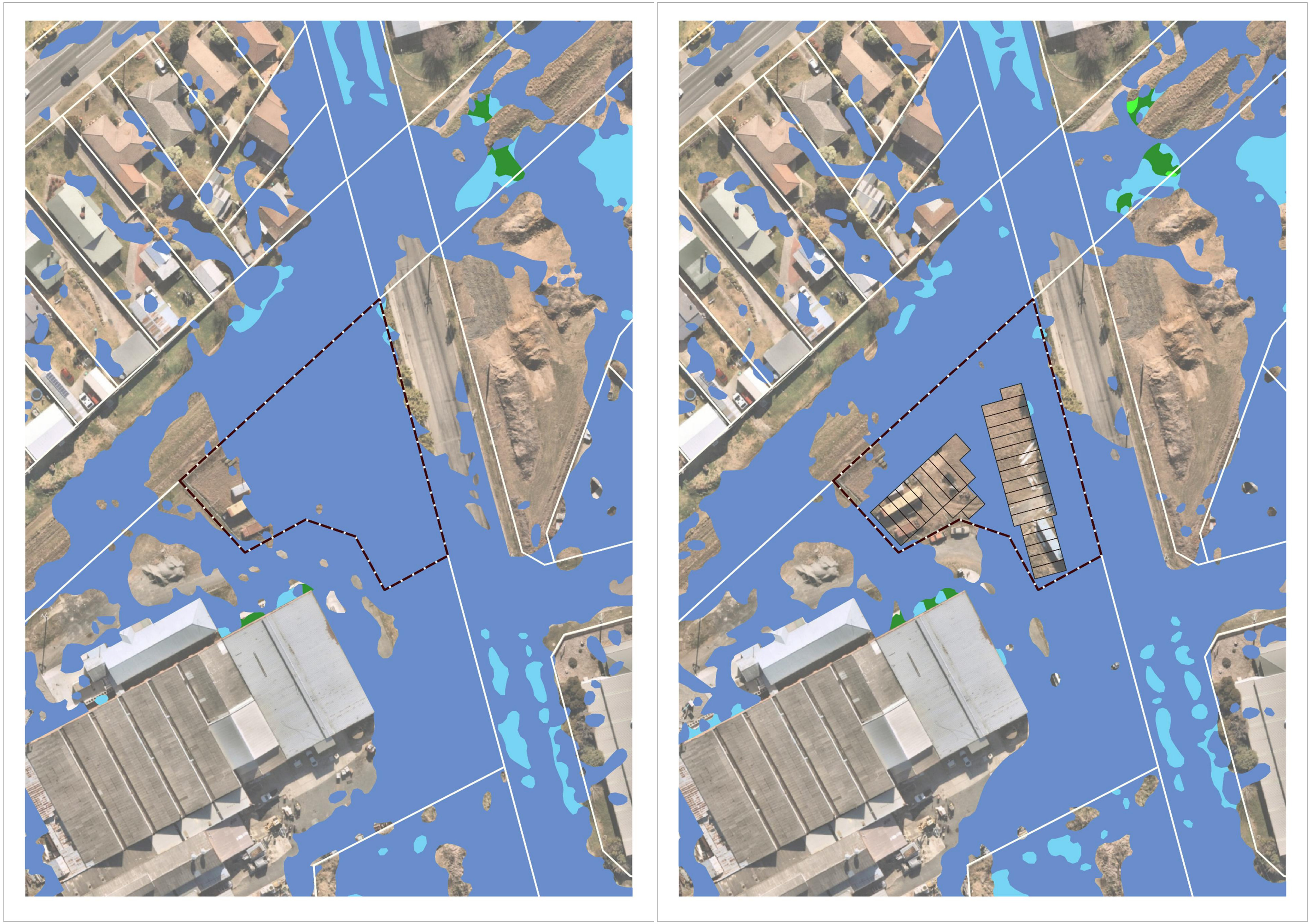

SELF-STORAGE SHEDS
27 ROSS STREET
GOULBURN. NSW. 2580

1% AEP
PRE-DEVELOPMENT &
POST DEVELOPMENT
FLOOD HAZARD
CATEGORY

FIGURE: 09

Site boundary

Cadastral boundary

Hazard Category

H1
(Generally safe for vehicles, people & buildings)

H2
(Unsafe for small vehicles)

H3
(Unsafe for vehicles, children & the elderly)

H4
(Unsafe for vehicles & people)

H5
(Unsafe for vehicles & people. All buildings subject to structural damage)

H6
(Unsafe for vehicles & people. All building types considered vulnerable to failure)

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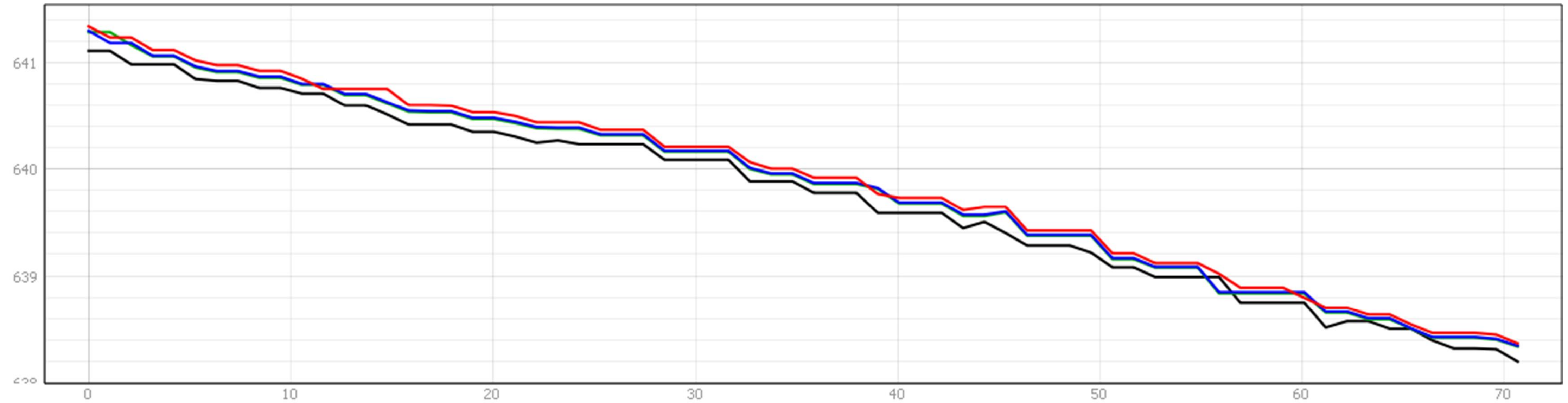
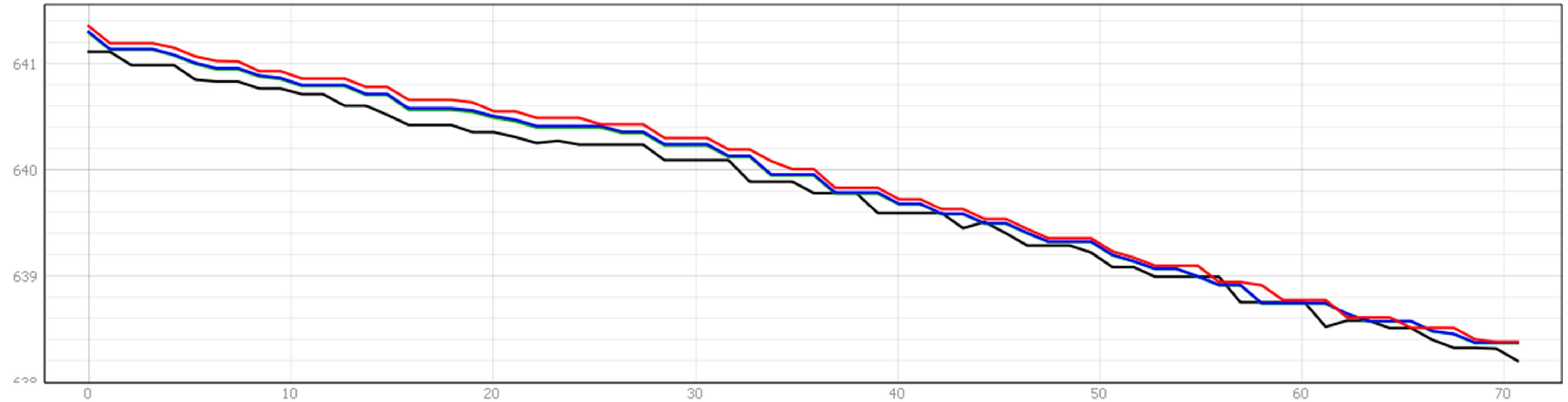


Pre-development overland flow water depths.



Post-development overland flow water depths.

SELF-STORAGE SHEDS
27 ROSS STREET
GOULBURN. NSW. 2580

TRANSECT 01
CROSS-SECTION VIEW OF THE PRE-DEVELOPMENT & POST DEVELOPMENT OVERLAND FLOW WATER DEPTHS

FIGURE: 10

Natural surface level

10% AEP water depths

5% AEP water depths

1% AEP water depths

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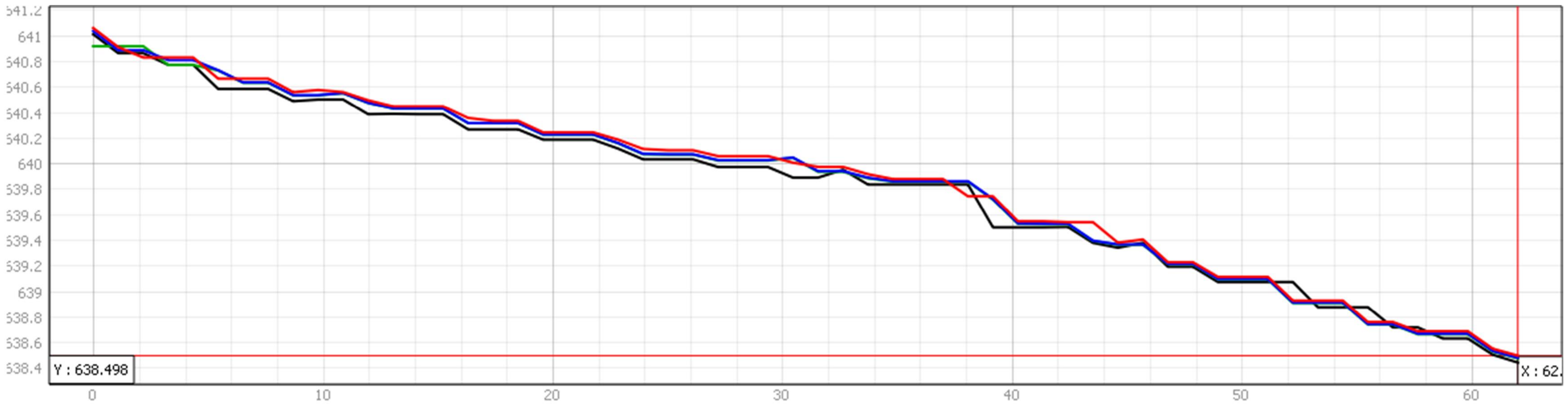
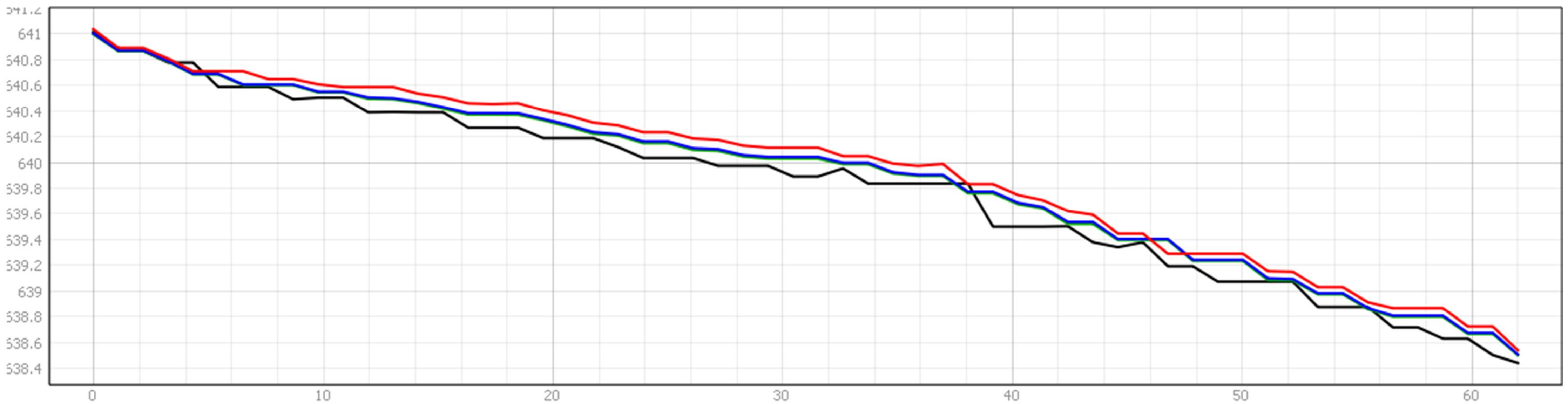


Pre-development overland flow water depths.



Post-development overland flow water depths.

SELF-STORAGE SHEDS
27 ROSS STREET
GOULBURN. NSW. 2580

TRANSECT 02
CROSS-SECTION VIEW OF THE PRE-DEVELOPMENT & POST DEVELOPMENT OVERLAND FLOW WATER DEPTHS

FIGURE: 11

Natural surface level

10% AEP water depths

5% AEP water depths

1% AEP water depths

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5. STORMWATER DRAINAGE		
#	***DESCRIPTION***	***DETAIL***
5.1	Site layout and design details	Once the flood function characteristics of the catchment have been identified and with the knowledge that site is within the 'flood fringe' areas the next part of the design process was to determine the water depths and flood water levels that impact the site during the various design events.
5.2		Using the 1% AEP event as the worst-case conditions, the water depths and levels were determined and used to design the shape, location, orientation, and the minimum floor levels for the proposed storage sheds.
5.3		With the predominant movement of overland flow through the site being in a north → south alignment – virtually parallel to the eastern boundary, it was considered best to have the access doors to the individual storage sheds facing the opposite direction for those parts of the site where the flows where the deepest, thereby forcing water around the building footprint and away from the entry points.
5.4		It was also considered best to have the buildings that are most affected by the flow of deep water aligned with the natural flow through the site and keep the width of the façade that faces upstream as narrow as possible.
5.5		The irregular shape of the development site meant that it was not possible to have two long banks of sheds aligned with the flow of water whilst also still allowing for sufficient space for vehicle access, however because the western portion of the site is only affected by shallow water depths (less than 50mm), and there is a section that is not burdened at all, this portion of the site was used to design a row of sheds that is aligned at right-angles to the flow of water.
5.6		The combination of shed layouts and orientations retains a sufficient number of individual self-storage shed units to make the development economically viable, but also retains as much of the existing and natural movement of overland flow through the development site and thereby not adversely affecting downstream flood characteristics.
5.7		Due to the natural slope of the land the water level across the site under the maximum flow conditions for the 1% AEP pre-development event varies from 641.00 mAHD at the northwestern boundary to 638.50 mAHD at the southern boundary, and the greatest depth of water along the northwestern boundary is 232mm (refer to Item 4.27), whilst the greatest depth of water across the southern boundary is 175mm.

5.8		The depth of water across the development site is not uniform with approximately 40% of the site (1,150m²) having a depth of water that is less than 50mm or not inundated at all in the 1% AEP pre-development design rain event.
5.9		The storage units have been divided into several 'clusters' based on 1% AEP pre-development water levels that burden the site with each group of units having a design finished floor level that is at least 300mm to 400mm above the modelled water level at the upstream end of the cluster.
5.10		An important characteristic of the storage sheds is to have an access provision that is suitable for a vehicle either partially or fully to enter without excessive height variances above the outside driveway.
5.11		If the height of the shed floor levels is too great then access will become a problem, as will other considerations such as the safe loading and unloading of items from vehicles.
5.12		The relevant clauses within the Council's Development Control Plan prescribe that the flood planning level for overland flows be 500mm above the 1% AEP flood levels which is normally a criterion used to establish the floor levels of habitable buildings, however there are provisions within the development controls for a merit-based approach based on a risk assessment to establish floor levels for other types of developments and this approach adopted for the proposed storage shed development.
5.13		A risk assessment has been undertaken for the proposed development as a 'commercial/ /industrial' land use in accordance with the Council's flood risk guidelines and matrix contained in Chapter 3.8 and Appendix J of the Development Control Plan which is included in Section 5 of this report.
5.14	Stormwater management	To manage rainwater in the frequent to lower end of the rare rain events (up to the 5% AEP) an internal stormwater drainage system has been designed that will remove most of the surface water from the site which will help avoid the creation of nuisance and unsafe conditions.
5.15		The stormwater drainage system is comprised of a series of grated surface water pits and pipes along the northern aspect of the sheds that extends around to the eastern aspect.
5.16		There is a row of pits just inside the northwestern boundary which are joined by 225mm diameter pipes and are intended to catch the first flush of overland flow as it enters the site, with a second set of pits on the northern aspect of the proposed sheds that are connected by 300mm diameter pipes.

5.17		The two northern lines merge at a grated inlet junction pit on the northern corner of the long row of sheds and then turns to the east and runs parallel to the eastern boundary, extending to the south beyond the entrance crossover into the site.
5.18		Because the site is not serviced by any form of inter-allotment or piped stormwater system within the road reserve the discharge of stormwater from the site will be to the kerb and gutter system in Ross Street with the transition from the last internal pit needing to be via three 150mm diameter pipes with kerb adaptors that will drain to the rear of the kerb approximately 6 metres downslope of the last internal pit.
5.19		The transition at the last internal stormwater pit from a single 300mm diameter pipe to the three 150mm diameter pipes may result in water being lost from the system as additional overland flows from the last two internal pit for rain events greater than the 20% AEP.
5.20		The potential loss of stormwater from the system at the last two stormwater pits is not a significant concern as there is already a body of overland flow that moves across the surface within each of the modelled rain events.
5.21		The Council's *Stormwater Drainage and Rainwater Collection System Policy* requires that non-residential developments provide a rainwater tank storage at the nominal rate of 1,000 litres per 10m² of effective roof area with the calculation of the effective roof area being inclusive of the roof pitch.
5.22		The proposed storage sheds will have a plan drawing roof area of 1,000m² with a roof pitch of 10° which according to Table 3.4.3.2 of AS/NZS 3500.3 has a multiplying factor of 1.09 – this equates to an effective roof area of 1,090m².
5.23		Using the rainwater tank storage calculation of 1,000 litres for every 10m² of effective roof area the required rainwater tank storage volume is 109,000 litres
5.24		This is considered an excessive requirement when considered in relation to the potential re-use of harvested rainwater on the site, which for the most part as a self-storage shed facility will be unoccupied except for intermittent attendances by the shed lessee's and minor ground maintenance.
5.25		The potential re-uses of harvested rainwater on the site will be limited to a bit of external hosing-down of the hardstand areas (although very rarely) and some minor irrigation of the proposed landscape strip along the eastern boundary which will be largely planted with native trees and shrubs that have minimal watering requirements.

5.26		Any yard taps installed on the site will be fitted with vandal-proof handles so that they are not accessible to the shed lessee's, this is to avoid people turning taps and not properly turning them off thereby wasting water, and to remove the potential for people steal water.
5.27		In lieu of the fact that the reuse of rainwater will be extremely limited on the site it is proposed that the rainwater storage provisions be reduced to slightly more than half of the Council's requirements – 60,000 litres.
5.28		Of the proposed 60,000 litres approximately 20,000 litres of the rainwater tank storage provisions would be used as a temporary detention zone to attenuate the peak discharge in all rain events up to and including the 1% AEP to levels that are less than an equivalent area as the proposed roofs in the pre-development conditions.
5.29		Utilising the *DRAINS* hydrological model, the pre-development plan drawing area for the roofs of 1,000m² has a peak runoff in the 1% AEP rain event of 0.023m³/s; using 20,000 litres of the rainwater tank provisions for a temporary detention zone with a 75mm orifice outlet the peak flow in the 1% AEP post-development rain event is 0.11m³/s with no overflows at the top of the tank.
5.30		The remaining volume of 40,000 litres in the rainwater tank provisions would form the permanent storage zone for re-use around the site – although this volume is still deemed to be excessive compared to the potential for re-uses.
5.31		Assuming a theoretical and best-case re-use of rainwater of 250 litres per day for every day of the year the proposed permanent storage zone of 40,000 litres in the rainwater tank provisions would provide 160 days of continued water supply without any additional inflows, however compliance with the Council's *Stormwater Drainage and Rainwater Collection System Policy* and the installation of 109,000 litres of permanent storage would equate to 436 days of continued water supply – almost 14 months.
5.32		To further support the proposal for a reduced rainwater tank storage provision - it is not clear what benefit would be gained by installing larger storage provisions because once the tanks/s are full and assuming very little re-use then any additional water will automatically be directed through the high-level overflow pipe and immediately to the stormwater system – hence no gain or improvement in the stormwater harvesting outcomes.

5.33		The site is considerably burdened by the impacts of overland flows that limit the full potential to develop the site, and the enforcement of larger rainwater tank provisions that will require significantly more land area free of vehicles movements will further reduce the site's potential for economically viable development.
5.34		It is strongly held that a merit-based approach be accepted for this development based on the presented arguments and proposed undertakings.
5.35		Because the site is adversely burdened by overland flows from 20 hectares of upstream catchment that will effectively still flow through the site in the post-development conditions it is not realistic to try and provide calculations or controls to maintain the post-development surface water runoff to be equal to or less than the pre-development rates as it would essentially be impossible to quantify the numbers, and also to establish what benefit is gained.
5.36		Any small reduction in post-development flows that could possibly be implemented on the site could very easily be lost at some future time as there are effectively no controls that can govern all possible changes to the sources of rainwater runoff and overland flow being created upstream of the development site, and only a small change is required to significantly influence the volume and velocity of water entering the site.
5.37	Development controls	An assessment of the proposed development against the controls for developments in flood liable lands is presented in Section 6 of this report.
5.38		The assessment summarises all the information contained in the previous sections and provides detailed responses to each of the applicable controls for each element of the design and risk considerations.
5.39	Stormwater drainage results	Following on from the development controls matrix assessment is Appendix A which contains a set of images (Figure 13 to Figure 18) from the *ICM Ultimate* post-development flood modelling that shows the long section details for the stormwater drainage system in each of the design events - there are two images for each event with the top image being the main drainage line and the second image being the inclusion of the two northern-most pits and pipes that junction into the main line (the pit identifications will align with the details in the accompanying Stormwater Drainage Site Plan – Ref: 0030724-01A.

6. FLOOD PLANNING CONSTRAINTS CATEGORY		
#	*DESCRIPTION*	*DETAIL*
6.1	Flood Planning Constraints Category and development controls	The southern portion of the development site is burdened by the margins of the probable maximum flood event associated with riverine flooding, and the site is also identified in a preliminary overland flow study undertaken on behalf of the Goulburn Mulwaree Council as being within the *Flood Planning Constraints Category* (FPCC) of '*FPCC 2, 3 and 4*' with the bulk of the site in *'FPCC 3 and 4'.*
6.2		The results of this overland flow study might suggest that the categorisation of part of the site as 'FPCC 2' may invariably be slightly inaccurate, however the development control requirements for commercial and industrial developments at both 'FPCC 2' and 'FPCC 3' are identical therefore arguing the merits of the classifications are irrelevant in this instance.
6.3		Chapter 3.8.2.3 of the Goulburn Mulwaree Council Development Control Plan discusses the different flood planning constraint categories and references Appendix J of the Council's Development Control Plan for the prohibited, permissible, and unrestricted land use activities within each land-use type category.
6.4		Appendix J of the Council's Development Control Plan includes a risk matrix table that plots the various development land uses against the relevant development planning control considerations, an assessment of this development in relation the provisions of the development control matrix are included at the end of Section 6 of this report.

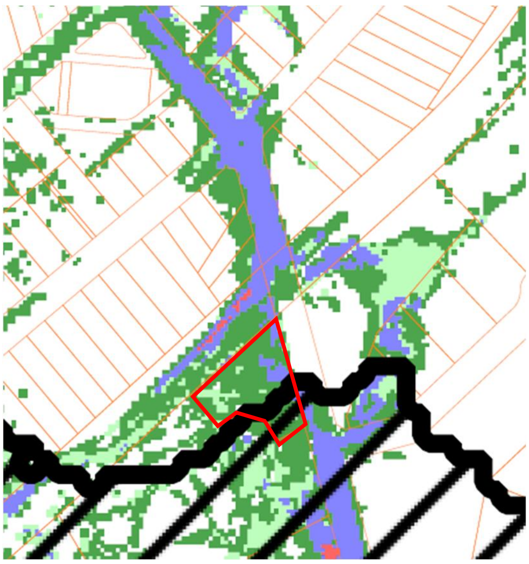


Figure 12: Screen shot from the FPCC mapping showing the categories in green and blue shading that burden the development site which is highlighted in red. The black lines represent the extents of the PMF associated with riverine flooding.

FLOOD PLANNING CONTROLS – DEVELOPMENT CONTROL MATRIX (APPENDIX J OF THE DEVELOPMENT CONTROL PLAN)

FLOOD PLANNING CONTROLS - DEVELOPMENT CONTROL MATRIX

	FPCC 1							
	Critical Uses & Facilities	Sensitive Uses & Facilities	Lot Subdivisions	Residential Development	Commercuial & Industrial	Recreational & Non-Urban	Sheds & Outbuildings	Minor Additions
Floor Level						A1	A1	
Building Components								
Structural Soundness								
Parking & Driveway Access						F2 F5	F1 F3 F4	
Evacuation & Refuge						G1 G3 G4	G1	
Management & Design						H2 H3 H4	H2 H3 H4	
Flood Impacts						J1	J1	

	FPCC 2 (Subcategory a,b,c,e)							
	Critical Uses & Facilities	Sensitive Uses & Facilities	Lot Subdivisions	Residential Development	Commercuial & Industrial	Recreational & Non-Urban	Sheds & Outbuildings	Minor Additions
Floor Level					A2 A6	A1	SA 2	A2
Building Components					D1	D1	D1	D1
Structural Soundness					E1	E1	E1	E1
Parking & Driveway Access					F1 F3 F4 F5	F2 F 5	F1 F3 F4	F5
Evacuation & Refuge					G2 G3	G2 G3 G4	G1	G1 G3
Management & Design					H2 H3 H4	H2 H3 H4	H2 H3 H4	H2 H3 H4
Flood Impacts					J1	J1	J1	J1

	FPCC 2 (Subcategory d)							
	Critical Uses & Facilities	Sensitive Uses & Facilities	Lot Subdivisions	Residential Development	Commercuial & Industrial	Recreational & Non-Urban	Sheds & Outbuildings	Minor Additions
Floor Level				A4 A6	A2 A6	A1	A2	A3
Building Components				D1	D1	D1	D1	D1
Structural Soundness				E1	E1	E1	E1	E1
Parking & Driveway Access			F1 F3 F4 F5	F1 F3 F4 F5	F1 F3 F4 F5	F2 F5	F1 F3 F4	
Evacuation & Refuge			G3 G4	G3	G3	G3		
Management & Design			H1 H5		H2 H3 H4	H2 H3 H4	H2 H3 H4	
Flood Impacts			J1	J1	J1	J1	J1	J1

	FPCC 3							
	Critical Uses & Facilities	Sensitive Uses & Facilities	Lot Subdivisions	Residential Development	Commercuial & Industrial	Recreational & Non-Urban	Sheds & Outbuildings	Minor Additions
Floor Level				A2 A6	A2 A6	A1	A2	A3
Building Components				D1	D1	D1	D1	D1
Structural Soundness				E1	E1	E1	E1	E1
Parking & Driveway Access			F1 F3 F4 F5	F1 F3 F4 F5	F1 F3 F4 F5	F2 F5	F1 F3 F4	
Evacuation & Refuge			G2 G3 G4	G2 G3	G2 G3	G3 G4	G1	
Management & Design			H1 H5		H2 H3 H4	H2 H3 H4	H2 H3 H4	
Flood Impacts			J1	J1	J1	J1	J1	J1

	FPCC 4							
	Critical Uses & Facilities	Sensitive Uses & Facilities	Lot Subdivisions	Residential Development	Commercuial & Industrial	Recreational & Non-Urban	Sheds & Outbuildings	Minor Additions
Floor Level	A5 A6	A5 A6						
Building Components	D2	D2						
Structural Soundness	E2	E2						
Parking & Driveway Access	F2 F3	F2 F3						
Evacuation & Refuge	G2 G3 G4	G2 G3 G4	G2 G3 G4					
Management & Design			H1 H5					
Flood Impacts								

Unsuitable Land Use   Not Relevant   Potentially unsuitable. Significant management required to manage flood risk

The highlighted cell in yellow represents the relevant Flood Planning Constraints Category and the land use type applicable to the proposed development

FLOOD PLANNING CONTROLS WITHIN THE ASSESSED 'FLOOD PRECINCT CONSTRAINT CATEGORY' OF *FPCC 2*

LAND USE CLASSIFICATION: *COMMERCIAL & INDUSTRIAL*

DEVELOPMENT TYPE: *SELF-STORAGE UNITS*

OUTSIDE OF THE ADOPTED FLOOD PLANNING AREA, SUBJECT TO OVERLAND FLOWS AND THEREFORE FREEBOARD = 500mm.

APPLICABLE CONTROLS:

A1	A2	A3	A4	A5	A6	D1	D2	E1	E2	F1	F2	F3	F4	F5	G1	G2	G3	G4	H1	H2	H3	H4	H5	J1
	☑				☑	☑		☑		☑		☑	☑	☑		☑	☑			☑	☑	☑		☑

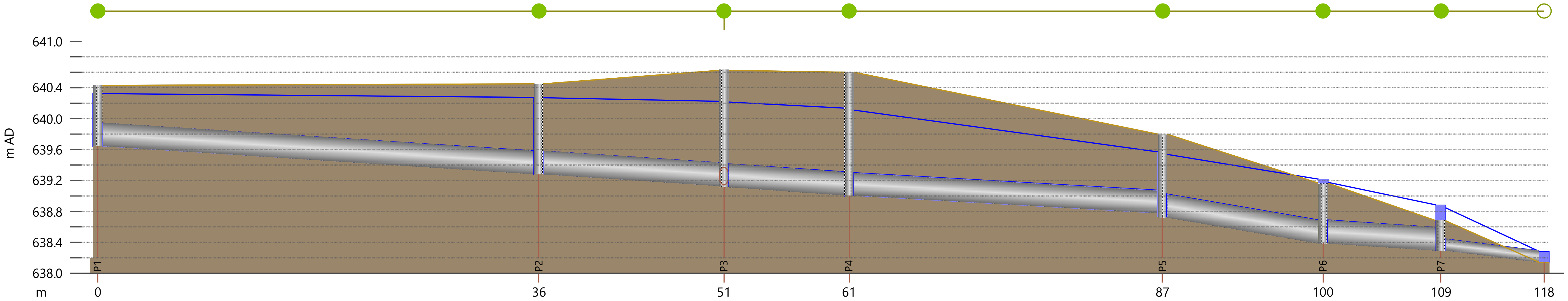
Flood Level Controls		
A2	All floor levels to be equal to or greater than the FPL (1% AEP flood level plus 0.5 m freeboard). If significant access issues or other constraints are present, a reduced floor level no lower than the 1% AEP flood level may be considered if justified by a site-specific assessment.	The design floor level for the individual storage Units will be approximately 300mm to 400mm above the modelled overland flow water level in the 1% AEP rain event. As opposed to riverine flooding, the effects of waves and wind on overland flow water levels are less problematic, in particular for sites where the period of maximum depth inundation is minimal due to the short duration of the flood event. A 500mm freeboard is not practical for the proposed self-storage shed development as the actual depths of water experienced on the site in the 1% AEP event is generally less than 300mm. The need for access to be closer to the ground surface level is important for the safe placement and removal of items, and also for the potential need for vehicles – either partially or fully to drive into the Unit at a grade that is not too excessive, therefore a reduced freeboard is justified. It is also noted that the proposed Units are not habitable buildings hence a variation to the Development Control Plan adopted freeboard levels can be considered on as merit-based approach.
A6	Entrance levels to underground spaces (basements, carparking etc.) are required to be above the level of the FPL (1% AEP flood level plus 0.5 m freeboard) or PMF level, whichever is higher	There are no underground spaces or car park areas

	Building Components	
D1	All structures to have flood compatible building components below the FPL (1% AEP flood level plus 0.5 m freeboard).	All blocks of storage shed units will be constructed on reinforced concrete bases that are tied into the natural ground by a combination of strip footings and piers.
	Structural Soundness	
E1	Engineers report to certify that any structure can withstand the forces of floodwater, debris and buoyancy up to and including the FPL (1% AEP flood level plus 0.5 m freeboard).	Structural engineer report to be provided upon request if deemed a requirement.
	Parking and Driveway Access	
F1	The minimum surface level of open car parking spaces or carports shall be as high as practical, but no lower than the 5% AEP flood or the level of the crest of the road at the location where the site has access. In the case of garages, the minimum surface level shall be as high as practical but no lower than the 5% AEP flood.	The design surface levels for the internal driveway areas that are adjacent to or north of the entranceway will be equal to or slightly above the natural surface level (639.435 mAHD) measured at the centreline of the road adjacent to the property entrance. In the 1% AEP rain event the water level within the site generally does not exceed 250mm. The site is exposed to a hydraulic hazard rating of 'H1' in all design rain events which is considered to be safe for all vehicles, pedestrians, and buildings. Approximately 210m^2 in the western corner of the site is outside of the mapped hydraulic hazard areas.
F3	Garages capable of accommodating more than three motor vehicles on land zoned for urban purposes, or enclosed car parking, must be protected from inundation by floods up to the FPL (1% AEP flood level plus 0.5 m freeboard).	There are no garages or enclosed car parking spaces
F4	The level of the driveway providing access between the road and parking space shall be no lower than 0.3 m below the 1% AEP flood or such that the depth of inundation during a 1% AEP flood is not greater than either the depth at the road or the depth at the car parking space. A lesser standard may be accepted for	The design finished surface levels within the site will ensure that more than 50% of the site area is above the 1% AEP water level at the entrance to the site. The 1% AEP water level at the site entrance is 639.250 mAHD. The design surface levels for approximately 86% of the site is higher than the same water level elevation, only that

	single detached dwelling houses where it can be demonstrated that risk to human life would not be compromised.	portion of the site to the south of the entrance will be lower than the 1% AEP water level of 639.250 mAHD.
F5	Enclosed car parking and car parking areas accommodating more than three vehicles (other than on Rural zoned land), with a floor level below the 5% AEP flood or more than 0.3 m below the 1% AEP flood level, shall have adequate warning systems, signage and exits. Restraints or vehicle barriers are to be provided to prevent floating vehicles leaving the site during a 1% AEP flood.	There are no enclosed car parking spaces.
	Evacuation and Rescue	
G2	Reliable access for pedestrians or vehicles required during a 1% AEP flood to a publicly accessible location above the PMF.	The development site sits on the edge of the mapped PMF levels that burden the site with the road corridor adjacent to the northeast corner being outside and above the PMF water levels. If required, pedestrians could walk to the road reserve outside the property and then walk to the nearby shopping centre.
G3	The development is to be consistent with any relevant flood evacuation strategy or similar plan	There are no known evacuation strategies for the development area however it is not considered likely that isolation or entrapment on the site would be an issue as the extent of potential flooding in the 1% AEP event is within the lower range of the hydraulic hazard categories.
	Management and Design	
H2	Site Emergency Response Flood Plan required where floor levels are below the FPL (1% AEP flood level plus 0.5 m freeboard), except for single dwelling-houses	A standard warning notification can be placed at the entrance to the site and at several locations throughout the site advising that the facilities are not to be used or accessed in a major rain event, it may also be an option to include such details in the shed lease agreements
H3	Applicant to demonstrate that area is available to store goods above the FPL (1% AEP flood level plus 0.5 m freeboard)	All Units will have a finished floor level that is at least 300mm above the 1% AEP flood level. As referenced earlier a reduced freeboard level is being sought due to the shallow depths of water that affect the site in the 1% AEP event.

H4	No storage of materials below the FPL (1% AEP flood level plus 0.5 m freeboard) which may cause pollution or be potentially hazardous during any flood.	As part of the rental agreements for the lease of the storage sheds hazardous items are not permitted to be stored in the Units. All floor levels within the Units will be above the 1% AEP flood level plus a freeboard of between 300m and 400mm.
	Flood Impacts	
J1	Provision of a report developed by an engineer who specialises in hydrology and floodplain modelling is required to certify that the development will not adversely affect flooding elsewhere. The report must show the: 1. Loss of storage in the floodplain. For sites located in areas of 1% AEP flood storage, assessment is to include consideration of the loss of storage resulting from cumulative development of the area. 2. Changes in flood levels and flow velocities caused by alteration of conveyance of flood waters. The capacity and conveyance of existing flowpaths shall be maintained. 3. Impacts of urbanisation on peak flood flows and volumes. There is an exception to this requirement – no report is required for small developments such as a car port, in ground swimming pool or backyard shed less than 9m², that do not alter the existing ground level	The proposed development on the site does not result in any loss of flood storage as the entire site and surrounding lands are defined as being 'flood fringe' in accordance with the calculation methodology of *Howells et al (2003)* which is adopted as the best practice determination for flood function in a catchment area. The civil works relating to the natural surface profile are essentially limited to providing a constant grade across the site and removing all undulations. Intentionally the site will retain as much of the natural profile and levels outside of the building footprints to ensure that existing overland flow paths are maintained. The flood modelling suggests that the in the post-development outcomes the flow of water is not significantly widened or pushed further into the adjoining land holdings, and existing exit points are maintained. The northern and northwestern boundaries of the site are where the overland flows enter the property, and it is a requirement that the existing natural surface level across the boundary on these aspects is maintained. There is no increase in flow rates discharging from the site as there is a requirement that the peak discharge in the post-development scenario is no greater than the pre-development flow rates. Rainwater tanks will be used to temporarily detain water from the roof areas for attenuation and gradual release after the main rain event has ceased. The bottom portion of the rainwater tanks will be used to retain water for external uses around the site such as irrigation and general cleaning.

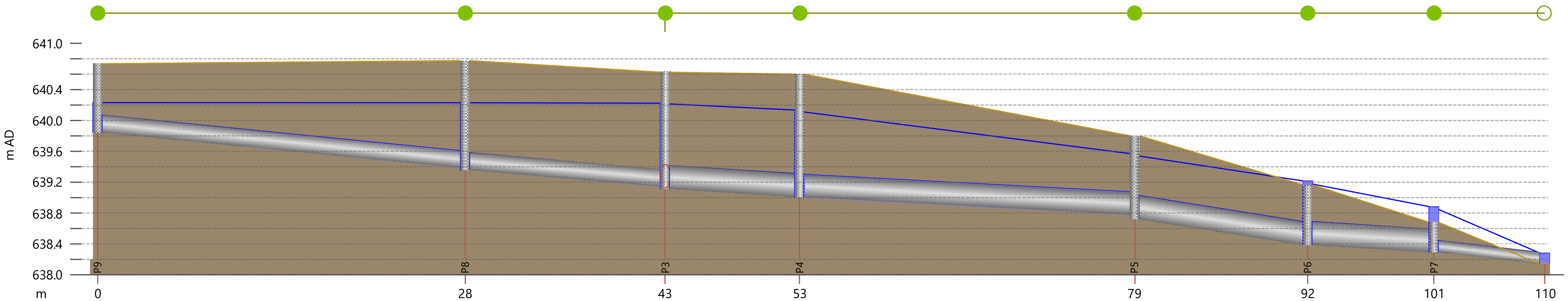
APPENDIX A – STORMWATER DRAINAGE LONG SECTION DETAILS FROM THE *ICM ULTIMATE* MODELS



Link	P1.1	P2.2	P3.3	P4.4	P5.5	P6.6	P7.7
width (mm)	300	300	300	300	300	300	150
numbarrels	1	1	1	1	1	1	3
grad (%)	0.998	1.000	1.001	0.888	2.564	1.004	1.806
DS flow (m3/s)	0.03568	0.05327	0.08458	0.14327	0.15565	0.16963	0.11860

Node	P1	P2	P3	P4	P5	P6	P7	Out

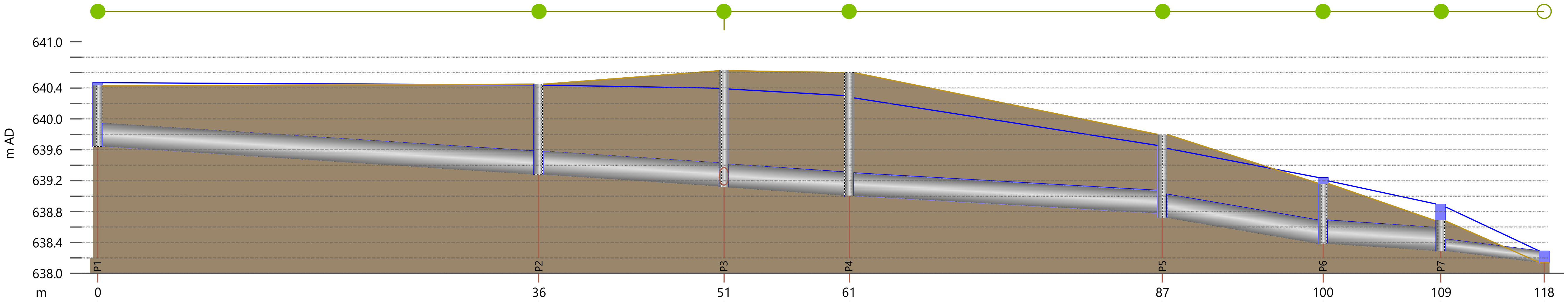
Figure 13. 10% AEP post-development stormwater drainage system for pits P1, P2 and P3 through to the Outlet being the kerb and gutter outlet at Ross Street – results from the *ICM Ultimate* modelling program.



Link	P9.1	P8.8	P3.3	P4.4	P5.5	P6.6	P7.7
width (mm)	225	225	300	300	300	300	150
numbarrels	1	1	1	1	1	1	3
grad (%)	1.654	1.439	1.001	0.888	2.564	1.004	1.806
DS flow (m3/s)	0.00505	0.01252	0.08458	0.14327	0.15565	0.16963	0.11860

Node	P9	P8	P3	P4	P5	P6	P7	Out

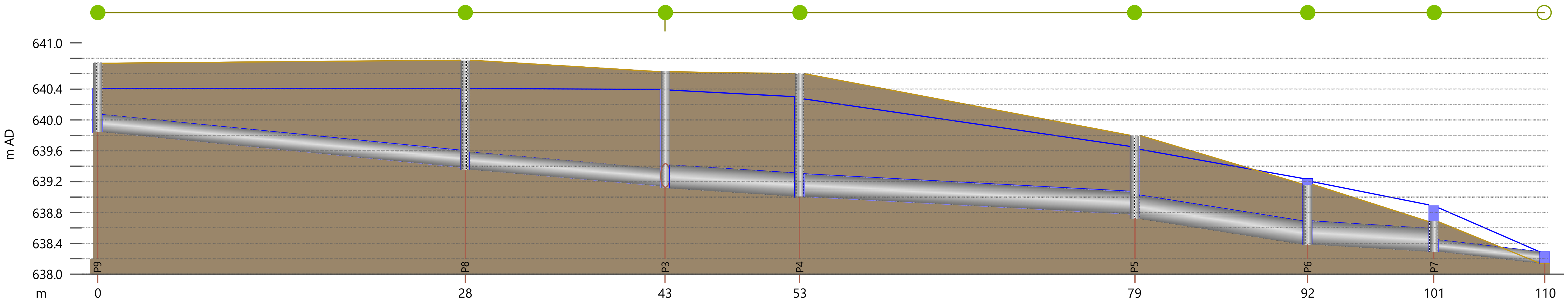
Figure 14. 10% AEP post-development stormwater drainage system for pits P9, P8 and P3 through to the Outlet being the kerb and gutter outlet at Ross Street – results from the *ICM Ultimate* modelling program.



Link	P1.1	P2.2	P3.3	P4.4	P5.5	P6.6	P7.7
width (mm)	300	300	300	300	300	300	150
numbarrels	1	1	1	1	1	1	3
grad (%)	0.998	1.000	1.001	0.888	2.564	1.004	1.806
DS flow (m3/s)	0.03650	0.05448	0.08866	0.15243	0.16574	0.17224	0.11922

Node	P1	P2	P3	P4	P5	P6	P7	Out

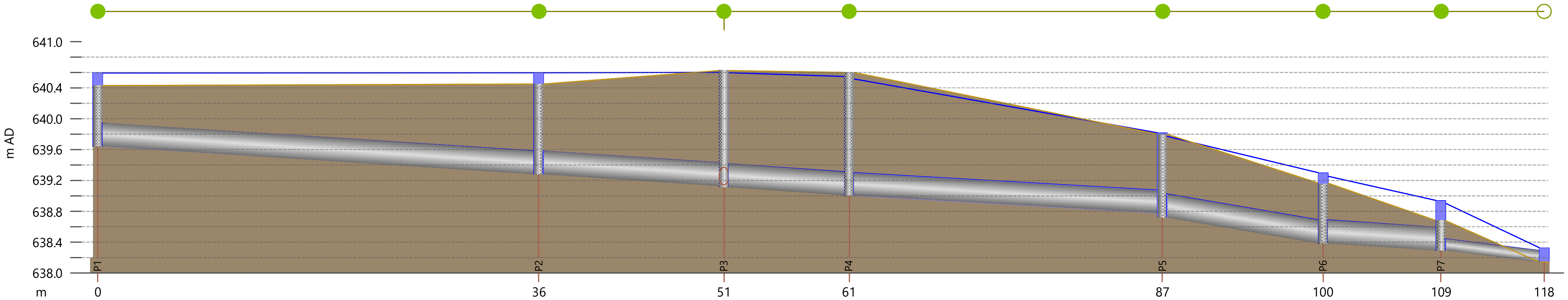
Figure 15. 5% AEP post-development stormwater drainage system for pits P1, P2 and P3 through to the Outlet being the kerb and gutter outlet at Ross Street – results from the *ICM Ultimate* modelling program.



Link	P9.1	P8.8	P3.3	P4.4	P5.5	P6.6	P7.7
width (mm)	225	225	300	300	300	300	150
numbarrels	1	1	1	1	1	1	3
grad (%)	1.654	1.439	1.001	0.888	2.564	1.004	1.806
DS flow (m3/s)	0.00532	0.01286	0.08866	0.15243	0.16574	0.17224	0.11922

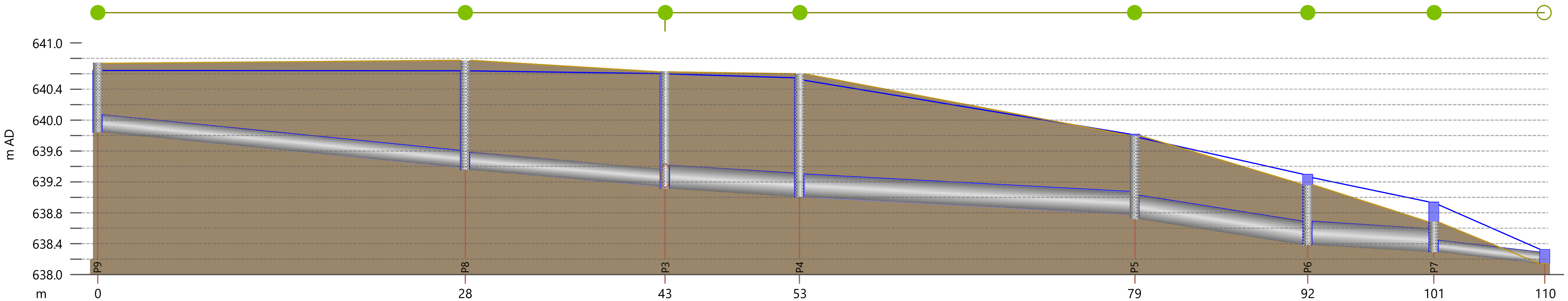
Node	P9	P8	P3	P4	P5	P6	P7	Out

Figure 16. 5% AEP post-development stormwater drainage system for pits P9, P8 and P3 through to the Outlet being the kerb and gutter outlet at Ross Street – results from the *ICM Ultimate* modelling program.



Link	P1.1	P2.2	P3.3	P4.4	P5.5	P6.6	P7.7
width (mm)	300	300	300	300	300	300	150
numbarrels	1	1	1	1	1	1	3
grad (%)	0.998	1.000	1.001	0.888	2.564	1.004	1.806
DS flow (m3/s)	0.03881	0.06208	0.08823	0.16327	0.18328	0.17592	0.11981
Node	P1	P2	P3	P4	P5	P6	P7 / Out

Figure 17. 1% AEP post-development stormwater drainage system for pits P1, P2 and P3 through to the Outlet being the kerb and gutter outlet at Ross Street – results from the *ICM Ultimate* modelling program.



Link	P9.1	P8.8	P3.3	P4.4	P5.5	P6.6	P7.7
width (mm)	225	225	300	300	300	300	150
numbarrels	1	1	1	1	1	1	3
grad (%)	1.654	1.439	1.001	0.888	2.564	1.004	1.806
DS flow (m3/s)	0.00634	0.02097	0.08823	0.16327	0.18328	0.17592	0.11981
Node	P9	P8	P3	P4	P5	P6	P7 / Out

Figure 18. 1% AEP post-development stormwater drainage system for pits P9, P8 and P3 through to the Outlet being the kerb and gutter outlet at Ross Street – results from the *ICM Ultimate* modelling program.

References.

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Goulburn Mulwaree Council – Development Control Plan – Chapter 3.80 'Flood Affected Lands' (as amended September 2022)