LAND REZONING PROPOSAL

LOT 2 DP569505

44 MIDDLE ARM ROAD

MIDDLE ARM. NSW, 2580

LOCAL FLOOD & OVERLAND FLOW STUDY

Prepared by SOWDES
26 April 2023

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Local Flood and Overland Flow Study

Executive Summary.

This *Local Flood and Overland Flow Study* has been prepared in support of a submission to the Goulburn Mulwaree Council for the rezoning of a parcel of land identified as Lot 2 DP569505 – 44 Middle Arm Road, Middle Arm from a current zoning status of 'RU6 – Transition' and 'RU1 – Rural Landscape' to 'R2 Low Density Residential'. The land rezoning opportunity has been identified in the *Urban and Fringe Housing Strategy* undertaken on behalf of the Goulburn Mulwaree Council by Elton Consulting which was adopted by Council in July 2020.

The submission of a *Local Flood and Overland Flow Study* for assessment of the land rezoning proposal satisfies the Ministerial Directions obligations under the Section 9.1 of the Environmental Planning and Assessment Act (1979) – Direction 4.1 Flooding.

The development property and surrounding lands are not identified in any current planning or mapping instruments as being within flood liable lands, and nor is there any knowledge of proposed studies to investigate the area for potential flood affectation. The property is however burdened by general overland flows associated with surface water runoff originating within adjoining lands and properties to the south, southeast, east, and to a lesser degree to the west of the site. This study is assessing the impacts of existing overland flow from these external sources and stormwater drainage generated within on the land rezoning proposal and potential future residential subdivision development for the site.

The subject site is located on the eastern aspect of the Middle Arm Road traffic corridor which heads north from the city of Goulburn – approximately 715 metres from the current 60 kph speed limited zones upon entering the city. Middle Arm Road is a Council maintained sealed road system that services many rural holdings and smaller lifestyle allotments between the city of Goulburn and outlying localities such as Middle Arm, Roslyn, and Tarlo.

The development site is a single parcel of land that averages 570 metres in length and 215 metres in width and is effectively shaped as a parallelogram that covers an area of approximately 11.92 hectares. The property presently supports an existing dwelling and ancillary buildings and infrastructure that is bound by a defined curtilage within the eastern half of the site, and the remainder of the holding has historically and is currently used for light grazing by a small number of cattle.

Council utilities such as reticulated water supply, gravity sewer, and interallotment stormwater drainage presently do not extend to the holding, however a future subdivision of the land would seek to extend the reticulated water to the site, whilst gravity sewer and interallotment stormwater drainage would also be provided.

Access to the development property is from an existing entrance located in the southwestern corner of the site which also doubles-up as an access to the adjoining property to the immediate east (identified as Lot 3 DP569505) via a registered 20 metre wide Right of Carriageway along the southern boundary. The northwestern corner of the property is burdened by an easement for the Moomba to Sydney high-pressure natural gas and ethane supply lines that runs diagonally across the site, and to the immediate south of the gas supply lines is an optic fibre cable that runs parallel but at slightly variable distances off the edge of the easement. In the adjoining land to the immediate south is a 20 metre wide easement running parallel to the entire length of the property that houses the 'Southern Highlands to Goulburn Emergency Water Supply' pipeline.

The topography within the central portion of the development property has a general fall from the south toward the north at relatively constant grades that average less than 5° with a diagonal crossfall in the eastern half of the site from the southeast to the northwest, and in the western third of the site from the southwest to the northeast. The vegetation formations within the site are dominated by historically improved pastures and natural grasses in the grazing paddocks, established and managed lawns and gardens within the dwelling curtilage, and a scattering of native and exotic trees within the eastern half and along the southern boundary.

A proposed subdivision design has been prepared to complement the land rezoning proposal which would realise a potential 93 residential allotments varying in size from 709m² to 1,195m², an internal road network, stormwater drainage and water quality management reserves, and several areas of open space, revegetation, and public recreation. The existing dwelling and curtilage would be decommissioned, two existing dams would be decanted and filled, and the existing Right of Carriageway along the southern boundary would be removed in favour of an access to Lot 3 DP569505 via the new internal road system. Future development of the northwest corner within the immediate vicinity of the existing high-pressure gas and ethane lines and the optic fibre cable has been avoided and will form part of the land dedicated to open space and stormwater management.

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

- 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.
- 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 roads and residential Lots will be located.
- For the purposes of the land rezoning proposal establishment of suitable hydrological and hydraulic models to provide a robust assessment of the potential for flooding within the development property

- 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 of the site.
- Identification of areas within the property and surrounding catchment that may be impacted by the proposed development in the 'design' rain event - the 1% AEP event, and the probable maximum flood event by undertaking pre-development and post-development comparison modelling.
- Identification and classification of the hydraulic hazard associated with the works in the design and probable maximum flood events
- A summary of the findings and the implications (if any) on the proposed development.

Whilst this report has based its determinations and recommendations on a proposed subdivision design that is subject to a raft of considerations and approvals it is recognised that the next stage of the development process following rezoning of the land is the submission of a formal subdivision application that will include detailed engineering plans and a flood risk assessment that expands further upon the information presented within this submission.

It is considered that the proposed rezoning of the land from the current 'RU6 – Transition' to 'R2 – Low Density Residential' and a subsequent subdivision of the land to create a total of 93 allotments plus internal access roads and ancillary infrastructure is consistent with the intent of the NSW Flood Prone Land Policy, the NSW Flood Risk Management Manual, and the publication titled 'Considering flooding in land use planning Guideline' (2021).

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26 April 2023

Figure 1. Recent aerial view showing the boundary of the property in yellow and the proximity of the site to the northern edges of the city of Goulburn.

1/. Overview of the Rezoning Submission, Description of the Land and Proposed Subdivision.

The Goulburn Mulwaree Council commissioned *Elton Consulting* to undertake an *Urban and Fringe Housing Strategy* study for the urban centres of both Goulburn and Marulan which was completed and adopted by Council in July 2020. To gain an appreciation of how the aforementioned study triggers the submission of the land rezoning application being the subject of this assessment the following extracts have been taken directly from the completed report to provide context;

"This Urban and Fringe Housing Strategy (Strategy) investigates and identifies areas suitable for the provision of additional housing to assist Goulburn Mulwaree Council (Council) meet the housing demands generated by expected continued population growth.

The Strategy has been prepared in response to both the limited supply of residential land available to meet the short and medium term needs of the community and the directions of the South East and Tablelands Regional Plan 2036.

The scope of the Strategy includes looking at the urban areas of Goulburn and Marulan and identifying opportunities for an additional recommended 3,500 dwellings over the next 18 years to 2036. The Strategy also considers land for large lot residential development (typically greater than 2ha and often referred to as rural residential development) particularly on the urban fringe of Goulburn.

Growth across the LGA has been strong over the past decade increasing by 14 percent. In Marulan population growth has been significant with an increase in population between 2006 and 2016 of 27 percent.

With the Goulburn Mulwaree LGA expected to reach between 33,350 and 37,202 residents by 2036, approximately 5,000 to 7,000 additional residents are expected. Given the drivers of growth include proximity to economically viable regions and affordable housing, these growth rates may increase over time if prices in Sydney and the ACT continue to rise. Advances in technology and improvements in transport, for example higher speed rail, may further stimulate growth.

The majority of recent growth has been through residential subdivisions in Goulburn and Marulan. These new subdivisions have typically provided R2 Low Density Residential zoned land with a minimum lot size of 700sqm. The market responded well to these releases driving demand for additional land as the currently zoned land nears full utilisation."

The development property is located on the northern outskirts of the city of Goulburn and is identified within the *Urban and Fringe Housing Strategy* study as a locality suitable for rezoning to 'R2 -Low Density Dwelling' to help meet future land and housing demands. The property which falls within the *Middle Arm* development precinct and is currently zoned 'RU6 – Transition' has been identified within the study with an overall potential yield of 8.55 Lots per hectare for Lot sizes not less than 700m² in area – however these numbers do not necessarily take into consideration a reduction in potential Lot yield associated with the proximity of major utility infrastructure.

The development property is located along Middle Arm Road approximately 715 metres north from the speed limited zone upon entering the city when travelling south, and whilst not directly benefited from existing Council maintained utilities and services it is in an ideal location to leverage off existing reticulated water supply and gravity sewer infrastructure that presently extends to the edge of the city limits within the Middle Arm Road traffic corridor. Extension and connection of these services to the development site does not require any significant engineering requirements.

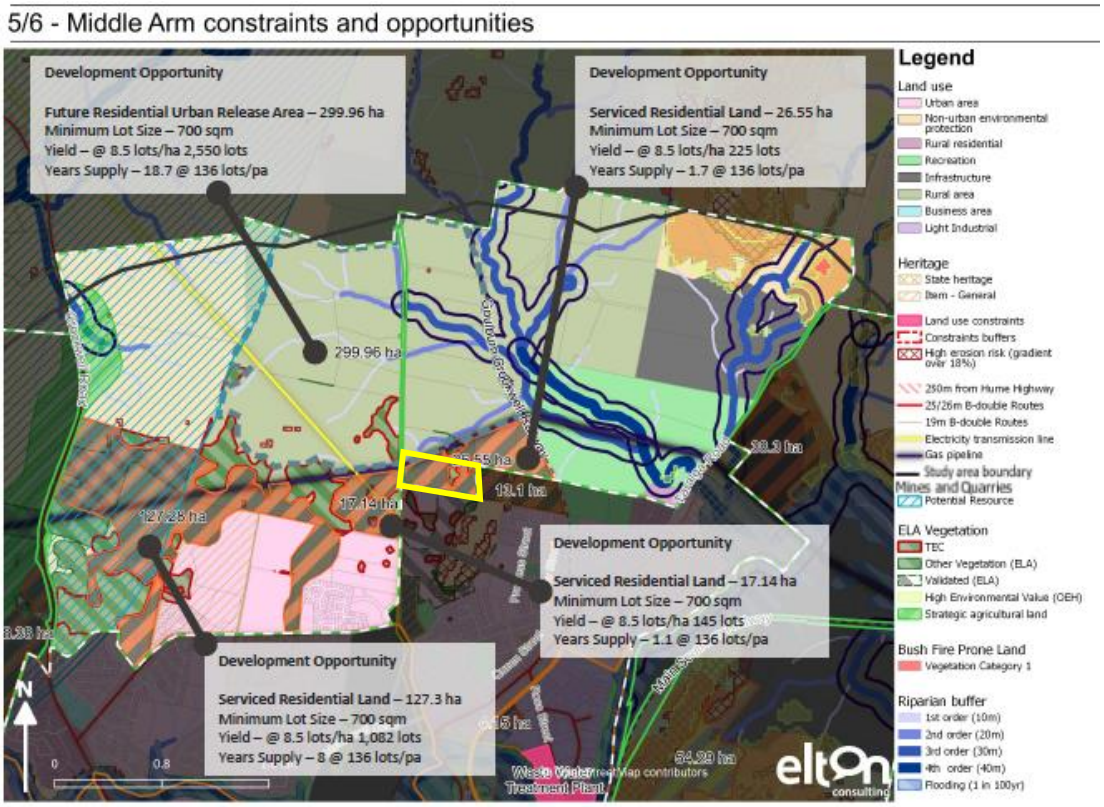

Image from the *Urban and Fringe Housing Strategy* report prepared by Elton Consulting showing the 'Middle Arm' development precinct and identified land rezoning opportunities. The boundary of the development site is highlighted by the solid yellow line in the centre of the image.

The proponent is seeking to rezone the land in accordance with Section 4.4.1 of the *Urban and Fringe Housing Strategy* study and in doing so establish the basis upon which to undertake a subdivision of the land. The site is burdened by two separate and adjacent 'major' inground utilities that run diagonally across the northwest corner of the site: the Moomba to Sydney high-pressure natural gas and ethane supply lines, and an optic fibre communication cable that lies to the southern side of the gas lines. The location of these utilities largely regulates the potential subdivision design and Lot sizes within this portion of the site due to various constraints and permissible activities within specified distances around the associated easements. A triangular area commencing from the northwestern corner and measuring 165 metres along the northern boundary and 103 metres along the western boundary (approximately 8,400m²) is effectively sterilised for residential development purposes due to the inground utilities, however the same area has been identified as part of an open space setting for community enjoyment.

Whilst not a direct constraint, the Southern Highlands to Goulburn water supply line which is designed to transfer raw water from the Wingecarribee Dam during periods of extreme drought is located within a 20 metre wide easement that runs parallel and for the full length of the southern boundary of the property. A 1.50 metre diameter concrete inspection and maintenance pit associated with the water supply line is located in the road reserve just outside the alignment of the western boundary – 5 metres from the southwest corner of the current holding. Approximately 150 metres along the southern boundary from the southwest corner of the property is an access gate to the water supply easement. An access gate will be retained but moved approximately 70 metres further to the east where a new entry will be provided at the junction of proposed 'Road 03' and 'Road 04' within the new subdivision layout.

The development site is bordered by the Middle Arm Road which runs north – south along the western boundary. Middle Arm Road is a Council maintained bitumen sealed formation that services many rural holdings to the north and provides an important transport link to the city of Goulburn from localities such as Middle Arm, Roslyn, and Tarlo that lie to the north of the city. The Middle Arm Road traffic corridor is also regularly used by cyclists and runners due to its general width, alignment, and long sight distance characteristics that support such activities.

The existing dwelling within the site is currently accessed via an unsealed carriageway that enters the property from the southwestern corner off the Middle Arm Road traffic corridor. The carriageway which averages 3 metres in width lies within a 20m metre wide Right of Carriageway easement that runs for the entire length of the southern boundary and benefits the adjoining property to the immediate east - Lot 3 DP569505. Approximately 260 metres along the length of the carriageway there is a fork in the formation that deviates off the to the northeast and directly services the existing dwelling. Whilst the access easement is 20 metres wide the alignment of the carriageway along the entire length of the southern boundary leading up to Lot 3 DP569505 is generally very close to the boundary fence – so much so that the centreline of the formation is never more than about 6 to 7 metres off the fence line.

From the point where the carriageway branches off to the existing dwelling a row of trees has been established between the carriageway formation and the curtilage associated with the dwelling to provide an element of privacy screening from the vehicular traffic heading into the adjoining property to the east. The trees which are sown about 8 metres off the southern boundary fence are comprised of a mixture of species including radiata pines and wattles, however most of the trees are an introduced native species – Paddy's River Box (*E. macarthurii).* Additional rows of conifers and screening trees have been established around the perimeter of several small paddocks adjacent to the access carriageway leading to the adjoining property to the east, and along the access carriageway leading up to the existing dwelling.

The terrain throughout the development property is fairly homogonous with a general fall from the south to the north at relatively minor grades that average less than 10°. The central portion of the site falls from the south to the north at less than 5° whilst the eastern half of the site has a crossfall from the southeast to the northwest, and the western third of the site has a crossfall from the southwest to the northeast.

There is an overall elevation difference of 23 metres between the higher southeastern corner (677 mAHD) and the lower northwestern corner (654 mAHD) over an effective distance of 650 metres.

The development property is burdened by two defined drainage corridors; one that travels south – north through the central portion of the site, and the other that flows diagonally across the northwestern corner – just to the north of the high-pressure gas supply lines. The head of the centre drainage line commences from the overflow path of a small sized dam within the neighbouring property to the south and follows a natural but rather broad depression through the development site – eventually draining into a small and shallow dam near to the northern boundary. Overflow from this dam continues along the defined drainage depression and discharges into the neighbouring property to the north.

The second drainage depression enters the development site approximately 50 metres south of the northwest corner post along the western boundary. This particular drainage line commences in the adjoining lands on the western side of the Middle Arm Road traffic corridor and after surface water runoff associated with the catchment passes through a series of dams it passes under the roadway via three 750mm diameter concrete pipes. Surface water that passes through the piped culverts enters the site and flows diagonally along the alignment of the natural gas pipeline easement and before exiting along the northern boundary and draining into a dam within the neighbouring property to the north. The two identified drainage depressions are essentially separate from each other and do not merge until much further north of the development site.

There is a second dam within the development property located in the higher southeast quarter. This dam is not associated with any defined or mapped drainage system however it does serve the purpose of collecting surface water runoff from upslope sources to the east and southeast and preventing it from directly flowing across the residential precinct within the site. Along the eastern half of the property's southern boundary a drainage channel has been formed between the edge of the access carriageway and the boundary fence line. This channel intercepts surface water runoff originating from the southeast and there are two 300mm diameter piped culverts spaced approximately 75 metres apart under the carriageway that direct some of the runoff into the dam. Flows within the drainage channel that bypass the drainage culverts simply continues along the southern boundary to the west where eventually the channel ceases and thereafter becomes broad overland flow across the carriageway near to where the formation forks and services the existing dwelling. This flow merges with the overflow from the dam to the south.

Surface water runoff from the neighbouring property to the east and some of the land within the development site is directed into the second dam via a broad and relatively flat drainage berm that has been formed along the 665.60 to 665.30 contour lines that runs diagonally across the site and directs the runoff into the eastern corner of the dam.

A second berm that runs parallel to the aforementioned system is located slightly further downslope to help manage surface water runoff around the dwelling precinct from other upslope sources, however it is not directed into the dam as it is too low in the terrain profile.

Overflow from the second dam and the discharge from the lower drainage berm are generally directed to flow toward the north via natural depressions and around the dwelling precinct however during periods of extended rain or large storms this source of water does enter the house paddock and surrounding curtilage.

There is a small source of surface water runoff burdening the site which is associated with runoff from the section of Middle Arm Road that lies to the south of the site. The roadside table drain on the eastern side of the road formation passes under the exiting entrance crossover via a 300mm diameter piped culvert and headwalls, and in the larger rain and storm events some of the runoff exiting the culvert can breach the top of the table drain and enter the site. There is shallow drainage depression in the southwest corner of the site that directs this flow in a southwest to northeast alignment and eventually drains into the dam in the lower northern portion of the site.

The vegetation formations throughout the property which has historically been used for grazing by sheep and cattle are dominated open paddocks of improved pastures and native grasslands, however over the past 5 or so years the property has seen less pasture improvement and only light grazing. The grazing paddocks are regularly raked and slashed to manage the height of the grasses, and some of the cut matter is retained for future feed stocks. Scattered throughout the eastern portion of the site and still within some of the grazing paddocks is a mix of native and exotic tree species, whilst the eastern section of the southern boundary is lined with a discontinuous row of an introduced species of native eucalypt (*E. macarthurii* - Paddy River Box Gum) that acts as both a wind break and privacy screen from the unsealed driveway that serves as access to the adjoining property to the east. The adjoining property to the immediate east which is effectively upslope has a discontinuous row of old radiata pine trees along the common boundary - again to act as both a wind break and privacy screen - with a scattering of endemic eucalypt trees further upslope and to the east.

The residential precinct within the site is set to established lawns and gardens within a defined house paddock and curtilage. Scattered throughout the managed lands are a variety of native and exotic trees and shrubs that provide a formal appearance to the site. The outer southern and western paddocks that form part of the curtilage and either side of the main access driveway are lined with established rows of cypress trees that provide screening from the prevailing winds and an element of privacy from the traffic along the southern boundary associated with the neighbouring property.

The surrounding landscape in adjoining lands is comprised of similar land uses and vegetation types, many with established residential dwellings surrounded by managed lands, and open paddocks of either improved pastures and/or native grasslands that are used for grazing purposes.

Future Subdivision Proposal.

The proposed subdivision design will seek to create the following: a total of 93 residential Lots that will range in size from 709m² to 1,195m²; several reserves for stormwater drainage and water quality measures; areas for landscaping, vegetation management and open space; and a network of new internal roads. An existing dwelling and several rural structures within the eastern portion of the site will be demolished and therefore all new Lots will be seeking residential dwelling permissibility.

The location of the existing easements for high-pressure gas supply and optic fibre cable in the northern portion of the site significantly influences the design of the future subdivision, including Lot layout and road locations. There are certain restrictions related to permissible activities around and near both easements, the most limiting of which is generally associated with the high-pressure gas and ethane supply line as it is the wider of the two and has very specific and documented controls.

The design of the proposed subdivision development has allowed for an increased separation distance for residential dwellings from the gas supply easement amongst other measures, and a pre-lodgement meeting has been held with APA Group – being the asset maintenance agency to discuss the potential risks, the integrity of the assets in the general vicinity of the development site, and proposed mitigation measures. A 'Safety Management Study' (SMS) report has been prepared by an accredited private facilitator in consultation with APA and the proponents (video meeting, Friday 21st March 2023) and it is concluded that the development can be undertaken in its current proposed layout without imposing any significant risks on the pipeline assets or to future landowners.

The proposed subdivision design allows for the formation of a new internal road system that will junction off Middle Arm Road which runs parallel to the western boundary of the property. The proposed road system will comprise a single entrance road that ends at a tee-intersection approximately 230 metres inside the boundary to form a looped perimeter road around the majority of the northern and southern boundaries. Prior to the tee-junction a smaller looped access road will junction off the entrance road at a chainage of approximately 110 metres to service several of the proposed Lots, and it will join back onto the perimeter road system near to the northern boundary. An existing Right of Carriageway easement along the southern boundary of the development property benefiting the adjoining property to the east will be removed in favour of improved access along the proposed new internal road system. The internal road will be a mix of 15, 18, and 20 metre wide reserves, however all carriageways will have a formed width of 9 metres between kerbs. At least one footpath will be provided within each road reserve.

A future subdivision of the site will include fully serviced Lots with a reticulated water supply throughout along with gravity sewer and interallotment stormwater drainage infrastructure. The water supply system will be installed to meet the requirements of the Council's engineering standards and the provisions of "AS2419.1.2021 - *Fire hydrant installations System design, installation and commissioning*" in relation to hydrant outlet spacing and locations.

The proposed subdivision design has identified the main sources of natural overland flow that affect the site and accordingly has included dedicated reserves for the purposes of drainage at strategic locations. Refer to Section2 of this report for details of the natural overland flow paths.

In particular, it is proposed that a formed drainage swale will be constructed within the reserve of perimeter road – 'Road 04' along the southern boundary to intercept and direct surface water runoff from the southern and southeastern aspects to a dedicated drainage channel to be formed parallel to one of the internal road corridors – 'Road 03'. The drainage channel is 8 metres wide and is aligned where the overflow from the dam in the neighbouring property to the south effectively enters the development site. The drainage channel will also be used for water quality treatment purposes that will include specific construction features and plantings of certain grasses, rushes, and sedges which will also double-up to form part of the landscaping features.

The proposed new Lots will be connected to an inter-allotment stormwater drainage system that will help manage runoff from hardstand areas and surface water that may enter or affect the individual sites, and the internal road system will have a separate network of pits and pipes designed in accordance with the relative engineering standards for safe the management of stormwater through the site.

All stormwater runoff that is generated within the site – with exception of the drainage system across the northwest corner, will be managed within an end-of-line wetland treatment device. The proposed wetland is located in the lower northern portion of the site adjacent to the high-pressure natural gas and optic fibre utilities which is a part of the site that is effectively not suitable residential dwelling purposes. The wetland will replace the existing lower dam and form a significant part of the water quality treatment measures associated with the development as well as providing detention measures to ensure that the post-development peak flow rates do not exceed those of the pre-development conditions for a range of rainfall events.

Sources of external water that enter the property from the southern aspect will be directed through the site in a separate 375mm diameter piped system to be laid within a 1 metre wide section of the central drainage corridor.

A vegetation buffer zone will be created along the entire length of the southern boundary, and the portion of the northern boundary between the edge of the wetland drainage reserve and the northeast corner. These buffer zones will be 3 metres wide commencing from the boundary line and will be used as areas for replacement planting and relocation of existing trees that are to be disturbed. Additional areas dedicated for landscaping, re-vegetation, and open spaces includes the drainage reserve running parallel to proposed 'Road 03'; the wetland reserve; a 12.75 metre wide buffer zone between the western boundary and proposed Lots 1, 19, and 20; a strip of land to the south of the high-pressure gas and ethane supply line easement that will vary between 13 and 10 metres wide, the area immediately above the high-pressure gas and ethane supply line easement, and the far northwest corner of the site to the north of the high-pressure gas and ethane supply line easement.

The total area identified for landscaping, re-vegetation and open space around the perimeter of the site and across the northwestern corner but excluding the main drainage corridor and wetland reserve is 1.105 hectares. The main drainage corridor and the wetland reserve will occupy another 6,570m² and these areas will be utilised for growing lower forms of plants species such as tall grasses, sedges, and rushes that are normally associated with macrophyte zones and riparian corridors.

2/. Stormwater drainage and overland flows.

The development property and surrounding lands are not identified in any current planning or mapping instruments as being within flood liable lands, and nor is there any knowledge of proposed studies to investigate the area for potential flood affectation. The property is however burdened by general overland flows associated with surface water runoff originating within adjoining lands and properties to the south, southeast, east, and to a lesser degree to the west of the site. This study is assessing the impacts of existing overland flow from these external sources and stormwater drainage generated within on the land rezoning proposal and potential future residential subdivision development for the site.

The development property is burdened by two defined drainage corridors; one that travels south – north through the central portion of the site, and the other that flows diagonally across the northwestern corner – just to the north of the high-pressure gas supply lines. The head of the centre drainage line commences from the overflow path of a small sized dam within the neighbouring property to the south and follows a natural but rather broad depression through the development site – eventually draining into a small and shallow dam near to the northern boundary. Overflow from this dam continues along the defined drainage depression and discharges into the neighbouring property to the north.

The second drainage depression enters the development site approximately 50 metres south of the northwest corner post along the western boundary. This particular drainage line commences in the adjoining lands on the western side of the Middle Arm Road traffic corridor and after surface water runoff associated with the catchment passes through a series of dams it passes under the roadway via three 750mm diameter concrete pipes. Surface water that passes through the piped culverts enters the site and flows diagonally along the alignment of the natural gas pipeline easement and before exiting along the northern boundary and draining into a dam within the neighbouring property to the north. The two identified drainage depressions are essentially separate from each other and do not merge under normal rain and storm flows until much further north of the development site.

There is a second dam within the development property located in the higher southeast quarter. This dam is not associated with any defined or mapped drainage system however it does serve the purpose of collecting surface water runoff from upslope sources to the east and southeast and preventing it from directly flowing across the residential precinct within the site. Along the eastern half of the property's southern boundary a drainage channel has been formed between the edge of the access carriageway and the boundary fence line. This channel intercepts surface water runoff originating from the southeast and there are two 300mm diameter piped culverts spaced approximately 75 metres apart under the carriageway that direct some of the runoff into the dam. Flows within the drainage channel that bypass the drainage culverts simply continues along the southern boundary to the west where eventually the channel ceases and thereafter becomes broad overland flow across the carriageway near to where the formation forks and services the existing dwelling. This flow merges with the overflow from the dam to the south.

Surface water runoff from the neighbouring property to the east and some of the land within the development site is directed into the second dam via a broad and relatively flat drainage berm that has been formed along the 665.60 to 665.30 contour lines that runs diagonally across the site and directs the runoff into the eastern corner of the dam.

A second berm that runs parallel to the aforementioned system is located slightly further downslope to help manage surface water runoff around the dwelling precinct from other upslope sources, however it is not directed into the dam as it is too low in the terrain profile. Overflow from the second dam and the discharge from the lower drainage berm are generally directed to flow toward the north via natural depressions and around the dwelling precinct however during periods of extended rain or large storms this source of water does enter the house paddock and surrounding curtilage.

There is a small source of surface water runoff burdening the site which is associated with runoff from the section of Middle Arm Road that lies to the south of the site. The roadside table drain on the eastern side of the road formation passes under the exiting entrance crossover via a 300mm diameter piped culvert and headwalls, and in the larger rain and storm events some of the runoff exiting the culvert can breach the top of the table drain and enter the site. There is shallow drainage depression in the southwest corner of the site that directs this flow in a southwest to northeast alignment and eventually drains into the dam in the lower northern portion of the site.

To ascertain the impacts (if any) of overland flows and surface water drainage on the proposed land rezoning and potential future subdivision a preliminary (pre-development) stormwater drainage and overland flow model was undertaken of the existing site and surrounding catchment area using a combination of Lidar mapping information and detailed contour survey of the property and connecting road corridor. To create a terrain profile for the stormwater drainage and overland flow assessment outside of the detailed property and road corridor survey LiDAR information was obtained for the development area from the Geoscience Australia '*Elevation and Depth Foundation Spatial Data'* website (ELVIS). The defined catchment area and development property is captured within a single dataset which has a grid area of 2km x 2km (Goulburn201906-LID1-AHD_7506146_55_0002_0002) which was downloaded as 2 metre grid Digital Elevation Model metadata item.

The primary objective of the modelling is to determine the existing overland flow patterns, water depths, and velocities within the development property and to conservatively estimate for the 'design rain event' – being the 1% AEP rain event where the main impacts (if any) from external sources would be experienced. Results from the modelling exercise were also used to help define primary areas for future stormwater drainage infrastructure. Software used to undertake the modelling is the '*InfoWorks ICM Ultimate*' which is licenced, distributed, and supported by Autodesk. '*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. 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 assessment purposes.

As no previous flood modelling of the development area is available for comparison, correlation, or validation the current recommended guidelines for rainfall information and flood modelling for small catchments as prescribed by Engineers Australia - Australian Rainfall and Runoff (2019) and the NSW Flood Risk Management Guide (2019) were adopted. 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. Design parameterisation and rainfall data for the site was obtained directly through the Australian Rainfall & Runoff Data Hub and the Bureau of Meteorology portal.

A range of IFD (intensity, frequency, and duration) information and Annual Exceedance Probability options were gathered to enable comparison modelling to be performed however most of the data was focused on the 1% AEP durations as this is generally the critical storm of interest for the development. As the characteristics of the upstream catchment area is reasonably homogonous and comprised of similar land use and surface types a single model has been prepared that has adopted a uniform roughness coefficient (Manning's 'n') of 0.035 that represents the generally short to medium height grasses associated with grazing activities - in accordance with Table 6.2.2 of the AR&R2019 guidelines. An initial loss of 16mm has been modelled in accordance with the storm loss figures from the Australian Rainfall & Runoff Data Hub for the geographical area, however a continuing loss was not included in the model.

The catchment area under review covers 125 hectares and is broken down into approximately 129,475 meshing triangles that have an average area of 10.50m², and each 'working' face allows normal flow conditions from one mesh triangle to the next. The large modelling area validates the effective upstream catchment that burdens the development property by identifying other drainage regimes that occur outside, around, and beyond the property, and which therefore can effectively be ignored.

Within the 1% AEP - 1-hour storm 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. For analysis purposes the 1-hour storm with temporal pattern #2 run for a 120-minute duration was adopted as this tended to have two bursts in the rainfall intensity with an irregular rainfall pattern continuing until the end of the run, and it was possible to observe how long the depths of water remained after the peak rain in the event.

The pre-development model comprised a total catchment area of approximately 125 hectares which included adjoining upslope properties to the south and east to gauge the impact of all external sources of surface water runoff that potentially burden the site. From the modelling outcomes it is possible to determine that the 'effective' catchment area that directs overland flows into the site is generally limited to south, east, and southeast and covers an area of approximately 20 hectares. The modelling results for the 1% AEP storm event indicates that the western third of the site – and in particular the central corridor is most affected by overland flows that run in a general south to north pattern along existing defined and undefined drainage corridors.

At the peak of the modelled rain event the depth of stormwater within these areas is generally less than 100mm however some sections of the site have slightly deeper bodies of water – particularly on the upstream side of the dam in the lower northwestern portion of the site. The pre-development model demonstrates that the main source of external overland flow is from the southern aspect of the site, however there is also a secondary flow of surface water that burdens the eastern portion of the site which is generally very limited in migration and depths, and tends to be confined to the shallow berms that have been formed. The pre-development model also confirms the restricted impact of the overland flows entering the northwestern corner of the site from the culverts under Middle Arm Road.

To gauge the potential impact of the external sources of overland flow on a future subdivision of the land a second 'post-development' model was prepared that incorporated the existing external terrain data with the proposed site regrading which includes decommissioning of the existing dams and the formation of the new internal road system. Also within the regraded site details was the conceptual design for the wetland treatment system in the lower northern portion of the property. The primary objective of the post-development model was to determine if the areas identified for the residential allotments and the access roads would be adversely impacted by overland flows in the same 1% AEP – 1-hour design rain event, and if so to what extent.

The post-development model was undertaken at a 'high-level' approach and did not include detailed designs for the proposed swales along the southern boundary, the configuration of the central drainage corridor, or the inclusion of 'pits and pipes' associated with the stormwater drainage system for the internal road network or the inter-allotment drainage system. The model also did not include the proposed 375mm diameter pipe to be installed within the central drainage corridor that will convey external sources of water through the site.

Based on the proposed site regrading and using the internal road corridors for the conveyance of surface water without any specific pit and pipe drainage information the post-development model demonstrated that essentially all surface water could be managed within the road reserves. There was a small area around the proposed residential Lots bounded by Roads 01, 02 and 03 where there was indication of overland flow, however the depths are less than 100m and would be easily removed by the proposed road and inter-allotment stormwater drainage systems. The depth of water within the roadways was generally less than 100mm except for where there was a sag in the formation, and it is anticipated that with a purpose designed pit and pipe drainage system included in the model the depth of water in the road reserves would be significantly less, and in many cases removed altogether. Additional information such as the shape and alignment of the swales along the southern boundary and the formation of the central drainage corridor would improve the results, but at this preliminary land rezoning stage it is considered that this level of detail is not required.

By the end of the simulation the water depths had subsided such that the only remaining water was associated with the wetland detention basin and minor undulations and depressions in and around the internal road corridor.

The 1% AEP modelling results for the post-development scenario have also been converted into a second level of risk assessment – a hydraulic hazard (flood depth and velocity) assessment based on the guidelines within Chapter 7 of Book 6 within AR&R2019 – Section 7.2. The model has categorised the hydraulic hazard into six separate risk profiles in accordance with the hazard curves and properties tables based on work undertaken by Smith et al. (2014).

The hydraulic hazard is a measure of the risk to human life and evacuation opportunities as a consequence of water depths and flows velocities with a scaling chart system used to identify suitable thresholds for different population demographic groups, structures, and vehicular transport options for evacuation situations. The hydraulic hazard is comprised of six critical levels, with levels 1 to 3 being acceptable for a range of human occupancy and transport options, whilst levels 4 to 6 are essentially unsuitable for people and vehicles but may be suitable for different types of building structures – although Level 6 is essentially not suitable for any form of land use.

The modelling results for the post-development conditions indicate that where a hydraulic hazard is created it generally follows the alignment of the proposed internal road reserves. The associated depths and velocities of water are within the lower end of the risk scale being predominantly 'Level 1' which is considered suitable for all demographic groups, buildings, and transport options. The only exception to the Level 1 risk classification across the site occurs at the proposed wetland which by default will be deeper than 1 metre and therefore in the higher end of the risk classification scale.

For the 1% AEP – 1-hour rain event it is concluded that overland flows that burden the property along with stormwater generated within a future subdivision of the site can be managed to a level where there are no adverse impacts on individual allotments or the proposed internal road system. Within the simulation the maximum flood inundation occurs for a very brief period of time with the peak in water levels occurring approximately 40 to 50 minutes into the rain event and all roadways are passable within 90 minutes from the commencement of the rainfall. The conveyance of stormwater along the internal roadways and through the site allows the areas identified for residential allotments to be remain relatively unaffected by overland flows with the majority of sites above the affected areas.

Refer to Figures 2.1 and 2.2 for the results of the 1% AEP – 1-hour pre-development and post-development overland flow modellings, to Figures 2.3 and 2.4 for the 1% AEP maxima hydraulic hazard details of the pre-development and post-development models, and to Figure 2.5 for the Hazard risk curves and classification tables from Chapter 7, Book 6 of AR&R2019.

Probable Maximum Precipitation – Probable Maximum Flood Modelling.

Comparative modelling for both the pre-development and post-development scenarios was also undertaken for the probable maximum precipitation / probable maximum flood event using the same duration of 1-hour with temporal pattern #2. The determination of the probable maximum precipitation was calculated in accordance with the *Generalised Short Duration Method* (GSDM) as prescribed by the Bureau of Meteorology (2003), and the terrain within the modelled catchment which is 125 hectares in area was determined to be 100% 'smooth'. A 'Moisture Adjustment Factor' (MAF) of 0.68 was adopted, and the 'Elevation Adjustment Factor' (EAF) was '1' as the elevation of the site is less than 1,500 mAHD. Via interpolation of the data within the '*Depth – Duration – Area Curves of Short Duration Rainfall*' the following probable maximum precipitation rainfall depths were determined for the site:

Duration (minutes)	30	45	60	90	120	180	240	300	360
Rainfall depth (mm)	236	297	343	393	439	493	537	578	581

The pre-development model for the probable maximum flood event highlighted that the general path for overland flows mimicked that of the 1% AEP model, and essentially there were no new sources of external overland flow that burdened the site. The extents and depth of water within the site broadened and deepened proportionately, and the flows associated with some of the individual drainage corridors merged when closer to the point of convergence.

In the post-development model for the probable maximum flood event the majority of flows were contained within or long the proposed internal road network, however some broader overland flows were evident around the proposed residential Lots bounded by Roads 01, 02 and 03. The majority of the flows within this specific area tend to be less than 300mm with a few isolated areas where the depths are slightly greater. As for the summary of the 1% AEP post-development model, it is anticipated that once the road network and the inter-allotment stormwater drainage systems are incorporated into the model and the design levels for the internal roads are finalised that the depths within this and any other burdened areas will be considerably less. It is also noted in the post-development model that the formation of the internal road network redirects some of the overflows within the eastern portion of the development site that in the pre-development case burdened the adjoining downstream property to the north.

As with the 1% AEP models a hydraulic hazard assessment was undertaken for the probable maximum flood event in the pre-development and post-development scenarios, and whilst there was an increase in the area burdened, the main area where depths and flow velocity increased was constrained to the portion of the site where the proposed loop road and central drainage corridor are proposed to be constructed. Essentially all the land area designated for residential dwelling purposes is still within the lower end of the hazard scale – being at 'Level 3' or less, and it is considered that once the stormwater drainage network and final design levels for the internal road system are more-accurately modelled than the results for hydraulic hazard will improve.

The development site is not located within a studied or adopted floodplain risk management area (flood prone lands) and therefore does not contain portions of land that fall within a defined 'flood planning area'. At the time of preparing the land rezoning planning proposal there was no known intention or trigger for the Goulburn Mulwaree Council to undertake a flood study of the development precinct. The results of the overland flow study presented in this submission therefore are partly associated with a due-diligence assessment of the proposal that also includes a 'neutral or beneficial effect' test on water quality for developments that are undertaken within the Sydney drinking water catchment. The overland flow study is largely used to determine the design of a future subdivision of the land by identifying natural flow corridors and trying to preserve those flow paths in the larger rain events. Locating roadways, public open spaces, and other non-habitable land uses within or adjoining the natural flow corridors ensures that the risks to people and property is minimised at the concept stage of the development.

The 'high-level' modelling results for the proposed development have identified the natural flow corridors, and for what would be deemed the 'design flood event' – being the 1% AEP event, the flows through the site in the corresponding post-development site conditions are maintained without having an adverse impact on the adjoining properties downstream of the development site. In a future development of the site each residential Lot will be required to satisfy the Council's relevant stormwater engineering requirements related to the management of the peak discharge from the individual site, and in doing so will help to alleviate any potential adverse impacts on downstream systems. Specific measures such as rainwater harvesting and reuse (including BASIX provisions), on site detention to manage the peak discharge, and stormwater quality measures to meet the NorBE criteria at the individual Lot scale will all work in combination to achieve this outcome.

It is important to note that information within this submission is not intended to be a 'detailed flood study' as defined by the NSW Flood Prone Land Policy and therefore it does not consider in detail the greater issues such development within the floodplain, flood planning areas and flood planning levels, emergency and risk management, and Special Flood Considerations. The level of flood risk associated with a proposed development of the site is considered to be relatively low as the site is only burdened by a small catchment area of less than 20 hectares that effectively commences at the crest of a shallow mountain within open grasslands approximately 400 metres upslope of the southern boundary. In the extreme probable maximum flood event the time to peak water level occurs between 40 and 50 minutes from the commencement of rainfall with receding flows and water levels starting at the 1 hour stage. By 90 minutes into the event all roadways are passable and where the is still residual bodies of water along the roadways the hydraulic hazard risk rating is 'Level 1'. At the end of the 120 minute simulation all roads are essentially free of pooled water.

Refer to Figures 2.6 and 2.7 for the results of the PMF – 1-hour pre-development and post-development overland flow modellings, to Figures 2.8 and 2.9 for the PMF maxima hydraulic hazard details of the pre-development and post-development models.

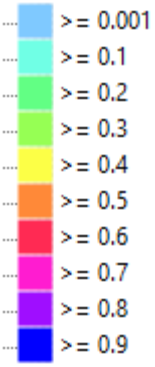

Figure 2.1. 1% AEP maxima stormwater depth and extent details of the pre-development model. Water depths of 25mm and less have been isolated for clarity of the main flow paths.

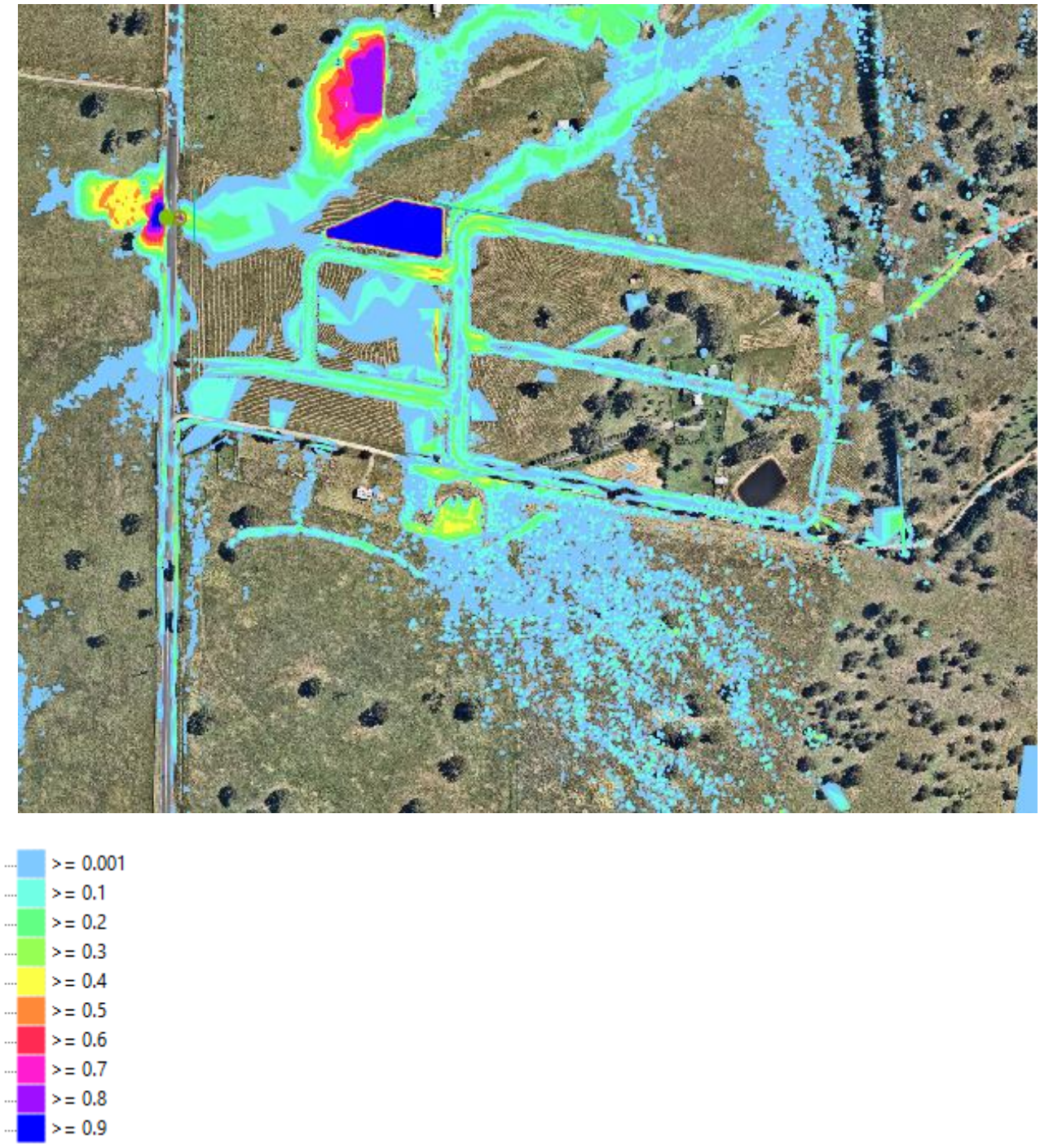

Figure 2.2. 1% AEP maxima stormwater depth and extent details of the post-development model. Water depths of 25mm and less have been isolated for clarity of the main flow paths. Detailed information such as drainage swale formations along the southern boundary, the formation of the central drainage corridor, pit and pipes associated with inter-allotment and road stormwater drainage, and the proposed 375mm diameter pipe to convey the external sources of water through the site have not been added to the post-development model.

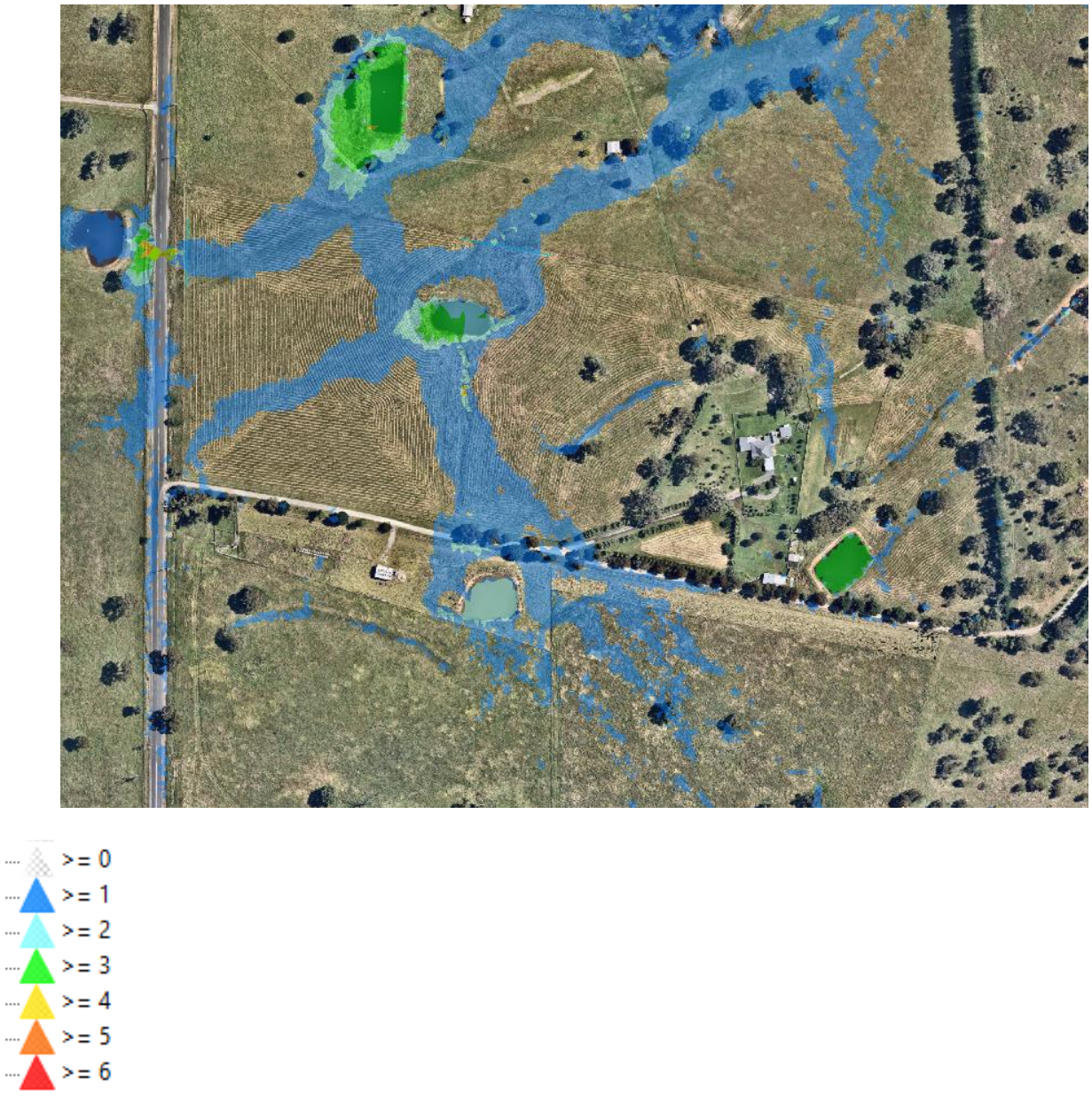

Figure 2.3. 1% AEP maxima hydraulic hazard details of the pre-development model.

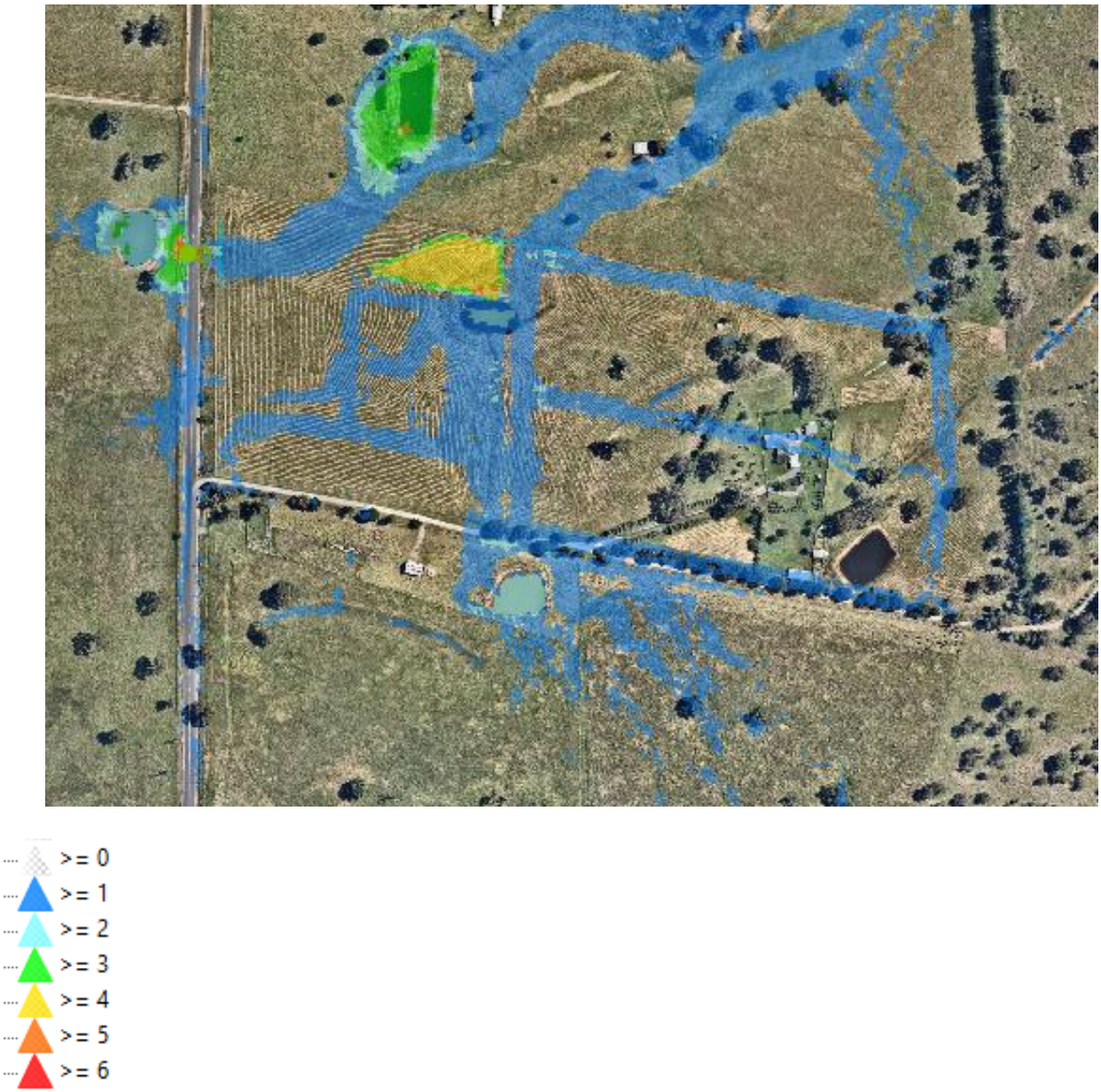

Figure 2.4. 1% AEP maxima hydraulic hazard details of the post-development model.

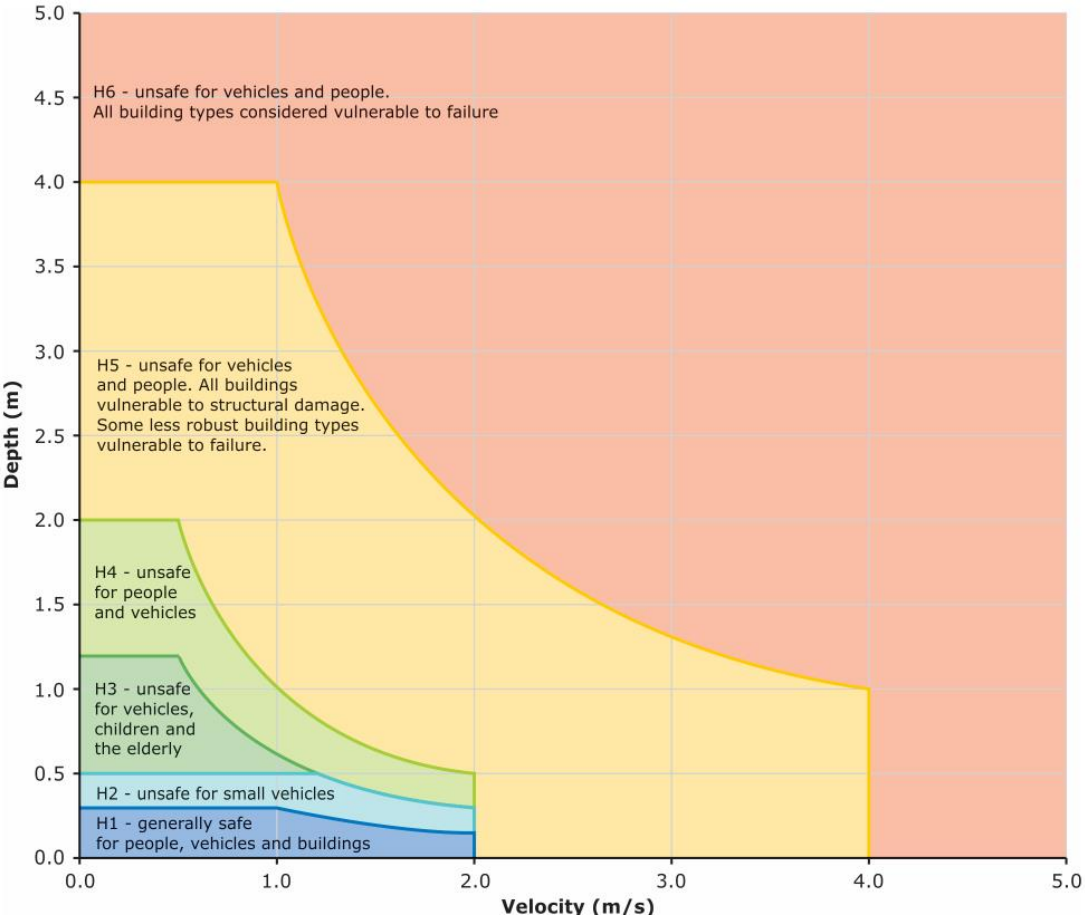

Table 6.7.3. Combined Hazard Curves - Vulnerability Thresholds (Smith et al., 2014)

Hazard Vulnerability Classification	Description
H1	Generally safe for vehicles, people and buildings.
H2	Unsafe for small vehicles.
H3	Unsafe for vehicles, children and the elderly.
H4	Unsafe for vehicles and people.
H5	Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure.

Table 6.7.4. Combined Hazard Curves - Vulnerability Thresholds Classification Limits (Smith et al., 2014)

Hazard Vulnerability Classification	Classification Limit (D and V in combination)	Limiting Still Water Depth (D)	Limiting Velocity (V)
H1	D*V ≤ 0.3	0.3	2.0
H2	D*V ≤ 0.6	0.5	2.0
H3	D*V ≤ 0.6	1.2	2.0
H4	D*V ≤ 1.0	2.0	2.0
H5	D*V ≤ 4.0	4.0	4.0
H6	D*V > 4.0	-	-

Figure 2.5. Hazard risk curves and classification tables from Chapter 7, Book 6 of AR&R2019.

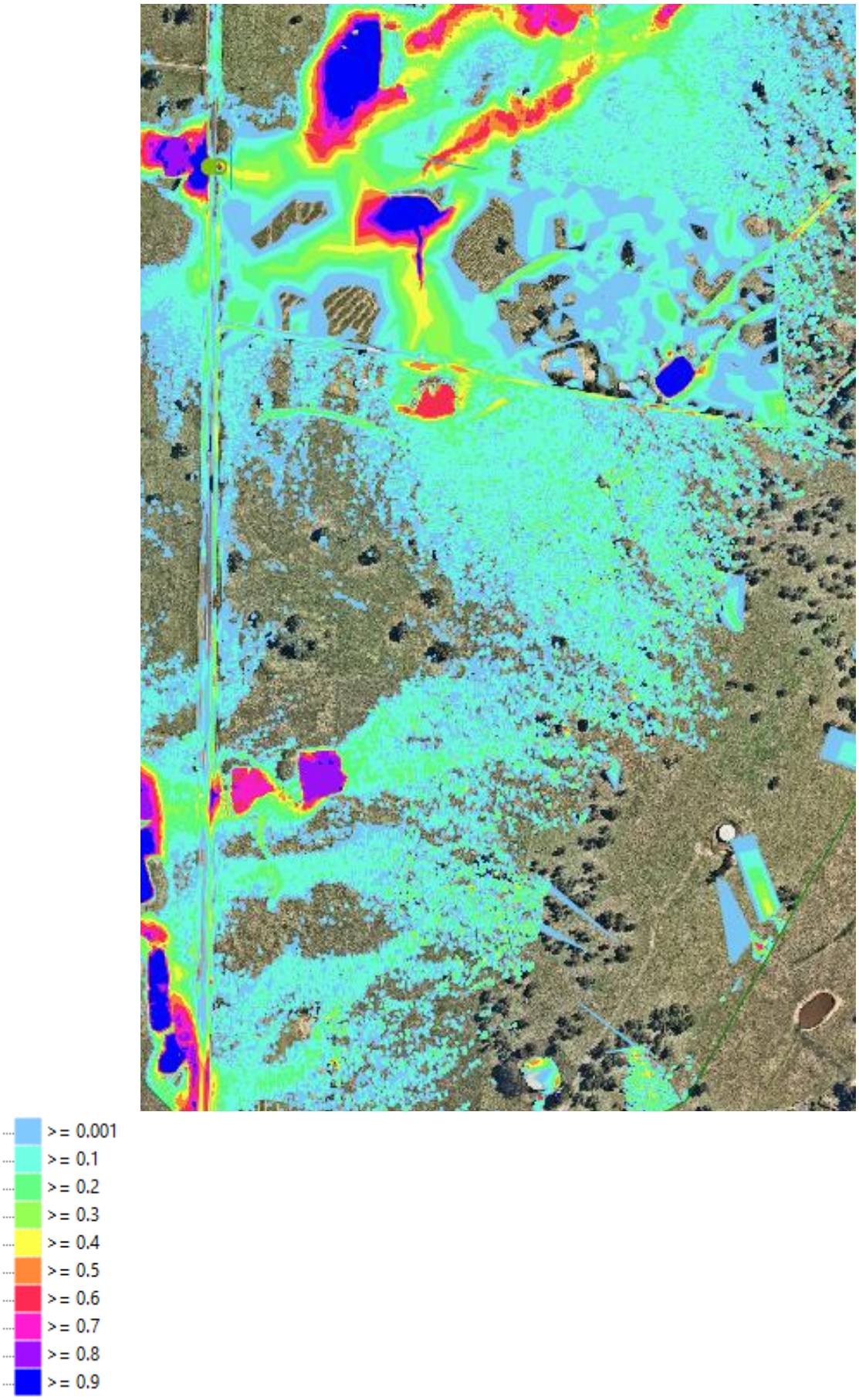

Figure 2.6. PMF maxima stormwater depth and extent details of the pre-development model. Water depths of 50mm and less have been isolated for clarity of the main flow paths.

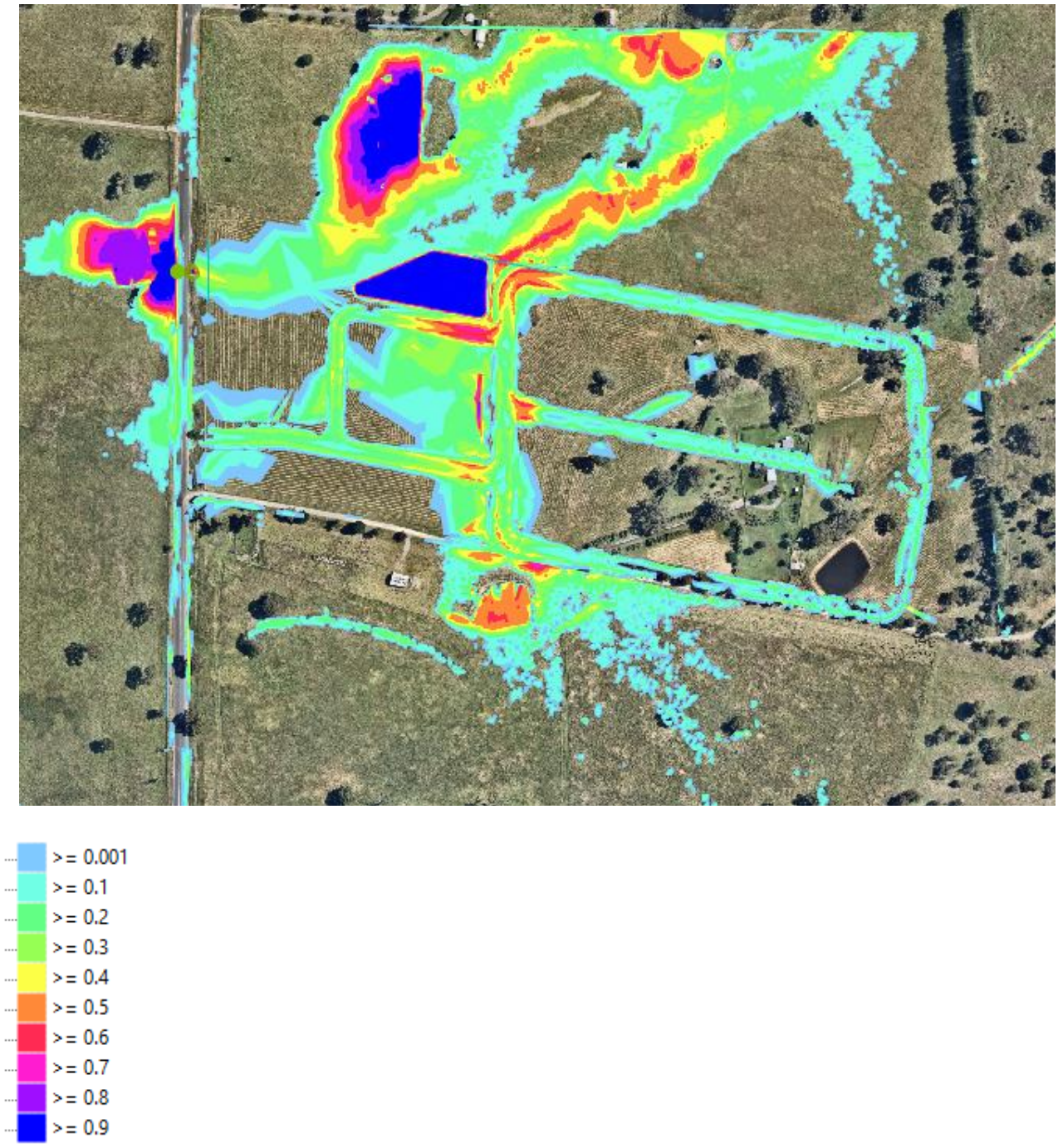

Figure 2.7. PMF maxima stormwater depth and extent details of the post-development model. Water depths of 100mm and less have been isolated for clarity of the main flow paths. Detailed information such as drainage swale formations along the southern boundary, the formation of the central drainage corridor, pit and pipes associated with inter-allotment and road stormwater drainage, and the proposed 375mm diameter pipe to convey the external sources of water through the site have not been added to the post-development model.

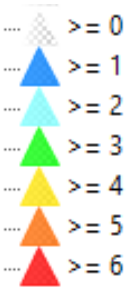

Figure 2.8. PMF maxima hydraulic hazard details of the pre-development model.

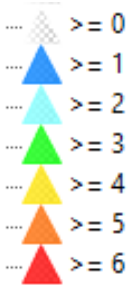

Figure 2.9. PMF maxima hydraulic hazard details of the post-development model.

3/. References.

Commonwealth Bureau of Meteorology – 'The Estimation of Probable Maximum Precipitation in Australia: Generalised Short Duration Method' (June 2003)

Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia (Geoscience Australia), 2019; Ball J, Babister M, et al.

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NSW Government Department of Infrastructure, Planning and Natural Resources – 'Floodplain Development Manual – The management of flood liable land' (April 2005)

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