



STORM FLOOD

FLOOD IMPACT ASSESSMENT

Proposed Development - Poultry Breeder Farm
1130 Gooloogong Road, Grenfell QLD
Prepared for MPN Consulting

Ref: SF-20-0048-002
Revision 1

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1 Background

1.1 Assessment Objectives

This Flood Impact Assessment (FIA) has been commissioned by MPN Consulting on behalf of Baiada Properties Pty Ltd, to investigate potential flooding impacts to support the Environmental Impact Statement and Development Application for a Proposed Poultry Breeder Farm at 1130 Gooloogong Road, Grenfell, located within the Weddington Shire Council (WSC) Local Government Authority (LGA).

The site is not mapped within WSC's Flood Planning Area, given this flood mapping is based off the Emu Creek flood study, which focuses on the township of Grenfell. However, given the topographical characteristics of the site, and the nearby Wallah Wallah and Warraderry Creeks within the vicinity of the site, the New South Wales Government's Spatial Services has determined perennial and non-perennial watercourses which require planning consideration. Accordingly, this flood study analyses the local and regional flooding, to appropriately address flood risks and impacts for the proposed development and its associated works.

No flood studies have covered the site to date, with the Emu Creek Flood Study (ECFS) being the closest catchment flood study, which was initially reported in February 2007. The site is located within the Lachlan River Basin, however there is no gauge with sufficient data to adopt within the regional sub-catchment of which the site belongs to. The closest gauge with significant data is the Lachlan River Station C67, some 70km downstream from the site's outlet point. Accordingly, a conservative hydrologic approach was adopted in accordance with the new South Wales *Review of ARR Design Inputs for NSW* report to account for potential data selection risks.

A baseline flood model has been built using BMT WBM's TuFLOW modelling software, in accordance with industry standards, to appropriately determine local and regional floodplain extents for the site. Hydraulic infrastructure for the site has been designed and assessed in conjunction with MPN Consulting, to determine flood impacts and risks for the proposed poultry farm.

This assessment is limited to the information provided by MPN Consulting Engineers, as well as publicly available information by the Local Government Authority (WSC), NSW Spatial Services (SixMAPS) and all other relevant authorities.

2 Site Information

2.1 Site Background

The subject site is located at 1130 Gooloogong Road, Grenfell, which consists of the following Registered Properties: Lot 1 on DP1022013, Lots 1-3 on DP1206485 and Lot 22 on DP866857. The combination of these sites (here within the 'subject site') contains an overall land area of 708.75ha (Source: PSA Consulting), as shown below in Figure 1.

The site has been zoned by Weddington Shire Council as Primary Production RU1 – WSC LEP 2011 (Source: WSC LEP 2011 Land Zone Map - LZN-008). The site does not contain a WSC Flood Planning Overlay, given the limits of the existing flood study for the Town, being the *Emu Creek Flood Study*, prepared by Lyall and Associates initially in February 2007. Other flood studies in nearby regional catchments include the Condobolin Flood Study (Oct 2007), Cowra Flood Study (October 2013), however these were undertaken prior to the release of Australian Rainfall and Runoff 2016 (now 2019) Guidelines.

Accordingly, there are no public flood studies within the site which have considered the latest methodologies and data from the Bureau of Meteorology's 2016 IFD Data, and therefore conservative measures have been adopted for this flood study.

Based on the New South Wales's Sharing and Enabling Environmental Data in NSW (SEED) Hydrography system, the site's hydrographical lines and potential waterbodies through the subject site have been mapped below in Figure 2.

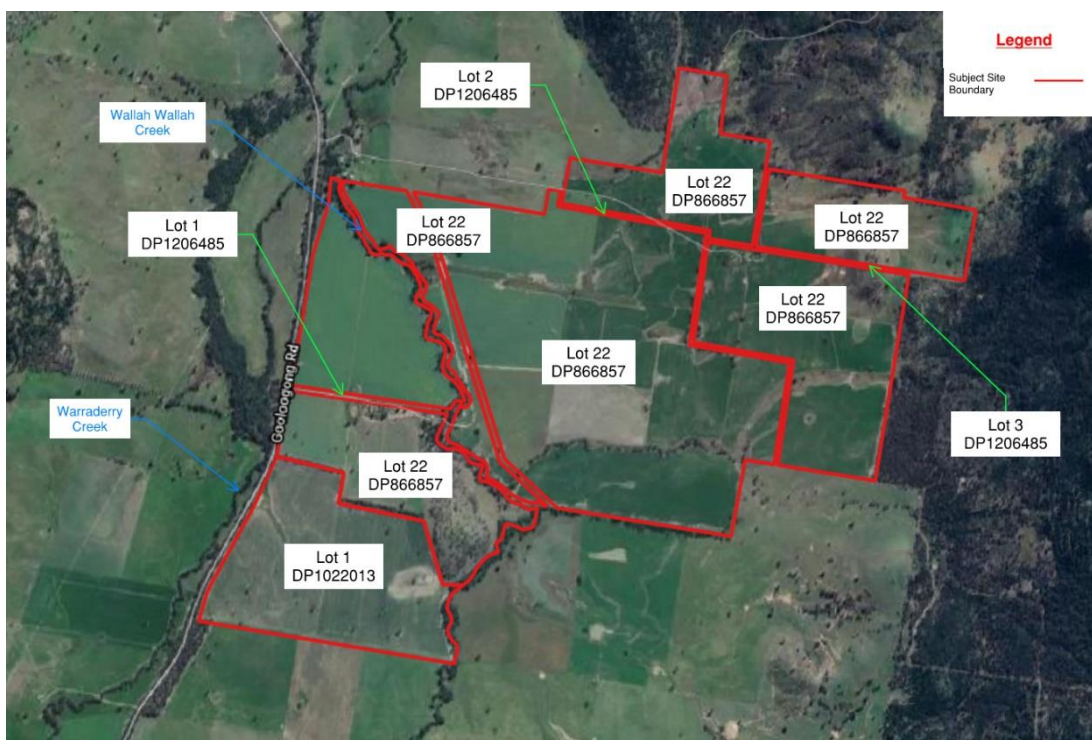


Figure 1: Subject Site – Aerial Imagery and Site Boundaries (Source: Google Maps and NSW Spatial Services)

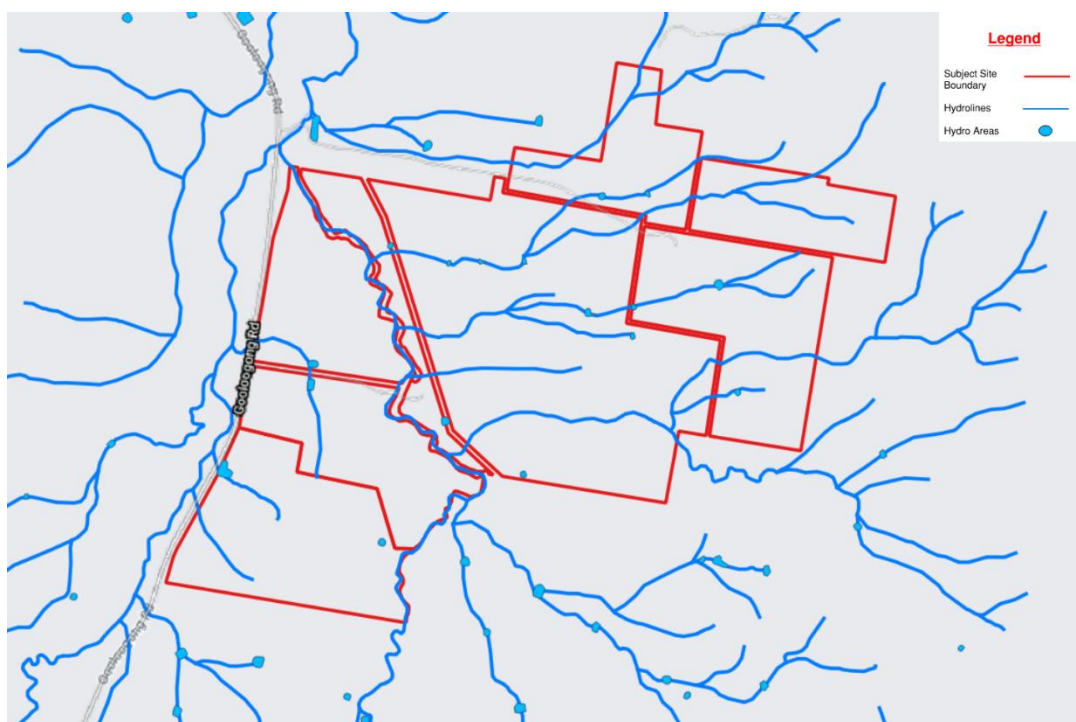


Figure 2: Subject Site – Hydrologic Features (Source: NSW SEED)

2.2 Site Characteristics

The site in its existing state is utilised for primary production purposes, as the site contains large green pastures with vegetated creeks and dirt pathways throughout the site. The site has varying topographies and grades, with a topographical map illustrated below in Figure 3 for an appreciation of the landform.

The site varies between approximately 326mAHN at the north-western corner of the subject site (Wallah Wallah Creek Discharge point), and 442mAHN (eastern mountainous terrain). There is also a hill at the south-central portion of the subject site which reaches approximately 370mAHN. The majority of the pasture land has an approximate average slope of 2%, whereas the small mountainous regions within the site can reach a slope of up to approximately 30%.

There are valleys within the site that are tributaries to the Wallah Wallah Creek, which is the main watercourse that runs within the site, as seen below in Figure 3. The downstream side of the subject site (Wallah Wallah Creek) converges with the Warranderry Creek, which runs parallel along the western boundary, west of Gooloogong Road.

Accordingly, the site contains multiple non-perennial localised overland flow paths from the hilly and rugged terrain from the east, which are tributaries into the regional Wallah Wallah Creek, and larger Warranderry Creeks. These creeks ultimately connect into Lachlan River system, some 40km further downstream.

A regional topographical map showing the Warranderry and Wallah Wallah Creek catchments which contribute to peak flooding across the site, are illustrated in Figure 4 below.

The topographical data is based off 2017 Aerial LiDAR Imagery, obtained via NSW Spatial Services.

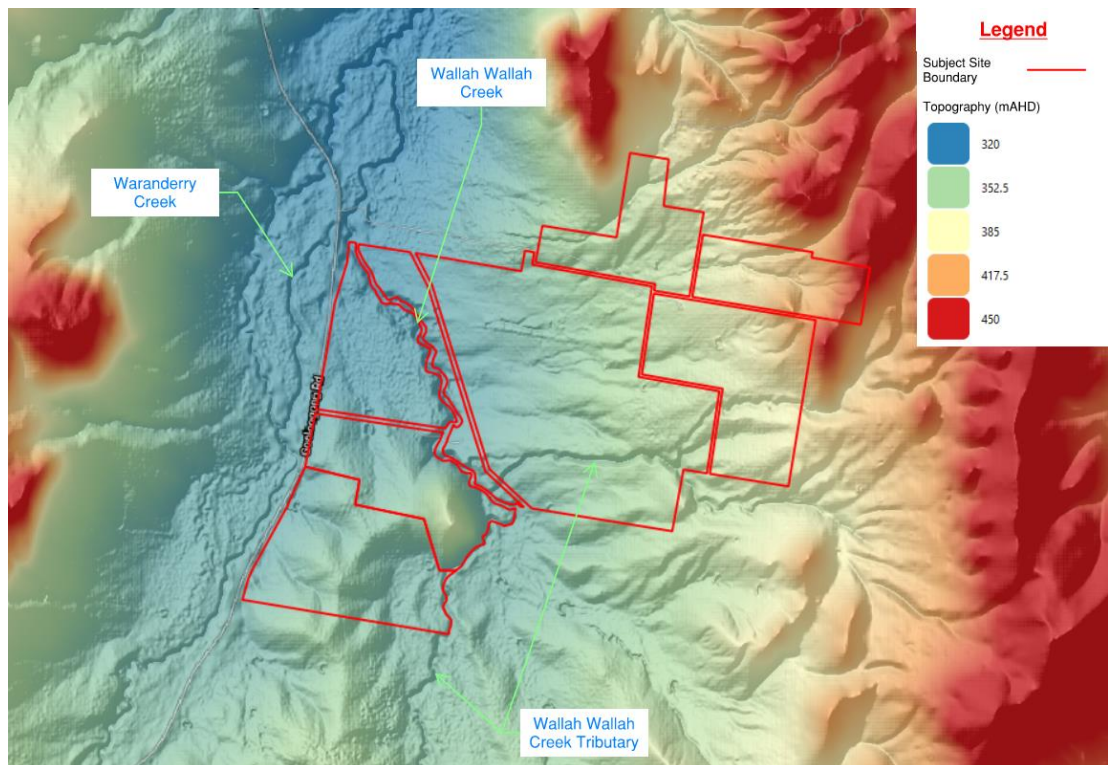


Figure 3: Existing Site Topography – (Source: 2017 LiDAR)

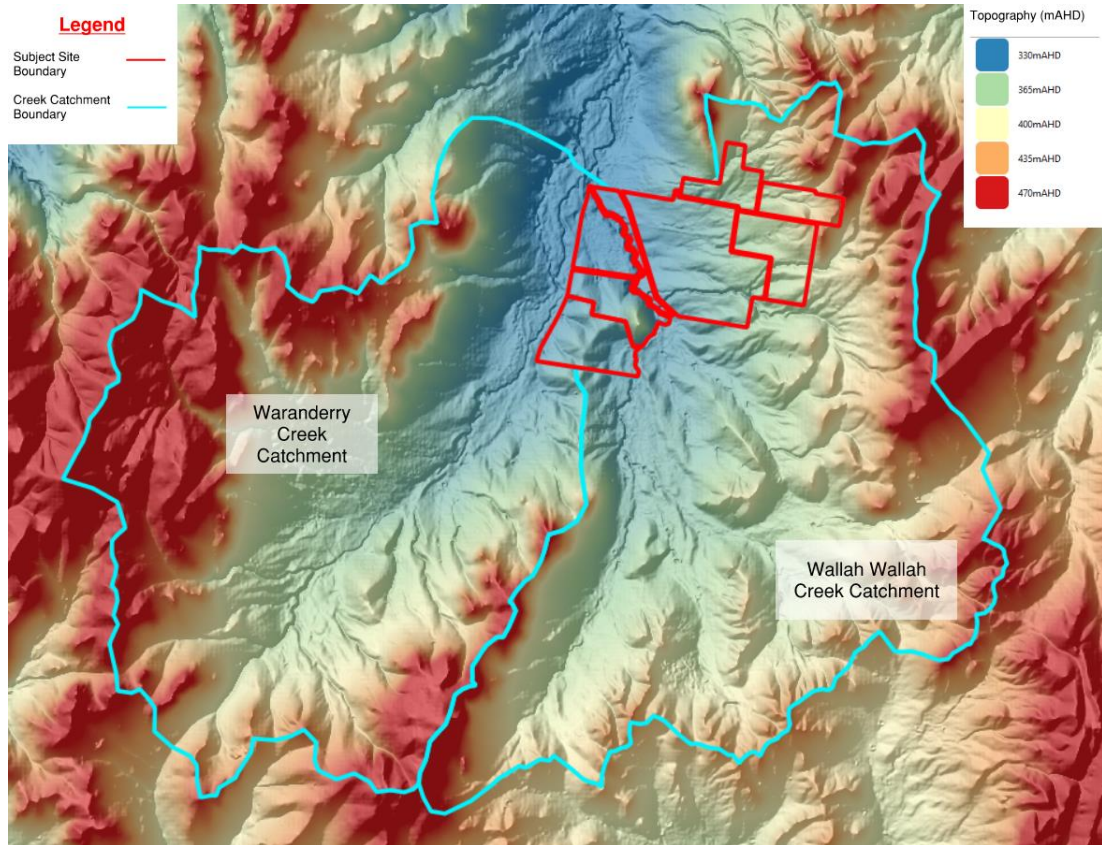


Figure 4: Regional Topography – (Source: 2017 LiDAR)

As seen above in Figure 4, there are two regional catchments that discharge through and adjacent to the site via perennial watercourses. The contributing catchment area that discharges within the site from the Wallah Wallah Creek tributaries (site tributaries included) is approximately 3,900ha, whereas the contributing catchment area that discharges adjacent to the site via the Waranderry Creek is approximately 4,360ha.

Accordingly, these catchments and their respective peak regional flood events have been analysed for the purposes of this report.

2.3 Proposed Development

The proposed development consists of four poultry farm sheds, with an internal road network that is accessed from Gooloogong Road. Each proposed shed has been located with consideration of existing local tributaries within the site, to minimise impacts on existing flow paths. The sheds also contain channels around the perimeter of each individual building, in order to capture sheet flow from local sub-catchments, and discharge downstream into the existing tributaries within the site.

The internal road network shall contain cross-road culverts where drainage lines are identified through this analysis, to ensure a design that provides an appropriate level of flood immunity during standard design AEP event events. A bridge is also proposed to be built over the Wallah Wallah Creek, to minimise impacts (in comparison to culverts), and to provide appropriate flood immunity. The bridge design is unknown at this preliminary stage, however an appropriate blockage factor has been assumed for the future bridge pier construction.

Additional flood risk assessment is suggested during detailed design of the bridge, to ensure flood immunity and flood impact requirements are achieved with the relevant standards.

This associated modelling and outcomes of this report will provide the minimum regional flood levels for the site, to ensure appropriate flood resilience in accordance with WSC and NSW Planning requirements.

Given the proposed development occurs within mapped hydrologic lines and watercourses, an impact assessment has been undertaken and presented within this report which demonstrates the impact deemed to be managed appropriately.

All proposed layout and civil earthworks data has been provided by MPN Consulting.

2.4 Assessment Requirements

In accordance with NSW Planning, Industry and Environment (PIE) Application Number SSD-13855453, the proposed Poultry Breeder Farm requires an Environmental Impact Statement, which includes a surface water flood assessment, to demonstrate the potential impacts that can occur from the proposed development.

Peak flood events that are to be assessed include the 39%, 5%, 1%, 0.5%, 0.2% and 0.05% AEP flood events, for the local and regional events. The identified duration flood events were combined into peak envelopes, in order to determine impacts due to the siting of farm sheds, roads and culverts via the localised peak flood, and the bridge impacts utilising the peak regional critical duration event. The shorter critical durations produced in the tributaries to Wallah Wallah Creek were deemed critical for the pads and road design, whereas the bridge had a higher likelihood to impact on Wallah Wallah Creek.

For flood planning purposes of the farm sheds, the 100 and 2000 year ARI (1% AEP and 0.05% AEP respectively) regional flood events were analysed, noting the Flood Planning Level (FPL) means the 100-year ARI (1% AEP) flood event. The adoption of a 500mm freeboard requirement is not typically required for a non-residential development and is subject to risk assessment. However the peak flood levels do demonstrate that the proposed barns contain a flood immunity level of at least a 0.05% AEP event, given the topographical characteristics of the site.

The NSW Floodplain Development Manual 2005 and Weddin Shire Council Local Environmental Plan 2011 (LEP2011) Planning Scheme was adopted as the relative planning assessment instruments.

2.5 Adopted Data and References

In order to provide an adequate hydraulic impact assessment for the site, the following data has been adopted for analysis:

- Bureau of Meteorology Design Rainfall Data System 2016 for Subject Site Co-ordinates;
- 5m LiDAR Data (2017) obtained via ELVIS Geospatial Data;
- *Emu Creek Flood Study (2007)* Report, by Lyall and Associates Consulting Engineers;
- Site and Layout Plans provided by MPN Consulting;
- 12D Earthworks Digital Model data by MPN Consulting;
- *Planning SEARs – Application SSD-13855453 dated 1st March 2021* by NSW PIE;
- NSW SixMaps GIS Data – Cadastral Data and Hydrologic Data;
- Site Specific ARR16 data - Australian Rainfall and Runoff Data Hub 2016 by Geosciences Australia;
- NearMap Imagery;
- *Review of ARR Design Inputs for NSW*, prepared by WMA Water, dated Feb 2019;
- *Regional Flood Frequency Estimation Model (RFFE)* – Online Tool by ARR;
- Weddin Shire Council Mapping and LEP 2011.

3 Hydrologic Modelling

The site is located within the Lachlan River Basin (NSW Basin No 412), with the closest Gauging Station with significant data being within the Lachlan River some 40km downstream. The two major creeks of interest do not contain reasonable gauges to calibrate the peak floods.

To determine peak flood events via a semi-lumped hydrologic method, the Laurenson Method (XPRAFTS) within the XPSWMM hydrologic modelling package was adopted, with comparisons undertaken against the Regional Flood Frequency Estimation (RFFE) technique. Appropriate measures have been adopted to determine the peak flooding throughout the site in absence of local high-quality data. The attributes and methodologies adopted to determine the hydrologic inputs for the hydraulic modelling has been detailed below.

It is noted that the hydrologic assessment had produced the hydrographs for source-area inflows for the regional and external catchments for the site, whereas the site itself had adopted a Rainfall-On-Grid approach, based on determination of the peak flood events (mean temporal event) realised in the hydrologic assessment.

3.1 Design Rainfall

The Bureau of Meteorology's (BOM) Design Rainfall Data System (2016) IFD values were adopted, in accordance with Australian Rainfall and Runoff 2019 methodologies for this assessment.

The IFD Data utilised for the site has been demonstrated in the chart below in Figure 5, extracted directly from BOM's website for the site location (33.8125 S, 148.2125 E).

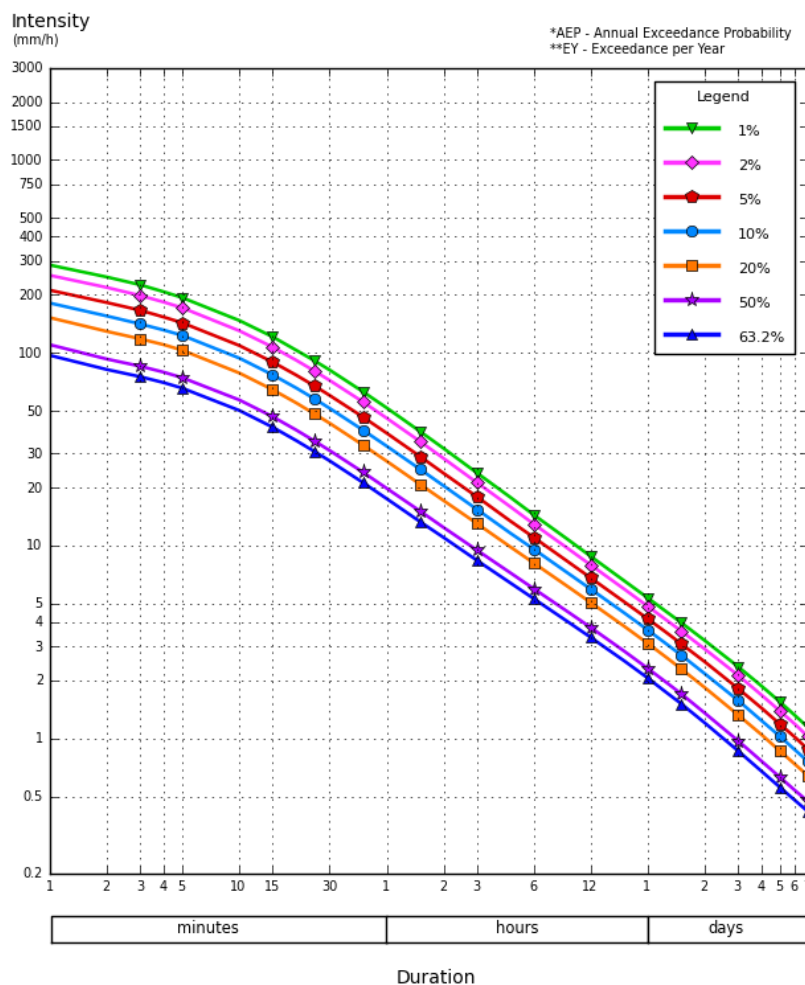


Figure 5: BOM 2016 IFD Data – Site Specific (Source: BOM)

3.2 ARR Data Hub and Losses

Australia Rainfall and Runoff's Online Data Hub tool was utilised for analysis of site-specific rainfall characteristics such as pre-burst depths, losses, and temporal patterns. In accordance with ARR Datahub, NSW has additional specific information to assist in under-estimation bias when utilising ARR2016 design event methods.

Given the lack of studies with calibrated losses within the catchment, or adjacent catchments, and also given the site is not located within a NSW FFA-reconciled losses catchment, the alternative option is to adopt the probability neutral burst initial loss values, or a continuing losses multiplication factor of 0.4.

The site's Initial Loss is 33.0mm and Continuing Loss is 3.7mm/hr, however the Probability Neutral Burst Initial Loss has been shown below in Figure 6.

Probability Neutral Burst Initial Loss

min (h)\AEP(%)	50.0	20.0	10.0	5.0	2.0	1.0
60 (1.0)	19.9	14.5	13.0	13.5	13.2	11.9
90 (1.5)	22.7	12.8	12.9	14.7	14.6	13.6
120 (2.0)	23.7	13.7	13.8	15.4	15.2	12.4
180 (3.0)	23.8	14.7	13.1	12.8	11.1	9.2
360 (6.0)	26.2	18.2	15.9	15.3	12.2	7.9
720 (12.0)	27.8	20.4	18.1	16.7	12.4	7.4
1080 (18.0)	29.3	22.4	21.0	19.9	16.5	10.1
1440 (24.0)	31.5	25.2	23.3	23.2	19.8	15.6
2160 (36.0)	32.0	26.7	26.6	27.3	24.2	18.4
2880 (48.0)	32.9	27.5	27.2	27.8	24.6	18.7
4320 (72.0)	33.8	28.5	28.9	29.8	27.4	22.3

Figure 6: ARR Datahub – Site Specific Probability Neutral Burst IL (Source: ARR DataHub)

The highest 1% AEP Pre-burst mean depth between the 60 minute and 72 hour storm events, was 9.9mm.

Therefore, based on the above information, an Initial Burst Loss of 15mm was deemed appropriate to adopt for the hydrologic model, with a continuing loss of 3.7mm/hr for the catchment.

3.3 Adopted Catchments

Catchment areas utilised within the TuFLOW model were delineated based off the Creek catchment areas external to the site, and smaller sub-catchments within the site itself.

The site's sub-catchments were only adopted in the hydrologic model for the purposes of determining mean temporal patterns to adopt in each duration event, as the site would adopt a Rainfall On Grid approach in the TuFLOW hydraulic model.

The regional sub-catchments were analysed and delineated based off LiDAR Aerial survey data, and represented by hydrologic runoff nodes within the XPSWMM modelling environment. The nodes were connected via links which represented physical characteristics of the reaches, for faster hydrologic modelling runs of the large amounts of ensemble events.

Site-based sub-catchments are illustrated below in Figure 7, and Regional sub-catchments in Figure 8.

Catchment Characteristics corresponding to each sub-catchment has been provided in Table 1.

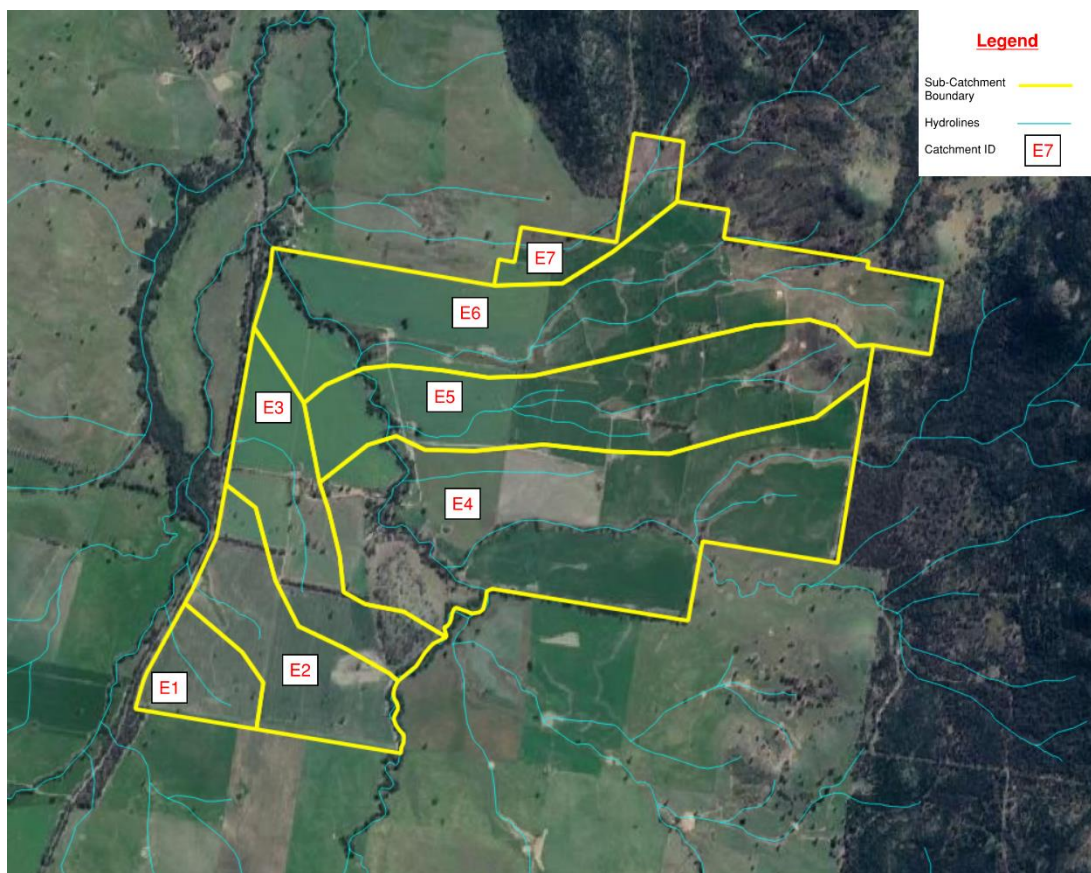


Figure 7: Adopted Site-Based Sub-Catchments

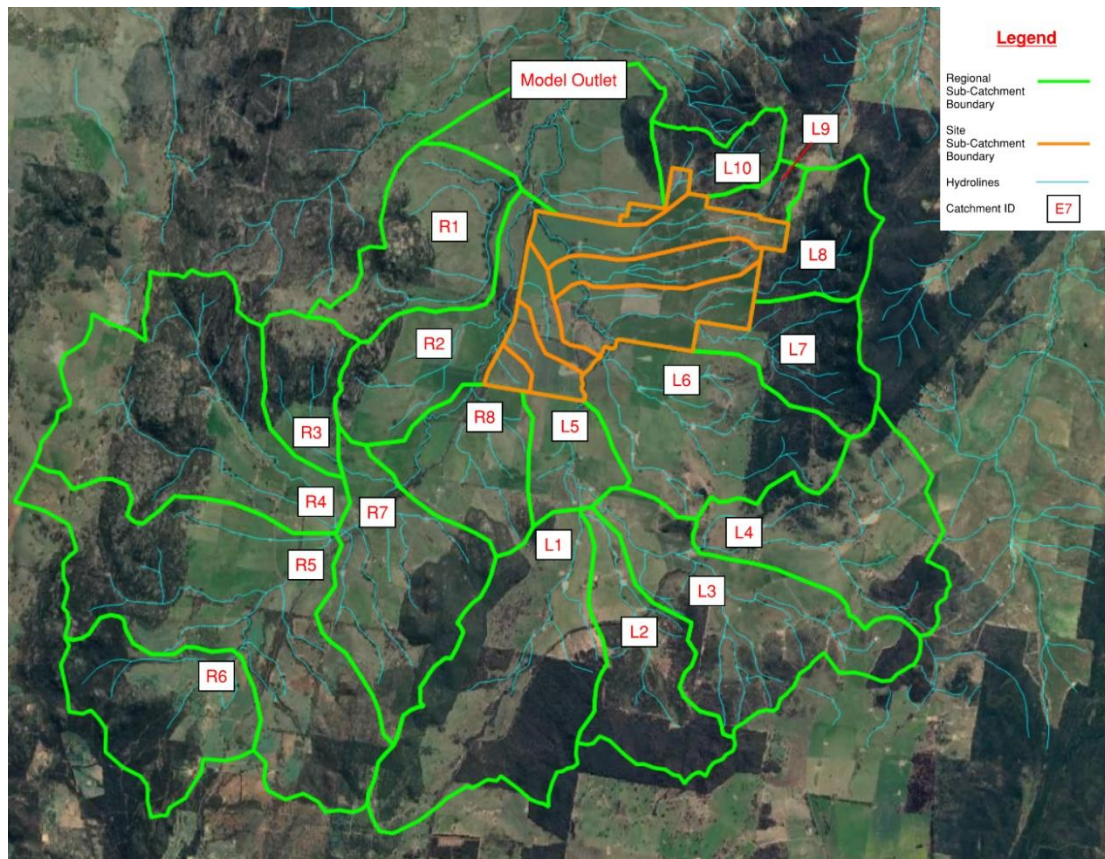


Figure 8: Adopted Regional Sub-Catchments

Table 1: Adopted Catchment Characteristics

Channel ID	Total Sub-Catchment Area (ha)	Average Slope adopted (%)
E1	27.1	1.70
E2	64.5	0.80
E3	67.0	0.90
E4	216.8	1.40
E5	134.9	2.70
E6	186.4	2.10
E7	25.6	2.70
R1	430.3	3.60
R2	375.3	2.70
R3	213.4	5.70
R4	901.9	3.70
R5	1100.3	3.60
R6	448.4	4.80
R7	548.3	4.30
R8	341.2	5.60
L1	815.6	1.50

L2	390.8	1.45
L3	620.3	1.60
L4	571.0	2.40
L5	181.8	0.55
L6	594.6	1.80
L7	285.4	2.66
L8	232.4	5.40
L9	59.8	5.30
L10	145.90	4.40

The site-based catchments were not updated for the post-development scenario hydrologically, given the adoption of a Rainfall On Grid Modelling approach, which takes into consideration the changes in infiltration and surfaces from pre to post-development. All other regional catchments and their respective hydrographs were input into the TuFLOW model for their respective events.

3.4 XPSWMM Modelling

The adopted catchment areas were modelled within XPSWMM, as shown below in Figure 9, to determine the suitability of losses, determine temporal patterns to adopt for each AEP/duration scenario, and to determine critical durations to consider in the 2D hydraulic model.

This approach is deemed appropriate in order to reduce unreasonable modelling times typically undertaken in TuFLOW, as links are able to adequately represent the runoff-routing component via a semi-lumped approach.

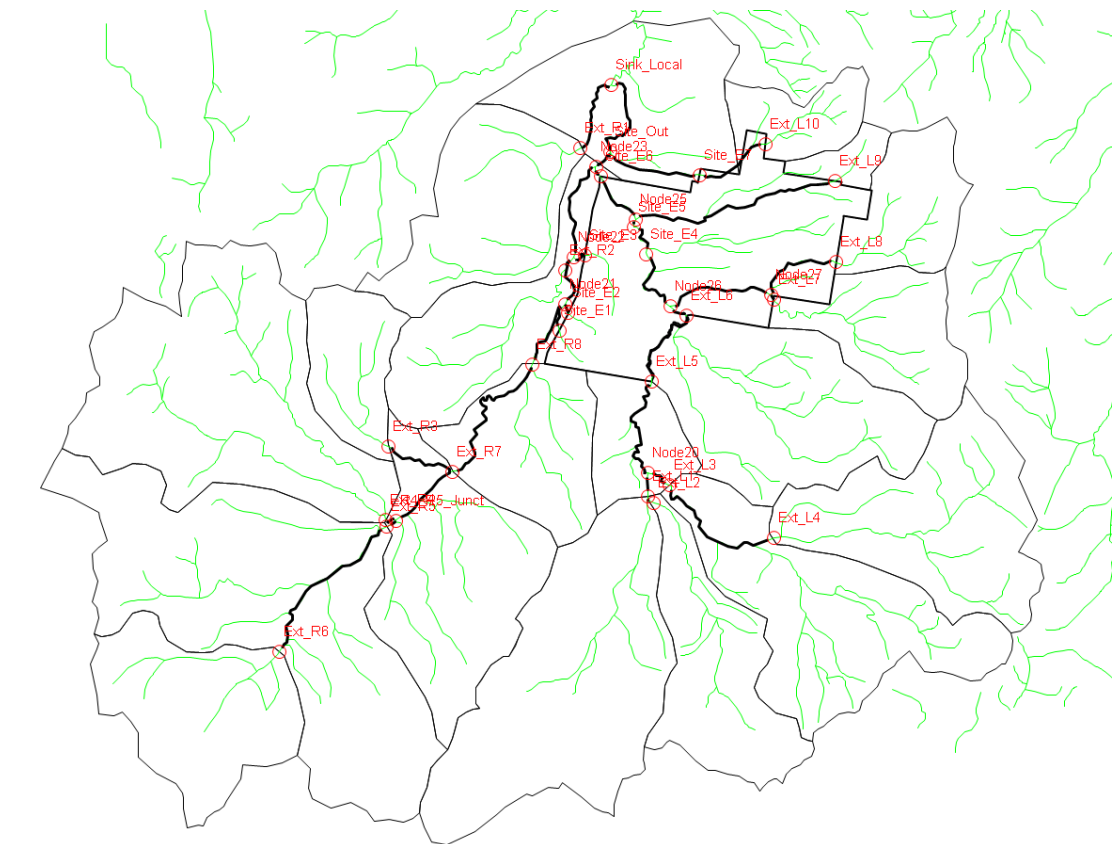


Figure 9: XPSWMM Hydrologic Model Setup

For an appreciation of the design storm selection process, a box and whisker plot at the convergence of the creeks (downstream of the site outlet), is illustrated below, which provides a graphical understanding of peak flows in each ensemble pattern for the 1% AEP design event.

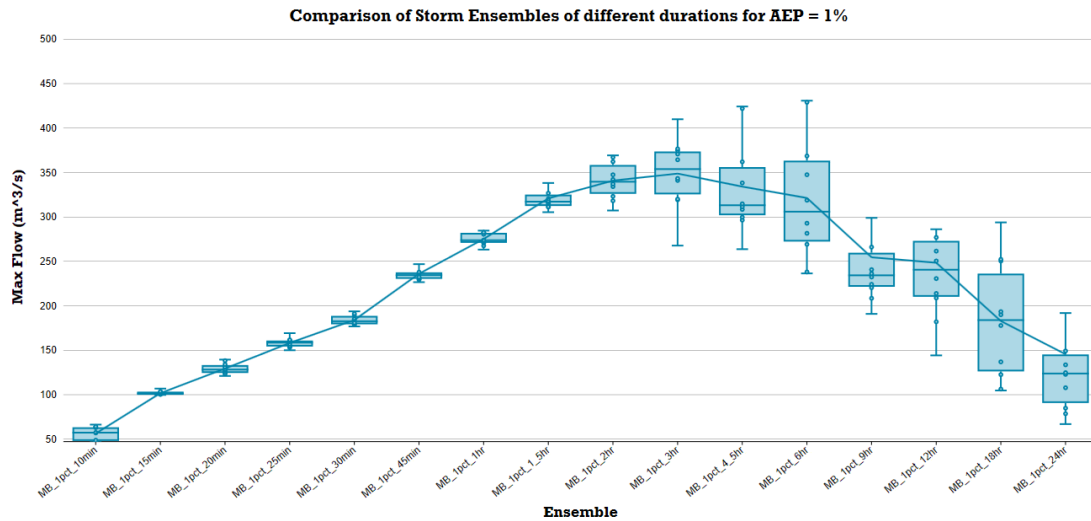


Figure 10: 1% AEP Storm Ensemble Results – Downstream Outlet Location

Based on this approach, it was determined the following events were the appropriate critical durations to adopt for each design AEP event for the regional assessment, based on an overall review of each node and link location, as shown in Table 2.

Table 2: Design AEP Critical Duration Events

Design AEP Event	Duration	Temporal Pattern No
39%	270min (4.5hr)	7
5%	180min (3.0hr)	8
1%	180min (3.0hr)	8
0.5%	180min (3.0hr)	8
0.2%	180min (3.0hr)	8
0.05%	180min (3.0hr)	8

However, given the differences between local and regional critical durations, additional review of the individual site-based catchments had determine the 90 min storm as the typical critical duration event from the site, as illustrated below in Figure 11, which represents the site sub-catchment E5's storm ensemble box and whisker plot for the 1% AEP design event.

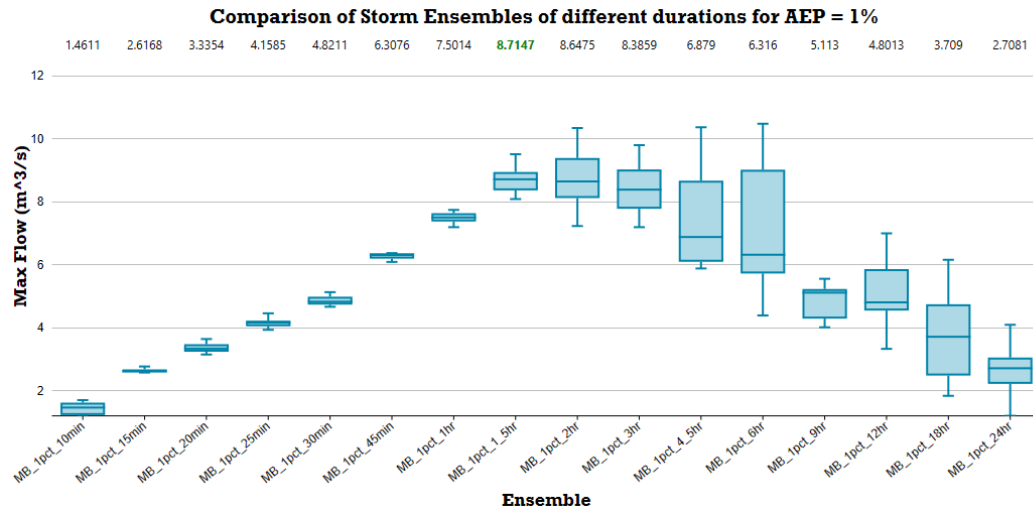


Figure 11: 1% AEP Storm Ensemble Results – Catchment E5

Accordingly, mean-temporal pattern selected duration events between 90 mins (1.5hr) to 180min (3 hour) were adopted for all design AEP events within the 2D hydraulic model, in order to confirm peak flood events in and around the site.

3.4.1 RFFE Comparison

A Regional Flood Frequency Estimation (RFFE) model was undertaken as a sanity check, to ensure the peak flows are not underestimated.

Based on the catchment outlet and area, the following graph in Figure 12 shows the estimated peak flows and the confidence limits that apply for each design AEP events.

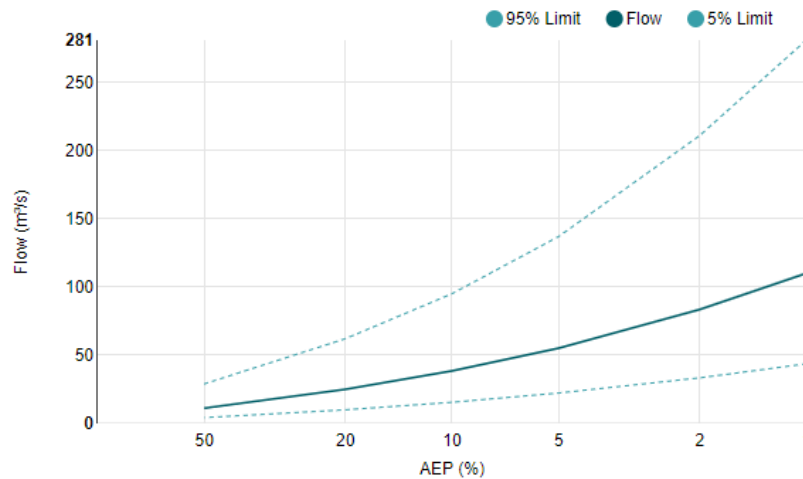


Figure 12: RFFE Peak Flows Graph – Catchment Outlet Location

When compared to the Peak flow outlets produced via XPSWMM for each design AEP event, it can be seen that the XPSWMM model for the design hydrographs are producing much higher peak values, as a result of the approach to initial losses required for NSW. Additional sensitivity analysis was undertaken to confirm results against the ARR DataHub's default Initial losses for the site, to compare between methods and approaches. The comparisons are demonstrated below in Table 3.

Table 3: RFFE vs XPSWMM Peak Flow Comparison

Design AEP Event	RFFE Model – Upper Confidence Limit (m ³ /s)	XPSWMM Model – Design Events (m ³ /s)	XPSWMM Model – Sensitivity Analysis (m ³ /s)
39%	29.0 (50% AEP)	77.6	18.5
5%	137.0	209.5	139.9
1%	281.0	364.4	277.2

*Sensitivity Analysis based on Initial Loss of 33mm

As can be seen above, the sensitivity analysis values of adopting the default Initial Losses, results in peak flow rates similar to Upper Confidence Limit levels by the RFFE model. However, given the site is approximately 70km away from the nearest Gauged catchment (Lachlan River), as well as the advice on design inputs for ARR16, the adoption of lower initial losses within the design events are appropriate as a conservative approach, as it removes underestimation bias for the study.

4 Hydraulic Assessment

4.1 Model Setup Overview

1D/2D Hydraulic modelling was undertaken to provide an appropriate flood impact assessment of the pre and post-development scenario for the subject site and critical surrounding locations. TuFLOW was adopted as the software package for this assessment, given its acceptance as a leading industry standard hydraulic software and given its ability to model floodplains via a 2-dimensional analysis. The adopted data and results have been detailed in the following sub-sections.

4.1.1 Scenarios

A pre-development scenario and a post-development scenario has been adopted, to determine the potential impacts as a result of development during the 39%, 5% and 1% AEP design events, and to review peak water levels in and around each proposed farm building during the peak 1% AEP event.

Additional sensitivity analysis has been undertaken for the 0.5% and 0.2% AEP events as proxies for Climate Change and the impacts as a result of the potential changes in rainfall intensity.

Other scenarios also include:

- 100% Design Culvert blockage scenario;
- 0.05% AEP event peak water level assessment; and
- 0.05% AEP Climate Change event peak water level assessment (in-lieu of an extreme event), whereby a 20% increase in rainfall is added.

Peak flood mapping for the above scenarios and where relevant the peak water level, depth, velocity, Depth-Velocity (DV), peak water level afflux and peak water velocity impacts, have been provided in Appendices C to F.

Flood Hazard Category mapping based on NSW Floodplain Management 2005 guidelines and the Australian Management Institute's 2014 flood hazard categorisations, have also been provided for the 1% AEP event.

4.1.2 Boundary Conditions

A HT downstream boundary condition as a free-outfall condition has been set approximately 2km downstream from the site's downstream outlet, where the two main creeks converge, to ensure the flooding is appropriately represented within the site and vicinity. It is not deemed that coincident flooding should be considered with the Lachlan River catchment, given it is approximately 40km downstream, and also given the rugged topography of the site's regional catchment.

4.1.3 Digital Terrain Model

The Digital Terrain Model (DTM) for this assessment has adopted the latest 5m resolution LiDAR (Source: ELVIS via NSW Spatial Services, 2017) and a detailed survey DEM for the site itself to provide better clarity of the site and vicinity. A 4m grid cell size was adopted within the TuFLOW model, which was deemed sufficient to represent the hydraulic features in both pre and post-development scenarios.

Minor smoothing adjustments were undertaken between the survey and LiDAR boundaries, to ensure hydraulic conveyance is maintained without unrealistic water storage volume within the model.

A post-development 12D earthworks model was overlayed into the model (provided by MPN Consulting) to represent the road, farm building pads and diversion channels around the building pads. Further modifications were undertaken in TuFLOW to model in the culvert invert levels, and a bridge opening (refer to hydraulic infrastructure section for further information on bridge).

Refer to Figure 13 below which demonstrates the existing surface (survey burn-in illustrated as well), and the post-development modifications which has been adopted within the TuFLOW model.

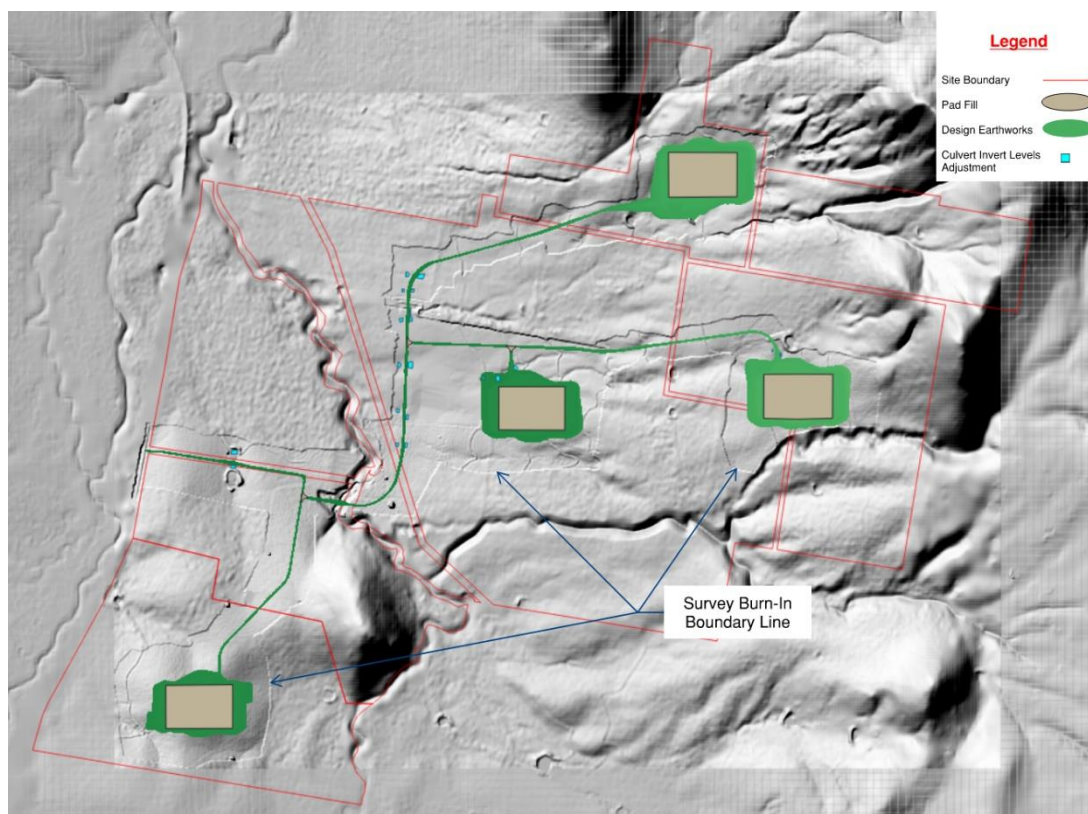


Figure 13: *TuFLOW Topographical Features*

4.1.4 Hydraulic Components

There are no existing stormwater infrastructure pertinent to the flood study area. Post-development design culverts (cross-road drainage) and the proposed bridge have been modelled as indicated below in Figure 14. The proposed culverts have been modelled via 1D elements dynamically linked to the 2D domain (with invert level modifications). The proposed design details of the culverts are provided in Table 4, and the proposed Bridge blockage considerations provided in Table 5.

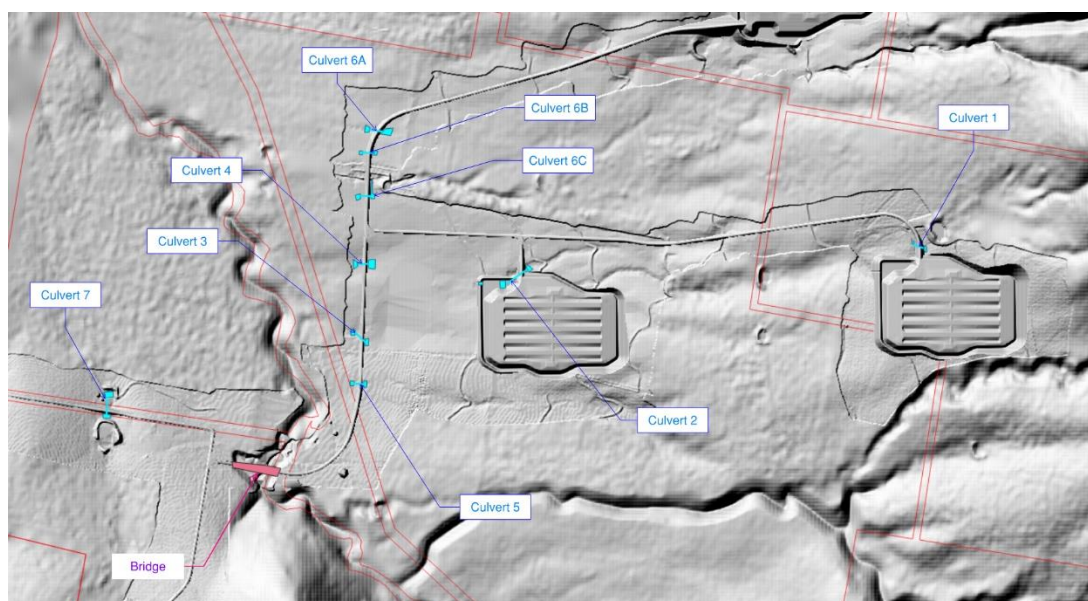


Figure 14: *TuFLOW Post-Development Hydraulic Infrastructure*

Table 4: *Proposed Culverts Characteristics*

Culvert ID	Culvert Details	Upstream Invert Level (mAHD)	Downstream Invert Level (mAHD)	Length (m)
Culvert 1	2no. 1800mm (W) x 600mm (H) RCBC	371.80	371.20	25
Culvert 2	3no. 1800mm (W) x 600mm (H) RCBC	342.40	341.00	96
Culvert 3	4no. 1800mm (W) x 600mm (H) RCBC	334.55	338.85	38
Culvert 4	3no. 1800mm (W) x 600mm (H) RCBC	335.20	334.50	25
Culvert 5	2no. 1800mm (W) x 600mm (H) RCBC	335.55	335.10	25
Culvert 6a	3no. 1800mm (W) x 1200mm (H) RCBC	337.00	336.40	30
Culvert 6b	1no. 1800mm (W) x 1200mm (H) RCBC	336.90	336.40	30
Culvert 6c	1no. 1800mm (W) x 1200mm (H) RCBC	336.60	336.00	30
Culvert 7	1no. 1800mm (W) x 600mm (H) RCBC	333.40	332.20	47

The above culverts were iteratively modelled until a suitable outcome was determined for impact purposes, and flood immunity purposes.

Table 5: *Proposed Bridge Characteristics*

Obvert Level	Bridge Pier Blockage	FLC Co-efficient
334.80mAHD	7%	0.15

It is noted that the bridge design is yet to be undertaken by others, however these blockage factors and minimum bridge deck levels can be adjusted to comply with the required standards at the detailed design stage.

4.1.5 TuFLOW Model Boundary Conditions

As noted in the hydrologic section of this report, the regional catchments (R and southern L- prefix catchments) hydrographs where flows were deemed to discharge collectively were extracted and adopted as source-area inflow boundaries at appropriate locations throughout the model.

Furthermore, a ROG boundary has been determined over the site and eastern external catchments, in the absence of hydrologic source-area inflow boundaries. This was deemed appropriate given the ability to assess changes and impacts between pre and post-development scenarios.

Initial Water Levels were applied at the embankment level of each waterbody to ensure storage effects do not impact the results of the peak assessment.

The TuFLOW model boundaries have been illustrated below in Figure 15, which are retained in pre and post-development scenarios.

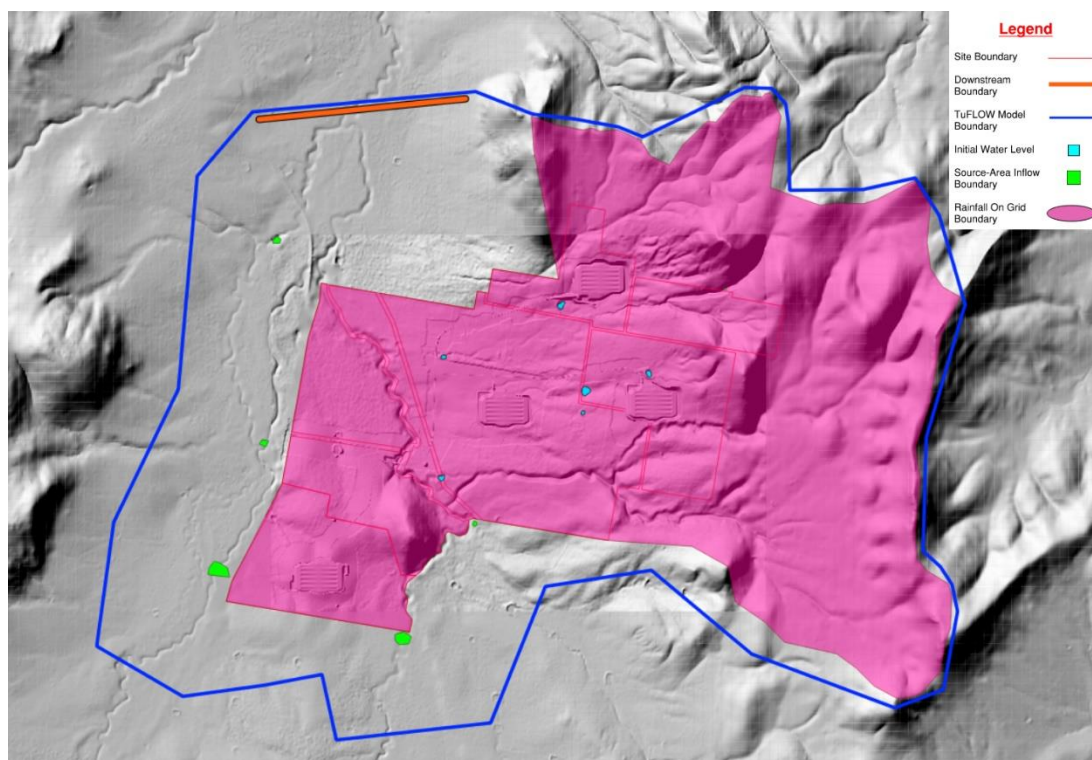


Figure 15: Adopted TuFLOW Model Boundaries

4.1.6 2D Hydraulic Roughness and Infiltration Parameters

The site contains a default manning's 'n' of 0.045 in the pre-development scenario, which is deemed to appropriately represent the mixture of pasture land, creek vegetation and small percentage of roads across the large model. The initial loss and continuing losses adopted for the ROG areas are 5.0mm and 3.7mm/hr, which allows some level of conservatism to occur from the ROG modelling.

Manning's roughness values applied across the 2D grid are based on the following land uses:

Roads	n=0.025	IL= 1.0mm	CL= 0mm/hr
Grassed/Earth	n=0.035	IL= 10mm	CL= 3.7mm/hr
Building Areas	n=0.300	IL= 1.0mm	CL= 0mm/hr

The Post-development manning's n roughness map is shown below in Figure 15. Areas where no specific land uses have been demonstrated, adopt the default value stated above.

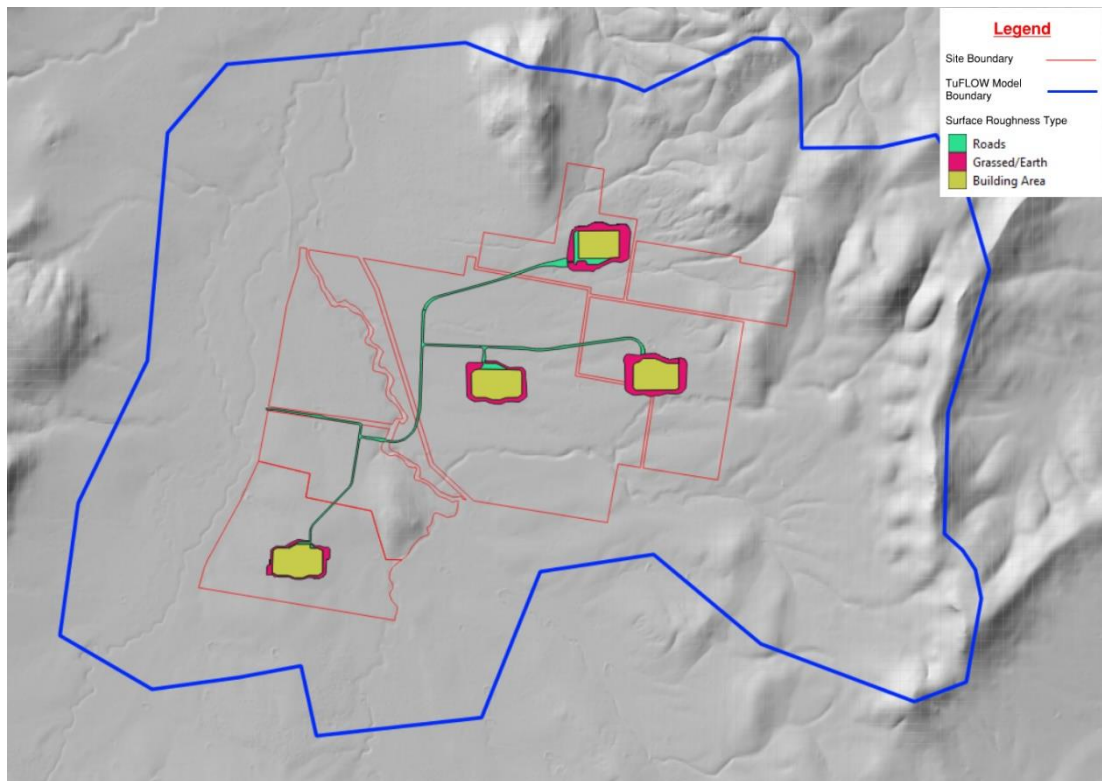


Figure 16: *TuFLOW Model Setup – Post-Development Mannings 'n'*

4.1.7 Peak Flood Map Results

2D Flood mapping has been produced for peak flood events as noted in Section 4.1.1. Pre-development maps have been provided in Appendix C and the post-development scenario design events in Appendix D.

The 1% AEP envelope peak water levels were utilised as a minimum 'Flood Planning Level' (FPL) for the proposed barn yards. An envelope of all design runs were combined to produce the peak level across the site, so as to adopt the highest of the peak regional and localised flood event level. It is noted that given the commercial nature of the development, the FPL's are a risk-based approach adopted by the operator of the site, in accordance with Appendix K of the FDM2005. It has been recommended that a 1% AEP flood event level is adopted as a minimum, however other flood event levels (such as the 0.05% Climate Change scenario) are presented within the report, for the owner of the development to consider risk implications, and potential opportunities to site the fill pads at a desired level that suits the risk-profile.

It is noted that there is overland flooding adjacent to all of the proposed barns, however as noted within the flood mapping, are not subject to inundation, as there is no breakout of flows onto the building pads. Given the steep topography of the region, flows are likely to follow the natural channel paths towards the west of the site.

An assessment of the proposed channels, demonstrate that the channels discharge appropriately back into the natural channels, thereby removing risk to the proposed barn buildings during a major peak flood event.

The peak 1% AEP level and proposed Barn ID is shown below in Figure 17, with the applicable regional FPL's shown in Table 6. Adjacent localised overland flood levels are shown for an appreciation of adjacent channel levels.

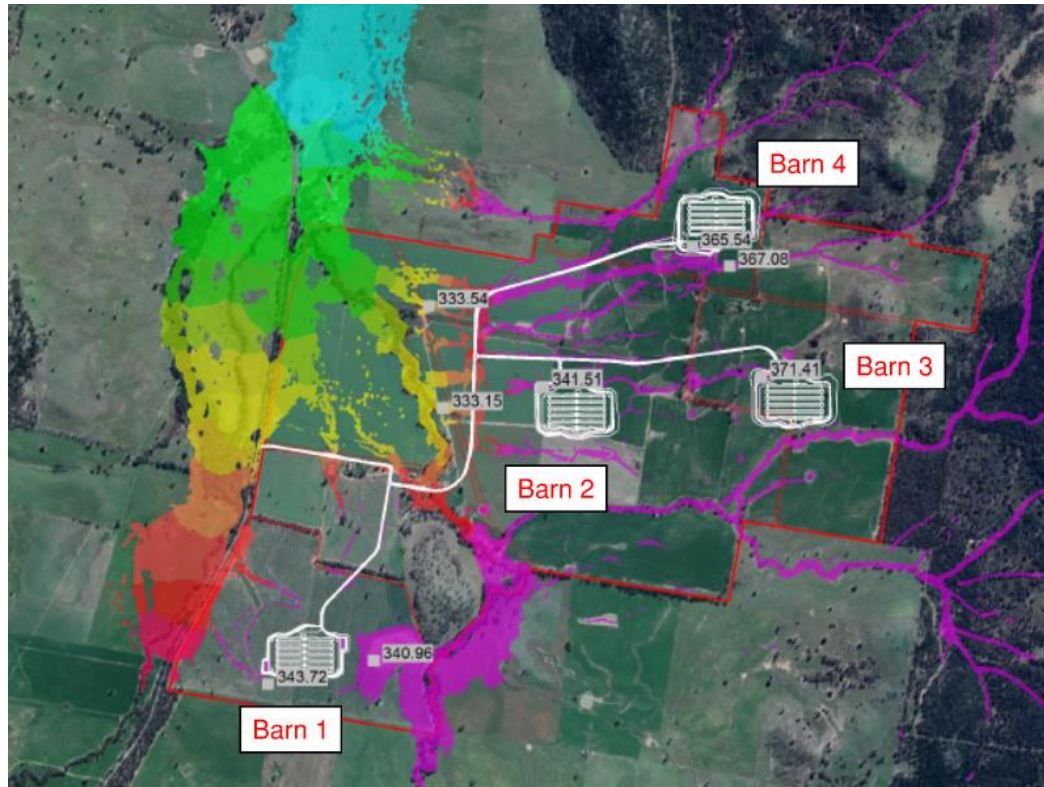


Figure 17: 1% AEP Peak Envelope Levels and Barn ID

Table 6: Applicable FPL for proposed Barns and Compliance Assessment

Barn ID	Applicable Regional FPL (mAHD)	Proposed Pad Level (mAHD)
Barn 1	340.96	346.00
Barn 2	333.15	345.48
Barn 3	333.54	375.00
Barn 4	333.54	369.00

Based on the above, it is noted that the proposed barns are sited at locations that are deemed flood immune up to the 1% AEP regional flood event, and therefore complies with the NSW Floodplain Development Manual and WSC LEP requirements.

4.1.8 Impact Assessment

The TuFLOW model was used to assess the flood impacts and flood risk of the proposed development. The proposed development works are still at a preliminary stage and as such no detailed design has yet been established. Accordingly, the flood impacts are only demonstrating a potential scenario that may occur as a result of the proposed development.

2D Flood mapping has been produced for peak impact water levels for the 5%, 1%, 0.5% and 0.2% design AEP events, noting that the 0.5% and 0.2% have been utilised as proxies for the Climate Change scenario as requested in the SEARs.

Overall, the modelling outcomes have demonstrated that the water level, velocity and depth-velocity product impacts are typically contained within the site boundaries, as illustrated in Appendix E.

Impacts are typically the greatest at the proposed design culvert locations and bridge location, which is to be anticipated given the hydraulic controls at these locations. However, the impacts external to the site are deemed acceptable up to the 0.5% AEP event. Minor water level impacts of up to 10mm are demonstrated in

the 0.2% AEP (500-year ARI) event within Gooloogong Road, however this event is the proxy for the Climate Change scenario.

Bridge impacts are currently based on a 7% pier blockage factor, resulting in up to 640mm of impact within the site during the 1% AEP event. However, this impact is not translated upstream beyond the site up to the 0.2% AEP, given the topography of the area.

The proposed barns are deemed to be situated in locations where minimal flood impacts will arise from their sitings, given the distances from the peak regional events. The channels around the proposed barns are demonstrated to appropriately capture any incoming sheetflow, to distribute back into existing overland flow paths within the site.

4.1.9 Flood Hazard Categorisation

The peak flood events have been assessed for their potential flood hazard characteristics across the site, in accordance with the NSW Floodplain Development Manual 2005 (FDP2005) categories, and also the more recently developed flood hazard categorisation by the Australian Emergency Management Institute (2014) which has been adopted within Australian Rainfall and Runoff 2019's (ARR2019) guidelines.

Extracts of flood hazard categorisation charts from the FDP2005 and ARR2019 are shown below in Figures 18 and Figure 19, respectively.

Flood Hazard Mapping has been provided as part of the post-development flood maps within Appendix D.

As shown in Figure D29, utilising the NSW FDM2005 Flood hazard categorisation, it can be seen that the 1% AEP flows within the vicinity of proposed barns are Low-hazard, and that flows adjacent to the internal road is low, with transition hazards at the upstream sides of culverts, which is to be anticipated.

The flows beneath the bridge do demonstrate high hazards, however it is anticipated the bridge will be designed (at detailed design), to be flood immune in accordance with bridge design industry standards.

Accordingly based on this assumption, a flood risk management plan should be provided upon completion of the bridge design, to confirm the flood risk management strategies to be adopted by occupants of the site, in the lead up, during and after a major flood event.

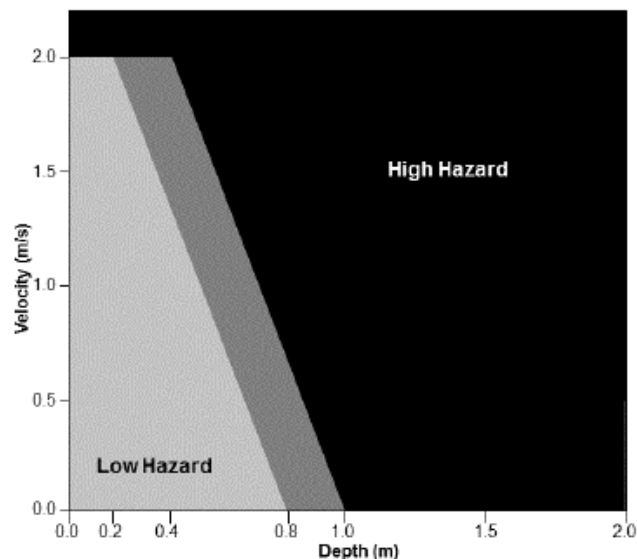


Figure 18: NSW FDM 2005 Flood Hazard Categorisation

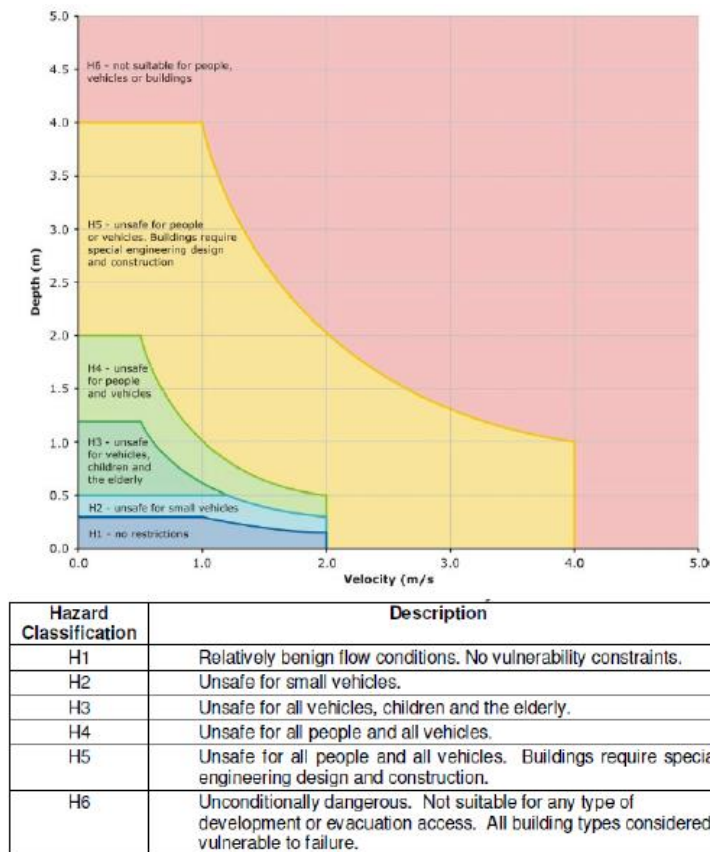


Figure 19: Australian Rainfall and Runoff 2019 - Flood Hazard Categorisation

4.1.10 Sensitivity Analysis and Risk Assessment

Additional 2D Flood mapping has been undertaken as sensitivity results, to determine extreme scenarios, such as the:

- 100% Blockage Scenario (of design culverts) for the design 1% AEP event; and
- An extreme weather event – a 0.05% (2000-year ARI) peak flood event plus 20% rainfall intensity increase (as a result of future Climate Change).

100% Design Blockage Scenario

A blockage scenario of the proposed design culverts were undertaken to determine the potential hazards if all culverts were completely blocked during a peak 1% AEP event. The results confirmed that flows would remain mostly upstream of the culverts, with the highest ARR19 Hazard risk being a H2 flood risk at Culvert 6C's location. All other culverts demonstrated an overtopping hazard category of no greater than a H1 flood risk Category.

Given the site use, it is deemed the majority of vehicles will be larger vehicles (ie. Not small vehicles), and therefore risks are minimised during a peak flood event.

As noted above, a flood risk management plan should identify the requirement to isolate in the flood free sections of the site and adopt a shelter-in-place approach, until the peak flood has receded.

Refer to Appendix F for peak flood mapping of the 1% AEP Blockage scenario.

Extreme Peak Flood Event – 0.05% AEP (2000-year ARI + Climate Change)

An assessment against an extreme weather event has been undertaken, to determine the flood risk to property. Accordingly, the flood maps demonstrate that the proposed barn locations are typically flood immune from the regional flood event, however still may be subject to localised flooding and ponding in the channels around the barns. Regardless, the localised flooding appears to be contained within the natural and proposed channels, such that the barns pads are not subject to inundation during the peak event.

4.1.11 Summary and Recommendations

The preliminary assessment demonstrates that the proposed barn and road design is deemed not to create adverse impacts externally to the site up to the 1% AEP peak flood event.

All proposed barns are located above the deemed Flood Planning Level's and are not demonstrated to be inundated by local flooding up to the 1% AEP peak event. Furthermore, all proposed channels around the site are demonstrating efficient capture and release from external incoming sheet flow from local sub-catchments.

Proposed roads have demonstrated immunity against the design 1% AEP peak flood event, with the exception of the location where the proposed bridge shall cross the Wallah Wallah Creek location within the site. A sensitivity analysis of the 1% AEP 100% blockage scenario demonstrates there is low-risk flood hazards at the proposed culvert locations, given the upstream localised storage ability during an extreme event.

The proposed bridge will require further assessment to confirm no adverse impacts external to the site, and also to demonstrate minimal impacts within Wallah Wallah Creek itself. It is deemed that the design will provide consideration for these requirements. Furthermore, the bridge shall demonstrate flood immunity requirements as per any relevant codes or planning requirements, such that the flood hazard risk is minimised up to an appropriately rarer peak flood event (ie. 2000-year ARI). Further review should be sought to confirm the bridges flood immunity and potential impacts upon detailed design of the bridge.

Flood risk management approaches should be adopted at the detailed design stage, with further consultation with NSW SES and council, to ensure occupants of the site are aware of their flood emergency management responsibilities and understanding of evacuation procedures. Based on the preliminary review of results, the flood risk to occupants would be deemed quite low, as there is opportunity for evacuation (provided an appropriate bridge design) or shelter-in-place if the need arises. Flood Evacuation Management plans are suggested to be provided at a later date.

The proposed development is not deemed to have any significant social or economic costs to the community, as a consequence of flood impacts associated with the development.

4.1.12 Limitations and Future Refinements

The flood modelling undertaken and presented within this report is limited to publicly available information, Engineering plans and models provided by MPN Consulting. All modelling is undertaken in accordance with industry standards and practices and is subject to review by NSW PIE for confirmation of study suitability.

The report may not represent the highest probable flood level that could occur on the property, given the lack of historical data. Floods levels for a property higher than what is considered probable, are possible, and their likelihood incalculable. There are many variables not able to be confirmed due to time and physical constraints to provide legal certainty (e.g. Creek depth causing volumetric variations in flow rate and overland spill). Changes in the condition of local creeks and waterways may also further alter the effects of flooding.

For the reasons set out above, Stormflood makes no warranty or representation regarding the accuracy or completeness of the Report. Although all reasonable steps have been taken for a professional engineering judgement, Stormflood disclaims any responsibility, liability or omission, arising in connection with or in relation to the use or reliance by any person on any of the Reports.

5 Conclusion

Stormflood has been commissioned by MPN Consulting on behalf of Baiada Properties Pty Ltd to undertake a Flood Impact Assessment Report, to investigate potential flooding impacts to support the Environmental Impact Statement and Development Application for a Proposed Poultry Breeder Farm at 1130 Gooloogong Road, Grenfell, located within the Weddin Shire Council (WSC) Local Government Authority (LGA).

The NSW Planning, Industry and Environment has issued a Planning Secretary's Environmental Assessment Requirements (SEARs) letter, which has requested a flood assessment be undertaken to support an Environmental Impact Statement for the proposed development.

A flood assessment has been undertaken given the topographical characteristics of the site, and the nearby Wallah Wallah and Warraderry Creeks within the vicinity of the site. The flood modelling had determined perennial and non-perennial watercourses that are subject to peak flooding, and therefore require planning consideration.

This report has addressed all the required assessment items set out by the NSW Planning, Industry and Environment's Planning Secretary's Environmental Assessment Requirements (SEARs) for Application No. SSD-13855453), such as:

- Determining flood prone areas within the subject site;
- Flood planning areas and peak flood design events;
- Flood risk categorisation and flood hazard risk assessment; and
- Flood Impact Assessment.

The flood assessment has been undertaken in accordance with the Weddin Shire Council's Local Environmental Plan 2011, NSW Floodplain Development Manual 2005 and the Australian Rainfall and Runoff 2019 guidelines (including NSW specific considerations). The site has not been located as part of a NSW Rural Floodplain Management Plan.

A hydrologic analysis determined that there is a level of uncertainty associated with the flooding, given the lack of sufficient gauge data within the local catchment, however a comparison of the design flood events against the Regional Flood Frequency Estimation technique confirms that the approach is conservative. No flood studies have covered the site to date, with the Emu Creek Flood Study (ECFS) being the closest catchment flood study, which was initially reported in February 2007 and therefore deemed inadequate for adoption, given the release of Australian Rainfall and Runoff 2019 and Bureau of Meteorology's 2016 IFD Data.

A 2D hydraulic model was built utilising publicly available data, as well as site plans and a roadworks and earthworks design (provided by MPN Consulting), to assess the potential impacts as a result of the proposed development works. The peak flood mapping has been presented within this report, which suggest that the flood impacts are deemed not to create adverse impacts external to the subject site boundaries, and that flood risks to occupants of the site are low, subject to an appropriate bridge design and adoption of a flood emergency management plan for the site. Additional advice should be sought at a future date upon detailed design of the bridge, to confirm flood risk and impacts are minimised.

The proposed development works are deemed to comply with the WSC LEP2011, and the provisions set out in the NSW Floodplain Development Manual 2005, and therefore supports the Environmental Impact Statement for approval of the proposed Poultry Breeder Farm.

This assessment is limited to the information provided by MPN Consulting Engineers, as well as publicly available information by the Local Government Authority (WSC), and all other relevant authorities.

6 Qualifications

Our analysis and overall approach has been specifically catered for the requirements of MPN Consulting and Baiada and may not be applicable beyond this scope. For this reason, any other third parties are not authorised to utilise this report without further input and advice from Stormflood Engineering Pty Ltd.

Stormflood has relied on the information as outlined in Section 2 of this Report, and therefore any information provided within this Report is limited to the data provided. Any changes beyond the data noted may alter the outcomes of this report, and therefore Stormflood takes no responsibility for any data or plans that negatively impact the outcomes noted in this report. Accordingly, it is recommended that further advice or comment is sought from Stormflood, if there are changes to any of the noted adopted data.

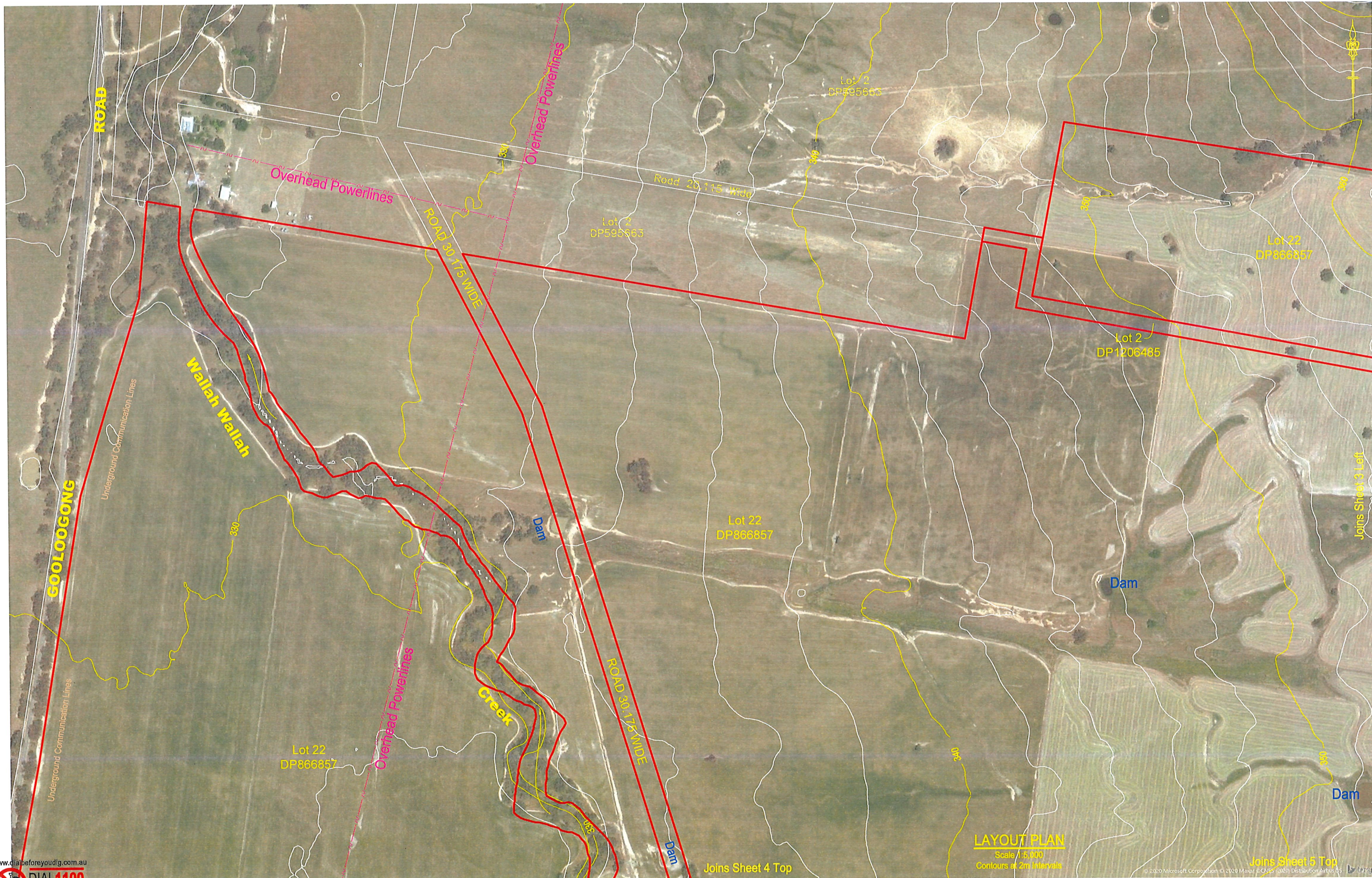
While Stormflood's Report assesses peak flows from design storms in accordance with best-practice and current industry standards and guidelines, future observed flows may vary from that predicted. For these reasons appropriate freeboards should be adopted.

Appendices

Appendix A	Site Survey Plans (by Bath Stewart Associates)
Appendix B	Proposed Engineering Site Plan (by MPN Consulting)
Appendix C	Pre-Development Peak Flood Mapping (39% to 0.05% AEP Events)
Appendix D	Post-Development Peak Flood Mapping (39% to 0.05% AEP Events)
Appendix E	Impact Flood Mapping (5% to 0.2% AEP Events)
Appendix F	Sensitivity Analysis Flood Mapping (100% Blockage – 1% AEP Event)

Appendix A

Site Survey Plans
(by Bath Stewart Associates)



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LEGEND (EXISTING - LIGHT PROPOSED - DARKER)
CENTRE LINE
KERB AND GUTTER
TOP OF BATTER
SURFACE DRAINAGE
EDGE OF BITUMEN SEAL
FENCELINE
SEWER MAIN (6 SIZE)
WATERMAIN (6 SIZE)
STORMWATER DRAINAGE
OVERHEAD POWER
UNDERGROUND ELECTRICAL

DESCRIPTION
TREE
SHRUB
SIGN
SEWER MANHOLE, INSPECTION PIT
DOWNPIPE & ROOFWATER OUTLET
POWER POLE
STREETLIGHT
GUIDE POST
WATER (HYDRANT, VALVE, METER)
TELSTRA PIT AND CABLES

APPROVED
J. Herdegen

DATE
23.12.20

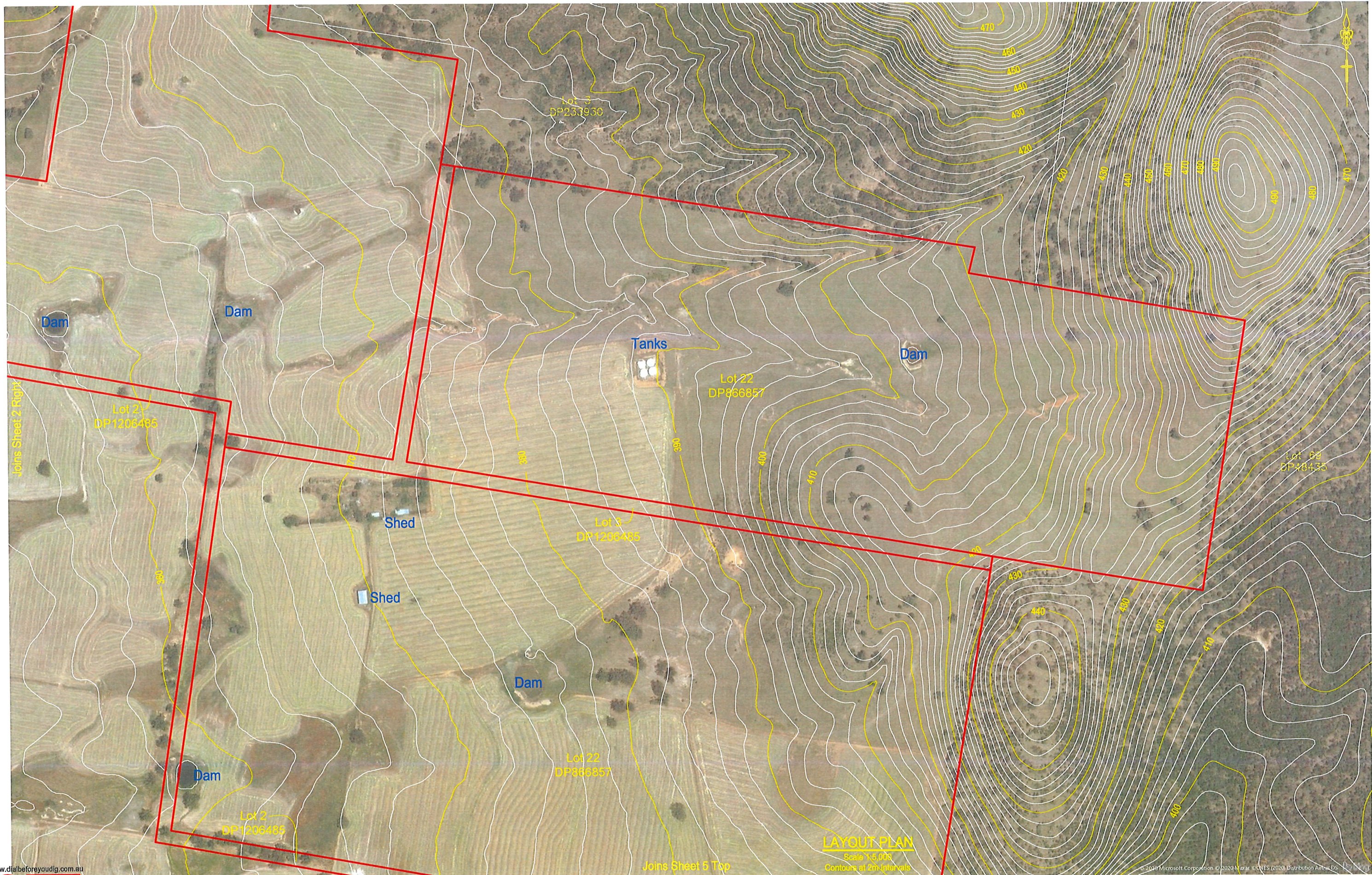
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GOOLOOGONG ROAD GRENELL
Lots 1 to 3 DP 1206485, Lot 22 DP 866857 & Lot 1 DP 1022013
TOPOGRAPHIC & DETAIL SURVEY (Sheet 1 of 5)

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KERB AND GUTTER
TOP OF BATTER
SURFACE DRAINAGE
EDGE OF BITUMEN SEAL
FENCELINE
SEWER MAIN (ø SIZE)
STORMWATER DRAINAGE
OVERHEAD POWER
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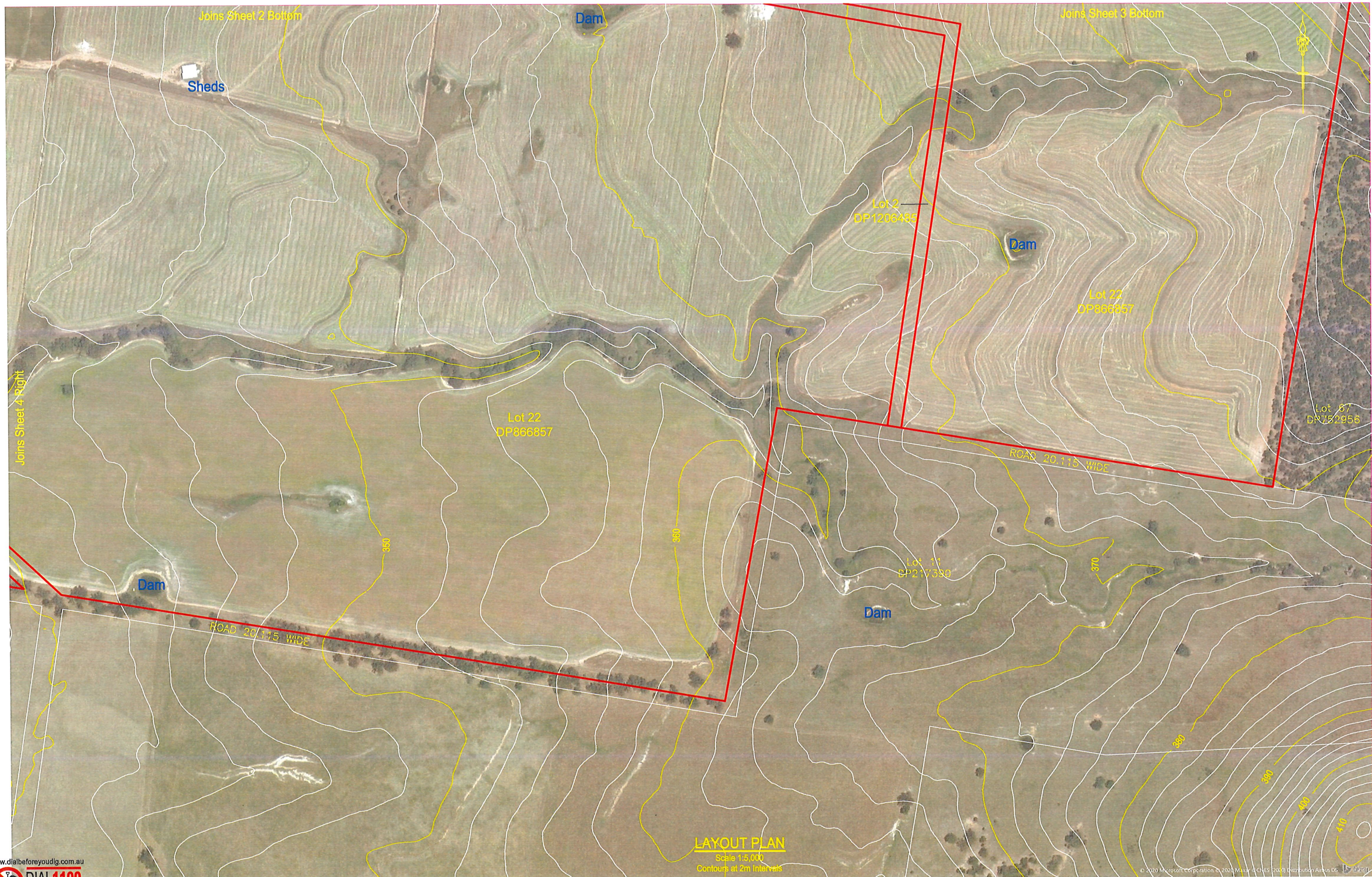
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TOP OF BATTER
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FENCE LINE
SEWER MAIN
WATER MAIN (& SIZE)
STORMWATER DRAINAGE
OVERHEAD POWER
UNDERGROUND ELECTRICAL

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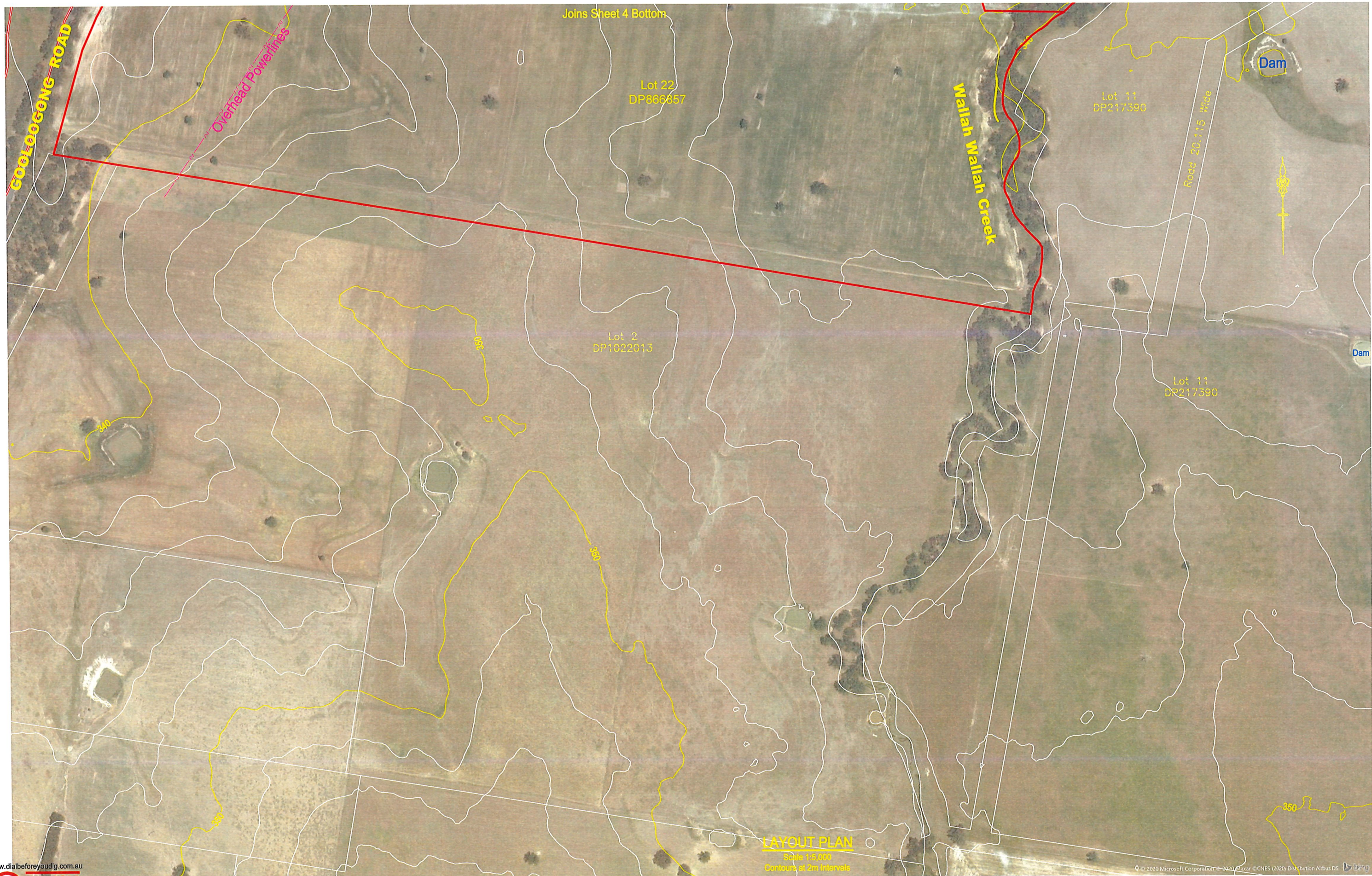
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WATERMAIN (& SIZE)				
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Appendix B

Proposed Engineering Site Plan
(by MPN Consulting)

Appendix C

Pre-Development Peak Flood Mapping 39% to 0.2% AEP Events

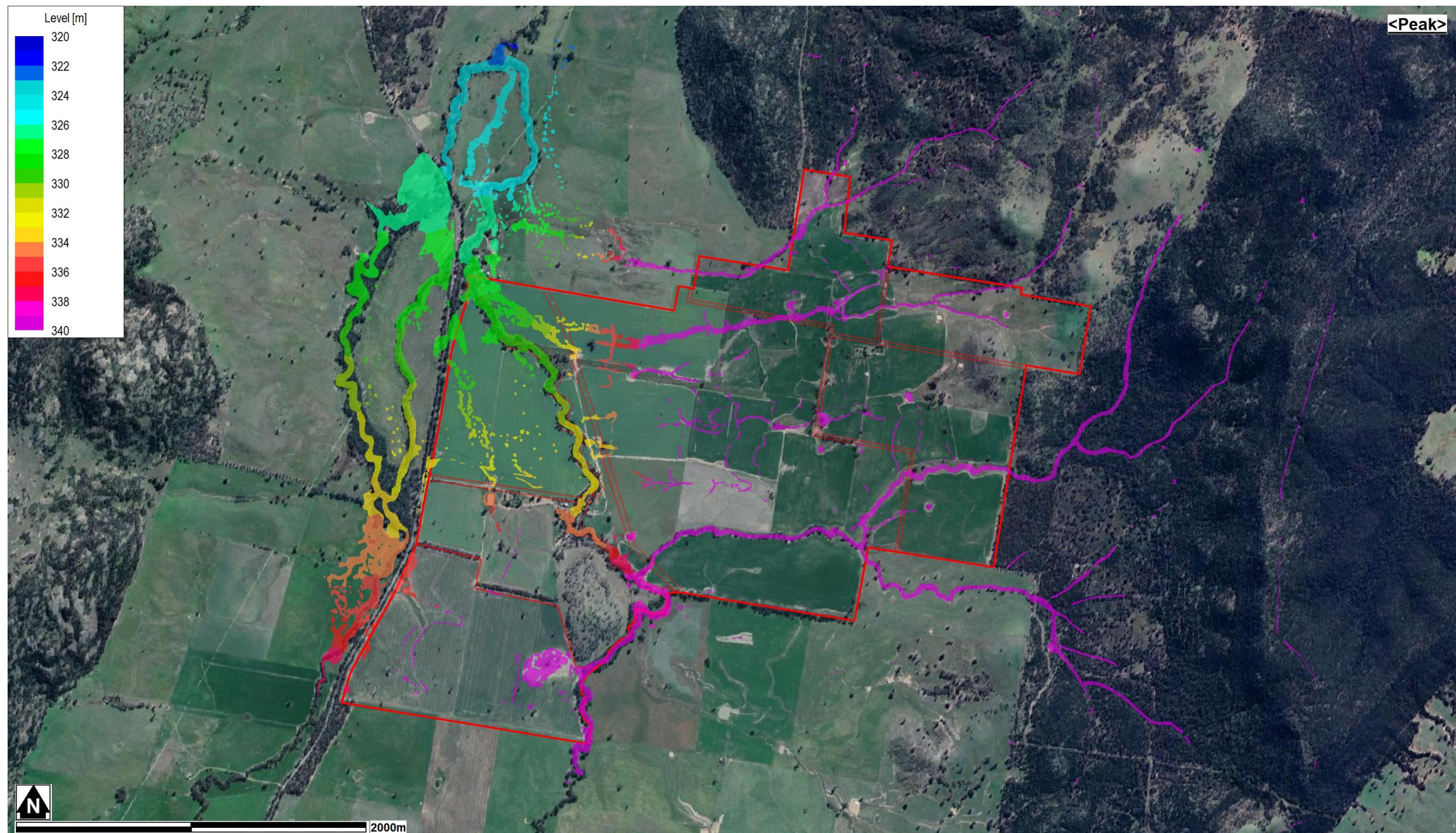


Figure C1 – 39% AEP Pre-Development Peak Water Level (Envelope)



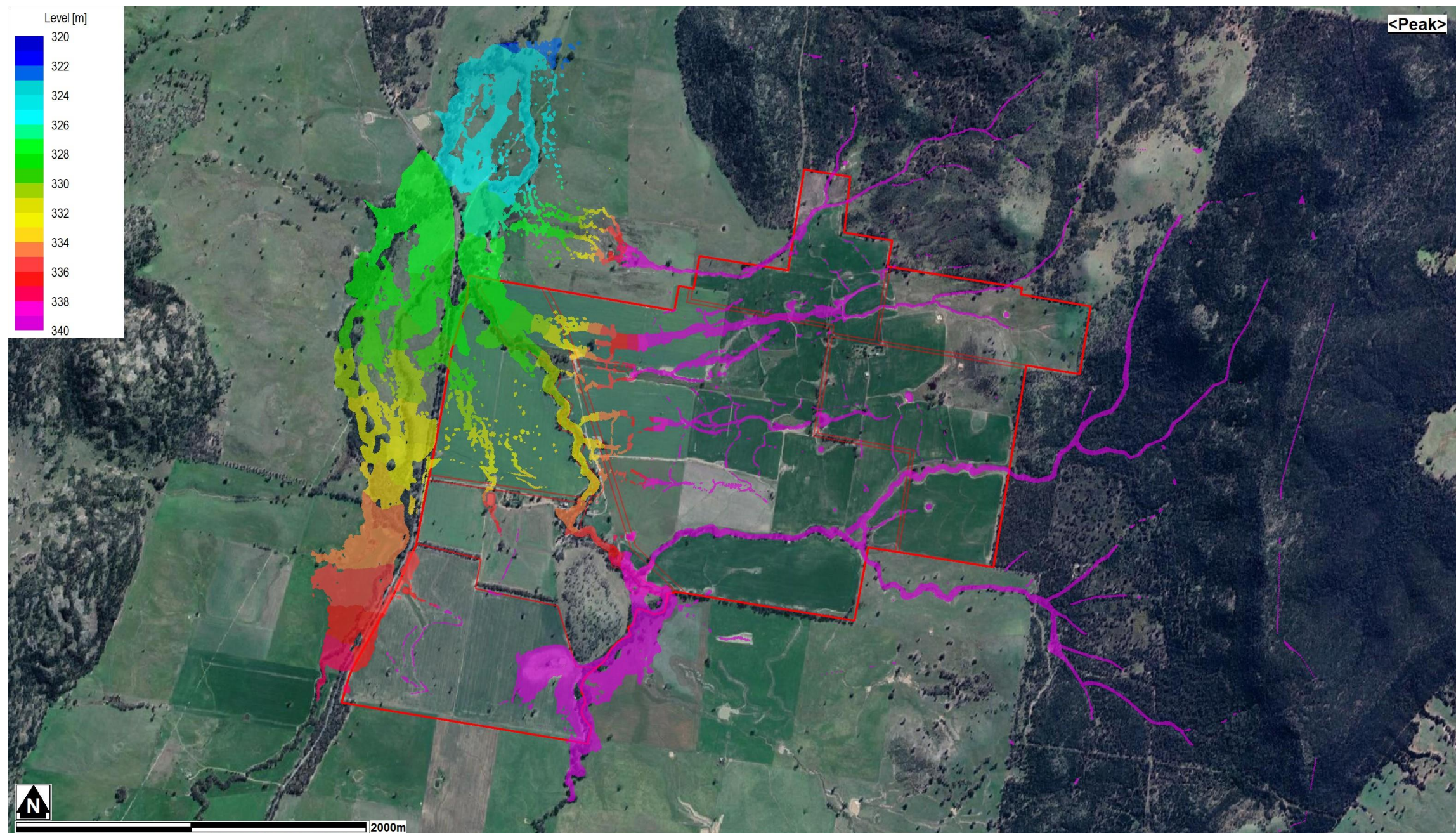


Figure C2 – 5% AEP Pre-Development Peak Water Level (Envelope)



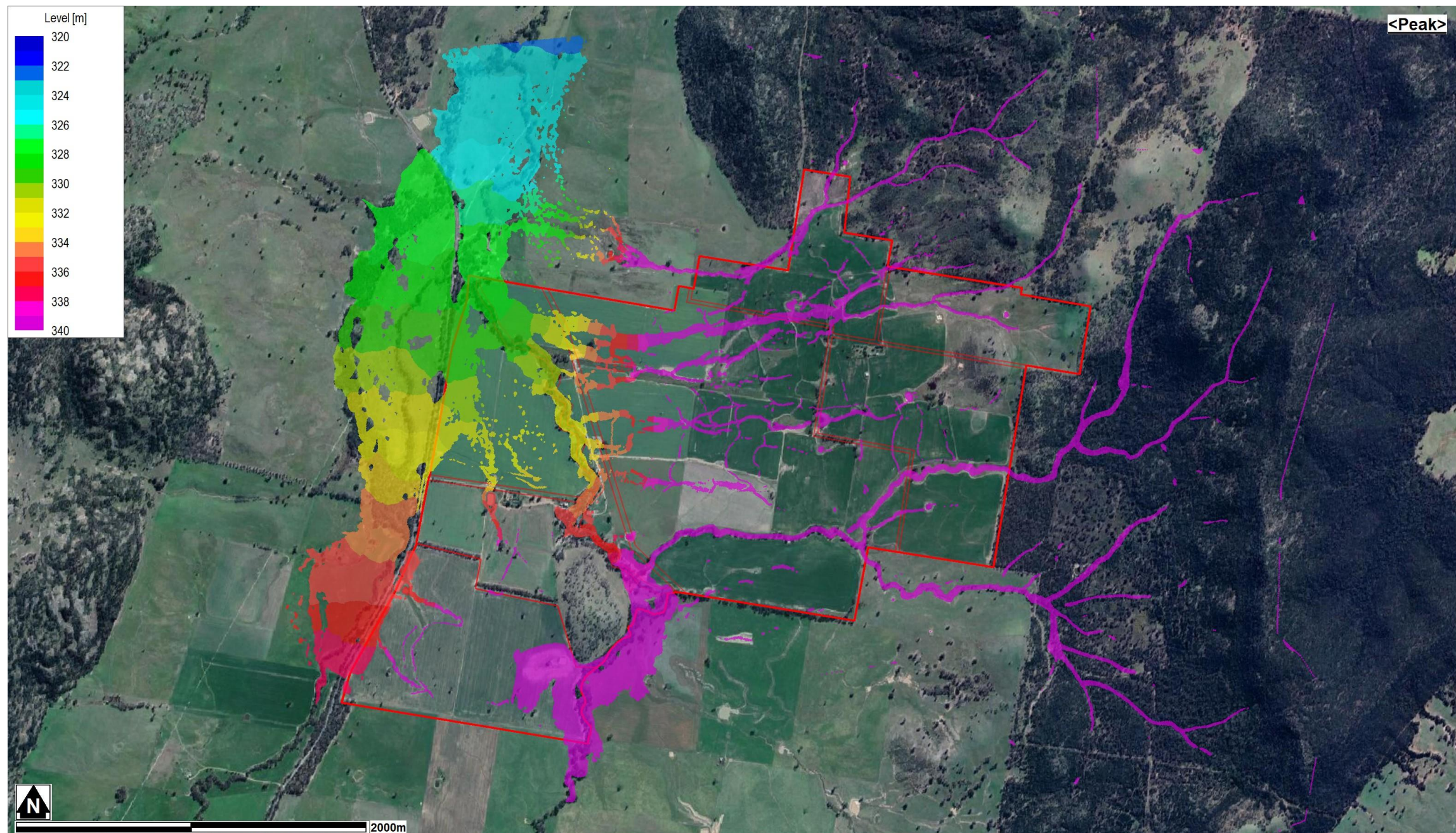


Figure C3 – 1% AEP Pre-Development Peak Water Level (Envelope)



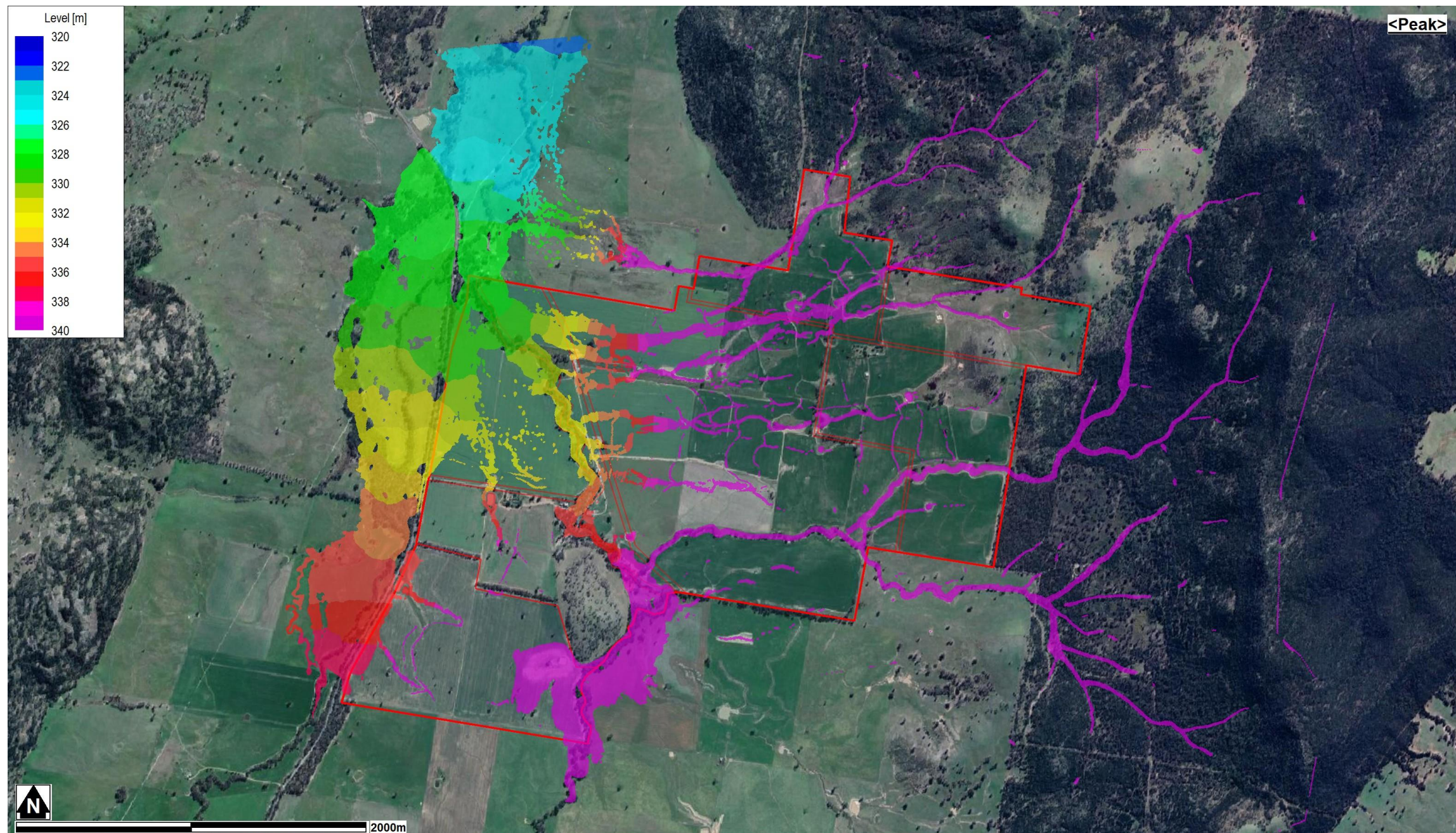


Figure C4 – 0.5% AEP Pre-Development Peak Water Level (Envelope)



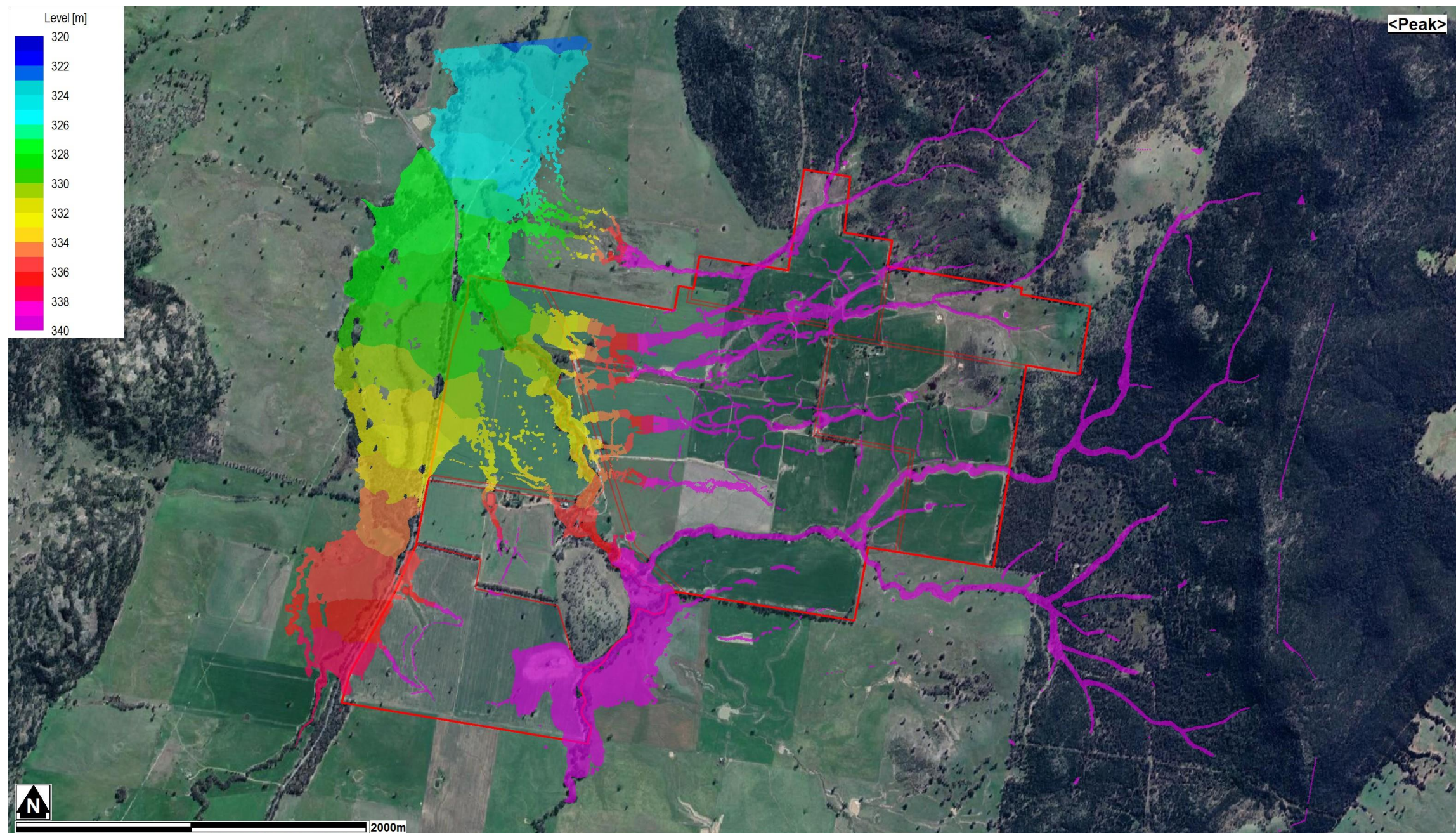


Figure C5 – 0.2% AEP Pre-Development Peak Water Level (Envelope)



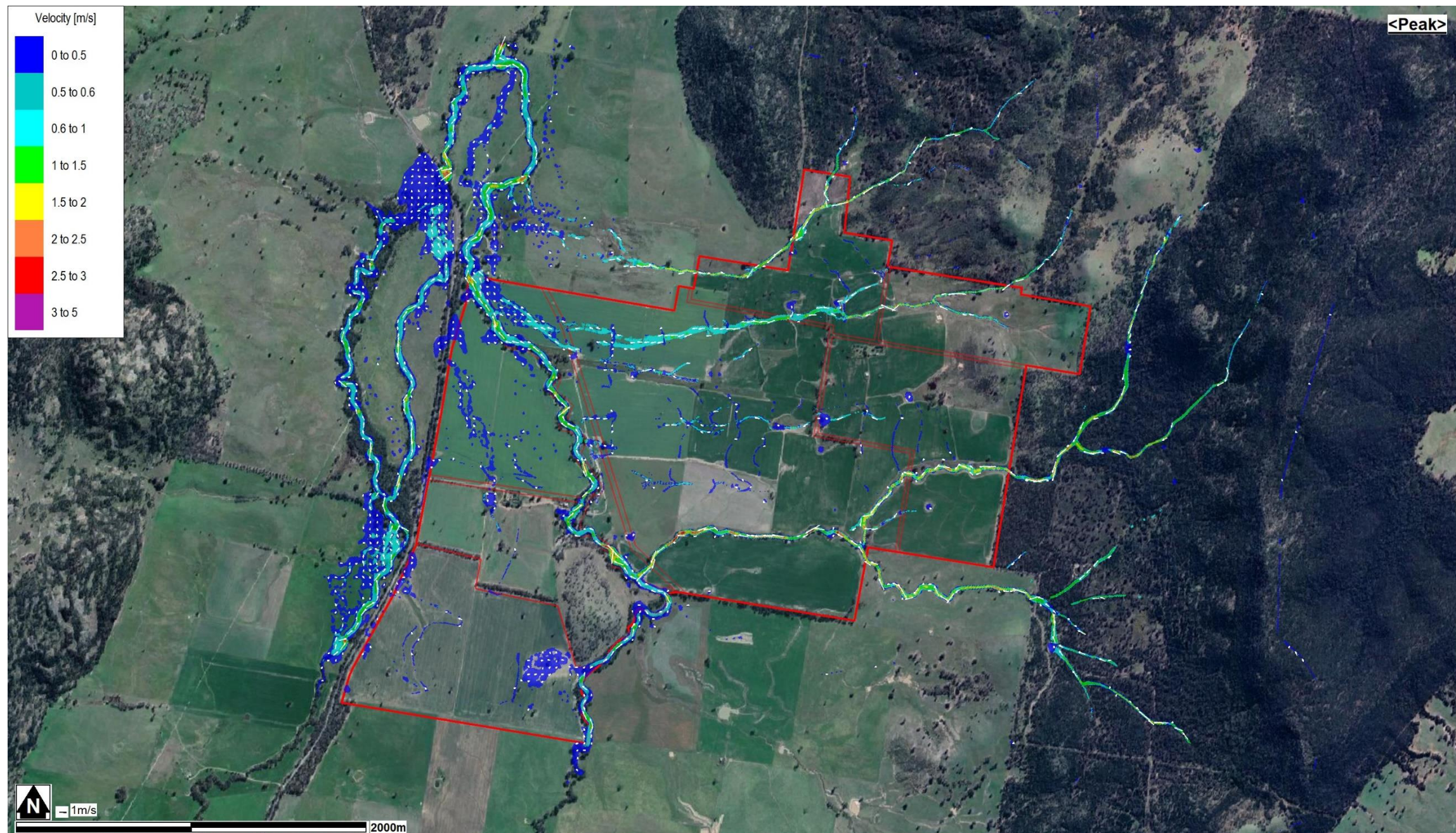


Figure C6 – 39% AEP Pre-Development Peak Water Velocity (Envelope)



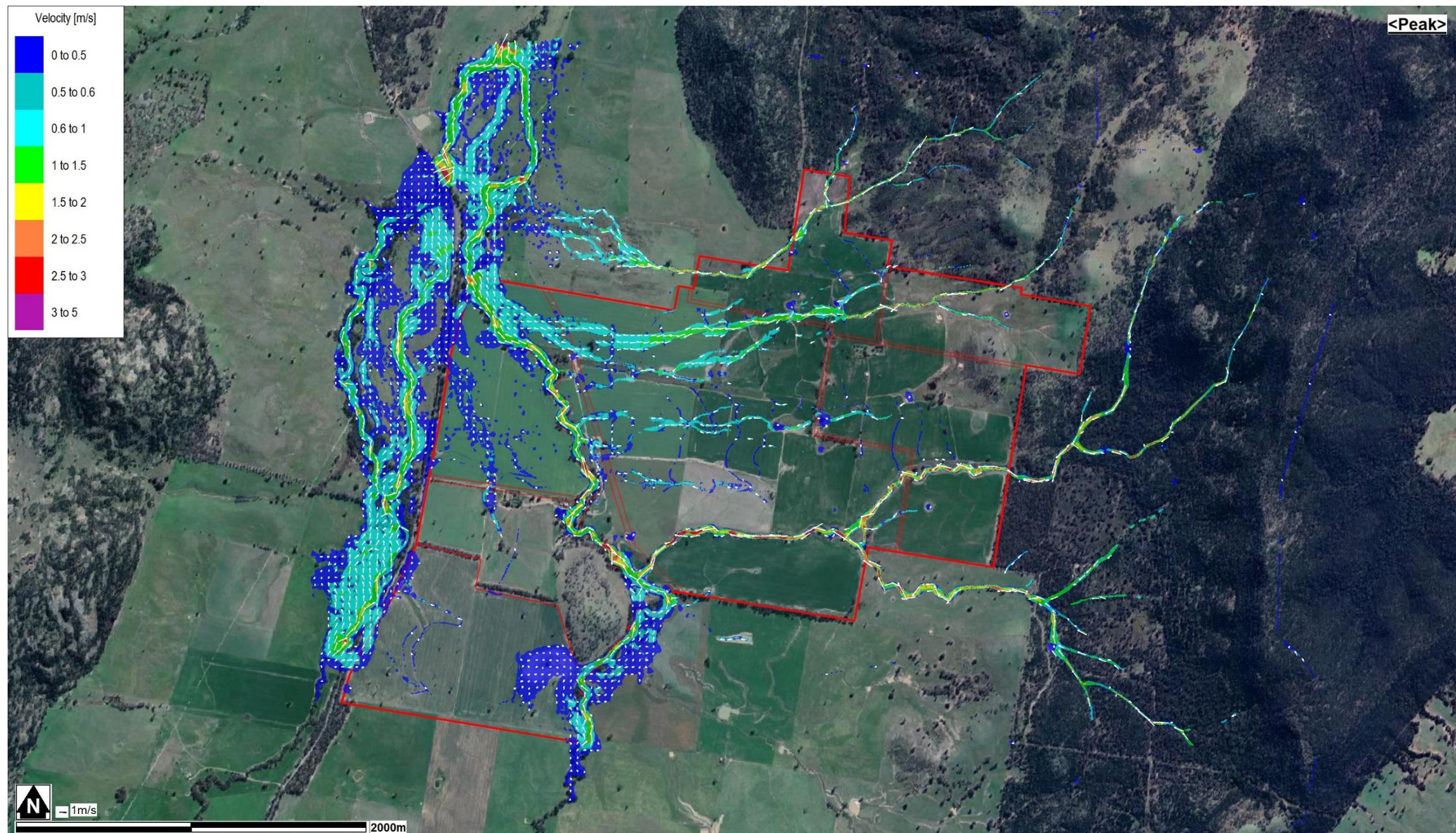


Figure C7 – 5% AEP Pre-Development Peak Water Velocity (Envelope)



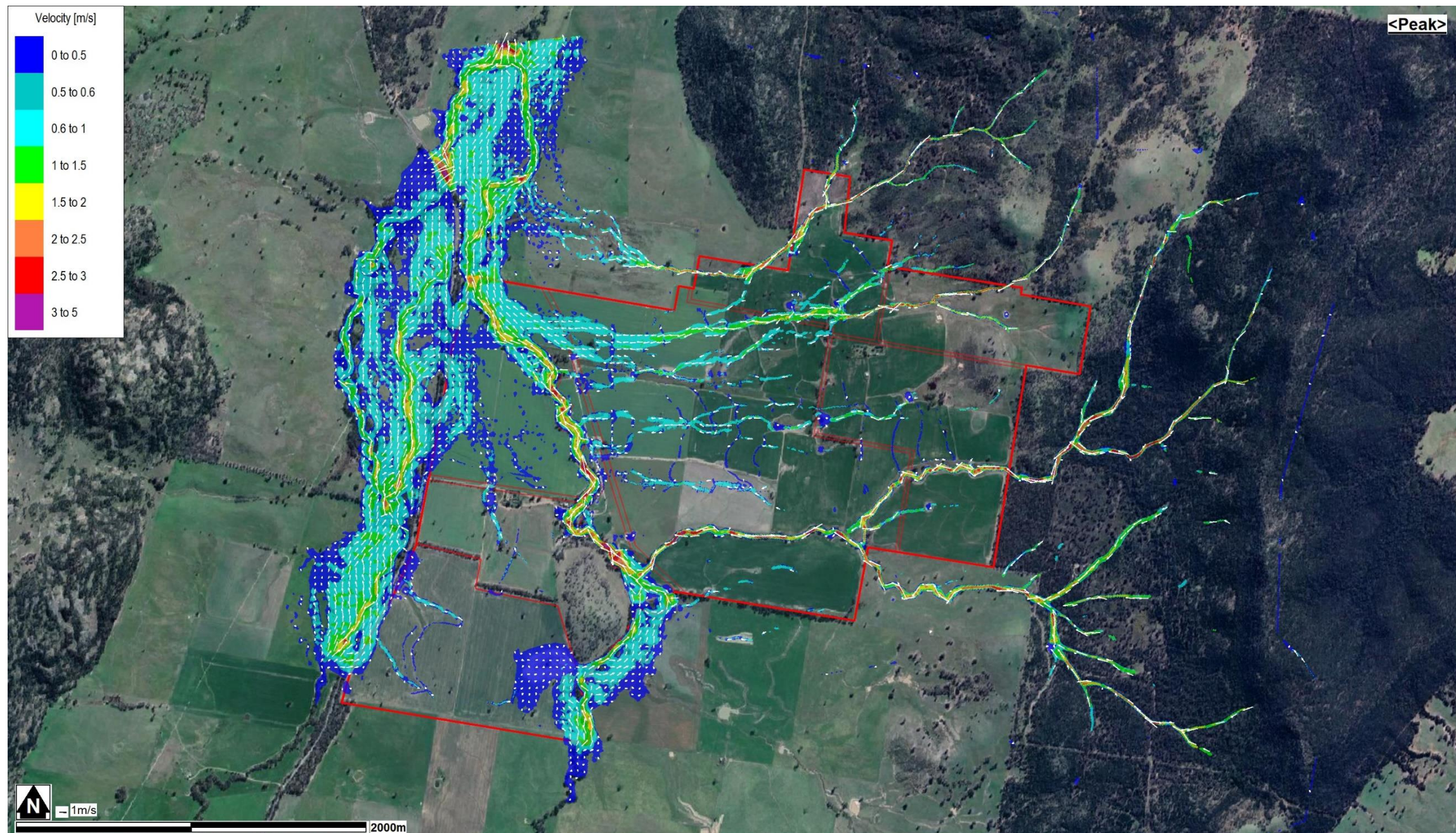


Figure C8 – 1% AEP Pre-Development Peak Water Velocity (Envelope)



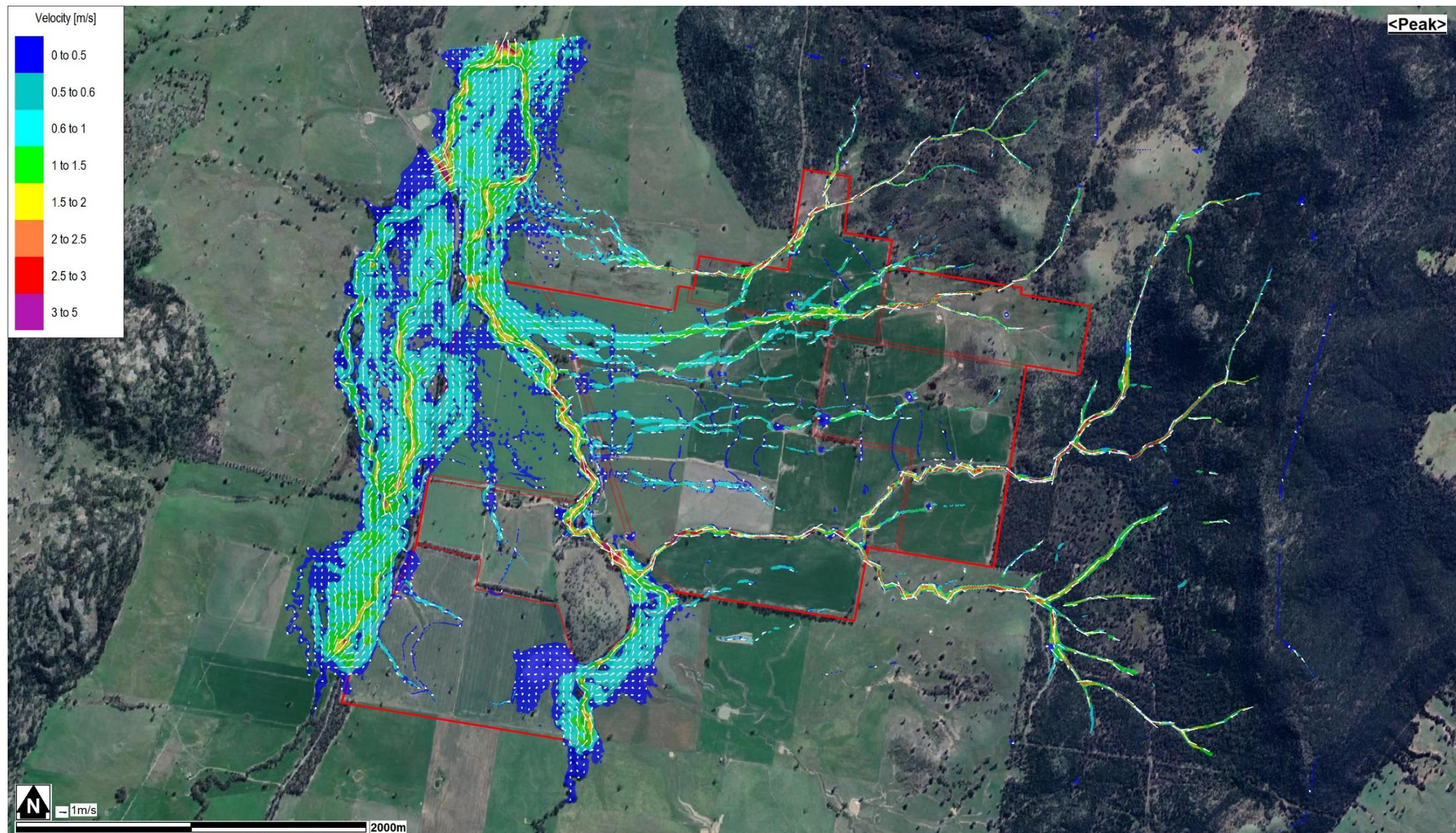


Figure C9 – 0.5% AEP Pre-Development Peak Water Velocity (Envelope)



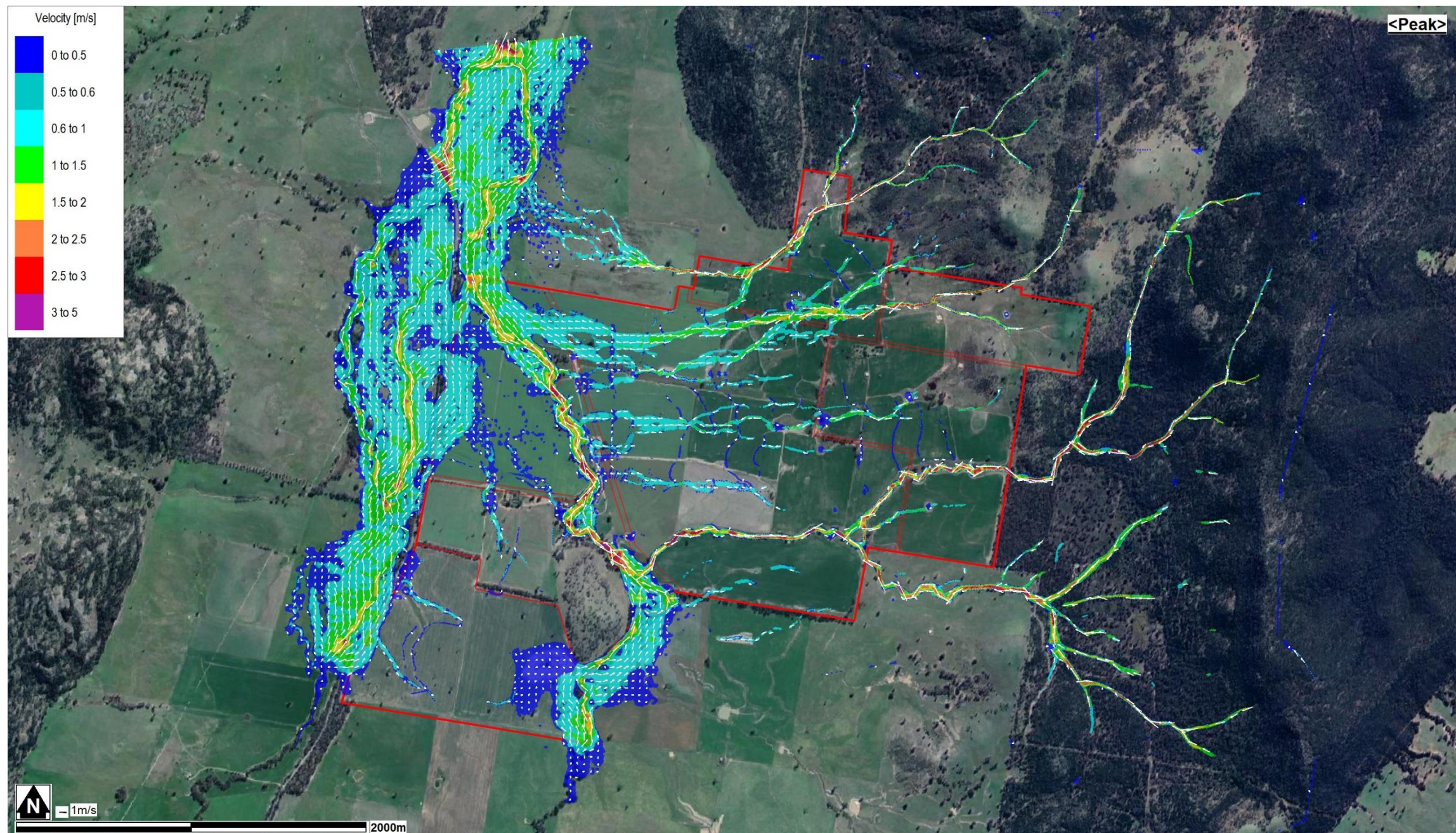


Figure C10 – 0.2% AEP Pre-Development Peak Water Velocity (Envelope)



Appendix D

Post-Development Peak Flood Mapping
39% to 0.05% AEP Events

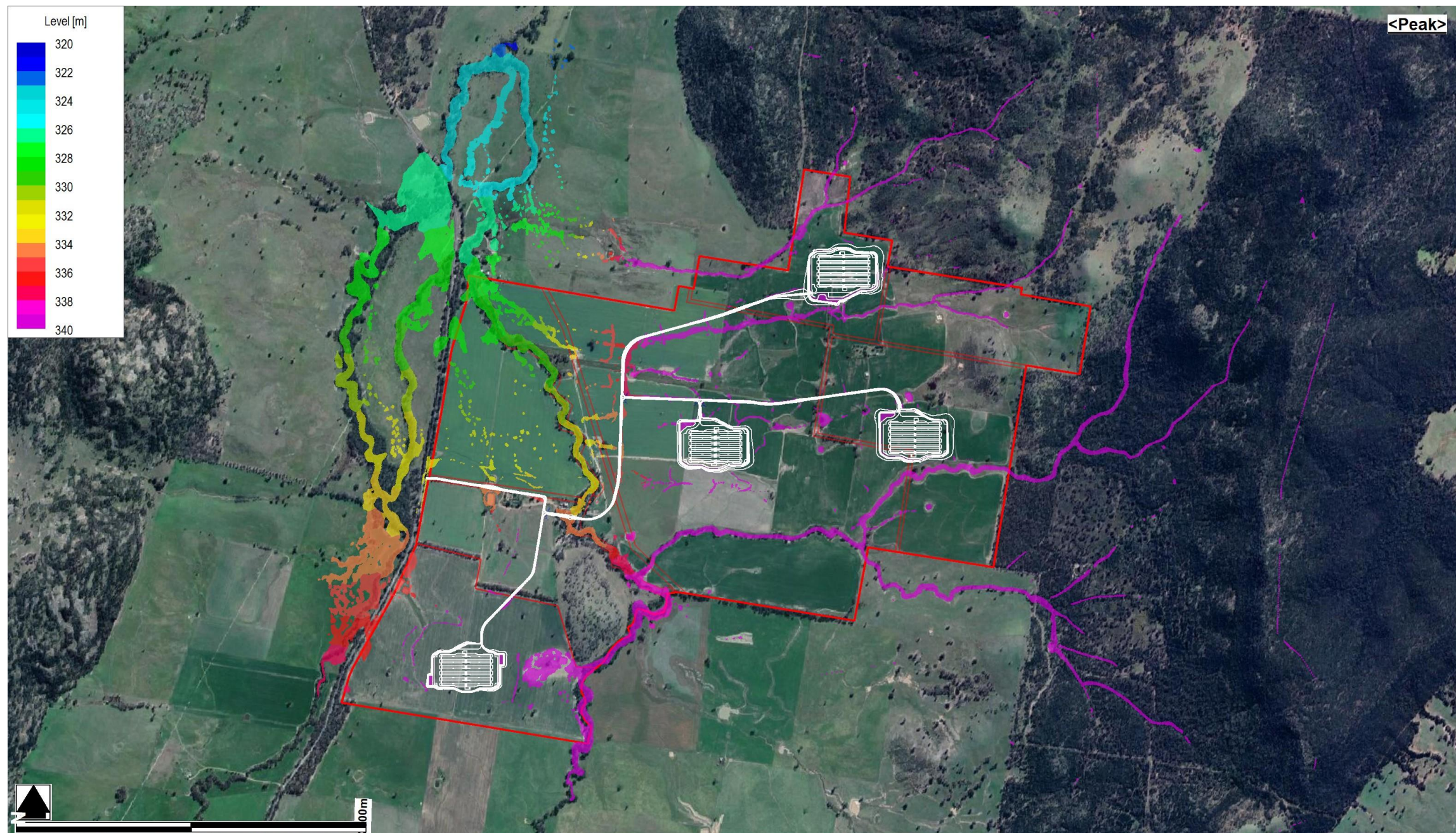


Figure D1 – 39% AEP Post-Development Peak Water Level (Envelope)



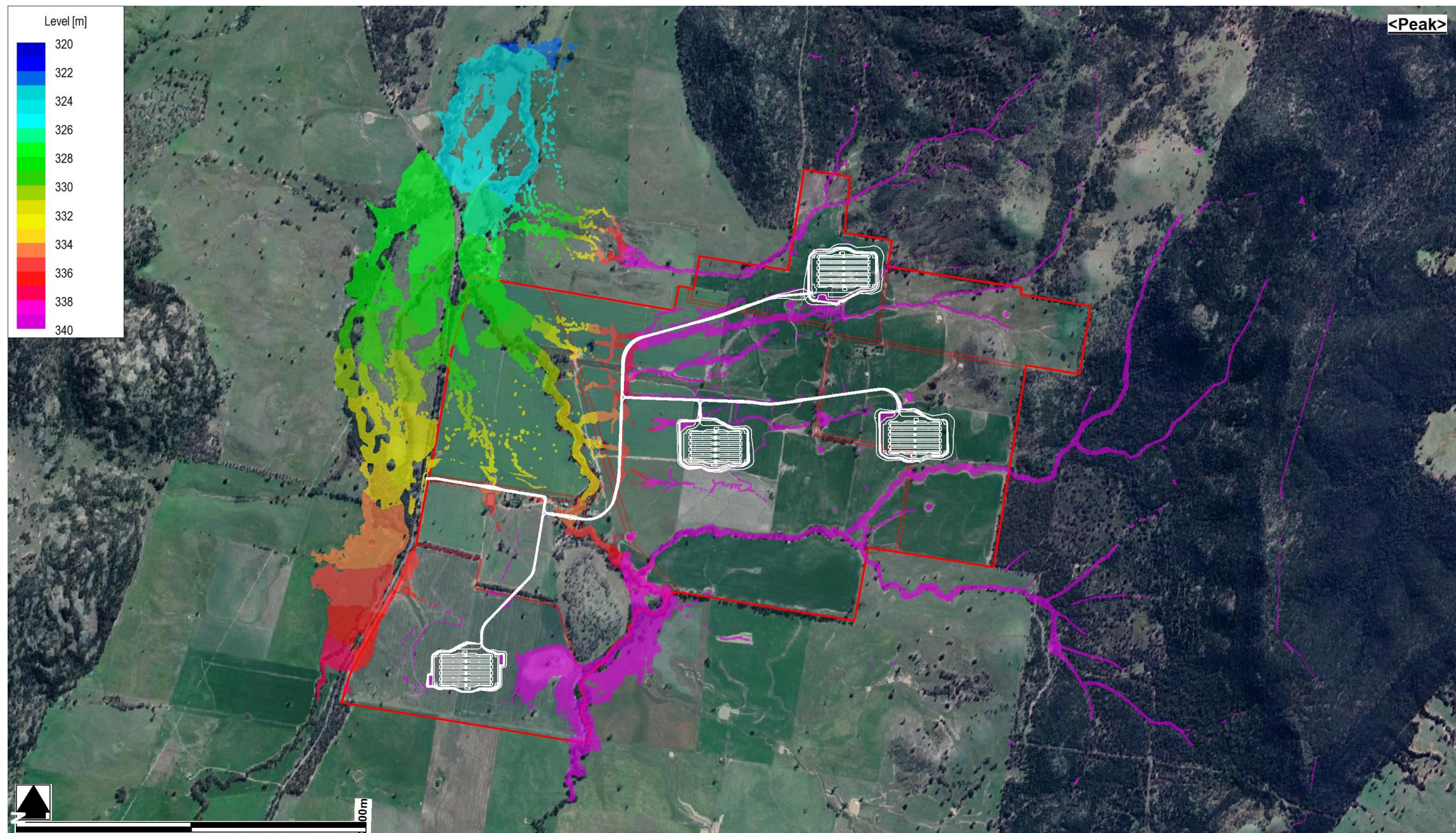


Figure D2 – 5% AEP Post-Development Peak Water Level (Envelope)



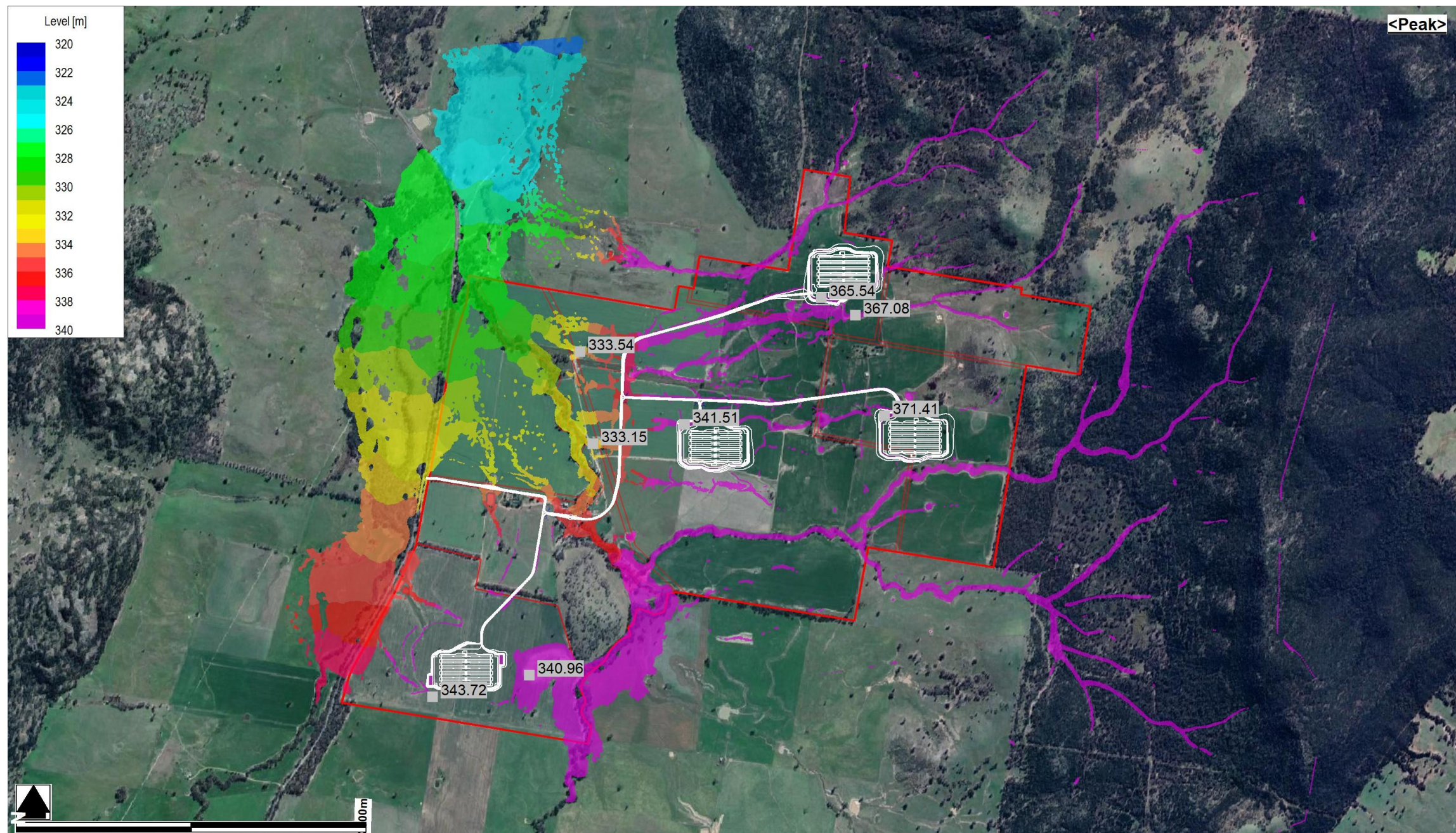


Figure D3 – 1% AEP Post-Development Peak Water Level (Envelope)



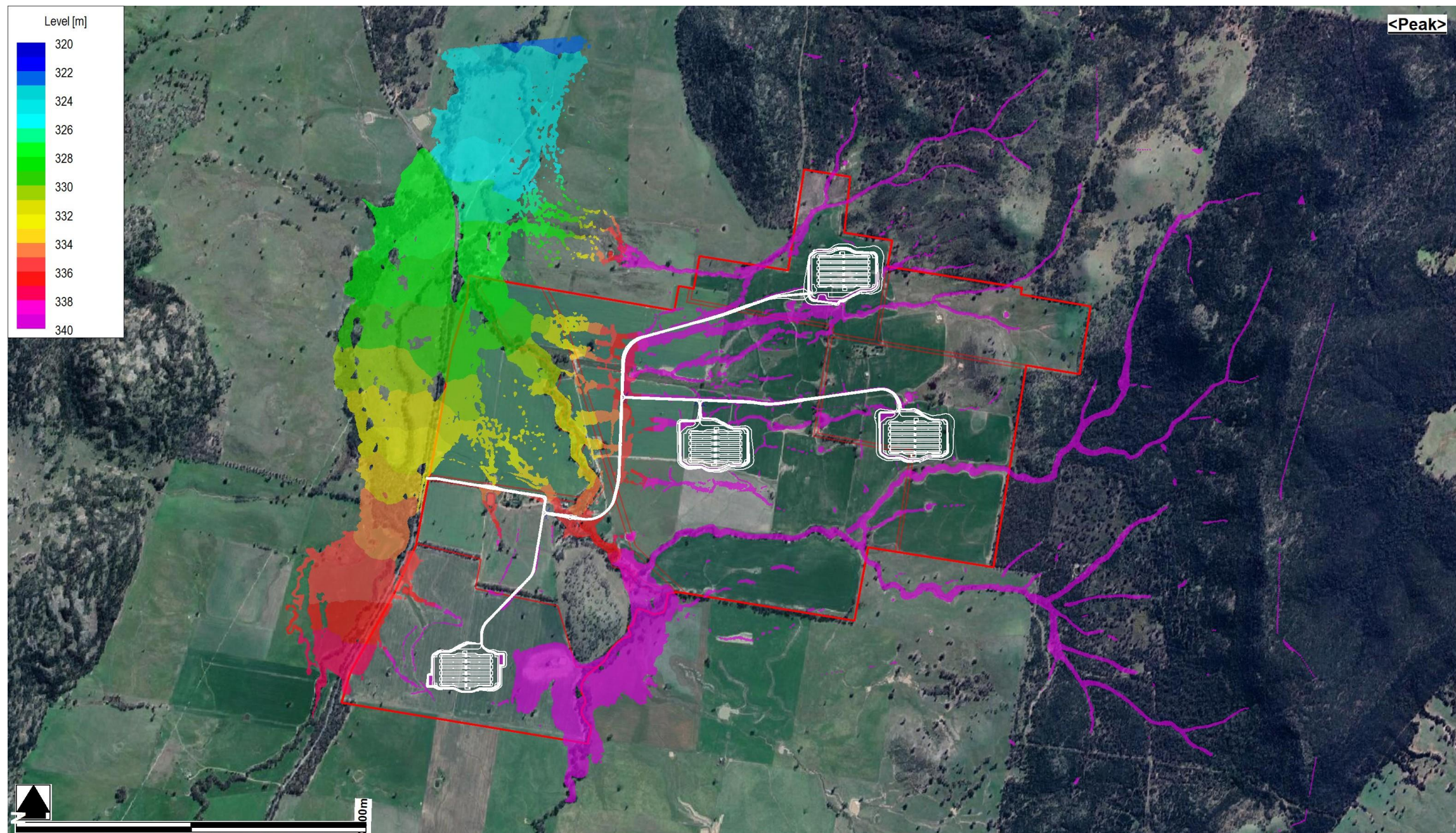


Figure D4 – 0.5% AEP Post-Development Peak Water Level (Envelope)



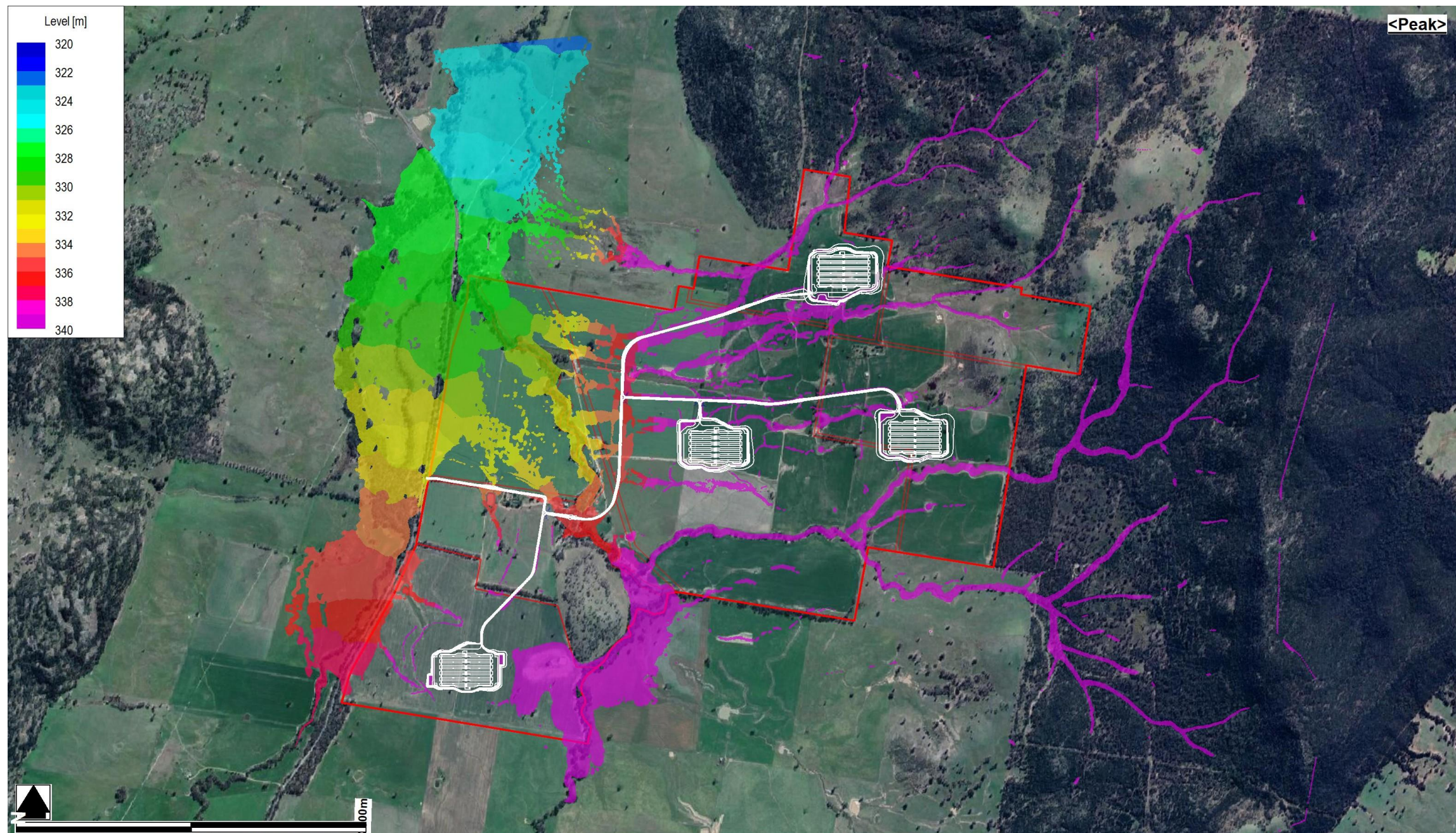


Figure D5 – 0.2% AEP Post-Development Peak Water Level (Envelope)



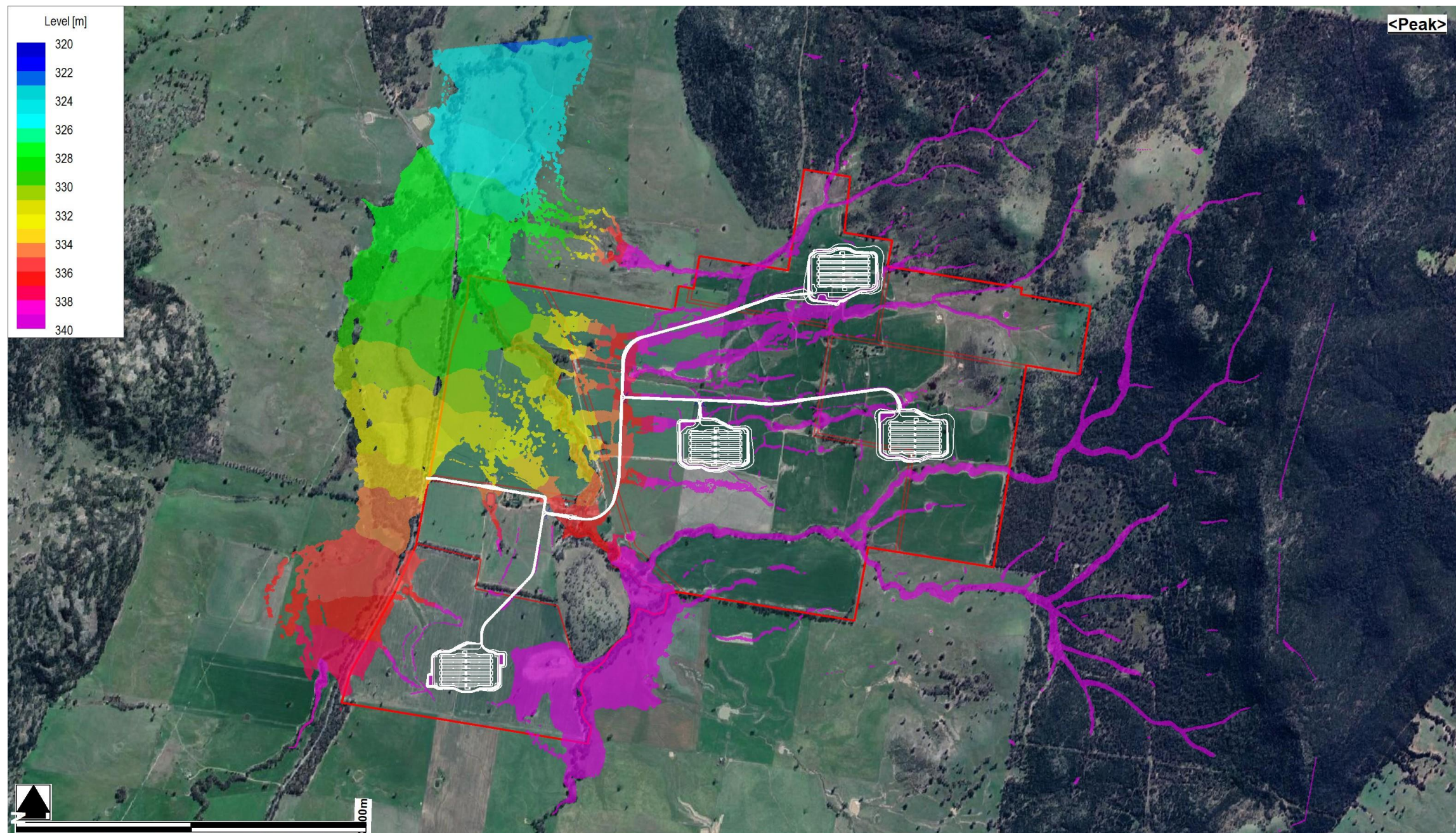


Figure D6 – 0.05% AEP Post-Development Peak Water Level (Envelope)



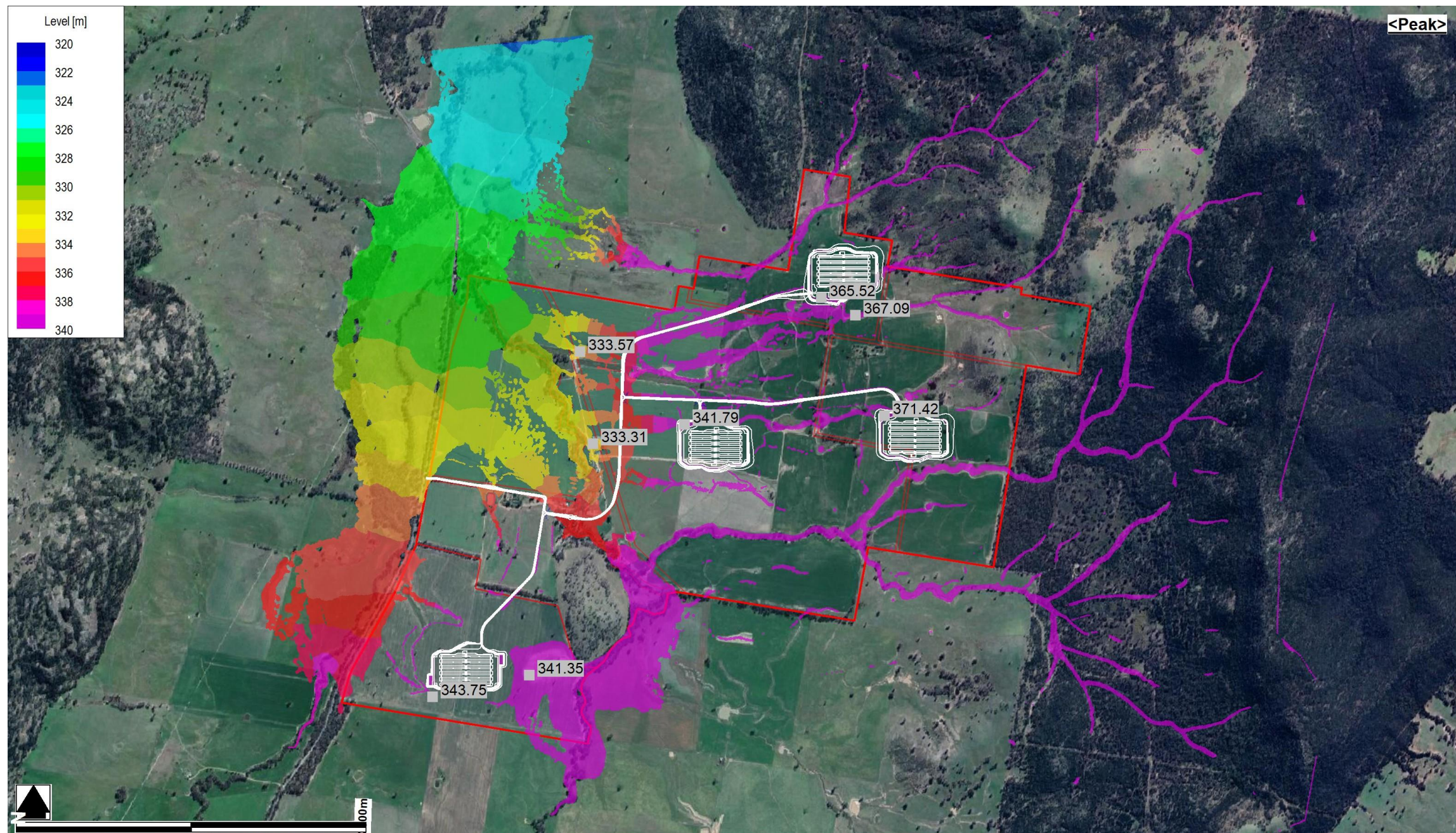


Figure D7 – 0.05% AEP Post-Development Peak Water Level (Envelope) – Climate Change Scenario (Extreme Event)



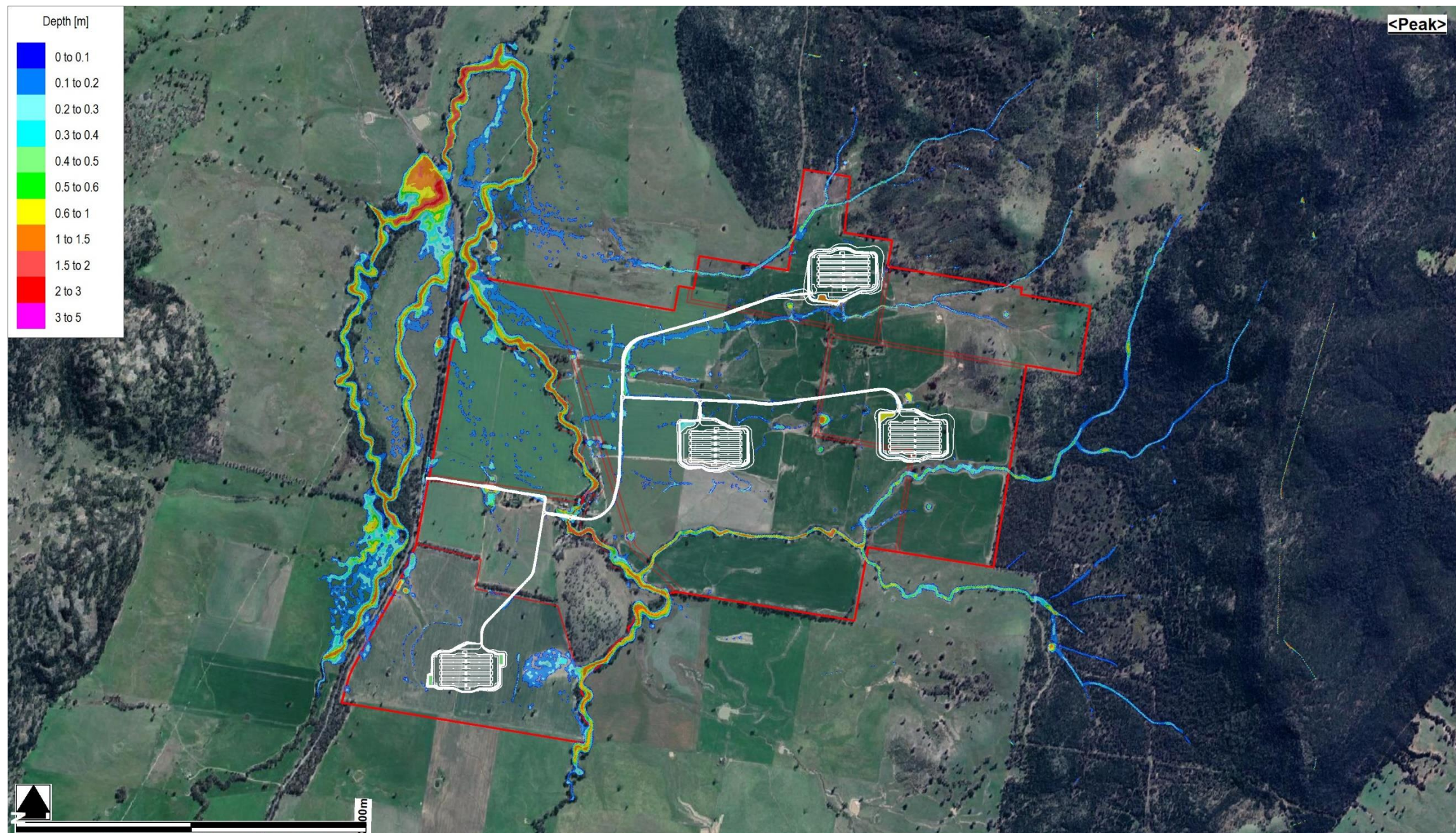


Figure D8 – 39% AEP Post-Development Peak Water Depth (Envelope)



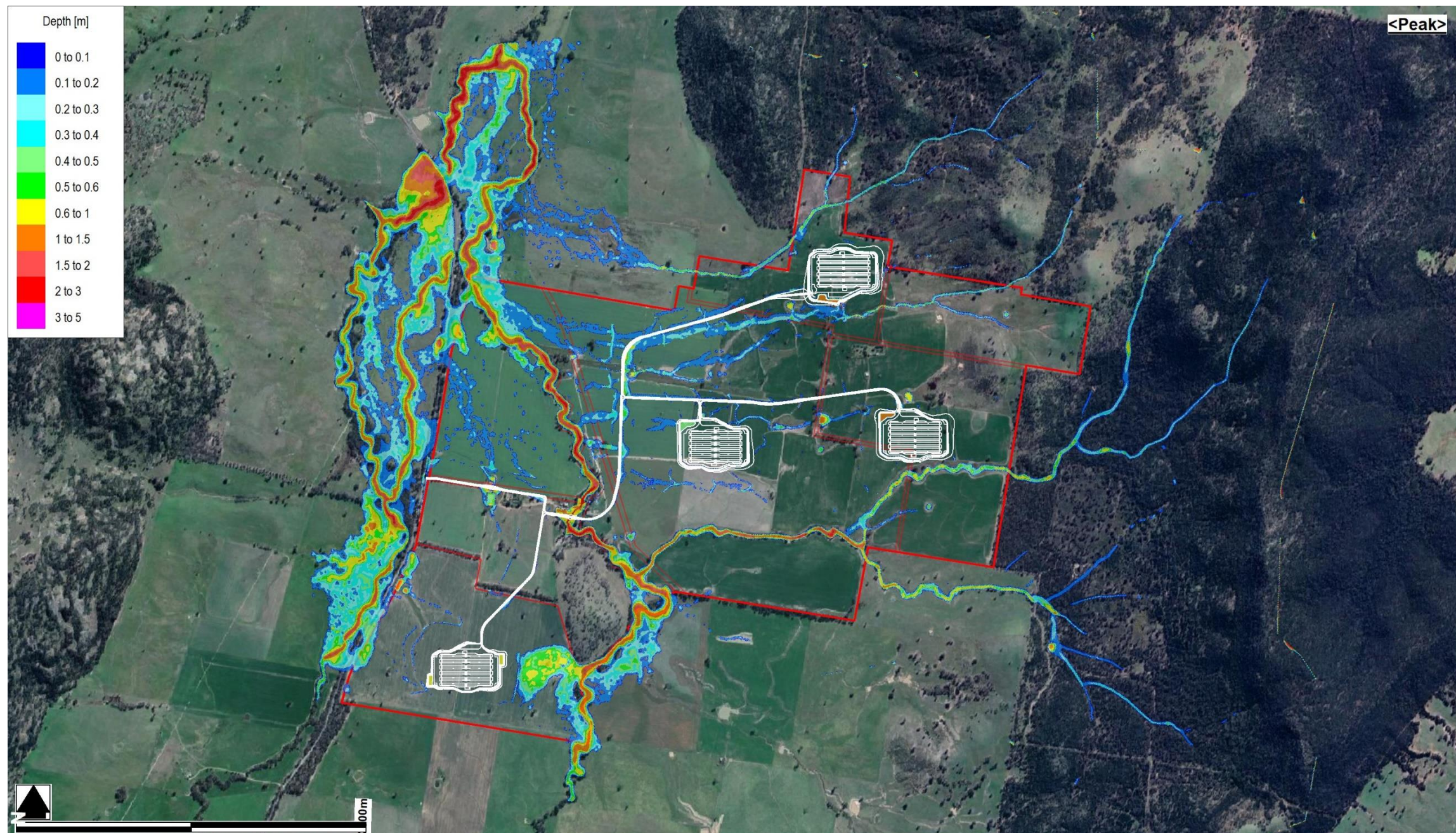


Figure D9 – 5% AEP Post-Development Peak Water Depth (Envelope)



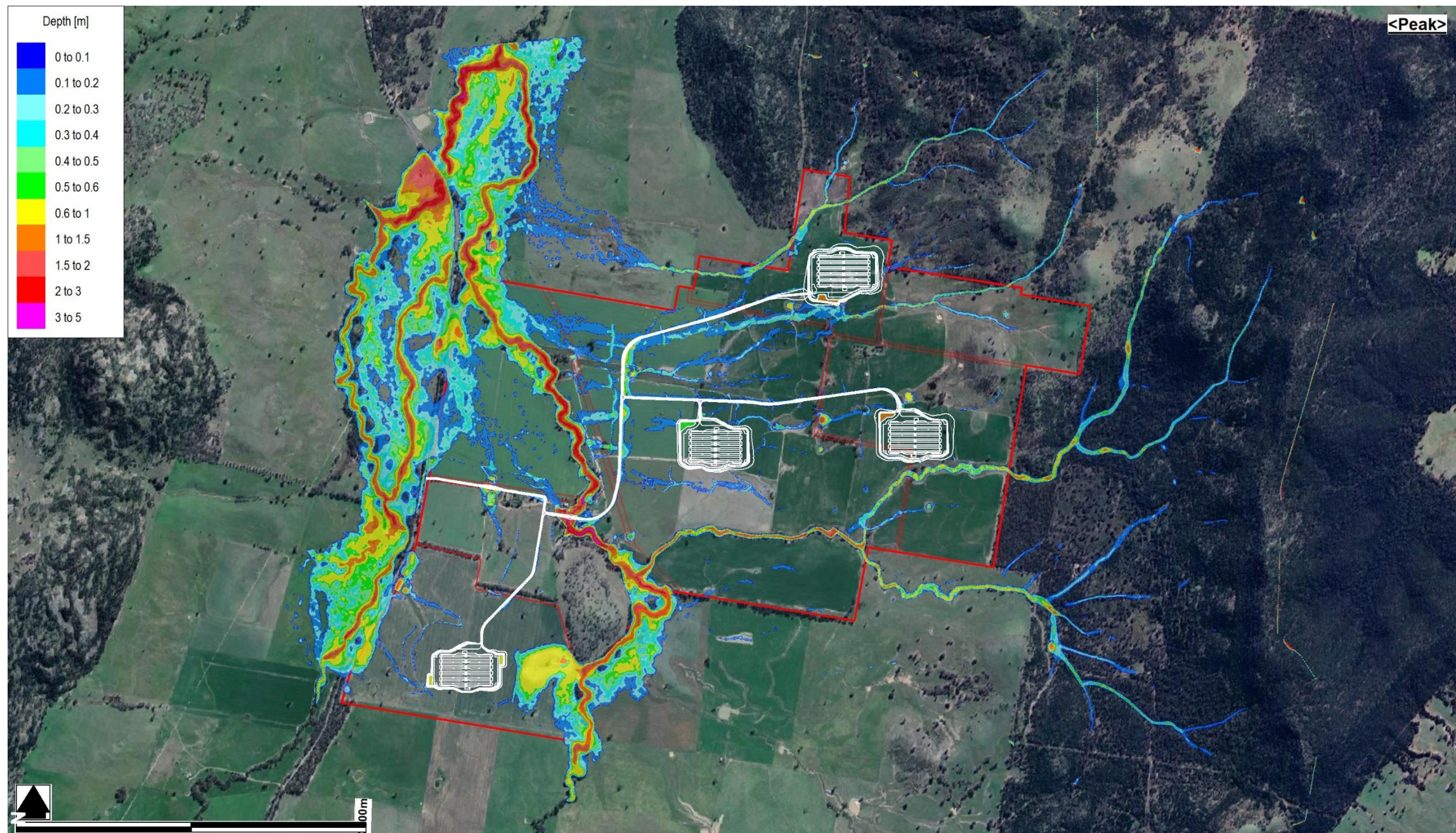


Figure D10 – 1% AEP Post-Development Peak Water Depth (Envelope)



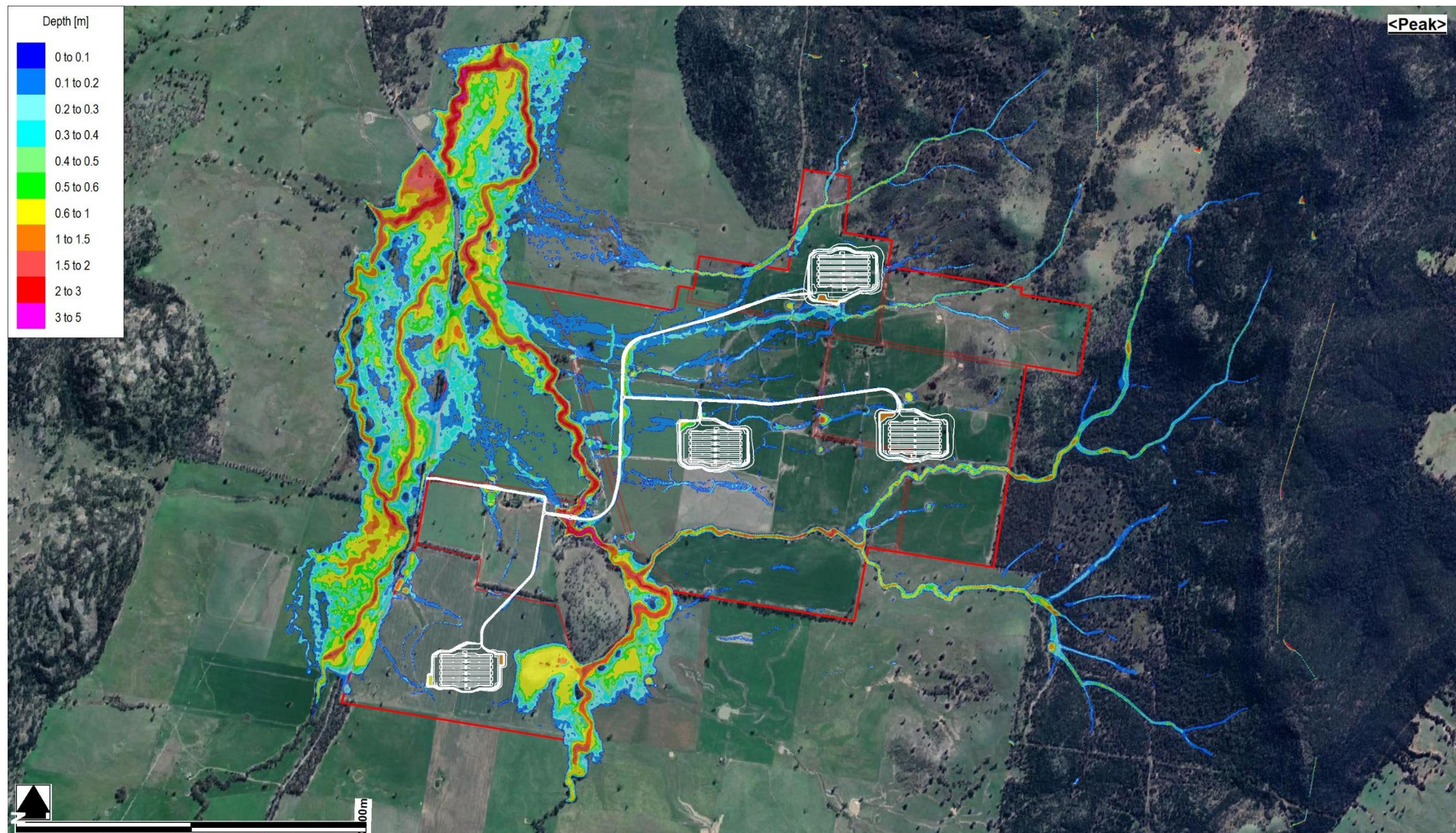


Figure D11 – 0.5% AEP Post-Development Peak Water Depth (Envelope)



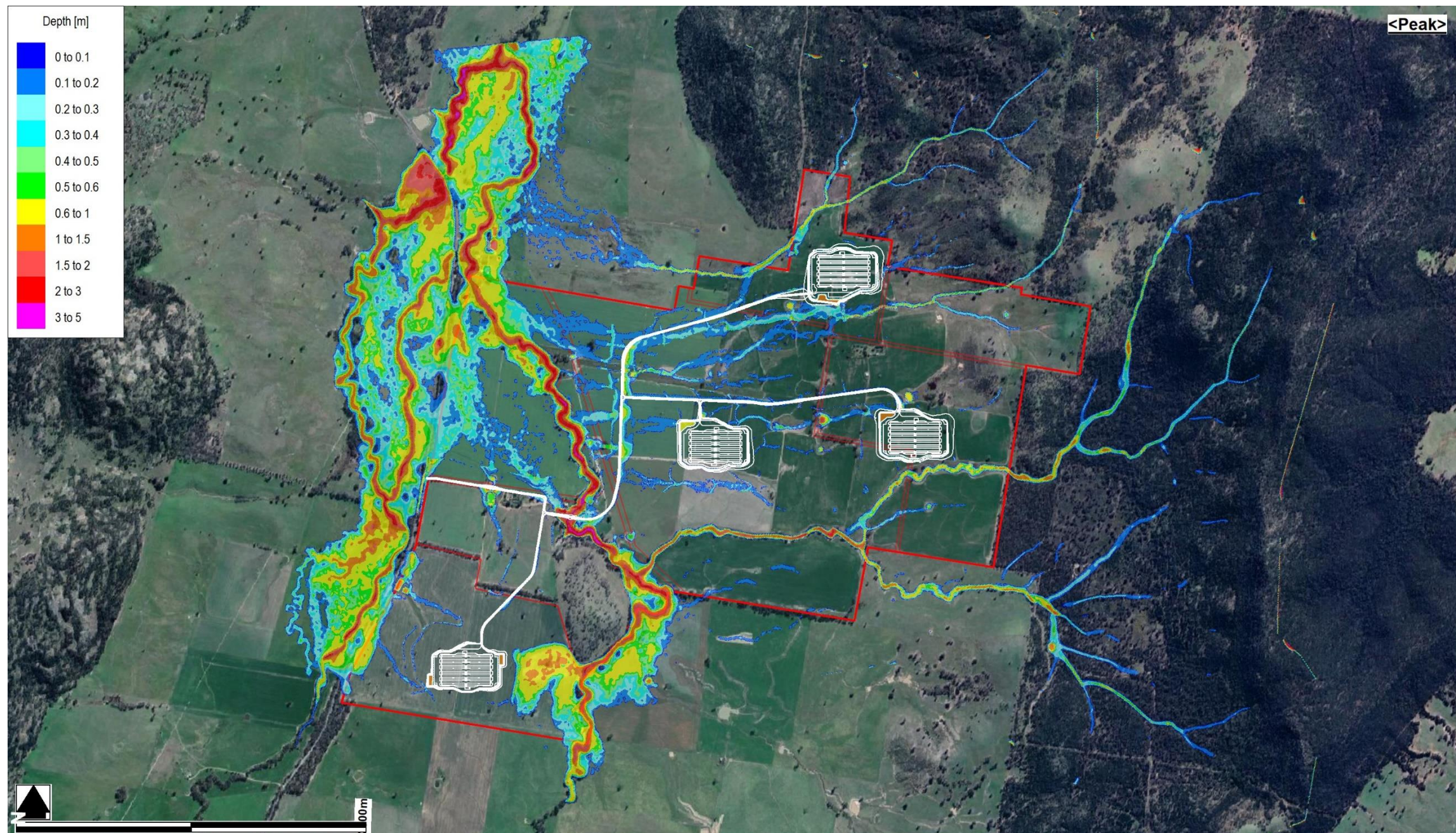


Figure D12 – 0.2% AEP Post-Development Peak Water Depth (Envelope)



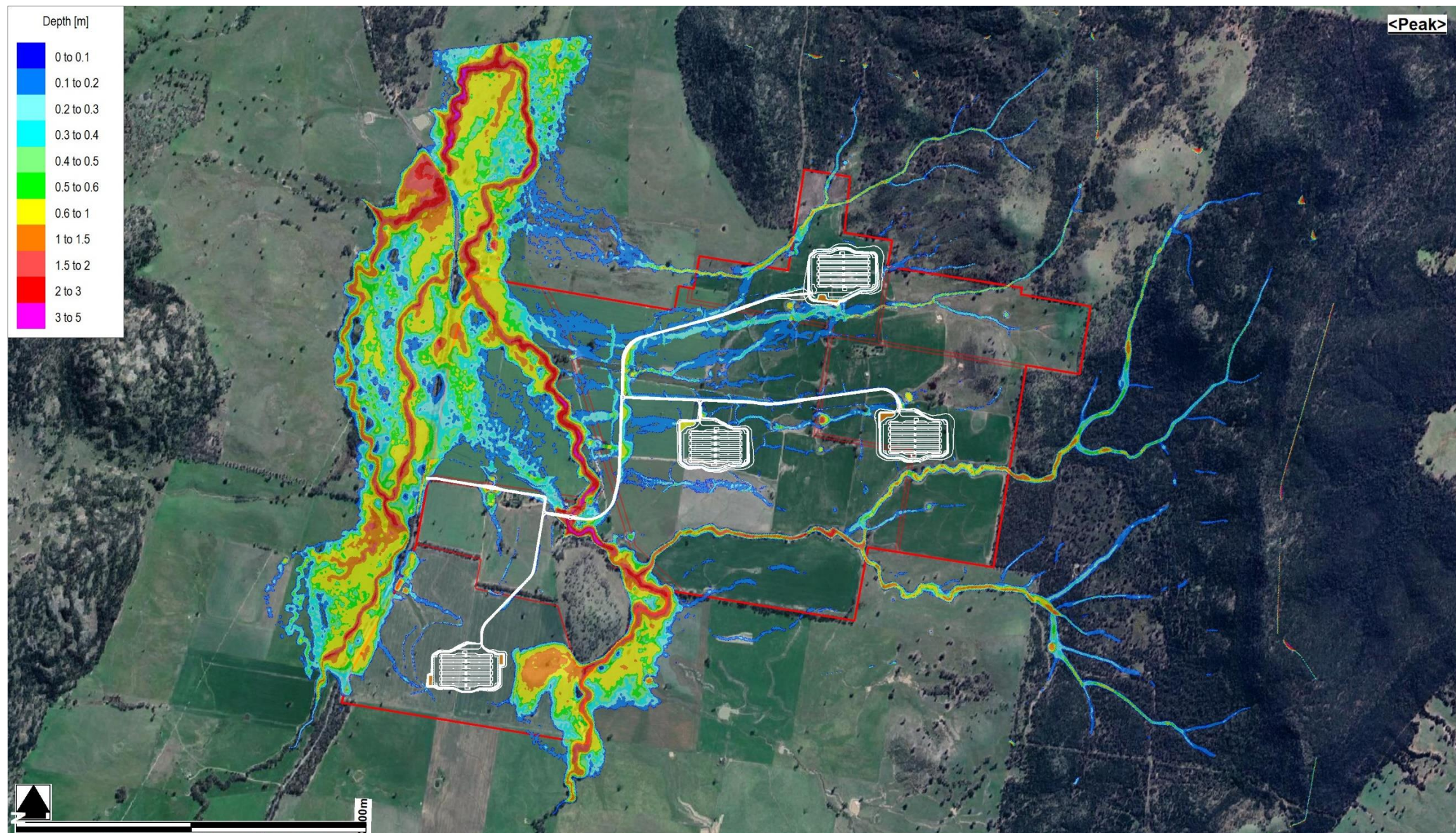


Figure D13 – 0.05% AEP Post-Development Peak Water Depth (Envelope)



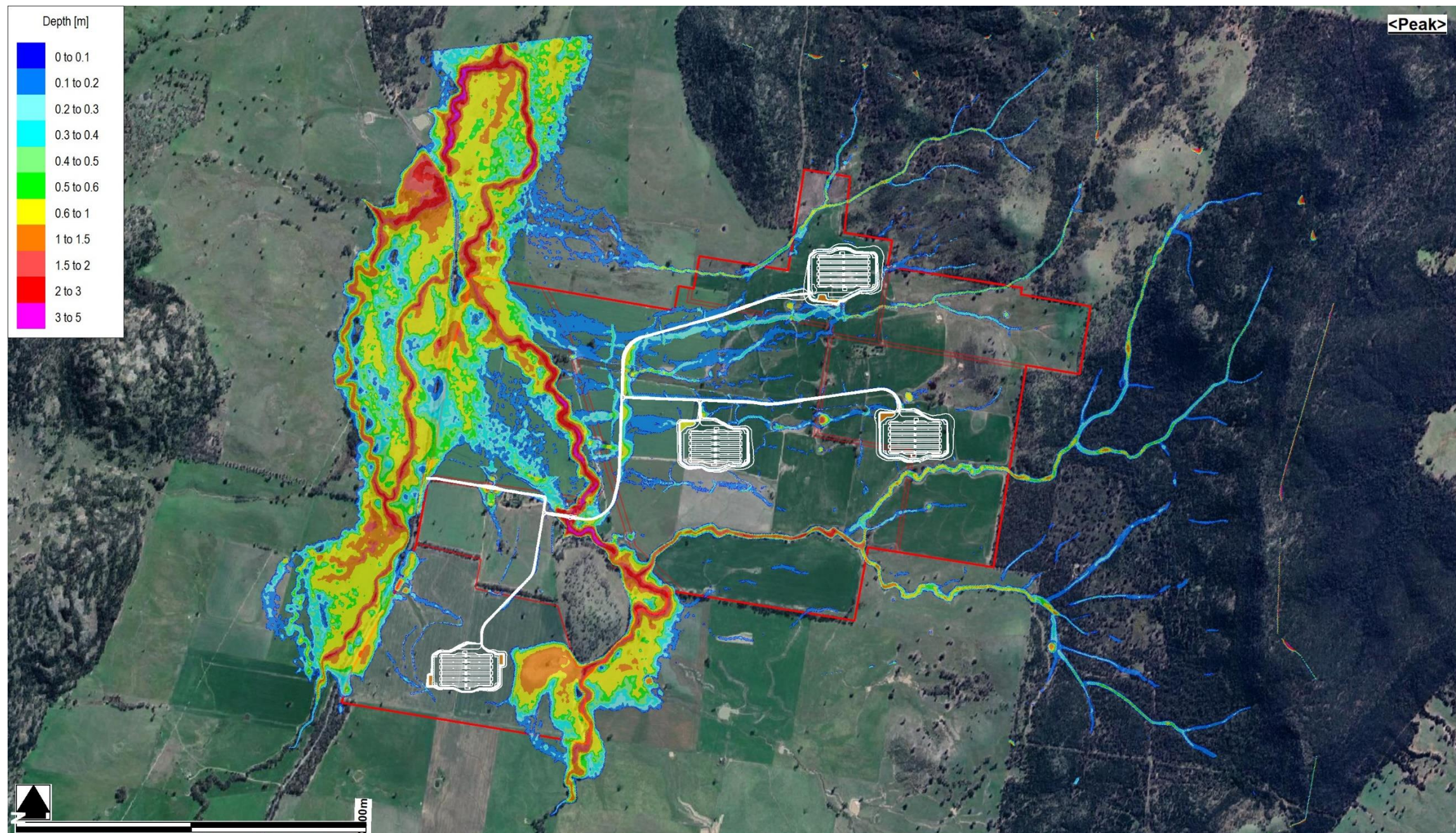


Figure D14 – 0.05% AEP Post-Development Peak Water Depth (Envelope) – Climate Change Scenario (Extreme Event)



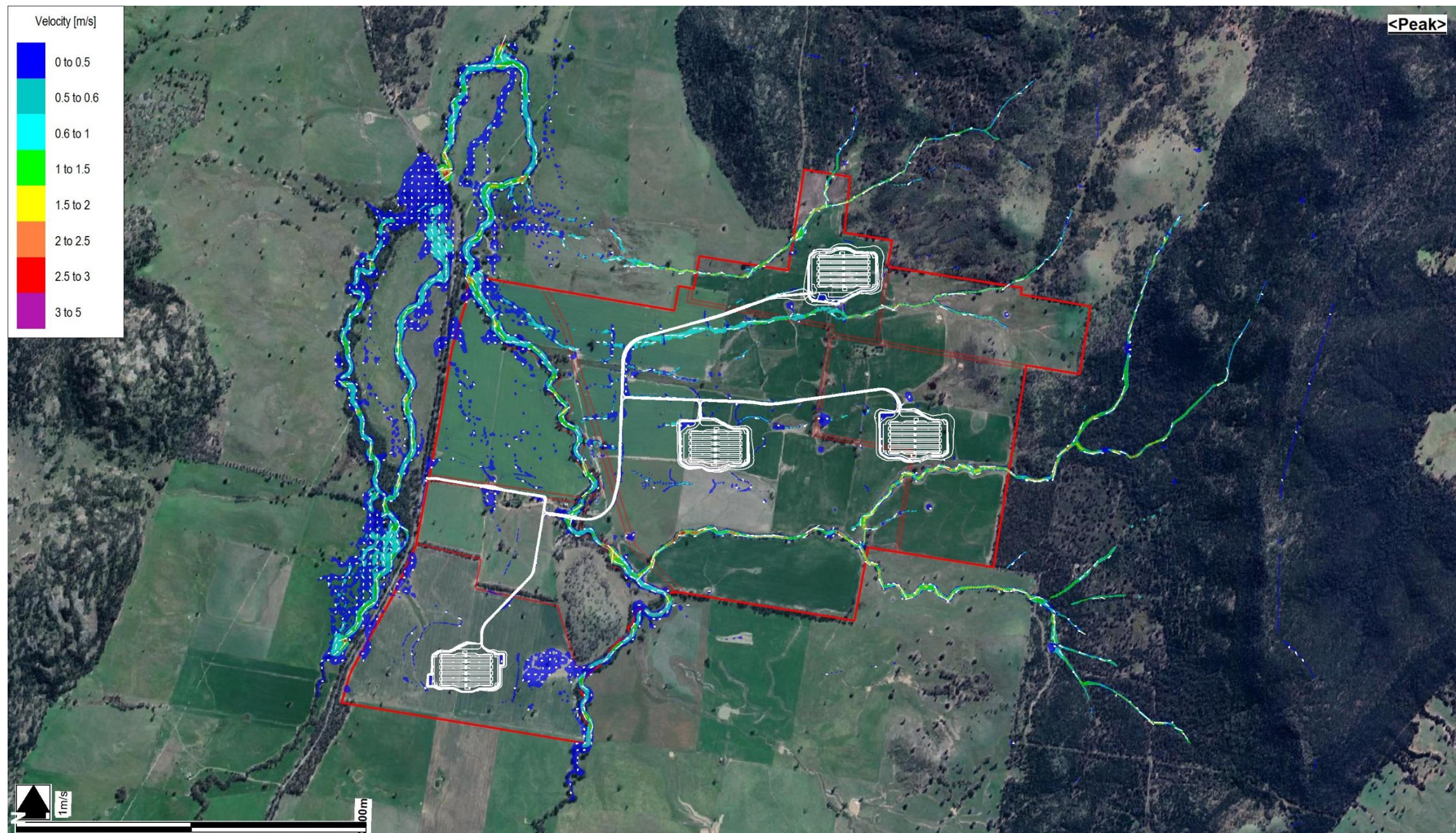


Figure D15 – 39% AEP Post-Development Peak Water Velocity (Envelope)



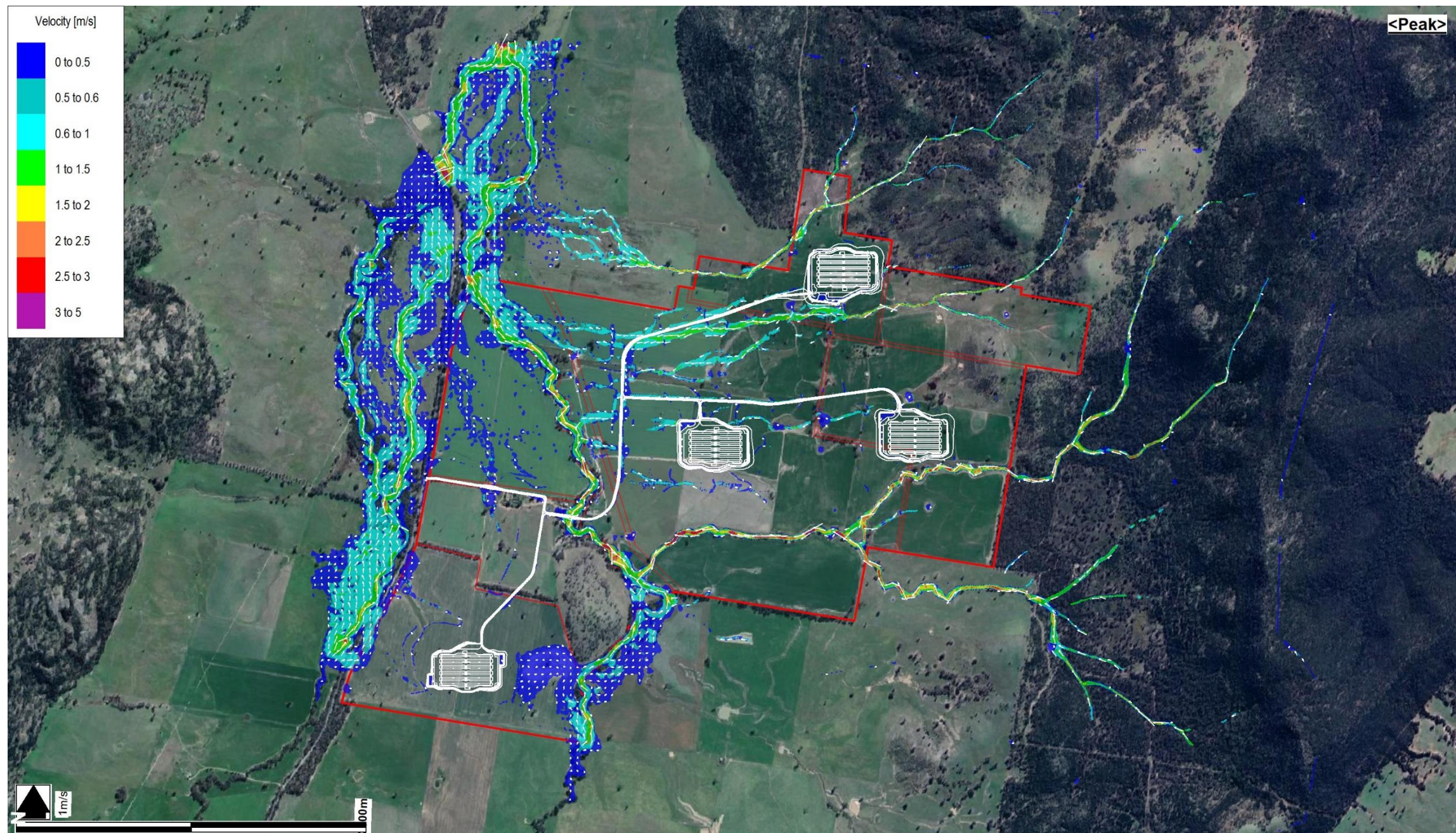


Figure D16 – 5% AEP Post-Development Peak Water Velocity (Envelope)



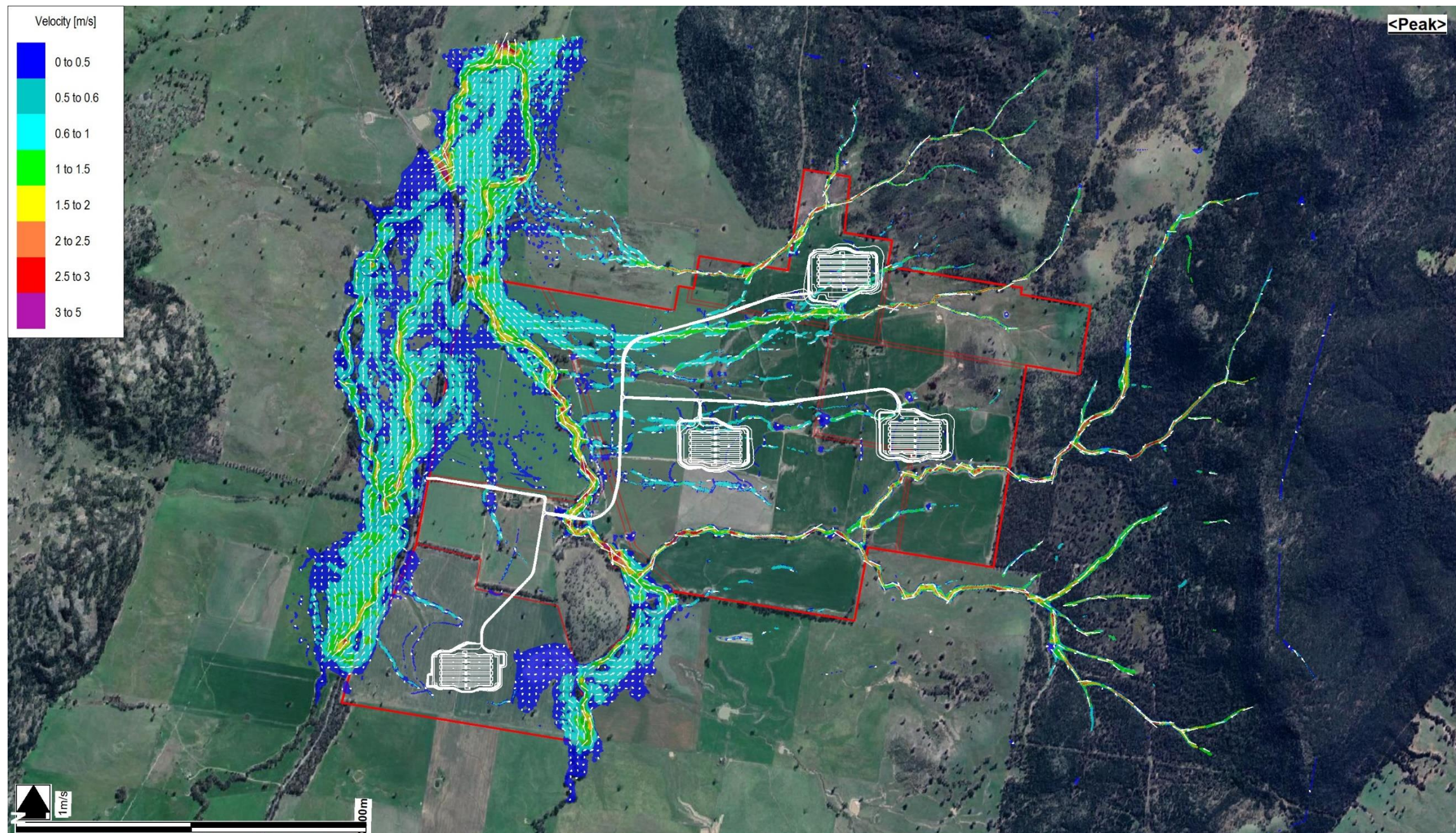


Figure D17 – 1% AEP Post-Development Peak Water Velocity (Envelope)



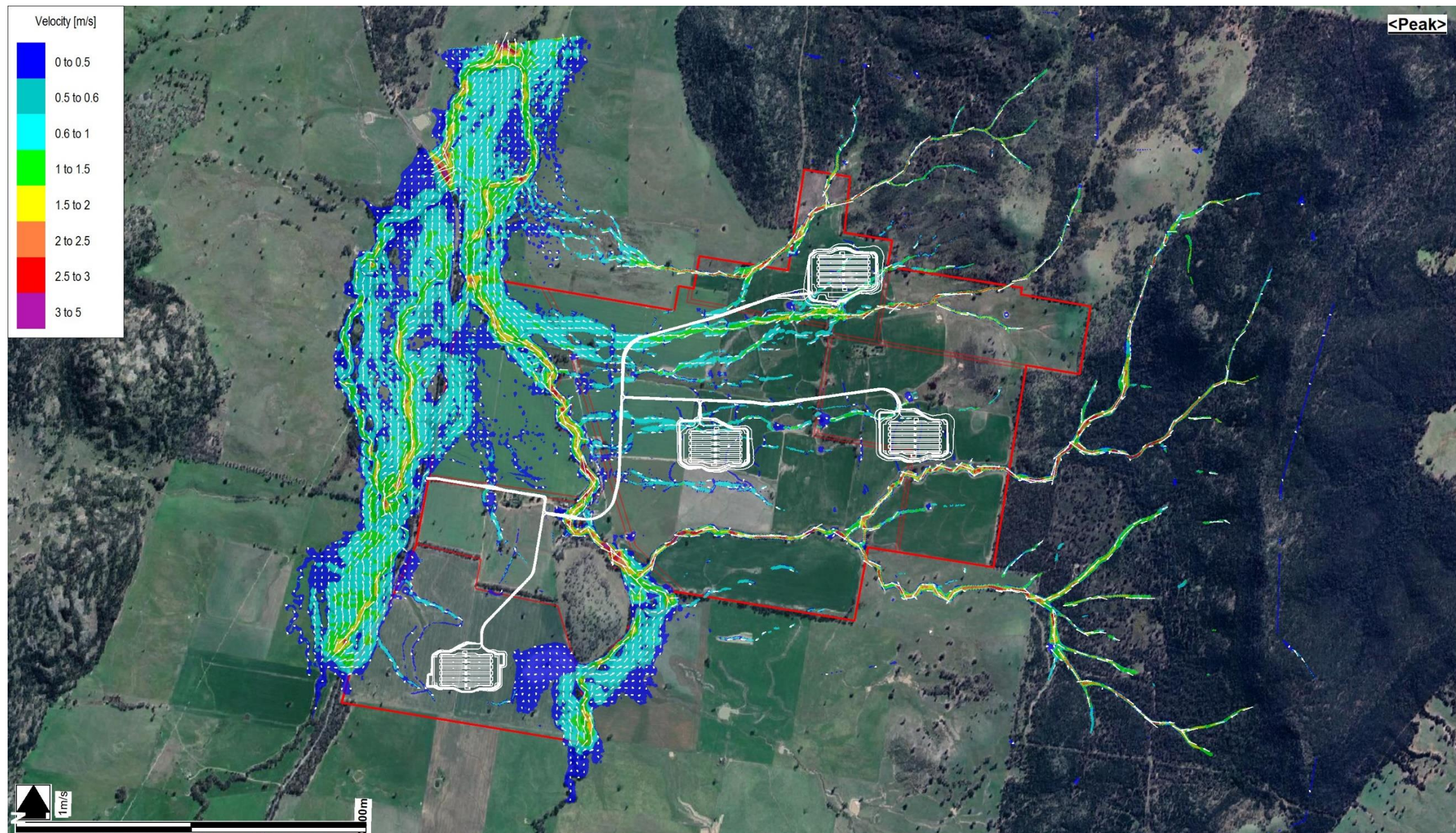


Figure D18 – 0.5% AEP Post-Development Peak Water Velocity (Envelope)



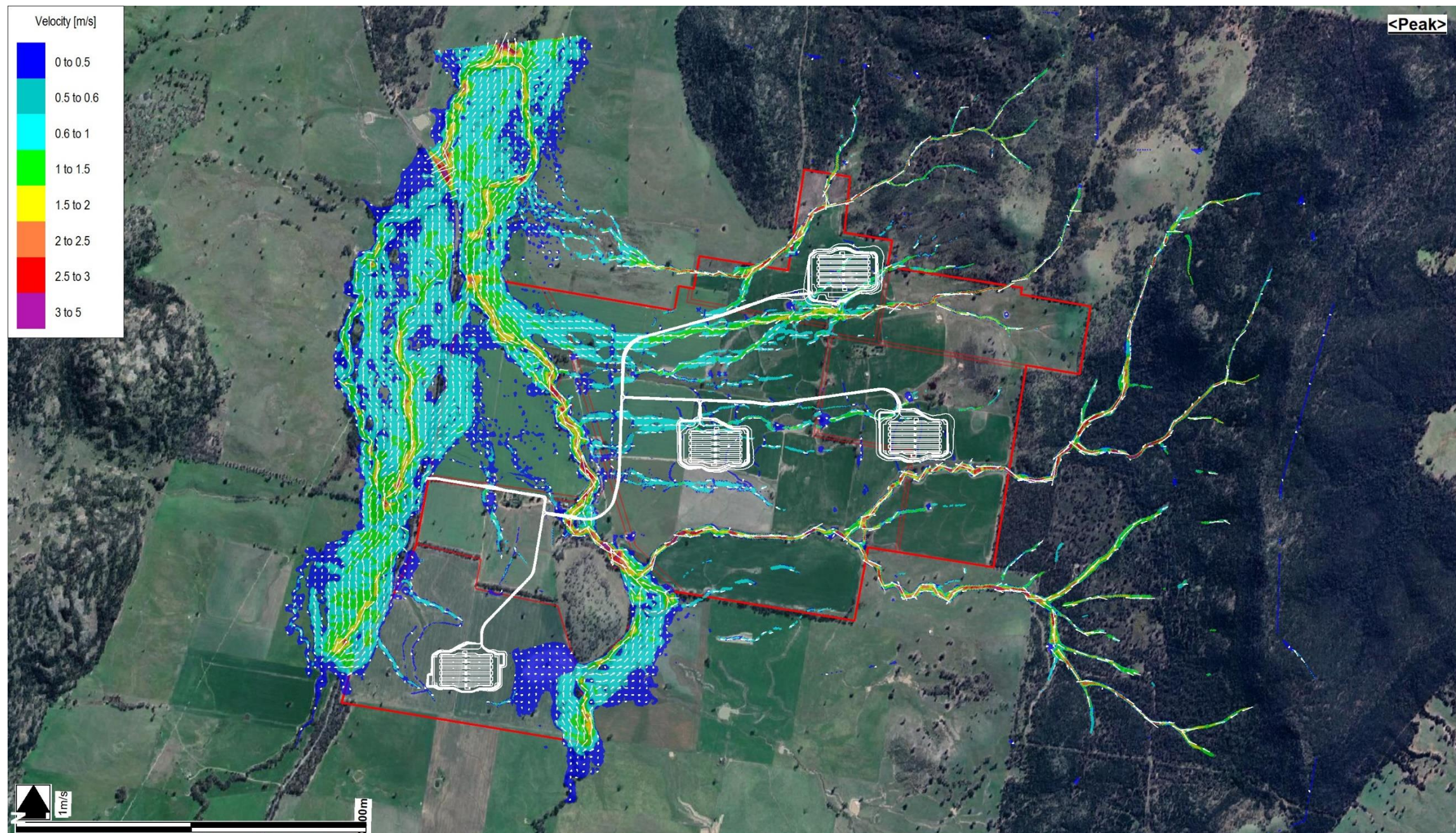


Figure D19 – 0.2% AEP Post-Development Peak Water Velocity (Envelope)



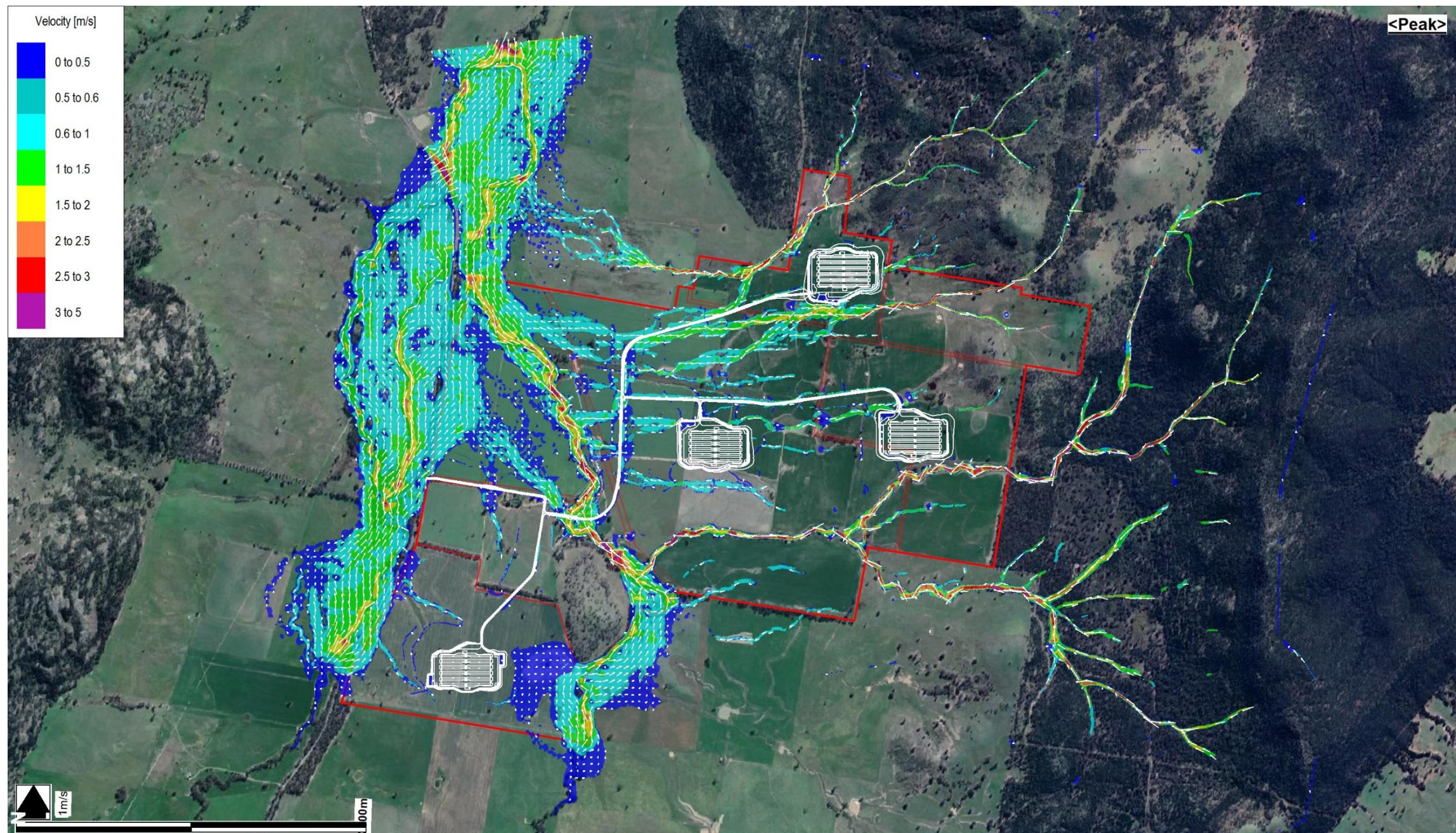


Figure D20 – 0.05% AEP Post-Development Peak Water Velocity (Envelope)



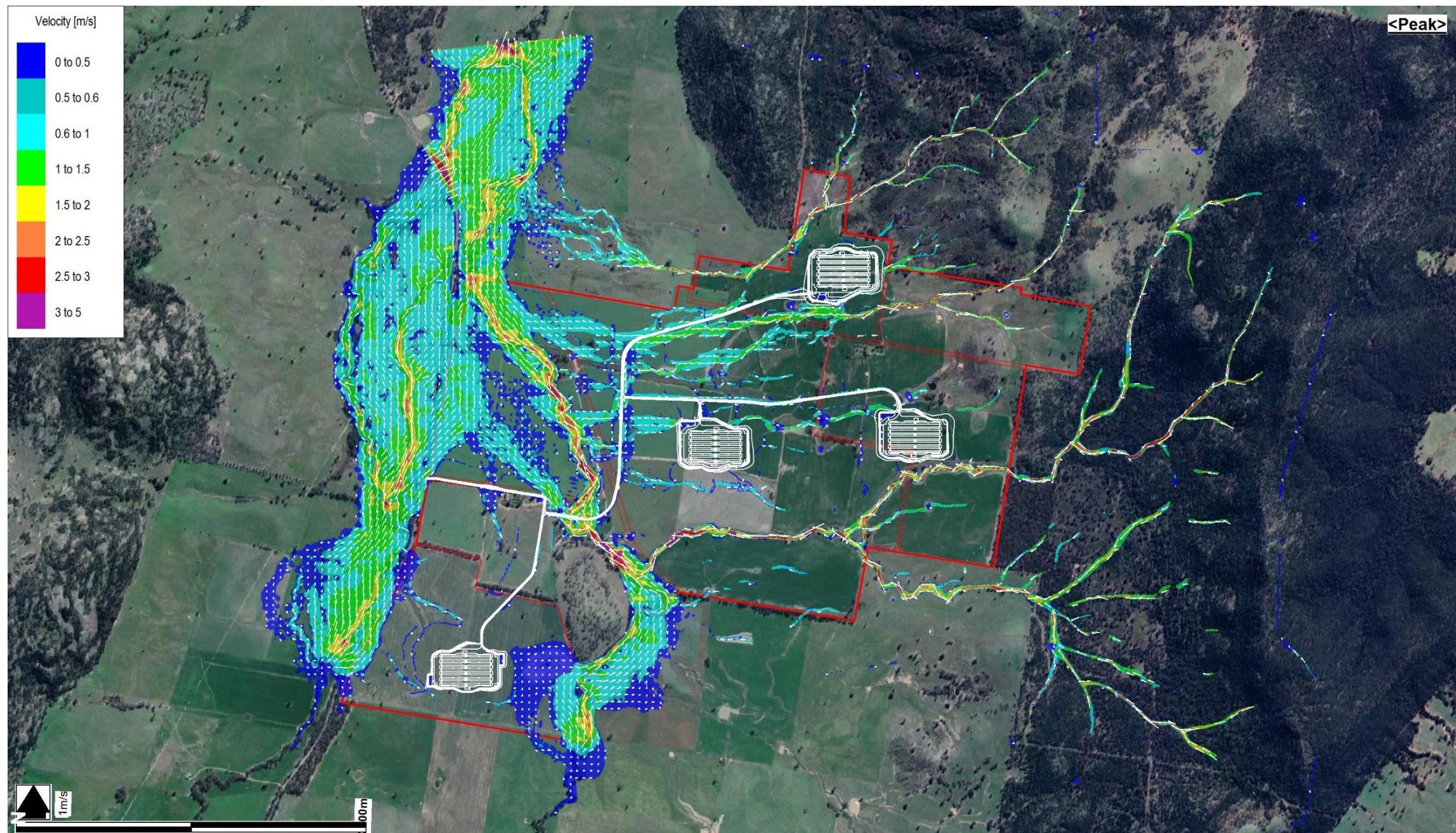


Figure D21 – 0.05% AEP Post-Development Peak Water Velocity (Envelope) – Climate Change Scenario (Extreme Event)



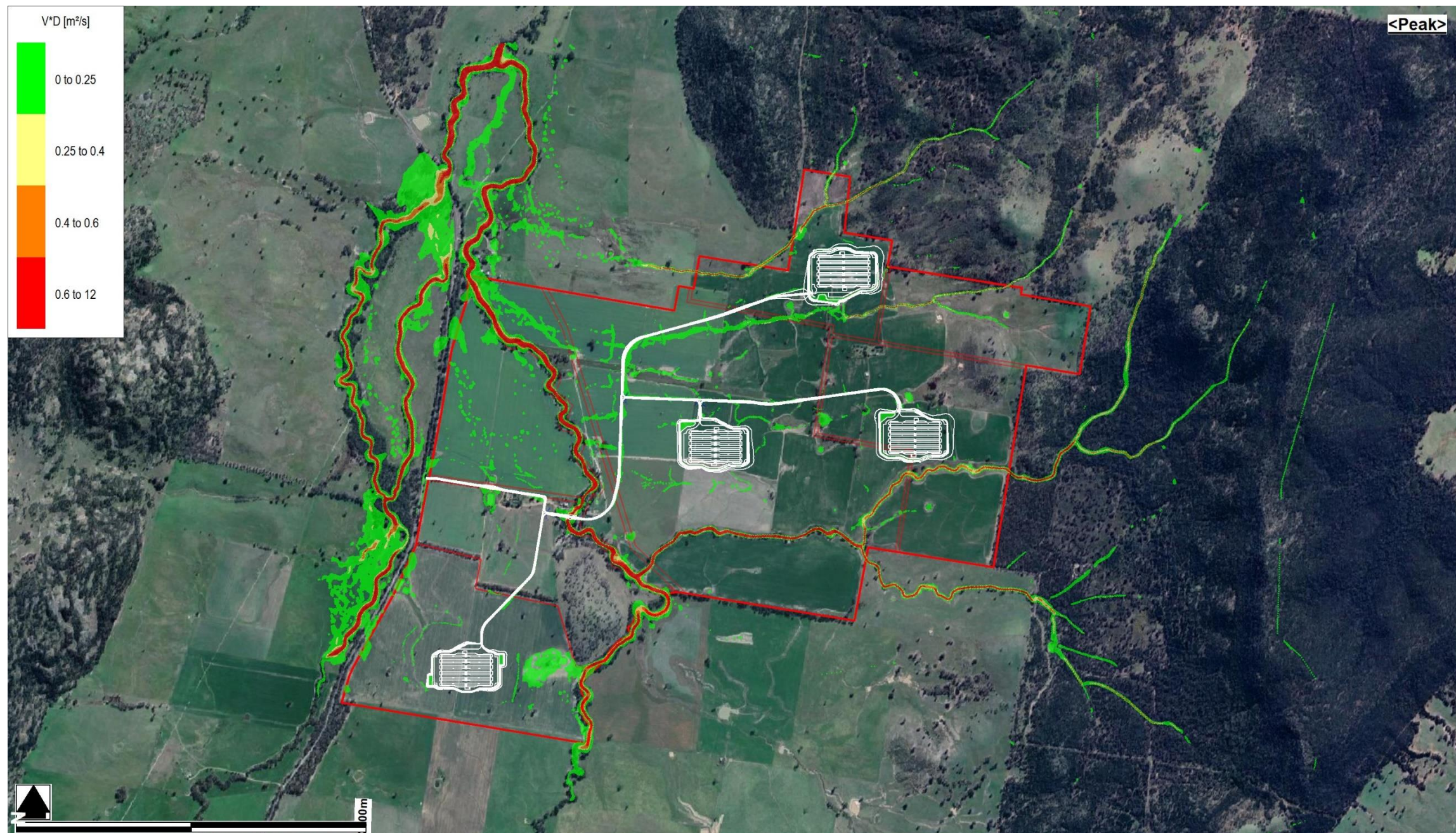


Figure D22 – 39% AEP Post-Development Peak Water Depth-Velocity Product (Envelope)



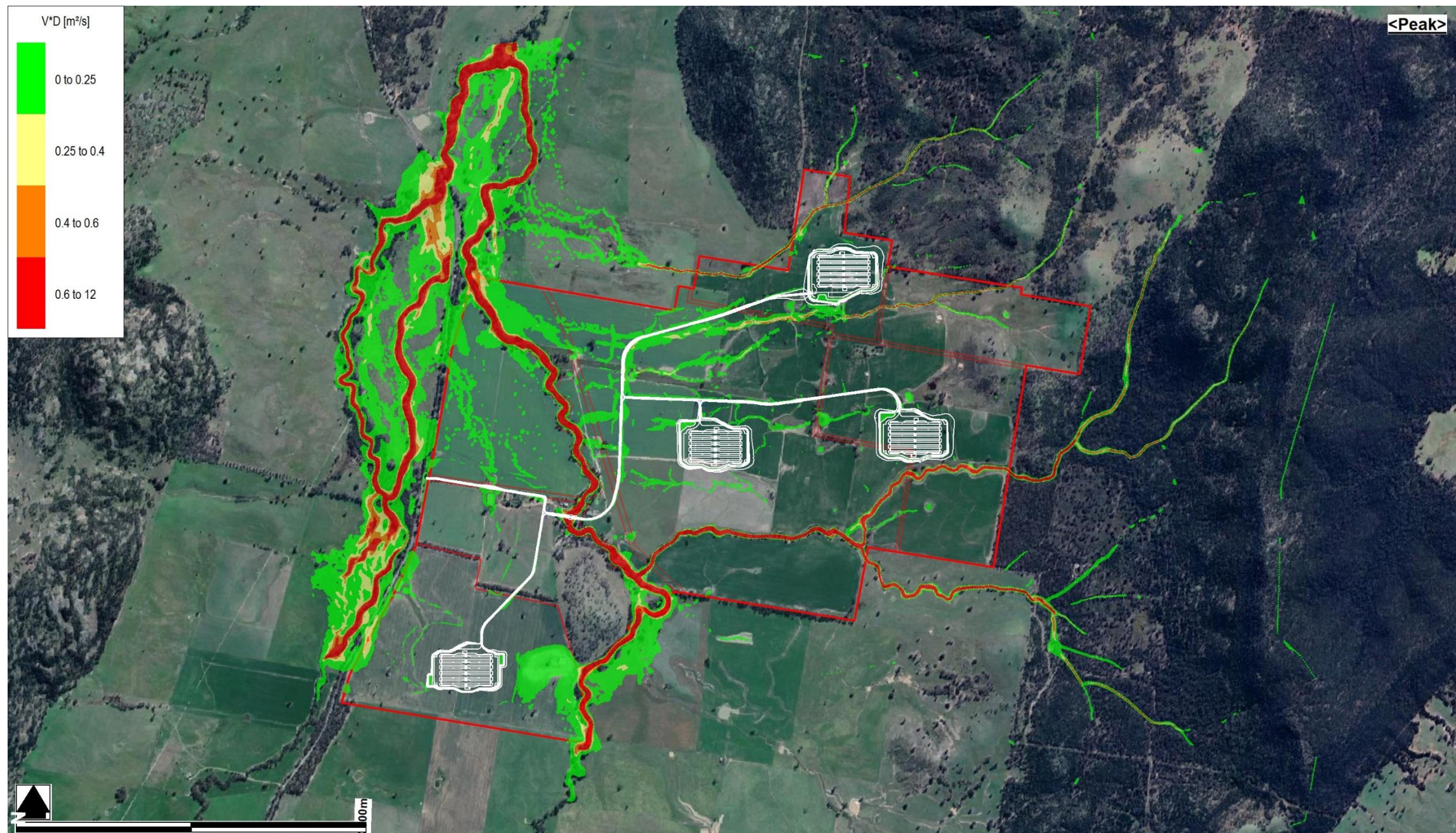


Figure D23 – 5% AEP Post-Development Peak Water Depth-Velocity Product (Envelope)



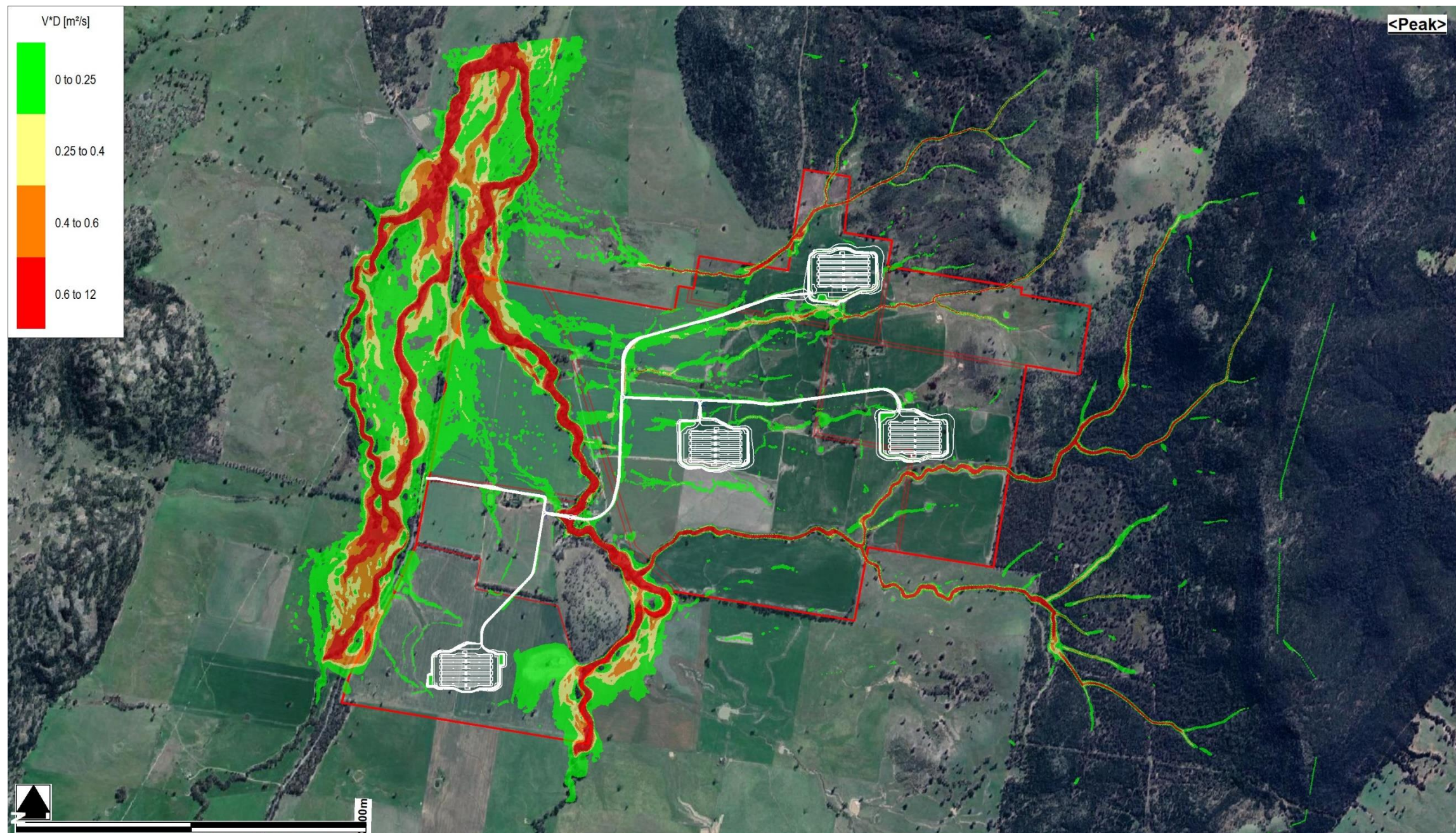


Figure D24 – 1% AEP Post-Development Peak Water Depth-Velocity Product (Envelope)



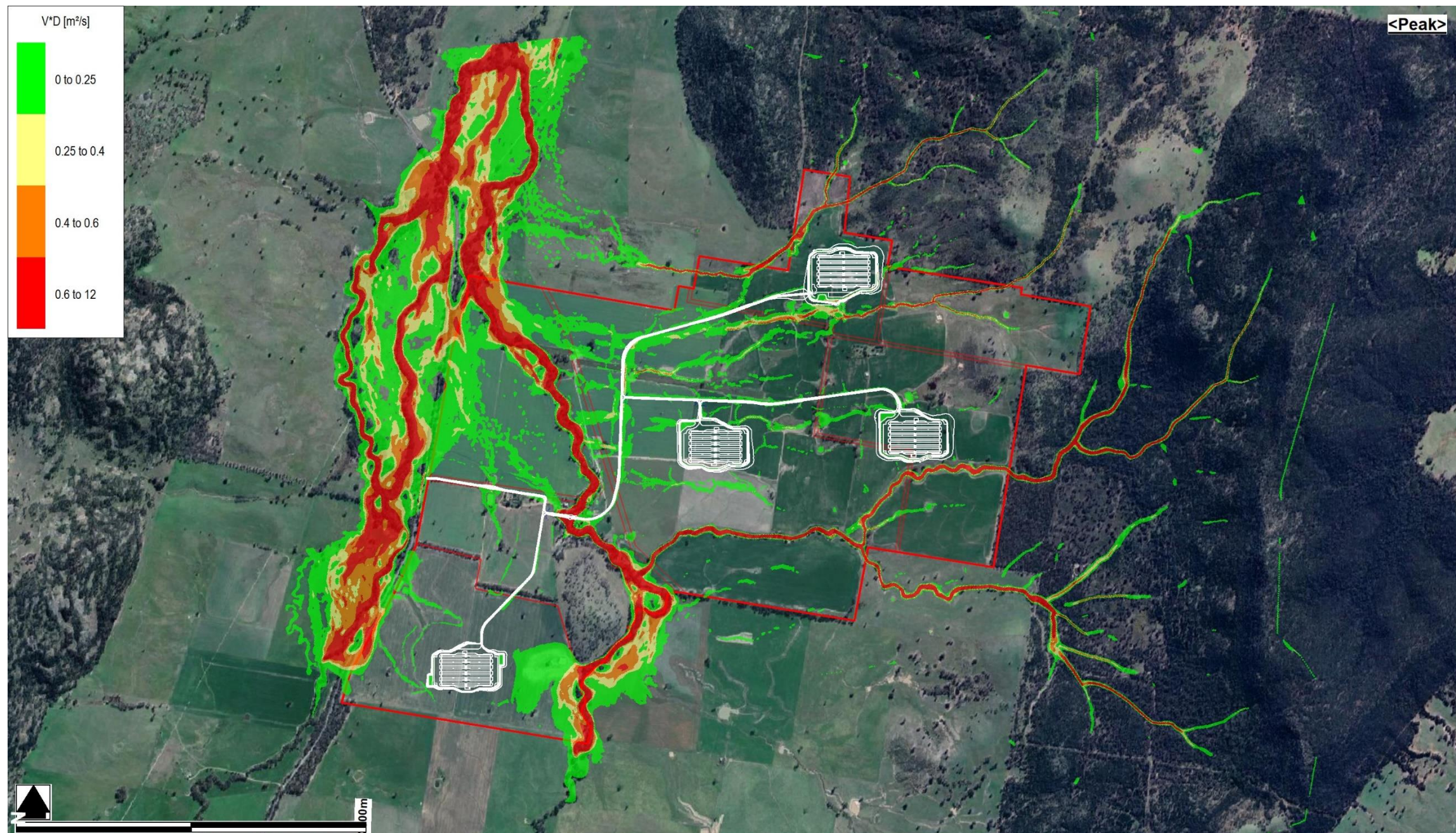


Figure D25 – 0.5% AEP Post-Development Peak Water Depth-Velocity Product (Envelope)



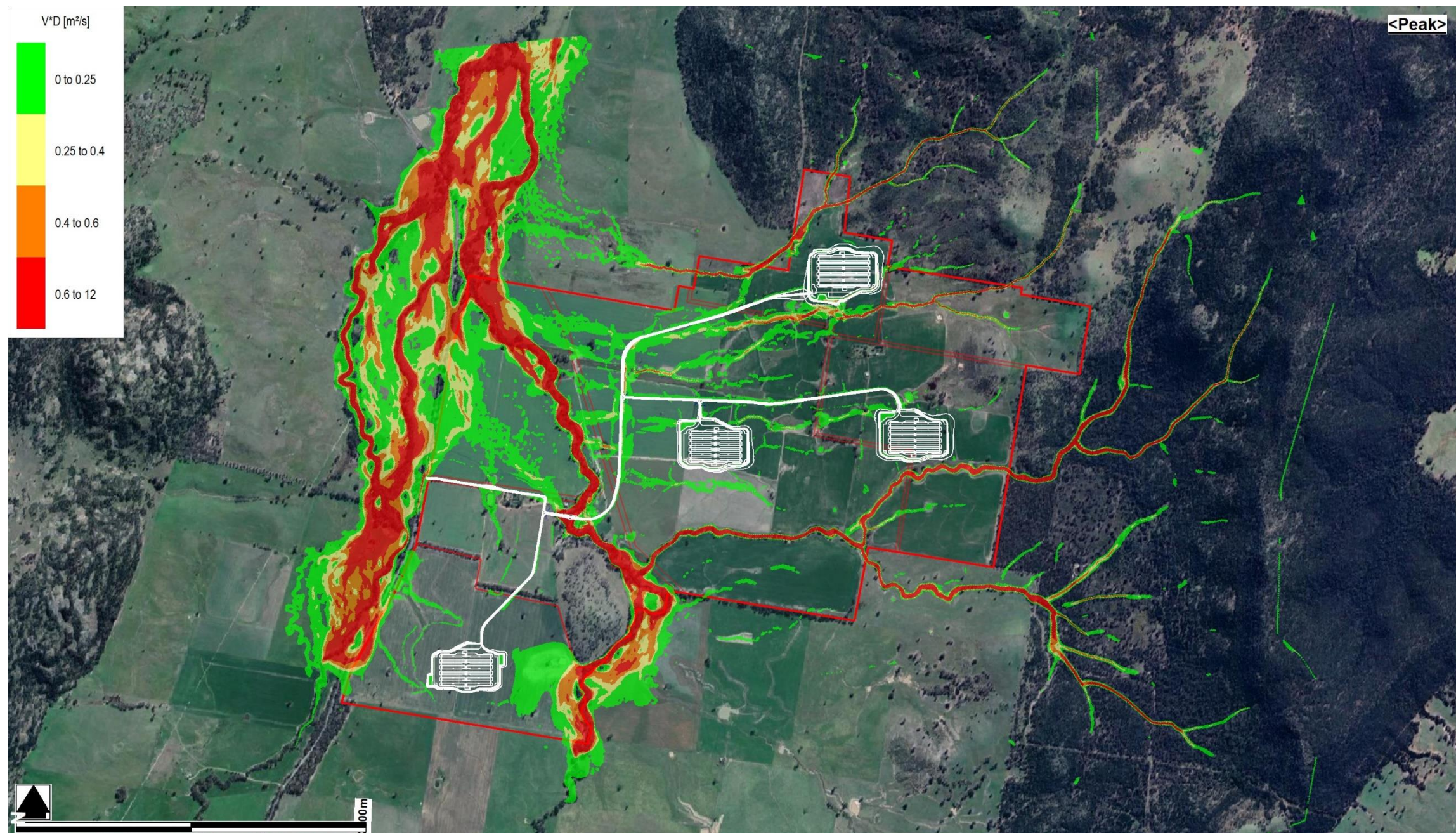


Figure D26 – 0.2% AEP Post-Development Peak Water Depth-Velocity Product (Envelope)



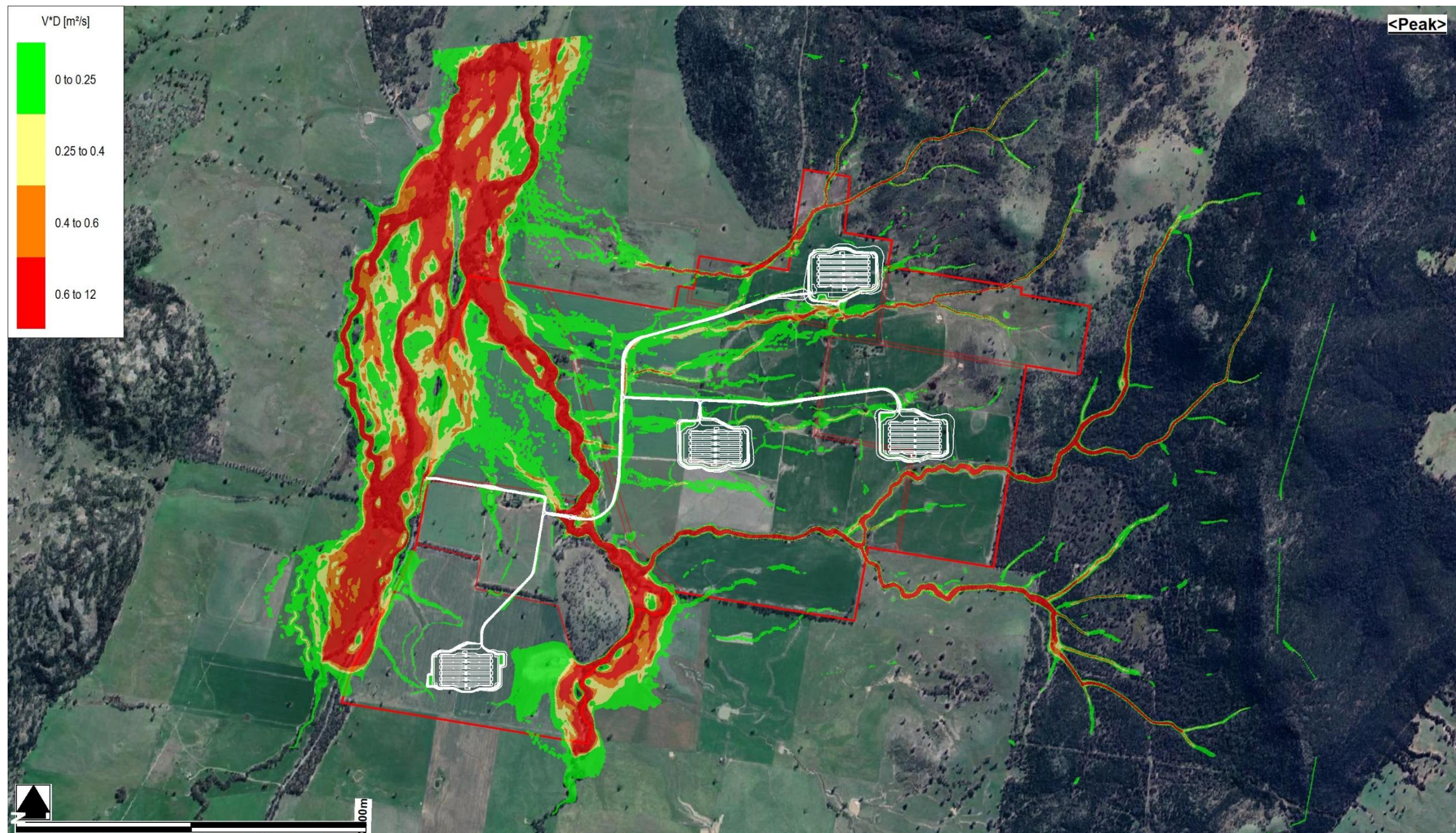


Figure D27 – 0.05% AEP Post-Development Peak Water Depth-Velocity Product (Envelope)



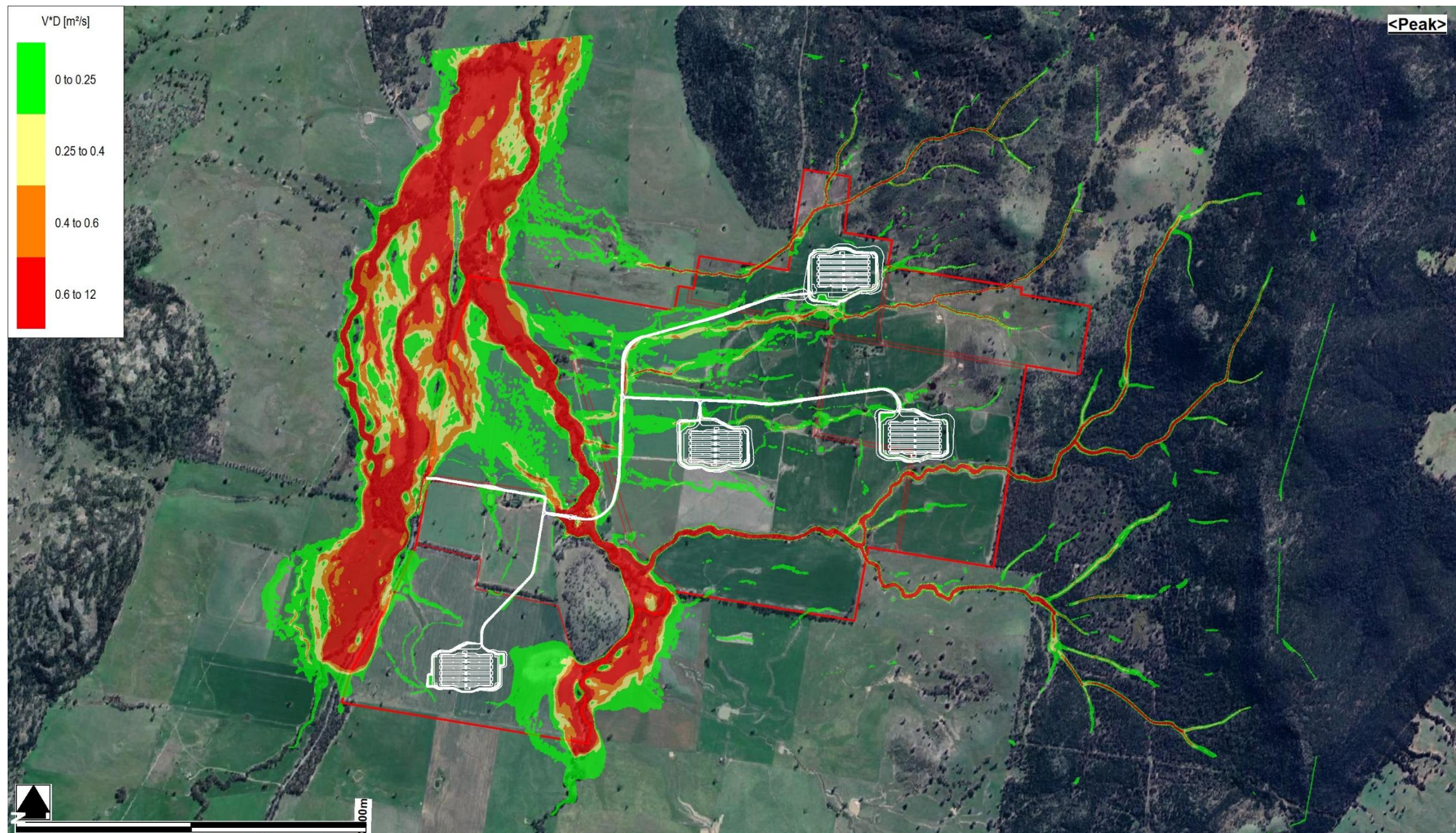


Figure D28 – 0.05% AEP Post-Development Peak Water Depth-Velocity Product (Envelope) – Climate Change Scenario (Extreme Event)



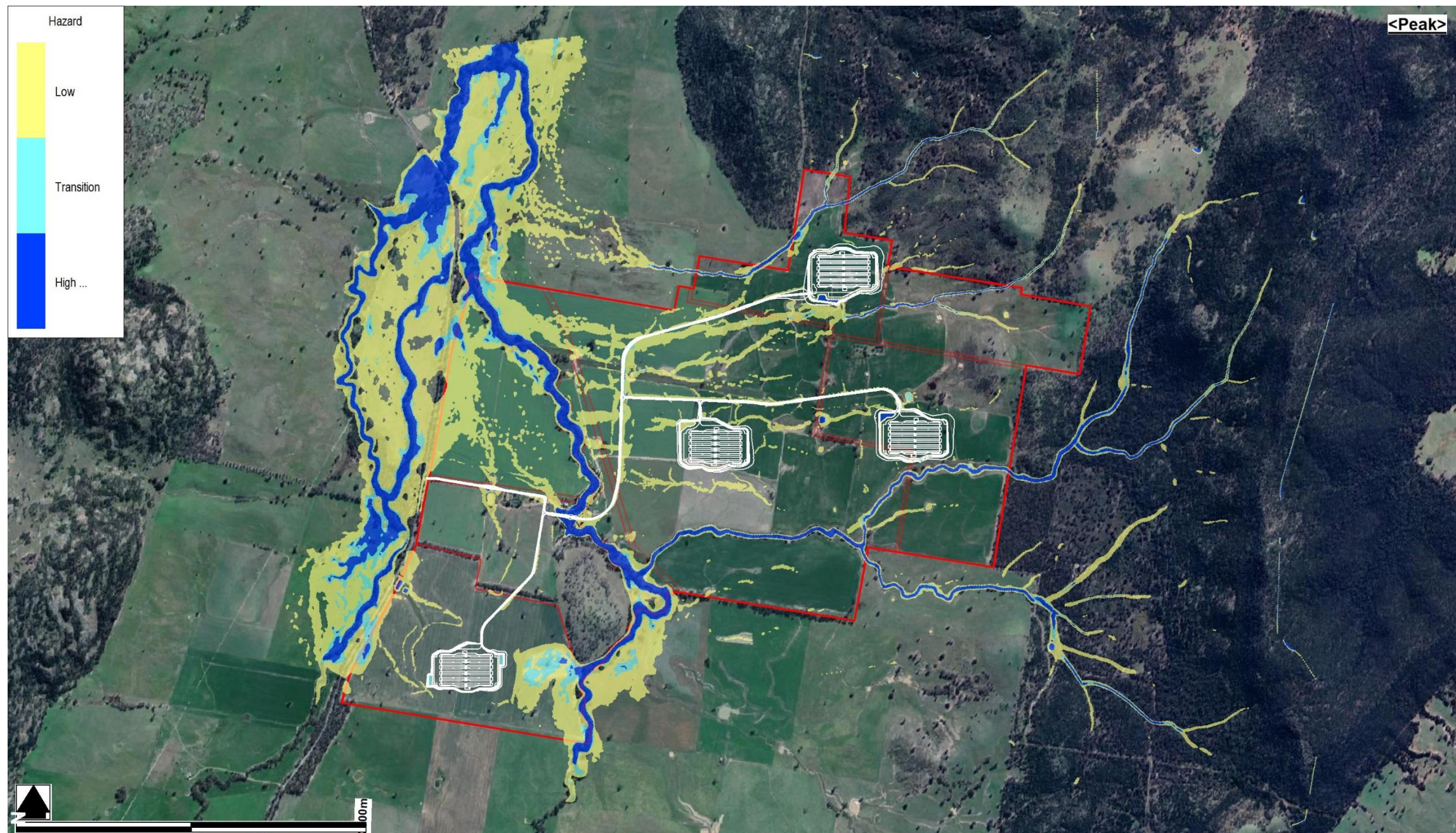


Figure D29 – 1% AEP Post-Development Peak Hazard (Envelope) – NSW Floodplain Development Manual 2005 Categorisation



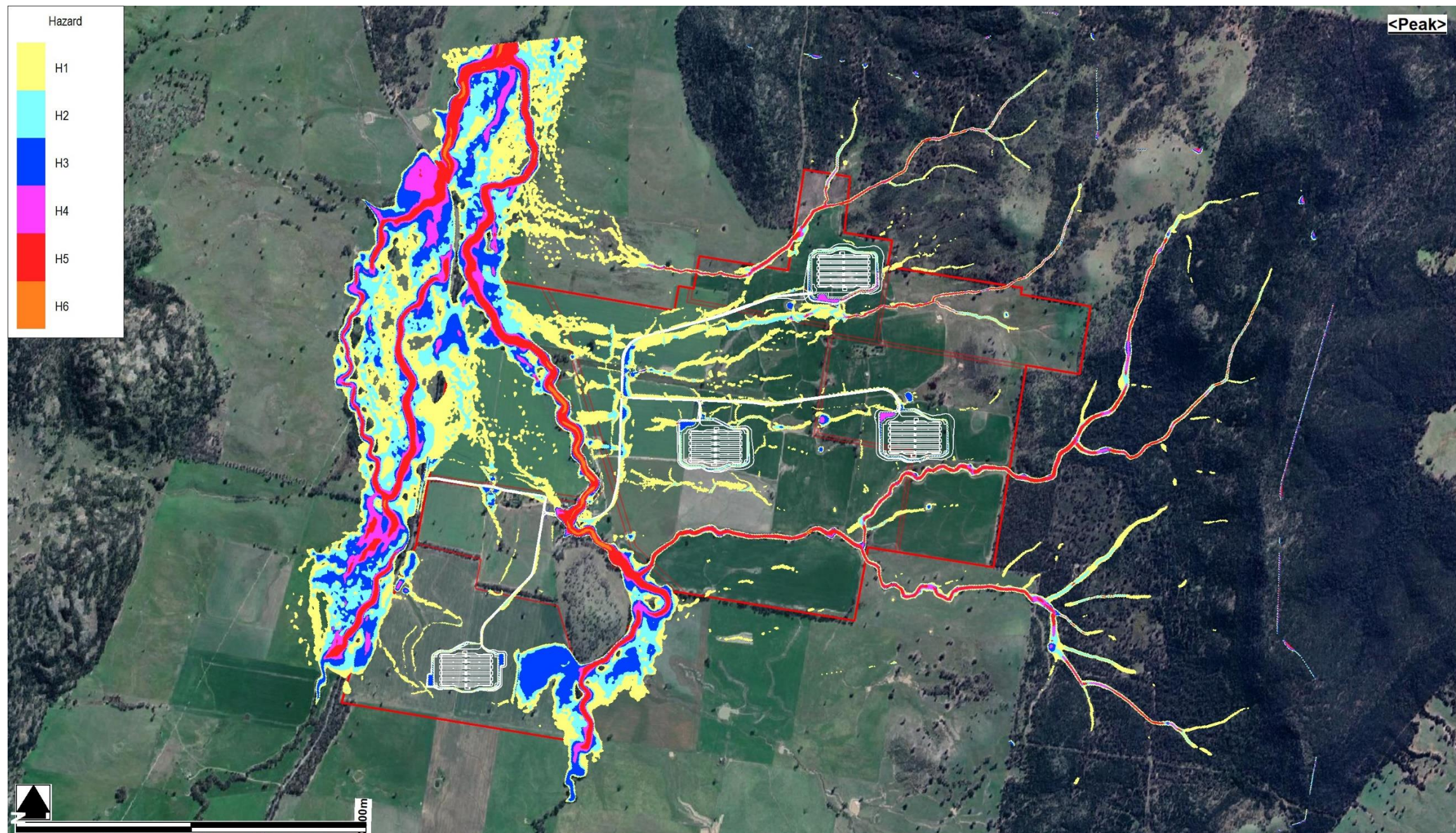


Figure D30 – 1% AEP Post-Development Peak Hazard (Envelope) – Australian Rainfall and Runoff 2019 Hazard Categorisation



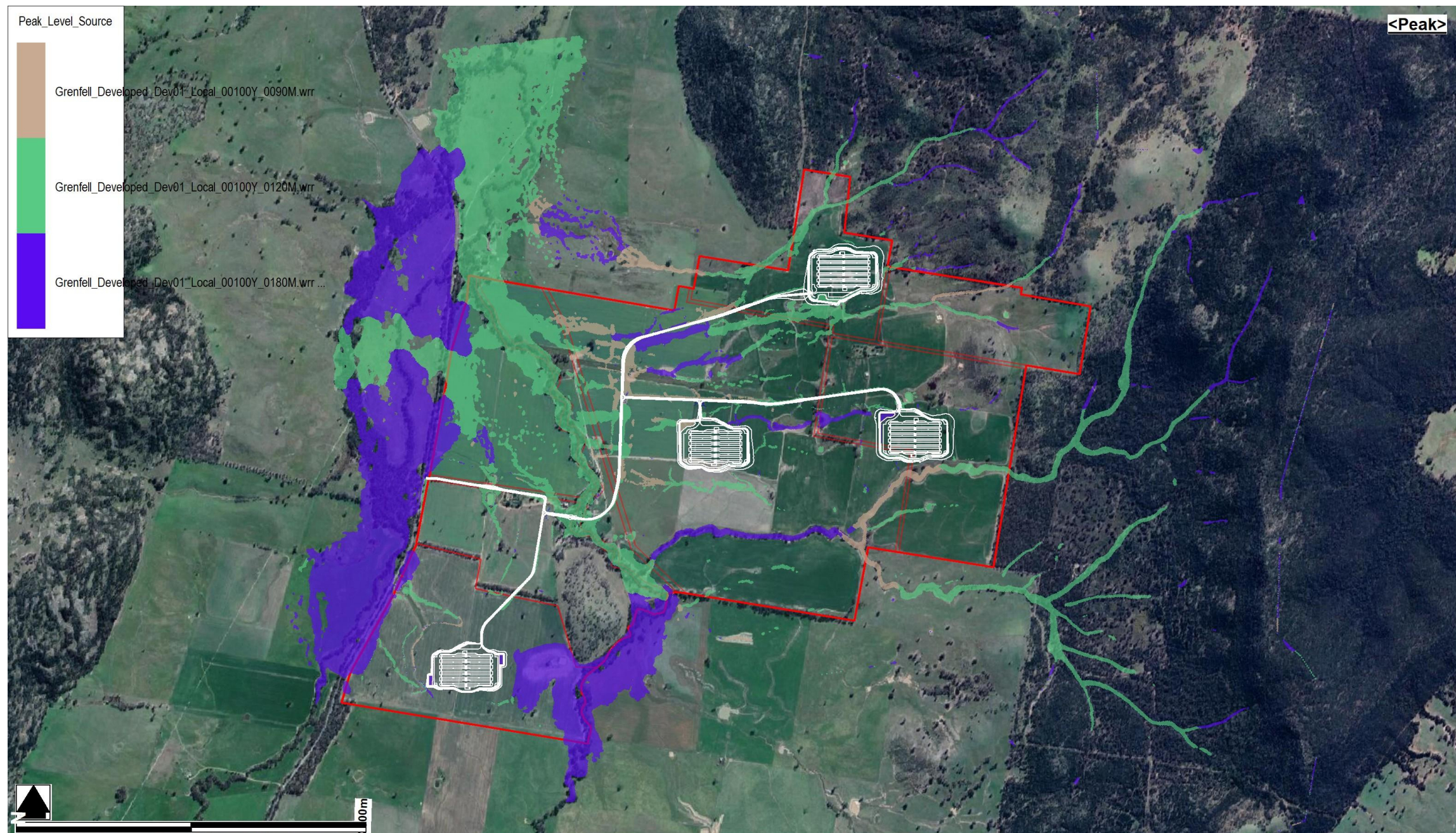


Figure D31 – 1% AEP Post-Development Critical Duration (Envelope)



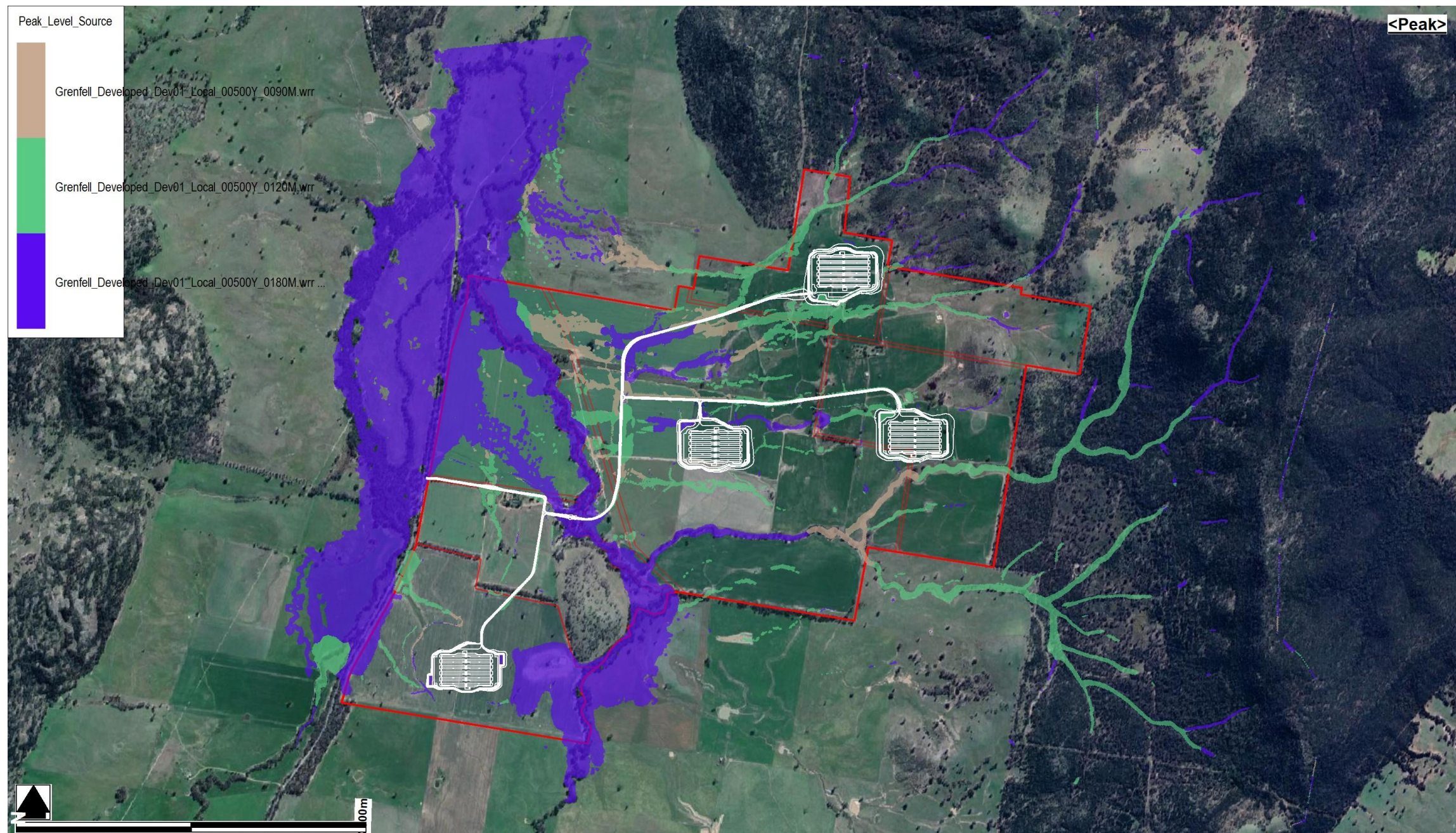


Figure D32 – 0.2% AEP Post-Development Critical Duration (Envelope)



Appendix E

Impact Flood Mapping
5% to 0.2% AEP Events

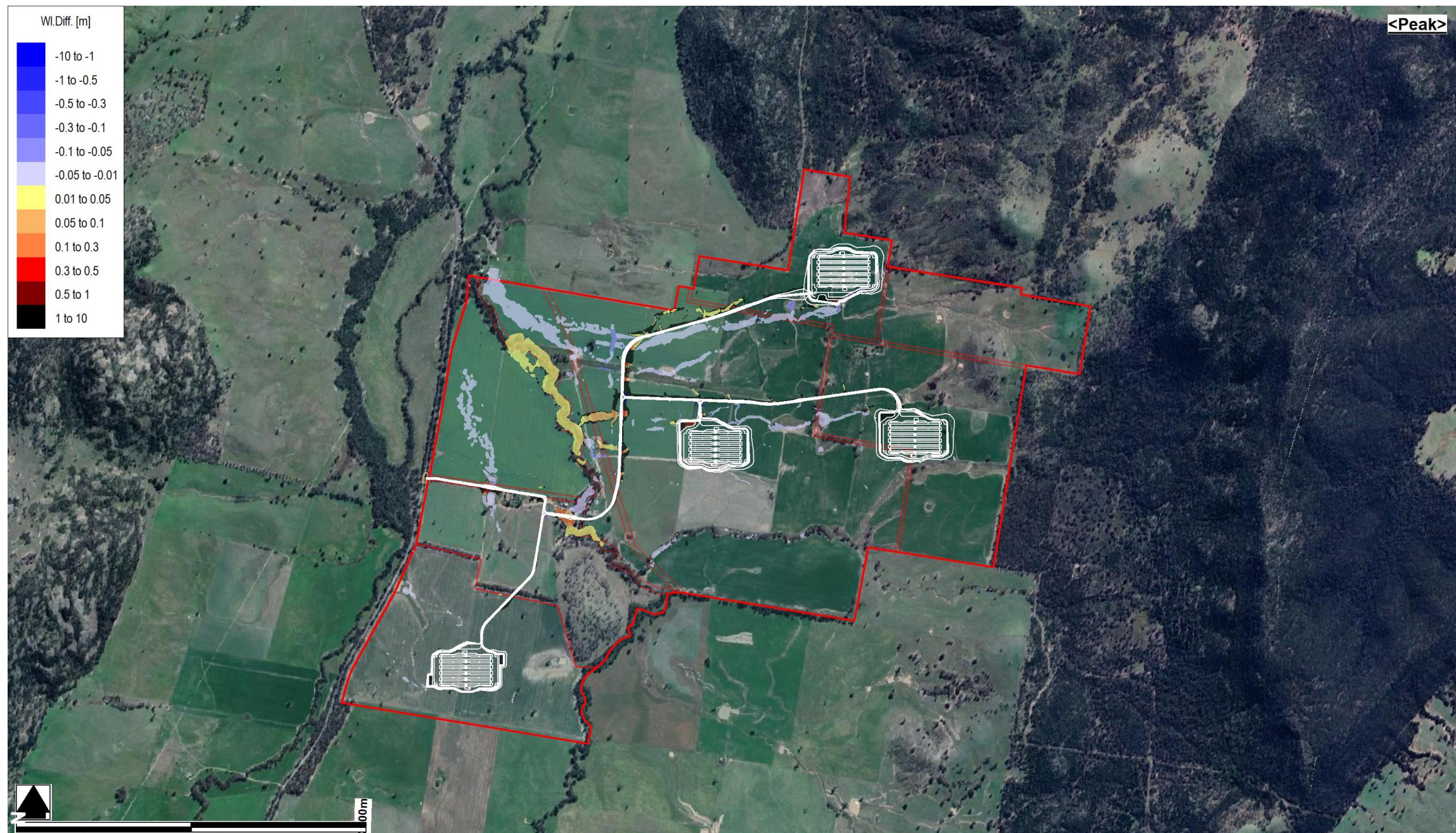


Figure E1 – 5% AEP Post-Development minus Pre-Development - Peak Water Level Impacts



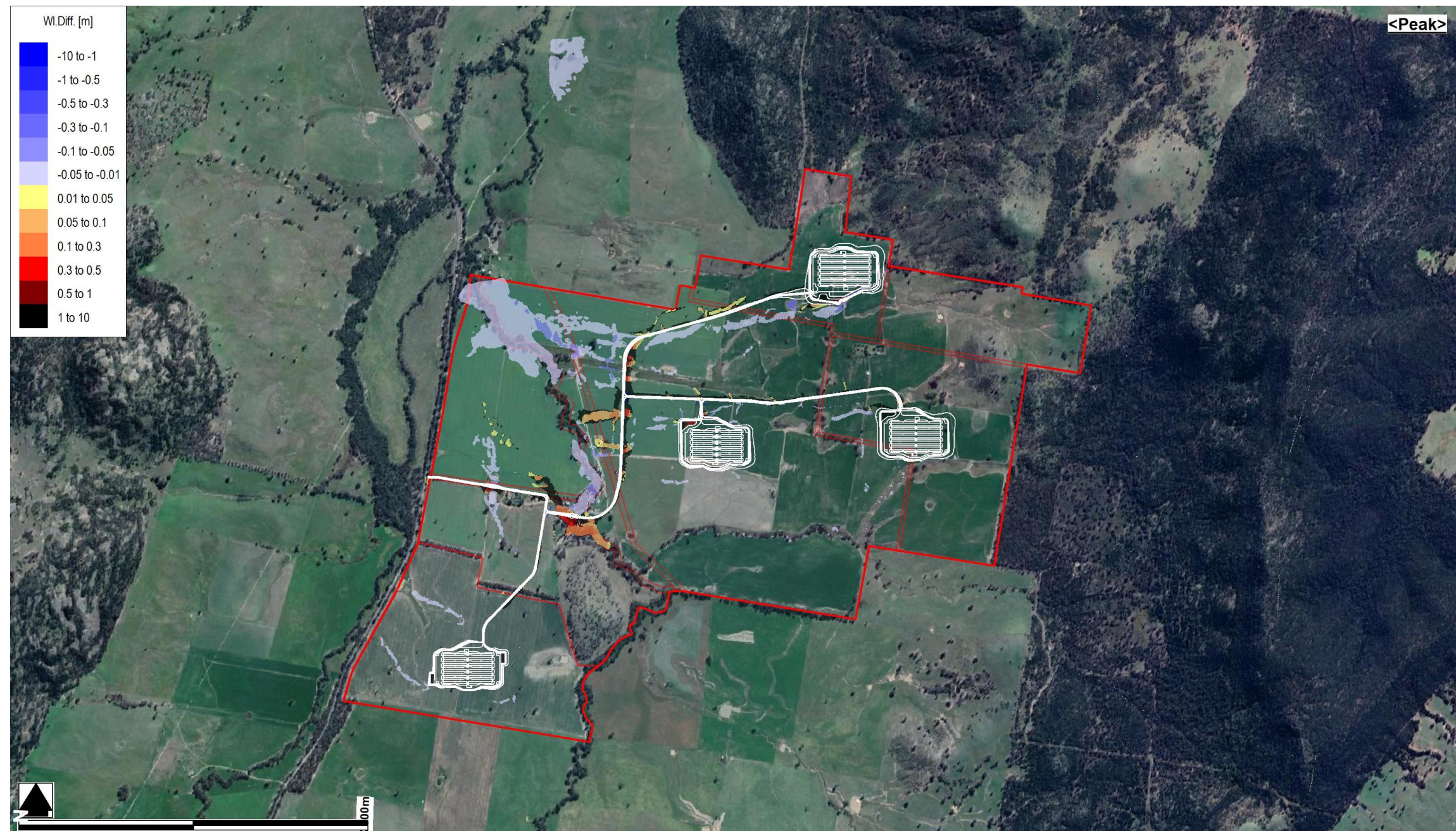


Figure E2 – 1% AEP Post-Development minus Pre-Development - Peak Water Level Impacts



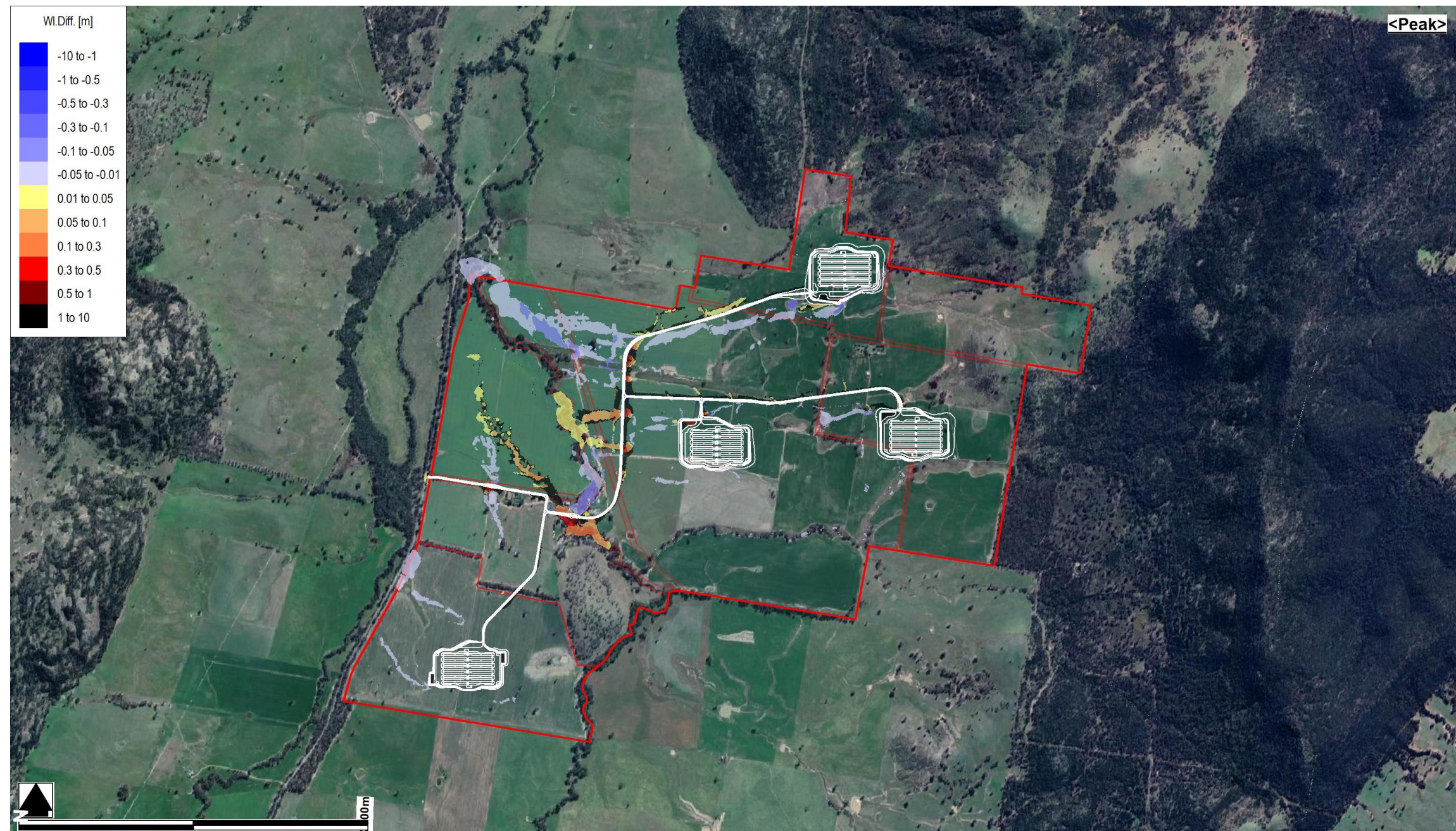


Figure E3 – 0.5% AEP Post-Development Peak Water Level (Envelope)



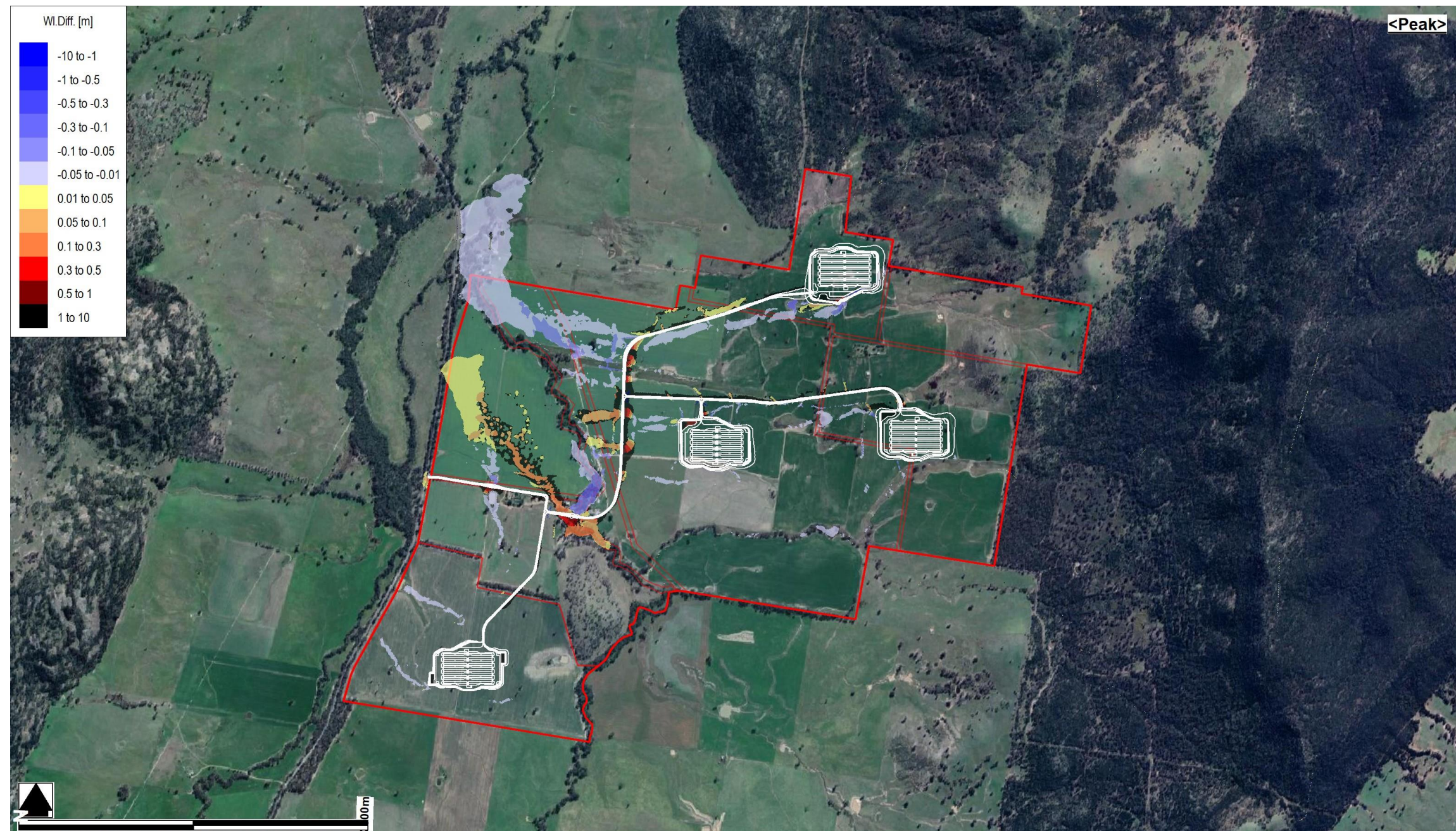


Figure E4 – 0.2% AEP Post-Development minus Pre-Development - Peak Water Level Impacts



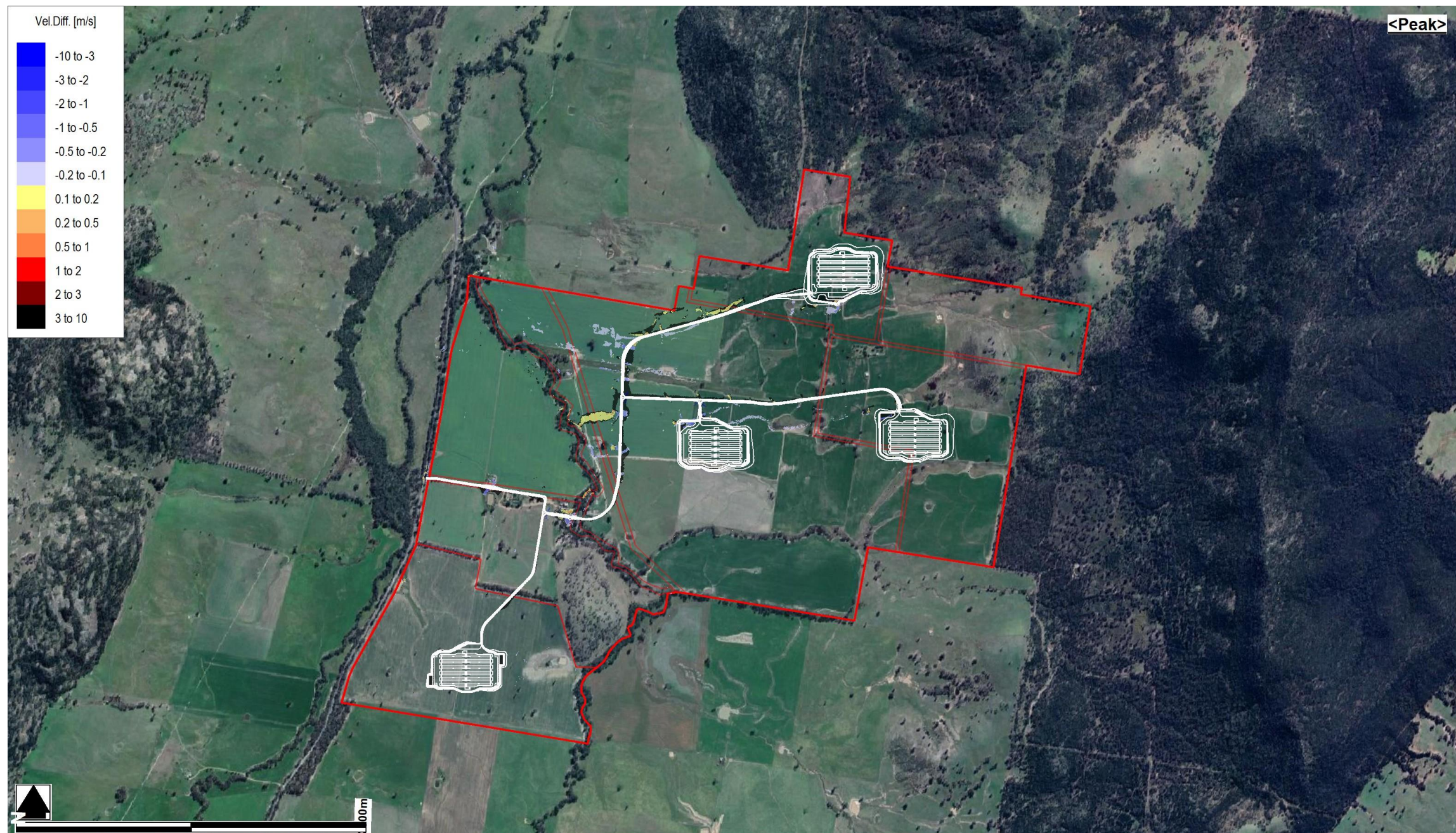


Figure E5 – 5% AEP Post-Development minus Pre-Development - Peak Velocity Impacts



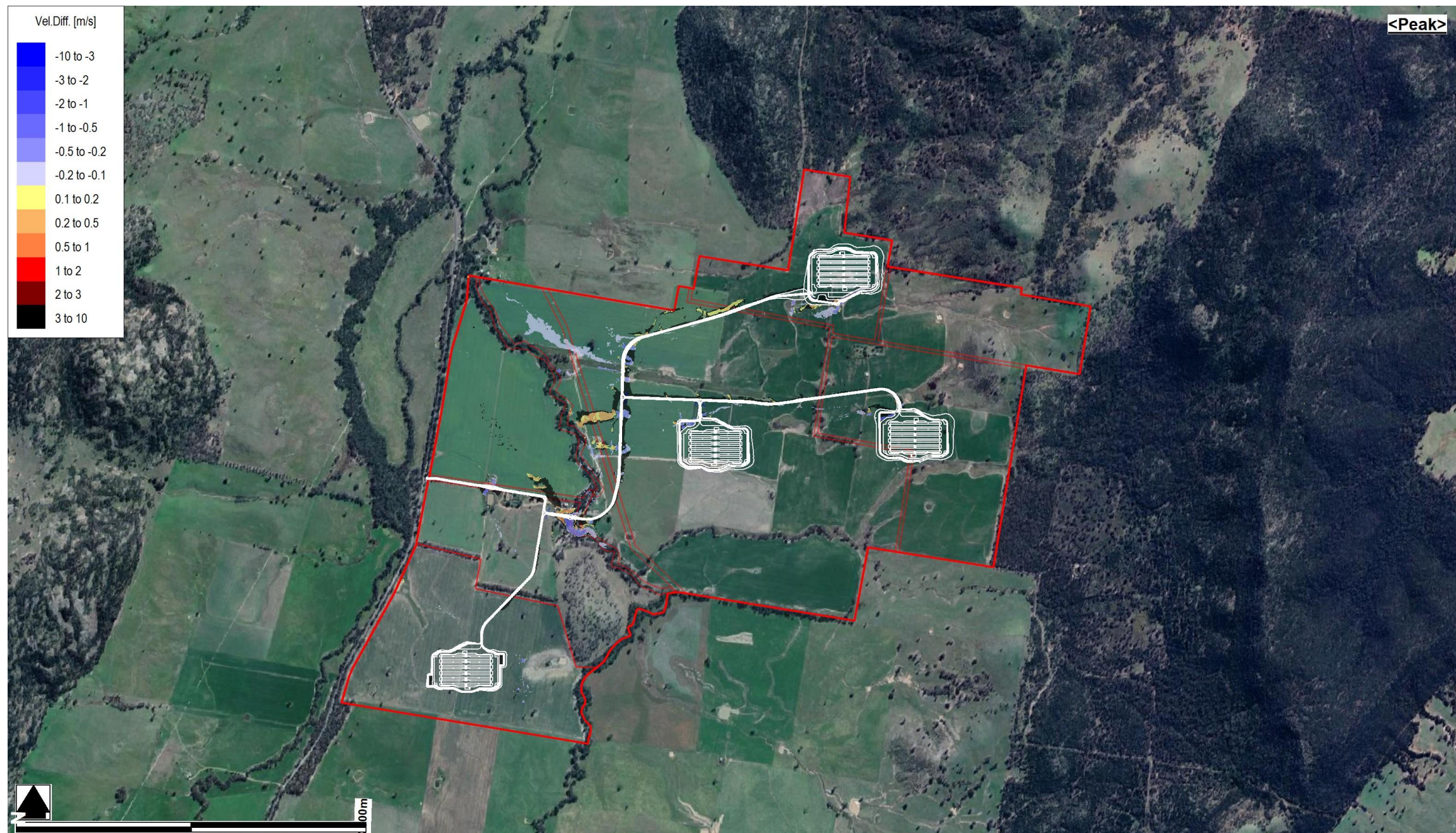


Figure E6 – 1% AEP Post-Development minus Pre-Development - Peak Velocity Impacts



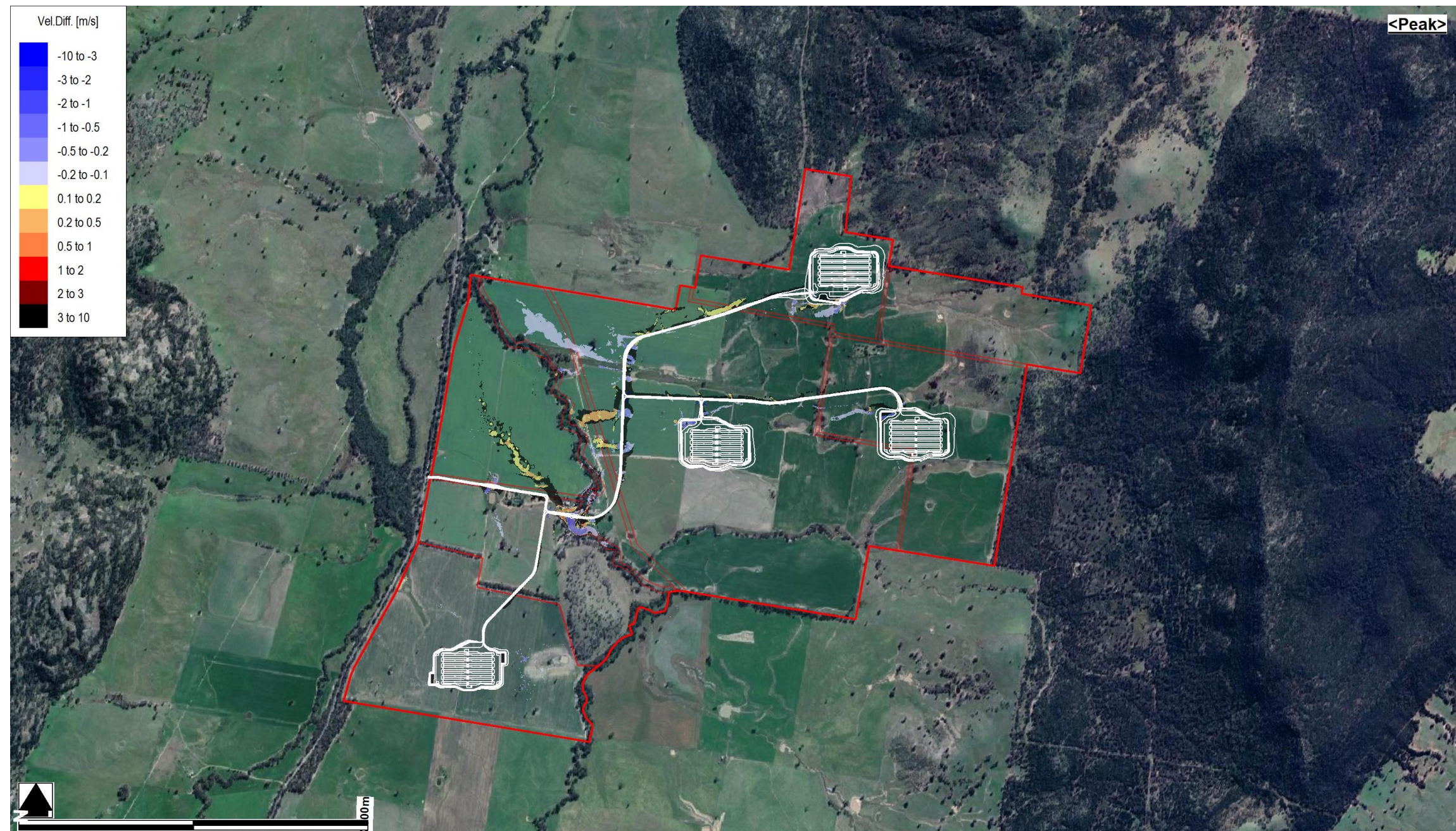


Figure E7 – 0.5% AEP Post-Development minus Pre-Development - Peak Velocity Impacts



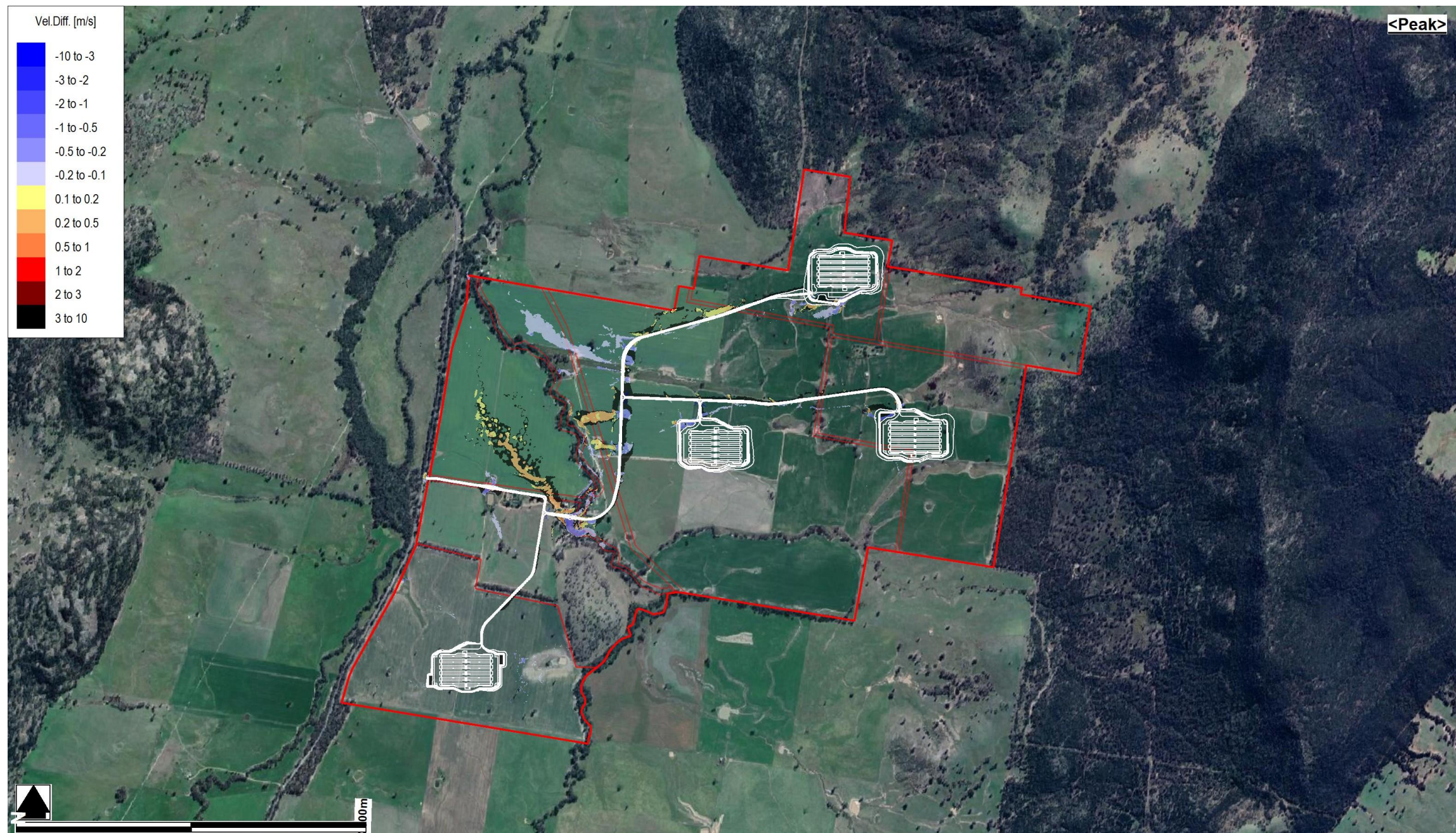


Figure E8 – 0.2% AEP Post-Development minus Pre-Development - Peak Velocity Impacts



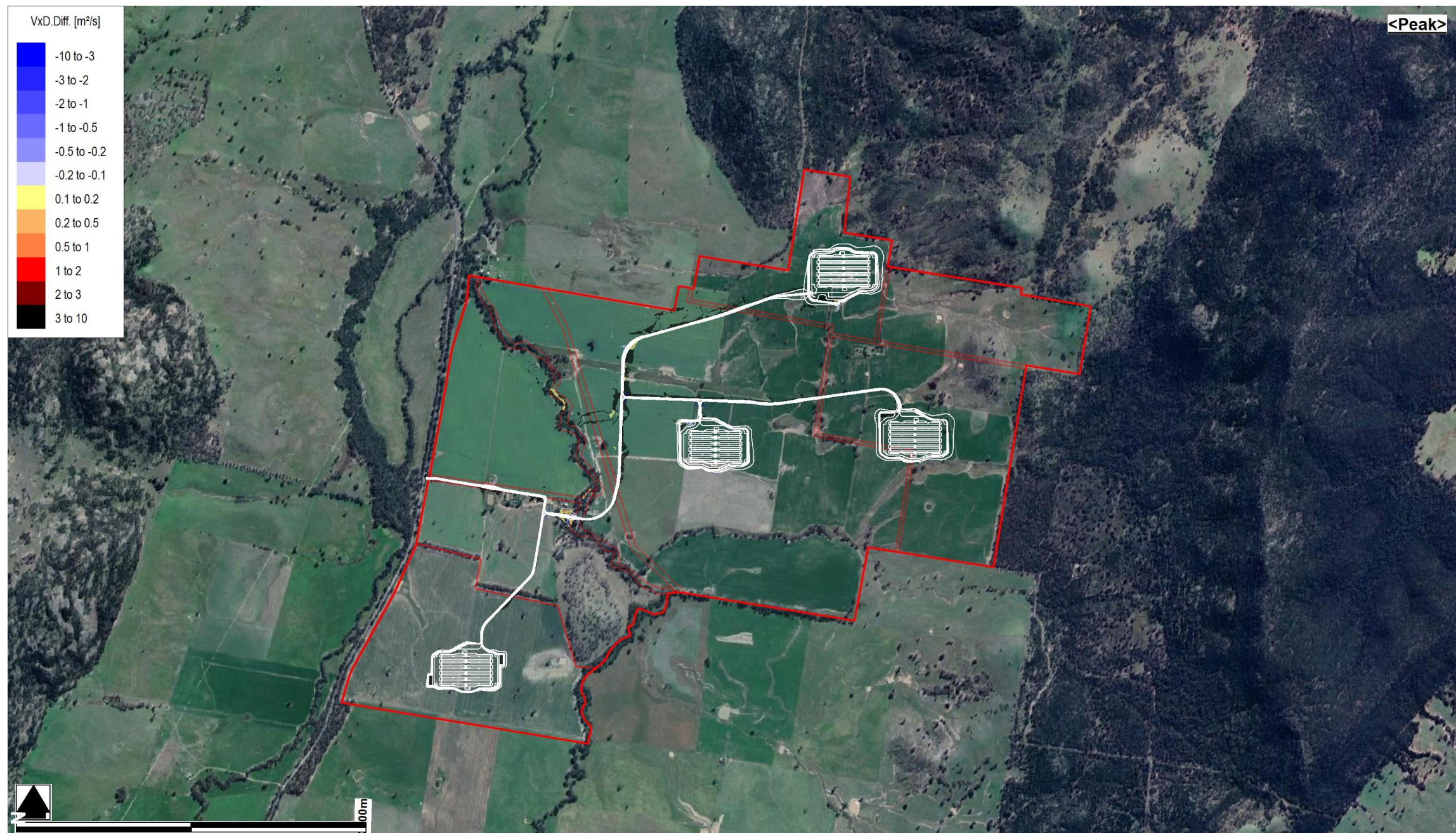


Figure E9 – 5% AEP Post-Development minus Pre-Development - Peak Depth-Velocity Product Impacts



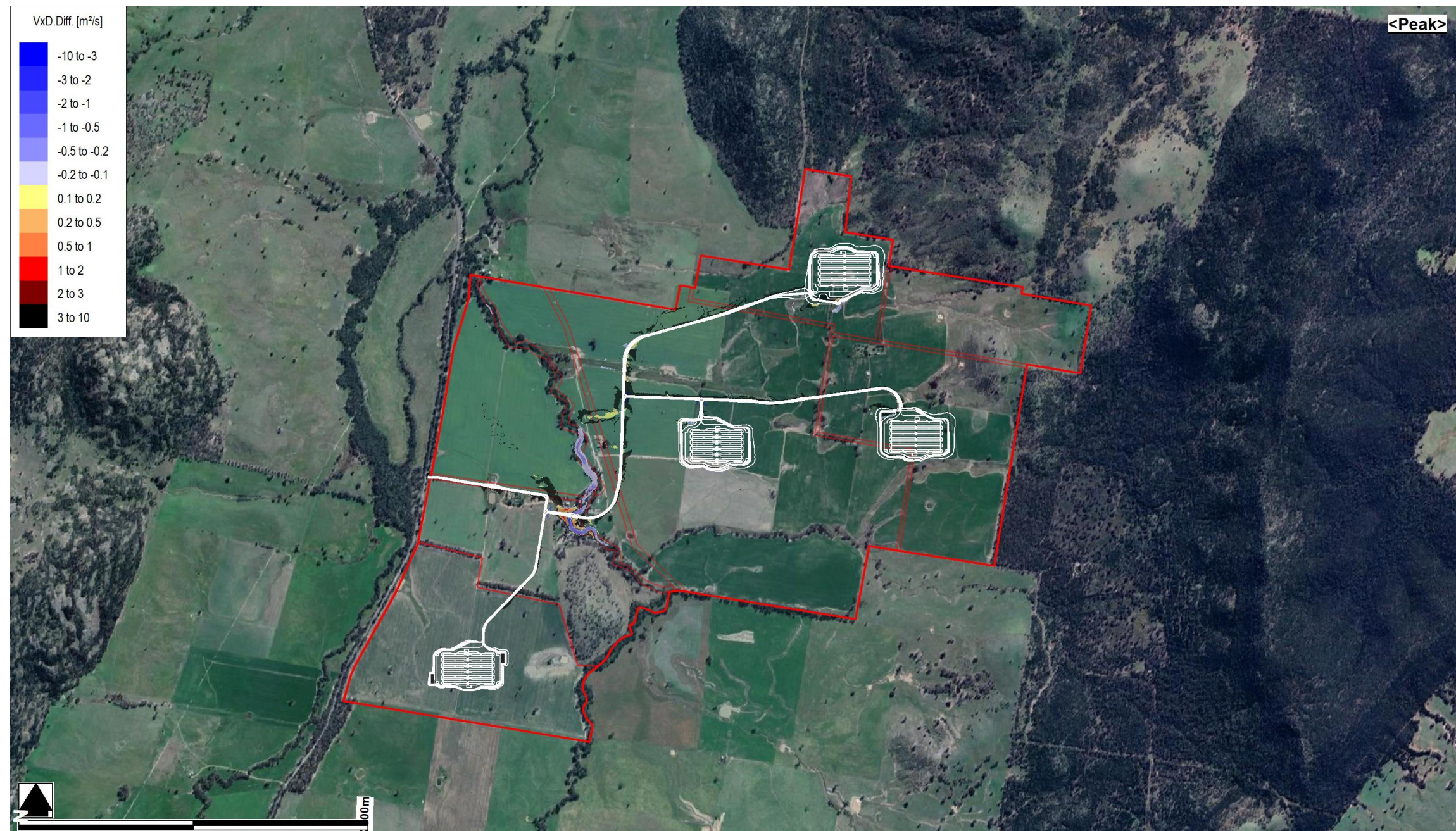


Figure E10 – 1% AEP Post-Development minus Pre-Development - Peak Depth-Velocity Product Impacts



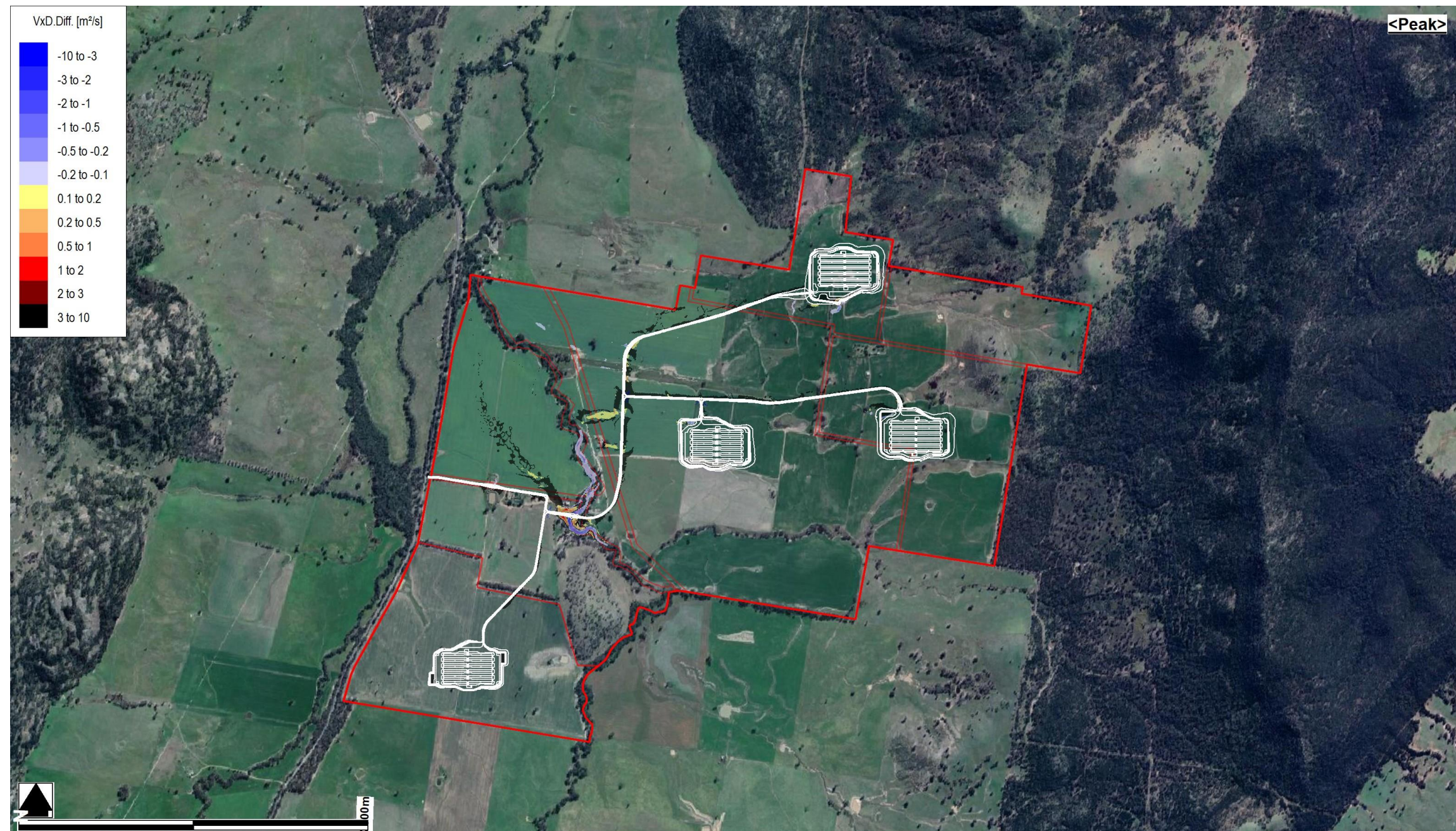


Figure E11 – 0.5% AEP Post-Development minus Pre-Development - Peak Depth-Velocity Product Impacts



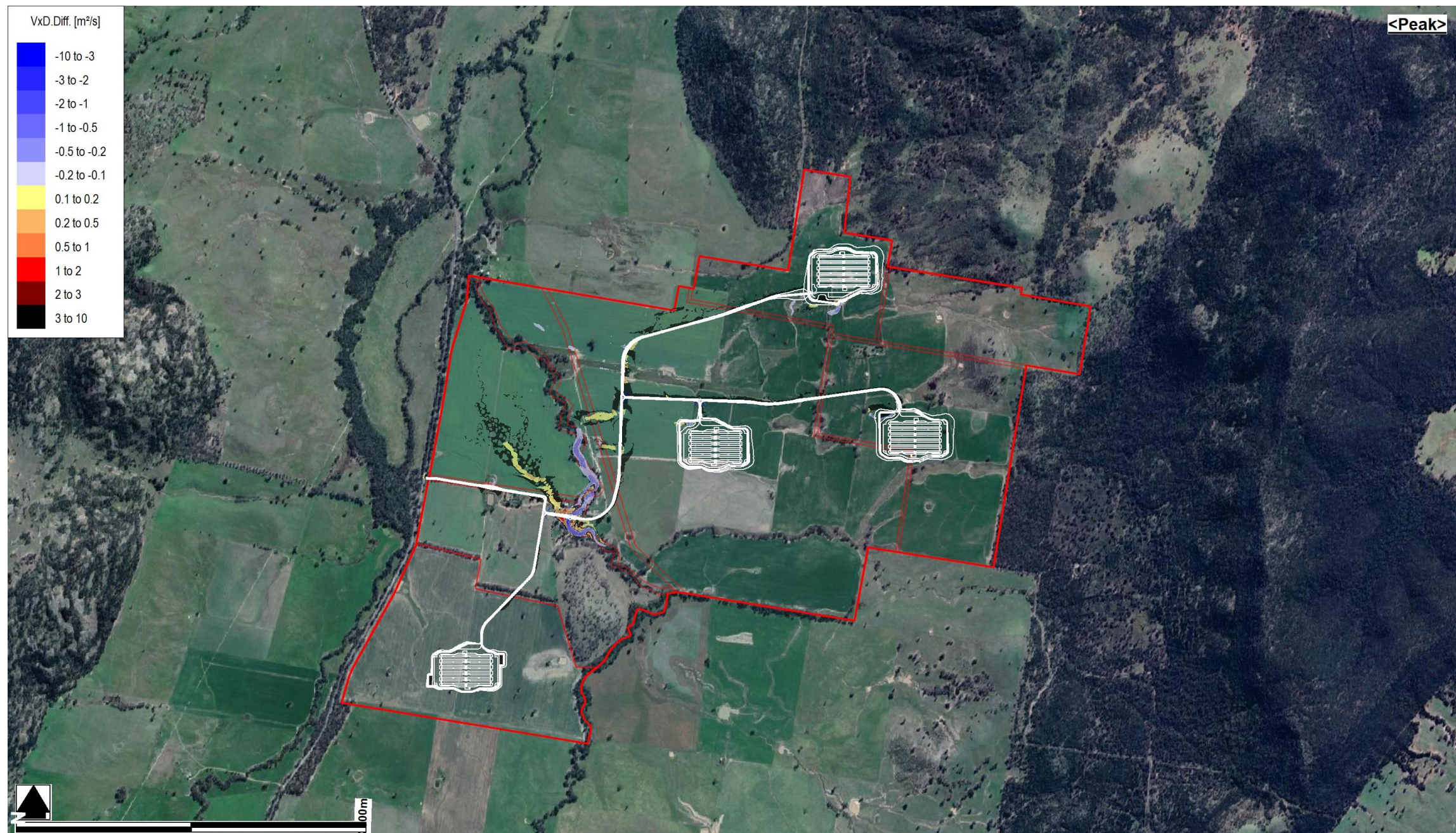


Figure E12 – 0.2% AEP Post-Development minus Pre-Development - Peak Depth-Velocity Product Impacts



Appendix F

Sensitivity Analysis Flood Mapping
(100% Blockage – 1% AEP Event)

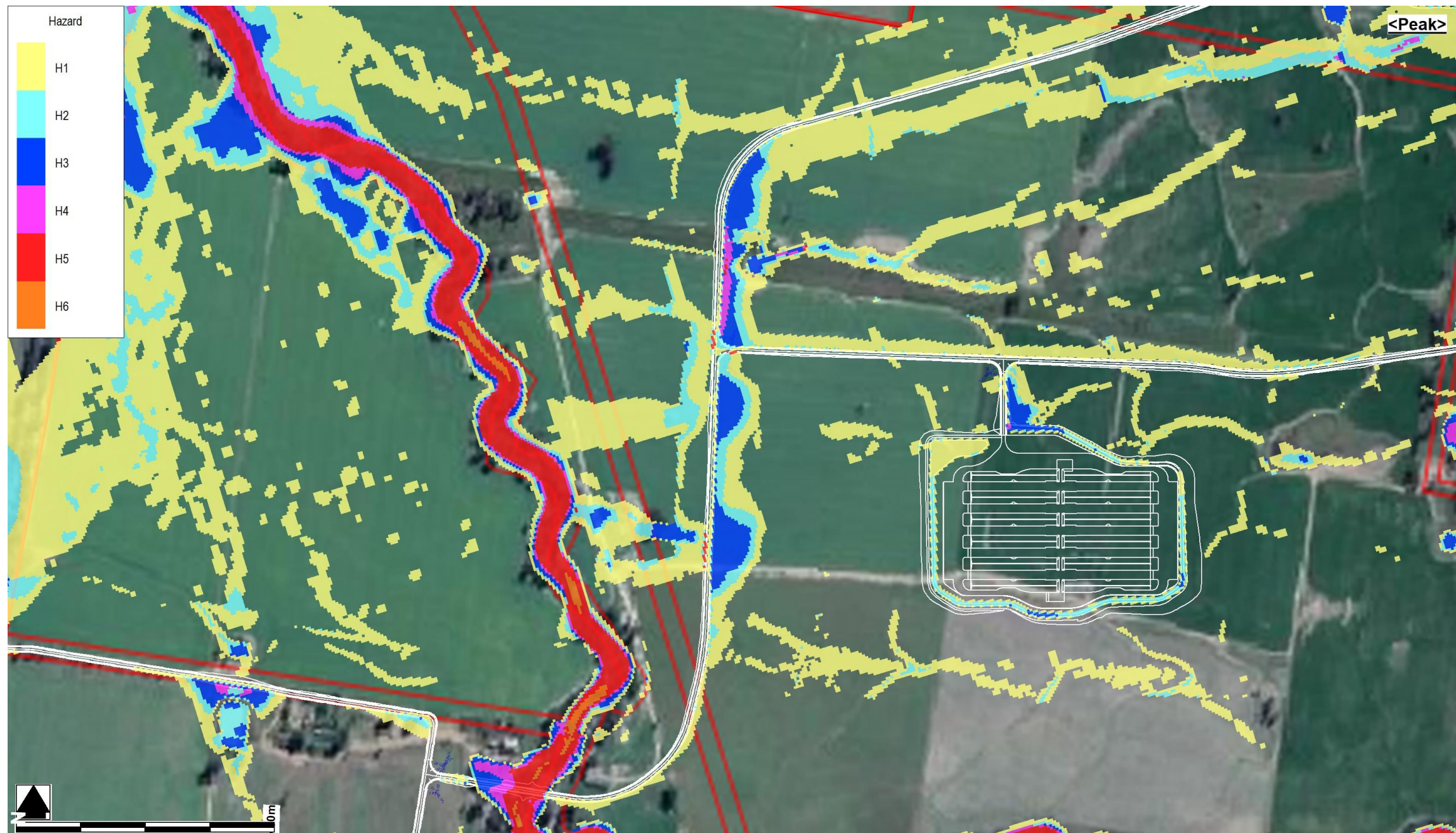


Figure F1 – 1% AEP Post-Development – ARR2019 Hazard Categorisation – Sensitivity Analysis (100% Design Culvert Blockage)





Figure F2 – 1% AEP Post-Development - Peak Water Depth-Velocity Product – Sensitivity Analysis (100% Design Culvert Blockage)

