Dunedoo Solar Farm Flood Impact Assessment

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Synopsis: Flood Impact Assessment for the proposed Dunedoo Solar Farm. This report details the model development, establishment of existing flood conditions and the assessment of flood risk associated with the proposed development. The potential flood impacts of the proposed development are also assessed.

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1 Introduction

1.1 Background

BMT was engaged by Ecotechnology Australia Pty Ltd to undertake a flood risk assessment, as part of a broader planning assessment for a proposed solar farm development at Dunedoo, NSW. The proposed site for the Dunedoo Solar Farm is near the floodplain of the Talbragar River. This report documents the assessment of flood risk associated with the proposed solar farm in relation to mainstream flooding from the Talbragar River.

1.2 Study Area

The study site is situated to the north of Dunedoo, NSW on the right floodplain of the Talbragar River. The southern section of the site is located within the active floodplain of the Talbragar River, whereas the northern section (within which the Dunedoo Solar Farm is proposed) is located on the fringe of the floodplain. The study site locality within the context of Dunedoo and the Talbragar River is presented in Figure 1-1.

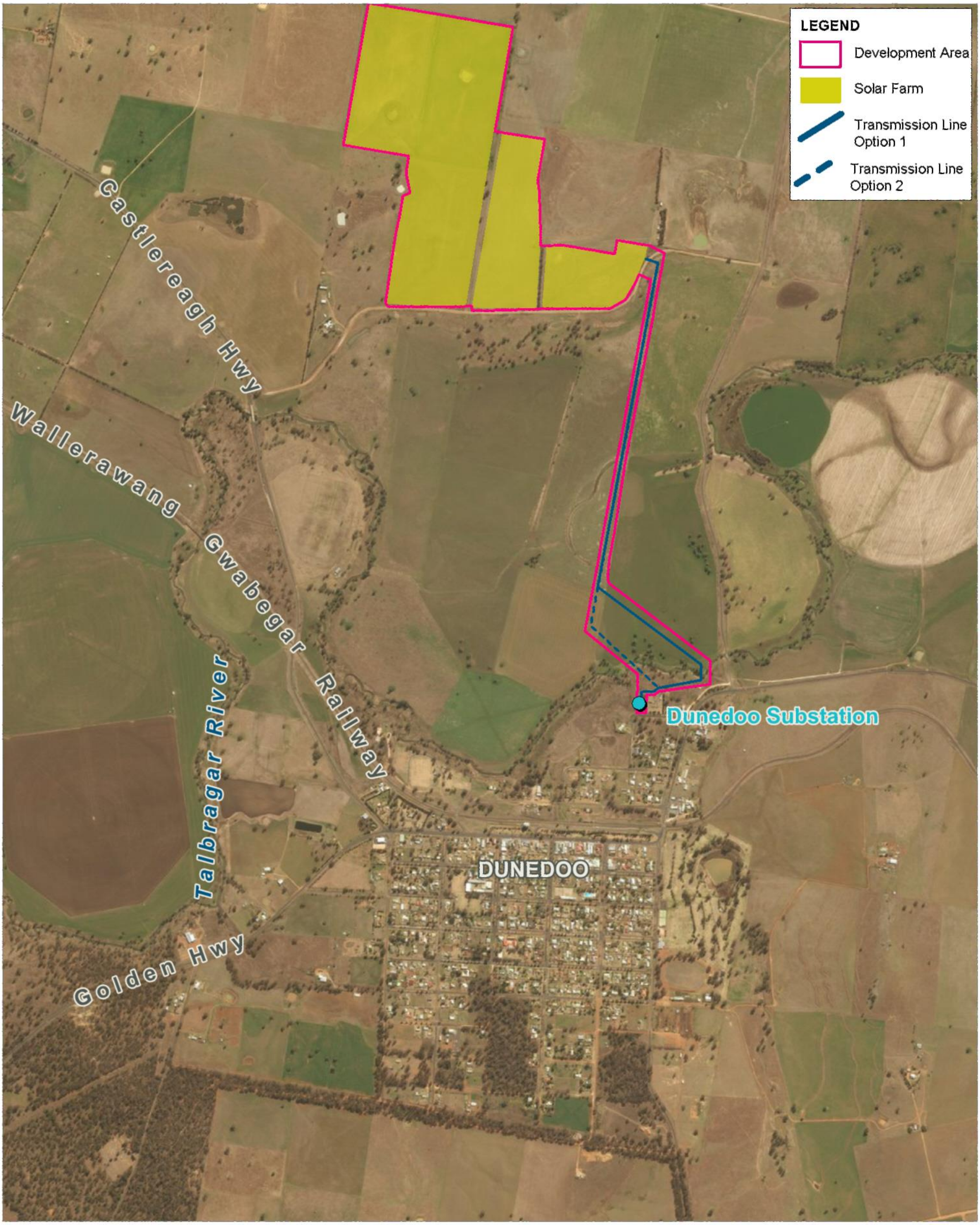
The Talbragar River drains the western slopes of the Great Dividing Range – its headwaters being situated in the Coolah Tops – and discharges to the larger Macquarie River, downstream at Dubbo. The Macquarie River forms part of the broader Murray-Darling basin. The contributing catchment area of the Talbragar River at Dunedoo is some 2000 km^2, as shown in Figure 1-2. The nearest river gauging station is located some 40 km downstream at Elong Elong.

1.3 Report Purpose

This report documents the flood risk assessment in relation to the proposed Dunedoo Solar Farm. The flooding assessment incudes consideration of the following:

- flood frequency analysis at the Elong Elong gauge to derive design flood flows
- analysis of recorded flood events to determine typical durations of flood inundation
- development of a TUFLOW model for hydraulic assessment

simulation of design flood conditions to establish the site flood risk.



Title:

Study Site Locality

Figure: 1-1

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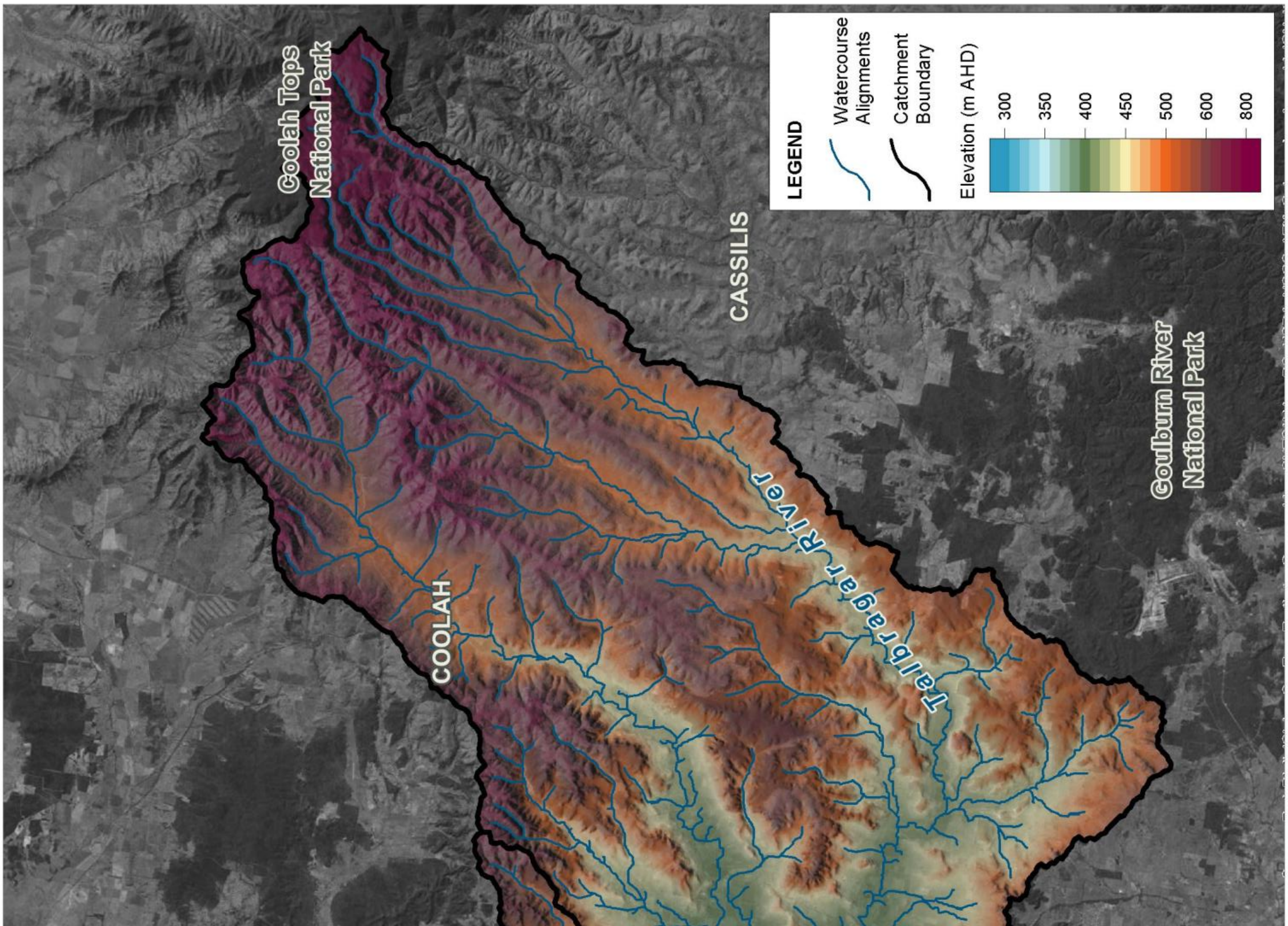

Title:
Catchment Topography and Gauge Location

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1-2

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2 Flood Frequency Analysis

The Elong Elong water level gauge is located some 40 km downstream of Dunedoo and has been in continuous operation since 1971. With 46 years of record available, it provides a suitable dataset from which to undertake a flood frequency analysis.

Frequency analyses are best undertaken using an annual series of maxima flows (AMAX). To derive the AMAX series for the analysis the peak water level recorded in each calendar year was converted to an approximate flow rate. The gauging site has rating curves available that represent the relationship between gauge heights and flows. However, these rating curves are often unreliable above the level of the maximum gauged flow. Therefore, a hydraulic analysis was undertaken to derive an appropriate rating curve for the site.

Surveyed channel (and floodplain) cross-section data is available at Elong Elong and was used to calculate cross-sectional flow areas at various gauge heights. Using a range of suitable estimates of hydraulic gradient and Manning's 'n' roughness values, synthetic rating curves for the gauging site can be readily generated. The gauged flow data (spot gaugings, independent of the continuously recorded water level) was used to calibrate an appropriate rating curve, which adopted a hydraulic gradient of 0.0015 and a Manning's 'n' roughness value of 0.04. The resultant rating curve is presented in Figure 2-1.

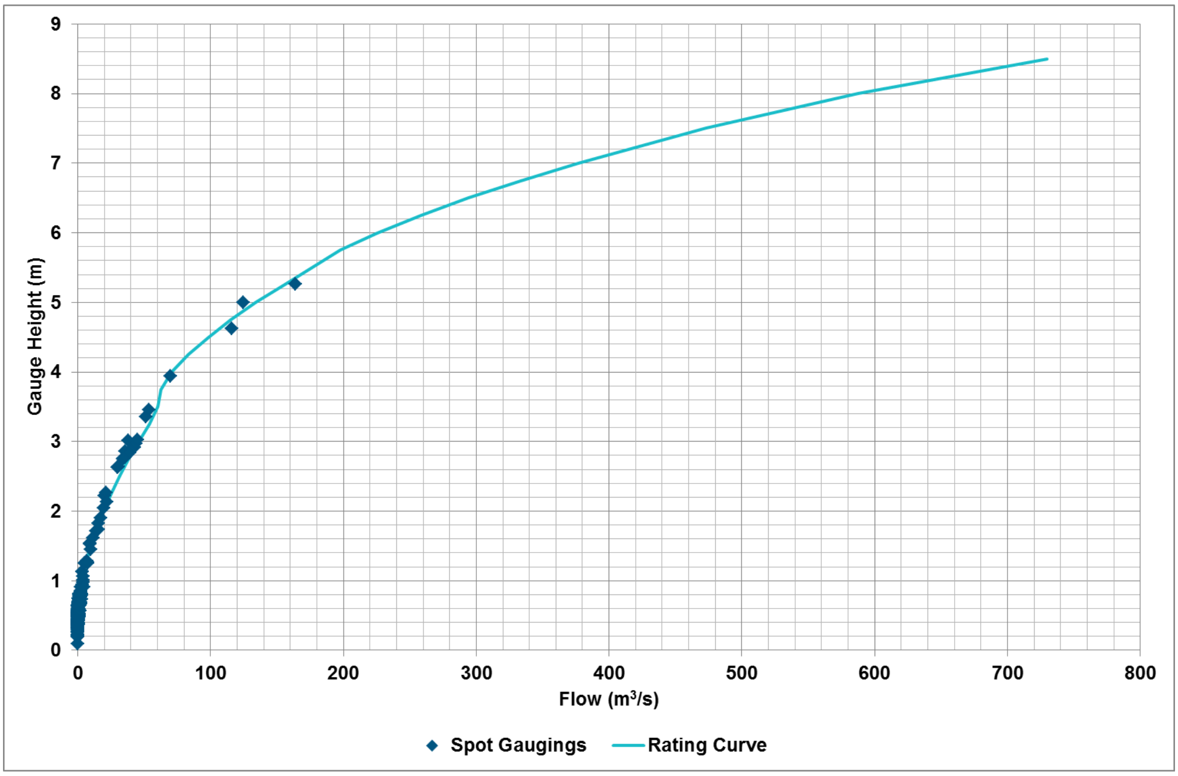


Figure 2-1 Adopted Rating Curve for the Talbragar River at Elong Elong

The adopted rating curve for the Talbragar River at Elong Elong was then used to derive an annual maxima flow series from the recorded peak water levels, for use in the flood frequency analysis.

The TUFLOW FLIKE extreme value analysis package was used to undertake the flood frequency analysis. Developed by Professor George Kuczera from the School of Civil Engineering at the University of Newcastle Australia, TUFLOW FLIKE is compliant with the recent major revision of industry guidelines for flood estimation, documented in the recent update of Australian Rainfall and Runoff (ARR 2016).

The FLIKE analysis used a Bayesian inference method with the Log Pearson (LPIII) probability model. The FLIKE package has the capability to perform probabilistic analysis with other models, including Log-normal, Gumbel, Generalised Extreme Value and Generalised Pareto. However, the LPIII distribution was selected as it provided the best fit against the recorded data.

The flood frequency analysis had a total of 46 annual maxima available, of which the lowest two (with zero flow) were excluded from the analysis. The fitted LPIII distribution is presented in Figure 2-2 along with the 90% confidence limits and plotting positions of the observed annual maxima.

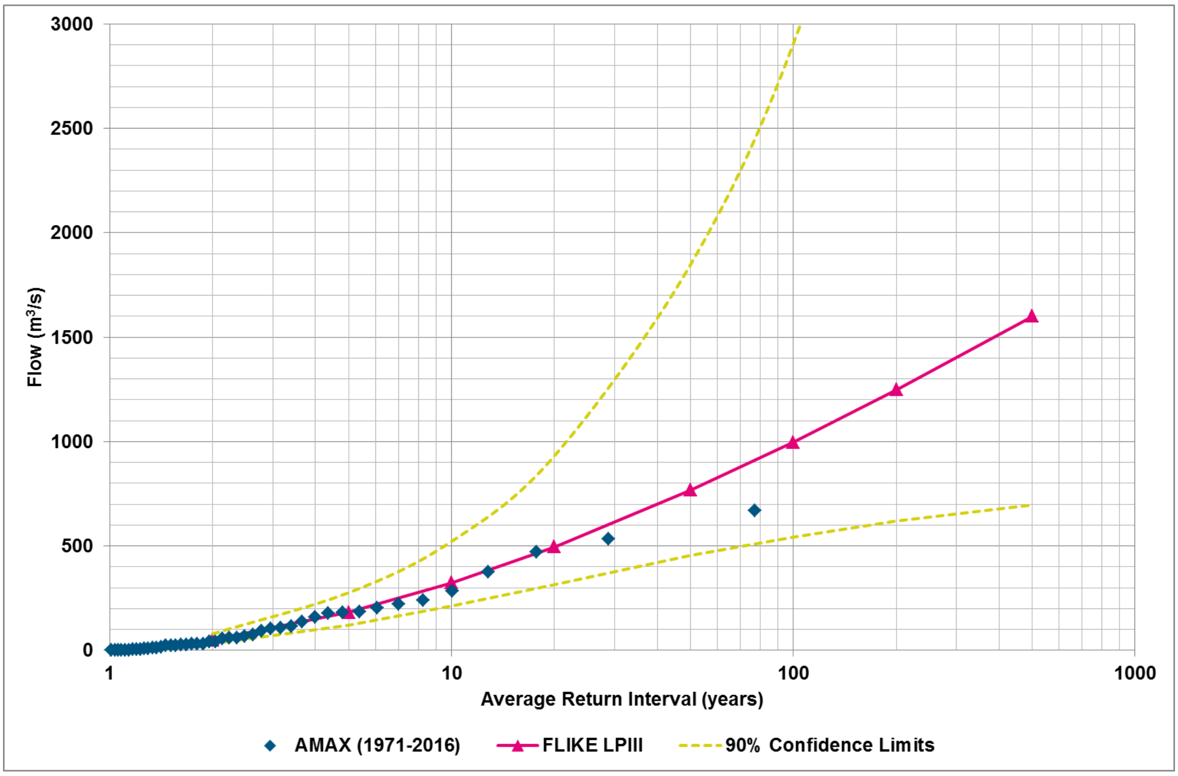


Figure 2-2 Flood Frequency Analysis for the Talbragar River at Elong Elong

The flood frequency analysis for the Talbragar River at Elong Elong presents the best available data from which to estimate design peak flood flows at Dunedoo. However, the catchment area of the Talbragar River downstream to Dunedoo is only around 2000 km^2 compared to that of around 3000 km^2 at Elong Elong. It is therefore necessary to scale down the flood frequency analysis flows at Elong Elong to provide a more reasonable estimate at Dunedoo. The catchment area at Dunedoo is around 67% of that at Elong Elong. However, scaling the design flood flows down to 67% of the Elong Elong flows would almost certainly be an underestimation, as the relationship between catchment area and peak flow is not linear. Therefore, a scaling factor of 84% was adopted, as it is halfway between scaling the flows based on catchment area and maintaining the same flows as

Elong Elong. The design peak flood flows derived from the Elong Elong flood frequency analysis and those adopted for Dunedoo are presented in Table 2-1.

Table 2-1 Design Peak Flood Flows

Design Event	Elong Elong (m^3/s)	Dunedoo (m^3/s)
20% AEP	180	160
10% AEP	320	280
5% AEP	500	420
2% AEP	770	650
1% AEP	1000	850
0.5% AEP	1250	1100
0.2% AEP	1600	1400

The ARR 2016 guidelines regarding the estimation of extreme events were used to determine an appropriate estimate of the Probable Maximum Flood (PMF) peak flood flow. Given the catchment size of around 2000 km^2 upstream of Dunedoo an AEP of 0.0002% is recommended. The plotting of design peak flood flows from the Flood Frequency Analysis on a log chart and subsequent extrapolation to the PMF suggests that a peak flow estimate of 4000 m^3/s is appropriate, as per Figure 2-3.

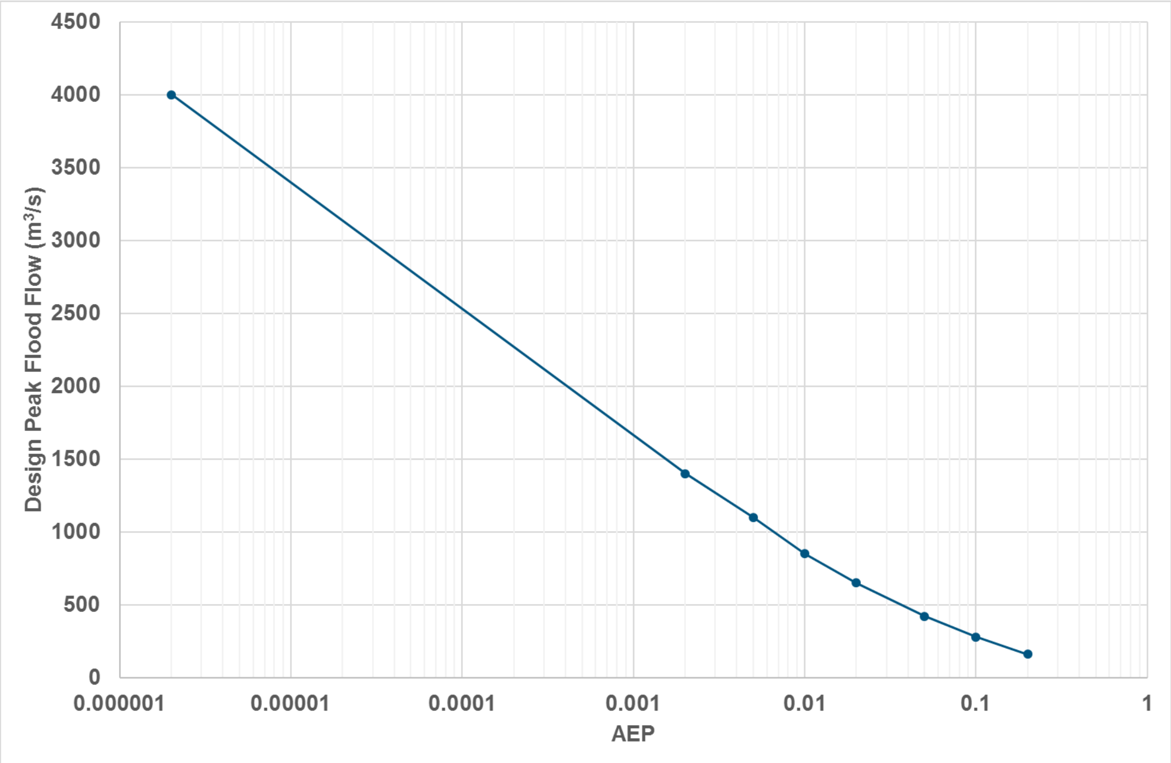


Figure 2-3 Estimation of PMF Event Peak Flow

3 Model Development

BMT has applied the fully 2D software modelling package TUFLOW HPC. The 2D model has distinct advantages over 1D and quasi-2D models in applying the full 2D unsteady flow equations. This approach is necessary to model the complex interaction between watercourses and floodplains and converging and diverging of flows through structures. The channel and floodplain topography is defined using a high resolution digital elevation model (DEM) for greater accuracy in predicting flows and water levels and the interaction of in-channel and floodplain areas.

The ability of the model to provide an accurate representation of the flow distribution on the floodplain ultimately depends upon the quality of the underlying topographic model. For this study, a 2 m by 2 m gridded DEM was derived from the NSW LPI LiDAR survey dataset, which covers a small 6 km by 6 km square local to Dunedoo. This was supplemented to the north by the NSW Department of Finance Services and Innovation (DFSI) Surface Model Enhancement (SME) product.

The extent of the hydraulic model is essentially limited to the east and west by the extent of the available elevation data. Available data outside of this extent is of insufficient accuracy for hydraulic assessment.

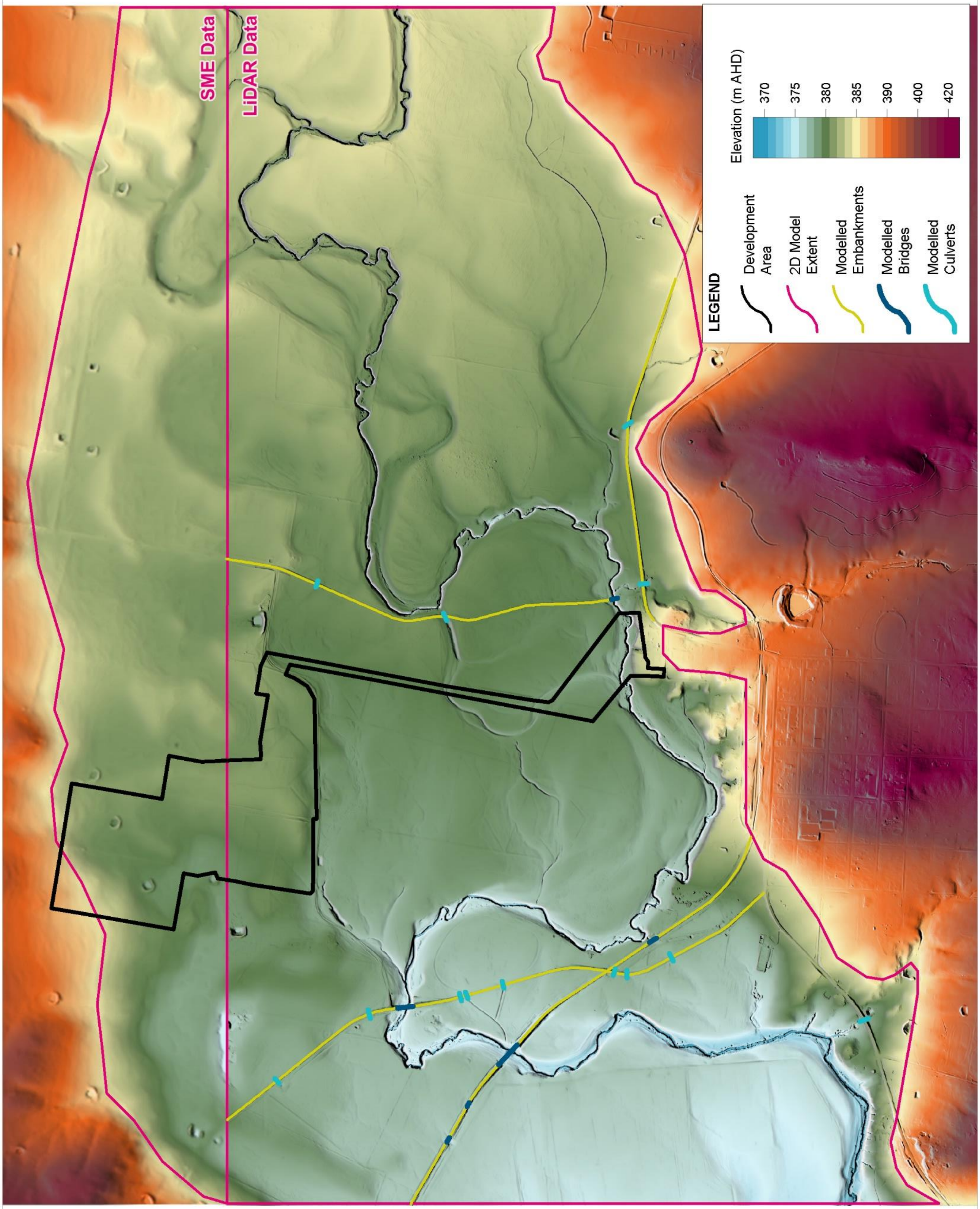
A TUFLOW 2D domain model resolution of 5 m was adopted for the study area, the extent of which is presented in Figure 3-1. Further detail of the topography within the proposed solar field extent is presented in This resolution was selected to give necessary detail required for accurate representation of floodplain and channel topography and its influence on flood flows. Due to the relatively dry nature of the river channel, it is considered that the LiDAR data provides a reasonable representation of the in-channel topography.

A 5 m grid model resolution may not pick up topographical features at a finer scale than 5 m (e.g. the crest of a roadway embankment). These features have been reinforced into the 2D model with “z-shapes” (3D topographical breaklines). These were defined for the road and rail embankments that traverse the floodplain, with elevations sourced from the LiDAR DEM. For the railway, a further 150 mm was added to the crest level to represent the top of rain control.

The development of the TUFLOW model requires the assignment of different hydraulic roughness zones. These zones are delineated from aerial photography and cadastral data identifying different land-uses (e.g. forest, cleared land, roads, urban areas, etc.) for modelling the variation in flow resistance.

A Manning’s ‘n’ value of 0.04 was adopted for the Talbragar River riparian corridor, consistent with the findings of the analysis at the Elong Elong gauge. A value of 0.06 was adopted for the floodplain extent beyond the riparian corridor.

There are a few large bridge crossings over the watercourses within the model extents. These structures vary in terms of construction type and configuration, with varying degrees of influence on local hydraulic behaviour. Incorporation of these major hydraulic structures in the model provides for simulation of the hydraulic losses associated with these structures and their influence on peak water levels within the study area.



Title:

TUFLOW Model Schematic

Figure: **3-1**

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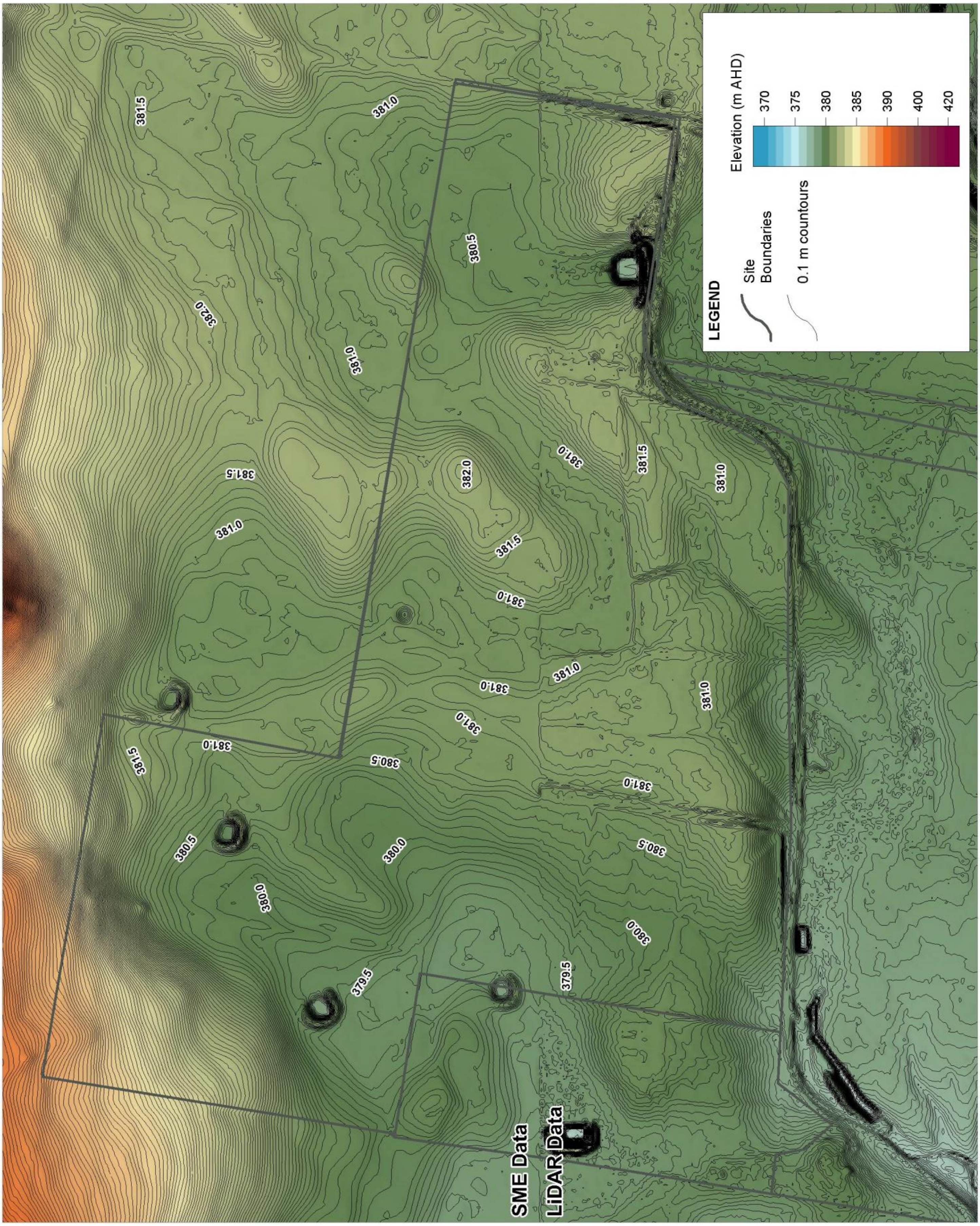

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Topography of the Proposed Solar Field

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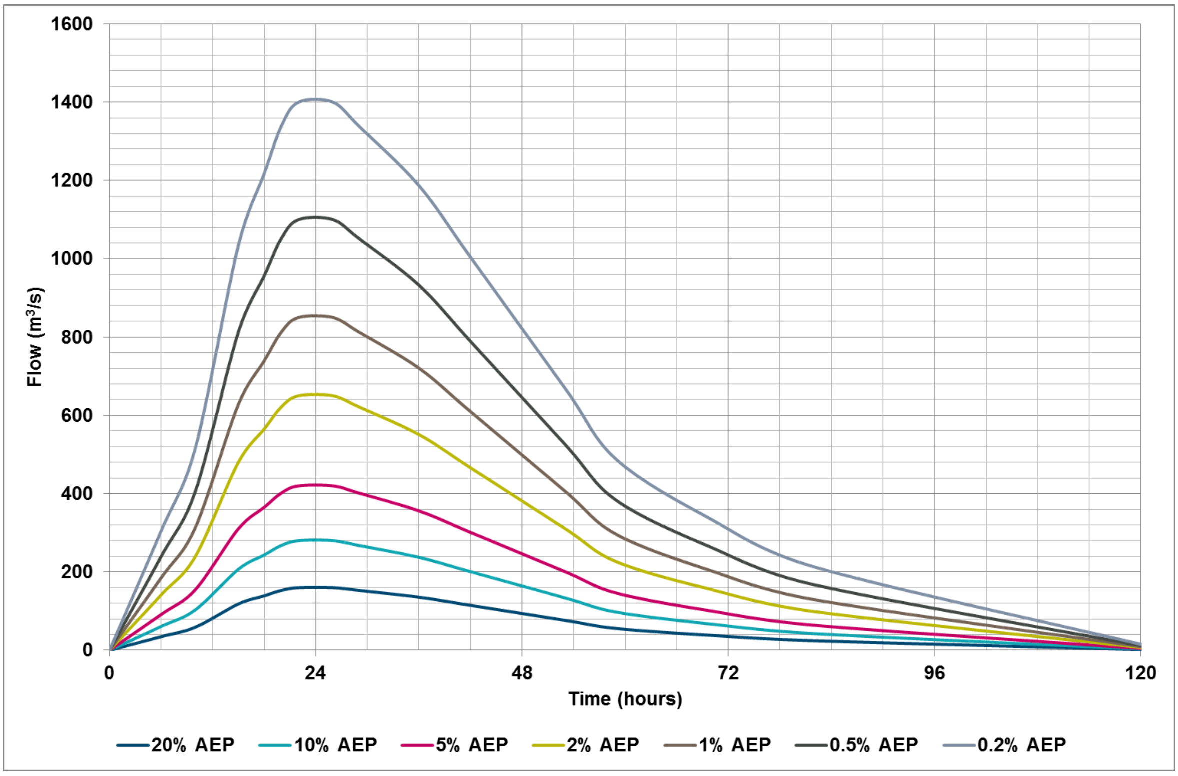
These hydraulic structures have been modelled as flow constrictions within the 2D domain. This utilises the layered flow constriction option available in TUFLOW, which represents the bridge superstructure and losses. Obvert levels and crest levels are entered along with additional form losses. Reasonable assumptions have been made as to pier blockages and bridge deck depths.

For smaller culvert structures, single cell openings (5 m width) have been provided through the embankments. However, these structures are unlikely to have a significant effect on the overall flood behaviour.

The upstream model limit corresponds to input flow hydrographs on the Talbragar River. The December 2010 recorded flood hydrograph shape at Elong Elong was used as the basis for design, being scaled to match the peak design flood flows for Dunedoo presented in Table 2-1. The model inflow hydrographs are presented in Figure 3-3.

The downstream model limit has adopted a normal flow boundary, with resultant water levels being computed from the model outflow, floodplain topography and Manning's 'n' roughness parameters.

Figure 3-3 Modelled Design Flood Flow Hydrographs



The northern area of the Talbragar River floodplain at Dunedoo is characterised by a series of relatively shallow local topographic depressions. These are expected to fill through local catchment runoff and then potentially receive additional flood flow contributions from the river during major flood events. To represent these local hydrological inputs to the northern floodplain area an XP-RAFTS hydrological model was developed, covering some 10.2 km^2, divided into 24 sub-catchments. It should be noted that this local catchment assessment is not comprehensive and so may not provide the critical flood conditions at the site. However, it should provide a better representation of potential flood depths on the site than by not accounting for local flow inputs.

The key assumptions regarding the local hydrological modelling include:

- Catchment areas and slopes derived from the available LiDAR and SME DEMs using Catchment SIM software
- hydraulic roughness for runoff calculations assumed to be 0.06
- 24-hour design rainfall intensities from BoM 2016 IFDs
- 24-hour design rainfall temporal pattern from Zone 1 of ARR 1987
- initial loss of 35 mm and continuing loss of 2.5 mm/h.

The 24-hour duration design storms were simulated in XP-RAFTS for the range of design event magnitudes being considered for the Talbragar River and were input as local flow vs. time boundaries to the TUFLOW hydraulic model.

4 Design Flood Conditions

4.1 Modelled Flood Conditions

The establishment of existing design flood conditions provides for description of the:

- general flood behaviour throughout the study area
- existing flooding conditions based on design flood events
- constraints and limitations to potential development with respect to flooding regimes.

Design flood modelling results are shown for the 20% AEP, 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.5% AEP and 0.2% AEP flood events in Appendix A. Figure 4-1 presents the flow distribution across the floodplain for the 1 % AEP design event. The riparian corridor of the Talbragar River conveys most of flow. However, there are also a few flood runners within the floodplain that act as significant conveyors of floodwater.

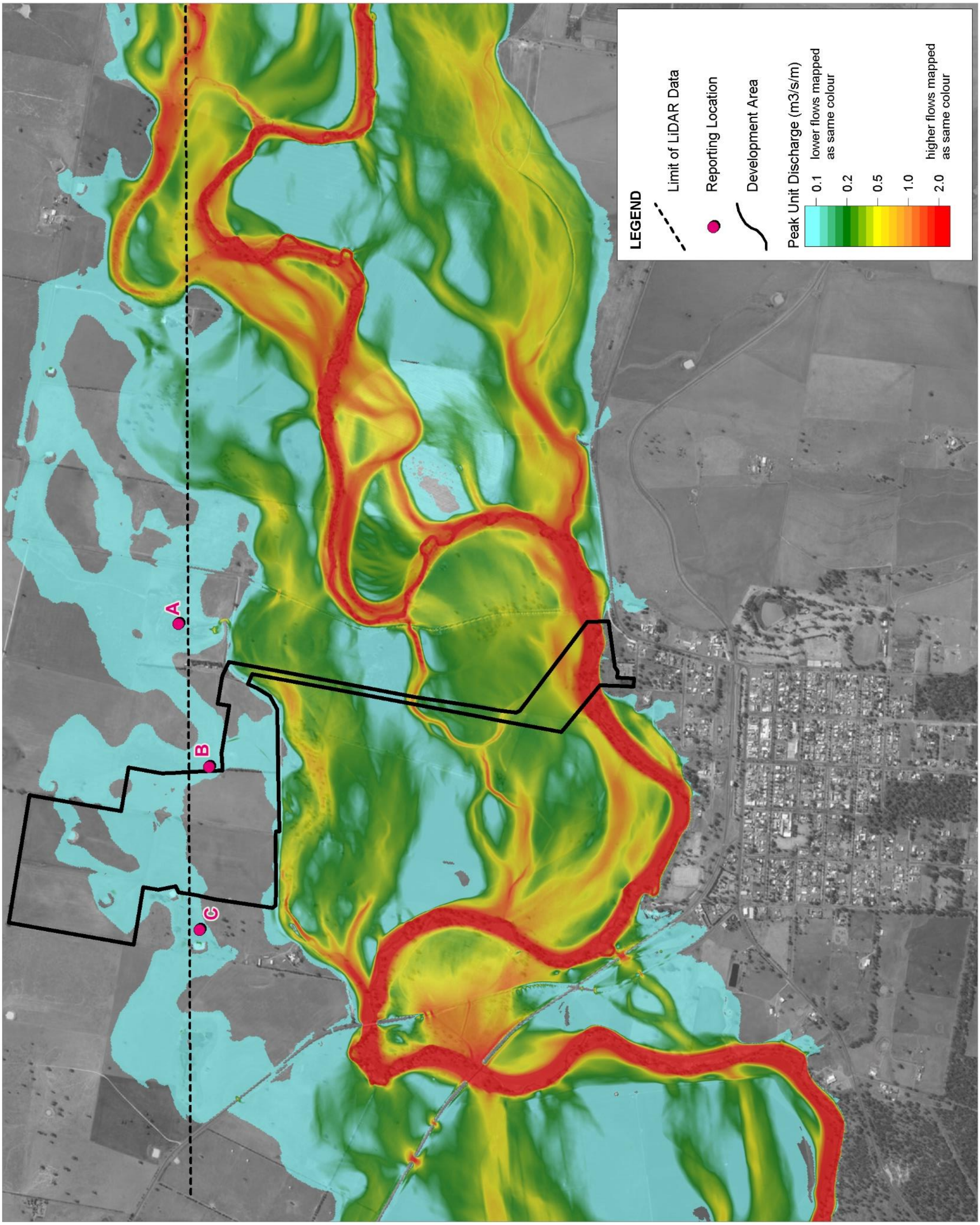
Modelled 1% AEP peak flood velocities within the Talbragar River channel are typically between 1.5 m/s and 2.5 m/s and between 0.5 m/s and 1.0 m/s within the major flood runners. Outside of the major flood runners the modelled velocities on the floodplain are less than 0.5 m/s.

The limit of the available LiDAR elevation data has been presented in Figure 4-1, with it being evident that the interface between the LiDAR and SME elevation datasets provides for a reasonably smooth and consistent transition. The nature of topography across the site is relatively flat with gentle undulations. Elevations within the proposed solar field extent range between around 379 m AHD to 382 m AHD. The proposed substation location is sited on land ranging between around 380.3 m AHD and 381.0 m AHD.

The modelled peak flood levels at the reporting locations presented in Figure 4-1 are provided in Table 4-1. Typical flood depths within the proposed solar field at the 1% AEP event range between around 0.2 m and 0.6 m. However, near Location A depths are much deeper, locally exceeding 3 m to the south of Location A.

Table 4-1 Modelled Design Peak Flood Levels (m AHD)

Design Event	Location A	Location B	Location C
Ground Surface	*380.5*	*380.7*	*379.2*
20% AEP	380.9	380.9	379.2
10% AEP	381.0	380.9	379.3
5% AEP	381.1	381.0	379.3
2% AEP	381.2	381.1	379.4
1% AEP	381.3	381.2	379.4
0.5% AEP	381.6	381.3	379.5
0.2% AEP	381.8	381.4	379.6
PMF	382.5	381.7	380.3



Title:
1% AEP Flood Flow Distribution

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4.2 Flood Risk to Study Site

The results of the flood modelling assessment suggest that the northern section of the site that has been identified for the development of the Dunedoo Solar Farm is not in an area of high flood risk. However, local catchment runoff supplemented by Talbragar River floodplain flows during major flood events impacts the site. The image presented in Figure 4-2 is a Landsat 7 satellite image captured following the flood event of November 2000. This event is the second largest within the continuous period of record at the Elong Elong gauge, since 1971. At a peak flow rate of around 535 m^3/s it is similar to the 5% AEP design flood magnitude.

The Landsat 7 imagery has been processed into a false colour composite using the near-infrared, shortwave-infrared and red channels. This highlights areas of standing water and wet ground. Relatively dry areas appear as greens within the image, with the extent of previous flood inundation appearing as blue/purple. The areas of inundation within the proposed Dunedoo Solar Farm are readily identifiable and total some 40 ha. If actual flood depths during the event were similar to those of the 5% AEP design flood then the average depth of flooding within the inundated areas of the solar field would be 0.3 m, with a peak depth of around 3.0 m in the dam in the east of the site. The existing Dunedoo Substation is situated a few metres above the floodplain and is free from inundation.

Based on the available elevation data it appears that there are a few small topographic depressions located within the site that would act as ephemeral wetlands, filling with water following periods of intense rainfall. These areas may also potentially be fed by overland flood flow paths during major flood breakouts from the Talbragar River further upstream. As can be seen within the topographic data in Figure 3-2, the elevation of these depressions is around 380.3 m AHD within the eastern depression, 380.7 m AHD in the central depression and 379.1 m AHD in the western depression. Expected depths of inundation within the depressions are in the order of up to 1.0 m in the eastern depression and up to 0.5 m in the other depressions.

To provide a better understanding of the flood risk across the site, flood hazard mapping has been provided in Appendix B for all the modelled design flood events. The hazard classification of the Flood Hazard Guideline 7-3 of the Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR, 2017) has been adopted, as presented in Figure 4-3. This approach to flood hazard mapping classifies the floodplain into six distinct hazard zones (H1 to H6), based on important thresholds of flood depth, velocity and depth-velocity product. The adopted thresholds identify when the modelled flood conditions present a risk to people, vehicles and building constructions. Descriptions of each hazard threshold have been reproduced in Table 4-2.

The flood hazard mapping shows that most of the inundated areas within the northern part of the site are between H1 and H3, with some localised areas of H4 and H5 around the existing farm dams. It may be possible to reduce local flood hazards through the filling of topographic depressions, if required. However, a flood impact assessment would be required to identify and quantify any potential flood impacts to neighbouring properties. The areas mapped for each hazard class within the proposed solar field are provided in Table 4-3. The existing Dunedoo Substation remains flood-free for all events, including the PMF.

Title:
November 2000 Landsat 7 Imagery

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Table 4-2 Flood Hazard Classification Thresholds

Hazard Classification	Description
H1	Relatively benign flow conditions. No vulnerability constraints.
H2	Unsafe for small vehicles.
H3	Unsafe for all vehicles, children and the elderly.
H4	Unsafe for all people and all vehicles.
H5	Unsafe for all people and all vehicles. Buildings require special engineering design and construction.
H6	Unconditionally dangerous. Not suitable for any type of development or evacuation access. All building types considered vulnerable to failure.

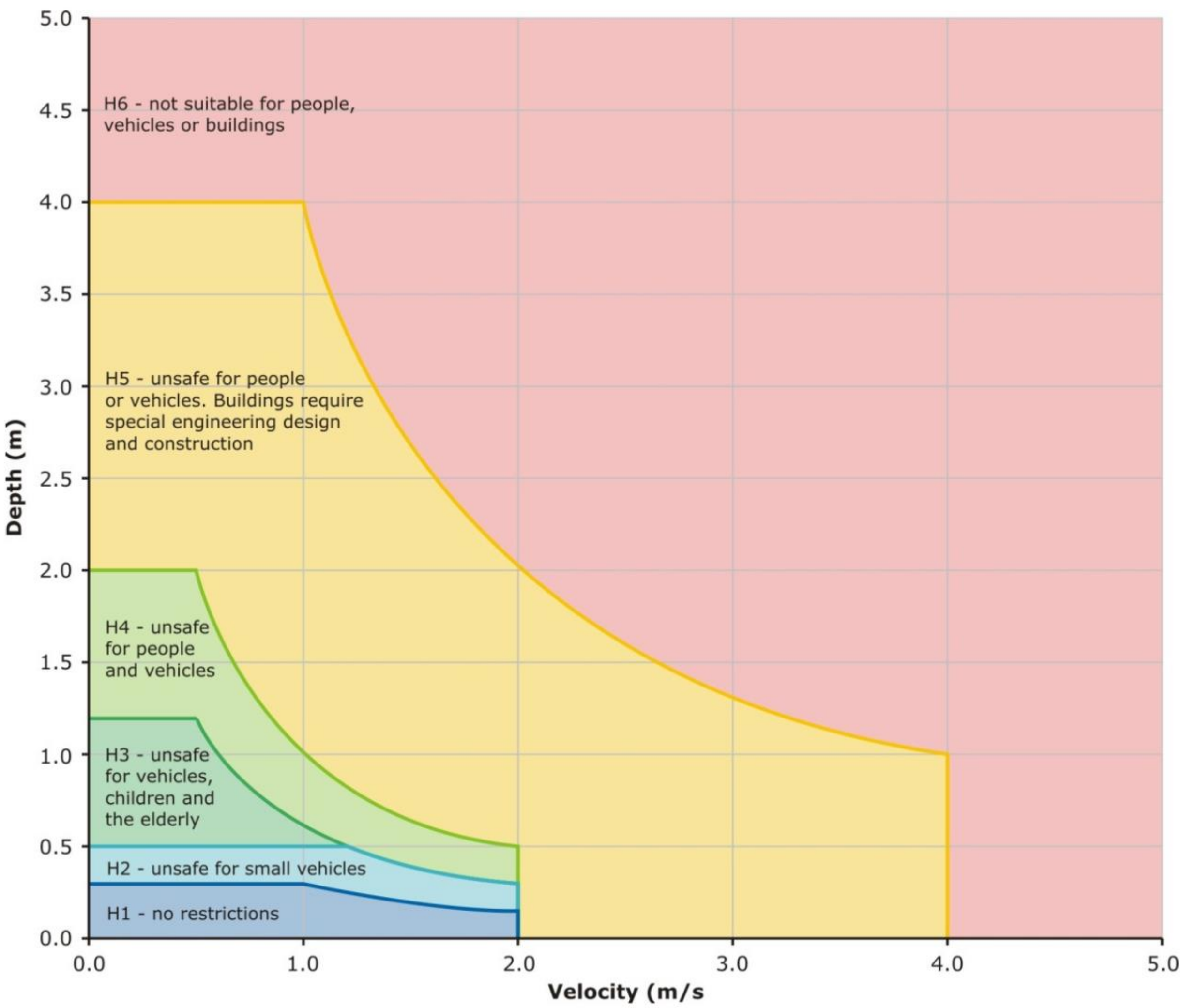


Figure 4-3 Flood Hazard Curves

Table 4-3 Area (ha) of Flood Hazard Inundation within the Solar Field

Design Event	H1	H2	H3	H4	H5	H6
20% AEP	21.6	6.1	0.7	0.1	0.2	0.0
10% AEP	25.5	5.1	4.3	0.1	0.2	0.0
5% AEP	28.4	6.9	6.6	0.1	0.2	0.0
2% AEP	32.9	12.4	8.1	0.1	0.2	0.0
1% AEP	38.0	16.7	11.1	0.1	0.2	0.0
0.5% AEP	42.7	14.5	21.0	0.5	0.2	0.0
0.2% AEP	48.1	15.1	23.0	6.5	0.3	0.0
PMF	17.7	21.1	51.5	22.5	6.9	0.1

The period of inundation during a flood event would be relatively variable, dependent on both event magnitude and duration. The three largest flood events recorded at Elong Elong are 1971, 2000 and 2010. Analysis of the recorded flood event hydrographs suggests that flood waters may potentially have flowed through the northern part of the site for around 16 hours during the 1971 and 2000 events, but in the order of three days during 2010, which was actually a series of three flood events. The topographic depressions would likely have been inundated for an extended period if there is no natural drainage, being reliant on seepage and evaporation.

Through correspondence with the client it is understood that areas of land that are subjected to peak flood depths below 1 m and peak flood velocities below 1 m/s are suitable for development of the Dunedoo Solar Farm (as are areas free from flood inundation). These suitable areas have been mapped in Appendix C. This shows that the proposed development footprint is compatible with the nature of flooding for events up to and including the 1% AEP (it is expected that the farm dam at the west of the site will be levelled). At the east of the site an area becomes unsuitable in the modelled 0.5% AEP and 0.2% AEP flood conditions, due to deep water building behind an existing dam structure at the southern boundary of the site. If required, this situation could potentially be improved through removal of the dam wall. However, this would require an impact assessment to ensure that areas downstream of the dam are not adversely affected.

4.3 Flood Planning Constraints

The flood function (or hydraulic categorisation) of a floodplain helps describe the nature of flooding in a spatial context and from a flood planning perspective can determine what can and can't be developed in areas of the floodplain. The hydraulic categories as defined in the Floodplain Development Manual are:

- Floodway - Areas that convey a significant portion of the flow. These are areas that, even if partially blocked, would cause a significant increase in flood levels or a significant redistribution of flood flows, which may adversely affect other areas.
- Flood Storage - Areas that are important in the temporary storage of the floodwater during the passage of the flood. If the area is substantially removed by levees or fill it will result in elevated

water levels and/or elevated discharges. Flood storage areas, if completely blocked would cause peak flood levels to increase by 0.1 m and/or would cause the peak discharge to increase by more than 10%.

- Flood Fringe - Remaining area of flood prone land, after floodway and flood storage areas have been defined. Blockage or filling of this area will not have any significant effect on the flood pattern or flood levels.

There are no prescriptive methods for determining what parts of the floodplain constitute floodways, flood storages and flood fringes. Descriptions of these terms within the Floodplain Development Manual are essentially qualitative in nature. Of difficulty is the fact that a definition of flood behaviour and associated impacts is likely to vary from one floodplain to another depending on the circumstances and nature of flooding within the catchment. However, an approach that is becoming increasingly accepted is to define the floodway extent as the area of floodplain conveying around 80% of the total flood flow. This is typically undertaken for the 1% AEP design flood event. For Dunedoo, a VxD threshold of around 0.3 (typically between 0.25 and 0.35 for selected cross-sections) at the 1% AEP was found to provide a good match to the flood extent conveying 80% of the total flow. Varying thresholds were used for other design events to improve the continuity of the mapped floodway, as below:

- VxD > 0.5 at the 0.2% AEP
- VxD > 0.4 at the 0.5% AEP
- VxD > 0.3 at the 1% AEP
- VxD > 0.2 at the 2% AEP
- VxD > 0.1 at the 5% AEP
- VxD > 0.01 at the 10% AEP

Flood storage was then mapped using a threshold depth of 0.3 m at the 1% AEP (unless already classified as floodway) and the flood fringe area has been defined as the remaining floodplain up to the 0.2% AEP extent.

Table 4-4 Flood Function

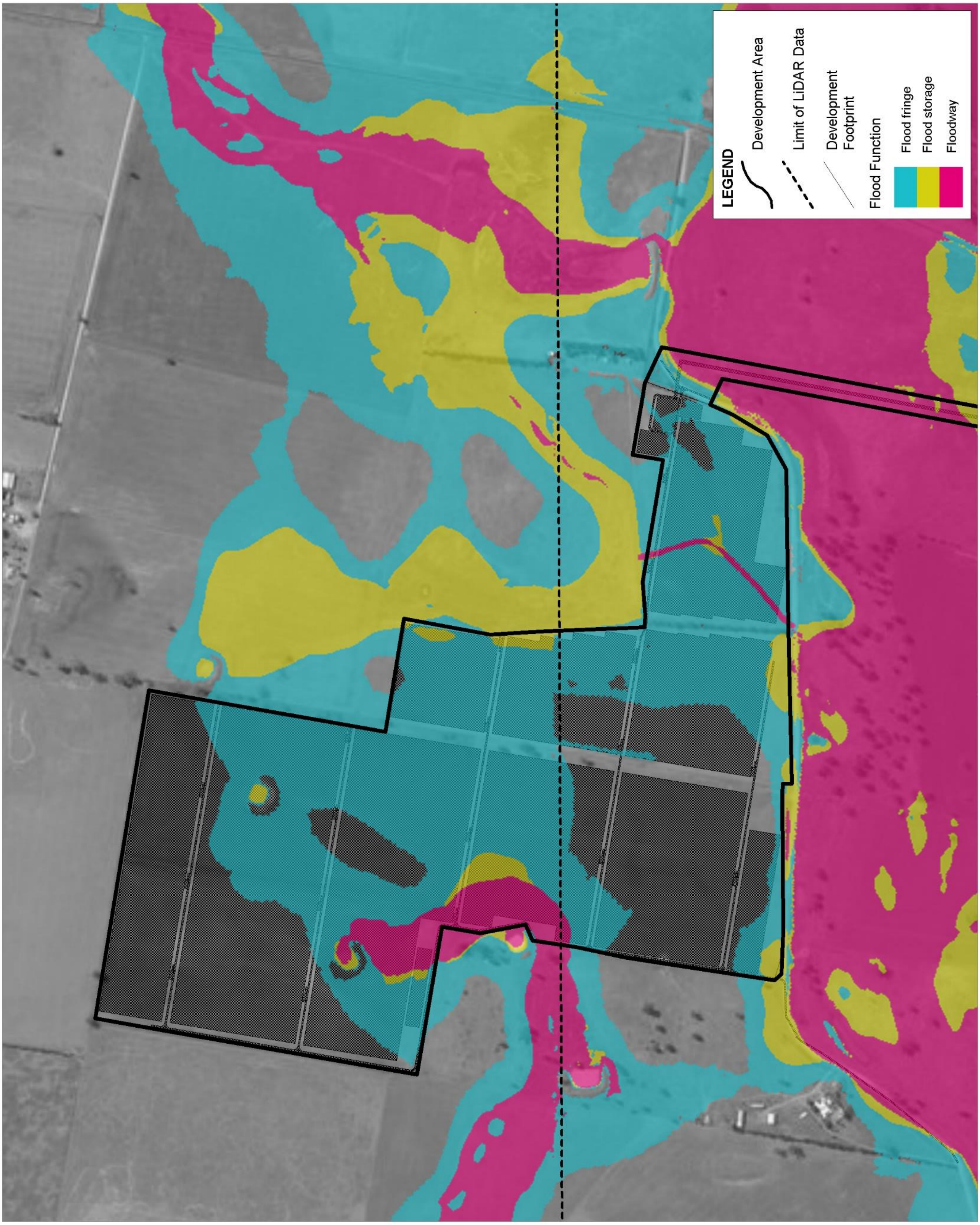
Hydraulic Category	Categorisation Criteria	Description
Floodway	VxD > 0.3 at the 1% AEP event (plus other event thresholds)	Areas and flowpaths where a significant proportion of floodwaters are conveyed (including all bank-to-bank creek sections).
Flood Storage	Depth > 0.3 m at the 1% AEP event (unless already classified as floodway	Areas where floodwaters accumulate before being conveyed downstream. These areas are important for detention and attenuation of flood peaks.
Flood Fringe	The extent of the 0.2% AEP floodplain not classified as floodway or flood storage	Areas that are low-velocity backwaters within the floodplain. Filling of these areas generally has little consequence to overall flood behaviour.

The flood function mapping for Dunedoo is presented in Figure 4-4.

The flood function mapping shows that much of the Talbragar River floodplain is considered floodway. There are some islands and floodplain edges that are flood fringe areas or flood storage. Much of the proposed Dunedoo Solar Farm is either flood free or flood fringe (64 ha). There are some areas of floodway (8.7 ha) and flood storage (20.5 ha), however, given the nature of the proposed development, it is considered a compatible use (subject to flood impact assessment) given that it presents limited obstruction to the flow of flood waters or loss of flood storage.

Flood Planning Levels (FPLs) are used for planning purposes, and directly determine the extent of the Flood Planning Area (FPA), which is the area of land subject to flood-related development controls. The FPL is the level below which a Council places restriction on development due to the hazard of flooding. Traditional floodplain planning has relied almost entirely on the definition of a singular FPL, which is usually based on the 1% AEP flood level plus a 0.5 m freeboard, for the purposes of applying floor level controls.

A representative FPA and associated FPL contour levels are presented in Figure 4-5. The FPL has been derived by applying a 0.5 m freeboard to the modelled 1% AEP peak flood levels. The FPA has been derived through intersection of the natural surface levels in the DEM with the FPL surface. Most of the site (106 ha) is identified as being within the FPA and therefore subject to flood planning controls. It is likely that critical infrastructure within the Dunedoo Solar Farm (such as the transfer station and inverterstations / transformers) will need to be situated above the FPL to minimise flood damages in the event of a major flood. This can be achieved through local raising of the ground surface with fill platforms and/or raising of critical infrastructure with elevated platforms.



Title:
Flood Function

Figure:
4-4

Rev:
D

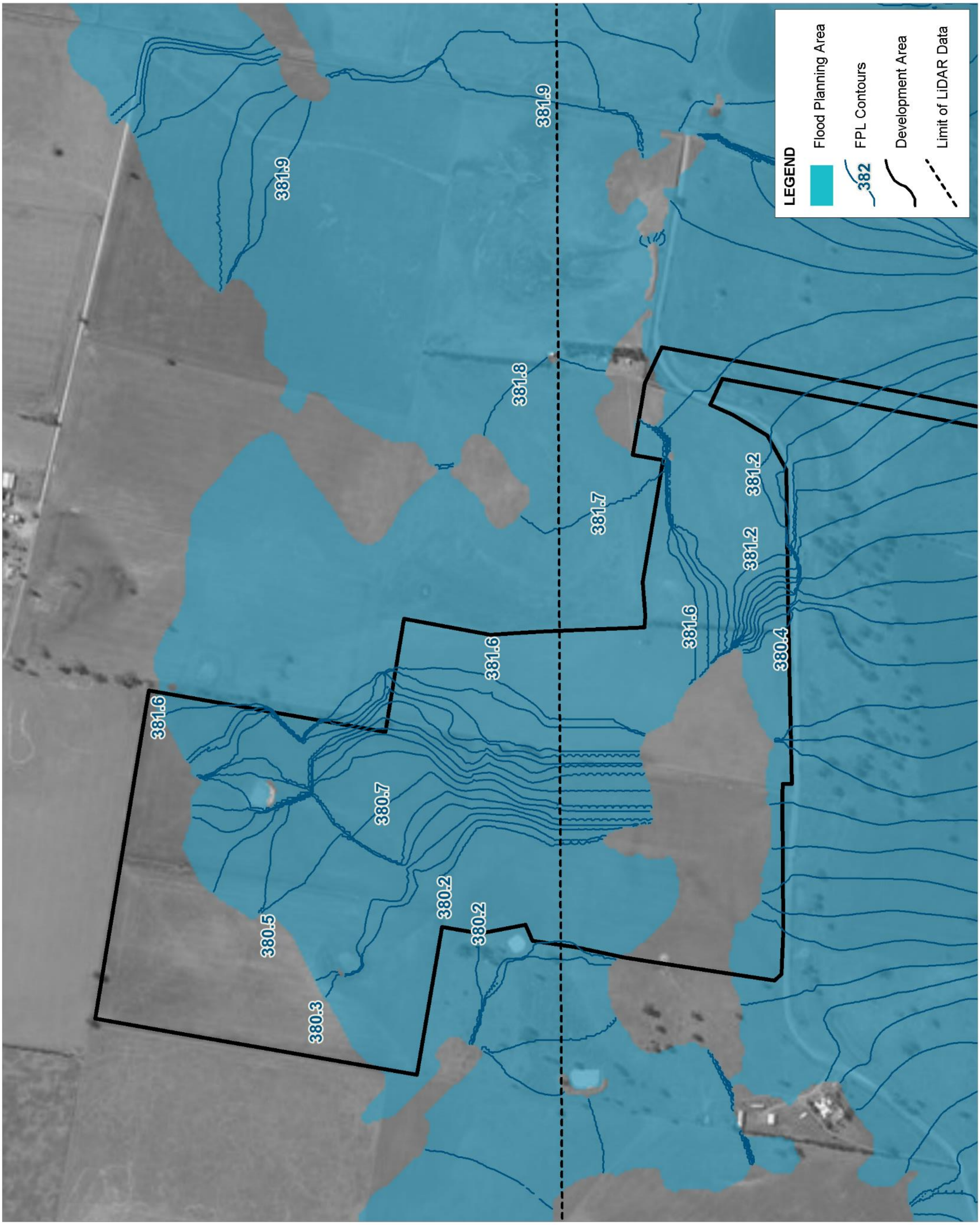
N

0 200 400m

Approx. Scale

BMT
www.bmt.org

Filepath : K:\N20883_Dunedoo_Substation_FRA\Mapinfo\Workspaces\DRG_046_180117_1%AEP_Function.WOR



Title:
Flood Planning Area and Flood Planning Levels

Figure: **4-5**

Rev: **C**

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N

0 200 400m

Approx. Scale

BMT

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Filepath : K:\N20883_Dunedoo_Substation_FRA\Mapinfo\Workspaces\DRG_047_180117_FPA.WOR

5 Flood Impact Assessment

A flood impact assessment is required to form part of the EIS for the proposed Dunedoo Solar Farm. The assessment is to consider both the compatibility of the proposed development with the existing flood conditions and to assess the potential for flood impacts associated with the development.

5.1 Proposed Development

Details of the proposed development configuration were provided within the drawing reference *17-362 Dunedoo Solar Farm 8.1.2020 \ Solar farm layout option 1* and associated CAD files, as presented in Figure 5-1.

The key elements of the proposed development that can potentially impact flood behaviour include:

- solar arrays
- access roads
- transfer station
- inverterstations / transformers
- boundary fence.

These elements of the design were incorporated into the TUFLOW hydraulic model representation to assess the potential flood impacts associated with the proposed development. The solar arrays were represented using the TUFLOW layered flow constriction functionality. A blockage of 10% was assumed within the solar array extents, with an associated form loss coefficient of 0.04 per metre. This assumes that the solar panels are constructed (or can be manoeuvred) to be clear of the flood water, leaving only the support infrastructure inundated. The boundary fence was also represented in this manner, with an assumed blockage of 50% and a form loss coefficient of 1.0.

The access roads were represented using the TUFLOW z-shape functionality, with model elevations along the road alignments being raised by 0.15 m to account for an assumed road surface construction. The transfer station and inverterstations / transformers were also represented in this manner, setting their elevations above the flood levels to provide a complete blockage to the passage of flood waters. There were a few existing farm dams located within the solar farm extent and these were regraded back to natural surface levels within the model.

It has been assumed that the powerline grid connection to the existing Dunedoo substation will have a negligible impact on flooding, due to the minor footprint of the associated infrastructure, and has therefore been excluded from the modelling assessment.

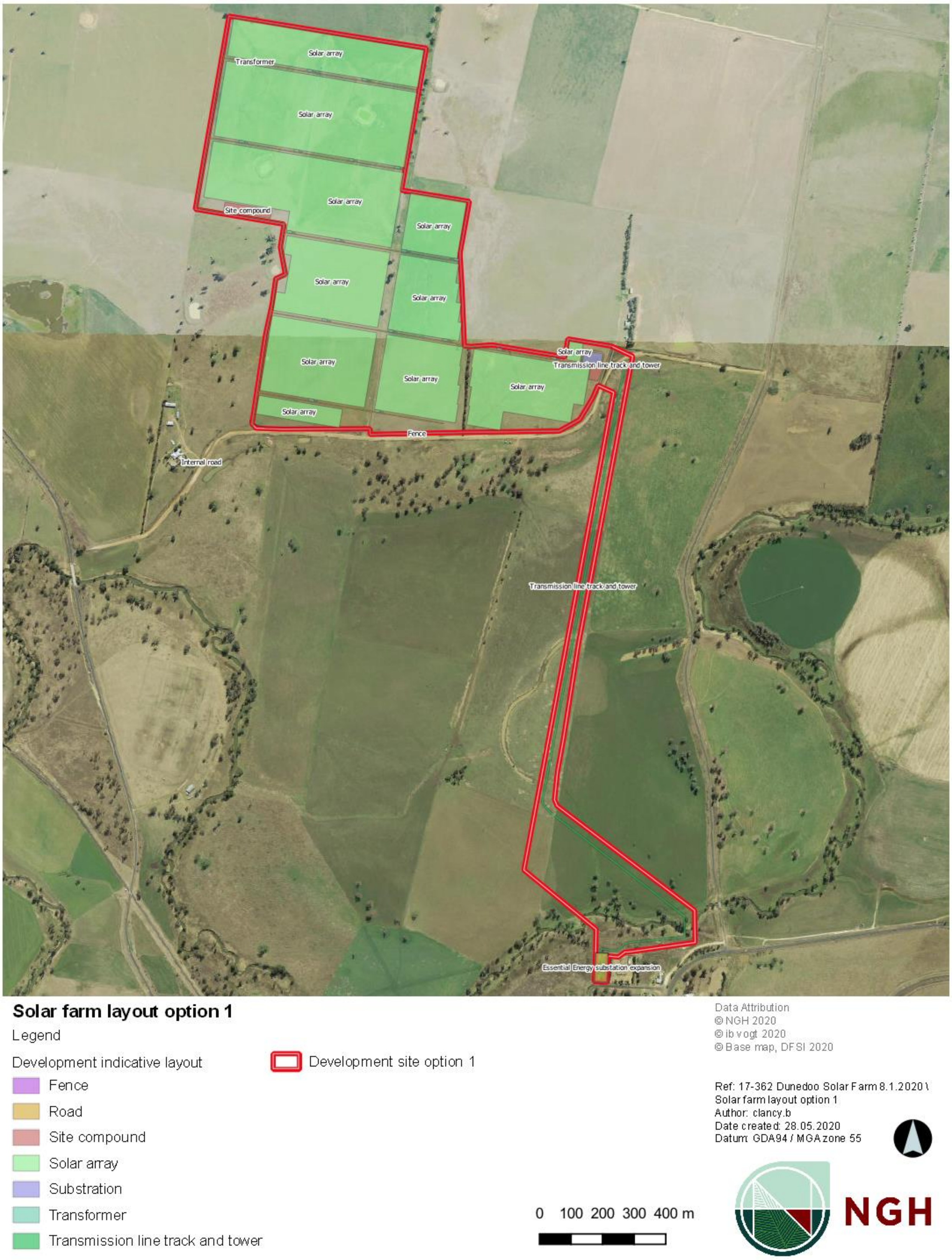


Figure 5-1 Proposed Dunedoo Solar Farm Layout

5.2 Model Results

Model simulations were completed for the existing and developed scenarios to assess the potential flood impacts. Overall, the developed flood conditions are largely compatible with existing conditions near the site. Reference to the flood level impact mapping in Appendix D and flood velocity impact mapping in Appendix E enables a better understanding of the nature and context of the impacts. The maps show the modelled change between existing and developed conditions, with positive changes indicating an expected increase in peak flood levels or velocities and negative changes indicating an expected decrease in peak flood levels or velocities.

Modelled off-site peak flood level impacts are typically less than 0.05 m but are up to around 0.07 m at the PMF event. The extent of impact is limited to the adjacent fields to the north and east of the site. Modelled peak flood velocity impacts are localised and effectively contained within the development site. The area of modelled flood impacts does not appear to affect any property, assets or infrastructure.

The compatibility of the proposed development with the flood hazard of the land is well demonstrated by the figures within Appendix C. These show that for flood events up to and including the 1% AEP, the solar arrays are compatible with the modelled flood hazard. This is also true for the 0.5% AEP and 0.2% AEP events. At the PMF event only 7 ha of land to be occupied by solar arrays is to be inundated. This is considered an excellent level of compatibility, with minimal flood damages expected for only extreme flood events.

The proposed development does not change the overall inundation extent within the floodplain and so no impacts with regards to environmentally beneficial flooding are expected. Flood inundation frequency and duration will remain consistent with the existing conditions. There are minimal changes to the modelled flood velocities, which are also remote from the local watercourses. Therefore, no changes to the geomorphological regime will result from the development, such as siltation, erosion, bank stability or the resultant implications for riparian vegetation.

The modelled flood impacts associated with the proposed development are negligible in terms of affecting property, assets and infrastructure and therefore result in no detriment to the overall social or economic status of the community. As the solar farm would be largely un-staffed, the development would not place any additional burden with regards to flood emergency response management. However, the development of a Flood Emergency Response Plan for the site would be beneficial to minimise the risk to property and risk to life on-site in advance of a potential impending major flood event.

The flood model results show that access to the site from Dunedoo via Digilah Road would be cut in even minor flood events such as the 20% AEP, due to the low level of the bridge crossing of the Talbragar River. The design flood model results indicate that access via the Digilah Road bridge may be expected to be cut for around a 2-day period for frequent flood events such as the 20% AEP and around 4-days for major flood events such as the 1% AEP. Access to Dunedoo via the Castlereagh Highway should remain trafficable during flood events up to the 10% AEP. However, for events of a 5% AEP or rarer the highway would be closed for a period, although alternative access to the site could potentially remain via the Castlereagh Highway to the north. For events of a 2% AEP or rarer, access to the site would not be possible due to the depth of inundation along Allweather Road. The existing Dunedoo Substation remains flood free even at the PMF event.

The modelled peak flood depths within the proposed solar farm PV tracker footprints does not exceed around 1.6 m at the PMF event. Therefore, it is assumed that in the event of a flood the solar arrays can be manoeuvred to remain clear of the water surface. It is expected that during a PMF event several of the inverter units would be damaged. However, at the 0.2% AEP event only four of the inverter units are predicted to be subject to flood depths exceeding 0.3 m and therefore the standard concrete footings should provide suitable flood immunity. Providing a 0.6 m clearance above ground surface levels should provide for a comparable level of flood immunity at the following inverter locations (GDA 94, MGA Zone 55):

- 725 677, 6 458 189
- 725 831, 6 458 163
- 726 207, 6 458 101
- 726 341, 6 457 817.

6 Conclusion

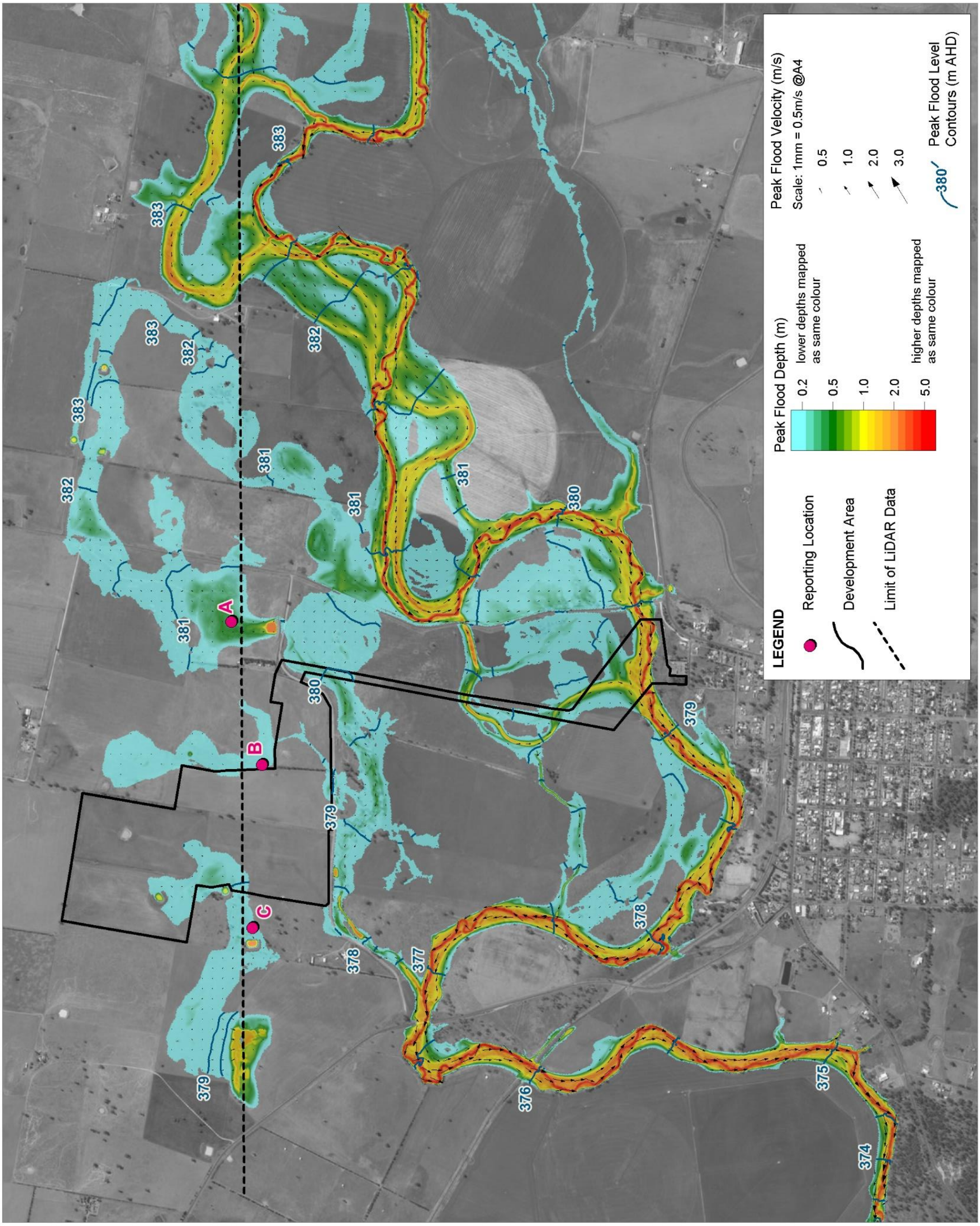
This flood risk assessment has utilised available gauge data on the Talbragar River, together with local LiDAR and SME elevation data at Dunedoo, to establish baseline hydraulic modelling at the proposed Dunedoo Solar Farm site.

The assessment has established that the proposed solar farm site (northern section) is not situated within an area of high flood risk of deep, fast-flowing flood waters. However, the site is subject to overland flood flows from local catchment runoff, which is exacerbated during major flood events resulting from a breakout of flood waters further upstream. Flood hazard mapping of the site indicates that the flood inundation across the northern section of the site is of a relatively low hazard, with locally higher hazards associated with areas of deeper water around existing farm dams. The southern section of the site is exposed to a greater area of high hazard, associated with the major floodplain flow areas of the Talbragar River.

Key elements of the proposed solar farm design have been incorporated into the hydraulic model and potential flood impacts associated with the development have been determined. This assessment has found the potential impacts of the proposed development on flooding to be minimal, with no adverse effects identified to existing property, assets and infrastructure or the natural environment. The solar farm would not place any additional burden on existing flood emergency response management. However, the development of a Flood Emergency Response Plan for the site would be beneficial to minimise the risk to property and risk to life on-site in advance of a potential impending major flood event.

Road access to the site should remain possible via Allweather Road (not Digilah Road) during flood events up to a 10% AEP, with access becoming difficult at the 5% AEP and not possible at the 2% AEP. The existing Dunedoo Substation remains flood free even at the PMF event.

Appendix A Design Flood Mapping



Title:

20% AEP Modelled Peak Flood Results

Figure: **A-1**

Rev: **E**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 375 750m

Approx. Scale

www.bmt.org

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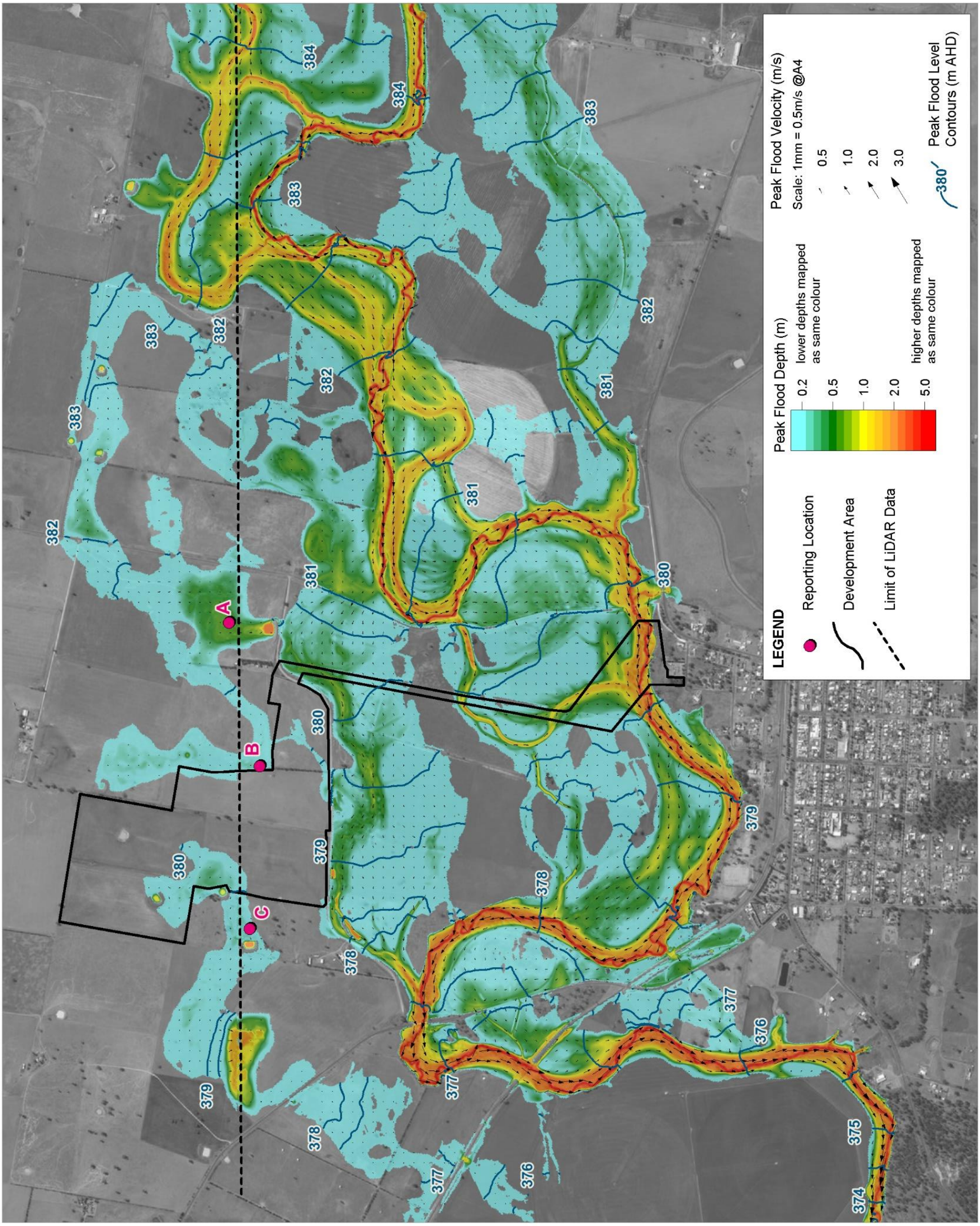

Title:

10% AEP Modelled Peak Flood Results

Figure:

A-2

Rev:

E

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N

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Approx. Scale

BMT

www.bmt.org

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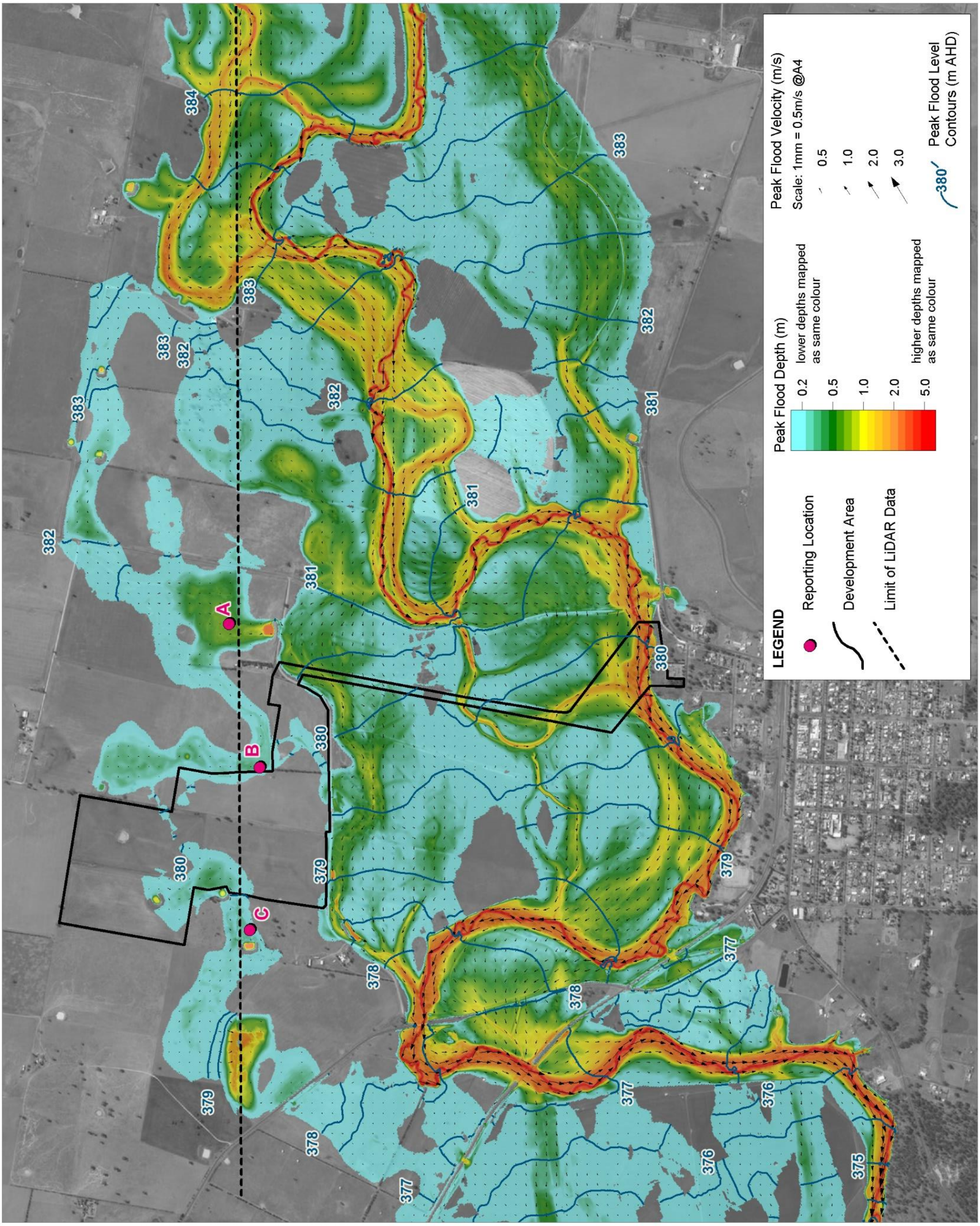

Title:
5% AEP Modelled Peak Flood Results

Figure:
A-3

Rev:
E

N

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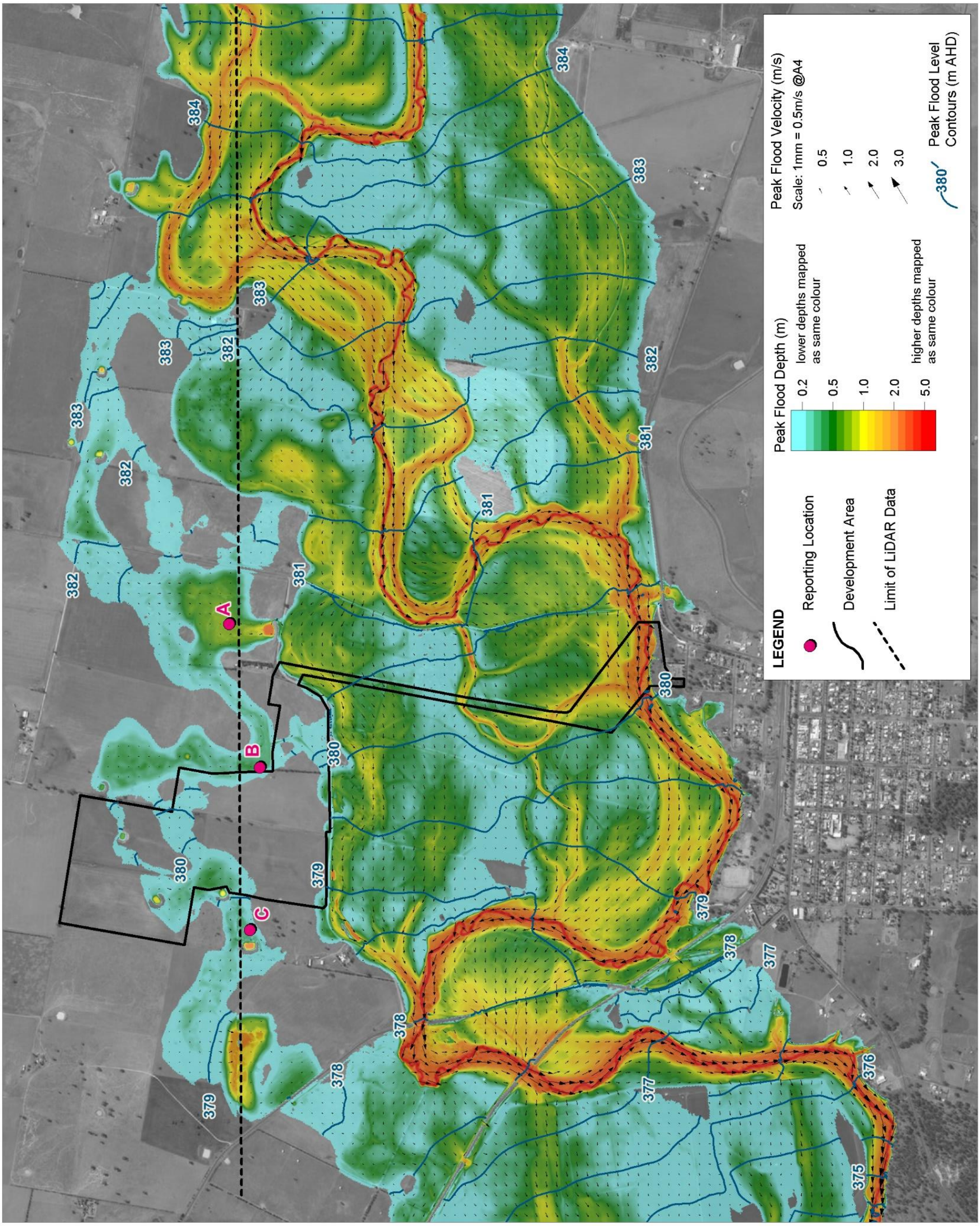
Approx. Scale

BMT
www.bmt.org

Filepath : K:\N20883_Dunedoo_Substation_FRA\Mapinfo\Workspaces\DRG_008_170720_5%AEP.WOR



Title:

2% AEP Modelled Peak Flood Results

Figure: **A-4**

Rev: **E**

N

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Approx. Scale

BMT
www.bmt.org

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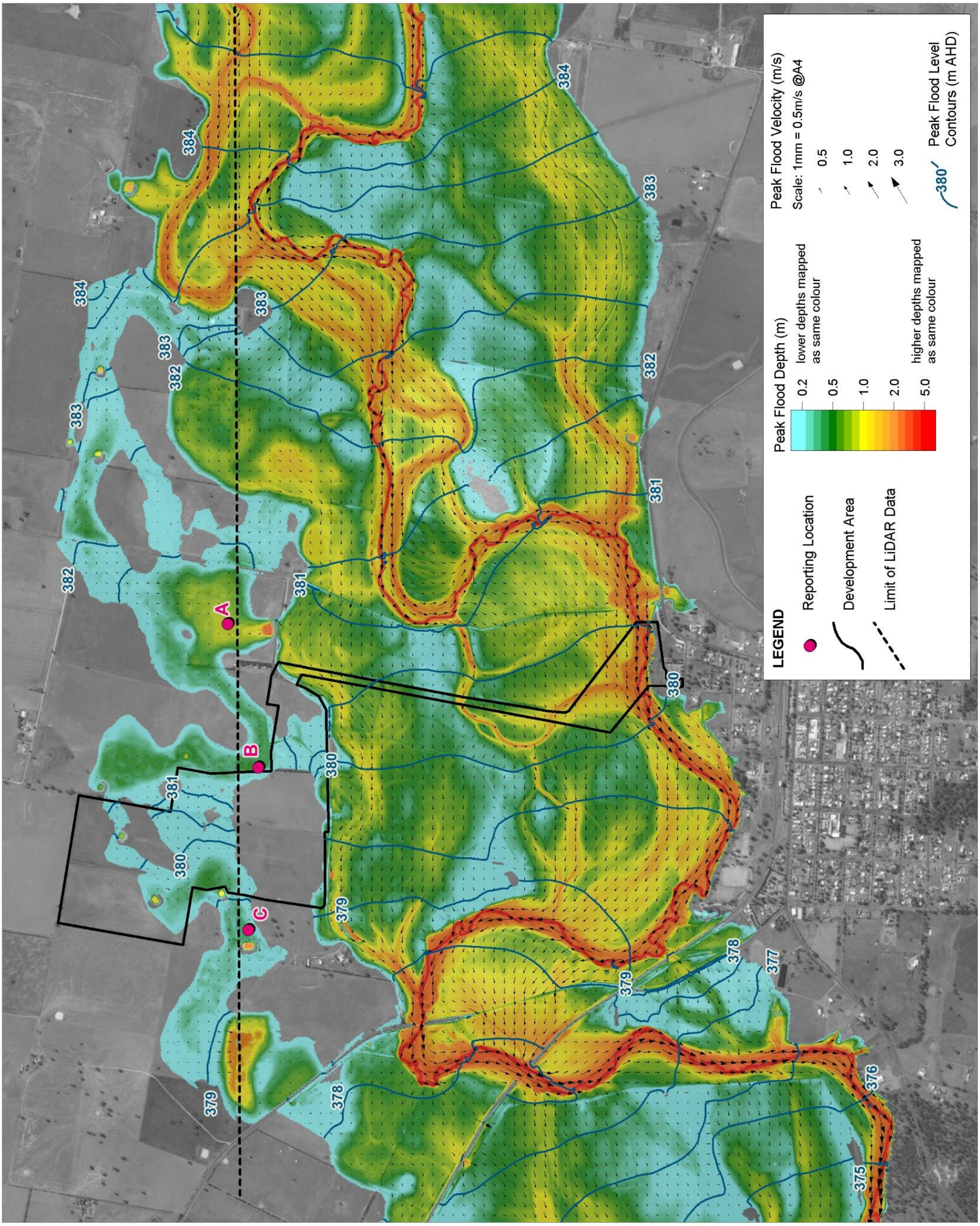

Title:
1% AEP Modelled Peak Flood Results

Figure: **A-5**

Rev: **E**

N

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Approx. Scale

BMT
www.bmt.org

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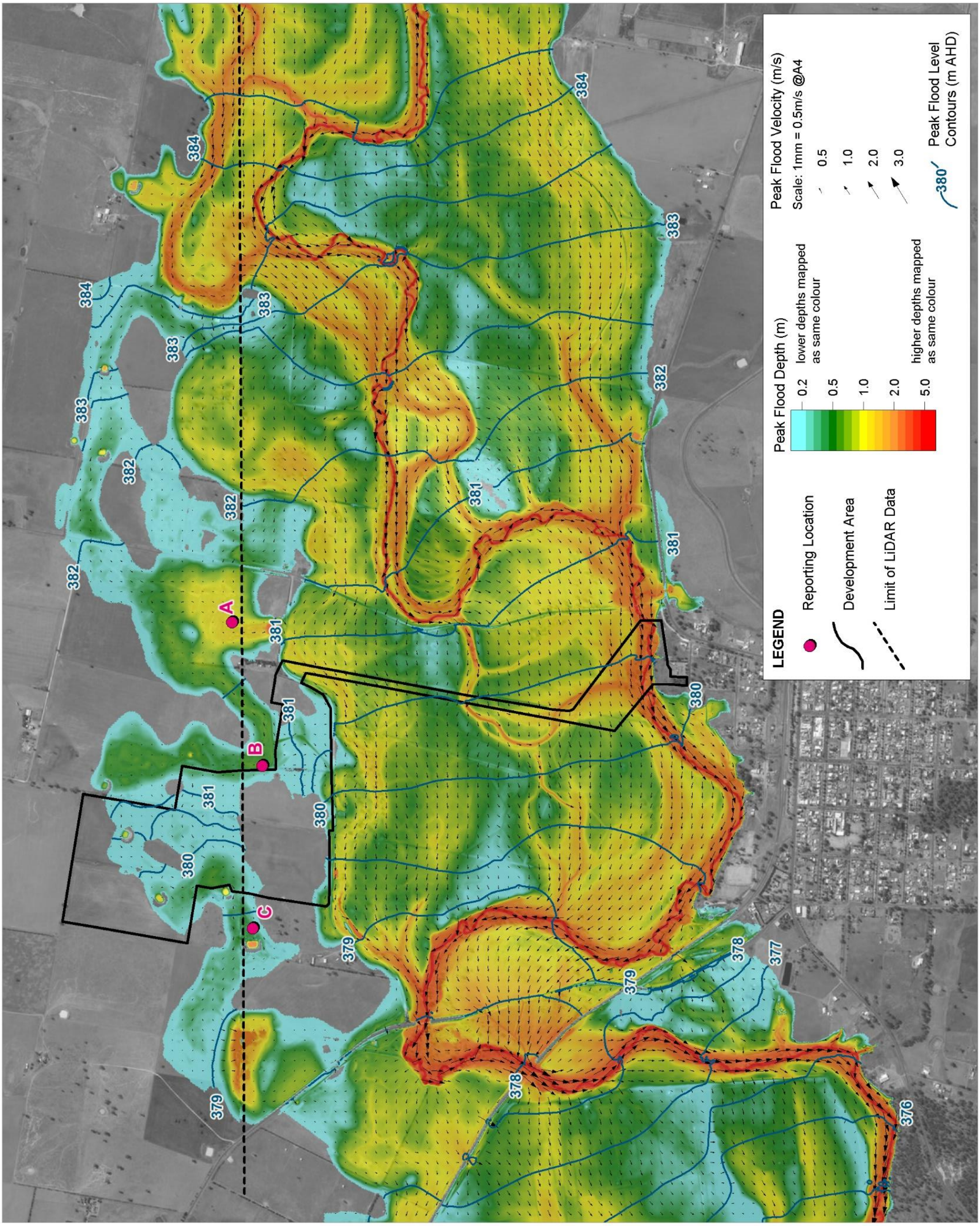

Title:

0.5% AEP Modelled Peak Flood Results

Figure: **A-6**

Rev: **E**

N

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Approx. Scale

BMT

www.bmt.org

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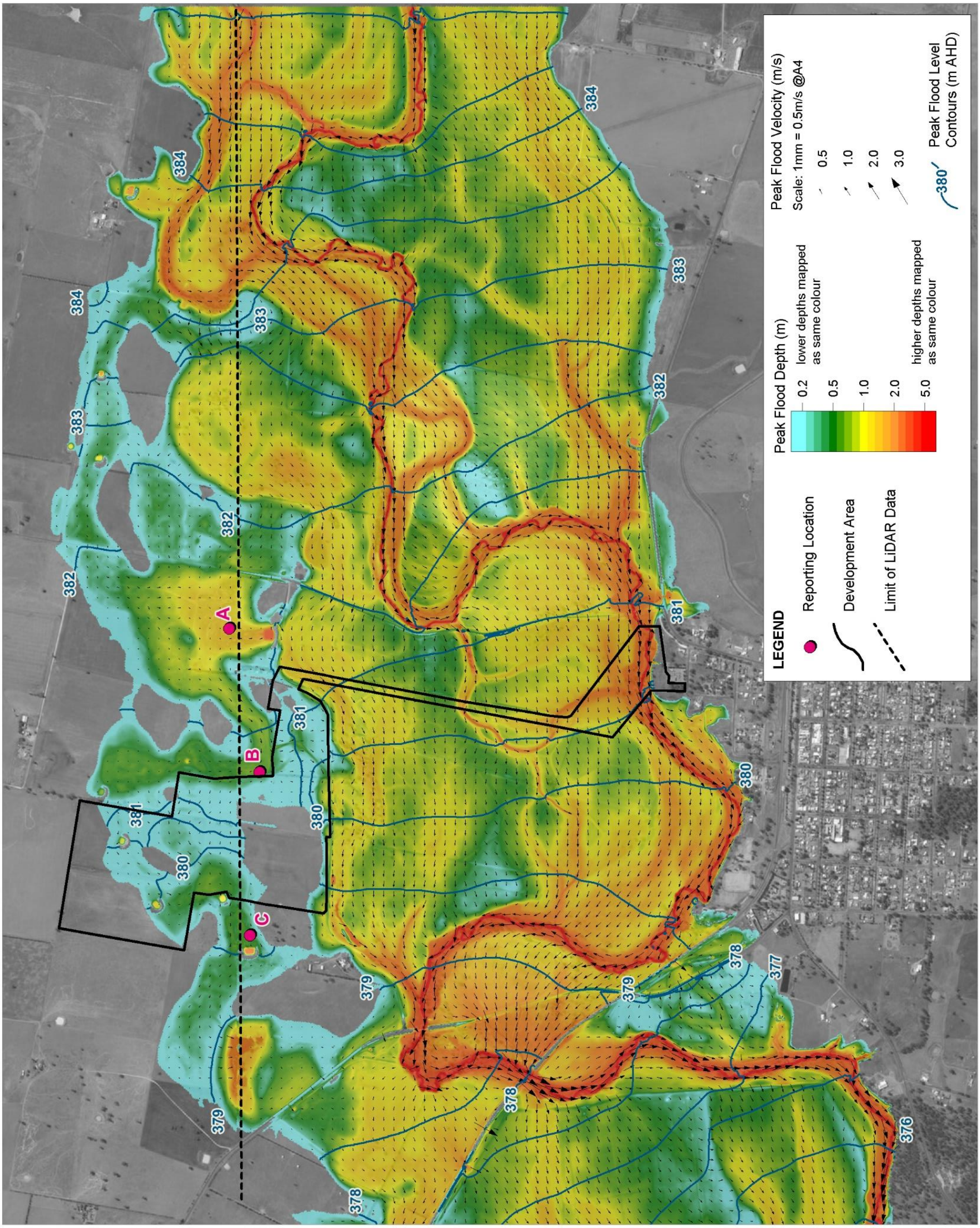

Title:

0.2% AEP Modelled Peak Flood Results

Figure: **A-7**

Rev: **E**

N

0 375 750m

Approx. Scale

www.bmt.org

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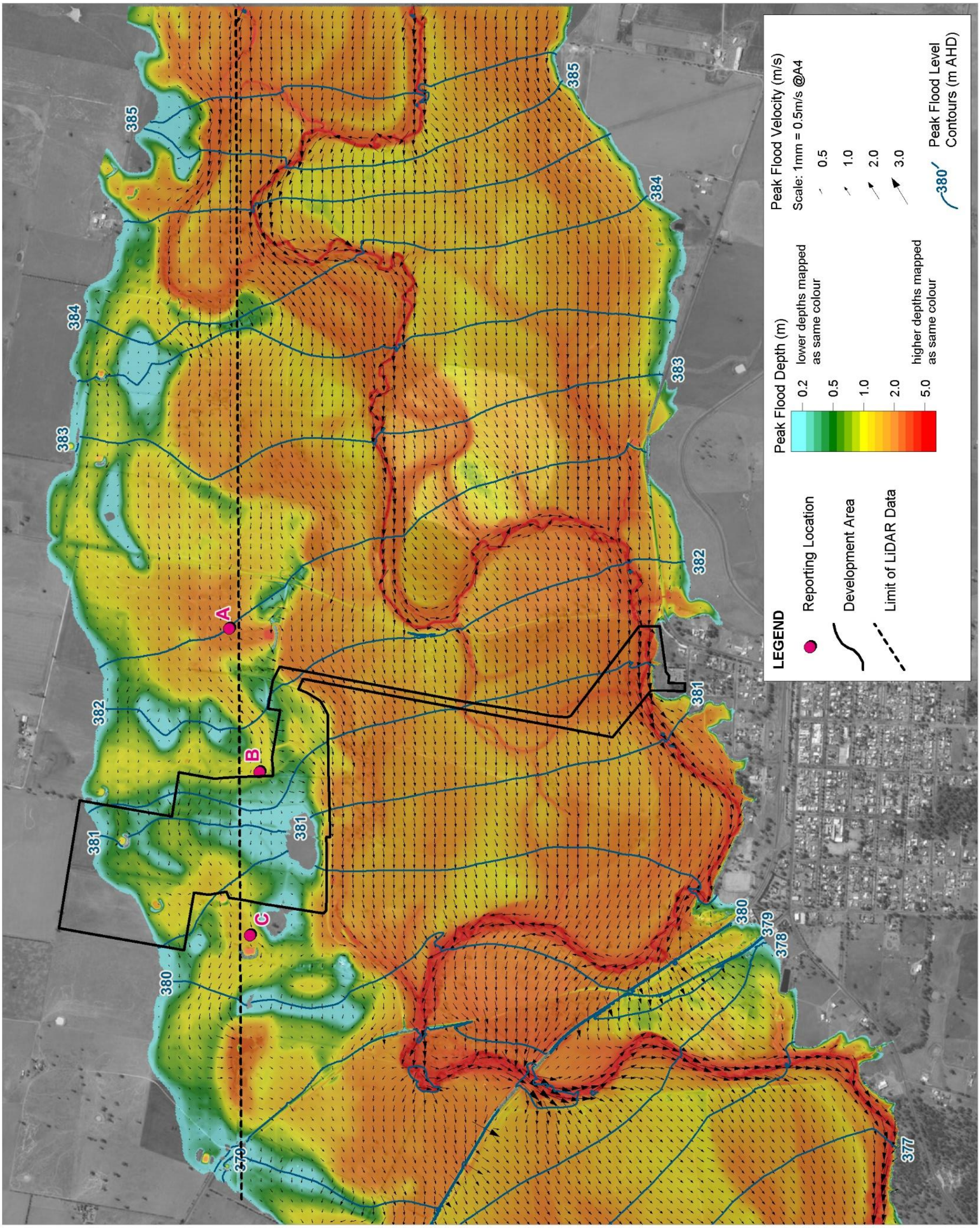

Title:
PMF Modelled Peak Flood Results

Figure: **A-8**

Rev: **C**

N

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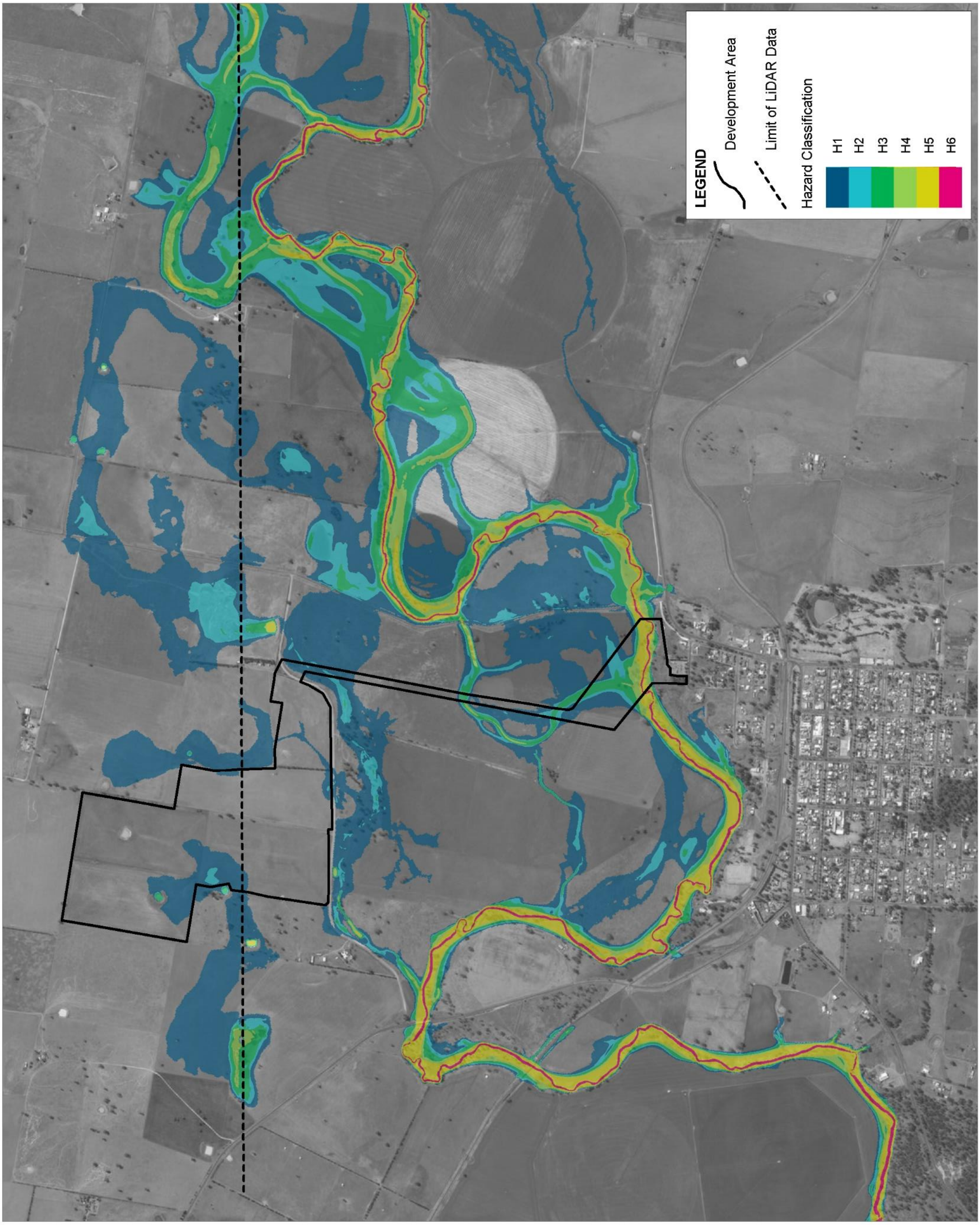
Approx. Scale

BMT
www.bmt.org

Filepath : K:\N20883_Dunedoo_Substation_FRA\Mapinfo\Workspaces\DRG_027_180112_PMF.WOR

Appendix B Flood Hazard Mapping



Title:

20% AEP Flood Hazard Classification

Figure:

B-1

Rev:

D

N

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Approx. Scale

BMT
www.bmt.org

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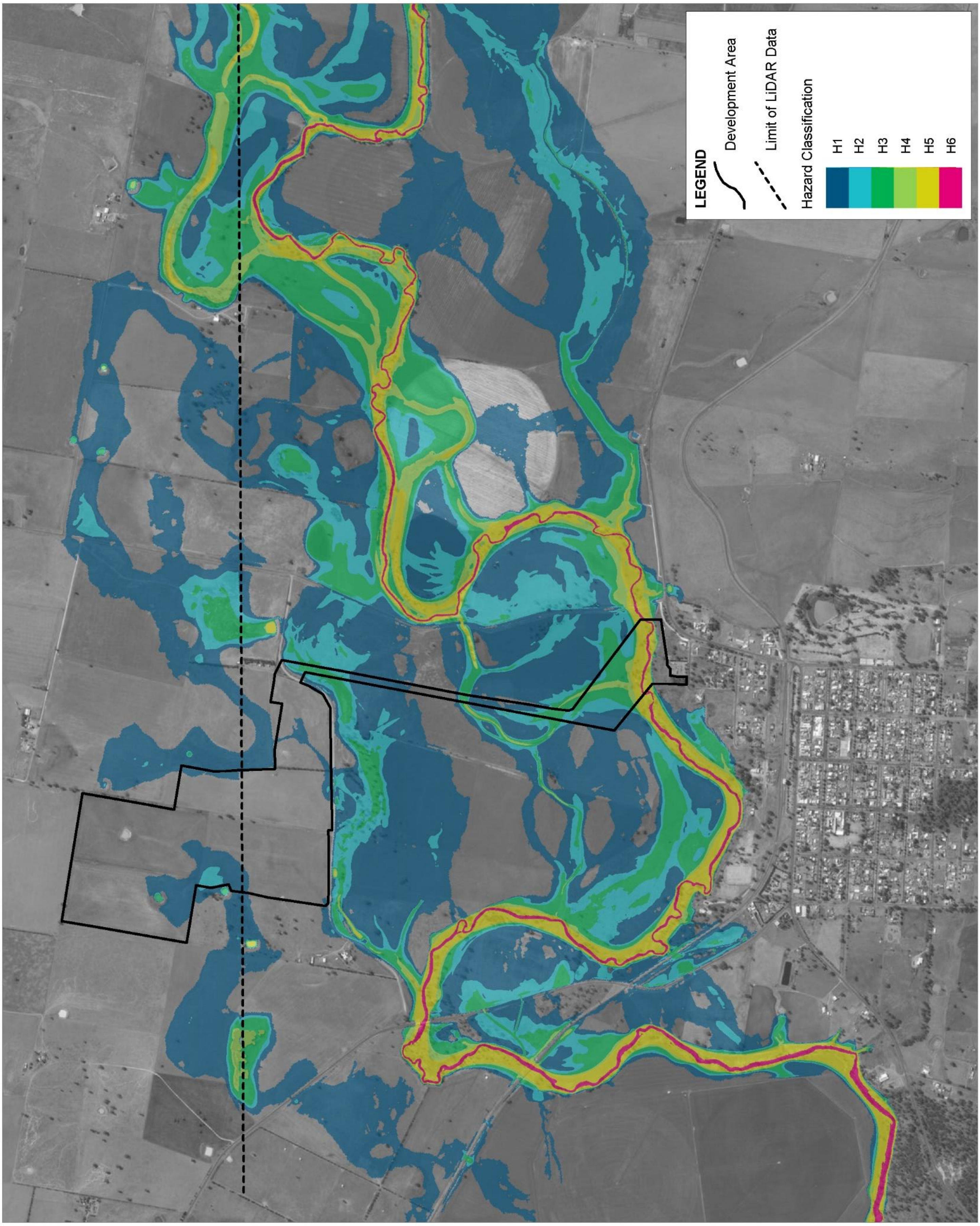

Title:

10% AEP Flood Hazard Classification

Figure: **B-2**

Rev: **D**

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N

0 375 750m

Approx. Scale

BMT

www.bmt.org

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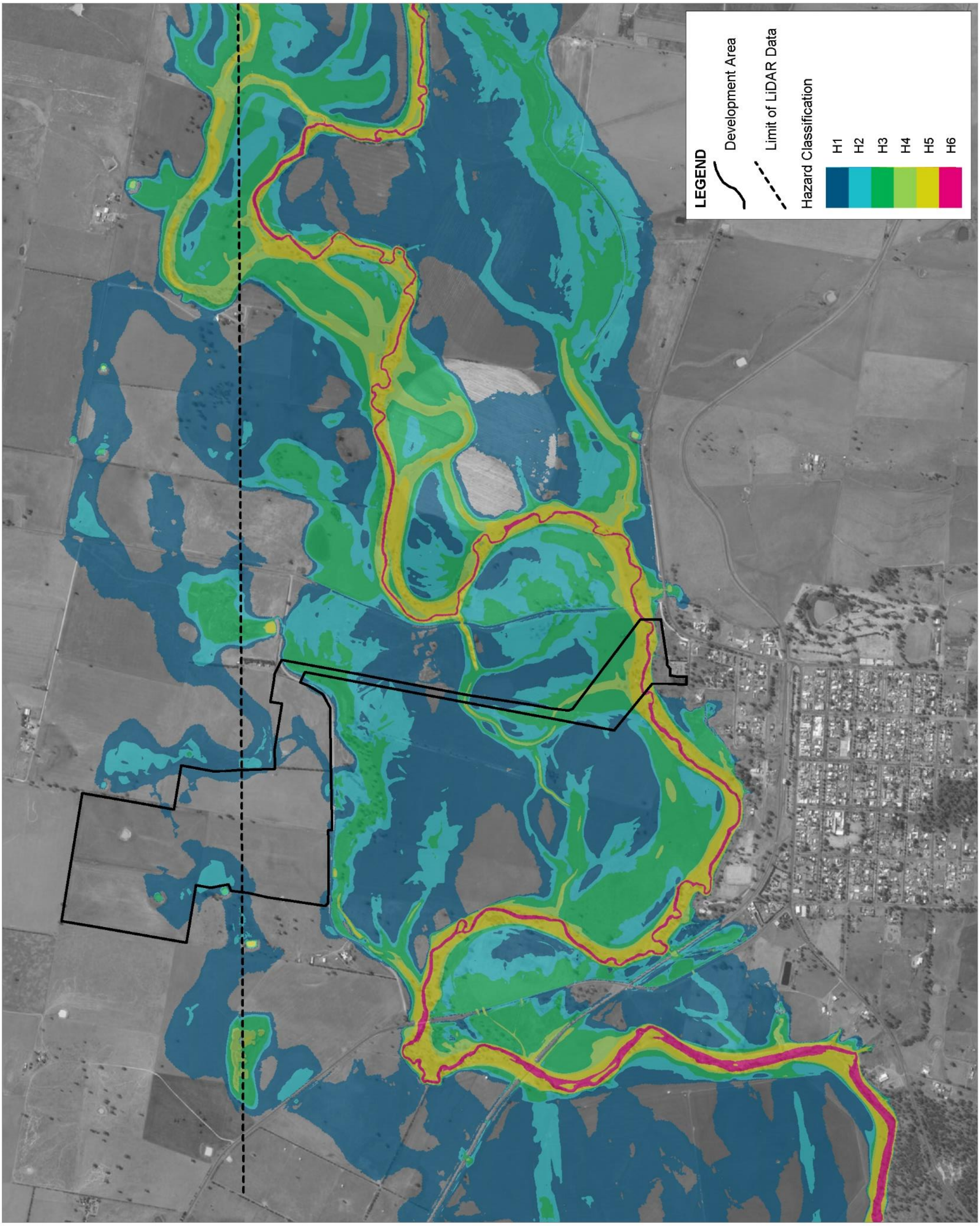


Title:

5% AEP Flood Hazard Classification

Figure:

B-3

Rev:

D

N

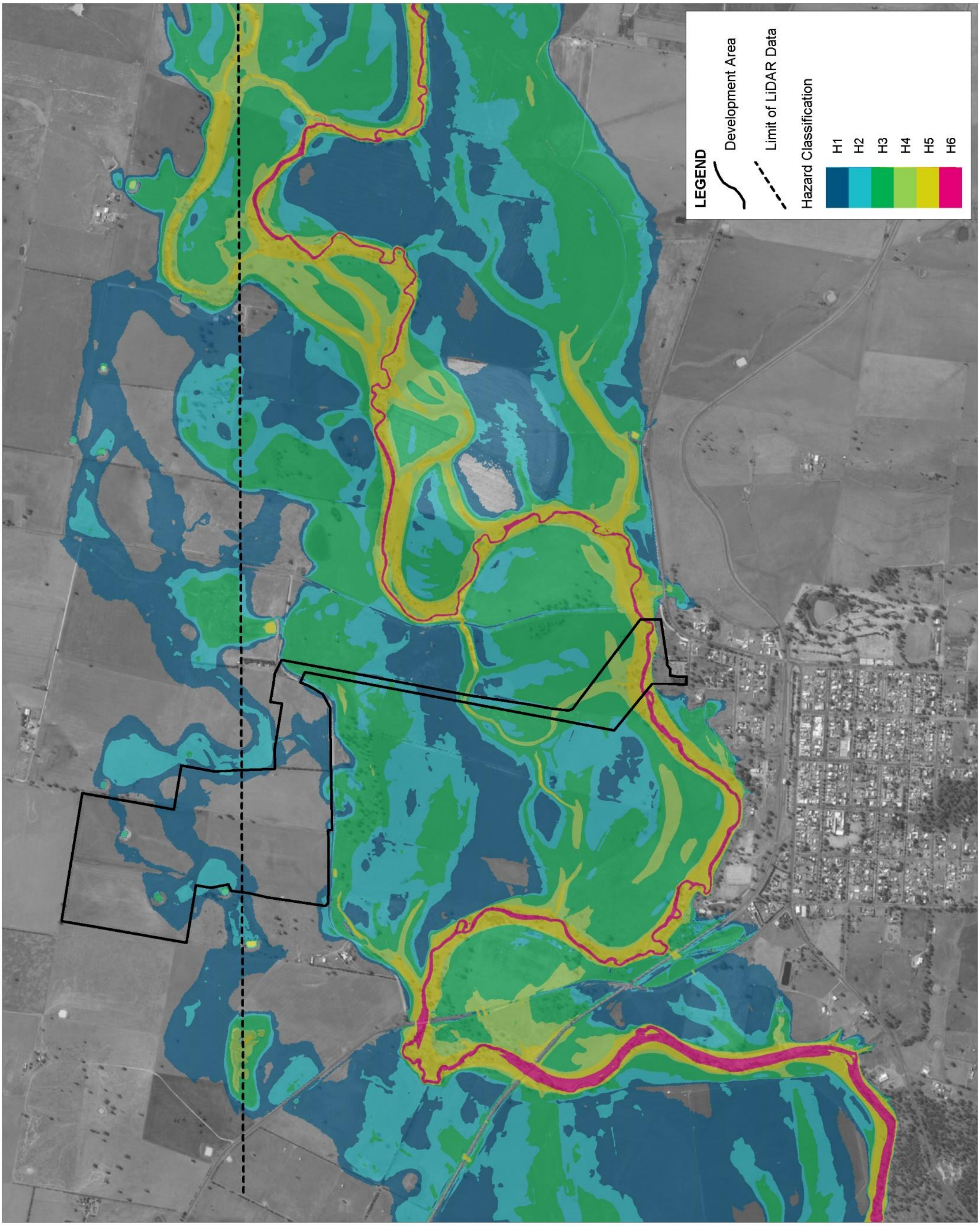
0 375 750m

Approx. Scale

BMT

www.bmt.org

Filepath : K:\N20883_Dunedoo_Substation_FRA\Mapinfo\Workspaces\DRG_015_170821_5%AEP_Hazard.WOR



Title:

2% AEP Flood Hazard Classification

Figure: B-4

Rev: D

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 375 750m

Approx. Scale

BMT

www.bmt.org

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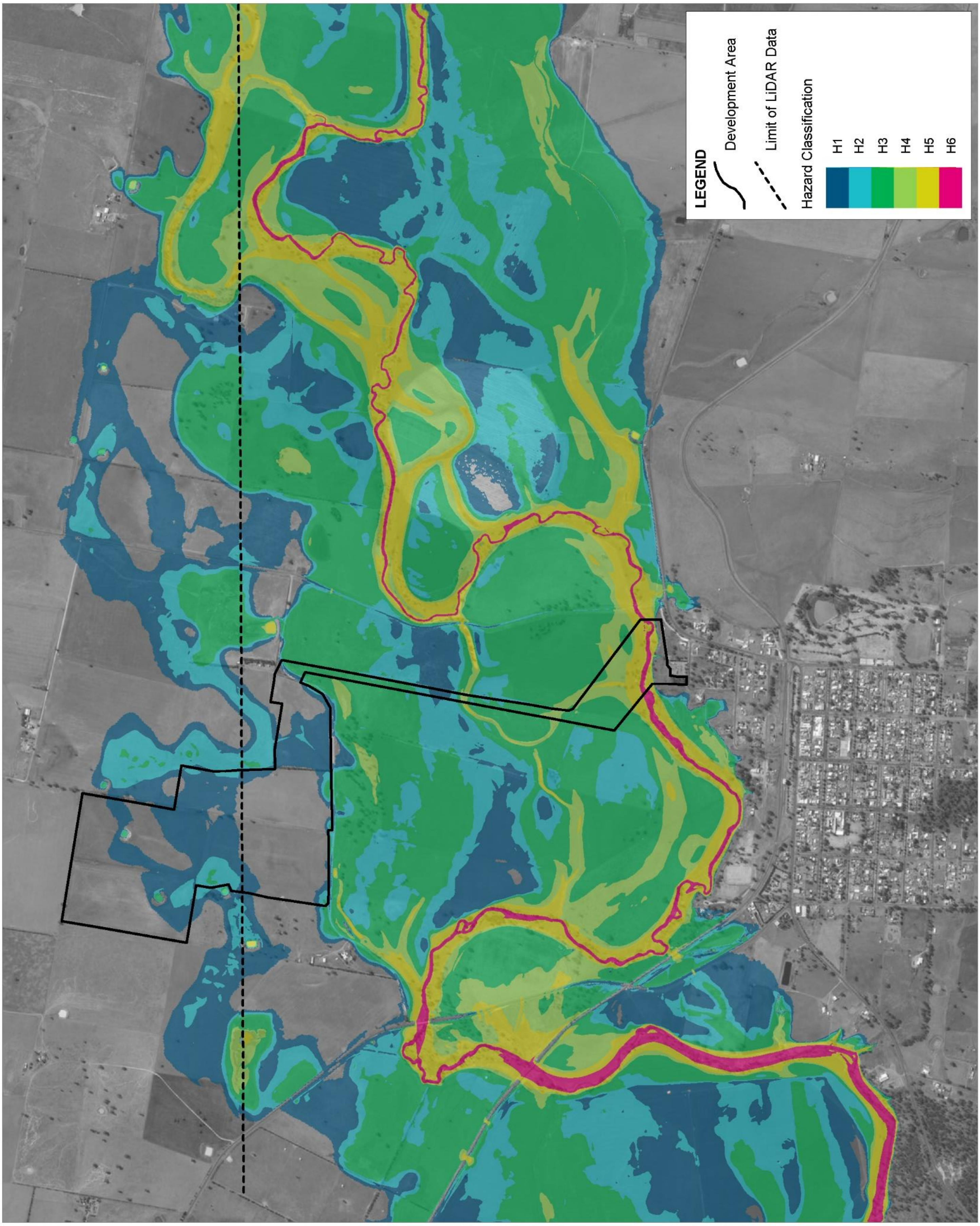


Title:

1% AEP Flood Hazard Classification

Figure: **B-5**

Rev: **D**

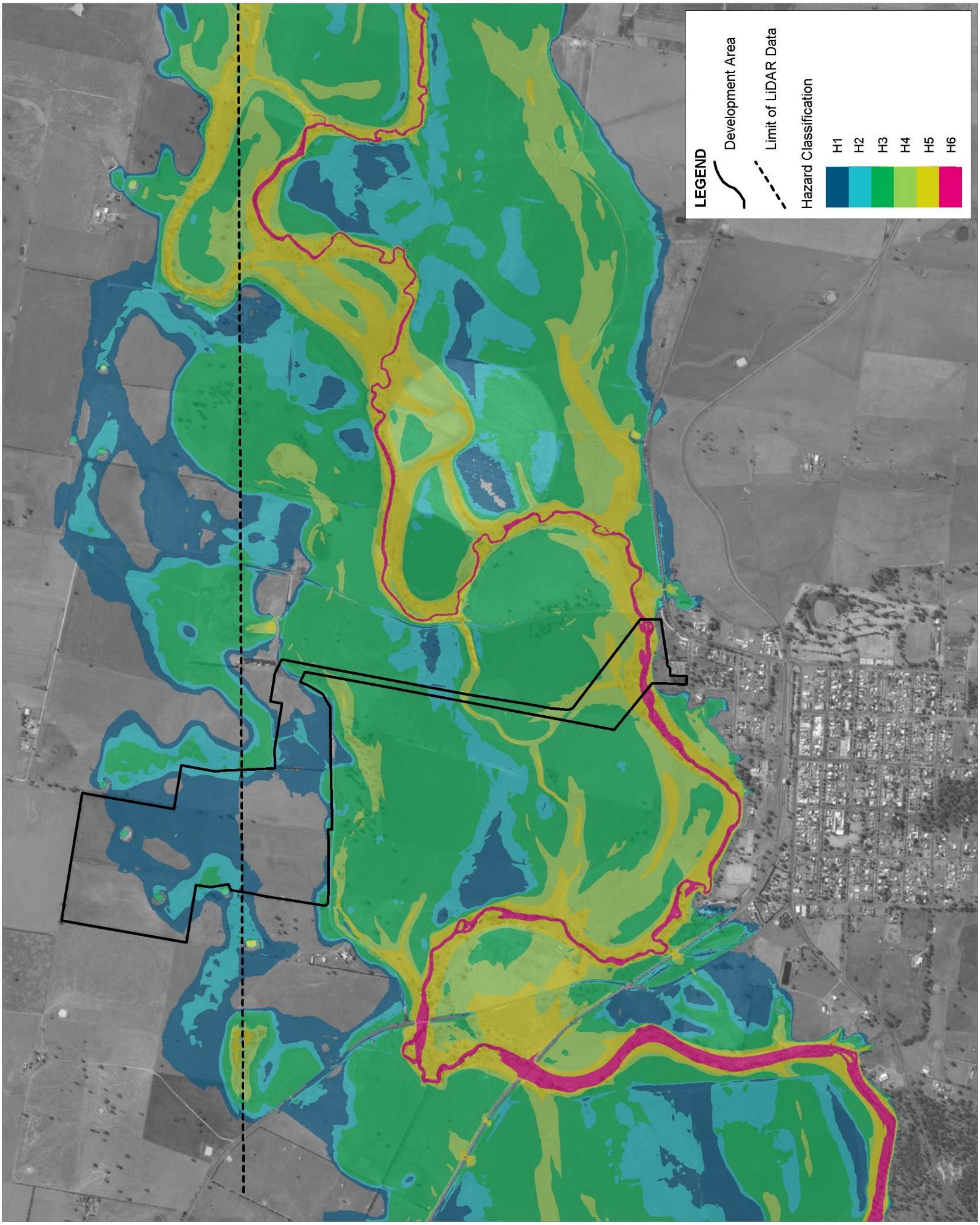
N

0 375 750m

Approx. Scale

www.bmt.org

Filepath : K:\N20883_Dunedoo_Substation_FRA\Mapinfo\Workspaces\DRG_017_170821_1%AEP_Hazard.WOR



Title:

0.5% AEP Flood Hazard Classification

Figure: **B-6**

Rev: **D**

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Approx. Scale

BMT

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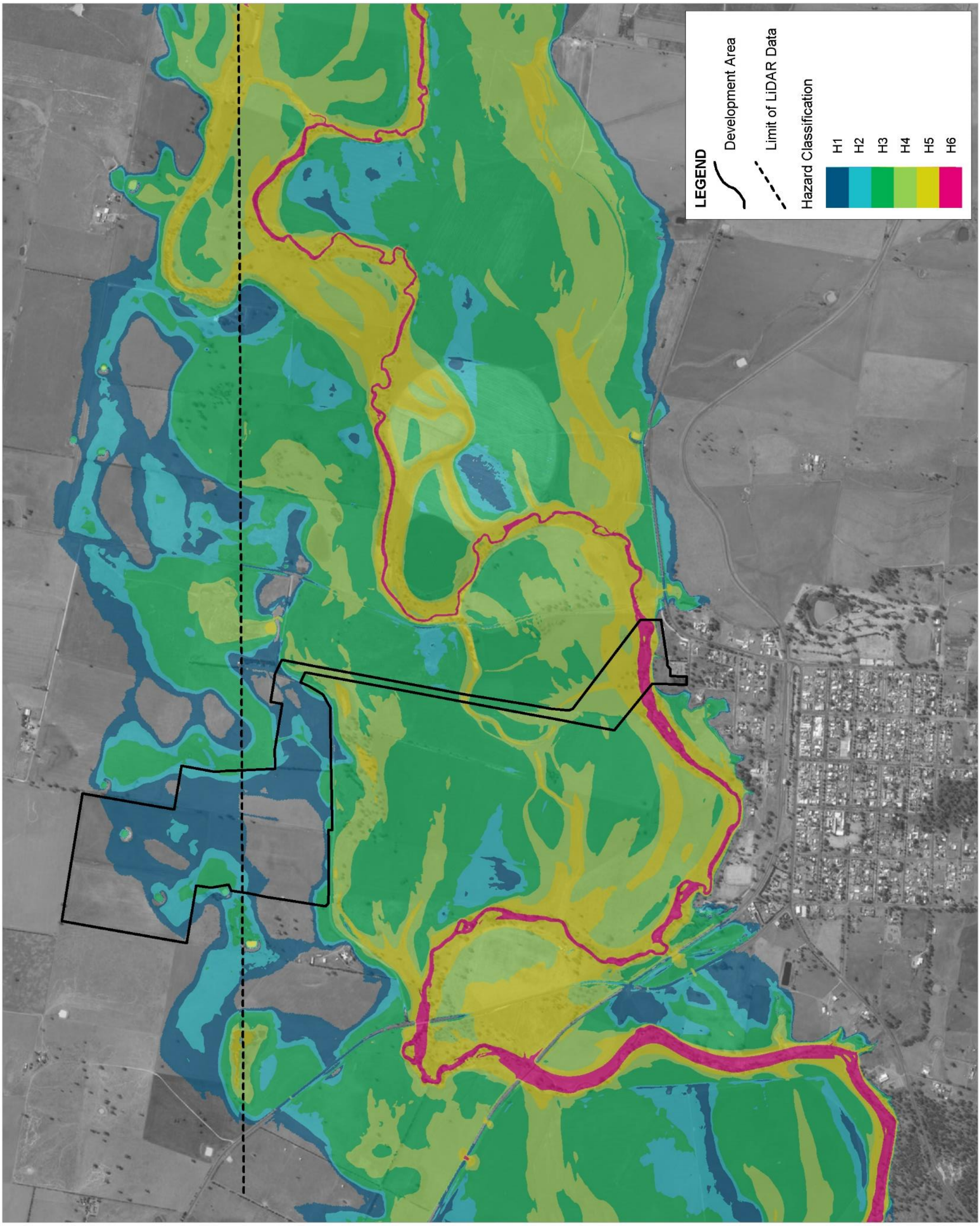

Title:
0.2% AEP Flood Hazard Classification

Figure:
B-7

Rev:
D

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N

0 375 750m
Approx. Scale

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www.bmt.org

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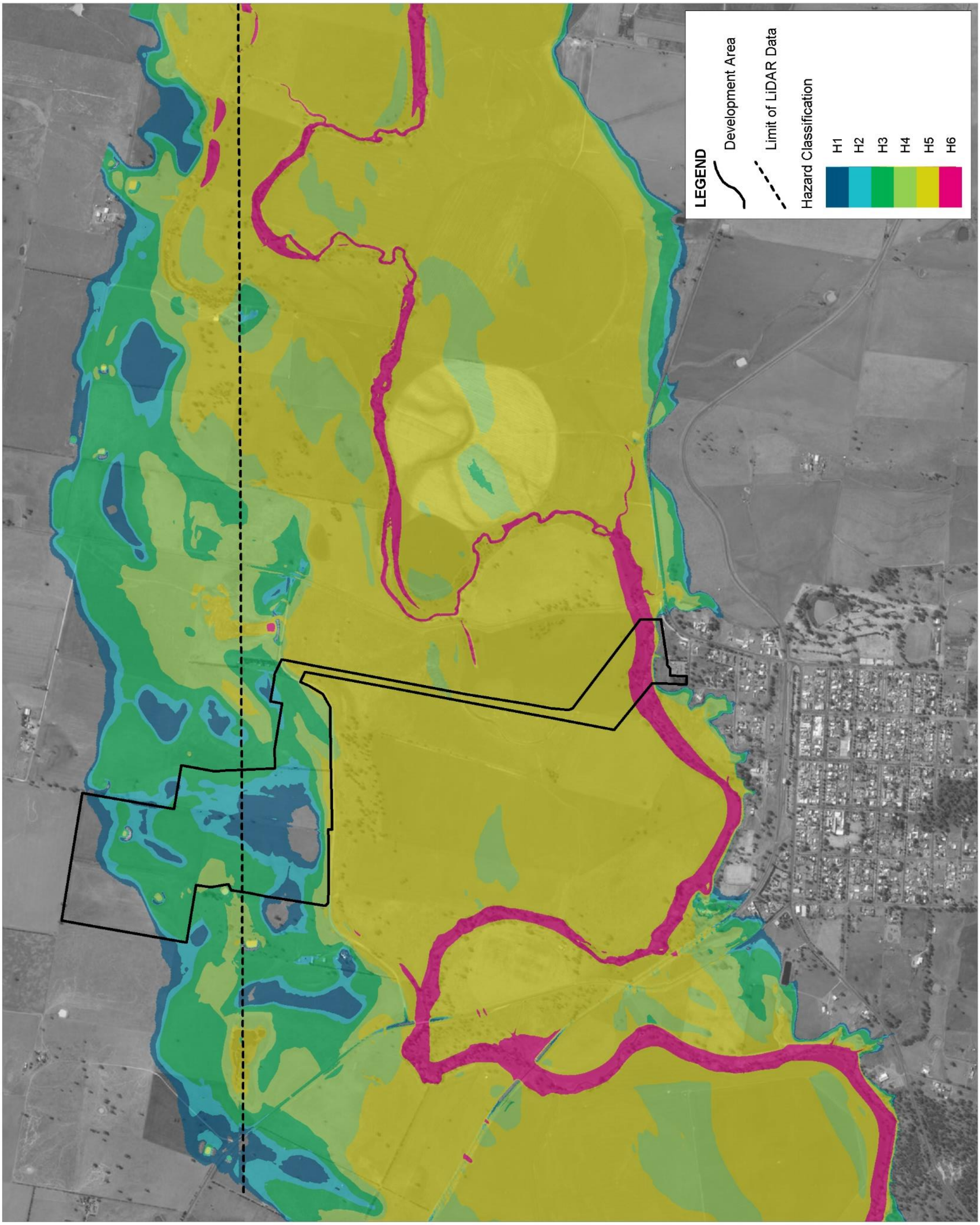

Title:

PMF Flood Hazard Classification

Figure: **B-8**

Rev: **C**

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N

0 375 750m

Approx. Scale

BMT

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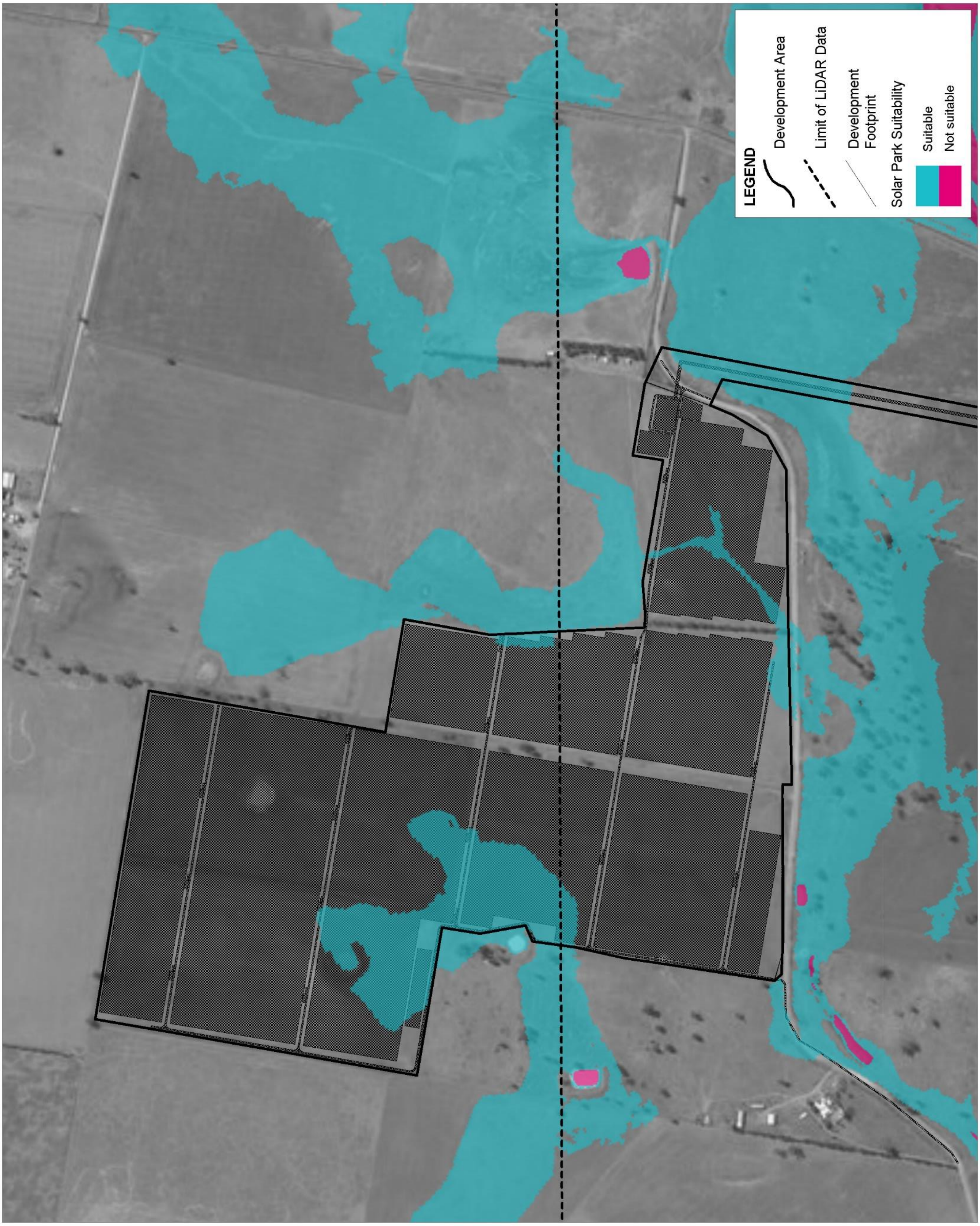
Filepath : K:\N20883_Dunedoo_Substation_FRA\Mapinfo\Workspaces\DRG_028_180112_PMF_Hazard.WOR

Appendix C Land Suitability Mapping



Title:

20% AEP Suitability of Modelled Flood Conditions for Dunedoo Solar Park Development

Figure: C-1

Rev: D

N

0 200 400m

Approx. Scale

BMT

www.bmt.org

Filepath : K:\N20883_Dunedoo_Substation_FRA\Mapinfo\Workspaces\DRG_020_170821_20%AEP_Suitability.WOR

Title:

10% AEP Suitability of Modelled Flood Conditions for Dunedoo Solar Park Development

Figure: **C-2**

Rev: **D**

N

0 200 400m

Approx. Scale

BMT

www.bmt.org

Filepath : K:\N20883_Dunedoo_Substation_FRA\Mapinfo\Workspaces\DRG_021_170821_10%AEP_Suitability.WOR

Title:

5% AEP Suitability of Modelled Flood Conditions for Dunedoo Solar Park Development

Figure: C-3

Rev: D

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 200 400m

Approx. Scale

BMT

www.bmt.org

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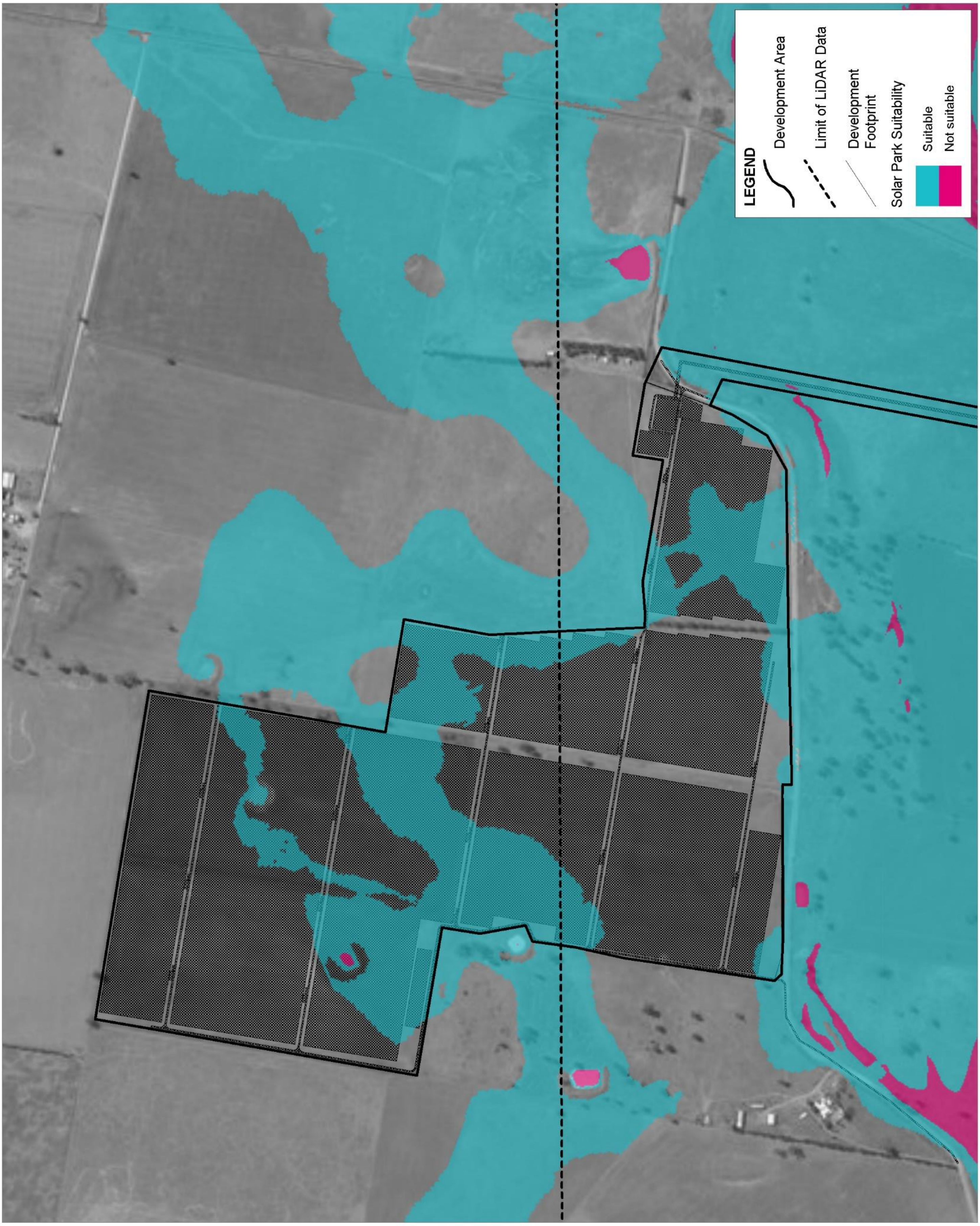

Title:

2% AEP Suitability of Modelled Flood Conditions for Dunedoo Solar Park Development

Figure: C-4

Rev: D

N

0 200 400m

Approx. Scale

BMT

www.bmt.org

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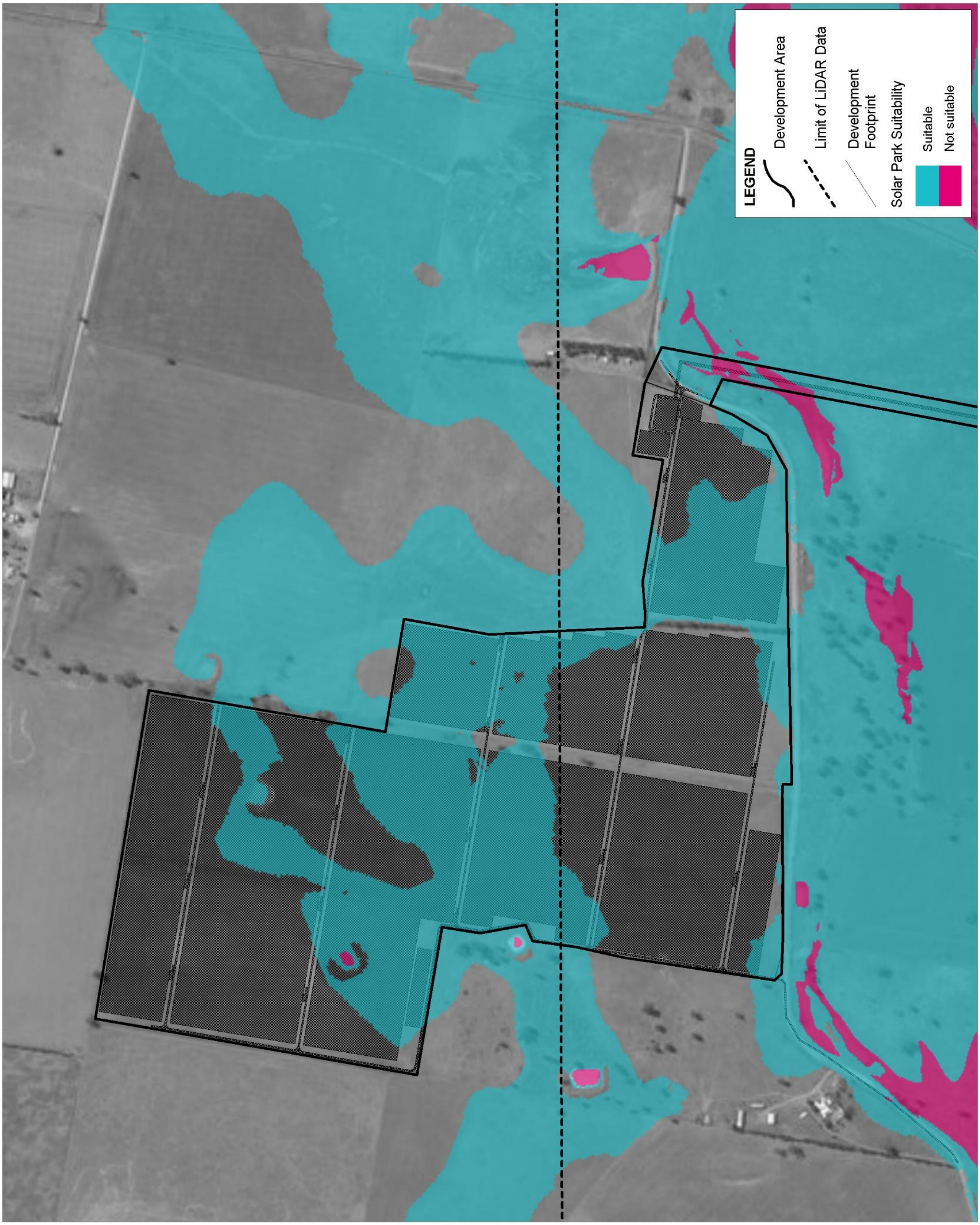

Title:

1% AEP Suitability of Modelled Flood Conditions for Dunedoo Solar Park Development

Figure: C-5

Rev: D

N

0 200 400m

Approx. Scale

BMT

www.bmt.org

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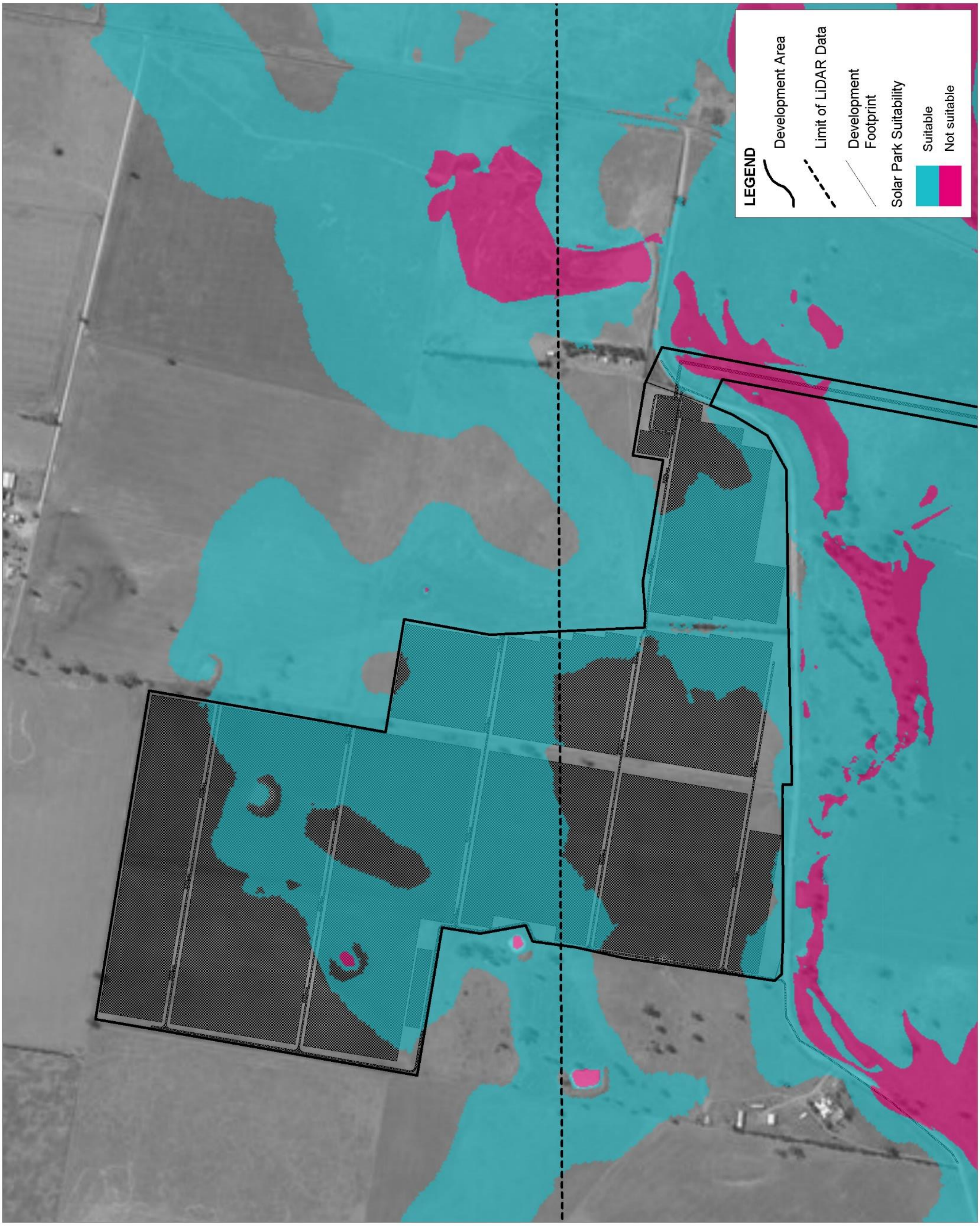

Title:

0.5% AEP Suitability of Modelled Flood Conditions for Dunedoo Solar Park Development

Figure: **C-6**

Rev: **D**

N

0 200 400m

Approx. Scale

BMT

www.bmt.org

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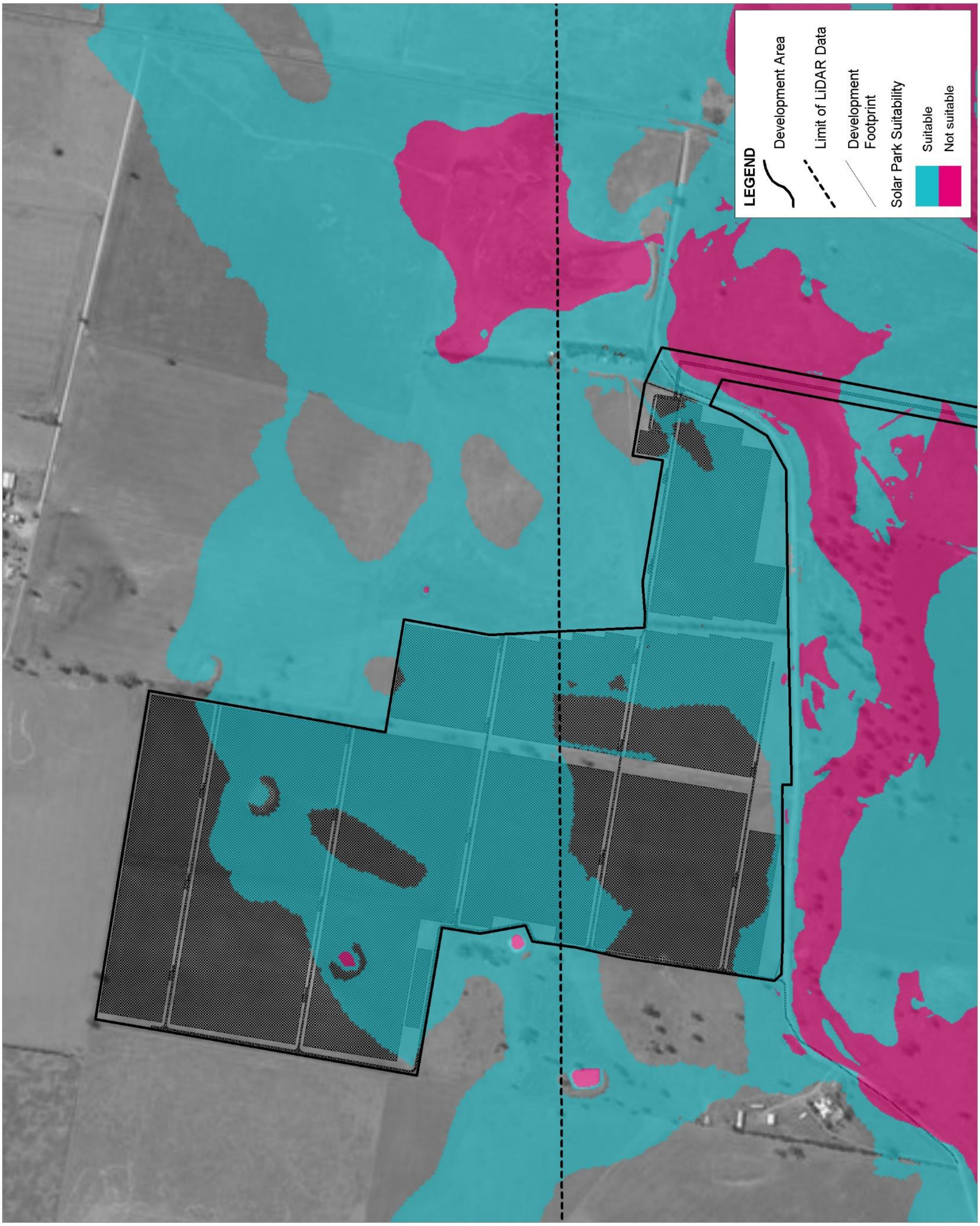

Title:
0.2% AEP Suitability of Modelled Flood Conditions for Dunedoo Solar Park Development

Figure: C-7

Rev: D

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N

0 200 400m

Approx. Scale

BMT

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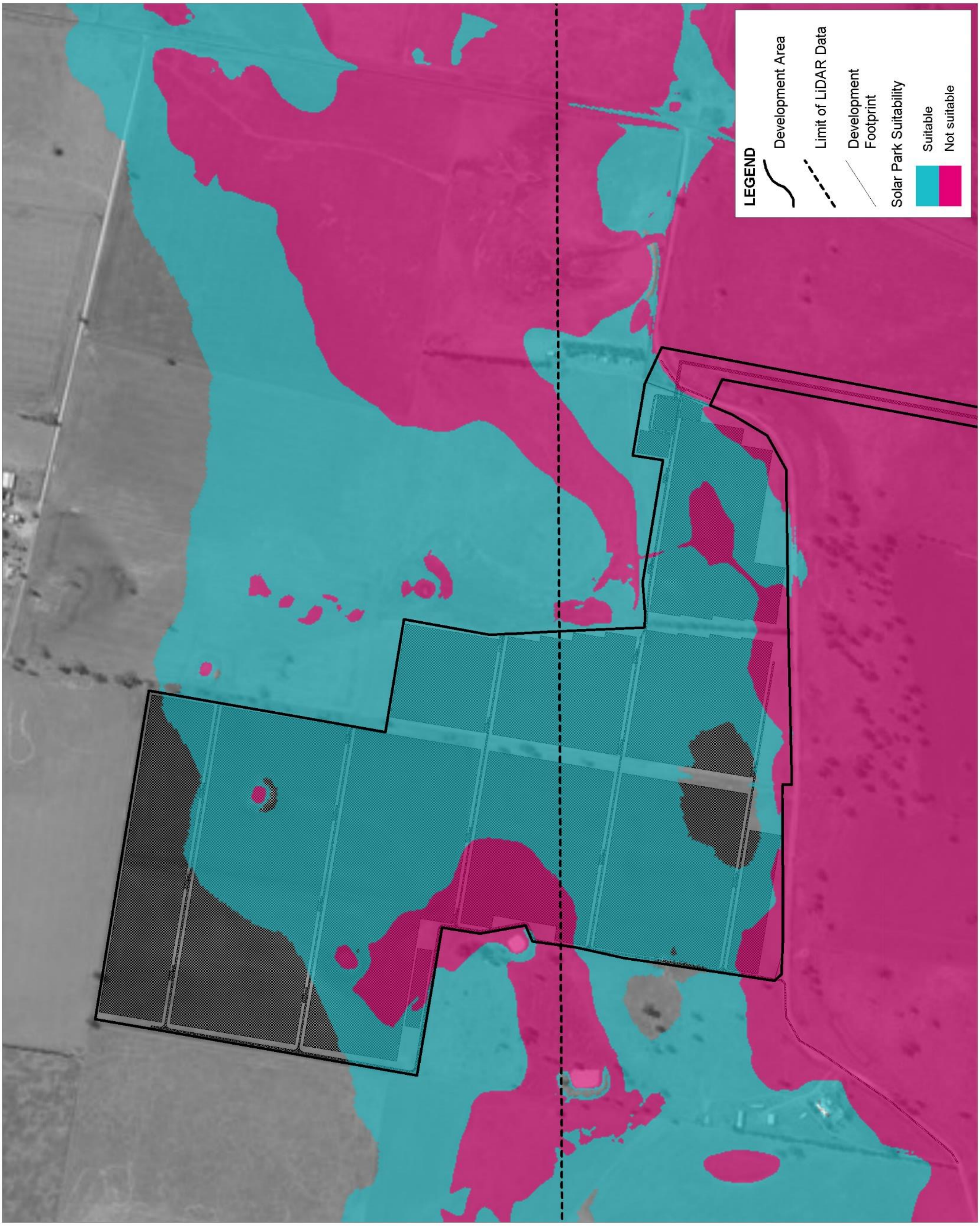

Title:

PMF Suitability of Modelled Flood Conditions for Dunedoo Solar Park Development

Figure: C-8

Rev: D

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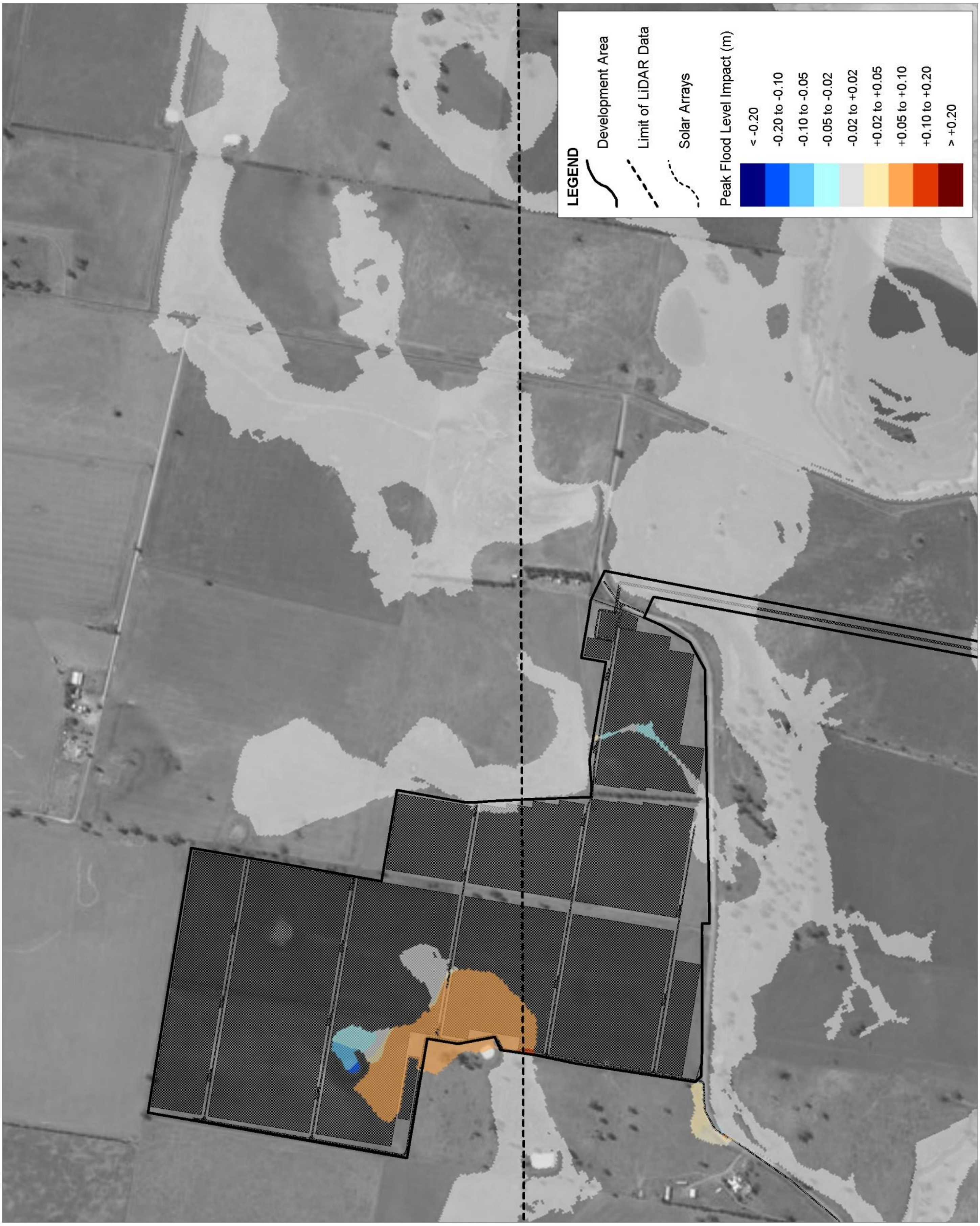
Filepath : K:\N20883_Dunedoo_Substation_FRA\Mapinfo\Workspaces\DRG_029_180112_PMF_Suitability.WOR

Appendix D Flood Level Impact Mapping



Title:

20% AEP Modelled Peak Flood Level Impact

Figure: D-1

Rev: D

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N

0 200 400m

Approx. Scale

BMT

www.bmt.org

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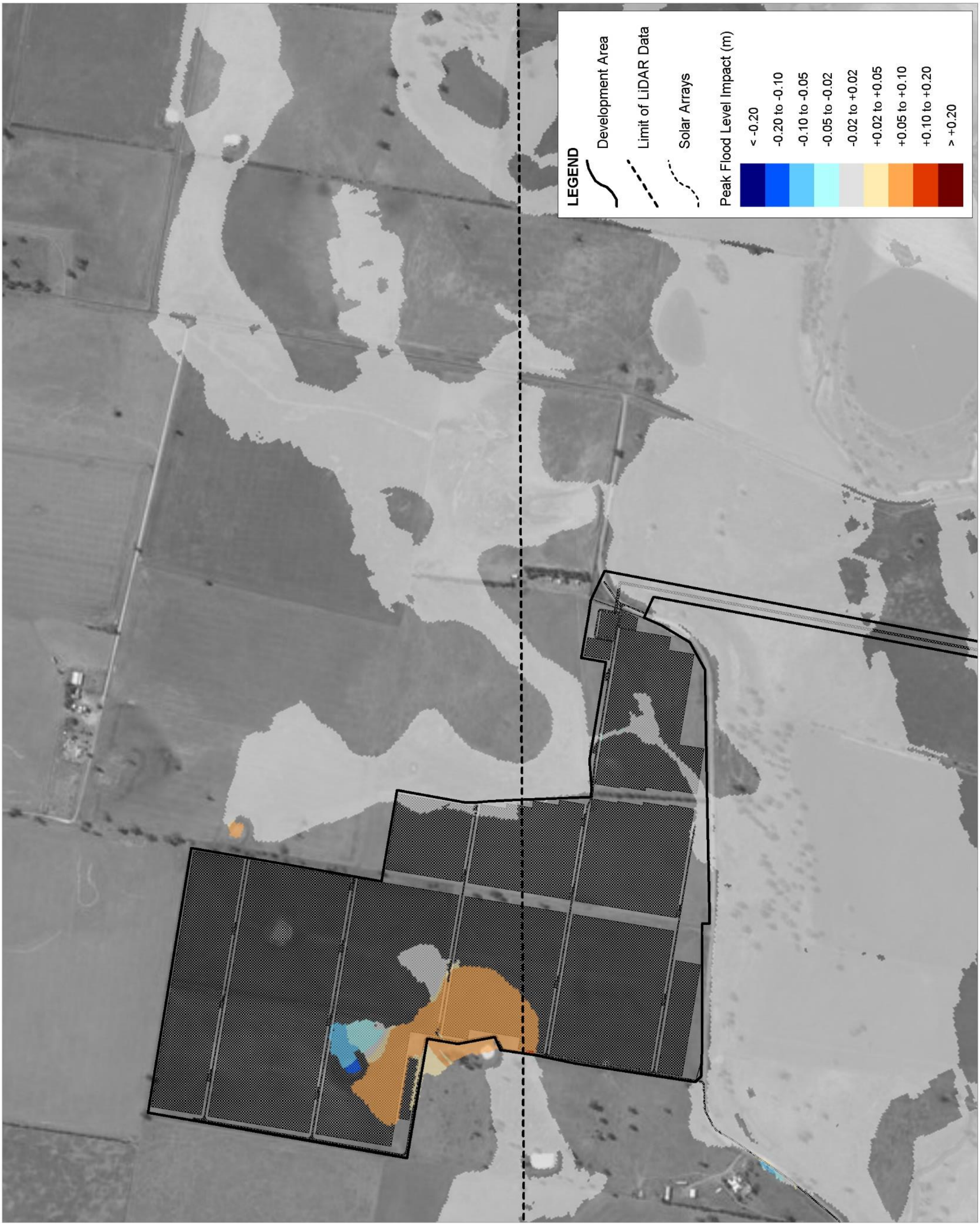

Title:
10% AEP Modelled Peak Flood Level Impact

Figure: **D-2**

Rev: **D**

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N

0 200 400m
Approx. Scale

BMT
www.bmt.org

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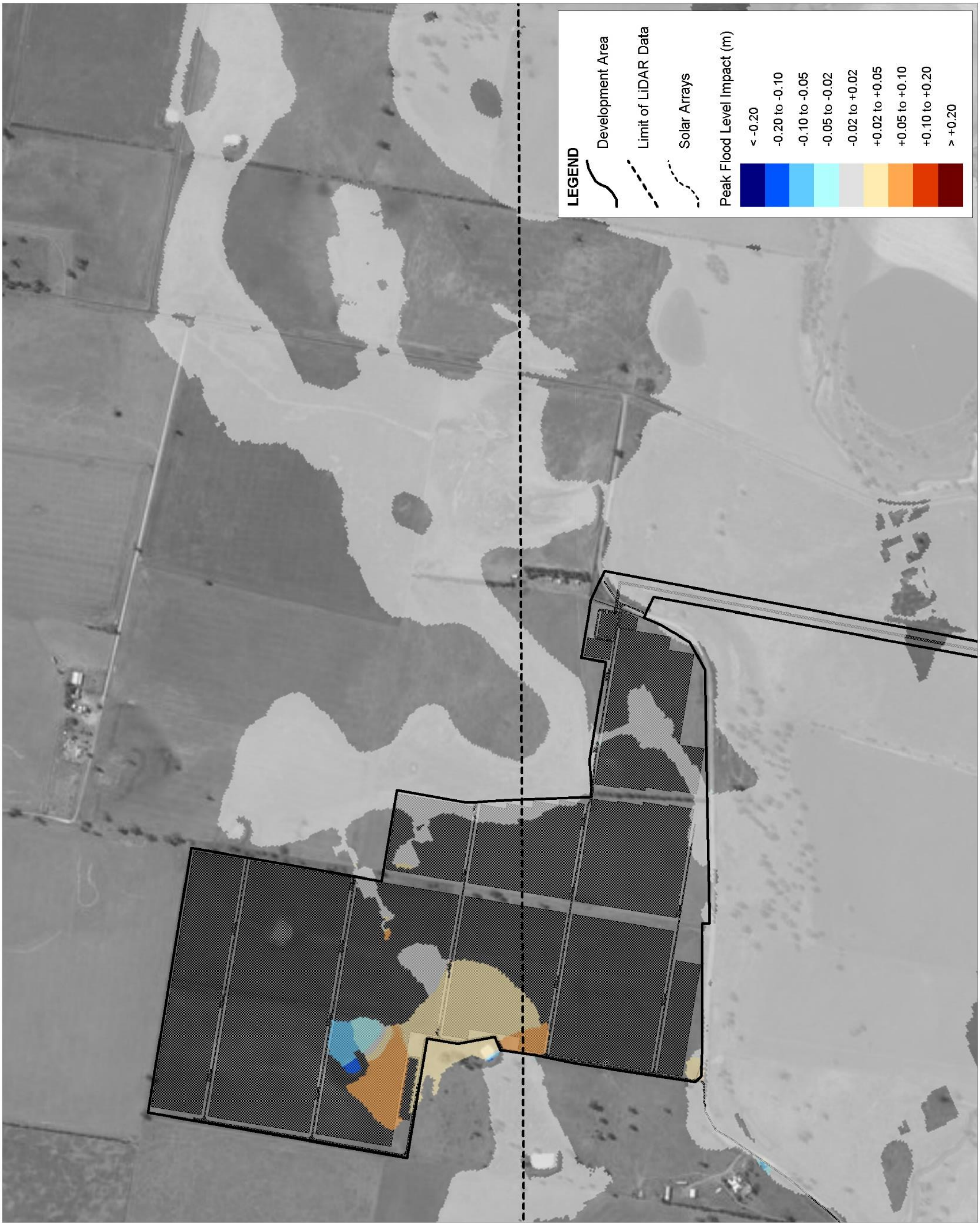

Title:

5% AEP Modelled Peak Flood Level Impact

Figure: **D-3**

Rev: **D**

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N

0 200 400m

Approx. Scale

BMT

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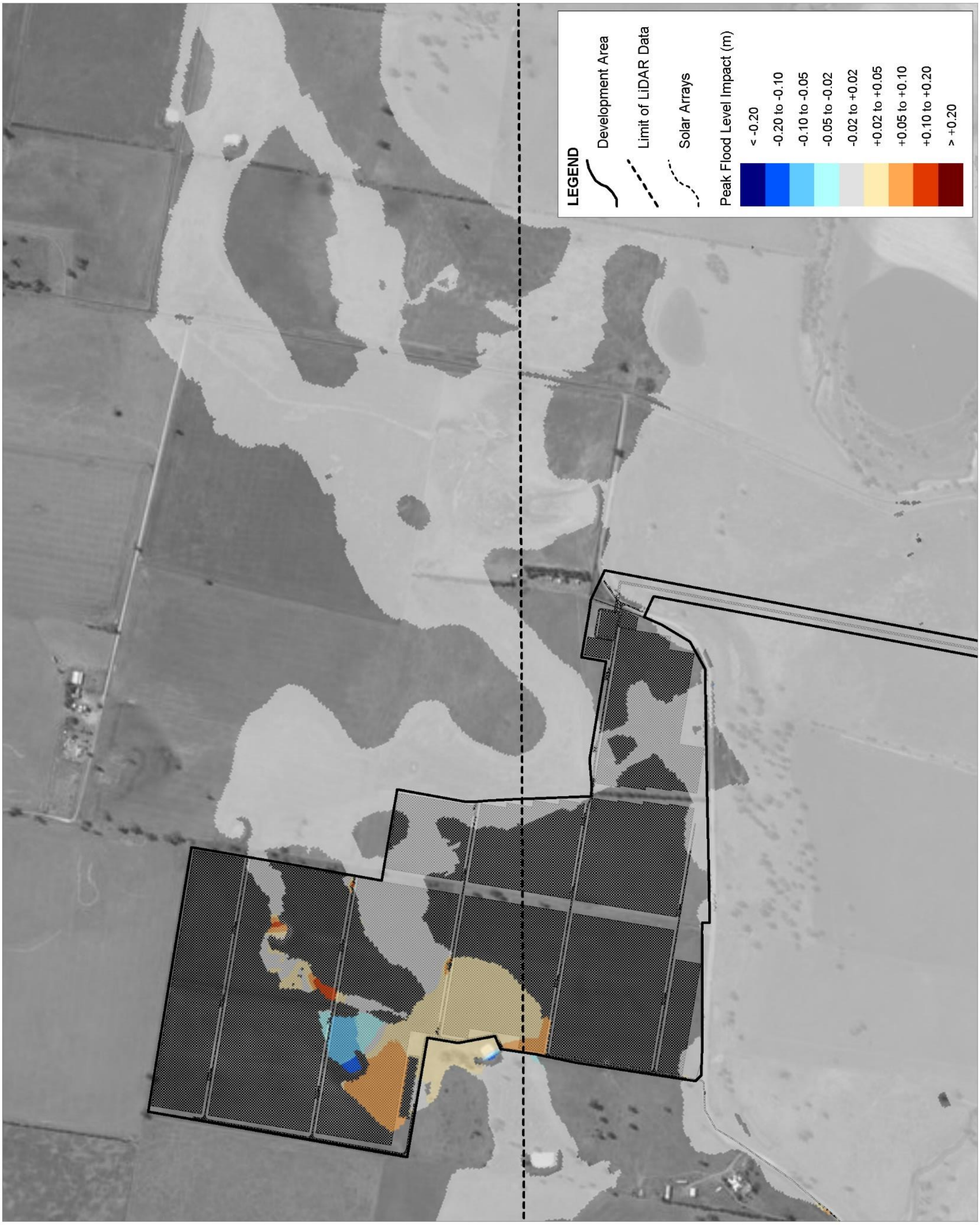

Title:
2% AEP Modelled Peak Flood Level Impact

Figure:
D-4

Rev:
D

N

0 200 400m
Approx. Scale

BMT
www.bmt.org

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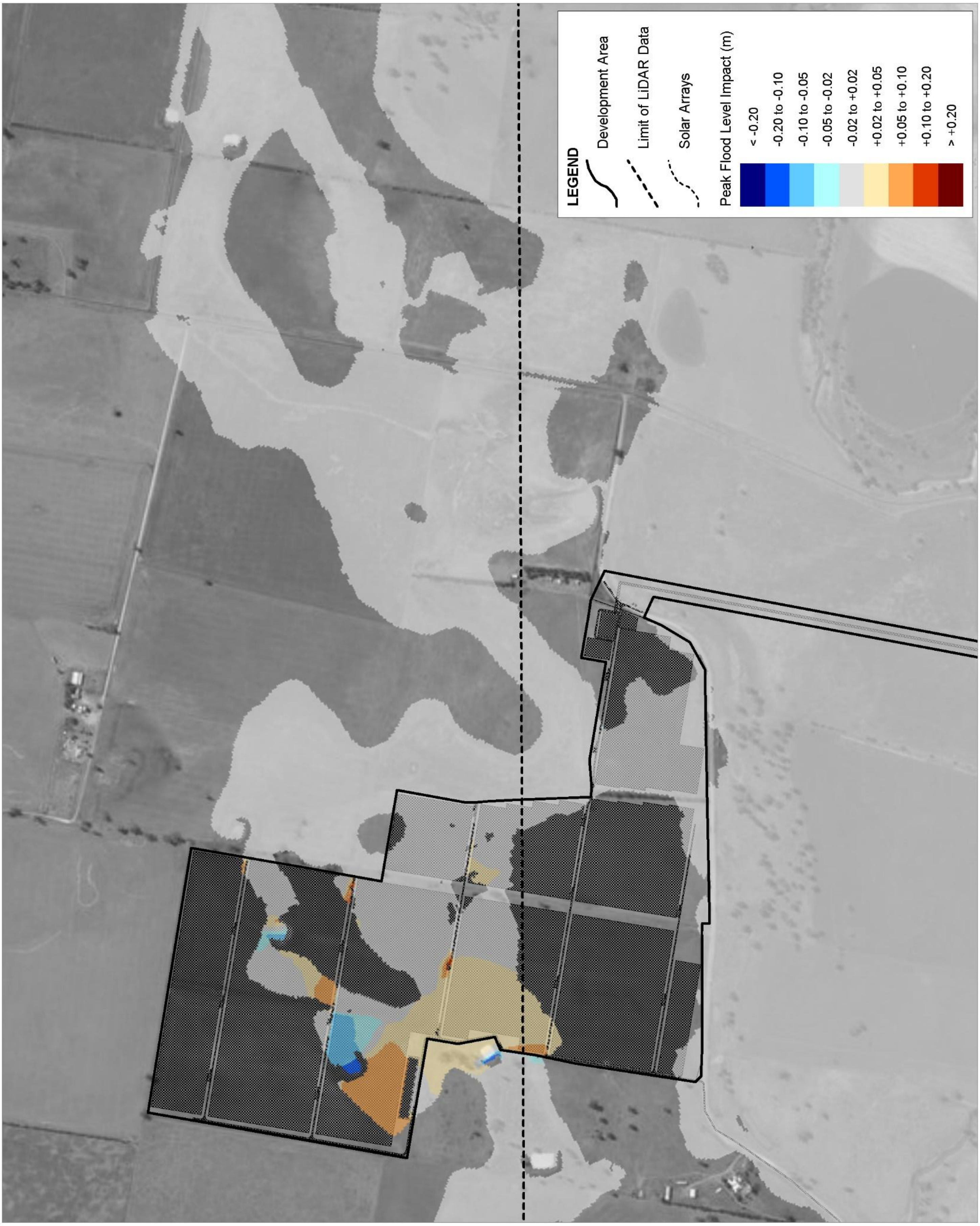

Title:
1% AEP Modelled Peak Flood Level Impact

Figure:
D-5

Rev:
D

N

0 200 400m
Approx. Scale

BMT
www.bmt.org

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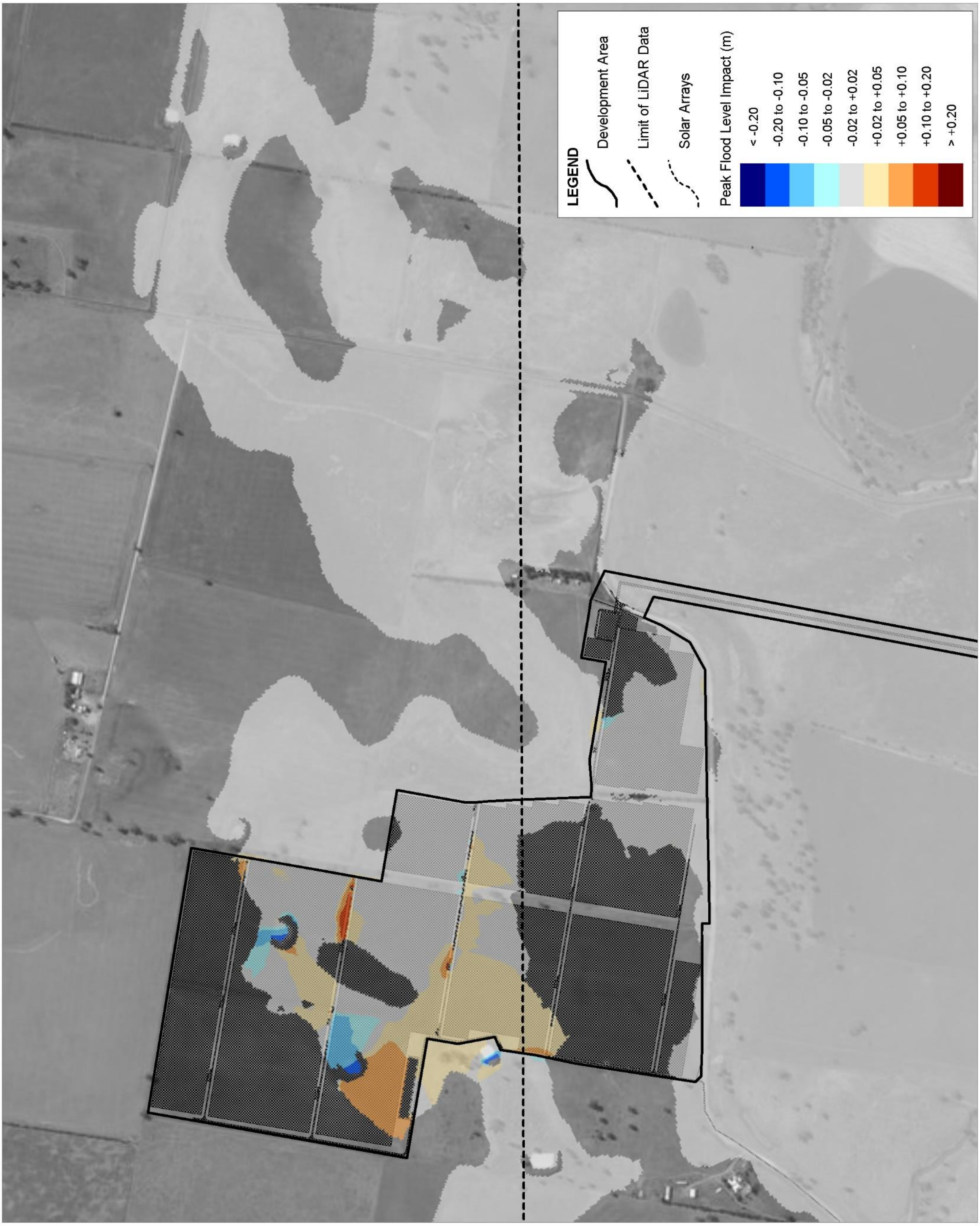

Title:

0.5% AEP Modelled Peak Flood Level Impact

Figure: D-6

Rev: D

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N

0 200 400m

Approx. Scale

BMT

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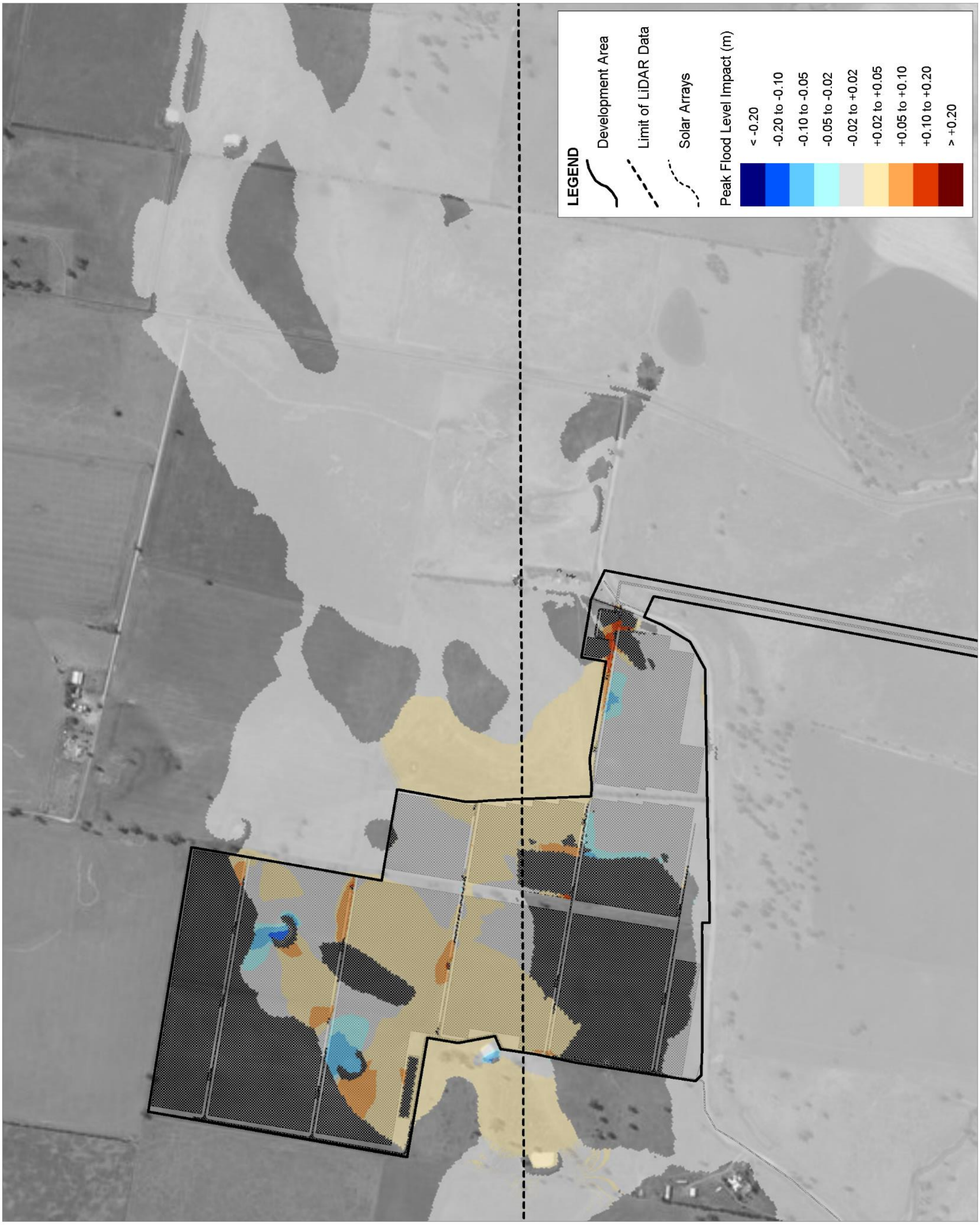

Title:
0.2% AEP Modelled Peak Flood Level Impact

Figure:
D-7

Rev:
D

N

0 200 400m
Approx. Scale

BMT
www.bmt.org

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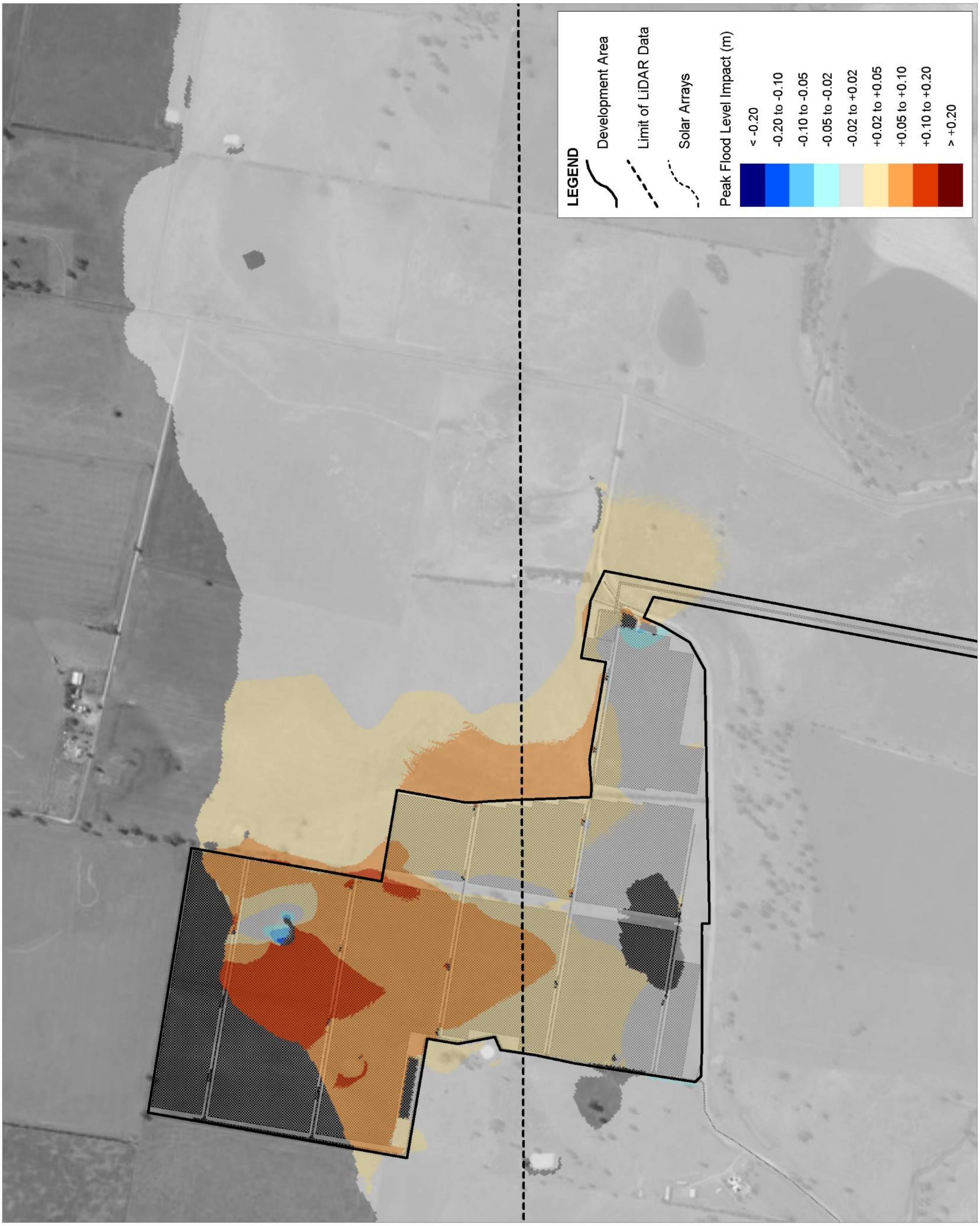

Title:

PMF Modelled Peak Flood Level Impact

Figure: **D-8**

Rev: **D**

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N

0 200 400m
Approx. Scale

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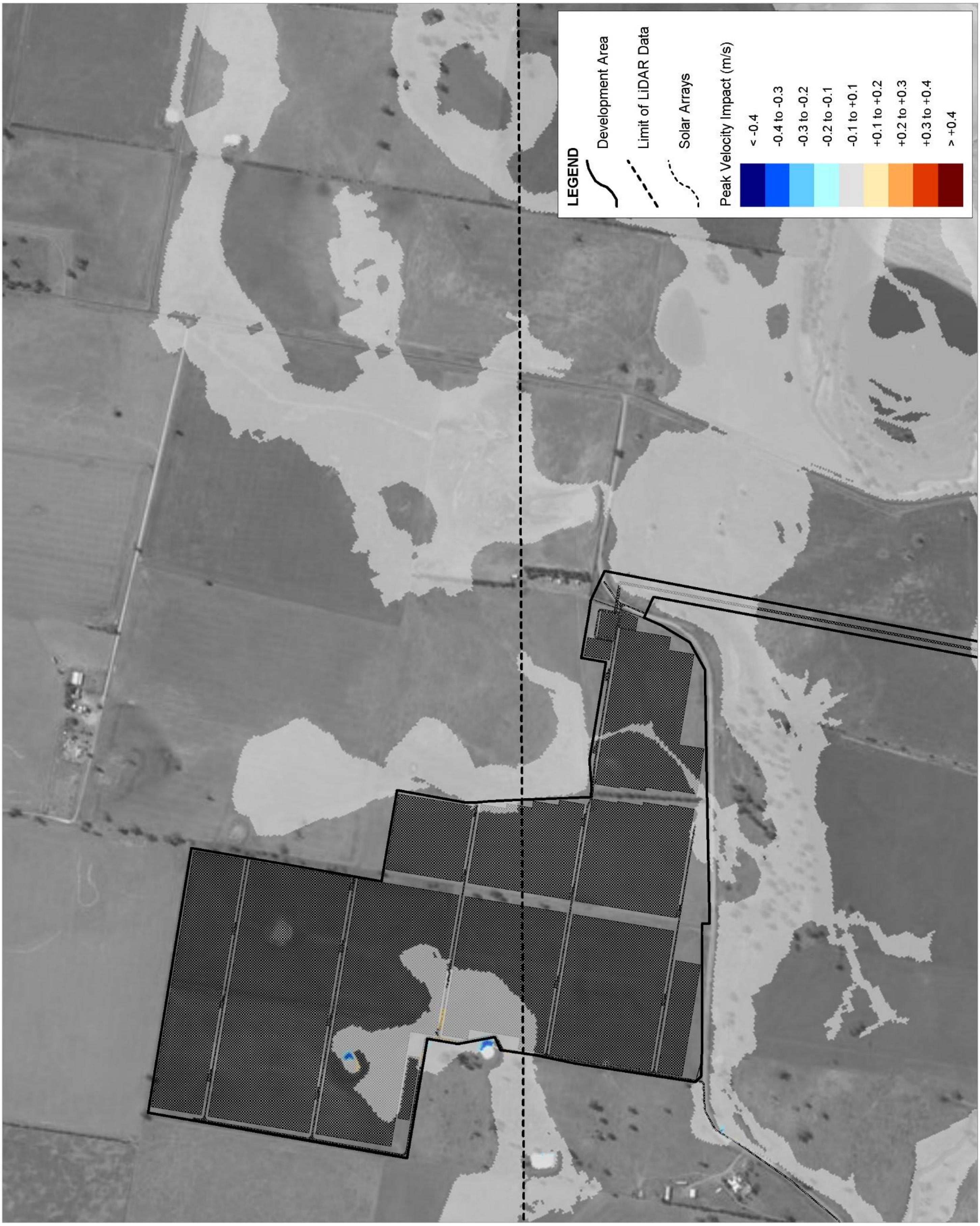
Filepath : K:\N20883_Dunedoo_Substation_FRA\Mapinfo\Workspaces\DRG_037_180112_PMF_h_Impact.WOR

Appendix E Flood Velocity Impact Mapping



Title:

20% AEP Modelled Peak Flood Velocity Impact

Figure: E-1

Rev: D

BMT
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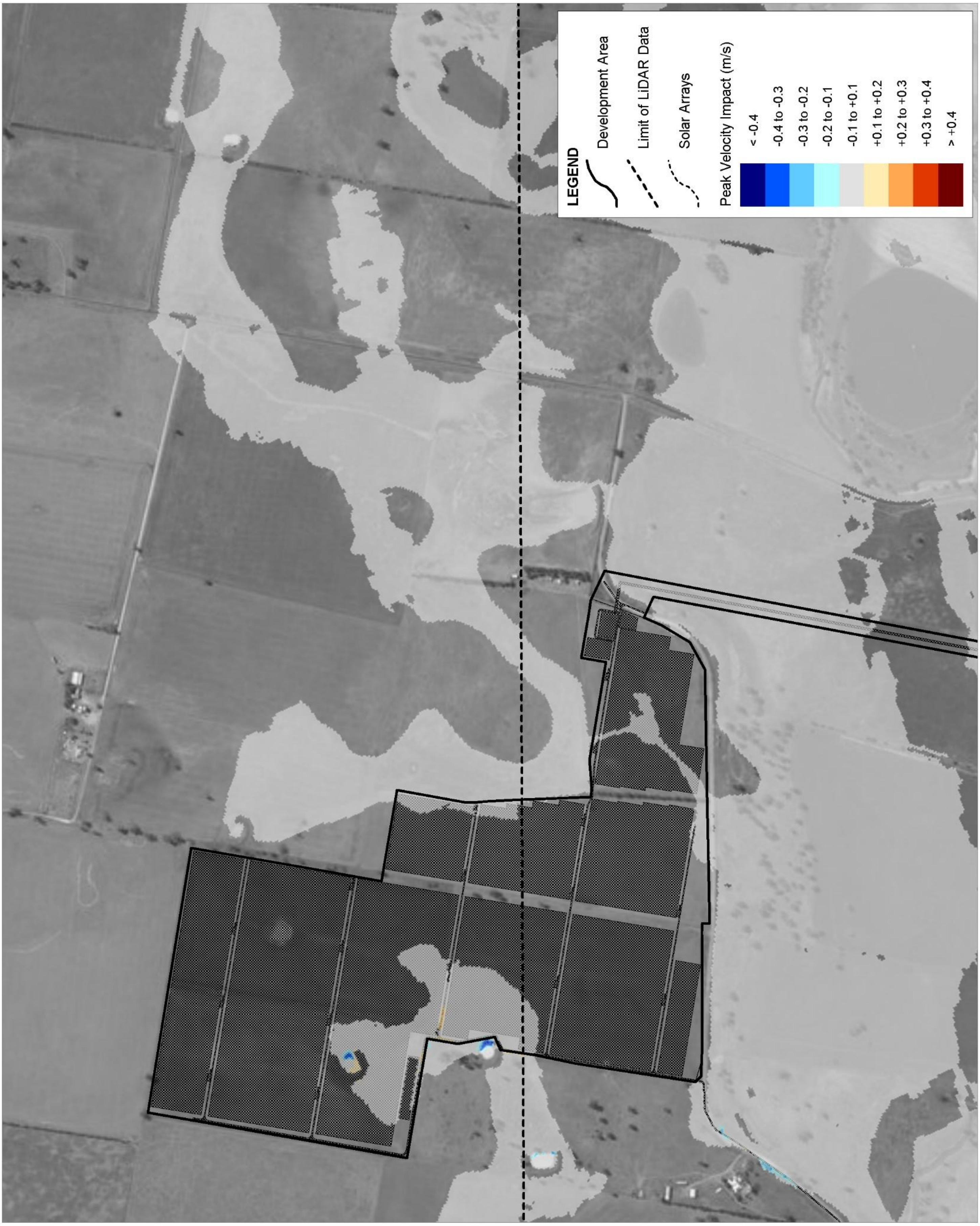
Filepath : K:\N20883_Dunedoo_Substation_FRA\Mapinfo\Workspaces\DRG_038_180112_20%AEP_v_impact.WOR



Title:
10% AEP Modelled Peak Flood Velocity Impact

Figure: **E-2**

Rev: **D**

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N

0 200 400m
Approx. Scale

BMT
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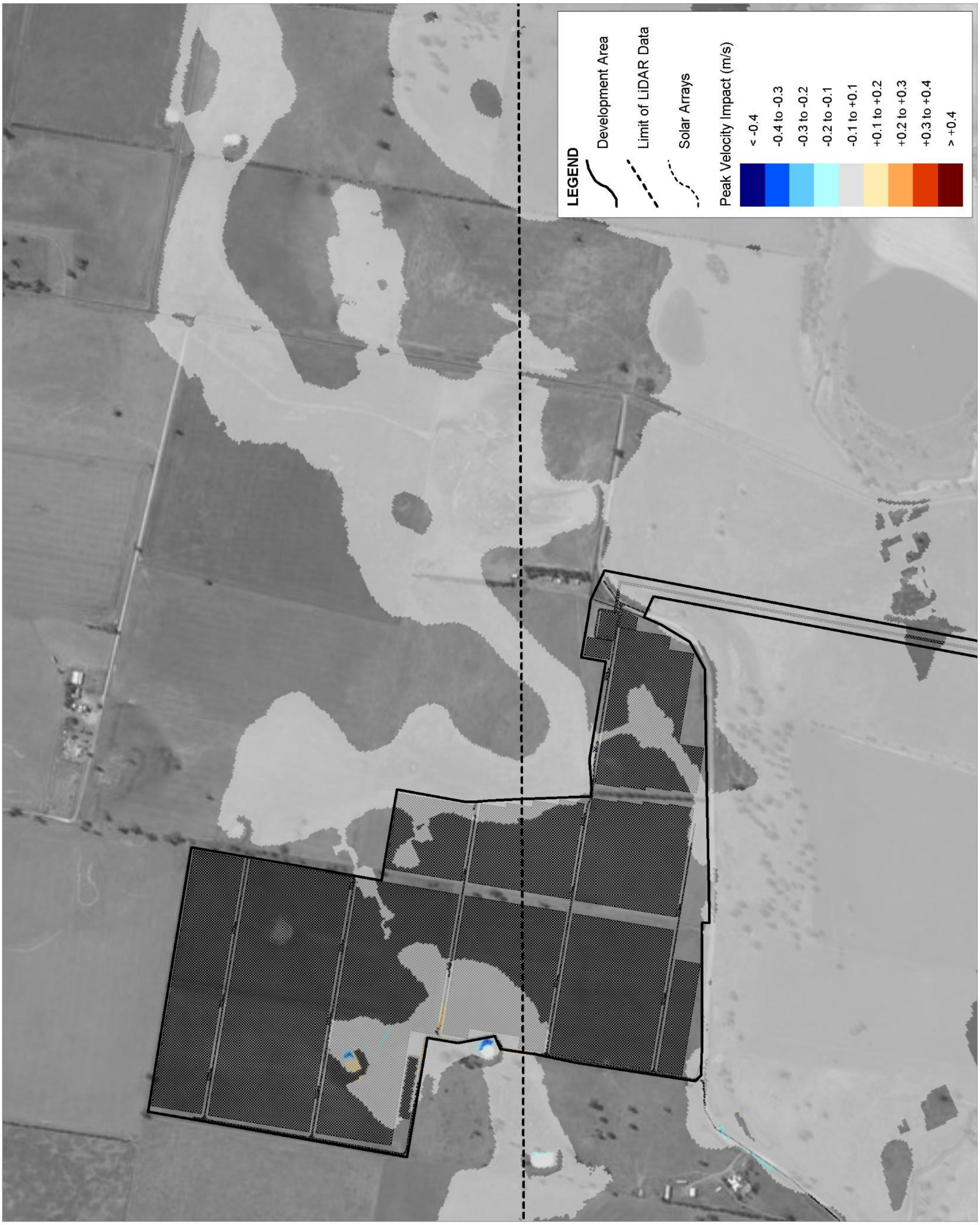

Title:
5% AEP Modelled Peak Flood Velocity Impact

Figure: **E-3**

Rev: **D**

N

0 200 400m
Approx. Scale

BMT
www.bmt.org

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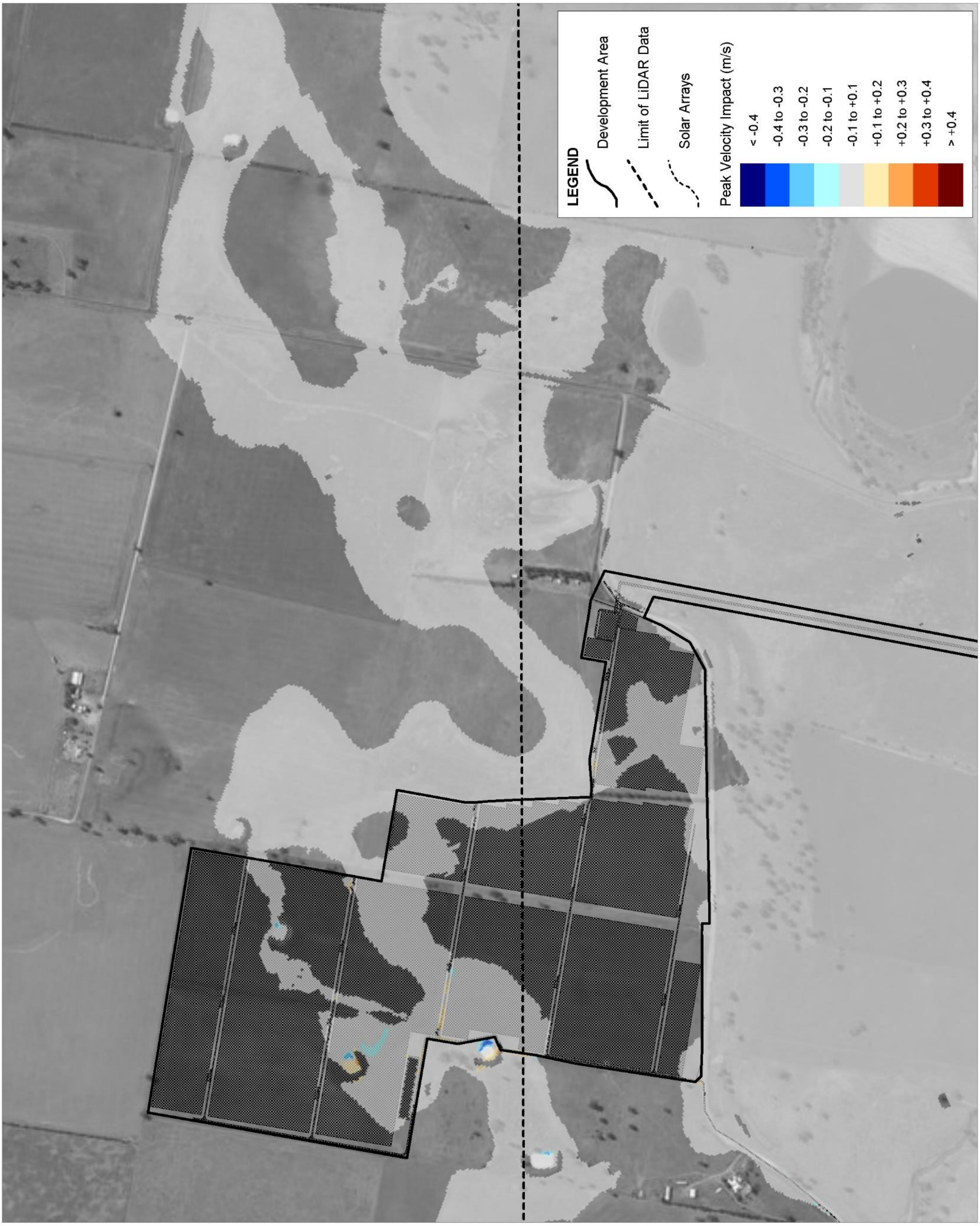


Title:
2% AEP Modelled Peak Flood Velocity Impact

Figure:
E-4

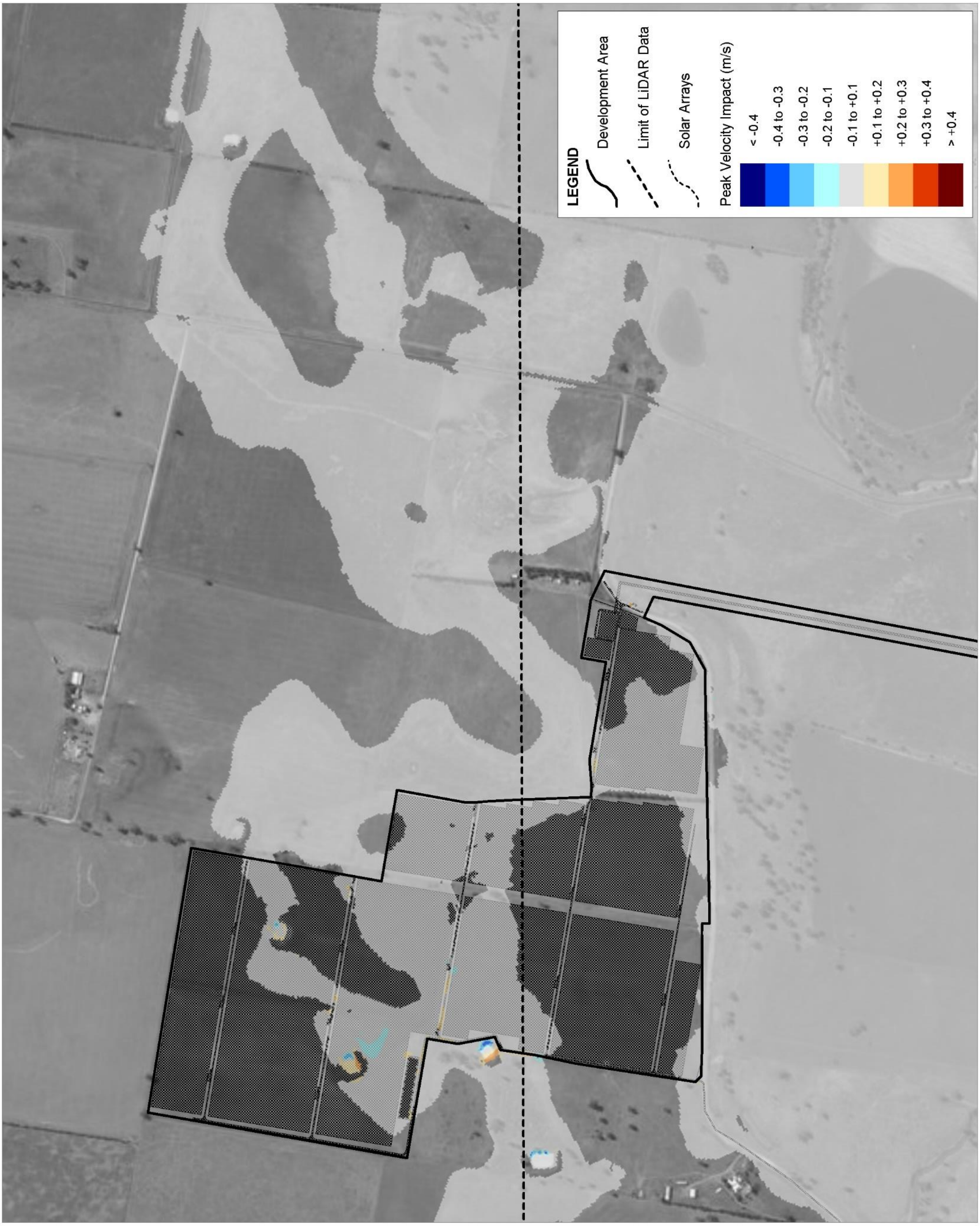
Rev:
D

N

0 200 400m
Approx. Scale

BMT
www.bmt.org

Filepath : K:\N20883_Dunedoo_Substation_FRA\Mapinfo\Workspaces\DRG_041_180112_2%AEP_v_impact.WOR



Title:

1% AEP Modelled Peak Flood Velocity Impact

Figure: E-5

Rev: D

N

0 200 400m

Approx. Scale

BMT

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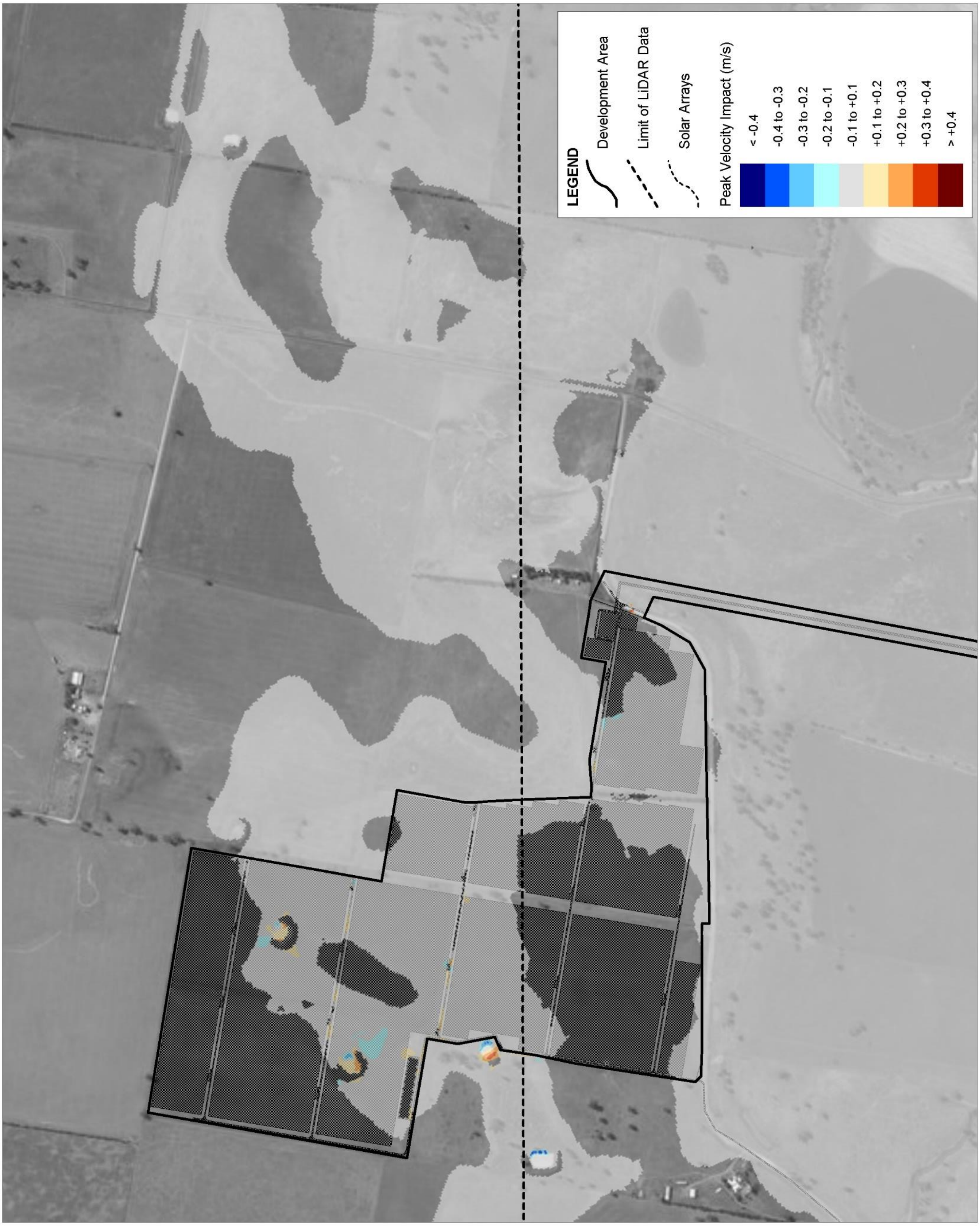

Title:

0.5% AEP Modelled Peak Flood Velocity Impact

Figure: **E-6**

Rev: **D**

N

0 200 400m

Approx. Scale

BMT

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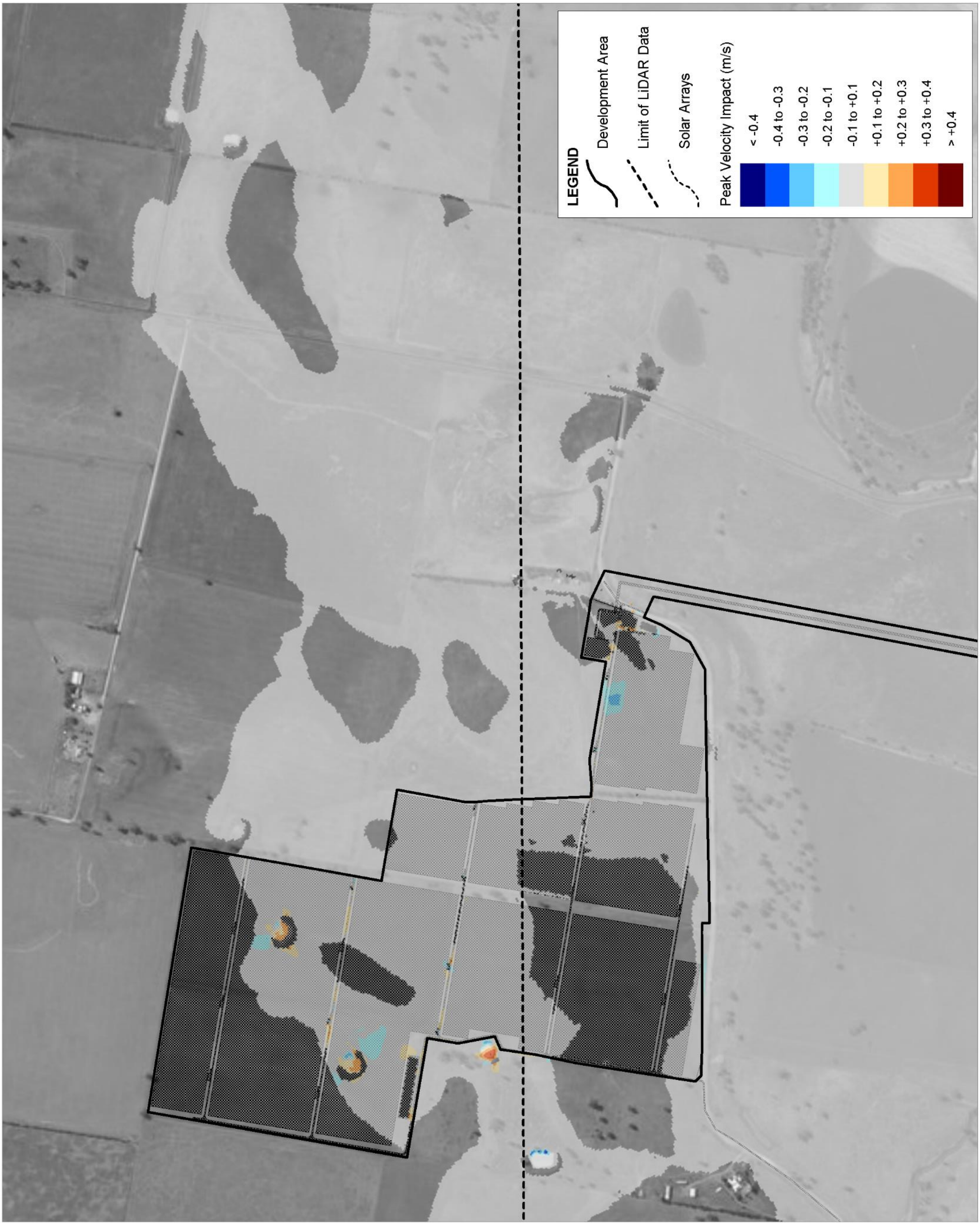

Title:
0.2% AEP Modelled Peak Flood Velocity Impact

Figure: **E-7**

Rev: **D**

N

0 200 400m
Approx. Scale

BMT
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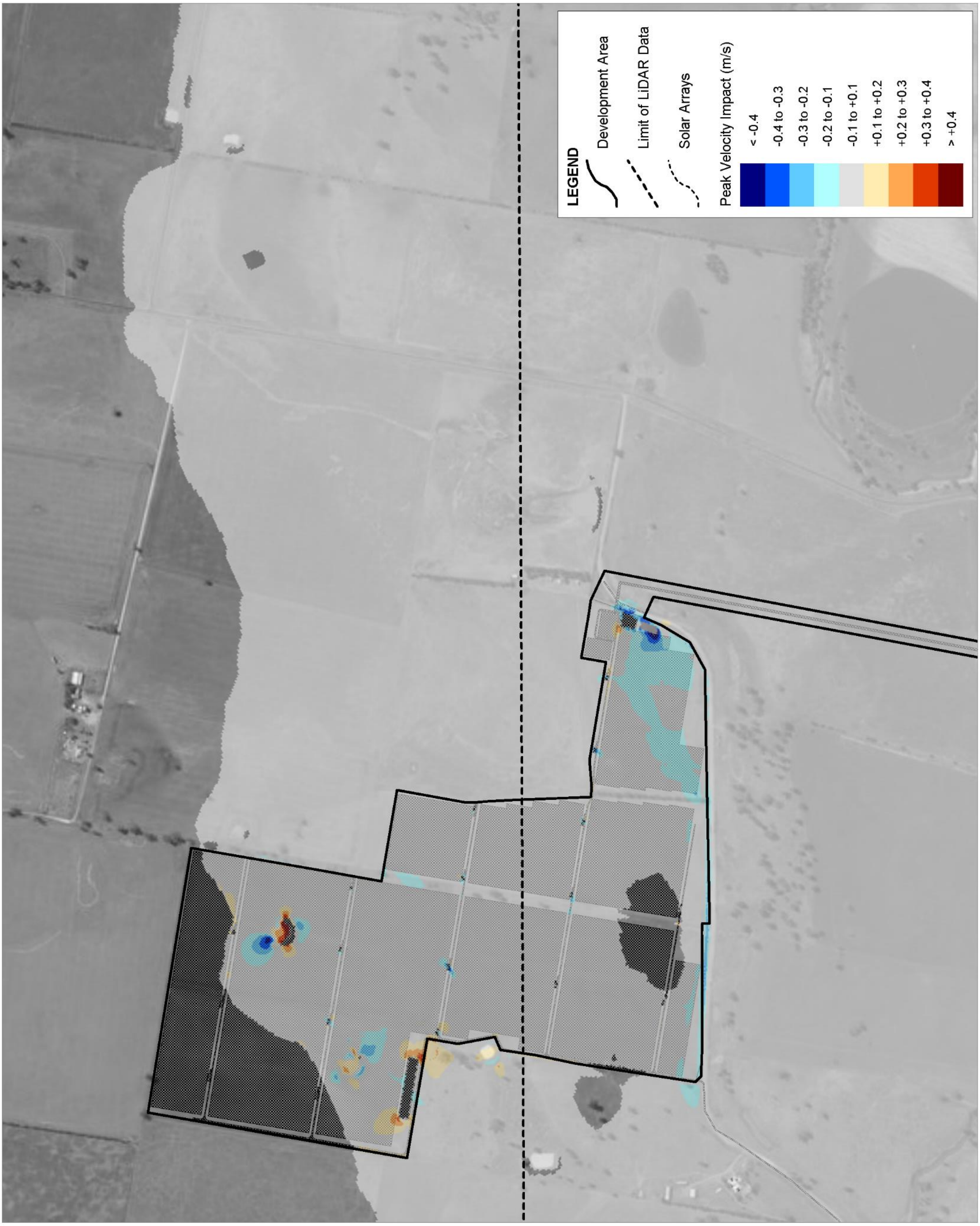
Filepath : K:\N20883_Dunedoo_Substation_FRA\Mapinfo\Workspaces\DRG_044_180112_0.2%AEP_v_impact.WOR



Title:

PMF Modelled Peak Flood Velocity Impact

Figure: **E-8**

Rev: **D**

N

0 200 400m

Approx. Scale

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