



APPENDIX P FLOOD ASSESSMENT

Keri Keri Wind Farm Flood Assessment

Final Report

Customer
Project
Deliverable
Version

Acciona Energy Australia Global Pty Ltd
000673
001
02
26 March 2024

Document Control

Document Identification

Title	Keri Keri Wind Farm Flood Assessment
Project No	000673
Deliverable No	001
Version No	02
Version Date	26 March 2024
Customer	ERM Australia Pty Ltd on behalf of Acciona Energy Australia Global Pty Ltd
Customer Contact	Mark Davey
Classification	BMT (OFFICIAL)
Synopsis	This report documents the flood assessment undertaken for the proposed Keri Keri Wind Farm as part of the Environmental Impact Statement (EIS) to address the Secretary's Environmental Assessment Requirements (SEARs)
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Amendment Record

The Amendment Record below records the history and issue status of this document.

Version	Version Date	Distribution	Record
00	13 March 2024	Acciona Energy Australia Global Pty Ltd	Draft Report
01	18 March 2024	Acciona Energy Australia Global Pty Ltd	Revised Draft Report
02	26 March 2024	Acciona Energy Australia Global Pty Ltd	Final Report

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1 Introduction

This report presents the flood assessment undertaken on behalf of Acciona Energy Australia Global Pty Ltd (Acciona) to support the State Significant Development Application (SSD-38358962) of the proposed Keri Keri Wind Farm Project (the “Project”). The flood assessment was undertaken to address the Secretary’s Environmental Assessment Requirements (SEARs) for SSD-38358962, including those recommended by the Biodiversity and Conservation Division (BCD) of DPE. The main objectives are to establish the flood risks and flood impacts of the Project infrastructure including the proposed wind turbine generators (WTGs) and waterway crossings.

1.1 Site Description

The approximate 18,012 ha (or 180 km²) Project site is located in Keri Keri approximately 30 km east of Balranald in NSW within the Murray River Council (“Council”) Local Government Area (LGA). Figure 1.1 shows the Project site locality in relation to Abercrombie Creek and surrounding floodplain, with Abercrombie Creek traverses near the southern site boundary. Murrumbidgee River, which is a major tributary of the Murray-Darling River System, is found approximately 30 km north of the Project site (at the closest point).

The Project site is bounded by Sturt Highway to the north, Keri Keri Road to the west, Abercrombie Creek to the south and rural lands to the east. The majority of the Project site is undeveloped rural lands.

The existing topography around the Project site is shown in Figure 1.2 and is based on the 1 m Digital Elevation Model (DEM) generated from LiDAR (Light Detection and Ranging) data collected in 2021 available from the ELVIS webpage¹. Additional LiDAR survey was also collected as part of the Project in early 2022. Based on the topographic information, the Project site terrain was found to vary between 65 and 70 m AHD, which signifies a flat terrain and typically sloping towards the west. A series of lake systems is found to the west, all of which eventually discharge into the Murray-Darling River System along with the Abercrombie Creek system. Figure 1.3 shows the Strahler stream orders derived from the DEM for the present Site.

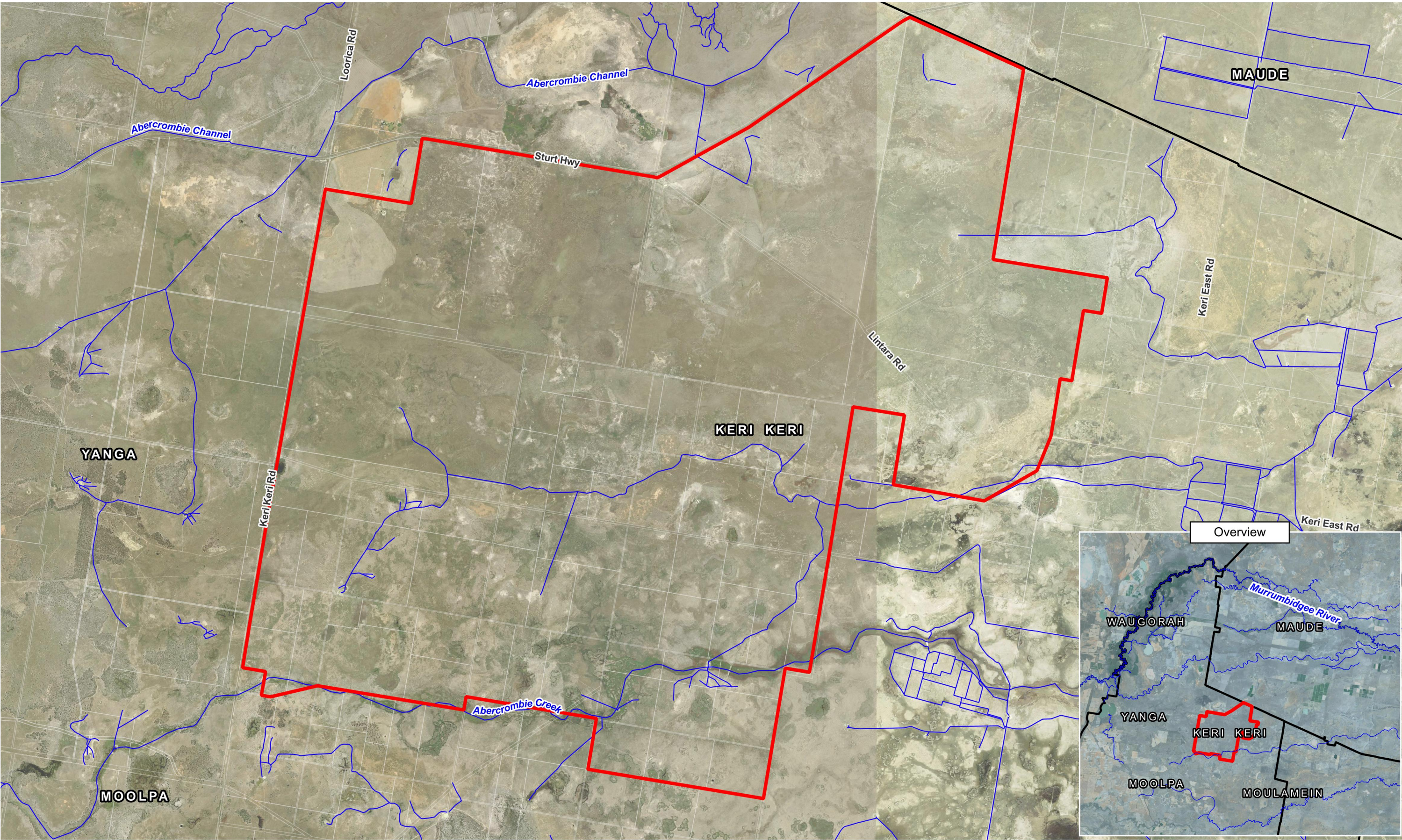
1.2 Scope of Assessment

The following tasks have been undertaken as part of the assessment:

- Review of available topographic and flood information for the Project site;
- Simulation and assessment of on-site flood risk for design flood events including the 20% Annual Exceedance Probability, 5% AEP, 1% AEP and the Probable Maximum Flood (PMF), as well as the 0.5% and 0.2% AEP events as proxies for climate change;
- Review of the proposed development works and assessment of flood impacts; and
- Summary of how SEARs have been addressed.

The scope of work does not include the development of a Stormwater Management Plan for the Project site.

¹ <https://elevation.fsd.org.au/>

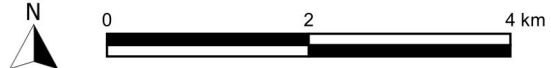


LEGEND

- Project Extent
- LGA Boundary
- Hydrolines
- Cadastre

Title:
Site Locality

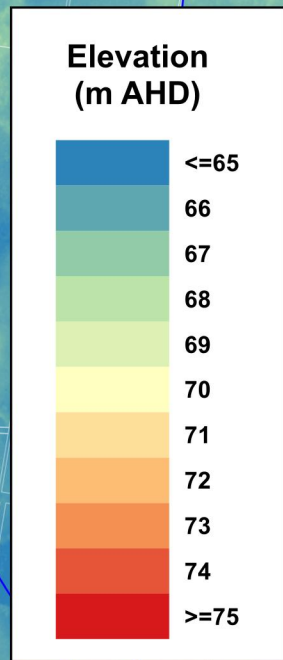
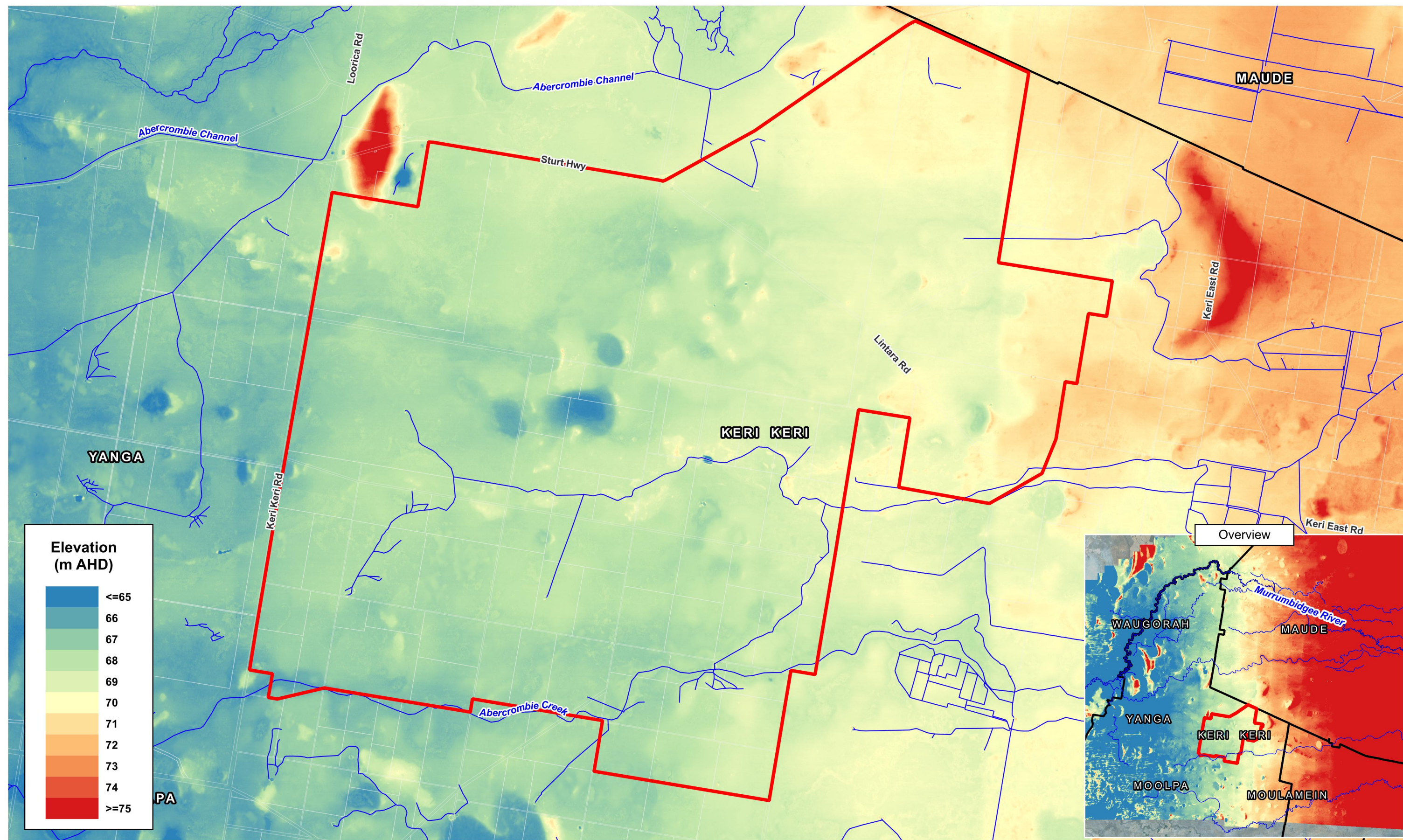
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- LEGEND**
- Project Extent
 - LGA Boundary
 - Hydrolines
 - Cadastre

Title:
Site Topography

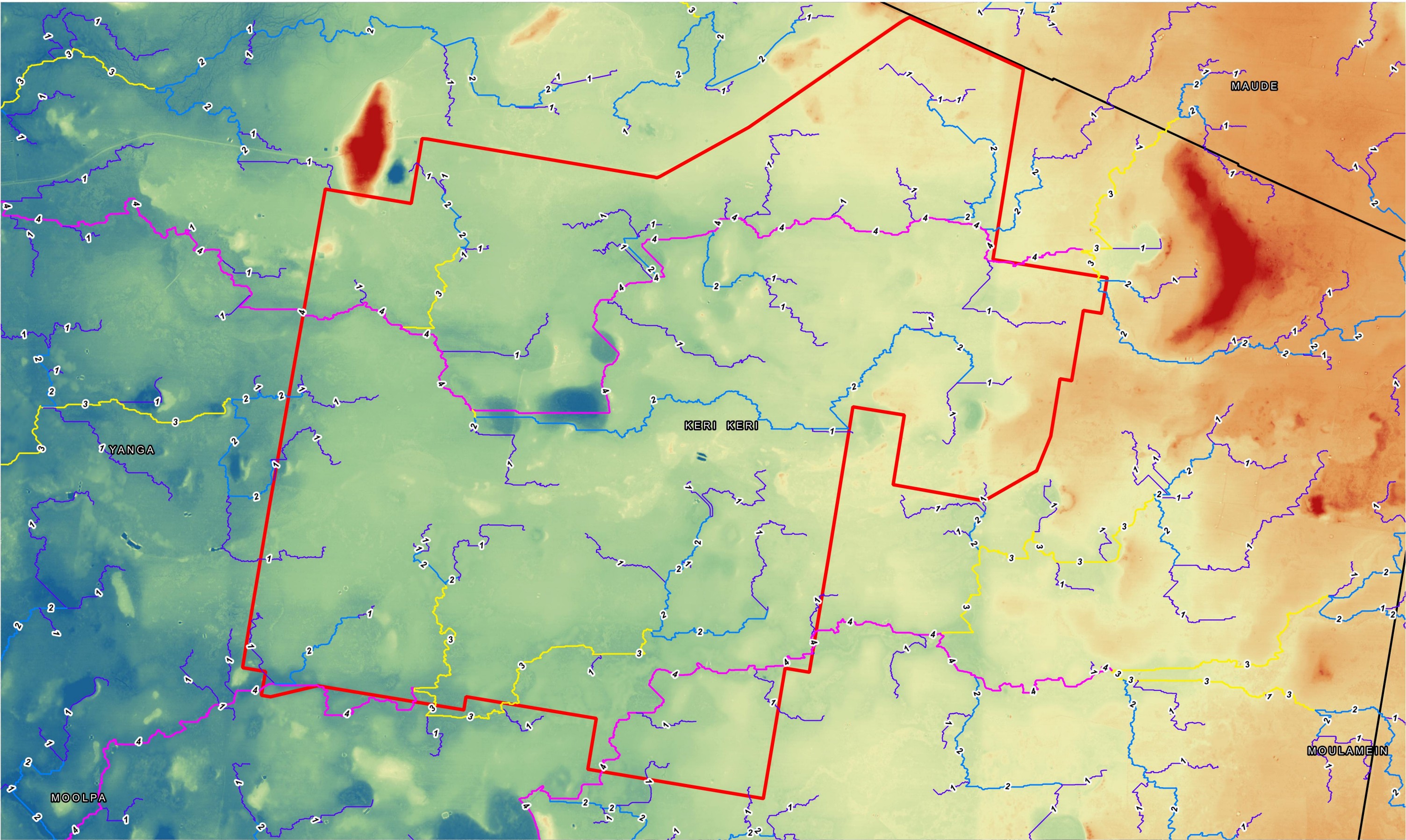
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Fig1-2

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- LEGEND**
- Project Extent
 - LGA Boundary

- Strahler Stream Order**
- 1
 - 2
 - 3
 - 4

Title:
Strahler Stream Order Mapping

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2 Project Description

The Project involves the construction, operation, maintenance and decommissioning of the Keri Keri Wind Farm, as generally illustrated on Figure 2.1, including:

- Up to 155 wind turbine generators (WTGs), each with:
 - A generating capacity of approximately 884 MW;
 - Three blades mounted to a rotor hub (hub height of 200 m) on a nacelle above a tubular steel tower, with a blade tip height (blade length plus hub height) of up to 291.5 m AGL²;
 - A gearbox and generator assembly housed in the nacelle; and
 - Adjacent hardstands for use as crane pads, assembly and laydown areas.
- Electrical infrastructure:
 - Three (3) 33/330 kV electrical substations, including control room, transformers, circuit breakers, switches and other ancillary equipment;
 - A battery energy storage system (BESS) of up to 200 MW/800 MWh (four hours of storage);
 - Overhead and underground 33 kV electrical reticulation connecting the WTGs to the onsite substations (generally following site access tracks); and
 - A 330 kV overhead transmission line of approximately 20 km, connecting the three substations to a new electrical switchyard (including circuit breakers, switches and other ancillary equipment) to provide connection to the planned NSW-SA interconnector, Project EnergyConnect currently under construction.
- Ancillary infrastructure:
 - Four (4) site access points with one along Sturt Highway and three along Keri Keri Road;
 - Three (3) operations and maintenance (O&M) facilities and four security huts;
 - Biosecurity wash bays for each site access;
 - Internal access tracks connecting the WTGs and associated Project infrastructure with the public road network; and,
 - Decommissioning of four (4) temporary meteorological monitoring masts and installation of up to four (4) permanent meteorological monitoring masts for power testing. The permanent monitoring masts will be located close to a WTG location and will have a maximum height of approximately 159 m AGL;
- Upgrades to roads and intersections required for the delivery of oversize and overmass WTG components, transformers and associated construction-phase materials and vehicular movements.

The following temporary elements will be required during the construction phase of the Project:

- Two (2) temporary construction compounds which includes buildings and facilities for construction contractors/equipment;
- One (1) workers accommodation compound;

² Above Ground Level

- Mobile concrete batching plants to supply concrete for WTG footings and substation construction works;
- Earthworks for access tracks, WTG platforms and foundations, potentially including controlled blasting in certain areas;
- Hardstand laydown areas for the storage of construction materials, plant, and equipment;
- Up to four (4) temporary meteorological monitoring masts. The temporary monitoring masts will be located close to a WTG location with a maximum height of approximately 159 m AGL;
- External water supply and storage for concrete batching and construction activities;
- The transport, storage and handling of fuels, oils and other hazardous materials for construction and operation of wind farm infrastructure; and
- Beneficial reuse of materials won from within the development footprint during cut and fill and WTG foundation excavation works for use in access track, hardstands and foundation material.

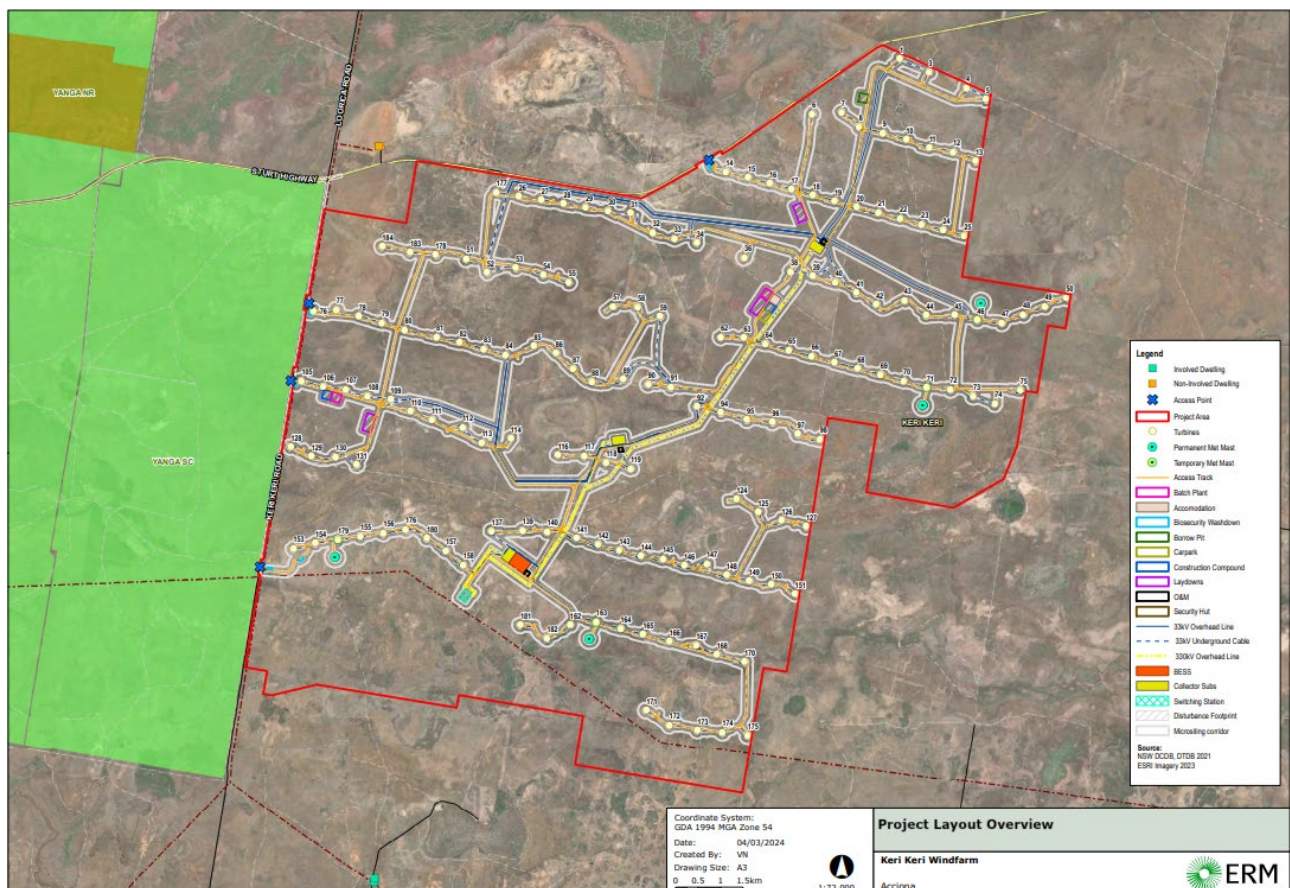


Figure 2.1 Project Layout (Source: Acciona)

3 Flood Assessment Approach

The flood assessment herein has been undertaken using new flood models developed based on the Australian Rainfall and Runoff 2019 (ARR 2019) data and methodology to establish existing (baseline) and post-development flood behaviour for the Project site. The assessment approach is discussed further in the following sections.

3.1 Input Data

To facilitate the assessment, the following datasets were reviewed and used to inform the assessment:

- Aerial imagery of the study area;
- Project description (current as of 20 February 2024);
- Project layout as GIS files and PDF (Reference: 20240219_KKWF_Infrastructure.pdf, issued 20 February 2024);
- Digital Elevation Model (DEM) in 1 m resolution tiles based on LiDAR aerial survey obtained from 2021 by the NSW Government³;
- DEM in 1 m resolution tiles based on LiDAR aerial survey obtained early 2022 for the Project by RPS;
- Cadastral information and hydrolines (watercourses) from SIX Maps⁴;
- Bureau of Meteorology (BoM) 2016 design rainfalls⁵; and
- Storm losses and temporal patterns for design rainfalls from ARR Data Hub⁶.

3.2 Preliminary Regional Modelling

In the present work, a regional model was developed (not detailed here) to analyse the break-out flows from the Murrumbidgee River system (referred to as 'Regional Model' hereafter). Using this model, the overall catchment area required for the model was identified. This was required due to the limitation of bathymetry, LiDAR information and the general flat slopes with significant storage components observed throughout the region.

A large-scale TUFLOW hydraulic model was developed to simulate the flow breakout from the Murrumbidgee River system, as predicted for major historical flood events and documented in the 'Murrumbidgee River Floodplain Hay to Maude Phase A – Flood Study and Data Collection' (Webb, McKeown and Associates, 2008). The so-called "Southern Bank Flood Runner", which is a result of the Murrumbidgee River flows overtopping its southern bank, would traverse the floodplain north of Sturt Highway in the direction of Keri Keri. Figure 3.1 shows the peak flood extent for the 1956 historical event, which is equivalent to a 1% AEP flood event (Webb, McKeown and Associates, 2008). The predicted flood extent for this historical event shows that the flow breakout from the Murrumbidgee River would largely be contained north of Sturt Highway as it approaches Ravensworth and heading towards Keri Keri.

³ <https://elevation.fsdof.org.au/>

⁴ <https://maps.six.nsw.gov.au/clipnship.html>

⁵ <http://www.bom.gov.au/water/designRainfalls/revised-ifd/>

⁶ <https://data.arr-software.org/>

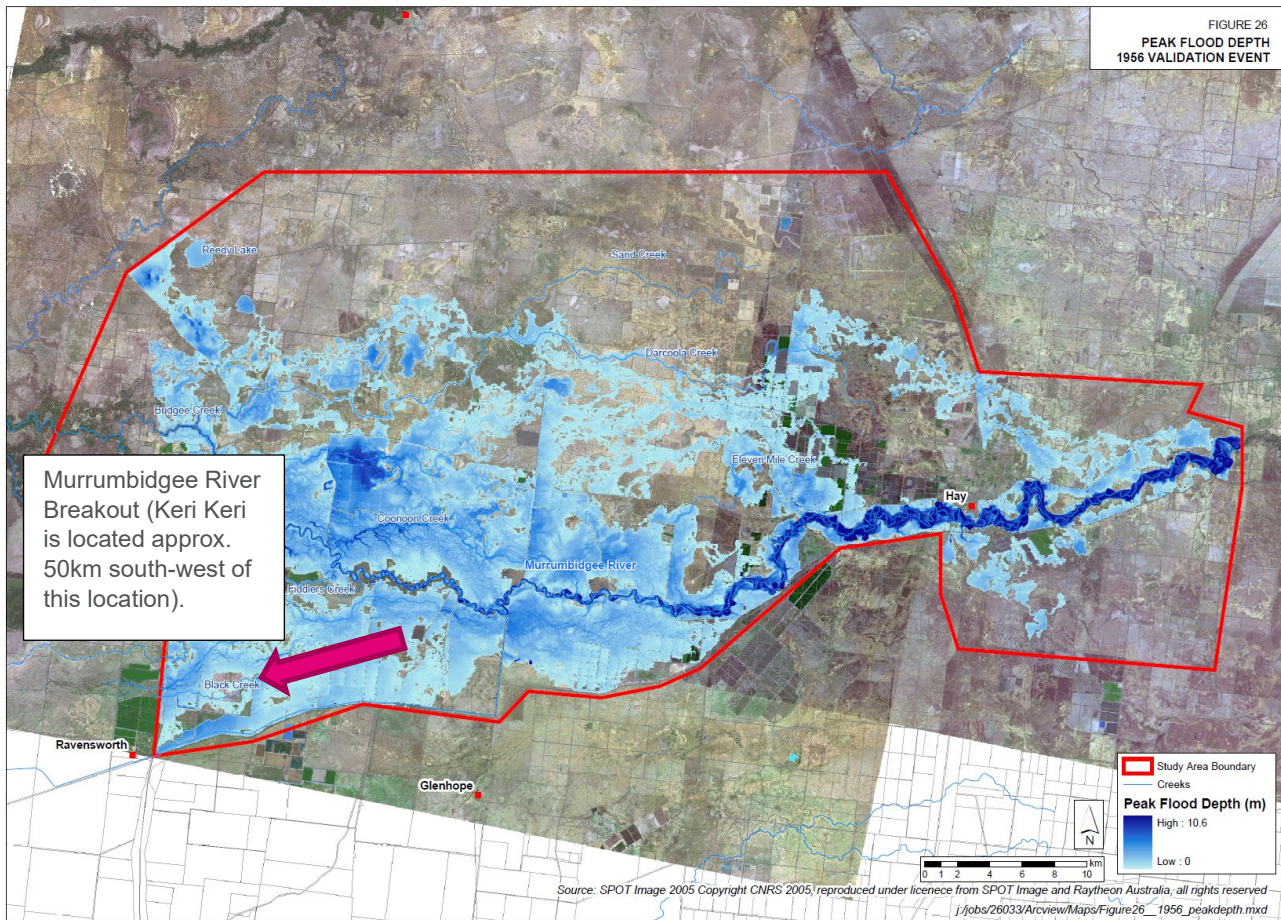


Figure 3.1 Peak Flood Extent for the 1956 Historical Event (Source: Webb, McKeown and Associates, 2008)

Following this preliminary assessment, a separate model was developed to assess the flood impacts near the proposed development (referred to as 'Abercrombie model'). The following sections 3.2.2 and 3.2.3 detail the hydrology and hydraulics of the Abercrombie model development.

3.2.2 Hydrology

As part of the flood assessment, a rain-on-grid (RoG) TUFLOW hydraulic model was developed based on the ARR 2019 data and methodology to facilitate the design flood simulation of the 20%, 5%, 1%, 0.5%, 0.2% AEP (Annual Exceedance Probability) and PMF events for the study area.

The design rainfall grids covering the study area were obtained from the BoM website for a range of storm duration for the 20%, 5% AEP, 1% AEP, 0.5% and 0.2% AEP events. The grids have a grid cell spacing of 0.025 degrees (approximately 2.5 km) and provide the spatial distribution of design rainfall across the study area. The spatially varying design rainfall depths were applied at the centroid of the sub-catchments. As per ARR 2019 methodology, ARFs are applied to the design rainfall for the events. For the PMF event, the rainfall values were obtained from GSAM methodology described by the BoM.

ARR 2019 recommends the application of an ARF in the determination of the design rainfall estimates, for catchments contributing flows to point of interest that is larger than 1 km². The ARF is the ratio between the average rainfall occurring on a specific area and the point rainfall computed for the same duration and AEP. This ratio is applied since design rainfall intensities at a point are not necessarily representative of the average rainfall intensity across the catchment, particularly for larger catchments.

Rainfall losses (i.e. infiltration) were determined at each sub-catchment centroid using ARR19 methodologies. The Initial Loss (IL) and Continuing Loss (CL) were adopted from spatially varying values recommended in the ARR datahub for each sub-catchment. In the PMF event, no initial and continuing losses applied to the sub-catchments.

As per ARR 2019 recommendations, an ensemble of ten temporal patterns for a range of durations have been modelled for the 20% AEP, 5% AEP, 1%, 0.5% and 0.2% AEP design flood events. The ten temporal patterns vary in terms of their distribution and variability (comprising front, middle and back loaded storms) and can result in a wide range of flood behaviour. The procedures for ARR 2019 provide for the selection of the temporal pattern that gives the peak flow closest to the mean across all ten temporal patterns. This method was followed to confirm the critical temporal pattern for each storm duration.

3.2.3 Flooding

The RoG hydraulic model requires hydrologic data as inputs, using the 2016 IFD (intensity-frequency-duration) design rainfall estimates developed by BoM. The hydraulic model was developed to simulate the dynamic interactions between watercourses and floodplains as well as overland flow paths within the study area, using the TUFLOW modelling software (version 2023-03-AC-iSP-w64 with HPC⁷ solver and Sub-grid Sampling (SGS)). An overview of the hydraulic model setup is shown in Figure 3.2.

The TUFLOW hydraulic model contains 35 sub-catchments. The model extent is contained within the available LiDAR data and covers all the proposed project infrastructure, with a total model area of approximately 3,200 km².

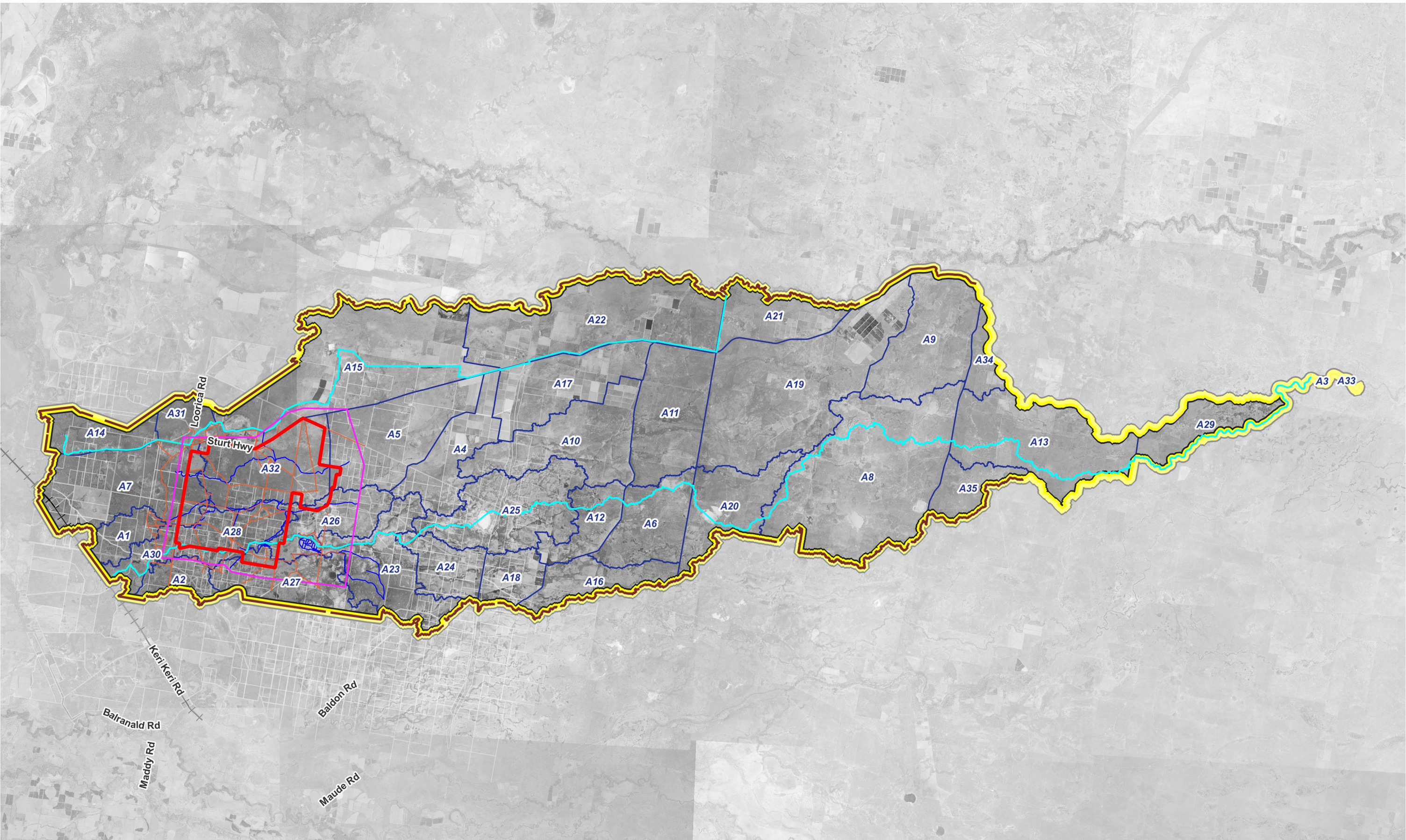
Due to the size of the model extents, the TUFLOW modelling software with HPC solver and SGS were used to improve simulation run times. To strike a balance between sufficiently representative overland flow distribution across the study area and reasonable simulation run times, a 100m global model cell size, 25m cell size within the proposed Site, and 1m SGS sampling distance was adopted. A map cut-off depth of 20mm was applied typical for RoG simulations.

The hydraulic model's Manning's roughness (n) was varied for each major land use (Chow, 1959), i.e.

- Medium vegetation (n=0.06)
- Roads (n=0.025)
- Buildings (n=0.2)

Model boundaries were determined through a combination of topography (LiDAR) and iterative RoG modelling to ensure all major and minor flow paths relevant to the proposed development were captured. Rainfall inflows were applied at each sub-catchment, with a free discharge at the catchment outlet using a stage-discharge boundary condition.

⁷ TUFLOW HPC (Heavily Parallelised Compute) is a solver which utilises Graphics Processor Unit (GPU) hardware to undertake simulation runs

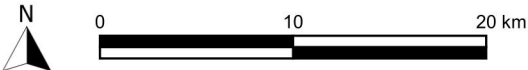


- LEGEND**
- Project Extent
 - Model Extent
 - Quadtree Region
 - Rainfall Inflows
 - Downstream Boundary

- Breaklines**
- Abercrombie Creek
 - Local Drains
 - Local Roads

Title:
Abercrombie Creek TUFLOW Model Setup

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Critical Duration Assessment

A critical duration analysis was undertaken for all Abercrombie model events. As per ARR 2019 recommendations, an ensemble of ten temporal patterns for each duration has been modelled for each flood event. The ten temporal patterns vary in terms of their distribution and variability (comprising front, middle and back loaded storms) and can result in a wide range of flooding behaviour within the catchment.

Due to the size of the study area, the generally flat slopes and significant storage capacity, a range of storm durations were tested for critical duration. Durations ranged from 9 hours up to 168 hours for the 10 temporal patterns, using a coarser model (without Quadtree for Site) with SGS for efficiency. Following the ARR 2019 procedures, the statistical median of water levels across 10 temporal patterns of each duration were determined. After this, the maximum duration from the water levels was determined. In this approach, peak water levels at the Site were prioritized over scattered peak water levels throughout the broader model extent. The critical duration and temporal pattern selected for each event are reported in Table 3.1.

Table 3.1 Critical Storm Duration

Design Storm (AEP)	Storm Duration (min) and Temporal Pattern
20%	10080m (TP09)
5%	10080m (TP04)
1%	10080m (TP03)
0.5%	10080m (TP05)
0.2%	10080m (TP05)
PMF ⁸	4320m

Grid filtering

The direct rainfall technique features the application of rainfall hyetographs directly onto the model grid and, as such, the model results are characterised by wet terrain throughout the model extent. For this reason, grid filtering of the model results is necessary to discern sheet flows from overland flowpaths and obtain a more realistic representation of the overland flowpaths in the local catchment.

The filtering criteria adopted in the present study featured the application of conditions to flood depths, velocity-depth product and pond sizes in order to obtain well-connected flowpaths and avoid the patchiness often resulting from the application of a simple cutoff depth criteria to the direct rainfall model results.

The final grids of each AEP event were filtered in accordance with the following filtering criteria:

- Step 1: The wet cells were retained for flood depths > 0.01 m AND depth-velocity product > 0.125 m² /s;
- Step 2: The remaining wet cells from step 1 were retained for flood depths > 0.2 m OR depth-velocity product > 0.02 m² /s;
- Step 3: Ponds smaller than 100 m² resulting from step 2 were removed.

⁸ PMF hydrology for the Abercrombie Creek TUFLOW model was determined based on the procedures outlined in 'Guidebook to the Estimation of Probable Maximum Precipitation: Generalised Southeast Australia Method' (BoM, 2006).

Model Verification

Comparison undertaken for Abercrombie Creek upstream catchments whereby flood storage attenuation is minimal, allowing for a like for like comparison between TUFLOW RoG against XP-RAFS as shown in Figure 3.3 and Figure 3.4.

TUFLOW generally predicts higher peak flows, based on the 1% AEP event upstream catchment critical storm duration of 7200 minutes.

Pre-wetting the model domain resulted in higher peak flow and significantly more different than the predicted peak flow by XP-RAFTS.

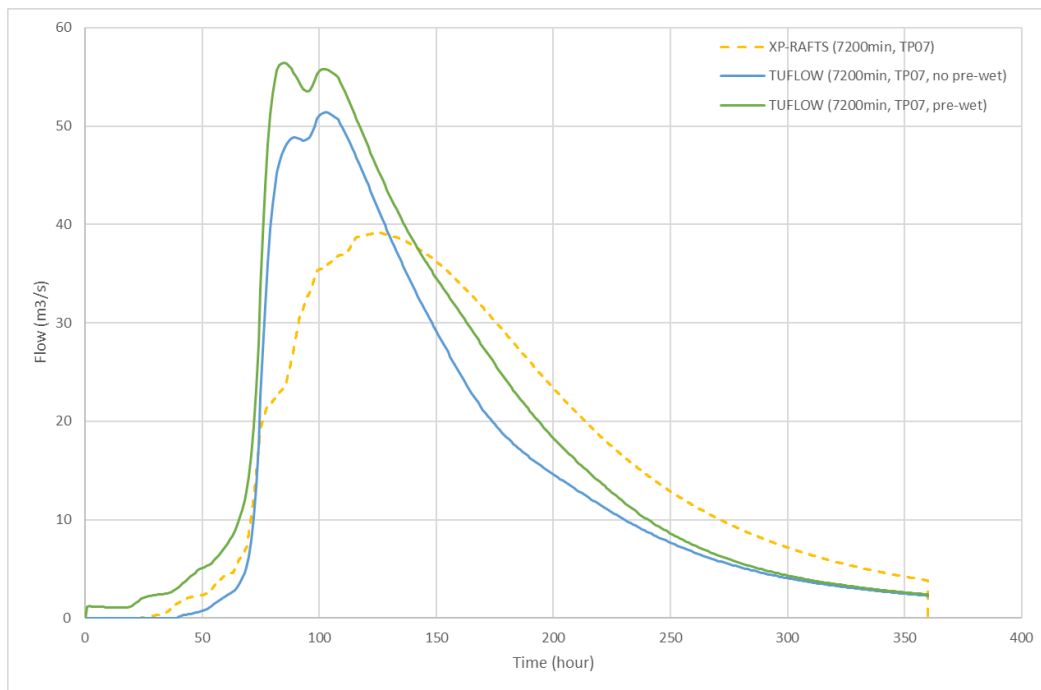


Figure 3.3 Comparison of Abercrombie Creek Upstream Catchment “A13” 1% AEP Flow Hydrographs

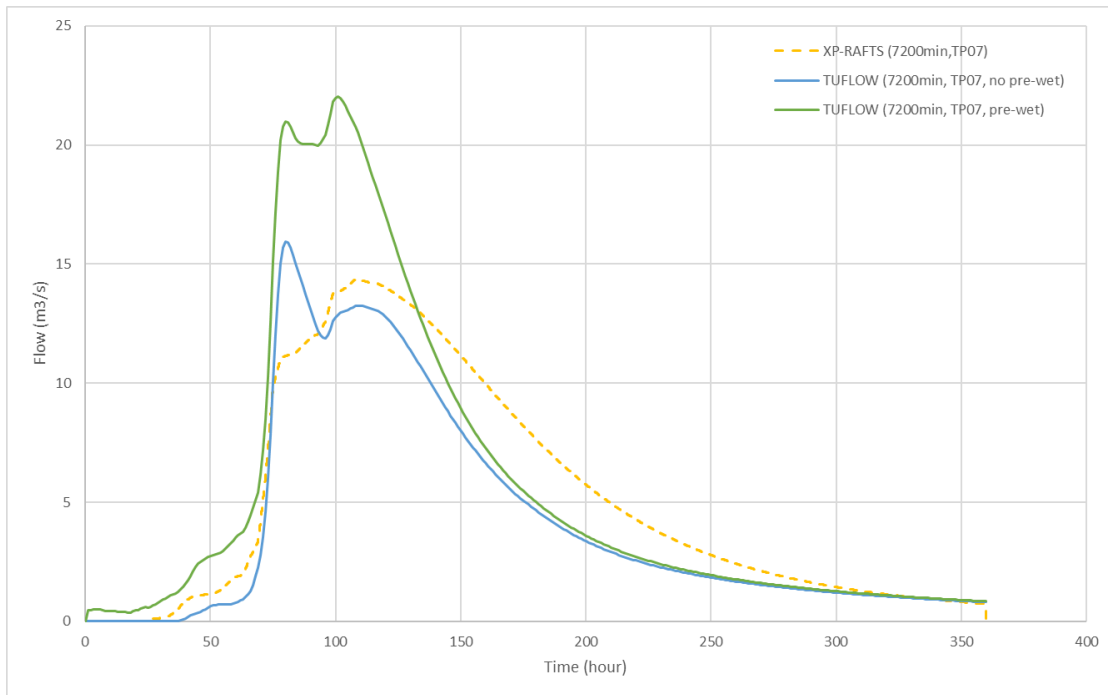


Figure 3.4 Comparison of Abercrombie Creek Upstream Catchment “A29” 1% AEP Flow Hydrographs

3.3 Proposed Development

The Client provided BMT with a list of elements for the proposed development on 05 March 2024. Table 3.2 summarises the elements with a description and their respective representation in the hydraulic model.

Table 3.2 Developed scenario representation in hydraulic model

Key Item	Description	Model Representation
Clearing Corridors	Gravel and Natural ground for clearing corridors	Model roughness.
Hardstand footprints	Foundation for N163 TS148: Diameter 21.8m Blinding Offset 1m Excavation Depth 3.035m @1:1 slope	The wind turbine footing elevation determined from example provided to BMT by the Client from Macintyre Wind Farm. Elevated regions and model roughness.
Biosecurity washdown	70m x 110m	Elevated regions and model roughness..
Security Hut	20m x 20m	Elevated regions.
Car Park	100m x 100m + 15m batters	Model roughness.
Powerlines	OHL- 45m lattice line, single circuit - 330kV UGC – 33kV 600-750 mm deep	Not represented due to width of powerline in comparison to cell size.

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Key Item	Description	Model Representation
Collector Subs	200 x 300m + 35m Bushfire APZ (all sides)	Elevated regions.
Switching Stations	200 x 300m + 35m Bushfire APZ (all sides)	Elevated regions.
Benches	Benches are related to the compound area. Construction compound - 100m x 100m + 15m batters Laydown area - 200m x 150m + 15m batters Workers accommodation Camp - 200m x 200m + 15m batters	Elevated regions.
Switching Station	200 x 300m + 35m Bushfire APZ (all sides)	Elevated regions.
Accommodation	200m x 200m + 15m batters	Elevated regions.

4 Results and Discussion

4.1 Flood Depths and Levels

The results shown indicate that the surface flow hydrodynamics are significantly storage driven due to the shallow slopes and presence of many small basins within the catchment. This is demonstrated by relatively low velocities observed in the events from 20% AEP up to the PMF (Figure A.2, Figure A.5, Figure A.8, Figure A.11, and Figure A.14). Significant ponded water depths are also observed in these regions for the same events.

Results indicate that WTG locations are subject to varying degrees of flood affection across the design events modelled. Most are located outside of modelled flood extents in the 20% AEP, while most are located within the modelled extents of the PMF. Proposed developments on the site (indicated on developed scenario maps) are flood free up to the 1% AEP event, with floodplain encroachment occurring in the 0.5% AEP and greater.

Flood level impacts are observed with the developed scenario outside the proposed Site for all events except 20% AEP:

- 5% AEP event: up to magnitude 60mm localized in storages outside Site,
- 1% AEP event: up to magnitude 112mm localized in storages outside Site,
- 1% AEP with climate change: up to 340mm in storages outside Site,
- 0.5% AEP event: up to 30mm distributed across the floodplain,
- 0.2% AEP event: up to 30mm distributed across the floodplain,
- PMF event: up to 46mm distributed across the floodplain.

Estimated flood impacts are considered non-detrimental, considering that the area affected is a State Conservation Area with no visible structures. It is noted that Austroads (2023) considers impacts of up to 400mm acceptable for open space / forest areas.

With regards to the turbines and proposed developments, it is observed that the impacts are outside development in the events from 20% AEP up to 0.2% AEP event. Impacts of up to 30mm are apparent towards the eastern part of the Site in the vicinity of some of the turbines, which are considered non-detrimental.

4.2 Flood Velocities

Flood velocities for the events from 20% AEP up to PMF event show that there is very slow moving water in the Abercrombie Creek (<0.4 m/s). The reason for slow velocities is understood to be the shallow slope in the catchment and presence of significant storage areas. Water is observed to fill up the existing basins and stagnate for the duration of the event. Due to this reason, it is expected that there will be limited erosion in the river banks, destruction of riparian vegetation or reduction in the stability of river banks or watercourses. No significant changes to velocity are expected as a result of the proposal, as indicated by pre and post velocity maps presented in this report.

4.3 Flood Hazards

The flood hazard for the Project site and its surrounding floodplain has been defined based on the composite six-tiered hazard classification in the 'Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia' (AIDR, 2017) and reproduced in Figure 4.1. These hazard classifications are based on adopted thresholds of flood depth, velocity and velocity-depth product that identify when flood conditions are likely to present a risk to people, vehicles and buildings. A description of each hazard threshold is provided in Table 4.1.

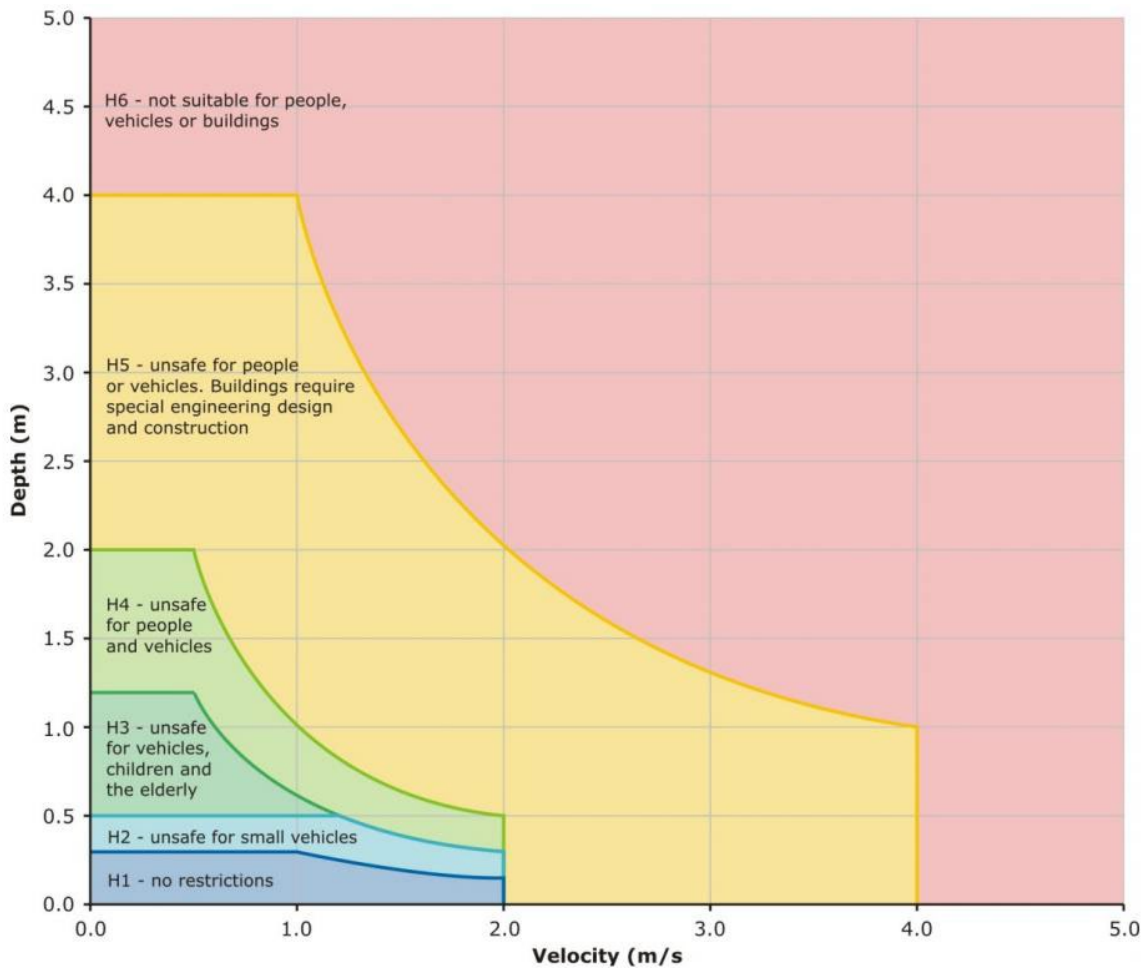


Figure 4.1 Flood Hazard Curves (AIDR, 2017)

Table 4.1 Flood Hazard Classification Thresholds (AIDR, 2017)

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 vehicles.
H5	Unsafe for all people and 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.

Modelling for the events from 20% AEP to the 0.2% AEP showed that there are relatively low hazards along the Abercrombie Creek (up to Hazard Category H3) as shown in Figure A.3, Figure A.6, Figure A.9, Figure A.12, Figure A.15 and Figure A.18. Higher hazard levels (up to H5) are observed in pits where water is shown to accumulate. In the PMF event, it is observed that there is high hazard (up to H5) in the Abercrombie creek as well as shown in Figure A.21.

No significant changes to hazard are expected as a result of the proposal, as indicated by pre and post hazard maps presented in this report. Flood hazards and their extents are considered generally compatible with the proposal.

4.4 Flood Planning Area

Flood Planning Levels (FPLs) are typically derived by adding a freeboard to a specific design flood level, with this specific design flood frequently referred to as the “planning” flood. The FPL can be applied directly to topographic data to determine the extent of the Flood Planning Area (FPA), which was determined in this assessment as requested by the SEARs.

The FPA has been derived based on the 1% AEP flood level plus 0.5 m freeboard, which is consistent with the ‘Floodplain Development Manual’ (NSW Government, 2005). The 0.5 m freeboard was applied to the peak 1% AEP flood level results from the TUFLOW modelling and the resultant flood surface was laterally extended until it intersected with the ground surface to develop the FPA for the study area presented Figure D.1.

4.5 Hydraulic Categories

Flood function categories (also referred to as hydraulic categories) defined in the ‘Floodplain Development Manual: Flood Risk Management Guideline FB02’ (DPE, 2023) 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.

For this FIA, hydraulic categorisation was determined according to the combination of flood depths, velocities and velocity-depth product (VxD), as shown in Table 4.2.

Table 4.2 Flood Categorisation Criteria

Classification	Criteria	Description
Floodway	[$VxD > 0.25 \text{ m}^2/\text{s}$ AND Velocity $> 0.25 \text{ m/s}$] OR [Velocity $> 1.0 \text{ m/s}$]	Areas and flow paths where a significant proportion of floodwaters are conveyed (including all bank-to-bank creek sections).
Flood Storage	Area outside floodway where depth $> 0.5 \text{ m}$	Areas where floodwaters accumulate before being conveyed downstream. These areas are important for detention and attenuation of flood peaks.
Flood Fringe	Remaining flood extent	Areas that are low-velocity backwaters within the floodplain. Filling of these areas generally has little consequence to overall flood behaviour.

As requested by the SEARs (and following the above criteria), pre and post flood function maps for the site are shown in Annex D based on the 1% AEP event. Due to the very slow moving water in the catchment, it is observed that the Site comprises of only Flood Storage and Flood Fringe regions. No significant changes to flood function is expected as a result of the proposal, as indicated by pre and post flood function maps presented in this report. Flood functions and their extents are considered generally compatible with the proposal.

4.6 Climate Change

As requested by the SEARs, the 0.5% and 0.2% AEP flood events have been modelled as proxies for increased rainfall intensity in a 1% AEP due to climate change. As would be expected, results indicate an increase in flood depths and extents for the proxies modelled. A corresponding increase in flood hazard is also observed, although no significant increase in flood velocity is expected in the climate change scenarios modelled.

4.7 Emergency Management

As indicated in the hazard maps derived for this assessment, the site is subject to hazards of H3 and above from the 5% AEP event. Although most of the site remains flood free in this event (and in all events except for the PMF), access throughout the site would be considered limited from the 5% AEP event due to these hazards, with most of the site becoming inundated in a PMF. As such, the risk of isolation during significant flood events (from the 5% AEP or greater) requires mitigation through appropriate emergency management.

It is proposed that the NSW Hazards Near Me app is monitored for warnings of extreme weather. This includes severe weather warnings and severe thunderstorm warnings issued by the Bureau of Meteorology and which may include warnings for possible flooding. These warnings are also disseminated via various media outlets and are available on the Bureau of Meteorology website. In the event of a local warning advising of the potential for flooding it is recommended that the Site is closed and evacuated.

Given the large catchment area upstream of the site, the time of concentration (i.e. time taken for rainfall to generate runoff at the site) is relatively long. This is reflected in the critical durations determined in this assessment (Table 3.1) which range from 3 to 7 days. Therefore it is expected that in the event of a major event occurring, there will be ample opportunity for any staff on site to evacuate prior to the onset of flooding. It is recommended that the site remain closed until floodwaters have receded entirely and safe access restored before reopening the site.

All site staff should be made aware of the potential flood risk during site induction. In the event of site closure, a safety bulletin should be sent to all workers via SMS. A staff member should be nominated to the role of chief flood warden, and ensure that the Site is fully evacuated in the event of a site closure.

4.8 SEARs Responses

Project specific SEARs were received in a letter dated 4 April 2022, with those relevant to flooding and how they have been addressed summarised in Table 4.3.

Table 4.3 Response to SEARs

SEAR	Response
7. The EIS must map the following features relevant to flooding as described in the Floodplain Development Manual 2005 (NSW Government 2005) including: a. Flood prone land. b. Flood planning area, the area below the flood planning level. c. Hydraulic categorisation (floodways and flood storage areas). d. Flood hazard.	Relevant flood maps are provided in Annexes of this report.
8. The EIS must describe flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 5% Annual Exceedance Probability (AEP), 1% AEP flood levels and the probable maximum flood, or an equivalent extreme event.	Flood assessment approach is described in Section 3 of this report.
9. The EIS must model the effect of the proposed development (including fill) on the flood behaviour under the following scenarios: a. Current flood behaviour for a range of design events as identified in 7 above. This includes the 0.5% and 0.2% AEP year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.	Flood impacts have been estimated for all requested design storm events, refer Annex C.
10. Modelling in the EIS must consider and document: a. Existing council flood studies in the area and examine consistency to the flood behaviour documented in these studies. b. The impact on existing flood behaviour for a full range of flood events including up to the probable maximum flood. c. Impacts of the development on flood behaviour resulting in detrimental changes in potential flood	There are no existing council flood studies in the area. Flood impacts have been estimated for all requested design storm events, refer Annex C. Any changes to flood extents, velocities, levels, hazards and hydraulic categories are highlighted in baseline and developed scenario maps, and discussed in Section 4.

SEAR	Response
affection of other developments or land. This may include redirection of flow, flow velocities, flood levels, hazards and hydraulic categories. d. Relevant provisions of the NSW Floodplain Development Manual 2005.	Relevant provisions in the NSW Floodplain Development Manual 2005 have been considered in this assessment.
11. The EIS must assess the impacts on the proposed development on flood behaviour, including: a. Whether there will be detrimental increases in the potential flood affectation of other properties, assets and infrastructure. b. Consistency with Council Floodplain Risk Management Plans. c. Consistency with any Rural Floodplain Management Plans. d. Compatibility with the flood hazard of the land. e. Compatibility with the hydraulic functions of flow conveyance in floodways and storage in flood storage areas of the land. f. Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site. g. Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses. h. Any impacts the development may have upon existing community emergency management arrangements for flooding. These matters are to be discussed with the SES and Council. i. Whether the proposal incorporates specific measures to manage risk to life from flood. These matters are to be discussed with the SES and Council. j. Emergency management, evacuation and access, and contingency measures for the development considering the full range of flood risk (based upon the probable maximum flood or an equivalent extreme flood event). These matters are to be discussed with and have the support of Council and the SES. k. Any impacts the development may have on the social and economic costs to the community as consequence of flooding.	The proposal does not result in detrimental increases to flood affectation as discussed in Section 4. There are no Council Floodplain Risk Management Plans in the study area. There are no Rural Floodplain Management Plans in the study area. Flood hazards and their extents are considered generally compatible with the proposal as indicated in mapping provided. Hydraulic functions and their extents are considered generally compatible with the proposal as indicated in mapping provided. The proposal does not result in detrimental increases to flood affectation as discussed in Section 4. Given the relatively low flood velocities across the site (and that these are not expected to change), no increases to erosion, siltation, or bank instability are expected. There are no existing community emergency management arrangements for flooding at the site. Recommended emergency management measures are discussed in Section 4.6. It is understood that Council / SES will have opportunity during EIS exhibition to provide comment, which may be followed by specific consultation if required. As above. Based on the non-detrimental nature of estimated impacts, no social or economic impacts are expected as a consequence of flooding.

5 Conclusions & Recommendations

A flood assessment was undertaken for the proposed Site in Keri Keri. The hydraulic model was verified against two hydrology models (WBNM and XP-RAFS) prior to undertaking the present flood assessment.

The following key observations were made on the flood risk to the Site:

- Local overland flows traversing the site observed which are observed to be of low velocity.
- It is observed that low hazards (Hazard Category from H1 to H3) in regions affected by Abercrombie Creek flow path.
- Flood impacts observed due to the proposed development are considered to be non-detrimental.
- In the PMF event:
 - Most of the site is is inundated.
 - Similar to more frequent events, generally low velocities (less than 0.4m/s) are estimated for most of the site.
 - Proposed developments (as shown on flood maps) are subject to depths of 0.5-1m, and Hazard Category H3.
 - Depths of 1-2m and Hazard Category H4 are estimated at some WTG locations.
- Emergency management measures may be required to mitigate risks associated with access or isolation during flood events.

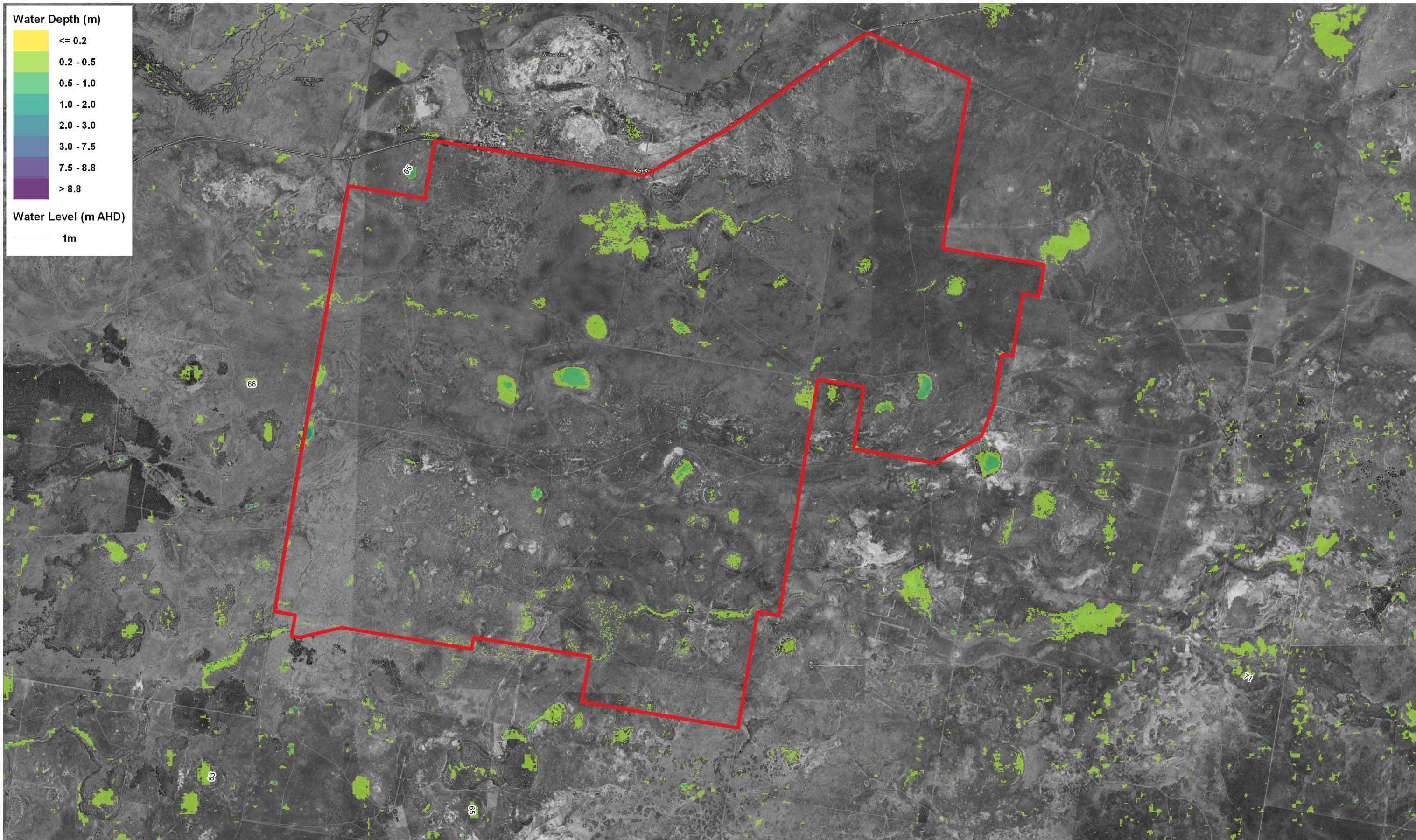
Based on the outcomes of this assessment, the following recommendations are suggested for consideration:

- Incorporate a 3D design surface into the model terrain to reflect any changes, should any be proposed in subsequent design phases.
- Include relevant cross-drainage structures into the model to further enhance model accuracy during subsequent design phases.

6 References

- Australian Institute for Disaster Resilience (2017), Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia.
- Austroads. (2023). Guide to Road Design Part 5: Drainage-General and Hydrology Considerations (Publication no. AGRD05-23) (4th ed.). ISBN: 978-1-922700-76-6. Published 30 January 2023.
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- NSW OEH (2019), Review of ARR Design Inputs for NSW.
- Webb, McKeown and Associates Pty Ltd (2008), Murrumbidgee River Floodplain Hay to Maude Phase A – Flood Study and Data Collection.

Annex A Baseline Scenario Flood Maps



LEGEND

 Project Extent

Title:

Keri Keri - Baseline - 20% AEP Peak Flood Depth and Level

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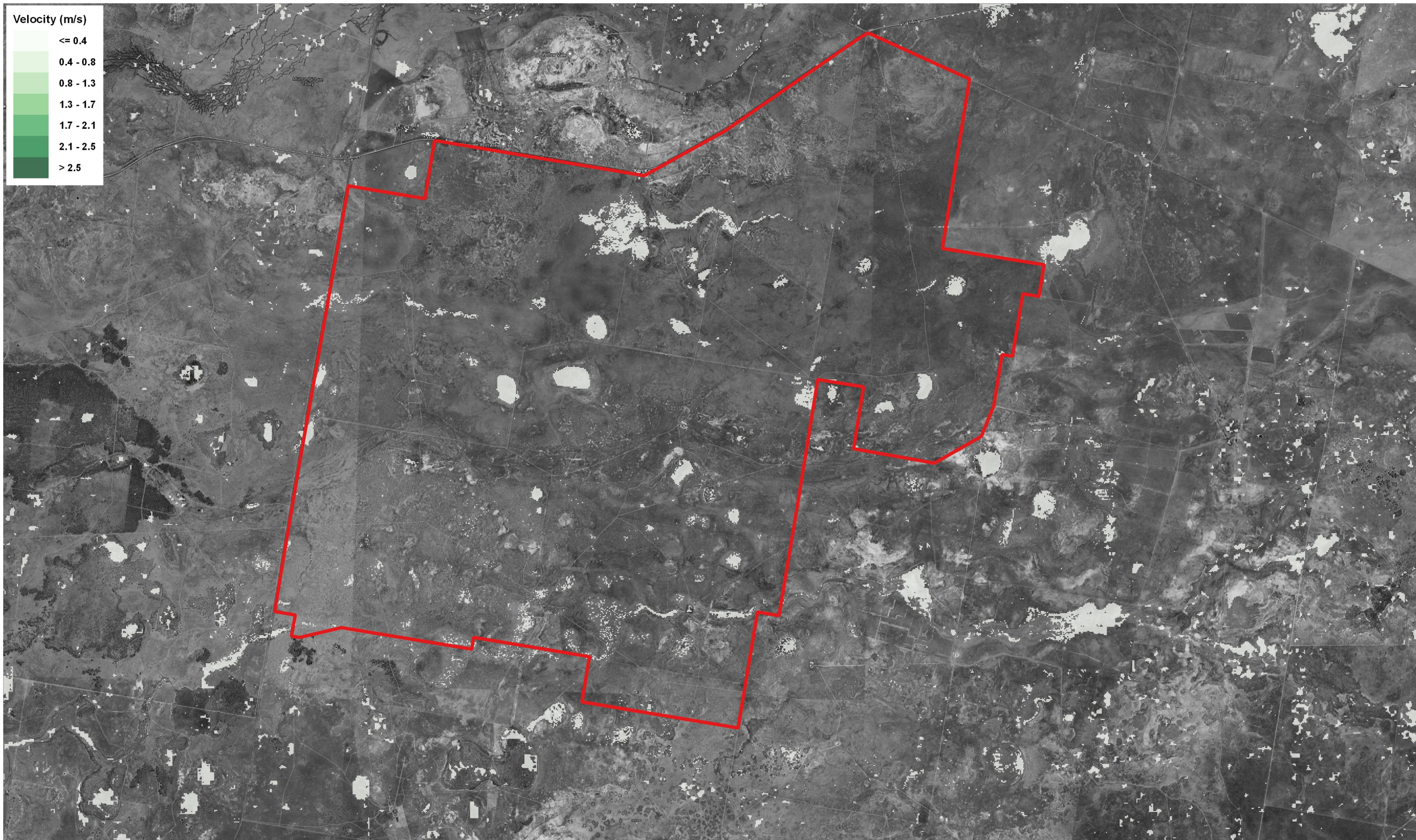
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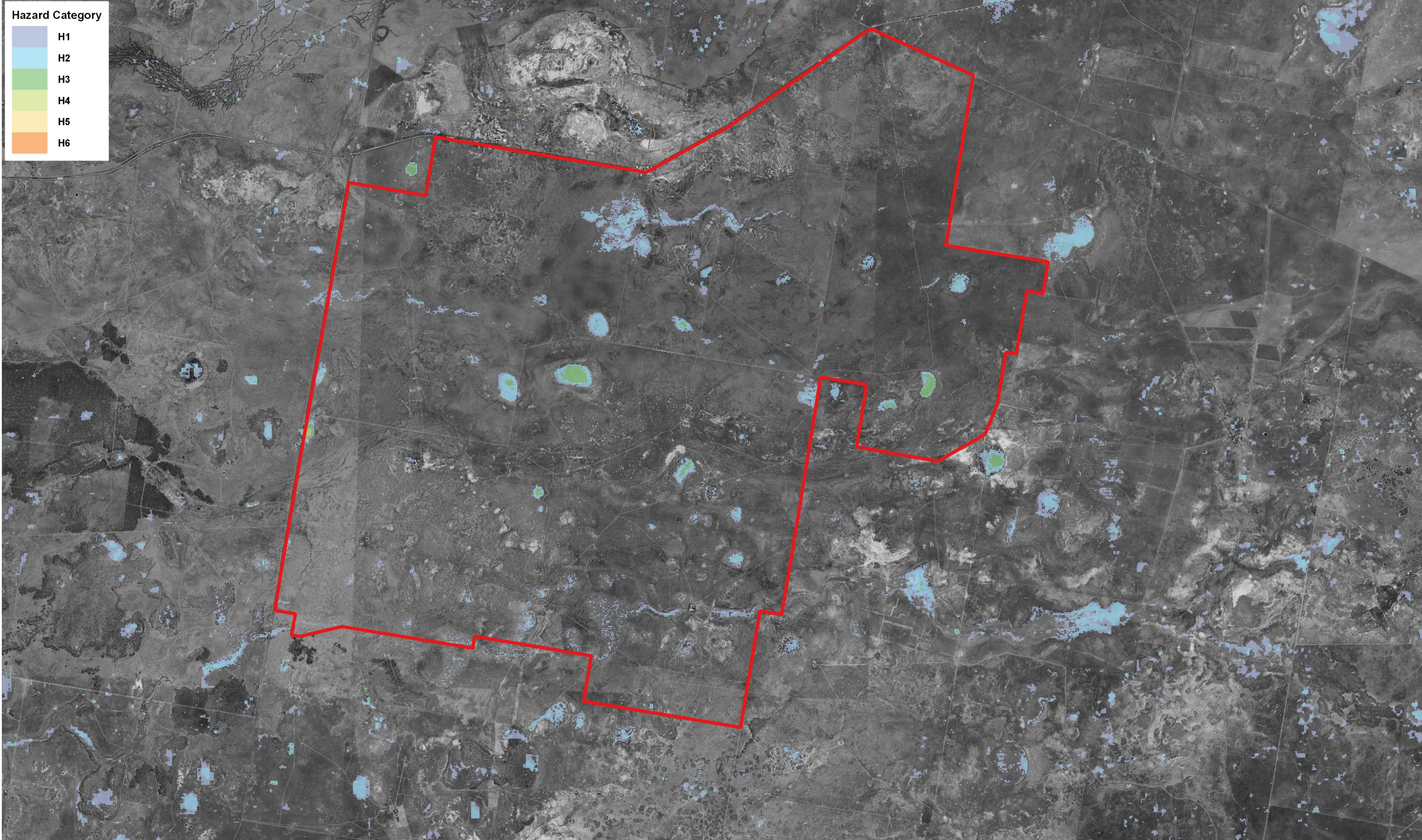
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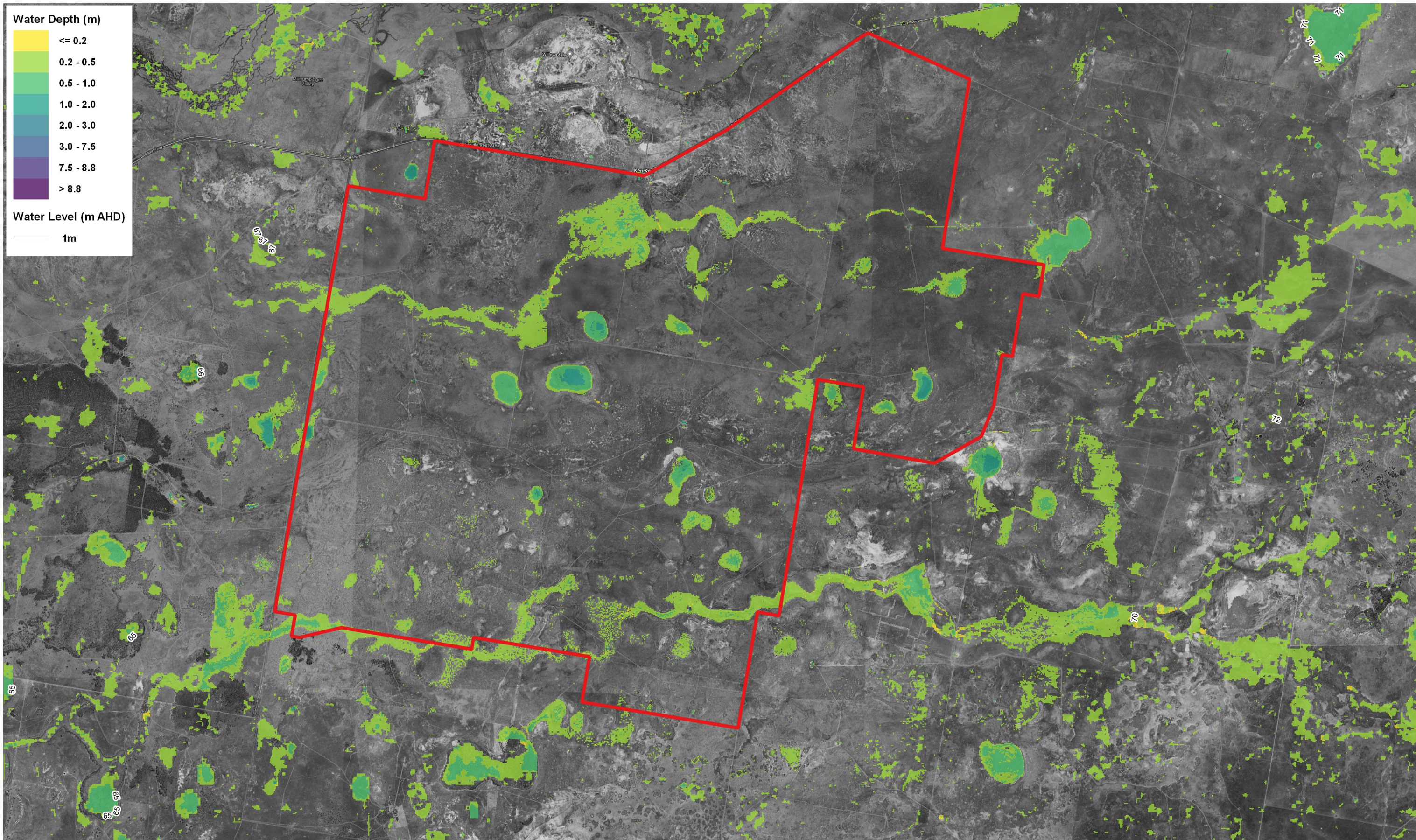
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 Project Extent

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Keri Keri - Baseline - 5% AEP Peak Flood Depth and Level

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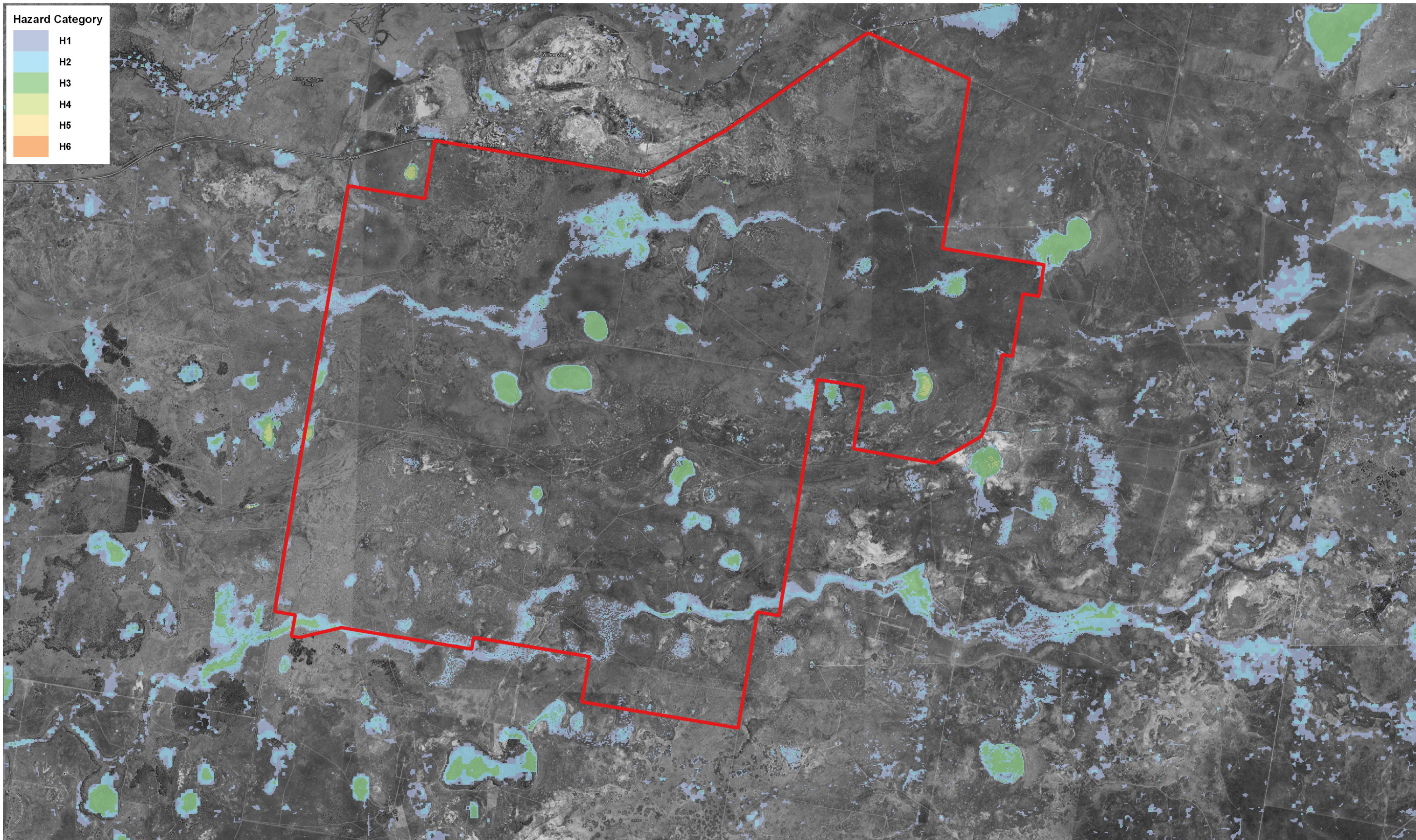
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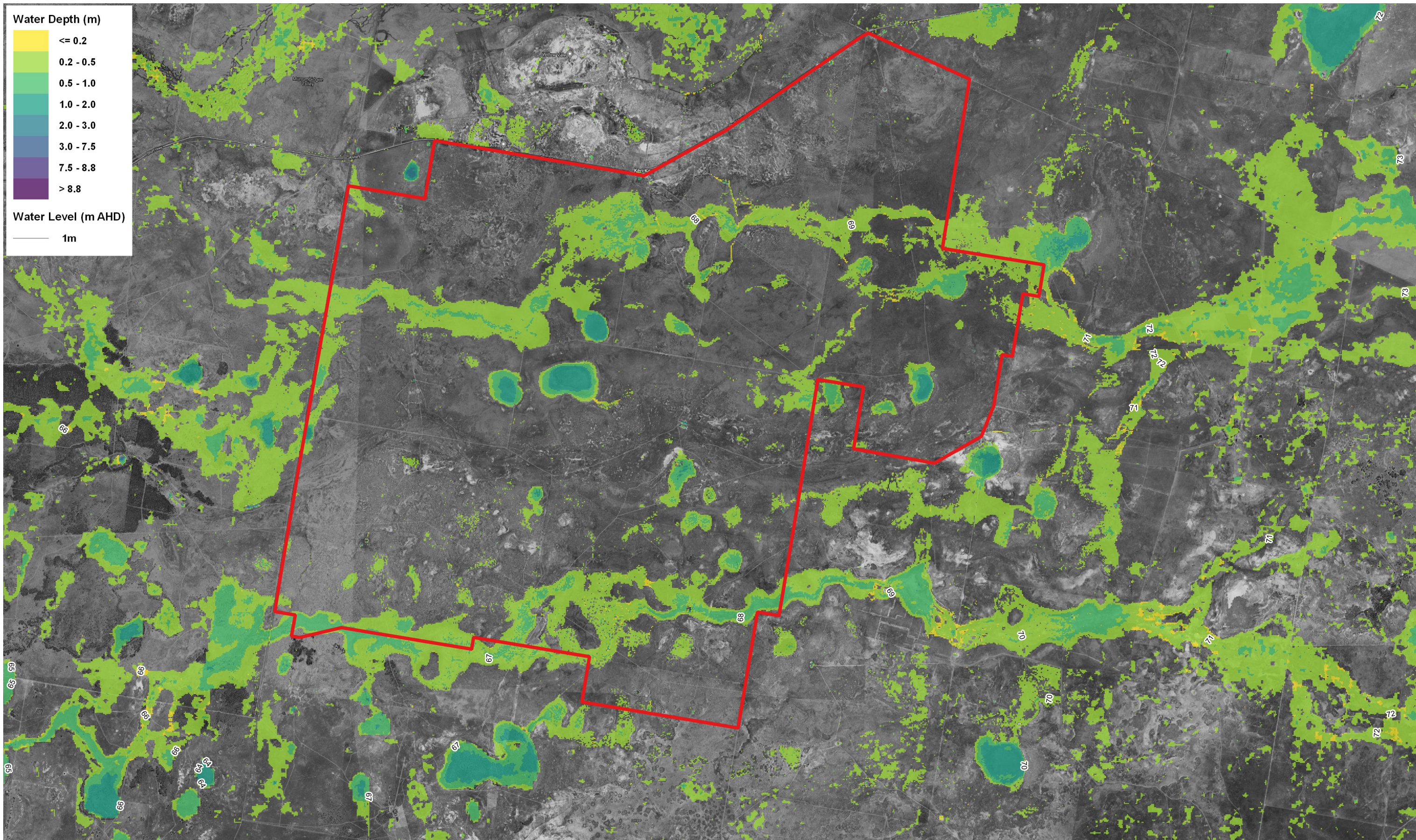
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LEGEND

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Keri Keri - Baseline - 1% AEP Peak Flood Depth and Level

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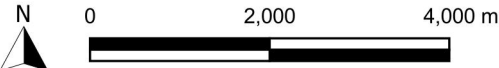
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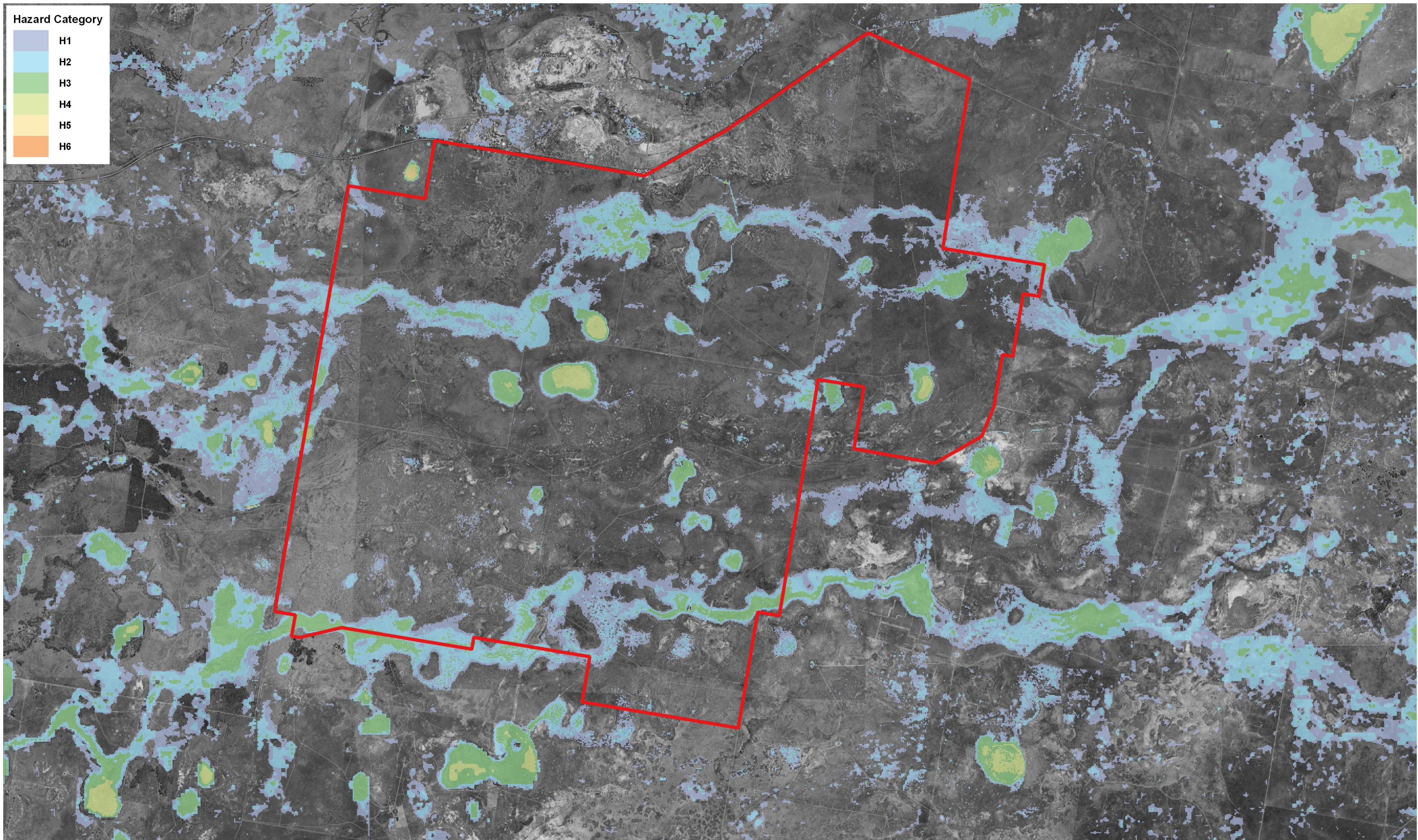
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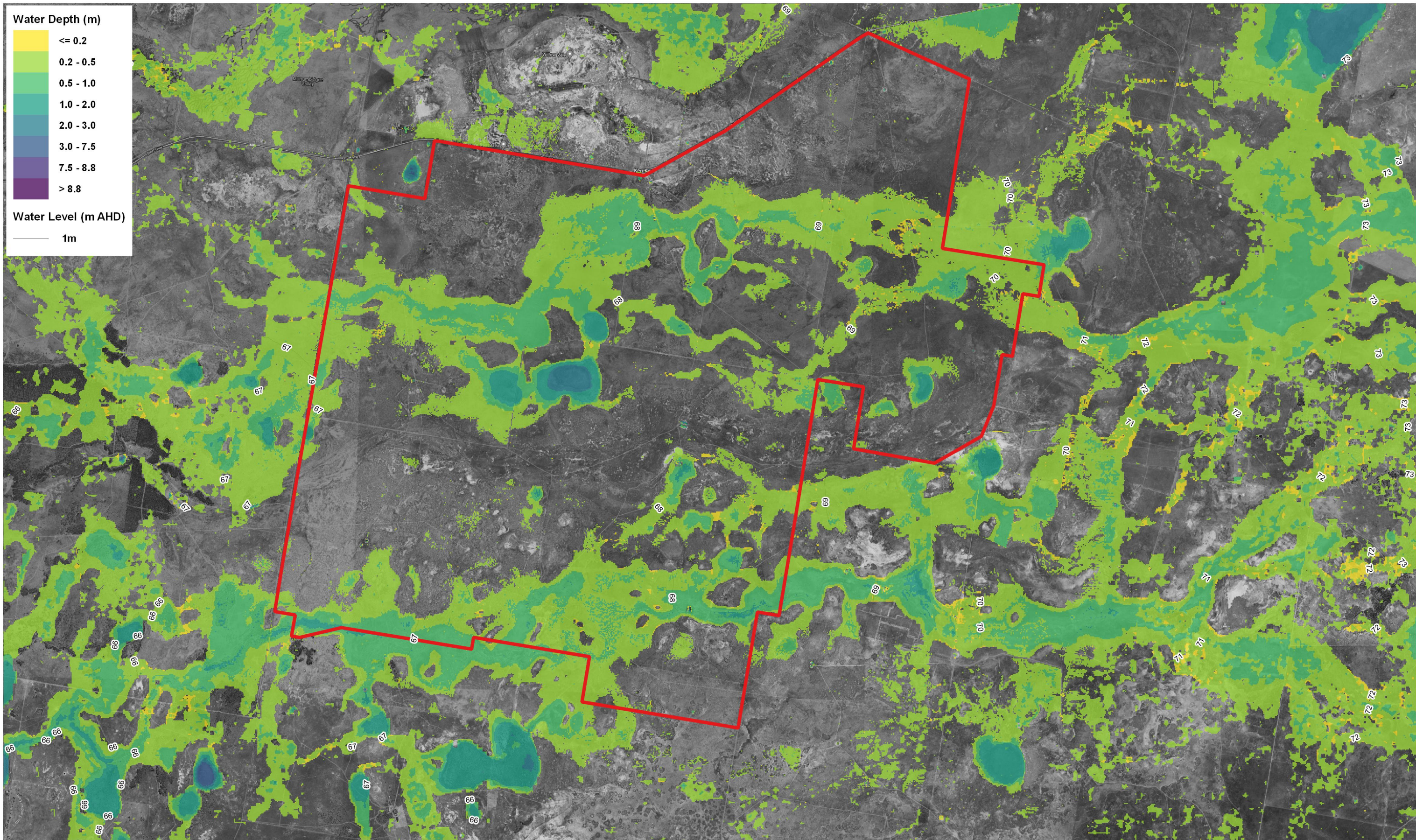
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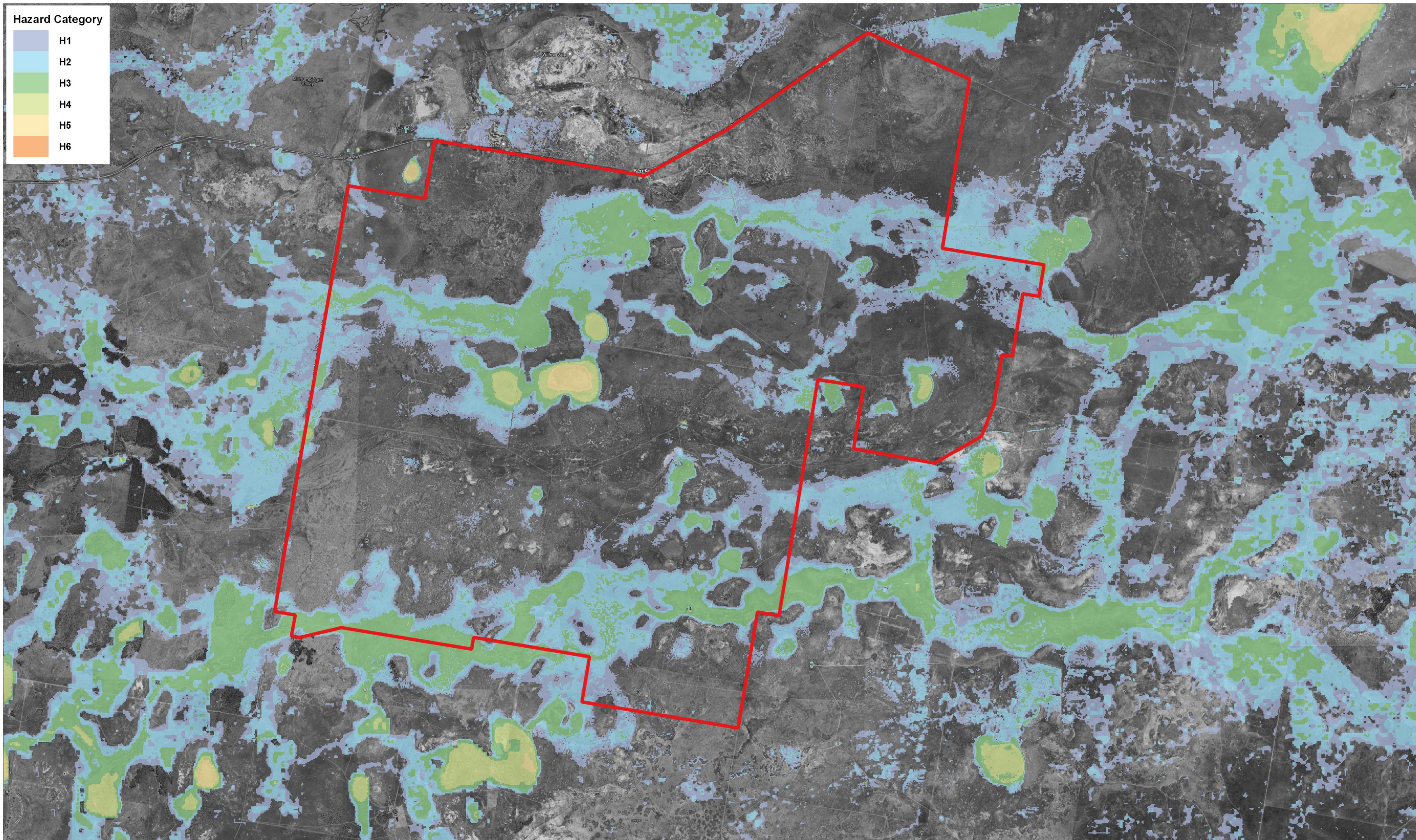
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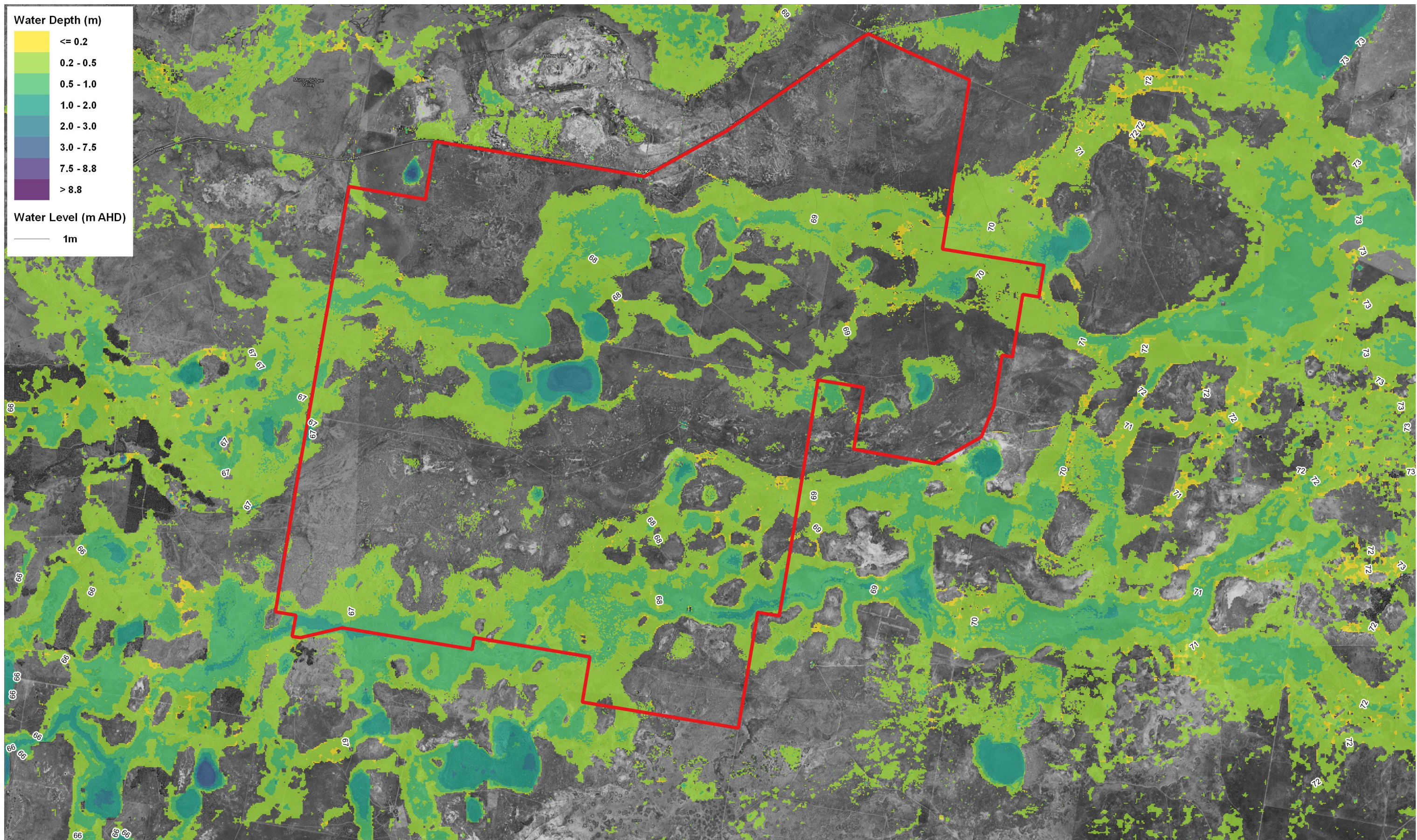
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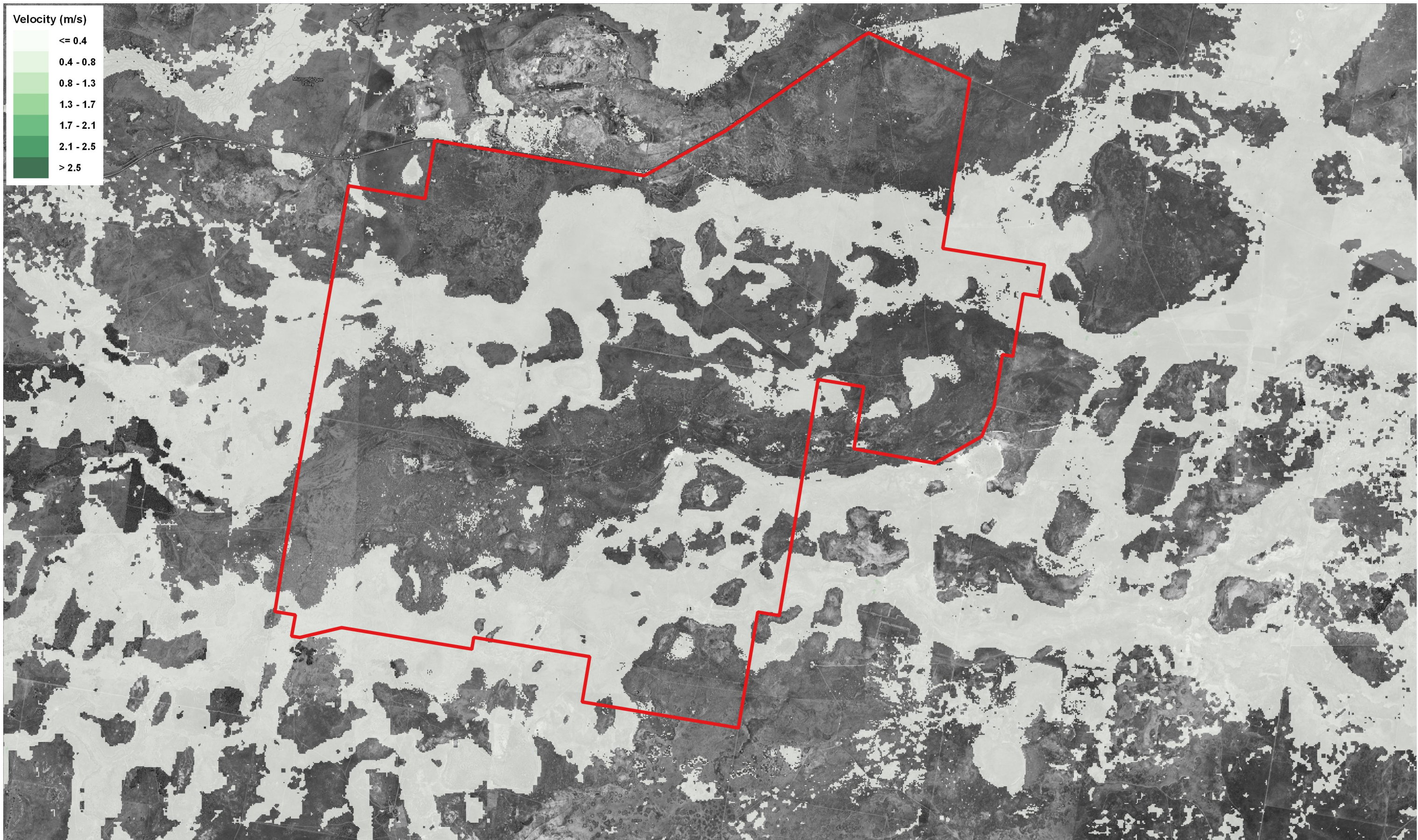
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 Project Extent

Title:

Keri Keri - Baseline - 0.2% AEP Peak Flood Velocity

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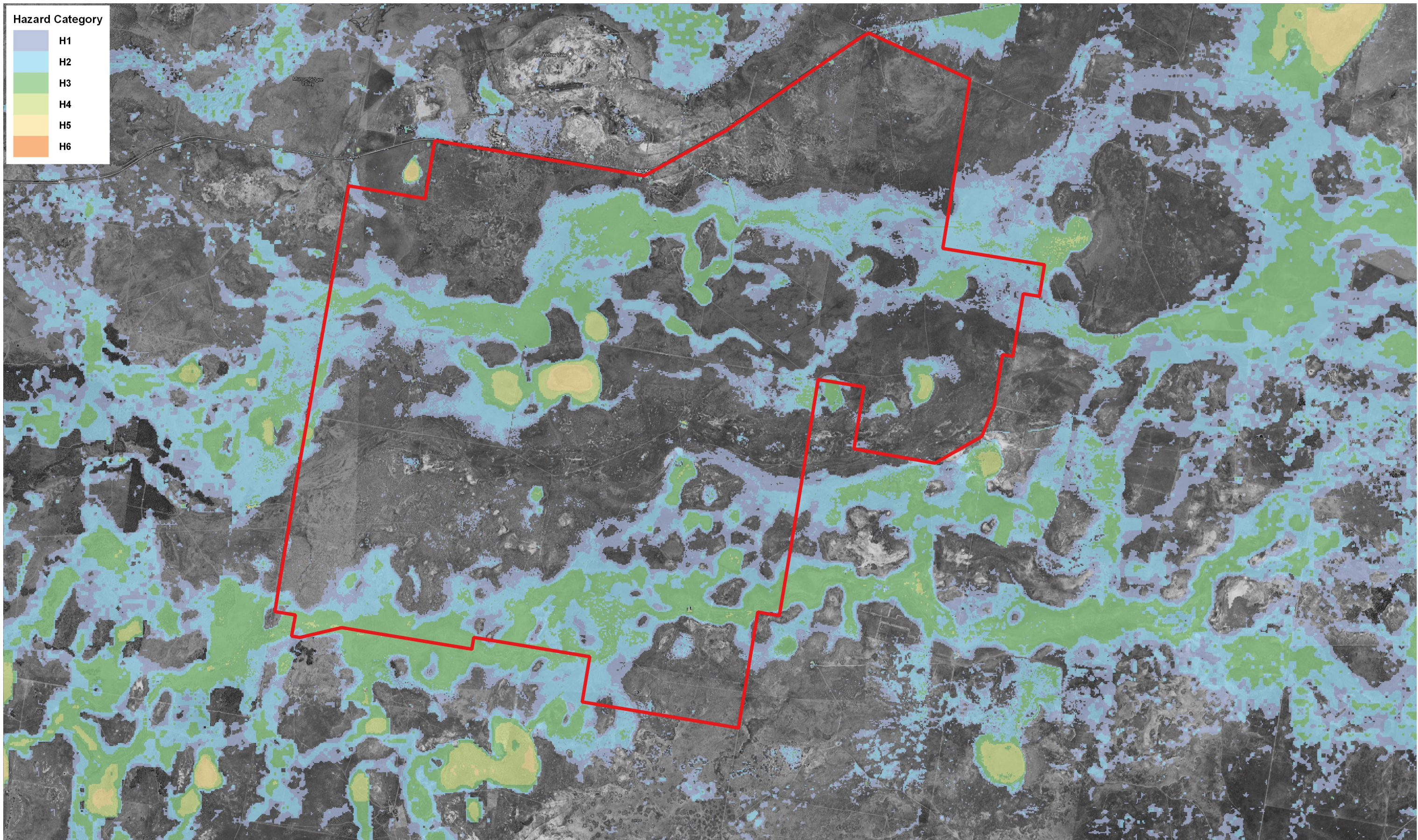
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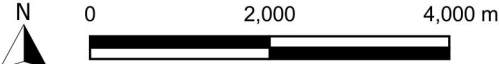
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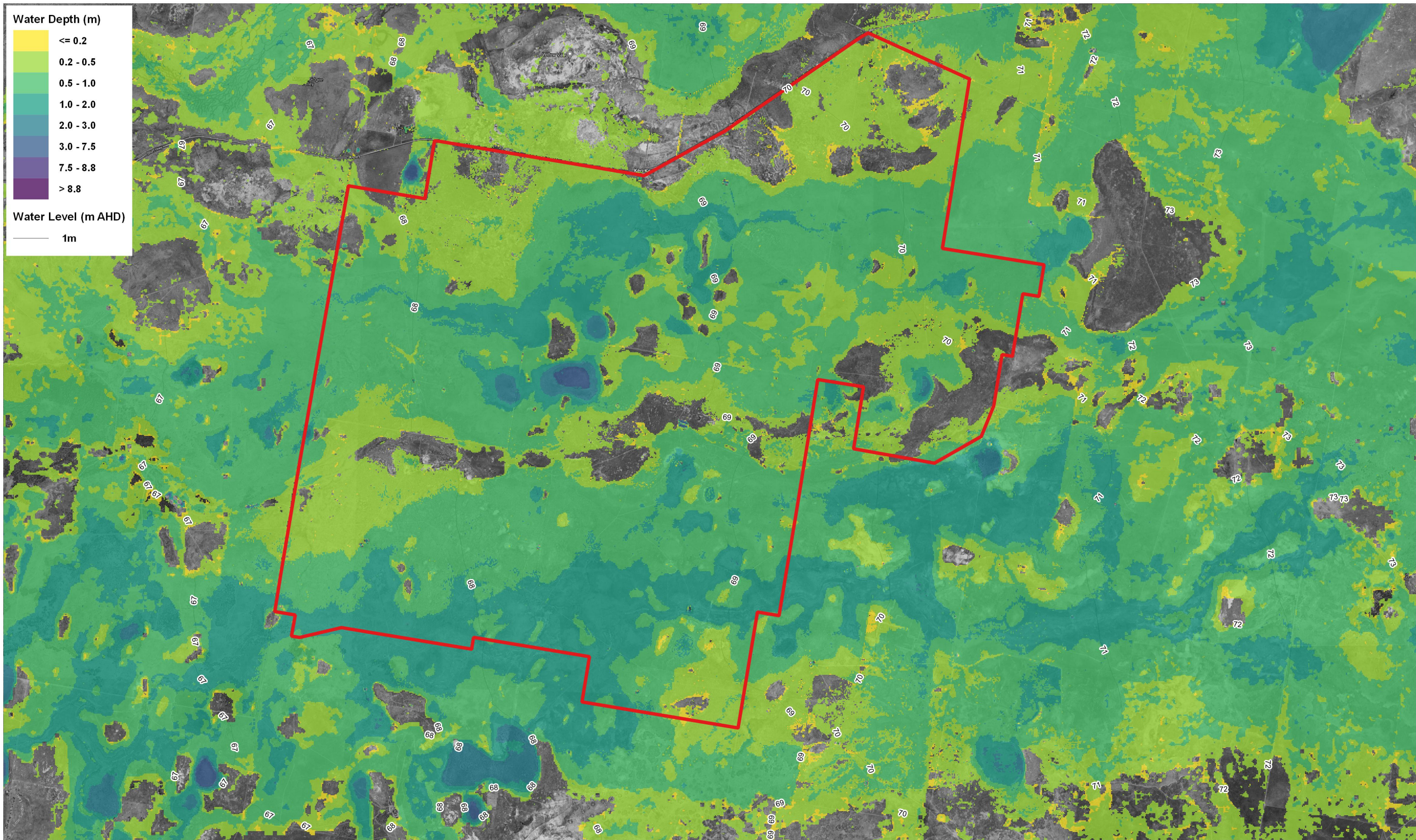
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LEGEND

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Keri Keri - Baseline - PMF Peak Flood Depth and Level

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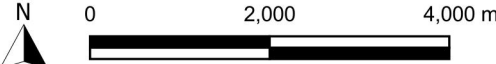


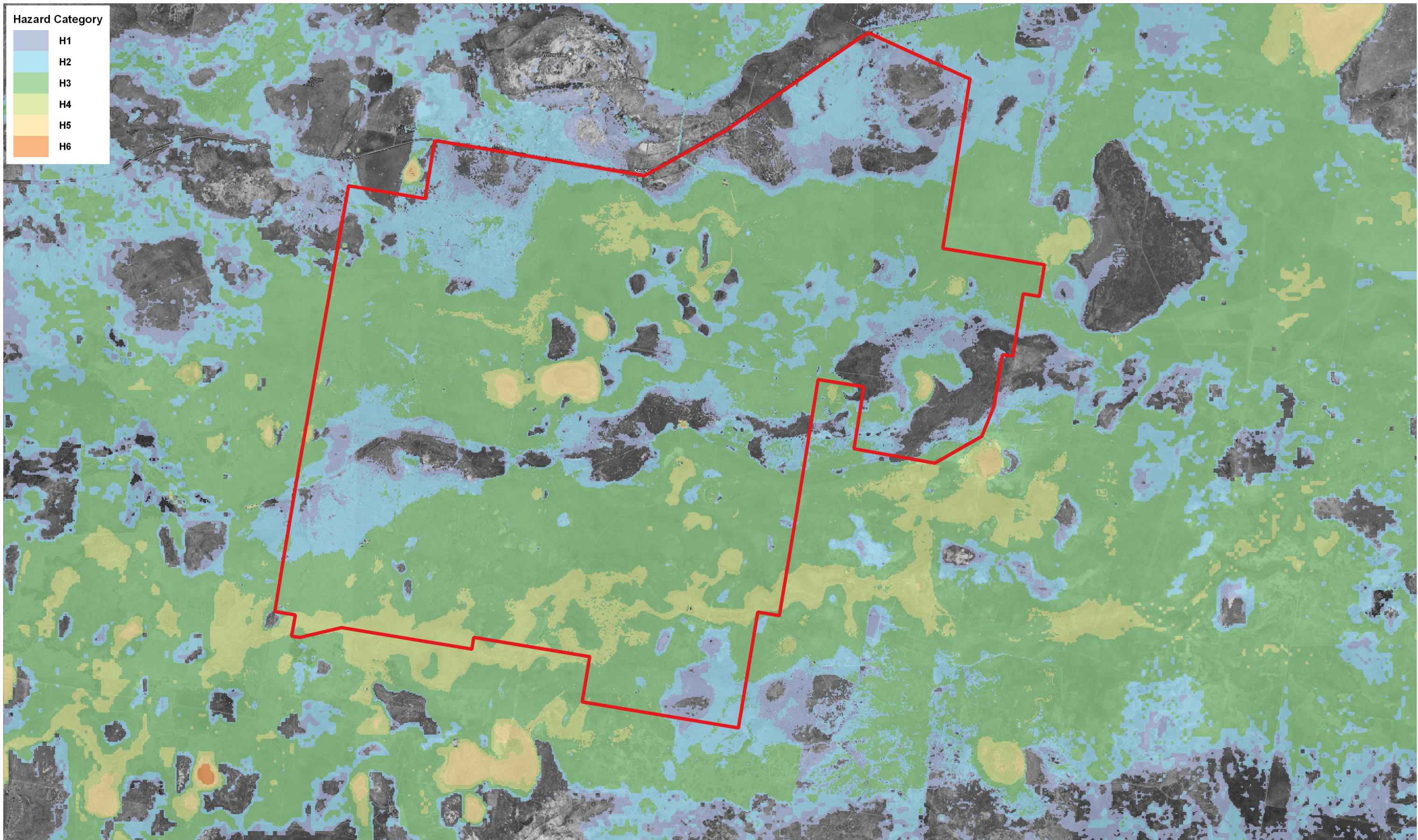
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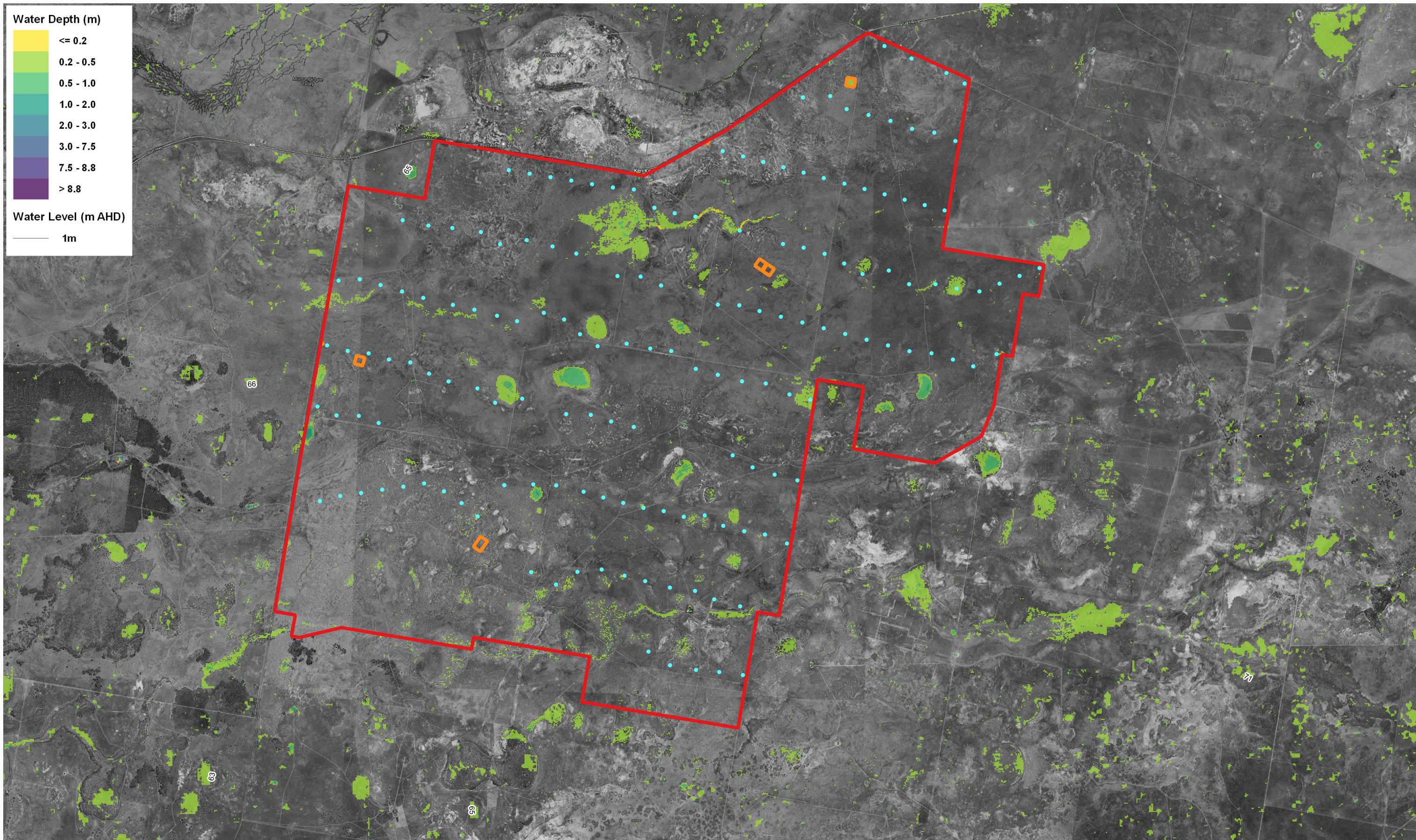
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	Filepath: K:\A10766_KeriKeri_WindSolar_EIS_Flooding\GIS\Figure_Generator\Project\KeriKeri_Flood_Maps.qgz			



LEGEND Project Extent	Title: Keri Keri - Baseline - PMF Peak Flood Hazard		Drawing: A-18	Rev: A
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	Filepath: K:\A10766_KeriKeri_WindSolar_EIS_Flooding\GIS\Figure_Generator\Project\KeriKeri_Flood_Maps.qgz			



Annex B Developed Scenario Flood Maps



LEGEND

-  Project Extent
-  Proposed Developments
-  Turbine Locations

Title:

Keri Keri - Developed Case - 20% AEP Peak Flood Depth and Level

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0 2,000 4,000 m

Drawing:

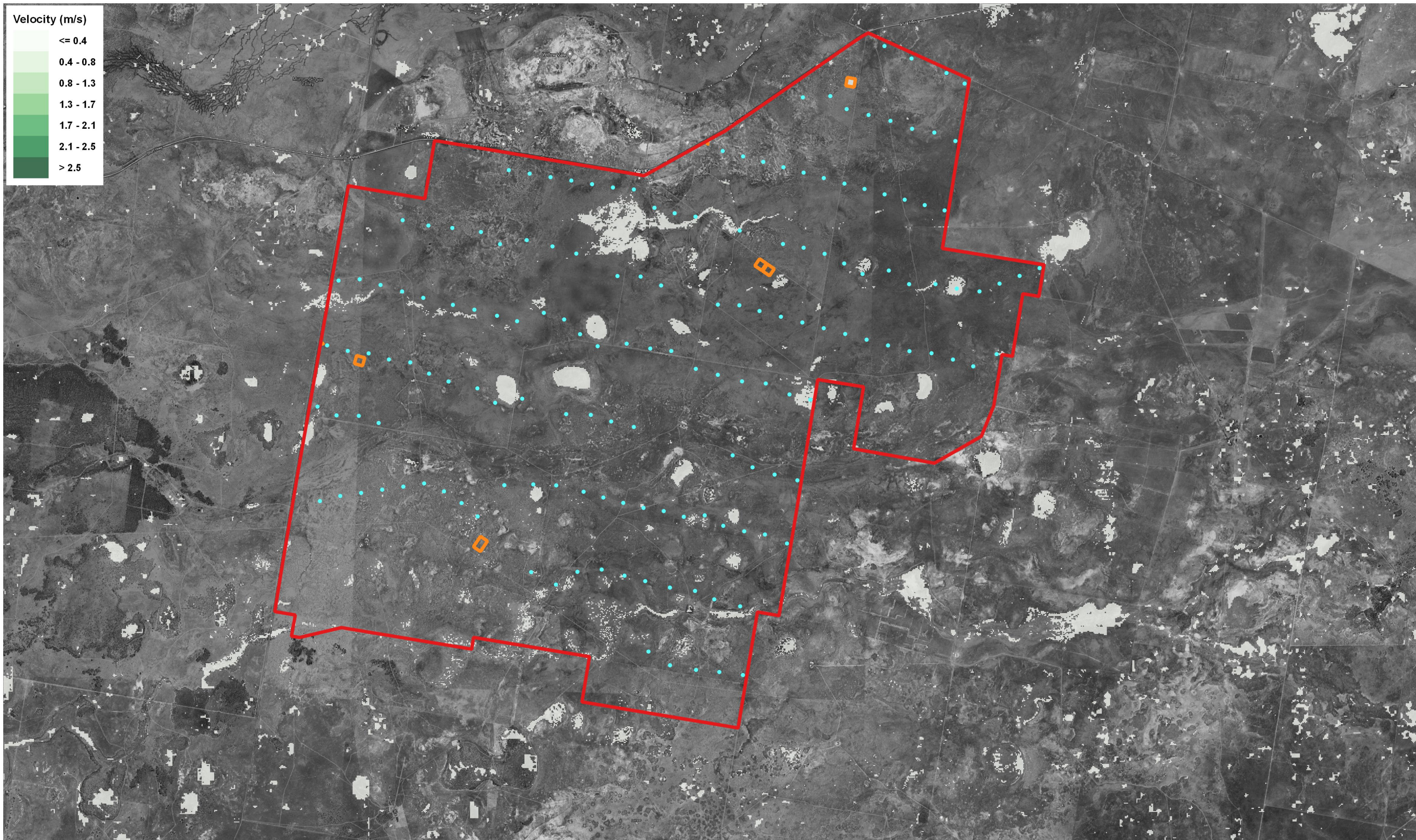
B-1

Rev:

A



Filepath: K:\A10766_KeriKeri_WindSolar_EIS_Flooding\GIS\Figure_Generator\Project\KeriKeri_Flood_Maps.qgz



LEGEND

-  Project Extent
-  Proposed Developments
-  Turbine Locations

Title:

Keri Keri - Developed Case - 20% AEP Peak Flood Velocity

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0 2,000 4,000 m

Drawing:

B-2

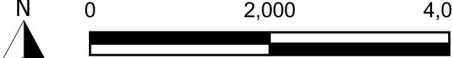
Rev:

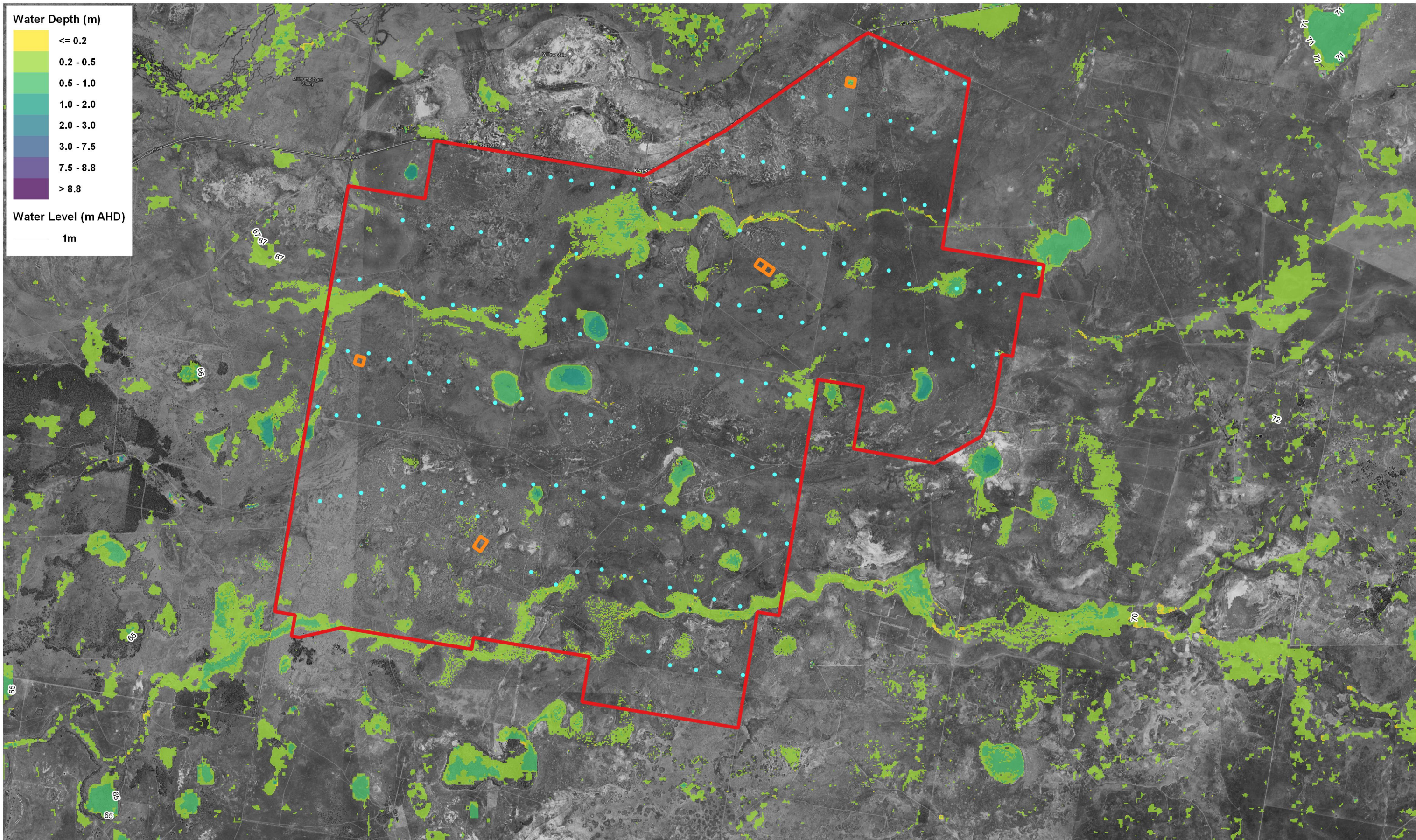
A



Filepath: K:\A10766_KeriKeri_WindSolar_EIS_Flooding\GIS\Figure_Generator\Project\KeriKeri_Flood_Maps.qgz



LEGEND  Project Extent  Proposed Developments  Turbine Locations	Title: Keri Keri - Developed Case - 20% AEP Peak Flood Hazard	Drawing: B-3	Rev: A	
	BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.	N 0 2,000 4,000 m 	 www.bmt.org	
	Filepath: K:\A10766_KeriKeri_WindSolar_EIS_Flooding\GIS\Figure_Generator\Project\KeriKeri_Flood_Maps.qgz			



LEGEND

- Project Extent
- Proposed Developments
- Turbine Locations

Title:

Keri Keri - Developed Case - 5% AEP Peak Flood Depth and Level

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0 2,000 4,000 m

Drawing:

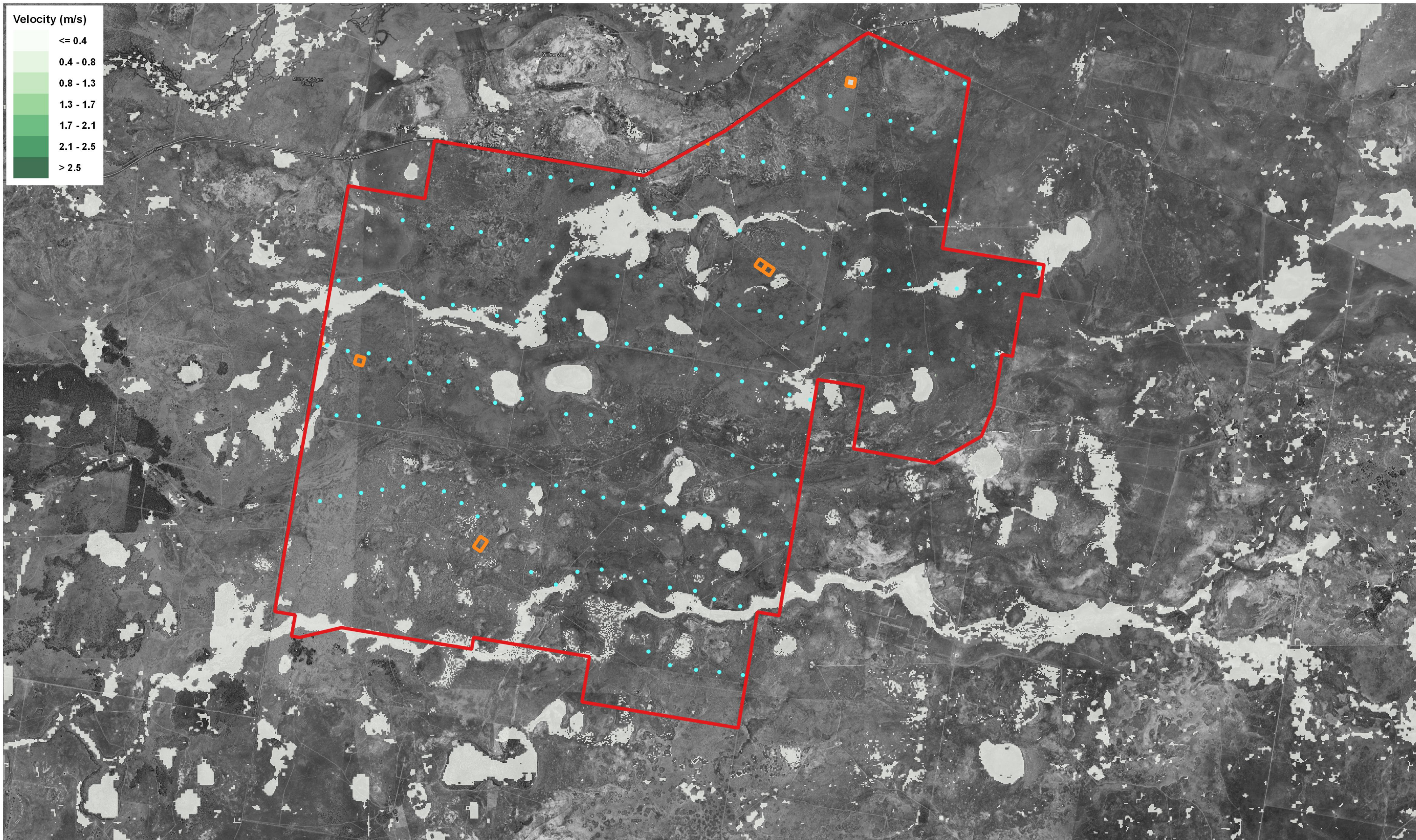
B-4

Rev:

A



Filepath: K:\A10766_KeriKeri_WindSolar_EIS_Flooding\GIS\Figure_Generator\Project\KeriKeri_Flood_Maps.qgz



LEGEND

-  Project Extent
-  Proposed Developments
-  Turbine Locations

Title:

Keri Keri - Developed Case - 5% AEP Peak Flood Velocity

Drawing:

B-5

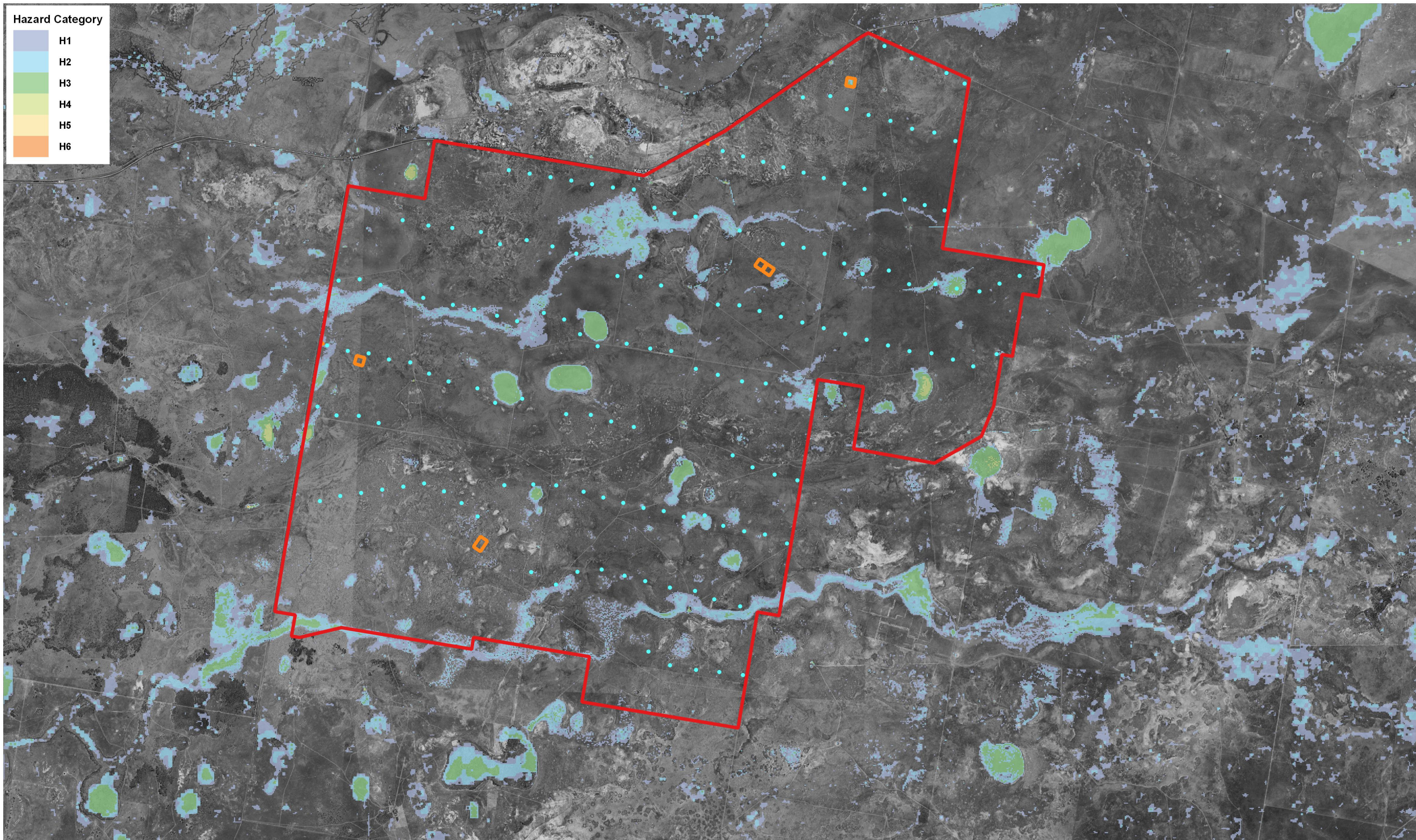
Rev:

A

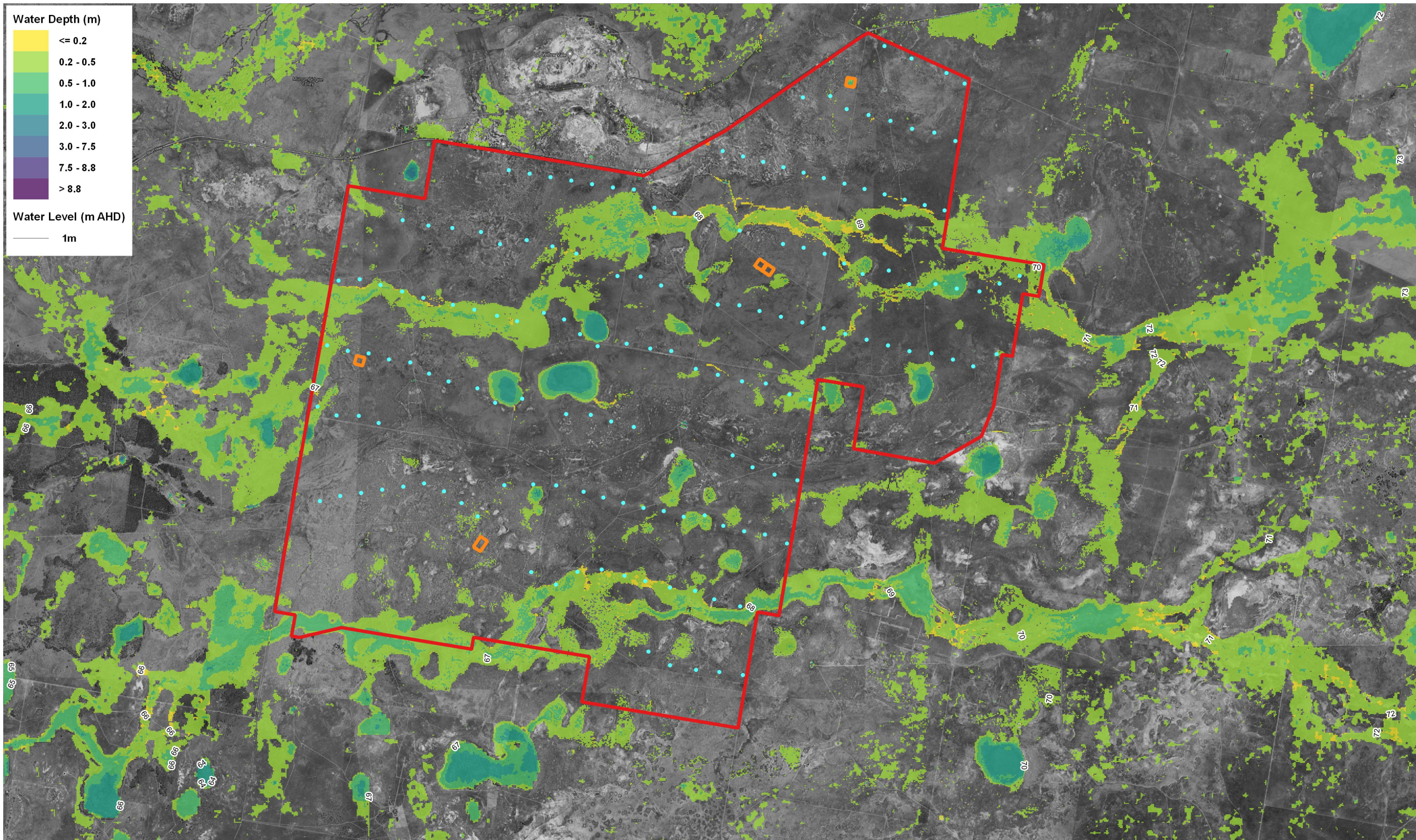
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Filepath: K:\A10766_KeriKeri_WindSolar_EIS_Flooding\GIS\Figure_Generator\Project\KeriKeri_Flood_Maps.qgz



LEGEND Project Extent Proposed Developments Turbine Locations	Title: Keri Keri - Developed Case - 5% AEP Peak Flood Hazard		Drawing: B-6	Rev: A
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	Filepath: K:\A10766_KeriKeri_WindSolar_EIS_Flooding\GIS\Figure_Generator\Project\KeriKeri_Flood_Maps.qgz			



LEGEND

- Project Extent
- Proposed Developments
- Turbine Locations

Title:

Keri Keri - Developed Case - 1% AEP Peak Flood Depth and Level

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0 2,000 4,000 m

Drawing:

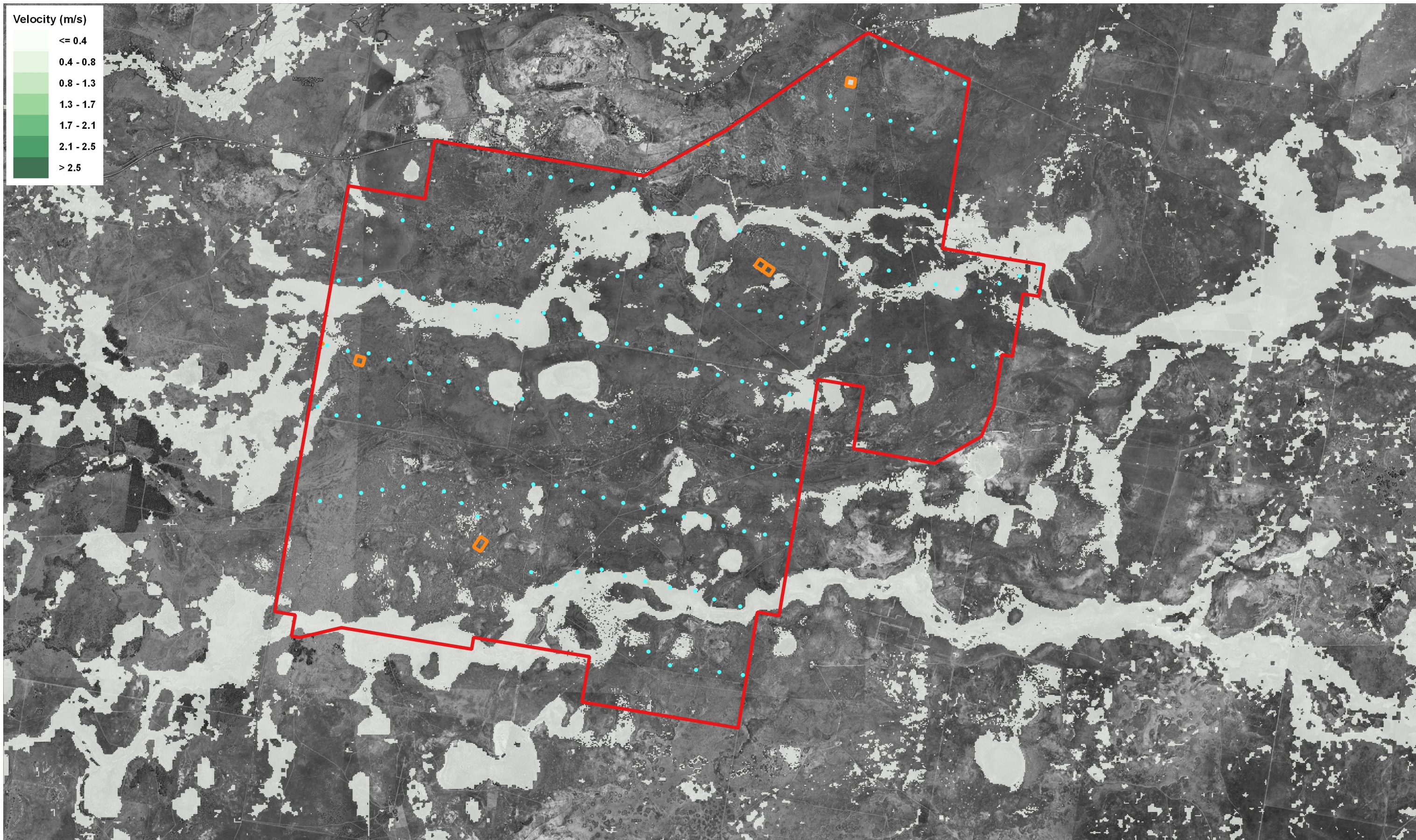
B-7

Rev:

A



Filepath: K:\A10766_KeriKeri_WindSolar_EIS_Flooding\GIS\Figure_Generator\Project\KeriKeri_Flood_Maps.qgz



LEGEND

-  Project Extent
-  Proposed Developments
-  Turbine Locations

Title:

Kerri Kerri - Developed Case - 1% AEP Peak Flood Velocity

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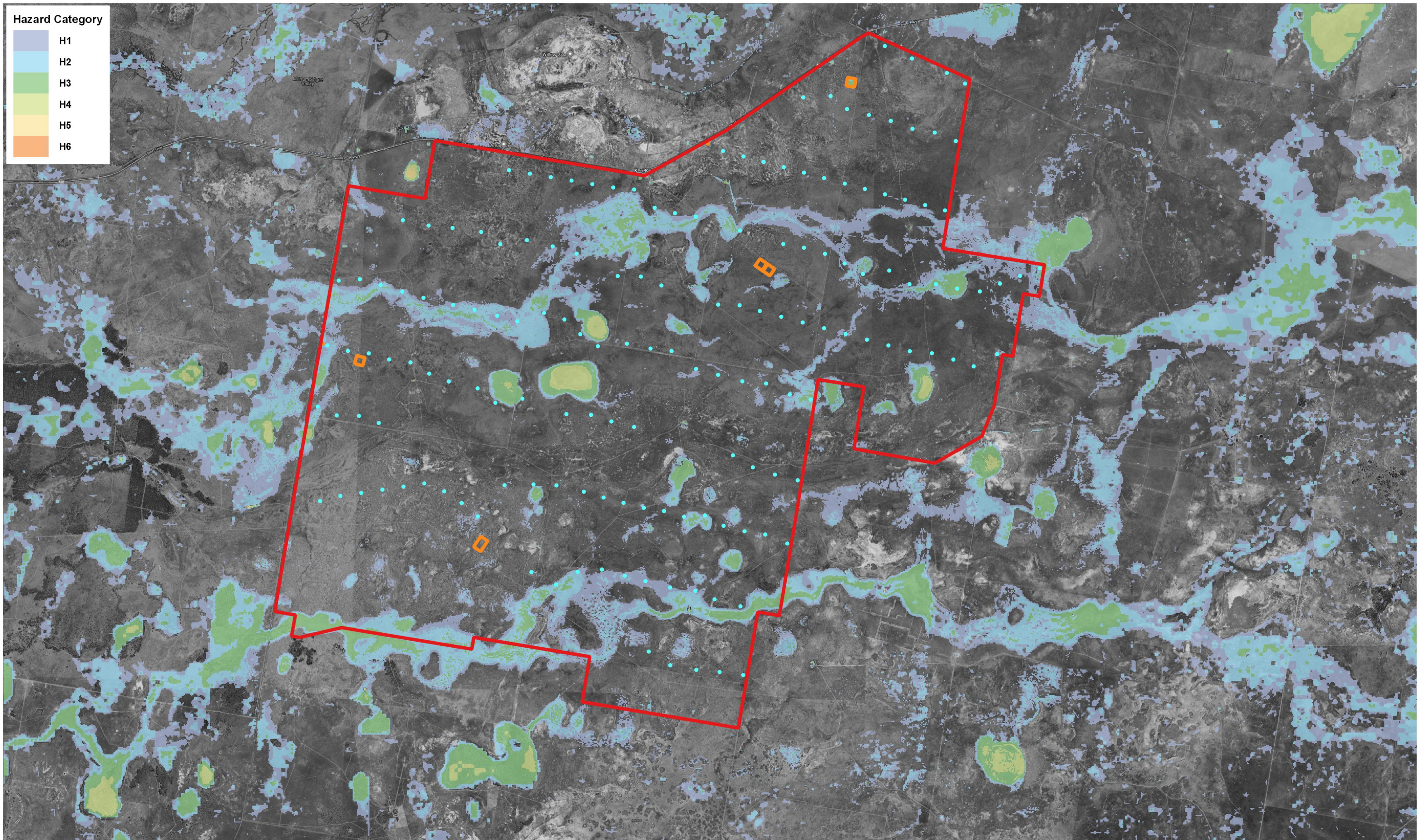
B-8

Rev:

A



Filepath: K:\A10766_KerriKerri_WindSolar_EIS_Flooding\GIS\Figure_Generator\Project\KerriKerri_Flood_Maps.qgz



LEGEND

-  Project Extent
-  Proposed Developments
-  Turbine Locations

Title:

Keri Keri - Developed Case - 1% AEP Peak Flood Hazard

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0 2,000 4,000 m

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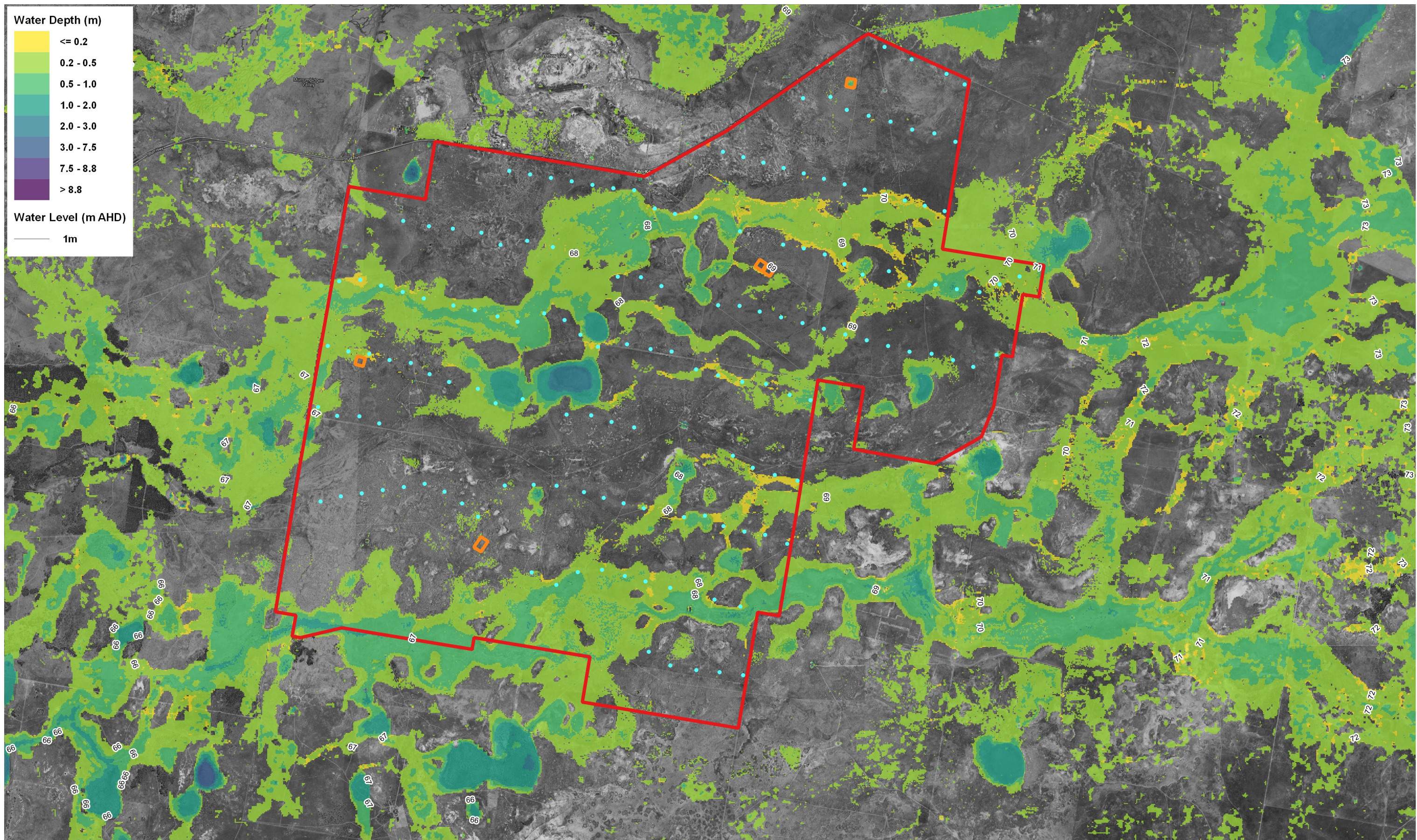
B-9

Rev:

A



Filepath: K:\A10766_KeriKeri_WindSolar_EIS_Flooding\GIS\Figure_Generator\Project\KeriKeri_Flood_Maps.qgz



LEGEND

- Project Extent
- Proposed Developments
- Turbine Locations

Title:

Keri Keri - Developed Case - 0.5% AEP Peak Flood Depth and Level

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0 2,000 4,000 m

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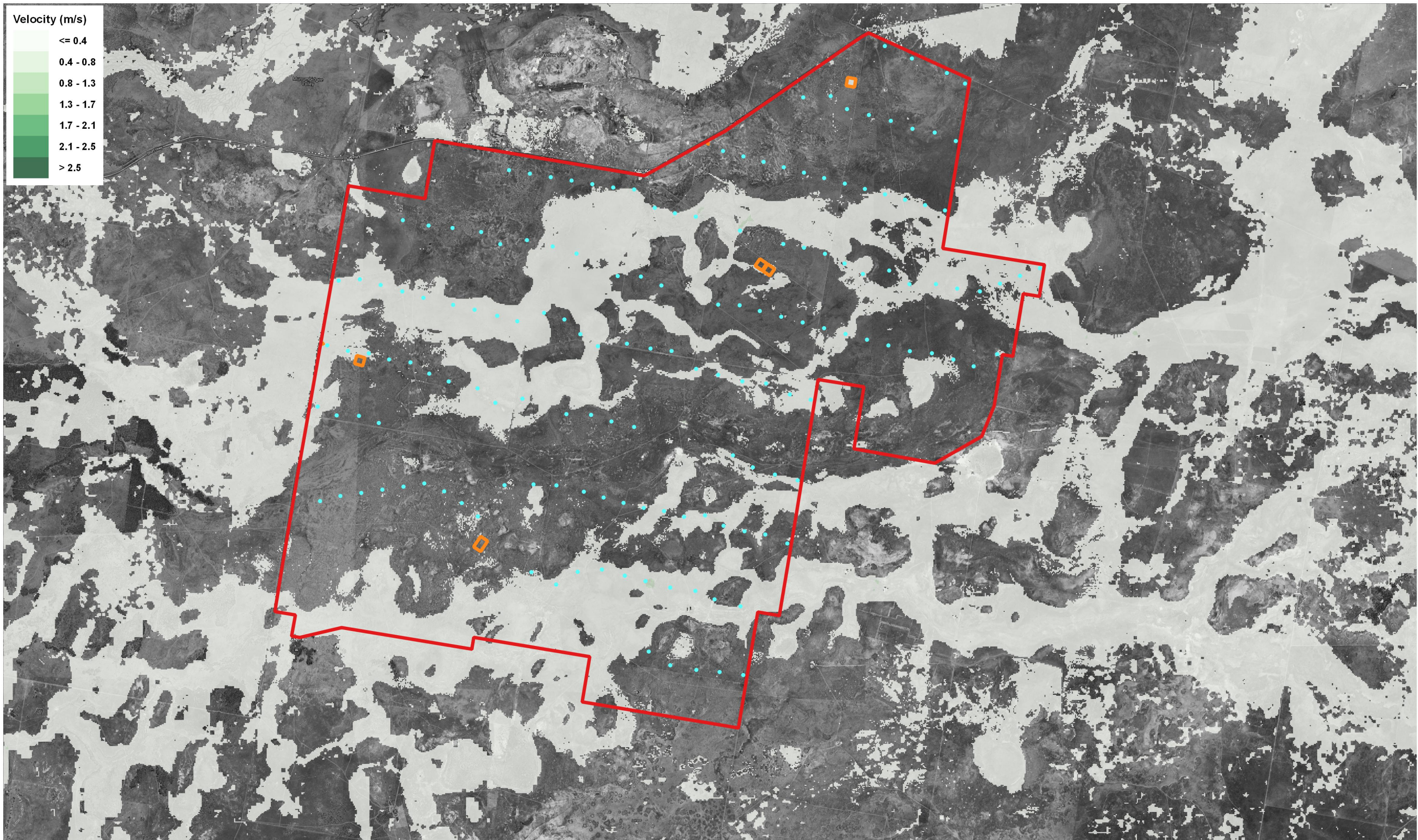
B-10

Rev:

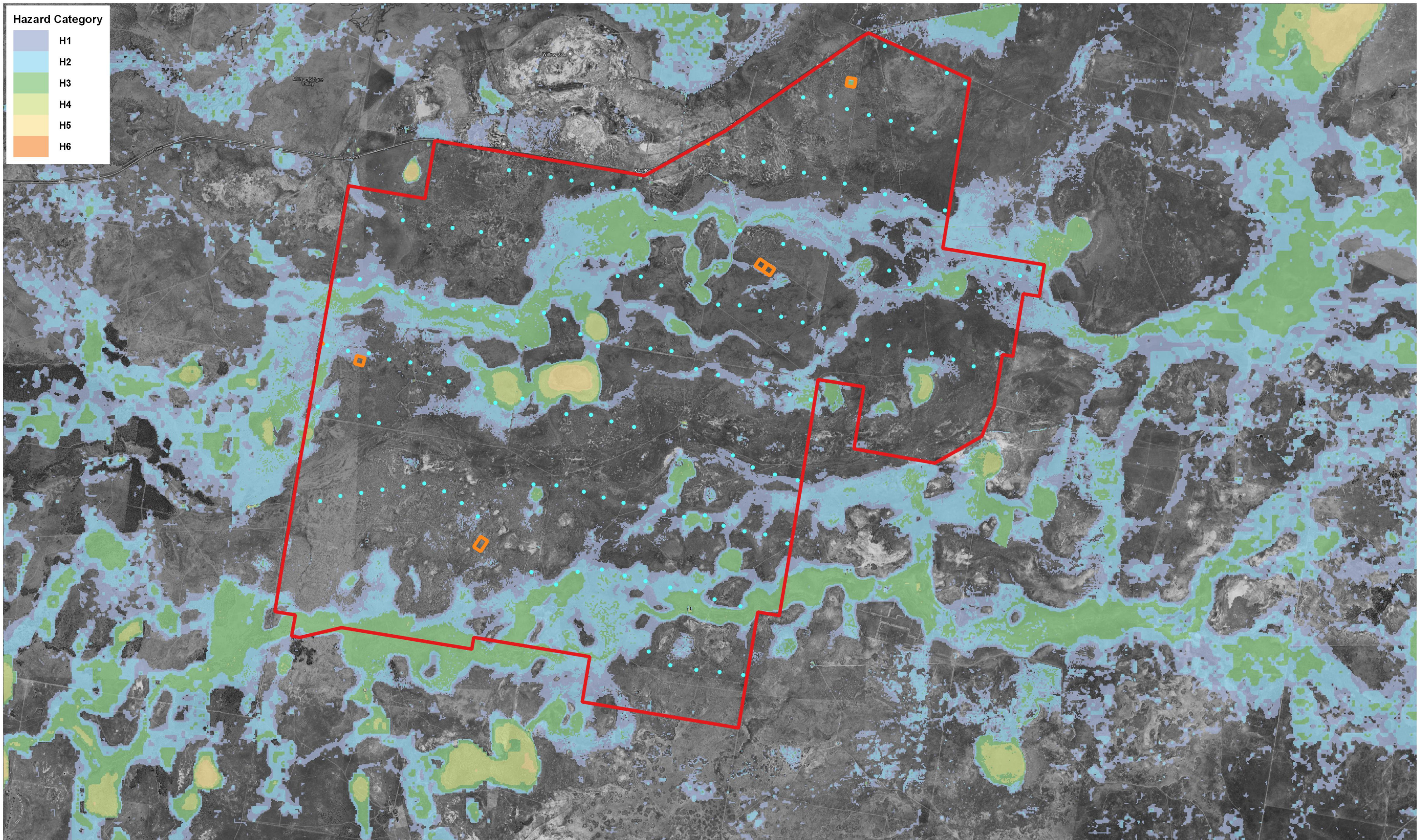
A



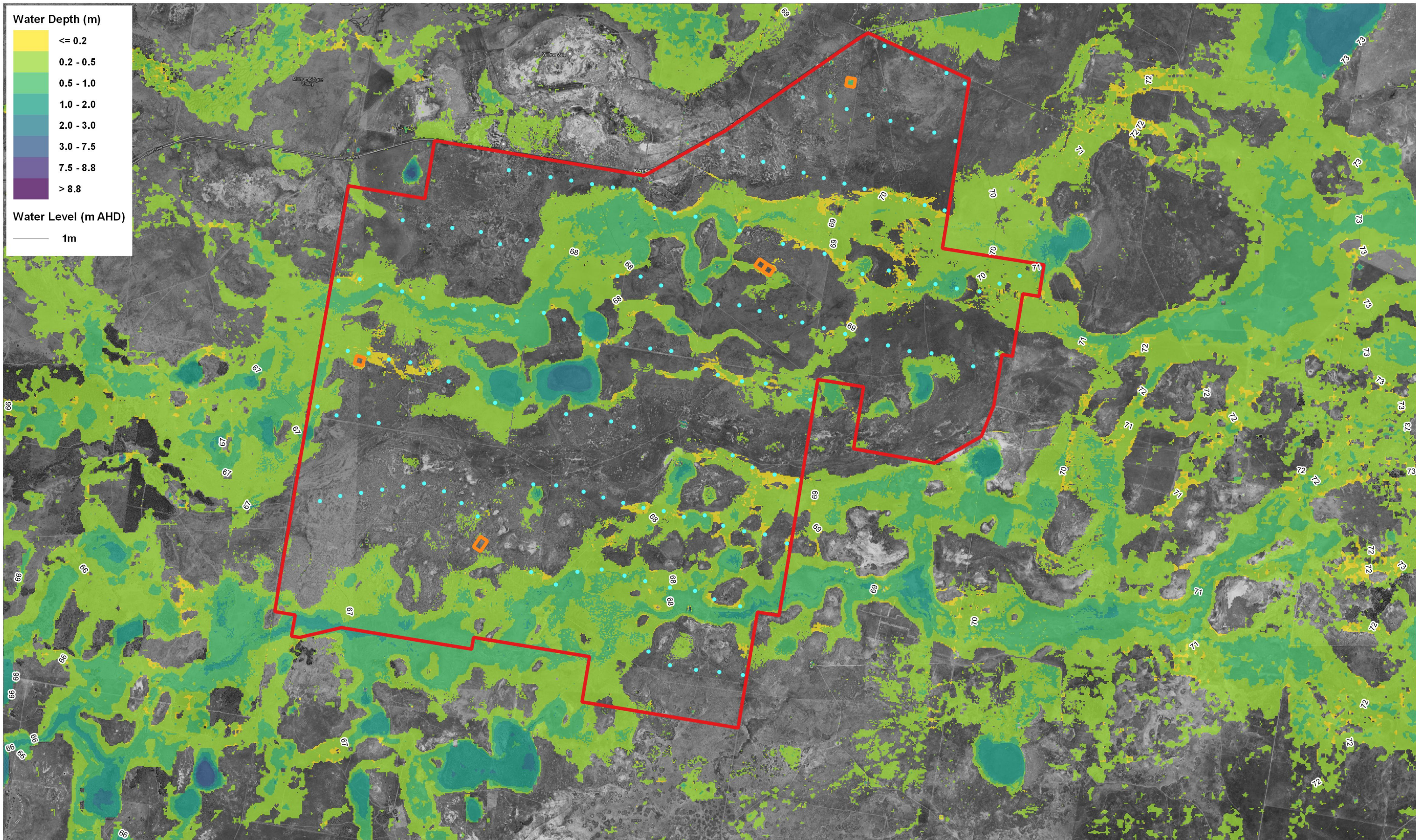
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LEGEND Project Extent Proposed Developments Turbine Locations	Title: Keri Keri - Developed Case - 0.5% AEP Peak Flood Velocity		Drawing: B-11	Rev: A
	BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.			
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LEGEND Project Extent Proposed Developments Turbine Locations	Title: Kerri Kerri - Developed Case - 0.5% AEP Peak Flood Hazard		Drawing: B-12	Rev: A
	BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.		 www.bmt.org	
	Filepath: K:\A10766_KerriKerri_WindSolar_EIS_Flooding\GIS\Figure_Generator\Project\KerriKerri_Flood_Maps.qgz			



LEGEND

- Project Extent
- Proposed Developments
- Turbine Locations

Title:

Keri Keri - Developed Case - 0.2% AEP Peak Flood Depth and Level

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0 2,000 4,000 m

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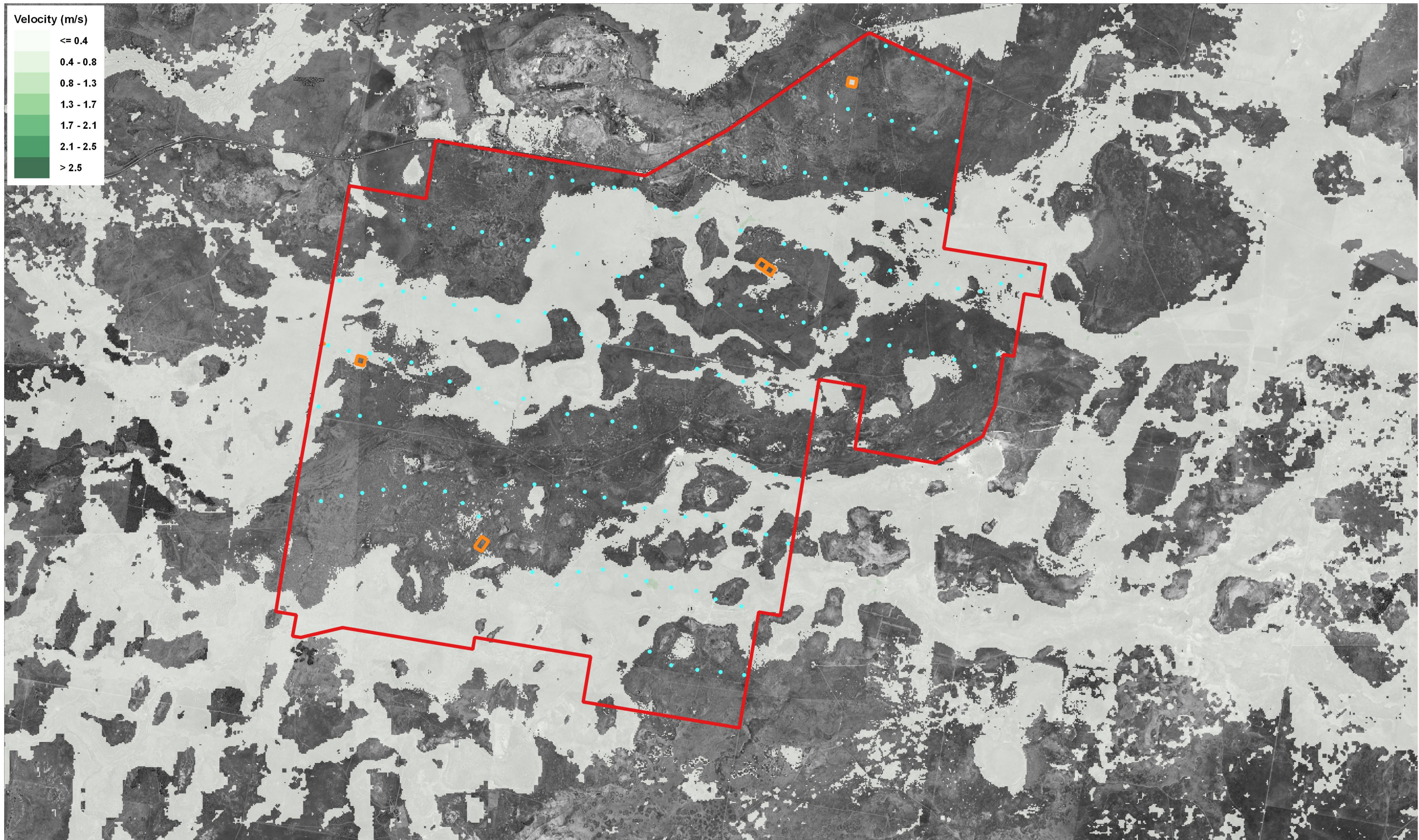
B-13

Rev:

A



Filepath: K:\A10766_KeriKeri_WindSolar_EIS_Flooding\GIS\Figure_Generator\Project\KeriKeri_Flood_Maps.qgz



LEGEND

-  Project Extent
-  Proposed Developments
-  Turbine Locations

Title:

Keri Keri - Developed Case - 0.2% AEP Peak Flood Velocity

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0 2,000 4,000 m

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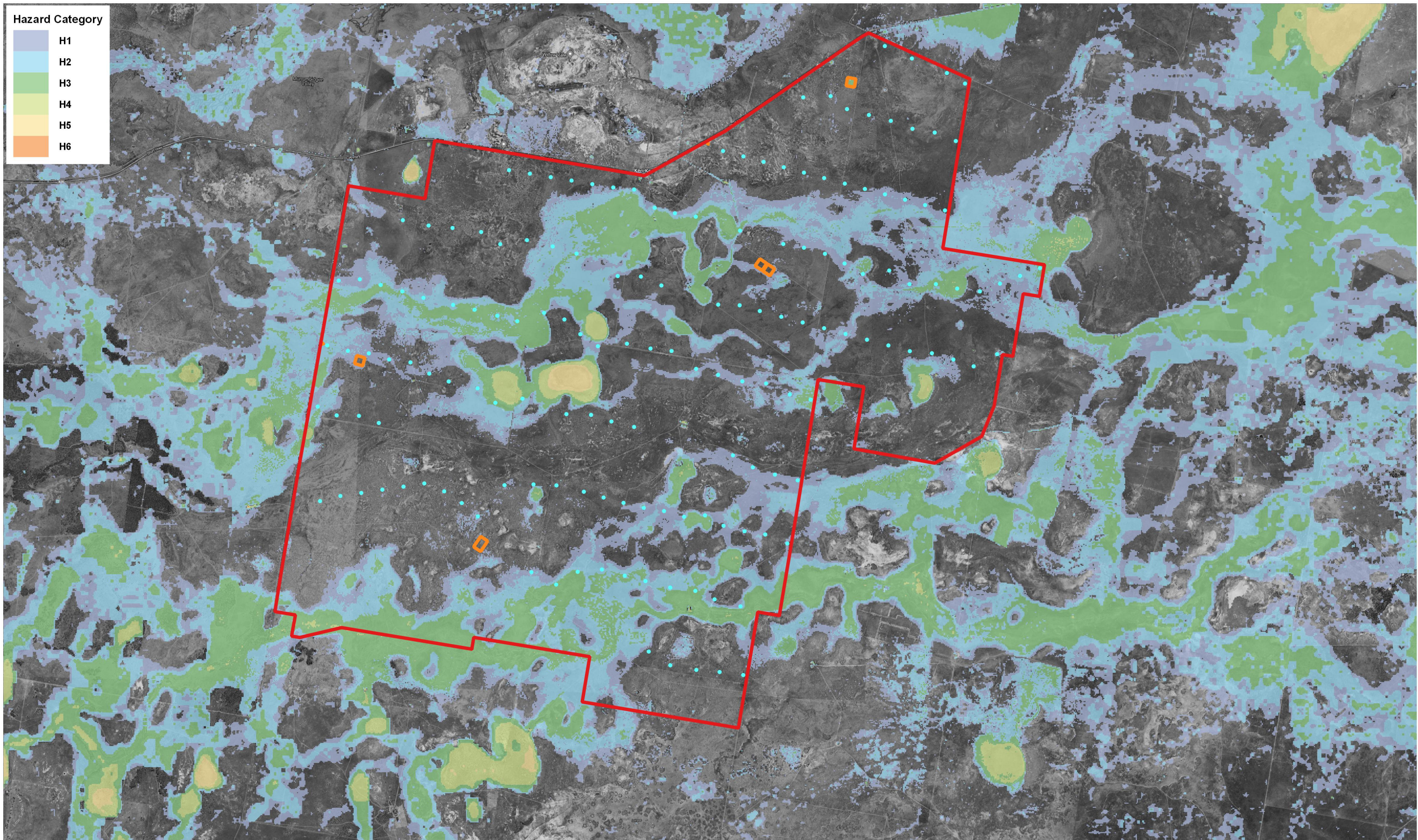
B-14

Rev:

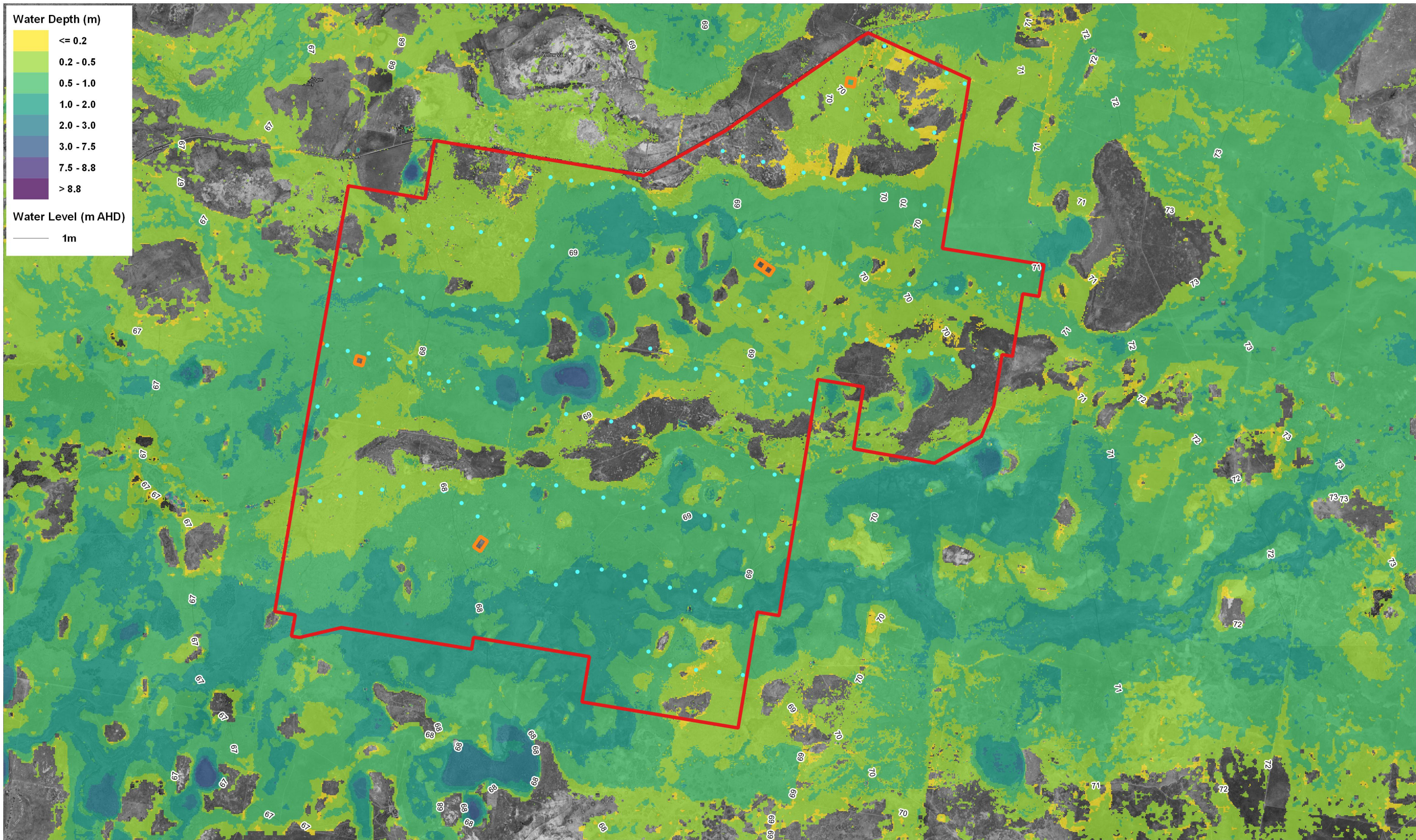
A

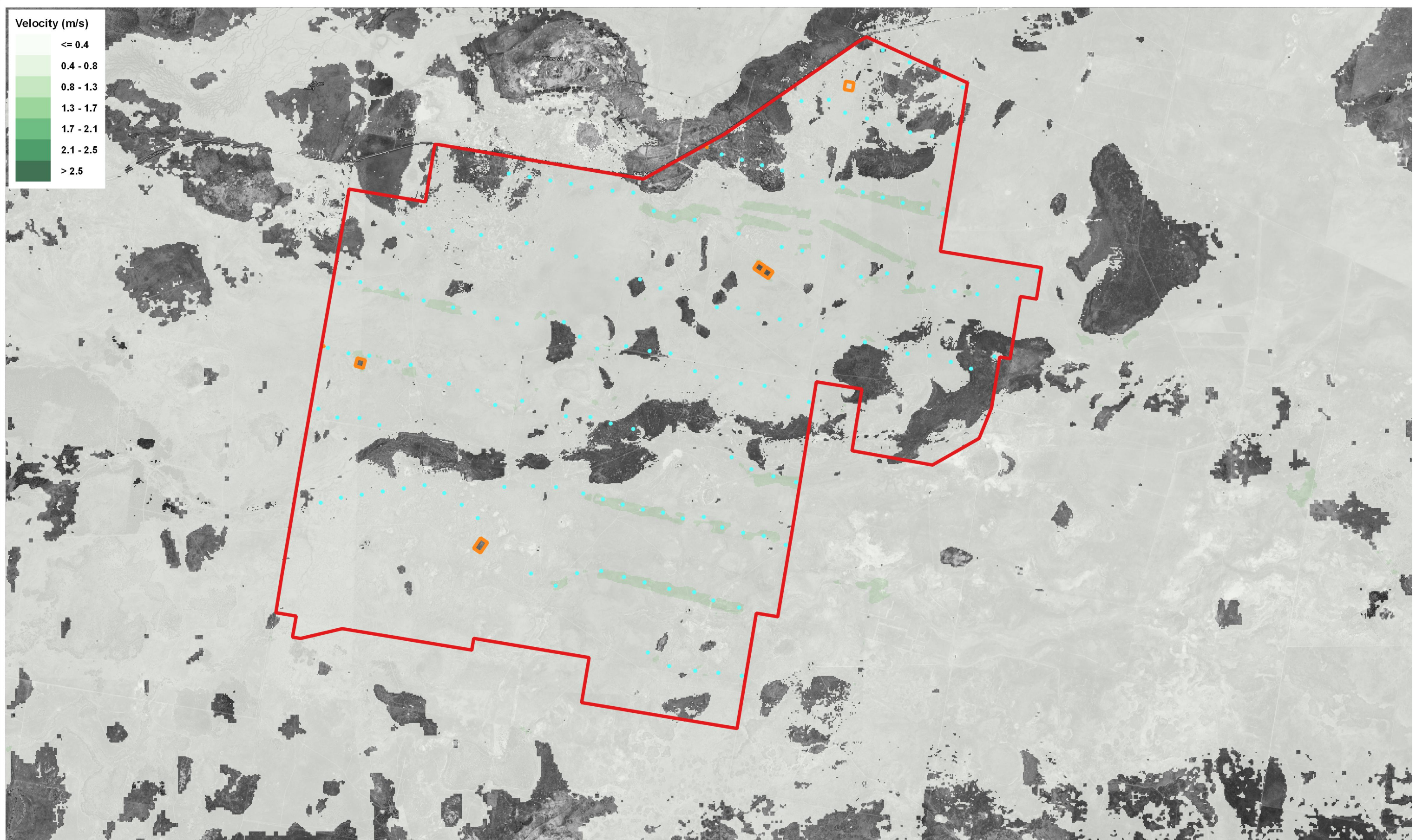


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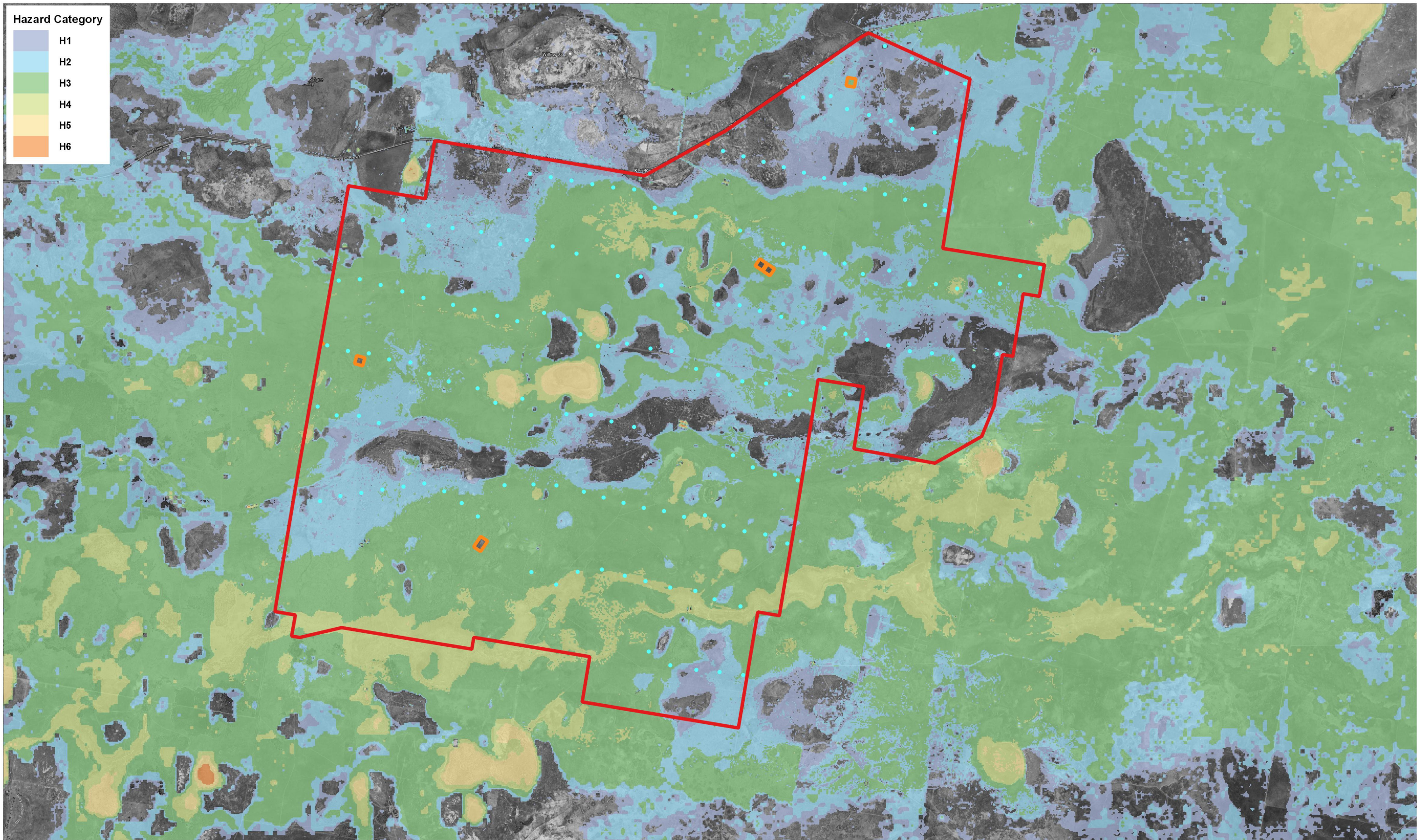


LEGEND		Title: Keri Keri - Developed Case - 0.2% AEP Peak Flood Hazard		Drawing: B-15	Rev: A
- Project Extent - Proposed Developments - Turbine Locations		BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map. 0 2,000 4,000 m BMT www.bmt.org		Filepath: K:\A10766_KeriKeri_WindSolar_EIS_Flooding\GIS\Figure_Generator\Project\KeriKeri_Flood_Maps.qgz	





LEGEND Project Extent Proposed Developments Turbine Locations	Title: Keri Keri - Developed Case - PMF Peak Flood Velocity		Drawing: B-17	Rev: A
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LEGEND

- Project Extent
- Proposed Developments
- Turbine Locations

Title:

Keri Keri - Developed Case - PMF Peak Flood Hazard

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0 2,000 4,000 m

Drawing:

B-18

Rev:

A



Filepath: K:\A10766_KeriKeri_WindSolar_EIS_Flooding\GIS\Figure_Generator\Project\KeriKeri_Flood_Maps.qgz

Annex C Flood Impact Maps



LEGEND Project Extent	Title: Keri Keri - Flood Impacts - 20% AEP Peak Flood Impacts		Drawing: C-1	Rev: A
	BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.		N 0 2,000 4,000 m  www.bmt.org	
	Filepath: K:\A10766_KeriKeri_WindSolar_EIS_Flooding\GIS\Figure_Generator\Project\KeriKeri_Flood_Maps.qgz			



Wet/Dry

Was Wet Now Dry

Was Dry Now Wet

Afflux (m)

<= -0.2

-0.2 - -0.1

-0.1 - -0.05

-0.05 - -0.02

-0.02 - 0.02

0.02 - 0.05

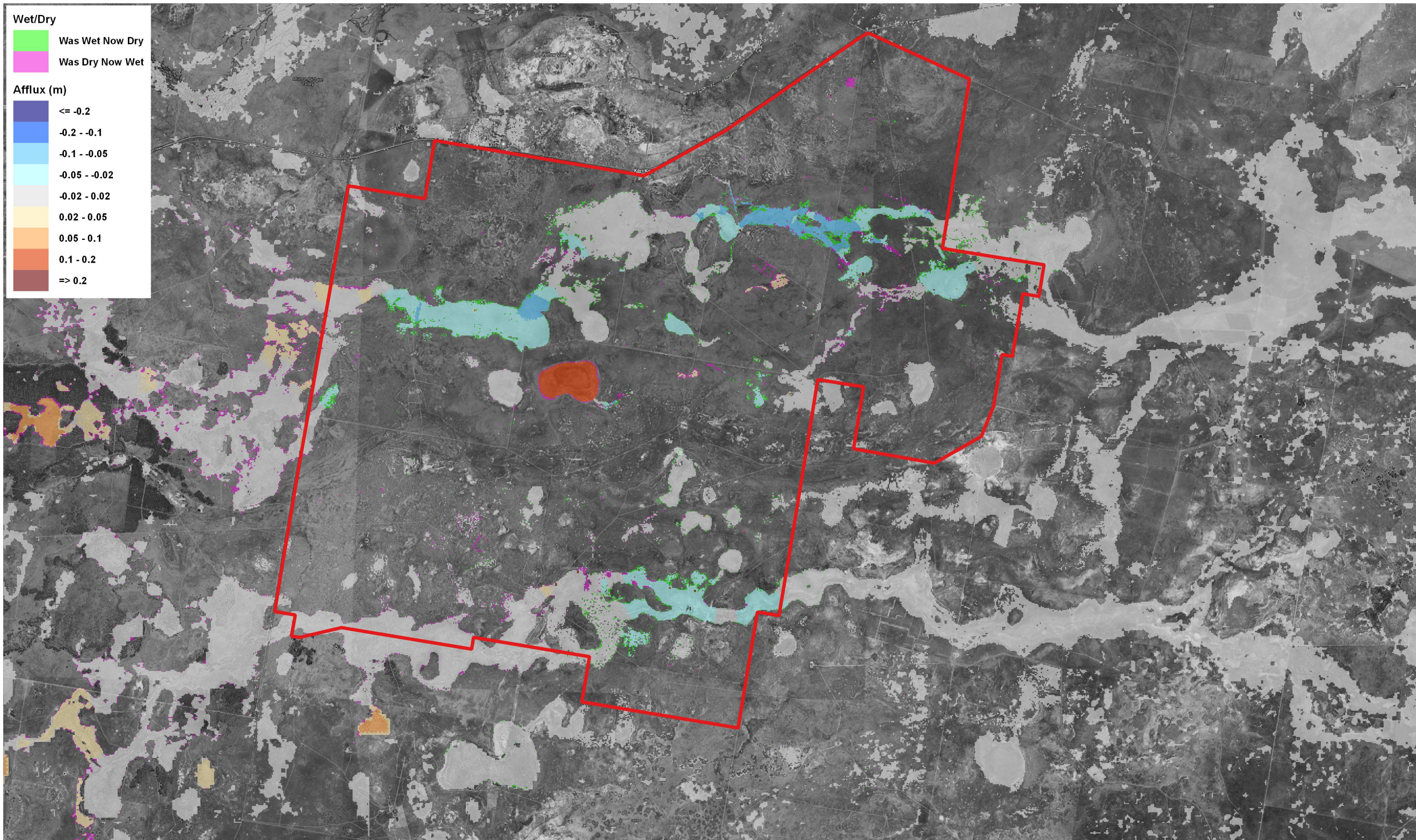
0.05 - 0.1

0.1 - 0.2

=> 0.2

LEGEND Project Extent	Title: Keri Keri - Flood Impacts - 5% AEP Peak Flood Impacts		Drawing: C-2	Rev: A
	BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.		 N 0 2,000 4,000 m	
	BMT www.bmt.org			

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LEGEND

 Project Extent

Title:

Keri Keri - Flood Impacts - 1% AEP Peak Flood Impacts

Drawing:

C-3

Rev:

A

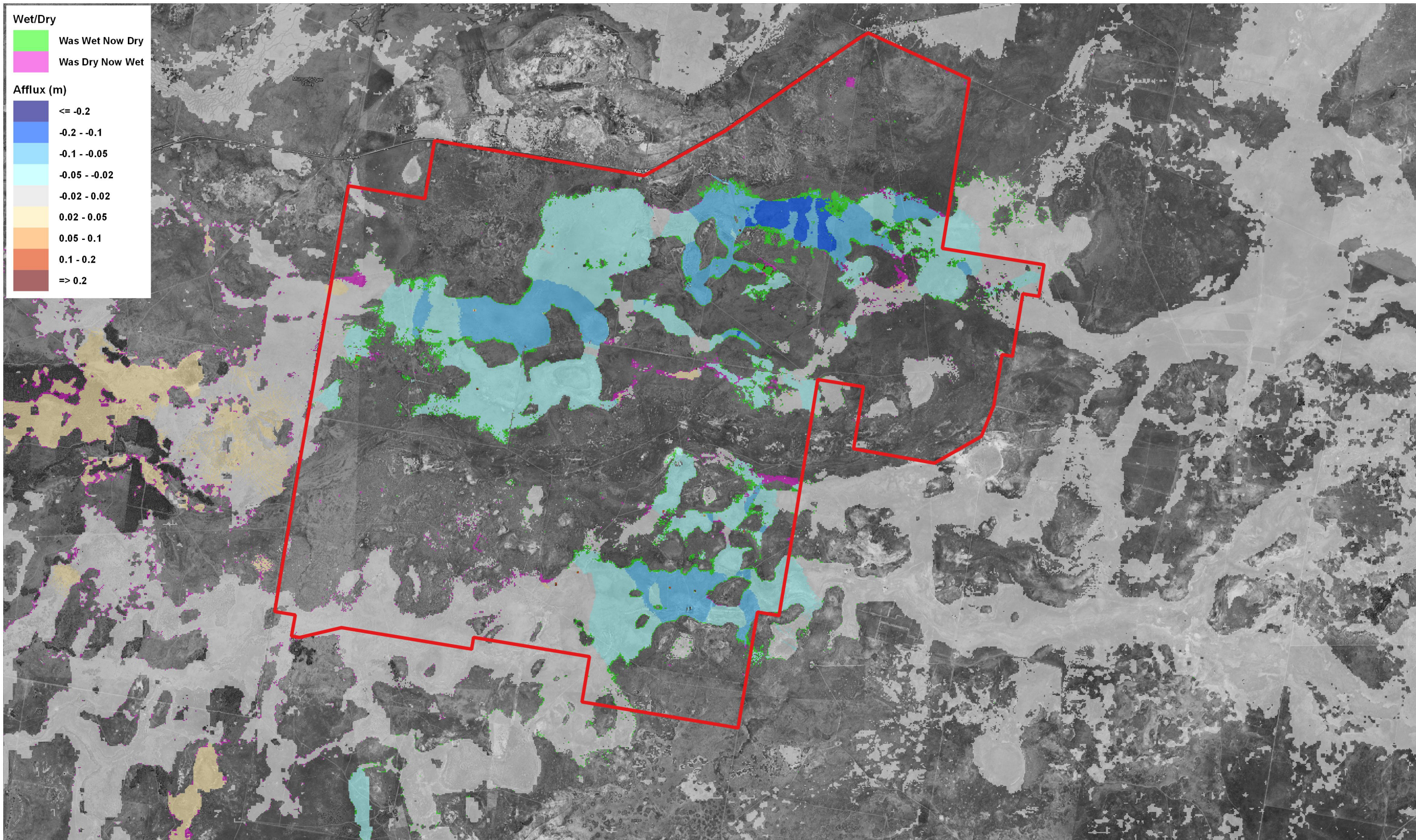
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0 2,000 4,000 m



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LEGEND

 Project Extent

Title:

Keri Keri - Flood Impacts - 0.5% AEP Peak Flood Impacts

Drawing:

C-4

Rev:

A

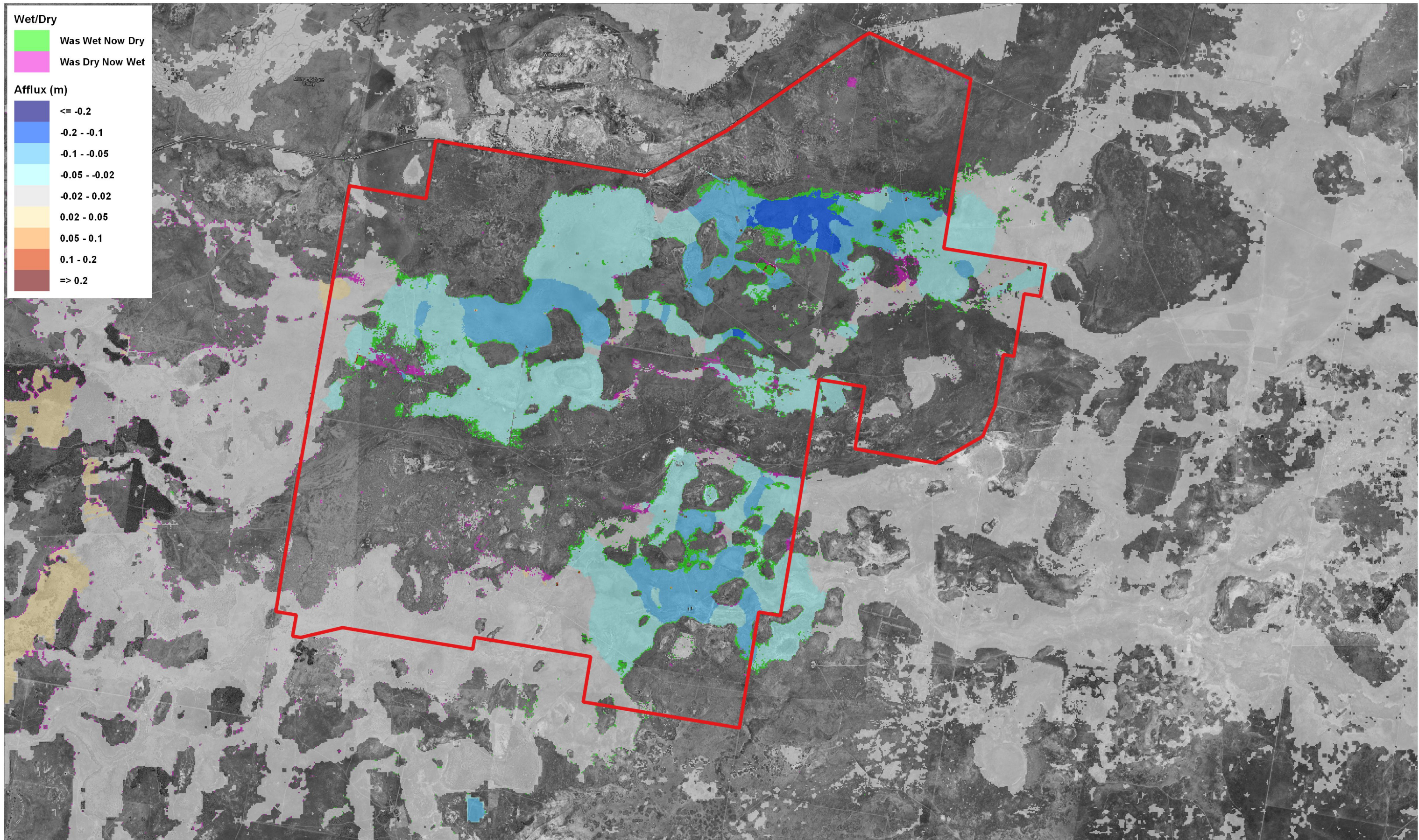
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LEGEND

 Project Extent

Title:

Kerri Kerri - Flood Impacts - 0.2% AEP Peak Flood Impacts

Drawing:

C-5

Rev:

A

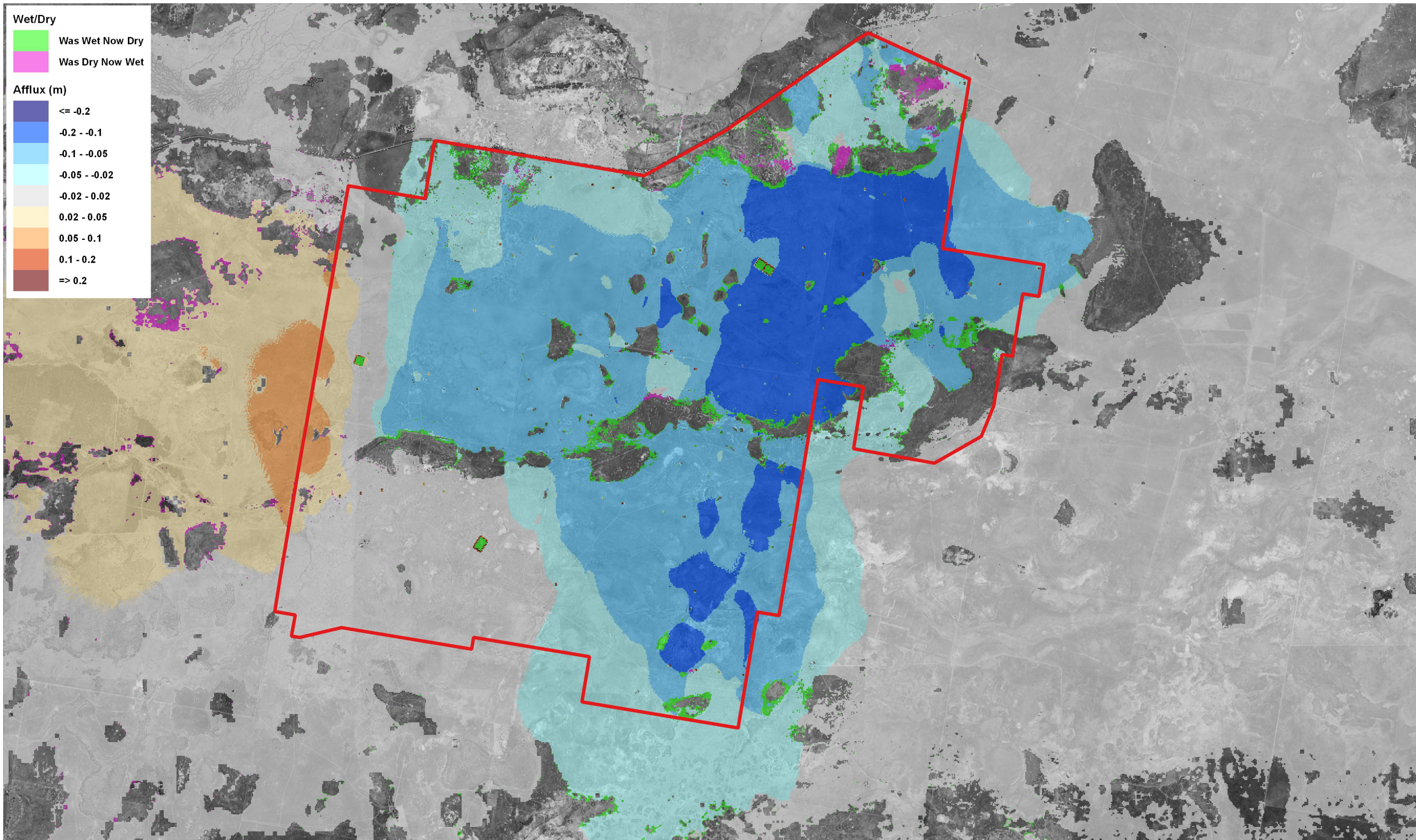
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0 2,000 4,000 m



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LEGEND

 Project Extent

Title:

Keri Keri - Flood Impacts - PMF Peak Flood Impacts

Drawing:

C-6

Rev:

A

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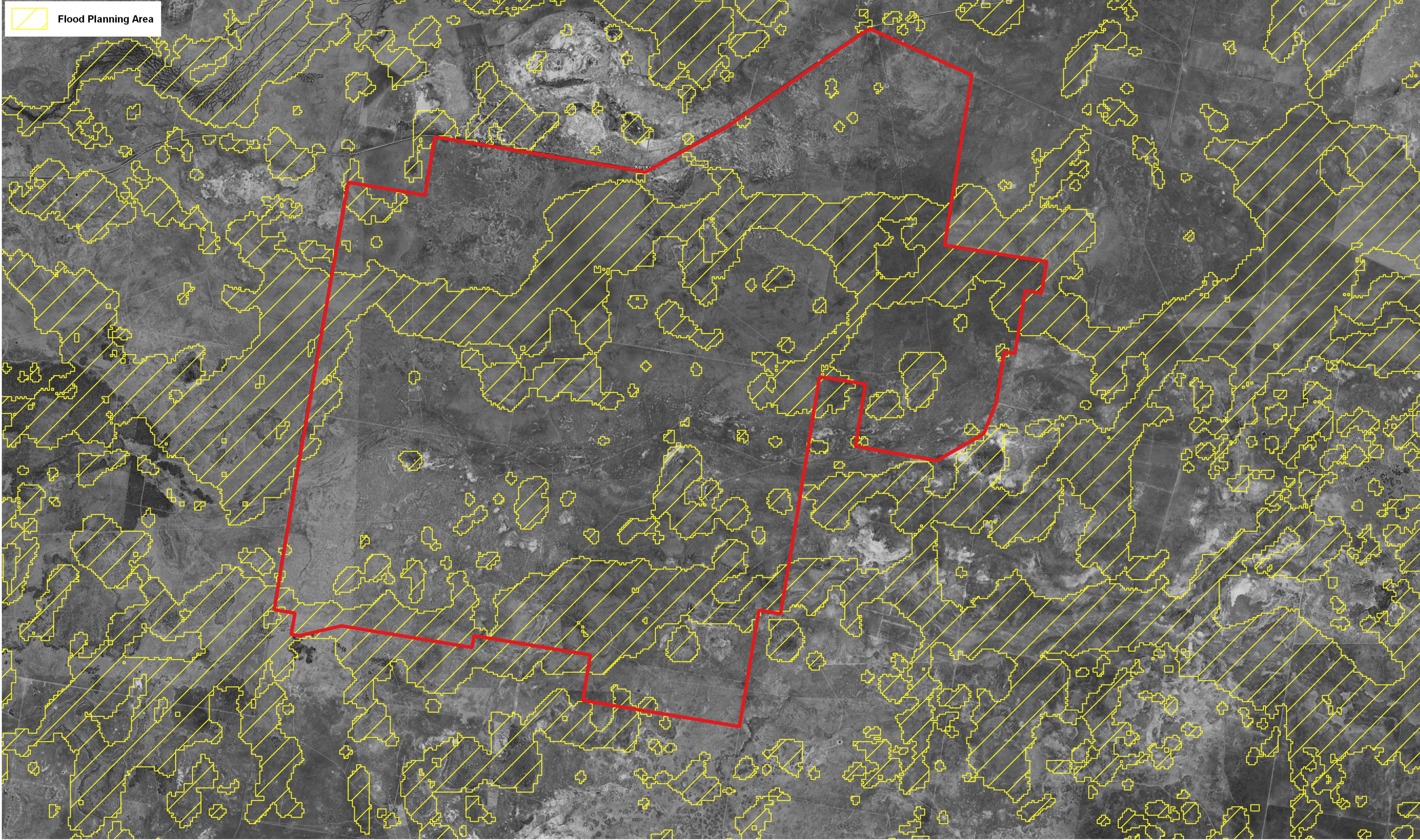


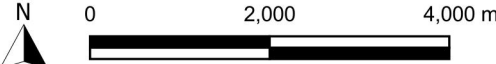
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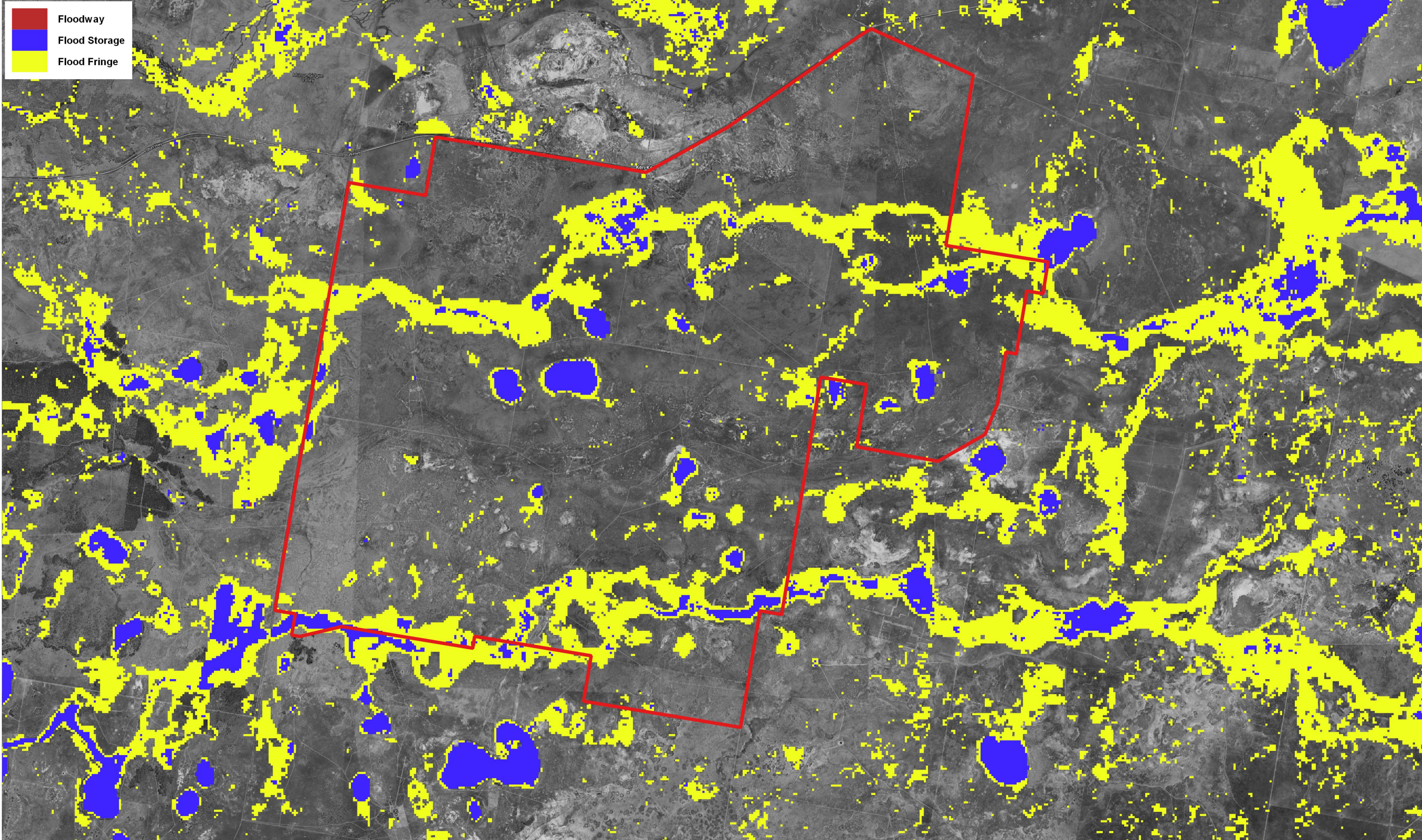


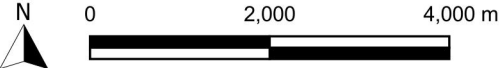
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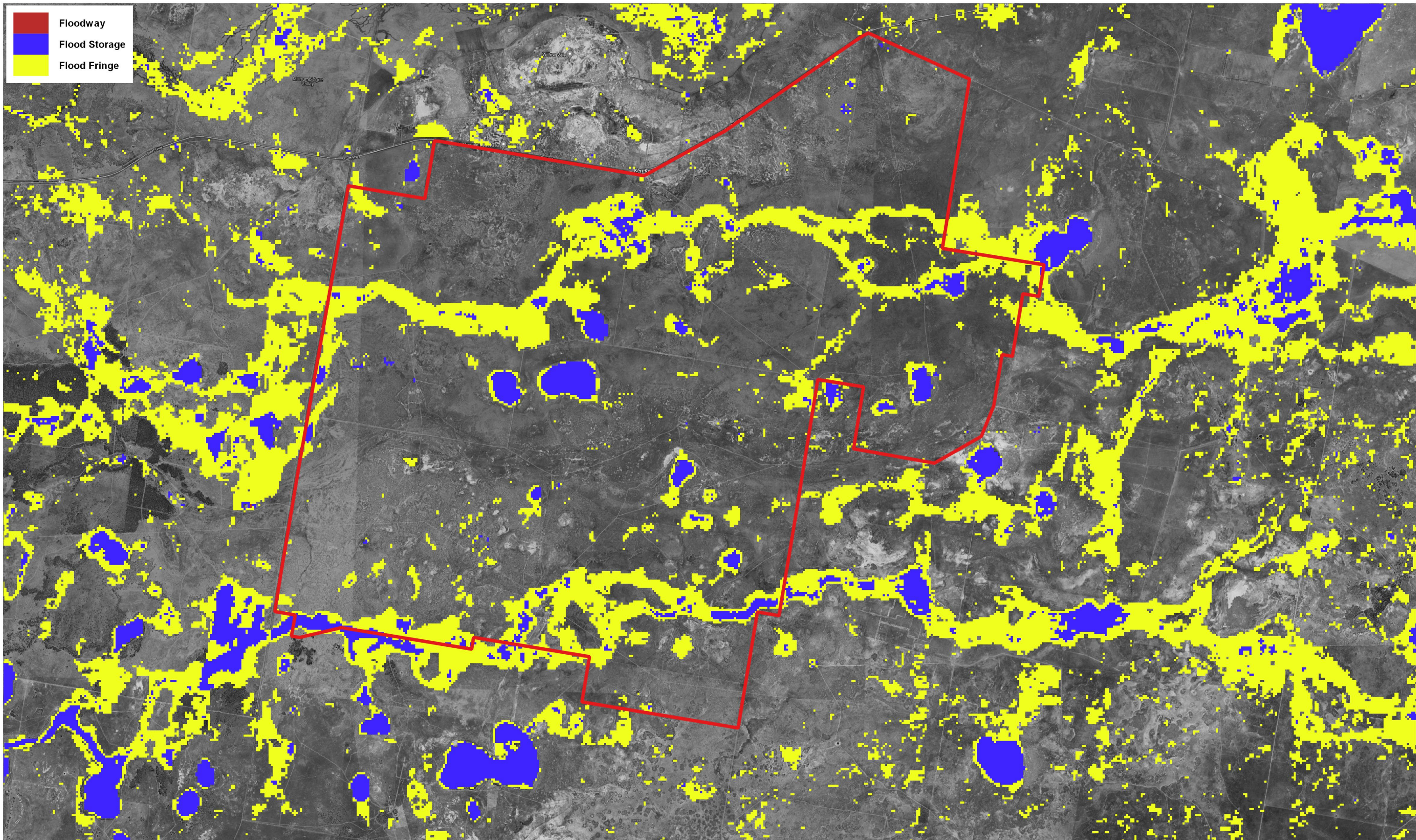
Annex D Flood Function and Flood Planning Area Maps



LEGEND  Project Extent	Title: Keri Keri - Flood Planning Area		Drawing: D-1	Rev: A
	BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.			
	Filepath: K:\A10766_KeriKeri_WindSolar_EIS_Flooding\GIS\Figure_Generator\Project\KeriKeri_Flood_Maps.qgz			



LEGEND  Project Extent	Title: Keri Keri - Flood Function	Drawing: D-2	Rev: A
	BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.		
Filepath: K:\A10766_KeriKeri_WindSolar_EIS_Flooding\GIS\Figure_Generator\Project\KeriKeri_Flood_Maps.qgz			



LEGEND

 Project Extent

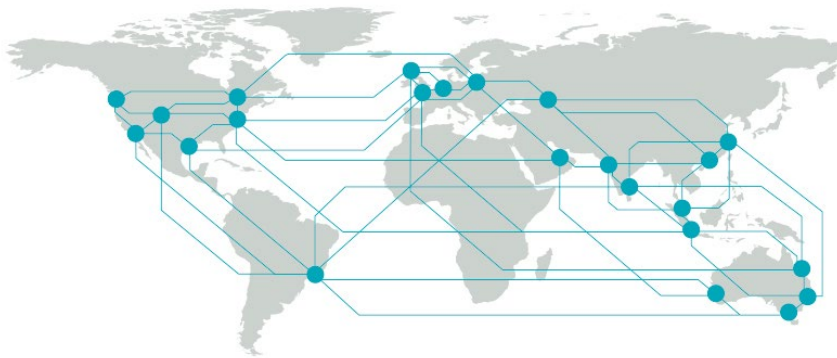
Title:
Keri Keri - Flood Function - Developed Scenario

Drawing: **D-3** Rev: **A**

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