

5 June 2026

KERALE DAM HYDRAULIC ASSESSMENT TO SUPPORT EA AMENDMENT APPLICATION AND PRCP SUBMISSION

INTRODUCTION

Engeny Australia Pty Ltd (Engeny) were engaged to undertake a design storm containment assessment for Kerale Dam at Collinsville Open Cut (COL) to support an Environmental Authority (EA) Amendment application and Progressive Rehabilitation and Closure Plan (PRCP). The assessment aims to characterise the containment performance of the eastern and western clean water drains that divert external catchment flows around the perimeter of Kerale Dam, in addition to the containment performance of Kerale Dam. The final landform topography including the layout of Kerale Dam and the clean water drains is shown in Figure 1.

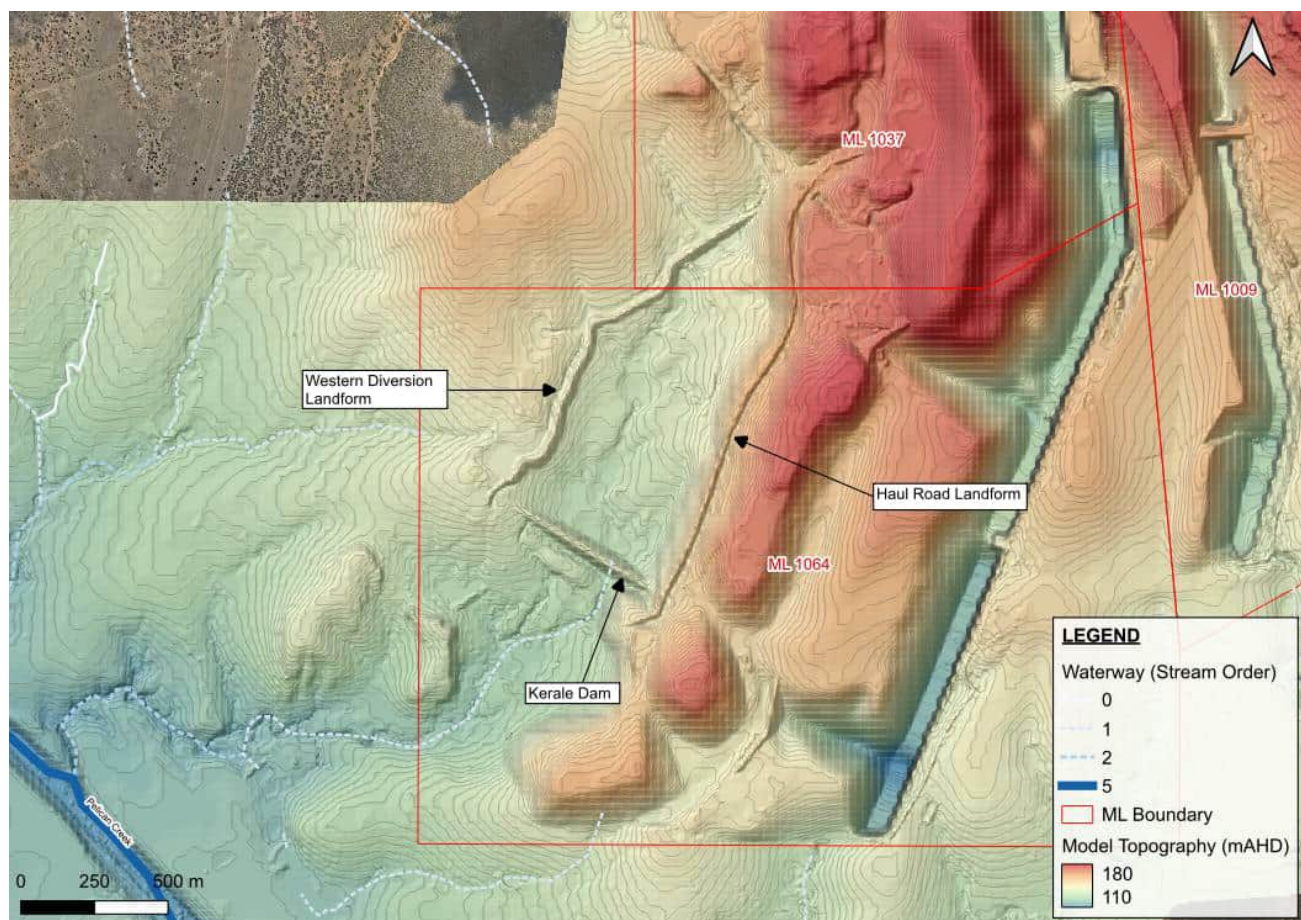


Figure 1: Kerale Dam and Landform Layout

The scope of this assessment included:

- Development of a hydraulic ‘rain-on-grid’ model in TUFLOW of Kerale Dam and surrounding areas.
- Simulation of the hydraulic model for short duration storms of up to 12 hours (to assess landform containment performance) and 7-day storms (to assess Kerale Dam containment performance) for the 50%, 2%, 1% and 0.1% Annual Exceedance Probability (AEP) events.
- Discussion of the results of the hydraulic modelling with respect to the containment performance of the landforms and Kerale Dam.

INPUT DATA

Topography and Aerial Imagery

The Digital Elevation Model (DEM) for Kerale Dam and surrounding areas was adopted from the PRCP final landform as generated by COL and provided to Engeny in April 2026 (col_landform_260402_p1_sw). Aerial imagery of the COL extents was most recently provided in April 2023. For the area beyond the mine extent, the aerial was sourced from QLD Globe and Google Maps.

Hydrologic Information

In accordance with Australian Rainfall and Runoff Guidelines 2019 (ARR 2019) methodology, rainfall data was obtained from the ARR Data Hub (Ball, et al., 2019). The data sets extracted included:

- Areal Temporal Patterns.
- Initial and continuing storm losses (rainfall losses).
- Design event rainfall Intensity Frequency Duration (IFD) data.
- Climate change adjustments to rainfall intensities and losses.

Climate Change

Global temperature increase from climate change is expected to impact the frequency and magnitude of flooding, primarily through increased intensity of severe storm events. The ARR guideline was recently updated with new methodologies for considering climate change for design flood hydrology by adopting the latest studies into climate science by the International Panel for Climate Change (IPCC). A sensitivity analysis of climate change has been undertaken to assess changes in flooding behaviour.

The latest update of the ARR Guidelines (Version 4.2) provided updated considerations for assessing climate change impacts on design flood hydrology. Updated guidance includes consideration of future climate projections based on Shared Socioeconomic Pathways (SSP) to align with the (IPCC). ARR V4.2 provides the following equation for scaling design rainfall depths and storm losses based on the rate of global temperature increase (Equation 1.6.1 of ARR V4.2):

$$I_p = I \times \left(1 + \frac{\alpha}{100}\right)^{\Delta T}$$

where,

- I_p is the project (future) design rainfall depth when accounting for climate change.
- α is the rate of change parameter, and varies with storm duration, starting at 1.15 for 1 hour and decreasing to 1.08 for 24 hours.
- I is the design rainfall depth or intensity in the absence of climate change.
- ΔT is the most up-to-date estimate of global temperature projection for the design period of interest and selected climate scenario relative to a baseline time period. When used with the 2016 IFD depths, the recommended baseline period is 1961-1990.

It is noted the same equation is used for determining scaling factors for initial loss (IL) and continuing loss (CL) with specific rate of change parameters (α) provided for various regions across Australia.

Climate change has been considered using the following methodology for the 'Base' and 'S1' scenarios:

- Base:
 - SSP1-2.6 and projection year 2030 (near term, 2021-2040) was adopted and aims to represent the impacts of climate change that have occurred since 2016 (date of issue of IFD). SSP1-2.6 was selected as the change in rainfall intensities for SSP2-4.5, SSP3-7.0 and SSP5-8.5 were considered immaterial (up to 2% increase for storm durations up to 7 days).
- S1:
 - SSP2-4.5 was selected as a representation of the current median climate change outcomes in terms of increase in flood magnitude.
 - Climate change projection year 2090 (long term, 2081-2100) was adopted as it represents the long-term climate projection.

Rainfall scaling factors calculated using the equation above are shown in Table 1 and initial and continuing loss scaling factors are shown in Table 2. All events simulated were considered for the climate change analysis.

Table 1: Climate Change Rainfall Scaling Factors

Storm Duration (Hours)	Scaling Factor (SSP1-2.6 – Near Term (2030))	Scaling Factor (SSP2-4.5 - Long Term (2090))
1	1.18	1.40
1.5	1.17	1.36
2	1.16	1.34
3	1.14	1.31
4.5	1.13	1.28
6	1.12	1.26
9	1.12	1.24
12	1.11	1.23
18	1.10	1.21
>24	1.10	1.20

Table 2: Climate Change Initial and Continuing Loss Scaling Factors

Scenario	Scaling Factor (SSP1-2.6 – Near Term (2030))	Scaling Factor (SSP2-4.5 – Long Term (2090))
Initial Loss Scaling Factor	1.02	1.05
Continuing Loss Scaling Factor	1.05	1.09

MODEL DEVELOPMENT

Design Event Simulation

Design Rainfall

Design rainfall depths for the 50%, 2%, 1% and 0.1% AEP events were generated from the BoM Intensity Frequency Duration (FD) tool (www.bom.gov.au/water/designRainfalls/revise-ifd/). An ensemble of 10 temporal patterns was simulated for each design storm AEP and storm duration as recommended by ARR 19 (Ball J, 2019). Temporal patterns were adopted from the ensemble temporal patterns for “East Coast North” sourced from the ARR Data Hub (<http://data.arr-software.org/>). Climate change rainfall scaling factors as presented in Table 1 were applied to the IFD rainfall depths.

Design Rainfall Losses

Default ARR Data Hub losses were adopted and are shown in Table 3. The median pre-burst rainfall depths sourced from the ARR Data Hub (<http://data.arr-software.org/>) were then subtracted from the initial storm loss to produce the design storm burst loss. Climate change rainfall scaling factors as presented in Table 2 were applied to the design rainfall losses as shown in Table 3.

Table 3: Design Rainfall Losses

Design Rainfall Loss	Value (No climate change)	Value (Base)	Value (\$1)
Initial Loss (mm)	35.0	35.8	36.7
Continuing Loss (mm/hr)	2.10	2.20	2.30

Model Simulation

Design event simulations were undertaken for a range of short durations to capture the critical storm events for the western diversion landform and haul road landform (up to 12 hours). To sufficiently capture the extent of filling of Keral Dam, the maximum duration storm of 7 days was also simulated. All ten temporal patterns for each duration were simulated. The results from the durations and temporal patterns simulated were processed to produce a flood grid across the site which represents the maximum flood depth result for each AEP simulated.

Model Validation

A peak flow validation exercise was undertaken to assess suitability of the hydraulic model. The modelled peak discharge at the outlet of the western diversion landform was compared with peak flows estimated through flood estimation techniques for ungauged catchments including the Regional Flood Frequency Estimation Model (RFFE) and Quantile Regression Technique (QRT). The RFFE peak flow estimates were calculated using the AR&R RFFE Model online tool (<http://rffe.arr-software.org/>). The Department of Main Roads Quantile Regression Technique (QRT) (Palmen & Weeks, 2008) is a method for peak flow estimation for rural catchments up to 1,000 km² in area. The QRT provides a peak flow estimate using a 50-year annual recurrence interval (ARI), 72-hour rainfall intensity and the total catchment area.

The peak flow estimates are shown in Figure 2. As the modelled flows for the 2% and 1% AEP events generally align with the QRT flows and the 50% AEP flows represent a conservative approach, use of the hydraulic model is considered suitable for the purposes of the containment assessment.

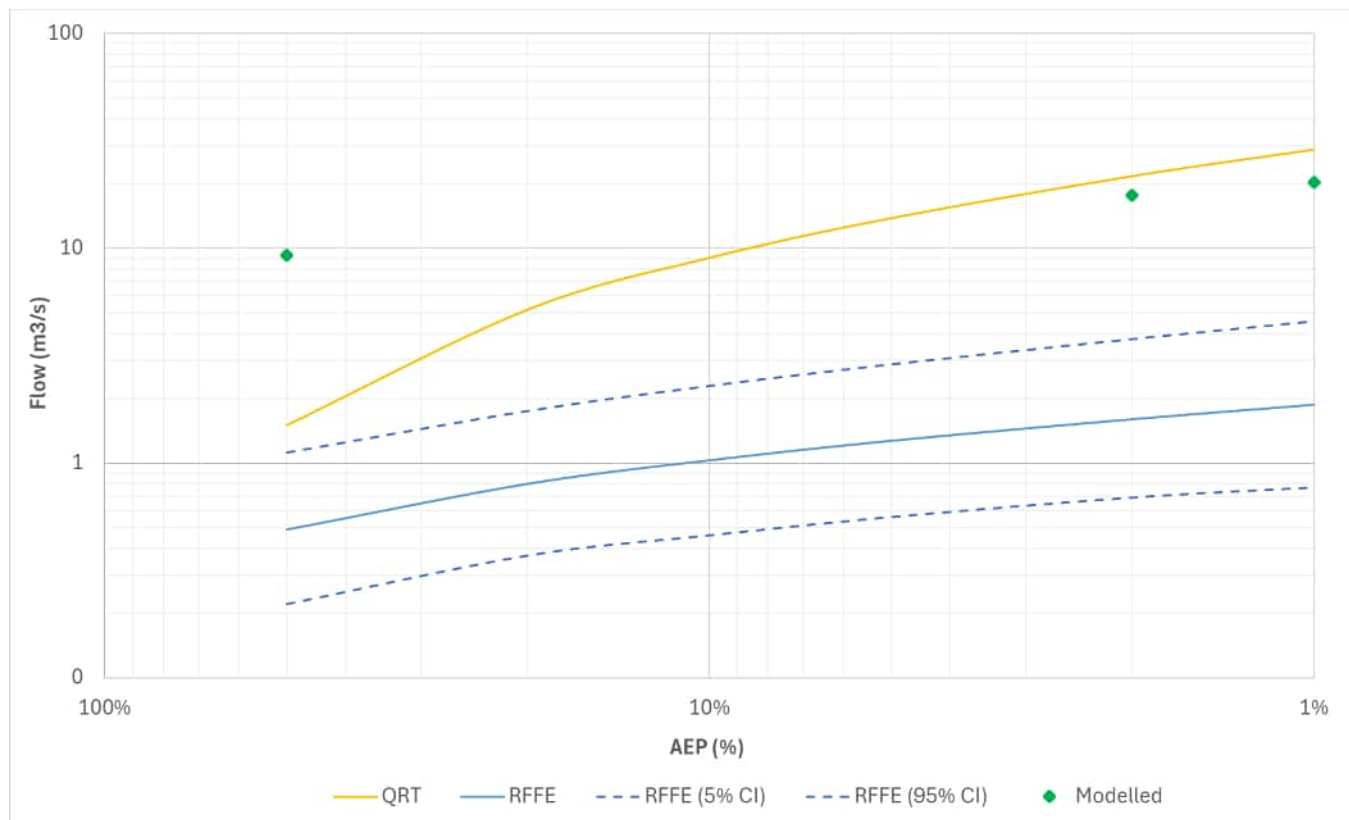


Figure 2: Flow Validation Result

Overview and Model Extent

This study has used the two-dimensional hydraulic modelling software TUFLOW to assess the containment performance of the Kerale Dam system. Two-dimensional models are best suited to scenarios where flow direction and water surface are not uniform across a section (i.e., floodplain and overbank areas). The model layout is shown in Figure 3.

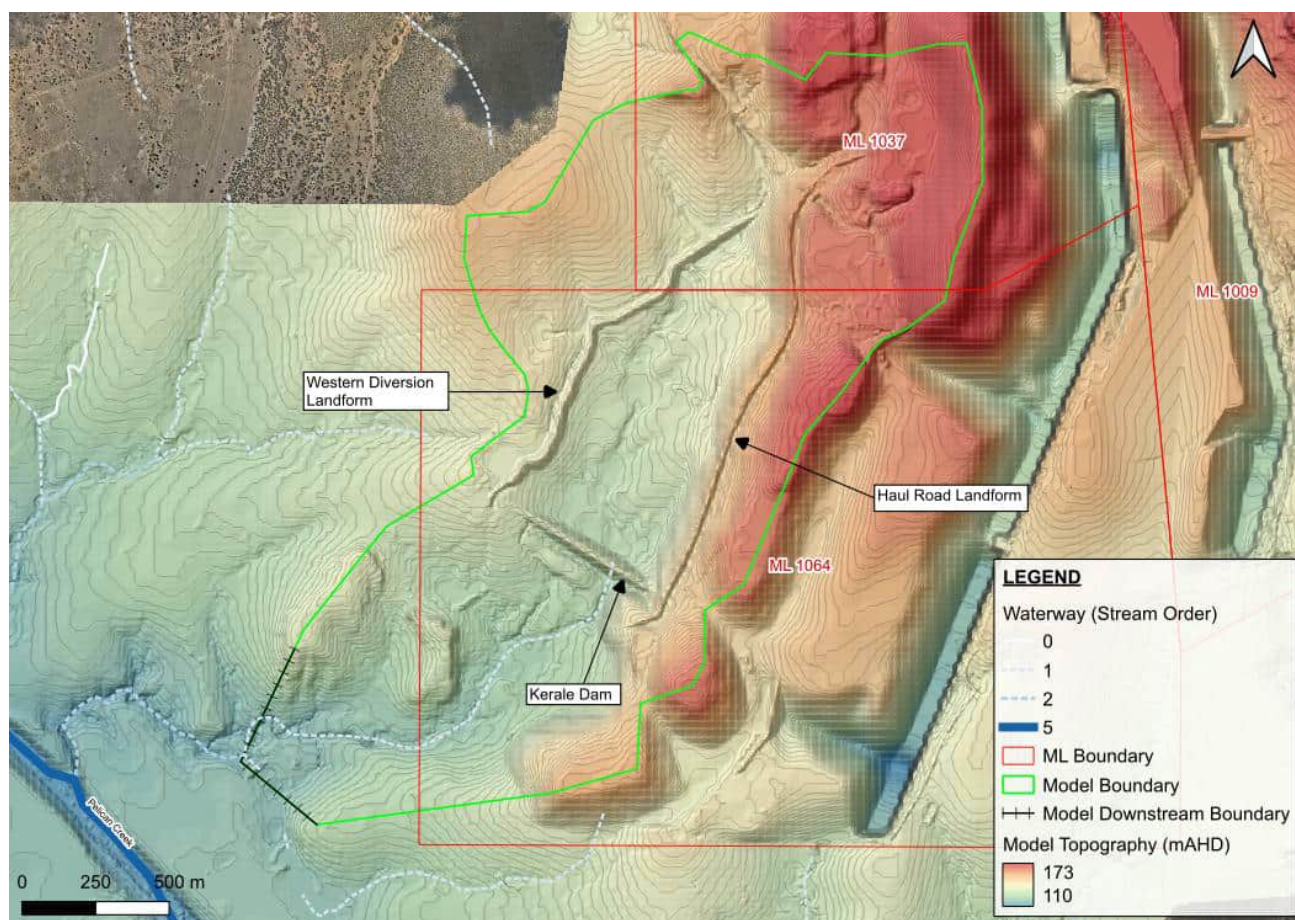


Figure 3: Hydraulic Model Layout

Boundary Conditions

Boundary conditions are required in the model to define inflows, flow leaving the model domain and interfaces between the one dimensional and two-dimensional model domains. The following boundary conditions have been used in the models:

- **Rainfall:** The extent to which rainfall is applied to the model is defined by the model extent shown in Figure 3.
- **Downstream:** The outflow boundary conditions of all models have been represented as a normal depth based on low flow channel grades at the downstream extent of the models. These boundaries are located a sufficient distance downstream in all models to not influence the flood behaviour of landforms.

Hydraulic Roughness

The Manning's roughness coefficients used in the model are based on aerial photography of the site and its surrounds. Roughness values for the landuse categories adopted are described in Table 4. Mapped hydraulic roughness extents are shown in Figure 4.

Table 4: Roughness Values

Landuse Category	Manning's "n"
Channel/drain/road	0.030
Rehabilitated spoil	0.040
Low density vegetation	0.050
Medium density vegetation	0.065

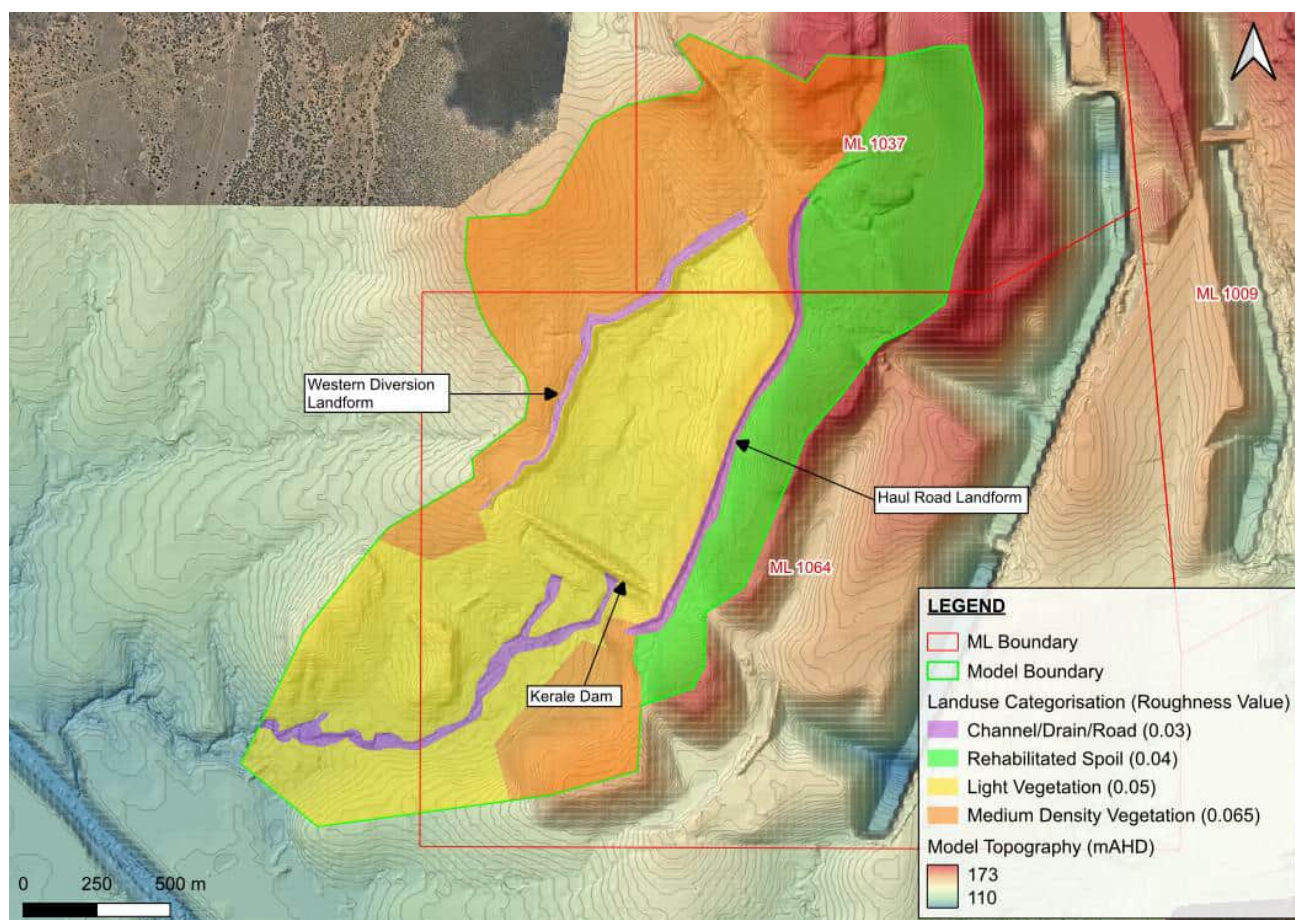


Figure 4: Hydraulic Model Roughness Mapping

Initial Conditions

As this assessment aims to support the EA amendment and PRCP (i.e. consideration of the containment performance of Kerale Dam post closure of the mine) and as a conservative approach, the initial water level in Kerale Dam was set as the average long-term water level as determined by WSP in the void lake hydrology assessment (134 mAHD).

RESULTS

The results of the assessment are summarised in the following sections with flood depth maps provided in Appendix C1.

Kerale Dam and Landform Containment Performance

Peak flood heights in Kerale Dam for all events simulated are shown in Table 5 and indicate the following:

- Runoff is effectively conveyed by the western diversion and haul road landforms, directing flows around Kerale Dam. In all events simulated, no breakout of flows from the western diversion and haul road landforms into the Kerale Dam storage area is predicted.
- During all events simulated, floodwaters remain contained within the drainage network and floodplain areas, and Kerale Dam does not spill (i.e. peak flood heights do not exceed 141.5 mAHD).
- Overall, the modelling indicates that the landforms that convey flood flows around Kerale Dam function as intended and Kerale Dam can contain design event inflows up to the 0.1% AEP event with up to 3.3 m freeboard.

Table 5: Peak Flood Heights in Kerale Dam

Scenario	Kerale Dam Spill Level	50% AEP	2% AEP	1% AEP	0.1% AEP
Base (mAHD)	141.5	135.2	137.0	137.3	138.1
S1 (mAHD)		135.5	137.2	137.5	138.2

Summary

The results of the hydraulic assessment indicated the following:

- There is sufficient capacity within the western diversion landform and haul road landform to contain up to 0.1% AEP flood flows.
- Kerale Dam in its current configuration can contain up to 0.1% AEP event flood flows with 3.3 m freeboard.

Regards,



Syed Ali
Senior Engineer

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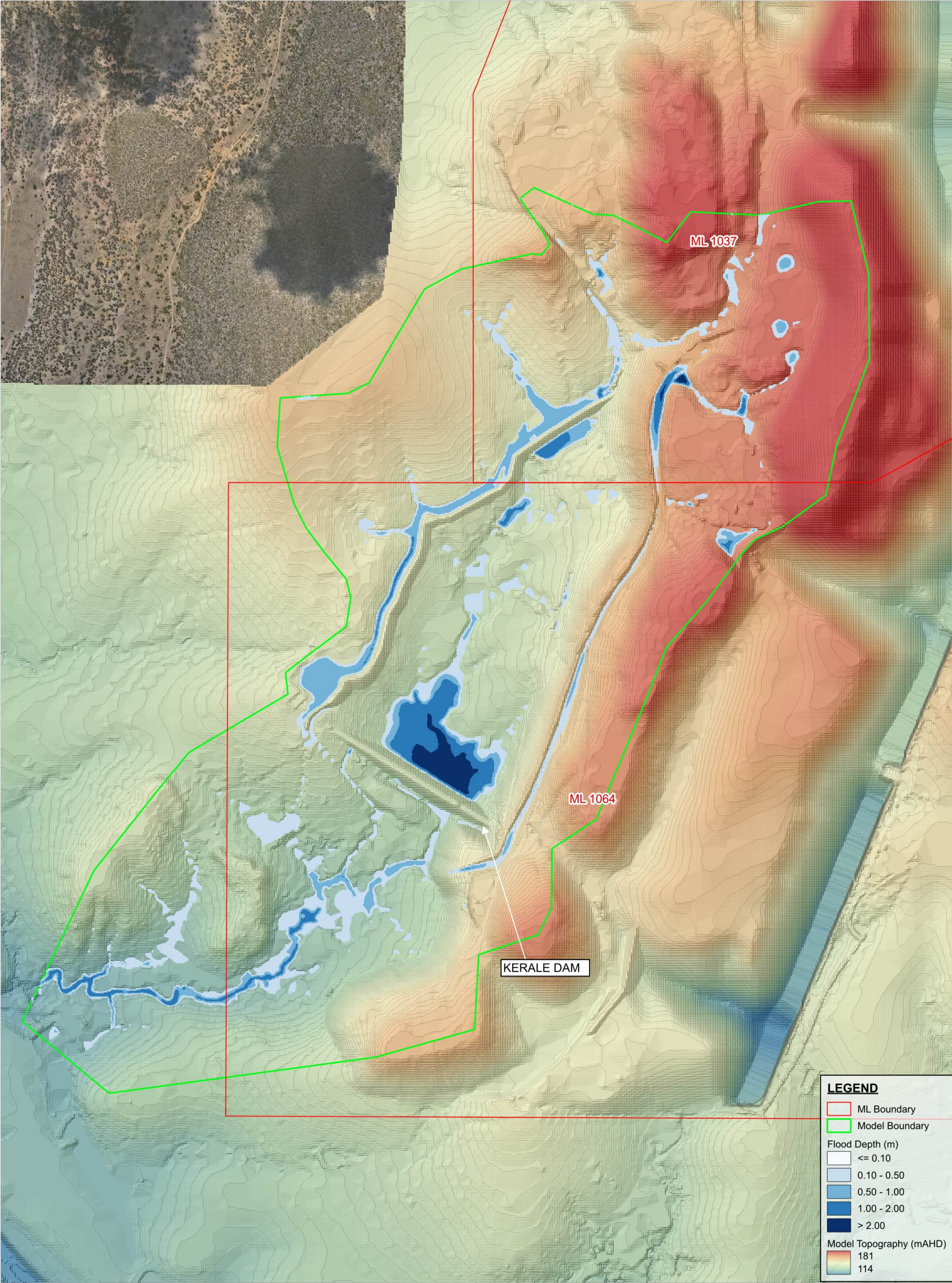
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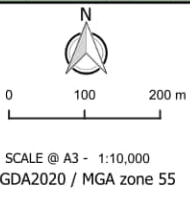
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APPENDIX C1: FLOOD DEPTH MAPS





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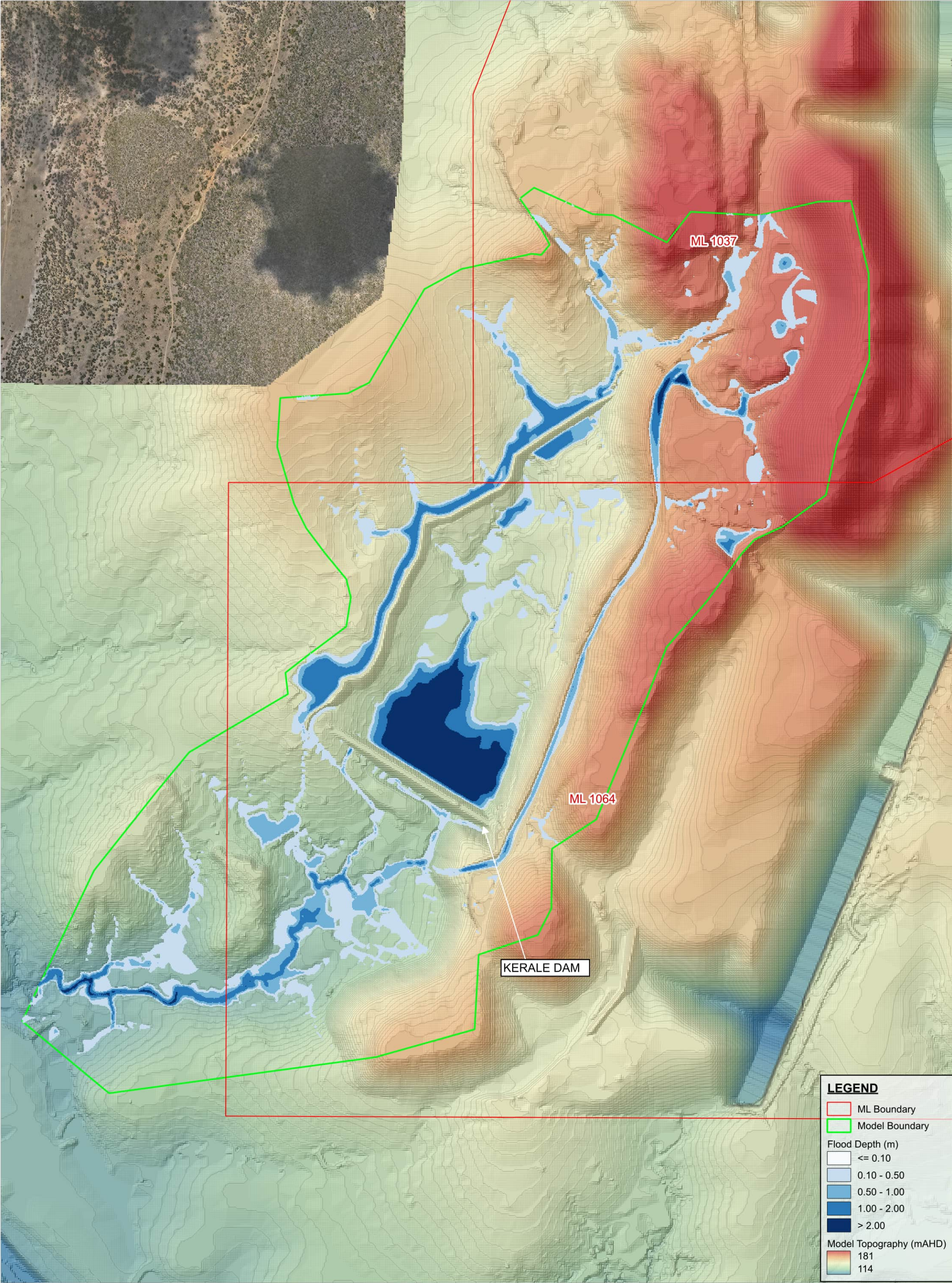
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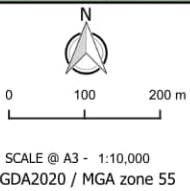
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Figure C1.1
Kerale Dam Assessment
50% AEP Flood Depth (Base)
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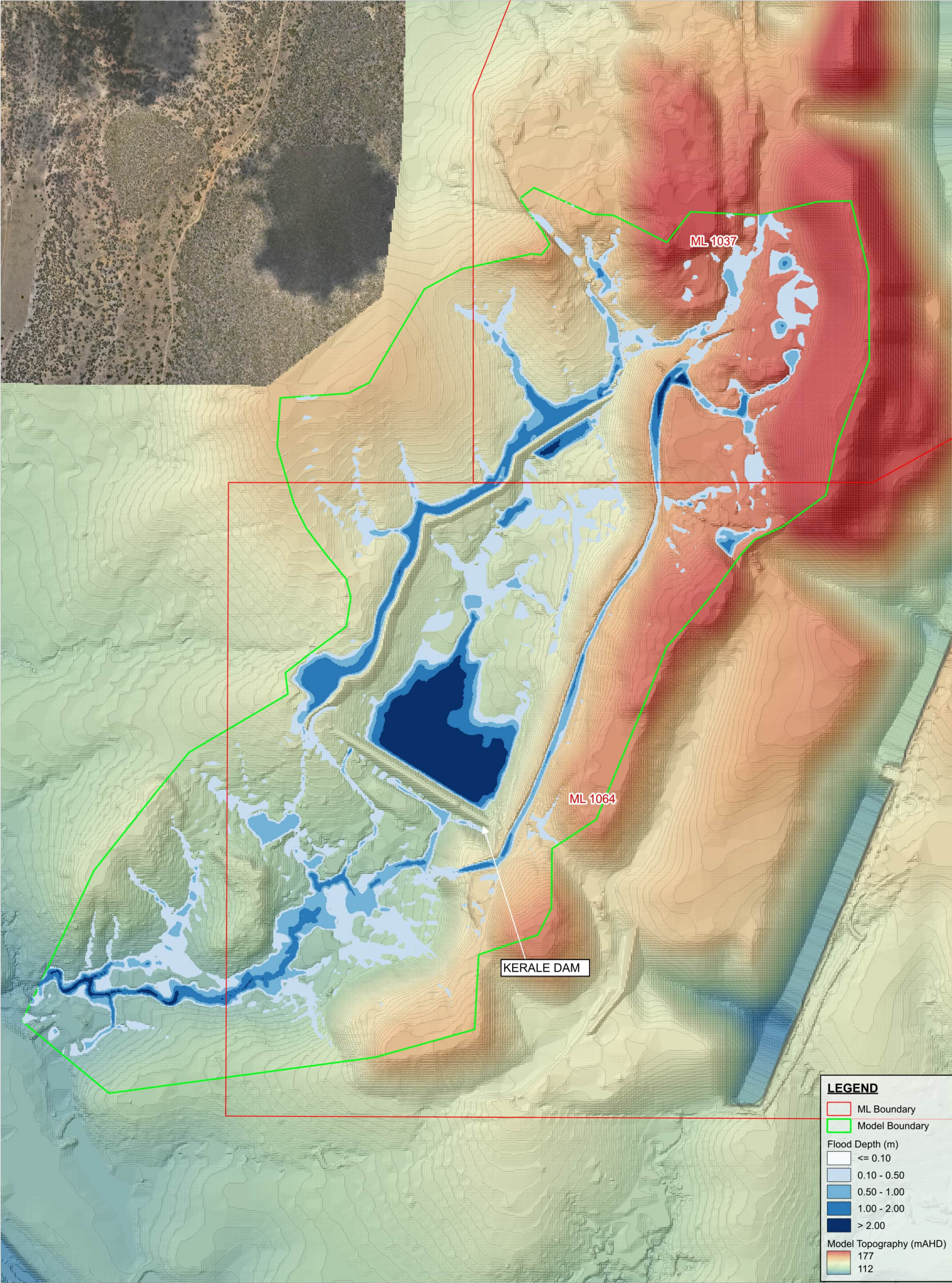
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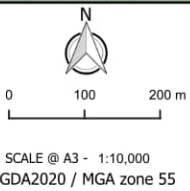
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Figure C1.2
Kerale Dam Assessment
2% AEP Flood Depth (Base)
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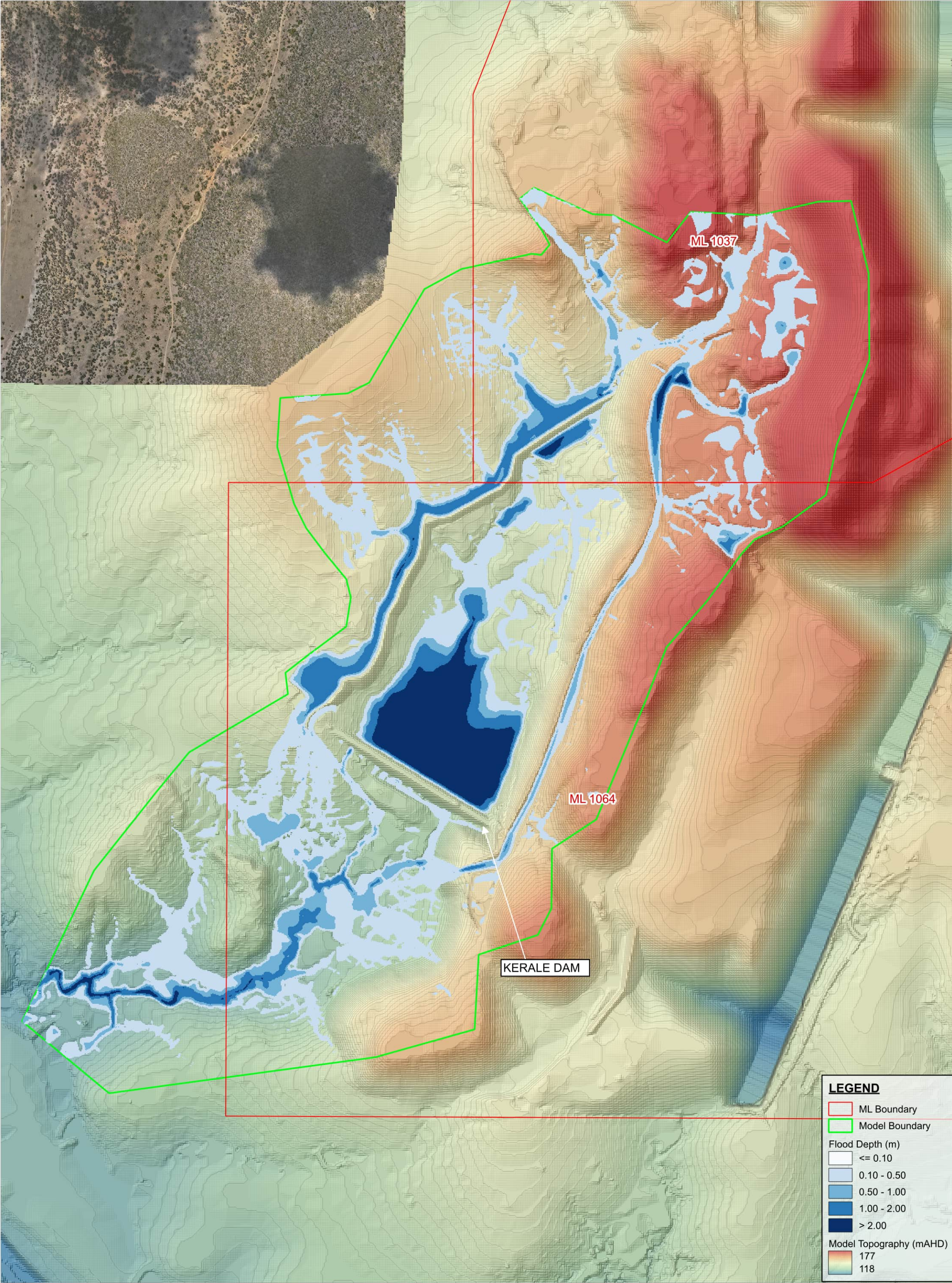
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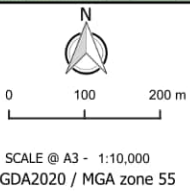


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Figure C1.3	
Kerale Dam Assessment 1% AEP Flood Depth (Base) Collinsville Open Cut	
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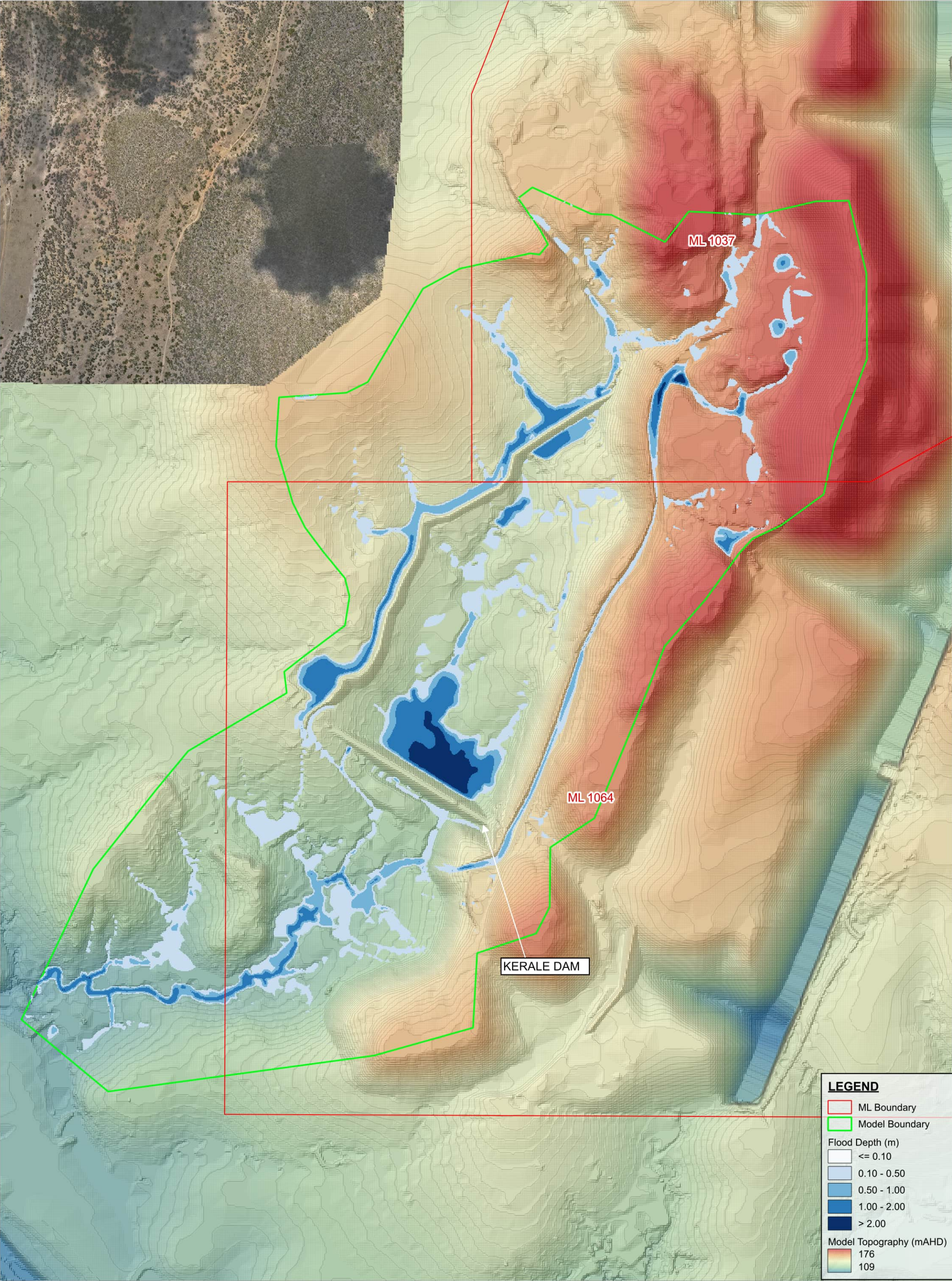
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Figure C1.4
Kerale Dam Assessment
0.1% AEP Flood Depth (Base)
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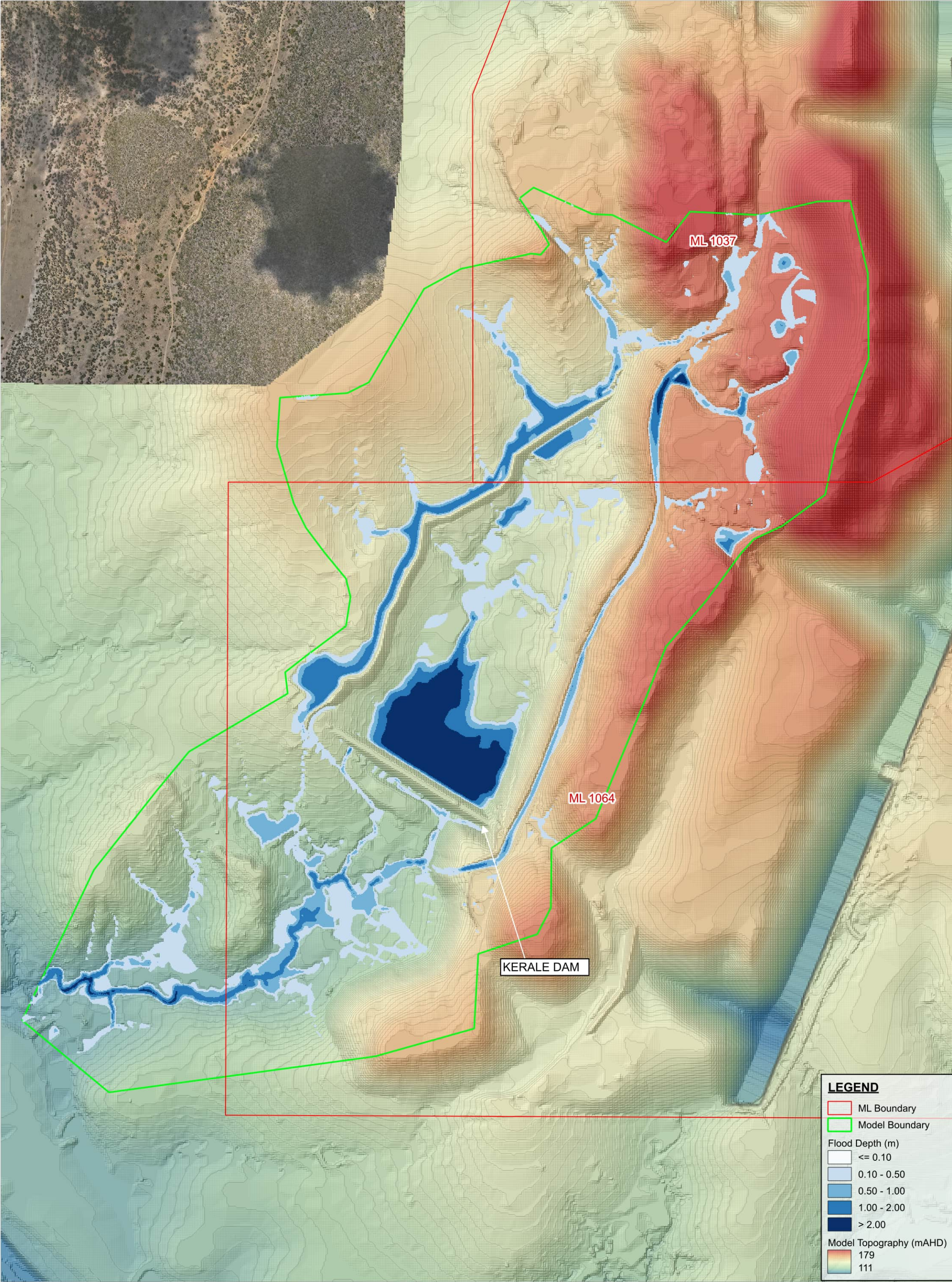


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Figure C1.5

Kerale Dam Assessment
50% AEP Flood Depth (S1)
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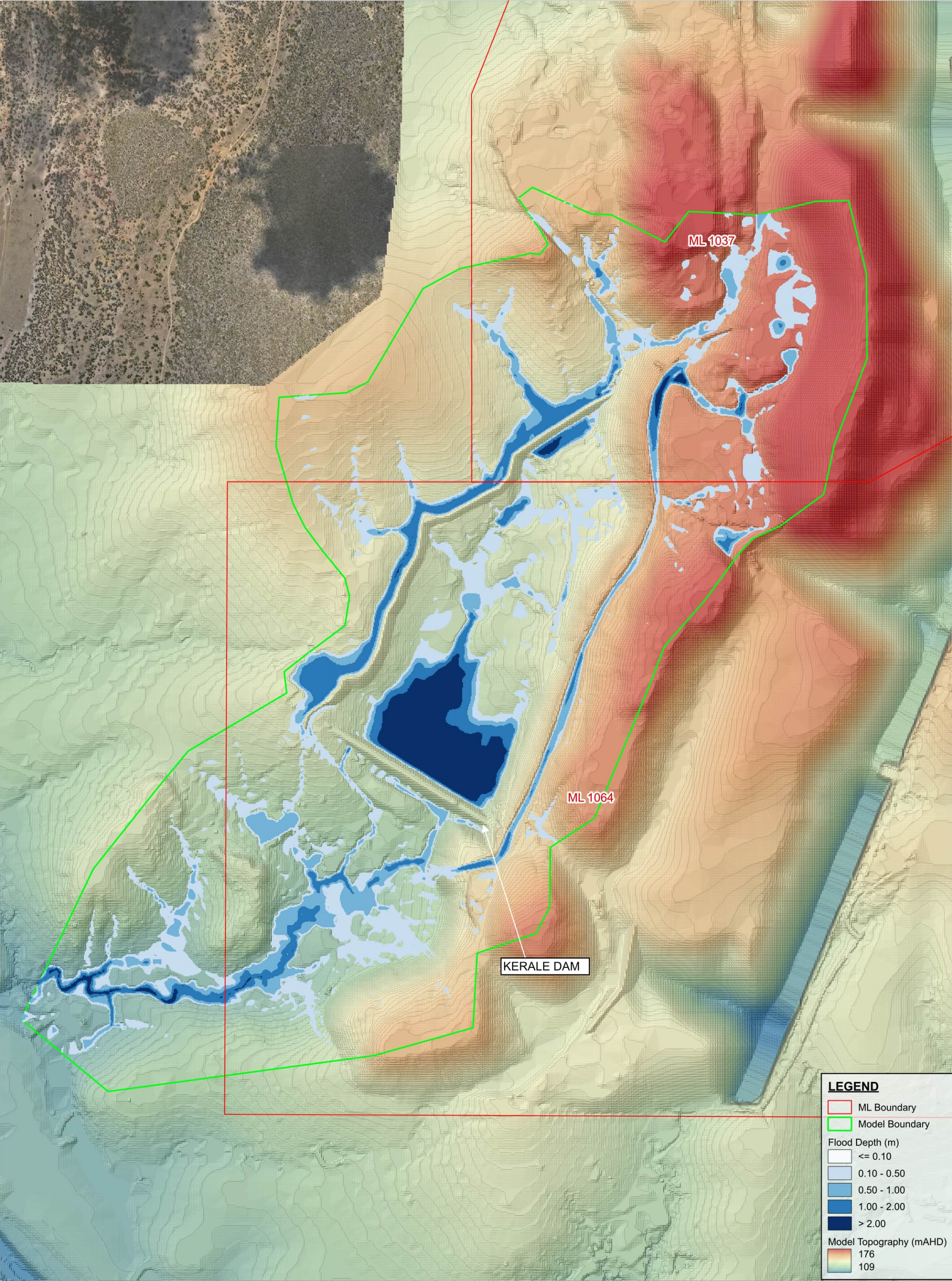
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Figure C1.6
Kerale Dam Assessment
2% AEP Flood Depth (S1)
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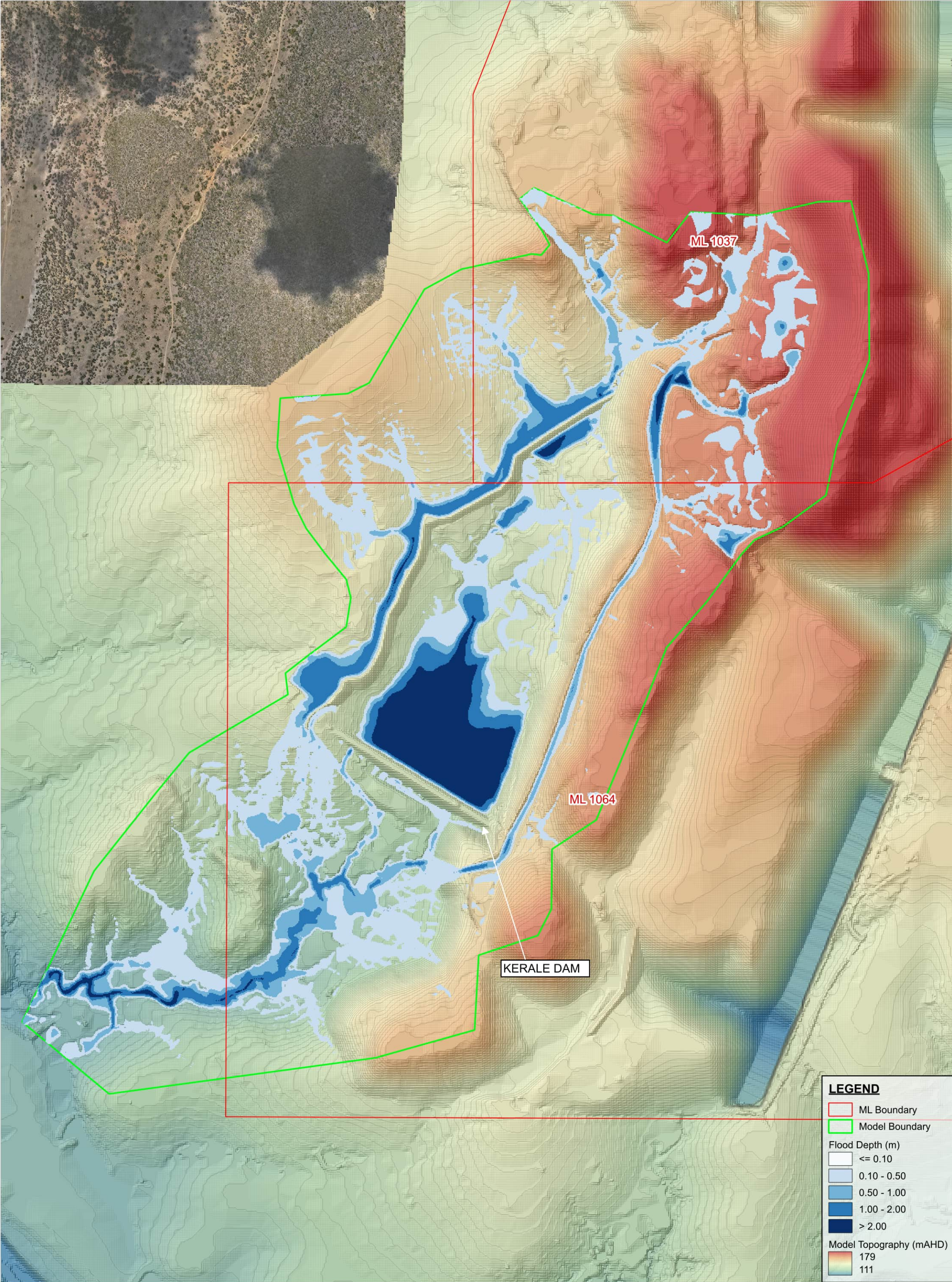
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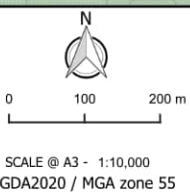
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Figure C1.7
Keral Dam Assessment
1% AEP Flood Depth (S1)
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Kerale Dam Assessment
0.1% AEP Flood Depth (S1)
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