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9 June 2022

Our ref: J1649

Lauren Connors
Enspire Solutons Pty Ltd
1302/83 Mount Street
North Sydney NSW 2060

Dear Lauren,

RE: Mount Gilead Preliminary Flood Modelling

Preliminary flood modelling has been undertaken for Mount Gilead to provide an understanding of the constraints and opportunities associated with development of the site with respect to flooding.

This letter report details the following elements of this preliminary study:

- Background:
- Methodology:
- Outputs; and,
- Limitations and Assumptions.

Background

Rhelm Pty Ltd (Rhelm) has been engaged by Enspire Solutions Pty Ltd (Enspire) on behalf of Lendlease Communities (Lendlease) to develop a flood constraints study to inform part of a Stormwater Management Strategy. The Stormwater Management Strategy forms part of a documentation package that will facilitate a Planning Proposal to rezone land within Lendlease's landholding at Gilead.

The objective of this study is to provide a high level understanding of the constraints and opportunities associated with development of the site with respect to flooding from the local upstream catchment as well as the Nepean River.

Study Area

The site is generally bounded by Appin Road to the east, the Nepean River in the west, Menangle Creek to the north and approximately Leafs Gully to the south. Several watercourses run through the site, discharging north into Menangle Creek and eventually the Nepean River. This includes Woodhouse Creek, Nepean Creek as well as other minor unnamed watercourses. The WaterNSW Upper Canal roughly bisects the site and would remain untouched within its cadastral boundaries.

The current site is largely cleared open space, with remnant pockets of denser vegetation, typically adjacent to creeks and watercourses.

It is noted that in general the watercourses within the study area have steep incised banks with relatively dense vegetation.

The study area is shown **Figure 1** below.

Data Review

The primary data inputs / sources for this study were:

- LiDAR data provided by Lendlease dated 2020 which covered the study area at a 3m resolution (provided as part of the previous study).
- Indicative Masterplan supplied by Enspire 8 June 2022.
- ARR Data Hub, which was used to source rainfall intensity and temporal pattern data.
- Australian Rainfall and Runoff 2019 (ARR2019) Guidelines, which were used to inform the selection of appropriate hydrological and hydraulic model parameters.
- NearMap aerial imagery, which was used to determine subcatchment impervious areas and to delineate land uses (for the purposes of applying model roughness).

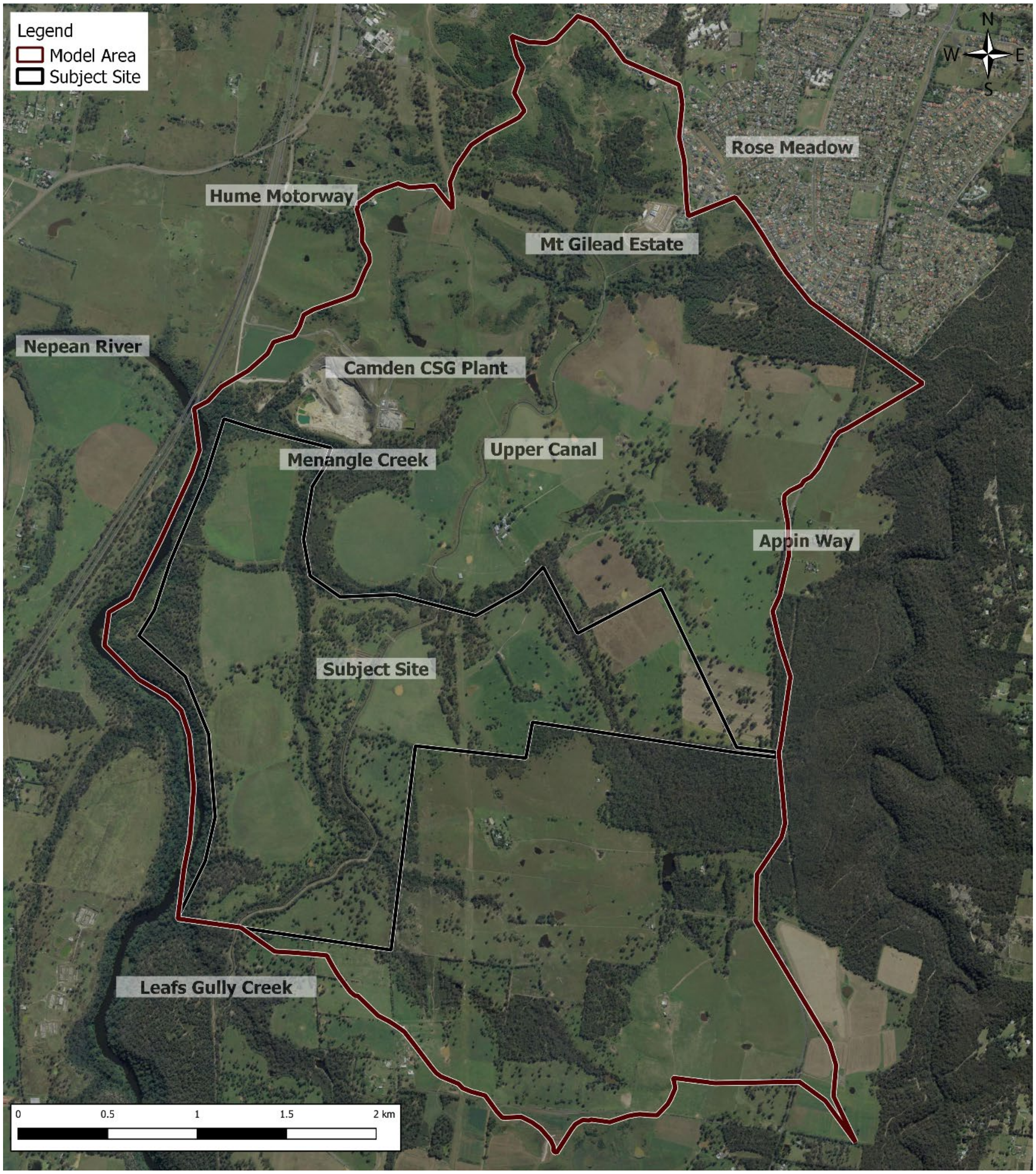


Figure 1 –Study Area

Hydrological Model Development

The hydrological modelling has been completed using the hydrological model in XP-RAFTS. The hydrology has been based on Australian Rainfall and Runoff 2019 (ARR2019) with the parameters extracted from the ARR DataHub shown in **Table 1** and inputs to the model and the data sources for those inputs are summarised in **Table 2**.

The subcatchment delineation is shown in **Figure 2**.

Table 1 – ARR DataHub Metadata

Parameter	Value
Storm Initial Losses (mm)	18 (NSW adjusted loss)
Storm Continuing Losses (mm/h)	2.4 (NSW adjusted loss)
River Region - Division	South East Coast (NSW)
River Region	Hawkesbury River
Point Temporal Pattern Label	East Coast South
Version	2016_v2

Table 2 – Hydrological Model Input Data

Parameter	Data Source
Area and slope	LiDAR data is available for full catchment and was used for this mapping.
Percentage impervious	Percentage impervious areas are largely a factor of development intensity and were determined from aerial imagery (NearMap, March, 2022). Adopted values were: • Open Space 2% • Light Vegetation 1% • Medium Vegetation 0% • Medium Density Residential 80% • Infrastructure 40%
Roughness	Values have been determined from an examination of aerial imagery and have been largely dependent on land use. Roughness values adopted were as per the hydraulic model (see **Table 3**).
Runoff routing	Routing refers to the transfer of flows from one sub-catchment to another. This routing can be done in XP-RAFTS through either specifying a lag time between sub-catchments (10 minutes for example) or inputting a typical cross section, roughness and length and allowing XP-RAFTS to compute the lag time based on the flow volume. For this model, the lag approach has been adopted.
Rainfall losses	Under ARR2019, rainfall parameters for hydrological modelling are all available from the ARR Data Hub have been downloaded directly from this website. Probability neutral losses have been adopted, and in the absence of calibrated site losses, the NSW adjusted losses from the Data Hub have been adopted as noted in **Table 1**.

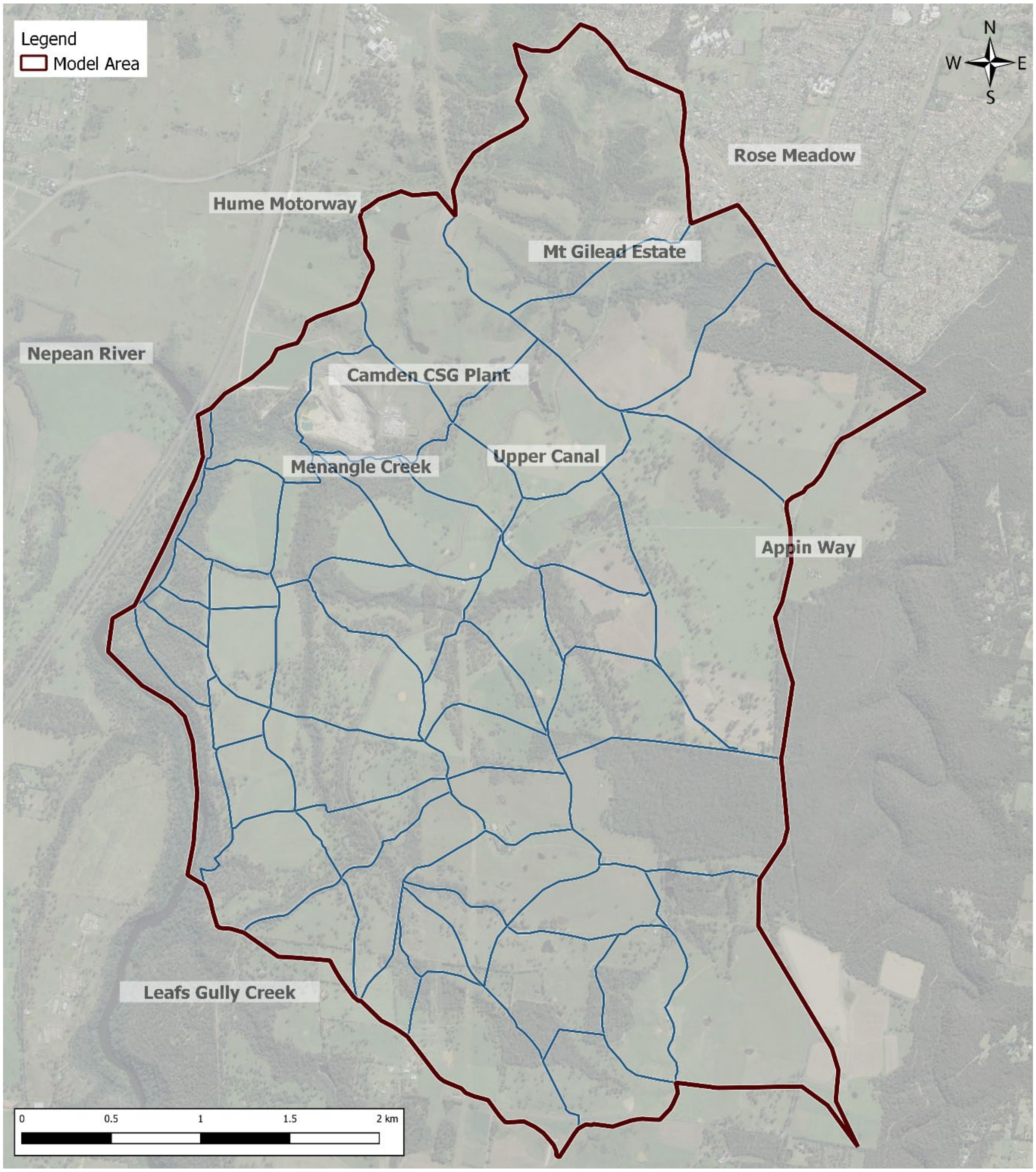


Figure 2 – Subcatchment Delineation

Hydraulic Model Development

The hydraulic modelling has been completed using TUFLOW. The TUFLOW model details are shown in **Figure 3**.

Inputs to the model and the data sources for those inputs are summarised in **Table 3**.

Table 3 - Hydraulic Model Input Data

Parameter	Data Source
Model Area	The full upstream catchment area has been included in the hydraulic model. This was feasible due to the relatively small size of the catchment, and allows for the full extent of the various creeks and channels to be included.
DEM	The LiDAR data provided by LendLease in 2020 was utilised as the DEM. This data was supplied in a post-processed format at a 3m grid cell resolution.
Grid Cell Resolution	The variety of creeks and channels within the study area require a grid cell resolution fine enough to appropriately their conveyance. A grid cell of 3x3 metres was adopted for this preliminary modelling which provided a reasonable balance between run times and terrain representation.
Roughness	Roughness values extents were determined based on land use mapping and aerial photography, with reference made to ARR Project 15. The Manning's 'n' values adopted were: • Open Space 0.035 • Light Vegetation 0.045 • Medium Vegetation 0.065 • Medium Density Residential 0.350 • Infrastructure 0.025 A lot averaged high roughness value has been adopted for residential (and to a lesser extent, infrastructure) to allow for buildings, structures and fences onsite that have not been explicitly mapped and accounted for in the model.
1D elements	The model is a pure 2D model and does not contain any 1D elements.
Inflows	Inflows were applied to the hydraulic model via SA polygons utilising standard SA polygons, whereby flows are applied to the lowest cell within the polygon. The SA polygons mirrored the subcatchment breakdown shown in **Figure 2**.
Downstream Boundary	The downstream boundary of the model is the Nepean River. No allowance for Nepean River flooding has been made. The downstream boundary incorporates some nominal level of flow in the Nepean River (that is, the river is not assumed to be dry), by adding 0.1m to the DEM heights. The DEM levels represent the river surface at the time the LiDAR was flown. This flow is fully contained within the riverbanks, and does not influence upstream flood behaviour.

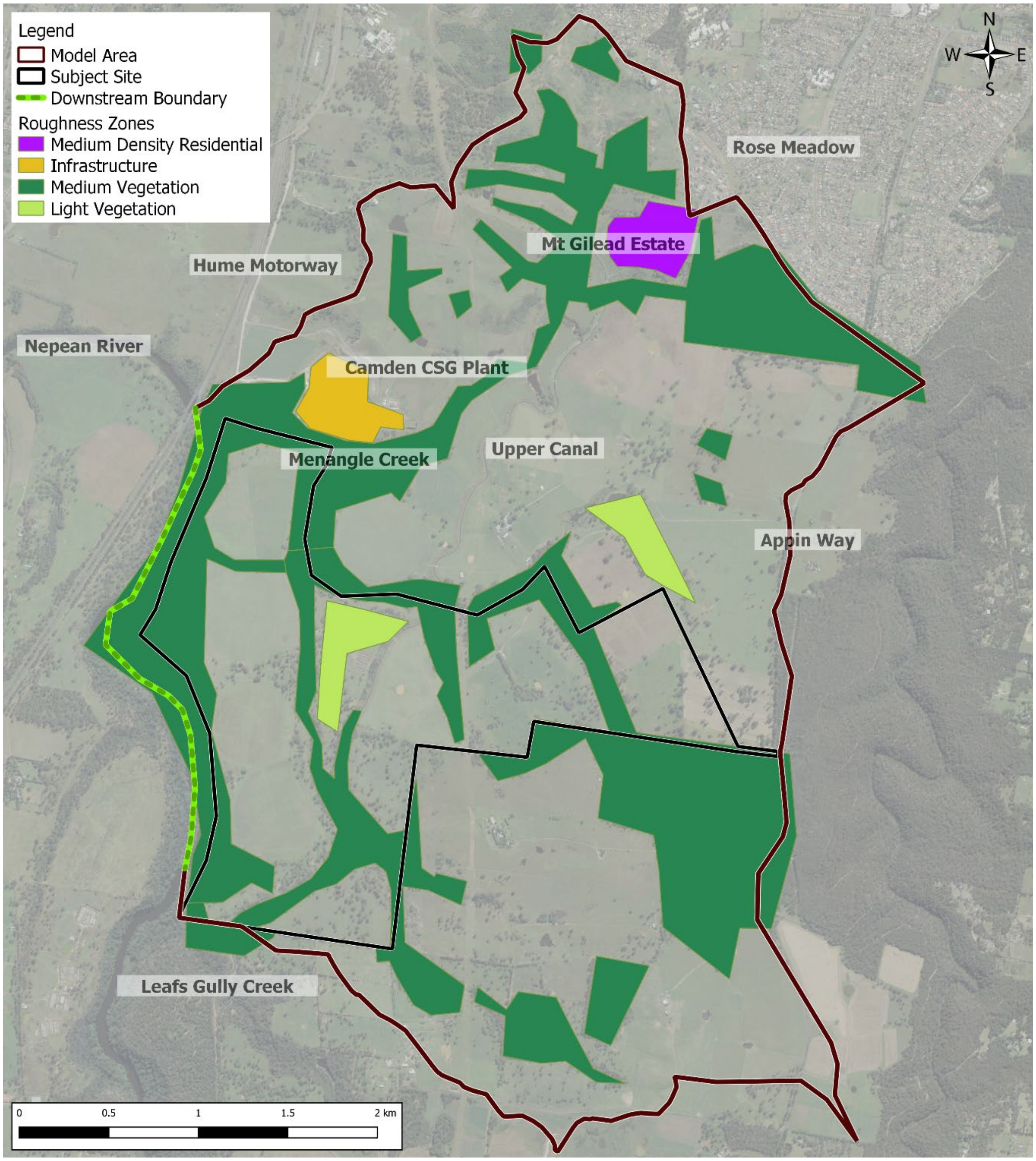


Figure 3 – TUFLOW Model Setup

Note: Areas without a roughness zone in the figure above have been classed as open space.

Modelled Flood Events

All modelling has been undertaken in accordance with ARR2019.

For the annual exceedance probability (AEP) event modelling, the full set of ensemble temporal patterns was run in the hydrological model for durations from 15 minutes to 12 hours. Critical durations for the study area were determined from the RAFTS model, with these selected durations then run in the hydraulic model (for all 10 temporal patterns).

PMF modelling was undertaken using the Generalised Short Duration Method (GSDM) as per the ARR2019 guidance for a catchment of this size.

The critical durations for each event were:

- 50% AEP 360-minute
- 1% AEP 60- and 120-minute
- PMF 30- and 60-minute

The results were then processed to:

- Extract the median plus one event from the peak water levels from the 10 temporal patterns for each duration, and
- Determine the maximum results from the set of median results.

Existing Flood Behaviour

Peak flood depths, with the proposed development extents overlaid, are attached to this letter report, and are shown in:

- RG-00-01 50% AEP
- RG-00-02 1% AEP
- RG-00-03 PMF

The results show that under existing conditions, due to the highly incised nature of the local creeks and channels, that flows are typically well contained throughout the study for events up to and including the PMF.

The exception to this is some minor flowpaths in the south-west of the site that drain directly to the Nepean River. The depths of these flowpaths are typically 0.1m – 0.2m in the 50% AEP and 1% AEP, but increase to 0.6m in the PMF.

Nepean River Flood Behaviour

The site lies adjacent to the Nepean River, and will be subject to some degree of riverine flooding.

A desktop search undertaken of available literature has not yet revealed any publicly available flood studies covering this area. It is noted that Wollondilly Shire Council is currently undertaking the *Draft Wollondilly Shire Flood Study Broad Scale Assessment* (https://flooddata.ses.nsw.gov.au/dataset/draft-flood-study-report) although it is not clear whether the study will contain data on Nepean River flooding in this vicinity.

It is noted that the proposed development areas sit approximately 25m to 45m above the typical river level (based on the water level captured by the LiDAR data), which will offer some level of protection from riverine. Flooding.

Limitations and Assumptions

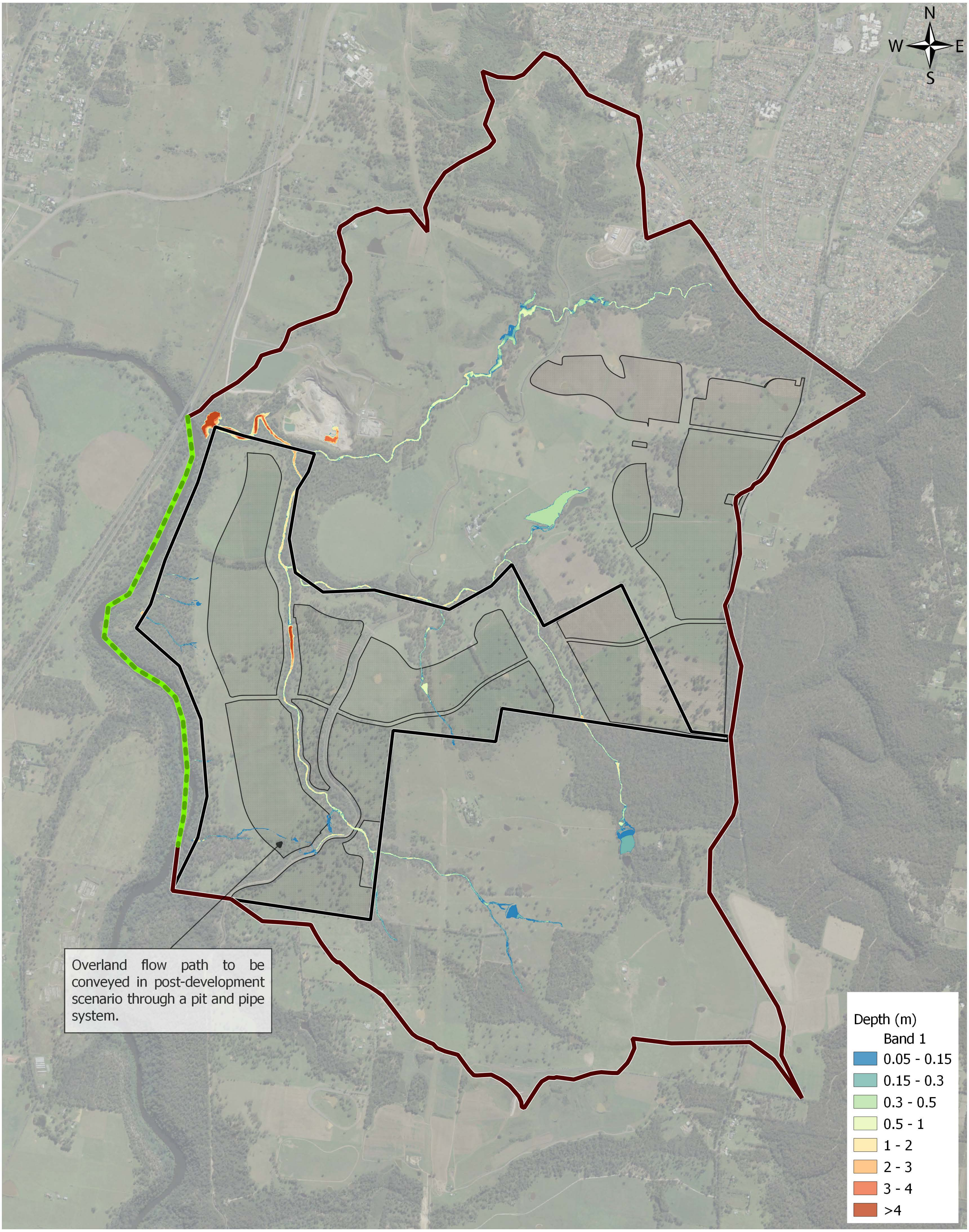
This assessment has been undertaken in accordance with the latest industry guidelines, namely ARR2019. However, the assessment is preliminary, and the following should be noted:

- No calibration, validation, sensitivity testing or ground truthing have been undertaken.
- All model parameters are as per typical values noted in ARR2019 and have not been adjusted for this catchment area.
- No survey of creeks or channels has been undertaken to confirm the representation of these features in the model DEM.
- No flooding of the Nepean River has incorporated in this assessment. The results presented are for local catchment flooding only.
- The LiDAR data underlying the model typically has a vertical accuracy of 0.1 – 0.3m. In the absence of ground survey to confirm LiDAR levels, or calibration / validation to confirm flood levels, a similar level of accuracy should be assumed for the reported preliminary results.
- Modelling of flood flows near the Upper Canal, while roughly represented in the LiDAR ground level data, does not incorporate any of the existing cross drainage structures. It is not expected that these cross-drainage structures would significantly impact the creek flows shown in these results. Future flood modelling will take this into account.

If you have any questions concerning this report or the attached maps, please do not hesitate to contact me.

Sincerely,

Luke Evans
Senior Engineer.



Rhelm

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Date : 7 June 2022
Revision : A
Created by : LRE
Coordinate System : MGA 2020/56

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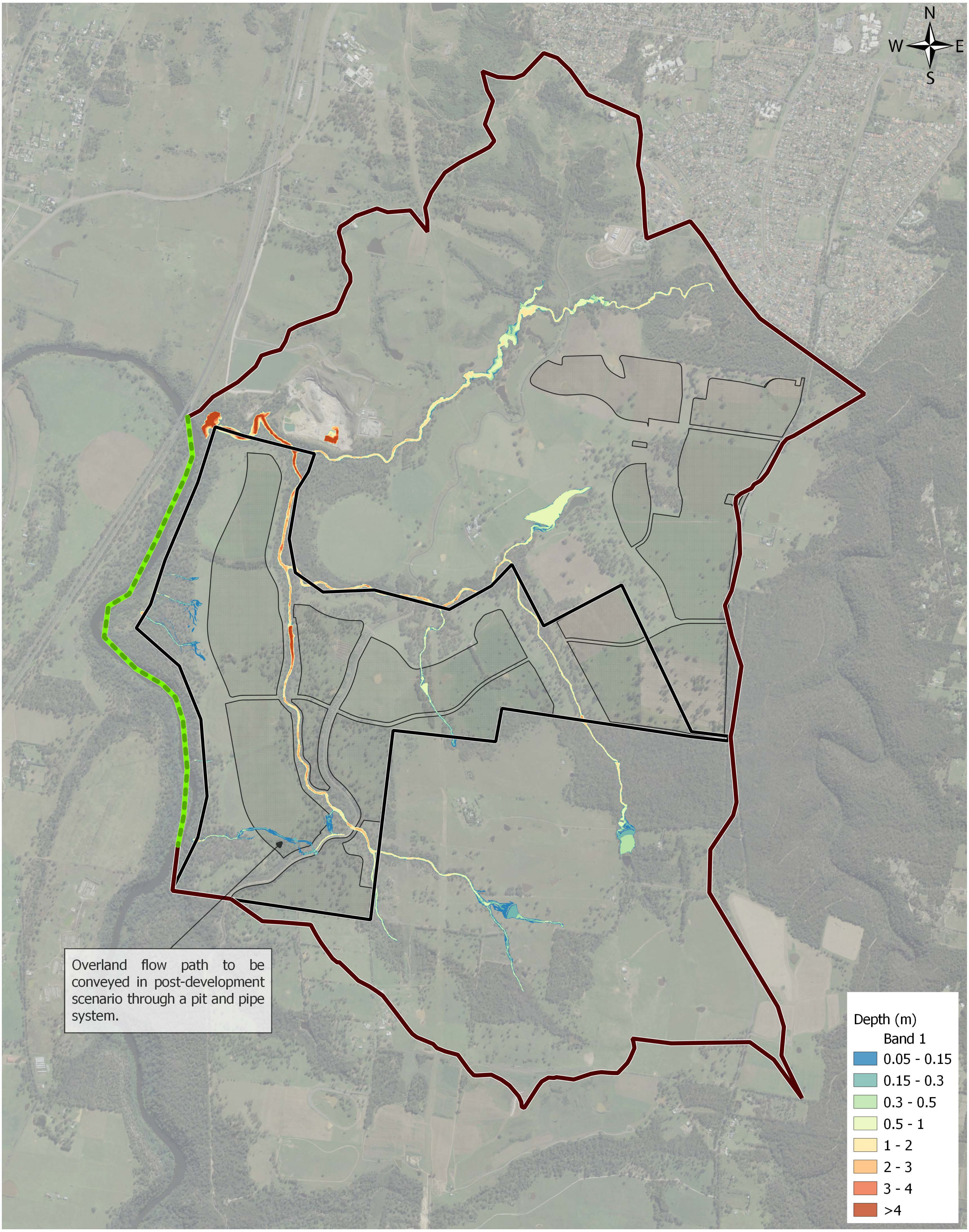
Legend
Model Area
Subject Site
Proposed Masterplan Development Regions

RG-00-01
Mount Gilead
Prelminary 50% AEP Depths and Extents



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Date : 7 June 2022
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Created by : LRE
Coordinate System : MGA 2020/56

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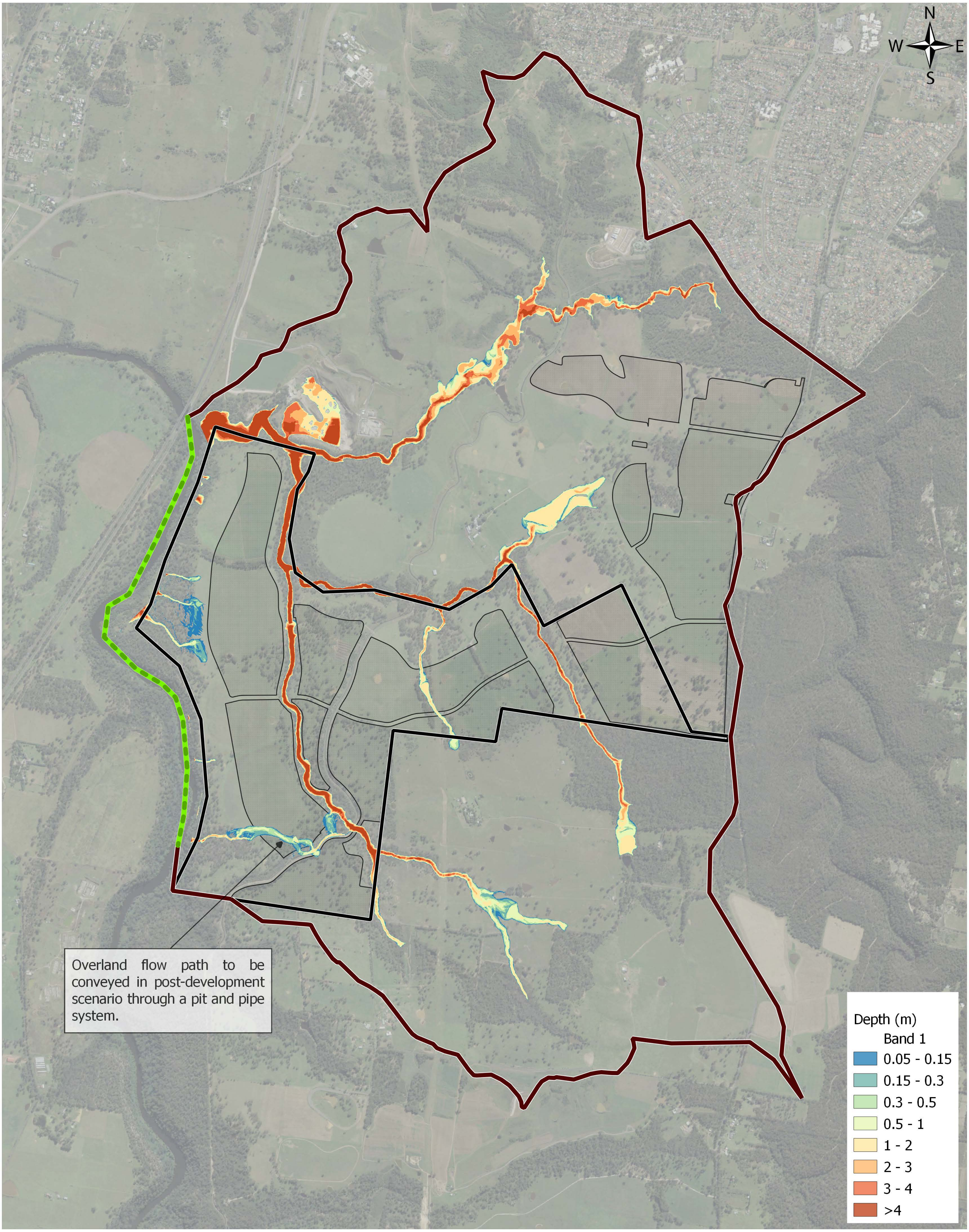
Legend
- Model Area
- Subject Site
- Proposed Masterplan Development Regions

RG-00-02
Mount Gilead
Prelminary 1% AEP Depths and Extents



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Date : 7 June 2022
Revision : A
Created by : LRE
Coordinate System : MGA 2020/56

0 250 500 750 1,000 m

Legend
- Model Area
- Subject Site
- Proposed Masterplan Development Regions

RG-00-03
Mount Gilead
Prelminary PMF Depths and Extents