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5 May 2019

Phoenix Builders
PO Box 342
Earlwood
NSW 2206

Attention: Adam Liw

Dear Adam

RE: 251 ADELAIDE STREET RAYMOND TERRACE - EARTHWORKS FLOOD IMPACT ASSESSMENT

BMT was requested to undertake a flood impact assessment to assist the development application for the proposed earthworks at 251 Adelaide Street, Raymond Terrace Road (Lot 232, DP 593512). Specifically, the assessment will involve determination of the peak flood levels and flood behaviour at the site for the 10% Annual Exceedance Probability (AEP) and 1% AEP design events. Any potential off-site flood impacts associated with the proposed works will be identified and assessed. The following provides a summary of the analysis and results.

The objective of this flood impact assessment was to provide a conceptual fill plan for the disused quarry that would have a minimal impact on the existing flood conditions. It is understood that a future DA will be submitted for use of the site as a golf course. As such, the requirements of the current assessment are limited to the potential flood impacts of filling the disused quarry. A future assessment will be required to address the management of flood risk with respect to property and life associated with the golf course development. However, the current assessment of the earthworks has considered the potential future use of the site through the provision of an area of high ground that can be utilised to provide the required flood immunity for development of the site.

Study Area and Catchment

The disused quarry site at 251 Adelaide St, Raymond Terrace, is located on the low-lying floodplain of Windeyers Creek, just upstream of the Hunter River. The site is positioned just south of the Raymond Terrace township and is bounded by the elevated road embankments of Adelaide Street and the Pacific Highway. A sewage treatment plant adjacent to the east of the site is raised above the Windeyers Creek floodplain. A levee is constructed along the Hunter River floodplain offering some protection from elevated water levels associated with Hunter River flood events.

The site is located within the low-lying floodplain area bounded by Adelaide Street and the Pacific Highway and provides a storage area for flooding of both Windeyers Creek and the Hunter River. Windeyers Creek is characterised by wide, low-lying swamp areas where ground levels are typically 1.0-1.5 m AHD. Windeyers Creek separates into two branches. The northern creek branch has been realigned into a well-defined channel running along the north and west boundaries of the site. Across the remaining site,

elevations are generally below 2.5 m AHD except for the north western corner of the block which is raised to around 3.0 m AHD. The site boundary and local topography is presented in Figure 1.

The site is subject to two flooding mechanisms:

- Local flooding of the Windeyers Creek catchment; and
- Backwater inundation from the broader Hunter River system.

Although the Hunter River flooding will result in peak flood conditions at the site, local flooding of Windeyers Creek is the critical condition in terms of assessing the impact of the earthworks.

Model Development

Hydrological Model

The hydrologic model predicts the amount of runoff from rainfall and the attenuation of the flood wave as it travels down the catchment. This process is dependent on catchment area, slope and vegetation; variation in distribution, intensity and amount of rainfall; and antecedent conditions of the catchment.

An XP-RAFTS hydrological model was developed to simulate the rate at which rainfall runs off the catchment. The amount of rainfall runoff and the attenuation of the flood wave as it travels down the catchment are dependent on:

- The catchment slope, area, vegetation and other characteristics;
- Variations in the distribution, intensity and amount of rainfall; and
- The antecedent conditions (dryness/wetness) of the catchment.

Catchment properties were determined from the high resolution (2 m grid size) Digital Elevation Model (DEM) derived from LiDAR data and aerial photography. Rainfall intensity-frequency-durations values and temporal patterns were adopted in accordance with the standard procedures outlined in ARR 2001. An initial loss of 20 mm and a continuing loss of 2.5 mm/h were adopted for this study and are within the limits recommended by ARR for a catchment in eastern NSW.

Hydraulic Model

A TUFLOW hydraulic model was developed for this study. TUFLOW is a two-dimensional (2D) hydraulic modelling software developed in-house at BMT to simulate flood depths, extents and velocities.

The model area covers around 25.4 km^2, extending around 4 km to the east and 2.2 km to the west of the site boundary. The downstream boundary is located along the Hunter River. A TUFLOW model cell size of 5 m was adopted to sufficiently represent overland flow distribution across the floodplain at the scale required for this study. The TUFLOW model samples cell elevations from a 2 m grid cell resolution Digital Elevation Model (DEM) of the floodplain topography.

Key hydraulic control structures including the Pacific Highway and Adelaide Street bridges were represented as layered flow constrictions where the flow impediment influence of the abutments, piers and bridge deck is modelled. Culverts within the study area (under the Pacific Highway and through the Hunter River levee) were also included within the 2D domain as 1D structures.

Another input required in the development of the TUFLOW model is the assignment of different hydraulic roughness zones to represent the variation in flow resistance. The spatial distribution of these zones (e.g.

paved driveway areas, cleared land or vegetated areas) was informed by inspection of aerial photography. The adopted roughness values are listed in Table 1.

Table 1 Adopted Manning 'n' Roughness Values

Land Use	Manning's 'n' Value
Vegetation	
Grass	0.035
Rough grass	0.04
Sandy forest	0.04
Light vegetation	0.05
Medium-dense vegetation	0.07
Dense vegetation	0.10
Urban Areas	0.08
Roads	0.025
Creek	0.035
Ponds / water bodies	0.025

Design Flood Results

Design flood simulations were undertaken for the 10% AEP and 1% AEP design events. Existing local peak flood depths and velocities have been mapped and are presented in Figure 2 and Figure 3 respectively. Table 2 summarises the Windeyers Creek peak flood levels at the site for the relevant design events.

Table 2 Modelled Peak Design Flood Levels

Design Event	Peak Flood Level (m AHD)
10% AEP	2.0
1 % AEP	2.2

The Adelaide Street road embankment acts as a major control for Windeyers Creek flooding, with flow confined to the existing bridge opening (i.e. no local overtopping of Adelaide Street). Upstream of the development site, the elevated Pacific Highway embankment also provides for a significant hydraulic control, particularly on the southern tributary of Windeyers Creek.

The extent of overbank inundation within the site boundary is generally maintained within the disused quarry lake area between the two Windeyers Creek branches, to the west of the elevated sewage treatment plant. Typical 1% AEP flood depths across the site are within the order of 0.8 - 1.25 m (above the modelled lake surface), with the peak water level at 2.2 m AHD. Velocity of floodwaters are generally less than 0.3 m/s, with higher velocities (up to 1 m/s) contained within the realigned Windeyers Creek channel along the northern boundary of the site. Due to the poorly defined nature of the southern creek branch, the main flood path along the southern boundary of the site is less distinct. Modelled floodwaters spill out of the natural creek channel onto the disused quarry area. The preferential flow path across the lake is indicated on Figure 3.

There is notable attenuation of floodwaters over the wider catchment due to the flat topography and remnant sand dunes. The local hydraulic model was developed by applying inflow boundary conditions derived from the XP-RAFTS hydrological model at selected locations. Due to the flooding behaviour of the broader

floodplain, the inflows derived from the XP-RAFTS model are expected to be slightly conservative, as some attenuation outside the model domain is not explicitly accounted for. The results found in this study are represent the maximum peak flood level likely across the site from Windeyers Creek catchment flooding.

Flood Impact Assessment

The objective of this assessment was to provide a conceptual fill plan for the disused quarry that would have a minimal impact on the existing flood conditions. An iterative flood modelling approach was undertaken to establish a conceptual earthworks plan that would maximise potential filling of the disused quarry, minimise potential flood impacts and provide flood immunity for potential future development opportunities.

The conceptual fill plan derived through the flood impact assessment process is presented in Figure 4. The concept plan sets much of the finished surface level of the fill at 1.1 m AHD, which is consistent with the broader levels throughout the local Windeyers Creek floodplain. This maintains the existing conveyance of floodwaters from the channel to the north of the site across the disused quarry to the south and through the Adelaide Street bridge structure. At the western end of the site the finished surface level of the fill rises from 1.1 m AHD to 2.1 m AHD over a 60 m distance. The area around the existing site access from Adelaide Street can then be filled to as high a level as required to satisfy potential future uses of the site without impacting the existing Windeyers Creek flood conditions.

Peak flood level impacts resulting from inclusion of the conceptual earthworks in the hydraulic model are presented in Figure 5 for the simulated 10% AEP and 1% AEP design flood conditions. Peak velocity impacts are shown in Figure 6. These diagrams show the difference between flood conditions resulting from filling the site in line with the concept plan and the existing baseline flood conditions. The impact mapping confirms that there are negligible peak flood level (peaking at 23 mm for the 10% AEP event) and velocity impacts resulting from the earthworks for the design events considered.

With regards to flooding from the Hunter River, the Windeyers Creek floodplain acts as a backwater storage from the Hunter River. It is therefore not important for the conveyance of Hunter River flood waters and the proposed loss of floodplain storage would be negligible in terms of the overall magnitude of Hunter River flood volumes and the quantity of storage available across the broader Hunter River floodplain. Flood impacts of the conceptual fill plan would therefore also be negligible for Hunter River flood events as well as those from the local Windeyers Creek catchment.

Conclusion

The site at 251 Adelaide Street, Raymond Terrace, is subject to mainstream Hunter River flooding and local catchment flooding of Windeyers Creek. Although the Hunter River flooding will result in peak flood conditions at the site, local flooding of Windeyers Creek is the critical condition in terms of assessing the impact of the earthworks.

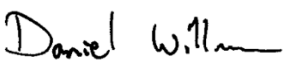
This assessment has developed a proposed concept earthworks plan for the site to maximise potential filling of the disused quarry, minimise potential flood impacts and provide flood immunity for potential future development opportunities.

An XP-RAFTS hydrologic model and a TUFLOW hydraulic model were developed for the assessment. Flood behaviour at the site for the 10% AEP and 1% AEP design flood events has been determined for existing and post-development scenarios, identifying that there will be negligible off-site peak flood level

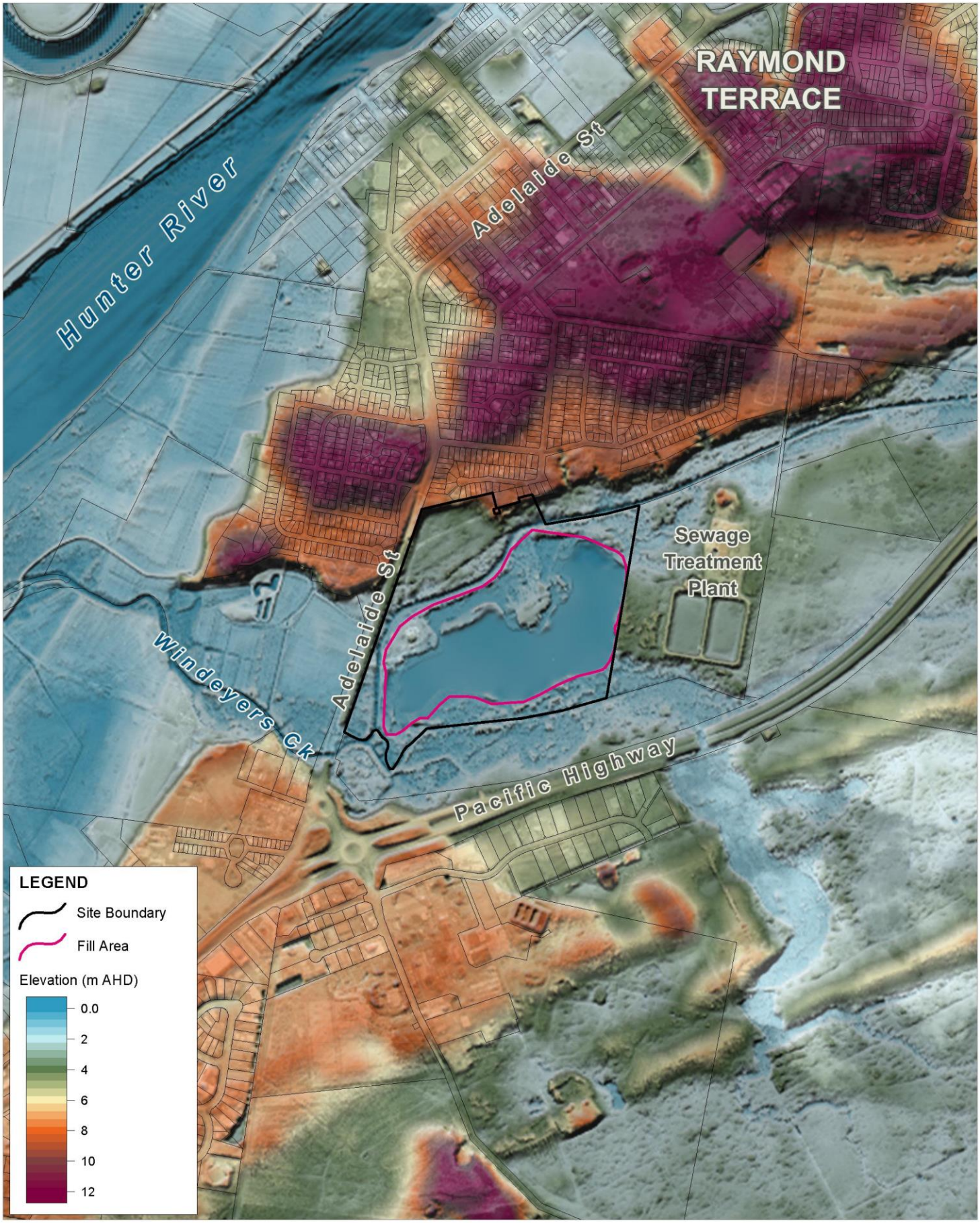
impacts associated with filling the site in this manner. This would also be the case for Hunter River flood events.

We trust that this report satisfies your requirements. If you have any further questions regarding any aspect of this report then please do not hesitate to contact the undersigned.

Yours Faithfully
BMT



Daniel Williams
NSW Flood Lead



Title:

Study Site Locality and Topography

Figure: 1

Rev: A

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0 250 500m

Approx. Scale

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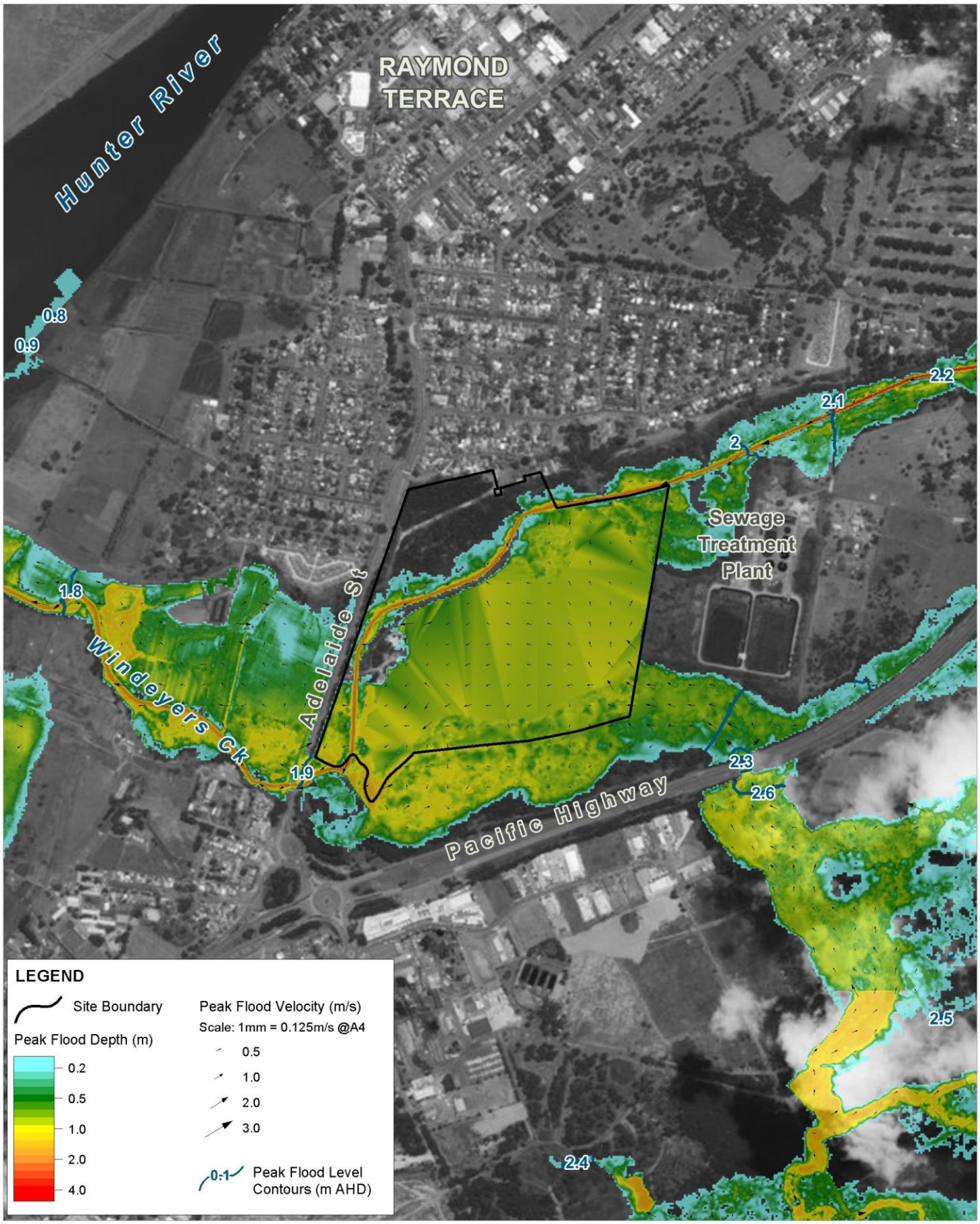

Title:

Modelled Flood Results
10% AEP Design Event Existing Condition

Figure: 2

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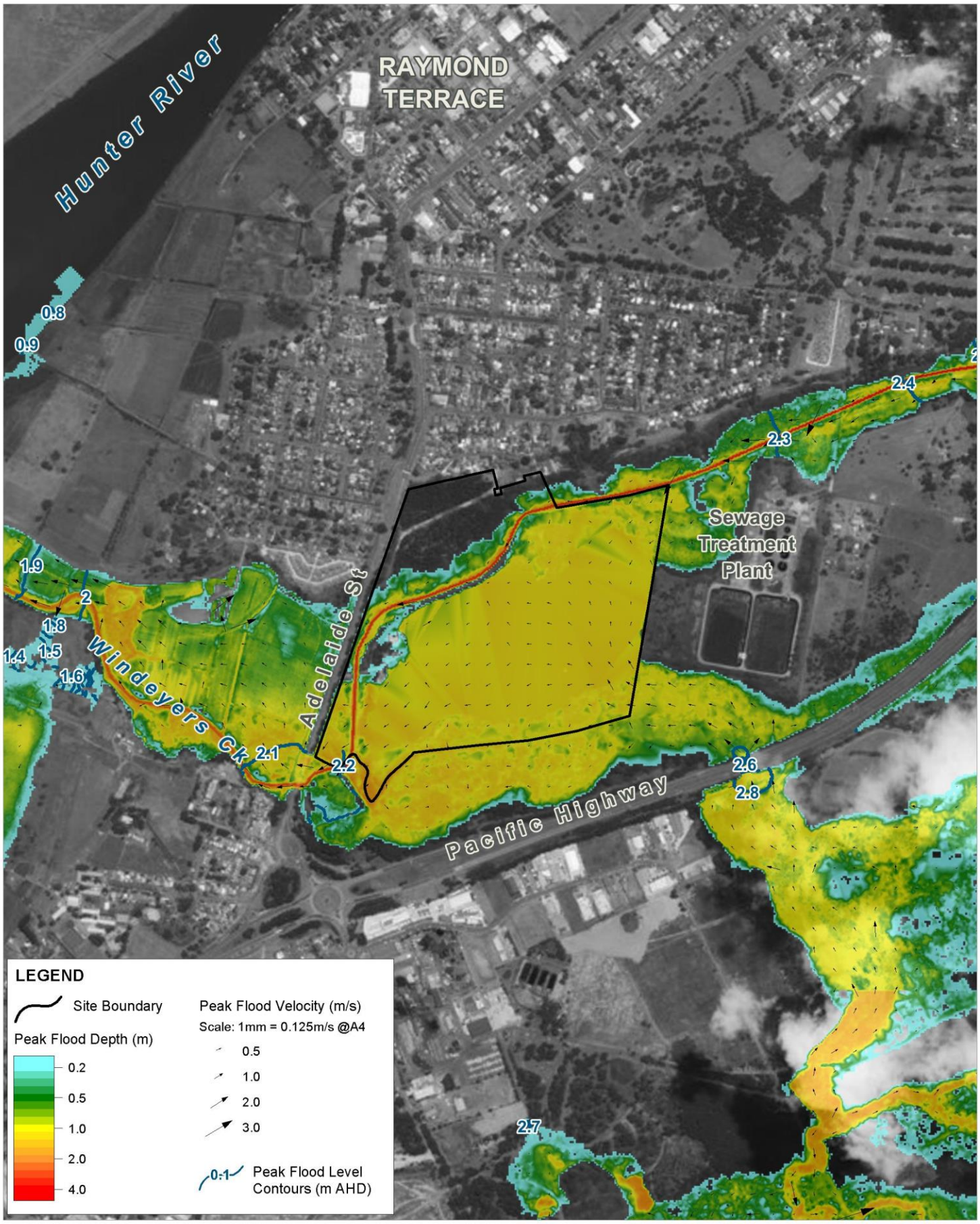

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Modelled Flood Results
1% AEP Design Event Existing Condition

Figure: 3

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Title:
Concept Fill Plan

Figure:	Rev:
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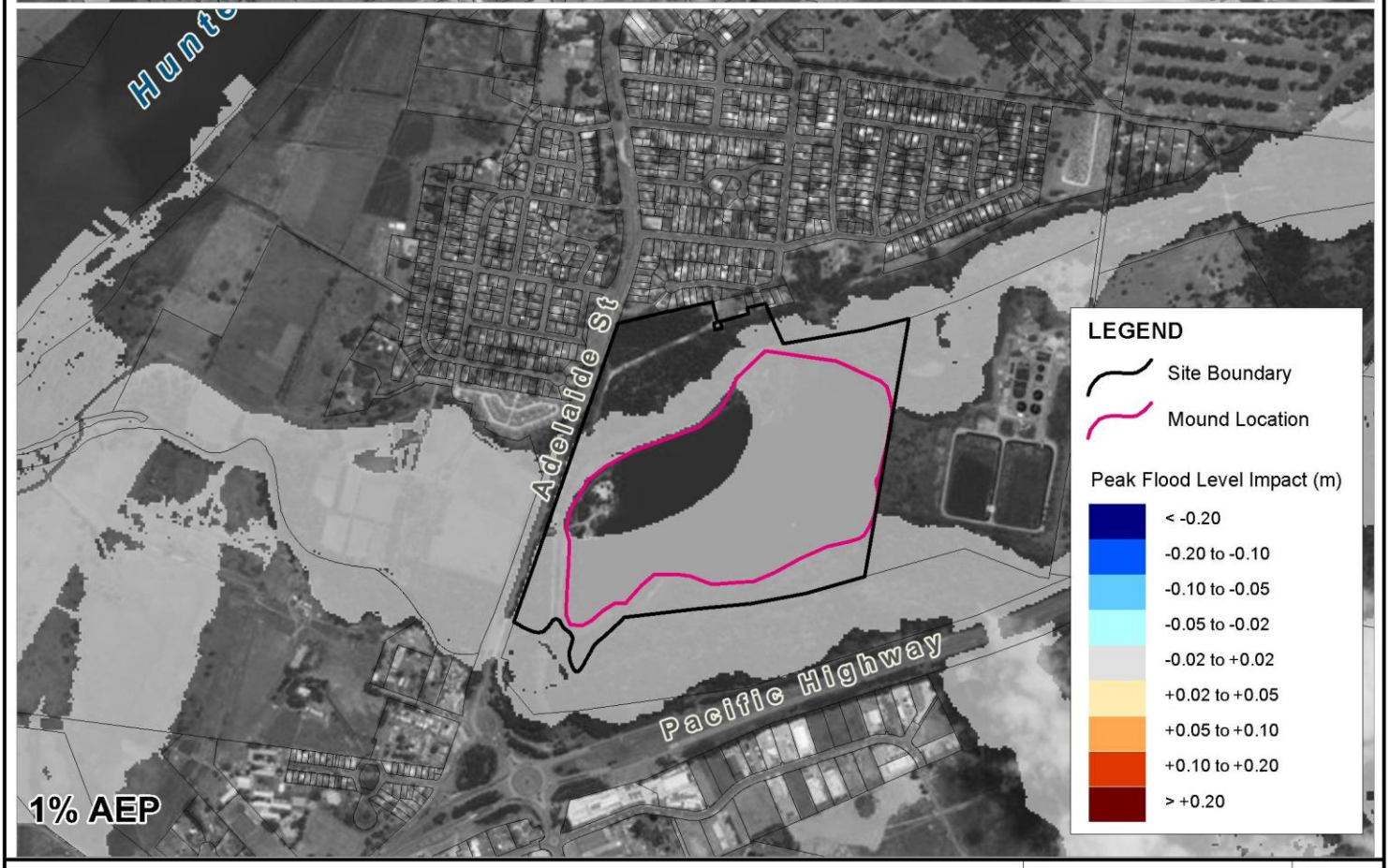

Title:

Modelled Peak Flood Level Impacts

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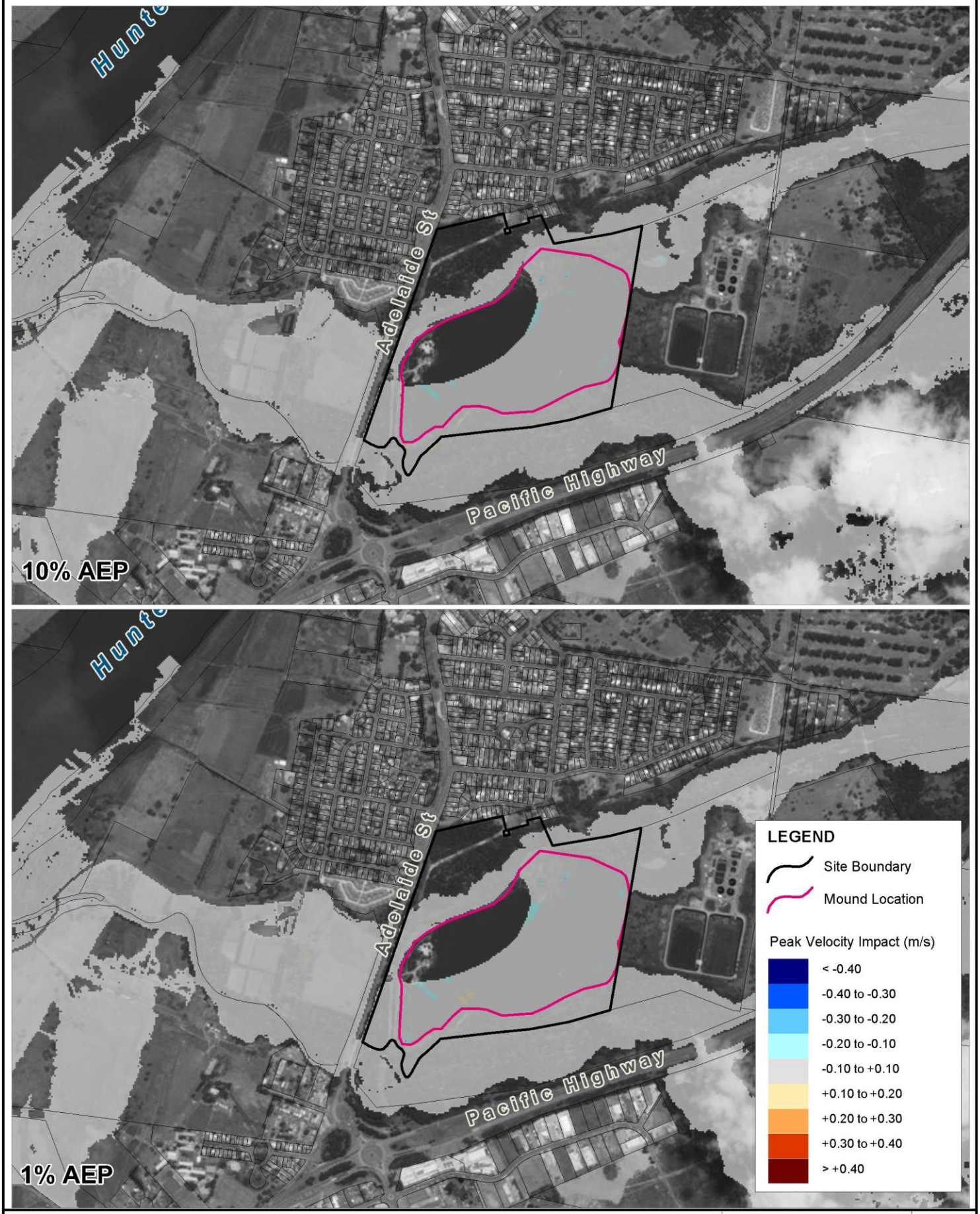

Title:

Modelled Peak Velocity Impacts

Figure: 6

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