

27 February 2023

Our Ref  
P1806743JC06V01

Pages  
15 + Attachment

Mitchell McCormac  
Terara Shoalhaven Sand  
By email

Dear Mitchell,

**RE: SUPPLEMENTARY FLOOD ASSESSMENT IN RESPONSE TO SHOALHAVEN CITY COUNCIL AND BIODIVERSITY AND CONSERVATION DIVISION COMMENTS – PROPOSED EXPANSION OF SAND EXTRACTION AT PIG ISLAND, TERARA, NSW**

## 1 Introduction

Martens and Associates (**MA**) have prepared this response on behalf of Terara Shoalhaven Sand (the **Proponent**) to address the flood related comments received from Shoalhaven City Council (**Council**, dated 7 October 2022) and the Biodiversity and Conservation Division of the Department of Planning and Environment (**BCD**, dated 8 December 2022) in relation to a proposed expansion of sand extraction and development of livestock stockpile refuge mounds at Pig Island, Terara, NSW (the **Site**).

This letter includes the following information to address the Council and BCD comments with respect to flooding:

1. Updates to hydraulic model.
2. Updated flood impact maps and discussion to reflect the updated extraction area and reduced mound sizes.
3. MA response to Council and BCD flood related comments.
4. Shoalhaven City Council LEP and DCP compliance assessments.

This letter should be read in conjunction with the following:

1. The MA report *Flood Assessment: Proposed Expansion of Sand Extraction Operations at Terara Sands, Terara, NSW* (2019: REF: P1806743JR04V02, the **Flood Report**); and
2. The MA letter report *Flood Assessment – Proposed Livestock Refuge Mounds, Pig Island, Terara, NSW* (2020, REF: P1404280JC01V02, the **Flood Mound Letter**), which updated the Flood Report to include the proposed livestock fill mounds.
3. The MA letter report *Supplementary Flood Assessment In Response To Shoalhaven City Council Request For Further Information – Proposed Expansion Of Sand Extraction At Pig Island, Terara, NSW* (2022, REF: P1806743C03V01, the **Flood Response Letter**), which updated the Flood Report and Flood Mound Letter to address Council comments from 19 April 2022.

## 2 Hydrologic and Hydraulic Modelling Updates

### 2.1 Overview

Full flood assessment details can be found in the Flood Report including site description, hydrologic and hydraulic model setup, flooding characteristics and compliance with Secretary's Environmental Assessment Requirements (**SEARs**). Following the hydraulic modelling of the proposed expanded extraction area, the livestock fill mounds were included as part of the proposed development, and flood impacts were assessed in the Flood Mound Letter. The livestock fill mounds were further modified as part of the Flood Response Letter.

### 2.2 Updates to Existing Conditions Flood Model

The *Lower Shoalhaven River Flood Study* (Cardno, 2022) underwent public exhibition in June 2022, and contained details of hydrologic and hydraulic modelling. As part of this response, MA have updated the existing conditions flood models to better match the Cardno report with respect to:

1. Peak flow rates.
2. Varying opening widths for the sand bar at Shoalhaven Heads.
3. Tailwater levels.

Comparison between Cardno (2022) and MA peak flood levels for the 1% annual exceedance probability (**AEP**) flood and probable maximum flood (**PMF**) events is given in Table 1. Comparison is made for the peak flood levels at the 6 locations shown in Attachment A Map FL01. The comparison shows flood levels as modelled by MA are generally consistent with Cardno modelling, and differences are  $\leq \pm 0.5$  m. MA modelled flood levels are slightly higher than those modelled by Cardno and are therefore considered conservative. Further, flood levels and extents throughout the MA model domain were compared to those modelled by Cardno and were found to have close agreement. We therefore consider the MA model closely matches the Council adopted flood characteristics, and is considered appropriate for the purposes of detailed site modelling.

**Table 1:** Comparison between Cardno and MA modelled peak water levels. Refer to Attachment A Map FL01 for point locations.

Validation Point	1% AEP Flood Level (mAHD)				PMF Flood Level (mAHD)			
	MA	Council	Difference (m)	Difference (%)	MA	Council	Difference (m)	Difference (%)
A	5.94	5.50	+0.44	8.0	7.38	7.00	+0.38	5.4
B	5.47	5.43	+0.04	0.8	6.72	6.50	+0.22	3.4
C	5.45	5.31	+0.14	2.6	6.82	6.50	+0.32	4.9
D	5.31	5.14	+0.17	3.3	6.67	6.50	+0.17	2.6
E	5.11	5.00	+0.11	2.1	6.49	7.00	-0.51	-7.3
F	4.88	4.50	+0.38	8.5	6.34	6.00	+0.34	5.6
Average	-	-	+0.21	4.2	-	-	+0.15	4.9

## 2.3 Updates to Proposed Conditions Flood Models

The following changes were made to the proposed conditions flood model as part of this response:

1. Proposed livestock mound sizes were significantly reduced to further reduce offsite flood level changes.
2. Proposed livestock mound locations were also modified to further reduce offsite flood level changes whilst maintaining a 25 m distance from the swamp oaks on Burruga Island / Pig Island.
3. The top of mound levels were modified to be just above the peak 1% AEP flood levels associated with the updated existing conditions flood model.
4. Mounds were located partly within flood storage areas as identified in the Cardno (2022) report.

The updated mound locations are shown in Attachment A and revised details of fill levels, areas and volumes in each lot are summarised in Table 2. Importantly, the total proposed fill volume has been reduced by approximately one third of that assessed as part of the Flood Response Letter.

**Table 2:** Updated approximate levels, volumes and areas of proposed livestock fill mounds.

Parameter	Lot 2 Fill Pad	Lot 3 Fill Pad	Lot 4 Fill Pad
Top of Mound Level (mAHD)	5.55	5.50	5.35
Area (m <sup>2</sup> )	11,200	14,300	16,300
Volume (m <sup>3</sup> )	38,500	43,400	44,000

## 3 Flood Results

Proposed condition water level and velocity afflux maps arising from the new mound locations are shown in Attachment A, with drawing references summarised in Table 3. The results in Attachment A supersede those previously provided in the Flood Mound Letter.

**Table 3:** Proposed condition flood map drawing references in Attachment A (MA MapSet P1806743MS02-R02).

Critical Duration Flood Event	Water Level Afflux	Water Velocity Afflux
10% AEP	Map FL02	Map FL03
1% AEP	Map FL04	Map FL05
0.5% AEP	Map FL06	Map FL07
0.2% AEP	Map FL08	Map FL09
PMF	Map FL010	Map FL11

### 3.1 Offsite Water Level Impacts

We note the following regarding offsite water level impacts:

1. With regards to the adopted flood level impact threshold:

- a. For the purpose of this assessment, the adopted threshold of no flood impact is 10 mm of water level increase, as requested by Council.
  - b. This 10 mm threshold was requested by Council on the basis that afflux ranges are 'typically taken as the precision of numerical models', with reference to an Australian Rainfall and Runoff (ARR) research project (2012). We note that this is not an adopted guideline or standard, and was not included in the adopted ARR guidelines (2019).
  - c. This threshold is inconsistent with other documented NSW DCP criterion for flood impact assessment, that generally utilise a range between 20-200 mm for events below the PMF, and > 50 mm in the PMF.
  - d. The typical flood level impact threshold adopted and approved in a number of recent NSW Land and Environment Court and Section 34 mediation conferences in which MA have been involved as flood experts is 20-50 mm.
  - e. An impact threshold of 20-50 mm was adopted for proposed developments at the following locations, which were all approved:
    - i. 91 Newton Road, Blacktown
    - ii. 127- 129 Garfield Road, East Riverstone
    - iii. 25-31 Railway Pde, Quakers Hill
    - iv. 19-21 Irelands Road, Blacktown
    - v. 33 Railway Road, Quakers Hill
    - vi. 7 Rivendell Way and 15 Linksley Avenue, Glenhaven
    - vii. 7-15 Gladstone Avenue, Wollongong
  - f. In addition, these proposed developments were approved with small areas of flood level impact greater than 20 mm offsite. Maximum offsite impacts for these sites ranged from 30-1100 mm. These were considered acceptable as they did not represent any actionable increase in flood risk to people or property, and did not affect offsite development potential.
  - g. Further, Arup (2018) recently prepared a flood study on behalf of NSW RMS, and documented it in the *Nowra Bridge Project: Technical Paper – Flooding and Hydrology Assessment*, which is approximately 1.2 km upstream of the site. This flood assessment showed flood level impacts of up to 0.2 m on residential land in the 1% AEP flood event and up to 1.0 m impact in the 'extreme event', and showed a large number of residential properties in Nowra becoming newly flood affected in the 1% AEP event. Despite this, the project was approved and is currently in the process of being constructed.
2. Despite the strict 10 mm threshold requested by Council, modelling has shown the proposed development has negligible offsite water level impacts in all modelled flood events up to and including the PMF.

3. There are minimal flood level increases above 10 mm on private land for all events up to and including the PMF event. These flood level increases are negligible considering the flood depths in existing conditions of up to 2.1 m in the 10% AEP event and 9.2 m in the PMF event.
4. There are no flood level impacts greater than 20 mm on private property and all impacts up to this threshold are fully contained within the banks of the Shoalhaven River.
5. The proposed development does not cause any lots to become newly flood affected.
6. In all modelled flood events, the area of flood level decrease exceeds the area of flood level increase, and therefore represents an overall net benefit to the local floodplain environment.
7. Overall, despite the strict 10 mm threshold required by Council, the proposed development has a net benefit on the local floodplain environment with respect to flood levels. The flood level changes are therefore of immaterial significance and are considered acceptable.

### 3.2 Offsite Water Velocity Impacts

We note the following regarding offsite water velocity impacts:

1. The proposed development has negligible offsite impact on water velocities in all modelled flood events up to and including the PMF event.
2. In all modelled events, flood velocity impacts are largely contained within the banks of the Shoalhaven River and do not affect private property.
3. Whilst modelling indicates some localised flow velocity increases in extreme flood events, these are primarily contained within the channel and are not aligned with significant channel bank flow velocity increases. Modelling therefore supports the proposition that bank shear stresses will not be materially increased such that bank erosion will be initiated.

## 4 LEP Flooding Compliance Assessment

The Shoalhaven City Council flood specific controls are provided in Clause 5.21(2) & 5.21 (3) of the Shoalhaven Local Environmental Plan (LEP) 2014, and a compliance assessment against these controls is summarised in Table 4. Table 4 demonstrates that all the applicable LEP flood planning requirements for the proposed development site are effectively addressed, and compliance with the Shoalhaven LEP is achieved.

**Table 4:** Compliance with Shoalhaven City Council LEP 2014 flooding controls (Clause 5.21(2) & 5.21 (3)).

Shoalhaven City Council LEP Requirement	Compliance Assessment
(2) Development consent must not be granted to development on land the consent authority considers to be within the flood planning area unless the consent authority is satisfied the development—	

Shoalhaven City Council LEP Requirement	Compliance Assessment
(a) is compatible with the flood function and behaviour on the land, and	<p>(1) The proposed livestock mounds are primarily located within a high hazard flood way. The proposed development is compatible with the site flood function and behaviour for the following reasons:</p> <ul style="list-style-type: none"> <li>a. An agricultural use is compatible with a high hazard flood way.</li> <li>b. The livestock mounds have been designed to have no adverse offsite flood impacts on private property for the full range of flood events up to and including the PMF, as discussed at Section 3.</li> <li>c. As there are no adverse offsite flood impacts, there is no increased flood risk to people or property.</li> <li>d. The use of the mounds as stock refuge is compatible with the site's flood characteristics. The proposal does not introduce additional stock or people to Pig Island as part of the application, and therefore there is no increase in flood risk. Rather, the livestock mounds represent a significant reduction of flood risk to the existing stock on the island, which currently have insufficient refuge in a flood event.</li> <li>e. The volume of fill proposed is insignificant compared to the volume of the island above the waterline.</li> </ul>
(b) will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties, and	(2) Refer to Section 3. The modelling results show that in all modelled flood events the proposed development does not materially alter the local flood characteristics. Overall, the proposed flooding conditions are largely unchanged from the existing conditions, and the flood impacts of the development are considered to be acceptable (i.e. below 20 mm). As there are no adverse offsite flood impacts, there is no increased flood risk to people or property.
(c) will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood, and	(3) As discussed at (1) and (2), no additional people are being introduced to the floodplain, and there are no adverse offsite flood impacts. The proposal will therefore not adversely affect the safe occupation or evacuation of people, and there would be no increased risk to life.
(d) incorporates appropriate measures to manage risk to life in the event of a flood, and	(4) As discussed at (3).
(e) will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.	(5) As discussed in Section 3, there are no significant offsite flood impacts, hence the proposed development will not adversely affect the environment or cause increased risk of erosion, siltation destruction of riparian vegetation or bank stability issues.

Shoalhaven City Council LEP Requirement	Compliance Assessment
(3) In deciding whether to grant development consent on land to which this clause applies, the consent authority must consider the following matters—	
(a) the impact of the development on projected changes to flood behaviour as a result of climate change,	(6) As requested as part of the SEARs, the 0.5% AEP and 0.2% AEP year flood events have been assessed 'as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change'. As discussed in Section 3, there are no significant offsite flood impacts including in these two events. The impact of climate change has therefore been evaluated and found to be acceptable.
(b) the intended design and scale of buildings resulting from the development,	(7) Multiple iterations of the livestock refuge mounds were modelled to achieve negligible offsite impacts.
(c) whether the development incorporates measures to minimise the risk to life and ensure the safe evacuation of people in the event of a flood,	(8) As discussed at (3).
(d) the potential to modify, relocate or remove buildings resulting from development of the surrounding area is impacted by flooding or coastal erosion.	(9) As discussed at (7).

## 5 DCP Flooding Compliance Assessment

We note the following based on Council's flood planning policies provided in the DCP (2014):

1. The site is classified as being within a High Hazard Floodway by Council.
2. The proposed development is the expansion of a sand dredging area and the construction of three stockpile livestock refuge mounds which are categorised as Resources Management/ Agricultural/ Recreations Activities land use.

Flood specific controls are provided in the DCP Chapter G9: 'Development on Flood Prone Land'. A compliance assessment for the proposed development based on the *Development Control Matrix, Schedule 2 – Flood Related Development Controls – Generic* of the DCP for a *Resources Management / Agricultural / Recreations Activities* land use in a high hazard floodway is summarised in Table 5, and the controls are shown in Figure 1. Table 5 demonstrates that all the applicable DCP flood planning requirements for the proposed development site are effectively addressed, and compliance with the Shoalhaven DCP is achieved.

## Schedule 2 – Flood Related Development Controls – Generic

Hazard/Hydraulic Category	High Hazard Floodway													
Land Use Category (As per schedule 1)	Single Residential / Habitable Buildings	Single Residential / Habitable Buildings	Other Residential / Habitable	Carparks	Commercial / Industrial / Agricultural Buildings / Retail	Commercial / Industrial / Agricultural Buildings / Retail Existing Use Rights Only	Subdivision	Earthworks	Resources Management / Agriculture / Recreational Activities	Critical Infrastructure Assets / Potentially Polluting Activities	Buildings and activities requiring special evacuation consideration	Minor Development	Ancillary Structures	Events
	A(I)	A(I)*	A(II)	B	C	C(I)*	D	E	F	G	H	I	J	K
FLOOR LEVEL*		1				1						1 or 4**		
BUILDING COMPONENTS		1, 2				1, 2			1, 2			1, 2	1, 2	
STRUCTURAL SOUNDNESS		2, 4				2, 4			3			2	3	
HYDRAULIC IMPACT		1				1			1, 2				1	
ACCESS		1, 2				1,2						3		
FLOOD EVACUATION PLAN		1				1						1		2
MANAGEMENT & DESIGN		1, 3				1, 2, 3			1, 2				1	



Not suitable for development



Not required

Note: For definitions of Land Use Categories refer to Schedule 1.

\* This type of development is not suitable within the risk category - however, if existing use rights (as defined in the *Environmental Planning and Assessment Act 1979*) can be established and there is no other option, the conditions as per Schedule 2 will apply.

\*\* Control no. 1 is desirable however if this cannot be achieved control no. 4 is acceptable.

Numbers in columns are described in the Development Controls Matrix Legend.

**Figure 1:** Development Control Matrix, Schedule 2 – Flood Related Development Controls – Generic from Shoalhaven City Council DCP (2014) Chapter G9 with Resources Management / Agricultural / Recreations Activities (Category F) highlighted.

**Table 5:** Compliance with Shoalhaven City Council DCP (2014) Schedule 2 – Flood Related Development Controls Matrix– Generic.

Shoalhaven City Council DCP Requirement	Compliance Assessment
<b>BUILDING COMPONENTS &amp; METHOD</b>	
1. Any portion of the building or structure below the FPL to be built from flood compatible materials (being those materials used in building that are resistant to damage when inundated); and	(1) No buildings are proposed as part of the development. The proposed livestock mounds will be constructed using dried waste fines which will be compacted to ensure they are compatible with the local flood behaviour.
2. All electrical installations to be above the FPL.	(2) Not Applicable – no electrical installations are proposed as part of the development.
<b>STRUCTURAL SOUNDNESS</b>	
1. Appropriate consulting engineer's report – the building can withstand forces of floodwaters including debris and buoyancy forces up to a 1% AEP flooding scenario;	(3) Not Applicable – no buildings are proposed as part of the development.

Shoalhaven City Council DCP Requirement	Compliance Assessment
<b>HYDRAULIC IMPACT</b>	
1. Appropriate consulting engineer's report for building footprint areas over 250 square metres, a footprint length of more than 20 metres or any development that in the view of Council has the potential to significantly impact on others. The report is to prove that the development will not increase flood hazard or flood damage to other properties or adversely affect flood behaviour for a 5% AEP up to the PMF scenario.  No hydraulic impact report is required if the proposed building is raised on piers allowing free flood flow for a 1% AEP flood event.	(4) Refer to Section 3. The modelling results show that in all modelled flood events the proposed development does not materially alter the local flood characteristics. Overall, the proposed flooding conditions are largely unchanged from the existing conditions, and the flood impacts of the development are considered to be acceptable.
2. Appropriate consulting engineers report for earthworks of volumes exceeding 250 cubic metres or with a length of more than 20 metres. The report is to prove that the earthworks will not increase flood hazard, flood damage or adversely affect other properties for a 5% AEP up to the PMF scenario.	(5) As discussed at (4).
<b>MANAGEMENT &amp; DESIGN</b>	
1. Applicant to demonstrate that there is an area where hazardous and valuable goods can be stored above the 1% AEP Flood Level;	(6) Not Applicable – no hazardous or valuable goods are proposed to be stored as part of the proposed development.
2. Bunding to the FPL to be installed around hazardous chemical storage areas or the like; and	(7) As discussed at (6).

## 6 Response to Council and BCD Flooding Comments

Council and the BCD have provided flood specific comments in their letters of 7 October 2022 and 8 December 2022 respectively, as summarised in Table 6. Table 6 provides responses to these flooding comments, and demonstrates that all the concerns raised have been effectively addressed.

**Table 6:** MA response to flood specific matters raised by Council and BCD.

Council / BCD Comments	MA Response
<b>Council Natural Resources &amp; Floodplain, 7 October 2022</b>	
<b>Proposed Filling in High Hazard Floodway Area</b>	
1. It has been proposed to construct livestock refuge mounds within each Lot on Pig Island using dried waste fines.	(1) The development only proposes stock refuge mounds in lots 2,3 and 4.
2. The Shoalhaven River and Pig Island comprises a High Hazard Floodway combined hazard and hydraulic category in the <i>Lower Shoalhaven River Floodplain Risk Management Study &amp; Plan (2011)</i> and the <i>Draft Lower Shoalhaven River Flood Study (2022)</i> which underwent public exhibition earlier this year.	(2) As discussed at Section 2, the MA hydrologic and hydraulic models have been updated to better match Council's latest 2022 flood study.

Council / BCD Comments	MA Response
<p>3. DCP Chapter G9: Development on Flood Prone Land, identifies that filling in High Hazard Floodway areas is not suitable for development (refer Acceptable Solutions in Schedule 2 and Performance Criteria P2 which requires that High Hazard Floodway areas are kept free of fill and/or obstructions).</p>	<p>(3) Although the proposed development does not strictly comply with the DCP with respect to fill within the High Hazard floodway, as discussed at Section 3, the hydraulic modelling demonstrates there are negligible offsite impacts and an overall net benefit arising from the proposed development. The proposed development therefore does not cause an obstruction to floodwater and is acceptable.</p>
<p>4. Therefore, the proposed filling on Pig Island is inconsistent with a merit-based assessment in accordance with DCP Chapter G9. As there are no exemptions from this performance criteria, constructions of stock refuge mounds in High Hazard Floodways, as proposed, are not supported by DCP Chapter G9.</p>	<p>(4) As discussed at (3).</p>
<p>5. The NSW Floodplain Development Manual (2005) identifies floodways as areas that even if only partially blocked would cause a significant increase in flood levels and/or significant redistribution of flood flow, which may in turn adversely affect others. Therefore, filling in High Hazard Floodway areas is inconsistent with the NSW Floodplain Development Manual (2005).</p>	<p>(5) As discussed at (3). There are no material adverse impacts as a result of the proposed development, and therefore compliance with the principles of the NSW Floodplain Development Manual are achieved.</p>
<p>6. Further to this Clause 5.21 (2)(a) of the Shoalhaven LEP 2014 identifies that "Development consent must not be granted to development on land the consent authority considers to be within the flood planning area unless the consent authority is satisfied the development is compatible with the flood function and behaviour on the land". As noted above filling of High Hazard Floodway areas is not compatible with the flood function and behaviour on the land at Pig Island.</p>	<p>(6) Refer to MA response (1) in Table 4.</p>
<p>7. No Flood Compliance Report as required by DCP Chapter G9 has been submitted to assess the proposed development against the acceptable solutions and performance criteria in DCP Chapter G9 and Clause 5.21 of SLEP 2014.</p>	<p>(7) This has been provided in Sections 4 and 5.</p>
<p>8. The submitted flood assessment has focused on completing a flood impact assessment to quantify the potential adverse flood impacts associated with the proposed filling. However as noted above filling within High Hazard Floodway areas is inconsistent with DCP Chapter G9 and the SLEP 2014.</p>	<p>(8) As discussed at (3) and in Sections 4 and 5.</p>
<p>9. The proposed stock refuge mounds on Pig Island should therefore be removed from the DA.</p>	<p>(9) As discussed at (3) and in Sections 4 and 5. MA have demonstrated that the proposed livestock mounds are compatible with the flood characteristics of the land and do not cause adverse offsite flood impacts, and therefore there is no need to remove them from the proposal.</p>

Council / BCD Comments	MA Response
<b>Flood Impacts</b>	
Regarding Council's requirements in relation to flood impacts, additional information is provided below for clarity.	
10. Council's Engineering Design Specification requires major structures to be designed for the 1% Annual Exceedance Probability (AEP) event without afflux (increased flood levels) in urban areas.	(10) As discussed at Section 3, the proposed development does not cause adverse offsite flood impacts in all modelled events up to and including the PMF.
11. The Flood Assessment – Supplementary Report (D22/420437) incorrectly notes that Council has no documented criteria for defining acceptable impacts and hence adopted a 20mm threshold based on previous NSW Land and Environment Court proceedings and Section 34 mediation conferences from other Local Government areas.	(11) As discussed at Section 3.
12. Council's Engineering Design Specification does not provide quantitative values for what constitutes no afflux. This is therefore typically taken as the precision of numerical flood models.	(12) As discussed at Section 3.
13. Section 8.5.1 "Impact Assessments" of the Australian Rainfall & Runoff Project 15 Two-Dimensional Modelling in Urban and Rural Floodplains (Engineers Australia, 2012) provides the following guidance regarding flood impact assessments.	(13) As discussed at Section 3.
14. "Typically, results are not reported to the nearest millimetre, and impacts less than 0.01m are not reported, as they are considered to be within the precision of the numerical model and data. However, the unrounded model results should be used to calculate the impact. Often, when the cumulative impact of development is considered, it is appropriate to report impacts less than 0.01m when considering the contribution to the cumulative impacts. It can be professionally irresponsible in some cases not to look at the cumulative impacts."	(14) As discussed at Section 3.
15. The Australian Rainfall & Runoff Revision Project reports were used to inform the development of the Australian Rainfall & Runoff – A Guide to Flood Estimation (2019) guidelines and used by the industry to define best practice guidance.	(15) As discussed at Section 3.

Council / BCD Comments	MA Response
<p>16. As such a +/- 10mm impact is the maximum allowable value to determine no afflux in urban areas. However, the guidance in Section 8.5.1 of the Australian Rainfall &amp; Runoff Project 15 Two-Dimensional Modelling in Urban and Rural Floodplains (Engineers Australia, 2012) document identifies that “when the cumulative impact of development is considered, it is appropriate to report impacts less than 0.01m when considering the contribution to the cumulative impacts”. The NSW Floodplain Development Manual (2005) requires the consideration of cumulative impacts on floodplains.</p>	<p>(16) As discussed at Section 3. Further, the proposed development results in a net benefit, and hence cumulative impacts to the floodplain will not arise as a result of the proposal.</p>
<p>17. Based on the above, additional information is required to demonstrate that no existing dwellings are impacted by more than +/- 10mm afflux during the 1% AEP event, as required by Council's Engineering Design Specifications.</p>	<p>(17) As discussed at Section 3. Although we disagree that 10 mm impact is the appropriate threshold, the proposed development has negligible offsite water level impacts in all modelled flood events up to and including the PMF using this threshold criterion. This has been achieved through the reduction of the proposed mound areas and volumes, as discussed at Section 2.3.</p>
<p>18. However, as the proposed stock refuge mounds are not permissible within a High Hazard Floodway, they should be removed from the development application and the flood impact assessment revised.</p>	<p>(18) As discussed at (9).</p>
<p>19. The proposed mounds are expected to be the key contributor to any potential adverse flood impacts (water level afflux and velocity increases). Therefore, when removed from the development application it is unlikely that there would be any unacceptable adverse flood impacts.</p>	<p>(19) As discussed at (9).</p>
<p><b>Bank Erosion / Scour Impacts upon Levee Banks and other Infrastructure</b></p>	
<p>20. The initial Flood Assessment (D21/203871) included flood level afflux mapping as a result of the increased dredging extent. The mapping provided indicated local, in-stream, flood level impacts only. The report did not include flood velocity afflux mapping.</p>	<p>(20) See Attachment A, Map FL03, Map FL05, Map FL07, Map FL09 &amp; Map FL11 for the full range of velocity afflux maps.</p>

Council / BCD Comments	MA Response
<p>21. The Flood Assessment – Supplementary Report, included flood level and flood velocity afflux mapping as requested by Council. However, the assessment was based on impacts from the proposed development, being the expansion of the dredging area and the construction of three stockpile mounds on Burrage Island (aka Pig Island). As a result, the flood velocity afflux mapping is for the combined impact from the proposed dredging and the stockpile mounds, and it cannot be determined how much impacts the proposed dredging may have on flood velocities in isolation.</p>	<p>(21) The proposed development includes both the expansion of the dredging area and the construction of three stockpile mounds, therefore showing afflux figures with both of these aspects of the proposed development is appropriate.</p>
<p>22. The 10% AEP flood event have been utilised to evaluate the effects of the proposed dredging (and the stockpile mounds) on exacerbated bank erosion. The combined flood velocity afflux indicates negligible impacts (&lt;0.1m/s) for the 10% AEP flood event along the southern bank of the Shoalhaven River and Burrage Island. Localised sections on the northern side of Shoalhaven River have a maximum flood velocity afflux of 0.25 m/s and the central-northern bank of Burrage Island have maximum water velocity afflux of 0.25 – 0.5 m/s. No velocity induced bank erosion is anticipated along the southern and northern Shoalhaven River banks or on the southern bank of Burrage Island. Furthermore, no flood velocity afflux is reported along the southern part of the Shoalhaven River in the vicinity of the Council's levee, except for the PMF event.</p>	<p>(22) MA Agrees with this assessment.</p>
<p>23. The geomorphology conclusions have been drawn based on flood level and velocity results for design event floods only and it is noted that shear stress and stream power are key hydraulic model outputs when assessing the potential impact of proposed instream works on geomorphology processes. Clarification is sought as to whether these hydraulic model outputs have been considered as part of the fluvial geomorphology assessment.</p>	<p>(23) The bed shear stress and stream power outputs from TUFLOW have been provided to the project geomorphologist for comment.</p>
<p><b>Biodiversity and Conservation, Department of Planning, Industry and Environment, 8 December 2022</b></p>	
<p>1. Based on our review of the Supplementary Flood Assessment letter, we remain concerned over floodplain risk management issues. Specifically, the proposal to place livestock refuge mounds within the high hazard floodway area on Burrage Island (aka Pig Island) is inconsistent with the NSW Floodplain Development Manual (2005), Council's DCP as well as Clause 5.21 (2) of the LEP and there is no supporting information to establish consistency with current controls.</p>	<p>(24) As discussed at (3) and in Sections 4 and 5.</p>

Council / BCD Comments	MA Response
2. It is demonstrated in the supplementary assessment provided by the proponent that any development including the proposed stock mound fill would not be compatible with the flood function and behaviour at that location.	(25) As discussed at (3) and in Sections 4 and 5.
3. The proposal to place the fill in a floodway for the purpose of refuge poses safety concerns as it presents a risk to life for both people and stock that can otherwise be avoided.	(26) The proposal does not introduce additional stock or people to Pig Island as part of the application, and therefore there is no increase in flood risk. Rather, the livestock mounds represent a significant reduction of flood risk to the existing stock on the island, which currently have insufficient refuge in a flood event.
4. It remains unclear how emergency management evacuation requirements have been assessed as any people or stock on the island need to evacuate at the early stages of a Shoalhaven River flood rather than encouraged to seek refuge on filled low flood island areas until evacuation is no longer safely possible and the fill is overwhelmed by fast flowing floodwater.	(27) As discussed at (26).
5. We note that council's floodplain team has provided a comprehensive assessment of the flood risks and bank erosion impacts of this proposal to which we fully concur and support.	(28) As discussed at (1) – (23).

## 7 Summary

Our assessment indicates that:

1. The proposed increased sand extraction area and livestock fill mounds will not adversely affect local flood conditions.
2. The proposed development has acceptable offsite impacts in all modelled flood events.
3. The proposed development has a net benefit on the local floodplain environment with respect to flood levels, and therefore there will be no cumulative impacts.
4. Compliance with Council flood planning requirements in the LEP and DCP are achieved.
5. The flood specific matters raised by Council and the BCD have been appropriately addressed by this response.



Please contact our offices if you have any further queries regarding this matter.

**For and on behalf of**

**MARTENS & ASSOCIATES PTY LTD**

A handwritten signature in grey ink, appearing to read 'D. Dhiacou'.

**DANIEL DHIACOU**

BEng (Hons1), DipEngPrac

Principal Civil Engineer / Flooding Lead



## Attachment A – Flood Assessment MapSet



0 100 200 300 400 500 m

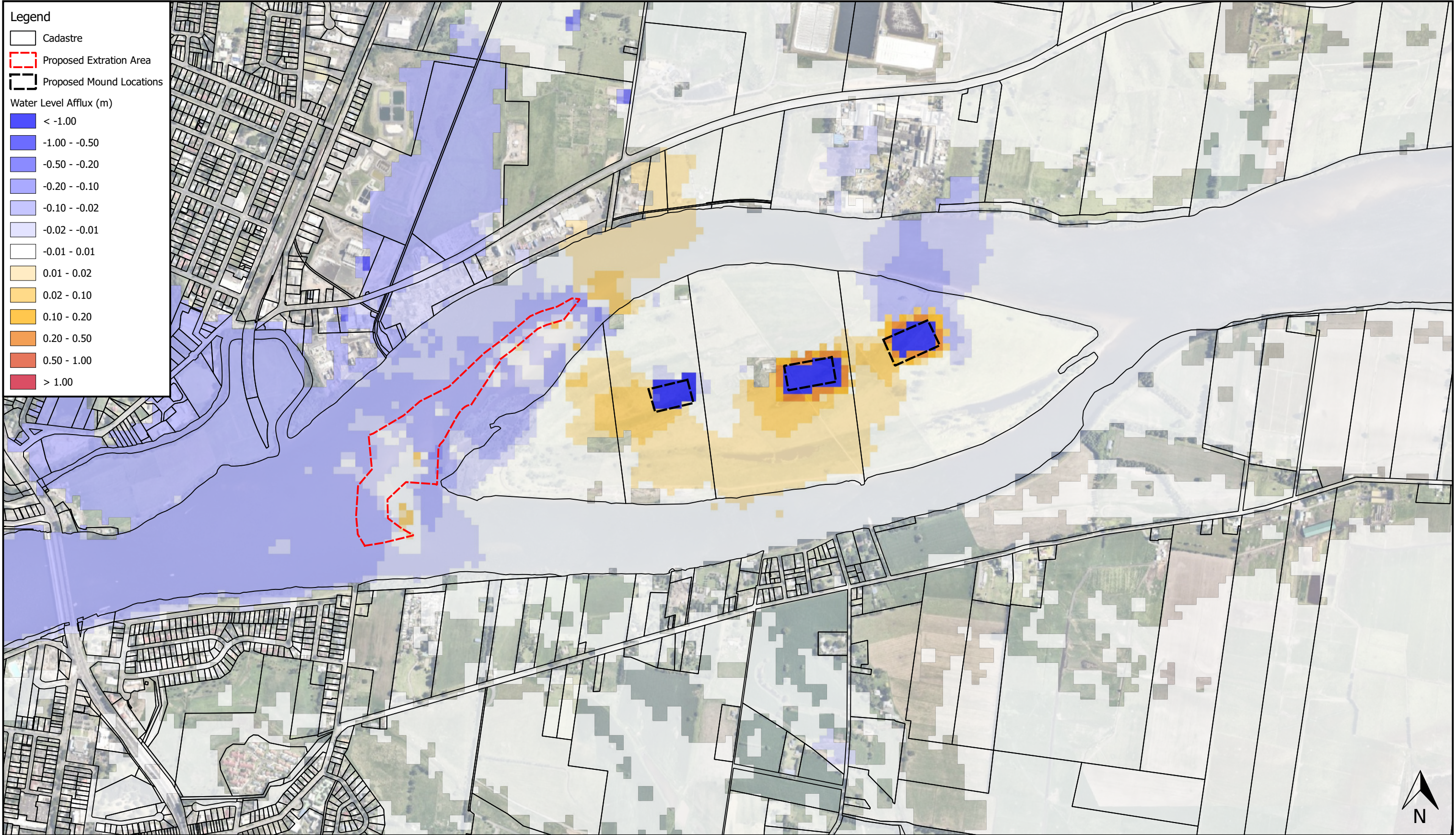
1:12500 @ A3

Viewport A

Notes:  
- Aerial from Nearmaps (2023)  
- Cadastre from NSW DFSI Clip and Ship (2023)

Map Title / Figure:  
**Validation Points**

FL01	Map
Pig Island, Terara, NSW	Site
Expansion of Sand Extraction	Project
Flood Assessment	Sub-Project
Terara Shoalhaven Sand	Client
27/02/2023	Date



0 100 200 300 400 500 m

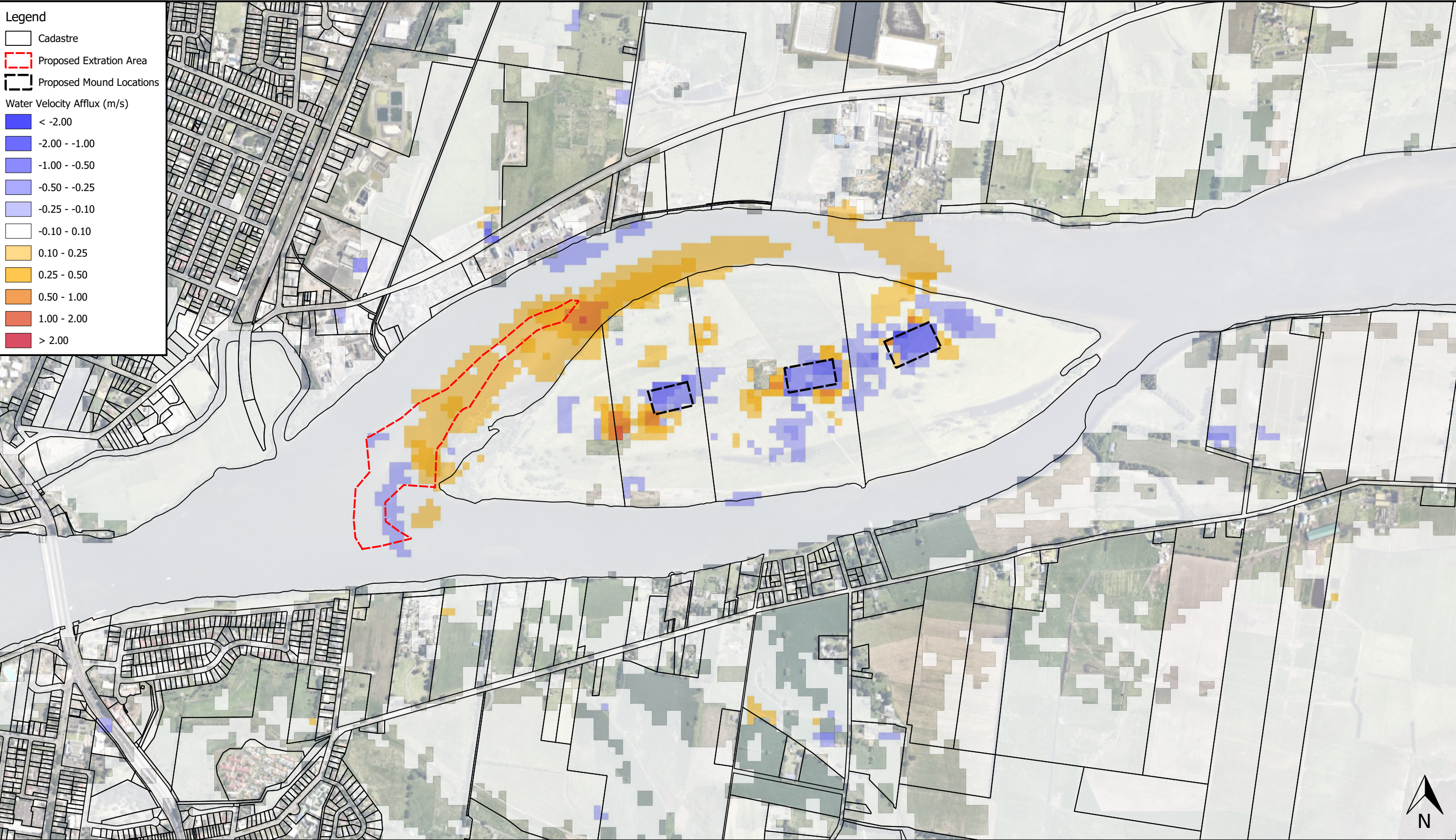
1:12500 @ A3

Viewport A

Notes:  
- Aerial from Nearmaps (2023)  
- Cadastre from NSW DFSI Clip and Ship (2023)  
- Areas coloured blue represent water level decrease. Areas coloured white represent negligible change. Areas coloured yellow / red represent water level increase.

Map Title / Figure:  
**10% AEP Critical Duration Storm - Proposed Condition  
Water Level Afflux**

FL02	Map
Pig Island, Terara, NSW	Site
Expansion of Sand Extraction	Project
Flood Assessment	Sub-Project
Terara Shoalhaven Sand	Client
27/02/2023	Date



**Legend**

— Cadastre

--- Proposed Extration Area

--- Proposed Mound Locations

**Water Velocity Afflux (m/s)**

Blue	< -2.00
Dark Blue	-2.00 - -1.00
Medium Blue	-1.00 - -0.50
Light Blue	-0.50 - -0.25
Very Light Blue	-0.25 - -0.10
White	-0.10 - 0.10
Yellow	0.10 - 0.25
Orange	0.25 - 0.50
Dark Orange	0.50 - 1.00
Red	1.00 - 2.00
Dark Red	> 2.00

0 100 200 300 400 500 m

1:12500 @ A3

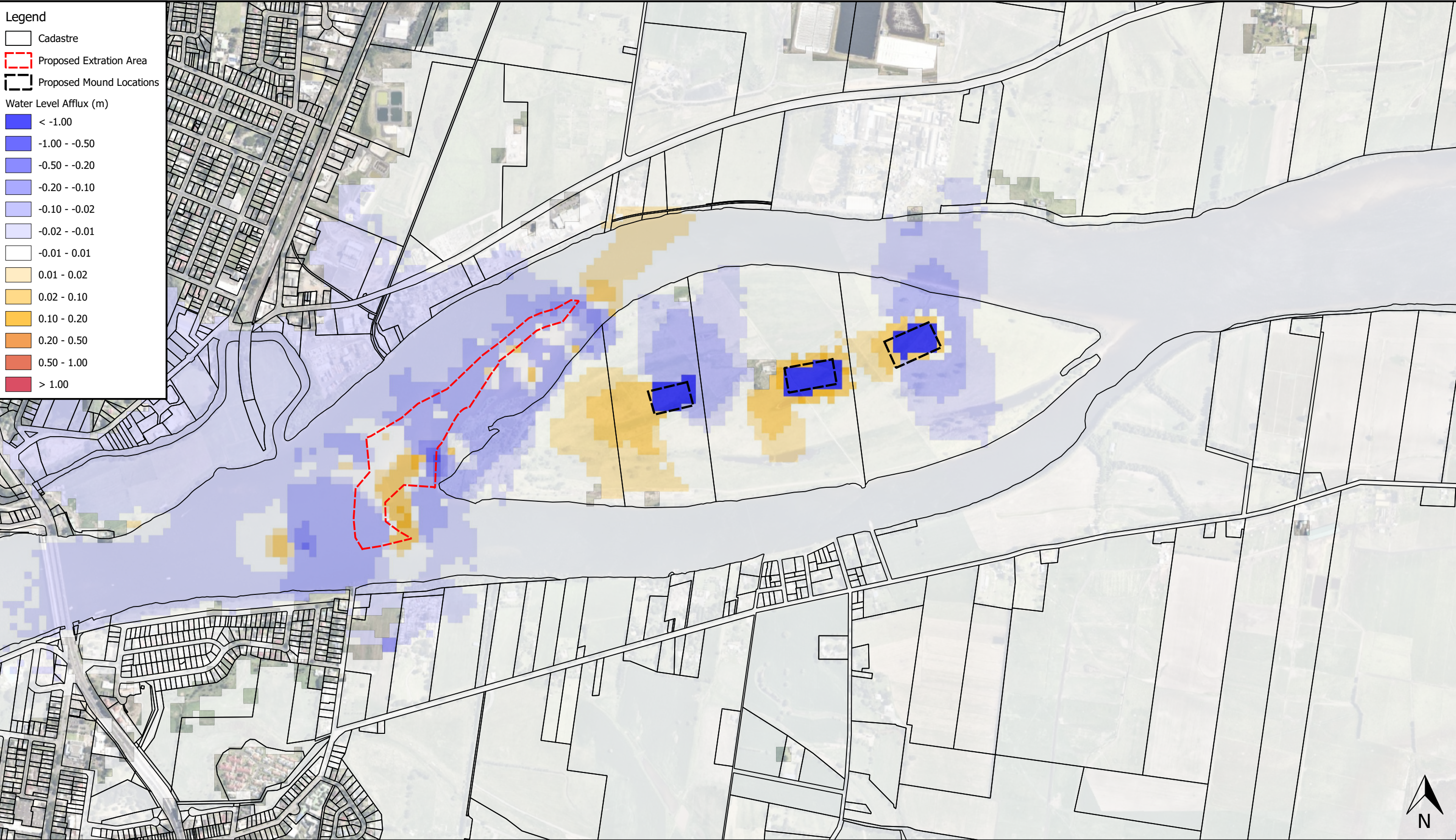
Viewport A

Notes:

- Aerial from Nearmaps (2023)
- Cadastre from NSW DFSI Clip and Ship (2023)
- Areas coloured blue represent water velocity decrease. Areas coloured white represent negligible change. Areas coloured yellow / red represent water velocity increase.

Map Title / Figure:  
**10% AEP Critical Duration Storm - Proposed Condition  
Water Velocity Afflux**

FL03	Map
Pig Island, Terara, NSW	Site
Expansion of Sand Extraction	Project
Flood Assessment	Sub-Project
Terara Shoalhaven Sand	Client
27/02/2023	Date



**Legend**

Cadastre

Proposed Extration Area

Proposed Mound Locations

Water Level Afflux (m)

- < -1.00
- 1.00 - -0.50
- 0.50 - -0.20
- 0.20 - -0.10
- 0.10 - -0.02
- 0.02 - -0.01
- 0.01 - 0.01
- 0.01 - 0.02
- 0.02 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- > 1.00

0 100 200 300 400 500 m

1:12500 @ A3

Viewport A

Notes:

- Aerial from Nearmaps (2023)
- Cadastre from NSW DFSI Clip and Ship (2023)
- Areas coloured blue represent water level decrease. Areas coloured white represent negligible change. Areas coloured yellow / red represent water level increase.

Map Title / Figure:  
**1% AEP Critical Duration Storm - Proposed Condition  
Water Level Afflux**

FL04	Map
Pig Island, Terara, NSW	Site
Expansion of Sand Extraction	Project
Flood Assessment	Sub-Project
Terara Shoalhaven Sand	Client
27/02/2023	Date



**Legend**

Cadastre

Proposed Extration Area

Proposed Mound Locations

Water Velocity Afflux (m/s)

- < -2.00
- 2.00 - -1.00
- 1.00 - -0.50
- 0.50 - -0.25
- 0.25 - -0.10
- 0.10 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00

0 100 200 300 400 500 m

1:12500 @ A3

Viewport A

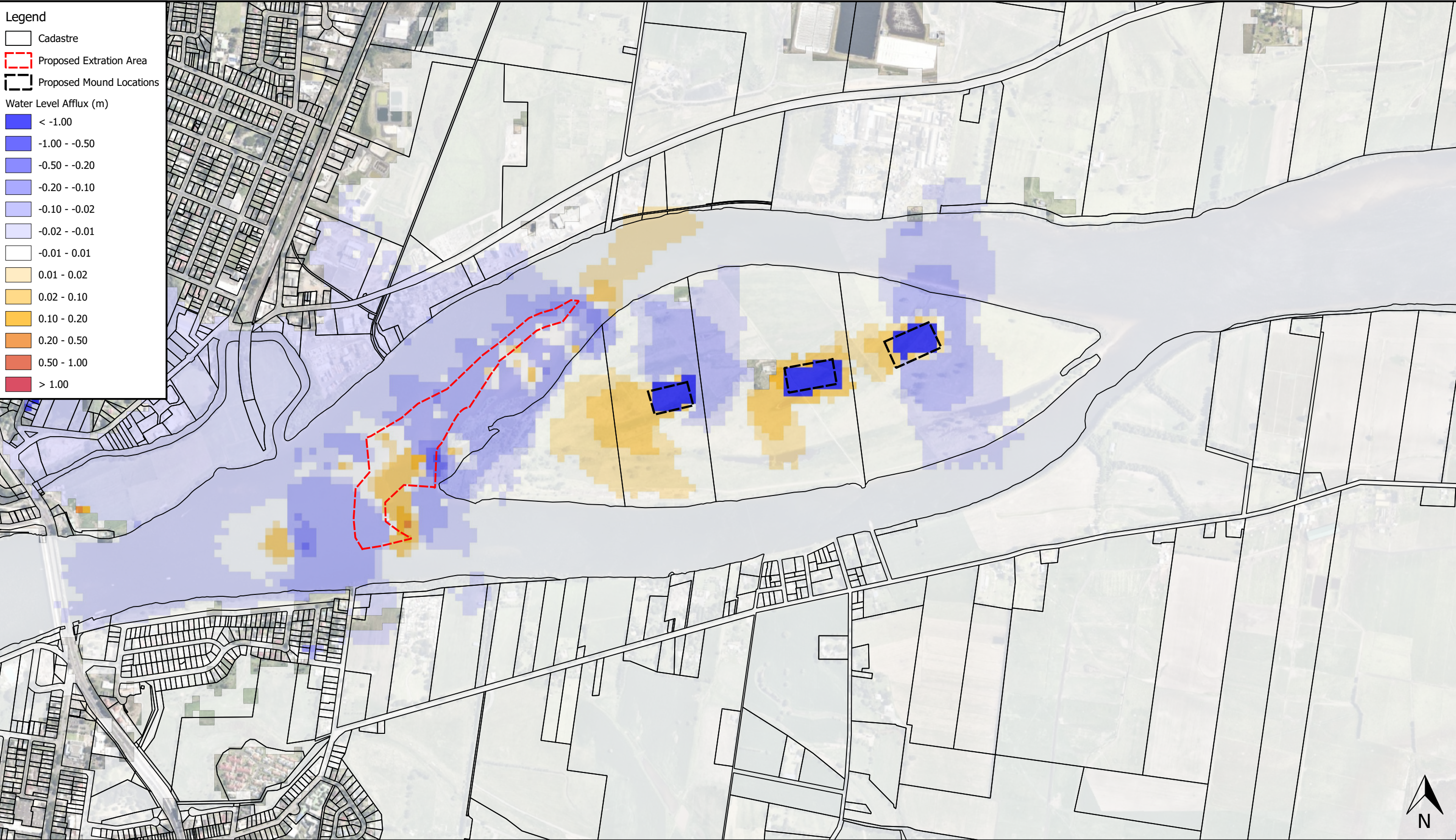
Notes:

- Aerial from Nearmaps (2023)
- Cadastre from NSW DFSI Clip and Ship (2023)
- Areas coloured blue represent water velocity decrease. Areas coloured white represent negligible change. Areas coloured yellow / red represent water velocity increase.

Map Title / Figure:

# 1% AEP Critical Duration Storm - Proposed Condition Water Velocity Afflux

FL05	Map
Pig Island, Terara, NSW	Site
Expansion of Sand Extraction	Project
Flood Assessment	Sub-Project
Terara Shoalhaven Sand	Client
27/02/2023	Date



**Legend**

Cadastre

Proposed Extration Area

Proposed Mound Locations

Water Level Afflux (m)

- < -1.00
- 1.00 - -0.50
- 0.50 - -0.20
- 0.20 - -0.10
- 0.10 - -0.02
- 0.02 - -0.01
- 0.01 - 0.01
- 0.01 - 0.02
- 0.02 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- > 1.00

0 100 200 300 400 500 m

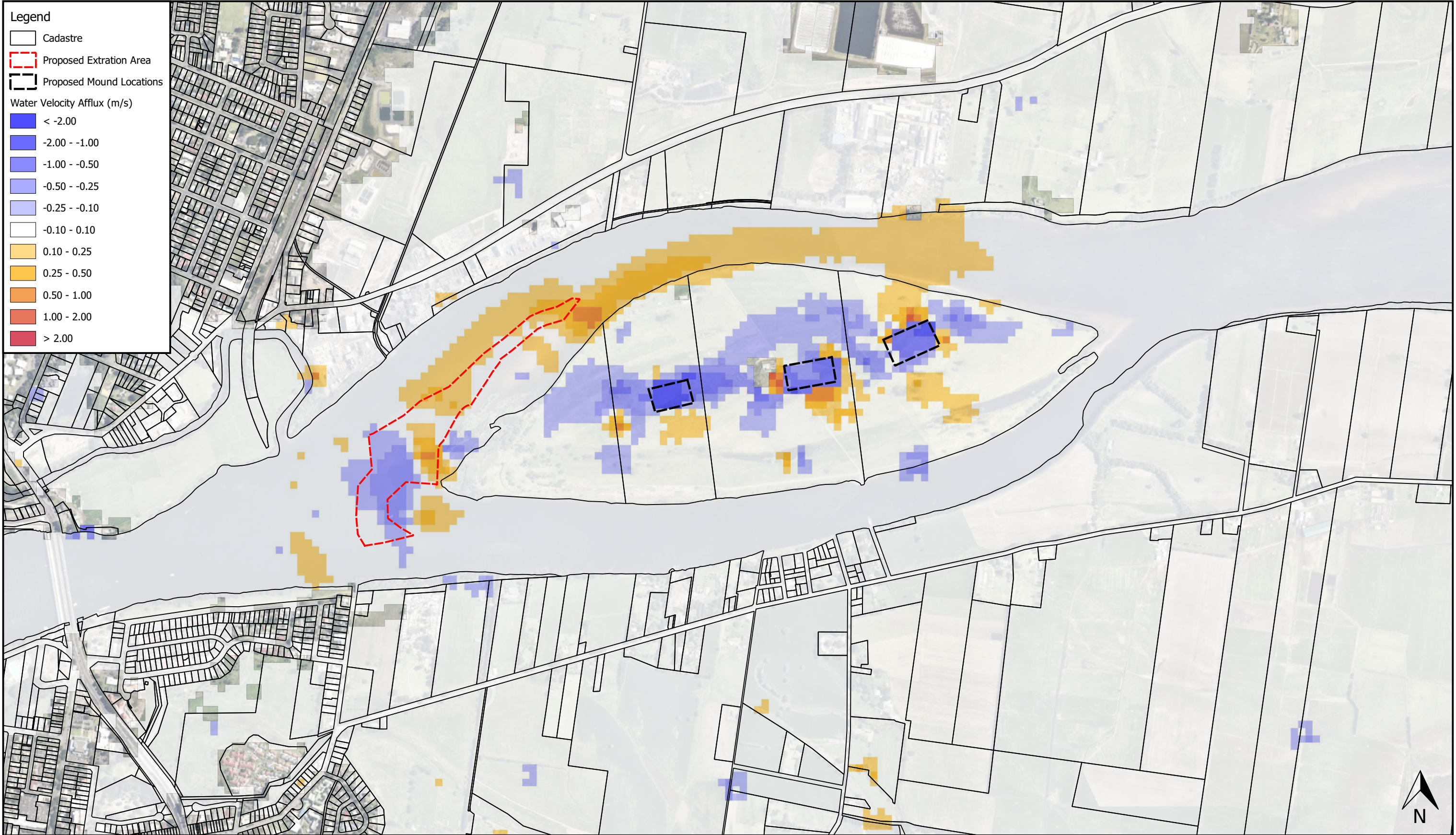
1:12500 @ A3

Viewport A

Notes:

- Aerial from Nearmaps (2023)
- Cadastre from NSW DFSI Clip and Ship (2023)
- Areas coloured blue represent water level decrease. Areas coloured white represent negligible change. Areas coloured yellow / red represent water level increase.

0.5% AEP Critical Duration Storm - Proposed Condition  
Water Level Afflux



**Legend**

Cadastre

Proposed Extration Area

Proposed Mound Locations

Water Velocity Afflux (m/s)

- < -2.00
- 2.00 - -1.00
- 1.00 - -0.50
- 0.50 - -0.25
- 0.25 - -0.10
- 0.10 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00

0 100 200 300 400 500 m

1:12500 @ A3

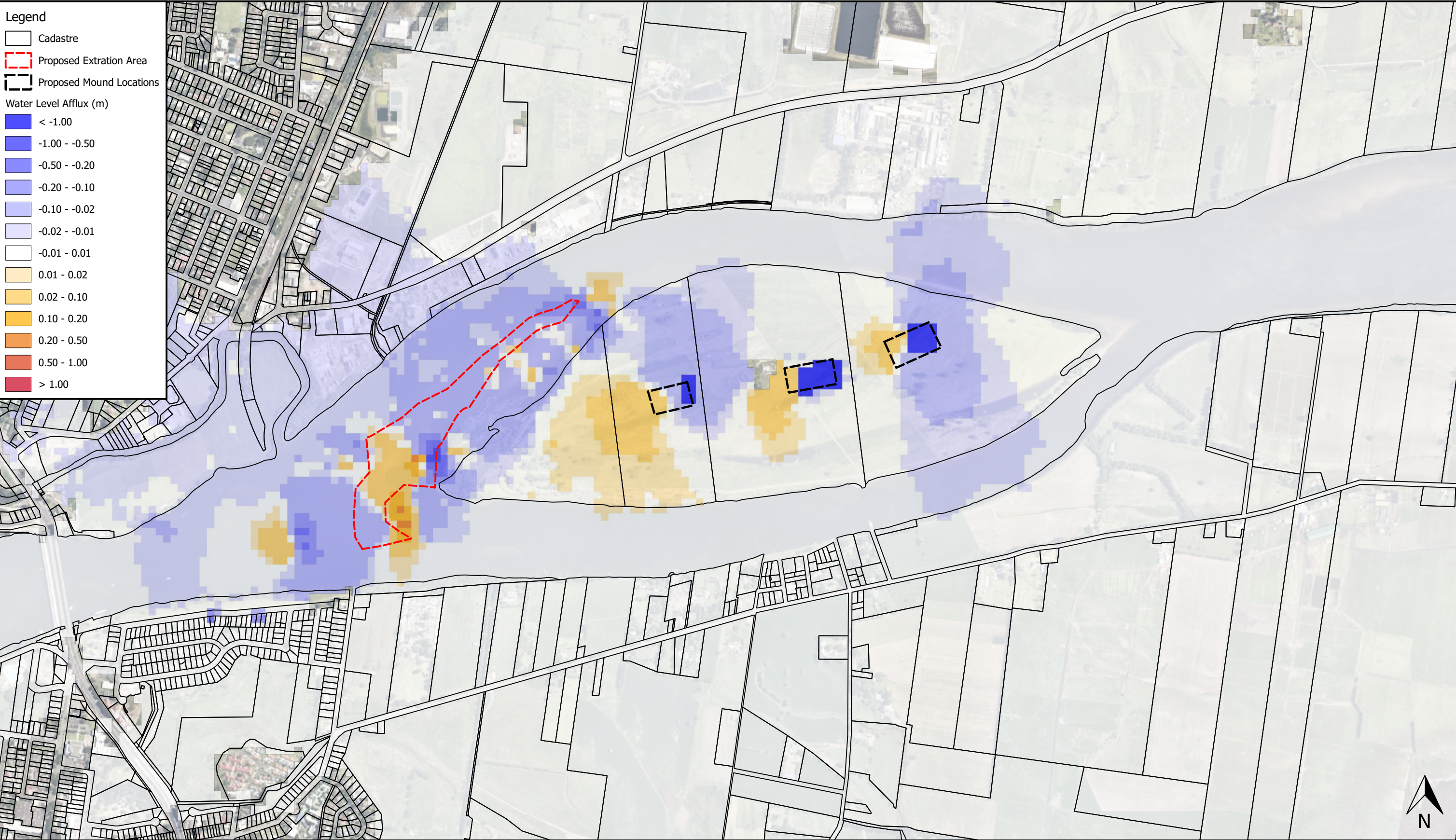
Viewport A

Notes:

- Aerial from Nearmaps (2023)
- Cadastre from NSW DFSI Clip and Ship (2023)
- Areas coloured blue represent water velocity decrease. Areas coloured white represent negligible change. Areas coloured yellow / red represent water velocity increase.

0.5% AEP Critical Duration Storm - Proposed Condition  
Water Velocity Afflux

FL07	Map
Pig Island, Terara, NSW	Site
Expansion of Sand Extraction	Project
Flood Assessment	Sub-Project
Terara Shoalhaven Sand	Client
27/02/2023	Date



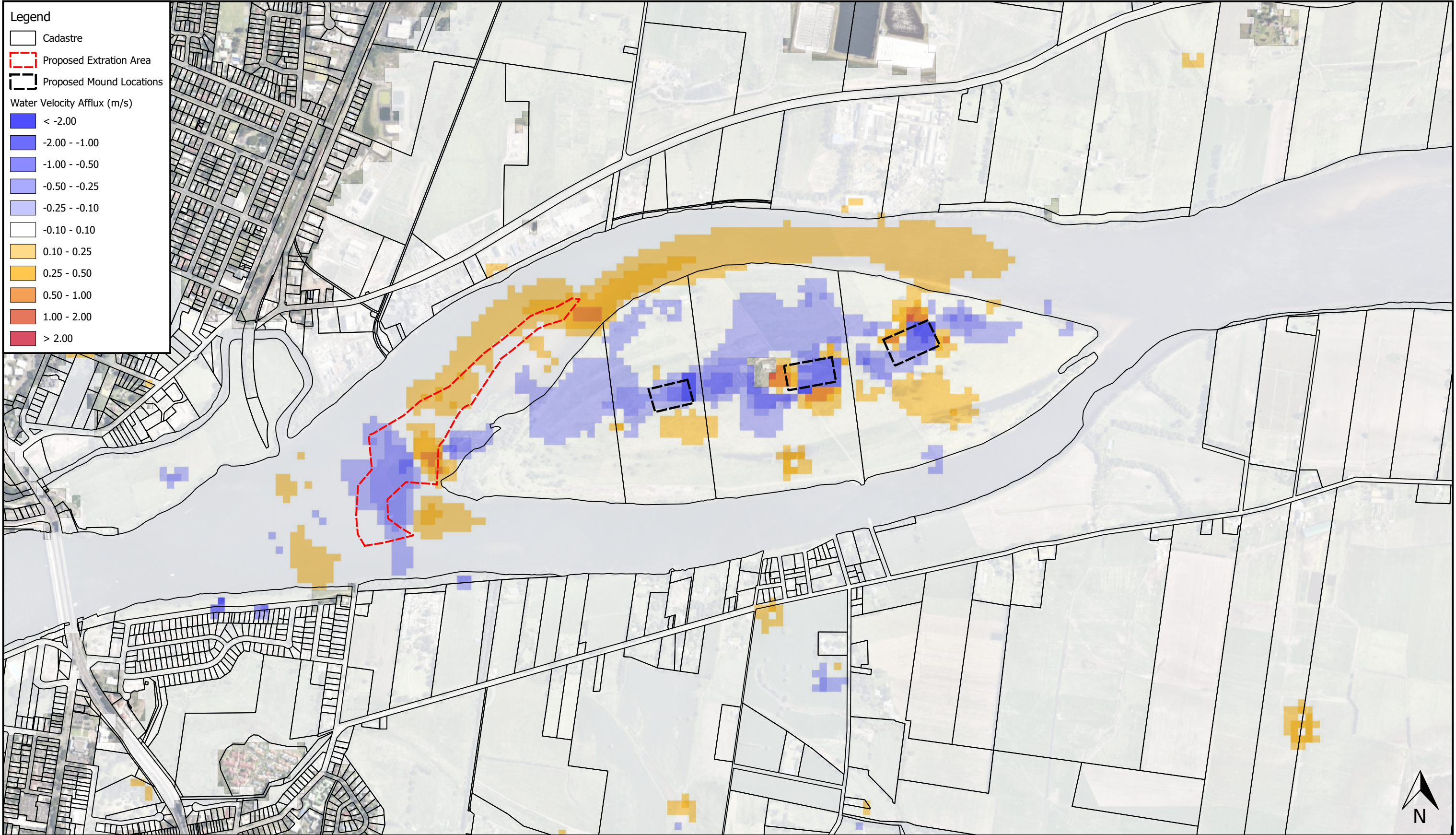
0 100 200 300 400 500 m

1:12500 @ A3

Viewport A

Notes:  
- Aerial from Nearmaps (2023)  
- Cadastre from NSW DFSI Clip and Ship (2023)  
- Areas coloured blue represent water level decrease. Areas coloured white represent negligible change. Areas coloured yellow / red represent water level increase.

0.2% AEP Critical Duration Storm - Proposed Condition  
Water Level Afflux



**Legend**

Cadastral

Proposed Extration Area

Proposed Mound Locations

Water Velocity Afflux (m/s)

- < -2.00
- 2.00 - -1.00
- 1.00 - -0.50
- 0.50 - -0.25
- 0.25 - -0.10
- 0.10 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00

0 100 200 300 400 500 m

1:12500 @ A3

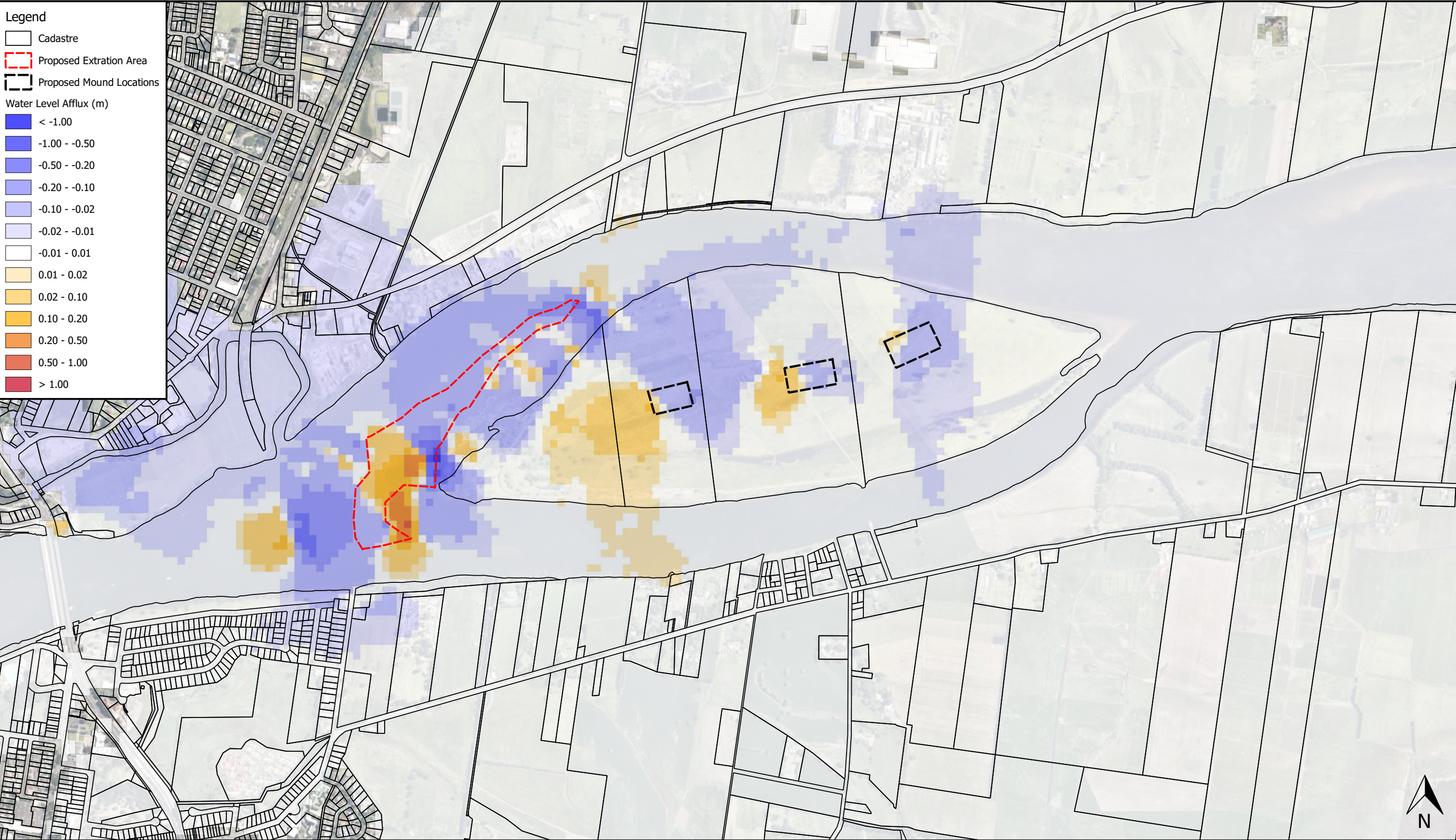
Viewport A

Notes:

- Aerial from Nearmaps (2023)
- Cadastral from NSW DFSI Clip and Ship (2023)
- Areas coloured blue represent water velocity decrease. Areas coloured white represent negligible change. Areas coloured yellow / red represent water velocity increase.

Map Title / Figure:  
**0.2% AEP Critical Duration Storm - Proposed Condition  
Water Velocity Afflux**

FL09	Map
Pig Island, Terara, NSW	Site
Expansion of Sand Extraction	Project
Flood Assessment	Sub-Project
Terara Shoalhaven Sand	Client
27/02/2023	Date



0 100 200 300 400 500 m

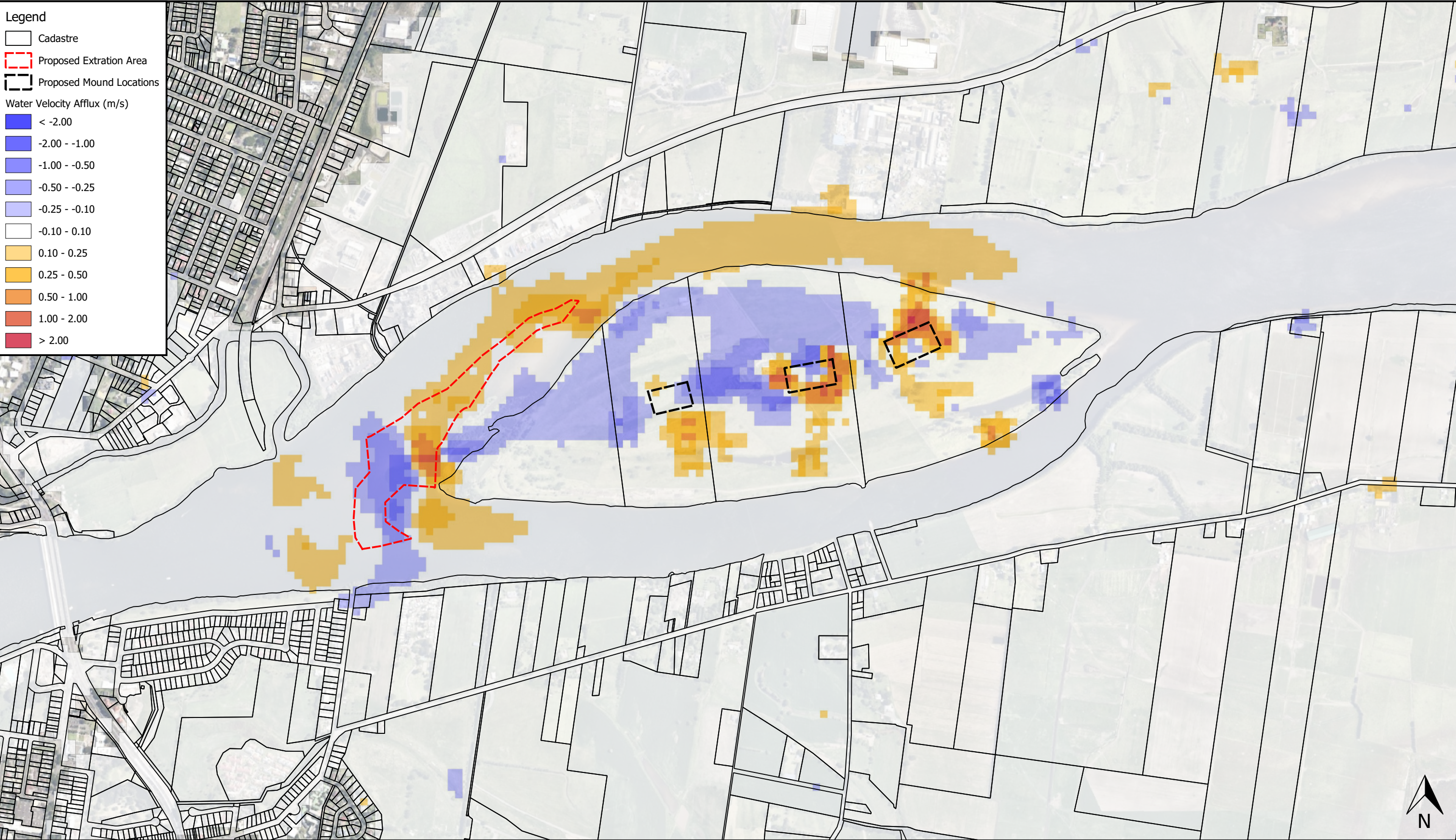
1:12500 @ A3

Viewport A

Notes:  
- Aerial from Nearmaps (2023)  
- Cadastre from NSW DFSI Clip and Ship (2023)  
- Areas coloured blue represent water level decrease. Areas coloured white represent negligible change. Areas coloured yellow / red represent water level increase.

Map Title / Figure:  
**PMF Critical Duration Storm - Proposed Condition  
Water Level Afflux**

FL10	Map
Pig Island, Terara, NSW	Site
Expansion of Sand Extraction	Project
Flood Assessment	Sub-Project
Terara Shoalhaven Sand	Client
27/02/2023	Date



0 100 200 300 400 500 m

1:12500 @ A3

Viewport A

Notes:  
- Aerial from Nearmaps (2023)  
- Cadastre from NSW DFSI Clip and Ship (2023)  
- Areas coloured blue represent water velocity decrease. Areas coloured white represent negligible change. Areas coloured yellow / red represent water velocity increase.

Map Title / Figure:  
**PMF Critical Duration Storm - Proposed Condition  
Water Velocity Afflux**

FL11	Map
Pig Island, Terara, NSW	Site
Expansion of Sand Extraction	Project
Flood Assessment	Sub-Project
Terara Shoalhaven Sand	Client
27/02/2023	Date