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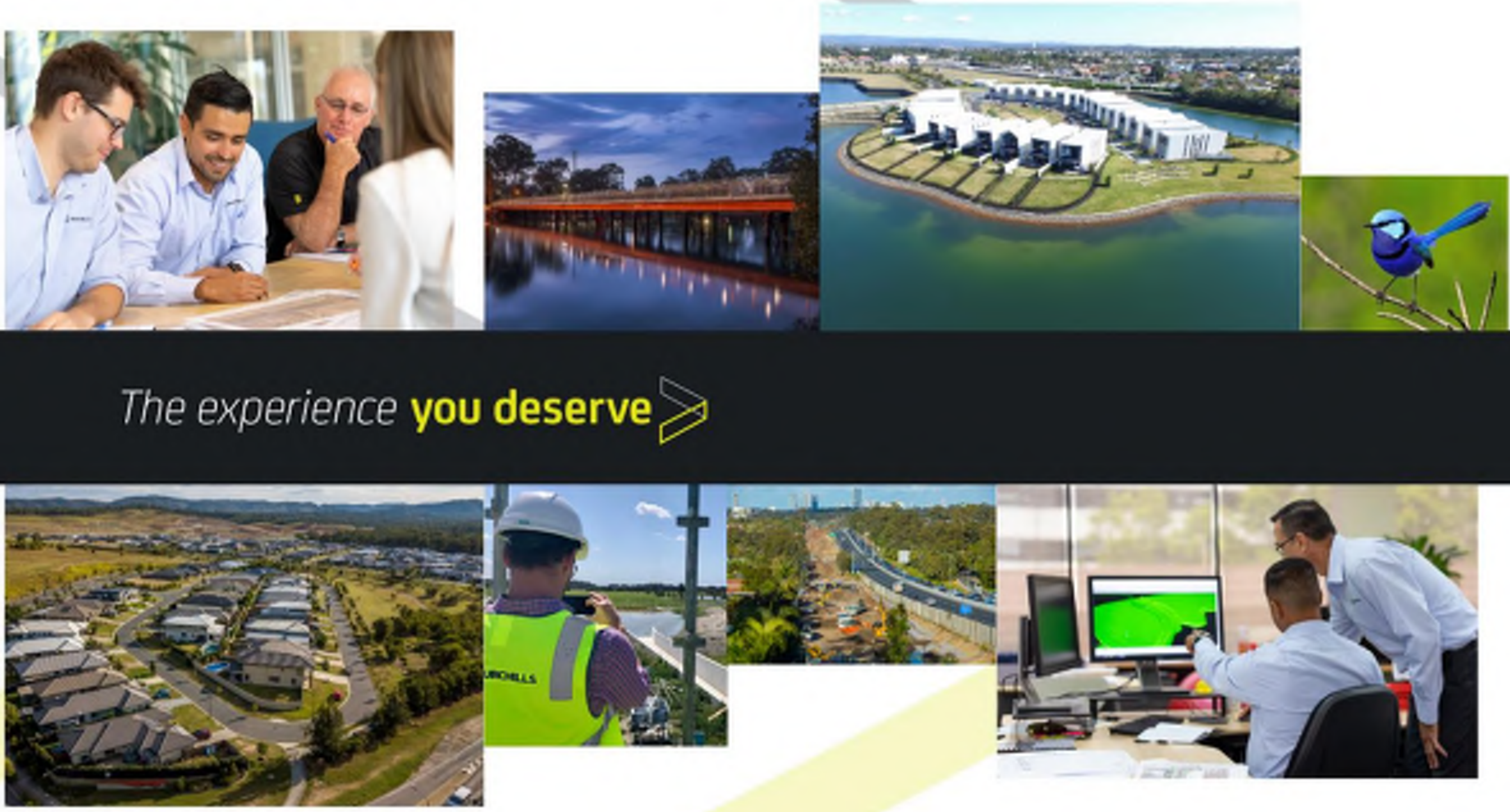

Tweed Sand Plant

Flood & Stormwater Assessment

Client: Hanson Construction Materials
Project No: BE190043
Document No: BE190043-RP-FSA-04
October 2021

Document Control Record

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Version No.	Description	Date	Prepared	Approved
00	Draft Submission	16/10/2020	SH	JC
01	Internal Submission	19/02/2021	SH	JC
02	EIS Submission	22/02/2021	SH	JC
03	Response to EIS Submission - Internal Review	19/10/2021	SH	JC
04	Response to EIS Submission	26/10/2021	SH	JC

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Executive Summary

Burchills Engineering Solutions have been engaged by Hanson Construction Materials Pty Ltd to prepare a Flood & Stormwater Assessment (FSA) for Hanson's Tweed Sand Plant which is located on Altona Road in Cudgen, NSW. The proposed development intends to expand the sand extraction area and increase operations from 500,000 tonnes/year to 950,000 tonnes/year over a period of 30 years.

In accordance with the requirements set out in the Planning Secretary's Environmental Assessment Requirements (SEARs) specific to this project, a scope was developed to assess the development's impact on stormwater and flooding. Version 02 of this report was submitted as part of the EIS and this version of the report address issues raised under the EIS submission. The assessment has focused on the local runoff from the subject site and its external catchments as well as the regional flooding at the site caused by the Tweed River.

The proposed expansion of the Sand Plant, including the proposed haulage route, introduces a significant change to the existing floodplain whereby agricultural land is converted into a pair of large, deep lakes. The hydraulic impacts caused by the development can be summarised as follows:

Changes in Peak Flood Level

This study has defined the allowable impacts on the surrounding land uses and has quantified the change to flooding as a result of the development. The changes to the flood behaviour for both the local and regional floods are generally within the acceptable limits as defined by this study. There are however some hydraulic impacts that are marginally outside of the allowable impact thresholds located in the Chinderah Township. These impacts however are short lived (occurring for only a three-year period during Phase 7), and as the Lakes take their ultimate form (Phase 11) become acceptable. Increases in peak flood level are primarily caused by a loss of floodplain storage.

Cumulative Development Scenario

The development has been assessed against the Tweed Shire Council's cumulative development scenario that was defined by BMT WBM in the 'Tweed Valley Floodplain Risk Management Study' (2014). It was found that with the introduction of the proposed Sand Plant expansion maintains the outcomes of the Management Study and is within the acceptable afflux range.

Changes In Peak Discharge at Critical Infrastructure

Two M1 culvert crossing have been assessed as part of this study, they are defined as the subject sites Legal Point of Discharge. As a result of the development there are no significant changes to peak flow at these culverts.

Changes in Inundation Time

Surrounding the proposed lakes are a number of existing agricultural landuses. Changes in inundation time will occur to a pair of properties located between the M1 and Tweed Valley Way, properties in this area will experience a nominal increase in time of inundation. Elsewhere, inundation time remain generally the same as the pre-existing condition.

Based on the finding of this study it is not anticipated that the future Hanson Sand Plant Expansion will give rise to actionable damage or nuisance flooding.

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1. Introduction

1.1 Background

Burchills Engineering Solutions have been engaged by Hanson Construction Materials Pty Ltd to prepare a Flood & Stormwater Assessment (FSA) for Hanson's Tweed Sand Plant which is located on Altona Road in Cudgen, NSW. The proposed development intends to expand the sand extraction area and increase operations from 500,000 tonnes/year to 950,000 tonnes/year over a 30 year period.

The assessment has been commissioned to satisfy the provisions of the Tweed Local Environmental Plan and State Planning requirements with respect to the potential impact on local stormwater conditions and regional flood behaviour caused by the proposed expansion. Prior to the preparation of the FSA a scoping exercise was conducted with State and Local Authorities to define the required assessment level for the application.

This assessment will form part of an Environmental Impact Statement to be issued to the NSW state Government for assessment.

1.2 Objectives

The objectives of this assessment have been developed through consultation with local and state authorities, as outlined in the Planning Secretary's Environmental Assessment Requirements (SEARs) for state significant development. The following broad objectives relating to Flood and Stormwater have been identified as key to the assessment of this project:

- Determine the characteristics of local hydrology and detail any changes as a result of the development;
- Detail stormwater management measurements for the development across the life of the expansion;
- Determine the impacts on the flood regime caused by the development across the life of the expansion;
- Determine the developments impact on flood storage balance;
- Address the provisions of the NSW Floodplain Development Manual; and
- Address the provisions in the Tweed Valley Floodplain Risk Management Strategy.

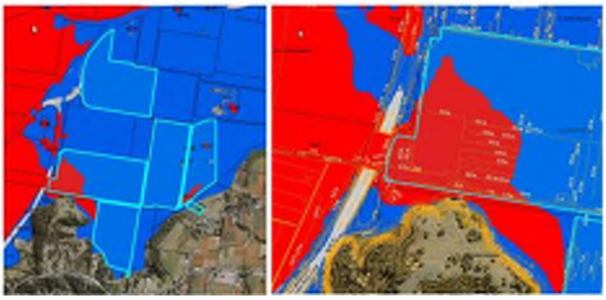
1.3 Scope

To comply with the objectives defined by the SEARs response the following scope has been developed:

- Review the subject site and determine the existing local hydrologic/hydraulic conditions for the local and regional system;
- Assess the proposed plant expansion and determine changes to the hydrologic regime;
- Outline 'high-level' stormwater management measures for future development hydraulics of the plant; and
- Develop a two-dimensional hydraulic model to assess the changes in regional flood behaviour across the study area as a result of the plant expansion.

1.3.1 Endorsed Tweed Shire Council Comments June 2021

In addition to the above-mentioned scope the following items were raised by Tweed Shire Council with respect to stormwater and flooding on the subject site (Council Reference: DA21/0233 LN 41917). A table has been prepared that summarises Burchills' response to the items raised by Tweed Shire Council.

Information Request	Request Response
1. Flooding	
1.1 High Flow Areas The majority of the site is classified as 'low flow' area. The exception to this is a small area in the south-west corner around the Pacific Motorway culvert/bridge (shown in red in Figure 1 below). In this area existing ground levels are as low as RL 0.5m AHD.  **Figure 1 – Low flow (blue) / High flow (red)** The proponent's FSA suggests that the proposed lake is to be bunded to RL 1.3m AHD. This will result in a bund approximately 0.8m high being placed directly downstream of the highway culverts. It should be noted this is a flow path of critical importance. It is the primary access to the wider Chinderah/Kingscliff flood storage. Any obstruction to flow here is likely to have significant impacts upstream. The proponent's flood impact assessment does not include the bunding of 'Lake 2' to RL 1.3m AHD. The FSA states that: *The proposed bunding at RL 1.3 m AHD has NOT been included as it is considered negligible due to its low level compared to the overall flood levels experienced at the site.* Council does not agree with the above statement. Whilst this may be valid for some areas of the	 The lake bunding configuration has been amended following a review of flood results with bunding at RL 1.3 m AHD. It is now proposed to set the lake bunding for 'Lake 2' (the southern lake) to RL 1.0 m AHD, this has been reflected in the modelling. Refer to Section 5.2 for more information. Lake Bunding at RL 1.0 m AHD has been selected because it best represents the existing ground level in the area of the lakes. No bunding is proposed for 'Lake 1' (the northern lake), Lake 1 will overtop at RL 0.5 m AHD toward the LPD.

proposed lake expansion (where existing topography is already around RL 1.3m AHD) it is not true of the critical high flow area adjacent to the Pacific Motorway culvert/bridge. An 800mm high bund in this area is likely to pose a significant barrier to flood waters entering the Chinderah/Kingscliff storage area and therefore have significant afflux upstream. It should be noted that DCP-A3 only permits changes to ground levels up to 300mm in high flow areas (for local drainage purposes). In this case, given the critical nature of the flow path, 300mm would not be automatically considered permissible and this would be subject to detailed flood modelling (with bunding included). Any significant bunding in this area is contrary to DCP-A3 and unlikely to be supported. This is a significant constraint for the proposal that has not been addressed and may have substantial implications as the ability to bund the lake to RL 1.3m AHD may not be possible. Refer to request for further information below (Item 8.1).	
1.2 Emergency Response Provisions The proposal does not include any habitable land uses. Therefore the Emergency Response Provisions (evacuation) of DCP-A3 do not apply. Nevertheless, the SEARs included similar assessment requirements and the proponent has adopted DCP-A3's framework and submitted a Flood Response Assessment Plan (FRAP). The FRAP identifies an evacuation approach to risk management, which is considered appropriate. It goes on to identify various flood action plan type measures, which is beyond the intended scope of a FRAP. The FRAP is noted.	No Response required.
1.3 Time of Inundation The FSA does not include any analysis of any changes in the time of inundation due to the proposal. This is particularly relevant to nearby agriculture and development/environmental areas. Prolonged inundation can kill crops, increase nuisance and change environmental values. The proposal will have significant changes to the low-flow drainage regime of the area and therefore may effect time of inundation of surrounding floodplain areas. Refer to request for further information below (Item 8.1).	Discussion on Time of Inundation has been included in Section 4.3.2 and 6.1.4 In summary, there are no significant times of inundation as a result of the development.

1.4 Reduction in Peak Flood Levels for Minor Events The FSA reports modelling results that predict: *For events lower than the 1% AEP, the development improves flooding in the area due to a large gain in flood storage.* Whilst the starting water level (at beginning of regional flood modelling event) for each model run is not explicitly stated in the FSA, section 4.7 suggests that the consultant may have adopted the dry weather standing (ground) water level. *Flood storage calculations taken from the DFL (3.23 m AHD) to the standing water level at site (0.3 m AHD).* The 2 x lakes are proposed to be bunded with overflow weirs at RL 1.0m AHD. Flooding in the Tweed Valley generally follows multiple days of heavy rain. A few hundred millimetres of rain falling over these bunded lakes in the lead up to a flood event would significantly reduce the 'large gain in flood storage'. These antecedent conditions are generally not included in flood model design event runs. Therefore, depending on the assumptions input to the model, the predicted improvements in flooding for events lower than 1% AEP may be invalid. The starting water levels and/or antecedent condition assumptions used for the flood assessment should be clarified to verify the validity of these predictions. Refer to request for further information below (Item 8.1).	The Assessment has adopted a lake full scenario for all hydraulic assessment, i.e. Lake Water levels are set as follows: • Lake 1 – 0.5 m AHD; and • Lake 2 – 1.0 m AHD.
1.5 Cumulative Development Scenario The proponent was advised at a pre-lodgement meeting with Council that "…the development must be assessed on an individual and cumulative development basis, consistent with the Tweed Valley Flood Study and Tweed Valley Floodplain Risk Management Study and Plan". They were also advised that "…Given other significant floodplain developments in the West	The allowable cumulative development scenario described in the Tweed Valley Flood Study and Tweed Valley Floodplain Risk Management Study and Plan has been assessed with the inclusion of the proposed lakes. It has been determined that the hydraulic impact associated with the cumulative development scenario remains consistent with the Tweed Shire Development Control Plan including

Kingscliff catchment, modelling of a cumulative development scenario for the 1% AEP and 1% climate change events is warranted. This includes expansion of the aquaculture farm, and sand mining and subdivision development by Gales Holdings. Gales Holdings is advancing their masterplanning and it is strongly advised that Hanson consults and consolidates the current technical studies if possible". Section 4.6 of the FSA notes (part of) the Gales Kingscliff developments (Lot 21) but does not provide any further, cumulative analysis. This is not considered to be acceptable. The proposal's impact on flooding in the area cannot be considered in isolation only. If co-operation from Gales Holdings, and their consultants, is not forthcoming the proponent can adopt the Tweed Valley Floodplain Risk Management Study 2014 cumulative development scenario and consult with Council to ensure any change since 2014 are included. A cumulative development scenario must be assessed otherwise the Flood Impact Assessment is not complete. Refer to request for further information below (Item 8.1).	the proposed lakes. Additional discussion is provided in Sections 4.4.1, 4.6.2 and 6.2.4.
1.6 Acceptable Afflux Claims The FSA repeatedly claims that afflux as a result of the proposal "…is within the allowable limits as set by the Tweed Council". It should be noted that these thresholds were adopted for the Tweed Valley Floodplain Risk Management Study cumulative development scenario which included all anticipated fill/development of the floodplain. They are not applicable to an individual development assessment and should not be deemed an acceptable target in isolation. Refer to request for further information below (Item 8.1).	The acceptable Afflux thresholds have been amended, refer to Section 4.6.
1.7 PMF Afflux Results The FSA makes a general conclusion: *The proposed lakes do allow flood waters to be conveyed across them with less resistance than the existing farm paddocks, creating a marginal change to the level of flooding in some areas of the model domain. This is specifically notable in extreme events including the 0.2% AEP and above events.*	No response required.

However, the PMF afflux maps depict the opposite result. A widespread reduction in peak water level to the east of the site and an area of increase to the south-east. This is inconsistent with the above commentary and the reason for it has not been explained. Refer to request for further information below (Item 8.1).	
2. Stormwater	
2.1 Predicted Afflux The FSA analyses local stormwater flooding and concludes that: It is shown from the local flood assessment an increase in water level outside the allowable increase for rural properties (100mm) is anticipated at interrogation locations B, D, E and F in various events. An increase in flooding is due to loss in conveyance area caused by the proposed lake bunds. It then goes on to claim that, as local stormwater peak flood levels are far lower than the regional peak flood levels, this is acceptable. It is considered that this is an over simplification of the problem. It is not acceptable to dismiss increases in local stormwater flooding simply because regional flooding is worse. Local drainage efficiency and time of inundation is important for the nearby agricultural land uses, for the viability of nearby development areas and for the ecology of environmental areas. The proponent has not demonstrated that the increases in local stormwater flooding are acceptable. Refer to request for further information below (Item 8.1).	 The method for local stormwater assessment has been updated to a Rain-On-Grid modelling approach. As such the results and results discussion have been updated.
2.2 Drain Upgrades It is noted that FSA Appendix C contains a map that outlines various drainage channel realignments. The document states that: *If during the operation of the sand plant, channels are required to be reformed or realigned, required channel sizing has been indicated in Appendix C.* The document then goes on to state: *No channel upgrades are proposed under this EIS submission. Predevelopment channel sizing is matched in the proposed scenario and generally*	 The development proposes to maintain the existing hydraulic regime of the floodplain as much as possible, this is achieved through the following: • Utilise existing channels wherever possible; • Maintain existing channel size parameters if realignment is required; • Maintain the general existing surface level in the area of the lakes during times of flood (i.e. RL 1.0 m AHD). Doing the above minimizes the changes to hydraulic condition, which is reflected in the hydraulic results.

catchment areas draining to the channels have been maintained. Further clarification is required in this regard. It appears the FSA local stormwater results conclude that local stormwater afflux is not acceptable, suggests drain upgrades to offset these impacts, but then declines to include them in the proposal. Refer to request for further information below (Item 8.1).	
2.3 Time of Inundation As per the abovementioned flood comments, the FSA does not include any analysis of any changes in the time of inundation due to the proposal. The changes to the southern drain result in a longer flow path for low flow drainage to take to reach the outlet. The stormwater analysis should include consideration of low flow drainage and time of inundation. Refer to request for further information below (Item 8.1).	Refer to Request Response Item 1.2.
2.4 Flow from Eastern Catchments Through direct experience and various assessments of development proposals east of the subject site it has been generally accepted that the Altona Road and Julius drains can flow in both directions depending on tail water levels, rainfall distribution and storage stages. The FSA selects a catchment divide that routes stormwater from the east of the site to the north. A sensitivity analysis should be considered where a suitable catchment east of the site are routed to the west, through and around the subject site. Refer to request for further information below (Item 8.1).	Stormwater flows from the eastern catchments have been considered as part of the updated Ran-On-Grid Assessment. Utilizing a Rain-On-Grid modelling approach ensures the complex flow behavior of the floodplain is modelled correctly.
2.5 Peak Discharges The FSA predicts significant increases in peak stormwater discharge at the catchment outlets in more frequent events (refer to tables 3.3 and 3.4). However, no justification as to why this is acceptable is provided by the proponent. It should be noted that, for natural (unsealed) drains, peak discharge increases in frequent events can be related to erosion and associated environmental problems. Avoiding these is the objective of the waterway stability control in Development Design Specification D7 – Stormwater Quality. The proponent should either provide justification as to why these increases will not have any detrimental impact or propose	The updated Rain-On-Grid assessment has resulted in changed results for the local assessment. Changes in peak flows are considered acceptable. Refer to section 6.1.1 for further reference.

mitigation measures. Refer to request for further information below (Item 8.1).	
8. Request For Further Information	
8.1 Flooding and Stormwater	
a. The proposed Southern lake is to be bunded to RL 1.3m AHD. The proponent's Flooding and Stormwater Assessment does not include this bunding in its flood model as it 'is considered negligible due to its low level compared to the overall flood levels experienced at the site'. The proposal will result in a bund approximately 0.8m high being placed directly downstream of the Pacific Highway Bridge which is a critical flow path for water entering the Chinderah/Kingscliff floodplain storage. Any obstruction to flow here is likely to have significant impacts upstream. It should also be noted that the area near the Pacific Highway Bridge is classified as "High Flow". Tweed Shire Development Control Plan section A3 – Development of Flood Liable Land strictly limits changes to ground levels in high flow areas in order to maintain flood conveyance in critical areas. Any significant bunding in this area is contrary to DCP-A3 and unlikely to be supported. This constraint has not been addressed and a proper assessment may reveal unacceptable flood impacts upstream that could have substantial implications for the proposal.	Refer to Request Response Item 1.1.
b. The Flooding and Stormwater Assessment does not include any analysis of changes in the time of inundation in the surrounding floodplain due to the proposal. This is particularly relevant to nearby agriculture, development and environmental areas. Prolonged inundation can kill crops, increase nuisance and change environmental values. The proposal will have significant changes to the low-flow drainage regime of the area and therefore may effect time of inundation of surrounding floodplain areas. This should be evaluated.	Refer to Request Response Item 1.2.
c. The Flooding and Stormwater Assessment predicts that 'for events lower than the 1% AEP, the development improves flooding in	Refer to Request Response Item 1.4.

	the area due to a large gain in flood storage'. These results are likely to be heavily dependent on the starting water level of the lakes input into the flood model runs, which are not defined in the Flooding and Stormwater Assessment. Flooding in the Tweed Valley generally follows multiple days of heavy rain, while the 2 x lakes are proposed to be bunded with overflow weirs at RL 1.0m AHD. It is likely that a large portion of the "gain in flood storage" would be consumed by this trapped 'pre-flood' rainfall. The proponent should define the starting water level and/or antecedent conditions applied to each flood model run so that the validity of this result can be assessed.	
d.	The Flooding and Stormwater Assessment analyses the proposals impact on flooding in isolation but does not consider a cumulative development scenario. This not acceptable and a comprehensive cumulative development scenario must be investigated. If the latest plans for surrounding development cannot be sourced from the relevant landowners and their consultants the proponent can adopt the Tweed Valley Floodplain Risk Management Study 2014 cumulative development scenario and consult with Council to ensure any changes since 2014 are included.	Refer to Request Response Item 1.5.
e.	The Flooding and Stormwater Assessment repeatedly claims that afflux as a result of the proposal 'is within the allowable limits as set by the Tweed Council'. It should be noted that these thresholds were adopted for the Tweed Valley Floodplain Risk Management Study cumulative development scenario which included all anticipated fill/development of the floodplain. They are not applicable to an individual development assessment considered in isolation only. These precedents can only be considered relevant if a comprehensive cumulative development scenario is undertaken.	Refer to Request Response Item 1.6.
f.	The Flooding and Stormwater Assessment makes a general conclusion that 'the proposed lakes do allow flood waters to be	Refer to Request Response Item 1.7.

	conveyed across them with less resistance than the existing farm paddocks, creating a marginal change to the level of flooding in some areas of the model domain. This is specifically notable in extreme events including the 0.2% AEP and above events'. However, the PMF afflux maps depict the opposite result - a widespread reduction in peak water level to the east of the site and an area of increase to the southeast. This is inconsistent with the above commentary and the reason for it should be explained.	
g.	The Flooding and Stormwater Assessment analyses local stormwater flooding and concludes that: 'an increase in water level outside the allowable increase for rural properties (100mm) is anticipated at interrogation locations B, D, E and F in various events. An increase in flooding is due to loss in conveyance area caused by the proposed lake bunds. It then goes on to claim that, as local stormwater peak flood levels are far lower than the regional peak flood levels, this is OK. It is not acceptable to dismiss increases in local stormwater flooding simply because regional flooding is worse. Local drainage efficiency and time of inundation is important for the nearby agricultural land uses, for the viability of nearby development areas and for the ecology of environmental areas. The proponent has not demonstrated that the expected increases in local stormwater flooding are acceptable.	Refer to Request Response Item 2.1.
h.	The Flooding and Stormwater Assessment predicts some significant changes to peak discharge and peak water level in local stormwater flooding scenarios. It does not propose any mitigation measures to manage these impacts. It is noted that Appendix C contains a map that outlines various drainage channel realignments/upgrades and the document text states that: 'If during the operation of the sand plant, channels are required to be reformed or realigned, required channel sizing has been indicated in Appendix C'. However, the document then goes on to state that 'no channel upgrades are proposed under this EIS submission.	Refer to Request Response Item 2.2.

	Pre-development channel sizing is matched in the proposed scenario and generally catchment areas draining to the channels have been maintained'. It appears the Flooding and Stormwater Assessment concludes that local stormwater afflux is not acceptable, suggests drain upgrades to offset these impacts, but then declines to include them in the proposal. This requires clarification.	
i.	The Flooding and Stormwater Assessment local stormwater analysis does not include any assessment of changes in the time of inundation due to the proposal. The changes to the southern drain result in a longer flow path for low flow drainage to take to reach the outlet. The stormwater analysis should include consideration of low flow drainage and time of inundation.	Refer to Request Response Item 2.3.
j.	The Altona Road and Julius (at the foot of Cudgen ridge) drains are known to flow in both directions depending on tail water levels, rainfall distribution and storage stages. The Flooding and Stormwater Assessment selects a catchment divide that routes stormwater from the east of the site to the north. A sensitivity analysis should be considered where a reasonable area of catchment east of the site is routed to the west, through and around the subject site.	Refer to Request Response Item 2.4.
k.	The Flooding and Stormwater Assessment predicts significant increase in peak discharge at the catchment outlets in more frequent events (tables 3.3 and 3.4). However, no justification as to why this is acceptable is provided. It should be noted that, for natural (unsealed) drains, peak discharge increases in frequent events can be related to erosion and related environmental problems (see Development Design Specification D7 – Stormwater Quality waterway stability objective). The proponent should either provide justification as to why these increases will not have any detrimental impact or propose mitigation measures	Refer to Request Response Item 2.5.
l.	Table 3.3 of the Flooding and Stormwater Assessment contains typographical errors that should be corrected.	Amended.

1.3.2 Gales-Kingscliff - Submission for Proposed Hanson Tweed Sand Plant Expansion (SSD-10398)

A submission made by Gales-Kingscliff on 19 May, 2021 requested updates to the hydraulic modelling within the FSA. A summary of the requests and the Burchills responses have been included in the below table.

Information Request	Request Response
B. Stormwater / Agricultural System	
We believe that the depiction of the stormwater and agricultural drainage system within the EIS and supporting Flood & Stormwater Report (Burchills, 2021) is erroneous. Specifically on Figures 3.2 and 3.3 of Burchills (2021) report the drain along the south-east part of the existing Quarry lake is not shown as a drain and Catchment 10 shows flow from Cudgen Plateau draining towards the east and north across bunded areas of CLSQ rather than to this unmarked drain. This is incorrect and is inconsistent with previous correspondence between Hanson and Gales regarding inundation of Gales lands caused by blockage in the agricultural drainage system impeding drainage from CLSQ to the west and contributing to wetting up of Gales land to the east of the blockage. It is acknowledged and appreciated that, in response to Gales raising this matter, Hanson commissioned Gilbert & Sutherland to investigate and provide reporting on this matter. Whilst the drainage lines and blockage appears to be on land immediately south of the Hanson operation (and where not owned by Hanson not a Hanson responsibility), the G&S report correctly depicts a portion of the drainage line south of the Hanson Tweed Sand Plant and indicates that this is tidal to the west by presence of salt tolerant aquatic vegetation. This is not reflected within the Burchill (2021) report. Whilst Gales continues to consult with Council, EPA and relevant land owners regarding removal of blockage to the drainage, it is requested that the Flood & Stormwater Report be revised to account for the correct drainage. This is of particular relevance given that Hanson's proposed expansion would remove the tidal connection of this area to the west and north to the Tweed River and as such should account for and consider the correct catchments on the basis of the properly functioning drainage	Catchment Mapping provided in Figure 3.2 and Figure 3.3 is indicative for the immediate local catchments and does not include regional external catchments that may or may not affect flows at the site depending on hydraulic grade. The catchment maps only pick the main flow paths of each catchment and do not pick up minor flow paths that feed to these main lines. Drainage lines along the south-east of the subject site are free from blockage as determined by a site inspection in February of 2021. Regardless of the nature in which drainage occurs around the site, a Rain-on-Grid model has been developed that accurately simulates the complex flow behaviour around the subject site. As rainfall has been applied to the entire model domain, all drainage paths (no matter the significance) have been modelled and the results of the proposed development on the local flood regime are discussed in Section 6.1.

system. The Burchill (2021) report appears to omit the existing drainage channel along the south-east part of the Hanson lake and to substantially underestimate the catchment area that would drain into the Hanson extraction pond. Given that the Hanson proposed expansion would permanently change the local drainage, proper assessment of this matter is essential. In addition to the above, in the drainage schematics shown in Appendix C of Burchill (2021) it is noted that the drainage direction for the existing drain adjacent Altona Road is incorrectly depicted as flowing from west to east. This drain cannot drain towards the east but drains westwards (towards the Tweed River). Gales is extremely concerned about the local drainage. CLSQ and Gales land beyond has become wetted up and Gales is currently in discussions with Council, local landowners and the EPA to determine to causes of the wetting up and blockages to drainage west. It is requested that the Burchill (2021) Flood & Stormwater Report be revised to account for the correct existing drainage, the blocked drains preventing flow west, and the impact of Hanson's proposed changes.	
C. Flood Assessment	
The assessment has not properly defined the external catchment influencing flood levels at the site (Figure 3.2). A local catchment flood assessment of the broader area undertaken for Gales by Venant Solutions established that during a 1% AEP event the drain along Altona Road flows from east to west towards the Hanson site. Further, this drain receives runoff from the catchment to the east of Tweed Coast Road.	As discussed above, the flood assessment has been updated to utilise Rain-On-Grid Modelling that accurately simulates the complex flow behaviour around the subject site.
There is no reporting of flood levels under existing and developed conditions at the eastern end of the site (western edge of Gales land) to demonstrate non-worsening.	Results discussion regarding hydraulic impact caused by the development is provided in Section 6.1 and 6.2. Flood mapping has been provided in Appendix F.
For the regional flood assessment, the afflux limits in Section 4.1.1 of Burchill (2021) are taken from the BMT WBM report prepared for Tweed Shire Council's cumulative fill assessment. Hence these are limits for the cumulative fill scenario, not an individual assessment. To use these limits, the	Acceptable afflux limits have been amended, please refer to Section 4.5 and 4.6. Cumulative development including the development has been assessed, please refer to Section 4.4.1 and 6.2.4.

proposed Hanson development should have been tested in combination with Council's cumulative fill scenario and assessed against a no fill scenario.	
The modelling did not include the proposed bund walls at 1.3 m AHD and 1.75 m AHD. A statement is made in Burchill (2021) that the bund walls were not included because they would have negligible effect, but the purposes of the modelling should have been to demonstrate that this is the case. If the bunds are included and the lakes are at 1.0 m AHD (the level of the weir outlet) when the main river flooding arrives this will represent a loss of flood storage which has not been included in Council's cumulative fill scenario as noted above. It is plausible that the lakes would be at 1.0 m AHD because of rainfall falling locally over the lakes prior to the main river flood arriving.	Flood modelling has been updated to include the proposed bunding associated with the subject site. Refer to Section 5.2 for more information.

1.4 Data Collection

A variety of data was collected and used as part of this assessment. The data and sources adopted include:

- Data contained within Tweed Shire Council's Tweed Valley Flood Study 2009 (Tweed Shire Council, 2009);
- 1m LiDAR (NSW Government Spatial Services, 2013);
- Survey of Culverts (Landsurv Pty Ltd, 2020);
- Council GIS data (Tweed Shire Council, 2020), including:
    - DCDB;
    - Zoning data; and
    - Stormwater Network data.

2. Site Details

The subject site is located on Altona Road, Cudgen, NSW and compromises the following parcels of land:

- Lot 22 DP1082435;
- Lot 23 DP1077509;
- Lot 494 DP720450;
- Lot 1 DP1250570;
- Lot 2 DP1192506;
- Lot 3 DP1243752;
- Lot 51 DP1166990; and
- Lot 50 DP1056966.

2.1 Land Use and Vegetation

Part of the subject site has been operating as a sand extraction plant since 1982 with Hanson taking over in 2007. Much of the site is currently vacant land with low ground cover (grass and sedges), prior landuses of the site have resulted in agricultural drainage lines throughout.

The site is surrounded by the following land uses/receptors:

- North – Tweed Shire Council's wastewater treatment facility; the proposed Carbrook Sands Plant isolated residential receptors; agricultural land (cane, grazing); Pacific Motorway and township of Chinderah in the distance (approximately 2 km);
- East – Cudgen Lake Sand Plant (Cudgen Lakes); township of Cudgen (approximately 1 km); Township of Kingscliff in the distance (approximately 3 km);
- South – Residential receptors located along Cudgen Road ridge; Farm & Co Kingscliff; and
- West – Australian Bay Lobster Producers Pty Ltd; Melaleuca Station Memorial Gardens and Crematorium; Pacific Motorway; agricultural land (cane, grazing).

An aerial photograph of the site in its current state is shown below in Figure 2.1.

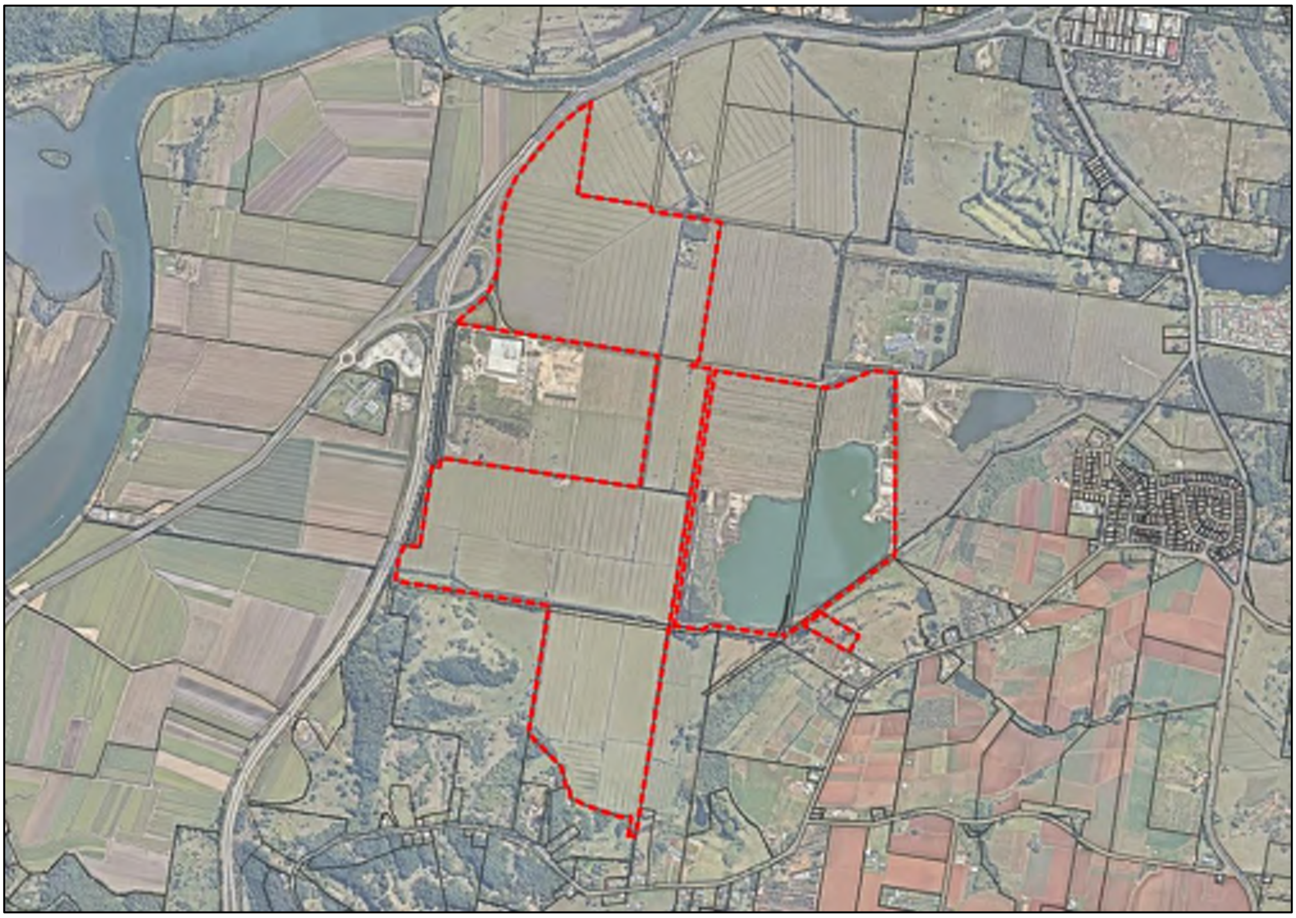


Figure 2.1 Site Aerial Photograph September 2020 (Nearmap)

2.2 Topography

The subject site is located within the Tweed Valley flood plain with the Tweed River approximately 3 km to the west. The subject site is generally flat with the average level of the site at relative level (RL) 1 m AHD.

There are many agricultural drainage channels present on the site these drain to main drainage lines that discharge flow at the M1.

2.3 Proposed Development

The Hanson Tweed Sand Plant Expansion involves an increase of extraction and processing of up to 950,000 tonnes of sand per annum for up to 30 years and the construction of a new building and wash plant. The project will also involve the transport of material off-site by public roads and progressive rehabilitation of the site this will involve the addition of a new haulage route in and out of the site.

The proposed phasing plan for the sand plant has been provided in Figure 2.2. A concept development/ extraction phasing plan for the expansion can be found in Appendix A.

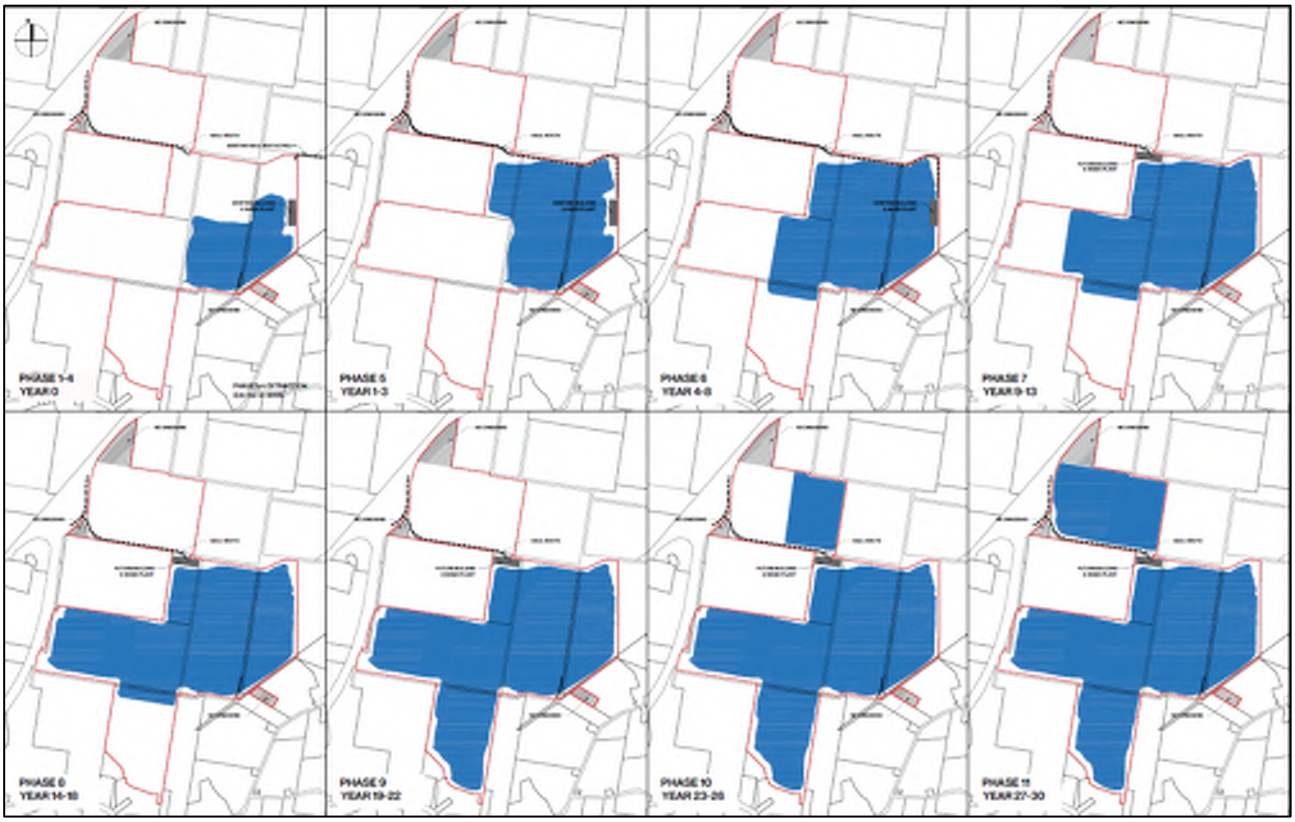


Figure 2.2 Proposed Site Phasing Layout (Zone, 2021)

3. Flooding and Stormwater Overview

3.1 Stormwater Management

The expansion of the sand plant production activities will result in the creation of large lakes, runoff produced over the lakes will be captured in the lakes and overtop once the lakes reach their limit. The lake bunding and overflow parameters are presented in the following table.

Table 3.1 Lake Stormwater Management Parameters

Lake	Lake Bunding Invert Level	Lake Overflow Invert Level	Lake Standing Water Level
Lake 1	No bunding proposed, lake level controlled by outlet set at RL 0.5 m AHD	0.5 m AHD	0.5 m AHD
Lake 2	Minimum bunding to RL 1.0 m AHD, set to match existing floodplain surface level	1.0 m AHD	1.0 m AHD

The ground level in the location of Lake 1 sits at approximately RL 1.0 m AHD. As Lake 1 water level will be controlled at the outlet of the lake to RL 0.5 m AHD, no specific bunding will be required around the perimeter of the lake.

To ensure that the existing hydraulic regime is maintained, no specific outlet control point is proposed for Lake 2. Runoff will be permitted to discharge freely on sides of the proposed Lake 2 to mirror existing conditions experienced in the current scenario. It is noted that generally, higher ground exists along the southern and eastern bounds of Lake 2. As such the majority of Lake 2 discharge will be at the western and northern bounds of the lake. The impact of this has been assessed and is presented in the preceding sections of the report.

In the proposed condition the general conveyance of external catchments is to be maintained using the existing drainage lines. Any realignment of existing channels will be minor in nature and ensure existing discharge locations are maintained. Once channels reach their hydraulic capacity, overtopping into the adjacent floodplains and Lakes is permitted as per the existing condition. Catchments to the south-east of the site (catchment 2 and 3 in Figure 3.3) will be permitted to enter the proposed lake via proposed culverts (4 x 600mm RCP).

If channel realignment is required to suit the proposed lake expansion, channel sizing has been indicated in Appendix B. **It is important to note that no channel upgrades are proposed under this EIS submission. Pre-development channel sizing is matched in the proposed scenario and generally catchment areas draining to the channels have been maintained.**

A new haulage route is proposed from the future washdown facility to the M1. The haulage route is proposed to be located at RL 1.35 m AHD (existing haulage route immunity), a culvert bank of 7 x 1500mm x 750mm RCBC is proposed at the existing channel location.

A conceptual drainage schematic for each of the proposed plant's expansions has been prepared in Figure 3.1, detailing the proposed channel realignments, bunding, hydraulic structures, control weir and washdown facility location at the subject site. Figure 3.2 and Figure 3.3 identify the site's local catchments and associated flow paths. Refer to Appendix B for reference to stormwater management through the development phases.

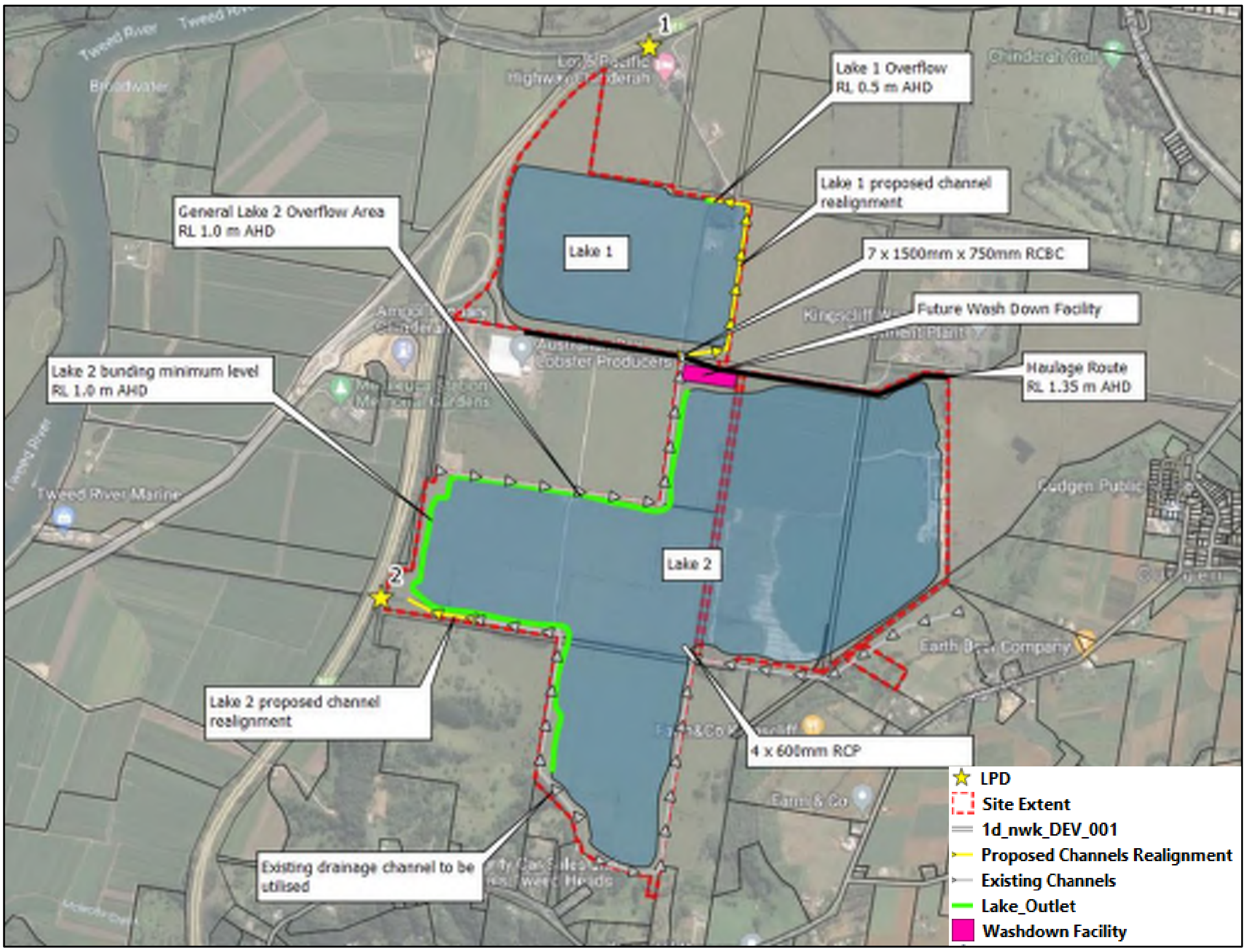


Figure 3.1 Conceptual Stormwater Management Schematic

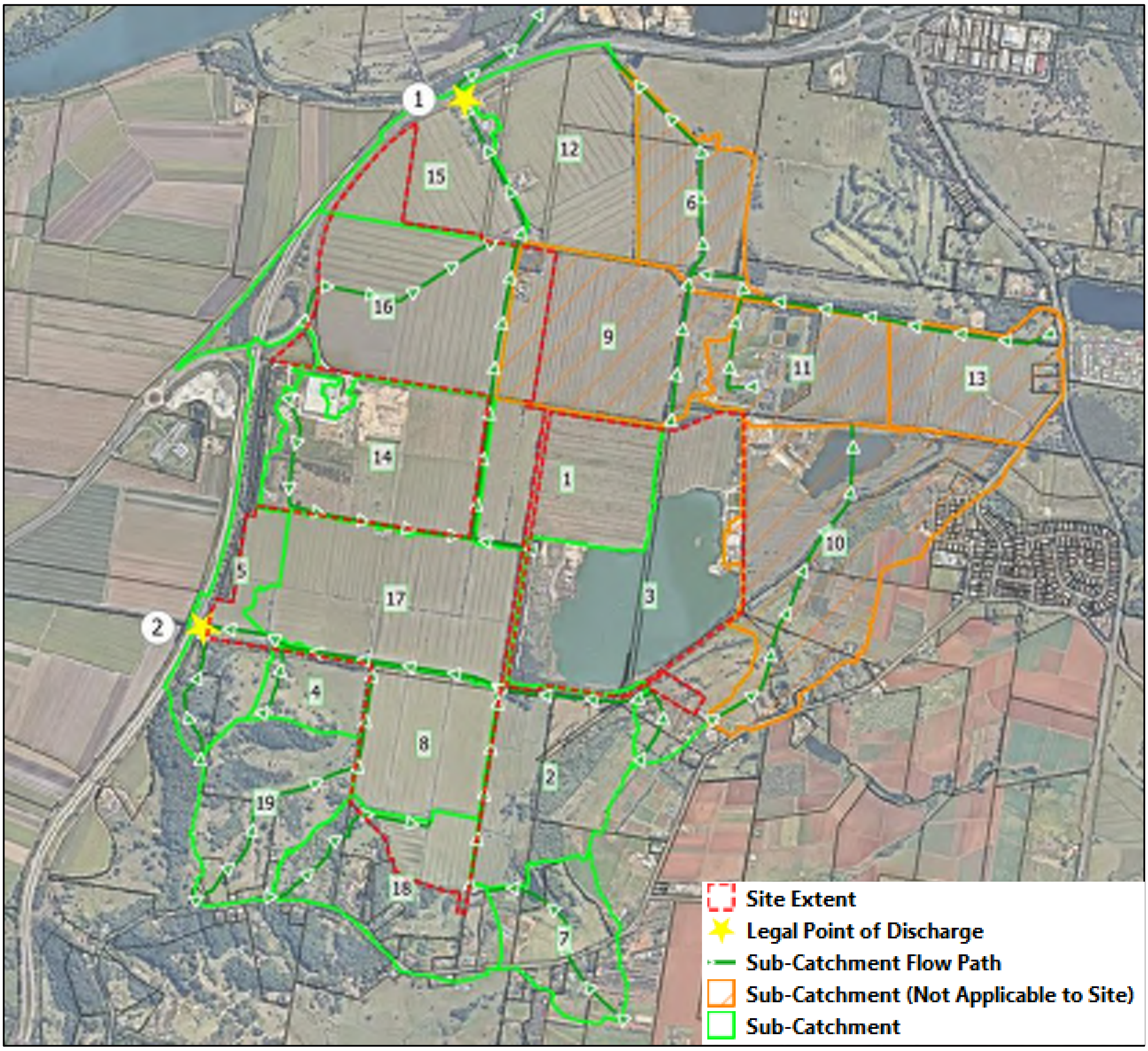


Figure 3.2 Local Catchment Map and Flow Paths – Existing Case

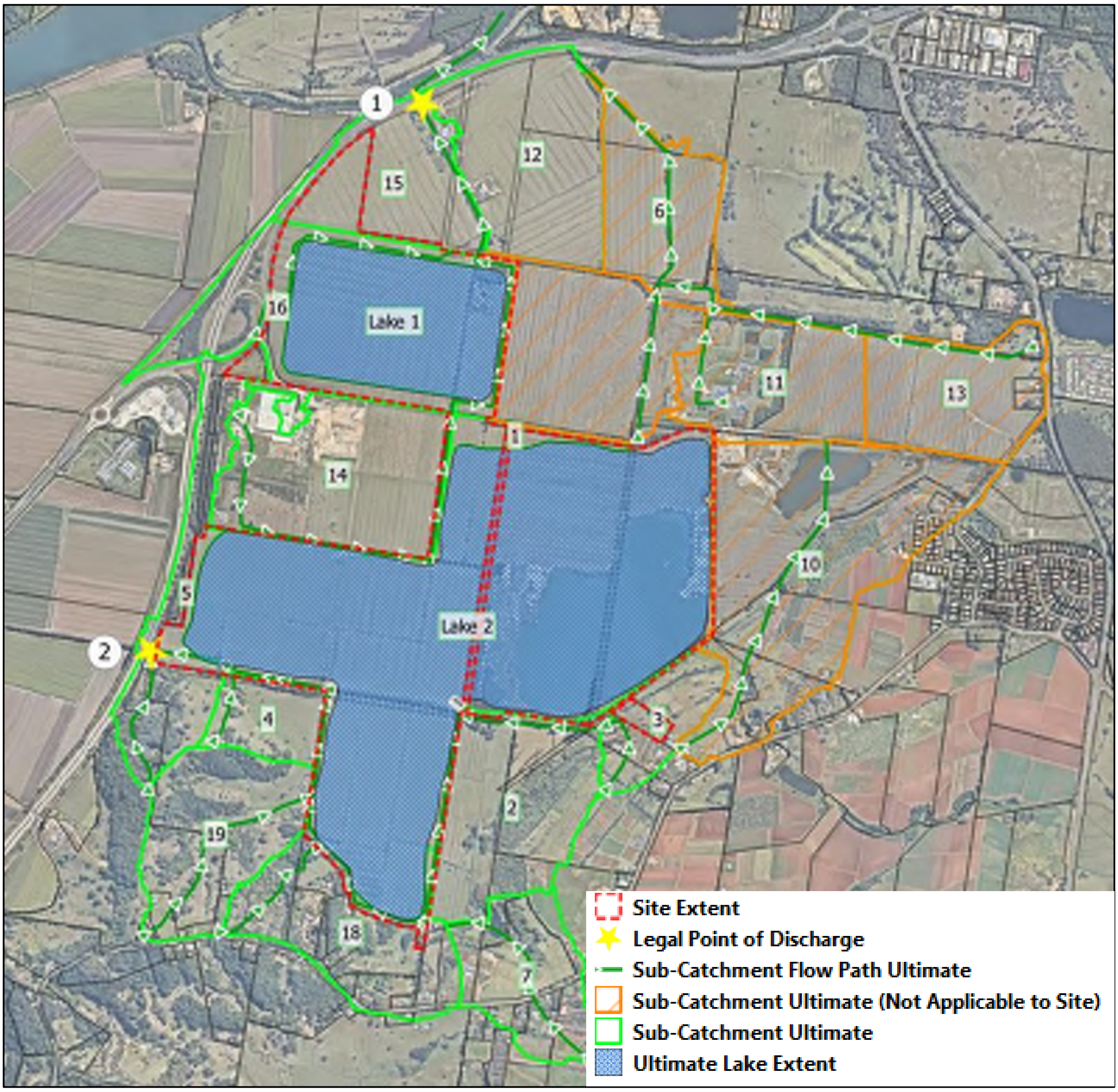


Figure 3.3 Local Catchment Map and Flow Paths – Ultimate Case (Phase 11)

3.2 Proposed Site Office and New Sand Washing Plant

A new building and sand washing plant has been proposed for later stages of the expansion (Phase 7). The layout of the proposed facility is to be confirmed at a later date, as such a Stormwater Management Plan (SMP) for the new facility will be prepared as this time.

The future SMP will need to consider the following:

- The management of runoff from the site, ensuring the proposed sand washing plant does not cause any adverse conditions to downstream properties.
- The management of stormwater quality, ensuring that the Water Quality Objectives of the local authority is achieved.

Runoff from the new sand washing plant will discharge back to the dredging lakes. This will ensure runoff and pollutants are captured on site and do not discharge externally to the site.

3.3 On-Going Maintenance Requirements

Hanson will conduct all necessary works during operation to maintain the proposed drainage regime. This will include the following works:

- On-Going scour protection remediation wherever erosion occurs at the lake outflow locations; and
- Ensure channels on site are free of debris and remain unblocked.

3.4 Regional Flooding

The existing site is located within the Tweed River Floodplain and is subject to regular inundation during high rainfall events. The majority of the flood inflow enters through the culverts that run beneath the M1 to the west of the TSP. Flood waters generally drain from the site through said culverts and to rural areas to the east. Typical flood depths within the site for a 1 in 100 AEP event prior to development is 2.0 – 2.1m with flood velocities of 0.1 m/s. The proposed haulage routes are set at RL 1.35m with a flood immunity that corresponds to approximately a 10% AEP local flood event. The existing washdown facility is at RL 3m with a flood immunity that corresponds to a 1% AEP event.

4. Flood Assessment Methodology

4.1 Overview

To assess the impact of the proposed development on the hydraulic regime, two-dimensional hydraulic modelling has been utilised that maps the flooding within the study area in both scenarios. TUFLOW hydraulic modelling software is the chosen platform. This assessment focuses on regional flooding at the site and investigates the potential for the proposed development to cause damage or nuisance to external properties.

4.2 Flood Assessment Scope

To assess the impact the proposal will have on the existing flood regime the following scope has been prepared:

- Data Collection:
  - Review and assessment of data completeness for use in the development hydraulic assessment.
  - Review existing Tweed Shire Council flood mapping, Flood Studies and Flood Policy.
- Hydraulic modelling:
  - Utilise Council's regional model, subdivide a smaller TUFLOW model with refined cell size, 1D elements, Manning's roughness values, and topography to represent the Tweed River floodplain;
  - Calibration of the refined TUFLOW model to Council's Designated Flood Level result (1% AEP);
  - Simulation of the regional flood event using the calibrated model;
  - Simulation of the local flood event utilising Rain-On-Grid Methodology.
    - Review of modelling results and identification of critical flood events for each AEP.
  - Review of modelling results including water level impacts, velocity impacts, hazards, and modelling inefficiencies; and
  - Refinement of proposed development to minimise flood impacts external to the subject site.
- Report and Mapping
  - Presentation of flood afflux maps for water surface level;
  - Impact assessment;
  - Review of any impacts resulting from the proposal in the context of whether such afflux may give rise to potential actionable damage to surrounding properties; and
  - Review of flood results in relation to the development conditions.

4.3 Local Flood Assessment

Local flooding within the study area has been assessed using a Rain-On-Grid method. Rain-On-Grid was adopted to accurately simulate the floodplain that is understood to flow in different directions depending on hydraulic grade within the system. In accordance with AR&R 2019 guidance the following statistical ensemble assessment method was used for the Local Flood Assessment.

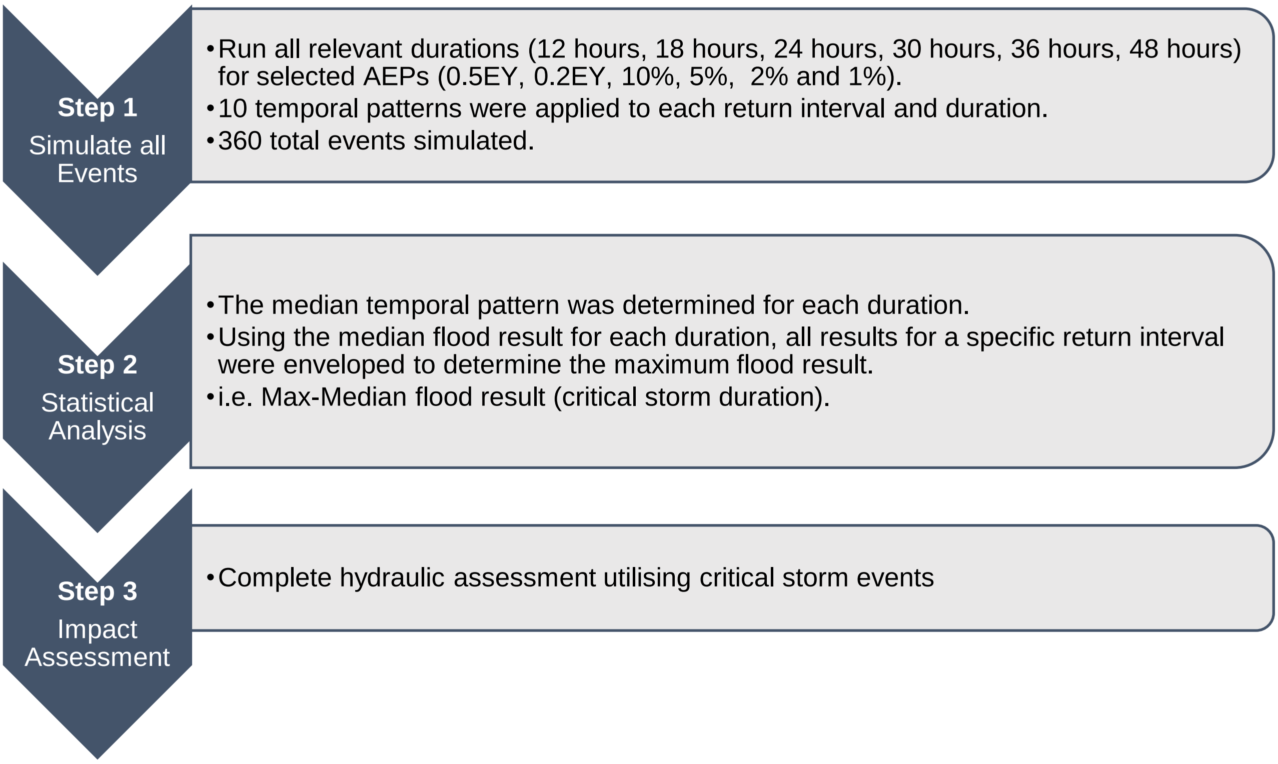


Figure 4.1 Local Flood Assessment Methodology Summary

4.3.1 Statistical Analysis

Based on the statistical analysis discussed above, critical storm durations could be identified for the Lower Tweed Valley Floodplain. The following critical storms were determined.

Table 4.1 Critical Storm Duration Lower Tweed Valley Floodplain

Return Interval	Critical Storm Duration (Max-Median)
1%	18-hour duration temporal pattern 8
2%	18-hour duration temporal pattern 8
5%	36-hour duration temporal pattern 6
10%	36-hour duration temporal pattern 1
0.2EY	36-hour duration temporal pattern 6
0.5EY	36-hour duration temporal pattern 6

4.3.2 Time of Inundation Assessment

A time of inundation assessment was completed utilizing the local model results. This assessment involved a review of the depth of local flooding on the surrounding agricultural properties for the existing and proposed development scenarios. A significant change in the shape or magnitude of the depth-time plot would indicate a change in inundation time, no significant change of flood behaviour was considered to indicate a negligible change to inundation time.

4.4 Regional Flood Assessment

Regional flooding has been assessed in accordance with the Tweed Shire Development Control Plan. The Regional Council model was adopted, and the design events proposed by the endorsed model were utilised for the assessment. The proposed development has been assessed for flooding at different stages within its operational life, those being:

- Existing Scenario;
- Phase 7 (year 9-13);
- Phase 9 (year 19-22); and
- Phase 11 (year 27-30).

4.4.1 Cumulative Development Assessment

In accordance with Tweed Shire Council's 'Tweed Valley Floodplain Risk Management Study (BMT WBM, 2014), a cumulative development scenario was assessed that considered future development within the lower Tweed River Catchment. Future Development proposed under the Floodplain Risk Management Study included the recommended allowable development outlined as Scenario 3 in Section 8.4.2.3 of the report. The cumulative development is summarised below:

- Residential development and infill in Kingscliff (minimum 1% AEP flood immunity);
- Industrial development in Chinderah (filled to 2.2 mAHD, to represent 65% site coverage for flow obstructions above 2.2 mAHD); and
- Other approved development, including;
  - Aquaculture development (bunded to 1% AEP flood level); and
  - Sewage treatment plant (1% AEP flood immunity).

A figure of the cumulative development modelled within this assessment is included in Figure 4.2.

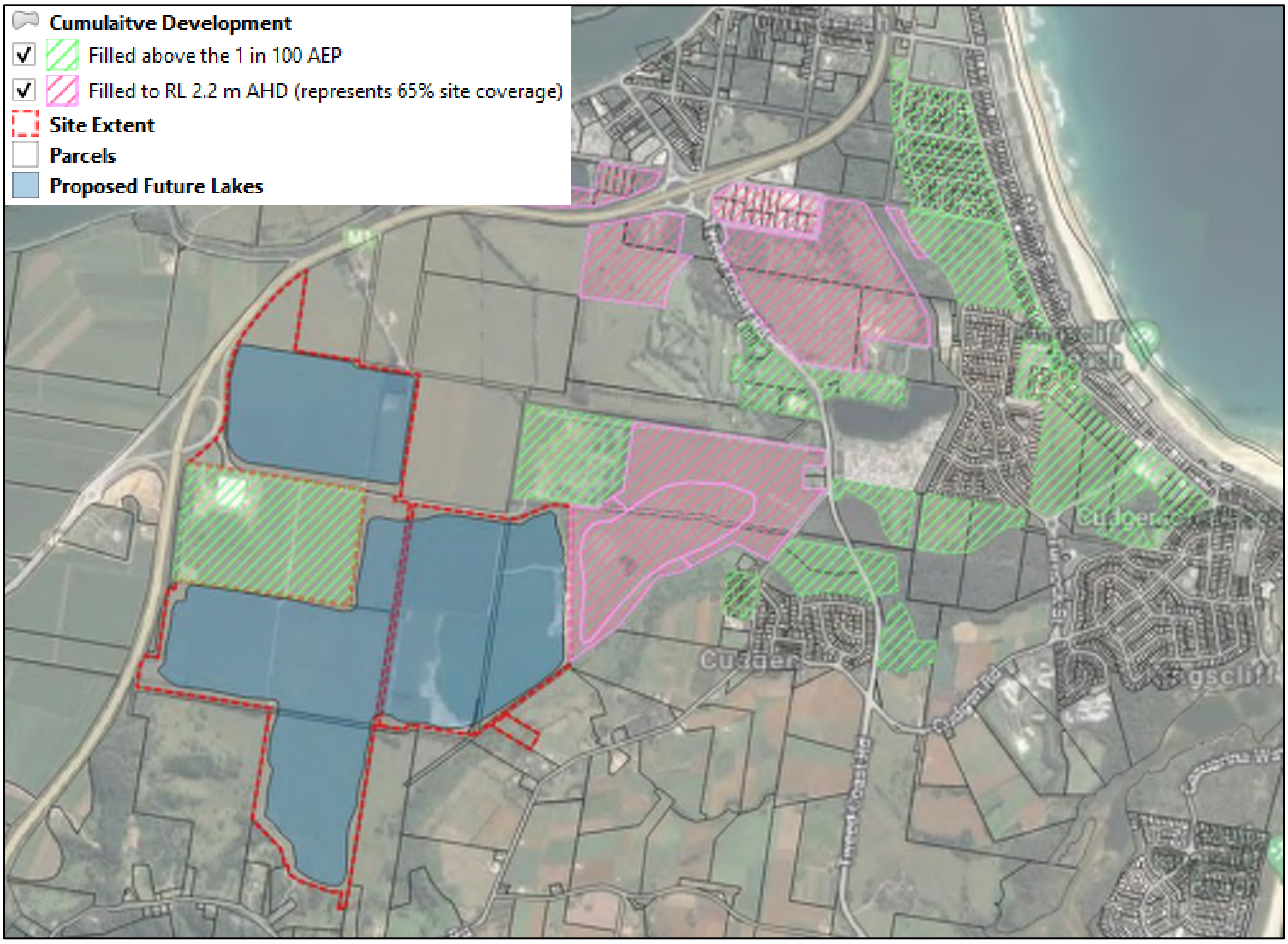


Figure 4.2 Cumulative Development Scenario

4.5 Impact Assessment Thresholds

Some documentation and guidance around practical hydraulic impact noise thresholds is available online. A presentation from the Hydrology and Water Resources Symposium, *Defining Acceptable Impacts for Flood Impact Assessments* (Retallick & Babister, 2018) which was published by Engineers Australia, recommends 10mm as a threshold for residential impact assessments. TUFLOW online support forums recommend 10mm generally (5mm under certain circumstances) with further judgement required (recommendation made by TUFLOW representatives) (TUFLOW, 2010).

4.5.1 Afflux Thresholds

A review of other LGA's and infrastructure projects around Australia has highlighted model thresholds. Of the reviewed reports listed below +/-10mm appears to be the standard.

- Chapter 13 – Surface Water and Hydrology – Calvert to Kagaru EIS (ARTC, 2021).
  - *Existing habitable and/or commercial and industrial buildings/premises – 10mm.*
  - *Residential or commercial/industrial properties/lots where flooding does not impact dwelling/buildings – 50mm.*
  - *Existing non-habitable structures – 100mm.*

  - o *Roadways – 100mm.*
  - o *Agricultural and grazing land/forest areas and other non-agricultural land – 200-400mm.*

- Sunshine Coast Airport Expansion Project Environmental Impact Statement – Chapter B5 Airport and Surrounds Flooding (Sunshine Coast Council, Sunshine Coast Airport, 2014)

  The Flood Impact Assessment undertaken for the Sunshine Coast Airport Expansion Project identified that the proposed development would result in afflux during the 1% AEP event which would result in overflow potentially flooding fifteen (15) houses on fourteen (14) properties.

  - *In all current day modelled events, except the 100-year ARI event, the modelling indicates there would be a negligible increase in peak flood levels (less than 10 mm);*
  - *Up to 15 houses on 14 properties within the affected area have existing floor levels that may be affected by the increase in depth of up to 18.5 mm in the 100-year ARI event. The owners of the affected properties would be contacted during the public notification for the EiS to conduct detailed surveys to confirm the potential impact and determine the need for property-scale mitigation*
  - *In the 100-year ARI event, the modelling indicates that an area of Marcoola north of RWY 18/36 would experience a small increase in peak flood levels of less than 18.5 mm. This area currently experiences flood depths of 0.25 to 0.8 m during the 100-year ARi event*

- Mordialloc Bypass – Surface Water Impact Assessment (WSP, 2018)

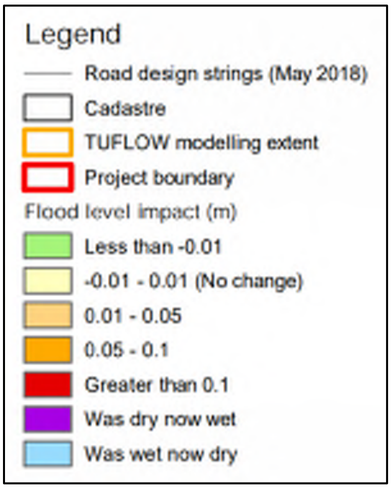


Figure 4.3 Flood Impact Mapping Legend - Mordialloc Bypass (WSP, 2018)

- Parramatta Light Rail – Flooding Technical Paper (ARUP, 2017)

  Differences in peak flood levels of less than or equal to 0.01 metres (one centimetre or 10 millimetres) are considered to be within the accuracy of the hydraulic model. The project is therefore considered to have a negligible effect on flood behaviour in areas where an afflux of ±0.01 metres is shown to be present.

- Suncoast Power Project (Suncoast Overhead Feeder Development, Eudlo Creek) (SMEC, 2017).
  - *DESIGN IMPACT – The project is to achieve a no worsening on private owned land with a maximum allowable afflux of less than 10mm in peak water levels; and*
  - *Affluxes greater than 10mm may be achieved where occurring on council owned land subject to Councils consent.*

- Kenmore Bypass Environmental Assessment Report – Chapter 5: Hydrology and Hydraulics (AECOM, 2009)
  - *The results show that the afflux attributable to the preferred KBP option dur to regional flooding is less that 0.02 metres in the Moggill Creek channel compared to the regional flood base case and is considered negligible.*

4.5.2 Afflux Analysis

TUFLOW modelling is not an exact science, and as such engineering judgement is required to establish whether results are representative of what may occur in reality. Modelling limitations should be considered when completing any hydraulic impact assessment.

The following partial extract, from ARR Revision Project 15: Two Dimensional Modelling in Urban and Rural Floodplains summarises as fundamental advice (Australian Rainfall and Runoff, 2012):

- All models are coarse simplifications of very complex processes. No model can therefore be perfect, and no model can represent all of the important processes accurately.
- Model accuracy and reliability will always be limited by the accuracy of the terrain and other input data.
- Model accuracy and reliability will always be limited by the reliability/uncertainty of the inflow data.
- A poorly constructed model can usually be calibrated to the observed data but will perform poorly in events both larger and smaller than the calibration data set.
- No model is 'correct' therefore the results require interpretation.
- A model developed for a specific purpose is probably unsuitable for another purpose without modification, adjustment, and recalibration. The responsibility must always remain with the modeller to determine whether the model is suitable for a given problem (task).

There are also a number of common problems that occur in hydraulic models that may give rise to unrealistic impact representation or impacts that require further assessment of likelihood. These can be summarised as follows:

- Poor topographic data:
    - The quality of the input data can cause model noise, particularly with un-realistic indentations or low sections within the model that are poor draining. Significant changes to elevation between cells can result in instability or high error in results, which in turn can cause un-realistic afflux (due to error in result).
- Low points:
    - Low points such as basins, driveways in high rises, parks, drainage channels etc can result in afflux that requires further assessment of likelihood, particularly if the drainage system is not included within the model (which it typically is not for regional impact assessments). Care should be taken in assessing whether impacts in these areas are realistic, with consideration given to the input data and circumstances of the event modelled. One method of assessing the accuracy is by interrogating the peak water level within the low point. If the water level within the low point is significantly lower than the surrounding flood levels then this could indicate the result is unreliable (typically due to cell size, lack of drainage model, or poor DEM). These low points should also be interrogated to establish whether the type of flooding scenario simulated is critical for that location i.e. are other local frequent events likely to cause more flooding?
- Missing drainage data:
    - As stated above most regional hydraulic impact assessment models do not include minor drainage network data, which can result in poorly represented flood levels, particularly in drainage channels, basins, and trap sags. This can lead to poor representation of impact results due to low points not being able to drain leading up to the flood peak.

4.6 Flood Impact Objectives

Tweed Shire Council has adopted general development guidelines as part of their floodplain management strategy. These guidelines are based on the works undertaken by BMT WBM as part of their original investigations into flooding along the Tweed River and acceptable limits of hydraulic impacts on the floodplain.

4.6.1 Acceptable Afflux

Afflux limits within the Tweed Shire Council LGA are assessed on a case-by-case basis. The following allowable afflux limits have been adopted as a guide for the development, justification for the limits has been provided in Section 4.5.

- A ‘no change’ modelling tolerance of 10 mm;
- Increase of peak flood levels up to 10 mm limit on residential dwellings;
- Increase of peak flood levels up to 30-50 mm limit for existing urban areas (depending on location); and
- Increase of peak flood levels up to 100 mm limit for existing rural zoned areas in the floodplain.

4.6.2 Cumulative Development Acceptable Afflux

The allowable afflux limits for development within the cumulative development scenario have been adopted from the ‘Tweed Valley Floodplain Risk Management Study (BMT WBM, 2014) and are summarised as follows:

- A ‘no change’ modelling tolerance of 30 mm;
- Increase of peak flood levels of up to 35 mm limit for existing residential zoned areas; and
- Increase of peak flood levels of up to 100 mm limit for existing rural zoned areas in the floodplain.

5. Flood Model

5.1 Hydraulic Model Representation

The study area is approximately 2600 ha and extends 8.5km along the tweed river encompassing the floodplain area to the east around the Kingscliff/Chinderah township areas. The model used for this study is a refined version of the Council Tweed River Flood Model, with greater resolution (8m grid cell size) and additional hydraulic elements including culverts and channels.

The TUFLOW model used for the preliminary assessment was based primarily off information sourced from Council's 2009 Tweed River TUFLOW Flood model. A summary of the model features has been provided in the following table. Model Features maps are included in Appendix C.

Table 5.1 Hydraulic Model Schematisation

Parameters	**Details**
Scenarios	• Existing; • Phase 7; • Phase 9; and • Phase 11, ultimate development scenario.

Design Events	• Regional Events sourced from Council's Tweed River Flood Model.
	  ○ 20% AEP;
	  ○ 5% AEP;
	  ○ 1% AEP;
	  ○ 1% + Climate Change factors; and
	  ○ 0.2% AEP.
	• Local Events
	  ○ 0.5EY AEP
	  ○ 0.2EY AEP
	  ○ 10% AEP
	  ○ 5% AEP
	  ○ 2% AEP
	  ○ 1% AEP

Topography	• 1m Lidar - NSW Government Spatial Services. • Culvert level survey – Landsurv Pty Ltd. • Local farmers drains were delineated using z-shapes (topography modifications). • All topography modification utilised in the Tweed River Flood Model have been adopted in this assessment (M1, Tweed Valley Way, Levee). • Channel realignment represented with z-shapes. • Proposed lake bunding of Lake 2 represented at RL 1.0 m AHD with z-shapes. • Proposed haulage route at RL 1.35 m AHD represented with z-shapes. • Cumulative development pads as per Figure 4.2.

Parameters	Details
2D Resolution	• 8m grid.
Timestep	• Adaptive timestep (HPC)

Inflows	• Regional assessment Inflows represented as 2D boundary conditions
	  ○ One (1) inflow represented as flow-time boundary conditions – extracted from Council's Regional Tweed River Flood model results.
	  ○ Five (5) inflows across the model domain represented as source area inflows – Adopted from Council's Regional Tweed River Flood model.
	  ○ One SA inflow polygon extent was altered to ensure consistent inflow locations between development scenarios.
	• All boundary conditions were sampled from consistent Council TUFLOW Flood event results.
	• Local flood model adopted rain-on-grid modelling. Refer to Section 4.3 for further detail on rainfall selection.

Downstream Boundary Condition	• Regional assessment water level represented as 2D boundary conditions
	  ○ One (1) location for water level-time boundary condition – taken from Council's TUFLOW Flood model.
	• Local flood assessment adopted a:
	  ○ Stage-Discharge (HQ) outflow boundary condition along model domain perimeter with prescribed water surface slope of 1%.
	  ○ Static tailwater (HT) of 0.6 m AHD within the Tweed River.

Surface Roughness (reflected as Manning's 'n')	• Please refer to Appendix C for Manning's roughness maps used within the TUFLOW model. The following roughness values have been applied depending land use:
	1D roughness values
	  ○ n = 0.022 – Water body
	  ○ n = 0.030 – Riverbed
	  ○ n = 0.125 – Riverbanks
	  ○ n = 0.060 – Floodplain
	  ○ n = 0.013 – Culverts
	2D roughness values
	  ○ n = 0.030 – River / waterways
	  ○ n = 0.026 – Tidal waterways
	  ○ n = 0.090 – Riverbanks
	  ○ n = 0.100 – Dense vegetation
	  ○ n = 0.080 – Vegetated islands in river
	  ○ n = 0.060 – Cleared / grazing / bare land
	  ○ n = 0.040 – Parks
	  ○ n = 0.150 – Sugarcane
	  ○ n = 1.000 – urban
	  ○ n = 0.025 – highway / roads

Parameters	Details
1D Hydraulic Structures	• Various hydraulic structures were represented across the model domain. Primarily these structures are large regional culverts and bridges. For further information on the structures modeled, please refer to Survey of Culverts Drawing in Appendix G. • Street drainage and small local drainage networks have not been represented within the model.

5.2 Development Representation

The hydraulic model has considered the sand plant expansion for a series of development scenarios (Phase 7, 9 and 11). The development has been represented in the following ways:

- Areas of sand extraction have been reduced to a depth of RL -20 m AHD.
- Areas of sand extraction have a Manning's Roughness value of 0.022.
- The proposed lakes have been modelled as full at the start of the event, i.e. Lake 1 at RL 0.5 m AHD and Lake 2 at RL 1.0 m AHD.
- The proposed new process facility was lifted to the Designated Flood Level for the site (RL 3.22 m AHD).
- The proposed bunding of Lake 2 at RL 1.0 m AHD has been represented in the hydraulic modelling.
- The proposed haulage route at RL 1.35 m AHD has been represented in the hydraulic modelling.
- All proposed hydraulic structures (culverts) associated with the development.

5.3 Model Calibration

The TUFLOW model was calibrated against the existing Tweed River Flood Model results at refined cell size (40m to 8m). The refined TUFLOW model was calibrated 1 in 100 AEP flood result from the regional council flood model. Refinements to the hydraulic model were made for a better representation of the drainage system this included:

- 1m resolution topography data;
- Defined farmers drains;
- Additional 1D elements (survey information);
- Revised SA inflow location.

Calibration of the model was achieved through an iterative process in which input parameters were adjusted. Input parameters adjusted included:

- Topographic model roughness (Manning's R=roughness); and
- Boundary condition location/type.

A number of other factors should be noted which can influence calibration including the following:

- Accuracy of topographic source data, typically +/- 300mm (E.g. Council LiDAR topography vs detailed bathymetry survey);
- Hydraulic model accuracy, understood to be typically +/- 10mm

With consideration of the above factors the TUFLOW model built for this report was calibrated to what was considered an acceptable level.

The results of the calibration are presented in Figure 05 of Appendix D. As shown the refined model is generally within 10mm to 20mm of the approved Council result.

6. Flood Results

6.1 Local Hydraulic Results

With the expansion of the plant and sand extraction area the existing hydraulic regime will be altered. To assess the impact of this, the following flooding has been quantified in the existing and proposed ultimate scenario (Phase 11):

- Peak flow at each of the floodplain's drainage points (the two culverts sets that run beneath the M1);
- Impact Assessment of the change in water level within the floodplain surrounding the development;
- Frequency at which it can be expected that the perimeter bunds will be overtopped by external catchment runoff; and
- Time of inundation on the surrounding agricultural properties.

6.1.1 Peak Flow Assessment

The following peak flows at each of the site's Legal Point of Discharge (LPD) have been calculated for the existing and proposed developed condition as shown in Table 6.1 and Table 6.2.

Table 6.1 Peak Flow Assessment LPD 1 (Northern M1 Culverts)

AEP	Existing Scenario		Proposed Ultimate Scenario		Change
	Critical Storm	Peak Flow (m^3/s)	Critical Storm	Peak Flow (m^3/s)	(m^3/s)
1%	18hr Ens 8	3.06	18hr Ens 8	3.03	-0.03
2%	18hr Ens 8	2.51	18hr Ens 8	2.50	-0.01
5%	36hr Ens 6	1.84	36hr Ens 6	1.92	0.08
10%	36hr Ens 1	1.68	36hr Ens 1	1.66	-0.02
20%	36hr Ens 6	1.37	36hr Ens 6	1.40	0.03
0.5EY	36hr Ens 9	1.06	36hr Ens 9	1.00	-0.06

Table 6.2 Peak Flow Assessment LPD 2 (Southern M1 Culverts)

AEP	Existing Scenario		Proposed Ultimate Scenario		Change
	Critical Storm	Peak Flow (m^3/s)	Critical Storm	Peak Flow (m^3/s)	(m^3/s)
1%	18hr Ens 8	19.36	18hr Ens 8	18.81	-0.55
2%	18hr Ens 8	12.79	18hr Ens 8	13.36	0.57
5%	36hr Ens 6	7.97	36hr Ens 6	8.01	0.04
10%	36hr Ens 1	5.79	36hr Ens 1	6.01	0.22
20%	36hr Ens 6	3.70	36hr Ens 6	4.03	0.33
0.5EY	36hr Ens 9	1.72	36hr Ens 9	2.06	0.34

Generally peak flows at the site's LPDs are maintained in the post-developed scenario. A maximum increase 0.57 m^3/s is experienced at the Southern M1 Culverts in the 2% AEP. This equates to a 4% increase in flows and it is not anticipated that this will cause adverse hydraulic impacts or give rise to nuisance in the downstream floodplain.

6.1.2 Local Hydraulic Impact Assessment

To assess the impacts of the proposed lakes and the associated bunding the peak water levels within the model domain were interrogated. Afflux mapping has been prepared in Appendix F of this report. All afflux associated with the development in the local scenario is within the limits of the defined acceptable afflux, discussed in Section 4.6.1. Notable local afflux within results has been described in Table 6.3 below.

Table 6.3 Noteable Local Afflux

	**1% AEP, 2% AEP, 5% AEP Phase 11** Minor afflux occurs within the location of the existing service center at the M1 Murwillumbah Exit. Afflux less than 30mm and within the acceptable threshold for afflux on a commercial property.

6.1.3 Lake Bund Overtop Frequency

A review of the frequency overtopping of the lake perimeter bund and overflow weir was completed to inform the assessment. The following table details the local flood immunity and associated expected frequency at which the lake will receive external runoff.

Table 6.4 Local Flood Bund Immunity

	Bund Invert Level (m AHD)	Bund Immunity* AEP	Overflow Weir Invert Level (m AHD)	Overflow Weir Immunity AEP
Lake 1	Nil	Nil	0.50	0.5EY
Lake 2	1.0	0.5EY	1.00	0.5EY

*NOTE: Bund immunity refers to the event in which overtopping first occurs.

As is shown in the above table, external flows are freely permitted to discharge into Lake 1 during storm events. No significant catchments exist at Lake 1. Lake 1 water level is controlled by the outlet weir that will discharge during most rainfall events.

Overtopping of Lake 2 bunding will occur in events above the 0.5EY. Drainage Channels that run around the perimeter of the lake will convey stormwater to the LPD as per the existing condition.

6.1.4 Time of Inundation

A time of inundation assessment was completed for the local flooding condition that reviewed flooding for all surrounding agricultural properties. The review focused on any significant changes to the rise and fall of flood waters on the subject site. The results of the inundation assessment are included in Appendix E.

It has been determined that alteration of the floodplain in the area of Lake 2 has changed the volume of runoff that drains to western cane farms located between the M1 and Tweed Valley Way. The increased volume of water in this area results in a longer drainage time for the farms. It is anticipated that these downstream properties will remain flooded for a longer period of time than experienced in the existing condition.

In other areas of the floodplain (to the north and east) it has been determined that there will be no significant change of inundation time in the developed scenario.

6.2 Regional Hydraulic Flood Results

A summary of the regional flooding at the subject site has been included in the below sections. The regional flood assessment also involved an impact assessment of the development effect on the surrounding water level.

6.2.1 Existing Flood Behaviour

The results of the hydraulic modelling were interrogated and assessed against the project objectives. Flooding at the subject site and within the model domain can be summarised as follows:

- The Designated Flood Level (DFL) for the subject site varies between RL 3.22 m AHD and 3.30 m AHD. The DFL refers to the 1% AEP event.
- The site is inundated from the west as flood waters from the Tweed river are conveyed over and under the M1.
- The M1 is overtopped by flood waters in approximately a 5% AEP flood event.
- Generally flooding at the site is low in velocity with peak velocities reaching 0.2 m/s. The highest velocity at the site reaches 0.6 m/s at the southern M1 culvert set.
- The hydraulic categorisation of flooding at the site can be defined as a flood storage area.
- The primary floodway within the model exists within the Tweed River.
- Parts of the Chinderah and Kingscliff townships are inundated in the existing condition.
  - In the 1% AEP the average flood depth in Chinderah is above 1.2m. Velocity in this area is low and the area can be defined as flood storage area.
  - In the 1% AEP the average flood depth in the area bounded by Kingscliff St and Sand St is above 0.8m. This are can be defined as flood fringe area.

6.2.2 Post-Development Flood Behaviour

The regional results of the hydraulic modelling for the ultimate developed case are generally the same as the existing scenario with the overall characteristics of flooding being unchanged. The proposed lakes allow flood waters to be conveyed across them with less resistance than the existing farm paddocks, creating a marginal change to the level of flooding in some areas of the model domain. Further discussion on the impacts cause by the development is included in Section 6.2.3.

The proposed development maintains a flood free processing plant up to the 1% AEP event, in times of flood equipment will be stored here and be safe from damage. The proposed haulage route has a 20% AEP immunity.

Peak water surface level and velocity plots for the modelled events have been included in Appendix F of this report.

The following design flood levels have been determined for the subject site in the post-development, the flood levels vary across the sites area due to its size, so the maximum flood level at the location of the future washdown facility has been taken for each event.

Table 6.5 Flood Levels at the Subject Site (Washdown Facility Vicintiy)

Flood Event (AEP)	Design Flood Levels (m AHD)	
	Existing Scenario	Ultimate Developed Scenario
20%	1.55	1.47
5%	2.31	2.35
1%	3.25	3.25
1% + CC	4.72	4.74
0.2%	4.71	4.74
PMF	6.48	6.48

6.2.3 Regional Hydraulic Impact Assessment

The changes that the development proposes to flooding within the Tweed Floodplain have been assessed against the acceptable afflux limits outlined in Section 4.6.1. Generally the proposed expansion of the sand plant results in acceptable flood impacts across the model domain. Impacts are primarily experienced in the more frequent flood events (20% AEP), a summary of the impact assessment for each AEP has been included in Table 6.6. Notable afflux within results has been described in Table 6.7. Afflux results are contained within Appendix F of this report.

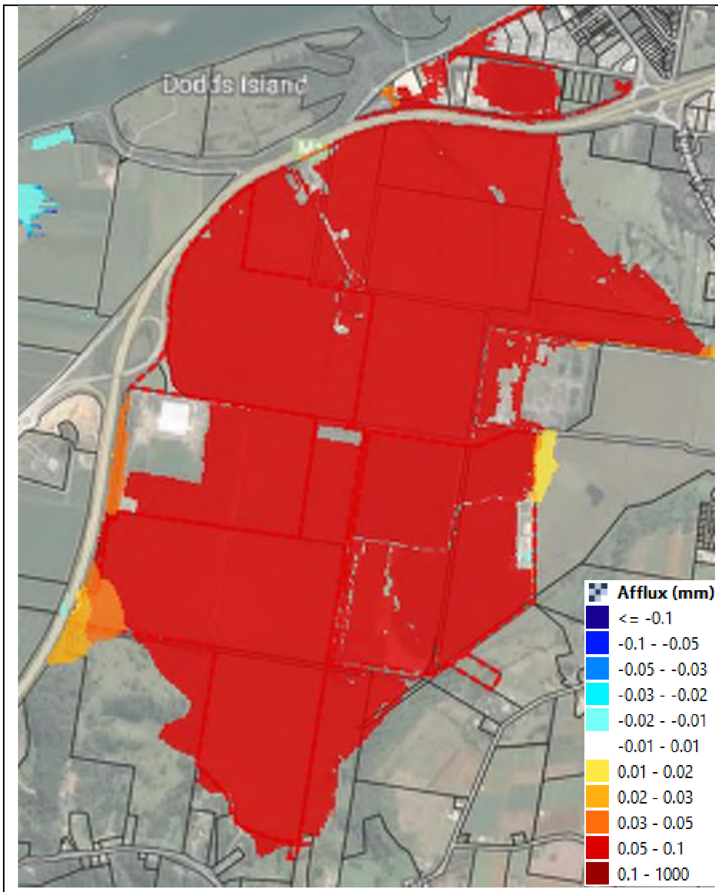
Within the model domain, small pockets of afflux (consisting of a small number of model cells) exist. These pockets of afflux have been removed from the assessment as they are classified as 'model noise'. Discussion on how this erroneous afflux is caused is provided in Section 4.5.2.

Table 6.6 Impact Assessment Summary

Event (AEP)	Impact Description
20%	The proposed development increases the flood level within the floodplain area by between 60-30mm depending on the development phasing. Increased flooding is primarily located on vacant agricultural land and does not specifically impact on any existing residential or commercial structures.

	Afflux is caused by a loss of flood storage over Lake 2 area that has a standing water level of RL 1.0 m AHD Impact in Phase 9 is the most significant with Phase 11 being the least, for the 20% AEP flood event.
5%	The proposed development proposes no significant change to flooding within the Lower Tweed River Floodplain for the 5% AEP in the Ultimate Development state. Minor afflux is experienced in isolated pockets during Phase 9 of the development as discussed below. Flood impact is comparable across the proposed development phasing for the 5% AEP.
1%	The proposed development proposes no significant change to flooding within the Lower Tweed River Floodplain for the 1% AEP for the ultimate development state. Flood impact is comparable across the proposed development phasing for the 1% AEP.
1% + Climate Change (CC)	The flood level for the 1% AEP + CC is largely unchanged in the proposed developed scenario. A decrease in flood level is experienced in the area around the southern M1 culvert set as flood water dips into the newly created lake, and a small increase in flood level (between 10mm-20mm) occurs immediately to the east of the subject site and the afflux extent is largest in the Phase 9 of the development staging. Afflux is reduced in the ultimate phase (Phase 11) and only exists within the floodplain area. The afflux is comparable in Phases 9 and 11 of the development and is reduced in Phase 7 of the development for the 1% + CC.
0.2%	The impacts experienced in the 0.2% are comparable to that experienced in the 1% climate change event, with no major noticeable difference in flooding afflux between the events.
EXT 0.005%	Generally, the flood level is improved across the model domain for the EXT event with a reduction in modelled flood level of 10-20mm across much of Chinderah and Kingscliff. A small area of flood area at the western M1 culverts to the west of the subject is impacted by the creation of the proposed lakes. Afflux in this area peaks at 30mm and does not impact on any residential dwellings.

Table 6.7 Noteable Regional Afflux

	**20% AEP – Phase 7-11** Signifcant afflux expereinced across the floodplain (peaking at 63mm) at the subject site and external to the development. Caused by the introduction of the development's proposed lakes and haulage route (that sits at RL 1.35 m AHD). The worst afflux occurs during Phase 9 of the development, with the development achiveing better afflux results in the Ultimate Phase (approximately 20mm less across the floodplain area) Afflux occurs primarily on vacant agricultural land and does not impact on residential dwellings. Some commercial landuses are impacted up to 50mm however these impacts are isolated to drainage areas and does not impact directly on the commercial buildings. Noting that afflux discussed above is within the acceptable limits as defined by Section 4.5.2 (less than 100mm).
	**20% AEP – Phase 7-11** Peak impact of 56mm experienced in driveway of Tweed Heritage Caravan Park in Phase 9 of the Development, afflux is reduced in Phase 11 to 36mm. While the afflux experienced on the driveway is outside of the acceptable afflux limits, it is noted that this afflux is only present on the driveway of the facility and does not effect any dwellings. The change in flood level is not considered to be adverse and unlikely to give rise to actionable damage. Afflux experienced to the north and south of the caravan park is located in drainage reserves and does not impact on dwellings and is unlikely to cause an adverse impact.

<table>
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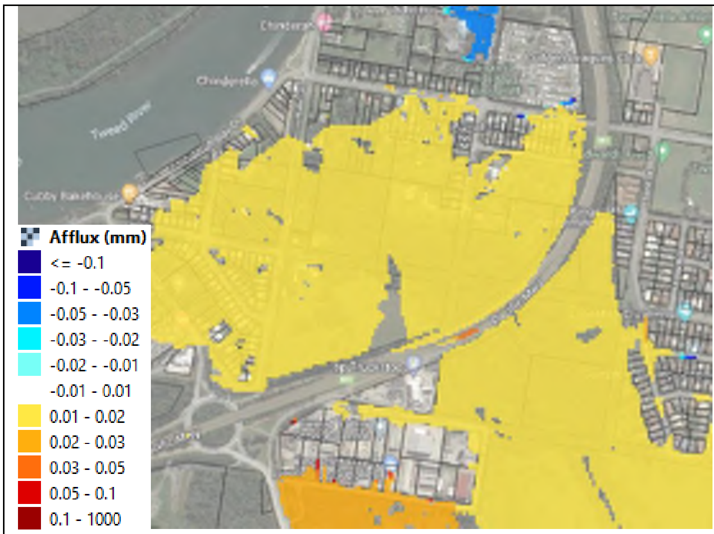
<td>
</td>
<td>5% AEP – Phase 9 ONLY

Hydraulic Impacts with magnitude of 11mm at a number of properties at Chinderah Road, Rutile Street and Terrace Road. Afflux is marginally (1mm) above the acceptable limit for residential dwellings.

Hydraulic impacts with magnitude of 12-13mm occurs along properties on Wommin Bay Road and Ocean Drive. Afflux is marginally above the acceptable limit for residential dwellings.

The following should be noted:

• Afflux occurs in an interim phase (Phase 9) of the development that will only exist for 3 years.
• Afflux returns to acceptable limits in the Ultimate development scenario for the 20% AEP event.</td>
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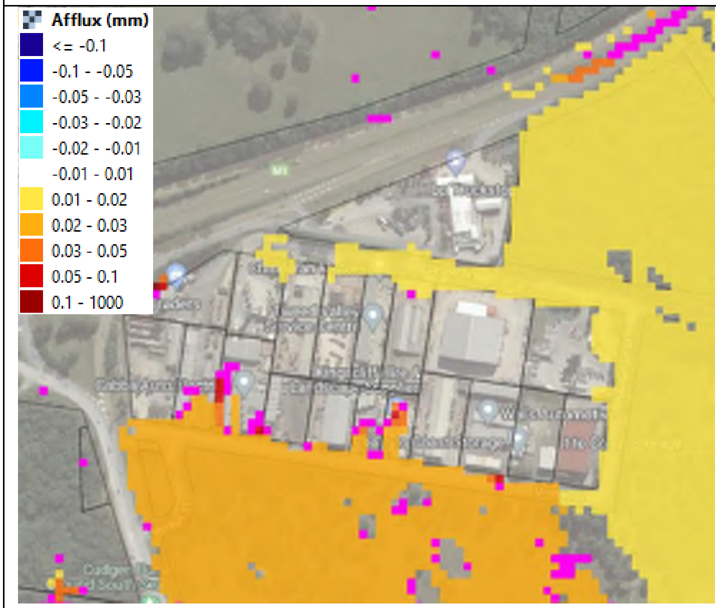
<tr>
<td>
</td>
<td>5% AEP – Phase 7-11

Minor afflux occurs along industrial properties Morton Street. Peak afflux occurs in Phase 9 of the development and is within acceptable afflux limits, peaking at 28mm.</td>
</tr>
</table>

6.2.4 Cumulative Development Scenario

At the request of Tweed Shire Council consideration has been given to the cumulative development scenario recommended by the Tweed Valley Floodplain Risk Management Study (BMT WBM, 2014). The results of the cumulative development scenario indicate that the addition of the proposed lakes maintain the desired flood outcome with consideration for all future development within the Lower Tweed River Floodplain. That is:

- A 'no change' modelling tolerance of 30 mm;

- Increase of peak flood levels of up to 35 mm limit for existing residential zoned areas; and
- Increase of peak flood levels of up to 100 mm limit for existing rural zoned areas in the floodplain.

Results of the cumulative development scenario are included in Appendix F of this report.

6.3 Flood Storage Assessment

The proposed expansion of the sand plant will result in a significant loss in flood storage volume as the proposal seeks to raise the standing water level of Lake 2 to RL 1.0 m AHD. Flood storage calculations taken from the DFL (3.22 m AHD) to the standing water level at site (1.0 m AHD) have been completed and are summarised in the following table.

Table 6.8 Flood Storage Balance

Existing Flood Storage Volume	Proposed Flood Storage Volume (Final Phase of Development)	Balance
4,829,760 m^3	4,611,069 m^3	Loss of 218,691 m^3

The loss in floodplain storage is the primary cause of increased flood level throughout the model domain.

7. Conclusion

Burchills Engineering Solutions have been engaged by Hanson Construction Materials Pty Ltd to prepare a Flood & Stormwater Assessment (FSA) for Hanson's Tweed Sand Plant, which is located on Altona Road in Cudgen, NSW. The proposed development intends to expand the sand extraction area and increase operations from 500,000 tonnes/year to 950,000 tonnes/year.

A local food assessment has been completed and it has been determined that the proposed development does not have an adverse impact on the local hydrological regime. No downstream properties will be negatively impacted by the proposed development with respect to stormwater quantity.

The hydraulic modelling has assessed the potential impacts caused by the proposed development in accordance with the *SEARs* documentation and Tweed Shire Council feedback. It has been determined that the proposed development is unlikely to cause adverse impacts on the regional flood behaviour for the design event simulated in the Ultimate development state.

8. References

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Appendix A –Proposed Sand Plant Phasing

PROJECT TITLE

HANSON TWEED SAND PLANT EXPANSION PHASE 5 TO PHASE 11

ENVIRONMENTAL IMPACT STATEMENT

DRAWING TITLE

FIGURE 19: EXTRACTION PHASES

REV	DESCRIPTION	DATE	DRAWN	DESIGN	CHECK	APPROVED
A	PHASING ARRANGEMENT CHANGES - REQ. PLANNER	25/01/2021	ZP	LN	LN	LN
B	PHASING ARRANGEMENT CHANGES - REQ. PLANNER	15/10/2021	MS	LN	LN	LN

ISSUE: PRELIMINARY

CLIENT: HANSON CONSTRUCTION MATERIALS PTY LTD

BASE PROVIDED BY: SIXMAPS DCDB

MANAGER: LANCE NEWLEY

ZONE PLANNING GROUP

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PO Box 3805, Burleigh Town QLD 4220

GLADSTONE
2/172 Goondoon St, Gladstone, QLD 4680
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JOB / DRAWING NO: Z19163- F119

SHEET NO. SHEET 17 OF 21

PROJECT TITLE

HANSON TWEED SAND PLANT EXPANSION PHASE 5 TO PHASE 11

ENVIRONMENTAL IMPACT STATEMENT

DRAWING TITLE

FIGURE 26: CONCEPT FINAL LANDFORM PLAN

REV	DESCRIPTION	DATE	DRAWN	DESIGN	CHECK	APPROVED
A	PRELIMINARY ISSUE	17/03/21	ZP	LN	LN	LN
B	RFI AMENDMENTS	14/10/21	ZP	LN	LN	LN
C	RFI AMENDMENTS	20/10/21	ZP	LN	LN	LN

ISSUE: PRELIMINARY

CLIENT: HANSON CONSTRUCTION MATERIALS PTY LTD

BASE PROVIDED BY: SIXMAPS DCDB

MANAGER: LANCE NEWLEY

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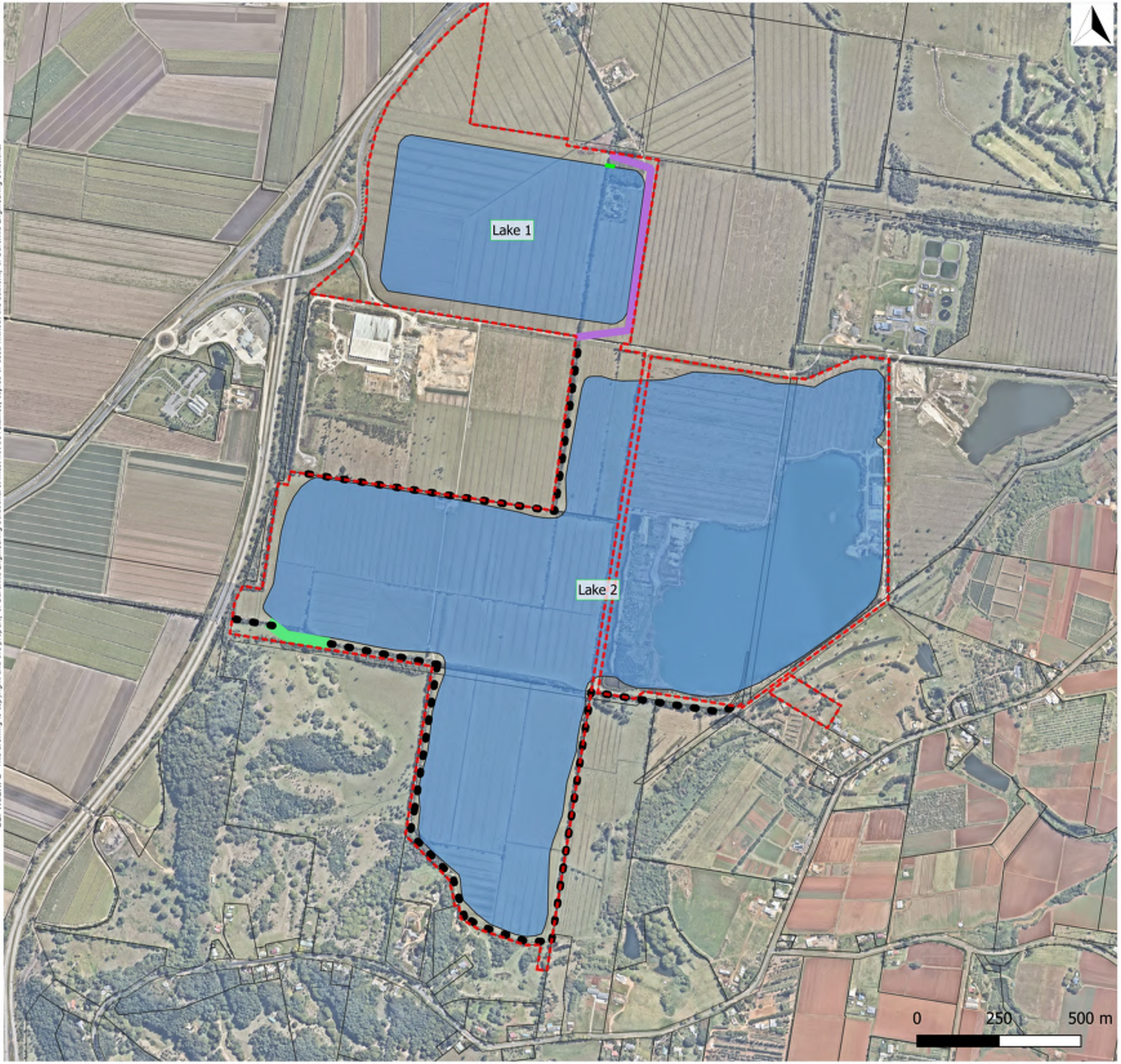
JOB / DRAWING NO:
Z19163- F126

SHEET NO.
SHEET 20 OF 21

Appendix B – Local Drainage Schematic

Tweed Sand Plant

Ultimate Drainage Schematic (Indicative Only)
&
Channel Sizing Requirements



Legend

- Site Extent
- Ultimate Lake Extent
- Proposed Bunding
- Controlled Lake Outlet

Channel Buffers

- 3.5m Base Width, 5.5m Top Width, Batter 1V:1H, 1m Depth
- 5m Base Width, 8m Top Width, Batter 1V:1H, 1.5m Depth
- Utilise Existing Channel

Project: BE190043

Date: 19-10-2021

Scale: 1:10,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources: X

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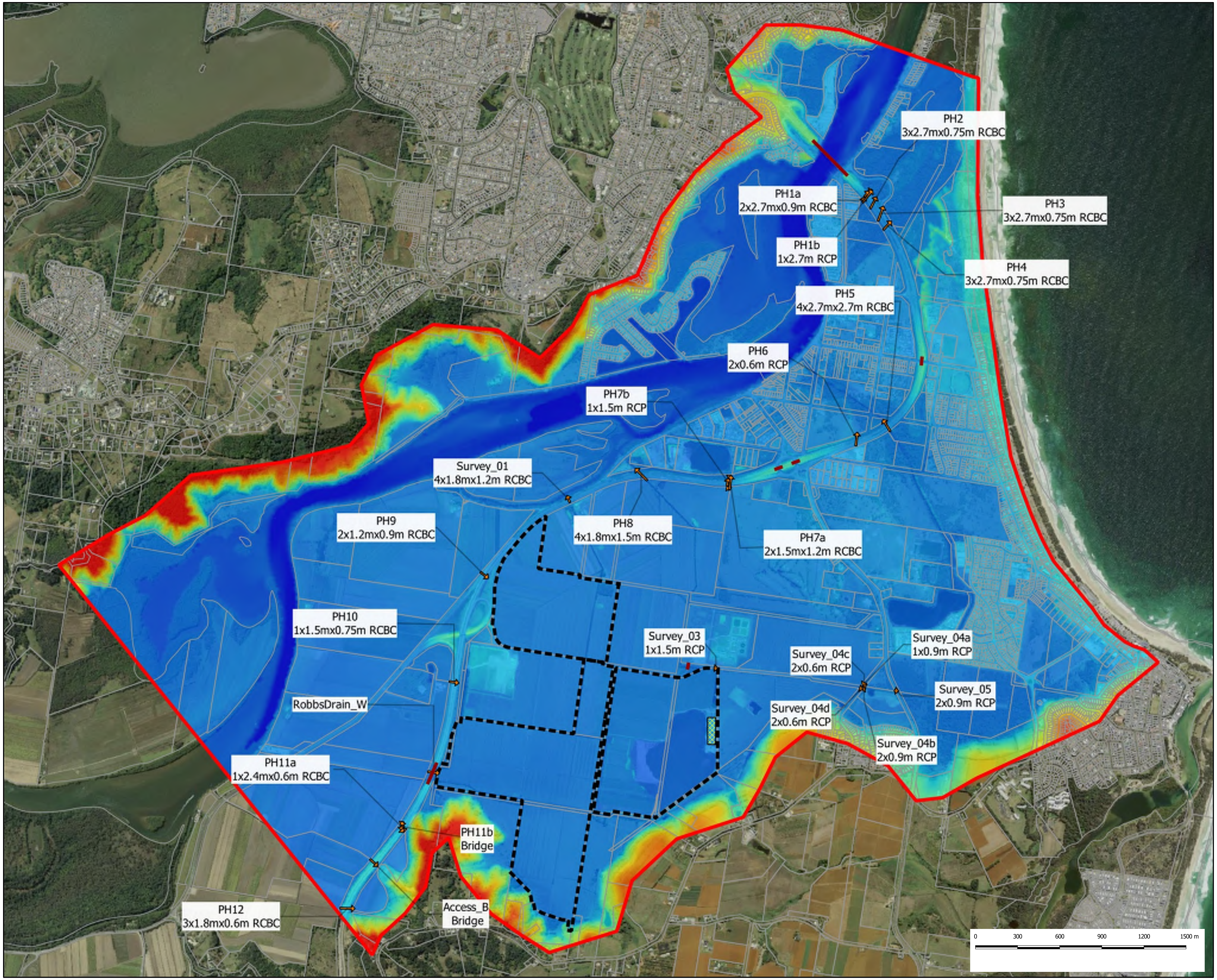
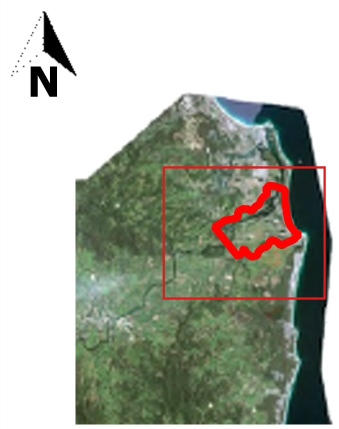
Appendix C – Hydraulic Model Features Maps



Tweed Sand Plant Flood Assessment

FIG 01 PRE DEVELOPMENT TUFLOW MODEL FEATURE - 1



Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Site
- Cadastral
- Hydraulic Structure
- Existing Building & Wash Plant
- 2d_Constriction

Surface Elevation(mAHD)

-5	20
0	30
5	40
10	50

Project: BE190043

Date: 16/10/2020

Scale: 1:25000 at A3

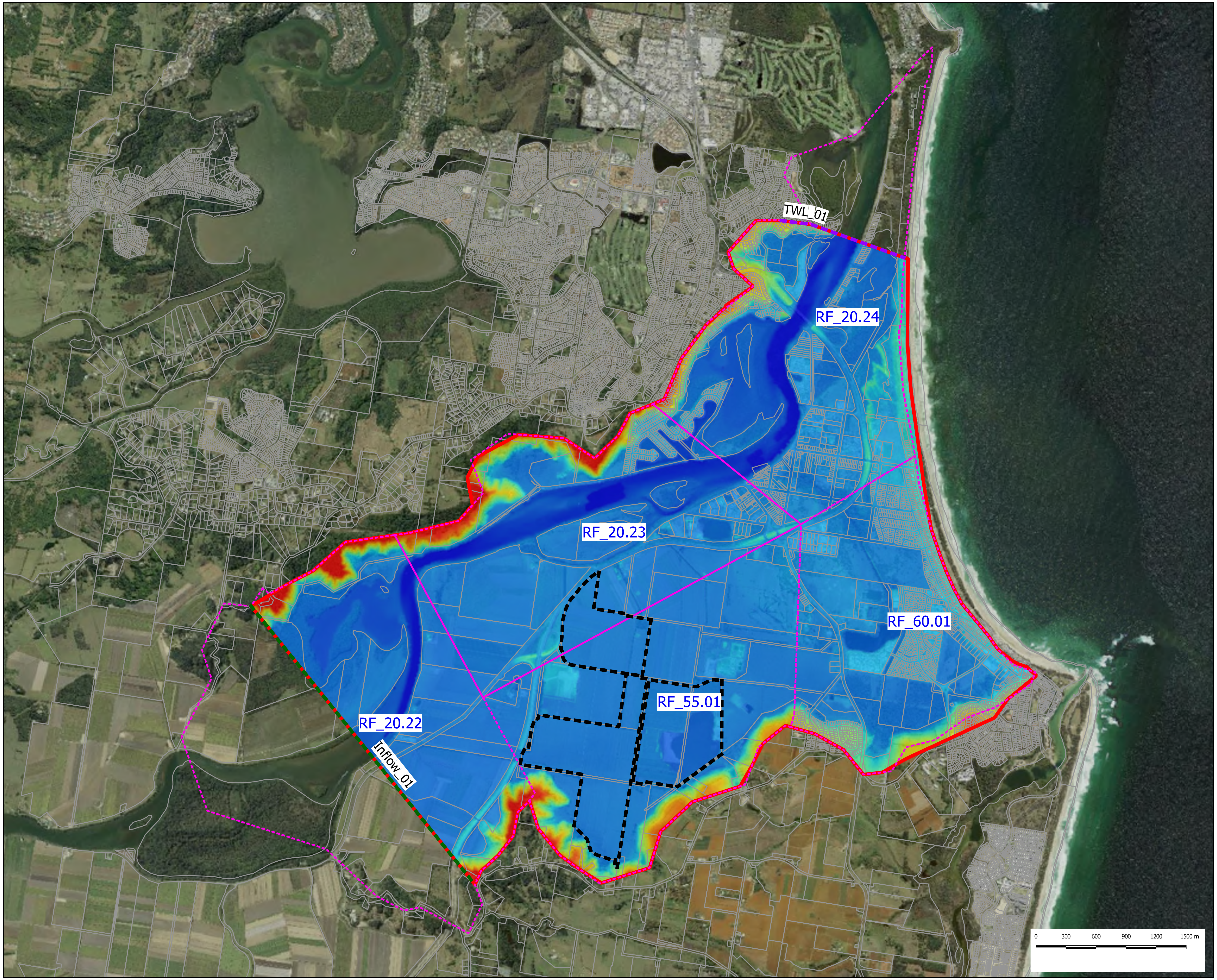
Projection: GDA 94 / MGA ZONE 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson



Tweed Sand Plant Flood Assessment

FIG 02 PRE DEVELOPMENT TUFLOW MODEL FEATURE - 2

N

Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Site
- Cadastral
- Inflow Location
- Inflow Boundary
- Downstream Boundary

Surface Elevation(mAHD)

-5	20
0	30
5	40
10	50

Project: BE190043

Date: 16/10/2020

Scale: 1:35000 at A3

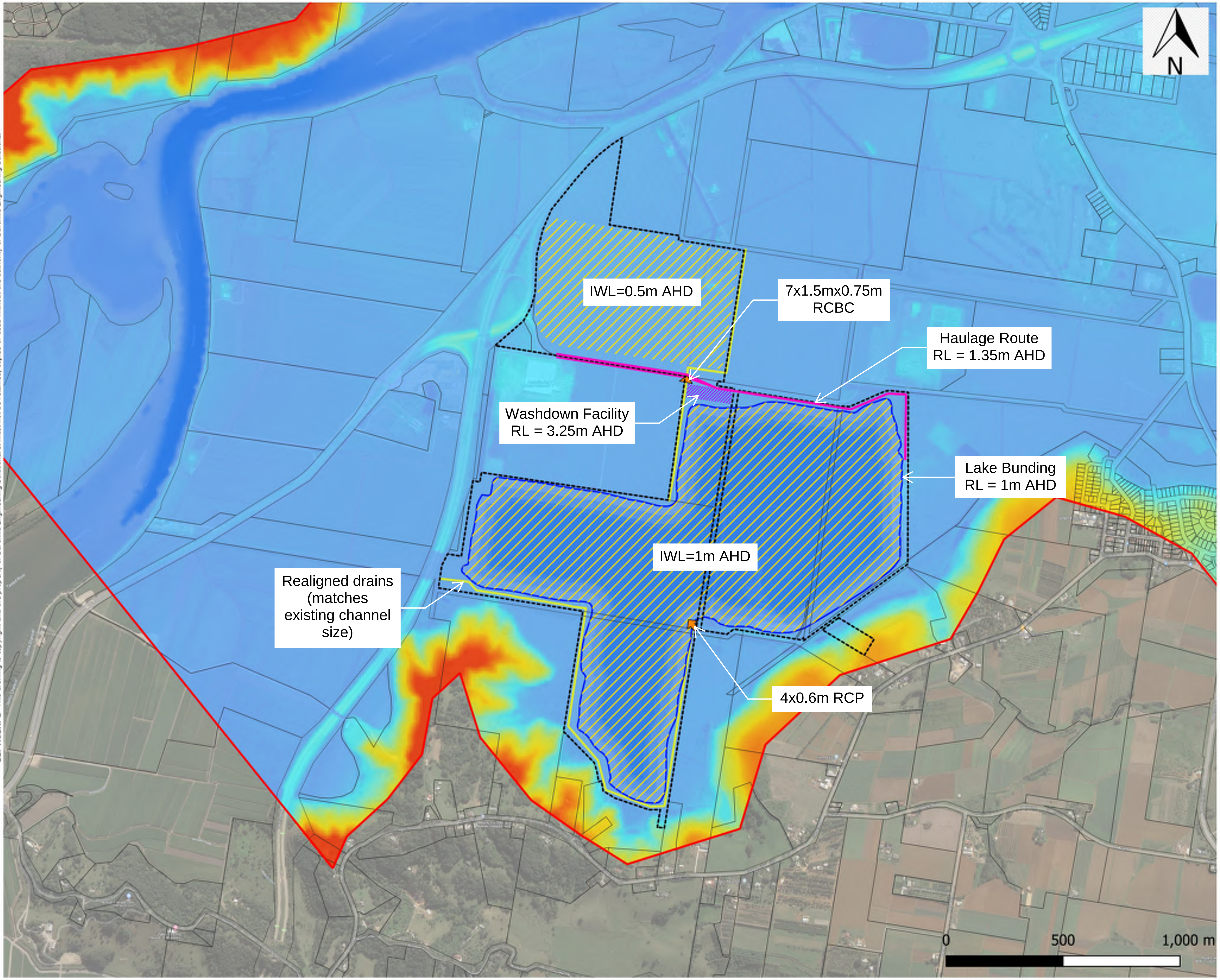
Projection: GDA 94 / MGA ZONE 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson



Tweed Sand Plant Flood Assessment

FIG C03 POST DEVELOPMENT TUFLOW MODEL FEATURE - 1

Legend

- Site Extent
- Model Extent
- Proposed Culvert
- Lake
- Future Building & Wash Plant
- Lake Bunding
- Haulage Route
- Realigned Drains
- Cadastral

Surface Elevation (m AHD)

- -5.0000
- 0.0000
- 5.0000
- 10.0000
- 20.0000
- 30.0000
- 40.0000
- 50.0000

Project: BE190043

Date: 26/10/2021

Scale: 1:15,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

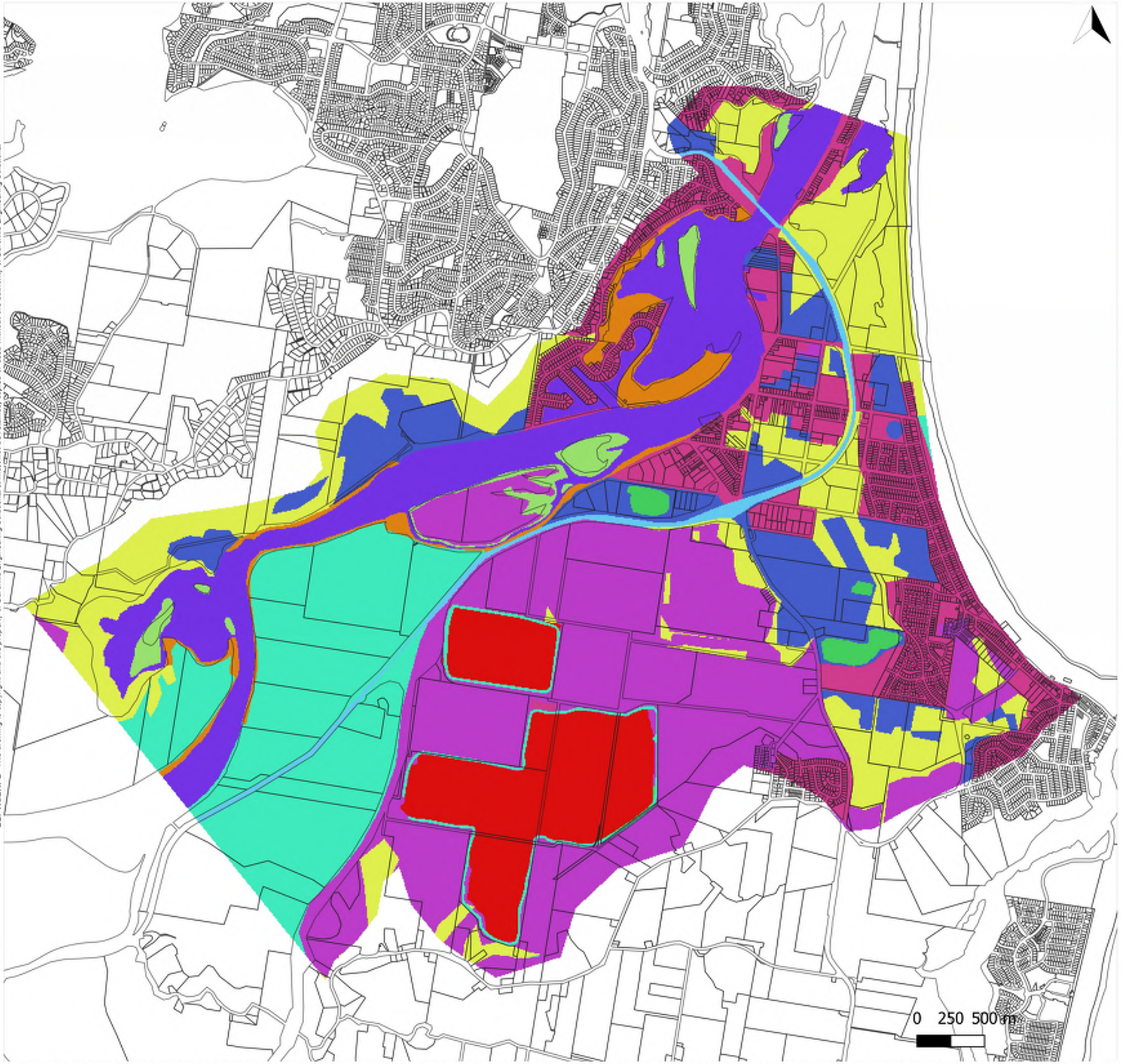
BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson

Tweed Sand Plant

Mannings Roughness Map - Post-Development



Legend

Mannings Roughness

- Waterbody
- River / Waterway
- Tidal Waterway
- River Bank
- Dense Forest
- Vegetated Islands
- Cleared / Grazing / Bare Land
- Parks
- Sugar Cane
- Urban
- Roads / Hwy

Project: BE190043

Date: 19-10-2021

Scale: 1:10,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources: X

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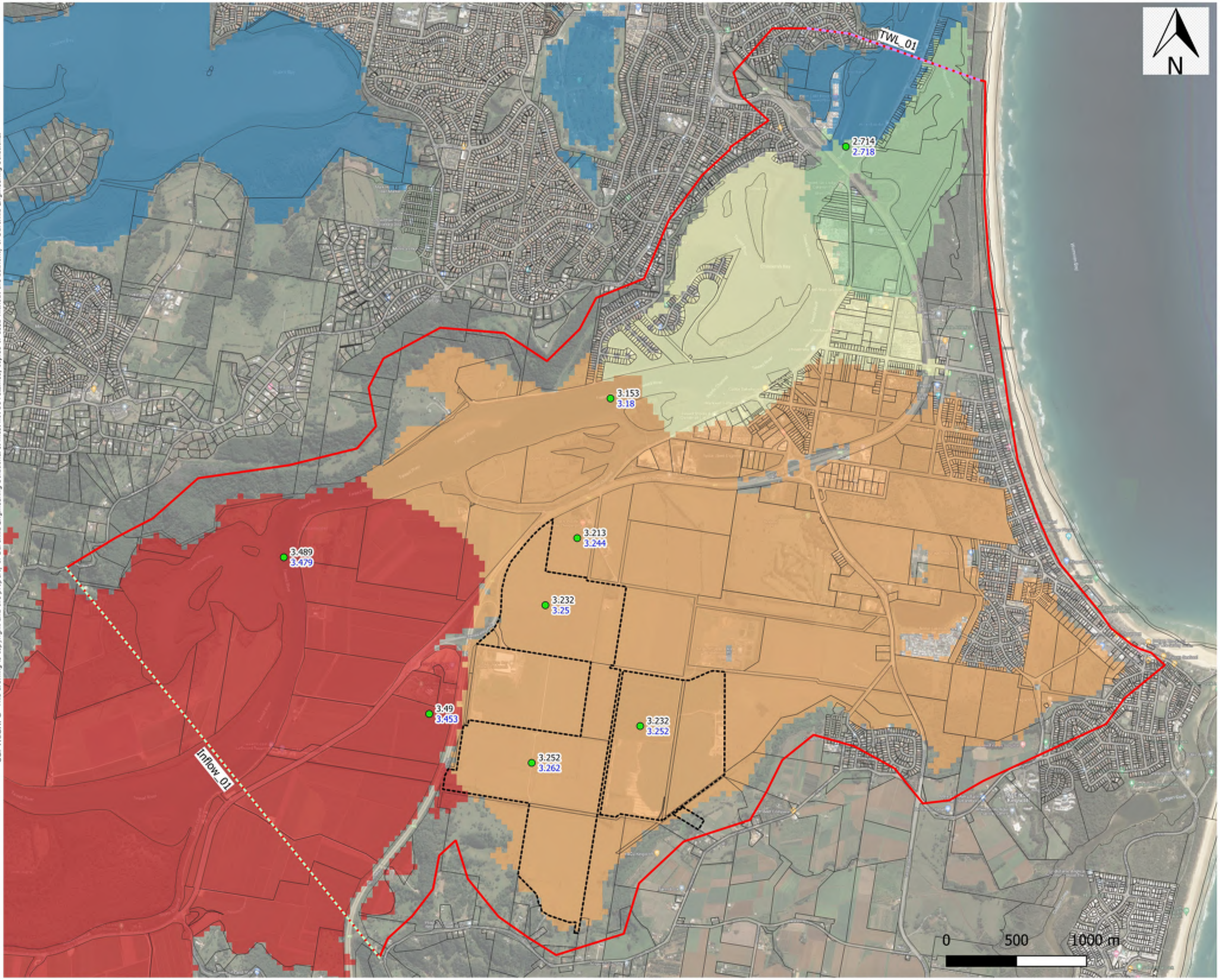
Appendix D – Hydraulic Calibration Results

Tweed Sand Plant Flood Assessment

FIG D01 CALIBRATION 1% AEP BETWEEN TUFLOW MODEL AND COUNCIL MODEL



Legend

- Site Extent
- Downstream Boundary
- Inflow Boundary
- Council Model | TUFLOW Model
- Model Extent
- Cadastral

Water Level (mAHD)

- <= 2.7
- 2.7 - 2.9
- 2.9 - 3.1
- 3.1 - 3.3
- > 3.3

Project: BE190043

Date: 11/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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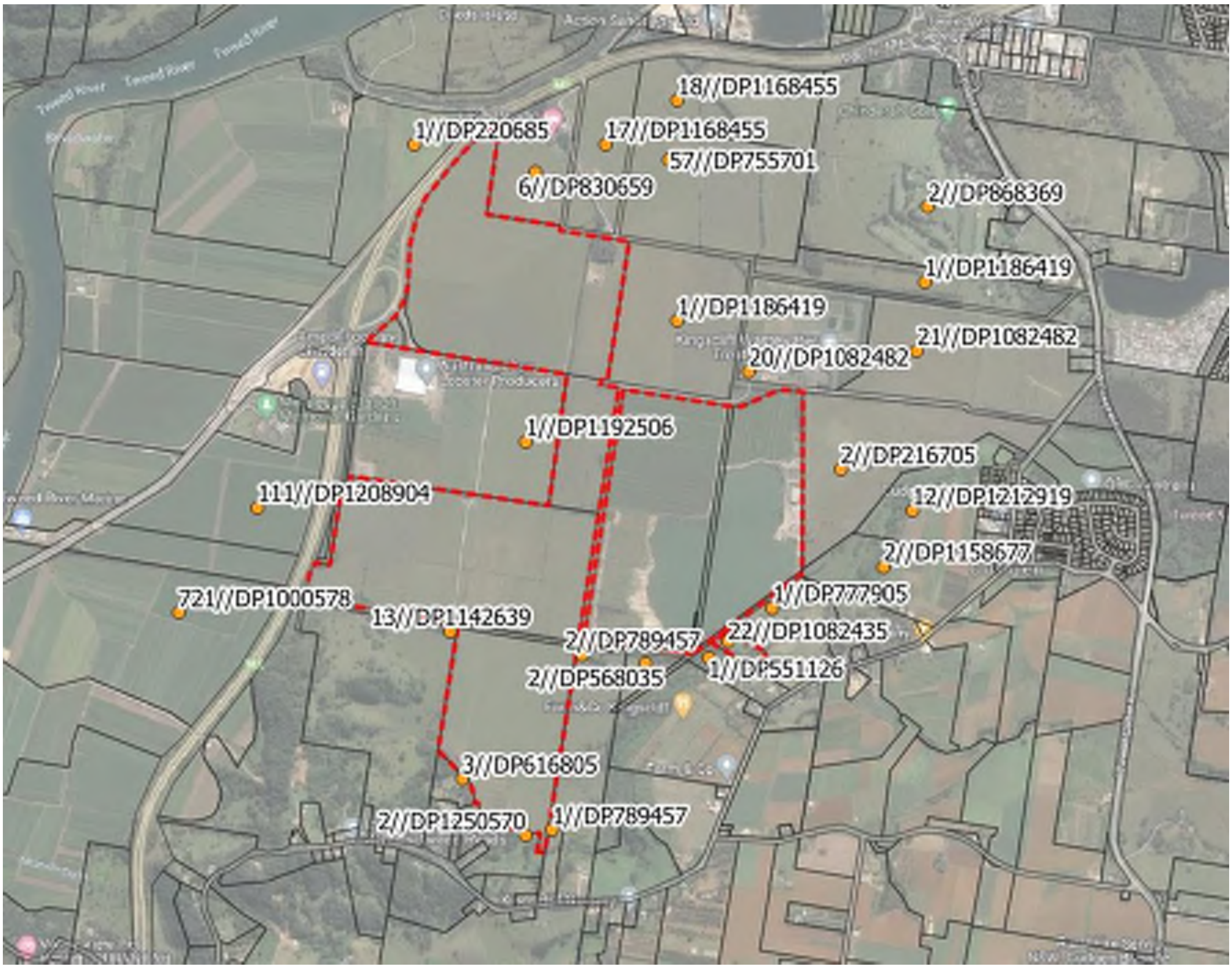
Appendix E – Time of Inundation Assessment Results



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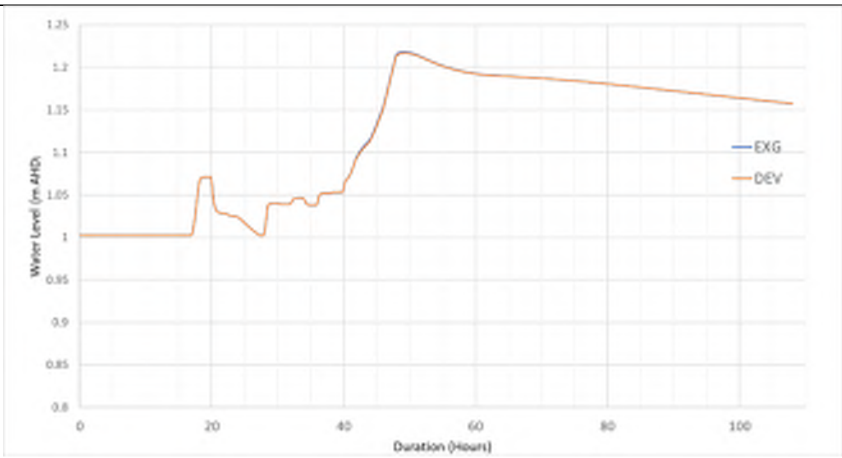
2//DP216705	

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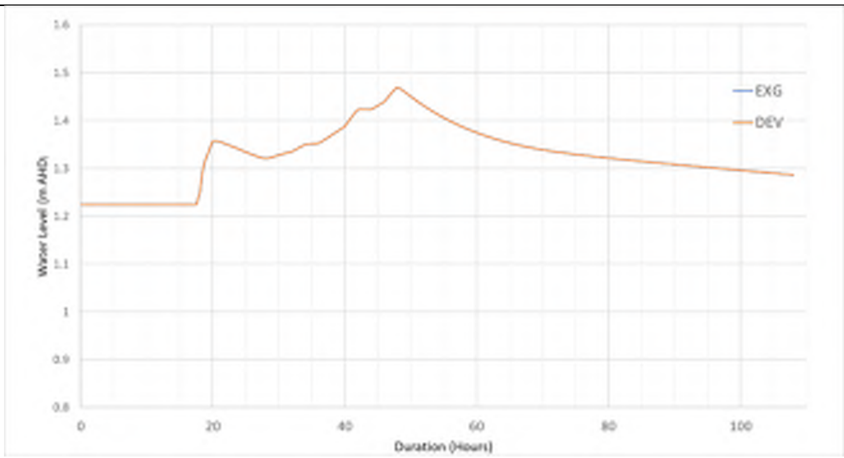
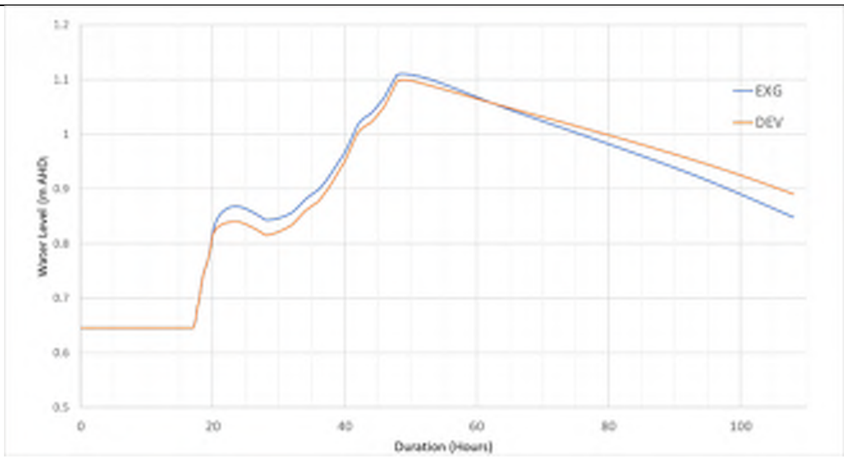
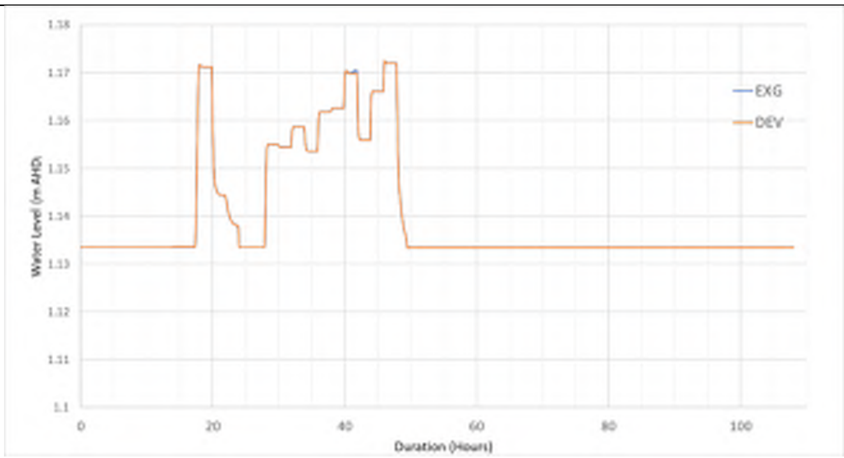
1//DP220685	
57//DP755701	
3//DP616805	

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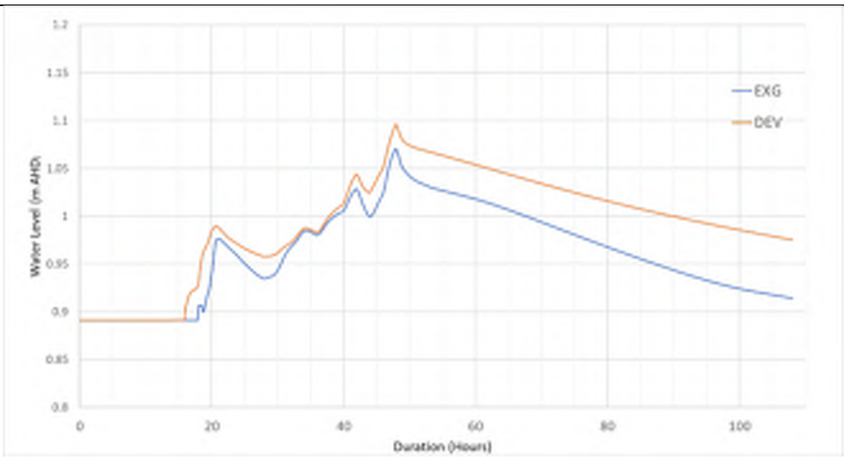
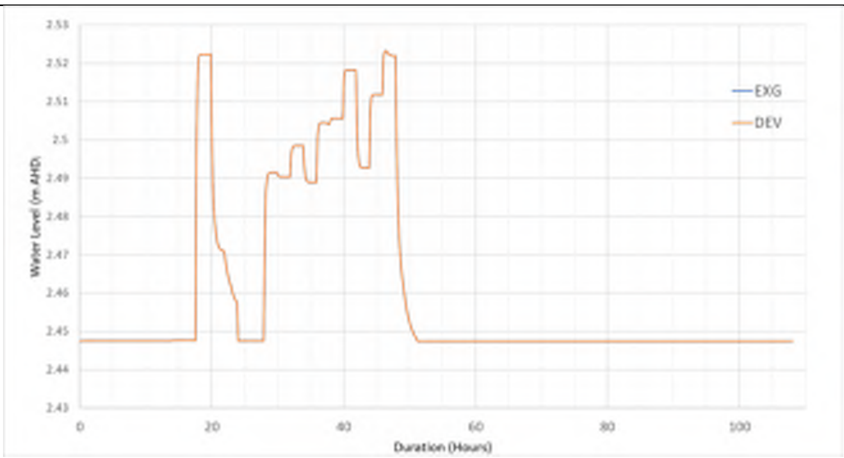
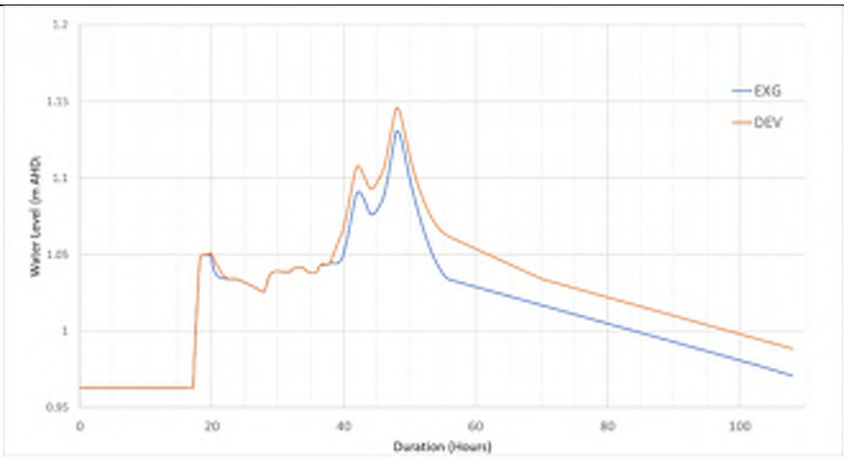
2//DP568035	
1//DP551126	
2//DP789457	

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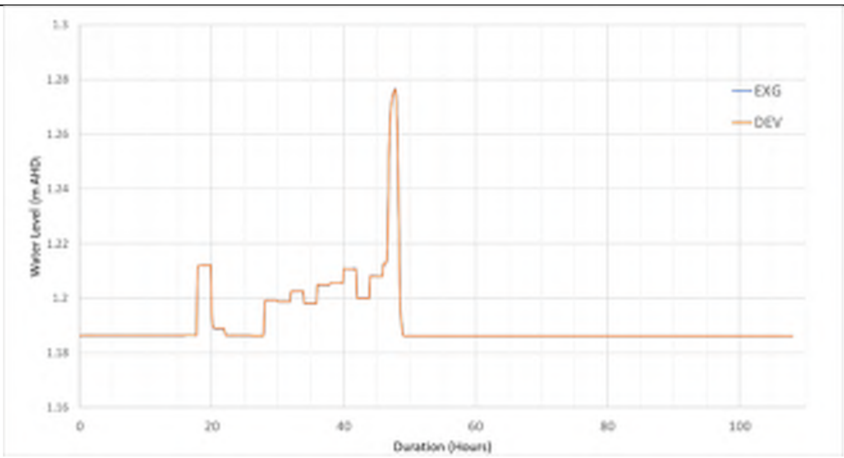
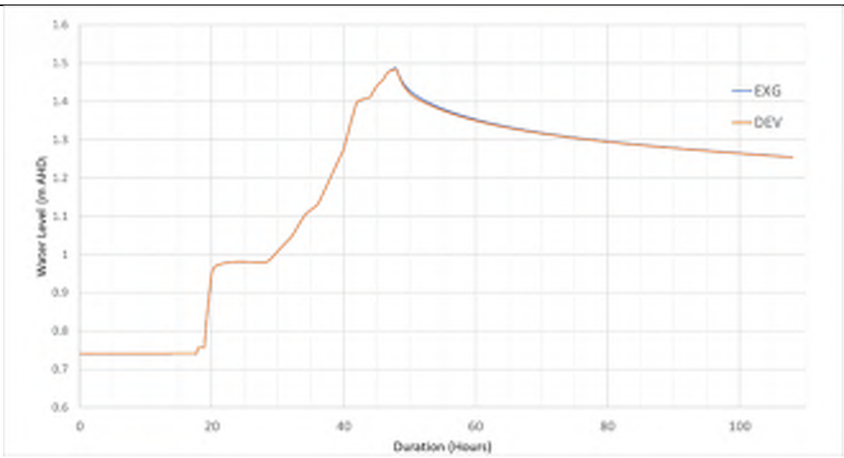
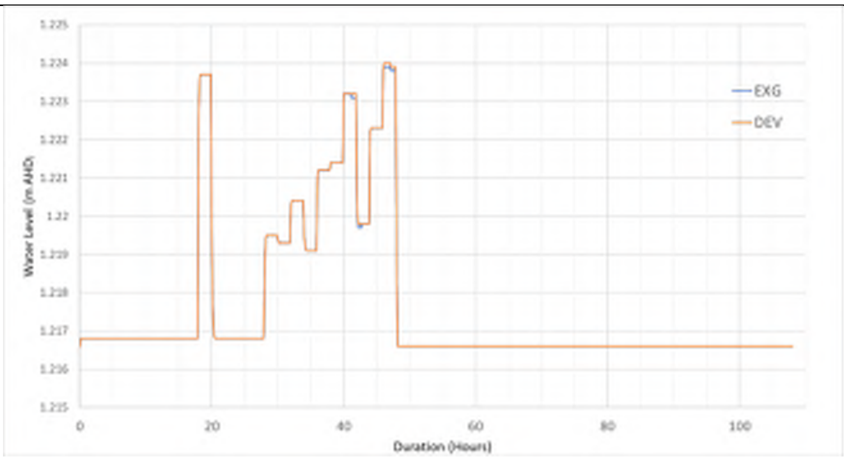
1//DP789457	
1//DP777905	
6//DP830659	

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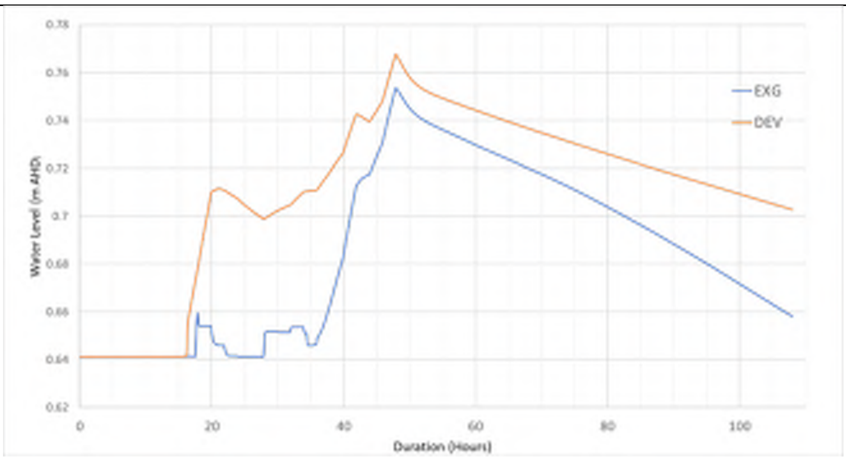
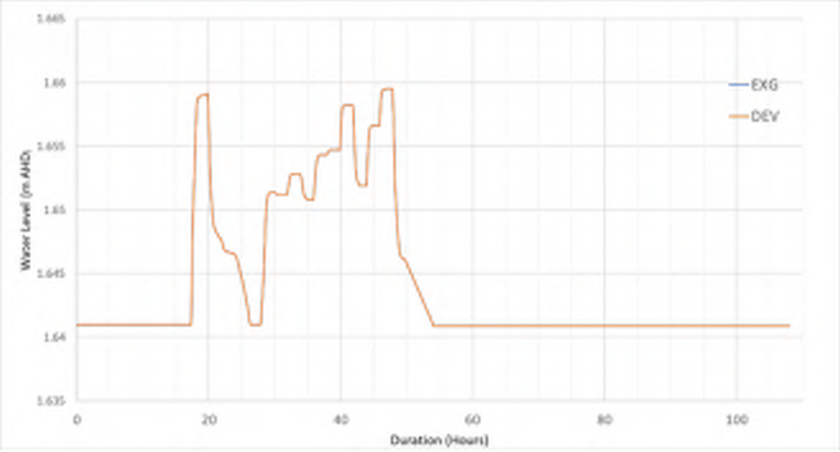
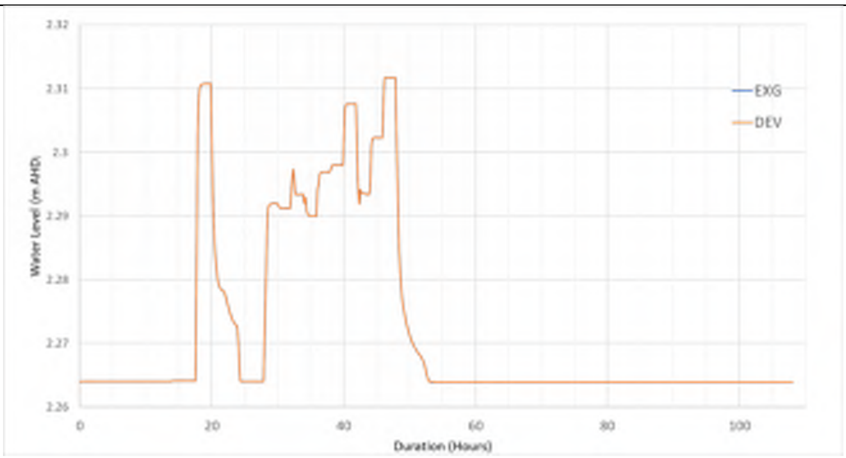
721//DP1000578	
2//DP868369	
22//DP1082435	

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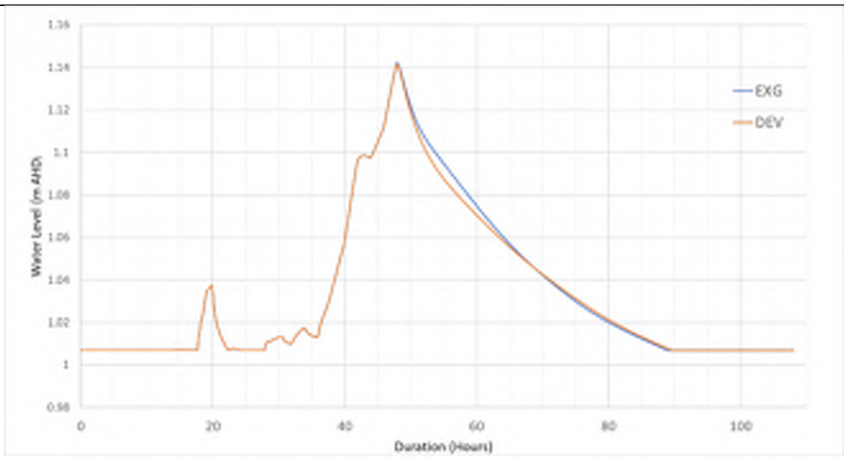
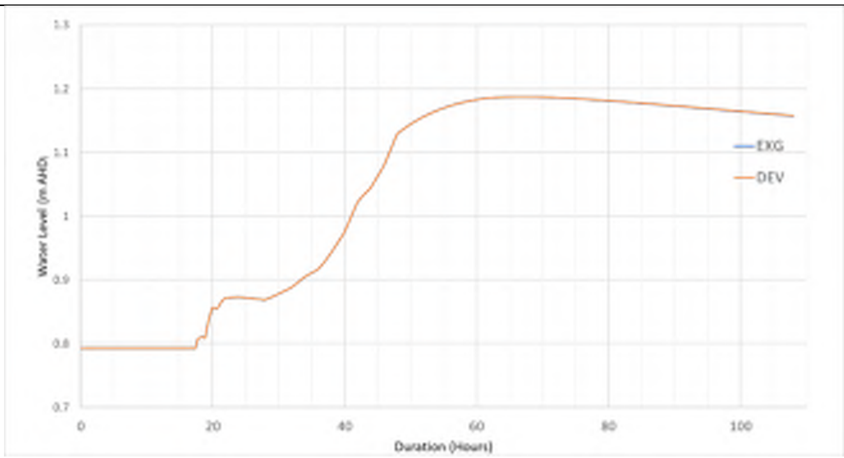
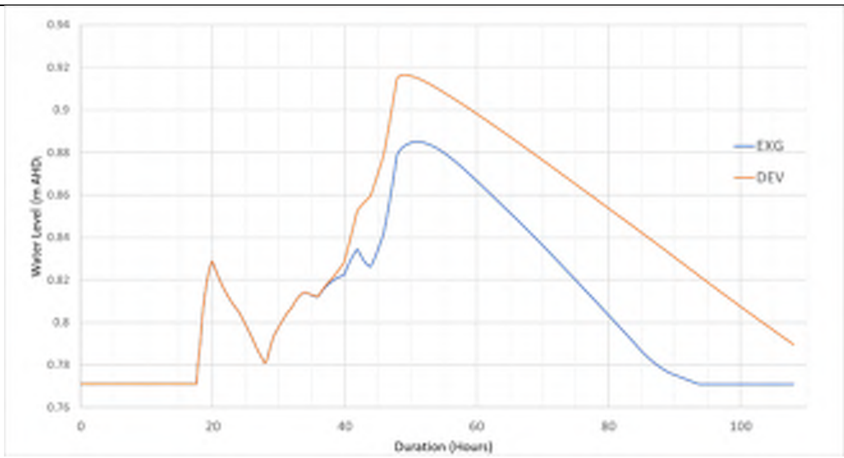
20//DP1082482	
21//DP1082482	
111//DP1208904	

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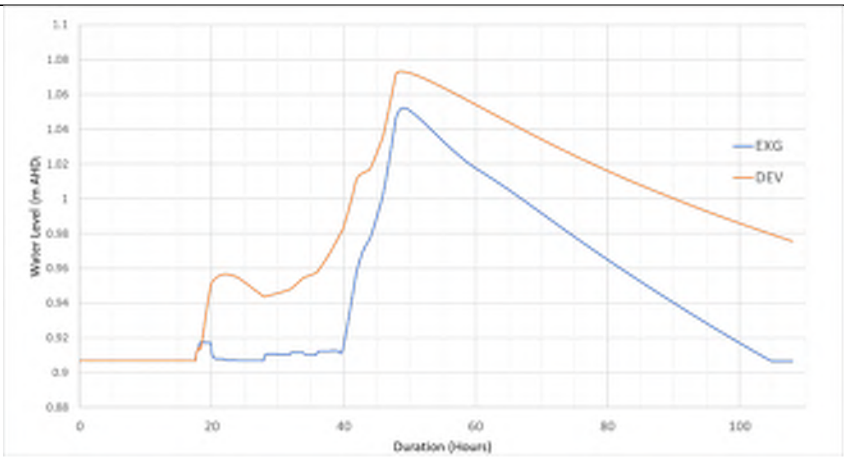
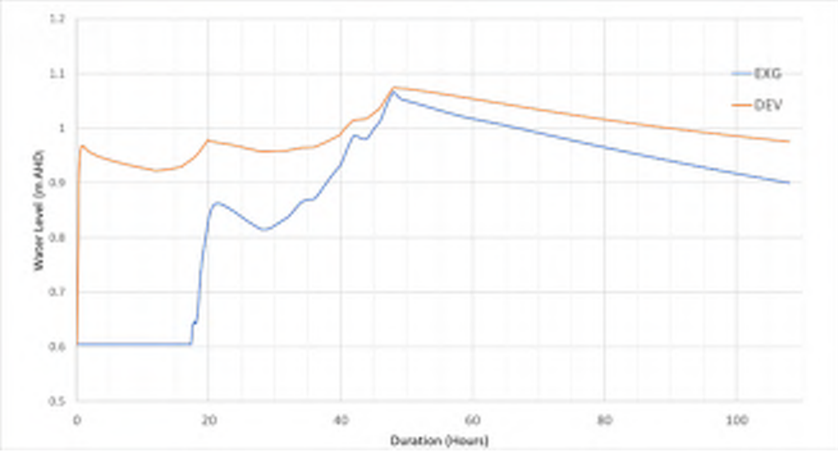
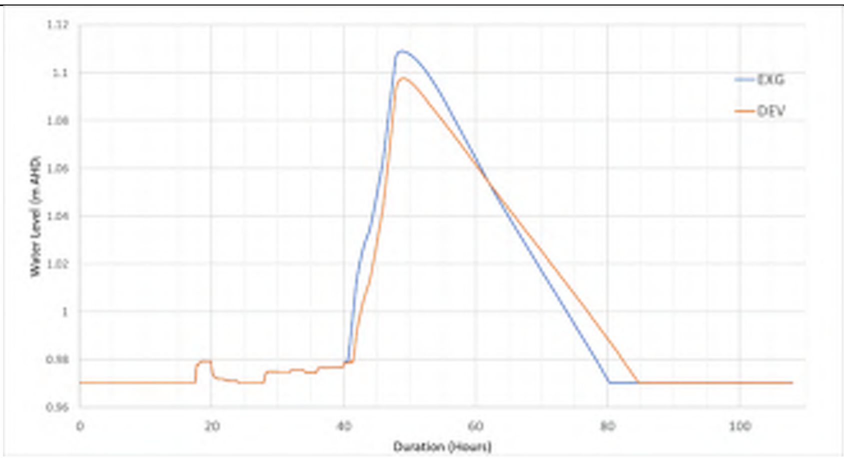
1//DP1192506	
2//DP1250570	
17//DP1168455	

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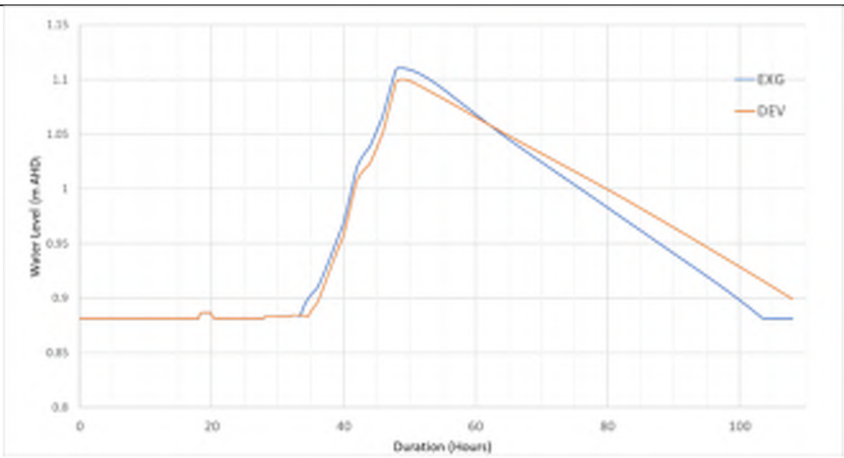
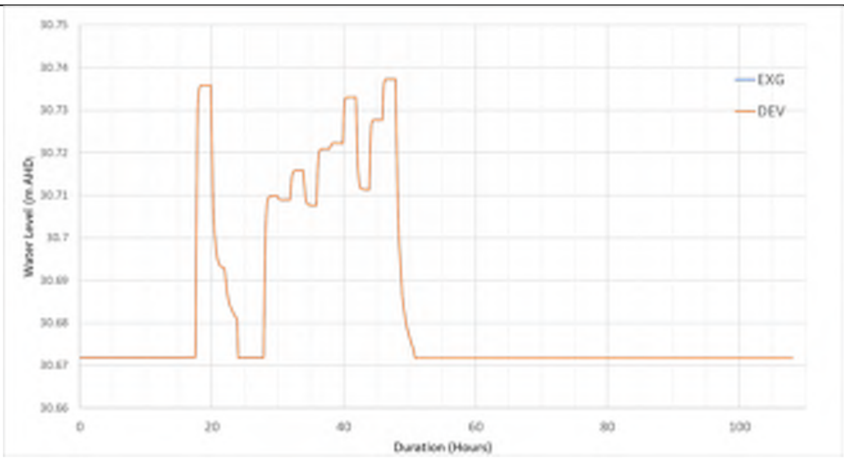
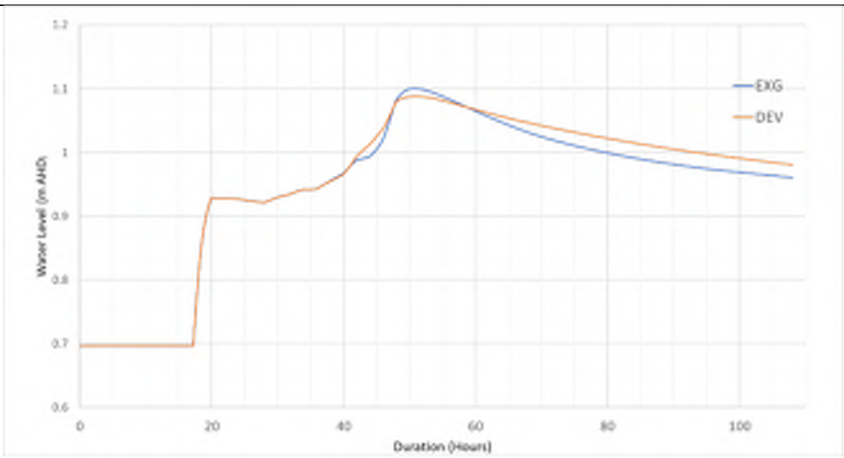
18//DP1168455	
12//DP1212919	
1//DP1186419_A	

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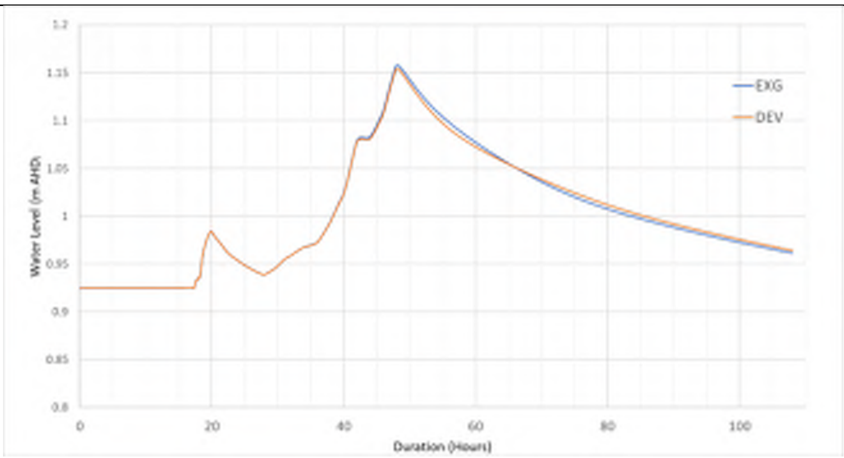
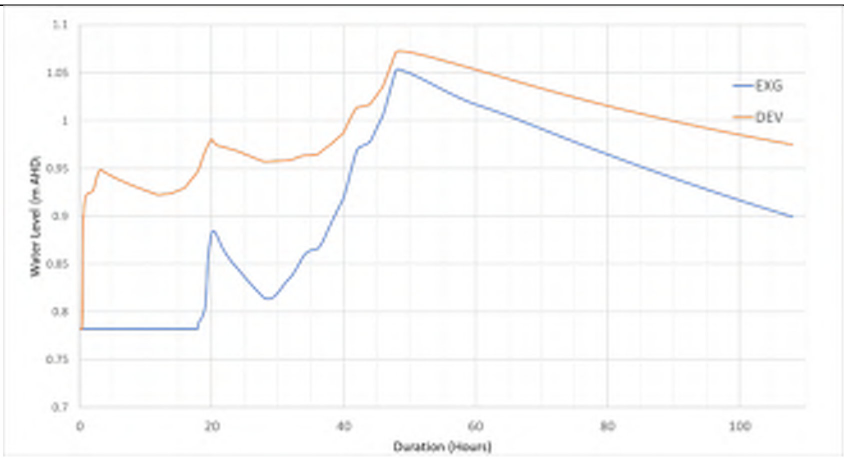
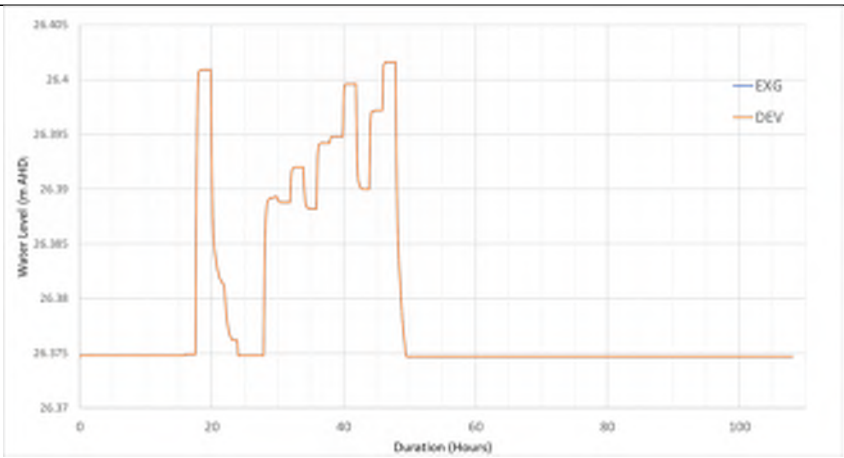
1//DP1186419_B	
13//DP1142639	
2//DP1158677	

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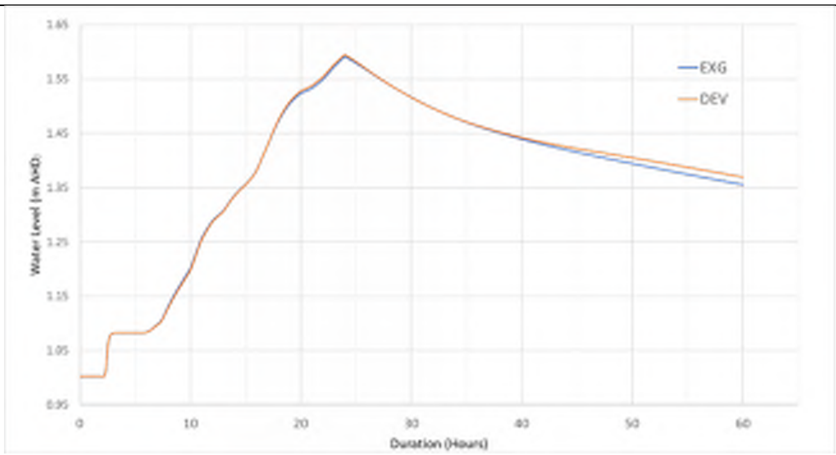
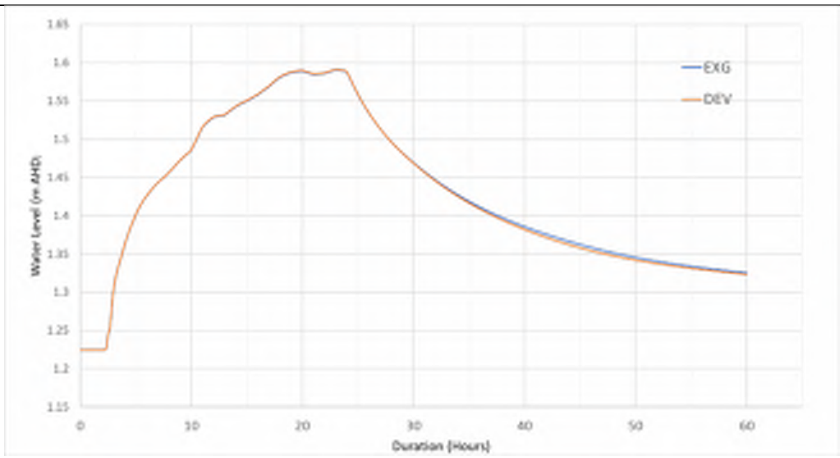
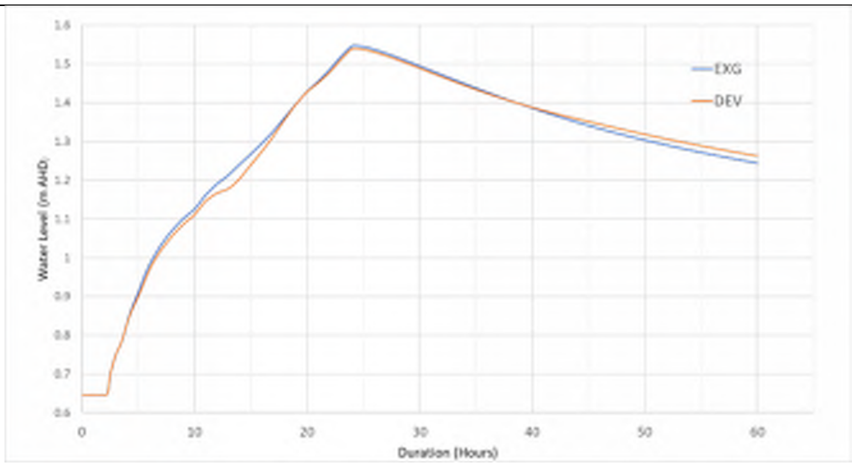
2//DP216705	
1//DP220685	
57//DP755701	

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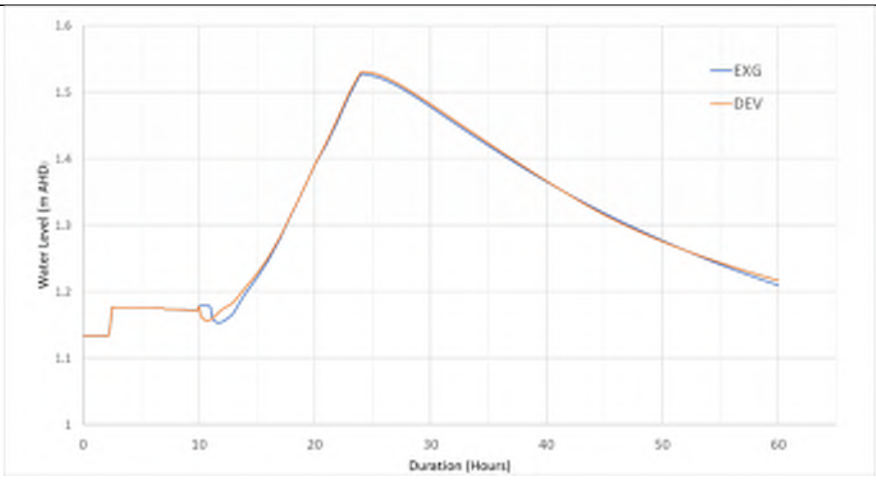
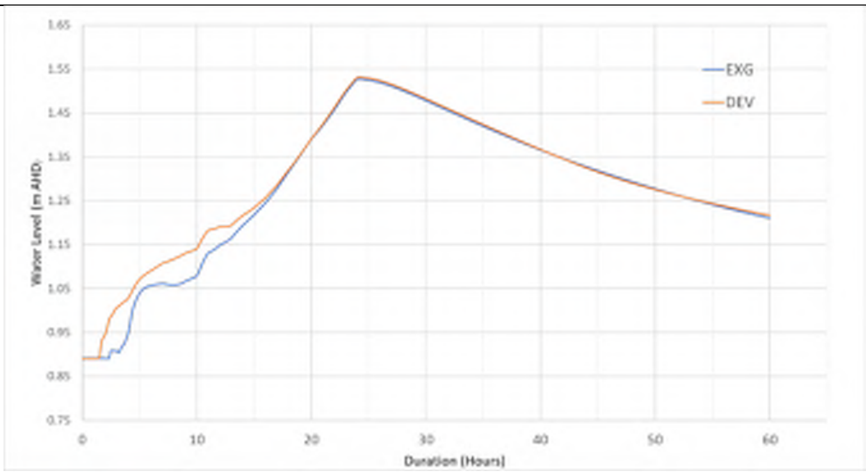
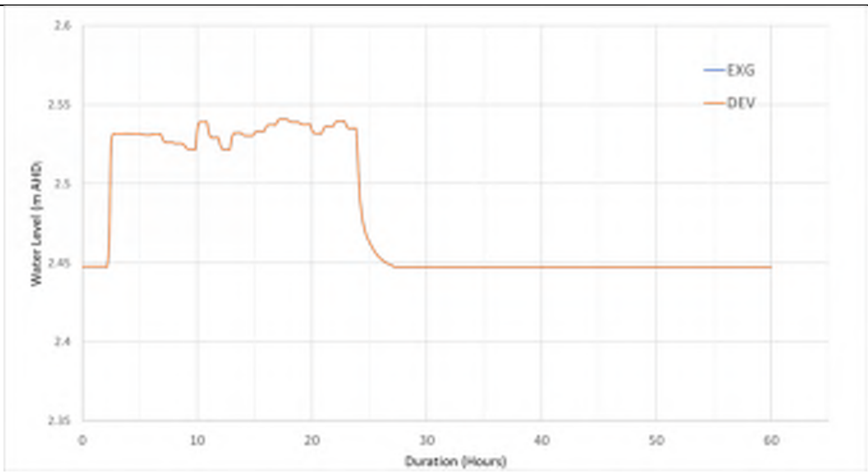
3//DP616805	
2//DP568035	
1//DP551126	

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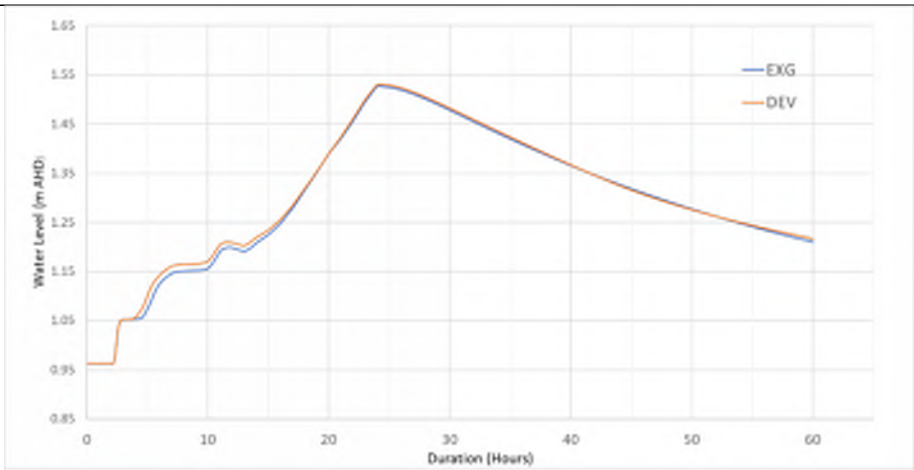
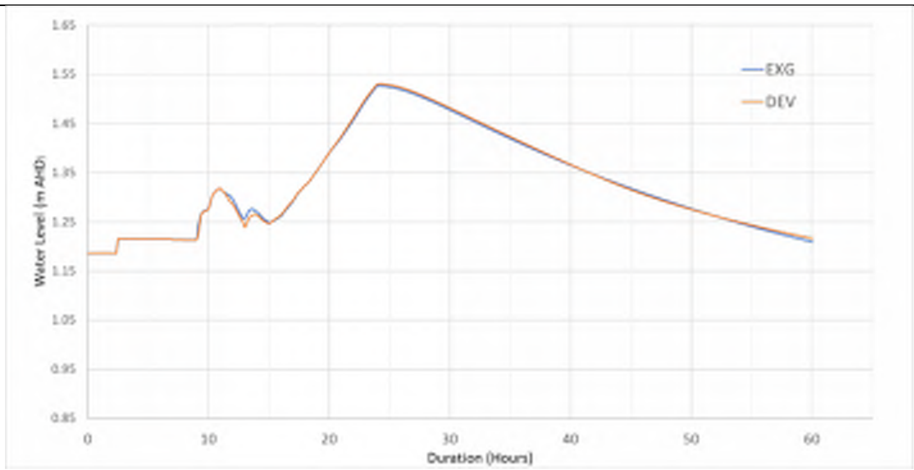
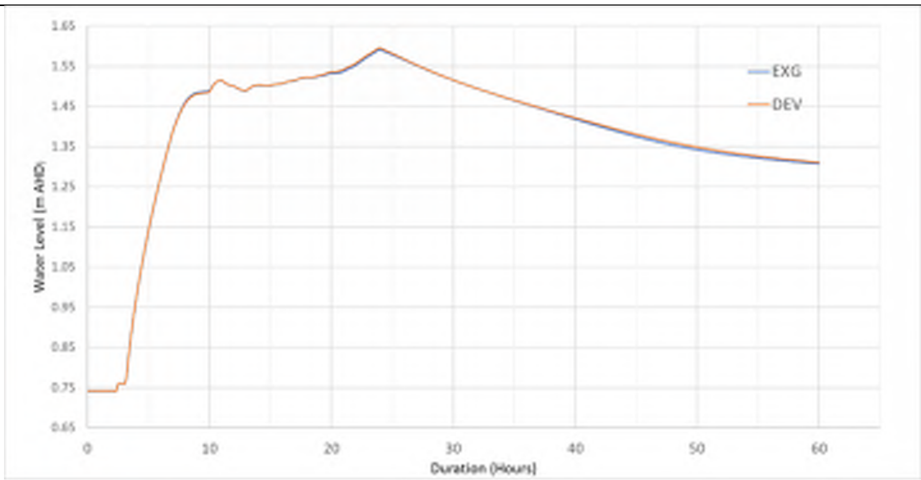
2//DP789457	
1//DP789457	
1//DP777905	

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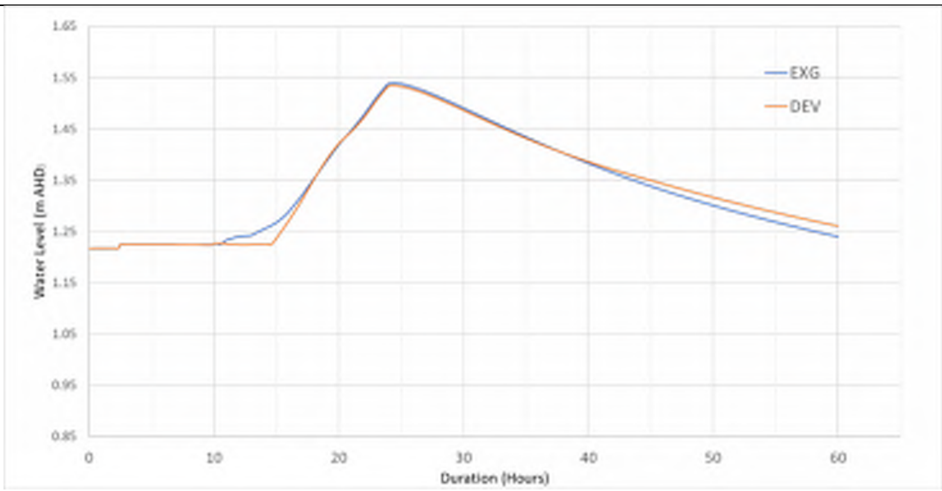
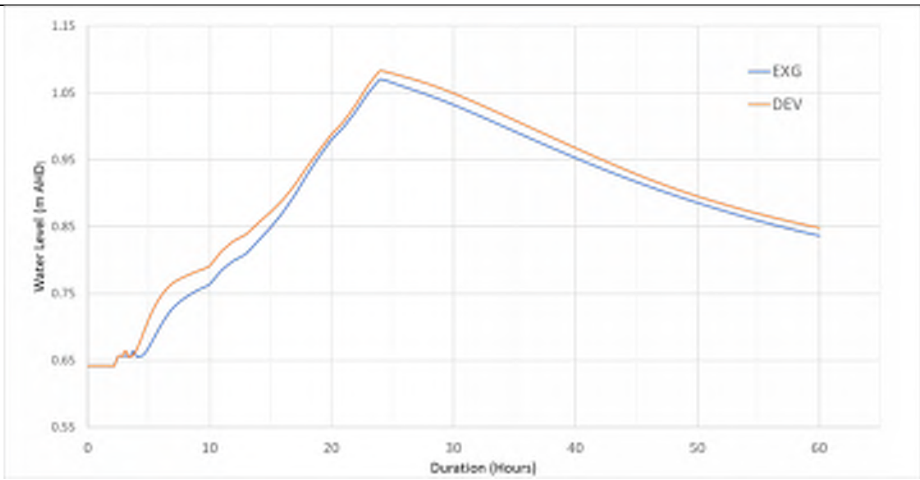
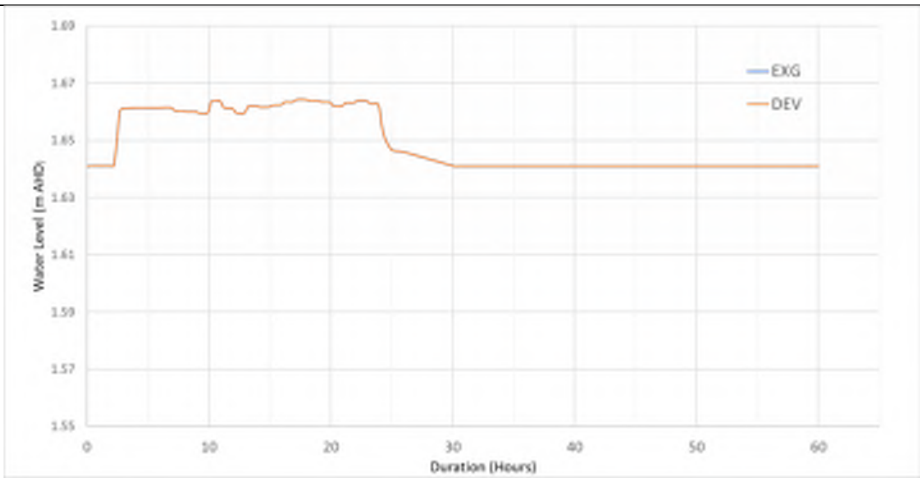
6//DP830659	
721//DP1000578	
2//DP868369	

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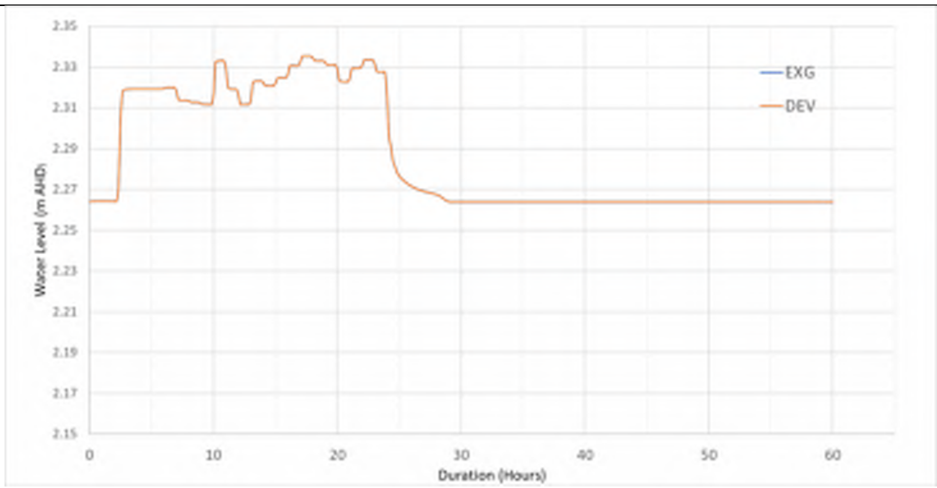
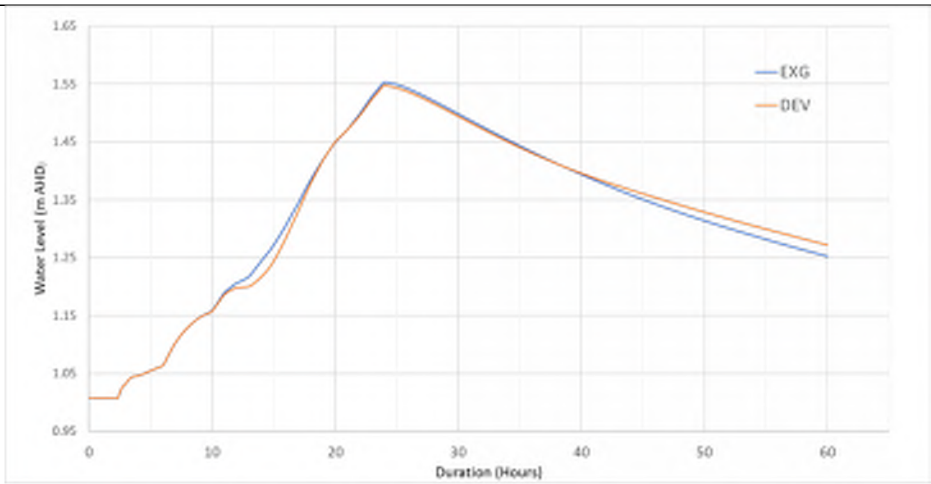
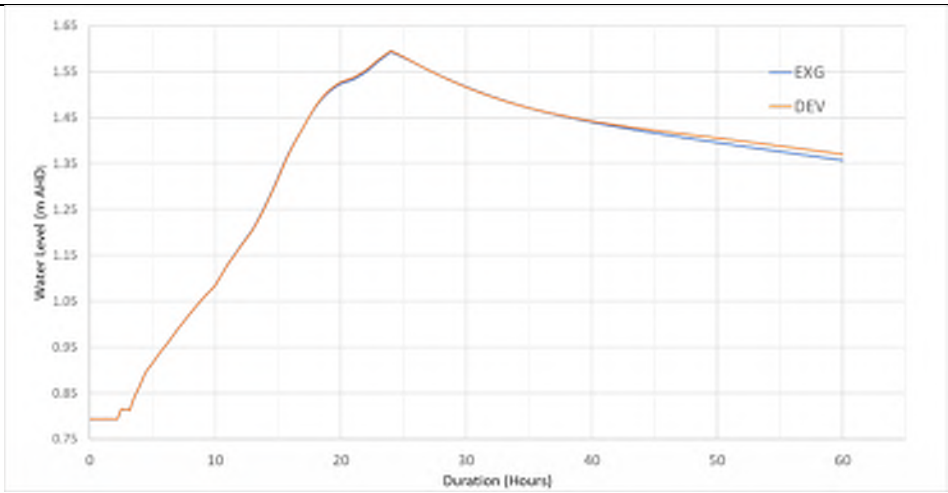
22//DP1082435	
20//DP1082482	
21//DP1082482	

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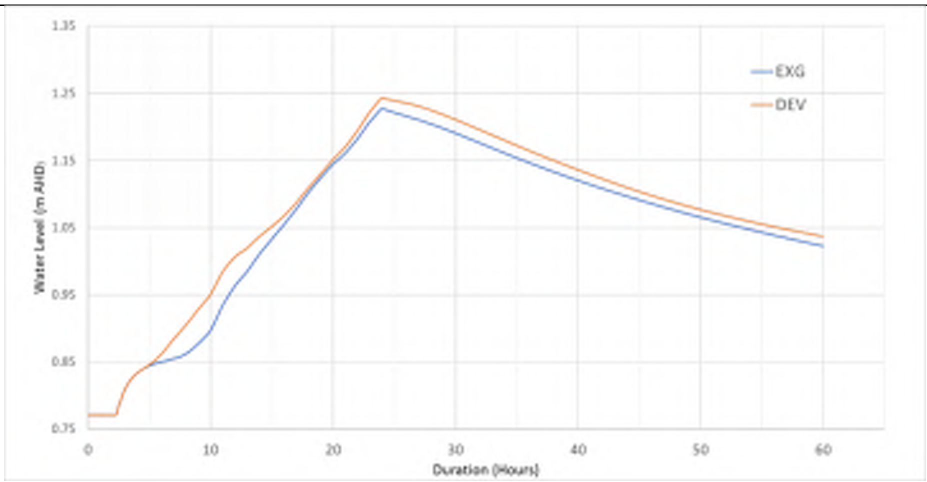
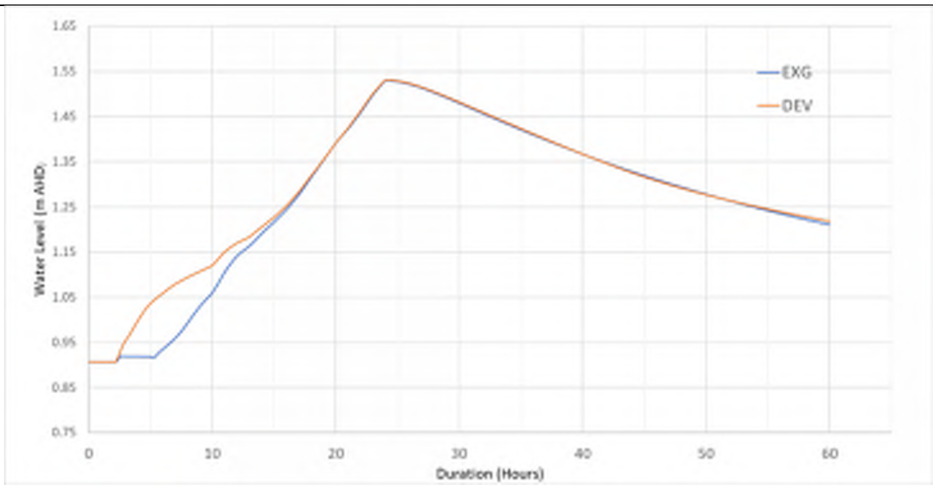
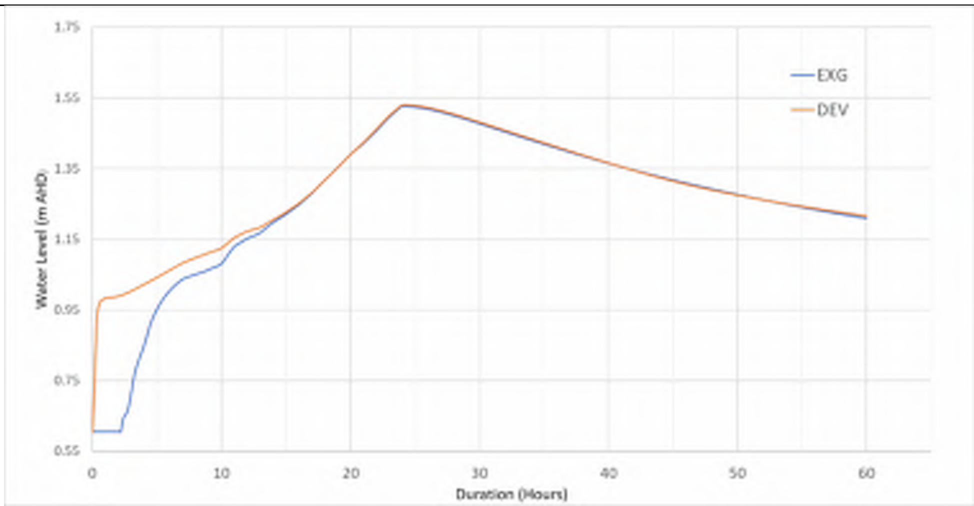
111//DP1208904	
1//DP1192506	
2//DP1250570	

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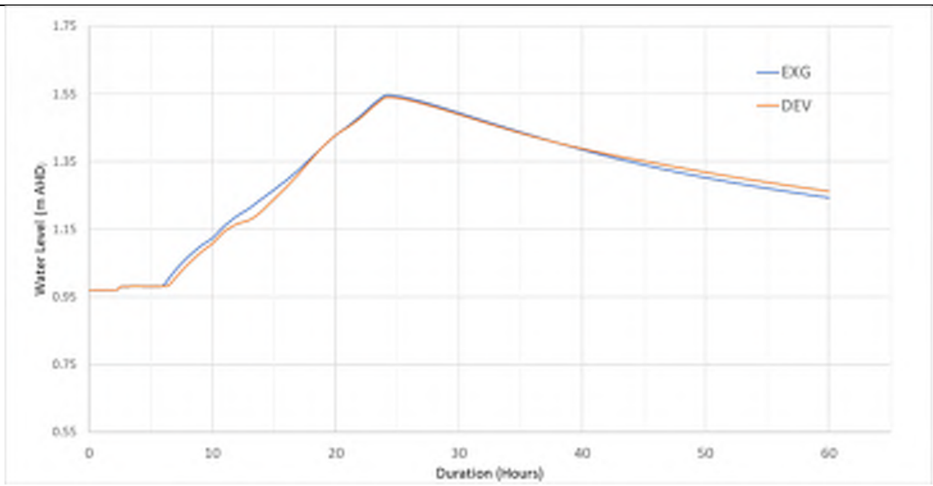
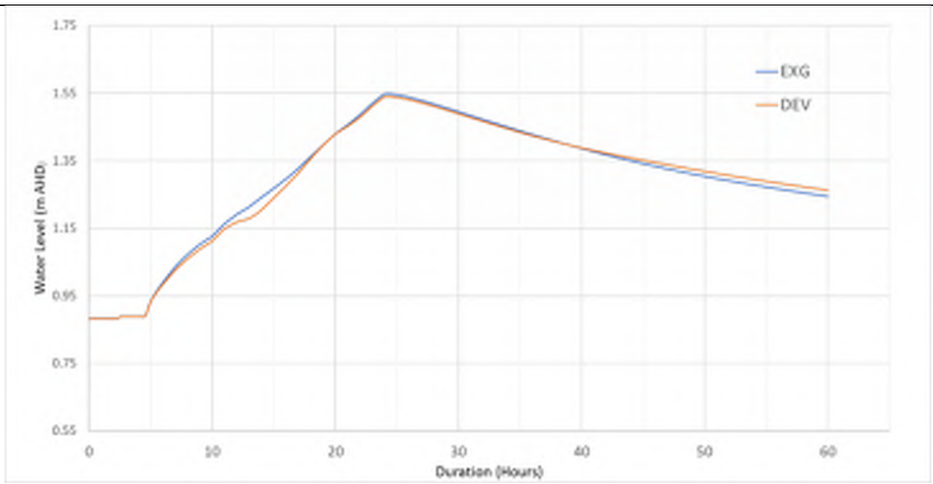
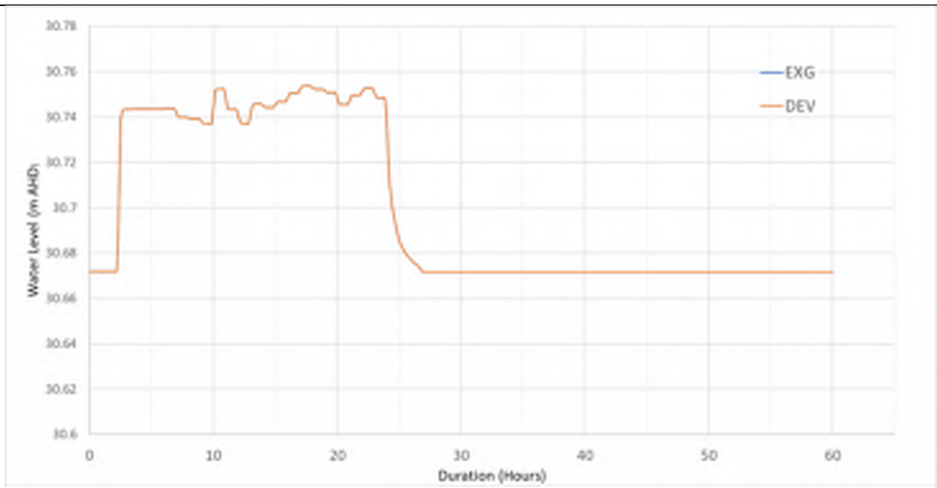
17//DP1168455	
18//DP1168455	
12//DP1212919	

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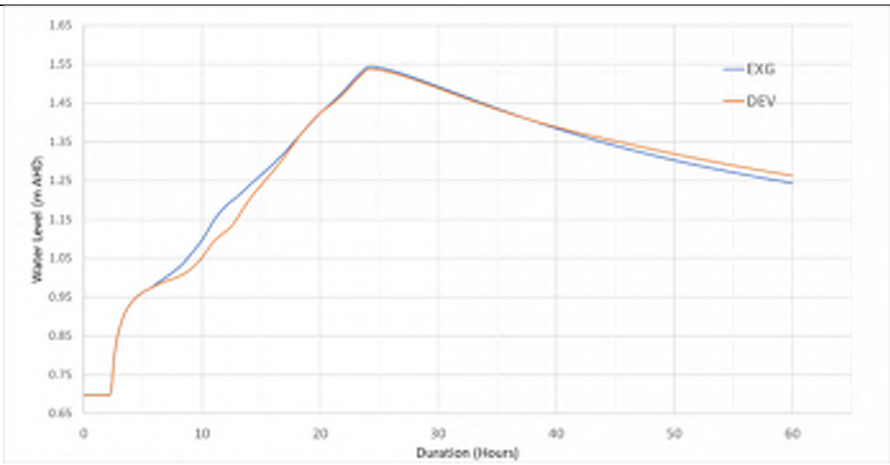
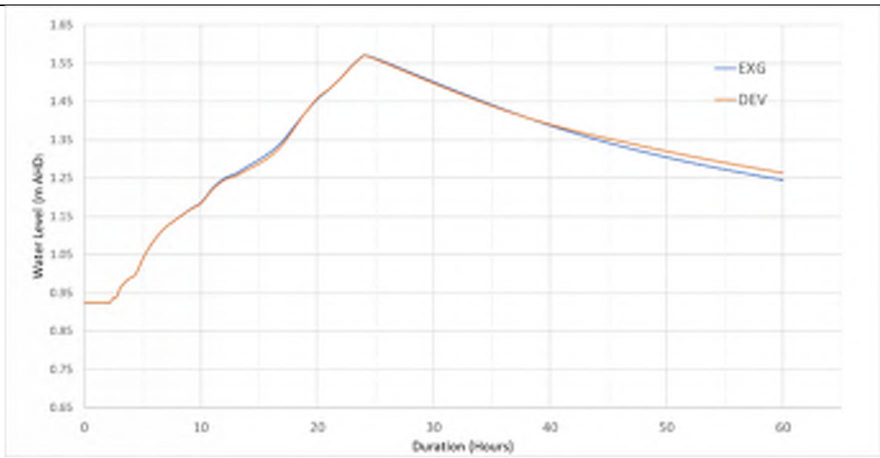
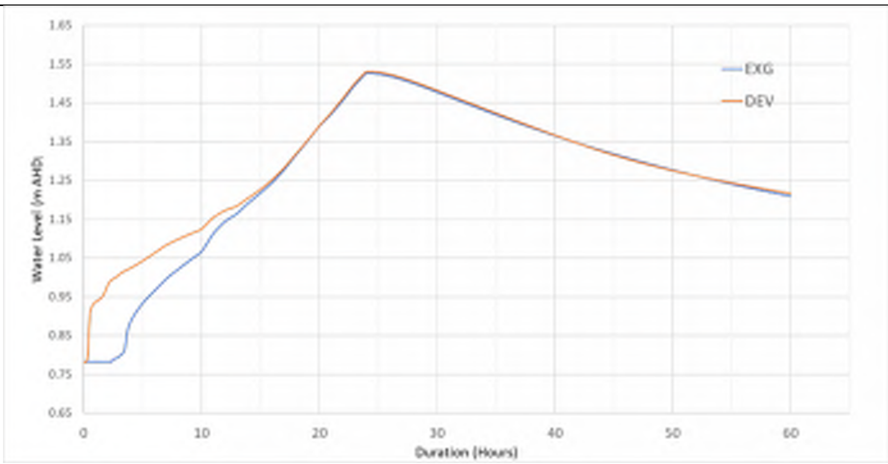
1//DP1186419_A	
1//DP1186419_B	
13//DP1142639	

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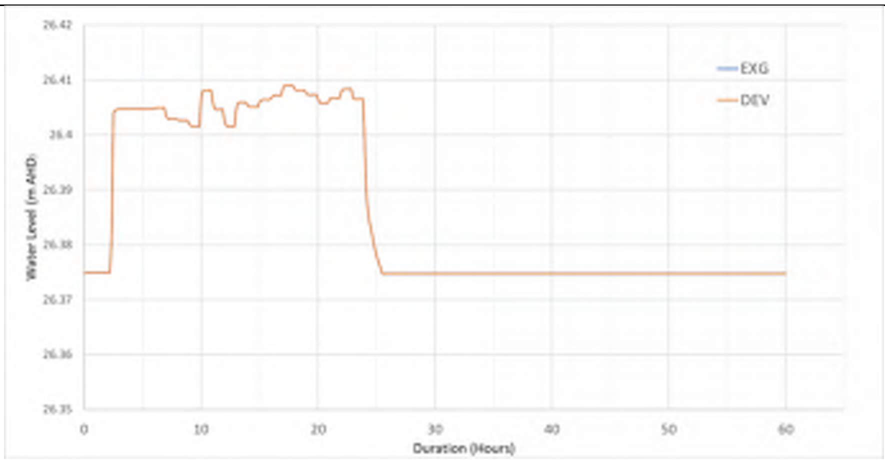
2//DP1158677	

Appendix F – Hydraulic Results

APPENDIX F - FLOOD RESULTS

REGIONAL FLOOD RESULTS

DRAWING SCHEDULE			
Figure No.	**Scenario**	**Event**	**Results**
F01	Existing	20%	WSL
F02	Existing	10%	WSL
F03	Existing	1%	WSL
F04	Existing	0.005%	WSL
F05	Existing	1%	Velocity
F06	Post-Developed (Phase 11)	20%	WSL
F07	Post-Developed (Phase 11)	5%	WSL
F08	Post-Developed (Phase 11)	1%	WSL
F09	Post-Developed (Phase 11)	1% CC	WSL
F10	Post-Developed (Phase 11)	0.2%	WSL
F11	Post-Developed (Phase 11)	0.005%	WSL
F12	Post-Developed (Phase 11)	1%	Velocity
F13	Post-Developed (Phase 11)	20%	Afflux
F14	Post-Developed (Phase 11)	5%	Afflux
F15	Post-Developed (Phase 11)	1%	Afflux
F16	Post-Developed (Phase 11)	1% CC	Afflux
F17	Post-Developed (Phase 11)	0.2%	Afflux
F18	Post-Developed (Phase 11)	0.005%	Afflux
F19	Post-Developed (Phase 9)	20%	Afflux
F20	Post-Developed (Phase 9)	5%	Afflux
F21	Post-Developed (Phase 9)	1%	Afflux
F22	Post-Developed (Phase 9)	1% CC	Afflux
F23	Post-Developed (Phase 7)	20%	Afflux
F24	Post-Developed (Phase 7)	5%	Afflux
F25	Post-Developed (Phase 7)	1%	Afflux
F26	Post-Developed (Phase 7)	1% CC	Afflux
F27	Post-Developed (Cumulative)	1%	Afflux

LOCAL FLOOD RESULTS

DRAWING SCHEDULE			
Figure No.	**Scenario**	**Event**	**Results**
F28	Post-Developed (Phase 11)	0.5EY 36hr TP9	Afflux
F29	Post-Developed (Phase 11)	0.2EY 36hr TP6	Afflux
F30	Post-Developed (Phase 11)	10% 36hr TP1	Afflux
F31	Post-Developed (Phase 11)	5% 18hr TP6	Afflux
F32	Post-Developed (Phase 11)	2% 36hr TP8	Afflux
F33	Post-Developed (Phase 11)	1% 18hr TP8	Afflux

TWEED SAND PLANT SUBJECT SITE

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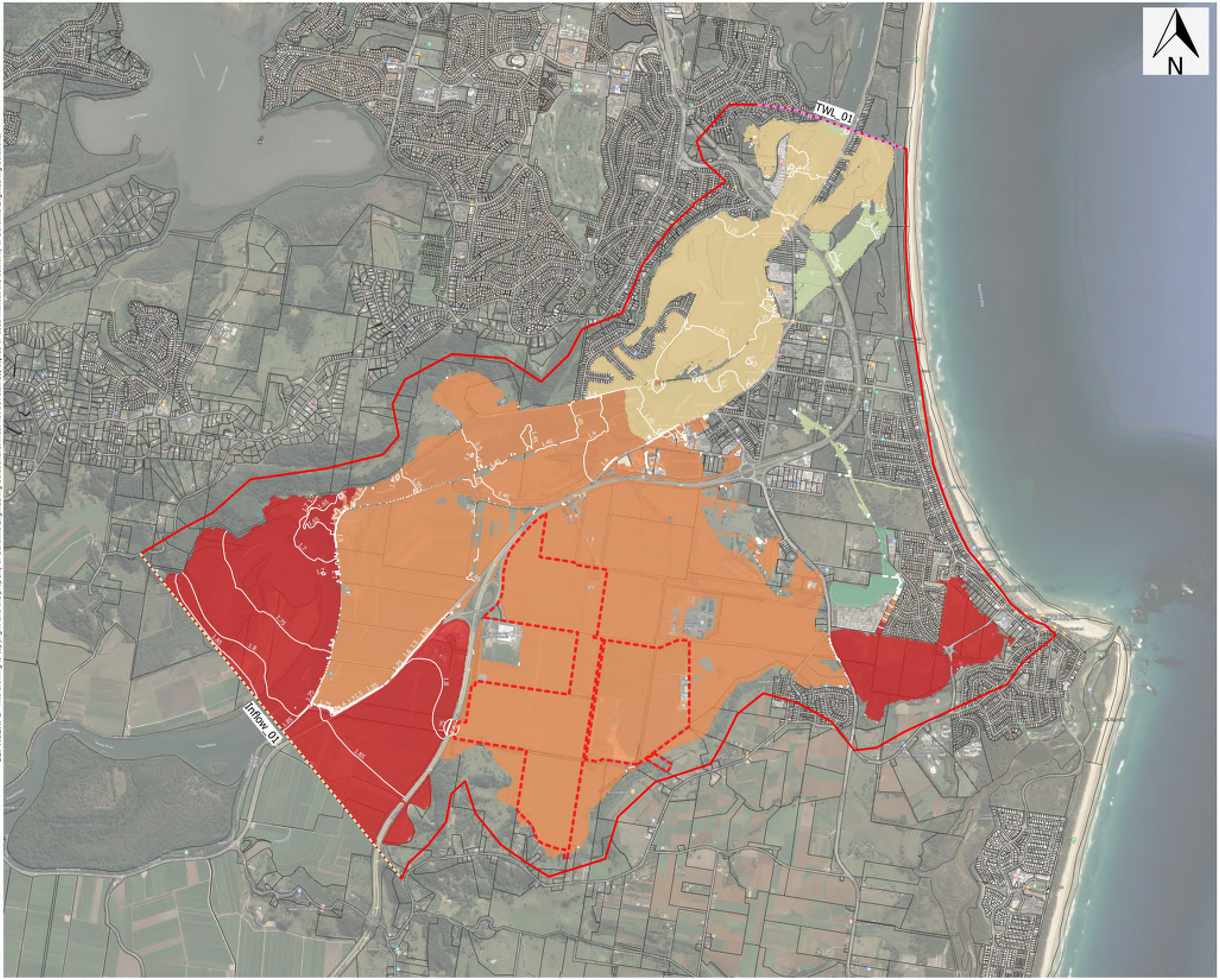

Tweed Sand Plant Flood Assessment

FIG F01 PRE DEVELOPED
20% AEP
FLOOD WATER LEVEL
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Downstream Boundary
- Inflow Boundary
- Cadastral
- Water Level Contour

Water Level (m AHD)

- <= 0.87
- 0.87 - 1.12
- 1.12 - 1.37
- 1.37 - 1.62
- > 1.62

Project: BE190043

Date: 06/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

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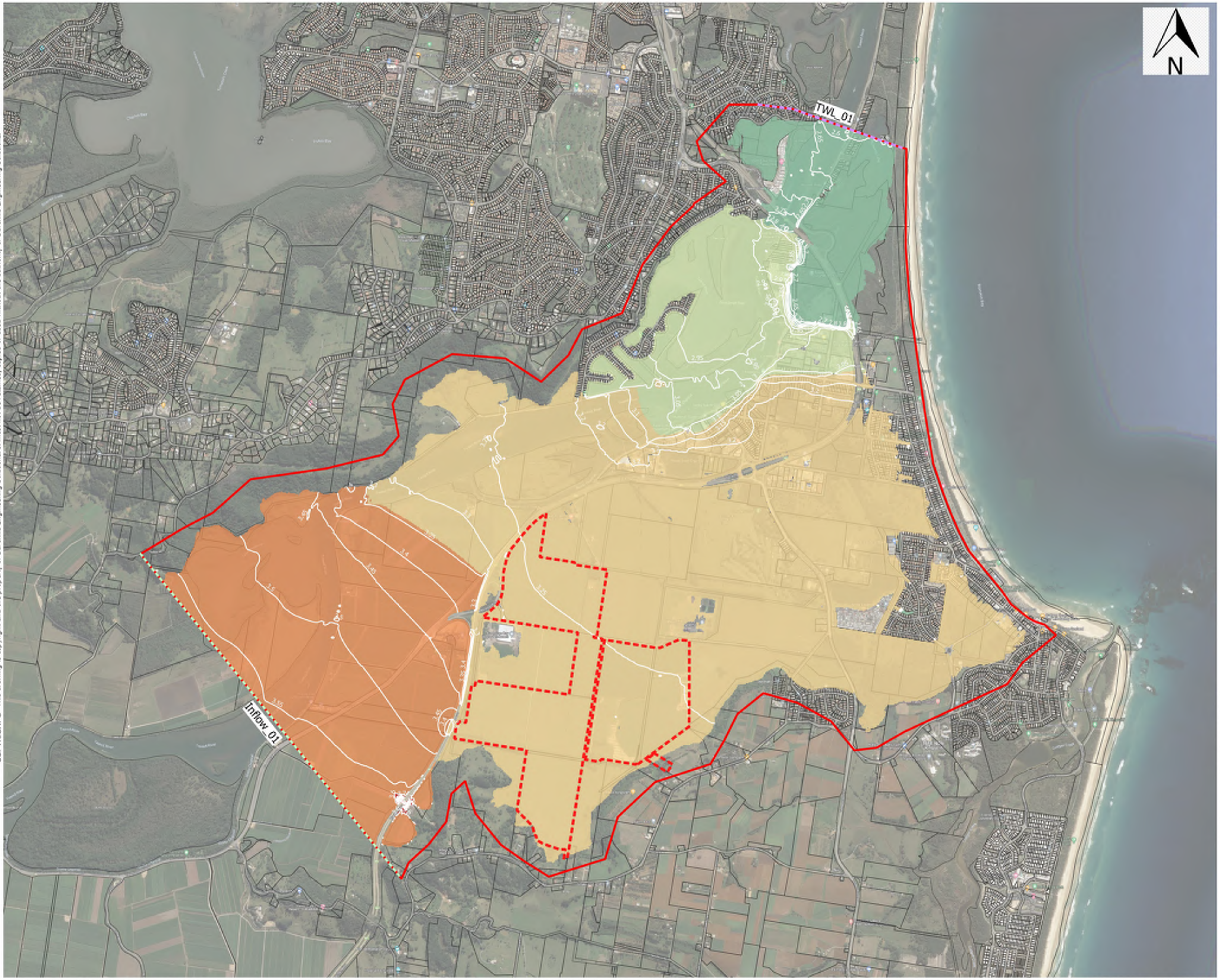


Tweed Sand Plant Flood Assessment

FIG F02 PRE DEVELOPED
1% AEP
FLOOD WATER LEVEL
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Downstream Boundary
- Inflow Boundary
- Cadastral
- Water Level Contour

Water Level (m AHD)

- <= 2.82
- 2.82 - 3.08
- 3.08 - 3.34
- 3.34 - 3.61
- > 3.61

Project: BE190043

Date: 06/10/2021

Scale: 1:30,000 at A3

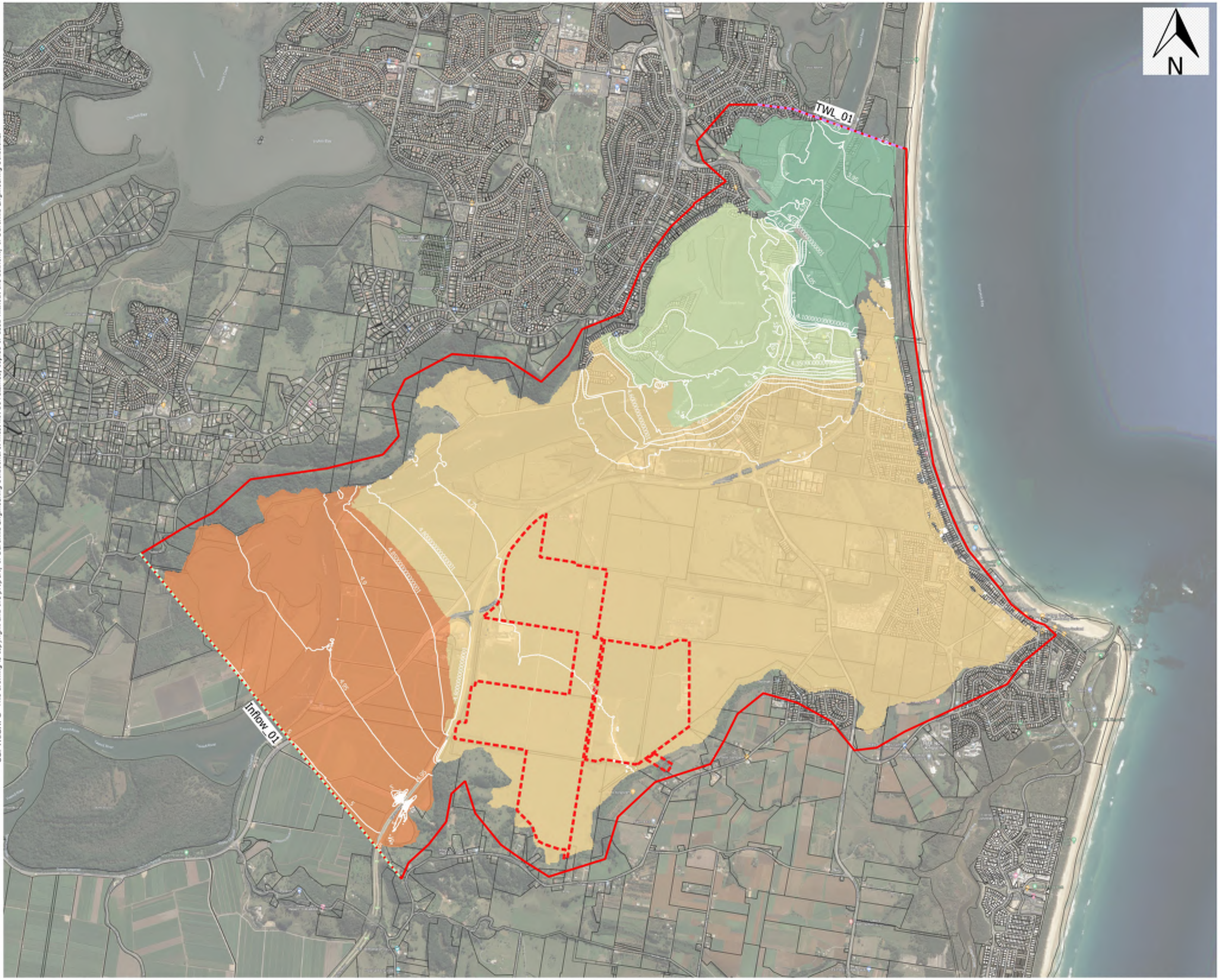
Projection: GDA94/MGA Zone 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson



Tweed Sand Plant Flood Assessment

FIG F03 PRE DEVELOPED 1% AEP CLIMATE CHANGE FLOOD WATER LEVEL (REGIONAL)

Legend

- Site Extent
- Model Extent
- Downstream Boundary
- Inflow Boundary
- Cadastral
- Water Level Contour

Water Level (m AHD)

- <= 4.20
- 4.20 - 4.52
- 4.52 - 4.83
- 4.83 - 5.15
- > 5.15

Project: BE190043

Date: 06/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

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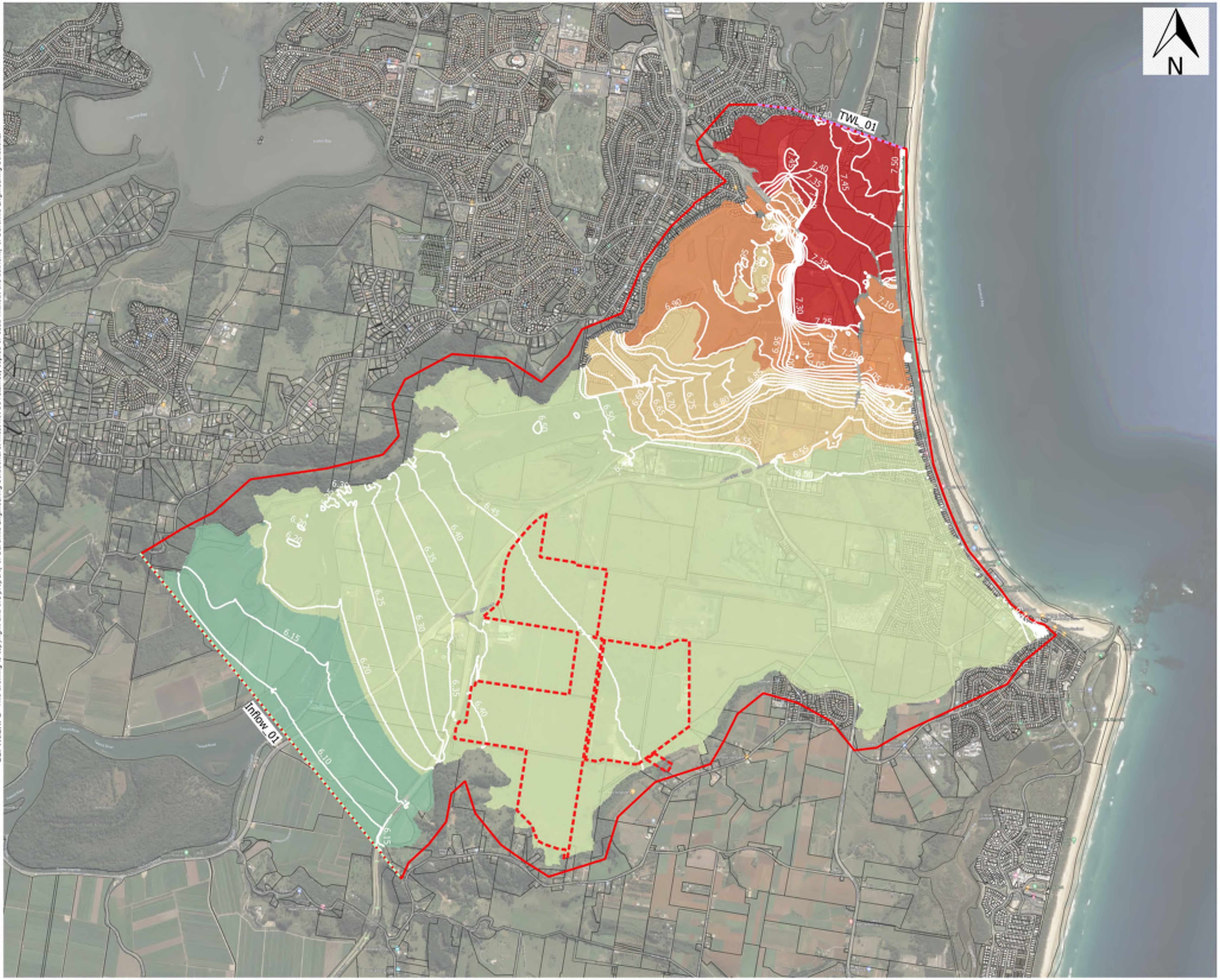

Tweed Sand Plant Flood Assessment

FIG F04 PRE DEVELOPED
0.005% AEP
FLOOD WATER LEVEL
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Downstream Boundary
- Inflow Boundary
- Cadastral
- Water Level Contour

Water Level (m AHD)

- <= 6.19
- 6.19 - 6.54
- 6.54 - 6.89
- 6.89 - 7.24
- > 7.24

Project: BE190043

Date: 06/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

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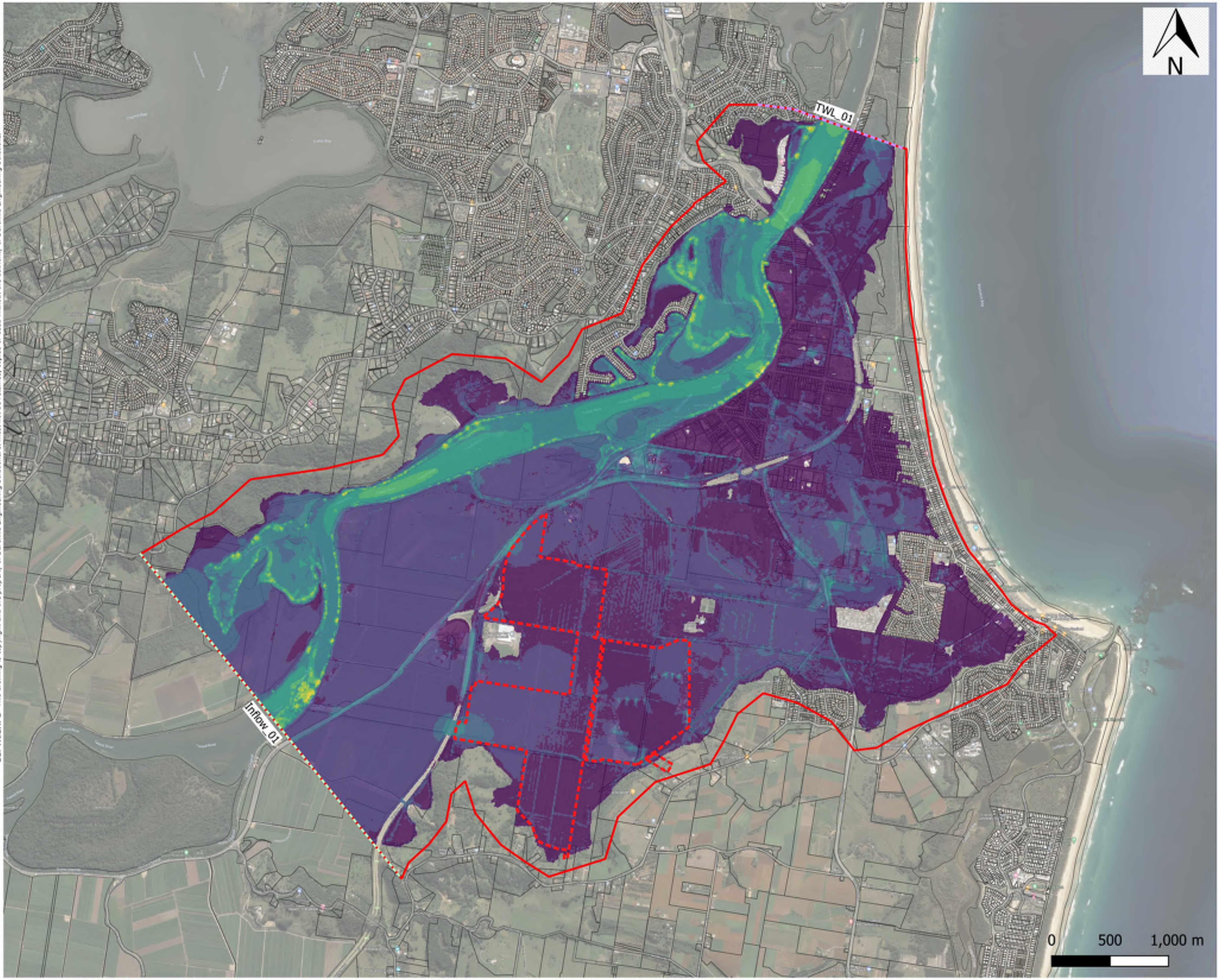

Tweed Sand Plant Flood Assessment

FIG F05 PRE DEVELOPED
1% AEP
FLOOD WATER VELOCITY
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Downstream Boundary
- Inflow Boundary
- Cadastral

Water Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 3.00
- > 3.00

Project: BE190043

Date: 06/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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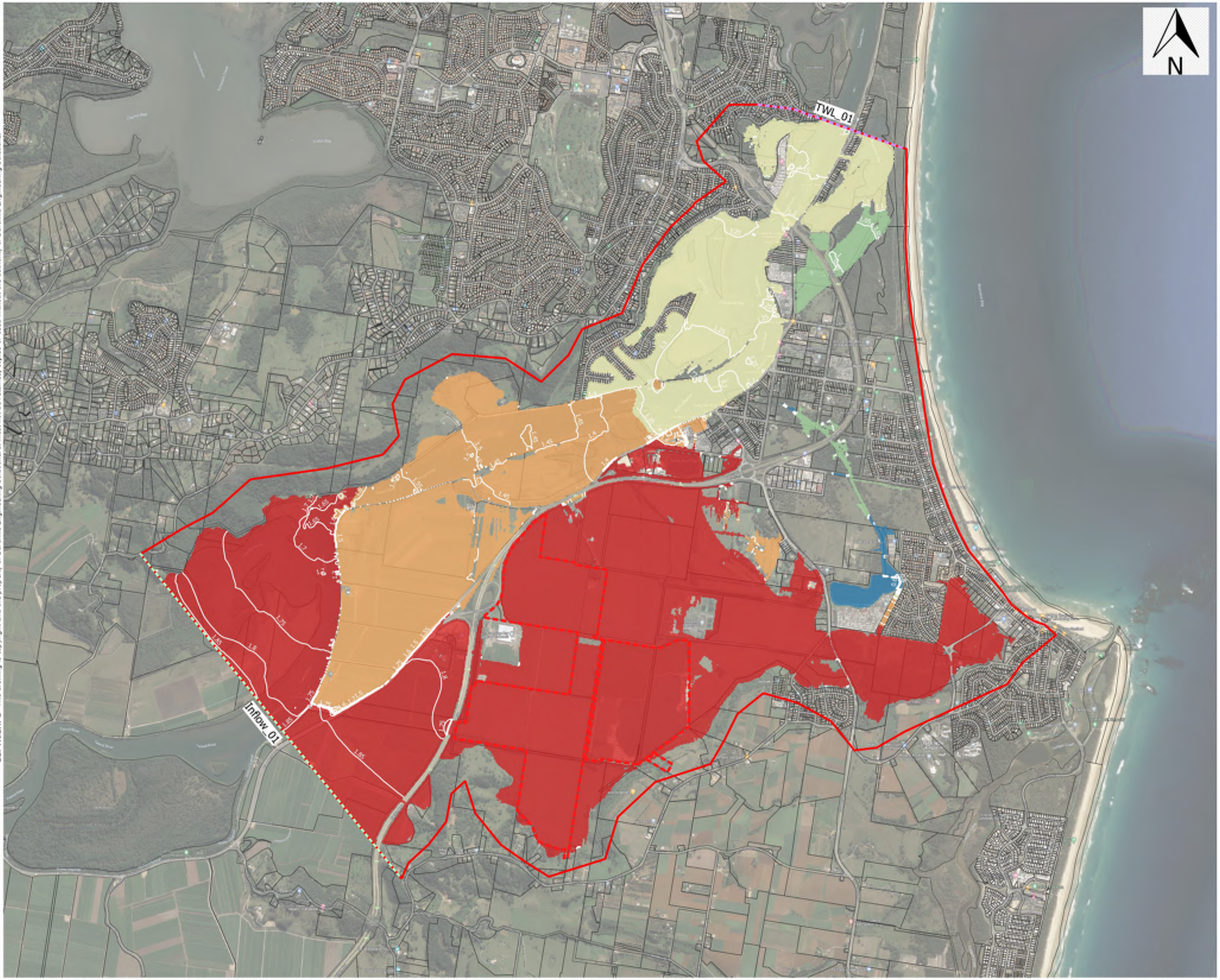

Tweed Sand Plant Flood Assessment

FIG F04 PHASE 11
20% AEP
FLOOD WATER LEVEL
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Downstream Boundary
- Inflow Boundary
- Cadastral
- Water Level Contour

Water Level (m AHD)

- <= 0.84
- 0.84 - 1.10
- 1.10 - 1.35
- 1.35 - 1.61
- > 1.61

Project: BE190043

Date: 06/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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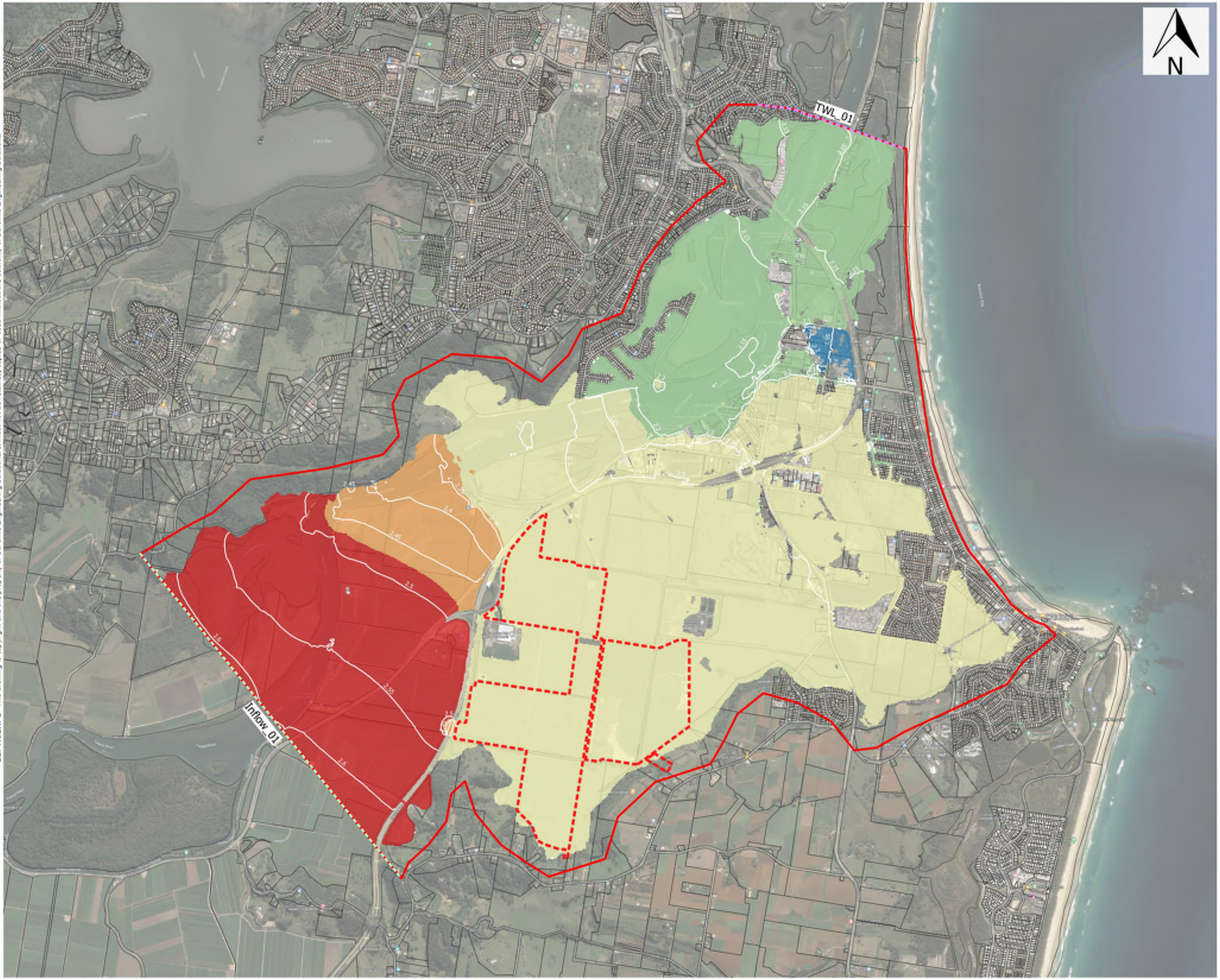

Tweed Sand Plant Flood Assessment

FIG F07 PHASE 11
5% AEP
FLOOD WATER LEVEL
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Downstream Boundary
- Inflow Boundary
- Cadastral
- Water Level Contour

Water Level (m AHD)

- <= 2.07
- 2.07 - 2.21
- 2.21 - 2.34
- 2.34 - 2.48
- > 2.48

Project: BE190043

Date: 06/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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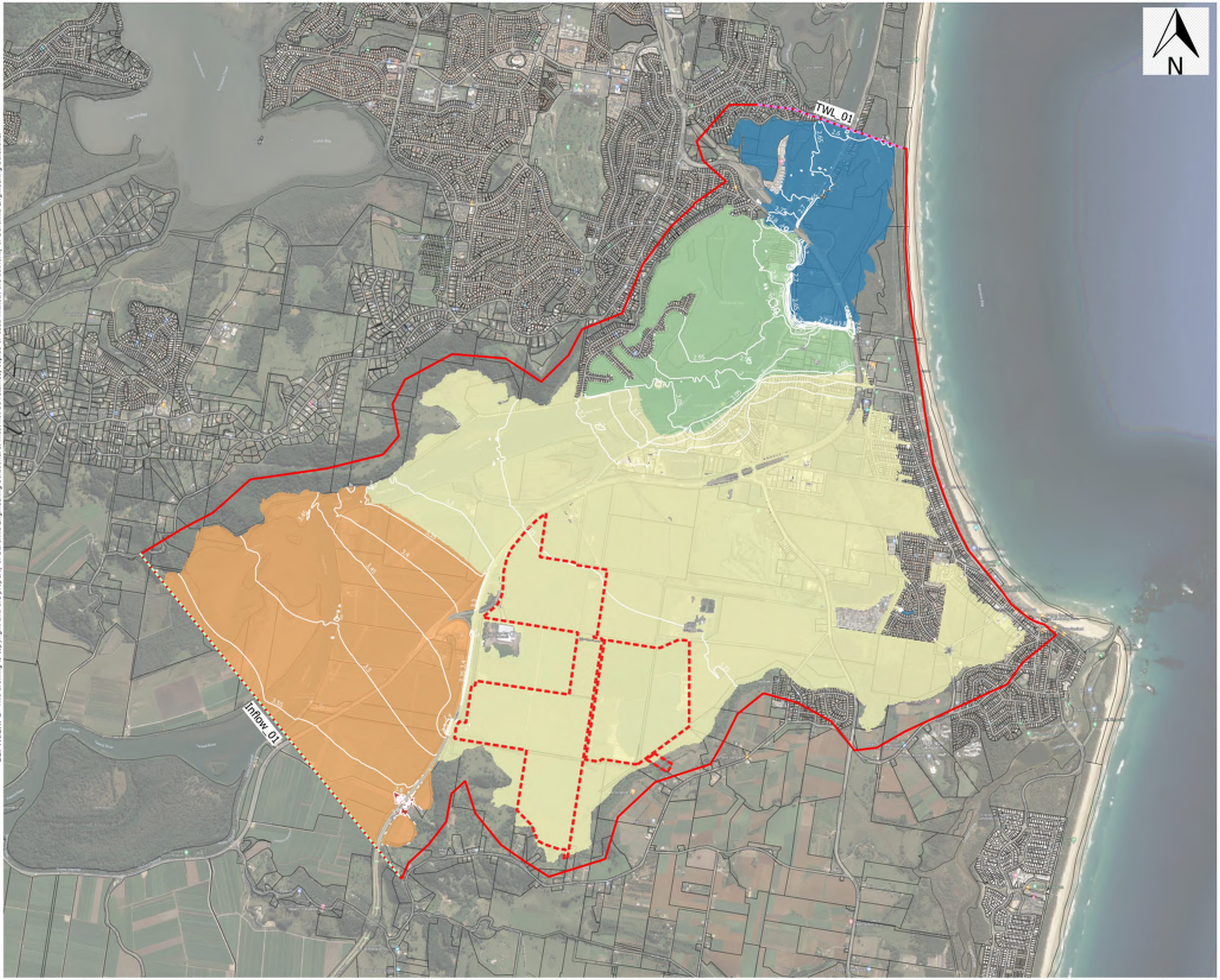

Tweed Sand Plant Flood Assessment

FIG F08 PHASE 11
1% AEP
FLOOD WATER LEVEL
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Downstream Boundary
- Inflow Boundary
- Cadastral
- Water Level Contour

Water Level (m AHD)

- <= 2.82
- 2.82 - 3.08
- 3.08 - 3.34
- 3.34 - 3.61
- > 3.61

Project: BE190043

Date: 06/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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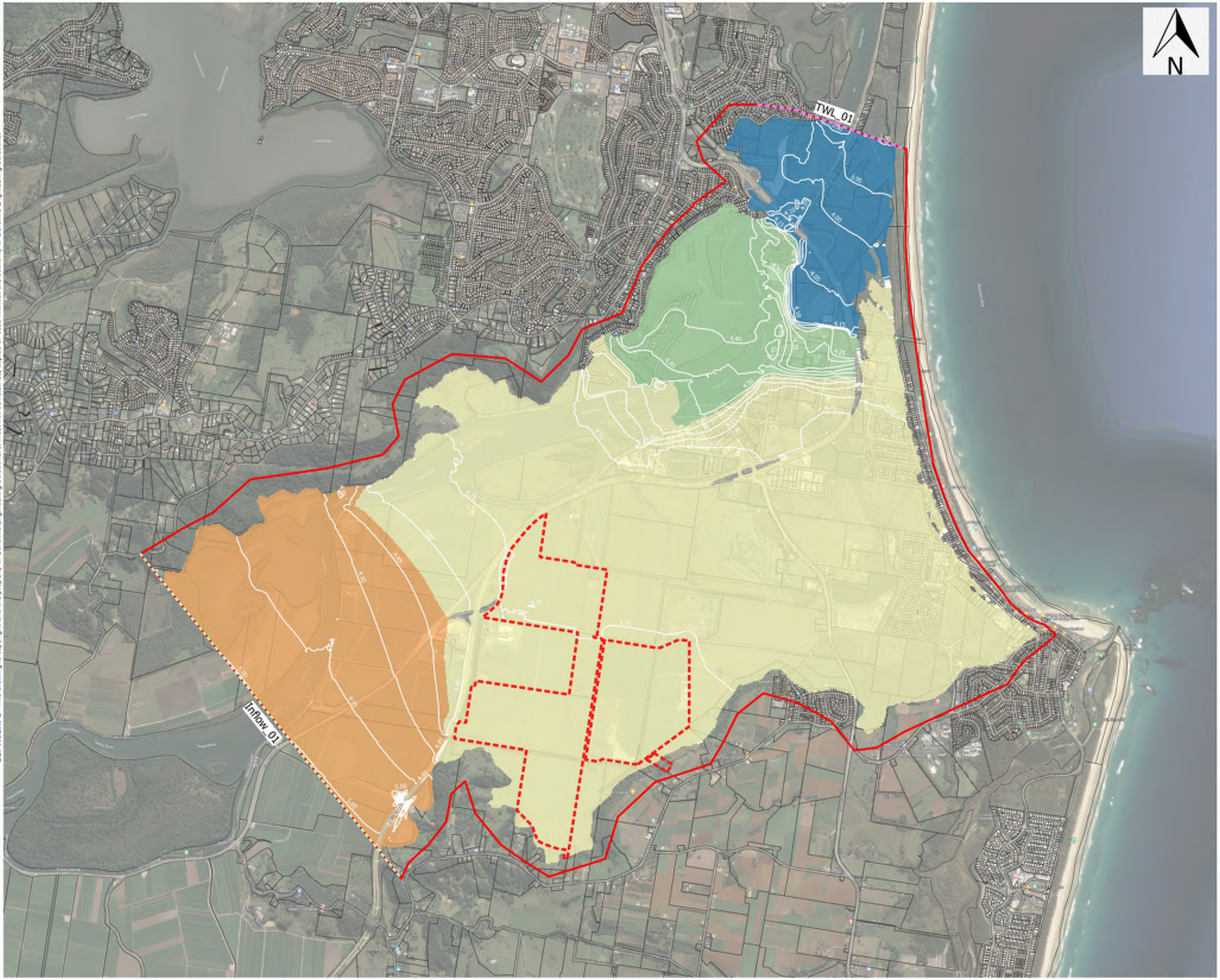

Tweed Sand Plant Flood Assessment

FIG F09 PHASE 11
1% AEP CLIMATE CHANGE
FLOOD WATER LEVEL
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Downstream Boundary
- Inflow Boundary
- Cadastral
- Water Level Contour

Water Level (m AHD)

- <= 4.20
- 4.20 - 4.52
- 4.52 - 4.83
- 4.83 - 5.15
- > 5.15

Project: BE190043

Date: 06/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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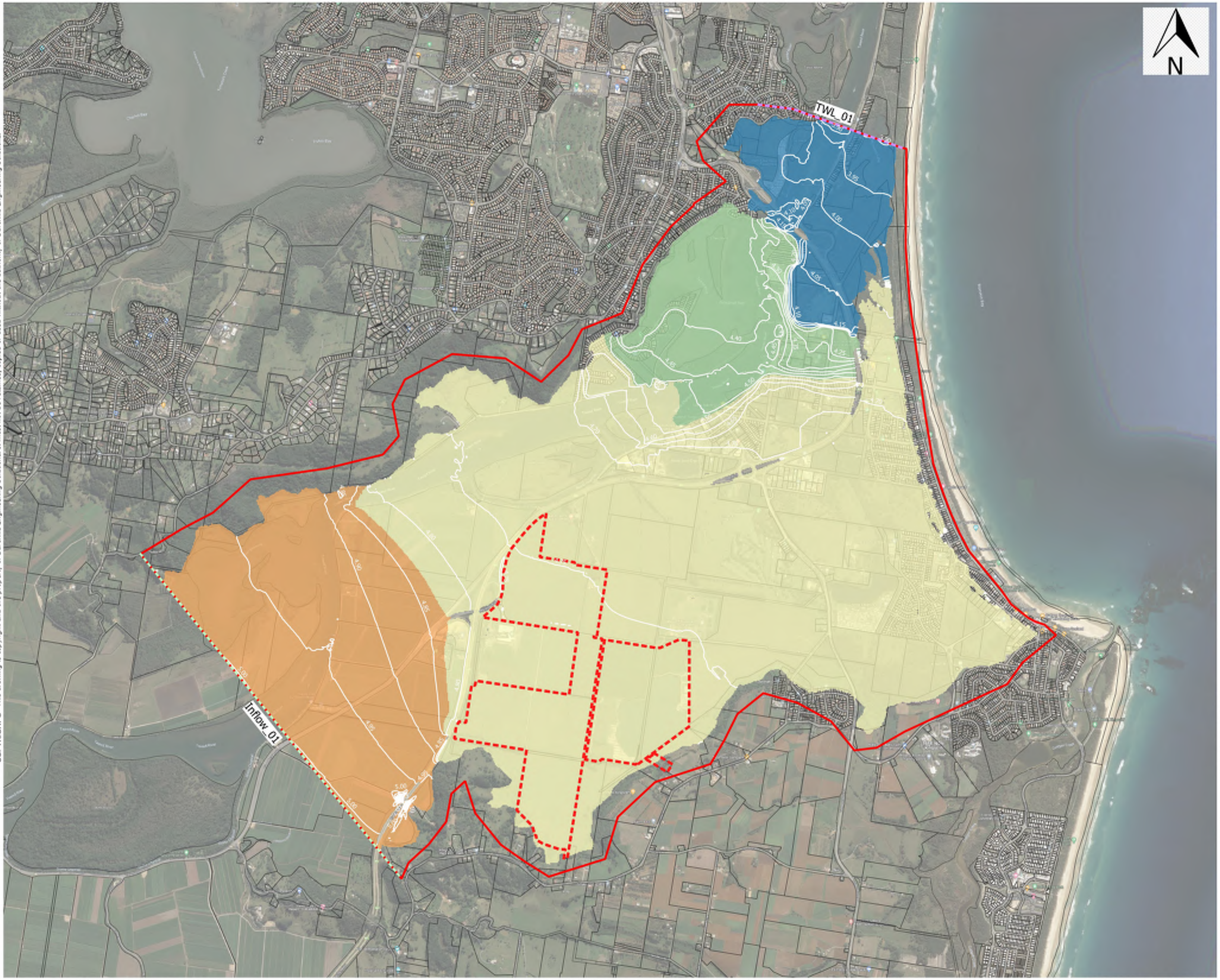

Tweed Sand Plant Flood Assessment

FIG F10 PHASE 11
0.2% AEP
FLOOD WATER LEVEL
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Downstream Boundary
- Inflow Boundary
- Cadastral
- Water Level Contour

Water Level (m AHD)

- <= 4.20
- 4.20 - 4.52
- 4.52 - 4.83
- 4.83 - 5.15
- > 5.15

Project: BE190043

Date: 06/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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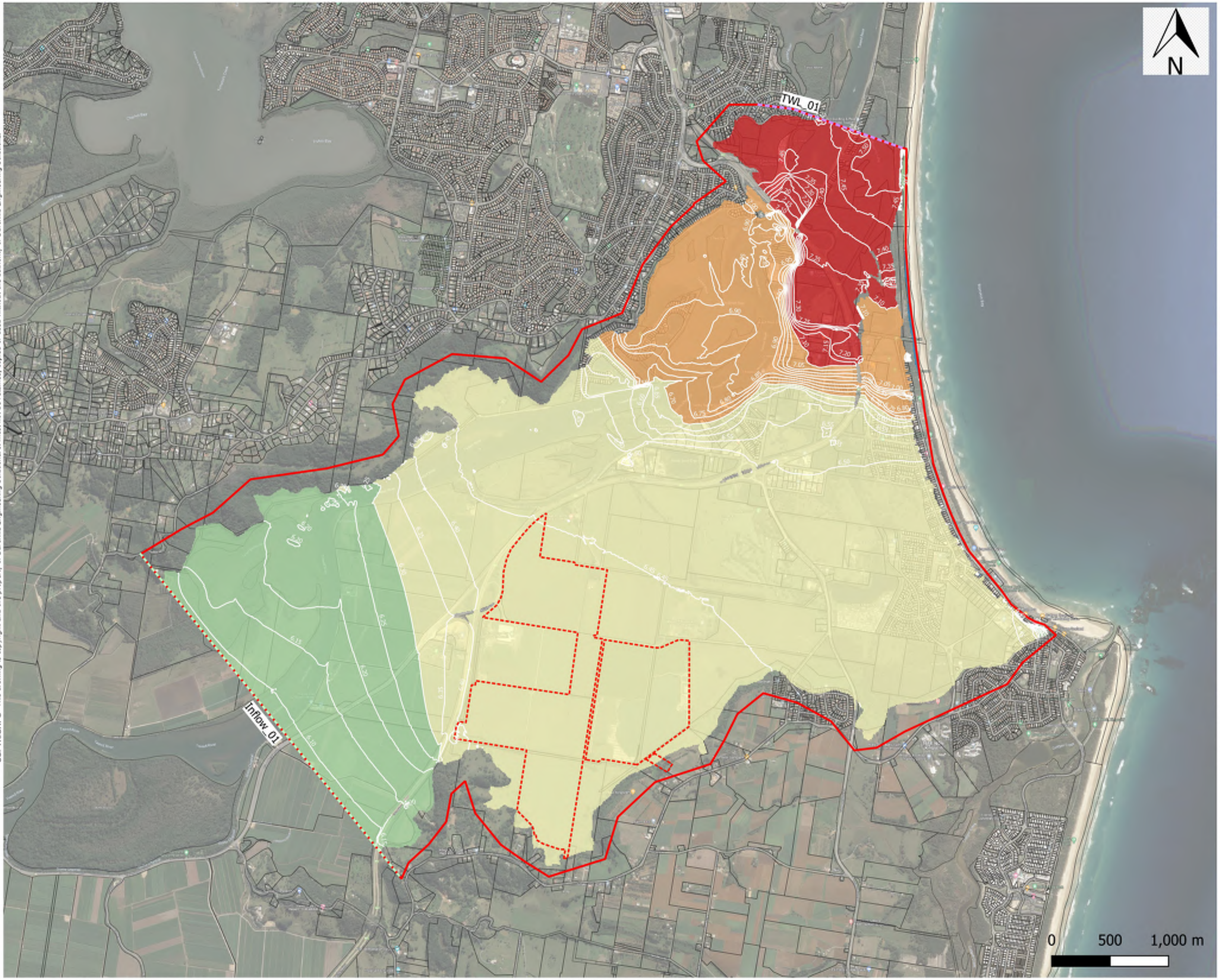

Tweed Sand Plant Flood Assessment

FIG F11 PHASE 11
0.005% AEP
FLOOD WATER LEVEL
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Downstream Boundary
- Inflow Boundary
- Cadastral
- Water Level Contour

Water Level (m AHD)

- <= 5.90
- 5.90 - 6.30
- 6.30 - 6.70
- 6.70 - 7.10
- > 7.10

Project: BE190043

Date: 11/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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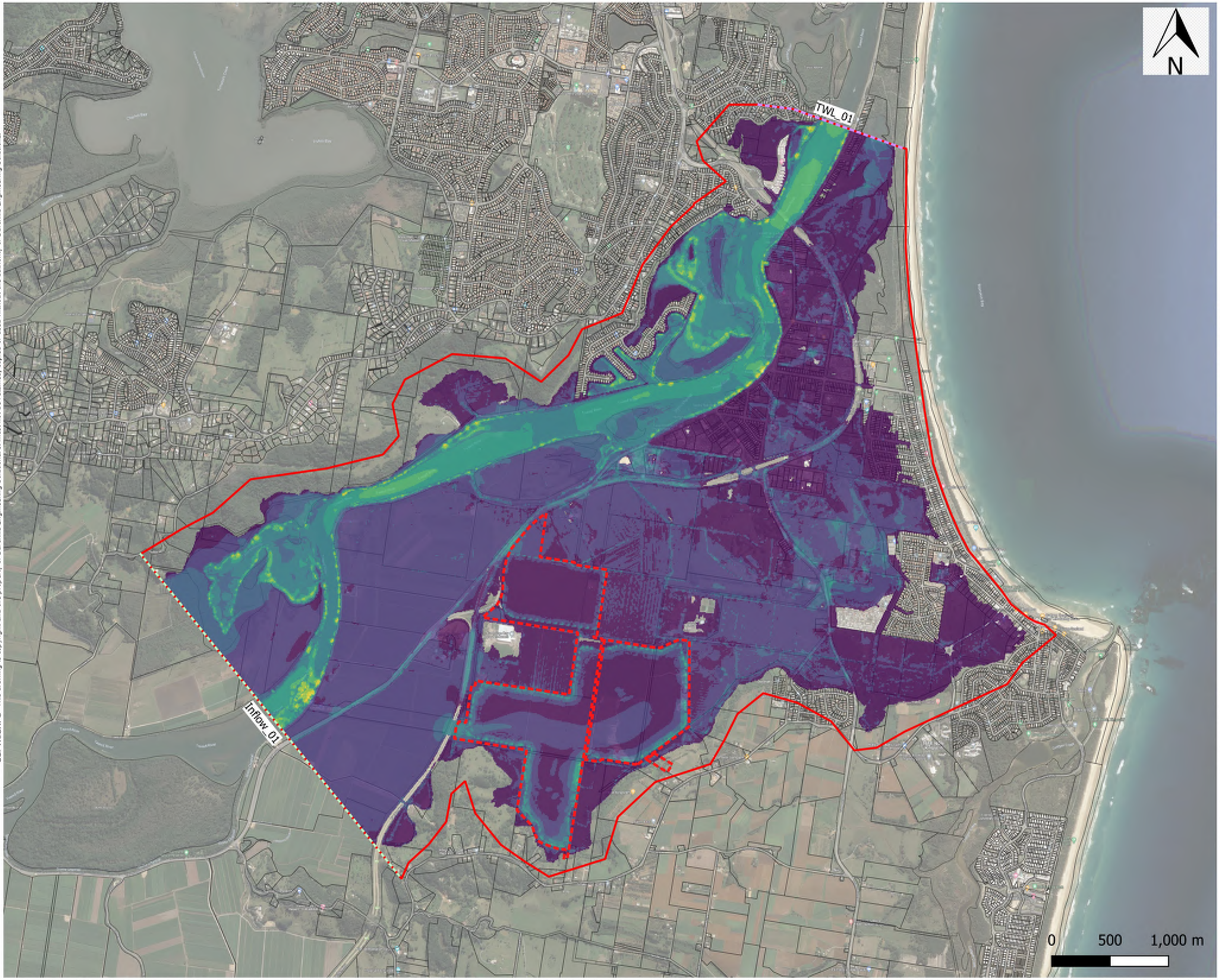

Tweed Sand Plant Flood Assessment

FIG F12 PHASE 11
1% AEP
FLOOD WATER VELOCITY
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Downstream Boundary
- Inflow Boundary
- Cadastral

Water Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 3.00
- > 3.00

Project: BE190043

Date: 06/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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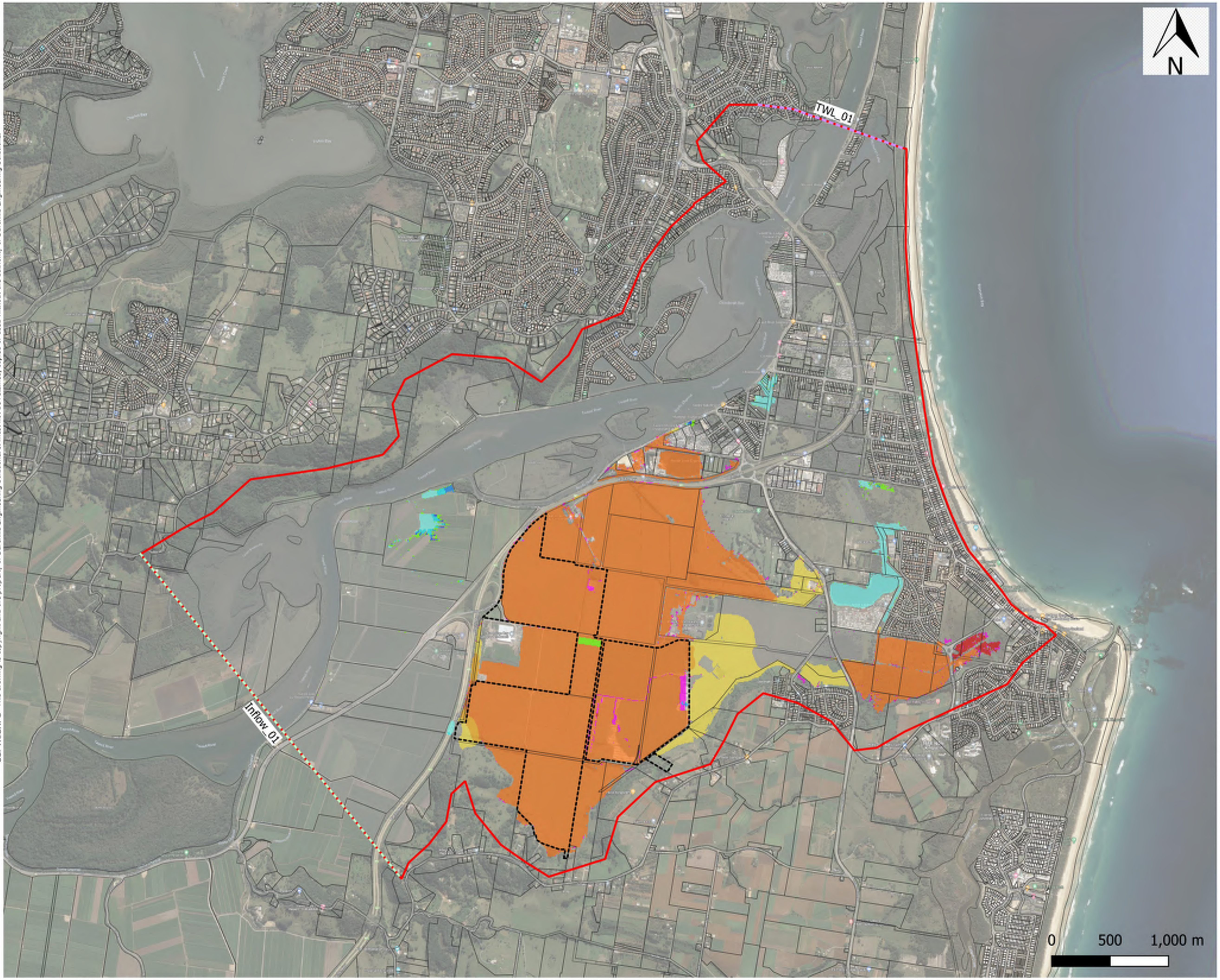

Tweed Sand Plant Flood Assessment

FIG F13 PHASE 11
20% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Cadastral
- Downstream Boundary
- Inflow Boundary

Afflux (mm)

- <-50
- -30- -50
- -20- -30
- -10- -20
- -10-10
- 10-20
- 20-30
- 30-50
- 50-100
- >100

Wet to Dry Afflux

- Was Wet Now Dry
- Was Dry Now Wet

Project: BE190043

Date: 11/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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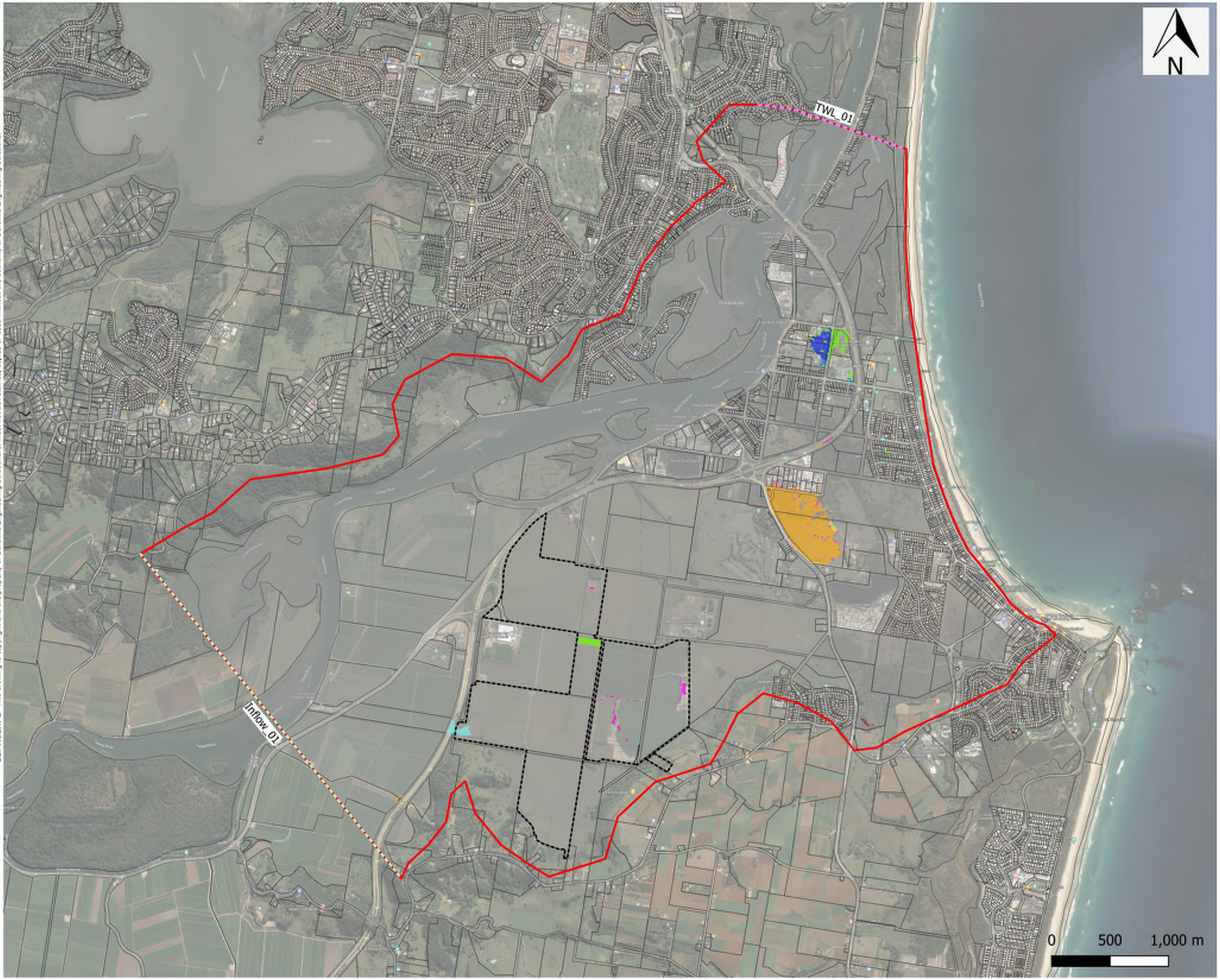

Tweed Sand Plant Flood Assessment

FIG F14 PHASE 11
5% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Cadastral
- Downstream Boundary
- Inflow Boundary

Afflux (mm)

- <-50
- -30- -50
- -20- -30
- -10- -20
- -10-10
- 10-20
- 20-30
- 30-50
- 50-100
- >100

Wet to Dry Afflux

- Was Wet Now Dry
- Was Dry Now Wet

Project: BE190043

Date: 18/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

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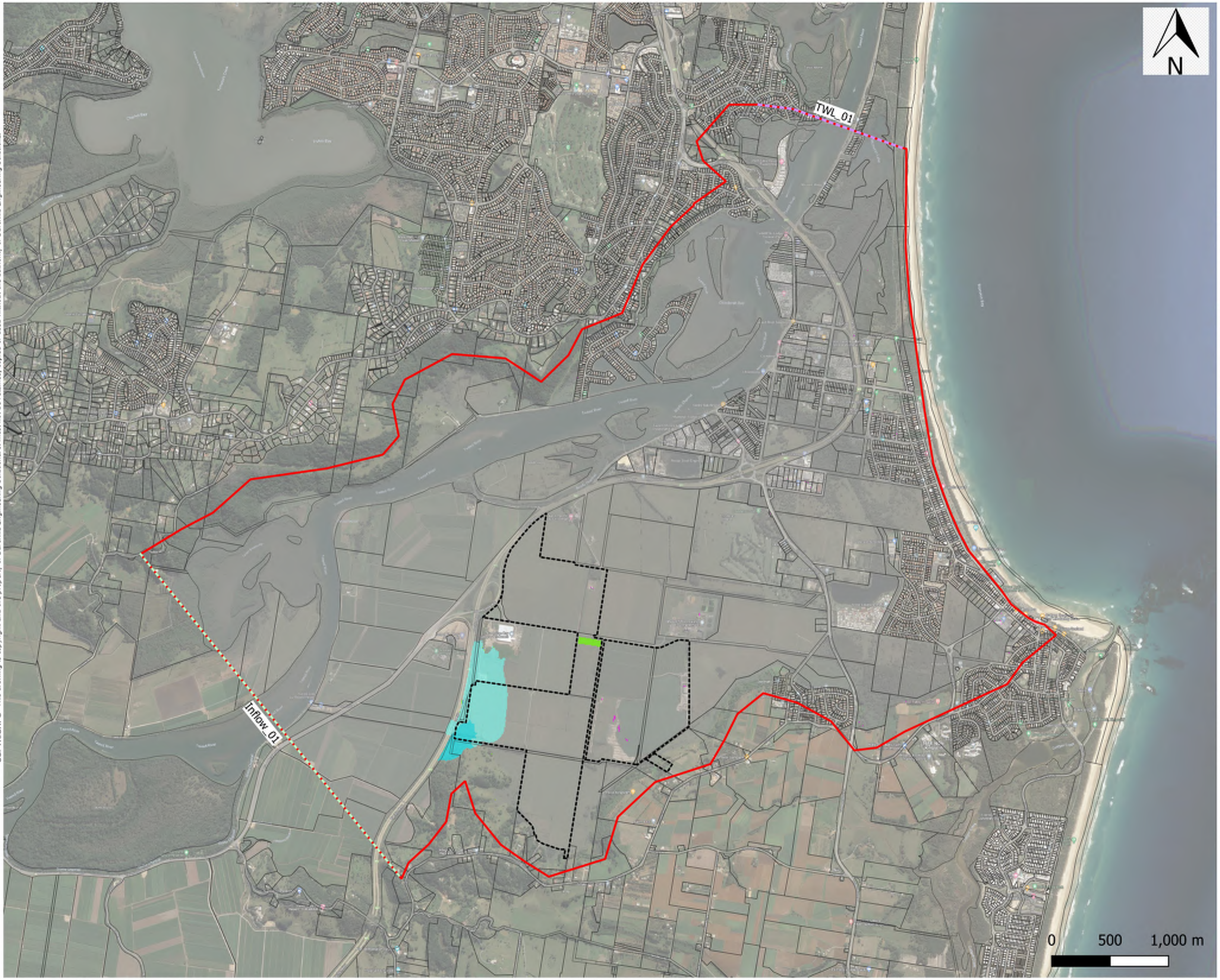

Tweed Sand Plant Flood Assessment

FIG F15 PHASE 11
1% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Cadastral
- Downstream Boundary
- Inflow Boundary

Afflux (mm)

- <-50
- -30- -50
- -20- -30
- -10- -20
- -10-10
- 10-20
- 20-30
- 30-50
- 50-100
- >100

Wet to Dry Afflux

- Was Wet Now Dry
- Was Dry Now Wet

Project: BE190043

Date: 18/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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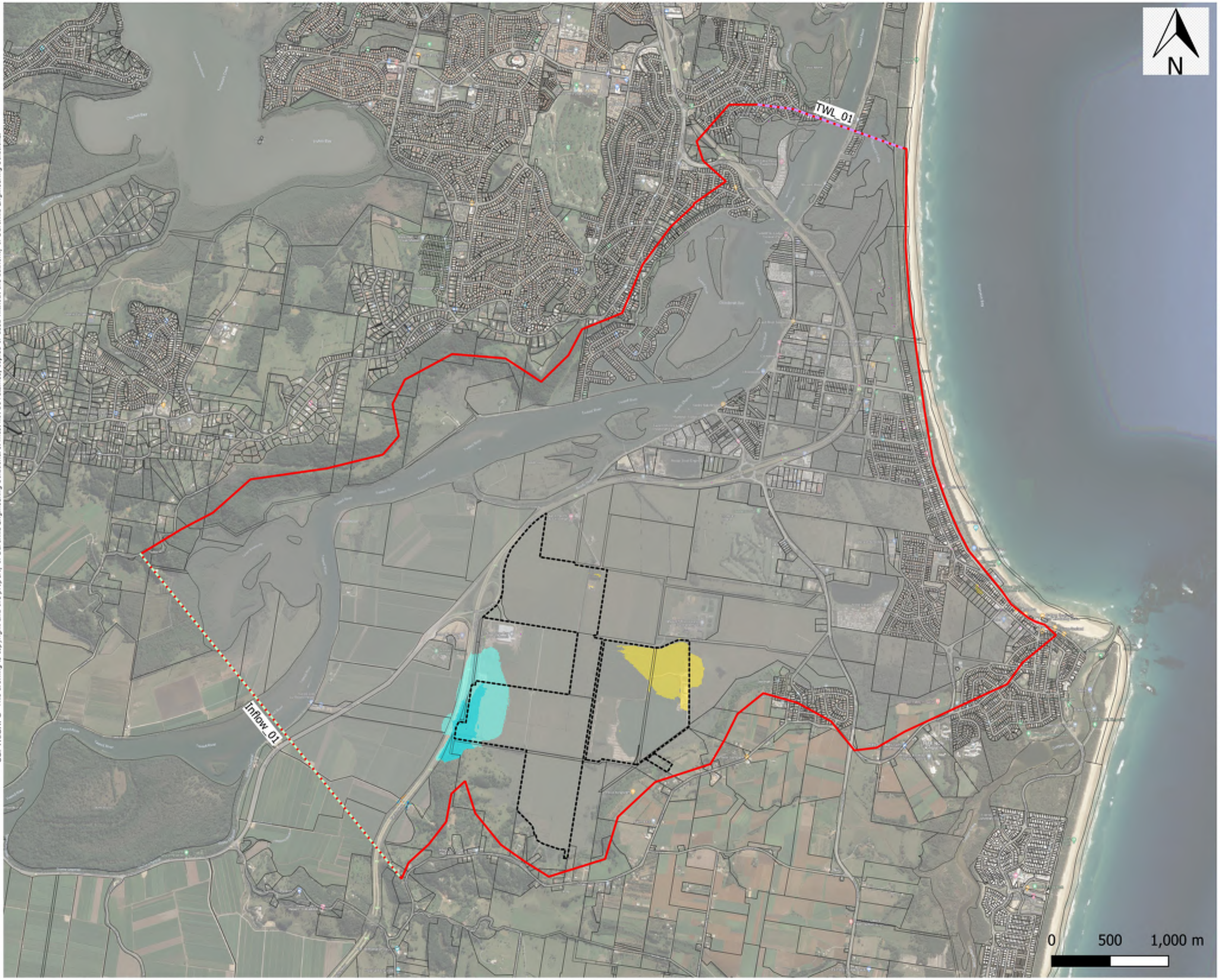

Tweed Sand Plant Flood Assessment

FIG F16 PHASE 11
1% AEP CLIMATE CHANGE
FLOOD WATER LEVEL AFFLUX
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Cadastral
- Downstream Boundary
- Inflow Boundary

Afflux (mm)

- <-50
- -30- -50
- -20- -30
- -10- -20
- -10-10
- 10-20
- 20-30
- 30-50
- 50-100
- >100

Wet to Dry Afflux

- Was Wet Now Dry
- Was Dry Now Wet

Project: BE190043

Date: 18/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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Tweed Sand Plant Flood Assessment

FIG F17 PHASE 11
0.2% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Downstream Boundary
- Inflow Boundary
- Cadastral

Afflux (mm)

- <-50
- -30- -50
- -20- -30
- -10- -20
- -10-10
- 10-20
- 20-30
- 30-50
- 50-100
- >100

Project: BE190043

Date: 11/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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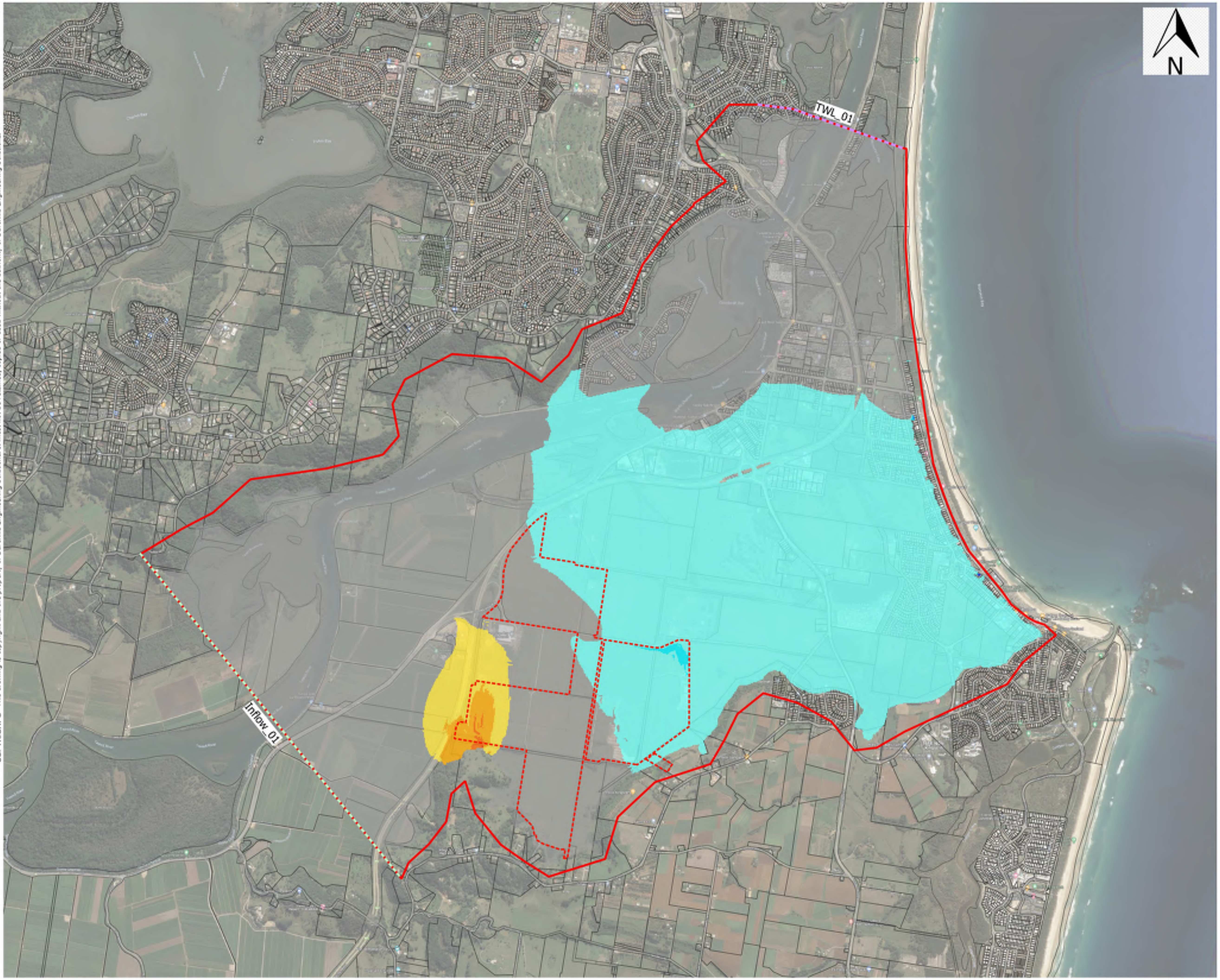

Tweed Sand Plant Flood Assessment

FIG F18 PHASE 11
0.005% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Downstream Boundary
- Inflow Boundary
- Cadastral

Afflux (mm)

- <-50
- -30- -50
- -20- -30
- -10- -20
- -10-10
- 10-20
- 20-30
- 30-50
- 50-100
- >100

Project: BE190043

Date: 11/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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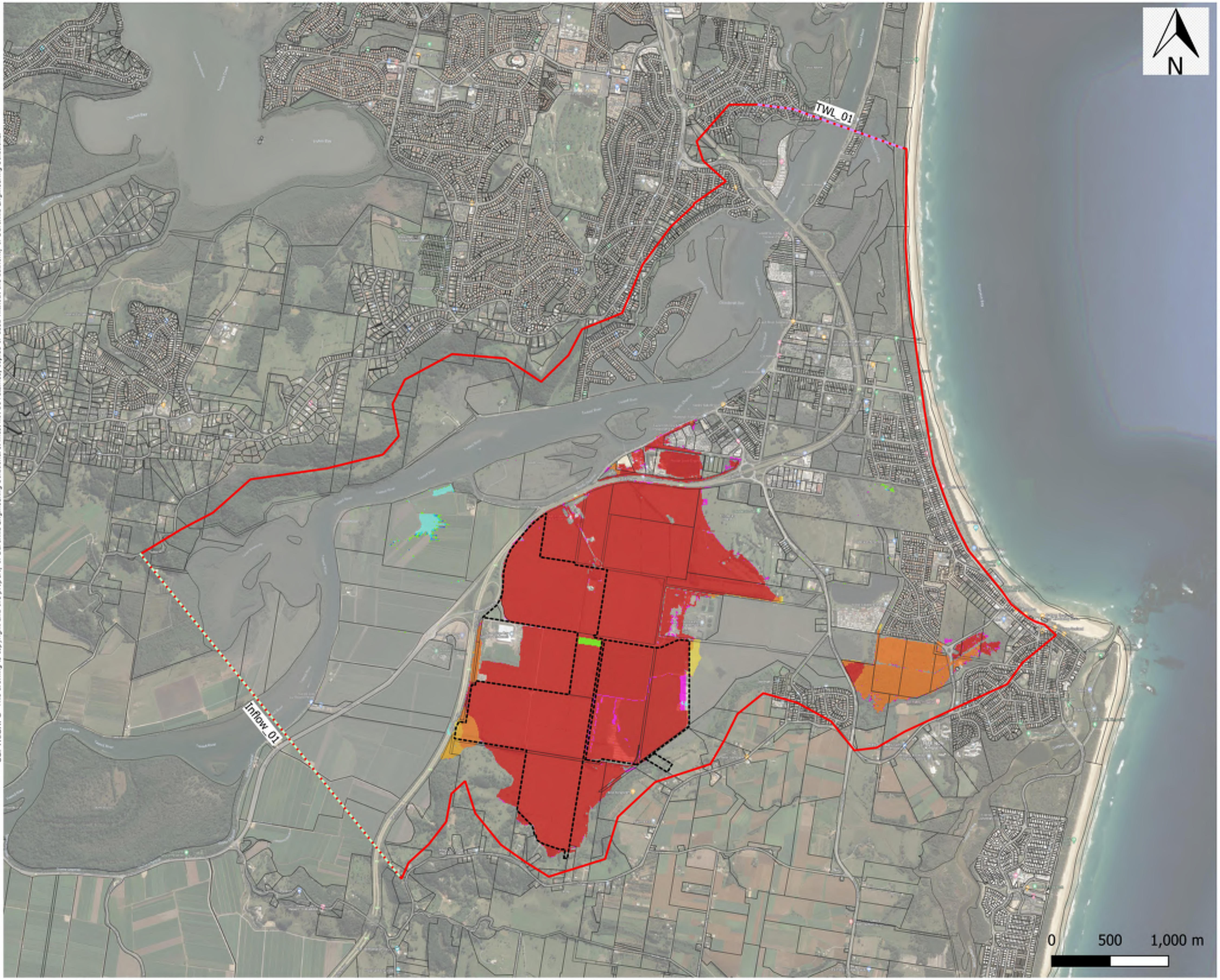

Tweed Sand Plant Flood Assessment

FIG F19 PHASE 9
20% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Cadastral
- Downstream Boundary
- Inflow Boundary

Afflux (mm)

- <-50
- -30- -50
- -20- -30
- -10- -20
- -10-10
- 10-20
- 20-30
- 30-50
- 50-100
- >100

Wet to Dry Afflux

- Was Wet Now Dry
- Was Dry Now Wet

Project: BE190043

Date: 18/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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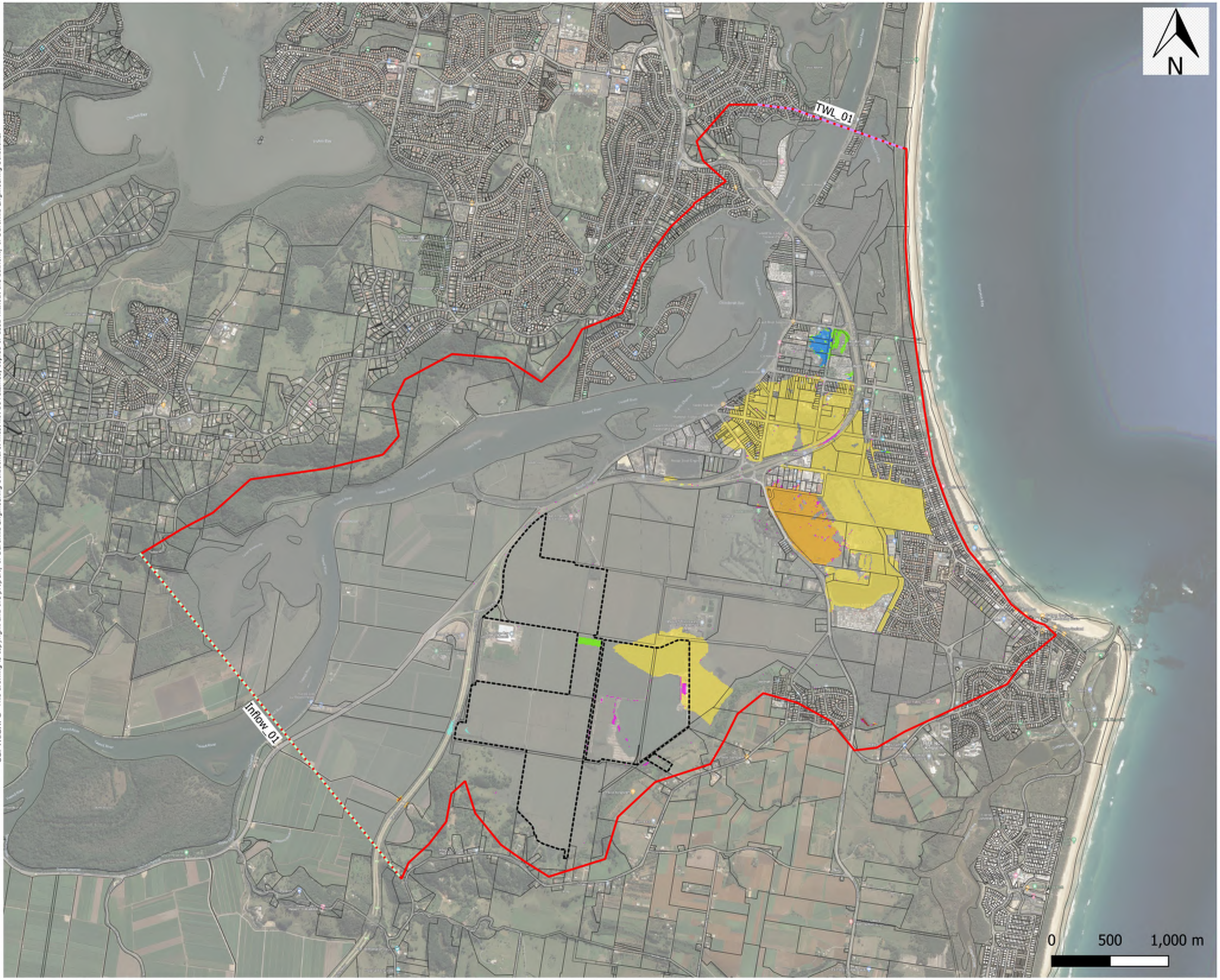

Tweed Sand Plant Flood Assessment

FIG F20 PHASE 9
5% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Cadastral
- Downstream Boundary
- Inflow Boundary

Afflux (mm)

- <-50
- -30- -50
- -20- -30
- -10- -20
- -10-10
- 10-20
- 20-30
- 30-50
- 50-100
- >100

Wet to Dry Afflux

- Was Wet Now Dry
- Was Dry Now Wet

Project: BE190043

Date: 18/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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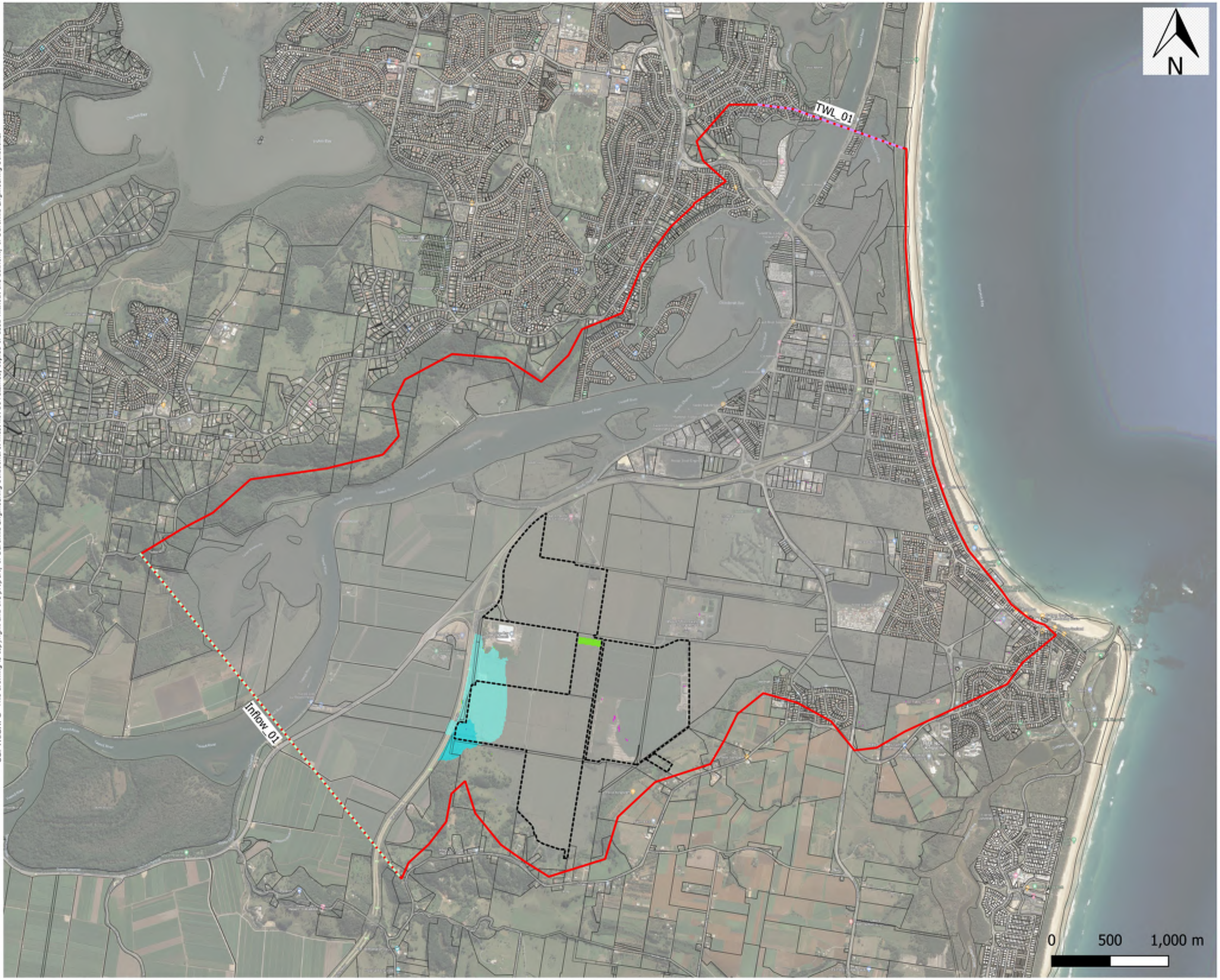

Tweed Sand Plant Flood Assessment

FIG F21 PHASE 9
1% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Cadastral
- Downstream Boundary
- Inflow Boundary

Afflux (mm)

- <-50
- -30- -50
- -20- -30
- -10- -20
- -10-10
- 10-20
- 20-30
- 30-50
- 50-100
- >100

Wet to Dry Afflux

- Was Wet Now Dry
- Was Dry Now Wet

Project: BE190043
Date: 18/10/2021
Scale: 1:30,000 at A3
Projection: GDA94/MGA Zone 56
Data Sources:

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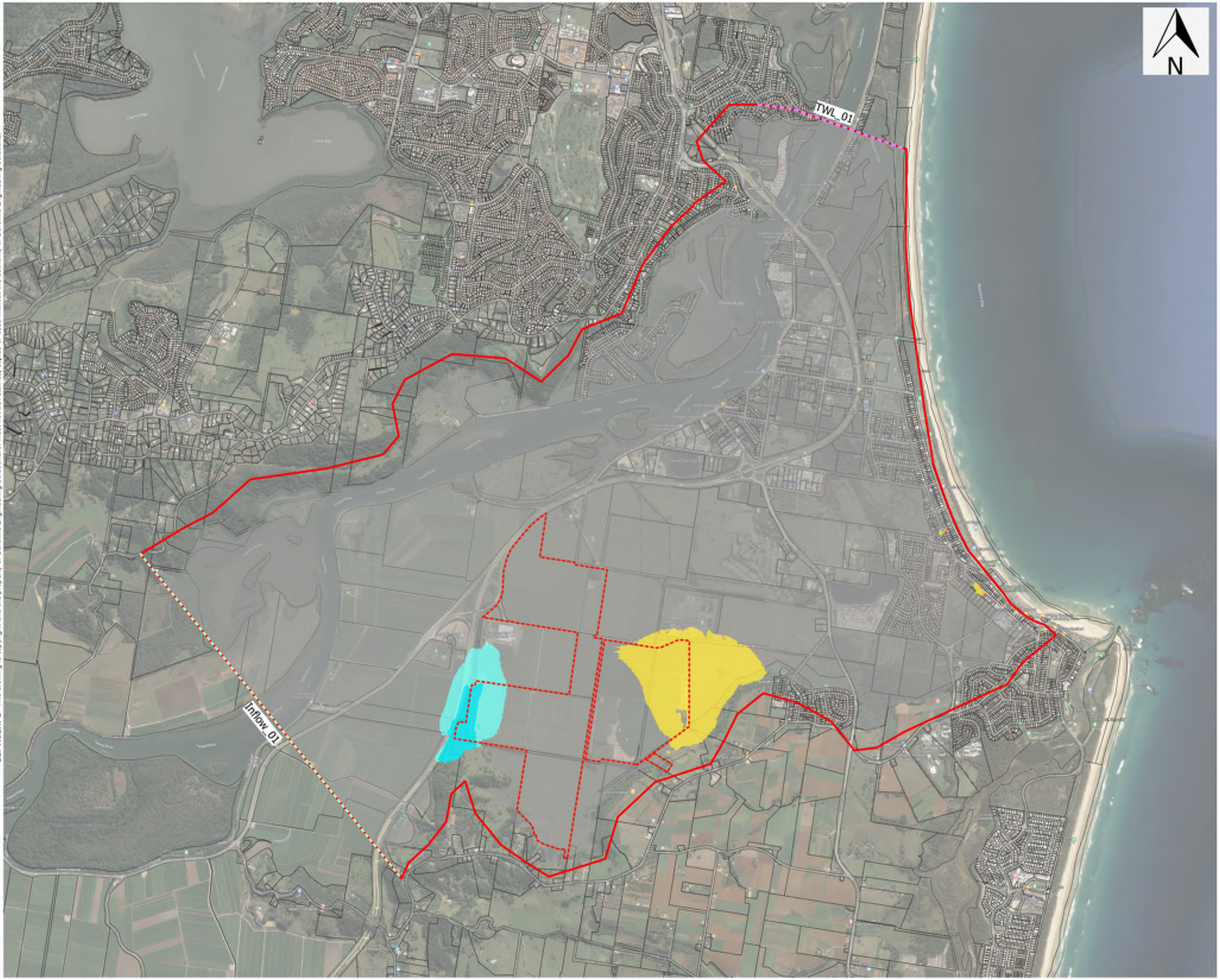

Tweed Sand Plant Flood Assessment

FIG F22 PHASE 9
1% AEP CLIMATE CHANGE
FLOOD WATER LEVEL AFFLUX
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Downstream Boundary
- Inflow Boundary
- Cadastral

Afflux (mm)

- <-50
- -30- -50
- -20- -30
- -10- -20
- -10-10
- 10-20
- 20-30
- 30-50
- 50-100
- >100

Project: BE190043

Date: 11/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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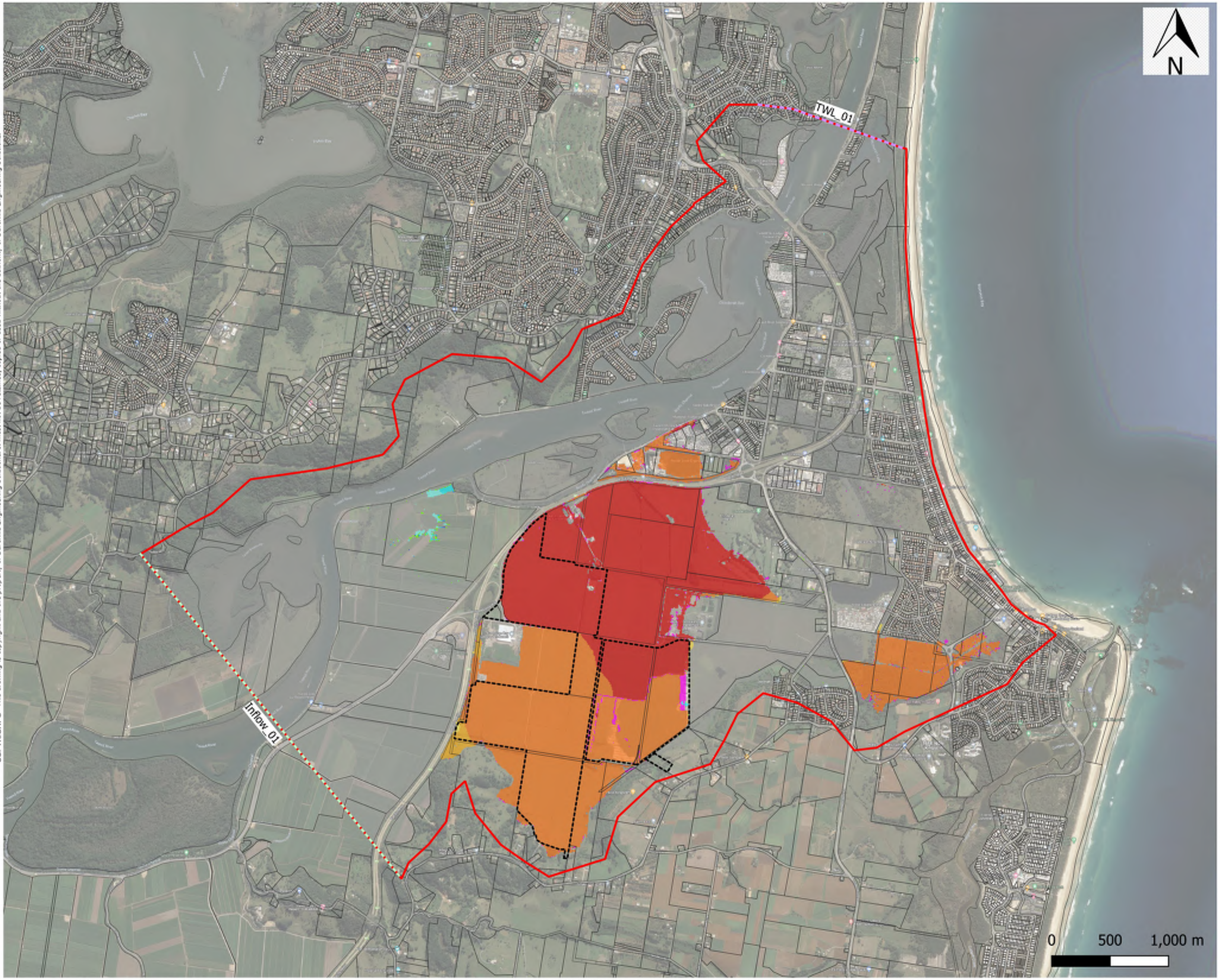

Tweed Sand Plant
Flood Assessment

FIG F23 PHASE 7
20% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL)

Legend
- Site Extent
- Model Extent
- Cadastral
- Downstream Boundary
- Inflow Boundary

Afflux (mm)
- <-50
- -30- -50
- -20- -30
- -10- -20
- -10-10
- 10-20
- 20-30
- 30-50
- 50-100
- >100

Wet to Dry Afflux
- Was Wet Now Dry
- Was Dry Now Wet

Project: BE190043
Date: 18/10/2021
Scale: 1:30,000 at A3
Projection: GDA94/MGA Zone 56
Data Sources:

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Tweed Sand Plant Flood Assessment

FIG F24 PHASE 7
5% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Cadastral
- Downstream Boundary
- Inflow Boundary

Afflux (mm)

- <-50
- -30- -50
- -20- -30
- -10- -20
- -10-10
- 10-20
- 20-30
- 30-50
- 50-100
- >100

Wet to Dry Afflux

- Was Wet Now Dry
- Was Dry Now Wet

Project: BE190043

Date: 18/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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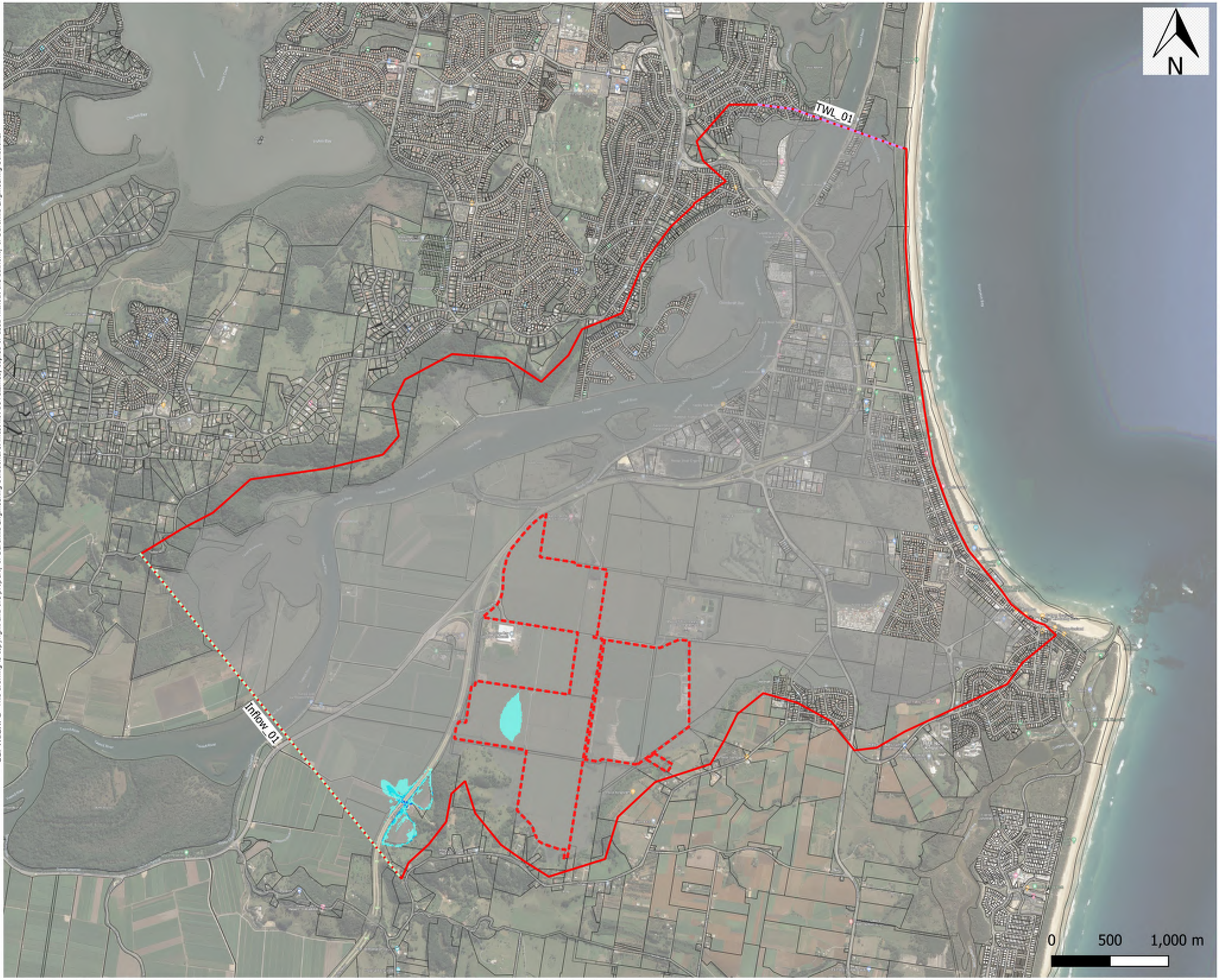

Tweed Sand Plant Flood Assessment

FIG F25 PHASE 7
1% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Downstream Boundary
- Inflow Boundary
- Cadastral

Afflux (mm)

- <-50
- -30- -50
- -20- -30
- -10- -20
- -10-10
- 10-20
- 20-30
- 30-50
- 50-100
- >100

Project: BE190043

Date: 06/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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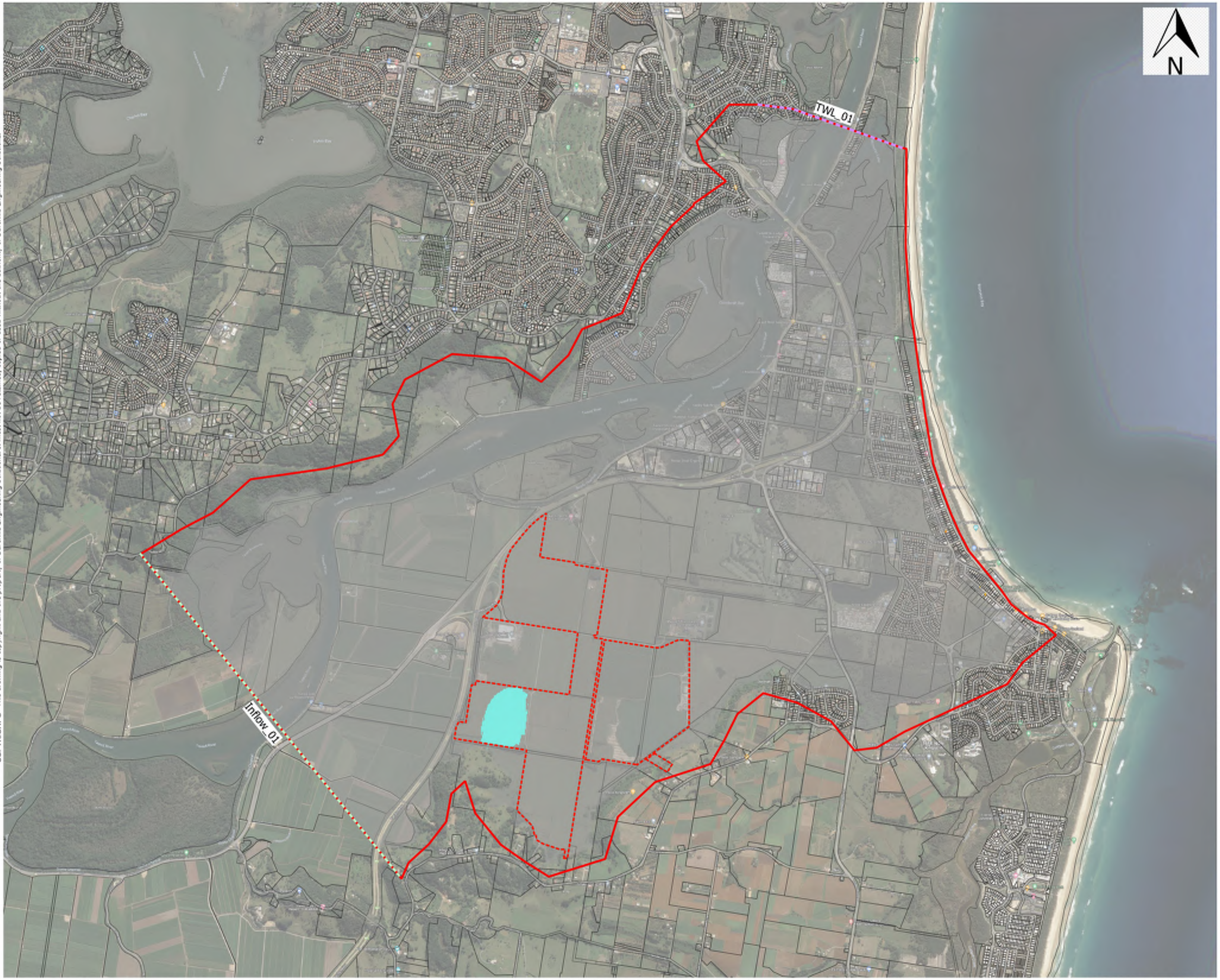

Tweed Sand Plant Flood Assessment

FIG F26 PHASE 7
1% AEP CLIMATE CHANGE
FLOOD WATER LEVEL AFFLUX
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Downstream Boundary
- Inflow Boundary
- Cadastral

Afflux (mm)

- <-50
- -30- -50
- -20- -30
- -10- -20
- -10-10
- 10-20
- 20-30
- 30-50
- 50-100
- >100

Project: BE190043

Date: 11/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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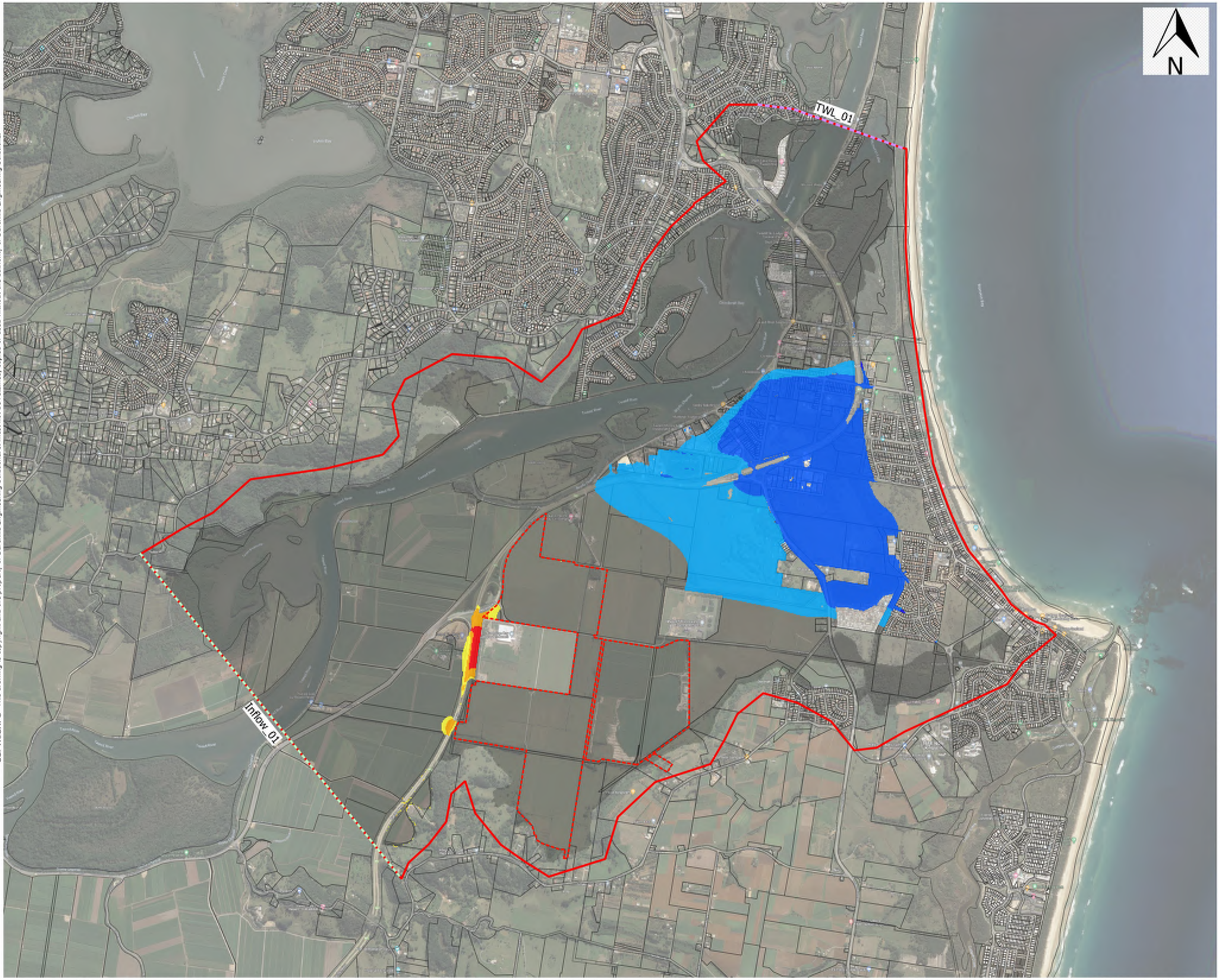

Tweed Sand Plant Flood Assessment

FIG F27 PHASE 11
CUMULATIVE DEVELEPMENT
1% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL)

Legend

- Site Extent
- Model Extent
- Downstream Boundary
- Inflow Boundary
- Cadastral

Afflux (mm)

- below -100
- -100 | -50
- -50 | -35
- -35 | 35
- 35 | 50
- 50 | 100
- 100 | 200
- above 200

Project: BE190043

Date: 11/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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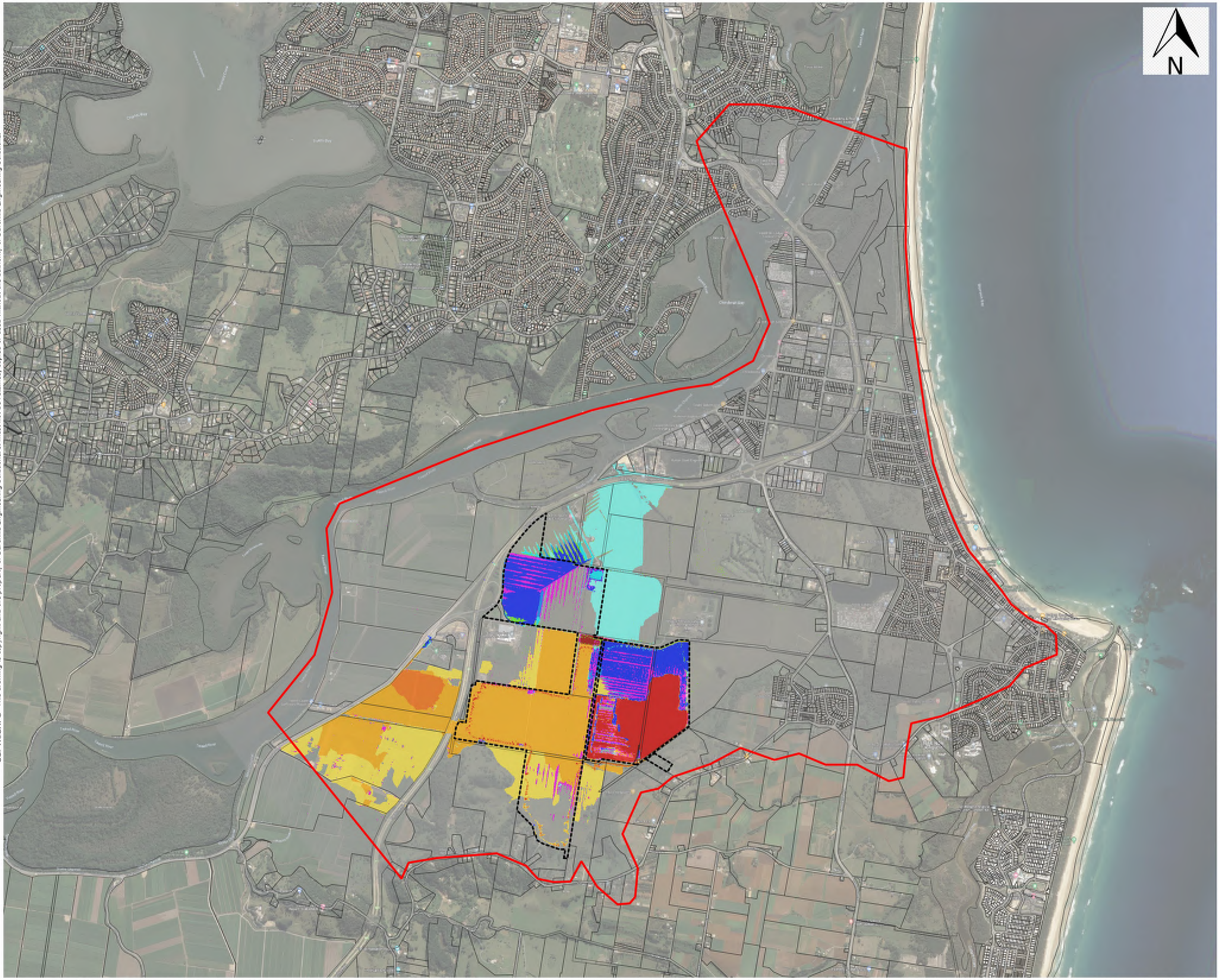

Tweed Sand Plant Flood Assessment

FIG F28 PHASE 11
50% AEP
FLOOD WATER LEVEL AFFLUX
(LOCAL)

Legend

- Site Extent
- Model Extent
- Cadastral

Afflux (mm)

- <-50
- -30- -50
- -20- -30
- -10- -20
- -10-10
- 10-20
- 20-30
- 30-50
- 50-100
- >100

Wet to Dry Afflux

- Was Wet Now Dry
- Was Dry Now Wet

Project: BE190043

Date: 18/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

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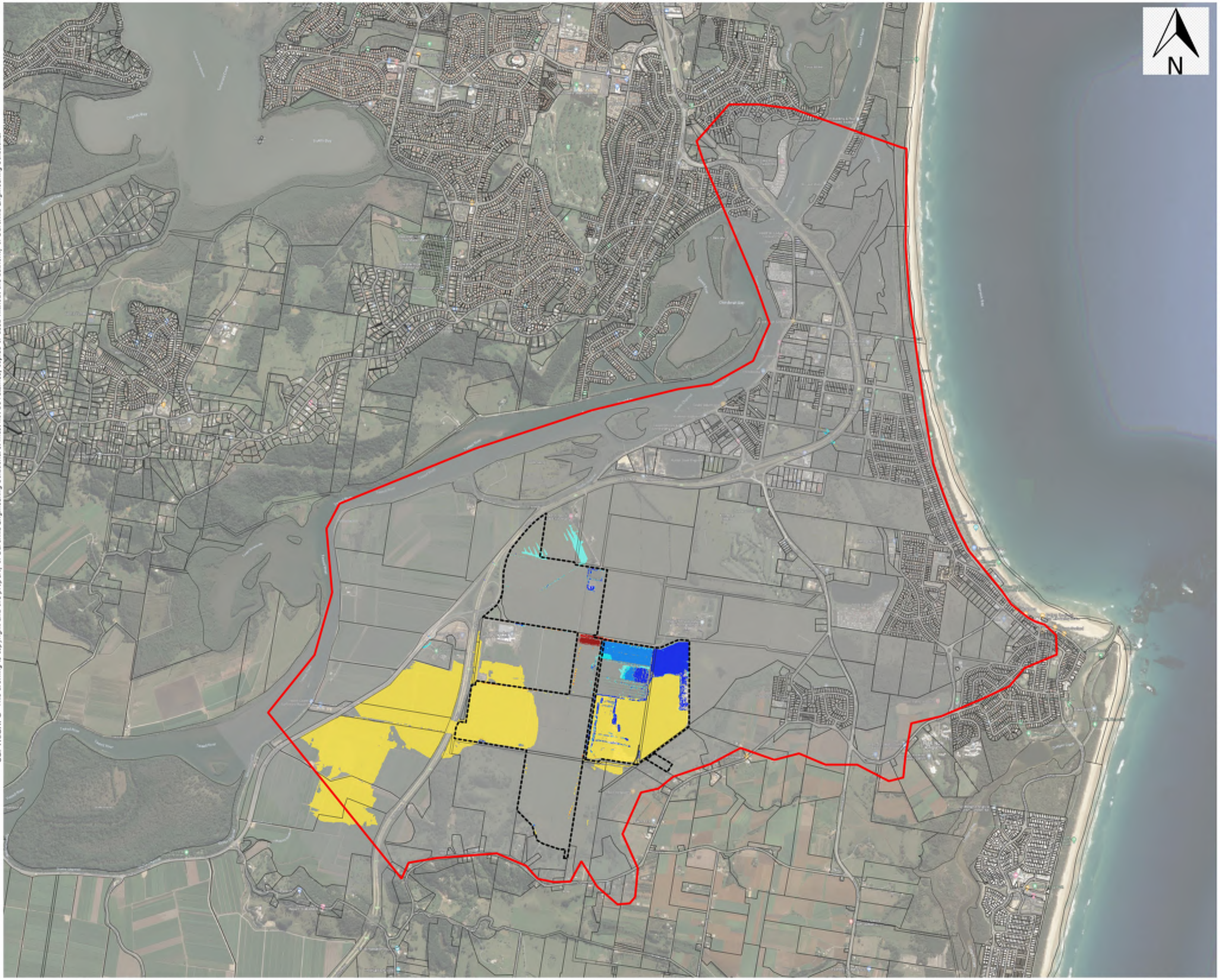

Tweed Sand Plant Flood Assessment

FIG F29 PHASE 11
20% AEP
FLOOD WATER LEVEL AFFLUX
(LOCAL)

Legend

- Site Extent
- Model Extent
- Cadastral

Afflux (mm)

- <-50
- -30- -50
- -20- -30
- -10- -20
- -10-10
- 10-20
- 20-30
- 30-50
- 50-100
- >100

Project: BE190043

Date: 11/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

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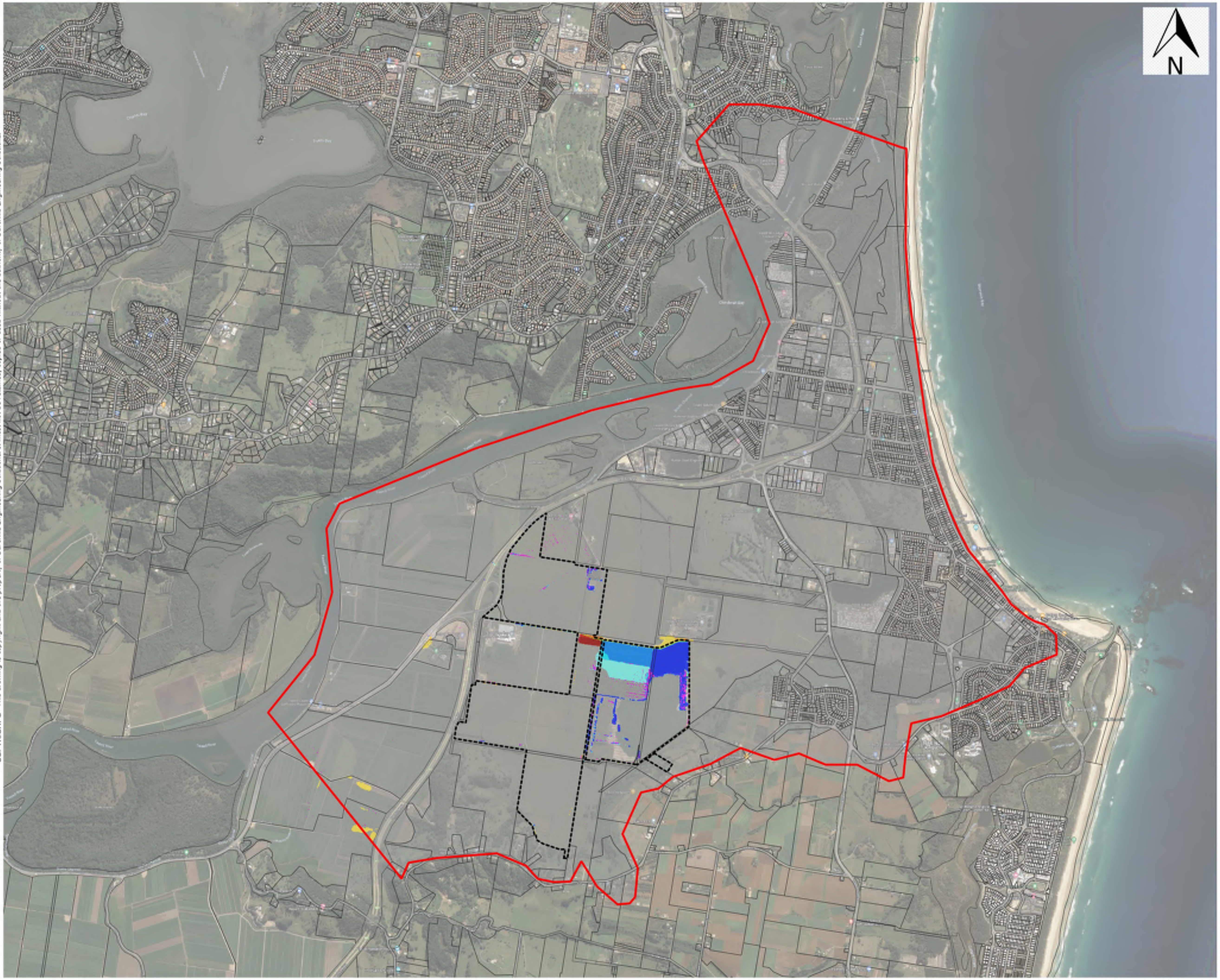


Tweed Sand Plant Flood Assessment

FIG F30 PHASE 11
10% AEP
FLOOD WATER LEVEL AFFLUX
(LOCAL)

Legend

- Site Extent
- Model Extent
- Cadastral

Afflux (mm)

- <-50
- -30- -50
- -20- -30
- -10- -20
- -10-10
- 10-20
- 20-30
- 30-50
- 50-100
- >100

Wet to Dry Afflux

- Was Wet Now Dry
- Was Dry Now Wet

Project: BE190043

Date: 18/10/2021

Scale: 1:30,000 at A3

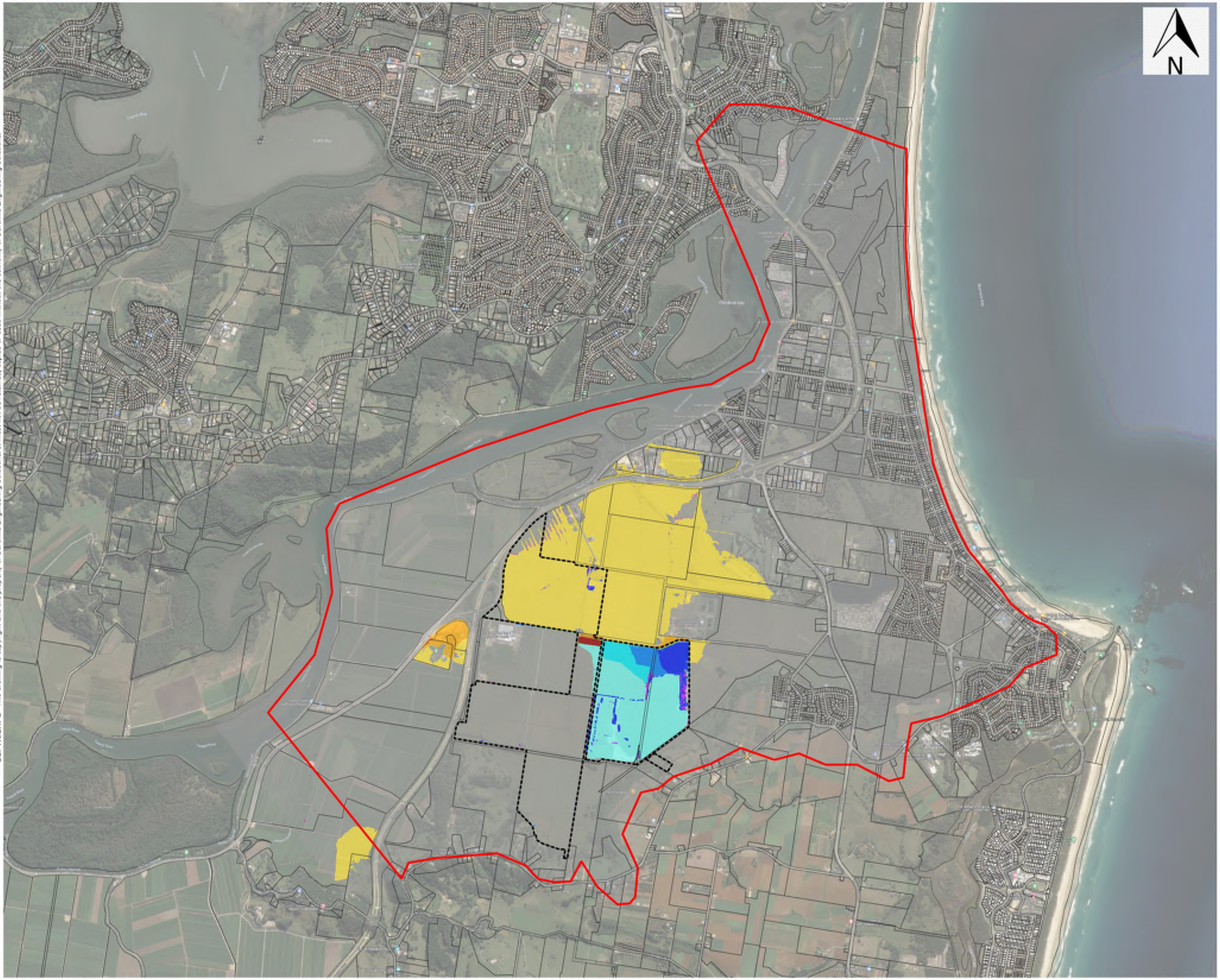
Projection: GDA94/MGA Zone 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson



Tweed Sand Plant Flood Assessment

FIG F31 PHASE 11
5% AEP
FLOOD WATER LEVEL AFFLUX
(LOCAL)

Legend

- Site Extent
- Model Extent
- Cadastral

Afflux (mm)

- <-50
- -30- -50
- -20- -30
- -10- -20
- -10-10
- 10-20
- 20-30
- 30-50
- 50-100
- >100

Wet to Dry Afflux

- Was Wet Now Dry
- Was Dry Now Wet

Project: BE190043

Date: 18/10/2021

Scale: 1:30,000 at A3

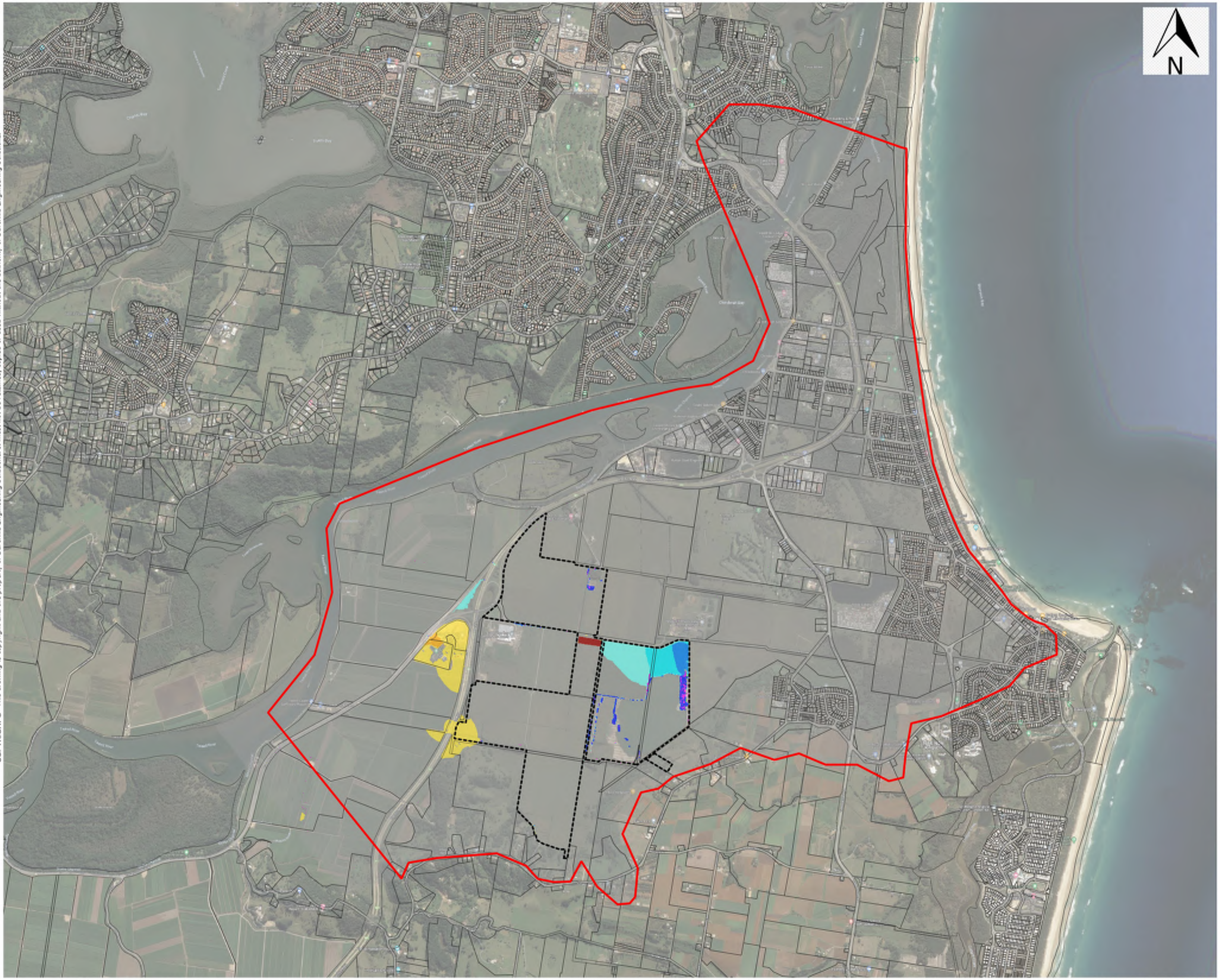
Projection: GDA94/MGA Zone 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson



Tweed Sand Plant Flood Assessment

FIG F32 PHASE 11
2% AEP
FLOOD WATER LEVEL AFFLUX
(LOCAL)

Legend

- Site Extent
- Model Extent
- Cadastral

Afflux (mm)

- <-50
- -30- -50
- -20- -30
- -10- -20
- -10-10
- 10-20
- 20-30
- 30-50
- 50-100
- >100

Wet to Dry Afflux

- Was Wet Now Dry
- Was Dry Now Wet

Project: BE190043

Date: 18/10/2021

Scale: 1:30,000 at A3

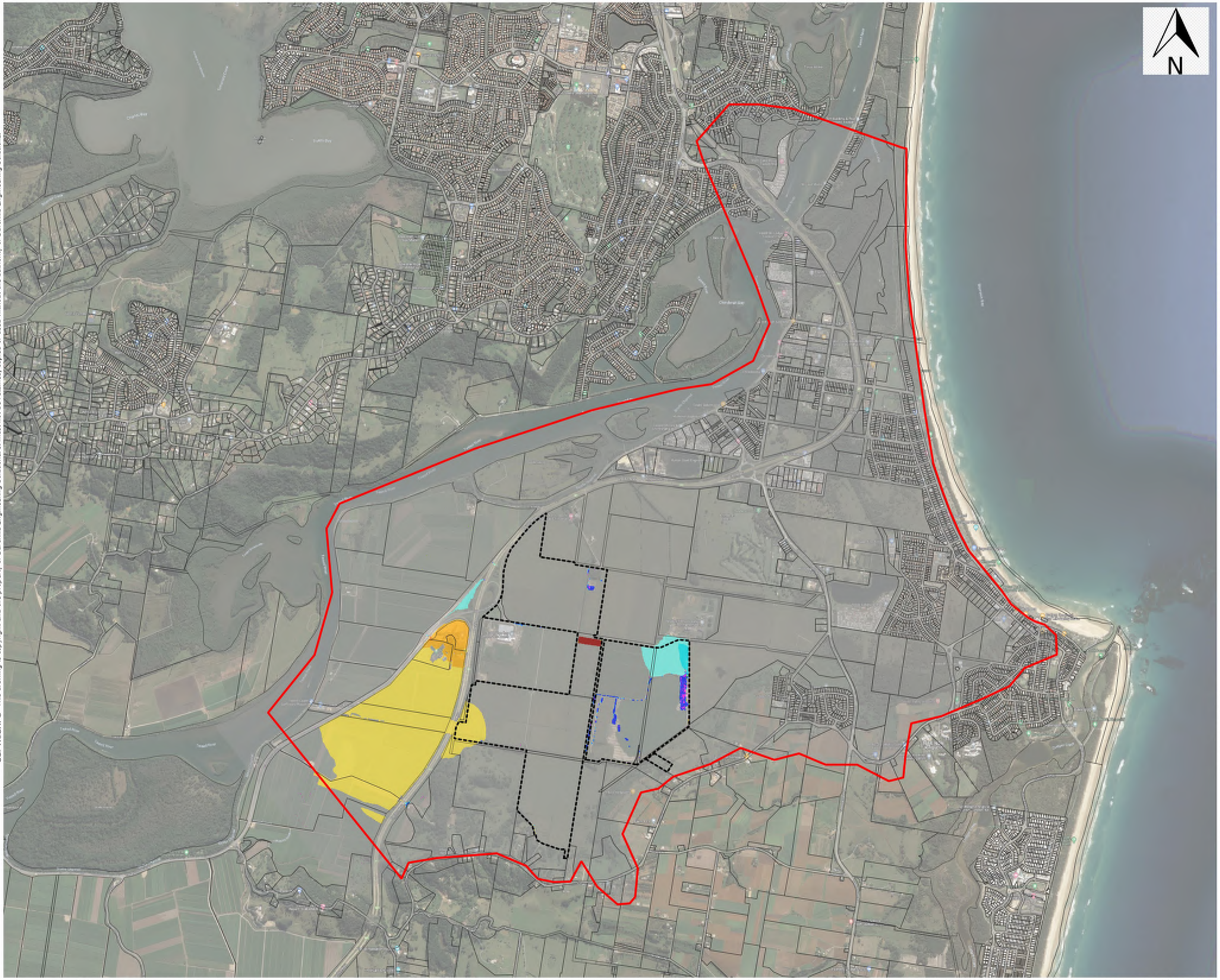
Projection: GDA94/MGA Zone 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson



Tweed Sand Plant Flood Assessment

FIG F33 PHASE 11
1% AEP
FLOOD WATER LEVEL AFFLUX
(LOCAL)

Legend

- Site Extent
- Model Extent
- Cadastral

Afflux (mm)

- <-50
- -30- -50
- -20- -30
- -10- -20
- -10-10
- 10-20
- 20-30
- 30-50
- 50-100
- >100

Wet to Dry Afflux

- Was Wet Now Dry
- Was Dry Now Wet

Project: BE190043

Date: 18/10/2021

Scale: 1:30,000 at A3

Projection: GDA94/MGA Zone 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson

Appendix G – Detailed Survey

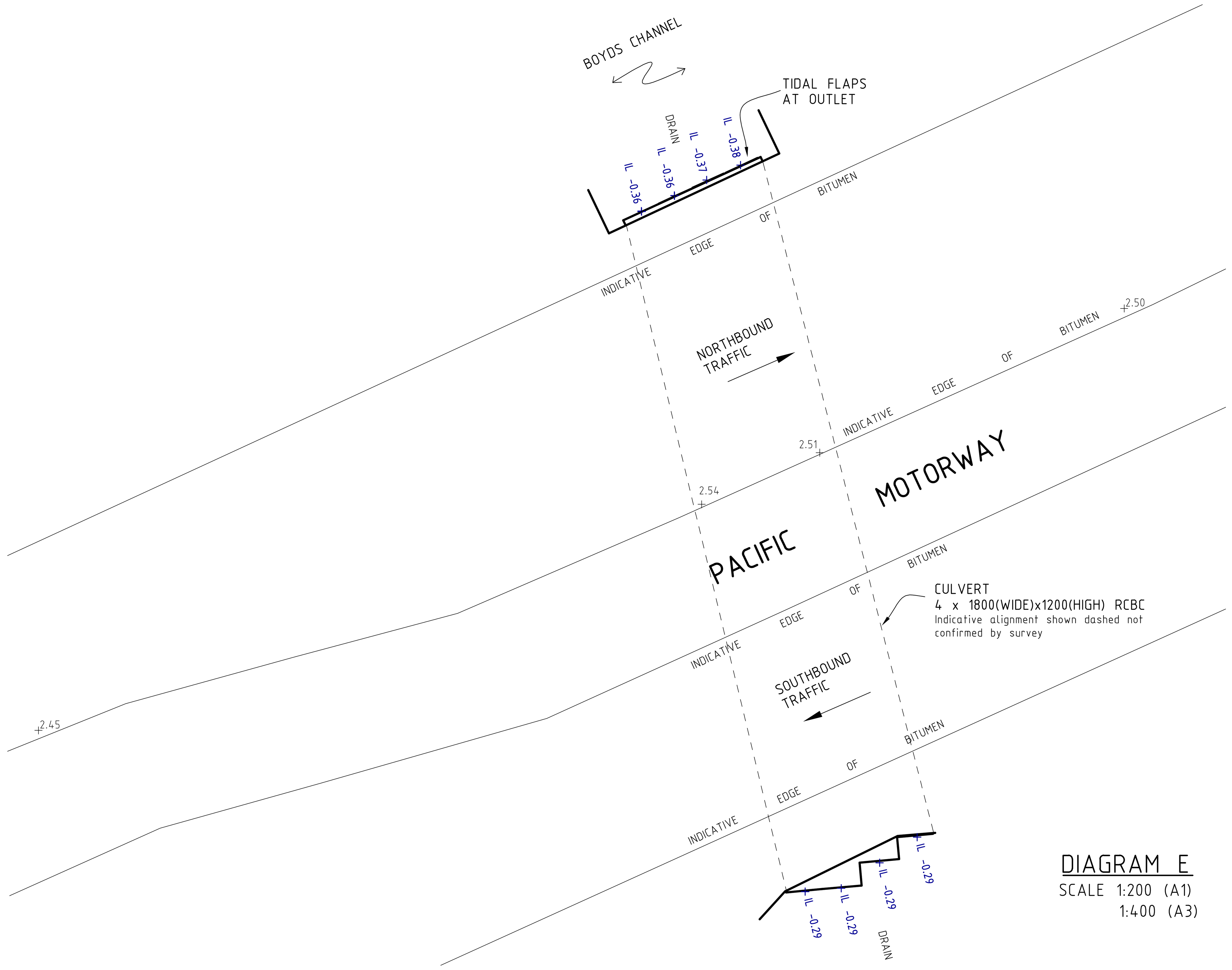


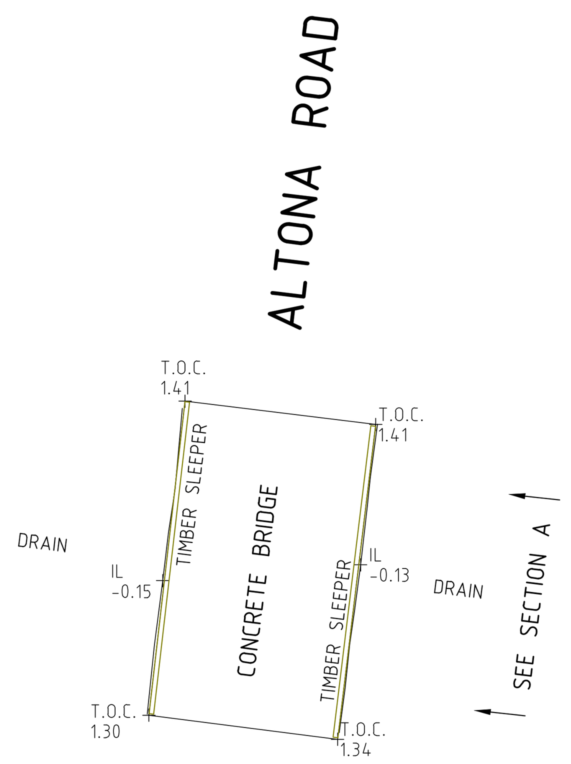
DIAGRAM E
SCALE 1:200 (A1)
1:400 (A3)

INSET
SCALE 1:10000 (A1)
1:20000 (A3)

NOTES

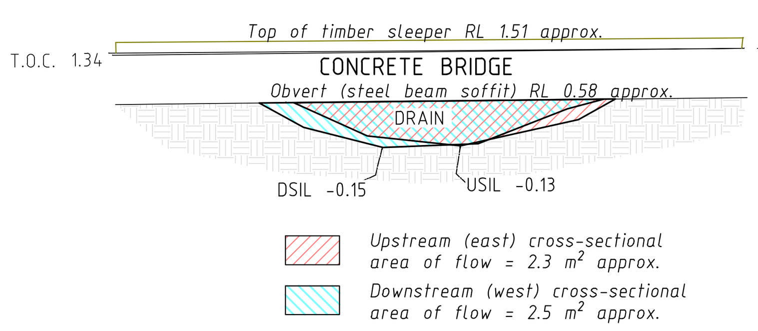
1. LEVEL DATUM IS AHD. ORIGIN OF LEVELS IS GNSS RTK OBSERVATIONS (AT PACIFIC MOTORWAY) AND PM65962 RL = 1.636 AHD AT ALL OTHER CULVERTS.

2. HORIZONTAL COORDINATE DATUM IS APPROXIMATE MGA (ZONE 56) ON GROUND DISTANCES (S.F=1). TO TRANSFORM TO MGA, ALL DATA MUST BE SCALED AROUND ORIGIN PM65962 (EASTING: 554918.577 NORTHING: 6874214.533) USING COMBINED SCALE FACTOR = 0.9996307.



T.O.C. = TOP OF CONCRETE

DIAGRAM D
SCALE 1:200 (A1)
1:400 (A3)



SECTION A
SCALE 1:100 (A1)
1:200 (A3)

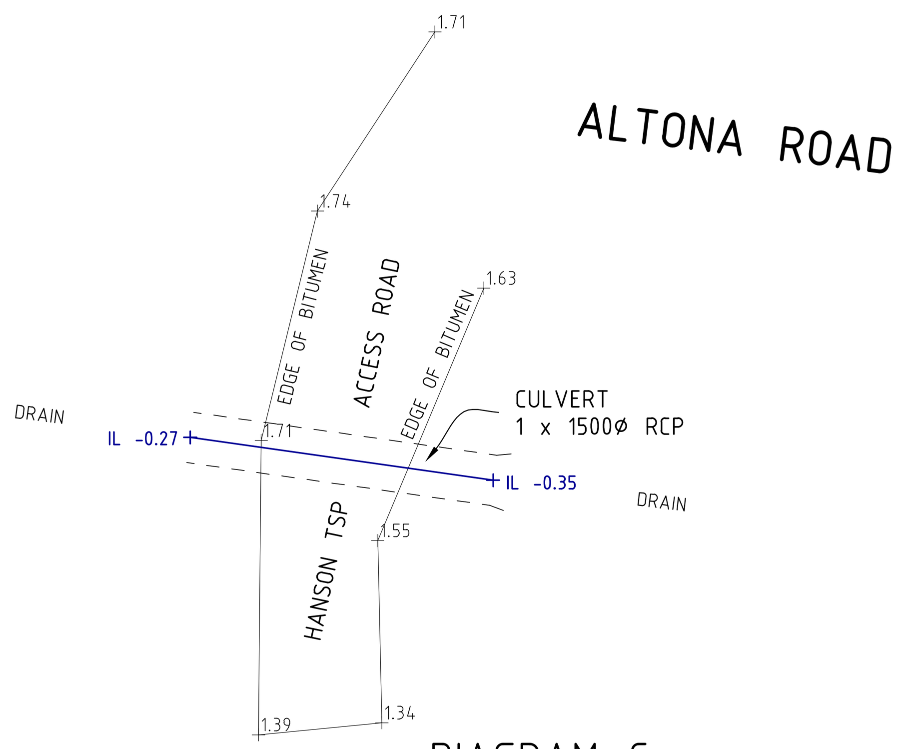


DIAGRAM C
SCALE 1:200 (A1)
1:400 (A3)

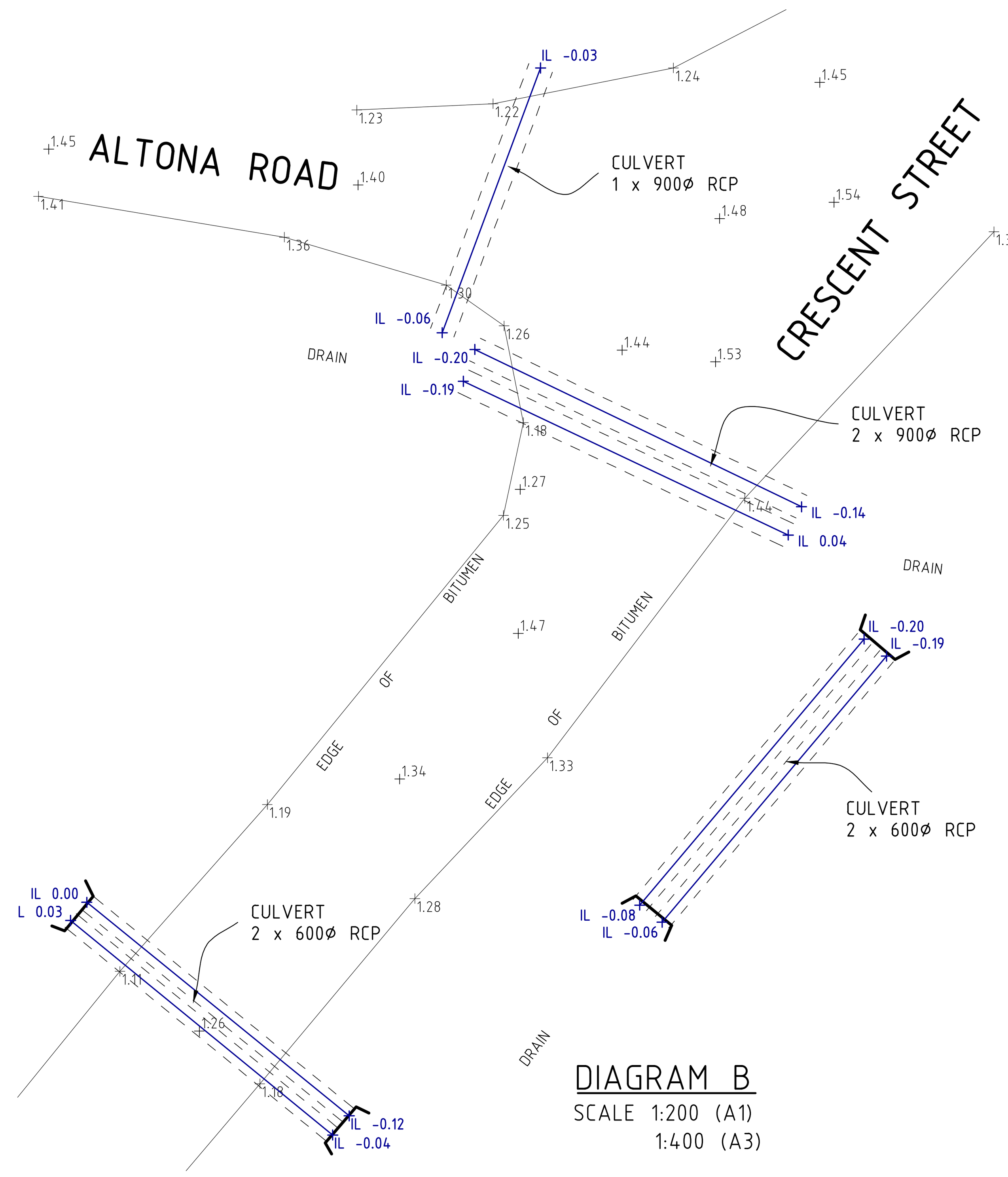


DIAGRAM B
SCALE 1:200 (A1)
1:400 (A3)

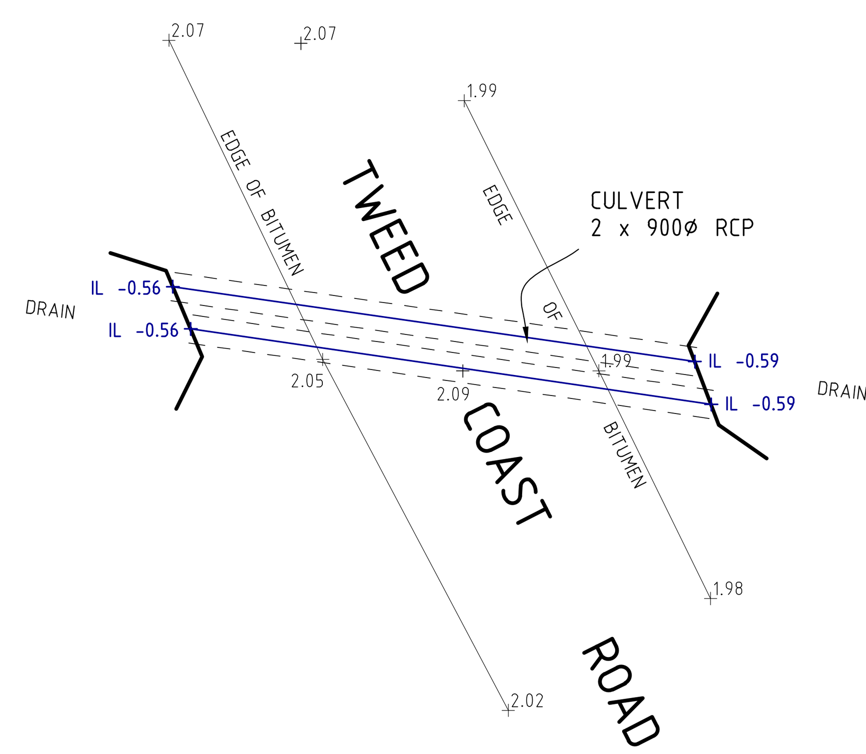


DIAGRAM A
SCALE 1:200 (A1)
1:400 (A3)

CLIENT:
HANSON TSP
c- BURCHILLS ENGINEERING SOLUTIONS

ALL UNDERGROUND SERVICES SHOULD BE LOCATED ON SITE BY RELEVANT AUTHORITIES BEFORE ANY WORK IS COMMENCED

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REVISION /DATE	REVISION DETAILS	REVISION BY

LANDSURV PTY LTD
REGISTERED SURVEYORS & DEVELOPMENT CONSULTANTS
14 ENID STREET TWEED HEADS NSW 2485
Ph. (07) 55366467 Fax (07)55367489 email: macsurv@landsurv.com.au

DATE OF SURVEY	31.03.20
DATE	01.03.20
DRAWN	CBS
CHECKED	BG
CAD FILE No.	39715_LEV

SURVEY OF CULVERTS
TWEED COAST ROAD, CRESCENT STREET, ALTONA ROAD, PACIFIC MOTORWAY
CUDGEN & CHINDERAH, NSW

LEVEL DATUM: AHD ORIGIN: SCIMS & GNSS RTK OBSERVATIONS

SCALE 1: 200 [A1]
REVISION:
SHEET 1 OF 1
JOB No 39718