Appendix D1 – Flood & Stormwater Report

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Tweed Sand Plant

Flood & Stormwater Assessment

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Prepared by:	Samuel Huddy
Position:	Water & Civil Engineer
Signed:	
Date:	22/02/2021

Approved by:	Jonathan Cuell
Position:	Water & Civil Manager RPEQ - 21773
Signed:	
Date:	22/02/2021

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Coote Burchills Engineering Pty Ltd ACN: 166 942 365

Level 2, 26 Marine Parade SOUTHPORT QLD 4215
PO Box 3766, Australia Fair SOUTHPORT QLD 4215
Telephone: +61 7 5509 6400 Facsimile: +61 7 5509 6411 Email: admin@burchills.com.au

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. 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.

It is proposed that runoff from all external catchments be conveyed around the proposed lakes to the specified discharge points at the M1. The rainfall that falls on the existing and proposed lakes will be largely detained within the lakes up to RL 1 mAHD, at which point overflow will be discharged to the existing drainage lines via controlled overflow weirs. Peak flow assessment for local storm events has shown the proposed expansion of the sand plant will maintain peak discharges at the Legal Point of Discharge for major storm events and create some minor increases for minor storm events.

Minor changes in the local hydraulic regime are caused by a loss in conveyance storage through the inclusion of bunding around the proposed lakes. The bunding around the lakes prevents external catchment runoff from entering the lakes frequently, major vents are permitted to overtop into the lakes. It is also anticipated that the changes to the local hydraulic behaviour around the site will not cause an adverse hydraulic condition.

Future expansion of the plant will require a new washdown and processing facility. As the current layout and details of this facility are unknown, an additional stormwater management plan will need to be prepared at the appropriate time.

Using the endorsed Tweed River Flood Model, an assessment was carried out to investigate the potential flood impacts caused by the development. Flood behaviour at the site for flood events up to and including the 1% AEP can be categorized as flood storage rather than conveyance. During events with higher flood waters (such as the 0.2% AEP event), flooding at the subject site changes to serve a conveyance purpose as large volumes of water overtop the M1 and water is pushed towards the townships of Kingscliff and Chinderah. The Designated flood Level (1% AEP event flood level) for the subject site is 3.22 mAHD.

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. The flood impact assessments undertaken as part of the Tweed Sand Plant, have been targeted to meet these same development assessment criteria as outlined below:

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

A flood impact assessment considering flooding in the existing and proposed conditions has been completed, all changes in flood level caused by the proposed development are within the allowable limit set by Tweed Shire Council (35mm) the following scenarios were assessed and the results of which are described:

- Development Phase 7 – Flood improvement for the 20% and 5% AEP events, impacts in the range of 10-20mm for the 1% and 0.2% AEP events in the Kingscliff township area.
- Development Phase 9 – Flood improvement for the 20% and 5% AEP events, impacts in the range of 10-20mm for the 1% AEP in the Kingscliff township area, impacts in the range of 20-30mm for the 1% AEP + Climate Change event 0.2% AEP over the Kingscliff and Chinderah area.
- Development Phase 11 (Ultimate) – Flood improvement for the 20% and 5% AEP events, no significant change to flood conditions in the 1% AEP, impacts in the range of 20-30mm for the 1% AEP + Climate Change event 0.2% AEP over the Kingscliff and Chinderah area.

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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 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 the flood regime caused by the development across the life of the expansion;
- Ensure the development does not result in a loss of floodplain storage;
- 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.

1.4 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, DP 1082435;
- Lot 23 DP1077509;
- Lot 494 DP720450;
- Lot 1 DP1250570;
- Lot 2 DP1192506;
- Lot 3 DP1243752;
- Lot 51 DP1166990;
- 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
- 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.

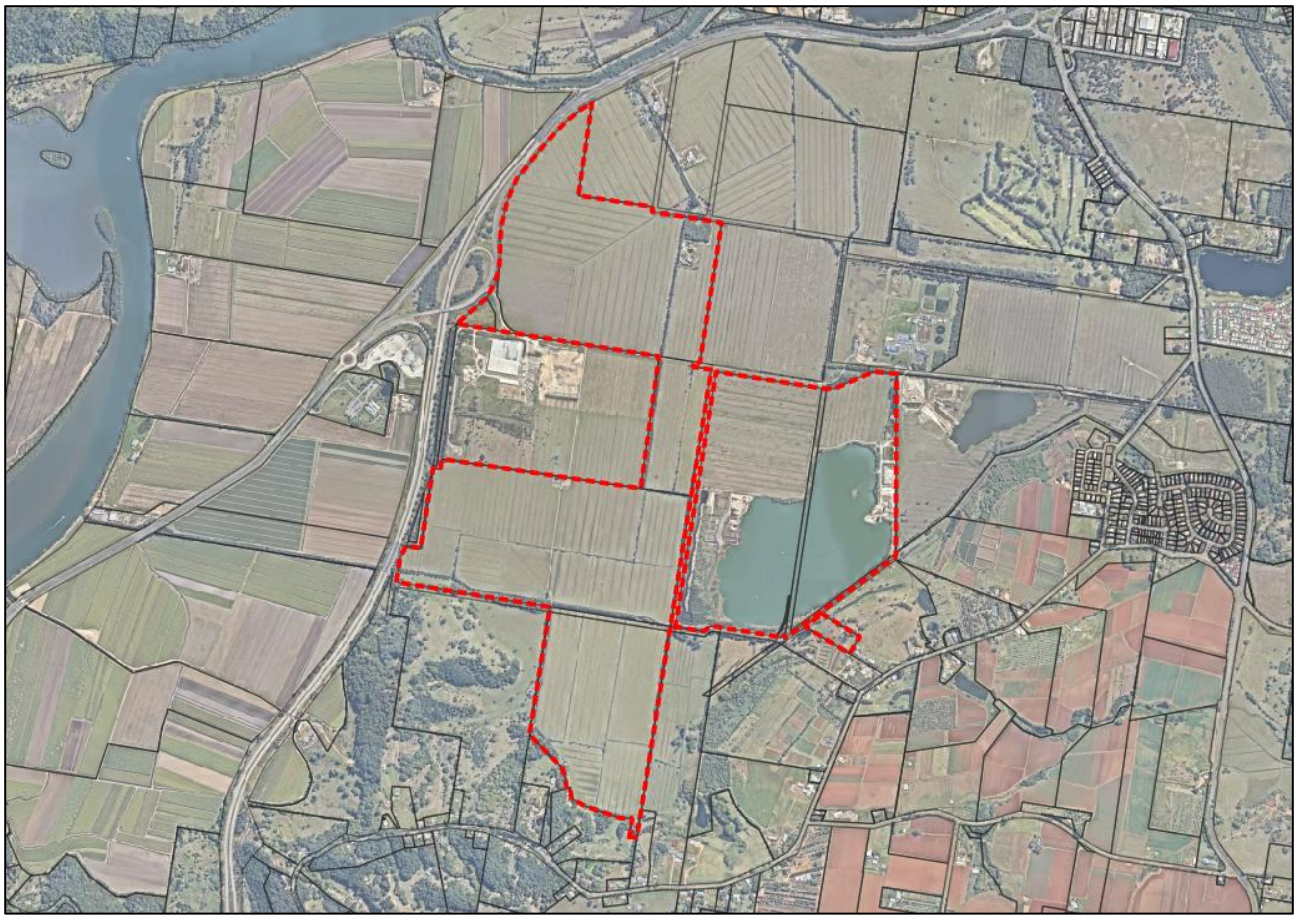


Figure 2.1 Site Aerial Photograph September 2020 (Nearmap)

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 mAHD.

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 two new haulage routes 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 B.

Figure 2.2 Proposed Site Phasing Layout (Zone, 2021)

3. Stormwater Management and Local Flood Assessment

3.1 Overview

The following section of this report outlines the existing local stormwater conveyance at the subject site and the required measures to implement successful stormwater management of the proposed development to ensure a non-worsened local hydraulic condition downstream.

3.1.1 Local Stormwater Assessment Objectives

The primary objectives of the stormwater assessment are to determine the following:

- Assess the changes to the local hydrologic and hydraulic regime caused by the development; and
- Assess the likeliness of the proposed lakes to overtop and the likeliness of runoff from external catchments to discharge to the lake.

3.2 Conveyance of Flows

3.2.1 Existing Stormwater Conveyance

In the existing scenario runoff that is generated over the vacant lots is collected by agricultural channels and conveyed to the central drainage lines that discharge to the culverts underneath the M1. Runoff that is produced over the existing sand extraction area is generally contained within the lake and prevented from over-topping into external drainage lines. A significant volume of runoff is produced over the external catchments to the south, this runoff is collected by existing drainage lines and conveyed to the culverts at the M1.

The subject site is completely flat and only drains once sufficient rain has fallen to create a hydraulic grade towards the outlets. The system is brackish and tidal water prevent the existing drainage lines from being completely free from water.

3.2.2 Proposed Stormwater Conveyance

The expansion of the sand plant production activities will result in the creation of large lakes, runoff produced over the lakes will generally be trapped in the lakes by bunding and be prevented from overtopping for most events. Overflow locations are proposed for both lakes. 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 1	1.75 mAHD (Lake 1 bunding also serves as the proposed haulage route)	1 mAHD
Lake 2	1.3 mAHD (1.3 mAHD minimum height)	1 mAHD

In storm events that cause the lakes to reach their limit, controlled overtopping is permitted through weirs that are located at the main drainage lines. This will occur in long duration events with high

volumes of rainfall. As these events are generally categorized by low intensity rainfall, the resultant flows out of the lakes will not be of high magnitude to stress the downstream infrastructure.

The site is completely flat and does not allow for water to completely drain for the system. In the proposed condition the general conveyance of external catchments is to be maintained with the existing drainage lines and where required existing drainage lines are to reformed to suit the proposed lake's layout. 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).

Existing channels may be used for conveyance of flow around the proposed lakes (specifically those servicing catchments 4, 7, 18, 19). 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.

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 drainage schematic for each of the proposed plant's expansions has been prepared in the following image, detailing the general conveyance routes through the subject site and controlled discharge points in the ultimate state. Refer to Appendix C for reference to stormwater management through the development phases.

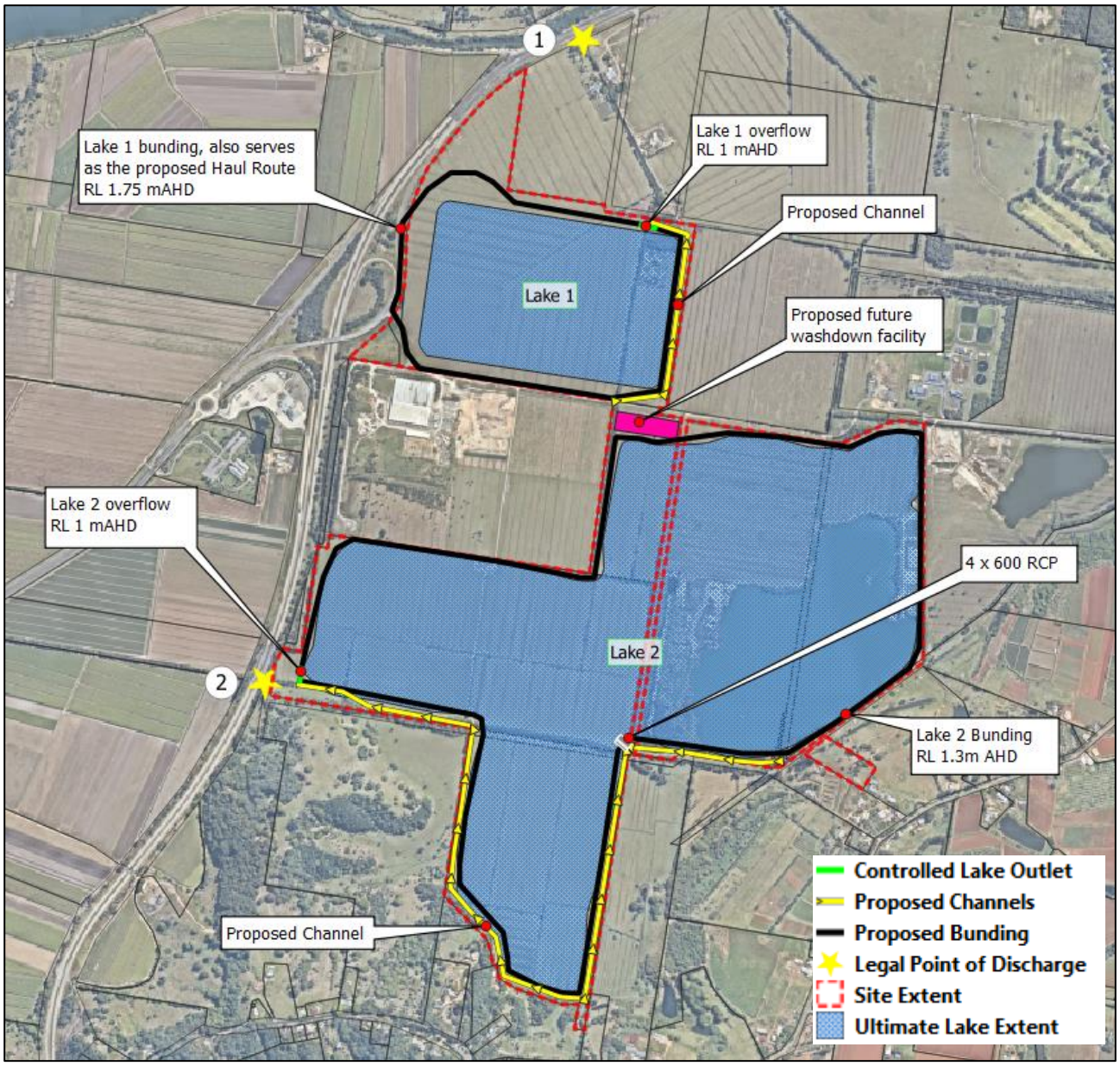


Figure 3.1 Conceptual Stormwater Management Schematic

3.3 Hydrological Analysis

Runoff from the subject site and applicable external catchments has been determined using the Laurenson Routing Method in the hydrologic/hydraulic modelling package, XPSTORM. All catchment runoff estimation was completed with reference to Australian Rainfall and Runoff Guidelines (2019).

Drainage catchments have been delineated using site survey, aerial imagery, and development plans for the post developed scenario. A catchment plan detailing the existing catchment extents and flow paths has been provided in Figure 3.2, and the Ultimate scenario (Phase 11) in Figure 3.3. Catchment parameters have been detailed in Appendix B.

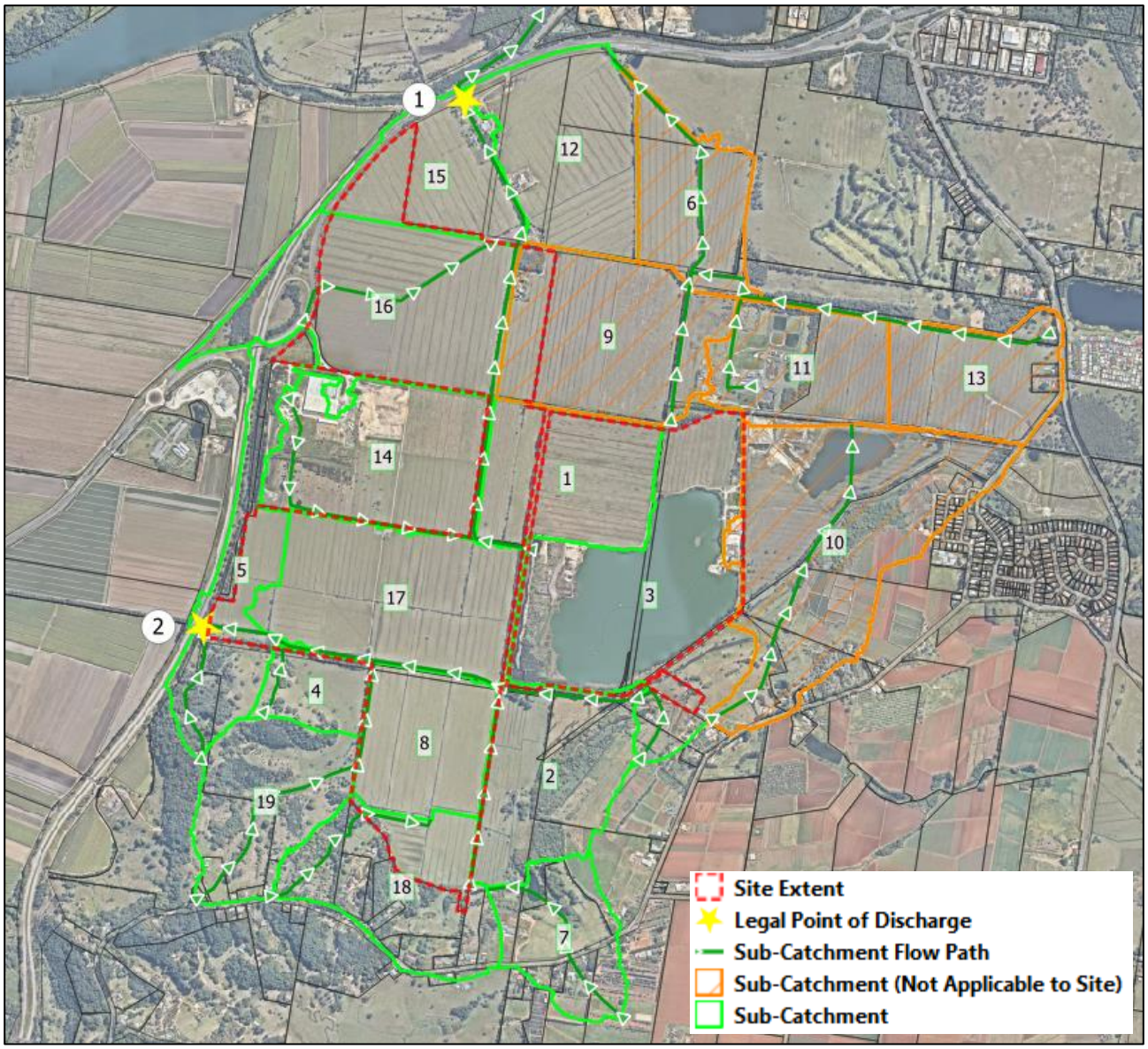


Figure 3.2 Local Catchment Map and Flow Paths – Existing Case

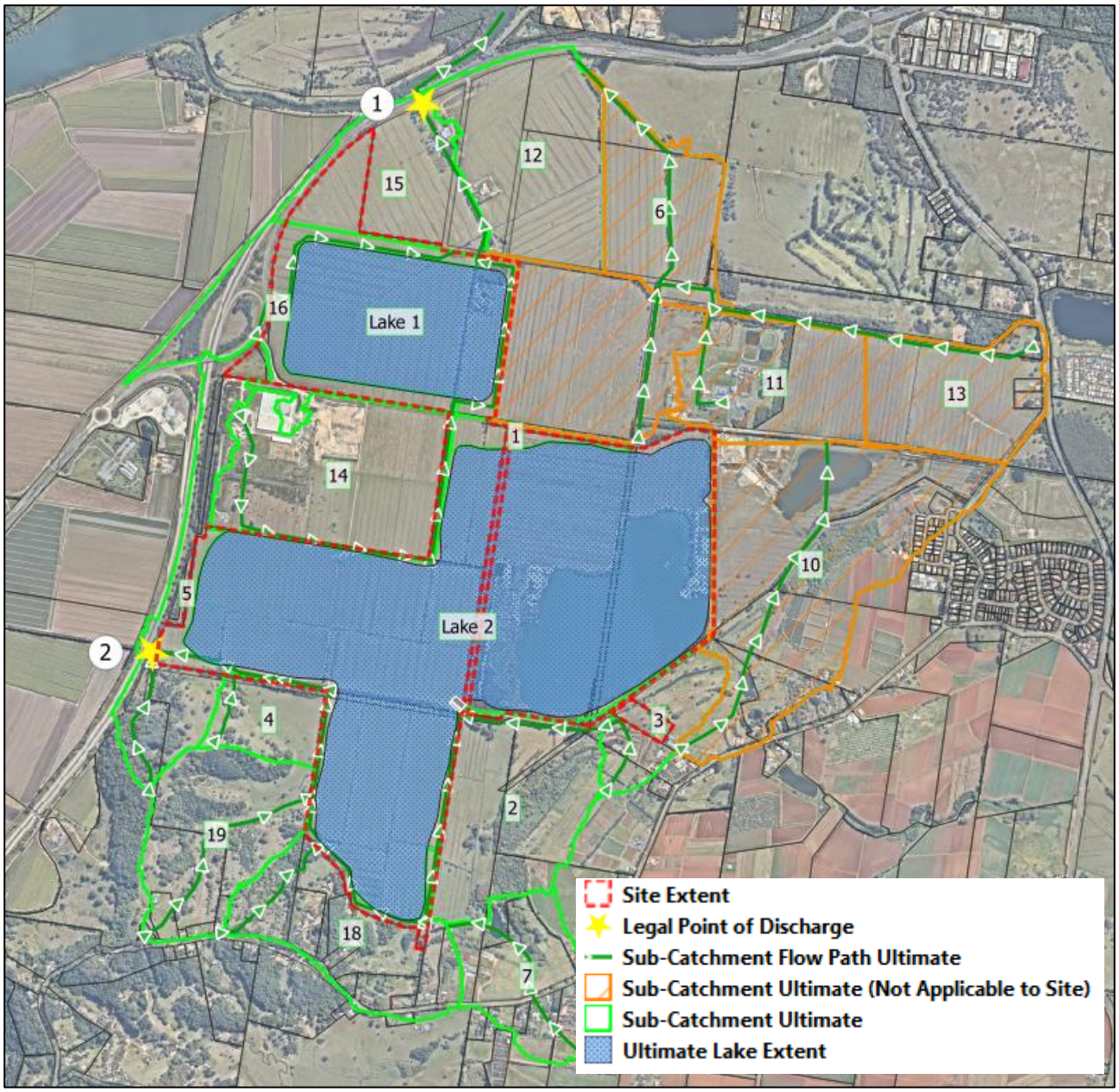


Figure 3.3 Local Catchment Map and Flow Paths – Ultimate Case (Phase 11)

3.3.1 Hydrological Losses

The hydrological loses modelled within the system are detailed in Table 3.2.

Table 3.2 Hydrological Losses

Landuse Type	Initial Loss	Continuing Loss
Pervious Surfaces	39mm (BOM)	1.2mm (BOM)
Impervious Surfaces	0mm	0mm
Lake Area	0mm	0mm

3.4 Local Hydraulic Model

3.4.1 Hydraulic Model Schematisation

The existing and proposed development have been modelled using XPSTORM which is hydraulic link-node model. All hydrological events were simulated in the system to determine the peak flows, water levels and flood timing at the site.

The existing model schematic is presented in Figure 3.4, the existing drainage channels have been defined through DEM interrogation, wide channel widths have been modelled to account for the floodplain storage present on the site. The floodplain area and associated drains are flat, with no grade modelled between nodes. All invert levels within the model have been set to RL 0 mAHD.

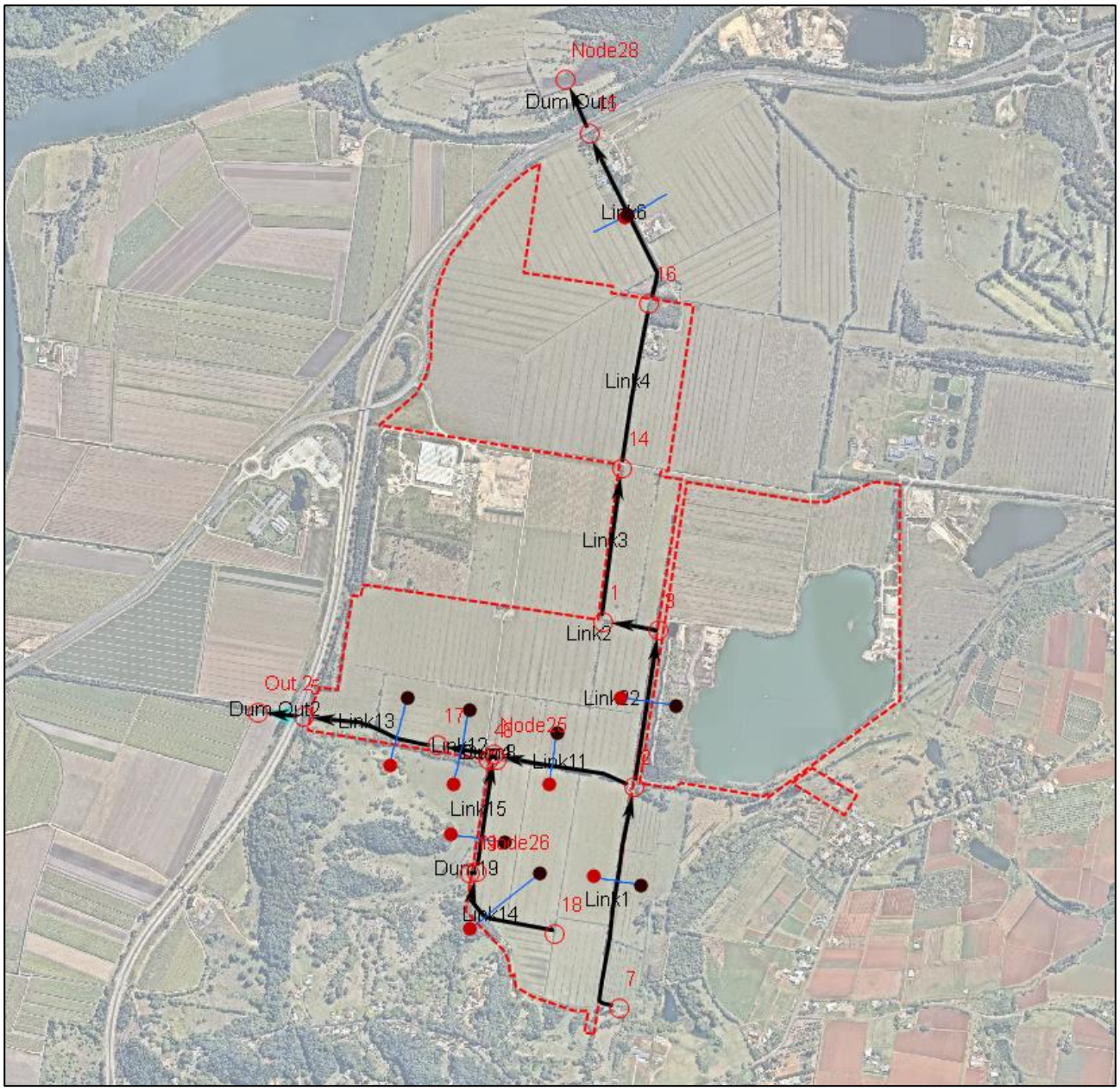


Figure 3.4 Existing Scenario XPSTORM Model Schematic

The proposed ultimate (Phase 11) state model schematic is presented in Figure 3.5. The channels within the model have been defined using DEM interrogation, however the channel section stops at the lake bund interface. Flood waters that reach the height of the bund are allowed to discharge into the proposed lakes. **The proposed lakes have been modelled as full** (initial water level at the overflow weir level – 1 mAHD). Both of the lakes overflow weirs are 10 meters wide.

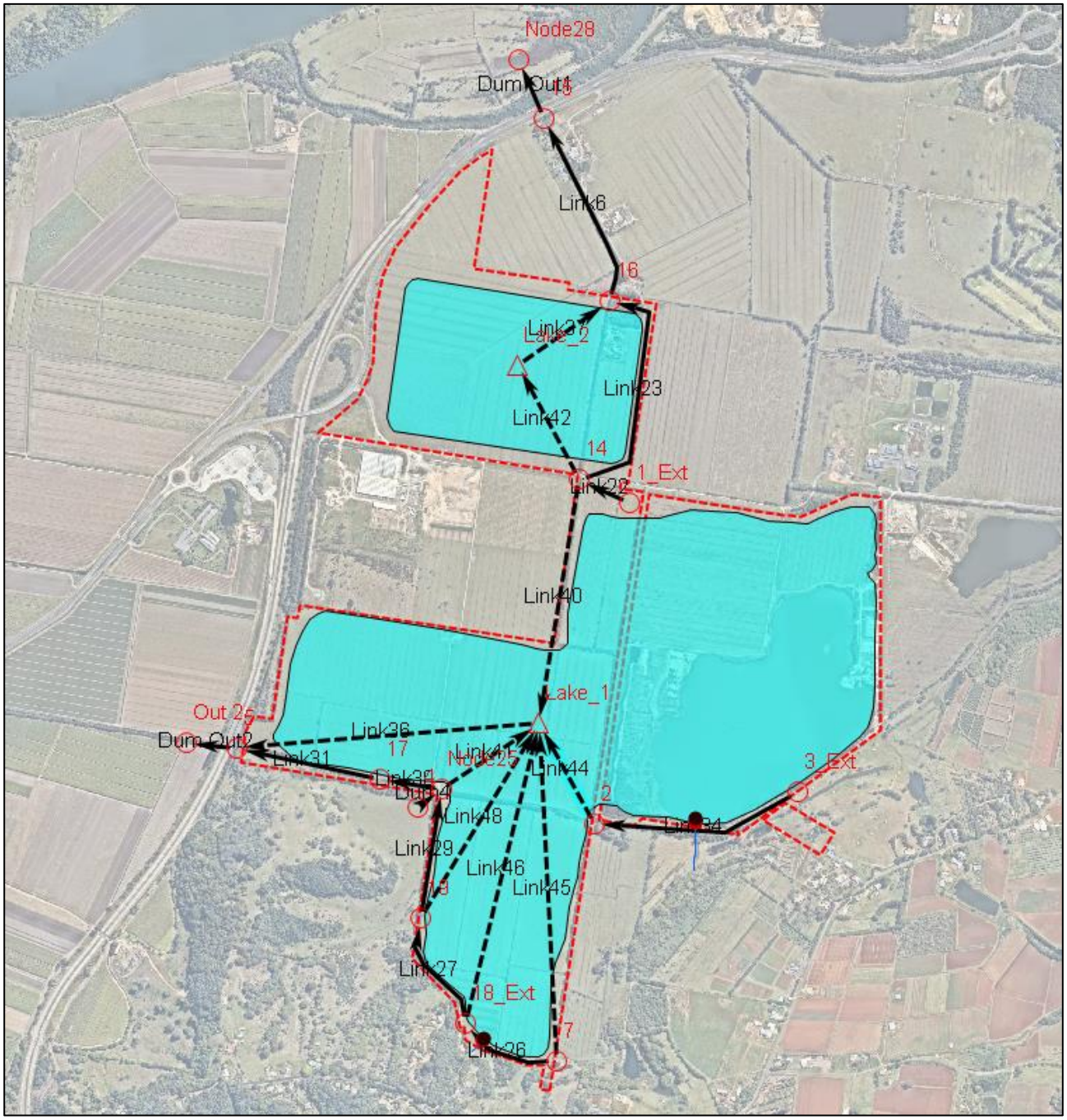


Figure 3.5 Ultimate Scenario (Phase 11) XPSTORM Model Schematic

The outlet of both models has a fixed tailwater level at that of the Mean High Water Springs (MHWS) for Tweed river – 0.6 mAHD.

3.5 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 peak flow at each of the floodplain's drainage points (the two culverts sets that run beneath the M1) have been quantified in the existing and proposed ultimate case (Phase 11). The change in water level has also been assessed around the perimeter of the lake in relevant locations where flooding on neighbouring properties is of concern as well as the frequency at which it can be expected that the perimeter bunds will be overtopped by external catchment runoff.

A hydraulic results reference image has been provided in the following Figure. Note the Legal Point of Discharge Locations (LPD) and water level interrogation points.

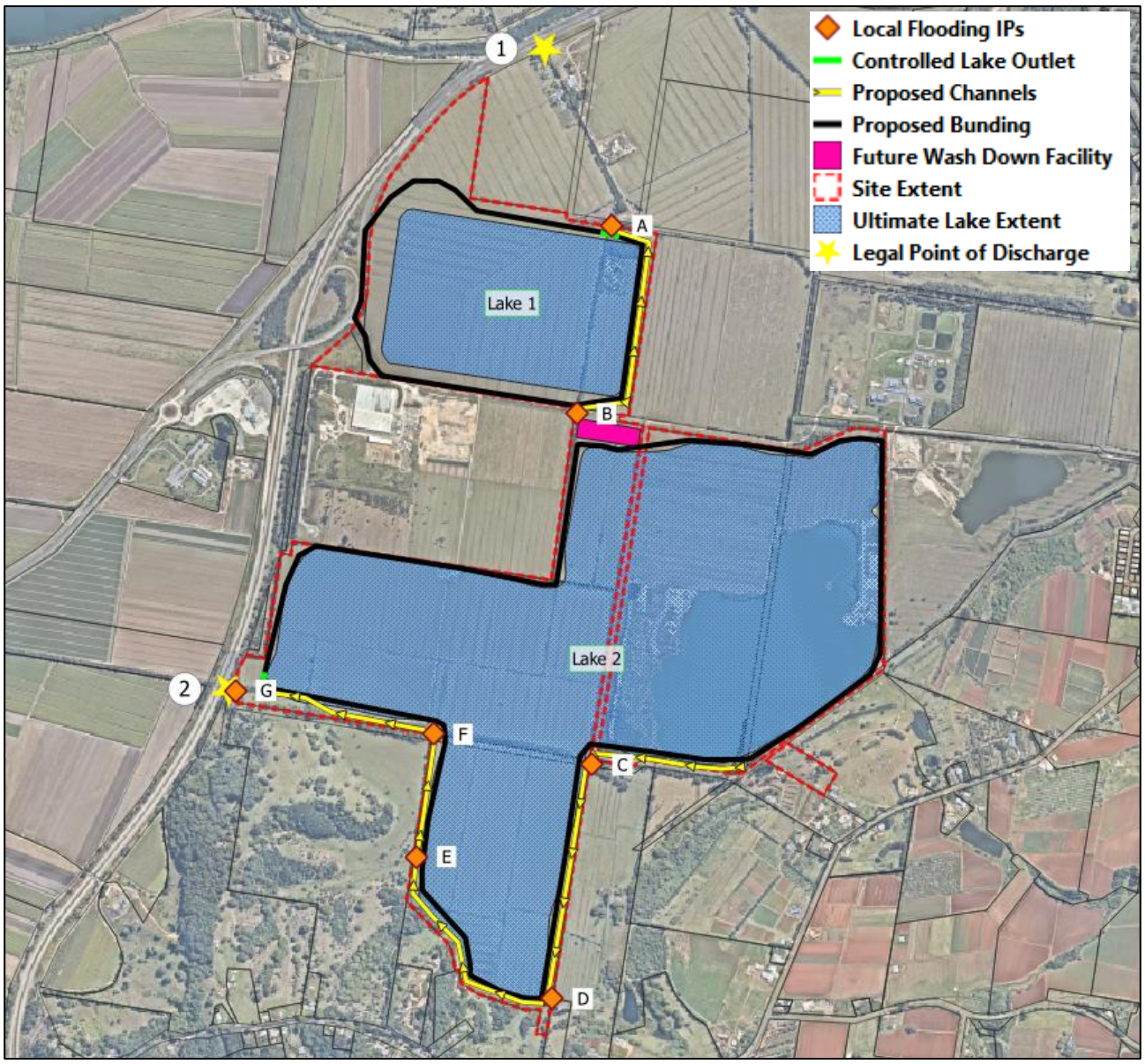


Figure 3.6 Local Flood Results Reference Image

3.5.1 Peak Flow Assessment

The following peak flows at each of the site's Legal Point of Discharge (LPD) has been calculated for the existing and proposed developed condition as shown in Table 3.3 and Table 3.4.

Table 3.3 Peak Flow Assessment LPD 1

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%	12hr Ens 3	12hr Ens 3	12.59	6hr Ens 4	7.51
2%	12hr Ens 3	12hr Ens 3	9.27	6hr Ens 4	6.66
5%	12hr Ens 1	12hr Ens 1	5.88	6hr Ens 1	5.79
10%	9hr Ens 7	9hr Ens 7	4.14	9hr Ens 8	5.10
20%	18hr Ens 3	18hr Ens 3	3.42	9hr Ens 5	4.24
0.5EY	24hr Ens 6	24hr Ens 7	2.35	9hr Ens 5	2.98

Table 3.4 Peak Flow Assessment LPD 2

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%	12hr Ens 3	18.12	6hr Ens 5	13.60	-4.52
2%	12hr Ens 3	15.38	6hr Ens 3	12.48	-2.9
5%	12hr Ens 1	11.59	6hr Ens 6	10.63	-0.96
10%	24hr Ens 7	8.89	6hr Ens 5	9.59	0.7
20%	18hr Ens 3	6.62	9hr Ens 10	8.63	2.01
0.5EY	18hr Ens 3	4.35	9hr Ens 4	6.28	1.93

A reduction in peak flows is experienced at the discharge points for the larger storm events and an increase in flows is experienced for the more frequent events. The increase in peak flows at the discharge points is caused by a loss in conveyance storage at lower flood level (below 1.3 mAHD or 1.75m depending on which lake)), caused by the lake bunding. With a reduced conveyance storage, water velocities increase and thus increase the peak flow at the LPDs.

It is important to note that as the water level within the lakes is at the average standing water level (0.3-0.5 mAHD), the lakes only overflow in the 1% AEP event.

3.5.2 Peak Water Level Assessment

To assess the impacts of the proposed lakes and the associated bunding the peak water levels at several locations around the perimeter were interrogated. Peak flood levels from the local events has been detailed in the following table.

Table 3.5 Peak Water Elevations – Local Flooding

Interrogation Point	AEP	Existing Scenario Flood Level (m)	Proposed Ultimate Flood Level (m)	Afflux (mm)
A	1%	1.403	1.169	-234
	2%	1.336	1.153	-183
	5%	1.233	1.123	-110
	10%	1.147	1.086	-61
	20%	1.063	1.049	-14
	0.5EY	0.964	0.931	-33
B	1%	1.405	1.362	-43
	2%	1.337	1.346	9
	5%	1.234	1.321	87
	10%	1.147	1.278	131
	20%	1.064	1.194	130
	0.5EY	0.965	1.024	59
C	1%	1.405	1.221	-184
	2%	1.337	1.138	-199
	5%	1.232	1.057	-175
	10%	1.146	0.914	-232
	20%	1.063	0.695	-368
	0.5EY	0.964	0.600	-364
D	1%	1.508	1.420	-88
	2%	1.488	1.401	-87
	5%	1.397	1.372	-25
	10%	1.368	1.357	-11
	20%	1.248	1.340	92
	0.5EY	1.149	1.303	154
E	1%	1.420	1.433	13
	2%	1.363	1.411	48
	5%	1.292	1.372	80
	10%	1.263	1.356	93
	20%	1.213	1.330	117
	0.5EY	1.157	1.219	62
F	1%	1.404	1.432	28
	2%	1.337	1.411	74
	5%	1.232	1.371	139
	10%	1.145	1.354	209
	20%	1.062	1.326	264
	0.5EY	0.964	1.214	250
G	1%	1.396	1.282	-114
	2%	1.329	1.250	-79
	5%	1.224	1.194	-30
	10%	1.138	1.161	23
	20%	1.054	1.129	75
	0.5EY	0.954	1.040	86

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.

While the increase in flood level occurs in some instances, the overall local flood is much less than that of the regional event, with the regional 0.5EY event level (1.47 mAHD) at the site above the local 1% event level (e.g. 1.51 mAHD). As the local flood level is so much lower than the regional flood level it is not anticipated that this increase in local flood level will give rise to adverse impacts external to the subject site.

3.5.3 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 3.6 Local Flood Bund Immunity

	Bund Invert Level (m AHD)	Bund Immunity* AEP	Overflow Weir Invert Level (m AHD)	Overflow Weir Immunity AEP
Lake 1	1.75	>1%	1.00	0.5EY
Lake 2	1.3	5%	1.00	0.5EY

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

As is shown in the above table, it is anticipated that external flow will be able to enter the lakes through the overflow weir in events over and including the 0.5EY. This will be considered in the detailed design.

3.6 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.

4. Regional Flood Assessment

4.1 Overview

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 area 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 current haulage routes are set at RL 1.75m with a flood immunity that corresponds to approximately a 1 in 5 AEP event. The existing washdown facility is at RL 3m with a flood immunity that corresponds to a 1 in 100 AEP event.

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.

4.1.1 Flooding Assessment Criteria

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. The flood impact assessments undertaken as part of the Tweed Sand Plant, have been targeted to meet these same development assessment criteria as outlined below:

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

4.2 Regional 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.
- 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;
  - 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 and velocities;
  - 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.
- Flood storage assessment – review of the flood storage in the existing and proposed development scenario.

4.3 Model Tolerances

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 isn’t 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.

4.4 Regional 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 refined version of the Council Tweed River Flood Model, with greater resolution (4m grid cell size) and additional hydraulic elements including culverts and channel.

4.4.1 Model Inputs

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 E.

Table 4.1 Hydraulic Model Schematisation

Parameters	**Details**
Scenarios	• Pre-development; • 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.

Parameters	Details
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)
2D Resolution	• 4m grid. • Sub-Grid-Sampling at 1m cell size.
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.

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.

Surface Roughness (reflected as Manning's 'n')	• Please refer to Appendix B 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
	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 F. • Street drainage and small local drainage networks have not been represented within the model.

4.4.2 Development Representation

The hydraulic model has considered the sand plant expansion for the ultimate development scenario (phase 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 new process facility was lifted to the Designated Flood Level for the site (RL 3.22 mAHD).
- The proposed bunding at RL 1.3 mAHD has NOT been included as it is considered negligible due to its low level compared to the overall flood levels experienced at the site.

4.4.3 Model Calibration

The TUFLOW model was calibrated against the existing Tweed River Flood Model results at refined cell size (40m to 4m). 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 +/- 5mm

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 E. As shown the refined model is generally within 10mm to 20mm of the approved Council result.

4.5 Regional Hydraulic Flood Results

4.5.1 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.

4.5.2 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 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. For events lower than the 1% AEP, the development improves flooding in the area due to a large gain in flood storage.

Further discussion on the impacts cause by the development is included in Section 4.5.3.

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 E 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 4.2 Flood Levels at the Subject Site (Processing Plant Vicintiy)

Flood Event (AEP)	Design Flood Levels (m AHD)	
	Existing Scenario	Ultimate Developed Scenario
20%	1.52	1.47
5%	2.29	2.28
1%	3.22	3.22
1% + CC	4.72	4.74
0.2%	4.71	4.74
PMF	6.48	6.48

4.5.3 Impact Assessment

Mapping of the hydraulic impact caused by the development across the development stages has been documented in Appendix E. It is noted that all impacts within residential areas are within the Tweed Council Local Government allowable tolerance of less than 35mm of increased flood level.

A summary of the impact assessment for each event has been included in the following table.

Table 4.3 Impact Assessment Summary

Event (AEP)	Impact Description
20%	The proposed development improves flooding in the area with the overall flood level reduced in the immediate area respective to the site by greater than 30mm. Multiple areas have gone from flooded to dry including parts of the Chinderah township. Impact in the 20%AEP event is comparable across all phases of the development (Phase 7, 9 and 11)
5%	The proposed development improves flooding in the area with the overall flood level reduced in the flood plain area to the east and at the site by between 10mm and 30mm. Impact in the 5% AEP event is comparable across all phases of the development (Phase 7, 9 and 11).
1%	The flood level for the 1% AEP 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 increase is within the allowable limit as set by Tweed Council (less than 35mm).

1% + CC	The proposed development causes minor afflux to the east of the site in the flood plain and Kingscliff/Chinderah township areas. The impact is in the magnitude of 20mm to 30mm and is within the allowable increase of less than 35mm as set by Tweed Council. A small area of floodplain immediately to the north-west of Lake 2 experiences between 30-35mm of afflux, this afflux is isolated to agricultural land and the Council waste treatment plant. The afflux is comparable in Phases 9 and 11 of the development and is reduced in Phase 7 of the development. The impact does not reduce the resilience of the proposed Tweed Hospital.
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.
PMF	Generally, the flood level is improved across the model domain for the PMF event with a reduction in modelled flood level of greater than 30mm 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 100mm and does not impact on any residential dwellings.

4.6 Cumulative Impact – Gales Kingscliff Pty Ltd Development (Lot 21 DP1082482)

At the request of Tweed Shire Council consideration has been given to the proposed development located on Lot 21 DP1082428. The proposed development seeks to establish a development pad at RL 2.2m AHD (less than 5% AEP immunity).

Modelling conducted by Vennant Solutions for the development has shown the proposal does not increase flooding beyond the allowable 35mm of afflux for the regional flood event.

While the proposed fill associated with the development at Lot 21 DP1082428 has not been included within the Burchills regional model, the following comments are made on the cumulative impact of the developments:

- Both developments result in afflux within the acceptable change of flood level (less than 35mm).
- The proposed development on Lot 21 DP1082428 may reduce the conveyance capacity across the floodplain, this may result in an increase in flood level to the east of Lot 21 DP1082428.

4.7 Flood Storage Assessment

The proposed expansion of the sand plant will result in a significant gain in flood storage volume as the proposal seeks to remove earth from an area of 194 ha with the only fill being for the future sand washing plant and processing facility. Flood storage calculations taken from the DFL (3.23 m AHD) to the standing water level at site (0.3 m AHD) have been completed and are summarised in the following table.

Table 4.4 Flood Storage Balance

Existing Flood Storage Volume	Proposed Flood Storage Volume (Final Phase of Development)	Balance
150,933 m^3	576,676 m^3	Gain of 425,743 m^3

5. 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 stormwater management plan has been assessed 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. It has been determined that the proposed development does not cause adverse impacts on the regional flood behaviour up to the 1 in 100 AEP flood event.

6. References

BMT WBM (2009), Tweed Valley Flood Study – 2009 Update, ref: TSC00290_TweedValleyFloodStudy2009Update.pdf, October 2009

BMT WBM (2014a), Tweed Valley Floodplain Risk Management Study - Final, ref: TSC06390_Tweed_Valley_Floodplain_Risk_Management_Study_Final_October_2014.pdf, October 2014

TSC (2012), Flood Risk Management – Policy, Version 1, ref: Flood Risk Management.pdf, Tweed Shire Council, adopted 18 December 2012

Venant Solutions (2020), Combined Development Application & Construction Certificate – Lot 21 DP1082482 Flood Impact Assessment Report

Retallick, M., & Babister, M. (2018). Defining acceptable Impacts for flood impact assessments. *Hydrology and Water Resources Symposium*

TUFLOW. (2010). TUFLOW Forum. Retrieved from TUFLOW Modelling/Miscellaneous/Probable Error: https://www.TUFLOW.com/forum/index.php?/topic/727-probable-error/

Australian Rainfall and Runoff. (2012). Revision Projects - Project 15 Two Dimensional Modelling in Urban and Rural Floodplains. Engineers Australia

Appendix A –Proposed Sand Plant Phasing

PROJECT TITLE

HANSON TWEED SAND PLANT

PHASE 5-11

DRAWING TITLE

CONCEPT DEVELOPMENT PHASING

REV	DESCRIPTION	DATE	DRAWN	DESIGN	CHECK	APPROVED
A	PASHING ARRANGEMENT CHANGES - REQ. PLANNER	25.01.2021	ZP	LN	LN	LN

ISSUE: PRELIMINARY

CLIENT: HANSON CONSTRUCTION MATERIALS PTY LTD

BASE PROVIDED BY: SIXMAPS DCDB

MANAGER: LANCE NEWLEY

ZONE PLANNING GROUP

GOLD COAST
1638 Tweed Street, Burleigh Heads QLD 4220
PO Box 3805, Burleigh Town QLD 4220

GLADSTONE
2/172 Goondoon St, Gladstone, QLD 4680
PO Box 5332, Gladstone QLD 4680

zonelandscape.com.au | 07 55622303

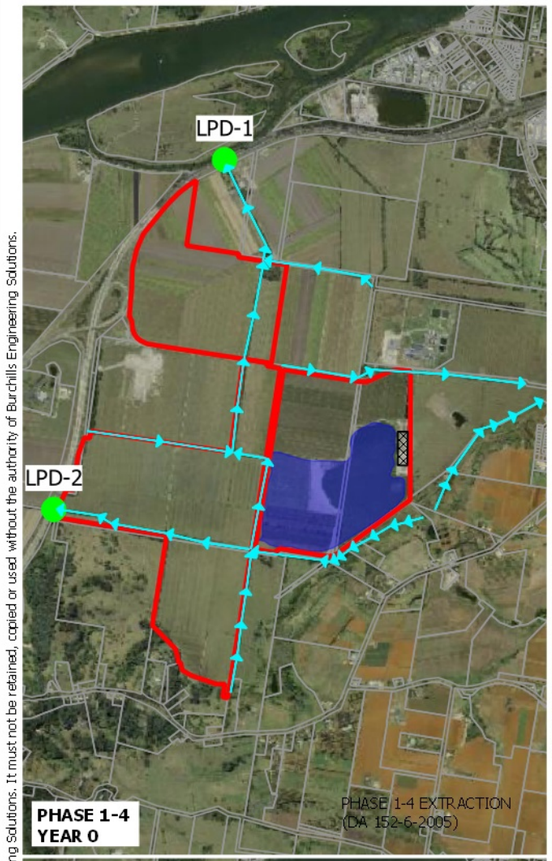
JOB / DRAWING NO: **Z19163- 104**

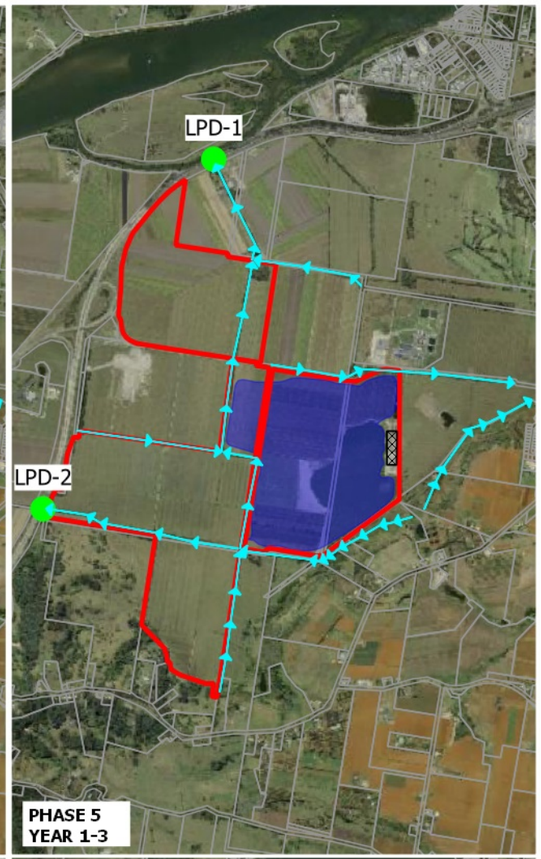
SHEET NO. **SHEET 01 OF 01**

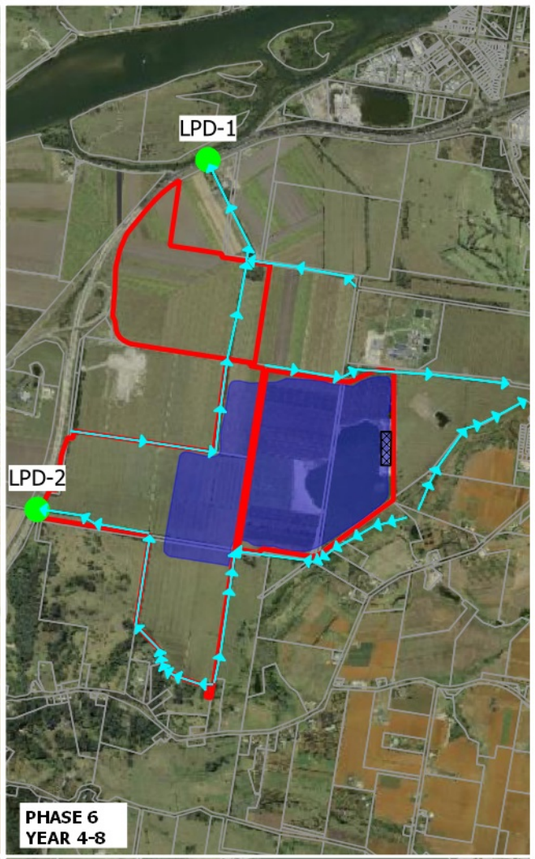
Appendix B – Catchment Parameters

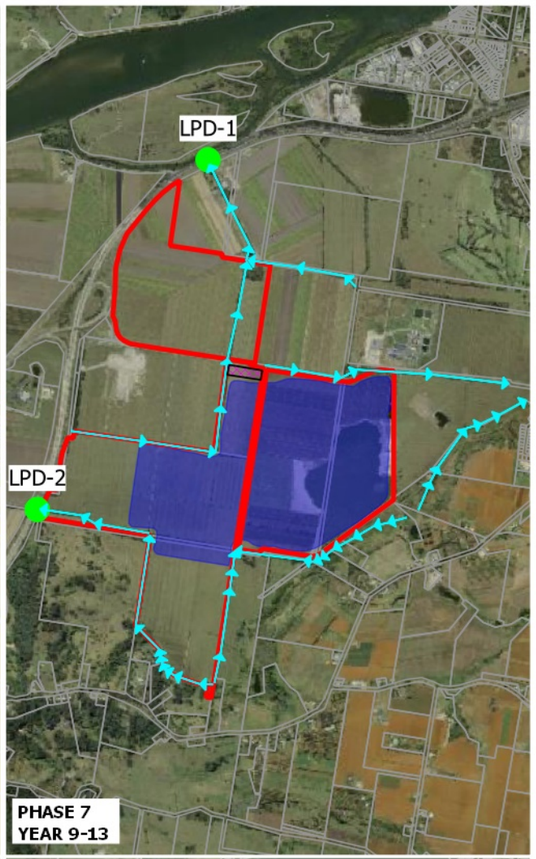
Catchment ID	Total Area (ha)	Impervious %	Catchment Slope (%)
1	31.9	0.1	1
2	34.6	0.3	7
3	68.2	46.0	9
4	41.2	0.00	18
5	32.2	4.86	25
6	24.3	0.00	1
7	21.7	6.68	2
8	25.4	0.00	1
9	44.6	0.92	1
10	69.2	10.72	6
11	27.6	14.88	1
12	37.1	1.32	1.5
13	26.0	1.35	1
14	41.1	4.73	1.5
15	26.1	4.27	1
16	54.4	5.46	1
17	46.6	0.36	1
18	36.2	2.17	10
19	30.3	0.64	10

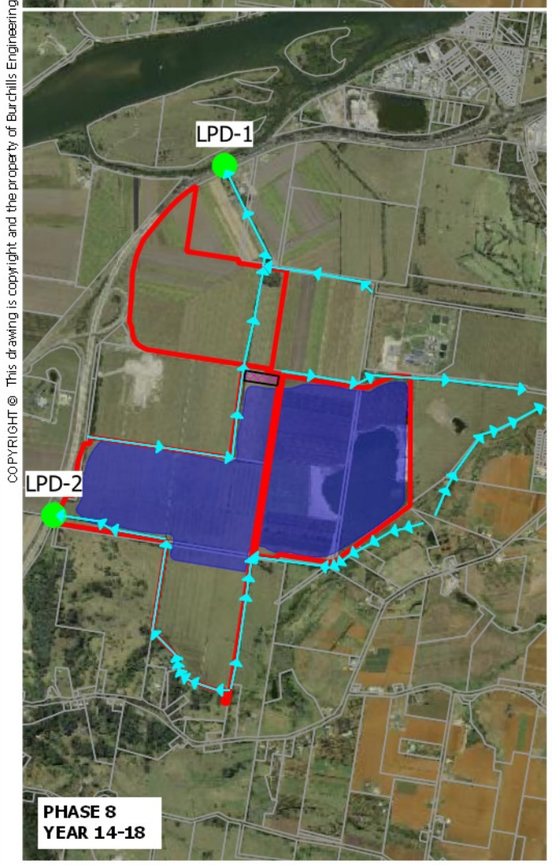
Appendix C – Local Drainage Schematic

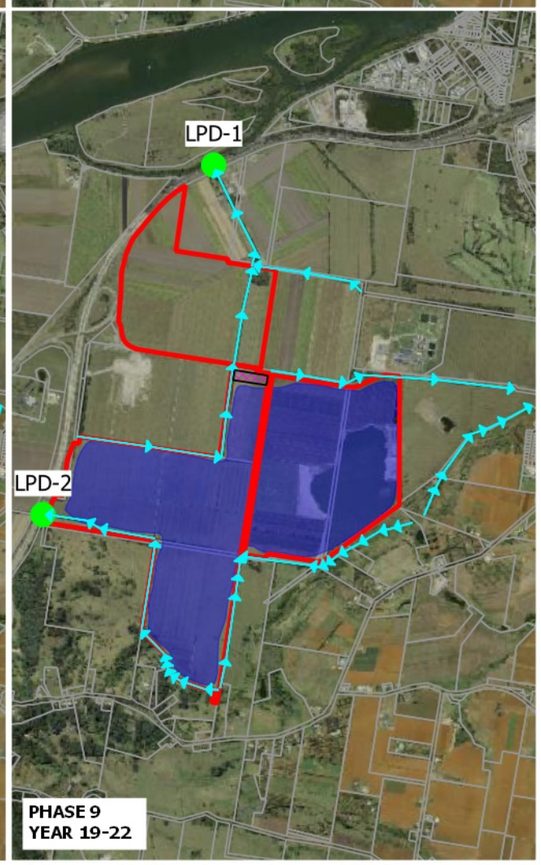


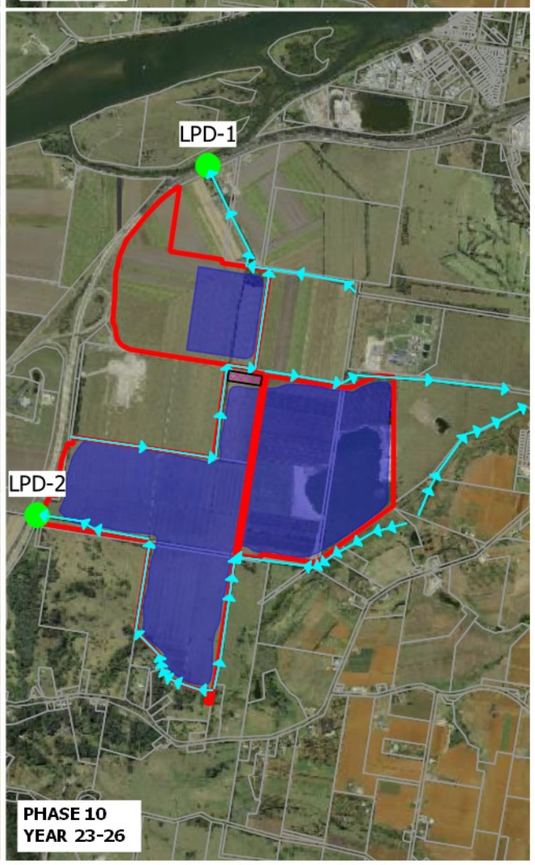


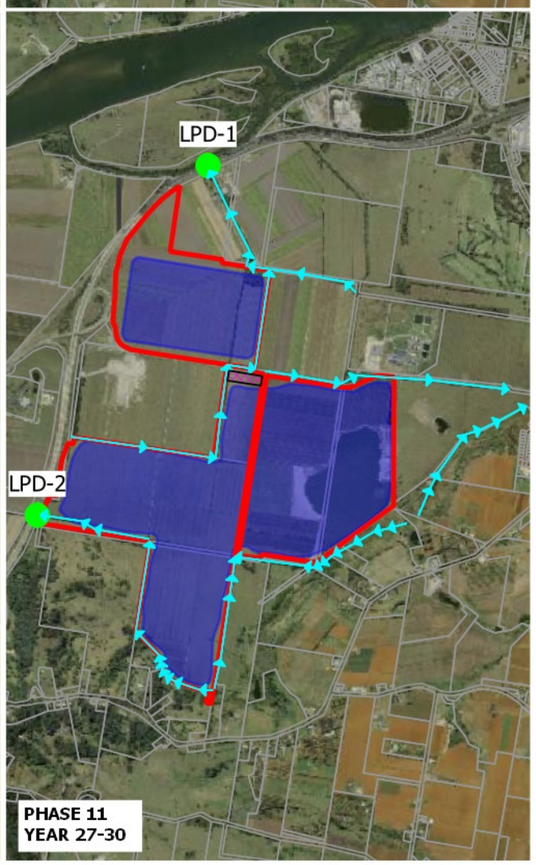












Tweed Sand Plant Flood Assessment

FIG 04
DRAINAGE SCHEMATIC

Location of the site within the Tweed Shire Council

Legend

- Site
- Cadastral
- Future Building & Wash Plant
- Existing Building & Wash Plant
- Proposed Quarry Area
- Runoff Drainage (Channels)

0 300 600 900 1,200 1,500 m

Project: BE190043

Date: 19/02/2021

Scale: 1:35000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

FOR

CLIENT

Tweed Sand Plant

Ultimate Drainage Schematic (Indicative Only)
&
Channel Sizing Requirements

Lake 1

Lake 2

Legend

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

Existing Channels to be Realigned as Required for Future Lake Expansion - Channel Dimensions as follows:

- 2.5m Base Width, 4.5m Top Width, Batter 1V:1H, 1m Depth
- 3.5m Base Width, 5.5m Top Width, Batter 1V:1H, 1m Depth
- 3m Base Width, 5m Top Width, Batter 1V:1H, 1m Depth
- 5m Base Width, 8m Top Width, Batter 1V:1H, 1.5m Depth
- Utilise Existing Channel (External to subject site)
- Proposed Culverts (4 x 600mm RCP)

Project:	BE190043
Date:	17-02-2021
Scale:	1:10,000 at A3
Projection:	GDA94/MGA Zone 56
Data Sources:	X

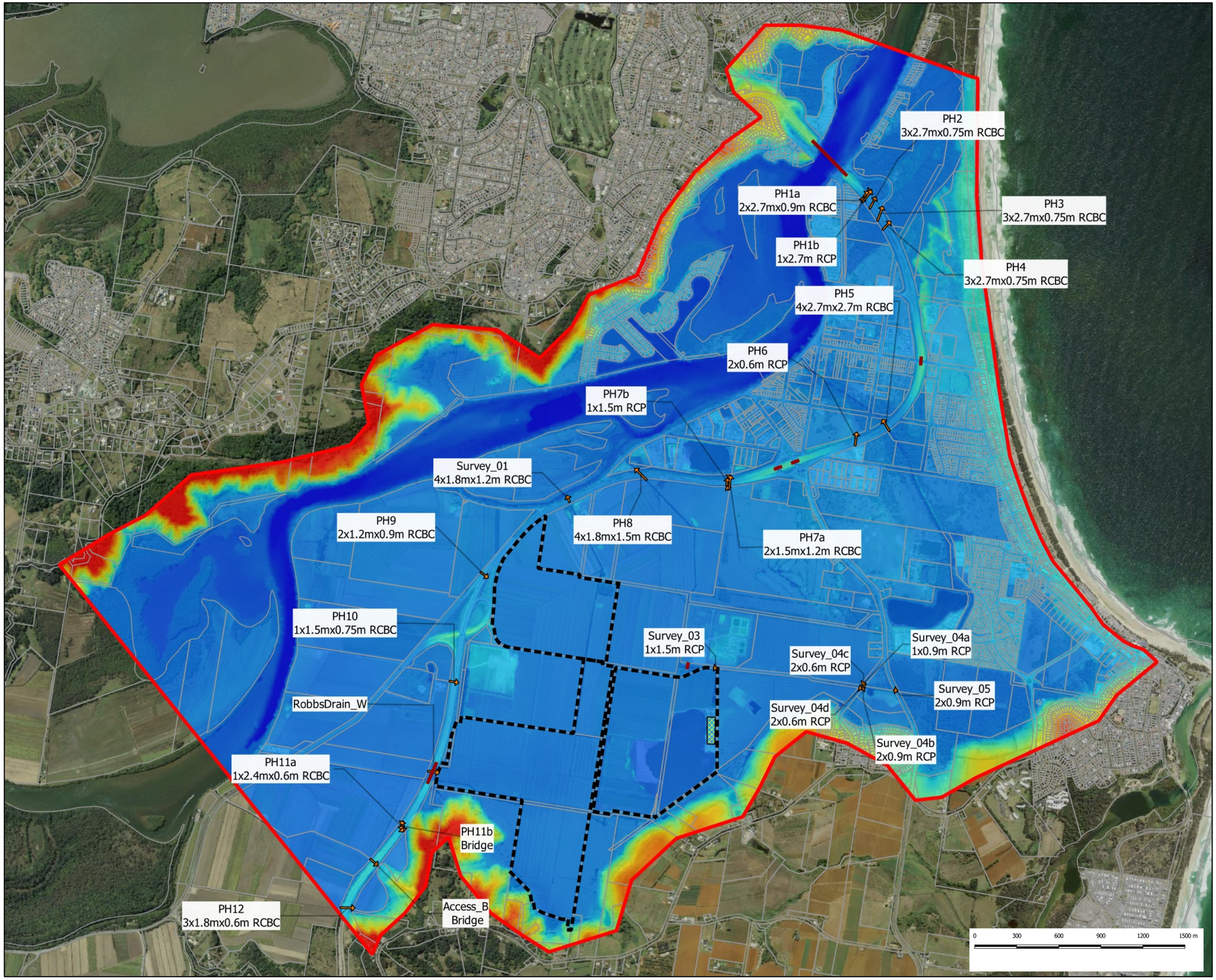
0 100 200 300 400 500 m

BURCHILLS ENGINEERING SOLUTIONS

Appendix D – Regional 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:

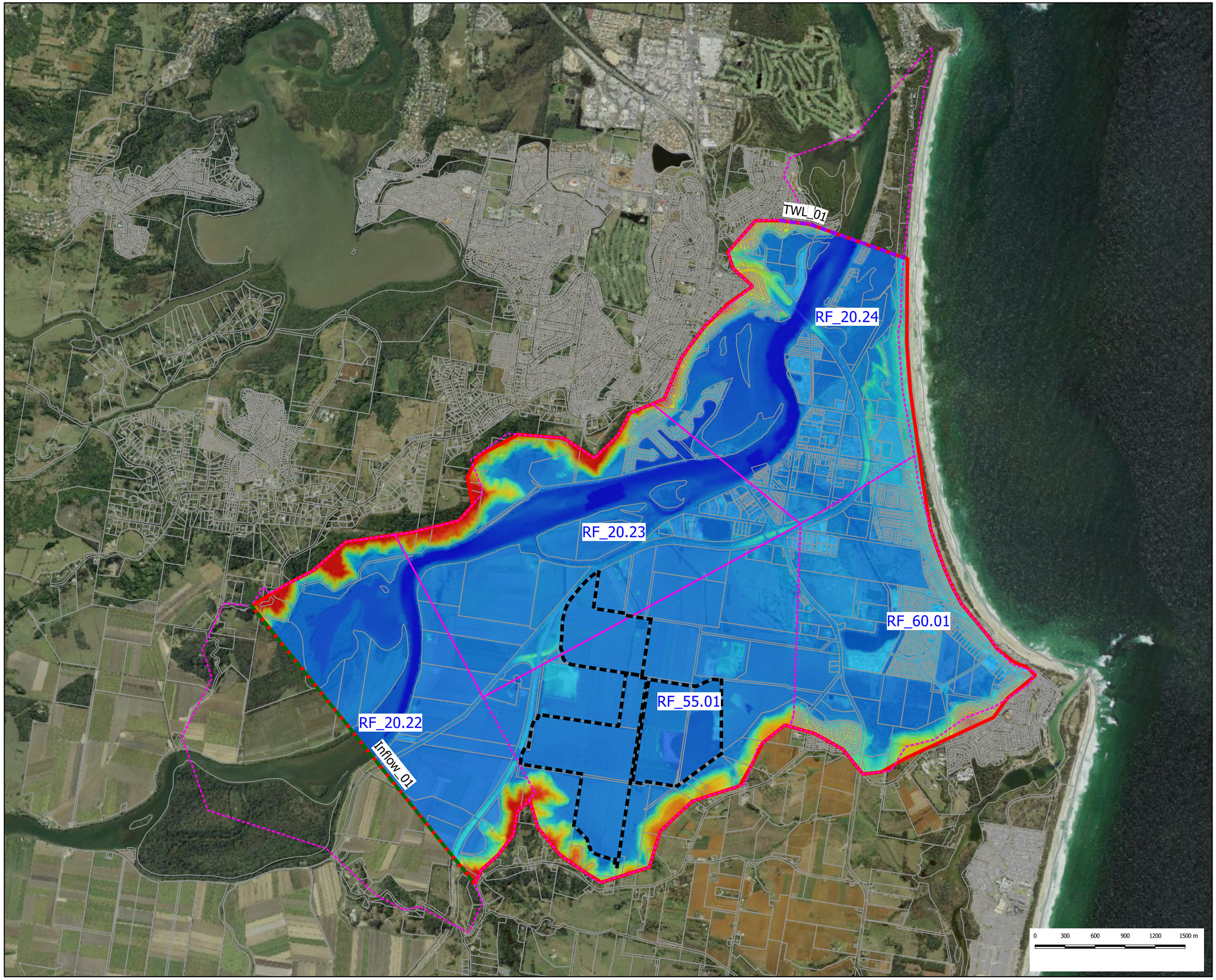
BURCHILLS ENGINEERING SOLUTIONS

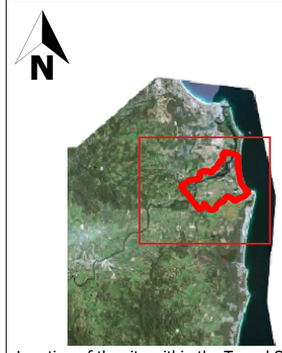
FOR

Hanson

Tweed Sand Plant Flood Assessment

FIG 02 PRE DEVELOPMENT
TUFLOW MODEL FEATURE - 2





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:

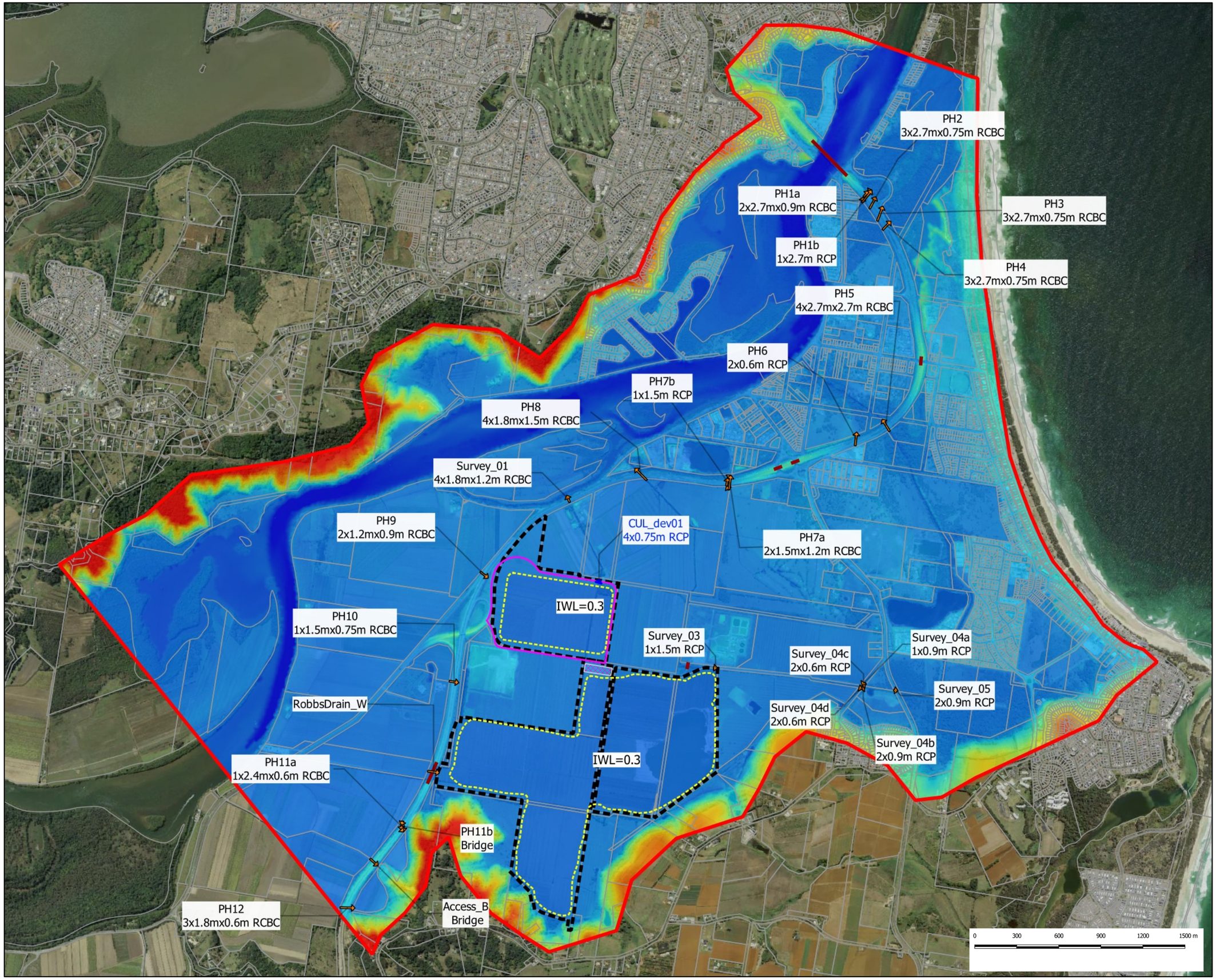
BURCHILLS ENGINEERING SOLUTIONS

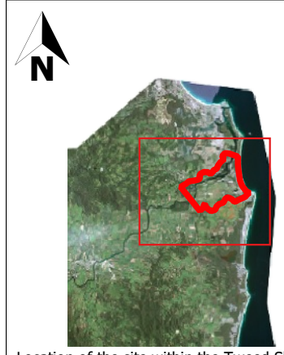
FOR

Hanson

Tweed Sand Plant Flood Assessment

FIG 03 POST DEVELOPMENT TUFLOW MODEL FEATURE - 1





Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Site
- Cadastral
- Proposed Hydraulic Structure
- Hydraulic Structure
- Future Building & Wash Plan
- Sand extraction and Plant
- Haul Route
- 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:

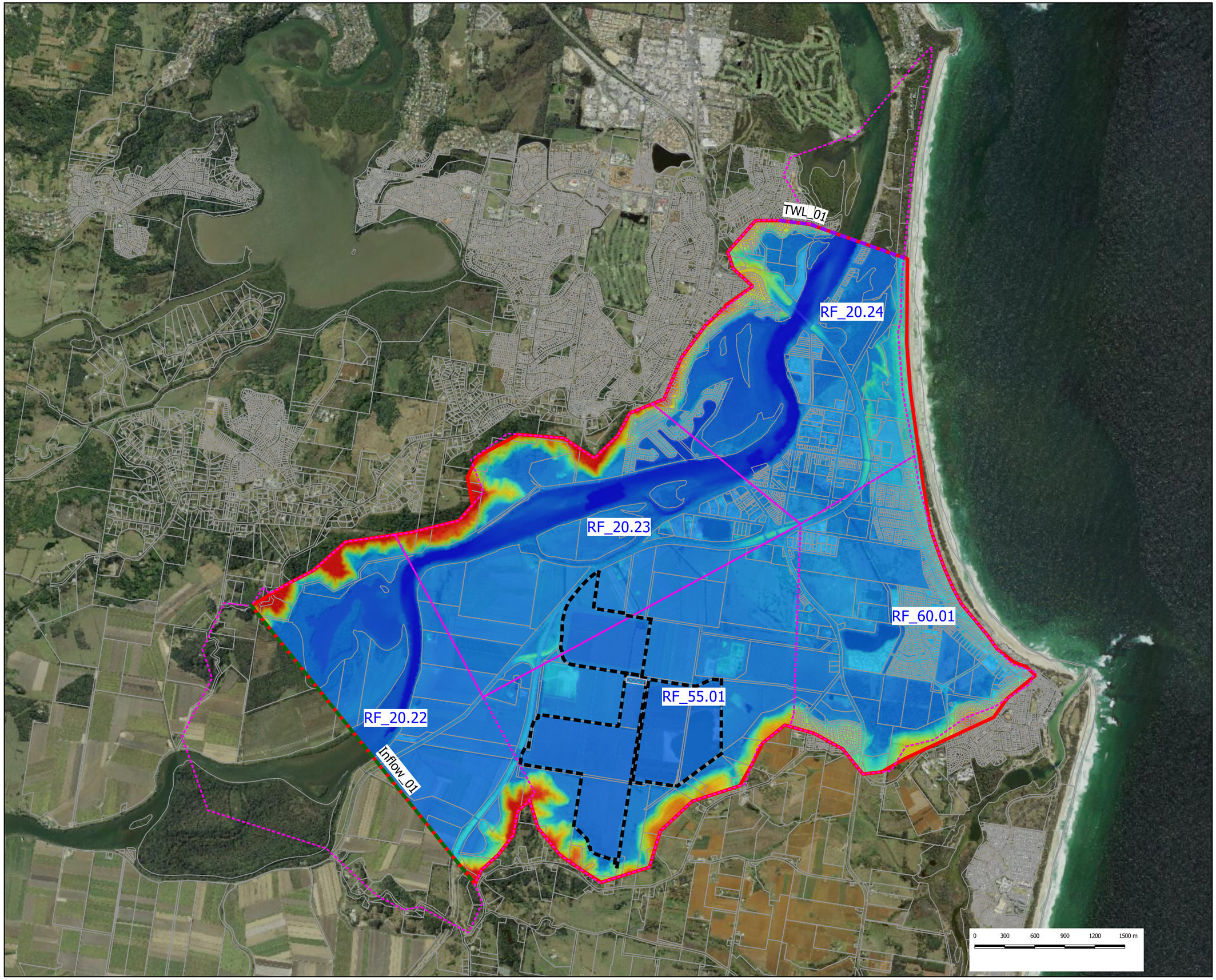
BURCHILLS ENGINEERING SOLUTIONS

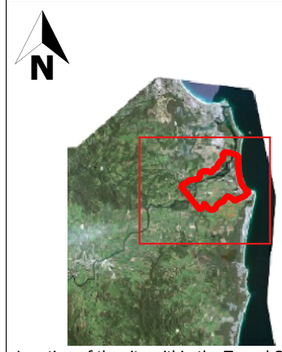
FOR

Hanson

Tweed Sand Plant Flood Assessment

FIG 04 POST DEVELOPMENT
TUFLOW MODEL FEATURE - 2





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: 1:25000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

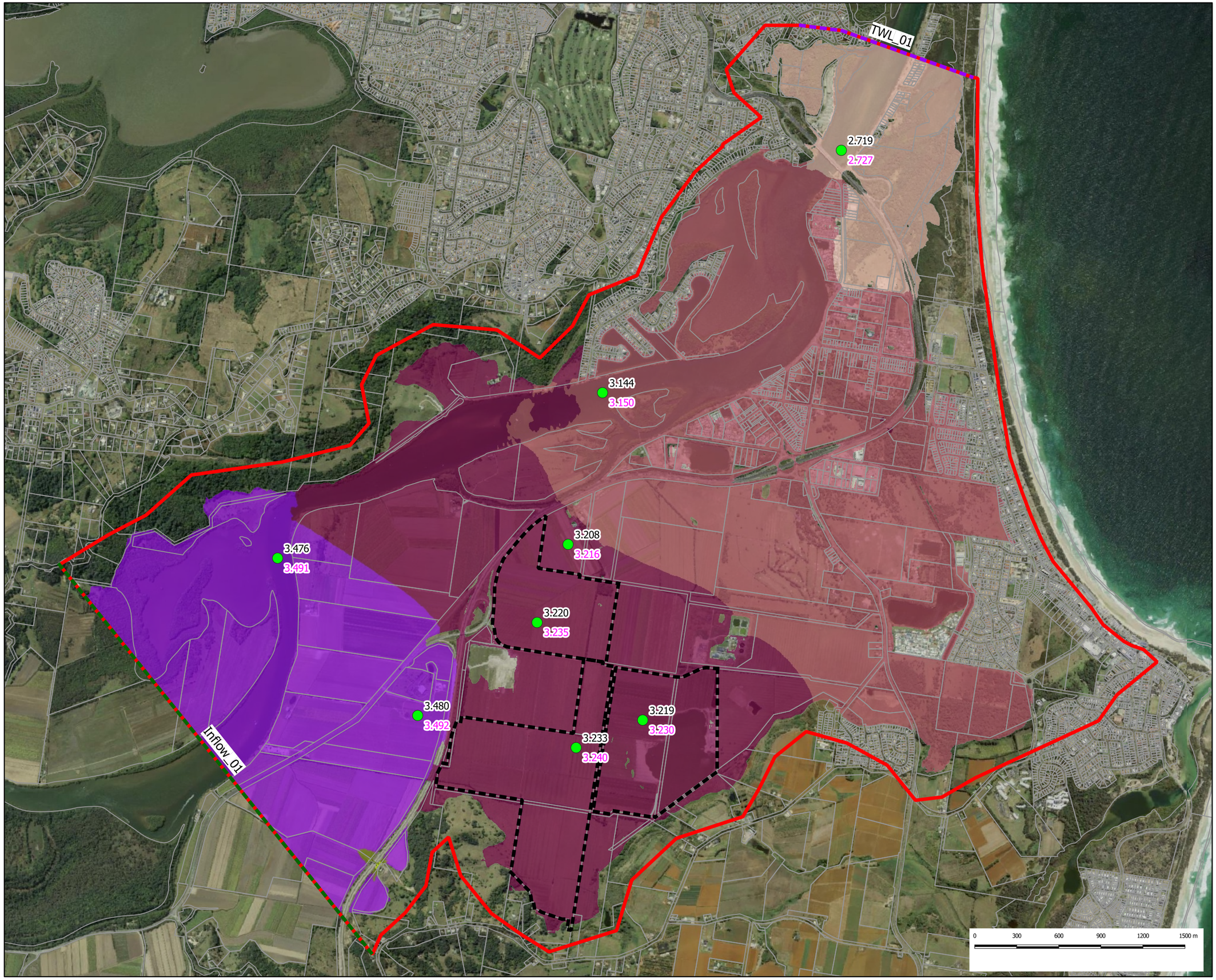
FOR

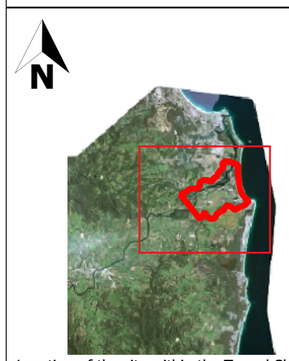
Hanson

Appendix E – Regional Hydraulic Calibration Results

Tweed Sand Plant Flood Assessment

FIG 05 CALIBRATION 1% AEP BETWEEN TUFLOW MODEL AND COUNCIL MODEL





Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Site
- Cadastral
- Inflow Boundary
- Downstream Boundary
- Tuflow modelCouncil model

Water Level (mAHD)

	below 0.8		3.0 - 3.2
	0.8 - 1.0		2.8 - 3.0
	1.0 - 1.2		2.8 - 3.0
	1.4 - 1.6		3.8 - 4.0
	1.6 - 1.8		4.0 - 4.2
	1.8 - 2.0		3.8 - 4.0
	1.8 - 2.0		4.6 - 4.8
	2.4 - 2.8		above 4.8
	2.8 - 3.0		

Project: BE190043

Date: 16/10/2020

Scale: 1:25000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

FOR

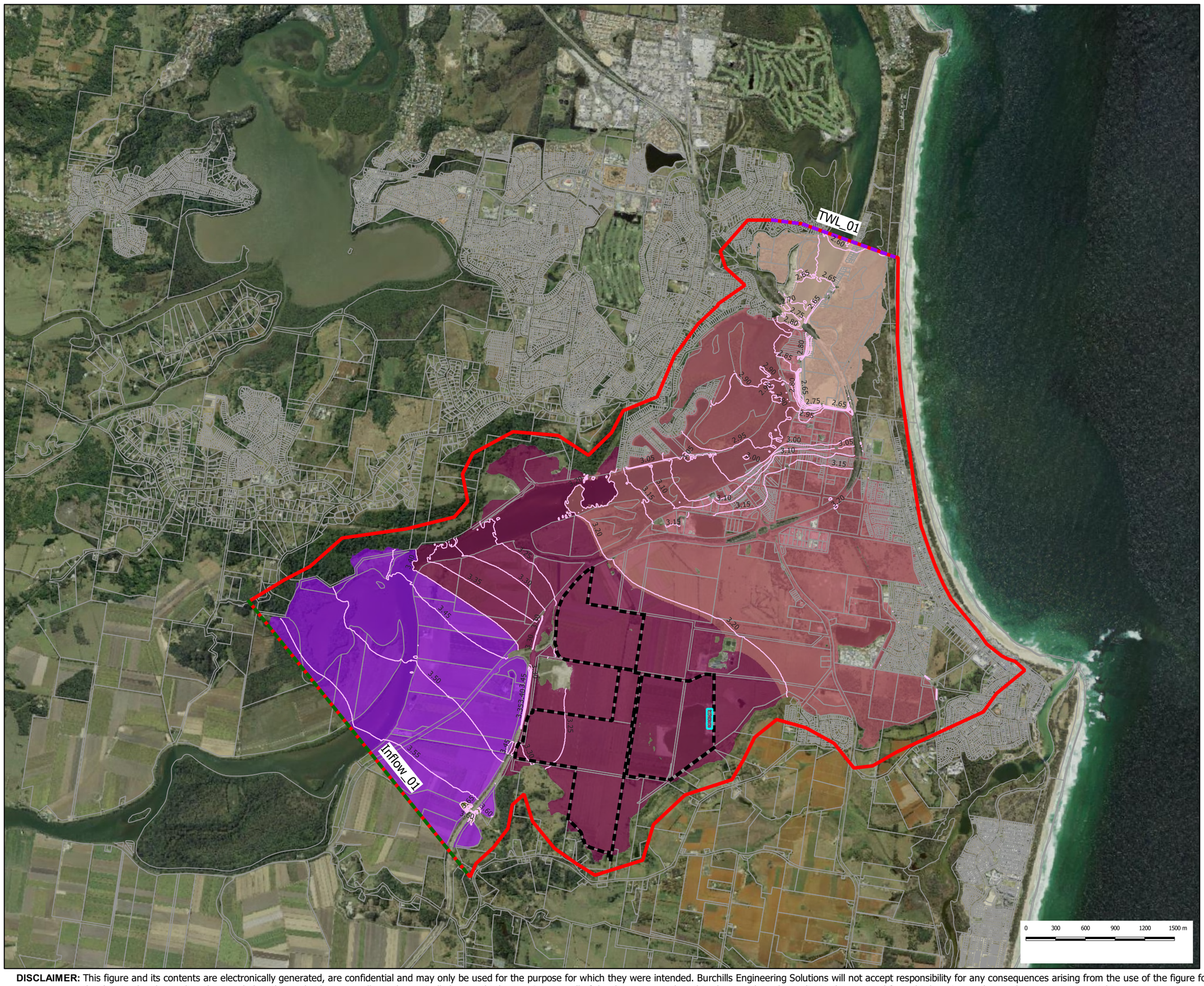
Hanson

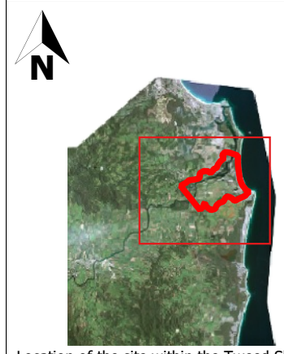
Appendix F – Regional Hydraulic Results

Existing Conditions – Flood Results

Tweed Sand Plant Flood Assessment

FIG A01 PRE DEVELOPMENT
1% AEP
FLOOD WATER LEVEL
(REGIONAL)





Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Existing Building & Wash Plant
- Water Level Contour

Water Level (mAHD)

below 0.8	3.0 - 3.2
0.8 - 1.0	2.8 - 3.0
1.0 - 1.2	2.8 - 3.0
1.4 - 1.6	3.8 - 4.0
1.6 - 1.8	4.0 - 4.2
1.8 - 2.0	3.8 - 4.0
1.8 - 2.0	4.6 - 4.8
2.4 - 2.8	above 4.8
2.8 - 3.0	

Project: BE190043

Date: Oct 2020

Scale: 1:35000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

FOR

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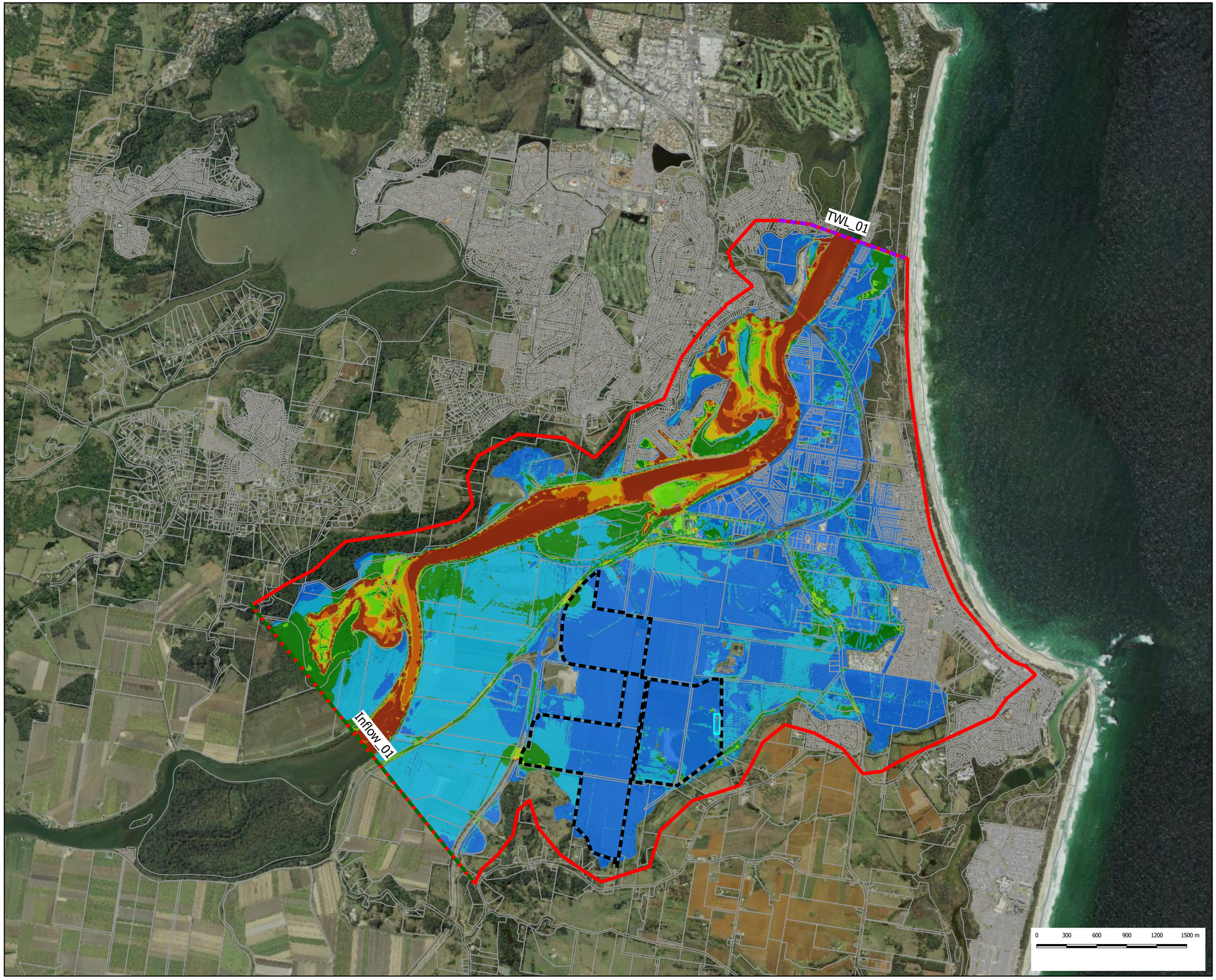
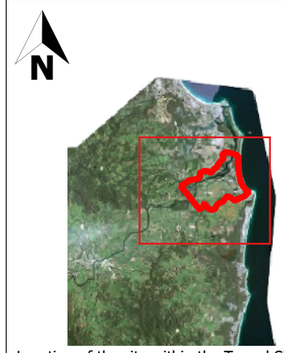
Tweed Sand Plant Flood Assessment

FIG A02 PRE DEVELOPMENT
1% AEP
FLOOD WATER VELOCITY
(REGIONAL)





Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Existing Building & Wash Plant

Water Velocity (m/s)

below 0.0	0.4 - 0.6
0.0 - 0.1	0.6 - 0.8
0.1 - 0.2	0.8 - 1.0
0.2 - 0.4	above 1.0

Project: BE190043

Date: Oct 2020

Scale: 1:35000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

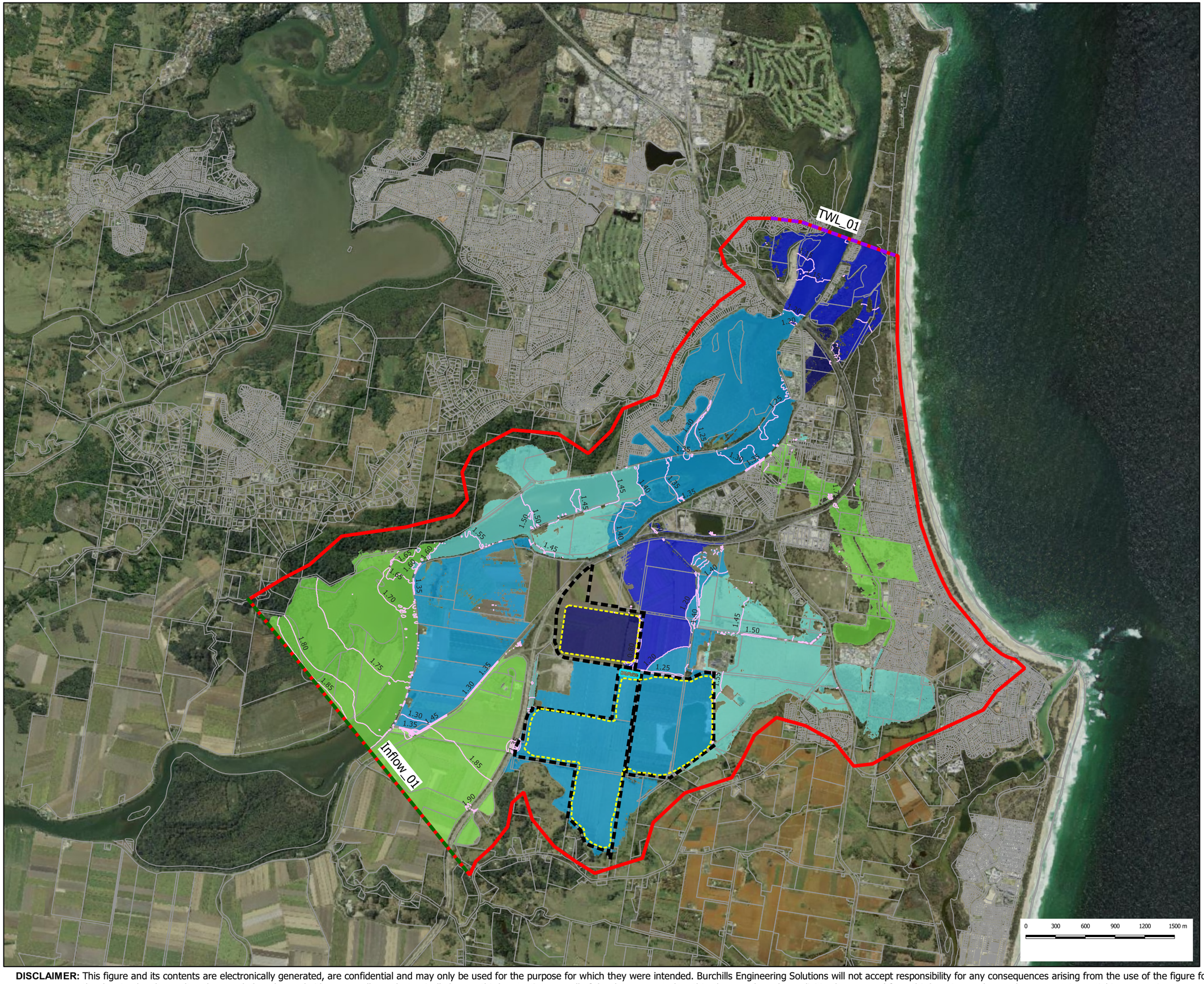
FOR

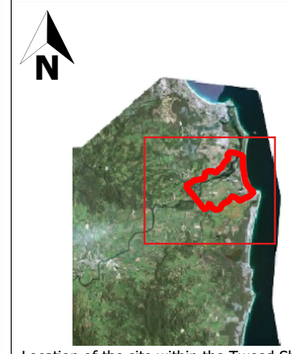
Hanson

Phase 11 – Flood Results

Tweed Sand Plant Flood Assessment

FIG B01 POST DEVELOPMENT
20% AEP
FLOOD WATER LEVEL
(REGIONAL)





Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant
- Water Level Contour

Water Level (mAHD)

below 1.0	3.2 - 3.4
1.0 - 1.2	3.4 - 3.6
1.2 - 1.4	3.6 - 3.8
1.4 - 1.6	3.8 - 4.2
1.6 - 2.0	4.2 - 4.4
2.0 - 2.2	4.4 - 4.6
2.2 - 2.4	4.6 - 4.8
2.4 - 2.8	above 4.8
2.8 - 3.2	

Project: BE190043

Date: Oct 2020

Scale: 1:35000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

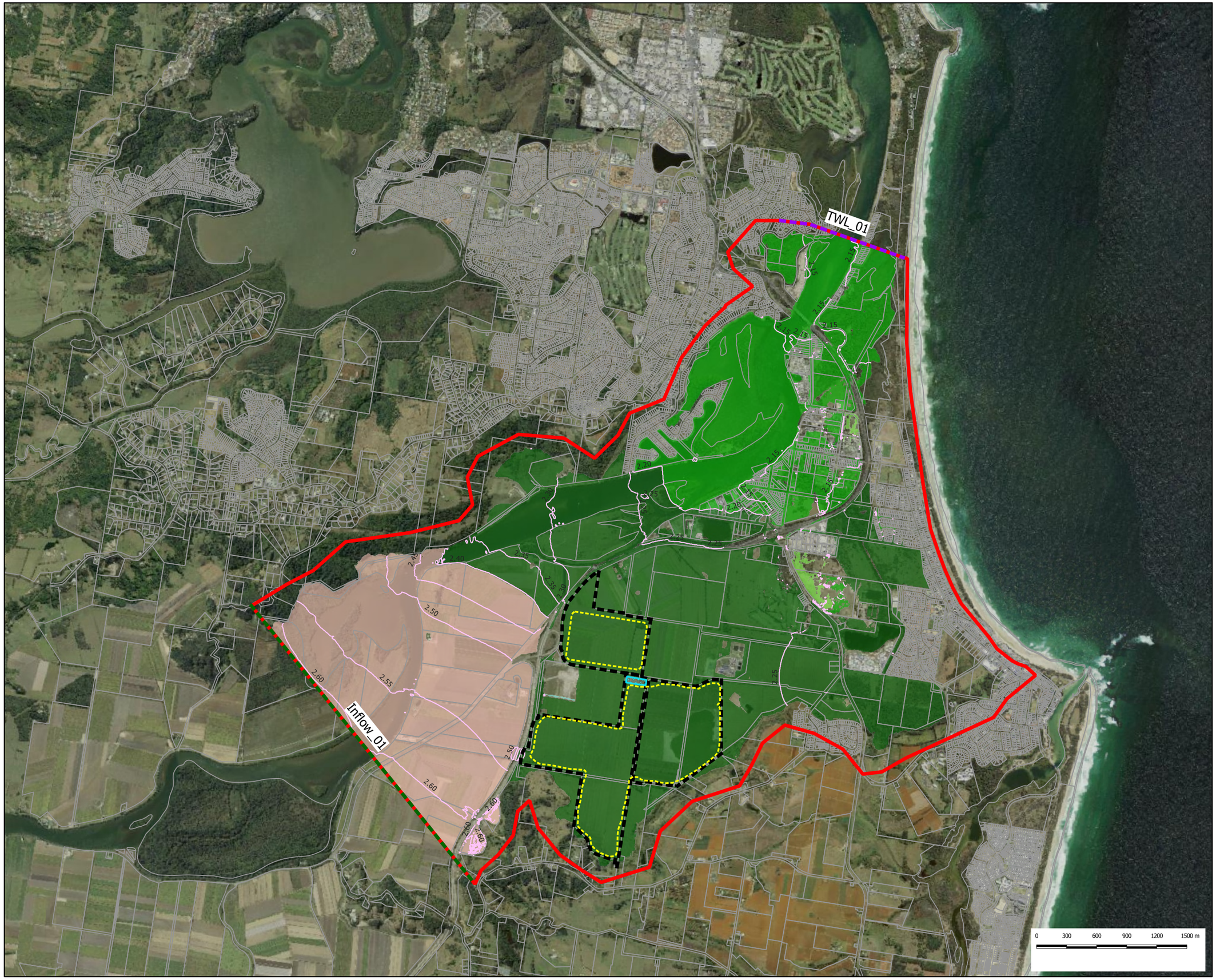
BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson

Tweed Sand Plant Flood Assessment

FIG B02 POST DEVELOPMENT
5% AEP
FLOOD WATER LEVEL
(REGIONAL)




Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant
- Water Level Contour

Water Level (mAHD)

below 1.0	3.2 - 3.4
1.0 - 1.2	3.4 - 3.6
1.2 - 1.4	3.6 - 3.8
1.4 - 1.6	3.8 - 4.2
1.6 - 2.0	4.2 - 4.4
2.0 - 2.2	4.4 - 4.6
2.2 - 2.4	4.6 - 4.8
2.4 - 2.8	above 4.8
2.8 - 3.2	

Project: BE190043

Date: Oct 2020

Scale: 1:35000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

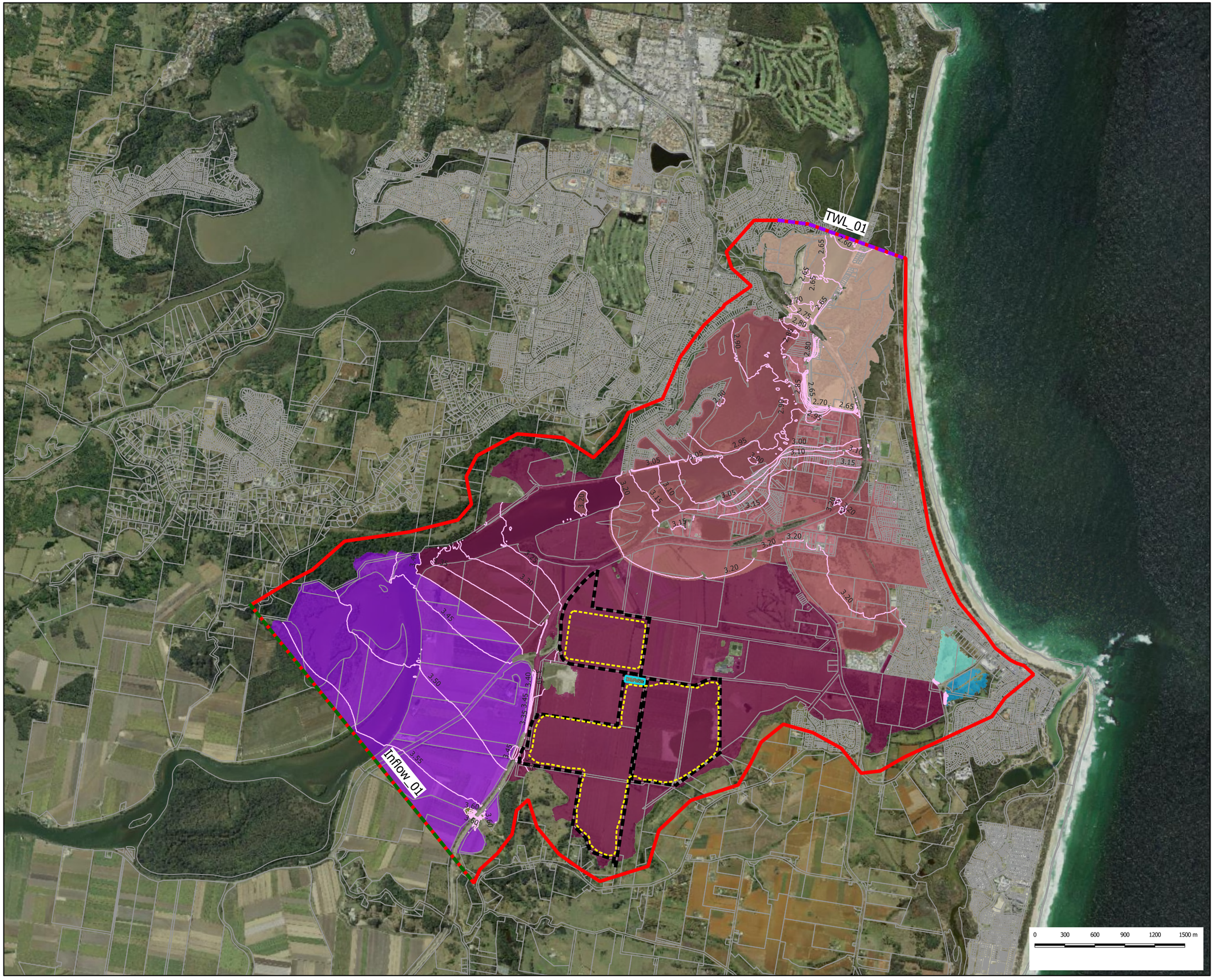
BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson

Tweed Sand Plant Flood Assessment

FIG B03 POST DEVELOPMENT
1% AEP
FLOOD WATER LEVEL
(REGIONAL)



Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant
- Water Level Contour

Water Level (mAHD)

below 1.0	3.2 - 3.4
1.0 - 1.2	3.4 - 3.6
1.2 - 1.4	3.6 - 3.8
1.4 - 1.6	3.8 - 4.2
1.6 - 2.0	4.2 - 4.4
2.0 - 2.2	4.4 - 4.6
2.2 - 2.4	4.6 - 4.8
2.4 - 2.8	above 4.8
2.8 - 3.2	

Project: BE190043

Date: Oct 2020

Scale: 1:35000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

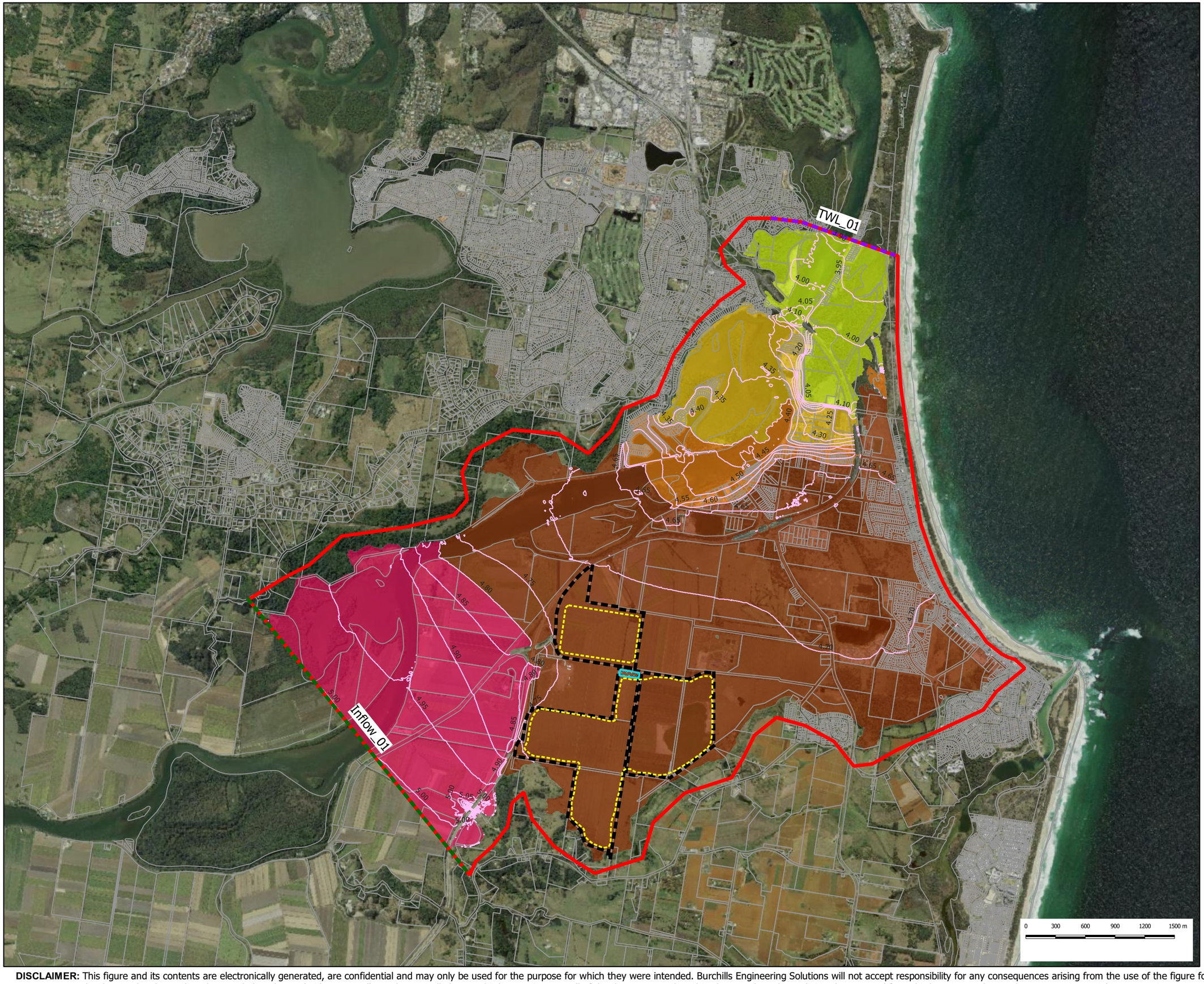
BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson

Tweed Sand Plant Flood Assessment

FIG B04 POST DEVELOPMENT 1% AEP CLIMATE CHANGE FLOOD WATER LEVEL (REGIONAL)



Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant
- Water Level Contour

Water Level (mAHD)

- below 1.0
- 1.0 - 1.2
- 1.2 - 1.4
- 1.4 - 1.6
- 1.6 - 2.0
- 2.0 - 2.2
- 2.2 - 2.4
- 2.4 - 2.8
- 2.8 - 3.2
- 3.2 - 3.4
- 3.4 - 3.6
- 3.6 - 3.8
- 3.8 - 4.2
- 4.2 - 4.4
- 4.4 - 4.6
- 4.6 - 4.8
- above 4.8

Project: BE190043

Date: Oct 2020

Scale: 1:35000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

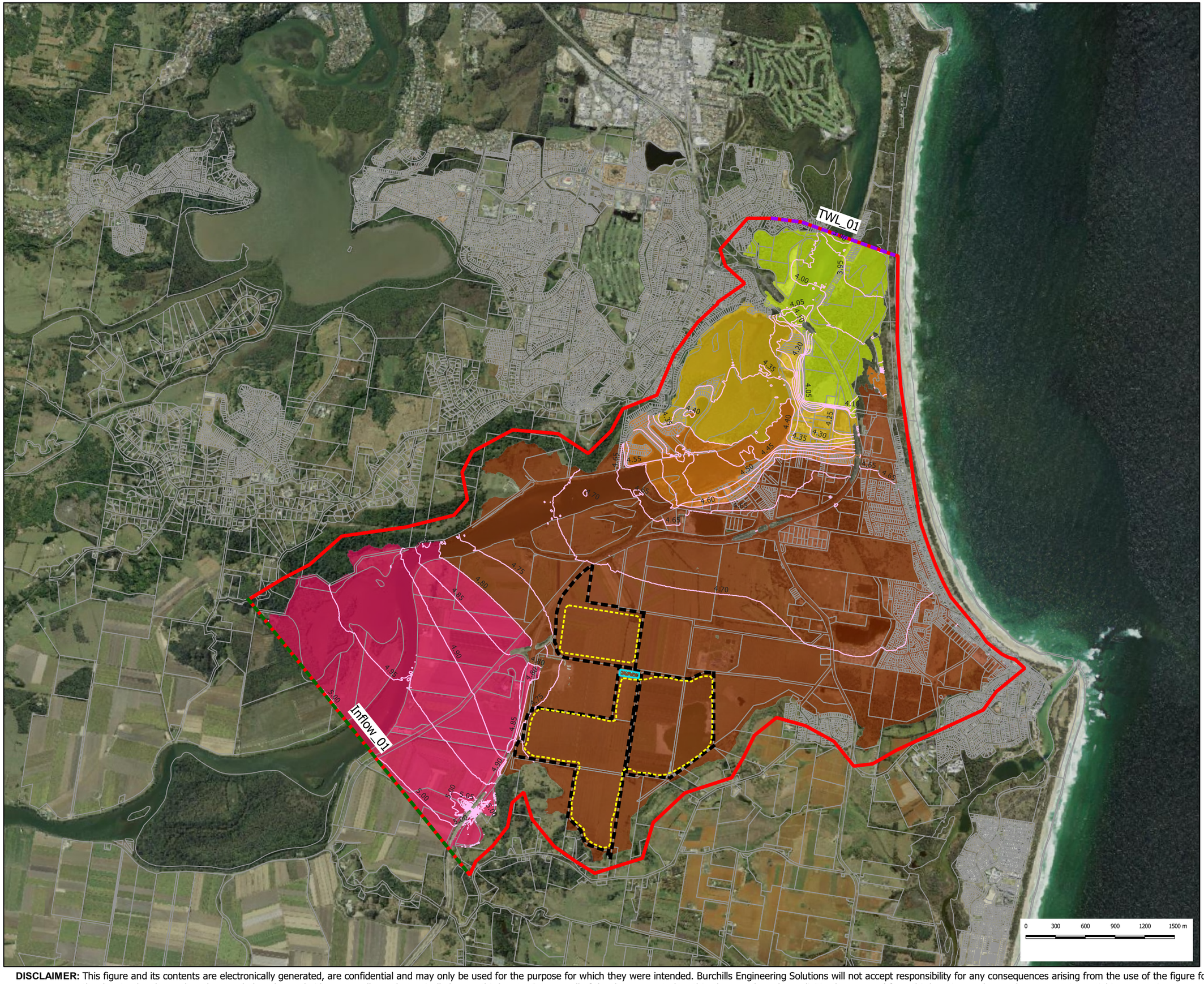
BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson

Tweed Sand Plant Flood Assessment

FIG B05 POST DEVELOPMENT 0.2% AEP CLIMATE CHANGE FLOOD WATER LEVEL (REGIONAL)



Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant
- Water Level Contour

Water Level (mAHD)

below 1.0	3.2 - 3.4
1.0 - 1.2	3.4 - 3.6
1.2 - 1.4	3.6 - 3.8
1.4 - 1.6	3.8 - 4.2
1.6 - 2.0	4.2 - 4.4
2.0 - 2.2	4.4 - 4.6
2.2 - 2.4	4.6 - 4.8
2.4 - 2.8	above 4.8
2.8 - 3.2	

Project: BE190043

Date: Oct 2020

Scale: 1:35000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

FOR

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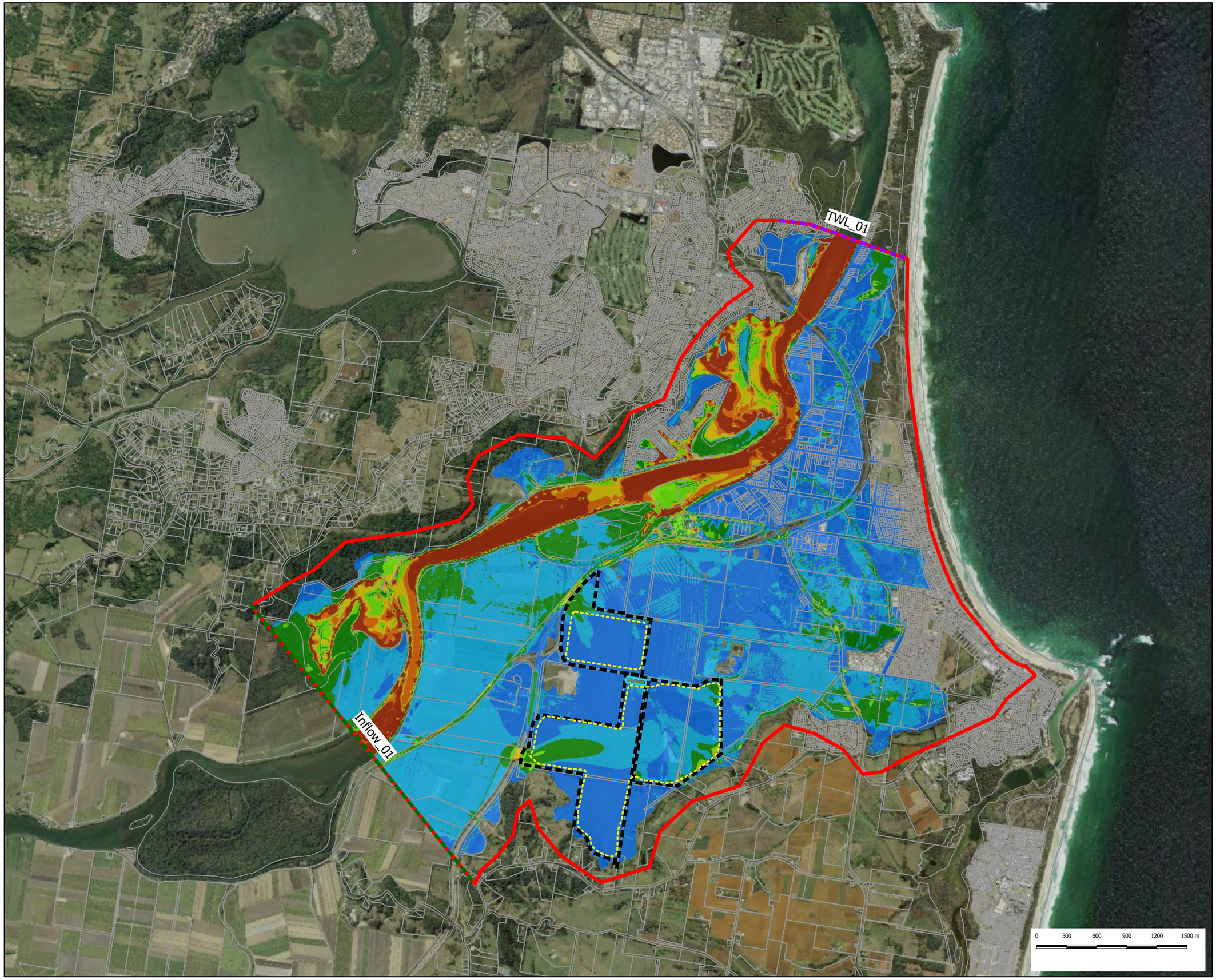
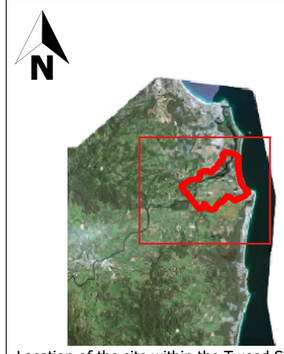
Tweed Sand Plant Flood Assessment

FIG B06 POST DEVELOPMENT
1% AEP
FLOOD WATER VELOCITY
(REGIONAL)





Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant

Water Velocity (m/s)

below 0.0	0.4 - 0.6
0.0 - 0.1	0.6 - 0.8
0.1 - 0.2	0.8 - 1.0
0.2 - 0.4	above 1.0

Project: BE190043

Date: Oct 2020

Scale: 1:35000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

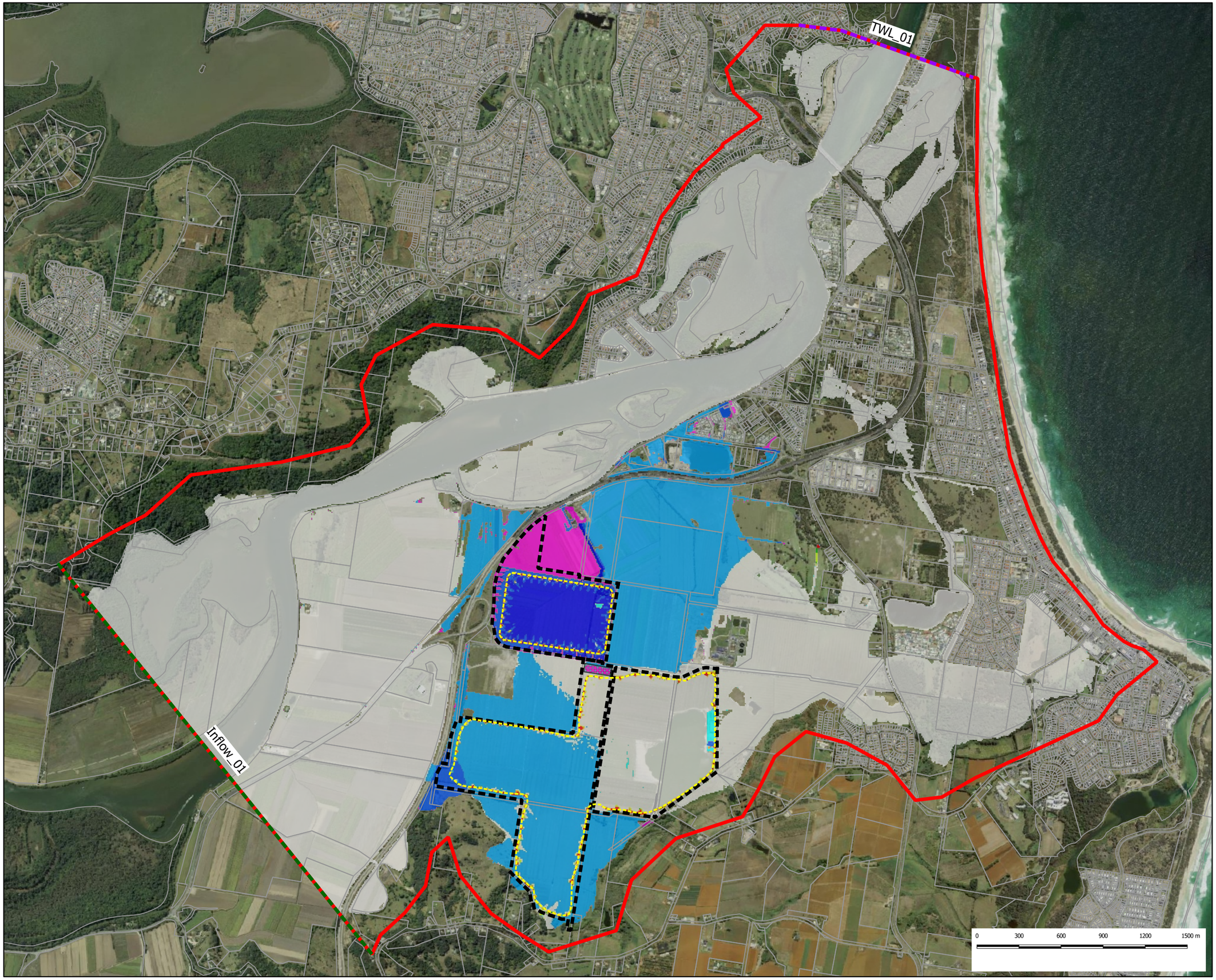
FOR

Hanson

Phase 11 - Regional Event Afflux Maps

Tweed Sand Plant Flood Assessment

FIG C01 POST DEVELOPMENT
20% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL - PHASE 11)



Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant

Water Level Afflux(mm)

<500	35 - 100
-500 - -100	100 - 300
-100 - -30	>300
-30 - 30	Was Wet Now Dry
30 - 35	Was Dry Now Wet

Project: BE190043

Date: 02.02.2021

Scale: 1:25000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

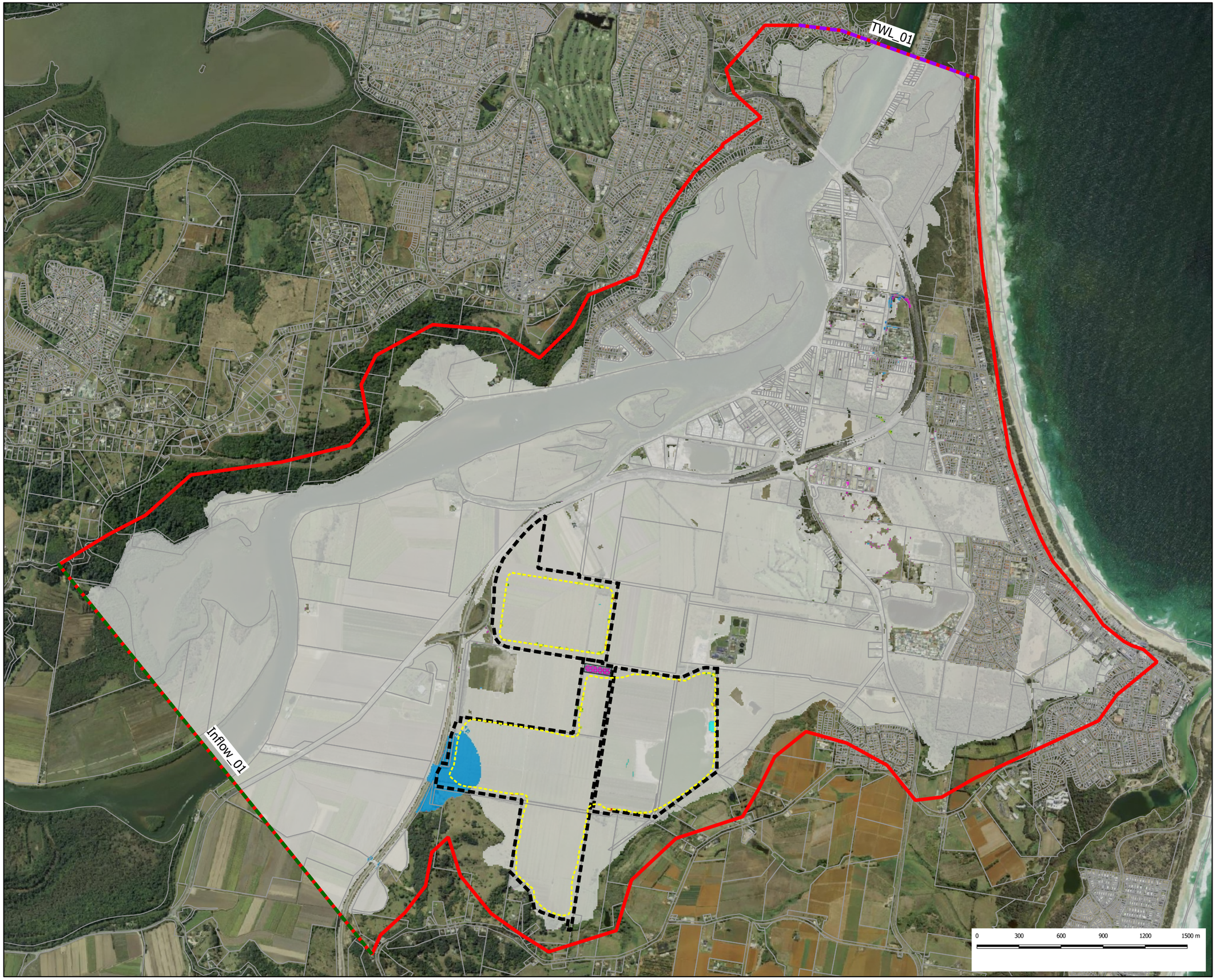
BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson

Tweed Sand Plant Flood Assessment

FIG C02 POST DEVELOPMENT
5% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL - PHASE 11)



Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant

Water Level Afflux(mm)

<500	35 - 100
-500 - -100	100 - 300
-100 - -30	>300
-30 - 30	Was Wet Now Dry
30 - 35	Was Dry Now Wet

Project: BE190043

Date: 02.02.2021

Scale: 1:25000 at A3

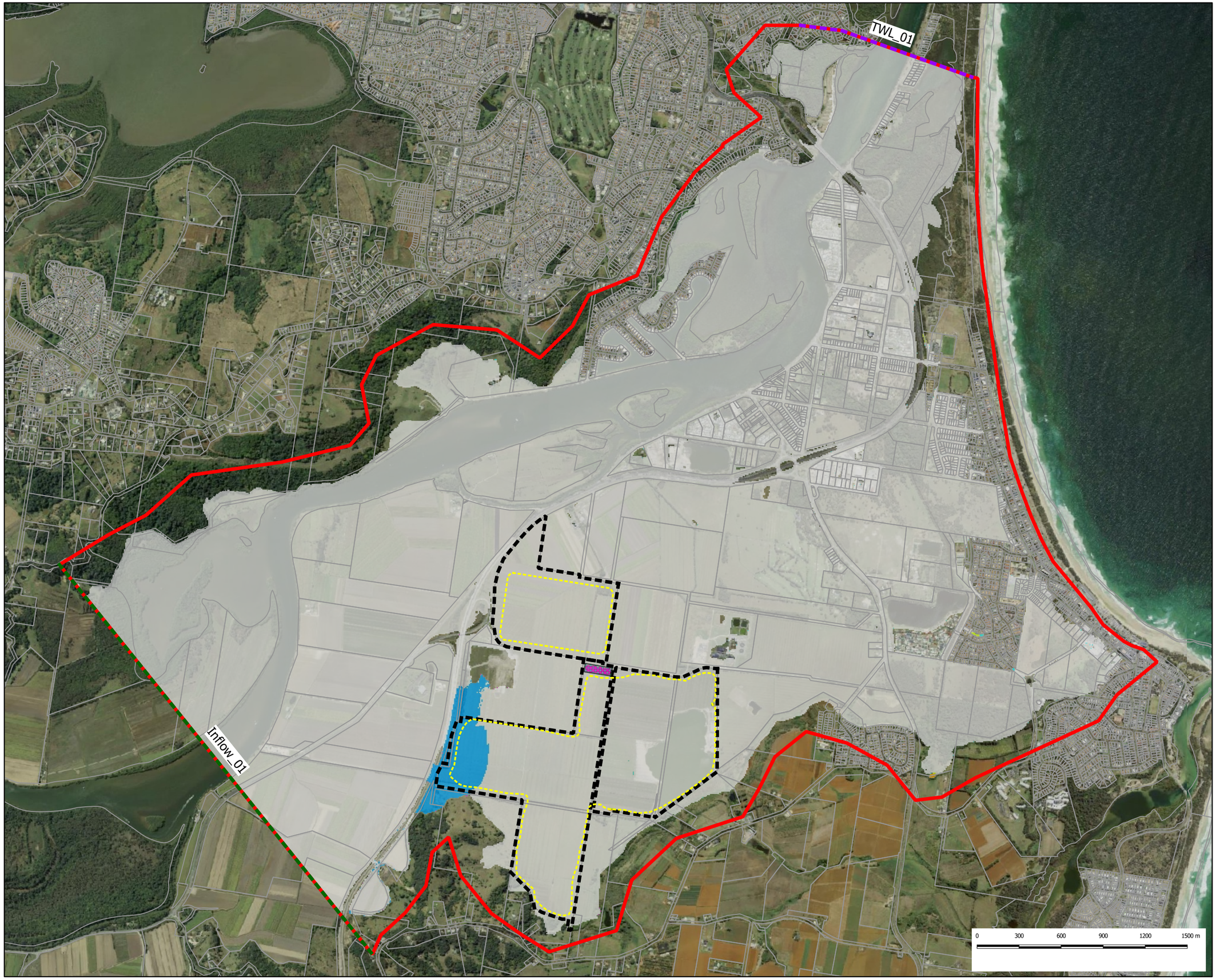
Projection: GDA 94 / MGA ZONE 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson



Tweed Sand Plant Flood Assessment

FIG C03 POST DEVELOPMENT
1% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL - PHASE 11)

N

Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant

Water Level Afflux(mm)

<500	35 - 100
-500 - -100	100 - 300
-100 - -30	>300
-30 - 30	Was Wet Now Dry
30 - 35	Was Dry Now Wet

Project: BE190043

Date: 02.02.2021

Scale: 1:25000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

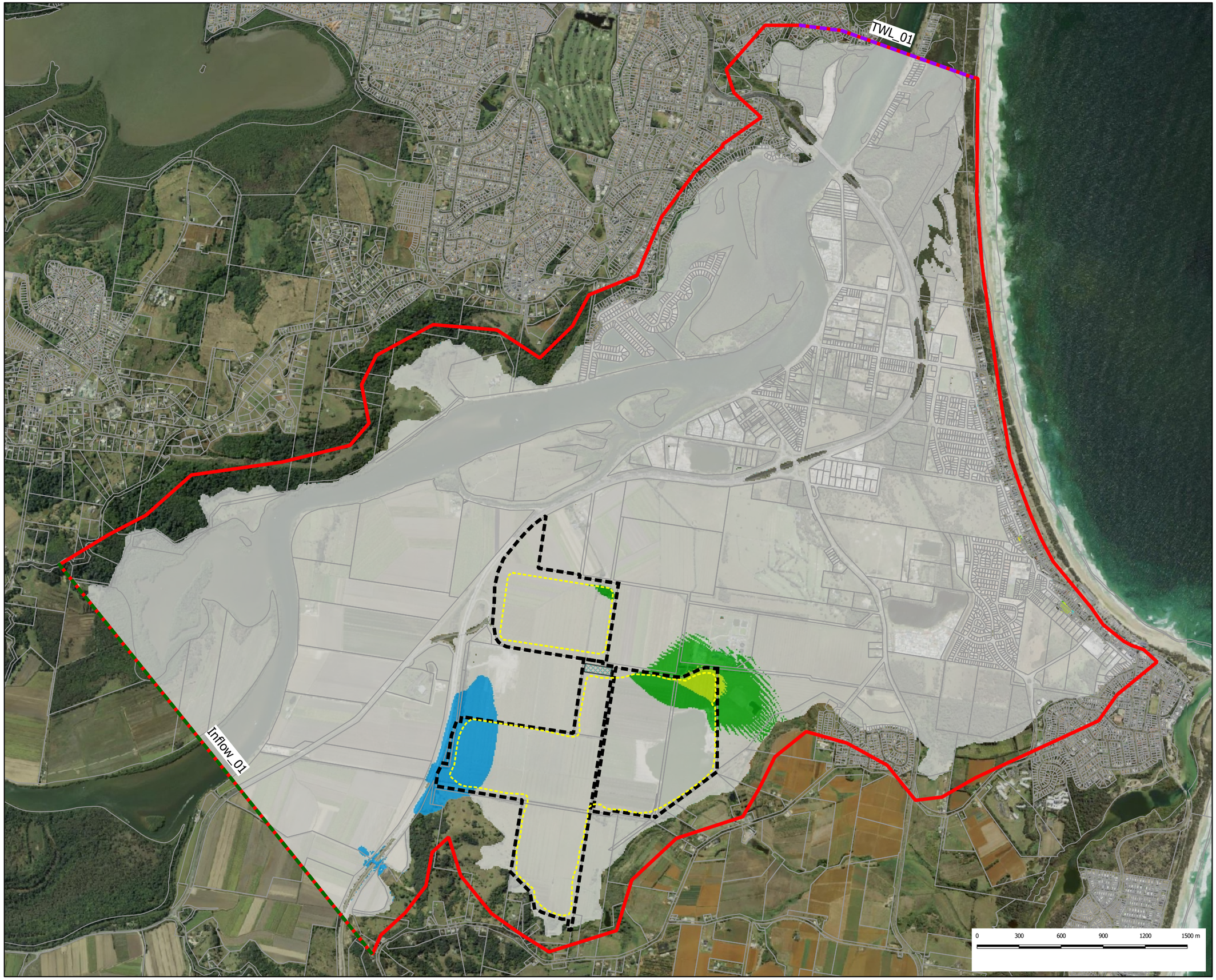
BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson

Tweed Sand Plant Flood Assessment

FIG C04 POST DEVELOPMENT 1% AEP CLIMATE CHANGE FLOOD WATER LEVEL AFFLUX (REGIONAL - PHASE 11)



Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant

Water Level Afflux(mm)

<500	35 - 100
-500 - -100	100 - 300
-100 - -30	>300
-30 - 30	Was Wet Now Dry
30 - 35	Was Dry Now Wet

Project: BE190043

Date: 02.02.2021

Scale: 1:25000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

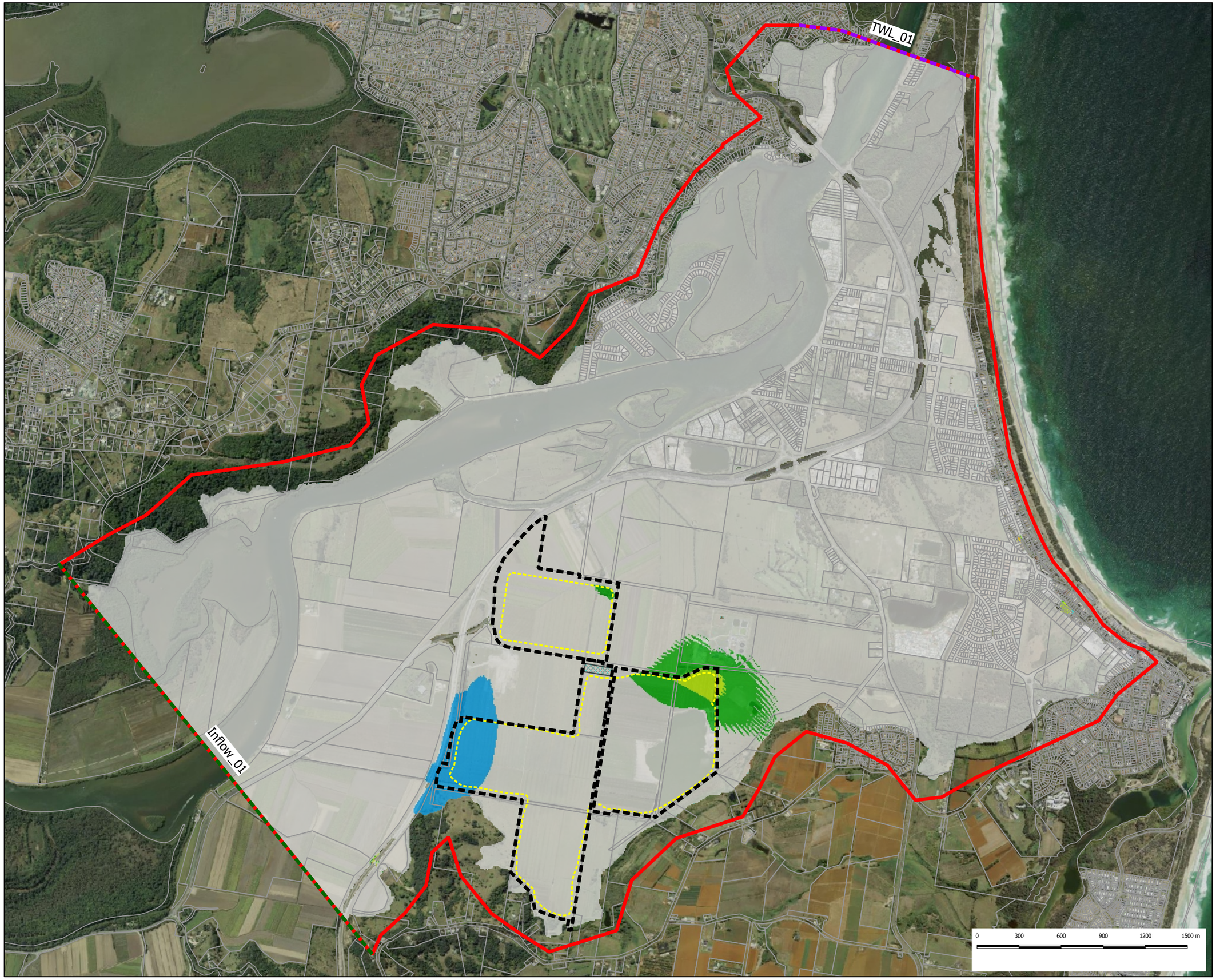
BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson

Tweed Sand Plant Flood Assessment

FIG C05 POST DEVELOPMENT
0.2% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL - PHASE 11)



Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant

Water Level Afflux(mm)

<500	35 - 100
-500 - -100	100 - 300
-100 - -30	>300
-30 - 30	Was Wet Now Dry
30 - 35	Was Dry Now Wet

Project: BE190043

Date: 02.02.2021

Scale: 1:25000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

FOR

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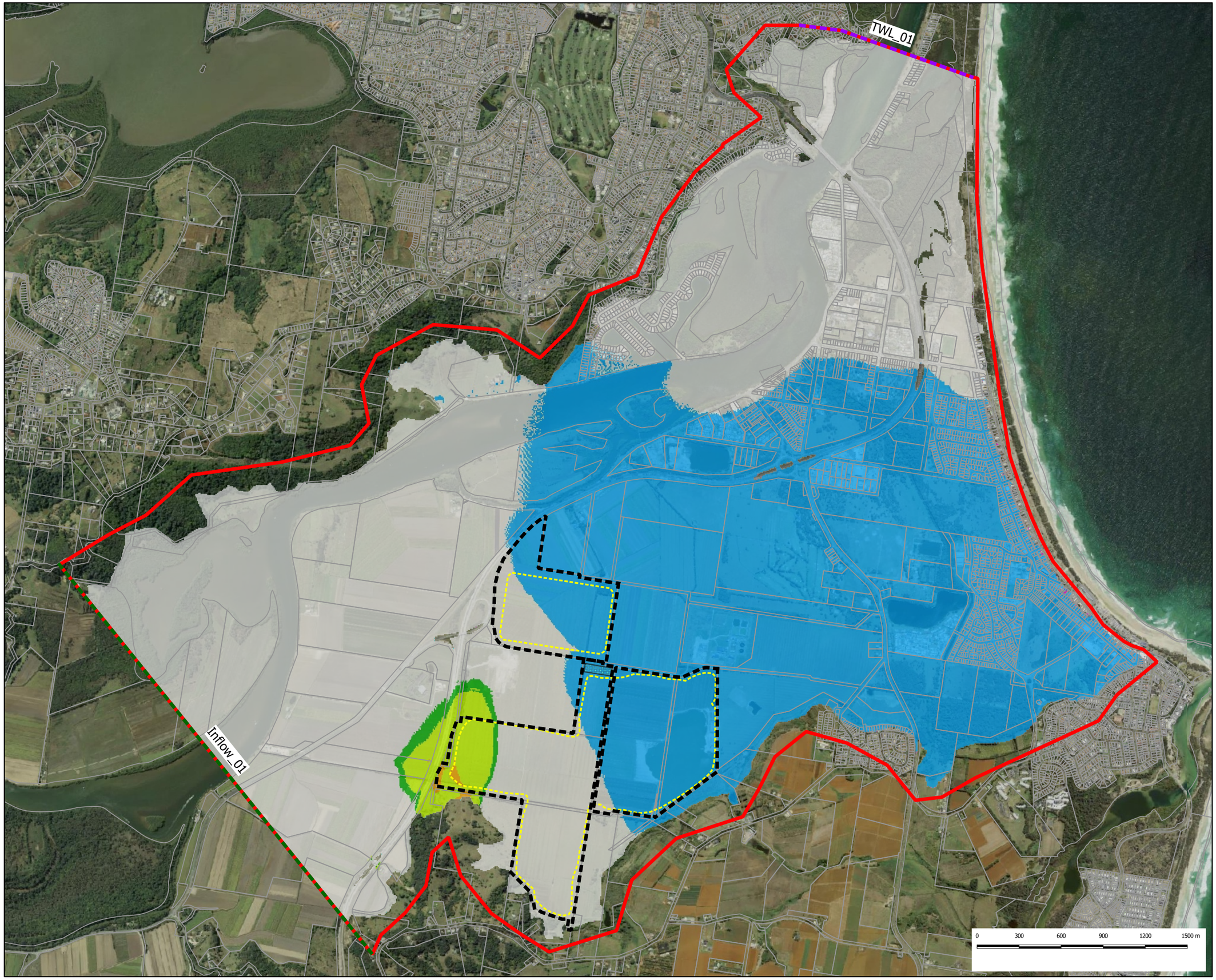
Tweed Sand Plant Flood Assessment

FIG C06 POST DEVELOPMENT
EXT EVENT
FLOOD WATER LEVEL AFFLUX
(REGIONAL - PHASE 11)



Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant

Water Level Afflux(mm)

<500	35 - 100
-500 - -100	100 - 300
-100 - -30	>300
-30 - 30	Was Wet Now Dry
30 - 35	Was Dry Now Wet

Project: BE190043

Date: 02.02.2021

Scale: 1:25000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

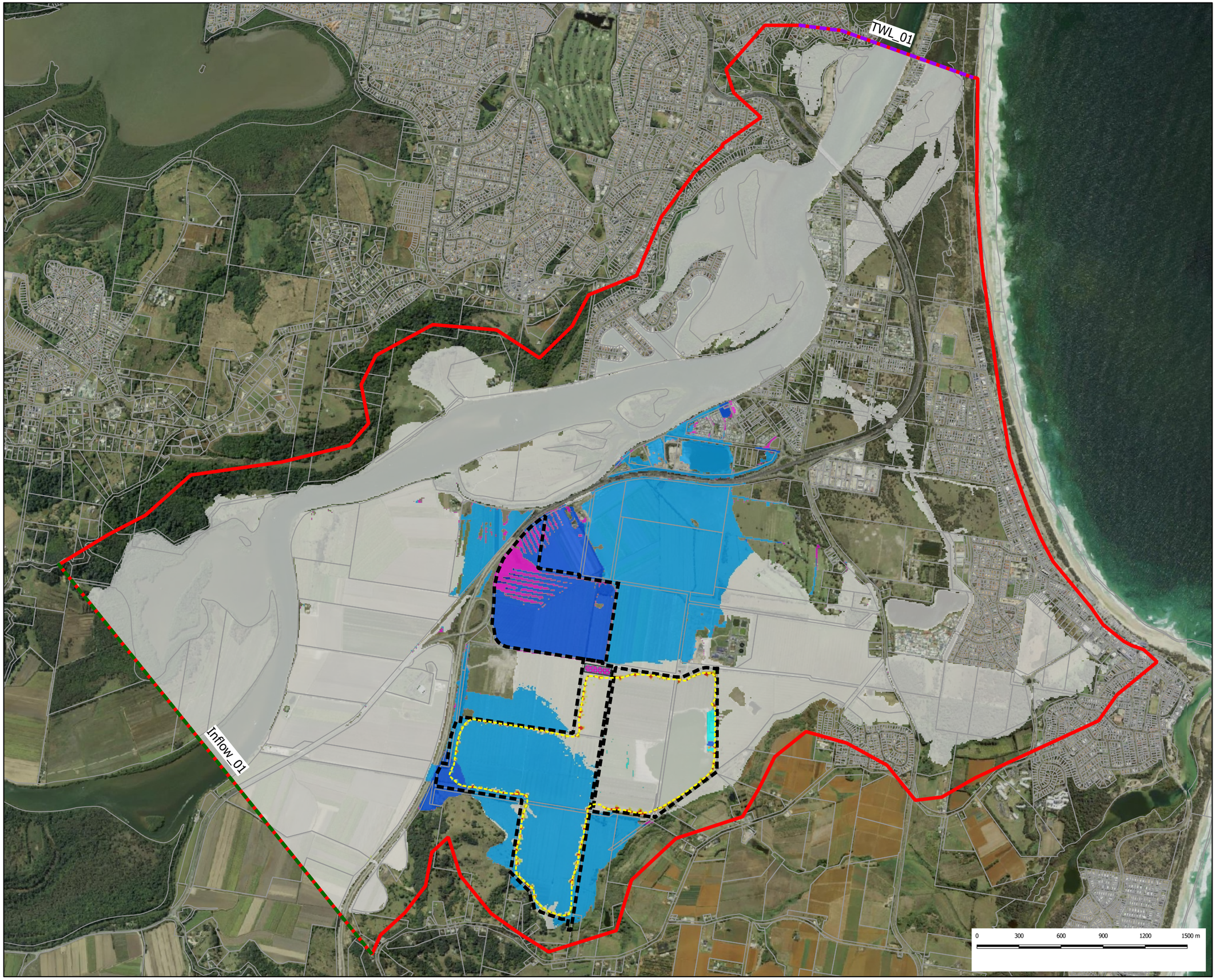
FOR

Hanson

Phase 9 – Regional Event Afflux Maps

Tweed Sand Plant Flood Assessment

FIG C07 POST DEVELOPMENT
20% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL - PHASE 9)



Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant

Water Level Afflux(mm)

<500	35 - 100
-500 - -100	100 - 300
-100 - -30	>300
-30 - 30	Was Wet Now Dry
30 - 35	Was Dry Now Wet

Project: BE190043

Date: 02.02.2021

Scale: 1:25000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

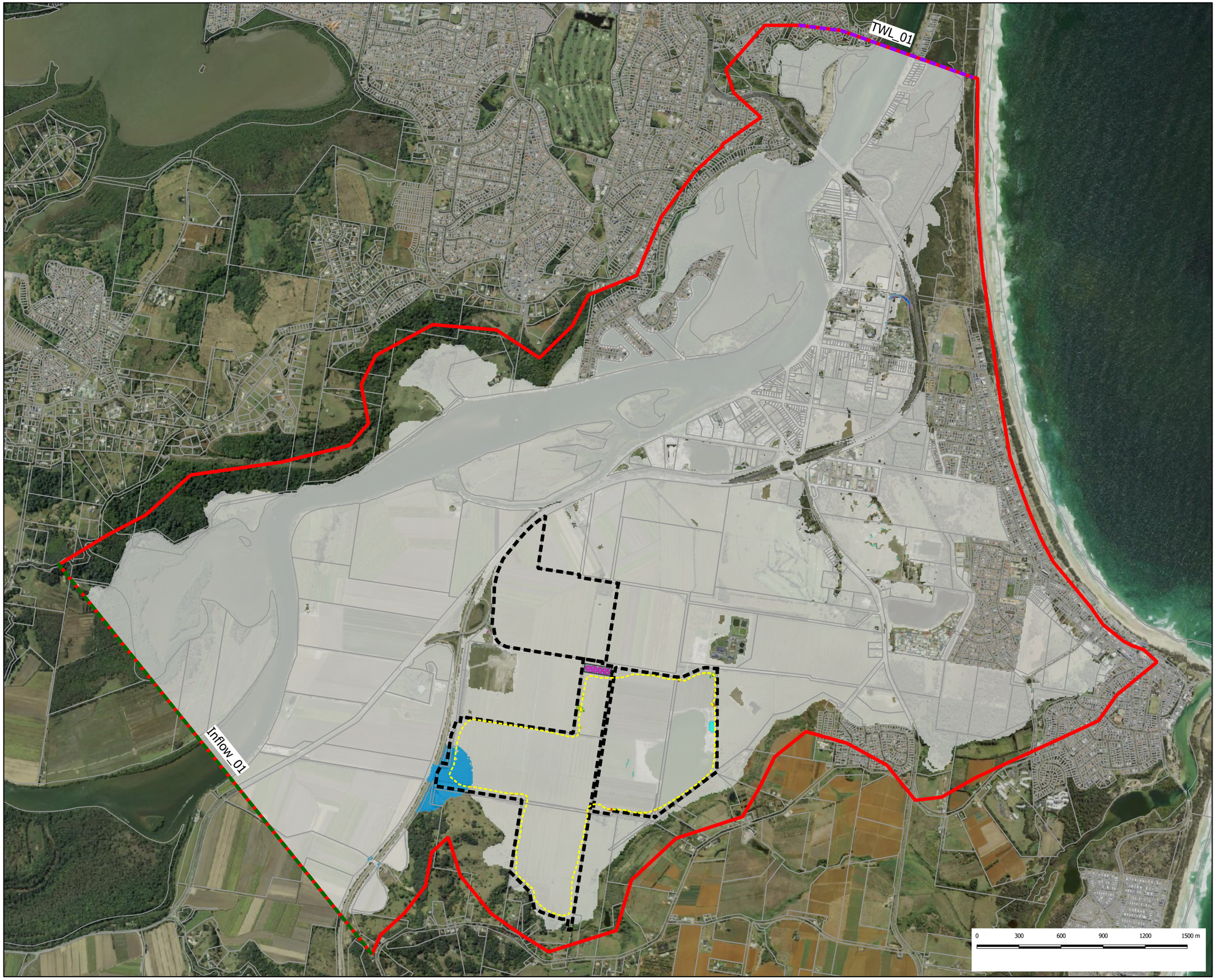
BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson

Tweed Sand Plant Flood Assessment

FIG C08 POST DEVELOPMENT
5% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL - PHASE 9)




Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant

Water Level Afflux(mm)

<500	35 - 100
-500 - -100	100 - 300
-100 - -30	>300
-30 - 30	Was Wet Now Dry
30 - 35	Was Dry Now Wet

Project: BE190043

Date: 02.02.2021

Scale: 1:25000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

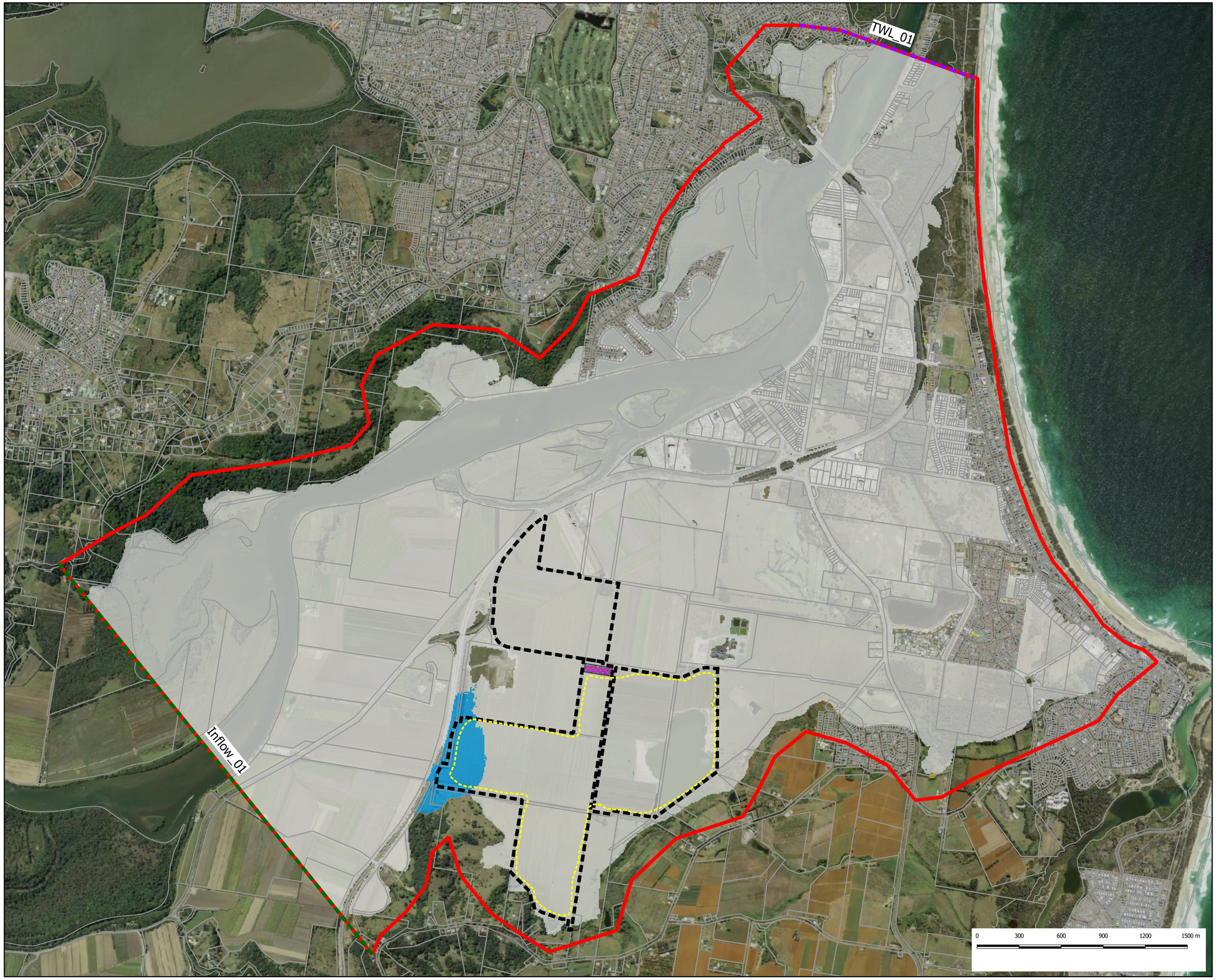
BURCHILLS ENGINEERING SOLUTIONS

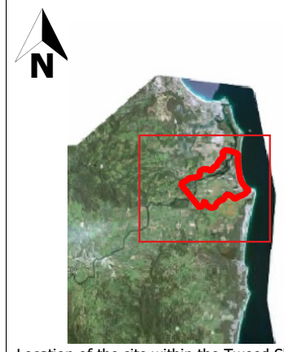
FOR

Hanson

Tweed Sand Plant Flood Assessment

FIG C09 POST DEVELOPMENT
1% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL - PHASE 9)




Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant

Water Level Afflux(mm)

<500	35 - 100
-500 - -100	100 - 300
-100 - -30	>300
-30 - 30	Was Wet Now Dry
30 - 35	Was Dry Now Wet

Project: BE190043

Date: 02.02.2021

Scale: 1:25000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

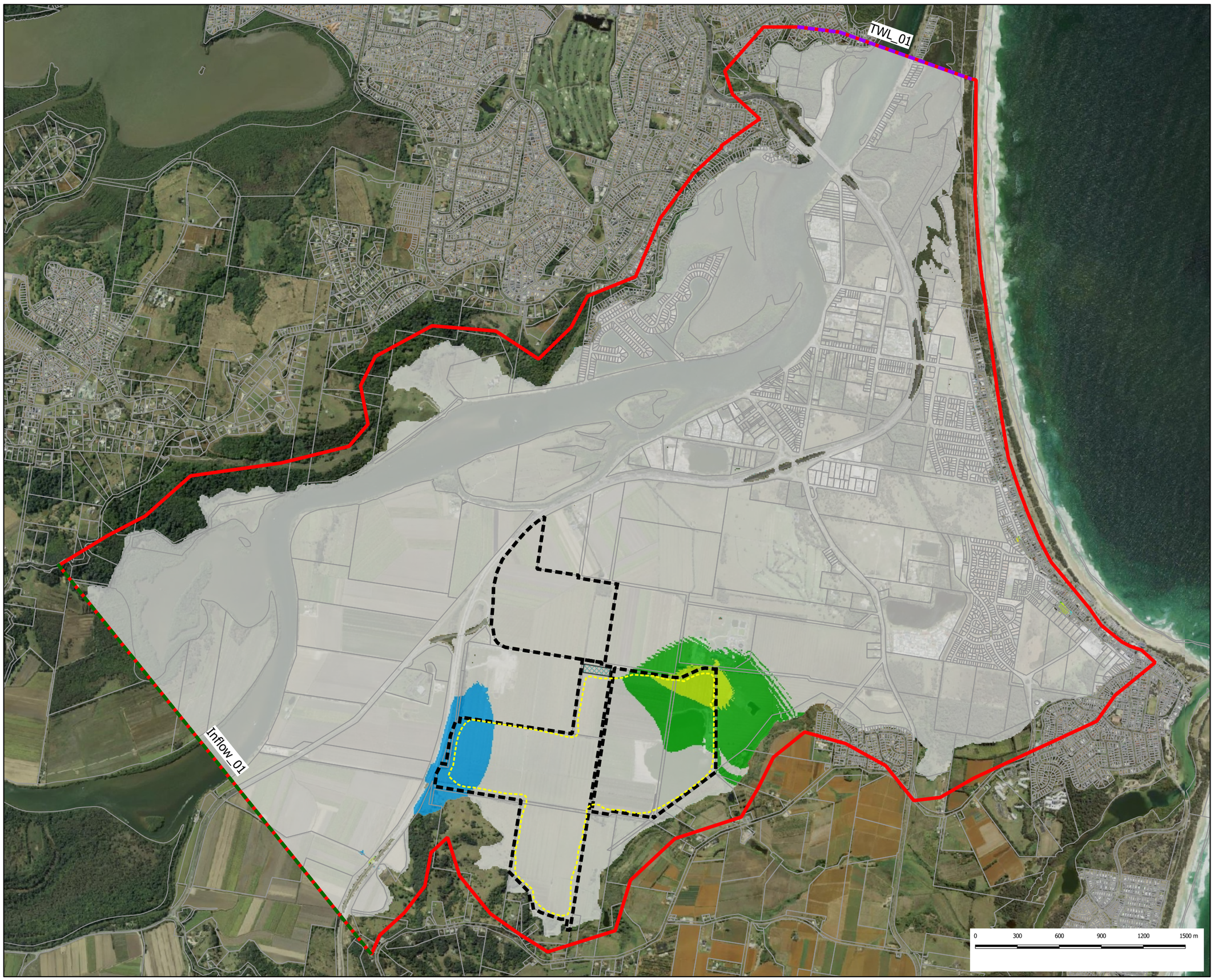
BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson

Tweed Sand Plant Flood Assessment

FIG C10 POST DEVELOPMENT 1% AEP CLIMATE CHANGE FLOOD WATER LEVEL AFFLUX (REGIONAL - PHASE 9)



Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant

Water Level Afflux(mm)

<500	35 - 100
-500 - -100	100 - 300
-100 - -30	>300
-30 - 30	Was Wet Now Dry
30 - 35	Was Dry Now Wet

Project: BE190043

Date: 02.02.2021

Scale: 1:25000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

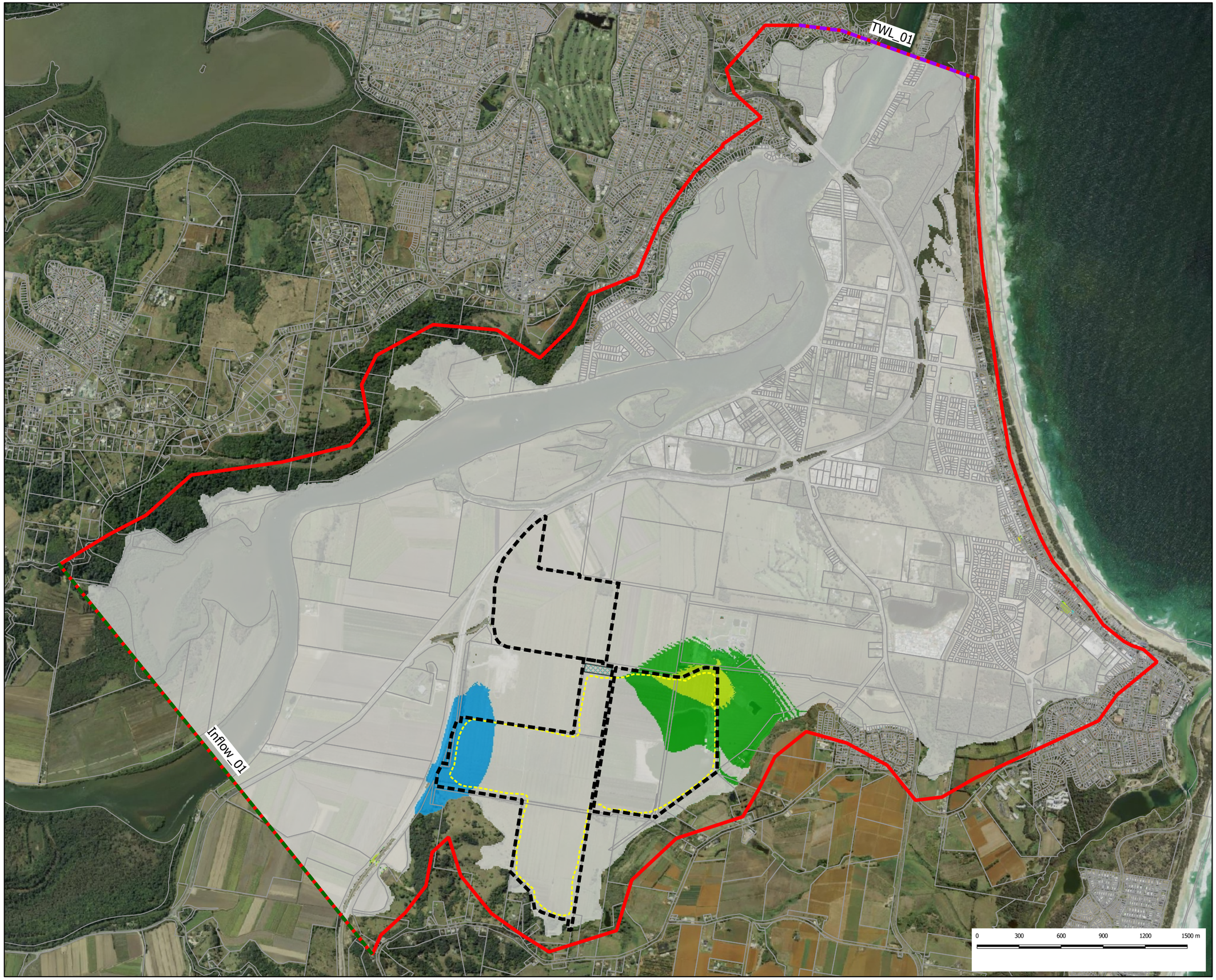
BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson

Tweed Sand Plant Flood Assessment

FIG C11 POST DEVELOPMENT
0.2% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL - PHASE 9)



Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant

Water Level Afflux(mm)

<500	35 - 100
-500 - -100	100 - 300
-100 - -30	>300
-30 - 30	Was Wet Now Dry
30 - 35	Was Dry Now Wet

Project: BE190043

Date: 02.02.2021

Scale: 1:25000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

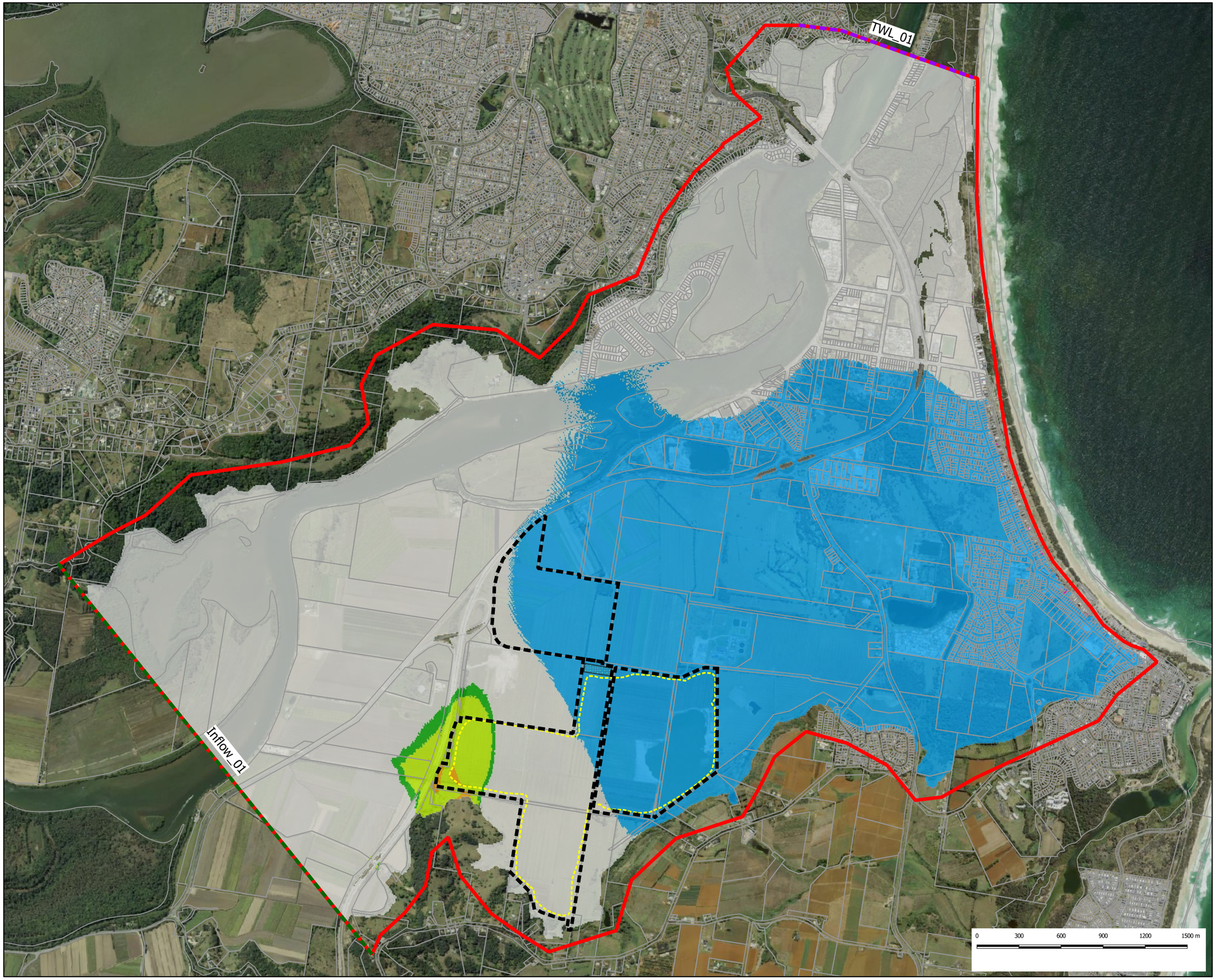
BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson

Tweed Sand Plant Flood Assessment

FIG C12 POST DEVELOPMENT
EXT EVENT
FLOOD WATER LEVEL AFFLUX
(REGIONAL - PHASE 9)



Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant

Water Level Afflux(mm)

<500	35 - 100
-500 - -100	100 - 300
-100 - -30	>300
-30 - 30	Was Wet Now Dry
30 - 35	Was Dry Now Wet

Project: BE190043

Date: 02.02.2021

Scale: 1:25000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

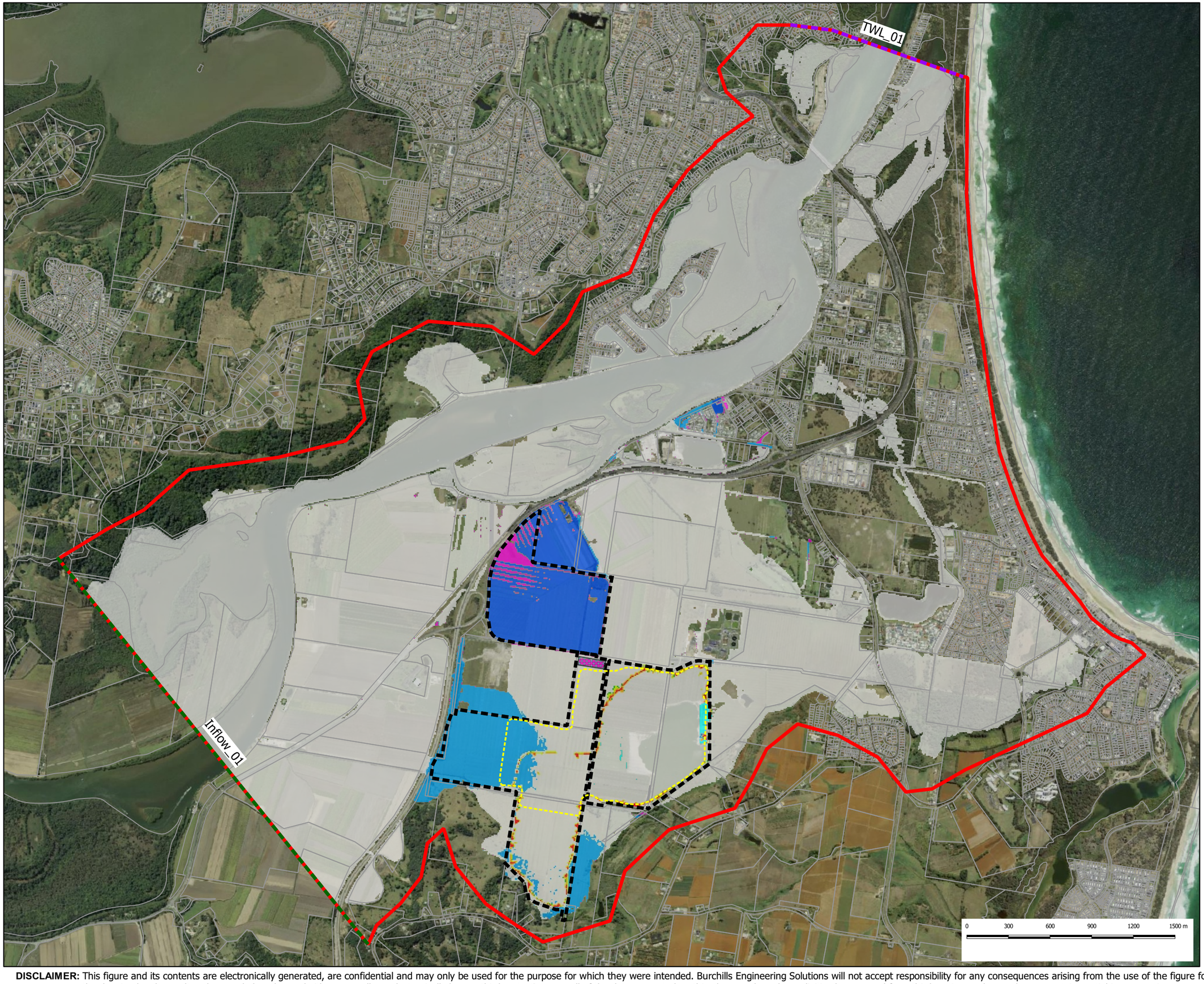
FOR

Hanson

Phase 7 – Regional Event Afflux Maps

Tweed Sand Plant Flood Assessment

FIG C13 POST DEVELOPMENT
20% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL - PHASE 7)



Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant

Water Level Afflux(mm)

<500	35 - 100
-500 - -100	100 - 300
-100 - -30	>300
-30 - 30	Was Wet Now Dry
30 - 35	Was Dry Now Wet

Project: BE190043

Date: 02.02.2021

Scale: 1:25000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

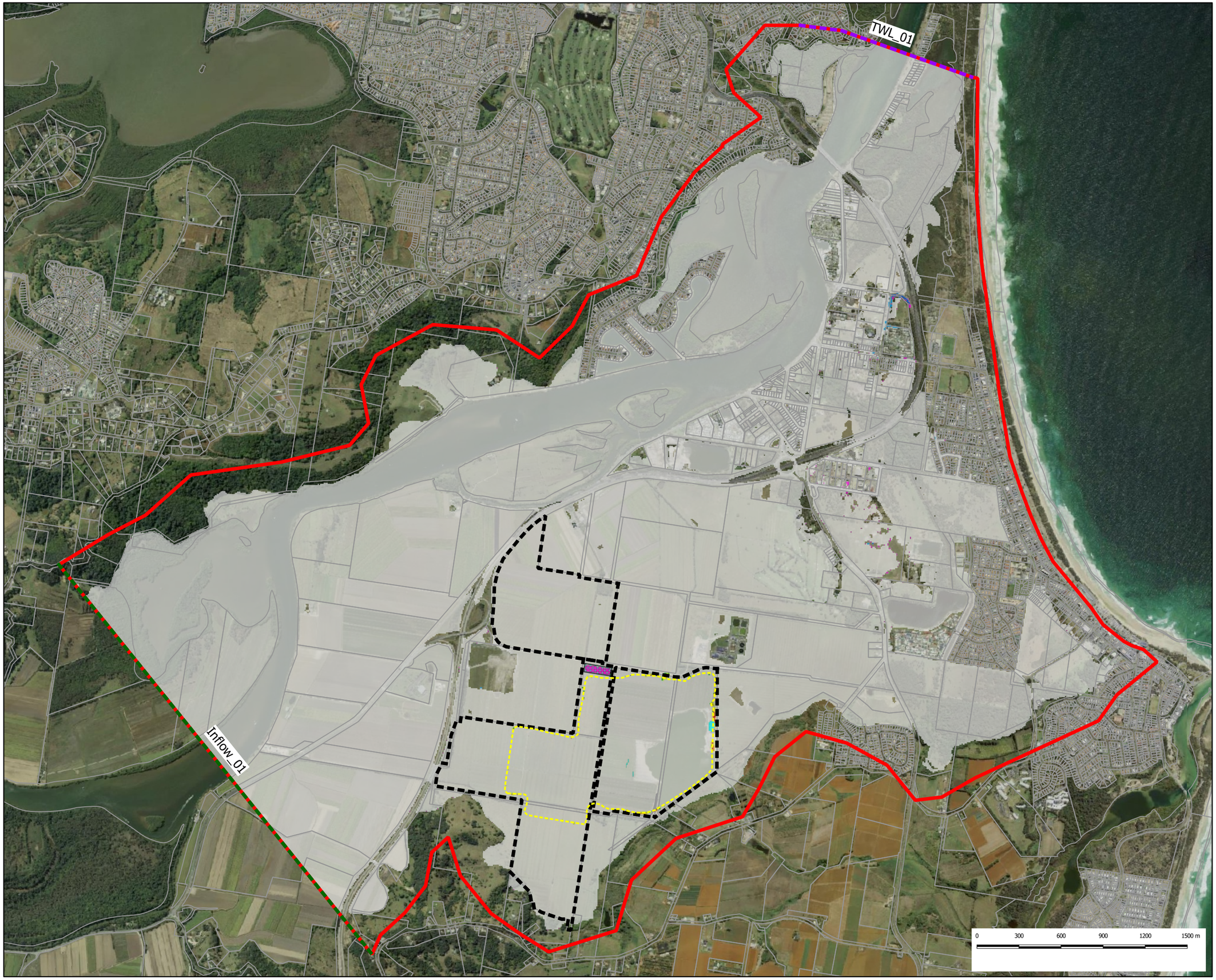
BURCHILLS ENGINEERING SOLUTIONS

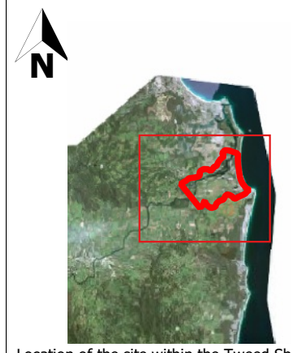
FOR

Hanson

Tweed Sand Plant Flood Assessment

FIG C14 POST DEVELOPMENT
5% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL - PHASE 7)





Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant

Water Level Afflux(mm)

<500	35 - 100
-500 - -100	100 - 300
-100 - -30	>300
-30 - 30	Was Wet Now Dry
30 - 35	Was Dry Now Wet

Project: BE190043

Date: 02.02.2021

Scale: 1:25000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

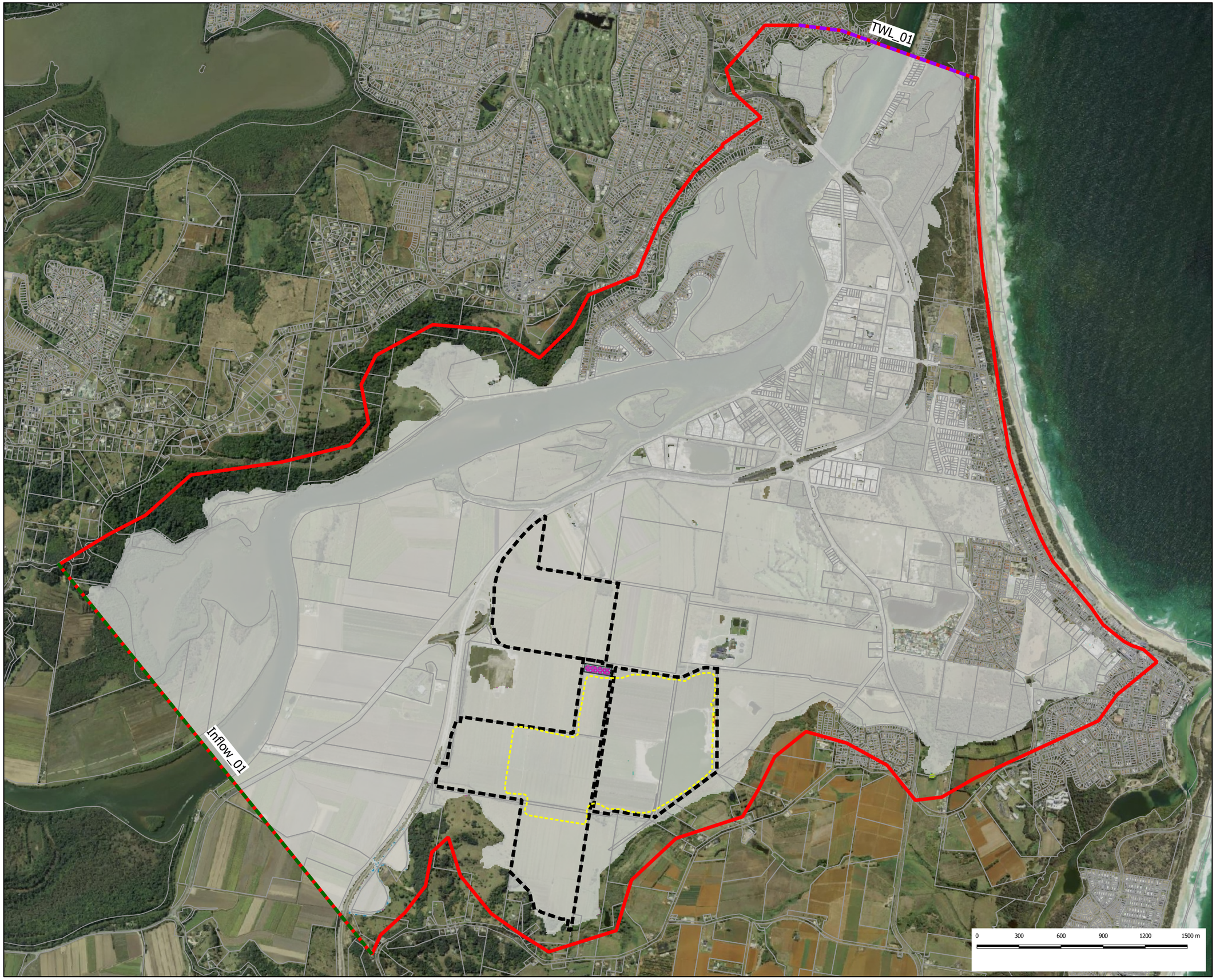
BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson

Tweed Sand Plant Flood Assessment

FIG C15 POST DEVELOPMENT
1% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL - PHASE 7)



Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant

Water Level Afflux(mm)

<500	35 - 100
-500 - -100	100 - 300
-100 - -30	>300
-30 - 30	Was Wet Now Dry
30 - 35	Was Dry Now Wet

Project: BE190043

Date: 02.02.2021

Scale: 1:25000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

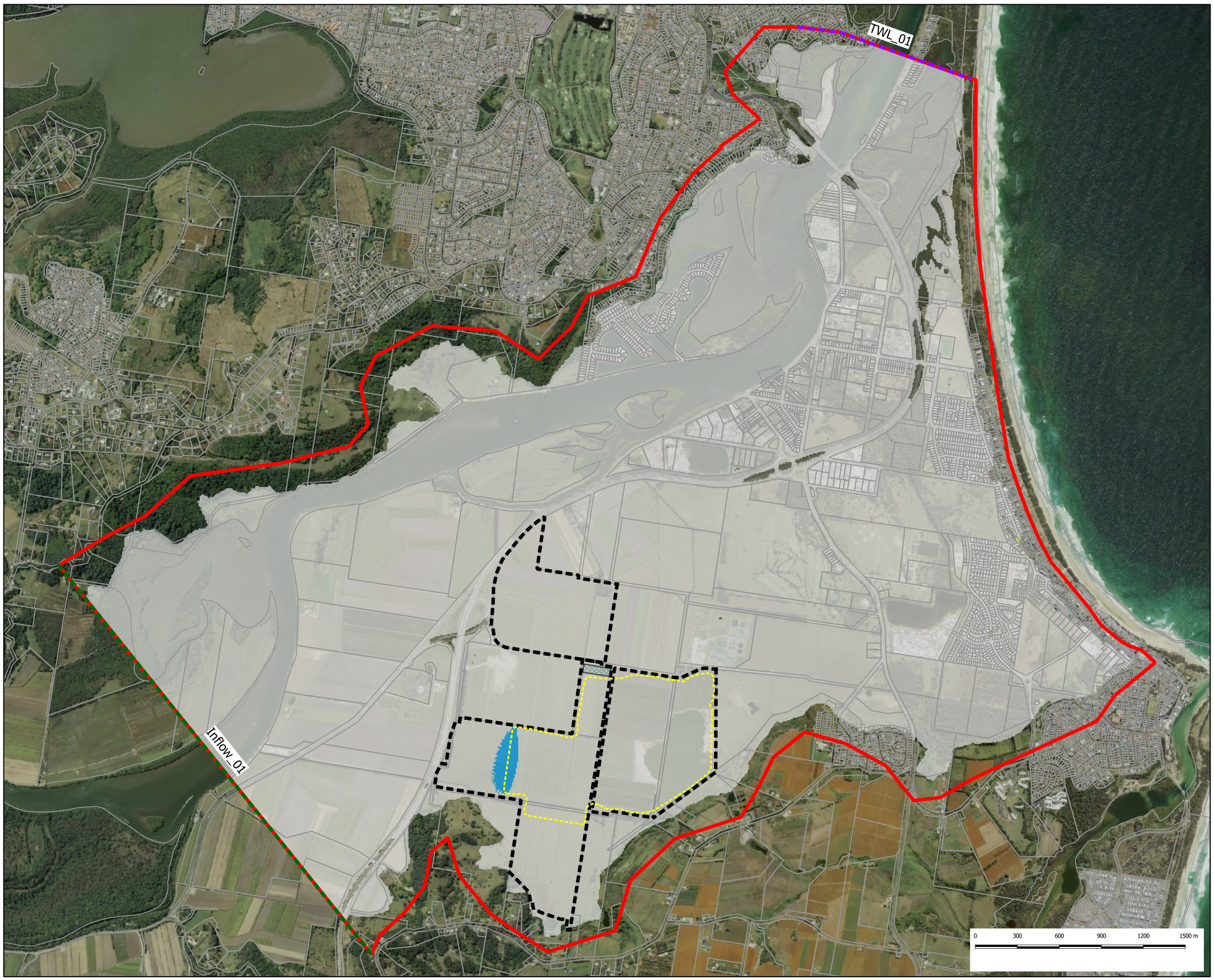
BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson

Tweed Sand Plant Flood Assessment

FIG C16 POST DEVELOPMENT 1% AEP CLIMATE CHANGE FLOOD WATER LEVEL AFFLUX (REGIONAL - PHASE 7)



Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant

Water Level Afflux(mm)

<500	35 - 100
-500 - -100	100 - 300
-100 - -30	>300
-30 - 30	Was Wet Now Dry
30 - 35	Was Dry Now Wet

Project: BE190043

Date: 02.02.2021

Scale: 1:25000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

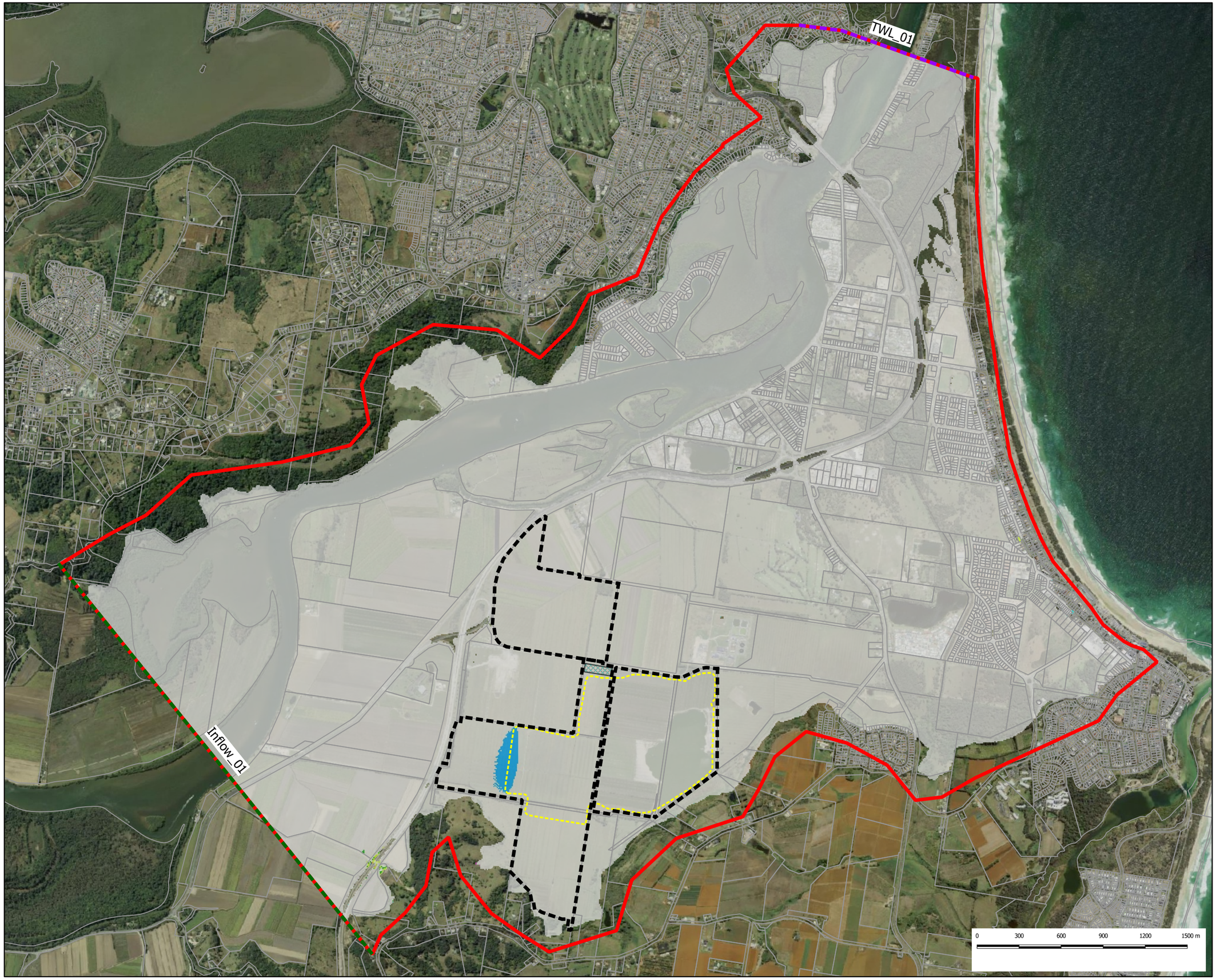
BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson

Tweed Sand Plant Flood Assessment

FIG C17 POST DEVELOPMENT
0.2% AEP
FLOOD WATER LEVEL AFFLUX
(REGIONAL - PHASE 7)



Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant

Water Level Afflux(mm)

<500	35 - 100
-500 - -100	100 - 300
-100 - -30	>300
-30 - 30	Was Wet Now Dry
30 - 35	Was Dry Now Wet

Project: BE190043

Date: 02.02.2021

Scale: 1:25000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

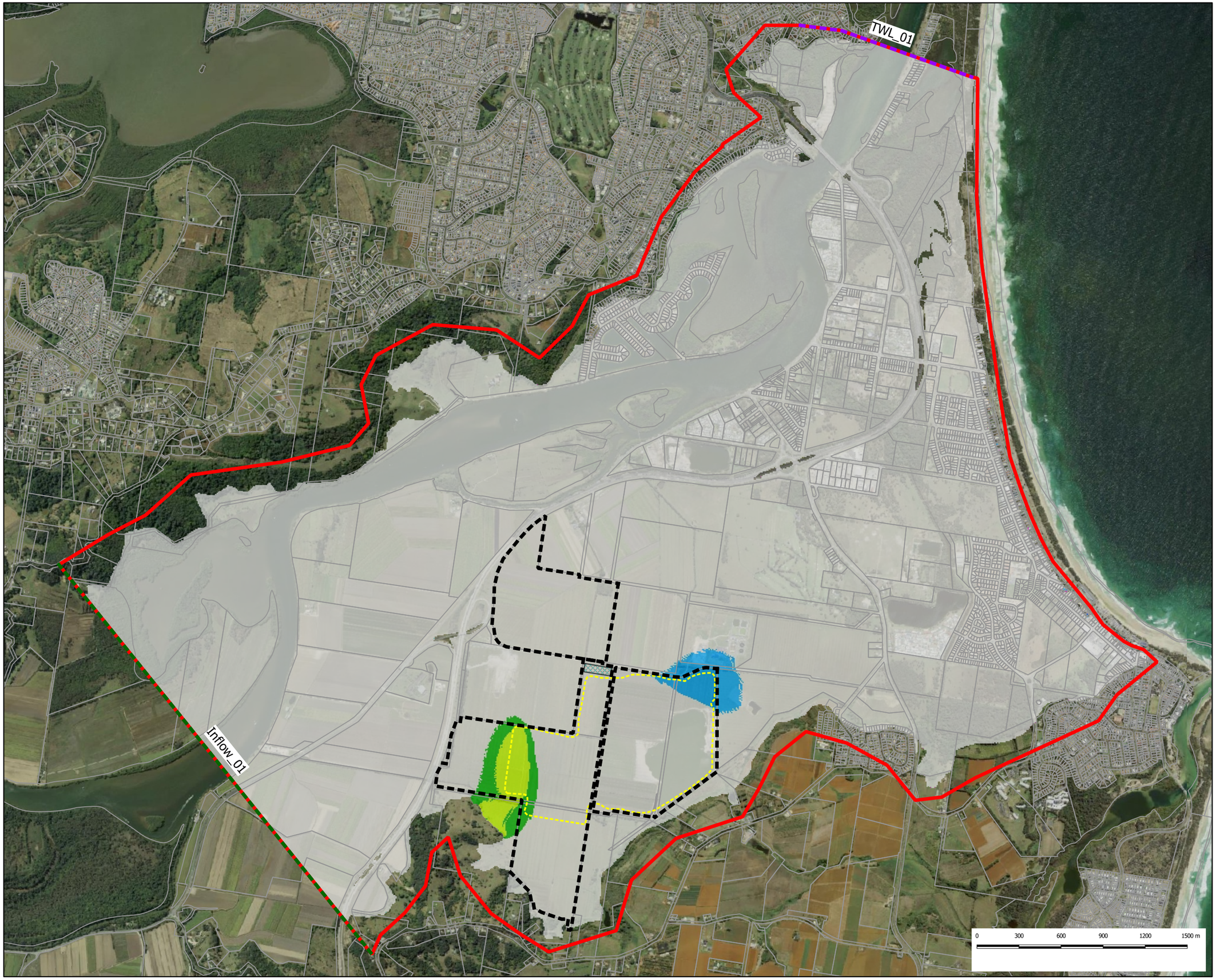
BURCHILLS ENGINEERING SOLUTIONS

FOR

Hanson

Tweed Sand Plant Flood Assessment

FIG C18 POST DEVELOPMENT
EXT EVENT
FLOOD WATER LEVEL AFFLUX
(REGIONAL - PHASE 7)



Location of the site within the Tweed Shire Council

Legend

- Model Extent
- Inflow Boundary
- Downstream Boundary
- Site
- Cadastral
- Future Building & Wash Plan
- Sand extraction and Plant

Water Level Afflux(mm)

<500	35 - 100
-500 - -100	100 - 300
-100 - -30	>300
-30 - 30	Was Wet Now Dry
30 - 35	Was Dry Now Wet

Project: BE190043

Date: 02.02.2021

Scale: 1:25000 at A3

Projection: GDA 94 / MGA ZONE 56

Data Sources:

BURCHILLS ENGINEERING SOLUTIONS

FOR

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Appendix G – Detailed Survey

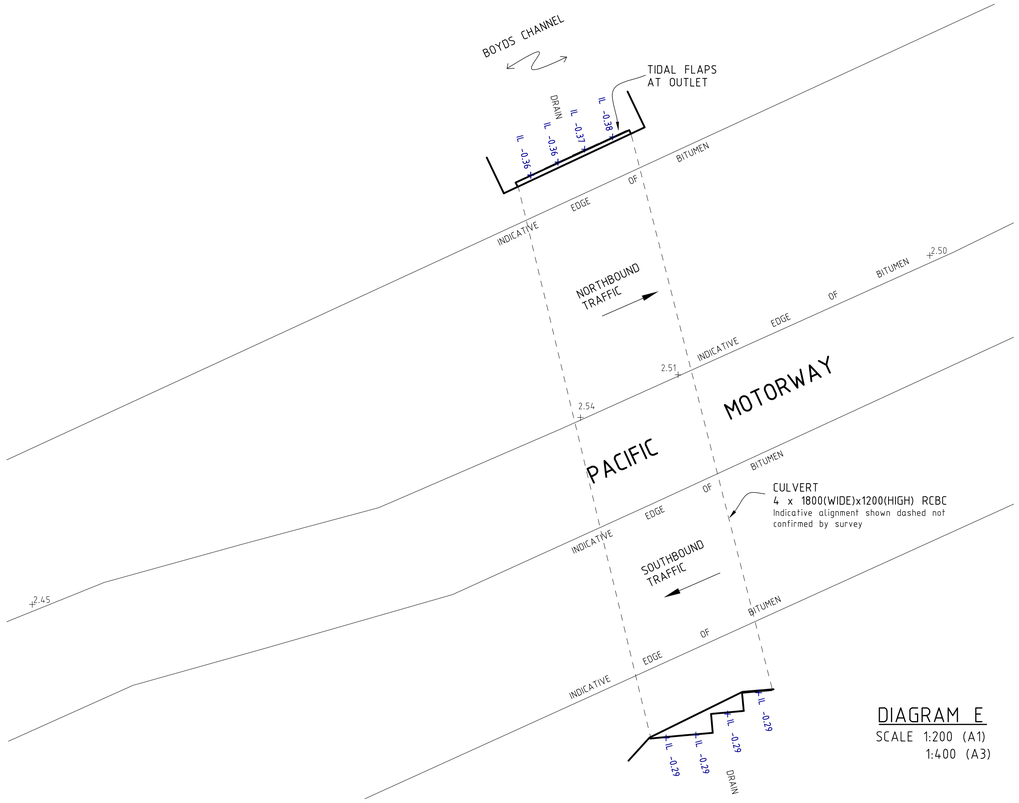


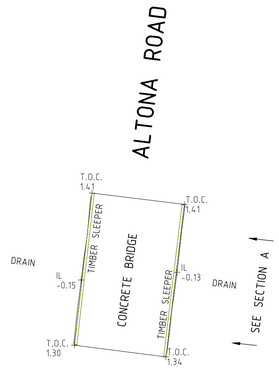
DIAGRAM E
SCALE 1:200 (A1)
1:400 (A3)

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

NOTES

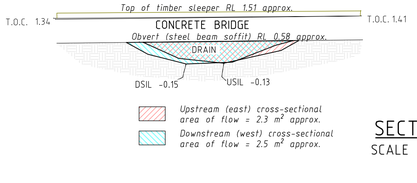
1. LEVEL DATUM IS AHD. ORIGIN OF LEVELS IS GNSS RTK OBSERVATIONS (AT PACIFIC MOTORWAY) AND PM65962 RL = 1.636 AHD AT ALL OTHER CULVERTS.

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)

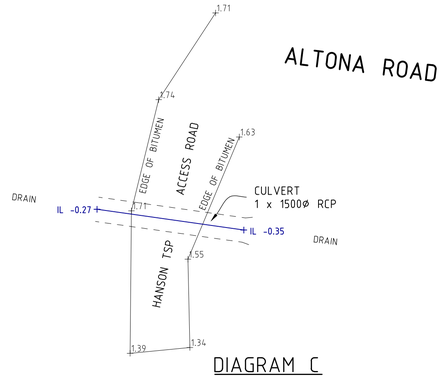


DIAGRAM C
SCALE 1:200 (A1)
1:400 (A3)

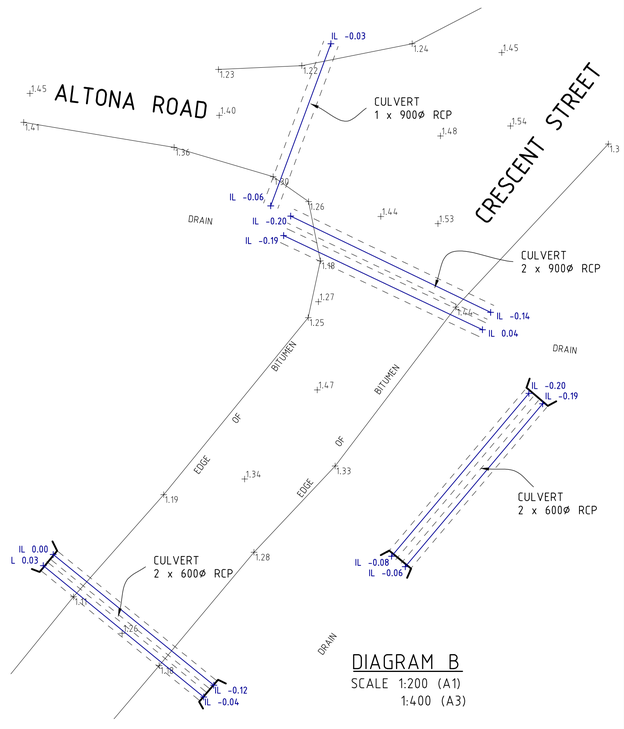


DIAGRAM B
SCALE 1:200 (A1)
1:400 (A3)

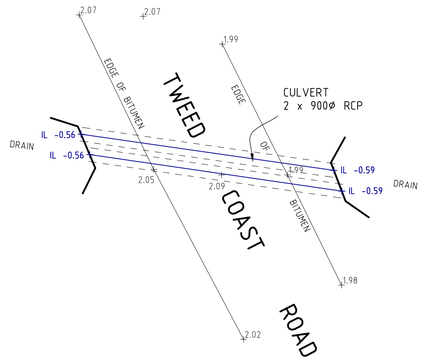


DIAGRAM A
SCALE 1:200 (A1)
1:400 (A3)

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