Tweed River Floodplain Prioritisation Study: Appendix A – L

WRL TR 2020/04, June 2023

By T A Tucker, D S Rayner, A J Harrison, G Lumiatti,
P F Rahman, D M Gilbert and W C Glamore

UNSW
Water Research
Laboratory

UNSW
SYDNEY

Appendix A Floodplain drainage

A1 Preamble

Up to date mapping of floodplain waterways within the study area was required to inform the prioritisation assessment and can also be used to inform the implementation of management options. The following section summarises the available existing data which maps present day waterways across the Tweed River floodplain (below 5 m AHD) and also presents an updated spatial waterways data layer, created using existing data, which provides a consistent and uniform dataset across the floodplain. This updated spatial layer incorporates the results of a detailed multi criteria analysis for categorising a waterways as natural waterbody watercourse, artificial waterbody, watercourse or connector watercourse. Details on the development of the updated spatial layer and the multi criteria analysis can be found in Section 12 of the Methods report (Rayner et al., 2023). The updated waterways layer was used to calculate subcatchment drainage density during the subcatchment prioritisation assessment, and will also be a valuable tool for informing management option implementation.

A2 Existing waterway data

Available information for the floodplain waterway network across the Tweed River floodplain was from multiple data sources as summarised in Table A-1.

Table A-1: Summary of available waterway data

Dataset	Data format	Provides waterway naming information?	Distinguishes between artificial and natural waterways?	Local or state wide dataset?
Geoscience Australia surface hydrology lines	Geodatabase	Yes	Yes	State wide
NSW Spatial Services hydrology lines	Shapefile	Yes	No	State wide
NSW Spatial Services hydrology lines	WMS layer	Yes	Yes	State wide
NSW DPI Fisheries manmade drains	Shapefile	No	Yes	State wide
Tweed Shire Council drainage lines	Shapefile	No	No	Local
Tweed Shire Council constructed drains	Shapefile	No	Yes	Local

A3 Waterway classification

For this study, an updated waterways spatial dataset was developed for the Tweed River floodplain to incorporate the most recent changes to the waterway network and ensure a consistent level of detail across the floodplain. The alignments and configurations of floodplain waterways are continuously changing due to varying management requirements of waterway owners across the floodplain. Inspection of the existing waterway data showed varying degrees of accuracy and detail for the different datasets in Table A-1 reflecting the different purposes for which the individual spatial layers had been created.

To ensure an up-to-date waterways dataset across all areas in the Coastal Floodplain Prioritisation Study, a multi criteria analysis was completed to categorise waterways into the following:

- Natural waterbody watercourses – a natural waterway that pre-dates European settlement. Natural waterbody watercourses are typically sinuous and follow geological features;
- Artificial waterbodies – a constructed waterway that was purpose built to enhance drainage of backswamps or redirect water. Artificial waterways are typically straight, and deep;
- Watercourses – typically a waterway that follows a natural drainage system, but has been heavily modified or disconnected from the upstream catchment; and
- Connector watercourses – a waterway with either natural or artificial sections that provides a connection between two natural waterbody watercourses. Typically connector watercourses flow through a drainage network which was once a backswamp connecting the upper catchment to the river.

Further details on the approach taken to update the waterways spatial layer and the multi criteria analysis can be found in Section 12 of the Methods report (Rayner et al., 2023). The updated spatial dataset and results of the multi criteria analysis are presented in Figure A-1. Note, update and classification of waterways was completed for elevations below 5 m Australian Height Datum (AHD) as is consistent with catchment delineation used for the subcatchment prioritisation.

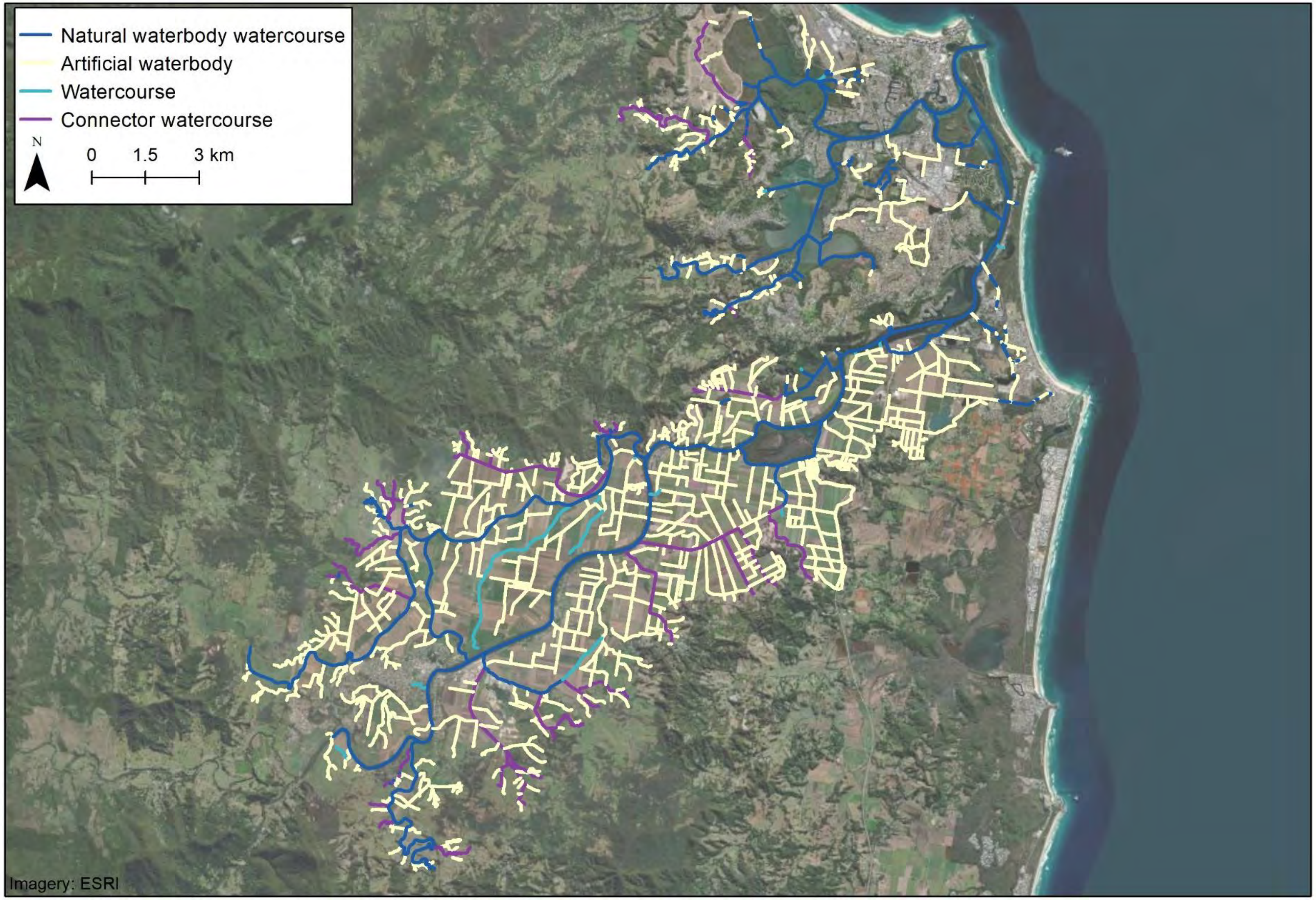


Figure A-1: Tweed River floodplain waterways

A4 Drainage density

The drainage density of each subcatchment is determined by the total waterway length across the subcatchment relative to the subcatchment area affected by acid sulfate soils (see Section 4.3.1 of the Methods report (Rayner et al., 2023)). When assessing the length of waterways that contribute to the drainage of an acid sulfate soil affected landscape, all waterways within the subcatchment boundaries were included in the priority assessment to provide a total waterway length for each subcatchment, as all waterways have the potential to impact acid sulfate soil oxidation and acid mobilisation. A summary of the floodplain drainage density analysis is provided in Table A-2 and the ranking of the drainage density factors for each subcatchment of the Tweed River floodplain is presented in Figure A-2.

Table A-2: Floodplain drainage density

Subcatchment	Total waterway length (m)	Floodplain area* (km^2)	Drainage density (m/km^2)	Drainage density rank**
Bilambil/Terranora	15,300	3.41	4,487	6
Cobaki	20,260	6.78	2,986	12
Commercial Road	10,550	2.32	4,544	4
Condong	54,510	13.90	3,897	10
Dulguigan	28,620	6.99	4,094	8
Dunbible Creek	11,800	2.17	5,450	1
East Chinderah	7,350	3.84	1,912	14
Kynnumboon	34,690	7.69	4,497	5
North Tumbulgum	31,320	6.55	4,781	3
South Murwillumbah	15,100	3.81	3,966	9
Stotts Creek	27,140	5.07	5,424	2
Tumbulgum/Eviron	54,870	12.81	4,287	7
Tygalgah	48,670	19.43	2,505	13
West Chinderah	44,770	11.69	3,829	11

* Floodplain area is calculated as the area below 5 m AHD that is high or low risk in the acid sulfate soil risk mapping.

** Ranking is from highest drainage density to lowest drainage density.

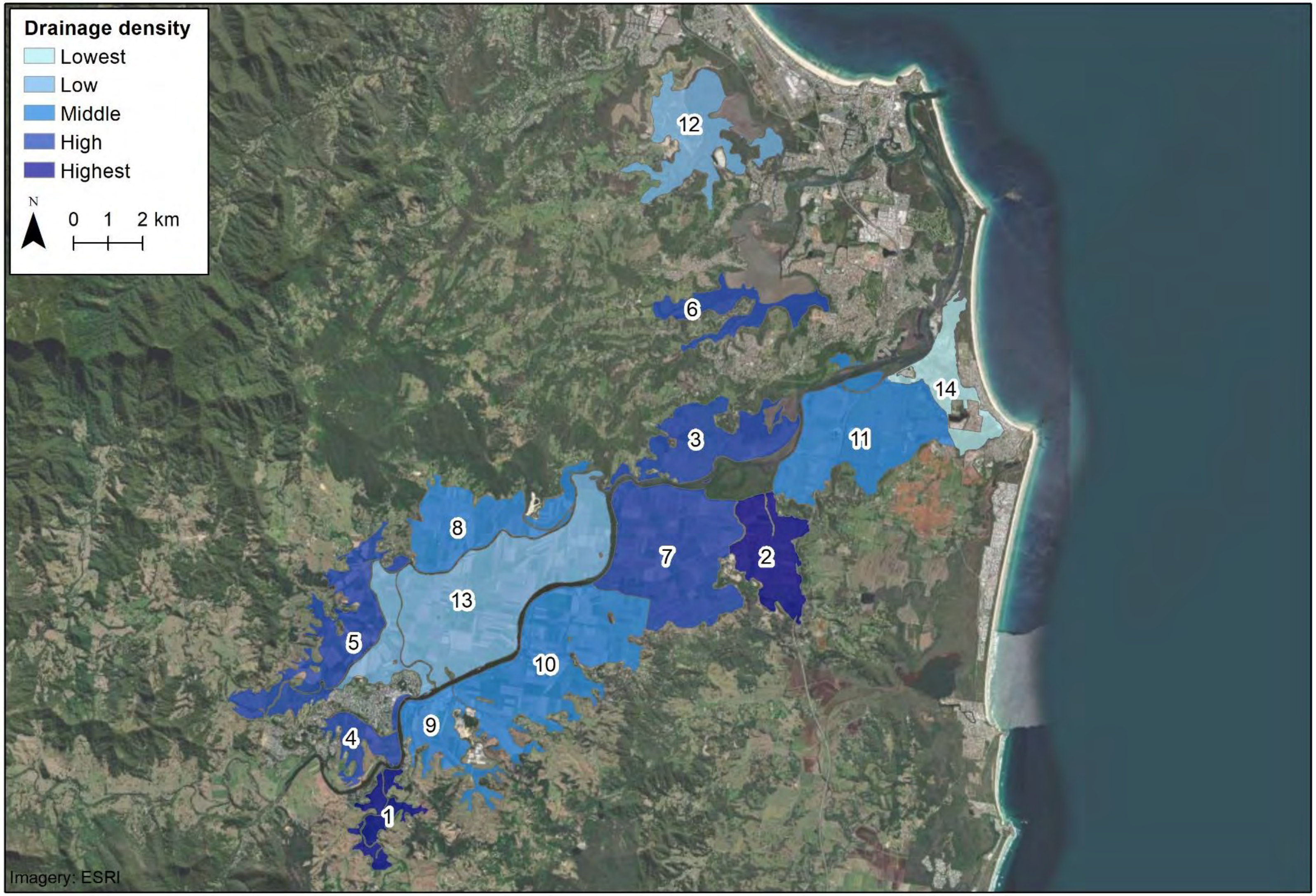


Figure A-2: Floodplain drainage density ranking

Appendix B Catchment hydrology

B1 Preamble

The following appendix details the catchment hydrology which is included in the normalised inflow factor in the acid sulfate soil prioritisation assessment, described in detail in Section 4.3.2 in the Methods report (Rayner et al., 2023). This includes the calculation of a runoff coefficient (Section B2) and a catchment size factor (Section B3), to determine an inflow factor (Section B4).

B2 Runoff coefficient

The catchment runoff assessment for the Tweed River floodplain was undertaken by comparing the volume of runoff generated by precipitation from incident rainfall with the observed subsequent streamflow data. Details of the methods used to calculate the runoff coefficient can be found in Section 4.3.2 in the Methods report (Rayner et al., 2023). The WaterNSW network of river flow gauges the available daily rainfall data from the Bureau of Meteorology (BOM) for the Tweed River floodplain is shown in Figure B-1.

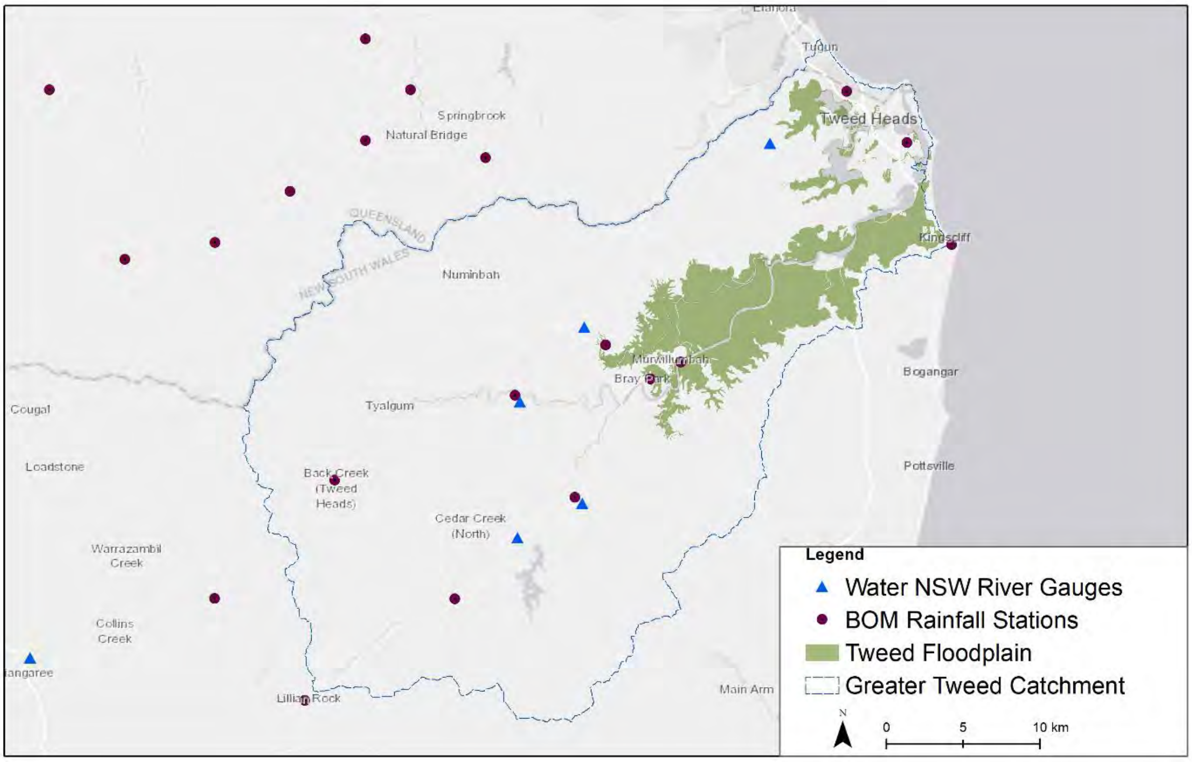


Figure B-1: Tweed River Floodplain location of rainfall and runoff stations

Stream flow gauges upstream of the tidal confluence that are most representative of the lower catchment rainfall-runoff conditions were selected for the catchment hydrology analysis. WaterNSW gauging stations 201001 and 201005 were selected for the Tweed River floodplain assessment. The upstream contributing areas for these sites were delineated using standard GIS techniques based on a digital elevation model (DEM) of the catchment. Daily rainfall data relative to each river gauging station was sourced from the BOM database and a Thiessen polygon approach was applied to weight the total rainfall to upstream areas. The location of the gauging sites, upstream catchment area of the gauging sites, and the BOM rainfall contributions used in the analysis are summarised in Figure B-2.

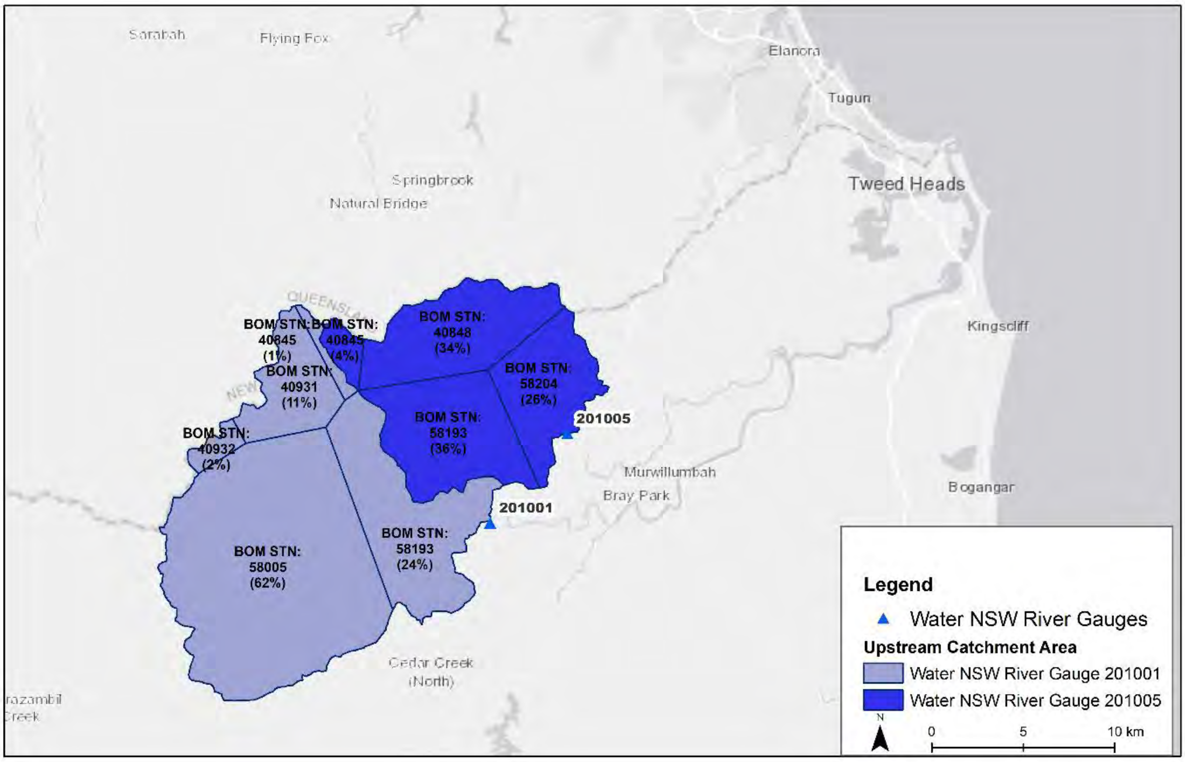
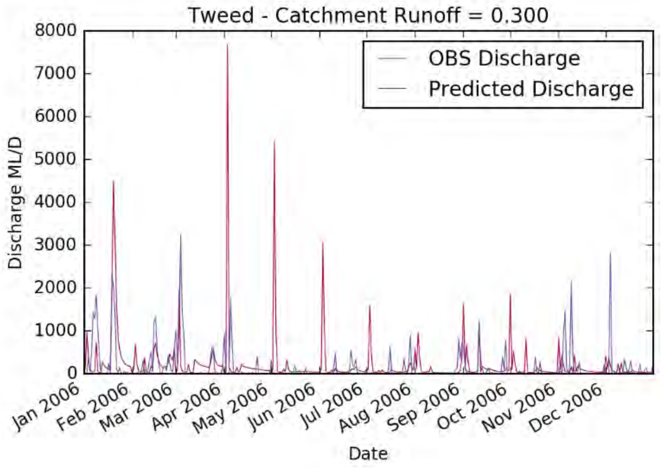


Figure B-2: Upstream catchment of selected flow sites including rainfall contribution (shown in parenthesis)

The runoff coefficient provides a relationship between rainfall-runoff volumes and allows for varying amounts of pervious and impervious surfaces across a catchment. It follows that if the predicted runoff volume from incident rainfall is known, and is compared to the available observed streamflow data, then the volume difference would be equivalent to the runoff coefficient (assuming the catchment was 100% impervious). For consistency, in this study, it was also assumed that land-use type, vegetation, and the proportion of pervious and impervious surfaces, was the same for each subcatchment in the floodplain (i.e. the runoff coefficient for this study represents an amalgamated factor taking into account catchment variables such as soil type, land use, etc. for each subcatchment).

The runoff co-efficient was selected by comparing the annual time-series of streamflow data for the predicted runoff volume calculated for the selected gauging stations. Figure B-3 shows an example time-series of predicted and observed runoff for 2006. This analysis yielded an estimated runoff coefficient of 0.3, which was applied to Tweed River floodplain subcatchments for the acid prioritisation assessment.



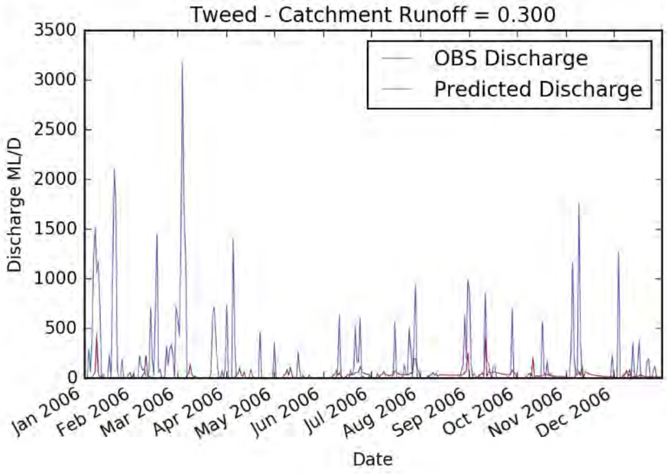


Figure B-3: Predicted and observed runoff for the catchment area upstream of river gauging station 201001 (top) and station 201005 (bottom)

B3 Catchment size factor

The size of the subcatchment influences the hydrological response of the site during a rainfall event. When comparing drainage areas of similar acidity, a large catchment will have a greater potential to discharge more acid than a small catchment. That is, an ASS affected drainage unit with high-risk ASS and a large catchment area contributing to acid drainage has a greater potential to produce higher potential acid flux during a post-flood recession period. Subsequently, accurate estimates of subcatchment areas and the potential discharge from those areas is critical to assessing subcatchments that are of a high-risk for acid drainage.

For the purpose of this study, the floodplain subcatchments have been defined as areas that are below 5 m AHD and classified as at risk for ASS. The whole floodplain area is considered to contribute to acid drainage risk. Upland catchments (above 5 m AHD) were divided into areas that discharge to the estuary via an end-of-system floodgate structure or discharge uninhibited to the estuary. In this study, only upland catchments that are upstream of floodgates have been considered to contribute to acid drainage potential. These areas were identified using information on floodgate infrastructure and the NSW hydrography layer. Contributing catchments were then delineated using standard GIS techniques as shown in Figure B-4.

The total areas of each subcatchment were then normalised against the subcatchment with the largest total area (i.e. catchment size factor = 1.0) for comparison.

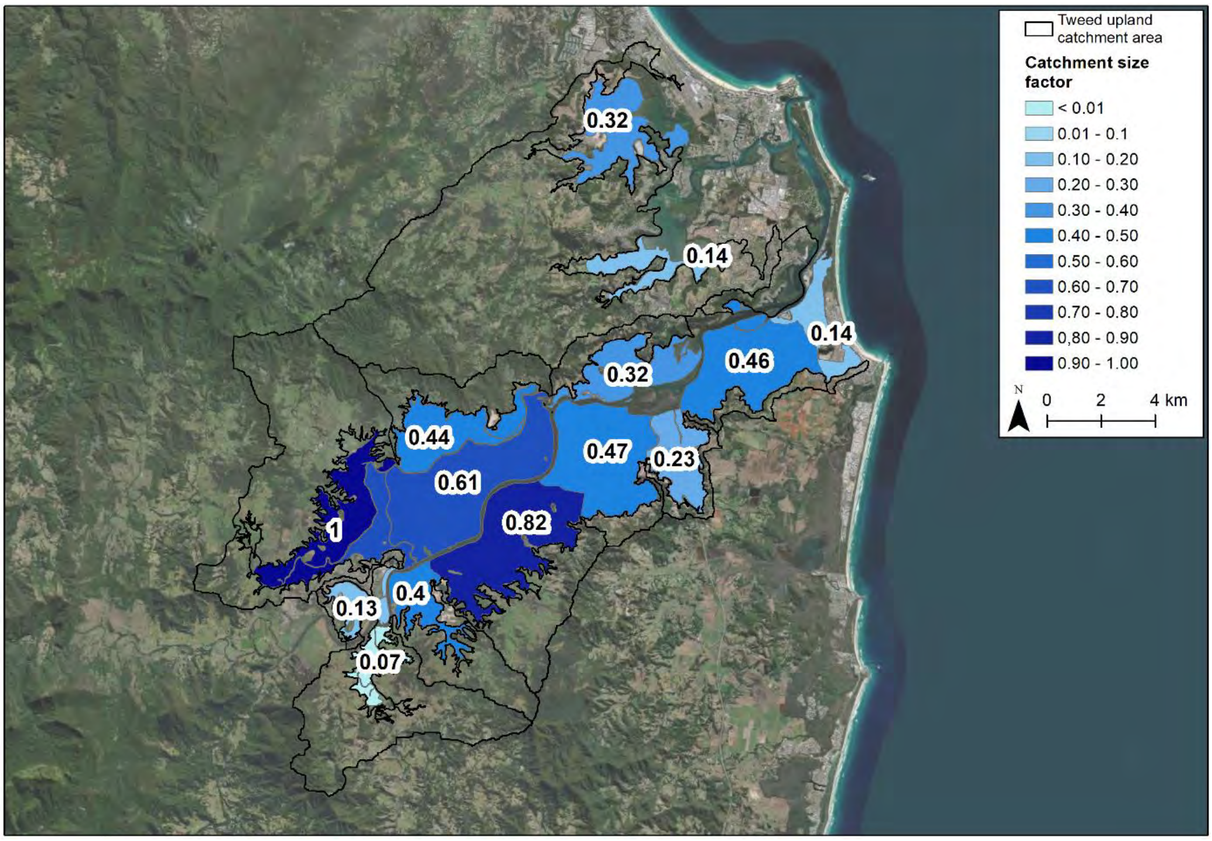


Figure B-4: Catchment size factor for each subcatchment in the Tweed River estuary

B4 Normalised inflow factor

The combination of a runoff coefficient and a normalised catchment size factor is used to provide an estimation of the relative water yield of each floodplain subcatchment. The inflow factor is calculated as per Equation B-1.

$$\boldsymbol{Normalised\ inflow\ factor = Runoff\ coefficient\ \times Catchment\ Size\ Factor} \qquad \textbf{Equation B-1}$$

The inflow factors for each Tweed River floodplain subcatchment are detailed in Table B-1 and shown in Figure B-5.

Table B-1: Catchment hydrology analysis summary table

Subcatchment	Runoff coefficient	Upland catchment area (m^2)	Total catchment area (m^2)	Catchment size factor	Inflow factor
Condong	0.3	13,269,800	27,168,800	0.815	0.245
Dunbible Creek	0.3	273,300	2,438,800	0.073	0.022
South Murwillumbah	0.3	9,660,900	13,468,500	0.404	0.121
Kynnumboon	0.3	25,637,750	33,332,000	1.000	0.300
East Chinderah	0.3	940,900	4,783,600	0.144	0.043
Dulguigan	0.3	7,620,150	14,610,650	0.438	0.132
Commercial Road	0.3	1,922,200	4,244,400	0.127	0.038
Tumbulgum/Eviron	0.3	2,895,600	15,701,300	0.471	0.141
Stotts Creek	0.3	2,607,200	7,673,550	0.230	0.069
West Chinderah	0.3	3,479,100	15,171,750	0.455	0.137
Cobaki	0.3	3,757,400	10,541,200	0.316	0.095
Bilambil/Terranora	0.3	1,307,800	4,716,900	0.142	0.042
Tygalgah	0.3	895,200	20,324,550	0.610	0.183
North Tumbulgum	0.3	4,025,200	10,576,550	0.317	0.095

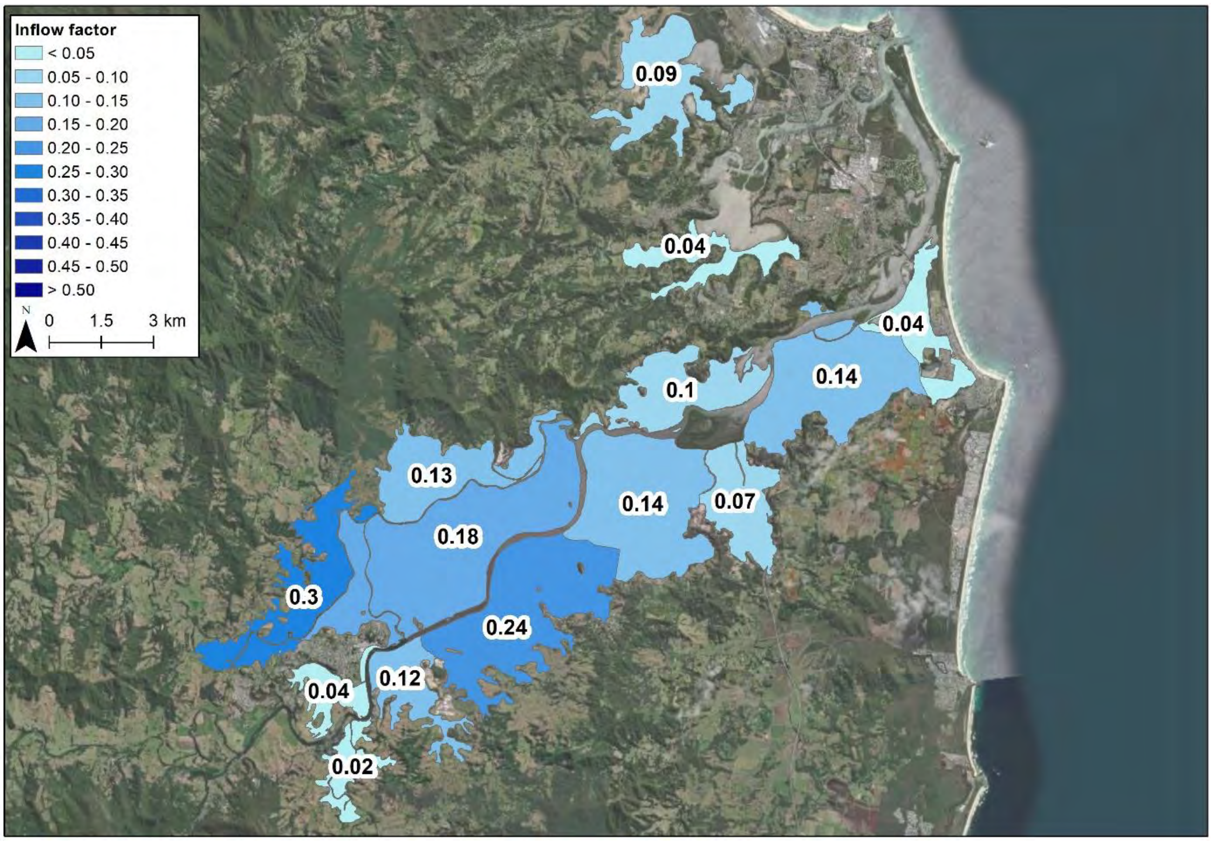


Figure B-5: Subcatchment inflow factors

Appendix C Groundwater hydraulic conductivity

C1 Preamble

The following section outlines the saturated hydraulic conductivity data (hereafter referred to as hydraulic conductivity) used in the prioritisation method (Section 4) for determining the groundwater factor for the Tweed River floodplain. A detailed discussion of the principles relating to hydraulic conductivity and data collection can be found in Appendix B of the Methods report (Rayner et al., 2023). Details on the techniques and methods used to collect the field data presented in this section can be found in Appendix A of the Methods report (Rayner et al., 2023).

C2 Existing saturated hydraulic conductivity data

A data gaps analysis was completed to identify existing hydraulic conductivity data within the Tweed River floodplain. The data identified was limited to certain areas of the floodplain as listed in Table C-1 and spatially presented in Figure C-1. Data was available from the following sources:

- White et al. (1993) measured hydraulic conductivity within the jarosite layer (-0.2m to 0.4m AHD) from a range of sites at Stotts Creek. Hydraulic conductivity data was collected using the auger hole method. The hydraulic conductivity value showed in Table C-1 is the average hydraulic conductivity value across all sites.

- Hirst et al. (2009) collected hydraulic conductivity data for ASS across six different NSW North Coast floodplains (Tweed, Richmond, Clarence, Hastings, Macleay, and Manning), using the pit bailing method. On the Tweed River floodplain, data was collected at South Murwillumbah, Stotts Creek and West Chinderah. The hydraulic conductivity values were calculated using the Bouwer and Rice (1983) and Boast and Langebartel (1984) techniques.

- Johnston et al. (2009) presented hydraulic conductivity data collected using the pit bailing method for the South Murwillumbah, Stotts Creek and West Chinderah subcatchments. Close inspection indicated that this data is the same that was presented by Hirst et al. (2009) so it has not been included in the analysis.

Table C-1: Summary of existing hydraulic conductivity data in the Tweed River floodplain

Point ID	Saturated hydraulic conductivity (m/day)			Risk classification	Reference	Method
	Bouwer and Rice (1983) method	Boast and Langebartel (1984) method	Other method			
1	3.3	4.6		Moderate	Hirst et al. (2009)	Pit bailing
2	5.0	7.1		Moderate	Hirst et al. (2009)	Pit bailing
3	1.7	2.0		Moderate	Hirst et al. (2009)	Pit bailing
4	1.0	1.9		Low - Moderate	Hirst et al. (2009)	Pit bailing
5	1.3	1.8		Moderate	Hirst et al. (2009)	Pit bailing
6	3.3	6.1		Moderate	Hirst et al. (2009)	Pit bailing
7	3.2	5.3		Moderate	Hirst et al. (2009)	Pit bailing
8	1.6	3.4		Moderate	Hirst et al. (2009)	Pit bailing
9	3.9	8.1		Moderate	Hirst et al. (2009)	Pit bailing
10	6.6	10.8		Moderate - High	Hirst et al. (2009)	Pit bailing
11	3.5	4.1		Moderate	Hirst et al. (2009)	Pit bailing
12	3.1	3.7		Moderate	Hirst et al. (2009)	Pit bailing
13			0.79	Low	White et al. (1993)	Auger hole
14	1.2	1.1		Low	Hirst et al. (2009)	Pit bailing
15	1.0	1.0		Low	Hirst et al. (2009)	Pit bailing
16	0.5	0.5		Low	Hirst et al. (2009)	Pit bailing
17	0.8	0.9		Low	Hirst et al. (2009)	Pit bailing
18	0.4	0.6		Low	Hirst et al. (2009)	Pit bailing

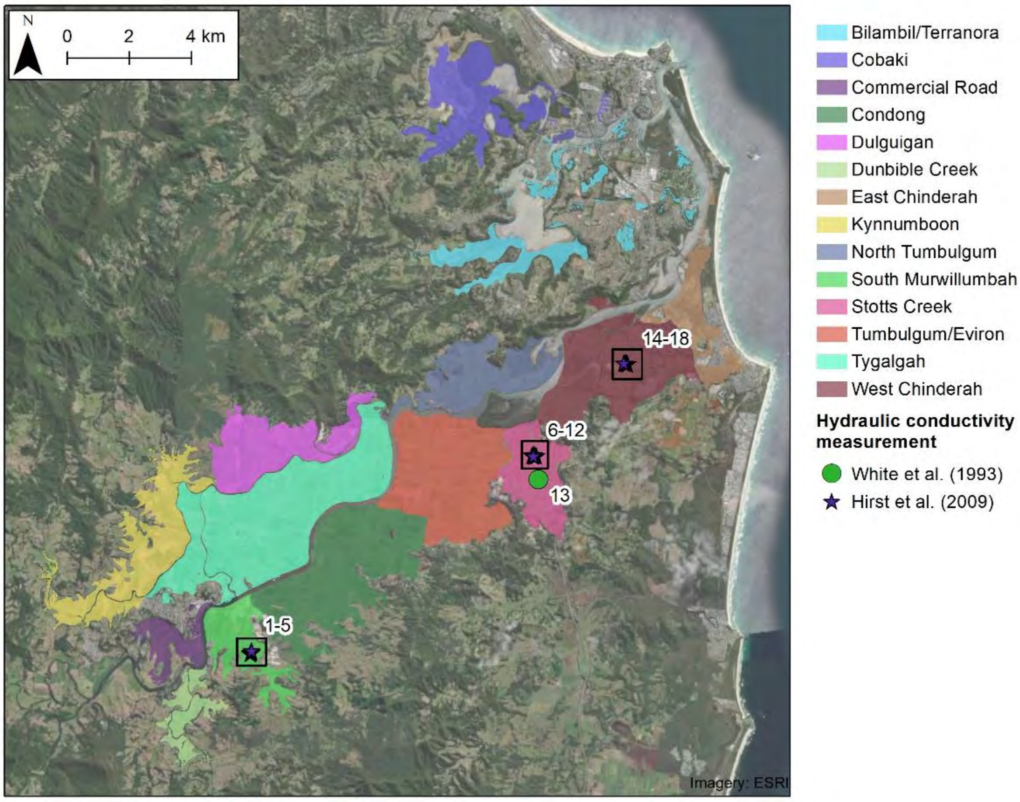


Figure C-1: Existing saturated hydraulic conductivity data available on the Tweed River floodplain

C3 Data collection

Following the data gaps analysis, a data collection program was completed to further supplement existing data. The auger hole slug test method was used to determine the hydraulic conductivity across the coastal floodplains. This method was chosen:

- Due to drought conditions occurring at the time of field investigations, and the water table depth was too low to determine hydraulic conductivity using the standard pit bailing method at many sites;
- As it was easily implemented using the existing soil sampling equipment and did not require additional large machinery to be transported on-site; and
- As it allowed for hydraulic conductivity measurements to be taken at most soil sample locations.

A detailed description of the sampling procedure and data analysis techniques used to calculate the hydraulic conductivity can be found in Appendix B of the Methods report (Rayner et al., 2023). The hydraulic conductivity measurements obtained across the Tweed River floodplain are summarised in Table C-2 and the measurement location shown in Figure C-2.

During the data collection field campaign, it was observed that the water table within the sample hole used to measure hydraulic conductivity was below the mean low water spring (MLWS) tide level of nearby waterways. This was due to the ongoing drought conditions that were prevalent at the time of data collection (August 2019 – March 2020). The result of this was that the hydraulic conductivity measured using the slug test method is of a soil layer that is unlikely to contribute to export of acid via horizontal water movement. For this reason, it was decided that only hydraulic conductivity measurements where the water table was above the MLWS tide level would be used. This meant that only a selection of measurements in Table C-2 are representative of groundwater flow potential within acidic soil layers and are therefore applicable in the prioritisation methodology. Hydraulic conductivity data that has been used for the Tweed River floodplain to supplement existing data for the calculation of the groundwater factor and subsequently the risk ratings of the subcatchments within the floodplain, are identified in Table C-2 and shown in Figure C-2.

Table C-2: Summary of saturated hydraulic conductivity data collected by WRL and used for the subcatchment prioritisation

Location ID	Easting (m) GDA94	Northing (m) GDA94	Hydraulic Conductivity (m/day)	Risk Classification	Measurement method	Data used for prioritisation?*
TP_26_S	541255.7	6871950.9	0.4	Low	Auger hole	Yes
TP_33_S	538982.5	6863861.9	211.3	Extremely high	Auger hole	Yes
TW_01_A	547286.9	6877932.9	0.3	Low	Auger hole	Yes
TW_03_A	545523.1	6872959.1	0.4	Low	Auger hole	Below MLWS
TW_04_P	545155.8	6872789.3	0.3	Low	Auger hole	Below MLWS
TW_05_P	544820.0	6871473.4	0.3	Low	Auger hole	Below MLWS
TW_07_A	537526.5	6868235.8	0.1	Low	Auger hole	Yes
TW_10_A	538147.6	6865632.6	0.1	Low	Auger hole	Yes
TW_12_A	540027.8	6865836.7	0.3	Low	Auger hole	Below MLWS
TW_13_A	542040.1	6865445.9	0.2	Low	Auger hole	Below MLWS
TW_13_P	543855.7	6869001.7	2.8	Moderate	Auger hole	Below MLWS
TW_27_A	540215.8	6869551.5	3.3	Moderate	Auger hole	Below MLWS
TW_27_P	539680.5	6869308.9	0.5	Low	Auger hole	Below MLWS
TW_31_P	536772.9	6867337.5	0.3	Low	Auger hole	Yes
TW_32_A	538725.0	6865243.3	0.7	Low	Auger hole	Below MLWS
TW_35_P	541453.3	6865542.3	0.3	Low	Auger hole	Below MLWS
TW_37_P	544020.7	6867003.8	5.0	Moderate	Auger hole	Below MLWS
TW_38_A	545358.8	6869126.9	0.4	Low	Auger hole	Below MLWS
TW_42_A	547652.2	6871886.3	0.7	Low	Auger hole	Below MLWS
TW_43_P	548377.3	6871744.6	2.1	Moderate	Auger hole	Below MLWS
TW_45_P	543189.1	6867459.4	2.9	Moderate	Auger hole	Yes
TW_46_P	545905.6	6871366.8	2.7	Moderate	Auger hole	Yes

*Note: Only hydraulic conductivity values where the water table was above the MLWS level were used for subcatchment prioritisation.

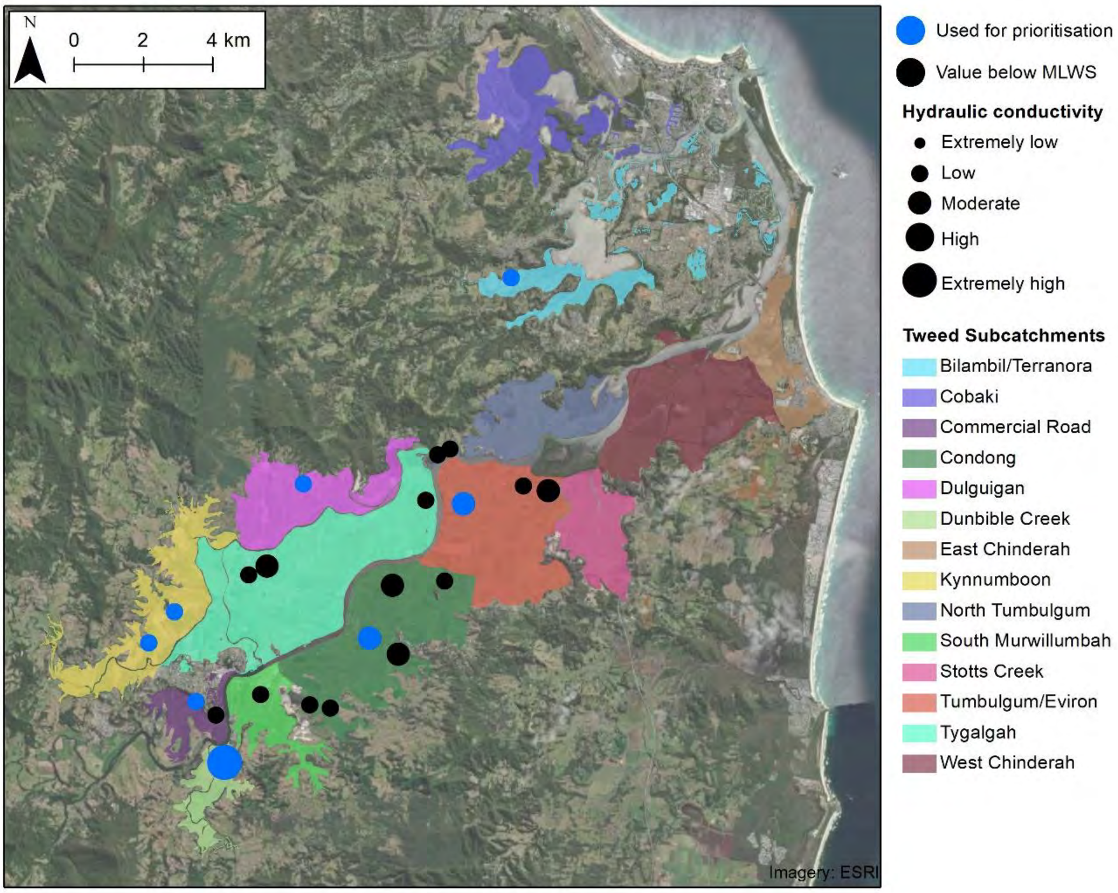


Figure C-2: Location of saturated hydraulic conductivity data collected by WRL and data used during the subcatchment prioritisation

C4 Summary of saturated hydraulic conductivity risk ratings

Hydraulic conductivity measurements have been used to determine a risk rating which forms part of the groundwater factor during the subcatchment prioritisation (see Appendix B of the Methods report (Rayner et al., 2023)). The risk rating applies on a scale of one (1) to five (5) corresponding to the risk classifications with extremely low equating to a risk rating of one and extremely high equating to a risk rating or five. This results in subcatchments with larger hydraulic conductivities having an increased risk as they are able to transport larger volumes of acidic groundwater to the estuary.

Note that the spatial coverage of hydraulic conductivity data across certain subcatchments of the Tweed River floodplain is poor. This is due to limitations experienced in the field investigations including situations whereby the groundwater table was sufficiently deep that no hydraulic conductivity measurements within contributing acidic soil layers could be taken. For subcatchments where there was no available data, it has been interpolated from adjacent subcatchments:

- Tygalgah has been assumed to have the same hydraulic conductivity as Dulguigan;
- North Tumbulgum has been assumed to have the same hydraulic conductivity as West Chinderah;
- East Chinderah has been assumed to have the same hydraulic conductivity as West Chinderah; and

- Cobaki has been assumed to have the same hydraulic conductivity as Bilambil/Terranora.

Since hydraulic conductivity measurements across ASS affected floodplains can be highly variable, further hydraulic conductivity investigations may be required to add further detail to the management options. An overall summary of the risk associated with hydraulic conductivity for each subcatchment is provided in Table C-3 and Figure C-3.

Table C-3: Summary of saturated hydraulic conductivity for each subcatchment in the Tweed River floodplain

Subcatchment	Hydraulic conductivity classification	Hydraulic conductivity risk rating	Number of data points per area*
Bilambil/Terranora	Low	2	1
Cobaki*	Low	2	0
Commercial Road	Low	2	1
Condong	Moderate	3	1
Dulguigan	Low	2	1
Dunbible Creek	Extremely high	5	1
East Chinderah*	Low	2	0
Kynnumboon	Low	2	2
North Tumbulgum*	Low	2	0
South Murwillumbah	Moderate	3	5
Stotts Creek	Moderate	3	8
Tumbulgum/Eviron	Moderate	3	1
Tygalgah*	Low	2	0
West Chinderah	Low	2	5

* Where no data was available risk classifications were interpolated from adjacent subcatchments.

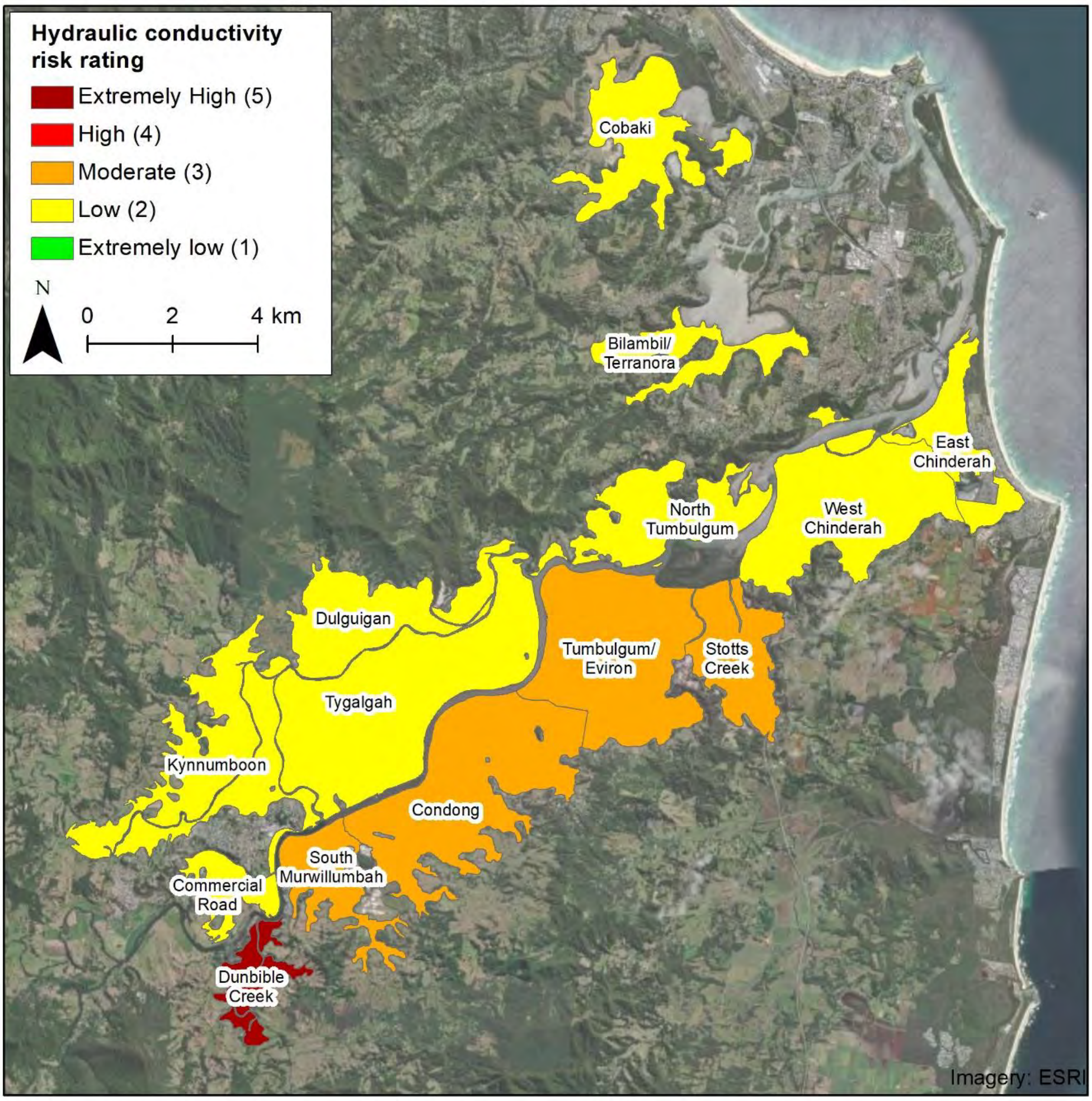


Figure C-3: Risk ratings for saturated hydraulic conductivity for each subcatchment in the Tweed River floodplain

Appendix D Acid sulfate soil distribution

D1 Preamble

This section provides an overview of the soil profile data, such as surface elevation, profile depths and minimum pH available within the Tweed River floodplain. This includes existing data available on the NSW Government eSPADE database and data in published literature where applicable (Section D2). In areas with limited existing soil profile information, a targeted field campaign was undertaken to address data gaps. Information on the data collected (including soil profiles) is summarised in Section D3.

D2 Existing soil profile data

Soil profile data on the Tweed River floodplain that was available prior to the commencement of this study was sourced from:

- eSPADE Database (DPIE, 2020);
- Smith et al. (2003);
- Kinsela (2007);
- Macdonald et al. (2004);
- Gilbert and Sutherland (2009); and
- JGA (2005).

D2.1 eSPADE database

eSPADE provides a database of information collected by earth scientists and other technical experts. eSPADE contains descriptions of soils, landscapes and other geographic features, and is used by the NSW Government, other organisations, and individuals, to improve planning and decision-making for land management. eSPADE contains extensive soil profile data for the Tweed area.

eSPADE data has been filtered to remove any profiles that do not contain acidity (pH) data for each of the layers. Elevation data has been extracted from a 1 m DEM of the Tweed River floodplain. Where data is available on the floodplain, it has been included in estimating acid export in the region. Note that a low pH often indicates oxidised acidic soils, particularly in conjunction with the presence of yellow/orange mottling (jarosite). A near neutral pH (pH 7 to 8) below an acidic layer indicates a potential acidic layer, often in conjunction with a soil description of dark grey estuarine muds and clays. The presence of potential acid sulfate soils can be confirmed via a field oxidation test, with high stored acidity confirmed by a violent oxidation reaction, although this is not typically provided in the eSPADE database. The location of all relevant eSPADE soil profiles within the study area is presented in Figure D-1, and a summary of the soil profile data, including approximate surface elevation and minimum profile pH (within the tidal range), is provided in Table D-1.

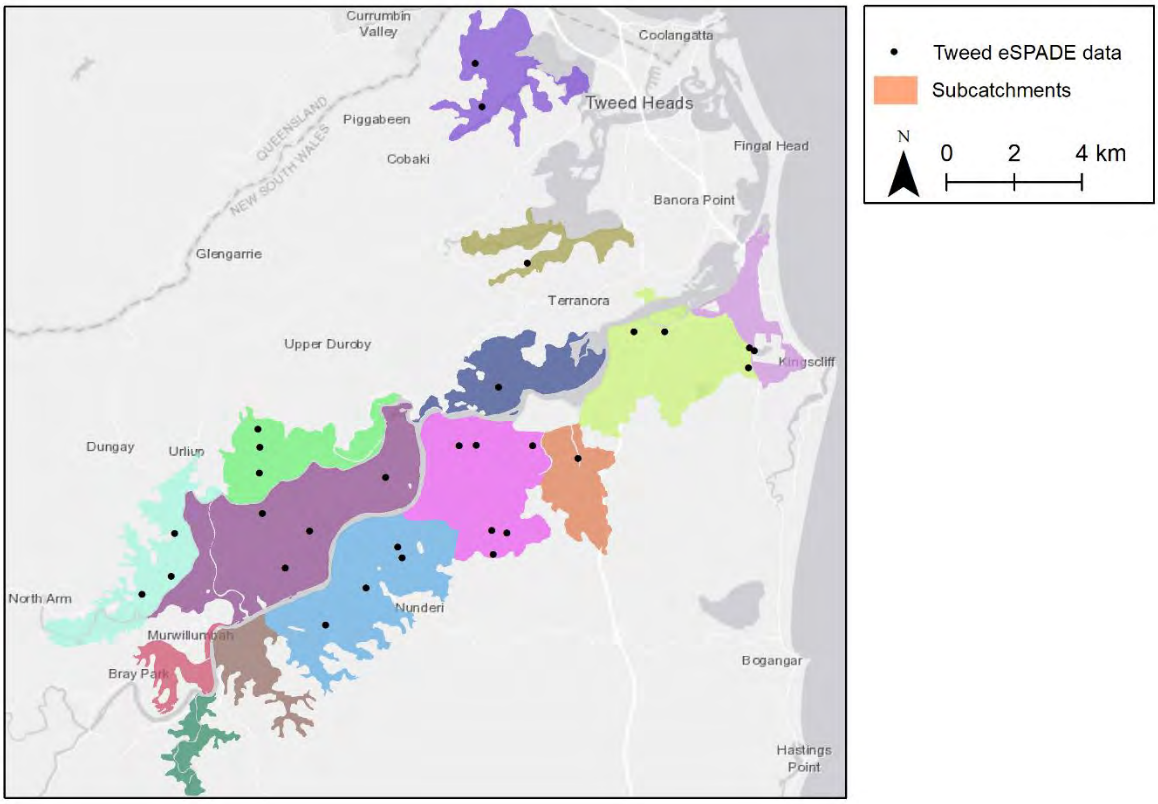


Figure D-1: Location of applicable eSPADE soil profiles in the study region

Table D-1: Summary of relevant eSPADE profiles (DPIE, 2020)

*Surface elevation extract from 1 m LiDAR.

** Minimum pH in this table is within the range of MLWS to 1 m AHD. Lower pH may have been observed elsewhere in the profile.

eSPADE Profile ID	Subcatchment	Easting	Northing	Surface Elevation (m AHD)*	Total Profile Depth (m)	Minimum pH**
9441	Bilambil/Terranora	548305	6877136	1.3	1.5	5.5
19891	Cobaki	546972	6881739	0.9	1.5	4
19892	Cobaki	546772	6883020	0.2	1.6	5
19872	Condong	544488	6868757	0.8	3.1	3.5
19874	Condong	543546	6867541	1.2	2.9	3.5
19875	Condong	542352	6866459	1.4	3.1	3.5
9513	Condong	544605	6868437	0.5	1.1	4.5
19881	Dulguigan	540422	6871706	0.6	3.1	4
9506	Dulguigan	540405	6870937	1.2	1	5
9510	Dulguigan	540355	6872237	0.7	1	4
96222	East Chinderah	555000	6874550	0.1	1.5	4.5
19880	Kynnumboon	537906	6869160	0.8	2.5	4
19896	Kynnumboon	536945	6867356	2.4	1.9	6
9505	Kynnumboon	537798	6867889	1.6	1.2	4.5
19890	North Tumbulgum	547457	6873471	0.8	2.35	5
90501	Stotts Creek	549791	6871371	0.3	1.2	5.5
19873	Tumbulgum/Eviron	547694	6869174	0.3	2.5	4
19876	Tumbulgum/Eviron	546295	6871744	2.2	2.6	7
19877	Tumbulgum/Eviron	546794	6871764	0.7	3.2	4.5
19878	Tumbulgum/Eviron	548461	6871743	0.8	3.1	3.5
9514	Tumbulgum/Eviron	547305	6868537	0.8	0.9	6
9515	Tumbulgum/Eviron	547254	6869237	0.5	1.1	4.5
19879	Tygalgah	541161	6868132	1.1	2.8	4
19882	Tygalgah	540481	6869745	1.2	2.7	5
19883	Tygalgah	544121	6870808	1.4	3	5.5
19884	Tygalgah	541880	6869226	0.8	2.6	4
19886	West Chinderah	551457	6875109	0.9	1.8	4
19887	West Chinderah	554824	6874041	1.2	1.85	4
96226	West Chinderah	552350	6875100	1.4	1.2	4.5
9403	West Chinderah	554855	6874636	1.8	1.2	8

D2.2 Other literature

Published and grey literature were investigated for other soil profiles within the Tweed River floodplain, which included data from journal papers (Smith et al. (2003), Kinsela (2007) and Macdonald et al. (2004)) and environmental assessments made to support developments (Gilbert and Sutherland (2009) and JGA (2005)). Locations of the profiles are shown in Figure D-2. Only literature that provided information on pH at depth and suitable location information was included. Where no surface elevation data was provided, it was extracted from a 1 m DEM of the Tweed floodplain. The location of all relevant soil profiles from the literature within the study area is presented in Figure D-2 and a summary of the soil profile data, including approximate surface elevation and minimum profile pH (within the tidal range), is provided in Table D-2.

In the case of Smith et al. (2003) and Macdonald et al. (2004), the literature provided a representative profile across the numerous locations sampled in each study. In these cases, a representative elevation was assigned.

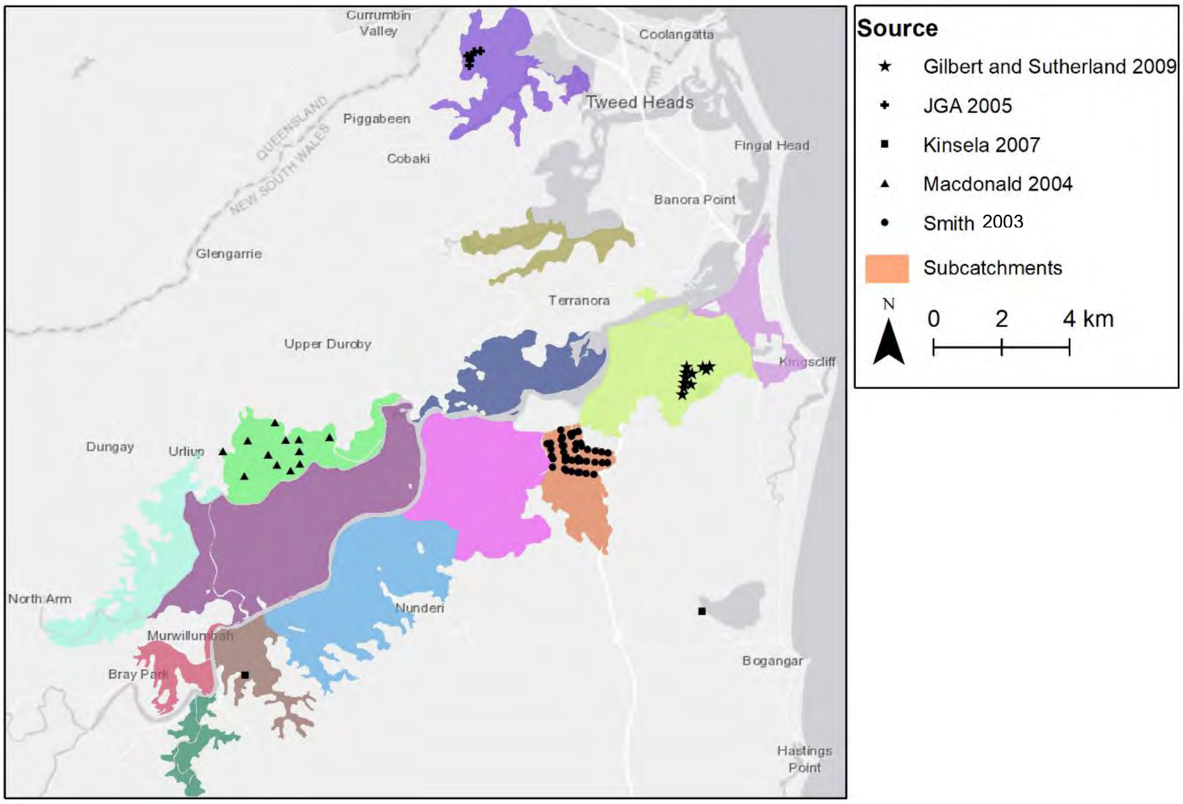


Figure D-2: Location of applicable soil profiles from literature in the study region

Table D-2: Summary of relevant soil profiles from literature

Profile	Subcatchment	Easting	Northing	Surface Elevation (m AHD)	Total Profile Depth (m)	Minimum pH
JBA_2009_TP1	Cobaki	546906	6883362	3.0	5.5	7.7
JBA_2009_TP2	Cobaki	546728	6883343	1.7	5.5	4.9
JBA_2009_TP3	Cobaki	546660	6883255	1.5	5.5	5.0
JBA_2009_TP4	Cobaki	546530	6883218	3.5	5.5	4.6
JBA_2009_TP5	Cobaki	546593	6883082	2.7	5.5	5.3
JBA_2009_TP6	Cobaki	546579	6882933	0.9	4.5	4.6
Macdonald_2004 Representative Profile	Dulguigan	NA	NA	1.0	2	3.0
Kinsela_2007	South Murwillumbah	539982	6864979	0.8	2.8	2.9
Smith_2003 Representative Profile	Stotts Creek	NA	NA	0.3	1.2	3.5
Gilbert_et_al_2005_BH1	West Chinderah	553665	6874095	1.1	17.5	5.2
Gilbert_et_al_2005_BH2	West Chinderah	552979	6874078	-0.1	15.5	5.5
Gilbert_et_al_2005_BH3	West Chinderah	553450	6874080	0.5	16	4.4
Gilbert_et_al_2005_BH4	West Chinderah	552952	6873913	0.6	15	6.3
Gilbert_et_al_2005_BH5	West Chinderah	552940	6873773	0.5	15	5.1
Gilbert_et_al_2005_BH6	West Chinderah	552907	6873608	0.7	15	4.9
Gilbert_et_al_2005_BH7	West Chinderah	552888	6873461	0.6	15.4	6.3
Gilbert_et_al_2005_BH8	West Chinderah	552850	6873258	0.5	13.5	6.7
Gilbert_et_al_2005_BH10	West Chinderah	553150	6873885	0.7	5.5	5.1

D3 Field campaign

Following a data collation and data gaps analysis, a targeted field campaign was undertaken to collect data in areas with limited information. Information on field data collection methods can be found in Appendix A of the Methods report (Rayner et al., 2023). The location of an additional 33 soils profiles collected for this study is shown in Figure D-3, and a summary of the soil profile data, including approximate surface elevation and minimum profile pH (within the tidal range), is provided in Table D-3. Detailed data logs of each of soil profile is provided in Appendix L.

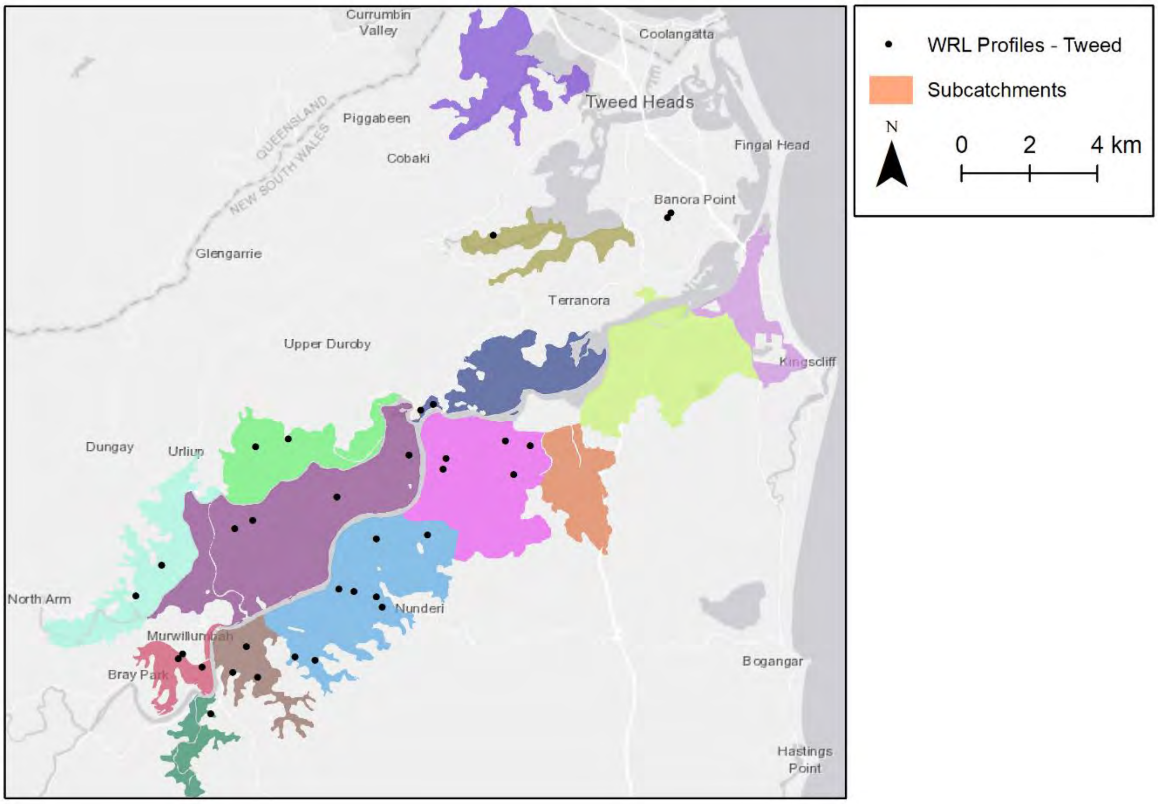


Figure D-3: Location of soil profiles from WRL field investigations

Table D-3: Summary of relevant soil profiles from WRL field investigations

Profile	Subcatchment	Easting	Northing	Surface Elevation (m AHD)	Total Profile Depth (m)	Minimum pH
TW_20_P	Bilambil/Terranora	552417	6878458	0.37	2.2	4.8
TW_22_A	Bilambil/Terranora	552525	6878599	-0.01	1.65	3.6
TW_01_A	Bilambil/Terranora	547287	6877933	0.78	2.15	5.3
TW_10_A	Commercial Road	538148	6865633	1.54	2.05	6.4
TW_11_P	Commercial Road	538013	6865487	1.36	2.85	6.1
TW_32_A	Commercial Road	538725	6865243	0.96	2.45	4.9
TW_43_A	Condong	542750	6867529	2.53	2.5	6.3
TW_45_P	Condong	543189	6867459	1.19	2.25	4.4
TW_38_A	Condong	545359	6869127	0.83	2.4	3.9
TW_37_A	Condong	543850	6867300	0.98	2	4.3
TW_13_P	Condong	543856	6869002	0.78	1.85	4.4
TW_37_P	Condong	544021	6867004	0.76	2	3.8
TW_35_P	Condong	541453	6865542	0.91	2.6	4.4
TW_13_A	Condong	542040	6865446	1.03	2.3	4.8
TW_26_A	Dulguigan	540293	6871721	0.74	2.5	4.1
TP_26_S	Dulguigan	541256	6871951	0.89	2.1	3.8
TP_33_S	Dunbible Creek	538983	6863862	2.35	1.9	6.2
TW_07_A	Kynnumboon	537527	6868236	1.23	2.7	4.3
TW_31_P	Kynnumboon	536773	6867338	0.91	2.1	4.3
TW_03_A	North Tumbulgum	545523	6872959	0.56	2.1	5.5
TW_04_P	North Tumbulgum	545156	6872789	0.58	2.42	3.9
TW_36_A	South Murwillumbah	539625	6865082	1.31	2.8	3.8
TW_12_A	South Murwillumbah	540028	6865837	1.56	2.3	6.3
TW_36_P	South Murwillumbah	540355	6864934	0.47	2.1	3.5
TW_14_P	Tumbulgum/Eviron	547888	6870903	0.34	1.65	4.6
TW_43_P	Tumbulgum/Eviron	548377	6871745	0.24	1	4.6
TW_42_A	Tumbulgum/Eviron	547652	6871886	0.53	1.85	4.8
TW_44_A	Tumbulgum/Eviron	545813	6871054	1.09	1.85	5.7
TW_46_P	Tumbulgum/Eviron	545906	6871367	0.63	1.86	5
TW_05_P	Tygalgah	544820	6871473	0.60	2.3	4.5
TW_27_A	Tygalgah	540216	6869551	0.84	2.05	4.9
TW_27_P	Tygalgah	539681	6869309	0.91	2	4.5
TW_05_A	Tygalgah	542691	6870240	0.42	2.1	4.2

D4 Summary of soil acidity for prioritisation

Section 4 of the Methods report (Rayner et al., 2023) summarises the method for prioritising subcatchments for acid generation. There are two key pieces of information that are used to determine the pH factor used in the priority assessment that can be derived from the ASS data:

- Depth averaged hydrogen ion concentration (related to soil pH); and
- The contributing depth.

All else being equal, a higher hydrogen concentration (i.e. more acidic) and larger contributing depth is an indicator of a greater potential for acid generation and export. More information on how these are calculated can be found in Section 4 of the Methods report (Rayner et al., 2023). These are multiplied together to get the pH factor which forms part of the final prioritisation. Table D-4 summarises the information per subcatchment in the Tweed River floodplain.

Table D-4: Summary of information from soil acidity information

Subcatchment	Depth averaged H+ concentration (µmol/L)	Contributing depth (m)	pH factor	Number of soil profiles available
Bilambil/Terranora	12.1	1.2	14.5	4
Cobaki	13.1	1.3	17.0	8
Commercial Road	1.1	1.3	1.5	3
Condong	78.4	1.3	101.9	12
Dulguigan	119.7	1.3	155.7	6*
Dunbible Creek	0.6	1.3	0.7	1
East Chinderah	15.0	0.4	6.0	1
Kynnumboon	39.3	1.3	51.1	5
North Tumbulgum	19.4	1.1	21.3	3
South Murwillumbah	146.6	1.3	190.5	4
Stotts Creek	96.3	0.6	57.8	2*
Tumbulgum/Eviron	20.4	1.3	26.5	11
Tygalgah	28.6	1.3	37.2	8
West Chinderah	20.0	1.3	26.0	15

* Stotts Creek and Dulguigan include representative profile from Smith et al. (2003) and Macdonald et al. (2004), which incorporated data from a much larger number of profiles.

D5 Data confidence

As shown in Table D-4, the number of profiles in each catchment varies quite significantly. There are two catchments in particular that only have one profile each (Dunbible Creek and East Chinderah). Confidence in this data is therefore limited, so information in literature on ASS or water quality has been consulted to provide greater certainty in the pH factor.

Both of these catchments with limited profiles have low pH factors (0.7 and 6.0 for Dunbible Creek and East Chinderah respectively). Neither of these areas were identified by Tulau (1999) as ASS hotspots on the Tweed River. Hydrosphere Consulting (2017) also documented a water quality monitoring program that was undertaken by Tweed Shire Council over a five (5) year program between 2012 – 2016, including a long term monitoring site at the discharge point of Dunbible Creek and another near the Pacific Highway bridge of the Tweed River (near East Chinderah). At each of these sites, pH complies with water quality guidelines 98% and 94% of the time respectively (compared to 80% or less of the time for sites on the Rous River). Neither Hydrosphere Consulting (2017) or Tulau (1999) have identified acidity as a major issue at either Dunbible Creek or East Chinderah. As there is no evidence to the contrary that these two (2) catchments should have a low pH factor, no adjustments have been made to account for lower confidence at these two (2) sites.

Appendix E Blackwater elevation threshold

E1 Preamble

This section provides an overview of the data used to develop the elevation thresholds for the prioritisation of blackwater generation potential for floodplain subcatchments in the Tweed River. The water level analysis undertaken is described in detail in Section 5 of the Methods report (Rayner et al., 2023).

E2 Water level gauges

There are seven (7) water level gauges operated by NSW DPIE Manly Hydraulics Laboratory (MHL) in the Tweed River estuary that have been used for the analysis of critical thresholds for blackwater generation. The location of the gauges is shown in Figure E-1 and detailed in Table E-1. Water level data has been provided on a 15-minute time step throughout each monitoring period, although intermittent data gaps do occur.

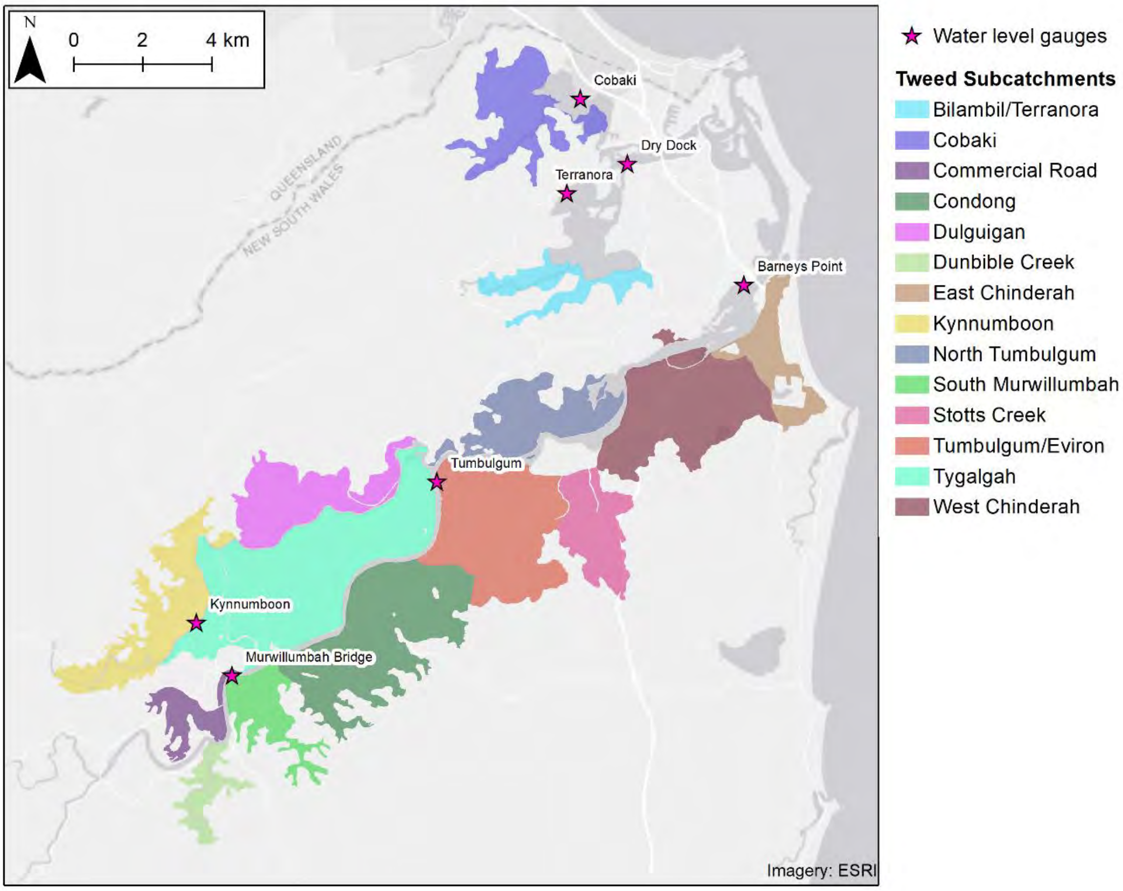


Figure E-1: Location of water level gauges used for blackwater elevation threshold

Table E-1: Details of water level gauges

Station	Chainage (km from entrance/ downstream confluence)	Length of record (years)*	Mean High Water (MHW) (m AHD)
Barneys Point	7.3 (Tweed River)	30.4	0.4
Cobaki	Not on main river	31.2	0.4
Terranora	Not on main river	30.8	0.4
Tumbulgum	20.0 (Tweed River) 0 (Rous River)	32.2	0.4
North Murwillumbah	29.6 (Tweed River)	27.8	0.4
Kynnumboon	12.8 (Rous River)	26.8	0.5

* Excluding data gaps of greater than 6 hours.

Water level time series data at each gauge was analysed to establish a range of levels which can be applied to each floodplain subcatchment whereby the potential for prolonged inundation can be assessed. This is related to floodplain topography and land use to prioritise blackwater generation across the floodplain. The analysis of the water level time series data is undertaken 25 times, to account for events that happen on average every 1, 2, 3, 4 and 5 years as well as events that result in inundation for 1, 2, 3, 4 and 5 days at a time. As a result, there can be up to 25 unique elevations at each gauge (noting that the minimum allowable level is mean high water (MHW)). The range of levels from this analysis, as well as the median and mean levels are shown in Table E-2.

Table E-2: Representative water level elevations at each water level gauge

Station	Minimum level (m AHD)	Median level (m AHD)	Mean level (m AHD)	Maximum level (m AHD)
Barneys Point	0.4	0.4	0.6	1.3
Cobaki	0.4	0.4	0.4	0.7
Terranora	0.4	0.4	0.4	0.7
Tumbulgum	0.4	0.9	1.1	2.6
North Murwillumbah	0.4	0.7	1.0	2.8
Kynnumboon	0.5	1.4	1.6	3.8

E3 Subcatchment elevation thresholds

The subcatchments of the Tweed River floodplain are shown in Figure E-1. For some of these catchments, the primary discharge point at the main river is sufficiently close to one of the water level gauges that the gauge well represents the downstream boundary condition. For other subcatchments, the main discharge points are located away from the available water level gauges. In these cases, the chainage along the river of the major discharge point has been measured, and the critical elevations have been interpolated between gauges. The water level stations used for each subcatchment are shown in Table E-3, as well as the interpolation used where required.

The range of levels, as well as the median and mean levels, at each subcatchment are shown in Table E-4. Figure E-2 shows spatially the area covered by the median elevation thresholds in each sub-catchment.

Table E-3: Water level stations and subcatchments

Subcatchment	Water level station(s) used
Bilambil-Terranora	Terranora
Cobaki	Cobaki
East Chinderah	0.91 x Barneys Point + 0.09 x Tumbulgum
West Chinderah	0.76 x Barneys Point + 0.24 x Tumbulgum
Stotts Creek	0.41 x Barneys Point + 0.59 x Tumbulgum
North Tumbulgum	0.32 x Barneys Point + 0.68 x Tumbulgum
Tumbulgum-Eviron	0.22 x Barneys Point + 0.78 x Tumbulgum
Condong	0.69 x Tumbulgum + 0.31 x North Murwillumbah
Dulguigan	0.78 x Tumbulgum + 0.22 x Kynnumboon
Tygalgah	0.73 x Tumbulgum + 0.27 x Kynnumboon
Kynnumboon	Kynnumboon
South Murwillumbah	North Murwillumbah
Dunbible Creek	North Murwillumbah
Commercial Road	North Murwillumbah

Table E-4: Representative elevations at each subcatchment in the Tweed River floodplain

Subcatchment	Minimum level (m AHD)	Median level (m AHD)	Mean level (m AHD)	Maximum level (m AHD)
Bilambil-Terranora	0.4	0.4	0.4	0.7
Cobaki	0.4	0.4	0.4	0.7
East Chinderah	0.4	0.4	0.6	1.4
West Chinderah	0.4	0.5	0.7	1.6
Stotts Creek	0.4	0.7	0.9	2.1
North Tumbulgum	0.4	0.7	0.9	2.2
Tumbulgum-Eviron	0.4	0.8	1.0	2.3
Condong	0.4	0.8	1.0	2.7
Dulguigan	0.4	1.0	1.2	2.9
Tygalgah	0.4	1.0	1.2	2.9
Kynnumboon	0.5	1.4	1.6	3.8
South Murwillumbah	0.4	0.7	1.0	2.8
Dunbible Creek	0.4	0.7	1.0	2.8
Commercial Road	0.4	0.7	1.0	2.8

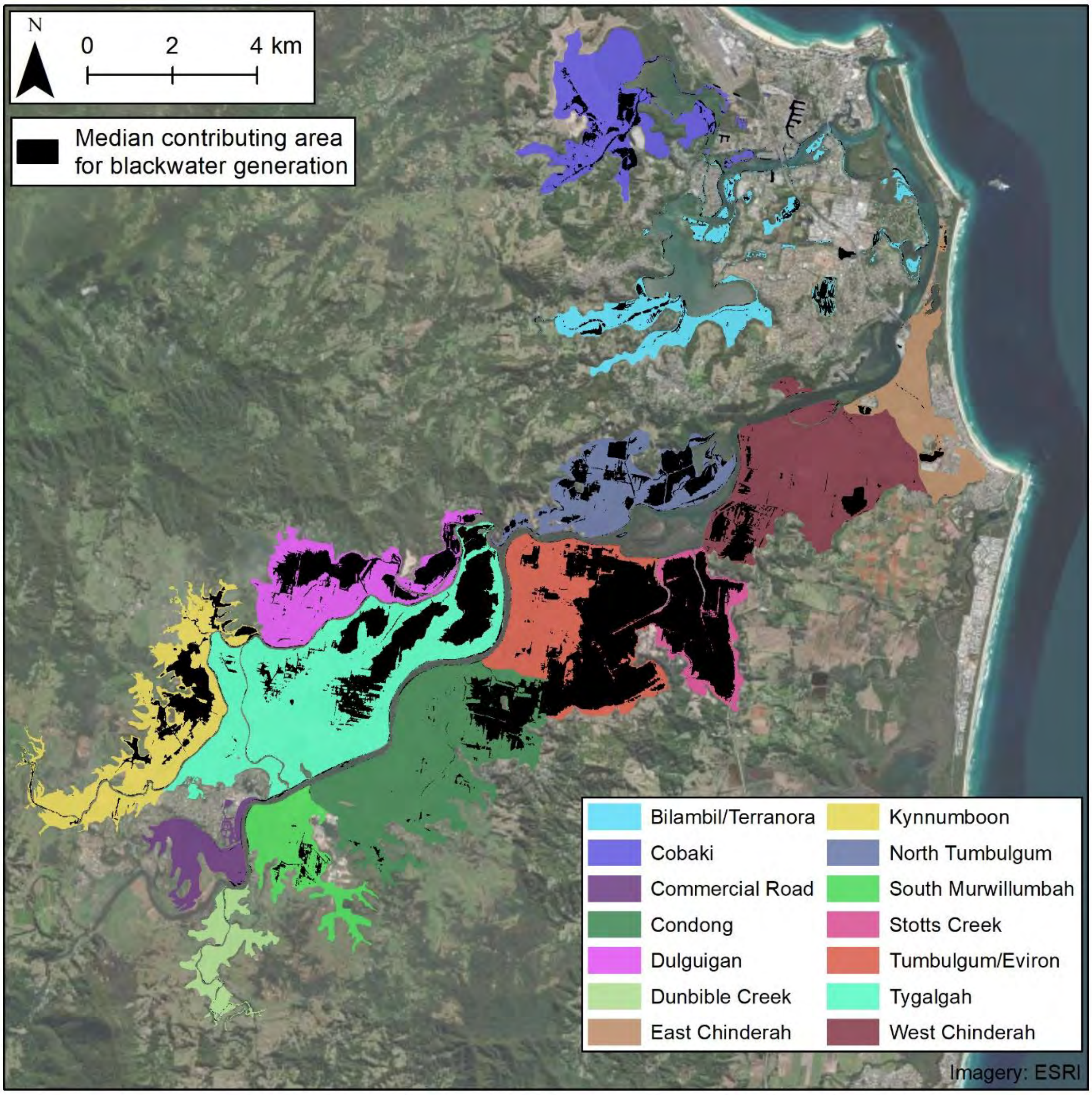


Figure E-2: Areas in the Tweed River floodplain below the median elevation threshold

Appendix F Floodplain infrastructure

F1 Preamble

A range of floodplain infrastructure exists across the Tweed River floodplain for the purpose of drainage and inundation protection (tidal and flooding). Included within this infrastructure is a number of structures that have been modified to improve water quality and aquatic connectivity across the floodplain. Floodplain infrastructure includes:

- Floodgates;
- Culverts or pipes;
- Weirs; and
- Levees.

The following section provides information on floodplain infrastructure for the Tweed River floodplain. This includes results of a data gaps analysis, an assessment of data for critical floodplain infrastructure and details of infrastructure condition and maintenance programs. Data tables containing information on floodplain infrastructure are provided.

F2 Data gaps analysis

F2.1 Existing infrastructure data

Prior to the data collection program undertaken as part of this study, the existing data available for floodplain infrastructure was collated. Floodplain infrastructure data was reviewed from the following sources and has been summarised in Table F-1.

- Floodgate and levee data provided by Tweed Shire Council (TSC);
- Flood mitigation work-as-executed drawings (Young, 1979);
- Bray Park Weir overtopping investigation (WRL, 2017); and
- Levee and structure data obtained during flood model development (Wallace et al., 2009).

Table F-1: Description of existing data sources

Source	Description
TSC – GIS	GIS shapefiles containing location and access information for floodgates and levees managed by TSC.
TSC - annotated photos	Photos of floodgates with headwall elevation and in some instances dimension information annotated to a reduced level of an unspecified datum.
TSC - spreadsheets	Spreadsheets containing details on floodgate dimensions and elevation measurements of floodgate headwalls to a reduced level of an unspecified datum.
Young (1979)	Work as executed drawings for flood mitigation floodgates and levees including dimension, invert and crest elevation information referenced to Standard Datum. Note, field inspections indicated that a number of floodgate structures were different than what was specified in the 1979 design drawings. Corrections from Standard Datum to Australian Height Datum have been applied where no other data was available.
WRL (2017)	A study investigating the overtopping of Bray Park Weir that states the crest elevation as provided by TSC.
Wallace et al. (2009)	A TUFLOW model was developed for the purpose of flood modelling of the Tweed River floodplain and included information on levee crest elevations and some culvert inverts. Data for the flood model was collated from design drawings and field investigations.

Across the Tweed River floodplain existing data for floodplain infrastructure is generally limited to location information with negligible data being available for invert, obvert or crest elevation measurements. The exception to this is for levees whereby detailed data collected for flood modelling along with LiDAR observations means that crest elevation data is well represented (information specific to levees has been addressed in Section F3.2). Where data was in Standard Datum, conversion to Australian Height Datum has been completed. This process included converting data from feet to metres and then subtracting a 0.132 m correction. This correction value has been calculated by the NSW Department of Finance and Services (2012) for the closest available survey mark (PM7892).

During the data gaps analysis, aerial imagery and waterways spatial datasets were used to determine possible locations for end of system infrastructure that was not included in the existing infrastructure data sources. Verification of the existence of these structures was undertaken, where possible, during the data collection campaign. Where inspection of these structures was not possible due to access restrictions, the structure has been marked as “unknown”. In these circumstances the existence of the structure and structure geometry requires confirmation.

A summary table of existing structure data is provided in Section F6. Note that during the gaps analysis only data for end of system structures such as floodgates that discharge directly to the Tweed River estuary was assessed. Subsequently, there may be existing data available for structures that are located upstream of end of system infrastructure which do not directly discharge to the Tweed River estuary.

F2.2 Data collection

Field investigations were completed to obtain invert and dimension data for floodplain infrastructure within the Tweed River floodplain. Initially WRL completed opportunistic surveys of easily accessible end of system structures. Abbott and Macro Land and Engineering Surveyors (Abbott & Macro LES) then collected further end of system structure data. Focus of the investigations was on collecting data for primary end of system floodgate structures, however, data was also collected opportunistically for other floodplain infrastructure. Figure F-1 summarises the data available for floodplain structures. Summary tables of all structure data measured during the field investigations is provided in Section F6.

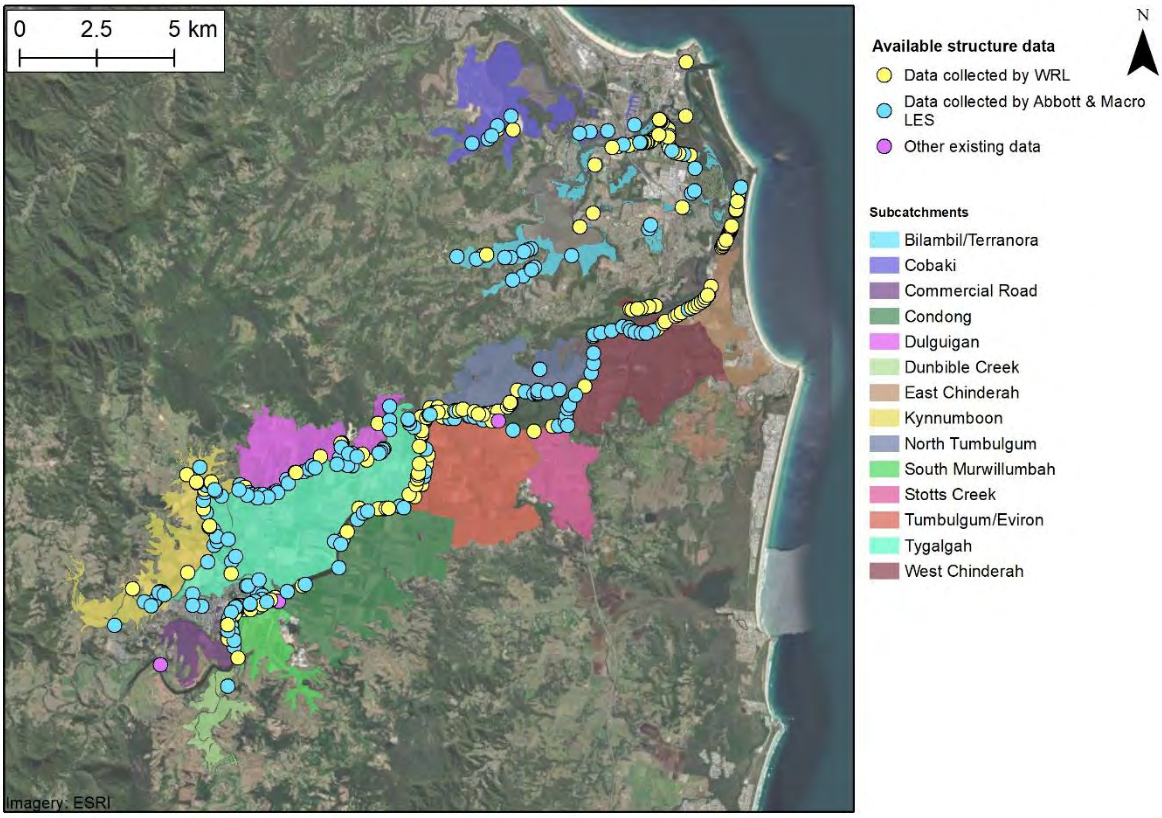


Figure F-1: Summary of structures where data available for the Tweed River floodplain

F3 Assessment of critical floodplain infrastructure

F3.1 End of system structures

A floodplain infrastructure assessment was completed with particular focus given to end of system (EOS) structures which act as barriers to prevent the upstream flow of tidal waters and limit the risk of backwater flooding from the river. Examples of EOS structures include weirs or one-way floodgates which work alongside levee banks to facilitate drainage while preventing inundation of the floodplain, often where agricultural land use practices are undertaken. These EOS structures have been separated into two categories:

1. Primary EOS structures: floodplain infrastructure that plays a significant role in draining the upstream catchment. An example of a primary EOS structure is the large floodgates on Condong Creek.
2. Secondary EOS structures: floodplain infrastructure that provides drainage for small floodplain areas which are insignificant when compared to the total catchment drainage. An example of a secondary EOS structure would be a 300 mm diameter floodgate draining local catchment runoff on a paddock scale.

The location and condition of individual EOS structures have management implications due to their operation as drainage and flood mitigation devices. For this reason, EOS structures have been carefully considered during the development of management options. Furthermore, EOS structures are vulnerable to sea level rise as a result of climate change, resulting in reduced drainage potential. A detailed vulnerability assessment has been completed for EOS floodgate structures (see Section 7). Figure F-2 provides the locations, category and survey status for the 369 EOS structures which have been identified within the Tweed River floodplain.

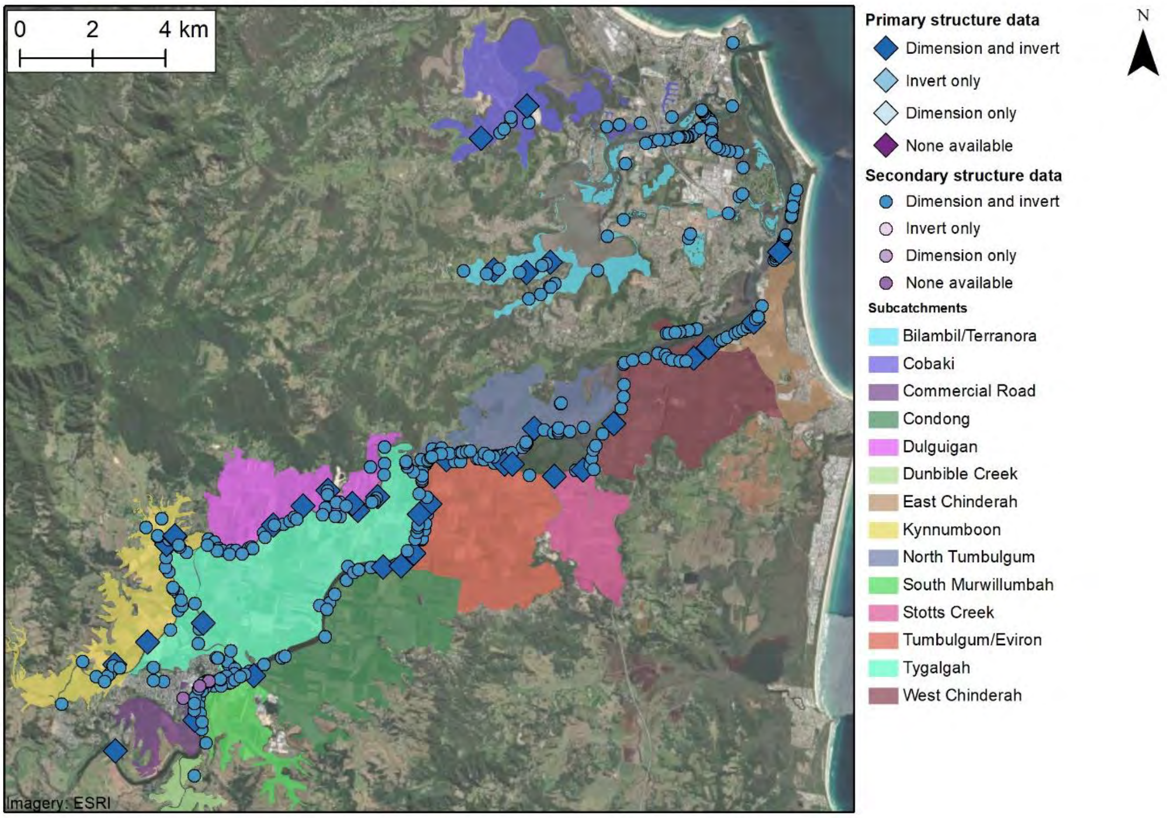


Figure F-2: Summary of data available for end of system structures of the Tweed River floodplain

F3.2 Levees

Levee structures are generally constructed to protect the floodplain from extreme flood events. They can also protect the floodplain from inundation due to high tidal levels. Within the Tweed River floodplain there are two sets of levee structures located at Tweed Heads South and Murwillumbah designed to protect urban areas from extreme flood events. The Tweed Heads South levee system was initially designed to protect against a 5% annual exceedance probability (AEP) flood event, however, flood modelling indicated that this was not the case and levees would begin to overtop with a flood of this level (Wallace et al., 2009). Flood modelling showed that the levee structures located at Murwillumbah would offer protection from a 5% AEP flood event and would begin to overtop during a 1% AEP flood event (Wallace et al., 2009). Figure F-3 shows the locations of flood mitigation levees across the Tweed River floodplain. All levees are actively managed by Tweed Shire Council with priority given to levees offering protection for urban areas.

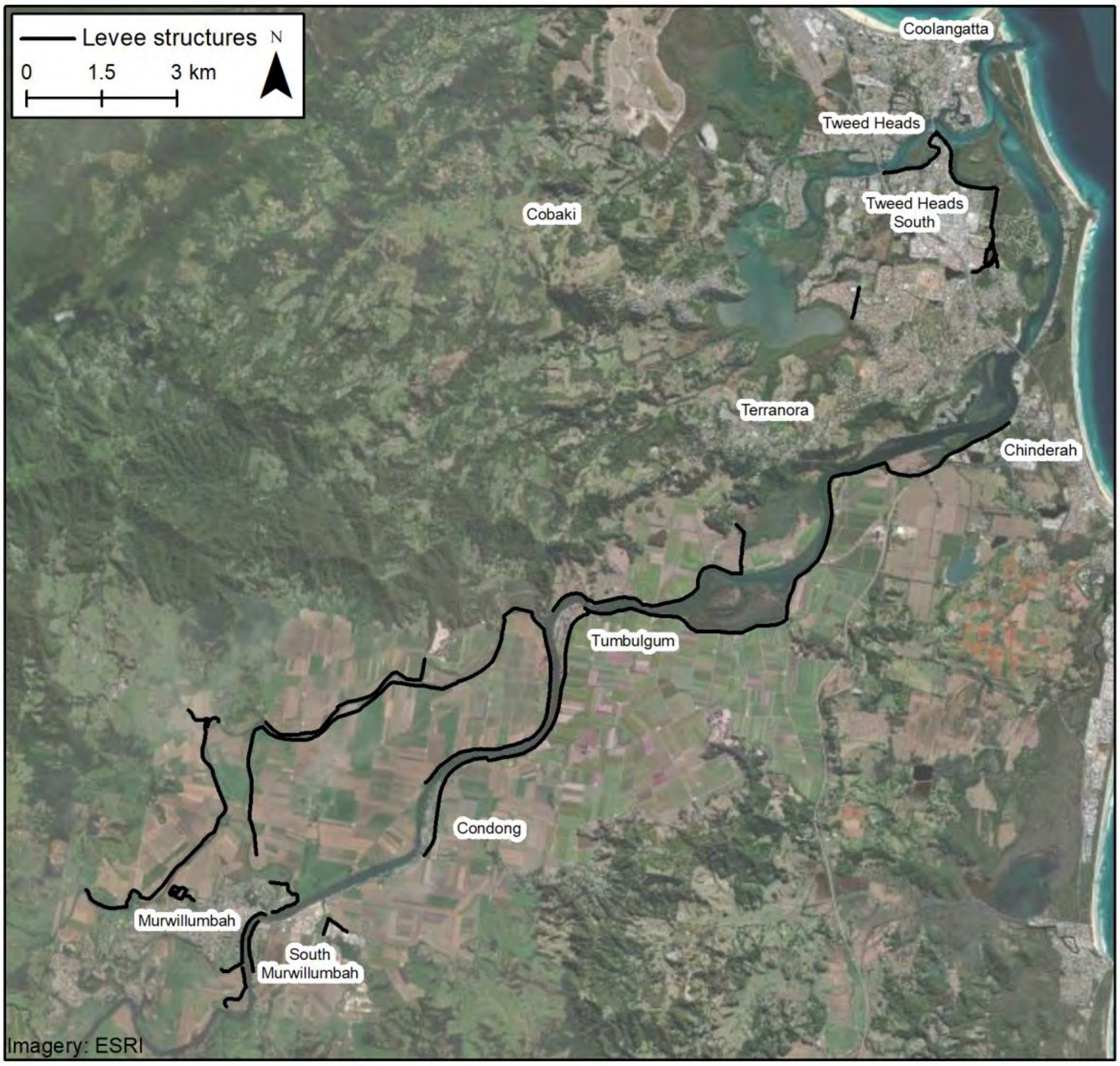


Figure F-3: Location of flood mitigation levee structures on the Tweed River floodplain managed by Tweed Shire Council

F4 Infrastructure tenure and maintenance

F4.1 Infrastructure tenure

Information on the tenure of EOS structures across the Tweed River floodplain is presented in Figure F-4.

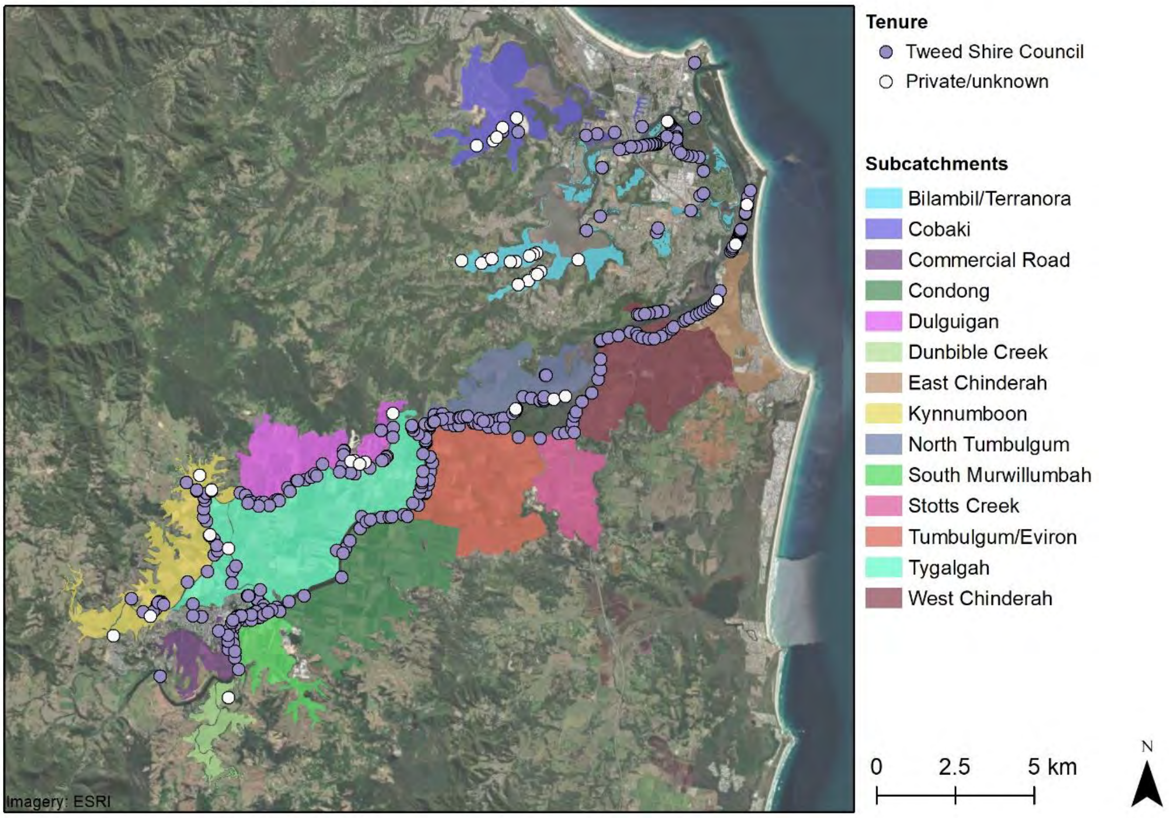


Figure F-4: Tenure of end of system structures on the Tweed River floodplain

F4.2 Maintenance schedule

Tweed Shire Council has a drainage asset management plan for ongoing maintenance of floodplain infrastructure (TSC, 2011). This plan outlines:

- The hierarchy for infrastructure including the strategic level of service for maintenance;
- The current and projected future demand for management of drainage infrastructure;
- A lifecycle management plan for drainage infrastructure;
- A summary of financial requirements and allocation for drainage infrastructure management;
- Asset management practices; and
- A plan for continued improvement of the drainage asset management plan.

Ongoing maintenance of floodplain infrastructure is important in ensuring that the way structures affect water quality and connectivity across the floodplain remains as per their design specifications. The level of maintenance floodplain infrastructure receives directly impacts the management option recommendations for the subcatchment where the structures are located. It has been assumed that for structures where the tenure was identified as private or unknown that routine maintenance is completed on an as required basis by the landholder.

F4.3 Condition assessment

During the fieldwork program, structures which were inspected were also assessed for condition. Floodgate structures were only assessed when access to the downstream (gated) side of the structure was available and the structure was above the water level. The condition assessment was completed using an approach similar to Walsh et al. (2012) as outlined in Table F-2. Where data was available, the structure condition has been considered during the development of management options.

Table F-2: Condition assessment criteria

Condition	Description
Good	The structure is in good working order. For floodgates, the seals work well. The structure does not require any maintenance in the near future.
Fair	The structure is functioning well however it is starting to become damaged. Issues such as rust or broken seals (for floodgates) are starting to become evident and affect the structure's performance. For floodgates some vegetation, oysters or debris may be partially blocking the gate or preventing it from closing. The structure will require some maintenance in the near future.
Poor	The structure is no longer functioning well. For floodgates, the flaps no longer close properly or have holes. There may be extensive rust or concrete cancer in the structure. Sections of the culvert may have collapsed. For floodgates, the flap may be blocked or obstructed from opening. The structure requires maintenance to allow it to function correctly.
Other	The structure is broken and irreparable or has been removed.

F5 Infrastructure terminology

The following section provides a number of figures which describe common types of floodplain infrastructure used to control water movement across the floodplain. These figures include descriptions for common terminology used to describe infrastructure.

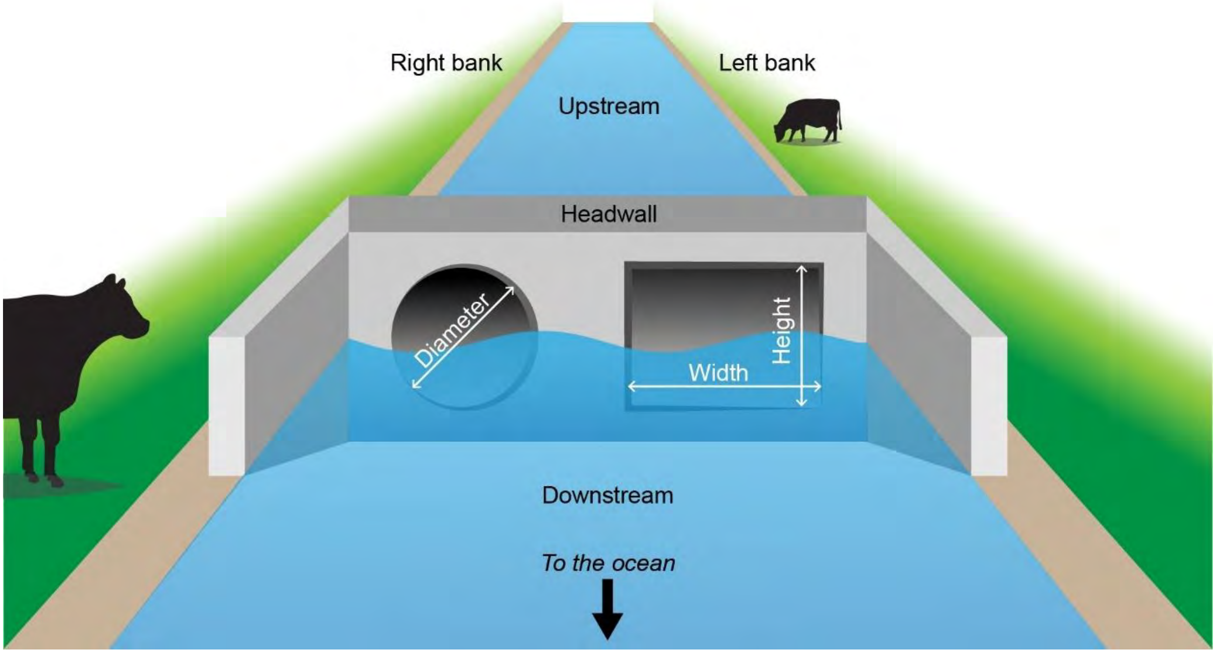


Figure F-5: Example of culverts controlling water in an agricultural drain

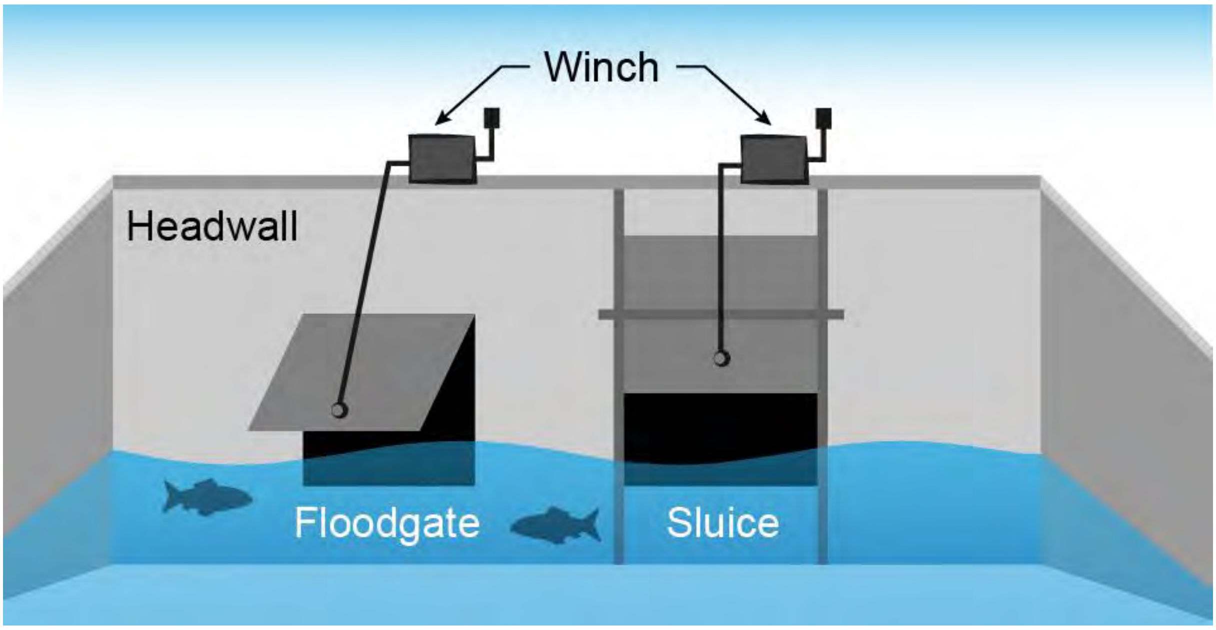


Figure F-6: Example of floodgate and sluice structures which can be fitted to culverts to control flow using a winch

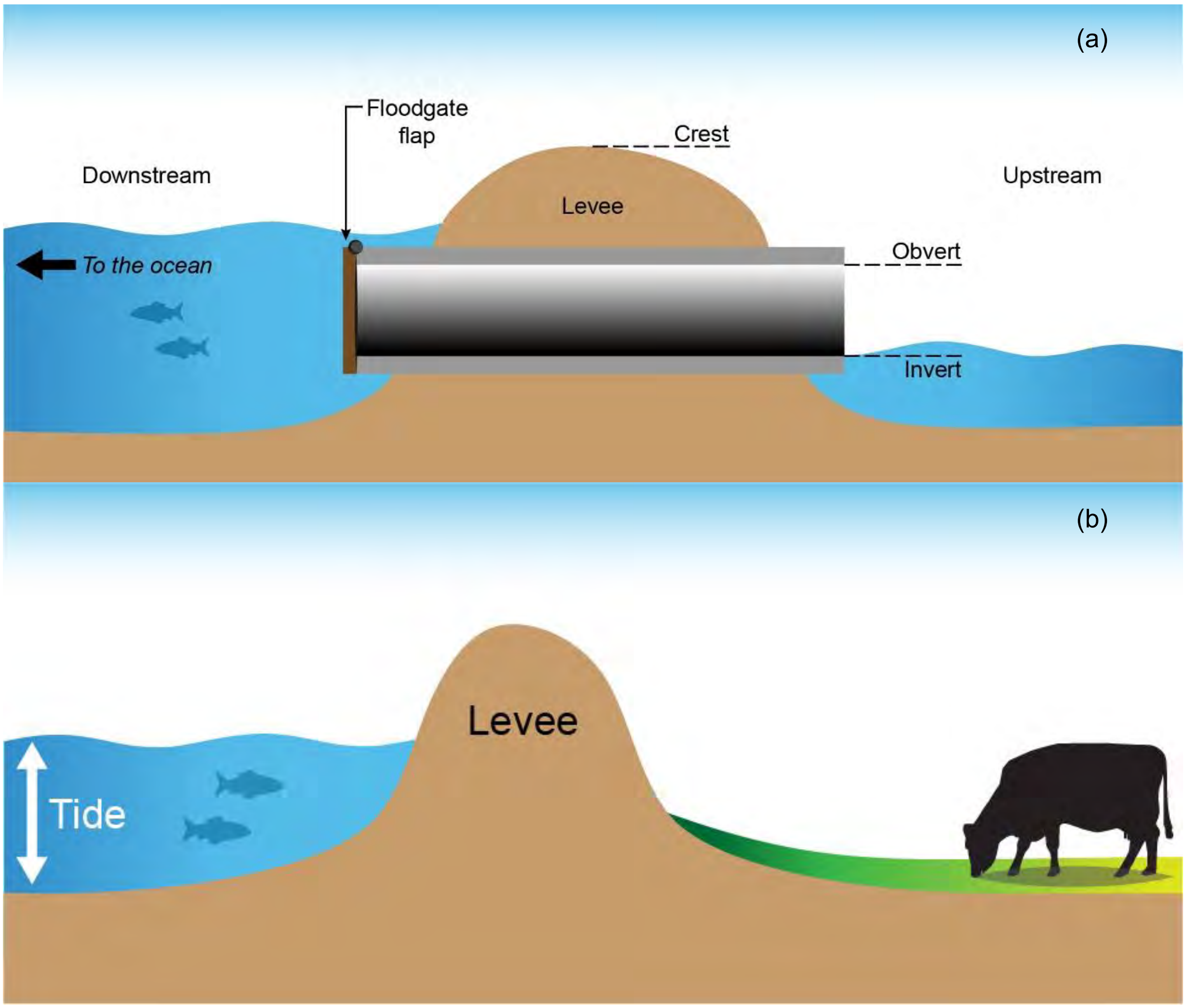


Figure F-7: Example of (a) a floodgate structure ensuring water levels upstream of a levee remain at the low tide level and (b) a levee preventing tidal inundation of the floodplain

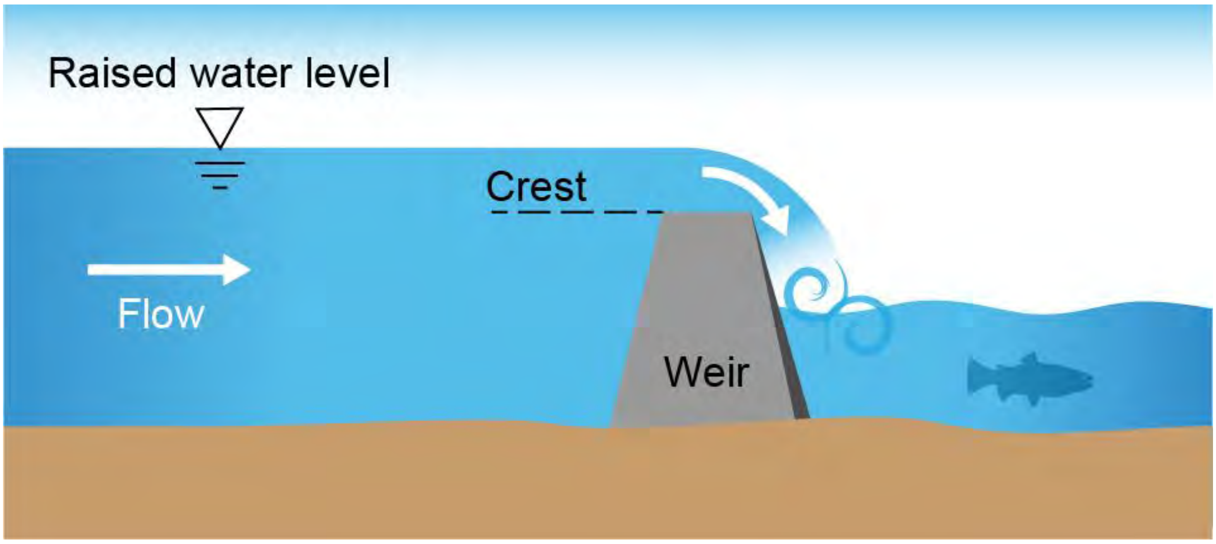


Figure F-8: Example of a weir ensuring a raised water level on the upstream side

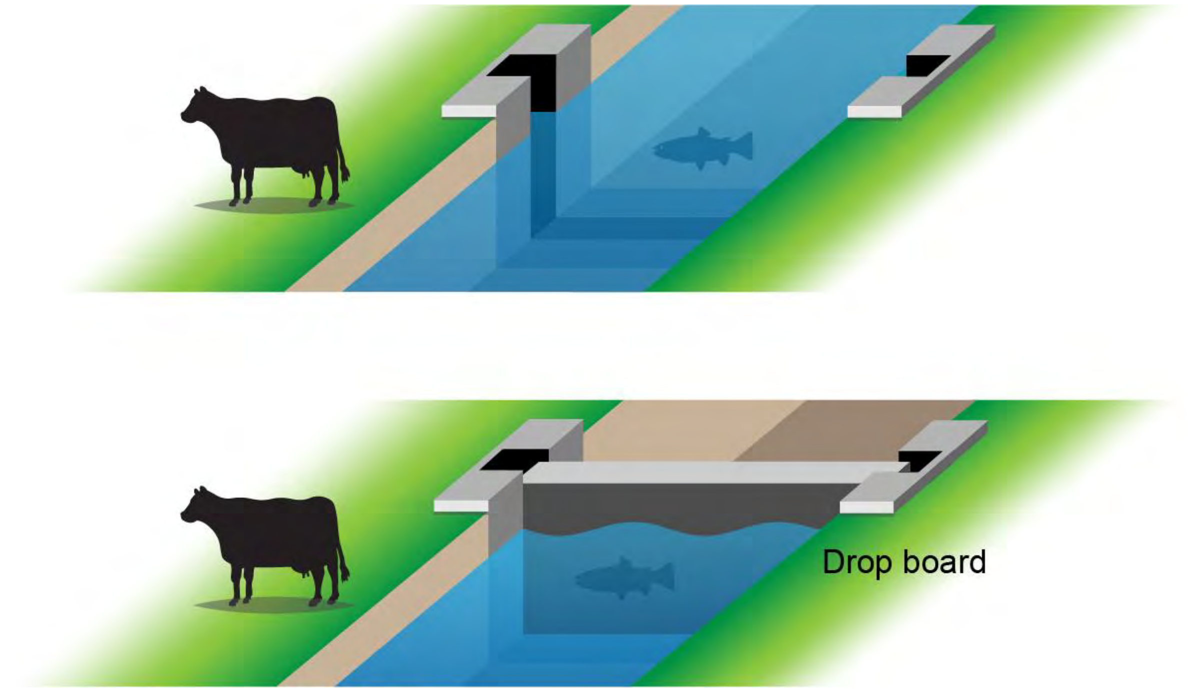


Figure F-9: Example of a drop board structure which can be used to control water levels and prevent inundation

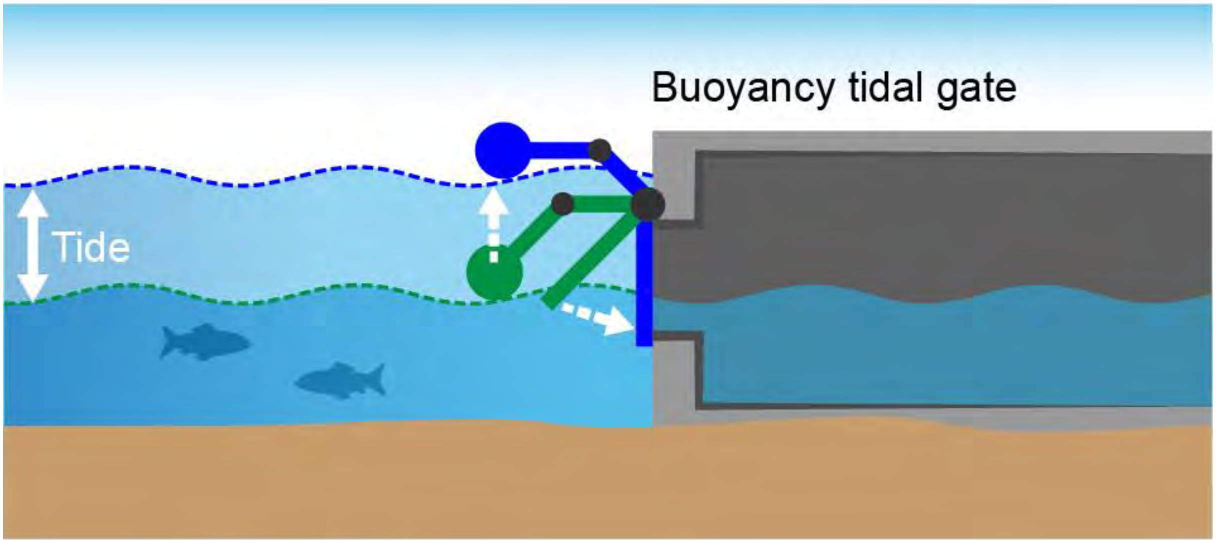


Figure F-10: Example of a buoyancy tidal gate that lets a controlled level of tidal water upstream of the structure (green) before closing due to a buoyancy mechanism and preventing further water ingress (blue)

F6 Floodplain infrastructure data tables

The following section includes:

1. A summary table for structures surveyed for this current project (Table F-3);
2. A summary table for structures based on surveys from Abbott and Macro in 2021 (Table F-4); and
3. A summary table for structures that were not surveyed (Table F-5).

Table F-3: Summary of structures where data was collected during this current project

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
1	30/09/2019 15:02	Floodgate	1	1.5			538916	6865608		-0.29	Good	Secondary	Tweed Shire Council	
1a	30/09/2019 15:32	Floodgate	1	0.3			538914	6865680		1.54	Fair	Secondary	Tweed Shire Council	
1b	30/09/2019 15:38	Floodgate	1	0.3			538917	6865861		1.76		Secondary	Tweed Shire Council	
2	27/08/2019 0:00	Floodgate	4		2.4	1.8	538926	6865406	-0.09		Good	Primary	Tweed Shire Council	Dimensions are approximate. Buoyancy tidal gate on floodgate flap second from the right.
3 lower	30/09/2019 15:59	Floodgate	2	1.8			538913	6865931		-0.15	Fair	Secondary	Tweed Shire Council	Two of four floodgates. Floodgates are arranged in a grid pattern with the two bottom floodgates being larger. Inverts are approximate. Top floodgates are attached to a pump on the upstream side.
3 upper	30/09/2019 15:59	Floodgate	2	1.2			538913	6865931		2.31	Fair	Secondary	Tweed Shire Council	Two of four floodgates. Floodgates are arranged in a grid pattern with the two bottom floodgates being larger. Inverts are approximate. Top floodgates are attached to a pump on the upstream side.
4	30/09/2019 16:40	Floodgate	1	1.5			539030	6866274		-0.54		Secondary	Tweed Shire Council	
4a	30/09/2019 16:46	Floodgate	1	0.3			539026	6866261		2.85	Good	Secondary	Tweed Shire Council	
6a	30/09/2019 17:05	Floodgate	1	0.3			539192	6866438		5.33		Secondary	Tweed Shire Council	There was poor GPS accuracy when measuring the invert.
7	30/09/2019 17:01	Floodgate	1	1.35			539248	6866476		0.74	Fair	Secondary	Tweed Shire Council	
8	1/10/2019 10:39	Floodgate	2	0.9			539272	6866483		0.22		Secondary	Tweed Shire Council	The downstream invert was estimated based on height above the water level (estimated as 0.25 m). Culvert dimensions estimated from viewing culvert from opposite side of the river.
10	1/10/2019 9:58	Floodgate	2		1.8	1.95	539260	6864785	-0.06		Good	Primary	Tweed Shire Council	Culvert is under a road. The right-hand floodgate has a winch.
16	24/10/2019 14:41	Floodgate	1	0.475			539129	6866213		0.03	Good	Secondary	Tweed Shire Council	Southbank near Murwillumbah.
17	1/10/2019 10:38	Floodgate	1	0.6			539225	6866327		-0.03	Good	Secondary	Tweed Shire Council	Culvert is near a bridge. Invert is approximate.
17a	1/10/2019 10:55	Floodgate	1	0.6			539451	6866349		0.59		Secondary	Tweed Shire Council	Could not find the upstream side of the culvert. Invert and dimensions are approximate.
17b	1/10/2019 11:06	Floodgate	1	0.6			539648	6866351		2.28	Good	Secondary	Tweed Shire Council	Could not find the upstream side of the culvert.
17f	1/10/2019 11:36	Floodgate	1	0.6			540031	6866515		2.56	Good	Secondary	Tweed Shire Council	

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
17g	1/10/2019 11:52	Floodgate	1	0.45			540248	6866646		2.88	Good	Secondary	Tweed Shire Council	Labelled as 17x in Tweed Shire Council GIS layer.
17h	1/10/2019 12:00	Floodgate	1	0.375			540303	6866675		2.75	Fair	Secondary	Tweed Shire Council	
17i	1/10/2019 12:06	Floodgate	1	0.45			540423	6866735		3.25		Secondary	Tweed Shire Council	
17k	1/10/2019 12:08	Floodgate	1	0.3			540436	6866745		2.21		Secondary	Tweed Shire Council	
17n	1/10/2019 12:59	Floodgate	1	0.45			541318	6867119		2.67		Secondary	Tweed Shire Council	
27b	1/10/2019 13:13	Floodgate	2	0.375			542770	6868866		2.78	Fair	Secondary	Tweed Shire Council	The downstream side of the culvert was blocked with trees inside.
29	1/10/2019 13:28	Floodgate	3	1.5			543769	6869590	-0.58		Good	Secondary	Tweed Shire Council	
30	1/10/2019 13:41	Floodgate	3	1.5			544035	6869601	-0.17		Poor	Primary	Tweed Shire Council	The downstream side of the culvert was almost completely blocked.
30c	1/10/2019 13:35	Floodgate	1	0.45			543965	6869615		1.65		Secondary	Tweed Shire Council	
31	1/10/2019 13:46	Floodgate	2		2.4	1.8	544101	6869597	-0.55		Good	Primary	Tweed Shire Council	Buoyance tidal gate located on the right flap.
31 buoyancy	1/10/2019 13:50	Floodgate			0.8	0.8	544104	6869623		-0.57	Good		Tweed Shire Council	Buoyancy gate for structure 31.
33	25/02/2020 9:24	Floodgate	4	1.8			544946	6870005		-0.76	Good	Primary	Tweed Shire Council	Buoyance tidal gate on second gate from the right.
34 left	1/10/2019 14:15	Floodgate	1		0.45	0.6	545160	6870371		0.14	Poor	Secondary	Tweed Shire Council	One of two culverts. Small culvert with gate on the left side of structure 34. Invert and dimensions approximate.
34 right	1/10/2019 14:10	Floodgate	1	1.5			545160	6870373		-0.34	Good	Secondary	Tweed Shire Council	One of two culverts. Partially wedged open.
34a	1/10/2019 14:19	Floodgate	1	0.45			545172	6870403		2.19	Good	Secondary	Tweed Shire Council	
37	1/10/2019 14:56	Floodgate	2	1.5			545327	6871075		-0.35	Fair	Secondary	Tweed Shire Council	There are mangroves on the downstream side of the culvert.
38	1/10/2019 15:18	Floodgate	1	1.5			545399	6871357	-1.15			Primary	Tweed Shire Council	
39	1/10/2019 15:18	Floodgate	1	0.375			545309	6871539				Secondary	Tweed Shire Council	Invert not measured due to poor GPS signal.
39a	27/08/2019 0:00	Floodgate	1	0.6			545179	6871966		0.01	Fair	Secondary	Tweed Shire Council	Deep drain, upstream side is dry.
39b	1/10/2019 16:00	Floodgate	1	0.375			545166	6872172		-0.03		Secondary	Tweed Shire Council	Invert measurement is approximate.
39c	1/10/2019 16:04	Floodgate	1	0.6			545178	6872241		-0.40		Secondary	Tweed Shire Council	
39d	1/10/2019 16:10	Floodgate	1	0.375			545258	6872434		0.46		Secondary	Tweed Shire Council	
39e	1/10/2019 16:13	Floodgate	1	0.375			545304	6872510		0.47	Good	Secondary	Tweed Shire Council	
39f	1/10/2019 16:15	Floodgate	1	0.9			545331	6872550		-0.70	Poor	Secondary	Tweed Shire Council	Culvert is very blocked and infilled with silt. It is unlikely to function.
39g	1/10/2019 16:15	Floodgate	1	0.375			545430	6872623			Fair	Secondary	Tweed Shire Council	Invert not measured due to poor GPS signal. Floodgate is within the tidal range.
39h	1/10/2019 16:15	Floodgate	1	0.3								Secondary	Tweed Shire Council	Invert not measured due to poor GPS signal. Floodgate is within the tidal range. Actual easting and northing unknown.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
39i	1/10/2019 16:30	Floodgate	1	0.3			545578	6872713		-0.05	Good	Secondary	Tweed Shire Council	
39j	1/10/2019 16:37	Floodgate	1	0.6			545640	6872728		-0.33	Good	Secondary	Tweed Shire Council	
39k	1/10/2019 16:39	Floodgate	1	0.45			545696	6872726		0.16	Good	Secondary	Tweed Shire Council	
39s	1/10/2019 15:38	Floodgate	1	0.375			545172	6872041		0.66	Good	Secondary	Tweed Shire Council	
39w	1/10/2019 15:42	Floodgate	1	0.375			545170	6872126		0.93	Good	Secondary	Tweed Shire Council	
40	1/10/2019 9:02	Floodgate	1	0.3			544759	6870064	0.59		Good	Secondary	Tweed Shire Council	Culvert is under a road.
41	1/10/2019 8:55	Floodgate	1	0.6			544978	6870388	0.76		Good	Secondary	Tweed Shire Council	Culvert is under a road. There was 0.2 m of sediment in the base of the culvert on the upstream side.
42	1/10/2019 8:49	Floodgate	1	0.375			545045	6870566		0.29	Good	Secondary	Tweed Shire Council	Culvert is under a road. The downstream side was partially submerged at the time of the survey.
43 box	27/08/2019 0:00	Floodgate	1		2.4	1.8	545050	6870702	-0.68		Fair	Primary	Tweed Shire Council	One of two culverts. One large box culvert with a buoyancy tidal gate on it. One smaller circular culvert.
43 buoyancy	27/08/2019 0:00	Floodgate	1			1.1	545050	6870702		-0.97	Good		Tweed Shire Council	Buoyancy gate for structure 43. Width not measured. Invert approximate.
43 circular	27/08/2019 0:00	Floodgate	1	0.4			545050	6870702	-0.45			Secondary	Tweed Shire Council	One of two culverts. One large box culvert with a buoyancy tidal gate on it. One smaller circular culvert.
43a	27/08/2019 0:00	Floodgate	1	0.375			545059	6870765		1.45	Fair	Secondary	Tweed Shire Council	Dry on the downstream side.
44	1/10/2019 8:36	Floodgate	1	1.5			545090	6871063	-0.34		Good	Secondary	Tweed Shire Council	There was a small culvert to the right of the main culvert (also in good condition) which is attached to a pump on the upstream side. The pump did not appear to be working.
45	1/10/2019 9:16	Floodgate	1	0.6			543141	6869629		0.94	Good	Secondary	Tweed Shire Council	Culvert is under a road.
46	1/10/2019 8:27	Floodgate	1	1.5			545093	6871629		-0.37	Fair	Secondary	Tweed Shire Council	Could not access the upstream side. The downstream side of the gate was blocked by 0.3 m of sediment. Culvert dimensions and invert are approximate.
47	2/10/2019 8:17	Floodgate	2	0.9			545153	6872575	0.00		Good	Secondary	Tweed Shire Council	
47a	2/10/2019 8:26	Floodgate	1	0.45			545455	6872865		-0.36	Fair	Secondary	Tweed Shire Council	Invert approximate.
48	2/10/2019 8:34	Floodgate	1	1.2			545712	6872886	0.15		Poor	Secondary	Tweed Shire Council	Floodgate flap is corroded and leaking. Culvert is under a road.
49	2/10/2019 10:41	Floodgate	1	1.5			545928	6872759	-0.80		Fair	Secondary	Tweed Shire Council	Culvert has been infilled with approximately 0.5 m of sediment.
50	2/10/2019 10:56	Floodgate	2	1.5			546242	6872764		0.09	Good	Secondary	Tweed Shire Council	
50a	2/10/2019 10:41	Floodgate	1	0.375			546393	6872790			Good	Secondary	Tweed Shire Council	Invert not measured due to poor GPS signal. Floodgate is above the tidal range.
51	2/10/2019 10:41	Floodgate	1	0.375			546274	6872766			Good	Secondary	Tweed Shire Council	Invert not measured due to poor GPS signal. Floodgate is above the tidal range.
51a	2/10/2019 11:15	Floodgate	1	0.375			546389	6872792	1.48		Poor	Secondary	Tweed Shire Council	The upstream side of the culvert is completely blocked.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
52	2/10/2019 11:20	Culvert	1		2.45	1.8	546496	6872822	-1.60		Other	Secondary	Tweed Shire Council	Floodgate flap has been removed
53	2/10/2019 11:30	Floodgate	1		2.55	1.8	546891	6872748	-0.69		Good	Primary	Tweed Shire Council	Invert is approximate.
54	2/10/2019 11:39	Floodgate	1	0.6			547011	6872665	1.16		Good	Secondary	Tweed Shire Council	
55	2/10/2019 11:46	Floodgate	1				547086	6872656		-0.63	Fair	Secondary	Tweed Shire Council	The downstream side of the floodgate was underwater at the time of inspection and there was approximately 0.5 m of sediment in front of the gate.
56	2/10/2019 11:50	Floodgate	1	0.375			547153	6872657	1.57		Fair	Secondary	Tweed Shire Council	
56a	2/10/2019 12:01	Floodgate	1	0.375			547225	6872662	1.94		Fair	Secondary	Tweed Shire Council	
57	2/10/2019 12:05	Floodgate	1	0.45			547389	6872689		1.07	Fair	Secondary	Tweed Shire Council	Culvert is within a stormwater pit on upstream side.
58	2/10/2019 12:17	Floodgate	1	1.2			547534	6872738	0.15		Good	Secondary	Tweed Shire Council	
59	2/10/2019 12:21	Floodgate	1	0.45			547638	6872752		1.32	Good	Secondary	Tweed Shire Council	Culvert is within a stormwater pit on upstream side.
60	2/10/2019 12:32	Floodgate	1	0.375			547934	6872915	0.94		Good	Secondary	Tweed Shire Council	
61	2/10/2019 12:39	Floodgate	1	0.375			548019	6872983	0.92		Good	Secondary	Tweed Shire Council	Culvert is within a stormwater pit on upstream side.
62	2/10/2019 12:47	Floodgate	1	0.9			548061	6873035		-0.17	Good	Secondary	Tweed Shire Council	Culvert is under a road. Invert is approximate.
63	2/10/2019 12:59	Floodgate	3		2.49	1.8	548255	6873436	-0.75		Fair	Primary	Tweed Shire Council	All gates have a winch. The right gate appears to be leaking.
68 centre	27/08/2019 0:00	Floodgate	3	1.5			545848	6872559	-0.25		Good	Primary	Tweed Shire Council	One of three culverts. All 1.5 m diameter circular culverts on upstream side. On the downstream side the two left culvers are rectangular and the right culvert is still circular.
68 left	27/08/2019 0:00	Floodgate	3	1.5			545848	6872559	-0.21		Good	Primary	Tweed Shire Council	One of three culverts. All 1.5 m diameter circular culverts on upstream side. On the downstream side the two left culverts are rectangular and the right culvert is still circular.
68 right	27/08/2019 0:00	Floodgate	3	1.5			545848	6872559	-0.45		Good	Primary	Tweed Shire Council	One of three culverts. All 1.5 m diameter circular culverts on upstream side. On the downstream side the two left culverts are rectangular and the right culvert is still circular.
75	25/02/2020 15:07	Floodgate	4	1.5			547457	6872445		-0.54	Good	Primary	Tweed Shire Council	Good condition.
76	25/02/2020 15:26	Floodgate	3		2.5	1.8	547658	6872452		-1.83		Secondary	Tweed Shire Council	Structure under water at time of survey. Approximate width estimated from other structures. Number of gates assumed from inspection (possible fourth gate was undetected).
78	25/02/2020 15:49	Floodgate	4		2.5	1.8	548811	6872119		-0.67	Good	Primary	Tweed Shire Council	Buoyancy tidal gate on left gate.
79	27/08/2019 0:00	Floodgate	2	0.5			549391	6872265		-0.21	Good	Secondary	Tweed Shire Council	Poor GPS precision reduced the accuracy for the invert level.
80	25/02/2020 16:09	Floodgate	6		2.5	1.8	549610	6872385		-0.76	Good	Primary	Tweed Shire Council	Dimensions and invert levels are an estimate. Could not access gates.
87	25/02/2020 16:25	Floodgate	2		2.4	1.8	550443	6873551		-0.98	Good	Primary	Tweed Shire Council	Sluice gate on left gate was closed.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
101	2/10/2019 14:21	Floodgate	1	0.45			552779	6875417		-2.80	Poor	Secondary	Tweed Shire Council	Culvert is under a highway. The downstream side is almost completely blocked with mangroves.
102	2/10/2019 14:29	Floodgate	2	0.45			552988	6875577	0.67		Good	Secondary	Tweed Shire Council	
103	2/10/2019 14:33	Floodgate	4		1.8	1.25	553041	6875634	-0.27		Good	Primary	Tweed Shire Council	Buoyancy tidal gate on left hand gate.
103 buoyancy	2/10/2019 14:41	Floodgate	1		0.6	0.6	553030	6875646		0.03	Good		Tweed Shire Council	Buoyance gate for structure 103.
104	2/10/2019 14:51	Floodgate	1	1.5			553360	6875828		-0.71	Good	Secondary	Tweed Shire Council	Floodgate winched open.
105	2/10/2019 14:56	Floodgate	1	0.6			553433	6875872		-0.01		Secondary	Tweed Shire Council	
106	27/08/2019 0:00	Floodgate	1	0.45			553548	6875936	0.40			Secondary	Tweed Shire Council	Poor GPS signal on downstream side so only upstream measurement reliable.
107	27/08/2019 0:00	Floodgate	2	0.45			553774	6876038			Fair	Secondary	Tweed Shire Council	Poor GPS reception did not allow for invert measurements. Downstream side partially blocked with sediment.
108 left	27/08/2019 0:00	Floodgate	2	0.9			553876	6876086		-0.40	Good	Secondary	Tweed Shire Council	One of two culverts. Two circular flaps flow into two rectangular culverts which are in a stormwater pit (i.e. there are rectangular culverts on the upstream side). Structure is different to the 1970s flood mitigation dataset.
108 right	27/08/2019 0:00	Floodgate	2	0.9			553876	6876086		-0.37	Good	Secondary	Tweed Shire Council	One of two culverts. Two circular flaps flow into two rectangular culverts which are in a stormwater pit (i.e. there are rectangular culverts on the upstream side). Structure is different to the 1970s flood mitigation dataset.
109	27/08/2019 0:00	Floodgate	1	0.385			553986	6876148		0.16	Good	Secondary	Tweed Shire Council	Structure is different to the 1970s flood mitigation dataset. The upstream side is within a stormwater system.
109A	27/08/2019 0:00	Floodgate	1	0.6			554109	6876219		-0.04	Fair	Secondary	Tweed Shire Council	The upstream side is within a stormwater system.
109B	27/08/2019 0:00	Floodgate	1	0.45			554200	6876284		-0.14	Good	Secondary	Tweed Shire Council	The upstream side is within a stormwater system.
110	27/08/2019 0:00	Floodgate	3		1.8	1.2	554286	6876351		-0.59	Good	Primary	Tweed Shire Council	Left culvert flap has an "L" shape to fit around a concrete bench on the side of the culvert.
110A centre	27/08/2019 0:00	Floodgate	1	0.6			554406	6876501		-0.21	Good	Secondary	Tweed Shire Council	One of three culverts.
110A left	27/08/2019 0:00	Floodgate	1	0.6			554406	6876501		-0.23	Good	Secondary	Tweed Shire Council	One of three culverts.
110A right	27/08/2019 0:00	Floodgate	1	0.6			554406	6876501		-0.19	Good	Secondary	Tweed Shire Council	One of three culverts.
110c	2/10/2019 15:09	Floodgate	1	0.45			554504	6876779		0.66	Good	Secondary	Tweed Shire Council	
110D	27/08/2019 0:00	Floodgate	1	0.3			554346	6876426		0.42	Poor	Secondary	Tweed Shire Council	Pipe cracked and in poor condition.
111 left	3/10/2019 10:40	Floodgate	7	1.35			553591	6879336		-0.79	Good	Secondary	Tweed Shire Council	Six of seven floodgates.
111 right	3/10/2019 10:40	Floodgate	7	1.8			553591	6879336		-0.97	Good	Secondary	Tweed Shire Council	One of seven floodgates. Buoyancy tidal gate on the right floodgate flap with an obvert of 0.279 m AHD - dimensions not measured.
111a	24/10/2019 16:40	Weir/ Culvert	3	0.6			550714	6879164			Good	Secondary	Tweed Shire Council	Three 0.6 m diameter culverts flow to a pit 3 m by 0.9 m, water only flows out if upstream water level is higher than pit crest level. Tide can flow upstream

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
														if higher than pit crest level. Measured overflow point (crest level) as 0.524 m AHD.
111B left 1	27/08/2019 0:00	Floodgate	1	0.9			550270	6878714	-0.51		Good	Secondary	Tweed Shire Council	One of six floodgates. Floodgate drains through a residential development.
111B right 1	27/08/2019 0:00	Floodgate	1	0.9			550270	6878714	-0.48		Good	Secondary	Tweed Shire Council	One of six floodgates. Floodgate drains through a residential development.
111B left 2	27/08/2019 0:00	Floodgate	1	0.9			550270	6878714	-0.53		Good	Secondary	Tweed Shire Council	One of six floodgates. Floodgate drains through a residential development.
111B right 2	27/08/2019 0:00	Floodgate	1	0.9			550270	6878714	-0.55		Good	Secondary	Tweed Shire Council	One of six floodgates. Floodgate drains through a residential development.
111B left 3	27/08/2019 0:00	Floodgate	1	0.9			550270	6878714	-0.53		Good	Secondary	Tweed Shire Council	One of six floodgates. Floodgate drains through a residential development.
111B right 3	27/08/2019 0:00	Floodgate	1	0.9			550270	6878714	-0.49		Good	Secondary	Tweed Shire Council	One of six floodgates. Floodgate drains through a residential development.
115	27/08/2019 0:00	Floodgate	1		1.8	1.2	553841	6881020	-0.87		Fair	Secondary	Tweed Shire Council	Weir located approximately 15 m upstream with a circular culvert approximately 0.6 m in diameter underneath it.
116	3/10/2019 10:03	Floodgate	1	0.45			553615	6881040			Fair	Secondary	Tweed Shire Council	Flap not closing properly due to debris. Invert not taken due to poor GPS signal.
119	3/10/2019 10:03	Floodgate	1	0.6			553472	6881070		-0.02	Fair	Secondary	Tweed Shire Council	
121	27/08/2019 0:00	Floodgate	4	1.5			553335	6881118	0.13	-0.87	Good	Secondary	Tweed Shire Council	Large drain. Left culvert invert measured. Left culvert gate winched open. Different structure to the 1970s flood mitigation dataset.
121a	3/10/2019 8:51	Floodgate	1	0.35			553250	6881165			Good	Secondary	Tweed Shire Council	Invert not measured due to poor GPS signal. Invert above 0.441 m AHD.
122	3/10/2019 8:51	Floodgate	1	0.45			553179	6881244		-0.10	Good	Secondary	Tweed Shire Council	
122a	3/10/2019 8:51	Floodgate	1	0.5			553167	6881280		-0.28	Good	Secondary	Tweed Shire Council	Lots of vegetation growth within pipe. The culvert is 0.1 m thick.
123	3/10/2019 8:51	Floodgate	1	0.375			553142	6881323		0.06	Good	Secondary	Tweed Shire Council	The culvert is 0.0625 m thick.
123a	3/10/2019 8:51	Floodgate	1	0.375			553130	6881605		0.14	Poor	Secondary	Tweed Shire Council	Cracks present in the concrete floodgate flap.
123b	3/10/2019 8:38	Floodgate	1	0.45			553133	6881662			Good	Secondary	Tweed Shire Council	Invert not measured due to poor GPS signal. Invert above 0.37 m AHD.
124	3/10/2019 8:38	Floodgate	1	0.45			553132	6881661			Fair	Secondary	Tweed Shire Council	Invert not measured due to poor GPS signal. Invert above 0.37 m AHD.
124a	3/10/2019 8:51	Floodgate	2	0.45			553119	6881452		0.06	Poor	Secondary	Tweed Shire Council	Left gate has no seal and right gate had holes in the flap. The culvert is 0.05 m thick.
124b	3/10/2019 8:51	Floodgate	1	0.75			553120	6881376			Good	Secondary	Tweed Shire Council	
125	3/10/2019 8:38	Floodgate	1	0.45			553128	6881848		0.09	Poor	Secondary	Tweed Shire Council	Floodgate flap had a few cracks near the hinge. There was sand halfway up the floodgate in front of the culvert blocking it.
126	3/10/2019 8:34	Floodgate	1	0.45			553080	6881910		0.02	Good	Secondary	Tweed Shire Council	There was 0.02 m of sand in front of the floodgate.
127	3/10/2019 8:29	Culvert	1	0.45			552999	6881995		0.36	Other	Secondary	Tweed Shire Council	The culvert was broken and half blocked with sand.
127A	27/08/2019 0:00	Floodgate	1	0.4			552917	6882073		0.23	Good	Secondary	Tweed Shire Council	
127a	3/10/2019 8:21	Floodgate	1	0.375			552917	6882073		0.39		Secondary	Tweed Shire Council	

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
127b	3/10/2019 8:18	Floodgate	1	0.45			552882	6882118		-0.06	Good	Secondary	Tweed Shire Council	
128	3/10/2019 13:20	Floodgate	1	0.75			552763	6881631		-0.10		Secondary	Tweed Shire Council	
128a	3/10/2019 13:27	Floodgate	1	0.45			552824	6881685		0.59		Secondary	Tweed Shire Council	
129	3/10/2019 13:34	Floodgate	1	0.9			552708	6881581	0.49	0.49		Secondary	Tweed Shire Council	The culvert is 0.05 m thick.
130	3/10/2019 13:13	Floodgate	1	0.45			552585	6881488		-0.10		Secondary	Tweed Shire Council	The culvert is 0.085 m thick.
131	3/10/2019 13:10	Floodgate	1		1.8	1.2	552549	6881454		-0.82	Good	Secondary	Tweed Shire Council	Invert is approximate.
132	3/10/2019 13:06	Floodgate	1	0.75			552474	6881443		-0.32		Secondary	Tweed Shire Council	Invert is approximate.
133	3/10/2019 13:01	Floodgate	1	0.9			552434	6881437		-0.01	Good	Secondary	Tweed Shire Council	Invert is approximate.
134	3/10/2019 12:56	Floodgate	1	0.45			552372	6881432	0.37	0.37		Secondary	Tweed Shire Council	The culvert is 0.095 m thick.
135	3/10/2019 12:53	Floodgate	1	0.45			552363	6881439		0.22	Fair	Secondary	Tweed Shire Council	
135a	3/10/2019 11:50	Floodgate	1	0.75			552268	6881429		0.18	Good	Secondary	Tweed Shire Council	Poor GPS signal during measurement of invert. Flap has a diameter of 0.9 m.
136	3/10/2019 12:02	Floodgate	1	0.9			552258	6881428		-0.08	Good	Secondary	Tweed Shire Council	
136a	3/10/2019 12:08	Floodgate	1	0.375						0.31		Secondary	Tweed Shire Council	The culvert is 0.0625 m thick.
138	3/10/2019 12:15	Floodgate	1	0.375			552048	6881376		0.06	Fair	Secondary	Tweed Shire Council	The culvert is 0.0625 m thick.
139b	3/10/2019 11:10	Floodgate	2	0.6			551516	6881272		0.32	Fair	Secondary	Tweed Shire Council	Poor GPS signal when measuring the invert. Approximately 0.3m of sediments infilling the base of the culvert.
139c	3/10/2019 11:19	Floodgate	2	0.15			551322	6881267		0.66	Good	Secondary	Tweed Shire Council	
140	30/09/2019 13:46	Floodgate	1		2.4	1.7	535855	6867036	0.03		Fair	Secondary	Tweed Shire Council	Buoyancy tidal gate present (not measured). Could not access the upstream side. Dimensions and invert are approximate.
139 left 1	27/08/2019 0:00	Floodgate	1	0.6			551859	6881317	-0.14		Good	Secondary	Tweed Shire Council	One of four gates. One gate wedged open. Fish upstream. Gate dimensions were different to 1970s flood mitigation dataset.
139 right 1	27/08/2019 0:00	Floodgate	1	0.6			551859	6881317	-0.22		Good	Secondary	Tweed Shire Council	One of four gates. One gate wedged open. Fish upstream. Gate dimensions were different to 1970s flood mitigation dataset.
139 left 2	27/08/2019 0:00	Floodgate	1	0.6			551859	6881317	-0.16		Good	Secondary	Tweed Shire Council	One of four gates. One gate wedged open. Fish upstream. Gate dimensions were different to 1970s flood mitigation dataset.
139 right 2	27/08/2019 0:00	Floodgate	1	0.6			551859	6881317	-0.15		Good	Secondary	Tweed Shire Council	One of four gates. One gate wedged open. Fish upstream. Gate dimensions were different to 1970s flood mitigation dataset.
145	30/09/2019 13:34	Floodgate	1		2.2	1.9	536724	6866962	0.04		Fair	Primary	Tweed Shire Council	Floodgate has a winch. Dimensions are approximate.
146	30/09/2019 13:23	Floodgate	1	0.4			536806	6866932	2.26		Good	Secondary	Tweed Shire Council	
148	30/09/2019 13:12	Floodgate	2		2.5	1.8	537618	6867563	-0.30		Good	Primary	Tweed Shire Council	Buoyancy gate on the right floodgate. Left floodgate has a winch.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
148 buoyancy	30/09/2019 13:17	Floodgate	1		0.5	1	537628	6867554		-0.55	Good		Tweed Shire Council	Buoyance gate for structure 148. Invert and dimensions are approximate.
153	25/02/2020 11:01	Floodgate	2		2.5	1.8	539033	6867519		-0.36	Good	Secondary	Tweed Shire Council	
155	25/02/2020 10:31	Floodgate	2		2.5	1.8	539142	6868064		-0.73	Good	Primary	Tweed Shire Council	Could not access the floodgate. Indicative invert estimated from water level. Dimensions taken from similar nearby gate.
159	30/09/2019 12:53	Floodgate	1	2.52	1.9		538318	6869035	-0.41		Good	Secondary	Tweed Shire Council	The culvert is under a road.
160a	30/09/2019 12:38	Floodgate	1	0.6			538128	6869606	2.08		Good	Secondary	Tweed Shire Council	Culvert is at a high elevation with respect to other structures.
162	25/02/2020 13:37	Floodgate	3		2.5	1.8	538151	6870237	-0.39		Good	Primary	Tweed Shire Council	
165	30/09/2019 11:39	Floodgate	1	0.6			537916	6870449	2.03			Secondary	Tweed Shire Council	Culvert is beside a road.
166	30/09/2019 11:42	Floodgate	1	1.5			537909	6870473	0.24			Secondary	Tweed Shire Council	Culvert is beside a road.
167	30/09/2019 12:10	Floodgate	1		2.6	1.3	537593	6870702		0.27	Good	Secondary	Tweed Shire Council	Culvert is under a road. Large tree inside the culvert. The floodgate was partially open. The invert level was approximate due to a poor GPS signal.
168	30/09/2019 11:24	Culvert	2	1.2			538393	6870454	-0.54		Fair	Primary	Tweed Shire Council	Culvert is under a road. The upstream side of the culvert was underwater.
170 left	30/09/2019 11:09	Floodgate	1	1.5			539471	6870313	-0.25		Good	Primary	Tweed Shire Council	One of three floodgates. Culvert is under a road. The upstream channel is very weedy. The left floodgate is slightly winched open.
170 right	30/09/2019 11:09	Floodgate	1	0.9			539471	6870313	0.26		Good	Primary	Tweed Shire Council	Two of three floodgates. Culvert is under a road. The upstream channel is very weedy. The left floodgate is slightly winched open.
183	30/09/2019 10:49	Floodgate	1	1.5			541089	6870782	-0.65		Fair	Secondary	Tweed Shire Council	Culvert is under a road.
183b	30/09/2019 10:55	Floodgate	1	0.45			541115	6870776	0.87		Good	Secondary	Tweed Shire Council	Culvert is beside a road.
188	30/09/2019 10:34	Floodgate	3		2.4	1.72	541915	6871300	-0.48		Good	Primary	Tweed Shire Council	Culvert under a road. Winch on the middle gate. Evidence of tidal flushing using a small sluice on the left gate.
190	30/09/2019 10:22	Floodgate	1	0.6			542565	6871729	-0.32		Fair	Secondary	Tweed Shire Council	Downstream floodgate was underwater and could not be seen at the time of inspection.
191	30/09/2019 10:14	Floodgate	3		2.45	1.85	542594	6871735	-0.91		Good	Primary	Tweed Shire Council	Winch located on the middle floodgate flap.
192	30/09/2019 9:58	Floodgate	1	1.5			543756	6872361	-0.73		Poor	Secondary	Tweed Shire Council	Old timber floodgate, leaking.
195	25/02/2020 14:24	Floodgate	2		2.5	1.8	543410	6871175	-0.76		Good	Primary	Tweed Shire Council	
199	25/02/2020 14:38	Floodgate	1		2.5	1.8	543960	6871543	-0.70		Good	Primary	Tweed Shire Council	
206	27/08/2019 0:00	Floodgate	2	0.75			550766	6880704		-0.14	Good	Secondary	Tweed Shire Council	Culvert invert is 0.08 m below buoyancy gate invert. Buoyancy tidal gate on right hand floodgate.
206 buoyancy	27/08/2019 0:00	Floodgate	1				550766	6880704		-0.06	Good		Tweed Shire Council	Buoyancy tidal gate for structure 206. Size not measured.
210 left	27/08/2019 0:00	Floodgate	1	0.6			551893	6876049	-0.21		Poor	Secondary	Tweed Shire Council	One of two floodgates. Mangroves upstream, farmer confirmed tide travels upstream of the floodgates.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
210 right	27/08/2019 0:00	Floodgate	1	0.6			551893	6876049	-0.35		Poor	Secondary	Tweed Shire Council	One of two floodgates. Mangroves upstream, farmer confirmed tide travels upstream of the floodgates
211	27/08/2019 0:00	Floodgate	1	0.4			551961	6876044	0.38		Poor	Secondary	Tweed Shire Council	Downstream side blocked with rocks.
211a	24/10/2019 16:08	Floodgate	1	0.375			552134	6876061	0.19	0.18	Fair	Secondary	Tweed Shire Council	Banora Point.
211b	24/10/2019 16:03	Floodgate	1	0.375			552246	6876079	0.37	0.28	Good	Secondary	Tweed Shire Council	Banora Point.
212	24/10/2019 15:49	Floodgate	1	0.375			552388	6876105	0.12		Poor	Secondary	Tweed Shire Council	Banora Point. Flap blocked by sand and wedged slightly open.
212a	24/10/2019 15:40	Floodgate	1	0.375			552509	6876114		0.29	Poor	Secondary	Tweed Shire Council	Banora Point. Flap blocked by sand preventing it from opening. Outer diameter is 0.4 m, assume 0.03 m pipe wall thickness (this is the same dimensions as Structure 212).
213	24/10/2019 15:34	Floodgate	1	0.475			552661	6876142		0.44	Good	Secondary	Tweed Shire Council	Banora Point.
214	27/08/2019 0:00	Floodgate	1	0.53			552721	6876156		0.02		Secondary	Tweed Shire Council	
220	2/10/2019 15:38	Floodgate	1	0.375			554855	6878045		0.22		Secondary	Tweed Shire Council	
221	2/10/2019 15:38	Floodgate	1	0.375			554892	6878086		0.16		Secondary	Tweed Shire Council	
222	2/10/2019 15:54	Floodgate	1	0.375			554912	6878151		0.38		Secondary	Tweed Shire Council	
223	27/08/2019 0:00	Floodgate	1	0.4			554931	6878191		-0.28		Secondary	Tweed Shire Council	
224	2/10/2019 16:06	Floodgate	1	0.45			555029	6878381		-0.04		Secondary	Tweed Shire Council	
225	2/10/2019 16:18	Floodgate	1	0.45			555099	6878519		0.08		Secondary	Tweed Shire Council	
226	2/10/2019 16:18	Floodgate	1	0.375			555121	6878580	0.93		Good	Secondary	Tweed Shire Council	
227	2/10/2019 16:21	Floodgate	1	0.5			555120	6878598		0.12		Secondary	Tweed Shire Council	
228	2/10/2019 16:22	Floodgate	1	0.3			555136	6878621	1.00		Good	Secondary	Tweed Shire Council	
229	2/10/2019 16:24	Floodgate	1	0.3			555145	6878644	0.93		Good	Secondary	Tweed Shire Council	
230	2/10/2019 16:25	Floodgate	1	0.3			555154	6878665	0.93		Fair	Secondary	Tweed Shire Council	
231	2/10/2019 16:26	Floodgate	1	0.3			555161	6878688	0.97		Good	Secondary	Tweed Shire Council	The upstream side of the culvert is partially broken. This is not affecting the floodgate performance.
232	2/10/2019 16:29	Floodgate	1	0.5			555174	6878741		0.21	Good	Secondary	Tweed Shire Council	
233	2/10/2019 16:50	Floodgate	1	0.3			555315	6879228	1.07		Good	Secondary	Tweed Shire Council	
234	2/10/2019 16:51	Floodgate	1	0.3			555321	6879261	1.15		Good	Secondary	Tweed Shire Council	
235	2/10/2019 16:54	Floodgate	1	0.3			555337	6879360	0.93		Good	Secondary	Tweed Shire Council	
236	2/10/2019 16:56	Floodgate	1	0.3			555346	6879404	0.95		Good	Secondary	Tweed Shire Council	

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
237	2/10/2019 16:57	Floodgate	1	0.3			555356	6879458	1.01		Fair	Secondary	Tweed Shire Council	The culvert is presenting cracks and starting to collapse, however the floodgate flap is in good condition.
238	2/10/2019 17:03	Floodgate	1	0.45			555370	6879615		0.03		Secondary	Tweed Shire Council	
239	2/10/2019 17:08	Floodgate	1	0.45			555385	6879772		-0.14	Good	Secondary	Tweed Shire Council	
251	25/10/2019 12:29	Floodgate	3	~1.2			553713	6884022		-0.66	Good	Secondary	Tweed Shire Council	Assumed that culverts had a diameter of 1.2 m - outside of the culverts was 1.5 m in diameter.
251a	25/10/2019 12:44	Floodgate	1	0.45			553703	6882295		0.68	Good	Secondary	Tweed Shire Council	
264	25/10/2019 11:45	Floodgate	1		1.18	0.7	548115	6881832		-0.31	Poor	Secondary	Tweed Shire Council	There is a leak in the side of the culvert. Culverts downstream are under a road; have no flaps and were not surveyed.
264a	25/10/2019 11:59	Floodgate	1	0.4			547637	6881839	-0.02		Good	Secondary	Tweed Shire Council	The upstream was infilled with 0.1 m of silt. The downstream side was underwater at the time of inspection. Flaps working well.
WRL_TW_01	27/08/2019 0:00	Floodgate	1	1			554404	6876495		-1.12	Poor	Secondary	Private/unknown	Dimensions and invert approximate only. Floodgate completely blocked by rocks. Gate leaks but cannot open.
WRL_TW_02	27/08/2019 0:00	Weir					554999	6878273			Good	Secondary	Private/unknown	Rock weir downstream of lake. Crest elevation of lowest point in weir was -0.222 m AHD.
WRL_TW_03	30/09/2019 11:27	Floodgate	1	1.2			538384	6870472	-0.12		Fair	Secondary	Private/unknown	Upstream of structure 168. Within private property.
WRL_TW_04	30/09/2019 12:47	Floodgate	1	0.45			538335	6869020	1.77		Good	Secondary	Private/unknown	Downstream of structure 159 on the right bank.
WRL_TW_05	30/09/2019 12:49	Floodgate	1	0.45			538327	6869051	1.52		Good	Secondary	Private/unknown	Downstream of structure 159 on the left bank.
WRL_TW_06	2/10/2019 12:49	Floodgate	1	0.45			548029	6873044	0.00		Fair	Secondary	Private/unknown	Upstream structure 62.
WRL_TW_07	2/10/2019 17:00	Floodgate	2	0.9			555366	6879518		-0.23		Secondary	Private/unknown	
WRL_TW_08	3/10/2019 8:13	Floodgate	1	0.15			552848	6882169		0.38	Good	Secondary	Private/unknown	
WRL_TW_09	3/10/2019 8:15	Culvert	1	0.375			552857	6882149		0.61	Other	Secondary	Private/unknown	Culvert broken.
WRL_TW_10	25/10/2019 11:13	Culvert	1	0.6			547279	6877801	-0.37		Poor	Secondary	Private/unknown	The downstream side of the culvert is blocked by corrugated metal however water can still leak past it. The culvert has been infilled with silt so there is approximately 0.2 m of freeboard.
WRL_TW_11	7/11/2019 0:00	Floodgate	1	0.6			542048	6865415	-0.13		Good	Secondary	Private/unknown	
WRL_TW_12	7/11/2019 0:00	Sluice gate	1		2.1		541459	6865616		-0.02	Good	Secondary	Private/unknown	Weir with sluice gate which was open at the time of inspection. Structure still acted as a weir when open. Current crest elevation is -0.019 m AHD. Crest elevation when sluice is used becomes 0.586 m AHD.
WRL_TW_13	8/11/2019 0:00	Floodgate	2		0.6	1	539874	6865034		-0.44	Fair	Secondary	Private/unknown	Structure has a pump mounted to it to allow discharge if the tide is high.
WRL_TW_14	8/11/2019 0:00	Floodgate	1	0.8			539935	6865056	-0.07		Good	Secondary	Private/unknown	
WRL_TW_15	25/02/2020 12:25	Floodgate	1	0.9			543253	6871369	-0.50		Good	Primary	Private/unknown	Weir over structure at 1.349 m AHD.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
WRL_TW_17	2/10/2019 12:23	Culvert	1	0.375			547632	6872768	1.69		Poor	Secondary	Private/unknown	Culvert is under a road.
WRL_TW_18	2/10/2019 12:40	Culvert	1	0.375			548013	6872989	0.93		Other	Secondary	Private/unknown	Flap has been removed. Culvert is under a road.

* Structure ID's have been provided by Tweed Shire Council. If a structure was identified that did not have a Tweed Council ID it has been given a WRL ID (WRL_TW_##).

Table F-4: Summary of data collected by Abbott and Marco Land and engineering surveyors and others

Structure ID	Type	# Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Invert (m AHD)	Category	Tenure	Condition	Data source	Comment
5	Floodgate	1	0.45			539176.9	6866435	1.559	Secondary	Tweed Shire Council	Good	Abbott and Macro	No pumping infrastructure observed
6	Floodgate	1	0.3			539177.8	6866439	4.252	Secondary	Tweed Shire Council	Good	Abbott and Macro	
9	Floodgate	1	0.6			539349.9	6866471	3.185	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure located on heavily vegetated bank
11	Floodgate	1	0.45			539122	6865151	3.586	Secondary	Tweed Shire Council	Good	Abbott and Macro	
12	Floodgate	1	0.6			539126	6865358	2.19	Secondary	Tweed Shire Council	Good	Abbott and Macro	
13	Floodgate	1	0.9			539070.7	6865602	-0.027	Secondary	Tweed Shire Council	Good	Abbott and Macro	Floodgates 13 and 13A are located in a shared headwall, recent rock work has been completed
18		1	0.45			539562.2	6866485	0.961	Secondary	Tweed Shire Council	Good	Abbott and Macro	
19	Floodgate	1	0.6			539734.2	6866569	0.764	Secondary	Tweed Shire Council	Good	Abbott and Macro	
20	Floodgate	1	0.9			540015	6866689	0.494	Secondary	Tweed Shire Council	Good	Abbott and Macro	
21	Floodgate	1	0.45			540031.2	6866791	2.177	Secondary	Tweed Shire Council	Good	Abbott and Macro	
22	Floodgate	1	0.45			540033.3	6866811	2.168	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure outlet is heavily overgrown
23	Floodgate	1	0.6			539939.3	6866882	1.793	Secondary	Tweed Shire Council	Good	Abbott and Macro	
24	Floodgate	1	0.9			539853.8	6866943	1.273	Secondary	Tweed Shire Council	Good	Abbott and Macro	
25	Floodgate	1	0.9			539831.8	6867018	1.589	Secondary	Tweed Shire Council	Good	Abbott and Macro	
35	Floodgate	1	0.9			545246	6870643	-0.698	Secondary	Tweed Shire Council	Good	Abbott and Macro	
36	Floodgate	1	0.6			545271.6	6870806	-0.476	Secondary	Tweed Shire Council	Good	Abbott and Macro	
39	Floodgate	1	0.45			545305.3	6871532	0.797	Secondary	Tweed Shire Council	Good	Abbott and Macro	Erosion observed under the structure headwall, ballast required to stabilise
51	Floodgate	1	0.375			546276.1	6872764	1.201	Secondary	Tweed Shire Council	Good	Abbott and Macro	
64	Floodgate	1	1.2			548519	6873390	-1.104	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure has a custom headwall
65	Floodgate	1	0.3			548798.8	6873302	0.488	Secondary	Tweed Shire Council	Fair	Abbott and Macro	Floodgate blocked with silt
66	Floodgate	1	0.45			548928.7	6873307	-0.543	Secondary	Tweed Shire Council	Good	Abbott and Macro	There is a private road on the levee this structure is located in
69	Floodgate	1	0.9			546075.5	6872513	-0.705	Secondary	Tweed Shire Council	Fair	Abbott and Macro	Floodgate is silted up, has no seal and is not closing. Erosion observed around the structure headwall
70	Floodgate	1	0.6			546239.1	6872519	-0.571	Secondary	Tweed Shire Council	Other	Abbott and Macro	The headwall and floodgate of this structure have collapsed into the river
72	Floodgate	1	0.9			546743.4	6872595	-0.658	Secondary	Tweed Shire Council	Good	Abbott and Macro	Minor silting observed at the base of the floodgate
73	Floodgate	1	0.9			546873	6872568	-0.881	Secondary	Tweed Shire Council	Fair	Abbott and Macro	Floodgate is blocked with silt with about ¾ of the floodgate buried
74	Floodgate	1	0.9			547157.7	6872479	-0.559	Secondary	Tweed Shire Council	Good	Abbott and Macro	
77	Floodgate	1	1.5			548118	6872142	-0.784	Secondary	Tweed Shire Council	Good	Abbott and Macro	
81	Floodgate	1	0.45			549803.1	6872428	-0.607	Secondary	Tweed Shire Council	Poor	Abbott and Macro	Floodgate is blocked with silt and stuck open
84	Floodgate	1	0.375			549884.9	6872834	-0.076	Secondary	Tweed Shire Council	Good	Abbott and Macro	
85	Floodgate	1	0.6			549944.9	6872956	0.033	Secondary	Tweed Shire Council	Good	Abbott and Macro	
89	Floodgate	1	1.5			550716.1	6874292	-1.202	Secondary	Tweed Shire Council	Good	Abbott and Macro	
90	Floodgate	1	1.5			550722.9	6874625	-0.335	Secondary	Tweed Shire Council	Good	Abbott and Macro	
91	Floodgate	1	0.6			550736.2	6875228	0.078	Secondary	Tweed Shire Council	Good	Abbott and Macro	
93	Floodgate	1		2.4	2.1	551297.3	6875357	-0.942	Secondary	Tweed Shire Council	Good	Abbott and Macro	
94	Floodgate	1	1.2			551668.3	6875484	-0.617	Secondary	Tweed Shire Council	Good	Abbott and Macro	

Structure ID	Type	# Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Invert (m AHD)	Category	Tenure	Condition	Data source	Comment
95	Floodgate	1	0.6			551867.2	6875443	0.12	Secondary	Tweed Shire Council	Good	Abbott and Macro	
96	Floodgate	1	1.2			552056.1	6875300	-0.514	Secondary	Tweed Shire Council	Good	Abbott and Macro	
97	Floodgate	1	0.9			552258.7	6875271	-0.568	Secondary	Tweed Shire Council	Good	Abbott and Macro	
99	Floodgate	1	0.9			552424.6	6875277	-0.352	Secondary	Tweed Shire Council	Good	Abbott and Macro	
116	Floodgate	1	0.45			553624.3	6881049	0.176	Secondary	Tweed Shire Council	Fair	Abbott and Macro	Floodgate is blocked with silt and stuck open
124	Floodgate	1	0.45			553136.2	6881670	0.419	Secondary	Tweed Shire Council	Good	Abbott and Macro	
141	Floodgate	1	0.6			536218.5	6866604	2.686	Secondary	Tweed Shire Council	Good	Abbott and Macro	Minor silting observed at the base of the floodgate
142	Floodgate	1	0.6			536532	6866612	2.215	Secondary	Tweed Shire Council	Poor	Abbott and Macro	Floodgate is blocked and buried in silt
143	Floodgate	1	1.2			536595.5	6866681	1.512	Secondary	Tweed Shire Council	Good	Abbott and Macro	Floodgate is located on internal levee bank
144	Floodgate	1	0.45			536672.2	6866861	2.729	Secondary	Tweed Shire Council	Good	Abbott and Macro	Minor silting observed at the base of the floodgate
147	Floodgate	1	0.9			536861.7	6866840	0.859	Secondary	Tweed Shire Council	Good	Abbott and Macro	
150	Floodgate	1		2.4	2.1	538472.7	6868427	-0.539	Secondary	Tweed Shire Council	Good	Abbott and Macro	
151	Floodgate	1	0.45			538578.6	6868548	2.003	Secondary	Tweed Shire Council	Good	Abbott and Macro	
152	Floodgate	1	0.375			539923.7	6867312	1.011	Secondary	Tweed Shire Council	Poor	Abbott and Macro	Floodgate is partially buried, stuck open and overgrown with vegetation
154	Culvert	1	1.2			539044.9	6867912	-0.912	Secondary	Tweed Shire Council	Other	Abbott and Macro	Floodgate has been removed, hinges still present
158	Floodgate	1	0.45			538461.2	6868911	2.386	Secondary	Tweed Shire Council	Good	Abbott and Macro	
160	Floodgate	1	0.6			538226.1	6869489	0.76	Secondary	Tweed Shire Council	Good	Abbott and Macro	
161	Floodgate	1		2.4	2.1	538134.2	6869875	-0.759	Secondary	Tweed Shire Council	Good	Abbott and Macro	
163	Floodgate	1	0.6			538179.8	6870136	0.87	Secondary	Tweed Shire Council	Good	Abbott and Macro	Area downstream of the structure is overgrown
164	Floodgate	1	0.45			538221.5	6870367	1.446	Secondary	Tweed Shire Council	Good	Abbott and Macro	The weed 'Singapore Daisy' was observed to be growing on the downstream side of the structure
169	Floodgate	1	1.2			539300.7	6870387	-0.121	Secondary	Tweed Shire Council	Fair	Abbott and Macro	Structure has a custom headwall and the rubber seal was seen to be falling off
172	Floodgate	1	0.6			539583.6	6870131	0.077	Secondary	Tweed Shire Council	Good	Abbott and Macro	
174	Floodgate	1	0.6			539680.8	6870068	0.11	Secondary	Tweed Shire Council	Good	Abbott and Macro	
175	Floodgate	1	0.6			539938.3	6870067	0.604	Secondary	Tweed Shire Council	Good	Abbott and Macro	
176	Floodgate	1	0.6			540055.3	6870069	0.245	Secondary	Tweed Shire Council	Good	Abbott and Macro	
179	Floodgate	1	0.9			540486	6870172	0.035	Secondary	Tweed Shire Council	Good	Abbott and Macro	
182	Floodgate	1	0.6			540815.8	6870553	0.035	Secondary	Tweed Shire Council	Good	Abbott and Macro	
184	Culvert	1	0.6			541365.9	6870799	0.667	Secondary	Tweed Shire Council	Good	Abbott and Macro	
185	Floodgate	1	0.6			541539.2	6870880	0.047	Secondary	Tweed Shire Council	Good	Abbott and Macro	Lots of plant growth was observed around the headwall
186	Floodgate	1	0.6			541659.3	6870989	0.396	Secondary	Tweed Shire Council	Good	Abbott and Macro	
193	Floodgate	1	0.6			542784.7	6871015	0.111	Secondary	Tweed Shire Council	Good	Abbott and Macro	
196	Floodgate	1	1.5			543789.8	6871398	-0.345	Secondary	Tweed Shire Council	Good	Abbott and Macro	An old structure is located downstream of this structure
197	Floodgate	1	1.5			543856.8	6871433	-0.513	Secondary	Tweed Shire Council	Good	Abbott and Macro	
198	Floodgate	1	0.6			543915	6871514	0.771	Secondary	Tweed Shire Council	Good	Abbott and Macro	
201	Floodgate	1	0.6			544145.8	6872454	-0.016	Secondary	Tweed Shire Council	Good	Abbott and Macro	
202	Floodgate	1	0.9			544733.6	6872511	-0.841	Secondary	Tweed Shire Council	Good	Abbott and Macro	

Structure ID	Type	# Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Invert (m AHD)	Category	Tenure	Condition	Data source	Comment
203	Floodgate	1	0.6			544735.6	6872467	-0.159	Secondary	Tweed Shire Council	Good	Abbott and Macro	
204	Culvert	1	0.6			544931.1	6872232	0.21	Secondary	Tweed Shire Council	Fair	Abbott and Macro	Floodgate flap has fallen off this structure
252	Floodgate	1		2	1.6	551173.5	6881809	-0.897	Secondary	Tweed Shire Council	Good	Abbott and Macro	
253	Floodgate	1	0.45			550606.3	6881770	-0.045	Secondary	Tweed Shire Council	Good	Abbott and Macro	
254	Floodgate	1		3.6	2.1	537788.1	6866851	-0.192	Secondary	Tweed Shire Council	Good	Abbott and Macro	Floodgate has a winch and was winched open at the time of survey
255	Floodgate	1	1.2			538075.7	6866463	1.69	Secondary	Tweed Shire Council	Good	Abbott and Macro	Floodgate is located in a semi-open pit
256	Floodgate	1	1.2			537788.4	6866493	0.166	Secondary	Tweed Shire Council	Good	Abbott and Macro	
502	Floodgate	1	1.5			539031.6	6866273	-0.612	Secondary	Tweed Shire Council	Good	Abbott and Macro	
503	Floodgate	1	0.3			538914.8	6865682	1.127	Secondary	Tweed Shire Council	Poor	Abbott and Macro	River bank has collapsed and the pipe is broken
100	Floodgate	1		1.8	1.5	552645	6875351	-0.688	Primary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 5 culverts with floodgates
100	Floodgate	1		1.8	1.5	552643.5	6875350	-0.711	Primary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 5 culverts with floodgates
100	Floodgate	1		1.8	1.5	552641.7	6875350	-0.707	Primary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 5 culverts with floodgates. This floodgate has a working tidal sluice installed on it
100	Floodgate	1		1.8	1.5	552639.8	6875349	-0.714	Primary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 5 culverts with floodgates
100	Floodgate	1	0.3			552638.3	6875348	-0.543	Primary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 5 culverts with floodgates
107	Floodgate	1	0.45			553772.1	6876042	0.084	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates. Lots of flood debris was observed in the downstream channel
107	Floodgate	1	0.45			553772.6	6876042	0.135	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates. Lots of flood debris was observed in the downstream channel
111C	Floodgate	1	0.9			552497.3	6878644	1.233	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure has pumping infrastructure on the upstream side
111D	Floodgate	1	1.5			553980.7	6879872	-0.875	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates and has been modified with a small tidal sluice
111D	Floodgate	1	1.5			553980.4	6879874	-0.875	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates and has been modified with a small tidal sluice
111E	Floodgate	1	1.2			553883	6879796	-0.835	Secondary	Tweed Shire Council	Good	Abbott and Macro	
111E	Floodgate	1	1.2			553883.6	6879797	-0.835	Secondary	Tweed Shire Council	Good	Abbott and Macro	
111F	Floodgate	1	0.6			552552.5	6878776	0.839	Secondary	Tweed Shire Council	Good	Abbott and Macro	
115B	Floodgate	1	0.45			553992.6	6880597	0.354	Secondary	Tweed Shire Council	Good	Abbott and Macro	
121A	Floodgate	1	0.45			553252	6881169	0.809	Secondary	Tweed Shire Council	Good	Abbott and Macro	
123B	Floodgate	1	0.45			553135.4	6881664	0.459	Secondary	Tweed Shire Council	Good	Abbott and Macro	
124B	Floodgate	1	0.9			553126.1	6881378	0.009	Secondary	Tweed Shire Council	Good	Abbott and Macro	
136A	Floodgate	1	0.375			552215.2	6881427	0.101	Secondary	Private/Unknown	Good	Abbott and Macro	
137	Floodgate	1	0.45			552145.2	6881409	-0.336	Secondary	Tweed Shire Council	Good	Abbott and Macro	
139A	Culvert	1	0.6			551675.8	6881362	-0.54	Secondary	Tweed Shire Council	Poor	Abbott and Macro	Structure is 1 of 2 culverts, this culvert has no floodgates and is cracked
139A	Floodgate	1	0.6			551676.6	6881362	-0.508	Secondary	Tweed Shire Council	Fair	Abbott and Macro	Structure is 1 of 2 culverts, this culvert has a floodgate that is blocked with oysters
13A	Floodgate	1	0.45			539070.9	6865601	0.014	Secondary	Tweed Shire Council	Good	Abbott and Macro	
144A	Floodgate	1	0.45			536694.4	6866901	2.516	Secondary	Tweed Shire Council	Good	Abbott and Macro	

Structure ID	Type	# Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Invert (m AHD)	Category	Tenure	Condition	Data source	Comment
149	Floodgate	1	1.2			538263	6867893	0.189	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
149	Floodgate	1	1.2			538263.8	6867894	1.214	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
15	Floodgate	1	0.6			539046.2	6866021	0.045	Secondary	Tweed Shire Council	Good	Abbott and Macro	The bank around this structure has been rock armored. Structure is 1 of 2 floodgates on twin pipes flowing into a concrete box
15	Floodgate	1	0.6			539045.9	6866020	0.014	Secondary	Tweed Shire Council	Good	Abbott and Macro	The bank around this structure has been rock armored. Structure is 1 of 2 floodgates on twin pipes flowing into a concrete box
151A	Floodgate	1	0.45			538554.7	6868707	1.496	Secondary	Tweed Shire Council	Good	Abbott and Macro	
155	Floodgate	1		2.4	1.8	539159.2	6868069	-0.519	Primary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates. The downstream area is overgrown
155	Floodgate	1		2.4	1.8	539159.1	6868071	-0.506	Primary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates. The downstream area is overgrown
168A	Floodgate	1	0.45			538708	6870024	-0.209	Secondary	Private/Unknown	Good	Abbott and Macro	Structure is 1 of 2 floodgates
168A	Floodgate	1		2.4	2.1	538706.3	6870024	-0.702	Secondary	Private/Unknown	Good	Abbott and Macro	Structure is 1 of 2 floodgates, this floodgate has an old winch that is not working
168B	Floodgate	1	0.45			538520.8	6870169	1.019	Secondary	Private/Unknown	Poor	Abbott and Macro	The floodgate on this structure is completely buried in silt and debris. The upstream invert was used
168C	Floodgate	1	0.6			538489	6870217	0.896	Secondary	Private/Unknown	Good	Abbott and Macro	Silting observed at the base of the floodgate
171	Floodgate	1	0.6			539548	6870057	-0.764	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
171	Floodgate	1		2.4	2.1	539546.1	6870057	-0.669	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
171A	Floodgate	1	0.45			539277.1	6870223	2.574	Secondary	Private/Unknown	Good	Abbott and Macro	
173	Floodgate	1	0.45			539878.4	6869960	-0.626	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 3 floodgates
173	Floodgate	1	1.5			539879.7	6869961	-0.268	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 3 floodgates
173	Floodgate	1	1.5			539881.6	6869962	-0.306	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 3 floodgates, this floodgate has been modified with a working tidal sluice
177	Floodgate	1		1.6	1.8	540225.7	6869985	-0.666	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
177	Floodgate	1	0.45			540227.2	6869985	-0.519	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
178	Floodgate	1	0.6			540408.2	6870131	-0.443	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
178	Floodgate	1	1.5			540407.3	6870131	-0.569	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
17C	Floodgate	1	0.6			539648.3	6866352	2.109	Secondary	Tweed Shire Council	Good	Abbott and Macro	
17D	Floodgate	1	0.45			539870.1	6866423	2.184	Secondary	Tweed Shire Council	Poor	Abbott and Macro	The floodgate flap on this structure has snapped at the hinge and needs repair
17E	Floodgate	1	0.45			539917.1	6866444	2.407	Secondary	Tweed Shire Council	Good	Abbott and Macro	
17L	Floodgate	1	1.85			540547.5	6866625	-0.487	Primary	Tweed Shire Council		Abbott and Macro	Data provided by Tweed Shire Council
17M	Floodgate	1	0.375			540838.4	6866933	0.416	Secondary	Tweed Shire Council	Good	Abbott and Macro	
17O	Floodgate	1	0.45			541415.7	6867169	2.398	Secondary	Private/Unknown	Good	Abbott and Macro	
17X	Floodgate	1	0.45			540170.3	6866599	2.616	Secondary	Tweed Shire Council	Poor	Abbott and Macro	The floodgate flap on this structure is broken and the bank is collapsing around the pipe
180	Floodgate	1	1.5			540525	6870132	-0.832	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
180	Floodgate	1	0.6			540525.8	6870132	-0.759	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
181	Floodgate	1	0.6			540867	6870433	-0.742	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates

Structure ID	Type	# Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Invert (m AHD)	Category	Tenure	Condition	Data source	Comment
181	Floodgate	1		1.8	1.8	540866.4	6870432	-0.806	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates, this floodgate has been modified with a working tidal sluice
187	Floodgate	1	1.5			541728.8	6870927	-0.925	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 3 floodgates
187	Floodgate	1	1.5			541730.4	6870929	-0.925	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 3 floodgates, this floodgate has been modified with a working tidal sluice
187	Floodgate	1	0.6			541727.5	6870926	-0.951	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 3 floodgates
189	Floodgate	1	1.5			542442.6	6871049	-0.964	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates, this floodgate has a strap attached to it by a farmer
189	Floodgate	1	0.6			542443.7	6871049	-0.948	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
18A	Floodgate	1	0.375			539643.8	6866522	0.046	Secondary	Tweed Shire Council	Good	Abbott and Macro	
190A	Floodgate	1	0.9			542577.5	6871596	-0.068	Secondary	Tweed Shire Council	Good	Abbott and Macro	
190B	Floodgate	1	0.45			542518.8	6871239	0.266	Secondary	Tweed Shire Council	Good	Abbott and Macro	
194	Floodgate	1	0.6			542928	6870992	-0.936	Secondary	Tweed Shire Council	Fair	Abbott and Macro	Structure is 1 of 2 floodgates, corrosion observed on the floodgate flap
194	Floodgate	1		1.8	1.8	542926.9	6870994	-0.992	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
200	Floodgate	1	0.45			544136	6872151	-0.25	Secondary	Tweed Shire Council	Fair	Abbott and Macro	Structure is 1 of 2 floodgates, both gates are silted up and not opening
200	Floodgate	1	1.5			544135.9	6872152	-0.15	Secondary	Tweed Shire Council	Fair	Abbott and Macro	Structure is 1 of 2 floodgates, both gates are silted up and not opening
205	Floodgate	1	0.6			544779.3	6872363	-0.749	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
205	Floodgate	1		1.8	1.8	544778.4	6872364	-0.761	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates, this floodgate has been modified with a tidal gate
20A	Floodgate	1	0.45			539781.2	6866577	0.146	Secondary	Tweed Shire Council	Good	Abbott and Macro	
239A	Floodgate	1	0.375			555468.6	6879979	0.362	Secondary	Tweed Shire Council	Good	Abbott and Macro	Erosion observed behind structure headwall
252A	Floodgate	1	0.45			552033.7	6881993	-0.307	Secondary	Tweed Shire Council	Fair	Abbott and Macro	Floodgate is stuck open with silt
253A	Floodgate	1	0.45			550254.9	6881720	-0.582	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
253A	Floodgate	1	0.45			550255.6	6881720	-0.634	Secondary	Tweed Shire Council	Fair	Abbott and Macro	Structure is 1 of 2 floodgates, this floodgate is stuck open with silt
27	Floodgate	1		2.4	1.8	542504.9	6867698	-0.36	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 4 floodgates
27	Floodgate	1		2.4	1.8	542506.9	6867700	-0.345	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 4 floodgates, this floodgate has been modified with a working tidal sluice
27	Floodgate	1		2.4	1.8	542508.7	6867701	-0.359	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 4 floodgates
27	Floodgate	1	0.6			542509.8	6867703	-0.23	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 4 floodgates
27A	Floodgate	1	0.375			542626.4	6868621	1.218	Secondary	Tweed Shire Council	Good	Abbott and Macro	Floodgate is being held open by debris
27C	Floodgate	1	0.375			542562.4	6868458	0.587	Secondary	Tweed Shire Council	Good	Abbott and Macro	
28	Floodgate	1	0.45			542362.1	6868560	-0.232	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 4 floodgates
28	Floodgate	1		2.4	1.8	542361.5	6868558	-0.684	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 4 floodgates
28	Floodgate	1		2.4	1.8	542360.6	6868555	-0.681	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 4 floodgates, this floodgate has been modified with a working tidal sluice
28	Floodgate	1		2.4	1.8	542359.7	6868553	-0.679	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 4 floodgates
28A	Floodgate	1	0.375			543100.7	6869257	2.867	Secondary	Tweed Shire Council	Good	Abbott and Macro	
28B	Floodgate	1	0.45			543297.6	6869472	1.601	Secondary	Tweed Shire Council	Good	Abbott and Macro	
28C	Floodgate	1	0.45			543429.7	6869537	1.357	Secondary	Tweed Shire Council	Good	Abbott and Macro	

Structure ID	Type	# Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Invert (m AHD)	Category	Tenure	Condition	Data source	Comment
31A	Floodgate	1	0.45			544470.5	6869683	1.553	Secondary	Tweed Shire Council	Good	Abbott and Macro	
32	Floodgate	1		2.4	1.8	544600.5	6869651	-0.596	Primary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 4 floodgates, this floodgate has been modified with a working tidal sluice
32	Floodgate	1		2.4	1.8	544599	6869649	-0.591	Primary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 4 floodgates
32	Floodgate	1		2.4	1.8	544597.6	6869646	-0.597	Primary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 4 floodgates
32	Floodgate	1		2.4	1.8	544596.1	6869644	-0.591	Primary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 4 floodgates
39G	Floodgate	1	0.375			545412.7	6872625	0.289	Secondary	Tweed Shire Council	Poor	Abbott and Macro	Floodgate is stuck open with silt
39H	Floodgate	1	0.375			545446.2	6872646	0.397	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure headwall is cracked
39X	Floodgate	1	0.375			545177.8	6871989	1.109	Secondary	Tweed Shire Council	Good	Abbott and Macro	
3A	Floodgate	1	0.375			538941.8	6866044	2.755	Secondary	Tweed Shire Council	Good	Abbott and Macro	
50A	Floodgate	1	0.9			546242.9	6872765	-0.339	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
50A	Floodgate	1	0.9			546244.4	6872766	-0.347	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
5A	Floodgate	1	0.375			539137.2	6866407	-0.44	Secondary	Tweed Shire Council	Good	Abbott and Macro	
5B	Floodgate	1	0.225			539160.2	6866427	2.76	Secondary	Tweed Shire Council	Good	Abbott and Macro	
66A	Floodgate	1	0.45			548927.3	6873354	0.213	Secondary	Tweed Shire Council	Good	Abbott and Macro	
66R	Floodgate	1	0.45			548927	6873437	0.249	Secondary	Tweed Shire Council	Good	Abbott and Macro	
67	Floodgate	1	1.5			548992	6874119	-0.72	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 3 floodgates, all with working winches.
67	Floodgate	1	1.5			548992	6874117	-0.707	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 3 floodgates, all with working winches. This floodgate also has been modified with a working tidal sluice
67	Floodgate	1	1.5			548992	6874114	-0.739	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 3 floodgates, all with working winches.
71	Floodgate	1	1.5			546691.2	6872598	-0.817	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 3 floodgates
71	Floodgate	1	1.5			546693.3	6872598	-0.822	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 3 floodgates
71	Floodgate	1	1.5			546695.3	6872598	-0.784	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 3 floodgates
80	Floodgate	1		2.4	1.8	549605.7	6872287	-0.998	Primary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 6 floodgates
80	Floodgate	1		2.4	1.8	549603.1	6872286	-0.998	Primary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 6 floodgates
80	Floodgate	1		2.4	1.8	549600.4	6872285	-0.998	Primary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 6 floodgates
80	Floodgate	1		2.4	1.8	549597.3	6872285	-0.998	Primary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 6 floodgates, this floodgate has been modified with a working tidal sluice
80	Floodgate	1		2.4	1.8	549594.6	6872284	-0.998	Primary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 6 floodgates
80	Floodgate	1		2.4	1.8	549592	6872283	-0.998	Primary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 6 floodgates
82	Floodgate	1	1.5			549882.4	6872303	-1.116	Secondary	Tweed Shire Council	Fair	Abbott and Macro	Structure is 1 of 4 floodgates, all floodgates badly corroded below the tidal line
82	Floodgate	1	1.5			549883.5	6872301	-1.116	Secondary	Tweed Shire Council	Fair	Abbott and Macro	Structure is 1 of 4 floodgates, all floodgates badly corroded below the tidal line
82	Floodgate	1	1.5			549884.7	6872300	-1.116	Secondary	Tweed Shire Council	Fair	Abbott and Macro	Structure is 1 of 4 floodgates, all floodgates badly corroded below the tidal line
82	Floodgate	1	1.5			549885.9	6872298	-1.116	Secondary	Tweed Shire Council	Fair	Abbott and Macro	Structure is 1 of 4 floodgates, all floodgates badly corroded below the tidal line
83	Floodgate	1	0.45			549841.4	6872602	-0.621	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates

Structure ID	Type	# Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Invert (m AHD)	Category	Tenure	Condition	Data source	Comment
83	Floodgate	1	0.9			549841.5	6872603	-0.792	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates, there is a tractor pump upstream
14	Floodgate	1	0.9			539043.8	6865814	-0.048	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 3 floodgates
14	Floodgate	1	0.9			539043.5	6865812	-0.05	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 3 floodgates
14	Floodgate	1	0.9			539043.3	6865811	-0.03	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 3 floodgates
86	Floodgate	1		2.4	2.1	550129.6	6873273	-1.075	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates, there are winches installed on both floodgates
86	Floodgate	1		2.4	2.1	550132.1	6873274	-1.291	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates, there are winches installed on both floodgates
88	Floodgate	1		2.4	2.1	550638.7	6873982	-1.25	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
88	Floodgate	1		2.4	2.1	550637.9	6873979	-1.276	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
8A	Floodgate	1	0.9			539293.5	6866478	0.574	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
8A	Floodgate	1	0.9			539294.5	6866478	0.569	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
91A	Floodgate	1	0.45			550710.3	6875188	0.18	Secondary	Tweed Shire Council	Good	Abbott and Macro	
92	Floodgate	1	1.5			550964.5	6875298	-1.098	Secondary	Tweed Shire Council	Fair	Abbott and Macro	Structure is 1 of 2 floodgates. Both floodgates have flaps in good condition but hinges in poor condition. Some erosion was observed around the headwall.
92	Floodgate	1	1.5			550962.2	6875297	-1.077	Secondary	Tweed Shire Council	Fair	Abbott and Macro	Structure is 1 of 2 floodgates. Both floodgates have flaps in good condition but hinges in poor condition. Some erosion was observed around the headwall.
96A	Floodgate	1	0.375			551917.1	6875351	0.598	Secondary	Tweed Shire Council	Good	Abbott and Macro	
UNK04	Culvert	1	0.9			538020.2	6870946	-0.152	Secondary	Private/unknown	Fair	Abbott and Macro	Structure is 1 of 3 culverts
UNK04	Culvert	1	0.9			538018.9	6870946	-0.3	Secondary	Private/unknown	Fair	Abbott and Macro	Structure is 1 of 3 culverts
UNK04	Culvert	1	0.9			538017.6	6870946	-0.245	Secondary	Private/unknown	Fair	Abbott and Macro	Structure is 1 of 3 culverts
26	Floodgate	1	1.2			539567.5	6867114	1.256	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
26	Floodgate	1	1.2			539570.1	6867114	1.197	Secondary	Tweed Shire Council	Good	Abbott and Macro	Structure is 1 of 2 floodgates
26A	Floodgate	1	0.75			539557	6867117	1.938	Secondary	Tweed Shire Council	Good	Abbott and Macro	
26B	Floodgate	1	0.45			539519.5	6867119	2.743	Secondary	Tweed Shire Council	Good	Abbott and Macro	
SML1	Floodgate	1	0.225			539590.4	6866510	3.422	Secondary	Tweed Shire Council	Good	Abbott and Macro	
SML2	Floodgate	1	0.25			539632.5	6866534	3.616	Secondary	Private/Unknown	Good	Abbott and Macro	
SML3	Floodgate	1	0.3			539673.9	6866556	3.668	Secondary	Tweed Shire Council	Good	Abbott and Macro	
SML4	Floodgate	1	0.25			539730.3	6866583	3.832	Secondary	Tweed Shire Council	Good	Abbott and Macro	
SML5	Floodgate	1	0.3			539800.1	6866617	3.069	Secondary	Tweed Shire Council	Good	Abbott and Macro	
UNK01	Culvert	1	0.6			538920.3	6863883	0.565	Secondary	Private/unknown	Fair	Abbott and Macro	No floodgates observed
UNK03	Culvert	1	0.6			538926.6	6868619	0.439	Secondary	Private/unknown	Good	Abbott and Macro	No floodgates observed
UNK06	Floodgate	1		1.2	1.5	536444.8	6866479	1.942	Secondary	Private/unknown	Good	Abbott and Macro	Structure is 1 of 2 floodgates
UNK06	Floodgate	1	0.9			536449.8	6866470	0.499	Secondary	Private/unknown	Good	Abbott and Macro	Structure is 1 of 2 floodgates
UNK08	Culvert	1	0.9			535270.3	6865854	0.7	Secondary	Private/unknown	Good	Abbott and Macro	No floodgates observed
UNK09	Floodgate	1	0.45			542906.3	6871397	-0.192	Secondary	Private/unknown	Good	Abbott and Macro	
UNK10	Floodgate	1	0.9			542810.3	6871389	-0.484	Secondary	Private/unknown	Good	Abbott and Macro	
UNK11	Floodgate	1	0.375			543087.4	6871288	0.483	Secondary	Private/unknown	Good	Abbott and Macro	
UNK12	Culvert	1		1	1	544141.8	6872908	-0.366	Secondary	Private/unknown	Other	Abbott and Macro	Structure is a culvert but a new floodgate was observed laying next to the structure, ready to be installed

Structure ID	Type	# Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Invert (m AHD)	Category	Tenure	Condition	Data source	Comment
UNK13	Floodgate	1	0.9			549232	6873350	-1.021	Secondary	Private/unknown	Good	Abbott and Macro	
UNK14	Floodgate	1	0.9			549611.6	6873449	-1.085	Secondary	Private/unknown	Good	Abbott and Macro	Floodgate is very overgrown with grass
UNK15	Floodgate	1	0.3			548814.3	6877406	-0.12	Secondary	Private/unknown	Good	Abbott and Macro	
UNK16	Floodgate	1	0.6			548668	6877304	-0.345	Secondary	Private/unknown	Good	Abbott and Macro	
UNK17	Floodgate	1	0.9			548433.9	6877113	-0.411	Secondary	Private/unknown	Good	Abbott and Macro	
UNK18	Floodgate	1	0.6			548103.5	6876992	-0.298	Secondary	Private/unknown	Good	Abbott and Macro	
UNK19	Floodgate	1	0.375			548717.9	6877314	-0.22	Secondary	Private/unknown	Fair	Abbott and Macro	Bad erosion observed around the structure, however it is not stopping the tide
UNK20	Floodgate	1	0.6			548697.7	6877995	-0.089	Primary	Private/unknown	Good	Abbott and Macro	
UNK21	Floodgate	1	0.375			548585.3	6877950	-0.091	Secondary	Private/unknown	Good	Abbott and Macro	
UNK22	Floodgate	1	0.45			548471	6877906	-0.45	Secondary	Private/unknown	Good	Abbott and Macro	
UNK23	Culvert	1	0.45			548036.9	6877710	-0.372	Primary	Private/unknown	Fair	Abbott and Macro	No floodgates observed
UNK24	Floodgate	1	0.6			547854.9	6877709	-0.535	Secondary	Private/unknown	Good	Abbott and Macro	
UNK25	Culvert	1				547141.4	6877779	0	Primary	Private/unknown	Other	Abbott and Macro	No floodgates observed, pipe is buried
UNK26	Floodgate	1	0.9			546943.6	6877669	-0.032	Secondary	Private/unknown	Good	Abbott and Macro	
UNK27	Culvert	1	0.9			546318.4	6877751	-0.135	Secondary	Private/unknown	Fair	Abbott and Macro	No floodgates observed
UNK30	Floodgate	1	1.2			548060.7	6882278	-0.507	Primary	Private/unknown	Poor	Abbott and Macro	Structure is 1 of 2 floodgates, both are rusty and need repair
UNK30	Floodgate	1	1.2			548059.5	6882277	-0.507	Primary	Private/unknown	Poor	Abbott and Macro	Structure is 1 of 2 floodgates, both are rusty and need repair
UNK31	Floodgate	1	0.75			547613.5	6881970	-0.593	Secondary	Private/unknown	Good	Abbott and Macro	Structure is 1 of 2 floodgates
UNK31	Floodgate	1	0.75			547613.2	6881969	-0.593	Secondary	Private/unknown	Good	Abbott and Macro	Structure is 1 of 2 floodgates
UNK32	Floodgate	1	0.6			547320.3	6881545	-0.283	Secondary	Private/unknown	Good	Abbott and Macro	
UNK33	Floodgate	1	0.275			546795.7	6881393	0.31	Primary	Private/unknown	Fair	Abbott and Macro	Floodgate is blocked and stuck open
UNK34	Floodgate	1	0.6			547430	6881650	-0.098	Secondary	Private/unknown	Good	Abbott and Macro	
UNK36	Floodgate	1	0.75			548974.9	6874109	-0.416	Secondary	Private/unknown	Good	Abbott and Macro	
UNK37	Floodgate	1		1.5	1.5	550004.9	6877772	-0.769	Secondary	Private/unknown	Good	Abbott and Macro	
Bray Park Weir	Weir			80		536749.85	6864570.34	1	Primary	Tweed Shire Council		WRL 2017	
WRL_TW_16	Culvert	1	0.375			547382	6872704	1.59	Primary	Tweed Shire Council	Fair	WRL 2017	Culvert is under a road

Table F-5 Summary of unsurveyed structures

Structure ID	Easting	Northing	Sub-catchment	Comment
500	539324.9	6866481	Commercial Road	Not inspected
501	539067.8	6866347	Commercial Road	Not inspected
3B	538614.3	6866012	Commercial Road	Not inspected

Appendix G Cross-sections

During field investigations, floodplain drainage channels and waterways were surveyed opportunistically. Measurements were taken using Trimble GNSS RTK survey equipment as specified in Appendix A of the Methods report (Rayner et al., 2023). Locations of cross-sectional measurements surveyed across the Tweed River floodplain are shown in Figure G-1. All sections were surveyed from left bank to right bank (when looking downstream). Table G-1 provides the start and end coordinates for each cross-section, and individual cross-section profiles are shown from Figure G-2 to Figure G-42.

Figure G-1: General location of cross-sections surveyed on the Tweed River floodplain

Table G-1: Coordinates for the start and end of each cross-sections profile

Cross-section ID	Coordinates (GDA 1994 MGA 56)			
	Start Easting (m)	Start Northing (m)	End Easting (m)	End Northing (m)
1	552516.8	6878558.9	552540.0	6878563.4
2	547299.2	6877892.2	547280.2	6877894.1
3	547276.5	6877883.8	547270.1	6877869.8
4	545518.5	6872958.5	545516.8	6872992.8
5	545202.7	6872759.6	545166.6	6872781.7
6	545154.0	6872701.0	545136.4	6872729.2
7	542682.2	6870253.3	542692.8	6870235.5
8	540291.0	6871724.3	540289.1	6871709.8
9	539665.8	6869319.1	539687.3	6869308.3
10	540216.2	6869554.3	540214.8	6869545.0
11	540224.3	6869551.1	540237.7	6869549.0
12	537534.0	6868233.9	537523.8	6868246.3
13	538011.0	6865486.8	538030.7	6865484.7
14	538720.4	6865241.2	538733.5	6865243.4
15	539619.1	6865086.7	539610.4	6865081.2
16	539629.3	6865064.0	539618.9	6865080.4
17	540343.4	6864945.9	540362.7	6864942.6
18	540346.1	6864979.2	540357.3	6864990.5
19	540046.7	6865826.5	540059.8	6865824.2
20	540028.8	6865846.8	540025.6	6865834.2
21	541453.9	6865614.2	541467.3	6865613.5
23	541455.7	6865551.4	541453.5	6865544.3
24	542053.0	6865435.0	542034.4	6865434.9
25	543994.9	6867003.3	544007.4	6867001.0
26	544019.8	6866998.3	544022.2	6867014.5
27	543851.1	6867285.7	543870.7	6867290.5
28	543174.3	6867457.9	543177.3	6867473.3
29	542720.1	6867517.7	542743.9	6867513.1
30	542763.9	6867529.4	542766.8	6867551.5
31	543852.1	6868993.6	543866.7	6868993.7
32	545365.4	6869104.7	545385.3	6869101.8
33	545399.7	6869118.5	545401.3	6869133.4
34	545353.4	6869126.6	545360.2	6869143.8
35	545810.8	6871048.2	545810.9	6871077.8
36	545915.1	6871365.0	545904.3	6871366.7
37	545903.1	6871395.9	545900.5	6871380.7
176	541235.4	6871962.6	541244.3	6871961.8
177	541251.4	6871985.6	541252.5	6871967.1
178	538925.6	6863887.0	538924.4	6863875.1
179	536780.4	6867326.6	536772.2	6867328.0
180	536761.9	6867325.1	536761.8	6867318.7

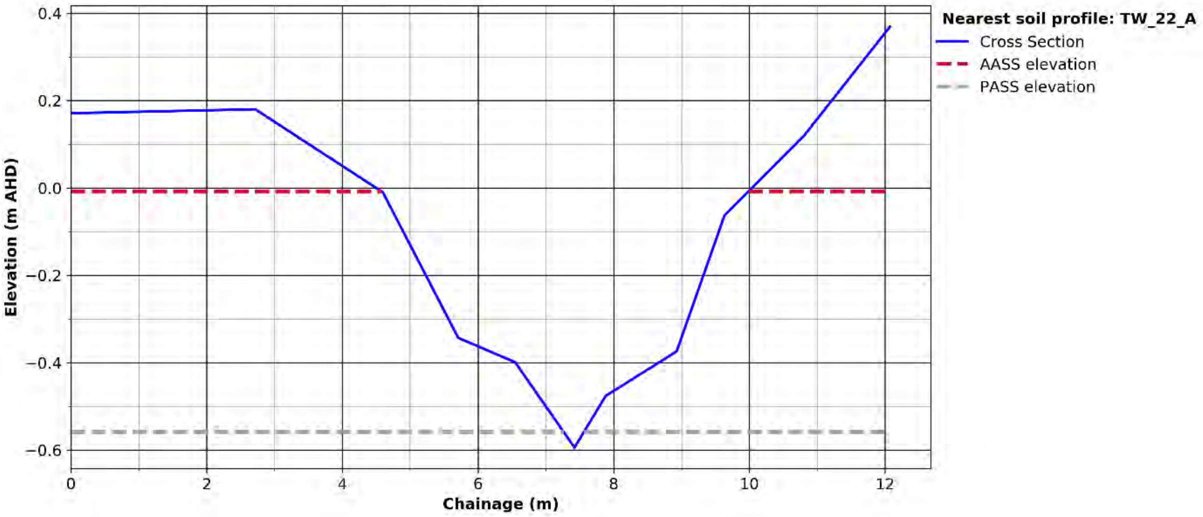


Figure G-2: Tweed cross-section 1

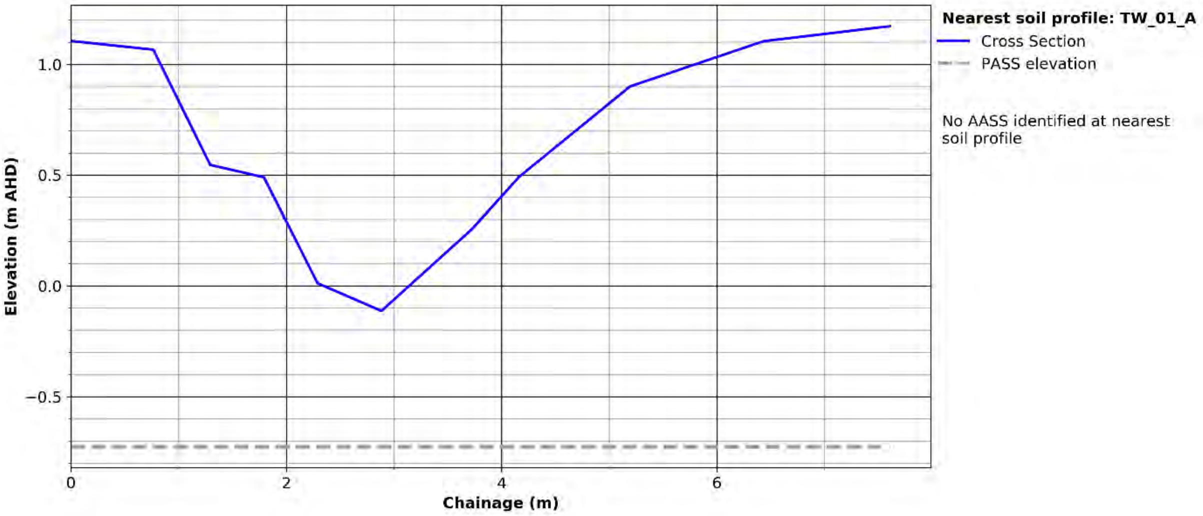


Figure G-3: Tweed cross-section 2

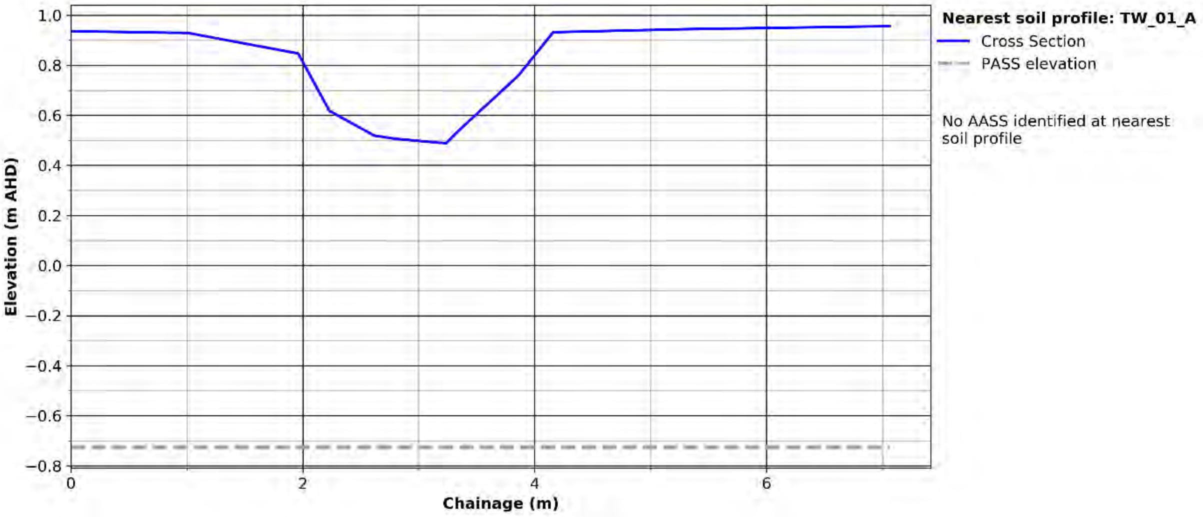


Figure G-4: Tweed cross-section 3

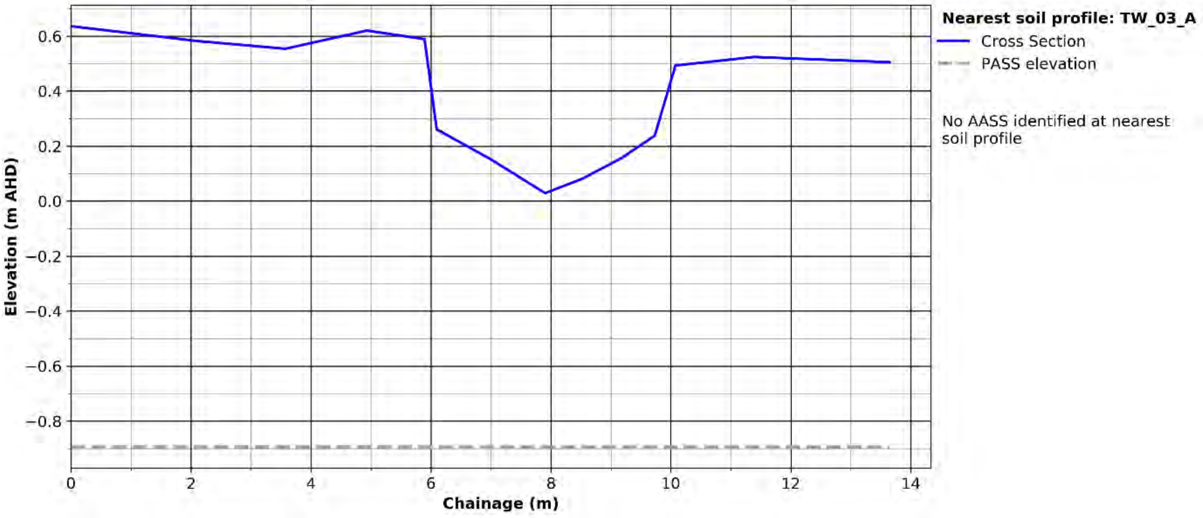


Figure G-5: Tweed cross-section 4

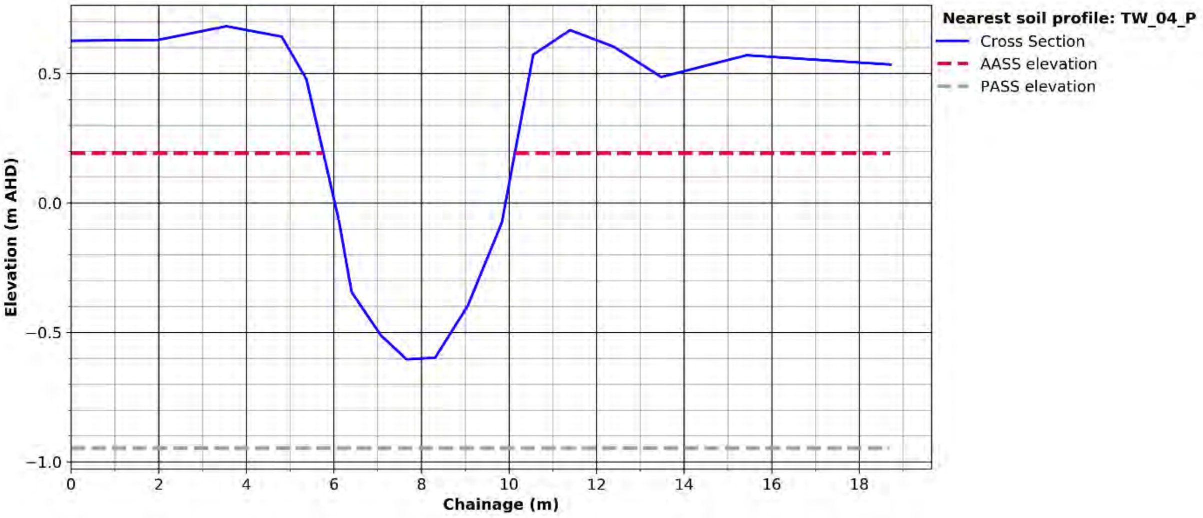


Figure G-6: Tweed cross-section 5

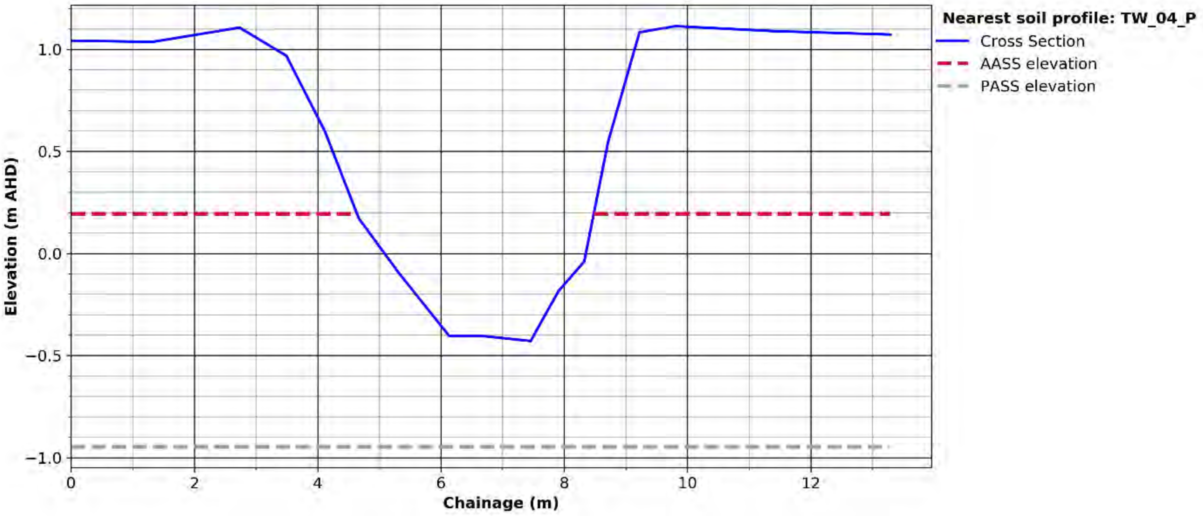


Figure G-7: Tweed cross-section 6

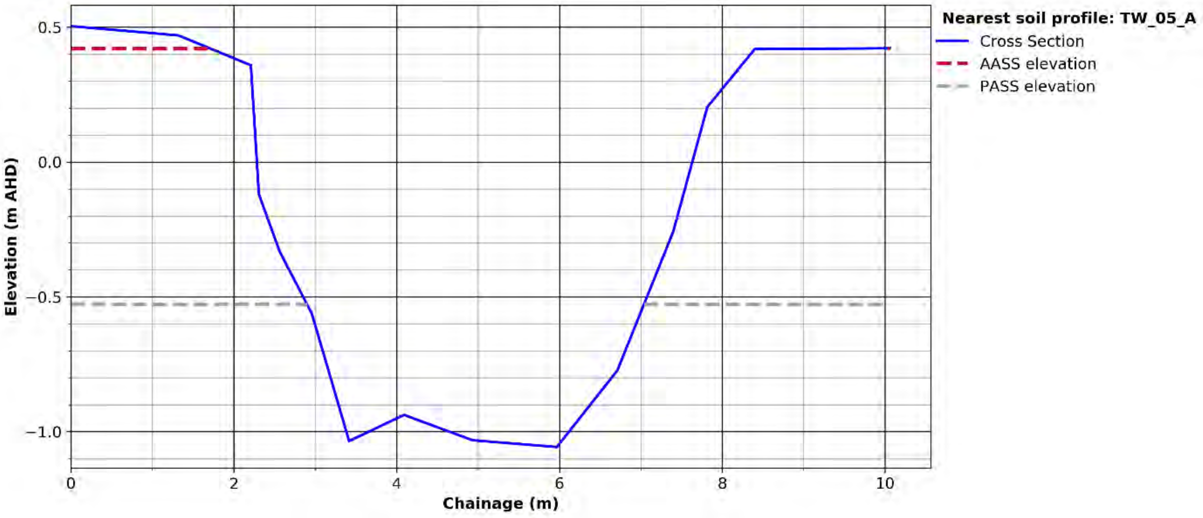


Figure G-8: Tweed cross-section 7

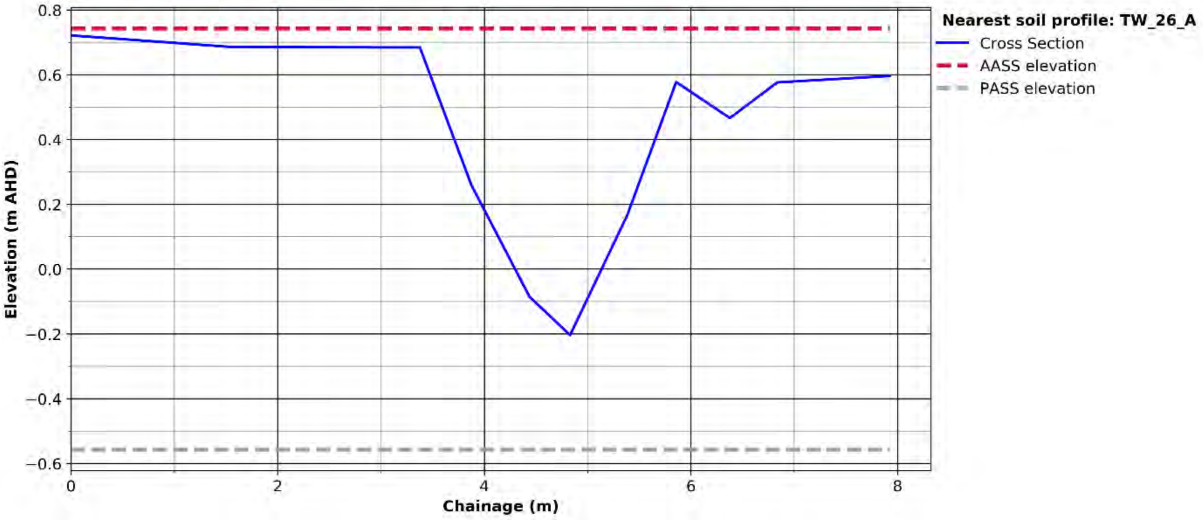


Figure G-9: Tweed cross-section 8

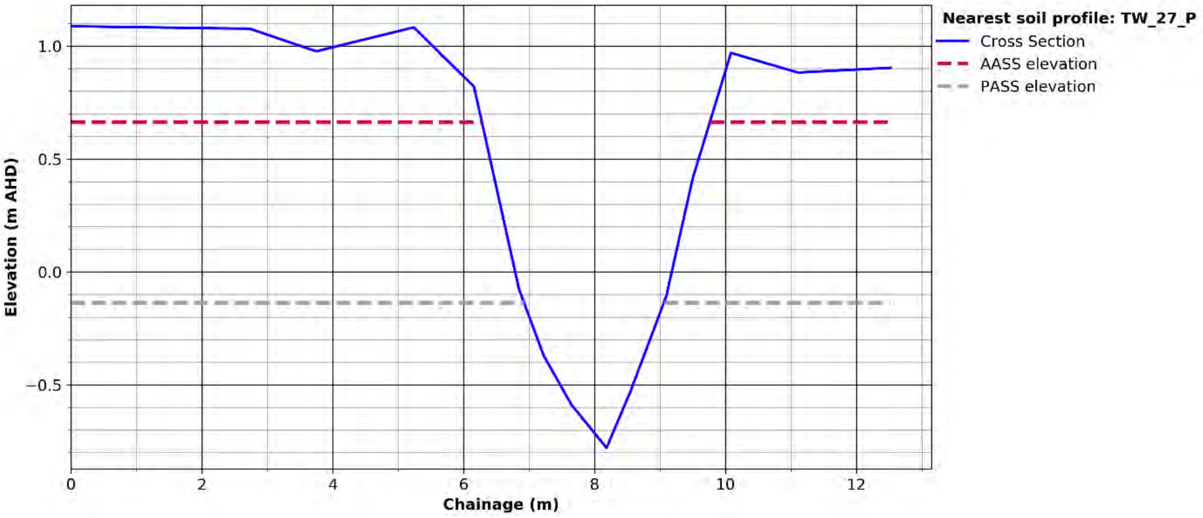


Figure G-10: Tweed cross-section 9

Figure G-11: Tweed cross-section 10

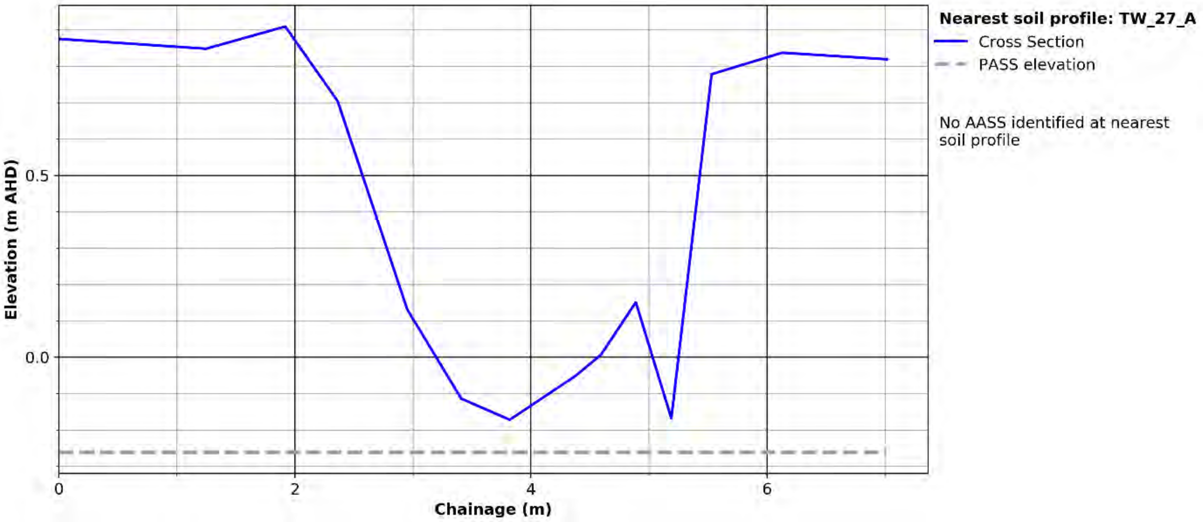


Figure G-12: Tweed cross-section 11

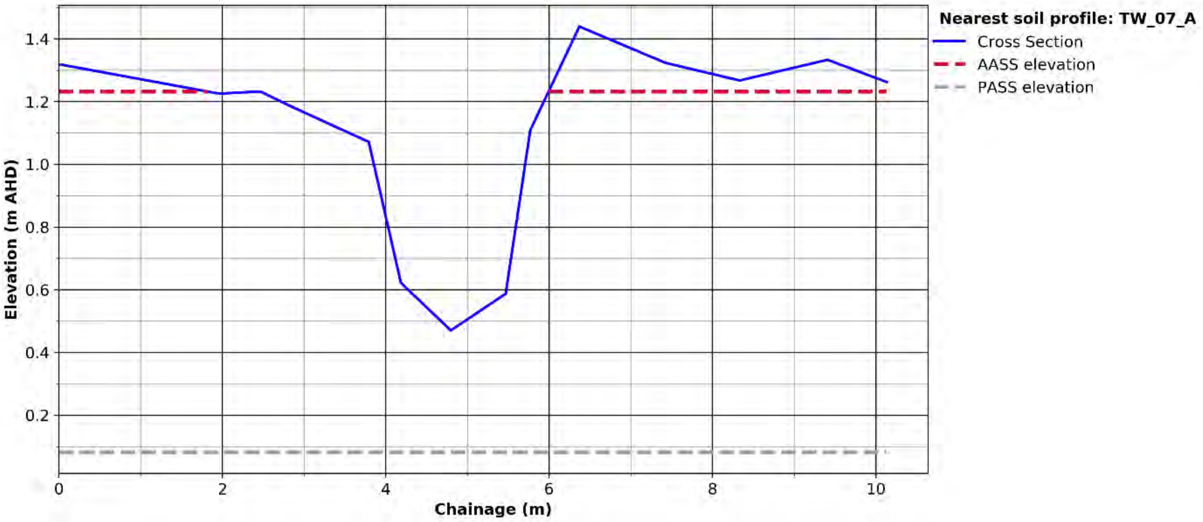


Figure G-13: Tweed cross-section 12

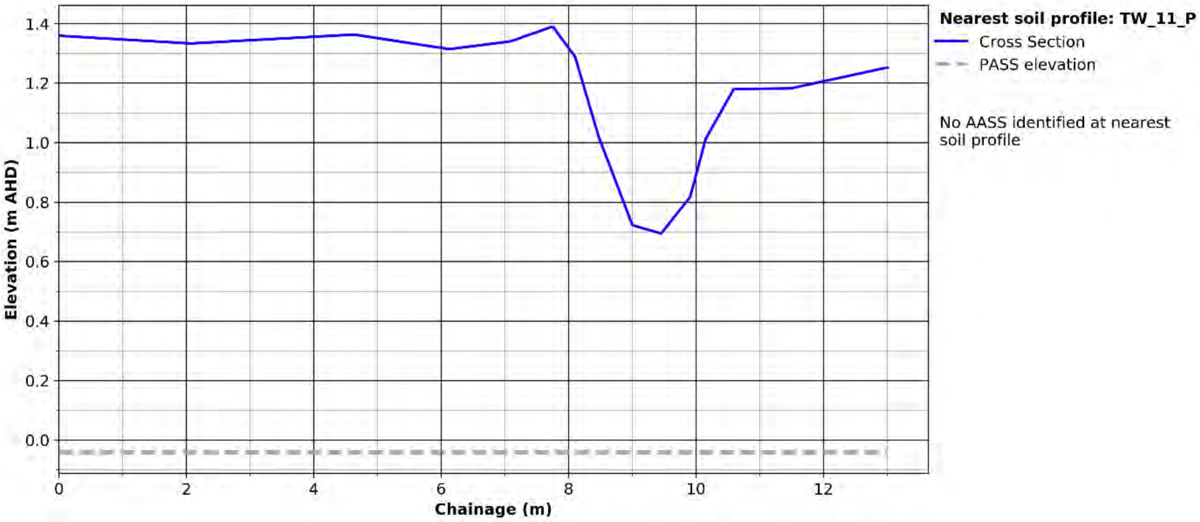


Figure G-14: Tweed cross-section 13

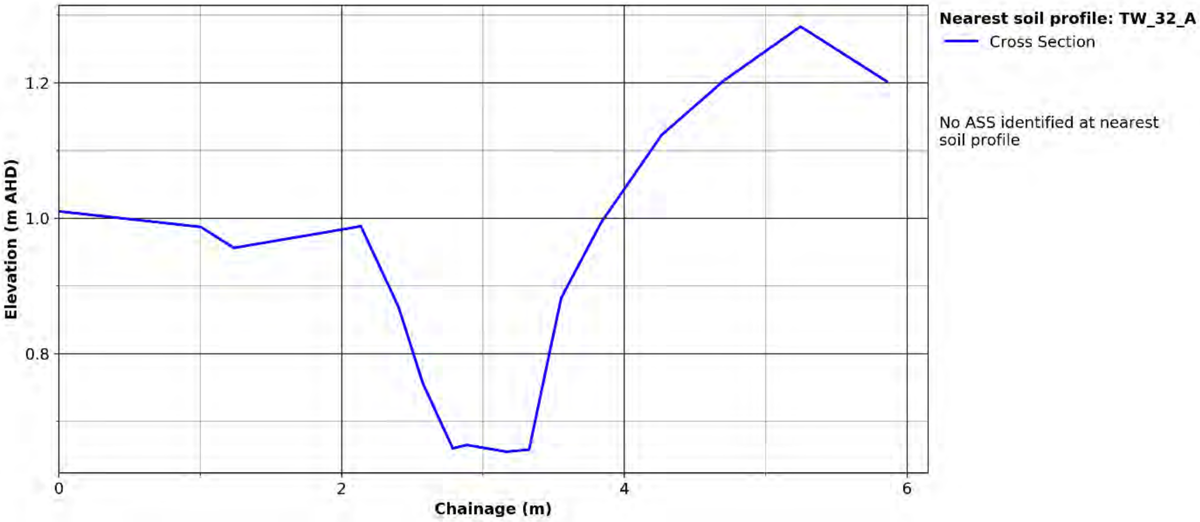


Figure G-15: Tweed cross-section 14

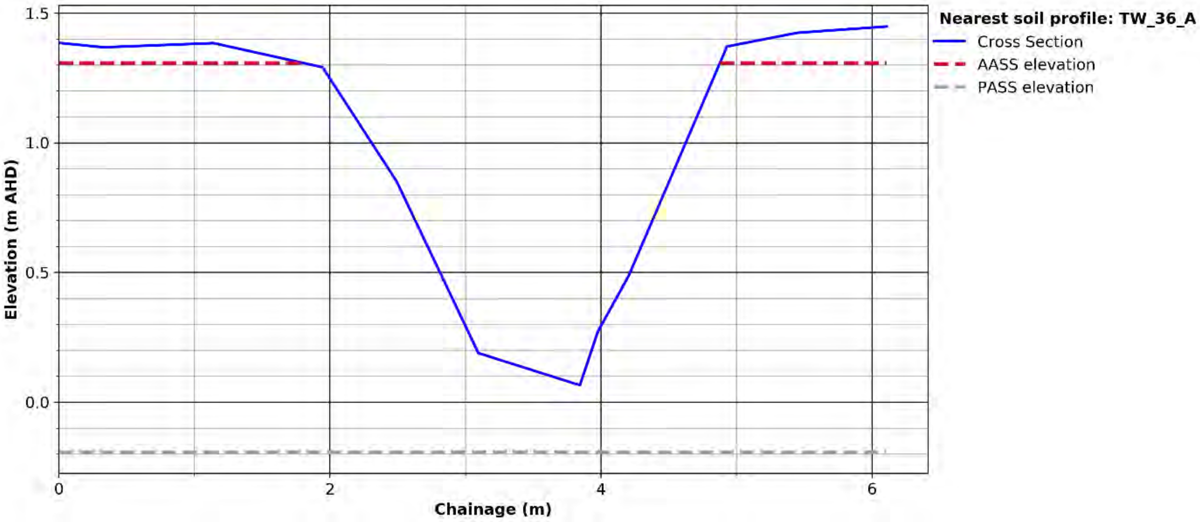


Figure G-16: Tweed cross-section 15

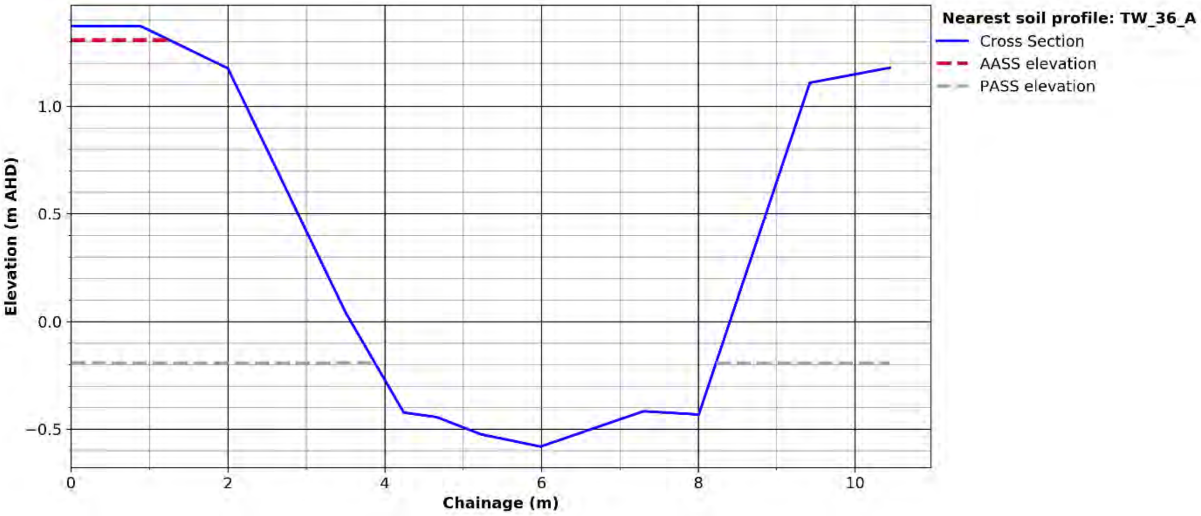


Figure G-17: Tweed cross-section 16

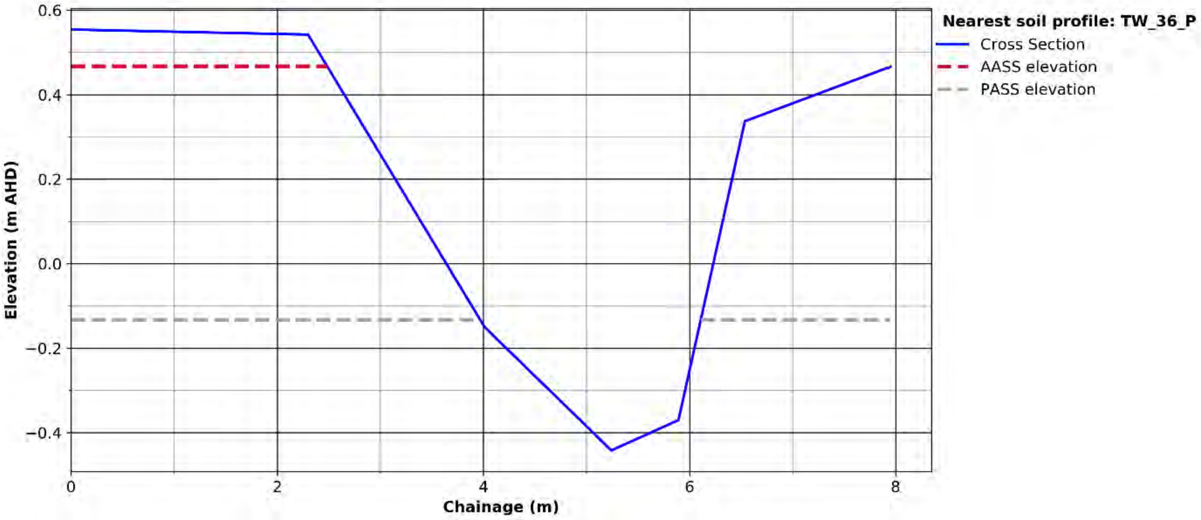


Figure G-18: Tweed cross-section 17

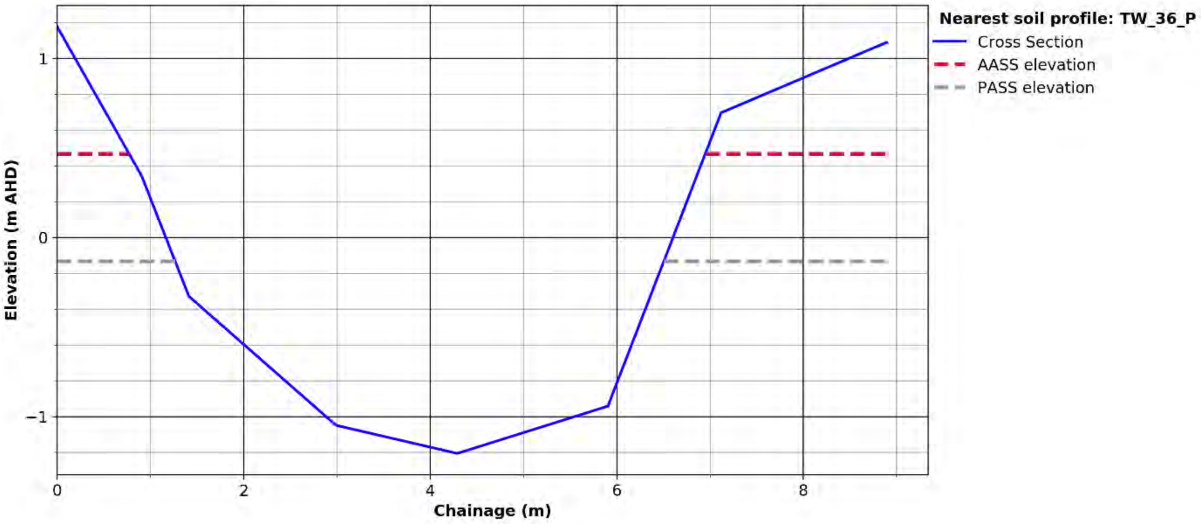


Figure G-19: Tweed cross-section 18

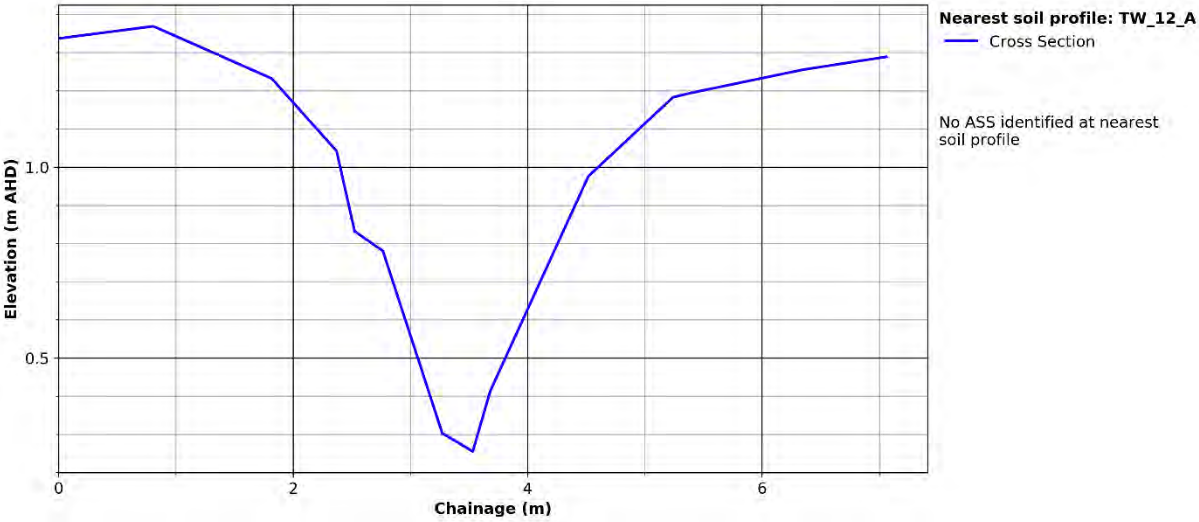


Figure G-20: Tweed cross-section 19

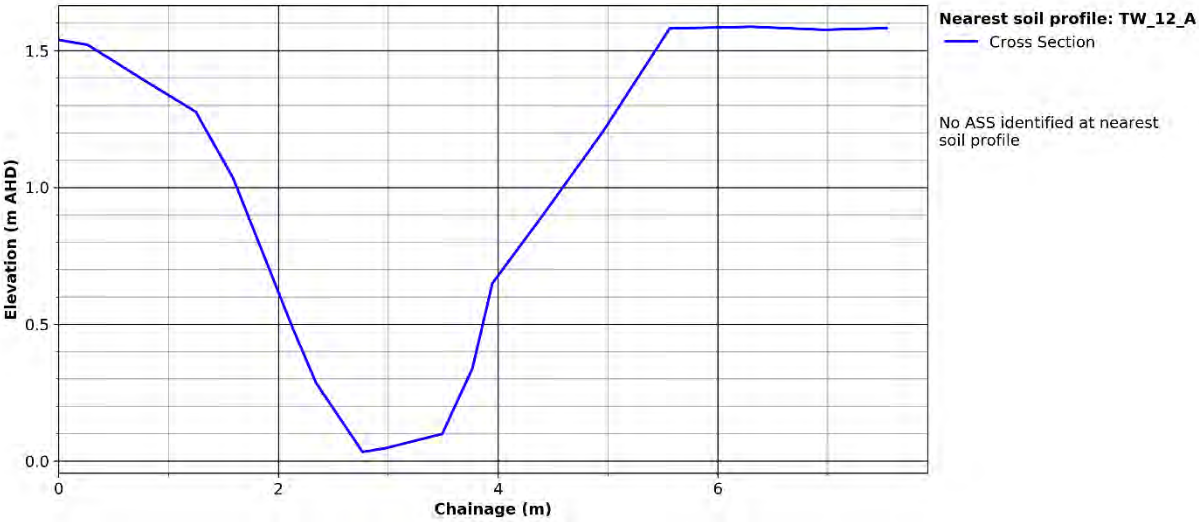


Figure G-21: Tweed cross-section 20

Figure G-22: Tweed cross-section 21

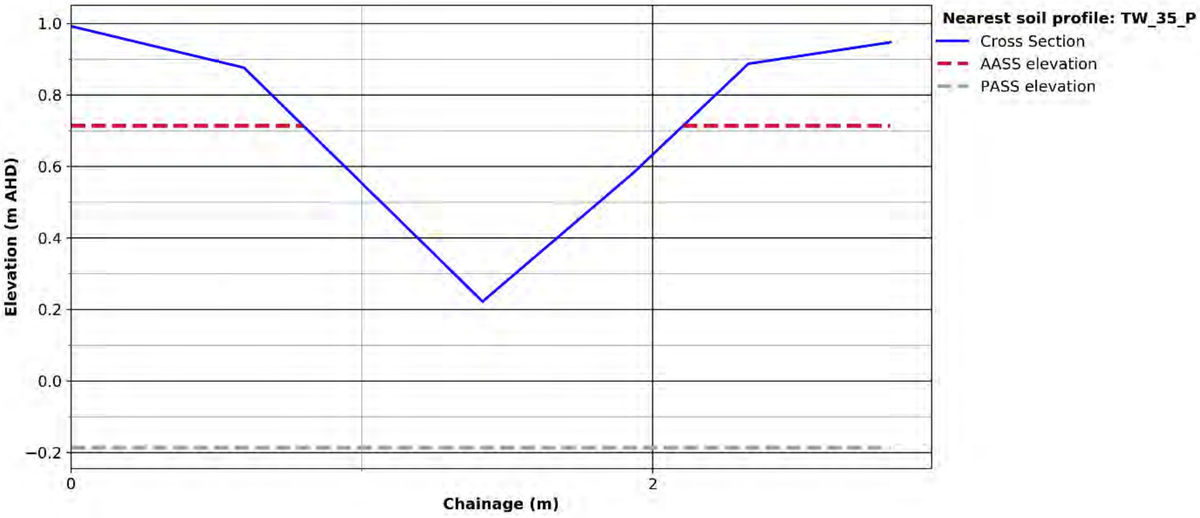


Figure G-23: Tweed cross-section 23

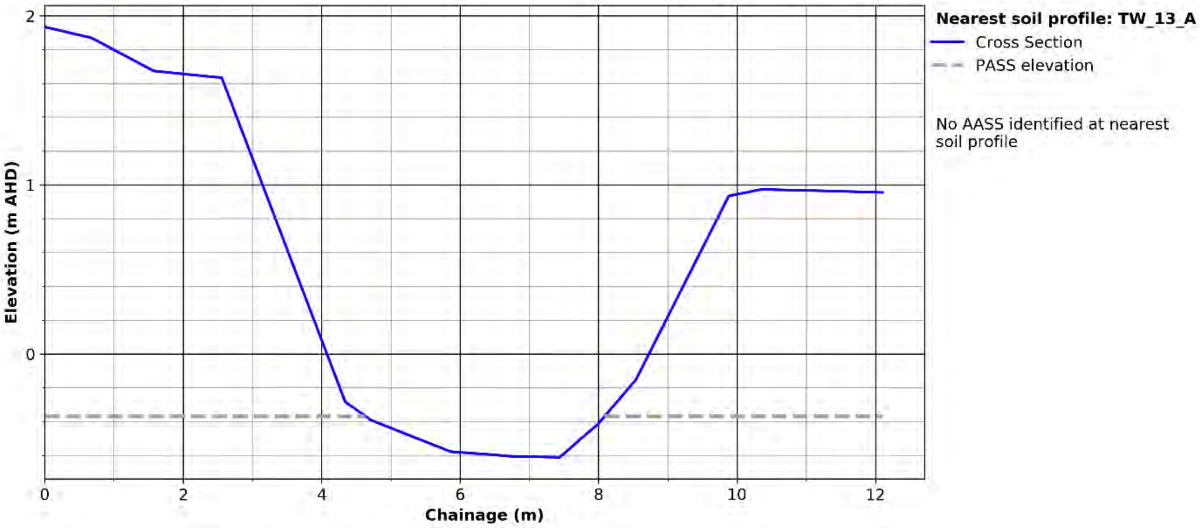


Figure G-24: Tweed cross-section 24

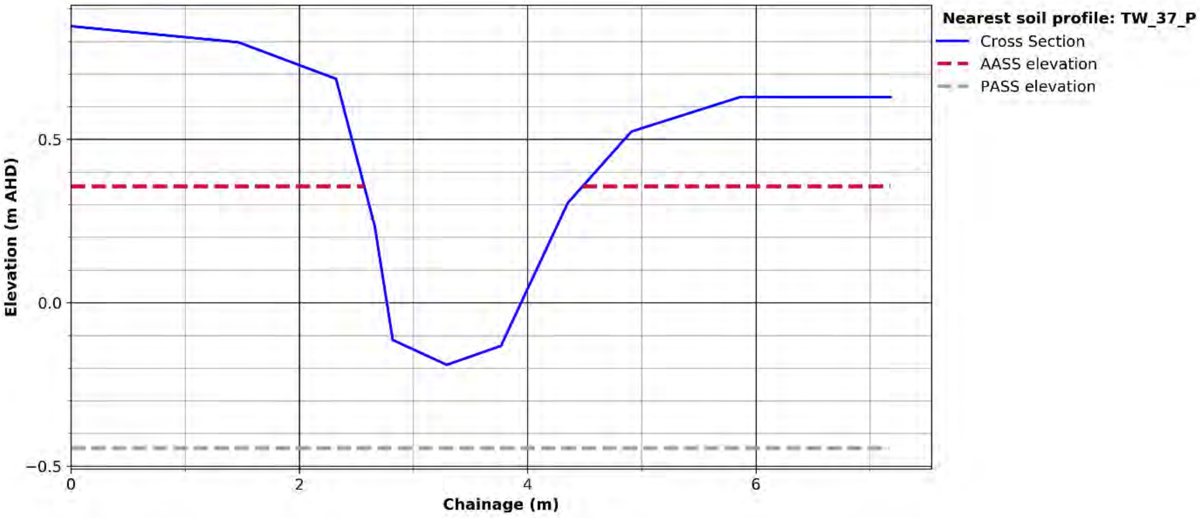


Figure G-25: Tweed cross-section 25

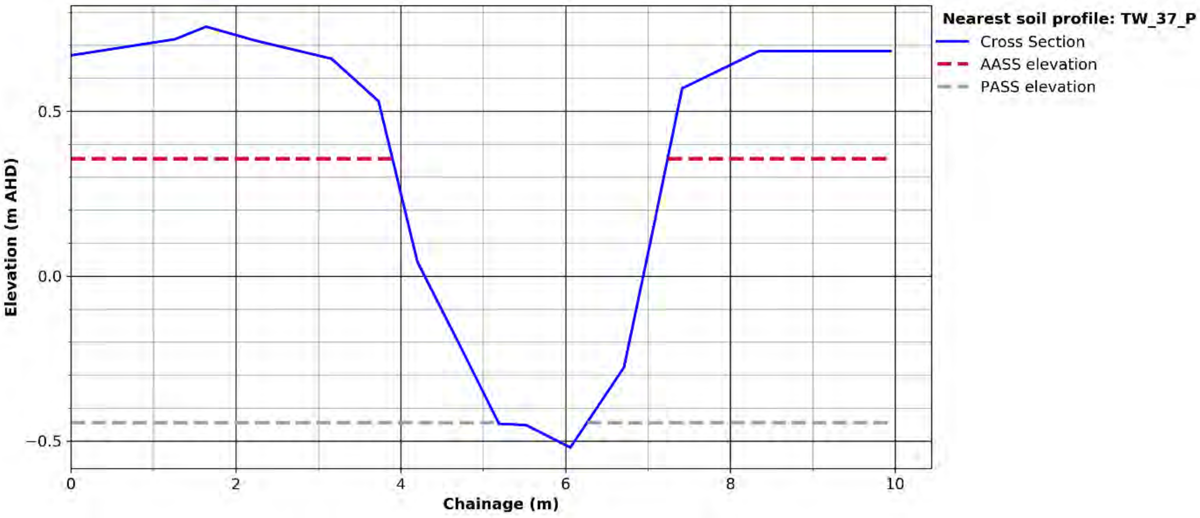


Figure G-26: Tweed cross-section 26

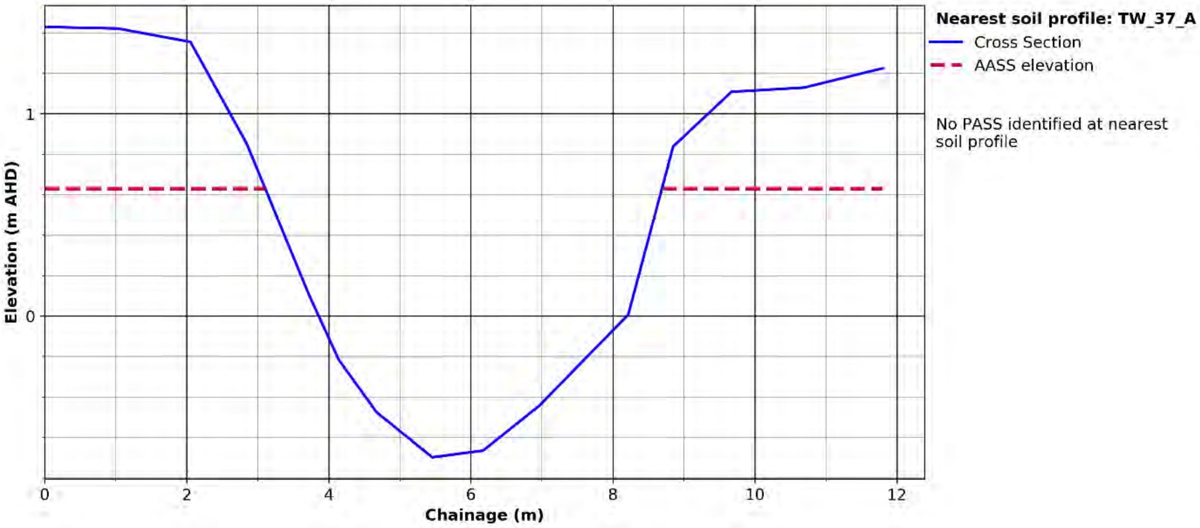


Figure G-27: Tweed cross-section 27

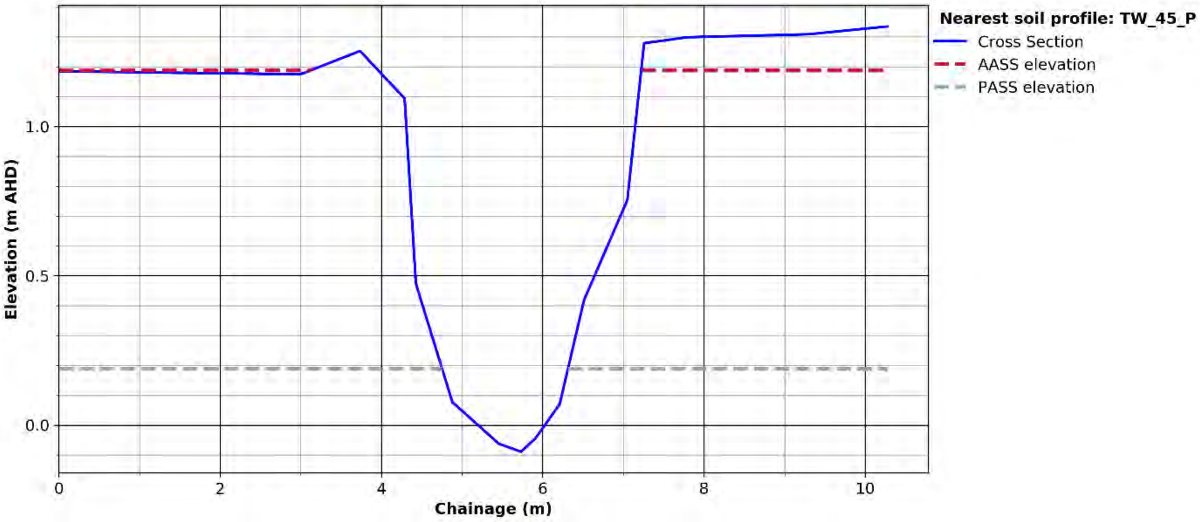


Figure G-28: Tweed cross-section 28

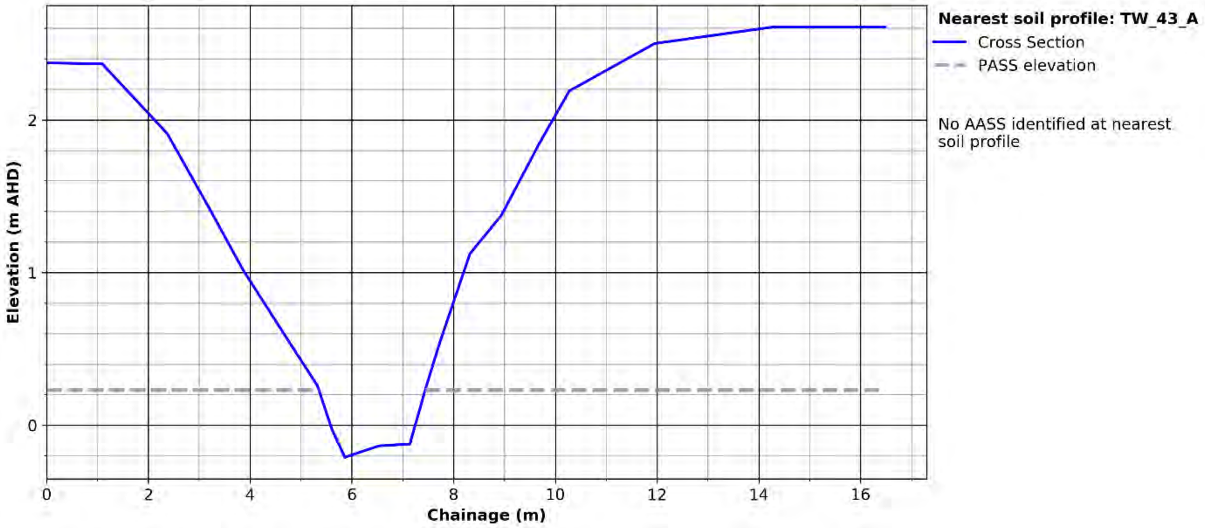


Figure G-29: Tweed cross-section 29

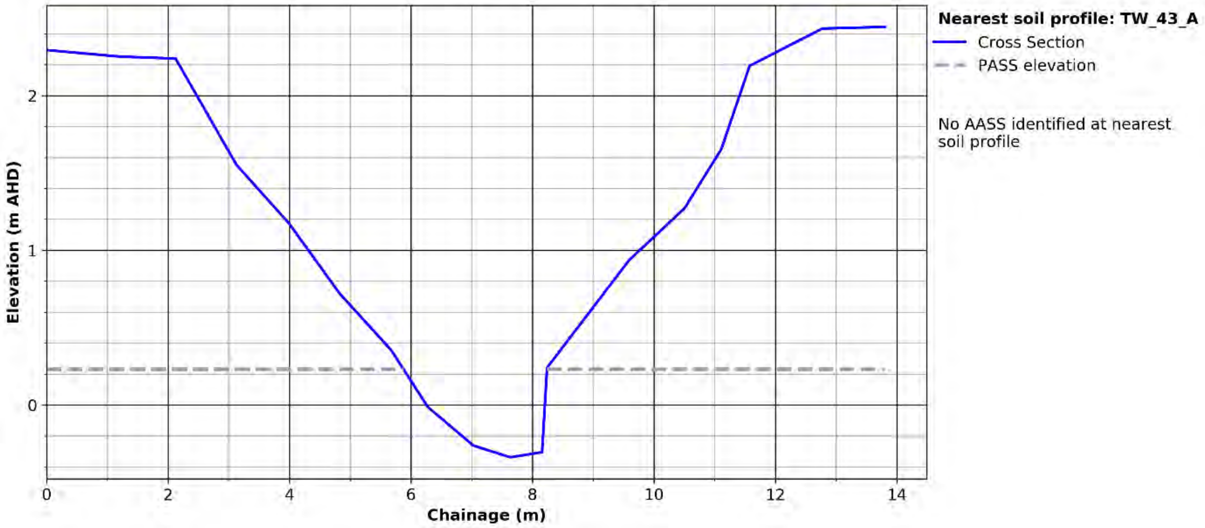


Figure G-30: Tweed cross-section 30

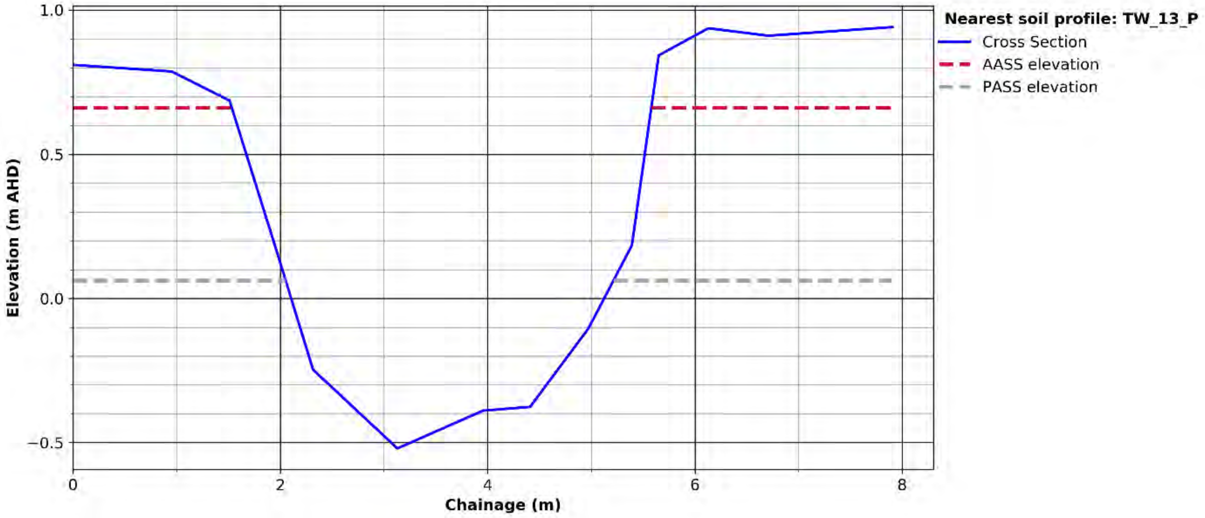


Figure G-31: Tweed cross-section 31

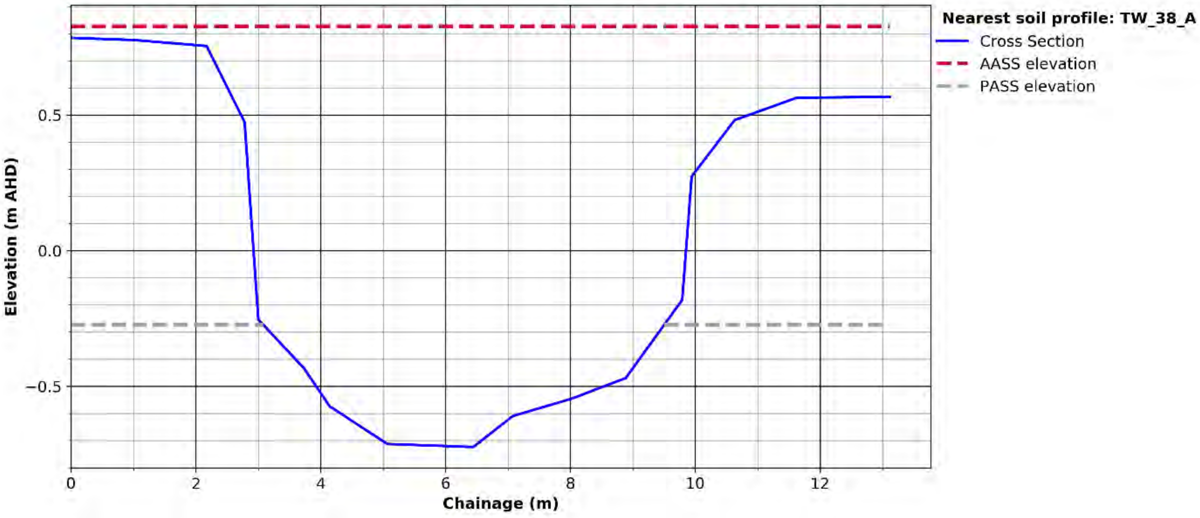


Figure G-32: Tweed cross-section 32

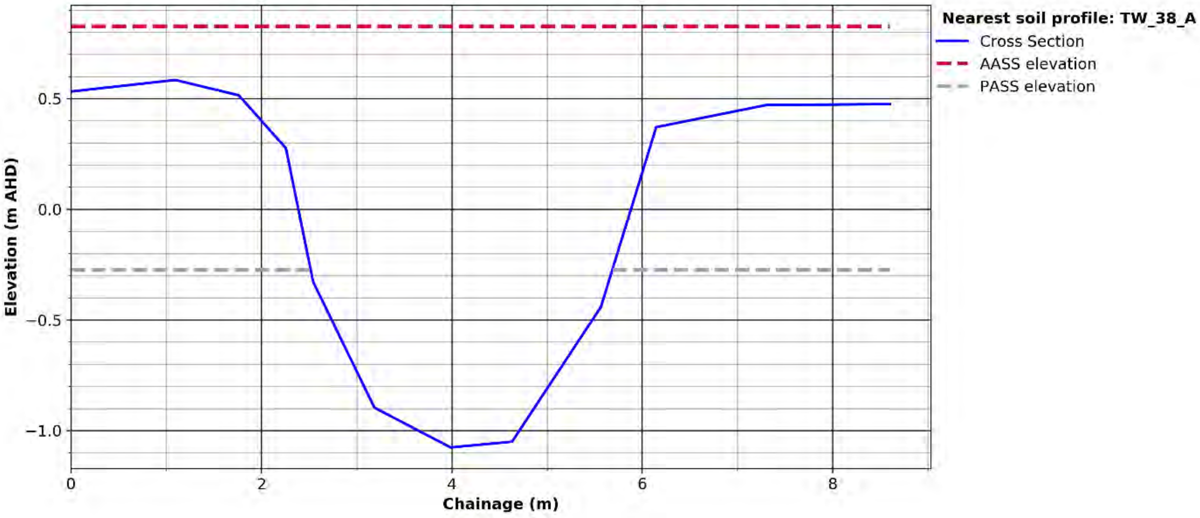


Figure G-33: Tweed cross-section 33

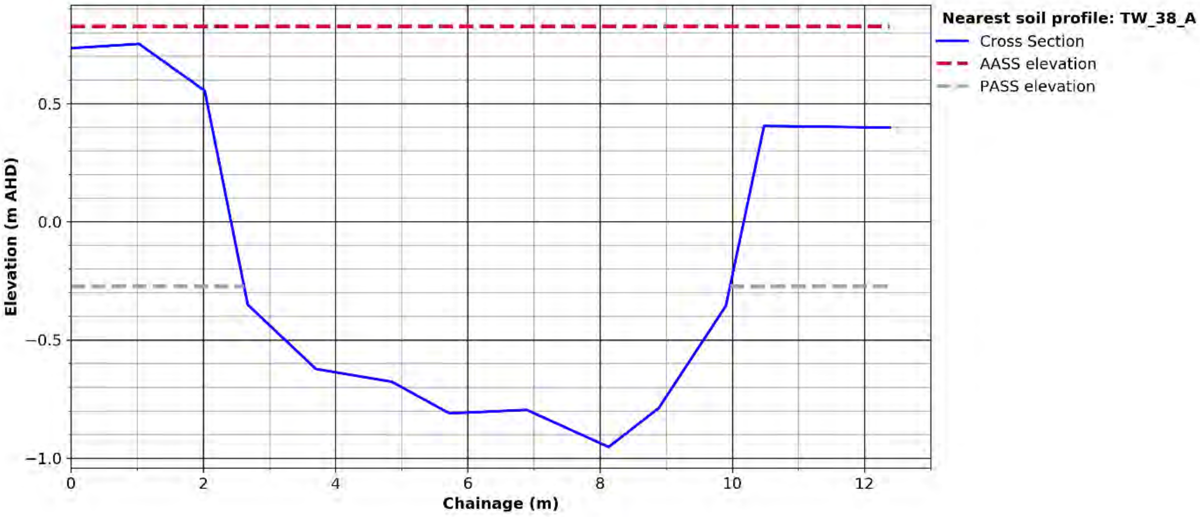


Figure G-34: Tweed cross-section 34

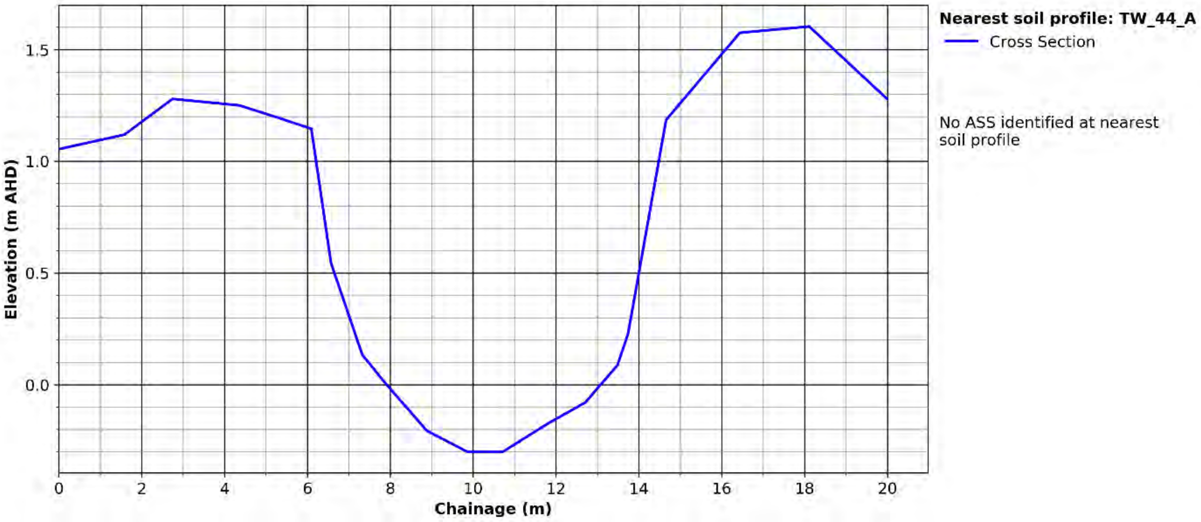


Figure G-35: Tweed cross-section 35

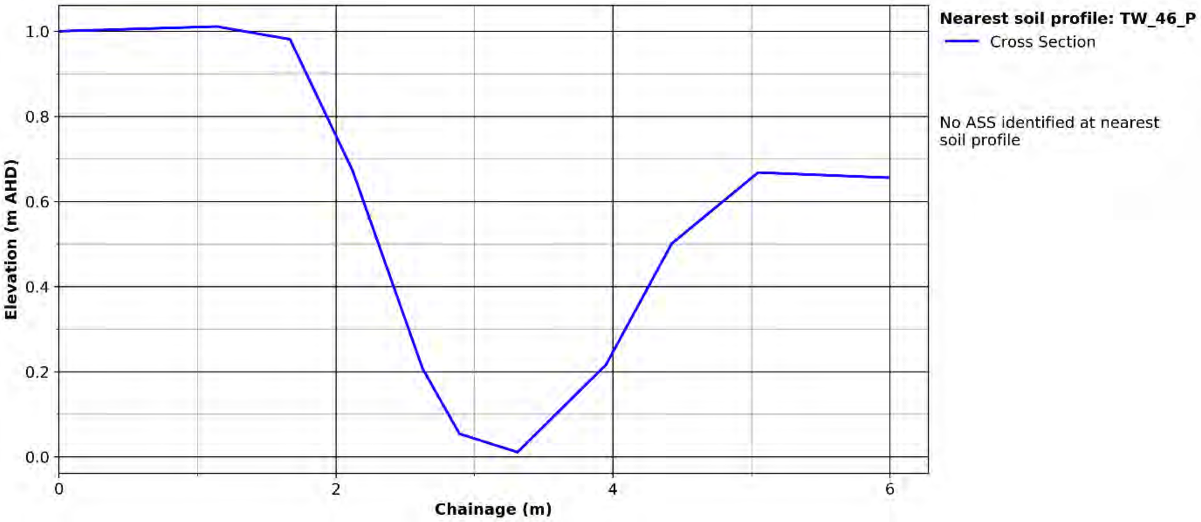


Figure G-36: Tweed cross-section 36

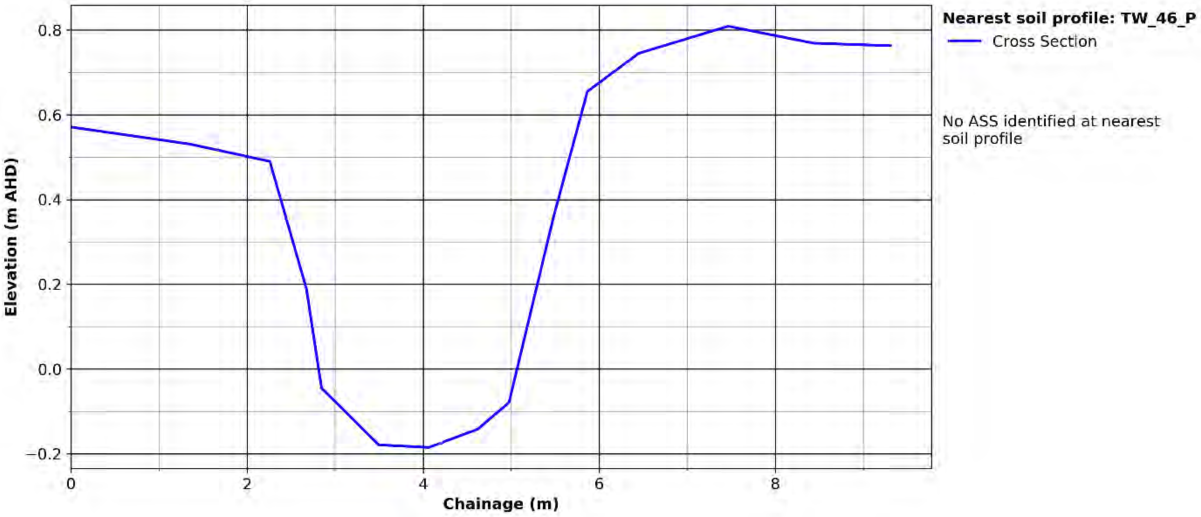


Figure G-37: Tweed cross-section 37

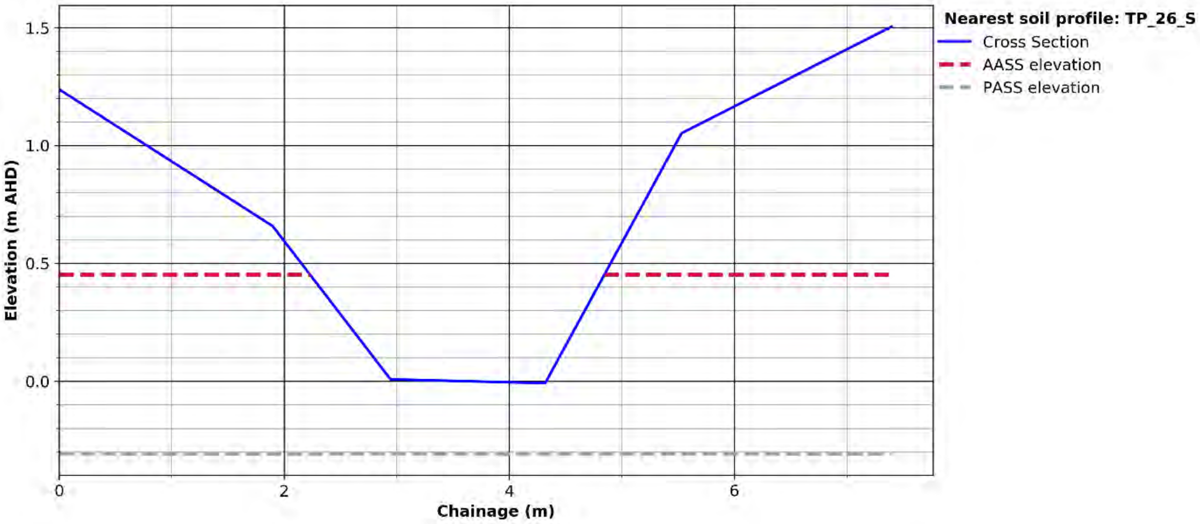


Figure G-38: Tweed cross-section 176

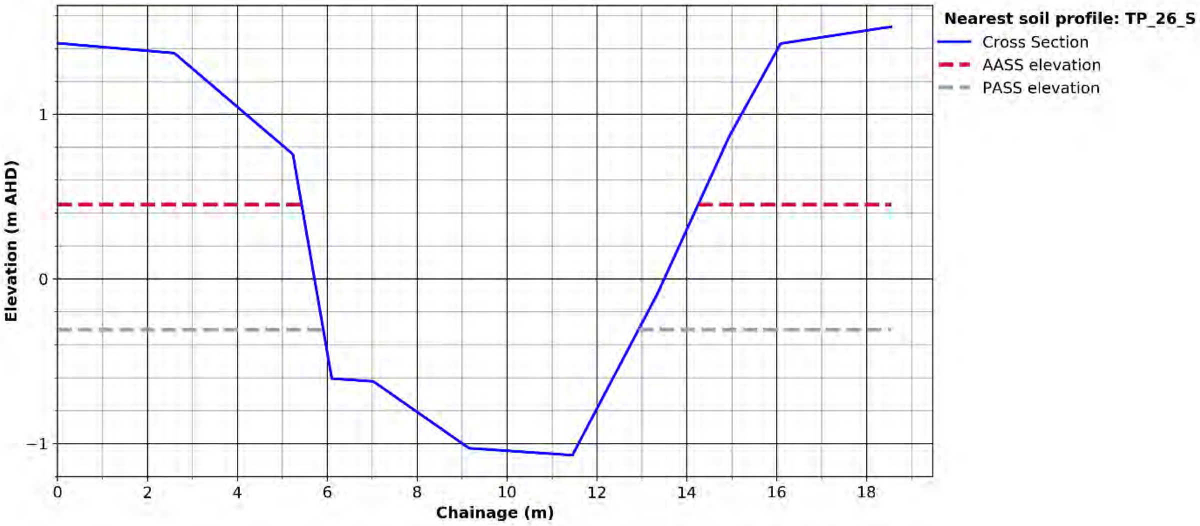


Figure G-39: Tweed cross-section 177

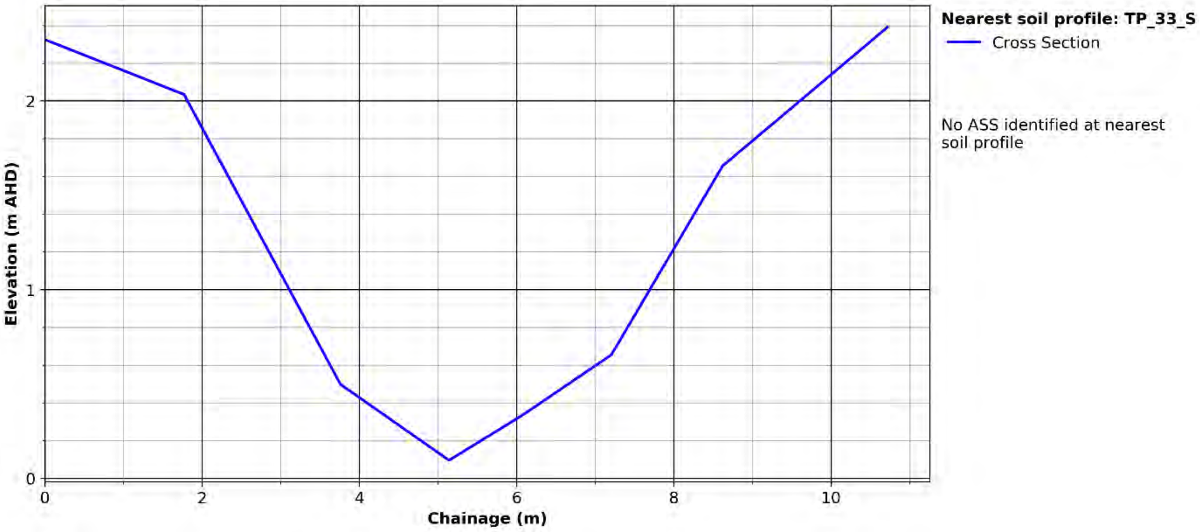


Figure G-40: Tweed cross-section 178

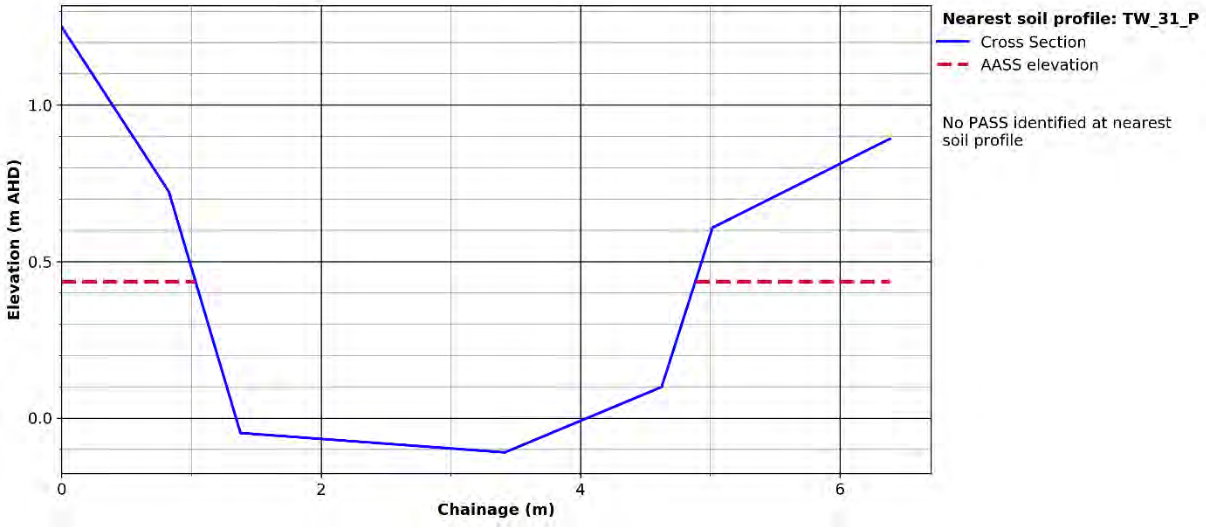


Figure G-41: Tweed cross-section 179

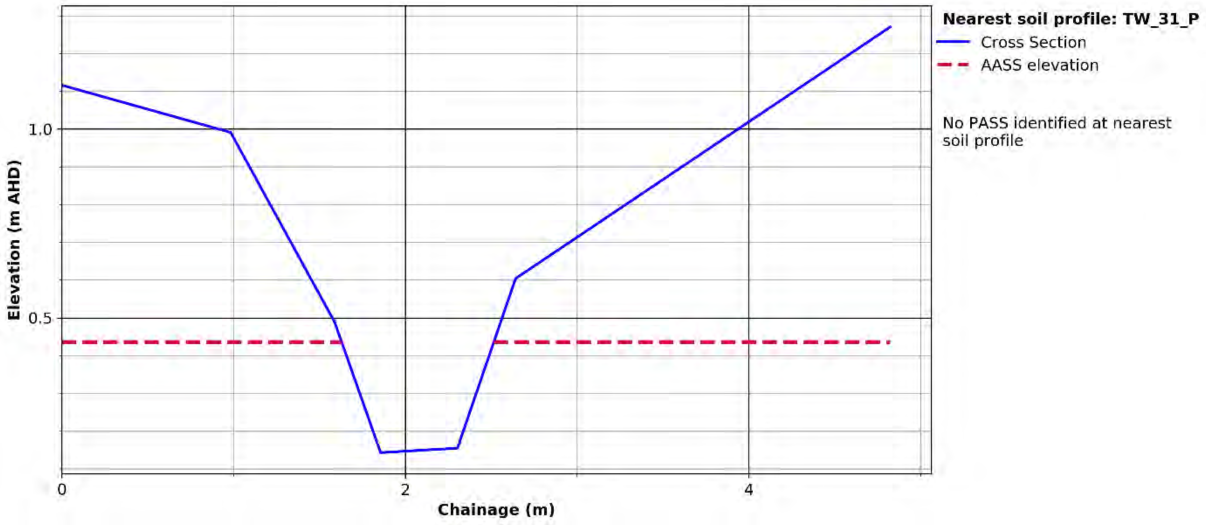


Figure G-42: Tweed cross-section 180

Appendix H Water quality

H1 Preamble

Water quality information provides an indication of the overall health of an estuary and the marine estate. The following section outlines:

- The water quality objectives for the Tweed River estuary which are used to assess estuarine health of the marine estate;
- A literature review compiling and summarising historic water quality measurement data; and
- Water quality collected during this study.

The Tweed River estuary and its tributaries have been extensively monitored using a number of water quality parameters and often in an ad-hoc manner. Monitoring has typically focused on spot checks of water quality at various locations across the estuary, with some targeted monitoring programs being implemented. For the purpose of this study, a focus has been given to surface and groundwater physical-chemical parameters associated with the disturbance of acid sulfate sols (ASS) and low dissolved oxygen blackwater. Key water quality parameters that relate to these processes are; pH, electric conductivity (EC), nutrients (e.g. nitrogen and phosphorus), dissolved oxygen (DO) and metals (e.g. aluminium and iron).

H2 Tweed River water quality objectives

In 2006, water quality objectives (WQOs) were developed for the Tweed River catchment by the NSW Department of Planning, Industry and Environment (DPIE, formerly the Department of Environment, Climate Change and Water). The goal of the WQOs are to set out community values and uses for waterways and to provide a range of water quality indicators to assess the condition of these values and uses (DPIE, 2006). Trigger levels for the water quality indicators within the WQOs are based on the Australian and New Zealand guidelines for fresh and estuarine waters (ANZG, 2018, formerly ANZECC 2000) and the Australian Drinking Water Guidelines (NHMRC, 2011). WQOs have been identified for uncontrolled streams, estuaries and waterways affected by urban development within the study area for the Tweed River estuary and include objectives for the protection of:

- Aquatic ecosystems;
- Visual amenity;
- Primary and secondary contact recreation;
- Aquatic foods (cooked);
- Livestock, irrigation and homestead water supply; and
- Drinking water at point of supply (disinfection only, clarification and disinfection, and groundwater)

Table H-1 outlines key trigger levels for stressors applicable to the Tweed River estuary for each of the WQOs. Trigger levels (and their associated WQOs) have only been presented for dissolved oxygen, pH, electrical conductivity and nutrients due to their relevance to this study. Trigger levels for metals (e.g. iron and aluminium) are dependent upon different ecosystem conditions and could vary throughout the estuary. For a complete list of trigger values consult the ANZ guidelines (ANZG, 2018) and the Australian Drinking Water Guidelines (NHMRC, 2011).

Protection of aquatic ecosystems is governed by the trigger levels for dissolved oxygen, pH and nutrients. For estuaries and waterways affected by urban development no guidance is provided for electrical conductivity values as it is expected that high values will occur due to the continuous flushing of these waters by sea water. Trigger levels for electrical conductivity were provided for uncontrolled streams which are freshwater and upstream of the estuary.

Table H-1: Water quality objective trigger levels

WQOs	Dissolved oxygen (% saturation)	pH	Electrical conductivity (µS/cm)	Total nitrogen (µg/L)	Total phosphorus (µg/L)
Aquatic ecosystems	80 - 110	7.0 - 8.5	Not applicable	300	30
Primary contact recreation	Not specified	5.0 - 9	Not applicable	Not specified	Not specified
Livestock water supply	Not specified	Not specified	0 – 3,350 (varies for different livestock)	Not specified	Not specified
Irrigation water supply	Not specified	Not specified	< 950 - >12,200 (varies for different crop)	Not specified	Not specified
Homestead water supply	Not specified	6.5 - 8.5	<1,000	Not specified	Not specified
Drinking water (treated)	> 80	6.5 – 8.5	<1,500	Not specified	Not specified

H3 Existing floodplain water quality data

H3.1 Summary

This study has focused on identifying water quality information that provides information on sources and impacts of blackwater (caused through deoxygenation) and acid sulfate soils within the Tweed River floodplain. Table H-2 provides a detailed summary of historic water quality investigations including monitoring dates, monitoring locations, parameters measured and a brief summary of the study findings. Note, in addition to this summary, reviews of existing water quality data have been completed by Tulau (1999), Makings and Pratt (2016) and Pratt (2017).

H3.2 Blackwater

Water quality measurements for nutrients (usually nitrogen and phosphorus) and dissolved oxygen can be used as an indicator for blackwater which results when oxygen is stripped from the water column usually via biological means (which can occur as a result of the breakdown of organic matter caused by eutrophication or prolonged inundation of water intolerant vegetation) or chemical means (as occurs when monosulfidic black ooze (MBO) is mobilised or acid sulfate soils are oxidised). Note, the blackwater prioritisation has focused on the biological cause of blackwater specifically through prolonged inundation of water on floodplains resulting in the die off and decomposition of organic matter which causes water to become ‘hypoxic’, whereby dissolved oxygen is consumed from a water body at a greater rate than they can be replenished. Alternative causes for blackwater have been assessed in literature and are discussed in this section. These include nutrient loading of waterways which causes eutrophication, which can lead to blackwater (in a mechanism similar to prolonged inundation) as biological matter breaks down, and also chemical causes of blackwater whereby minerals oxidise during chemical reactions stripping oxygen from the water column.

Numerous studies have measured dissolved oxygen levels and/or nutrient levels throughout the Tweed River estuary. The SPCC (1985) found that nutrient loading resulting from effluent discharge was a key stressor for Cobaki and Teranora Creeks and would need to be managed to ensure activities like dredging did not result in blackwater. This study also discovered that within canal estates there was clear stratification with lower dissolved oxygen levels at depths. Manly Hydraulics Laboratory (1997) observed that following rainfall events the dissolved oxygen level within floodplain waterways tended to drop at the same time pH levels dropped. It was unclear whether this was due to runoff resulting in a greater nutrient load in the waterways or the increased chemical demand of oxygen caused during the creation of acid. Pratt (2017) also observed low dissolved oxygen levels in the estuary specifically within the Rous River, however, their findings concluded that this resulted from nutrient loads and runoff from farmland. They also found that the dissolved oxygen levels in the estuary had, on average, decreased in comparison to previous monitoring rounds (conducted in five (5) year blocks). Since 2018, dissolved oxygen saturation levels were found to be between 80% and 110% (NSW DPIE, 2019). This is within the required levels needed to support aquatic ecosystems as outlined in the water quality objectives (DPIE, 2006; NSW DPIE, 2019).

H3.3 Acid sulfate soils

The oxidisation of acid sulfate soils (ASS) results in the development of acid which can be transported via groundwater to nearby waterways resulting in acidic water with a low pH. To understand the impact of ASS within the Tweed River estuary, a number of studies have measured water acidity (pH). The discharge of acidic waster following large runoff events in the Tweed River estuary has been observed by numerous studies and investigations (Wilson, 1995; Willett et al., 1993; White et al., 1993; Lin et al., 1998). A number of these studies also observed that saline tidal water within the estuary had capacity to act as a natural buffer to acidic water. Following prolonged dry periods, water quality in agricultural drains would often become neutral, particularly if one-way floodgates connecting them to the estuary leaked (Wilson, 1995; White et al., 1993; Lin et al., 1998). It was found that the pH and electrical conductivity (a measure of salinity) at different locations within the estuary were highly variable and dependant on rainfall events which, when occurred, resulted in higher acidity levels and lower salinity levels. Indeed, recent spot check measurements for acidity in 2018 and 2019 did not find any acidic water (NSW DPIE, 2019), potentially due to prolonged drought conditions during this period.

Table H-2: Existing water quality data for the Tweed River floodplain

Study	Sampling dates	Location	Parameters	Findings
SPCC (1985)	27/01/1983, 31/10/1983, 17-19/01/1984	Tweed River Rous River Terranora Creek Cobaki Creek	pH, salinity, Temperature, dissolved oxygen, total suspended solids, chlorophyll a, nitrogen, phosphorus	pH was consistently measured between 7.3 and 8.2 at all sites. Nutrient levels in Terranora and Cobaki Creeks due to effluent disposal have potential to cause deoxygenation of water. Dredging activities could further exacerbate this. Stratification was identified within canal estates with oxygen depletion increasing with depth.
PWD (1991)	14 – 22/10/1987	Tweed River estuary	pH	It was observed that fish kills resulted from iron and aluminium being released to waterways during acid sulfate soil oxidisation caused by drainage. Low pH levels were observed at Kynnumboon, Tygalgah, South Murwillumbah, Dulguigan and Stotts Creek.
Willett et al. (1993)	February 1990, November 1991	Stotts Creek (referred to as Macleods Creek in the study)	pH, chloride, sulfate, iron, aluminium	Pumping of water from drained farmland behind floodgates during dry periods caused oxidisation of acid sulfate soils. Following wet events oxidised acid sulfate soil products including acidic water with high aluminium concentrations were exported to the estuary.
White et al. (1993)	November 1990 to 1993	Stotts Creek (referred to as McLeods Creek in the study)	pH, dissolved oxygen, electrical conductivity, temperature	Following heavy rainfall causing discharges greater then 1m^3/s pH levels dropped from 7 to 4. During dry spells the pH was neutral (approximately 7) due to floodgates leaking allowing saline water from the estuary to buffer acid and limited export of acid from the groundwater.
Wilson (1995)	2/05/1992 to 20/05/1993	Stotts Creek (referred to as McLeods Creek in the study)	pH, dissolved oxygen, electrical conductivity, temperature.	Changes in water quality were dependent on rainfall events and proportionate to their size and duration. Measurements indicated buffering of acidic water with saline water occurred.
Lin et al. (1995)	March 1993	Stotts Creek (referred to as McLeods Creek in the study)	pH	Acidic pulses resulted from runoff on drain banks where acid sulfate soils were exposed. Saline water from the estuary acts as a natural buffer to acidic water. Following a rainfall event there was a significant drop in pH (from 6 to 4) upstream of floodgates.
MHL (1997)	17/11/1994 to 31/07/1996	Tumbulgum/Eviron Stotts Creek	Electrical conductivity (salinity), pH, temperature, dissolved oxygen	Rainfall events that result in a rise in the water level result in a drop in pH. Dissolved oxygen levels drop significantly when pH drops. This could be caused from either increased biological oxygen demand or chemical demand from oxidisation of iron ions.
Yang (1997)	Not specified	Stotts Creek (referred to as McLeods Creek in the study)	Not specified	It was observed that leaking floodgates that supplied tidal water to drains resulted in neutralisation of acid. It was observed that low oxygen levels and high acidity occurred behind floodgates.
WBM Oceanics Australia (1997)	Not specified	Tweed River estuary	Faecal coliforms, nitrogen, phosphorus, suspended solids, chlorophyll a, dissolved oxygen, pH	Contains a review of water quality data collected by Tweed Shire Council and the Environment Protection Authority. There were high nutrient levels recorded in the estuary that could lead to eutrophication and deoxygenation of the waterways.
Lin et al. (1998)	16/12/1991, 23/11/1991, 14/01/1993, 28/02/1993 to 26/03/1993	Stotts Creek (referred to as McLeods Creek in the study)	pH	Pulses of acidic discharge into the creek occurred following most rainfall events due to runoff across the creek banks where acid sulfate soils were exposed. A dry period followed by rainfall resulted in pH dropping from 7 to 4 behind floodgates. There was evidence of saline tidal water buffering acidic discharge.
Tulau (1999)	Not applicable	Tweed River estuary	Not applicable	Contains a literature review including multiple datasets that are not publicly available. Multiple studies identified Stotts Creek as an acid hot spot. Studies assessing water quality and specifically acidity in Stotts Creek have been completed by WBM Oceanics Australia, the Public Works Department and Patterson Britton and Partners. The NSW Sugar Milling Cooperative carries out regular water quality monitoring in union drains following heavy rainfall events. There was clear evidence that acid from Stotts Creek lowered the acidity in Stotts Channel indicating that the Tweed River has a relatively low neutralisation capacity despite regular flushing of the channel.
Eyre and Pepperell (1999)	5/09/1997 to 7/09/1997	Rous River	Nitrogen, phosphorus, chlorophyll a, faecal coliforms, turbidity, pH, dissolved oxygen, temperature, electrical conductivity/salinity	It was found that cane land resulted in elevated values for nutrients and lower values for acidity.

Study	Sampling dates	Location	Parameters	Findings
				Correlation between nitrogen concentration and chlorophyll a indicated that nitrogen was stimulating biological growth. A decrease in dissolved oxygen with chlorophyll a also indicated that biodegrading organic matter was stripping oxygen from the water.
Wilson et al. (1999)	2/02/1992 to 29/01/1994	Stotts Creek (referred to as McLeods Creek in the study)	pH, electrical conductivity, dissolved oxygen, temperature	A neutral pH (7.5) was recorded when the water table was below unoxidized acid sulfate soils. When there was a high water table the pH decreased becoming acidic (pH ~3.5). Small diurnal changes in both pH and electrical conductivity were measured during dry periods.
Green (2005)	2001 to 2002	Stotts Creek (referred to as McLeods Creek in the study);	Electrical conductivity, pH, temperature, cations, anions, organic carbon, dissolved oxygen, redox potential, alkalinity	It was found that hydrolysis of dissolved metals can contribute to acidity meaning pH measurements can underpredict the actual acidity. pH measurements only contributed to 30% of the overall acidity. Minimum pH measurements in waterways were observed within a few hours following a rainfall event.
Genn (2009)	12/09/1991 to 13/12/1991; 22/10/2007 to not specified	Cobaki	Nitrogen, phosphorus, turbidity	Presents historic water quality monitoring collected by WBM Oceanics Australia. On average the phosphorus levels were recorded above ANZECC guideline levels. Nitrogen levels have increased since historic monitoring and are now above ANZECC guideline levels.
IWC (2009)	November 2007 to October 2008	Cobaki Terranora	Turbidity, salinity, total suspended solids, dissolved oxygen, pH, nitrogen, phosphorus, chlorophyll a.	No acid was measured during the sampling period with pH levels between 7 and 9. Mixing resulted in less variability in dissolved oxygen measurements within the lower estuary when compared to the upper estuary.
Holloway et al. (2010)	26/10/2007 to 30/10/2007	Cobaki Terranora	Salinity, dissolved oxygen, total suspended solids, chlorophyll a, nitrogen, phosphorus	There are consistently low levels of dissolved oxygen particularly in the estuarine creeks. Higher levels of nitrogen and phosphorus were observed as a result of sediment resuspension.
Roper et al. (2010)	1970 to 2009	Tweed River	Salinity, temperature, dissolved oxygen, pH, Secchi depth, turbidity, chlorophyll a, total suspended solids, nitrogen, phosphorus, silicon	Out of 101 NSW estuaries assessed for condition the Tweed River was given a 'good' rating (along with 38% of estuaries, 27% were 'very good'). Out of 184 NSW estuaries assessed for susceptibility to environmental pressures the Tweed River was given a 'high' rating (along with 6% of all estuaries, no estuaries were 'very high').
Ferguson (2012)	2007 to 2011	Tweed River estuary	Temperature, salinity, pH, nitrogen, phosphorus, chlorophyll a, total suspended solids, Secchi depth, dissolved oxygen,	Protrusion of salinity was observed up the estuary to the Bray Park Weir on the Tweed River, to Dulguigan on the Rous River and through to Cobaki – Terranora systems. Measurements of pH indicated that acid sulfate soils had a greater influence in the Rous River. Lower dissolved oxygen measurements were observed in the mid to upper estuary and appeared to be driven by residence times resulting in increased biological matter.
Makings and Pratt (2016)	1996 to 2017	Tweed River estuary	Not applicable	Contains a review of water quality monitoring completed in the Tweed Estuary from 1996 to 2007 including data that is not publicly available. 80% of the estuary was ranked as poor to very poor with low pH, high nutrients and low dissolved oxygen contributing to this ranking. Runoff from farmland was attributed with high nutrient loads which can cause eutrophication. Stormwater often accounted for variations of up to 90% in water quality within the lower estuary. Key water quality problems result from acid sulfate soils in the mid and lower estuary and from nutrient loads in the mid to upper estuary. Floods are one of the key drivers for low dissolved oxygen, low pH and high levels of nutrients. Hypoxia was observed to be caused in the mid to upper estuary during periods of low to medium flow by a high sediment demand caused by oxygen demand from enriched organic matter.
Pratt (2017)	January 2012 to November 2016	Tweed River Rous River	pH, salinity, temperature, dissolved oxygen, total suspended solids, Secchi depth, biological oxygen demand, colour, chlorophyll a, nitrogen, phosphorus, coliforms, enterococci	Impacts of acid sulfate soil runoff was observed in the mid to upper estuary and specifically in the Rous River, however, these impacts had improved from a the previous 5 year monitoring program. Low dissolved oxygen was observed in the mid estuary and specifically in the Rous River, however, these impacts had improved from a the previous 5 year monitoring program. Low dissolved oxygen in the estuary is linked to high nutrient loads and runoff from rural land. Salinity in the upper estuary is impacted by environmental flows during dry periods.

Study	Sampling dates	Location	Parameters	Findings
Pratt et al. (2017)	28 March 2017	Tweed River estuary	Electrical conductivity, pH, dissolved oxygen, temperature	Acid hot spots were identified upstream of Dulguigan Creek, on the north side of Main Trust Canal, Condong Creek, Blacks Drain and the floodplain between Bray Park and Murwillumbah. Following a flood event low dissolved oxygen was thought to be associated with the breakdown of organic material. Tidal influence was observed in the electrical conductivity levels in the mid-estuary immediately following a runoff event.
NSW Food Authority (2019)	21/07/2013 to present	Terranora	Bacteria, salinity, temperature	Average salinity was recorded as 30.5ppt with a 10th percentile of 23ppt and 90th percentile of 35ppt.
NSW DPIE (2019)	2009, 2010, 2018, 2019	Tweed River	Secchi depth, temperature, electrical conductivity (salinity), turbidity, chlorophyll a, colour, nitrogen, phosphorus, pH, CDOM, fDOM, dissolved oxygen, blue green algae, silicon	Salinity measured in the mid to upper estuary varied from 1ppt to 24ppt; pH measurements varied from 7.1 to 7.8 (only measured in 2018 and 2019); Dissolved oxygen varied from 81.1% to 108.8% (only measured in 2018 and 2019).

H4 Field investigations

During field investigations, surface water and groundwater water quality measurements were opportunistically collected at various locations across the Tweed River floodplain. Water quality parameters measured included pH and electrical conductivity (EC). Details on the instrumentation used to measure water quality parameters can be found in Appendix A of the Methods report (Rayner et al., 2023).

Water quality data was collected during structure surveys (surface water quality upstream of the structures) and soil profile sampling (surface water quality of nearby waterways and groundwater quality within the soil sample holes). Water quality measurements taken during structure surveys upstream of the structures are summarised in Table H-3. Surface water quality measurements taken from nearby water bodies during soil profile sampling are summarised in Table H-4. Groundwater quality measurements taken during soil profile sampling are summarised in Table H-5. This data has also been spatially represented to show the variability of pH and electrical conductivity across the Tweed River floodplain. Surface water quality measurements for the Tweed River floodplain are presented in Figure H-1 and Figure H-2 for pH and electrical conductivity, respectively. Groundwater quality measurements for the Tweed River floodplain are presented in Figure H-3 and Figure H-4 for pH and electrical conductivity, respectively.

Table H-3 Summary of surface water quality measurements taken upstream of structures

Nearby structure ID	Date	Easting (m)	Northing (m)	pH	Electrical conductivity (µS/cm)
WRL_TW_12	7/11/2019	541459	6865616	6.7	1,300

Table H-4: Summary of surface water quality measurements taken in waterbodies near soil profile sample holes

Nearby soil profile ID	Date	Easting (m)	Northing (m)	pH	Electrical conductivity (µS/cm)	Notes
TW_45_P	15/10/2019	543189	6867459	5.0	11,876	
TW_44_A	16/10/2019	545813	6871054	7.1	36,046	
TW_26_A	17/10/2019	540293	6871722	5.7	4,467	
TW_27_A	18/10/2019	540216	6869552	7.1	20,751	
TW_05_A	21/10/2019	542691	6870240	6.0	28,213	
TW_13_P	22/10/2019	543856	6869002	6.9	36,551	
TW_10_A	23/10/2019	538121	6865604	3.8	3,162	Measured in nearby creek

Nearby soil profile ID	Date	Easting (m)	Northing (m)	pH	Electrical conductivity (µS/cm)	Notes
TW_10_A	23/10/2019	538147	6865621	6.3	250	Measured in nearby dam
TW_32_A	23/10/2019	538725	6865243	6.3	24,591	
TW_07_A	24/10/2019	537527	6868236	7.1	5,814	
TW_01_A	25/10/2019	547287	6877933	7.7	66,201	
TW_36_A	7/11/2019	539625	6865082	7.1	31,203	
TW_12_A	8/11/2019	540028	6865837	7.8	1,500	
TW_36_P	8/11/2019	540355	6864934	6.9	23,000	Measured in Black Drain
TP_33_S	24/02/2020	538983	6863862	6.3	1,196	
TW_31_P	24/02/2020	536773	6867338	6.0	343	
TP_26_S	24/02/2020	541256	6871951	3.5	346	

Table H-5: Summary of groundwater quality measurements taken from soil sample holes

Soil profile ID	Date	Easting (m)	Northing (m)	pH	Electrical conductivity (µS/cm)
TW_43_P	15/10/2019	548377	6871745	6.5	6,348
TW_05_P	16/10/2019	544820	6871473	6.1	7,215
TW_38_A	16/10/2019	545359	6869127	6.5	3,431
TW_42_A	16/10/2019	547652	6871886	6.4	4,658
TW_03_A	17/10/2019	545523	6872959	5.7	14,176
TW_04_P	17/10/2019	545156	6872789	5.9	11,866
TW_46_P	17/10/2019	545906	6871367	6.3	5,556
TW_27_A	18/10/2019	540216	6869551	5.0	3,547
TW_27_P	18/10/2019	539681	6869309	6.8	2,452
TW_37_A	19/10/2019	543850	6867300	4.0	1,189
TW_13_P	22/10/2019	543856	6869002	6.7	3,737
TW_37_P	22/10/2019	544021	6867004	6.9	3,915
TW_10_A	23/10/2019	538148	6865633	6.1	618
TW_32_A	23/10/2019	538725	6865243	6.3	1,757
TW_07_A	24/10/2019	537527	6868236	6.8	2,009
TW_01_A	25/10/2019	547287	6877933	5.9	13,520
TW_35_P	7/11/2019	541453	6865542	5.6	3,600
TW_13_A	8/11/2019	542040	6865446	6.4	1,520
TW_12_A	8/11/2019	540028	6865837	6.4	1,835
TP_33_S	24/02/2020	538983	6863862	5.6	387
TW_31_P	24/02/2020	536773	6867338	5.1	1,646
TP_26_S	24/02/2020	541256	6871951	3.6	1,412

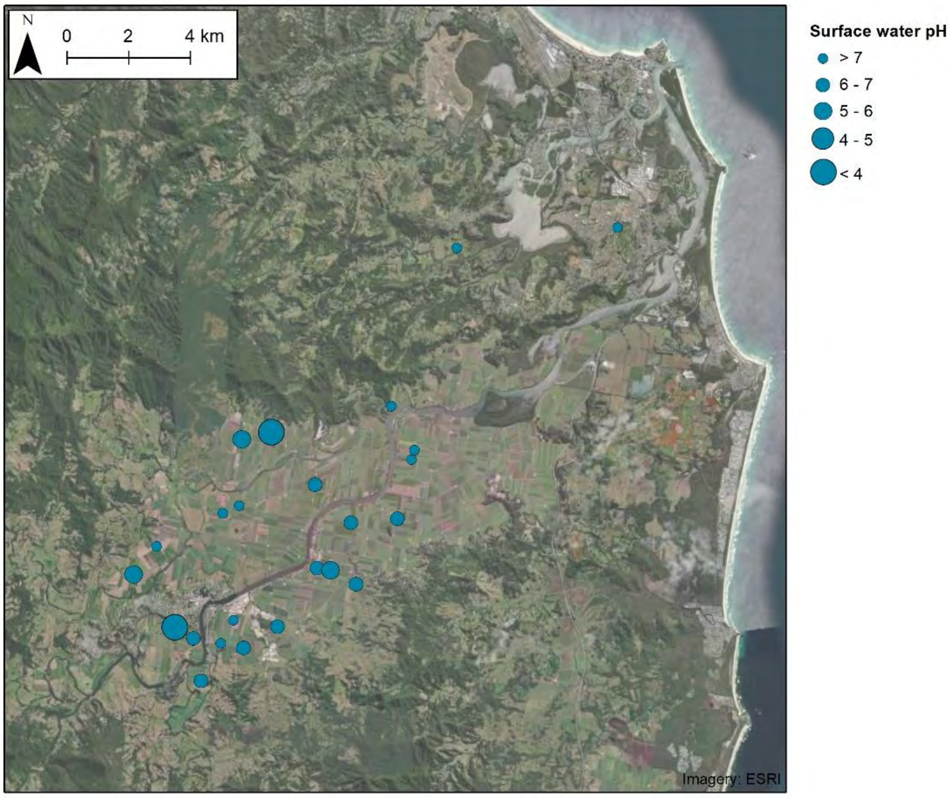


Figure H-1: Surface water pH measurements taken across the Tweed River floodplain

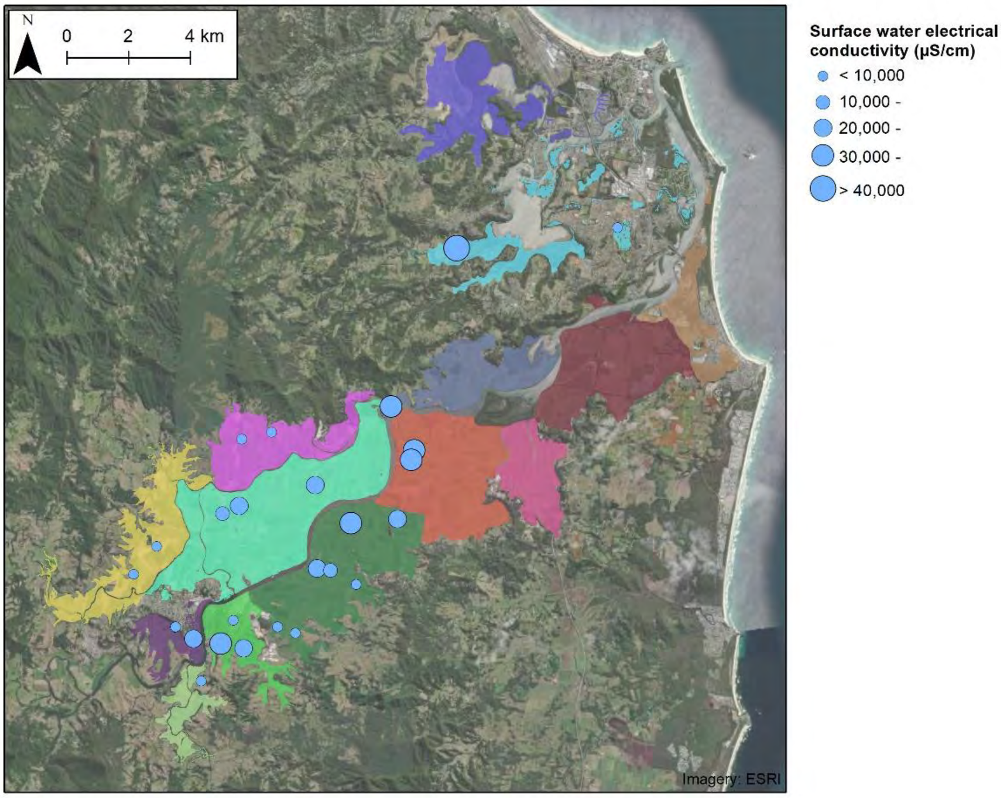


Figure H-2: Surface water electrical conductivity measurements taken across the Tweed River floodplain

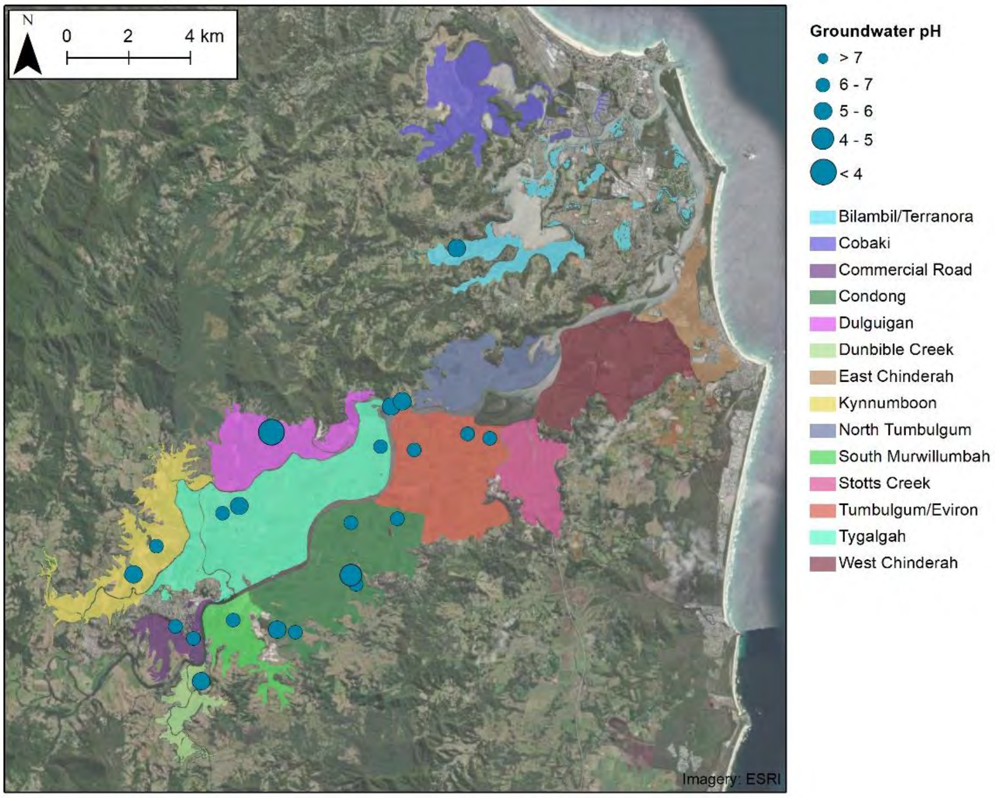


Figure H-3: Groundwater pH measurements taken across the Tweed River floodplain

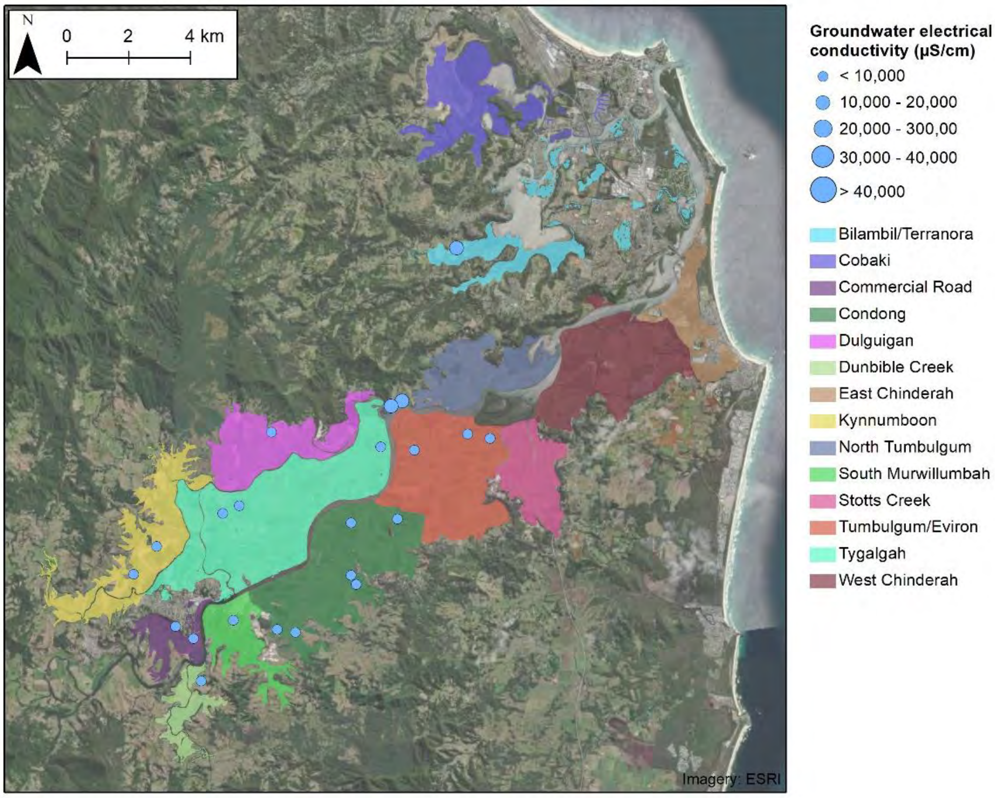


Figure H-4: Groundwater electrical conductivity measurements taken across the Tweed River floodplain

Appendix I Numerical modelling

I1 Preamble

The following section provides a summary of the hydrodynamic numerical model developed for the Tweed River estuary. Results of the hydrodynamic modelling were used for the floodplain vulnerability assessments, detailed in Section 11 of the Methods report (Rayner et al., 2023).

I2 Hydrodynamic model

Hydrodynamics is the study of water movement. In an estuary, three main elements control the movement of water (tidal hydrodynamics). This includes, estuary geometry, upstream catchment inflows and downstream ocean tides. The geometry of an estuary is defined by its width, length, depth or the shape and storage of sidearms. Upstream catchment inflows are based on rainfall and runoff and downstream tidal inflows are based on the water levels in the ocean.

I2.1 Numerical model

Numerical modelling of the Tweed River estuary tidal hydrodynamics was undertaken using the RMA modelling suite (King, 2015). The RMA-2 hydrodynamic model solves the shallow water wave equations and is suitable for the simulation of flow in vertically, well-mixed water bodies such as, estuaries. RMA-2 uses the principles of conservation of mass and momentum, and represents typical processes of bed and bank friction, turbulence and wind stress.

RMA-2 calculates a finite element solution of the Reynolds-form of the Navier-Stokes equations for turbulent flows. The main internal model parameters applied to the model are eddy viscosity, bed friction and turbulent mixing. The horizontal eddy viscosity (ε) is specified in terms of a scaled velocity and element size as presented in Equation I-2:

$$\varepsilon_{xy} = \alpha(x,y,t) \cdot V(x,y,t) \cdot \Delta_{elt}(x,y)$$ **Equation I-2**

Where:

ε = horizontal eddy viscosity (m^2/s)

V = velocity (m/s)

α = non-dimensional scaling factor

Δ_{elt} = a length representative of the element size (m)

The RMA-2 model utilises a finite element mesh consisting of an irregular connection of nodes and elements to represent the model domain. Finite elements are suitable to model complex estuaries as the elements can vary in size and shape to represent the geometry of the waterbody. Accurate representation of the waterway geometry is important as it is a major factor in replicating and predicting tidal hydrodynamics.

Water levels and flow velocities are predicted at every node within the finite element mesh of the model. One dimensional (1-D) elements are used to represent channel flow velocities in one horizontal direction (i.e. upstream to downstream and where flow occurs perpendicular to the channel cross section), whereas two dimensional (2-D) elements represent depth-averaged flow velocities in two-horizontal directions (i.e. x-y plane). RMA-2 simulates the process of bank wetting and drying as the water level changes through the use of marshing elements. Marshing simulates drying by approximating elements with a smaller width and higher friction for water transfer thereby effectively preventing flow in those elements while conserving mass.

I2.2 Model domain

A 1-D/2-D hydrodynamic model of the Tweed River estuary was developed to simulate the typical tidal water level variations within the estuary. The hydrodynamic model extends to the tidal limits of major rivers, tributaries and creeks in the estuary, including the Tweed River, Rous River and Terranora Creek. The model also includes smaller tributaries and creeks in the lower estuary that contained important floodgate structures. A model grid representing the study area provided increased resolution in areas around the lower estuary where complex 2-D flows were expected and lower resolution in the upper reaches of the estuary where flows were modelled using 1-D elements. The model area is shown in Figure I-1.

Figure I-1: Tweed River estuary – tidal hydrodynamic model extent

I2.3 Model inputs

The hydrodynamic model comprised of three (3) main inputs, including channel geometry, downstream ocean tidal water levels and upstream catchment inflows.

Channel geometry below 2 m AHD was digitised using standard GIS methods for the main flow pathways up to the tidal extent of the Tweed River estuary. The bathymetry hydrodynamic model was extracted from the most recent hydrodynamic flood model developed for the Tweed River floodplain (BMT, 2019).

Catchment inflows were based on observed river flow data from WaterNSW gauging stations in the upper Tweed River catchment as shown in Figure I-2. The flow gauging stations are located upstream of the numerical model boundary, and therefore required adjustment to account for the additional catchment area and runoff that could occur in between the flow gauging location and the model inflow boundary. To account for this, catchment runoff data was scaled by the additional contributing catchment areas that were missed between the gauges and the model boundary. This was achieved using standard GIS methods to compare the upstream area of the gauging sites to the upstream area of the model domain. A summary table of the upstream inflow boundaries and scaling factors are provided in Table I-1. Localised floodplain subcatchment runoff inflows were excluded from the model as sensitivity testing indicated that day-to-day water levels in the lower reaches of the estuary were found to be dominated by tidal fluctuations. The downstream ocean tidal boundary of the model was based on the observed water levels from the NSW DPIE Manly Hydraulics Laboratory (MHL) station at Tweed Entrance South (station number 201472).

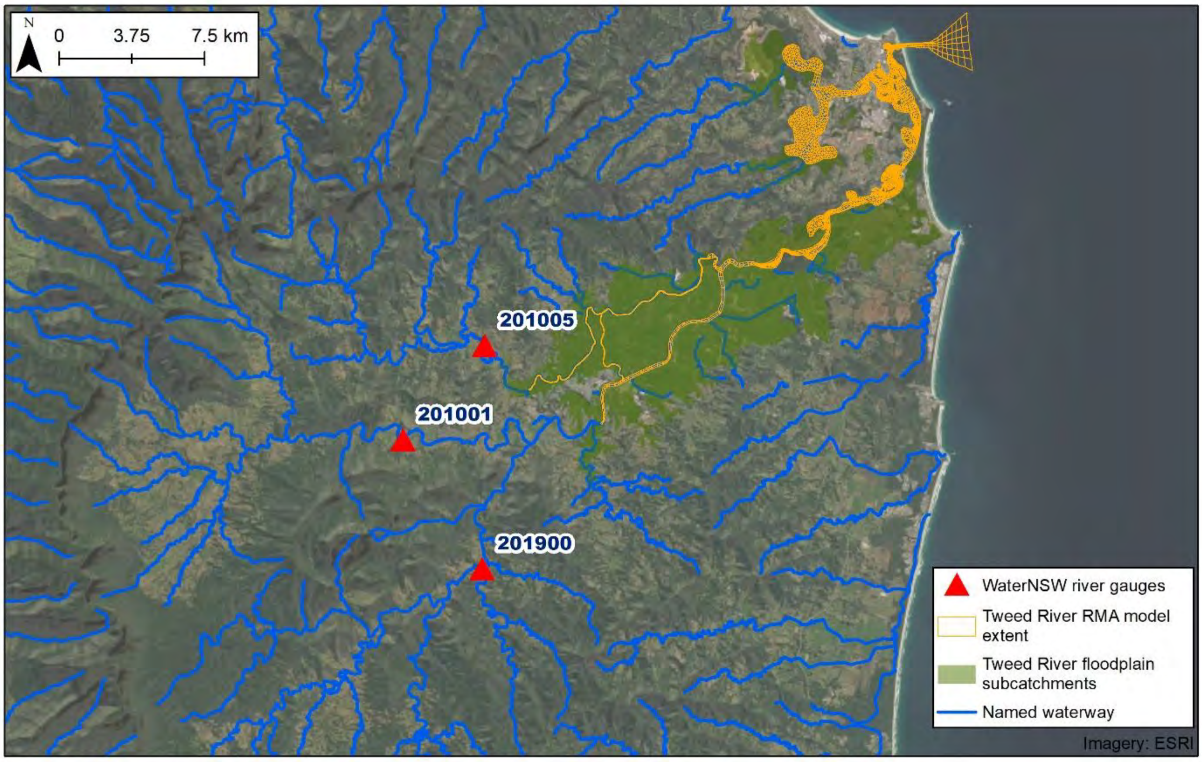


Figure I-2: Location of WaterNSW river flow gauges with relation to the hydrodynamic model extent

Table I-1: Summary of model boundary conditions

Gauging station name	Data source	Station number	Scale factor
Oxley River at Eungella	WaterNSW	201001	1.178
Tweed River at Uki	WaterNSW	201900	1.
Rous River at Boat Harbour 3	WaterNSW	201005	1.103
Tweed Entrance South	MHL	201472	N/A

I2.4 Model calibration

The hydrodynamic model for the Tweed River estuary was calibrated to selected water level gauging stations along the main river channel for 2017. The year 2017 was selected based on BOM rainfall records for the northern parts of NSW closely representing the long-term annual average rainfall for this region. The locations of the water level stations used for the water level calibrations are shown in Figure I-3. Water level data was sourced from NSW DPIE Manly Hydraulics Laboratory (MHL).

The main internal model parameters in the RMA-2 hydrodynamic model are eddy viscosity and friction (applied as Manning's n). The model was calibrated by adjusting the Manning's n value to match the observed tidal ranges and phasings throughout the estuary. A Manning's n value of value of 0.020 was adopted offshore near the estuary entrance and a value of 0.023 was adopted for the main channel up to the tidal limit to achieve final calibrations.

The calibration results for a selected 20-day window are provided in Figure I-4 to Figure I-8. The model was calibrated (for dry weather periods) to within 0.05 m in the lower estuary and to within 0.15 m in the upper estuary, where the channel geometry incorporated into the model was less reliable.

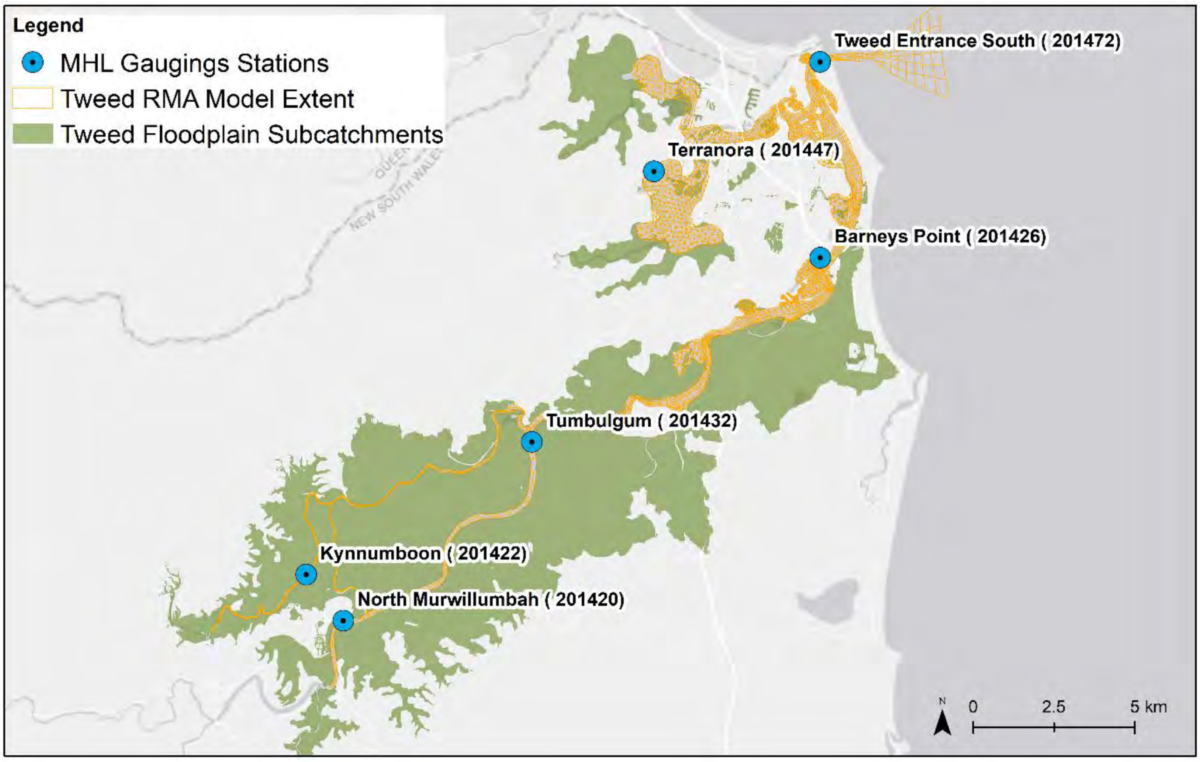


Figure I-3: Location of selected water level stations used for calibration of the Tweed River estuary hydrodynamic model

I2.5 Model verification

The calibrated model was then used to simulate a representative 'wet' year (i.e. more rain than average across the catchment) and a representative 'dry' year (i.e. less rain than average across the catchment) based on analysis of BOM rainfall records in Northern NSW. For this study, 2013 and 2019 were selected as the wet and dry years respectively. The model results from these simulations were then used to verify the tidal water calibrations throughout the estuary. Tidal water level verification plots for the Tweed Estuary for 2013 and 2019 are provided in Figure I-9 to Figure I-17.

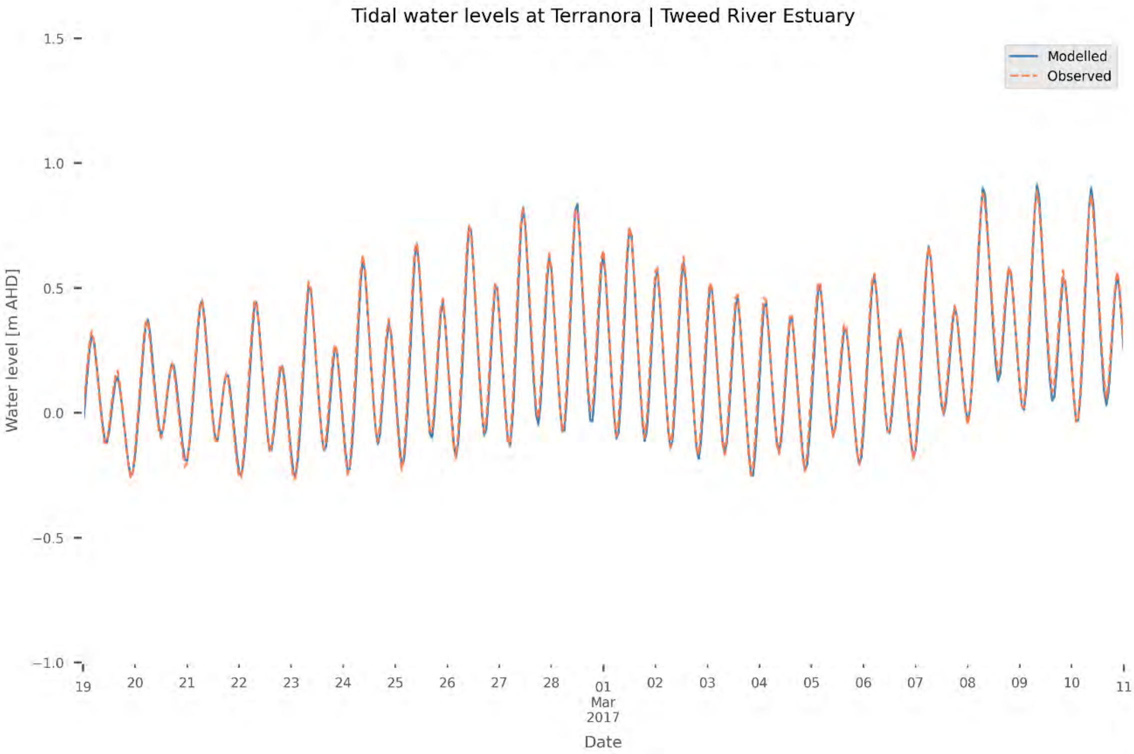


Figure I-4: Tweed hydrodynamic model calibration results (2017) at Terranora (201447)

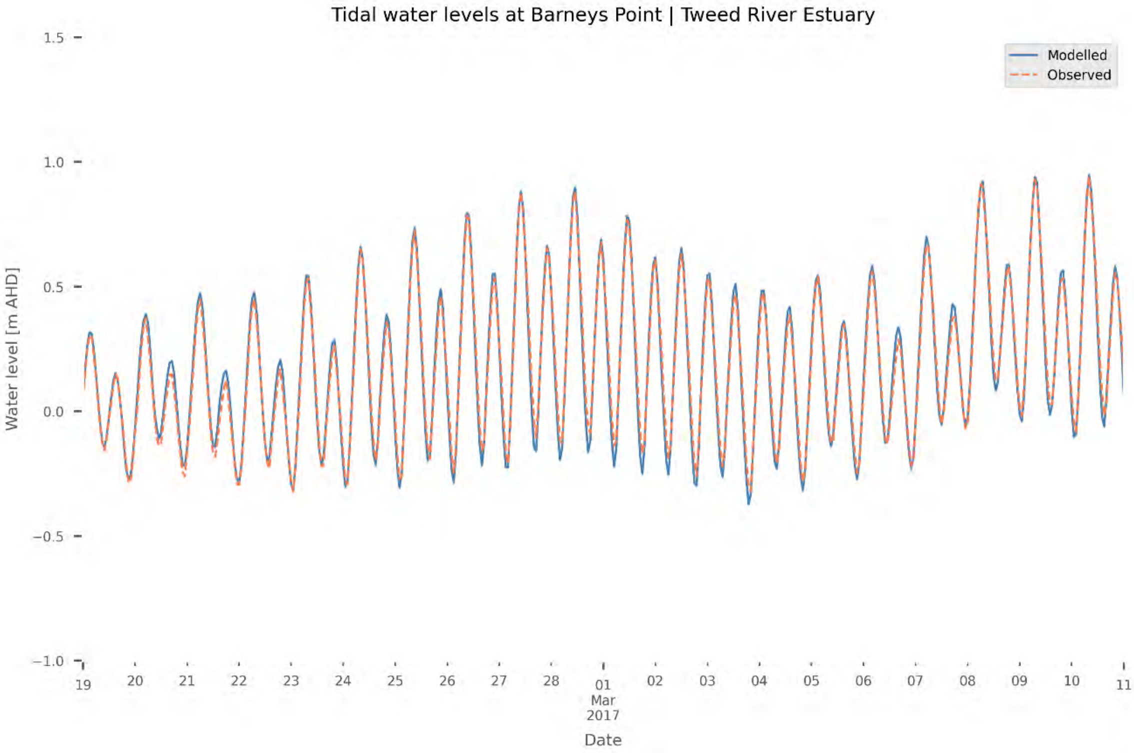


Figure I-5: Tweed hydrodynamic model calibration results (2017) at Barneys Point (201426)

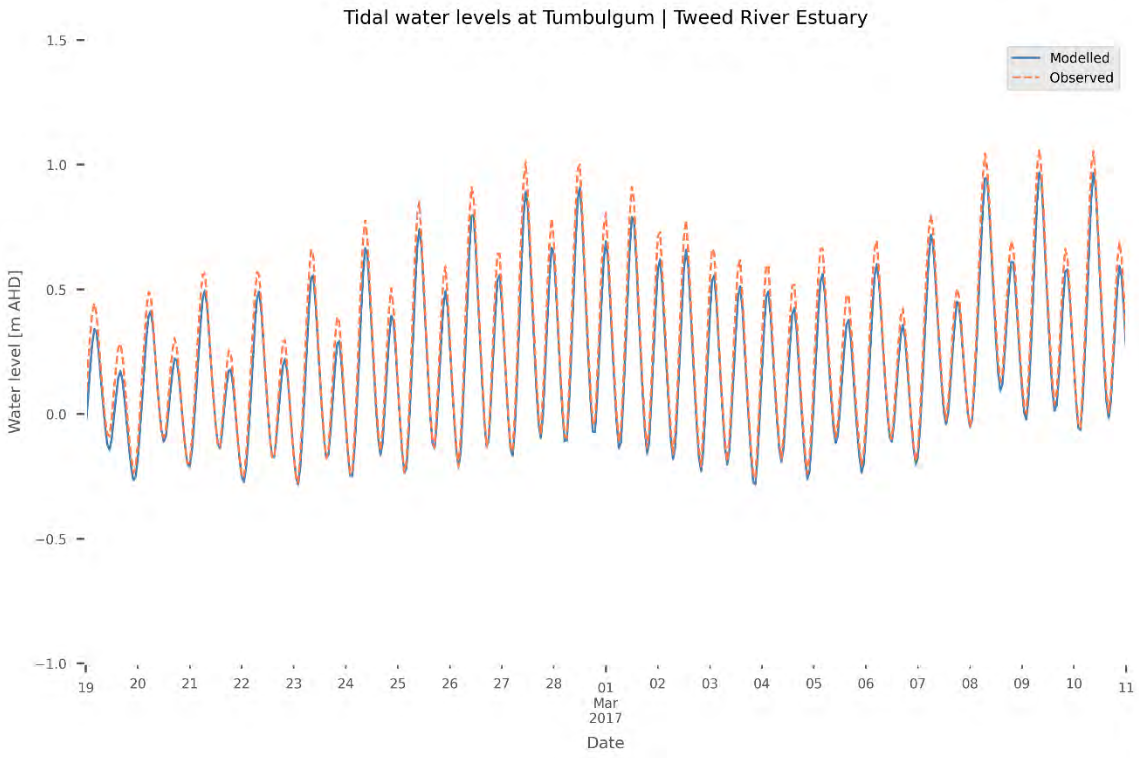


Figure I-6: Tweed hydrodynamic model calibration results (2017) at Tumbulgum (201432)

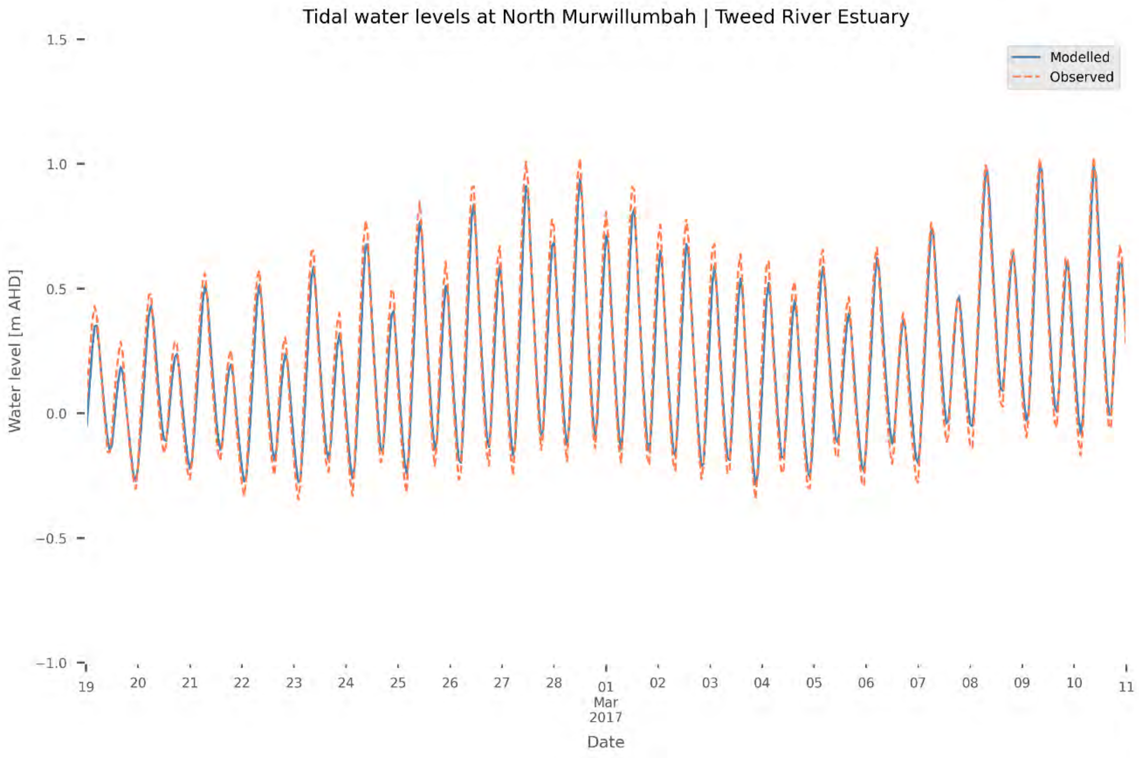


Figure I-7: Tweed hydrodynamic model calibration results (2017) at North Murwillumbah (201420)

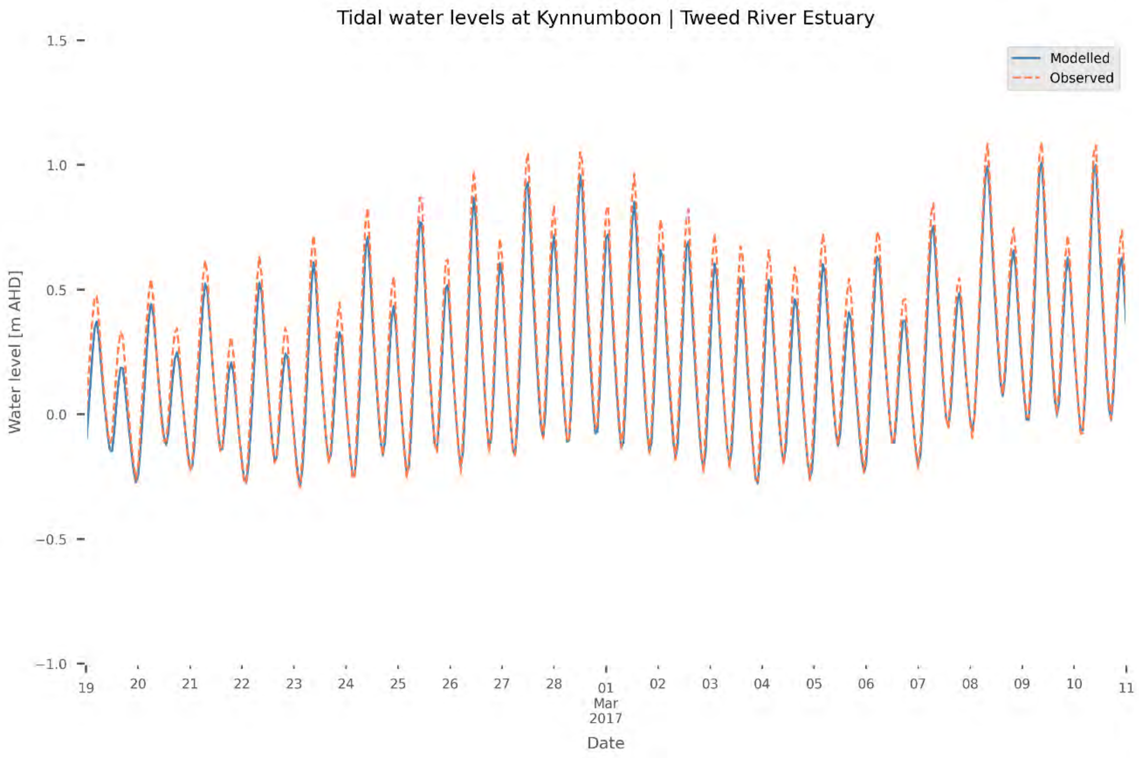


Figure I-8: Tweed hydrodynamic model calibration results (2017) at Kynnumboon (201422)

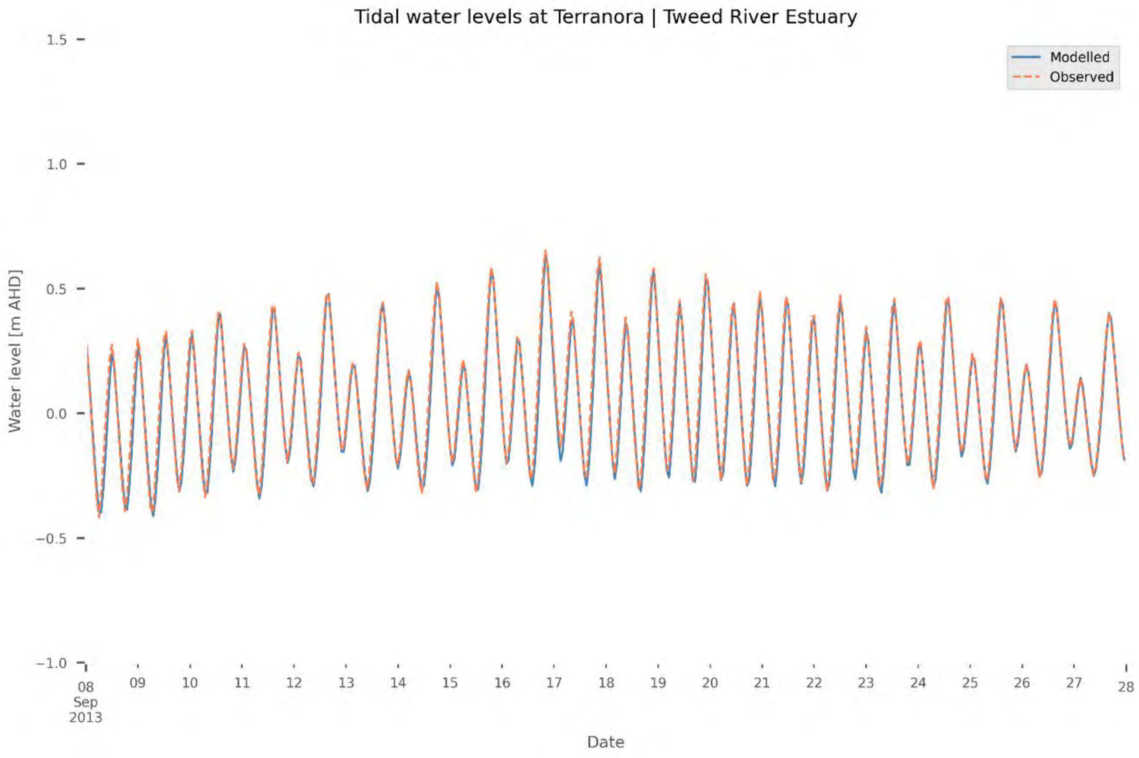


Figure I-9: Tweed hydrodynamic model verification results (2013) at Terranora (201447)

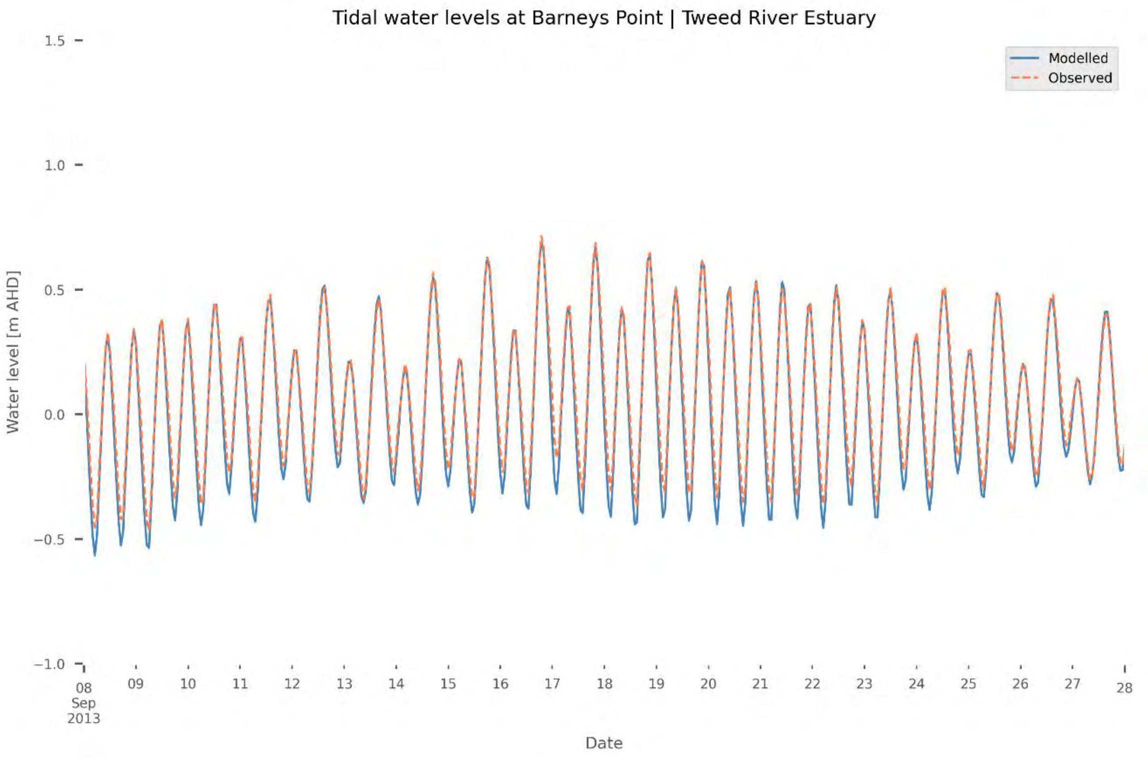


Figure I-10: Tweed hydrodynamic model verification results (2013) at Barneys Point (201426)

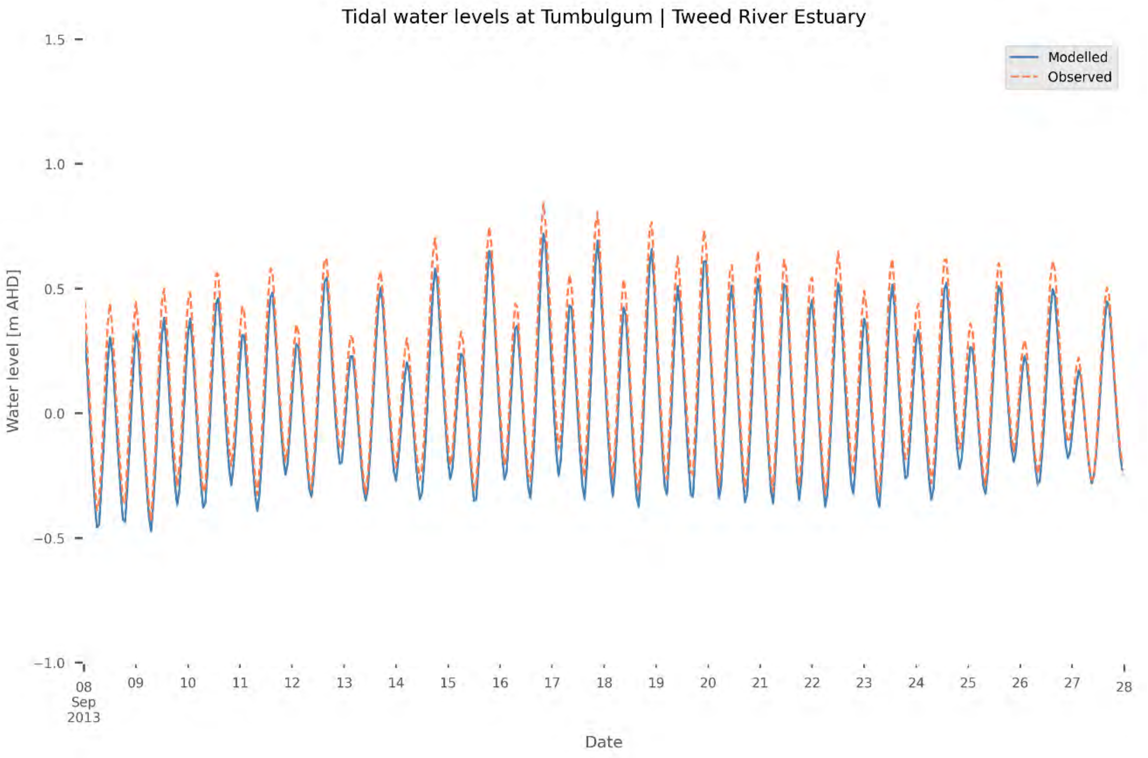


Figure I-11: Tweed hydrodynamic model verification results (2013) at Tumbulgum (201432)

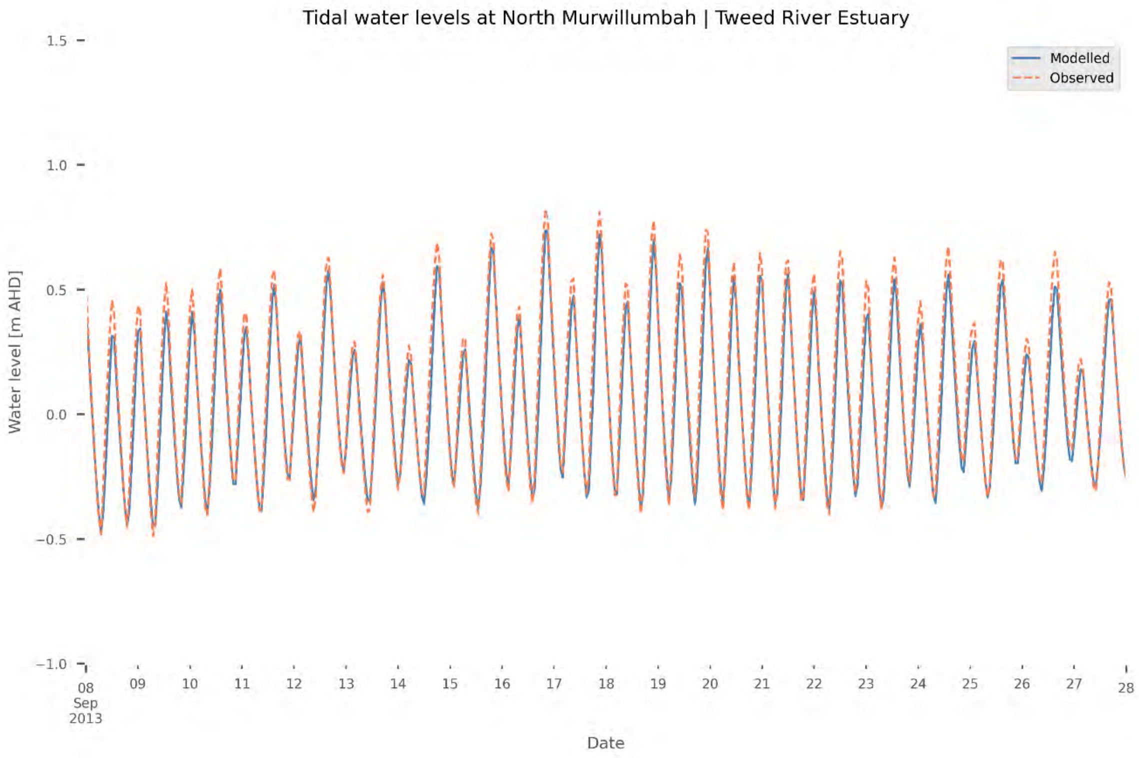


Figure I-12: Tweed hydrodynamic model verification results (2013) at North Murwillumbah (201420)

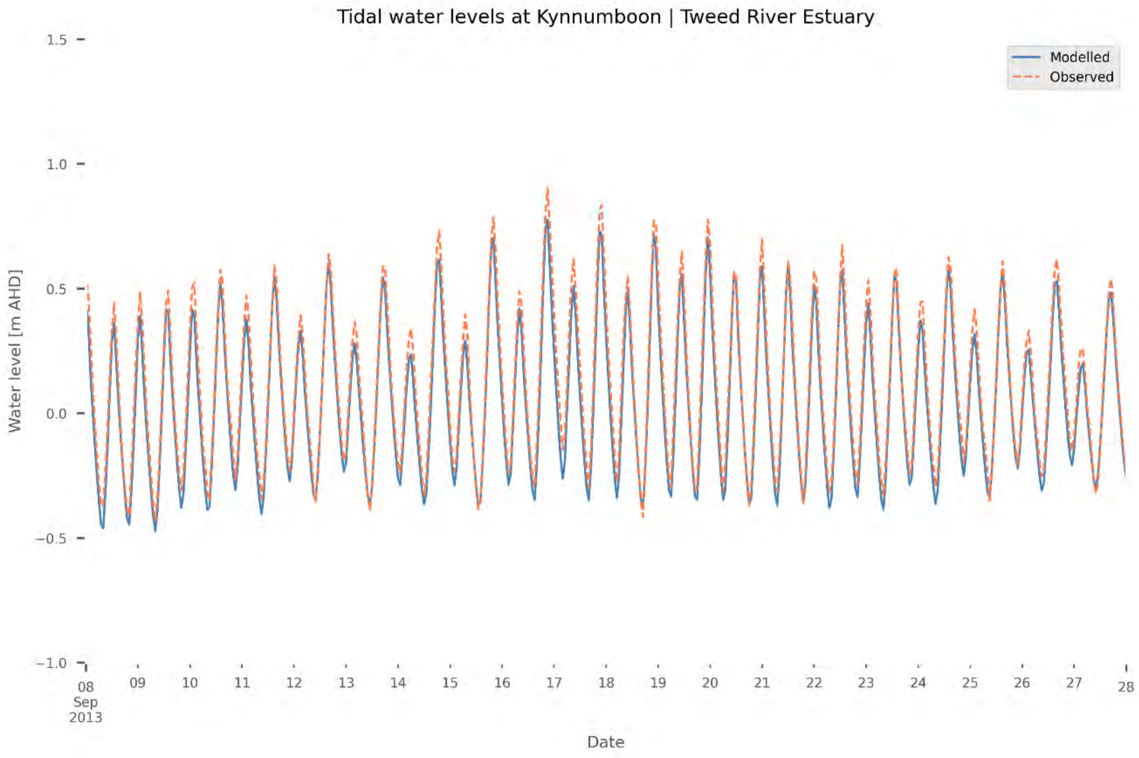


Figure I-13: Tweed hydrodynamic model verification results (2013) at Kynnumboon (201422)

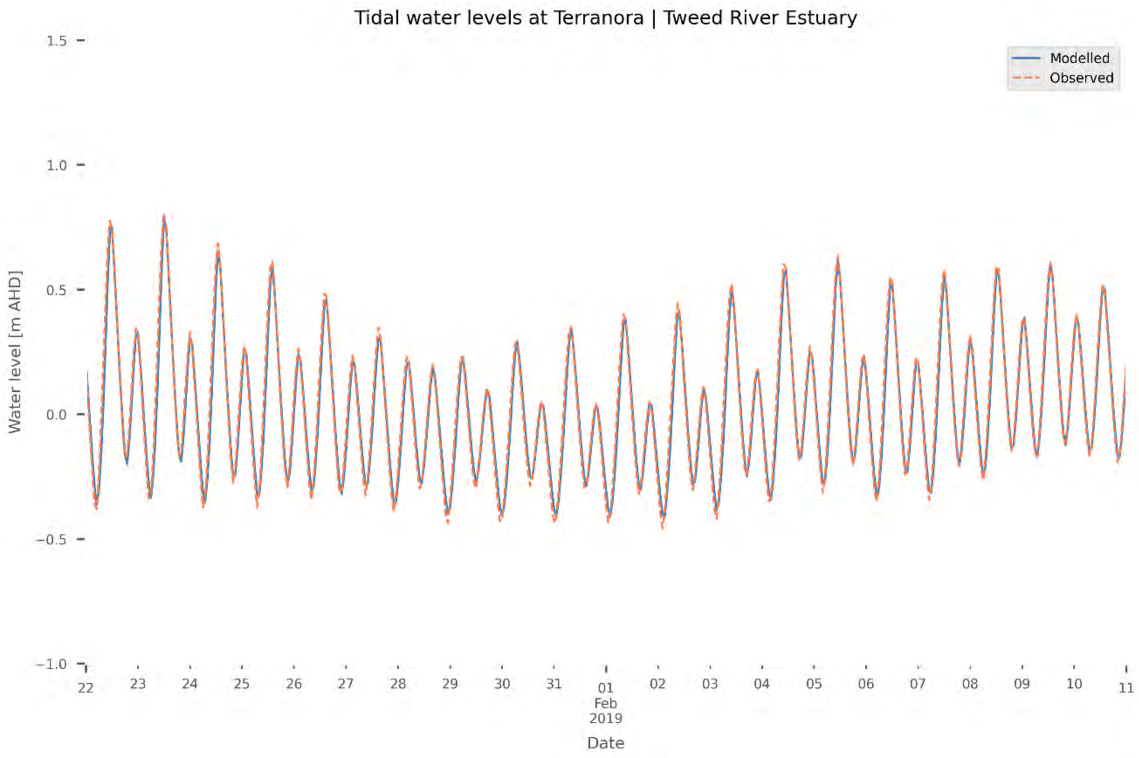


Figure I-14: Tweed hydrodynamic model verification results (2019) at Terranora (201447)

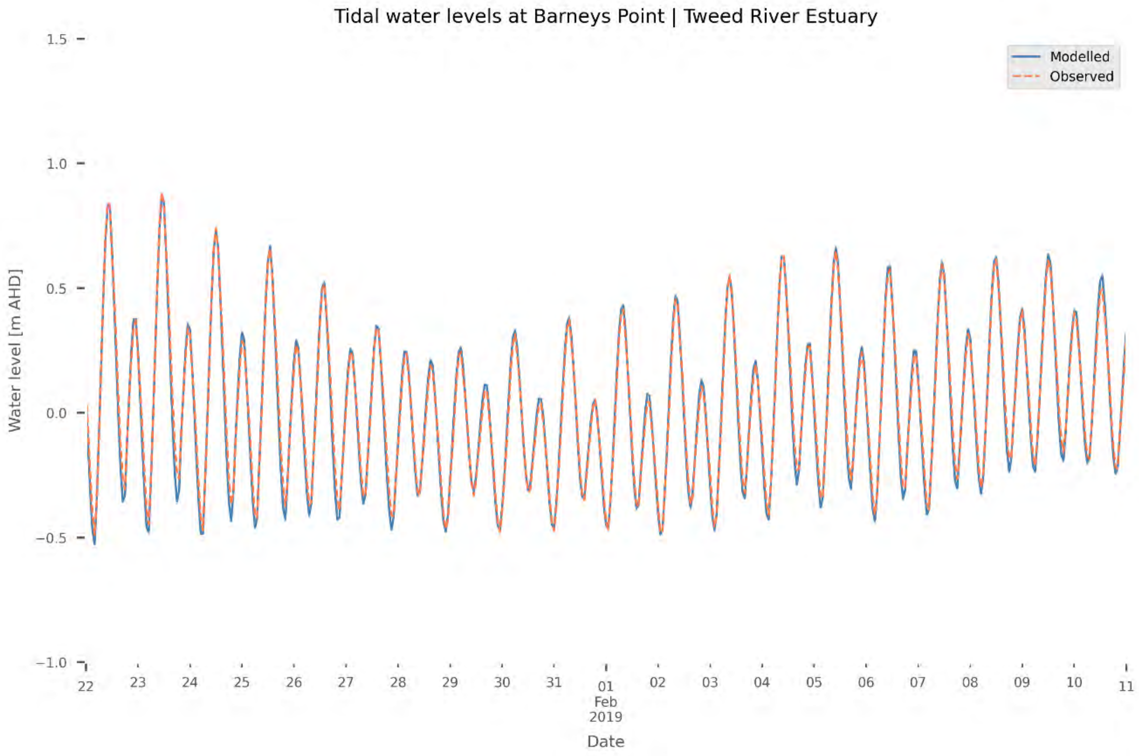


Figure I-15: Tweed hydrodynamic model verification results (2019) at Barneys Point (201426)

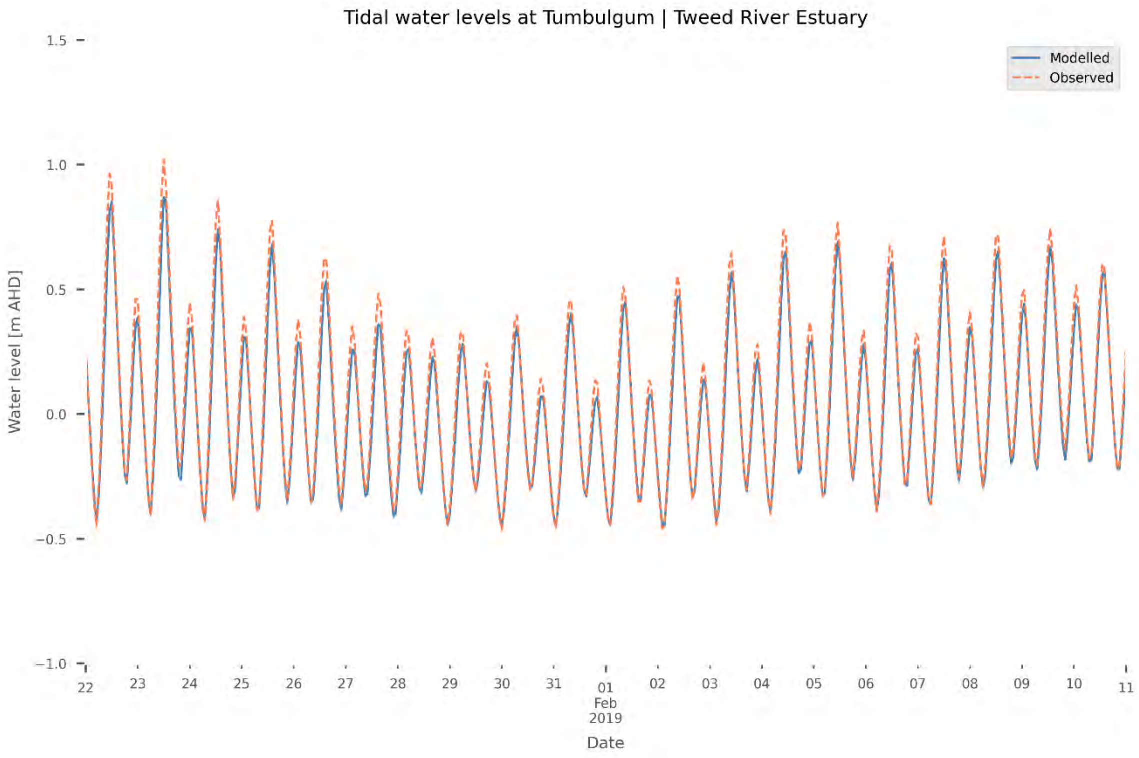


Figure I-16: Tweed hydrodynamic model verification results (2019) at Tumbulgum (201432)

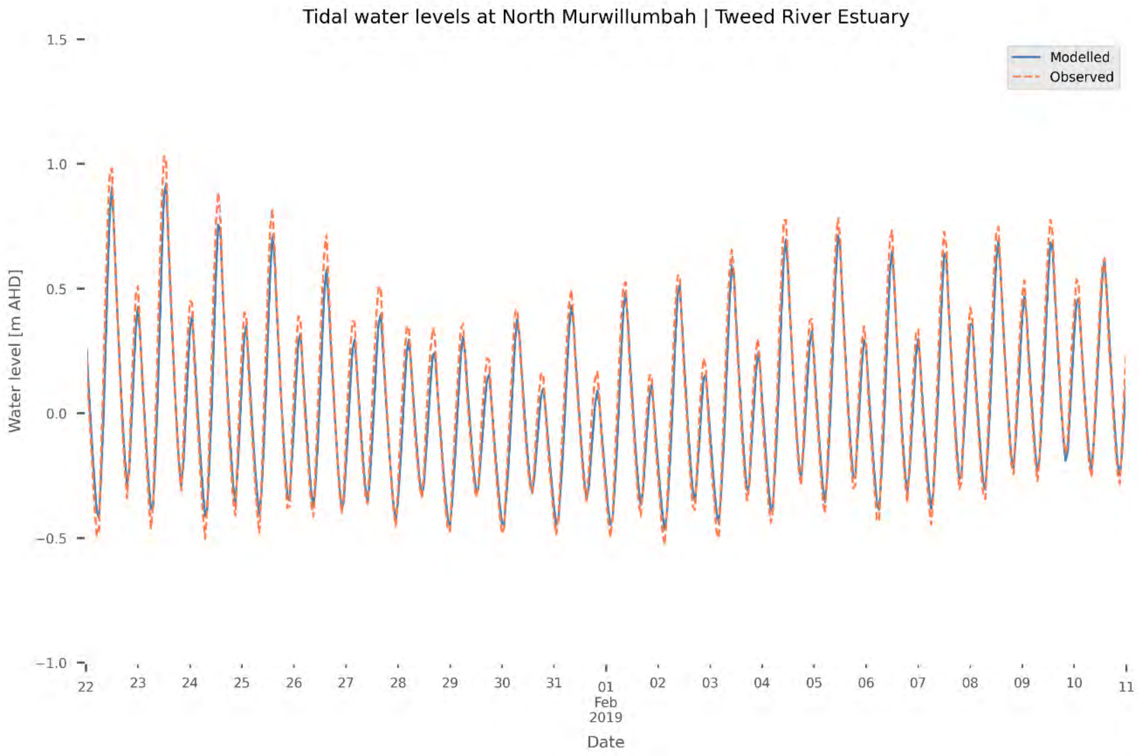


Figure I-17: Tweed hydrodynamic model verification results (2019) at North Murwillumbah (201420)

Appendix J Sensitive receivers

J1 Preamble

Acid discharges from ASS-affected floodplains are well reported to cause stress to sensitive environmental receivers (Rayner, 2010; Winberg and Heath, 2010; Glamore, 2003; Sammut et al., 1996). Furthermore, water control structures associated with ASS-affected drains, such as one-way floodgates, prohibit the passage of aquatic species and limit the overall primary production of estuaries (Winberg and Heath, 2010). Sensitive environmental receivers are widespread throughout the Tweed River estuary. This section provides an overview of the proximity of sensitive environmental receivers to acidic drainage areas within the study area, and the information provided in this section was used to inform the prioritisation of each sub-catchment.

J2 Sensitive environmental receivers of the Tweed River estuary

Several sensitive environmental receivers were identified during the course of this investigation. Both aquatic and terrestrial ecological communities and sensitive locations were identified and mapped as provided in Figure J-1 to Figure J-4, including:

- Key fish habitat relating to the Fisheries Management Act (1994);
- Oyster leases;
- Estuarine macrophytes; and
- Coastal wetlands as defined by the State Environmental Planning Policy (Coastal Management) 2018.

The proximity of each sub-catchment in the study area to downstream stationary sensitive receivers was calculated as provided in Table J-1.

Table J-1: Summary of approximate proximity (in metres) of sensitive environmental receivers (SER) to each subcatchment within the study area

Subcatchment	Oyster leases	Estuarine macrophytes			Coastal wetlands	SER within subcatchment*
		Saltmarsh	Seagrass	Mangroves		
Bilambil/ Terranora	700	0	800	0	0	Saltmarsh, mangroves, coastal wetlands, key fish habitat
Cobaki	2,700	0	0	0	0	Saltmarsh, seagrass, mangroves, coastal wetlands, key fish habitat
Commercial Road	33,500	16,600	20,300	1,500	1,200	None
Condong	25,400	8,900	12,200	0	3,200	None
Dulguigan	25,500	8,300	12,400	0	0	Mangroves, coastal wetlands, key fish habitat
Dunbible Creek	35,700	18,900	22,500	3,700	0	Coastal wetlands, key fish habitat
East Chinderah	10,800	200	0	0	0	Mangroves, coastal wetlands, key fish habitat
Kynnumboon	32,100	14,800	18,900	2,000	0	Coastal wetlands, key fish habitat
North Tumbulgum	17,200	0	4,000	0	0	Mangroves, coastal wetlands, key fish habitat
South Murwillumbah	32,300	15,500	19,200	300	2,200	None
Stotts Creek	19,600	3,100	6,500	0	100	None
Tumbulgum/ Eviron	20,700	4,200	7,500	0	100	Key fish habitat
Tygalgah	24,900	7,700	11,800	0	0	Mangroves, coastal wetlands, key fish habitat
West Chinderah	14,000	0	500	0	0	Saltmarsh, mangroves, coastal wetlands, key fish habitat

*Note: Within subcatchment does not include SER that may be found on the outside boundary (i.e. downstream of floodgates) of the subcatchment.

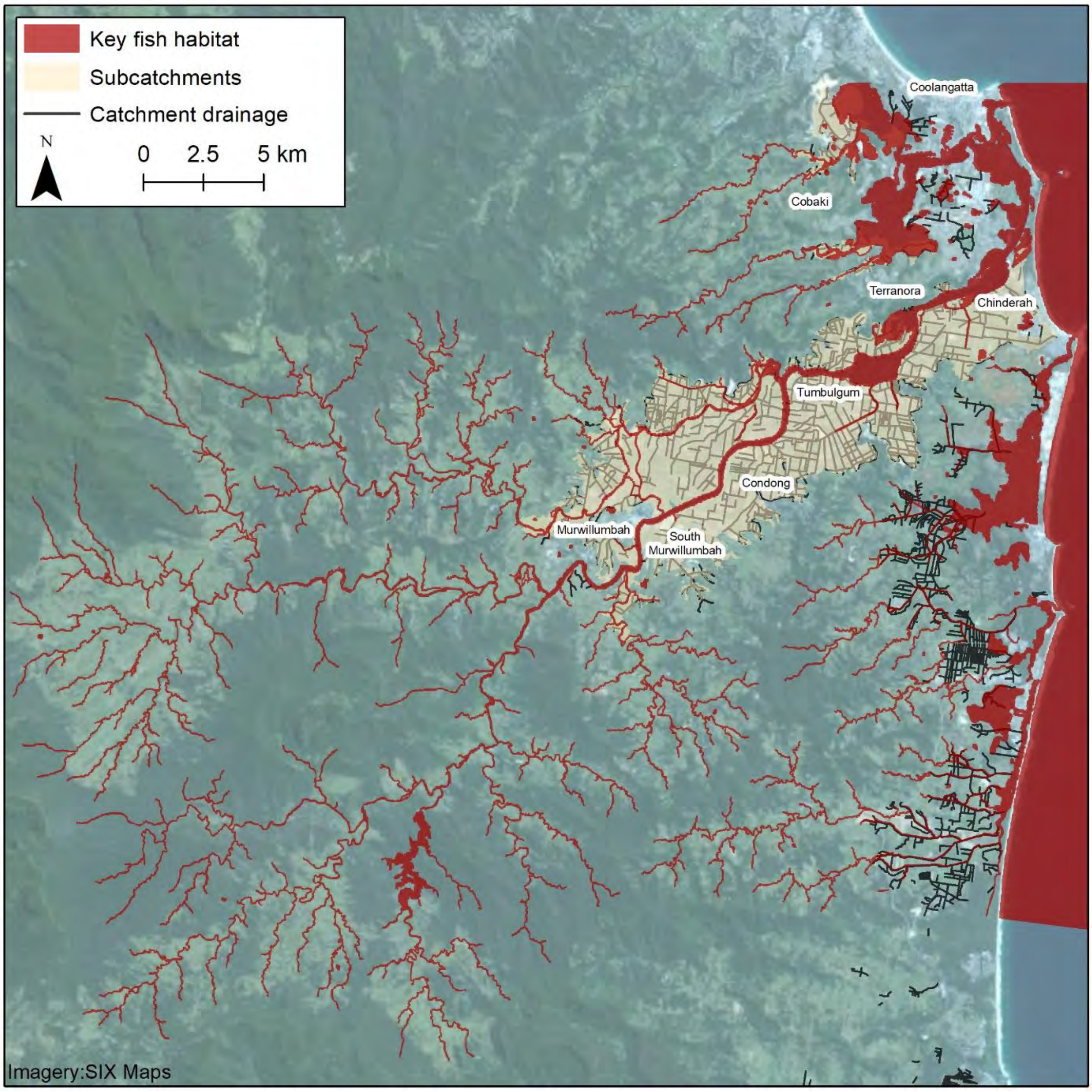


Figure J-1: Key fisheries habitat (Source: NSW DPI Fisheries)

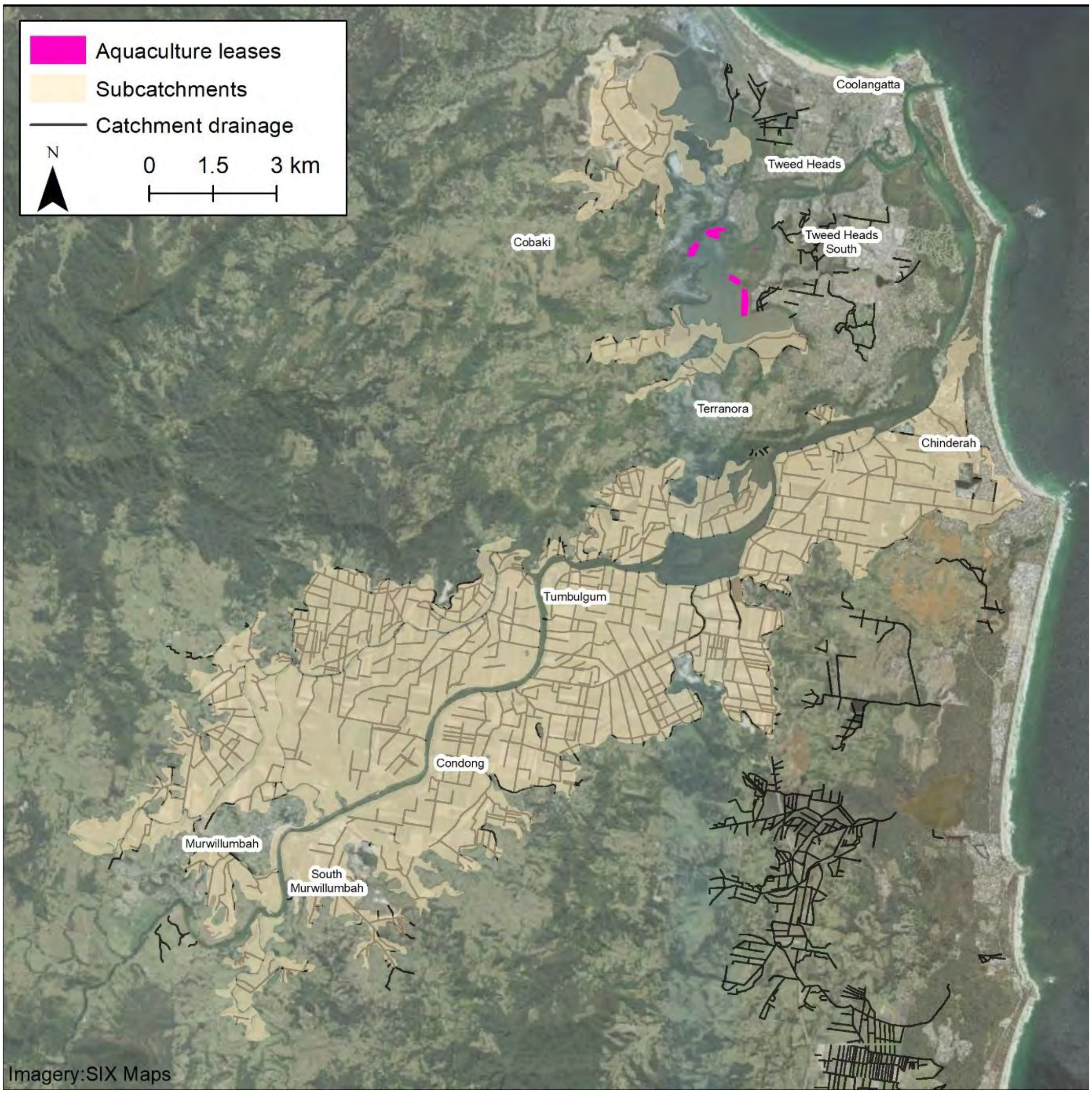


Figure J-2: Priority oyster leases (Source: NSW DPI Fisheries)

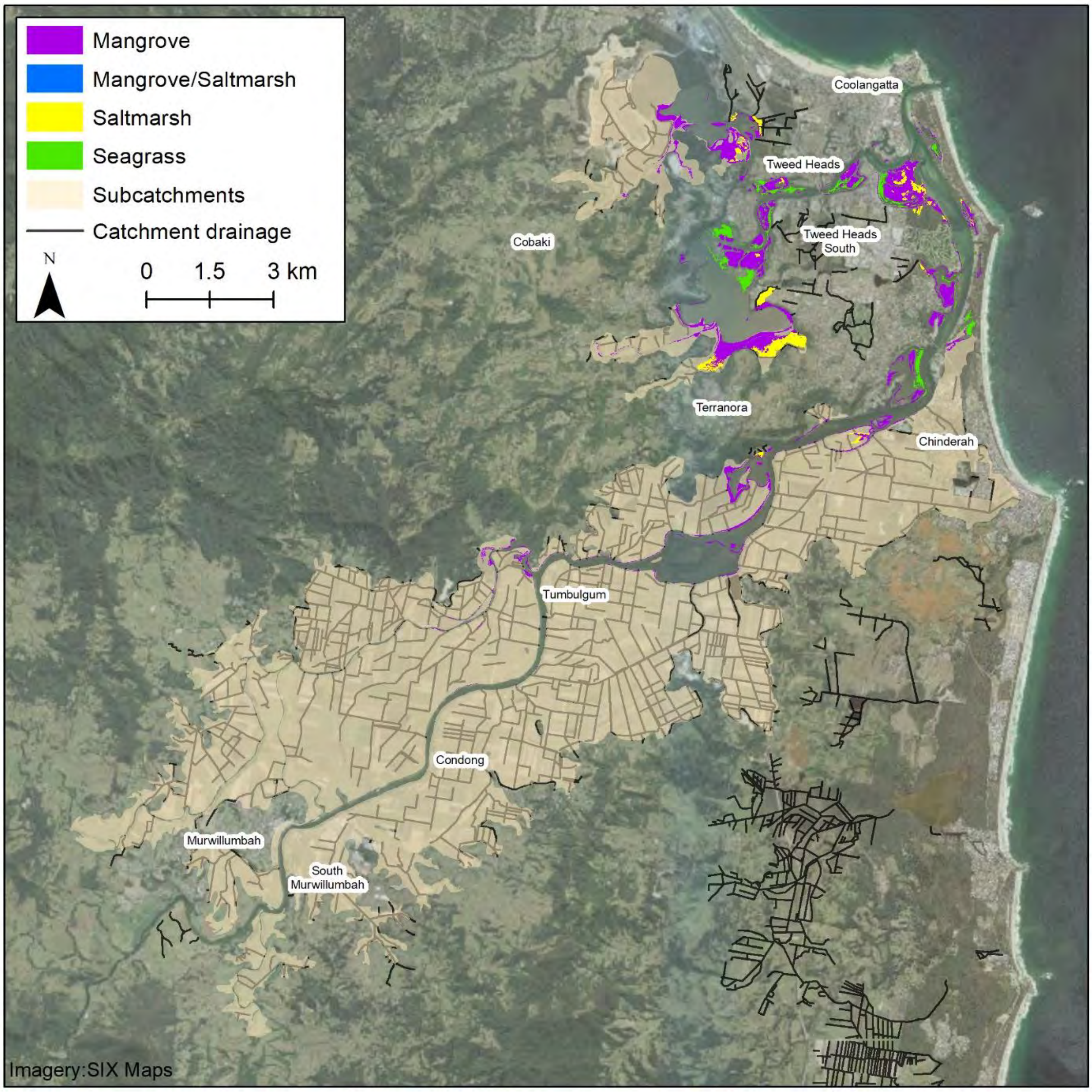


Figure J-3: Estuarine macrophytes (Source: NSW DPI Fisheries)

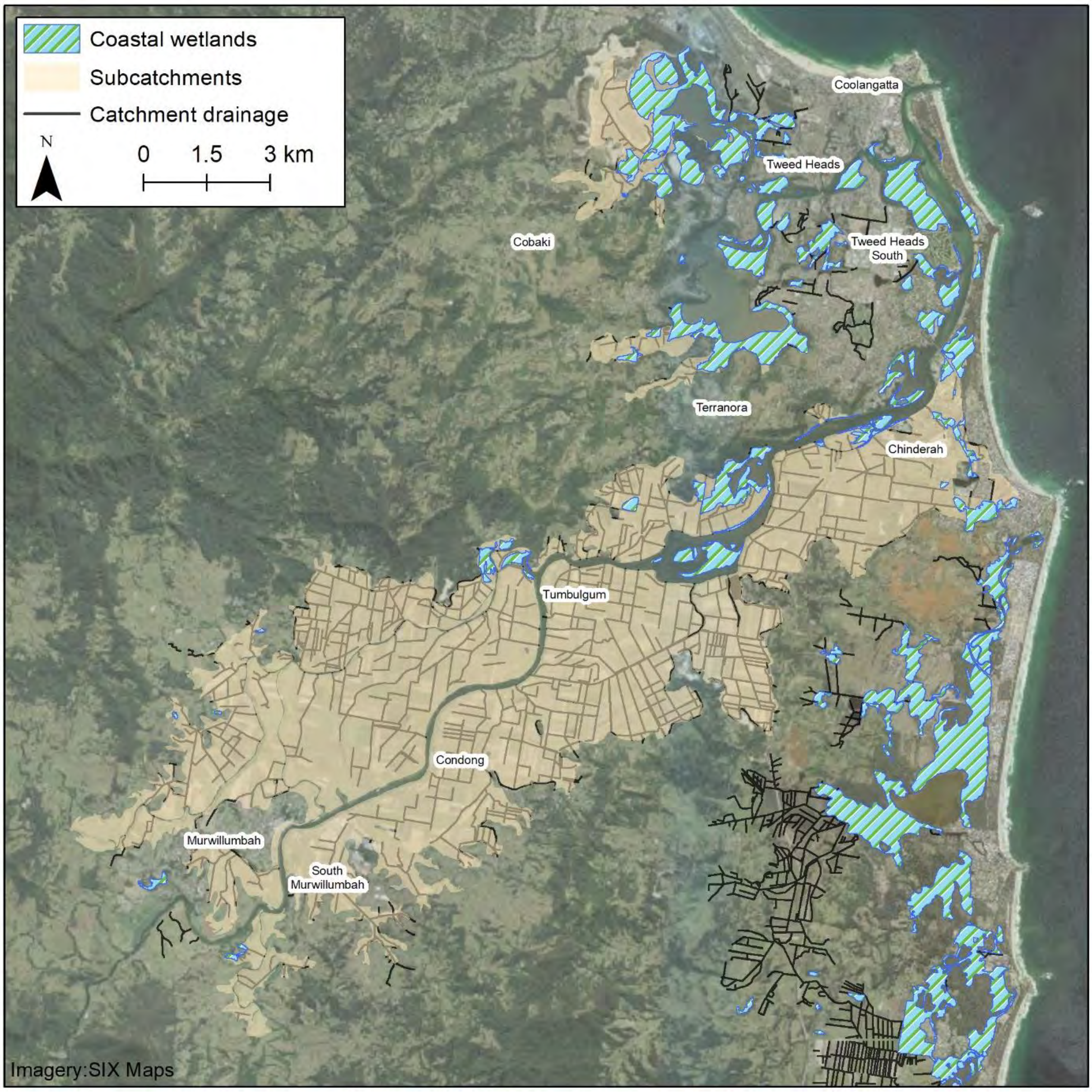


Figure J-4: Coastal Management SEPP coastal wetlands (Source: SEED NSW data portal)[1]

---

[1] Note that the State Environmental Planning Policy No. 14 (SEPP14) for Coastal Wetlands was repealed by cl 9 (a) of State Environmental Planning Policy (Coastal Management) 2018 (106) with effect from 3.4.2018. This policy aims to promote an integrated and co-ordinated approach to land use planning in the coastal zone to ensure that these areas, including coastal wetlands are preserved and protected in the environmental and economic interests of the State.

Appendix K Heritage

K1 Preamble

Heritage listings in NSW are protected by law under the Heritage Act, 1977 (amended 1998) and the Environmental Planning and Assessment Act 1979. Nationally significant heritage items are protected under the Environment Protection and Biodiversity Conservation Act 1999. Heritage items protected include:

- Items listed in local councils Local Environmental Plan (LEP) or Regional Environmental Plan (REP);
- Items listed on the State Heritage Register;
- Items listed on State Agency Heritage Registers (under Section 170 of the Heritage Act, 1977);
- Items listed on Interim Heritage Orders;
- Items listed on the Aboriginal Heritage Information Management System (AHIMS);
- Items listed on the Maritime Heritage Database;
- Items listed on the Commonwealth Heritage List; and
- Items listed on the National Heritage List.

Implementation of management options need to consider any heritage listed items that may be affected during on-ground works. Heritage items fall under the category of implementation constraint in the prioritisation methodology (see Section 2 of the Methods Report (Rayner et al., 2023)). Note that new heritage items are continuously being registered. Subsequently, items identified and presented in this section should only be used as a guide and it is encouraged that anyone seeking to identify the most recent information on heritage listed items will need to consult the relevant registers which contain current information.

K2 Aboriginal heritage

Aboriginal sites across the Tweed River floodplain listed within the Aboriginal Heritage Information Management System (AHIMS) have been identified to determine if they affect the implementation of management options. Due to the sensitive nature of this information no data can be presented here, however, some aboriginal heritage items are presented within the NSW State Heritage Inventory where there is no restriction (see Section K3).

Note that for any works that will alter the landscape due diligence may need to be carried out as per the National Parks and Wildlife Act 1974. Searching AHIMS is only part of this due diligence process. Furthermore, AHIMS data sourced for this study is only up to date as of October 2019. Prior to any activities being undertaken such as actions outlined in the management options, a renewed search of AHIMS will need to be undertaken to ensure the most current information is being used.

K3 European heritage

Heritage listed items, including items of European origin, have been identified from the Commonwealth Heritage List, National Heritage List and the NSW State Heritage Inventory, which includes:

- Items listed on the State Heritage Register;
- Listed Interim Heritage Orders;
- Items listed on State Agency Heritage Registers; and
- Items listed on the Tweed Shire Council LEP.

Figure K-1 outlines items that have been identified on the National Heritage List, the NSW State Heritage Register and the NSW Office of Environment and Heritage (OEH) Agency Register, and the Historic Heritage Information Management System (HHIMS). Items listed on the Commonwealth Heritage Register overlap with the NSW State Heritage Register in the study region so only the NSW State Register items have been displayed. As of June 2020, no Interim Heritage Order items were identified within the study area. Note, prior to any activities being undertaken such as actions outlined in the management options, a renewed search of registers will need to be undertaken to ensure the most current information is being used.

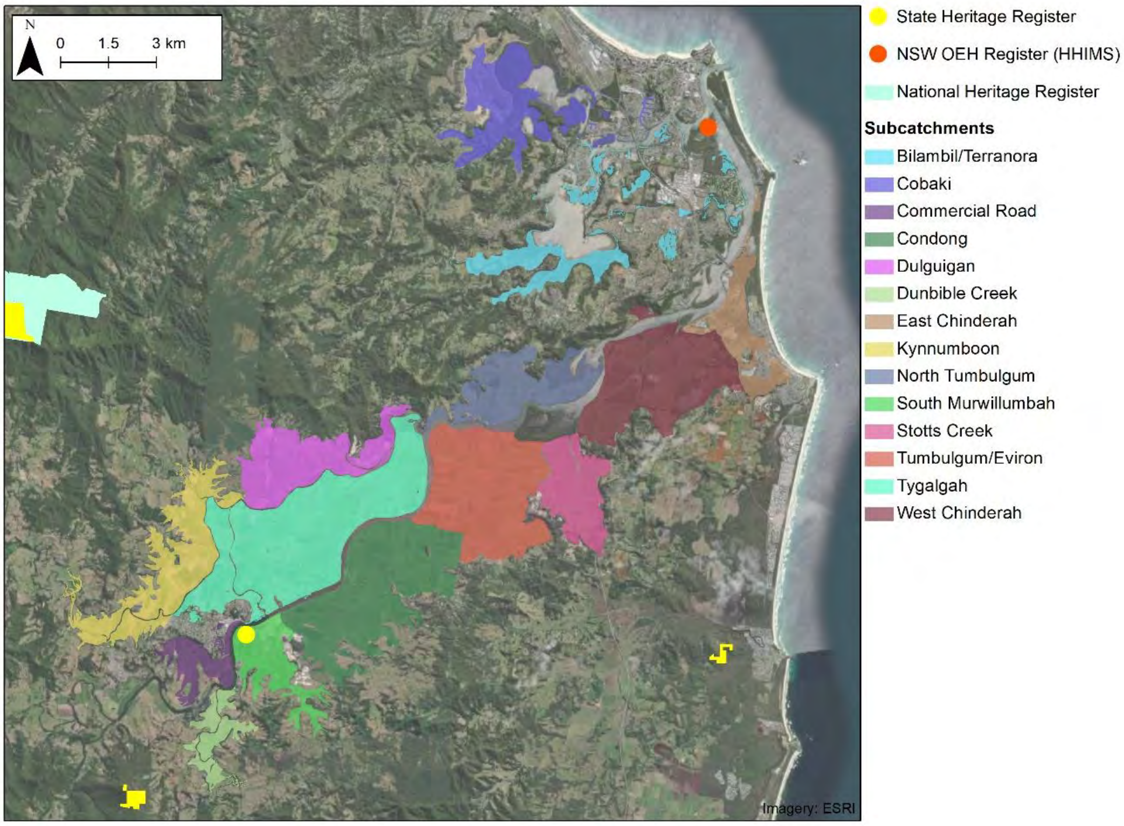


Figure K-1: Heritage items listed on Australian and NSW registers with location information

A total of 169 items were identified as listed on State Agency Registers and the Tweed Shire Council LEP. For an up to date list of these items consult the NSW State Heritage Inventory.

K4 Maritime heritage

In addition to provisions outlined under the NSW Heritage Act 1977, items of maritime heritage are protected by the Commonwealth Underwater Cultural Heritage Act 2018. Maritime heritage items can be found on the following registers:

- The Australian Underwater Cultural Heritage Database (AUCHD); and
- The NSW Maritime Heritage Database.

Items of maritime heritage listed in the aforementioned registers are displayed in Figure K-2. Note that items added after June 2020 are not included in this list. Prior to any activities being undertaken, such as actions outlined in the management options, a renewed search of registers will need to be undertaken to ensure the most current information is being used. Furthermore, the Maritime Heritage specialist services team should be contacted to determine if there are any items of importance that have not been listed.

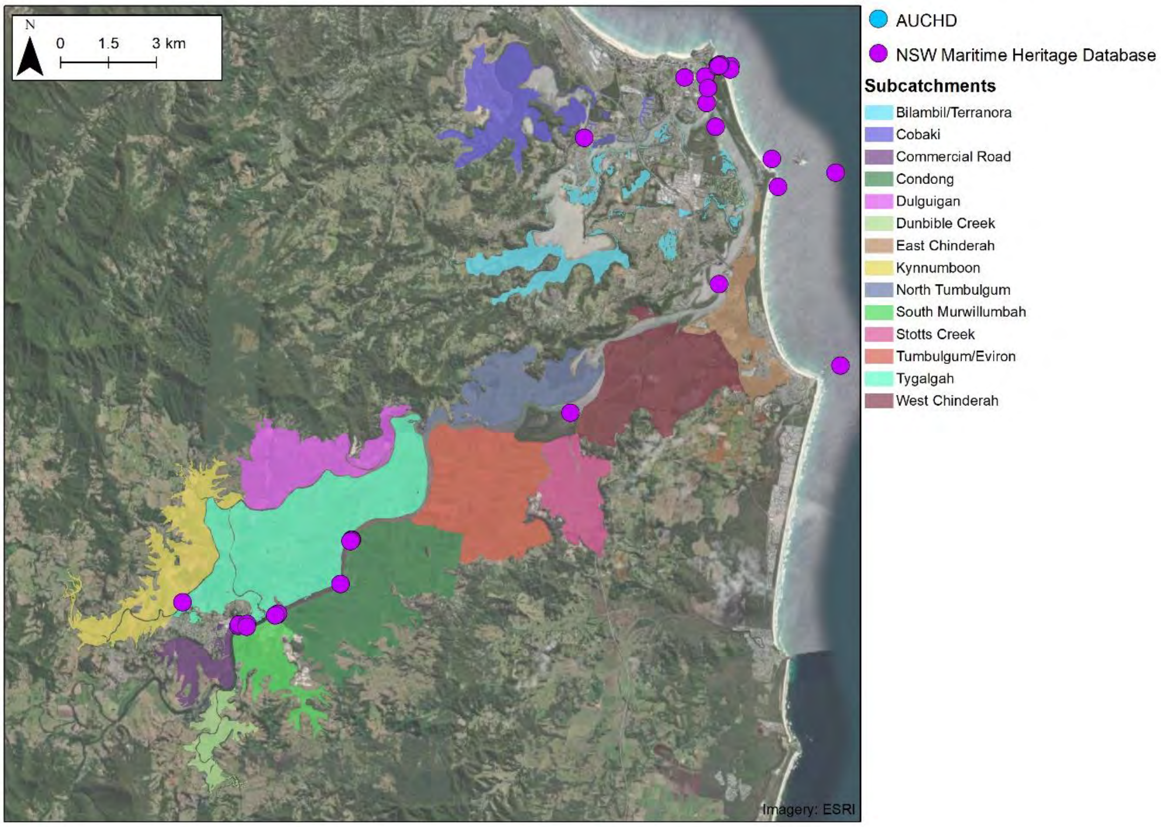


Figure K-2: Maritime heritage items listed on Australian and NSW registers

Appendix L Soil profile data sheets

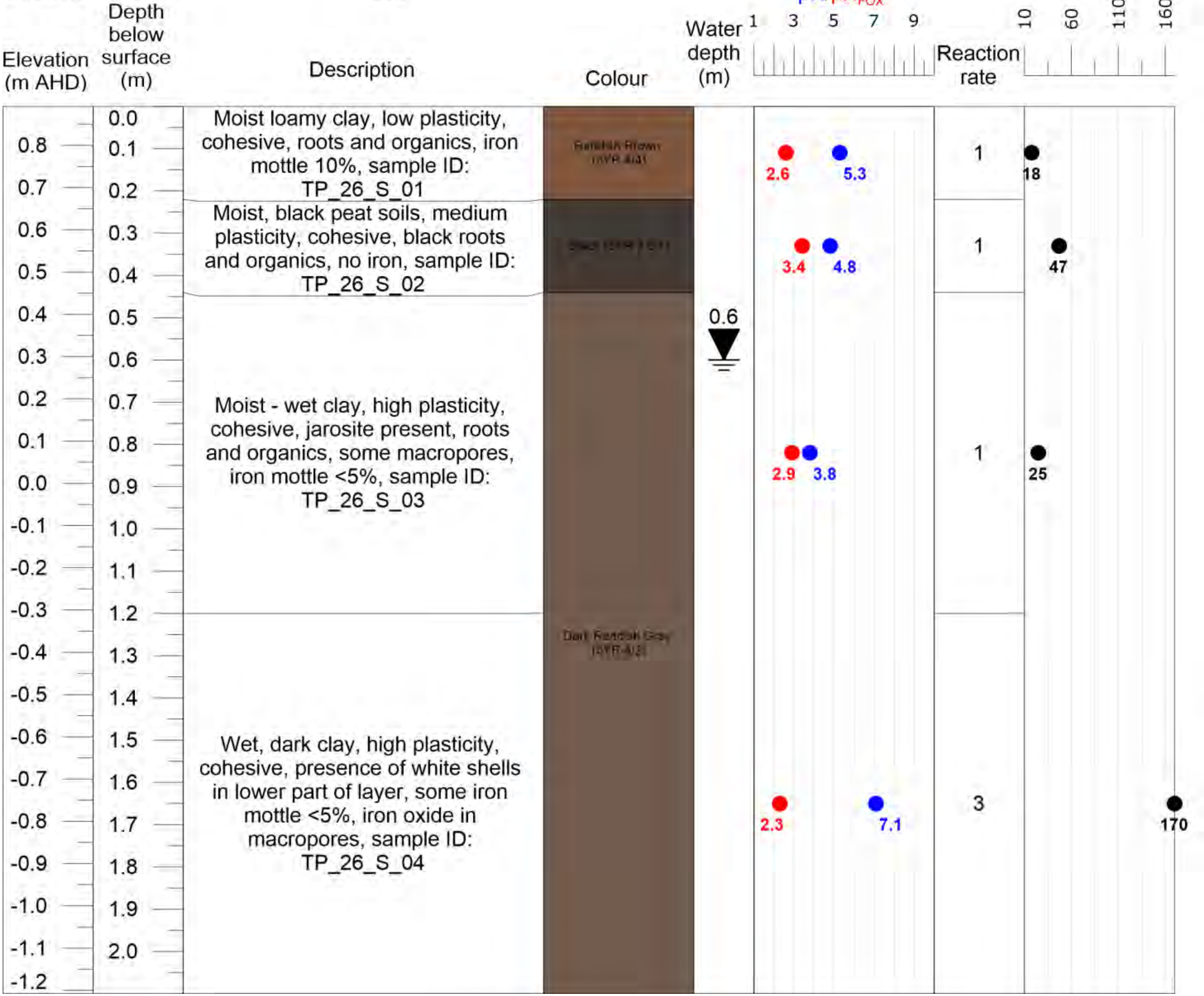
Soil profile details:

Project Number: 2018064
River/estuary: Tweed
Easting: 541255.7
Northing: 6871950.9
Profile ID: TP_26_S
Sample date: 24/02/20
Sampled by: AJH DWJ

Ground elevation (m AHD): 0.89
Hydraulic conductivity (m/d): 0.37

Water quality:

Surface water EC (µS/cm): 346
Surface water pH: 3.46
Groundwater EC (µS/cm): 1,412
Groundwater pH: 3.6

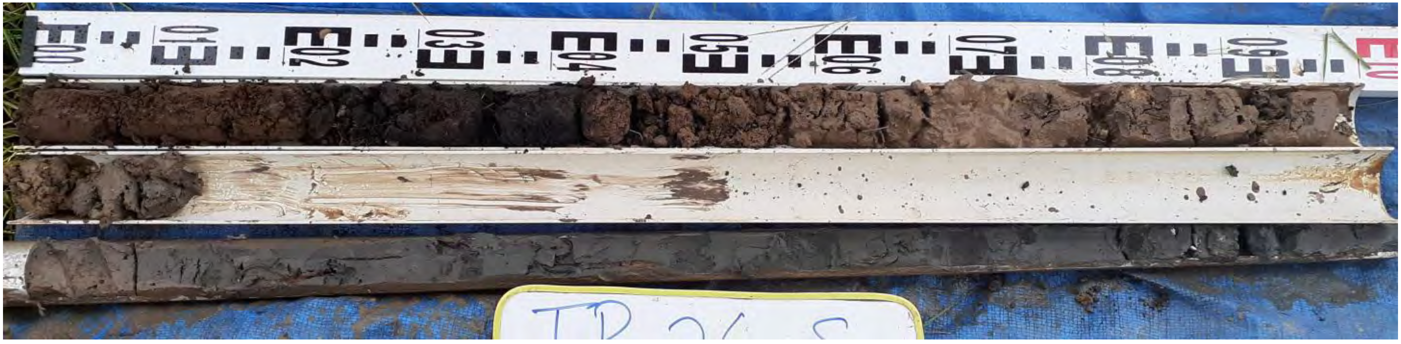


Moist loamy clay, low plasticity, cohesive, roots and organics, iron mottle 10%, sample ID: TP_26_S_01

Moist, black peat soils, medium plasticity, cohesive, black roots and organics, no iron, sample ID: TP_26_S_02

Moist - wet clay, high plasticity, cohesive, jarosite present, roots and organics, some macropores, iron mottle <5%, sample ID: TP_26_S_03

Wet, dark clay, high plasticity, cohesive, presence of white shells in lower part of layer, some iron mottle <5%, iron oxide in macropores, sample ID: TP_26_S_04



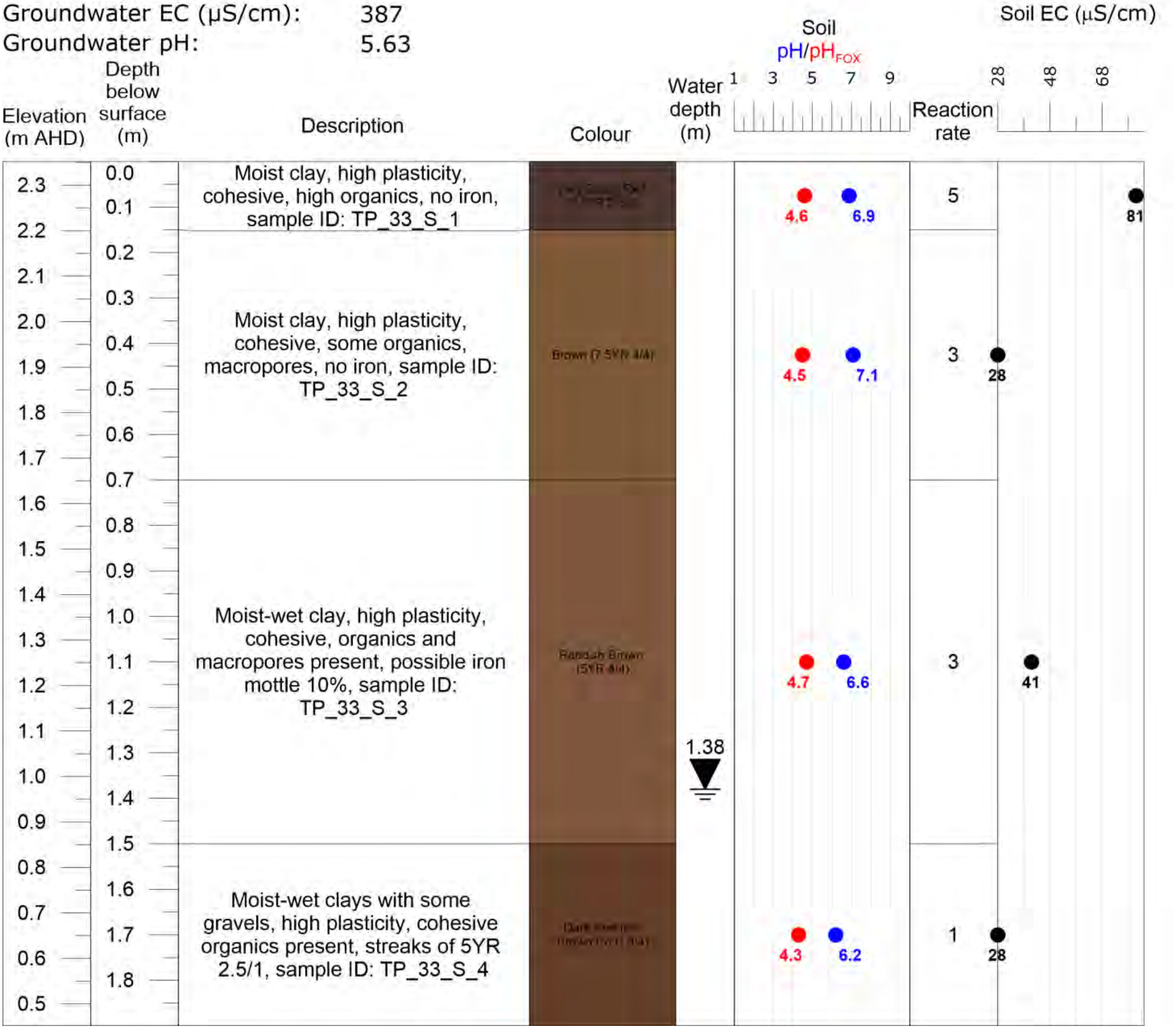
Soil profile details:

Project Number:	2018064	Profile ID:	TP_33_S
River/estuary:	Tweed	Sample date:	24/02/20
Easting:	538982.5	Sampled by:	AJH DWJ
Northing:	6863861.9		

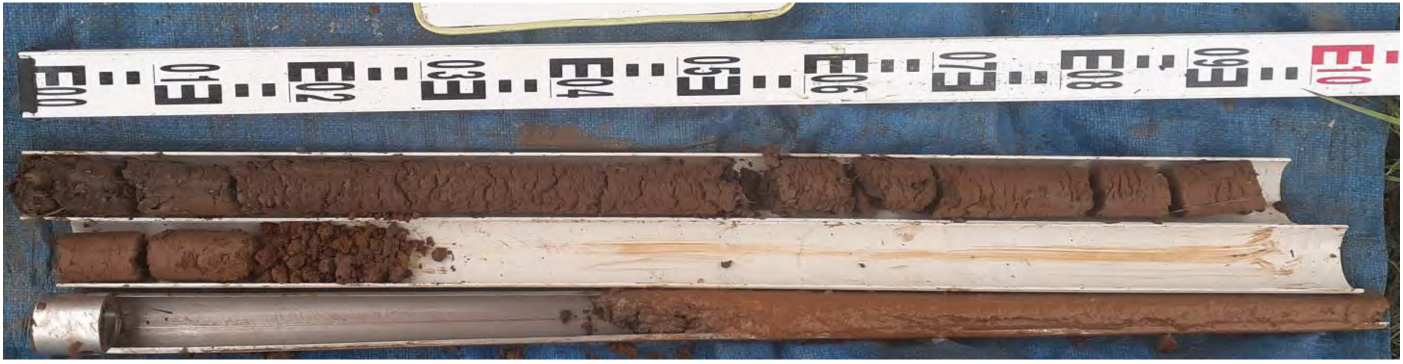
Ground elevation (m AHD):	2.35
Hydraulic conductivity (m/d):	211.28

Water quality:

Surface water EC (µS/cm):	1,196
Surface water pH:	6.25
Groundwater EC (µS/cm):	387
Groundwater pH:	5.63



Description	Colour	Soil pH	Soil pH$_{FOX}$	Reaction rate	Soil EC (µS/cm)
Moist clay, high plasticity, cohesive, high organics, no iron, sample ID: TP_33_S_1	[illegible]	6.9	4.6	5	81
Moist clay, high plasticity, cohesive, some organics, macropores, no iron, sample ID: TP_33_S_2	Brown (7.5YR 4/4)	7.1	4.5	3	28
Moist-wet clay, high plasticity, cohesive, organics and macropores present, possible iron mottle 10%, sample ID: TP_33_S_3	Reddish Brown (5YR 4/4)	6.6	4.7	3	41
Moist-wet clays with some gravels, high plasticity, cohesive organics present, streaks of 5YR 2.5/1, sample ID: TP_33_S_4	[illegible]	6.2	4.3	1	28



Soil profile details:

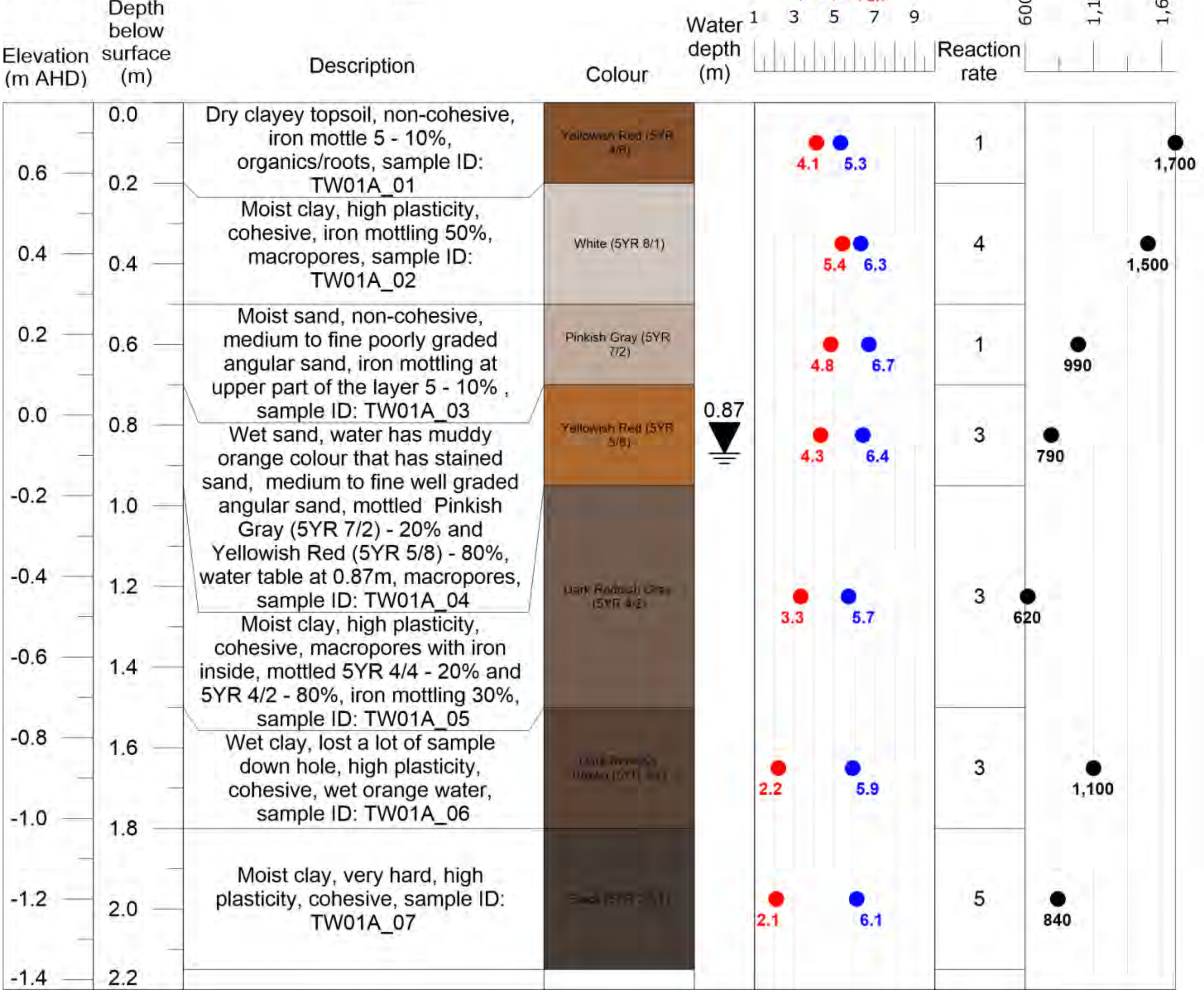
Project Number:	2018064	Profile ID:	TW_01_A
River/estuary:	Tweed	Sample date:	25/10/19
Easting:	547286.9	Sampled by:	TAT DWJ
Northing:	6877932.9		

Ground elevation (m AHD):	0.78
Hydraulic conductivity (m/d):	0.27

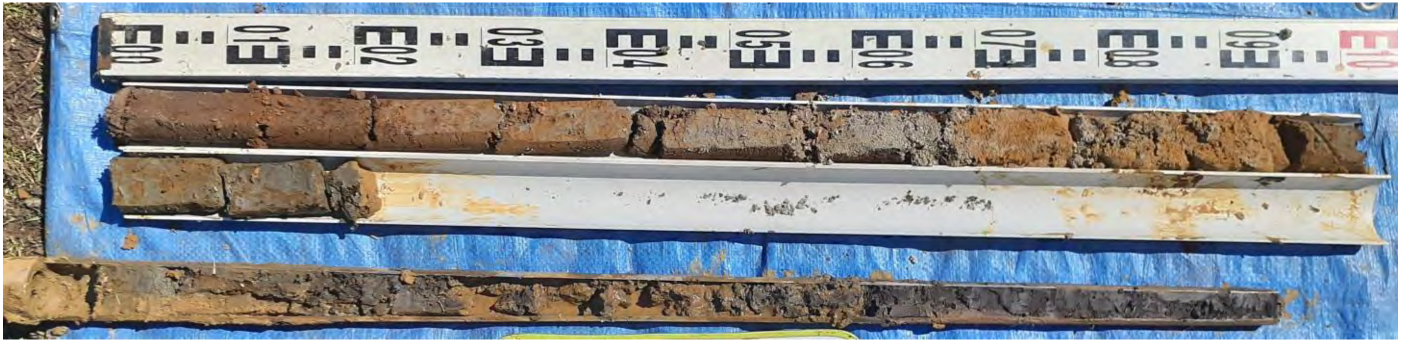
Water Research Laboratory
School of Civil and Environmental Engineering
UNSW SYDNEY

Water quality:

Surface water EC (µS/cm):	66,201
Surface water pH:	7.65
Groundwater EC (µS/cm):	13,520
Groundwater pH:	5.85



Description	Colour	Soil pH	Soil pH$_{FOX}$	Reaction rate	Soil EC (µS/cm)
Dry clayey topsoil, non-cohesive, iron mottle 5 - 10%, organics/roots, sample ID: TW01A_01	Yellowish Red (5YR 4/6)	5.3	4.1	1	1,700
Moist clay, high plasticity, cohesive, iron mottling 50%, macropores, sample ID: TW01A_02	White (5YR 8/1)	6.3	5.4	4	1,500
Moist sand, non-cohesive, medium to fine poorly graded angular sand, iron mottling at upper part of the layer 5 - 10% , sample ID: TW01A_03	Pinkish Gray (5YR 7/2)	6.7	4.8	1	990
Wet sand, water has muddy orange colour that has stained sand, medium to fine well graded angular sand, mottled Pinkish Gray (5YR 7/2) - 20% and Yellowish Red (5YR 5/8) - 80%, water table at 0.87m, macropores, sample ID: TW01A_04	Yellowish Red (5YR 5/8)	6.4	4.3	3	790
Moist clay, high plasticity, cohesive, macropores with iron inside, mottled 5YR 4/4 - 20% and 5YR 4/2 - 80%, iron mottling 30%, sample ID: TW01A_05	Dark Reddish Gray (5YR 4/2)	5.7	3.3	3	620
Wet clay, lost a lot of sample down hole, high plasticity, cohesive, wet orange water, sample ID: TW01A_06	Dark Reddish Brown (5YR [illegible])	5.9	2.2	3	1,100
Moist clay, very hard, high plasticity, cohesive, sample ID: TW01A_07	Black (5YR 2.5/1)	6.1	2.1	5	840



UNSW SYDNEY

Water Research Laboratory
School of Civil and Environmental Engineering

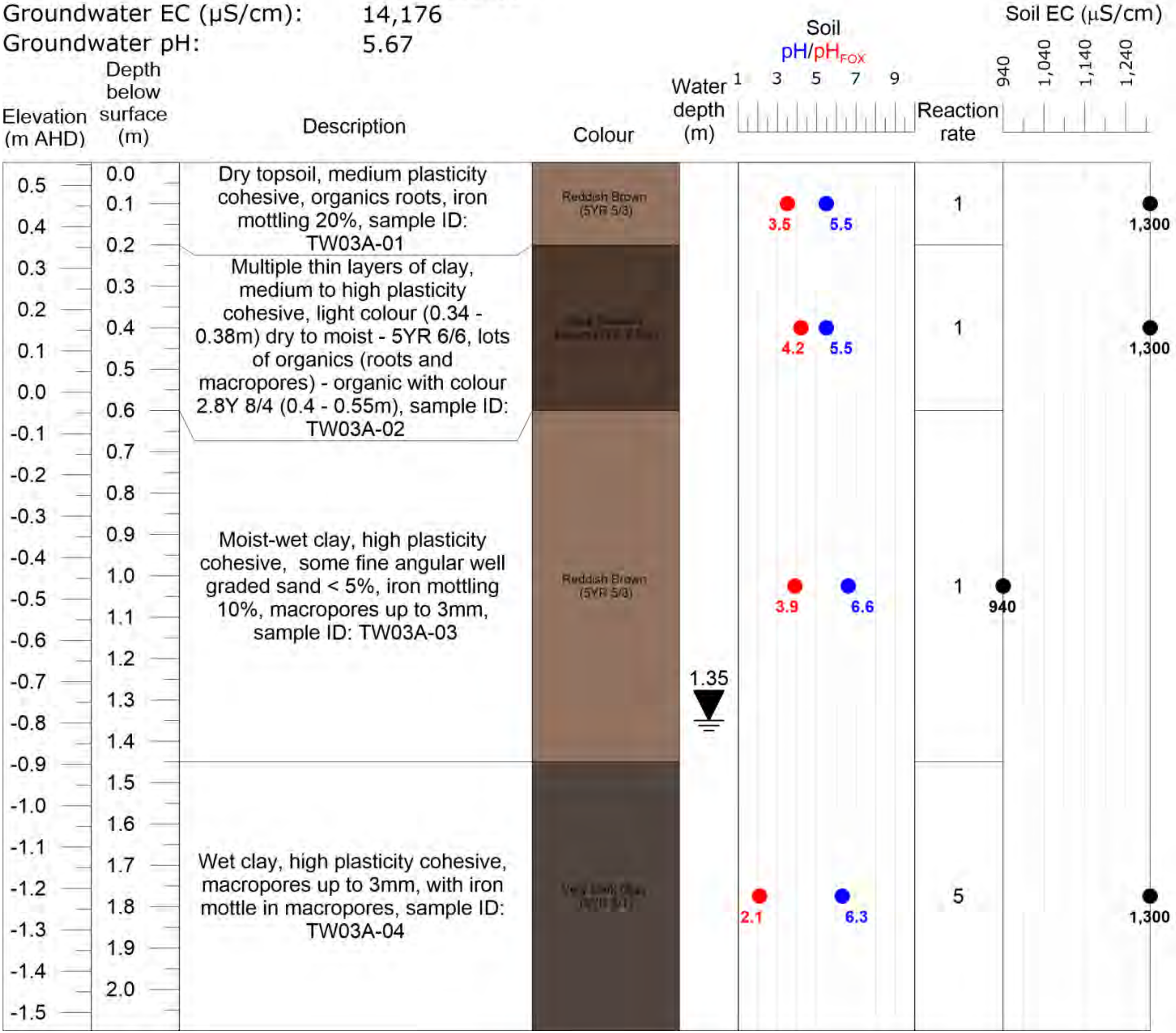
Soil profile details:

Project Number:	2018064	Profile ID:	TW_03_A
River/estuary:	Tweed	Sample date:	17/10/19
Easting:	545523.1	Sampled by:	TAT DWJ
Northing:	6872959.1		

Ground elevation (m AHD): 0.56
Hydraulic conductivity (m/d): 0.39

Water quality:

Surface water EC (μS/cm): Not measured
Surface water pH: Not measured
Groundwater EC (μS/cm): 14,176
Groundwater pH: 5.67

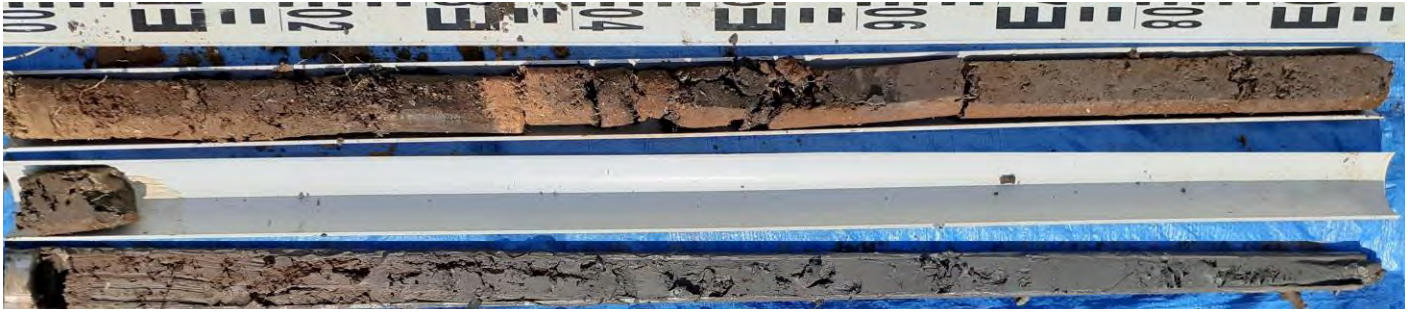


Dry topsoil, medium plasticity cohesive, organics roots, iron mottling 20%, sample ID: TW03A-01

Multiple thin layers of clay, medium to high plasticity cohesive, light colour (0.34 - 0.38m) dry to moist - 5YR 6/6, lots of organics (roots and macropores) - organic with colour 2.8Y 8/4 (0.4 - 0.55m), sample ID: TW03A-02

Moist-wet clay, high plasticity cohesive, some fine angular well graded sand < 5%, iron mottling 10%, macropores up to 3mm, sample ID: TW03A-03

Wet clay, high plasticity cohesive, macropores up to 3mm, with iron mottle in macropores, sample ID: TW03A-04



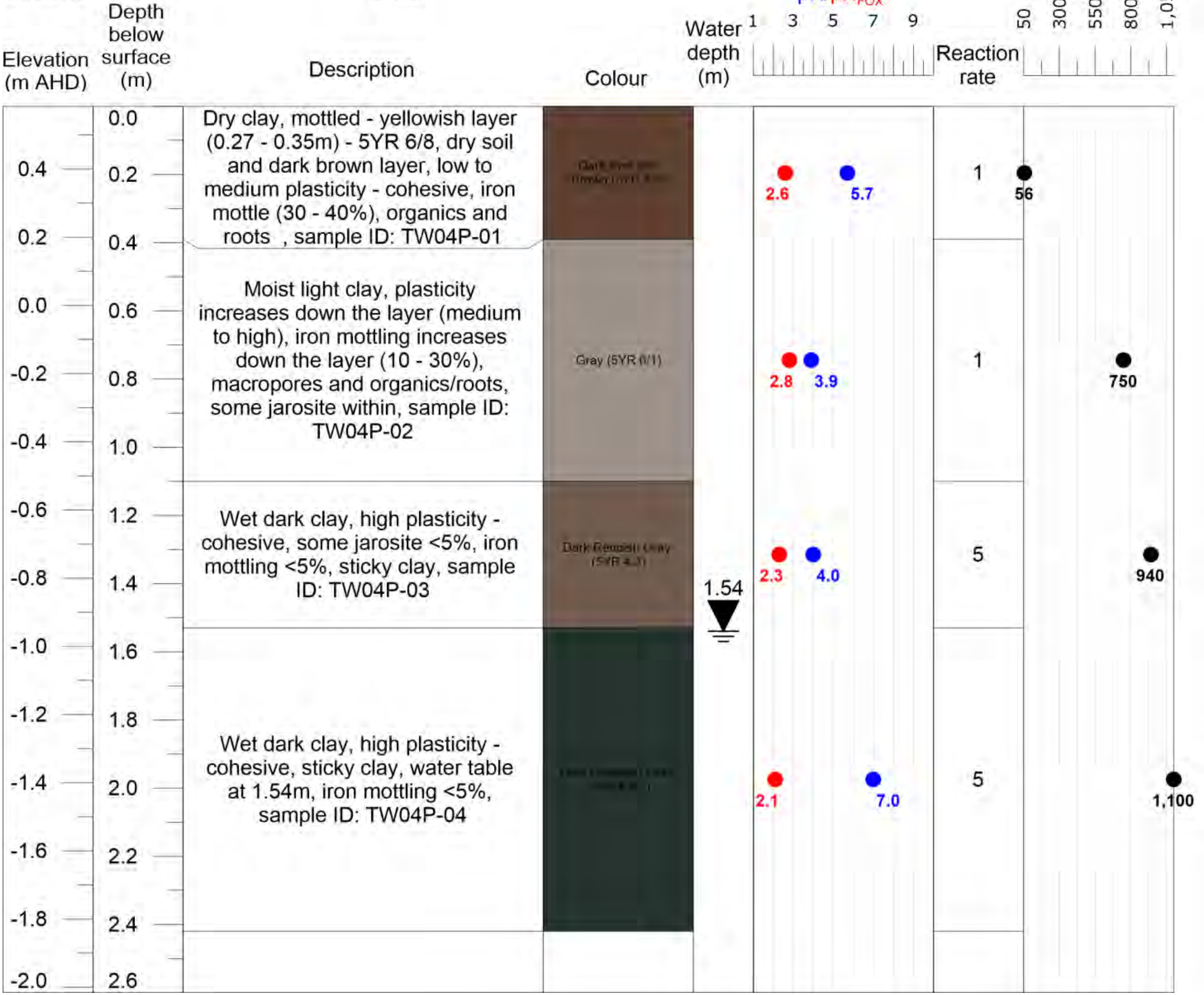
Soil profile details:

Project Number:	2018064	Profile ID:	TW_04_P
River/estuary:	Tweed	Sample date:	17/10/19
Easting:	545155.8	Sampled by:	TAT DWJ
Northing:	6872789.3		

Ground elevation (m AHD): 0.58
Hydraulic conductivity (m/d): 0.28

Water quality:

Surface water EC (µS/cm): 37,796
Surface water pH: 7.69
Groundwater EC (µS/cm): 11,866
Groundwater pH: 5.88



Dry clay, mottled - yellowish layer (0.27 - 0.35m) - 5YR 6/8, dry soil and dark brown layer, low to medium plasticity - cohesive, iron mottle (30 - 40%), organics and roots , sample ID: TW04P-01

Moist light clay, plasticity increases down the layer (medium to high), iron mottling increases down the layer (10 - 30%), macropores and organics/roots, some jarosite within, sample ID: TW04P-02

Wet dark clay, high plasticity - cohesive, some jarosite <5%, iron mottling <5%, sticky clay, sample ID: TW04P-03

Wet dark clay, high plasticity - cohesive, sticky clay, water table at 1.54m, iron mottling <5%, sample ID: TW04P-04

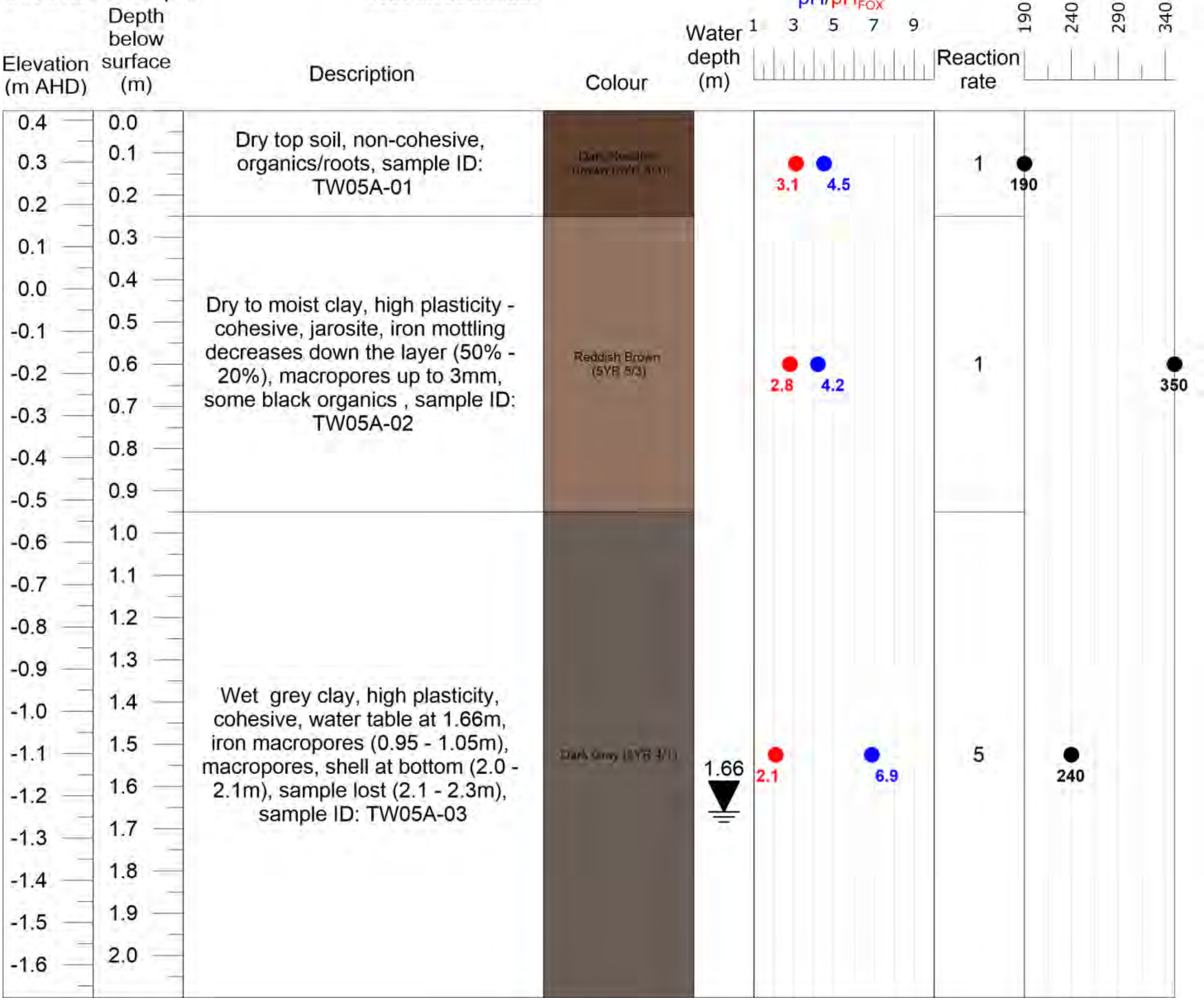
Soil profile details:

Project Number:	2018064	Profile ID:	TW_05_A
River/estuary:	Tweed	Sample date:	21/10/19
Easting:	542691.4	Sampled by:	TAT DWJ
Northing:	6870240.2		

Ground elevation (m AHD):	0.42
Hydraulic conductivity (m/d):	Not measured

Water quality:

Surface water EC (µS/cm):	28,213
Surface water pH:	6.04
Groundwater EC (µS/cm):	Not measured
Groundwater pH:	Not measured



Description	Colour	Water depth (m)	Soil pH$_{FOX}$	Soil pH	Reaction rate	Soil EC (µS/cm)
Dry top soil, non-cohesive, organics/roots, sample ID: TW05A-01	Dark Reddish Brown (5YR 3/3)		3.1	4.5	1	190
Dry to moist clay, high plasticity - cohesive, jarosite, iron mottling decreases down the layer (50% - 20%), macropores up to 3mm, some black organics , sample ID: TW05A-02	Reddish Brown (5YR 5/3)		2.8	4.2	1	350
Wet grey clay, high plasticity, cohesive, water table at 1.66m, iron macropores (0.95 - 1.05m), macropores, shell at bottom (2.0 - 2.1m), sample lost (2.1 - 2.3m), sample ID: TW05A-03	Dark Grey (5YR 4/1)	1.66	2.1	6.9	5	240

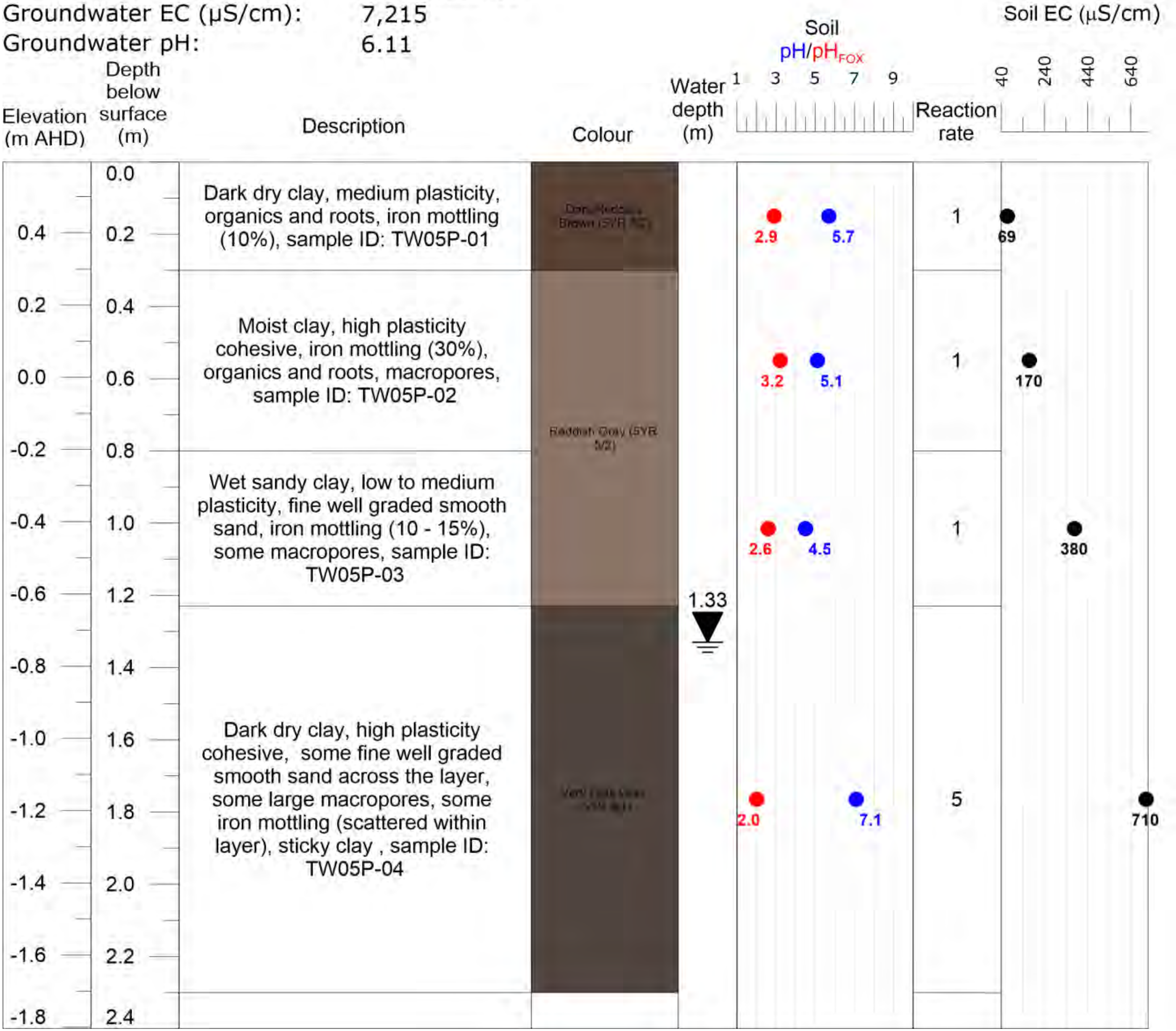
Soil profile details:

Project Number:	2018064	Profile ID:	TW_05_P
River/estuary:	Tweed	Sample date:	16/10/19
Easting:	544820	Sampled by:	TAT DWJ
Northing:	6871473.4		

Ground elevation (m AHD):	0.60
Hydraulic conductivity (m/d):	0.30

Water quality:

Surface water EC (µS/cm):	Not measured
Surface water pH:	Not measured
Groundwater EC (µS/cm):	7,215
Groundwater pH:	6.11



Description	Colour	Soil pH	Soil pH$_{FOX}$	Reaction rate	Soil EC (µS/cm)
Dark dry clay, medium plasticity, organics and roots, iron mottling (10%), sample ID: TW05P-01	Dark Reddish Brown (5YR [illegible])	5.7	2.9	1	69
Moist clay, high plasticity cohesive, iron mottling (30%), organics and roots, macropores, sample ID: TW05P-02	Reddish Gray (5YR 5/2)	5.1	3.2	1	170
Wet sandy clay, low to medium plasticity, fine well graded smooth sand, iron mottling (10 - 15%), some macropores, sample ID: TW05P-03		4.5	2.6	1	380
Dark dry clay, high plasticity cohesive, some fine well graded smooth sand across the layer, some large macropores, some iron mottling (scattered within layer), sticky clay , sample ID: TW05P-04	[illegible]	7.1	2.0	5	710

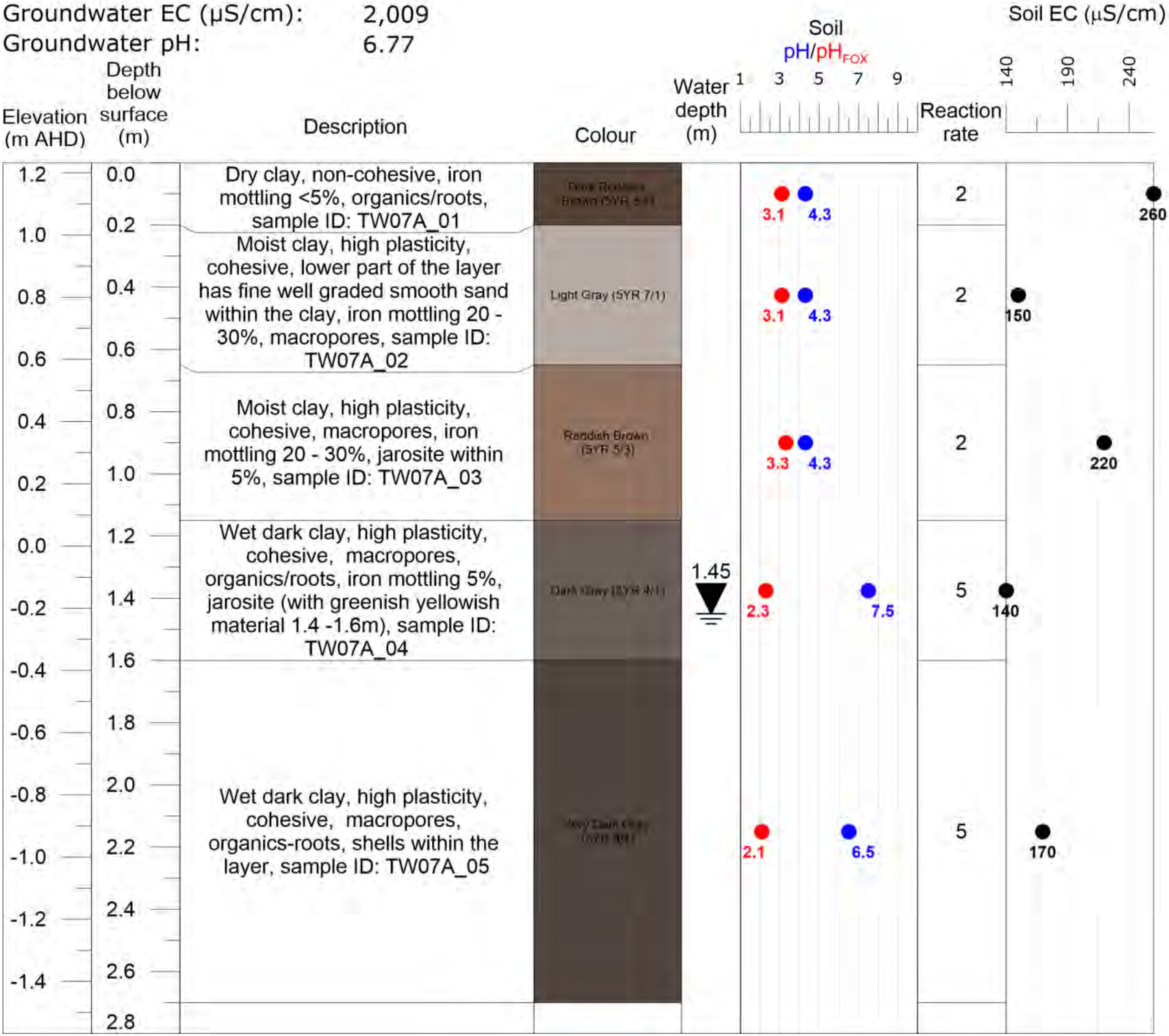
Soil profile details:

Project Number:	2018064	Profile ID:	TW_07_A
River/estuary:	Tweed	Sample date:	24/10/19
Easting:	537526.5	Sampled by:	TAT DWJ
Northing:	6868235.8		

Ground elevation (m AHD): 1.23
Hydraulic conductivity (m/d): 0.10

Water quality:

Surface water EC (µS/cm): 5,814
Surface water pH: 7.09
Groundwater EC (µS/cm): 2,009
Groundwater pH: 6.77



Depth below surface (m)	Description	Colour	Water depth (m)	Soil pH$_{FOX}$	Soil pH	Reaction rate	Soil EC (μS/cm)
0.0 – 0.22	Dry clay, non-cohesive, iron mottling <5%, organics/roots, sample ID: TW07A_01	Dark Reddish Brown (5YR [illegible])		3.1	4.3	2	260
0.22 – 0.65	Moist clay, high plasticity, cohesive, lower part of the layer has fine well graded smooth sand within the clay, iron mottling 20 - 30%, macropores, sample ID: TW07A_02	Light Gray (5YR 7/1)		3.1	4.3	2	150
0.65 – 1.15	Moist clay, high plasticity, cohesive, macropores, iron mottling 20 - 30%, jarosite within 5%, sample ID: TW07A_03	Reddish Brown (5YR 5/3)		3.3	4.3	2	220
1.15 – 1.6	Wet dark clay, high plasticity, cohesive, macropores, organics/roots, iron mottling 5%, jarosite (with greenish yellowish material 1.4 -1.6m), sample ID: TW07A_04	Dark Gray (5YR 4/1)	1.45	2.3	7.5	5	140
1.6 – 2.7	Wet dark clay, high plasticity, cohesive, macropores, organics-roots, shells within the layer, sample ID: TW07A_05	Very Dark Gray (5YR 3/1)		2.1	6.5	5	170

UNSW SYDNEY

Water Research Laboratory
School of Civil and Environmental Engineering

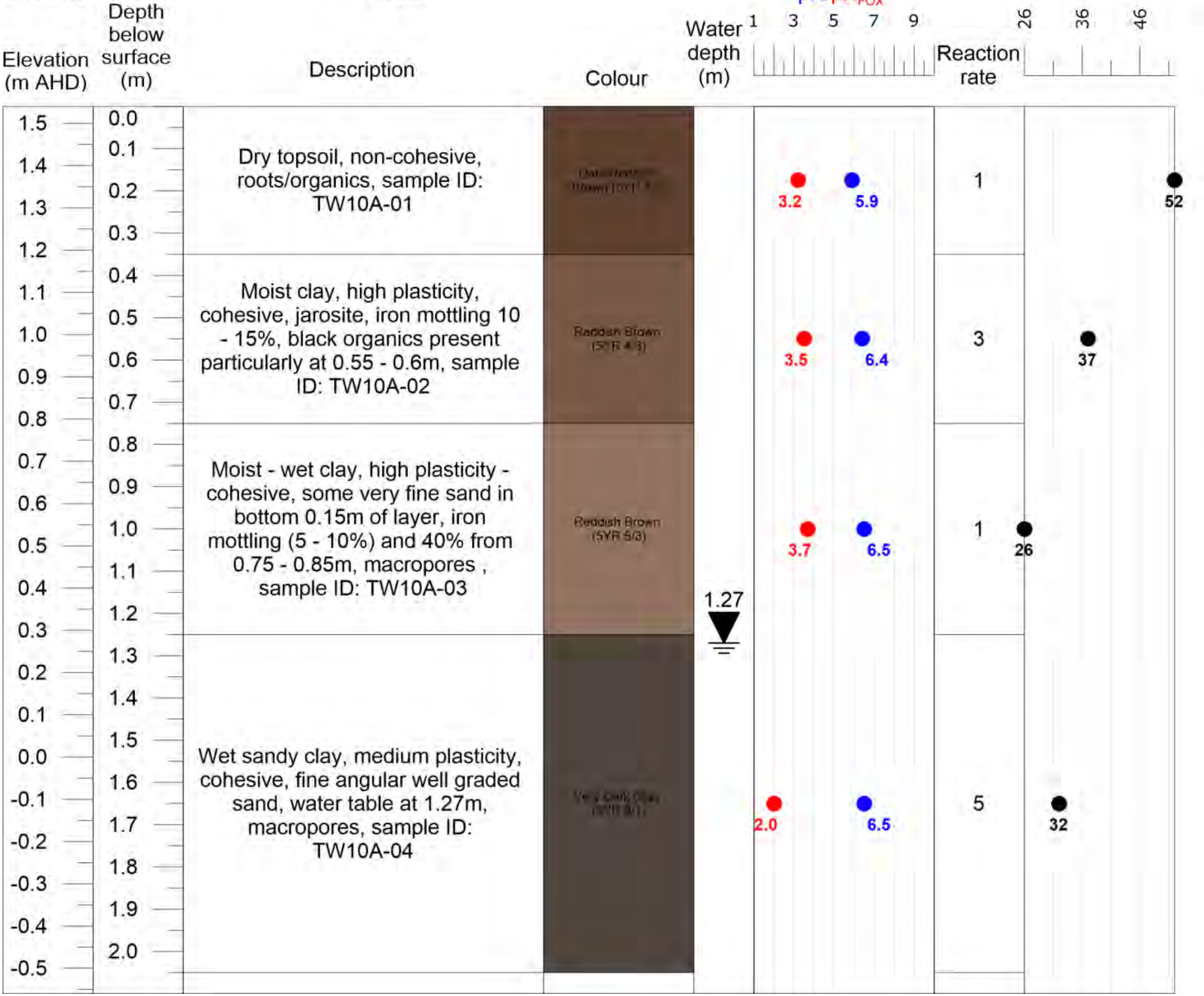
Soil profile details:

Project Number:	2018064	Profile ID:	TW_10_A
River/estuary:	Tweed	Sample date:	23/10/19
Easting:	538147.6	Sampled by:	TAT DWJ
Northing:	6865632.6		

Ground elevation (m AHD):	1.54
Hydraulic conductivity (m/d):	0.10

Water quality:

Surface water EC (µS/cm):	3162 (creek), 250 (nearby dam)
Surface water pH:	3.83 (creek), 6.25 (nearby dam)
Groundwater EC (µS/cm):	618
Groundwater pH:	6.08



Dry topsoil, non-cohesive, roots/organics, sample ID: TW10A-01

Moist clay, high plasticity, cohesive, jarosite, iron mottling 10 - 15%, black organics present particularly at 0.55 - 0.6m, sample ID: TW10A-02

Moist - wet clay, high plasticity - cohesive, some very fine sand in bottom 0.15m of layer, iron mottling (5 - 10%) and 40% from 0.75 - 0.85m, macropores , sample ID: TW10A-03

Wet sandy clay, medium plasticity, cohesive, fine angular well graded sand, water table at 1.27m, macropores, sample ID: TW10A-04

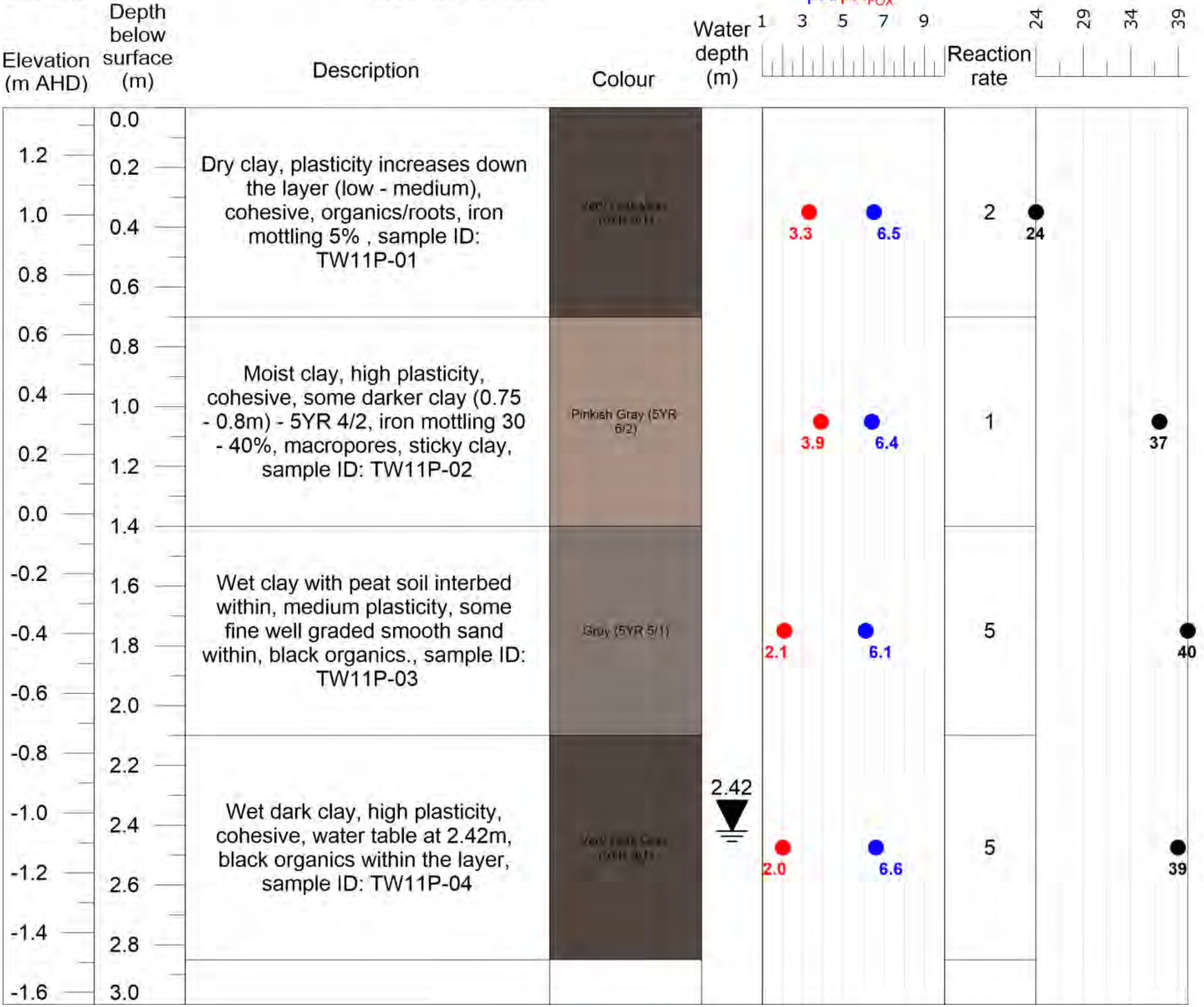
Soil profile details:

Project Number:	2018064	Profile ID:	TW_11_P
River/estuary:	Tweed	Sample date:	23/10/19
Easting:	538013	Sampled by:	TAT DWJ
Northing:	6865486.9		

Ground elevation (m AHD): 1.36
Hydraulic conductivity (m/d): Not measured

Water quality:

Surface water EC (μS/cm): Not measured
Surface water pH: Not measured
Groundwater EC (μS/cm): Not measured
Groundwater pH: Not measured



Description	Colour	Water depth (m)	Soil pH	Soil pH_{FOX}	Reaction rate	Soil EC (μS/cm)
Dry clay, plasticity increases down the layer (low - medium), cohesive, organics/roots, iron mottling 5% , sample ID: TW11P-01	[illegible]		6.5	3.3	2	24
Moist clay, high plasticity, cohesive, some darker clay (0.75 - 0.8m) - 5YR 4/2, iron mottling 30 - 40%, macropores, sticky clay, sample ID: TW11P-02	Pinkish Gray (5YR 6/2)		6.4	3.9	1	37
Wet clay with peat soil interbed within, medium plasticity, some fine well graded smooth sand within, black organics., sample ID: TW11P-03	Gray (5YR 5/1)		6.1	2.1	5	40
Wet dark clay, high plasticity, cohesive, water table at 2.42m, black organics within the layer, sample ID: TW11P-04	Very Dark Gray ([illegible])	2.42	6.6	2.0	5	39

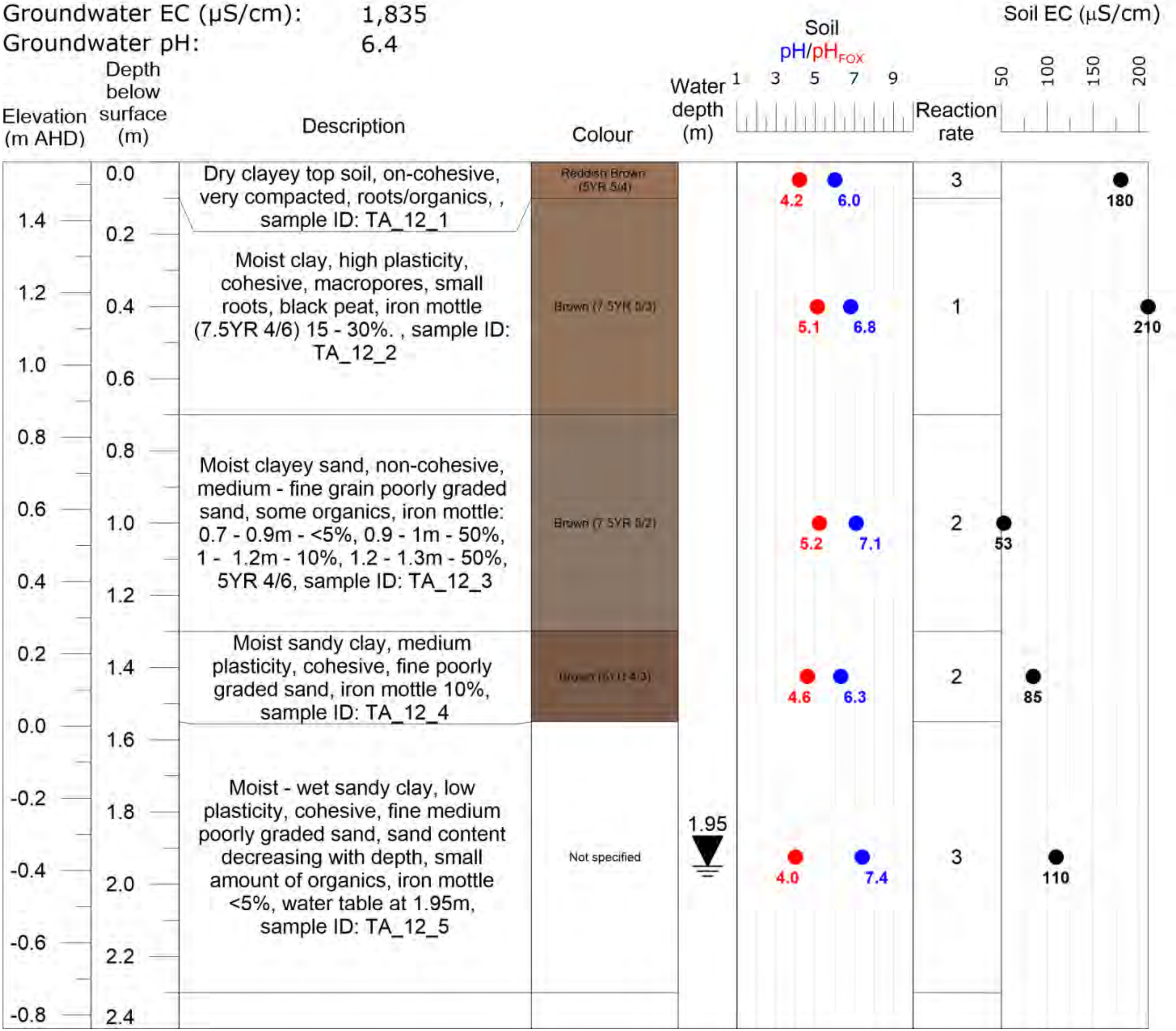
Soil profile details:

Project Number:	2018064	Profile ID:	TW_12_A
River/estuary:	Tweed	Sample date:	08/11/19
Easting:	540027.8	Sampled by:	AJH GL
Northing:	6865836.7		

Ground elevation (m AHD):	1.56
Hydraulic conductivity (m/d):	0.34

Water quality:

Surface water EC (µS/cm):	1,500
Surface water pH:	7.79
Groundwater EC (µS/cm):	1,835
Groundwater pH:	6.4



Description	Colour	Water depth (m)	Soil pH$_{FOX}$	Soil pH	Reaction rate	Soil EC (µS/cm)
Dry clayey top soil, on-cohesive, very compacted, roots/organics, , sample ID: TA_12_1	Reddish Brown (5YR 5/4)		4.2	6.0	3	180
Moist clay, high plasticity, cohesive, macropores, small roots, black peat, iron mottle (7.5YR 4/6) 15 - 30%. , sample ID: TA_12_2	Brown (7.5YR 5/3)		5.1	6.8	1	210
Moist clayey sand, non-cohesive, medium - fine grain poorly graded sand, some organics, iron mottle: 0.7 - 0.9m - <5%, 0.9 - 1m - 50%, 1 - 1.2m - 10%, 1.2 - 1.3m - 50%, 5YR 4/6, sample ID: TA_12_3	Brown (7.5YR 5/2)		5.2	7.1	2	53
Moist sandy clay, medium plasticity, cohesive, fine poorly graded sand, iron mottle 10%, sample ID: TA_12_4	Brown (5YR 4/3)		4.6	6.3	2	85
Moist - wet sandy clay, low plasticity, cohesive, fine medium poorly graded sand, sand content decreasing with depth, small amount of organics, iron mottle <5%, water table at 1.95m, sample ID: TA_12_5	Not specified	1.95	4.0	7.4	3	110

Soil profile details:

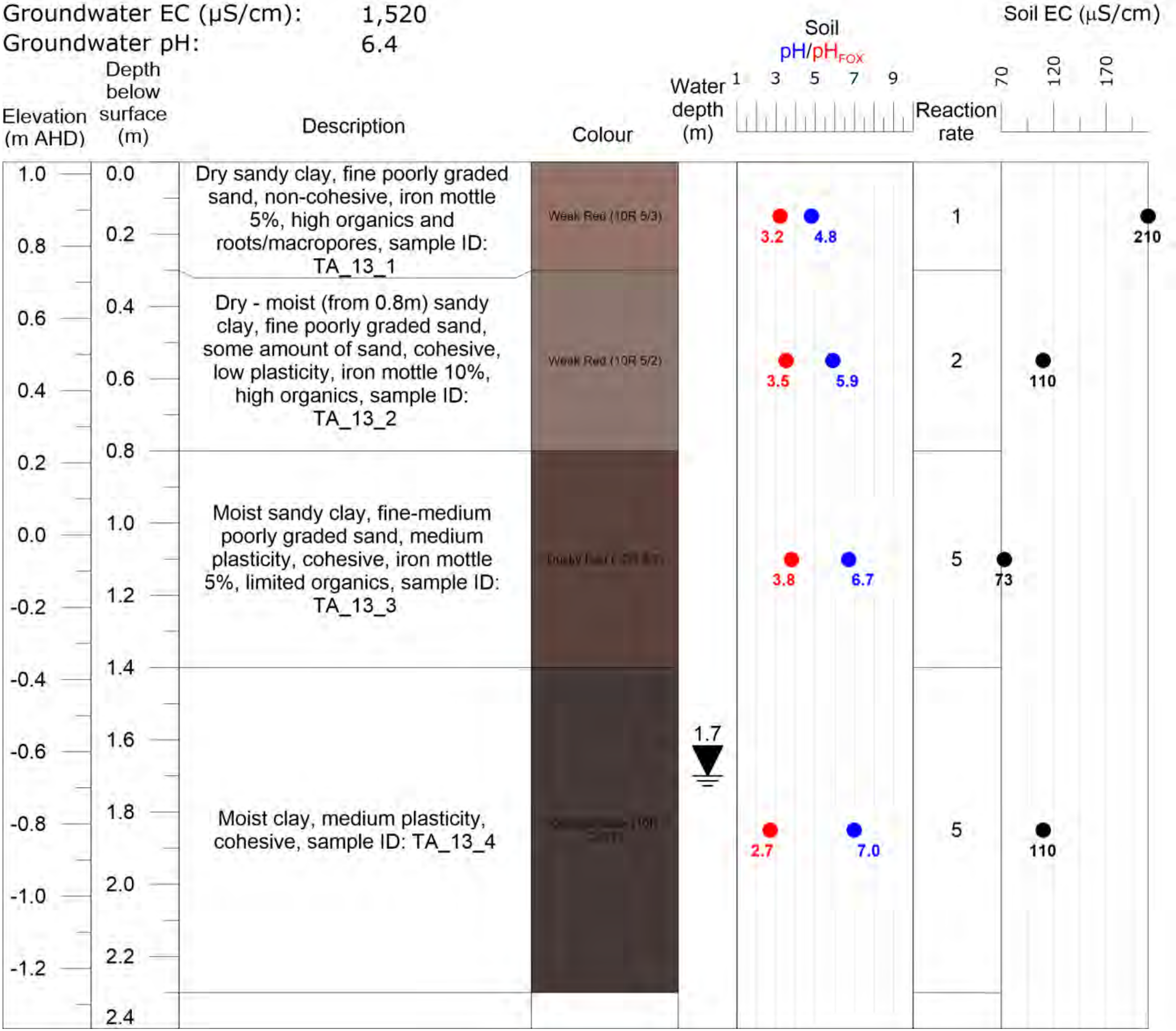
Project Number:	2018064	Profile ID:	TW_13_A
River/estuary:	Tweed	Sample date:	08/11/19
Easting:	542040.1	Sampled by:	AJH GL
Northing:	6865445.9		

Ground elevation (m AHD):	1.03
Hydraulic conductivity (m/d):	0.20

UNSW SYDNEY
Water Research Laboratory
School of Civil and Environmental Engineering

Water quality:

Surface water EC (µS/cm):	840
Surface water pH:	6.6
Groundwater EC (µS/cm):	1,520
Groundwater pH:	6.4



Description	Colour	pH_{FOX}	pH	Reaction rate	Soil EC (µS/cm)
Dry sandy clay, fine poorly graded sand, non-cohesive, iron mottle 5%, high organics and roots/macropores, sample ID: TA_13_1	Weak Red (10R 5/3)	3.2	4.8	1	210
Dry - moist (from 0.8m) sandy clay, fine poorly graded sand, some amount of sand, cohesive, low plasticity, iron mottle 10%, high organics, sample ID: TA_13_2	Weak Red (10R 5/2)	3.5	5.9	2	110
Moist sandy clay, fine-medium poorly graded sand, medium plasticity, cohesive, iron mottle 5%, limited organics, sample ID: TA_13_3	Dusky Red ([illegible])	3.8	6.7	5	73
Moist clay, medium plasticity, cohesive, sample ID: TA_13_4	[illegible]	2.7	7.0	5	110

UNSW SYDNEY

Water Research Laboratory
School of Civil and Environmental Engineering

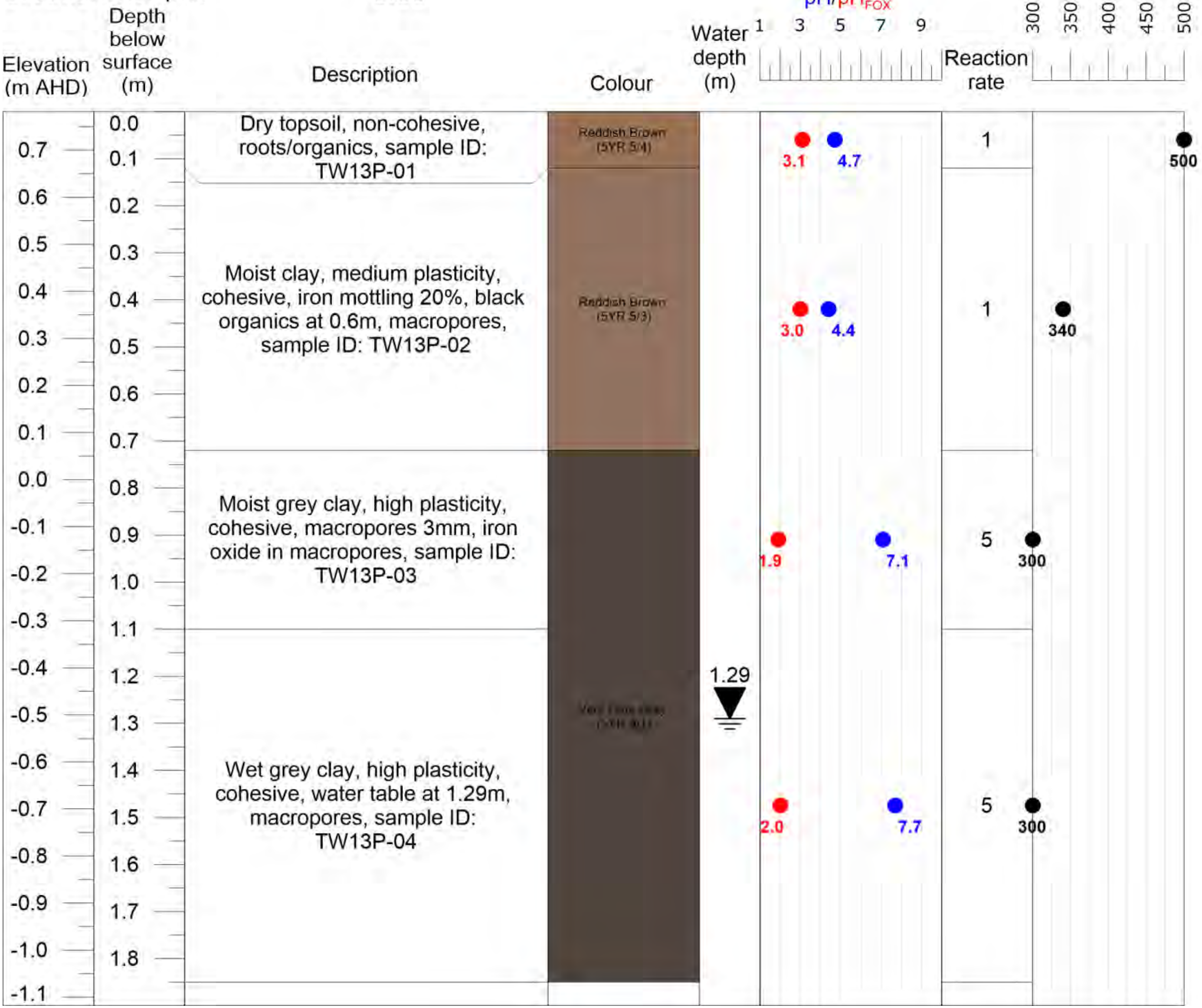
Soil profile details:

Project Number: 2018064
River/estuary: Tweed
Easting: 543855.7
Northing: 6869001.7
Profile ID: TW_13_P
Sample date: 22/10/19
Sampled by: TAT DWJ

Ground elevation (m AHD): 0.78
Hydraulic conductivity (m/d): 2.84

Water quality:

Surface water EC (µS/cm): 36,551
Surface water pH: 6.87
Groundwater EC (µS/cm): 3,737
Groundwater pH: 6.66



Dry topsoil, non-cohesive, roots/organics, sample ID: TW13P-01

Moist clay, medium plasticity, cohesive, iron mottling 20%, black organics at 0.6m, macropores, sample ID: TW13P-02

Moist grey clay, high plasticity, cohesive, macropores 3mm, iron oxide in macropores, sample ID: TW13P-03

Wet grey clay, high plasticity, cohesive, water table at 1.29m, macropores, sample ID: TW13P-04

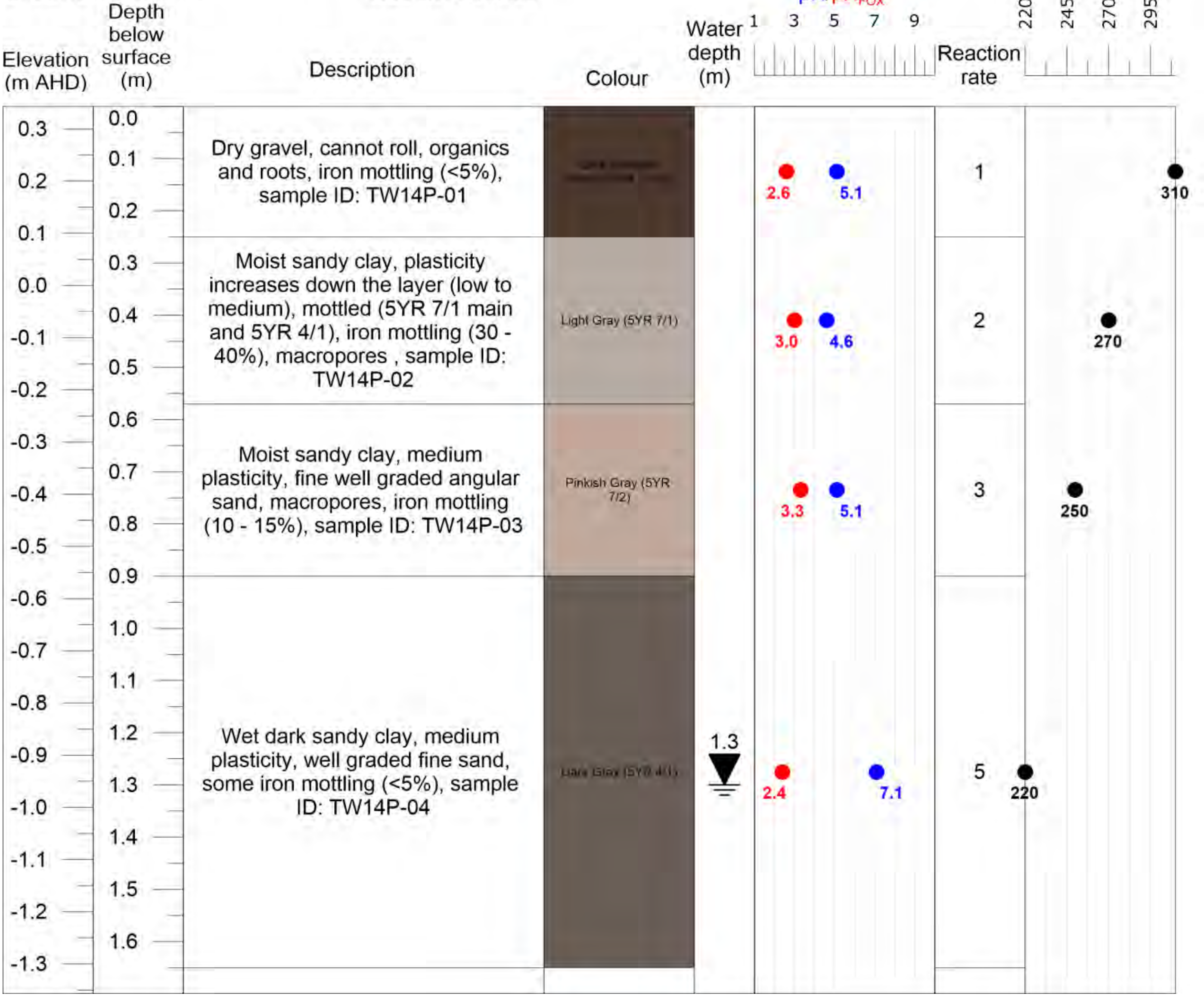
Soil profile details:

Project Number:	2018064	Profile ID:	TW_14_P
River/estuary:	Tweed	Sample date:	15/10/19
Easting:	547887.7	Sampled by:	TAT DWJ
Northing:	6870903.2		

Ground elevation (m AHD):	0.34
Hydraulic conductivity (m/d):	Not measured

Water quality:

Surface water EC (µS/cm):	Not measured
Surface water pH:	Not measured
Groundwater EC (µS/cm):	Not measured
Groundwater pH:	Not measured



Description	Colour	Water depth (m)	Soil pH$_{FOX}$	Soil pH	Reaction rate	Soil EC (µS/cm)
Dry gravel, cannot roll, organics and roots, iron mottling (<5%), sample ID: TW14P-01	[illegible]		2.6	5.1	1	310
Moist sandy clay, plasticity increases down the layer (low to medium), mottled (5YR 7/1 main and 5YR 4/1), iron mottling (30 - 40%), macropores , sample ID: TW14P-02	Light Gray (5YR 7/1)		3.0	4.6	2	270
Moist sandy clay, medium plasticity, fine well graded angular sand, macropores, iron mottling (10 - 15%), sample ID: TW14P-03	Pinkish Gray (5YR 7/2)		3.3	5.1	3	250
Wet dark sandy clay, medium plasticity, well graded fine sand, some iron mottling (<5%), sample ID: TW14P-04	Dark Gray (5YR 4/1)	1.3	2.4	7.1	5	220

Soil profile details:

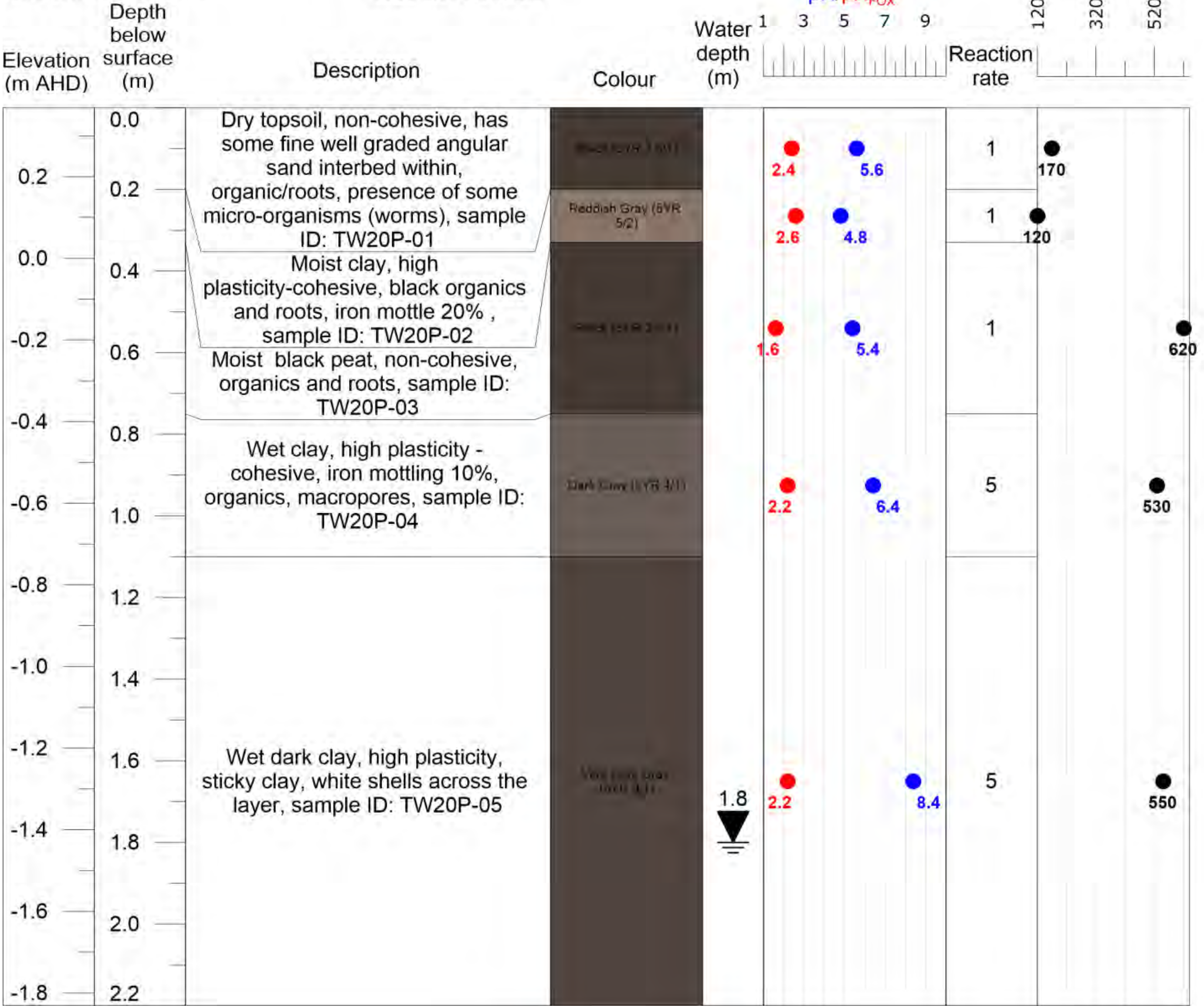
Project Number: 2018064
River/estuary: Tweed
Easting: 552417
Northing: 6878457.6

Profile ID: TW_20_P
Sample date: 21/10/19
Sampled by: TAT DWJ

Ground elevation (m AHD): 0.37
Hydraulic conductivity (m/d): Not measured

Water quality:

Surface water EC (µS/cm): Not measured
Surface water pH: Not measured
Groundwater EC (µS/cm): Not measured
Groundwater pH: Not measured



Dry topsoil, non-cohesive, has some fine well graded angular sand interbed within, organic/roots, presence of some micro-organisms (worms), sample ID: TW20P-01

Moist clay, high plasticity-cohesive, black organics and roots, iron mottle 20% , sample ID: TW20P-02

Moist black peat, non-cohesive, organics and roots, sample ID: TW20P-03

Wet clay, high plasticity - cohesive, iron mottling 10%, organics, macropores, sample ID: TW20P-04

Wet dark clay, high plasticity, sticky clay, white shells across the layer, sample ID: TW20P-05

Soil profile details:

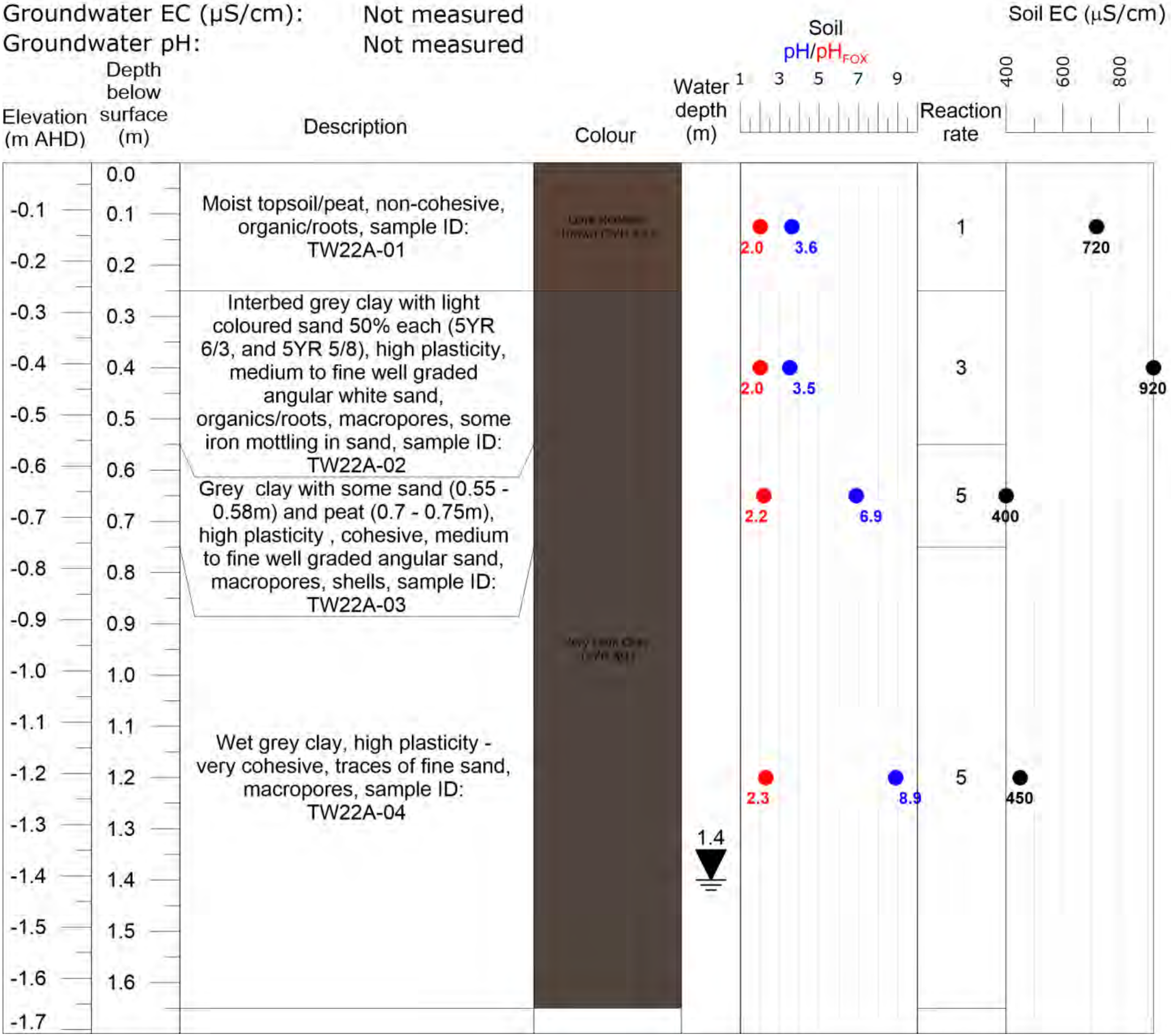
Project Number:	2018064	Profile ID:	TW_22_A
River/estuary:	Tweed	Sample date:	21/10/19
Easting:	552524.6	Sampled by:	TAT DWJ
Northing:	6878598.9		

Ground elevation (m AHD): -0.01
Hydraulic conductivity (m/d): Not measured

UNSW SYDNEY
Water Research Laboratory
School of Civil and Environmental Engineering

Water quality:

Surface water EC (µS/cm):	3,118
Surface water pH:	7.81
Groundwater EC (µS/cm):	Not measured
Groundwater pH:	Not measured



Moist topsoil/peat, non-cohesive, organic/roots, sample ID: TW22A-01

Interbed grey clay with light coloured sand 50% each (5YR 6/3, and 5YR 5/8), high plasticity, medium to fine well graded angular white sand, organics/roots, macropores, some iron mottling in sand, sample ID: TW22A-02

Grey clay with some sand (0.55 - 0.58m) and peat (0.7 - 0.75m), high plasticity , cohesive, medium to fine well graded angular sand, macropores, shells, sample ID: TW22A-03

Wet grey clay, high plasticity - very cohesive, traces of fine sand, macropores, sample ID: TW22A-04

UNSW SYDNEY

Water Research Laboratory
School of Civil and Environmental Engineering

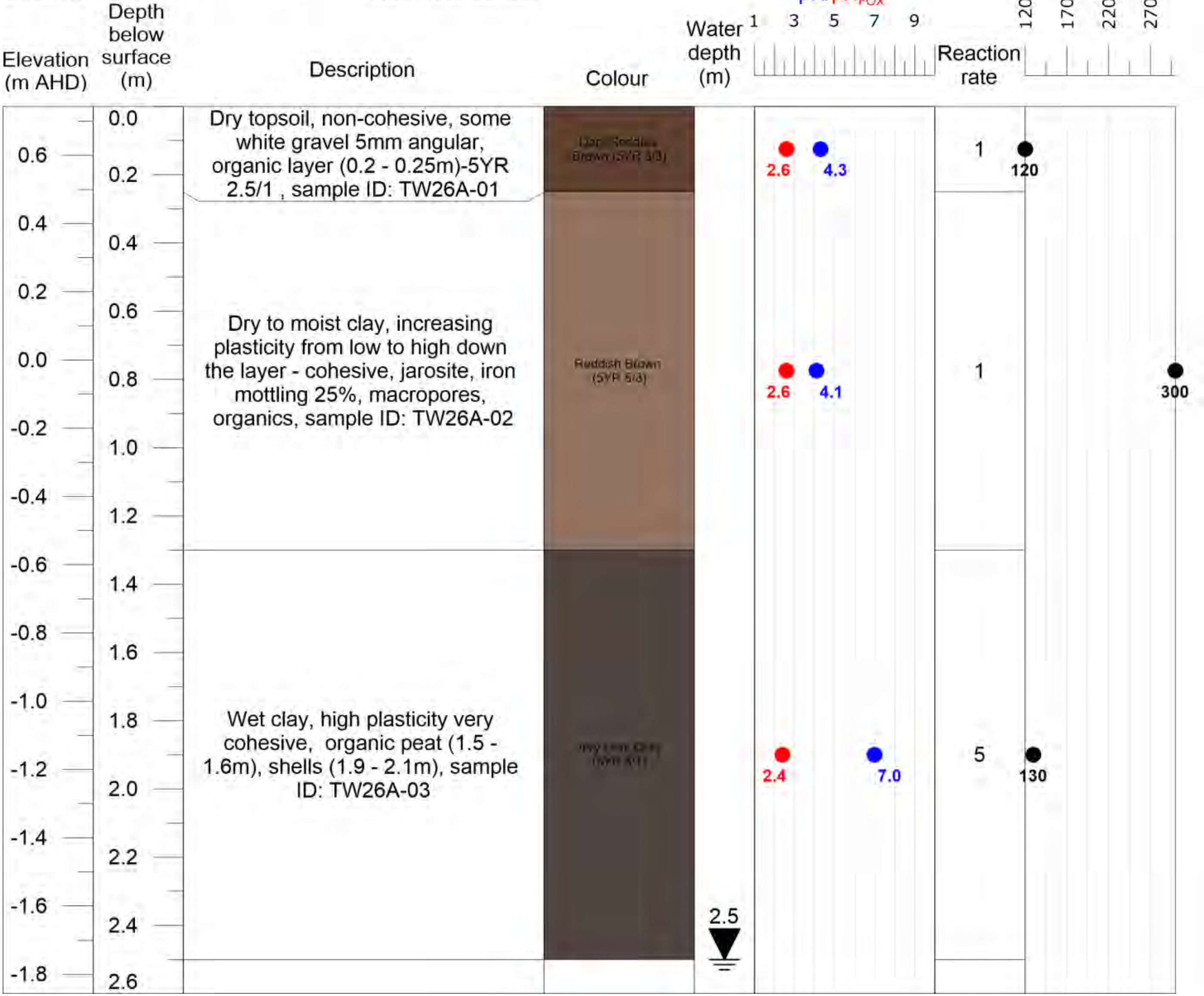
Soil profile details:

Project Number:	2018064	Profile ID:	TW_26_A
River/estuary:	Tweed	Sample date:	17/10/19
Easting:	540293.4	Sampled by:	TAT DWJ
Northing:	6871721.5		

Ground elevation (m AHD):	0.74
Hydraulic conductivity (m/d):	Not measured

Water quality:

Surface water EC (µS/cm):	4,467
Surface water pH:	5.74
Groundwater EC (µS/cm):	Not measured
Groundwater pH:	Not measured



Dry topsoil, non-cohesive, some white gravel 5mm angular, organic layer (0.2 - 0.25m)-5YR 2.5/1 , sample ID: TW26A-01

Dry to moist clay, increasing plasticity from low to high down the layer - cohesive, jarosite, iron mottling 25%, macropores, organics, sample ID: TW26A-02

Wet clay, high plasticity very cohesive, organic peat (1.5 - 1.6m), shells (1.9 - 2.1m), sample ID: TW26A-03

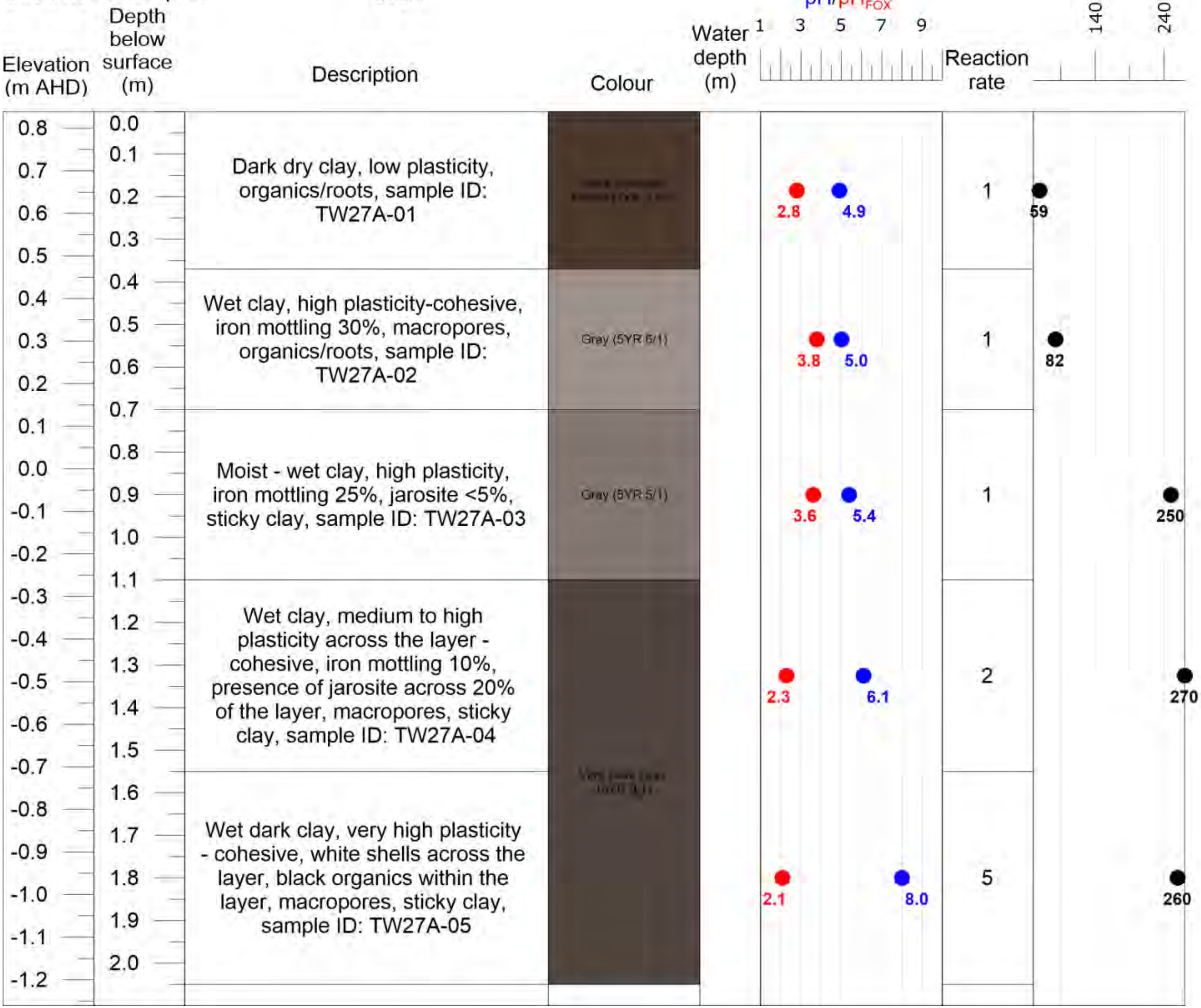
Soil profile details:

Project Number:	2018064	Profile ID:	TW_27_A
River/estuary:	Tweed	Sample date:	18/10/19
Easting:	540215.8	Sampled by:	TAT DWJ
Northing:	6869551.5		

Ground elevation (m AHD):	0.84
Hydraulic conductivity (m/d):	3.27

Water quality:

Surface water EC (µS/cm):	20,751
Surface water pH:	7.07
Groundwater EC (µS/cm):	3,547
Groundwater pH:	5.04



Description	Colour	Soil pH/pH_{FOX}	Reaction rate	Soil EC (µS/cm)
Dark dry clay, low plasticity, organics/roots, sample ID: TW27A-01	[illegible]	4.9 / 2.8	1	59
Wet clay, high plasticity-cohesive, iron mottling 30%, macropores, organics/roots, sample ID: TW27A-02	Gray (5YR 6/1)	5.0 / 3.8	1	82
Moist - wet clay, high plasticity, iron mottling 25%, jarosite <5%, sticky clay, sample ID: TW27A-03	Gray (5YR 5/1)	5.4 / 3.6	1	250
Wet clay, medium to high plasticity across the layer - cohesive, iron mottling 10%, presence of jarosite across 20% of the layer, macropores, sticky clay, sample ID: TW27A-04	[illegible]	6.1 / 2.3	2	270
Wet dark clay, very high plasticity - cohesive, white shells across the layer, black organics within the layer, macropores, sticky clay, sample ID: TW27A-05		8.0 / 2.1	5	260

UNSW
SYDNEY

Water Research Laboratory
School of Civil and Environmental Engineering

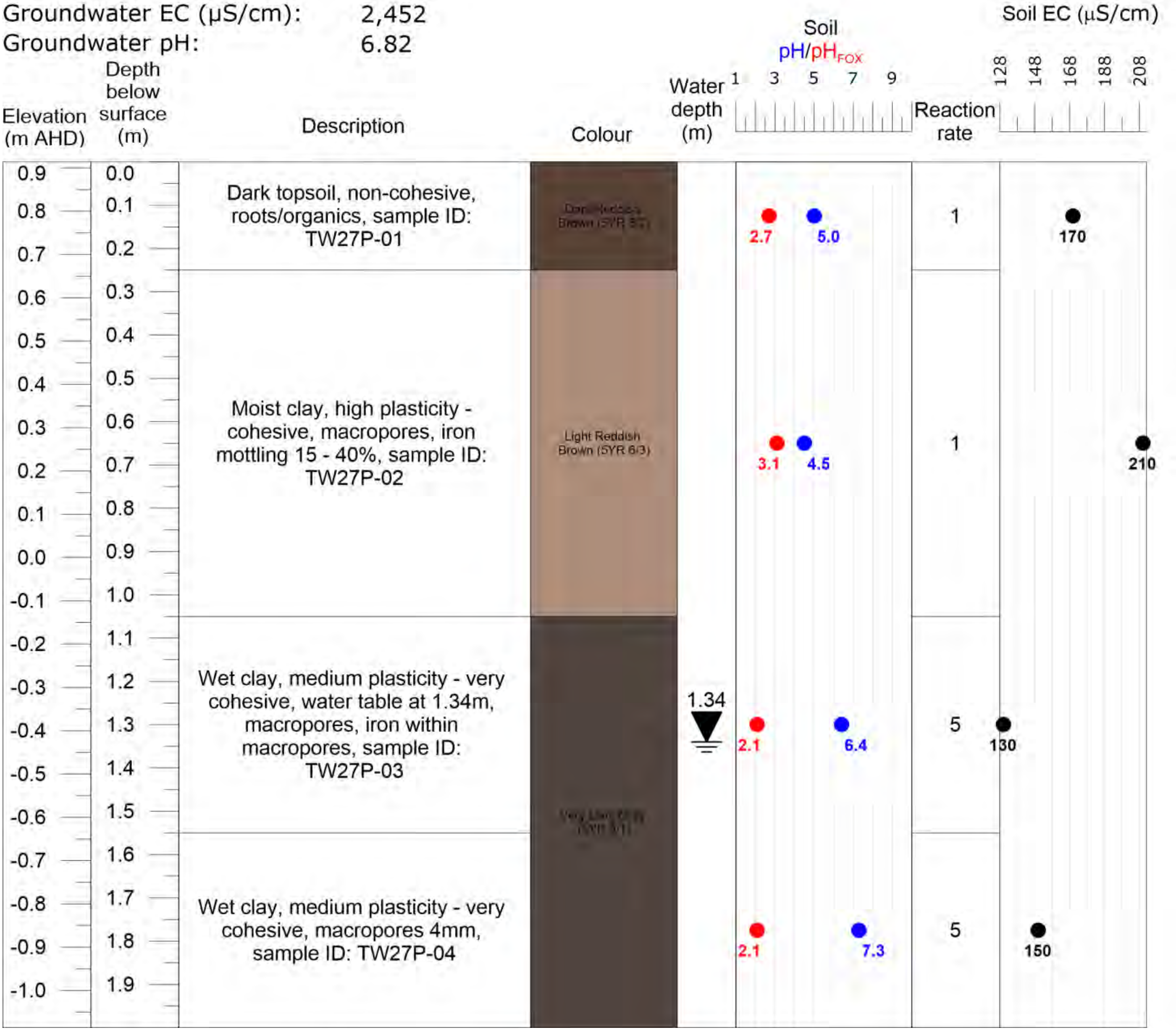
Soil profile details:

Project Number:	2018064	Profile ID:	TW_27_P
River/estuary:	Tweed	Sample date:	18/10/19
Easting:	539680.5	Sampled by:	TAT DWJ
Northing:	6869308.9		

Ground elevation (m AHD):	0.91
Hydraulic conductivity (m/d):	0.47

Water quality:

Surface water EC (µS/cm):	16,124
Surface water pH:	7.34
Groundwater EC (µS/cm):	2,452
Groundwater pH:	6.82



Description	Colour	Water depth (m)	Soil pH	Soil pH_{FOX}	Reaction rate	Soil EC (µS/cm)
Dark topsoil, non-cohesive, roots/organics, sample ID: TW27P-01	Dark Reddish Brown (5YR 3/2)		5.0	2.7	1	170
Moist clay, high plasticity - cohesive, macropores, iron mottling 15 - 40%, sample ID: TW27P-02	Light Reddish Brown (5YR 6/3)		4.5	3.1	1	210
Wet clay, medium plasticity - very cohesive, water table at 1.34m, macropores, iron within macropores, sample ID: TW27P-03	Very Dark Gray (5YR 3/1)	1.34	6.4	2.1	5	130
Wet clay, medium plasticity - very cohesive, macropores 4mm, sample ID: TW27P-04			7.3	2.1	5	150

UNSW SYDNEY

Water Research Laboratory
School of Civil and Environmental Engineering

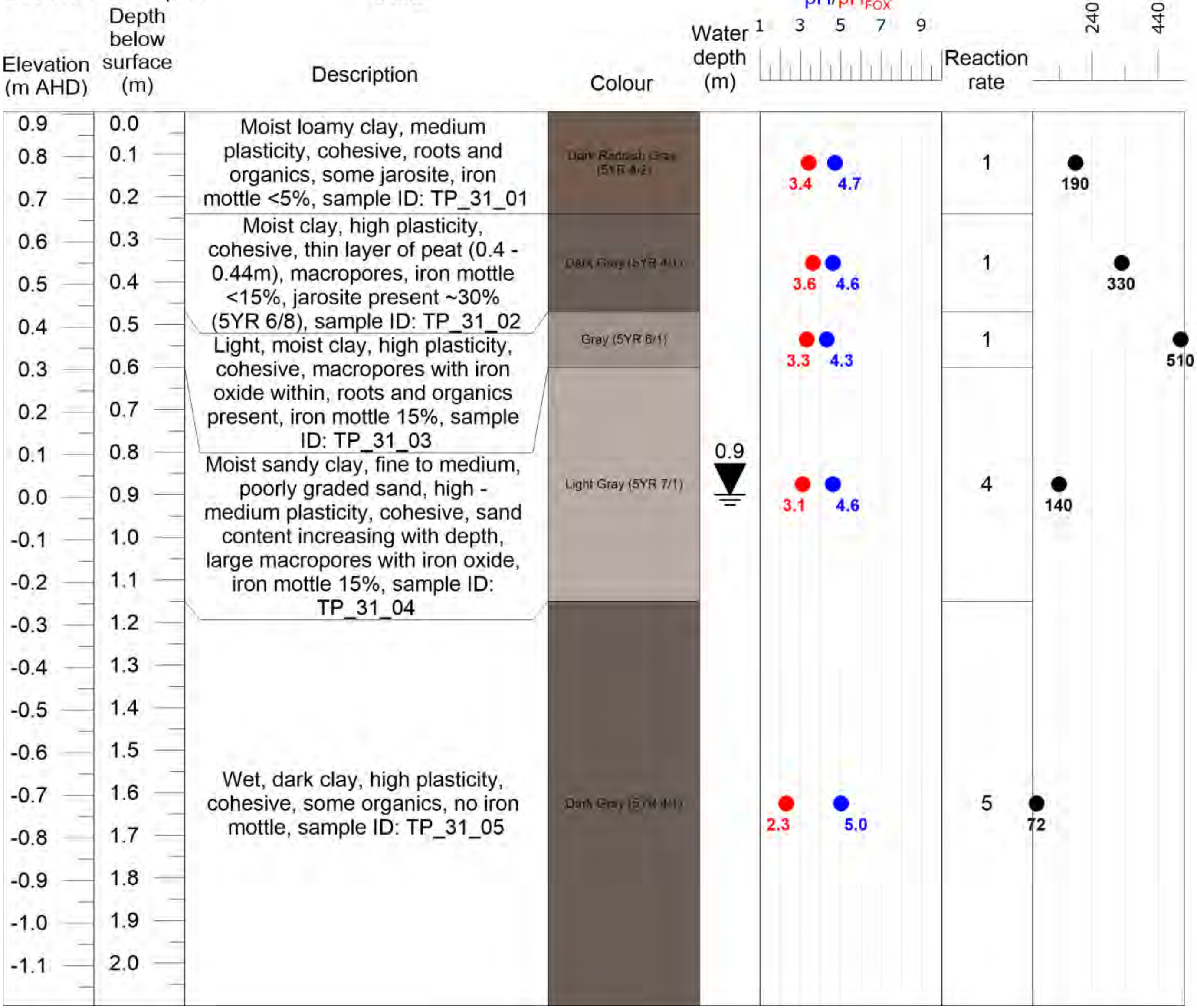
Soil profile details:

Project Number:	2018064	Profile ID:	TW_31_P
River/estuary:	Tweed	Sample date:	24/02/20
Easting:	536772.9	Sampled by:	AJH DWJ
Northing:	6867337.5		

Ground elevation (m AHD):	0.91
Hydraulic conductivity (m/d):	0.25

Water quality:

Surface water EC (µS/cm):	343
Surface water pH:	6
Groundwater EC (µS/cm):	1,646
Groundwater pH:	5.05



Description	Colour	Soil pH/pH$_{FOX}$	Reaction rate	Soil EC (µS/cm)
Moist loamy clay, medium plasticity, cohesive, roots and organics, some jarosite, iron mottle <5%, sample ID: TP_31_01	Dark Reddish Gray (5YR 4/2)	3.4 4.7	1	190
Moist clay, high plasticity, cohesive, thin layer of peat (0.4 - 0.44m), macropores, iron mottle <15%, jarosite present ~30% (5YR 6/8), sample ID: TP_31_02	Dark Gray (5YR 4/1)	3.6 4.6	1	330
Light, moist clay, high plasticity, cohesive, macropores with iron oxide within, roots and organics present, iron mottle 15%, sample ID: TP_31_03	Gray (5YR 6/1)	3.3 4.3	1	510
Moist sandy clay, fine to medium, poorly graded sand, high - medium plasticity, cohesive, sand content increasing with depth, large macropores with iron oxide, iron mottle 15%, sample ID: TP_31_04	Light Gray (5YR 7/1)	3.1 4.6	4	140
Wet, dark clay, high plasticity, cohesive, some organics, no iron mottle, sample ID: TP_31_05	Dark Gray (5YR 4/1)	2.3 5.0	5	72

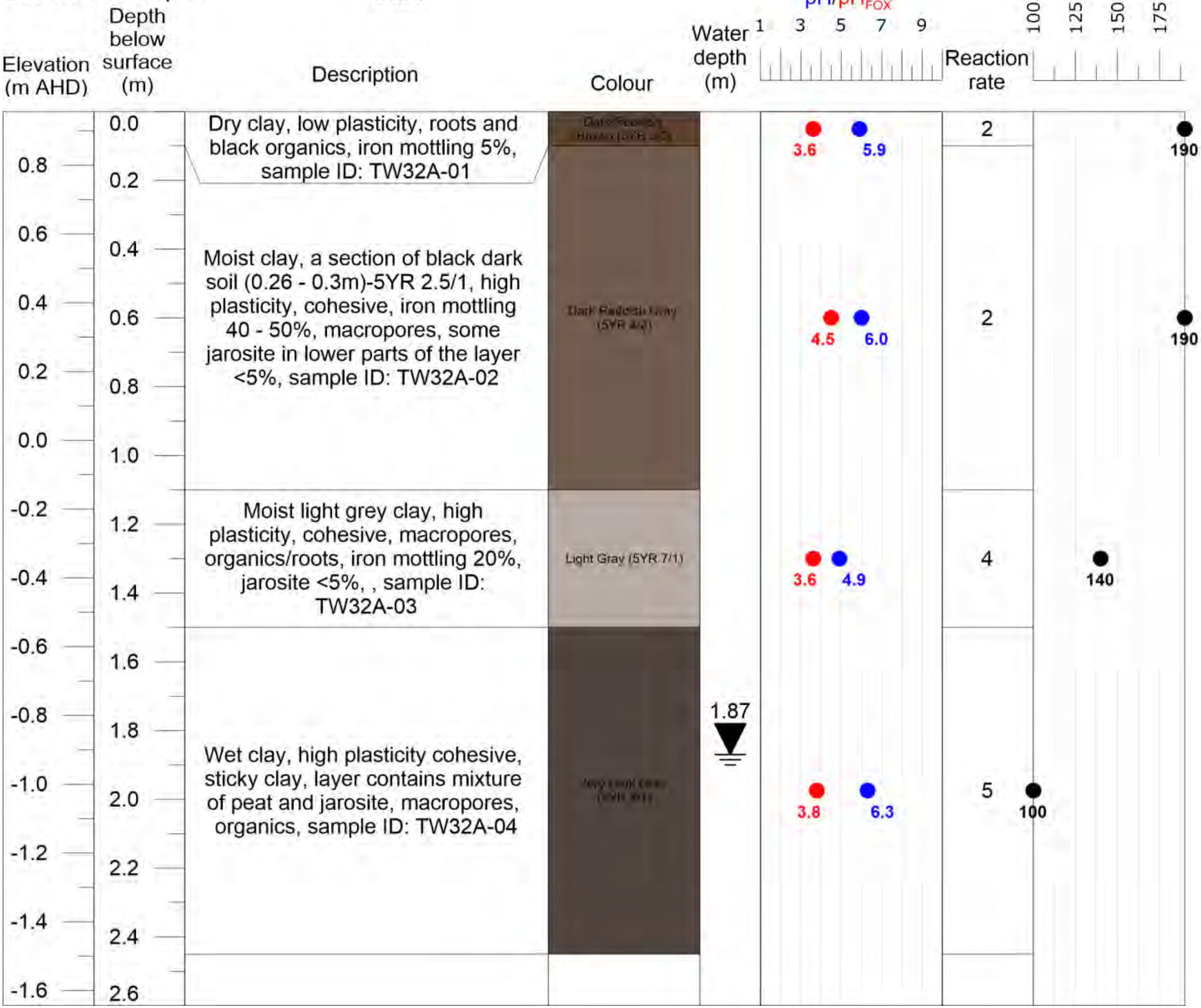
Soil profile details:

Project Number:	2018064	Profile ID:	TW_32_A
River/estuary:	Tweed	Sample date:	23/10/19
Easting:	538725	Sampled by:	TAT DWJ
Northing:	6865243.3		

Ground elevation (m AHD):	0.96
Hydraulic conductivity (m/d):	0.74

Water quality:

Surface water EC (µS/cm):	24,591
Surface water pH:	6.29
Groundwater EC (µS/cm):	1,757
Groundwater pH:	6.26



Description	Colour	pH	pH_FOX	Reaction rate	Soil EC (µS/cm)
Dry clay, low plasticity, roots and black organics, iron mottling 5%, sample ID: TW32A-01	Dark Reddish Brown (5YR [illegible])	5.9	3.6	2	190
Moist clay, a section of black dark soil (0.26 - 0.3m)-5YR 2.5/1, high plasticity, cohesive, iron mottling 40 - 50%, macropores, some jarosite in lower parts of the layer <5%, sample ID: TW32A-02	Dark Reddish Gray (5YR 4/2)	6.0	4.5	2	190
Moist light grey clay, high plasticity, cohesive, macropores, organics/roots, iron mottling 20%, jarosite <5%, , sample ID: TW32A-03	Light Gray (5YR 7/1)	4.9	3.6	4	140
Wet clay, high plasticity cohesive, sticky clay, layer contains mixture of peat and jarosite, macropores, organics, sample ID: TW32A-04	Very Dark Gray (5YR 3/1)	6.3	3.8	5	100

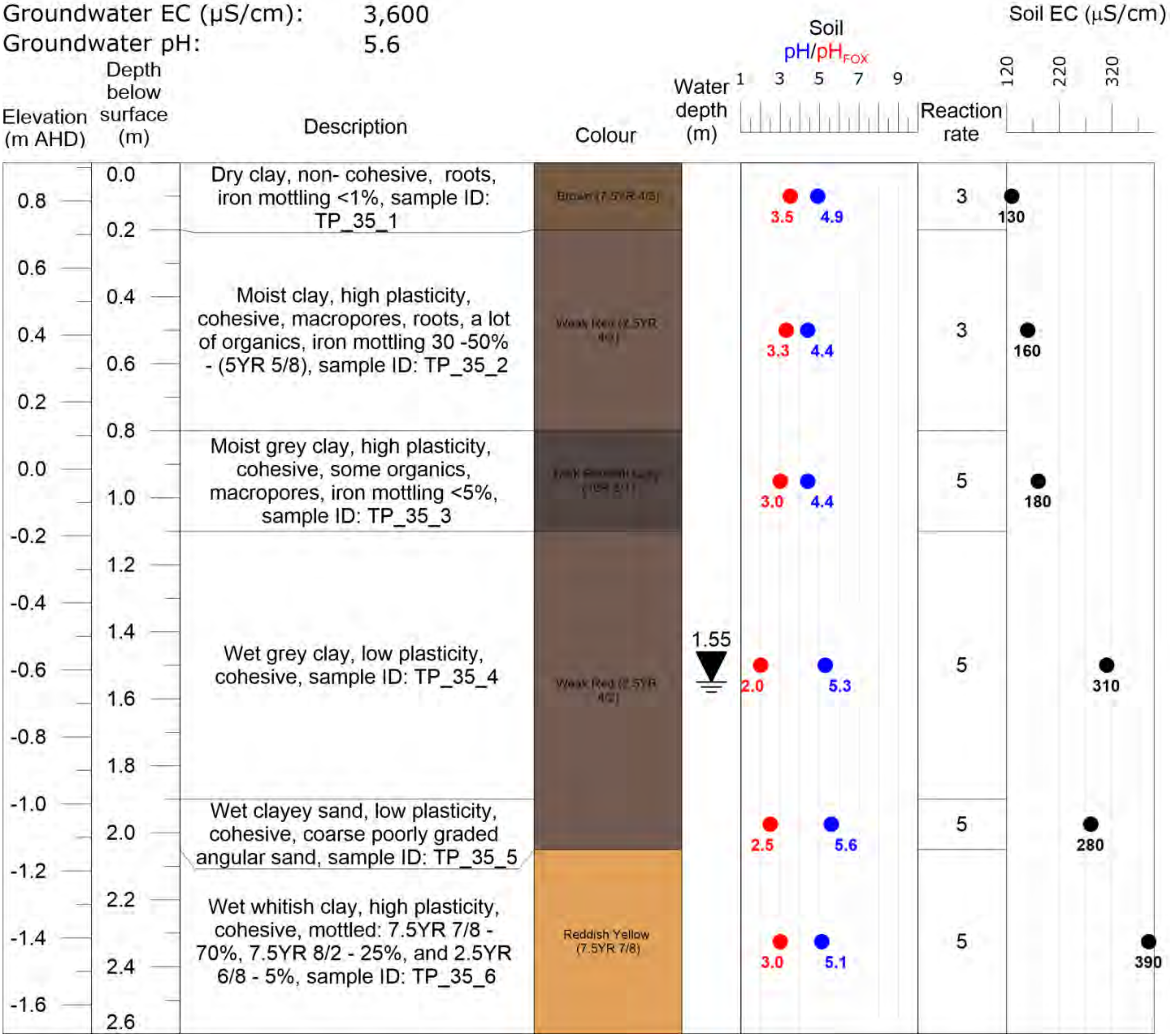
Soil profile details:

Project Number:	2018064	Profile ID:	TW_35_P
River/estuary:	Tweed	Sample date:	07/11/19
Easting:	541453.3	Sampled by:	AJH GL
Northing:	6865542.3		

Ground elevation (m AHD):	0.91
Hydraulic conductivity (m/d):	0.31

Water quality:

Surface water EC (µS/cm):	1,300
Surface water pH:	6.7
Groundwater EC (µS/cm):	3,600
Groundwater pH:	5.6



Description	Colour	pH_FOX	pH	Reaction rate	Soil EC (µS/cm)
Dry clay, non- cohesive, roots, iron mottling <1%, sample ID: TP_35_1	Brown (7.5YR 4/3)	3.5	4.9	3	130
Moist clay, high plasticity, cohesive, macropores, roots, a lot of organics, iron mottling 30 -50% - (5YR 5/8), sample ID: TP_35_2	Weak Red (2.5YR 4/2)	3.3	4.4	3	160
Moist grey clay, high plasticity, cohesive, some organics, macropores, iron mottling <5%, sample ID: TP_35_3	Dark Reddish Gray (10R 3/1)	3.0	4.4	5	180
Wet grey clay, low plasticity, cohesive, sample ID: TP_35_4	Weak Red (2.5YR 4/2)	2.0	5.3	5	310
Wet clayey sand, low plasticity, cohesive, coarse poorly graded angular sand, sample ID: TP_35_5		2.5	5.6	5	280
Wet whitish clay, high plasticity, cohesive, mottled: 7.5YR 7/8 - 70%, 7.5YR 8/2 - 25%, and 2.5YR 6/8 - 5%, sample ID: TP_35_6	Reddish Yellow (7.5YR 7/8)	3.0	5.1	5	390

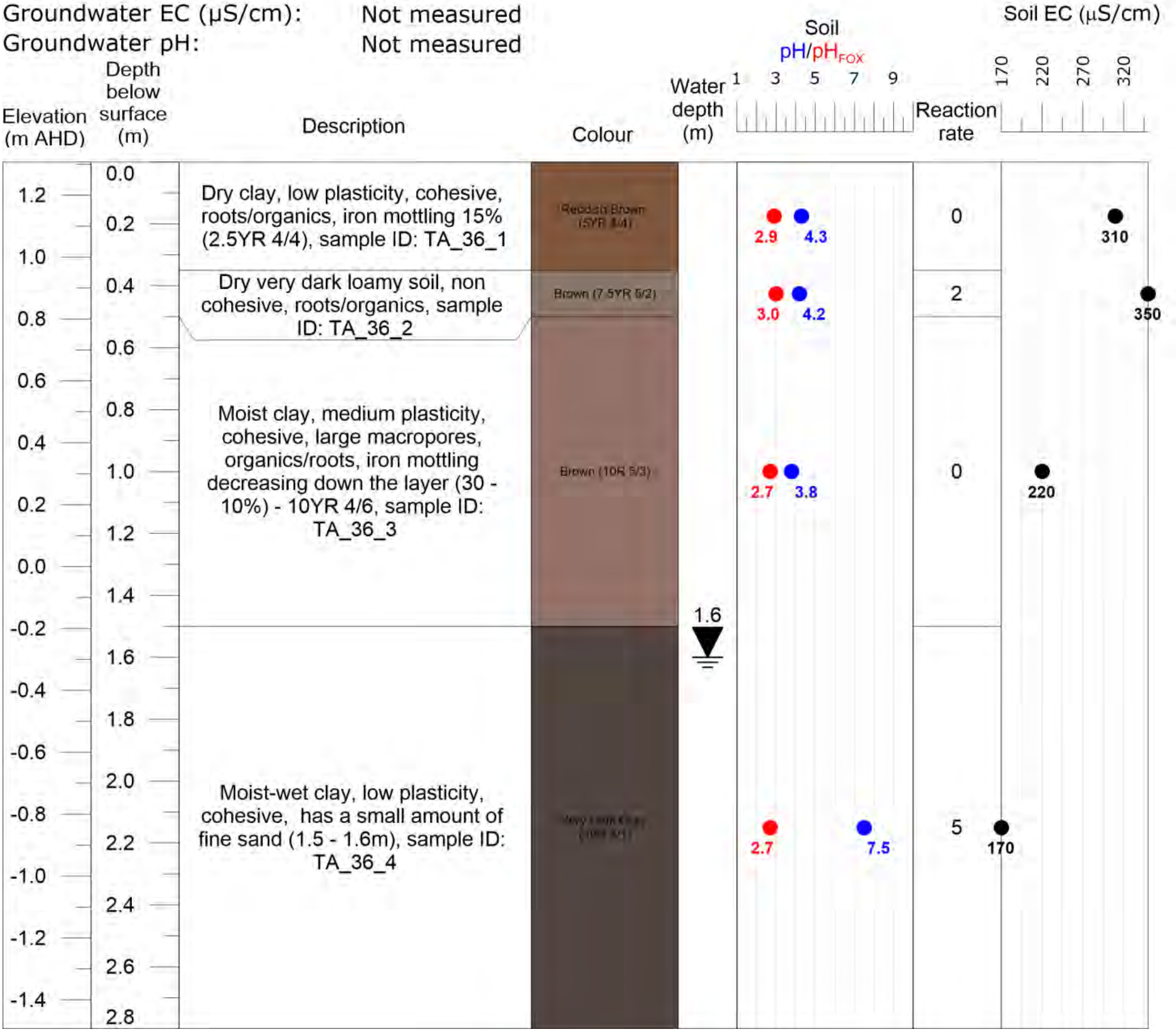
Soil profile details:

Project Number:	2018064	Profile ID:	TW_36_A
River/estuary:	Tweed	Sample date:	07/11/19
Easting:	539624.6	Sampled by:	AJH GL
Northing:	6865081.8		

Ground elevation (m AHD):	1.31
Hydraulic conductivity (m/d):	Not measured

Water quality:

Surface water EC (μS/cm):	31,203
Surface water pH:	7.09
Groundwater EC (μS/cm):	Not measured
Groundwater pH:	Not measured

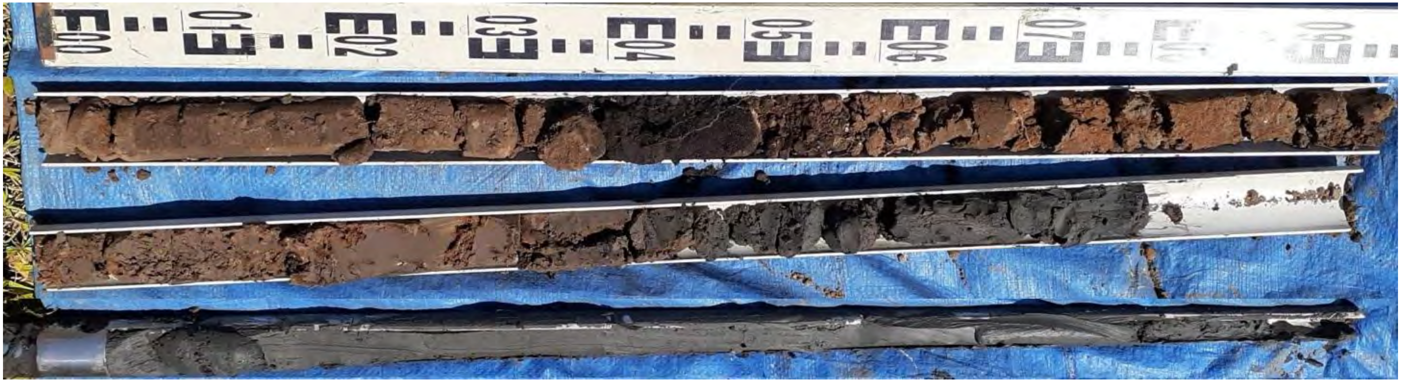


Dry clay, low plasticity, cohesive, roots/organics, iron mottling 15% (2.5YR 4/4), sample ID: TA_36_1

Dry very dark loamy soil, non cohesive, roots/organics, sample ID: TA_36_2

Moist clay, medium plasticity, cohesive, large macropores, organics/roots, iron mottling decreasing down the layer (30 - 10%) - 10YR 4/6, sample ID: TA_36_3

Moist-wet clay, low plasticity, cohesive, has a small amount of fine sand (1.5 - 1.6m), sample ID: TA_36_4



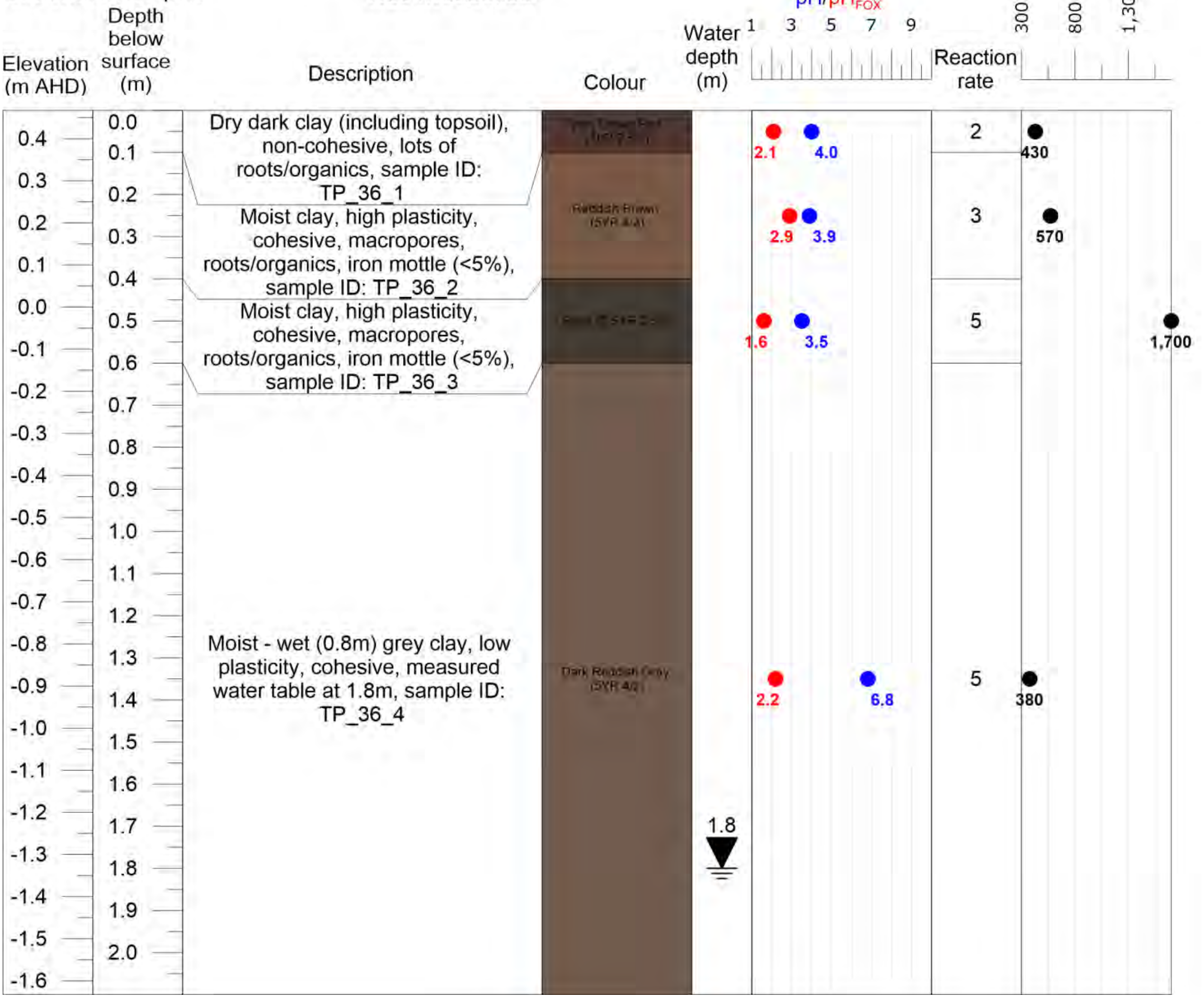
Soil profile details:

Project Number:	2018064	Profile ID:	TW_36_P
River/estuary:	Tweed	Sample date:	08/11/19
Easting:	540355.4	Sampled by:	AJH GL
Northing:	6864934.2		

Ground elevation (m AHD): 0.47
Hydraulic conductivity (m/d): Not measured

Water quality:

Surface water EC (µS/cm): 23,000 (Black Drain)
Surface water pH: 6.9 (Black Drain)
Groundwater EC (µS/cm): Not measured
Groundwater pH: Not measured

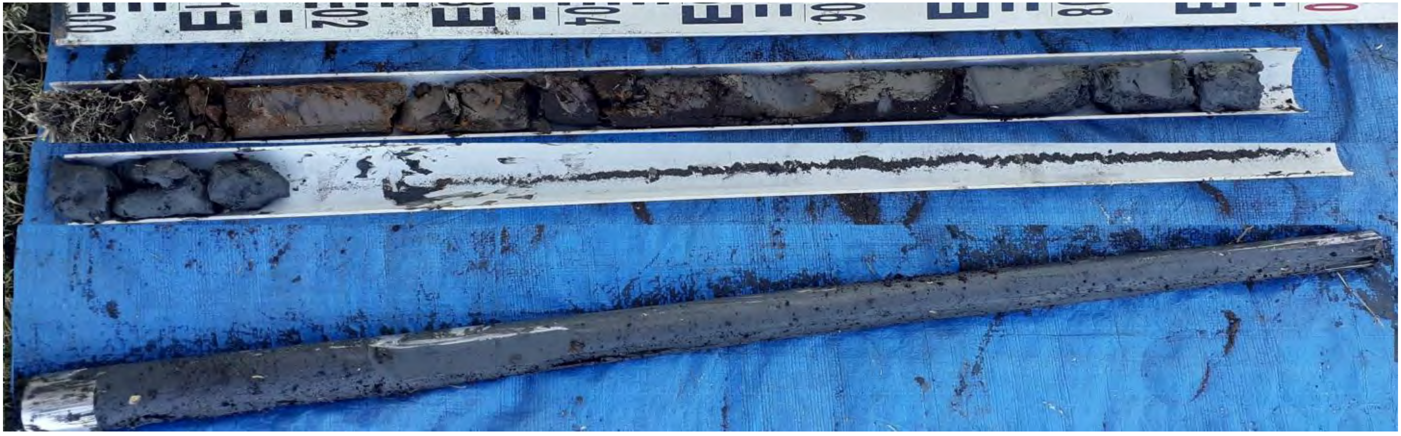


Dry dark clay (including topsoil), non-cohesive, lots of roots/organics, sample ID: TP_36_1

Moist clay, high plasticity, cohesive, macropores, roots/organics, iron mottle (<5%), sample ID: TP_36_2

Moist clay, high plasticity, cohesive, macropores, roots/organics, iron mottle (<5%), sample ID: TP_36_3

Moist - wet (0.8m) grey clay, low plasticity, cohesive, measured water table at 1.8m, sample ID: TP_36_4



Soil profile details:

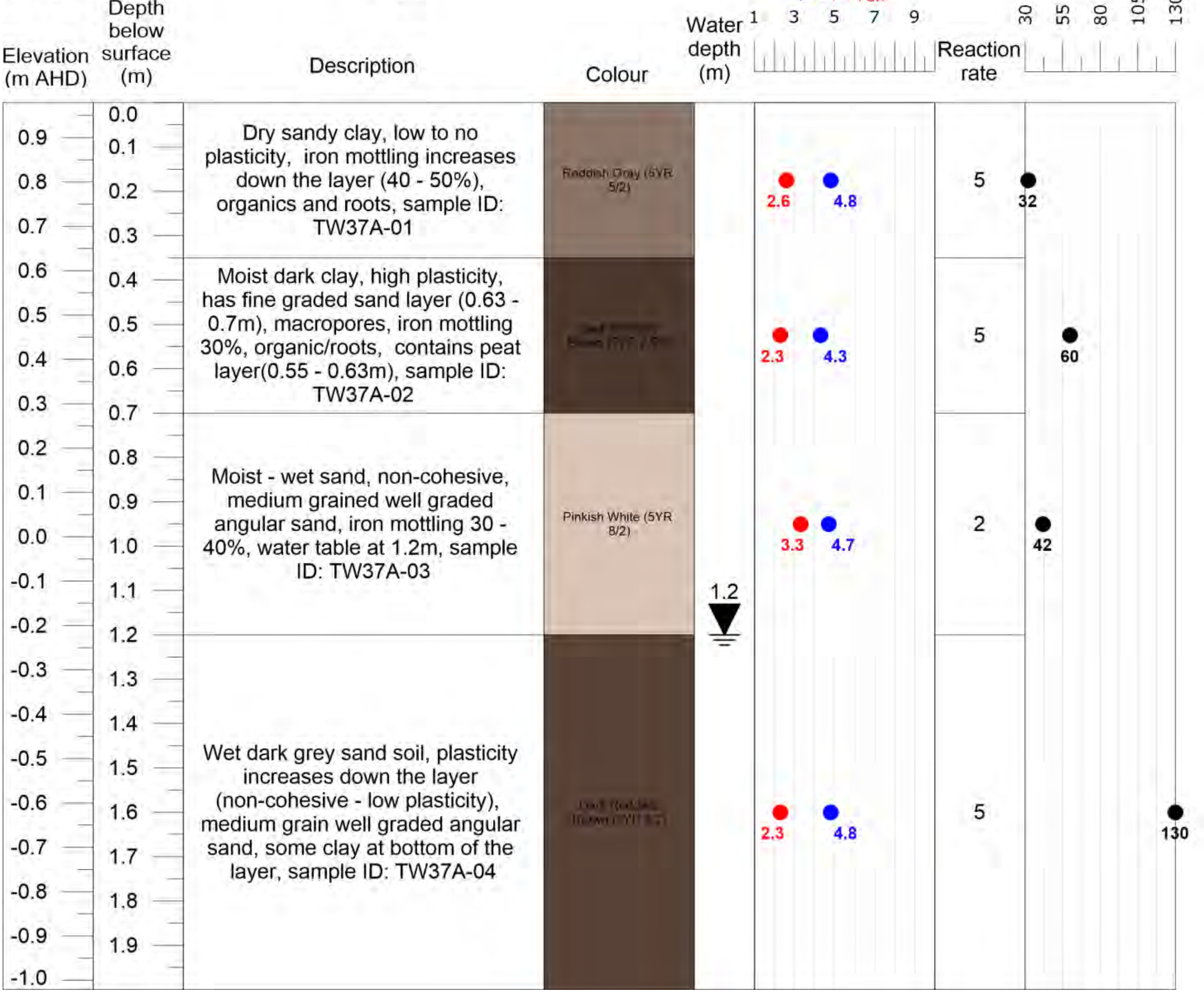
Project Number:	2018064	Profile ID:	TW_37_A
River/estuary:	Tweed	Sample date:	19/10/19
Easting:	543850	Sampled by:	TAT DWJ
Northing:	6867300.3		

Ground elevation (m AHD): 0.98
Hydraulic conductivity (m/d): Not measured

Water Research Laboratory
School of Civil and Environmental Engineering

Water quality:

Surface water EC (µS/cm): Not measured
Surface water pH: Not measured
Groundwater EC (µS/cm): 1,189
Groundwater pH: 4.04



Description	Colour	Water depth (m)	Soil pH$_{FOX}$	Soil pH	Reaction rate	Soil EC (µS/cm)
Dry sandy clay, low to no plasticity, iron mottling increases down the layer (40 - 50%), organics and roots, sample ID: TW37A-01	Reddish Gray (5YR 5/2)		2.6	4.8	5	32
Moist dark clay, high plasticity, has fine graded sand layer (0.63 - 0.7m), macropores, iron mottling 30%, organic/roots, contains peat layer(0.55 - 0.63m), sample ID: TW37A-02	[illegible]		2.3	4.3	5	60
Moist - wet sand, non-cohesive, medium grained well graded angular sand, iron mottling 30 - 40%, water table at 1.2m, sample ID: TW37A-03	Pinkish White (5YR 8/2)	1.2	3.3	4.7	2	42
Wet dark grey sand soil, plasticity increases down the layer (non-cohesive - low plasticity), medium grain well graded angular sand, some clay at bottom of the layer, sample ID: TW37A-04	Dark Reddish Brown (5YR 3/2)		2.3	4.8	5	130

Soil profile details:

Project Number:	2018064	Profile ID:	TW_37_P
River/estuary:	Tweed	Sample date:	22/10/19
Easting:	544020.7	Sampled by:	TAT DWJ
Northing:	6867003.8		

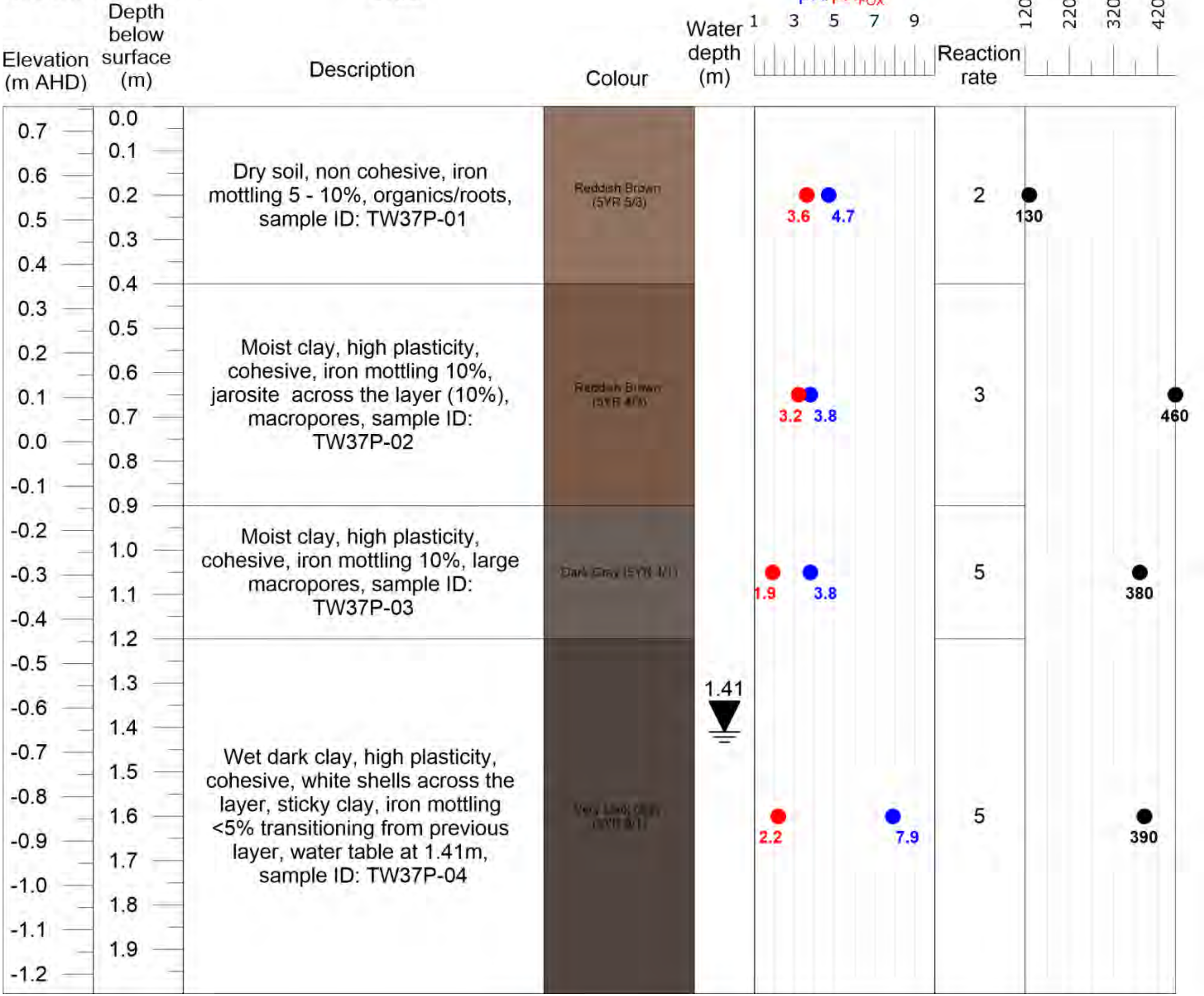
UNSW
SYDNEY

Water Research Laboratory
School of Civil and Environmental Engineering

Ground elevation (m AHD):	0.76
Hydraulic conductivity (m/d):	4.96

Water quality:

Surface water EC (µS/cm):	1,269
Surface water pH:	6.93
Groundwater EC (µS/cm):	3,915
Groundwater pH:	6.88



Description	Colour	Water depth (m)	Soil pH/pH$_{FOX}$	Reaction rate	Soil EC (µS/cm)
Dry soil, non cohesive, iron mottling 5 - 10%, organics/roots, sample ID: TW37P-01	Reddish Brown (5YR 5/3)		3.6 / 4.7	2	130
Moist clay, high plasticity, cohesive, iron mottling 10%, jarosite across the layer (10%), macropores, sample ID: TW37P-02	Reddish Brown (5YR 4/3)		3.2 / 3.8	3	460
Moist clay, high plasticity, cohesive, iron mottling 10%, large macropores, sample ID: TW37P-03	Dark Gray (5YR 4/1)		1.9 / 3.8	5	380
Wet dark clay, high plasticity, cohesive, white shells across the layer, sticky clay, iron mottling <5% transitioning from previous layer, water table at 1.41m, sample ID: TW37P-04	Very Dark Gray (5YR 3/1)	1.41	2.2 / 7.9	5	390

Soil profile details:

Project Number:	2018064	Profile ID:	TW_38_A
River/estuary:	Tweed	Sample date:	16/10/19
Easting:	545358.8	Sampled by:	TAT DWJ
Northing:	6869126.9		

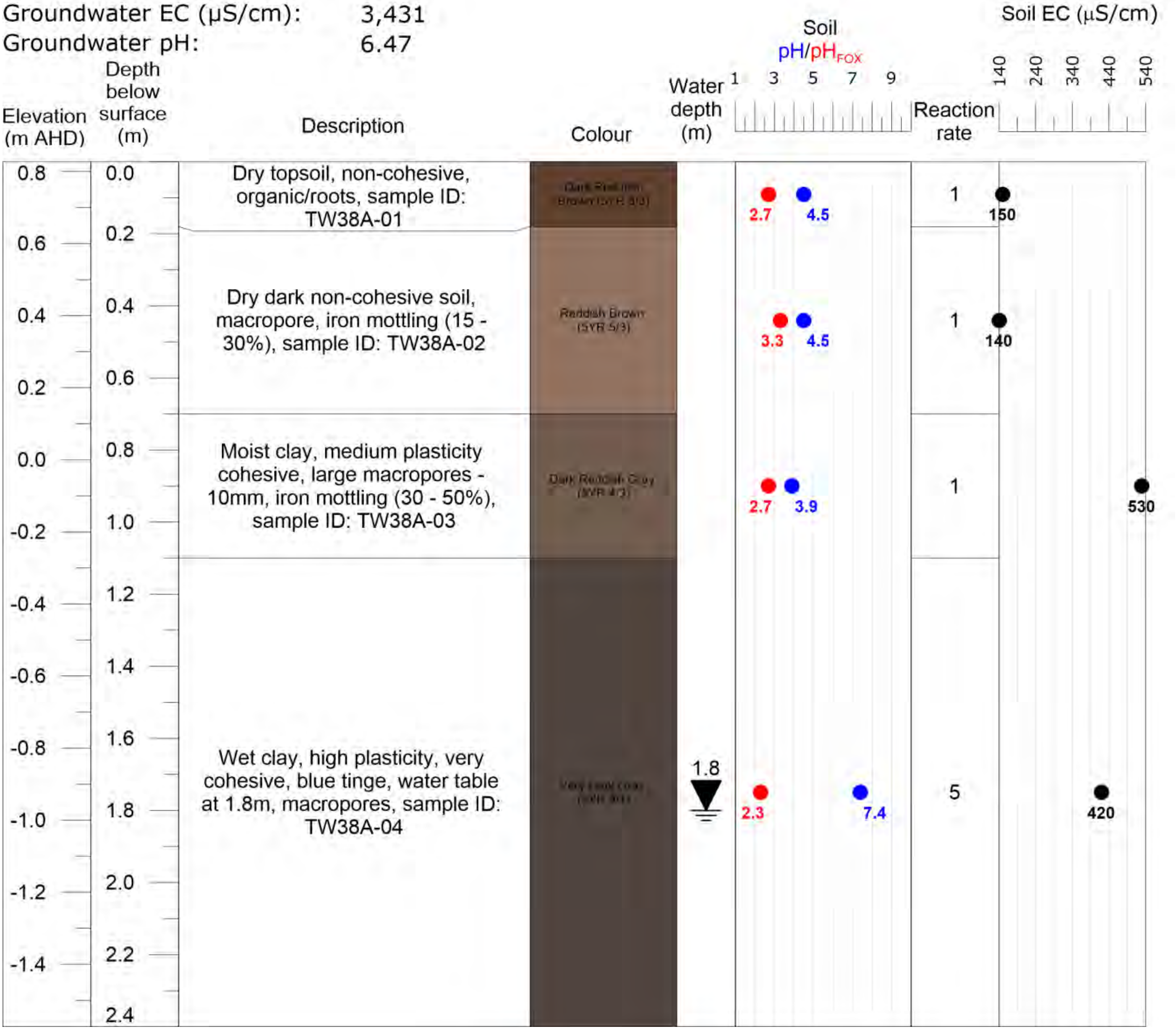
Ground elevation (m AHD):	0.83
Hydraulic conductivity (m/d):	0.38

UNSW SYDNEY

Water Research Laboratory
School of Civil and Environmental Engineering

Water quality:

Surface water EC (µS/cm):	24,852
Surface water pH:	6.87
Groundwater EC (µS/cm):	3,431
Groundwater pH:	6.47



Dry topsoil, non-cohesive, organic/roots, sample ID: TW38A-01

Dry dark non-cohesive soil, macropore, iron mottling (15 - 30%), sample ID: TW38A-02

Moist clay, medium plasticity cohesive, large macropores - 10mm, iron mottling (30 - 50%), sample ID: TW38A-03

Wet clay, high plasticity, very cohesive, blue tinge, water table at 1.8m, macropores, sample ID: TW38A-04

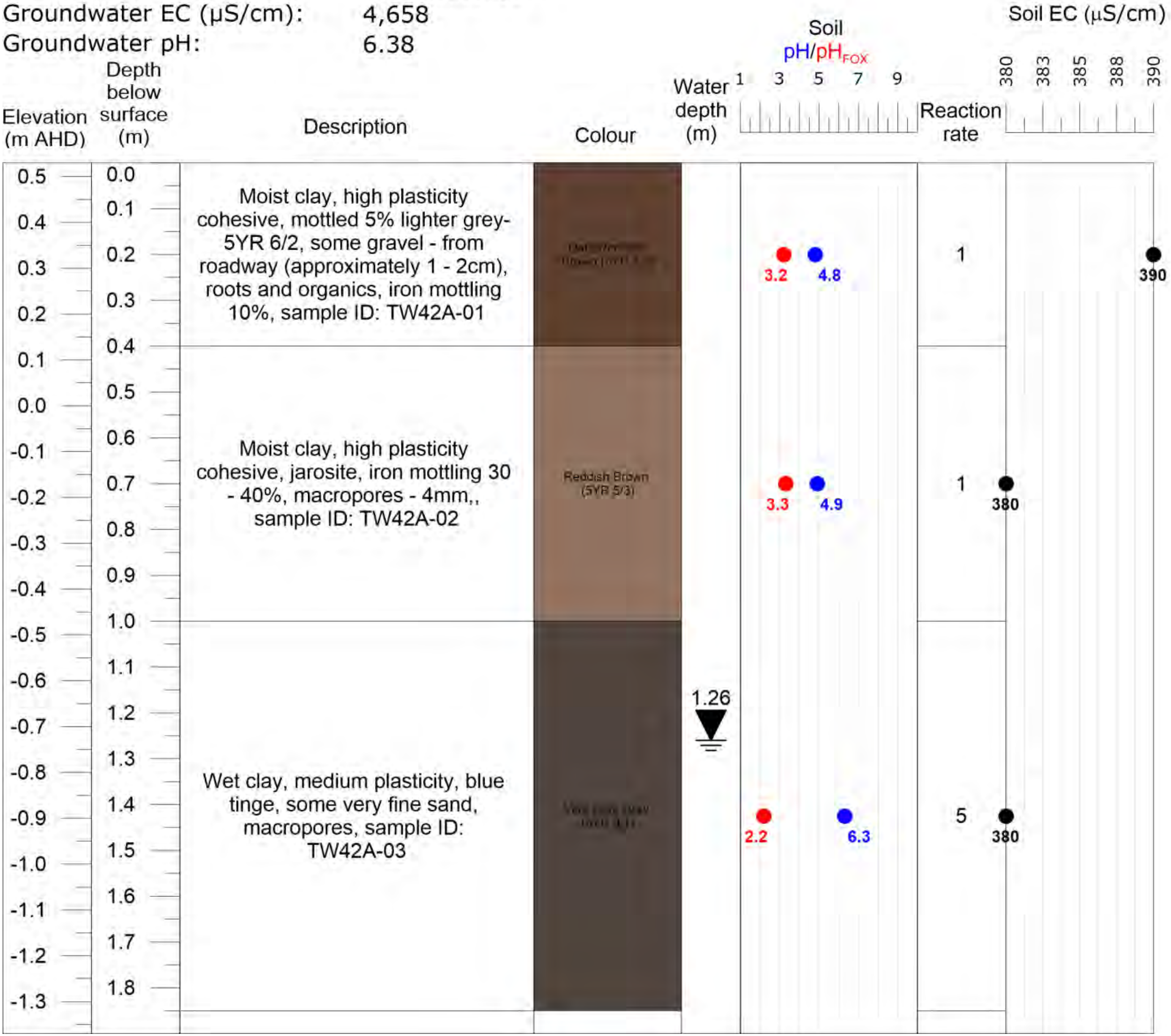
Soil profile details:

Project Number:	2018064	Profile ID:	TW_42_A
River/estuary:	Tweed	Sample date:	16/10/19
Easting:	547652.2	Sampled by:	TAT DWJ
Northing:	6871886.3		

Ground elevation (m AHD): 0.53
Hydraulic conductivity (m/d): 0.67

Water quality:

Surface water EC (µS/cm):	Not measured
Surface water pH:	Not measured
Groundwater EC (µS/cm):	4,658
Groundwater pH:	6.38



Description	Colour	pH$_{FOX}$	pH	Reaction rate	Soil EC (µS/cm)
Moist clay, high plasticity cohesive, mottled 5% lighter grey-5YR 6/2, some gravel - from roadway (approximately 1 - 2cm), roots and organics, iron mottling 10%, sample ID: TW42A-01	[illegible]	3.2	4.8	1	390
Moist clay, high plasticity cohesive, jarosite, iron mottling 30 - 40%, macropores - 4mm,, sample ID: TW42A-02	Reddish Brown (5YR 5/3)	3.3	4.9	1	380
Wet clay, medium plasticity, blue tinge, some very fine sand, macropores, sample ID: TW42A-03	[illegible]	2.2	6.3	5	380

Soil profile details:

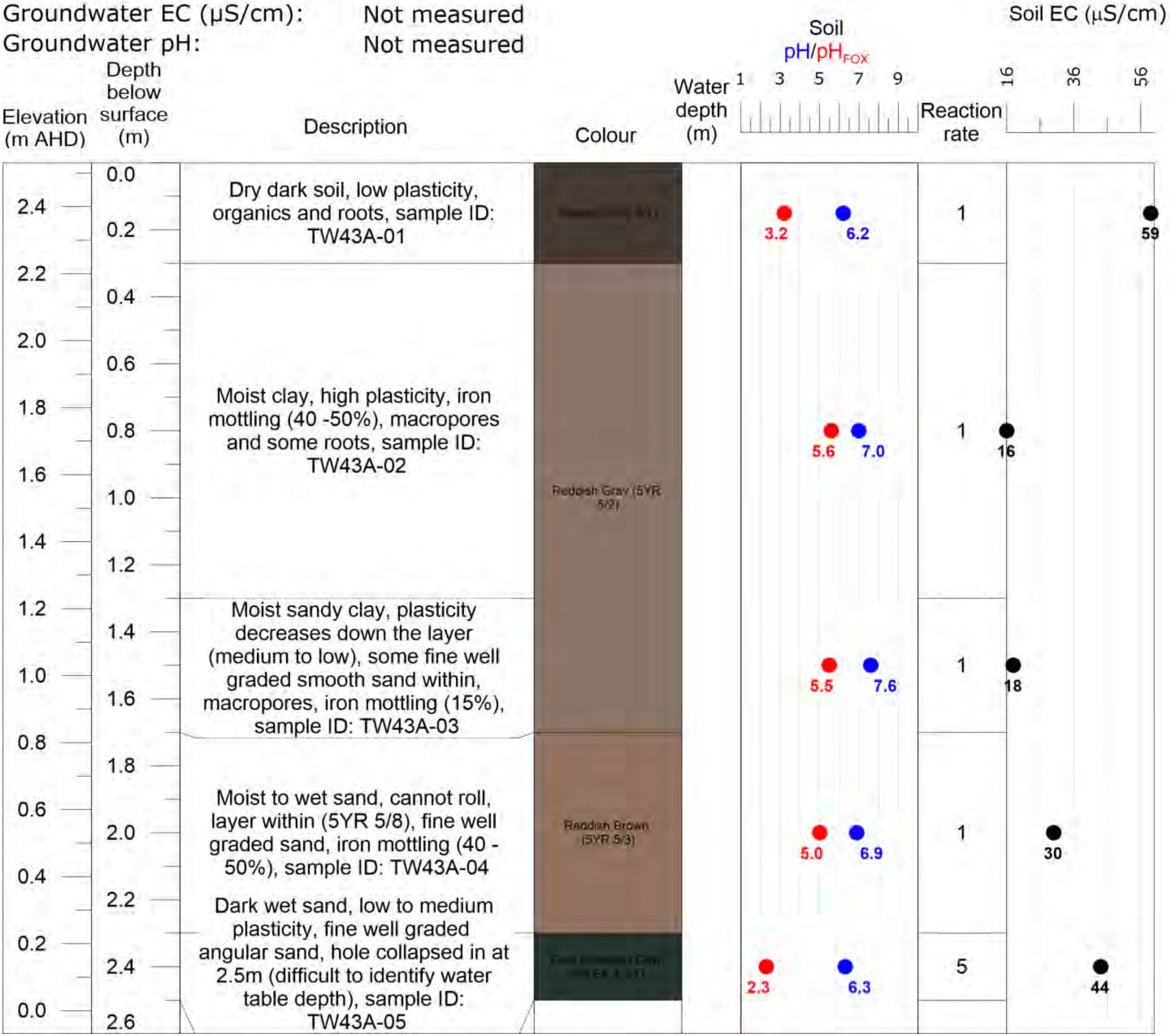
Project Number:	2018064	Profile ID:	TW_43_A
River/estuary:	Tweed	Sample date:	15/10/19
Easting:	542750.3	Sampled by:	TAT DWJ
Northing:	6867528.9		

Water Research Laboratory
School of Civil and Environmental Engineering

Ground elevation (m AHD):	2.53
Hydraulic conductivity (m/d):	Not measured

Water quality:

Surface water EC (µS/cm):	20,988
Surface water pH:	6.99
Groundwater EC (µS/cm):	Not measured
Groundwater pH:	Not measured



Dry dark soil, low plasticity, organics and roots, sample ID: TW43A-01

Moist clay, high plasticity, iron mottling (40 -50%), macropores and some roots, sample ID: TW43A-02

Moist sandy clay, plasticity decreases down the layer (medium to low), some fine well graded smooth sand within, macropores, iron mottling (15%), sample ID: TW43A-03

Moist to wet sand, cannot roll, layer within (5YR 5/8), fine well graded sand, iron mottling (40 - 50%), sample ID: TW43A-04

Dark wet sand, low to medium plasticity, fine well graded angular sand, hole collapsed in at 2.5m (difficult to identify water table depth), sample ID: TW43A-05

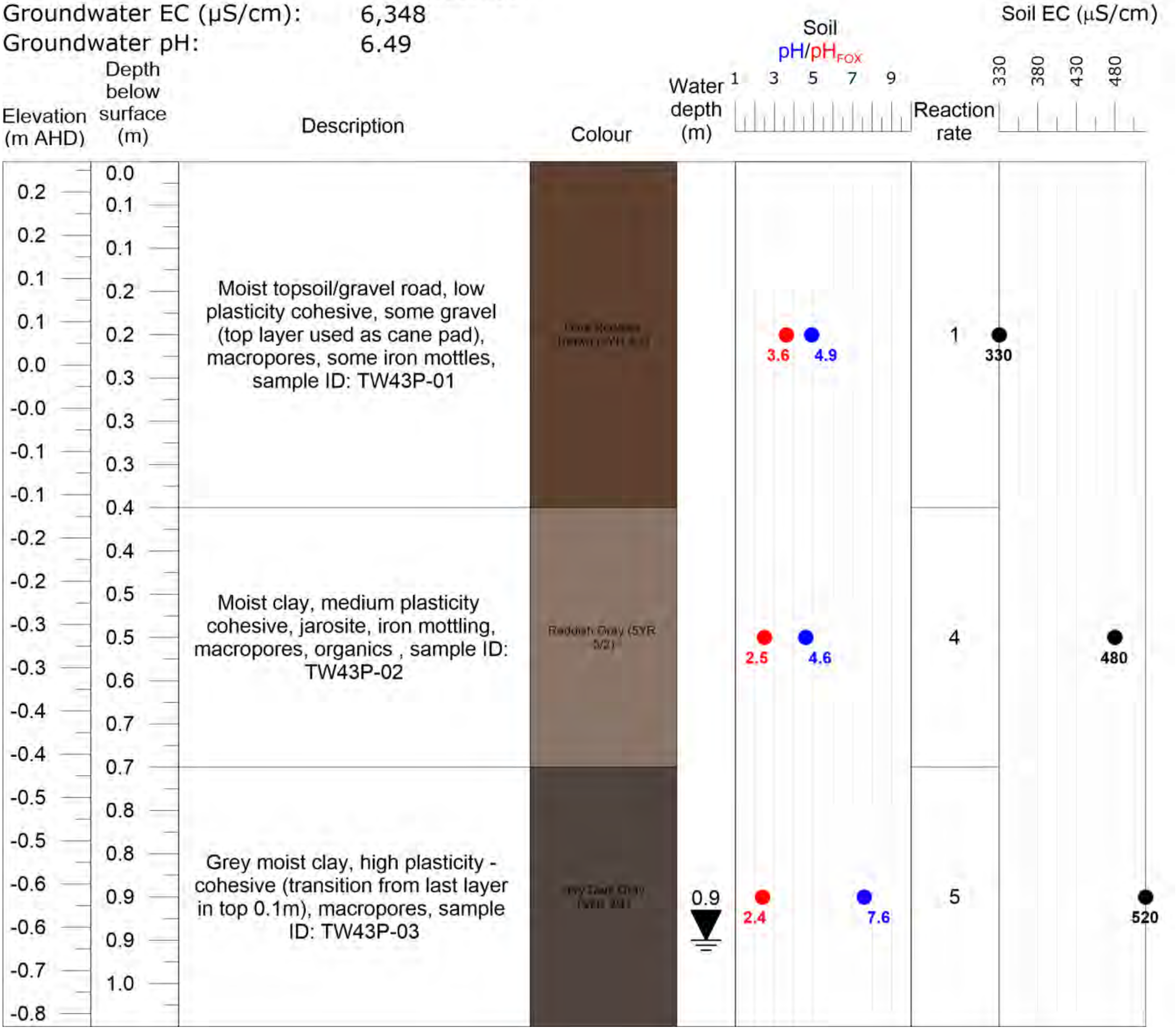
Soil profile details:

Project Number:	2018064	Profile ID:	TW_43_P
River/estuary:	Tweed	Sample date:	15/10/19
Easting:	548377.3	Sampled by:	TAT DWJ
Northing:	6871744.6		

Ground elevation (m AHD):	0.23
Hydraulic conductivity (m/d):	2.12

Water quality:

Surface water EC (µS/cm):	Not measured
Surface water pH:	Not measured
Groundwater EC (µS/cm):	6,348
Groundwater pH:	6.49



Moist topsoil/gravel road, low plasticity cohesive, some gravel (top layer used as cane pad), macropores, some iron mottles, sample ID: TW43P-01

Moist clay, medium plasticity cohesive, jarosite, iron mottling, macropores, organics , sample ID: TW43P-02

Grey moist clay, high plasticity - cohesive (transition from last layer in top 0.1m), macropores, sample ID: TW43P-03

Soil profile details:

Project Number:	2018064	Profile ID:	TW_44_A
River/estuary:	Tweed	Sample date:	16/10/19
Easting:	545813	Sampled by:	TAT DWJ
Northing:	6871053.6		

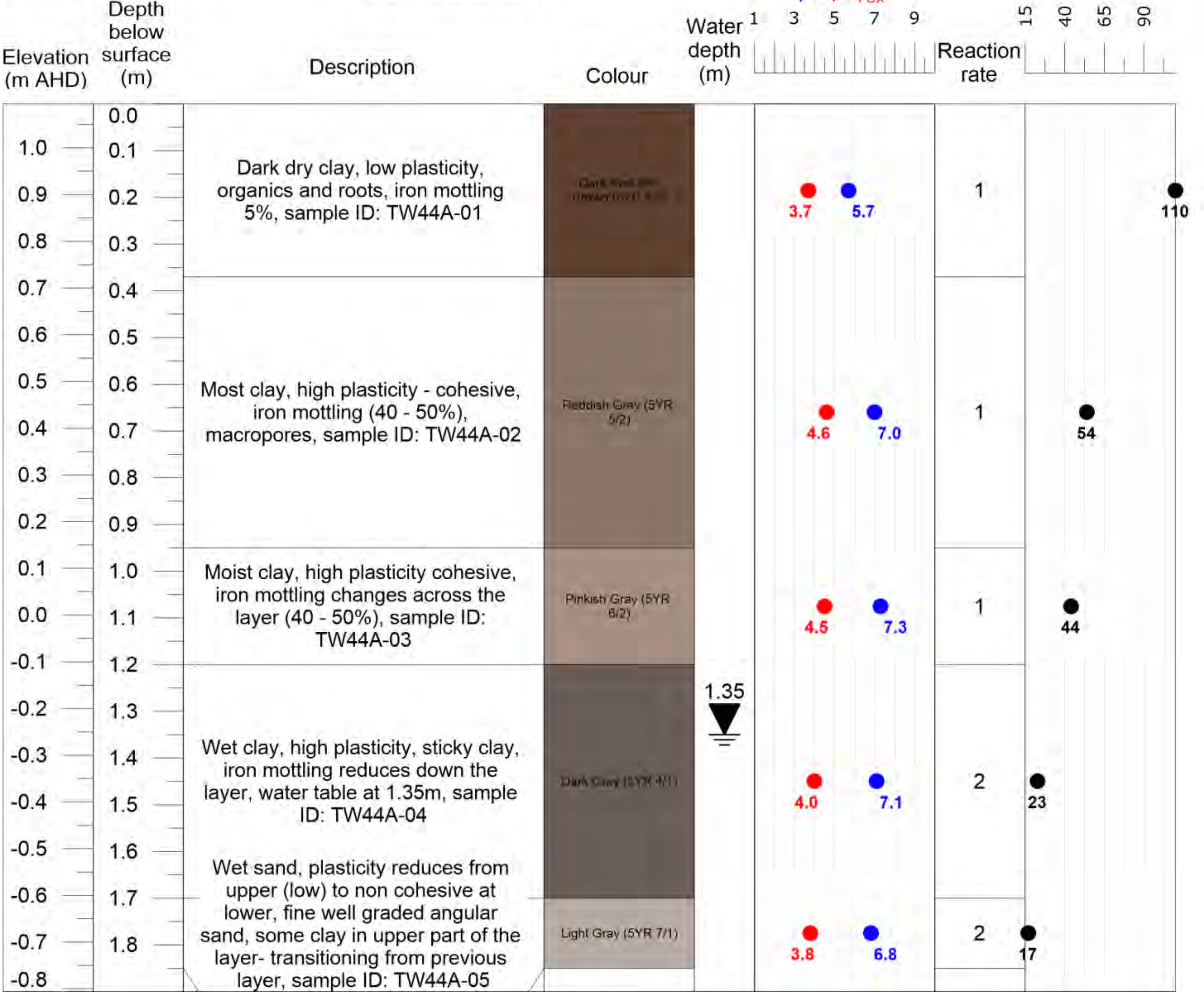
Ground elevation (m AHD):	1.09
Hydraulic conductivity (m/d):	Not measured

UNSW
SYDNEY

Water Research Laboratory
School of Civil and Environmental Engineering

Water quality:

Surface water EC (µS/cm):	36,046
Surface water pH:	7.12
Groundwater EC (µS/cm):	Not measured
Groundwater pH:	Not measured



Dark dry clay, low plasticity, organics and roots, iron mottling 5%, sample ID: TW44A-01	[illegible]	3.7	5.7	1	110
Most clay, high plasticity - cohesive, iron mottling (40 - 50%), macropores, sample ID: TW44A-02	Reddish Gray (5YR 5/2)	4.6	7.0	1	54
Moist clay, high plasticity cohesive, iron mottling changes across the layer (40 - 50%), sample ID: TW44A-03	Pinkish Gray (5YR 6/2)	4.5	7.3	1	44
Wet clay, high plasticity, sticky clay, iron mottling reduces down the layer, water table at 1.35m, sample ID: TW44A-04	Dark Gray (5YR 4/1)	4.0	7.1	2	23
Wet sand, plasticity reduces from upper (low) to non cohesive at lower, fine well graded angular sand, some clay in upper part of the layer- transitioning from previous layer, sample ID: TW44A-05	Light Gray (5YR 7/1)	3.8	6.8	2	17

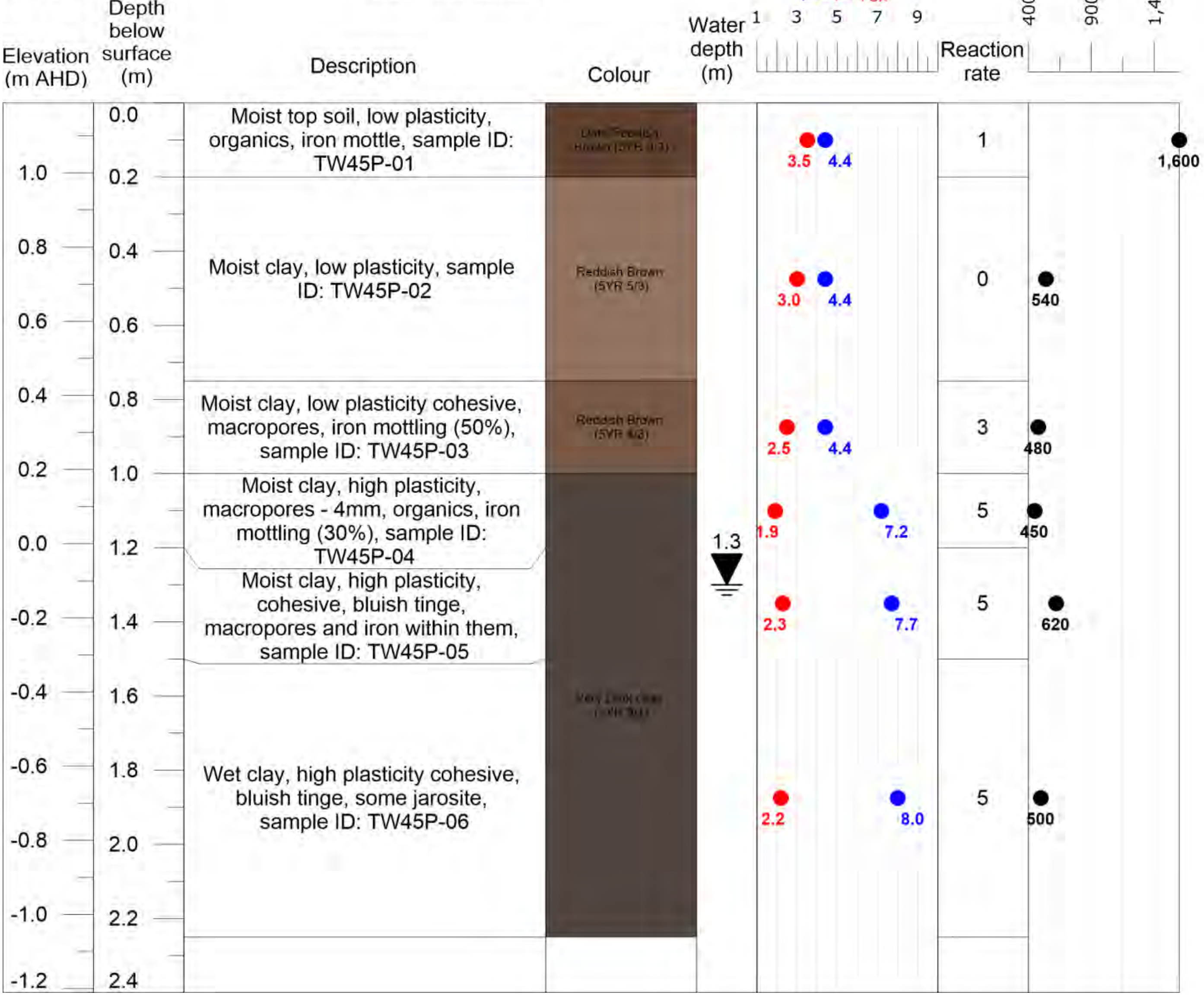
Soil profile details:

Project Number:	2018064	Profile ID:	TW_45_P
River/estuary:	Tweed	Sample date:	15/10/19
Easting:	543189.1	Sampled by:	TAT DWJ
Northing:	6867459.4		

Ground elevation (m AHD):	1.19
Hydraulic conductivity (m/d):	2.88

Water quality:

Surface water EC (µS/cm):	11,876
Surface water pH:	5.03
Groundwater EC (µS/cm):	Not measured
Groundwater pH:	Not measured



Description	Colour	Soil pH$_{FOX}$	Soil pH	Reaction rate	Soil EC (µS/cm)
Moist top soil, low plasticity, organics, iron mottle, sample ID: TW45P-01	Dark Reddish Brown (5YR 3/3)	3.5	4.4	1	1,600
Moist clay, low plasticity, sample ID: TW45P-02	Reddish Brown (5YR 5/3)	3.0	4.4	0	540
Moist clay, low plasticity cohesive, macropores, iron mottling (50%), sample ID: TW45P-03	Reddish Brown (5YR 4/3)	2.5	4.4	3	480
Moist clay, high plasticity, macropores - 4mm, organics, iron mottling (30%), sample ID: TW45P-04	Very Dark Gray (5YR 3/1)	1.9	7.2	5	450
Moist clay, high plasticity, cohesive, bluish tinge, macropores and iron within them, sample ID: TW45P-05		2.3	7.7	5	620
Wet clay, high plasticity cohesive, bluish tinge, some jarosite, sample ID: TW45P-06		2.2	8.0	5	500

Soil profile details:

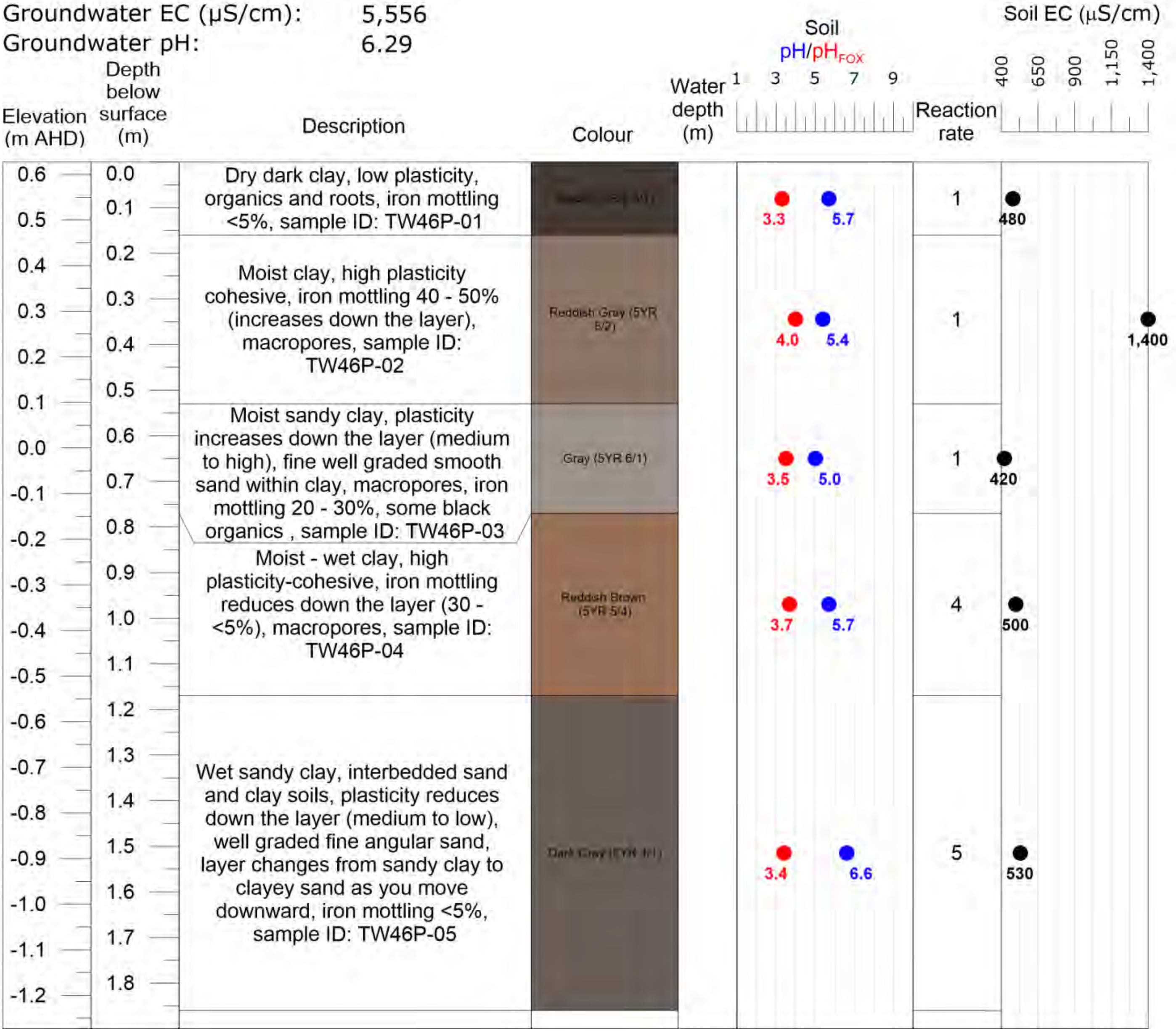
Project Number:	2018064	Profile ID:	TW_46_P
River/estuary:	Tweed	Sample date:	17/10/19
Easting:	545905.6	Sampled by:	TAT DWJ
Northing:	6871366.8		

Ground elevation (m AHD):	0.63
Hydraulic conductivity (m/d):	2.72

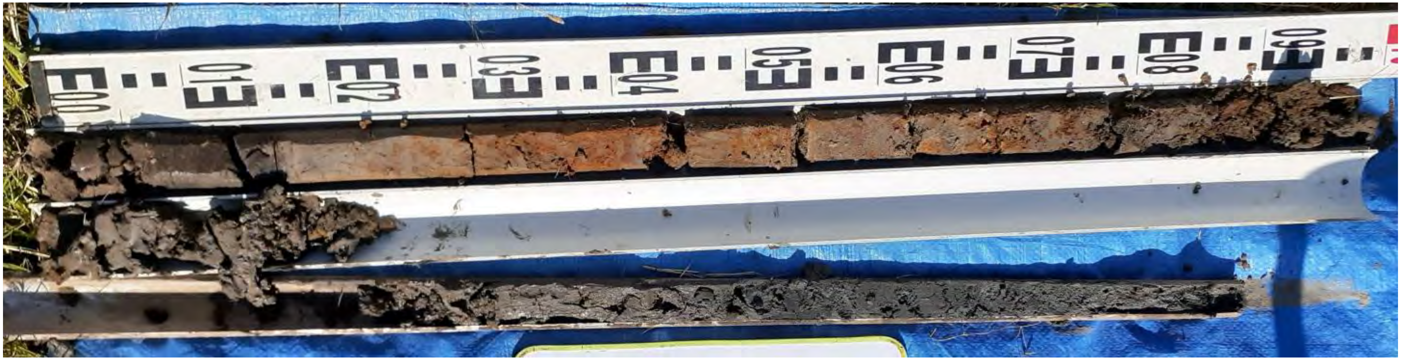
UNSW SYDNEY
Water Research Laboratory
School of Civil and Environmental Engineering

Water quality:

Surface water EC (µS/cm):	36,728
Surface water pH:	8.29
Groundwater EC (µS/cm):	5,556
Groundwater pH:	6.29



Description	Colour	pH$_{FOX}$	pH	Reaction rate	Soil EC (µS/cm)
Dry dark clay, low plasticity, organics and roots, iron mottling <5%, sample ID: TW46P-01	[illegible]	3.3	5.7	1	480
Moist clay, high plasticity cohesive, iron mottling 40 - 50% (increases down the layer), macropores, sample ID: TW46P-02	Reddish Gray (5YR 5/2)	4.0	5.4	1	1,400
Moist sandy clay, plasticity increases down the layer (medium to high), fine well graded smooth sand within clay, macropores, iron mottling 20 - 30%, some black organics , sample ID: TW46P-03	Gray (5YR 6/1)	3.5	5.0	1	420
Moist - wet clay, high plasticity-cohesive, iron mottling reduces down the layer (30 - <5%), macropores, sample ID: TW46P-04	Reddish Brown (5YR 5/4)	3.7	5.7	4	500
Wet sandy clay, interbedded sand and clay soils, plasticity reduces down the layer (medium to low), well graded fine angular sand, layer changes from sandy clay to clayey sand as you move downward, iron mottling <5%, sample ID: TW46P-05	Dark Gray (5YR 4/1)	3.4	6.6	5	530



Appendix references

ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. *In:* GOVERNMENTS, A. A. N. Z. G. A. A. S. A. T. (ed.).

BMT 2019. Tweed Estuary Tidal Inundation Assesment and Mapping.

Boast, C. W. & Langebartel, R. G. 1984. Shape Factors for Seepage into Pits. *Soil Science Society of America Journal,* 48**,** 10-15.

Bouwer, H. & Rice, R. C. 1983. The pit bailing method for hydraulic conductivity measurement of isotropic or anisotropic soil.

DPIE. 2006. *NSW Water Quality and River Flow Objectives* [Online]. NSW Department of Planning, Industry and Environment. Available: https://www.environment.nsw.gov.au/ieo/ [Accessed 17 July 2020].

DPIE. 2020. *eSpade NSW Soil and Land Information* [Online]. Available: https://www.environment.nsw.gov.au/eSpade2WebApp [Accessed 2019].

Eyre, B. D. & Pepperell, P. 1999. A spatially intensive approach to water quality monitoring in the Rous River catchment, NSW, Australia. *Journal of Environmental Management,* 56**,** 97-118.

Ferguson, A. 2012. Review of water quality in the Tweed Estuary 2007 - 2011. ABER Pty Ltd.

Genn, A. 2009. Stormwater Assessment and Management Plan Cobaki Lakes Estate Central Open Space Cobaki, NSW. Gilbert & Sutherland P/L.

Gilbert and Sutherland 2009. Acid Sulfate Soil Assessment & Management Plan Central Open Space Area, Cobaki Lakes.

Glamore, W. 2003. *Evaluation and Analysis of Acid Sulfate Soil Impacts via Tidal Restoration.* PhD Thesis, Faculty of Engineering, University of Wollongong.

Green, R. 2005. *Acidity Barriers for Improving the Quality of Acid Sulfate Soil Discharge Water.* Doctor of Philosophy, University of New South Wales.

Hirst, P., Slavich, P., Johnston, S. & Walsh, S. 2009. Assessment of Hydraulic Conductivity in Coastal Floodplain Acid Sulphate Soils on the North Coast of NSW. Orange, Australia: Industry & Investment NSW.

Holloway, S., Green, J., Chadwick, T., Ferguson, A., Dilworth, T., Rohweder, D. & Alleston, T. 2010. Coastal Zone Management Plan for Cobaki Broadwater and Terranora Broadwater. Australian Wetlands, ABER.

Hydrosphere Consulting 2017. Coastal Management Program for the Tweed River Estuary: Water Quality Assessment.: Prepared on behalf of Tweed Shire Council.

IWC 2009. Cobaki and Terranora Ecosystem Health Monitoring Program 2009 Technical Report. International WaterCentre.

JGA 2005. ENVIRONMENTAL IMPACT STATEMENT: PROPOSED EXPANSION OF SAND QUARRY AT AT CRESCENT STREET, CUDGEN.

Johnston, S. G., Hirst, P., Slavich, P. G., Bush, R. T. & Aaso, T. 2009. Saturated hydraulic conductivity of sulfuric horizons in coastal floodplain acid sulfate soils: Variability and implications. *Geoderma,* 151**,** 387-394.

King, I. P. 2015. Documentation RMA2 – A Two Dimensional Finite Element Model for Flow in Estuaries and Streams. Sydney Australia.

Kinsela, A. S. 2007. *Volatile Sulfur Compounds in Coastal Acid Sulfate Soils, Northern N.S.W.* Doctor of Philosophy, The University of New South Wales, Australia.

Lin, C., Melville, M. D., Islam, M. M., Wilson, B. P., Yang, X. & van Oploo, P. 1998. Chemical controls on acid discharges from acid sulfate soils under sugarcane cropping in an eastern Australian estuarine floodplain. *Environmental Pollution,* 103**,** 269-276.

Lin, C., Melville, M. D., White, I. & Wilson, B. P. 1995. Human and Natural Controls on the Accumulation, Acidification and Drainage of Pyritic Sediments: Pearl River Delta, China and Coastal New South Wales. *Australian Geographical Studies,* 33**,** 77-88.

Macdonald, B. C. T., White, I., Keene, A., Melville, M. D. & Reynolds, J. 2004. Acidity, metals and acid sulfate soils.

Makings, U. & Pratt, K. 2016. Coastal Management Program for the Tweed River Estuary Literature Review (Working Draft). Hydrosphere Consulting.

Manly Hydraulics Laboratory 1997. Tuckean Broadwater Water Quality Monitoring. Manly Hydraulics Laboratory.

MHL 1997. Tumbulgum Canefields Water Quality Monitoring. Manly Hydraulics Laboratory.

NHMRC 2011. Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy. Canberra: National Health and Medical Research Council, National Resource Management Ministerial Council, Commonwealth of Australia.

NSW Department of Finance and Services 2012. Standard Datum to AHD Corrections NSW. Land and Property Information, NSW Department of Finance and Services.

NSW DPIE 2019. NSW Spatial Data Catalogue.

NSW Food Authority 2019. http://www.foodauthority.nsw.gov.au/industry/shellfish.

Pratt, K. 2017. Coastal Management Program for the Tweed River Estuary: Water Quality Assessment.: Prepared on behalf of Tweed Shire Council.

Pratt, K., Seccull, O. & Conroy, R. 2017. Coastal Management Program for the Tweed River Estuary: Ecological Assessment. Ballina, NSW: Hydrosphere Consulting.

PWD 1991. Lower Tweed Estuary River Management Plan: Influent Audit Technical Report No. 2. NSW Public Works.

Rayner, D. 2010. Understanding the Transport and Buffering Dynamics of Acid Plumes within Estuaries. Water Research Laboratory, WRL Research Report 238.

Rayner, D. S., Harrison, A. J., Tucker, T. A., Lumiatti, G., Rahman, P. F., Waddington, K., Juma, D. & Glamore, W. 2023. Coastal Floodplain Prioritisation Study – Background and Methodology WRL TR2020/32. Water Research Laboratory, University of New South Wales.

Sammut, J., White, I. & Melville, M. D. 1996. Acidification of an estuarine tributary in eastern Australia due to drainage of acid sulfate soils. *Marine & Freshwater Research***,** 669-684.

Smith, J., van Oploo, P., Marston, H., Melville, M. D. & Macdonald, B. C. T. 2003. Spatial distribution and management of total actual acidity in an acid sulfate soil environment, McLeods Creek, northeastern NSW, Australia. *Catena,* 51**,** 61-79.

SPCC 1985. Water Quality in the Tweed-Terranora Estuary. *State Pollution Control Commission Northern Rivers Study No. 1.*: State Pollution Control Commission,.

TSC 2011. Drainage Assets Management Plan. Murwillumbah, NSW: Tweed Shire Council.

Tulau 1999. Acid Sulfate Soil Management Priority Areas in the Lower Tweed Floodplains. Department of Land and Water Conservation, Sydney.

Wallace, S., Barton, C., Rogencamp, G. & Dearnley, C. 2009. Tweed Valley Flood Study - 2009 Update. Brisbane, QLD: BMT WBM Pty Ltd.

Walsh, S., Riches, M. & John, H. 2012. North Coast Floodgate Project. Final Report.

WBM Oceanics Australia 1997. Tweed River Water Quality Review. Prepared for Tweed Shire Council.

White, L., Melville, M. D., Wilsor, B. P., Price, C. B. & Willett, L. Understanding acid sulphate soils in canelands. Proceedings of the National Conference on Acid Sulphate Soils, 1993 Coolongatta, Queensland. CSIRO, NSW Agriculture, Tweed Shire Council, Australia, 130-148.

Willett, L., Melville, M. D. & White, I. Acid drainwaters from potential acid sulphate soils and their impact on estuarine ecosystems. M.E.F. Van Mensvoort and D. Dent (cds.) Proc. 4th Int. SympAcid Sulphate Soils,, 1993 Ho Chi Mink City.

Wilson, B. P. 1995. *Soil and Hydrological Relations to Drainage from Sugarcane on Acid Sulfate Soils.* Doctor of Philosophy, University of New South Wales.

Wilson, B. P., White, I. & Melville, M. D. 1999. Floodplain hydrology, acid discharge and change in water quality associated with a drained acid sulfate soil.

Winberg, P. & Heath, T. 2010. Ecological Impacts of Floodgates on Estuarine Tributary Fish Assemblages. Report to the Southern Rivers Catchment Management Authority.

WRL 2017. Assessment of the Risk of Overtopping of Bray Park Weir and Contamination of Drinking Water Supply Due to Climate Change.

Yang, X. 1997. *Applications of Remote Sensing and GIS to Acid Drainage Management in an Estuary Floodplain Agricultural Environment.* PhD, University of New South Wales.

Young, W. D., Henley, J., 1979. Tweed River Flood Mitigation Work as Executed. Tweed Shire Council.