Clarence River Floodplain Prioritisation Study: Appendix A – L

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Appendix A Floodplain waterways

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 Clarence 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 waterways as a natural waterbody watercourse, an 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 Clarence 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
Clarence Valley Council all drains	Shapefile	Yes	No	Local
Clarence Valley Council drains	TAB	Yes	No	Local
Clarence Valley Council drain private	TAB	Yes	No	Local
Clarence Valley Council drains	KML	No	No	Local

A3 Waterway classification

For this study, an updated waterways spatial dataset was developed for the Clarence 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 (2) 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 were completed for elevations below 5 m Australian Height Datum (AHD) as is consistent with catchment delineation used for the subcatchment prioritisation.

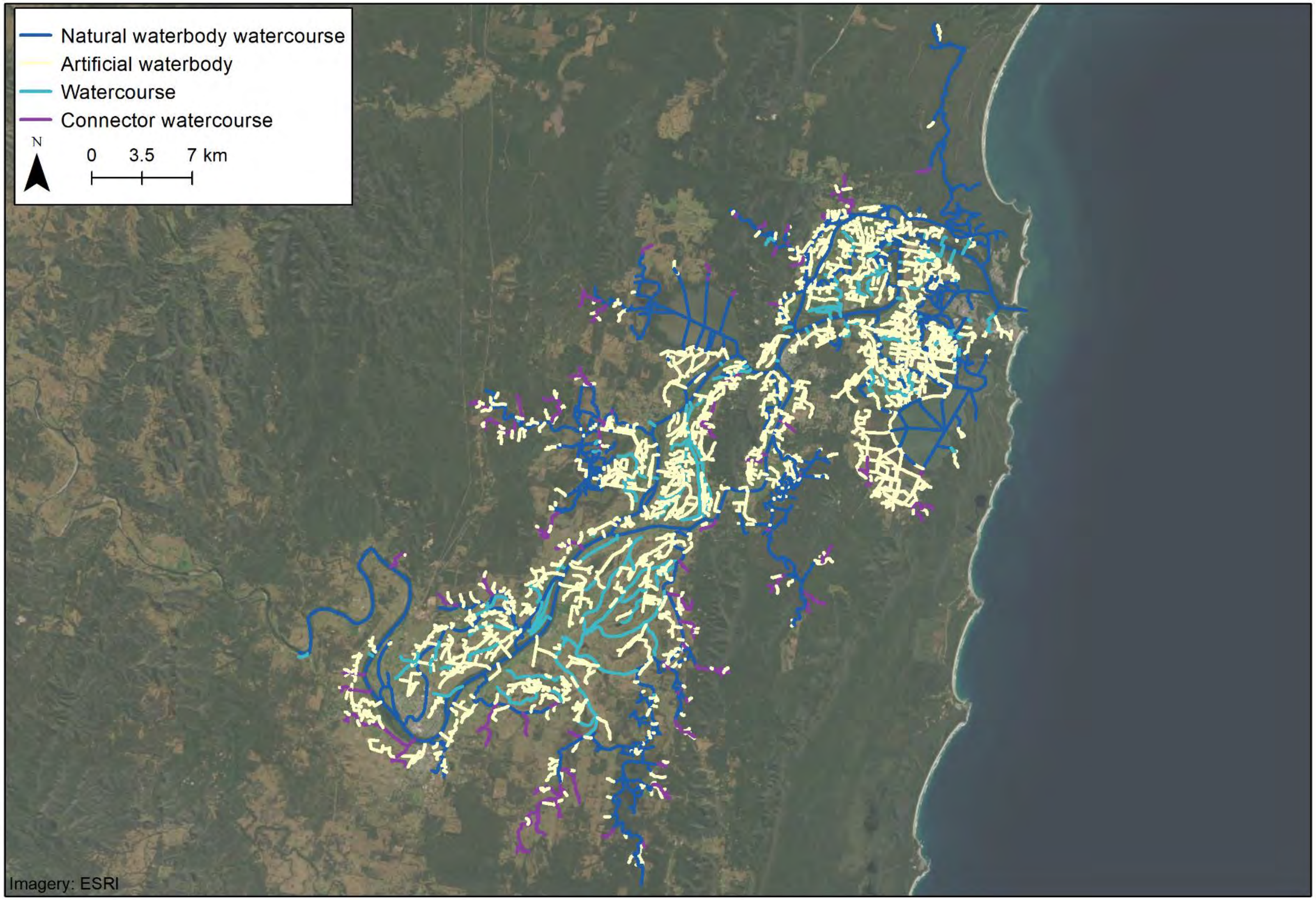


Figure A-1: Clarence River floodplain waterways

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 Clarence 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**
Alumy Creek	86,070	46.91	1,835	13
Coldstream River	196,330	122.78	1,599	14
Gulmarrad/East Woodford Island	47,570	15.63	3,044	3
Harwood/Chatsworth/Goodwood/ Warregah Islands	105,460	41.45	2,545	8
Maclean	17,960	8.47	2,120	10
Mororo/Ashby	36,350	14.23	2,554	6
Palmers Island/Micalo Island/ Yamba	136,090	45.83	2,969	4
Shark Creek	67,460	34.53	1,954	12
South Grafton	49,750	19.54	2,545	7
Southgate	27,990	10.00	2,800	5
Sportsmans Creek	119,650	50.27	2,380	9
Swan Creek	88,420	44.36	1,993	11
Taloumbi/Palmers Channel	140,060	43.15	3,246	2
The Broadwater	42,710	30.38	1,406	15
The Freshwater	5,320	21.71	245	16
West Woodford Island	124,930	37.93	3,294	1

* 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.

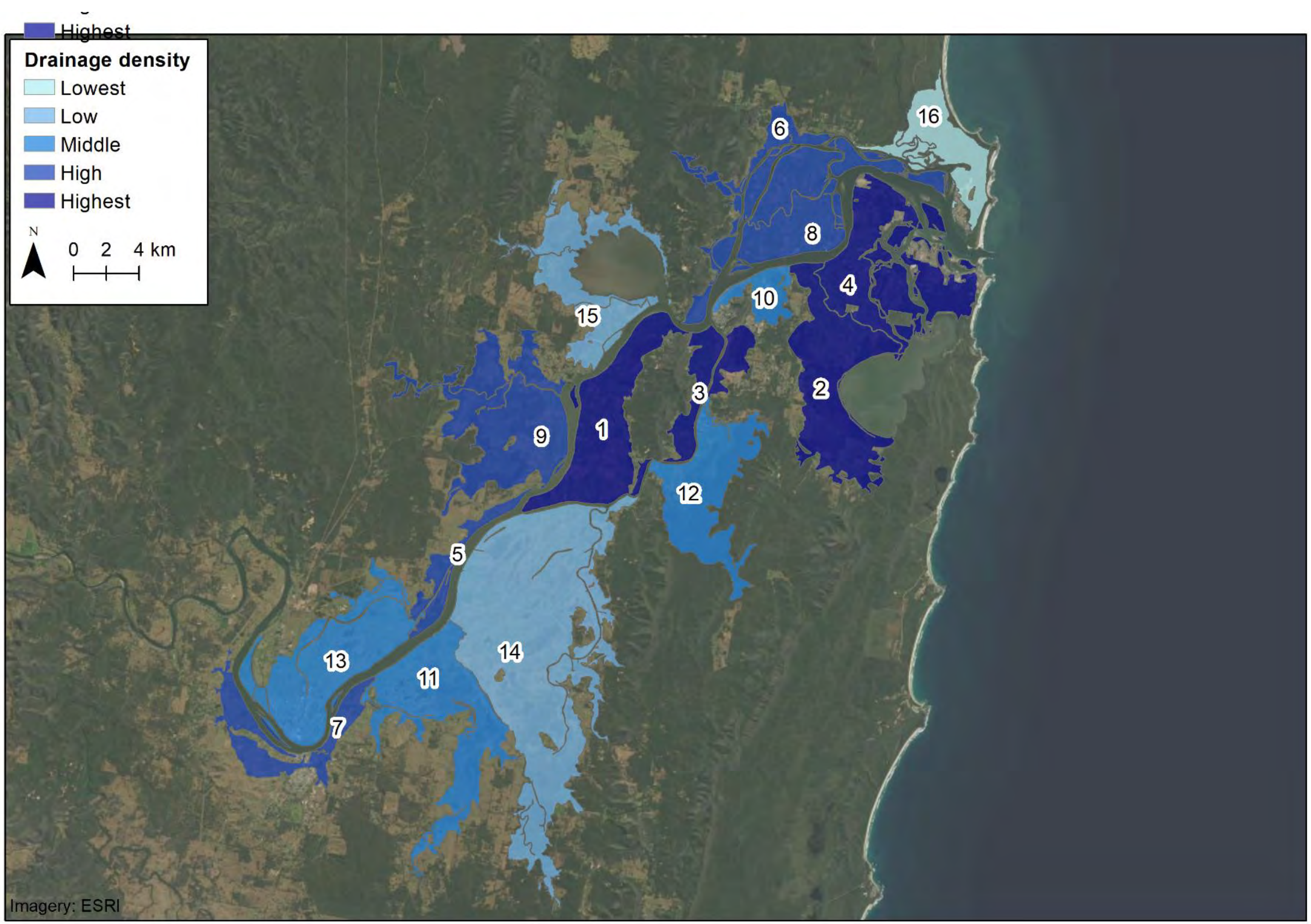


Figure A-2: Floodplain drainage density ranking

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 Clarence 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 and the available daily rainfall data from the Bureau of Meteorology (BOM) for the Clarence River floodplain are shown in Figure B-1.

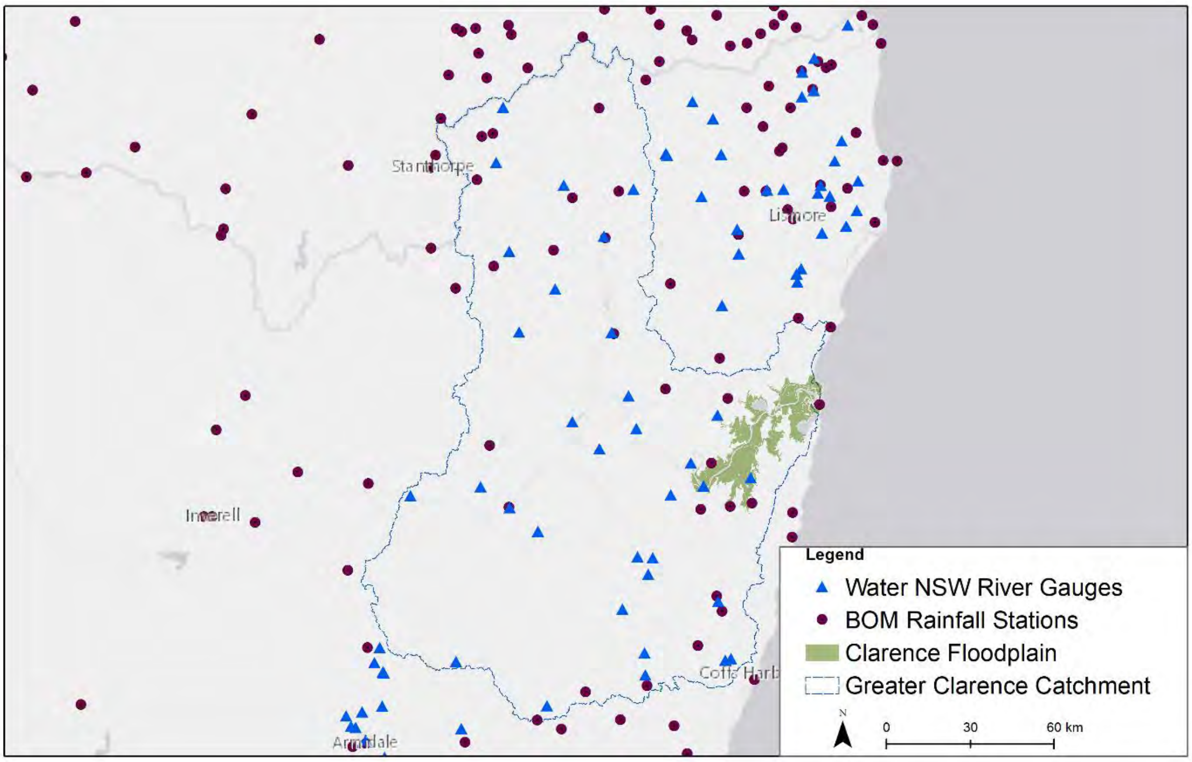


Figure B-1: Clarence River Floodplain location of rainfall and runoff stations

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 204041 and 204055 were selected for the Clarence 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 (shown in parenthesis) used in the analysis are summarised in Figure B-2.

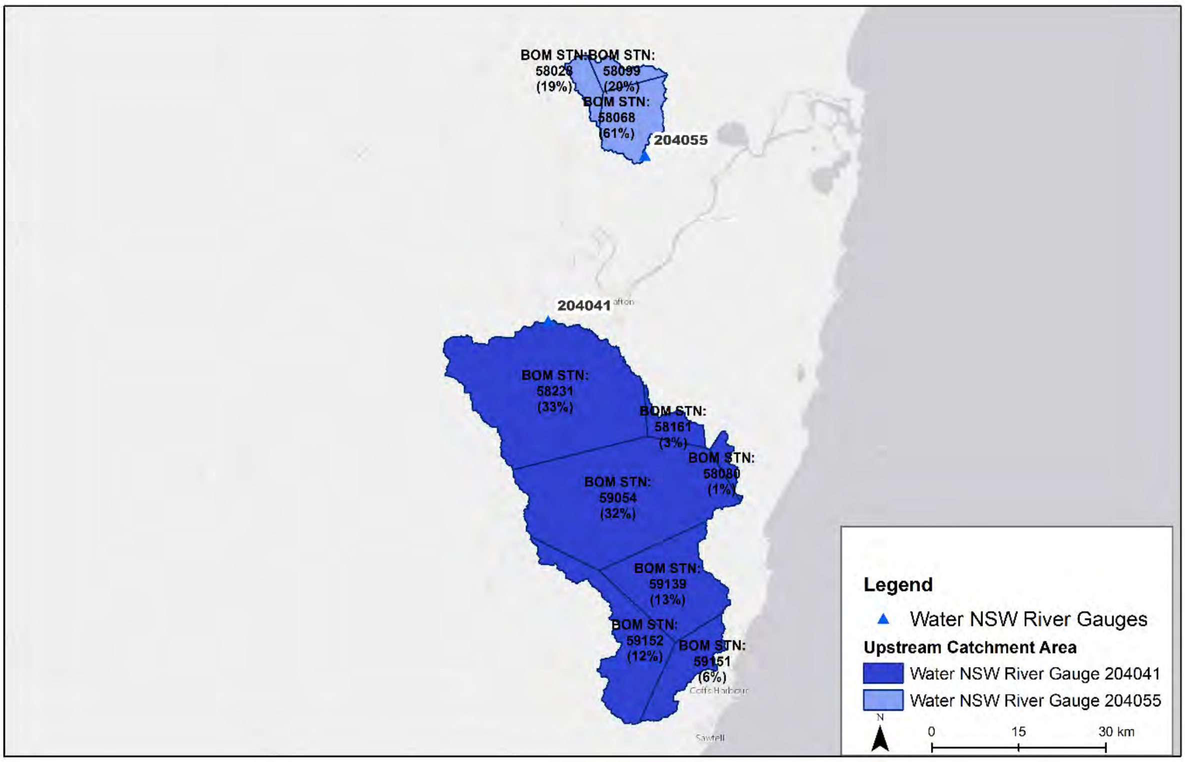


Figure B-2: Upstream catchment of selected flow sites

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 2017. This analysis yielded an estimated runoff coefficient of 0.7 and 0.3 which were applied to Clarence Floodplain subcatchments for the acid prioritisation assessment.

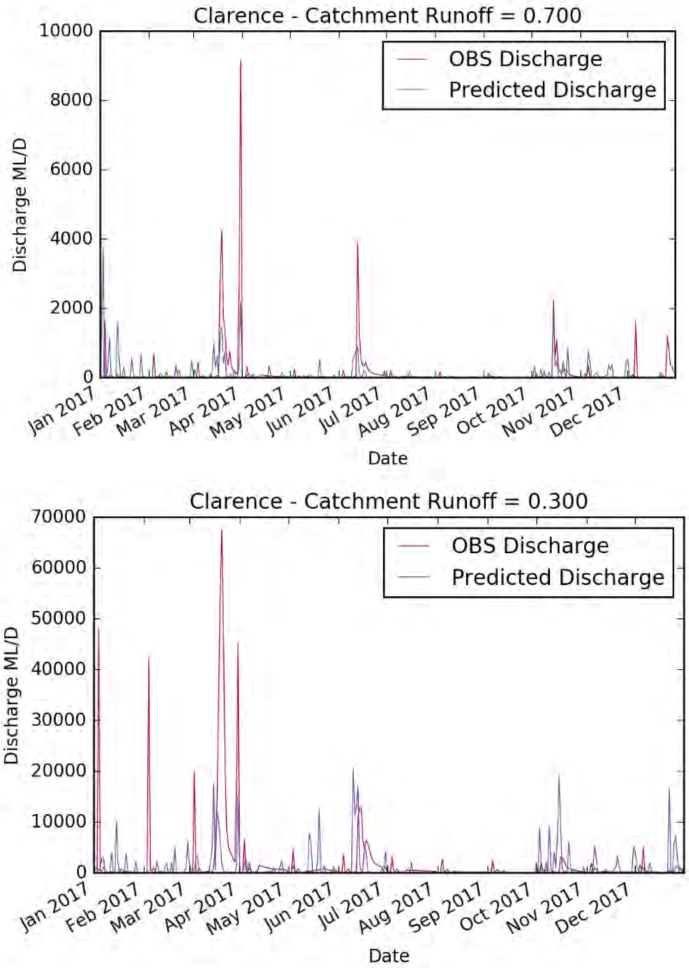


Figure B-3: Predicted and observed runoff for the catchment area upstream of river gauging station 204041 (top) and station 204055 (bottom)

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 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 strucoture, 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.

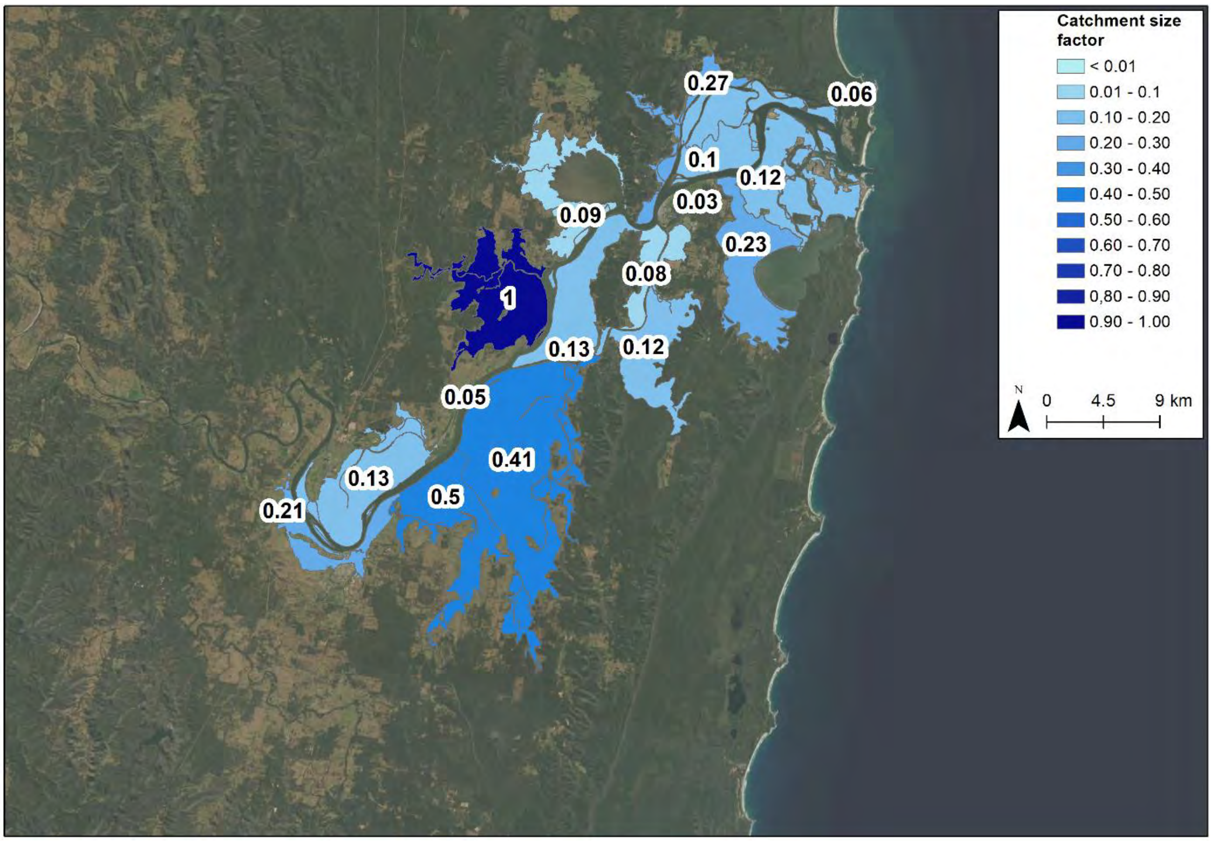


Figure B-4: Catchment size factor for each subcatchment in the Clarence Estuary

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.

$$\mathbf{\mathit{Normalised\ inflow\ factor}} = \mathbf{\mathit{Runoff\ coefficient}} \times \mathbf{\mathit{Catchment\ Size\ Factor}} \tag{Equation B-1}$$

The inflow factors for each Clarence 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
Sportsmans Creek	0.7	352,979,500	403,249,100	1.000	0.700
Coldstream River	0.3	43,742,500	166,521,800	0.413	0.124
Swan Creek	0.3	157,254,900	201,616,850	0.500	0.150
Southgate	0.3	10,040,300	20,037,800	0.050	0.015
The Freshwater	0.7	3,556,800	25,266,350	0.063	0.044
Mororo/Ashby	0.7	94,973,100	109,204,650	0.271	0.190
South Grafton	0.3	64,237,250	83,782,100	0.208	0.062
Alumy Creek	0.3	6,316,400	53,227,950	0.132	0.040
The Broadwater	0.7	7,791,750	38,172,550	0.095	0.066
Shark Creek	0.7	13,139,300	47,667,500	0.118	0.083
West Woodford Island	0.7	15,952,450	53,880,250	0.134	0.094
Harwood/Chatsworth/ Goodwood/Warregah Islands	0.7	0	41,445,550	0.103	0.072
Maclean	0.7	5,005,000	13,477,650	0.033	0.023
Taloumbi/Palmers Channel	0.7	50,048,450	93,196,600	0.231	0.162
Gulmarrad/East Woodford Island	0.7	15,019,800	30,646,150	0.076	0.053
Palmers Island/Micalo Island/Yamba	0.7	4,357,100	50,185,950	0.124	0.087

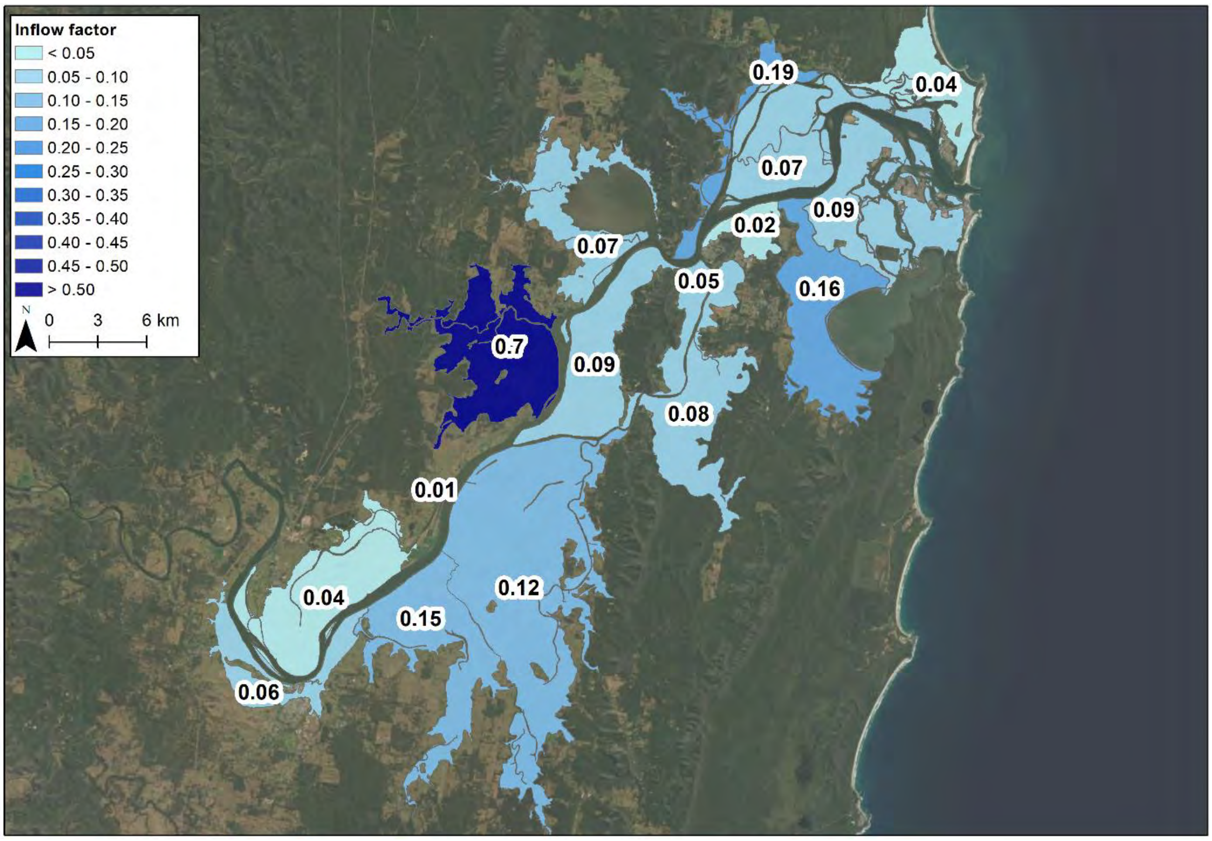


Figure B-5: Subcatchment inflow factors

Appendix C Groundwater saturated hydraulic conductivity data

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 Clarence River floodplain. A detailed discussion of the principles relating to hydraulic conductivity and data collection can be found in Appendix A 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 B 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 Clarence 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:

- Johnston et al. (2002) presented hydraulic conductivity within the Shark Creek subcatchment, however, data is only presented qualitatively and does not have specific location information so has not been used during the analysis.

- Johnston et al. (2004) presented the same hydraulic conductivity data as Johnston et al. (2002) collected within the Sportsmans Creek and Shark Creek subcatchments. Pit bailing and auger hole slug tests were completed to assess the hydraulic conductivity. Quantitative values were determined accordingly to Bouwer and Rice (1983) and Boast and Langebartel (1984) for pit bailing method data and Bouwer and Rice (1976) and Bouwer (1989) for auger hole slug test data.

- Johnston (2004) presented the same hydraulic conductivity data as Johnston et al. (2002) and Johnston et al. (2004). In addition to this, new data was collected in the Shark Creek subcatchment using the tidal amplitude dampening technique (Ferris, 1963) and in the Palmers Island/Micalo Island/Yamba subcatchment using the Bouwer and Rice (1976) and Bouwer (1989) method auger hole slug tests.

- Johnston et al. (2005c) presented hydraulic values within Shark Creek and Palmers Island/Micalo Island/Yamba subcatchments. Close inspection showed that this data was the same as that presented by Johnston (2004).

- Hirst et al. (2009) collected hydraulic conductivity data for ASS across six (6) different NSW North Coast floodplains (Tweed, Richmond, Clarence, Hastings, Macleay, and Manning), using the pit bailing method. On the Clarence, data was collected at Coldstream, Palmers Island and Lake Wooloweyah, and The Broadwater. 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 in The Broadwater, Coldstream River, Gulmarrad/East Woodford Island, Maclean, Shark Creek and Sportsmans Creek subcatchments. Close inspection indicated that the majority of this data is the same as was presented by Hirst et al. (2009). Furthermore, there was no specific location information provided with this data to determine their exact location within subcatchments. For these reasons, this data has not been included in the analysis.

- Rayner et al. (2016) collected hydraulic conductivity data at two (2) locations within the Sportsmans Creek subcatchment using the pit bailing method. Discrete hydraulic conductivity values have been calculated using the Boast and Langebartel (1984) method.

Table C-1 Summary of existing hydraulic conductivity data in the Clarence 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	9.0	10.6		Moderate	Hirst et al. (2009)	Pit bailing
2	1.7	2.3		Moderate	Hirst et al. (2009)	Pit bailing
3	36.0	34.7		High	Hirst et al. (2009)	Pit bailing
4	11.8	12.8		Moderate	Hirst et al. (2009)	Pit bailing
5	3.2	3.9		Moderate	Hirst et al. (2009)	Pit bailing
6	1.6	2.2		Moderate	Hirst et al. (2009)	Pit bailing
7	2.2	3.0		Moderate	Hirst et al. (2009)	Pit bailing
8	12.6	12.8		Moderate	Hirst et al. (2009)	Pit bailing
9	4.4	5.8		Moderate	Hirst et al. (2009)	Pit bailing
10	6.7	7.3		Moderate	Hirst et al. (2009)	Pit bailing
11	6.0	7.7		Moderate	Hirst et al. (2009)	Pit bailing
12	5.9	7.0		Moderate	Hirst et al. (2009)	Pit bailing
13	5.8	7.9		Moderate	Hirst et al. (2009)	Pit bailing
14	1.3	2.2		Low - Moderate	Hirst et al. (2009)	Pit bailing
15	6.2	7.8		Moderate	Hirst et al. (2009)	Pit bailing
16	16.8	17.9		High	Johnston et al. (2004)	Pit bailing
17			8.7	Moderate	Johnston et al. (2004)	Auger hole
18			0.4	Low	Johnston (2004)	Auger hole
19			0.89	Low	Johnston (2004)	Auger hole
20	184	183		Extremely high	Johnston et al. (2004)	Pit bailing
21			125	Extremely high	Johnston et al. (2004)	Auger hole
22			192	Extremely high	Johnston (2004)	Tidal amplitude dampening
23		3.6		Moderate	Rayner et al. (2016)	Pit bailing
24		7.9		Moderate	Rayner et al. (2016)	Pit bailing

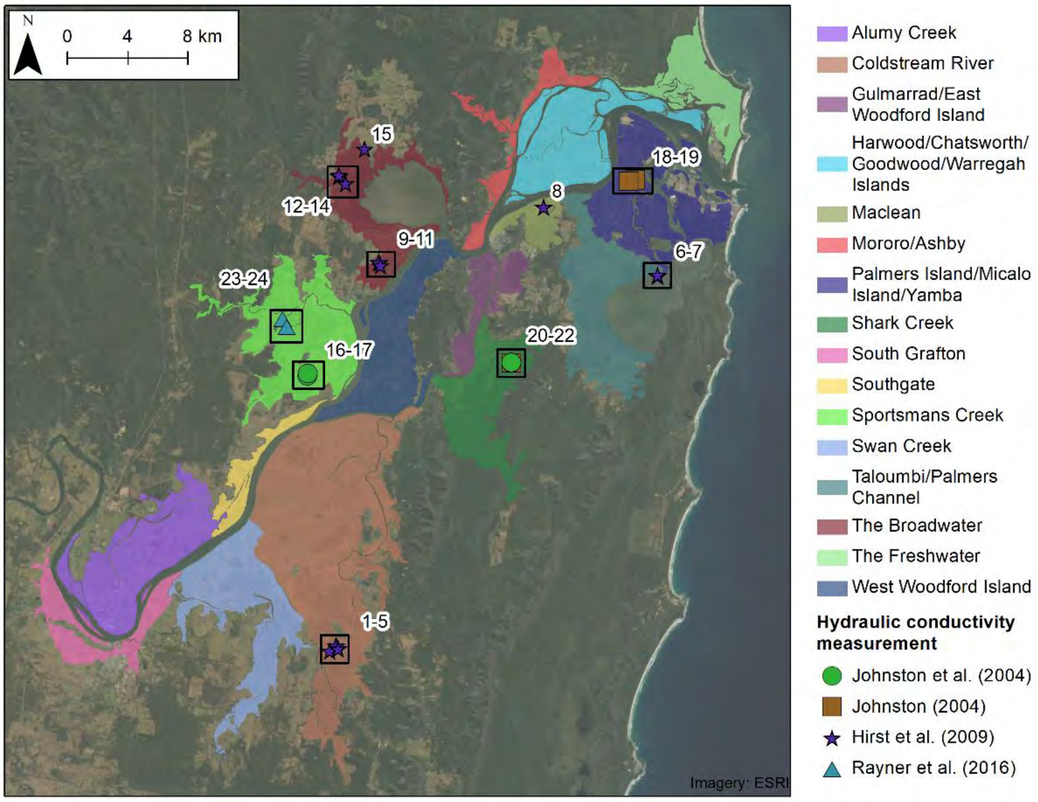


Figure C-1: Existing saturated hydraulic conductivity data available on the Clarence River floodplain

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 as the primary way 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.

In addition to the auger hole slug test method, the pit bailing and inverse auger methods were also used. Wherever the water table was high enough, a pit bailing test was completed as well as an auger hole slug test allowing for comparison of the two (2) methodologies. In some circumstances, the water table was sufficiently deep below the ground surface that the auger hole created by the soil sampling equipment could not reach the water table. In these instances, the inverse auger method was used to obtain a hydraulic conductivity measurement. 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

Clarence 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 Clarence 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?*
CA_01	503856.0	6713573.4	0.9	Low	Inverse auger	Yes
CA_02	504678.9	6716092.0	4.7	Moderate	Inverse auger	Yes
CA_04	509538.7	6715052.0	0.3	Low	Auger hole	Below MLWS
CA_06	496866.1	6717435.9	0.2	Low	Auger hole	Below MLWS
CA_12	498861.2	6722066.9	0.1	Low	Inverse auger	Yes
CA_17	505811.6	6726847.6	0.1	Low	Inverse auger	Yes
CA_25_S	514569.6	6737720.9	1.1	Low	Auger hole	Yes
CA_29	512197.2	6728469.3	0.1	Low	Auger hole	Below MLWS
CA_33	511844.3	6734261.6	0.1	Low	Auger hole	Yes
CA_33	511844.3	6734261.6	2.9	Moderate	Pit bailing	Yes
CA_37	513556.4	6740946.0	0.3	Low	Auger hole	Below MLWS
CA_45	518369.2	6729889.6	0.2	Low	Auger hole	Below MLWS
CA_49	520265.1	6733196.9	20.3	High	Auger hole	Yes
CA_52_S	524586.7	6740218.8	0.2	Low	Auger hole	Yes
CA_57	528787.3	6740781.5	0.4	Low	Inverse auger	Yes
CA_60_S	528507.3	6743655.6	0.1	Low	Auger hole	Yes
CA_64	524806.0	6749176.0	0.0	Low	Auger hole	Below MLWS
CA_65	525874.2	6748327.1	0.0	Low	Inverse auger	Yes
CA_76	509382.8	6744863.1	2.4	Moderate	Inverse auger	Yes
CA_80	520890.3	6742837.6	0.1	Low	Inverse auger	Yes
CP_11	492122.4	6713745.0	0.1	Low	Auger hole	Yes
CP_12	489259.4	6718301.0	0.8	Low	Auger hole	Yes
CP_12	489259.4	6718301.0	5.0	Moderate	Pit bailing	Yes
CP_16	501776.4	6719716.4	0.5	Low	Inverse auger	Yes
CP_17	501596.9	6722914.1	1.5	Moderate	Inverse auger	Yes
CP_19	501761.8	6723802.0	0.2	Low	Auger hole	Below MLWS

Location ID	Easting (m) GDA94	Northing (m) GDA94	Hydraulic Conductivity (m/day)	Risk Classification	Measurement method	Data used for prioritisation?*
CP_20	497099.5	6721006.3	0.1	Low	Inverse auger	Yes
CP_20	497099.5	6721006.3	2.1	Moderate	Auger hole	Yes
CP_25	509376.4	6721704.8	1.4	Low	Inverse auger	Yes
CP_28	510413.3	6719595.1	0.8	Low	Inverse auger	Yes
CP_37	511395.1	6736943.2	3.3	Moderate	Auger hole	Yes
CP_37	511395.1	6736943.2	3.4	Moderate	Pit Method	Yes
CP_39	517367.1	6730094.5	0.1	Low	Auger hole	Below MLWS
CP_42_S	519880.7	6733056.9	0.4	Low	Auger hole	Yes
CP_54_S	522182.5	6734543.7	0.4	Low	Auger hole	Yes
CP_55_S	525455.0	6740511.7	0.5	Low	Inverse auger	Yes
CP_61_S	526171.6	6732672.9	60.3	High	Auger hole	Yes
CP_61_X	525416.2	6733044.8	0.1	Low	Auger hole	Yes
CP_65	529134.1	6740719.4	0.1	Low	Auger hole	Below MLWS
CP_67	531618.7	6752206.8	2.2	Moderate	Inverse auger	Yes
CP_68	530334.5	6742929.3	0.4	Low	Inverse auger	Yes
CP_70	529045.5	6748258.3	0.1	Low	Inverse auger	Yes
CP_72	527017.9	6750089.1	0.2	Low	Inverse auger	Yes
CP_76	523473.8	6747741.4	0.1	Low	Auger hole	Below MLWS
CP_81	526240.8	6747490.8	0.3	Low	Inverse auger	Yes
CP_82	522465.0	6750013.0	0.1	Low	Auger hole	Below MLWS
CP_84_C	523623.4	6752251.9	7.2	Moderate	Inverse auger	Yes
CP_85_S	524187.8	6750590.2	0.4	Low	Auger hole	Below MLWS

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

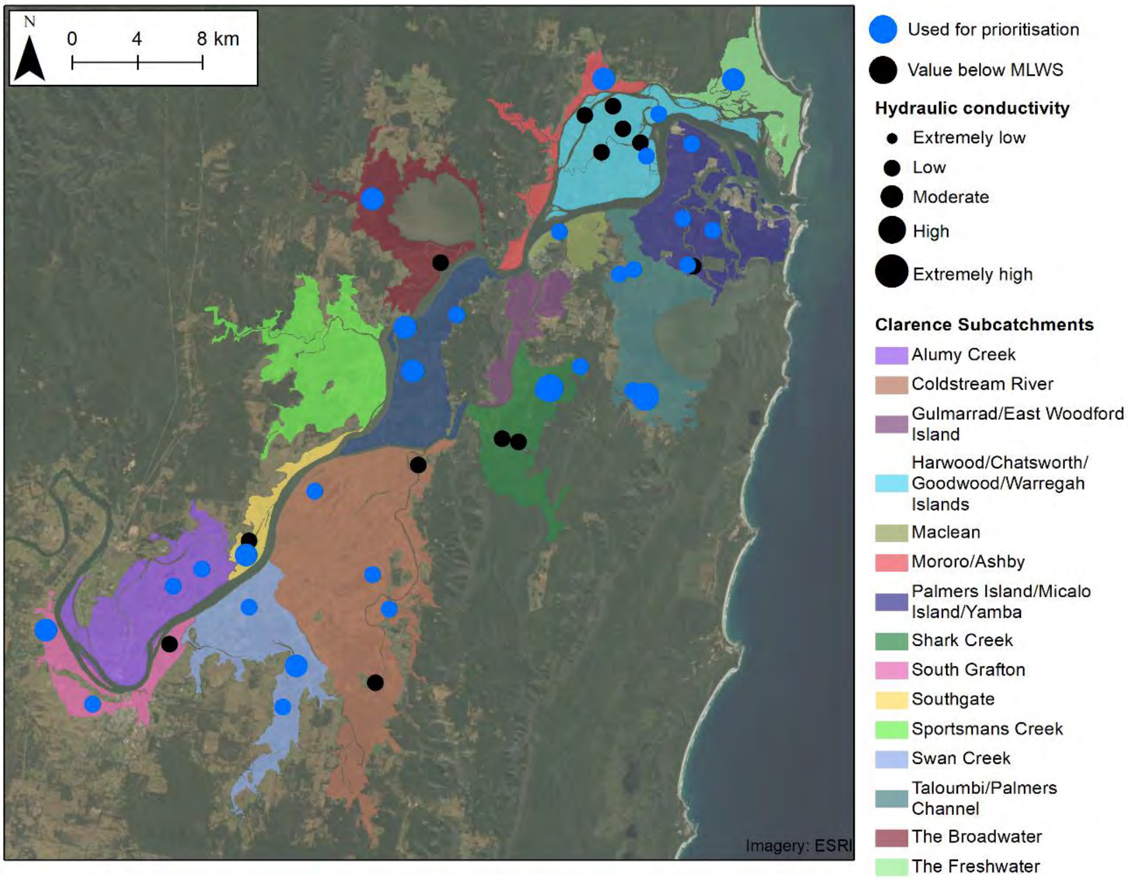


Figure C-2: Location of saturated hydraulic conductivity data collected by WRL and data used during the subcatchment prioritisation

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 Section 4 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 (1) and extremely high equating to a risk rating or five (5). 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 the Gulmarrad/East Woodford Island subcatchment of the Clarence 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 the Gulmarrad/East Woodford Island subcatchment, where there was no available data, hydraulic conductivity has been interpolated from the adjacent Shark Creek subcatchment. This agrees with measurements of hydraulic conductivity measured in the Gulmarrad area presented by Johnston et al. (2009).

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 subcatchment 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 Clarence River floodplain

Subcatchment	Hydraulic conductivity classification	Hydraulic conductivity risk rating	Number of data points per area*
Alumy Creek	Low	2	3
Coldstream River	Moderate	3	8
Gulmarrad/East Woodford Island*	Moderate	3	0
Harwood/Chatsworth/ Goodwood/Warregah Islands	Low	2	3
Maclean	Moderate	3	2
Mororo/Ashby	Moderate	3	1
Palmers Island/Micalo Island/Yamba	Low	2	6
Shark Creek	High	4	6
South Grafton	Moderate	3	3
Southgate	Moderate	3	1
Sportsmans Creek	Moderate	3	4
Swan Creek	Moderate	3	3
Taloumbi/Palmers Channel	High	4	6
The Broadwater	Moderate	3	8
The Freshwater	Moderate	3	1
West Woodford Island	Moderate	3	5

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

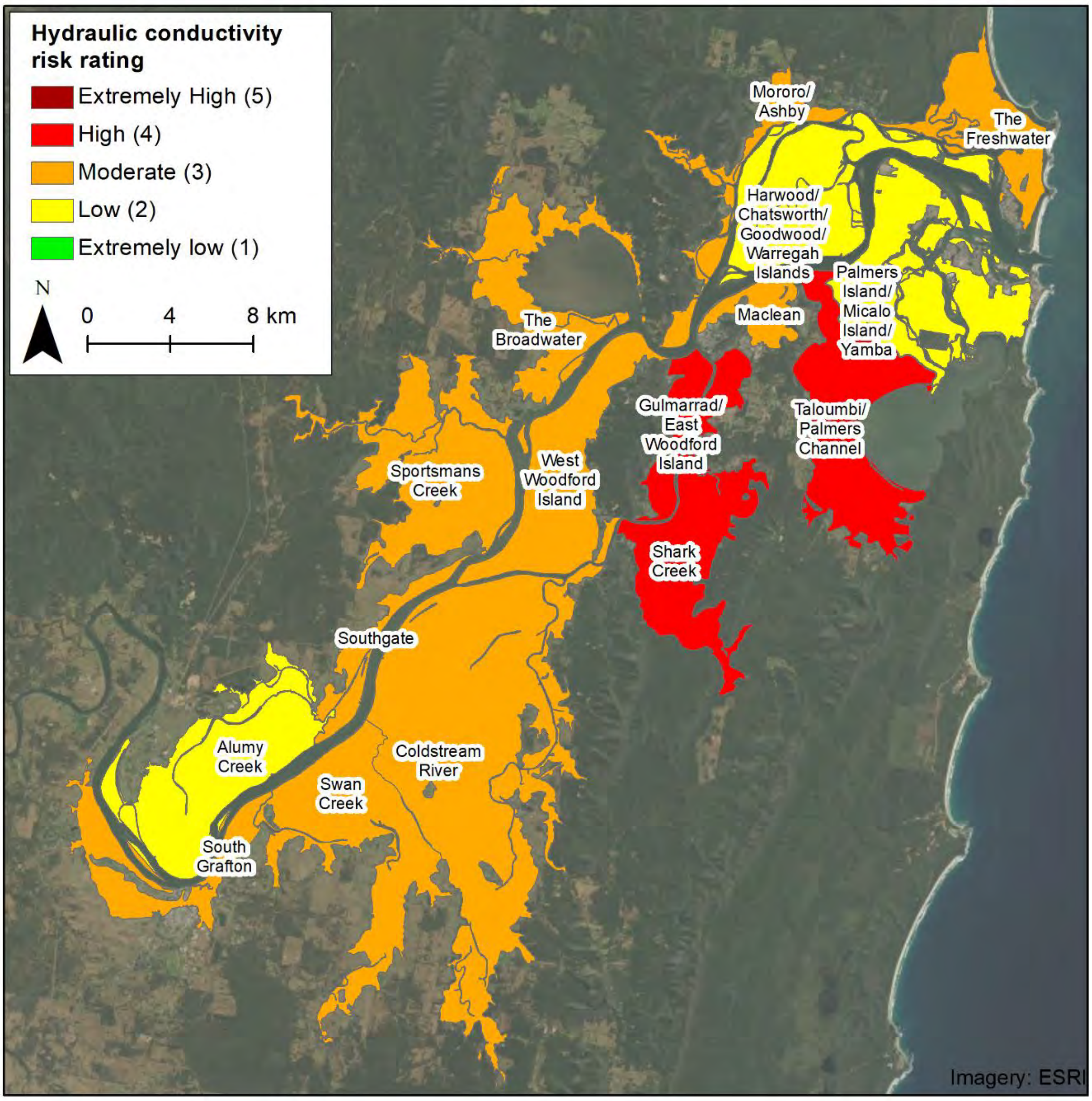


Figure C-3: Risk ratings for saturated hydraulic conductivity for each subcatchment in the Clarence River floodplain

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 Clarence 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 Clarence River floodplain that was available prior to the commencement of this study was sourced from:

- eSPADE Database (DPIE, 2020);
- Beveridge (1998);
- Maher (2013);
- Rayner et al. (2016); and
- Glamore et al. (2018).

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 Clarence 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 Clarence 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 layer of near neutral pH (pH 7 to 8) below an acidic layer indicates potential acidic soils, 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.

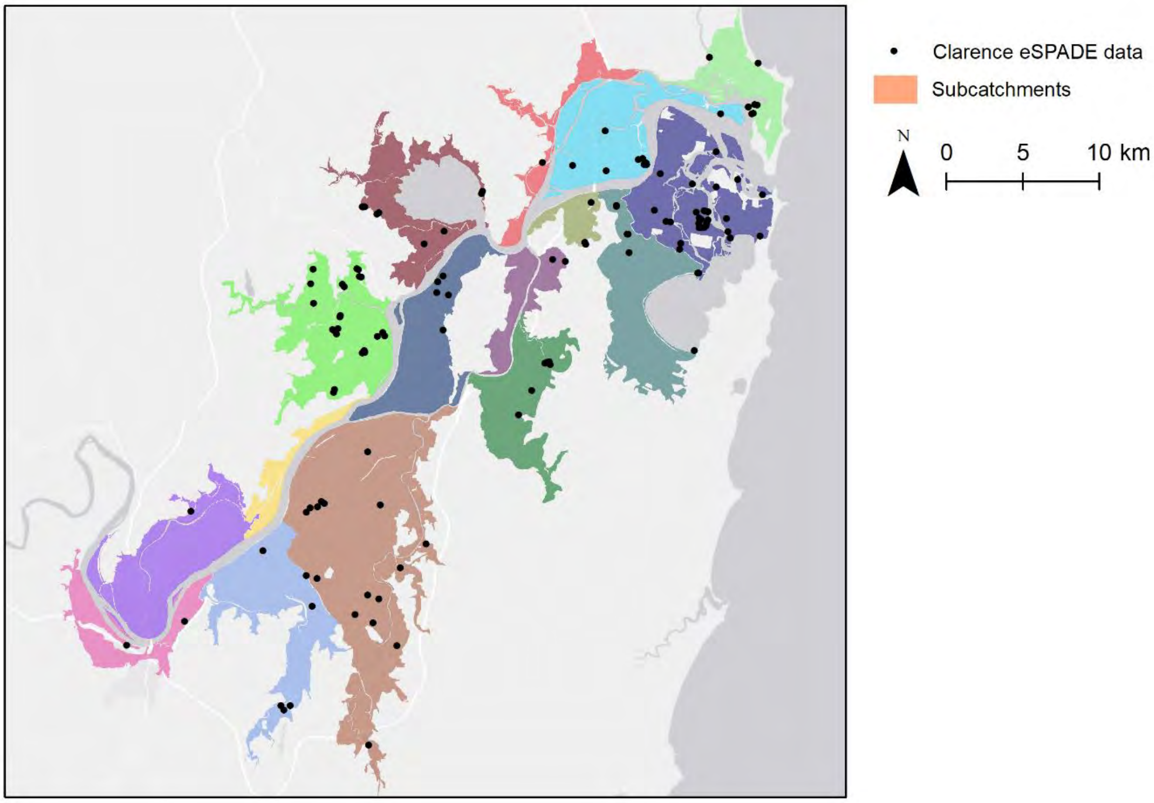


Figure D-1: Location of applicable eSPADE soil profiles in the study region

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**
96519	Alumy Creek	497020	6723172	1.62	0.8	4.5
16974	Coldstream River	504829	6723412	2.29	2	6.5
16975	Coldstream River	504579	6723137	2.22	1.5	6.5
16976	Coldstream River	505304	6723462	0.58	1.5	4
16977	Coldstream River	505554	6723812	1.80	2.1	7.5
16978	Coldstream River	505754	6723687	1.13	1.3	5.5
16979	Coldstream River	508579	6727062	1.61	1.8	5.5
16989	Coldstream River	510709	6719500	0.62	2.5	5.5
16991	Coldstream River	508929	6715902	0.38	2.3	4
16992	Coldstream River	508654	6707887	1.86	2	6
16993	Coldstream River	510492	6714396	0.69	3	4
16994	Coldstream River	509406	6723603	1.11	2.25	6
16995	Coldstream River	509304	6717462	0.31	3.2	4.5
72917	Coldstream River	505274	6718792	1.36	1	5
77935	Coldstream River	508575	6717708	0.43	0.8	4.5
26785	Coldstream River	512417	6721037	0.64	1.3	4.5

eSPADE Profile ID	Subcatchment	Easting	Northing	Surface Elevation (m AHD)*	Total Profile Depth (m)	Minimum pH**
26800	Coldstream River	507754	6716425	0.84	1.1	4
17050	Gulmarrad/ East Woodford Island	520694	6739667	0.42	0.8	3.5
17051	Gulmarrad/ East Woodford Island	521509	6739527	0.55	1.3	4
17030	Harwood/ Chatsworth/ Goodwood/ Warregah Islands	524175	6745452	1.09	2.1	5.5
17033	Harwood/ Chatsworth/ Goodwood/ Warregah Islands	524130	6748072	1.21	2.1	6
17034	Harwood/ Chatsworth/ Goodwood/ Warregah Islands	521989	6745792	1.86	1.9	6
96460	Harwood/ Chatsworth/ Goodwood/ Warregah Islands	526830	6745878	1.13	0.7	5.5
96484	Harwood/ Chatsworth/ Goodwood/ Warregah Islands	526827	6745876	1.13	0.65	5.5
96461	Harwood/ Chatsworth/ Goodwood/ Warregah Islands	526802	6745963	0.58	0.5	5.5
96462	Harwood/ Chatsworth/ Goodwood/ Warregah Islands	526797	6745971	0.57	0.56	6
96459	Harwood/ Chatsworth/ Goodwood/ Warregah Islands	526666	6745859	1.43	0.85	5.5
96463	Harwood/ Chatsworth/ Goodwood/ Warregah Islands	526659	6745863	1.31	0.75	5.5
96464	Harwood/ Chatsworth/ Goodwood/ Warregah Islands	526587	6746240	0.81	0.9	5.5
96465	Harwood/ Chatsworth/ Goodwood/ Warregah Islands	526591	6746234	0.87	0.62	5.5
96485	Harwood/ Chatsworth/ Goodwood/ Warregah Islands	526294	6746196	1.57	0.8	5.5

eSPADE Profile ID	Subcatchment	Easting	Northing	Surface Elevation (m AHD)*	Total Profile Depth (m)	Minimum pH**
14883	Harwood/ Chatsworth/ Goodwood/ Warregah Islands	531690	6749187	0.71	1	6.5
17031	Maclean	522784	6740782	0.53	1	4
17032	Maclean	522845	6740637	0.40	1.8	4
17047	Maclean	523199	6743382	0.29	1.4	4.5
17037	Mororo/Ashby	520005	6745982	1.20	1.7	4.5
17038	Palmers Island/ Micalo Island/ Yamba	532139	6741462	0.60	1.9	5.5
17041	Palmers Island/ Micalo Island/ Yamba	532799	6744887	0.50	0.7	6.5
17042	Palmers Island/ Micalo Island/ Yamba	527714	6745247	1.52	1.65	5
17043	Palmers Island/ Micalo Island/ Yamba	529839	6744577	0.46	1.3	7
17044	Palmers Island/ Micalo Island/ Yamba	534421	6743887	0.35	0.5	8.5
17057	Palmers Island/ Micalo Island/ Yamba	531404	6744387	0.83	1.8	4.5
16616	Palmers Island/ Micalo Island/ Yamba	531404	6746687	0.80	1.88	6
69595	Palmers Island/ Micalo Island/ Yamba	528122	6742138	0.47	1.5	4
69596	Palmers Island/ Micalo Island/ Yamba	528404	6742104	0.57	1.2	5.5
69597	Palmers Island/ Micalo Island/ Yamba	529007	6740328	0.61	1.5	6
69598	Palmers Island/ Micalo Island/ Yamba	529074	6740720	0.22	1.8	5.5
14790	Palmers Island/ Micalo Island/ Yamba	534254	6741187	1.05	0.65	6
14791	Palmers Island/ Micalo Island/ Yamba	532055	6742337	0.93	1.5	5
14793	Palmers Island/ Micalo Island/ Yamba	527354	6742887	0.94	0.8	6
14957	Palmers Island/ Micalo Island/ Yamba	532325	6741055	0.44	1.1	6

eSPADE Profile ID	Subcatchment	Easting	Northing	Surface Elevation (m AHD)*	Total Profile Depth (m)	Minimum pH**
31062	Palmers Island/ Micalo Island/ Yamba	530837	6742777	0.78	1.5	5.5
31063	Palmers Island/ Micalo Island/ Yamba	530841	6742792	1.07	1.5	5.5
31064	Palmers Island/ Micalo Island/ Yamba	530685	6742815	0.71	1.1	5.5
31065	Palmers Island/ Micalo Island/ Yamba	530594	6742842	1.38	1.4	5
31066	Palmers Island/ Micalo Island/ Yamba	530619	6741762	0.52	1	5
31067	Palmers Island/ Micalo Island/ Yamba	530704	6741847	0.53	1	5.5
31068	Palmers Island/ Micalo Island/ Yamba	530744	6741977	0.72	1	5.5
31069	Palmers Island/ Micalo Island/ Yamba	530401	6741730	0.37	1.6	5
31070	Palmers Island/ Micalo Island/ Yamba	530285	6741729	0.56	1.7	5.5
31071	Palmers Island/ Micalo Island/ Yamba	530838	6742233	1.20	1.3	7.5
31072	Palmers Island/ Micalo Island/ Yamba	530239	6741998	0.34	1.1	5.5
31073	Palmers Island/ Micalo Island/ Yamba	530285	6742374	1.48	1.5	7.5
31074	Palmers Island/ Micalo Island/ Yamba	530082	6742736	0.93	1.65	5.5
31075	Palmers Island/ Micalo Island/ Yamba	530395	6742275	0.29	1	5
16987	Shark Creek	519304	6731087	0.56	1.5	4
72277	Shark Creek	520512	6732780	0.15	1	4.5
72221	Shark Creek	520332	6732923	0.26	0.65	5
72222	Shark Creek	520184	6732879	0.18	0.6	5.5
73415	Shark Creek	520462	6732974	0.18	1	5
26791	Shark Creek	518467	6729487	0.29	1	4.5
77440	South Grafton	492821	6714417	1.34	0.9	5.5
26734	South Grafton	496604	6715987	1.90	1.1	5
16967	Sportsmans Creek	509704	6734662	1.95	2.2	7.5

eSPADE Profile ID	Subcatchment	Easting	Northing	Surface Elevation (m AHD)*	Total Profile Depth (m)	Minimum pH**
16968	Sportsmans Creek	509579	6734862	0.48	2	6.5
16969	Sportsmans Creek	509204	6734637	1.59	1.4	6
16970	Sportsmans Creek	508229	6733547	0.37	1.6	5
16971	Sportsmans Creek	508354	6733687	0.57	1.9	4.5
16972	Sportsmans Creek	508380	6733637	0.57	1.4	5
16973	Sportsmans Creek	508404	6733562	0.70	2.25	6
16980	Sportsmans Creek	506404	6731137	0.20	2.4	3.5
16982	Sportsmans Creek	506354	6730962	0.21	2	4
16985	Sportsmans Creek	506279	6735062	0.15	2	5
16986	Sportsmans Creek	506804	6735987	0.11	1.5	5
17022	Sportsmans Creek	507885	6739047	0.50	1.5	5
17023	Sportsmans Creek	507985	6738986	0.44	1.8	4.5
68789	Sportsmans Creek	508028	6738542	0.28	1.25	4.5
68790	Sportsmans Creek	508130	6738517	0.28	0.25	4.5
68791	Sportsmans Creek	508180	6738499	0.19	0.7	4.5
68792	Sportsmans Creek	507062	6737879	0.26	0.5	4.5
68793	Sportsmans Creek	506918	6738024	0.28	0.4	4.5
68794	Sportsmans Creek	506775	6735898	0.06	0.35	4.5
68797	Sportsmans Creek	506537	6734788	0.27	0.05	
68798	Sportsmans Creek	506483	6734901	0.28	0.05	
68799	Sportsmans Creek	506635	6735140	0.21	0.05	4.5
16990	Swan Creek	504946	6716975	0.14	3	4
536	Swan Creek	503104	6710187	0.84	0.37	3.5
537	Swan Creek	502904	6710487	0.88	0.37	3.5
539	Swan Creek	503504	6710487	0.80	0.37	3.5
26799	Swan Creek	504579	6718987	1.49	0.7	5
22479	Swan Creek	501729	6720592	2.32	2.52	7
17039	Taloumbi/ Palmers Channel	525689	6740097	0.68	1.5	5.5
26803	Taloumbi/ Palmers Channel	529954	6733687	0.77	0.55	4.5
69592	Taloumbi/	524850	6743135	1.81	1.9	5

eSPADE Profile ID	Subcatchment	Easting	Northing	Surface Elevation (m AHD)*	Total Profile Depth (m)	Minimum pH**
	Palmers Channel					
69593	Taloumbi/ Palmers Channel	530241	6738767	0.60	1.45	6.5
69594	Taloumbi/ Palmers Channel	530188	6738760	0.27	0.9	6.5
69601	Taloumbi/ Palmers Channel	524870	6743183	1.54	1.6	5
69599	Taloumbi/ Palmers Channel	525556	6741299	1.37	1.7	4.5
69600	Taloumbi/ Palmers Channel	525627	6741314	1.56	2.15	5
17024	The Broadwater	508229	6743087	1.77	1.7	4.5
17025	The Broadwater	508385	6743087	1.23	1	4.5
17027	The Broadwater	516104	6744127	0.42	0.6	4.5
17028	The Broadwater	516049	6743962	0.79	0.4	5.5
17053	The Broadwater	512264	6740667	1.70	1.9	5
17054	The Broadwater	513585	6741487	1.04	1.3	6
73413	The Broadwater	509314	6742719	0.52	0.95	4.5
73414	The Broadwater	509190	6742617	0.91	0.9	4.5
17019	The Freshwater	533504	6749637	1.37	1.22	5
17020	The Freshwater	533729	6749187	0.25	0.7	8.5
17021	The Freshwater	533804	6749212	1.06	0.9	6
17035	The Freshwater	534054	6749767	0.84	0.8	7.5
17036	The Freshwater	533897	6749799	0.95	0.9	6
17045	The Freshwater	533504	6749637	1.37	1.22	5
17046	The Freshwater	530930	6752862	1.68	1.8	4
14859	The Freshwater	534124	6752505	1.64	1.8	8
16984	West Woodford Island	513505	6735037	1.93	2.2	5.5
17048	West Woodford Island	513854	6737332	1.07	1.8	6

D2.2 Other literature

Published and grey literature was investigated for other soil profiles within the Clarence River floodplain, which included data from thesis documents (Maher (2013) and Beveridge (1998)) and previous WRL investigations undertaken on behalf of Clarence Valley Council (Glamore et al., 2018; Rayner et al., 2016). 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 Clarence 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.

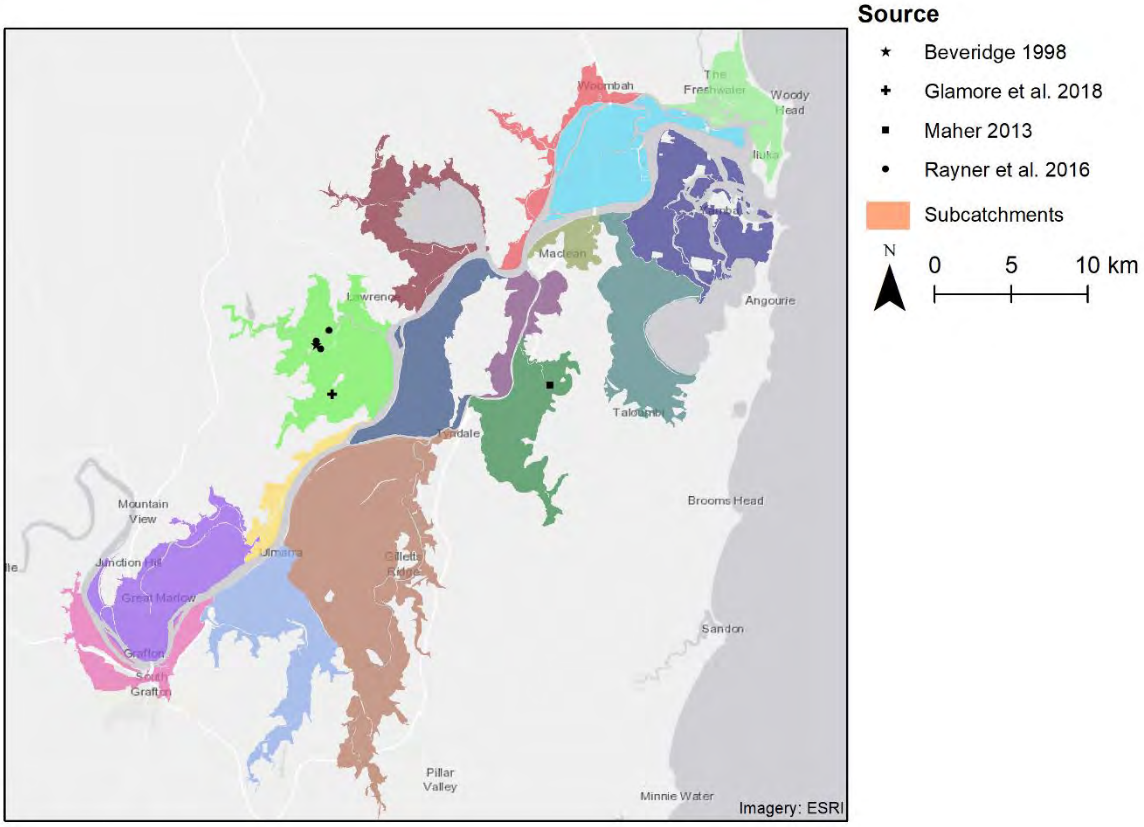


Figure D-2: Location of applicable soil profiles from literature in the study region

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

Profile	Subcatchment	Easting	Northing	Surface Elevation (m AHD)	Total Profile Depth (m)	Minimum pH
Rayner_2016_1	Sportsmans Creek	505202	6735857	0.1	2	4.4
Rayner_2016_2	Sportsmans Creek	506030	6736562	0.1	3	4.9
Rayner_2016_3	Sportsmans Creek	505488	6735340	0.1	2	4.8
Glamore_2018_1	Sportsmans Creek	506209	6732373	0.1	1	4.0
Beveridge_1998	Sportsmans Creek	505150	6735575	0.0	2	4.0
Maher_2013	Shark Creek	520472	6732986	0.2	1.8	4.2
Johnston_2003_1	Shark Creek	521011	6734028	0.1	1.5	3.7
Johnston_2003_2	Shark Creek	521067	6733979	0.2	1.5	3.6
Johnston_2003_3	Shark Creek	521148	6733910	0.1	1.5	3.2
Johnston_2003_4	Shark Creek	521234	6733836	0.0	1.5	2.9

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 49 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.

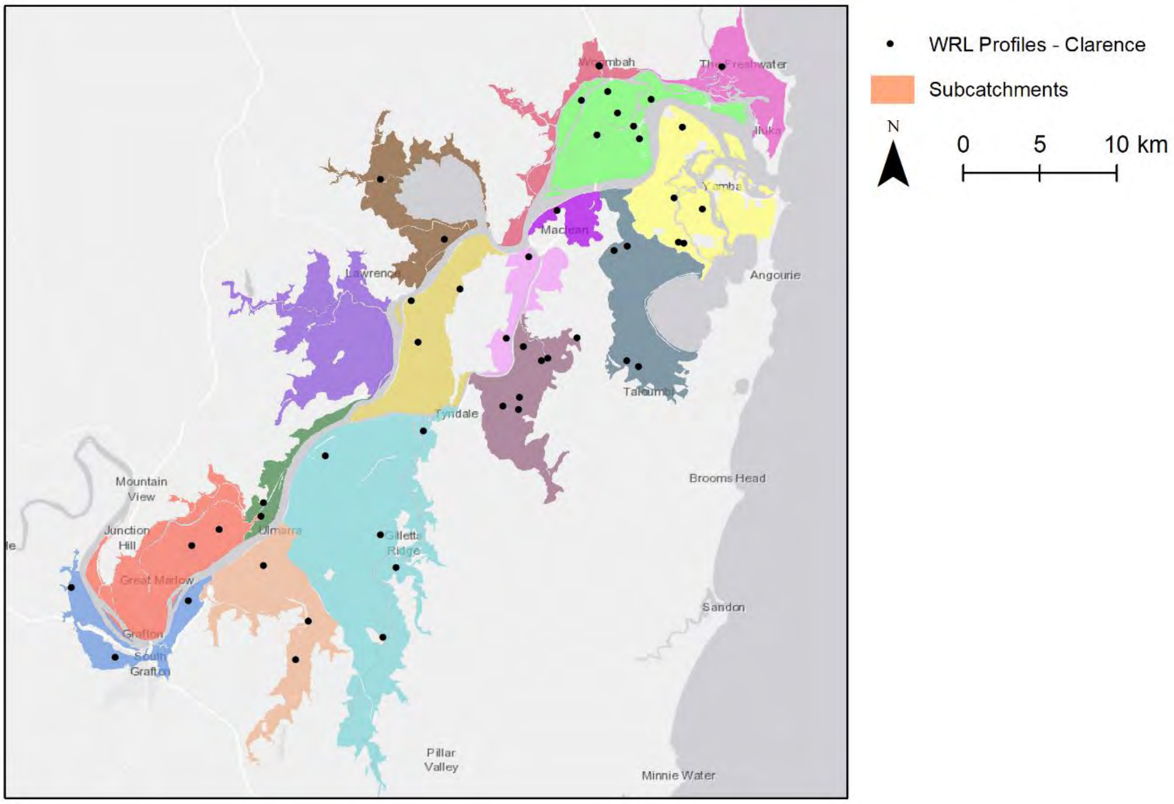


Figure D-3: Location of soil profiles from WRL field investigations

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
CA_12	Alumy Creek	498861	6722067	1.15	2.3	5.9
CP_20	Alumy Creek	497099	6721006	0.07	2	4.5
CA_04	Coldstream River	509539	6715052	0.00	1.7	4.6
CA_29	Coldstream River	512197	6728469	0.88	2.6	5.5
CP_25	Coldstream River	509376	6721705	0.07	1.9	4.2
CP_28	Coldstream River	510413	6719595	0.70	2	4.6
CA_17	Coldstream River	505812	6726848	-0.17	2.8	
CP_51	Gulmarrad/East Woodford Island	519039	6739814	0.03	1.5	6.9
CP_43	Gulmarrad/East Woodford Island	517565	6734521	0.07	2.4	4.6
CP_76	Harwood/Chatsworth/ Goodwood/Warregah Islands	523474	6747741	0.54	1.9	5.4
CP_72	Harwood/Chatsworth/	527018	6750089	0.17	1.2	3.7

Profile	Subcatchment	Easting	Northing	Surface Elevation (m AHD)	Total Profile Depth (m)	Minimum pH
	Goodwood/Warregah Islands					
CP_81	Harwood/Chatsworth/ Goodwood/Warregah Islands	526241	6747491	1.62	1.7	4.5
CA_65	Harwood/Chatsworth/ Goodwood/Warregah Islands	525874	6748327	0.41	1.8	5.6
CP_82	Harwood/Chatsworth/ Goodwood/Warregah Islands	522465	6750013	-0.05	1.4	6.7
CA_64	Harwood/Chatsworth/ Goodwood/Warregah Islands	524806	6749176	0.24	2	4.6
CP_85_S	Harwood/Chatsworth/ Goodwood/Warregah Islands	524188	6750590	0.80	2.25	5.2
CA_80	Maclean	520890	6742838	-0.04	1.5	5.2
CP_84_C	Mororo/Ashby	523623	6752252	1.85	1.55	5.3
CP_84_X	Mororo/Ashby	523630	6752244	1.86	1.85	5.3
CP_68	Palmers Island/ Micalo Island/Yamba	530335	6742929	0.50	2.25	6.5
CP_65	Palmers Island/ Micalo Island/Yamba	529134	6740719	0.00	2.25	4.4
CA_57	Palmers Island/ Micalo Island/Yamba	528787	6740781	-0.07	1.5	4.6
CP_70	Palmers Island/ Micalo Island/Yamba	529046	6748258	0.31	1.4	4.5
CA_60_S	Palmers Island/ Micalo Island/Yamba	528507	6743656	0.76	1.6	5.5
CA_45	Shark Creek	518369	6729890	0.61	2.3	4.2
CP_47	Shark Creek	518451	6730666	0.74	3	4.5
CP_39	Shark Creek	517367	6730095	0.35	2	4.6
CP_54_S	Shark Creek	522183	6734544	0.64	1.5	5.6
CA_49	Shark Creek	520265	6733197	1.00	2	4.6
CP_42_S	Shark Creek	519881	6733057	0.87	2	5.6
CA_47	Shark Creek	518680	6733987	0.76	1.8	5.5
CA_06	South Grafton	496866	6717436	-0.01	2.2	4.5
CP_12	South Grafton	489259	6718301	0.88	1.8	5.7
CP_11	South Grafton	492122	6713745	1.84	2	6.6
CP_17	Southgate	501597	6722914	2.40	2.8	5.6
CP_19	Southgate	501762	6723802	0.74	2.3	4.9
CP_16	Swan Creek	501776	6719716	0.50	3	4.9
CA_02	Swan Creek	504679	6716092	0.71	1.8	4.7
CA_01	Swan Creek	503856	6713573	0.17	2.4	4.5
CP_55_S	Taloumbi/Palmers Channel	525455	6740512	1.65	1.5	6.8
CA_52_S	Taloumbi/Palmers Channel	524587	6740219	1.06	2.8	5.2

Profile	Subcatchment	Easting	Northing	Surface Elevation (m AHD)	Total Profile Depth (m)	Minimum pH
CP_61_S	Taloumbi/Palmers Channel	526172	6732673	0.78	1.85	4.6
CP_61_X	Taloumbi/Palmers Channel	525416	6733045	0.64	1.85	5.4
CA_37	The Broadwater	513556	6740946	0.35	1.8	4.9
CA_76	The Broadwater	509383	6744863	0.69	2.5	3.9
CP_67	The Freshwater	531619	6752207	1.14	1.1	7.7
CA_25_S	West Woodford Island	514570	6737721	1.79	1.3	7.1
CA_33	West Woodford Island	511844	6734262	0.79	1.8	5.7
CP_37	West Woodford Island	511395	6736943	0.78	2	5.4

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 (2) 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 Clarence 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
Alumy Creek	6.6	1.2	7.9	3
Coldstream River	16.2	1.2	19.5	21
Gulmarrad/ East Woodford Island	62.2	0.7	43.5	4
Harwood/Chatsworth/ Goodwood/Warregah Islands	6.2	1.2	7.5	20
Maclean	33.9	0.7	23.7	4
Mororo/Ashby	6.3	1.2	7.5	3
Palmers Island/ Micalo Island/Yamba	3.5	1.3	4.5	34
Shark Creek	29.7	1.2	35.6	18
South Grafton	3.3	1.2	3.9	5
Southgate	3.1	1.2	3.7	2
Sportsmans Creek	13.2	1.2	15.9	27
Swan Creek	43.5	1.2	52.3	9
Taloumbi/Palmers Channel	5.2	1.3	6.7	12
The Broadwater	21.0	1.2	25.2	10
The Freshwater	5.1	1.6	8.2	9
West Woodford Island	1.4	1.2	1.7	8

D5 Data confidence

As shown in Table D-4, the number of profiles in each catchment varies quite significantly. There are five (5) catchments in particular that have less than five (5) profiles in the area:

- Alumy Creek (3 profiles);
- Gulmarrad/East Woodford Island (4 profiles);
- Maclean (4 profiles);
- Mororo/Ashby (3 profiles); and
- Southgate (2 profiles).

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.

Alumy Creek has three (3) profiles and a pH factor of 7.9, which is the 8th highest pH factor in Table D-4 (out of 16 subcatchments). Alumy Creek was identified by Tulau (1999a) as an ASS hotspot, although there was little available soil pH available at the time. However, it very acidic surface water measurement (pH of 2.9) was noted by the author. Woodhouse (2001b) documented a water quality monitoring program that was undertaken in Alumy Creek (and its tributaries) throughout 1999 and 2000. Of the pH measurements made during this program, over 85% of the readings were above 6.5, and the lowest reading was 5.9, suggesting that very acidic discharges are not overly common. A pH of 5.9 is equivalent to a hydrogen ion concentration of 1.2 µmol/L, in the same order of magnitude as the depth averaged H+ concentration at Alumy Creek. Based on this information, a mid-range pH factor appears to be justified.

The Gulmarrad/East Woodford Island spans over the South Arm of the Clarence River and has four (4) profiles, two (2) either side of the river channel. The pH factor for this subcatchment is 43.5, the second highest in the Clarence floodplain. This area is not identified as an ASS hotspot in Tulau (1999a). Three (3) of the four (4) profiles available have a minimum pH of 4.6 or less, however one of the WRL profiles (CP_51) has a minimum pH of 6.9. Surface water quality samples collected by WRL on East Woodford Island were all neutral (pH>7), although these samples were taken during a prolonged drought when drainage from ASS was limited, so cannot be directly used to contradict the high pH factor in Table D-4. Wet weather water quality was measured by Roads and Maritime Services (RMS) during the upgrade of the Pacific Highway in Gulmarrad on the eastern side of the South Arm of the Clarence River. Monitoring was upstream of the floodgate on Edwards Creek (floodgate ID - F-2200-FB-0001). The pH in this creek was, on three (3) occasions below five (5) (minimum value recorded was 4.2), although the average pH was neutral. Based on the notes from the monitoring, high acidity readings were more likely when the electrical conductivity was also low, usually related to greater rainfall flushing the system. This water quality monitoring indicated the ASS are likely to be impacting surface water quality at Gulmarrad. It is suggested that more soil profile data should be collected in this area to confirm the high pH factor, although water quality monitoring supports the current soil profile information indicating acidity may periodically be a problem in the area.

The Maclean subcatchment only has four (4) soil profiles (one (1) WRL profile, three (3) eSPADE profiles). However, Maclean is also the smallest floodplain subcatchment in the Clarence River floodplain. Therefore, the number of profiles per square kilometre of floodplain is actually quite high (approximately 0.5 profiles/km^2). It is therefore more likely to be well represented than a catchment like Gulmarrad/East Woodford Island which has the same number of profiles, but approximately twice the floodplain area.

The Mororo/Ashby subcatchment has three (3) profiles, including two (2) WRL profiles that are very close to one another (CP_84_C and CP_84_X) and has a pH factor of 7.5. It is an unusual catchment as it spans 15 km of the North Arm of the Clarence River and it has a small floodplain area, mostly within 1 km of the river channel. There is limited available information on water quality and soil profiles in this area to compare the pH factor to. However, the Harwood/Chatsworth/Goodwood/Warregah Islands subcatchment is across the North Arm of the river and The Freshwater subcatchment is just downstream. Both are likely to have similar depositional environments to the Mororo/Ashby subcatchment and result in very similar pH factors (7.5 and 8.2 respectively), providing some improved confidence in the factor used in this area. However, once again, more extensive soil information should be collected to verify the acidity in this area.

The Southgate subcatchment has the least number of profiles in the Clarence River (two (2) WRL profiles), both on the western side of the subcatchment. There was no existing soil profile information at Southgate, nor has any available water quality data been identified, although the area has not been identified as an ASS hotspot in Tulau (1999a), which is consistent with the low pH factor in Table D-4. It is recommended that more extensive soil information should be collected in this area to provide greater confidence in the presence of ASS prior to any on-ground works.

Appendix E Blackwater elevation thresholds

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 Clarence River. The water level analysis undertaken is described in detail in Section 6 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 Clarence 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.

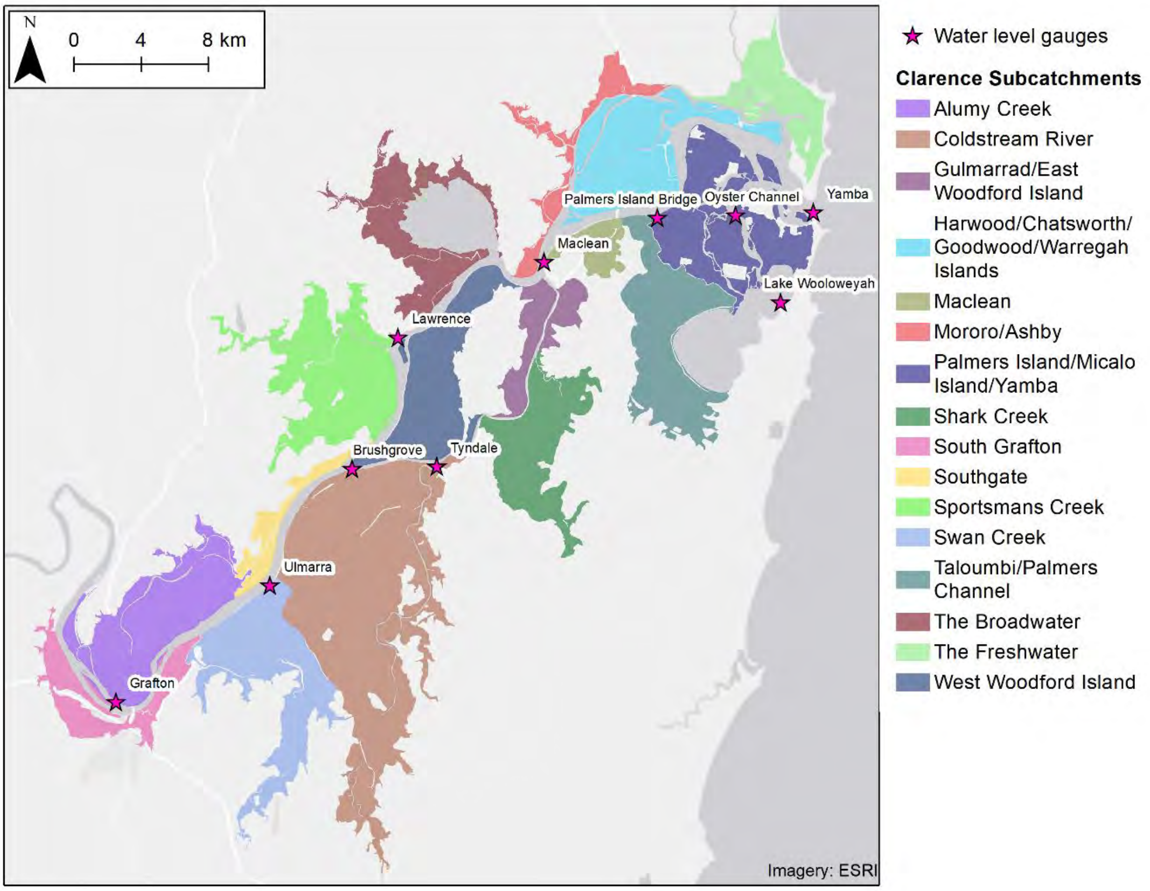


Figure E-1: Locations of water level gauges used for blackwater elevation thresholds

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)
Yamba	0.3 (Clarence River)	32.5	0.5
Oyster Channel	Not on main river	15.9	0.3
Palmers Island Bridge	16.2 (Clarence River)	17.8	0.3
Maclean	24.3 (Clarence River) 0 (South Arm)	29.3	0.3
Tyndale	16.3 (South Arm)	16.3	0.3
Brushgrove	44.9 (Clarence River) 21.5 (South Arm)	27.7	0.3
Lawrence	35.9 (Clarence River)	10.8	0.3
Ulmarra	54.0 (Clarence River)	15.6	0.4
Grafton	66.6 (Clarence River)	28.9	0.4

* 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)
Yamba	0.6	0.9	0.9	1.9
Oyster Channel	0.3	0.5	0.5	0.8
Palmers Island Bridge	0.3	0.9	1.0	1.8
Maclean	0.3	0.8	1.0	2.5
Tyndale	0.4	1.9	1.8	3.8
Brushgrove	0.3	1.4	1.7	4.1
Lawrence	0.4	1.9	2.0	3.4
Ulmarra	0.4	2.2	2.2	5.0
Grafton	0.4	1.5	2.1	6.2

E3 Subcatchment elevation thresholds

The subcatchments of the Clarence 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 is 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
Palmers Island/Micalo Island/Yamba	Oyster Channel
Taloumbi/Palmers Channel	Palmers Island Bridge
The Freshwater	0.76 x Yamba + 0.24 x Palmers Island Bridge
Mororo/Ashby	Palmers Island Bridge + 0.46 x Maclean
Harwood/Chatsworth/Goodwood/ Warregah Islands	0.31 x Yamba + 0.69 x Palmers Island Bridge
Maclean	0.69 x Palmers Island Bridge + 0.31 x Maclean
The Broadwater	0.64 x Maclean + 0.36 x Lawrence
West Woodford Island	0.23 x Maclean + 0.77 x Lawrence
Gulmarrad/East Woodford Island	0.89 x Maclean + 0.11 x Tyndale
Shark Creek	0.65 x Maclean + 0.35 x Tyndale
Coldstream River	Tyndale
Sportsmans Creek	Lawrence
Southgate	0.46 x Brushgrove + 0.54 x Ulmarra
Alumy Creek	0.83 x Ulmarra + 0.17 x Grafton
Swan Creek	0.60 x Ulmarra + 0.40 x Grafton
South Grafton	Grafton

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

Subcatchment	Minimum level (m AHD)	Median level (m AHD)	Mean level (m AHD)	Maximum level (m AHD)
Palmers Island/Micalo Island/Yamba	0.3	0.5	0.5	0.8
Taloumbi/Palmers Channel	0.3	0.9	1.0	1.8
The Freshwater	0.5	0.9	0.9	1.9
Mororo/Ashby	0.3	0.9	1.0	2.1
Harwood/Chatsworth/Goodwood/Warregah Islands	0.4	0.9	1.0	1.8
Maclean	0.3	0.9	1.0	2
The Broadwater	0.3	1.3	1.3	2.8
West Woodford Island	0.4	1.6	1.7	3.2
Gulmarrad/East Woodford Island	0.3	0.9	1.1	2.6
Shark Creek	0.3	1.1	1.3	3
Coldstream River	0.4	1.9	1.8	3.8
Sportsmans Creek	0.4	1.9	2.0	3.4
Southgate	0.4	1.8	2.0	4.6
Alumy Creek	0.4	2.1	2.2	5.2
Swan Creek	0.4	1.9	2.2	5.5
South Grafton	0.4	1.5	2.1	6.2

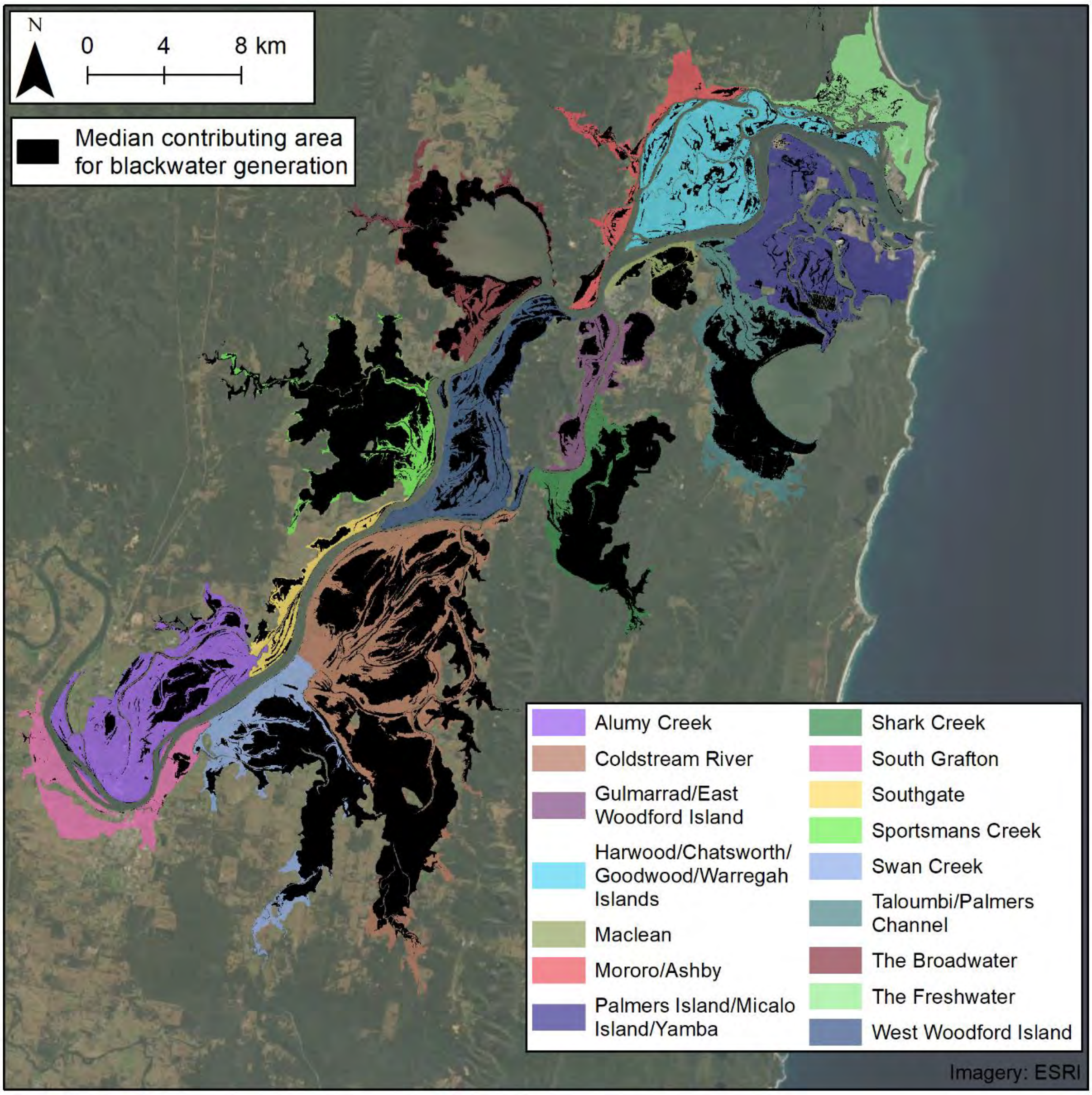


Figure E-2: Areas in the Clarence River floodplain below the median elevation threshold

Appendix F Floodplain infrastructure

F1 Preamble

A range of floodplain infrastructure exists across the Clarence River floodplain for the purpose of drainage and inundation protection (tidal and flooding). Included within this infrastructure are 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 Clarence 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 Clarence Valley Council (CVC);
- An assessment of waterways with floodgates in the Clarence River estuary (Williams, 2000); and
- An options study for remediation of Everlasting Swamp (Glamore et al., 2019).

Across the Clarence 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. However, the elevation of the crest of levees can be extracted from readily available LiDAR information (information specific to levees has been addressed in Section F3.2).

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 Clarence River estuary were 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 Clarence River estuary.

Table F-1: Description of existing data sources

Source	Description
CVC – GIS	GIS shapefiles containing location, access, dimension and maintenance information for floodgates and levees managed by CVC. Note that infrastructure data from CVC has not been presented in this section, however the Council has additional information on hand that was used to assist in field data collection.
CVC - CAD	CAD files containing survey data for the drains and structures located in and around the Taloumbi ring drain system. Note that infrastructure data from CVC has not been presented in this section, however the Council has additional information on hand that was used to assist in field data collection.
CVC – photos	Photos of the drains and structures located in and around the Taloumbi ring drain system.
Williams (2000)	A report assessing floodgates on the Clarence River floodplain to prioritise their management for environmental purposes. The report contains information on structure dimensions and invert levels. Assessment and validation of the data indicated that invert levels provided in the report were unreliable.
Glamore et al. (2019)	A study that developed a detailed hydrodynamic model to assess different remediation options for Everlasting Swamp. As part of the model development a detailed fieldwork campaign was completed, including the survey of a number of structures (e.g. Sportsmans Creek Weir).

F2.2 Data collection

Field investigations were completed to obtain invert and dimension data for floodplain infrastructure within the Clarence River floodplain. Initially WRL completed opportunistic surveys of easily accessible end of system structures. Abbott and Macro Land and Engineering Surveyors (Abbott and 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. A summary table of all structure data measured during the field investigations is provided in Section F6.

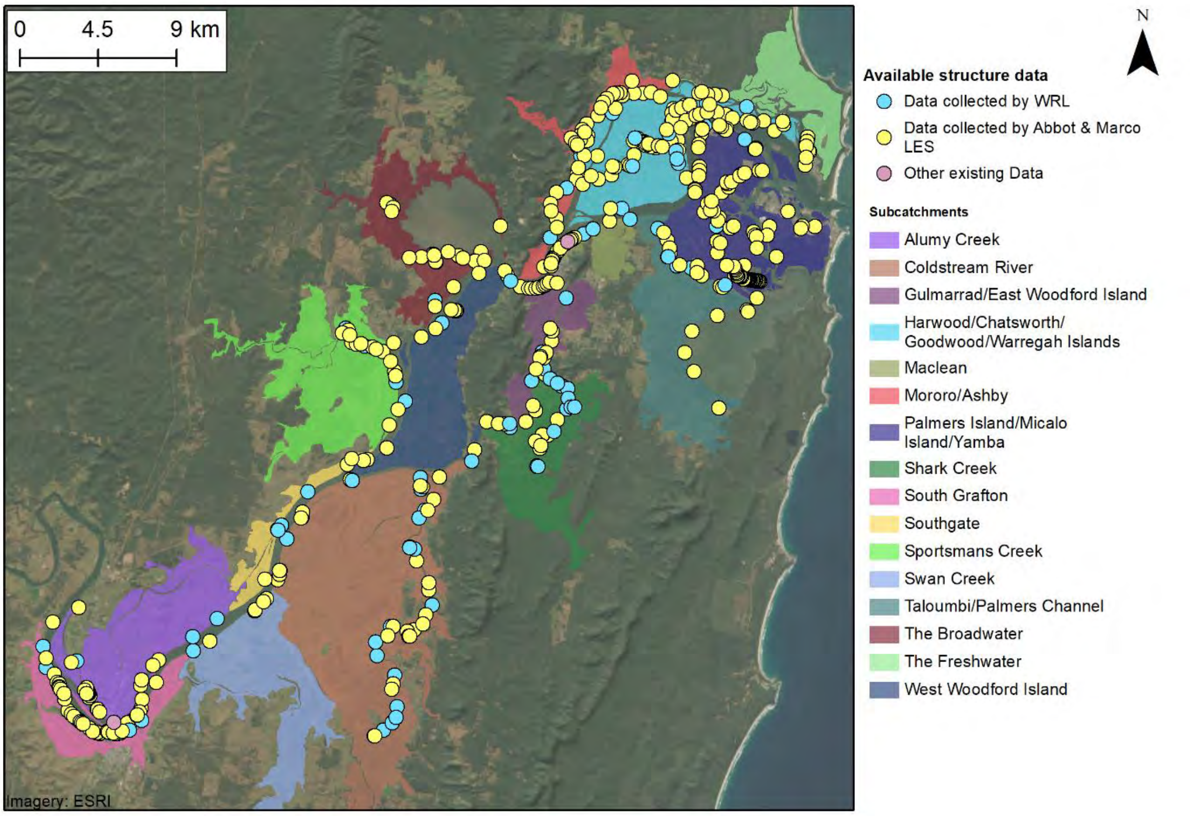


Figure F-1: Summary of structures were data available for the Clarence River floodplain

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 (2) 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 Sportsmans Creek Weir.
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 the subcatchment 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 471 EOS structures which have been identified within the Clarence River floodplain.

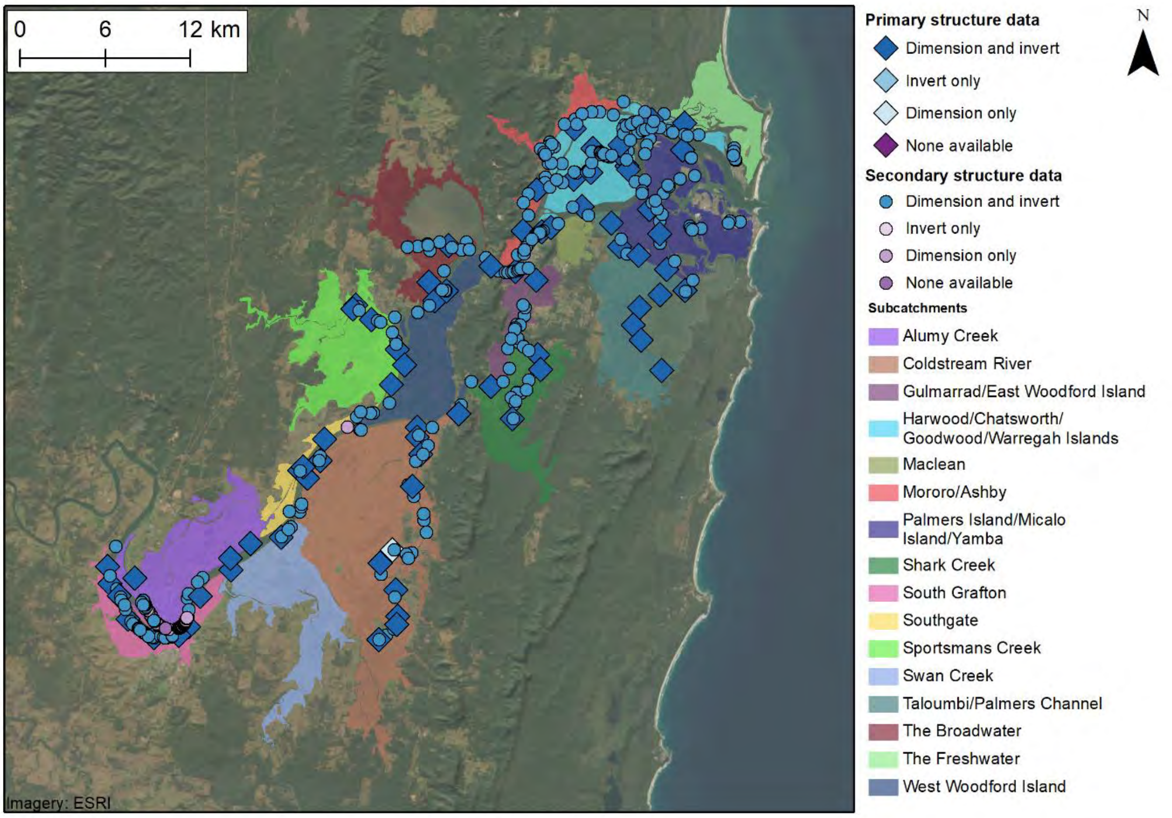


Figure F-2: Summary of data available for end of system structures of the Clarence River floodplain

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 Clarence River floodplain there are two (2) sets of levee structures located at Grafton and Maclean designed to protect urban areas from extreme flood events. Flood modelling showed that the Grafton levee system will protect the urban area from a 20% annual exceedance probability (AEP) flood event (Farr and Huxley, 2013). Modelling also showed that the levee structures located at Maclean would offer protection from a 5% AEP flood event, beginning to overtop during a 2% AEP flood event (Farr and Huxley, 2013). Figure F-3 shows the locations of flood mitigation levees across the Clarence River floodplain. All levees are actively managed by Clarence Valley Council with priority given to levees offering protection for urban areas.

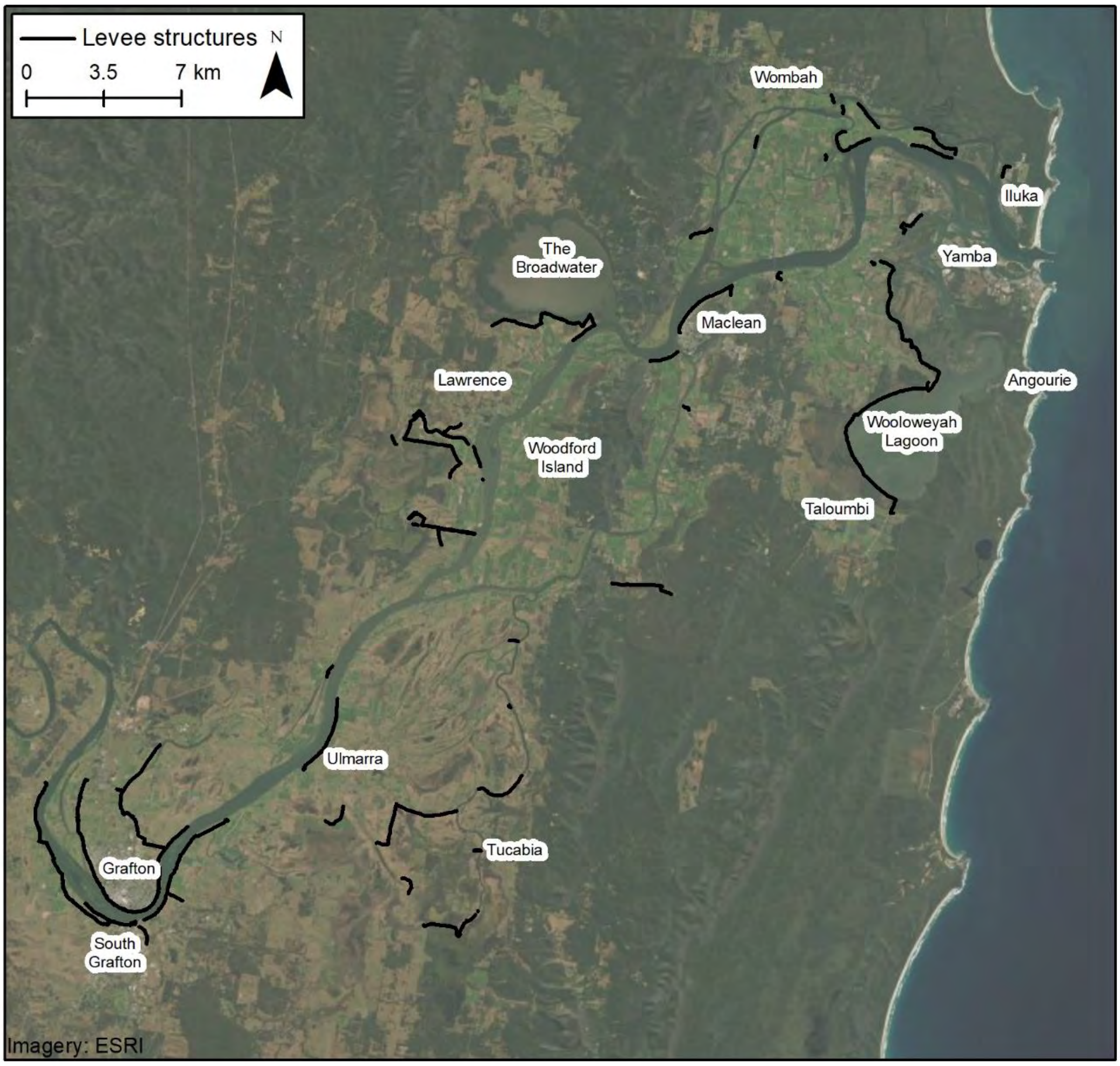


Figure F-3: Locations of flood mitigation levee structures on the Clarence River floodplain managed by Clarence Valley Council

F4 Infrastructure tenure and maintenance

F4.1 Infrastructure tenure

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

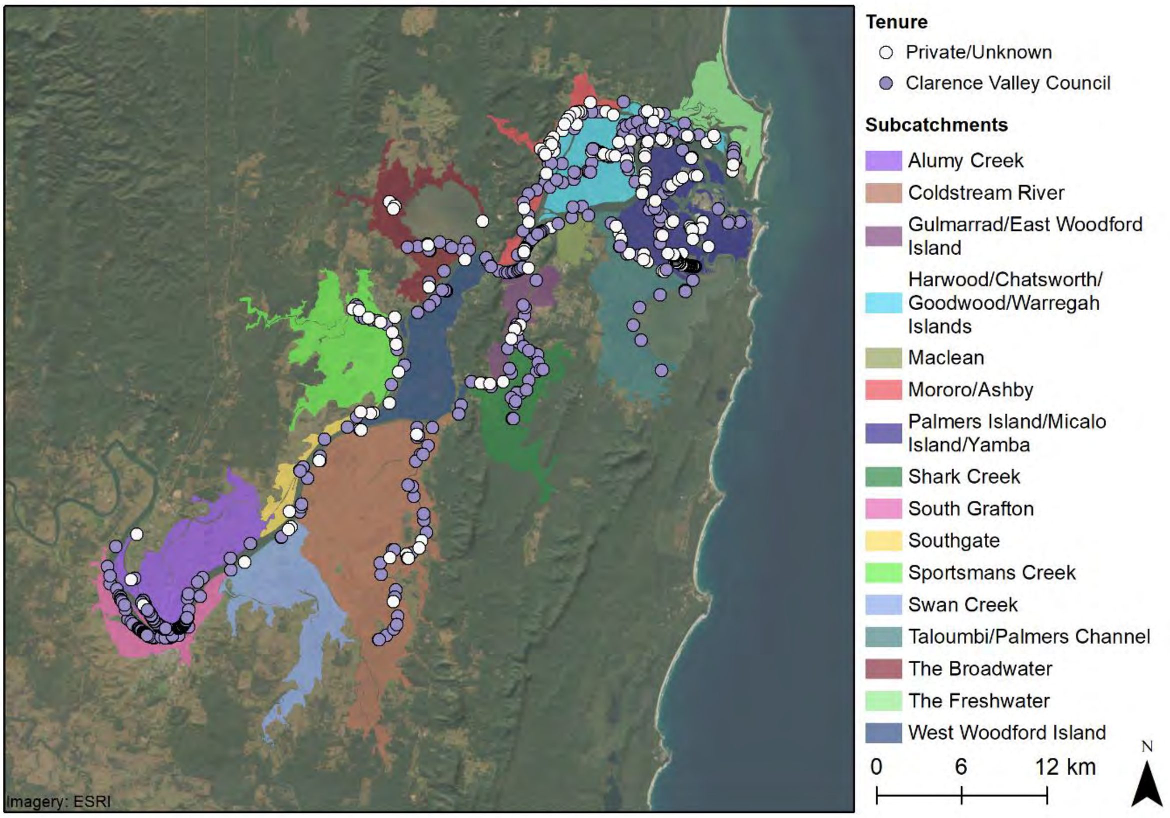


Figure F-4: Tenure of end of system structures on the Clarence River floodplain

F4.2 Maintenance schedule

Clarence Valley Council has an ongoing maintenance program for extensive floodplain infrastructure network (Clarence Valley Council, 2020). This program implements Clarence Valley Council's asset management strategy which includes (Clarence Valley Council, 2019b):

- A four (4) yearly inspection and maintenance program for levee structures;
- A floodplain infrastructure inspection following flood events;
- A regular floodplain infrastructure inspection program;
- The development of a climate change management plan;
- Review of infrastructure design periods; and
- Development and implementation of maintenance and inspection processes and procedures.

Currently, Clarence Valley Council is custodian of a detailed asset maintenance register which includes details on maintenance required and current condition of floodgate and levee infrastructure (Clarence

Valley Council, 2019a). Further procedures for floodgate and drain management have been developed for the Clarence Valley floodplain by Robert J. Smith and Associates (1999).

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 maintenance of floodplain infrastructure has been considered in the development of subcatchment management options where relevant. It has been assumed that for structures where the tenure was identified as private or unknown, that routine maintenance is completed by the landholder as required.

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 remediation actions plans.

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.

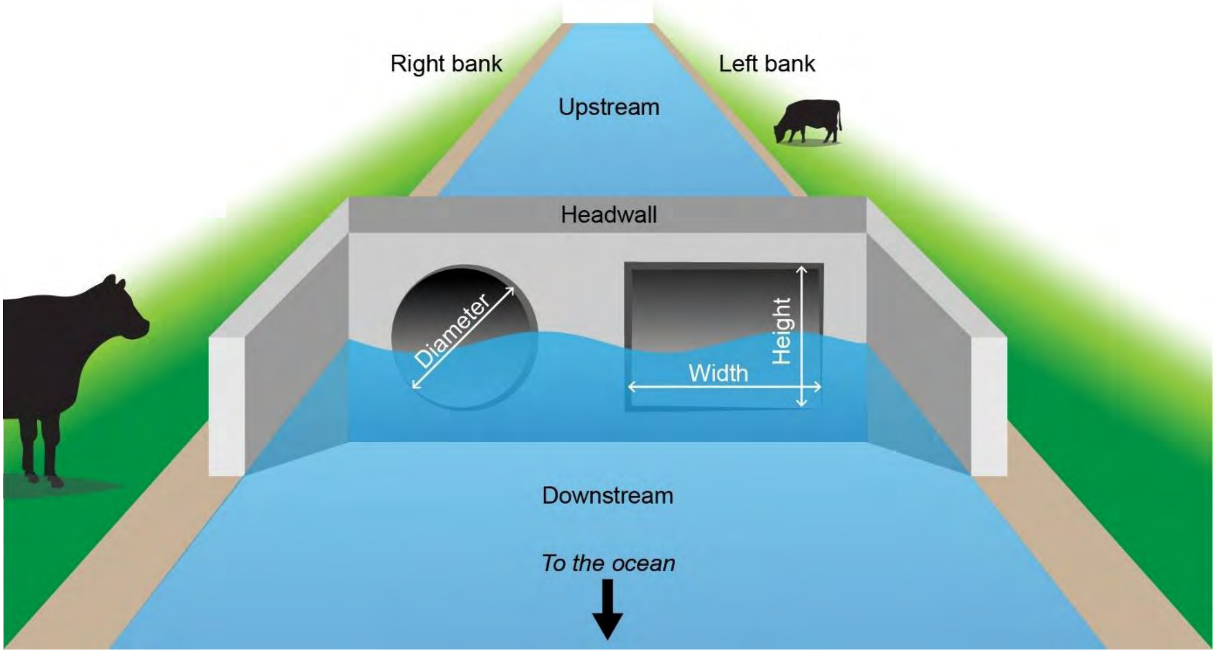


Figure F-5: Example of culverts controlling water in an agricultural drain

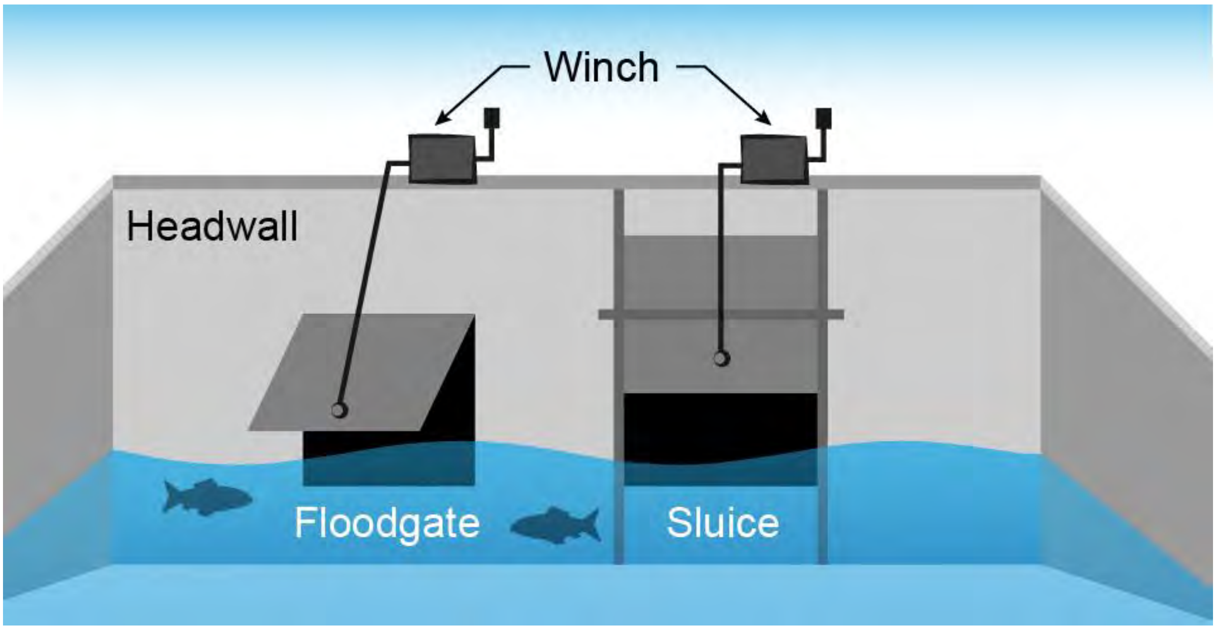


Figure F-6: Example of floodgate and sluice structures which can be fitted to culverts to control flow using a winch

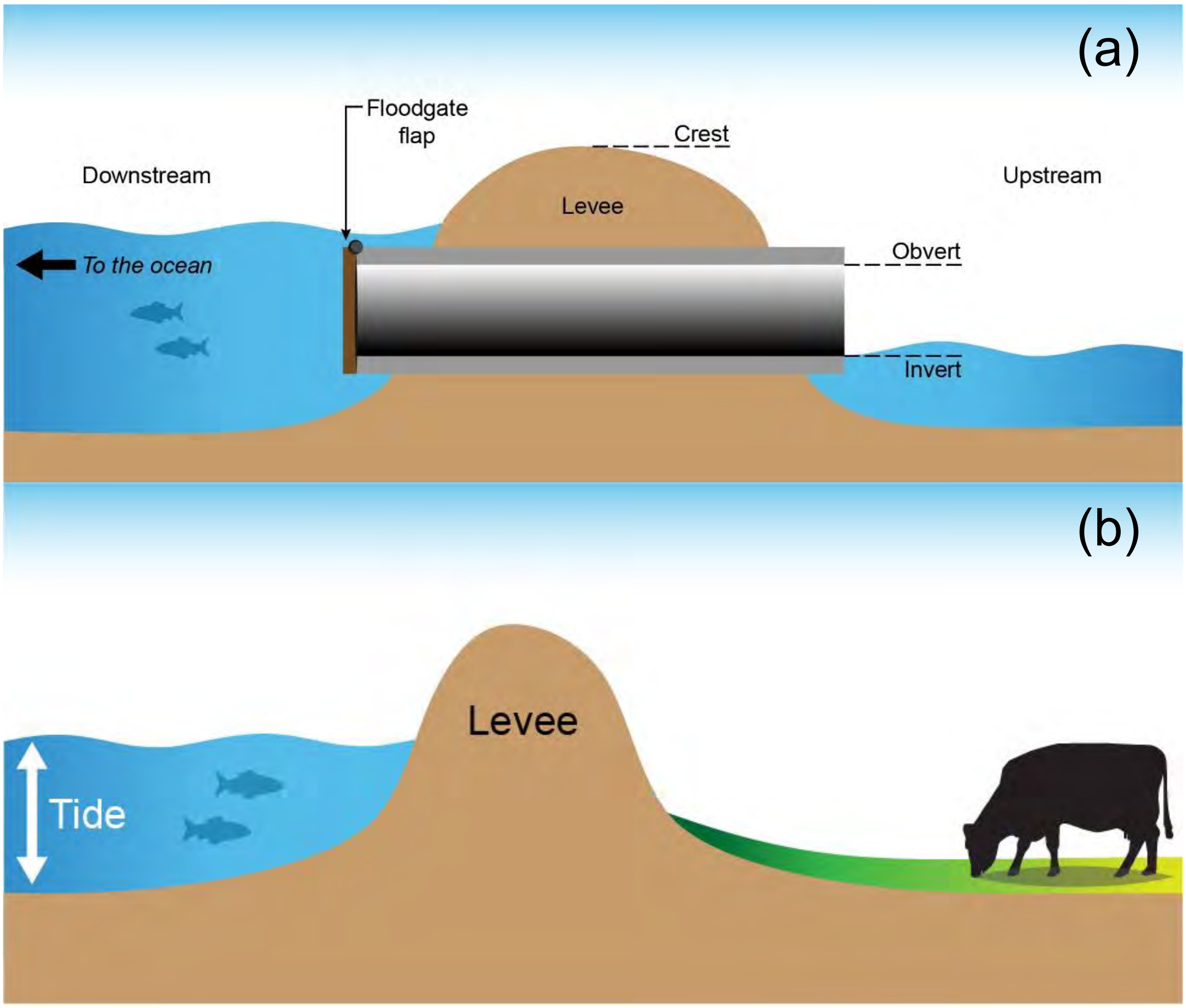


Figure F-7: Example of (a) a floodgate structure ensuring water levels upstream of a levee remain at the low tide level and (b) a levee preventing tidal inundation of the floodplain

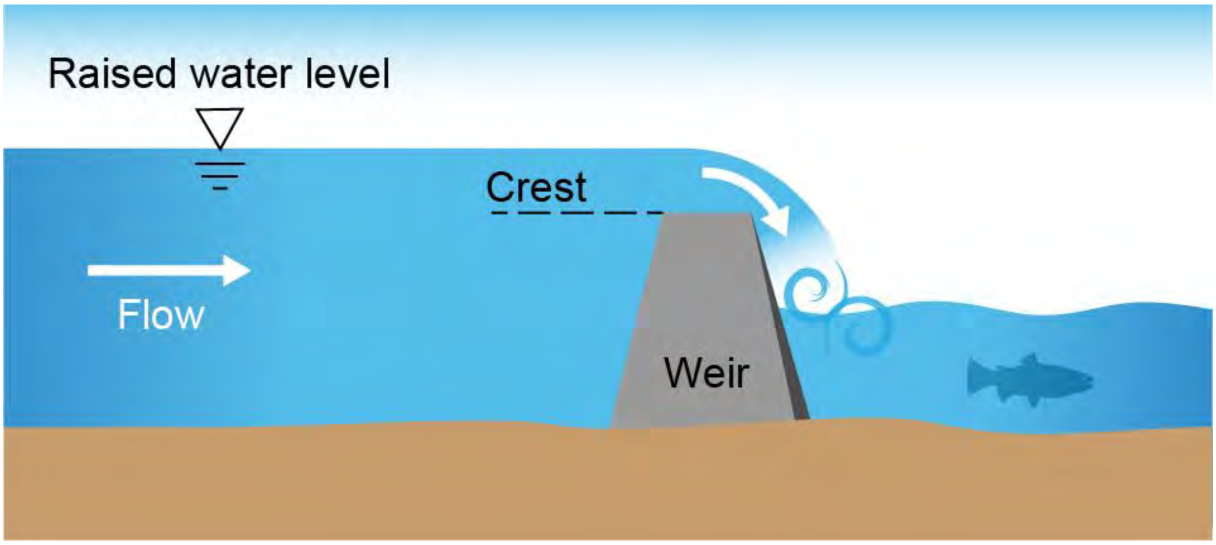


Figure F-8: Example of a weir ensuring a raised water level on the upstream side

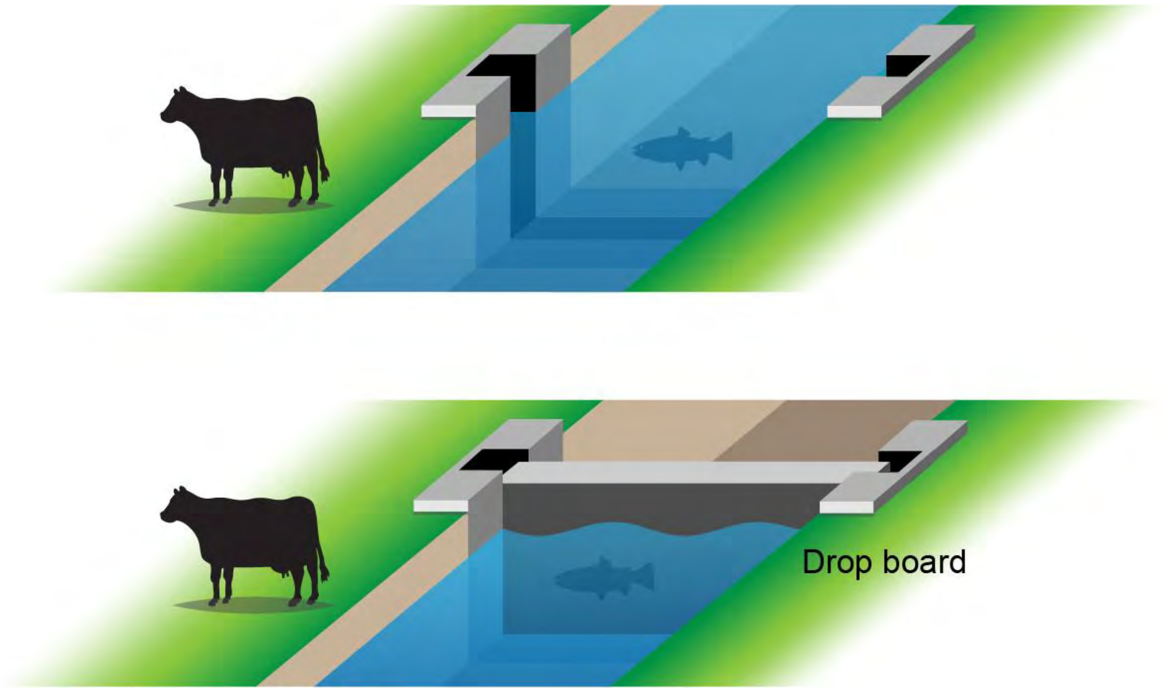


Figure F-9: Example of a drop board structure which can be used to control water levels and prevent inundation

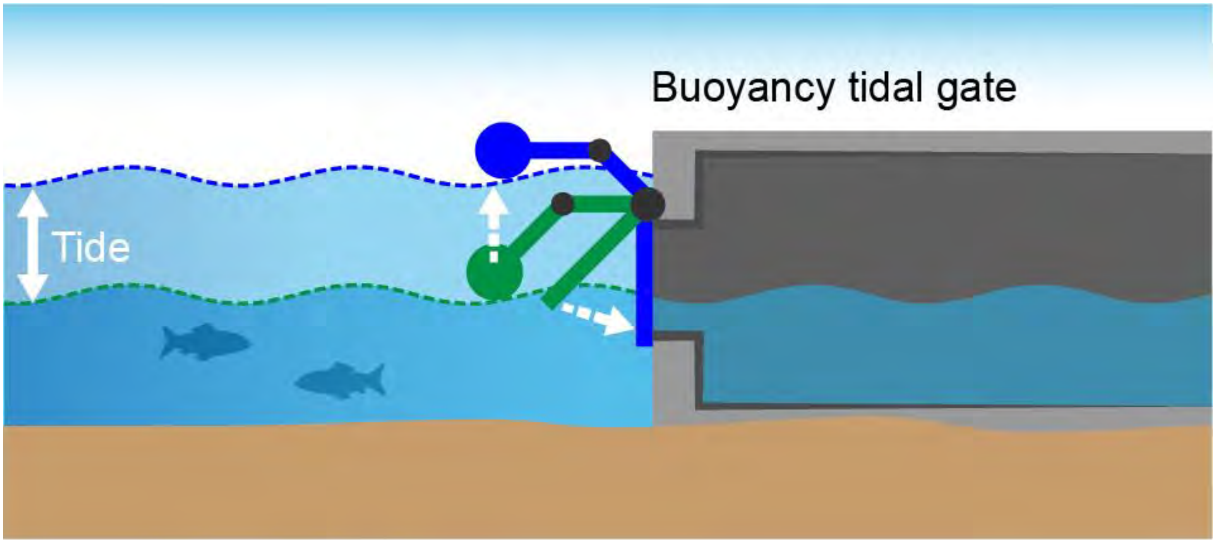


Figure F-10: Example of a buoyancy tidal gate that lets a controlled level of tidal water upstream of the structure (green) before closing due to a buoyancy mechanism and preventing further water ingress (blue)

F6 Floodplain infrastructure data tables

The following section includes:

1. A summary table for structures surveyed for this current project (Table F-2); and
2. A summary table for structures based on surveys from Abbott and Macro in 2022 and Glamore et al. (2019) (Table F-3); 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
F-1010-FB-0001	1/03/2020 16:08	Floodgate	2		2	2	489756	6719335		-1.02	Good	Primary	Clarence Valley Council	Winches on each gate.
F-1020-FB-0001	27/02/2020 16:08	Floodgate	4		2	2.4	489922	6718140		-1.34	Good	Primary	Clarence Valley Council	Dimensions are approximate only. Right gate (looking downstream) can be winched open.
F-1050-FB-0002	1/03/2020 15:48	Floodgate	5		2.1	2.1	492998	6714326		0.09	Good	Primary	Clarence Valley Council	
F-1110-FB-0001	1/03/2020 16:34	Floodgate	2		2	2	491677	6718511		-0.95	Good	Primary	Clarence Valley Council	Buoyancy tidal gate on right floodgate flap.
F-1130-FP-0006	1/03/2020 17:09	Floodgate	1	1.2			495204	6715344		0.02	Good	Secondary	Clarence Valley Council	
F-1160-FB-0001	1/03/2020	Floodgate	7		2.1	2.1	498400	6719092		-1.10	Good	Primary	Clarence Valley Council	Winch on left four (4) gates.
F-1160-FP-0012	3/12/2019	Floodgate	1	1.2			504595	6716181	-0.62		Good	Secondary	Clarence Valley Council	On the upstream side there is 0.2 m of sediment in the base of the culvert.
F-1190-FB-0001	1/03/2020 15:17	Floodgate	3		2	2.1	495430	6715089		-0.91	Good	Primary	Clarence Valley Council	Sluice gate on right two (2) gates.
F-1190-FP-0001	1/03/2020 15:30	Floodgate	1	1.2			494732	6714503		-0.17	Good	Primary	Clarence Valley Council	Buoyancy tidal gate.
F-1220-FB-0001	1/03/2020 14:46	Floodgate	4		1.8	2.1	498382	6719917		-0.16	Fair	Primary	Clarence Valley Council	Rubber seal peeling off flaps.
F-1230-FB-0001	1/03/2020 14:30	Floodgate	4		2.2	2.2	499785	6720946		-0.80	Good	Primary	Clarence Valley Council	
F-1310-FP-0001	1/03/2020 13:47	Floodgate	1	1.5			503254	6726071	-0.33		Good	Primary	Clarence Valley Council	Rock weir immediate on upstream side of floodgate with crest elevation of 0.58 m AHD. Square flap on circular culvert.
F-1410-FB-0001	6/02/2020 11:10	Floodgate	2		2	2.4	501932	6721384		-1.12	Fair	Primary	Clarence Valley Council	Rubber seal missing on the left side gate (looking downstream). Dimensions approximate.
F-1420-FB-0001	1/03/2020 11:55	Floodgate	2		2.1	2.1	509998	6717693		-1.07	Good	Primary	Clarence Valley Council	Winches for each gate
F-1425-FP-0001	6/02/2020 11:31	Floodgate	2	0.9			508973	6718801	-0.20		Good	Secondary	Clarence Valley Council	Cannot be winched open.
F-1430-FB-0001	6/02/2020 11:47	Floodgate	1		2	2.4	508899	6719584		-0.62	Good	Primary	Clarence Valley Council	Dimensions approximate.
F-1440-FB-0001	1/03/2020 11:45	Floodgate	1		2.1	2.15	510135	6715851		-1.12	Good	Primary	Clarence Valley Council	Gate acts as a sluice.
F-1450-FB-0001	1/03/2020 11:12	Floodgate	1		1.5	1.5	509342	6714510		-1.24	Good	Primary	Clarence Valley Council	Gate acts as a sluice.
F-1480-FP-0001	25/11/2019	Floodgate	1	0.9			509858	6714944	-0.51		Good	Secondary	Clarence Valley Council	Drop board upstream that is 1.5 m wide and has a crest elevation of 0.01 m AHD.
F-1530-FB-0001	1/03/2020 11:36	Floodgate	2		1.55	1.55	510065	6715254		-1.38	Good	Primary	Clarence Valley Council	Sluice on left gate.

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
F-1570-FB-0001	6/02/2020 12:06	Floodgate	4		2	2.2	509761	6720489			Poor	Primary	Clarence Valley Council	Left gate winched open and leaking. Dimensions approximate. QA check found poor GPS signal resulted in incorrect invert measurement.
F-1590-FP-0001	6/02/2020 12:21	Floodgate	1	1.2			510849	6725055		-0.73	Good	Primary	Clarence Valley Council	Invert based on 0.08 m pipe thickness. Dimensions approximate.
F-1590-FP-0001 buoyancy gate	6/02/2020 12:20	Buoyancy gate	1		0.6	0.9	510850	6725056		-0.50	Good		Clarence Valley Council	F1590 buoyancy tidal gate. Dimensions approximate.
F-1610-FP-0001	1/03/2020 12:26	Floodgate	1	1.2			512150	6721737		-0.23	Good	Primary	Clarence Valley Council	Square flap on circular culvert. Winch to open gate present.
F-1650-FB-0001	1/03/2020 14:01	Floodgate	3		2	2.5	503801	6725543		-0.54	Good	Primary	Clarence Valley Council	Water had foul odour. Boat access was good.
F-1660-FB-0001	1/03/2020 13:16	Floodgate	4		1.8	2.6	504666	6726776		-1.03	Good	Primary	Clarence Valley Council	Observed blackwater event.
F-1680-FB-0001	29/02/2020 14:22	Floodgate	3		2.1	2.1	511488	6729094		1.13	Good	Primary	Clarence Valley Council	Gates act as sluices.
F-1690-FP-0001	6/02/2020 12:58	Floodgate	2	1.8			511505	6728417		-0.33	Good	Secondary	Clarence Valley Council	Appears to have square flaps on circular culverts. The upstream side of the culvert is in private property.
F-1700-FB-0001	6/02/2020 12:46	Floodgate	6		2	2.4	511727	6727199		-1.31	Good	Primary	Clarence Valley Council	Left gate winches open. The upstream side of the culvert is in private property. Dimensions are approximate.
F-1710-FP-0001	6/02/2020 12:37	Floodgate	1	1.2			511395	6726746		-0.89	Poor	Primary	Clarence Valley Council	Gate leaking and rusty. Buoyancy tidal gate present. Dimensions approximate.
F-1730-FP-0001	1/03/2020 13:33	Floodgate	3	1.5			503478	6726338		-1.00	Good	Primary	Clarence Valley Council	Square flaps on circular culverts.
F-1740-FB-0001	1/03/2020 13:04	Floodgate	1		2.1	2.1	504997	6728275		-0.90	Good	Primary	Clarence Valley Council	
F-1790-FB-0001	29/02/2020 13:11	Floodgate	2		1.5	1.6	508268	6736660	-1.02		Good	Primary	Clarence Valley Council	
F-1805-FB-0001	29/02/2020 13:31	Floodgate	1		1.5	1.5	510081	6734576		-0.72	Good	Primary	Clarence Valley Council	Gate acts as a sluice.
F-1890-FB-0001	29/02/2020 13:48	Floodgate	4		2.1	2.1	510602	6733483		-1.50	Good	Primary	Clarence Valley Council	Sluice on two (2) right gates.
F-1900-FP-0001	29/02/2020 12:22	Floodgate	2	1.5			512721	6738018		-0.44	Good	Primary	Clarence Valley Council	Both gates have sluice function. Square flaps on circular culverts.
F-2030-FB-0001	29/02/2020 14:48	Floodgate	2		2.4	2.4	511152	6724947		-1.32	Good	Primary	Clarence Valley Council	Gates act as sluices.
F-2050-FP-0001	29/02/2020 15:09	Floodgate	1	1.5			514430	6730052		-0.81	Good	Primary	Clarence Valley Council	Square flap on circular culvert.
F-2080-FB-0001	4/02/2020 13:35	Floodgate	1		1.2	1.2	519625	6734359	-0.41		Good	Secondary	Clarence Valley Council	
F-2085-FP-0001	4/02/2020 12:50	Floodgate	1	1.5			519910	6733031	-0.37		Fair	Secondary	Clarence Valley Council	New culvert, old flap.
F-2150-FP-0001	29/02/2020 15:22	Floodgate	4	1.8			516660	6731989		-0.93	Good	Primary	Clarence Valley Council	Square flaps on circular culverts.
F-2200-FB-0001	28/02/2020 16:54	Floodgate	4		2.1	2.5	519874	6739439		-1.43	Good	Primary	Clarence Valley Council	Sluice on right gate.
F-2210-FB-0001	6/02/2020 9:17	Floodgate	3		2.1	2.2	519963	6734220	-0.37		Good	Primary	Clarence Valley Council	
F-2220-FP-0001	6/02/2020 8:57	Floodgate	1	1.2			520000	6733655	-1.10		Fair	Primary	Clarence Valley Council	Upstream and downstream sides underwater at the time of inspection
F-2230-FH-0001	4/02/2020 11:27	Weir	1		1.43		520342	6733167			Good	Secondary	Clarence Valley Council	GPS point was taken for the weir crest as 0.19 m AHD. Weir located upstream of F-2230-FP-0001.
F-2230-FP-0001	4/02/2020 11:01	Floodgate	1	1.2			520165	6733166	-1.13		Fair	Primary	Clarence Valley Council	Culvert was underwater.

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
F-2240-FP-0001	6/02/2020 8:48	Floodgate	1	1.2			519184	6731743	-0.6		Fair	Secondary	Clarence Valley Council	Bad vertical precision.
F-2260-FB-0001	6/02/2020 9:50	Floodgate	1		2	2	518576	6735376	-0.09		Good	Secondary	Clarence Valley Council	Cannot be winched open. Dimensions approximate.
F-2270-FB-0001	6/02/2020 9:40	Floodgate	1		2	2	518960	6734793	-0.09		Good	Secondary	Clarence Valley Council	Cannot be winched open. Dimensions approximate.
F-2275-FP-0001	6/02/2020 9:29	Floodgate	1	0.9			519357	6734524	-0.52		Fair	Secondary	Clarence Valley Council	
F-2300-FP-0003	27/02/2020 10:48	Floodgate	5	1.2			518387	6740069	-0.64		Good	Primary	Clarence Valley Council	Winches on upstream side. Good access to upstream side.
F-2340-FP-0001	26/11/2019	Floodgate	2		2.13	2.13	517885	6734659	-1.13		Good	Secondary	Clarence Valley Council	
F-2350-FP-0001	6/02/2020 14:28	Floodgate	2	1.8			518486	6736318		-0.21	Fair	Secondary	Clarence Valley Council	Dimensions approximate.
F-2380-FB-0001	29/02/2020 11:38	Floodgate	3		2.15	2.3	513561	6738710	-1.09		Good	Primary	Clarence Valley Council	Observed blackwater event.
F-2400-FB-0001 left	27/02/2020 10:30	Floodgate	1		2.1	1.5	516668	6740427	-0.49		Good	Primary	Clarence Valley Council	Good condition. Another circular structure in channel. See F-2400-FB-0001-Right.
F-2400-FB-0001 right	27/02/2020 10:36	Floodgate	1	1.5			516678	6740425		-0.44	Good	Primary	Clarence Valley Council	Good condition. Gate has buoyancy tidal gate. Another circular structure in channel. See F-2400-FB-0001-Left.
F-2440-FB-0001	29/02/2020 12:56	Floodgate	2		1.5	1.5	507183	6737694		-1.03	Good	Primary	Clarence Valley Council	
F-2490-FB-0001	29/02/2020 12:07	Floodgate	1		2.2	2.15	512323	6739309	-1.19		Good	Primary	Clarence Valley Council	Buoyancy tidal gate.
F-2540-FP-0001	29/02/2020 10:04	Floodgate	1	1.2			520711	6747671	-0.71		Fair	Primary	Clarence Valley Council	Makeshift plywood flap.
F-2560-FB-0001	29/02/2020 10:56	Floodgate	3		1.6	1.6	519891	6745794	-0.95		Good	Primary	Clarence Valley Council	Buoyancy tidal gate on centre flap. All gates have sluice capability.
F-2590-FB-0001	28/02/2020 17:14	Floodgate	1		1.5	1.6	518936	6742911	-1.34		Good	Primary	Clarence Valley Council	
F-2630-FB-0001 left	6/02/2020 14:59	Floodgate	1		2	2.2	520227	6742837	-0.40		Poor	Secondary	Clarence Valley Council	Both gates are leaking - the left hand side one quite significantly. The invert is the same for both culverts - dimensions are slightly different.
F-2630-FB-0001 right	6/02/2020 14:59	Floodgate	1		1.5	1.5	520227	6742837	-0.40		Poor	Secondary	Clarence Valley Council	Both gates are leaking - the left hand side one quite significantly. The invert is the same for both culverts - dimensions are slightly different.
F-2640-FB-0001	6/02/2020 15:09	Floodgate	1		1.96	1.7	520890	6743154		-0.41	Good	Primary	Clarence Valley Council	The upstream side of the culvert is in private property. Dimensions were taken from Clarence Valley Council dataset.
F-2640-FP-0001	6/02/2020 15:10	Floodgate	1	1.5			520893	6743159		-0.94	Good	Primary	Private/unknown	The upstream side of the culvert is in private property.
F-2670-FP-0001	6/02/2020 15:18	Floodgate	1	0.9			521419	6743419	-0.73		Good	Secondary	Clarence Valley Council	
F-2690-FP-0001	6/02/2020 16:14	Floodgate	2	1.5			525146	6743468		-1.06	Fair	Primary	Clarence Valley Council	A buoyancy tidal gate was located on the left flap however it was not surveyed (its invert was approximately 1 m below top of the pipe).
F-2700-FP-0001	6/02/2020 16:00	Floodgate	2	1.5			525726	6741828	-1.07		Good	Primary	Clarence Valley Council	Buoyancy tidal gate on the left flap.
F-2700-FP-0001 buoyancy gate	6/02/2020 16:05	Buoyancy gate			0.5	0.8	525747	6741833		-0.42	Good		Clarence Valley Council	Located on the left flap of F-2700-FP-0001. Dimensions approximate.
F-2710-FP-0001	6/02/2020 15:54	Floodgate	1	0.9			526233	6741291	-0.90		Good	Secondary	Clarence Valley Council	
F-2820-FT-0001	3/02/2020 16:32	Floodgate	3		1.52	1.52	526242	6747470	-0.46		Good	Primary	Clarence Valley Council	One buoyancy tidal gate located on the right hand gate (looking downstream).

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
F-2820-FT-0001 buoyancy gate	3/02/2020 16:39	Buoyancy gate			0.8	0.8	526250	6747473		0.15	Good		Clarence Valley Council	On the right hand gate of F-2820-FT-0001 (looking downstream).
F-2830-FT-0001	29/02/2020 9:06	Floodgate	1		1.5	1.5	526343	6747215	-0.79		Good	Primary	Clarence Valley Council	Gate acts as a sluice.
F-2890-FB-0001	7/02/2020 10:20	Floodgate	1		1.7	1.7	523082	6744618	-1.18		Fair	Primary	Clarence Valley Council	It has a buoyance tidal gate with an obvert of 0.21 m AHD (dimensions not measured). Dimensions approximate for the culvert.
F-2910-FB-0001	26/02/2020 16:23	Floodgate	2		1.3	1.5	523689	6747034	-1.02		Fair	Primary	Clarence Valley Council	Some weed in front of the gate. Buoyancy tidal gate located on the right hand flap (looking downstream). Width is approximate.
F-2910-FB-0001 buoyancy gate	26/02/2020 16:26	Buoyancy gate	1				523681	6747046		-0.79	Fair		Clarence Valley Council	Located on the right gate of F-2910-FB-0001. Invert and dimensions are approximate only.
F-2920-LD-0001	4/02/2020 15:40	Floodgate	2	1.5			525734	6748344	-0.75		Good	Primary	Clarence Valley Council	Buoyance tidal gate on the left gate approximately 0.6 wide by 0.8 m high. Head wall falling in. Otherwise in good condition.
F-2940-LD-0001	27/02/2020 14:44	Floodgate	5		1.5	1.5	525761	6748931	-0.84		Good	Primary	Clarence Valley Council	Tidal fish gate on right hand side gate.
F-2950-FB-0001	5/02/2020 9:55	Floodgate	3		1.5	1.8	523835	6748684	-1.32		Good	Primary	Clarence Valley Council	Buoyancy tidal gate on the right hand flap (looking downstream).
F-2950-FB-0001 buoyancy gate	5/02/2020 9:59	Buoyancy gate	1		0.6	0.6	523835	6748674		-0.49	Good		Clarence Valley Council	Buoyancy tidal gate on the right gate of F-2950-FB-0001. Approximate invert level. Gate was underwater when inspected.
F-3000-FB-0001	5/02/2020 10:51	Floodgate	1		1.52	1.52	522547	6750112	-0.96		Fair	Primary	Clarence Valley Council	Can be winched open. No dimensions recorded so taken from CRCC dataset.
F-3090-FB-0001	27/02/2020 15:23	Floodgate	1		1.5	1.6	527970	6750712	-1.34		Good	Primary	Clarence Valley Council	
F-3100-FB-0001	27/02/2020 15:43	Floodgate	1		1.5	1.6	530269	6750488	-1.05		Good	Primary	Clarence Valley Council	Buoyancy tidal gate.
F-3130-FP-0001	7/02/2020 10:20	Floodgate	1	0.9			528239	6750218	-0.10		Good	Secondary	Clarence Valley Council	
F-3135-FP-0001	7/02/2020 11:09	Floodgate	1	0.9			529179	6749981	-0.28		Good	Secondary	Clarence Valley Council	
F-3170-FB-0001	27/02/2020 13:54	Floodgate	3		1.6	1.6	530154	6748601	-1.17		Good	Primary	Clarence Valley Council	Winch on two (2) right gates.
F-3190-FP-0001	27/02/2020 14:15	Floodgate	1	1.2			527851	6749393	-1.06		Good	Primary	Clarence Valley Council	Underwater at time of inspection. Log present to use to winch gates open.
F-3210-FB-0001	6/02/2020 16:30	Floodgate	2		1.4	1.6	529017	6740209	-0.95		Fair	Primary	Clarence Valley Council	Buoyancy tidal gate on the right flap. Dimensions approximate.
F-3210-FB-0001 buoyancy gate	6/02/2020 16:32	Buoyancy gate			0.5	0.8	529015	6740199		-0.05	Good		Clarence Valley Council	Located on the right flap of F-3210-FB-0001. Dimensions approximate.
F-3220-FP-0001	6/02/2020 16:41	Floodgate	1	1.5			527066	6741197		-1.30	Fair	Primary	Clarence Valley Council	Tidal flush not surveyed (approximate dimensions are 0.5m wide by 0.8 m high).
F-3250-FP-0001	3/03/2020 13:57	Floodgate	1	1.2			528527	6743588	-0.81		Poor	Secondary	Clarence Valley Council	The pipe is cracked. There are mangroves in the channel upstream.
F-3250-FP-0005	3/03/2020 14:05	Floodgate					528602	6743904			Fair	Primary	Clarence Valley Council	Could not see the culvert due to the water level being too high. Culvert appeared blocked. Survey measurement was taken of concrete that was believed to be the obvert. Obvert elevation was 0.15 m AHD. Could not determine the number of culverts or their dimensions.
F-4530-FP-0001	27/11/2019	Floodgate	1	1.2			518240	6729728	-0.25		Fair	Secondary	Clarence Valley Council	Flap is kept partially opened by a large piece of wood.
F-4770-FP-0001	27/02/2020 9:43	Floodgate	1	0.45			523545	6743997		1.25	Good	Secondary	Clarence Valley Council	Side channel structure. Approximate obvert measured.

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 CLAR 10	6/02/2020 14:09	Culvert	1	1.8			516614	6732189		0.37	Good	Secondary	Private/unknown	Upstream side is in good condition, however, downstream side was not accessible.
WRL_CLAR_01	26/11/2019	Culvert	1	1			517576	6734524	-1.43	-1.48	Good	Secondary	Private/unknown	Water quality upstream and downstream are the same as there is no flap.
WRL_CLAR_02	26/11/2019	Floodgate	1	0.5			517597	6734538		2.15	Good	Secondary	Private/unknown	There is a pump upstream.
WRL_CLAR_03	26/11/2019	Floodgate	1	1.5			517594	6734532	0.19		Good	Secondary	Private/unknown	
WRL_CLAR_04	26/11/2019	Floodgate	1	0.9			517596	6734527		-0.60	Fair	Secondary	Private/unknown	
WRL_CLAR_05	27/11/2019	Culvert	2		2		517174	6729856			Good		Private/unknown	Sluice gate on right hand culvert and a drop board on the left hand culvert (looking downstream). Crest elevation of the top right corner on the left hand drop board was measured. Actual crest elevation is 0.35 m below the GPS measurement (0.29 m AHD) at -0.06 m AHD.
WRL_CLAR_06	4/02/2020 15:05	Floodgate	1	0.6			526194	6747923	-0.62		Fair	Secondary	Private/unknown	Upstream and downstream were underwater at the time of inspection.
WRL_CLAR_07	6/02/2020 13:42	Floodgate	1	1.5			507564	6728925	0.05			Secondary	Private/unknown	The downstream side of the culvert is in private property.
WRL_CLAR_08	29/02/2020 15:30	Culvert	1	1.8			518060	6732955		-1.00	Other	Secondary	Private/unknown	Floodgate removed and relocated upstream.
WRL_CLAR_09	1/03/2020 13:44	Weir/sluice gate	4		1.8	0.6	503282	6726052		-0.84	Good	Secondary	Clarence Valley Council	Alumy Creek weir with crest elevation of 1.1 m AHD. Four (4) sluice gates that can be removed (currently in place) to lower weir crest level.

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

Table F-4: Summary of data from other sources

Structure ID	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Invert (m AHD)	Category	Tenure	Condition	Data source	Comment
F1005 FP0001	Floodgate	1	0.6			490319	6720735	5.748	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1025 FP0001	Floodgate	1	1.05			490397	6717748	3.975	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1030 FB0001	Floodgate	1		1.2	1.2	490574	6717270	0.606	Primary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1030 FP0001	Floodgate	1	1.2			490684	6717173	0.205	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1060 FP0001	Floodgate	1	1.65			493009	6714357	-0.828	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1060 FP0002	Floodgate	1	1.65			493000	6714348	0.161	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1060 FP0003	Floodgate	1	1.2			493032	6714357	0.109	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1130 FB0004	Floodgate	1	1.2			495381	6715784	0.091	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1130 FP0002	Floodgate	1	1.2			495371	6717104	2.056	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1130 FP0003	Floodgate	1	0.75			495464	6716277	0.68	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1130 FP0005	Floodgate	1		1.2	1.2	495319	6715545	0.777	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1130 FP0007	Floodgate	1		1.5	1.5	495026	6715162	-0.606	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1130 FP0008	Floodgate	1	1.65			494868	6715044	-0.088	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1130 FP0009	Floodgate	1		1.5	1.5	494611	6714938	-0.025	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1130 FP0019	Floodgate	1	0.45			492874	6715735	3.821	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1130 FP0020	Floodgate	1	1.05			492240	6716965	2.787	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Floodgate located inside a grated pit
F1130 PR0001	Floodgate	1	1.65			495429	6717413	-0.314	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1170 FB0001	Floodgate	7		2.1	2.1	496257	6717261	-1.037	Primary	Clarence Valley Council	Good	Abbot and Macro 2023	Structure consists of 6 2.1 m by 2.1 m box culverts at the given invert level, plus one higher 0.6 m diameter pipe at 1.532 m AHD. All 7 culverts are fitted with floodgates, and one of the box culverts is fitted with a winch
F1520 FT0001	Floodgate	1	1.65			509918	6717188	-1.023	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1560 FB0001	Floodgate	1		2.1	2.3	511967	6722606	-1.005	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1590 FP0001	Floodgate	1	1.65			510850	6725057	-0.728	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1595 FB0001	Floodgate	2		1.8	1.8	511261	6724283	-0.357	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	2 floodgates
F1600 FP0001	Floodgate	1	1.35			511126	6720288	-1.059	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1665 FP0001	Floodgate	1	1.65			504688	6727090	0.262	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1750 FP0001	Floodgate	1	1.65			507260	6729850	-0.92	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1800 FB0001	Floodgate	2		2.1	2.1	509984	6735201	-0.752	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	2 floodgates
F1810 FB0001	Floodgate	2		2.15	2.15	509694	6732122	-1.21	Primary	Clarence Valley Council		Glamore et al. 2019	2 floodgates
F1910 FB0001	Floodgate	1		1.8	1.8	511529	6737190	0.263	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1950 FP0001	Floodgate	1	1.65			514601	6730680	0.243	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1960 FP0001	Floodgate	1	1.65			515307	6732321	0.19	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F1970 FP0001	Floodgate	1	1.2			512359	6737680	0.259	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2000 FT0001	Floodgate	1	1.65			511600	6728544	-0.973	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2010 FB0001	Floodgate	1		2.1	2.1	512244	6727832	-0.651	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2020 FP0001	Floodgate	1	1.65			511903	6727203	-0.838	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2040 FP0001	Floodgate	1	1.65			511962	6723034	-0.969	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2060 FP0001	Floodgate	1	1.05			512564	6729115	1.725	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2090 FP0001	Floodgate	1	1.2			518795	6731538	-0.425	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2100 FP0001	Floodgate	1	0.9			518515	6731556	-0.655	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2110 FP0001	Floodgate	4	1.2			518505	6731550	-0.269	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	4 floodgates
F2120 FP0001	Floodgate	1	1.2			518352	6730763	-0.617	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Adjustable weir observed upstream
F2130 FP0001	Floodgate	2	1.65			518190	6729721	-0.912	Primary	Clarence Valley Council	Good	Abbot and Macro 2023	2 floodgates
F2160 FP0001	Floodgate	1	1.2			518654	6735049	0.129	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2170 FP0001	Floodgate	1	1.65			518118	6731179	-0.029	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	An old culvert was observed downstream
F2235 FP0001	Floodgate	1	1.2			519363	6732418	-0.712	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2245 FP0001	Floodgate	1	1.2			518423	6730938	-1.23	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2250 FP0002	Floodgate	1	1.65			519033	6736984	-1.027	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2290 FP0001	Floodgate	1	1.05			519063	6737524	-0.719	Secondary	Clarence Valley Council	Fair	Abbot and Macro 2023	Floodgate has an old concrete flap with a broken seal, leaking observed
F2300 FP0004	Floodgate	1	1.8			518949	6737691	-0.639	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2310 FP0001	Floodgate	5	0.9			518732	6740246	-0.646	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	5 floodgates
F2310 FP0003	Floodgate	1	0.375			518725	6740247	0.046	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	

Structure ID	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Invert (m AHD)	Category	Tenure	Condition	Data source	Comment
F2320 FP0001	Floodgate	1	1.65			517979	6739992	-1.154	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2330 FP0001	Floodgate	1	1.5			517232	6740092	0.081	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2340 FB0001	Floodgate	1	0.6			517974	6733252	-0.75	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2380 FP0001	Floodgate	1	1.05			513539	6738724	-0.842	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2380 FP0002	Floodgate	1	1.05			513537	6738711	-0.683	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2380 FP0003	Floodgate	1	0.45			513450	6738727	0.348	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2380 FP0004	Floodgate	1	0.45			513244	6738764	1.019	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2380 FP0005	Floodgate	1	0.45			513453	6738741	1.085	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2380 FP0006	Floodgate	1	0.45			513250	6738778	0.771	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2385 FP0001	Floodgate	1	1.65			516485	6740755	-0.468	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Lots of native freshwater fish and weeds observed upstream
F2395 FP0001	Floodgate	1	1.5			516344	6741023	-0.431	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2430 FB0001	Floodgate	1		1.5	1.5	508729	6736606	-1.12	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2500 FB0001	Floodgate	1		1.8	1.8	513678	6741875	0.456	Primary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2510 FB0001	Floodgate	1		1.5	1.5	512382	6741535	-1.255	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2510 FP0001	Floodgate	1	0.3			512218	6741969	-0.169	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2520 FP0001	Floodgate	1	0.9			514956	6742123	-0.475	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2530 FB0001	Floodgate	1	1.35			513378	6740089	-1.081	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2550 FP0001	Floodgate	1	1.35			520510	6748212	-0.992	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2552 FP0001	Floodgate	1	1.05			520506	6746664	-0.376	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Watermain and pipe observed downstream
F2554 FP0001	Floodgate	1	1.05			520472	6746306	-0.803	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Structure has a steel chute above for pumping
F2570 FP0001	Floodgate	1	0.9			519306	6745530	-1.064	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2580 FP0001	Floodgate	1	0.9			518978	6744893	-0.675	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2600 FP0001	Floodgate	1	1.05			518569	6741234	-0.945	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2620 FP0001	Floodgate	1	1.35			519324	6744015	-1.233	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2650 FP0001	Culvert	2	1.5			522378	6743885	-1.728	Primary	Clarence Valley Council	Fair	Abbot and Macro 2023	Culvert is half full of silt, evidence of recent erosion mitigation works above, 2 floodgates
F2730 FP0001	Floodgate	3	1.5			530296	6738744	-1.082	Primary	Clarence Valley Council		Invert: Clarence Valley Council Dimensions: Abbot and Macro 2023	3 floodgates
F2740 FP0001	Floodgate	2	1.5			528580	6738429	-0.882	Primary	Clarence Valley Council		Invert: Clarence Valley Council Dimensions: Abbot and Macro 2023	2 floodgates
F2750 FP0001	Floodgate	3	1.5			527130	6737539	-1.005	Primary	Clarence Valley Council		Invert: Clarence Valley Council Dimensions: Abbot and Macro 2023	3 floodgates
F2760 FP0001	Floodgate	2	1.5			526688	6736305	-0.904	Primary	Clarence Valley Council		Invert: Clarence Valley Council Dimensions: Abbot and Macro 2023	2 floodgates
F2770 FP0001	Floodgate	3	1.5			527227	6735217	-0.893	Primary	Clarence Valley Council		Invert: Clarence Valley Council Dimensions: Abbot and Macro 2023	3 floodgates
F2780 FP0001	Floodgate	3	1.5			528659	6733100	-0.984	Primary	Clarence Valley Council		Invert: Clarence Valley Council Dimensions: Abbot and Macro 2023	3 floodgates
F2850 FP0001	Floodgate	1	1.5			526819	6746374	-0.776	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2860 FB0001	Floodgate	2		2.1	2.1	522491	6746546	-1.379	Primary	Clarence Valley Council	Good	Abbot and Macro 2023	2 floodgates
F2870 FP0001	Floodgate	1	1.35			520826	6746005	-0.666	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2880 FP0001	Floodgate	1	1.35			523450	6747132	1.19	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2900 FP0001	Floodgate	1	1.05			522688	6746999	-0.226	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2905 FB0001	Floodgate	1	1.35			521724	6746290	-0.354	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Some rust on flap
F2905 FP0002	Floodgate	1	0.9			521312	6746490	-0.035	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2910 FB0002	Floodgate	1	0.75			525052	6748107	-0.378	Secondary	Clarence Valley Council	Fair	Abbot and Macro 2023	Floodgate flap rusty and hanging from chains

Structure ID	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Invert (m AHD)	Category	Tenure	Condition	Data source	Comment
F2915 FP0001	Floodgate	1	1.35			524766	6748182	-0.508	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2925 FP0001	Floodgate	1	1.05			526306	6748543	-0.508	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2925 FP0002	Floodgate	1	0.45			525907	6748482	0.205	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2930 FP0001	Floodgate	1	1.5			523565	6747081	-0.077	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2935 FP0001	Floodgate	1	1.35			522429	6744601	-0.572	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2945 FP0001	Floodgate	1	1.2			526048	6750361	-0.477	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Structure has a tidal sluice, in good condition
F2946 FB0001	Floodgate	1		1.2	1.4	526722	6750567	-0.51	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2947 FP0001	Floodgate	1	0.9			525962	6750107	-0.539	Secondary	Clarence Valley Council	Fair	Abbot and Macro 2023	Floodgate has rusted hinges and a custom flap
F2960 FB0001	Floodgate	1		1.5	1.5	523781	6747704	-0.883	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2970 FB0001	Floodgate	1		1.5	1.5	522551	6747061	-1.149	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F2980 FP0001	Floodgate	2	0.9			521678	6747651	-0.97	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	2 floodgates
F2985 FP0001	Floodgate	1	0.9			524320	6751254	-0.131	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F3010 FP0001	Floodgate	1	1.05			521118	6748832	-0.588	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F3020 FP0001	Floodgate	1	0.9			520909	6747683	-0.845	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F3030 FP0001	Floodgate	1	0.9			523768	6751267	-1.295	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F3040 FP0001	Floodgate	1	0.9			522619	6750748	-0.834	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F3050 FP0002	Floodgate	1	0.9			523098	6751134	-0.929	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F3080 FP0001	Floodgate	1	1.5			525986	6751993	-0.982	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F3085 FP0001	Floodgate	1	1.2			528850	6751129	-0.293	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F3110 FP0001	Floodgate	1	0.9			527519	6751271	-0.463	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Structure pipe is cracked
F3120 FP0001	Floodgate	1	0.75			527037	6749804	0.423	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F3140 FP0001	Floodgate	1	0.9			531256	6749657	-0.476	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F3180 FP0001	Floodgate	1	1.5			529960	6746583	-0.851	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F3182 FP0001	Floodgate	1	1.5			528821	6745537	-0.843	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F3195 FP0001	Floodgate	1	1.2			527645	6748926	-0.299	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F3200 FP0001	Floodgate	1	1.65			527822	6744425	-0.727	Primary	Clarence Valley Council	Good	Abbot and Macro 2023	
F3205 FP0001	Floodgate	2	1.35			528029	6744898	-0.769	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	2 floodgates
F3240 FT0001	Floodgate	2	1.35			528572	6742045	-0.8	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	2 floodgates
F3250 FP0002	Floodgate	1	0.9			528701	6744078	-0.467	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F3250 FP0003	Floodgate	1	0.75			530354	6738650	-0.243	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Sheet piles blocking drain upstream
F3250 FP0004	Floodgate	2	1.05			528541	6742718	-0.496	Primary	Clarence Valley Council	Good	Abbot and Macro 2023	2 floodgates
F3250 FP0006	Floodgate	1	1.05			529585	6740774	-0.158	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F3250 FT0007	Floodgate	1	1.35			530845	6739442	-0.661	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Structure has a tidal sluice which looks seized
F3500 FB0001	Floodgate	2		1.8	1.5	534188	6743571	-0.385	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	2 floodgates
F3500 FP0002	Floodgate	1	0.375			533471	6743596	-0.173	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Structure has a rubber diaphragm for the floodgate
F3500 FP0005	Floodgate	1	0.6			533379	6743471	0.283	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F3500 FP0006	Culvert	2	0.6			532635	6744450	0.297	Secondary	Clarence Valley Council	Fair	Abbot and Macro 2023	Structure has silt half way up the pipe, 2 floodgates
F4010 FP0002	Floodgate	1	0.3			492816	6714376	3.329	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4010 FP0003	Floodgate	1	0.3			492866	6714378	0.86	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4010 FP0005	Floodgate	1	0.3			493462	6714422	4.076	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4010 FP0007	Floodgate	1	0.3			493683	6714358	4.631	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4010 FP0009	Floodgate	1	1.5			494176	6714417	0.267	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4010 FP0010	Floodgate	1	0.6			494174	6714359	5.605	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Floodgate located above the levee
F4010 FP0011	Floodgate	1	0.3			494277	6714444	6.143	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4010 FP0012	Floodgate	1	0.45			493900	6714331	2.705	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Floodgate located in grated pit
F4010 FP0014	Floodgate	1	0.15			494290	6714445	6.154	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4010 FP0015	Floodgate	1	0.45			493801	6714348	2.186	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4010 FP0016	Floodgate	1	0.15			494293	6714445	6.554	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4010 FP0017	Floodgate	1	0.225			494312	6714452	5.588	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4020 FB0001	Floodgate	2		2.1	2.1	491185	6715624	0.766	Primary	Clarence Valley Council	Good	Abbot and Macro 2023	2 floodgates
F4020 FP0001	Floodgate	1	0.3			491386	6715449	7.33	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4020 FP0002	Floodgate	1	0.3			491626	6715212	6.702	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4020 FP0003	Floodgate	1	0.375			491781	6715109	6.026	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Structure in South Grafton caravan park
F4020 FP0004	Floodgate	1	0.3			491836	6715063	6.27	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Structure in South Grafton caravan park
F4020 FP0008	Floodgate	1	0.15			491531	6715302	7.259	Secondary	Clarence Valley Council	Fair	Abbot and Macro 2023	

Structure ID	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Invert (m AHD)	Category	Tenure	Condition	Data source	Comment
F4020 FP0006	Floodgate	1	0.15			491897	6714995	6.544	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4020 FP0007	Floodgate	1	0.3			491973	6714945	5.349	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Floodgate blocked by silt and grass
F4020 FP0009	Floodgate	1	0.3			492052	6714863	6.305	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4020 FP0014	Floodgate	1	0.15			492428	6714619	6.625	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4020 FP0015	Floodgate	1	0.375			492430	6714617	5.775	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4020 FP0020	Floodgate	1	0.375			492629	6714441	6.933	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4030 FD0001	Floodgate	1	0.1			489927	6718682	7.853	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4030 FP0004	Floodgate	1	0.375			490994	6716315	6.637	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4030 FP0005	Floodgate	1	0.45			490791	6716827	6.679	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4030 FP0006	Culvert	1	0.15			490678	6717018	7.708	Secondary	Clarence Valley Council	Fair	Abbot and Macro 2023	
F4030 FP0007	Floodgate	1	0.15			490707	6716966	7.787	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4030 FP0008	Culvert	1	0.15			490759	6716882	7.422	Secondary	Clarence Valley Council	Fair	Abbot and Macro 2023	
F4030 FP0009	Floodgate	1	0.15			490950	6716632	7.662	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4070 FP0048	Floodgate	1	0.15			495143	6715365	6.19	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4070 FP0051	Floodgate	1	0.6			495162	6715376	4.563	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4090 FP0014	Floodgate	1	0.45			492893	6715724	6.139	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4090 FP0021	Floodgate	1	0.6			492389	6716404	1.167	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4090 FP0022	Floodgate	1	0.45			492441	6716495	7.745	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4090 FP0023	Floodgate	1	0.3			492390	6716614	6.139	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4090 FP0024	Floodgate	1	0.3			492390	6716617	6.261	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4090 FP0025	Floodgate	1	0.3			492367	6716677	6.449	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4090 FP0026	Floodgate	1	0.3			492359	6716677	5.159	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4090 FP0027	Floodgate	1	0.3			492338	6716743	6.542	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4090 FP0028	Floodgate	1	0.3			492333	6716745	5.071	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4090 FP0029	Floodgate	1	0.3			492306	6716812	5.71	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4090 FP0030	Floodgate	1	0.45			492263	6716915	6.305	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4090 FP0031	Floodgate	1	0.3			492255	6716953	7.044	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4090 FP0032	Floodgate	1	1.05			492126	6716804	0.33	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4110 FP0001	Floodgate	1	0.9			496416	6718555	2.535	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4110 FP0002	Floodgate	1	0.9			496076	6718253	1.626	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4250 FP0001	Floodgate	1	0.75			501964	6721437	3.486	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4260 FP0002	Floodgate	1	0.3			503249	6723178	3.56	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4260 FP0003	Floodgate	1	0.3			503354	6723498	3.651	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4260 FP0004	Floodgate	1	0.3			503387	6723711	3.67	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4320 FP0001	Floodgate	3	1.5			508808	6714178	-0.243	Primary	Clarence Valley Council	Good	Abbot and Macro 2023	Structure consists of 3 floodgates, winch located on north pipe
F4320 FP0004	Floodgate	1	1.35			508838	6714177	-0.888	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4360 FP0001	Floodgate	1	0.6			509897	6720490	2.042	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4460 FP0034	Culvert	1	0.45			507517	6736884	0.793	Secondary	Clarence Valley Council	Fair	Abbot and Macro 2023	Structure pipe cracked and falling into river
F4460 FP0037	Culvert	1	0.45			509326	6736351	2.091	Secondary	Clarence Valley Council	Fair	Abbot and Macro 2023	Floodgate flap has fallen off, headwall falling into pit
F4460 FP0038	Culvert	1	0.45			507815	6736788	1.101	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	No floodgates, structure is just a pipe
F4570 FP0001	Floodgate	1	0.375			517709	6739998	1.538	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4570 FP0002	Floodgate	1	0.375			517868	6739993	1.106	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4570 FP0003	Floodgate	1	0.375			518132	6740014	1.227	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4570 FP0004	Floodgate	1	0.3			518294	6740063	1.469	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4570 FP0005	Floodgate	1	0.375			518560	6740145	0.608	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4570 FP0006	Floodgate	1	0.375			518671	6740210	0.478	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4570 FP0007	Floodgate	1	0.375			518785	6740286	0.757	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4610 FB0001	Floodgate	5		1.2	1.2	507314	6737597	0.191	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	5 floodgates
F4650 FP0001	Floodgate	1	1.2			514613	6741566	-1.51	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4650 FP0002	Floodgate	1	1.2			513926	6741751	-1.376	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Observed large hole in levee above pipe, possibly collapsed
F4650 FP0003	Floodgate	2	1.65			515163	6741601	-1.139	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	2 floodgates
F4650 FP0005	Floodgate	2	1.5			513083	6742117	-0.723	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	2 floodgates
F4650 FP0006	Floodgate	2	1.5			511537	6741813	-0.22	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	2 floodgates
F4650 FP0007	Floodgate	2	1.5			510827	6741776	-0.726	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	2 floodgates
F4730 FP0001	Floodgate	1	0.225			520138	6742811	2.09	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4730 FP0002	Floodgate	1	0.3			519012	6741498	0.501	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4730 FP0004	Floodgate	1	0.3			519008	6741482	0.558	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	

Structure ID	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Invert (m AHD)	Category	Tenure	Condition	Data source	Comment
F4730 FP0005	Floodgate	1	0.3			518997	6741357	1.272	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4730 FP0006	Floodgate	1	0.3			519000	6741408	0.322	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4730 FP0007	Floodgate	1	0.3			519025	6741532	0.362	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4730 FP0011	Floodgate	1	0.45			519101	6741677	-0.206	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4730 FP0012	Floodgate	1		1.2	1.2	519203	6741859	-0.664	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Pump observed above levee wall
F4730 FP0013	Floodgate	1	0.375			520352	6742924	1.061	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4730 FP0015	Floodgate	1	0.45			519778	6742546	0.417	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4730 FP0017	Floodgate	1	0.375			520017	6742729	1.5004	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4730 FP0018	Floodgate	1	0.375			520189	6742840	0.597	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4730 FP0019	Floodgate	1	0.375			520091	6742785	0.514	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4730 FP0020	Floodgate	2	0.45			519377	6742130	-0.251	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	2 floodgates
F4730 FP0021	Floodgate	1	0.3			519006	6741465	-0.19	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4730 FP0028	Floodgate	1	0.45			519143	6741753	0.126	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Structure has a cage around the outlet
F4730 FP0029	Floodgate	1		2.4	1.2	518997	6741286	-0.027	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Screw down floodgate
F4730 FP0030	Floodgate	1	0.3			518992	6741299	0.349	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4730 FP0031	Floodgate	1	0.6			519550	6742324	0.181	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Drain downstream needs clearing
F4730 RA0003	Floodgate	3		1.5	1.5	519053	6741586	-0.482	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	3 floodgates
F4870 FP0001	Culvert	1	0.45			525927	6749583	-0.067	Secondary	Clarence Valley Council	Fair	Abbot and Macro 2023	Bottom of the culvert is blocked with silt
F4870 FP0002	Floodgate	1	0.6			526002	6749741	0.083	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4950 FP0001	Floodgate	1	0.75			526200	6750276	0.026	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4950 FP0002	Floodgate	1	1.2			526535	6750410	-0.544	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4950 FP0003	Floodgate	1	0.9			530283	6749689	-0.222	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Box culvert located downstream
F4950 FP0004	Culvert	1	0.9			526773	6749684	-1.044	Secondary	Clarence Valley Council	Poor	Abbot and Macro 2023	Sheet piles installed, pipe may be redundant
F4950 FP0005	Floodgate	1	0.45			526985	6750591	0.063	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4950 FP0007	Floodgate	1	0.45			528551	6750180	0.354	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4950 FP0008	Floodgate	1	0.45			529446	6749829	0.695	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Structure at Port of Yamba wharf, box drain located above
F4950 FP0009	Floodgate	1	0.45			527349	6749958	0.133	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4950 FP0010	Floodgate	1	0.45			527553	6750044	0.747	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F4950 FP0011	Floodgate	1	0.375			527980	6750166	0.771	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F5020 FP0002	Floodgate	1	1.2			529178	6746041	-0.529	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F5020 FP0003	Floodgate	1	1.2			529120	6746116	-0.205	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F5050 FP0001	Floodgate	1	0.45			528360	6744455	0.023	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F5130	Floodgate	2	0.45			533704	6748406	0.201	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	2 floodgates
F5130 FP0001	Floodgate	1	0.3			533741	6748569	0.468	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Rubber diaphragm for floodgate
F5130 FP0002	Floodgate	1	0.3			533770	6748667	1.334	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Pump out device observed near levee wall
F5130 FP0004	Floodgate	1	0.3			533778	6748724	0.209	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F5130 FP0006	Floodgate	1		1	1.2	533887	6747884	0.465	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	Piece of wood jammed in gate
F5130 FP0007	Floodgate	1	0.45			533839	6747933	0.906	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
F5130 FP0008	Floodgate	3	0.75			533732	6748495	-0.477	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	3 floodgates
F5130 FP0014	Floodgate	1	1.2			533693	6748212	0.226	Secondary	Clarence Valley Council	Good	Abbot and Macro 2023	
Sportsmans Creek Weir	Floodgate	40		1.2	1.8	506990	6737418	-0.62	Primary	Sportsmans Creek Drainage Union		Invert: Glamore et al. (2019) Dimensions: Abbot and Macro 2023	
UNK001	Drain	1				531593	6743566	0.228	Secondary	Private/Unknown		Abbot and Macro 2023	
UNK002	Floodgate	2	0.45			531435	6743073	0.039	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	Erosion observed around pipe, 2 floodgates
UNK003	Culvert	1		0.9	0.6	531974	6741821	-0.042	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	
UNK004	Floodgate	1	0.9			530658	6743263	-0.849	Secondary	Private/Unknown	Good	Abbot and Macro 2023	Structure has a tidal sluice without float
UNK005	Floodgate	1	0.9			530727	6743072	-0.499	Secondary	Private/Unknown	Good	Abbot and Macro 2023	Structure has a missing tidal float, rope used
UNK006	Floodgate	1	0.9			530831	6742967	-0.908	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	Floodgate flap damaged with holes, hand winch located on fence

Structure ID	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Invert (m AHD)	Category	Tenure	Condition	Data source	Comment
UNK007	Bund	1				530864	6742335	-0.274	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	Structure is a bridge with bund, invert of bund given
UNK008	Culvert	1	1.2			531024	6740412	-0.853	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	Structure has steel headwalls and a steel pipe but no floodgate. Erosion was observed around the pipe
UNK009	Culvert	1	1.2			530123	6741327	-1.536	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	Structure located at start of fish farm. Pipe buried beneath rocks and rubble
UNK010	Culvert	1	0.75			530964	6740419	-0.673	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	Erosion observed downstream
UNK011	Culvert	1	0.75			530939	6740424	-0.635	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	Headwall is broken
UNK012	Culvert	1	0.75			530844	6740437	-0.464	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	
UNK013	Culvert	1	0.75			530756	6740452	-0.68	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	
UNK014	Culvert	1	0.75			530734	6740454	-1.214	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	Erosion observed around pipe
UNK015	Culvert	1	0.75			530651	6740463	-0.762	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	Bund is collapsed and headwall is leaning. Tide is bypassing the pipe
UNK016	Culvert	1	0.75			530602	6740470	-1.119	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	Erosion observed behind the headwall
UNK017	Culvert	1	0.75			530567	6740477	-0.796	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	Erosion observed behind the headwall
UNK018	Culvert	1	0.75			530484	6740491	0.055	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	Pond is full of grass
UNK019	Culvert	1	0.75			530468	6740493	-0.612	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	Erosion observed behind the headwall
UNK020	Culvert	1	0.75			530411	6740501	-0.802	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	Headwall is broken
UNK021	Culvert	1	0.75			530348	6740509	-0.338	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	
UNK022	Culvert	1	0.75			530300	6740515	-0.569	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	Headwall is falling off
UNK023	Culvert	1	0.75			530264	6740519	-0.908	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	Bad erosion, bund wall is gone
UNK024	Culvert	1	0.75			530193	6740531	-0.644	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	
UNK025	Culvert	1	0.75			530146	6740538	-0.25	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	
UNK026	Culvert	1	0.75			530100	6740542	-0.604	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	The headwall is sunk, bad erosion
UNK027	Culvert	1	0.75			530057	6740551	-0.577	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	Erosion observed around pipe
UNK028	Culvert	1	0.75			529948	6740645	-0.819	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	
UNK029	Culvert	1	0.75			529906	6740675	-0.719	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	Headwall is falling off
UNK030	Culvert	1	0.75			529861	6740698	-0.618	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	Headwall is falling off
UNK031	Culvert	1	0.75			529758	6740718	-0.571	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	
UNK032	Culvert	1	0.75			529734	6740727	-0.256	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK033	Culvert	1	0.75			529697	6740838	-0.59	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	
UNK034	Culvert	1	0.75			529665	6740937	-0.388	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK035	Culvert	1	0.75			529628	6741034	-0.225	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK036	Culvert	1	0.75			529588	6741136	-0.446	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	
UNK037	Culvert	1	0.45			529550	6741211	-0.187	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	Smaller pond
UNK038	Culvert	1	0.45			529510	6741270	-0.494	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	Smaller pond
UNK040	Culvert	1	0.6			529309	6743473	999	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	
UNK041	Culvert	1	0.6			529490	6743591	-0.115	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	
UNK043	Floodgate	1	0.6			528232	6745024	-0.223	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	Custom flap
UNK045	Inlet pipes	1				529874	6746493	999	Secondary	Private/Unknown		Abbot and Macro 2023	3x 300 mm inlet pipes to fish farm, no ends found
UNK046	Culvert	1	0.9			530148	6746666	-1.159	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK047	Floodgate	1	1.05			530997	6746787	-0.529	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK048	Sheet pile	1				531166	6746795	1.471	Secondary	Private/Unknown		Abbot and Macro 2023	Pipe has been removed and sheet piles are in place. Elevation of top of sheet pile is given
UNK049	Culvert	1	0.45			530807	6748092	0.257	Secondary	Private/Unknown	Good	Abbot and Macro 2023	Fish farm outlet pipe
UNK050	Floodgate	1	0.3			530728	6748037	0.035	Secondary	Private/Unknown	Good	Abbot and Macro 2023	PVC pipe
UNK051	Floodgate	1	0.3			530744	6748034	-0.312	Secondary	Private/Unknown	Good	Abbot and Macro 2023	PVC pipe
UNK053	Culvert	1	1.05			533620	6747116	-0.419	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	Pipe is crakced
UNK054	Culvert	1	0.45			533699	6747564	0.773	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	One quarter full of silt

Structure ID	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Invert (m AHD)	Category	Tenure	Condition	Data source	Comment
UNK058	Ground	1	0.3			530599	6749538	0.836	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	Pump pipes for fish farm, end location unknown, ground elevation given at pipes
UNK059	Floodgate	1	0.6			530494	6749592	-0.029	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	Floodgate is very rusty and not functioning, full of mud
UNK060	Culvert	2	0.45			531850	6749095	-0.149	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	2 culverts
UNK064	Floodgate	1	0.375			528135	6750609	0.454	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK069	Inlet pipes	1				527701	6749205	999	Secondary	Private/Unknown		Abbot and Macro 2023	Fish farm pump station. 2x 450 mm and 1x 150 mm steel pipes underwater
UNK071	Floodgate	1	0.375			527520	6748314	0.321	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK073	Culvert	1	0.75			527550	6747015	0.06	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	Old flap fallen off in front of floodgate
UNK074	Culvert	1	0.375			527536	6746808	0.975	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK075	Floodgate	1	0.45			527515	6746485	-0.429	Secondary	Private/Unknown	Good	Abbot and Macro 2023	1050 pipe redundant. 450 pipe in use
UNK076	Floodgate	1	0.45			527296	6745733	0.104	Secondary	Private/Unknown	Good	Abbot and Macro 2023	Quarter full of silt
UNK077	Culvert	1	0.3			527288	6745680	0.832	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	Pipe and headwall broken off pipeline
UNK078	Floodgate	1	0.6			527284	6745535	0.589	Secondary	Private/Unknown	Good	Abbot and Macro 2023	Lots of flood debris around headwall
UNK079	Culvert	1	0.375			525680	6742787	0.345	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	
UNK080	Culvert	1	0.45			526406	6741341	0.747	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	Headwall fallen off, no floodgate
UNK082	Culvert	1		1.2	0.9	527687	6740742	-0.566	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK083	Culvert	1	0.3			528733	6740106	-0.02	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	Floodgate fallen off
UNK084	Culvert	1	0.375			528877	6740073	-0.067	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	Pipe cracked floodgate flap fallen off, hinges still there
UNK085	Culvert	1	0.45			527408	6740894	-0.112	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	Pipe no floodgate
UNK086	Culvert	1	0.45			527408	6740897	0.033	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	Pipe and headwall no floodgate
UNK088	Floodgate	1	0.375			525831	6742336	0.407	Secondary	Private/Unknown	Good	Abbot and Macro 2023	Macadamia plantation
UNK090	Floodgate	1	0.9			523757	6748504	-0.396	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK091	Culvert	1	0.375			523974	6748646	-0.381	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	
UNK092	Floodgate	1	0.45			524341	6748447	-0.195	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK093	Floodgate	1	0.45			524395	6748398	-0.149	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK094	Floodgate	1	0.75			524446	6748269	-0.64	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK095	Floodgate	1	0.45			524509	6748353	0.112	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK096	Floodgate	1	0.375			524629	6748331	0.39	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK097	Floodgate	1	0.45			525184	6748228	-0.274	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK100	Floodgate	1	0.45			526473	6749279	0.304	Secondary	Private/Unknown	Good	Abbot and Macro 2023	Downstream drain recently dug
UNK103	Culvert	1	0.9			524755	6751315	-0.691	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	Pipe quarter full of silt
UNK104	Floodgate	2	0.9			525289	6751078	-0.375	Secondary	Private/Unknown	Good	Abbot and Macro 2023	2 floodgates
UNK106	Bridge	1				521088	6748545	-0.916	Secondary	Private/Unknown		Abbot and Macro 2023	No pipes wooden bridge
UNK108	Floodgate	1	0.6			522711	6750402	0.275	Secondary	Private/Unknown	Poor	Abbot and Macro 2023	Flap falling off, pipe half full of silt
UNK118	Bridge	1				522206	6750949	999	Secondary	Private/Unknown		Abbot and Macro 2023	Wooden bridge, no pipes
UNK119	Culvert	1	0.6			522012	6750734	0.245	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK120	Floodgate	1	0.75			521854	6750419	-0.559	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK122	Floodgate	1	0.45			520813	6749145	-0.416	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK123	Floodgate	1	0.45			520709	6748855	-0.463	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK124	Floodgate	1	0.375			520689	6748581	-0.171	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK125	Floodgate	1	0.3			520955	6749014	-0.208	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK126	Floodgate	1	0.6			520164	6748667	-0.363	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK127	Floodgate	1	0.1			520399	6748410	0.435	Secondary	Private/Unknown	Good	Abbot and Macro 2023	100mm pvc pipe with flap
UNK128	Floodgate	1	0.3			520530	6748273	-0.235	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK131	Culvert	1	0.1			518994	6744474	0.492	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	100mm pvc pipe with no flap
UNK138	Floodgate	1	0.9			512254	6741908	-0.388	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK139	Floodgate	1	0.9			512257	6741900	-0.504	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK141	Culvert	1	0.375			514847	6740877	0.23	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	
UNK142	Floodgate	1	0.45			509556	6730797	1.849	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK143	Floodgate	1	1.05			508425	6730127	0.752	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK144	Floodgate	1	0.9			508204	6730080	0.934	Secondary	Private/Unknown	Good	Abbot and Macro 2023	

Structure ID	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Invert (m AHD)	Category	Tenure	Condition	Data source	Comment
UNK145	Floodgate	1	1.05			519329	6740322	0.501	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK147	Culvert	1		1.2	1.2	518575	6735981	0.293	Secondary	Private/Unknown	Good	Abbot and Macro 2023	Very old box culvert
UNK148	Floodgate	1	0.6			518717	6736305	2.005	Secondary	Private/Unknown	Good	Abbot and Macro 2023	Floodgate in grated pit
UNK151	Floodgate	1	0.45			510735	6720200	2.168	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK153	Floodgate	1	1.35			510874	6719927	-0.218	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK154	Culvert	1	0.6			509589	6719967	-0.031	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	
UNK157	Floodgate	1	0.3			507449	6728976	2.072	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK158	Floodgate	1	0.375			518395	6736079	2.242	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	
UNK159	Floodgate	1	0.375			518362	6735983	2.105	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	Bad siltation around flap
UNK160	Floodgate	1	0.375			518124	6735345	1.404	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK161	Floodgate	1	0.375			517537	6732322	1.702	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK162	Culvert	1	0.375			516328	6732182	2.777	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK163	Culvert	1	0.375			515968	6732202	1.657	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK164	Floodgate	1		0.9	1.4	509934	6736858	0.403	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK166	Floodgate	1	0.45			507416	6737312	1.044	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK167	Culvert	1	0.45			508069	6736815	1.398	Secondary	Private/Unknown	Good	Abbot and Macro 2023	No gate just pipe
UNK168	Floodgate	1	0.45			508934	6736505	-0.076	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK169	Floodgate	1	0.225			509770	6735786	2.327	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK170	Floodgate	1	0.3			510040	6734957	2.303	Secondary	Private/Unknown	Good	Abbot and Macro 2023	Has pit just upstream
UNK172	Floodgate	1	1.05			507529	6730189	0.022	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK173	Floodgate	1	0.9			502516	6723204	-0.217	Secondary	Private/Unknown	Good	Abbot and Macro 2023	Has floodgate on downstream side as well
UNK175	Floodgate	1	0.9			504604	6726767	1.741	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK176	Floodgate	1	0.45			502622	6722107	4.585	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK177	Floodgate	1	0.6			502453	6721929	3.338	Secondary	Private/Unknown	Good	Abbot and Macro 2023	Inside a grated pit
UNK178	Culvert	1	0.45			499367	6719653	2.09	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK184	Floodgate	1	0.09			492999	6715543	7.304	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK189	Floodgate	1	1.05			492254	6716614	1.319	Secondary	Private/Unknown	Good	Abbot and Macro 2023	
UNK191	Culvert	1	1.2			491807	6721582	2.421	Secondary	Private/Unknown	Fair	Abbot and Macro 2023	
UNK192	Floodgate	1	0.15			492041	6714867	6.977	Secondary	Private/Unknown	Good	Abbot and Macro 2023	Inside a grated pit

Table F-5 Summary of Unsurveyed Structures

Structure ID	Easting (m)	Northing (m)	Sub-catchment	Comment
F1130 FP0010	493980	6714919	Alumy Creek	Not inspected
F1130 FP0011	493725	6714955	Alumy Creek	Not inspected
F1130 FP0012	493528	6715064	Alumy Creek	Not inspected
F1130 FP0013	493523	6715069	Alumy Creek	Not inspected
F1130 FP0014	493390	6715170	Alumy Creek	Not inspected
F1130 FP0015	493268	6715249	Alumy Creek	Not inspected
F1130 FP0016	493163	6715353	Alumy Creek	Not inspected
F1130 FP0017	493154	6715362	Alumy Creek	Not inspected
F1130 FP0018	493090	6715425	Alumy Creek	Not inspected
F4070 FP0001	493302	6715251	Alumy Creek	Not inspected
F4070 FP0002	493334	6715220	Alumy Creek	Not inspected
F4070 FP0004	493415	6715173	Alumy Creek	Not inspected
F4070 FP0005	493568	6715074	Alumy Creek	Not inspected
F4070 FP0006	493604	6715054	Alumy Creek	Not inspected
F4070 FP0007	493629	6715053	Alumy Creek	Not inspected
F4070 FP0008	493638	6715048	Alumy Creek	Not inspected
F4070 FP0009	493699	6715015	Alumy Creek	Not inspected
F4070 FP0010	493750	6715003	Alumy Creek	Not inspected

Structure ID	Easting (m)	Northing (m)	Sub-catchment	Comment
F4070 FP0011	493737	6714998	Alumy Creek	Not inspected
F4070 FP0012	493754	6715007	Alumy Creek	Not inspected
F4070 FP0013	493756	6715004	Alumy Creek	Not inspected
F4070 FP0014	493757	6715004	Alumy Creek	Not inspected
F4070 FP0015	493760	6715002	Alumy Creek	Not inspected
F4070 FP0016	493783	6714975	Alumy Creek	Not inspected
F4070 FP0017	493828	6714968	Alumy Creek	Not inspected
F4070 FP0018	493877	6714941	Alumy Creek	Not inspected
F4070 FP0019	494029	6714910	Alumy Creek	Not inspected
F4070 FP0022	494749	6714993	Alumy Creek	Not inspected
F4070 FP0023	494770	6715005	Alumy Creek	Not inspected
F4070 FP0024	494806	6715014	Alumy Creek	Not inspected
F4070 FP0025	494778	6715008	Alumy Creek	Not inspected
F4070 FP0026	494820	6715035	Alumy Creek	Not inspected
F4070 FP0027	494828	6715039	Alumy Creek	Not inspected
F4070 FP0028	494836	6715050	Alumy Creek	Not inspected
F4070 FP0029	494874	6715064	Alumy Creek	Not inspected
F4070 FP0030	494885	6715071	Alumy Creek	Not inspected
F4070 FP0031	494893	6715083	Alumy Creek	Not inspected
F4070 FP0032	494902	6715091	Alumy Creek	Not inspected
F4070 FP0033	494906	6715098	Alumy Creek	Not inspected
F4070 FP0034	494920	6715107	Alumy Creek	Not inspected
F4070 FP0035	494933	6715115	Alumy Creek	Not inspected
F4070 FP0037	494965	6715143	Alumy Creek	Not inspected
F4070 FP0038	494971	6715147	Alumy Creek	Not inspected
F4070 FP0039	495005	6715147	Alumy Creek	Not inspected
F4070 FP0040	495024	6715197	Alumy Creek	Not inspected
F4070 FP0041	495083	6715255	Alumy Creek	Not inspected
F4070 FP0042	495092	6715279	Alumy Creek	Not inspected
F4070 FP0043	495113	6715301	Alumy Creek	Not inspected
F4070 FP0044	495116	6715320	Alumy Creek	Not inspected
F4070 FP0045	495130	6715332	Alumy Creek	Not inspected
F4070 FP0046	495131	6715346	Alumy Creek	Not inspected
F4070 FP0047	495141	6715354	Alumy Creek	Not inspected
F4070 FP0052	495182	6715416	Alumy Creek	Not inspected
F4070 FP0053	495179	6715424	Alumy Creek	Not inspected
F4070 FP0054	495219	6715480	Alumy Creek	Not inspected
F4070 FP0055	495224	6715483	Alumy Creek	Not inspected
F4070 FP0056	495223	6715496	Alumy Creek	Not inspected
F4070 FP0057	495236	6715518	Alumy Creek	Not inspected
F4070 FP0058	495242	6715526	Alumy Creek	Not inspected
F4070 FP0059	495244	6715533	Alumy Creek	Not inspected
F4070 FP0060	495309	6715677	Alumy Creek	Not inspected
F4070 FP0061	495315	6715702	Alumy Creek	Not inspected
F4070 FP0062	495323	6715720	Alumy Creek	Not inspected

Structure ID	Easting (m)	Northing (m)	Sub-catchment	Comment
F4070 FP0063	495335	6715748	Alumy Creek	Not inspected
F4090 FP0001	493291	6715292	Alumy Creek	Not inspected
F4090 FP0002	493206	6715329	Alumy Creek	Not inspected
F4090 FP0004	493040	6715477	Alumy Creek	Not inspected
F4090 FP0005	493030	6715492	Alumy Creek	Not inspected
F4090 FP0006	492938	6715638	Alumy Creek	Not inspected
F4090 FP0007	492937	6715639	Alumy Creek	Not inspected
F4090 FP0008	492931	6715651	Alumy Creek	Not inspected
F4090 FP0009	492935	6715648	Alumy Creek	Not inspected
F4090 FP0010	492937	6715646	Alumy Creek	Not inspected
F4090 FP0011	492929	6715652	Alumy Creek	Not inspected
F4090 FP0012	492918	6715663	Alumy Creek	Not inspected
F4090 FP0013	492918	6715672	Alumy Creek	Not inspected
F4090 FP0015	492805	6715855	Alumy Creek	Not inspected
F4090 FP0016	492818	6715921	Alumy Creek	Not inspected
F4090 FP0017	492799	6715920	Alumy Creek	Not inspected
F4090 FP0018	492644	6716179	Alumy Creek	Not inspected
F4090 FP0019	492548	6716296	Alumy Creek	Not inspected
PRIVATE 4070 FP11V2	493831	6714968	Alumy Creek	Not inspected
UNK190	491388	6718407	Alumy Creek	Inspected not found
F4260 FP0005	503378	6723718	Coldstream River	Inspected not found
UNK149	511803	6721163	Coldstream River	Inspected not found
UNK150	511630	6720630	Coldstream River	Inspected not found
UNK152	510802	6719921	Coldstream River	Inspected not found
UNK155	509833	6716862	Coldstream River	Inspected not found
UNK156	511467	6728604	Coldstream River	Inspected not found
F4570 FP0008	518920	6740370	Gulmarrad/East Woodford Island	Inspected not found
F4950 FP0006	529042	6750028	Harwood/Chatsworth/Goodwood/Warregah Islands	Inspected not found
UNK061	0	0	Harwood/Chatsworth/Goodwood/Warregah Islands	Inspected not found
UNK062	532402	6749456	Harwood/Chatsworth/Goodwood/Warregah Islands	Inspected not found
UNK063	532345	6749625	Harwood/Chatsworth/Goodwood/Warregah Islands	Inspected not found
UNK098	525413	6748174	Harwood/Chatsworth/Goodwood/Warregah Islands	Inspected not found
UNK101	526339	6747968	Harwood/Chatsworth/Goodwood/Warregah Islands	Inspected not found
UNK105	525663	6749156	Harwood/Chatsworth/Goodwood/Warregah Islands	Inspected not found
UNK107	521713	6749967	Harwood/Chatsworth/Goodwood/Warregah Islands	Inspected not found
F4730 FP0008	519422	6742197	Maclean	Inspected not found
F4730 FP0016	519963	6742696	Maclean	Not inspected
UNK109	519102	6741689	Maclean	Inspected not found
UNK110	519061	6741613	Maclean	Inspected not found
UNK111	519053	6741604	Maclean	Inspected not found
UNK112	519005	6741431	Maclean	Inspected not found
UNK113	523670	6751952	Mororo/Ashby	Inspected not found
UNK114	522988	6751289	Mororo/Ashby	Inspected not found
UNK115	522693	6751271	Mororo/Ashby	Inspected not found
UNK116	522808	6751272	Mororo/Ashby	Inspected not found

Structure ID	Easting (m)	Northing (m)	Sub-catchment	Comment
UNK117	522582	6751223	Mororo/Ashby	Inspected not found
UNK121	521061	6749498	Mororo/Ashby	Inspected not found
UNK129	520584	6746954	Mororo/Ashby	Inspected not found
UNK130	520586	6746954	Mororo/Ashby	Inspected not found
UNK132	519340	6743514	Mororo/Ashby	Inspected not found
F3250 FP0005	528601	6743907	Palmers Island/Micalo Island/Yamba	Inspected not found
F5020 FP0001	529233	6745834	Palmers Island/Micalo Island/Yamba	Inspected not found
F5050 FP0002	528176	6744532	Palmers Island/Micalo Island/Yamba	Inspected not found
UNK039	528746	6742617	Palmers Island/Micalo Island/Yamba	Inspected not found
UNK042	529117	6741320	Palmers Island/Micalo Island/Yamba	Inspected not found
UNK044	529384	6746145	Palmers Island/Micalo Island/Yamba	Inspected not found
UNK052	530763	6748025	Palmers Island/Micalo Island/Yamba	Inspected not found
UNK065	529113	6749202	Palmers Island/Micalo Island/Yamba	Inspected not found
UNK066	529057	6749130	Palmers Island/Micalo Island/Yamba	Inspected not found
UNK067	528792	6749317	Palmers Island/Micalo Island/Yamba	Inspected not found
UNK068	528680	6749399	Palmers Island/Micalo Island/Yamba	Inspected not found
UNK070	527697	6749181	Palmers Island/Micalo Island/Yamba	Inspected not found
UNK072	527491	6748117	Palmers Island/Micalo Island/Yamba	Inspected not found
UNK081	527425	6741294	Palmers Island/Micalo Island/Yamba	Inspected not found
F2130 FP0002	518195	6729760	Shark Creek	Inspected not found
F2140 FP0001	518097	6732947	Shark Creek	Inspected not found
F4010 DB0002	494058	6714329	South Grafton	Inspected not found
F4010 DB0003	494059	6714338	South Grafton	Inspected not found
F4010 DB0004	494079	6714346	South Grafton	Inspected not found
F4010 DB0005	494084	6714370	South Grafton	Inspected not found
F4010 DB0006	494086	6714379	South Grafton	Inspected not found
F4010 DB0007	494092	6714377	South Grafton	Inspected not found
F4010 FP0013	493520	6714400	South Grafton	Inspected not found
F4020 FP0009	492118	6714829	South Grafton	Not inspected
F4020 FP0010	492258	6714725	South Grafton	Not inspected
F4020 FP0011	492325	6714704	South Grafton	Not inspected
F4020 FP0012	492350	6714687	South Grafton	Not inspected
F4020 FP0013	492397	6714651	South Grafton	Not inspected
F4020 FP0016	492455	6714593	South Grafton	Not inspected
F4020 FP0017	492486	6714567	South Grafton	Not inspected
F4020 FP0018	492531	6714516	South Grafton	Not inspected
F4020 FP0019	492528	6714495	South Grafton	Not inspected
F1760 FP0001	506612	6729145	Southgate	Not inspected
UNK171	510195	6733008	Sportsmans Creek	Inspected not found
UNK087	525851	6742067	Taloumbi/Palmers Channel	Inspected not found
UNK089	525496	6743239	Taloumbi/Palmers Channel	Inspected not found
F2510 FP0002	512340	6741559	The Broadwater	Inspected not found
UNK133	516077	6743610	The Broadwater	Inspected not found
UNK134	509734	6744833	The Broadwater	Inspected not found
UNK135	509555	6744951	The Broadwater	Inspected not found

Structure ID	Easting (m)	Northing (m)	Sub-catchment	Comment
UNK136	509910	6744665	The Broadwater	Inspected not found
UNK137	509832	6744435	The Broadwater	Inspected not found
UNK140	512326	6738954	The Broadwater	Inspected not found
UNK055	528443	6751165	The Freshwater	Inspected not found
UNK056	528008	6751174	The Freshwater	Inspected not found
UNK057	527684	6751347	The Freshwater	Inspected not found

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 Clarence 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-47.

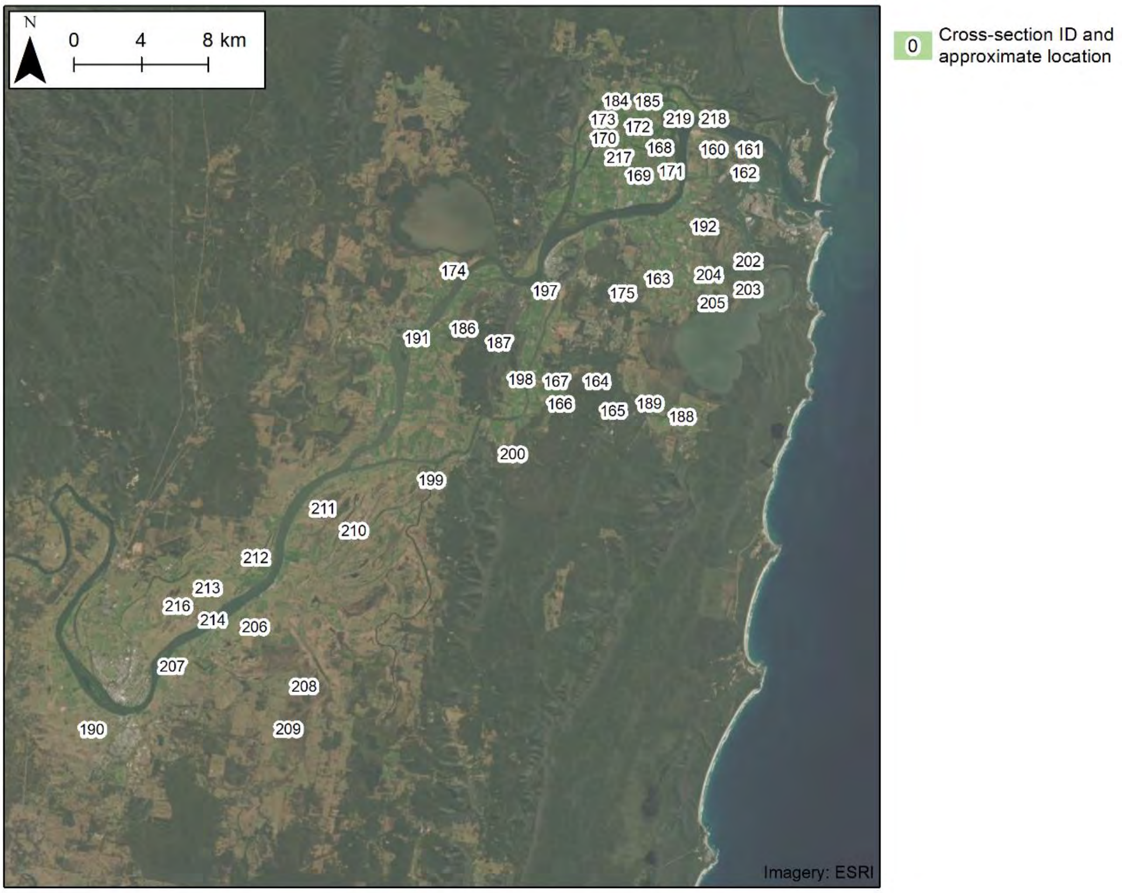


Figure G-1: General location of cross-sections surveyed on the Clarence River floodplain

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)
160	529058.8	6748251.7	529064.0	6748244.5
161	529078.6	6748240.2	529085.6	6748238.0
162	529093.5	6748252.1	529092.9	6748244.0
163	525735.6	6740487.1	525759.4	6740518.5
164	522069.8	6734391.5	522078.3	6734398.4

Cross-section ID	Coordinates (GDA 1994 MGA 56)			
	Start Easting (m)	Start Northing (m)	End Easting (m)	End Northing (m)
165	522040.5	6734395.6	522040.3	6734392.7
166	519900.3	6733051.8	519893.0	6733044.4
167	518684.1	6733984.5	518679.7	6733985.5
168	525859.3	6748336.5	525853.9	6748346.7
169	525870.4	6748322.8	525873.2	6748324.3
170	524773.8	6749200.3	524771.7	6749186.9
171	524549.0	6749566.3	524557.0	6749565.3
172	524551.2	6749600.8	524545.3	6749588.3
173	522480.9	6750032.2	522499.0	6750024.0
174	513539.7	6740986.6	513543.2	6740980.2
175	524573.9	6740204.0	524572.4	6740196.1
184	524195.2	6750581.5	524198.9	6750591.9
185	524197.6	6750571.7	524205.9	6750567.5
186	514127.5	6737547.1	514116.2	6737553.7
187	514186.1	6737545.4	514187.1	6737550.5
188	526179.2	6732694.7	526187.4	6732690.8
189	525242.9	6733062.9	525254.5	6733062.6
190	491930.3	6713600.5	491930.3	6713584.9
191	511366.4	6736966.7	511373.4	6736960.9
192	528531.8	6743641.0	528521.7	6743643.3
197	519016.2	6739800.3	519038.1	6739798.8
198	517560.1	6734518.8	517565.5	6734509.1
199	512196.3	6728474.5	512204.6	6728478.9
200	517105.6	6730053.0	517092.4	6730037.0
202	529114.3	6740698.8	529116.0	6740709.7
203	529093.8	6740719.7	529110.3	6740715.8
204	528801.9	6740757.1	528822.3	6740752.4
205	528800.3	6740951.2	528799.5	6740941.4
206	501653.5	6719721.3	501662.4	6719718.0
207	496741.0	6717370.5	496730.0	6717376.1
208	504631.3	6716164.9	504632.9	6716181.7
209	503678.0	6713614.6	503653.5	6713618.4
210	505693.3	6726740.8	505690.1	6726752.9
211	505776.3	6726785.2	505765.7	6726793.1
212	501750.2	6723860.3	501753.1	6723837.4
213	498867.9	6722057.2	498851.5	6722038.5
216	497062.2	6720973.7	497076.1	6720984.9
217	523460.7	6747755.6	523459.8	6747743.9
218	526999.7	6750084.5	527002.9	6750077.0
219	526991.5	6750069.3	526999.4	6750072.6
214	497113.3	6720984.2	497107.9	6721004.1

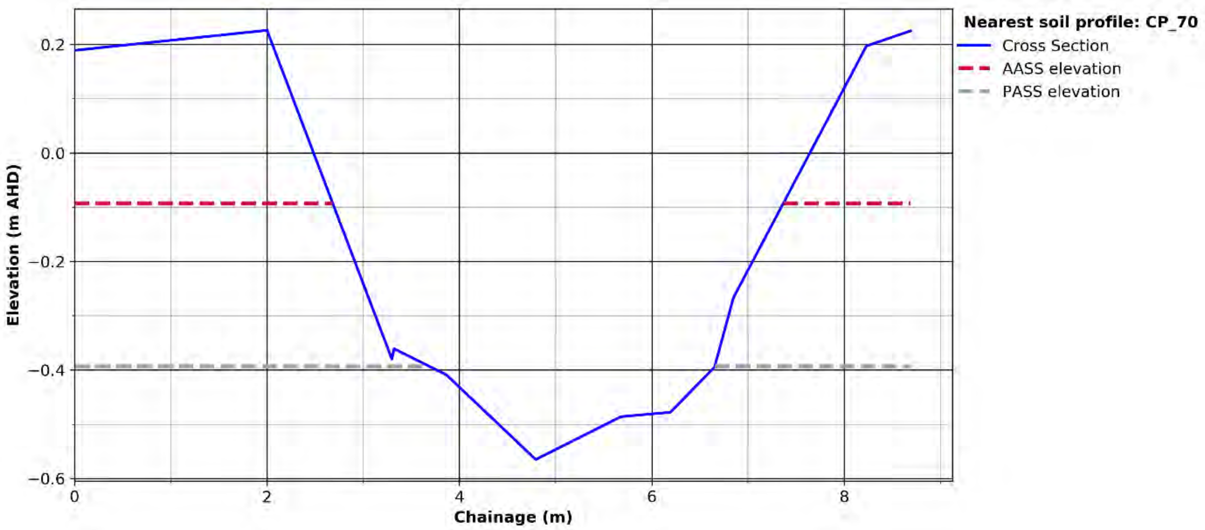


Figure G-2: Clarence cross-section 160

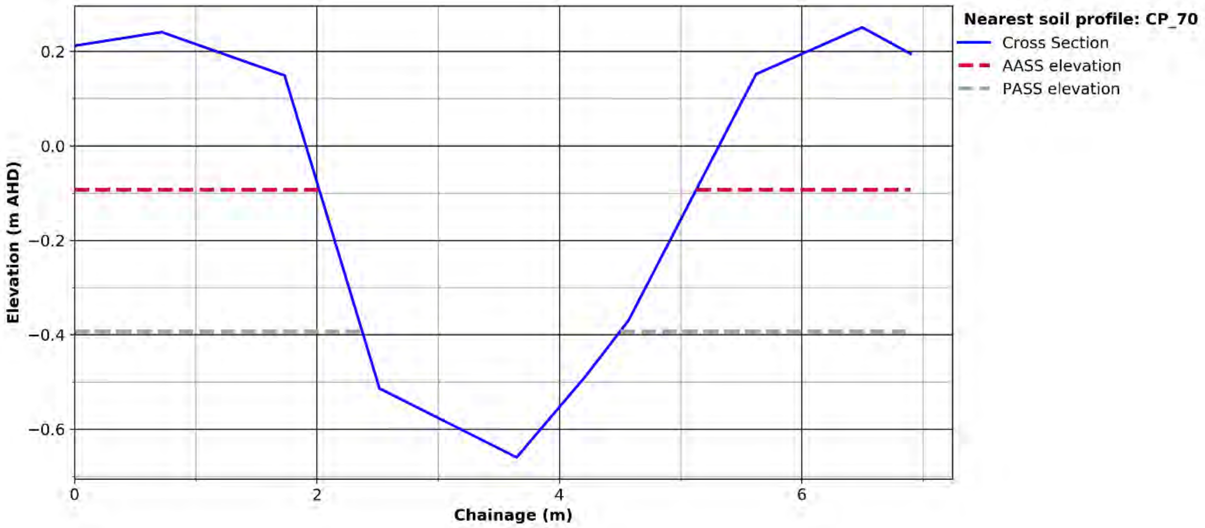


Figure G-3: Clarence cross-section 161

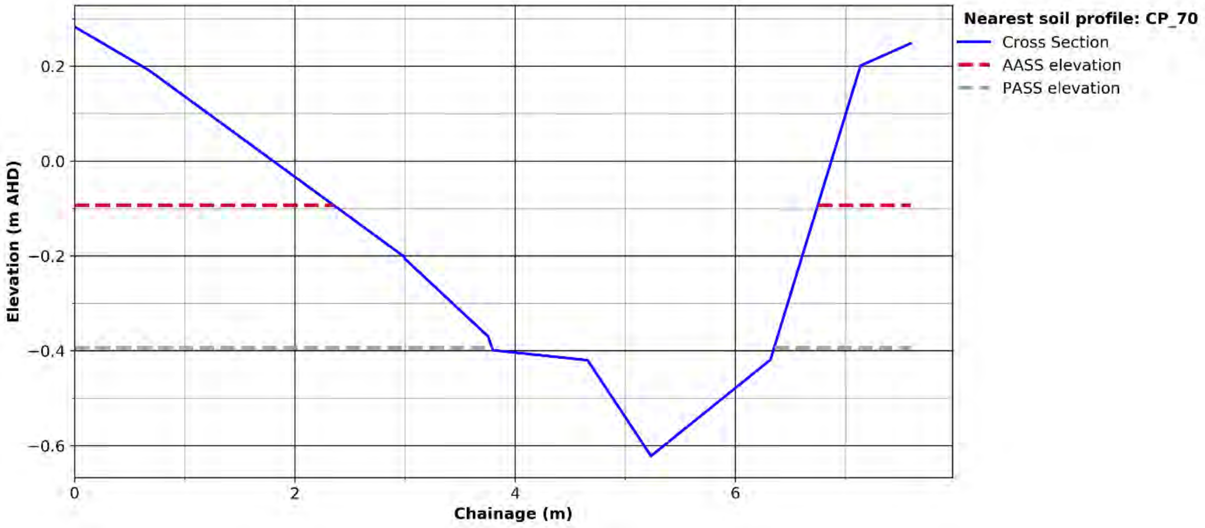


Figure G-4: Clarence cross-section 162

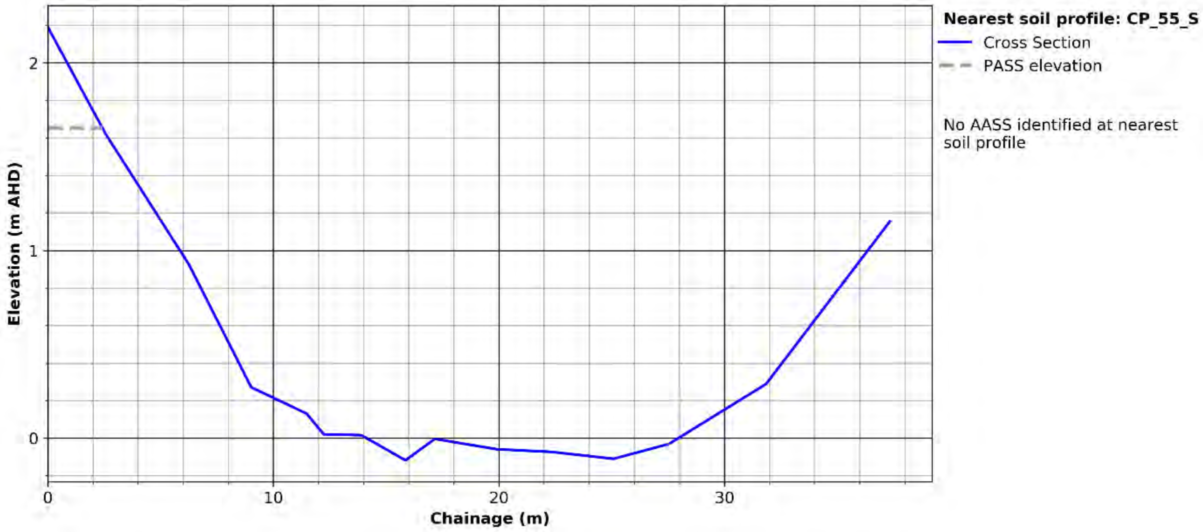
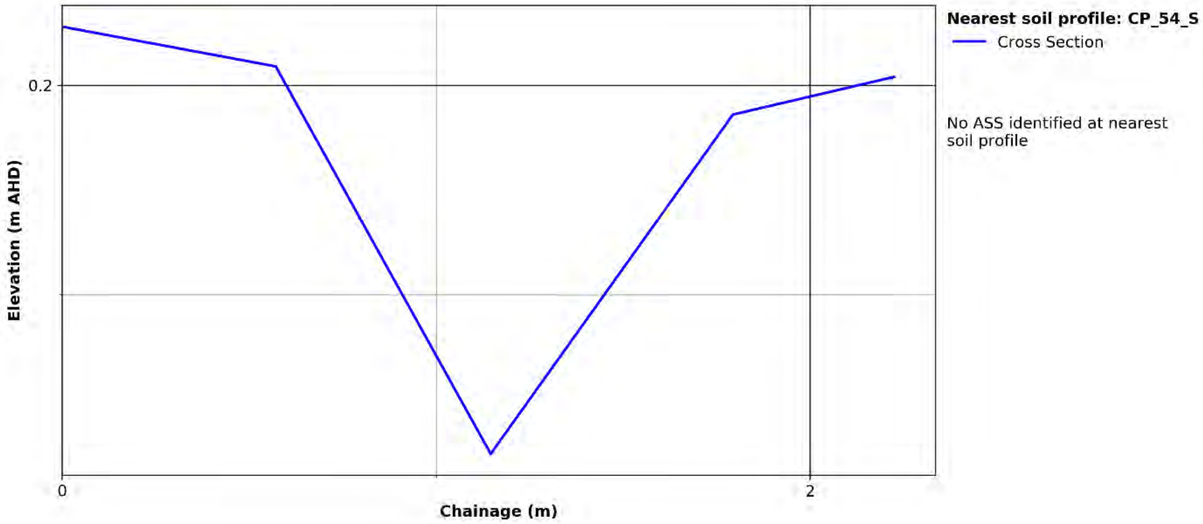


Figure G-5: Clarence cross-section 163

Figure G-6: Clarence cross-section 164



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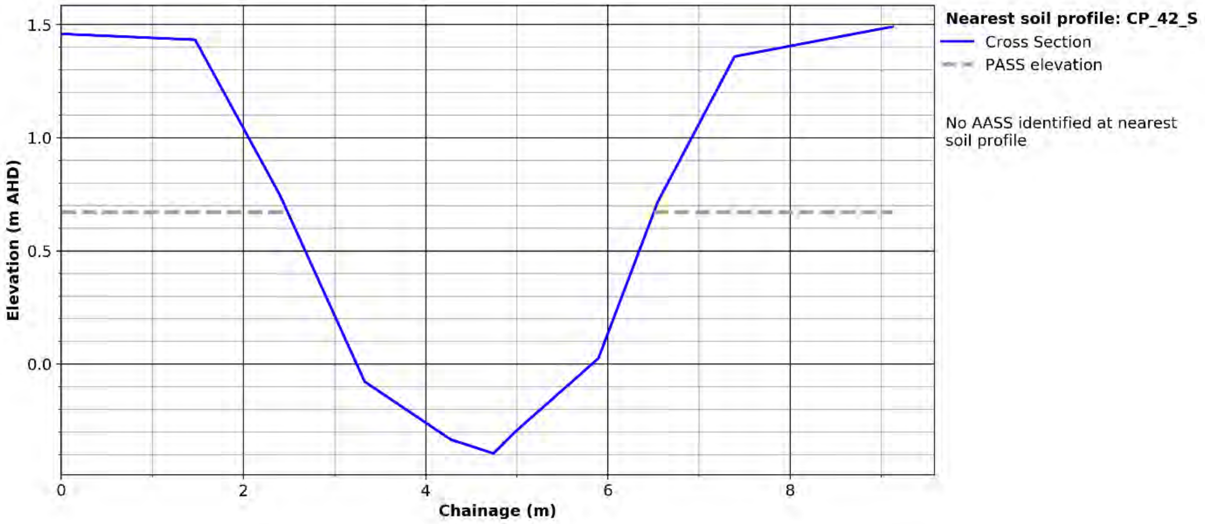

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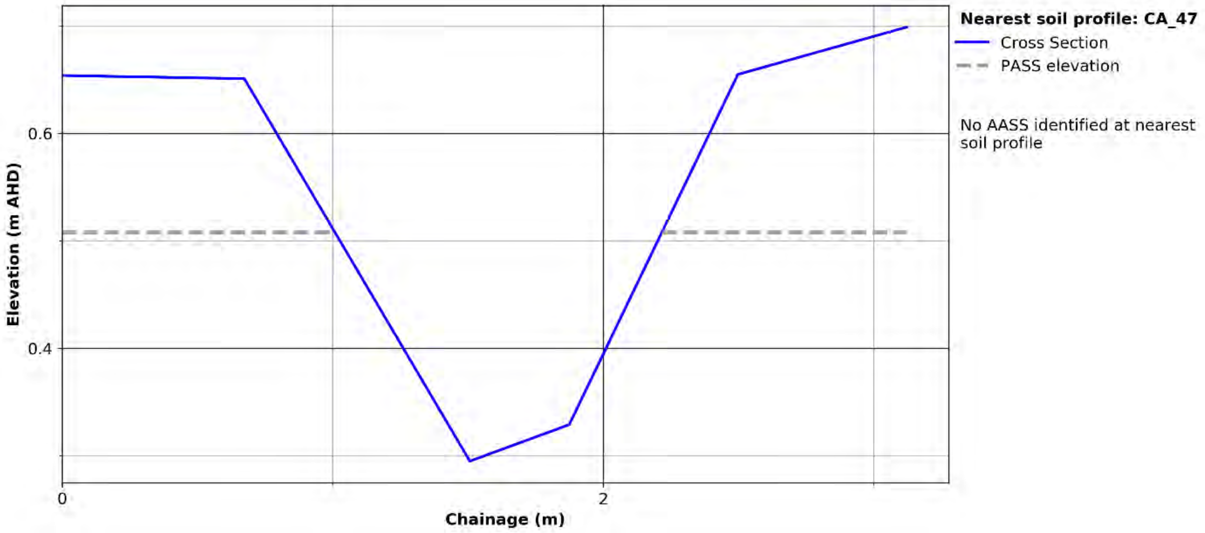

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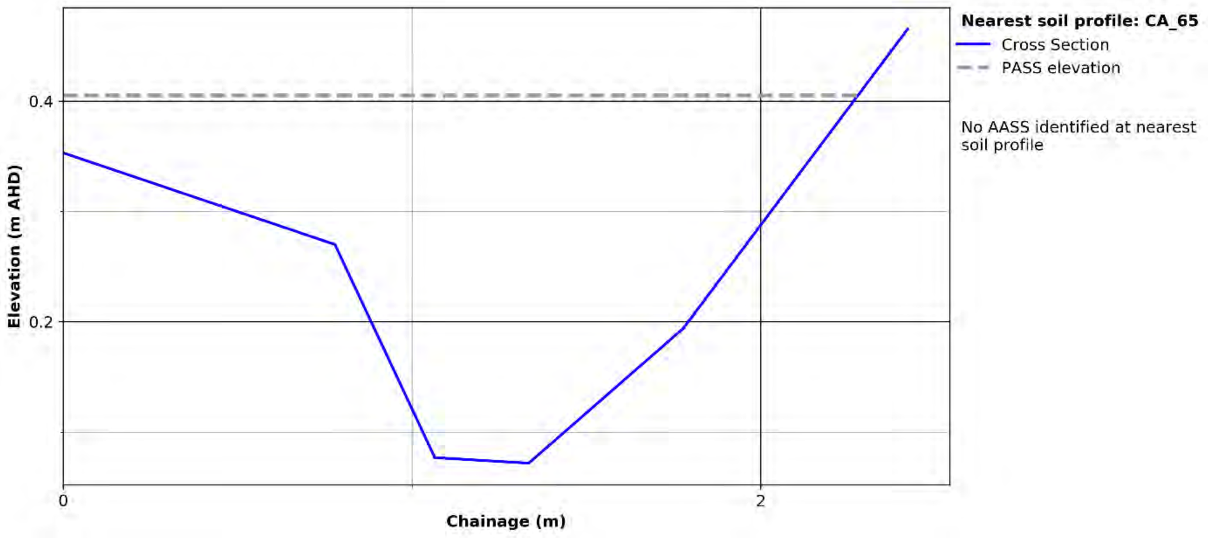

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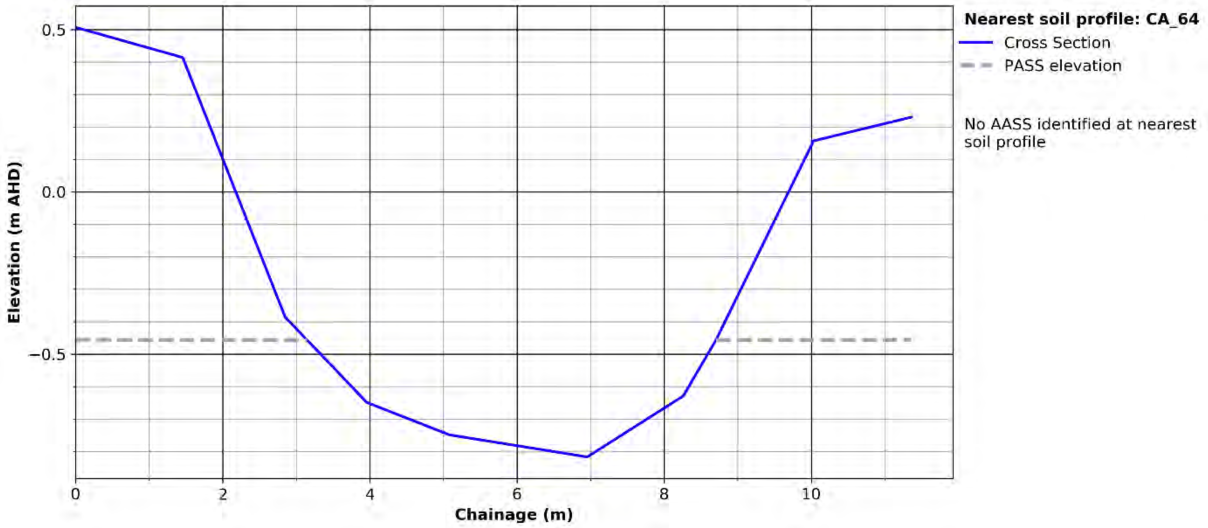

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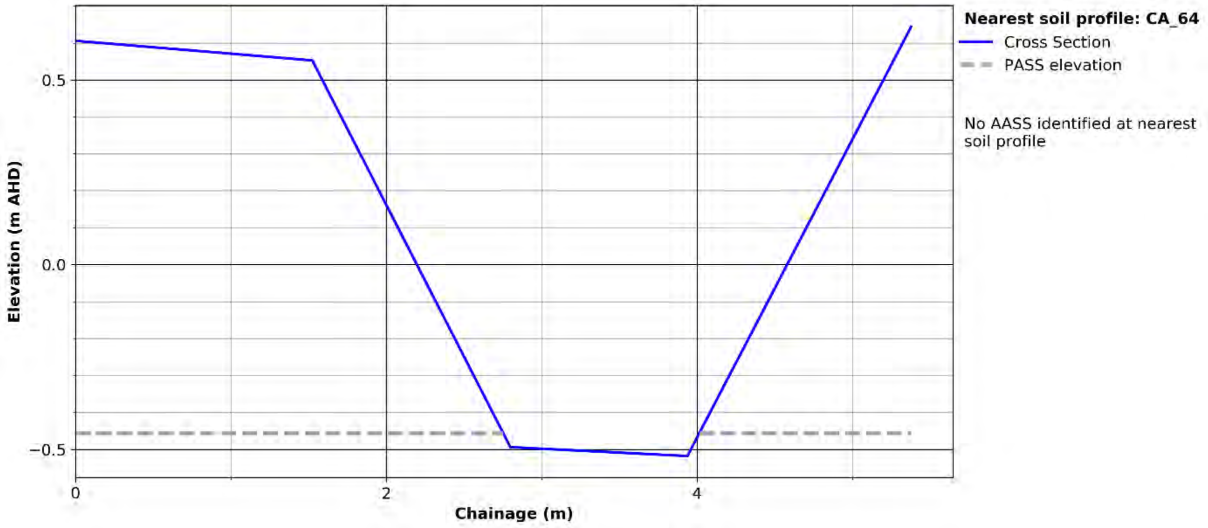

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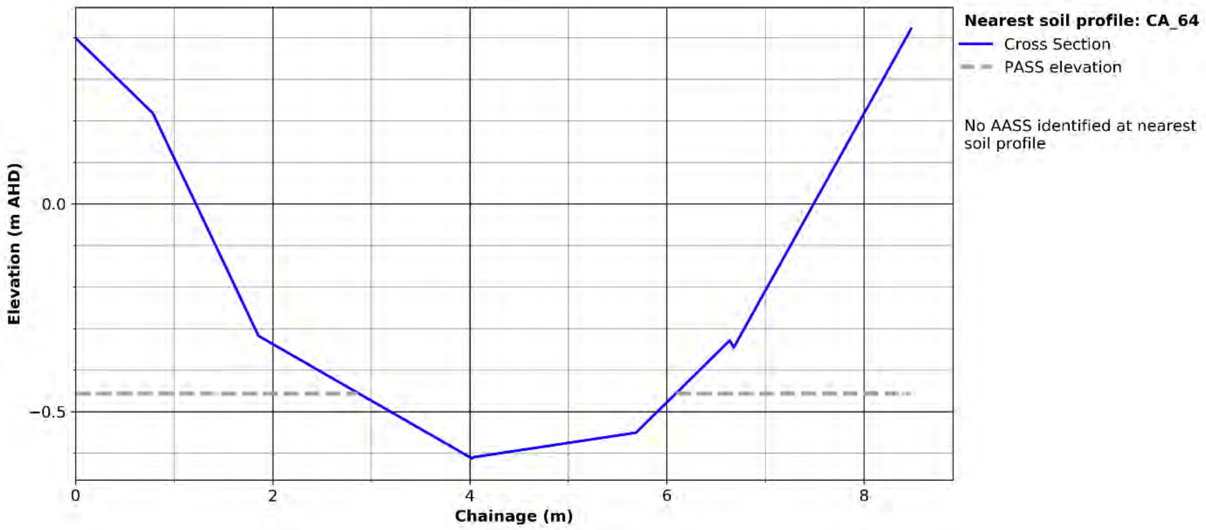

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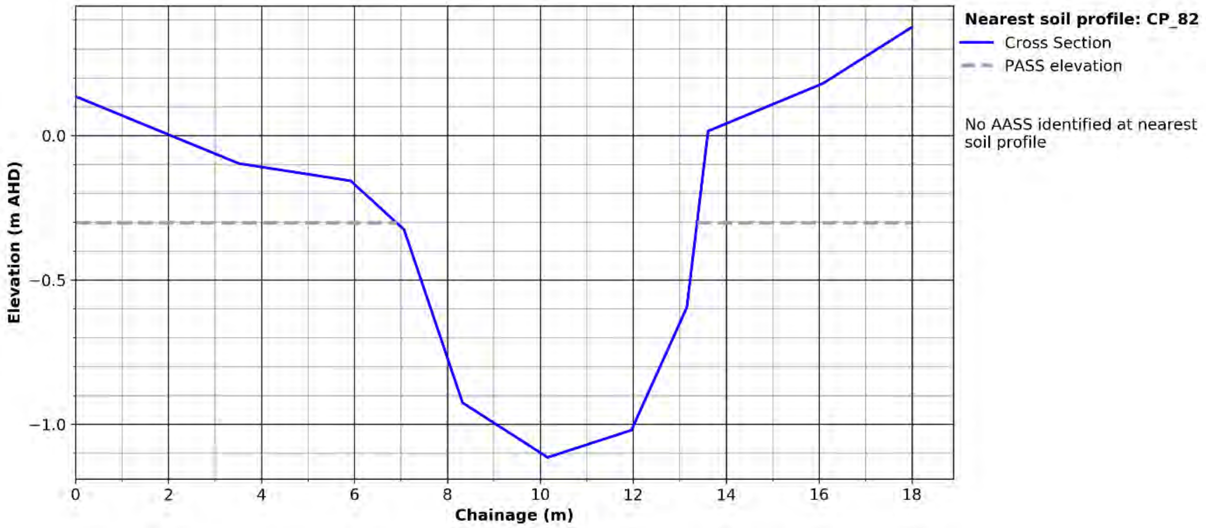

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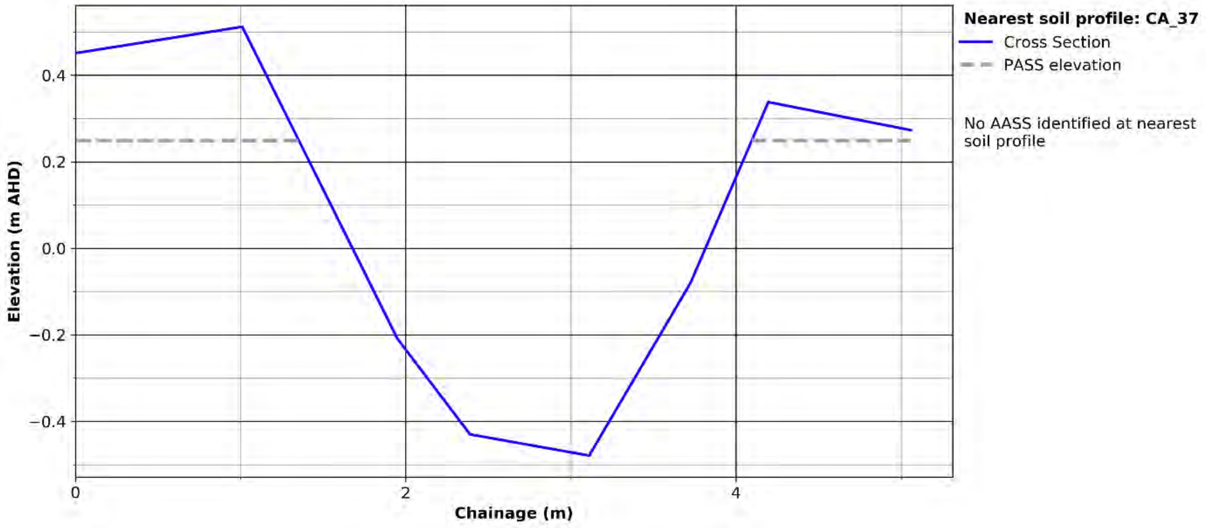

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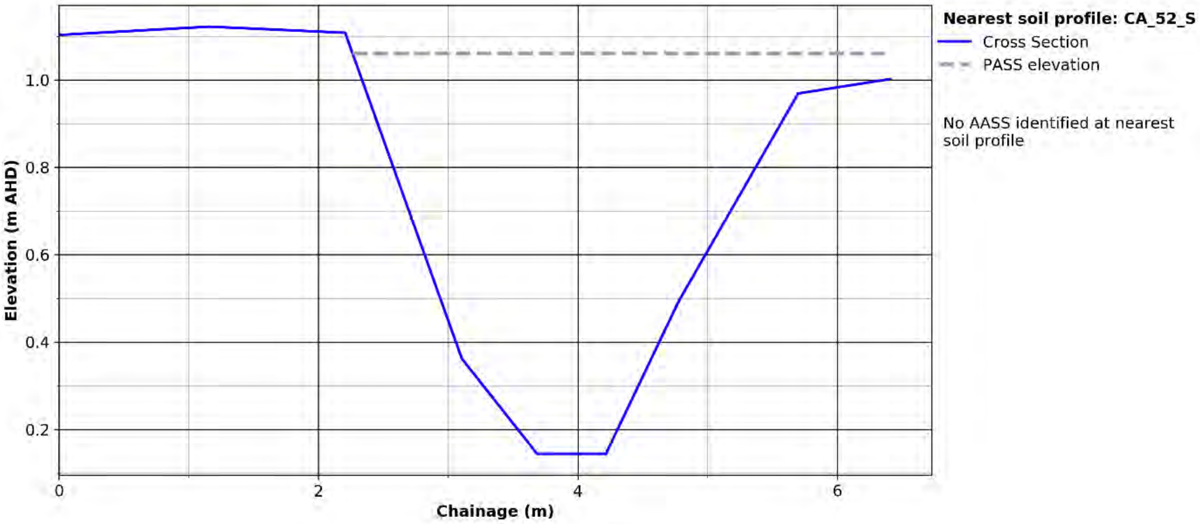

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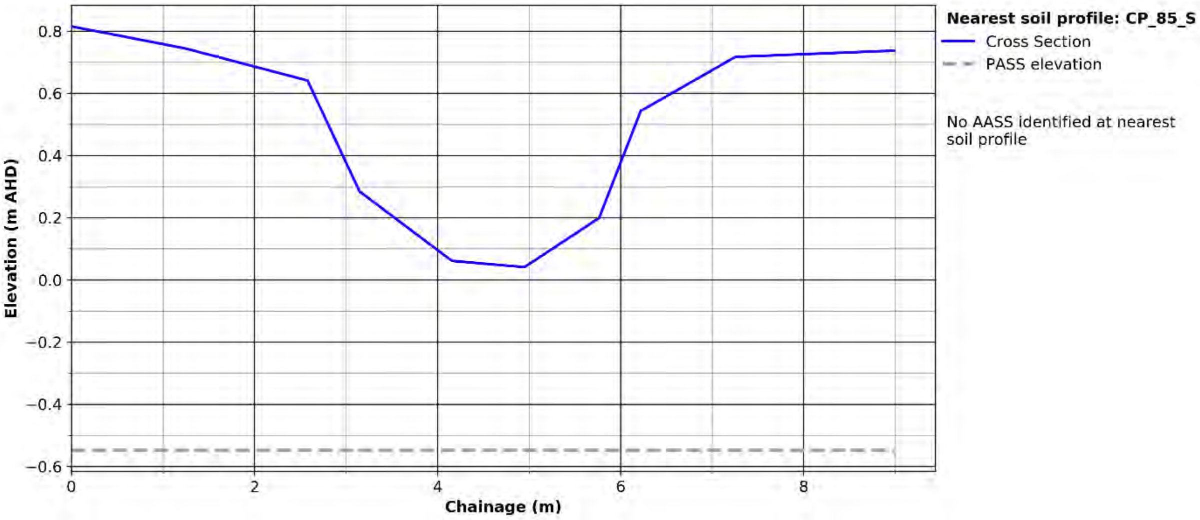

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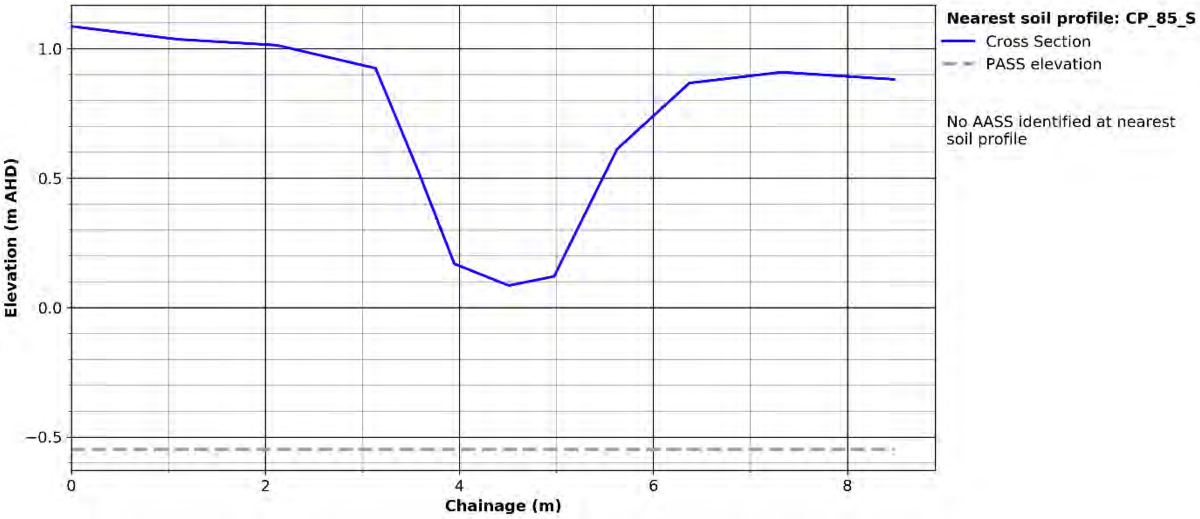

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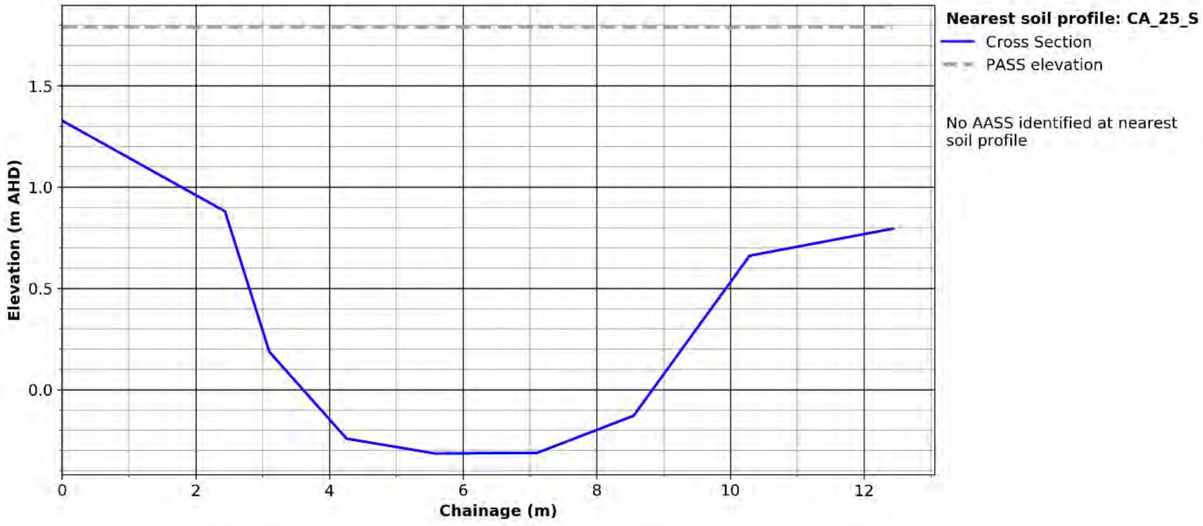

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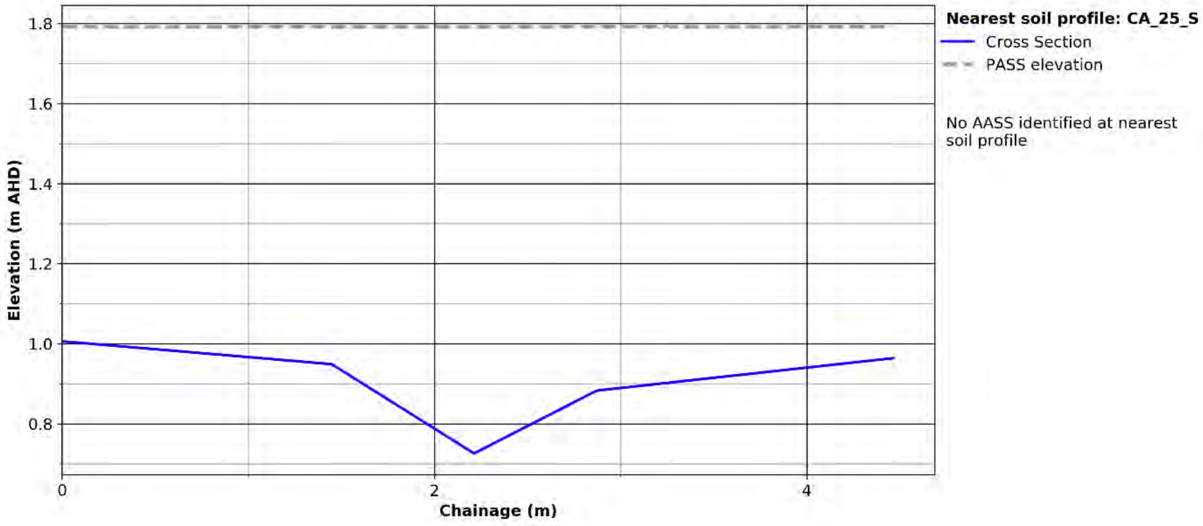

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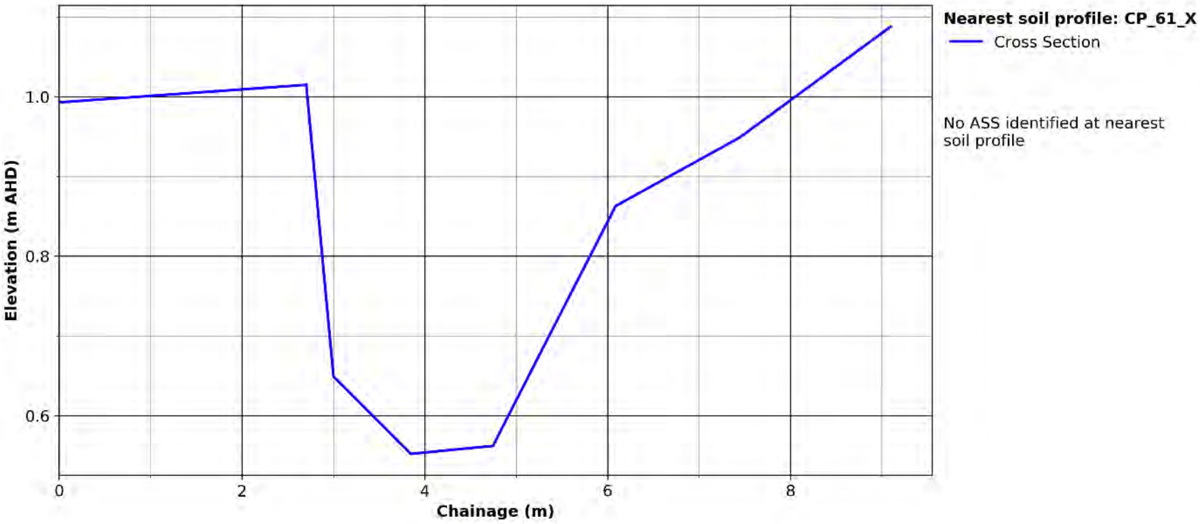

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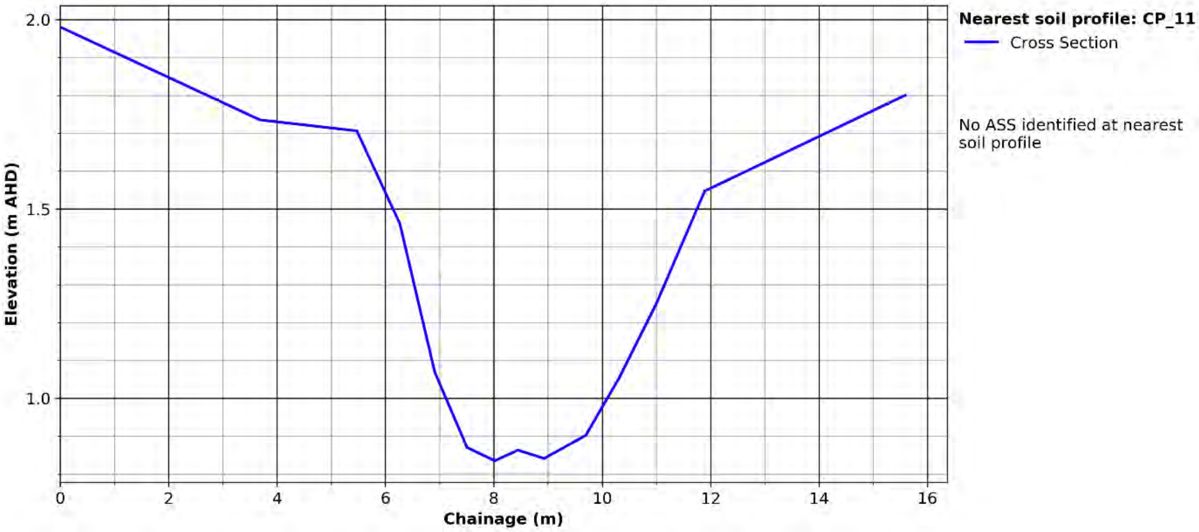

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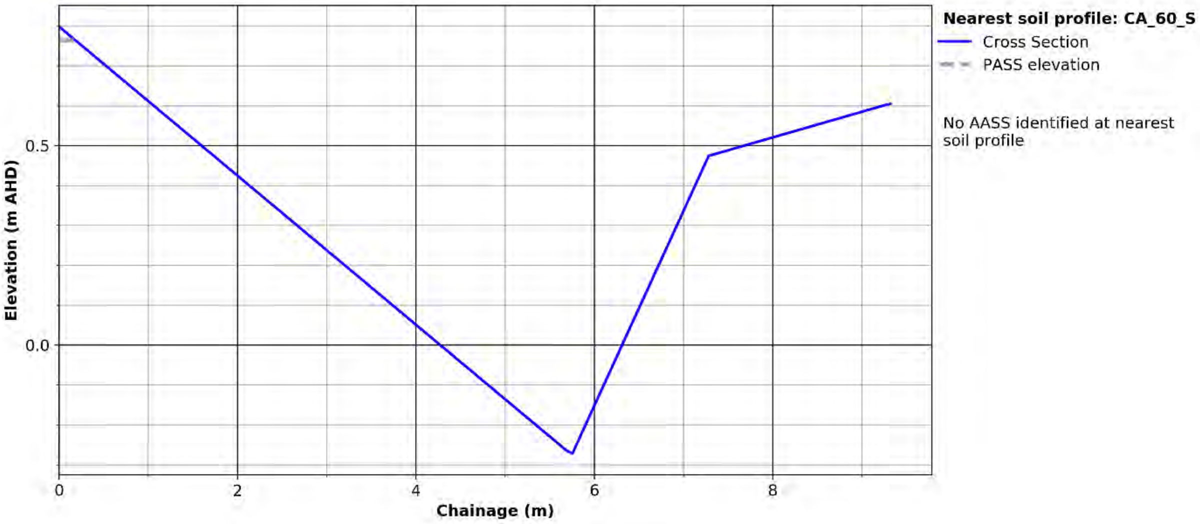

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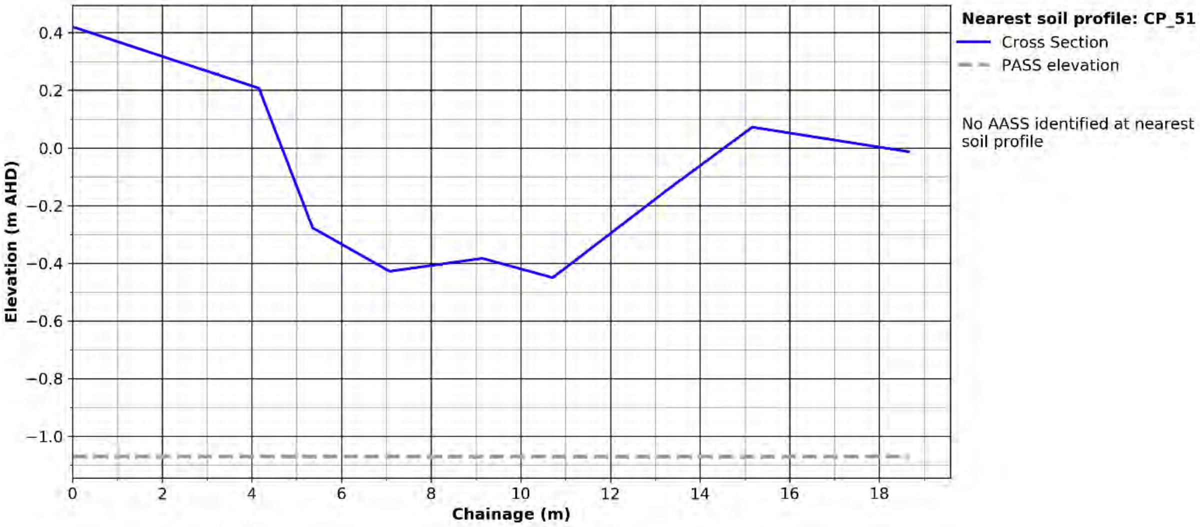

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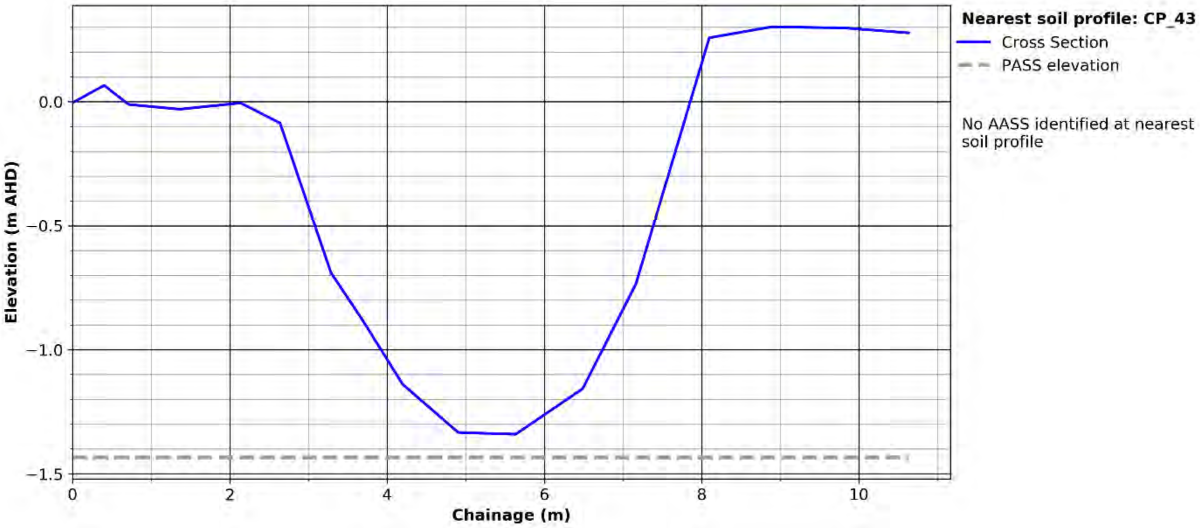

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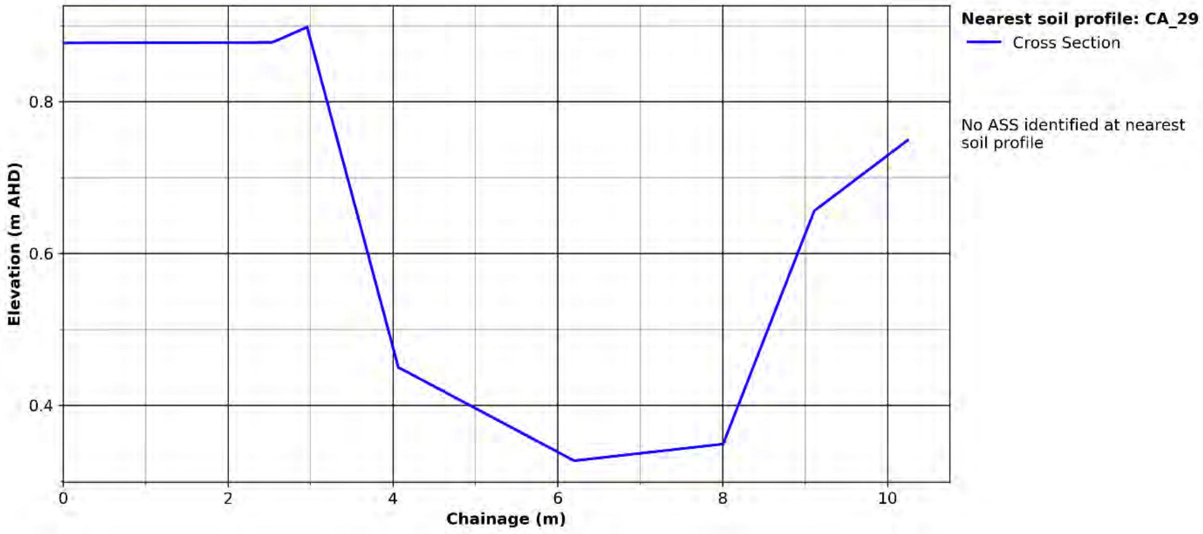

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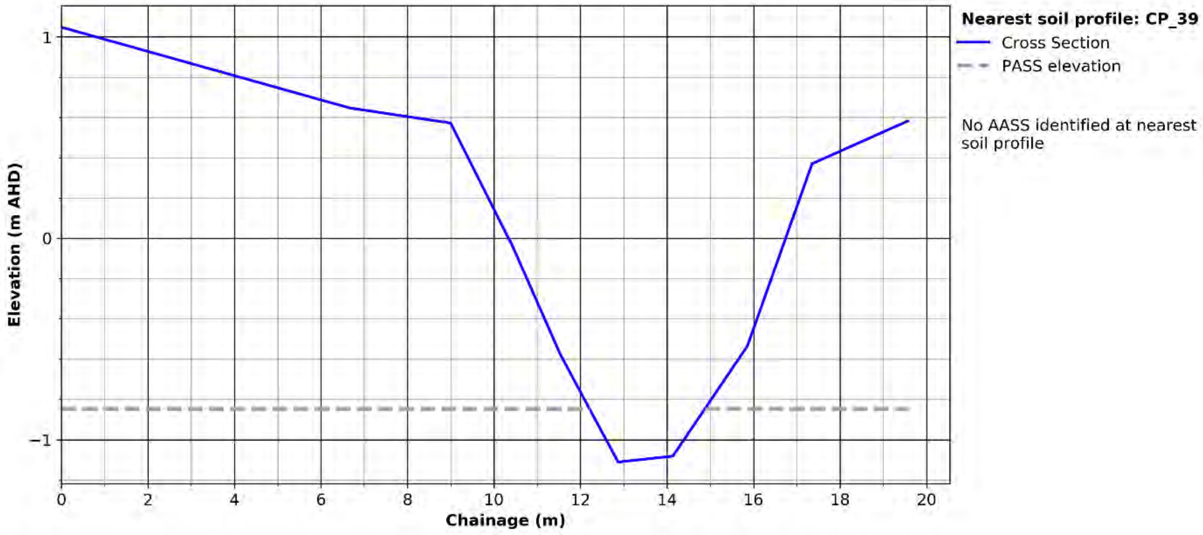

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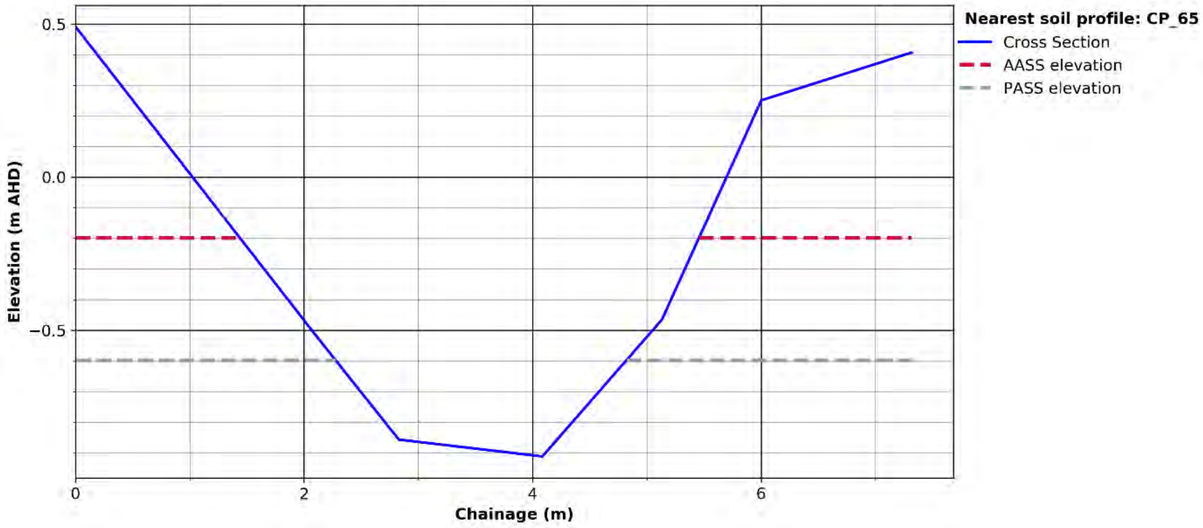

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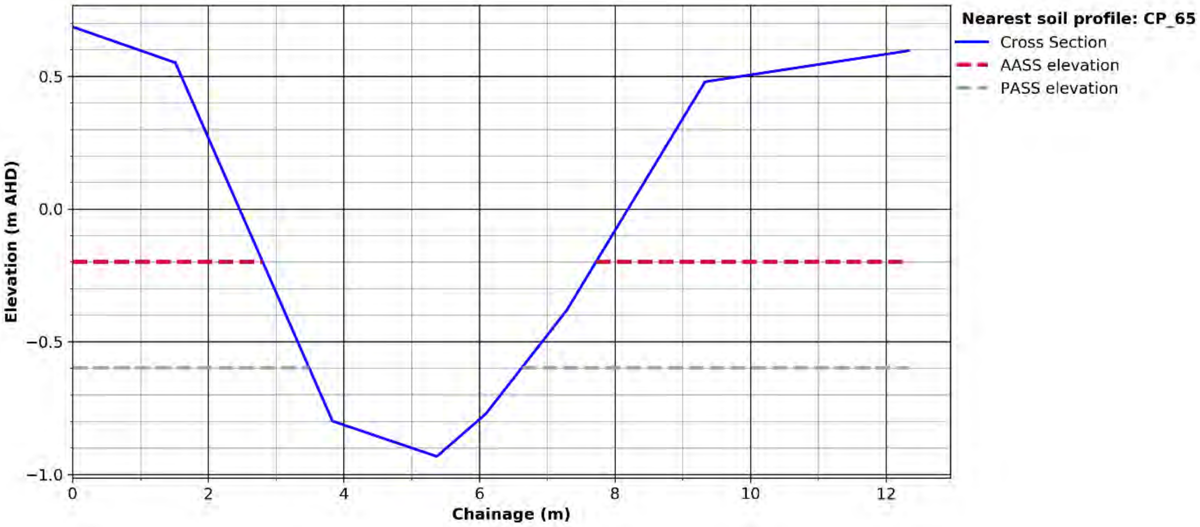

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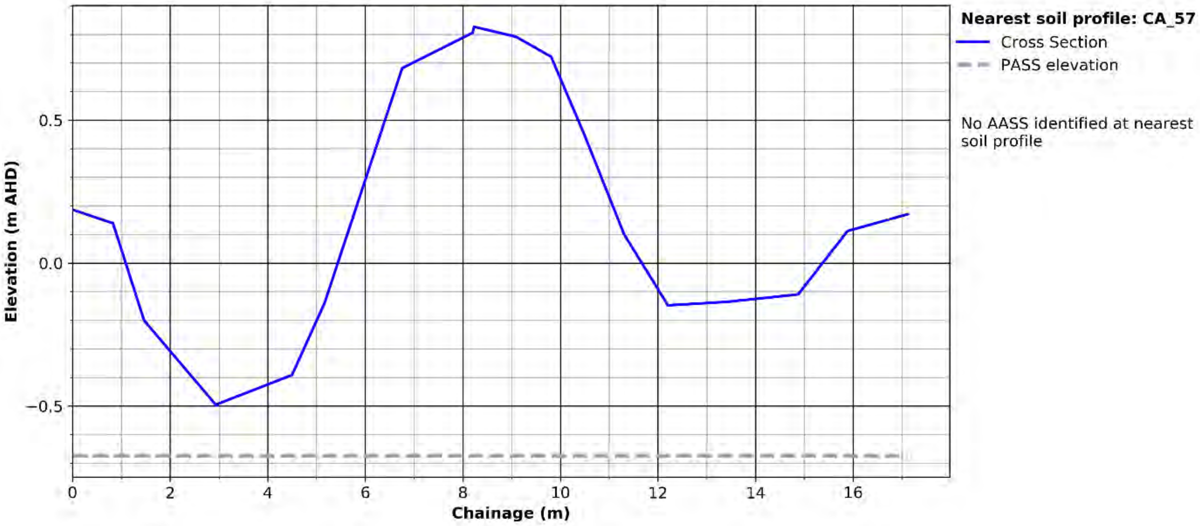

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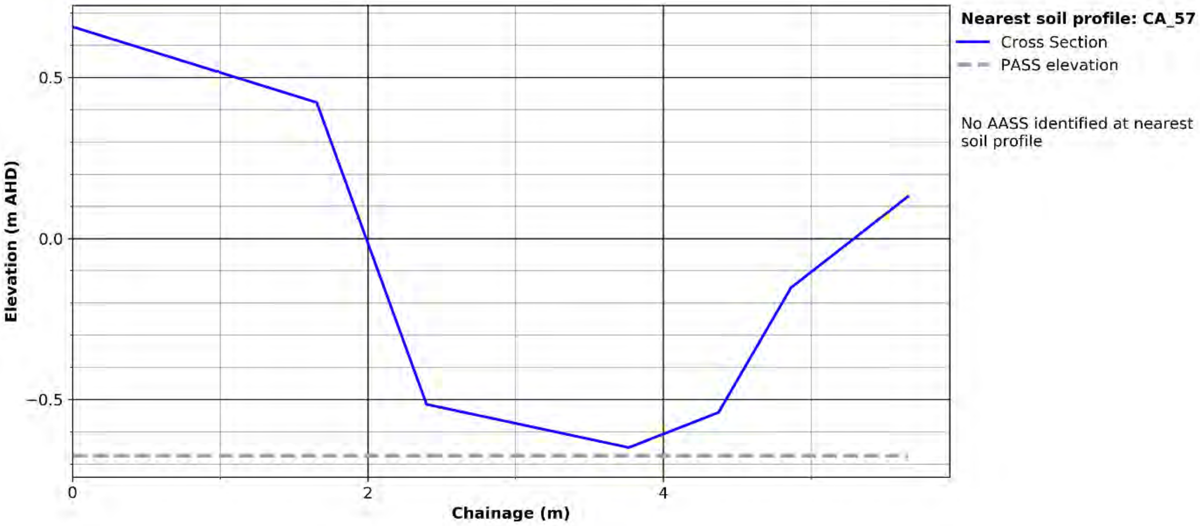

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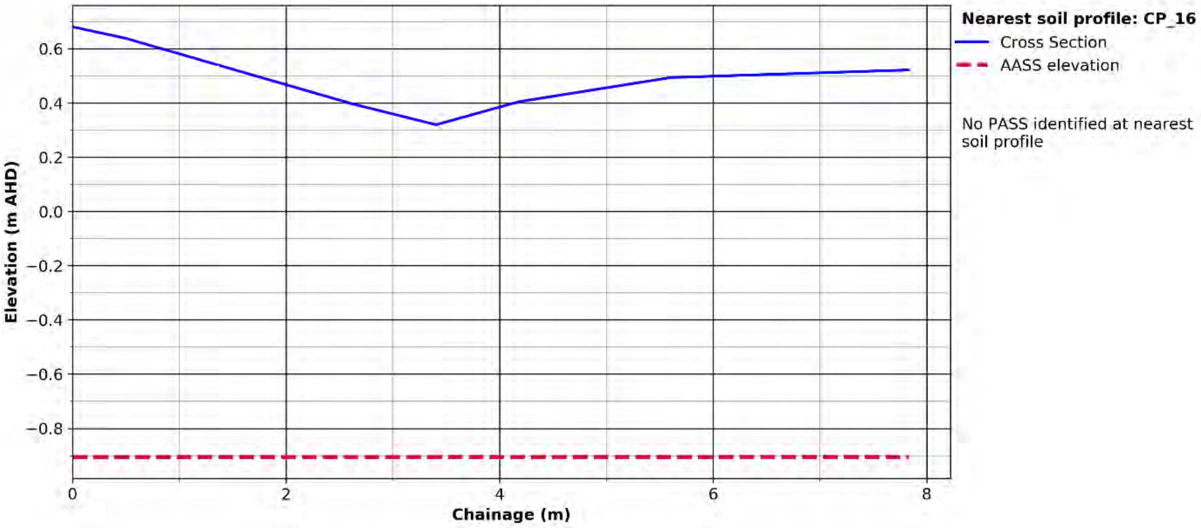

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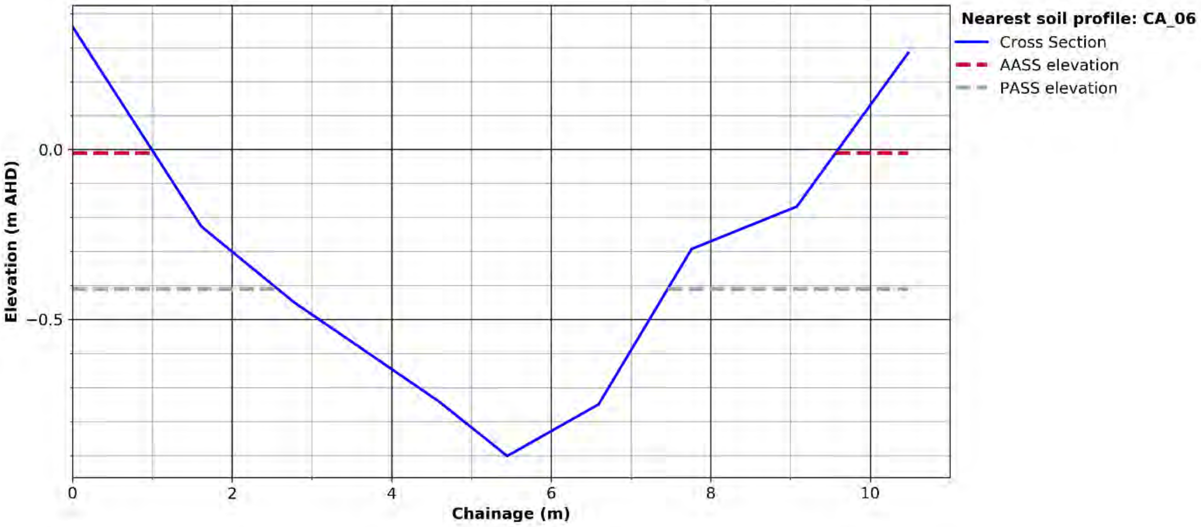

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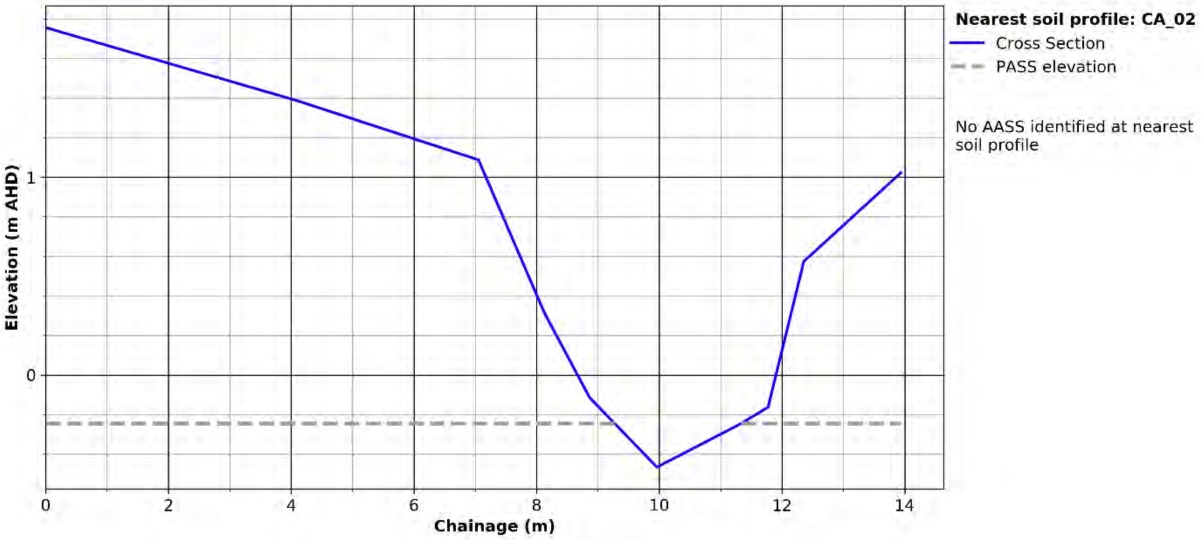

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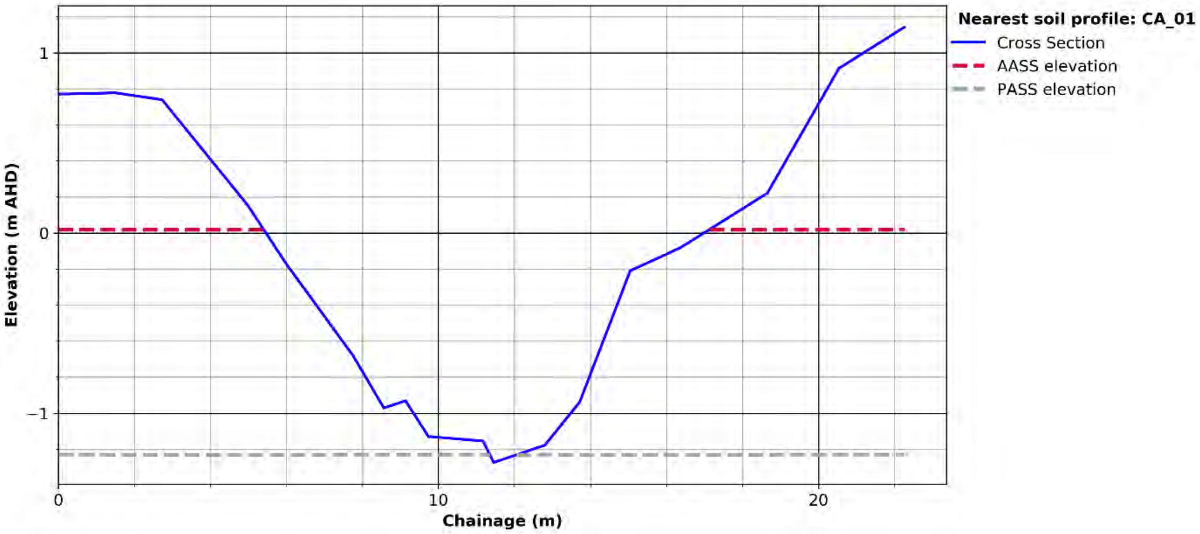

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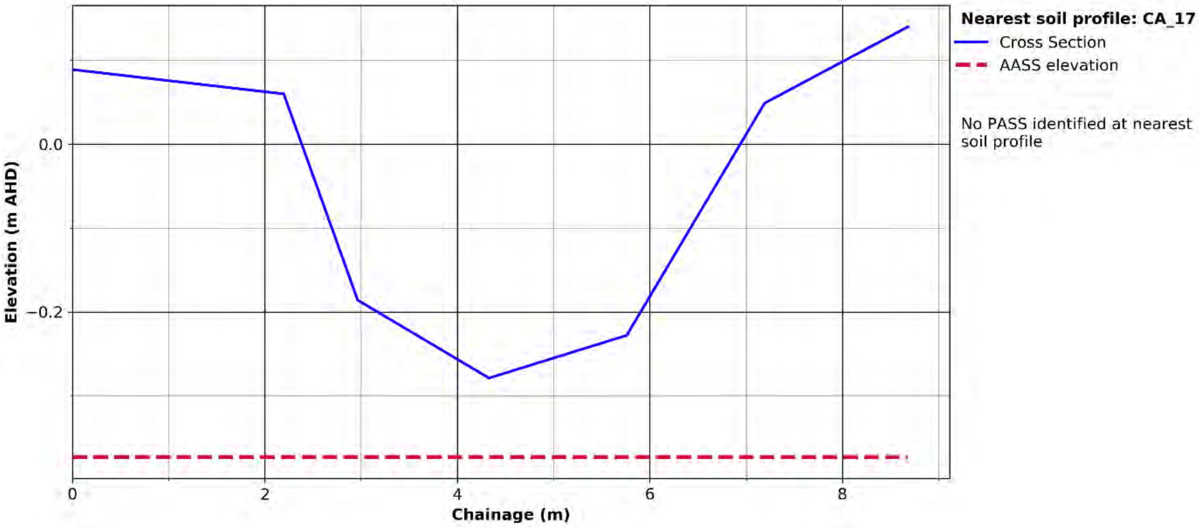

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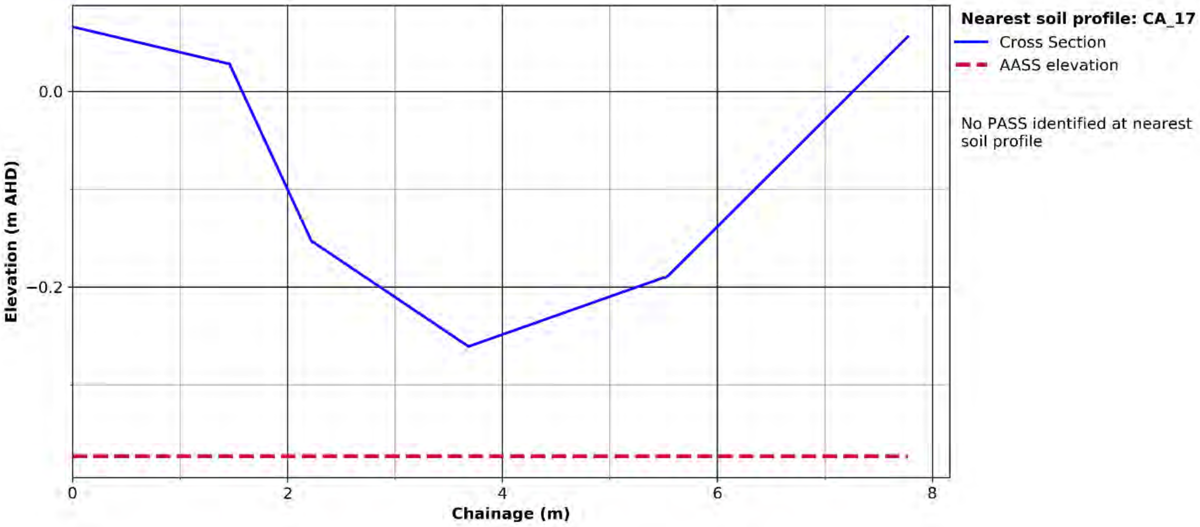

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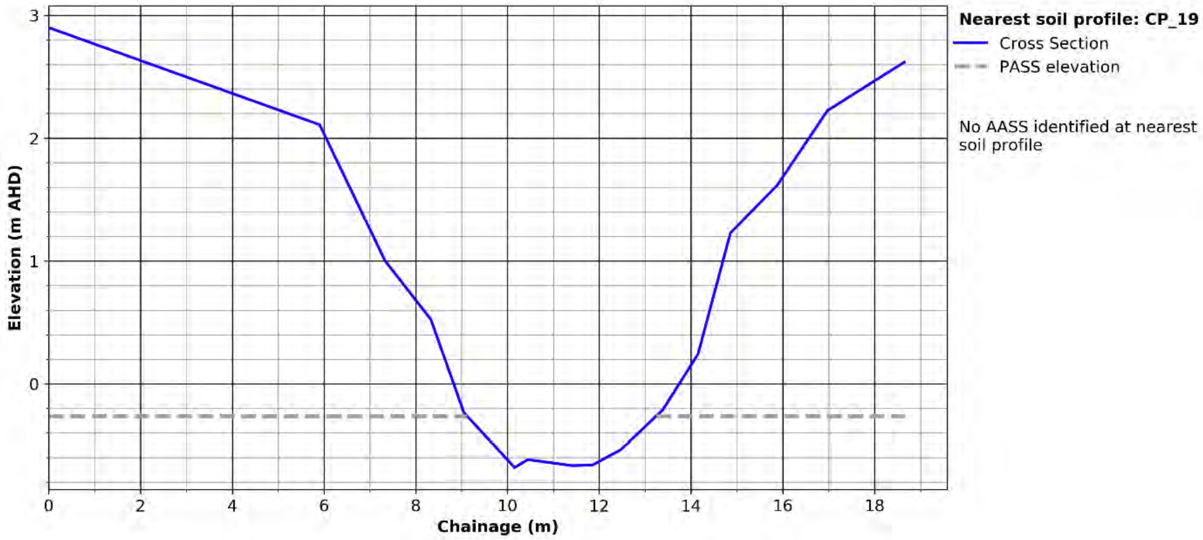

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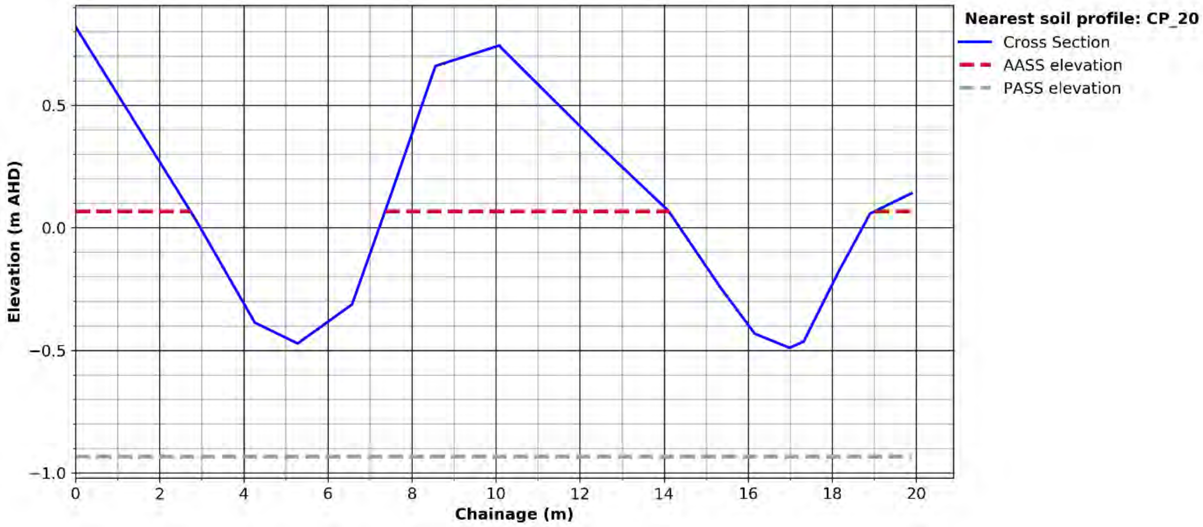
Figure G-42: Clarence cross-section 213



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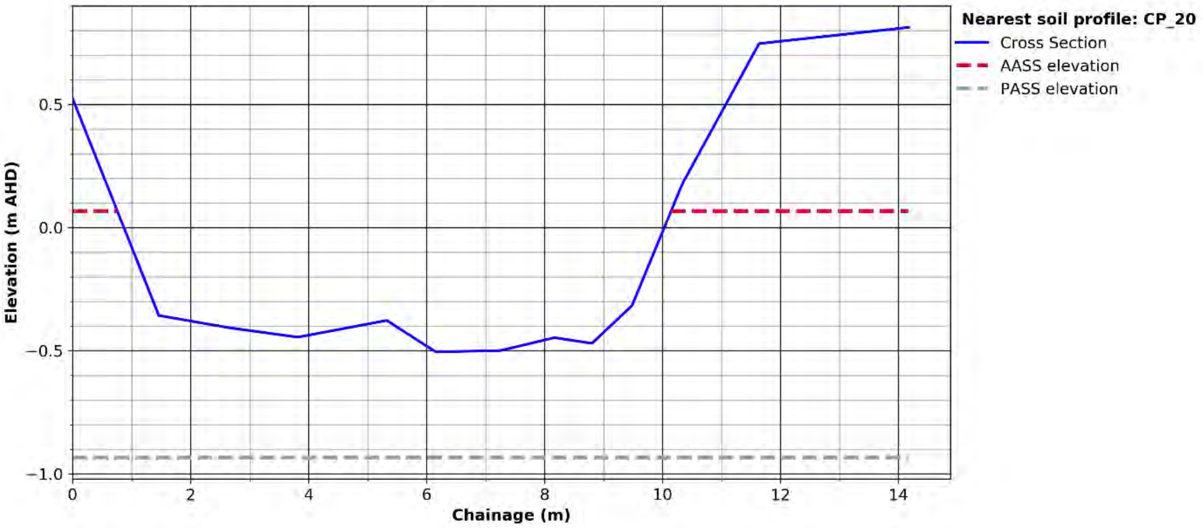

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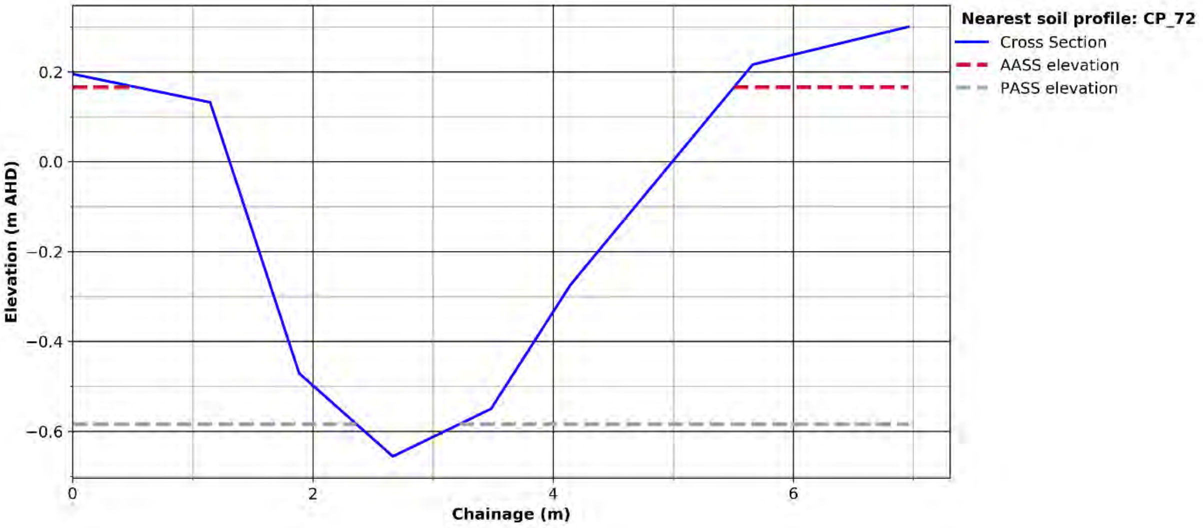
Figure G-45: Clarence cross-section 217



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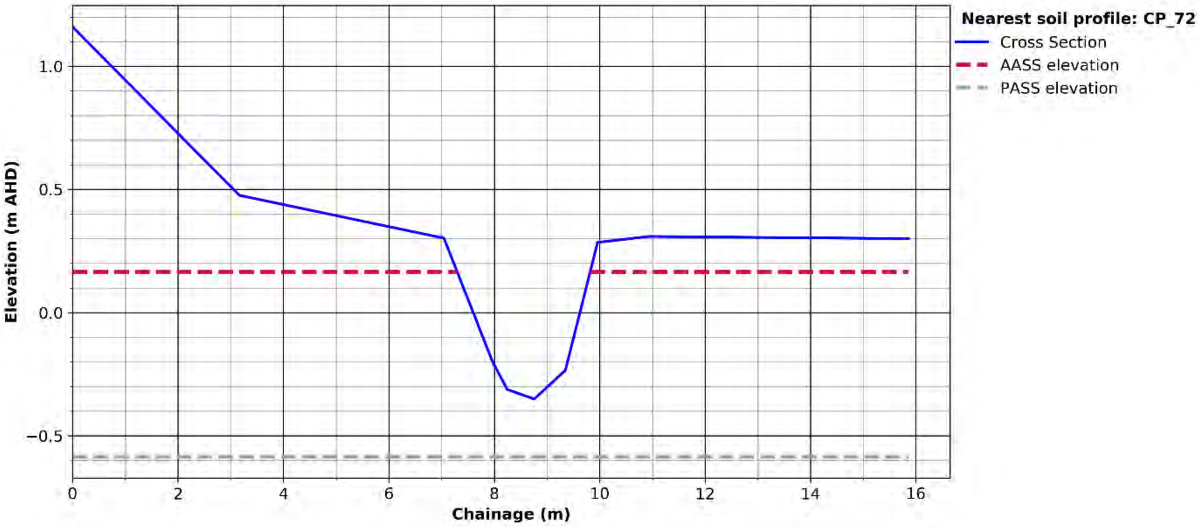

Figure G-47: Clarence cross-section 219

Appendix H Water quality

H1 Preamble

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

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

The Clarence 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 soils (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 Clarence River water quality objectives

In 2006, water quality objectives (WQOs) were developed for a number of coastal estuaries by the NSW Department of Planning, Industry and Environment (DPIE, formerly the Department of Environment, Climate Change and Water). The goal of the WQOs was 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). At the time WQOs were being established by the Healthy Rivers Commission (HRC, now the National Resource Commission) was investigating interim environmental objectives for the Clarence River. Subsequently, the Clarence River WQOs have been outlined by the Healthy Rivers Commission (1999). Similar to the WQOs developed by DPIE, the objectives have been designed to address environmental values associated with water quality expressed by the community for the Clarence River. Findings of the Clarence Estuary Management Plan support these objectives (Umwelt, 2003).

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 for the Clarence River Estuary include consideration for the protection of:

- Aquatic ecosystems;
- Primary and secondary contact recreation;
- Visual amenity;
- 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 as is outlined by the WQOs described by the Healthy Rivers Commission (1999) which considered the ANZECC (1992) guidelines (which have now been replaced by the ANZG (2018) guidelines) and the Australian Drinking Water Guidelines (NHMRC and ARMCANZ, 1996) (which have now been replaced by NHMRC (2011)). Trigger levels 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).

Table H-1: Water quality objective trigger levels

Category	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	400	50
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 provided information on sources and impacts of blackwater (caused through deoxygenation) and acid sulfate soils within the Clarence River Estuary 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, a number of reviews of water quality data in the Clarence River Estuary have previously been completed (Glamore et al., 2019; Manly Hydraulics Laboratory, 1995; Manly Hydraulics Laboratory, 2000; Tulau, 1999b)

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. This usually occurs 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 (see Section 4) 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.

Blackwater has been a continuing issue in the Clarence River Estuary with numerous studies investigating its sources and causes. Manly Hydraulics Laboratory (1995) found that existing water quality data indicated low dissolved oxygen levels occurred around Woodford Island. This could be explained due to blackwater events occurring in Sportsmans Creek and the Coldstream River. Smith (1999) noted that the decomposition of organic matter within the Everlasting Swamp system resulted in blackwater being discharged down Sportsmans Creek. This observation was further supported by findings from Manly Hydraulics Laboratory (2001), the Northern Rivers Catchment Management Authority (2006) and Rayner et al. (2016). Similarly, Manly Hydraulics Laboratory (2000) and Roads and Maritime Services (2016) both observed that the Coldwater River is a major source of blackwater. A number of studies have found low dissolved oxygen events occur across the estuary which have been attributed to eutrophication (Manly Hydraulics Laboratory, 2000; Woodhouse, 2001b) as well as breakdown of organic matter (Johnston et al., 2003; Roads and Maritime Services, 2016; Wetland Care Australia, 2002). Additionally, low oxygen events have been found to occur following rainfall events (Foley and White, 2007; White, 2009a). Johnston et al. (2003) linked blackwater to acid sulfate soils finding that the reduction of sulfate and iron results in oxygen being removed from the water column (Johnston, 2004; Johnston et al., 2004). Some investigations have been completed in the Clarence River looking at remediating poor water quality caused by blackwater. Studies have found that by allowing tidal flushing of constructed drains that there were improvements for dissolved oxygen levels (Johnston et al., 2005b; Johnston et al., 2005c). During field investigations completed as part of this study, a large flood event that occurred in February 2020 was observed to have caused a significant blackwater event that resulted in fish kills (Figure H-1). The cause of this blackwater was prolonged inundation of water on the floodplain causing the breakdown of vegetation. This highlights the ongoing water quality issues the Clarence River faces associated with blackwater.

Figure H-1: Fish kill observed on 1 March 2020 within Cowper No. 1 Drain due to blackwater caused from prolonged inundation of water causing the decomposition of vegetation

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. Historically backswamps on the Clarence River floodplain were not connected to the estuary. Connection of these floodplain areas to the estuary via efficient drainage infrastructure has resulted in the groundwater table being lowered causing the oxidisation of acid sulfate soils (Manly Hydraulics Laboratory, 1995; Tulau, 1999b). An example is Everlasting Swamp, where studies have consistently shown drainage has resulted in low acidic water being exported to the estuary (Beveridge, 1998; Bush et al., 2006; Glamore et al., 2019; Johnston, 2004; Johnston et al., 2002; Johnston et al., 2004; Johnston et al., 2005b; Johnston et al., 2005c; Johnston et al., 2003; Manly Hydraulics Laboratory, 2001; Rayner et al., 2016; Smith, 1999; Tulau, 1999b; Wilkinson, 2003). Other Backswamps that have been identified as draining acid sulfate soils include: Alumy Creek (Manly Hydraulics Laboratory, 2000; Tulau, 1999b; Woodhouse, 2001b), Shark Creek (Johnston, 2004; Johnston et al., 2002; Johnston et al., 2004; Johnston et al., 2005b; Johnston et al., 2005c; Johnston et al., 2003; Tulau, 1999b), The Broadwater (Department of Environment and Conservation (NSW), 2006; Wetland Care Australia, 2003) and lower floodplain islands (Davison and Wilson, 2003; Foley and White, 2007; Tulau, 1999b). There is some contradiction amongst literature with some studies failing to find poor water quality resulting from ASS in the Palmers Channel or the Taloumbi area (Wetland Care Australia, 2002; White, 2009a). Remediation of ASS has been actively investigated on the Clarence River Estuary. Davison and Wilson (2003) found that buoyancy driven tidal floodgates provided significantly improved water quality while being comparatively easier to maintain and manage compared to other options such as sluice gates. During multiple investigations Johnston et al. (2004) found that opening floodgates can drastically improve water quality upstream of floodgates. However, water quality rapidly declined once floodgates were closed again. They suggested that structures such as drop boards may be better suited to raising groundwater levels (Johnston et al., 2002; Johnston et al., 2004). Johnston et al. (2005b) noted that care needs to be taken when tidal flushing of floodgates systems that are surrounded by soils with high hydraulic conductivity, as in some circumstances flushing can increase acid export. Investigations by Bush et al. (2006) on Sportsmans Creek looked at the effectiveness of remediation efforts within Teal Lagoon and Little Broadwater. There was a good indication that remediation works had improved water quality, however, there were still sources of poor water quality impacting remediated areas. These investigations highlight the importance of investigations of the local floodplain before implementing remediation options as ASS can be extremely heterogeneous and detailed knowledge of the area is required for success (Johnston et al., 2005a; White, 2009b).

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

Study	Sampling dates	Location	Parameters	Findings
Manly Hydraulics Laboratory (1995)	Not applicable	Clarence River Estuary	Not applicable	Contains a detailed list of water quality datasets published between 1940 and 1993 that are not publicly available. The further upstream influence of saline water was found to be at Ulmarra (58 km from the river mouth). High macrophyte growth was observed in Sportsmans, Southgate and Coldstream creeks and was associated with deoxygenation during low flows. Low dissolved oxygen levels were found between Lawrence and Maclean. Acid sulfate soils were found to be the cause of fish kills. Drainage of wetlands has resulted in the increased likelihood that acid sulfate soils will affect the estuary.
Beveridge (1998)	2/04/1998 to 30/08/1998	Sportsmans Creek	pH, total dissolved solids, chloride, sulfate, iron, aluminium, calcium, sodium, potassium, magnesium.	The acidity measured within drains lowered with greater distance upstream of the Sportsmans Creek weir where lower salinity levels meant less buffering of acid could occur. Discharge of poor quality water from the area was associated with large rainfall and runoff events.
Smith (1999)	29/09/1998	Everlasting Swamp	pH	pH measurements were recorded at various locations within Everlasting Swamp showing a high degree of variability from acidic (pH<4) to neutral (pH≈7). Observations of blackwater caused by the decomposition of organic matter was observed to occur at the end of the dry season due to accumulation of dead plant material.
Tulau (1999b)	Not applicable	Clarence River Estuary	Not applicable	Contains a literature review including multiple datasets that are not publicly available (a number overlap with those outlined by Manly Hydraulics Laboratory (1995)). Four (4) areas were identified as acid sulfate soil hotspots: Everlasting Swamp, Shark Creek, lower estuary floodplains and islands, and Alumy Creek. Tributaries blocked by floodgates tended to have lower dissolved oxygen levels. Flushing time of the estuary decreases when there are low flows reducing water quality. Concrete erosion and iron flocculation have occurred due to acid sulfate soils. Anecdotal evidence suggests that the hulls of boats were cleaned when exposed to acidic water in Shark Creek. There are a number of cases of eutrophication occurring around Palmers Channel and in Wooloweyah Lagoon.
Manly Hydraulics Laboratory (2000)	Not applicable	Clarence River Estuary	Not applicable	Contains additional water quality datasets that were not presented in a data compilation study by Manly Hydraulics Laboratory (1995). Low pH levels were recorded in Alumy Creek and Shark Creek. Wooloweyah Lagoon was observed to be eutrophic periodically.
Robert J. Smith and Associates (2000)	Not specified	Swan Creek	Phosphate, nitrogen, salinity, pH	Review of water quality data collected by the NSW Department of Land and Water Conservation. Salinity levels are driven by rainfall events at Swan Creek. There is evidence of acid sulfate soils at Swan Creek, however, this does not appear to be affecting the nearby waterways.
Williams (2000)	Not applicable	Clarence River Estuary	Not applicable	Contains a literature review including multiple datasets that are not publicly available. The upper Coldstream River was identified as having some of the poorest water quality in the Clarence River estuary. Shark Creek was identified as having acidic water with low pH. Floodgates act to store acidic water upstream which is released into the estuary during dry times. Poor water quality on the lower Clarence was found to be due to high sediment load, nutrients, acidity, low dissolved oxygen and high temperatures.
Manly Hydraulics Laboratory (2001)	April 2000 to June 2001	Sportsmans Creek	Temperature, electrical conductivity/salinity, pH, dissolved oxygen, turbidity	A maximum electrical conductivity measurement of 10mS/cm was recorded. pH measurements were neutral on average with a low of 5.72. Water deoxygenation was recorded with a low measurement of 1% dissolved oxygen.
Woodhouse (2001a)	29/01/1999 to 12/09/2000	Alumy Creek	pH, electrical conductivity, temperature, dissolved oxygen, turbidity	Upstream sections of Alumy Creek were observed to be affected by acid sulfate soils to a greater degree than the downstream agricultural areas. Low dissolved oxygen levels were measured across the creek.
Johnston et al. (2002)	8/09/2000 to 20/09/2001	Blanches Drain; Maloneys Drain	Dissolved oxygen, pH, electrical conductivity, temperature, redox potential, iron aluminium, chloride, sulfate	Benefits of opening floodgates to improve water quality is related to the frequency, magnitude and duration of the opening. Opening of floodgates can reduce discharge from the groundwater to drains. Maintaining high drain water levels such as via dropboard structures is more effective at reducing acidic discharge than only opening floodgates.
Wetland Care Australia (2002)	21/07/1999 to 16/12/1999	Taloumbi	Electrical conductivity/salinity, pH, temperature, dissolved oxygen, turbidity	pH measurements did not indicate that there was any acid being discharged from the site. Low dissolved oxygen results from decomposition of vegetation.
Davison and Wilson (2003)	May 2001 to August 2002; 29/11/2002	Palmers Island	pH, salinity, dissolved oxygen, total dissolved solids, chloride, sulfate, iron, aluminium	Buoyancy driven tidal floodgates were shown to significantly improve water quality in upstream waterways. Levels of salinity were found to correlate positively with levels of pH for levels below 20,000µS/cm and 7.5 respectively. Acid was found to decrease after rainfall events.

Study	Sampling dates	Location	Parameters	Findings
Wetland Care Australia (2003)	December 2002	The Broadwater	pH, electrical conductivity	Low acidity levels (pH<4) and high electrical conductivity levels (>19mS/cm) were observed across the site and were not related to drainage infrastructure.
Wilkinson (2003)	December 2001 to December 2002	Sportsmans Creek	pH electrical conductivity dissolved oxygen, oxygen reduction potential, temperature, chloride, sulfate, iron, aluminium	Acid discharge to Sportsmans Creek was found to be primarily driven by surface water due to a low groundwater gradient between the backswamp and the creek. Acid discharge was found to be episodic and dependent on rainfall events.
Johnston et al. (2003)	December 2000 to October 2003 (hourly measurements)	Blanches Drain; Maloneys Drain	pH, chemical oxygen demand, iron, aluminium , chloride, sulfate, dissolved organic carbon, acetate	Artificial drainage of acid sulfate soils significantly contributes to deoxygenation events as oxygen depleting compound which used to be restricted to backswamps are now exported to the estuary. Existing organic matter load, depth of flooding and temperature all contribute to blackwater generation. Iron and sulfate reduction from acid sulfate soils contributes to the causation of blackwater.
Johnston (2004)	2001 to 2003	Clarence River Estuary	pH, electrical conductivity, redox potential, dissolved oxygen, temperature, iron, aluminium , dissolved organic carbon	Drainage of acid sulfate soils is a key contributor to blackwater events. Change in vegetation due to the impacts of acid sulfate soils has major implications for generation of blackwater. Opening of floodgates was found to provide short term water quality improvements that only remained as long at the floodgates were open.
Johnston et al. (2004)	January 2001 to December 2001	Blanches Drain; Maloneys Drain	pH electrical conductivity dissolved oxygen, redox potential, temperature chloride, sulfate, iron, aluminium	Hydraulic conductivity and physical properties of soil layers influence the discharge rate from acid sulfate soils. There is a large degree of heterogeneity in acid sulfate soils meaning that site specific investigations are important.
Johnston et al. (2005b)	2001 to 2003	Blanches Drain; Maloneys Drain	pH electrical conductivity dissolved oxygen, redox potential, temperature	Opening floodgates can improve water quality by decreasing acidity levels and increasing dissolved oxygen levels and fluctuation. In some instances, opening of floodgates can increase acid export, particularly where there is high hydraulic conductivity and low acid levels.
Johnston et al. (2005c)	2001	Blanches Drain; Maloneys Drain	pH electrical conductivity dissolved oxygen, redox potential, temperature chloride, sulfate, iron, aluminium	Transport rates of acid through groundwater dependent upon hydraulic conductivity and geomorphic setting. Impact of tidal water on a backswamps groundwater table is highly localized and this can change the rate at which tidal water buffers acid sulfate soils and impacts the broader environment.
Sinclair Knight Merz (2005)	October 2002 to February 2004	Clarence River Estuary	Nitrogen, phosphorus, fecal coliforms, turbidity	Investigations of existing water quality showed that nutrient levels and fecal coliform levels were within guideline levels specified in the water quality objectives.
Bush et al. (2006)	March 2002 to July 2005	Sportsmans Creek	pH, electrical conductivity, dissolved oxygen, oxidation reduction potential	Investigations showed that remediation works at Teal Lagoon and Little Broadwater improved water quality. Observations indicated poor water quality from other areas still impact the area.
Kroon and Ansell (2006)	September 2000 to July 2001	Clarence River Estuary	Temperature, pH, electrical conductivity/salinity, dissolved oxygen, total dissolved solids, turbidity, phosphorus, nitrogen, aluminium, iron	Closed floodgates affect fish abundance due to the impact on water quality. Nutrient levels in floodgate systems were consistently above guideline levels. Allowing tidal exchange between the estuary and constructed drains will improve fish habitat.
Department of Environment and Conservation (NSW) (2006)	May and June of 2005	The Broadwater	Dissolved oxygen, nitrogen, phosphorus, pH, chlorophyll a, turbidity, electrical conductivity, temperature	Water quality measurements ranged from poor to good water quality across The Broadwater. Lower dissolved oxygen and pH levels were observed for bottom measurements.
Northern Rivers Catchment Management Authority (2006)	Not applicable	Little Broadwater	Not applicable	Contains a summary of water quality measurements observed for at Little Broadwater. pH levels tended to drop following rainfall events while salinity levels followed seasonal patterns. In 2005 during a fish kill event low pH and low dissolved oxygen were observed. Re-introduction of tidal water to Little Broadwater improved water quality.
Foley and White (2007)	Not specified	Palmers Island; Wooloweyah Lagoon	Salinity, pH, dissolved oxygen; nitrogen, phosphorus, cations	Salinity levels were found to vary dependent upon rainfall and averaged 20ppt. Levels of cations and pH following runoff events indicated the presence of acid sulfate soils. Following large runoff events dissolved oxygen levels dropped to levels outside of the water quality objectives.
White (2009a)	August 2008 to July 2009	Wooloweyah Lagoon	pH, salinity, dissolved oxygen, turbidity, phosphorus, nitrogen, chlorophyll a	Intense rainfall events did not impact pH levels which remained above 6. Low dissolved oxygen was observed following rainfall events.
White (2009b)	March 2002 to February 2007	Little Broadwater	Electrical conductivity, pH, dissolved oxygen, temperature, aluminium, calcium, chloride, iron, potassium, manganese, magnesium, sodium, sulfate, nitrogen, phosphorus	Re-introduction of tidal water to the backswamp resulted increased water quality predominantly through reduction of acid sulfate soil oxidation. Poor connectivity resulted in variable water quality spatially. It was found that a semi-confining soil layer separated acidic groundwater from the surface of the backswamp.
Ryder et al. (2014)	August 2012 to August 2013	Clarence River	pH, electrical conductivity, turbidity, chlorophyll a, nitrogen, phosphorus,	In the estuary low dissolved oxygen was most common following flood events. Lower tributaries of the Clarence River had consistently low pH levels.

Study	Sampling dates	Location	Parameters	Findings
			dissolve oxygen, Secchi depth, total suspended solids	
Roads and Maritime Services (2016)	Not specified	Clarence River Estuary	Not specified	Water quality in the Coldstream River was generally poor with low dissolved oxygen and pH due to acid sulfate soils. Blackwater was also observed due to breakdown of organic matter. Numerous areas in the Clarence River failed to meet guideline levels including the Coldstream River, South Arm and Shark Creek.
Rayner et al. (2016)	9 to 11 March 2016	Sportsmans Creek	pH, electrical conductivity, temperature, dissolve oxygen	Measurements of low dissolved oxygen hypoxic for flora and fauna were measured in drains flowing into Sportsmans Creek. Salinity measurements which had the ability to buffer acidic runoff were observed.
Glamore et al. (2019)	November 2016 to August 2017	Sportsmans Creek	pH, electrical conductivity, temperature	Provides a detailed literature review for water quality for Everlasting Swamp. Electrical conductivity data indicated that levels measured within drainage channels in Everlasting Swamp would be similar to those in Sportsmans Creek.
Roads and Maritime Services (2019)	1/7/2018 to 30/6/2019	Clarence River Estuary	pH, temperature, electrical conductivity, dissolved oxygen, turbidity, total suspended solids, oils and grease, phosphorus, nitrogen, hydrocarbons	Prolonged inundation of flood events was observed to be a cause of low dissolved oxygen events. Acid sulfate soils were recognised to cause acidification of waterways when disturbed. No significant impacts of construction activities on pH, electrical conductivity or dissolved oxygen were observed.
NSW Food Authority (2019)	2001 to 2019	Yamba	Salinity, temperature, bacteria	Average salinity was recorded as 30.8ppt with a 10th percentile of 25.1ppt and 90th percentile of 34.1ppt.

H4 Field investigation

During field investigations, surface water and groundwater water quality measurements were opportunistically collected at various locations across the Clarence River floodplain. Water quality parameters measured included pH, electrical conductivity (EC) and rugged dissolved oxygen. 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 and downstream 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 and downstream 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 Clarence River floodplain. Surface water quality measurements for the Clarence River floodplain are presented in Figure H-2 and Figure H-3 for pH and electrical conductivity, respectively. Groundwater quality measurements for the Clarence River floodplain are presented in Figure H-4 and Figure H-5 for pH and electrical conductivity, respectively.

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

Nearby structure ID	Date	Easting (m)	Northing (m)	Upstream of the structure		Downstream of the structure		
				pH	Electrical Conductivity (µS/cm)	pH	Electrical Conductivity (µS/cm)	Rugged Dissolved Oxygen (%)
F-1160-FP-0012	3/12/2019	504595	6716181			7.1	22,120	
F-1425-FP-0001	6/02/2020	508973	6718801	6.6	502			
F-1480-FP-0001	25/11/2019	509858	6714944	8.4	22,600	7.3	16,100	
F-1590-FP-0001	6/02/2020	510849	6725055	5.7	675	6.6	629	
F-1660-FB-0001	1/03/2020	504666	6726776			6.2	481	1%
F-2085-FP-0001	4/02/2020	519910	6733031	6.4	635			
F-2210-FB-0001	6/02/2020	519963	6734220	5.7	730			
F-2220-FP-0001	6/02/2020	520000	6733655	4.8	1,260	6.2	625	
F-2230-FH-0001	4/02/2020	520342	6733167	6.3	552			
F-2230-FP-0001	4/02/2020	520165	6733166	6.3	552			
F-2260-FB-0001	6/02/2020	518576	6735376	6.3	1,825			
F-2270-FB-0001	6/02/2020	518960	6734793	6.2	572			

Nearby structure ID	Date	Easting (m)	Northing (m)	Upstream of the structure		Downstream of the structure		
				pH	Electrical Conductivity (µS/cm)	pH	Electrical Conductivity (µS/cm)	Rugged Dissolved Oxygen (%)
F-2380-FB-0001	29/02/2020	513561	6738710			5.6	293	21%
F-2920-LD-0001	4/02/2020	525734	6748344	6.7	23,500	6.9	25,000	
F-3000-FB-0001	5/02/2020	522547	6750112	6.8	15,430			
F-3130-FP-0001	7/02/2020	528239	6750218	6.0	981			
F-3135-FP-0001	7/02/2020	529179	6749981	5.9	235	6.7	22,129	
F-4530-FP-0001	27/11/2019	518240	6729728	6.6	23,600	6.6	23,600	
WRL_CLAR_02	26/11/2019	517597	6734538	7.3	34,132	7.6	12,232	
WRL_CLAR_05	27/11/2019	517174	6729856	7.9	2,400	7.9	2,400	

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
CP_51	26/11/2019	519039	6739814	8.3	64,400	
CA_29	26/11/2019	512197	6728469	7.0	31,300	
CA_45	27/11/2019	518369	6729890	6.8	23,500	
CP_47	27/11/2019	518451	6730666	6.9		
CA_80	28/11/2019	520890	6742838	6.9	52,630	
CP_25	28/11/2019	509376	6721705	7.9	27,400	
CP_28	28/11/2019	510413	6719595	8.5	24,450	
CP_68	29/11/2019	530335	6742929	7.8	66,821	
CP_65	29/11/2019	529134	6740719	7.5	81,400	
CA_06	2/12/2019	496866	6717436	7.3	27,830	
CA_01	3/12/2019	503856	6713573	7.2	900	
CP_19	4/12/2019	501762	6723802	7.9	28,904	
CA_12	4/12/2019	498861	6722067	7.7	26,250	
CP_20	4/12/2019	497099	6721006	7.2	30,000	
CP_76	5/12/2019	523474	6747741	7.6	64,286	
CP_70	4/02/2020	529046	6748258	6.9	11,000	
CP_55_S	4/02/2020	525455	6740512	6.4	1,336	
CP_54_S	4/02/2020	522183	6734544	3.6	776	
CA_47	4/02/2020	518680	6733987	6.7	643	
CA_65	4/02/2020	525874	6748327	5.5	11,660	
CA_37	5/02/2020	513556	6740946	6.4	2,712	
CA_76	5/02/2020	509371	6744795	5.7	760	Measured in nearby creek

Nearby soil profile ID	Date	Easting (m)	Northing (m)	pH	Electrical Conductivity (µS/cm)	Notes
CA_76	5/02/2020	509421	6744949	6.3	8,700	Measured in nearby lake
CA_64	5/02/2020	524806	6749176	7.1	17,000	
CA_52_S	5/02/2020	524587	6740219	6.2	271	
CP_85_S	26/02/2020	524188	6750590	6.4	4	
CA_25_S	27/02/2020	514570	6737721	5.6	116	
CA_33	27/02/2020	511844	6734262	5.0	2,267	
CP_61_S	2/03/2020	526172	6732673	6.8	409	
CP_61_X	2/03/2020	525416	6733045	5.4	112	
CA_60_S	3/03/2020	528507	6743656	6.6	4,909	
CP_37	3/03/2020	511395	6736943	5.8	4,700	
CP_11	3/03/2020	492122	6713745	7.2	227	

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)
CA_45	27/11/2019	518369	6729890	4.2	50,260
CP_39	27/11/2019	517367	6730095	6.1	14,700
CP_25	28/11/2019	509376	6721705	5.4	15,200
CP_68	29/11/2019	530335	6742929	6.7	28,000
CP_65	29/11/2019	529134	6740719	6.7	40,800
CA_06	2/12/2019	496866	6717436	6.3	7,800
CP_19	4/12/2019	501762	6723802	6.5	3230
CP_20	4/12/2019	497099	6721006	4.6	4,760
CP_76	5/12/2019	523474	6747741	6.8	27,059
CP_70	4/02/2020	529046	6748258	6.6	24,000
CP_54_S	4/02/2020	522183	6734544	4.5	150
CA_49	4/02/2020	520265	6733197	3.8	13,700
CP_42_S	4/02/2020	519881	6733057	6.3	3,219
CA_37	5/02/2020	513556	6740946	5.1	14,332
CP_82	5/02/2020	522465	6750013	7.0	5,317
CA_64	5/02/2020	524806	6749176	6.8	9,334
CA_52_S	5/02/2020	524587	6740219	5.4	1,920
CP_85_S	26/02/2020	524188	6750590	6.8	1,151
CA_25_S	27/02/2020	514570	6737721	5.4	163
CA_33	27/02/2020	511844	6734262	5.7	3,318
CP_12	27/02/2020	489259	6718301	5.5	481
CP_61_S	2/03/2020	526172	6732673	3.9	4,432
CP_61_X	2/03/2020	525416	6733045	4.4	807
CA_60_S	3/03/2020	528507	6743656	5.8	20,943
CP_37	3/03/2020	511395	6736943	5.7	16,800
CP_11	3/03/2020	492122	6713745	5.2	795

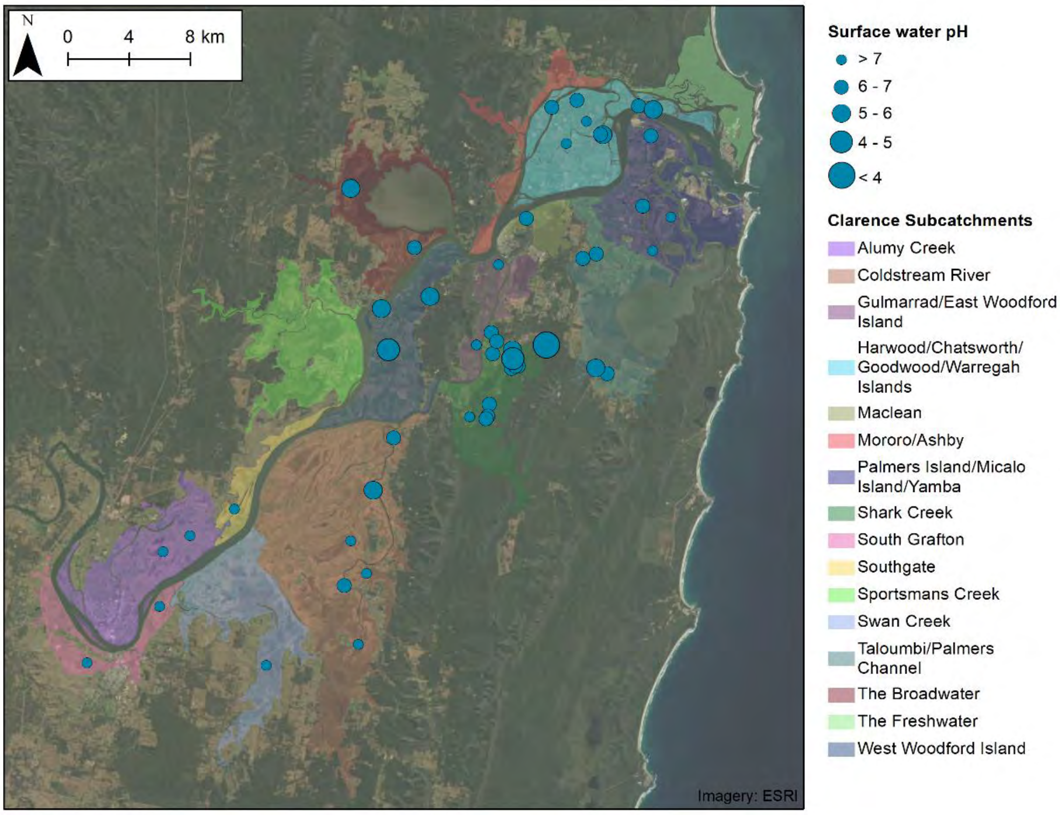

Figure H-2: Surface water pH measurements taken across the Clarence River floodplain

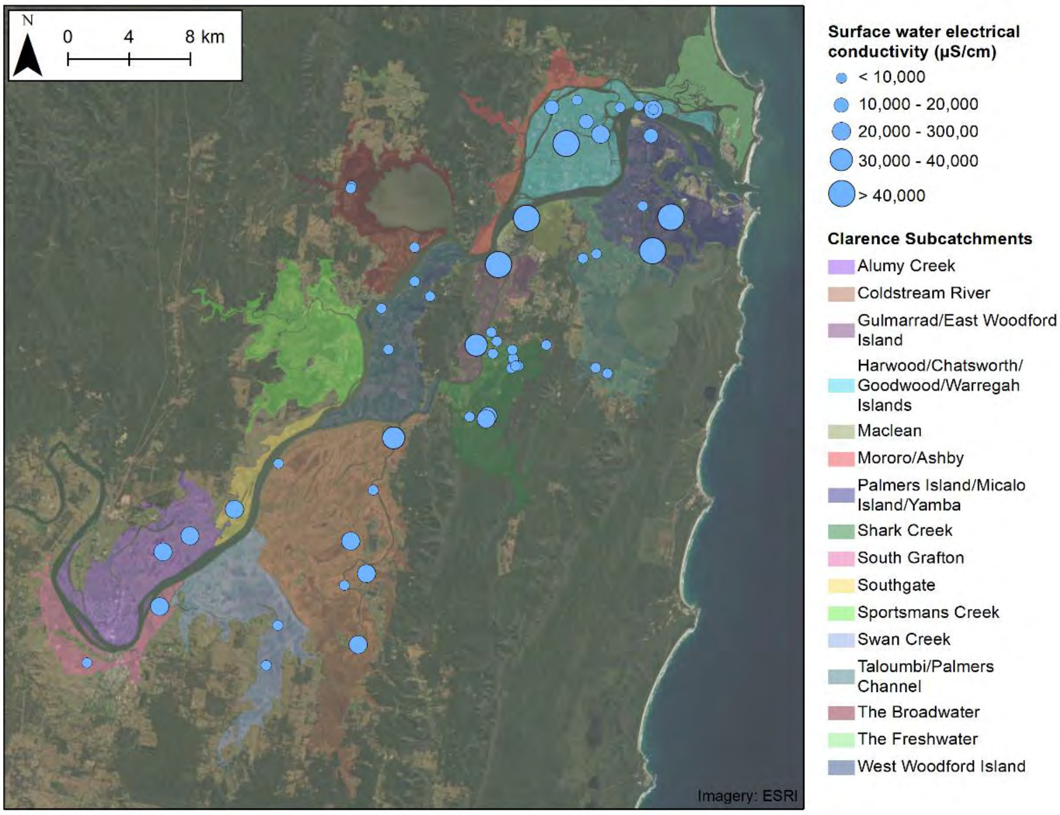

Figure H-3: Surface water electrical conductivity measurements taken across the Clarence River floodplain

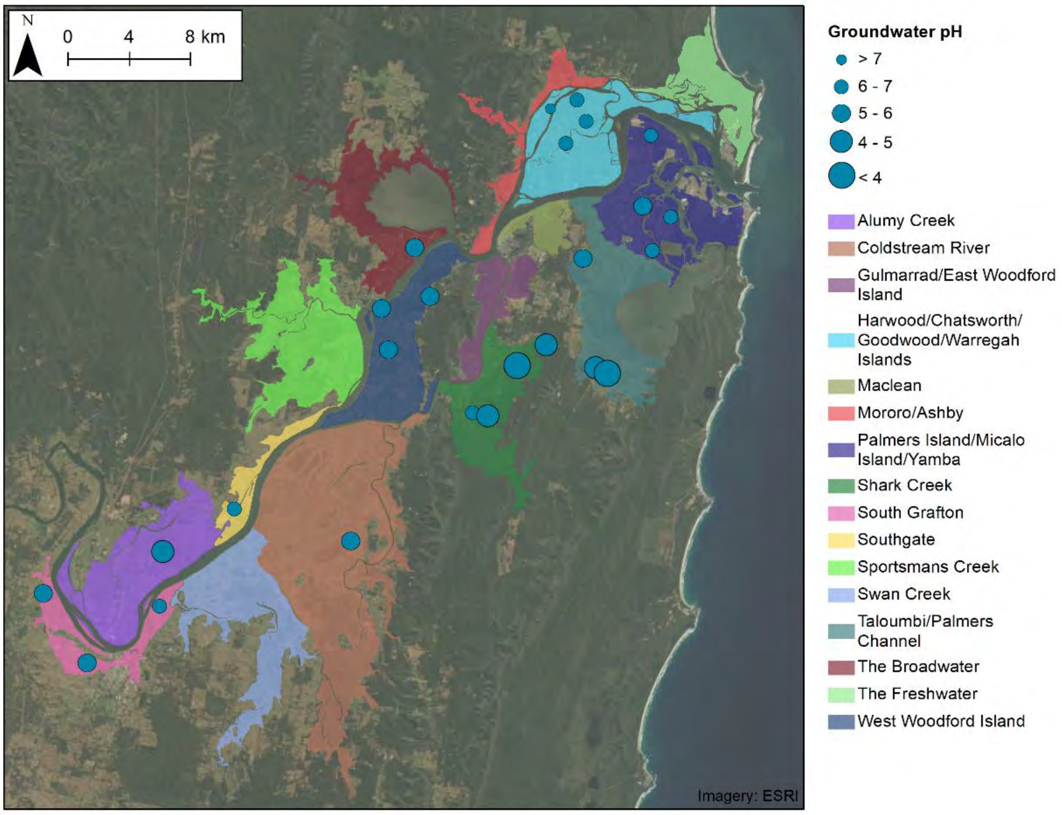

Figure H-4: Groundwater pH measurements taken across the Clarence River floodplain

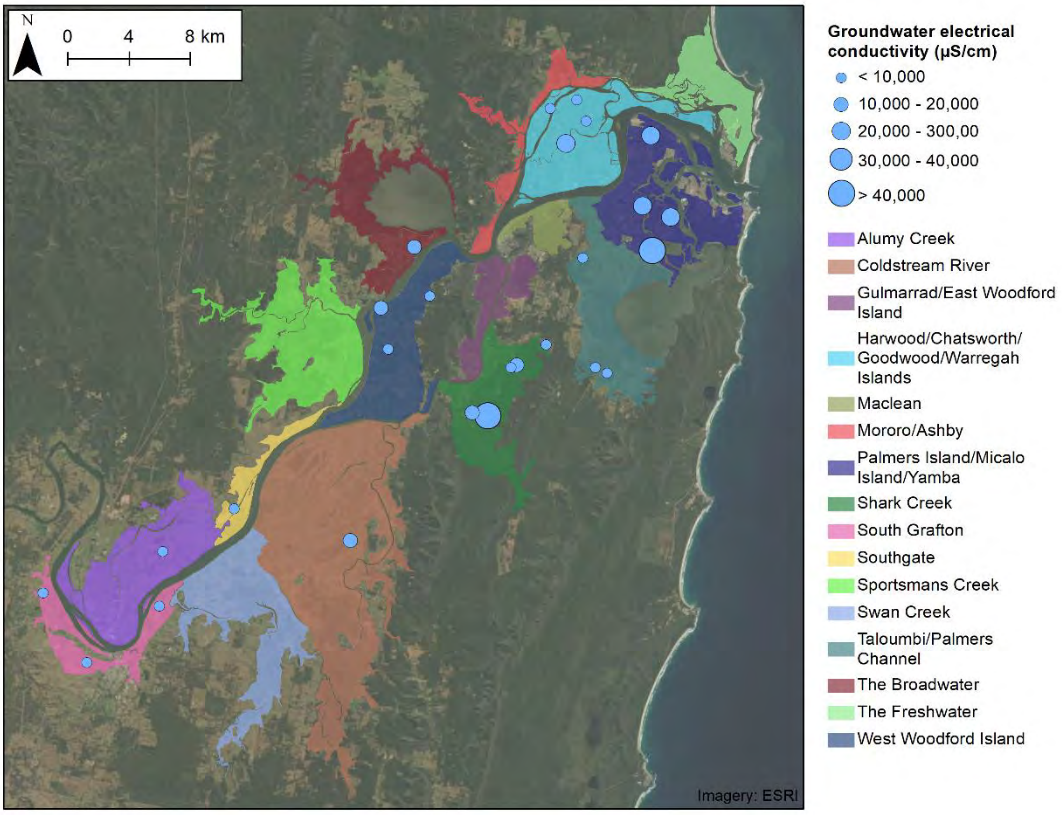

Figure H-5: Groundwater electrical conductivity measurements taken across the Clarence River floodplain

Appendix I Hydrodynamic modelling

I1 Preamble

The following section provides a summary of the hydrodynamic numerical model adopted for the Clarence 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 (3) 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 Clarence 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:

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

Where:

ε = horizontal eddy viscosity (m^2/s)
V = velocity (m/s)
α = non-dimensional scaling factor
Δ_{elt} = is 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 mo del 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 RMA-2 hydrodynamic model of the Clarence River Floodplain was adopted from Glamore et al. (2014) and used to simulate the typical tidal water level variations within the estuary. This numerical model had been previously calibrated against water levels and tidal discharge throughout the estuary. The model domain extended across the major tidal regions of the Clarence River and its tributaries, including; Cold Stream River, Sportsman Creek, Esk River, North Arm, South Arm, the Broadwater, the Back Channel, Oyster Channel, Palmers Channel and Wooloweyah Lagoon. For this study, the previously developed model was refined in areas around Oyster Channel and Wooloweyah Lagoon to improve resolution in areas around the lower estuary where complex 2-D flows and tidal attenuation were expected to occur. The updated model area is shown in Figure I-1.

Figure I-1: Clarence 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.

Upstream channel bathymetry was based on the previous modelling of the Clarence River Estuary (Glamore et al., 2014). The downstream areas of the model were updated using data from a hydrographic survey undertaken by WRL during 16-19 June, 2020 around Oyster Channel and Wooloweyah Lagoon.

Catchment inflows were based on observed river flow data from WaterNSW gauging stations in the upper Clarence River catchment as shown in Figure I-2. A summary table of the upstream inflow boundaries 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 MHL station at Yamba (Station Number 204454).

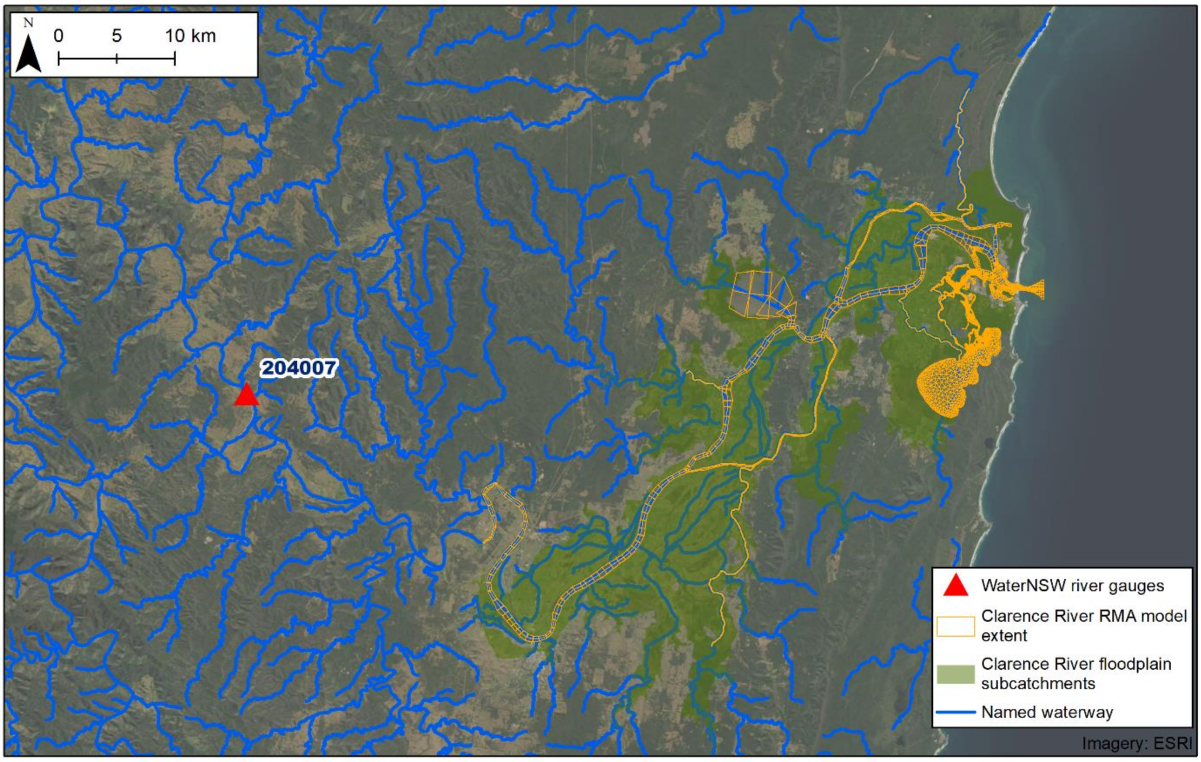

Figure I-2: Location of WaterNSW river flow gauges with relation to the hydrodynamic model extent

Table I-1: Summary of model boundary conditions

Gauging Station Name	Data Source	Station Number	Scale Factor
Clarence River at Lilydale	WaterNSW	204007	1
Yamba	MHL	204454	NA

I2.4 Model calibration

The hydrodynamic model for the Clarence River estuary was calibrated to selected water level and tidal flow gauging stations for 1996. The year 1996 was selected based on short-term tidal flow gauging of the Clarence Estuary which were recorded at various locations within the estuary on 24 October 1996 (MHL, 1996). These locations are shown in Figure I-3. Water level data was sourced from NSW DPIE Manly Hydraulics Laboratory (MHL). These locations[1] are shown in Figure I-4.

The main internal model parameters for hydrodynamic calibrations in the RMA-2 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 flow, tidal ranges and phasings throughout the estuary. A Manning's n value of 0.20 was adopted for the main Clarence River channel, 0.025 in Oyster Channel, 0.045 in Palmers Channel and 0.20 for areas around culverts and bridges.

The flow calibration results are shown in Figure I-5 to Figure I-9. The water level calibration results for a 2-day window during this period are shown in Figure I-10 to Figure I-12. The model was calibrated (for dry weather periods) to less than 0.2 m for the entire estuary.

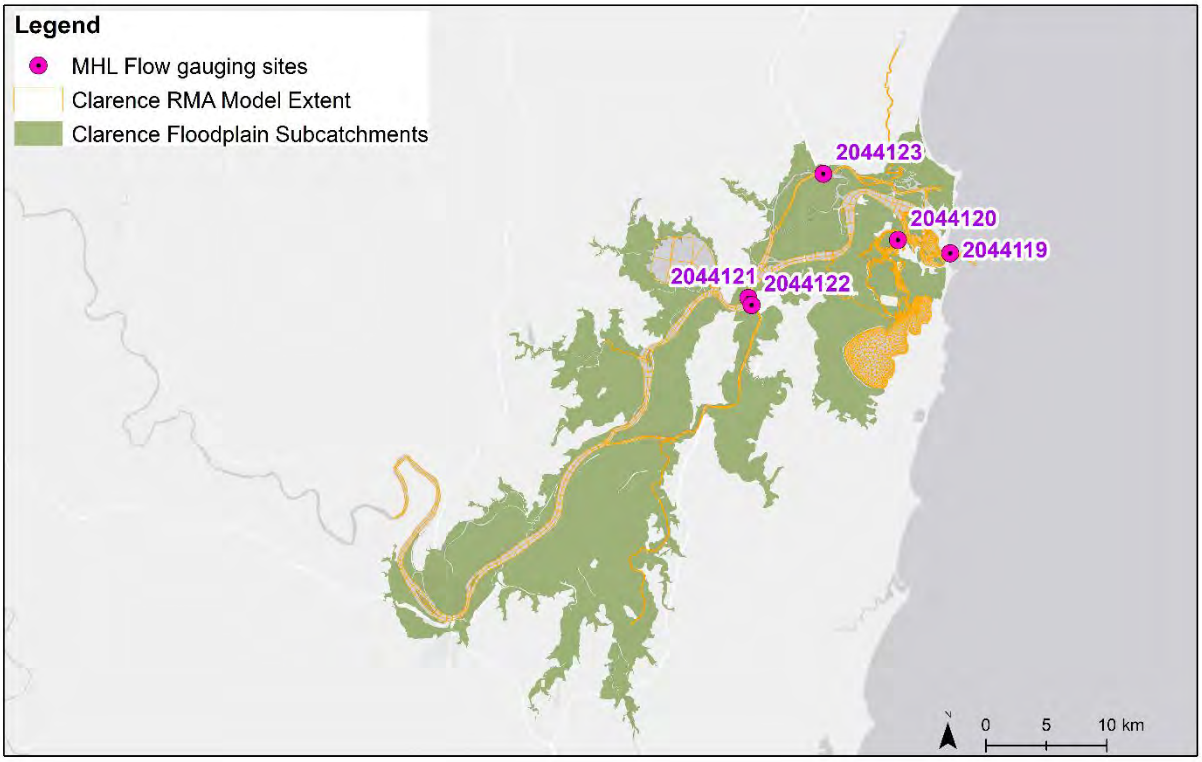

Figure I-3: Location of selected tidal flow gauging stations used for calibration of the Clarence River estuary hydrodynamic model

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[1] Note that that only some of the MHL water level stations shown in Figure I-4 had recorded data during the calibration period in 1996. The calibration results at these sites are shown in Figure I-10 to Figure I-12. The remaining sites shown in Figure I-4 are used during hydrodynamic model verification.

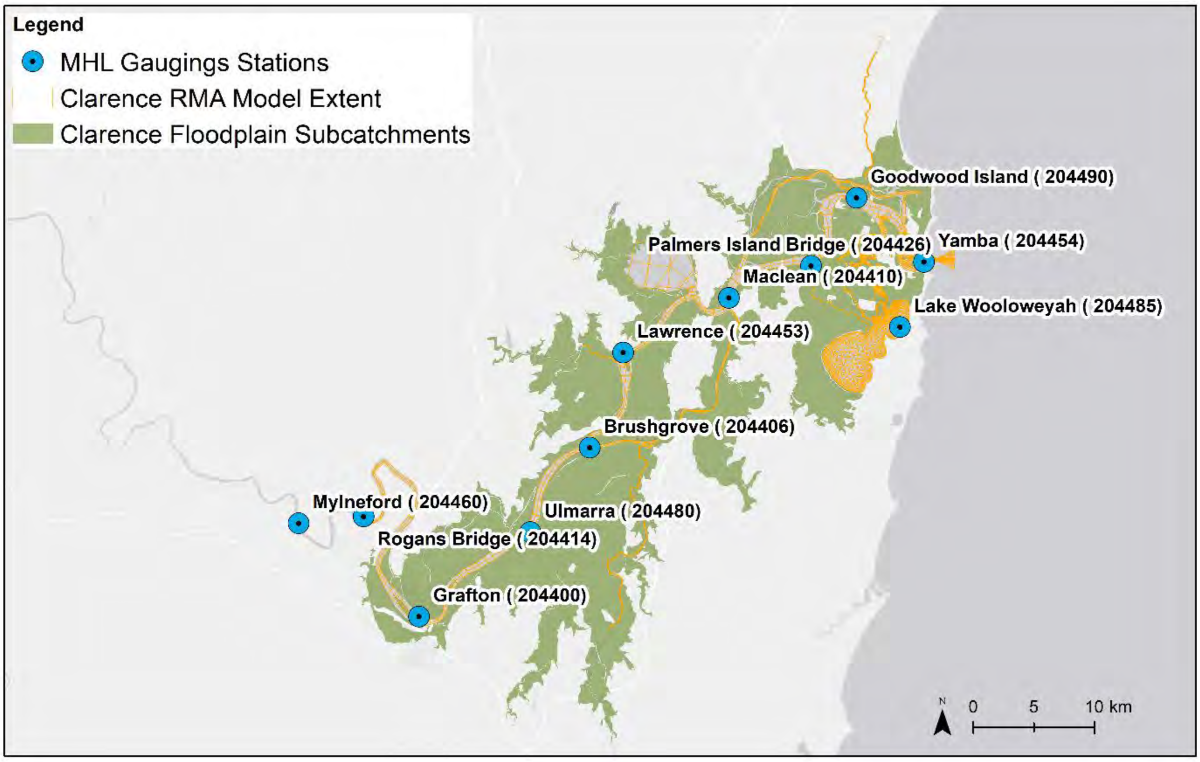

Figure I-4: Location of selected water level stations used for calibration of the Clarence River estuary hydrodynamic model

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 a 20-day window for the Clarence Estuary for 2013 and 2019 are provided in Figure I-13 to Figure I-32.

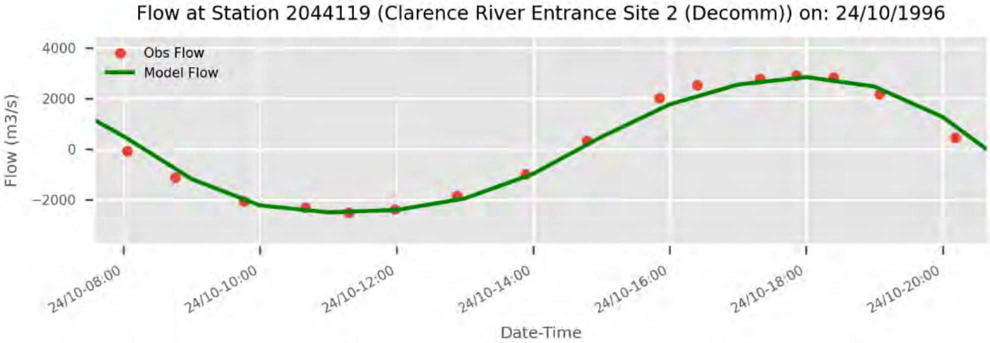

Figure I-5: Clarence hydrodynamic model flow calibrations at Station 2044119

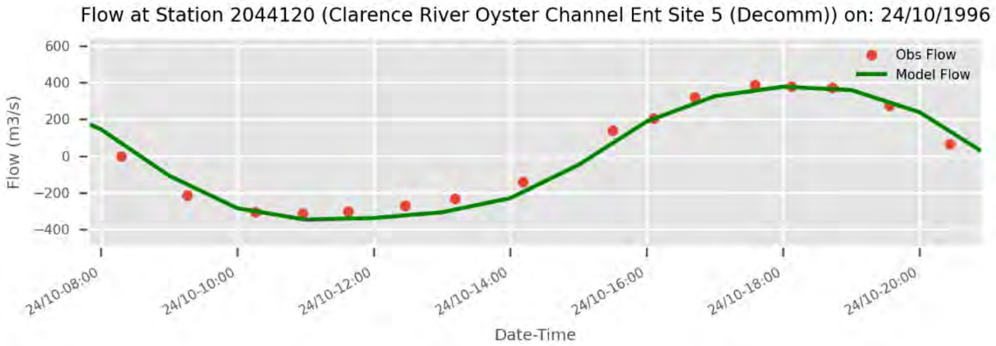

Figure I-6: Clarence hydrodynamic model flow calibrations at Station 2044120

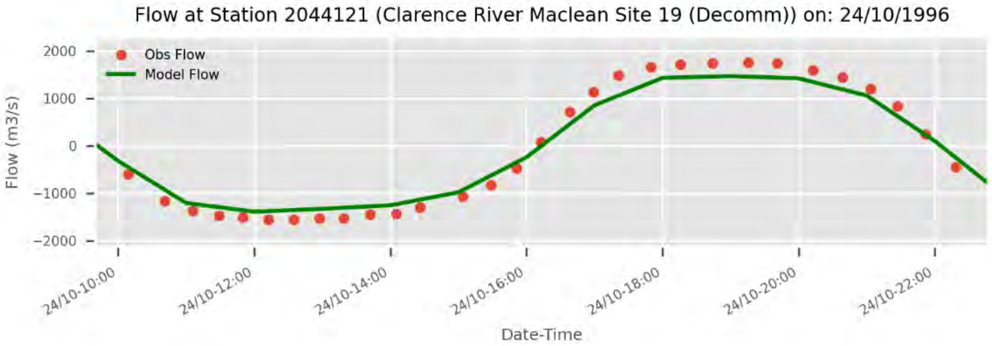

Figure I-7: Clarence hydrodynamic model flow calibrations at Station 2044121

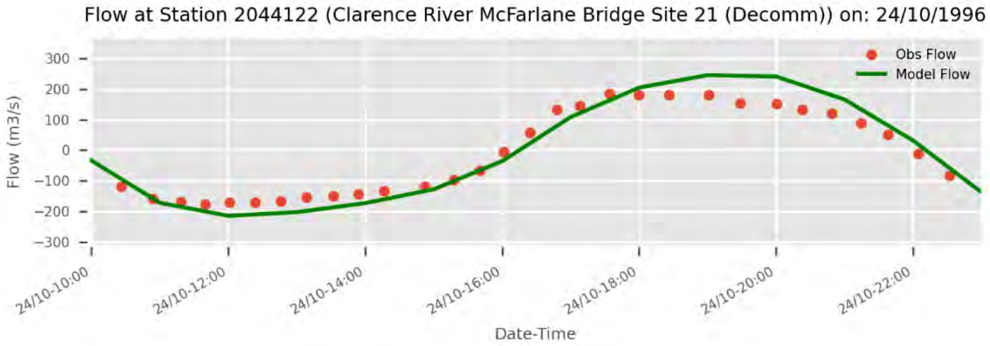

Figure I-8: Clarence hydrodynamic model flow calibrations at Station 2044122

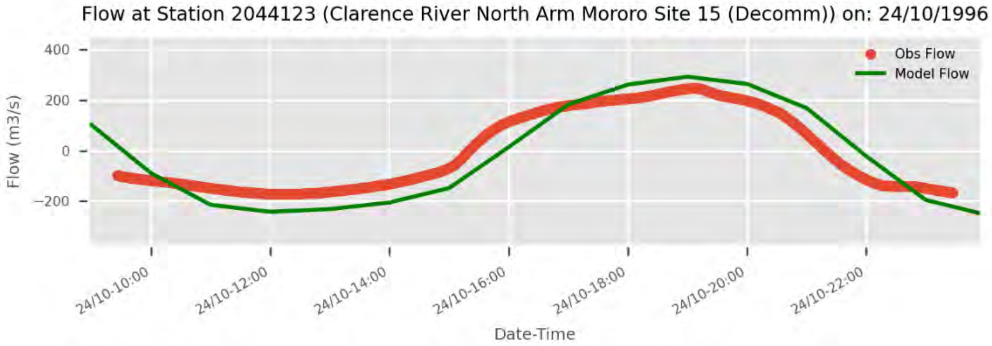

Figure I-9: Clarence hydrodynamic model flow calibrations at Station 2044123

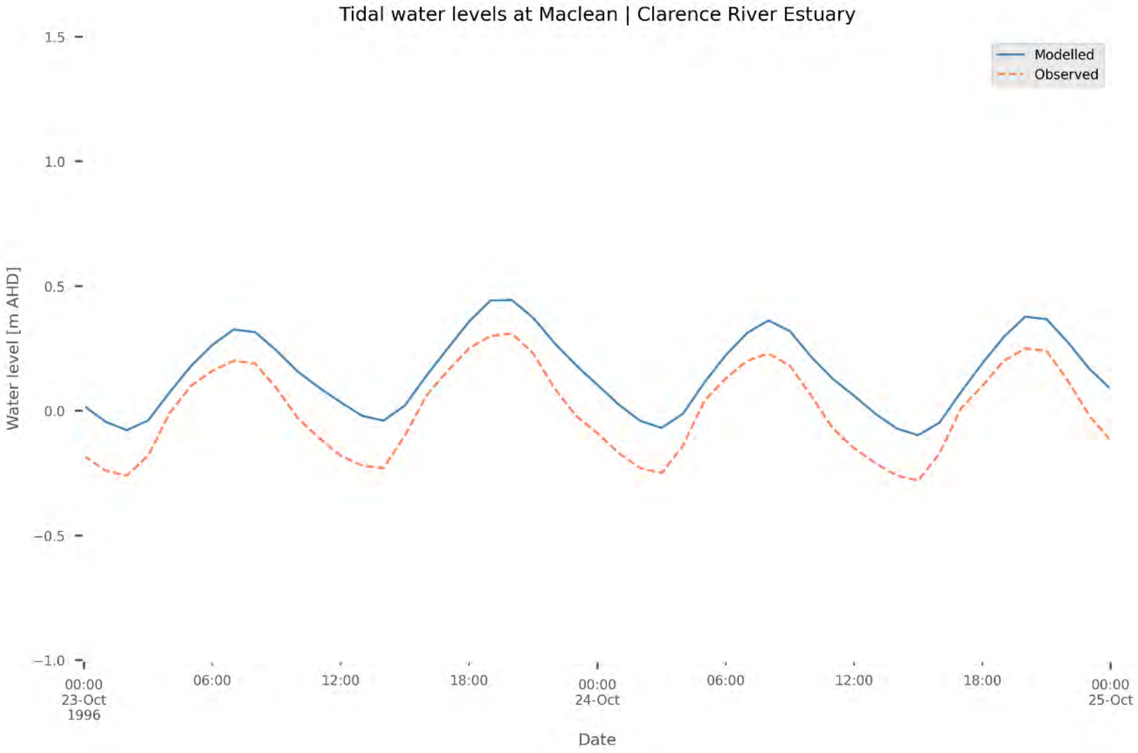

Figure I-10: Clarence hydrodynamic model calibration results at Maclean (204410)

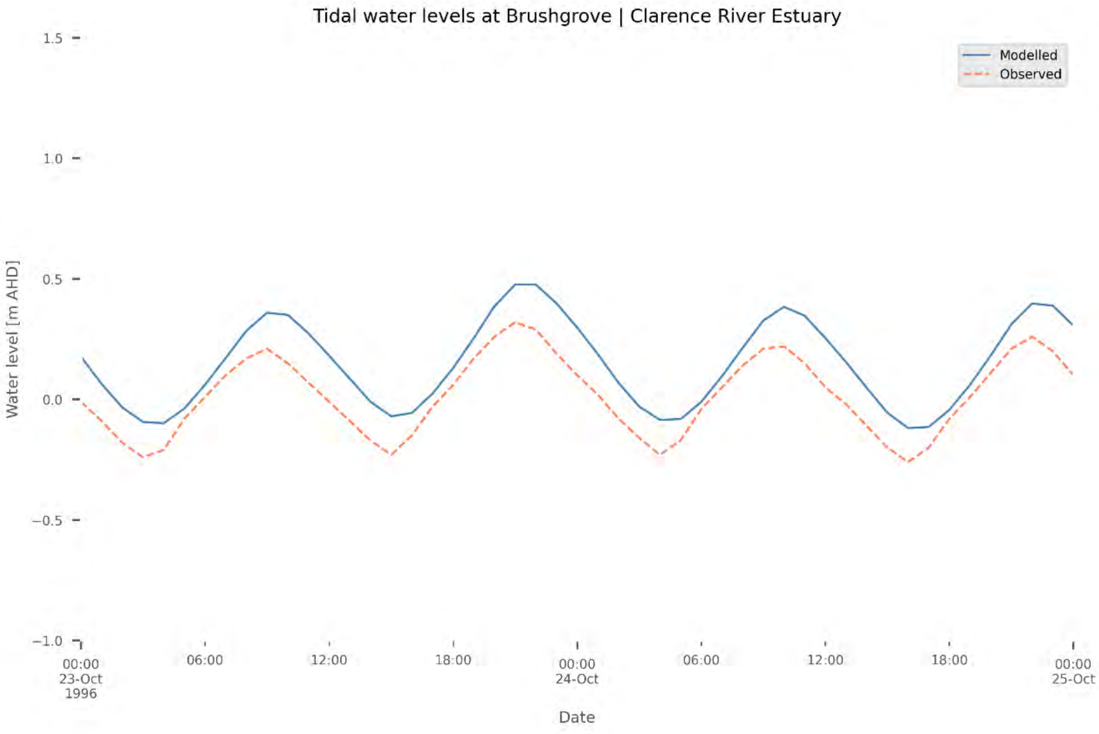

Figure I-11: Clarence hydrodynamic model calibration results at Brushgrove (204406)

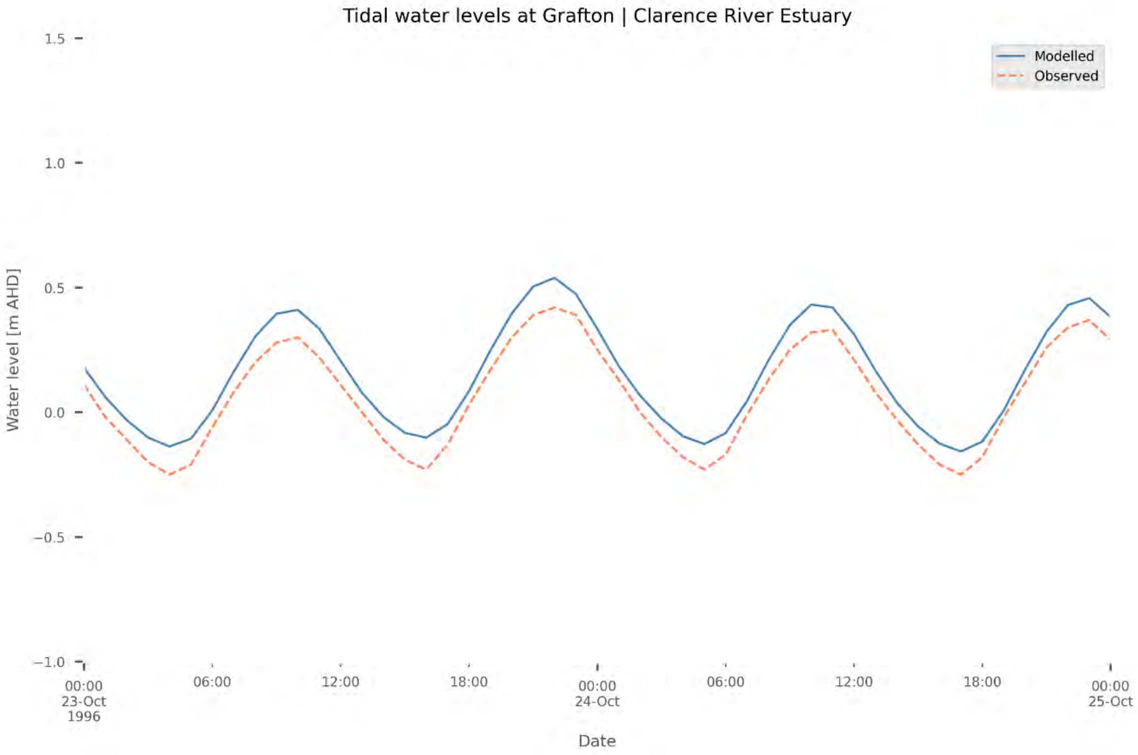

Figure I-12: Clarence hydrodynamic model calibration results at Grafton (204400)

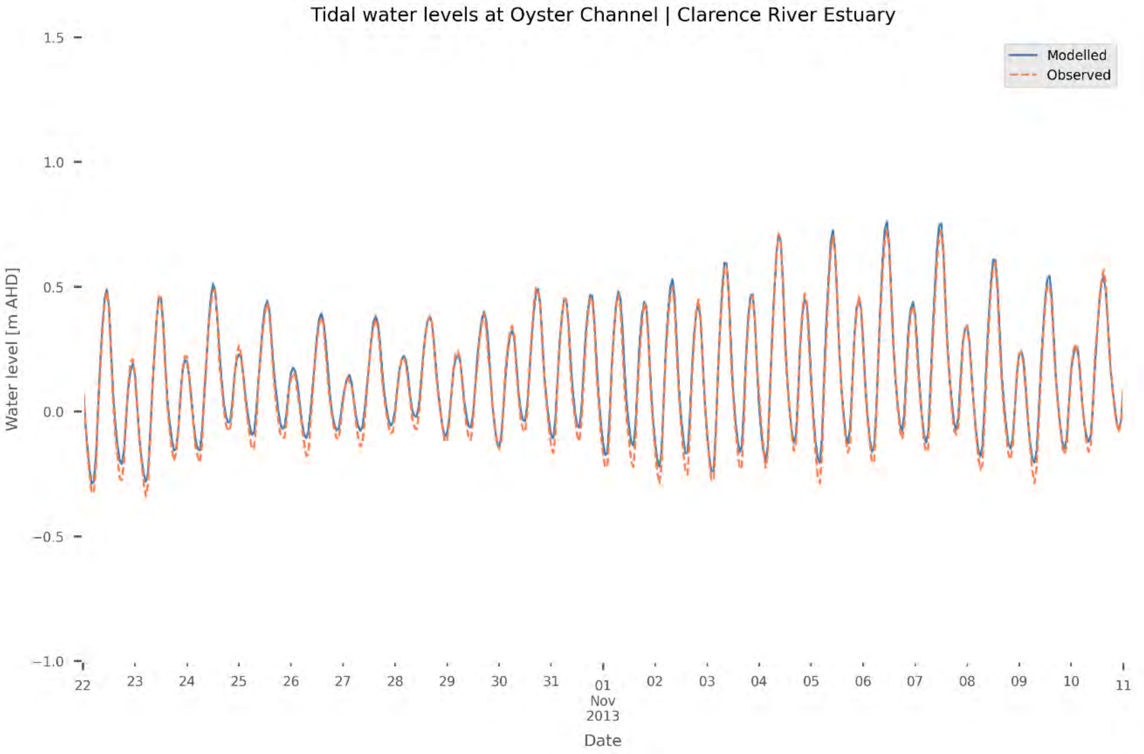

Figure I-13: Clarence hydrodynamic model verification results (2013) at Oyster Channel (204451)

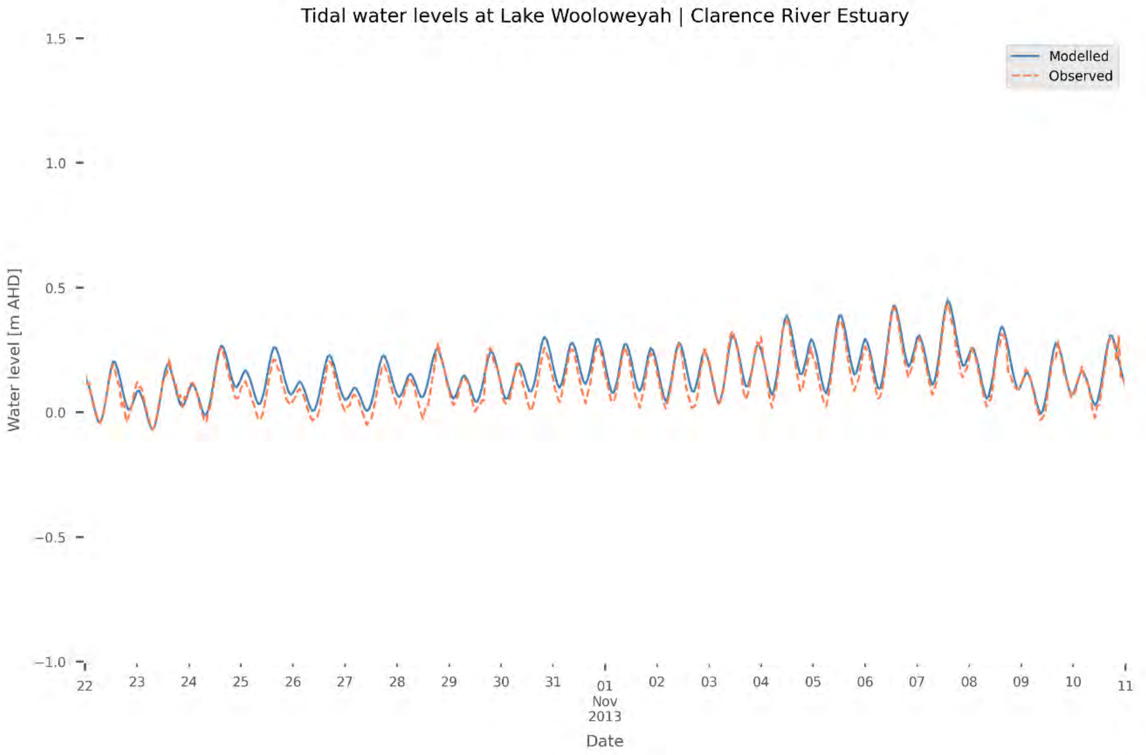

Figure I-14: Clarence hydrodynamic model verification results (2013) at Lake Wooloweyah (204485)

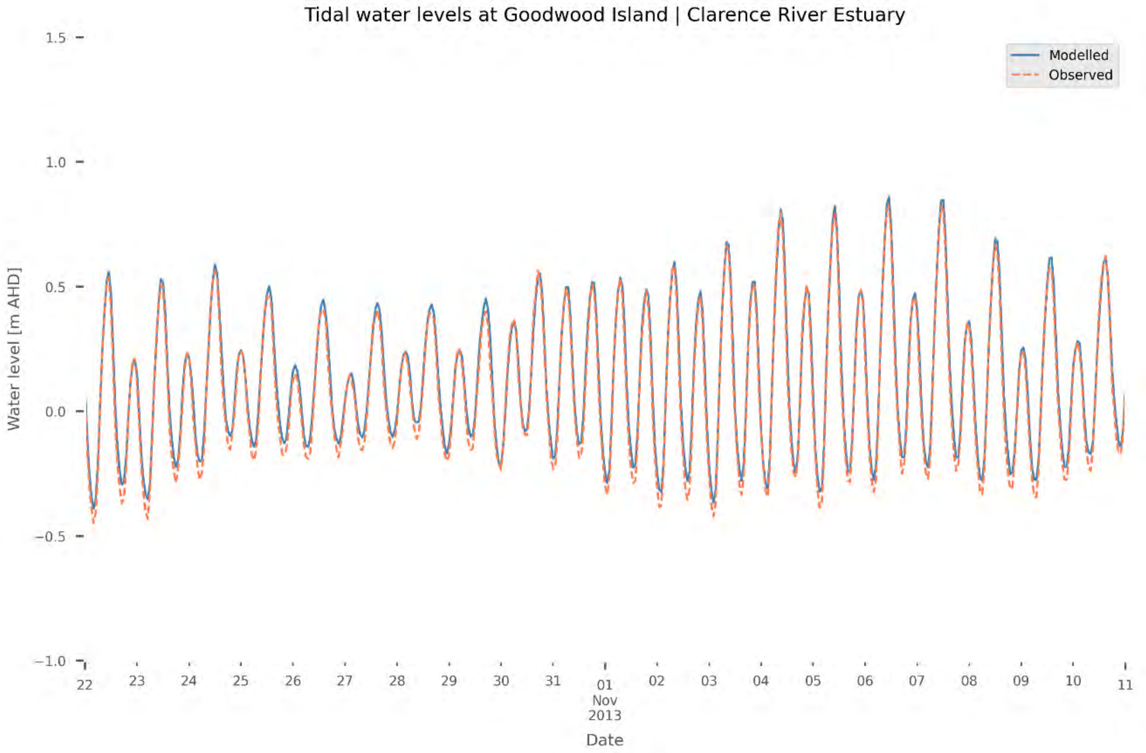

Figure I-15: Clarence hydrodynamic model verification results (2013) at Goodwood Island (204490)

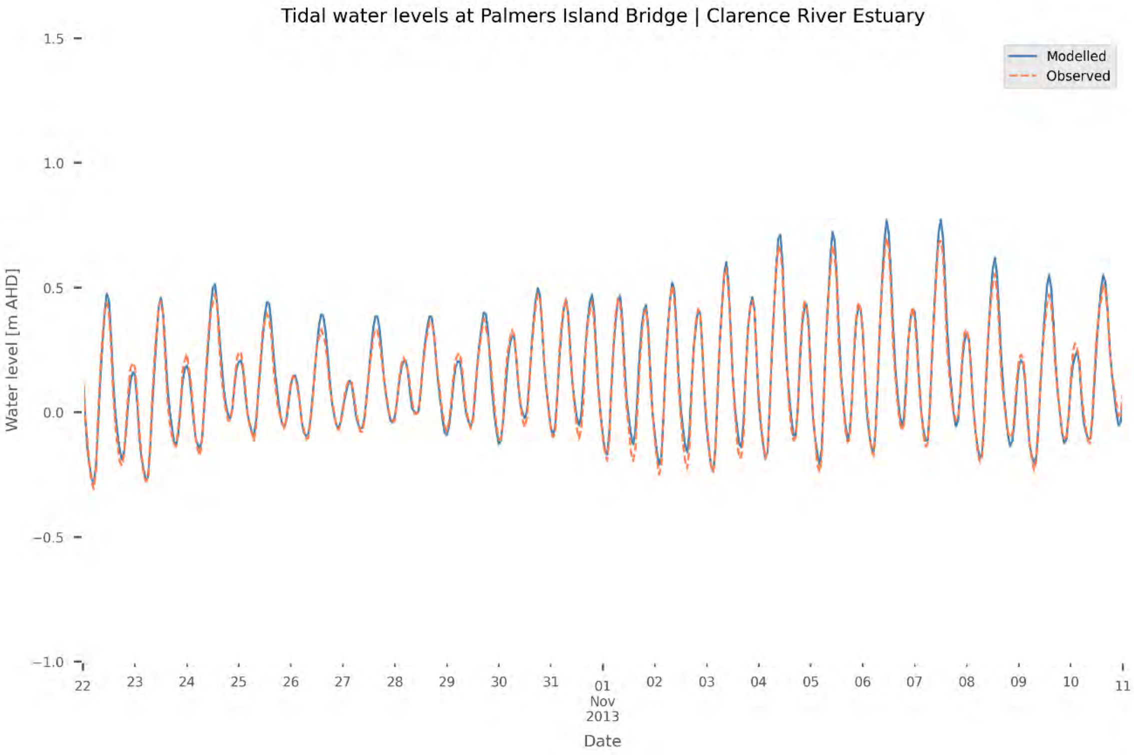

Figure I-16: Clarence hydrodynamic model verification results (2013) at Palmers Island Bridge (204426)

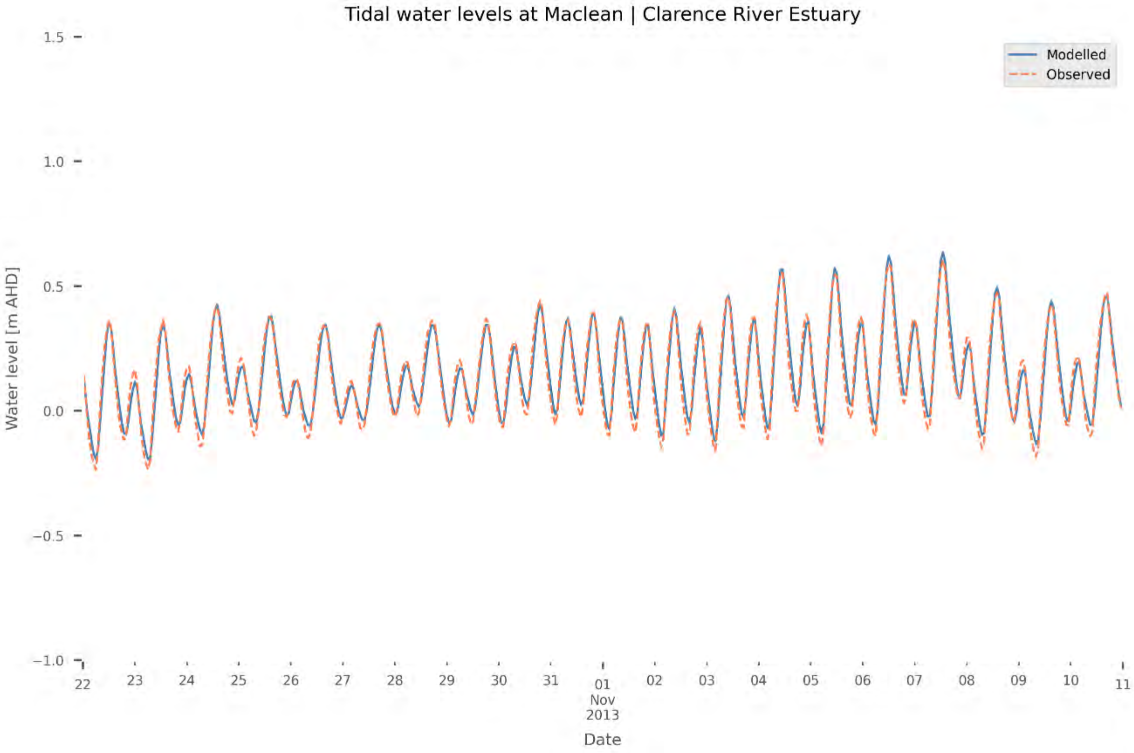

Figure I-17: Clarence hydrodynamic model verification results (2013) at Maclean (204410)

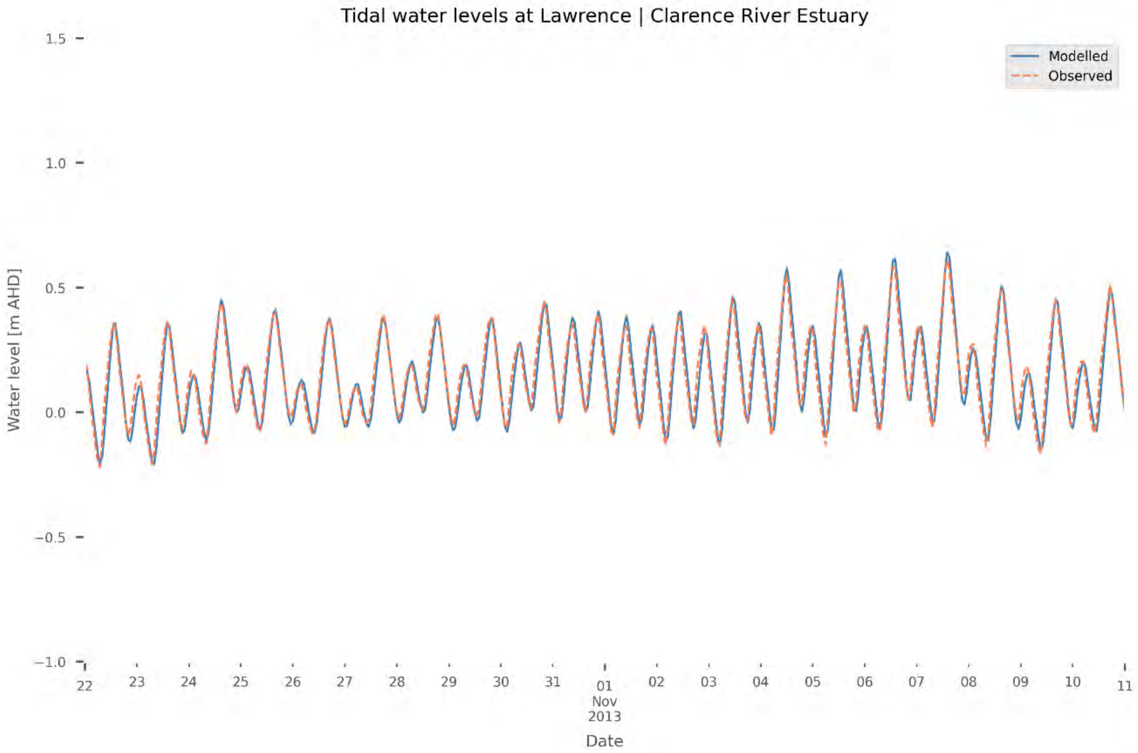

Figure I-18: Clarence hydrodynamic model verification results (2013) at Lawrence (204453)

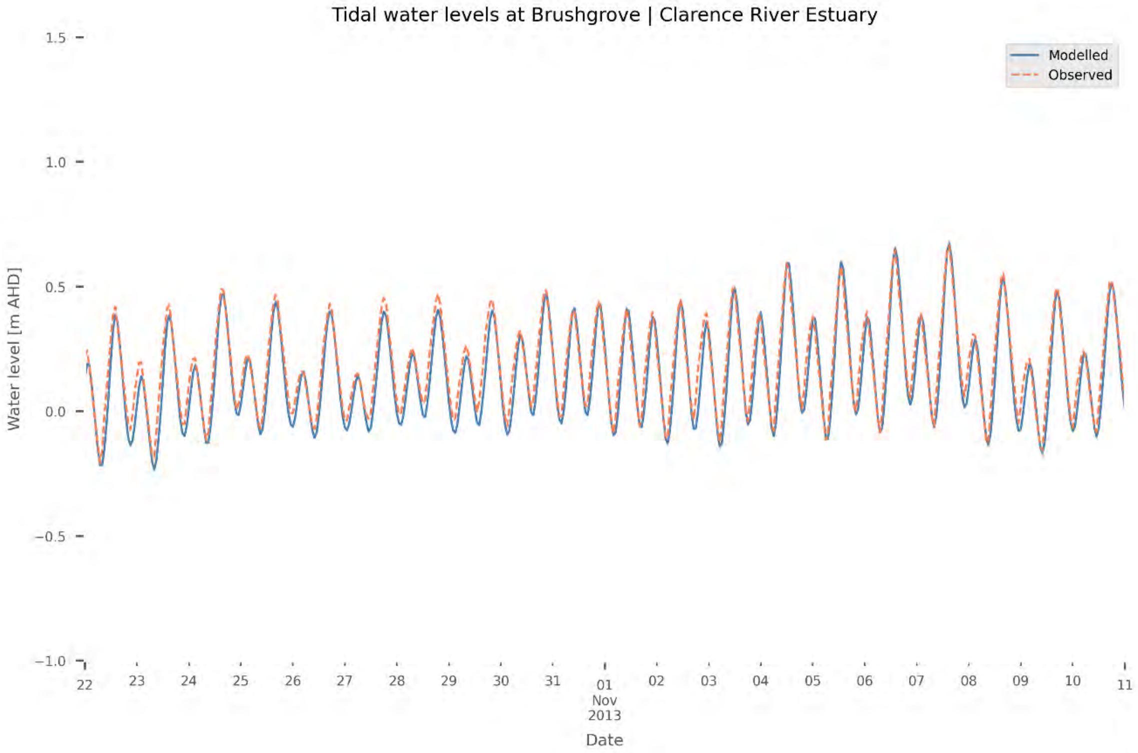

Figure I-19: Clarence hydrodynamic model verification results (2013) at Brushgrove (204406)

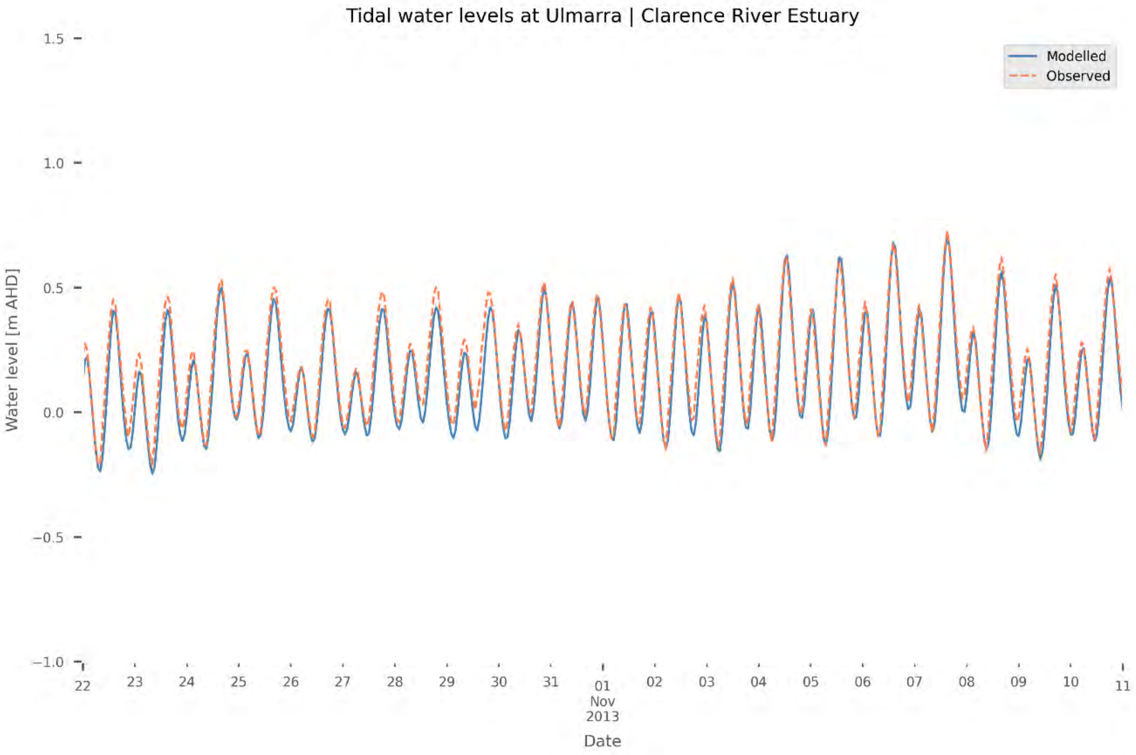

Figure I-20: Clarence hydrodynamic model verification results (2013) at Ulmarra (204480)

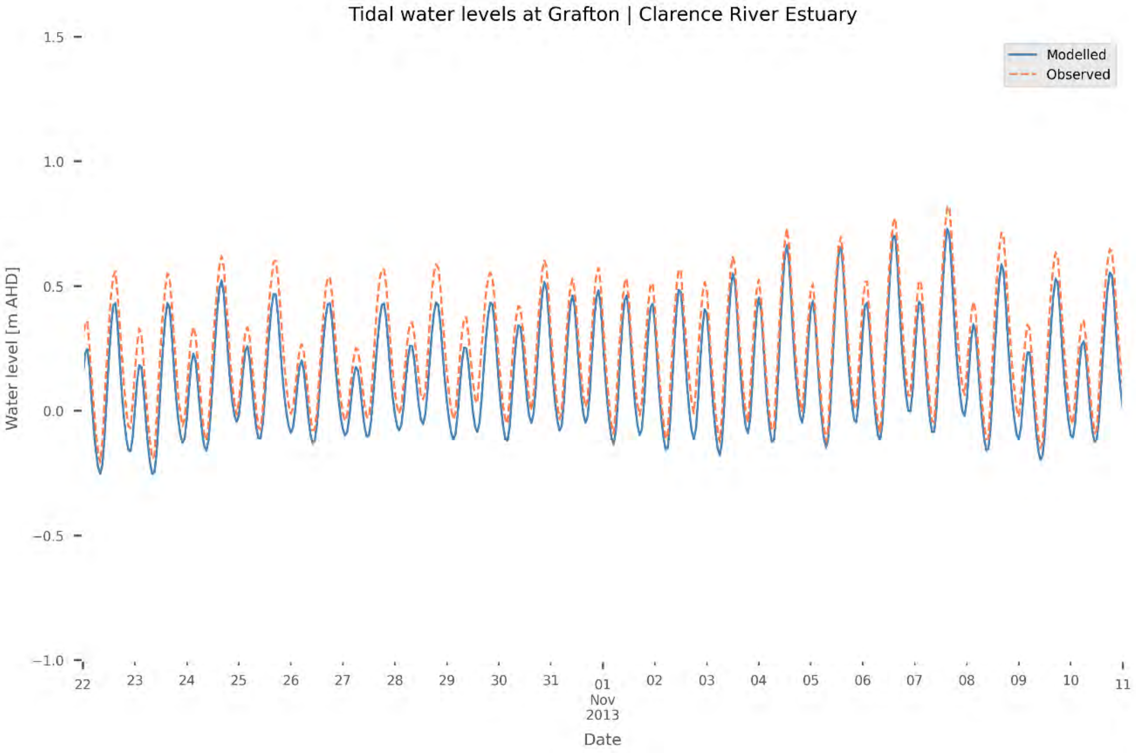

Figure I-21: Clarence hydrodynamic model verification results (2013) at Grafton (204400)

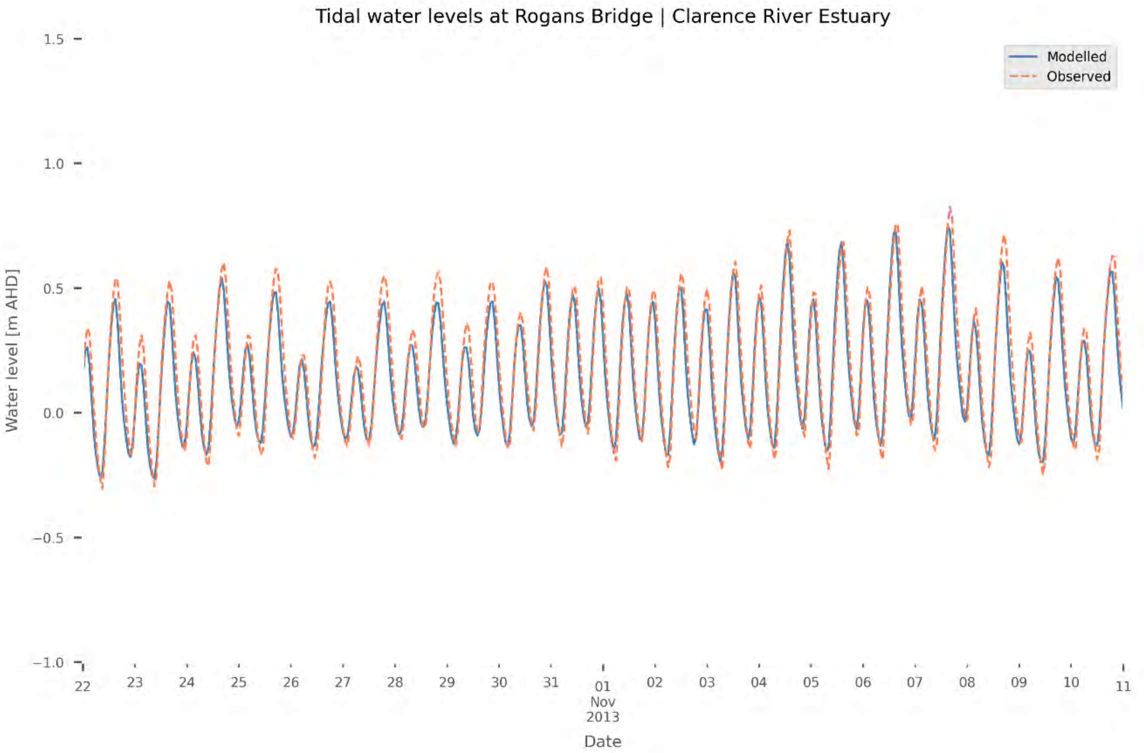

Figure I-22: Clarence hydrodynamic model verification results (2013) at Rogan's Bridge (204414)

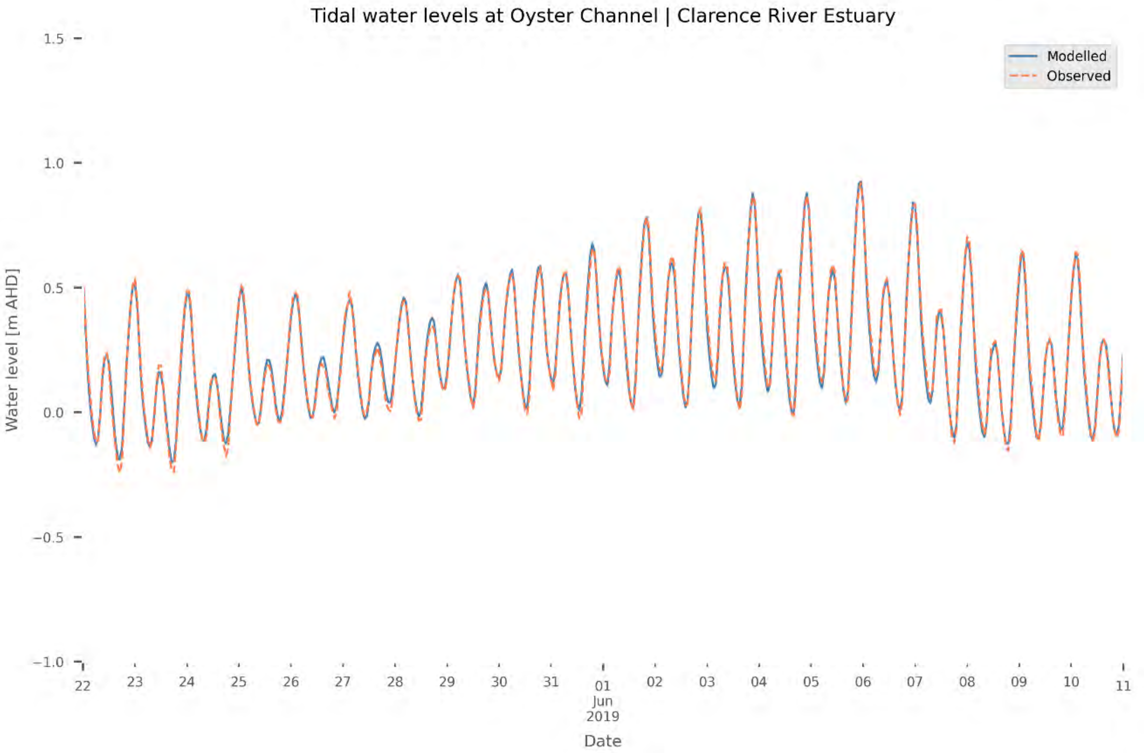

Figure I-23: Clarence hydrodynamic model verification results (2019) at Oyster Channel (204451)

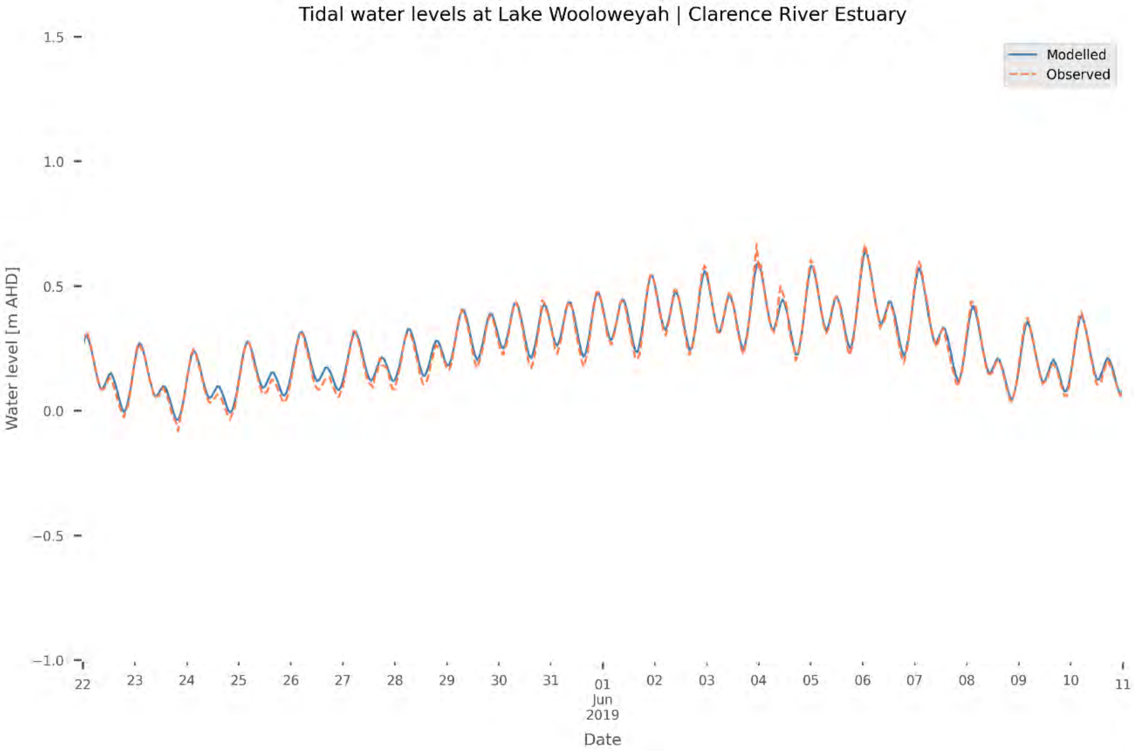

Figure I-24: Clarence hydrodynamic model verification results (2019) at Lake Wooloweyah (204485)

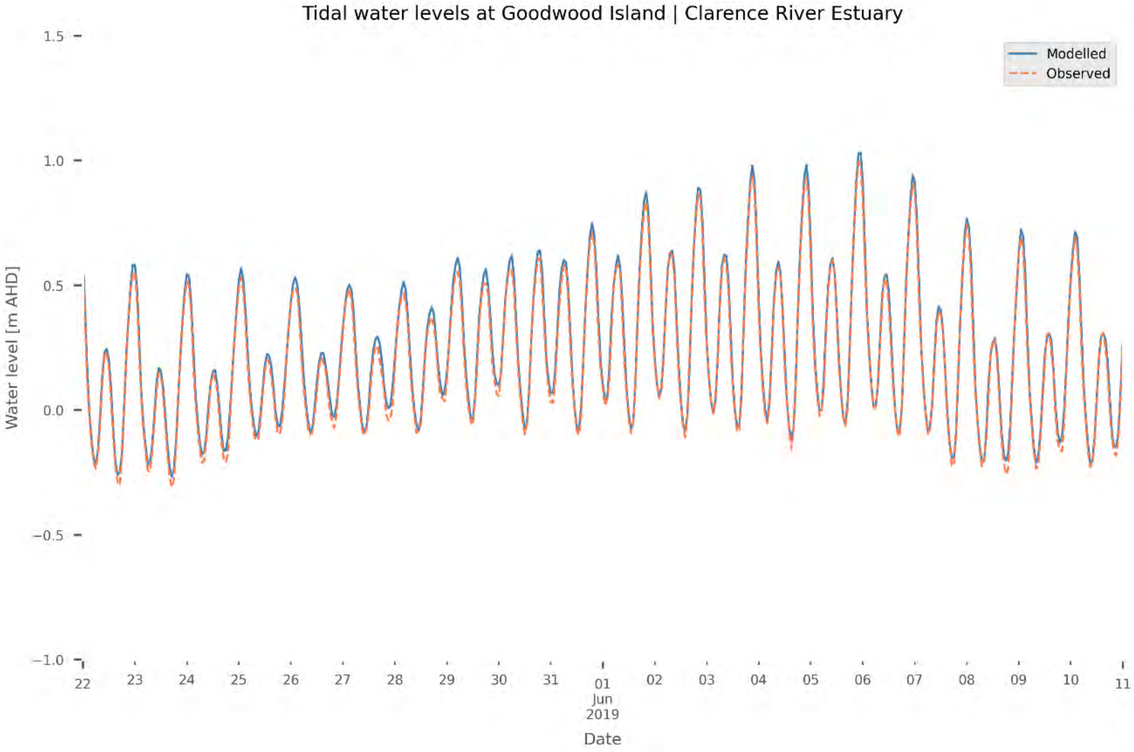

Figure I-25: Clarence hydrodynamic model verification results (2019) at Goodwood Island (204490+)

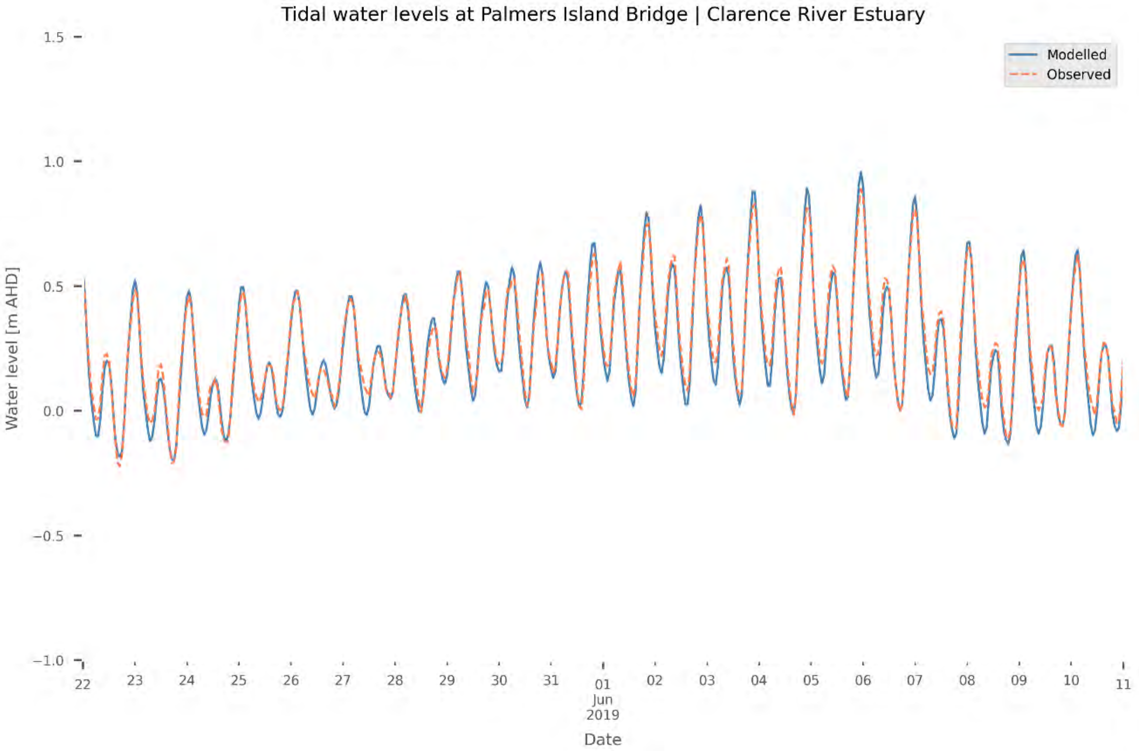

Figure I-26: Clarence hydrodynamic model verification results (2019) at Palmers Island Bridge (204426)

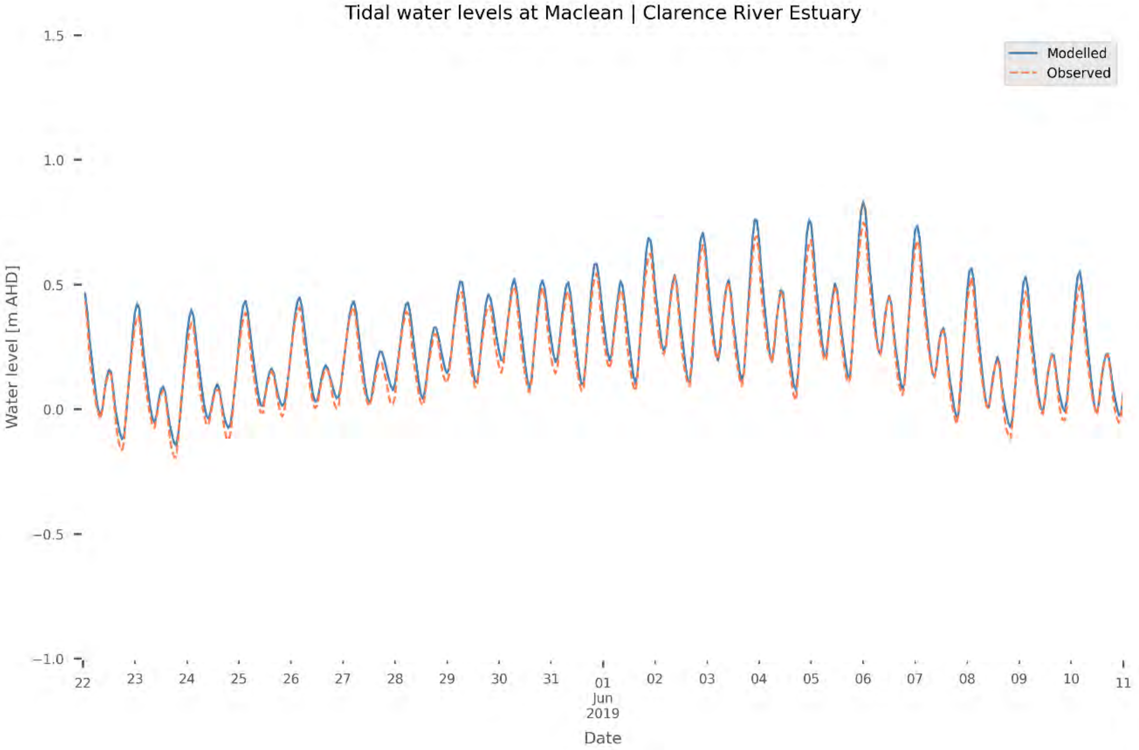

Figure I-27: Clarence hydrodynamic model verification results (2019) at Maclean (204410)

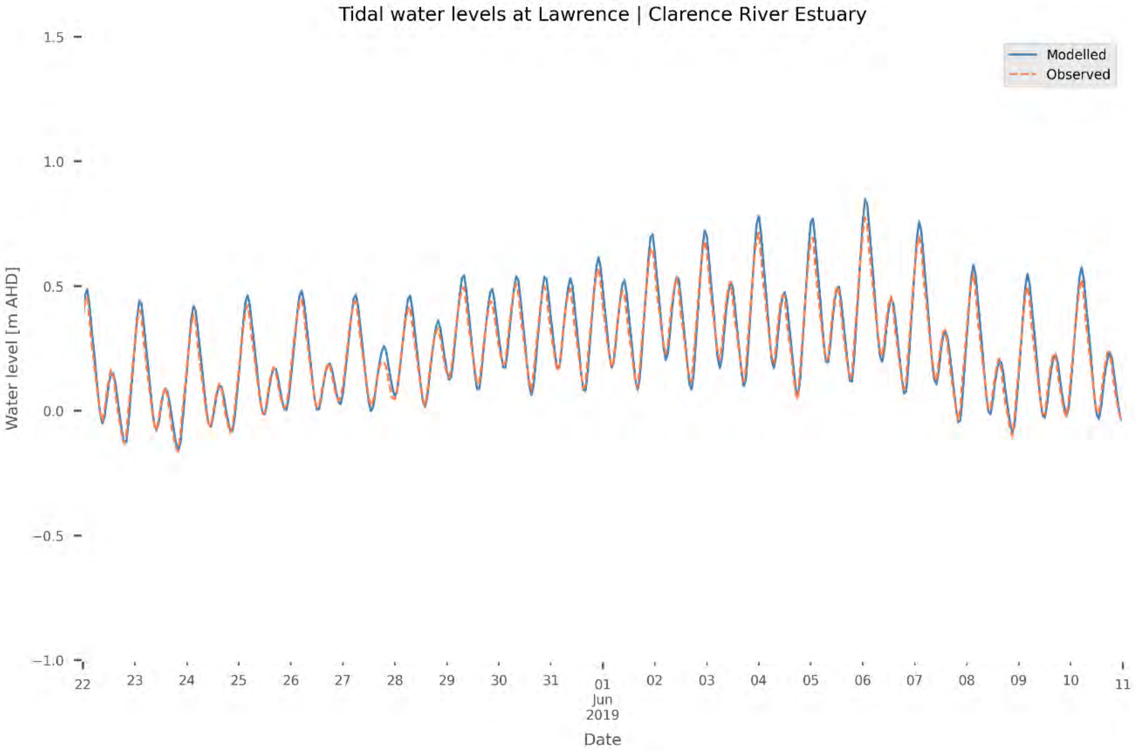

Figure I-28: Clarence hydrodynamic model verification results (2019) at Lawrence (204453)

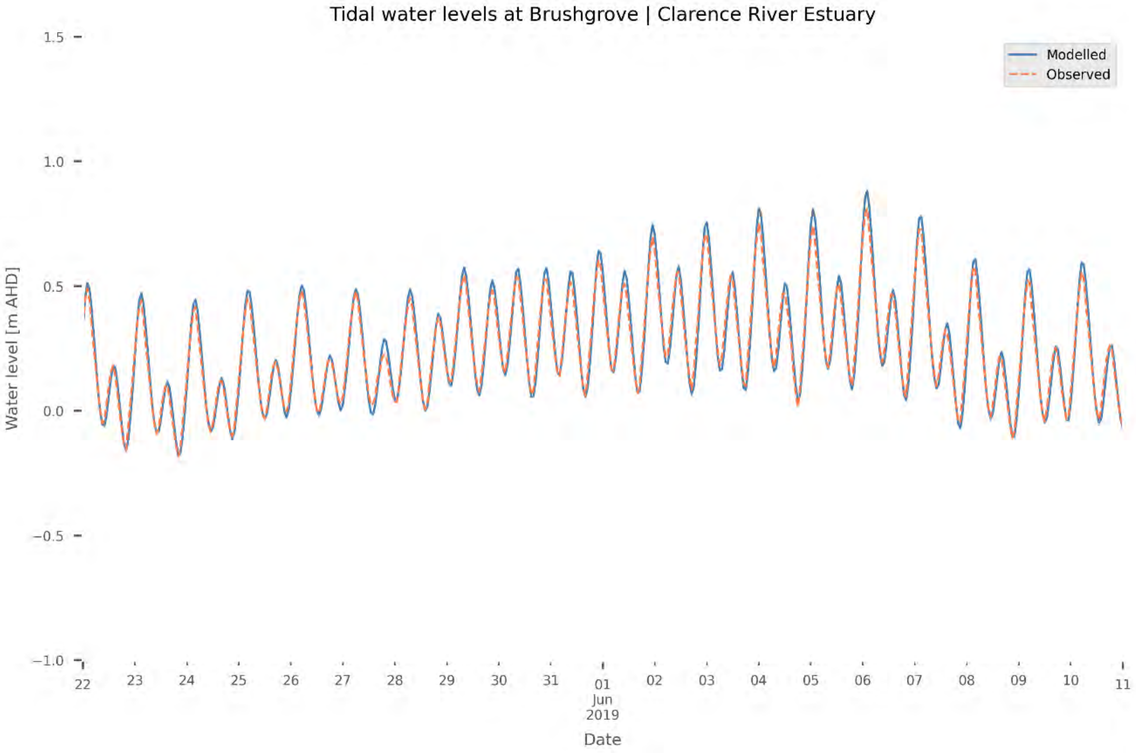

Figure I-29: Clarence hydrodynamic model verification results (2019) at Brushgrove (204406)

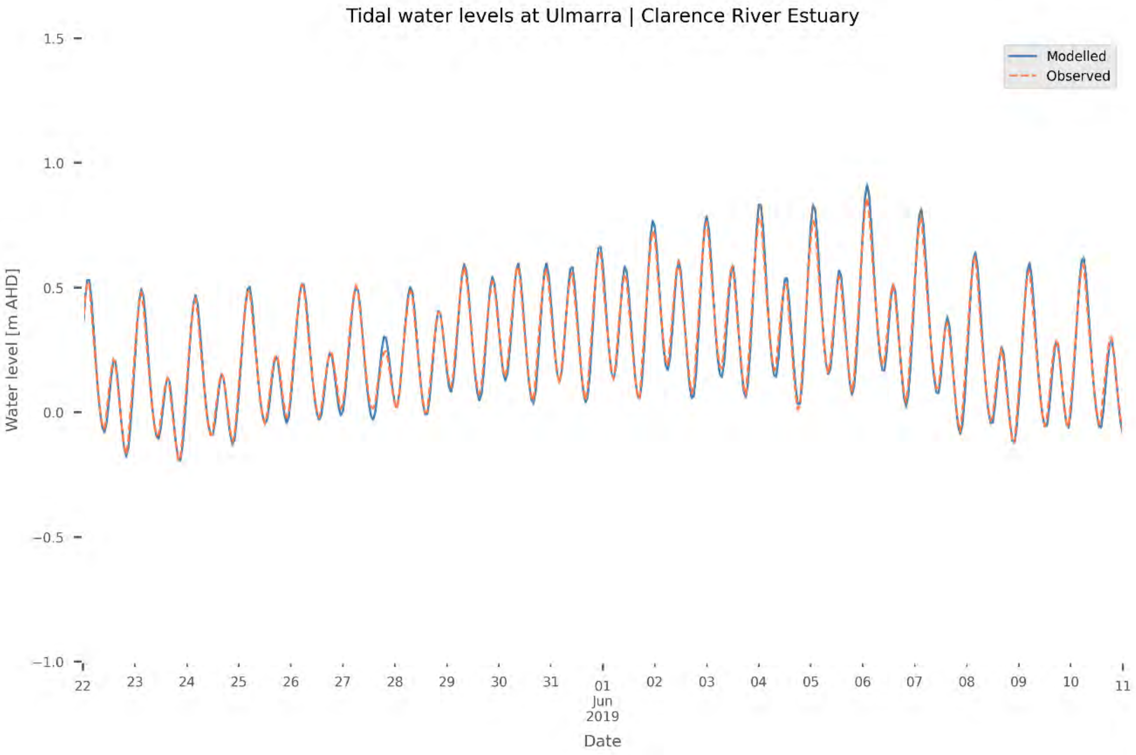

Figure I-30: Clarence hydrodynamic model verification results (2019) at Ulmarra (204480)

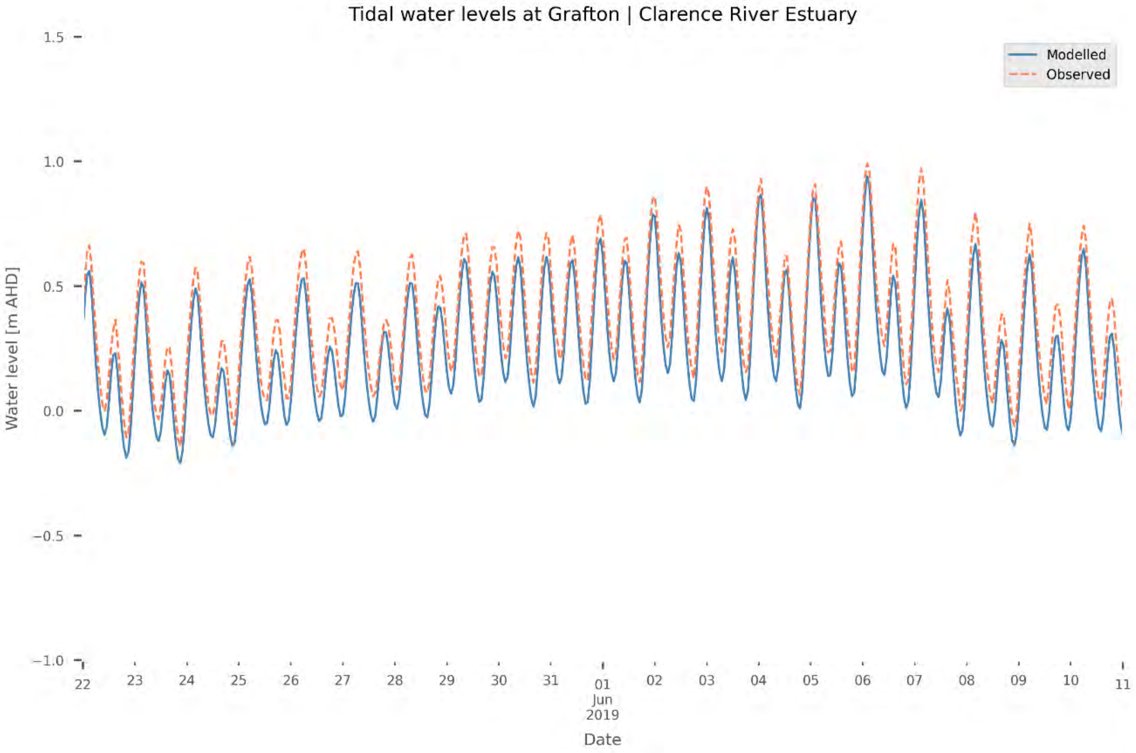

Figure I-31: Clarence hydrodynamic model verification results (2019) at Grafton (204400)

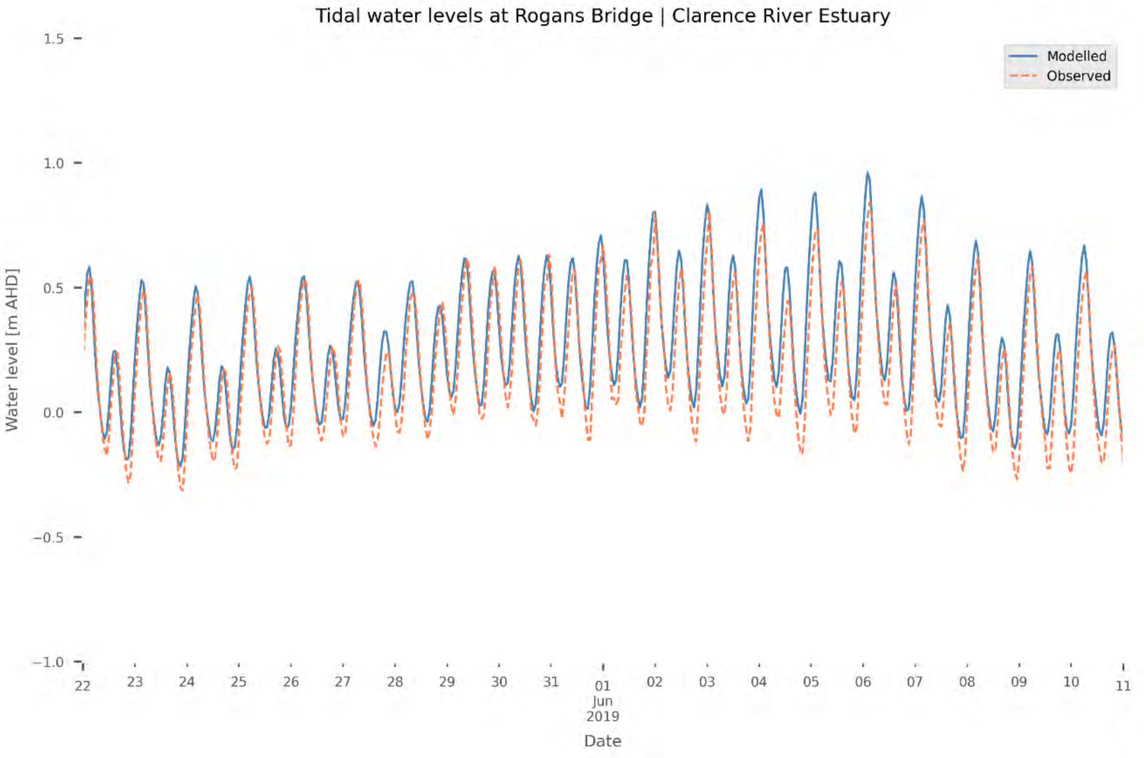

Figure I-32: Clarence hydrodynamic model verification results (2019) at Rogans Bridge (204414)

Appendix J Sensitive environmental receivers

J1 Preamble

Acid discharges from ASS-affected floodplains are well reported to cause stress to sensitive environmental receivers (Glamore, 2003; Rayner, 2010; Sammut et al., 1996; Winberg and Heath, 2010). 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 Clarence 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 Clarence 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 Figures J-1 to 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 sub-catchment within the study area

Subcatchment	Oyster leases	Estuarine Macrophytes			Coastal Management SEPP coastal wetlands	SER within subcatchment*
		Saltmarsh	Seagrass	Mangroves		
Alumy Creek	52,400	25,400	43,600	9,000	8,100	Key fish habitat
Coldstream River	37,400	16,700	28,600	200	0	Coastal wetlands, key fish habitat
Gulmarrad/ East Woodford Island	23,700	3,500	14,900	0	100	None
Harwood/ Chatsworth/ Goodwood/ Warregah Islands	4,900	0	0	0	0	Saltmarsh, mangroves, coastal wetlands, key fish habitat
Maclean	17,000	4,300	8,200	0	0	Coastal wetlands, key fish habitat
Mororo/ Ashby	14,000	0	0	0	0	Mangroves, coastal wetlands, key fish habitat
Palmers Island/ Micalo Island/ Yamba	0	0	0	0	0	Saltmarsh, seagrass, mangroves, coastal wetlands, key fish habitat
Shark Creek	28,600	9,300	19,800	100	0	Coastal wetlands, key fish habitat
South Grafton	57,700	30,800	49,000	14,400	11,000	Key fish habitat
Southgate	41,200	14,200	32,400	0	2,500	None
Sportsmans Creek	34,300	7,300	25,500	0	0	Coastal wetlands, key fish habitat
Swan Creek	52,300	25,300	43,500	8,900	0	Coastal wetlands, key fish habitat
Taloumbi/ Palmers Channel	12,600	0	2,600	0	0	Saltmarsh, mangroves, coastal wetlands
The Broadwater	27,100	0	18,300	0	0	Saltmarsh, coastal wetlands
The Freshwater	2,000	0	0	0	0	Saltmarsh, mangroves, coastal wetlands, key fish habitat
West Woodford Island	24,500	600	15,700	0	0	None

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

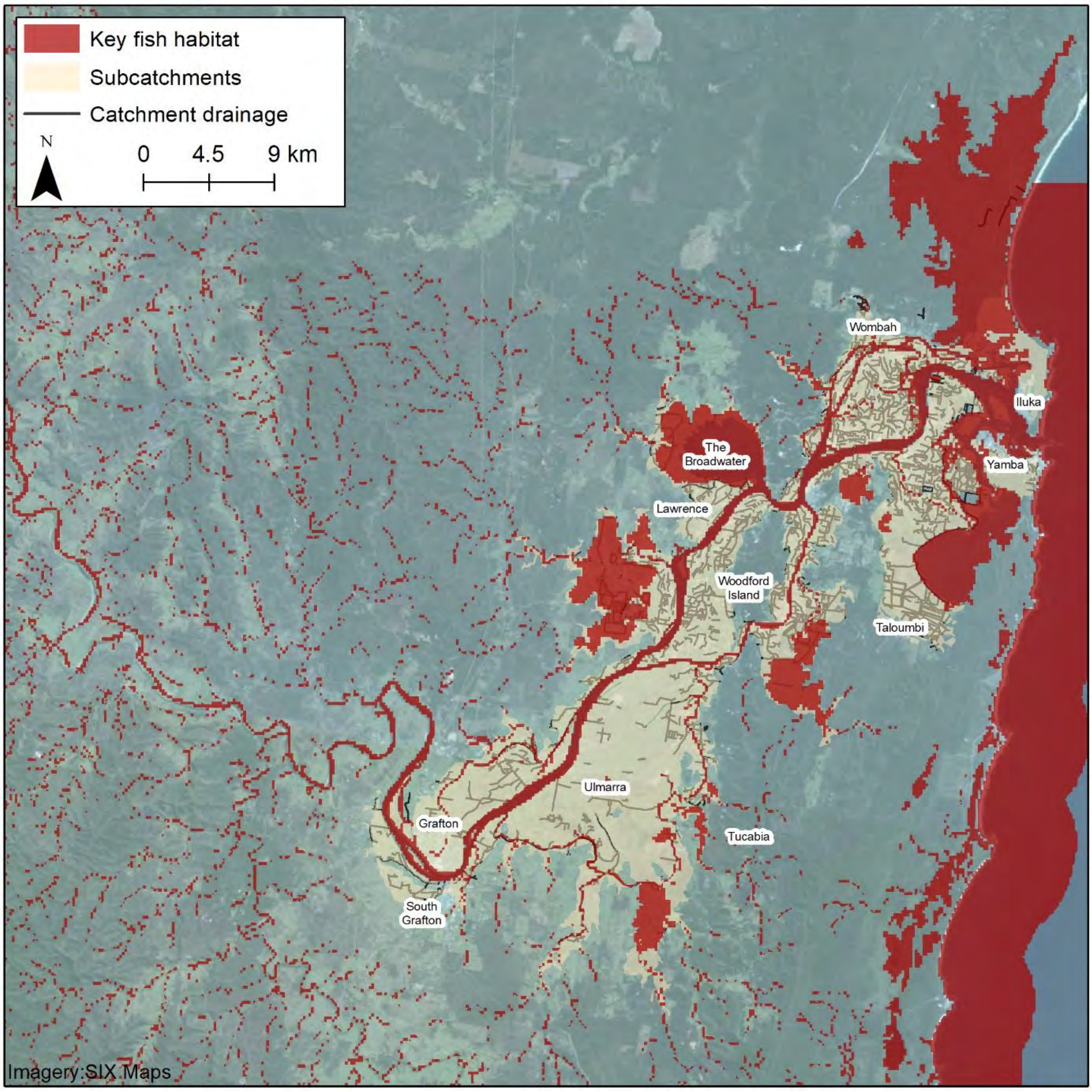

Figure J-1: Key fisheries habitat (Source: NSW DPI Fisheries)

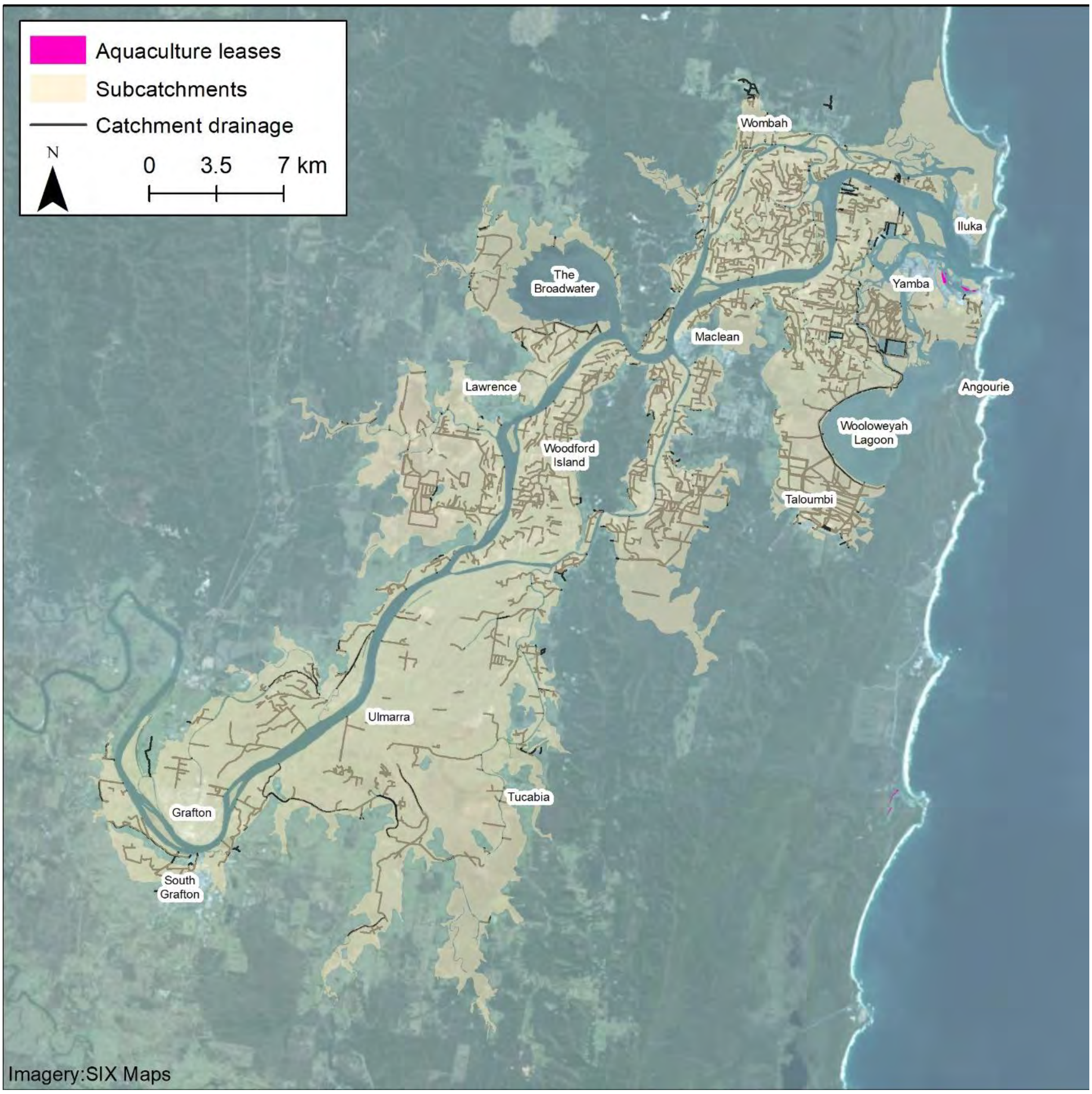

Figure J-2: Priority oyster leases (Source: NSW DPI Fisheries)

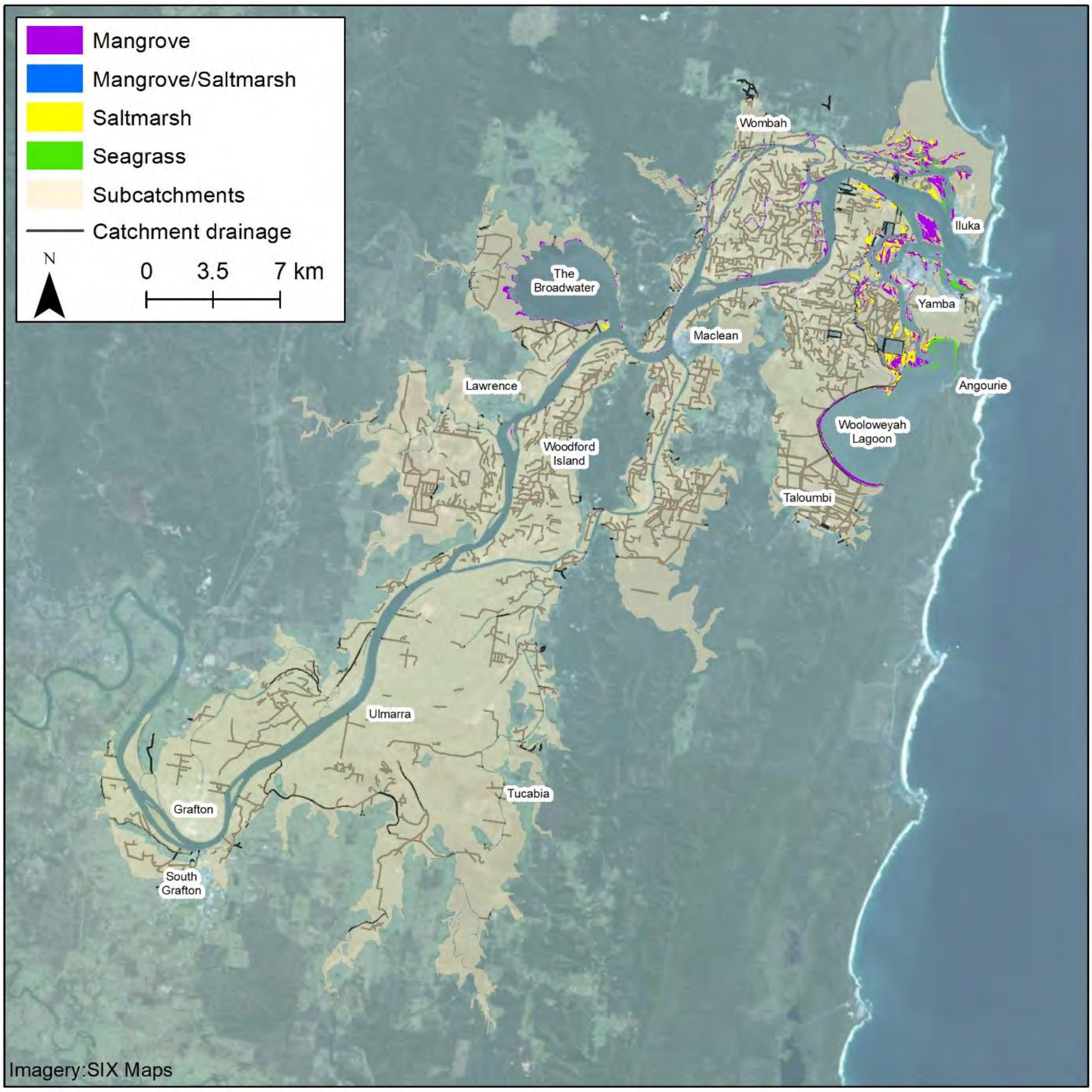

Figure J-3: Estuarine macrophytes (Source: NSW DPI Fisheries)

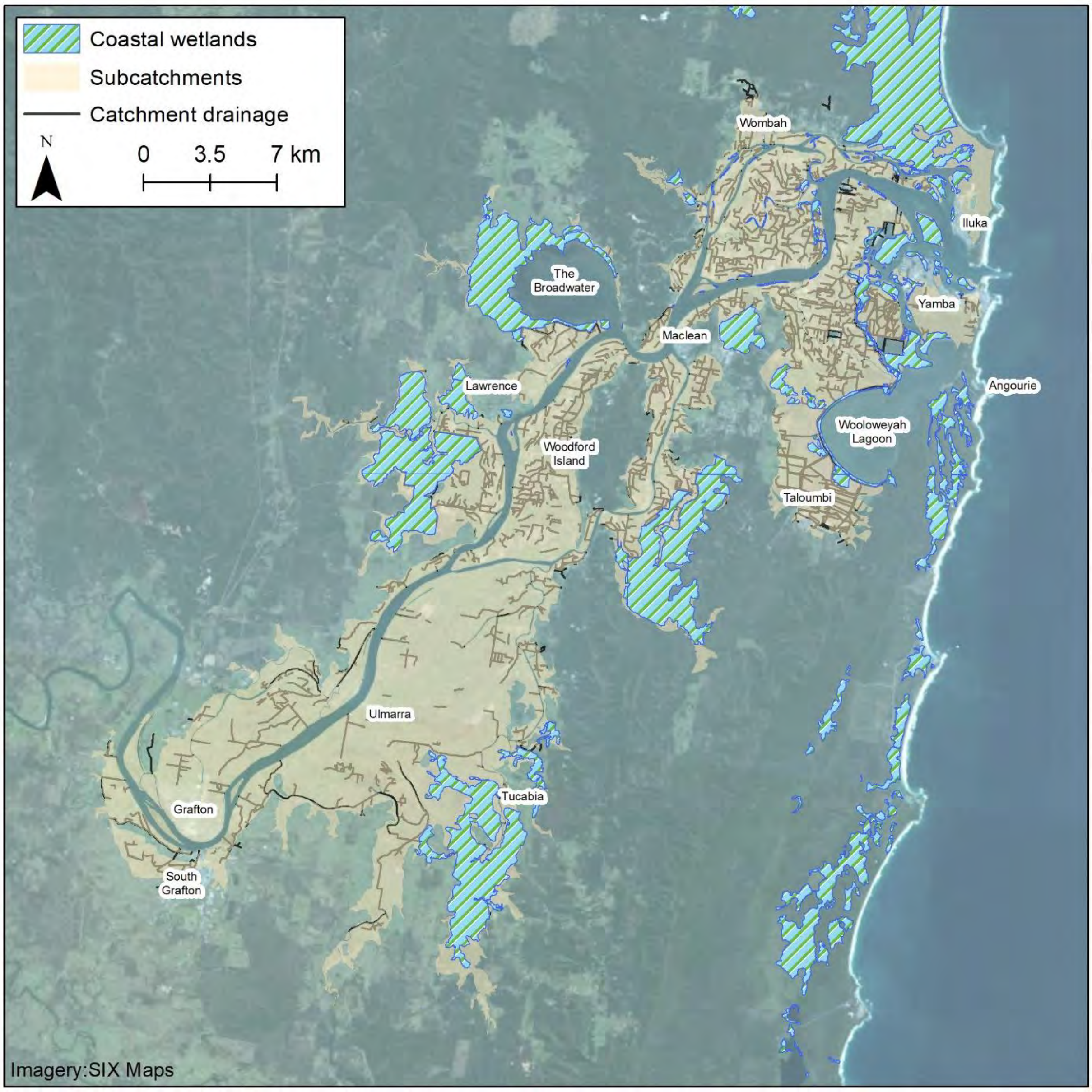

Figure J-4: Coastal Management SEPP coastal wetlands (Source: SEED NSW data portal)[1]

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[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 April 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 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 subcatchment management options need to consider any heritage listed items that may be affected during remediation. 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 Clarence River floodplain listed within the Aboriginal Heritage Information Management System (AHIMS) have been identified to determine if they affect the implementation of subcatchment 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 subcatchment 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 Clarence Valley 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, 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 subcatchment management options, a renewed search of registers will need to be undertaken to ensure the most current information is being used.

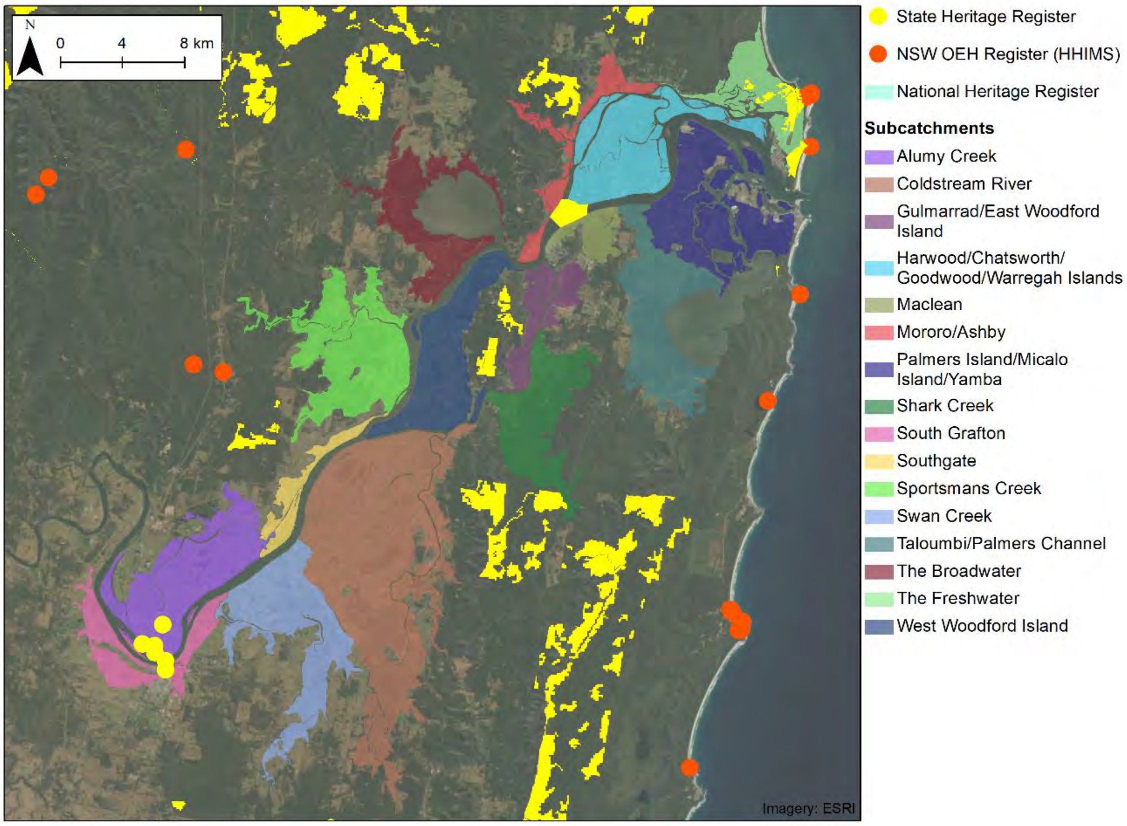


Figure K-1: Heritage items listed on Australian and NSW registers with location information

A total of 1,024 items were identified as listed on State Agency Registers and the Clarence Valley 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 subcatchment 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.

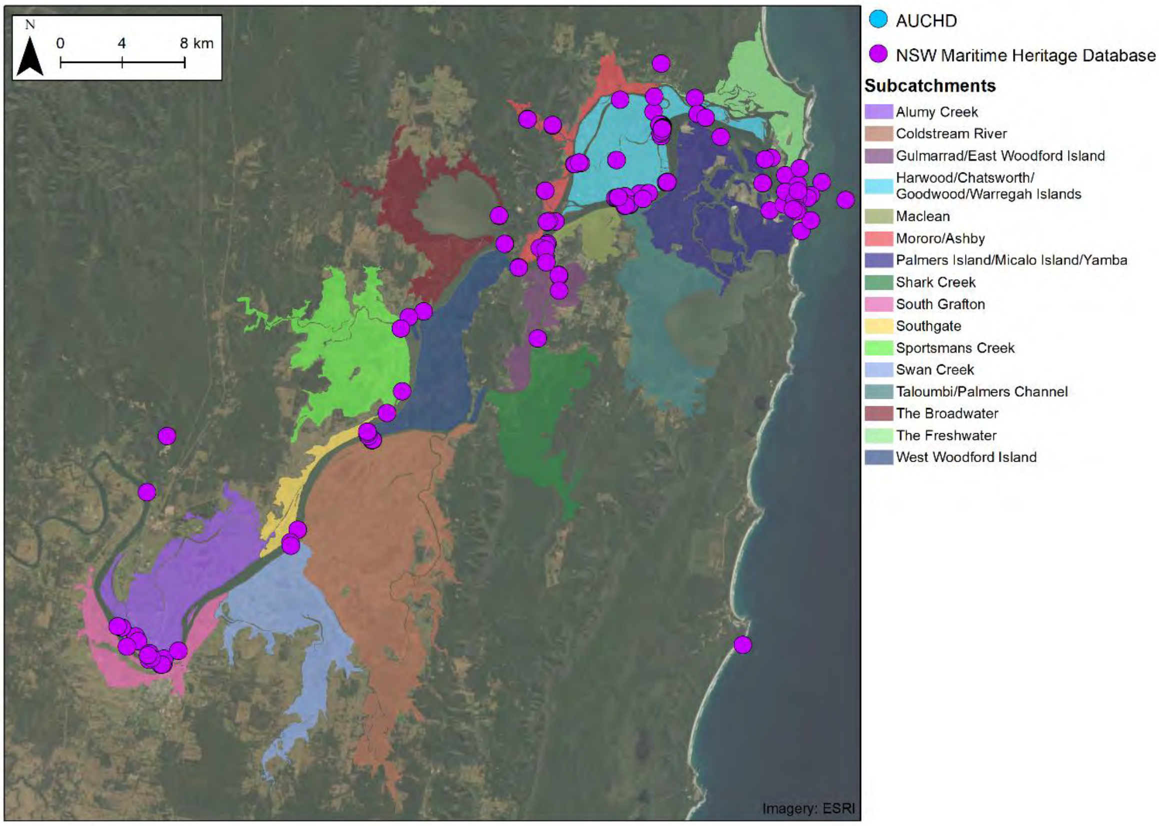


Figure K-2: Maritime heritage items listed on Australian and NSW registers

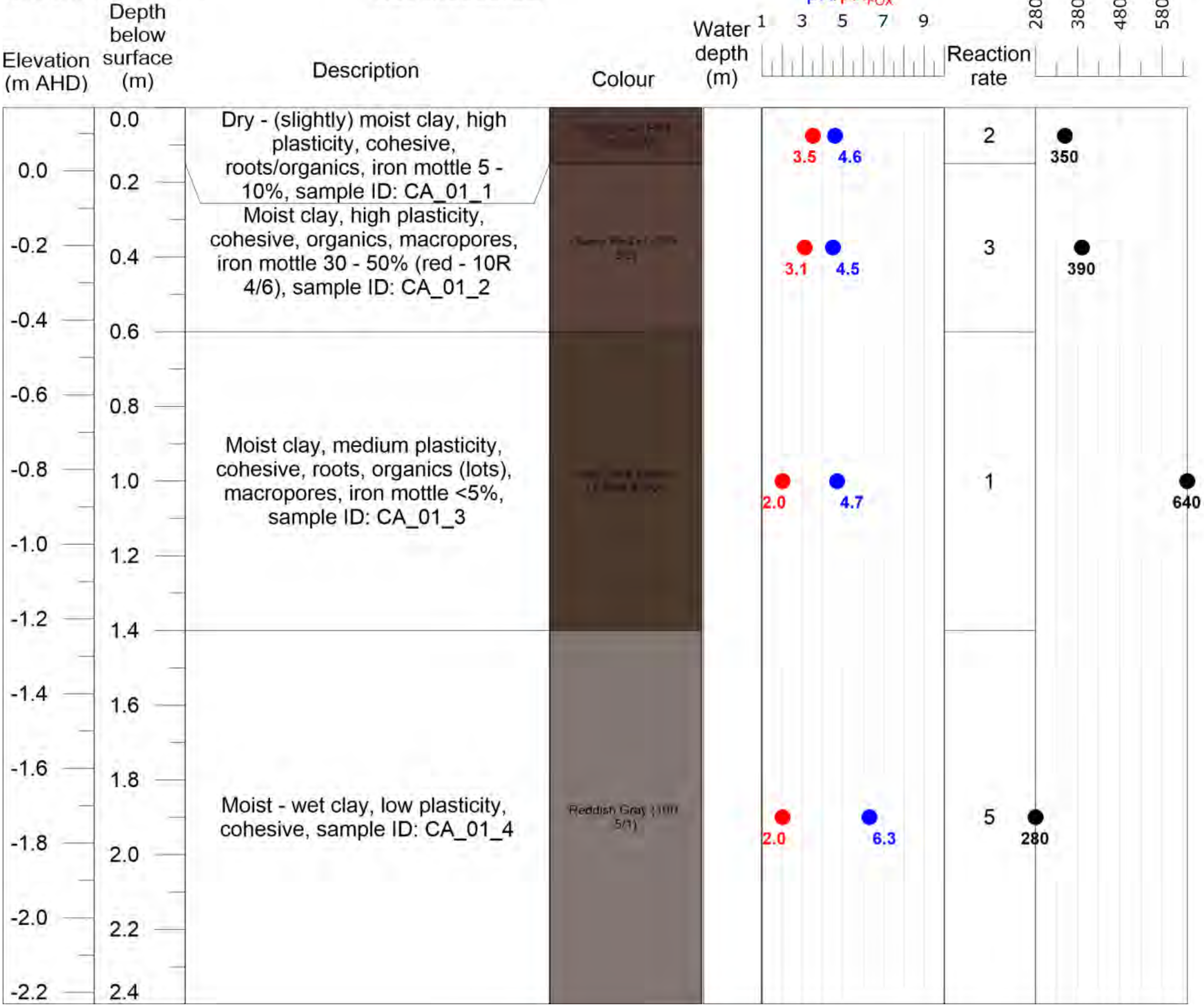
Appendix L Soil profile data sheets

Soil profile details:

Project Number: 2018064
River/estuary: Clarence
Easting: 503856
Northing: 6713573.4
Profile ID: CA_01
Sample date: 03/12/19
Sampled by: AJH GL
Ground elevation (m AHD): 0.17
Hydraulic conductivity (m/d): 0.89

Water quality:

Surface water EC (µS/cm): 900
Surface water pH: 7.2
Groundwater EC (µS/cm): Not measured
Groundwater pH: Not measured

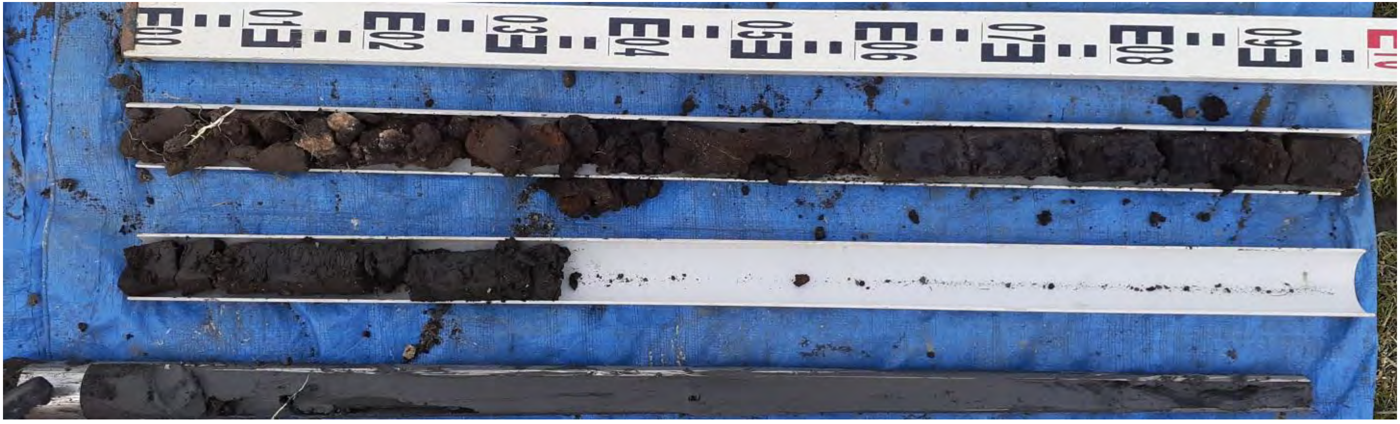


Dry - (slightly) moist clay, high plasticity, cohesive, roots/organics, iron mottle 5 - 10%, sample ID: CA_01_1

Moist clay, high plasticity, cohesive, organics, macropores, iron mottle 30 - 50% (red - 10R 4/6), sample ID: CA_01_2

Moist clay, medium plasticity, cohesive, roots, organics (lots), macropores, iron mottle <5%, sample ID: CA_01_3

Moist - wet clay, low plasticity, cohesive, sample ID: CA_01_4



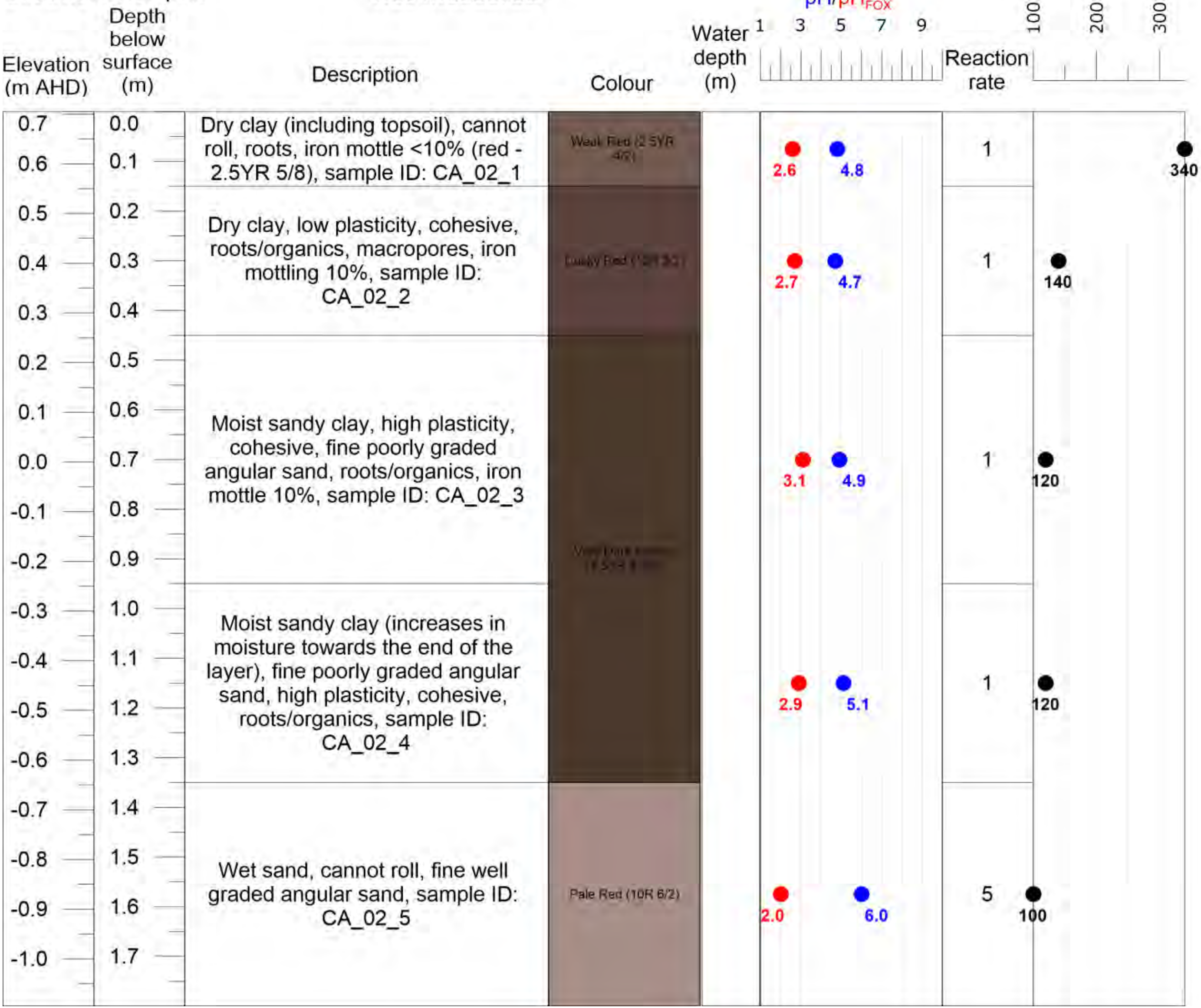
Soil profile details:

Project Number:	2018064	Profile ID:	CA_02
River/estuary:	Clarence	Sample date:	03/12/19
Easting:	504678.9	Sampled by:	AJH GL
Northing:	6716092.0		

Ground elevation (m AHD):	0.70
Hydraulic conductivity (m/d):	4.7

Water quality:

Surface water EC (µS/cm):	2,120
Surface water pH:	7.1
Groundwater EC (µS/cm):	Not measured
Groundwater pH:	Not measured



Depth below surface (m)	Description	Colour	Soil pH	Soil pH_{FOX}	Reaction rate	Soil EC (µS/cm)
0.0–0.15	Dry clay (including topsoil), cannot roll, roots, iron mottle <10% (red - 2.5YR 5/8), sample ID: CA_02_1	Weak Red (2.5YR 4/2)	4.8	2.6	1	340
0.15–0.45	Dry clay, low plasticity, cohesive, roots/organics, macropores, iron mottling 10%, sample ID: CA_02_2	Dusky Red ([illegible])	4.7	2.7	1	140
0.45–0.95	Moist sandy clay, high plasticity, cohesive, fine poorly graded angular sand, roots/organics, iron mottle 10%, sample ID: CA_02_3	Very Dark [illegible] ([illegible])	4.9	3.1	1	120
0.95–1.35	Moist sandy clay (increases in moisture towards the end of the layer), fine poorly graded angular sand, high plasticity, cohesive, roots/organics, sample ID: CA_02_4		5.1	2.9	1	120
1.35–1.8	Wet sand, cannot roll, fine well graded angular sand, sample ID: CA_02_5	Pale Red (10R 6/2)	6.0	2.0	5	100

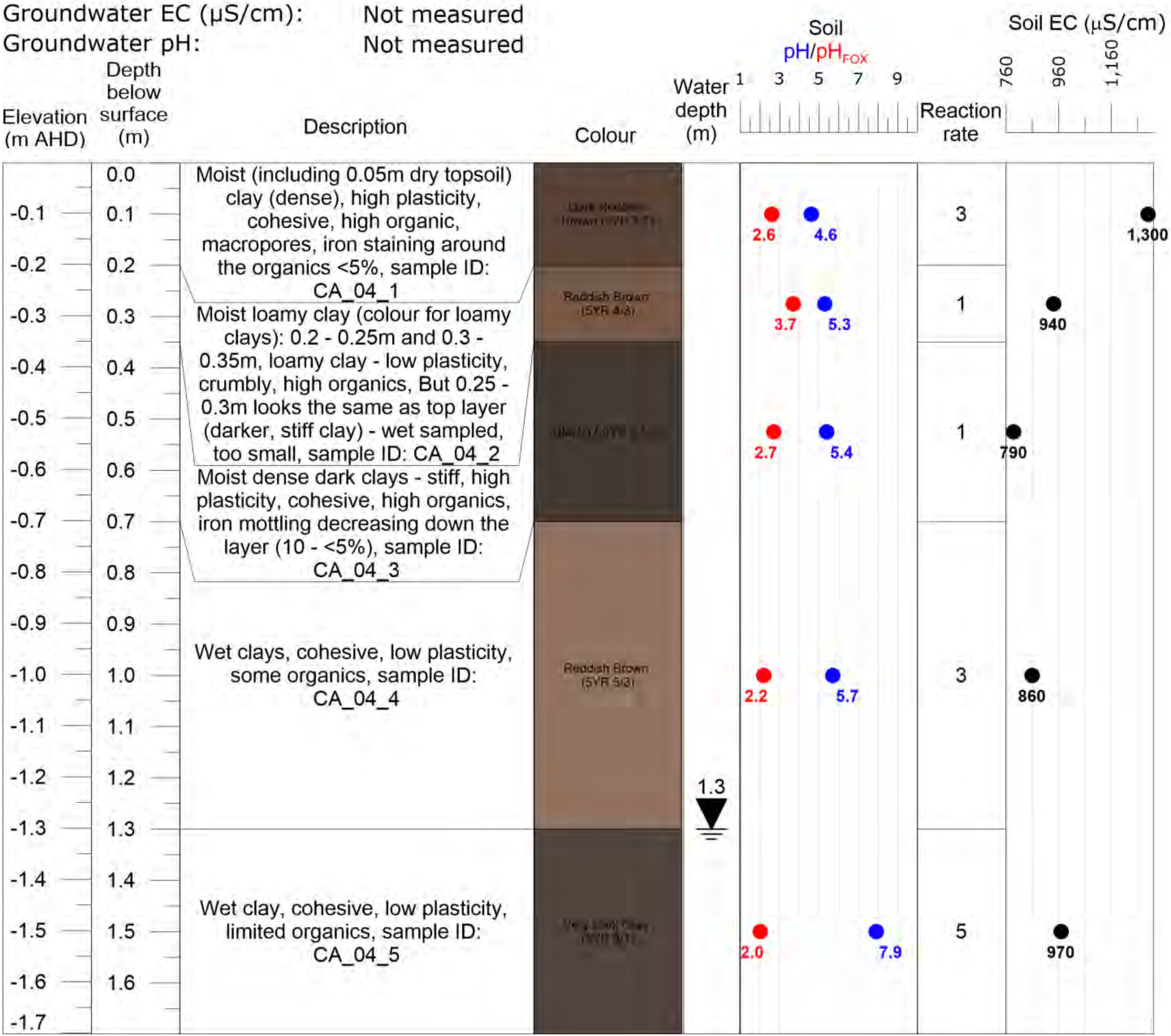
Soil profile details:

Project Number:	2018064	Profile ID:	CA_04
River/estuary:	Clarence	Sample date:	25/11/19
Easting:	509538.7	Sampled by:	AJH GL
Northing:	6715052.0		

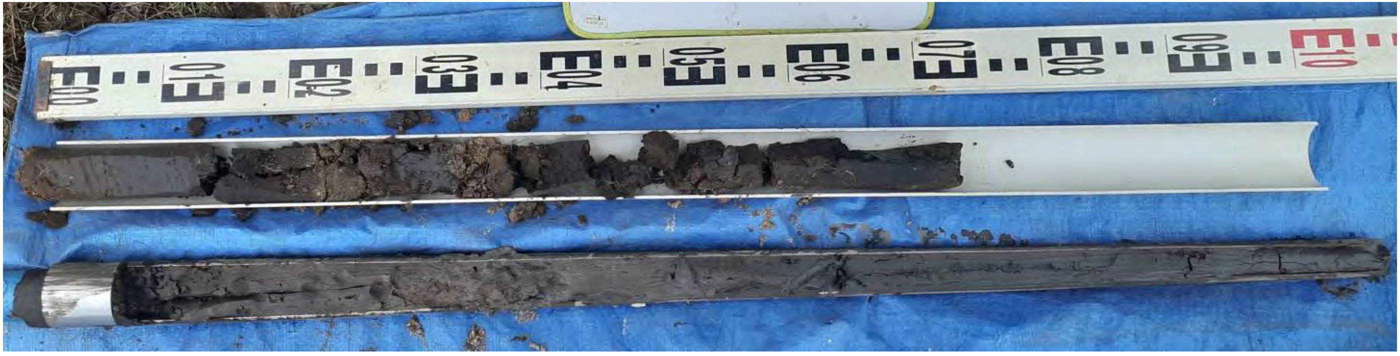
Ground elevation (m AHD):	-0.00
Hydraulic conductivity (m/d):	0.27

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	pH	pH_{FOX}	Reaction rate	Soil EC (µS/cm)
Moist (including 0.05m dry topsoil) clay (dense), high plasticity, cohesive, high organic, macropores, iron staining around the organics <5%, sample ID: CA_04_1	Dark Reddish Brown (5YR 3/2)	4.6	2.6	3	1,300
Moist loamy clay (colour for loamy clays): 0.2 - 0.25m and 0.3 - 0.35m, loamy clay - low plasticity, crumbly, high organics, But 0.25 - 0.3m looks the same as top layer (darker, stiff clay) - wet sampled, too small, sample ID: CA_04_2	Reddish Brown (5YR 4/3)	5.3	3.7	1	940
Moist dense dark clays - stiff, high plasticity, cohesive, high organics, iron mottling decreasing down the layer (10 - <5%), sample ID: CA_04_3	Black (7.5YR 2.5/1)	5.4	2.7	1	790
Wet clays, cohesive, low plasticity, some organics, sample ID: CA_04_4	Reddish Brown (5YR 5/3)	5.7	2.2	3	860
Wet clay, cohesive, low plasticity, limited organics, sample ID: CA_04_5	Very Dark Gray (5YR 3/1)	7.9	2.0	5	970



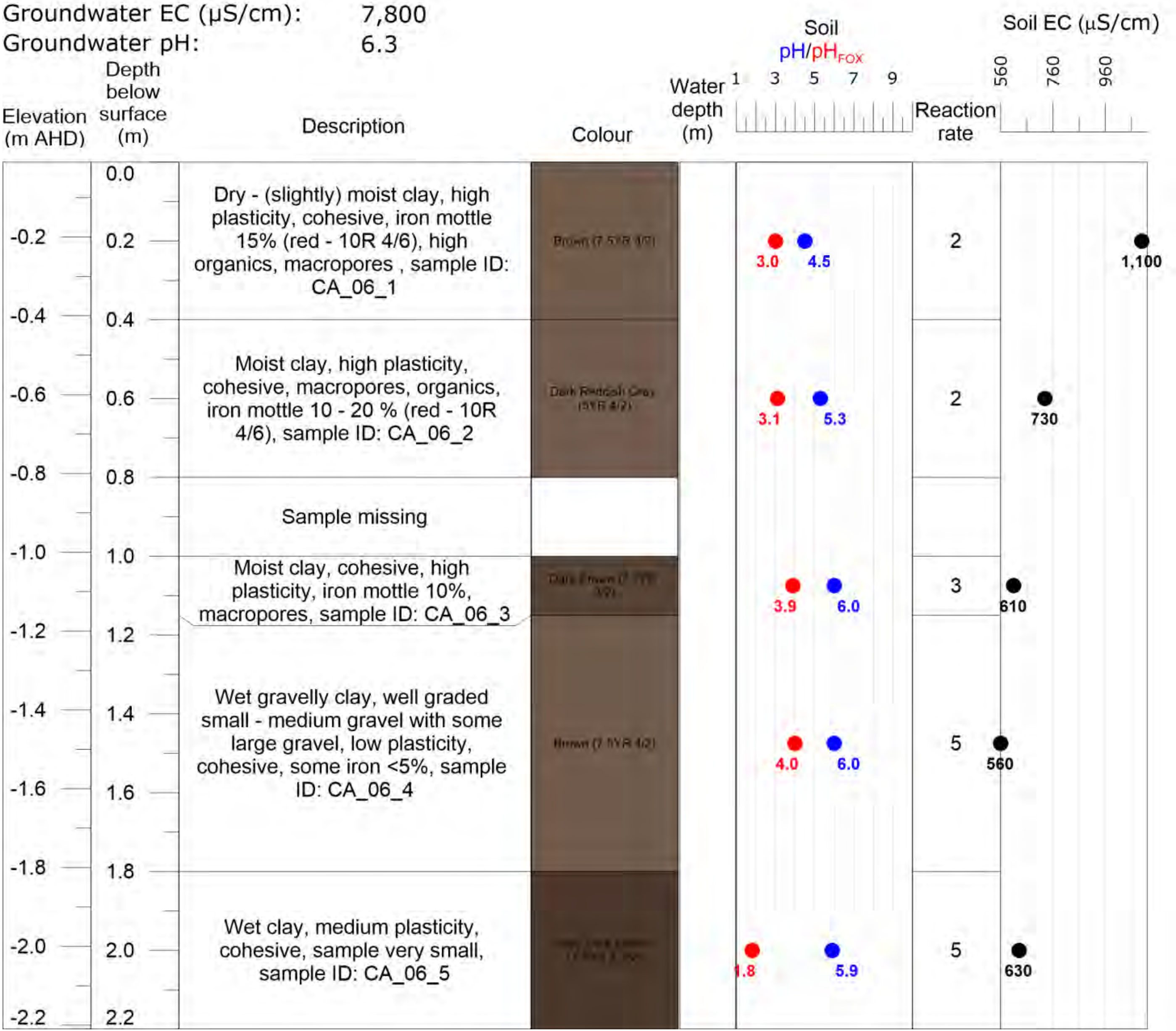
Soil profile details:

Project Number:	2018064	Profile ID:	CA_06
River/estuary:	Clarence	Sample date:	02/12/19
Easting:	496866.1	Sampled by:	AJH GL
Northing:	6717435.9		

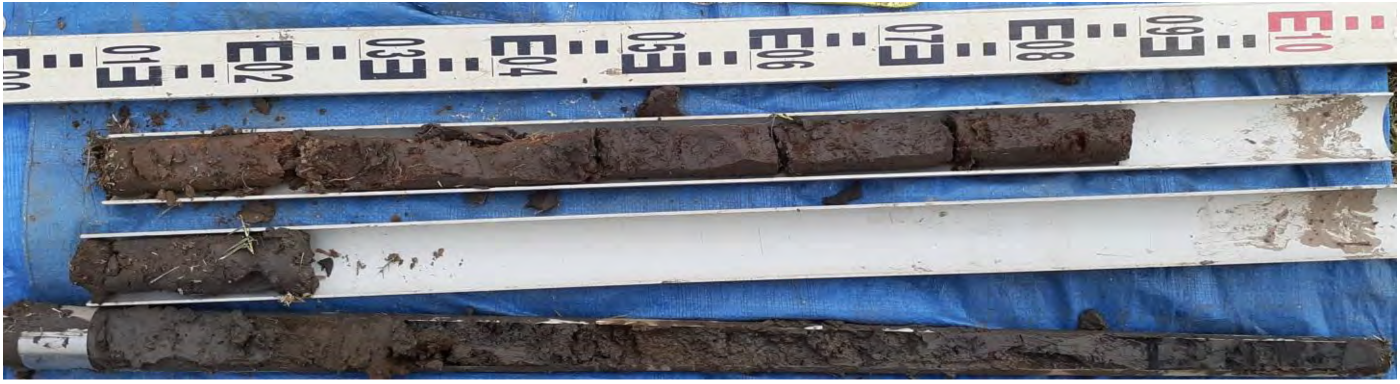
Ground elevation (m AHD):	-0.01
Hydraulic conductivity (m/d):	0.18

Water quality:

Surface water EC (µS/cm):	27,830
Surface water pH:	7.3
Groundwater EC (µS/cm):	7,800
Groundwater pH:	6.3



Elevation (m AHD)	Depth below surface (m)	Description	Colour	Water depth (m)	Soil pH	Soil pH$_{FOX}$	Reaction rate	Soil EC (µS/cm)
-0.2	0.0 – 0.4	Dry - (slightly) moist clay, high plasticity, cohesive, iron mottle 15% (red - 10R 4/6), high organics, macropores , sample ID: CA_06_1	Brown (7.5YR 4/[illegible])		4.5	3.0	2	1,100
-0.6	0.4 – 0.8	Moist clay, high plasticity, cohesive, macropores, organics, iron mottle 10 - 20 % (red - 10R 4/6), sample ID: CA_06_2	Dark Reddish Gray (5YR 4/2)		5.3	3.1	2	730
-0.8 – -1.0	0.8 – 1.0	Sample missing						
-1.1	1.0 – 1.15	Moist clay, cohesive, high plasticity, iron mottle 10%, macropores, sample ID: CA_06_3	Dark Brown (7.5YR 3/2)		6.0	3.9	3	610
-1.5	1.15 – 1.8	Wet gravelly clay, well graded small - medium gravel with some large gravel, low plasticity, cohesive, some iron <5%, sample ID: CA_06_4	Brown (7.5YR 4/2)		6.0	4.0	5	560
-2.0	1.8 – 2.2	Wet clay, medium plasticity, cohesive, sample very small, sample ID: CA_06_5	[illegible]		5.9	1.8	5	630



Soil profile details:

Project Number: 2018064
River/estuary: Clarence
Easting: 498861.2
Northing: 6722066.9
Profile ID: CA_12
Sample date: 04/12/19
Sampled by: AJH GL

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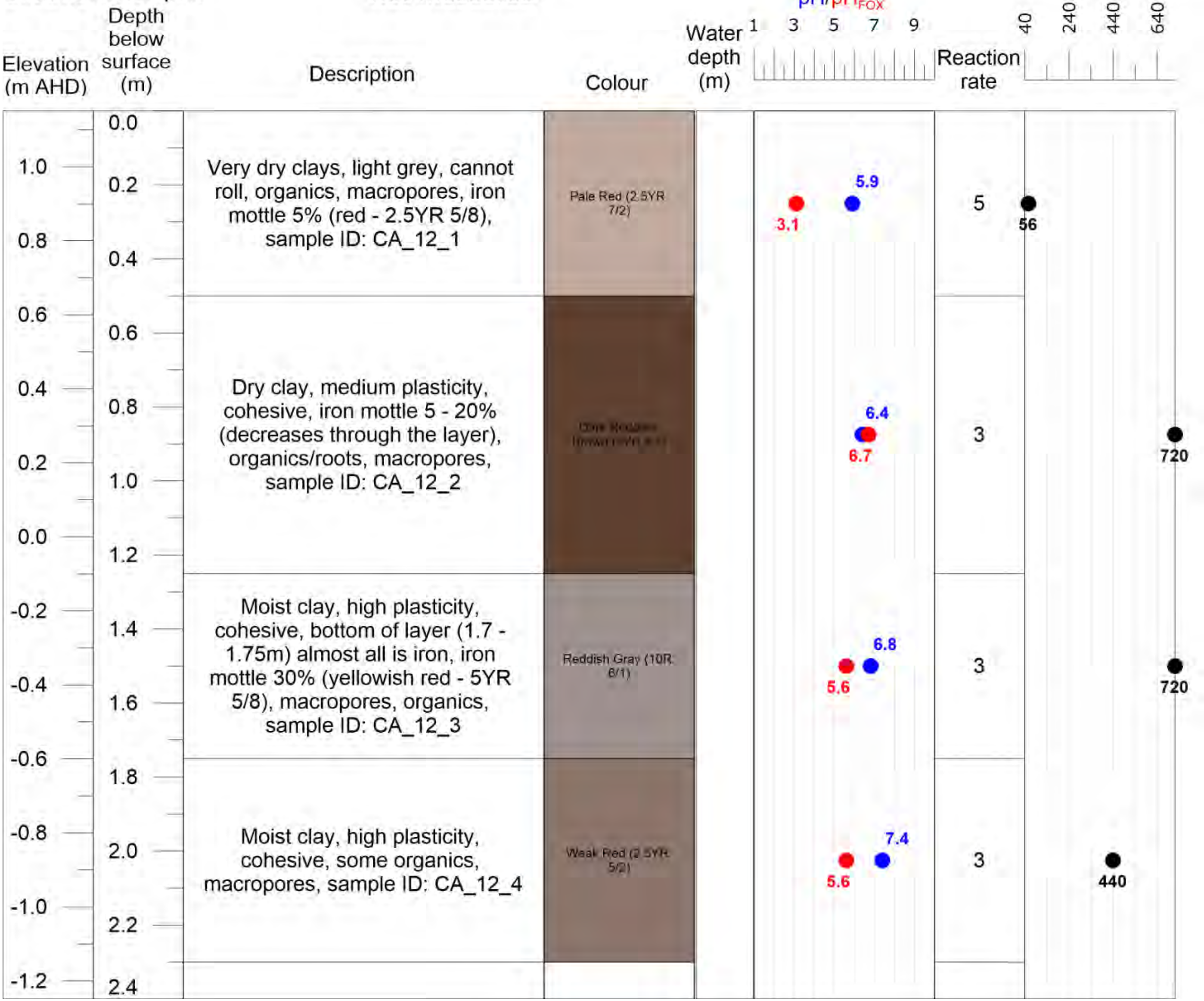
Ground elevation (m AHD): 1.15
Hydraulic conductivity (m/d): 0.13

Water quality:

Surface water EC (µS/cm): 26,250
Surface water pH: 7.7
Groundwater EC (µS/cm): Not measured
Groundwater pH: Not measured



Description	Colour	Soil pH	Soil pH_{FOX}	Reaction rate	Soil EC (μS/cm)
Very dry clays, light grey, cannot roll, organics, macropores, iron mottle 5% (red - 2.5YR 5/8), sample ID: CA_12_1	Pale Red (2.5YR 7/2)	5.9	3.1	5	56
Dry clay, medium plasticity, cohesive, iron mottle 5 - 20% (decreases through the layer), organics/roots, macropores, sample ID: CA_12_2	Dark Reddish Brown (5YR 3/3)	6.4	6.7	3	720
Moist clay, high plasticity, cohesive, bottom of layer (1.7 - 1.75m) almost all is iron, iron mottle 30% (yellowish red - 5YR 5/8), macropores, organics, sample ID: CA_12_3	Reddish Gray (10R 6/1)	6.8	5.6	3	720
Moist clay, high plasticity, cohesive, some organics, macropores, sample ID: CA_12_4	Weak Red (2.5YR 5/2)	7.4	5.6	3	440

Soil profile details:

Project Number:	2018064	Profile ID:	CA_17
River/estuary:	Clarence	Sample date:	03/12/19
Easting:	505811.6	Sampled by:	AJH GL
Northing:	6726847.6		

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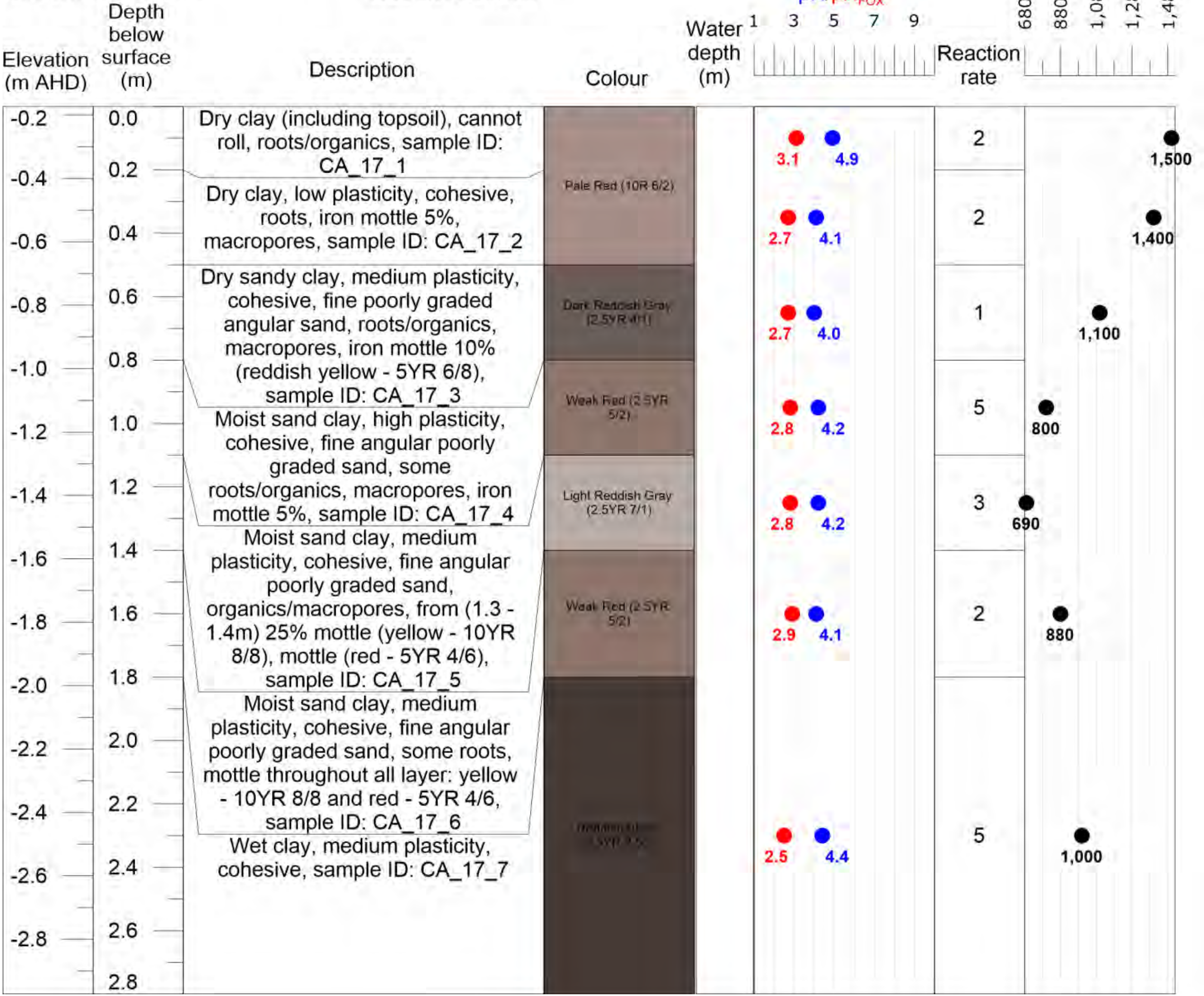
Ground elevation (m AHD):	-0.17
Hydraulic conductivity (m/d):	0.15

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	pH	pH$_{FOX}$	Reaction rate	Soil EC (µS/cm)
Dry clay (including topsoil), cannot roll, roots/organics, sample ID: CA_17_1	4.9	3.1	2	1,500
Dry clay, low plasticity, cohesive, roots, iron mottle 5%, macropores, sample ID: CA_17_2	4.1	2.7	2	1,400
Dry sandy clay, medium plasticity, cohesive, fine poorly graded angular sand, roots/organics, macropores, iron mottle 10% (reddish yellow - 5YR 6/8), sample ID: CA_17_3	4.0	2.7	1	1,100
Moist sand clay, high plasticity, cohesive, fine angular poorly graded sand, some roots/organics, macropores, iron mottle 5%, sample ID: CA_17_4	4.2	2.8	5	800
Moist sand clay, medium plasticity, cohesive, fine angular poorly graded sand, organics/macropores, from (1.3 - 1.4m) 25% mottle (yellow - 10YR 8/8), mottle (red - 5YR 4/6), sample ID: CA_17_5	4.2	2.8	3	690
Moist sand clay, medium plasticity, cohesive, fine angular poorly graded sand, some roots, mottle throughout all layer: yellow - 10YR 8/8 and red - 5YR 4/6, sample ID: CA_17_6	4.1	2.9	2	880
Wet clay, medium plasticity, cohesive, sample ID: CA_17_7	4.4	2.5	5	1,000

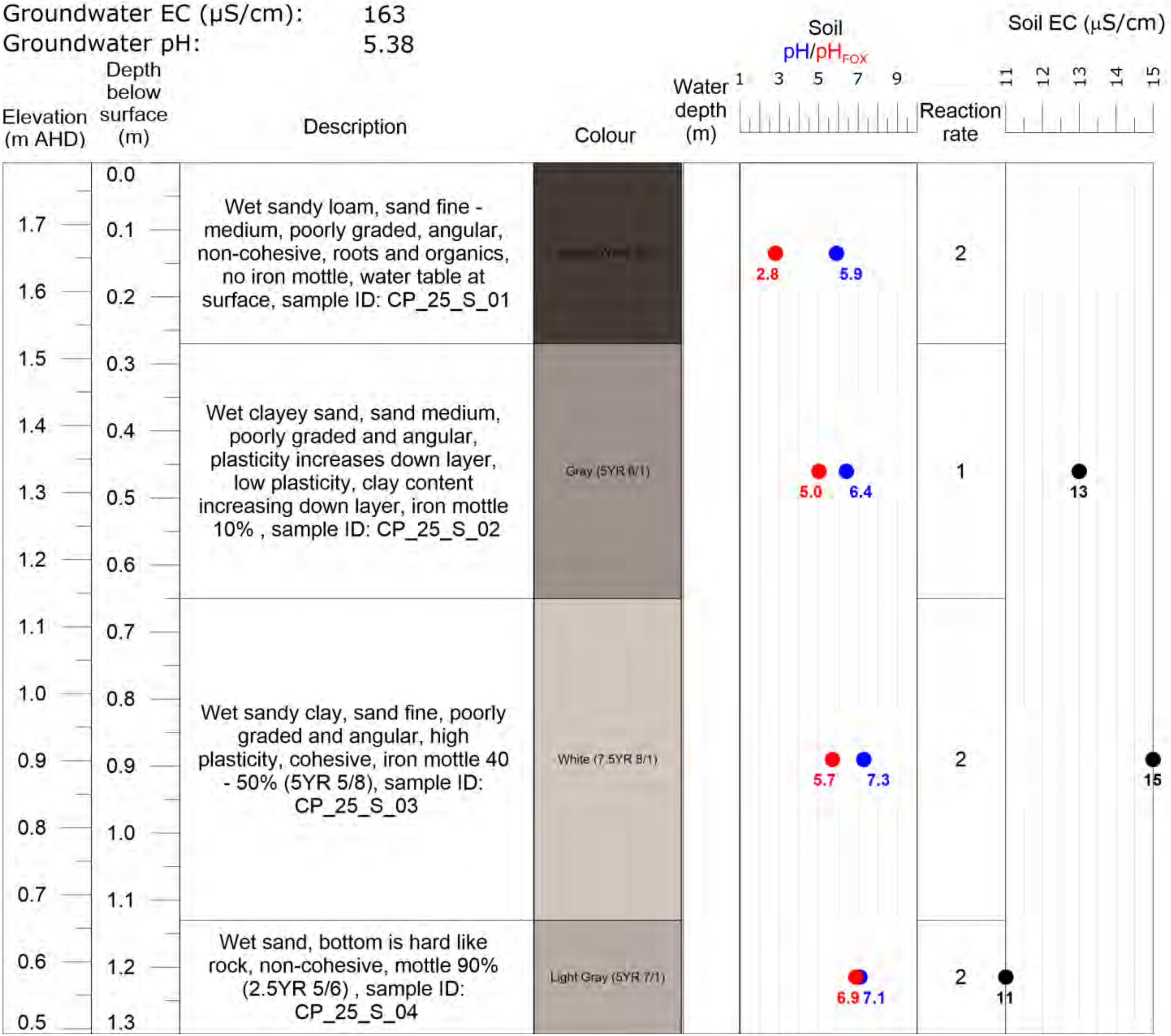
Soil profile details:

Project Number:	2018064	Profile ID:	CA_25_S
River/estuary:	Clarence	Sample date:	27/02/20
Easting:	514569.6	Sampled by:	AJH DWJ
Northing:	6737720.9		

Ground elevation (m AHD):	1.79
Hydraulic conductivity (m/d):	1.1

Water quality:

Surface water EC (µS/cm):	116
Surface water pH:	5.6
Groundwater EC (µS/cm):	163
Groundwater pH:	5.38



Description	Colour	Soil pH/pH$_{FOX}$	Reaction rate	Soil EC (µS/cm)
Wet sandy loam, sand fine - medium, poorly graded, angular, non-cohesive, roots and organics, no iron mottle, water table at surface, sample ID: CP_25_S_01	[illegible]	2.8 5.9	2	
Wet clayey sand, sand medium, poorly graded and angular, plasticity increases down layer, low plasticity, clay content increasing down layer, iron mottle 10% , sample ID: CP_25_S_02	Gray (5YR 6/1)	5.0 6.4	1	13
Wet sandy clay, sand fine, poorly graded and angular, high plasticity, cohesive, iron mottle 40 - 50% (5YR 5/8), sample ID: CP_25_S_03	White (7.5YR 8/1)	5.7 7.3	2	15
Wet sand, bottom is hard like rock, non-cohesive, mottle 90% (2.5YR 5/6) , sample ID: CP_25_S_04	Light Gray (5YR 7/1)	6.9 7.1	2	11

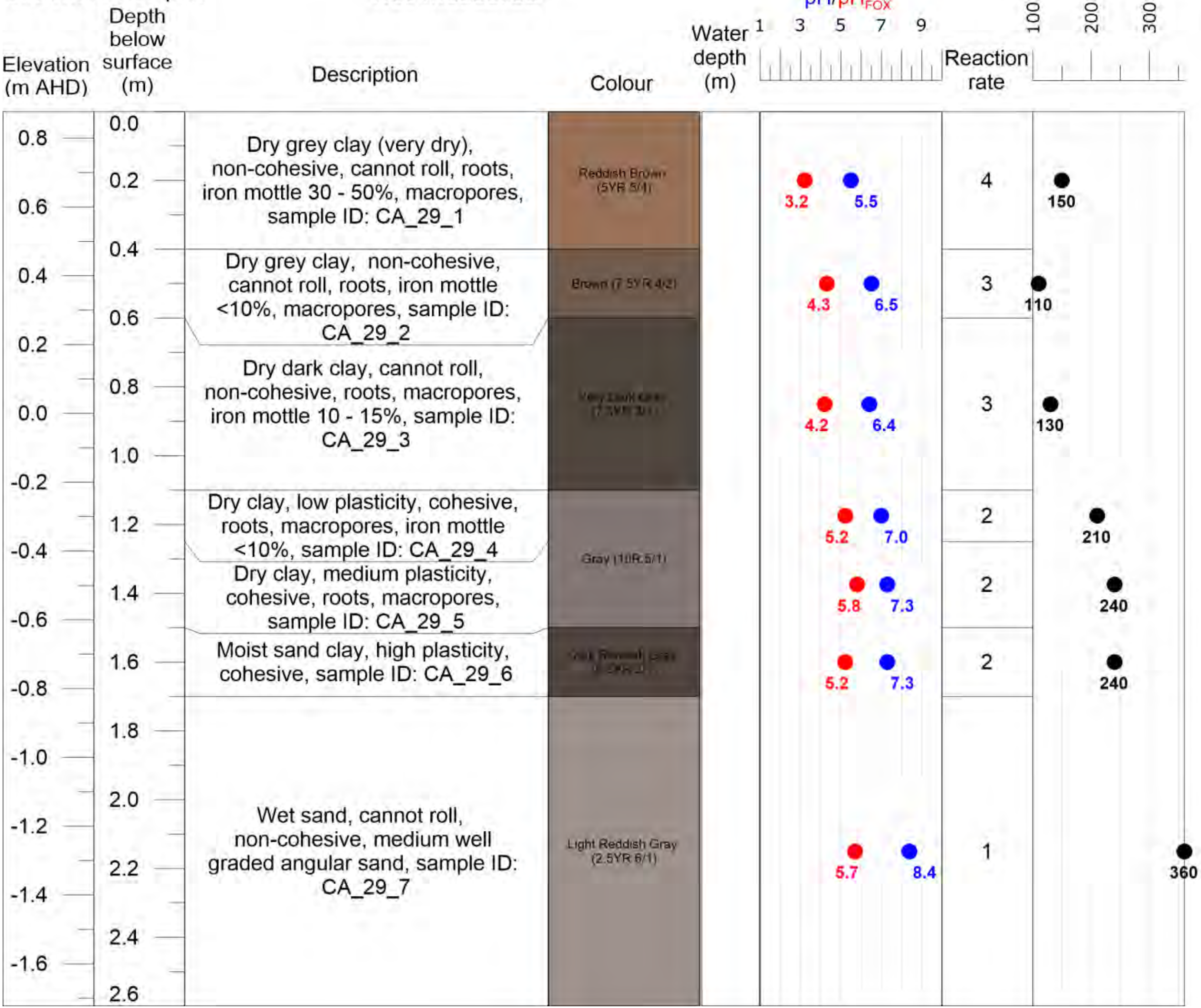
Soil profile details:

Project Number:	2018064	Profile ID:	CA_29
River/estuary:	Clarence	Sample date:	26/11/19
Easting:	512197.2	Sampled by:	AJH GL
Northing:	6728469.3		

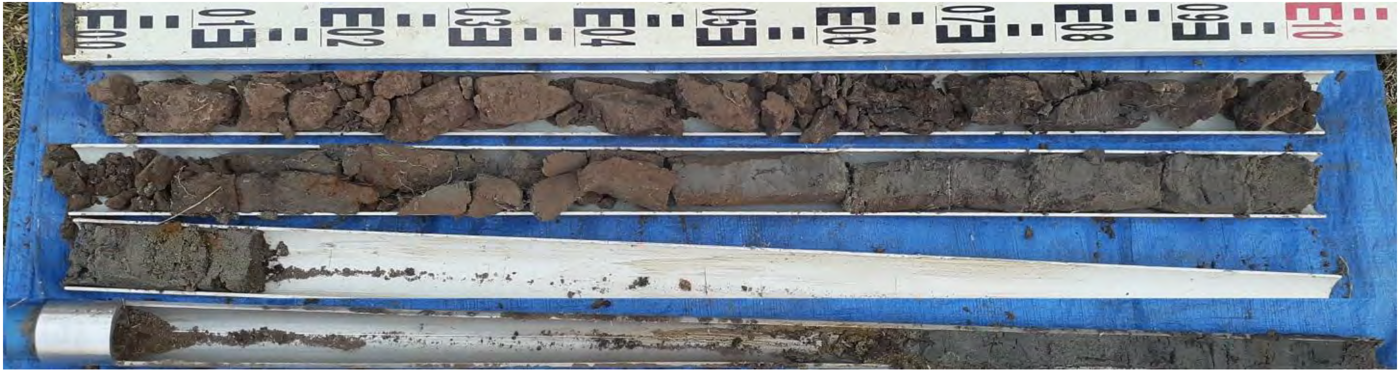
Ground elevation (m AHD):	0.88
Hydraulic conductivity (m/d):	0.089

Water quality:

Surface water EC (µS/cm):	31,300
Surface water pH:	7
Groundwater EC (µS/cm):	Not measured
Groundwater pH:	Not measured



Description	Colour	pH$_{FOX}$	pH	Reaction rate	Soil EC (µS/cm)
Dry grey clay (very dry), non-cohesive, cannot roll, roots, iron mottle 30 - 50%, macropores, sample ID: CA_29_1	Reddish Brown (5YR 5/1)	3.2	5.5	4	150
Dry grey clay, non-cohesive, cannot roll, roots, iron mottle <10%, macropores, sample ID: CA_29_2	Brown (7.5YR 4/2)	4.3	6.5	3	110
Dry dark clay, cannot roll, non-cohesive, roots, macropores, iron mottle 10 - 15%, sample ID: CA_29_3	Very Dark Gray (7.5YR 3/1)	4.2	6.4	3	130
Dry clay, low plasticity, cohesive, roots, macropores, iron mottle <10%, sample ID: CA_29_4	Gray (10R 5/1)	5.2	7.0	2	210
Dry clay, medium plasticity, cohesive, roots, macropores, sample ID: CA_29_5		5.8	7.3	2	240
Moist sand clay, high plasticity, cohesive, sample ID: CA_29_6	Dark Reddish Gray [illegible]	5.2	7.3	2	240
Wet sand, cannot roll, non-cohesive, medium well graded angular sand, sample ID: CA_29_7	Light Reddish Gray (2.5YR 6/1)	5.7	8.4	1	360



Soil profile details:

Project Number:	2018064	Profile ID:	CA_33
River/estuary:	Clarence	Sample date:	27/02/20
Easting:	511844.3	Sampled by:	AJH DWJ
Northing:	6734261.6		

Ground elevation (m AHD):	0.79
Hydraulic conductivity (m/d):	1.5

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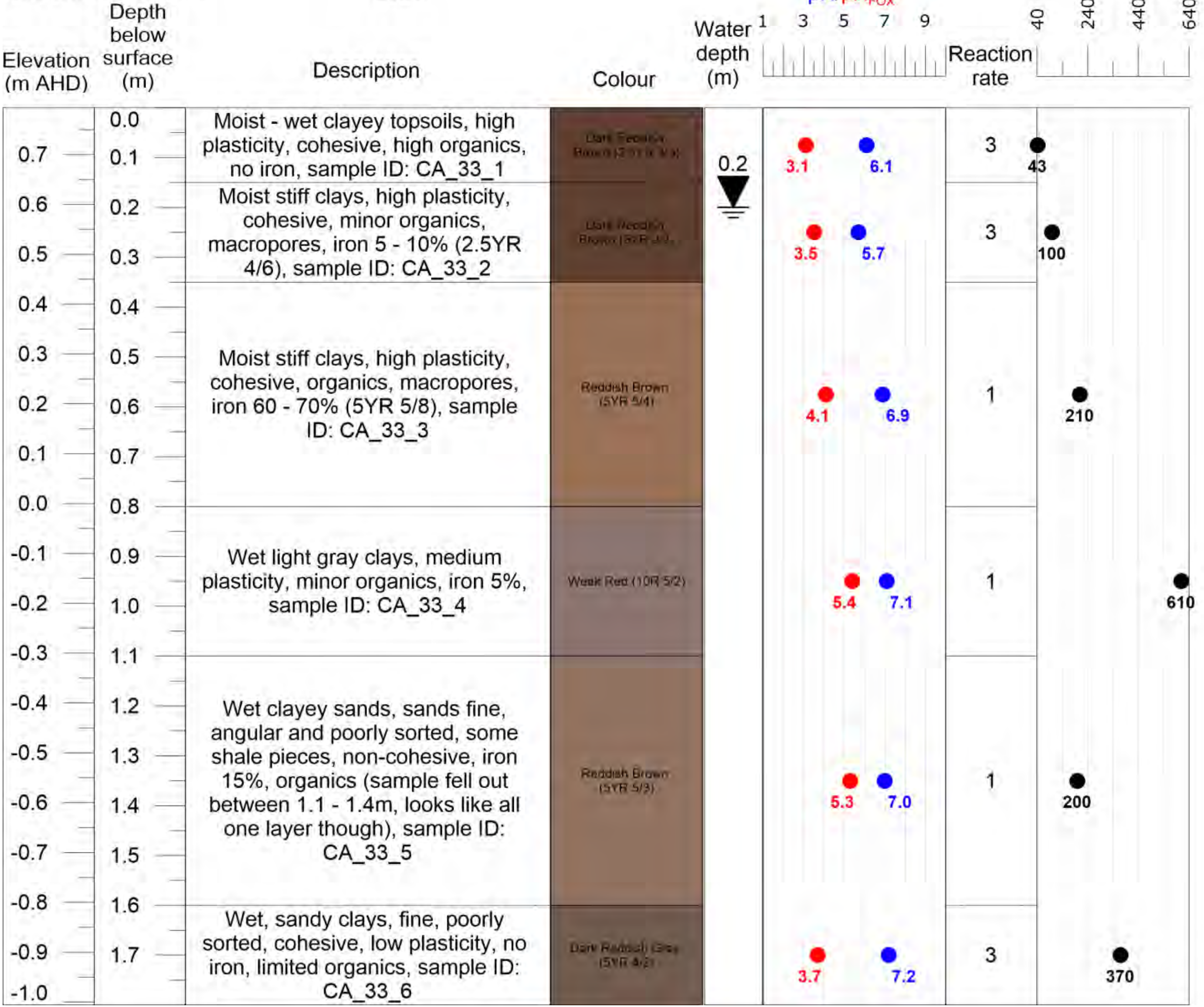
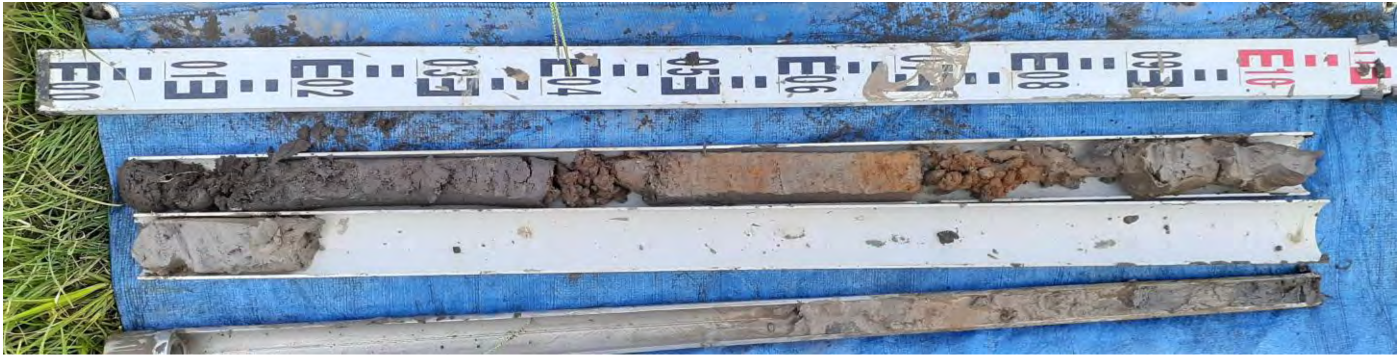
Water quality:

Surface water EC (µS/cm):	2,267
Surface water pH:	4.97
Groundwater EC (µS/cm):	3,318
Groundwater pH:	5.67



Description	Colour	pH	pH$_{FOX}$	Reaction rate	Soil EC (µS/cm)
Moist - wet clayey topsoils, high plasticity, cohesive, high organics, no iron, sample ID: CA_33_1	Dark Reddish Brown (2.5YR 3/3)	6.1	3.1	3	43
Moist stiff clays, high plasticity, cohesive, minor organics, macropores, iron 5 - 10% (2.5YR 4/6), sample ID: CA_33_2	Dark Reddish Brown (5YR 3/3)	5.7	3.5	3	100
Moist stiff clays, high plasticity, cohesive, organics, macropores, iron 60 - 70% (5YR 5/8), sample ID: CA_33_3	Reddish Brown (5YR 5/4)	6.9	4.1	1	210
Wet light gray clays, medium plasticity, minor organics, iron 5%, sample ID: CA_33_4	Weak Red (10R 5/2)	7.1	5.4	1	610
Wet clayey sands, sands fine, angular and poorly sorted, some shale pieces, non-cohesive, iron 15%, organics (sample fell out between 1.1 - 1.4m, looks like all one layer though), sample ID: CA_33_5	Reddish Brown (5YR 5/3)	7.0	5.3	1	200
Wet, sandy clays, fine, poorly sorted, cohesive, low plasticity, no iron, limited organics, sample ID: CA_33_6	Dark Reddish Grey (5YR 4/2)	7.2	3.7	3	370



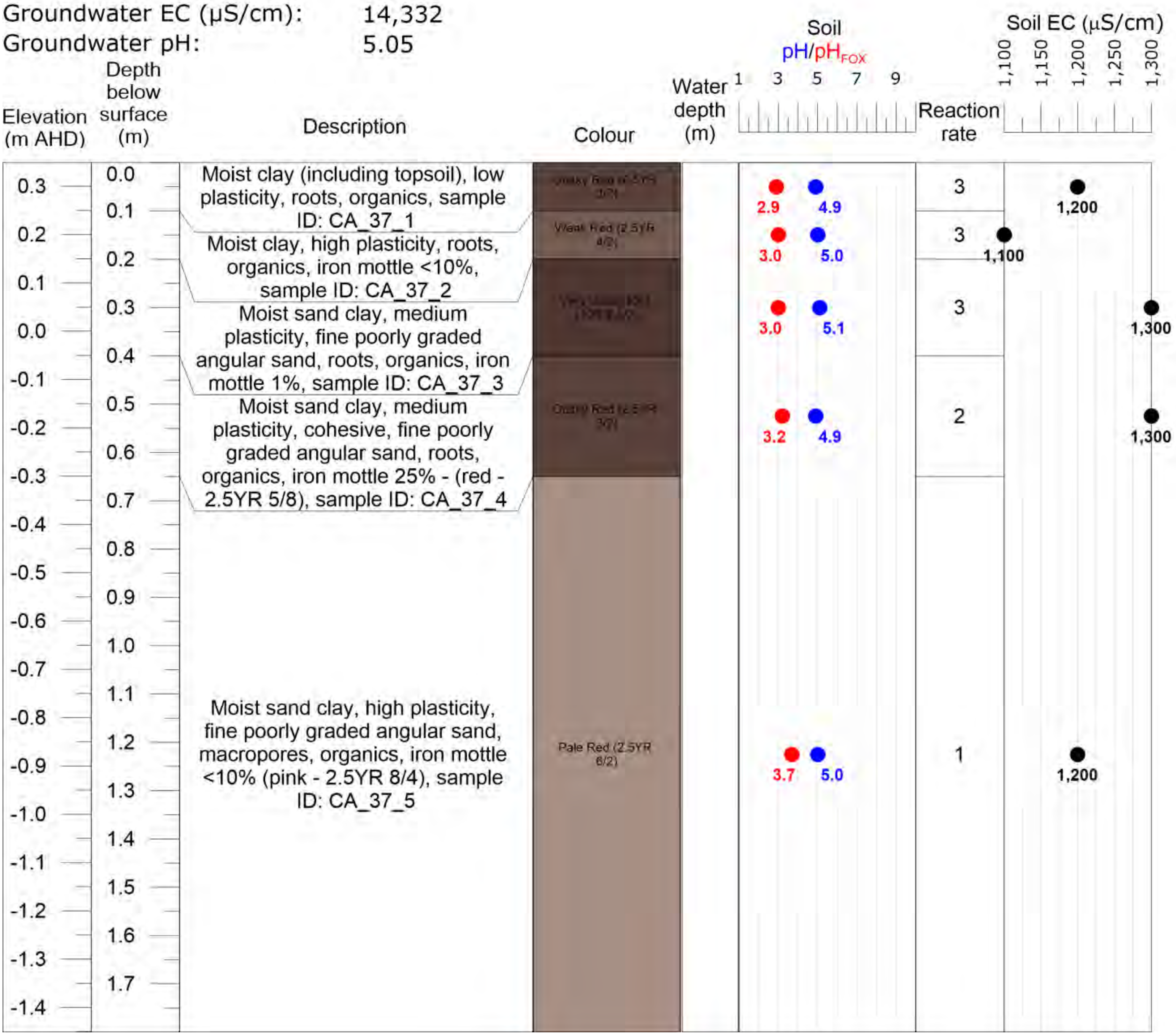
Soil profile details:

Project Number:	2018064	Profile ID:	CA_37
River/estuary:	Clarence	Sample date:	05/02/20
Easting:	513556.4	Sampled by:	AJH GL
Northing:	6740946.0		

Ground elevation (m AHD):	0.35
Hydraulic conductivity (m/d):	0.25

Water quality:

Surface water EC (µS/cm):	2,712
Surface water pH:	6.37
Groundwater EC (µS/cm):	14,332
Groundwater pH:	5.05



Description	Colour	Soil pH	Soil pHFOX	Reaction rate	Soil EC (µS/cm)
Moist clay (including topsoil), low plasticity, roots, organics, sample ID: CA_37_1	Dusky Red (2.5YR 3/2)	4.9	2.9	3	1,200
Moist clay, high plasticity, roots, organics, iron mottle <10%, sample ID: CA_37_2	Weak Red (2.5YR 4/2)	5.0	3.0	3	1,100
Moist sand clay, medium plasticity, fine poorly graded angular sand, roots, organics, iron mottle 1%, sample ID: CA_37_3	Very Dusky Red (10R 2.5/2)	5.1	3.0	3	1,300
Moist sand clay, medium plasticity, cohesive, fine poorly graded angular sand, roots, organics, iron mottle 25% - (red - 2.5YR 5/8), sample ID: CA_37_4	Dusky Red (2.5YR 3/2)	4.9	3.2	2	1,300
Moist sand clay, high plasticity, fine poorly graded angular sand, macropores, organics, iron mottle <10% (pink - 2.5YR 8/4), sample ID: CA_37_5	Pale Red (2.5YR 6/2)	5.0	3.7	1	1,200

Soil profile details:

Project Number: 2018064
River/estuary: Clarence
Easting: 518369.2
Northing: 6729889.6
Profile ID: CA_45
Sample date: 27/11/19
Sampled by: AJH GL

Ground elevation (m AHD): 0.60
Hydraulic conductivity (m/d): 0.2

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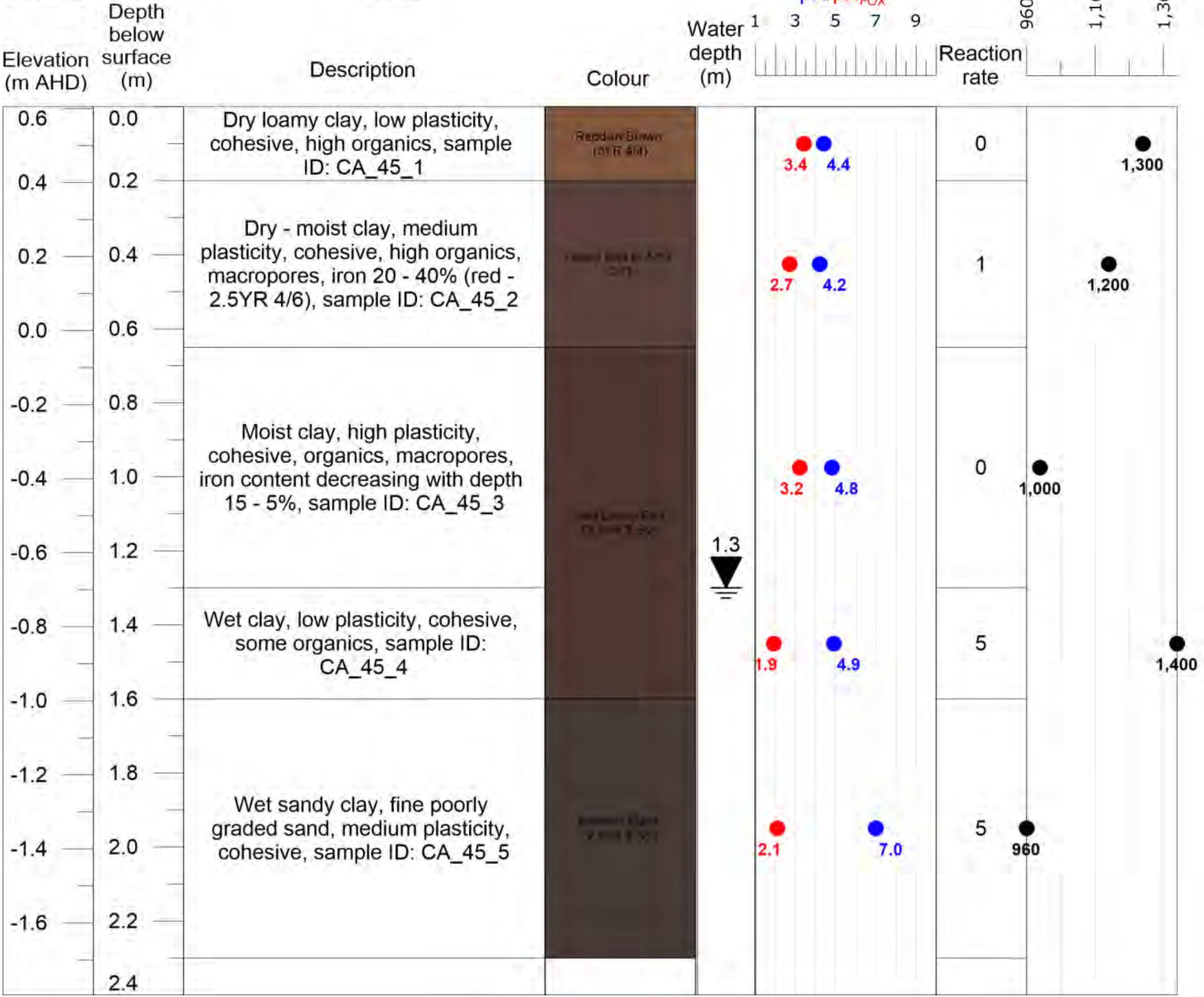
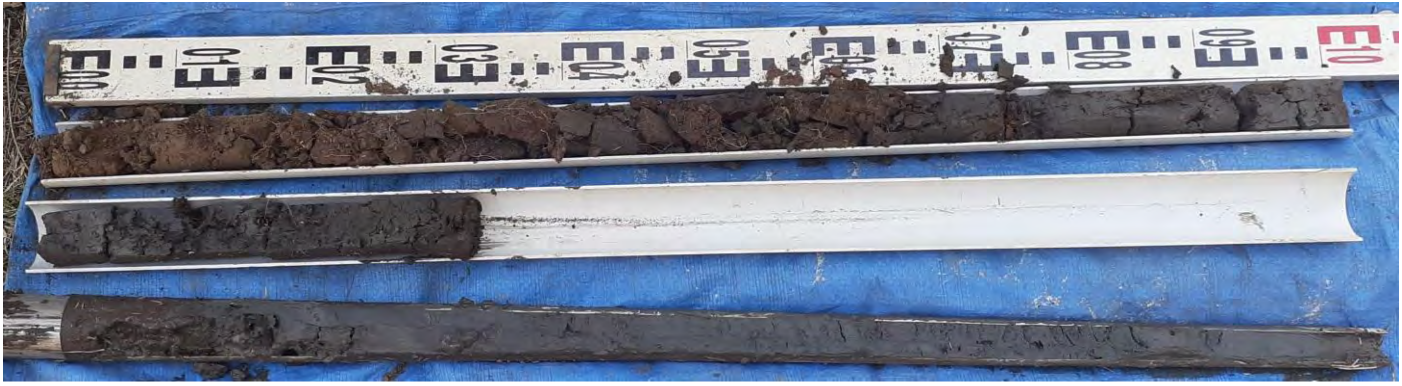
Water quality:

Surface water EC (µS/cm): 23,500
Surface water pH: 6.8
Groundwater EC (µS/cm): 50,260
Groundwater pH: 4.15



Description	Soil pH/pH$_{FOX}$	Reaction rate	Soil EC (µS/cm)
Dry loamy clay, low plasticity, cohesive, high organics, sample ID: CA_45_1	3.4 4.4	0	1,300
Dry - moist clay, medium plasticity, cohesive, high organics, macropores, iron 20 - 40% (red - 2.5YR 4/6), sample ID: CA_45_2	2.7 4.2	1	1,200
Moist clay, high plasticity, cohesive, organics, macropores, iron content decreasing with depth 15 - 5%, sample ID: CA_45_3	3.2 4.8	0	1,000
Wet clay, low plasticity, cohesive, some organics, sample ID: CA_45_4	1.9 4.9	5	1,400
Wet sandy clay, fine poorly graded sand, medium plasticity, cohesive, sample ID: CA_45_5	2.1 7.0	5	960



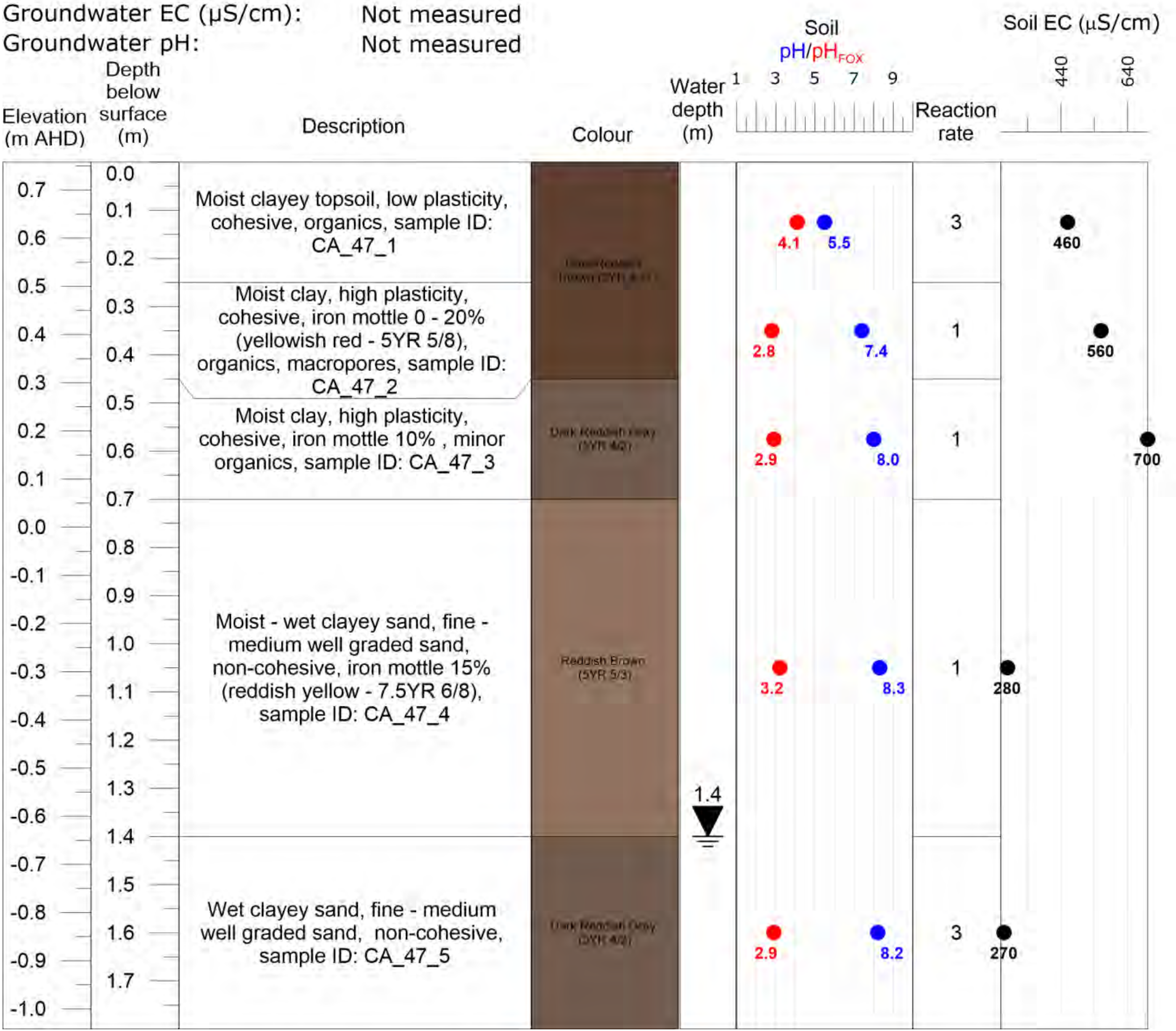
Soil profile details:

Project Number:	2018064	Profile ID:	CA_47
River/estuary:	Clarence	Sample date:	04/02/20
Easting:	518679.7	Sampled by:	AJH GL
Northing:	6733986.7		

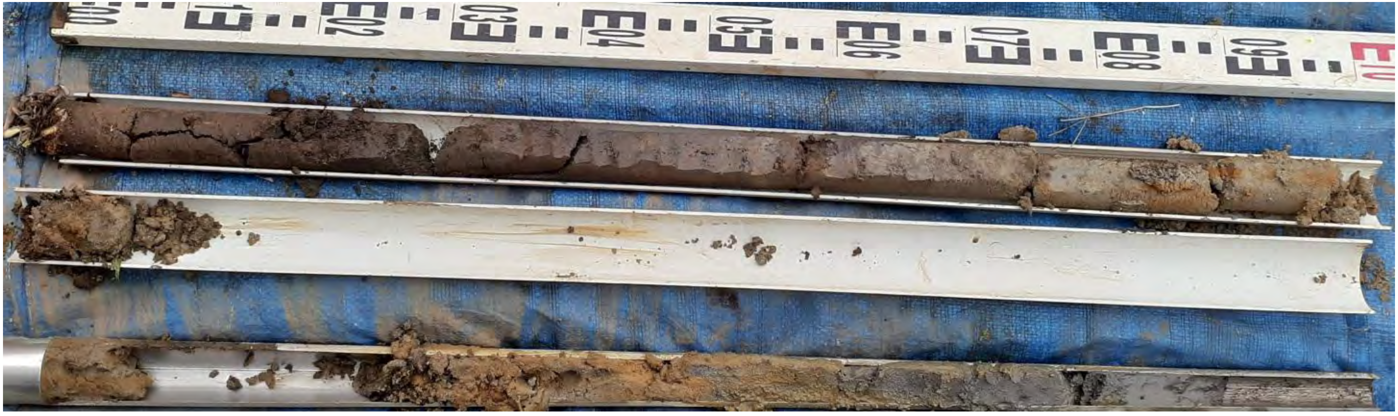
Ground elevation (m AHD):	0.76
Hydraulic conductivity (m/d):	Not measured

Water quality:

Surface water EC (µS/cm):	643
Surface water pH:	6.7
Groundwater EC (µS/cm):	Not measured
Groundwater pH:	Not measured



Description	Colour	Soil pH$_{FOX}$	Soil pH	Reaction rate	Soil EC (µS/cm)
Moist clayey topsoil, low plasticity, cohesive, organics, sample ID: CA_47_1	Dark Reddish Brown (5YR 3/3)	4.1	5.5	3	460
Moist clay, high plasticity, cohesive, iron mottle 0 - 20% (yellowish red - 5YR 5/8), organics, macropores, sample ID: CA_47_2		2.8	7.4	1	560
Moist clay, high plasticity, cohesive, iron mottle 10% , minor organics, sample ID: CA_47_3	Dark Reddish Gray (5YR 4/2)	2.9	8.0	1	700
Moist - wet clayey sand, fine - medium well graded sand, non-cohesive, iron mottle 15% (reddish yellow - 7.5YR 6/8), sample ID: CA_47_4	Reddish Brown (5YR 5/3)	3.2	8.3	1	280
Wet clayey sand, fine - medium well graded sand, non-cohesive, sample ID: CA_47_5	Dark Reddish Gray (5YR 4/2)	2.9	8.2	3	270



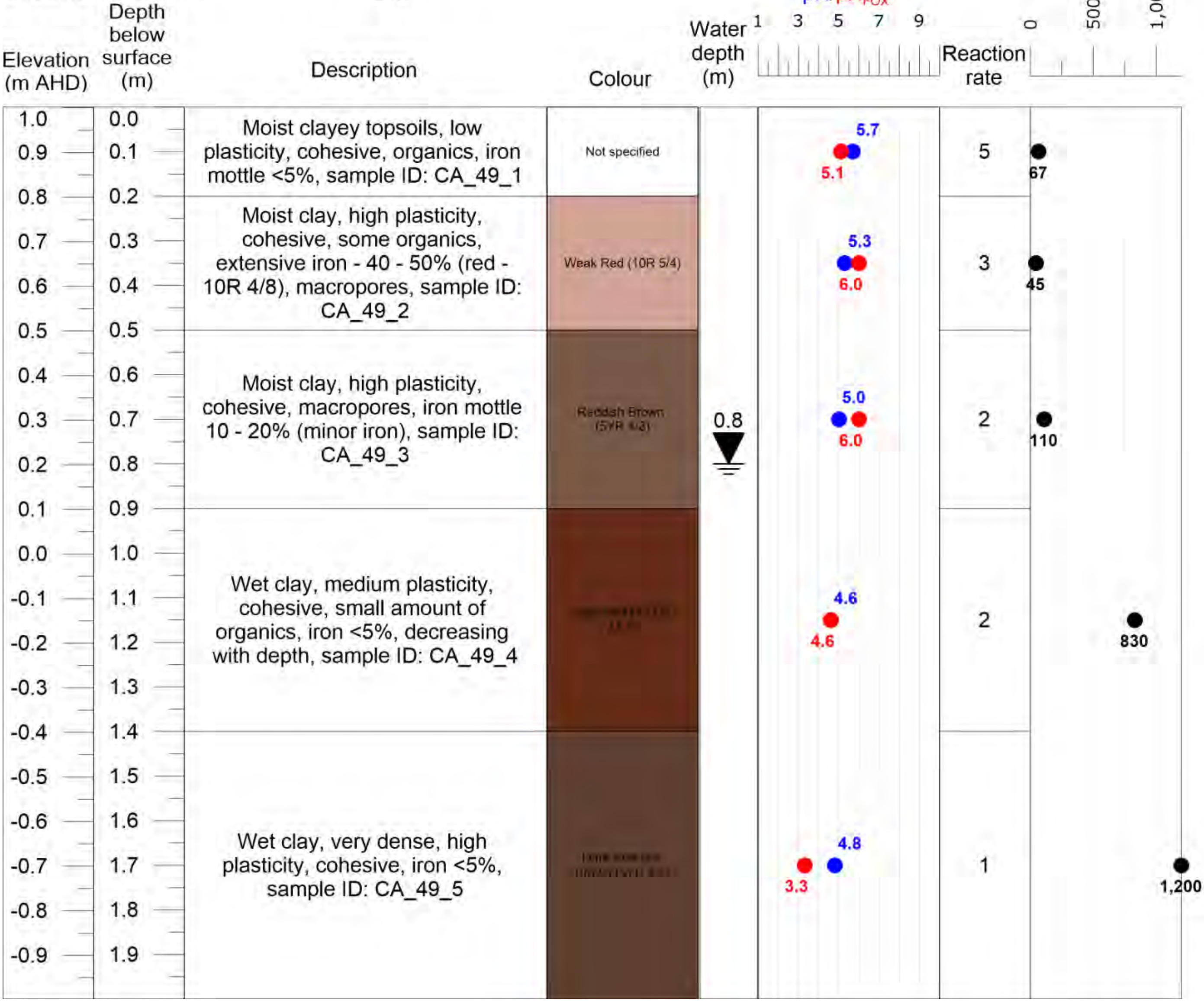
Soil profile details:

Project Number:	2018064	Profile ID:	CA_49
River/estuary:	Clarence	Sample date:	04/02/20
Easting:	520265.1	Sampled by:	AJH GL
Northing:	6733196.9		

Ground elevation (m AHD):	1.00
Hydraulic conductivity (m/d):	Not measured

Water quality:

Surface water EC (µS/cm):	Not measured
Surface water pH:	Not measured
Groundwater EC (µS/cm):	13,700
Groundwater pH:	3.8



Depth below surface (m)	Description	Colour	Soil pH	pH FOX	Reaction rate	Soil EC (µS/cm)
0.0–0.2	Moist clayey topsoils, low plasticity, cohesive, organics, iron mottle <5%, sample ID: CA_49_1	Not specified	5.7	5.1	5	67
0.2–0.5	Moist clay, high plasticity, cohesive, some organics, extensive iron - 40 - 50% (red - 10R 4/8), macropores, sample ID: CA_49_2	Weak Red (10R 5/4)	5.3	6.0	3	45
0.5–0.9	Moist clay, high plasticity, cohesive, macropores, iron mottle 10 - 20% (minor iron), sample ID: CA_49_3	Reddish Brown (5YR 4/3)	5.0	6.0	2	110
0.9–1.4	Wet clay, medium plasticity, cohesive, small amount of organics, iron <5%, decreasing with depth, sample ID: CA_49_4	[illegible]	4.6	4.6	2	830
1.4–2.0	Wet clay, very dense, high plasticity, cohesive, iron <5%, sample ID: CA_49_5	[illegible]	4.8	3.3	1	1,200

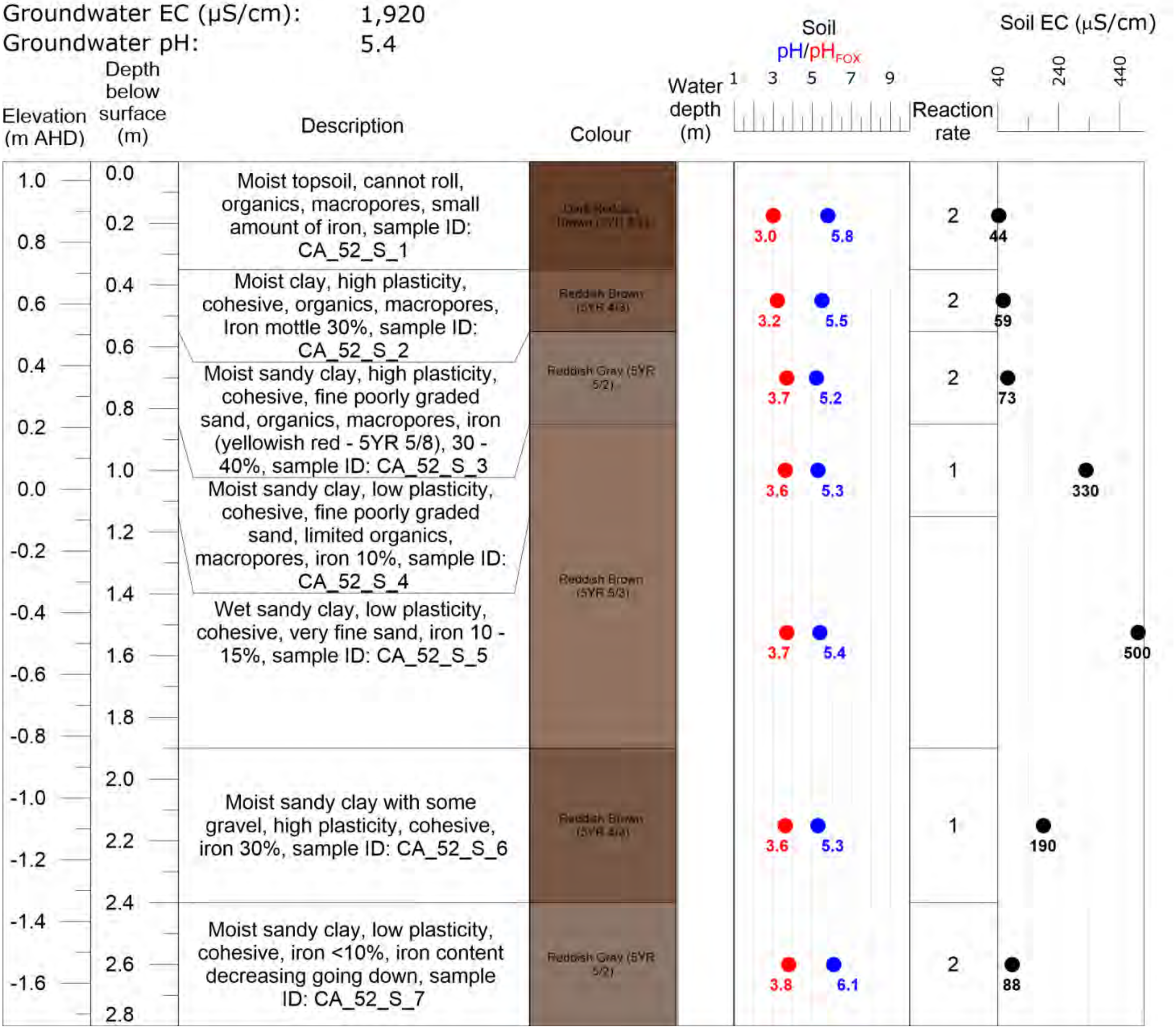
Soil profile details:

Project Number:	2018064	Profile ID:	CA_52_S
River/estuary:	Clarence	Sample date:	05/02/20
Easting:	524586.7	Sampled by:	AJH GL
Northing:	6740218.8		

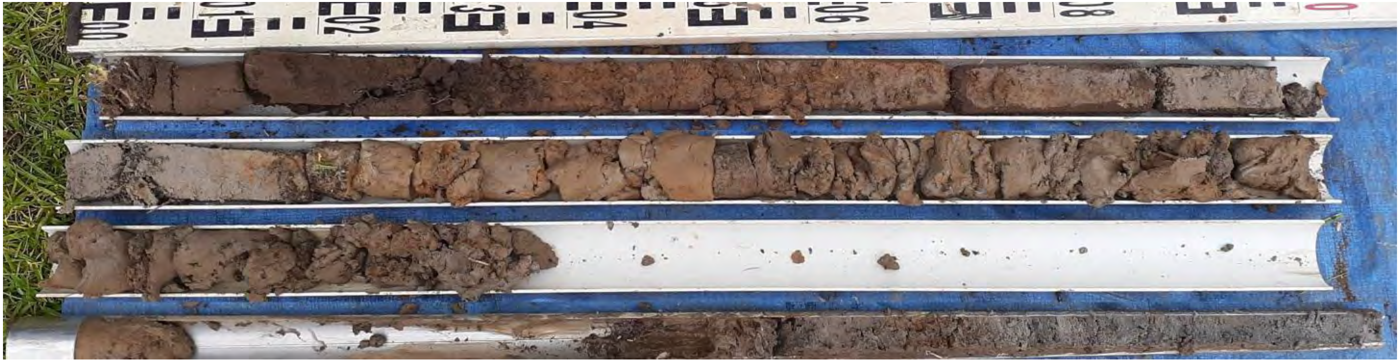
Ground elevation (m AHD):	1.06
Hydraulic conductivity (m/d):	0.19

Water quality:

Surface water EC (µS/cm):	271
Surface water pH:	6.2
Groundwater EC (µS/cm):	1,920
Groundwater pH:	5.4



Description	Colour	pH$_{FOX}$	pH	Reaction rate	Soil EC (µS/cm)
Moist topsoil, cannot roll, organics, macropores, small amount of iron, sample ID: CA_52_S_1	Dark Reddish Brown ([illegible])	3.0	5.8	2	44
Moist clay, high plasticity, cohesive, organics, macropores, Iron mottle 30%, sample ID: CA_52_S_2	Reddish Brown (5YR 4/3)	3.2	5.5	2	59
Moist sandy clay, high plasticity, cohesive, fine poorly graded sand, organics, macropores, iron (yellowish red - 5YR 5/8), 30 - 40%, sample ID: CA_52_S_3	Reddish Gray (5YR 5/2)	3.7	5.2	2	73
Moist sandy clay, low plasticity, cohesive, fine poorly graded sand, limited organics, macropores, iron 10%, sample ID: CA_52_S_4	Reddish Brown (5YR 5/3)	3.6	5.3	1	330
Wet sandy clay, low plasticity, cohesive, very fine sand, iron 10 - 15%, sample ID: CA_52_S_5		3.7	5.4		500
Moist sandy clay with some gravel, high plasticity, cohesive, iron 30%, sample ID: CA_52_S_6	Reddish Brown (5YR 4/4)	3.6	5.3	1	190
Moist sandy clay, low plasticity, cohesive, iron <10%, iron content decreasing going down, sample ID: CA_52_S_7	Reddish Gray (5YR 5/2)	3.8	6.1	2	88



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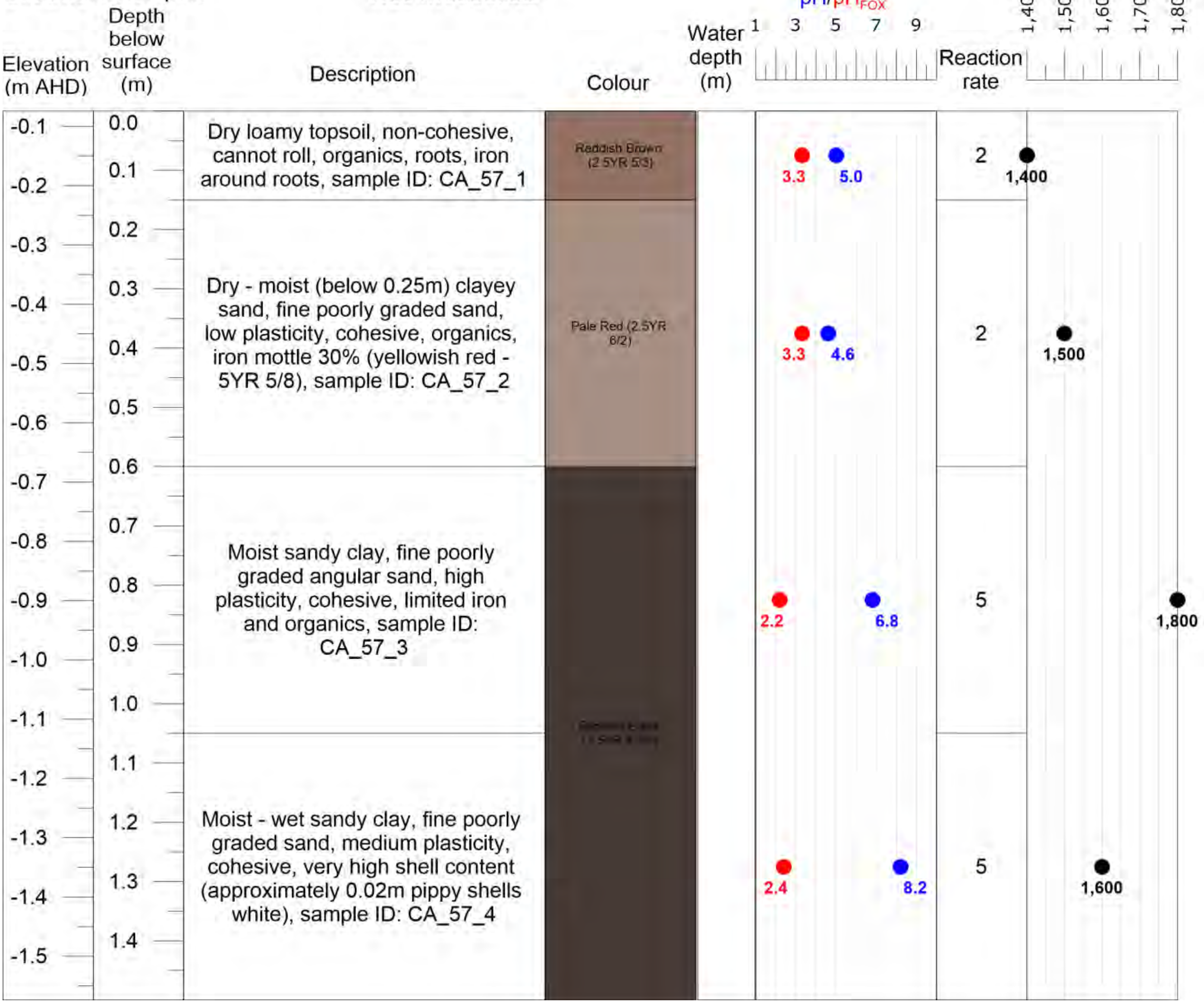
Soil profile details:

Project Number: 2018064
River/estuary: Clarence
Easting: 528787.3
Northing: 6740781.5
Profile ID: CA_57
Sample date: 05/12/19
Sampled by: AJH GL
Ground elevation (m AHD): -0.07
Hydraulic conductivity (m/d): 0.43

Water quality:

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

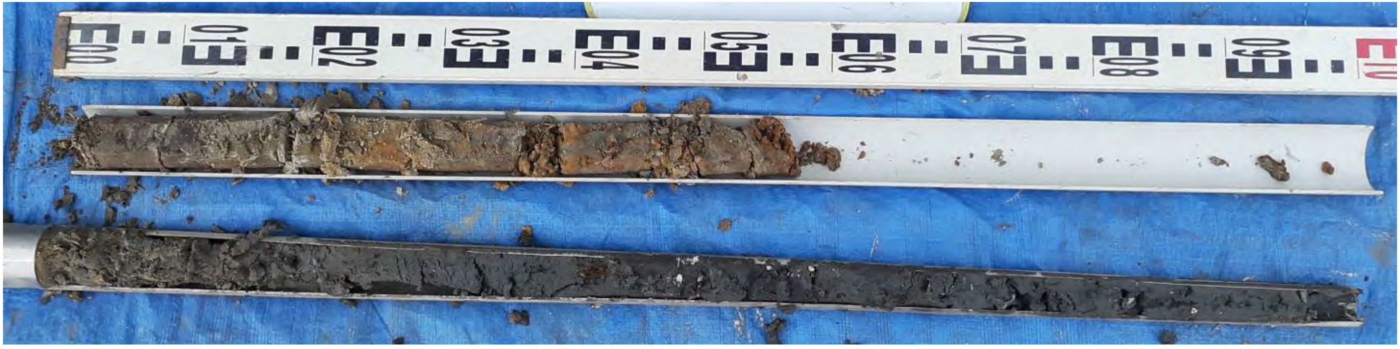


Dry loamy topsoil, non-cohesive, cannot roll, organics, roots, iron around roots, sample ID: CA_57_1

Dry - moist (below 0.25m) clayey sand, fine poorly graded sand, low plasticity, cohesive, organics, iron mottle 30% (yellowish red - 5YR 5/8), sample ID: CA_57_2

Moist sandy clay, fine poorly graded angular sand, high plasticity, cohesive, limited iron and organics, sample ID: CA_57_3

Moist - wet sandy clay, fine poorly graded sand, medium plasticity, cohesive, very high shell content (approximately 0.02m pippy shells white), sample ID: CA_57_4



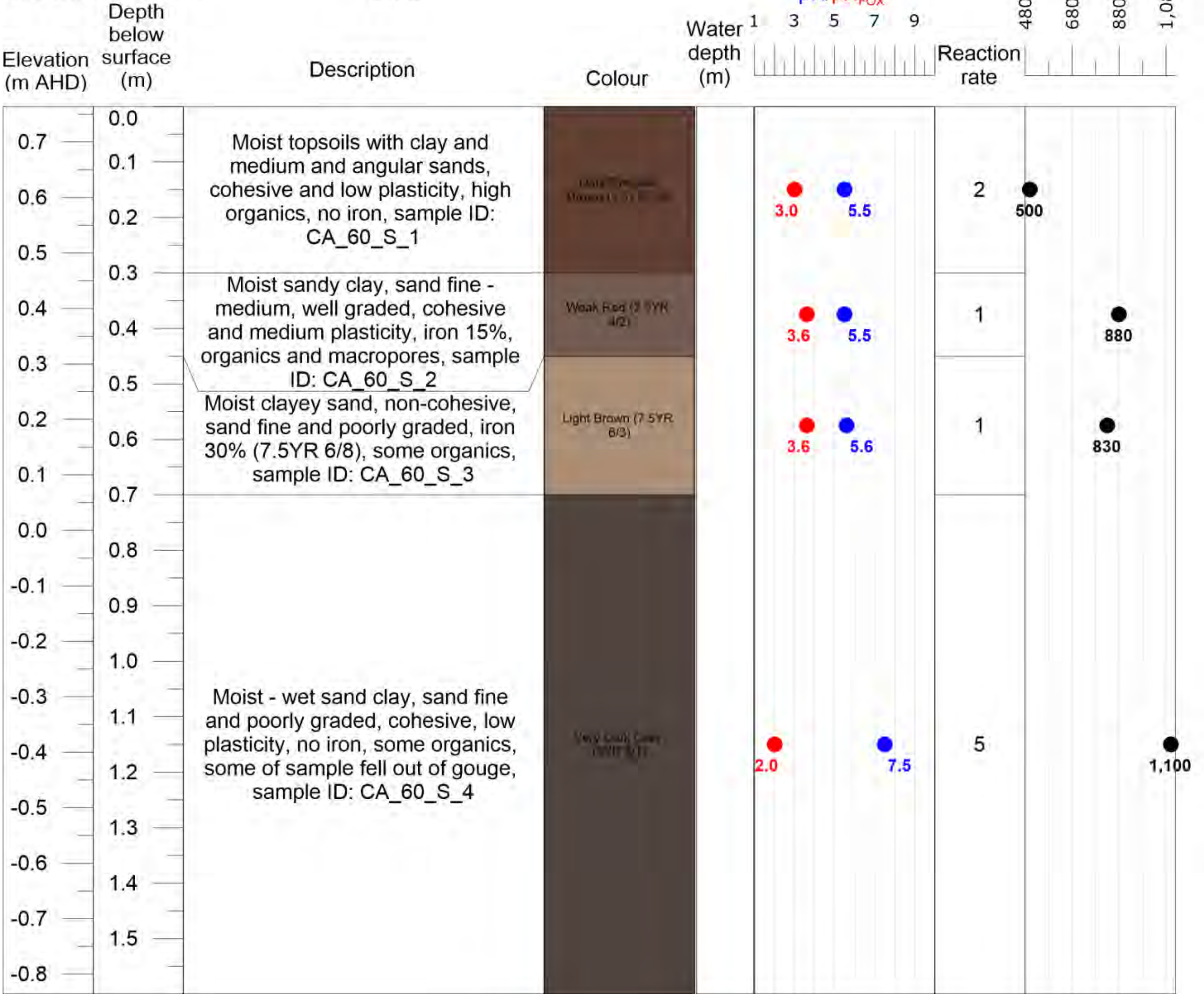
Soil profile details:

Project Number:	2018064	Profile ID:	CA_60_S
River/estuary:	Clarence	Sample date:	03/03/20
Easting:	528507.3	Sampled by:	AJH KW
Northing:	6743655.6		

Ground elevation (m AHD):	0.76
Hydraulic conductivity (m/d):	0.072

Water quality:

Surface water EC (µS/cm):	4,909
Surface water pH:	6.6
Groundwater EC (µS/cm):	20,943
Groundwater pH:	5.75



Description	Colour	pH$_{FOX}$	pH	Reaction rate	Soil EC (µS/cm)
Moist topsoils with clay and medium and angular sands, cohesive and low plasticity, high organics, no iron, sample ID: CA_60_S_1	[illegible]	3.0	5.5	2	500
Moist sandy clay, sand fine - medium, well graded, cohesive and medium plasticity, iron 15%, organics and macropores, sample ID: CA_60_S_2	Weak Red (2.5YR 4/2)	3.6	5.5	1	880
Moist clayey sand, non-cohesive, sand fine and poorly graded, iron 30% (7.5YR 6/8), some organics, sample ID: CA_60_S_3	Light Brown (7.5YR 6/3)	3.6	5.6	1	830
Moist - wet sand clay, sand fine and poorly graded, cohesive, low plasticity, no iron, some organics, some of sample fell out of gouge, sample ID: CA_60_S_4	Very Dark Grey (10YR 3/1)	2.0	7.5	5	1,100

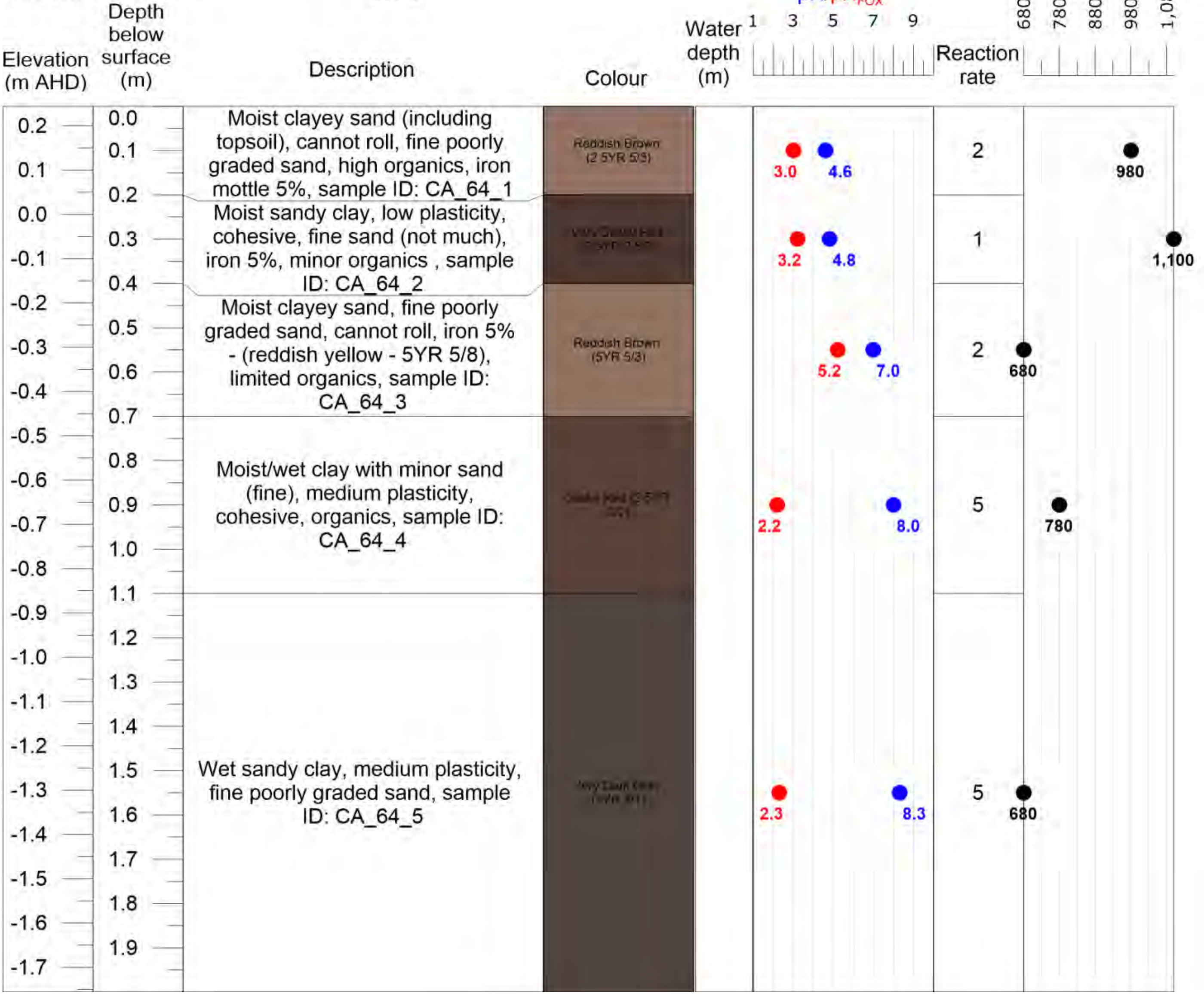
Soil profile details:

Project Number:	2018064	Profile ID:	CA_64
River/estuary:	Clarence	Sample date:	05/02/20
Easting:	524806	Sampled by:	AJH GL
Northing:	6749176.0		

Ground elevation (m AHD):	0.24
Hydraulic conductivity (m/d):	0.046

Water quality:

Surface water EC (µS/cm):	17,000
Surface water pH:	7.1
Groundwater EC (µS/cm):	9,334
Groundwater pH:	6.79



Depth below surface (m)	Description	Colour	pH	pH_{FOX}	Reaction rate	Soil EC (µS/cm)
0.0–0.2	Moist clayey sand (including topsoil), cannot roll, fine poorly graded sand, high organics, iron mottle 5%, sample ID: CA_64_1	Reddish Brown (2 5YR 5/3)	4.6	3.0	2	980
0.2–0.4	Moist sandy clay, low plasticity, cohesive, fine sand (not much), iron 5%, minor organics , sample ID: CA_64_2	Very Dusky Red ([illegible])	4.8	3.2	1	1,100
0.4–0.7	Moist clayey sand, fine poorly graded sand, cannot roll, iron 5% - (reddish yellow - 5YR 5/8), limited organics, sample ID: CA_64_3	Reddish Brown (5YR 5/3)	7.0	5.2	2	680
0.7–1.1	Moist/wet clay with minor sand (fine), medium plasticity, cohesive, organics, sample ID: CA_64_4	Dusky Red (2.5YR [illegible])	8.0	2.2	5	780
1.1–2.0	Wet sandy clay, medium plasticity, fine poorly graded sand, sample ID: CA_64_5	Very Dark Gray ([illegible])	8.3	2.3	5	680

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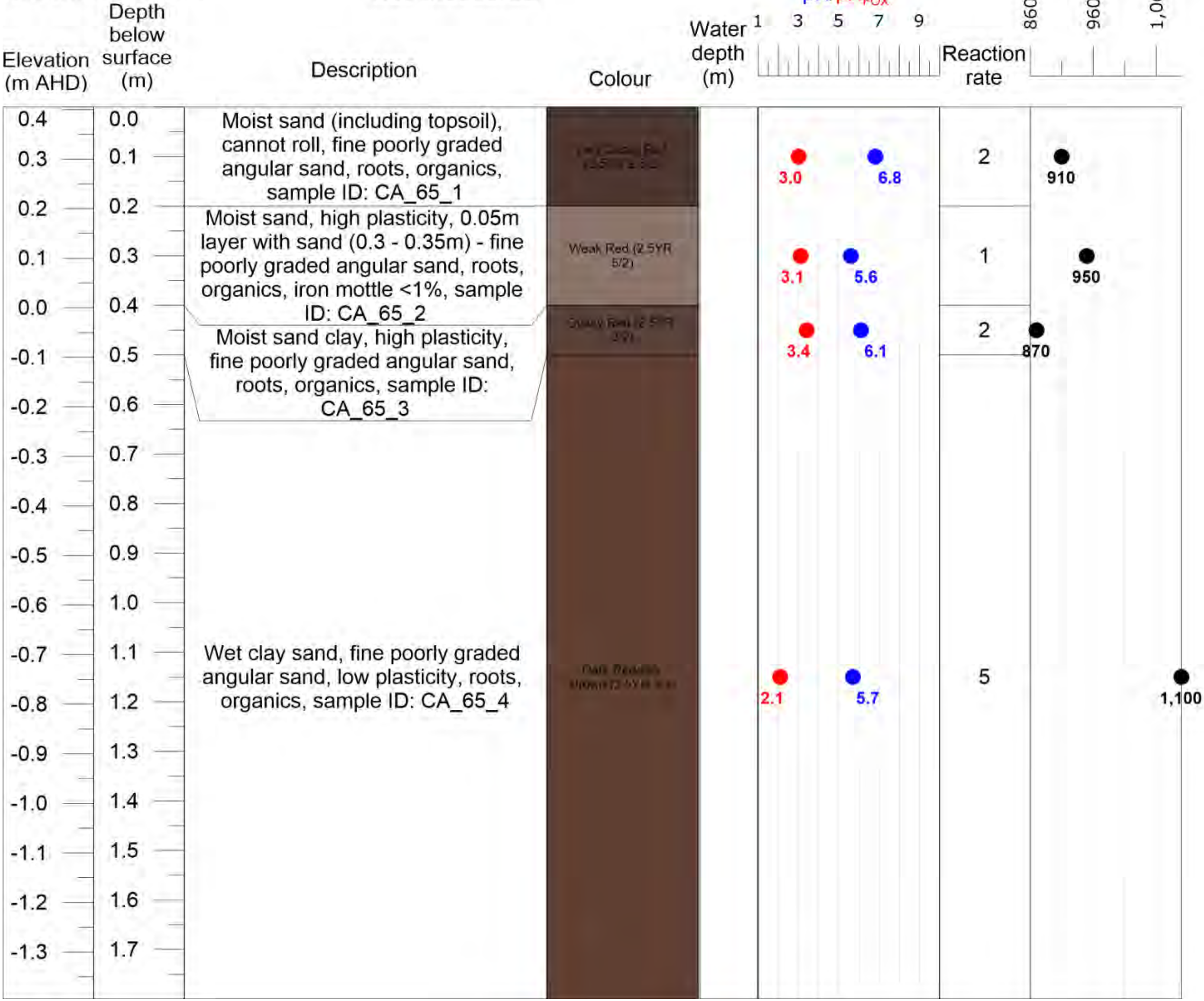
Soil profile details:

Project Number:	2018064	Profile ID:	CA_65
River/estuary:	Clarence	Sample date:	04/02/20
Easting:	525874.2	Sampled by:	AJH GL
Northing:	6748327.1		

Ground elevation (m AHD):	0.41
Hydraulic conductivity (m/d):	0.02

Water quality:

Surface water EC (µS/cm):	11,660
Surface water pH:	5.53
Groundwater EC (µS/cm):	Not measured
Groundwater pH:	Not measured

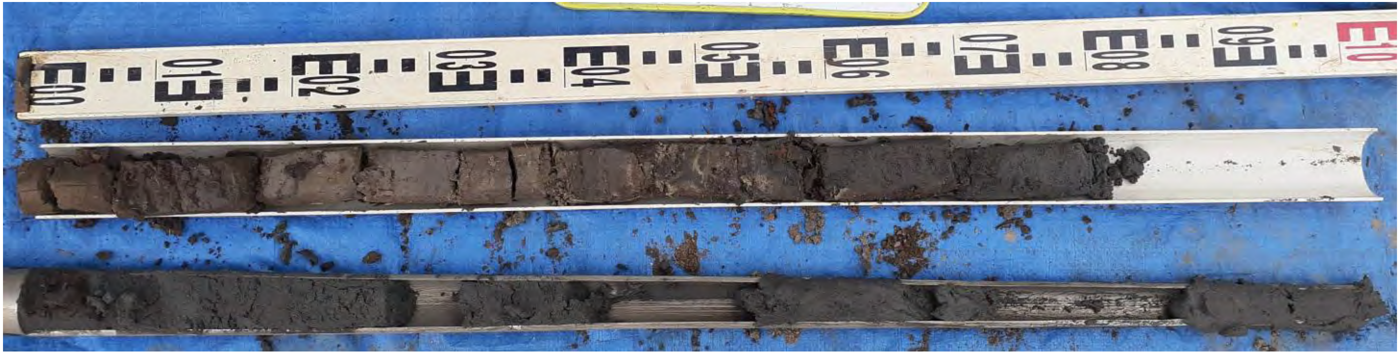


Moist sand (including topsoil), cannot roll, fine poorly graded angular sand, roots, organics, sample ID: CA_65_1

Moist sand, high plasticity, 0.05m layer with sand (0.3 - 0.35m) - fine poorly graded angular sand, roots, organics, iron mottle <1%, sample ID: CA_65_2

Moist sand clay, high plasticity, fine poorly graded angular sand, roots, organics, sample ID: CA_65_3

Wet clay sand, fine poorly graded angular sand, low plasticity, roots, organics, sample ID: CA_65_4



Soil profile details:

Project Number:	2018064	Profile ID:	CA_76
River/estuary:	Clarence	Sample date:	05/02/20
Easting:	509382.8	Sampled by:	AJH GL
Northing:	6744863.1		

Ground elevation (m AHD): 0.69

Hydraulic conductivity (m/d): 2.4

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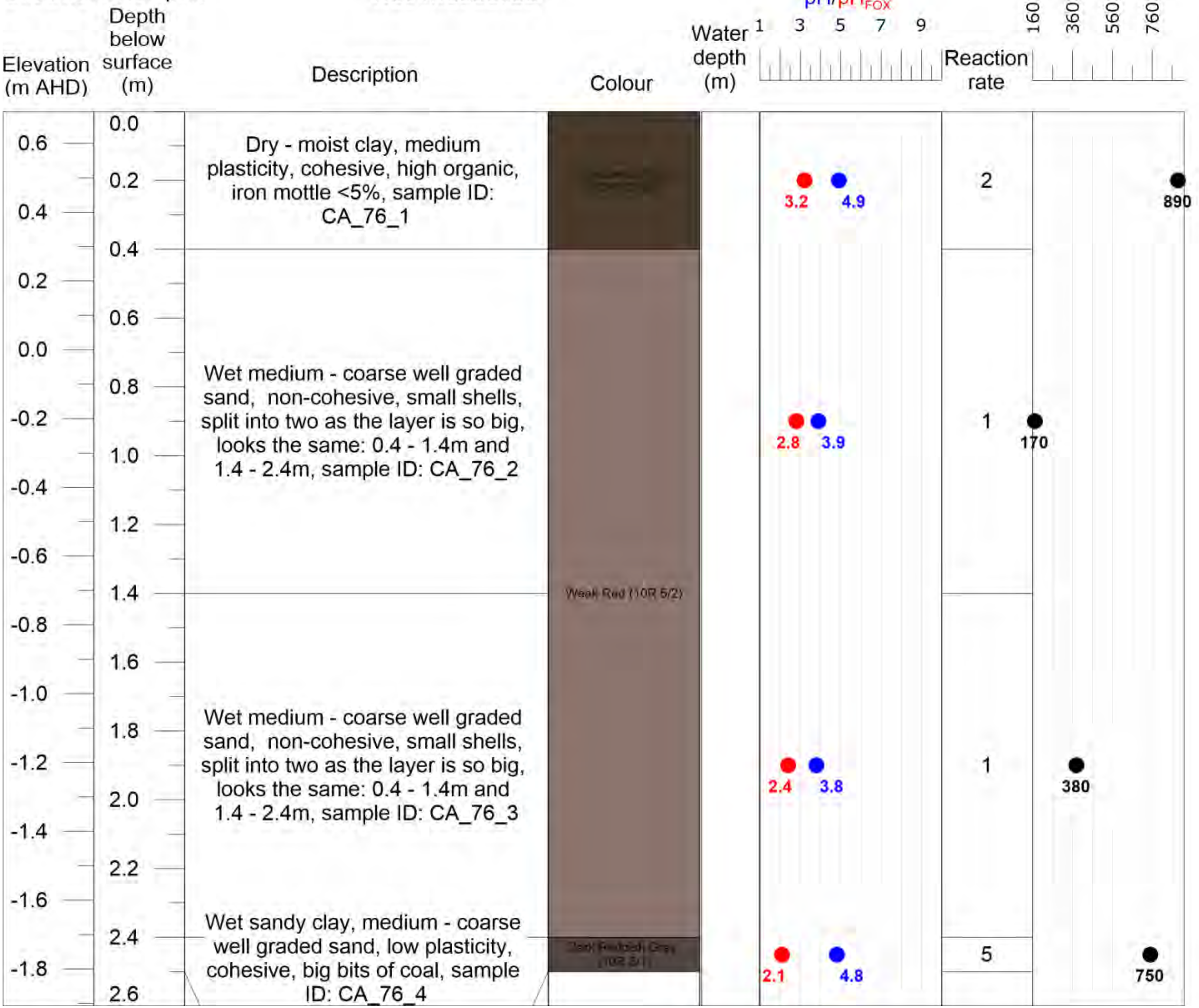
Water quality:

Surface water EC (µS/cm):	760 (creek), 8,700 (lake)
Surface water pH:	5.7 (creek), 6.3 (lake)
Groundwater EC (µS/cm):	Not measured
Groundwater pH:	Not measured



Dry - moist clay, medium plasticity, cohesive, high organic, iron mottle <5%, sample ID: CA_76_1

Wet medium - coarse well graded sand, non-cohesive, small shells, split into two as the layer is so big, looks the same: 0.4 - 1.4m and 1.4 - 2.4m, sample ID: CA_76_2

Wet medium - coarse well graded sand, non-cohesive, small shells, split into two as the layer is so big, looks the same: 0.4 - 1.4m and 1.4 - 2.4m, sample ID: CA_76_3

Wet sandy clay, medium - coarse well graded sand, low plasticity, cohesive, big bits of coal, sample ID: CA_76_4

Soil profile details:

Project Number:	2018064	Profile ID:	CA_80
River/estuary:	Clarence	Sample date:	28/11/19
Easting:	520890.3	Sampled by:	AJH GL
Northing:	6742837.6		

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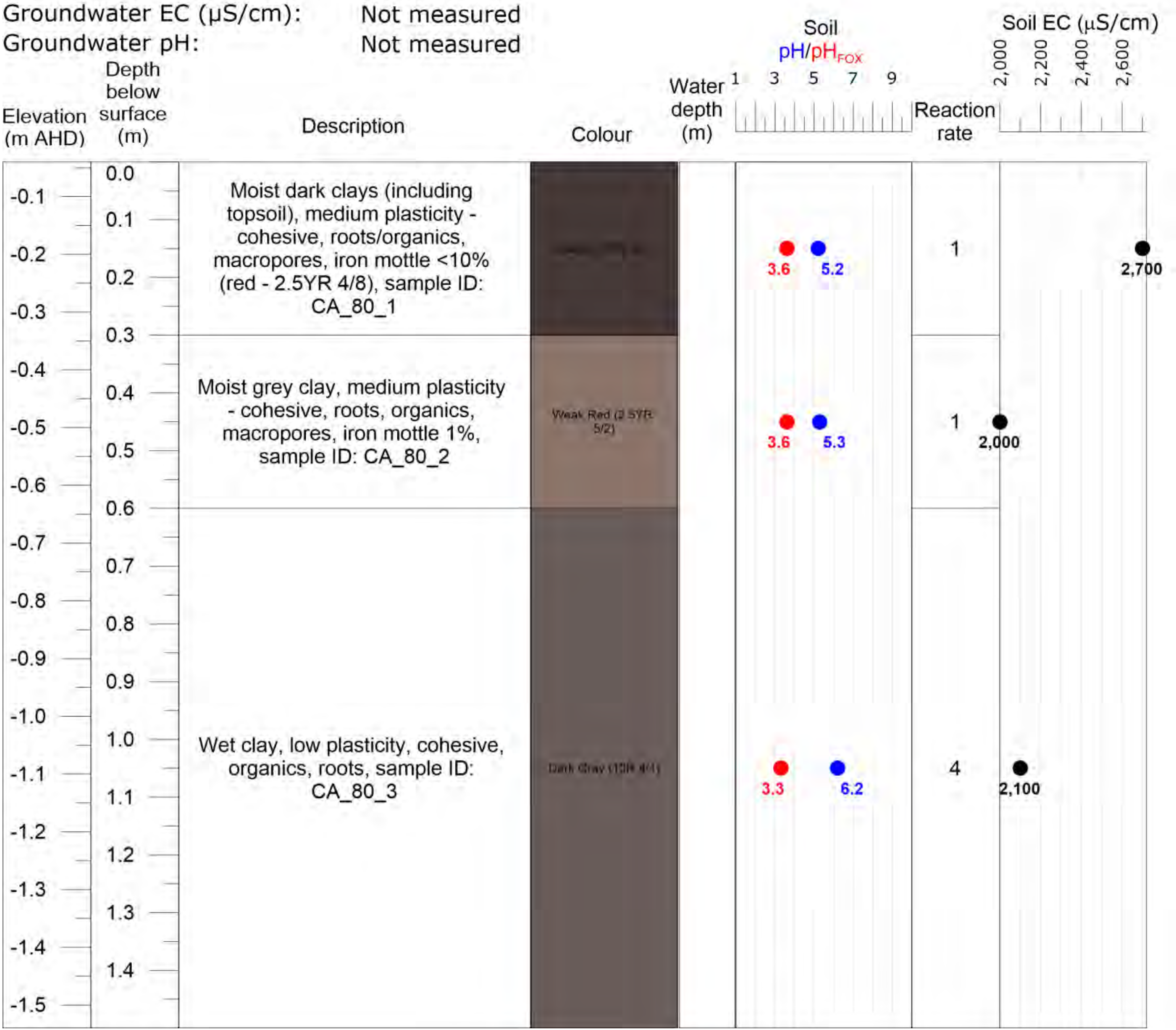
Ground elevation (m AHD):	-0.04
Hydraulic conductivity (m/d):	0.13

Water quality:

Surface water EC (µS/cm):	52,630
Surface water pH:	6.91
Groundwater EC (µS/cm):	Not measured
Groundwater pH:	Not measured



Depth below surface (m)	Description	Colour	Soil pH	Soil pH$_{FOX}$	Reaction rate	Soil EC (µS/cm)
0.0–0.3	Moist dark clays (including topsoil), medium plasticity - cohesive, roots/organics, macropores, iron mottle <10% (red - 2.5YR 4/8), sample ID: CA_80_1	[illegible]	5.2	3.6	1	2,700
0.3–0.6	Moist grey clay, medium plasticity - cohesive, roots, organics, macropores, iron mottle 1%, sample ID: CA_80_2	Weak Red (2.5YR 5/2)	5.3	3.6	1	2,000
0.6–1.5	Wet clay, low plasticity, cohesive, organics, roots, sample ID: CA_80_3	Dark Gray (10R 4/1)	6.2	3.3	4	2,100

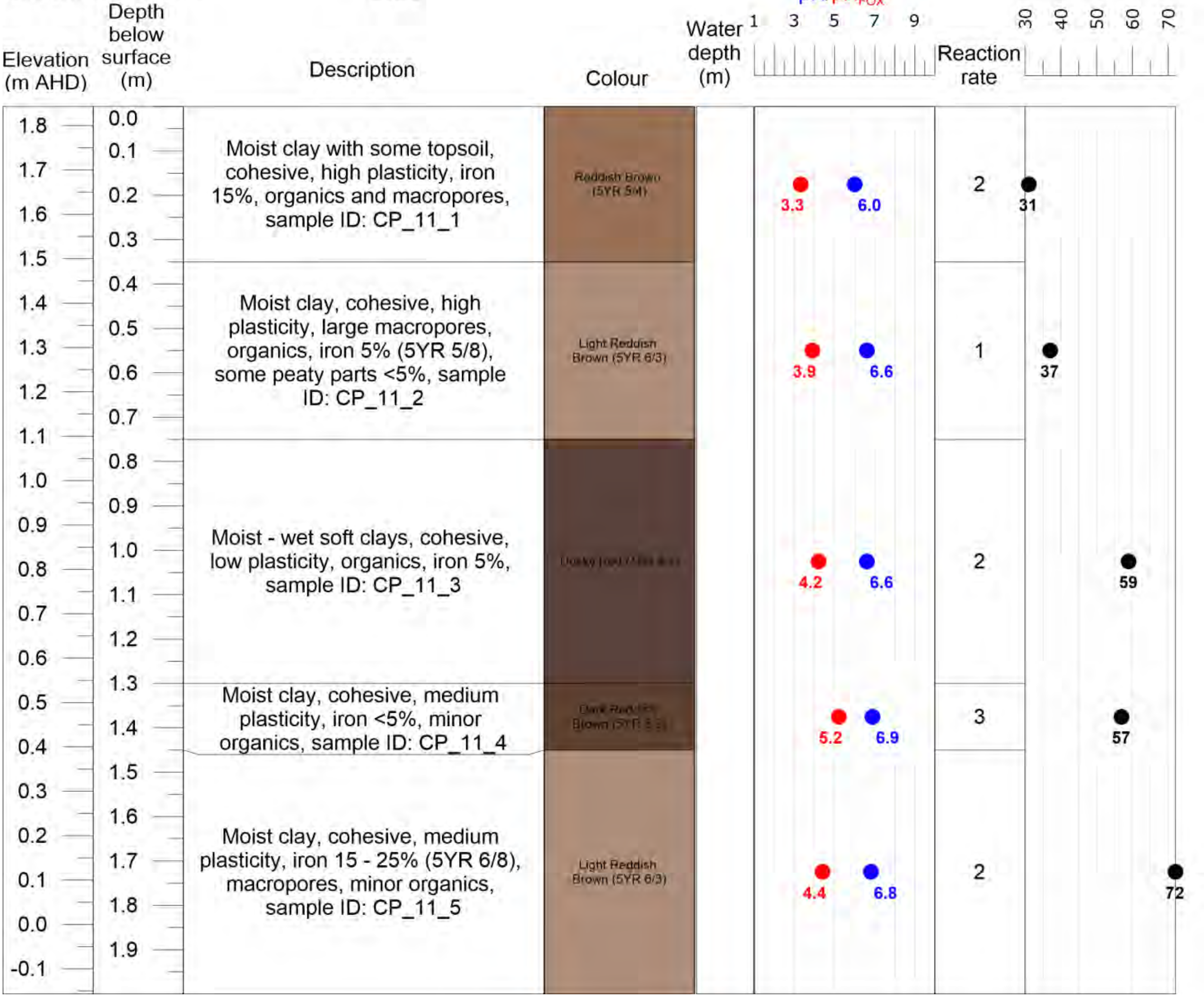
Soil profile details:

Project Number:	2018064	Profile ID:	CP_11
River/estuary:	Clarence	Sample date:	03/03/20
Easting:	492122.4	Sampled by:	AJH KW
Northing:	6713745.0		

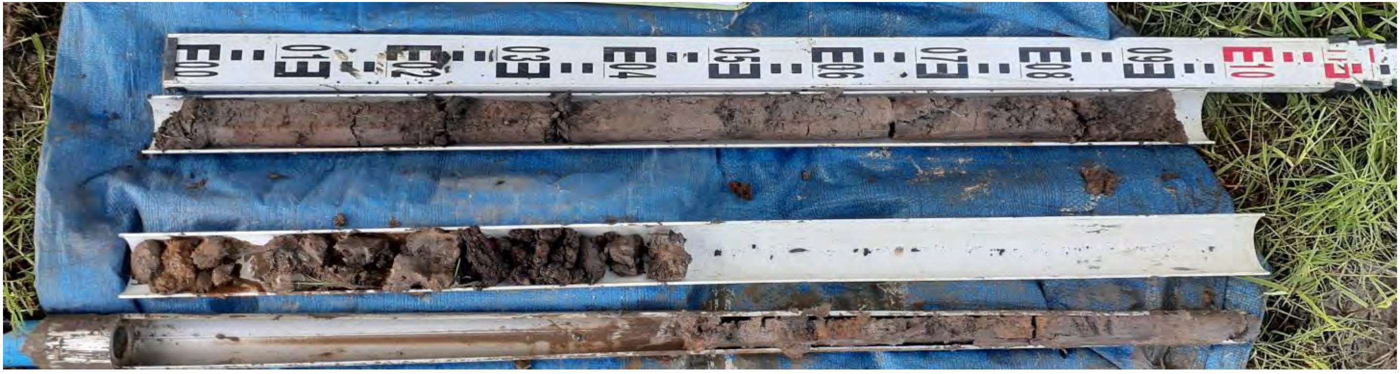
Ground elevation (m AHD):	1.84
Hydraulic conductivity (m/d):	0.11

Water quality:

Surface water EC (µS/cm):	227
Surface water pH:	7.21
Groundwater EC (µS/cm):	795
Groundwater pH:	5.21



Description	Colour	pH_{FOX}	pH	Reaction rate	Soil EC (µS/cm)
Moist clay with some topsoil, cohesive, high plasticity, iron 15%, organics and macropores, sample ID: CP_11_1	Reddish Brown (5YR 5/4)	3.3	6.0	2	31
Moist clay, cohesive, high plasticity, large macropores, organics, iron 5% (5YR 5/8), some peaty parts <5%, sample ID: CP_11_2	Light Reddish Brown (5YR 6/3)	3.9	6.6	1	37
Moist - wet soft clays, cohesive, low plasticity, organics, iron 5%, sample ID: CP_11_3	Dusky Red ([illegible])	4.2	6.6	2	59
Moist clay, cohesive, medium plasticity, iron <5%, minor organics, sample ID: CP_11_4	Dark Reddish Brown (5YR 3/3)	5.2	6.9	3	57
Moist clay, cohesive, medium plasticity, iron 15 - 25% (5YR 6/8), macropores, minor organics, sample ID: CP_11_5	Light Reddish Brown (5YR 6/3)	4.4	6.8	2	72



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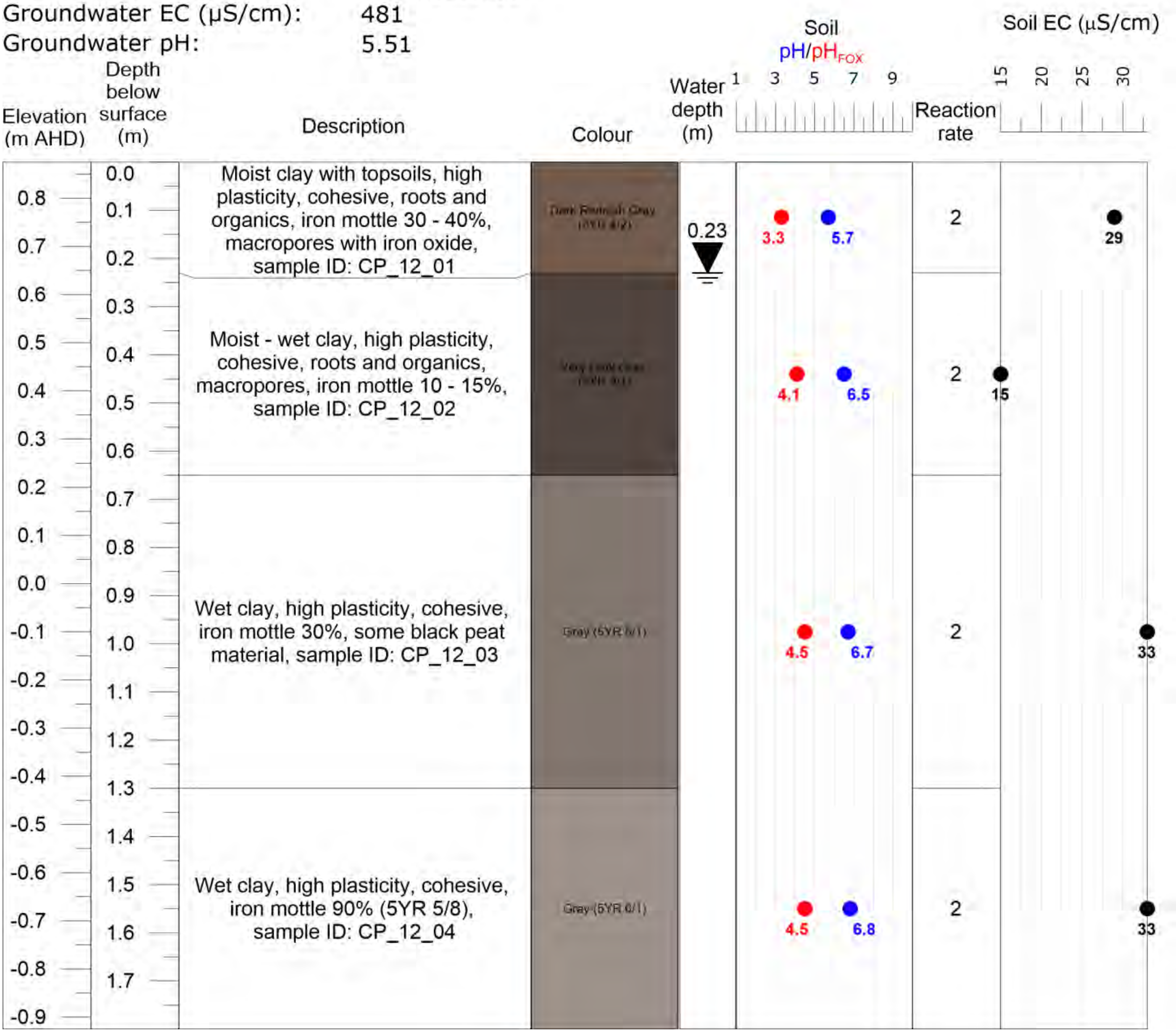
Soil profile details:

Project Number:	2018064	Profile ID:	CP_12
River/estuary:	Clarence	Sample date:	27/02/20
Easting:	489259.4	Sampled by:	AJH DWJ
Northing:	6718301.0		

Ground elevation (m AHD):	0.88
Hydraulic conductivity (m/d):	1.9

Water quality:

Surface water EC (µS/cm):	Not measured
Surface water pH:	Not measured
Groundwater EC (µS/cm):	481
Groundwater pH:	5.51



Description	Colour	Water depth (m)	Soil pH/pH$_{FOX}$	Reaction rate	Soil EC (µS/cm)
Moist clay with topsoils, high plasticity, cohesive, roots and organics, iron mottle 30 - 40%, macropores with iron oxide, sample ID: CP_12_01	Dark Reddish Gray (5YR 4/2)	0.23	5.7 / 3.3	2	29
Moist - wet clay, high plasticity, cohesive, roots and organics, macropores, iron mottle 10 - 15%, sample ID: CP_12_02	Very Dark Gray (5YR 3/1)		6.5 / 4.1	2	15
Wet clay, high plasticity, cohesive, iron mottle 30%, some black peat material, sample ID: CP_12_03	Gray (5YR 5/1)		6.7 / 4.5	2	33
Wet clay, high plasticity, cohesive, iron mottle 90% (5YR 5/8), sample ID: CP_12_04	Gray (5YR 6/1)		6.8 / 4.5	2	33

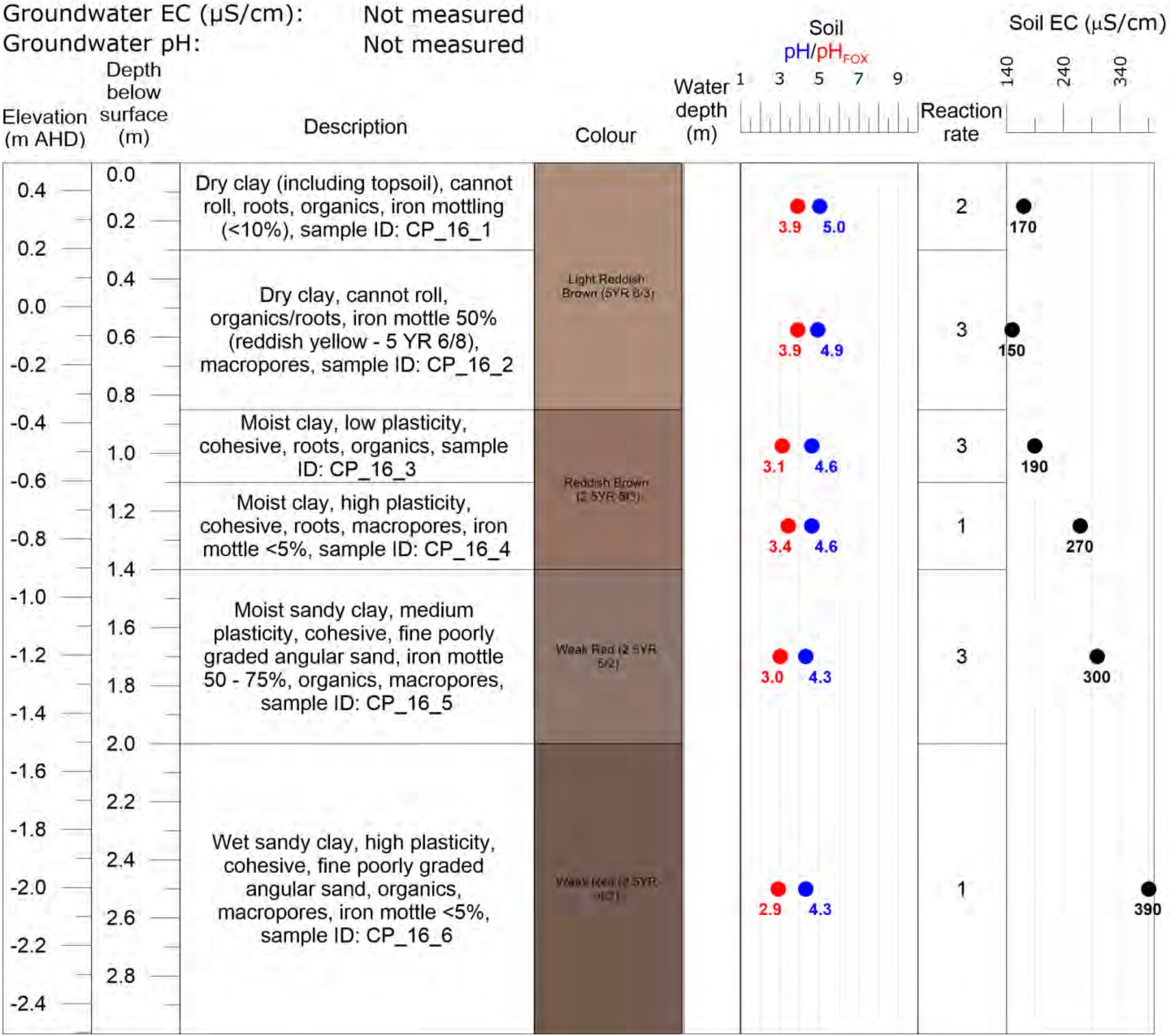
Soil profile details:

Project Number:	2018064	Profile ID:	CP_16
River/estuary:	Clarence	Sample date:	02/12/19
Easting:	501776.4	Sampled by:	AJH GL
Northing:	6719716.4		

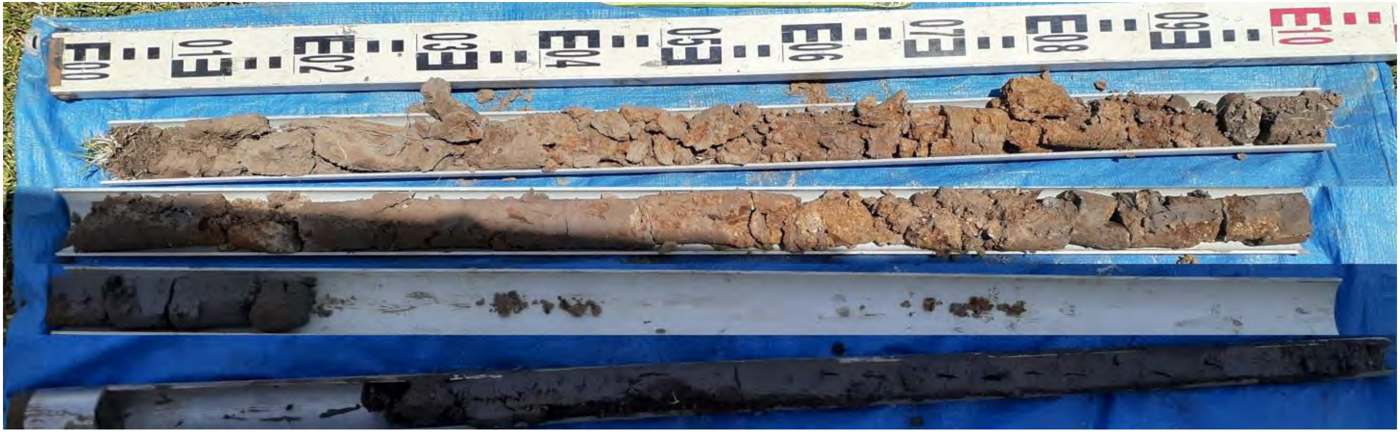
Ground elevation (m AHD): 0.49
Hydraulic conductivity (m/d): 0.55

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	pH$_{FOX}$	pH	Reaction rate	Soil EC (µS/cm)
Dry clay (including topsoil), cannot roll, roots, organics, iron mottling (<10%), sample ID: CP_16_1	Light Reddish Brown (5YR 6/3)	3.9	5.0	2	170
Dry clay, cannot roll, organics/roots, iron mottle 50% (reddish yellow - 5 YR 6/8), macropores, sample ID: CP_16_2		3.9	4.9	3	150
Moist clay, low plasticity, cohesive, roots, organics, sample ID: CP_16_3	Reddish Brown (2.5YR 5/3)	3.1	4.6	3	190
Moist clay, high plasticity, cohesive, roots, macropores, iron mottle <5%, sample ID: CP_16_4		3.4	4.6	1	270
Moist sandy clay, medium plasticity, cohesive, fine poorly graded angular sand, iron mottle 50 - 75%, organics, macropores, sample ID: CP_16_5	Weak Red (2.5YR 5/2)	3.0	4.3	3	300
Wet sandy clay, high plasticity, cohesive, fine poorly graded angular sand, organics, macropores, iron mottle <5%, sample ID: CP_16_6	Weak Red (2.5YR 4/2)	2.9	4.3	1	390



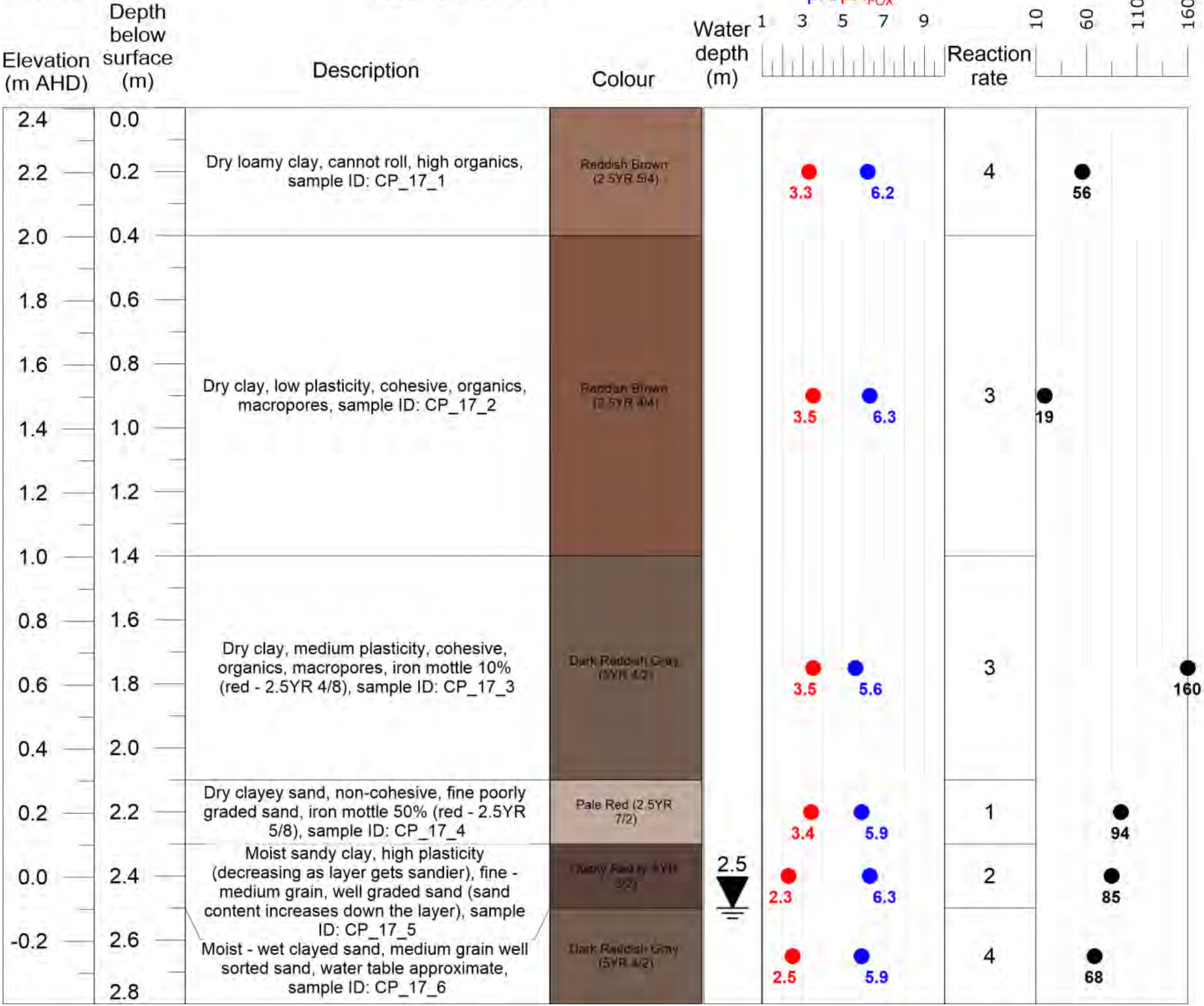
Soil profile details:

Project Number:	2018064	Profile ID:	CP_17
River/estuary:	Clarence	Sample date:	04/12/19
Easting:	501596.9	Sampled by:	AJH GL
Northing:	6722914.1		

Ground elevation (m AHD): 2.40
Hydraulic conductivity (m/d): 1.5

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 loamy clay, cannot roll, high organics, sample ID: CP_17_1	Reddish Brown (2.5YR 5/4)		3.3	6.2	4	56
Dry clay, low plasticity, cohesive, organics, macropores, sample ID: CP_17_2	Reddish Brown (2.5YR 4/4)		3.5	6.3	3	19
Dry clay, medium plasticity, cohesive, organics, macropores, iron mottle 10% (red - 2.5YR 4/8), sample ID: CP_17_3	Dark Reddish Gray (5YR 4/2)		3.5	5.6	3	160
Dry clayey sand, non-cohesive, fine poorly graded sand, iron mottle 50% (red - 2.5YR 5/8), sample ID: CP_17_4	Pale Red (2.5YR 7/2)		3.4	5.9	1	94
Moist sandy clay, high plasticity (decreasing as layer gets sandier), fine - medium grain, well graded sand (sand content increases down the layer), sample ID: CP_17_5	Dusky Red (2.5YR 3/2)	2.5	2.3	6.3	2	85
Moist - wet clayed sand, medium grain well sorted sand, water table approximate, sample ID: CP_17_6	Dark Reddish Gray (5YR 4/2)		2.5	5.9	4	68

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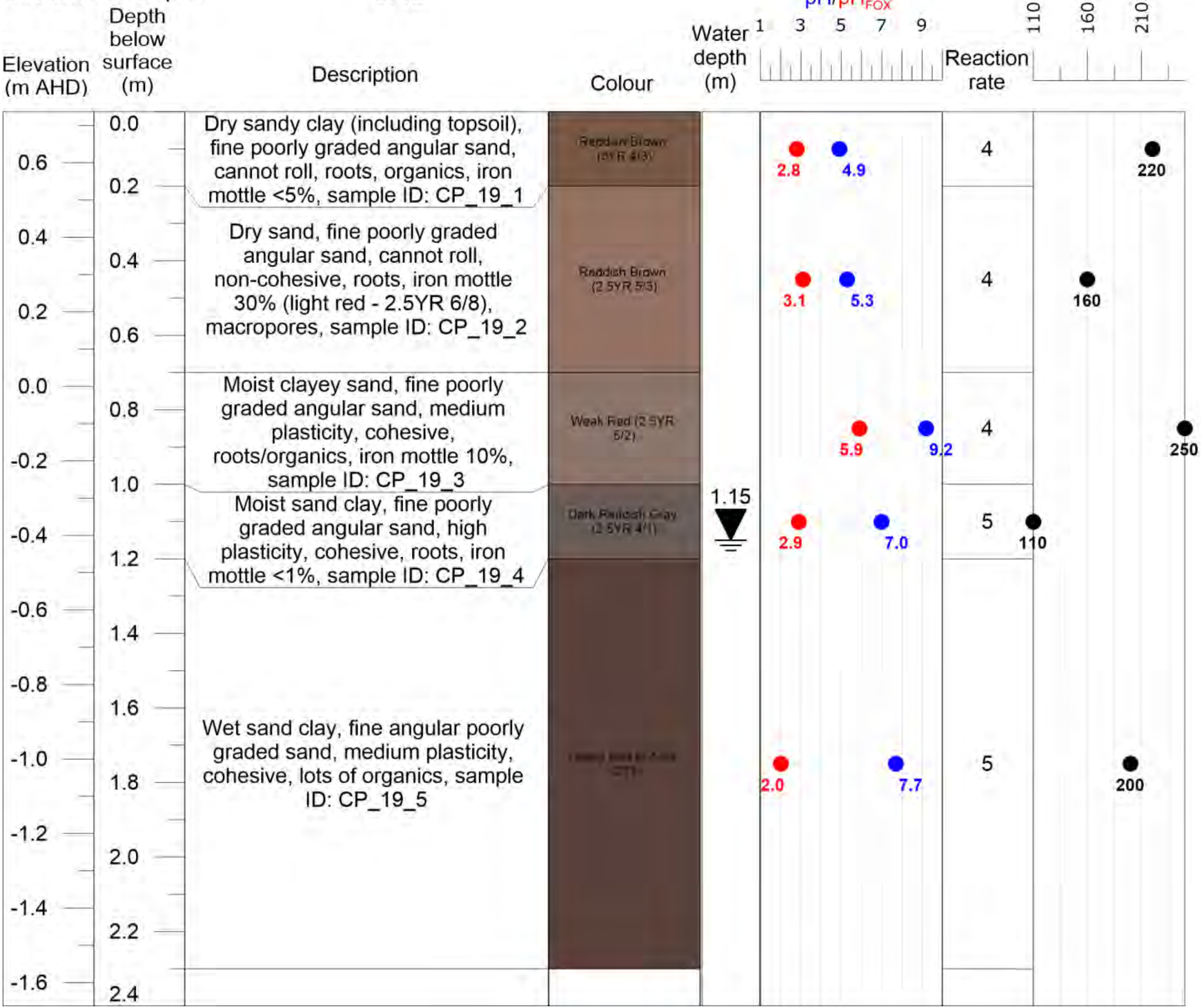
Soil profile details:

Project Number:	2018064	Profile ID:	CP_19
River/estuary:	Clarence	Sample date:	04/12/19
Easting:	501761.8	Sampled by:	AJH GL
Northing:	6723802.0		

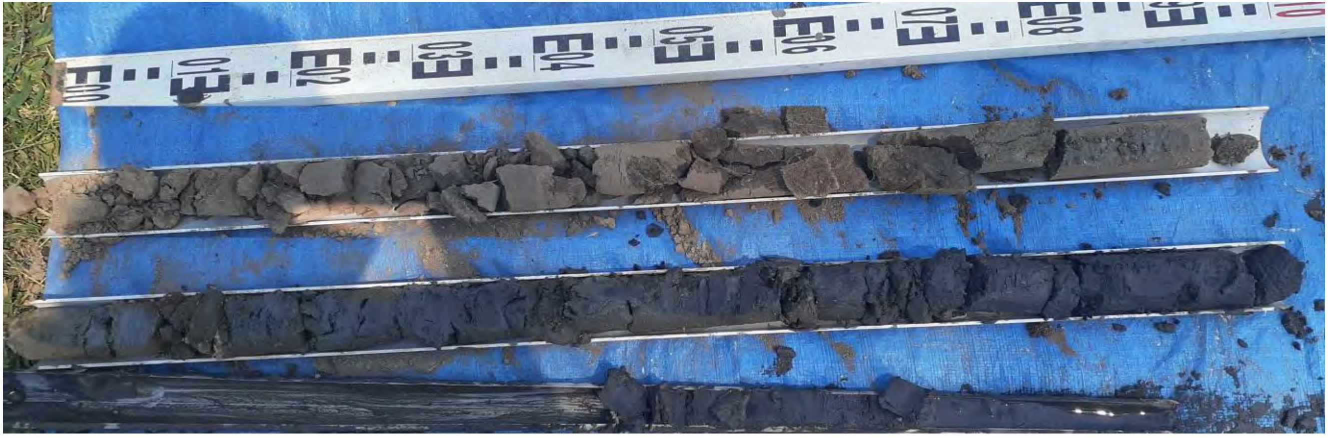
Ground elevation (m AHD):	0.74
Hydraulic conductivity (m/d):	0.25

Water quality:

Surface water EC (µS/cm):	28,904
Surface water pH:	7.85
Groundwater EC (µS/cm):	3,230
Groundwater pH:	6.45



Description	Colour	pH$_{FOX}$	pH	Reaction rate	Soil EC (µS/cm)
Dry sandy clay (including topsoil), fine poorly graded angular sand, cannot roll, roots, organics, iron mottle <5%, sample ID: CP_19_1	Reddish Brown (5YR 4/3)	2.8	4.9	4	220
Dry sand, fine poorly graded angular sand, cannot roll, non-cohesive, roots, iron mottle 30% (light red - 2.5YR 6/8), macropores, sample ID: CP_19_2	Reddish Brown (2.5YR 5/3)	3.1	5.3	4	160
Moist clayey sand, fine poorly graded angular sand, medium plasticity, cohesive, roots/organics, iron mottle 10%, sample ID: CP_19_3	Weak Red (2.5YR 5/2)	5.9	9.2	4	250
Moist sand clay, fine poorly graded angular sand, high plasticity, cohesive, roots, iron mottle <1%, sample ID: CP_19_4	Dark Reddish Gray (2.5YR 4/1)	2.9	7.0	5	110
Wet sand clay, fine angular poorly graded sand, medium plasticity, cohesive, lots of organics, sample ID: CP_19_5	[illegible]	2.0	7.7	5	200



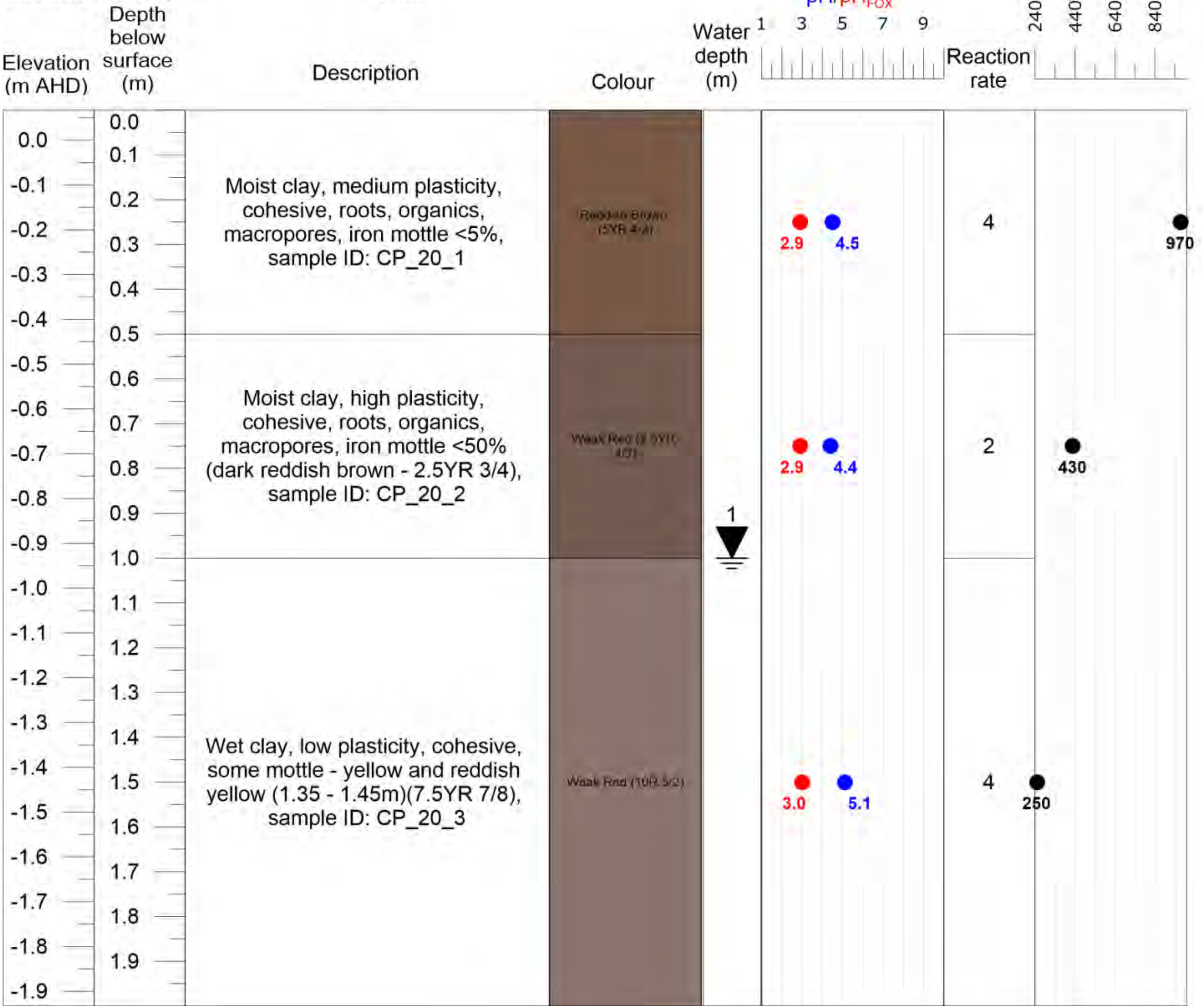
Soil profile details:

Project Number:	2018064	Profile ID:	CP_20
River/estuary:	Clarence	Sample date:	04/12/19
Easting:	497099.5	Sampled by:	AJH GL
Northing:	6721006.3		

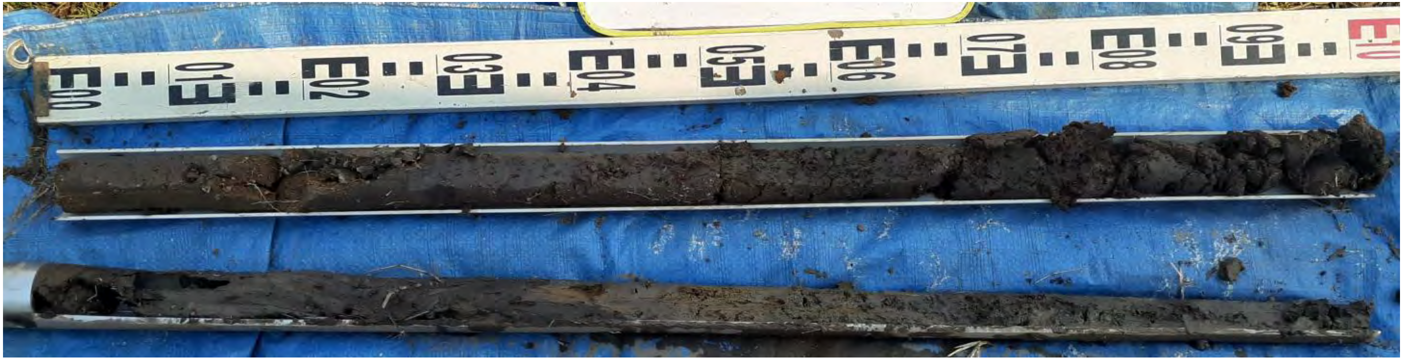
Ground elevation (m AHD):	0.07
Hydraulic conductivity (m/d):	1.1

Water quality:

Surface water EC (μS/cm):	30,000
Surface water pH:	7.19
Groundwater EC (μS/cm):	4,760
Groundwater pH:	4.62



Moist clay, medium plasticity, cohesive, roots, organics, macropores, iron mottle <5%, sample ID: CP_20_1	Reddish Brown (5YR 4/4)	2.9	4.5	4	970
Moist clay, high plasticity, cohesive, roots, organics, macropores, iron mottle <50% (dark reddish brown - 2.5YR 3/4), sample ID: CP_20_2	Weak Red (2.5YR 4/2)	2.9	4.4	2	430
Wet clay, low plasticity, cohesive, some mottle - yellow and reddish yellow (1.35 - 1.45m)(7.5YR 7/8), sample ID: CP_20_3	Weak Red (10R 5/2)	3.0	5.1	4	250



Soil profile details:

Project Number:	2018064	Profile ID:	CP_25
River/estuary:	Clarence	Sample date:	28/11/19
Easting:	509376.4	Sampled by:	AJH GL
Northing:	6721704.8		

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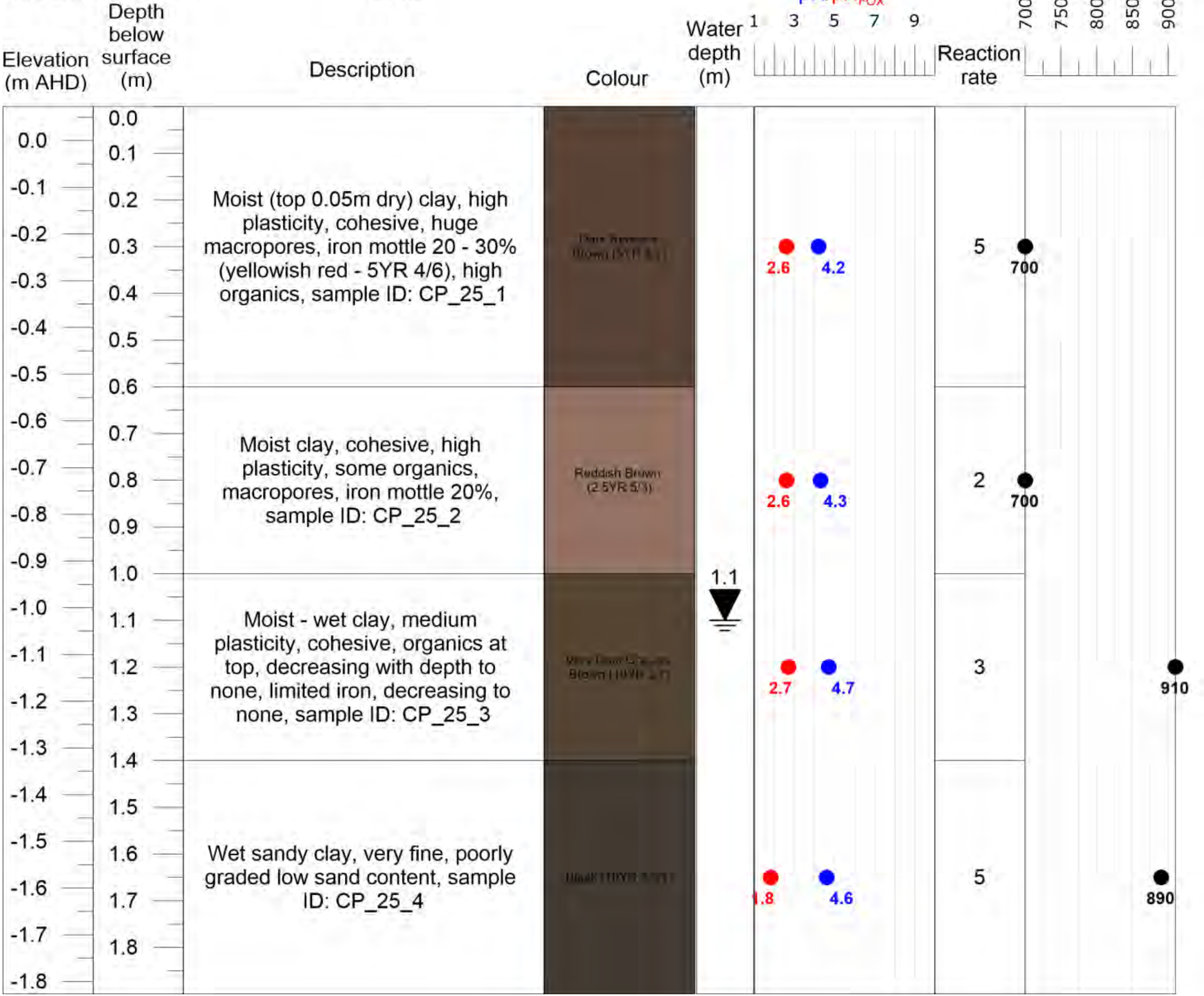
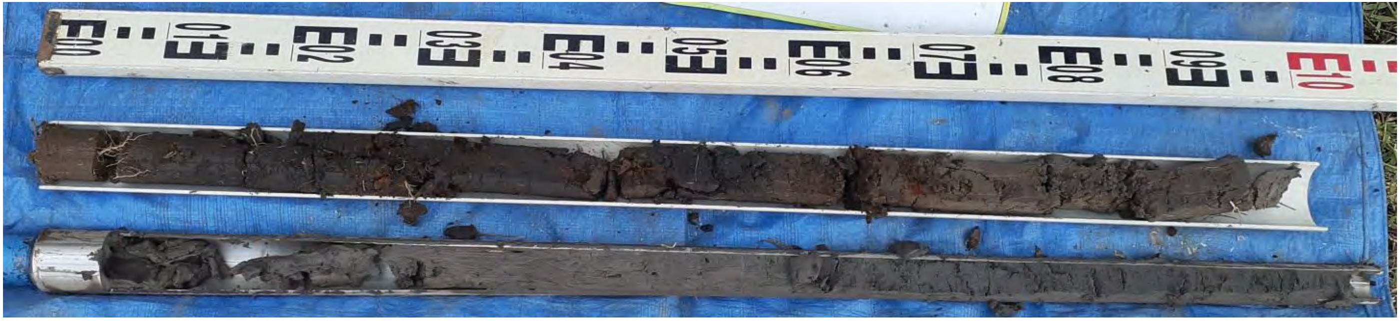
Ground elevation (m AHD):	0.07
Hydraulic conductivity (m/d):	1.4

Water quality:

Surface water EC (µS/cm):	27,400
Surface water pH:	7.9
Groundwater EC (µS/cm):	15,200
Groundwater pH:	5.43



Description	Colour	pH$_{FOX}$	pH	Reaction rate	Soil EC (µS/cm)
Moist (top 0.05m dry) clay, high plasticity, cohesive, huge macropores, iron mottle 20 - 30% (yellowish red - 5YR 4/6), high organics, sample ID: CP_25_1	[illegible]	2.6	4.2	5	700
Moist clay, cohesive, high plasticity, some organics, macropores, iron mottle 20%, sample ID: CP_25_2	Reddish Brown (2.5YR 5/3)	2.6	4.3	2	700
Moist - wet clay, medium plasticity, cohesive, organics at top, decreasing with depth to none, limited iron, decreasing to none, sample ID: CP_25_3	[illegible]	2.7	4.7	3	910
Wet sandy clay, very fine, poorly graded low sand content, sample ID: CP_25_4	[illegible]	.8	4.6	5	890



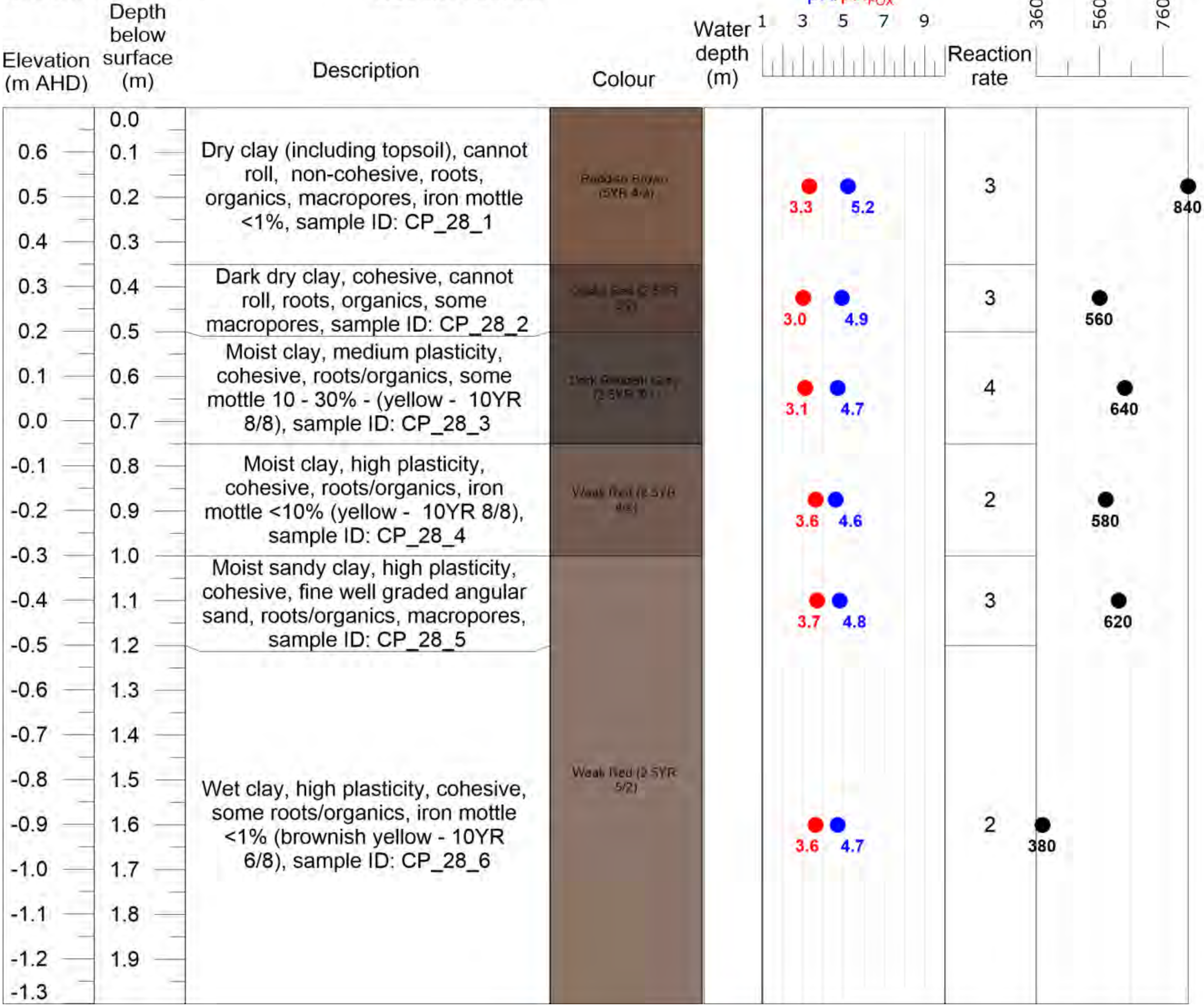
Soil profile details:

Project Number:	2018064	Profile ID:	CP_28
River/estuary:	Clarence	Sample date:	28/11/19
Easting:	510413.3	Sampled by:	AJH GL
Northing:	6719595.1		

Ground elevation (m AHD):	0.70
Hydraulic conductivity (m/d):	0.83

Water quality:

Surface water EC (µS/cm):	24,450
Surface water pH:	8.5
Groundwater EC (µS/cm):	Not measured
Groundwater pH:	Not measured



Description	Colour	Soil pH/pH$_{FOX}$	Reaction rate	Soil EC (µS/cm)
Dry clay (including topsoil), cannot roll, non-cohesive, roots, organics, macropores, iron mottle <1%, sample ID: CP_28_1	Reddish Brown (5YR 4/4)	3.3 5.2	3	840
Dark dry clay, cohesive, cannot roll, roots, organics, some macropores, sample ID: CP_28_2	Dusky Red (2.5YR 3/2)	3.0 4.9	3	560
Moist clay, medium plasticity, cohesive, roots/organics, some mottle 10 - 30% - (yellow - 10YR 8/8), sample ID: CP_28_3	Dark Reddish Grey (2.5YR 3/1)	3.1 4.7	4	640
Moist clay, high plasticity, cohesive, roots/organics, iron mottle <10% (yellow - 10YR 8/8), sample ID: CP_28_4	Weak Red (2.5YR 4/2)	3.6 4.6	2	580
Moist sandy clay, high plasticity, cohesive, fine well graded angular sand, roots/organics, macropores, sample ID: CP_28_5		3.7 4.8	3	620
Wet clay, high plasticity, cohesive, some roots/organics, iron mottle <1% (brownish yellow - 10YR 6/8), sample ID: CP_28_6	Weak Red (2.5YR 5/2)	3.6 4.7	2	380

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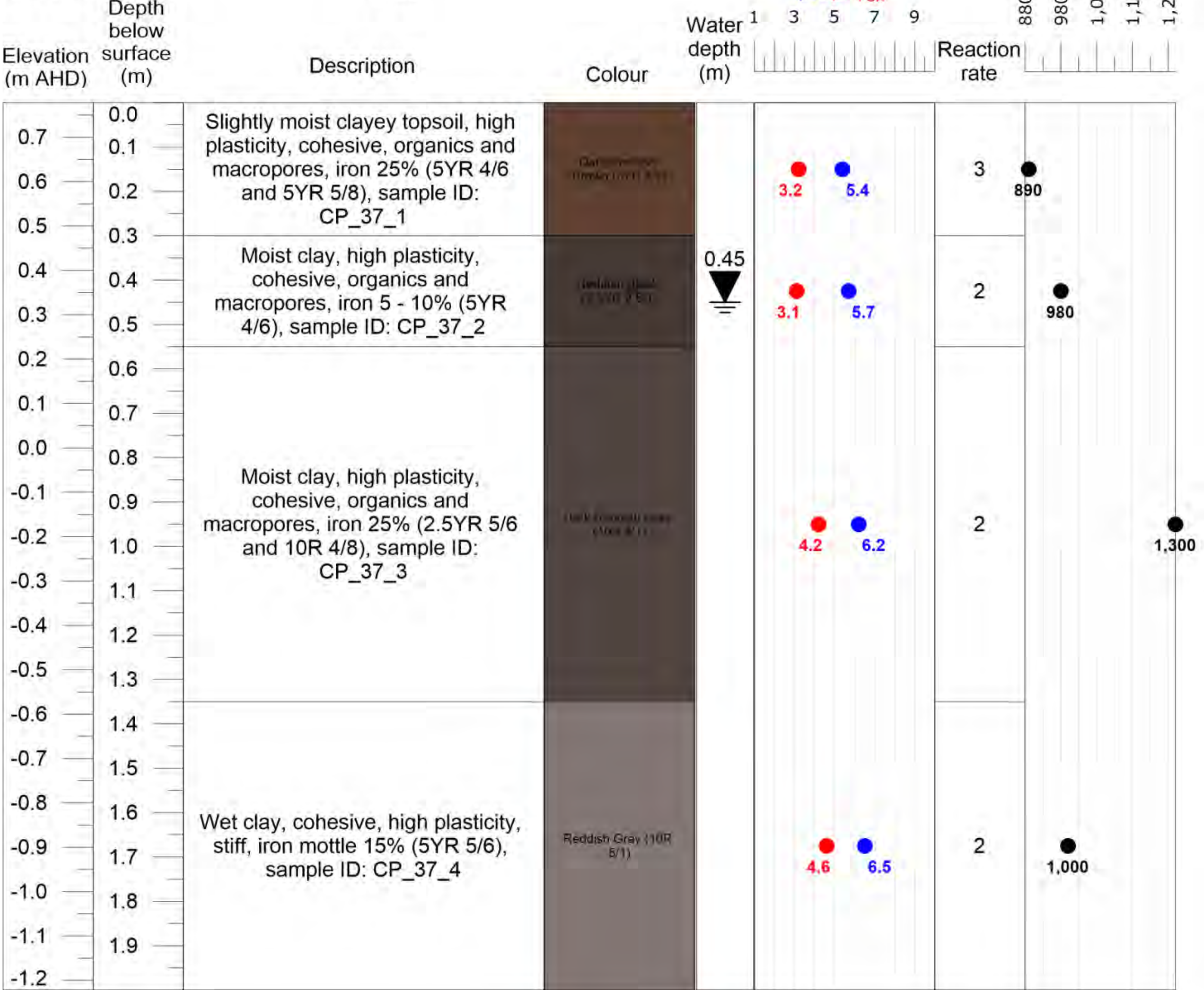
Soil profile details:

Project Number:	2018064	Profile ID:	CP_37
River/estuary:	Clarence	Sample date:	03/03/20
Easting:	511395.1	Sampled by:	AJH KW
Northing:	6736943.2		

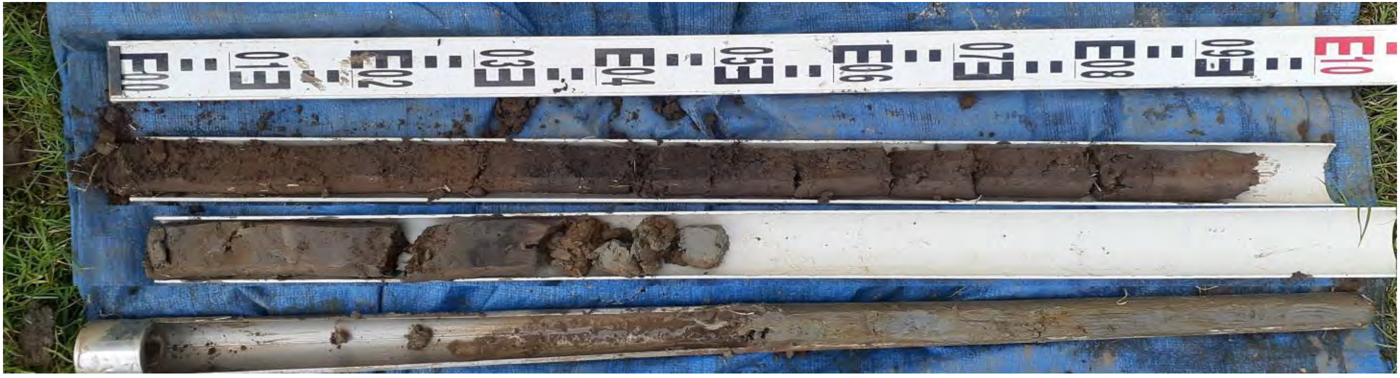
Ground elevation (m AHD):	0.78
Hydraulic conductivity (m/d):	3.4

Water quality:

Surface water EC (μS/cm):	4,700
Surface water pH:	5.8
Groundwater EC (μS/cm):	16,800
Groundwater pH:	5.65



Description	Colour	Water depth (m)	Soil pH	Soil pH$_{FOX}$	Reaction rate	Soil EC (μS/cm)
Slightly moist clayey topsoil, high plasticity, cohesive, organics and macropores, iron 25% (5YR 4/6 and 5YR 5/8), sample ID: CP_37_1	[illegible]		5.4	3.2	3	890
Moist clay, high plasticity, cohesive, organics and macropores, iron 5 - 10% (5YR 4/6), sample ID: CP_37_2	[illegible]	0.45	5.7	3.1	2	980
Moist clay, high plasticity, cohesive, organics and macropores, iron 25% (2.5YR 5/6 and 10R 4/8), sample ID: CP_37_3	[illegible]		6.2	4.2	2	1,300
Wet clay, cohesive, high plasticity, stiff, iron mottle 15% (5YR 5/6), sample ID: CP_37_4	Reddish Gray (10R 5/1)		6.5	4.6	2	1,000



Soil profile details:

Project Number: 2018064
River/estuary: Clarence
Easting: 517367.1
Northing: 6730094.5
Profile ID: CP_39
Sample date: 27/11/19
Sampled by: AJH GL

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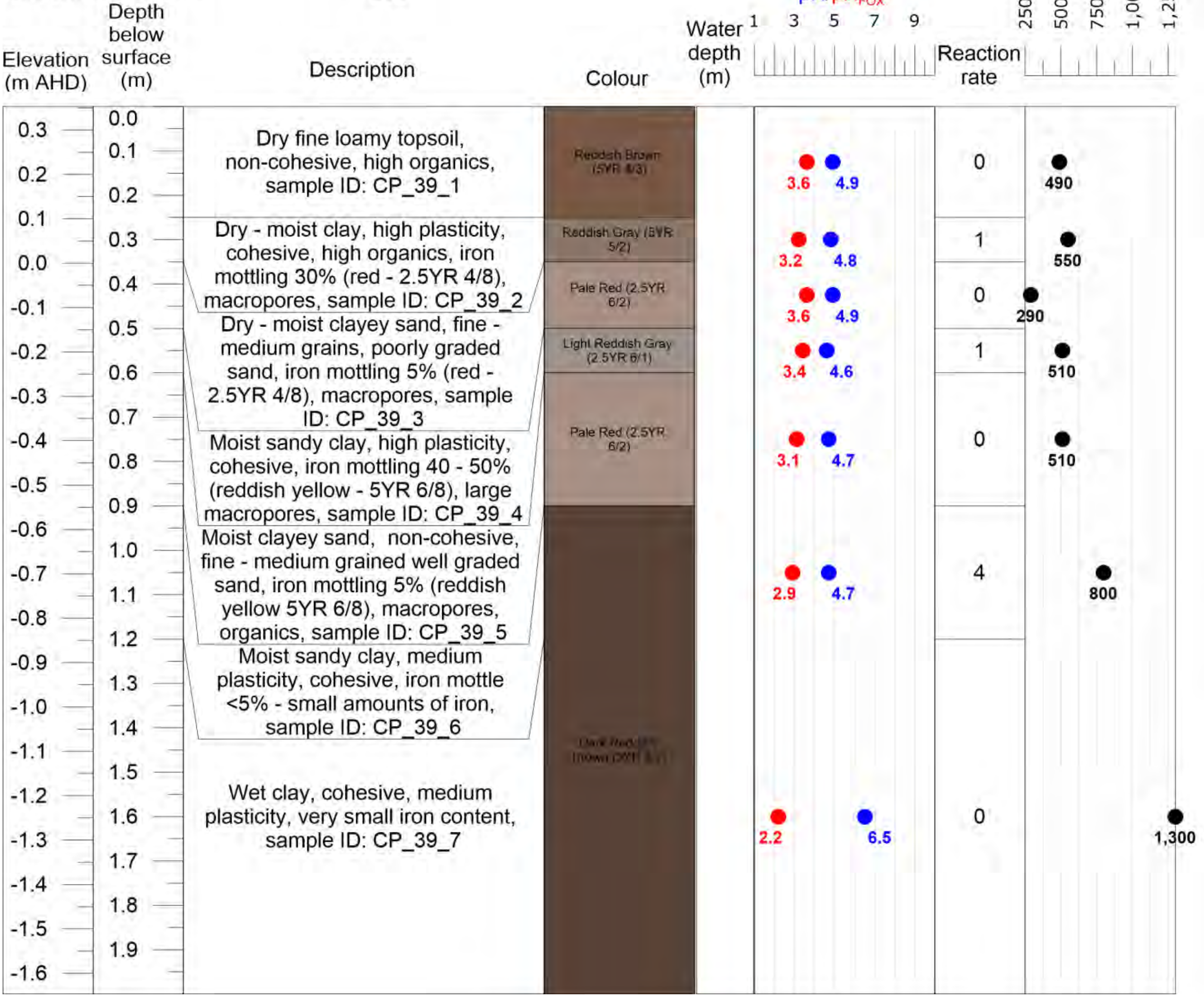
Ground elevation (m AHD): 0.35
Hydraulic conductivity (m/d): 0.11

Water quality:

Surface water EC (µS/cm): 2,400
Surface water pH: 7.8
Groundwater EC (µS/cm): 14,700
Groundwater pH: 6.1



Dry fine loamy topsoil, non-cohesive, high organics, sample ID: CP_39_1

Dry - moist clay, high plasticity, cohesive, high organics, iron mottling 30% (red - 2.5YR 4/8), macropores, sample ID: CP_39_2

Dry - moist clayey sand, fine - medium grains, poorly graded sand, iron mottling 5% (red - 2.5YR 4/8), macropores, sample ID: CP_39_3

Moist sandy clay, high plasticity, cohesive, iron mottling 40 - 50% (reddish yellow - 5YR 6/8), large macropores, sample ID: CP_39_4

Moist clayey sand, non-cohesive, fine - medium grained well graded sand, iron mottling 5% (reddish yellow 5YR 6/8), macropores, organics, sample ID: CP_39_5

Moist sandy clay, medium plasticity, cohesive, iron mottle <5% - small amounts of iron, sample ID: CP_39_6

Wet clay, cohesive, medium plasticity, very small iron content, sample ID: CP_39_7

Soil profile details:

Project Number:	2018064	Profile ID:	CP_42_S
River/estuary:	Clarence	Sample date:	04/02/20
Easting:	519880.7	Sampled by:	AJH GL
Northing:	6733056.9		

Ground elevation (m AHD):	0.87
Hydraulic conductivity (m/d):	0.43

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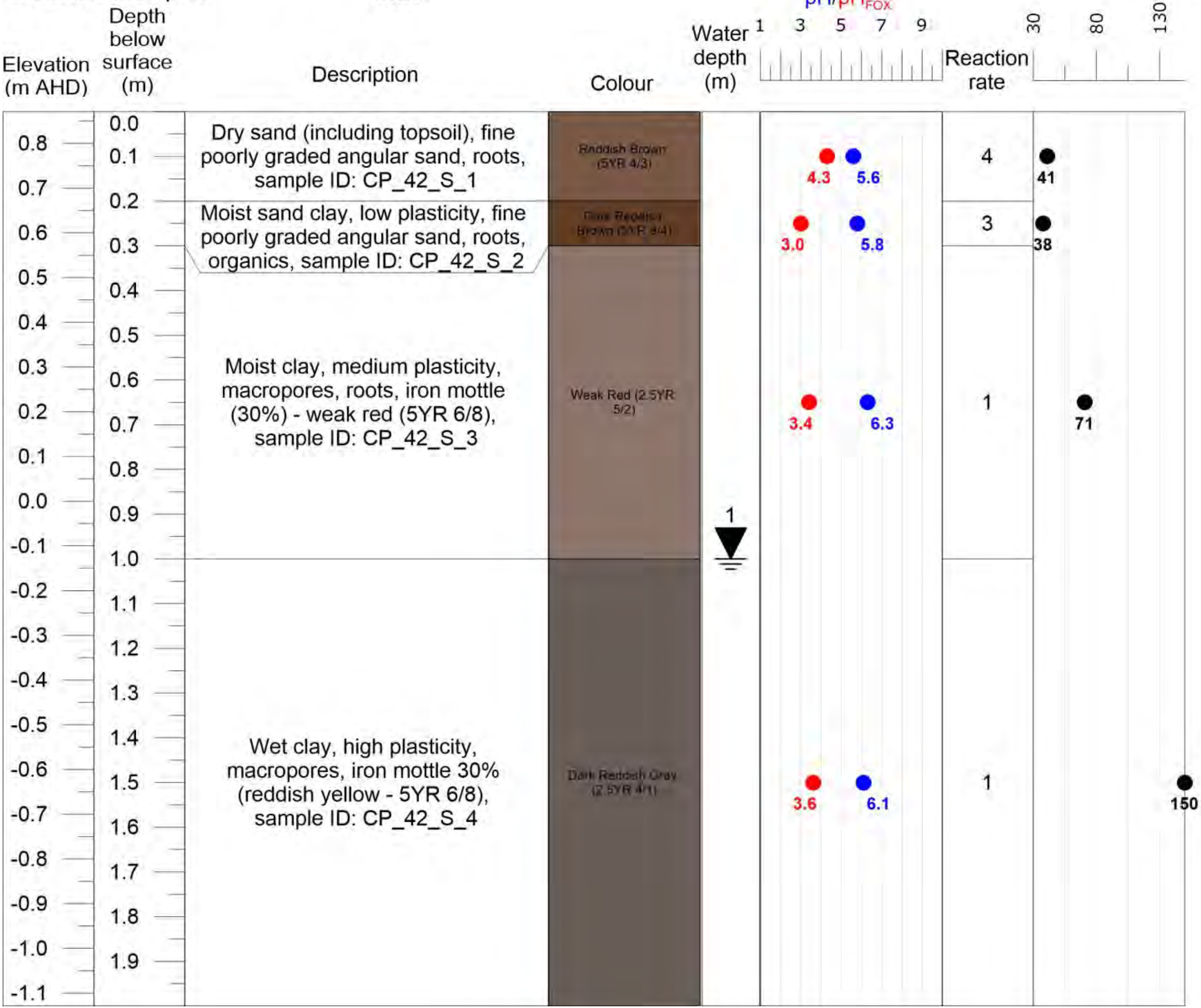
Water quality:

Surface water EC (µS/cm):	635
Surface water pH:	6.36
Groundwater EC (µS/cm):	3,219
Groundwater pH:	6.27

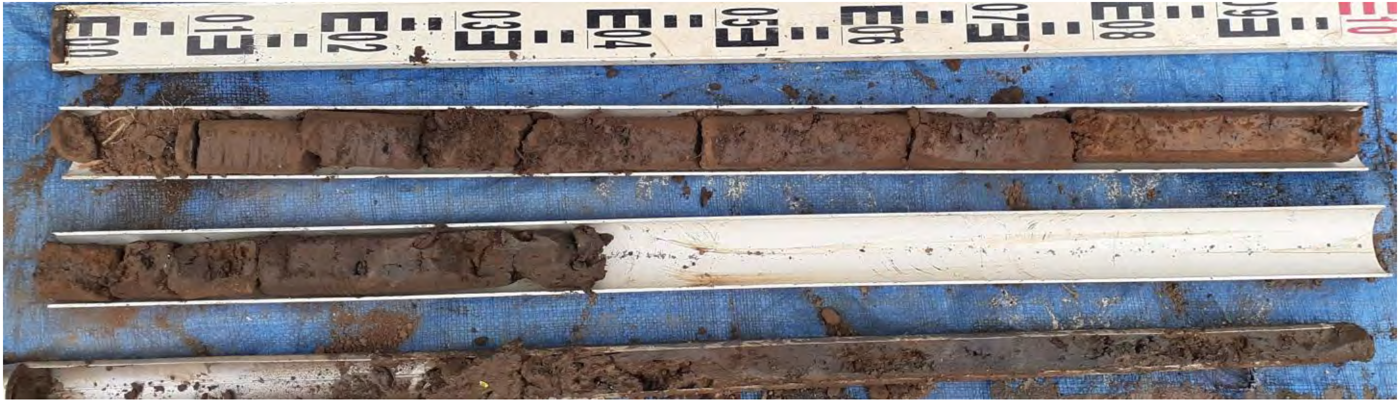


Dry sand (including topsoil), fine poorly graded angular sand, roots, sample ID: CP_42_S_1

Moist sand clay, low plasticity, fine poorly graded angular sand, roots, organics, sample ID: CP_42_S_2

Moist clay, medium plasticity, macropores, roots, iron mottle (30%) - weak red (5YR 6/8), sample ID: CP_42_S_3

Wet clay, high plasticity, macropores, iron mottle 30% (reddish yellow - 5YR 6/8), sample ID: CP_42_S_4



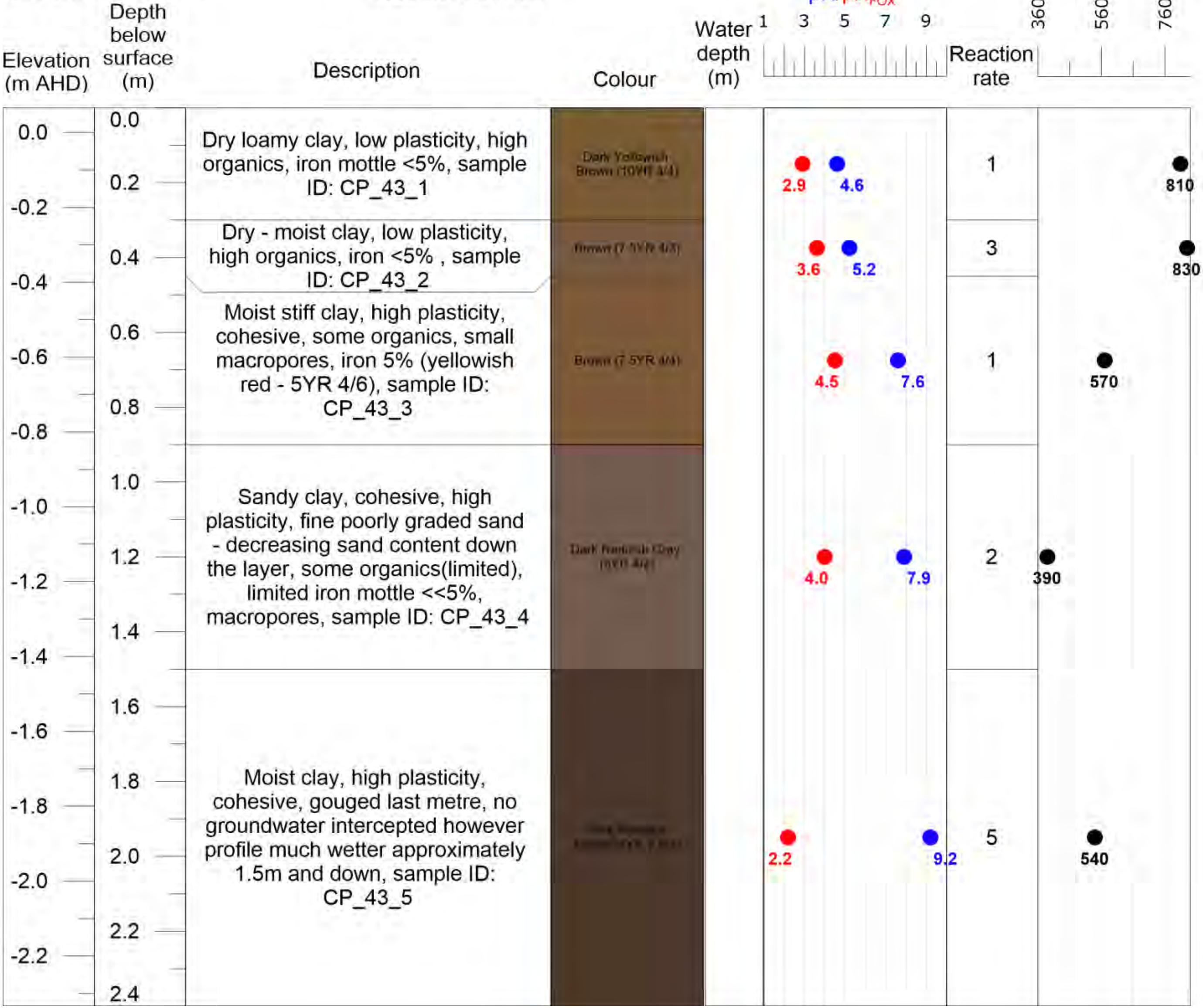
Soil profile details:

Project Number:	2018064	Profile ID:	CP_43
River/estuary:	Clarence	Sample date:	26/11/19
Easting:	517565.2	Sampled by:	AJH GL
Northing:	6734520.7		

Ground elevation (m AHD):	0.07
Hydraulic conductivity (m/d):	Not measured

Water quality:

Surface water EC (μS/cm):	12,232 (upstream of floodgate) , 34,132 (downstream of floodgate)
Surface water pH:	7.56 (upstream of floodgate), 7.26 (downstream of floodgate)
Groundwater EC (μS/cm):	Not measured
Groundwater pH:	Not measured



Description	Colour	pH	pH$_{FOX}$	Reaction rate	Soil EC (μS/cm)
Dry loamy clay, low plasticity, high organics, iron mottle <5%, sample ID: CP_43_1	Dark Yellowish Brown (10YR 3/4)	4.6	2.9	1	810
Dry - moist clay, low plasticity, high organics, iron <5% , sample ID: CP_43_2	Brown (7.5YR 4/3)	5.2	3.6	3	830
Moist stiff clay, high plasticity, cohesive, some organics, small macropores, iron 5% (yellowish red - 5YR 4/6), sample ID: CP_43_3	Brown (7.5YR 4/4)	7.6	4.5	1	570
Sandy clay, cohesive, high plasticity, fine poorly graded sand - decreasing sand content down the layer, some organics(limited), limited iron mottle <<5%, macropores, sample ID: CP_43_4	Dark Reddish Gray (5YR 4/2)	7.9	4.0	2	390
Moist clay, high plasticity, cohesive, gouged last metre, no groundwater intercepted however profile much wetter approximately 1.5m and down, sample ID: CP_43_5	[illegible]	9.2	2.2	5	540

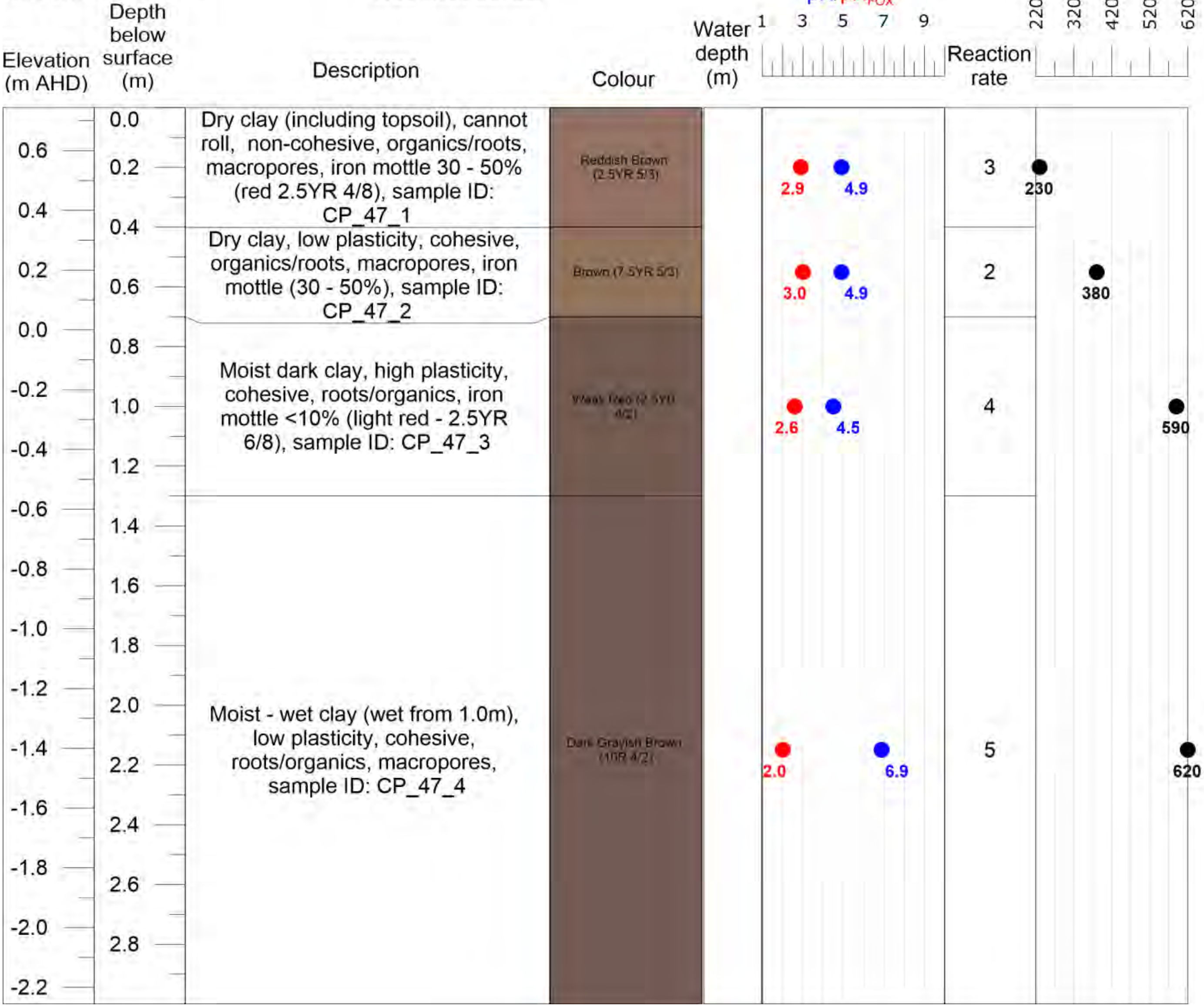
Soil profile details:

Project Number:	2018064	Profile ID:	CP_47
River/estuary:	Clarence	Sample date:	27/11/19
Easting:	518451.4	Sampled by:	AJH GL
Northing:	6730665.6		

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

Water quality:

Surface water EC (µS/cm):	Not measured
Surface water pH:	6.9
Groundwater EC (µS/cm):	Not measured
Groundwater pH:	Not measured

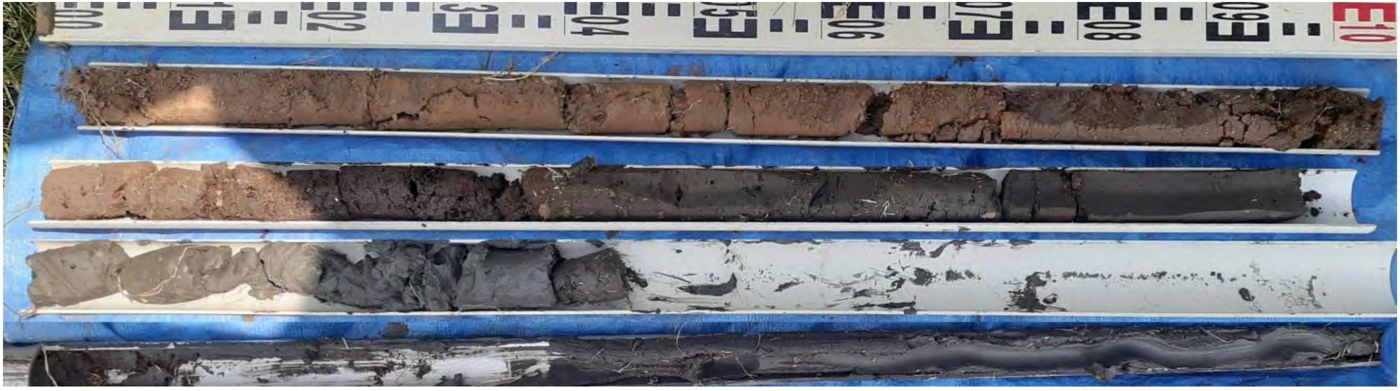


Dry clay (including topsoil), cannot roll, non-cohesive, organics/roots, macropores, iron mottle 30 - 50% (red 2.5YR 4/8), sample ID: CP_47_1

Dry clay, low plasticity, cohesive, organics/roots, macropores, iron mottle (30 - 50%), sample ID: CP_47_2

Moist dark clay, high plasticity, cohesive, roots/organics, iron mottle <10% (light red - 2.5YR 6/8), sample ID: CP_47_3

Moist - wet clay (wet from 1.0m), low plasticity, cohesive, roots/organics, macropores, sample ID: CP_47_4



Soil profile details:

Project Number:	2018064	Profile ID:	CP_51
River/estuary:	Clarence	Sample date:	26/11/19
Easting:	519038.9	Sampled by:	AJH GL
Northing:	6739813.8		

Ground elevation (m AHD):	0.03
Hydraulic conductivity (m/d):	Not measured

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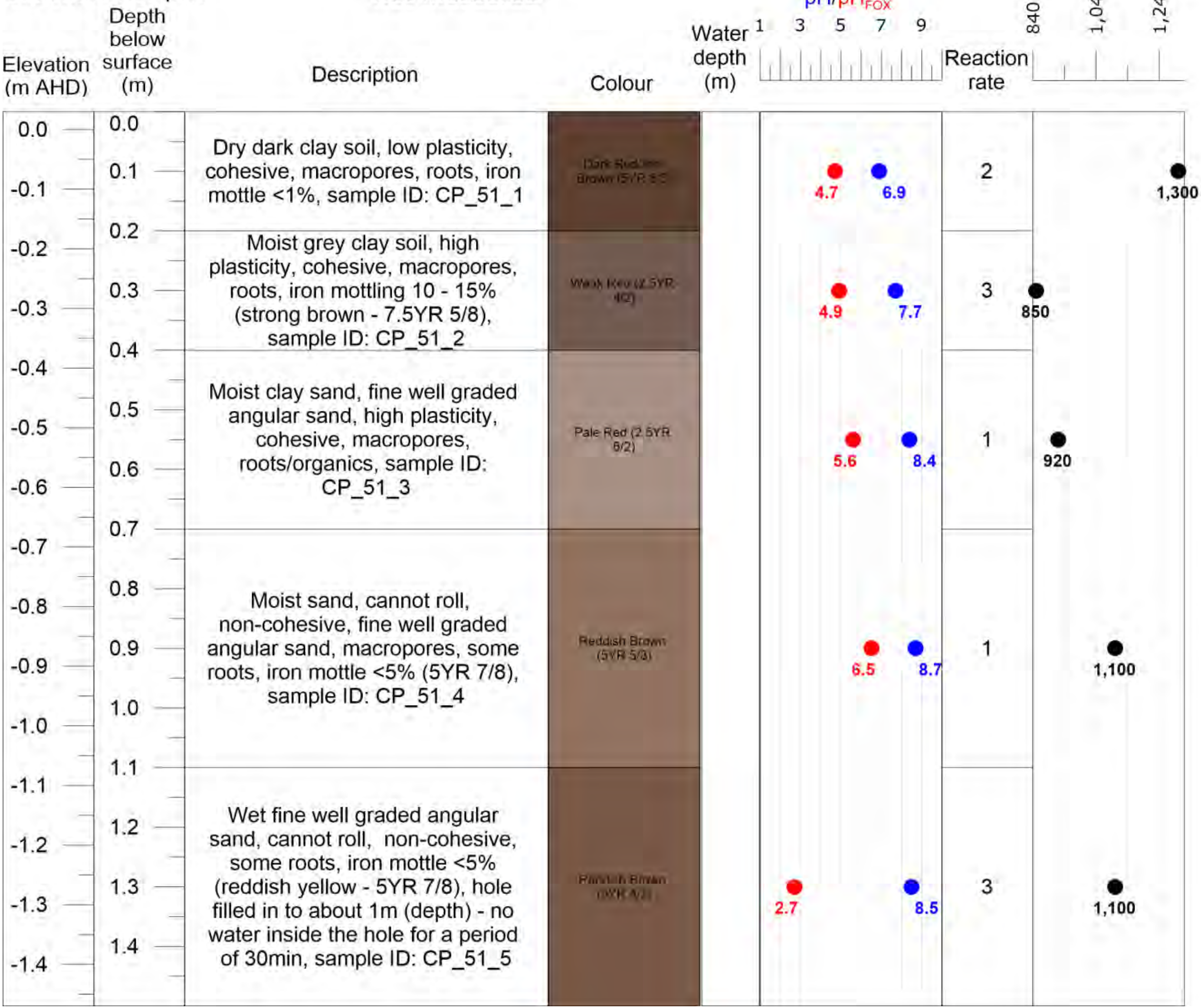
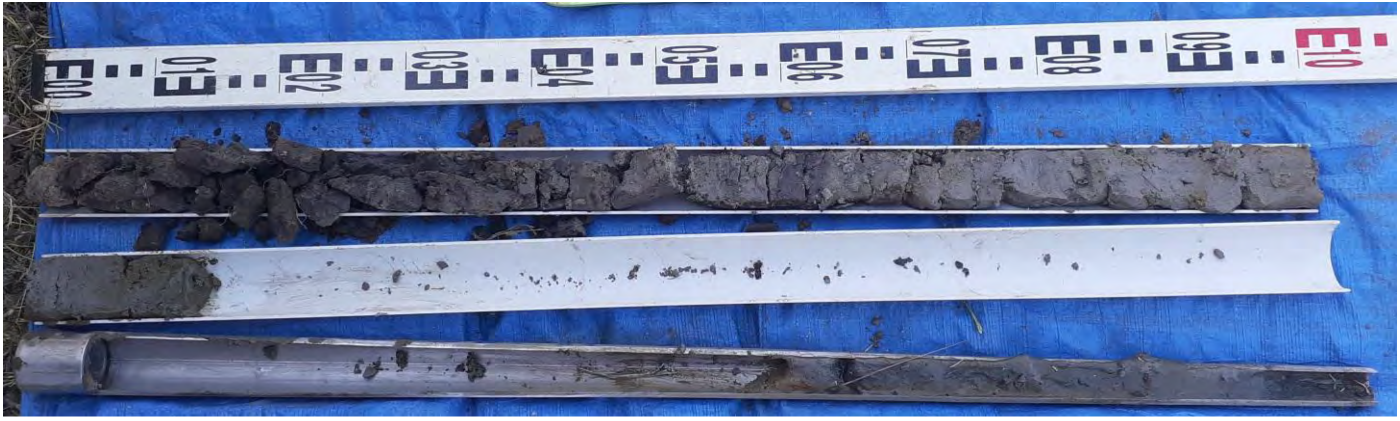
Water quality:

Surface water EC (μS/cm):	64,400
Surface water pH:	8.3
Groundwater EC (μS/cm):	Not measured
Groundwater pH:	Not measured



Description	Colour	Soil pH	Soil pH$_{FOX}$	Reaction rate	Soil EC (μS/cm)
Dry dark clay soil, low plasticity, cohesive, macropores, roots, iron mottle <1%, sample ID: CP_51_1	Dark Reddish Brown (5YR 3/3)	6.9	4.7	2	1,300
Moist grey clay soil, high plasticity, cohesive, macropores, roots, iron mottling 10 - 15% (strong brown - 7.5YR 5/8), sample ID: CP_51_2	Weak Red (2.5YR 4/2)	7.7	4.9	3	850
Moist clay sand, fine well graded angular sand, high plasticity, cohesive, macropores, roots/organics, sample ID: CP_51_3	Pale Red (2.5YR 6/2)	8.4	5.6	1	920
Moist sand, cannot roll, non-cohesive, fine well graded angular sand, macropores, some roots, iron mottle <5% (5YR 7/8), sample ID: CP_51_4	Reddish Brown (5YR 5/3)	8.7	6.5	1	1,100
Wet fine well graded angular sand, cannot roll, non-cohesive, some roots, iron mottle <5% (reddish yellow - 5YR 7/8), hole filled in to about 1m (depth) - no water inside the hole for a period of 30min, sample ID: CP_51_5	Reddish Brown (5YR 4/3)	8.5	2.7	3	1,100



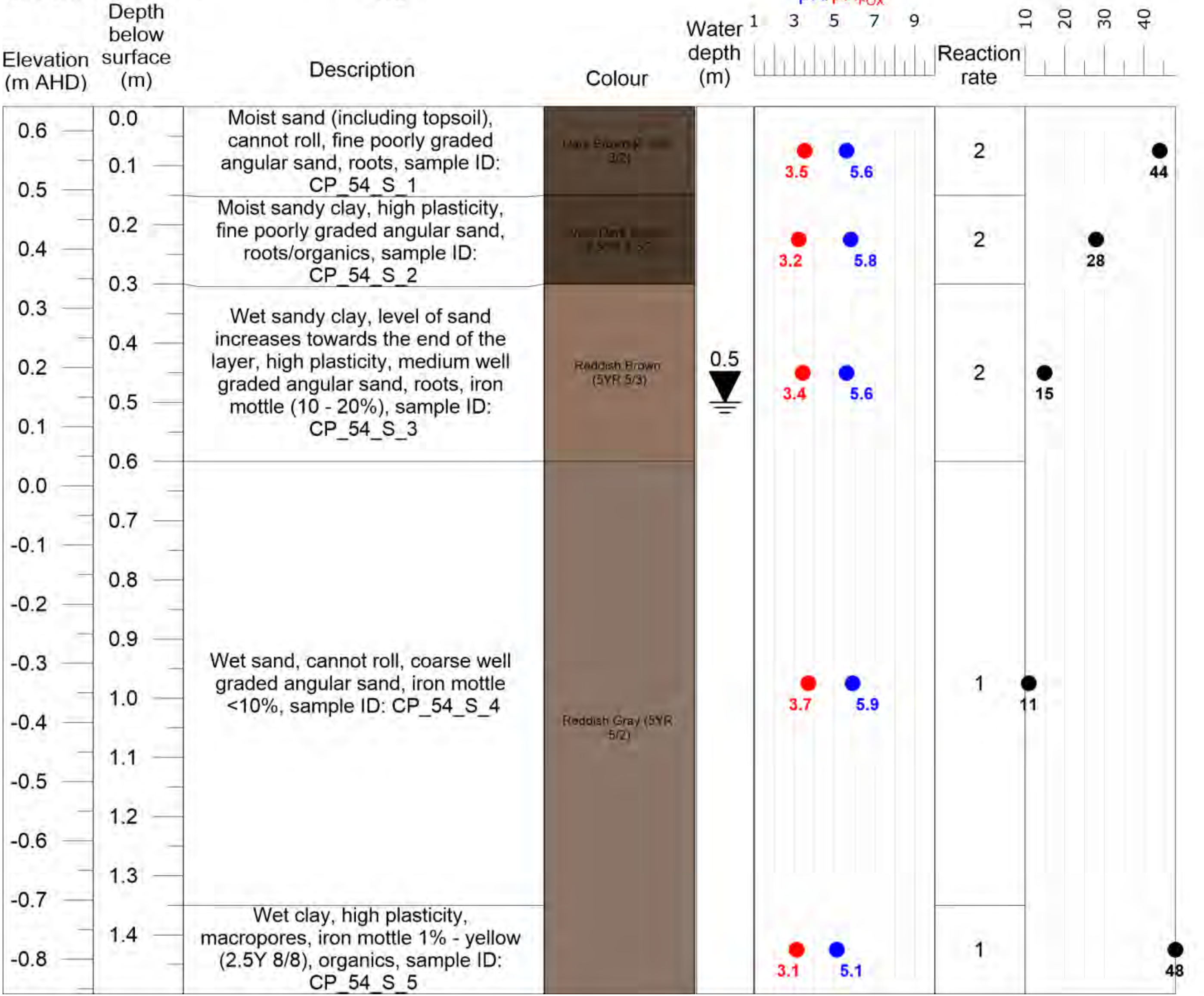
Soil profile details:

Project Number:	2018064	Profile ID:	CP_54_S
River/estuary:	Clarence	Sample date:	04/02/20
Easting:	522182.5	Sampled by:	AJH GL
Northing:	6734543.7		

Ground elevation (m AHD): 0.64
Hydraulic conductivity (m/d): 0.44

Water quality:

Surface water EC (µS/cm): 776
Surface water pH: 3.55
Groundwater EC (µS/cm): 150
Groundwater pH: 4.5



Description	Colour	Soil pH (pH$_{FOX}$)	Reaction rate	Soil EC (µS/cm)
Moist sand (including topsoil), cannot roll, fine poorly graded angular sand, roots, sample ID: CP_54_S_1	Dark Brown ([illegible] 3/2)	3.5 / 5.6	2	44
Moist sandy clay, high plasticity, fine poorly graded angular sand, roots/organics, sample ID: CP_54_S_2	Very Dark Brown ([illegible])	3.2 / 5.8	2	28
Wet sandy clay, level of sand increases towards the end of the layer, high plasticity, medium well graded angular sand, roots, iron mottle (10 - 20%), sample ID: CP_54_S_3	Reddish Brown (5YR 5/3)	3.4 / 5.6	2	15
Wet sand, cannot roll, coarse well graded angular sand, iron mottle <10%, sample ID: CP_54_S_4	Reddish Gray (5YR 5/2)	3.7 / 5.9	1	11
Wet clay, high plasticity, macropores, iron mottle 1% - yellow (2.5Y 8/8), organics, sample ID: CP_54_S_5		3.1 / 5.1	1	48

Soil profile details:

Project Number:	2018064	Profile ID:	CP_55_S
River/estuary:	Clarence	Sample date:	04/02/20
Easting:	525455	Sampled by:	AJH GL
Northing:	6740511.7		

Ground elevation (m AHD): 1.65

Hydraulic conductivity (m/d): Not measured

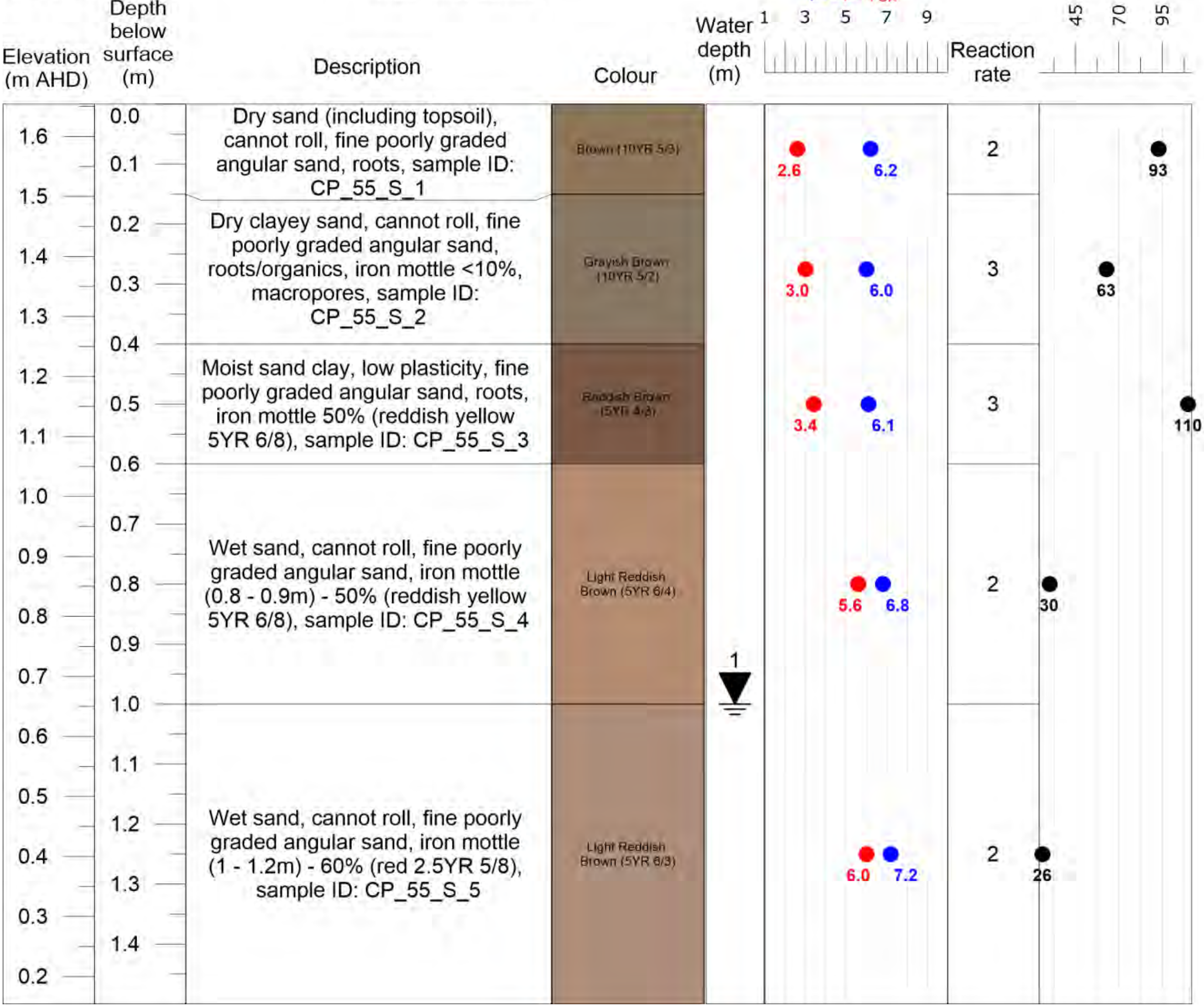
Water quality:

Surface water EC (µS/cm): 1,336

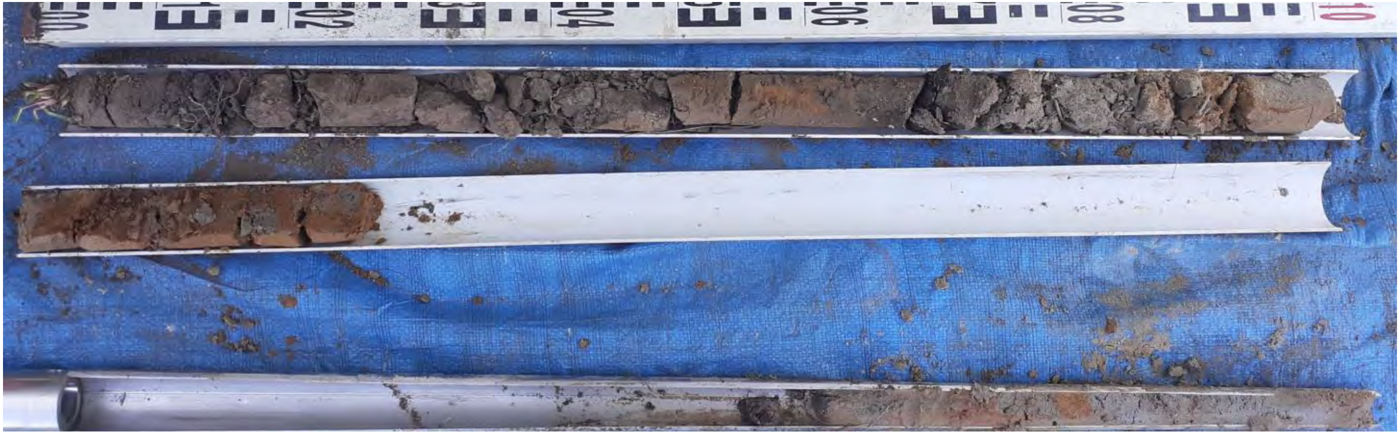
Surface water pH: 6.4

Groundwater EC (µS/cm): Not measured

Groundwater pH: Not measured



Description	Colour	Soil pH_{FOX}	Soil pH	Reaction rate	Soil EC (µS/cm)
Dry sand (including topsoil), cannot roll, fine poorly graded angular sand, roots, sample ID: CP_55_S_1	Brown (10YR 5/3)	2.6	6.2	2	93
Dry clayey sand, cannot roll, fine poorly graded angular sand, roots/organics, iron mottle <10%, macropores, sample ID: CP_55_S_2	Grayish Brown (10YR 5/2)	3.0	6.0	3	63
Moist sand clay, low plasticity, fine poorly graded angular sand, roots, iron mottle 50% (reddish yellow 5YR 6/8), sample ID: CP_55_S_3	Reddish Brown (5YR 4/3)	3.4	6.1	3	110
Wet sand, cannot roll, fine poorly graded angular sand, iron mottle (0.8 - 0.9m) - 50% (reddish yellow 5YR 6/8), sample ID: CP_55_S_4	Light Reddish Brown (5YR 6/4)	5.6	6.8	2	30
Wet sand, cannot roll, fine poorly graded angular sand, iron mottle (1 - 1.2m) - 60% (red 2.5YR 5/8), sample ID: CP_55_S_5	Light Reddish Brown (5YR 6/3)	6.0	7.2	2	26



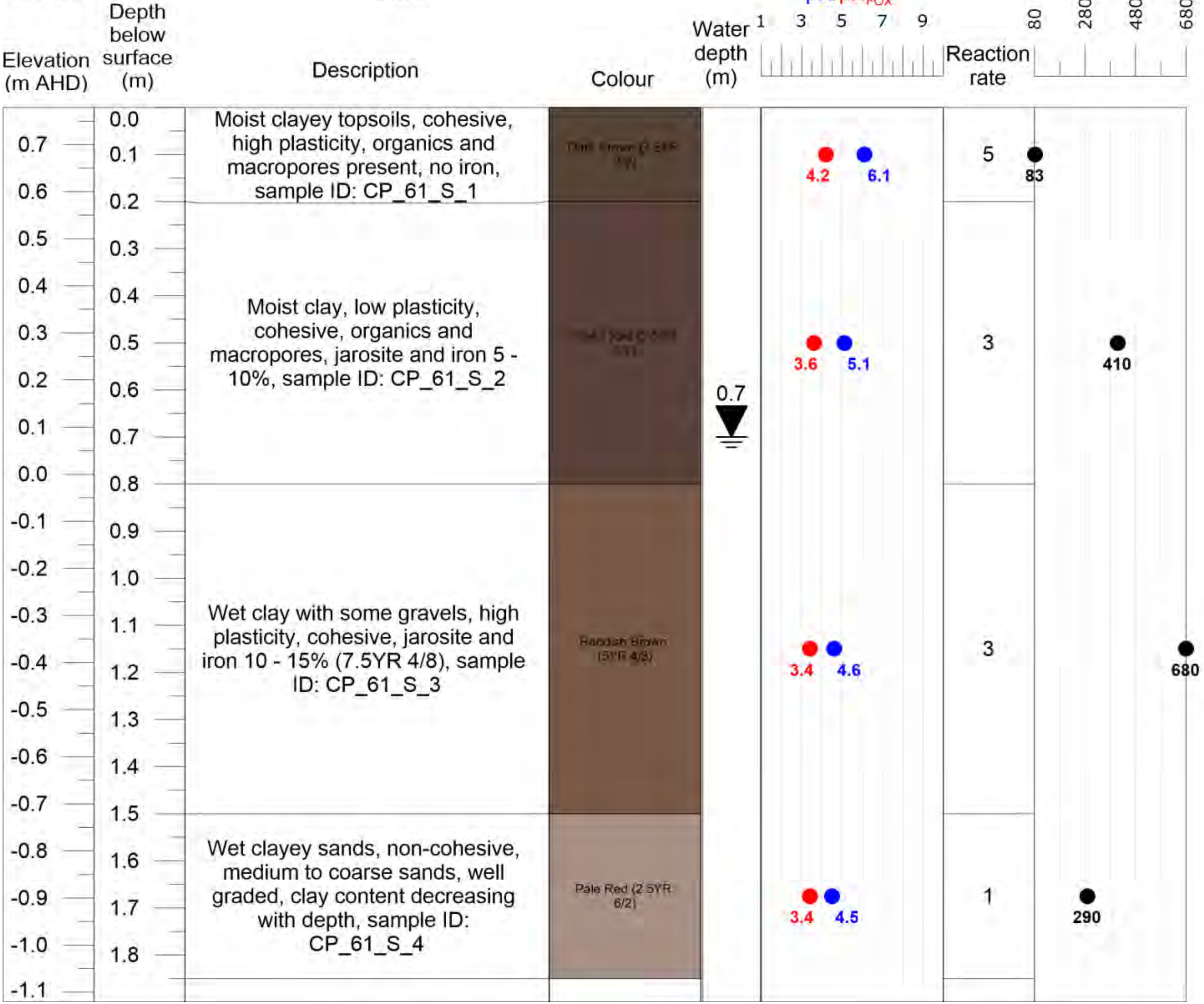
Soil profile details:

Project Number:	2018064	Profile ID:	CP_61_S
River/estuary:	Clarence	Sample date:	02/03/20
Easting:	526171.6	Sampled by:	AJH KW
Northing:	6732672.9		

Ground elevation (m AHD):	0.78
Hydraulic conductivity (m/d):	60

Water quality:

Surface water EC (µS/cm):	409
Surface water pH:	6.76
Groundwater EC (µS/cm):	4,432
Groundwater pH:	3.86



Description	Colour	pH$_{FOX}$	pH	Reaction rate	Soil EC (µS/cm)
Moist clayey topsoils, cohesive, high plasticity, organics and macropores present, no iron, sample ID: CP_61_S_1	Dark Brown (7.5YR 3/3)	4.2	6.1	5	83
Moist clay, low plasticity, cohesive, organics and macropores, jarosite and iron 5 - 10%, sample ID: CP_61_S_2	Weak Red (2.5YR 4/2)	3.6	5.1	3	410
Wet clay with some gravels, high plasticity, cohesive, jarosite and iron 10 - 15% (7.5YR 4/8), sample ID: CP_61_S_3	Reddish Brown (5YR 4/3)	3.4	4.6	3	680
Wet clayey sands, non-cohesive, medium to coarse sands, well graded, clay content decreasing with depth, sample ID: CP_61_S_4	Pale Red (2.5YR 6/2)	3.4	4.5	1	290

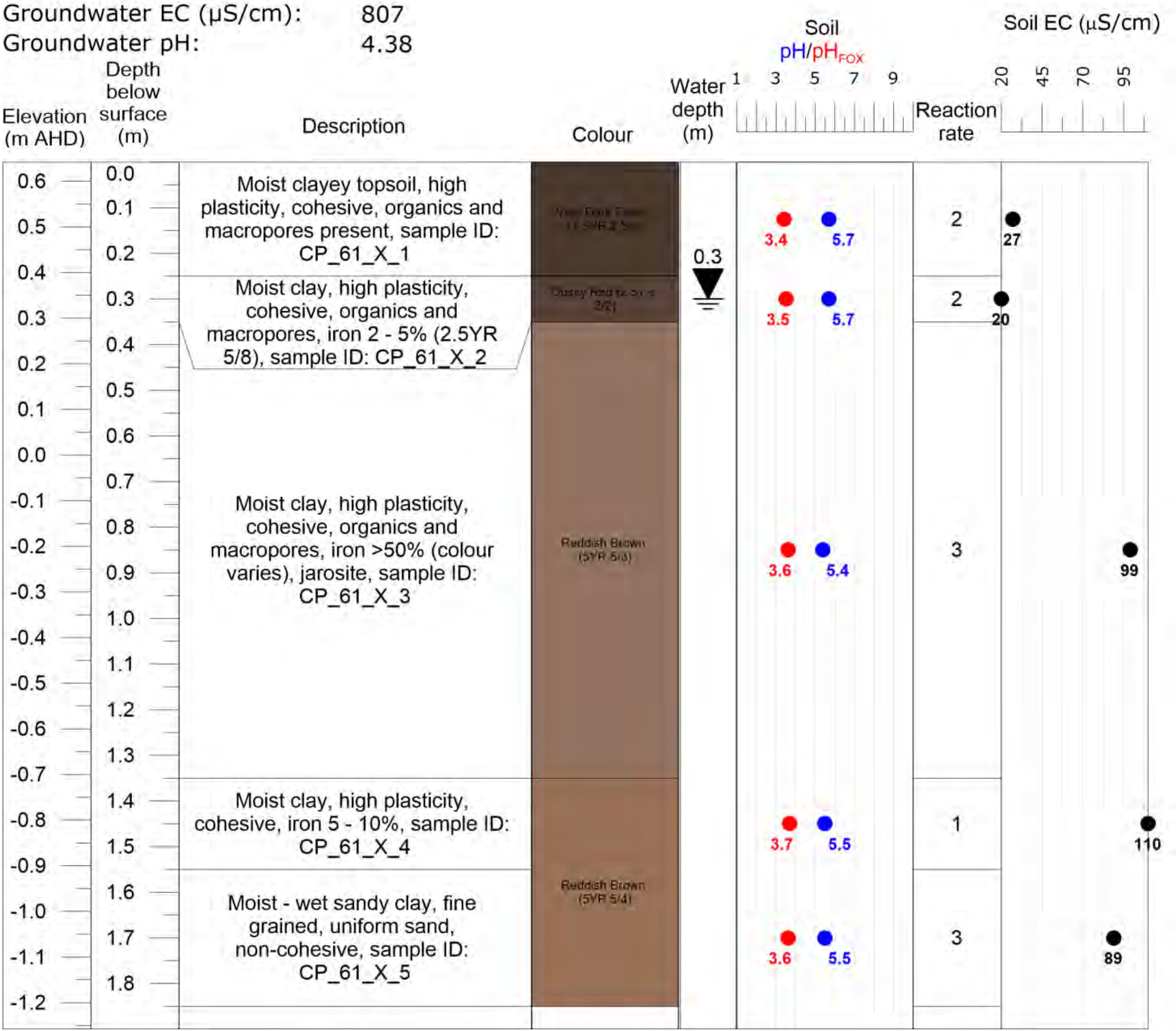
Soil profile details:

Project Number:	2018064	Profile ID:	CP_61_X
River/estuary:	Clarence	Sample date:	02/03/20
Easting:	525416.2	Sampled by:	AJH KW
Northing:	6733044.8		

Ground elevation (m AHD):	0.64
Hydraulic conductivity (m/d):	0.072

Water quality:

Surface water EC (µS/cm):	112
Surface water pH:	5.38
Groundwater EC (µS/cm):	807
Groundwater pH:	4.38



Description	Colour	pH_FOX	pH	Reaction rate	Soil EC (µS/cm)
Moist clayey topsoil, high plasticity, cohesive, organics and macropores present, sample ID: CP_61_X_1	Very Dark Brown (7.5YR 2.5/[illegible])	3.4	5.7	2	27
Moist clay, high plasticity, cohesive, organics and macropores, iron 2 - 5% (2.5YR 5/8), sample ID: CP_61_X_2	Dusky Red (2.5YR 2/2)	3.5	5.7	2	20
Moist clay, high plasticity, cohesive, organics and macropores, iron >50% (colour varies), jarosite, sample ID: CP_61_X_3	Reddish Brown (5YR 5/3)	3.6	5.4	3	99
Moist clay, high plasticity, cohesive, iron 5 - 10%, sample ID: CP_61_X_4	Reddish Brown (5YR 5/4)	3.7	5.5	1	110
Moist - wet sandy clay, fine grained, uniform sand, non-cohesive, sample ID: CP_61_X_5		3.6	5.5	3	89

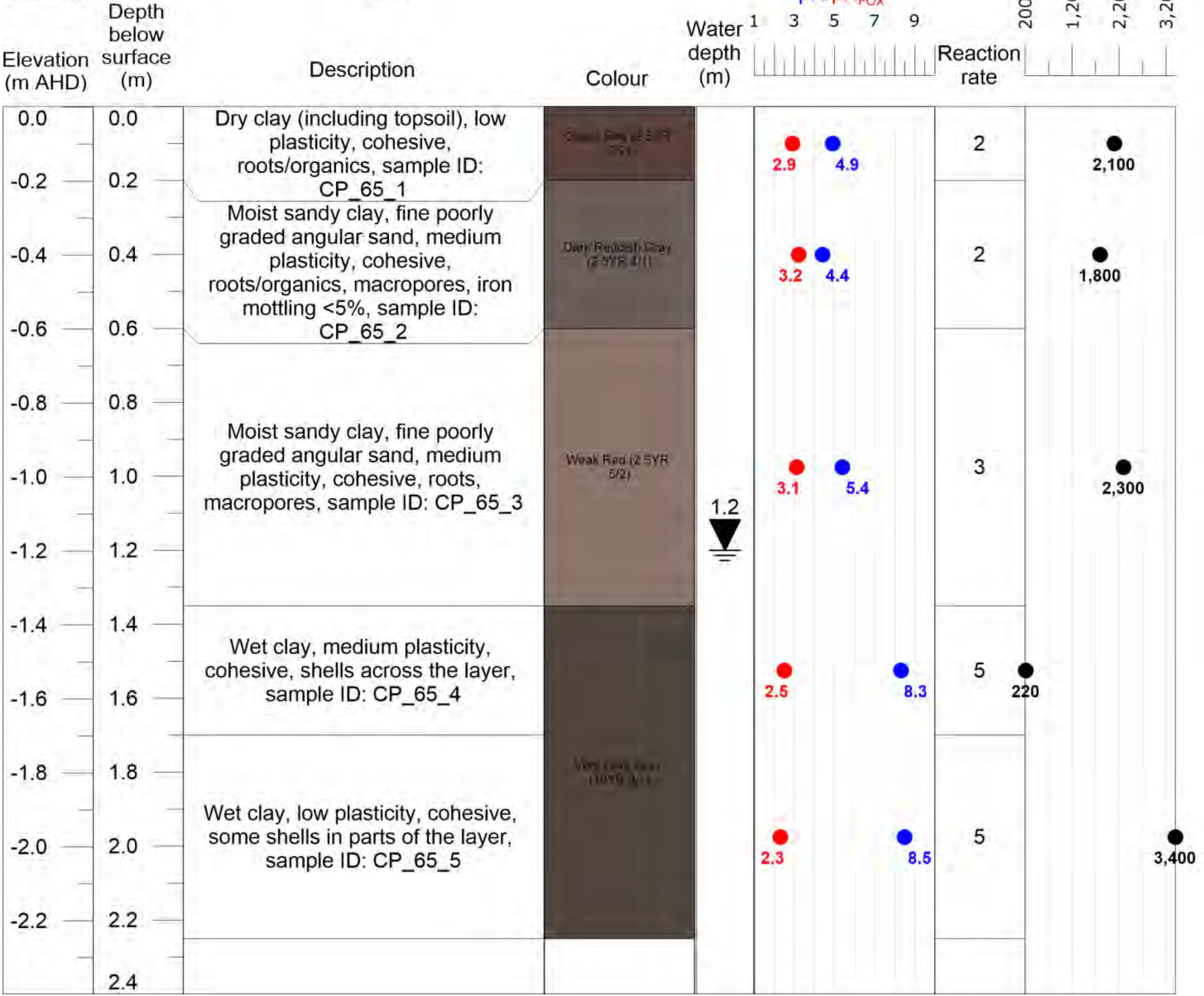
Soil profile details:

Project Number:	2018064	Profile ID:	CP_65
River/estuary:	Clarence	Sample date:	29/11/19
Easting:	529134.1	Sampled by:	AJH GL
Northing:	6740719.4		

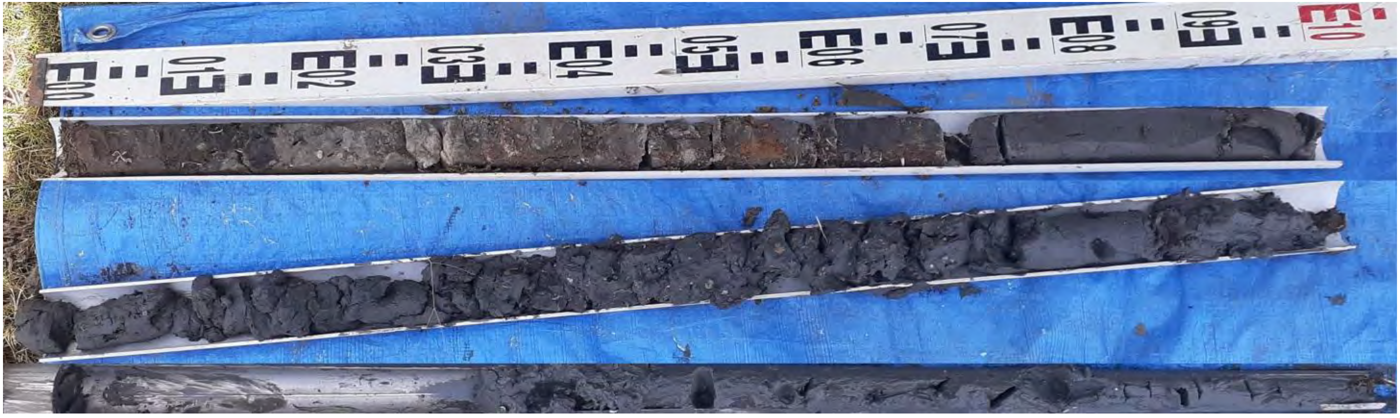
Ground elevation (m AHD):	0.00
Hydraulic conductivity (m/d):	0.086

Water quality:

Surface water EC (µS/cm):	81,400
Surface water pH:	7.5
Groundwater EC (µS/cm):	40,800
Groundwater pH:	6.7



Description	Colour	pH_{FOX}	pH	Reaction rate	Soil EC (µS/cm)
Dry clay (including topsoil), low plasticity, cohesive, roots/organics, sample ID: CP_65_1	[illegible]	2.9	4.9	2	2,100
Moist sandy clay, fine poorly graded angular sand, medium plasticity, cohesive, roots/organics, macropores, iron mottling <5%, sample ID: CP_65_2	Dark Reddish Gray (2.5YR 4/1)	3.2	4.4	2	1,800
Moist sandy clay, fine poorly graded angular sand, medium plasticity, cohesive, roots, macropores, sample ID: CP_65_3	Weak Red (2.5YR 5/2)	3.1	5.4	3	2,300
Wet clay, medium plasticity, cohesive, shells across the layer, sample ID: CP_65_4	Very Dark Gray (10YR 3/1)	2.5	8.3	5	220
Wet clay, low plasticity, cohesive, some shells in parts of the layer, sample ID: CP_65_5		2.3	8.5	5	3,400



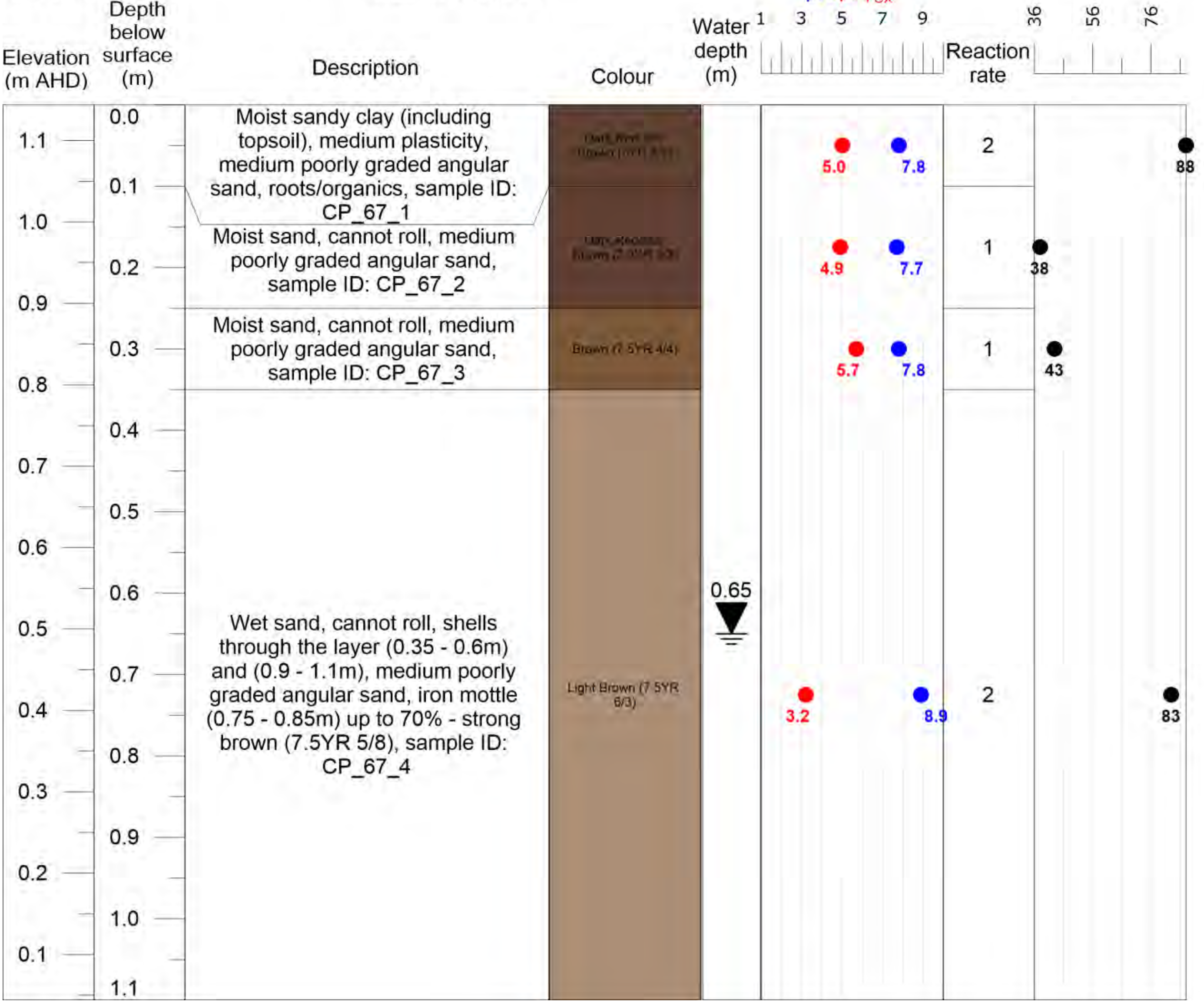
Soil profile details:

Project Number: 2018064
River/estuary: Clarence
Easting: 531618.7
Northing: 6752206.8
Profile ID: CP_67
Sample date: 03/02/20
Sampled by: AJH GL

Ground elevation (m AHD): 1.14
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



Moist sandy clay (including topsoil), medium plasticity, medium poorly graded angular sand, roots/organics, sample ID: CP_67_1

Moist sand, cannot roll, medium poorly graded angular sand, sample ID: CP_67_2

Moist sand, cannot roll, medium poorly graded angular sand, sample ID: CP_67_3

Wet sand, cannot roll, shells through the layer (0.35 - 0.6m) and (0.9 - 1.1m), medium poorly graded angular sand, iron mottle (0.75 - 0.85m) up to 70% - strong brown (7.5YR 5/8), sample ID: CP_67_4

Soil profile details:

Project Number:	2018064	Profile ID:	CP_68
River/estuary:	Clarence	Sample date:	29/11/19
Easting:	530334.5	Sampled by:	AJH GL
Northing:	6742929.3		

Ground elevation (m AHD):	0.50
Hydraulic conductivity (m/d):	0.36

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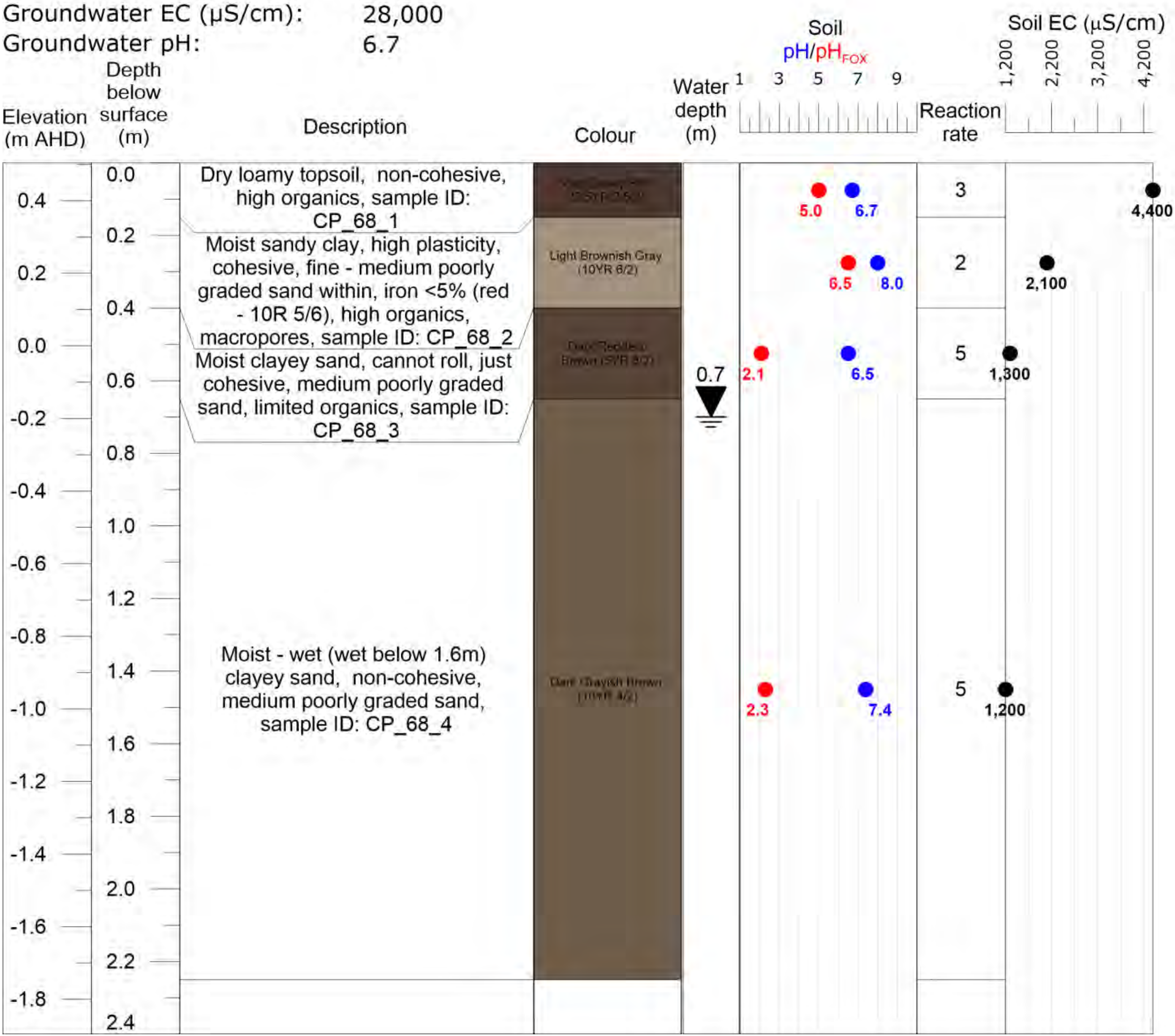
Water quality:

Surface water EC (µS/cm):	66,821
Surface water pH:	7.8
Groundwater EC (µS/cm):	28,000
Groundwater pH:	6.7

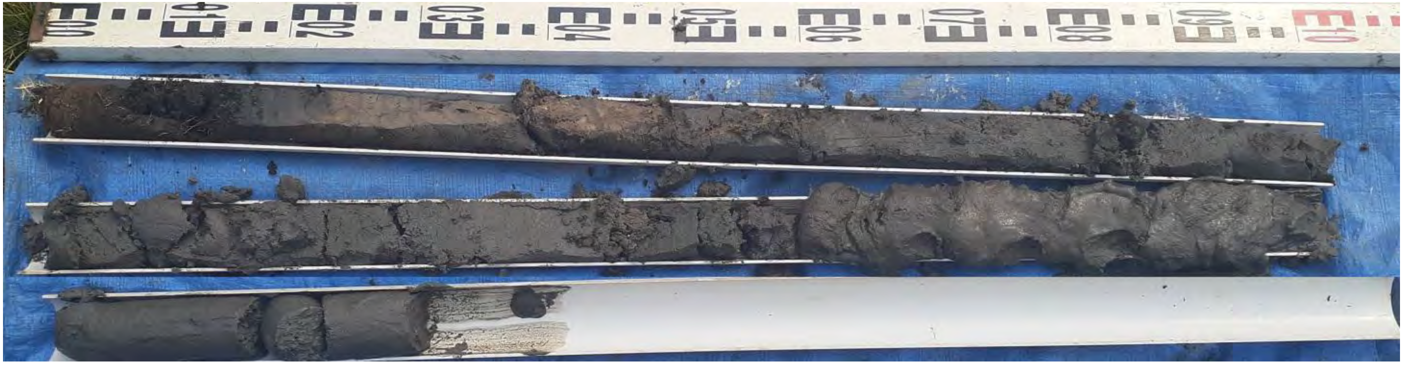


Dry loamy topsoil, non-cohesive, high organics, sample ID: CP_68_1

Moist sandy clay, high plasticity, cohesive, fine - medium poorly graded sand within, iron <5% (red - 10R 5/6), high organics, macropores, sample ID: CP_68_2

Moist clayey sand, cannot roll, just cohesive, medium poorly graded sand, limited organics, sample ID: CP_68_3

Moist - wet (wet below 1.6m) clayey sand, non-cohesive, medium poorly graded sand, sample ID: CP_68_4



Soil profile details:

Project Number: 2018064
River/estuary: Clarence
Easting: 529045.5
Northing: 6748258.3

Profile ID: CP_70
Sample date: 04/02/20
Sampled by: AJH GL

Ground elevation (m AHD): 0.31
Hydraulic conductivity (m/d): 0.07

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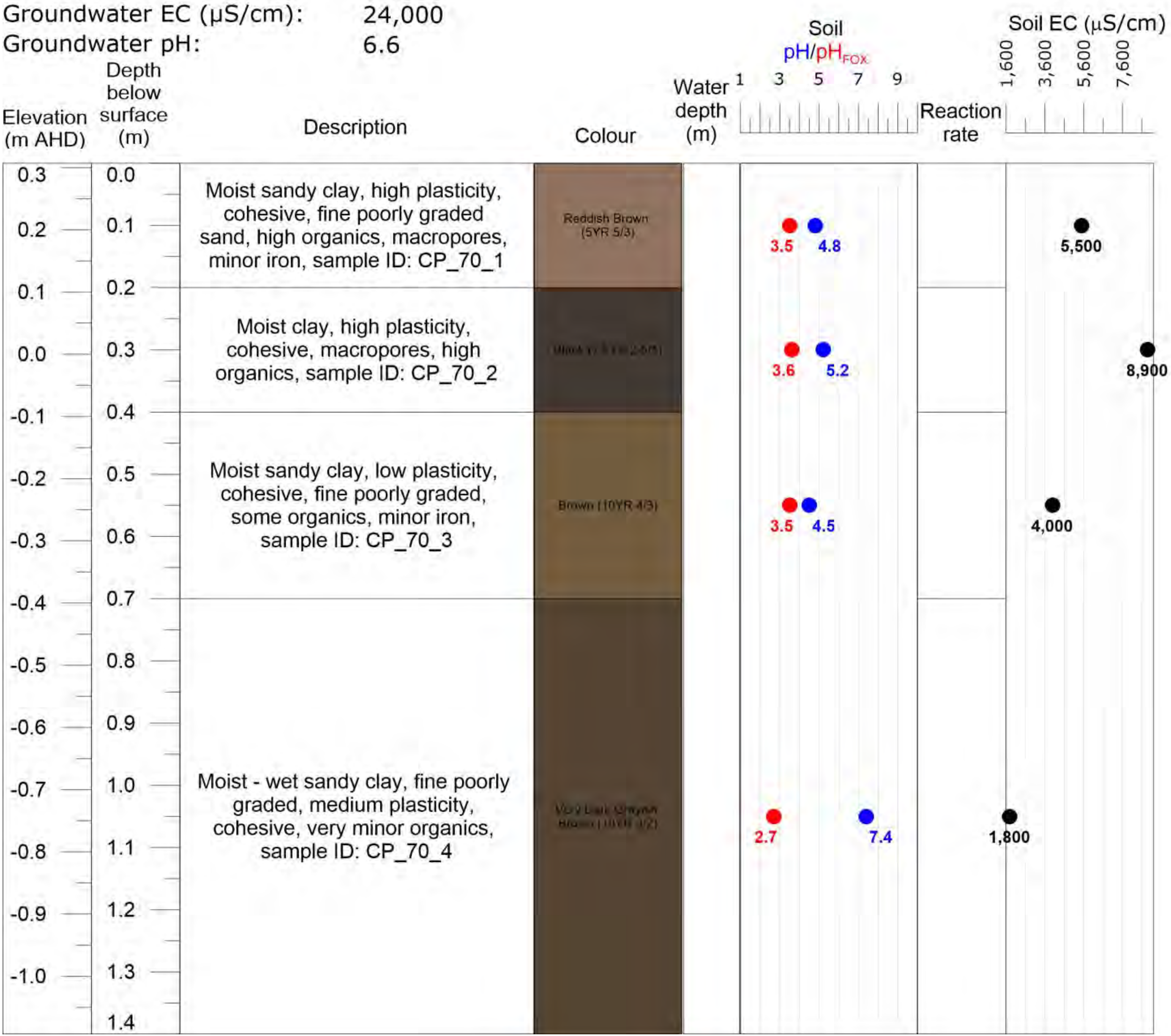
Water quality:

Surface water EC (µS/cm): 11,000
Surface water pH: 6.85
Groundwater EC (µS/cm): 24,000
Groundwater pH: 6.6



Depth below surface (m)	Description	Colour	Soil pH	pH_FOX	Soil EC (µS/cm)
0.0–0.2	Moist sandy clay, high plasticity, cohesive, fine poorly graded sand, high organics, macropores, minor iron, sample ID: CP_70_1	Reddish Brown (5YR 5/3)	4.8	3.5	5,500
0.2–0.4	Moist clay, high plasticity, cohesive, macropores, high organics, sample ID: CP_70_2	Black (7.5YR 2.5/1)	5.2	3.6	8,900
0.4–0.7	Moist sandy clay, low plasticity, cohesive, fine poorly graded, some organics, minor iron, sample ID: CP_70_3	Brown (10YR 4/3)	4.5	3.5	4,000
0.7–1.4	Moist - wet sandy clay, fine poorly graded, medium plasticity, cohesive, very minor organics, sample ID: CP_70_4	Very Dark Grayish Brown (10YR 3/2)	7.4	2.7	1,800

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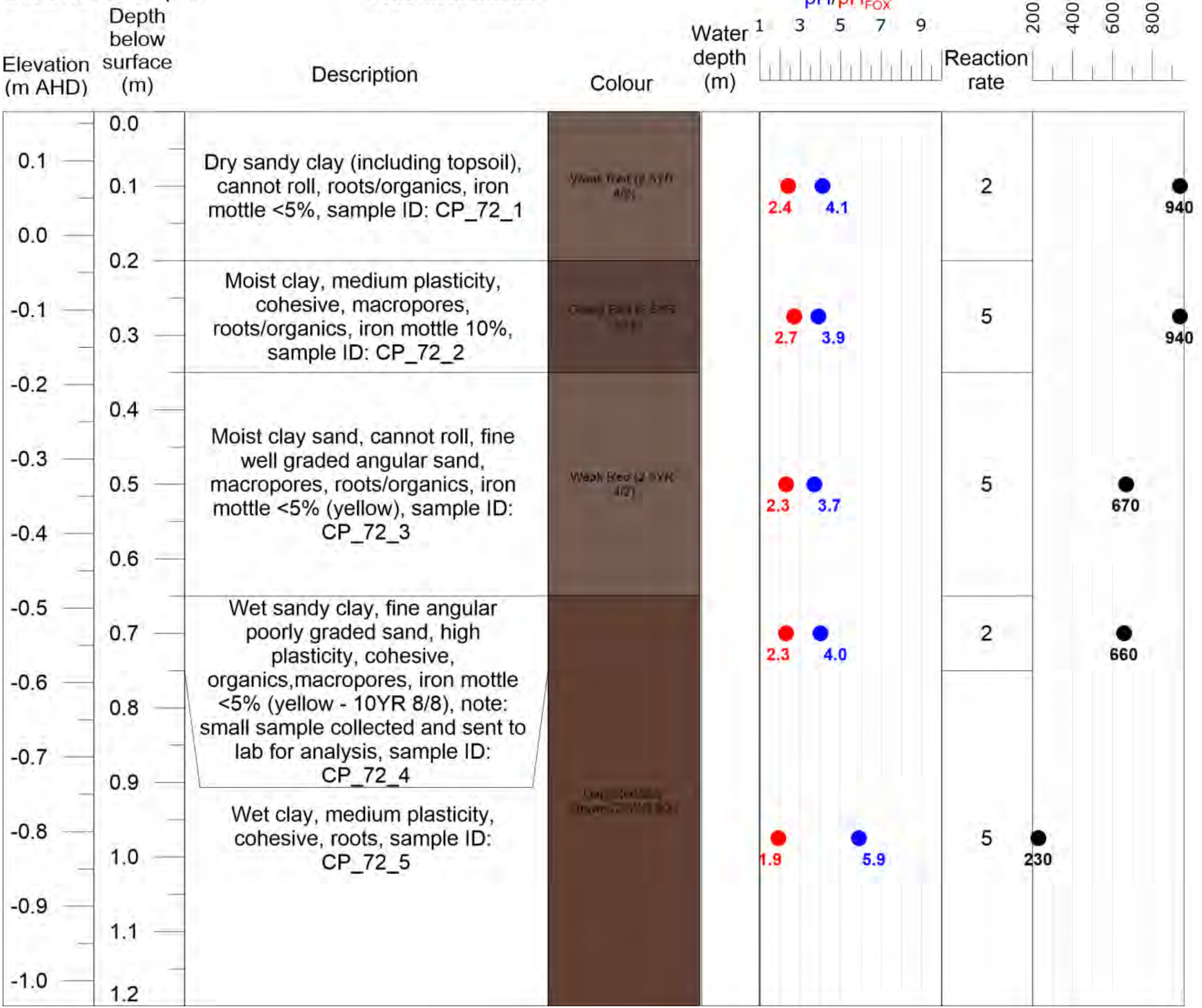
Soil profile details:

Project Number:	2018064	Profile ID:	CP_72
River/estuary:	Clarence	Sample date:	05/12/19
Easting:	527017.9	Sampled by:	AJH GL
Northing:	6750089.1		

Ground elevation (m AHD): 0.17
Hydraulic conductivity (m/d): 0.18

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 sandy clay (including topsoil), cannot roll, roots/organics, iron mottle <5%, sample ID: CP_72_1	Weak Red (2.5YR 4/2)	2.4	4.1	2	940
Moist clay, medium plasticity, cohesive, macropores, roots/organics, iron mottle 10%, sample ID: CP_72_2	[illegible]	2.7	3.9	5	940
Moist clay sand, cannot roll, fine well graded angular sand, macropores, roots/organics, iron mottle <5% (yellow), sample ID: CP_72_3	Weak Red (2.5YR 4/2)	2.3	3.7	5	670
Wet sandy clay, fine angular poorly graded sand, high plasticity, cohesive, organics,macropores, iron mottle <5% (yellow - 10YR 8/8), note: small sample collected and sent to lab for analysis, sample ID: CP_72_4	[illegible]	2.3	4.0	2	660
Wet clay, medium plasticity, cohesive, roots, sample ID: CP_72_5		1.9	5.9	5	230

Soil profile details:

Project Number:	2018064	Profile ID:	CP_76
River/estuary:	Clarence	Sample date:	05/12/19
Easting:	523473.8	Sampled by:	AJH GL
Northing:	6747741.4		

Ground elevation (m AHD): 0.54
Hydraulic conductivity (m/d): 0.13

Water quality:

Surface water EC (µS/cm): 64,286
Surface water pH: 7.62
Groundwater EC (µS/cm): 27,059
Groundwater pH: 6.76

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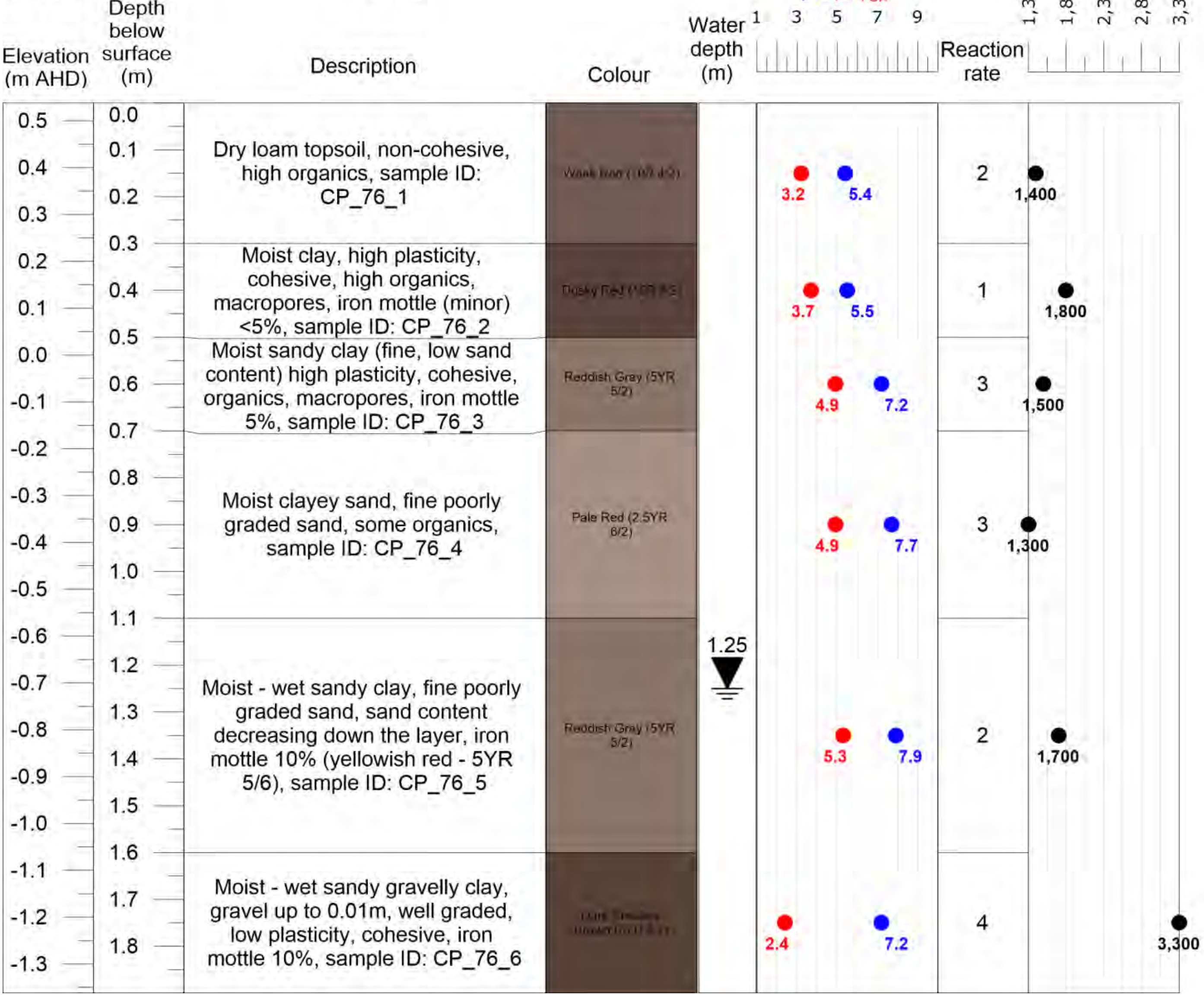

Dry loam topsoil, non-cohesive, high organics, sample ID: CP_76_1	Weak Red (10R 4/2)	3.2	5.4	2	1,400
Moist clay, high plasticity, cohesive, high organics, macropores, iron mottle (minor) <5%, sample ID: CP_76_2	Dusky Red (10R 3/3)	3.7	5.5	1	1,800
Moist sandy clay (fine, low sand content) high plasticity, cohesive, organics, macropores, iron mottle 5%, sample ID: CP_76_3	Reddish Gray (5YR 5/2)	4.9	7.2	3	1,500
Moist clayey sand, fine poorly graded sand, some organics, sample ID: CP_76_4	Pale Red (2.5YR 6/2)	4.9	7.7	3	1,300
Moist - wet sandy clay, fine poorly graded sand, sand content decreasing down the layer, iron mottle 10% (yellowish red - 5YR 5/6), sample ID: CP_76_5	Reddish Gray (5YR 5/2)	5.3	7.9	2	1,700
Moist - wet sandy gravelly clay, gravel up to 0.01m, well graded, low plasticity, cohesive, iron mottle 10%, sample ID: CP_76_6	[illegible]	2.4	7.2	4	3,300

Soil profile details:

Project Number:	2018064	Profile ID:	CP_81
River/estuary:	Clarence	Sample date:	03/02/20
Easting:	526240.8	Sampled by:	AJH GL
Northing:	6747490.8		

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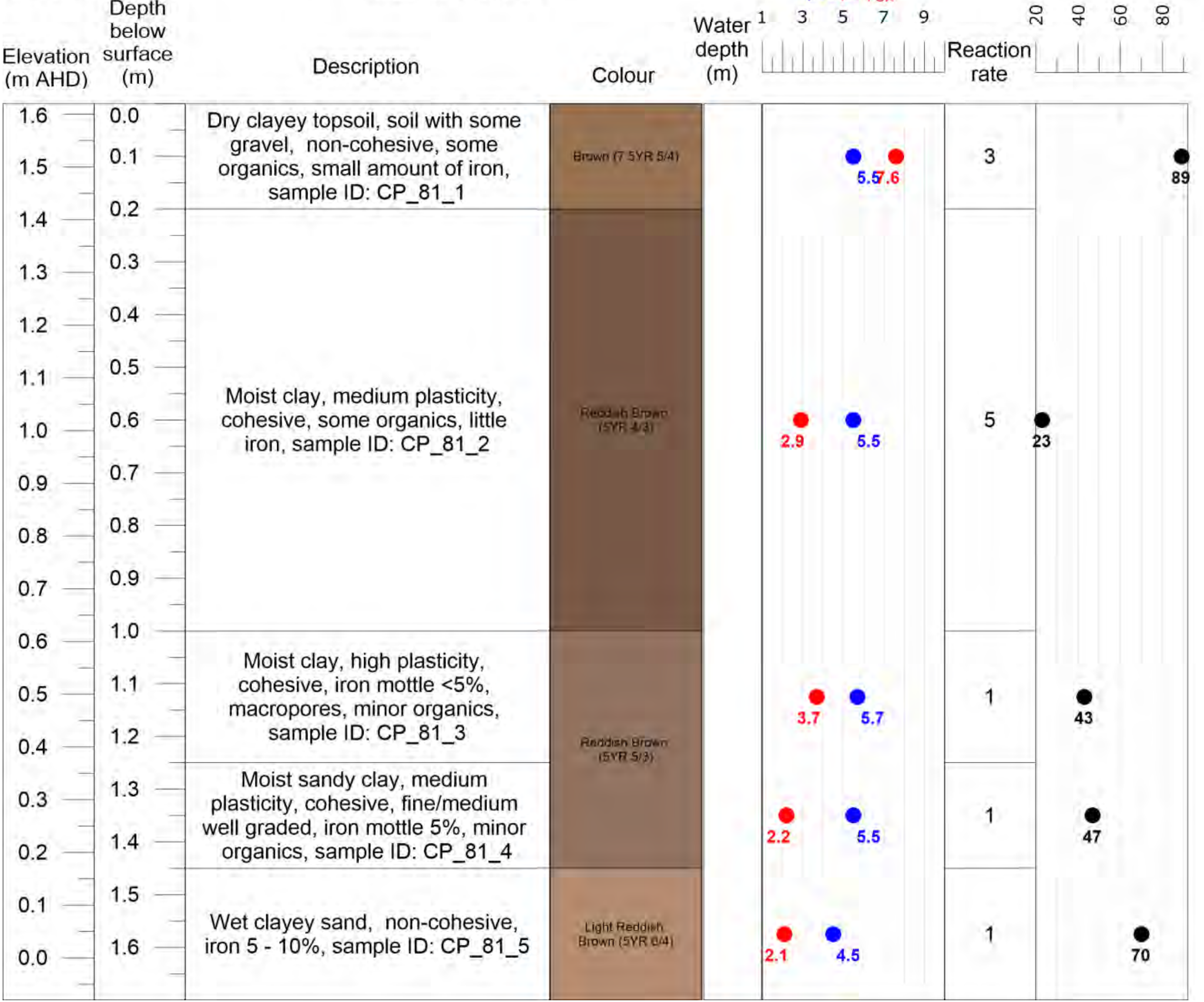
Ground elevation (m AHD):	1.62
Hydraulic conductivity (m/d):	0.31

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	Soil pH	pH$_{FOX}$	Reaction rate	Soil EC (µS/cm)
Dry clayey topsoil, soil with some gravel, non-cohesive, some organics, small amount of iron, sample ID: CP_81_1	Brown (7.5YR 5/4)	5.5	7.6	3	89
Moist clay, medium plasticity, cohesive, some organics, little iron, sample ID: CP_81_2	Reddish Brown (5YR 4/3)	5.5	2.9	5	23
Moist clay, high plasticity, cohesive, iron mottle <5%, macropores, minor organics, sample ID: CP_81_3	Reddish Brown (5YR 5/3)	5.7	3.7	1	43
Moist sandy clay, medium plasticity, cohesive, fine/medium well graded, iron mottle 5%, minor organics, sample ID: CP_81_4		5.5	2.2	1	47
Wet clayey sand, non-cohesive, iron 5 - 10%, sample ID: CP_81_5	Light Reddish Brown (5YR 6/4)	4.5	2.1	1	70

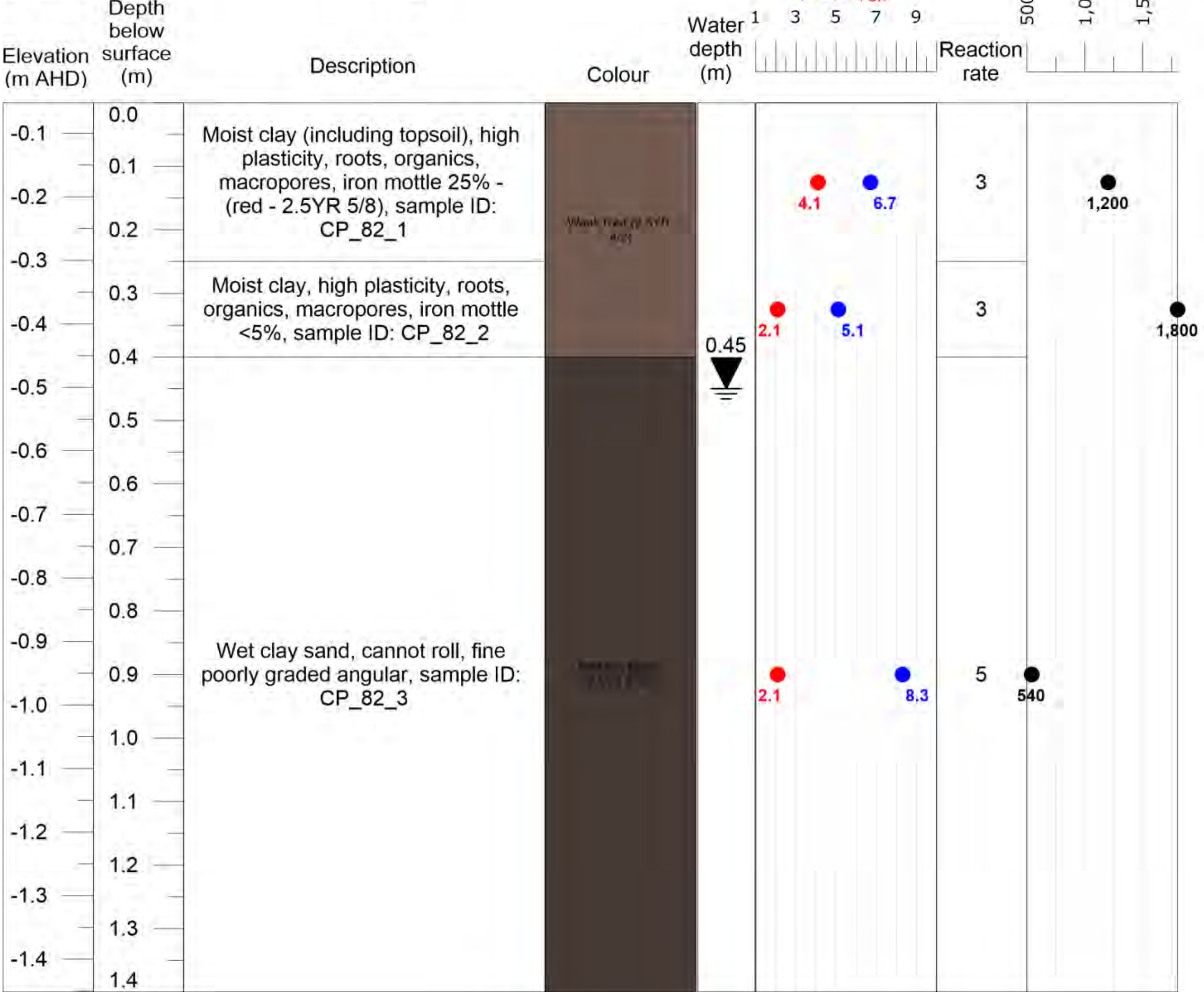
Soil profile details:

Project Number:	2018064	Profile ID:	CP_82
River/estuary:	Clarence	Sample date:	05/02/20
Easting:	522465	Sampled by:	AJH GL
Northing:	6750013.0		

Ground elevation (m AHD):	-0.05
Hydraulic conductivity (m/d):	0.11

Water quality:

Surface water EC (µS/cm):	15,430
Surface water pH:	6.82
Groundwater EC (µS/cm):	5,317
Groundwater pH:	7.02



Moist clay (including topsoil), high plasticity, roots, organics, macropores, iron mottle 25% - (red - 2.5YR 5/8), sample ID: CP_82_1

Moist clay, high plasticity, roots, organics, macropores, iron mottle <5%, sample ID: CP_82_2

Wet clay sand, cannot roll, fine poorly graded angular, sample ID: CP_82_3

Soil profile details:

Project Number:	2018064	Profile ID:	CP_84_C
River/estuary:	Clarence	Sample date:	28/02/20
Easting:	523623.4	Sampled by:	AJH DWJ
Northing:	6752251.9		

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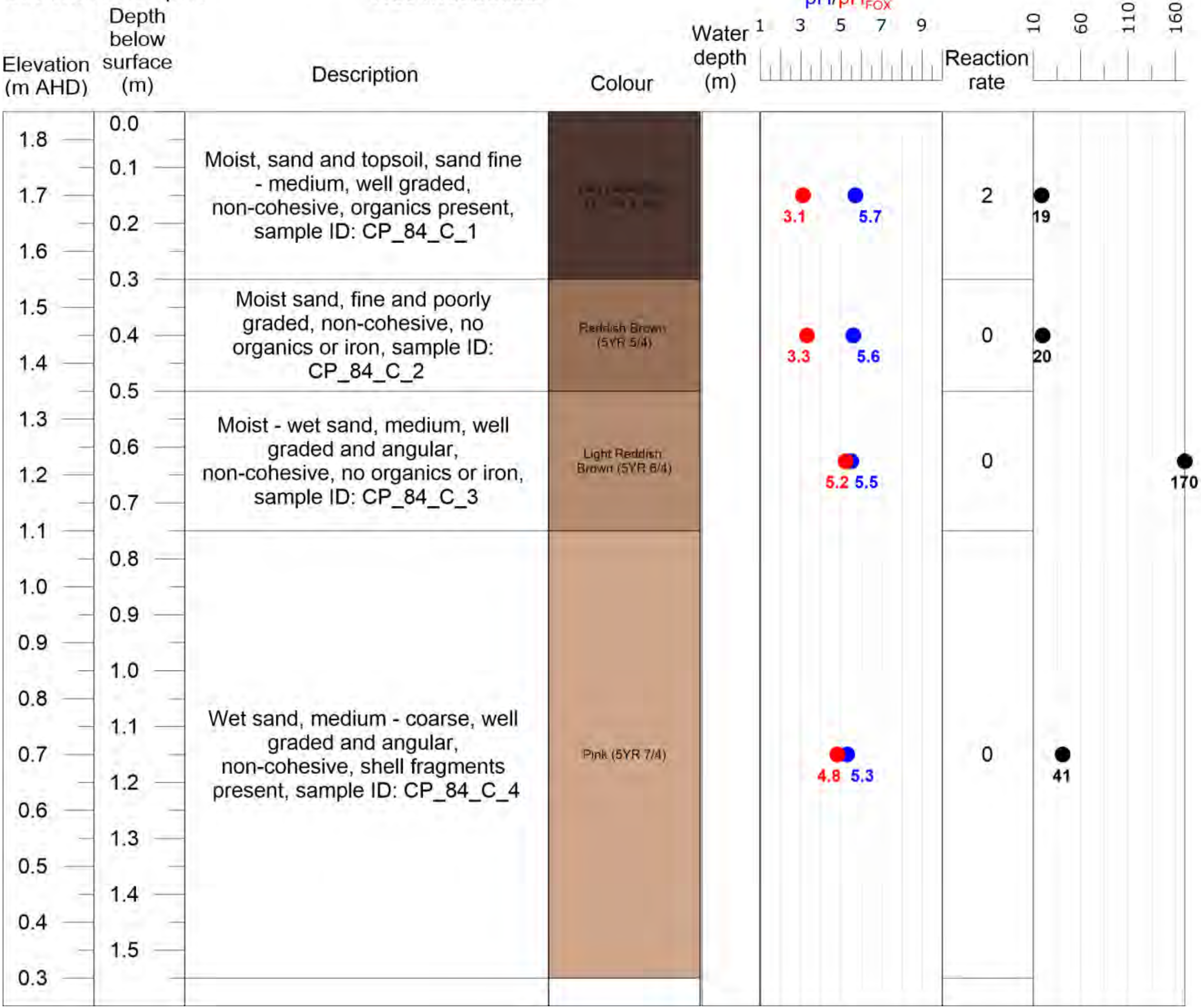
Ground elevation (m AHD):	1.85
Hydraulic conductivity (m/d):	Not measured

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	Soil pH$_{FOX}$	Soil pH	Reaction rate	Soil EC (µS/cm)
Moist, sand and topsoil, sand fine - medium, well graded, non-cohesive, organics present, sample ID: CP_84_C_1	[illegible]	3.1	5.7	2	19
Moist sand, fine and poorly graded, non-cohesive, no organics or iron, sample ID: CP_84_C_2	Reddish Brown (5YR 5/4)	3.3	5.6	0	20
Moist - wet sand, medium, well graded and angular, non-cohesive, no organics or iron, sample ID: CP_84_C_3	Light Reddish Brown (5YR 6/4)	5.2	5.5	0	170
Wet sand, medium - coarse, well graded and angular, non-cohesive, shell fragments present, sample ID: CP_84_C_4	Pink (5YR 7/4)	4.8	5.3	0	41

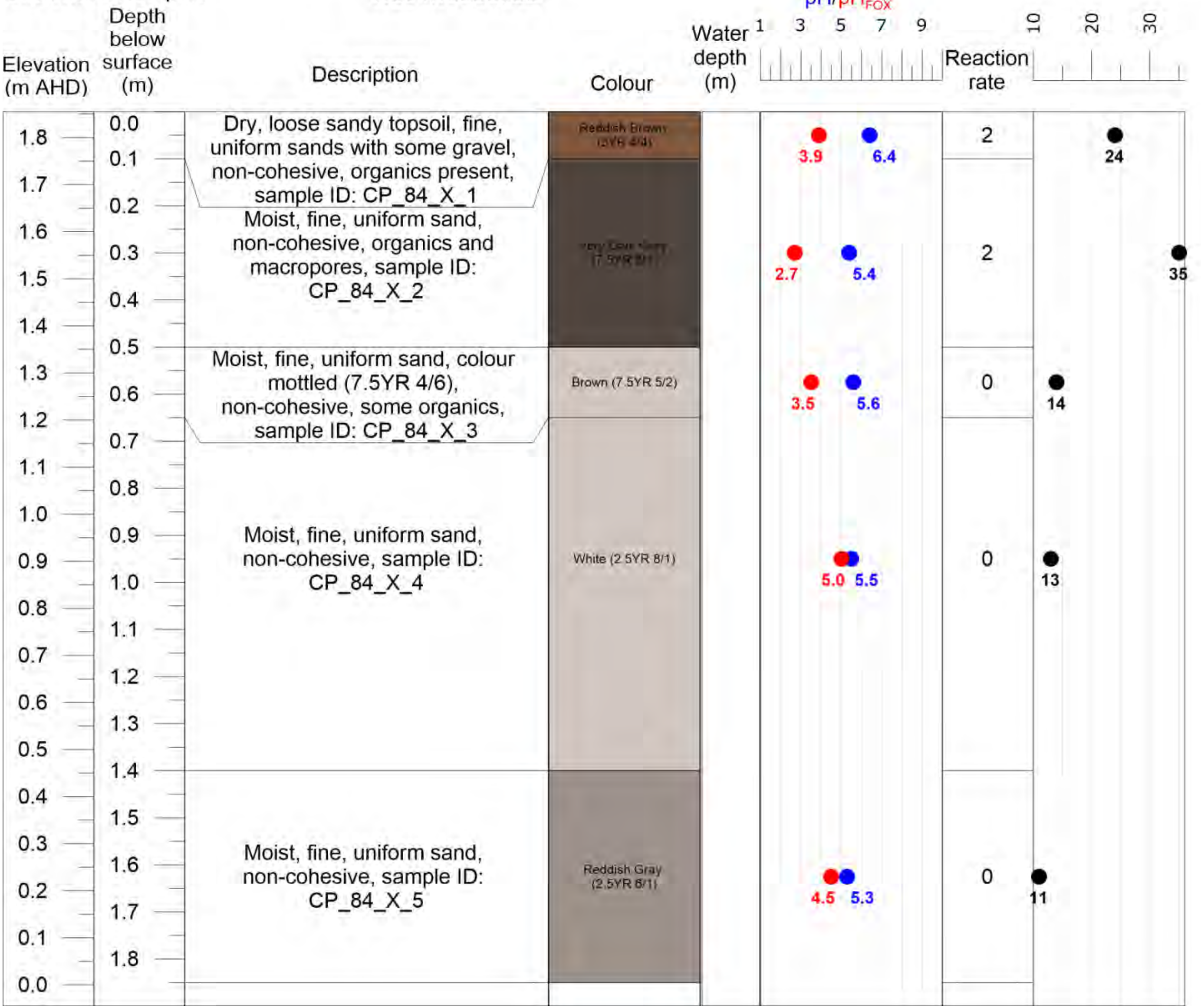
Soil profile details:

Project Number:	2018064	Profile ID:	CP_84_X
River/estuary:	Clarence	Sample date:	03/03/20
Easting:	523630.4	Sampled by:	AJH KW
Northing:	6752244.3		

Ground elevation (m AHD): 1.85
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	Soil pH/pH$_{FOX}$	Reaction rate	Soil EC (µS/cm)
Dry, loose sandy topsoil, fine, uniform sands with some gravel, non-cohesive, organics present, sample ID: CP_84_X_1	Reddish Brown (5YR 4/4)	3.9 / 6.4	2	24
Moist, fine, uniform sand, non-cohesive, organics and macropores, sample ID: CP_84_X_2	Very Dark Gray (7.5YR 3/1)	2.7 / 5.4	2	35
Moist, fine, uniform sand, colour mottled (7.5YR 4/6), non-cohesive, some organics, sample ID: CP_84_X_3	Brown (7.5YR 5/2)	3.5 / 5.6	0	14
Moist, fine, uniform sand, non-cohesive, sample ID: CP_84_X_4	White (2.5YR 8/1)	5.0 / 5.5	0	13
Moist, fine, uniform sand, non-cohesive, sample ID: CP_84_X_5	Reddish Gray (2.5YR 6/1)	4.5 / 5.3	0	11

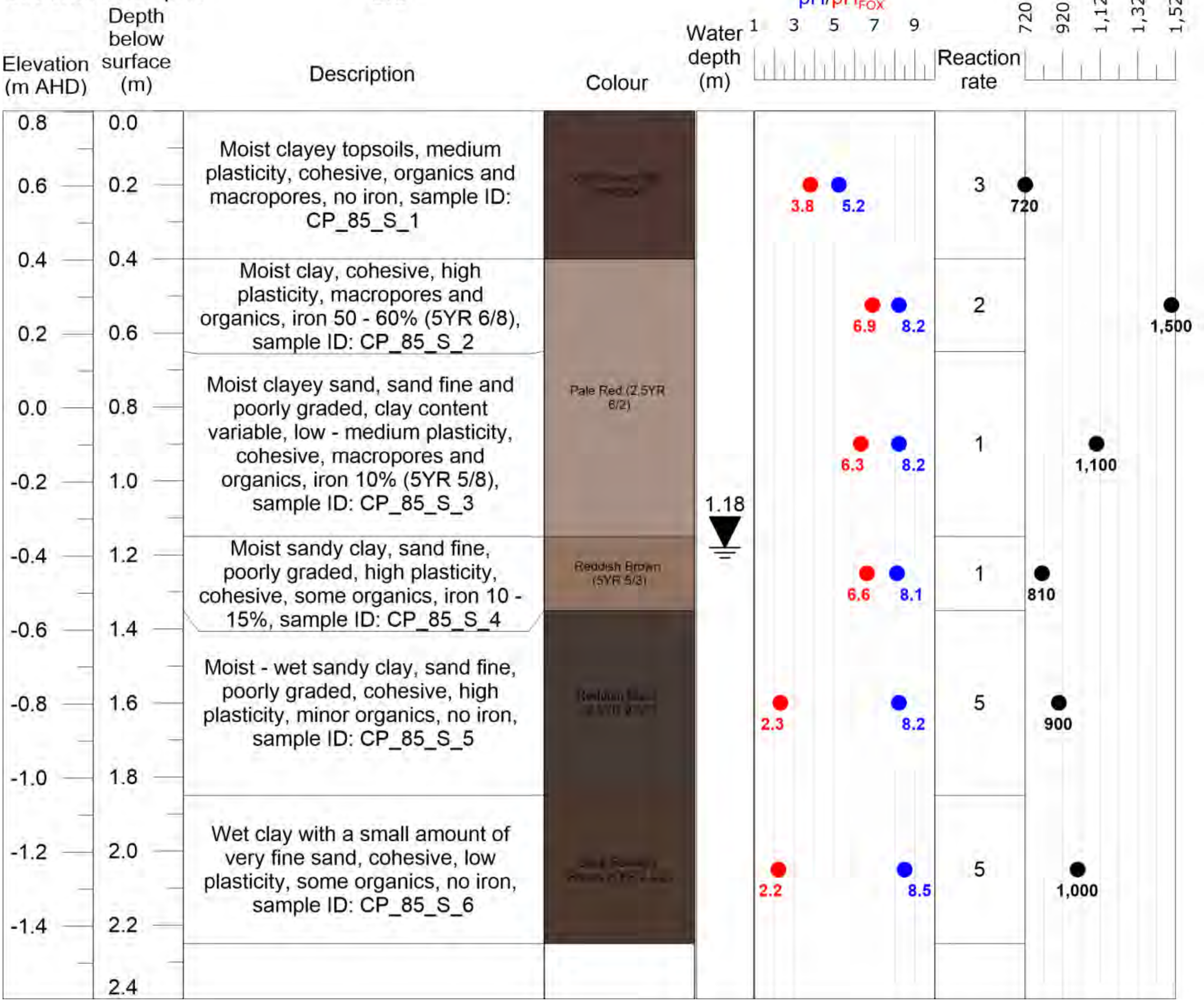
Soil profile details:

Project Number:	2018064	Profile ID:	CP_85_S
River/estuary:	Clarence	Sample date:	26/02/20
Easting:	524187.8	Sampled by:	AJH DWJ
Northing:	6750590.2		

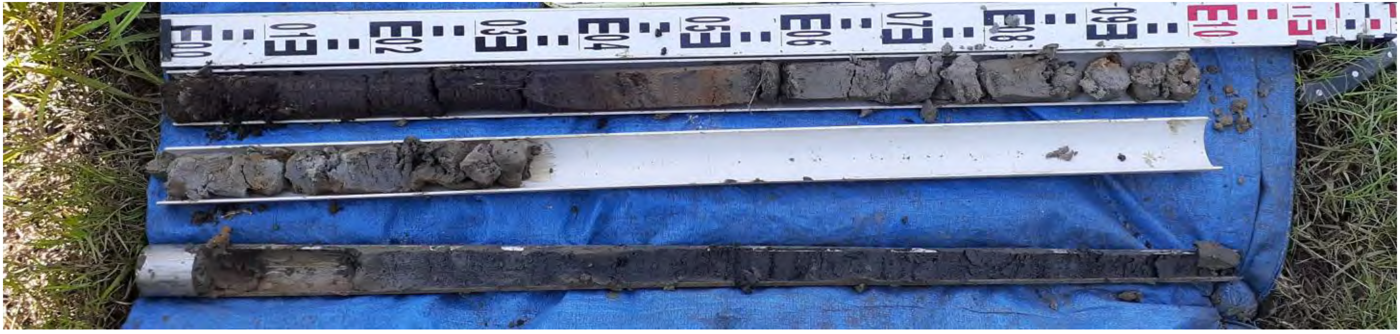
Ground elevation (m AHD):	0.80
Hydraulic conductivity (m/d):	0.37

Water quality:

Surface water EC (µS/cm):	3.66
Surface water pH:	6.43
Groundwater EC (µS/cm):	1,151
Groundwater pH:	6.8



Depth (m)	Description	Colour	pH_FOX	pH	Reaction rate	Soil EC (µS/cm)
0.0–0.4	Moist clayey topsoils, medium plasticity, cohesive, organics and macropores, no iron, sample ID: CP_85_S_1	[illegible]	3.8	5.2	3	720
0.4–0.65	Moist clay, cohesive, high plasticity, macropores and organics, iron 50 - 60% (5YR 6/8), sample ID: CP_85_S_2	Pale Red (2.5YR 6/2)	6.9	8.2	2	1,500
0.65–1.15	Moist clayey sand, sand fine and poorly graded, clay content variable, low - medium plasticity, cohesive, macropores and organics, iron 10% (5YR 5/8), sample ID: CP_85_S_3	Pale Red (2.5YR 6/2)	6.3	8.2	1	1,100
1.15–1.35	Moist sandy clay, sand fine, poorly graded, high plasticity, cohesive, some organics, iron 10 - 15%, sample ID: CP_85_S_4	Reddish Brown (5YR 5/3)	6.6	8.1	1	810
1.35–1.85	Moist - wet sandy clay, sand fine, poorly graded, cohesive, high plasticity, minor organics, no iron, sample ID: CP_85_S_5	[illegible]	2.3	8.2	5	900
1.85–2.25	Wet clay with a small amount of very fine sand, cohesive, low plasticity, some organics, no iron, sample ID: CP_85_S_6	[illegible]	2.2	8.5	5	1,000



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