A Montrose Environmental Company

Water Quality Monitoring Report

Department for Environment and Water
Adelaide Beach Management Review Implementation

SWS240047.01
24 February 2025

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1 INTRODUCTION

Epic Environmental Pty Ltd (Epic) were engaged by the Department for Environment and Water (DEW) to develop and implement a marine Water Quality Monitoring Plan (WQMP) during dredging and placement undertaken as part of a dredging trial for the Adelaide Beach Management Review Implementation (ABMRI).

The South Australian Government conducted the dredging trial to determine its feasibility as a long-term solution for managing sand on Adelaide beaches. This will involve the restoration of West Beach with approximately 550,000 m^3 of sand over the next five years.

DEW is working closely with the Environment Protection Authority (EPA) to ensure potential impacts to sensitive environmental receivers are mitigated. As such, implementation of the WQMP was required as part of the approved Dredge Management Plan (DMP) to manage water quality during the dredging trial.

1.1 Aims and Objectives

The aim of this report is to present the water quality data collected by Epic during implementation of the WQMP. The objectives of this monitoring report are to:

- Describe the methodology and procedures for data collection and analysis
- Describe spatial and temporal patterns in water quality, likely drivers for those patterns, and potential dredging impacts
- Assess compliance with water quality limits specified in the WQMP, the DMP and the dredging permit, and describe any corrective actions required
- Provide recommendations to inform future water quality monitoring activities.

2 OVERVIEW OF DREDGING PROGRAM

The dredging program included the following:

- Dredging sand from the following Sand Borrow Areas (SBAs):
  - North Haven Marina sand trap (SBA1)
  - West Beach boat ramp sand trap (SBA3)
- Depositing sand within the nearshore zone West Beach (SPA1)

These areas are shown in **Figure 1**. Note that dredging from the West Beach sand bar (SBA2) was planned but was not undertaken, and the rehandling area was not used for dredging.

Dredging was undertaken using cutter suction dredge (CSD) '*Kingston*' working inwards towards the beach, cutting a path into the shallower waters (targeting contour -3m AHD or approximately -1.5m CD).

Sand dredged from SBA1 was pumped from the CSD to a Split Hopper Barge (SHB) and transported to West Beach where it was placed in the nearshore area via bottom placement by the SHB.

Sand dredged from SBA3 was pumped from the CSD to the SPA1 West Beach placement area by direct pipeline. The pipeline was submersed resting on the seabed during dredging operations and floated when moving or inspecting pipeline via use of introducing air into the dredge pipeline.

Dredging was undertaken as follows:

- Mobilisation of plant and equipment in September 2024
- Commencement of dredging operations at North Haven (SBA1) on 3 October 2024
- Cessation of dredging at North Haven on 21 October 2024
- Commencement of dredging operations at West Beach (SBA3) on 30 October 2024
- Cessation of dredging at West Beach on 30 November 2024

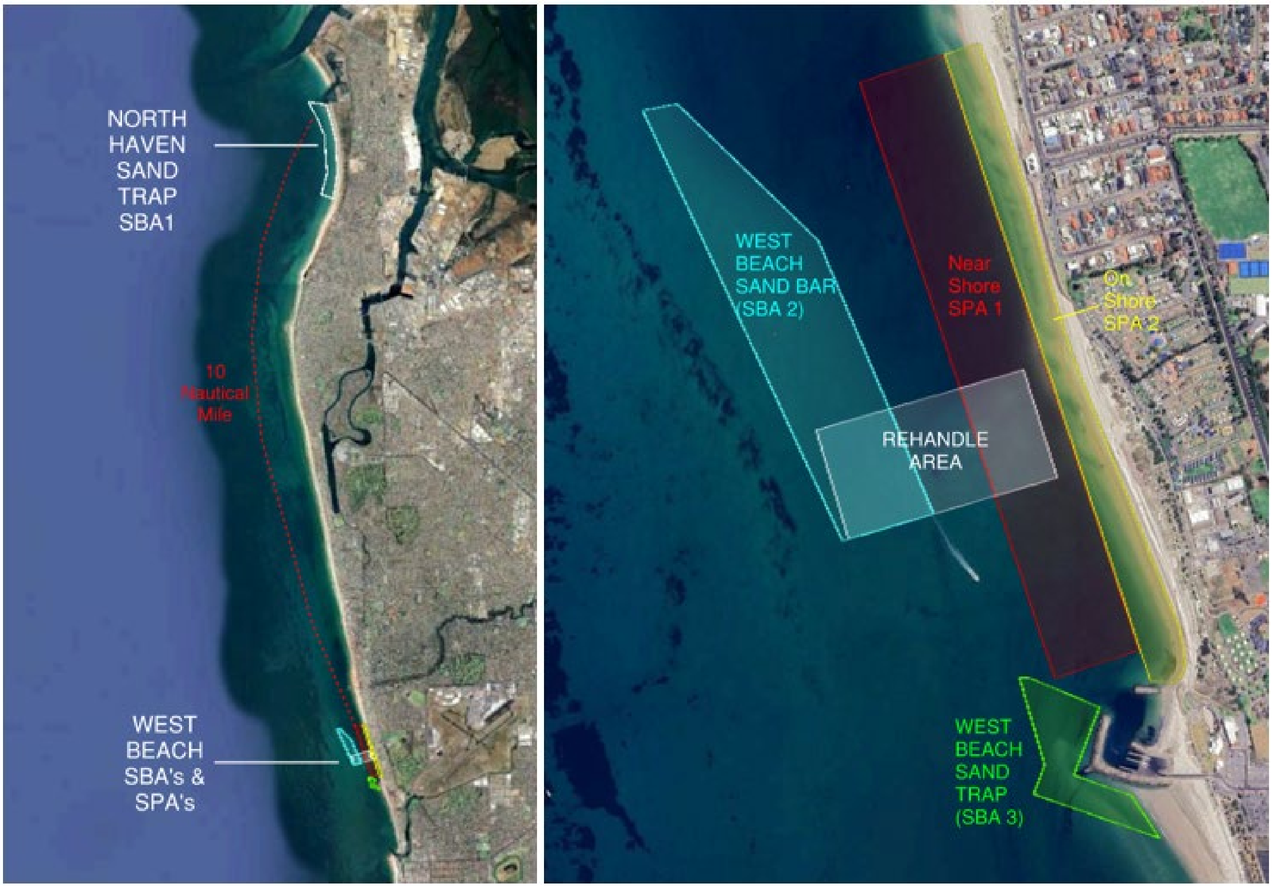


Figure 1. Sand Borrow Areas (SBAs) and Sand Placement Areas (SPAs)

3 WATER QUALITY MONITORING METHODOLOGY

3.1 Overview

Monitoring comprised a combination of surface and benthic water quality loggers, as follows:

- **Near-surface** (1 m below surface) - monitoring buoys with twin turbidity sensors (and dissolved oxygen/salinity/temperature sensors at select locations) near the surface. Buoys fitted with telemetry for real-time data feed, automatic processing of data and comparison to trigger levels, with alerts sent to notify of exceedances
- **Near-bed** (0.5 m above seabed) - benthic frames mounted with turbidity sensors. These sensors logged data internally with data downloaded during servicing trips and post-processed

3.2 Monitoring Sites

Water quality monitoring was undertaken at six monitoring sites as follows:

- **Dredge area** – two dredge plume monitoring sites (D1 and D2) located at North Haven
- **Dredge/placement area** – two dredge/material placement sites (P1 and P2) located at West Beach
- **Background** – two 'background' sites (B1 was the background site for the North Haven dredge area sites, while B2 was the background site for the West Beach sites)

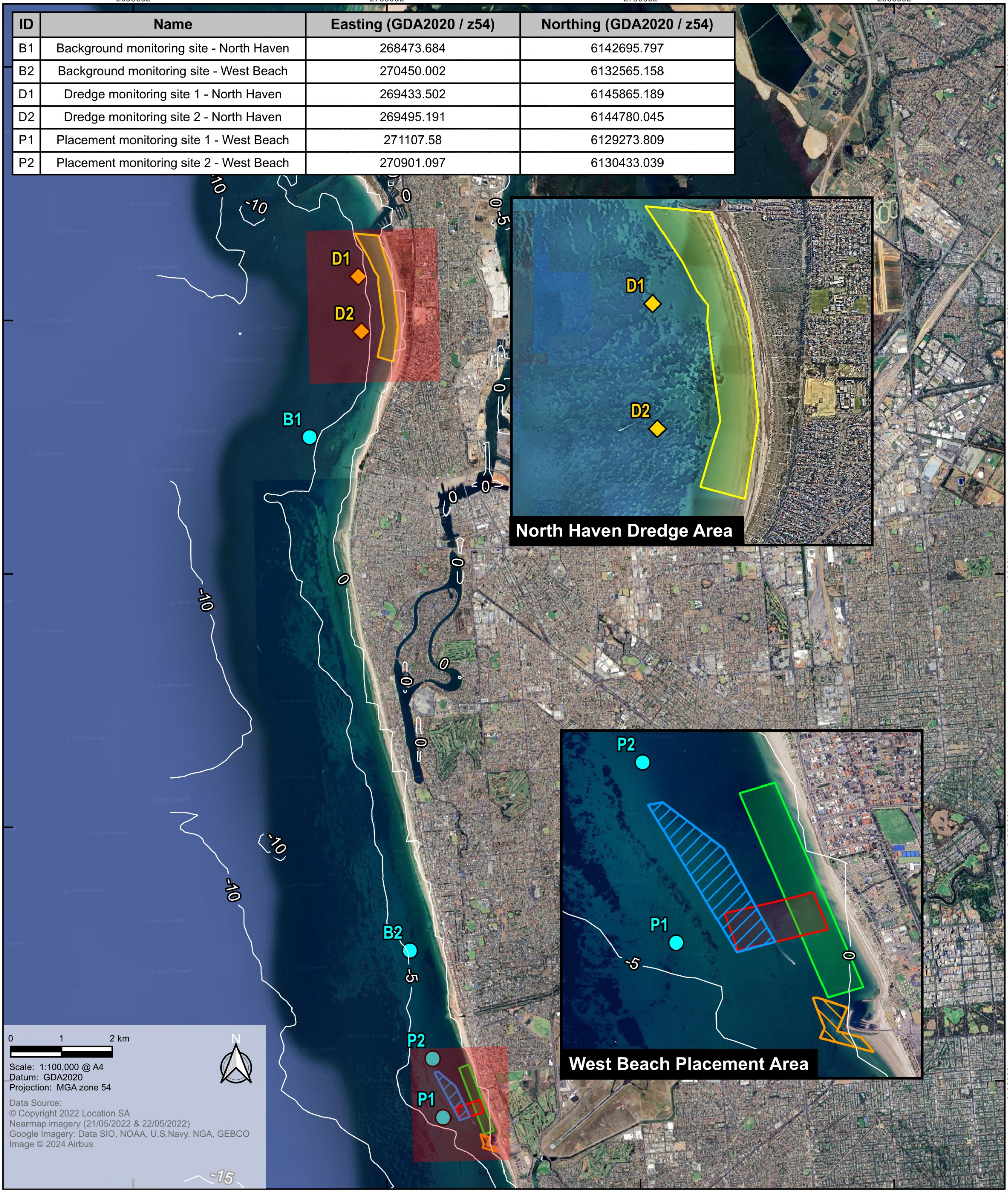
Surface and benthic water quality monitoring equipment was deployed at the monitoring locations listed in **Table 1** and shown in **Figure 2**.

To supplement historical datasets, where possible the monitoring sites were selected based on previous DEW harbour dredging monitoring sites (2021-2022) as indicated in **Table 1**. The sites were located in similar water depths near the 5 m Lowest Astronomical Tide (LAT) depth contour (**Figure 2**) to ensure data was comparable between sites.

Table 1. Monitoring Sites

Site	Description	Previous DEW Monitoring Site (2021/22)	Approximate Coordinates		Water depth (LAT)
			Latitude	Longitude	
D1	Dredge monitoring site 1 – North Haven	Near M1	-34.801550	138.480950	~5 m
D2	Dredge monitoring site 2 – North Haven	Near M1	-34.813172	138.479966	~5 m
B1	Background monitoring site – North Haven	B1	-34.831717	138.468233	~5 m
P1	Dredge/Placement monitoring site 1 – West Beach	N/A	-34.958466	138.492449	~5 m
P2	Dredge/Placement monitoring site 2 – West Beach	M2	-34.942741	138.491397	~5 m
B2	Background monitoring site – West Beach	B2	-34.923431	138.487048	~5 m

ID	Name	Easting (GDA2020 / z54)	Northing (GDA2020 / z54)
B1	Background monitoring site - North Haven	268473.684	6142695.797
B2	Background monitoring site - West Beach	270450.002	6132565.158
D1	Dredge monitoring site 1 - North Haven	269433.502	6145865.189
D2	Dredge monitoring site 2 - North Haven	269495.191	6144780.045
P1	Placement monitoring site 1 - West Beach	271107.58	6129273.809
P2	Placement monitoring site 2 - West Beach	270901.097	6130433.039



Filepath: ~SWS\SWS240047.01 DEW ADL Dredge WQ\Workspaces\1. Water Quality Monitoring Plan\Rev 0\Figure 1 Monitoring sites.qgz

Legend

- Sand borrow area 1
- Sand borrow area 2
- Sand borrow area 3
- Rehandling area
- Placement area
- Background/Placement monitoring site
- Dredge monitoring site

Department of Environment and Water
Adelaide Beaches
Water Quality Monitoring Plan

Figure 1
Monitoring sites

SWS240047.01 Rev 0 12/09/2024

3.3 Duration of Monitoring

Water quality monitoring was undertaken for the periods shown in **Table 2**.

Table 2. Monitoring Periods

Activity	Date
Deployment of equipment	25 July 2024
Commencement of dredging	3 October 2024
Cessation of dredging at North Haven	21 October 2024
Retrieval of North Haven sites (D1, D2, B1)	14 November 2024
Cessation of dredging at West Beach	30 November 2024
Retrieval of West Beach sites (P1, P2, B2)	11 December 2024

3.4 Parameters

The following parameters were continuously measured (i.e. data logged every 15 minutes) throughout the monitoring program (refer to **Table 3**):

- Turbidity – monitored at each surface monitoring site and benthic monitoring site as measured by optical scatter via a nephelometer producing readings in Nephelometric Turbidity Units (NTU)
- Turbidity at the surface monitoring sites was measured using twin turbidity sensors for quality control purposes. Turbidity provides a proxy for suspended sediments within the water column
- Electrical conductivity (EC), pH, dissolved oxygen (DO) and temperature – were monitored at three out of the six sites; one site represented the North Haven dredge area (D2), one site represented the West Beach area (P2) and one site represented background area (B2).

Table 3. Sites and Parameters

Area	Site	Type	Parameters	
			Surface	Benthic
North Haven	D1	Dredging	Twin turbidity	Turbidity
	D2	Dredging	Twin turbidity, DO, pH, EC, temp	Turbidity
	B1	Background	Twin turbidity	Turbidity
West Beach	P1	Dredging/Placement	Twin turbidity	Turbidity
	P2	Dredging/Placement	Twin turbidity, DO, pH, EC, temp	Turbidity
	B2	Background	Twin turbidity, DO, pH, EC, temp	Turbidity

3.5 Monitoring Equipment

3.5.1 Near-Surface Monitoring

To collect real-time water quality measurements from near-surface, water quality loggers were mounted on purpose-built monitoring buoys (**Figure 3**). The buoys were anchored to the seabed using a mooring system to maintain position. With the loggers installed in each monitoring buoy, the sensors were located at a depth of approximately 1 m below the water surface.

The water quality loggers (YSI EXO sonde) were fitted with sensors designed for long-term deployments in the marine environment. The sensors measured turbidity, with dissolved oxygen, pH, electrical conductivity and water temperature sensors installed at monitoring sites D2, P2 and B2. The water quality loggers were capable of continuous logging of data, with a copper anti-fouling guard, copper tape and sensor wiping apparatus to prevent interference to sensors from marine growth. The loggers were programmed to log data once every 15 minutes.

The monitoring buoys were fitted with navigation lights set to flash in accordance with advice from the Harbour Master. Real-time data from each buoy was made available via telemetry using in-built Campbell Scientific data loggers, 4G modems, batteries and solar panels.

Each buoy was fitted with a secondary turbidity sensor for QA/QC purposes and redundancy (in case a turbidity sensor malfunctions or becomes fouled).

The monitoring equipment was secured to the seabed using robust mooring lines and bruce anchors, and each buoy was fitted with a GPS tracking device.

Equipment issues encountered during the monitoring program are discussed in **Section 4.1**.

Figure 3. Monitoring buoy

3.5.2 Benthic Monitoring

To collect near-bed benthic water quality data, benthic frames with water quality loggers (YSI EXO sondes) were deployed (**Figure 4**). The water quality loggers were fitted with turbidity sensors capable of continuous logging of data, with a copper anti-fouling guard, copper tape and sensor wiping apparatus to prevent interference to sensors from marine growth.

The benthic loggers were programmed to log data once every 15 minutes with data downloaded during servicing trips.

Figure 4. Benthic frames – previous DEW monitoring (left) and current program (right) showing accumulation of seagrass wrack

3.5.3 Calibration and Servicing

All monitoring equipment was calibrated prior to deployment as per the manufacturer's specifications. Optical sensors (such as turbidity and DO) and EC sensors are fairly robust and the manufacturer recommends calibration at least once every 6-12 months during use, while pH sensors are recommended to be calibrated at least once every 2-4 months. To avoid disruption to the monitoring program, sensors were calibrated prior to deployment and then calibration was routinely checked throughout the monitoring program as follows:

- A calibrated, hand-held water quality meter recorded measurements from surface to bottom at each site during servicing trips to confirm the ongoing accuracy of the sensor readings. If a sensor was not reading correctly, it would have been replaced with a calibrated sensor. However, this was not necessary during the monitoring program.
- Data could be adjusted via the monitoring portal (Eagle.io) to account for any sensor drift based on the above monthly calibration checks. This was not necessary during the monitoring program as deployed sensors recorded similar data to the hand-held water quality meter.
- Water quality grab samples collected adjacent to each buoy were analysed for turbidity as a secondary calibration check. The results from this secondary calibration check indicated that the deployed turbidity sensors were recording accurate data throughout the program.

Servicing of the water quality loggers was undertaken approximately every 4-6 weeks (depending on weather conditions). The servicing trips involved cleaning and calibration-check of all instrumentation, and any repairs or other maintenance required.

3.6 Water Quality Trigger Values

An adaptive management program using varying turbidity trigger levels was implemented during the dredge program. Trigger levels were set based on EPA guidance, previous DEW monitoring data (2021/22) and the 2019 Outer Harbour Channel Widening (OHCW) project (BMT, 2019). The trigger levels take into account natural background turbidity and zones of impact thresholds for seagrass.

To set appropriate trigger values for this project, the DEW monitoring data (2021/22) was analysed. The DEW data was collected using sensors mounted on benthic frames approximately 0.5 m above the sea bed, and the data was collected over a 12-month period between November 2021 and December 2022. Based on the results of the analysis, a baseline turbidity value of 2.8 NTU was assumed at the nearshore monitoring sites (compared to a baseline turbidity of 0.8 NTU for the OHCW project in 2019 in surface waters). When the zone of impact threshold values were added to this baseline value, the revised trigger levels that were applied to this project are as follows:

- **Alarm level** (associated with boundary of the zone of low to moderate impact):
  - 4.8 NTU based on a 15 day rolling median
  - 7.8 NTU based on a 6 day rolling median
- **Hold level** (associated with boundary of the zone of high impact):
  - 7.8 NTU based on a 15 day rolling median
  - 17.8 NTU based on a 6 day median rolling median

The 15-day and 6-day rolling median turbidity values were compared to the ‘Alarm’ and ‘Hold’ criteria. Upon reaching the Alarm trigger level, the dredge contractor was to assess the source of increased turbidity, slow dredging, and/or implement management measures to reduce turbidity levels. Otherwise, if the rolling median at either of the background sites (B1 or B2) also exceeded the trigger values (or was within 20%), then dredging could continue.

Upon reaching the Hold trigger level, the dredge contractor was to cease dredging as soon as practicable. An assessment would then be undertaken by the EPA to determine whether background turbidity was a significant influence and if so, then dredging could recommence.

The above triggers were applicable for dredging up to 31 October. As per advice received from the EPA, dredging may pose a higher risk to seagrass if dredging continues into November. As such, lower (more stringent) triggers were implemented for dredging undertaken during November. These triggers, which were the same used for the OHCW project in 2019, included the following:

- **Alarm level**:
  - 2.8 NTU based on a 15 day rolling median
  - 5.8 NTU based on a 6 day rolling median
- **Hold level**:
  - 5.8 NTU based on a 15 day rolling median
  - 15.8 NTU based on a 6 day median rolling median

3.7 Data Management and Analysis

Real-time telemetered data was collected from each of the surface sites and compared to the trigger values throughout the duration of the dredging trial. Data from the benthic sites was logged internally and downloaded during servicing trips. Benthic data was post processed at the end of the dredging program.

Water quality data collected at surface monitoring buoys during dredging was managed as follows:

- Data was automatically downloaded on an hourly basis via a remote telemetry system. This raw data (not quality controlled) was displayed on a monitoring portal (Eagle.io) developed for the project
- Raw data underwent an automatic QC checking process, followed by a manual QC checking process (refer to **Section 3.10**) and any potentially erroneous data was quarantined from the data set
- The QC-cleaned data underwent automatic calculation of required metrics (e.g. 15-day and 6-day rolling medians) for comparison to trigger limits (**Section 3.6**). The calculated medians were displayed on the monitoring portal as time series charts with trigger levels displayed. Alerts were programmed to be sent out to key project personnel if trigger limits were exceeded.

3.8 Grab Samples

At each site, grab samples were collected during deployment, servicing and retrieval trips. Samples were collected from the top, middle and bottom of the water column at each site using a Van Dorn Sampler. Water samples were collected into laboratory supplied sample containers and sent to a National Association of Testing Authorities (NATA) certified laboratory for the analysis of the following:

- Total suspended solids (TSS)
- Turbidity (NTU)

Analytical data from the grab samples was used to determine TSS/NTU ratio at the dredging, sand placement and background locations, and to cross-check deployed sensor readings.

3.9 Satellite Imagery

Satellite imagery was used to validate measured data. Site-specific algorithms were used to convert satellite backscatter data into satellite-derived turbidity maps. Twice-daily MODIS images (250 m grid) were converted to turbidity maps and automatically uploaded to the Eagle.io monitoring portal. Satellite imagery was used for the following:

- To complement measured monitoring data and detect dredge plumes in areas not captured by deployed instrumentation
- To validate sensor readings at monitoring buoys

3.10 Quality Assurance and Quality Control

The following was undertaken to ensure data quality and to minimise any data loss from the monitoring equipment:

- The real-time data from surface monitoring buoys on the Eagle.io monitoring portal was maintained regularly to ensure good quality data was being recorded. If it became evident that poor quality data was being collected (potentially due to sensor fouling or malfunction), actions would have been initiated to rectify (e.g. servicing trip)
- Sensors and equipment were cleaned regularly (approximately once every 4-6 weeks, depending on weather conditions). All sensors were calibrated prior to deployment as recommended by the manufacturer using standard solutions prepared from the National Institute of Standards and Technology (NIST) traceable reagents.
- Calibration checks were undertaken during servicing trips to ensure accuracy and precision of sensor data. If necessary, minor sensor drift was adjusted in the monitoring portal, while major sensor drift would have been addressed by re-calibration of sensors
- When sensors were serviced in the field, their condition and appearance was noted. This would identify if a sensor had been biofouled or had any other noticeable issues. This data was used to assist in the post-processing assessment of the data.

3.10.1 Data Quality Control Procedures

As real-time data from surface monitoring buoys was automatically downloaded by the web-based monitoring portal, any potential outliers and questionable data was assigned a quality code which was then be examined further. Rules to flag potential outliers and questionable data was as follows:

- If any individual measurement was >100% higher or lower than adjacent measurements (e.g. a brief spike in turbidity)
- If data was outside the bounds of typical readings, e.g. negative turbidity or turbidity higher than 1,000 NTU, pH values less than 4 or greater than 10
- The data was automatically plotted on the web-based monitoring portal as a time series chart and visually scanned for outliers and evidence of fouled sensors, including data which had been assigned a poor-quality code. Obvious failures resulted in the data being quarantined from the dataset

- The use of twin turbidity sensors assisted investigations into the validity of potential outliers and questionable turbidity data. The two data sources underwent automatic processing by the monitoring portal as follows:
  - Data from the two concurrent turbidity sensors was downloaded and compared
  - If the difference in readings was within 20%, then the average turbidity value was used
  - If the difference was greater than 20%, then the minimum turbidity value was used (this assumes that biofouling would increase turbidity values)
- If turbidity readings were unusually high, data was then examined with consideration to the meteorological conditions at the time (with data from the Bureau of Meteorology) to determine whether wind and wave conditions may have affected the measurements in question. If strong winds did not accompany spikes in turbidity, the data was considered potentially erroneous and subjected to further scrutiny.

4 MONITORING RESULTS

4.1 Loss of Data / Equipment Issues

Following the quality control procedures outlined in **Section 3.10**, any data suspected to be of poor quality was quarantined from the data set. This produced a validated data set from which further analysis was undertaken.

Overall, the data collected from surface monitoring buoys throughout the dredging trial was high quality, with approximately 98% data capture rates of QA-checked data for each monitoring site.

The only issue encountered with the surface monitoring equipment was during a significant storm with strong northerly winds in mid-August (prior to commencement of dredging), when monitoring buoy B2 moved approximately 200 m to the south-east. The buoy continued to collect water quality data, and once the winds abated the buoy was relocated back to its original position and supplementary anchors were deployed on each buoy to prevent further movement during storms.

Data from the benthic instruments was also mostly of high quality, except for the following issue:

- Benthic site B2 – data loss for period between 19 October and 11 December. This was due to an internal power failure in the water quality logger a few days after battery replacement during the October servicing trip causing the logger to shut down. New batteries were installed during the November servicing trip, however the logger failed again within a few hours.

As B2 was a background site, the implications for this data loss are inconsequential, especially considering that turbidity data was well below trigger values at all monitoring sites during this period.

4.2 Wave and Wind Data

Wave data was sourced from a Spotter buoy deployed on behalf of DEW at West Beach from mid-September 2024. This data is shown in **Figure 5** and indicates that the wave climate during the monitoring period was characterised by periods of frequent larger waves which typically coincided with sustained south-west winds (refer wind data in **Figure 6**), with calm conditions in between these periods typically coinciding with offshore winds predominantly from the north-north east (**Figure 6**).

The spotter buoy wave data, complemented by SA Waves wave buoy data from Brighton (prior to September), is presented in turbidity graphs in **Section 4.3** to provide an indication of correlation between wave climate and turbidity.

Wind data was sourced from the Bureau of Meteorology (BOM) monitoring station at Outer Harbor (Station ID: 022053). This is located approximately 8 km north of North Haven and 25 km north of West Beach, and provides a general indication of wind speed and direction during the dredging trial.

Wind direction data for the monitoring period is shown in **Figure 6.** The prevailing wind direction during the monitoring period was from the south west (SW) and north-north east (NNE) directions. Wind speed data is shown in **Figure 7**.

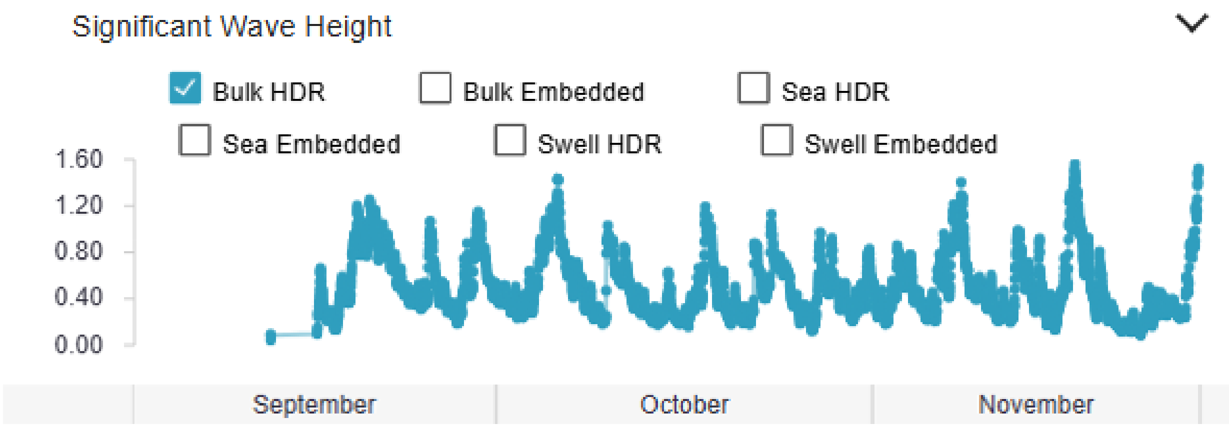


Figure 5. West Beach wave buoy data – September to November 2024

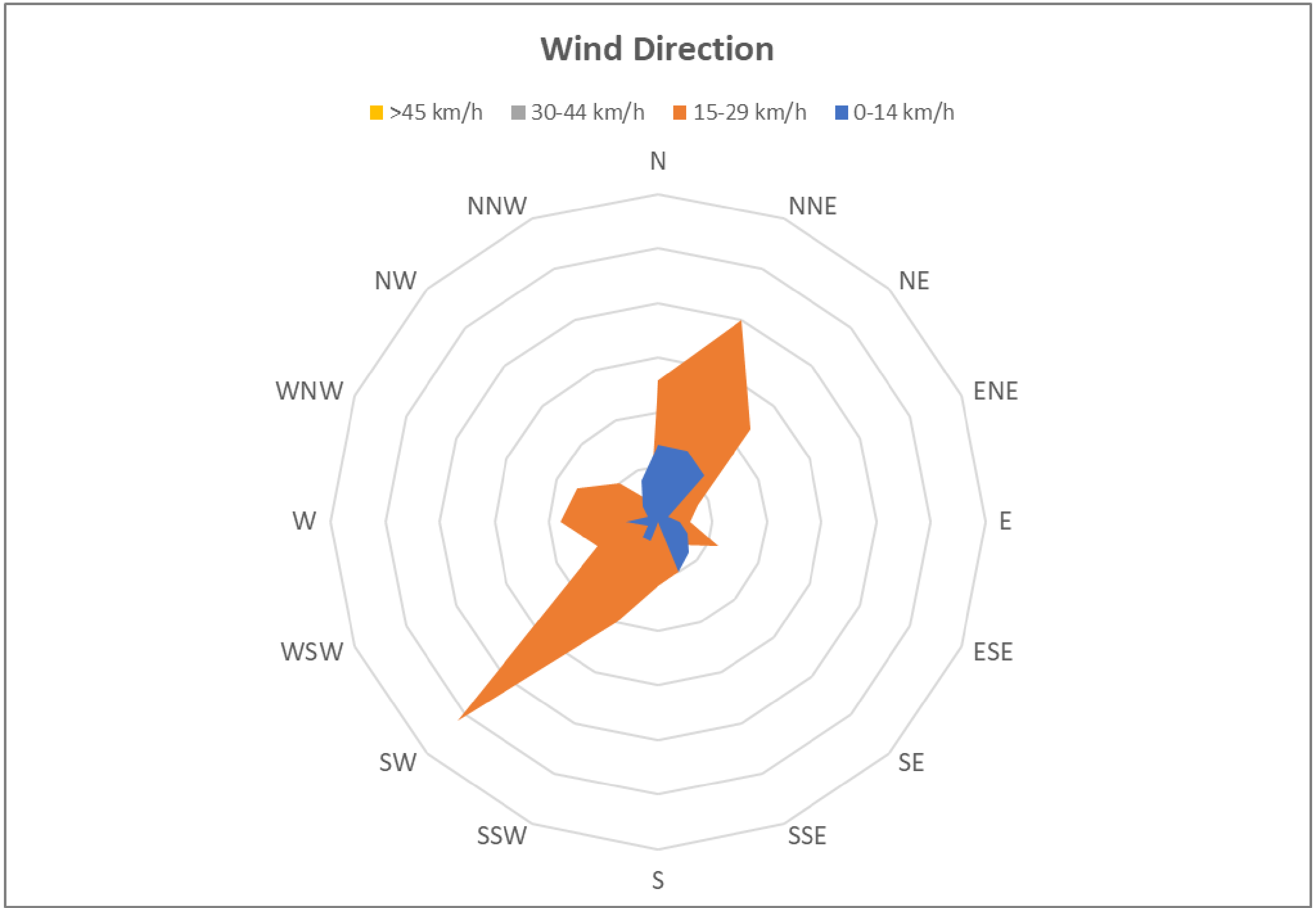


Figure 6. Wind direction data – July to November 2024

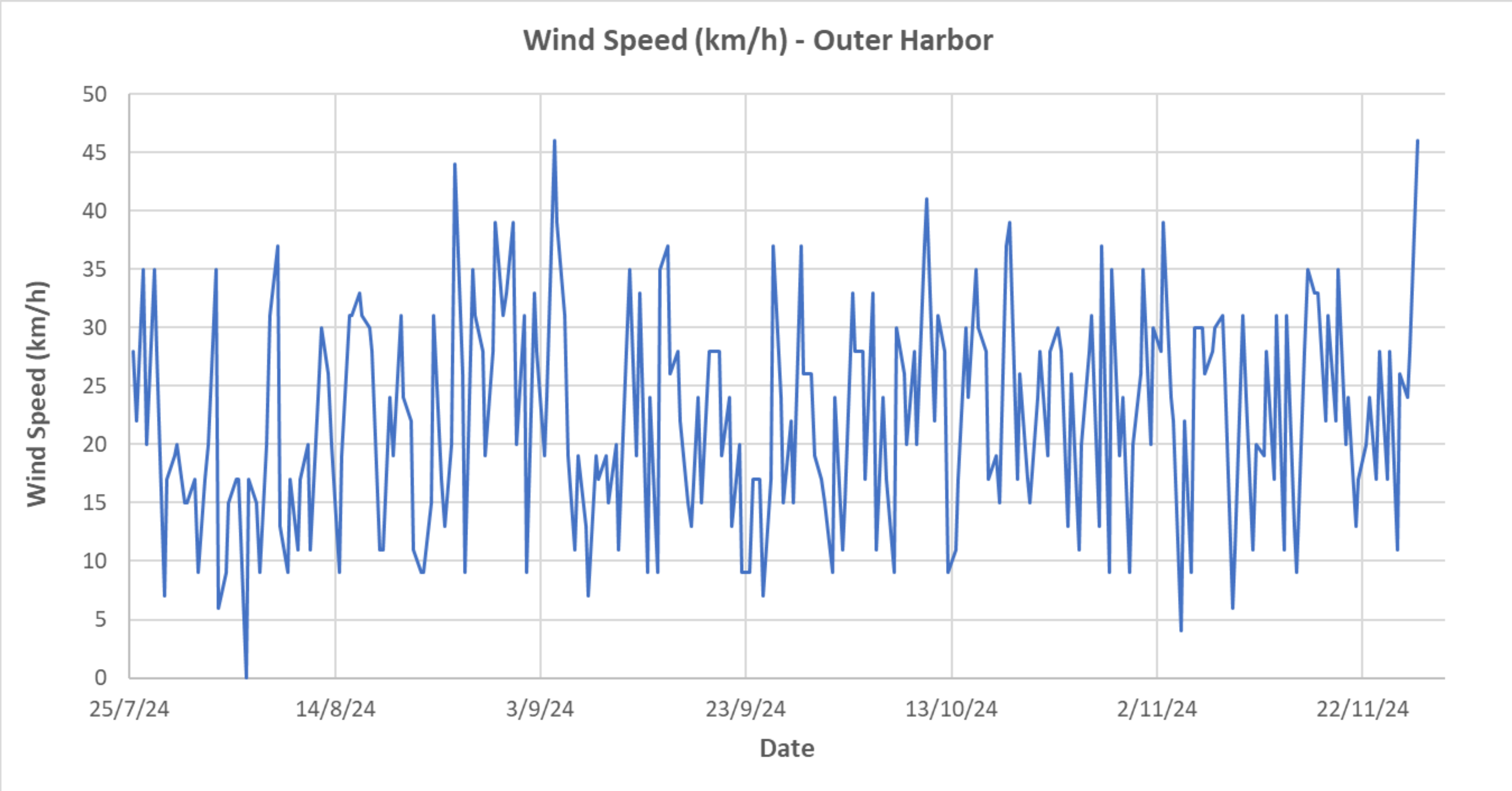


Figure 7. Wind speed data – July to November 2024

4.3 Near-Surface Turbidity Data

The near-surface turbidity data (collected using monitoring boys) is presented in **Figure 8** for North Haven sites (D1, D2 and background site B1) and **Figure 11** for West Beach sites (P1, P2 and background site B2). The spotter buoy wave data, complemented by SA Waves wave buoy data from Brighton (prior to September), is also shown in the turbidity graphs to provide an indication of correlation between wave climate and turbidity.

Key findings from the turbidity data includes the following:

- Turbidity fluctuated from around 0.3 NTU during calm conditions and up to 15–20 NTU during windier periods. The highest turbidity was recorded in late August (prior to dredging) during a period of sustained strong winds from the south west. These stronger wind periods resulted in increased wave action causing natural resuspension of sediments and increased turbidity.
- During the dredging period at both locations (North Haven and West Beach), turbidity increased sporadically during intermittent periods of increased wind and waves, but turbidity remained below 10 NTU at all sites during dredging.
- Turbidity appeared to be strongly corelated with wave height, with increases in turbidity coincident with increased wave height. There was no discernible signal of dredge plumes in the turbidity data.
- The 6-day and 15-day rolling median turbidity data (**Figure 9**, **Figure 10**, **Figure 12** and **Figure 13**) indicated that turbidity remained below the trigger values during dredging periods, even where the more stringent November trigger values were applied. 6-day and 15-day rolling median turbidity remained around 1–2 NTU during dredging.
- Prior to dredging, the 6-day and 15-day rolling median turbidity spiked in early September in response to the storm event in late August. 6-day and 15-day rolling median turbidity at North Haven sites remained below the more stringent November trigger values (**Figure 9** and **Figure 10)**, while 15-day rolling median turbidity at West Beach sites slightly exceeded the more stringent 15-day Alarm level trigger value (2.8 NTU) for November (**Figure 13**). However, when using the pre-November trigger value of 4.8 NTU, the 15-day rolling median turbidity was lower than this.

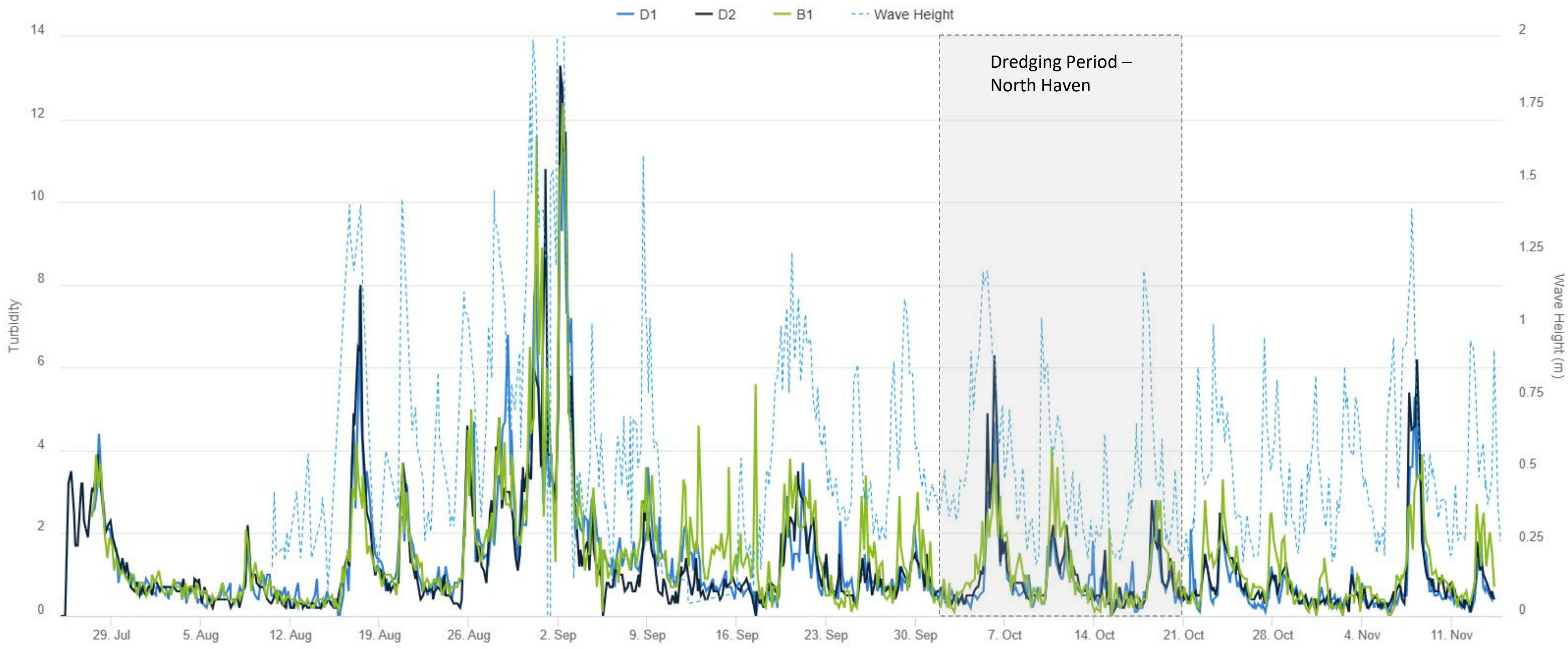


Figure 8. Turbidity data (15 minute intervals) at North Haven sites (D1, D2 and background site B1)

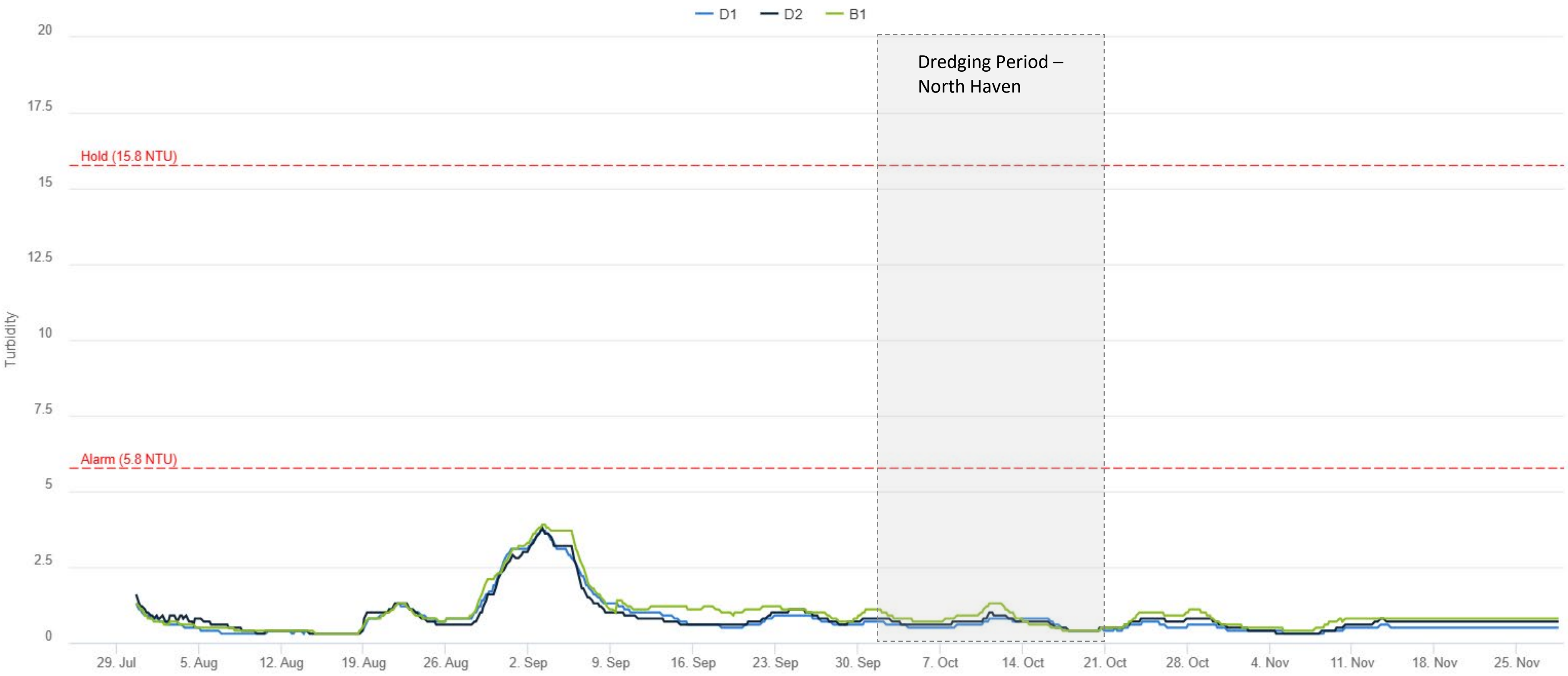


Figure 9. 6-day rolling median turbidity at North Haven sites (D1, D2 and background site B1) – more stringent November trigger levels shown

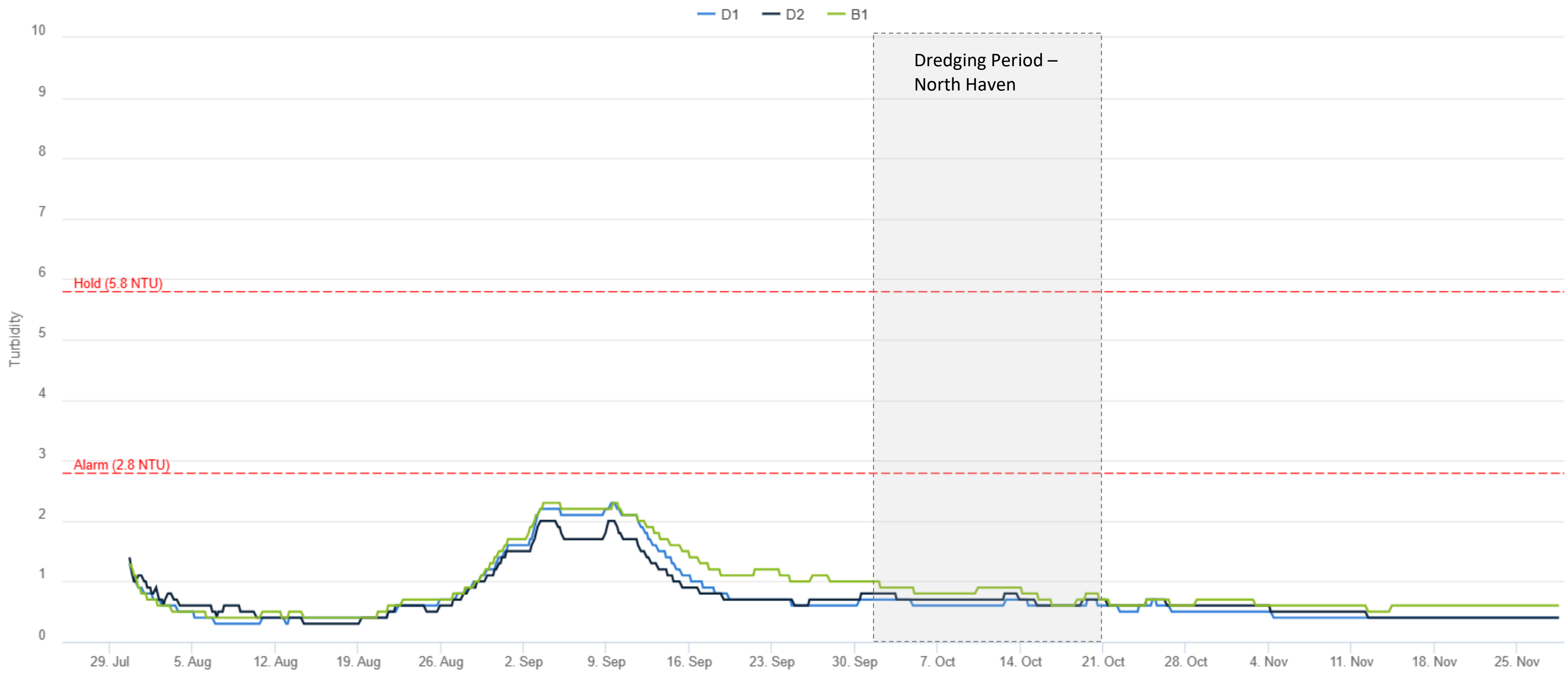


Figure 10. 15-day rolling median turbidity at North Haven sites (D1, D2 and background site B1) – more stringent November trigger levels shown

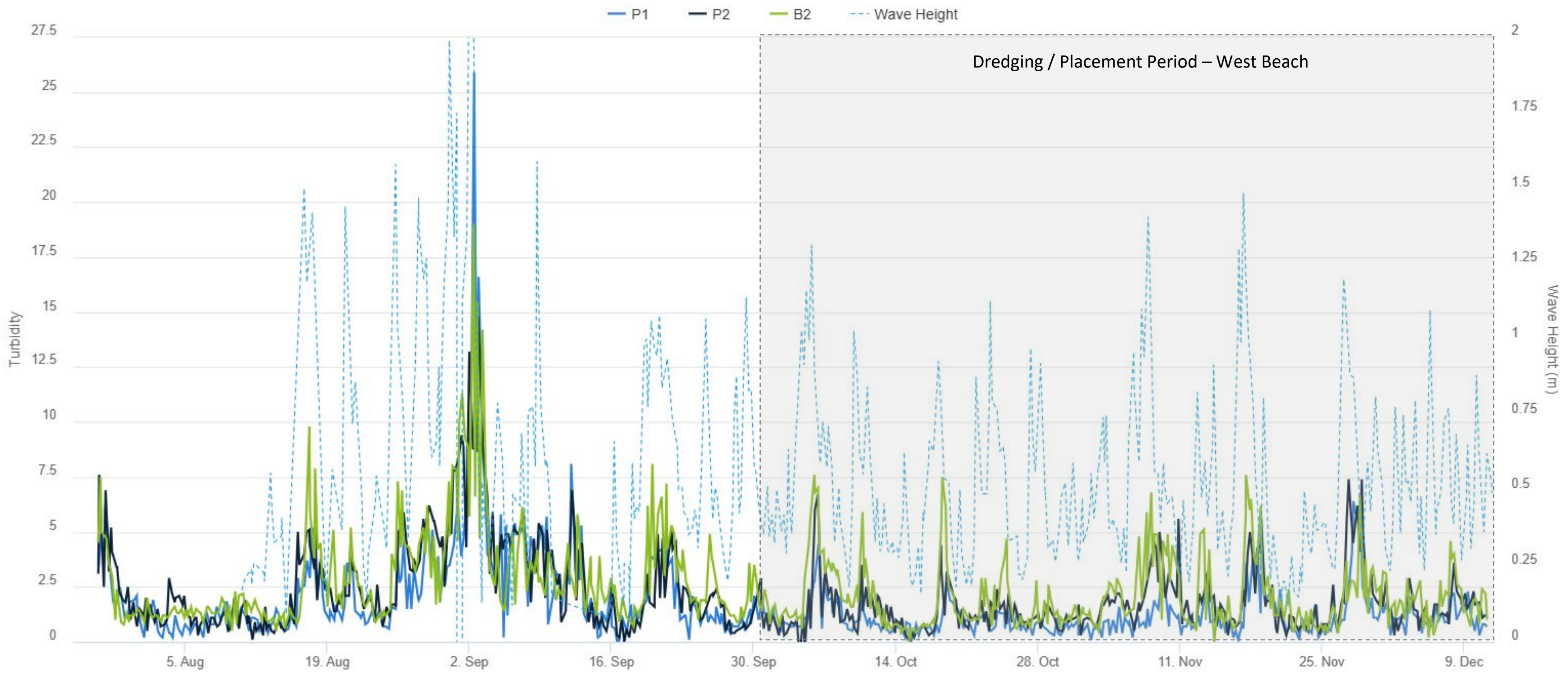


Figure 11. Turbidity data (15 minute intervals) at West Beach sites (P1, P2 and background site B2)

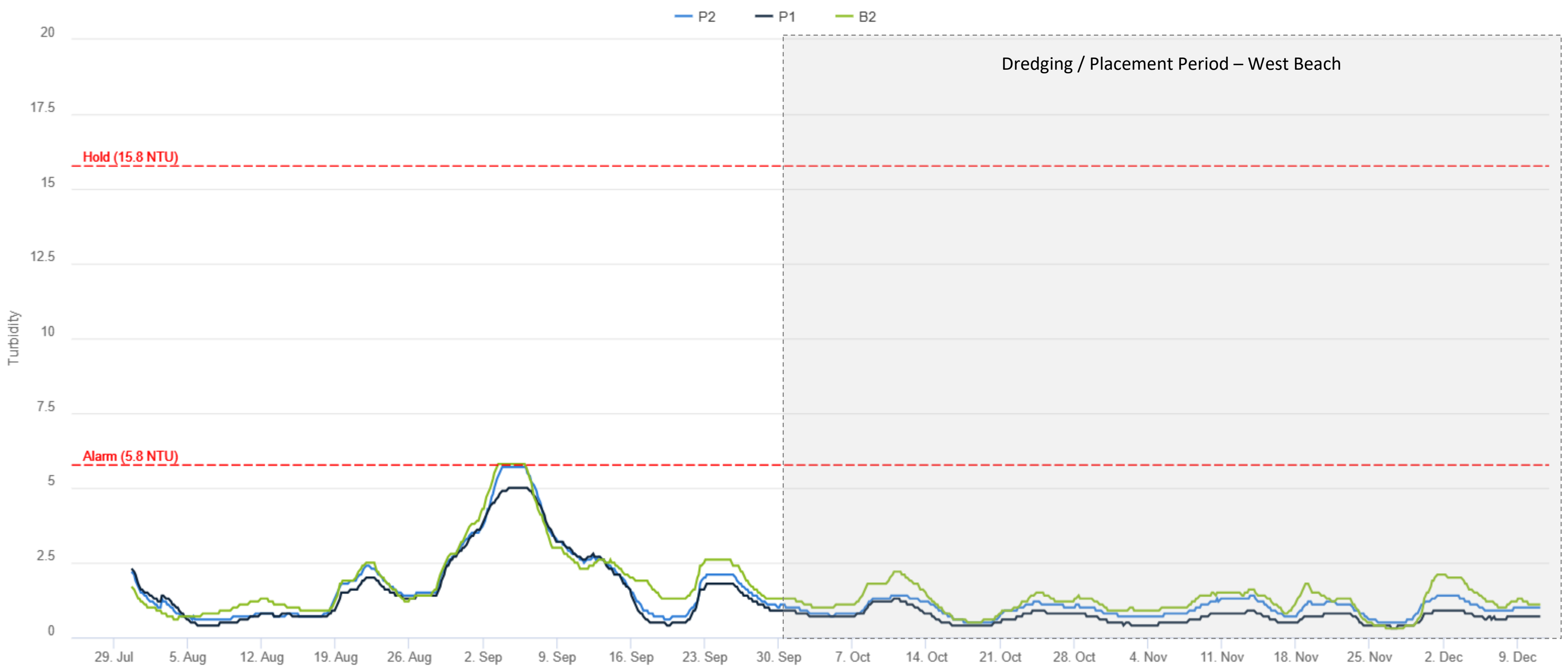


Figure 12. 6-day rolling median turbidity at West Beach sites (P1, P2 and background site B2) – more stringent November trigger levels shown

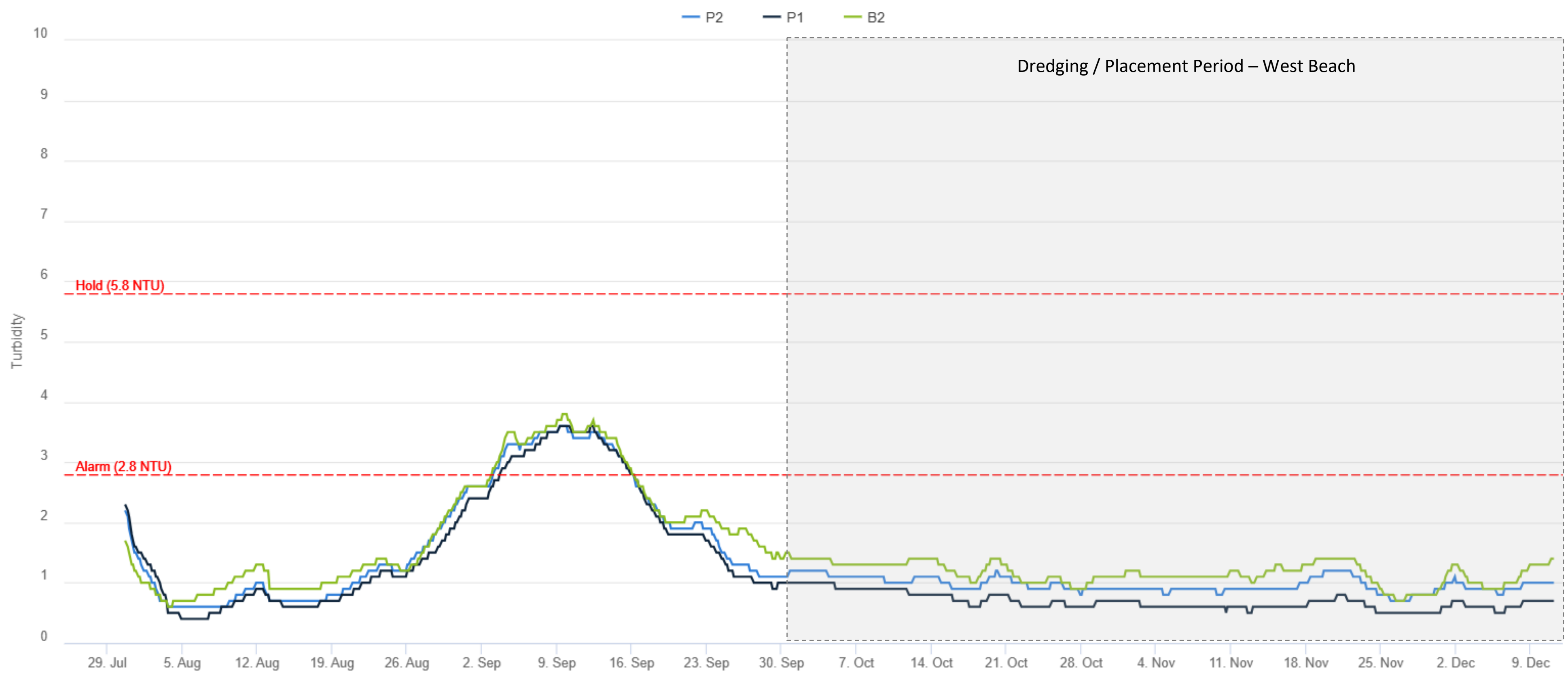


Figure 13. 15-day rolling median turbidity at West Beach sites (P1, P2 and background site B2) – more stringent November trigger levels shown

4.4 Benthic Turbidity Data

The benthic turbidity data (collected using loggers deployed on benthic frames) is presented in **Figure 14** for North Haven sites (D1, D2 and background site B1) and **Figure 15** for West Beach sites (P1, P2 and background site B2). For comparative purposes, the surface turbidity data is also shown on these figures as blue lines.

Key findings from the benthic turbidity data includes the following:

- Benthic turbidity had similar fluctuations in turbidity as surface sensors, with increases in turbidity coincident with increased wind and wave action.
- The highest turbidity was recorded during a large storm event in late August, while turbidity during the dredging period was relatively low.
- While benthic turbidity had a similar pattern to surface turbidity, there was more noise in the data, with turbid spikes occurring more often compared to surface data. This is likely due to sensor interference from seagrass wrack, as evident in photos (**Figure 4**).
- Benthic turbidity was higher than surface turbidity – around 2-3 NTU higher at most sites until around mid-September. From early September on, benthic turbidity was only around 0.5–1 NTU higher than surface turbidity, which may be due to the relatively calmer conditions compared to August.
- The higher benthic turbidity compared to surface turbidity is likely due to increased debris and suspended sediments near the seabed.

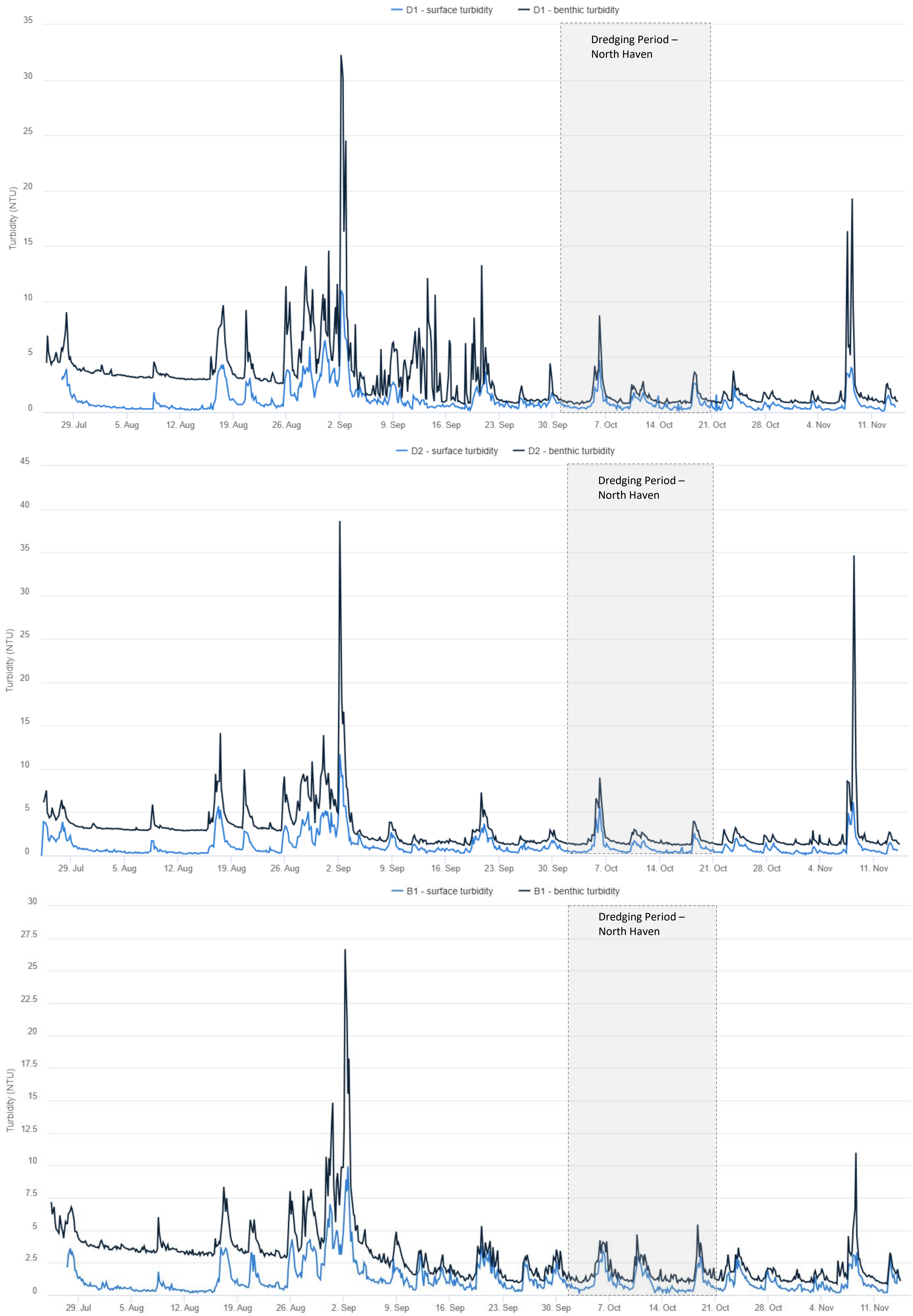


Figure 14. Benthic turbidity data (black line) with surface turbidity data (blue line) – North Haven sites D1 (top), D2 (mid) and B1 (bottom)

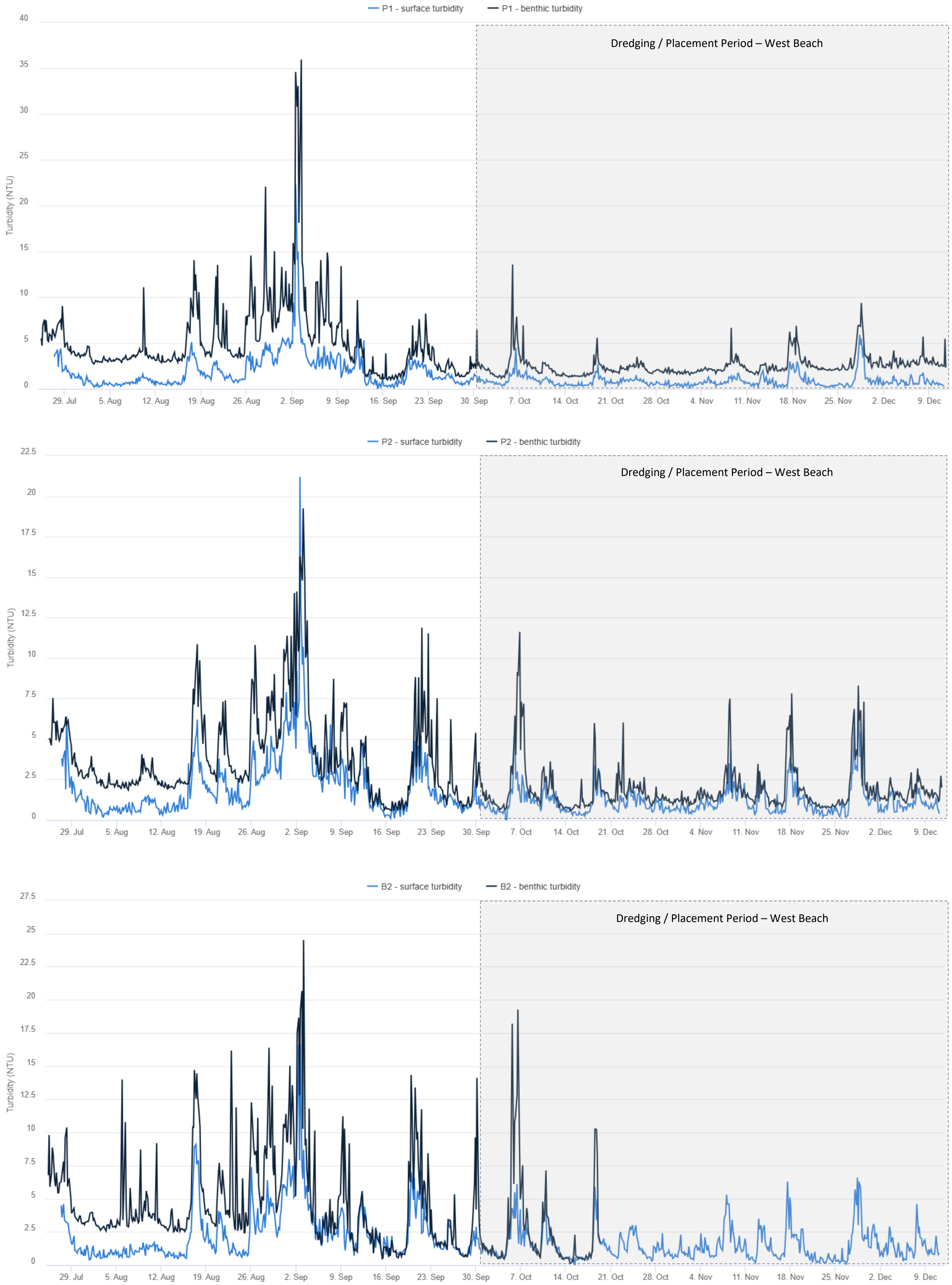


Figure 15. Benthic turbidity data (black line) with surface turbidity data (blue line) – West Beach sites P1 (top), P2 (mid) and B2 (bottom)

4.5 Other Parameters

Along with turbidity, EC, pH, DO and temperature sensors were installed at three sites - one North Haven site (D2), one West Beach site (P2) and one background site (B2). The data from these sites is presented in **Figure 16** with key findings as follows:

- As expected in a marine environment, EC was relatively consistent at all sites, with EC around 55 mS/cm throughout the monitoring period.
- Also to be expected in a marine environment, pH was relatively consistent at all sites with pH values between 8.0 and 8.2.
- Water temperature was around 12°C during equipment deployment in late July, with temperature increasing gradually throughout the monitoring period up to a temperature of approximately 23°C in December.
- Dissolved oxygen was relatively consistent at all sites throughout the monitoring period, with DO values between 95% sat and 115% sat, which are typical values in the marine environment.

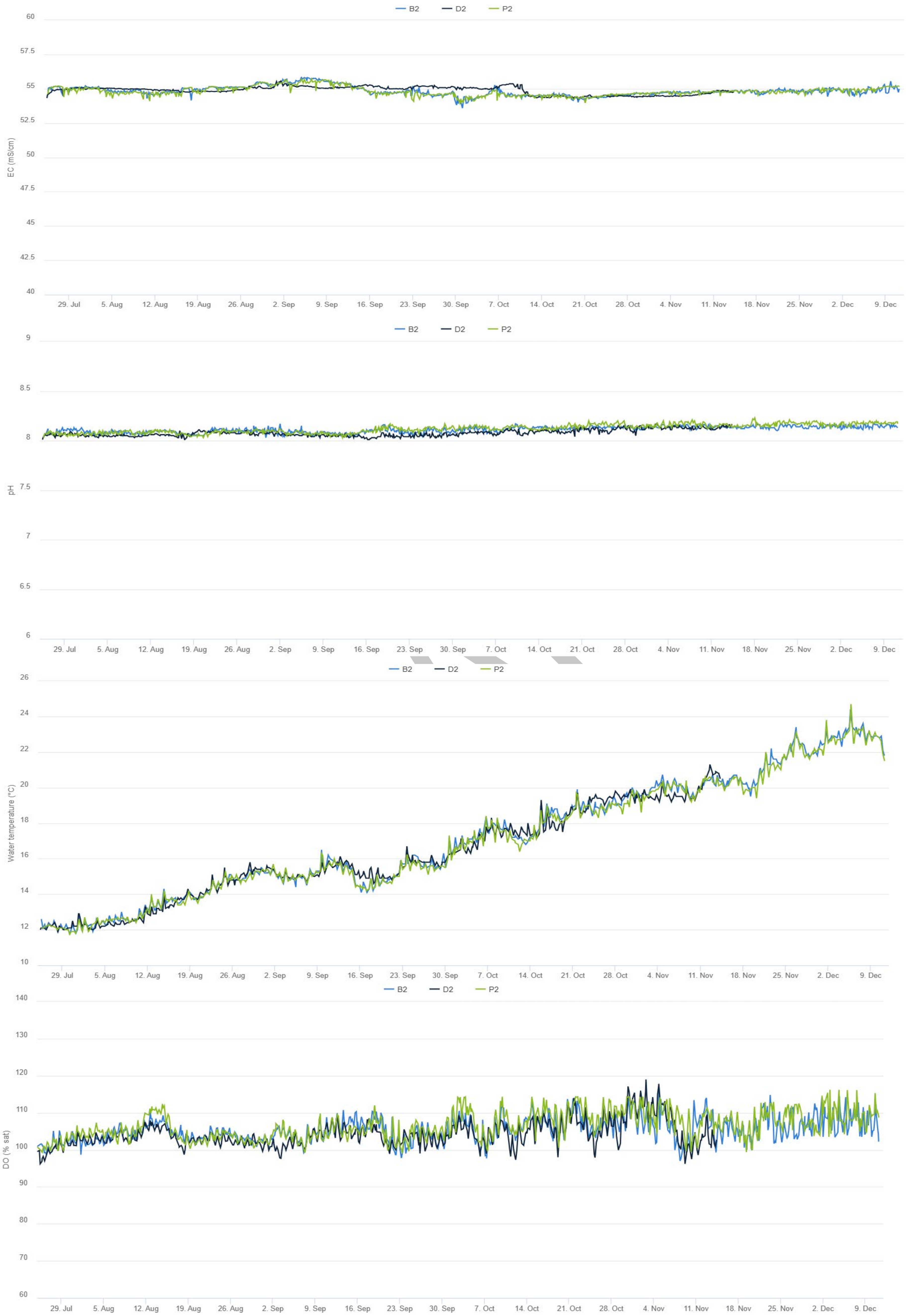


Figure 16. EC (top), pH (mid), water temperature (mid) and DO (bottom) at sites B2, D2 and P2

4.6 TSS/Turbidity Data

Water quality grab samples were collected at each location during deployment, servicing and retrieval trips. These samples were collected from the surface, middle and bottom of the water column to capture a range of concurrent measurements. The data was analysed by a NATA-accredited laboratory for total suspended solids (TSS) and turbidity, and the data was used for the following purposes:

- To calculate a site-specific TSS/turbidity correlation for potential use in future dredge plume modelling studies
- To cross-check sensor readings at surface buoys and benthic instruments.

The laboratory data is presented in **Table 4**. Note that samples collected during deployment on 25 July were analysed by a different laboratory and TSS data was not accurate, so has not been included in **Table 4** or included in the TSS/turbidity correlation analysis. This lack of data is unlikely to be an issue as the correlation would have been low (see below) regardless of whether this data was included or not.

To assess TSS/turbidity correlation, the laboratory data was used to produce a scatter plot with a line of best fit (**Figure 17**). The best correlation was a logarithmic relationship (refer equation in **Figure 17**), with an R^2 value of 0.26. However, this R^2 value is fairly low indicating the correlation between TSS and turbidity is fairly weak. This weak correlation is likely due to samples collected of low TSS/turbidity waters. Ideally, samples would be collected over a broader range of TSS/turbidity values which would likely result in a stronger correlation.

Table 4. TSS and turbidity lab data

Site	Date	TSS (mg/L)	Turbidity (NTU)	Site	Date	TSS (mg/L)	Turbidity (NTU)
P1 TOP	25/07/2024	ND	1.3	D1-TOP	15/10/2024	3.2	0.2
P1 MID	25/07/2024	ND	1.4	D1-MID	15/10/2024	2.8	0.37
P1 BED	25/07/2024	ND	1.3	D1-BED	15/10/2024	1.7	0.13
P2 TOP	25/07/2024	ND	1.3	D2-TOP	15/10/2024	2.6	0.21
P2 MID	25/07/2024	ND	1.3	D2-MID	15/10/2024	3.7	0.21
P2 BED	25/07/2024	ND	1.5	D2-BED	15/10/2024	2.3	0.24
B2 TOP	25/07/2024	ND	< 1	B1-TOP	15/10/2024	1.9	0.2
B2 MID	25/07/2024	ND	< 1	B1-MID	15/10/2024	1.7	0.33
B2 BED	25/07/2024	ND	1.5	B1-BED	15/10/2024	2.6	0.54
D1 TOP	25/07/2024	ND	1.3	P1-TOP	15/10/2024	8.3	0.29
D1 MID	25/07/2024	ND	1.3	P1-MID	15/10/2024	1.4	0.37
D1 BED	25/07/2024	ND	2.1	P1-BED	15/10/2024	< 1	0.26
D2 TOP	25/07/2024	ND	1.3	P2-TOP	15/10/2024	3.4	0.4
D2 MID	25/07/2024	ND	1.6	P2-MID	15/10/2024	2.8	0.63
D2 BED	25/07/2024	ND	1.3	P2-BED	15/10/2024	2.1	0.3
B1 TOP	25/07/2024	ND	2	B2-TOP	15/10/2024	1.9	0.34
B1 MID	25/07/2024	ND	1.4	B2-MID	15/10/2024	3.5	0.53
B1 BED	25/07/2024	ND	1.1	B2-BED	15/10/2024	< 1	0.22
P1 TOP	5/09/2024	7.8	3.4	P1-TOP	14/11/2024	1.3	0.65
P1 MID	5/09/2024	6.9	3.4	P1- MID	14/11/2024	1.3	0.5
P1 BED	5/09/2024	5.6	4.2	P1- BED	14/11/2024	1.6	0.26
P2 TOP	5/09/2024	3.8	3.8	P2- TOP	14/11/2024	< 1	0.56
P2 MID	5/09/2024	2.1	2.8	P2- MID	14/11/2024	< 1	0.29
P2 BED	5/09/2024	3	2.9	P2- BED	14/11/2024	1.7	0.24
B2 TOP	5/09/2024	4.1	2.4	B2- TOP	14/11/2024	1.9	< 0.1
B2 MID	5/09/2024	4.6	3.3	B2- MID	14/11/2024	< 1	0.14
B2 BED	5/09/2024	3.6	2	B2- BED	14/11/2024	1.1	0.24
D1 TOP	5/09/2024	12	0.87	D1- TOP	14/11/2024	1.2	0.22
D1 MID	5/09/2024	5	1	D1- MID	14/11/2024	< 1	0.16
D1 BED	5/09/2024	3	0.89	D1- BED	14/11/2024	< 1	0.16
D2 TOP	5/09/2024	5.3	0.98	D2- TOP	14/11/2024	< 1	0.25

D2 MID	5/09/2024	4.6	1.3	D2- MID	14/11/2024	< 1	0.1
D2 BED	5/09/2024	3.9	1.1	D2- BED	14/11/2024	< 1	0.16
B1 TOP	5/09/2024	3.5	1	B2- TOP	14/11/2024	2.3	0.35
B1 MID	5/09/2024	2.5	1.2	B2- MID	14/11/2024	2.1	0.96
B1 BED	5/09/2024	7.4	0.76	B2- BED	14/11/2024	2.6	0.84

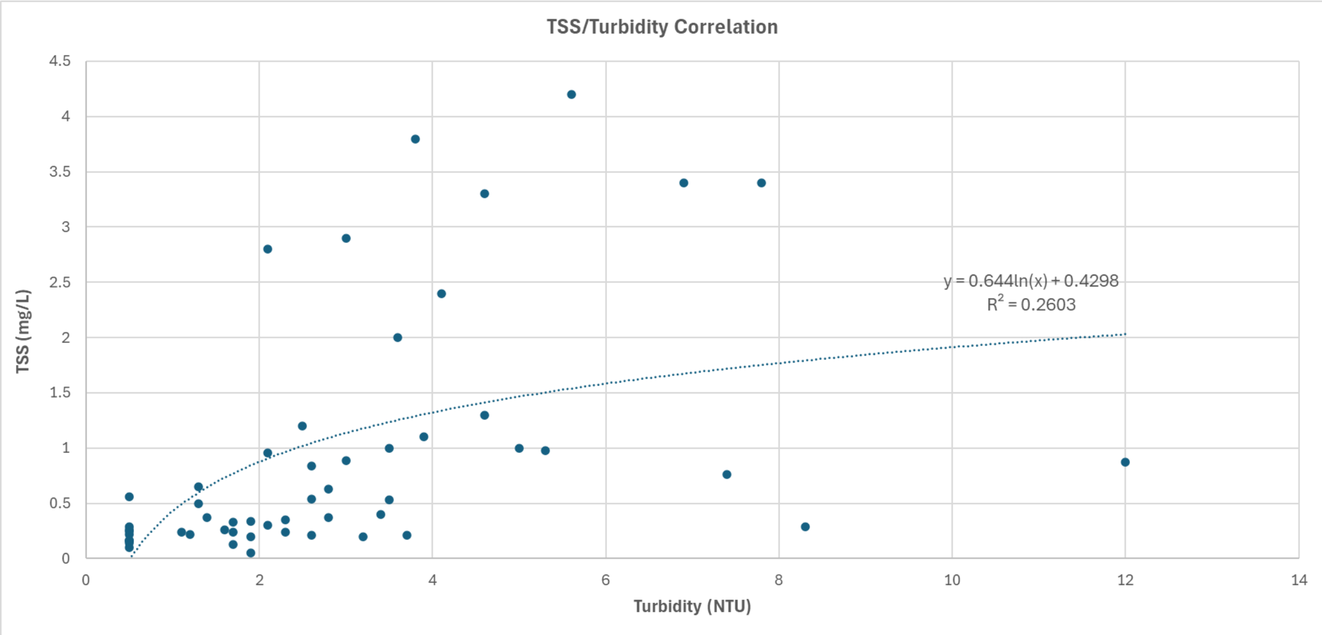


Figure 17. TSS/turbidity correlation

4.7 Satellite Imagery

The satellite-inferred turbidity maps are included in **Appendix A**. During cloud-free periods (when satellite data is useful), generally the maps confirm the turbidity readings collected at the surface monitoring buoys. However, due to the course resolution of the MODIS images (250 m grid), the resolution in the nearshore areas (where the dredging/placement areas and monitoring sites are located) was often poor (refer to **Figure 18** for an example). This is a limitation of using the MODIS images, which are more suited to areas further offshore.

Despite the limitations, the satellite data was able to confirm there was no evidence of dredge plumes mobilised into offshore waters that were missed by the deployed instrumentation.

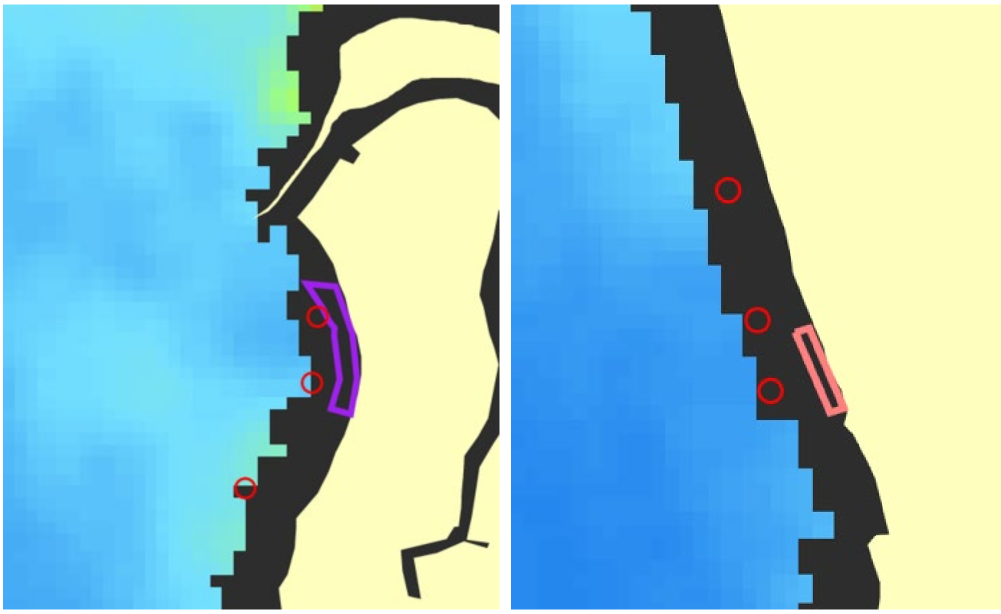


Figure 18. Example of poor satellite image resolution in nearshore areas – North Haven (left) and West Beach (right)

4.8 Exceedances and Adaptive Management

As mentioned in **Section 4.3**, there were no exceedances of the water quality trigger levels during the dredging period. Therefore, there was no requirement for implementation of adaptive management measures in accordance with the dredge management plan.

5 RECOMMENDATIONS

Based on findings from implementation of the WQMP, the following key recommendations are provided to inform future water quality monitoring activities.

Benthic data

As shown in the monitoring data, surface turbidity and benthic turbidity displayed similar fluctuations, with increases in turbidity coincident with increased wind and wave action. This indicates that surface turbidity is a good indicator of patterns in benthic turbidity in the study area.

However, while benthic turbidity had a similar pattern to surface turbidity, there was more noise in the data, with turbid spikes occurring more often compared to surface data. This was likely due to sensor interference from seagrass wrack and other benthic influences. If benthic data is used for real-time processing, alerts and dredge management, then the increased sensor interference from benthic sensors would make processing of data more difficult and prone to false exceedances.

Another consideration is the logistics involved in bringing real-time benthic data to a surface telemetry station (e.g. buoy), which typically involves cables or acoustic modems, both of which have limitations, especially in active coastal environments like the Adelaide beaches.

Recommendation – for future dredging compliance monitoring programs, it is recommended that real-time data (and associated alerts) is limited to surface monitoring instruments only. If benthic data is required (e.g. PAR sensors), it is recommended this is limited to internal logging instruments which are downloaded routinely with data post-processed.

Satellite data

For dredging projects, MODIS satellite images are often used to track dredge plumes as the satellites pass over an area twice per day, where other satellites are much less frequent. However, MODIS images have a coarse resolution (250 m grid), which can result in shoreline interference in nearshore areas.

For this project, as the dredging/placement areas and monitoring sites were located in nearshore areas, the satellite inferred turbidity in these areas was often poor resolution (as shown in **Figure 18**). This is a limitation of using the MODIS images, which are more suited to areas further offshore.

Recommendation – for future dredging compliance monitoring programs in nearshore areas, MODIS satellite imagery may be of limited value. Therefore, it is recommended that for future dredging programs in nearshore areas, higher resolution (but less frequent) Sentinel satellite imagery should be used, possibly combined with opportunistic drone imagery (when weather conditions permit).

However, for dredging activities further offshore (i.e. further than ~1 km from shore), MODIS imagery would be more valuable to track dredge plumes.

TSS/turbidity

A TSS to turbidity correlation is typically required where turbidity needs to be converted to TSS or vice versa. Typical applications include dredge plume modelling (which need to convert TSS model outputs into turbidity plume impact maps) and approval conditions where criteria are specified as TSS (e.g. dredging tailwater).

For this project, samples were collected during equipment deployment and servicing trips at all sites to produce a TSS/turbidity correlation that could be used for future modelling studies. However, as shown in **Section 4.6**, the correlation between TSS and turbidity data was fairly weak. This weak correlation is likely due to samples collected of low TSS/turbidity waters. Ideally, samples would be collected over a broader range of TSS/turbidity values which would likely result in a stronger correlation.

Recommendation – if TSS/turbidity correlation is required for future modelling studies, it is recommended that a targeted sampling campaign be undertaken to collect a range of water quality samples, from clear waters to turbid waters. Ideally samples would be collected within turbid dredge plumes. The duration of sampling is not important (i.e. can be collected in a single sampling event), however the number of samples (at least 10) and type of samples (low turbidity to high turbidity) is important.

6 SUMMARY

Epic were engaged by DEW to develop and implement a marine WQMP during dredging and placement undertaken as part of a dredging trial for the ABMRI project.

Monitoring equipment was deployed on 25 July 2024 to commence pre-dredging water quality monitoring. Dredging commenced at Noth Haven on 3 October 2024 and ceased on 21 October. Dredging commenced at West Beach on 30 October 20024 and continued until 30 November 2024.

Monitoring comprised a combination of surface monitoring using monitoring buoys and benthic loggers deployed on benthic frames. Key findings from the turbidity data includes the following:

- Turbidity fluctuated from around 0.3 NTU during calm conditions and up to 15–20 NTU during windier periods. The highest turbidity was recorded in late August (prior to dredging) during a period of sustained strong winds from the south-west. These stronger wind periods resulted in increased wave action causing natural resuspension of sediments and increased turbidity.
- Turbidity appeared to be strongly corelated with wave height, with increases in turbidity coincident with increased wave height. There was no discernible signal of dredge plumes in the turbidity data.
- The 6-day and 15-day rolling median turbidity data indicated that turbidity remained below the trigger values during dredging periods, even using the more stringent November trigger values.
- There were no exceedances of the water quality trigger levels during the dredging period. Therefore, there was no requirement for implementation of adaptive management measures in accordance with the dredge management plan.
- As expected in a marine environment, EC, pH and DO were relatively consistent at all sites throughout the monitoring period, and were consistent with values typically recorded in the marine environment.
- Water temperature was around 12°C during equipment deployment in late July, with temperature increasing gradually throughout the monitoring period up to a temperature of approximately 23°C in December.

Key learnings from the monitoring program included the following:

- Based on assessment of surface and benthic turbidity data, it is recommended that telemetered surface monitoring buoys should be a key inclusion in dredge monitoring programs. The data suggests that near-surface turbidity provides a good representation of the turbidity regime throughout the water column, but is less susceptible to sensor interference from seagrass wrack and other benthic influences associated with benthic instruments. Furthermore, the logistics involved in bringing real-time benthic data to a surface telemetry station adds additional complexity and fragility to a monitoring program.
- If benthic data is required (e.g. PAR sensors), it is recommended this is limited to internal logging instruments which are downloaded routinely with data post-processed.
- For future dredging programs in nearshore areas, higher resolution (but less frequent) Sentinel satellite imagery should be used instead of lower resolution MODIS imagery. This could possibly be combined with opportunistic drone imagery (when weather conditions permit).

7 REFERENCES

BMT (2019). *Adelaide Outer Harbor Channel Widening Project: Environmental Monitoring Program*. Report prepared for Flinders Ports.

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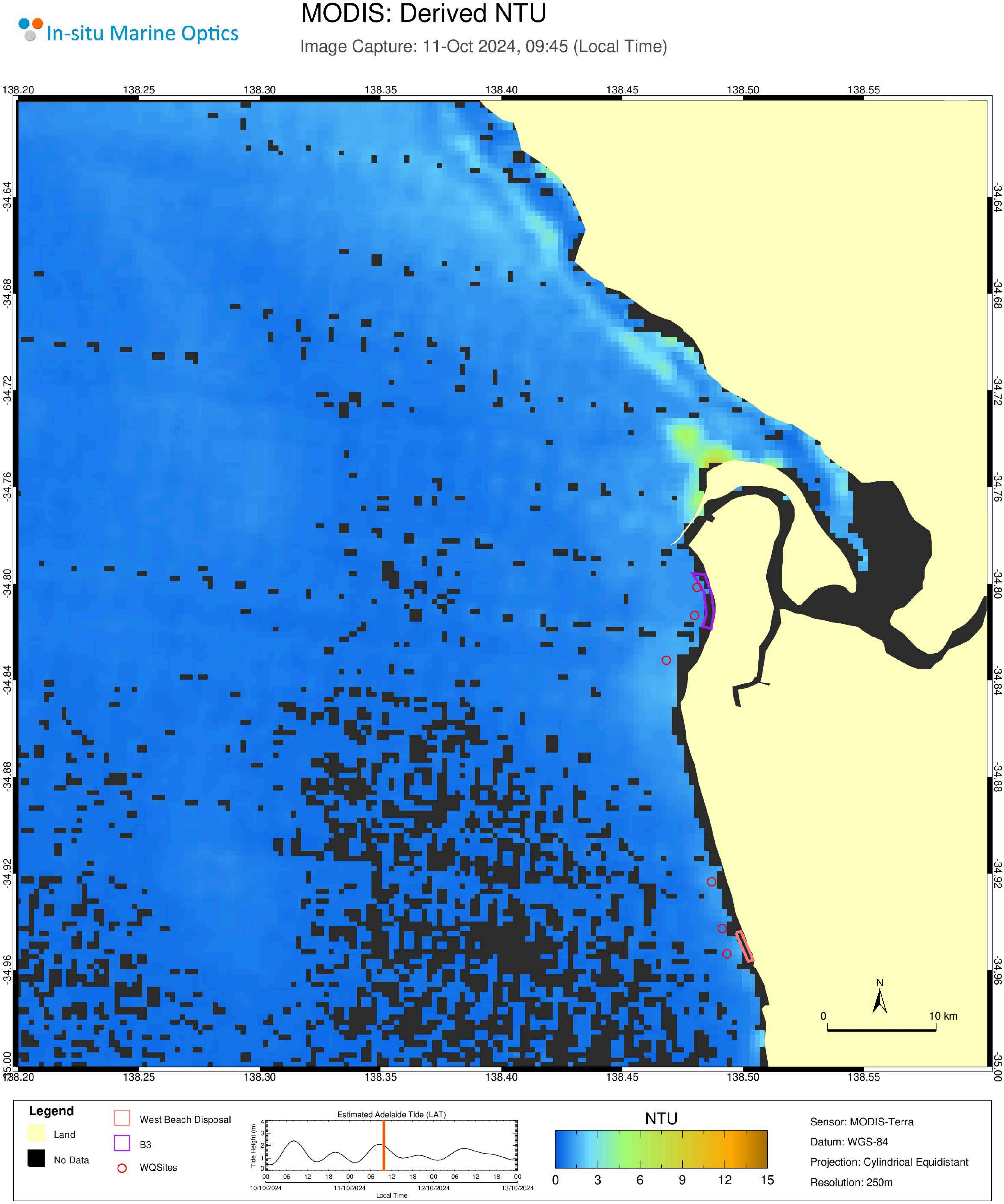
APPENDIX A SATELLITE-INFERRED TURBDITY MAPS

MODIS: Derived NTU

Image Capture: 11-Oct 2024, 09:45 (Local Time)



In-situ Marine Optics

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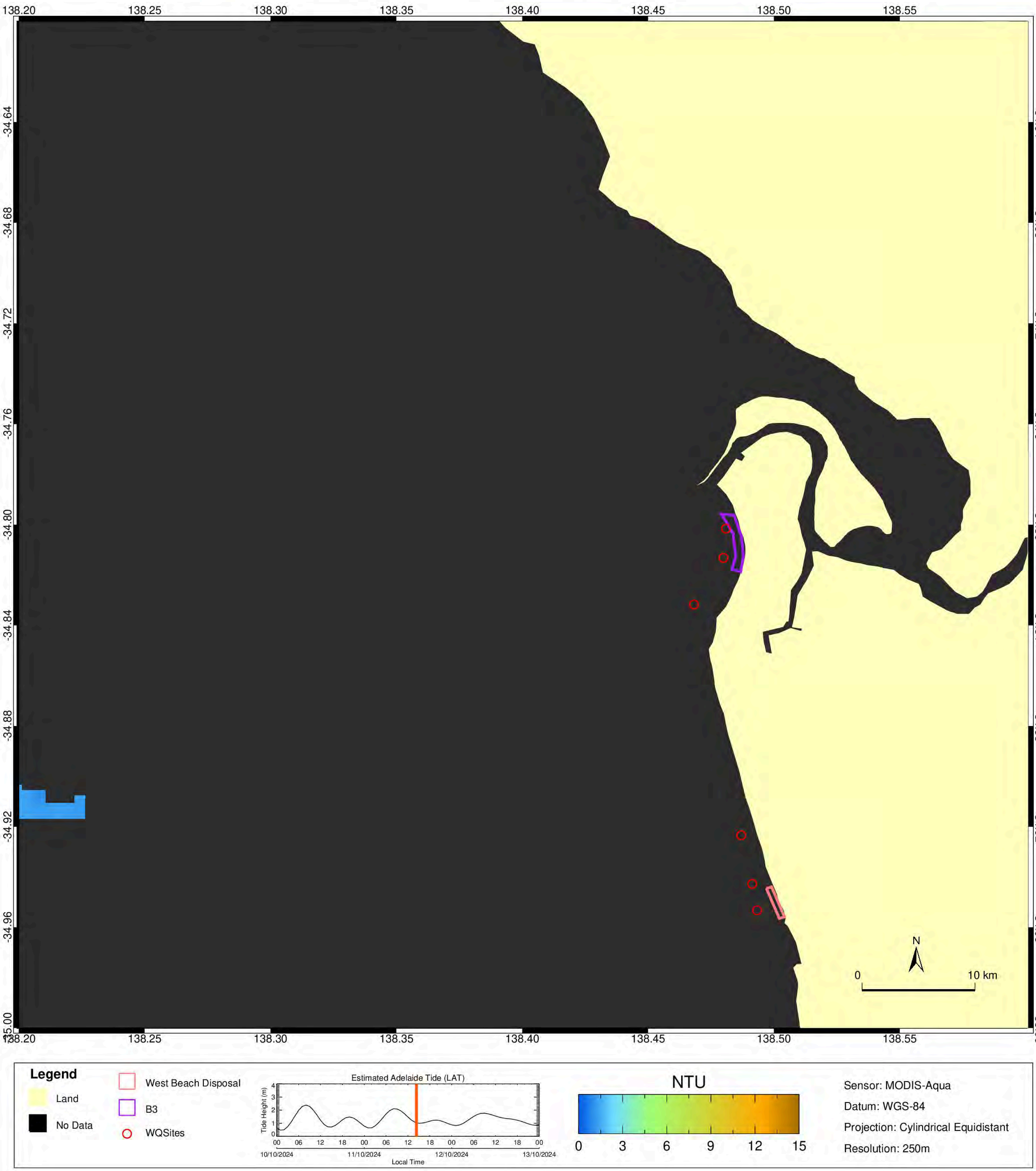

In-situ Marine Optics

MODIS: Derived NTU

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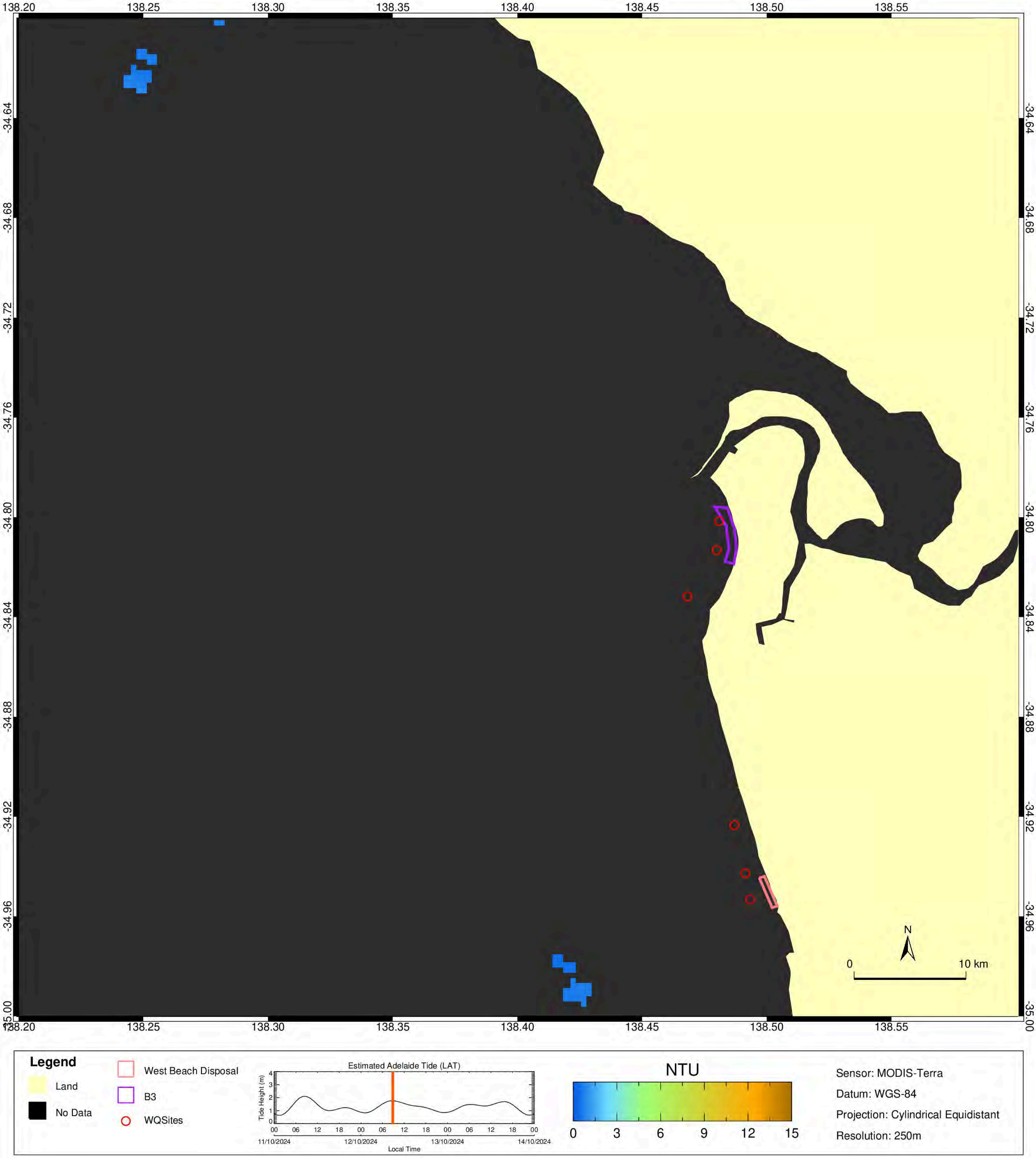


In-situ Marine Optics
MODIS: Derived NTU
Image Capture: 12-Oct 2024, 15:00 (Local Time)
138.20
138.25
138.30
138.35
138.40
138.45
138.50
138.55
-34.64
-34.68
-34.72
-34.76
-34.80
-34.84
-34.88
-34.92
-34.96
-35.00
N
0
10 km
Legend
Land
No Data
West Beach Disposal
B3
WQSites
Estimated Adelaide Tide (LAT)
Tide Height (m)
Local Time
11/10/2024
12/10/2024
13/10/2024
14/10/2024
NTU
0
3
6
9
12
15
Sensor: MODIS-Aqua
Datum: WGS-84
Projection: Cylindrical Equidistant
Resolution: 250m

In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 13-Oct 2024, 09:30 (Local Time)

Legend

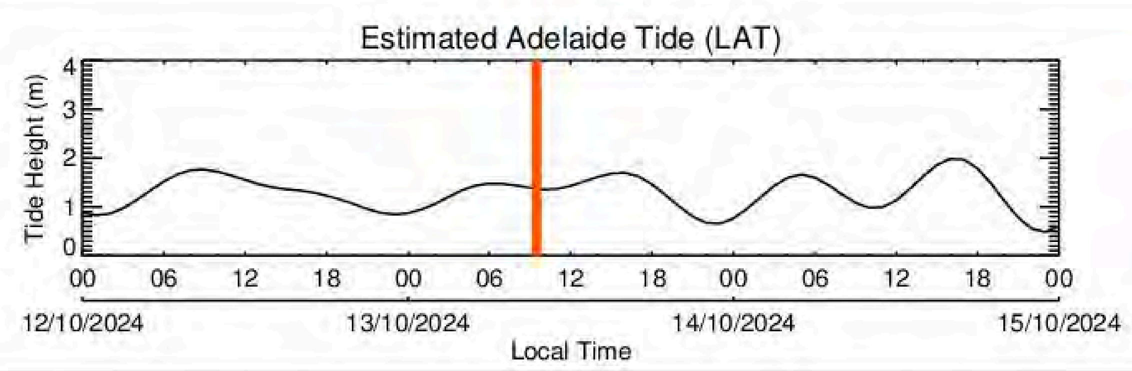
Land

No Data

West Beach Disposal

B3

WQSites



NTU

0 3 6 9 12 15

Sensor: MODIS-Terra

Datum: WGS-84

Projection: Cylindrical Equidistant

Resolution: 250m

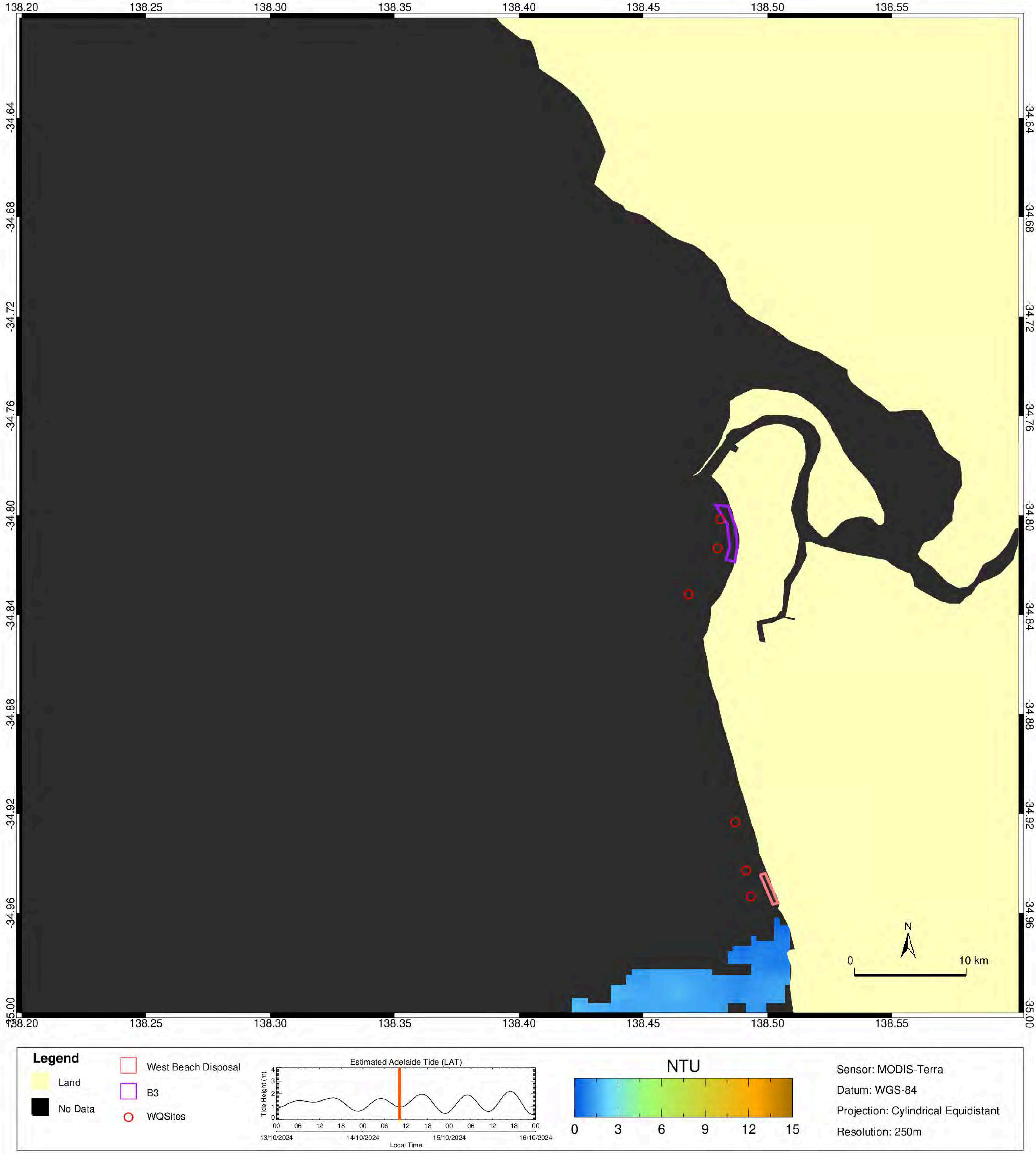
MODIS: Derived NTU

Image Capture: 13-Oct 2024, 15:40 (Local Time)

In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 14-Oct 2024, 10:10 (Local Time)



MODIS: Derived NTU

In-situ Marine Optics

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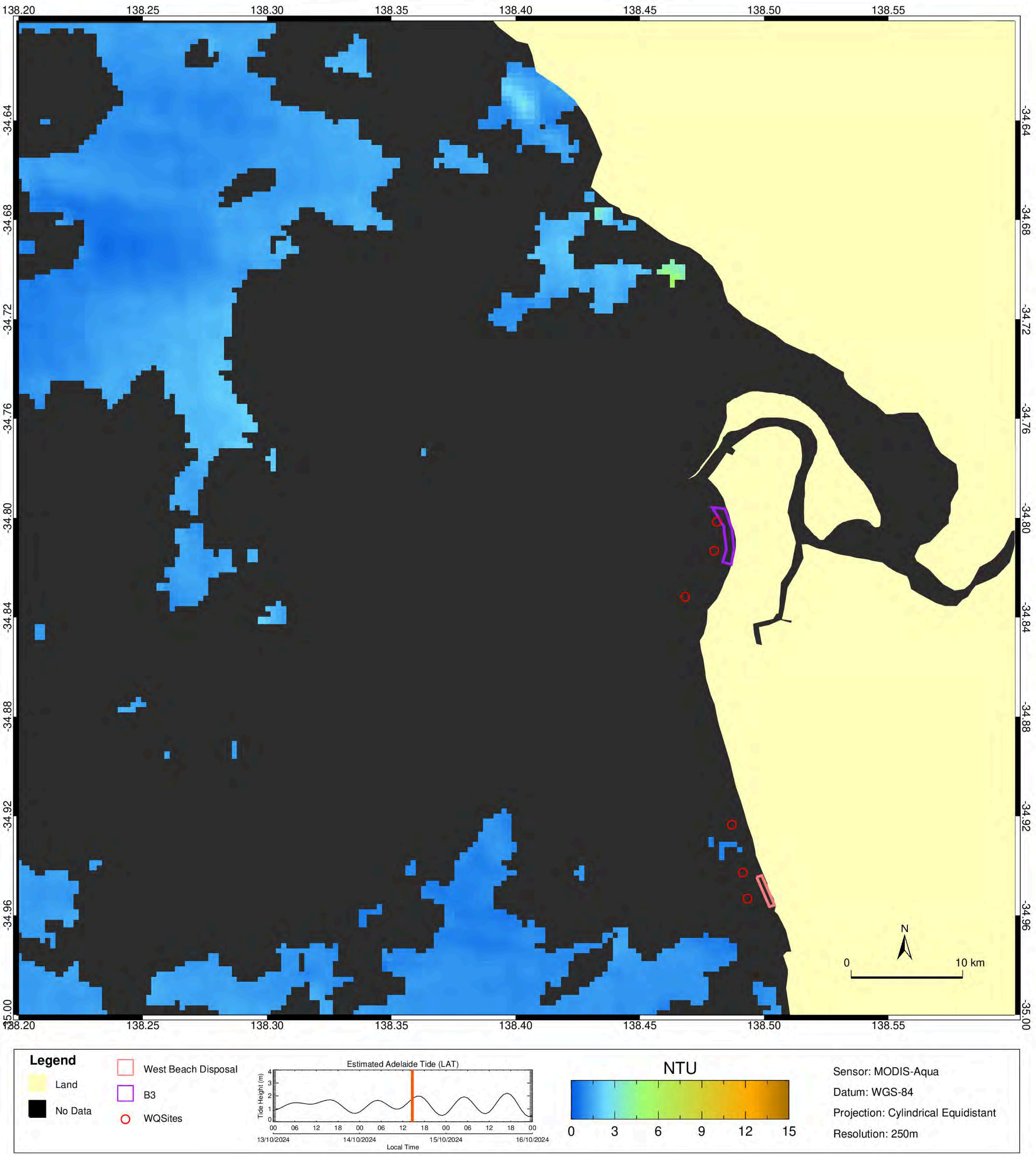

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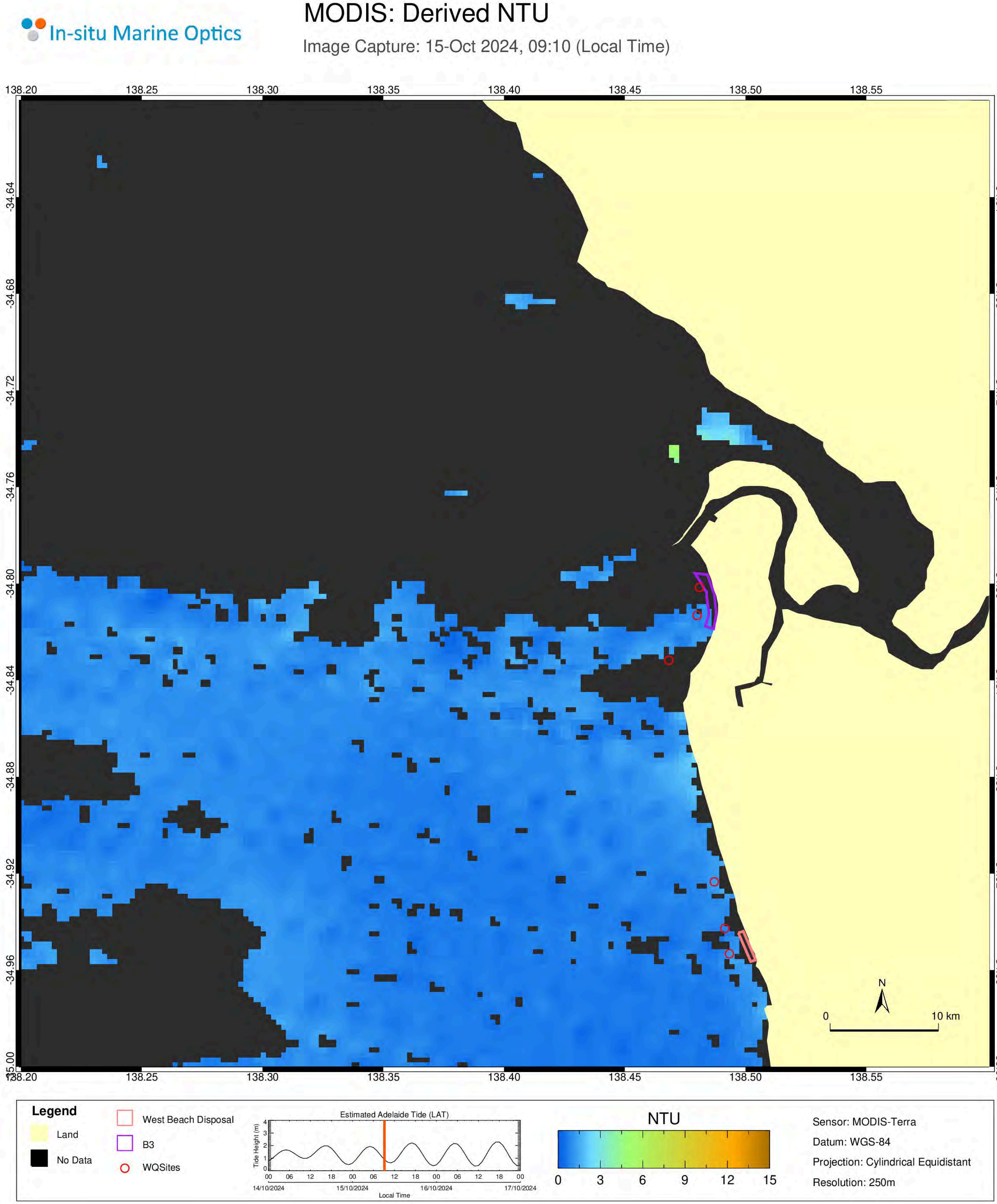

In-situ Marine Optics

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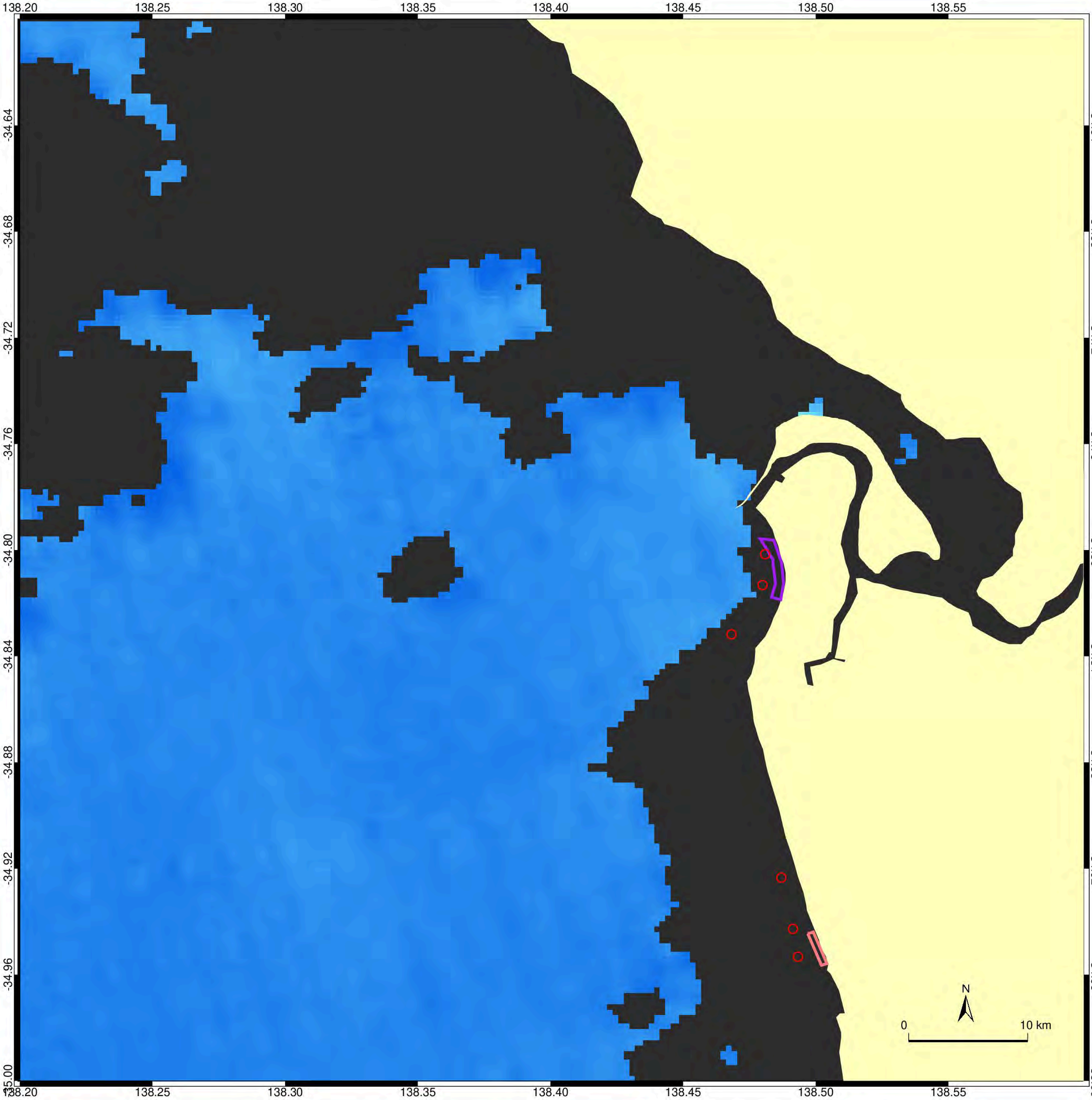


Legend

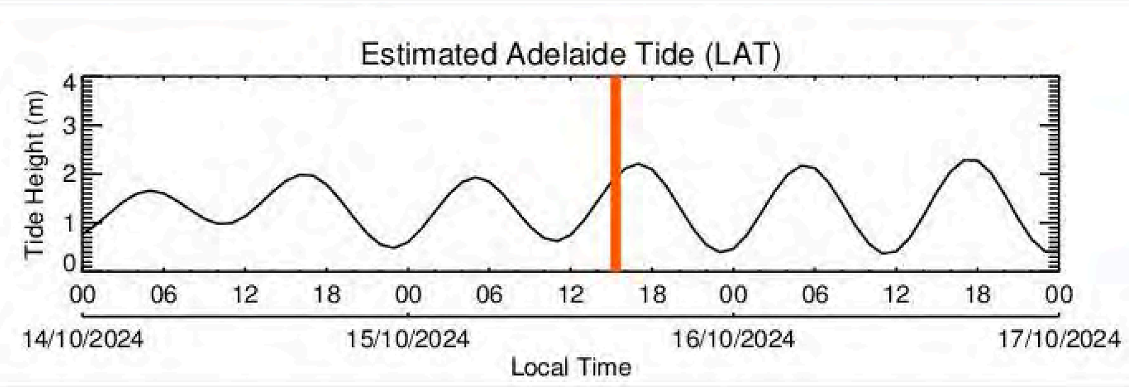
Land

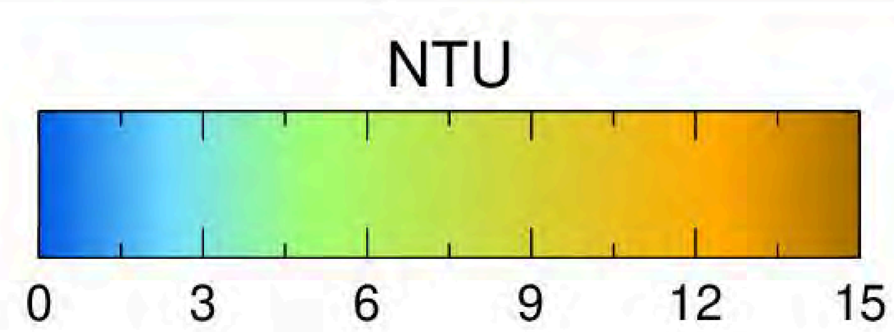
No Data

West Beach Disposal

B3

WQSites





Sensor: MODIS-Aqua

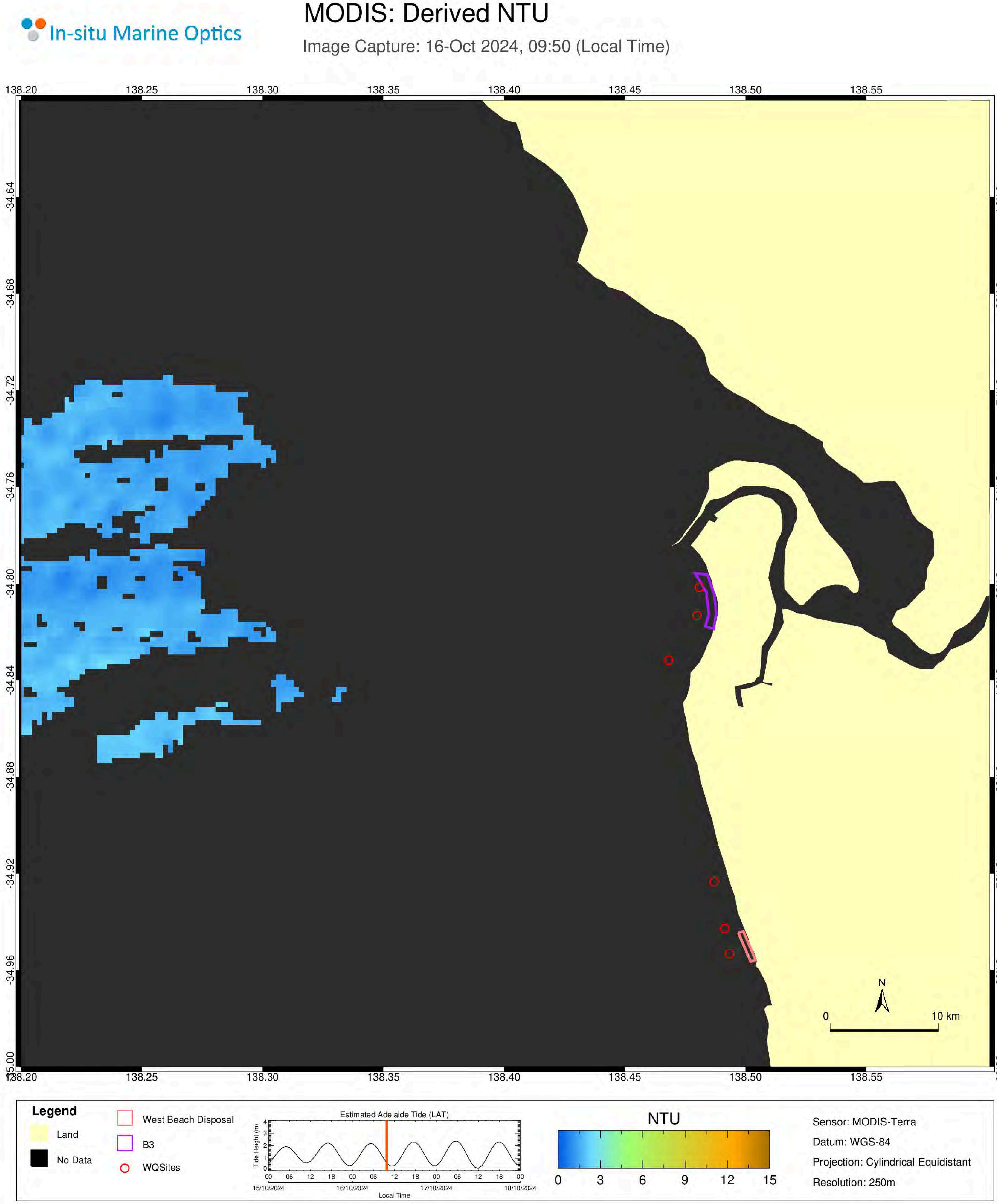
Datum: WGS-84

Projection: Cylindrical Equidistant

Resolution: 250m

MODIS: Derived NTU

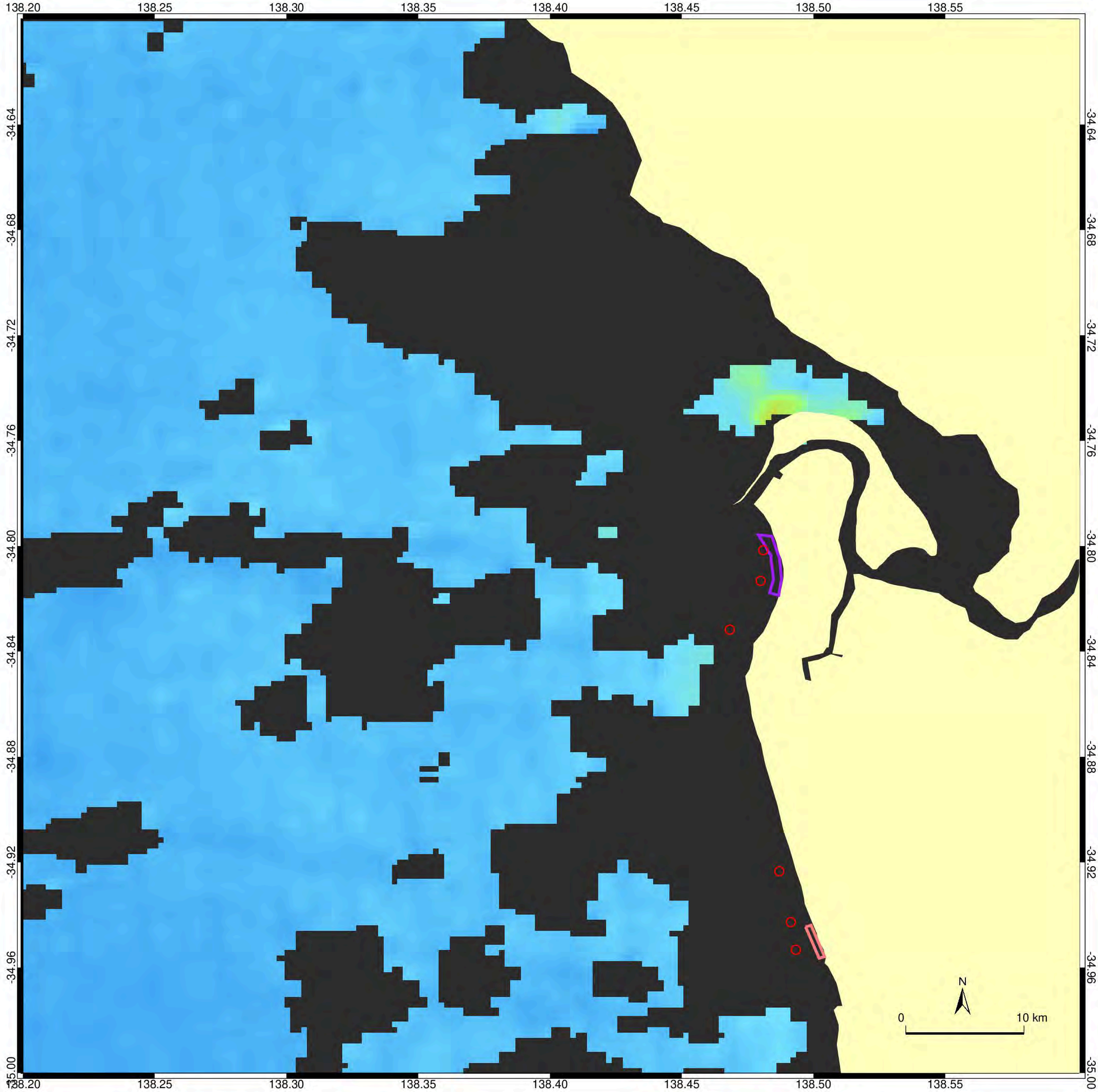
Image Capture: 16-Oct 2024, 09:50 (Local Time)

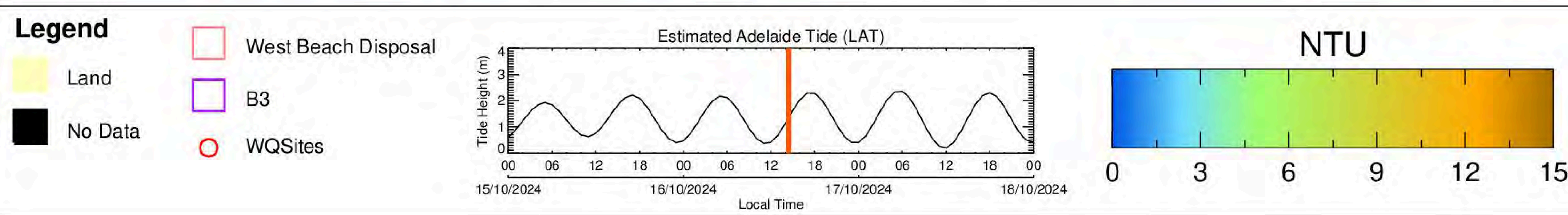


In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 16-Oct 2024, 14:25 (Local Time)





Sensor: MODIS-Aqua

Datum: WGS-84

Projection: Cylindrical Equidistant

Resolution: 250m

MODIS: Derived NTU

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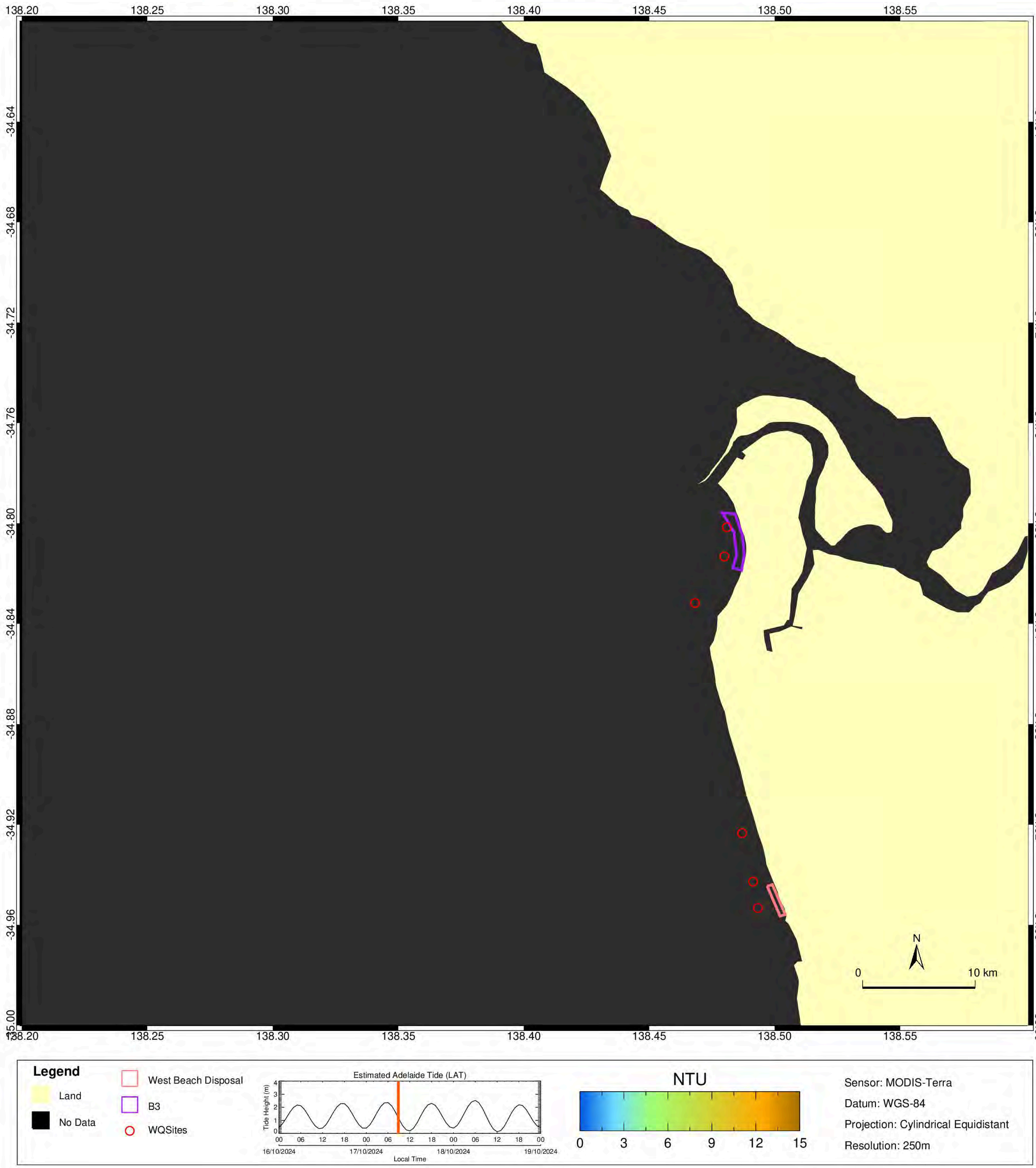

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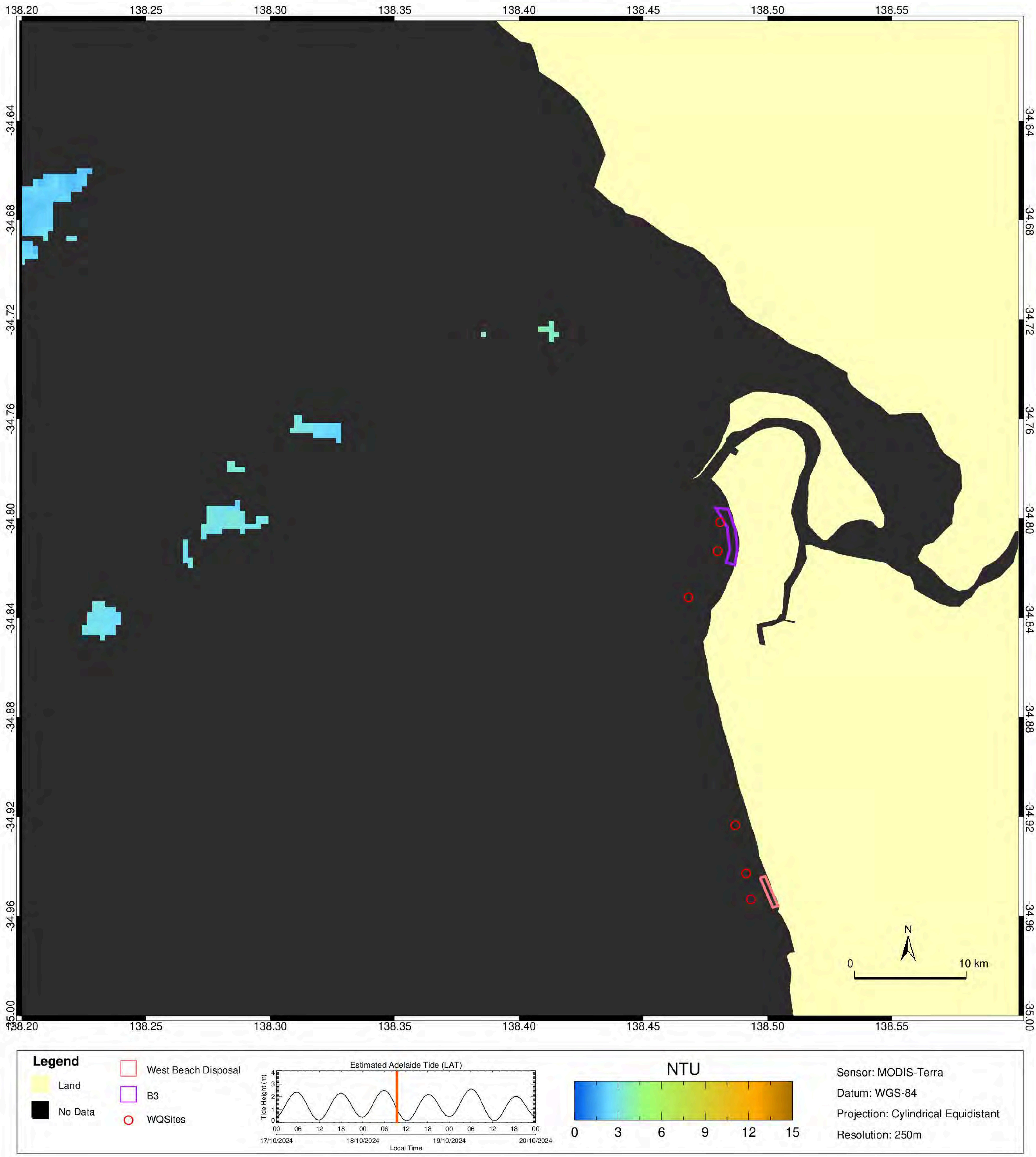
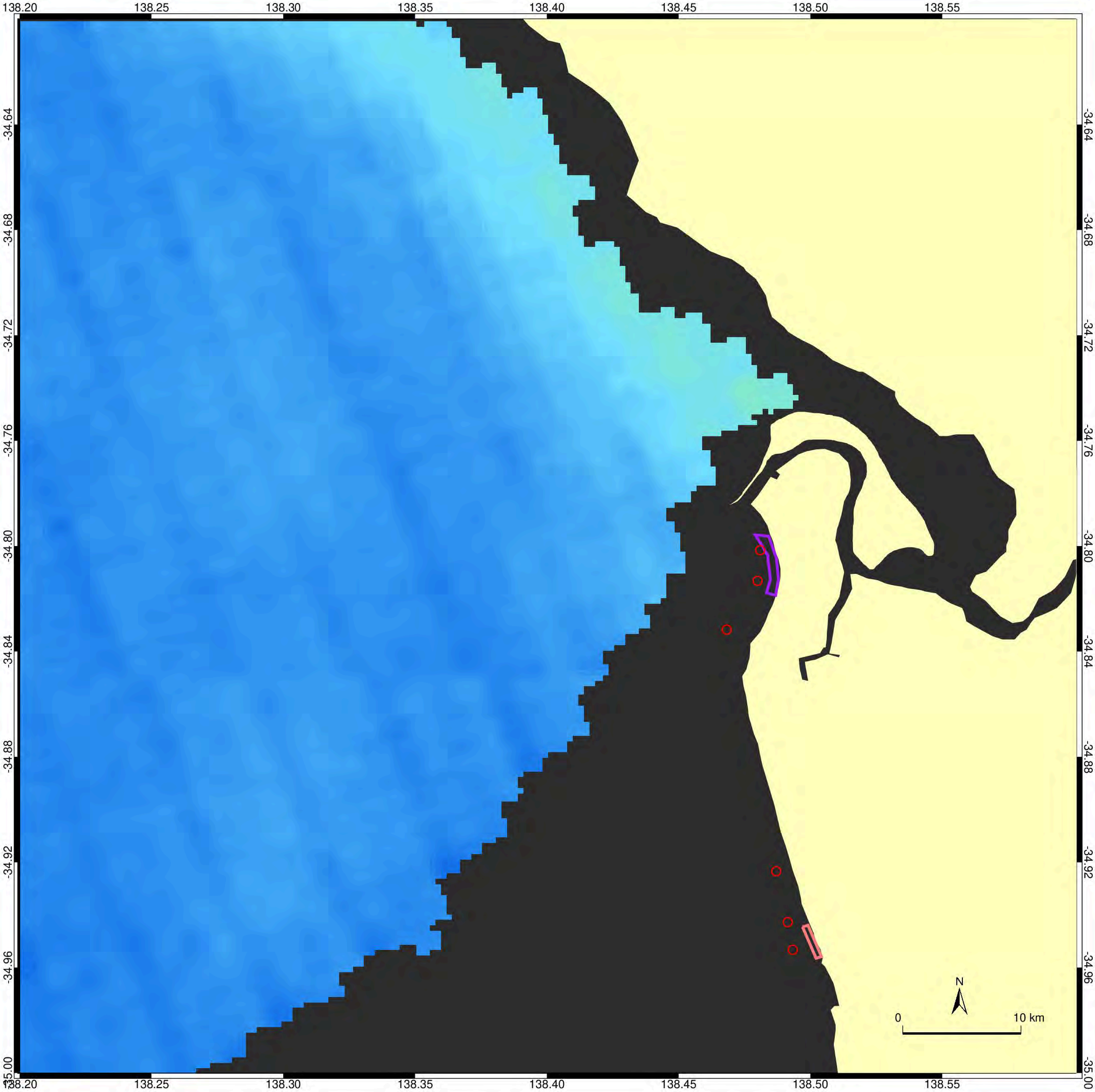
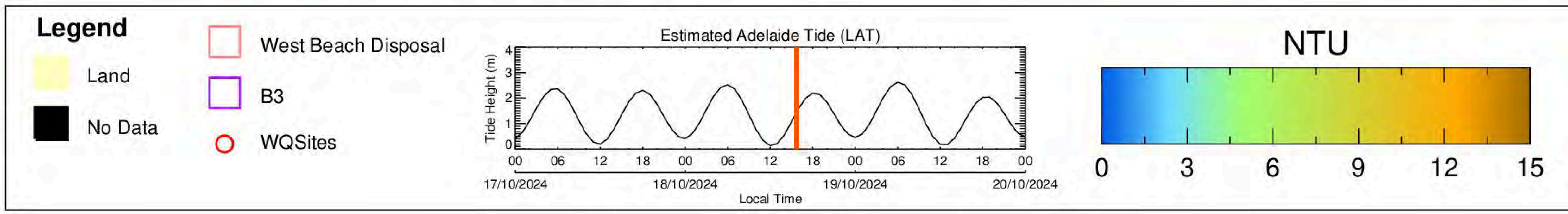


In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 18-Oct 2024, 15:45 (Local Time)





Sensor: MODIS-Aqua

Datum: WGS-84

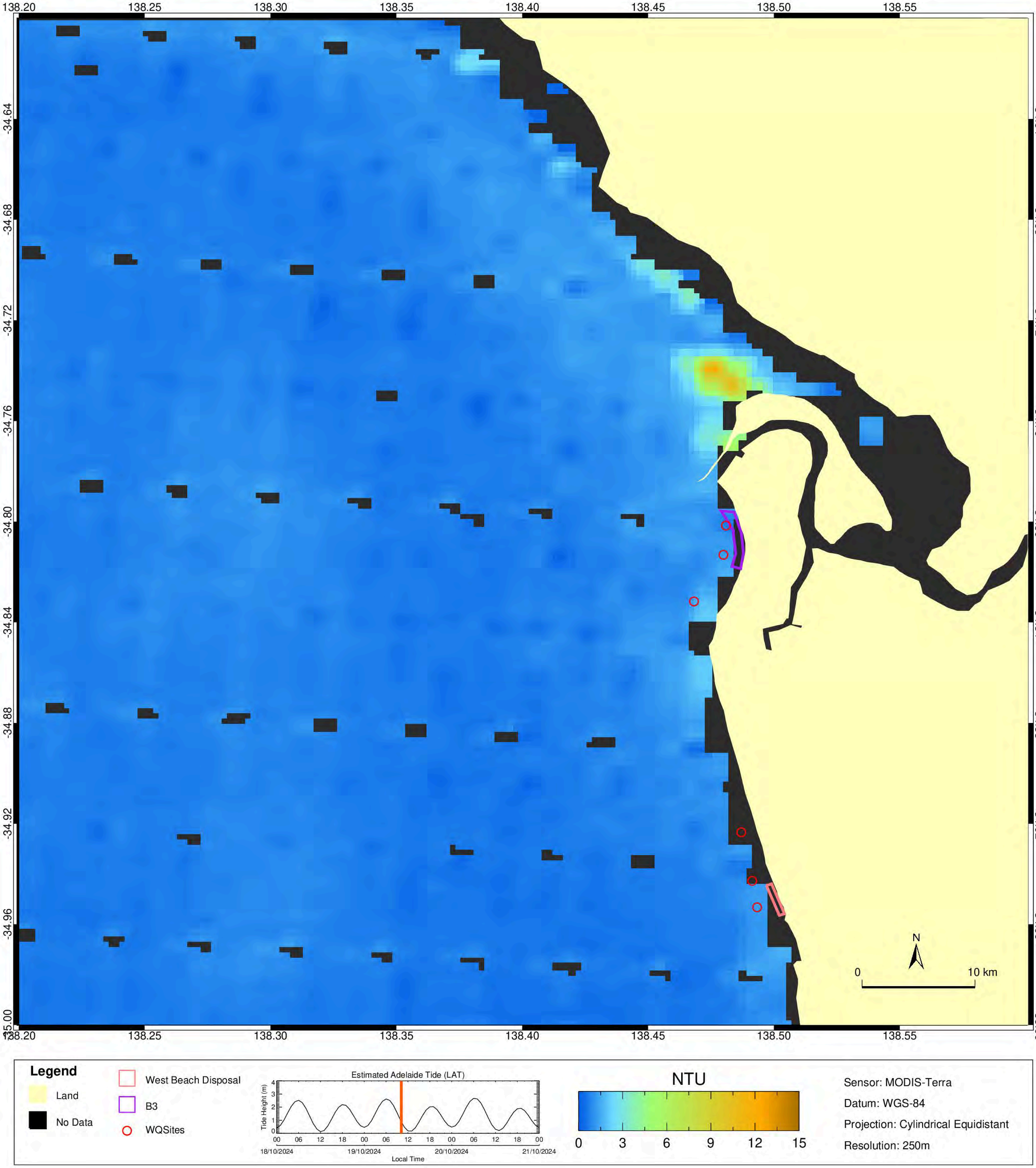
Projection: Cylindrical Equidistant

Resolution: 250m

In-situ Marine Optics

MODIS: Derived NTU

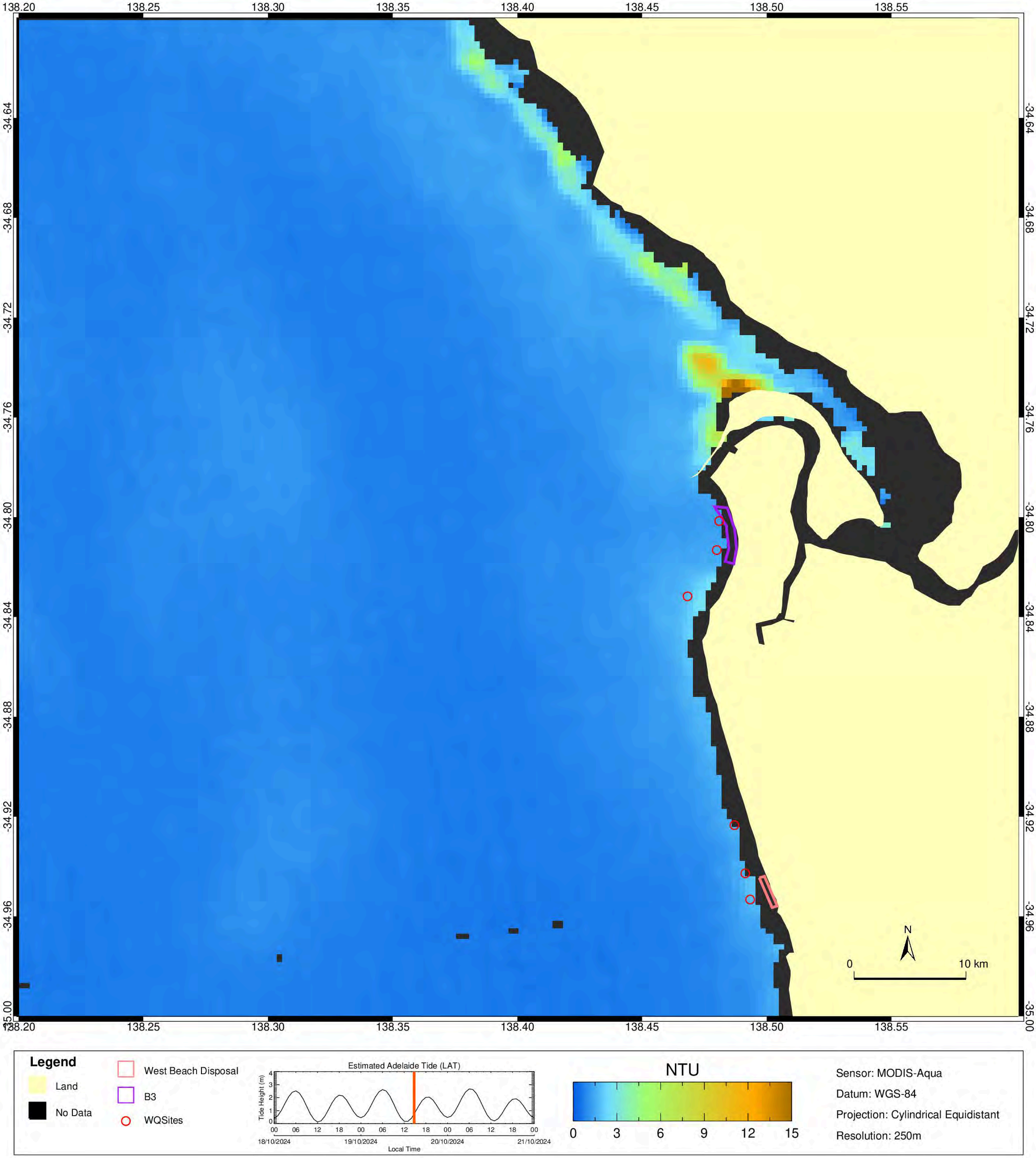
Image Capture: 19-Oct 2024, 10:10 (Local Time)



In-situ Marine Optics

MODIS: Derived NTU

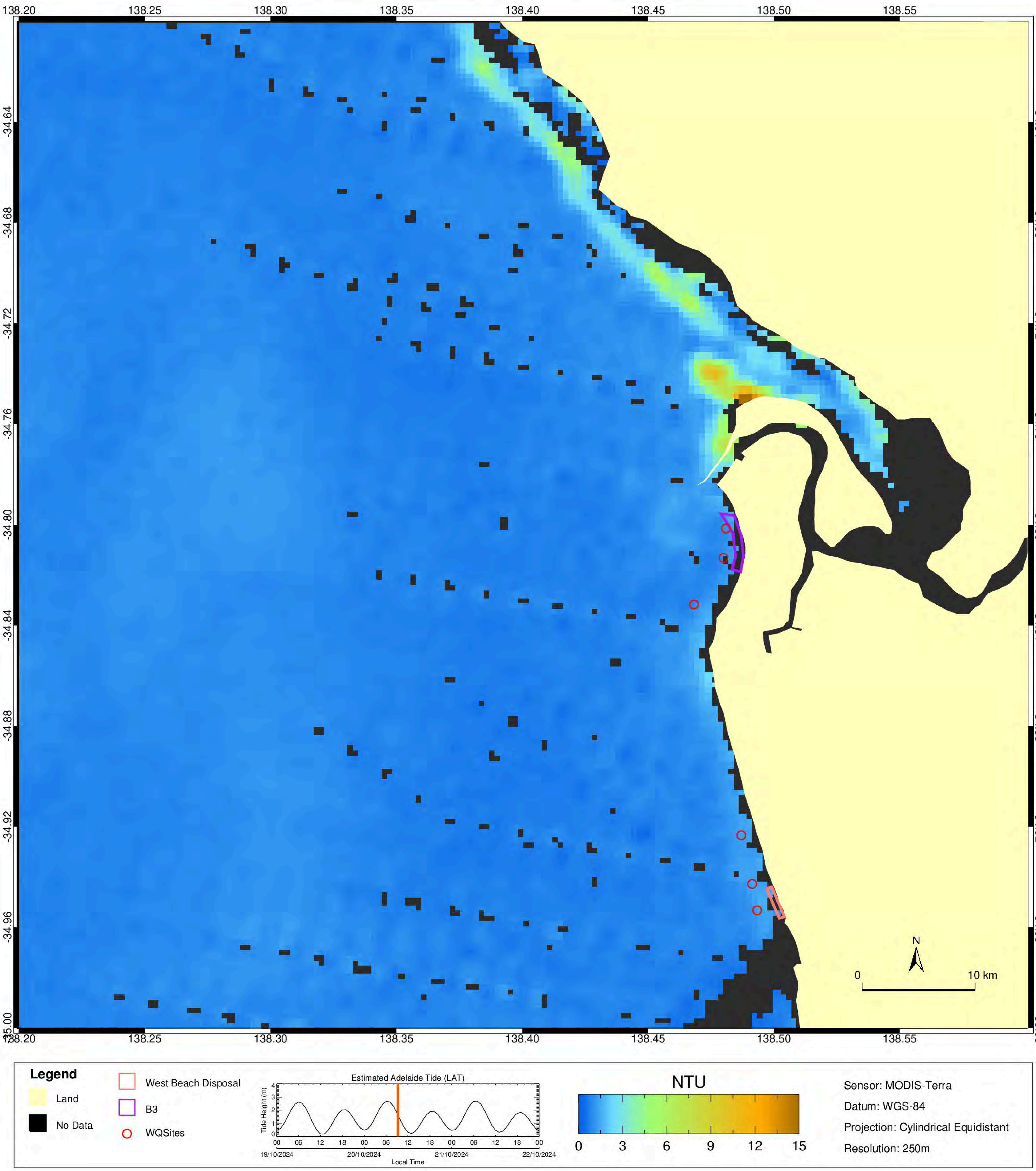
Image Capture: 19-Oct 2024, 14:45 (Local Time)



In-situ Marine Optics

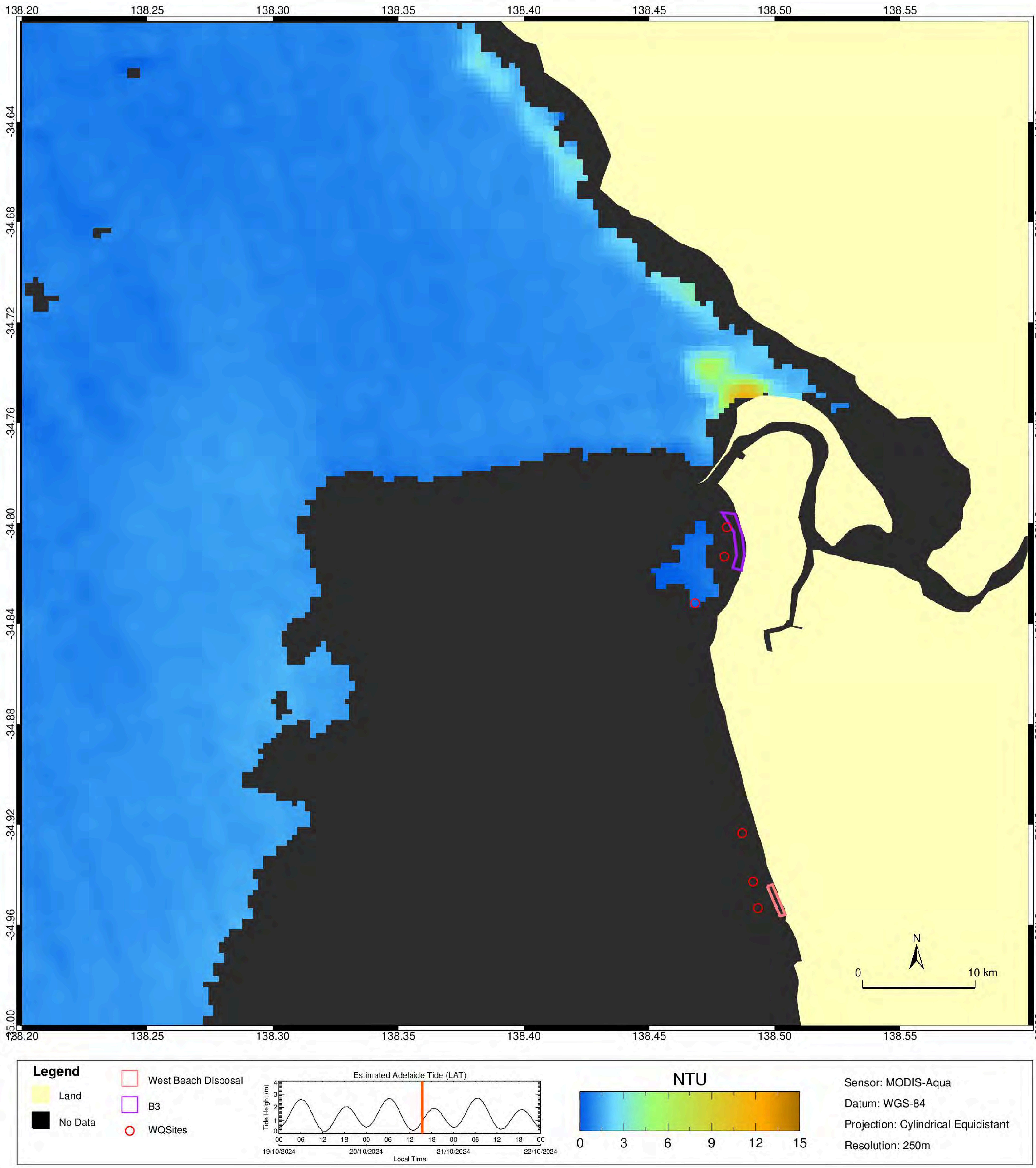
MODIS: Derived NTU

Image Capture: 20-Oct 2024, 09:15 (Local Time)



MODIS: Derived NTU

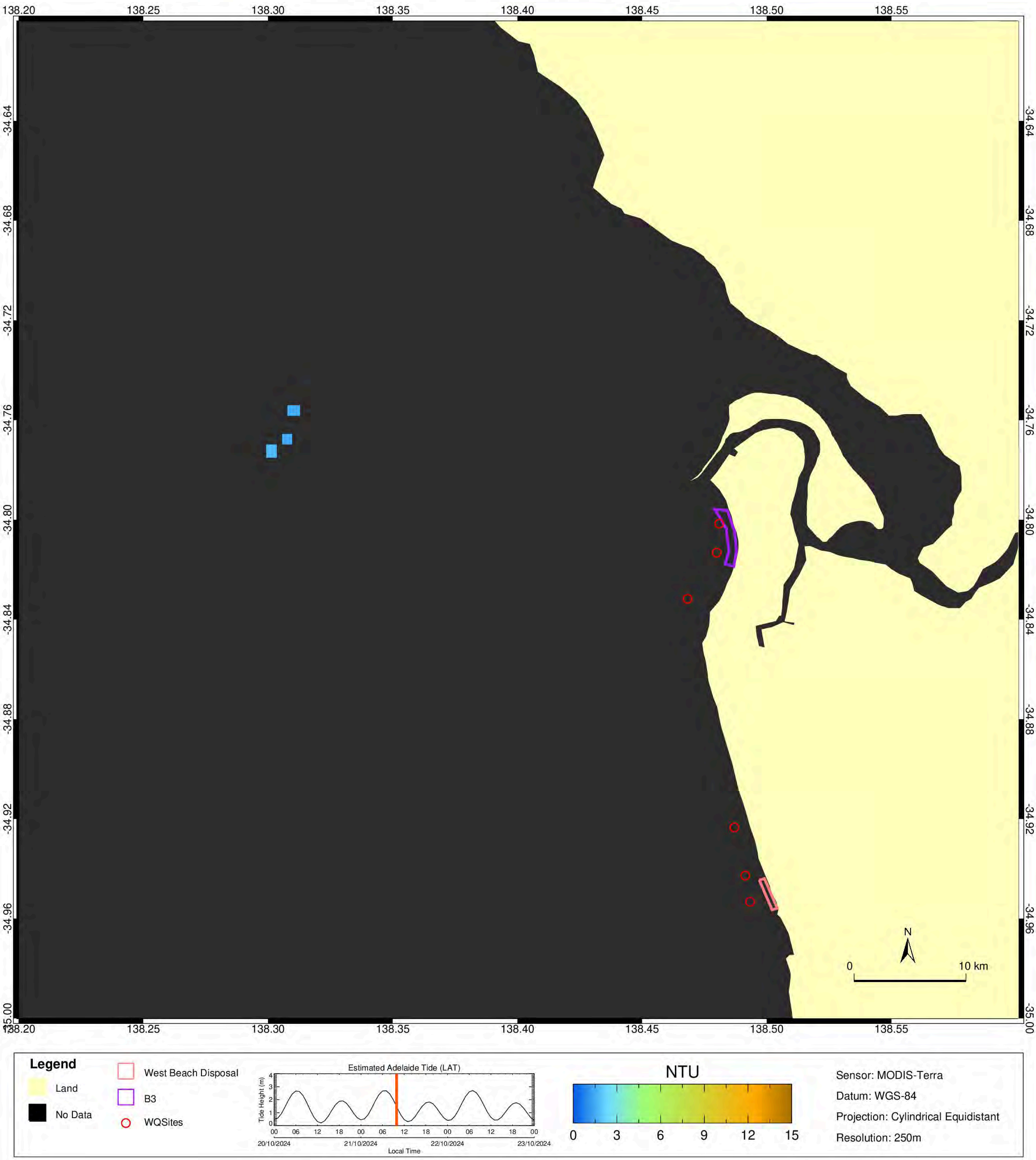
Image Capture: 20-Oct 2024, 15:25 (Local Time)



In-situ Marine Optics

MODIS: Derived NTU

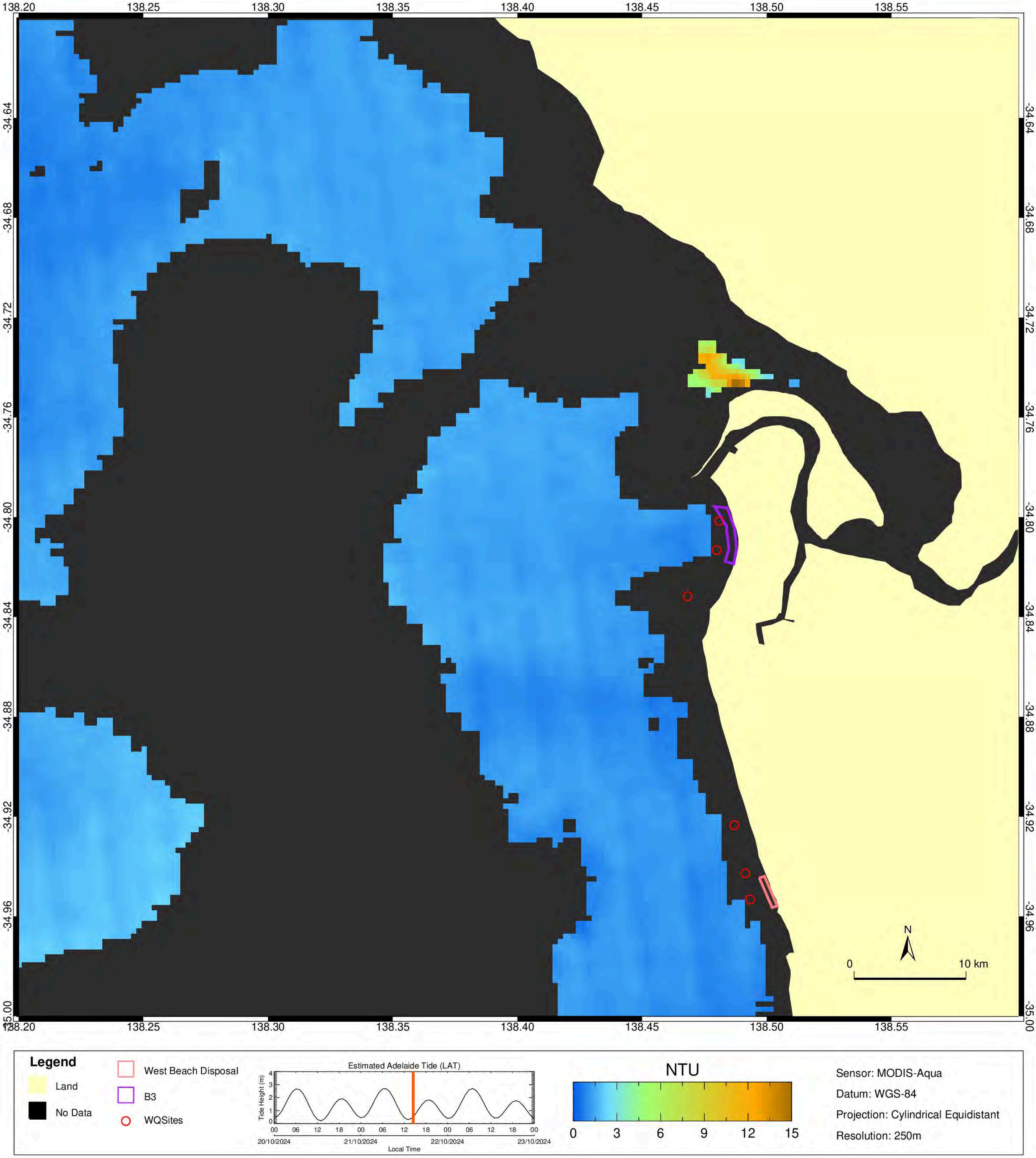
Image Capture: 21-Oct 2024, 09:55 (Local Time)



In-situ Marine Optics

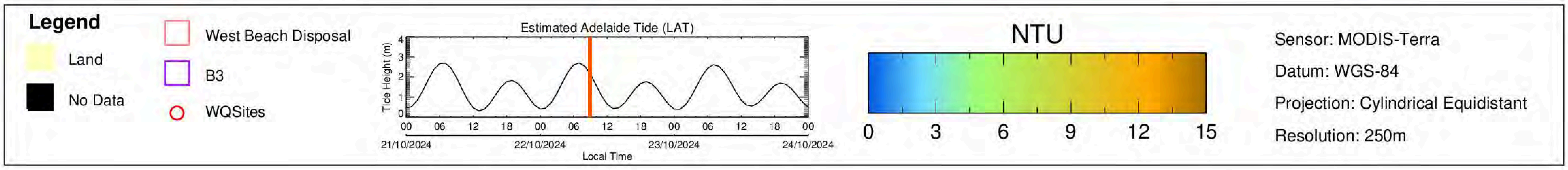
MODIS: Derived NTU

Image Capture: 21-Oct 2024, 14:30 (Local Time)



MODIS: Derived NTU

Image Capture: 22-Oct 2024, 08:55 (Local Time)



In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 22-Oct 2024, 15:10 (Local Time)

Legend

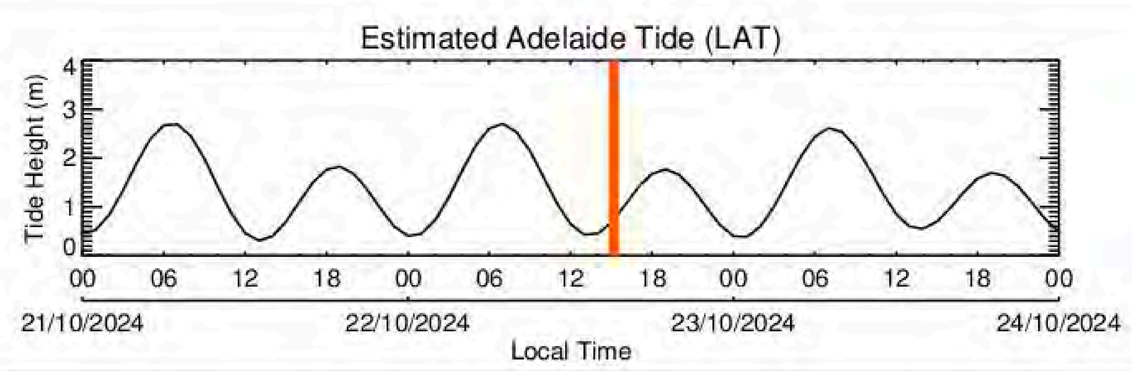
Land

No Data

West Beach Disposal

B3

WQSites



NTU

0 3 6 9 12 15

Sensor: MODIS-Aqua

Datum: WGS-84

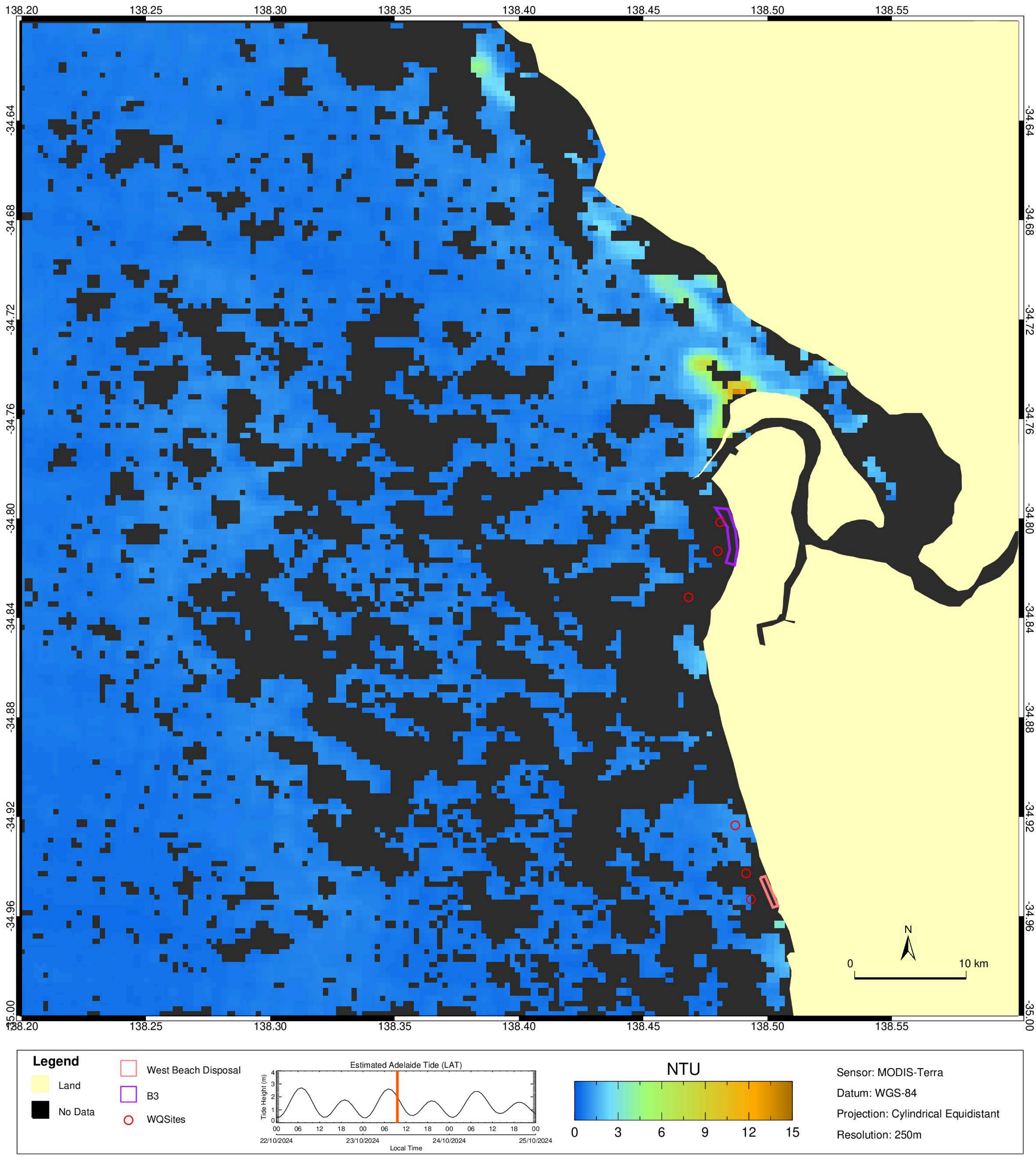
Projection: Cylindrical Equidistant

Resolution: 250m

In-situ Marine Optics

MODIS: Derived NTU

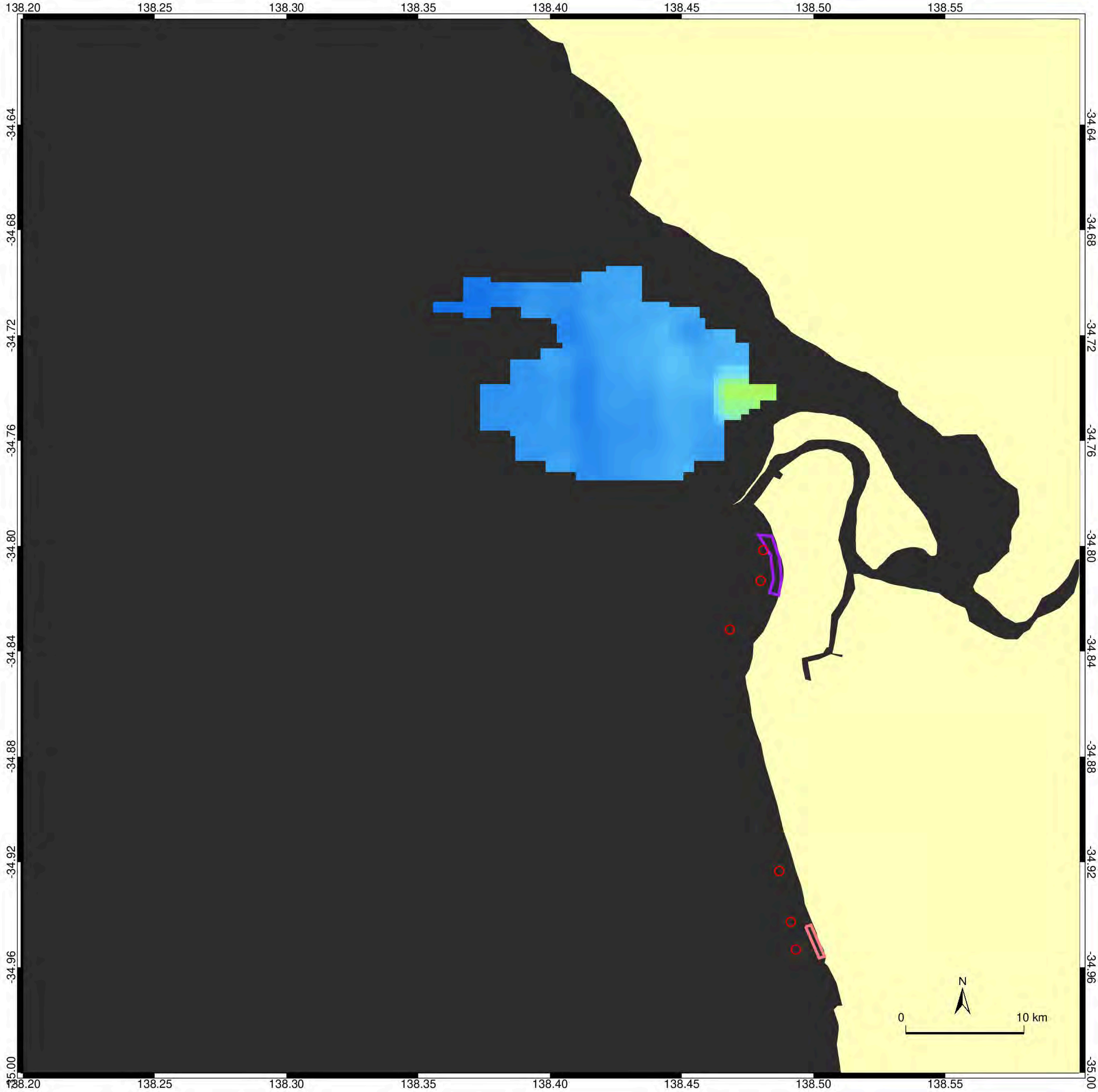
Image Capture: 23-Oct 2024, 09:35 (Local Time)



In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 23-Oct 2024, 14:10 (Local Time)



Legend

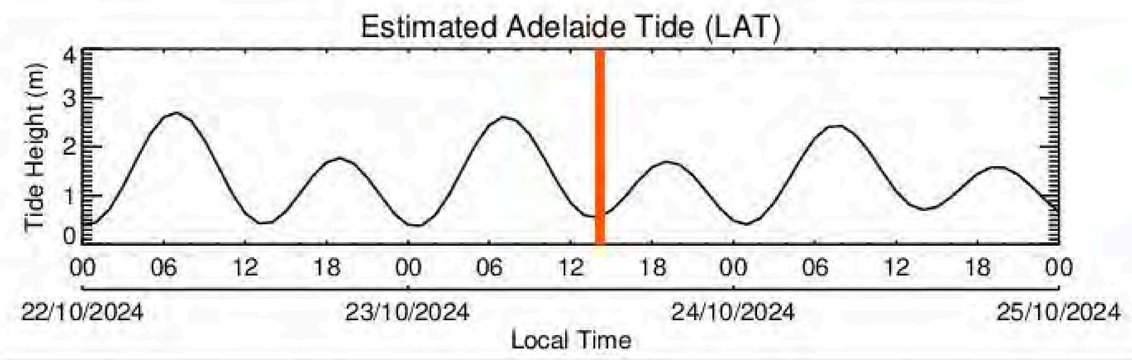
Land

No Data

West Beach Disposal

B3

WQSites



NTU

0 3 6 9 12 15

Sensor: MODIS-Aqua

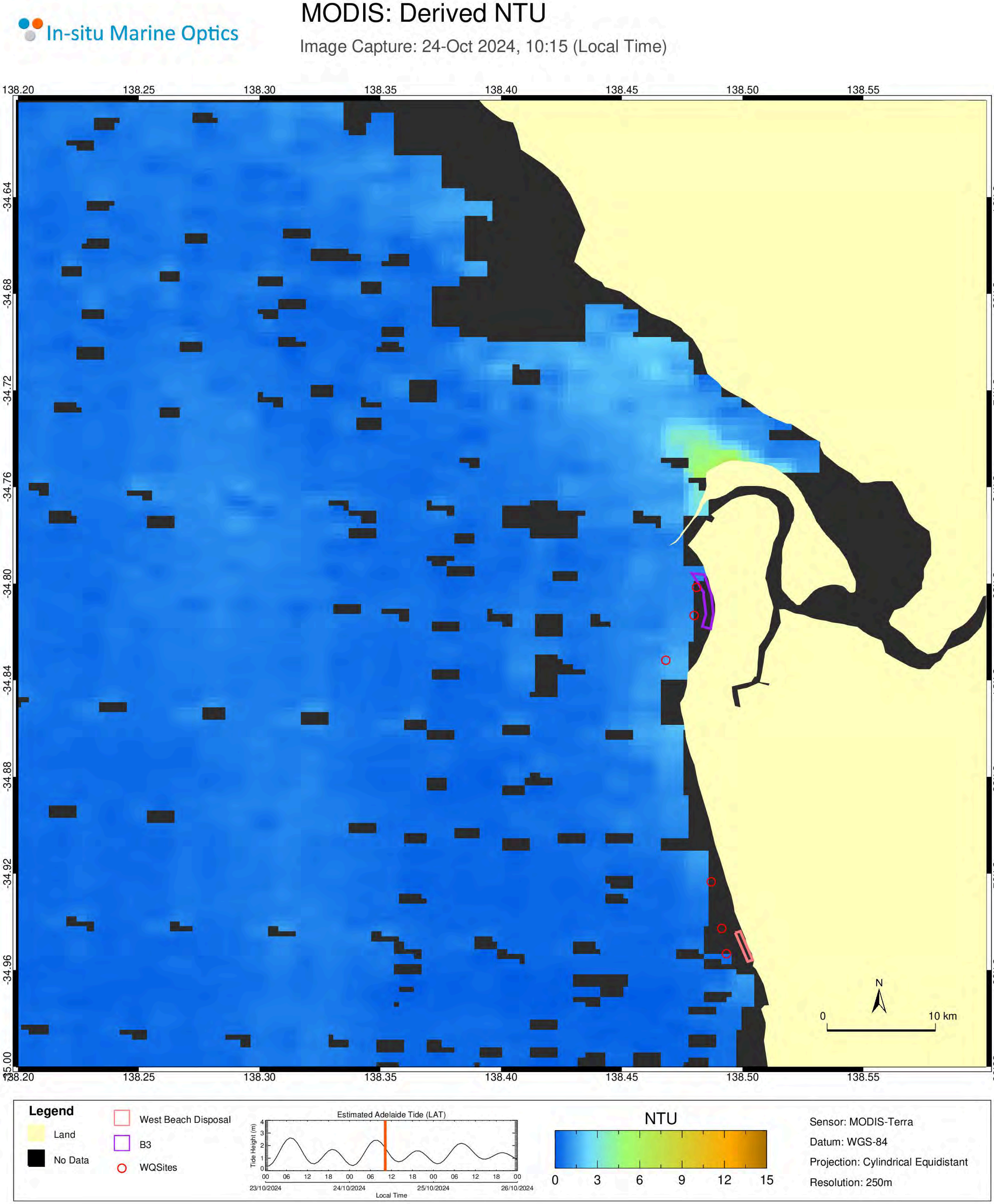
Datum: WGS-84

Projection: Cylindrical Equidistant

Resolution: 250m

MODIS: Derived NTU

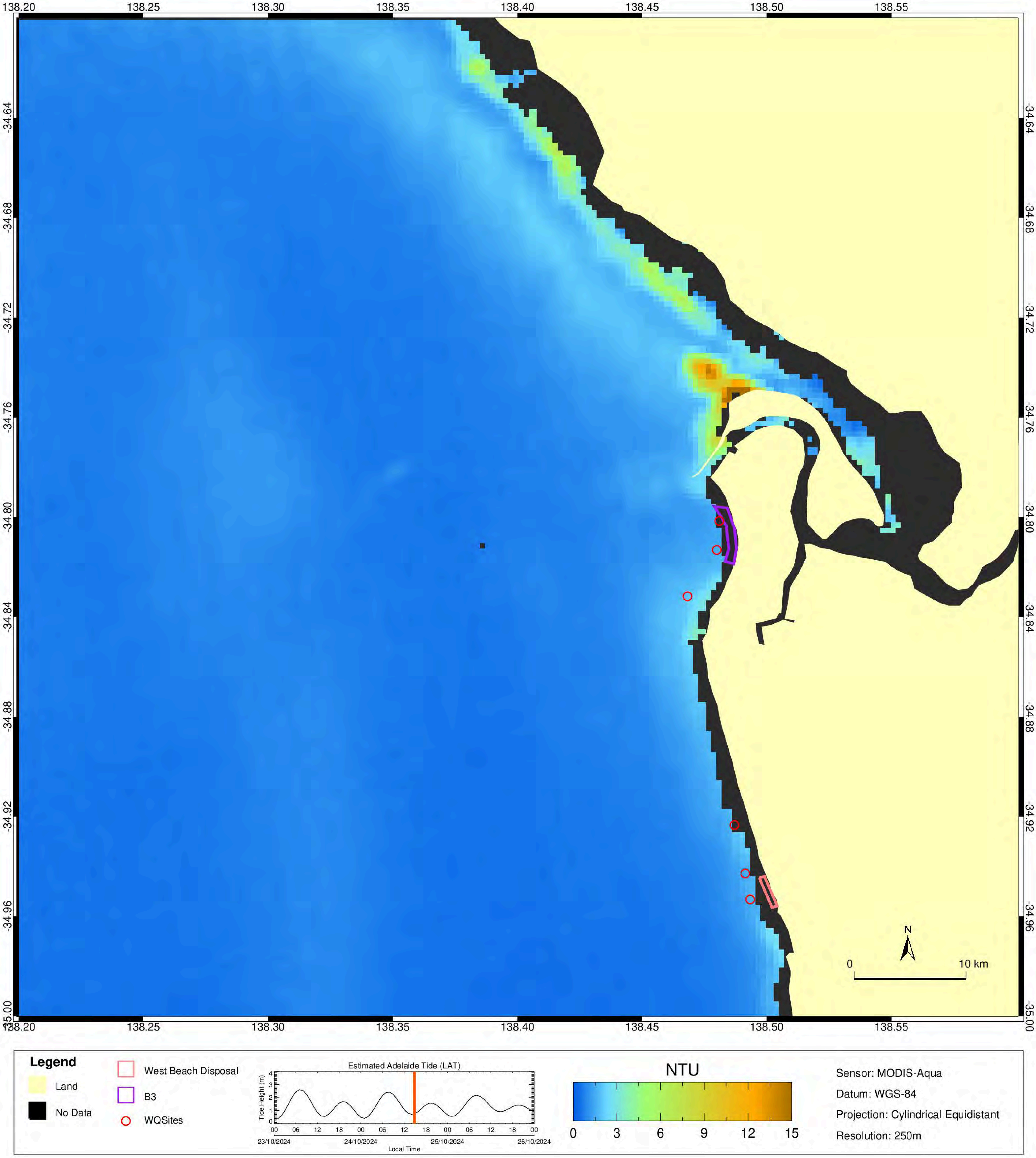
Image Capture: 24-Oct 2024, 10:15 (Local Time)



In-situ Marine Optics

MODIS: Derived NTU

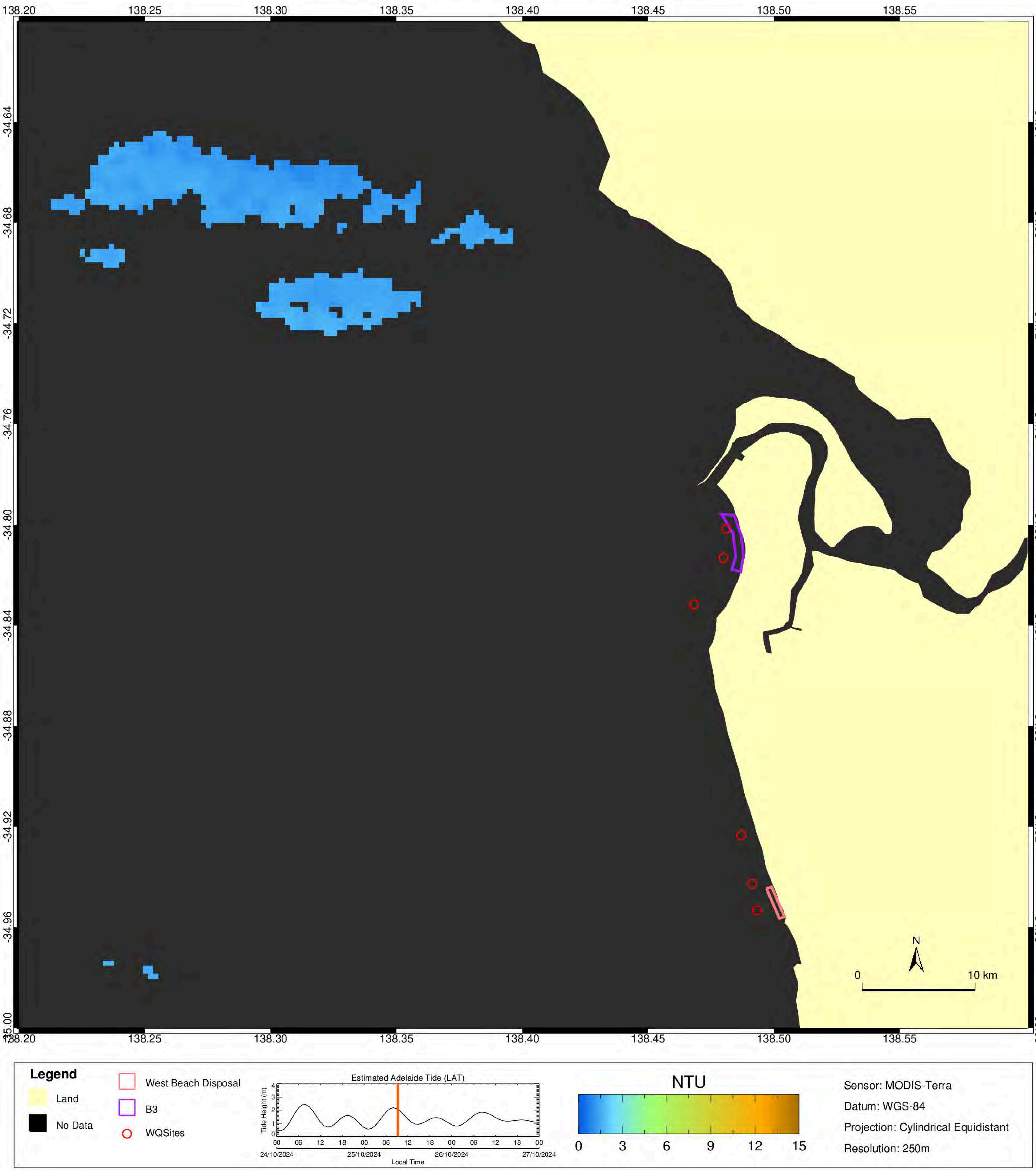
Image Capture: 24-Oct 2024, 14:50 (Local Time)



In-situ Marine Optics

MODIS: Derived NTU

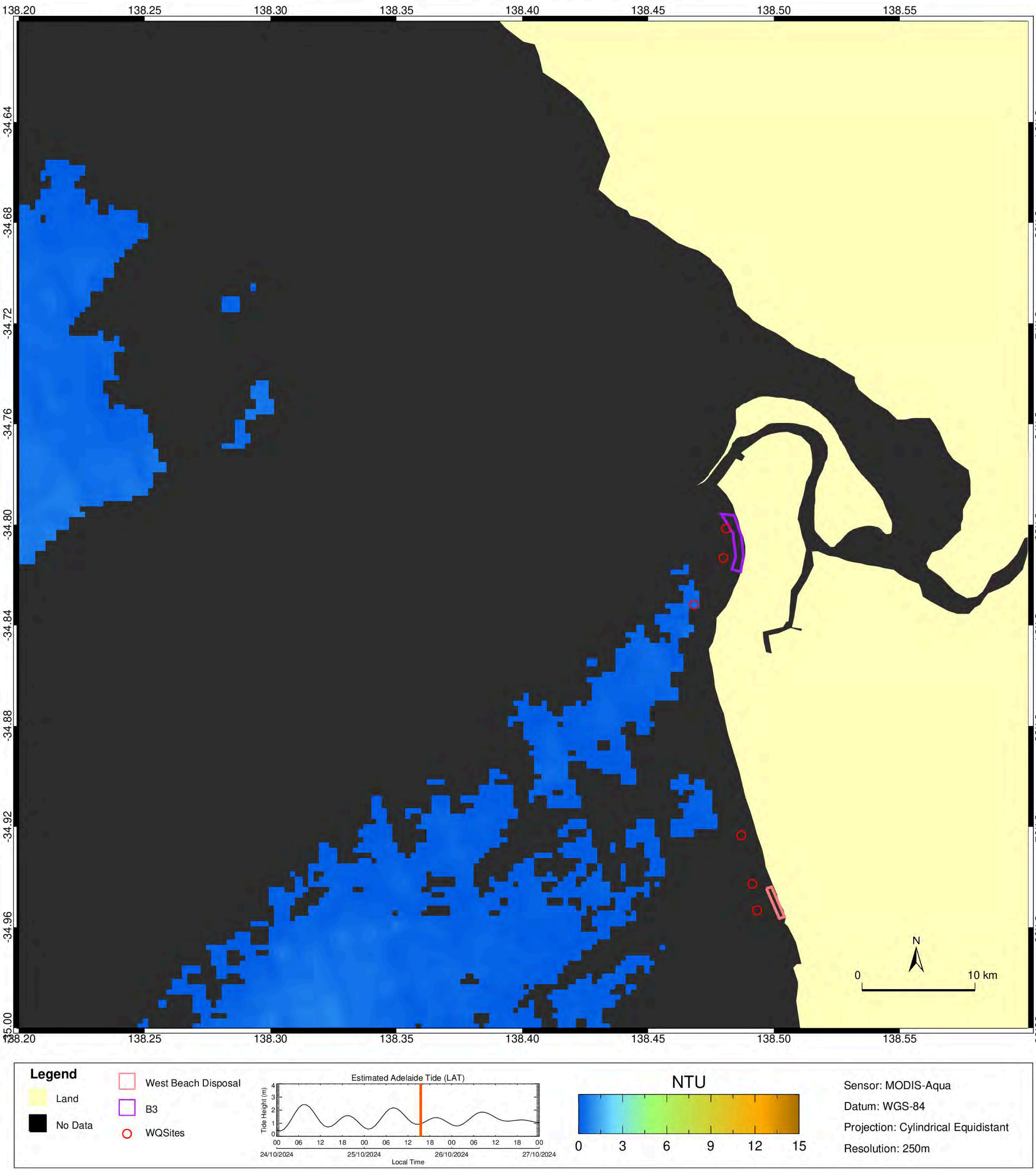
Image Capture: 25-Oct 2024, 09:15 (Local Time)



In-situ Marine Optics

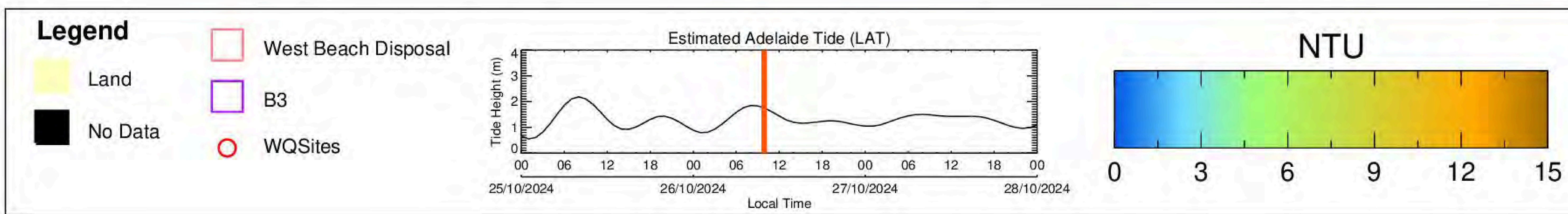
MODIS: Derived NTU

Image Capture: 25-Oct 2024, 15:30 (Local Time)



MODIS: Derived NTU

Image Capture: 26-Oct 2024, 09:55 (Local Time)



Sensor: MODIS-Terra

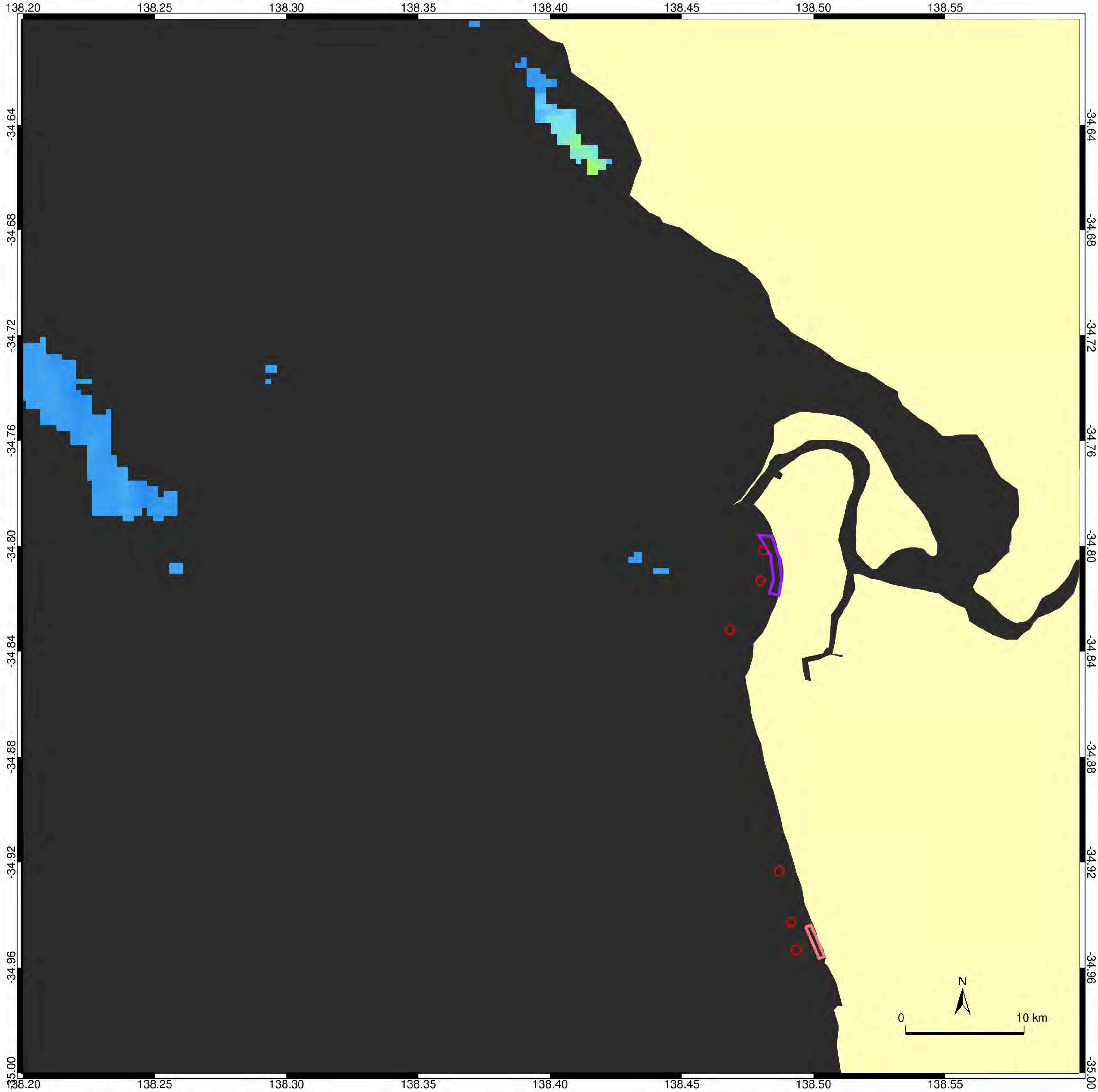
Datum: WGS-84

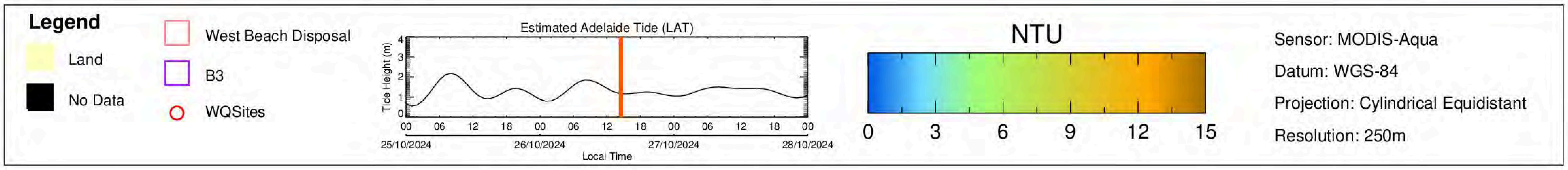
Projection: Cylindrical Equidistant

Resolution: 250m

MODIS: Derived NTU

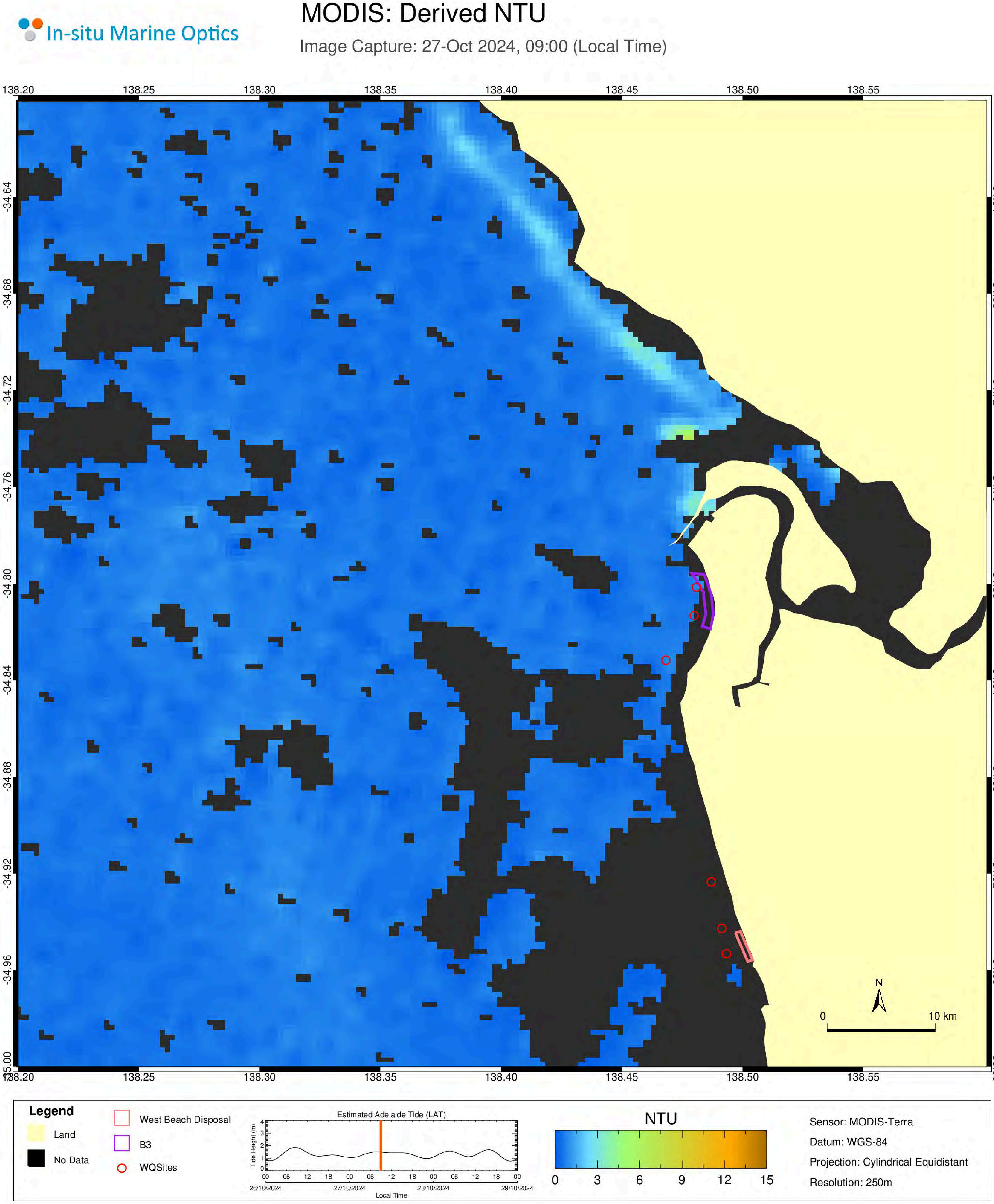
Image Capture: 26-Oct 2024, 14:30 (Local Time)





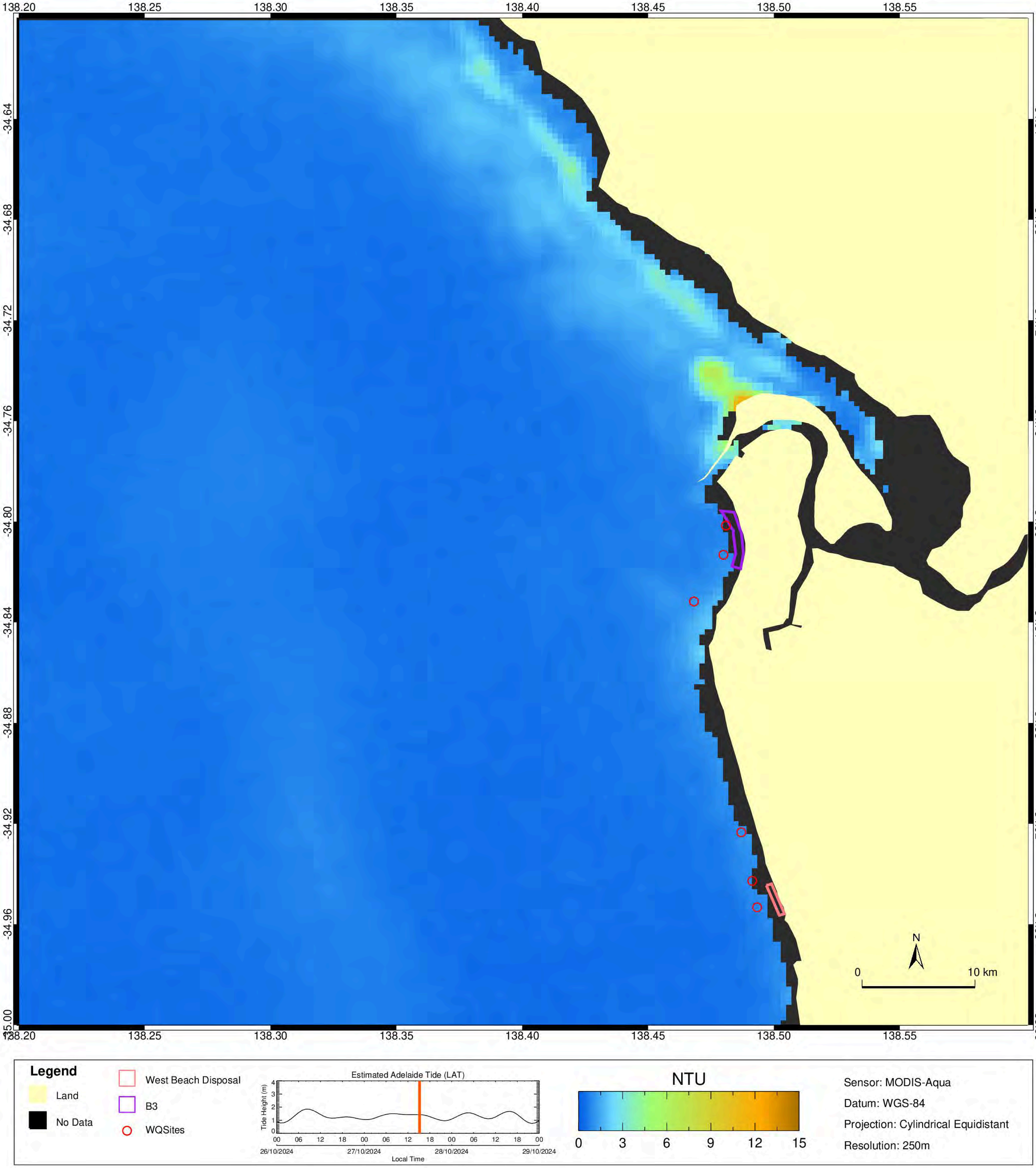
MODIS: Derived NTU

Image Capture: 27-Oct 2024, 09:00 (Local Time)



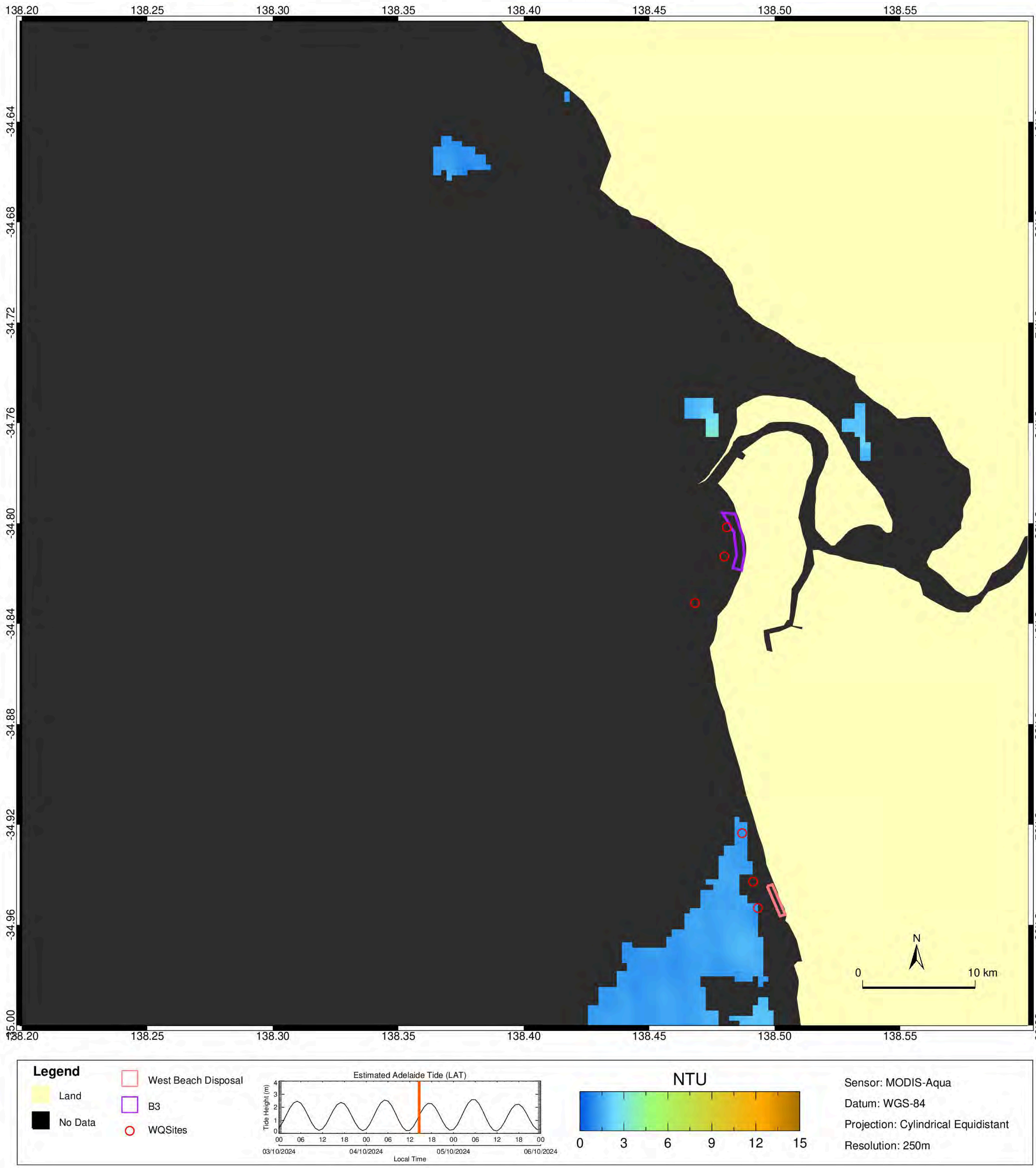
MODIS: Derived NTU

Image Capture: 27-Oct 2024, 15:10 (Local Time)



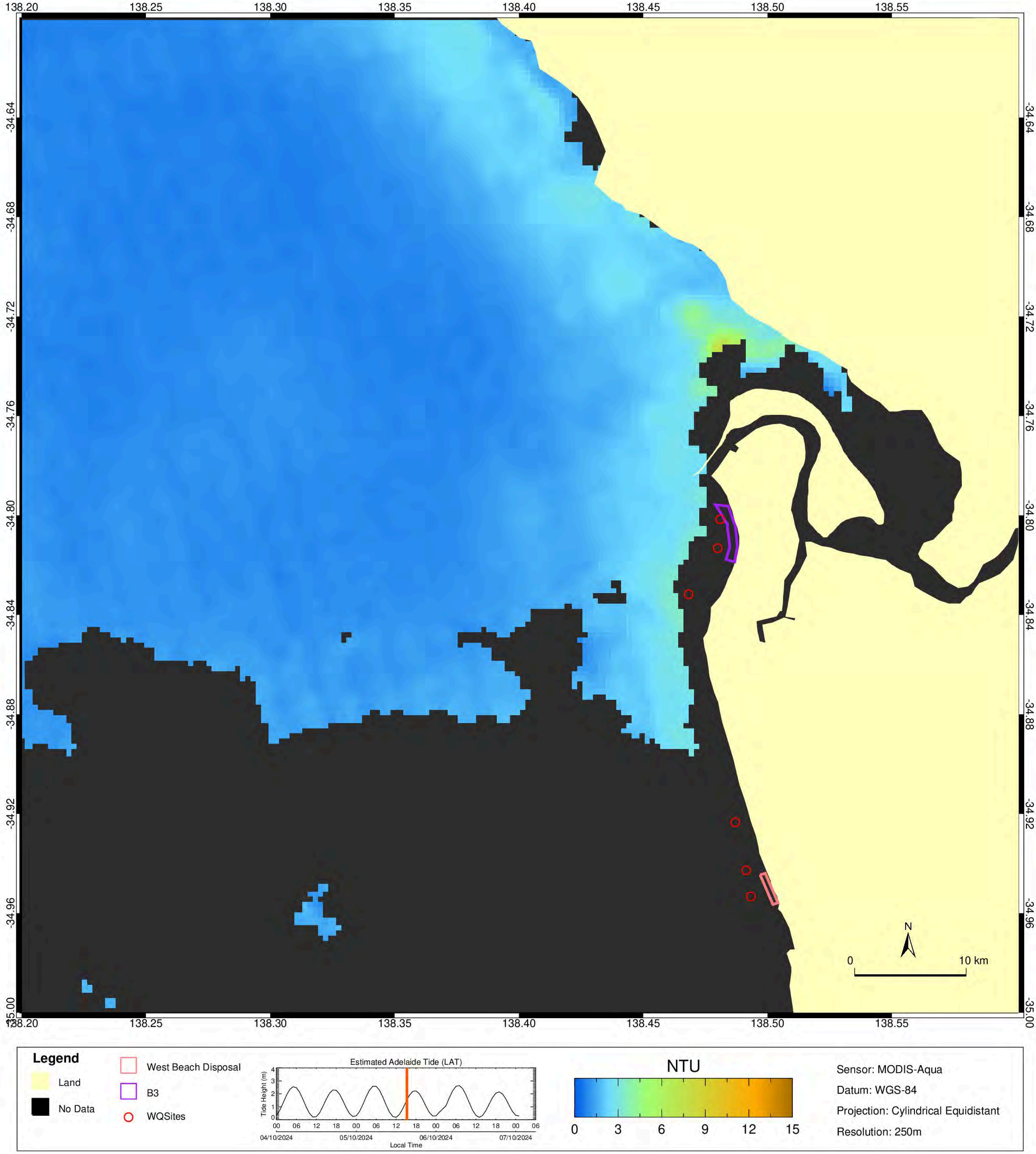
MODIS: Derived NTU

Image Capture: 4-Oct 2024, 14:35 (Local Time)



MODIS: Derived NTU

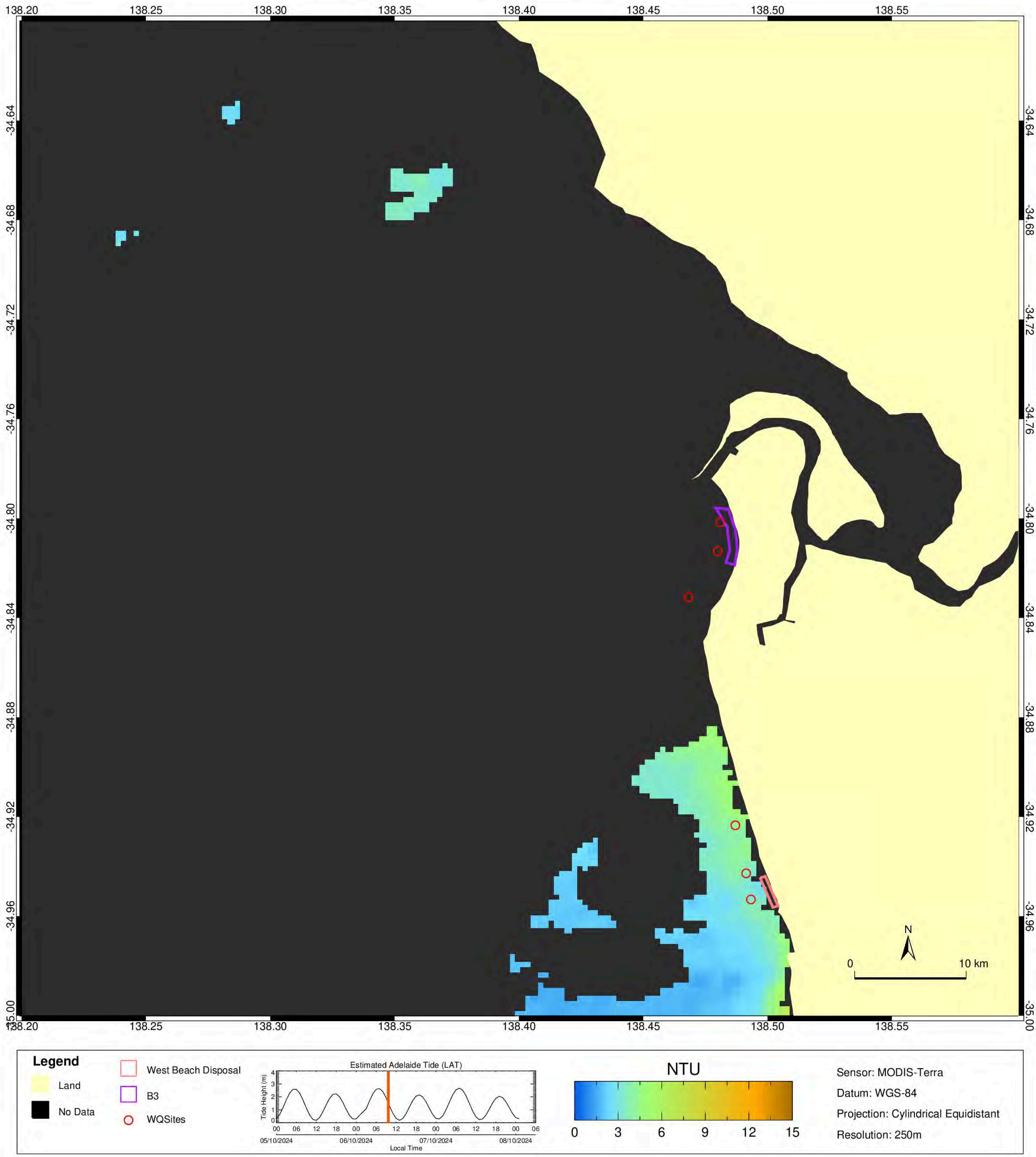
Image Capture: 5-Oct 2024, 15:15 (Local Time)



In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 6-Oct 2024, 09:40 (Local Time)



Sensor: MODIS-Terra

Datum: WGS-84

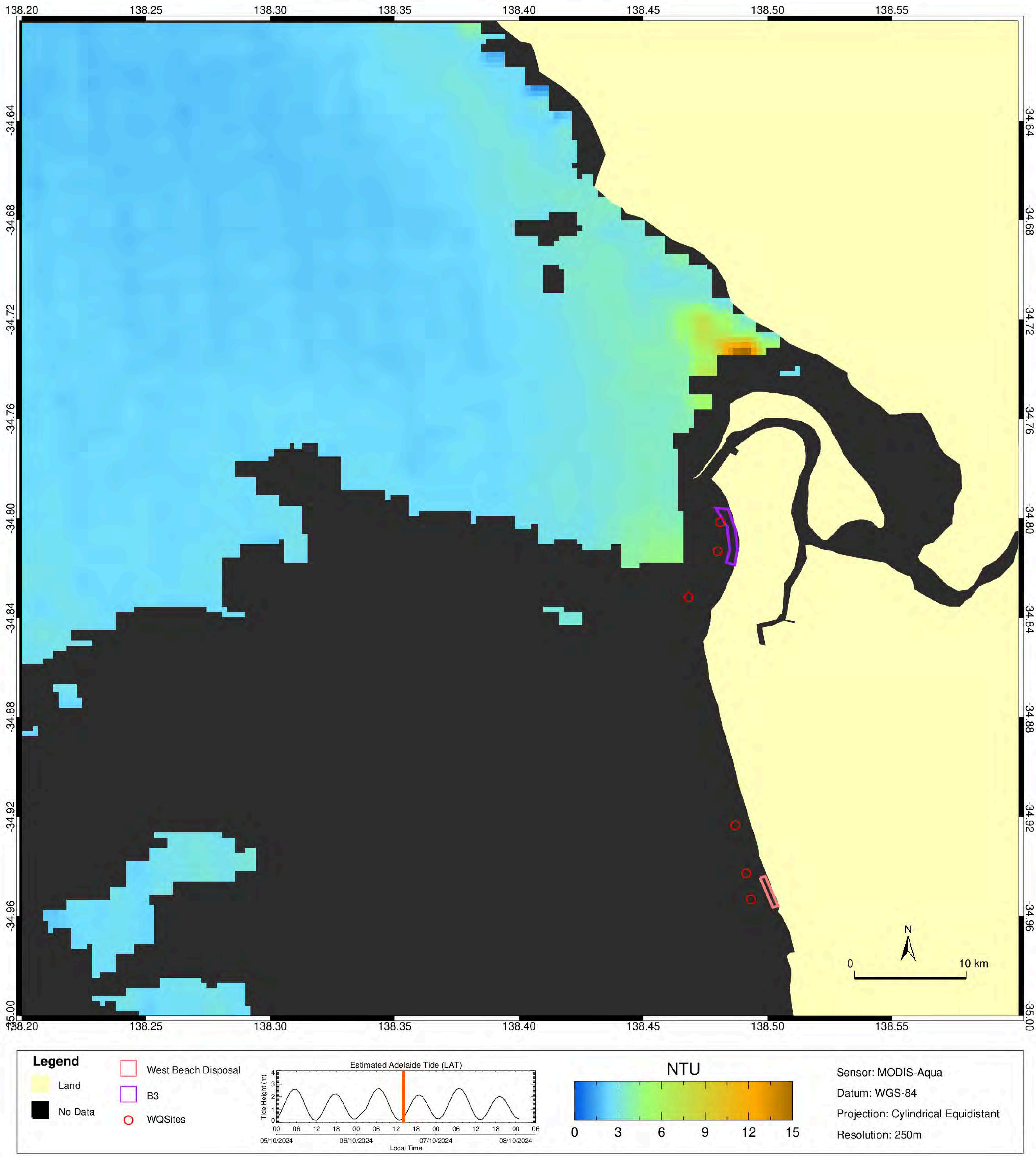
Projection: Cylindrical Equidistant

Resolution: 250m

In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 6-Oct 2024, 14:15 (Local Time)



Sensor: MODIS-Aqua

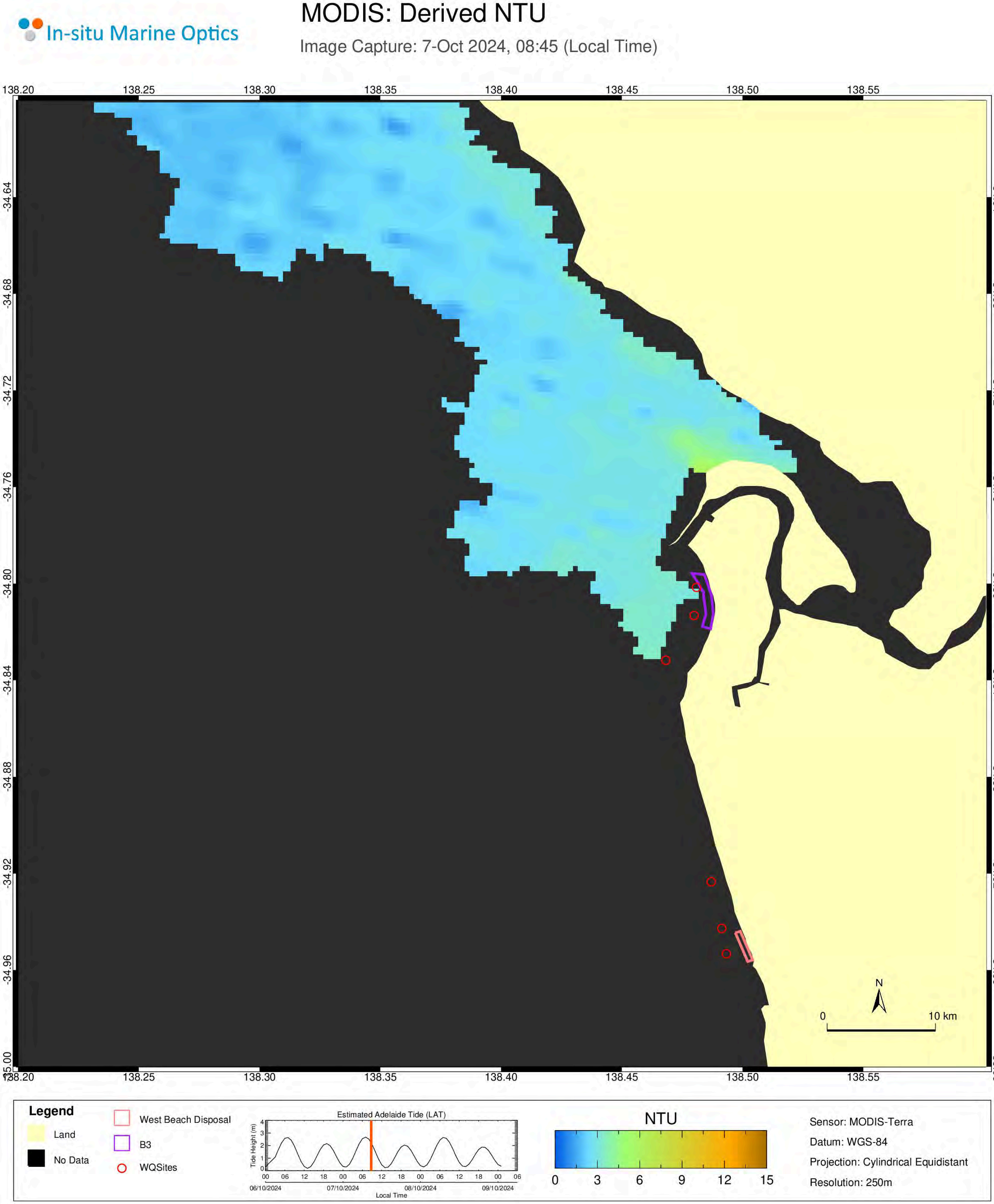
Datum: WGS-84

Projection: Cylindrical Equidistant

Resolution: 250m

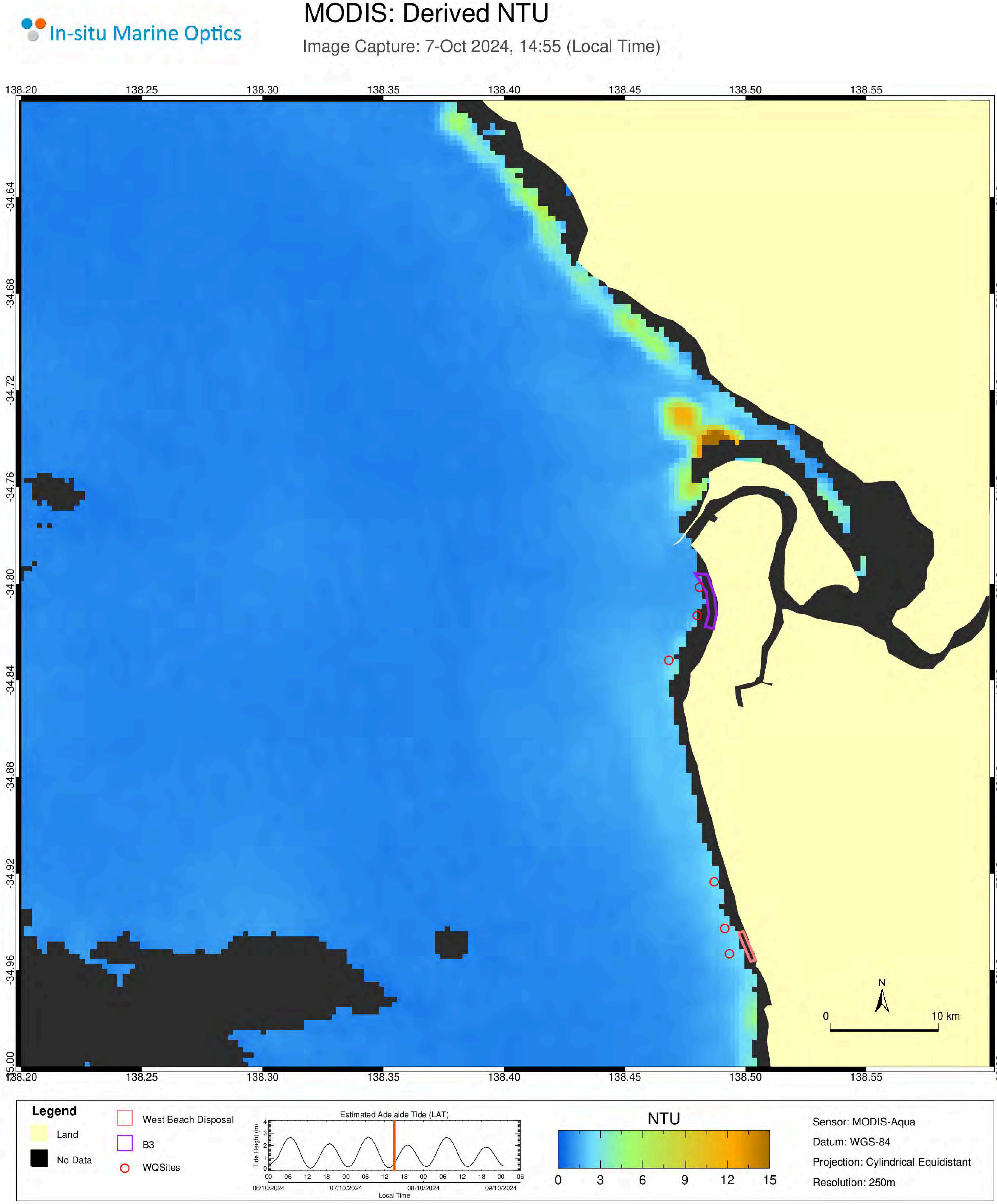
MODIS: Derived NTU

Image Capture: 7-Oct 2024, 08:45 (Local Time)



MODIS: Derived NTU

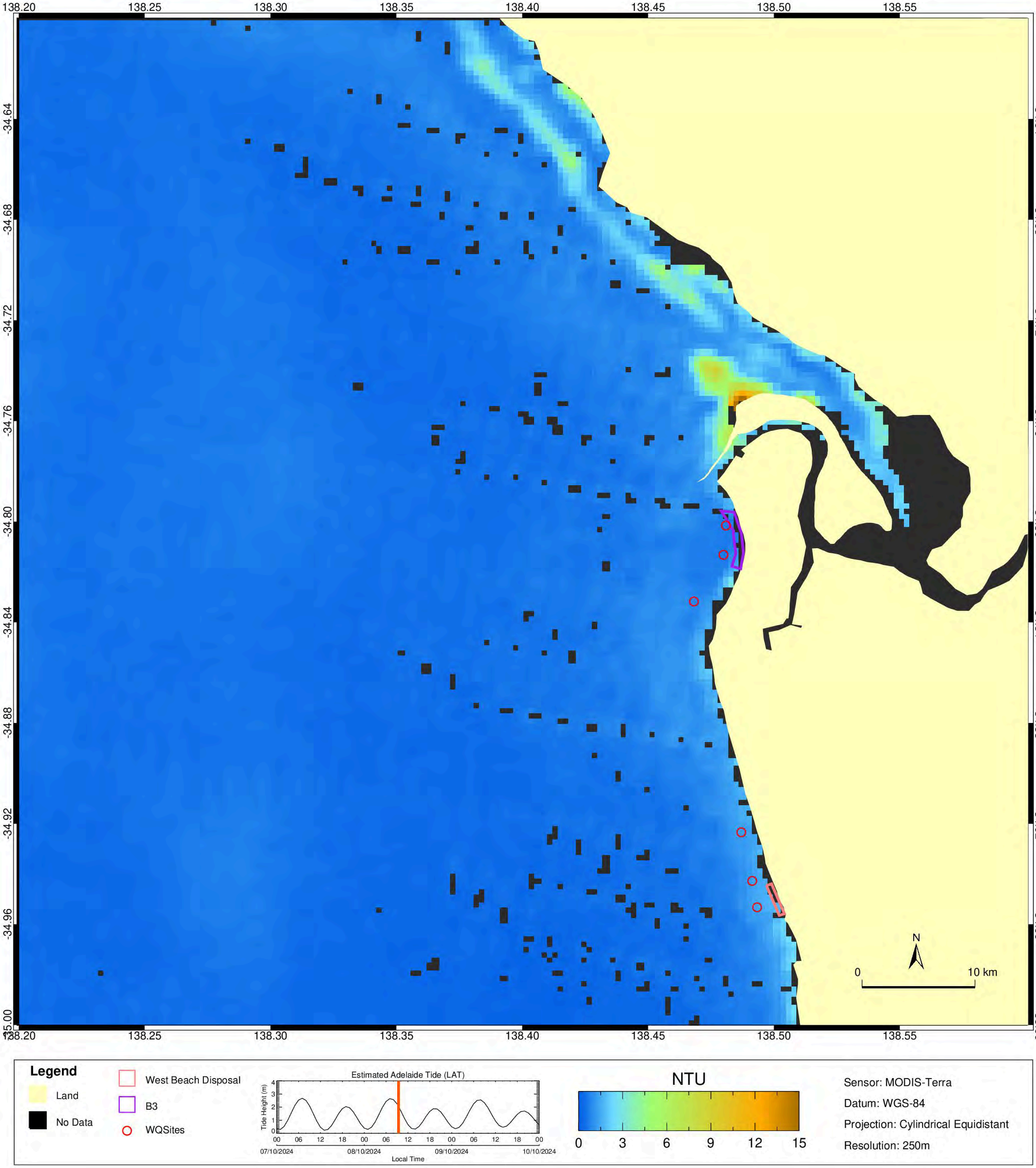
Image Capture: 7-Oct 2024, 14:55 (Local Time)



In-situ Marine Optics

MODIS: Derived NTU

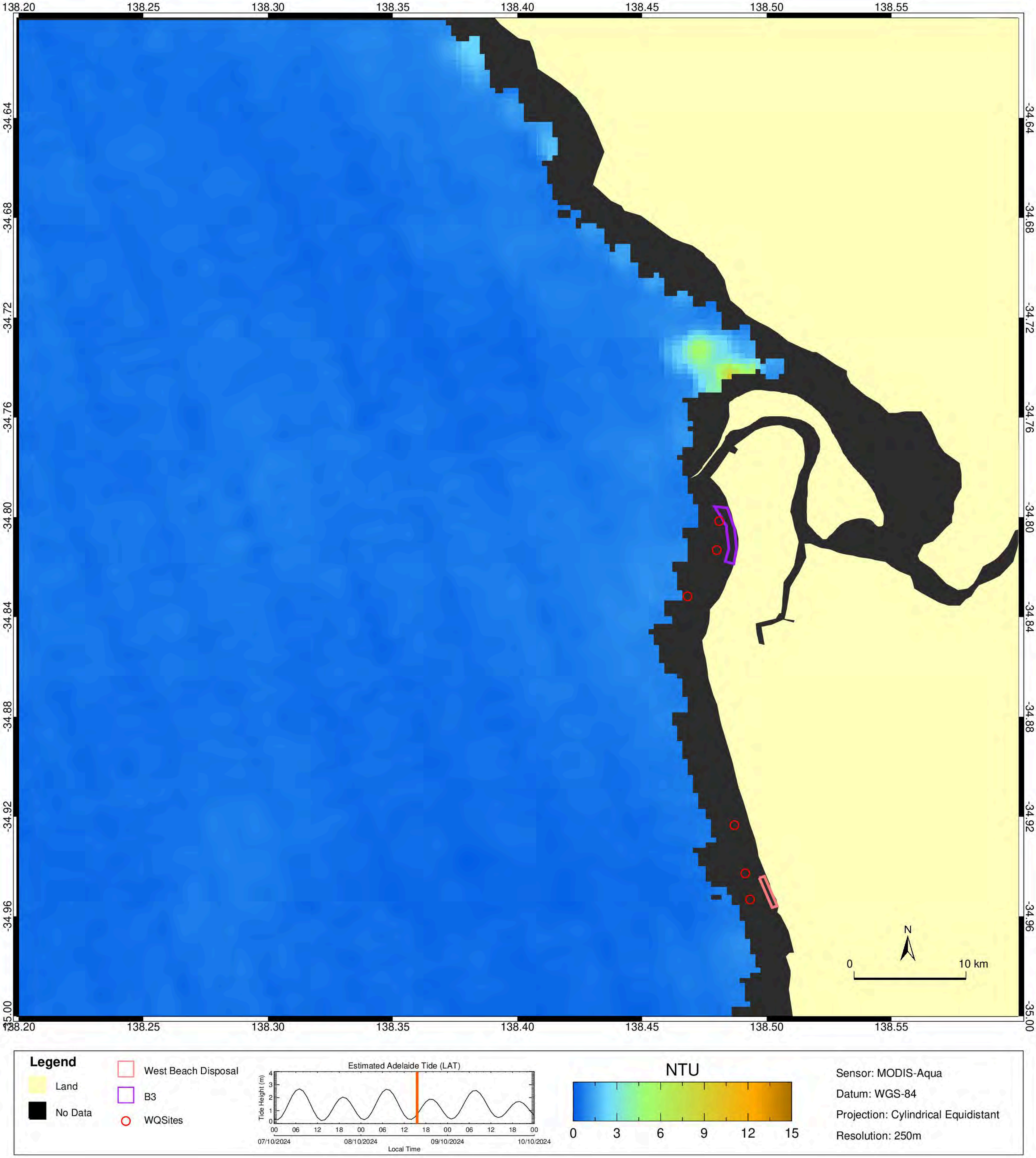
Image Capture: 8-Oct 2024, 09:25 (Local Time)



MODIS: Derived NTU

In-situ Marine Optics

Image Capture: 8-Oct 2024, 15:35 (Local Time)



Sensor: MODIS-Aqua

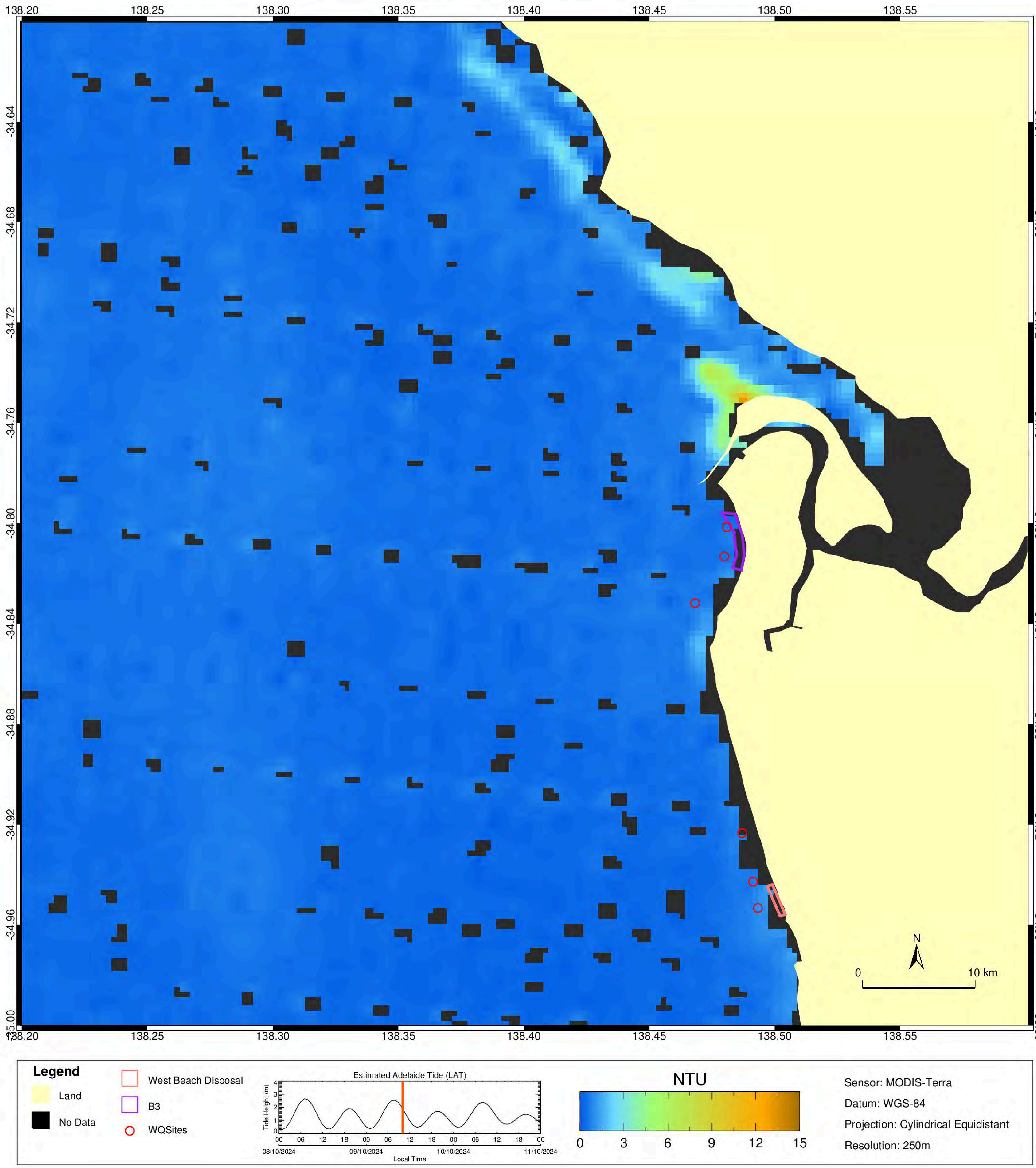
Datum: WGS-84

Projection: Cylindrical Equidistant

Resolution: 250m

MODIS: Derived NTU

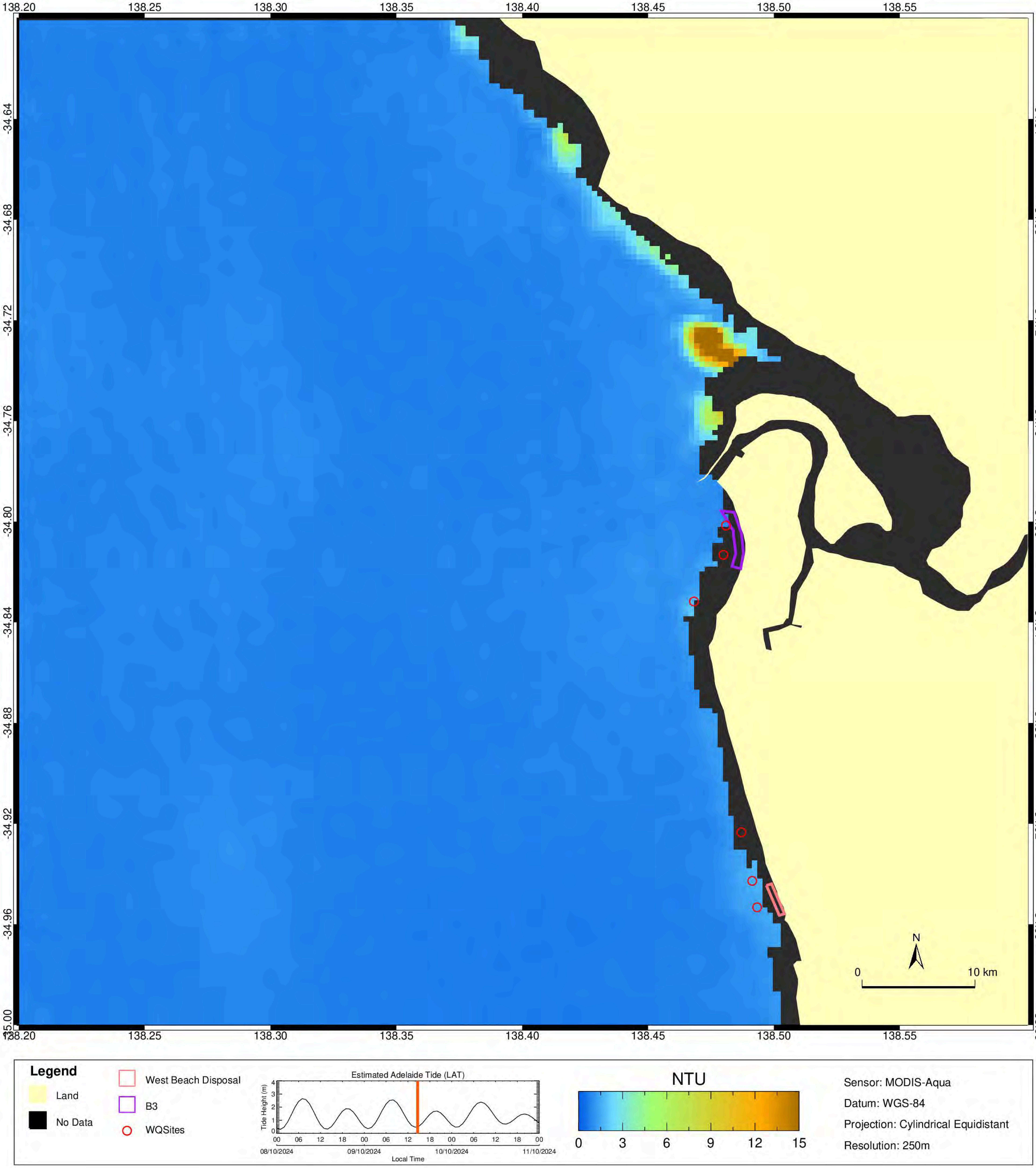
Image Capture: 9-Oct 2024, 10:05 (Local Time)



In-situ Marine Optics

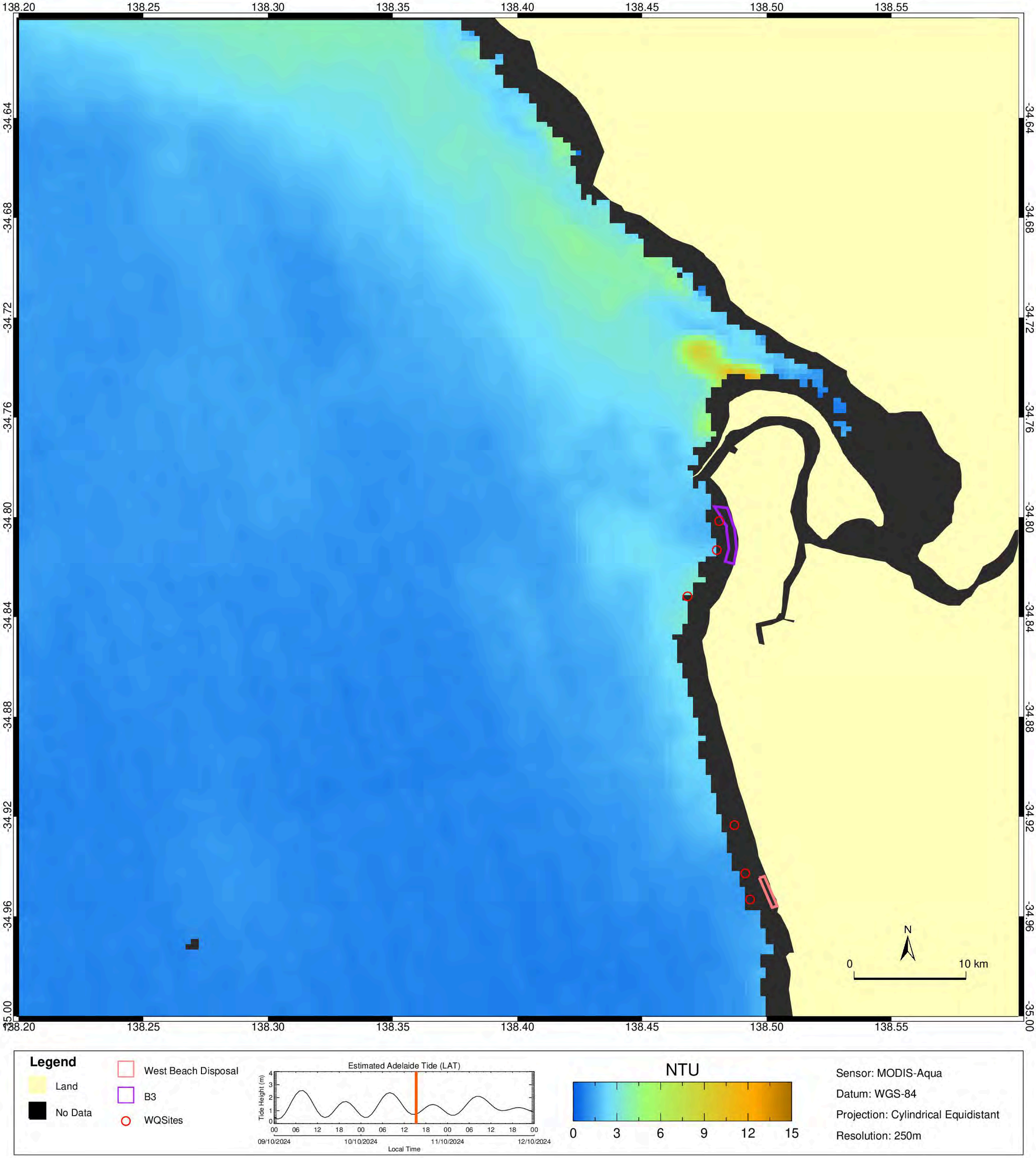
MODIS: Derived NTU

Image Capture: 9-Oct 2024, 14:40 (Local Time)



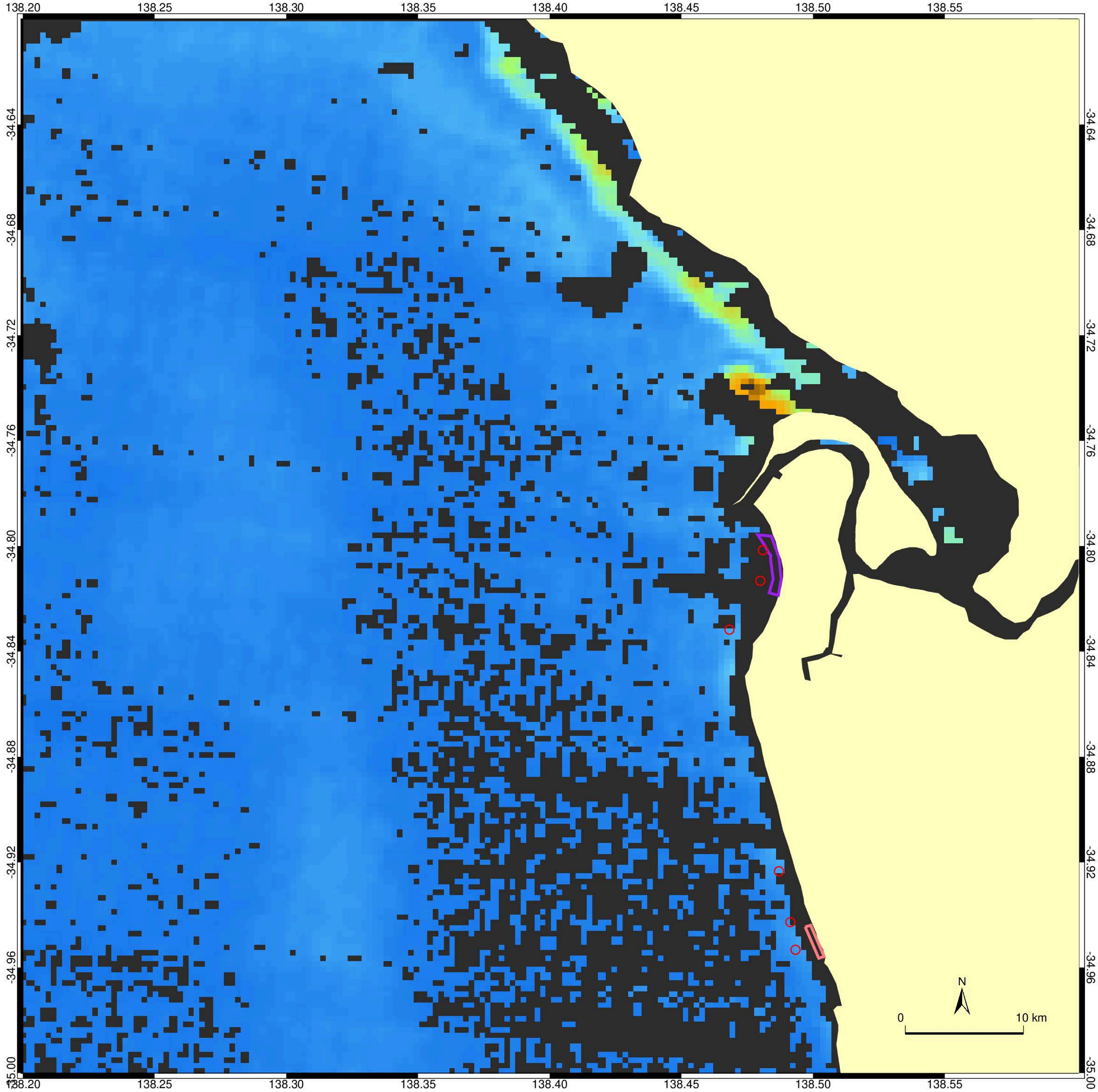
MODIS: Derived NTU

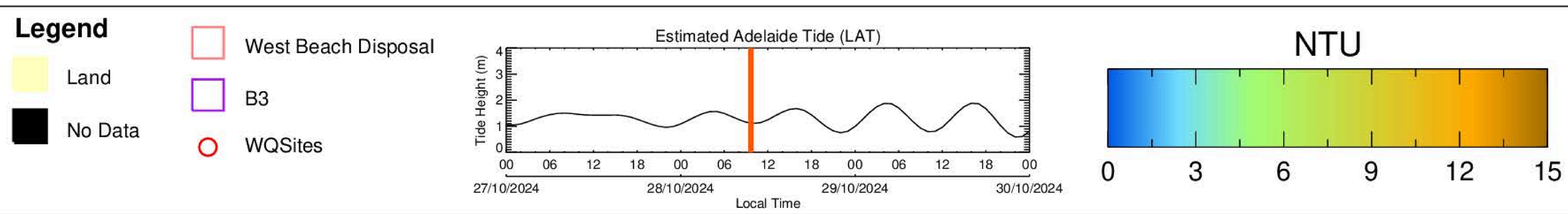
Image Capture: 10-Oct 2024, 15:20 (Local Time)



MODIS: Derived NTU

Image Capture: 28-Oct 2024, 09:40 (Local Time)





Sensor: MODIS-Terra

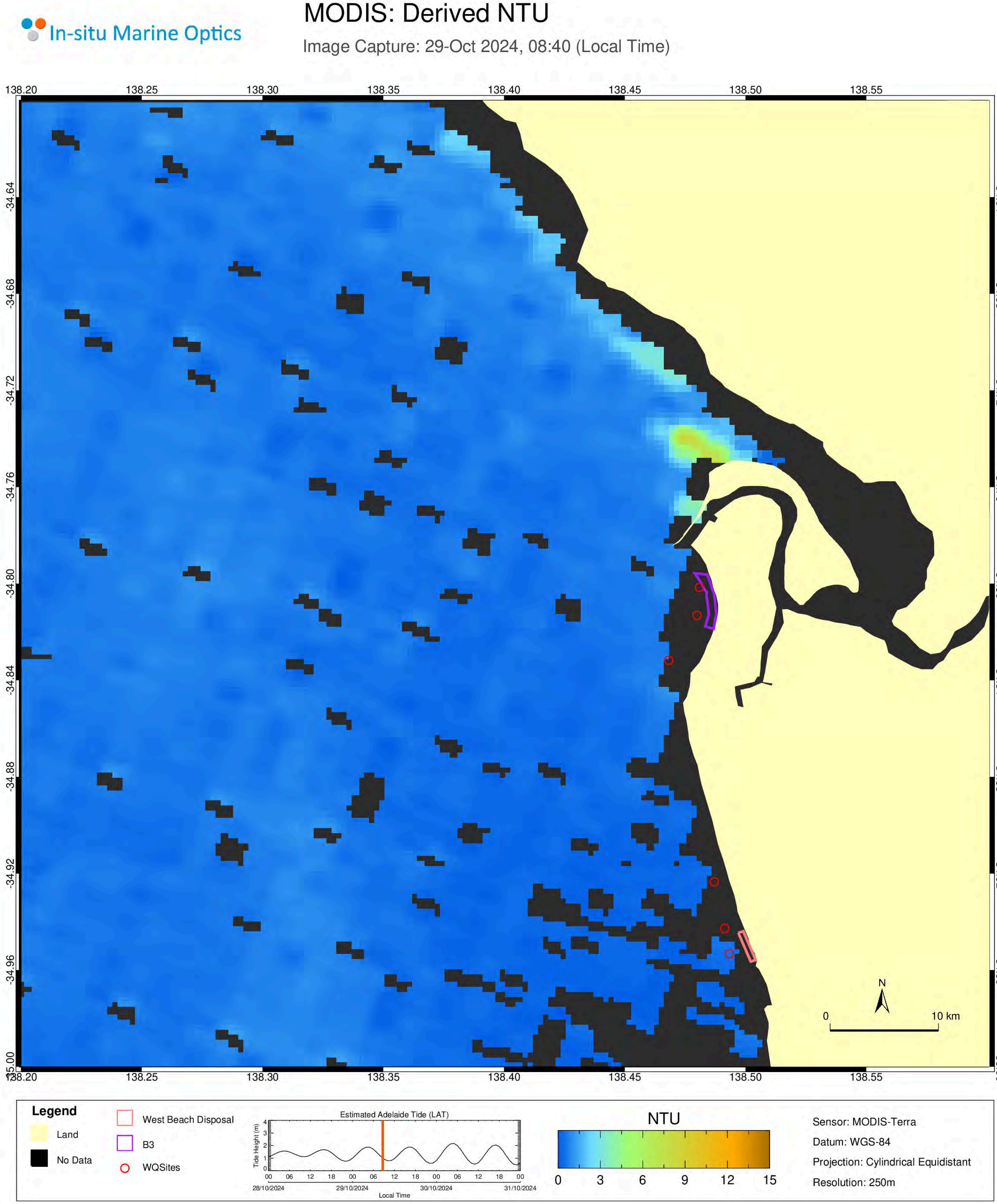
Datum: WGS-84

Projection: Cylindrical Equidistant

Resolution: 250m

MODIS: Derived NTU

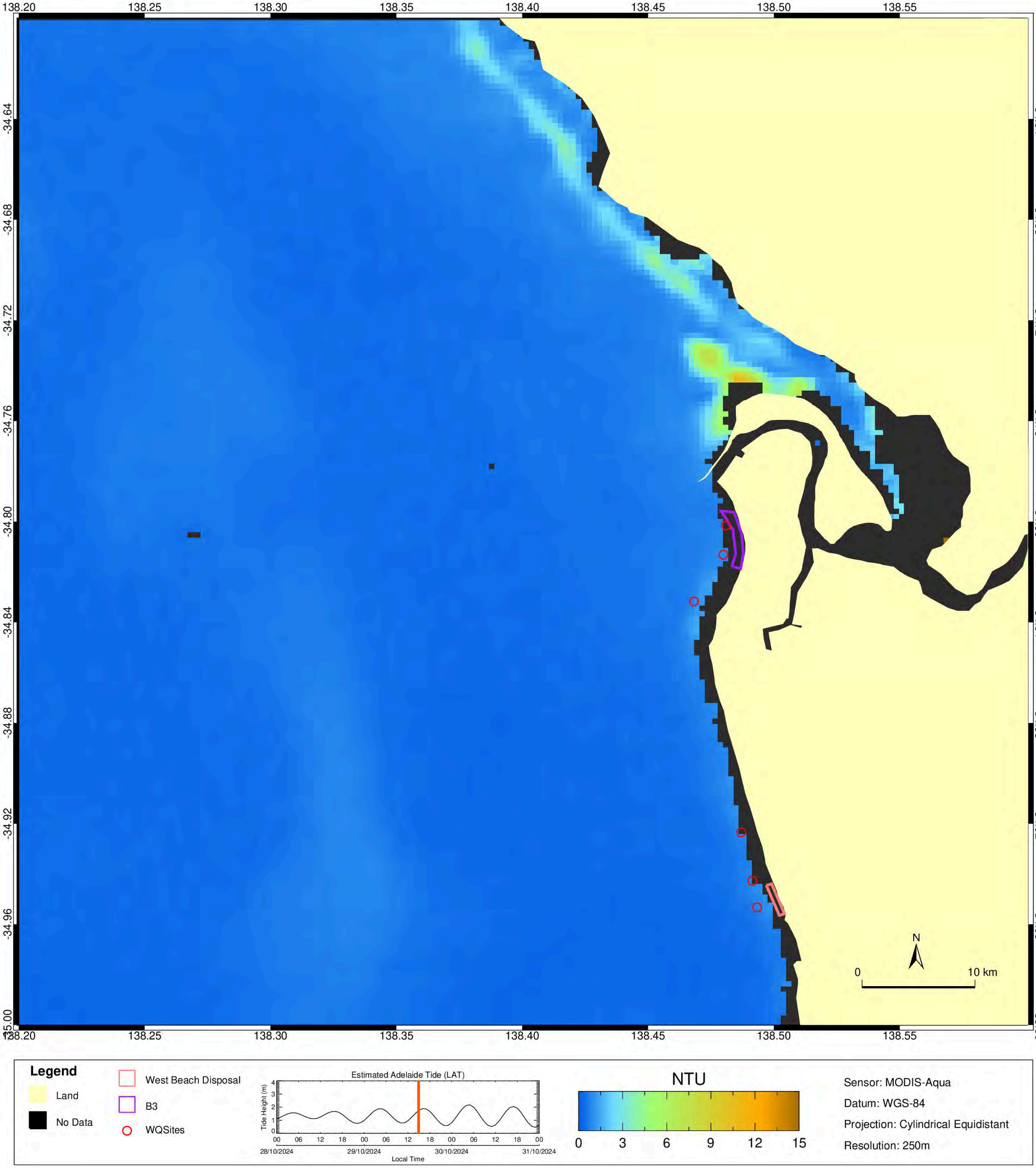
Image Capture: 29-Oct 2024, 08:40 (Local Time)



In-situ Marine Optics

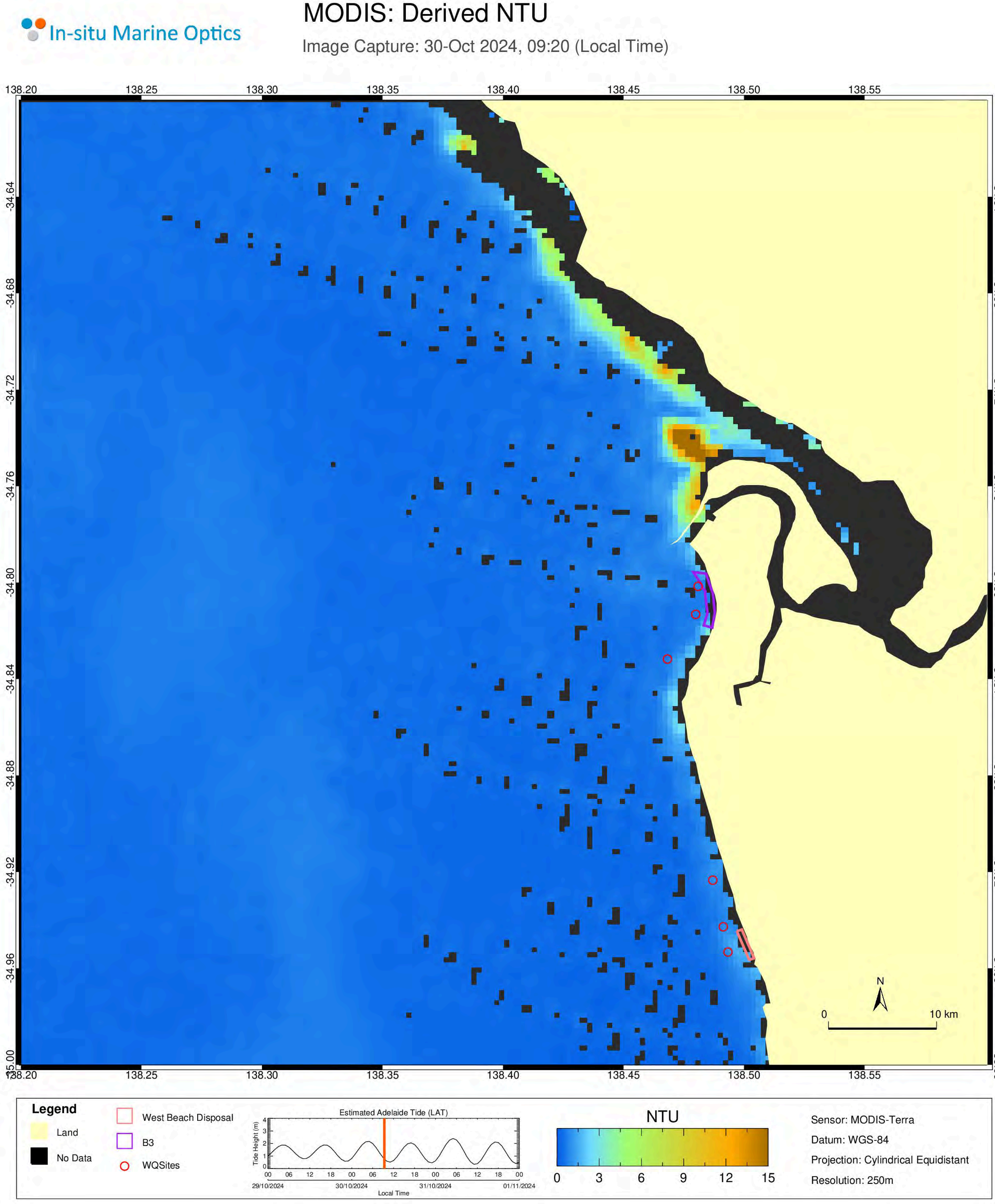
MODIS: Derived NTU

Image Capture: 29-Oct 2024, 14:55 (Local Time)



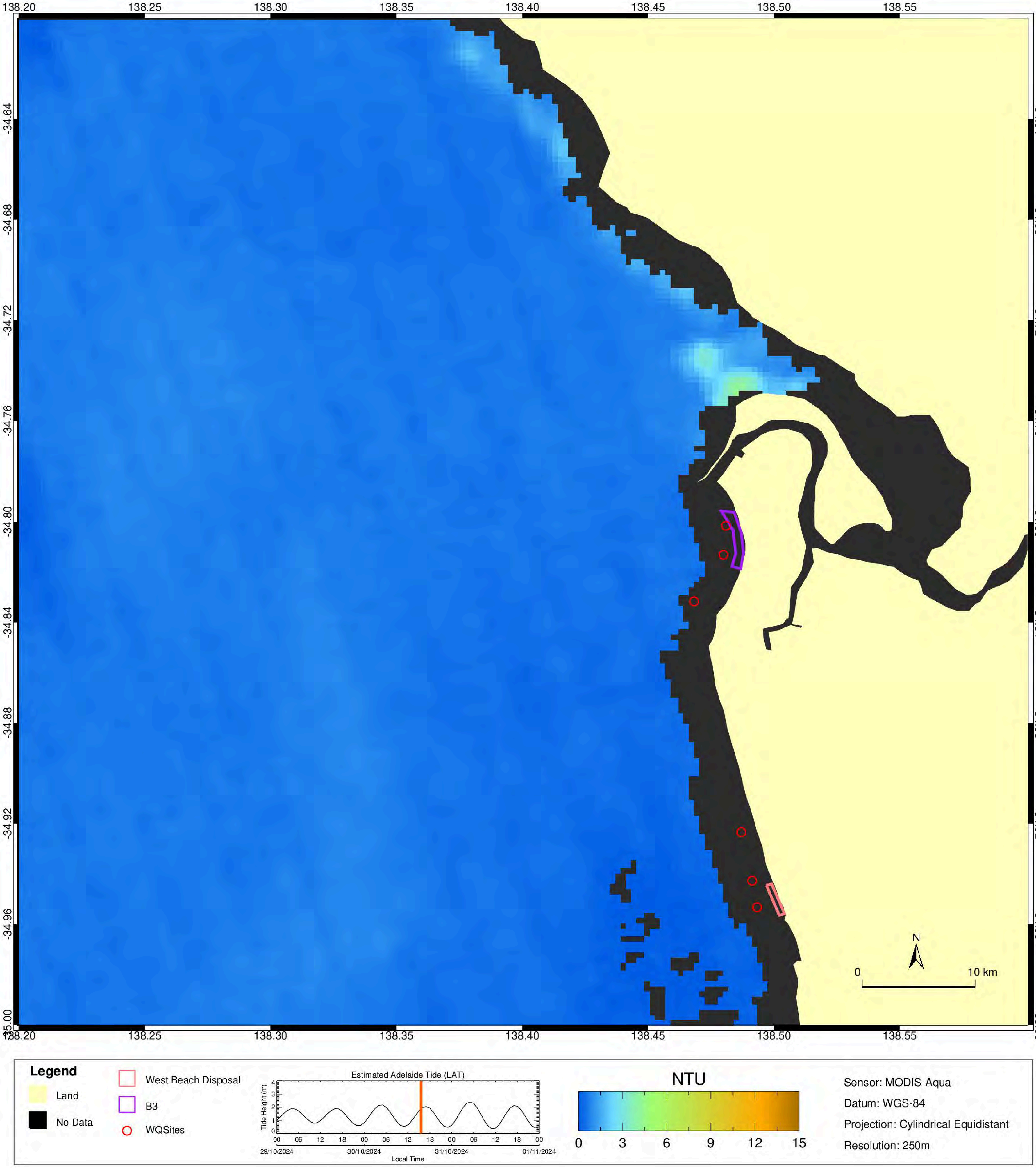
MODIS: Derived NTU

Image Capture: 30-Oct 2024, 09:20 (Local Time)



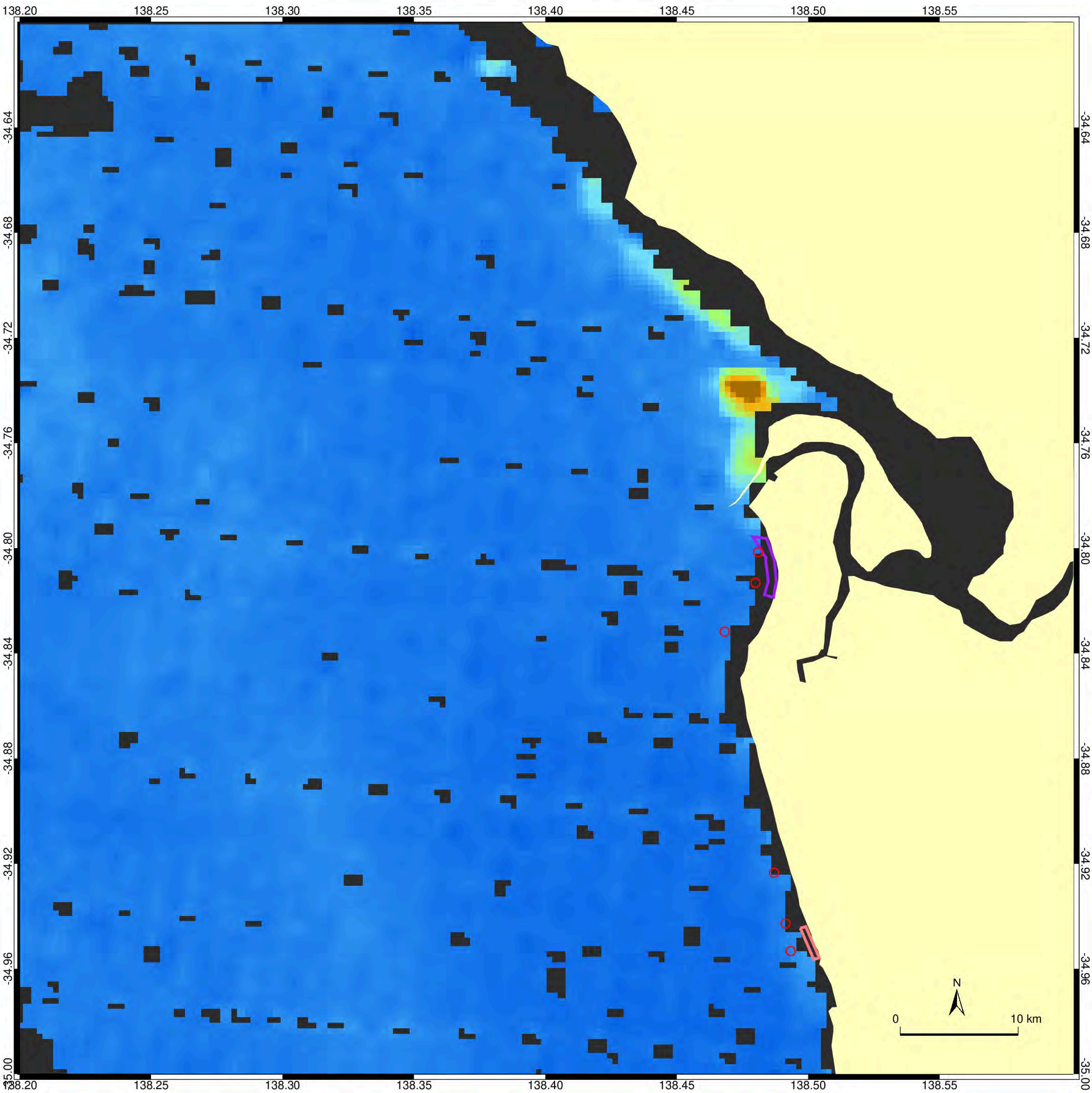
MODIS: Derived NTU

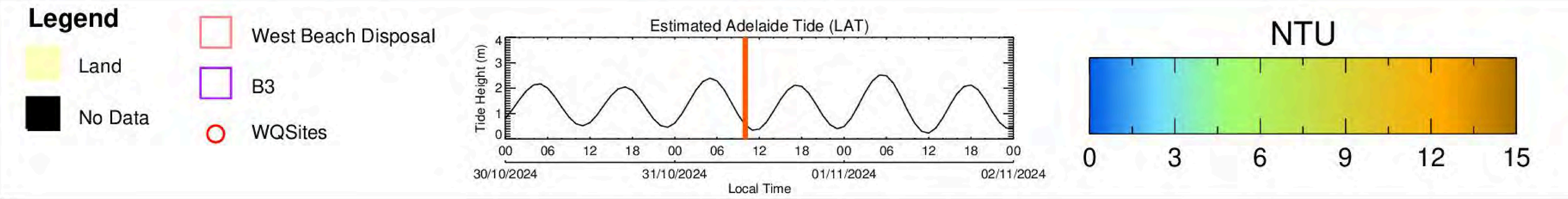
Image Capture: 30-Oct 2024, 15:35 (Local Time)



MODIS: Derived NTU

Image Capture: 31-Oct 2024, 10:00 (Local Time)





Sensor: MODIS-Terra

Datum: WGS-84

Projection: Cylindrical Equidistant

Resolution: 250m

MODIS: Derived NTU

Image Capture: 31-Oct 2024, 14:35 (Local Time)

Legend

Land

No Data

West Beach Disposal

B3

WQSites

Estimated Adelaide Tide (LAT)

NTU

0 3 6 9 12 15

Sensor: MODIS-Aqua

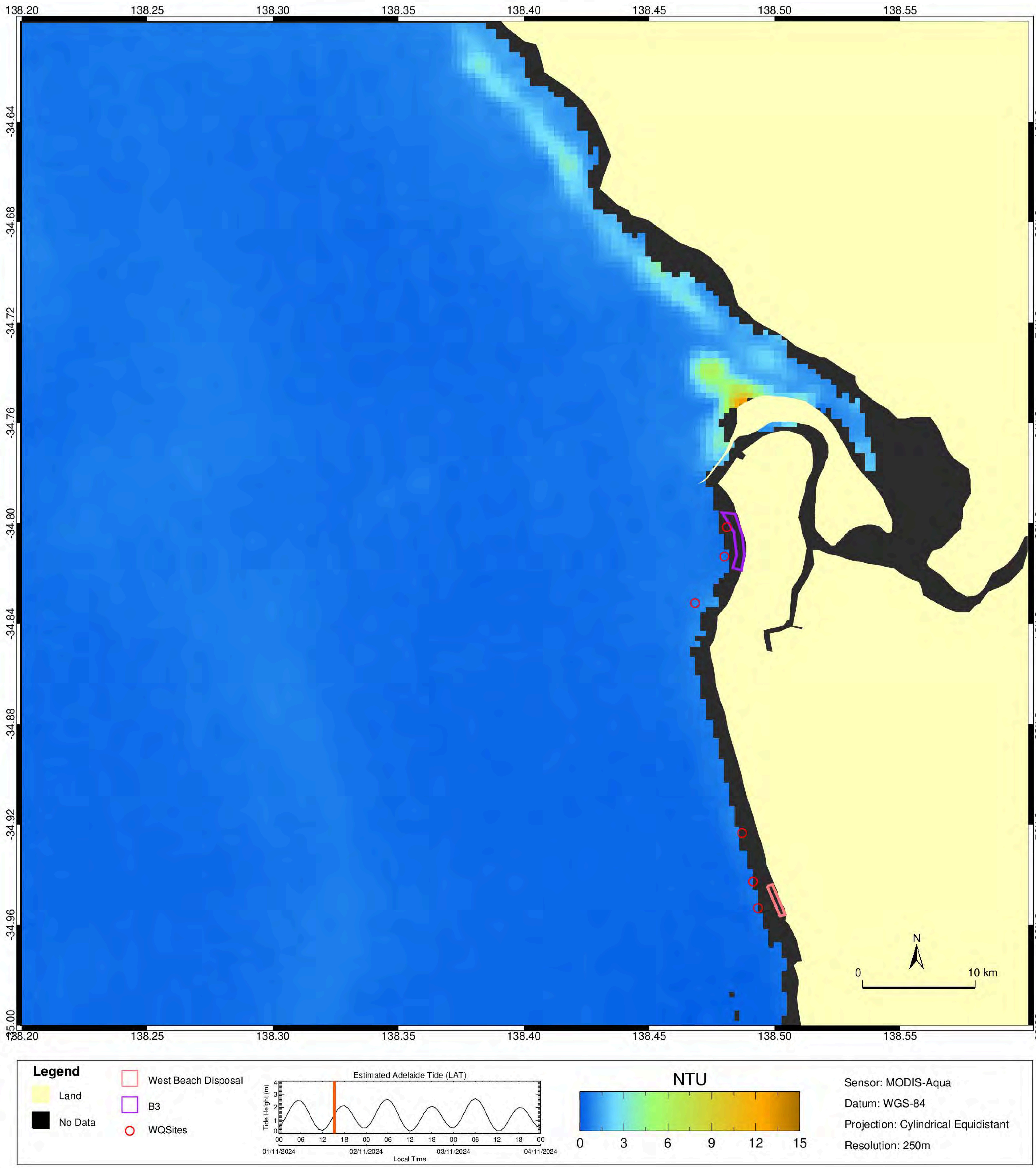
Datum: WGS-84

Projection: Cylindrical Equidistant

Resolution: 250m

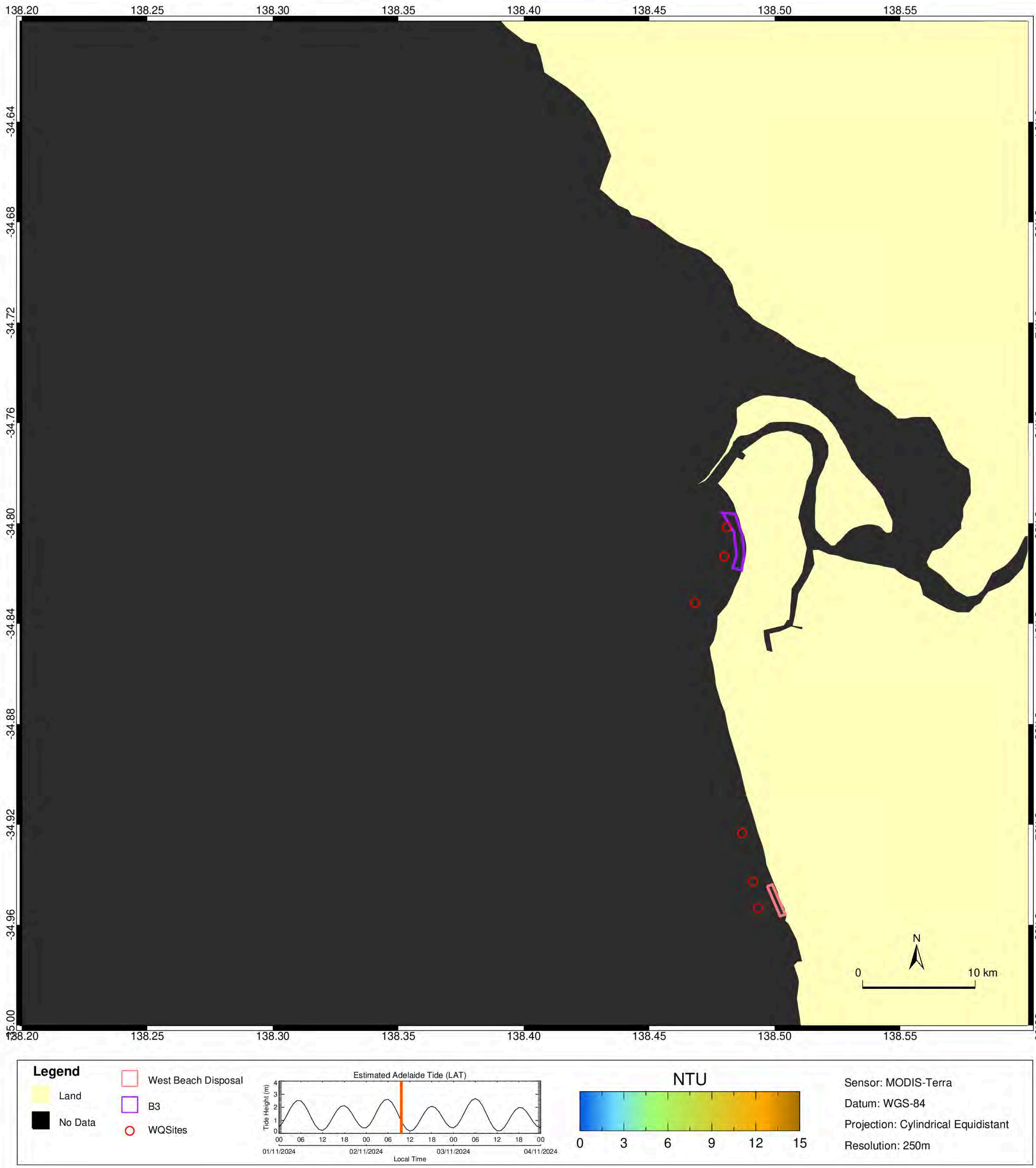
MODIS: Derived NTU

Image Capture: 1-Nov 2024, 15:15 (Local Time)



MODIS: Derived NTU

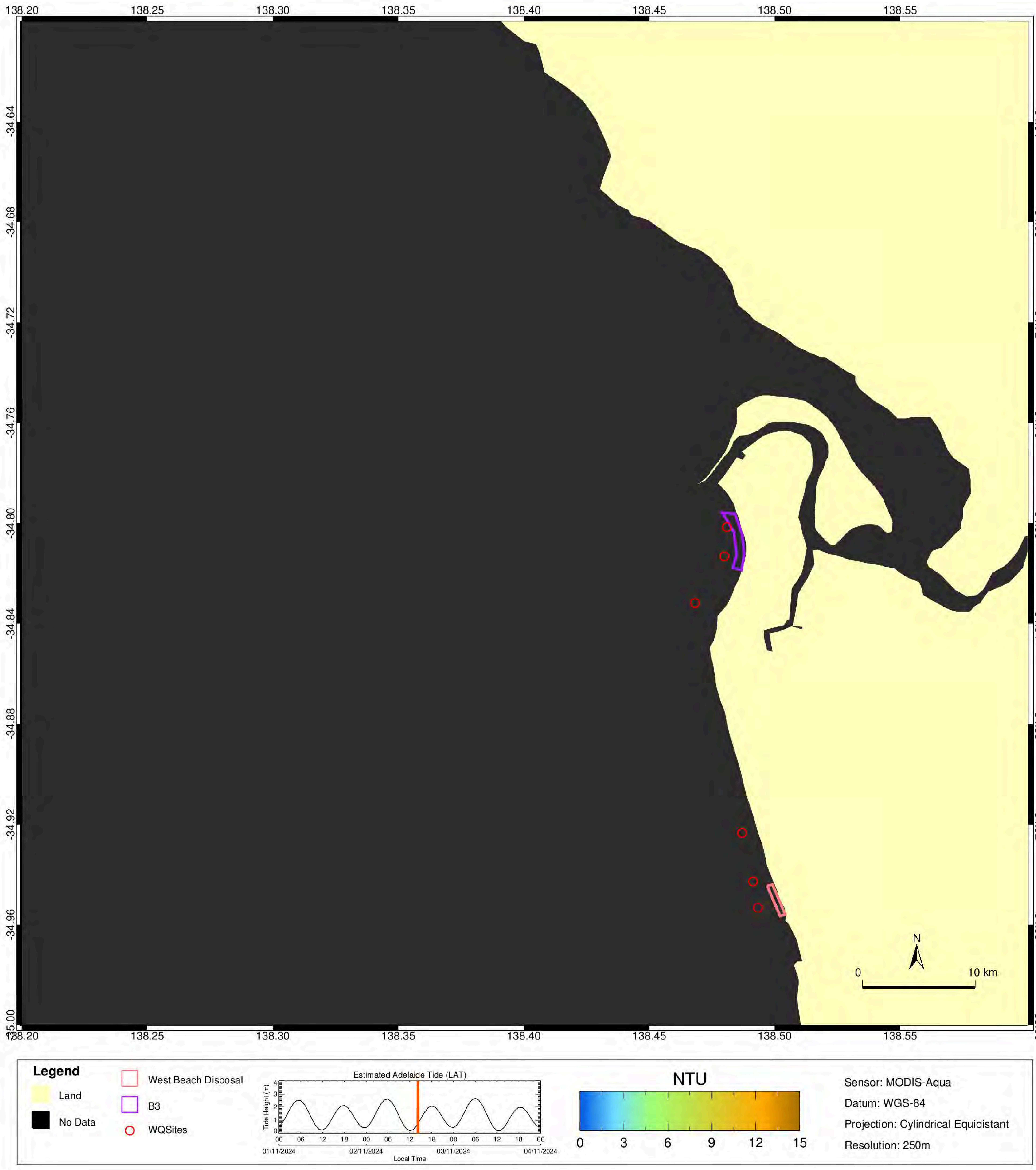
Image Capture: 2-Nov 2024, 09:40 (Local Time)



In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 2-Nov 2024, 14:15 (Local Time)



MODIS: Derived NTU

Image Capture: 3-Nov 2024, 08:45 (Local Time)

Legend

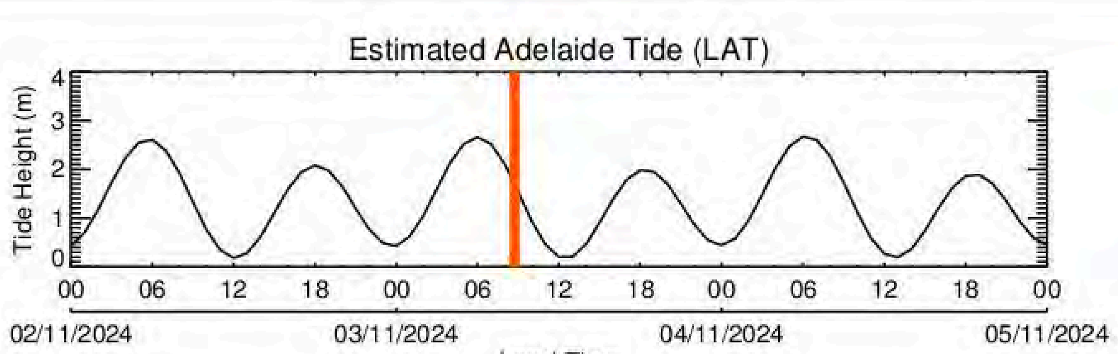
Land

No Data

West Beach Disposal

B3

WQSites



NTU

0 3 6 9 12 15

Sensor: MODIS-Terra

Datum: WGS-84

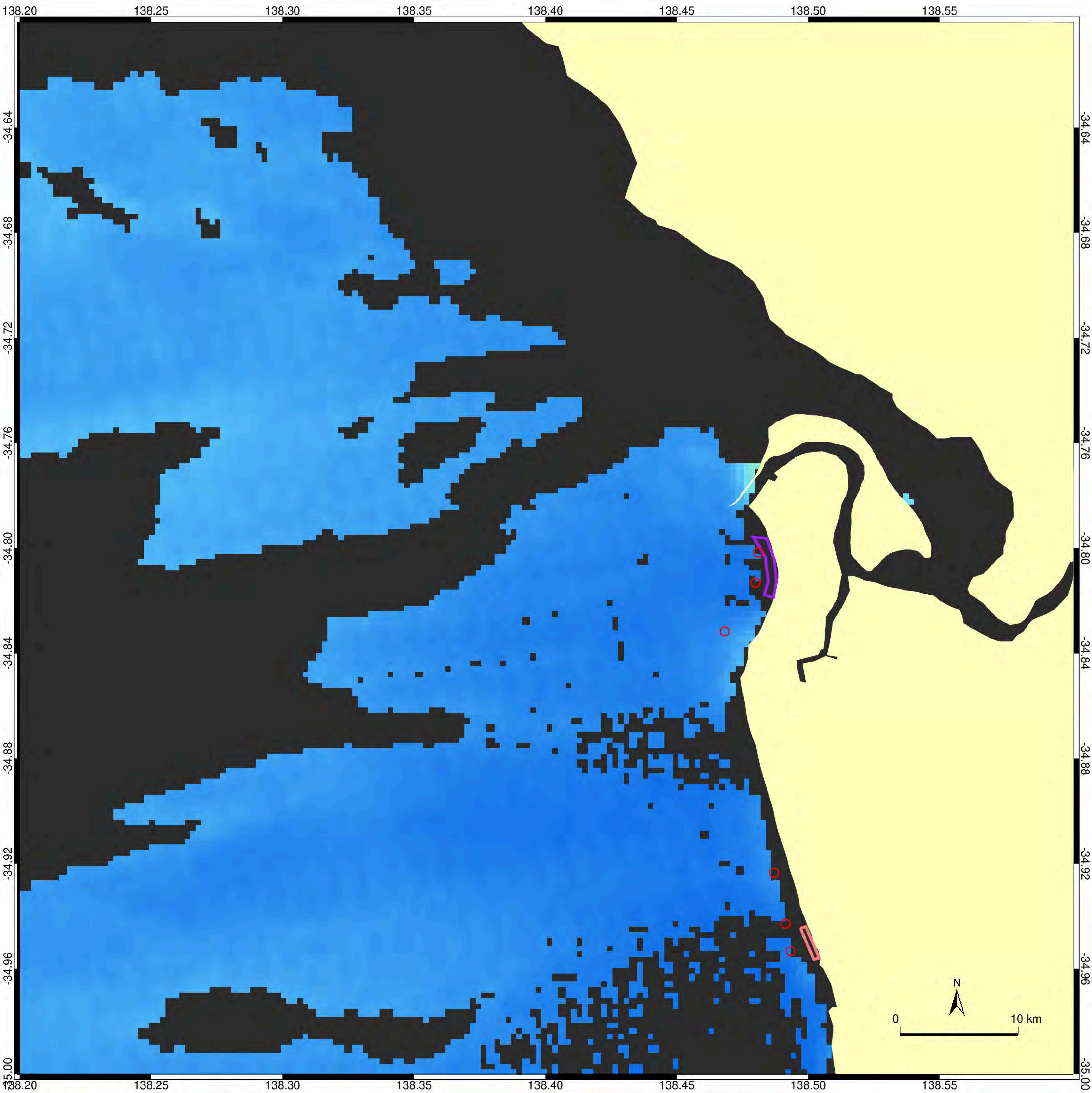
Projection: Cylindrical Equidistant

Resolution: 250m

In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 3-Nov 2024, 14:55 (Local Time)



Legend

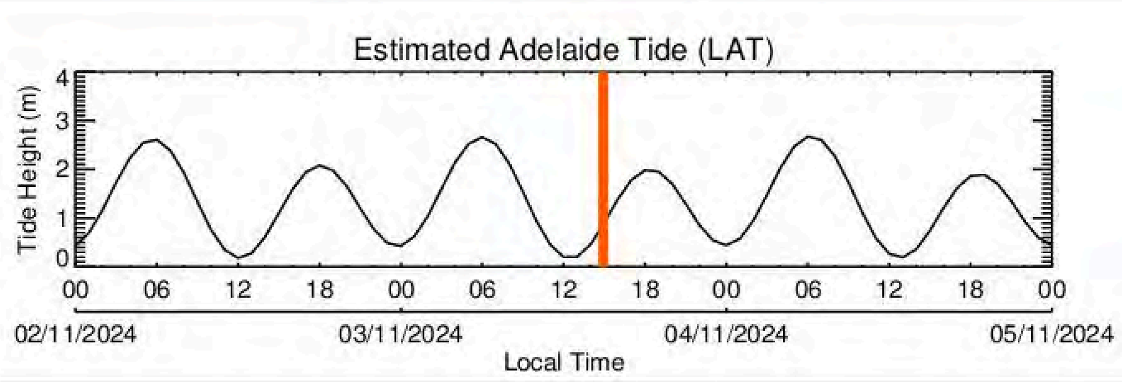
Land

No Data

West Beach Disposal

B3

WQSites



NTU

0 3 6 9 12 15

Sensor: MODIS-Aqua

Datum: WGS-84

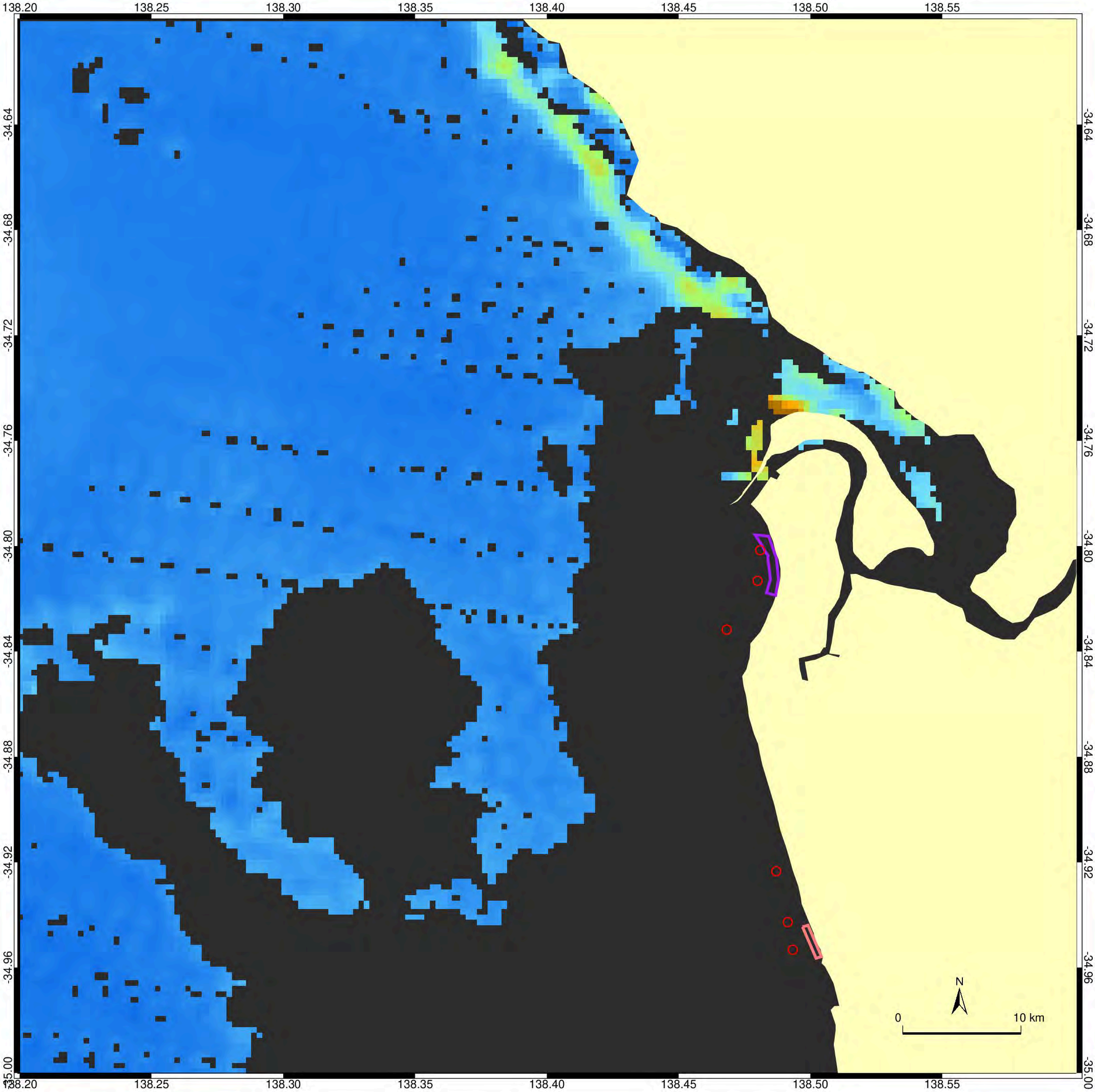
Projection: Cylindrical Equidistant

Resolution: 250m

MODIS: Derived NTU

In-situ Marine Optics

Image Capture: 4-Nov 2024, 09:25 (Local Time)



Legend

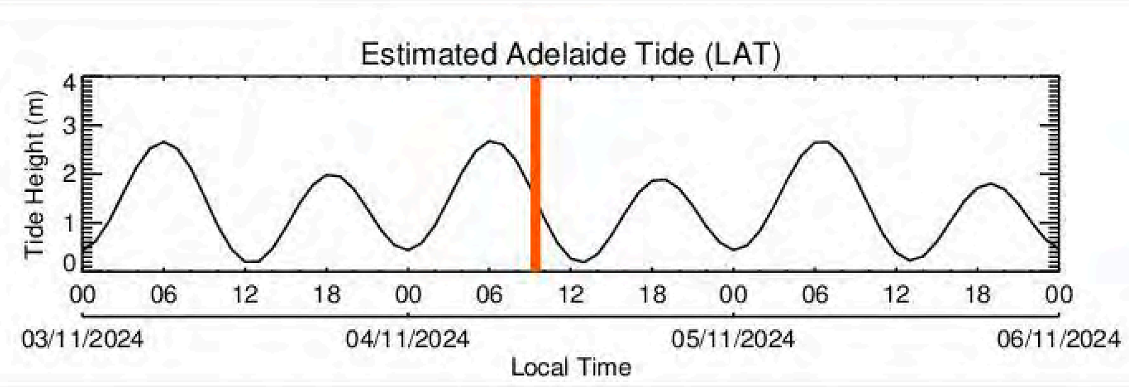
Land

No Data

West Beach Disposal

B3

WQSites



NTU

0 3 6 9 12 15

Sensor: MODIS-Terra

Datum: WGS-84

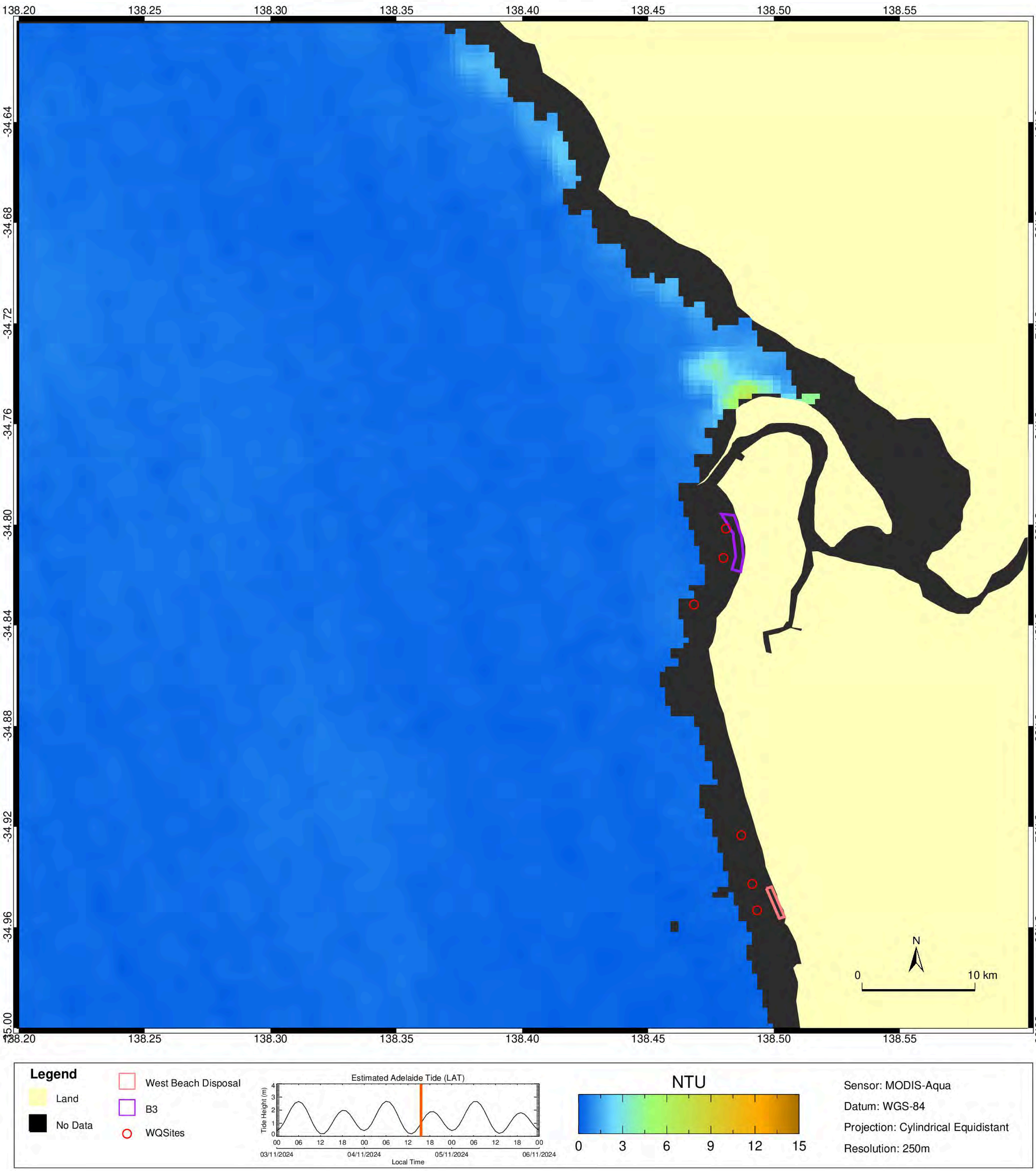
Projection: Cylindrical Equidistant

Resolution: 250m

In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 4-Nov 2024, 15:35 (Local Time)

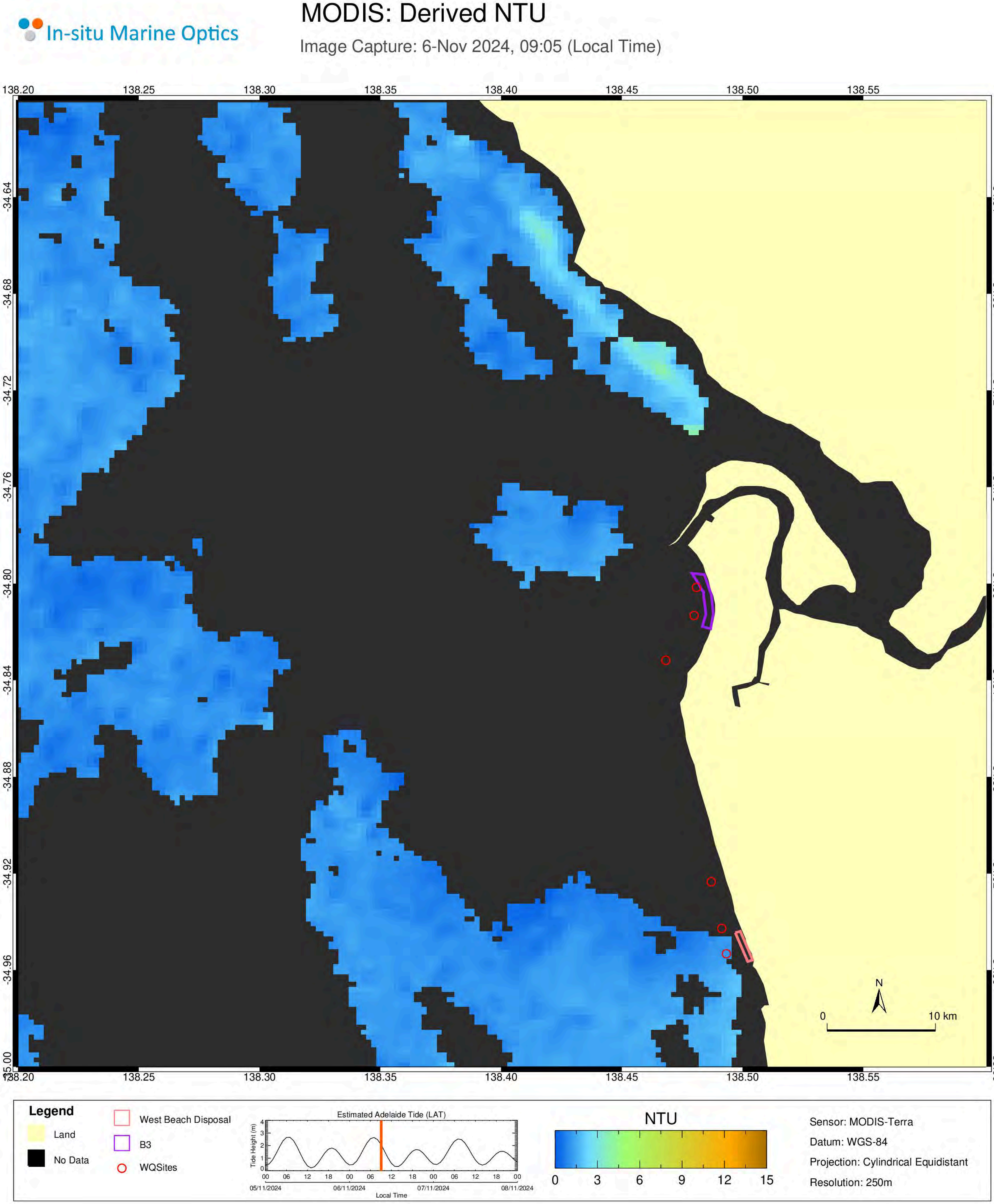


MODIS: Derived NTU

Image Capture: 5-Nov 2024, 14:40 (Local Time)

MODIS: Derived NTU

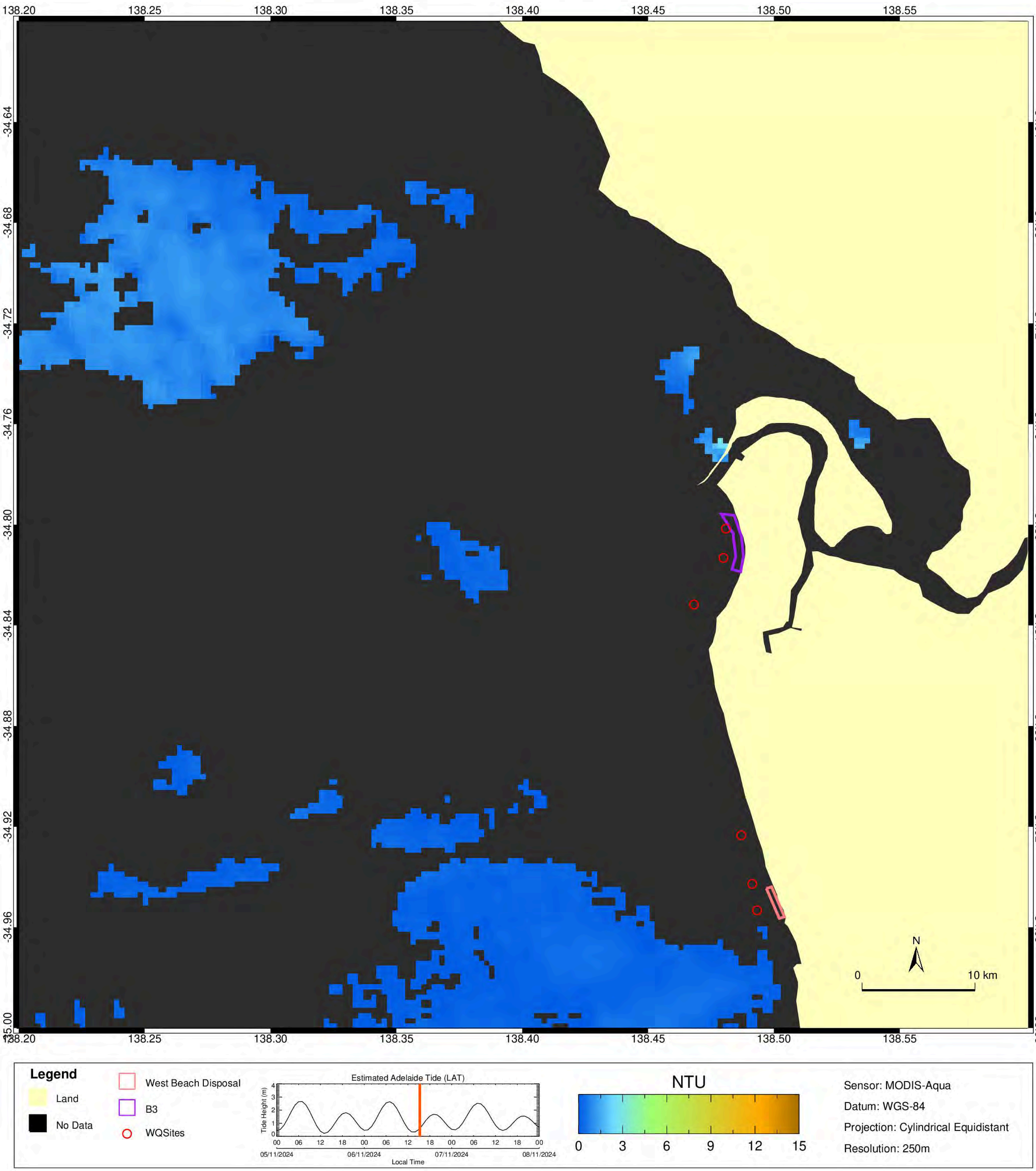
Image Capture: 6-Nov 2024, 09:05 (Local Time)



In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 6-Nov 2024, 15:15 (Local Time)



In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 7-Nov 2024, 14:20 (Local Time)

Legend

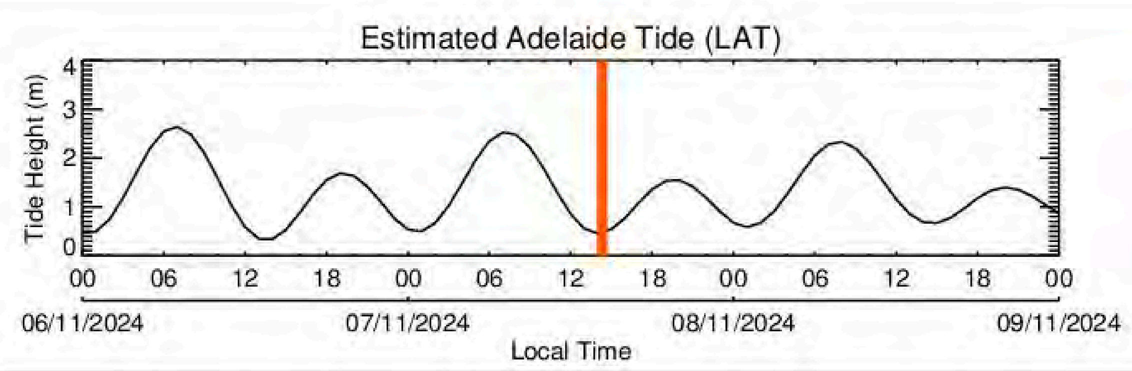
Land

No Data

West Beach Disposal

B3

WQSites



NTU

0 3 6 9 12 15

Sensor: MODIS-Aqua

Datum: WGS-84

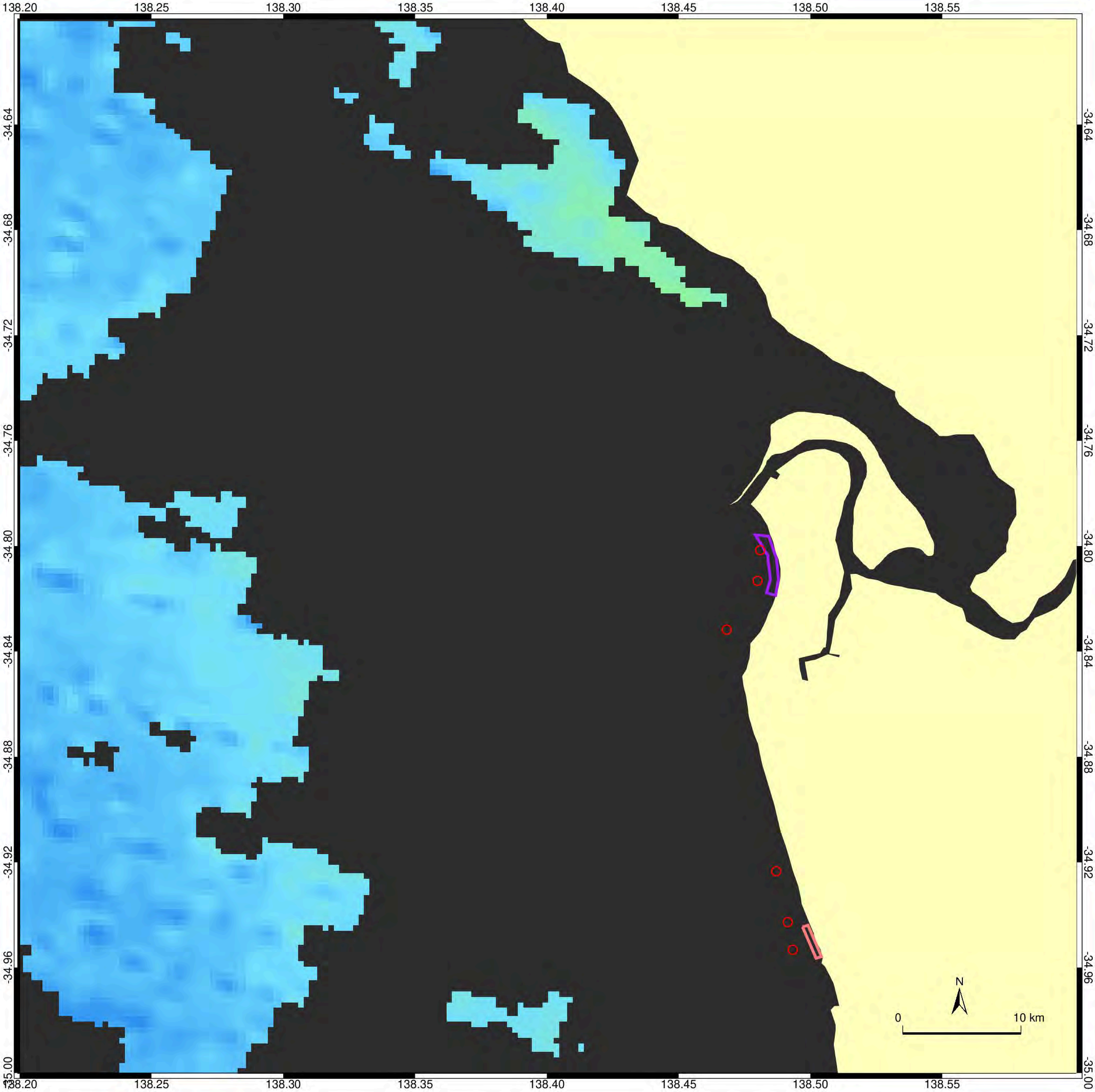
Projection: Cylindrical Equidistant

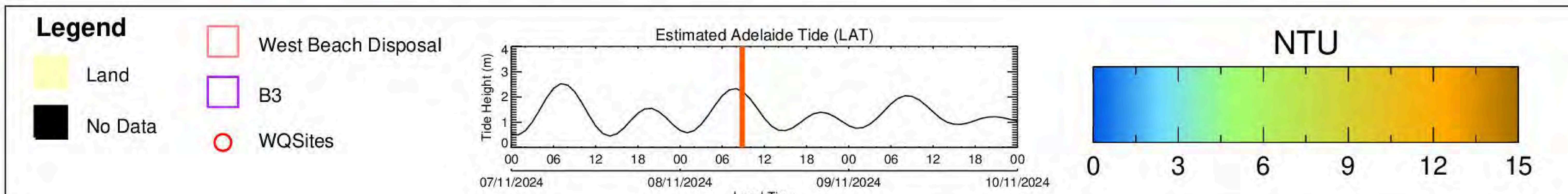
Resolution: 250m

MODIS: Derived NTU

In-situ Marine Optics

Image Capture: 8-Nov 2024, 08:50 (Local Time)





Sensor: MODIS-Terra

Datum: WGS-84

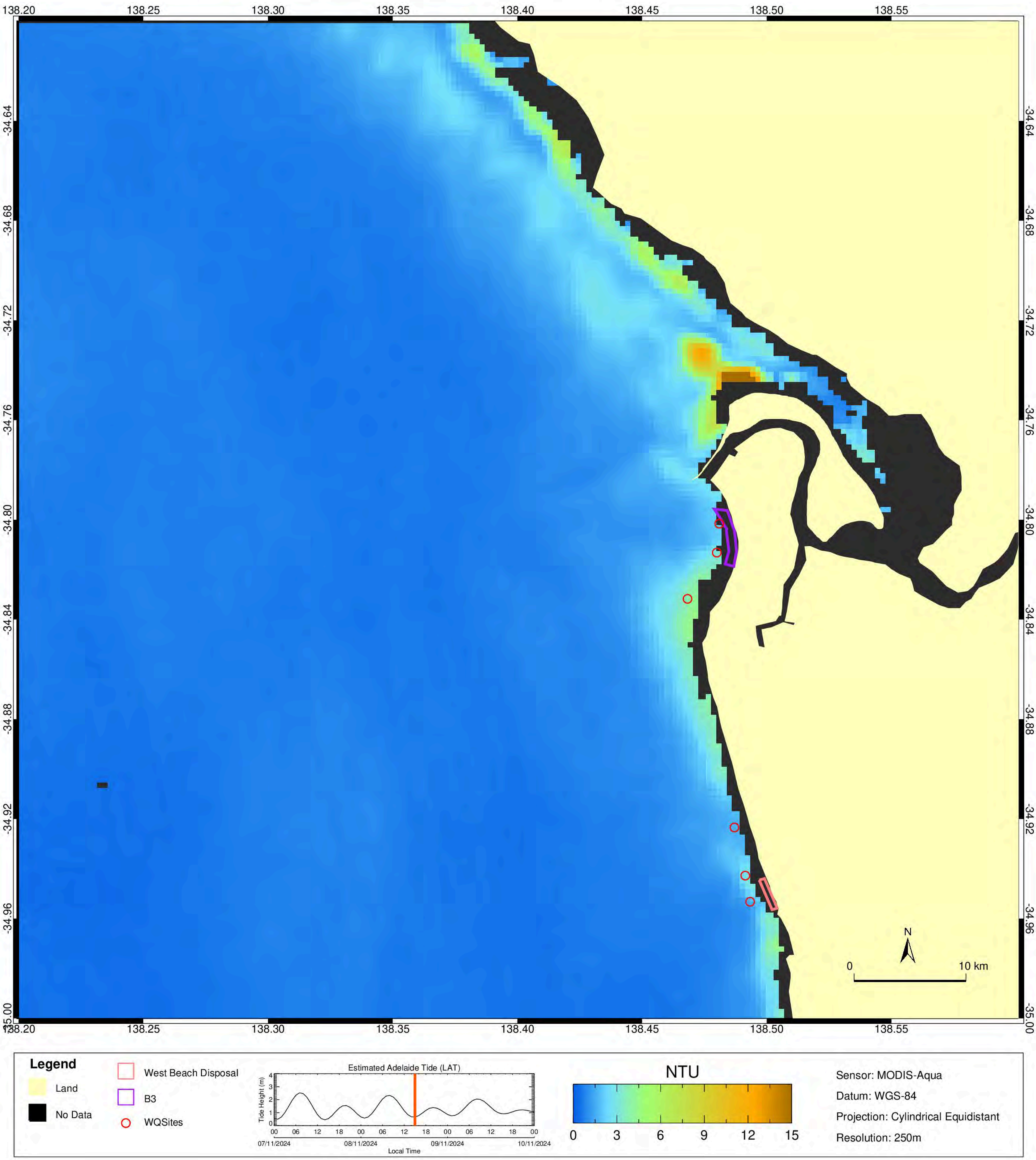
Projection: Cylindrical Equidistant

Resolution: 250m

In-situ Marine Optics

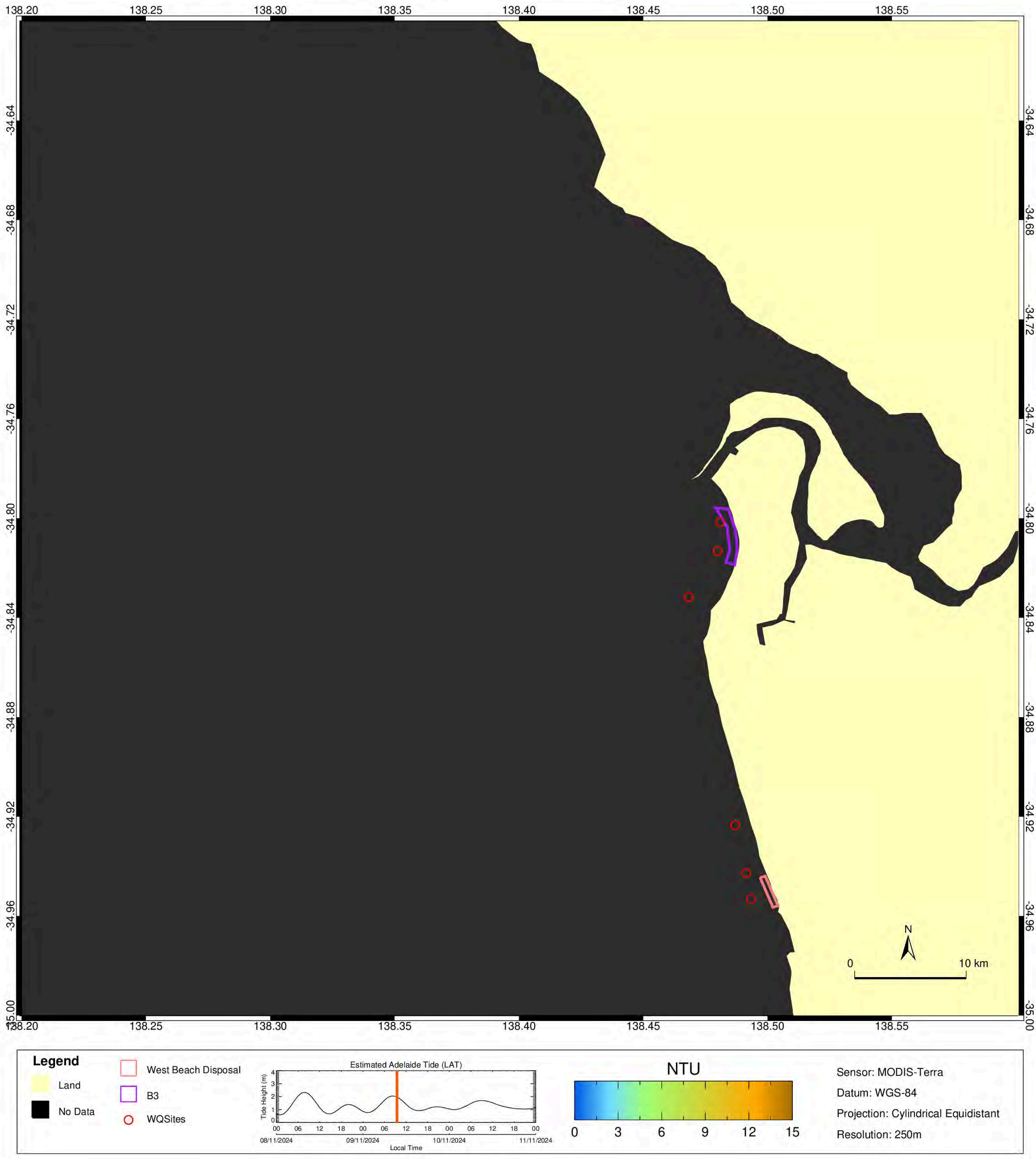
MODIS: Derived NTU

Image Capture: 8-Nov 2024, 15:00 (Local Time)



MODIS: Derived NTU

Image Capture: 9-Nov 2024, 09:30 (Local Time)



Sensor: MODIS-Terra

Datum: WGS-84

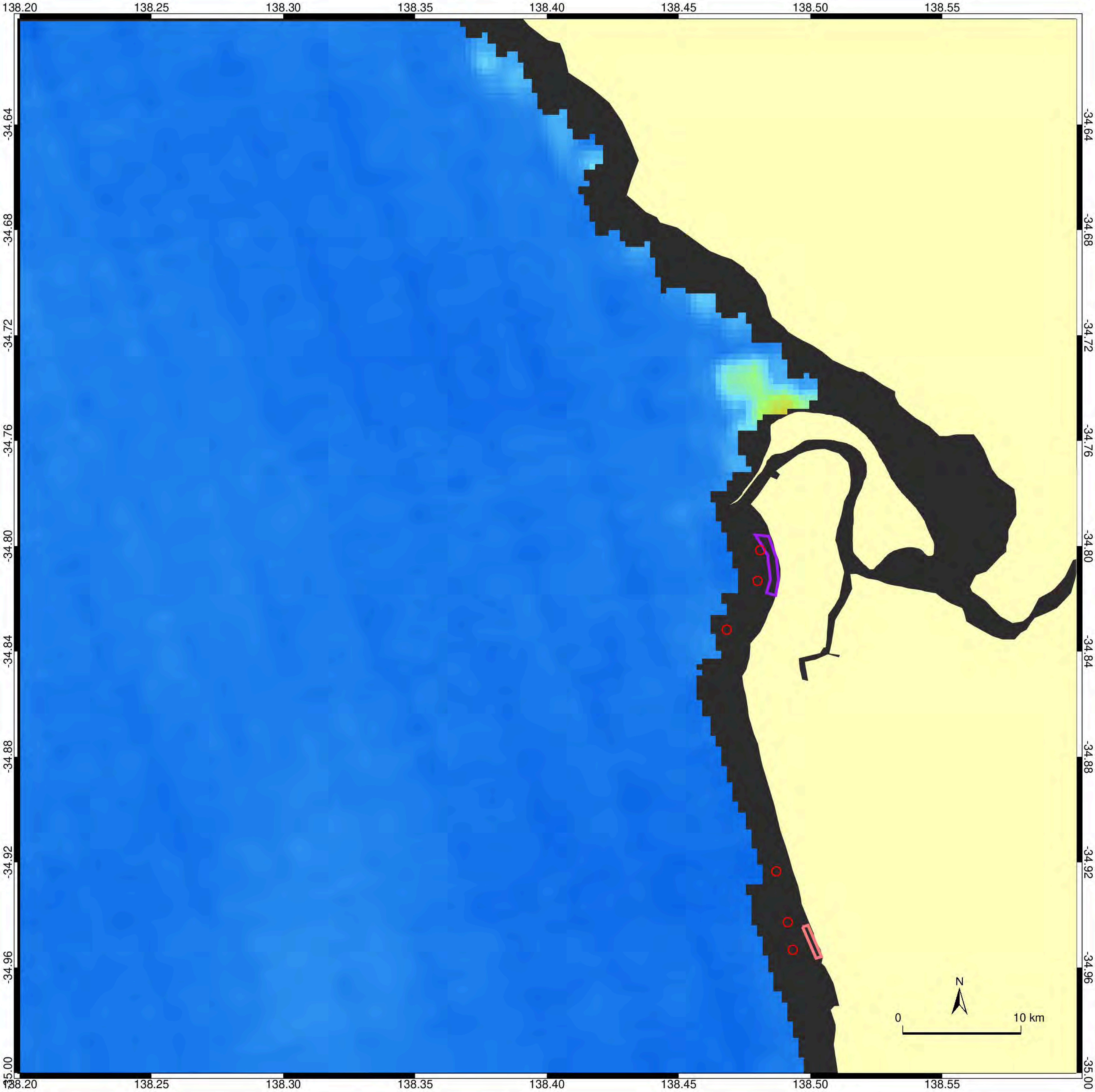
Projection: Cylindrical Equidistant

Resolution: 250m

In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 9-Nov 2024, 15:40 (Local Time)



Legend

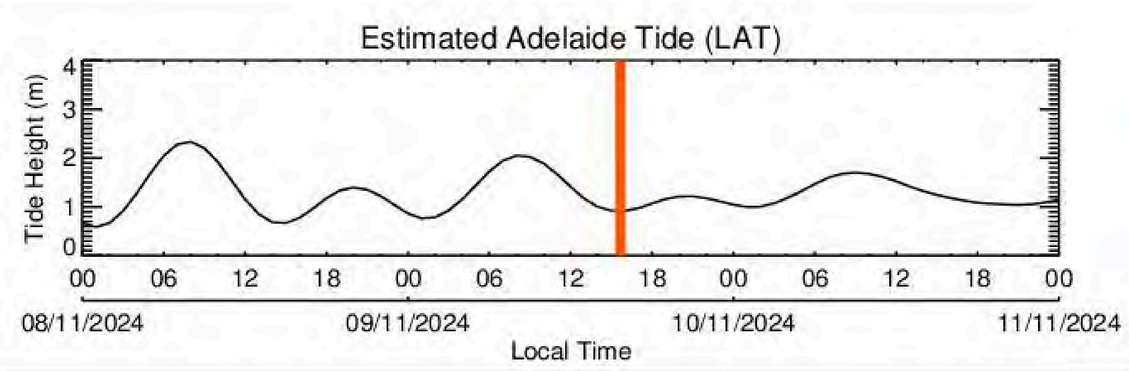
Land

No Data

West Beach Disposal

B3

WQSites



NTU

0 3 6 9 12 15

Sensor: MODIS-Aqua

Datum: WGS-84

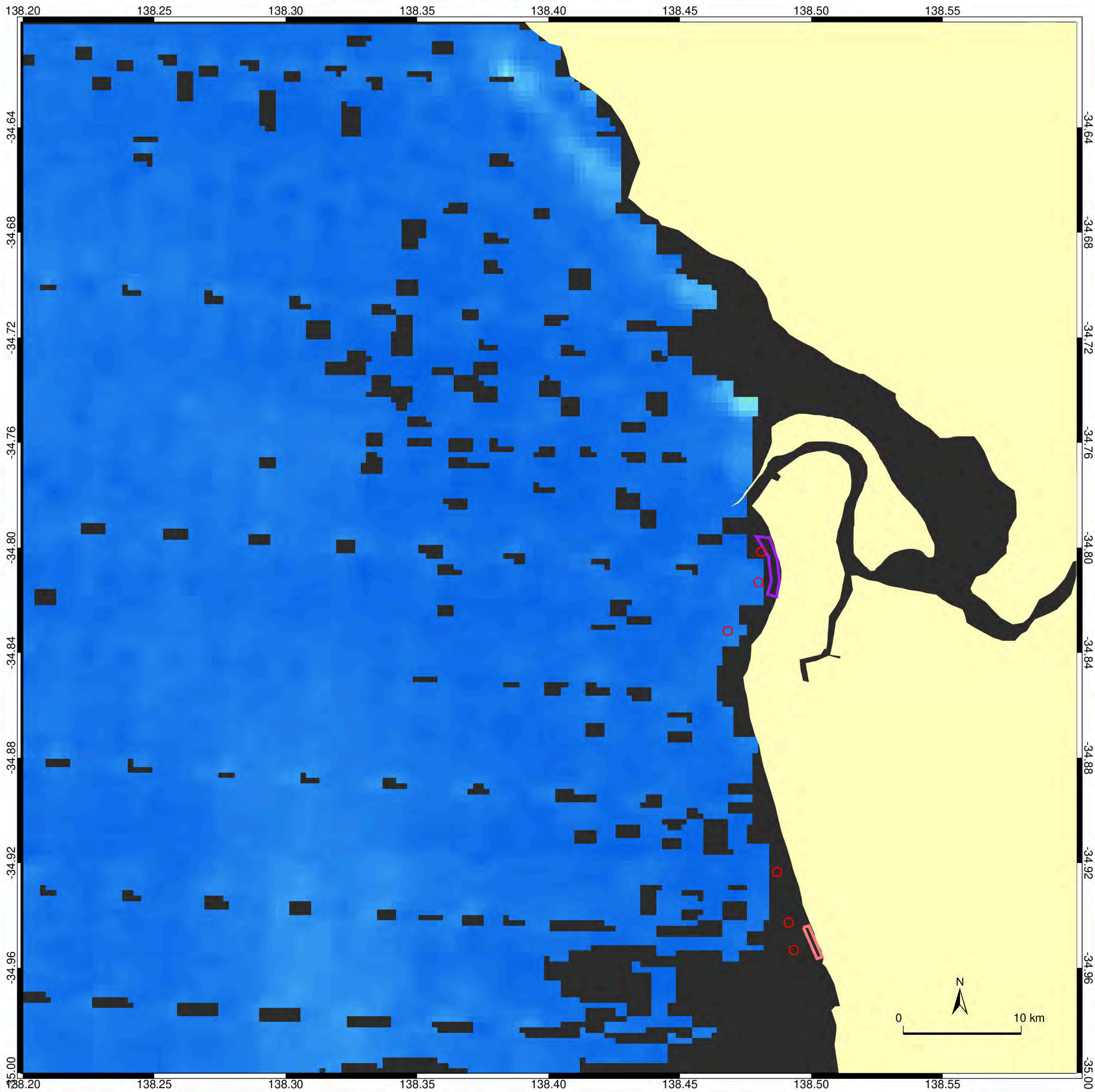
Projection: Cylindrical Equidistant

Resolution: 250m

In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 10-Nov 2024, 10:10 (Local Time)



Legend

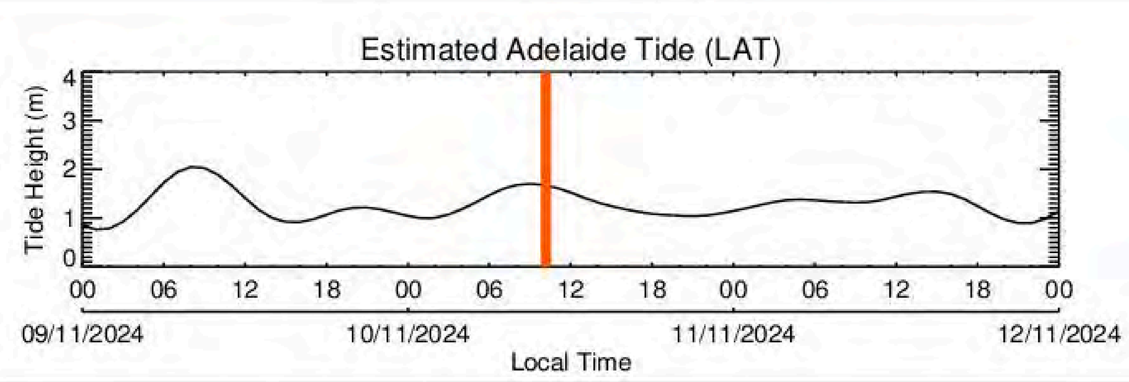
Land

No Data

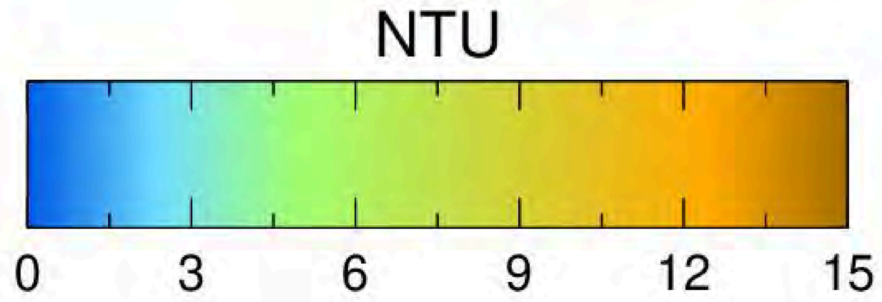
West Beach Disposal

B3

WQSites



NTU



Sensor: MODIS-Terra

Datum: WGS-84

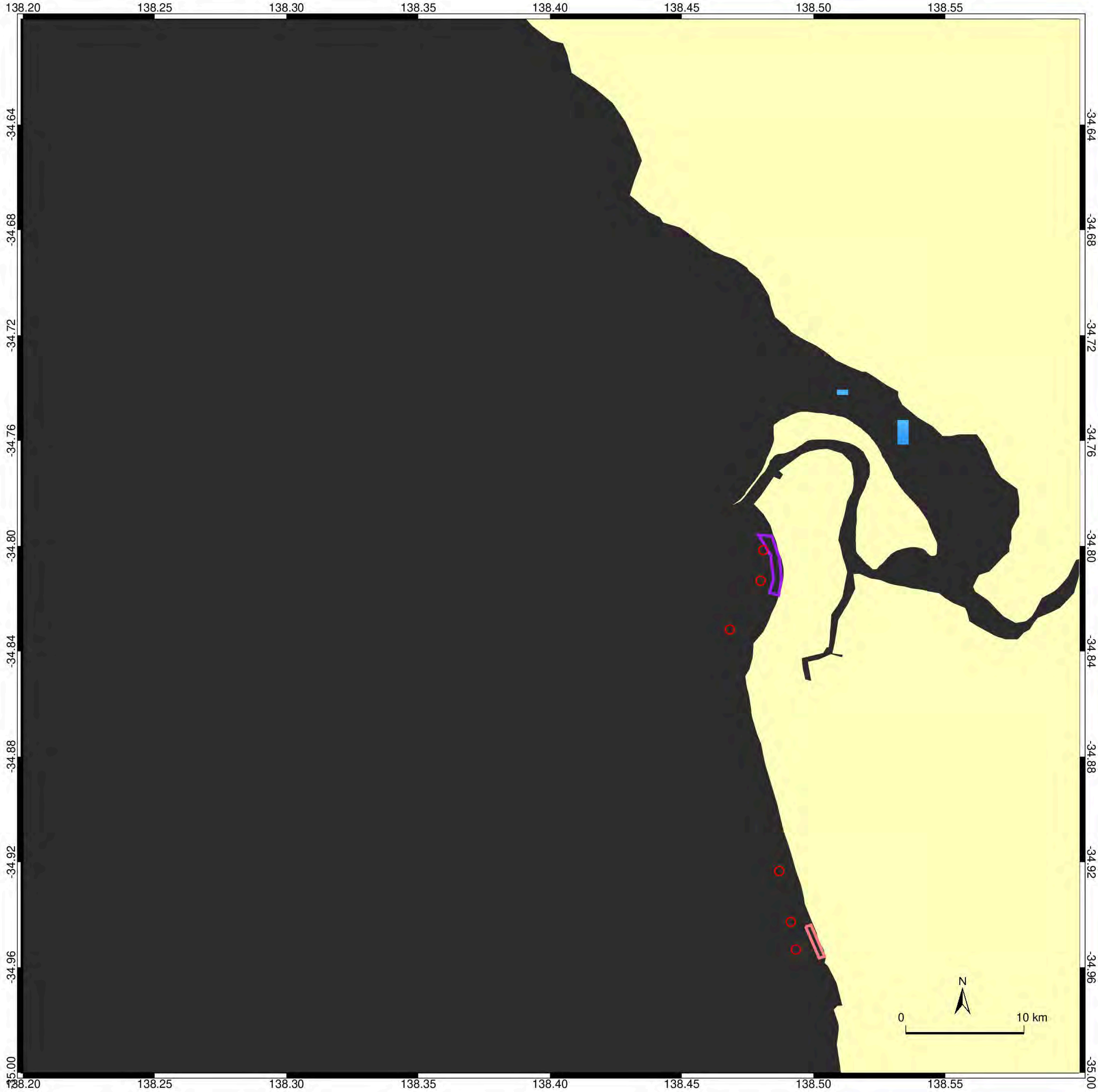
Projection: Cylindrical Equidistant

Resolution: 250m

In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 10-Nov 2024, 14:40 (Local Time)



Legend

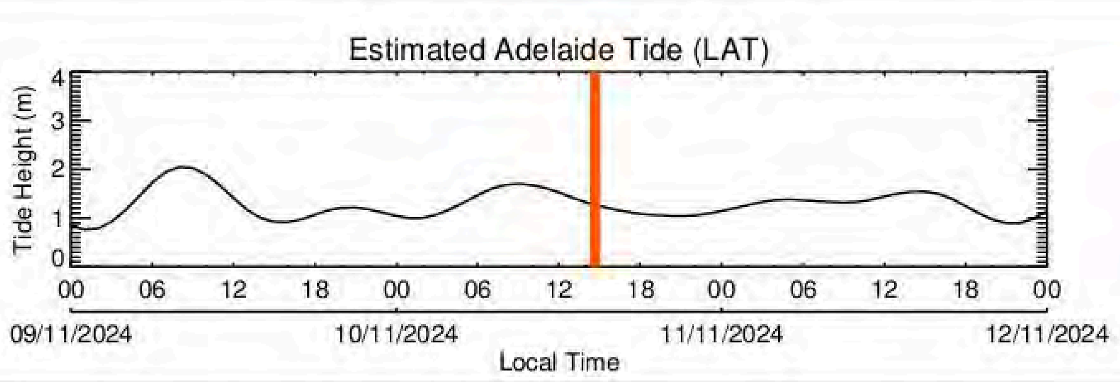
Land

No Data

West Beach Disposal

B3

WQSites



NTU

0 3 6 9 12 15

Sensor: MODIS-Aqua

Datum: WGS-84

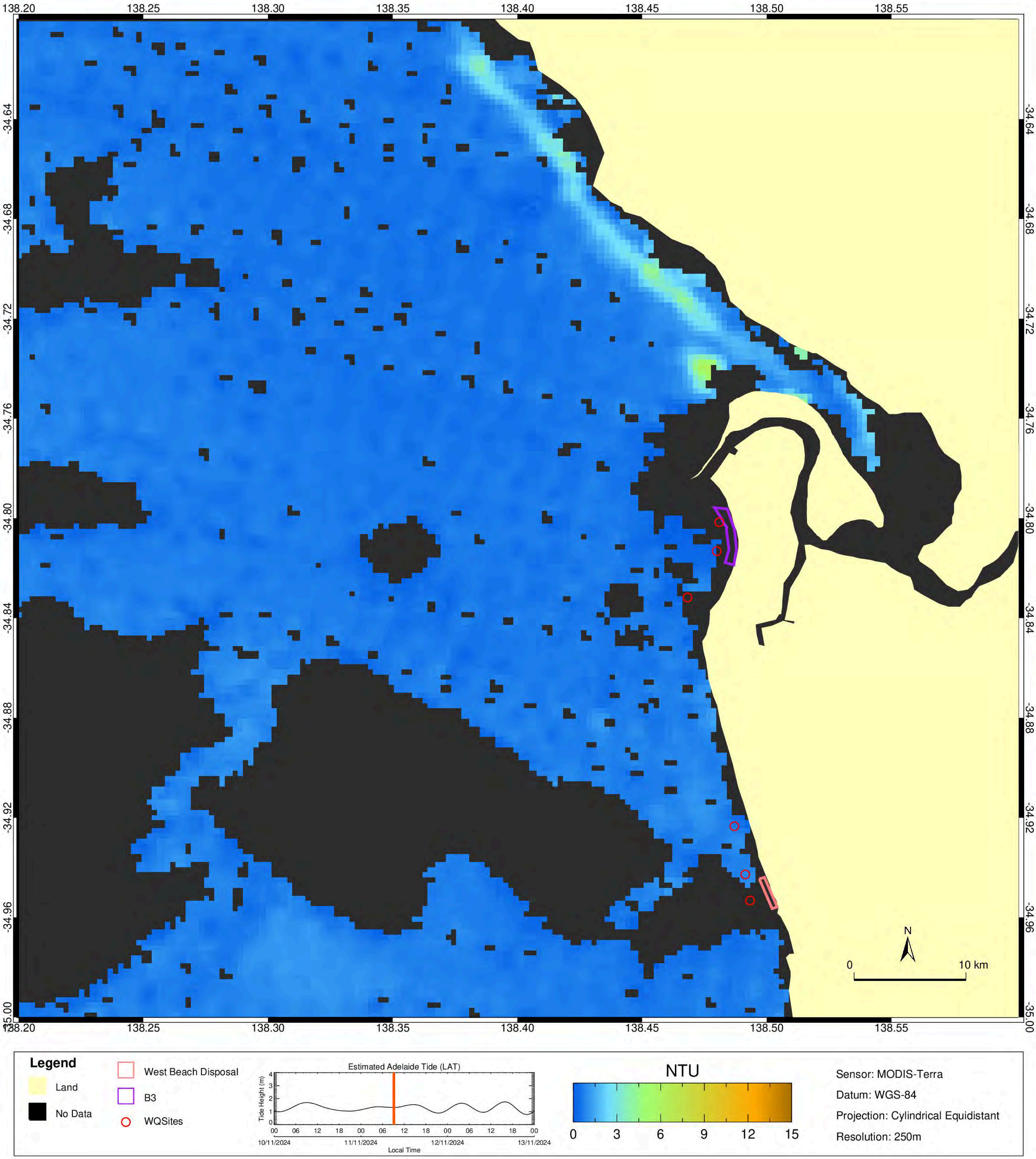
Projection: Cylindrical Equidistant

Resolution: 250m

In-situ Marine Optics

MODIS: Derived NTU

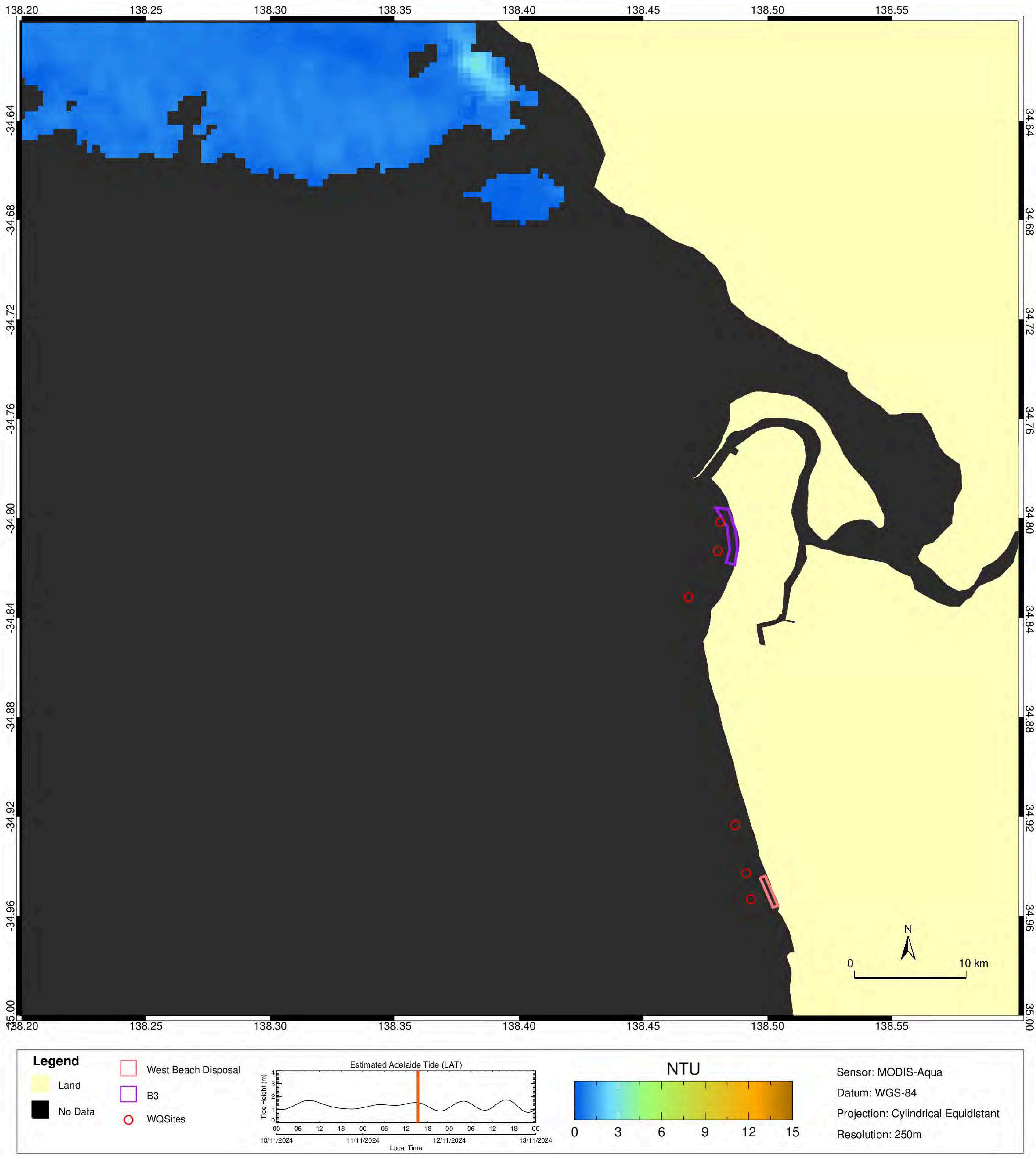
Image Capture: 11-Nov 2024, 09:10 (Local Time)



In-situ Marine Optics

MODIS: Derived NTU

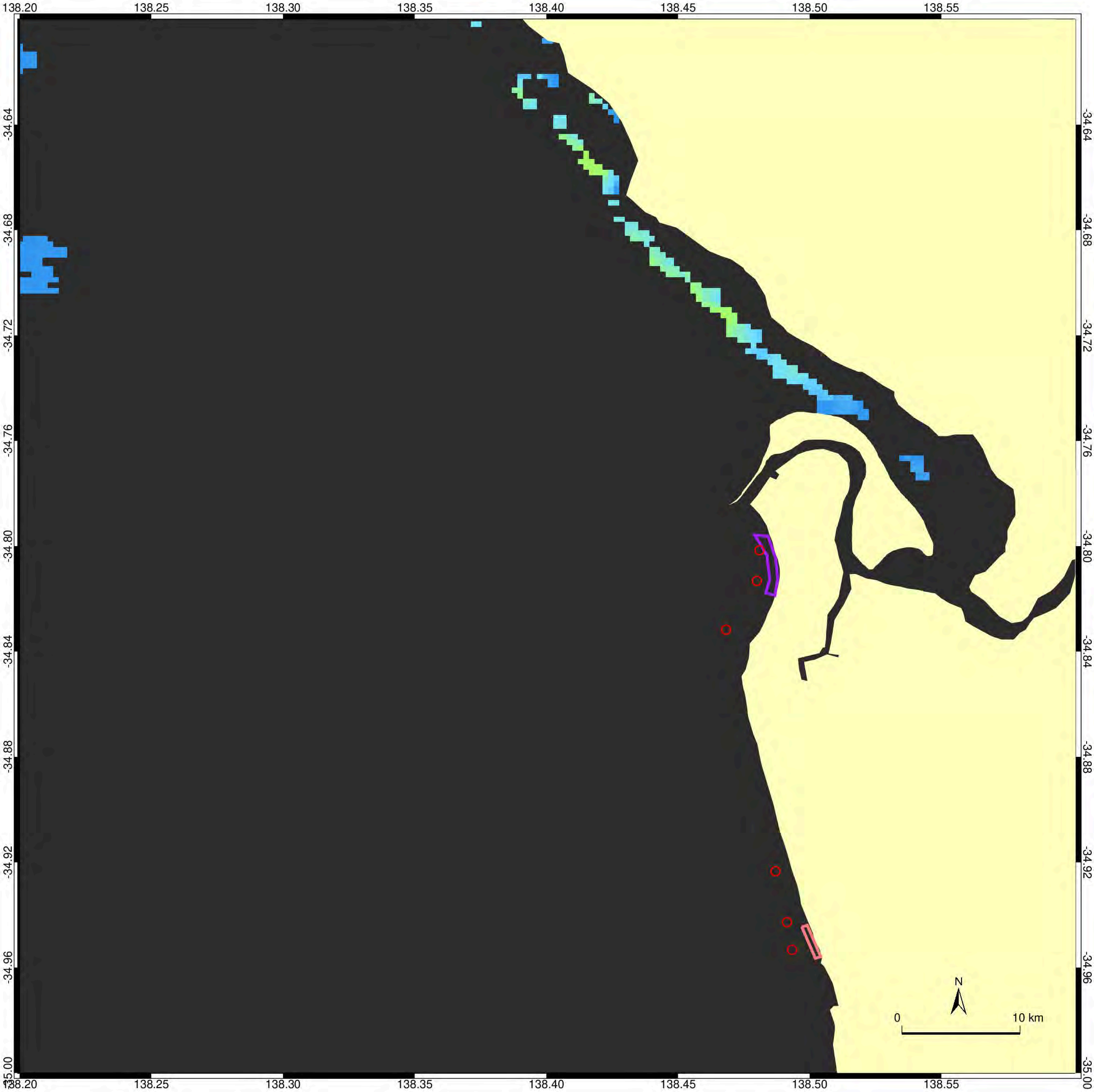
Image Capture: 11-Nov 2024, 15:20 (Local Time)



MODIS: Derived NTU

In-situ Marine Optics

Image Capture: 12-Nov 2024, 09:50 (Local Time)



Legend

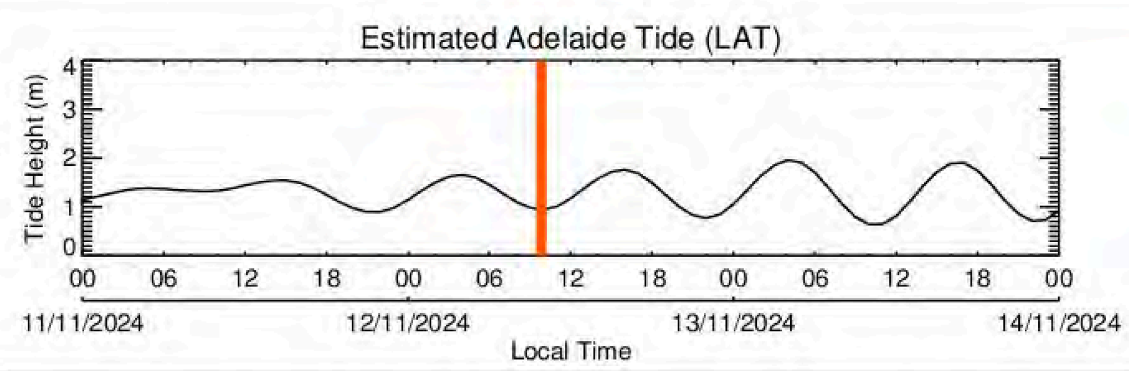
Land

No Data

West Beach Disposal

B3

WQSites



NTU

0 3 6 9 12 15

Sensor: MODIS-Terra

Datum: WGS-84

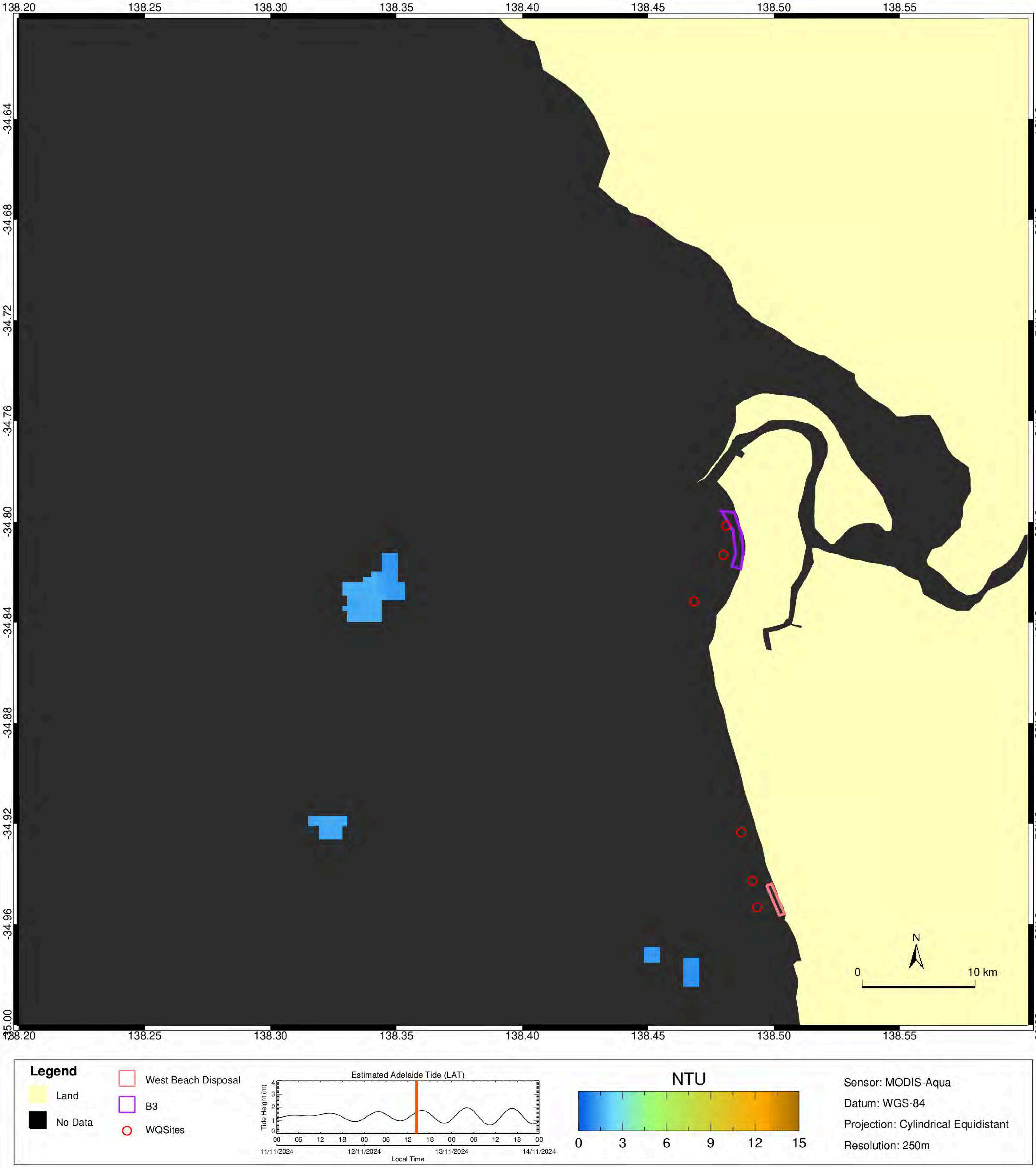
Projection: Cylindrical Equidistant

Resolution: 250m

In-situ Marine Optics

MODIS: Derived NTU

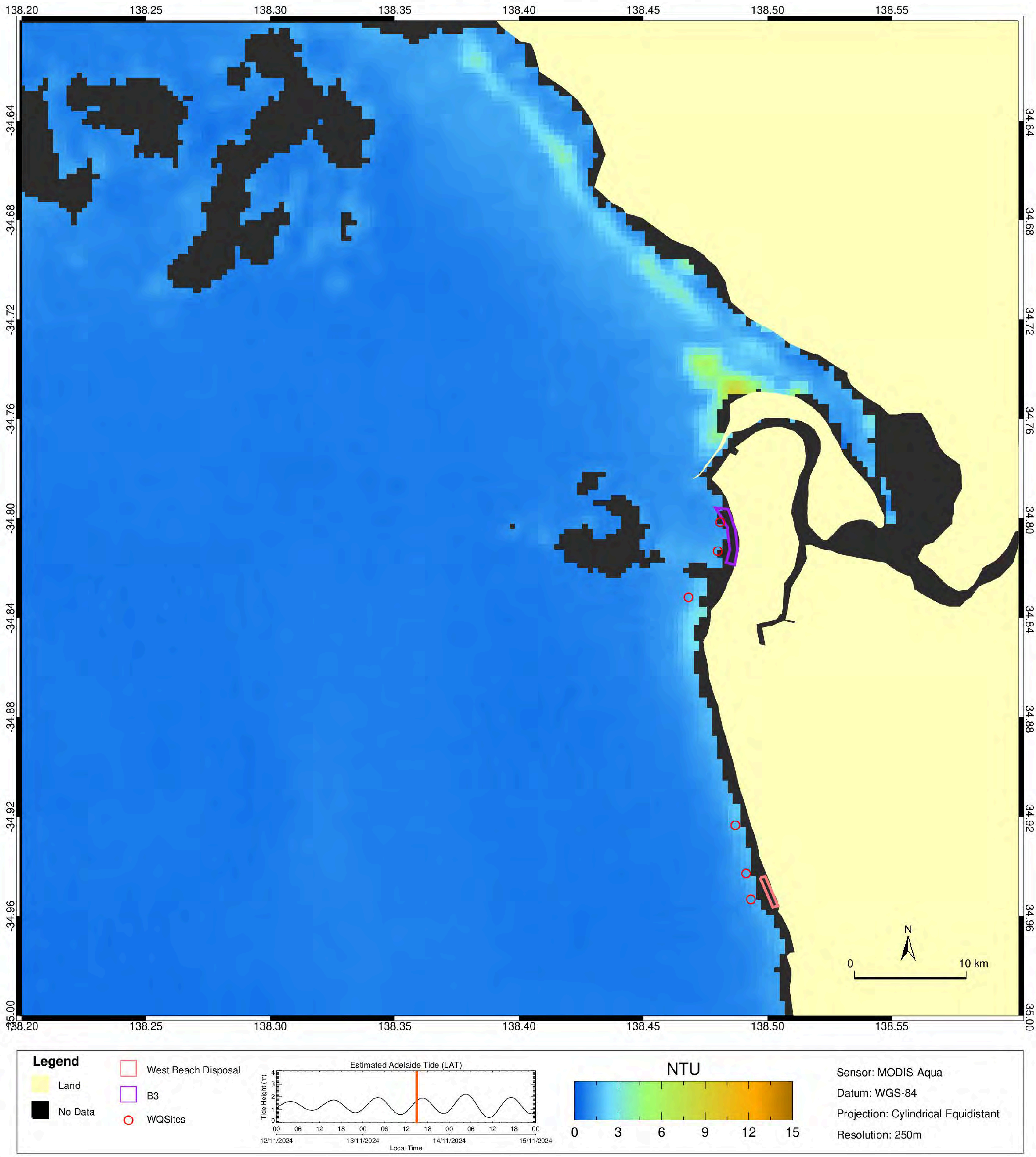
Image Capture: 12-Nov 2024, 14:20 (Local Time)



In-situ Marine Optics

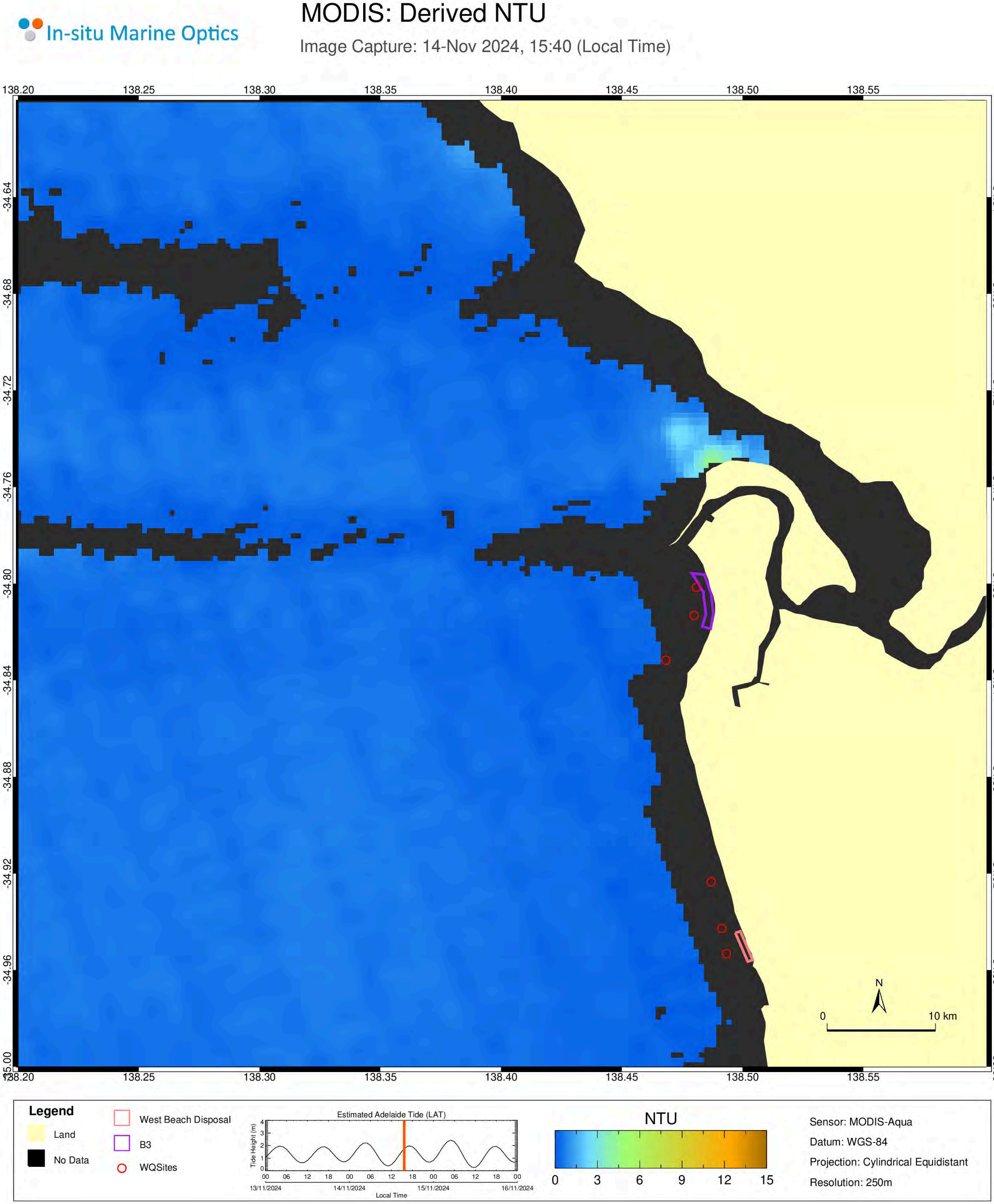
MODIS: Derived NTU

Image Capture: 13-Nov 2024, 15:00 (Local Time)



MODIS: Derived NTU

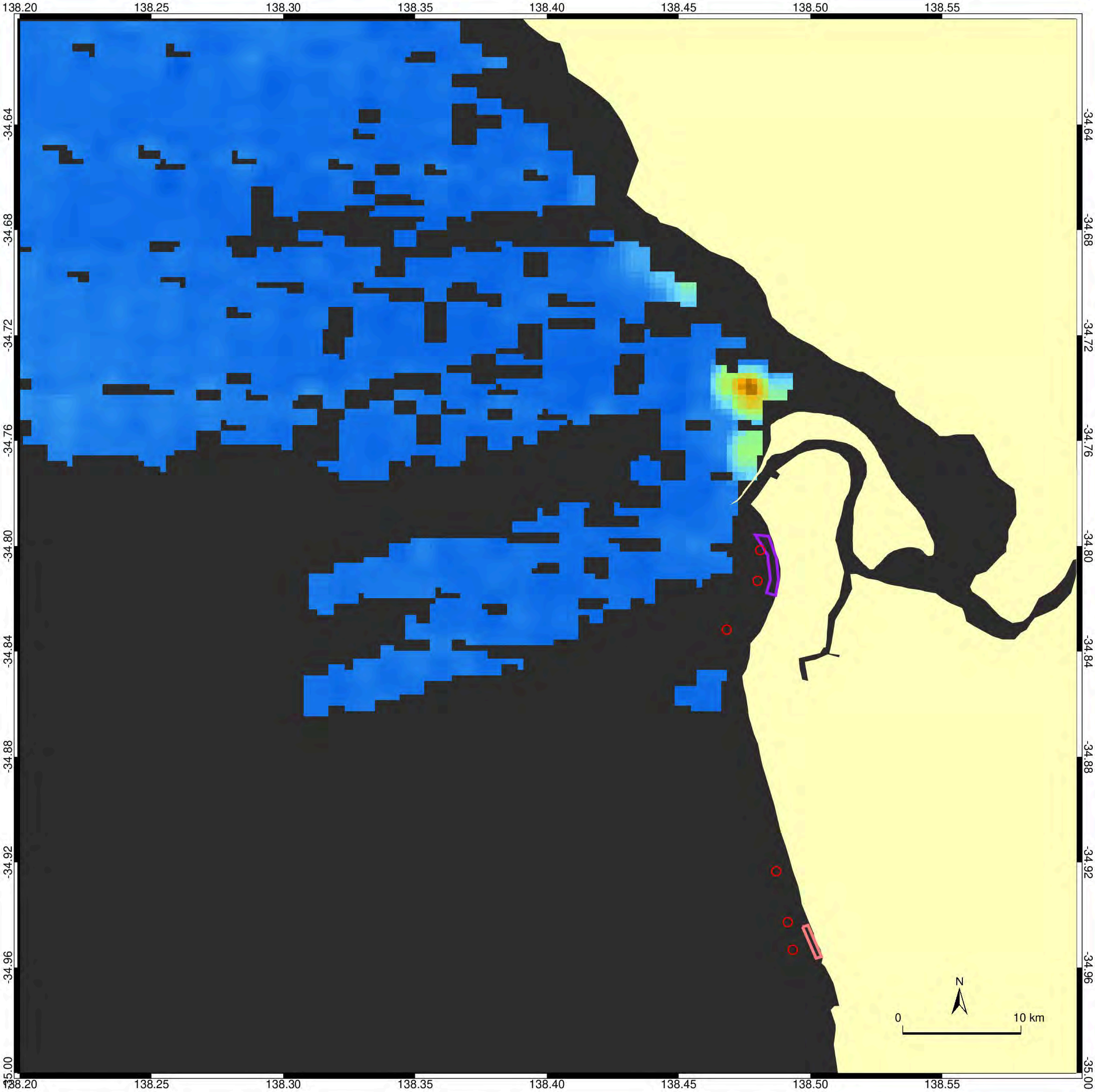
Image Capture: 14-Nov 2024, 15:40 (Local Time)

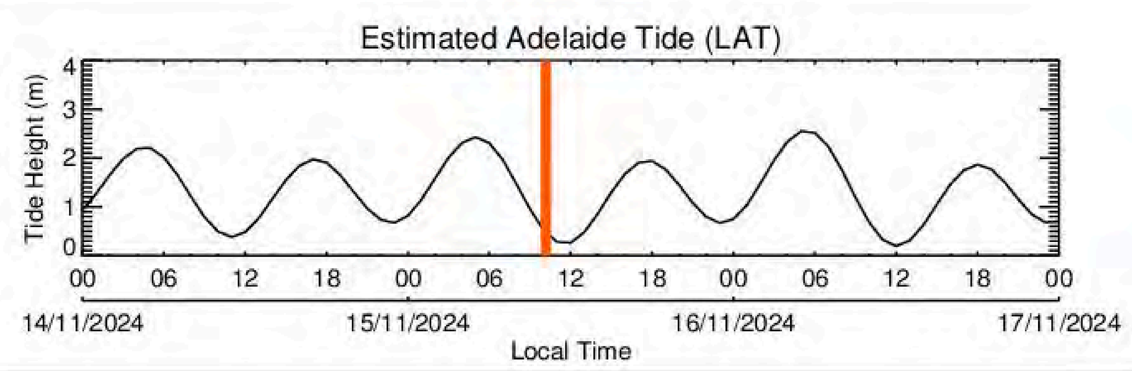


MODIS: Derived NTU

In-situ Marine Optics

Image Capture: 15-Nov 2024, 10:10 (Local Time)





Legend

Land

No Data

West Beach Disposal

B3

WQSites

NTU

0 3 6 9 12 15

Sensor: MODIS-Terra

Datum: WGS-84

Projection: Cylindrical Equidistant

Resolution: 250m

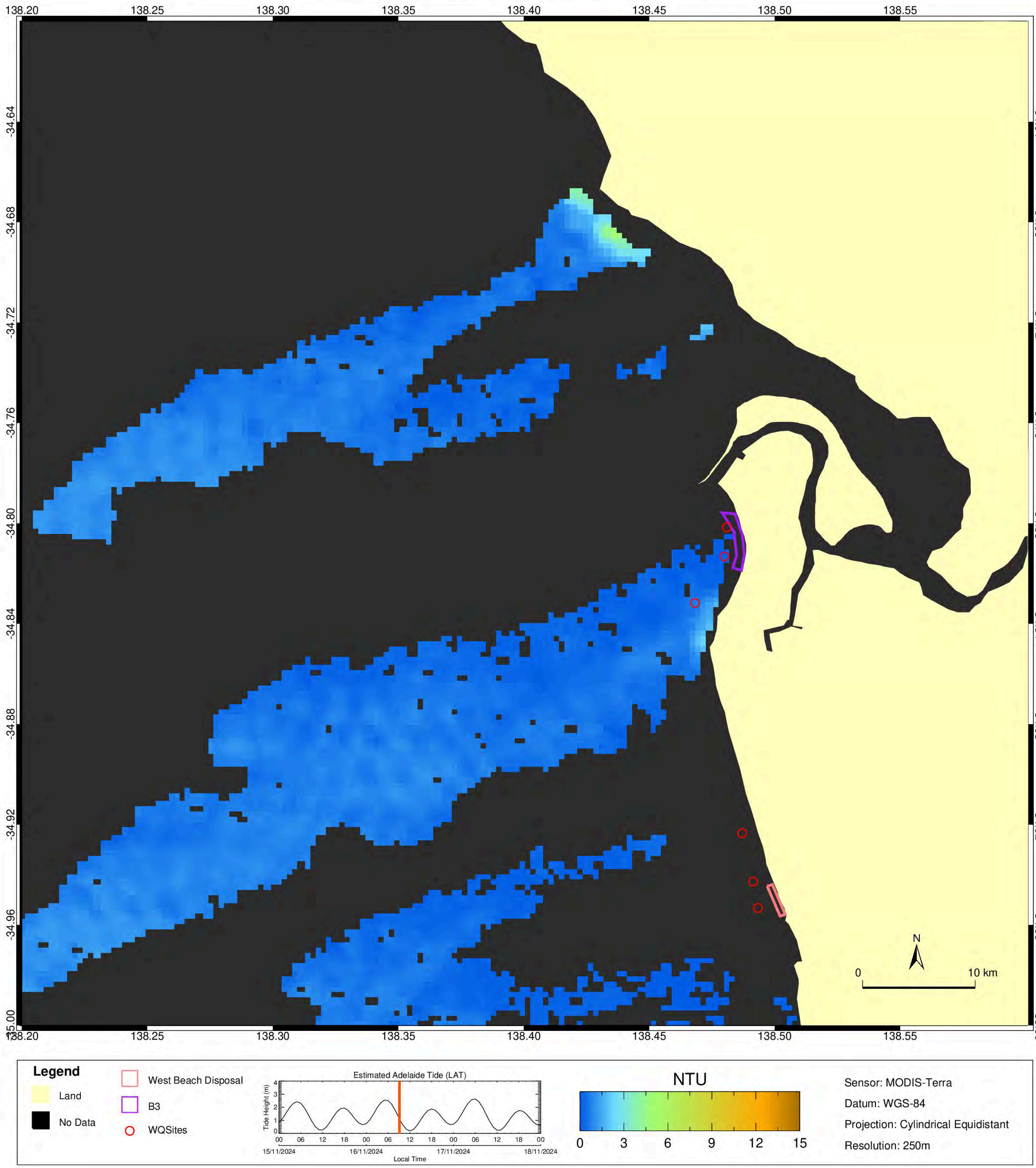
MODIS: Derived NTU

Image Capture: 15-Nov 2024, 14:45 (Local Time)

In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 16-Nov 2024, 09:10 (Local Time)

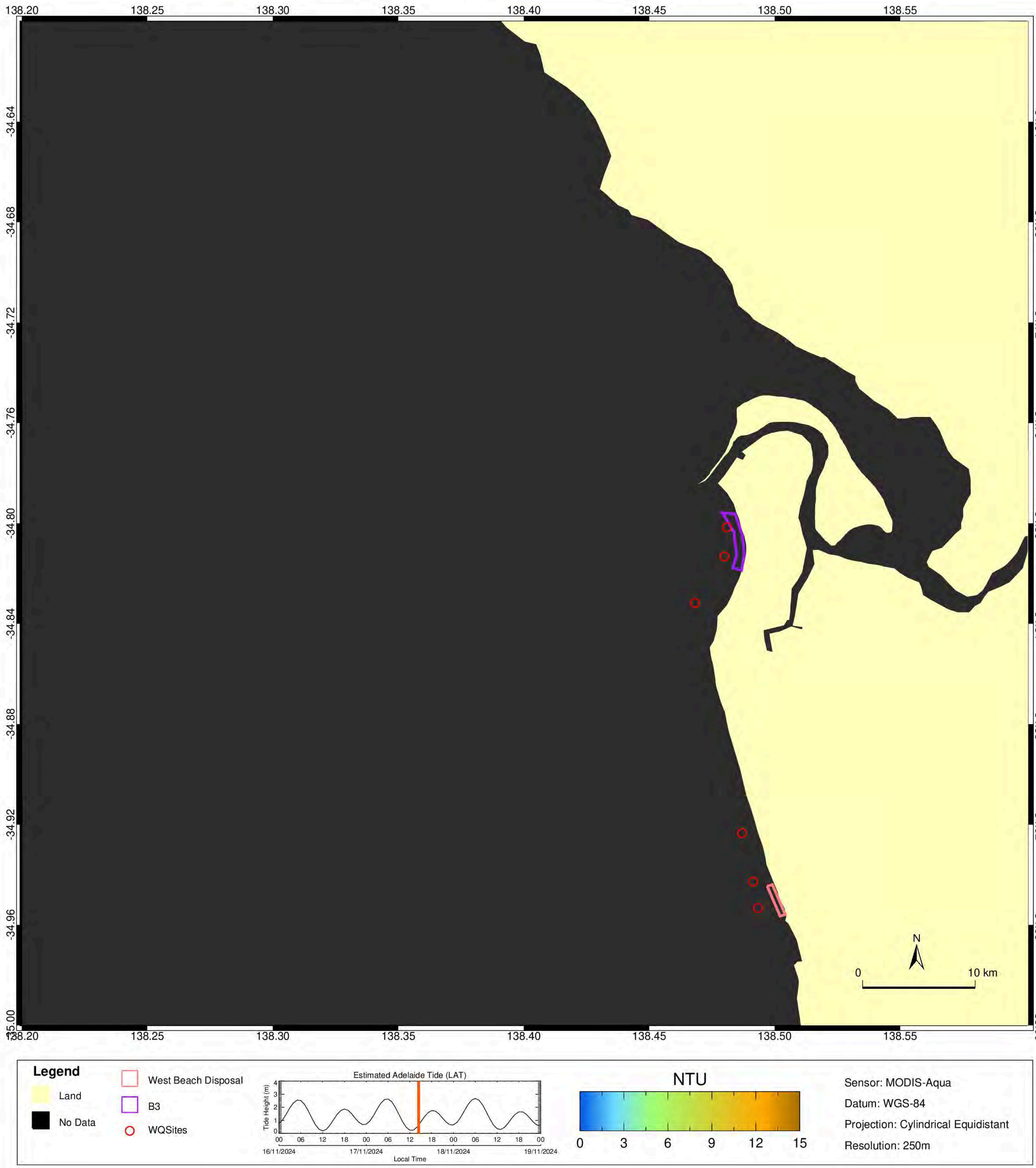


MODIS: Derived NTU

Image Capture: 16-Nov 2024, 15:25 (Local Time)

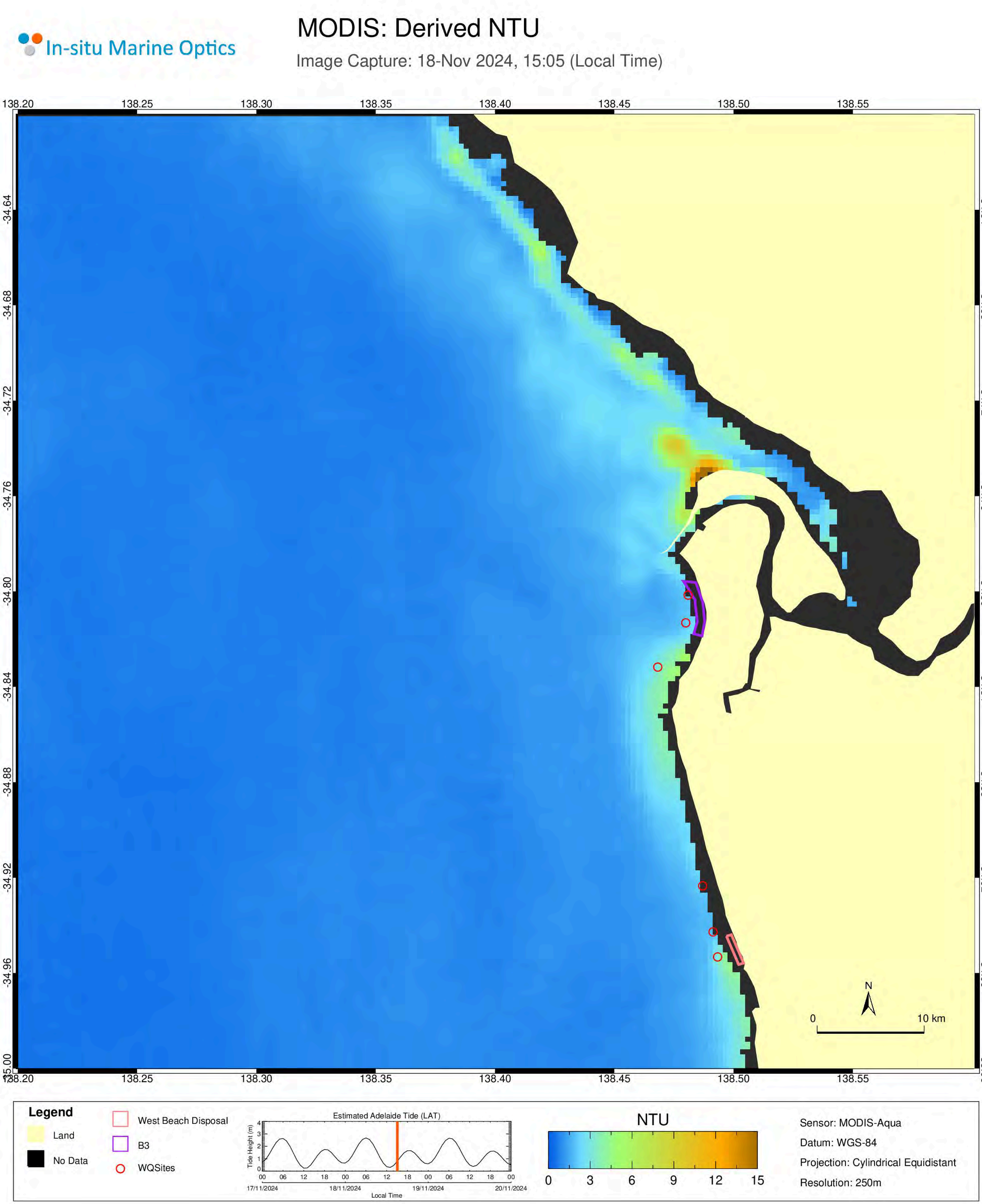
MODIS: Derived NTU

Image Capture: 17-Nov 2024, 14:25 (Local Time)



MODIS: Derived NTU

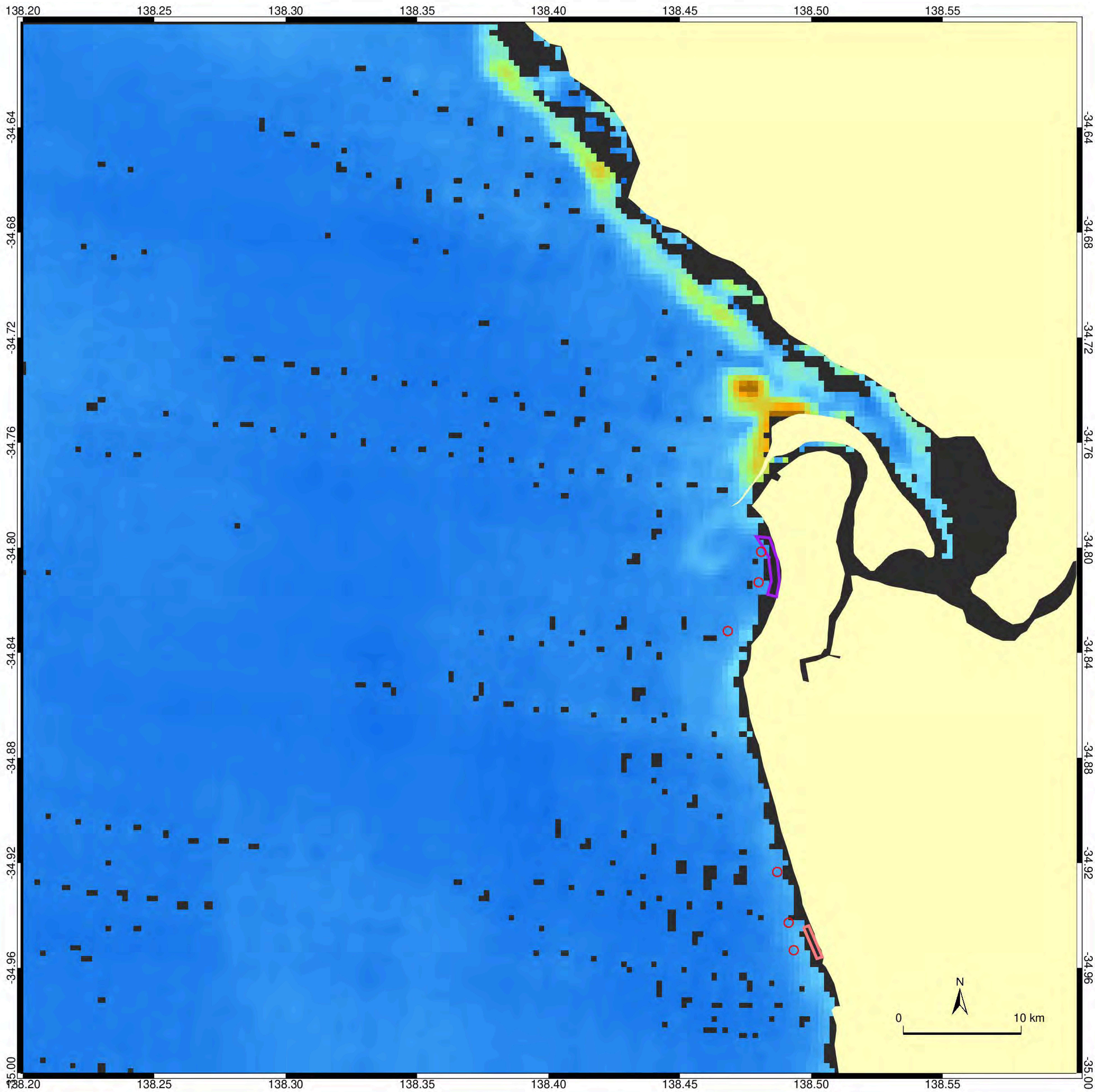
Image Capture: 18-Nov 2024, 15:05 (Local Time)



In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 19-Nov 2024, 09:35 (Local Time)



Legend

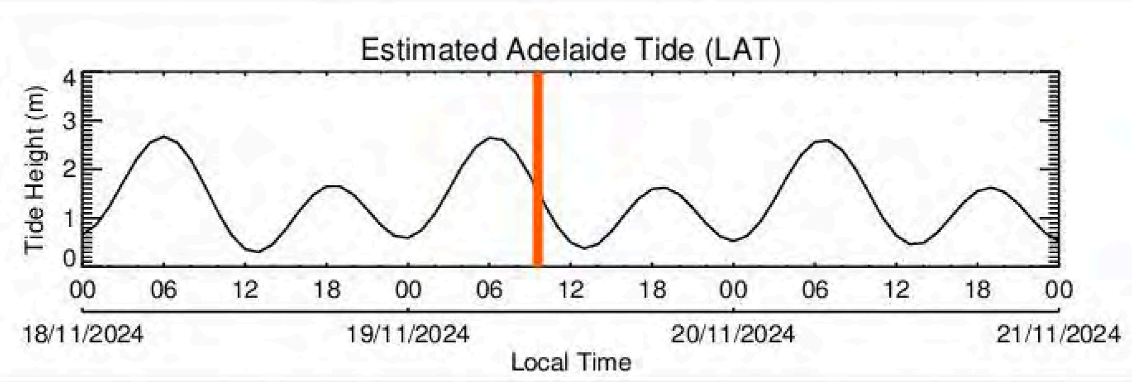
Land

No Data

West Beach Disposal

B3

WQSites



NTU

0 3 6 9 12 15

Sensor: MODIS-Terra

Datum: WGS-84

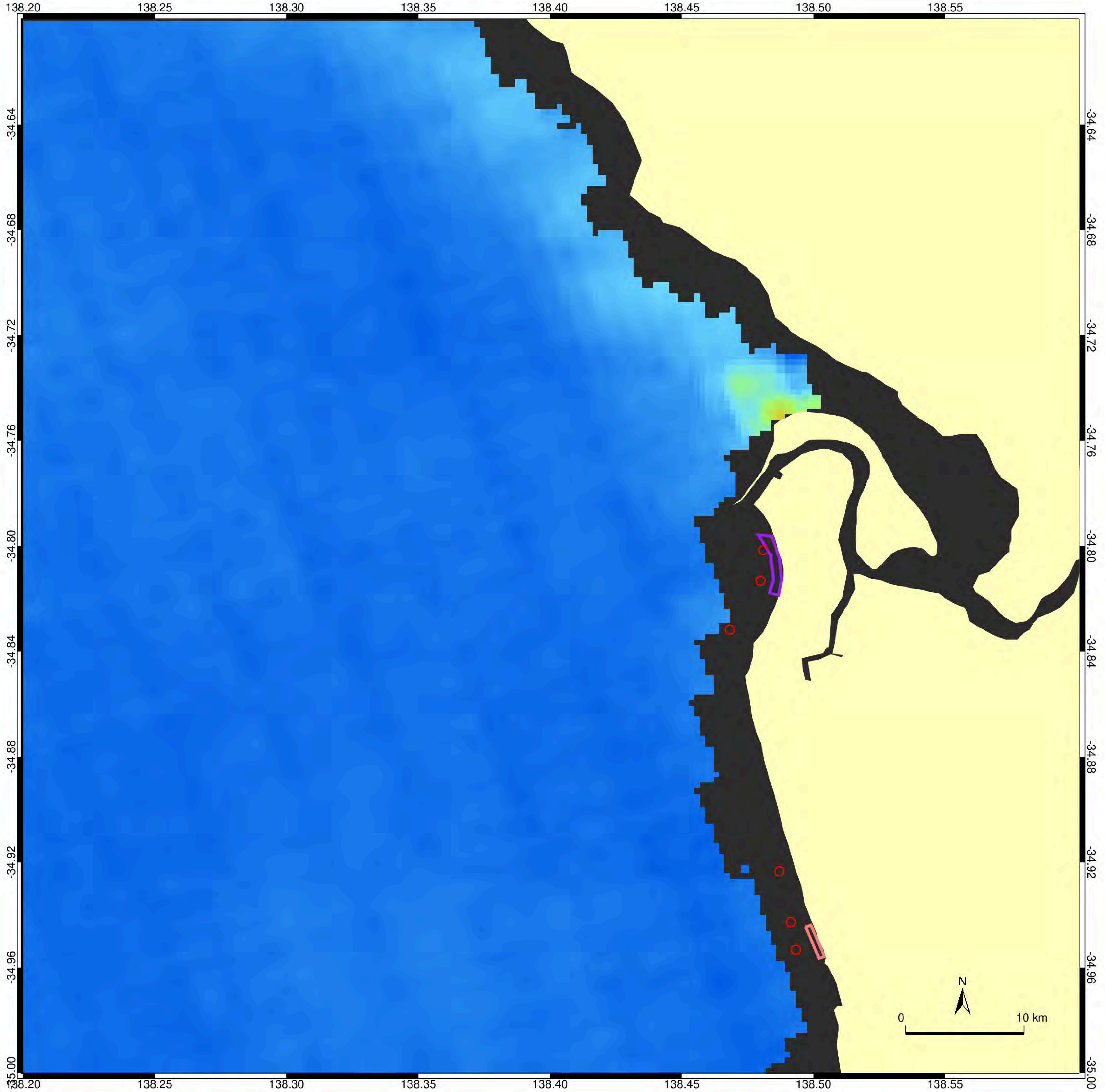
Projection: Cylindrical Equidistant

Resolution: 250m

MODIS: Derived NTU

In-situ Marine Optics

Image Capture: 19-Nov 2024, 15:45 (Local Time)



Legend

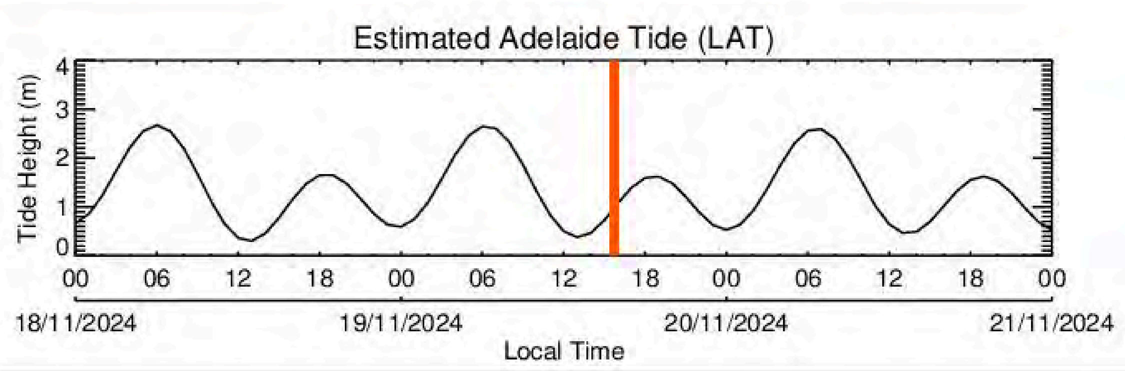
Land

No Data

West Beach Disposal

B3

WQSites



NTU

0 3 6 9 12 15

Sensor: MODIS-Aqua

Datum: WGS-84

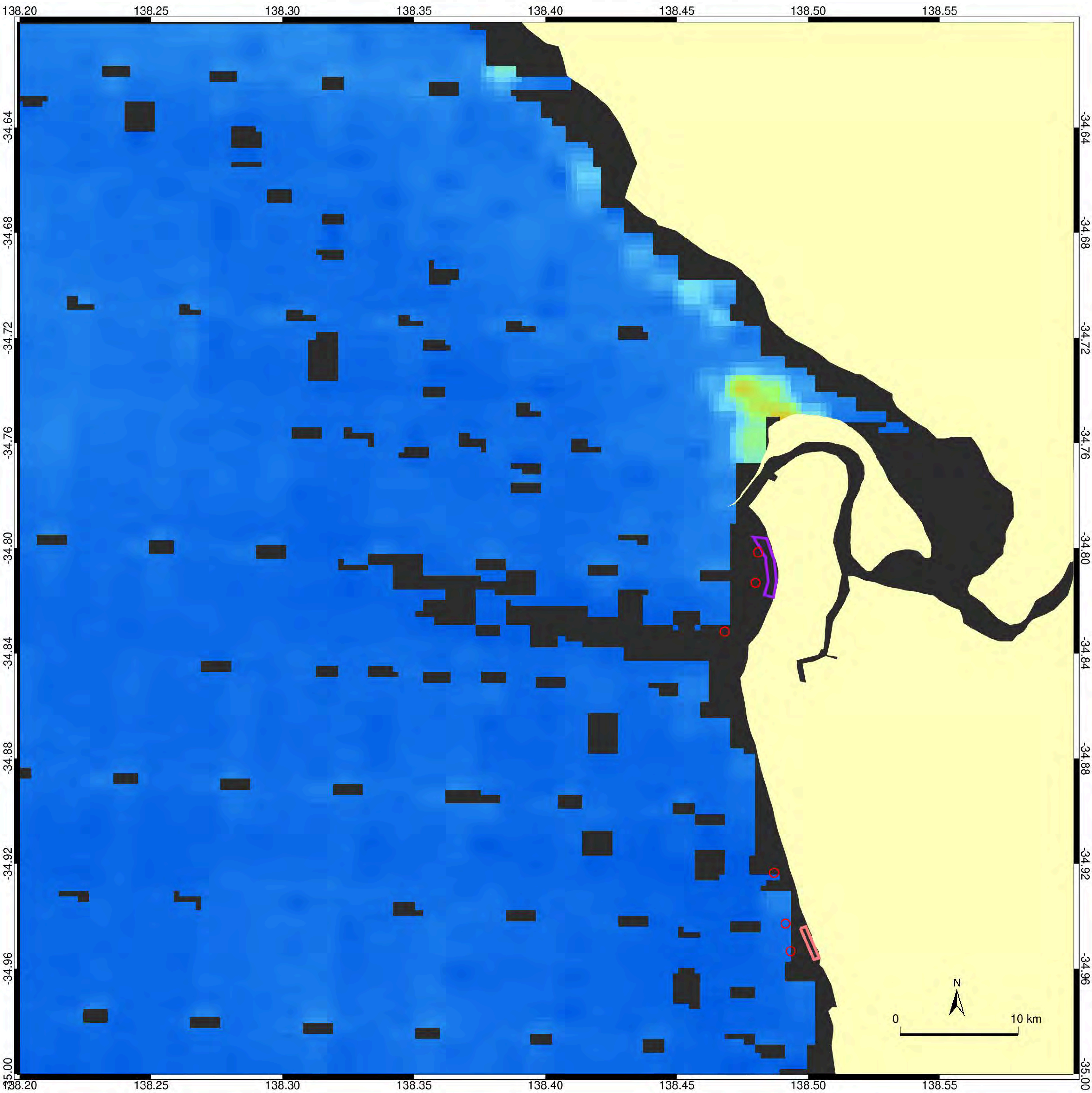
Projection: Cylindrical Equidistant

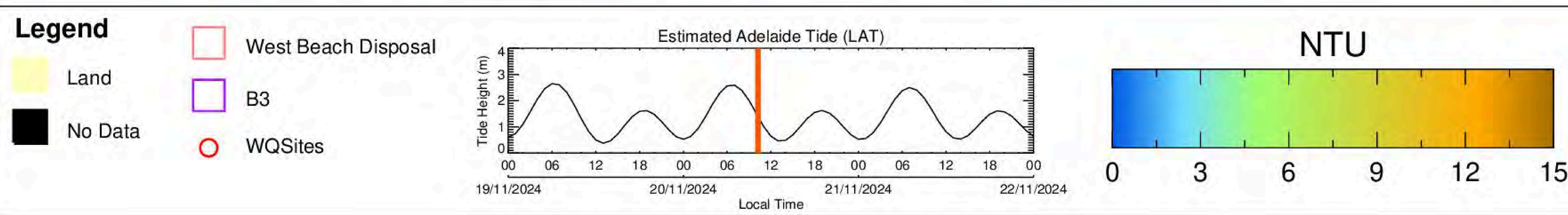
Resolution: 250m

In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 20-Nov 2024, 10:15 (Local Time)





Sensor: MODIS-Terra

Datum: WGS-84

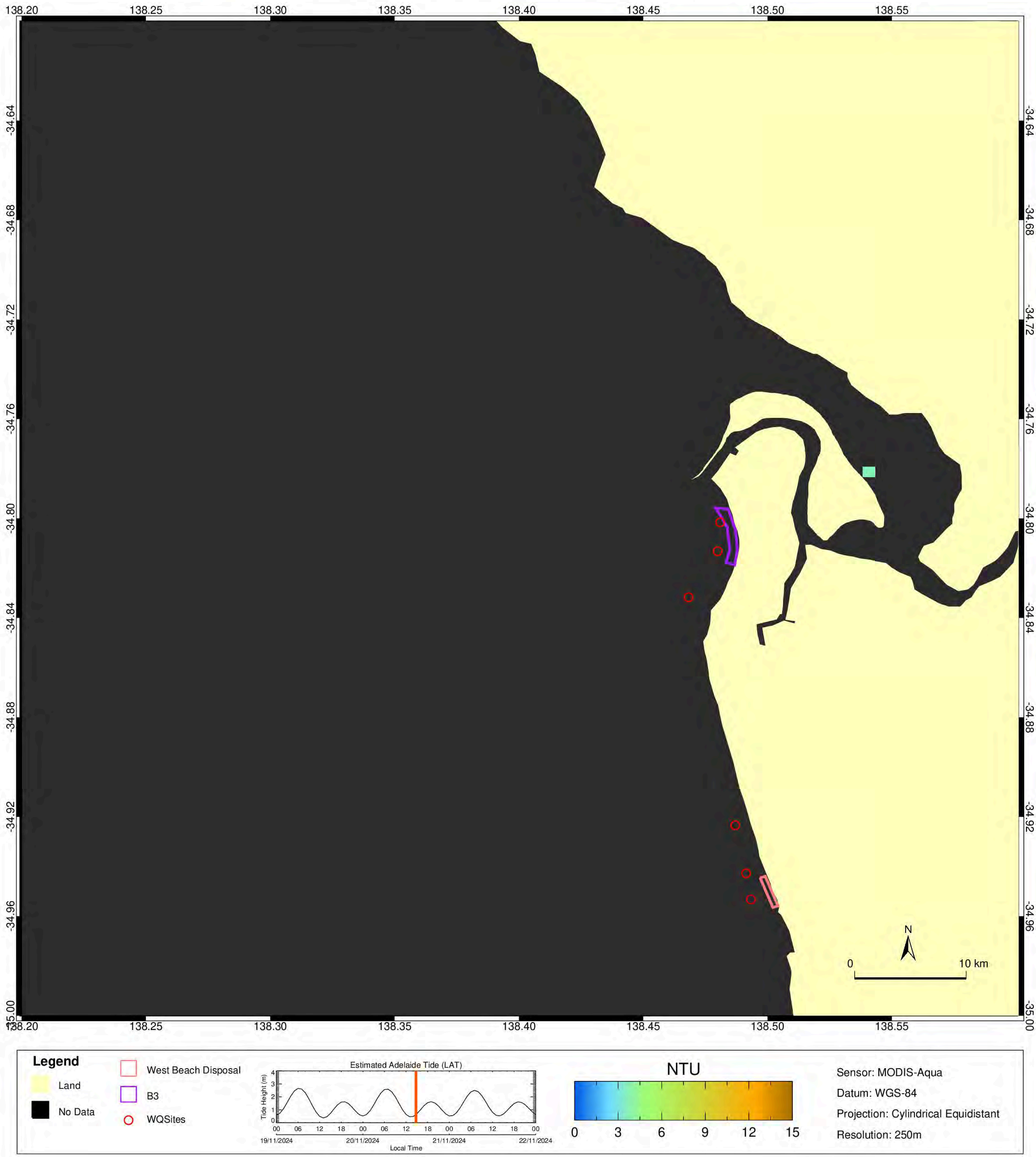
Projection: Cylindrical Equidistant

Resolution: 250m

In-situ Marine Optics

MODIS: Derived NTU

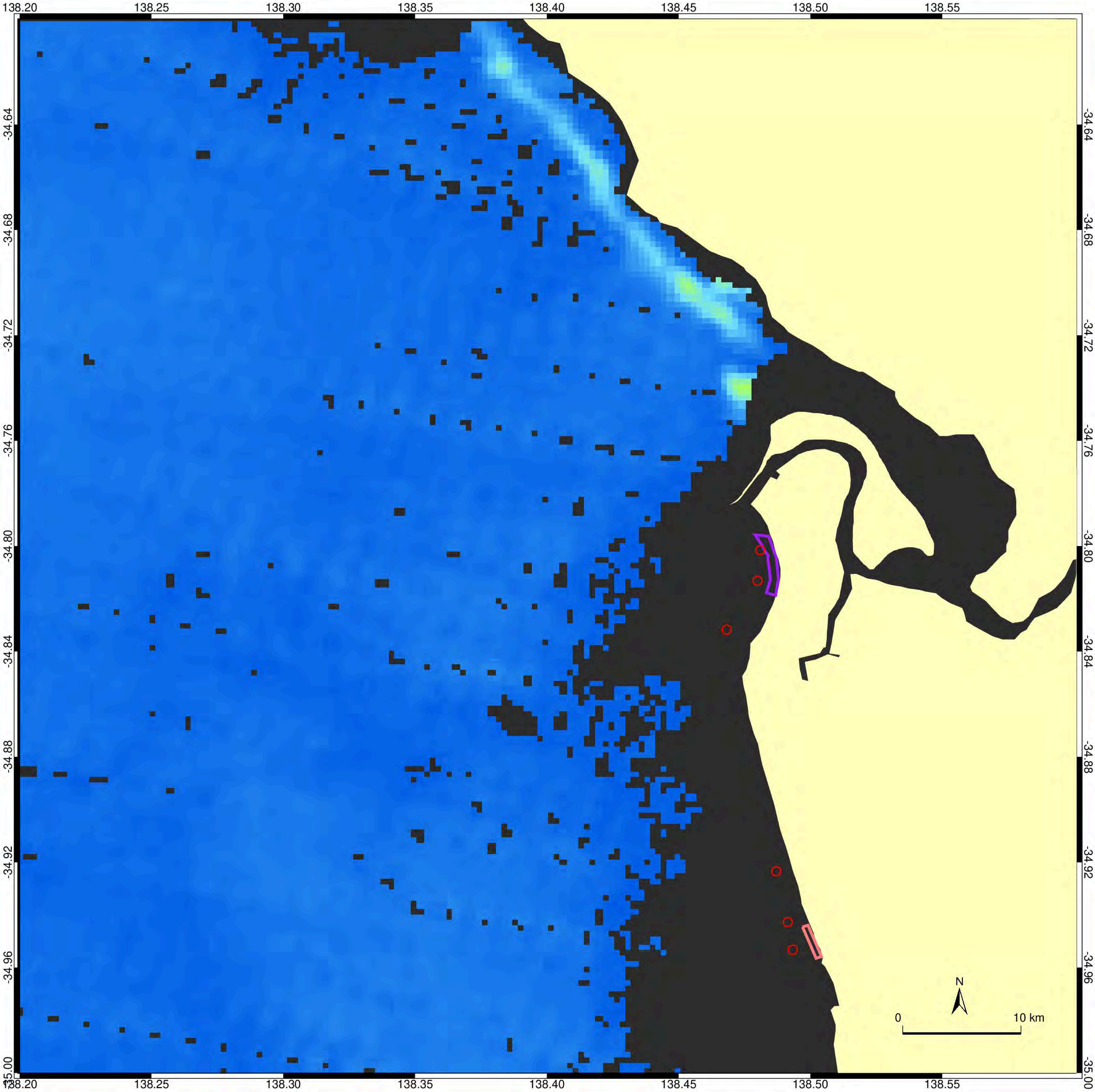
Image Capture: 20-Nov 2024, 14:45 (Local Time)



In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 21-Nov 2024, 09:15 (Local Time)



Legend

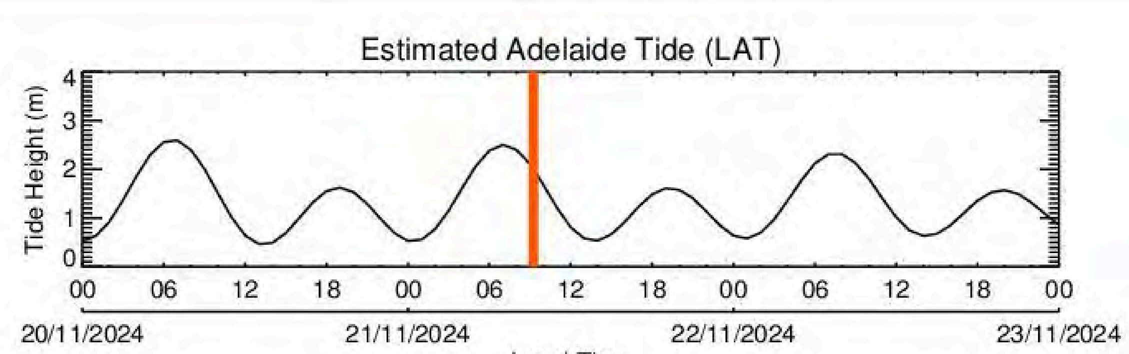
Land

No Data

West Beach Disposal

B3

WQSites



NTU

0 3 6 9 12 15

Sensor: MODIS-Terra

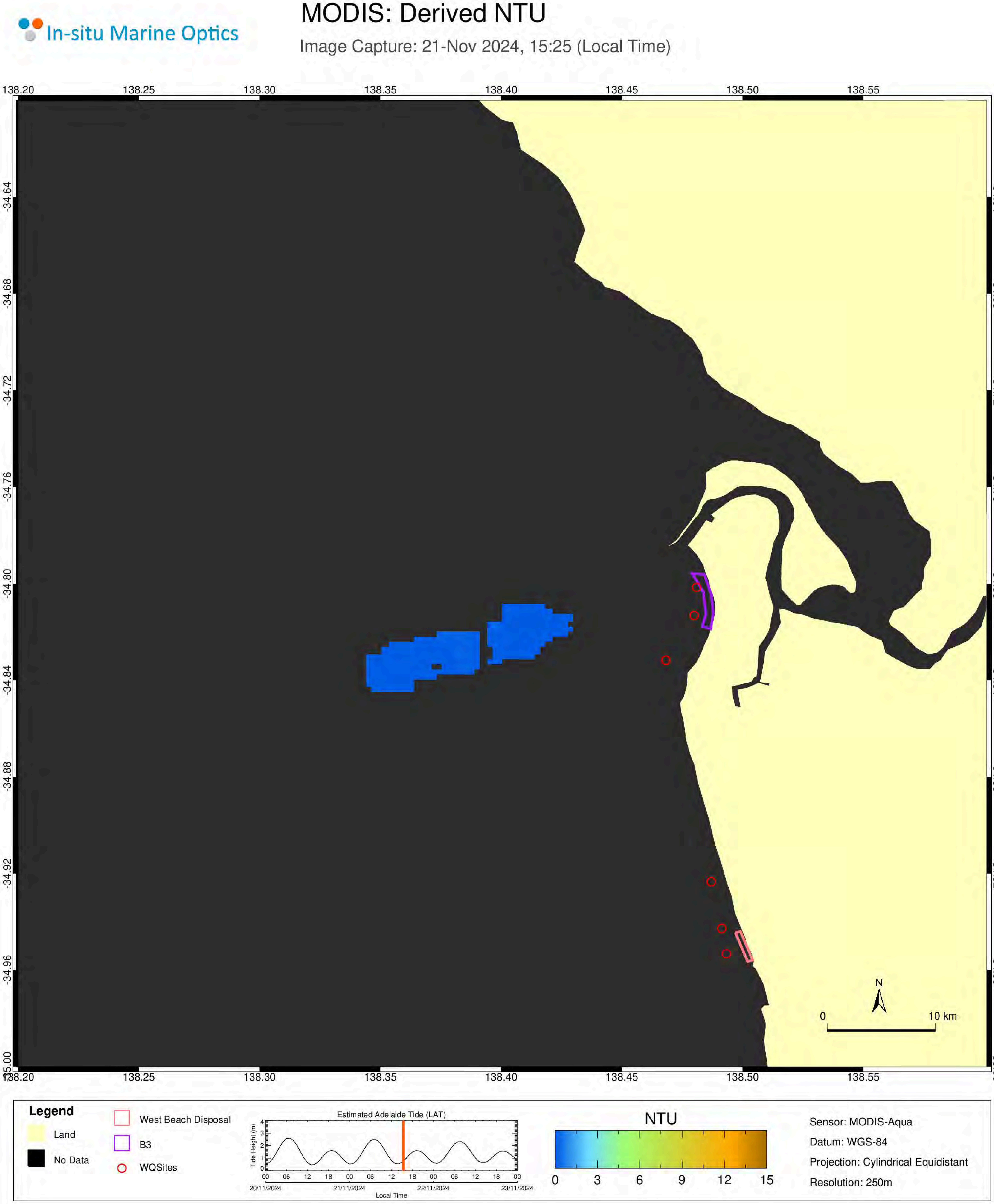
Datum: WGS-84

Projection: Cylindrical Equidistant

Resolution: 250m

MODIS: Derived NTU

Image Capture: 21-Nov 2024, 15:25 (Local Time)

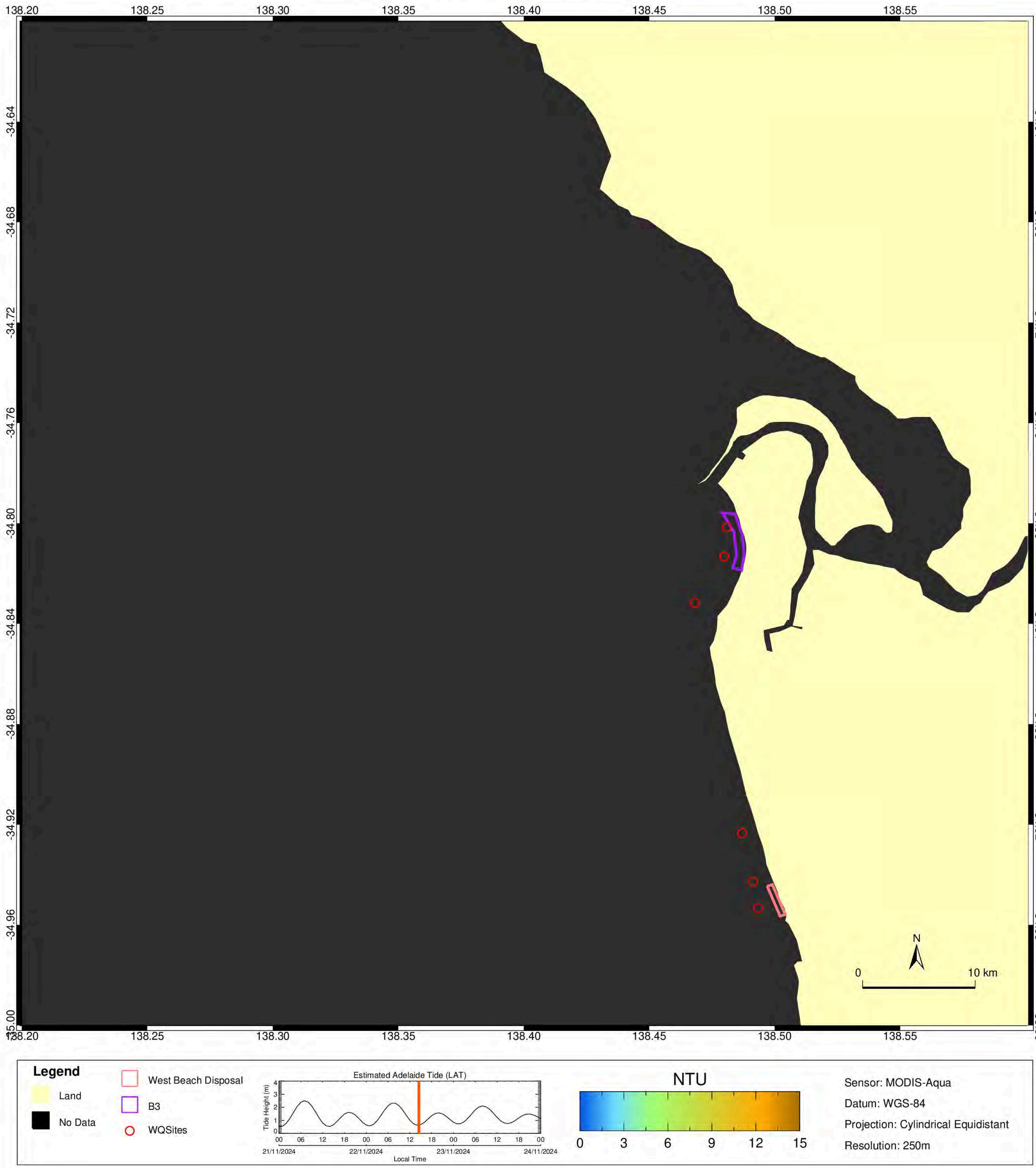


MODIS: Derived NTU

Image Capture: 22-Nov 2024, 09:55 (Local Time)

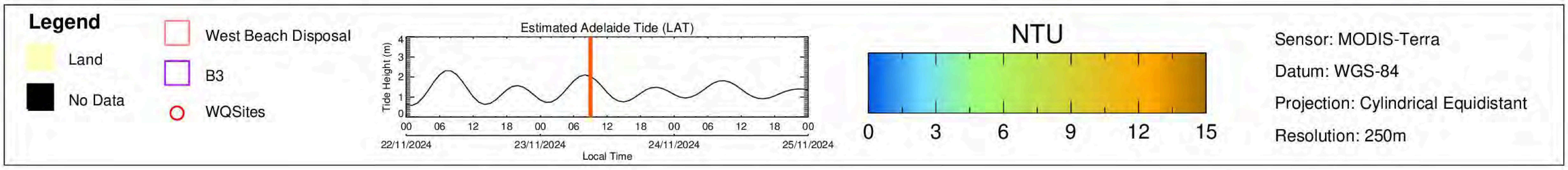
MODIS: Derived NTU

Image Capture: 22-Nov 2024, 14:30 (Local Time)



MODIS: Derived NTU

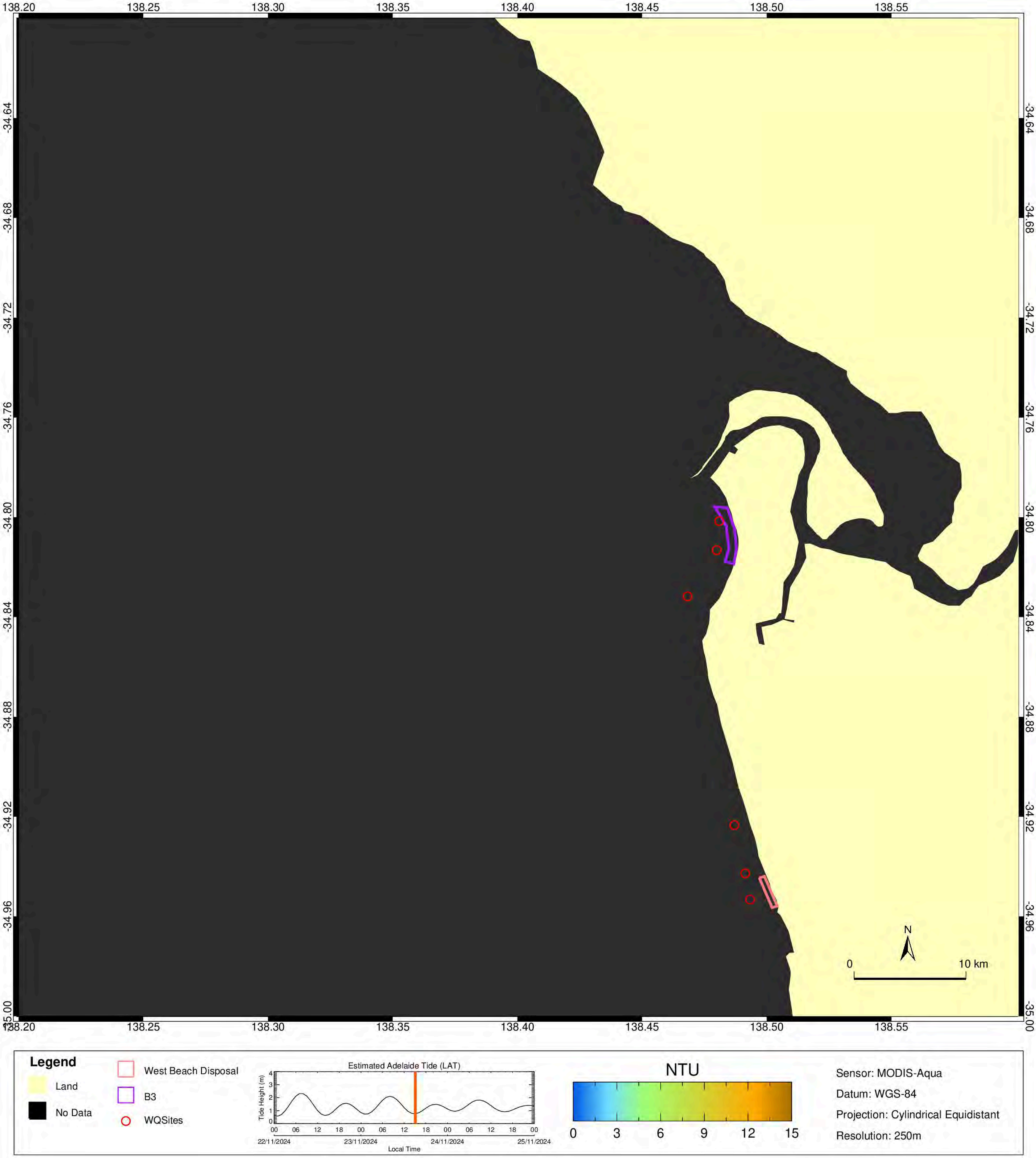
Image Capture: 23-Nov 2024, 09:00 (Local Time)



In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 23-Nov 2024, 15:05 (Local Time)



In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 24-Nov 2024, 15:45 (Local Time)

Legend

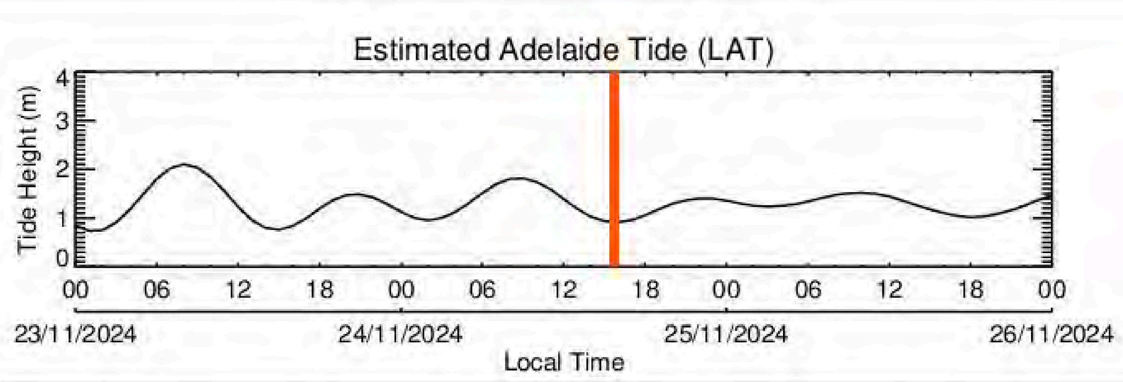
Land

No Data

West Beach Disposal

B3

WQSites



NTU

0 3 6 9 12 15

Sensor: MODIS-Aqua

Datum: WGS-84

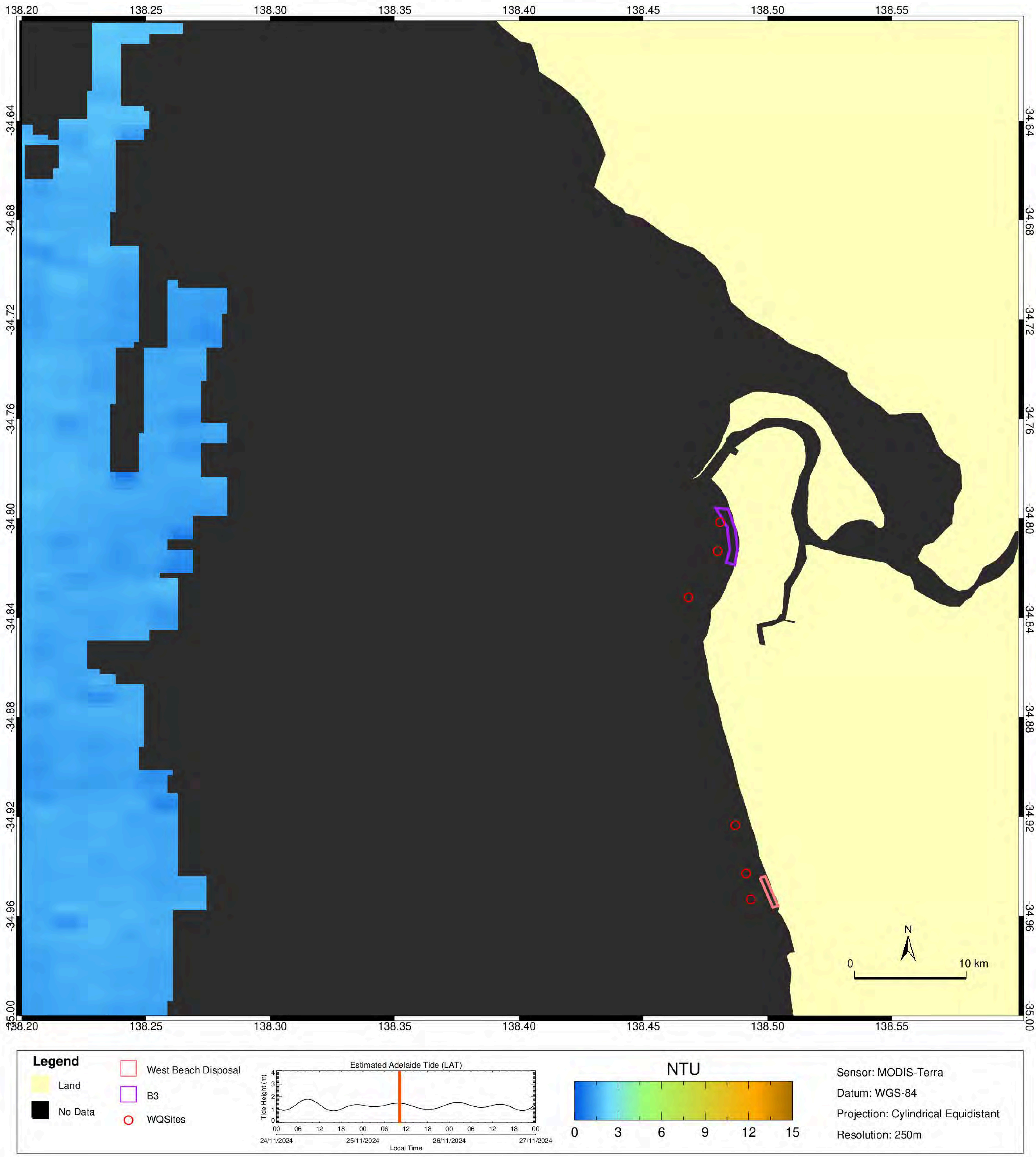
Projection: Cylindrical Equidistant

Resolution: 250m

In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 25-Nov 2024, 10:15 (Local Time)



Sensor: MODIS-Terra

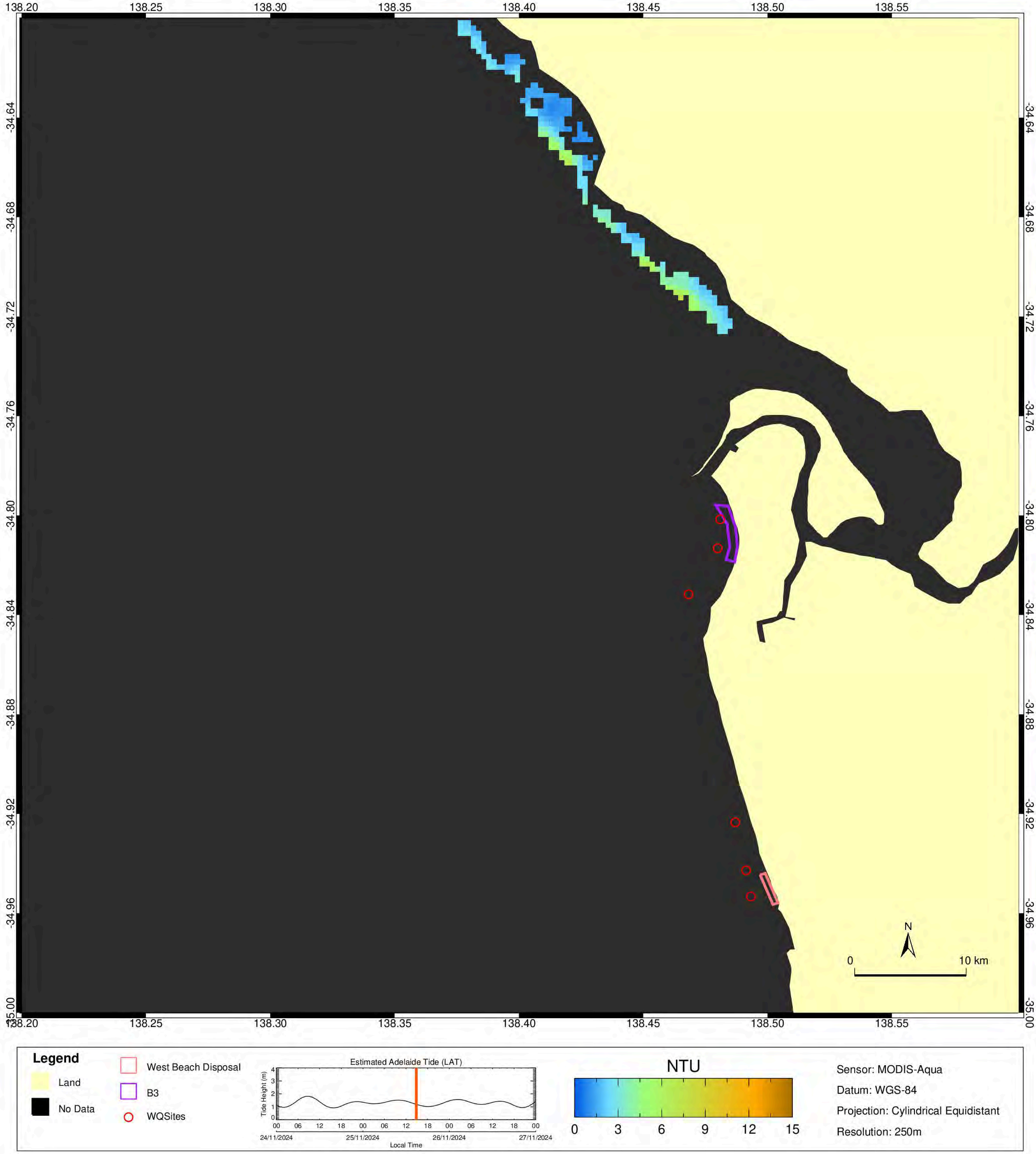
Datum: WGS-84

Projection: Cylindrical Equidistant

Resolution: 250m

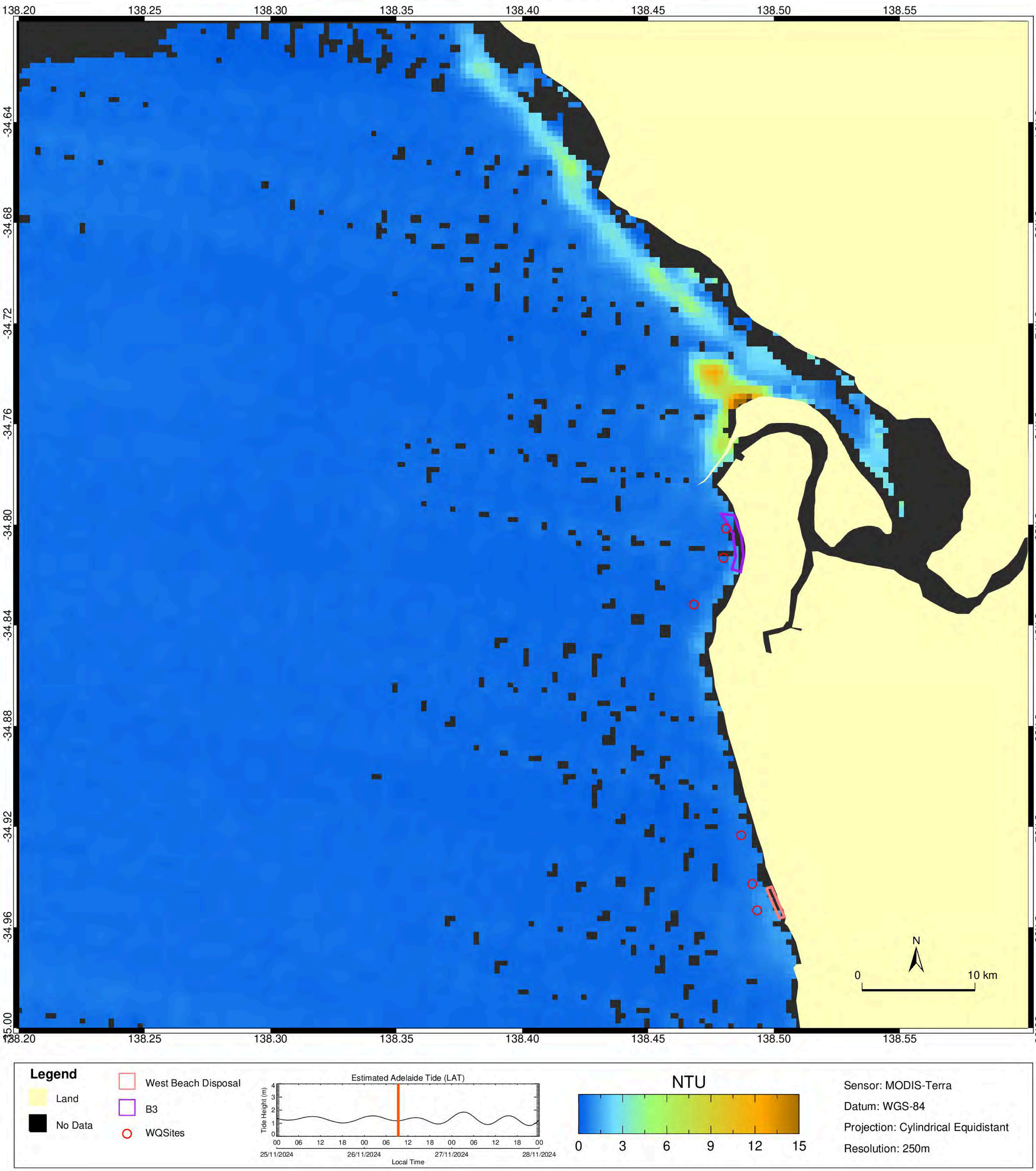
MODIS: Derived NTU

Image Capture: 25-Nov 2024, 14:50 (Local Time)



MODIS: Derived NTU

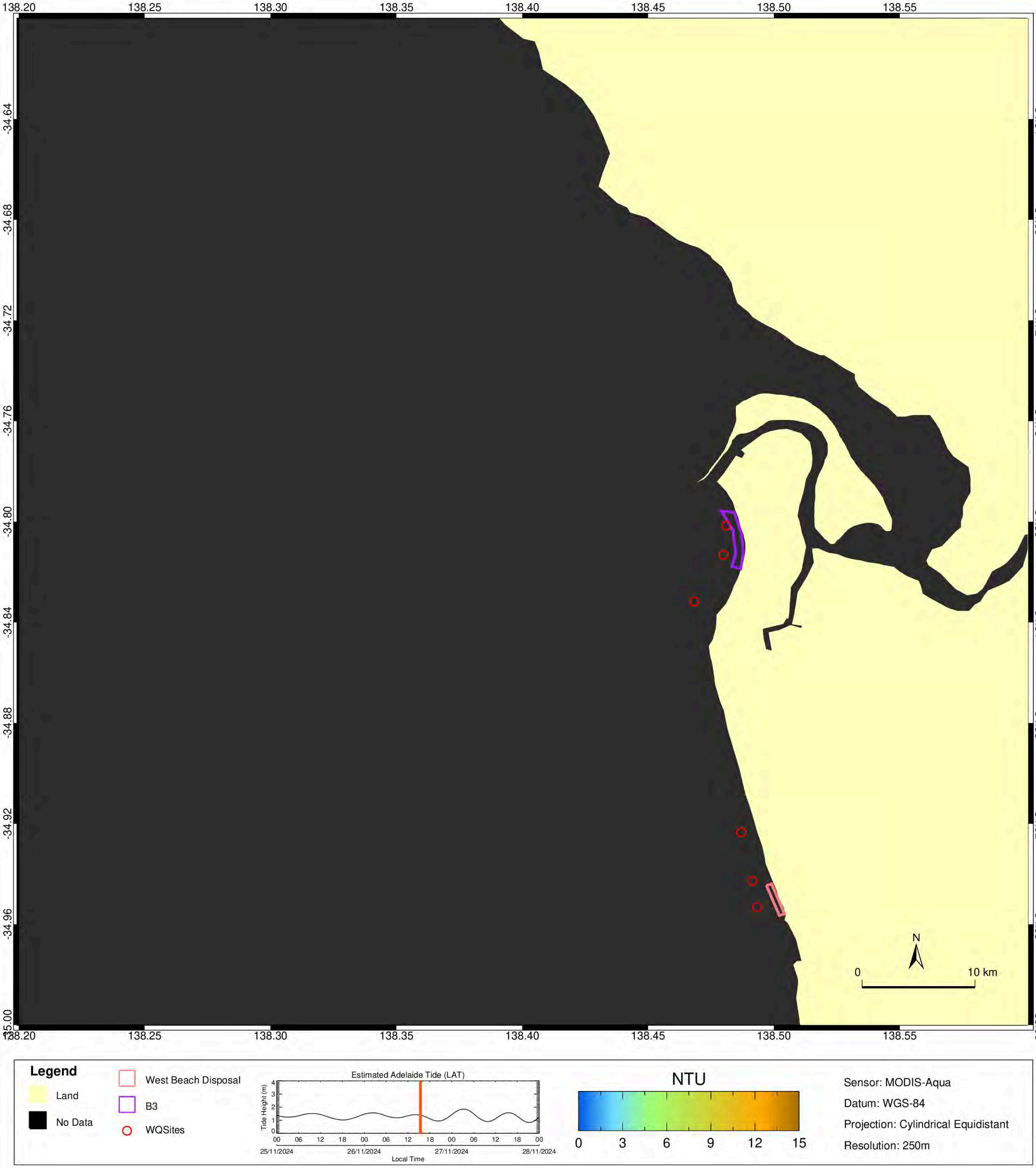
Image Capture: 26-Nov 2024, 09:20 (Local Time)



In-situ Marine Optics

MODIS: Derived NTU

Image Capture: 26-Nov 2024, 15:25 (Local Time)



MODIS: Derived NTU

Image Capture: 27-Nov 2024, 10:00 (Local Time)

Legend

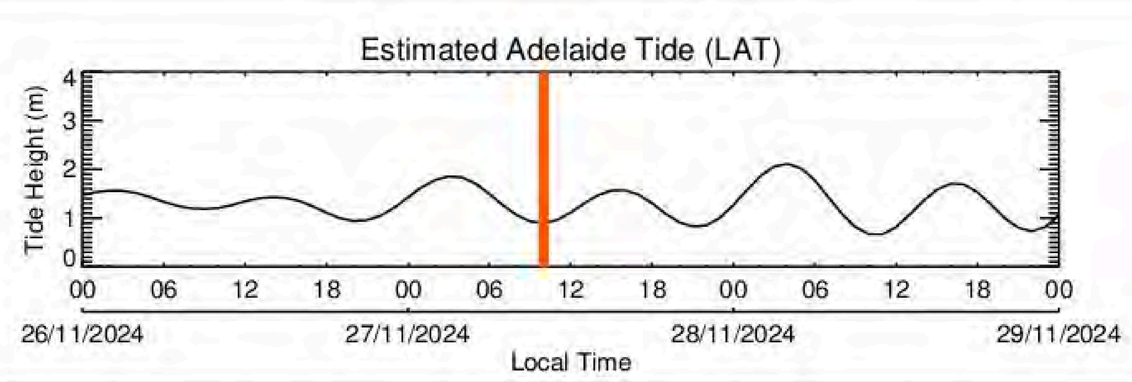
Land

No Data

West Beach Disposal

B3

WQSites



NTU

0 3 6 9 12 15

Sensor: MODIS-Terra

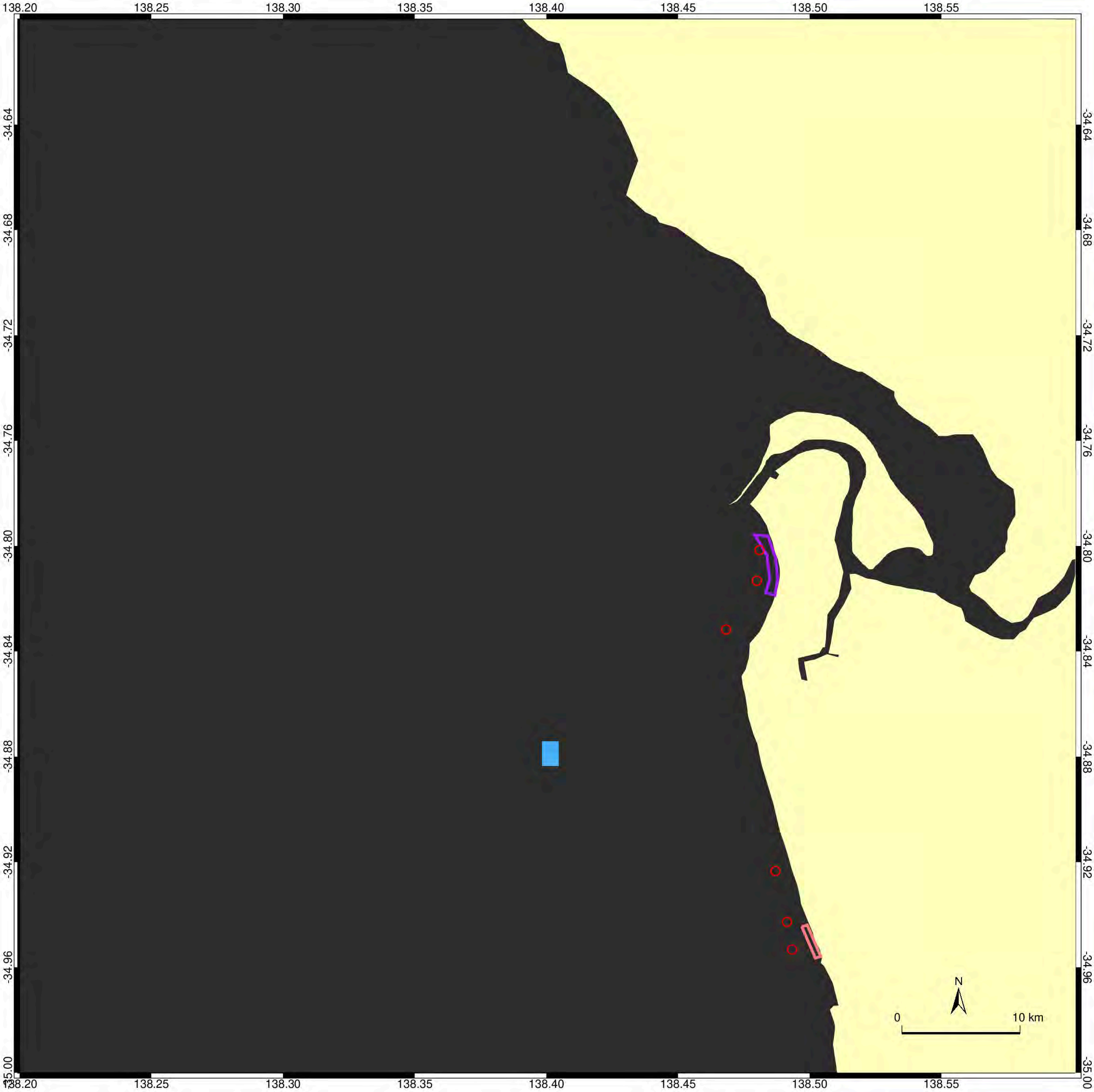
Datum: WGS-84

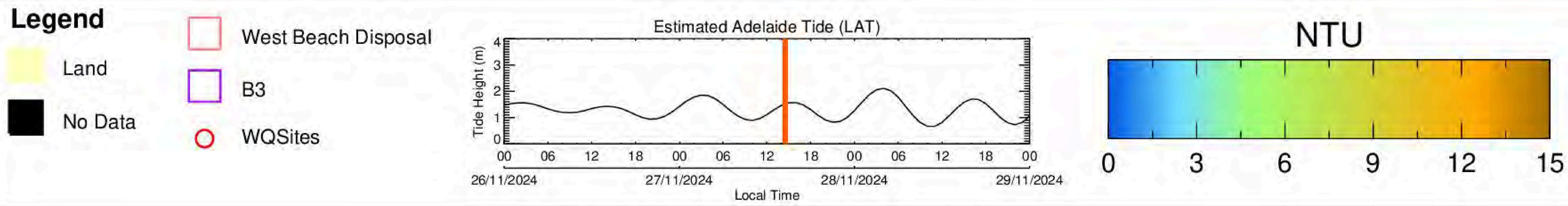
Projection: Cylindrical Equidistant

Resolution: 250m

MODIS: Derived NTU

Image Capture: 27-Nov 2024, 14:30 (Local Time)





Sensor: MODIS-Aqua

Datum: WGS-84

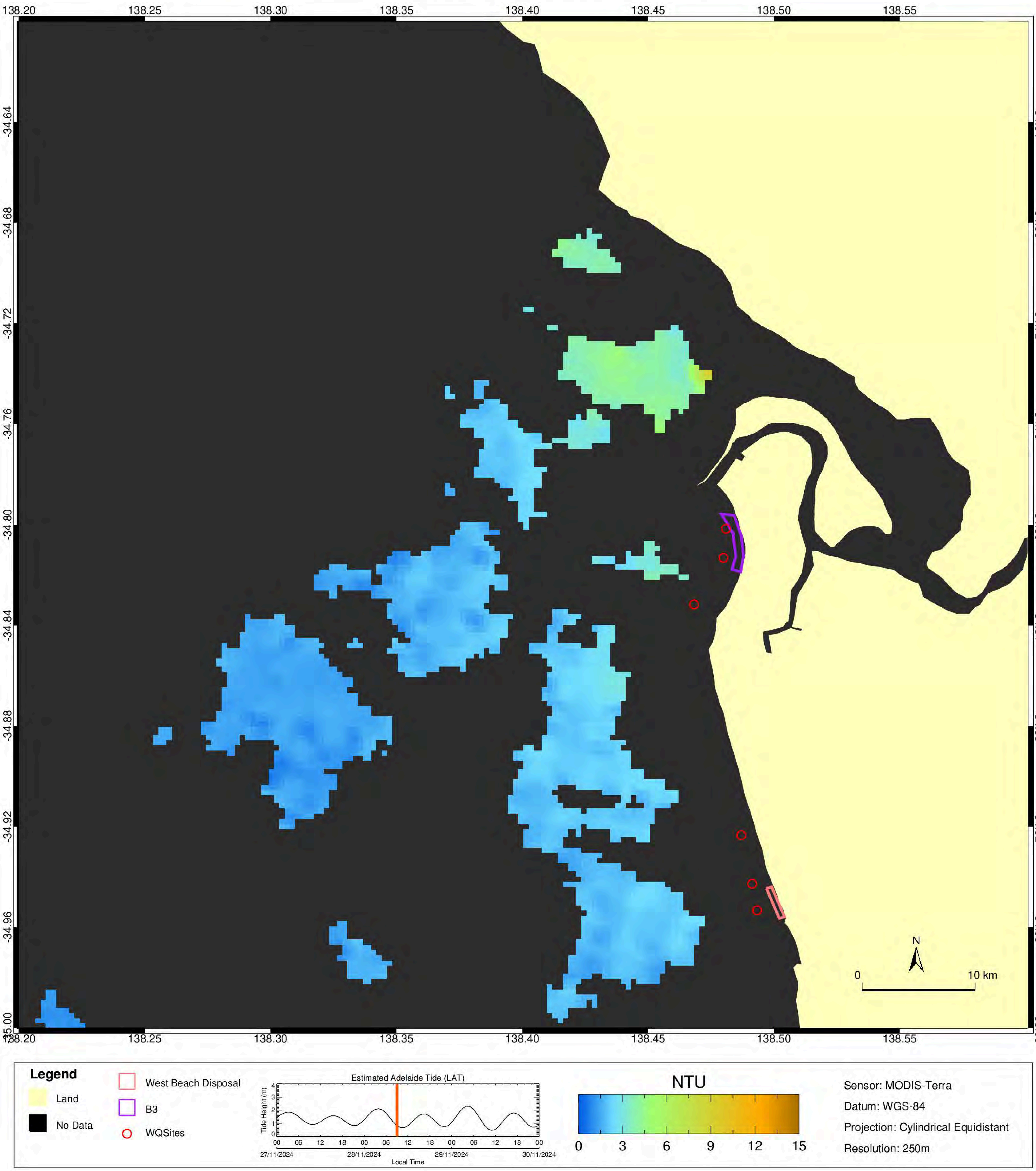
Projection: Cylindrical Equidistant

Resolution: 250m

MODIS: Derived NTU

Image Capture: 28-Nov 2024, 09:00 (Local Time)

In-situ Marine Optics



MODIS: Derived NTU

Image Capture: 28-Nov 2024, 15:10 (Local Time)

In-situ Marine Optics

Legend

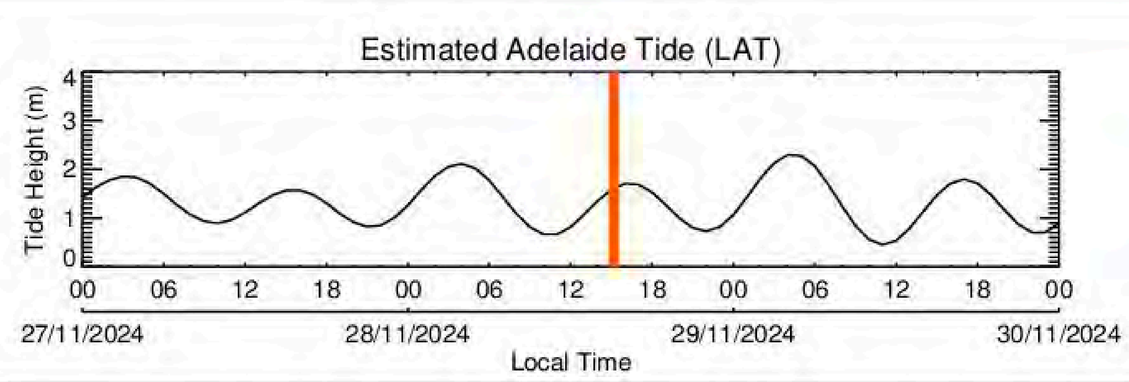
Land

No Data

West Beach Disposal

B3

WQSites



NTU

0 3 6 9 12 15

Sensor: MODIS-Aqua

Datum: WGS-84

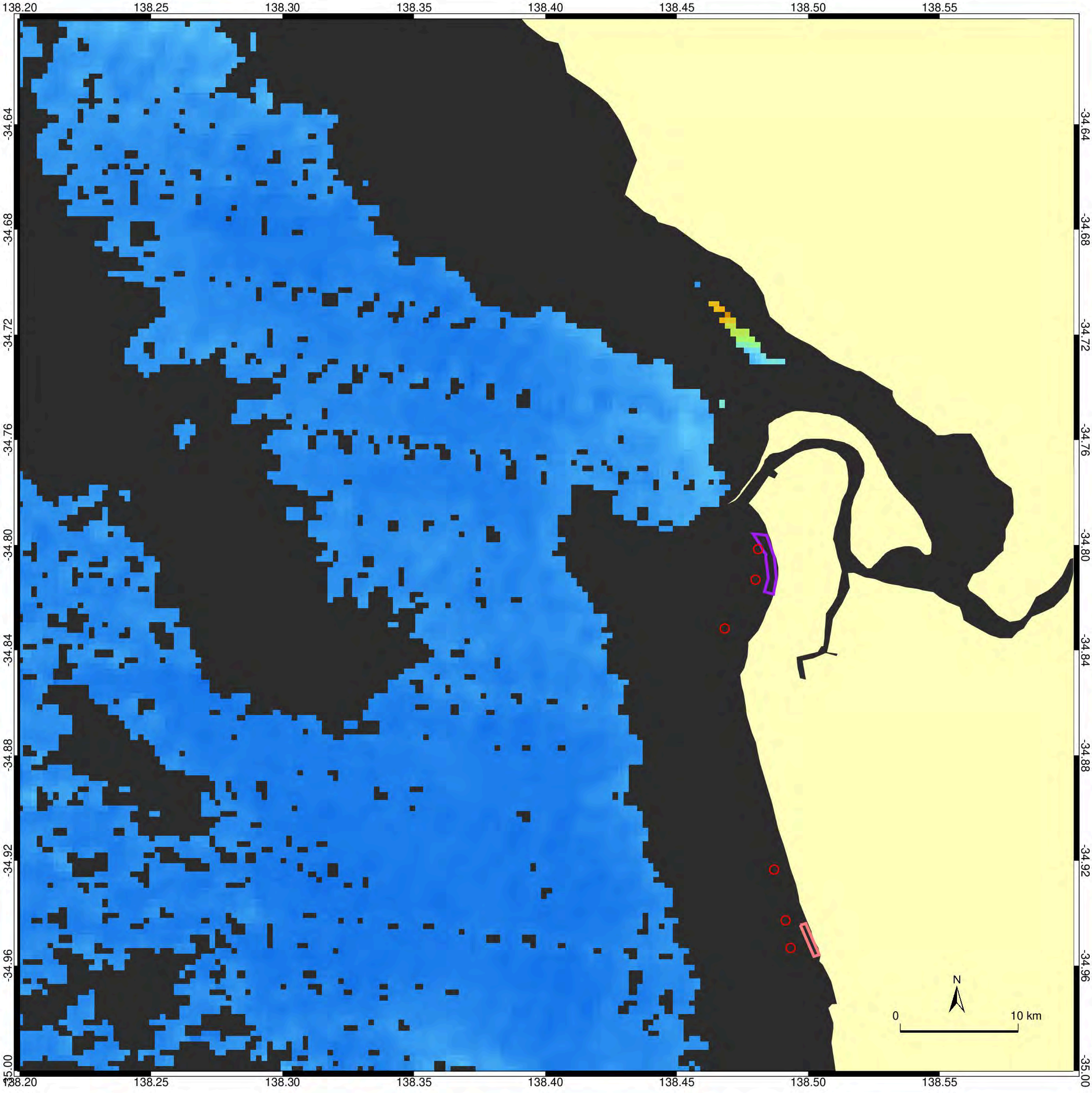
Projection: Cylindrical Equidistant

Resolution: 250m

MODIS: Derived NTU

In-situ Marine Optics

Image Capture: 29-Nov 2024, 09:40 (Local Time)



Legend

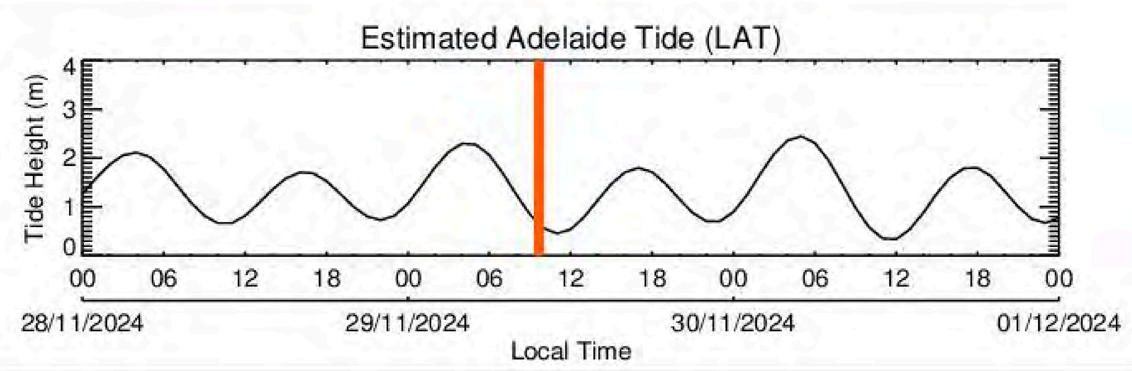
Land

No Data

West Beach Disposal

B3

WQSites



NTU

0 3 6 9 12 15

Sensor: MODIS-Terra

Datum: WGS-84

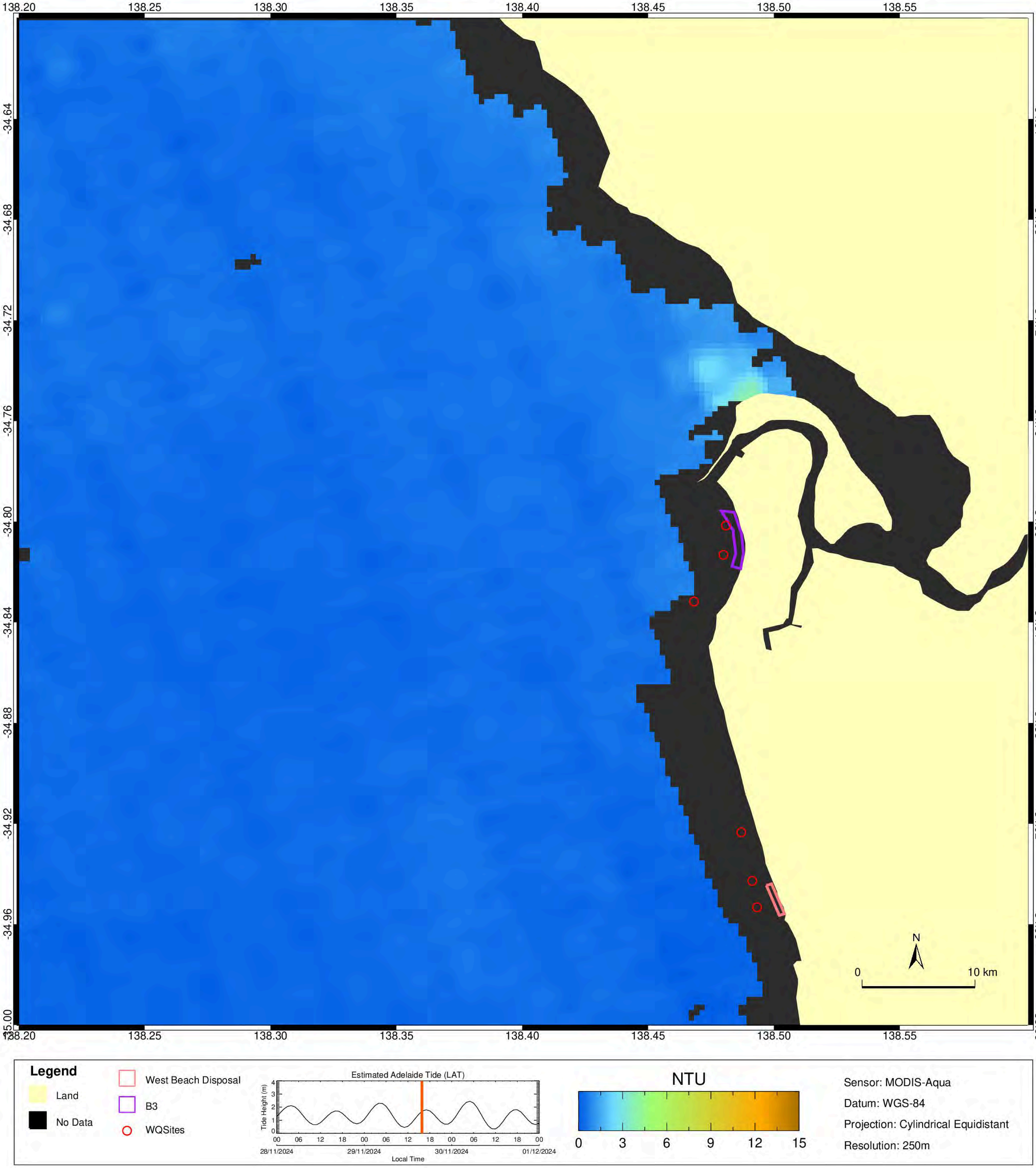
Projection: Cylindrical Equidistant

Resolution: 250m

MODIS: Derived NTU

In-situ Marine Optics

Image Capture: 29-Nov 2024, 15:50 (Local Time)



Sensor: MODIS-Aqua

Datum: WGS-84

Projection: Cylindrical Equidistant

Resolution: 250m

A Montrose Environmental Company

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