

City of Wanneroo Coastal Monitoring Report April 2022



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1 Introduction

1.1 Coastal Foreshore Monitoring

A long-term coastal monitoring program has been undertaken by the City of Wanneroo (CoW) since 2014. The purpose of the program is to evaluate the seasonal, annual and long-term trends in erosion and accretion along the City's coastline. This helps to better inform future coastal management measures, identify key areas requiring future management and to provide data for future coastal hazard studies.

At present, the coastal monitoring program involves the acquisition and assessment of the following data sets.

- Biannual manual images taken at 49 beach monitoring sites;
- Hourly automatic photographic monitoring taken at five sites along Quinns Beach and Yanchep;
- 6 monthly LiDAR aerial surveys undertaken across all vulnerable areas;
- Bi-monthly aerial imagery taken across the entire CoW coastline;
- Metocean conditions including:
 - Half-hourly wave data from the Department of Transport (DoT) Rottnest Island Wave Station; and
 - 5-minute water level data from the DoT Fremantle Fishing Boat Harbour Tide Station.

This document outlines the methodology and results obtained from the seasonal and long-term assessments of coastline changes at priority locations along the CoW coastline.

1.2 Coastal Structures Monitoring

The City's coastal monitoring program also includes 6 monthly monitoring of coastal structures and includes photographic monitoring of coastal infrastructure assets within the City's vulnerable coastal locations. This is used to capture a photographic record of the assets, identify and address any public safety and minor maintenance requirements and to flag any major structural concerns that may require further detailed investigation.

2 Metocean Conditions

Metocean conditions including wave and water level data are assessed as part of the coastal monitoring program. Data is obtained from the following instrumentation managed by the Department of Transport (DoT).

- Half-hourly wave data from the DoT Rottneest Island Wave Station; and
- 5-minute water level data from the DoT Fremantle Fishing Boat Harbour Tide Station.

Locations of these instruments are presented in Figure 2-1.

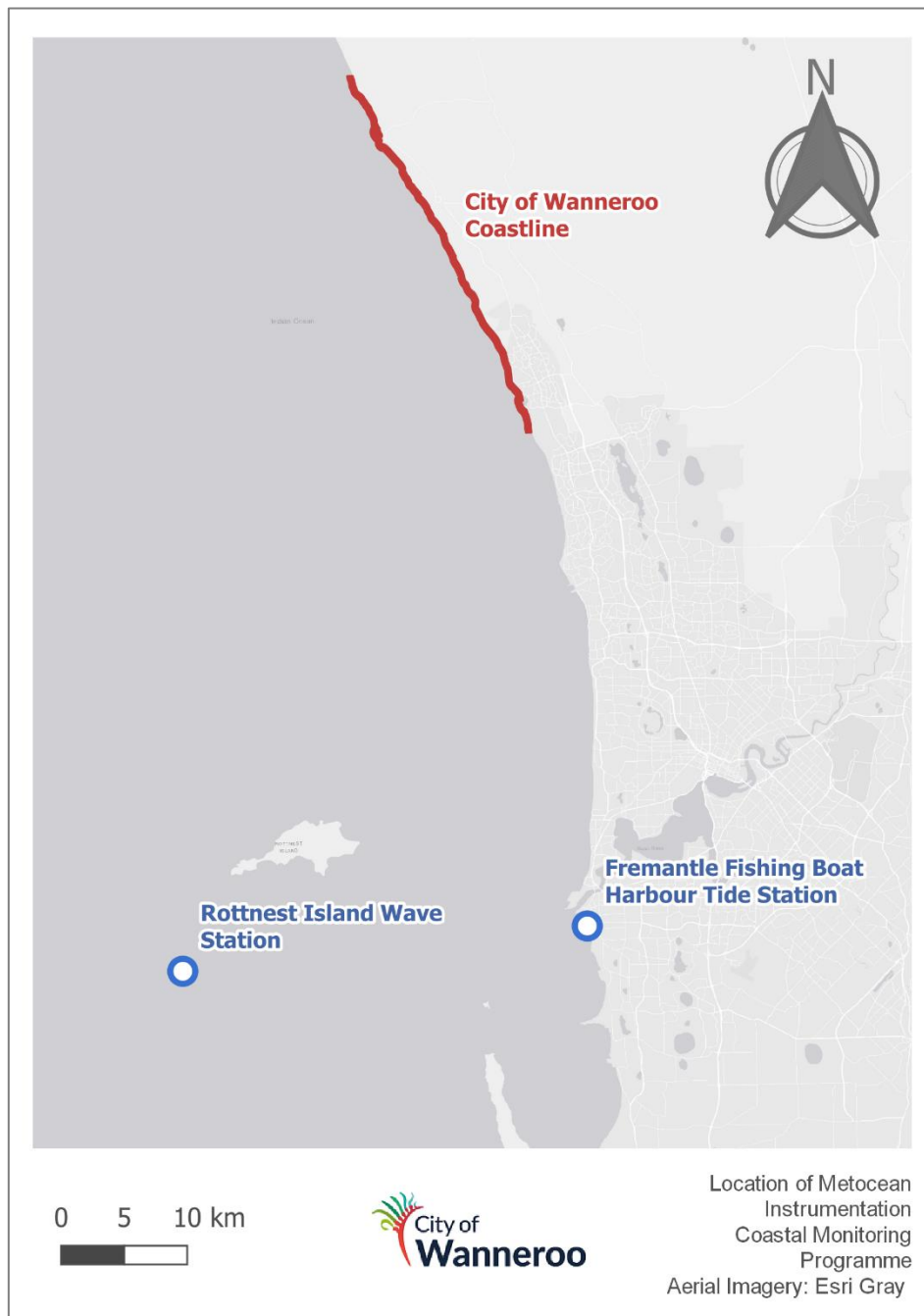


Figure 2-1

Location of Instruments

2.1 Assessment Methodology

The data from these instruments is obtained from the Department of Transport for the annual monitoring period April 2021 to April 2022. The data is assessed using time series plots where trends and major weather events are identified.

Metoccean conditions at the time of manual photographic monitoring is also specifically noted and used to interpret qualitative observations from visual assessments of photo comparison (both seasonal and long term).

2.2 Results

2.2.1 Annual

Time series plots of the total significant wave height (Hs) and swell direction recorded at the Rottnest Island Wave Station from May 2021 to April 2022 are presented below in Figure 2-2 and Figure 2-3.

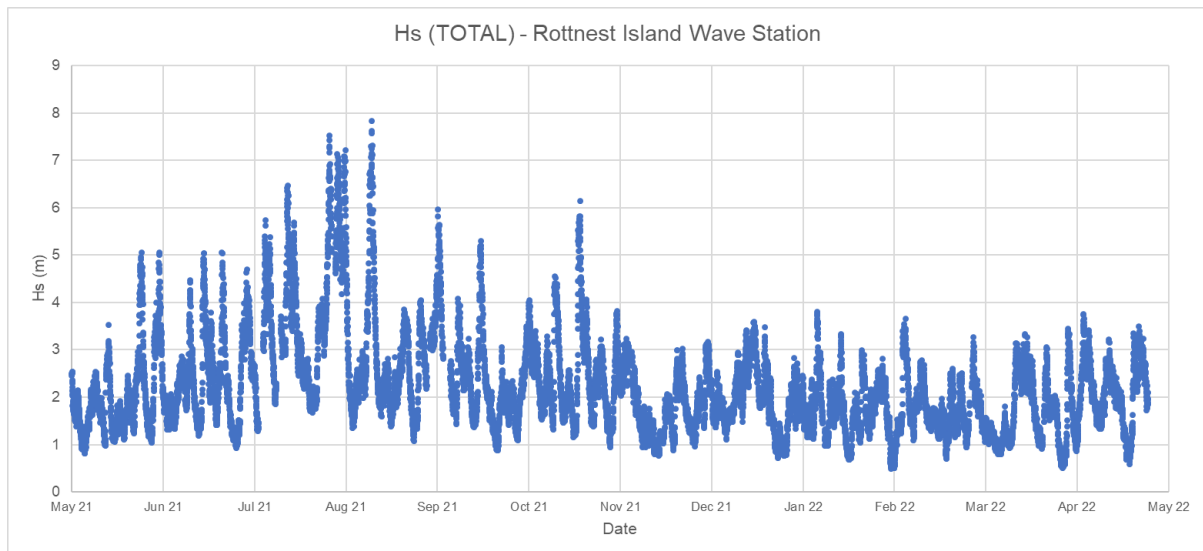


Figure 2-2 Total Significant Wave Height (Hs) recorded at the Rottnest Island Wave Station from May 2021 to April 2022.

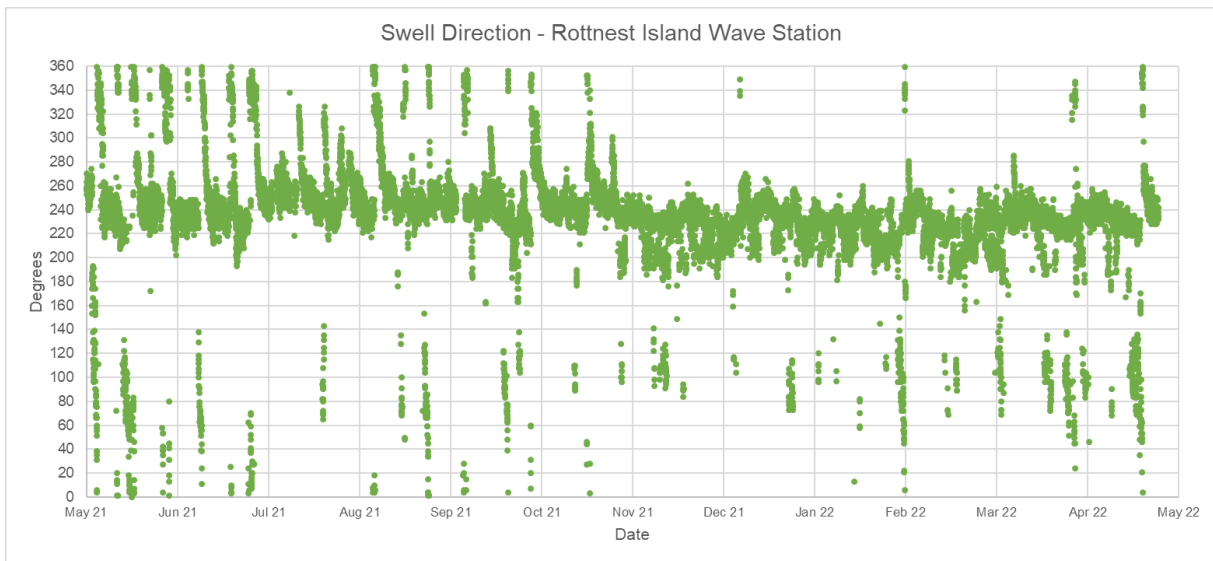


Figure 2-3 Swell Direction Recorded at the Rottnest Island Wave Station from May 2021 to April 2022.

The most notable observations from Figure 2-2 and Figure 2-3 are the storms that were recorded on 1 August, 10 August, 2 September and 19 October 2021. The storm that resulted in the most significant infrastructure damage and erosion along the City's coastline occurred on the 10th of August 2021. The storm recorded a peak total significant wave height of 7.84m at 1:55 PM on 10 August 2021.

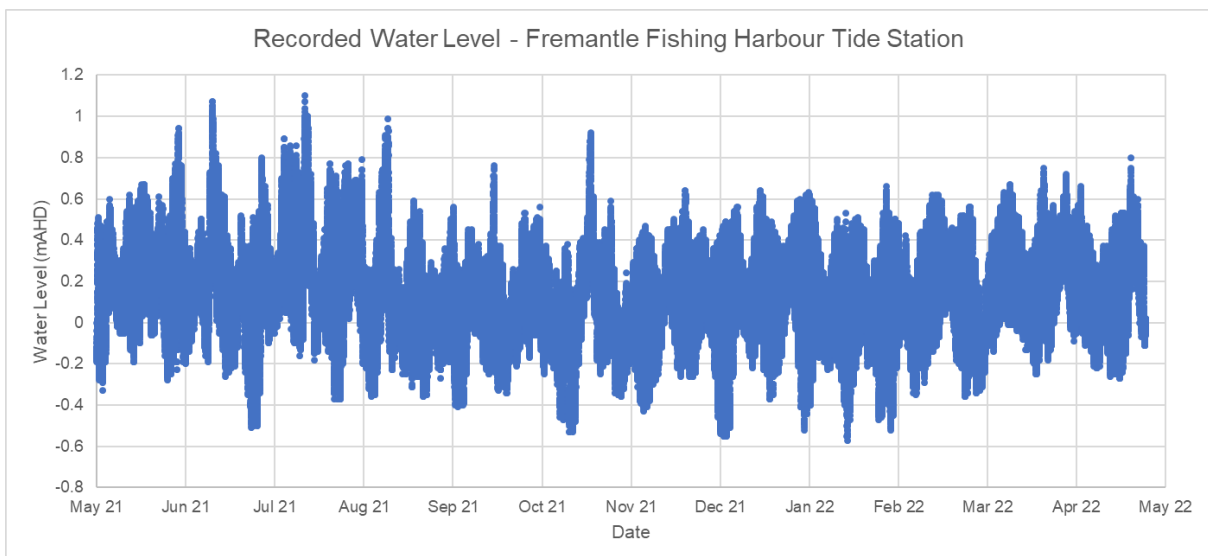


Figure 2-4 Water level (mAHD) recorded at the Fremantle Fishing Harbour Tide Station from May 2021 to April 2022.

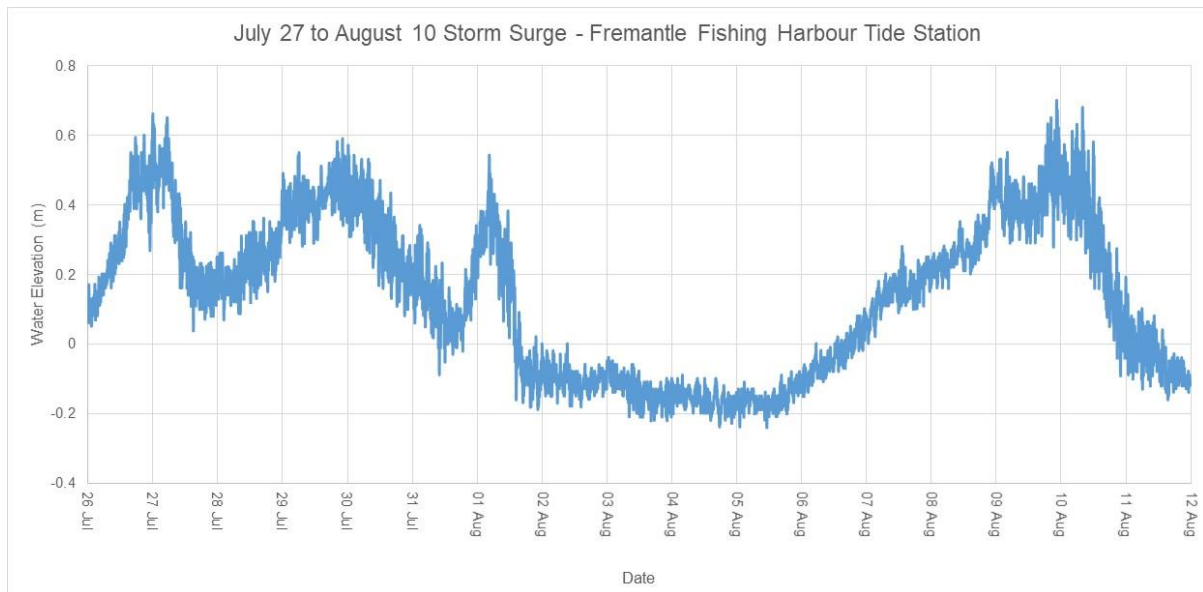


Figure 2-5 Storm surge recorded at the Fremantle Fishing Harbour Tide Station during the storms on the 26th and 27th of July and the 1st and 10th of August 2021.

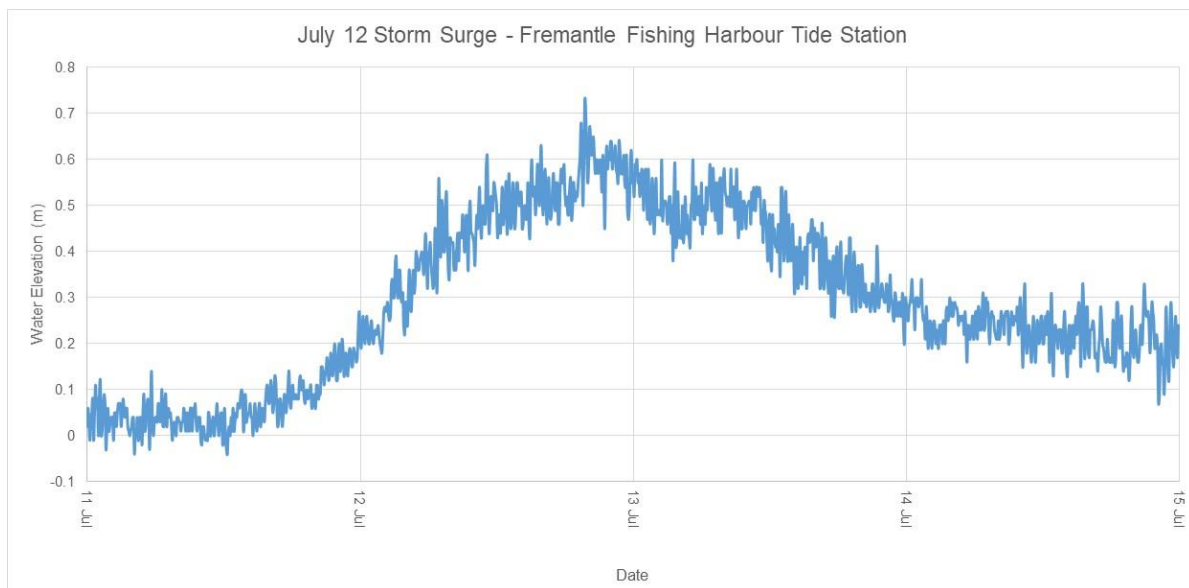


Figure 2-6 Storm surge recorded at the Fremantle Fishing Harbour Tide Station during the July 12th storm.

Total recorded water level at the Fremantle Tide Station for October 2020 to October 2021 is presented in Figure 2-4. The highest water level recorded was 1.10 mAHD recorded at 11:10 on 12 July 2021. The peak storm surge (0.73m) was also observed on the 12th of July at 7:45pm. While the storm that occurred on the 12th of July resulted in significant erosion, particularly to the north of Frederick Stubbs Carpark and to the south of Groyne 4 in Quinns Rocks, the most significant erosion and infrastructure damage was identified following the August 10th storm event which had the highest maximum significant wave height (7.84m) for the observation period. With a number of significant storm events occurring in quick succession, the result of accumulated erosion events saw major damage to Claytons Beach access ways and dune system, Mindarie Breakwater, Frederick Stubbs GSC Revetment, Frederick Stubbs Carpark, Queenscliffe Dog Beach dune system, Jindalee staircases, Amberton beach access ways and Fisherman's Hollow beach access in Yanchep. More information on storm damage is outlined in **Section 3**.

2.2.2 During Monitoring

Manual imagery and aerial surveys for this monitoring period were undertaken between 4 April 2022 and 8 April 2022. The water levels during these monitoring periods are presented below in Figure 2-7.

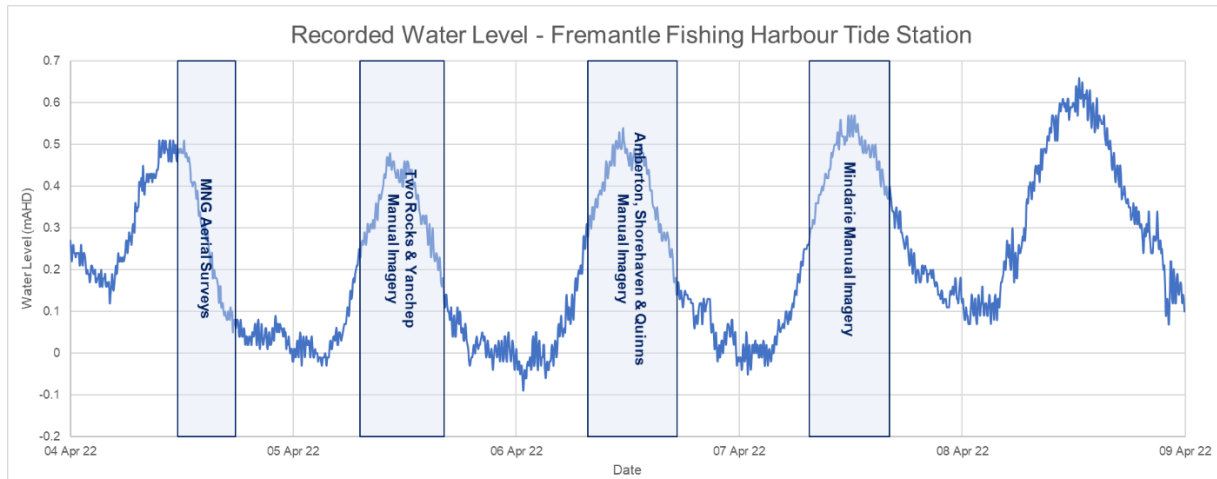




Figure 2-7 Recorded water level during April 2022 monitoring activities.





Most monitoring was undertaken during high tide, aside from the aerial surveys undertaken within Quinns Rocks and Mindarie. Changes in beach volumes are calculated from the area above the waterline so the falling tide will not affect the survey results however, it is important to note when assessing manual imagery that most images were taken close to high tide, with a maximum water level of 0.66mAHD.




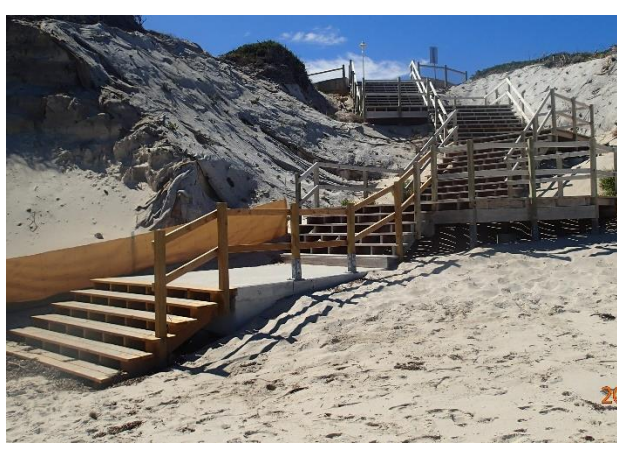
3 Storm Damage




As outlined above in Section 2.2.1, a number of storm events occurred during the 2021 winter period. These storm events happened in quick succession and the accumulated erosion and wave impacts caused significant damage to a number of dune systems and coastal infrastructure assets. Repair works were undertaken on these assets to ensure public safety and beach usability. Examples of significant storm damage and subsequent repair works are outlined below in Table 3-1.



Table 3-1 Examples of major infrastructure and dune damage caused by winter storms.

Damaged Asset	Damage	Action Taken by the City	Photograph of the asset following actions
Mindarie Breakwater		<p>Immediately following the 10 August storm event, the road was cleaned and any debris was removed. In September, the City engaged WA Limestone to place additional rock adjacent to the road and footpath to repair the structure and limit the road impacts for future years. Complete asset upgrade/renewal works are planned for the Mindarie Breakwater in October 2022.</p>	

Damaged Asset	Damage	Action Taken by the City	Photograph of the asset following actions
<p>Frederick Stubbs GSC Revetment, Quinns Rocks</p>		<p>Some of the geotextile sand containers (GSCs) were buried shortly after being dislodged from the revetment. The GSCs that could be recovered were removed from the beach. Any additional repair works will be investigated if the structure begins to slump.</p>	
<p>Frederick Stubbs Carpark, Quinns Rocks</p>		<p>Repair works were undertaken on the informal rock revetment wall adjacent to the carpark in February 2022. Nourishment was also undertaken at the site in April 2022 to create a buffer against impacts of any 2022 winter storms.</p>	

Damaged Asset	Damage	Action Taken by the City	Photograph of the asset following actions
<p>Queenscliffe Dog Beach Dune System</p>		<p>Repairs have been undertaken on the wind break fencing. The site is being monitored closely to analyse any safety risks.</p>	
<p>Jindalee Beach Access Staircases</p>		<p>This asset is currently managed and maintained by the Jindalee Beachside Estate Residential Development. The developer has extended some staircase footings and added additional steps to the bottom of the staircase.</p>	

Damaged Asset	Damage	Action Taken by the City	Photograph of the asset following actions
<p>Amberton Beach Access Pathway</p>		<p>This asset is currently managed and maintained by the Amberton Beach Residential Development. As a short term remediation measure the developer has backfilled this area. The City is currently working with the developer to develop a long term solution.</p>	
<p>Fisherman's Hollow Beach Access, Yanchep</p>		<p>The City is currently in the process of obtaining the required approvals to install an extension to the southern arm of the staircase</p>	<p>Action is yet to be taken as the City are awaiting heritage approval for the works.</p>

Damaged Asset	Damage	Action Taken by the City	Photograph of the asset following actions
<p>Yanchep Lagoon Beach Access, Yanchep</p>		<p>The City undertook reactive beach renourishment at Yanchep Lagoon in October 2021 to provide a safe beach for beach users. Further details of the nourishment are outlined in Section 8.5.</p>	

4 Manual Imagery

There are a total of 49 manual imagery beach monitoring sites located in key vulnerable coastal areas along the CoW coastline. The position of these sites are presented in Figure 4-1 to Figure 4-4. Images are taken 6 monthly in April and October each year to assess seasonal and long term changes to beach morphology. Images are taken by CoW's Coastal Engineer and are taken at the same location and with same field of view each time.



Figure 4-1 Two Rocks Coastal Monitoring Locations.

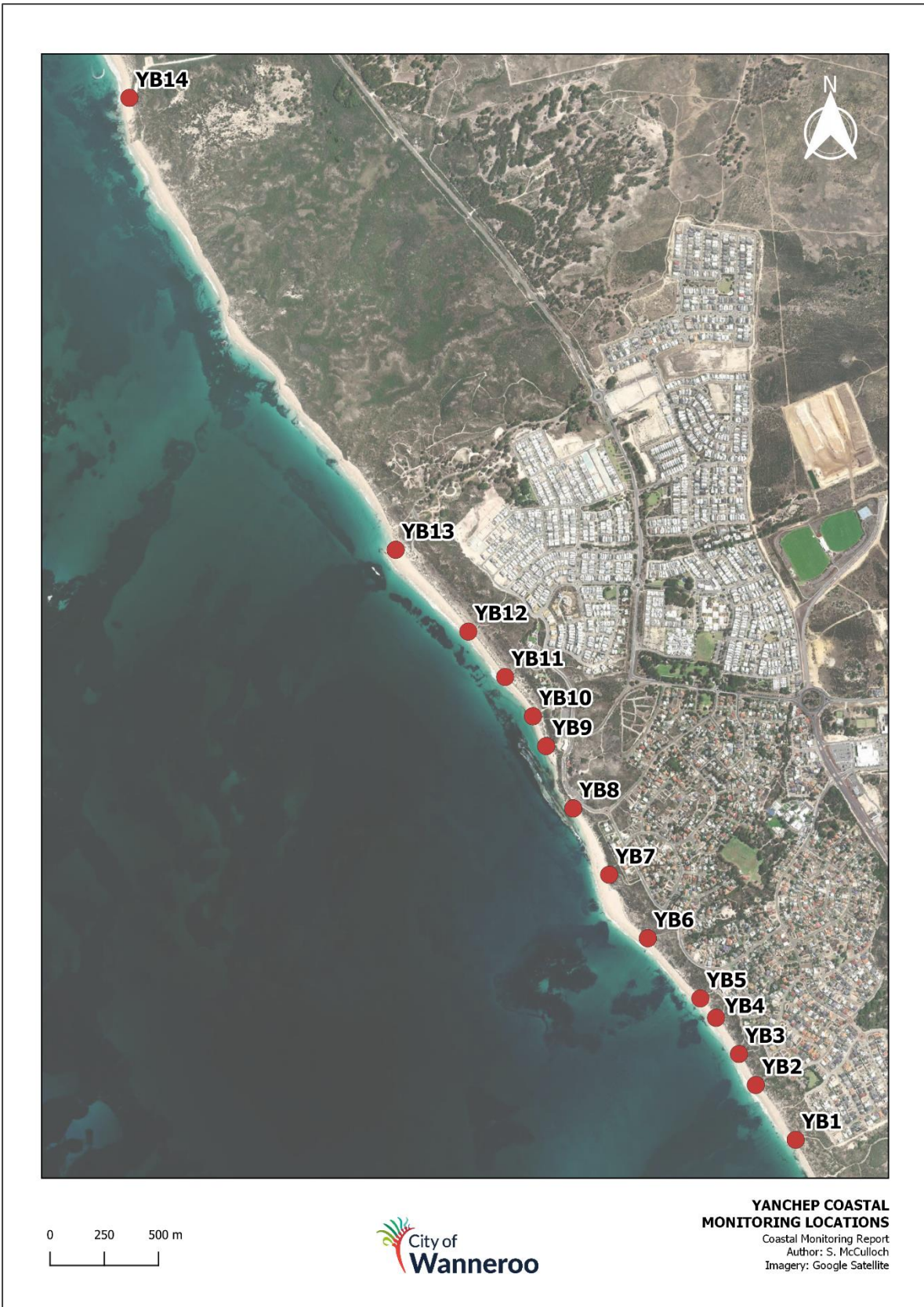


Figure 4-2 Yanchep Coastal Monitoring Locations.

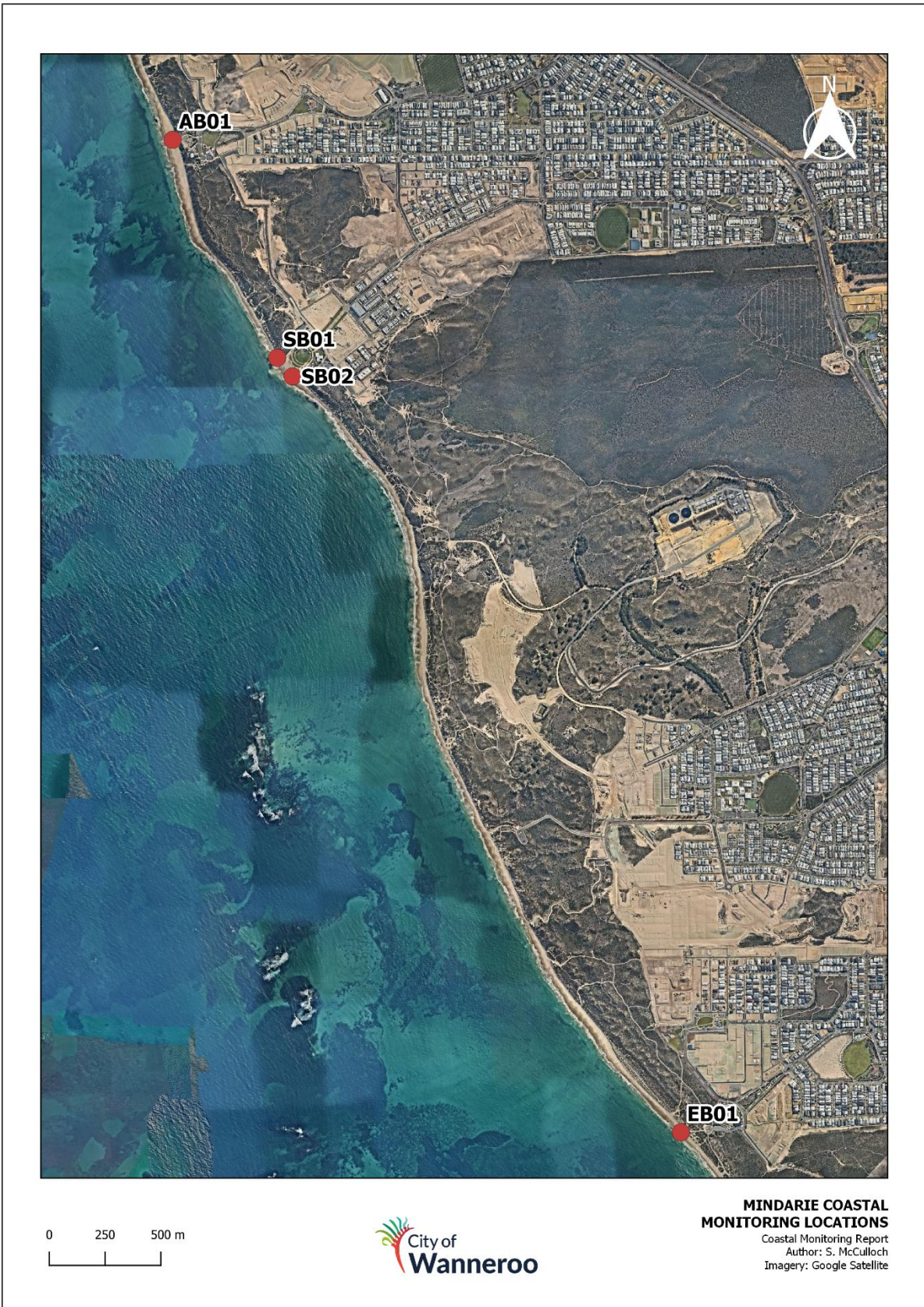


Figure 4-3 Amberton, Shorehaven & Eden Coastal Monitoring Locations.

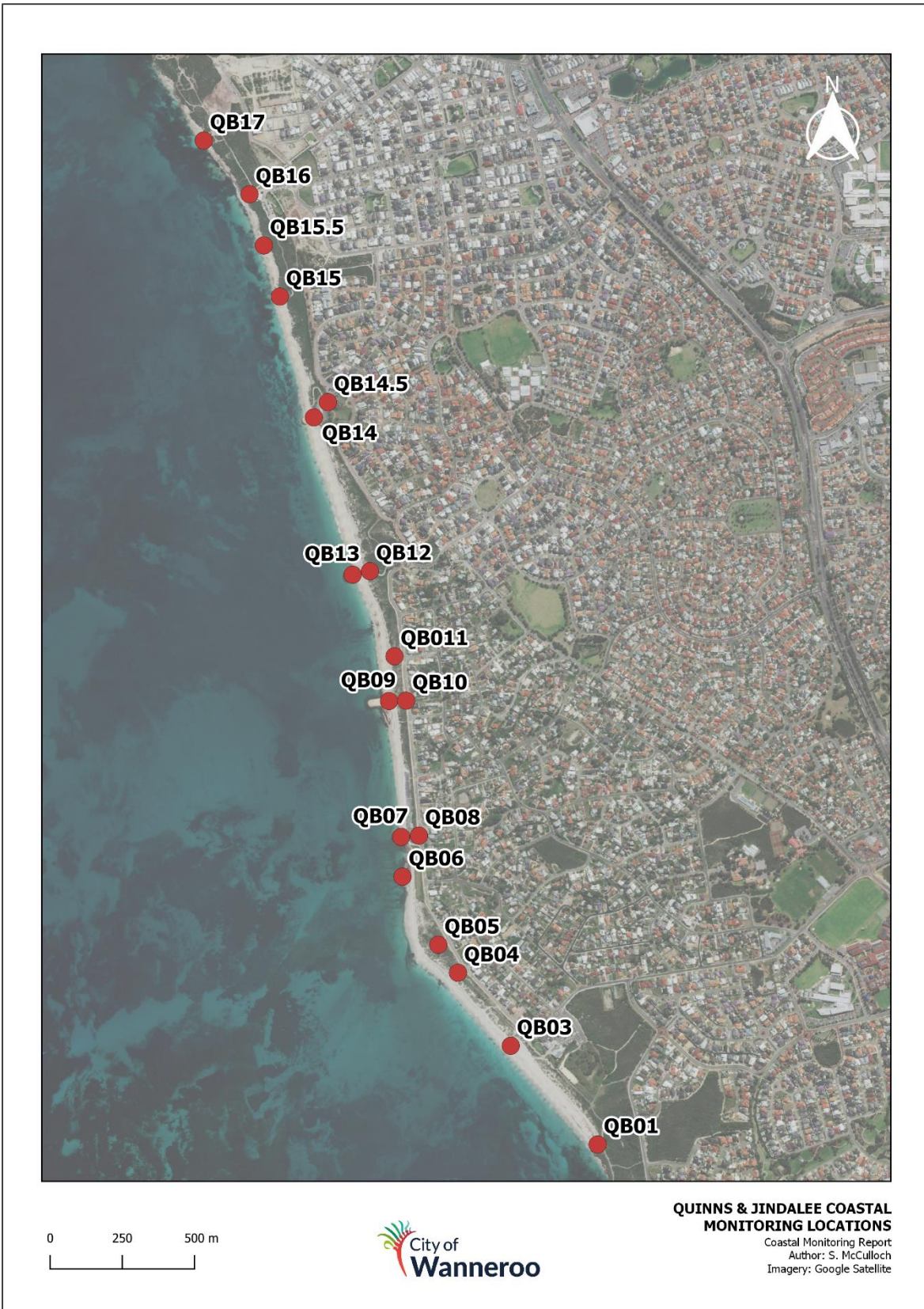


Figure 4-4 Quinns and Jindalee Coastal Monitoring Locations.

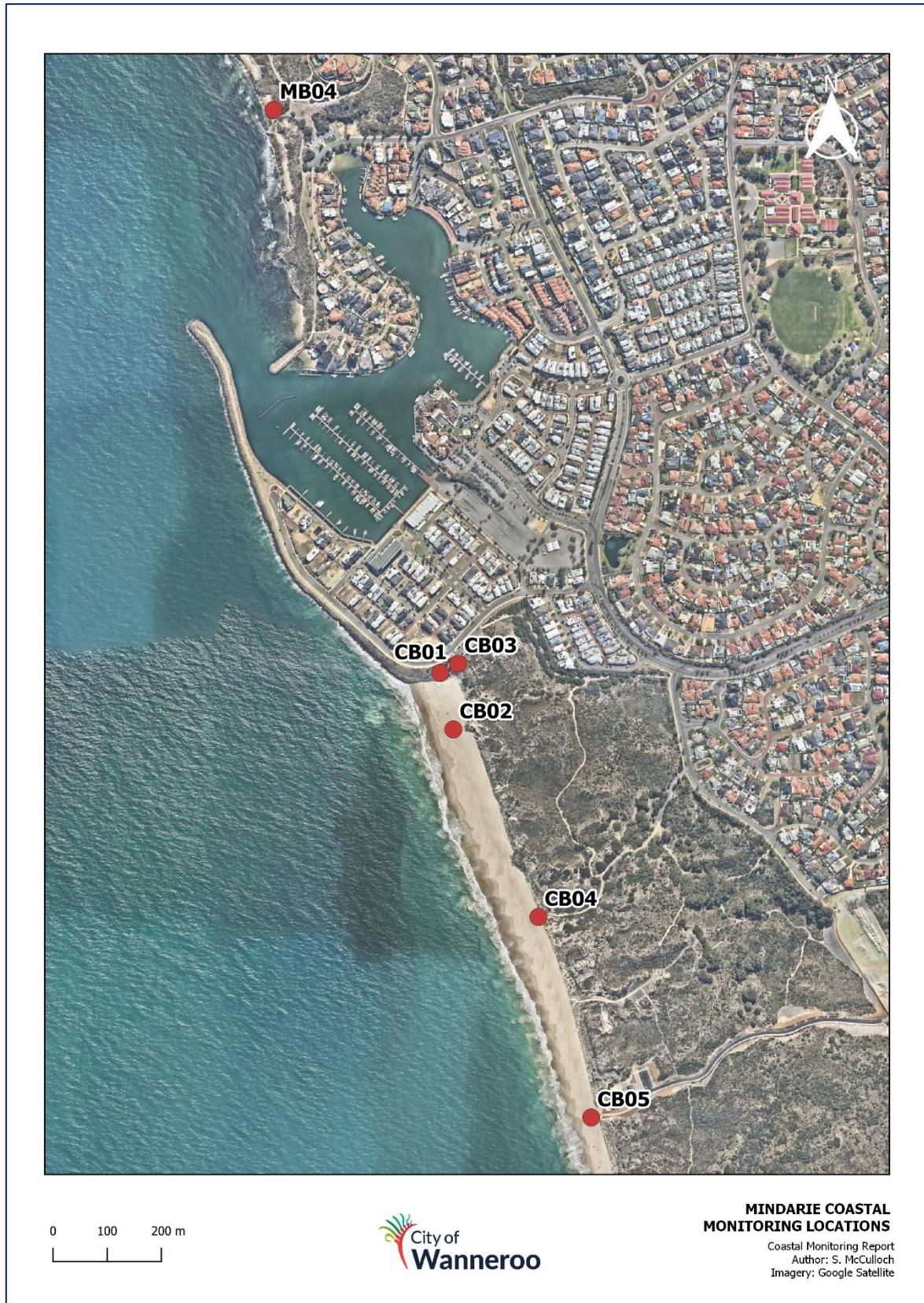


Figure 4-5 Mindarie Coastal Monitoring Locations.

4.1 Assessment Methodology

Manual imagery is assessed via visual comparison. Images, once taken, are filed individually for each monitoring site allowing for an effective analysis of long-term and seasonal beach changes.

Seasonal changes are assessed by comparing the images taken in April (current year) with October (previous year) and October (previous year) with April (previous year). Long-term changes are assessed by comparing current images with the earliest images taken at the same time of year for each monitoring location.

Comments are made on the severity of beach changes observed at each monitoring site following the visual assessment. The severity of beach change is based upon the definitions as defined in Table 4-1.

Table 4-1 Severity of Beach Change Definitions.

Accretion	<ul style="list-style-type: none"> • Increase in beach width; • Notable sand build up; or • Improvement in dune condition.
No change	<ul style="list-style-type: none"> • No identifiable change in beach width, slope or dune condition.
Minor Erosion	<ul style="list-style-type: none"> • Slight or minor decrease in beach width; • Slight or nil impact to dune condition; and • Remaining beach is sufficient to protect the dunes or infrastructure that lie landward of the beach.
Major Erosion	<ul style="list-style-type: none"> • Major decrease in beach width; • Some impact to dune condition; and • Remaining beach is NOT sufficient to protect dunes or infrastructure landward of the beach in the event of erosion.

4.2 Results

The severity of beach change and comments are presented in Table 4-2, Table 4-3, Table 4-4, Table 4-5, Table 4-7 and Table 4-8.

Images of sites with notably severe beach changes are presented in **Section 4.2.1**. All other manual images are saved on the City's server for future analysis and review.

Table 4-2 Visual observations of beach changes at manual imagery monitoring sites in Two Rocks.

Photo Monitoring Site	Summer Seasonal Changes (September 2021 to April 2022)		Winter Seasonal Changes (April 2021 to September 2021)		Long-term Changes (April 2015 to April 2022)		Long-term Changes (October 2014 to September 2021)	
	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments
Two Rocks								
B01	Minor erosion	Slight reduction in beach width. No notable impact to dunes.	Accretion	Increase in beach width and increases in dune vegetation.	Minor erosion	Decrease in beach width with some improvement to dune condition.	Accretion	Improvements in dune condition. Beach width is similar.
B02 UP-COAST	Accretion	Notable increase in beach width.	Minor erosion	Slight decrease in beach width. Limited visibility due to angle of the photo.	Minor erosion	Notable decrease in beach width.	Minor erosion	Slight reduction in beach width. Dune condition cannot be determined.
B03 UP-COAST	Accretion	Slight reduction in beach width however there was notable build-up of dune toe.	Accretion	Slight increase in beach width. Dunes remain in similar condition.	Minor erosion	Notable decrease in beach width.	Minor erosion	Erosion is evident at the base of the dunes.
B03 DOWN-COAST	Minor erosion	Slight decrease in beach width.	Accretion	Slight increase in beach width. Minimal vegetation loss at the base of the dunes.	Minor erosion	Slight decrease in beach width.	Minor erosion	Erosion is evident along the dune face.
B04 UP-COAST	Minor erosion	Very slight decrease in beach width. Build up at the base of the dunes.	Accretion	Noticeable increase in beach width. Some vegetation loss at the base of the dunes.	Minor erosion	Slight decrease in beach width.	No change	No notable change in beach width or dune condition.
B04 DOWN-COAST	Minor erosion	Very slight decrease in beach width. Build up at the base of the dunes.	Accretion	Slight increase in beach width. Minimal vegetation loss at the base of the dunes.	Minor erosion	Slight decrease in beach width.	No change	No notable change in beach width or dune condition.
B05	Accretion	Significant increase in beach width. No notable changes to dune condition.	Minor erosion	Notable reduction in beach width. Some impact to the dunes is evident, however the beach width remains sufficient to protect dune system.	Unable to assess - photo monitoring began in 2019.			
B06 UP-COAST	Accretion	Significant increase in beach width and build up at the base of the dunes.	Minor erosion	Notable reduction in beach width. Dune condition remains the same.				
B06 DOWN-COAST	Accretion	Significant increase in beach width and build up at the base of the dunes.	Minor erosion	Notable reduction in beach width. Some impact to the dunes is evident, however the beach width remains sufficient to protect dune system.	Unable to assess – photo monitoring began in 2021.			

Table 4-3 Visual observations of beach changes at manual imagery monitoring sites in Yanchep.

Photo Monitoring Site	Seasonal Changes (October 2021 to April 2022)		Seasonal Changes (April 2021 to October 2021)		Mid-term Changes (April 2019 to April 2022)		Mid-term Changes (October 2018 to October 2021)	
	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments
Yanchep								
B01 UP-COAST	Minor erosion	Slight reduction in beach width, however there was build up at the base of the dunes.	Accretion	Increased beach width and notable sand build up. Some erosion evident at the base of the dunes.	Minor erosion	Slight apparent reduction in beach height.	Minor erosion	Slight reduction in beach width with erosion evident at the base of the dunes.
B01 DOWN-COAST	Minor erosion	Significant erosion scarp. Slight reduction in beach width. Not notable impact to dunes.	Accretion	Significant increase in beach width. Dunes remain in good condition.	Minor erosion	Notable reduction in beach width and apparent beach height.	Accretion	Slight increase in beach width noted. Dunes remain in similar condition.
B02 UP-COAST	Minor erosion	Slight reduction in beach width however a notable build up at the base of the dunes.	Accretion	Significant increase in beach width. Some vegetation lost from the base of the dunes.	Minor erosion	Significant decrease in beach height, notable erosion at the base of the dunes.	Minor erosion	Flattening of beach slope, erosion at the base of the dunes.
B02 DOWN-COAST	Minor erosion	Slight reduction in beach width.	Accretion	Significant increase in beach width. Some erosion noted and vegetation lost from the base of the dunes.	Minor erosion	Significant decrease in beach height, notable erosion at the base of the dunes.	Minor erosion	Slight erosion at the base of the dunes. Beach width remains largely the same.
B03 UP-COAST	No change	No notable change in beach width or dune condition.	Minor erosion	Beach width remains largely unchanged. Erosion is evident at the base of the dunes.	Minor erosion	Slight decrease in beach height.	Minor erosion	Flattening of beach slope, some erosion evident at the base of the dunes.
B03 DOWN-COAST	Minor erosion	Slight reduction in beach width. Improvement in dune condition.	Accretion	Increase in beach width however notable erosion at the base of the dunes.	Minor erosion	Erosion at the base of the dunes is evident, representing a reduction in beach height.	Minor erosion	Flattening of beach slope, erosion is evident at the base of the dunes.
B04 UP-COAST	Accretion	Increase in beach width and build up at the base of the dunes.	Minor erosion	Beach width remains largely unchanged. Erosion is evident at the base of the dunes.	Minor erosion	Erosion at the base of the dunes is evident, representing a reduction in beach height.	Minor erosion	Flattening of beach slope, significant erosion is evident at the base of the dunes.
B04 DOWN-COAST	No change	No notable change in beach width or dune condition.	Accretion	Slight increase in beach width. Dunes remain in good condition.	No change	No notable change in beach width or dune condition.	Minor erosion	Flattening of beach slope, erosion is evident at the base of the dunes.
B05 UP-COAST	Accretion	Build up at the base of the dunes. No notable changes to beach width.	Minor erosion	Beach width remains largely unchanged. Significant erosion is evident at the base of the dunes.	No change	No notable change in beach width or dune condition.	Minor erosion	Reduction in beach width, with significant erosion evident at the base of the dunes.
B05 DOWN-COAST	Accretion	Build up at the base of the dunes and increase in beach width.	Minor erosion	Decrease in beach width. Significant erosion is evident at the base of the dunes.	No change	No notable change in beach width or dune condition.	Minor erosion	Flattening of beach slope, erosion is evident at the base of the dunes.
B06 UP-COAST	Accretion	Slight increase in beach width and improvement to dune condition.	Minor erosion	Beach width remains largely unchanged. Significant erosion is evident at the base of the dunes.	Minor erosion	Significant drop in beach height. Notable erosion at the base of the dunes.	Minor erosion	Significant erosion is evident at the base of the dunes. Flattening of beach slope and decrease in beach width.
B06 DOWN-COAST	No change	No notable change in beach width or dune condition.	Minor erosion	Beach width remains largely unchanged. Significant erosion is evident at the base of the dunes.	Minor erosion	Significant drop in beach height. Notable erosion at the base of the dunes.	Minor erosion	Erosion is evident at the base of the dunes. Flattening of beach slope and decrease in beach width.
B07 UP-COAST	Accretion	Significant increase in beach width.	Major erosion	Significant decrease in beach width. Little to no beach remaining.	Minor erosion	Slight decrease in beach width.	Minor erosion	Significant reduction in beach width. Some erosion evident at the base of the dunes.
B07 DOWN-COAST	Accretion	Significant increase in beach width.	Major erosion	Significant decrease in beach width. No beach remaining in some areas.	Minor erosion	Slight decrease in beach width.	Minor erosion	Significant reduction in beach width.
B08 UP-COAST	Accretion	Notable increase in beach width.	Minor erosion	Beach width remains similar, erosion is significant with rocks exposed that were otherwise buried.	Accretion	Notable increase in beach width.	Minor erosion	Notable reduction in beach width.

Photo Monitoring Site	Seasonal Changes (October 2021 to April 2022)		Seasonal Changes (April 2021 to October 2021)		Mid-term Changes (April 2019 to April 2022)		Mid-term Changes (October 2018 to October 2021)	
	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments
Yanchep								
B08 DOWN-COAST	Accretion	Significant increase in beach width and improvement in dune condition.	Minor erosion	Beach width remains largely unchanged. Erosion is evident at the base of the dunes.	Accretion	Notable increase in beach width.	Minor erosion	Erosion is evident at the base of the dunes. Flattening of beach slope and decrease in beach width.
B09 UP-COAST	Accretion	Build-up in beach volume as a result of nourishment.	Minor erosion	Erosion noted with flattening of beach slope and erosion at the base of the dunes.	Minor erosion	Significant reduction in beach width with notable erosion scarp.	Minor erosion	Flattening of beach slope, erosion at the base of the dunes.
B09 DOWN-COAST	Accretion	Build-up in beach volume as a result of nourishment.	Minor erosion	Erosion noted with flattening of beach slope.	Minor erosion	Slight reduction in beach width with notable erosion scarp.	Minor erosion	Flattening of beach slope and decreased beach width.
B11 UP-COAST	Minor erosion	Slight reduction in beach width.	Accretion	Increase in beach width. No notable change in dune condition.	Minor erosion	Notable reduction in beach height.	Minor erosion	Flattening of beach slope with increase in beach width.
B11 DOWN-COAST	Minor erosion	Slight reduction in beach width.	Accretion	Increase in beach width. Some erosion is noted at the base of the dunes.	Minor erosion	Slight reduction in beach height with erosion evident at the base of the dunes.	Accretion	Slight increase in beach width.
B12 UP-COAST	Minor erosion	Slight reduction in beach width and notable erosion scarp.	Accretion	Increase in beach width. Some erosion is noted at the base of the dunes.	Minor erosion	Notable erosion scarp and reduction in beach width.	Accretion	Significant increase in beach width and improvement in dune condition.
B12 DOWN-COAST	Minor erosion	Slight reduction in beach width, no notable changes to the dune condition.	Accretion	Increase in beach width. Some erosion is noted at the base of the dunes with a loss of vegetation evident.	Accretion	Slight increase in beach width and build up at the toe of the dune.	Accretion	Significant increase in beach width and improvement in dune condition.
B13 UP-COAST	Minor erosion	Slight reduction in beach width, no notable changes to the dune condition.	Accretion	Increase in beach width. Some erosion is noted at the base of the dunes.	Accretion	Slight increase in beach width and build up at the toe of the dune.	Minor erosion	Reduction in beach width as well as notable erosion at the base of the dune.
B13 DOWN-COAST	Accretion	Significant increase in beach width and improvement in dune condition.	Minor erosion	Notable reduction in beach width. Some erosion is evident at the base of the dunes,	Accretion	Slight increase in beach width and build up at the toe of the dune.	Minor erosion	Reduction in beach width as well as some erosion at the base of the dune.

Table 4-4 Visual observations of beach changes at manual imagery monitoring sites in Amberton.

Photo Monitoring Site	Seasonal Changes (April 2021 to October 2021)		Seasonal Changes (October 2020 to April 2021)		Long-term Changes (October 2018 to October 2021)		Long-term Changes (April 2019 to April 2021)	
	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments
Amberton								
B01 UP-COAST	Accretion	Increase in beach width and improvement in dune condition.	Minor erosion	Reduction in beach width with notable erosion at the base of the dunes.	Unable to assess – photo monitoring began in 2021.			
B01 DOWN-COAST	Accretion	Significant increase in beach width and improvement in dune condition.	Minor erosion	Reduction in beach width with notable erosion at the base of the dunes.				

Table 4-5 Visual observations of beach changes at manual imagery monitoring sites in Shorehaven.

Photo Monitoring Site	Seasonal Changes (April 2021 to October 2021)		Seasonal Changes (October 2020 to April 2021)		Long-term Changes (October 2018 to October 2021)		Long-term Changes (April 2019 to April 2021)	
	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments
Shorehaven								
B01 UP-COAST	Minor erosion	Slight decrease in beach width, no changes to dune condition.	Accretion	Slight increase in beach width.	Unable to assess – monitoring began in 2020.			
B01 DOWN-COAST	No change	No change in beach width and no notable erosion.	No change	No change in beach width and no notable erosion.				
B02 UP-COAST	Minor erosion	Slight decrease in beach width, no changes to dune condition.	Accretion	Increase in beach width, erosion scarp no longer evident.				
B02 DOWN-COAST	Minor erosion	Slight decrease in beach width.	Accretion	Increase in beach width.				

Table 4-6 Visual observations of beach changes at manual imagery monitoring sites in Eden

Photo Monitoring Site	Seasonal Changes (April 2021 to October 2021)		Seasonal Changes (October 2020 to April 2021)		Long-term Changes (October 2018 to October 2021)		Long-term Changes (April 2019 to April 2021)	
	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments
Eden								
B01 UP-COAST	Minor erosion	Slight decrease in beach width.	Unable to assess – photo monitoring began in October 2021.					
B01 DOWN-COAST	Minor erosion	Slight decrease in beach width.						

Table 4-7 Visual observations of beach changes at manual imagery monitoring sites in Quinns Rocks

Photo Monitoring Site	Seasonal Changes (April 2021 to September 2021)		Seasonal Changes (October 2020 to April 2021)		Long-term Changes (April 2014 to April 2022)		Long-term Changes (November 2013 to October 2021)	
	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments
Quinns Beach								
B01	Minor erosion	Slight reduction in beach width. No notable changes to beach condition.	Accretion	Widening of beach width. Some lower dune vegetation loss is evident.	Accretion	Significant increase in beach width.	Accretion	Slightly wider beach however dune vegetation loss is evident at the base of the dunes.
B03 UP-COAST	Minor erosion	Notable reduction in beach width.	Accretion	Widening of beach width. Dunes remain in similar condition.	Accretion	Slight increase in beach width. No notable changes to dune condition.	Minor erosion	Slight reduction in beach width.
B03 DOWN-COAST	Minor erosion	Notable reduction in beach width, no notable impacts to dune condition.	Accretion	Significantly wider beach width.	No change	No notable change in beach width. Dunes remain in similar condition.	No change	No notable change in beach width. Dunes remain in similar condition.
B04 UP-COAST	No change	No notable change in beach width. Dunes remain in similar condition.	No change	No notable change in beach width. Dunes remain in similar condition.	No change	No notable change in beach width. Dunes remain in similar condition.	Minor erosion	Slight reduction in beach width.
B04 DOWN-COAST	No change	No notable change in beach width. Dunes remain in similar condition.	No change	No notable change in beach width. Dunes remain in similar condition.	Minor erosion	Slight reduction in beach width.	Minor erosion	Slight reduction in beach width.
B06 UP-COAST	Accretion	Significant increase in beach width and beach height.	Major Erosion	Significant decrease in beach width. Water level is at the base of the GSC revetment.	Accretion	Slight increase in beach width however as there was no GSC revetment in 2014 it makes it difficult to assess the extent of the erosion.	Minor erosion	Reduction in beach width however as there was no GSC revetment in 2013 it makes it difficult to assess the extent of the erosion.
B06 DOWN-COAST	Accretion	Significant increase in beach width and beach height.	Major Erosion	Significant decrease in beach width. Water level is at the base of the GSC revetment and four rows of GSCs have been exposed.	Accretion	Slight increase in beach width however as there was no GSC revetment in 2014 it makes it difficult to assess the extent of the erosion.	Minor erosion	Reduction in beach width however as there was no GSC revetment in 2013 it makes it difficult to assess the extent of the erosion.
B07 UP-COAST	Major Erosion	Significant decrease in beach width and drop in beach height.	Accretion	Slight increase in beach width however it is important to note that nourishment was undertaken in this area in April 2021 following monitoring.	Minor erosion	Reduction in beach width is notable. It is important to note however that nourishment is undertaken annually at this site.	Minor erosion	Slight reduction in beach width and flattening. It is important to note however that nourishment is undertaken annually at this site.
B07 DOWN-COAST	Accretion	Significant increase in beach width and beach height.	Major Erosion	Significant decrease in beach width. Water level is at the base of the GSC revetment and two rows of GSCs have been exposed.	No change	Unable to determine any changes. Installation of the GSC Revetment was ongoing in 2014 and this could affect the long-term assessment.	Minor erosion**	Slight decrease in beach width. Installation of the GSC Revetment was ongoing in 2014 and this could affect the long-term assessment.
B09 UP-COAST	Minor erosion	Slight reduction in beach width.	Accretion	Slightly wider beach width. Some improvement in dune vegetation at the base of the	Minor erosion	Slight reduction in beach width however there is a notable improvement in dune condition.	Minor erosion	Reduction in beach width, dunes condition has improved with dune vegetation growing at the base of the dunes.
B09 DOWN-COAST	Accretion	Slight increase in beach width, improvements in dune condition.	Minor erosion	Reduction in beach width, erosion is evident at the base of the dunes.	Minor erosion	Slight reduction in beach width however there is a notable improvement in dune condition.	Minor erosion	Reduction in beach width, dunes are in a similar condition.
B11 UP-COAST	No change	No notable change in beach width or dune condition.	Minor erosion	Slight decrease in beach width.	Accretion	Slight increase in beach width and improvement in dune condition.	Minor erosion	Slight decrease in beach width, dune loss is evident at the base of the dunes.
B11 DOWN-COAST	Minor erosion	Slight decrease in beach width. Dune condition remains unchanged.	Accretion	Slight increase in beach width.	Accretion	Slight increase in beach width and improvement in dune condition.	Minor erosion	Slight decrease in beach width.
B13 UP-COAST	Major erosion	Major reduction in beach width and significant erosion scarp. Limited beach width protecting the base of the dunes.	Accretion	Significant increase in beach width. Erosion scarp no longer present.	Major erosion	Significant erosion scarp and reduction in beach width.	Accretion	Beach width has increased and dune condition has improved.
B13 DOWN-COAST	Accretion	Increase in beach width and build up at the base of the dunes.	Minor erosion	Notable decrease in beach width, dunes have been eroded at the base with dune vegetation missing.	Minor erosion	Slight reduction in beach width and notable erosion at the base of the dunes.	Minor erosion	Notable decrease in beach width, erosion scarp is present just south of the groyne.

Photo Monitoring Site	Seasonal Changes (April 2021 to September 2021)		Seasonal Changes (October 2020 to April 2021)		Long-term Changes (April 2014 to April 2022)		Long-term Changes (November 2013 to October 2021)	
	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments
B14 UP-COAST	Minor erosion	Major reduction in beach width and significant erosion scarp. Limited beach width protecting the base of the dunes.	Accretion	Slight increase in beach width.	Minor erosion	Significant reduction in beach width and notable erosion scarp.	Minor erosion	Significant reduction in beach width.
B14 DOWN-COAST	Accretion	Slight increase in beach width.	Minor erosion	Notable decrease in beach width, dunes in poor condition.	Minor erosion	Significant reduction in beach width.	Minor erosion**	Similar beach width, dunes in poor condition.
B15 UP-COAST	Minor erosion	Slight erosion scarp.	No change	No identifiable change in beach width. No erosion identified.	Minor erosion*	Reduction in beach height and beach width evident.	Accretion**	Significant sand build up since 2014.
B15 DOWN-COAST	Minor erosion	Slight reduction in beach width and erosion scarp is notable.	Accretion	Increase in beach width. Dunes remain in same condition.	Minor erosion*	Significant reduction in beach width with notable erosion scarp.	Accretion**	Significant sand build up since 2014.
B15.5 UP-COAST	Minor erosion	Slight reduction in beach width. No notable changes to dune condition.	Accretion	Slight increase in beach width.	Unable to be assessed – first image taken in 2017.			
B15.5 DOWN-COAST	Minor erosion	Slight reduction in beach width. Notable erosion scarp.	Accretion	Slight increase in beach width.				
B16 UP-COAST	Accretion	Slight increase in beach width.	Minor erosion	Reduction in beach width.	Minor erosion*	Significant reduction in beach width.	Accretion**	Slight sand build up since 2014.
B16 DOWN-COAST	Accretion	Slight increase in beach width.	Minor erosion	Reduction in beach width.	Minor erosion*	Significant reduction in beach width.	Accretion**	Slight sand build up since 2014.
B17 UP-COAST	Accretion	Increase in beach width and build up at the base of the dunes.	Minor erosion	Reduction in beach width and exposed under layer of rock.	Unable to assess – Monitoring began in 2021.			
B17 DOWN-COAST	Accretion	Notable build up at the base of the dunes.	Minor erosion	Reduction in beach width and exposed under layer of rock.				

*Long-term changes have been assessed through images taken in 2015.

**Long-term changes have been assessed through images taken in 2014.

Table 4-8 Visual observations of beach changes at manual imagery monitoring sites in Mindarie

Photo Monitoring Site	Seasonal Changes (October 2021 to April 2022)		Seasonal Changes (April 2021 to October 2021)		Long-term Changes (February 2019 to April 2022)		Long-term Changes (October 2018 to October 2021)	
	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments
Mindarie								
B01	Accretion	Significant increase in beach width.	Major Erosion	Significant decrease in beach width. Dune erosion is evident.	Unable to assess – monitoring began in 2020.			
B02 UP-COAST	Accretion	Significant increase in beach width and improvement to the condition of the dunes.	Major Erosion	Significant decrease in beach width. Dune erosion is evident.				
B02 DOWN-COAST	Accretion	Significant increase in beach width and improvement to the condition of the dunes.	Major Erosion	Significant decrease in beach width. Dune erosion is evident.				
B03	Accretion	Significant increase in beach width and improvement to the condition of the dunes.	Major Erosion	Significant decrease in beach width. Dune erosion is evident.				
B04	Minor erosion	Slight decrease in beach width.	Unable to assess - Monitoring began in October 2021.					

4.2.1 Areas Experiencing Major Seasonal Erosion

While assessing seasonal changes, two areas were identified as having experienced major erosion over the summer period (October 2021 to April 2022) and four areas were identified as having experienced major erosion over the winter months (April 2021 to October 2021). Images of the identified areas experiencing major seasonal erosion are shown below.

Quinns Rocks B07 Up-Coast – Major Erosion, Summer 2021/22



Figure 4-6 Major erosion over summer 2021/22 at Quinns B07 Up-Coast.

Major erosion was identified through manual imagery in the area immediately north of Quinns Groyne 1. Major seasonal erosion is experienced at this site each year and in response, the City undertakes planned re-nourishment at the site prior to each winter period. Following the April 2022 monitoring round, approximately 4000 tonnes of sand was placed at this site. The additional sand that is placed following renourishment creates a buffer against the impacts of winter storm events and limits the damage to coastal assets.

Quinns Rocks B13 Up-Coast – Major Erosion, Summer 2021/22



Figure 4-7 Major erosion over summer 2021/22 at Quinns B13 Up-Coast.

Major erosion was identified at Quinns Rocks site B13 Up-Coast between October 2021 and April 2022. Similarly to site B07 Up-Coast, significant seasonal erosion is expected at this site each year. Renourishment activities are often undertaken at the site if major seasonal erosion is identified. Following the April 2022 monitoring round, approximately 4000 tonnes of sand was placed at the site to mitigate the effects of winter storm events and limit the damage to coastal assets. Photos of the site following the nourishment, which was undertaken in April 2022, are presented in Figure 4-7.

Yanchep B07 Up-Coast and Down-Coast – Major Erosion, Winter 2021

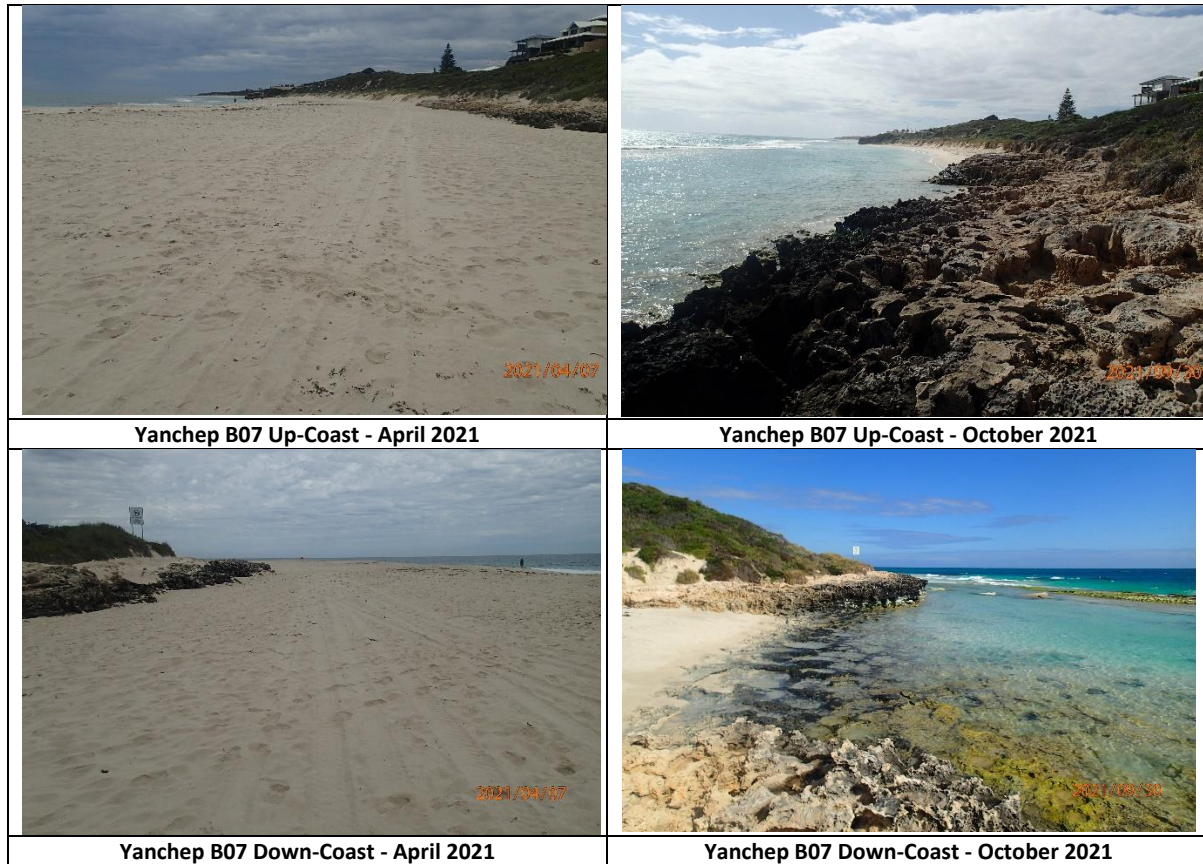


Figure 4-8 Major erosion over winter 2021 at Yanchep B07 Up-Coast and Down-Coast.

The beach captured in the photographs taken up-coast and down-coast at the Yanchep monitoring location B07 is bounded by a headland to the north and south. There was a significant reduction in beach width over the 2021 winter period with the transport of sediment southward over the winter months resulting in erosion to the south of the headland. Subsequently, however, northward movement of sediment during the summer months resulted in significant accretion at the site which provided a substantial buffer against early winter storms. While there is major seasonal changes at the site, the long term manual imagery assessment suggests that the site has experienced very minor erosion since the start of monitoring in 2019. It is important to note, however, that residential houses and road infrastructure are in close proximity to the site and could, in future, be susceptible to the effects of coastal erosion. It is therefore recommended that the site be monitored closely.

Quinns B06 and B07 Down-Coast – Major Erosion, Winter 2021



Figure 4-9 Major erosion over winter 2021 at Quinns B06 Up-Coast, Down-Coast and Quinns B07 Down-Coast.

Major seasonal erosion is experienced adjacent to the GSC and Rock Revetment at Quinns Rocks each year. The area is bound by Quinns Groyne 1 to the north and the Artificial Headland to the south. As presented in Figure 4-9 significant erosion was experienced over the 2021 winter period with very little beach remaining adjacent to the GSC Revetment. While seasonal erosion happens in the area each year, the GSC Revetment provides sufficient protection to adjacent assets and park land. In November 2021, just after the October images were taken, significant accretion was noted at the site. The area will continue to be monitored and the GSC Revetment will continue to be assessed to ensure that it continues to function as a coastal protection structure.

Mindarie B01, B02 and B03 – Major Erosion, Winter 2021



Figure 4-10 Major erosion over winter 2021 at Mindarie B01, B02 and B03.

Significant erosion was observed at Claytons Beach over the 2021 winter period. While the images show some beach remaining in October 2021, images taken at site B01 and B02 show significant impact to the base of the dunes at Claytons Beach. Claytons Beach experiences significant seasonal erosion and accretion each year however, the recurring winter storms in 2021 resulted in significant impact to the dune system including exposure of the concrete foundations for the Claytons beach access staircase. While there is little infrastructure landward of Claytons Beach it is recommended that the area be closely monitored in future coastal monitoring reports and if significant erosion continues coastal management measures should be investigated for the area.

It is important to note that whilst changes to beach width is minimal at many sites there is still notable erosion at the base of the dunes as a result of this years' winter storms. Dune volume loss is significant in some areas which is often not captured effectively through manual imagery. Dune volume loss is more effectively assessed through survey results as outlined in **Section 5**.

4.2.2 Areas Experiencing Major Long-Term Erosion

One site in Quinns Rocks was identified through manual imagery as having experienced major long-term erosion. The site, which is outlined below in Figure 4-11, is situated immediately north of Quinns Groyne 3, along Quinns Dog Beach. Despite the significant nourishment that has been undertaken at the site since 2004 (~80,000 m³), a narrow beach is evident in the image taken in April 2022 with notable impact to the base of the dunes. It is recommended that this site continue to be monitored closely.

Quinns Rocks B13 Up-Coast – Long-Term Major Erosion

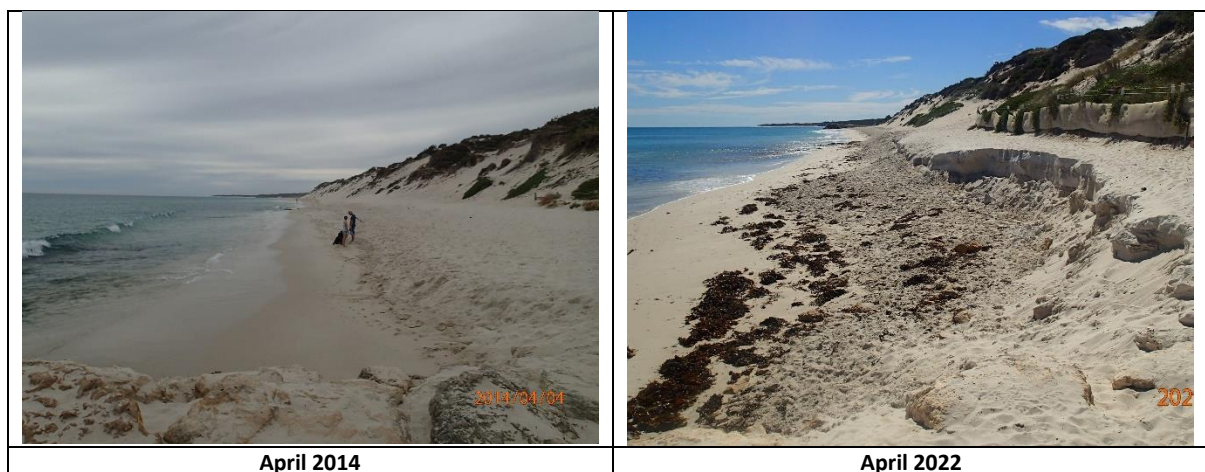


Figure 4-11 Major long term erosion at Quinns Rocks B13.

5 LIDAR and Ground Based Transect Surveys

Both LiDAR aerial surveys and nearshore ground based transect surveys are undertaken by MNG Surveyors including all post processing and analysis. LiDAR surveys are completed along the entire CoW coastal corridor including and in between the following areas:

- Two Rocks Beach;
- Yanchep Beach;
- Quinns Rocks Beach; and
- Claytons Beach.

129 nearshore ground based transect surveys are undertaken around the same time as the LiDAR aerial surveys. These surveys extend into the nearshore area, to a maximum depth of one meter, to collect the data within the nearshore area that is otherwise missed in LiDAR surveys due to constraints. LiDAR Aerial Surveys can only capture areas above the waterline and when the shoreline has receded, the area of analysis is limited. This is the first monitoring round where nearshore surveys have been undertaken which will allow for a better understanding of the morphological changes to the nearshore area.

These surveys are undertaken 6 monthly in April and October each year, in line with the timing of manual photographic monitoring.

5.1 Assessment Methodology

14 discrete study areas within the overall survey area are then assessed for changes in beach volume. Note that for this survey technique, this assessment is limited to dry areas landward of the waterline. Seasonal changes (October 2021 to April 2022) and annual changes (April 2021 to April 2022) to beach volume is assessed for each discrete area via difference plots of the two survey surfaces.

129 beach cross sections are extracted from the aerial survey profiles within each of the study areas. These cross sections are combined with the nearshore ground based survey transects and compared to earlier cross sections at the same location to further evaluate the extent of seasonal and long term erosion or accretion at the location.

5.2 Elevation Difference Plot Results

5.2.1 Seasonal Changes

Plots depicting the difference in elevation between the April 2022 surveys and October 2021 surveys as well as the difference between the October 2021 surveys and the April 2021 surveys for each beach section are output by MNG are assessed to identify areas of significant seasonal erosion. These plots are in Appendix A.

From the elevation difference plots, the change in beach volume between April 2022 and October 2021 as well as October 2021 and April 2021 is calculated for each of the 14 discrete study areas, the results of which are presented below in Table 5-1.

Table 5-1 Seasonal Net Volume Change of Beach Sections.

Beach Section	Section Description	Winter Net Volume Change October 2021 – April 2021	Summer Net Volume Change April 2022 – October 2021
Clayton Section 1	Claytons Beach, Mindarie	-45,435 m ³	+30,741 m ³
Quinns Section 1	Quinns Main Beach – South of Artificial Headland	+496 m ³	+5,605 m ³

Beach Section	Section Description	Winter Net Volume Change October 2021 – April 2021	Summer Net Volume Change April 2022 – October 2021
Quinns Section 2	Frederick Stubbs Park and GSC Revetment	-7,377 m ³	+5,031 m ³
Quinns Section 3	Frederick Stubbs Carpark, South of Groyne 2	-4,946 m ³	+1,429 m ³
Quinns Section 4	North of Groyne 2, South of Groyne 3	-3,228 m ³	+2,689 m ³
Quinns Section 5	North of Groyne 3, South of Groyne 4	-5,135 m ³	+3,775 m ³
Quinns Section 6	North of Groyne 4, Jindalee	-12,472 m ³	+4,460 m ³
Yanchep Section 1	South of Fisherman's Hollow Beach Access	-15,148 m ³	+11,040 m ³
Yanchep Section 2	South of Headland, North of Fisherman's Hollow Beach Access	-4,303 m ³	+1,792 m ³
Yanchep Section 3	Yanchep Lagoon	-1,147 m ³	-54 m ³
Yanchep Section 4	South of Capricorn Groyne	-17,102 m ³	+8,051 m ³
Yanchep Section 5	North of Capricorn Groyne	-8,885 m ³	+3,687 m ³
Two Rocks Section 1	South of Two Rocks Marina	-12,754 m ³	+1,792 m ²
Two Rocks Section 2	North of Two Rocks Marina	-8,885 m ³	+8,051 m ²

Overall, there was an increase in beach volume across the summer 2021/22 period. The combined net volume changes of the Mindarie, Quinns, Yanchep and Two Rocks foreshore areas are as follows:

- The one beach section that is assessed within the Mindarie foreshore area (Claytons Beach) had a net beach volume gain of 30,741 m³ between October 2021 and April 2022;
- The six beach sections along the Quinns foreshore area had a combined net beach volume gain of 22,989 m³ between October 2021 and April 2022;
- The five beach sections along the Yanchep foreshore area had a combined net beach volume gain of 24,516 m³ between October 2021 and April 2022; and
- The two beach sections along the Two Rocks foreshore area had a combined net beach volume gain of 9,843 m³ between October and April 2021.

While these results represent an overall increase in beach volume over the 2021/22 summer period there was a notably greater beach volume loss in winter 2021 than was gained in summer 2021/22, as outlined below in **Section 5.2.2**. Areas with significant seasonal changes in beach volume were consistent with manual imagery observations. It is important to note that the overall assessment of beach volume change is still limited by the water line which reduces the area of beach that can be assessed.

5.2.2 Annual Changes – April 2021 to April 2022

Elevation difference plots depicting the difference in surface elevation between the April 2022 surveys and April 2021 surveys are output by MNG and are assessed to identify areas of significant annual erosion. These plots are in Appendix A.

The change in beach volume over the year is calculated for each of the 14 discrete study areas, the results of which are presented below in Table 5-2.

Table 5-2 Annual Net Volume Change of Beach Sections October 2021 –October 2020.

Beach Section	Section Description	Net Volume Change April 2022 – April 2021
Clayton Section 1	Claytons Beach	-5,841* m ³
Quinns Section 1	Quinns Main Beach – South of Artificial Headland	+3,513 m ³
Quinns Section 2	Frederick Stubbs Park and GSC Revetment	-287 m ³
Quinns Section 3	Frederick Stubbs Carpark, South of Groyne 2	-3,874 m ³
Quinns Section 4	North of Groyne 2, South of Groyne 3	-789 m ³
Quinns Section 5	North of Groyne 3, South of Groyne 4	-4,573 m ³
Quinns Section 6	North of Groyne 4, Jindalee	-4,748 m ³
Yanchep Section 1	South of Fisherman's Hollow Beach Access	-4,240 m ³
Yanchep Section 2	South of Headland, North of Fisherman's Hollow Beach Access	-1,301 m ³
Yanchep Section 3	Yanchep Lagoon	-1,500 m ³
Yanchep Section 4	South of Capricorn Groyne	-7,112 m ³
Yanchep Section 5	North of Capricorn Groyne	-5,112* m ³
Two Rocks Section 1	South of Two Rocks Marina	+2,042 m ³
Two Rocks Section 2	North of Two Rocks Marina	-5,559 m ³

*Note that the net volume change calculated for Claytons Beach and Yanchep Section 5 is inclusive of some cut material that was removed from the beach section for residential developments.

It is apparent that there was an overall loss of beach volume across the year, particularly along the Quinns Rocks, Claytons and Yanchep Beach areas. It is important to note however, that the net beach volume change calculated for Claytons Beach and Yanchep Section 5 is inclusive of some cut material that was removed from the beach section for residential developments and the actual total beach volume change is likely to be less than what is indicated. As part of the annual beach renourishment program, 10,000 tonnes (~6,500 m³) of sand was used in April 2021 for renourishment at Quinns Sections 3, 5 and 6. In response to the erosion caused by the 2021 winter storms, reactive beach renourishment works were also undertaken at Quinns Section 3 and Yanchep Section 3, where 6,000 tonnes (~3,900 m³) was placed in October 2021. Despite these renourishment activities, Quinns Sections 3, 5 and 6 still saw a total net reduction of 13,195 m³ in beach volume and Yanchep Section 3 still saw a total net reduction of 1,500 m³ between April 2022 and April 2021. This highlights the importance of beach renourishment in these areas as without it, we would see a significantly larger reduction in beach volume which would result in significant impacts to coastal assets and the dune systems.

5.2.3 Long Term Trends

Seasonal changes in beach volumes have been assessed by the City since the summer of 2018/19. To identify any long term trends in seasonal beach volume change, net beach volume change per season was plotted for each beach section. These plots are presented in Figure 5-1, Figure 5-2, Figure 5-3 and Figure 5-4 below.

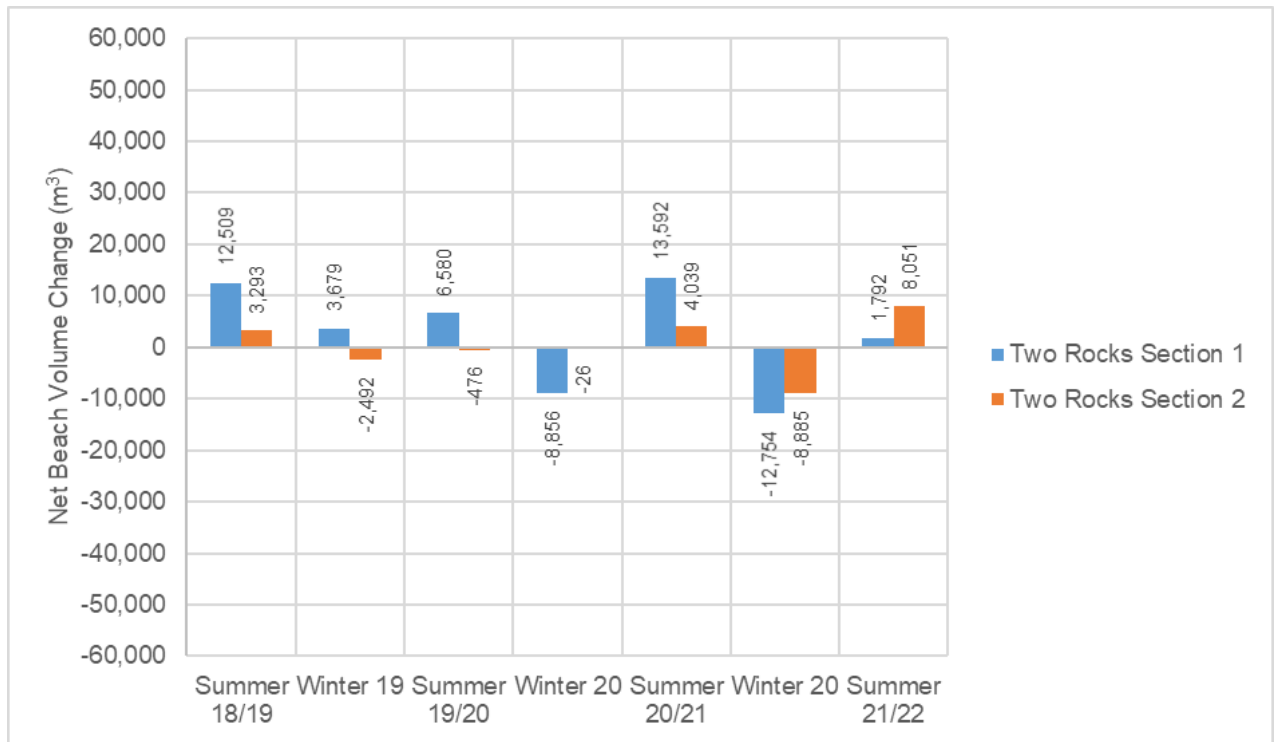


Figure 5-1 Seasonal net beach volume changes for Two Rocks Section 1 and 2.

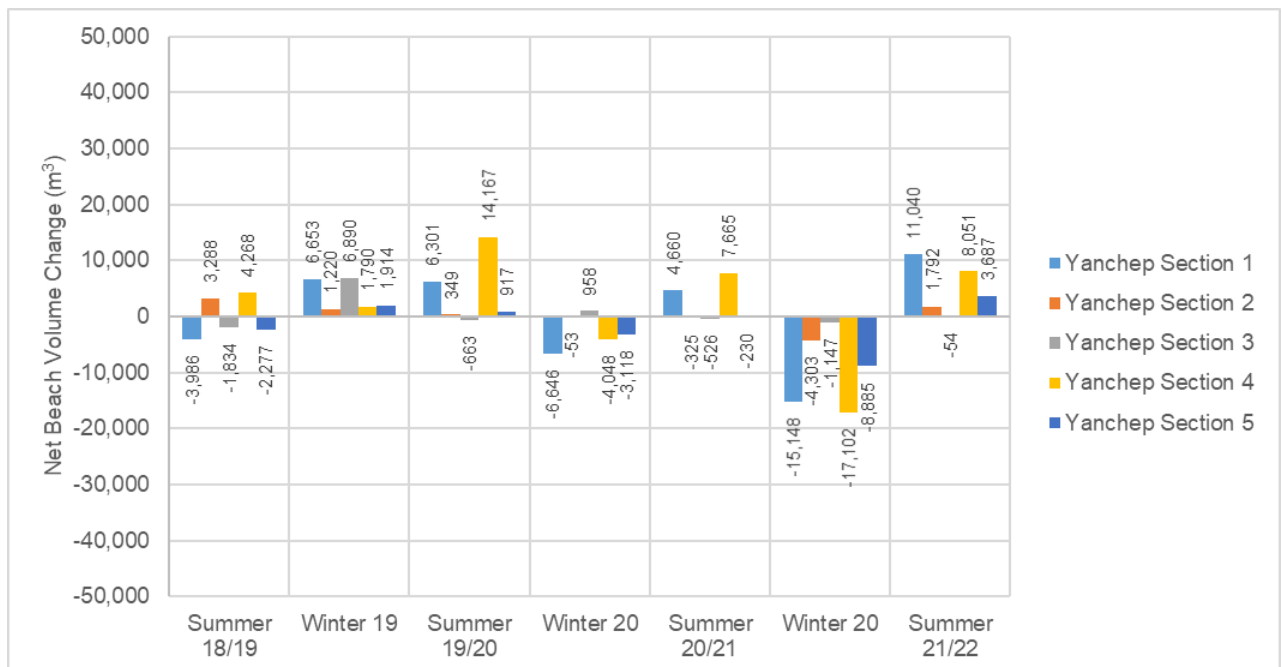


Figure 5-2 Seasonal net beach volume changes for Yancheep Section 1, 2, 3, 4 and 5.

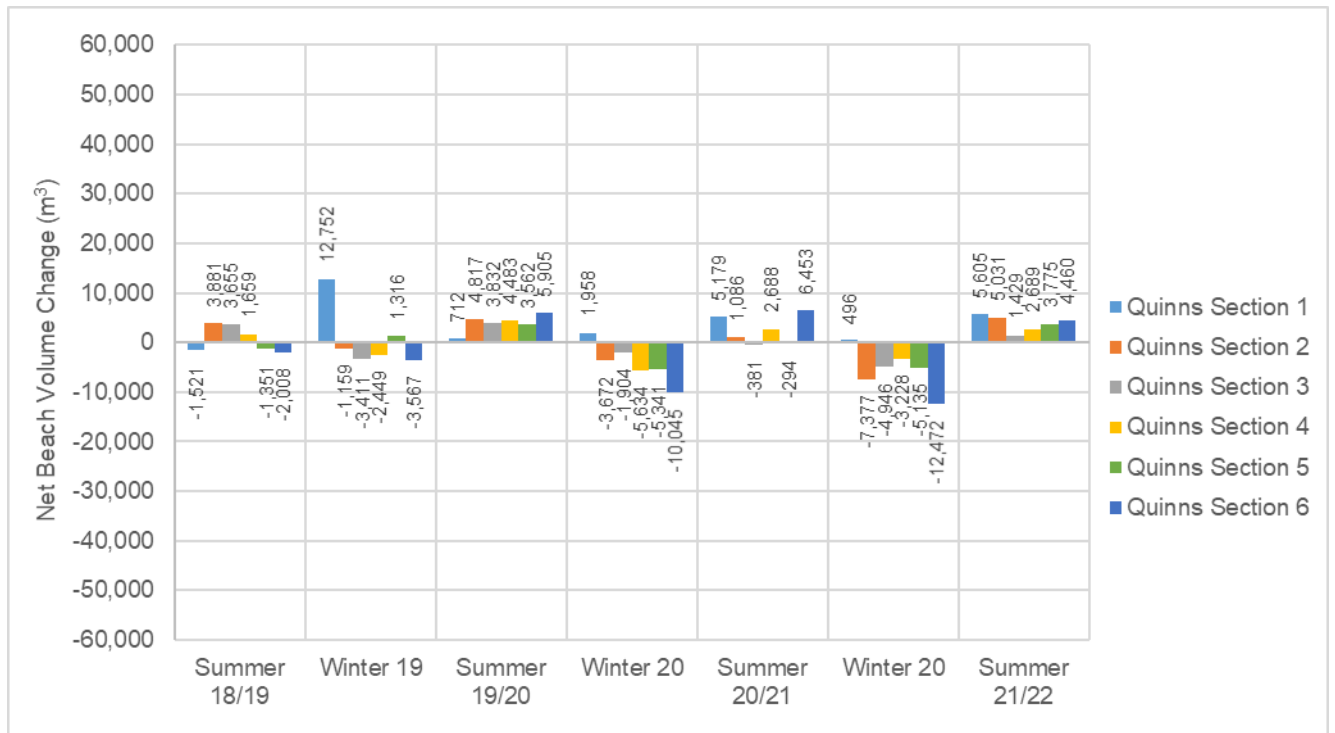


Figure 5-3 Seasonal net beach volume changes for Quinns Section 1, 2, 3, 4, 5 and 6.

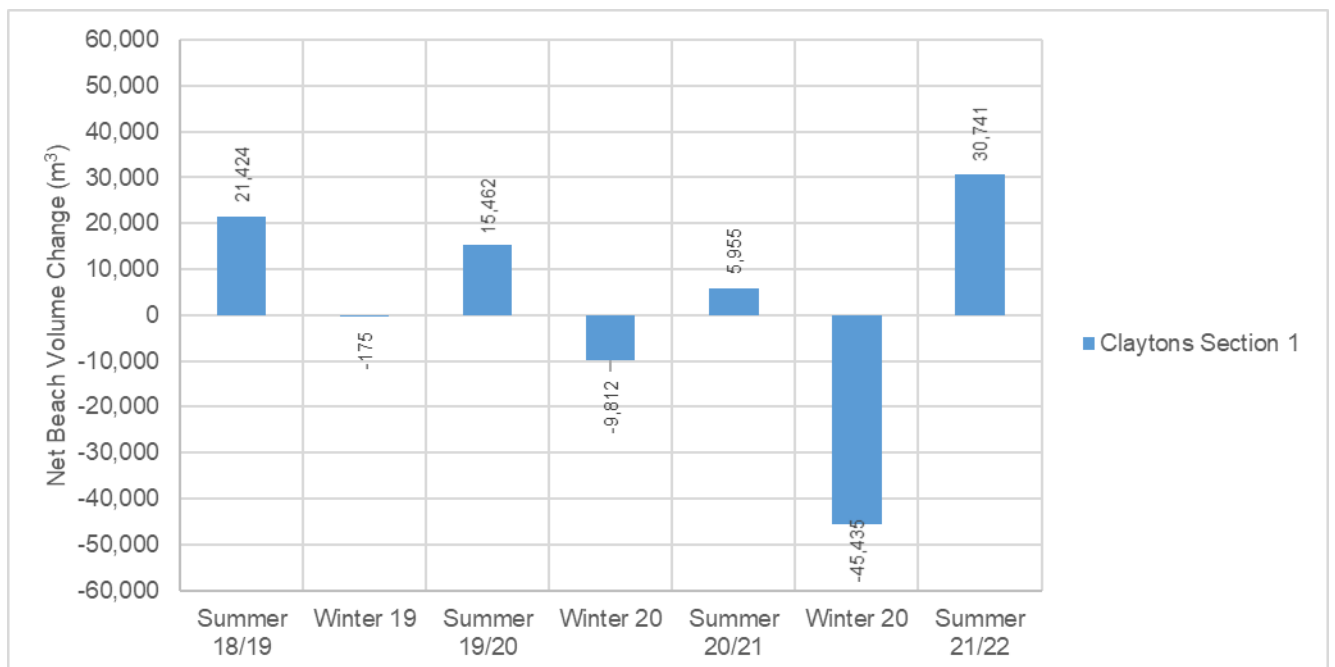


Figure 5-4 Seasonal net beach volume changes for Claytons Section 1.

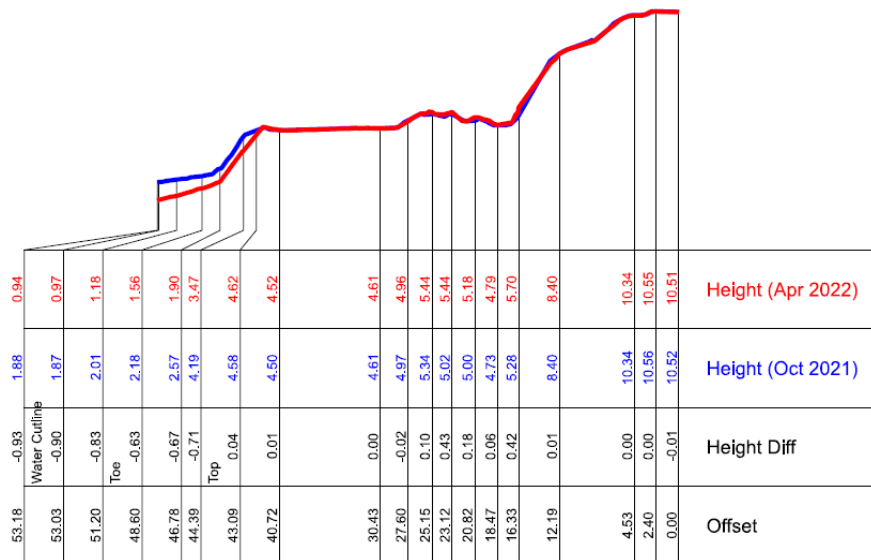
Most areas present clear seasonal trends, often with a net beach volume loss recorded after the winter months and a net beach volume gain after the summer months. The seasonal net beach volume change plots also show that 11 out of the 13 beach sections assessed as part of the Coastal Monitoring Program display a negative trend in net beach volume change, that is, it appears as though beach volumes are decreasing overall. The most significant negative trend in net beach

volume was recorded at Claytons Beach in Mindarie which has seen a decrease in beach volume since 2018. It is recommended that Claytons Beach be closely monitored in future coastal monitoring reports to assess the long term changes in net beach volume. If net beach volume continues to decline rapidly at Claytons Beach, coastal management methods may need to be investigated and implemented.

5.3 Beach Cross Section Results

Beach cross sections of areas that were identified as having experienced major erosion in the manual imagery analysis (**Section 4.2.1**) were analysed to assess the extent of erosion experienced in these areas. The results are presented below.

5.3.1 Quinns Rocks B07 Up-Coast – Major Erosion, Summer 2021/22



Section 16 [E38103.88, N294544.73 to E38051.03, N294538.88]

Figure 5-5 Quinns cross section 16 elevation comparison between April 2022 and October 2021 surveys.

Quinns Rocks beach cross-section 16 is situated within the field of view of manual imagery point 'Quinns Rocks B04 Up-Coast'. There is minimal elevation difference apparent between the April 2022 and October 2021 surveys aside from just prior to the water line where there was maximum reduction in elevation of 0.93m between the surveys. In this instance it is difficult to assess the total reduction in elevation as the assessment is limited to the 'safe wading depth' past the waterline. However, the cross-section indicates that erosion did occur over the summer period seaward of the dune toe which is consistent with manual imagery observations.

5.3.2 Quinns Rocks B13 Up-Coast – Major Erosion, Summer 2020/21

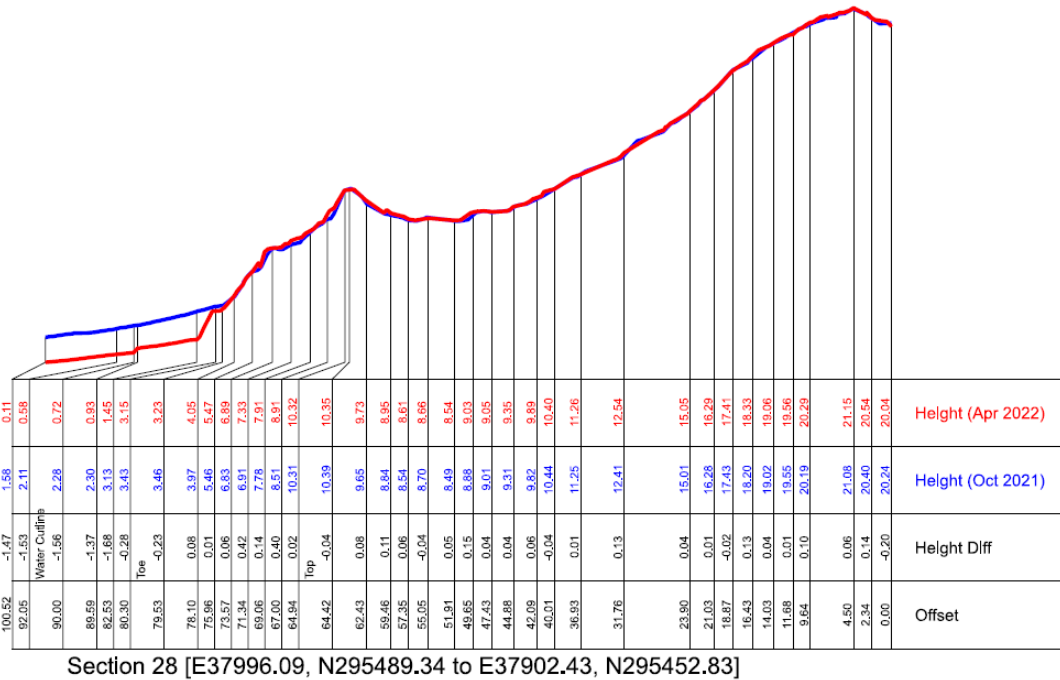
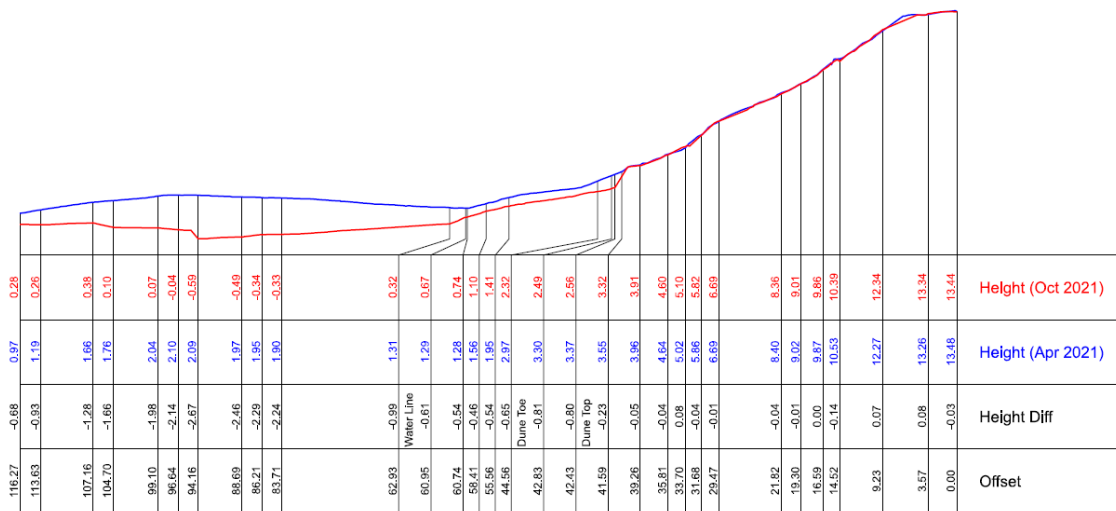


Figure 5-6 Quinns beach cross section 28 elevation comparison between October 2021 and April 2022 surveys.

Quinns beach cross-section 29 is situated within the field of view of manual imagery point 'Quinns Rocks B13 Up-Coast'. Figure 4-6 shows a significant reduction in elevation (1.68m) between the October 2021 and April 2022 surveys which is consistent with the major seasonal summer erosion that was identified at the site through manual imagery analysis (**Section 4.2.1**). Significant seasonal summer erosion is common at this site as strong sea breeze conditions promote the northward transport of sediment, away from Quinns Groyne 3.

5.3.3 Yanchep B07 Up-Coast and Down-Coast – Major Erosion, Winter 2021

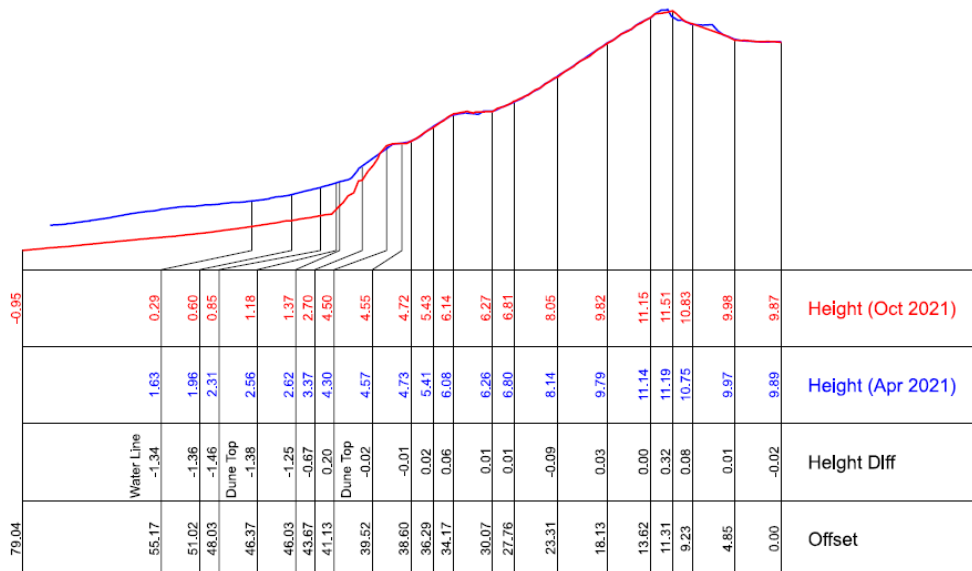


Section 21 [E32020.00, N307577.30 to E31914.25, N307528.96]

Figure 5-7 Yanchep Beach cross section 21 elevation comparison between April 2021 and October 2021 surveys.

Yanchep Beach cross section 21 is situated within the field of view of manual imagery point ‘Yanchep B07 Up-Coast’ where significant erosion was observed between April and October 2021 in manual imagery. While levels above the water line show only a minor drop in elevation, levels below the water line show quite a significant reduction in elevation, with the maximum height difference between the April and October 2021 survey was 2.67m. These results outline the benefits of undertaking additional ground based nearshore survey transects as without the nearshore transects we would only see the elevation difference above the waterline which is minimal in comparison to the elevation difference below the waterline. The significant drop in elevation below the waterline suggests significant erosion in area over winter 2021 which is consistent with manual imagery observations.

5.3.4 Quinns B06 Down-Coast – Major Erosion Winter 2021

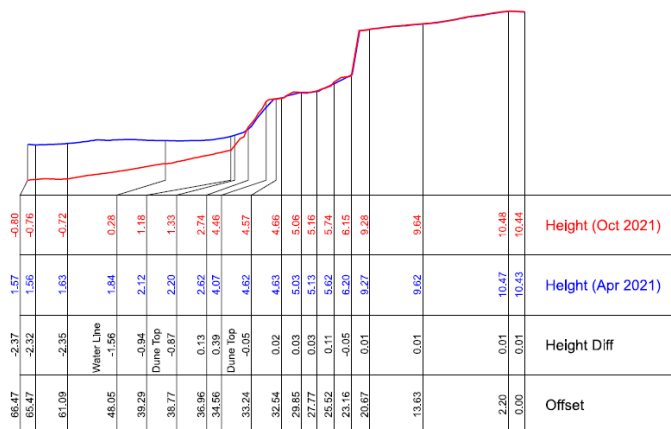


Section 13 [E38125.29, N294290.91 to E38046.74, N294282.21]

Figure 5-8 Quinns Beach cross section 13 elevation comparison between April 2021 and October 2021 surveys.

Quinns Beach cross section 13 is situated within the field of view of manual monitoring point 'Quinns B06 Down-Coast'. The elevation difference presented in Figure 5-8 shows quite significant erosion at the site over the winter period, between April and October 2021, which is consistent with manual imagery observations. The most significant drop in elevation (1.46m) was just below the toe of the GSC Revetment. Significant seasonal erosion is common in this area, as sediment builds up southward of Quinns Groyne 1 in the summer months and erodes away in the winter months as sand moves southward.

5.3.5 Quinns B07 Down-Coast and B06 Up-Coast – Major Erosion Winter 2021



Section 14 [E38116.88, N294390.59 to E38050.81, N294383.28]

Figure 5-9 Quinns Beach cross section 14 elevation comparison between April 2021 and October 2021 surveys.

Quinns Beach cross section 14 is situated within the field of view of both Quinns manual imagery sites 'B07 Down-Coast' and 'B06 Up-Coast'. The cross section shows a significant drop in elevation between April and October 2021, where the maximum recorded elevation difference was 2.37m. Similarly to Yanchep cross-section 21, the highest elevation differences were recorded below the water line. These differences would not have been recorded without nearshore ground based transect surveys which allow us to determine the broader extent of erosion at the site. The significant elevation difference recorded between April and October 2021 is consistent with the major erosion that was observed at site in manual imagery (**Section 4.2.1**).

5.3.6 Mindarie B01, B02 Up-Coast & B03 - Major Erosion Winter 2021

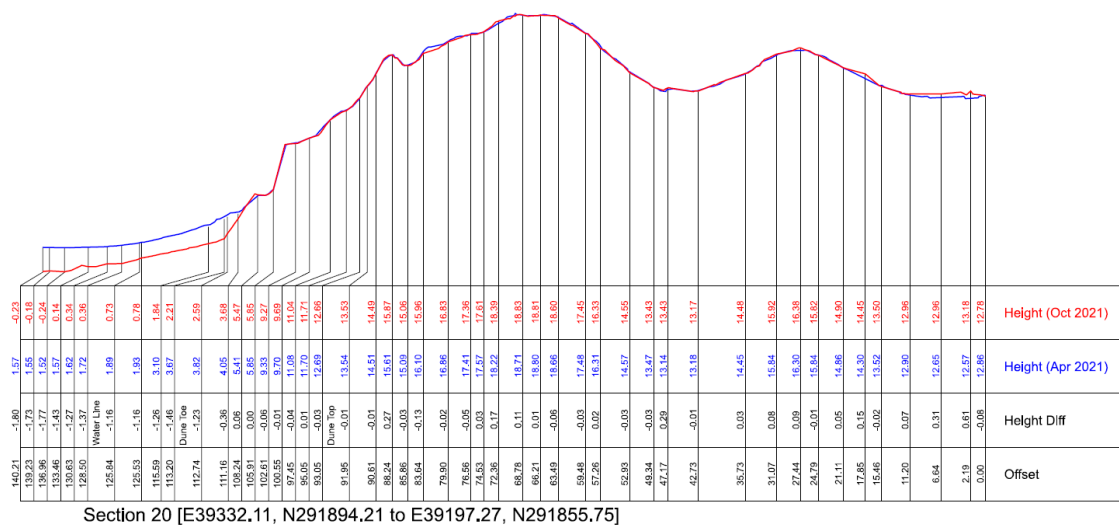


Figure 5-10 Mindarie cross section 20 elevation comparison between April 2021 and October 2021 surveys.

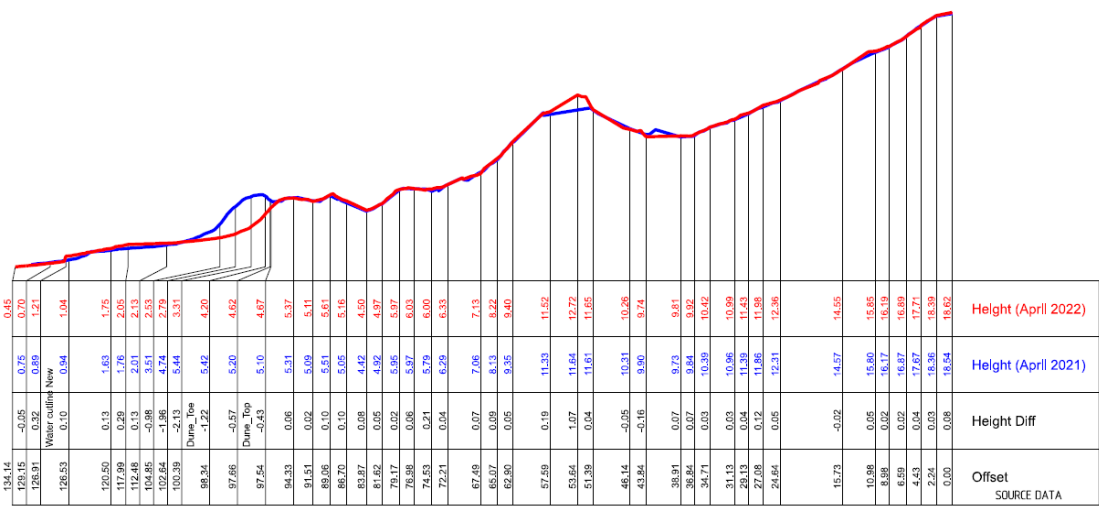
Mindarie cross section 20 is situated within the field of view of Mindarie manual imagery sites 'B01', 'B02 Up-Coast' and 'B03'. The elevation difference between April 2021 and October 2021 shows significant erosion at the site which is consistent with the manual imagery observations outlined in **Section 4.2.1**. Additional to Quinns Beach cross section 14 and Yanchep Beach cross section 21, the most significant elevation difference (-1.80m) was recorded below the water level, demonstrating the importance of nearshore ground based transects for assessing the extent of erosion at the site.

5.3.7 Additional Transects with Significant Elevation Difference

A number of transects, additional to those identified through manual imagery, were identified as having significant elevation difference (greater than 2.0m) between surveys. These areas were not identified in the manual imagery campaign but represent areas of major erosion and are important to identify as part of the coastal monitoring program. Most areas identified are not within the field of view of manual imagery sites and were therefore unable to be assessed as part of the manual imagery assessment. This outlines the importance of utilising different data sets when undertaking coastal monitoring, while some areas of major erosion can be missed in some data sets, they can often be captured within other datasets.

5.3.7.1 Mindarie

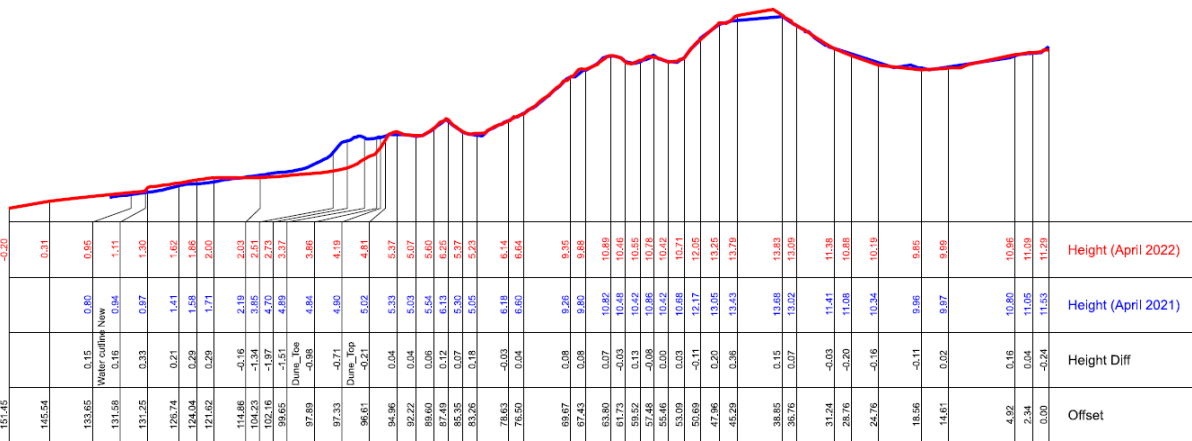
The elevation cross section comparisons between the April 2021 survey and the April 2022 survey along Claytons Beach in Mindarie show a significant recession of the fore dune between the two surveys. Figure 5-11, Figure 5-12 and Figure 5-13 below show a recession of up to 4m in some areas along Claytons Beach.



Section 8 [E39609.72, N290809.39 to E39475.81, N290801.57]

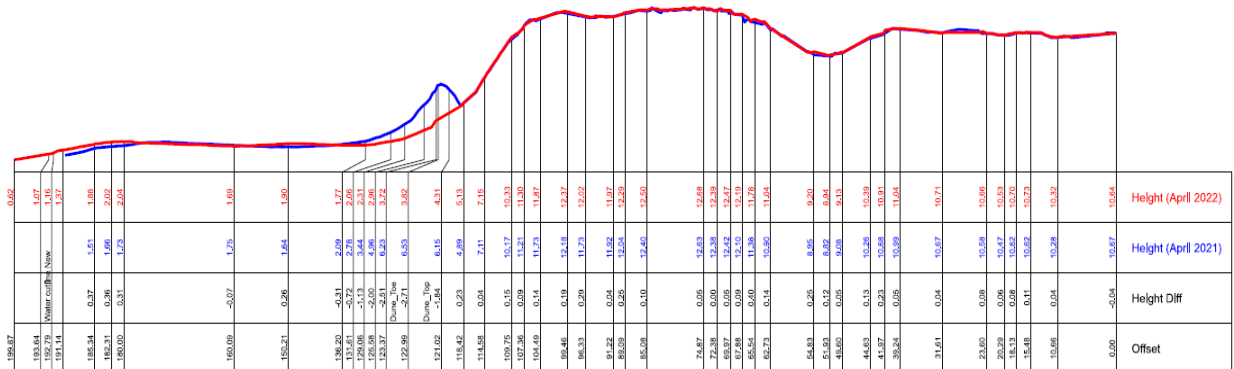
AERIAL PHOTOGRAPHY

Figure 5-11 Mindarie cross section annual comparison shows a major recession of the dune along Claytons Beach between April 2021 and April 2022.



Section 9 [E39599.41, N290908.96 to E39448.22, N290900.13]

Figure 5-12 Mindarie cross section annual comparison shows a major recession of the dune along Claytons Beach between April 2021 and April 2022.



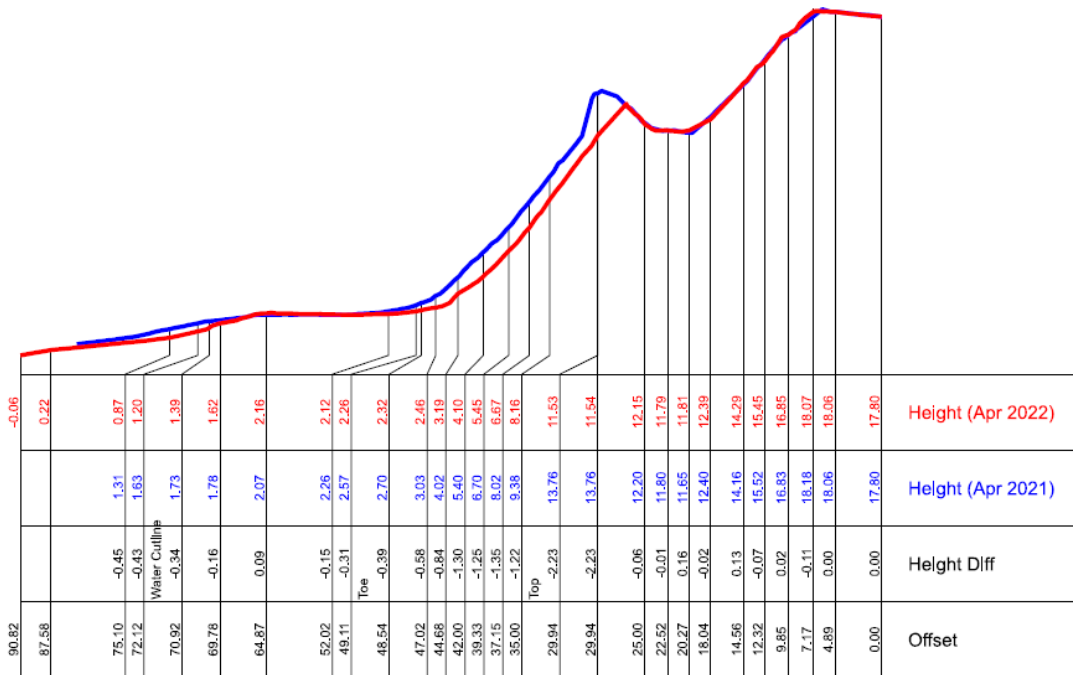
Section 18 [E39404.51, N291706.89 to E39212.32, N291652.06]

Figure 5-13 Mindarie cross section annual comparison shows a major recession of the dune along Claytons Beach between April 2021 and April 2022.

5.3.7.2 Quinns

Results from the cross section comparisons show major erosion between April 2021 and April 2022 at an additional two sites along Quinns Beach that were not identified through manual imagery. These sites, and the corresponding manual imagery site, are outlined below.

Cross Section 32 – Manual Imagery Site B14 Down-Coast



Section 32 [E37837.70, N295882.31 to E37753.08, N295849.32]

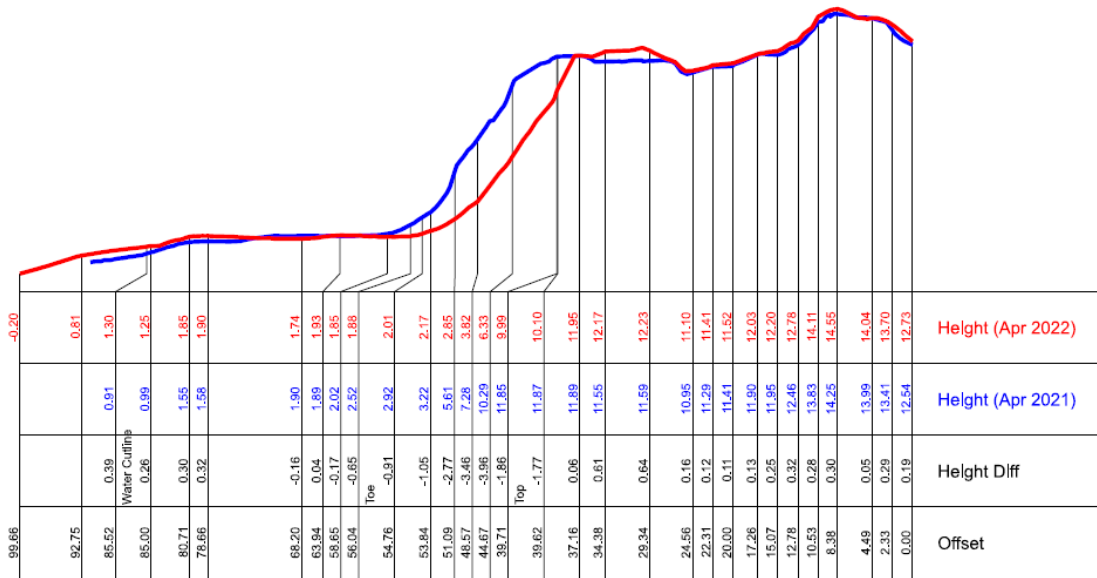
Figure 5-14 Cross section 32 at Quinns Beach which shows dune recession of 3m between April 2022 and April 2021.



Figure 5-15 Manual images taken at Quinns B14 Down-Coast.

The cross section presented in Figure 5-14 shows a significant recession of the dune face between the April 2021 survey and the April 2022 survey. This was not identified in manual imagery (Figure 5-15) as the dune face is not a main focus of the manual imagery field of view and recession in the dune face is difficult to interpret using manual imagery alone.

Cross Section 53 – No Manual Imagery Site

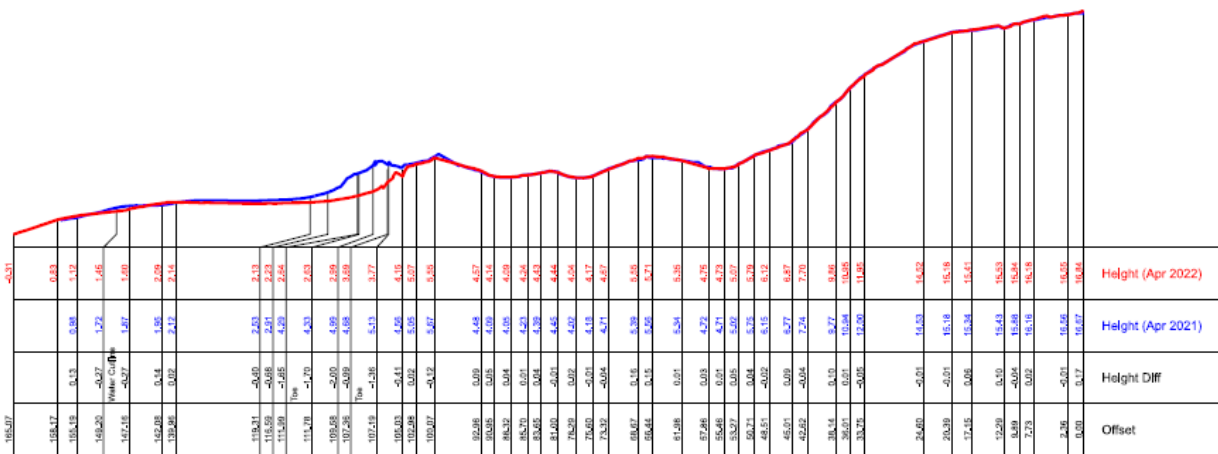


Section 53 [E37229.95, N297359.72 to E37139.95, N297316.92]

Figure 5-16 Cross section 53 at Quinns Beach which shows an elevation difference of 3.96m at the top of the dune between April 2022 and April 2021 which translates to a recession of approximately 4m of the dune.

Cross section 53 at Quinns Beach is situated to the north of Jindalee, where there are no manual imagery monitoring sites. The results of the elevation comparisons between the April 2021 surveys and the April 2022 surveys show that there was an approximate 4m recession of the dune between the two dates. This is an indication of major erosion in the area and surveys of the site should continue to be monitored moving forward.

5.3.7.3 Yanchep



Section 39 [E31253.91, N308866.12 to E31124.15, N308864.09]

Figure 5-17 Additional Yanchep cross sections that experienced major erosion between April 2021 and October 2021 surveys.

The results from cross section 39 along Yanchep Beach show a dune recession of approximately 7m in the area to the south of the Capricorn Groyne. While the field of view of manual imagery site B13 Down-Coast captures a part of this area it does not provide a suitable view of the dune for the identification of dune recession.

6 Remote Monitoring

Five remote monitoring cameras were installed along Quinns and Yanchep Beach in November 2021. The location and field of view of the cameras was selected to monitor vulnerable sections of the City's coastline, these locations are presented below in Figure 6-1 and Figure 6-2. The remote monitoring cameras take photos hourly between 7:00am and 6:00pm. Timelapse videos were created for each camera to assess morphological changes to the coastline between November 2021 and the beginning of April 2022.



Figure 6-1

Quinns Rocks Remote Coastal Monitoring Camera Locations.

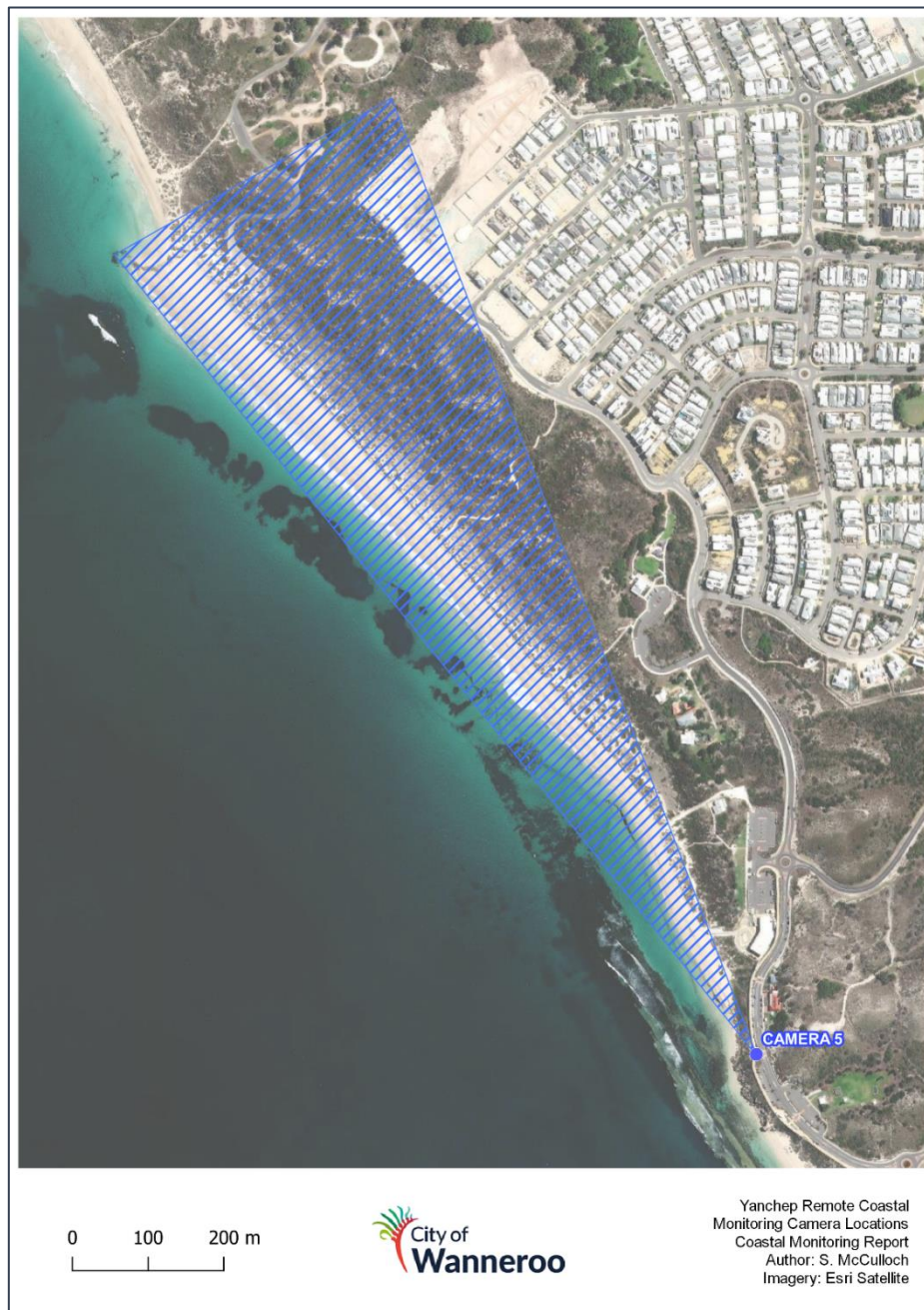


Figure 6-2

Yanchep Remote Coastal Monitoring Location.

6.1 Quinns Camera 1

Quinns Camera 1 captures the beach immediately to the south of Groyne 1, adjacent to the GSC Revetment. The time series of images taken from Quinns Camera 1 between November 2021 and April 2022 show the beach accreting up until the beginning of February 2022. After February the beach begins to erode and continues to erode until the end of the dataset in April 2022. Significant seasonal erosion is experienced at this site each year and it is expected that beach will continue to erode well into the winter months. This will be further assessed once additional data is captured.

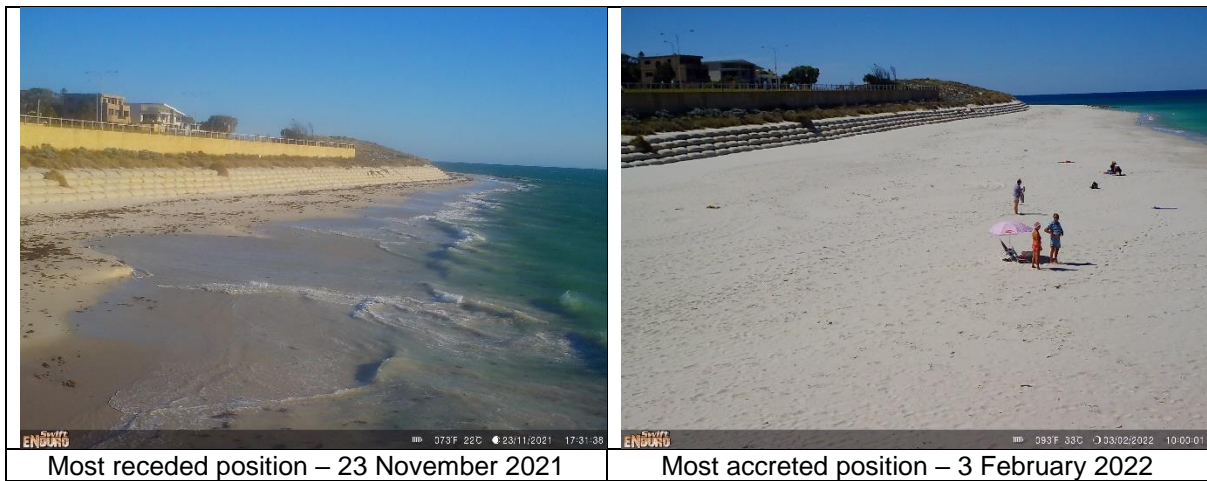


Figure 6-3 Most receded position – 23 November 2021 Most accreted position – 3 February 2022
Most receded and most accreted shoreline position to the south of Quinns Groyne 1 during the study period.

6.2 Quinns Camera 2

Quinns Camera 2 captures the beach immediately north of Groyne 1, adjacent to the Frederick Stubbs Carpark. Hourly images from the camera show the beach eroding significantly over November 2021 through to January at which point the beach begins accreting up until the end of the study period in April 2022. Accretion of the beach in the summer period is not expected, as prevailing southerly winds generally transport sand north where it is deposited to the south of the Groyne 2 however it is believed that the significant build up to the south of Groyne 1 has resulted in bypassing of sand around the Groyne and onto the beach, adjacent to the carpark.



Figure 6-4 Most receded position – 5 December 2021 Most accreted position – 14 April 2022
Most receded and most accreted shoreline position to the north of Quinns Groyne 1 during the study period.

6.3 Quinns Camera 3

Quinns Camera 3 monitors the beach and dunes to the south of Quinns Groyne 4. The timelapse video of the hourly images that was created shows slow accretion of the beach area up until early February where the beach begins to erode. The most receded shoreline position can be seen in the

image taken towards the end of the monitoring period in April 2022. It is important to note that these images were only taken two months apart and represent a significant change in beach condition over a short time period.



Figure 6-5

Most receded and most accreted shoreline position to the south of Quinns Groyne 4 during the study period.

6.4 Quinns Camera 4

The area to the north of Quinns Groyne 4, along the Quinns Dog Beach, continuously eroded throughout the study period. The beach was at its most accreted position at the beginning of the study period in November 2021 and its most eroded position towards the end of study period, in March 2022. Seasonal erosion over the summer period is expected in this area as prevailing southerly winds generally transport sand to the north, away from the Groyne. The significant seasonal summer erosion leaves the beach, and adjacent dune areas, vulnerable to the impacts of winter storms however over the winter months it is expected that the beach will build up as a result of southerly longshore transport.



Figure 6-6

Most receded and most accreted shoreline position to the north of Quinns Groyne 4 during the study period.

6.5 Yanchep Camera

The Yanchep Lagoon beach area that is monitored by Camera 5 experienced erosion over the study period, with the most receded beach position at the site identified toward the end of the study period, in March 2022. Again, seasonal erosion over the summer period is expected in this area as prevailing southerly winds generally transport sand to the north, away from the limestone outcrop to the south of the Lagoon.



Figure 6-7

Most receded and most accreted shoreline position at Yanchep Lagoon Beach.

7 Aerial Imagery

Aerial imagery obtained from Nearmap and taken during the 6 monthly LiDAR Surveys is used to assess changes of the CoW coastline.

The improved temporal resolution of aerial imagery allows us to assess the condition of the coastline throughout the year, unlike manual imagery where we are limited to only two snapshots in time. There is, however, much less detail in aerial imagery.

During the study period, from April 2021 to April 2022, a total of ten aerial images of the sites were available. The temporal resolution of the images equates to an average of 1.2 months with images taken on the following dates

Table 7-1 Date of Aerial Images

Monitoring Date	Monitoring Time	Source	Water Level at Time of Monitoring (Fremantle Tide Gauge – mAHD)
10 April 2021	10:30 AM to 02:30 PM	MNG	0.13 to 0.27 mAHD
25 April 2021	09:54 AM	Nearmap	0.30 mAHD
14 August 2021	10:57 AM	Nearmap	0.01 mAHD
22 October 2021	09:59 AM to 12:27 PM	MNG	-0.07 to 0.07 mAHD
13 November 2021	8:16 AM	Nearmap	0.04 mAHD
19 December 2021	3:00 PM	Nearmap	0.06 mAHD
2 January 2022	8:43 AM	Nearmap	-0.28 mAHD
29 January 2022	8:51 AM	Nearmap	-0.13 mAHD
4 April 2022	12:29 PM to 16:01 PM	MNG	0.12 to 0.47 mAHD
15 April 2022	9:53 AM	Nearmap	0.17 mAHD

7.1 Assessment Methodology

Similar to the analysis of remote imagery, aerial and satellite imagery is assessed through visual assessment.

Visual assessment allows for the identification of major erosion or accretion periods and is used to determine the most advanced and receded shoreline position during the observation period. Visual assessment also allows for the identification of additional vulnerable coastline areas that may require more detailed assessment into the future. Images obtained throughout the observation period are all loaded into QGIS software, georeferenced and assessed individually.

7.2 Results

For assessment purposes the coastline has been divided into fourteen discrete areas of coastline as depicted in Table 7-2. The most advanced and most receded shoreline position was identified for each of the discrete areas.

Table 7-2 Most advanced and receded shoreline positions as identified through aerial imagery review.

Area	Most Receded Shoreline Position	Most Advanced Shoreline Position
Claytons Beach	14 August 2021	15 April 2022
Quinns Main Beach	14 August 2021	13 November 2021
Quinns – GSC Revetment	14 August 2021	15 April 2022
Quinns – Groyne 1 to Groyne 2	29 January 2022	22 October 2021
Quinns – Groyne 2 to Groyne 3	14 August 2021	13 November 2021
Quinns – Groyne 3 to Groyne 4	14 August 2021	13 November 2021
Jindalee	25 April 2021	13 November 2021
Eden Beach	25 April 2021	13 November 2021
Shorehaven	15 April 2022	13 November 2021
Eglinton Beach	14 August 2021	13 November 2021
South Yanchep	14 August 2021	15 April 2022
North Yanchep	14 August 2021	13 November 2021
South of Two Rocks Marina	14 August 2021	10 April 2021
North of Two Rocks Marina	15 April 2022	2 January 2022

A number of areas experienced the most receded shoreline position in August 2021. This can likely be attributed to the series of storms that occurred in late July and early August 2021 that resulted in significant erosion along the City's coastline and damaged a number of the City's coastal assets. Additional details on the attributes and effects of these storms are in **Section 2**. Most areas that experienced significant erosion in August 2021 had an already receded shoreline which was exacerbated by the July/August storms that occurred in quick succession leaving little time for the beaches to recover between storm events.

There were also two areas that experienced the most receded shoreline position on the 25th of April 2021. While it is likely that the shoreline was the most receded at Jindalee and Eden Beach at this time it is important to note that the water level at the time of the imagery was significantly higher than the time of other imagery and this is likely to have affected the assessment. It is also important to note that while the imagery can present the shoreline at its most receded position it does not necessarily mean that the coastline is at its most 'eroded position' for the year.

Some areas experienced the most receded and advanced shoreline positions outside of the survey periods (April and October). This indicates that while seasonal assessment of beach volume changes as detailed in **Section 5.2.1** are indicative, they do not necessarily capture the total seasonal beach volume change of each area. Further assessment of satellite, aerial and remote imagery allows for the identification of the most appropriate time for surveys to capture the most accurate seasonal changes in beach volumes. However, what is most appropriate for some areas will not necessarily be most appropriate for other areas of the coast. It is most likely that these results will simply allow us to assess whether the volume changes calculated are accurate or are an underestimation of the actual seasonal volume changes.

8 Results and Recommendations

8.1 Seasonal Changes

Areas that experienced major seasonal erosion were identified via manual imagery and the analysis of beach cross-sections. These areas are as follows.

- 1. Fisherman's Hollow Beach:** Fisherman's Hollow Beach, south of Yanchep Lagoon, experienced major erosion between April 2021 and October 2021, below the waterline a maximum elevation difference of 2.67m was recorded at cross section 21. While the dunes appear to be in good condition, residential houses and road infrastructure are in close proximity to the site and could, in future, be susceptible to the effects of coastal erosion. There is however, significant seasonal accretion each year at this site and long-term manual imagery results show only minor erosion at the site. It is recommended that this area is closely monitored moving forward.
- 2. Quinns Beach North of Groyne 3:** A significant reduction in beach width and major erosion scarp was noted at Quinns Dog Beach immediately north of Groyne 3 in the April 2022 manual images. There was little remaining beach protecting the dunes from further erosion and a notable erosion scarp resulted in issues in beach accessibility. Beach cross-section analysis noted a drop in elevation of 1.68 m just landward of the water line at this location. However, renourishment was undertaken at this location in late April 2022, after monitoring, in response to the eroded beach conditions which improved beach usability at the site and provided a buffer for erosion that resulted from the subsequent winter storms.
- 3. Quinns Beach North of Groyne 1:** Manual imagery results show significant erosion of the beach area to the north of Quinns Groyne 1, adjacent to the Frederick Stubbs Carpark, over the 2021/22 summer period. Significant erosion in this area over the summer period is common with planned renourishment occurring at this site each year to improve beach accessibility and protect coastal infrastructure. While manual imagery results show significant erosion at the site, survey cross sections only show a reduction in elevation of 0.93 just landward of the waterline.
- 4. Quinns Beach GSC Revetment South of Groyne 1:** A major reduction in beach width over winter 2021 was noted in the manual imagery review of the beach immediately south of Quinns Groyne 1. There was very little remaining beach in October 2021 and there was wave impact to the GSC revetment over winter causing some damage to the structure. Similar to the beach in front of Frederick Stubbs Carpark, this is an area that is known to experience significant erosion annually and has caused major maintenance issues in the past. The GSC Revetment was constructed in 2014 and despite the minor damage sustained from the 2021 storm event, the structure works effectively in protecting adjacent coastal infrastructure.
- 5. Claytons Beach, Mindarie:** Major erosion over the winter 2021 period was apparent at Claytons Beach in Mindarie from both manual imagery and survey results. Of the 21 beach survey transects taken along Claytons Beach, 15 transects showed a significant drop in elevation between the April 2021 and October 2021 surveys which is consistent with major erosion in the area. Additionally, results from each of the Mindarie manual photographic monitoring sites show major erosion over the winter 2021 period. These observations are supported by the results of the elevation difference plot for the area which outlined a major net beach volume loss of 45,435 m³ over the winter period.

8.2 Annual Change

Changes in beach volumes between April 2021 and April 2022 were assessed via LiDAR survey elevation difference plots, volume change calculations and cross section transect comparisons undertaken by MNG. Overall, volume change calculations show a significant net reduction in beach volume across the coastline between April 2021 and April 2022. The most notable areas of beach volume loss include Yanchep and Quinns. Despite the April and October 2021 renourishment activities, Quinns Sections 3, 5 and 6 still saw a total reduction of 13,195 m³ in beach volume and Yanchep Lagoon still experienced a total reduction of 1,500 m³ in beach volume. This points to the importance of beach renourishment in this area, without it we would see a significantly larger reduction in beach volume which would cause significant impact to coastal assets and limit the accessibility and usability of the beach.

Survey cross section results outline additional areas that experienced significant erosion between April 2022 and April 2021. The survey results from Jindalee Beach, to the north of Wardaanup Park, show a 4m recession of the dune toe between the April 2021 and the April 2022 surveys. This area is not monitored through manual imagery as there are challenges with accessibility of the site. Additionally, the survey results from the dog beach to the south of Groyne 4 show a 3m recession of the dune toe between the April 2021 and the April 2022 surveys. This was not identified in the manual imagery (site Quinns B14 Down-Coast) as the dune face is not the main focus of the image and recession in the dune face is difficult to interpret using manual imagery alone. This highlights the importance of utilising multiple data sets when undertaking coastal monitoring.

8.3 Long-term Changes

Long-term changes to the shoreline were assessed via manual imagery where, in Quinns Rocks and Two Rocks, April 2022 images were compared to images taken at the same location at the same time of the year but were taken as late as 2014, allowing for an assessment of long-term changes of the coastline from up to seven years prior. At Yanchep, the earliest recorded monitoring images were taken in October 2018 and therefore the long-term changes of the coastline can only be assessed from up to three years prior.

One site in Quinns Rocks was identified through manual imagery as having experienced major long-term erosion. The site is situated immediately north of Quinns Groyne 3 along Quinns Dog Beach. Despite the significant nourishment that has been undertaken at the site since 2004 (~80,000 m³), a narrow beach is evident in the image taken in April 2022 with notable impact to the base of the dunes.

No other areas were found to have experienced major erosion over the long-term period. Of all 50 manual imagery sites, 32 sites appeared to experience minor erosion, 11 appeared to experience accretion and the beach condition in the 6 remaining areas appeared to remain largely unchanged.

8.4 Notable Erosion Events

A number of notable erosion events occurred during the study period between July and August 2021. The most notable of which was the storm that occurred on the 10th of August 2021 which resulted in significant erosion to most of the coastline including Claytons Beach, Quinns Dog Beach, Jindalee Beach, Amberton Beach, Yanchep Lagoon and Yanchep Dog Beach. The storm event also impacted a number of coastal infrastructure assets with damage to the Mindarie Breakwater, Frederick Stubbs GSC Revetment, Frederick Stubbs Carpark, Jindalee Staircase, Amberton Beach Access Ramp and Staircase, Fisherman's Hollow Twin Staircase Structure as well as minor damage to the Yanchep Lagoon Beach Access Way. Most areas that experienced significant erosion in August 2021 had an already receded shoreline which was exacerbated by the August storms that occurred in quick succession, leaving little time for the beaches to recover between storm events.

A review of aerial imagery showed that a number of areas experienced the most receded shoreline position in August 2021 which can likely be attributed to the series of storms that occurred in late July and early August 2021.

8.5 Renourishment Activities

The location, date and quantity of renourishment activities along the coastline within the past 12 months is outlined in the table below.

Table 8-1 Renourishment locations and quantities within the study period.

Date	Renourishment Location	Renourishment Quantity
April 2021	Quinns Beach, adjacent to Frederick Stubbs Carpark	7,000 tonnes
April 2021	Quinns Beach, north of Groyne 3	2,000 tonnes
April 2021	Quinns Beach, north of Groyne 4	2,000 tonnes
October 2021	Yanchep Lagoon	2,800 tonnes
November 2021	Quinns Beach, adjacent to Frederick Stubbs Carpark	3,000 tonnes

An additional 8,000 tonnes of sand was used for renourishment just after the April 2022 monitoring period. 4,000 tonnes was placed at Quinns Beach, adjacent to Frederick Stubbs Carpark, at the end of April 2022 and an additional 4,000 tonnes was placed at Quinns Beach, north of Groyne 3, in May 2022.

8.6 Recommendations

8.6.1 Additional Survey Analysis

Long-term coastline changes are currently assessed via manual imagery alone. As LiDAR surveys have been undertaken since October 2018 it is recommended that beach volume changes and elevation difference plots are developed by MNG to assess longer-term beach volume changes once sufficient historical data is captured. This will allow for a quantitative assessment of long-term changes of the coastline which will help to inform future long term coastal management strategies.

8.6.2 Automatic Tracking of Shorelines

Five remote monitoring cameras were installed at Quinns and Yanchep in November 2021. Remote monitoring cameras allow for the continuous assessment of the coastline, particularly in problem areas. It is recommended that once 12 months of the data is collected, automatic shoreline tracking be used to analyse the data and incorporated into the next monitoring report. Automatic shoreline tracking can be used with imagery obtained from remote monitoring cameras to track the shoreline across the study period and estimate changes in beach volume.

8.6.3 Yanchep Study to Inform Coastal Management

It is recommended that, similar to the Quinns Beach Long-Term Coastal Management Study, a Yanchep Beach Long-Term Management Study be undertaken to inform the future long-term management practices for Yanchep Beach. Yanchep Beach, particularly Yanchep Lagoon, is one of the most popular beaches within the City and is subject to both seasonal and annual erosion. Sections of the Yanchep Coastline have also been identified as vulnerable coastal locations from the City's Coastal Hazard Risk Management and Adaptation Plan (CHRMAP). Additionally, Fisherman's Hollow Beach, just south of Yanchep Lagoon, experienced major erosion over the winter 2021 period and while the dunes appear to be in good condition, residential houses and road infrastructure are in close proximity to the site and could, in future, be susceptible to the effects of coastal erosion.

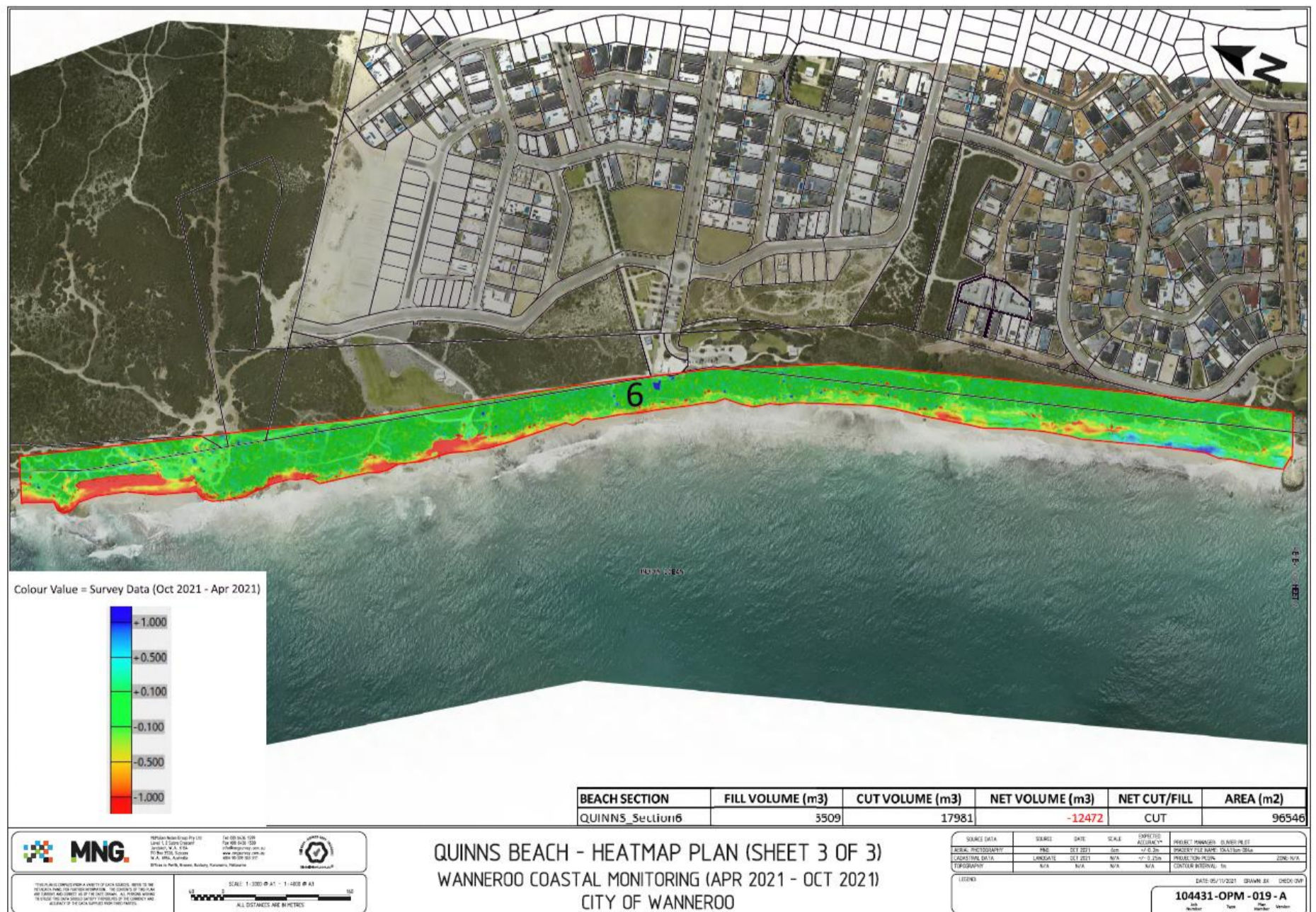
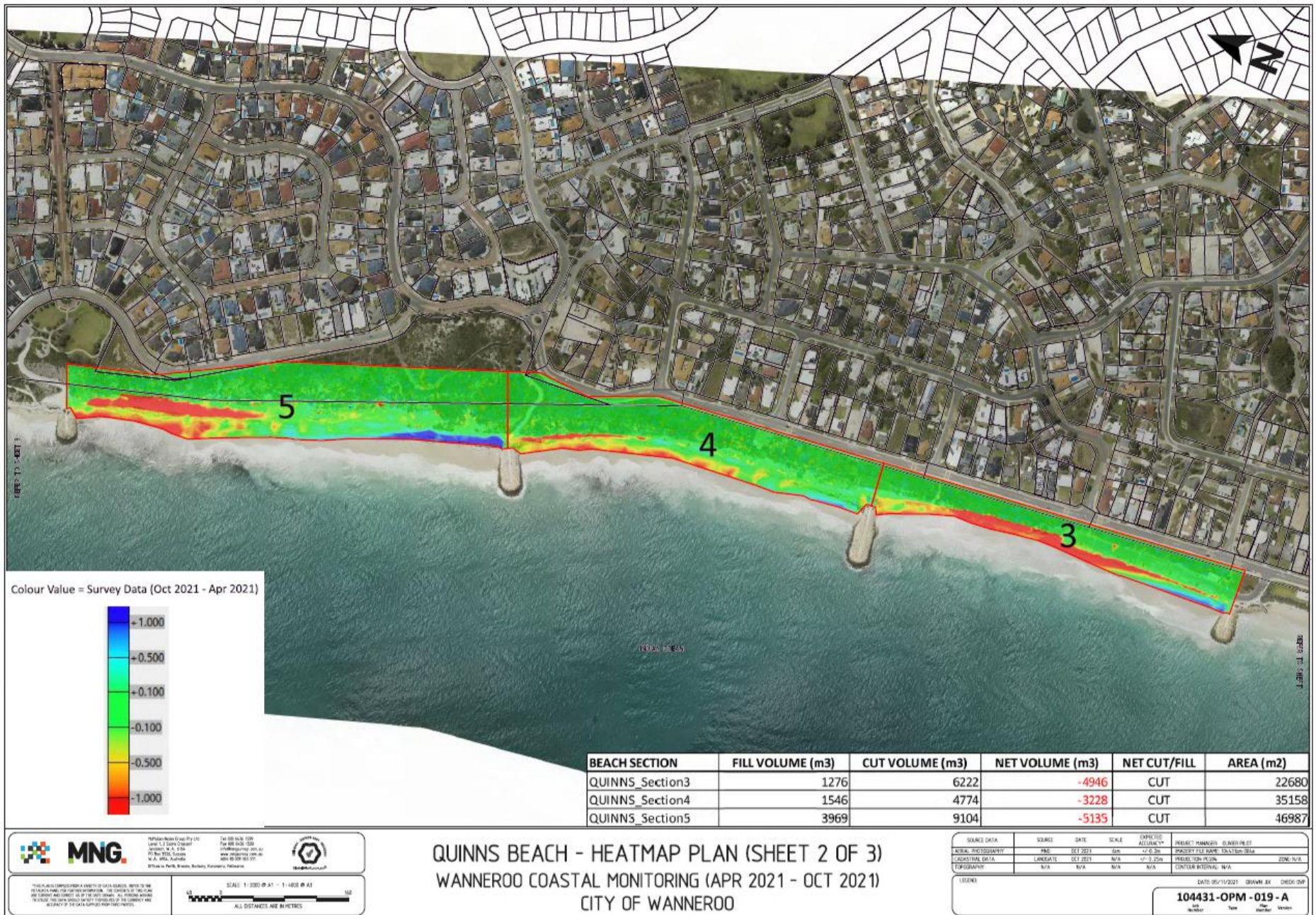
8.6.4 Continued Beach Renourishment

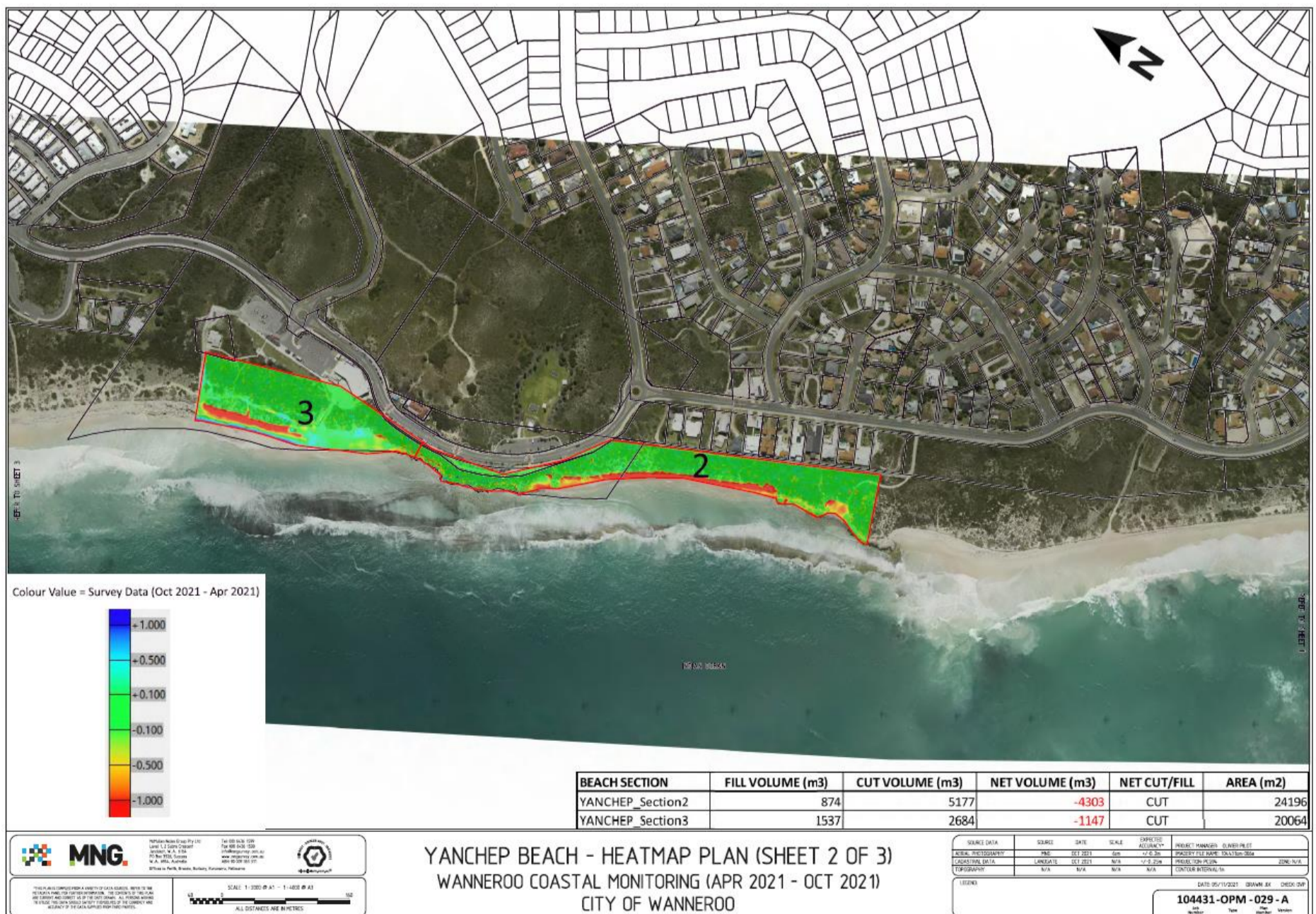
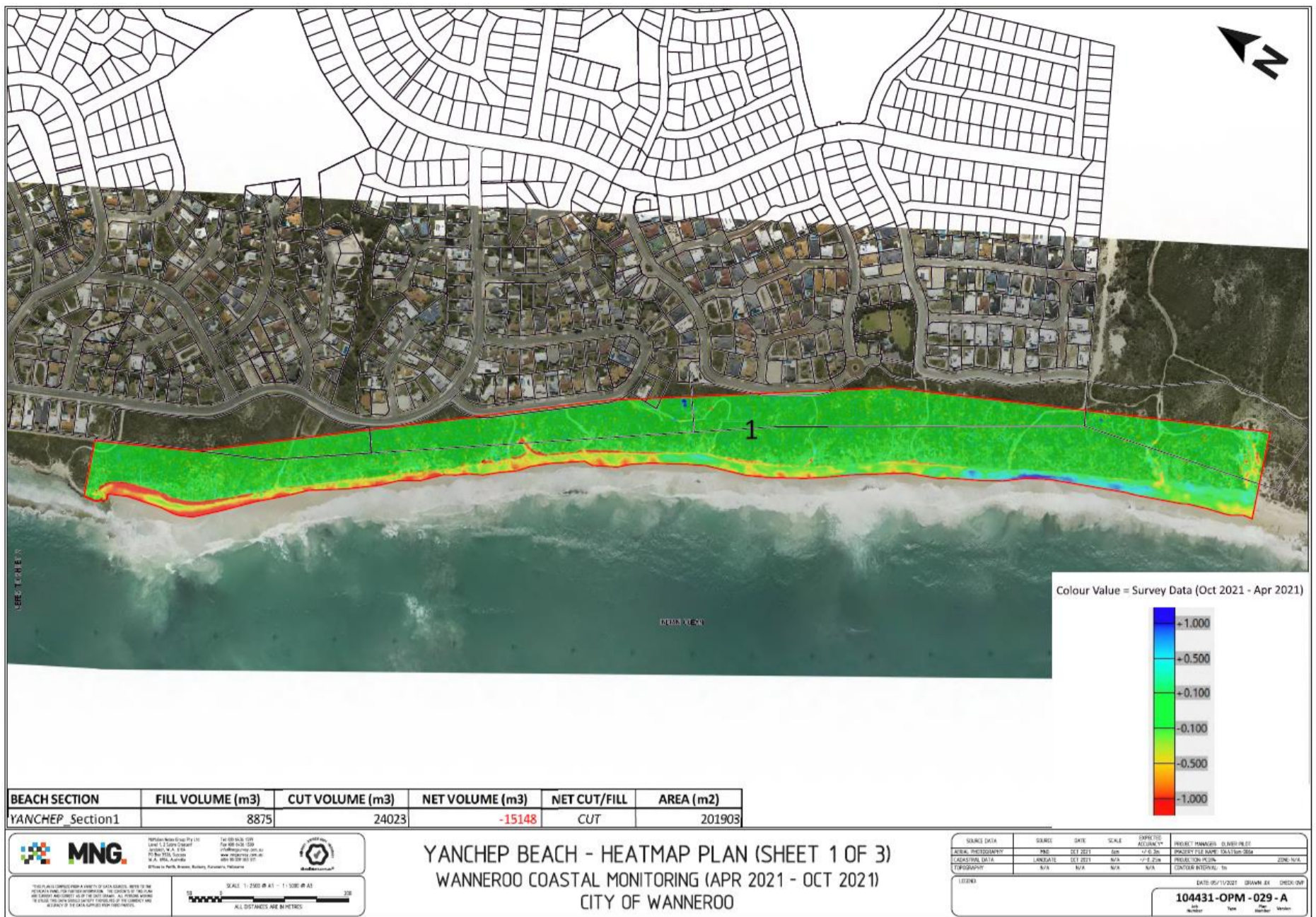
Beach volume changes between April 2022 and April 2021 show a significant reduction in beach volume over the year. It is recommended that beach renourishment continues to be undertaken in vulnerable areas to minimise the effects of erosion on coastal infrastructure. It is recommended that the results from this report be utilised to identify areas that require ongoing scheduled renourishment works.

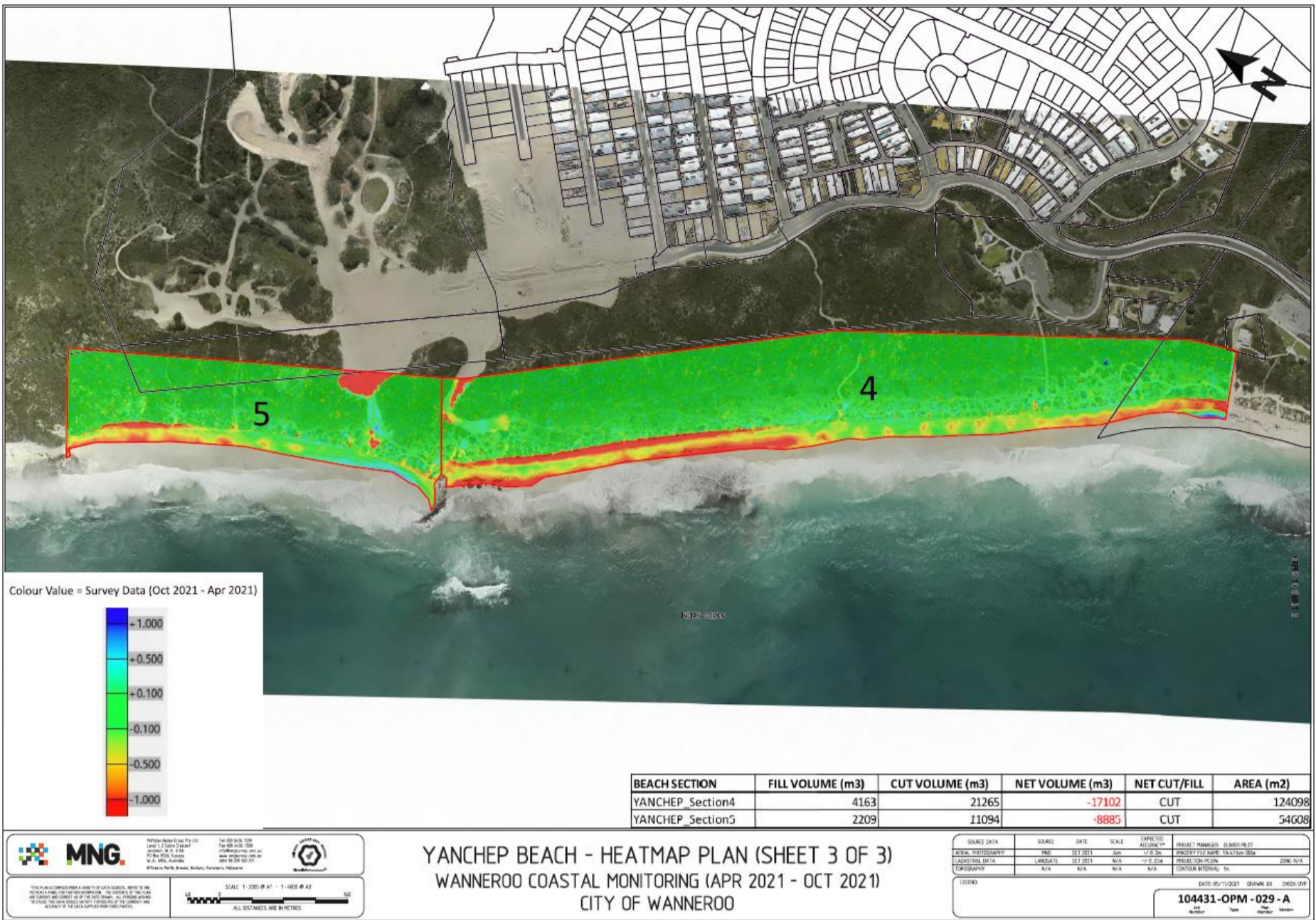
Appendix A – Elevation Difference Plots

Beach Volume Changes between April 2021 and October 2021

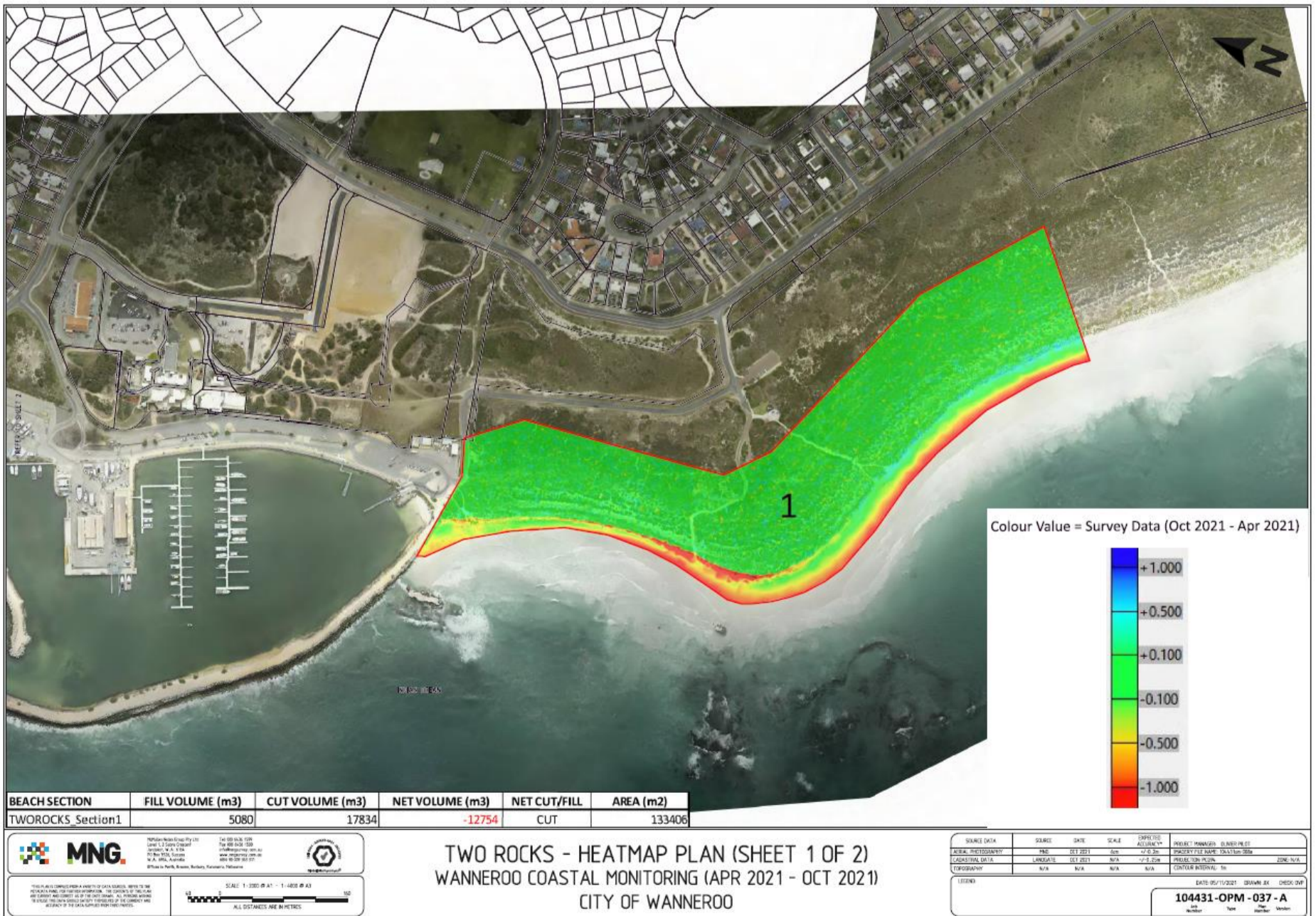




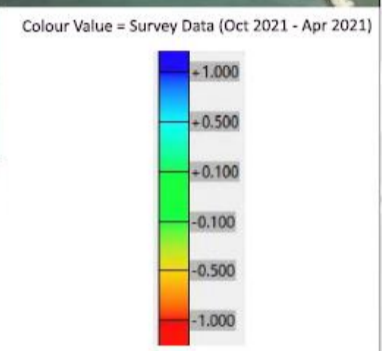
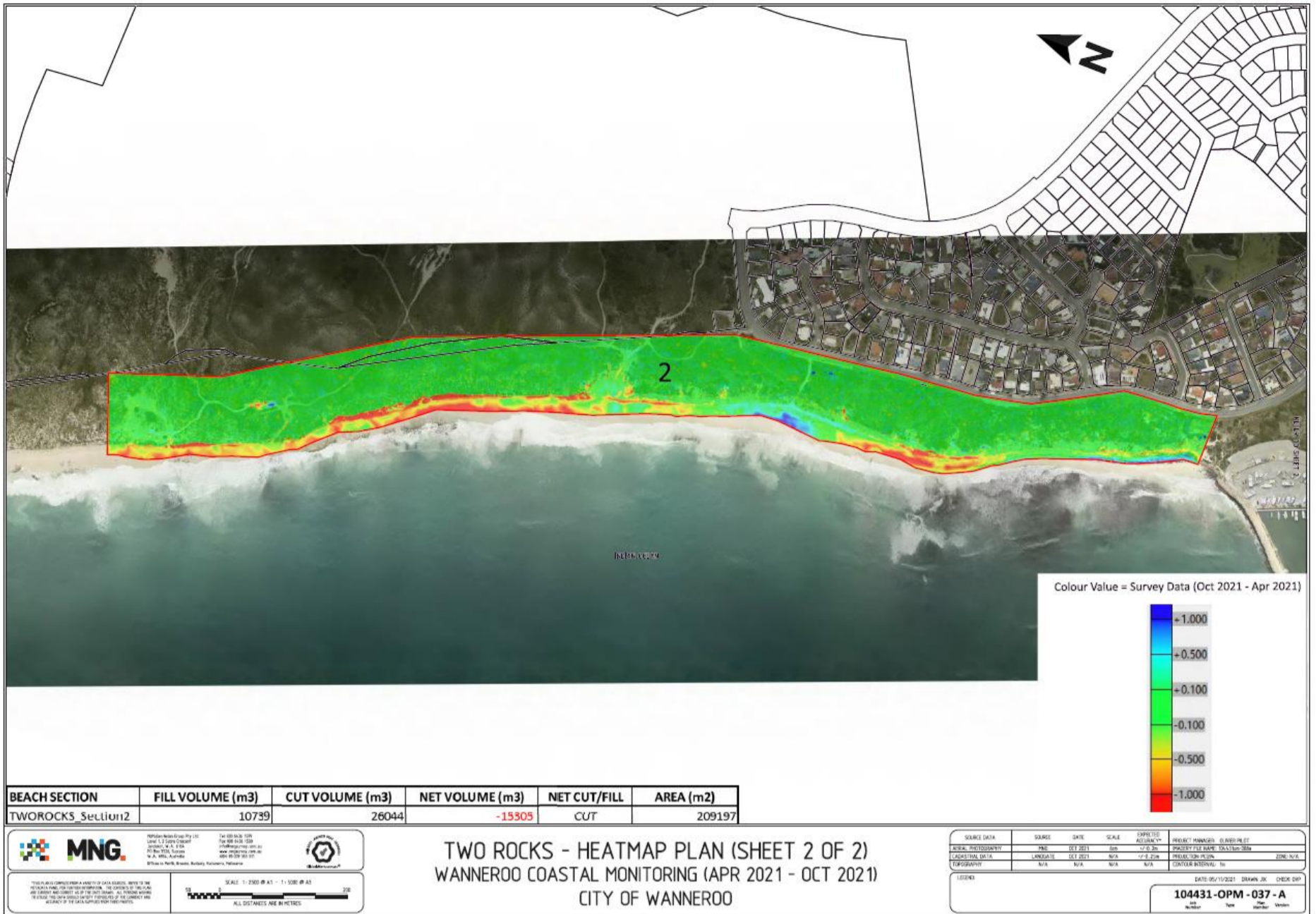




YANCHEP BEACH - HEATMAP PLAN (SHEET 3 OF 3)
 WANNEROO COASTAL MONITORING (APR 2021 - OCT 2021)
 CITY OF WANNEROO



TWO ROCKS - HEATMAP PLAN (SHEET 1 OF 2)
 WANNEROO COASTAL MONITORING (APR 2021 - OCT 2021)
 CITY OF WANNEROO



BEACH SECTION	FILL VOLUME (m3)	CUT VOLUME (m3)	NET VOLUME (m3)	NET CUT/FILL	AREA (m2)
TWOROCKS Section 2	10739	26044	-15305	CUT	209197

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Scale: 1:200 @ A1 - 1:100 @ A2
ALL DISTANCES ARE IN METRES

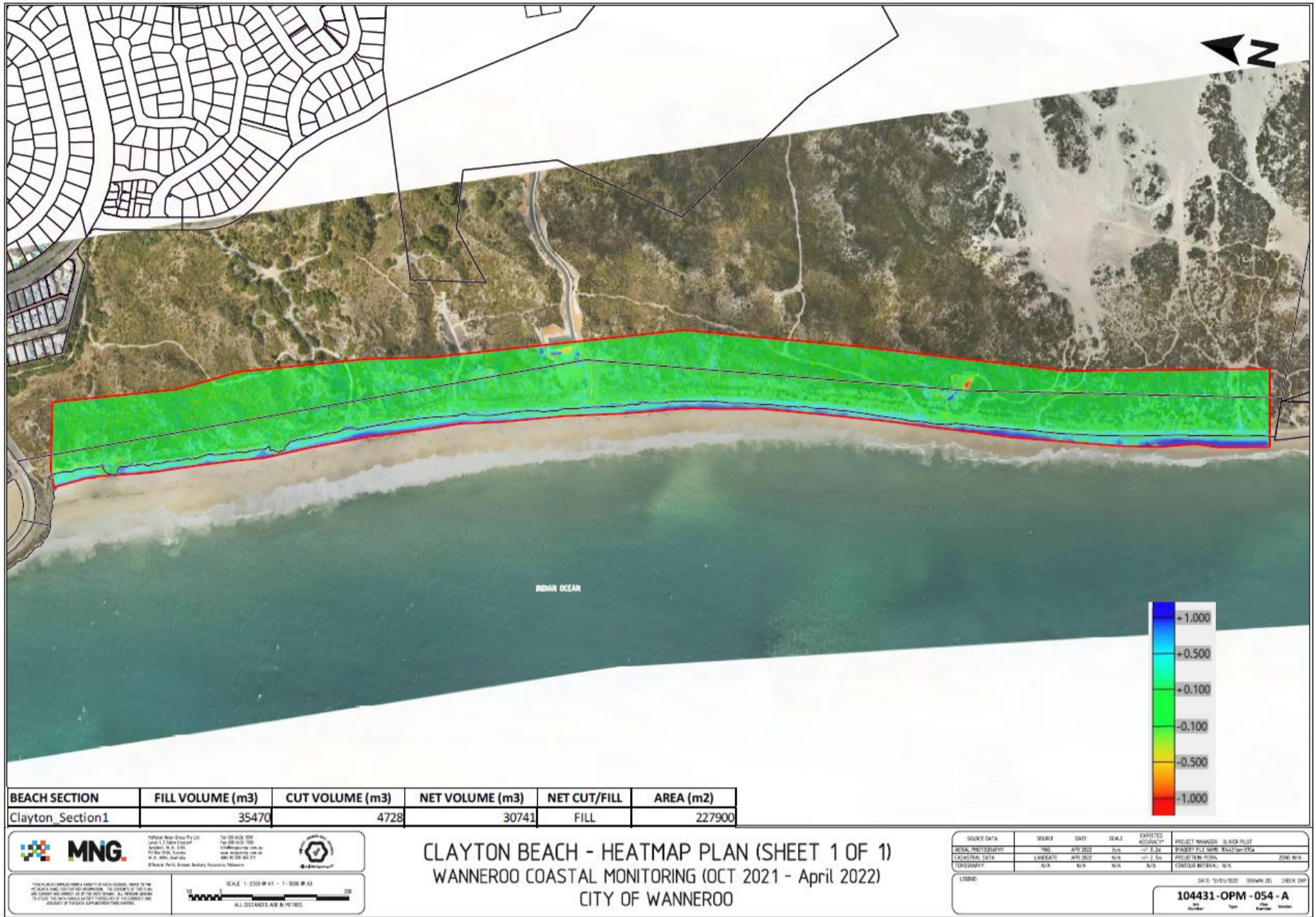
TWO ROCKS - HEATMAP PLAN (SHEET 2 OF 2)
WANNEROO COASTAL MONITORING (APR 2021 - OCT 2021)
CITY OF WANNEROO

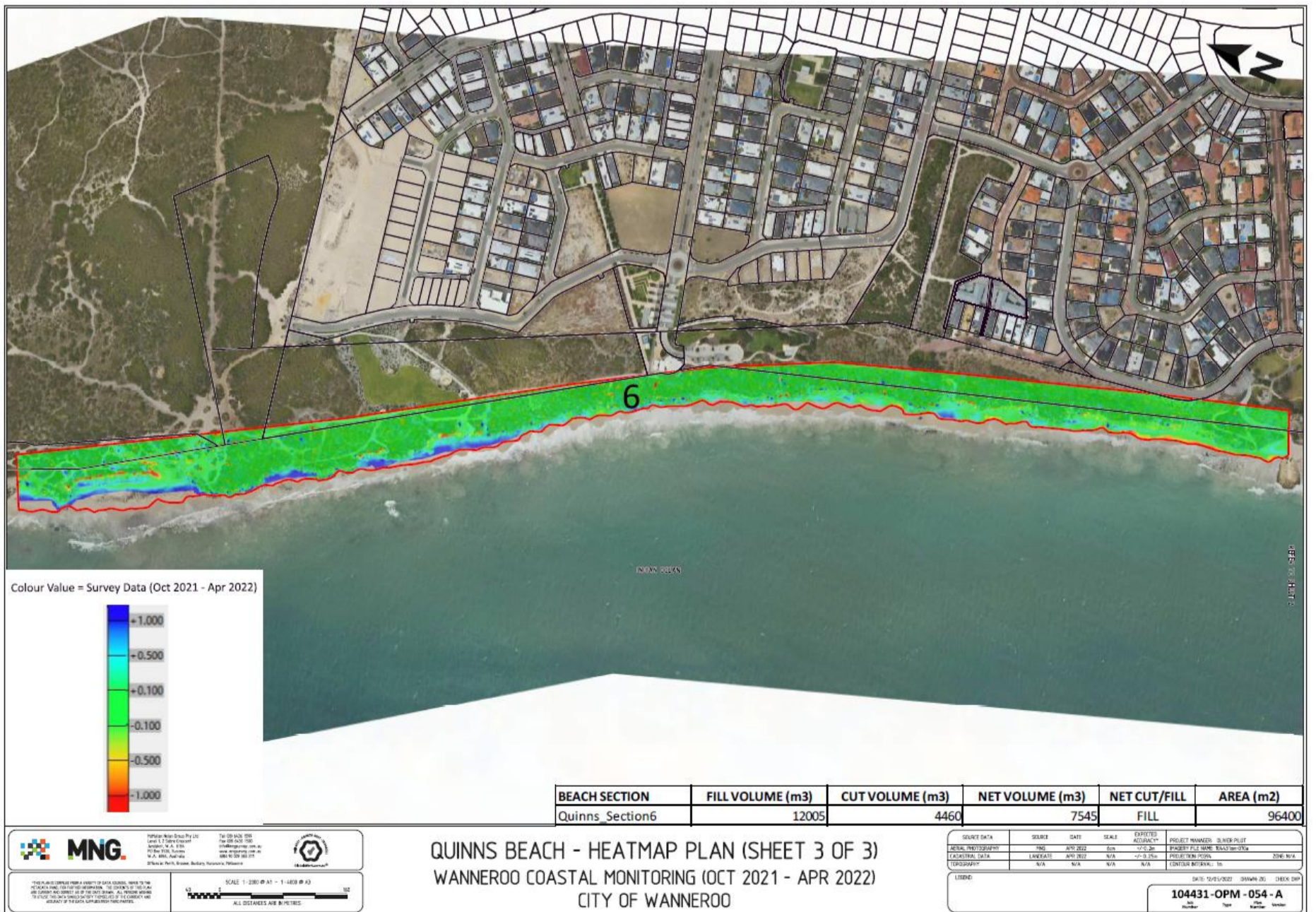
SOURCE DATA	SCALE	DATE	SCALE	DATE	PROJECT / DRAWING / SHEET NO.
AERIAL PHOTOGRAPHY	N/A	OCT 2021	1:500	03/01/2021	PROJECT 104431 - WANNEROO COASTAL MONITORING
TOPOGRAPHICAL DATA	N/A	OCT 2021	N/A	17/01/2021	PROJECT 104431 - WANNEROO COASTAL MONITORING
TOPOGRAPHY	N/A	N/A	N/A	N/A	CONTOUR INTERVAL: 10

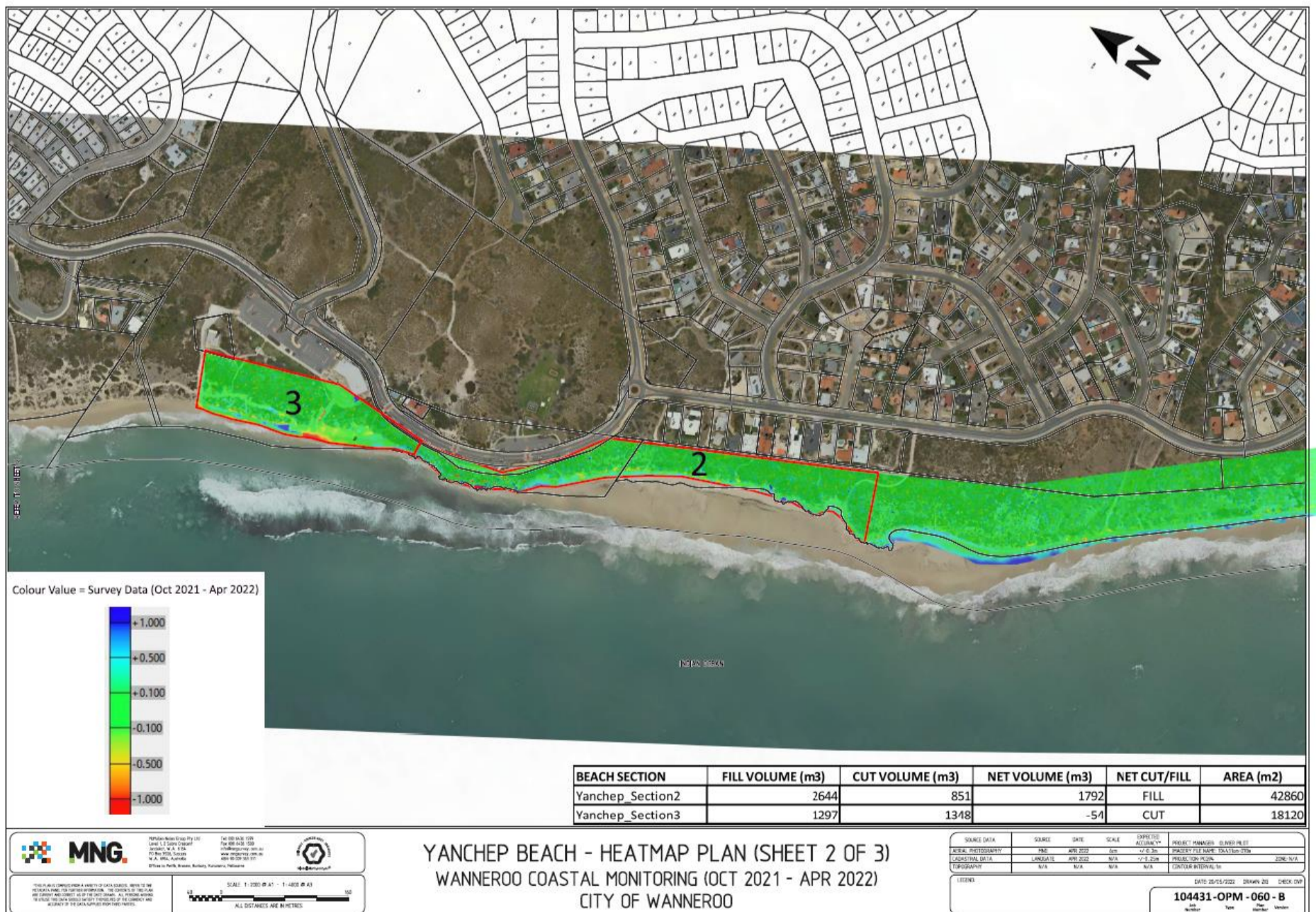
DATE: 05/11/2021 DRAWN: JK CHECK: GP

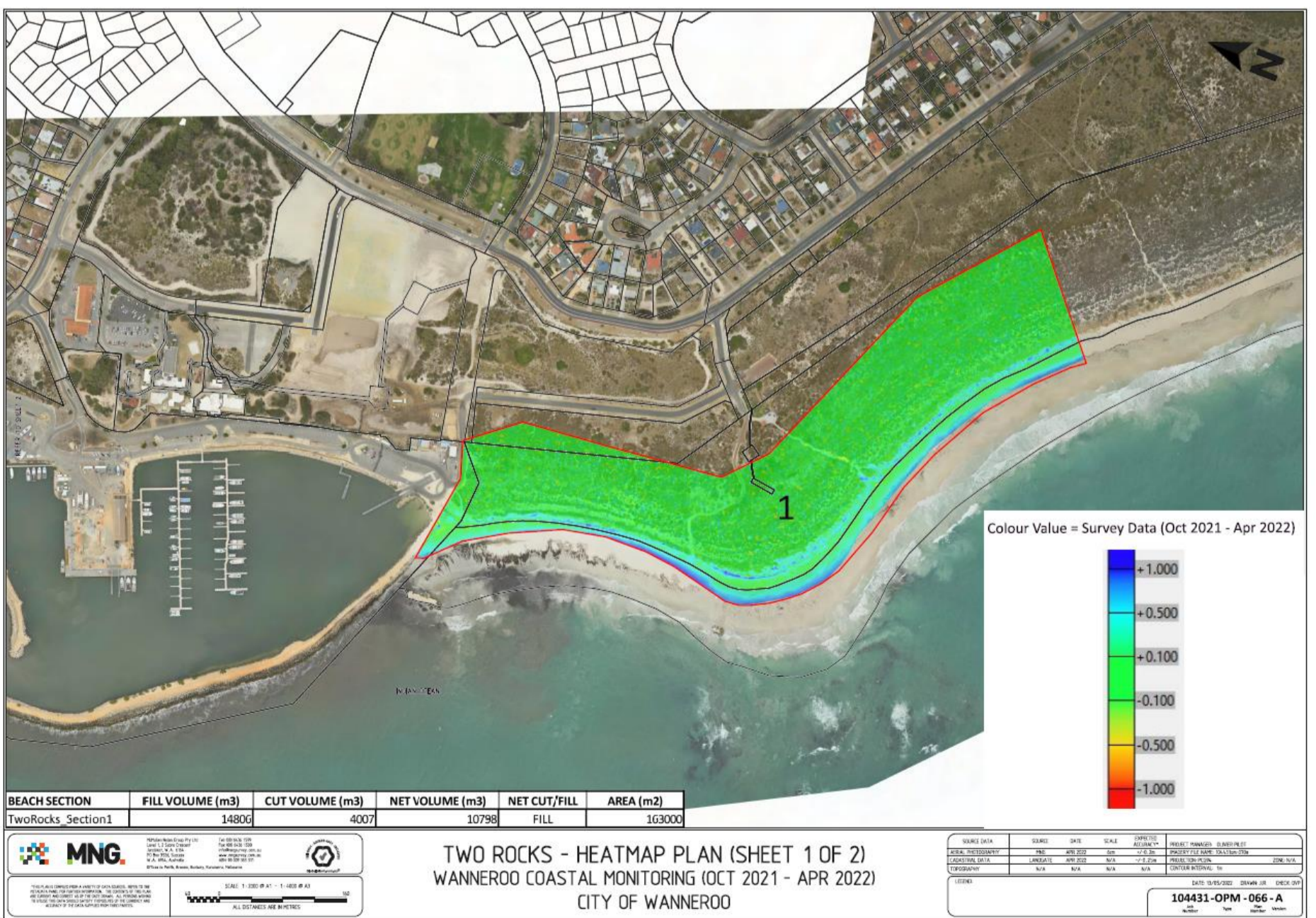
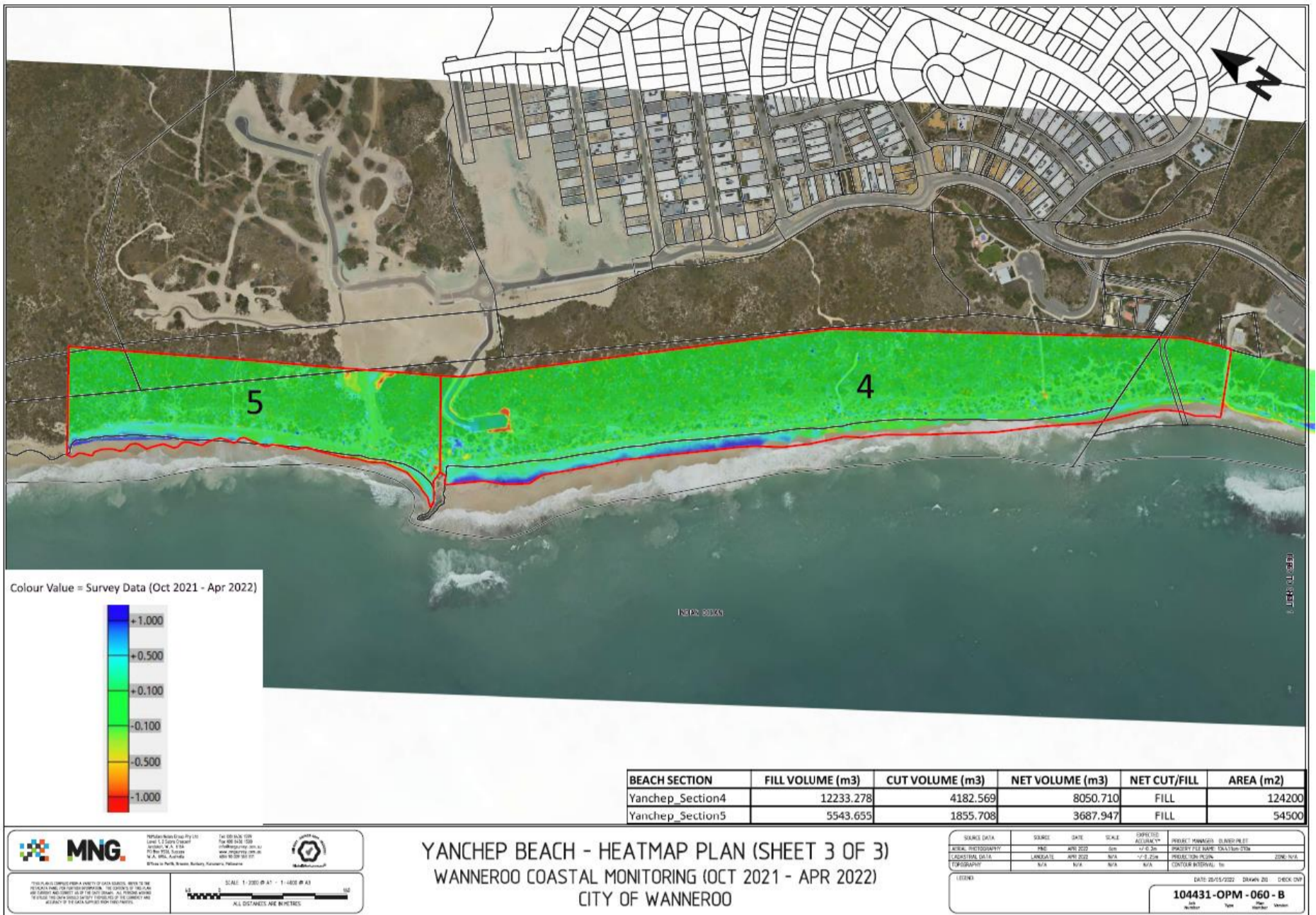
104431-OPM-037-A

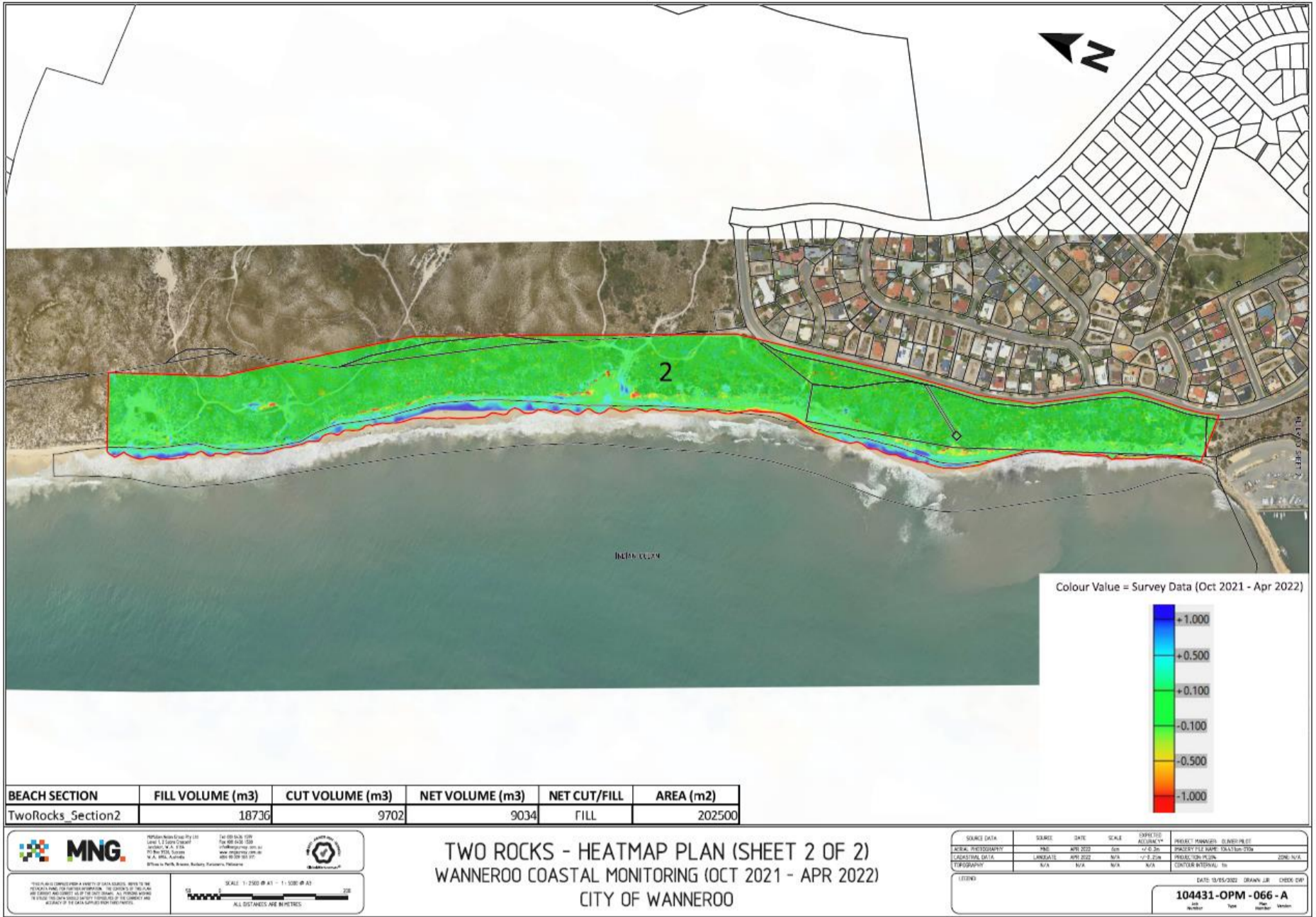
Beach Volume Changes between October 2021 and April 2022



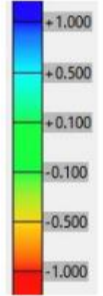








Colour Value = Survey Data (Oct 2021 - Apr 2022)



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 605 555 1001

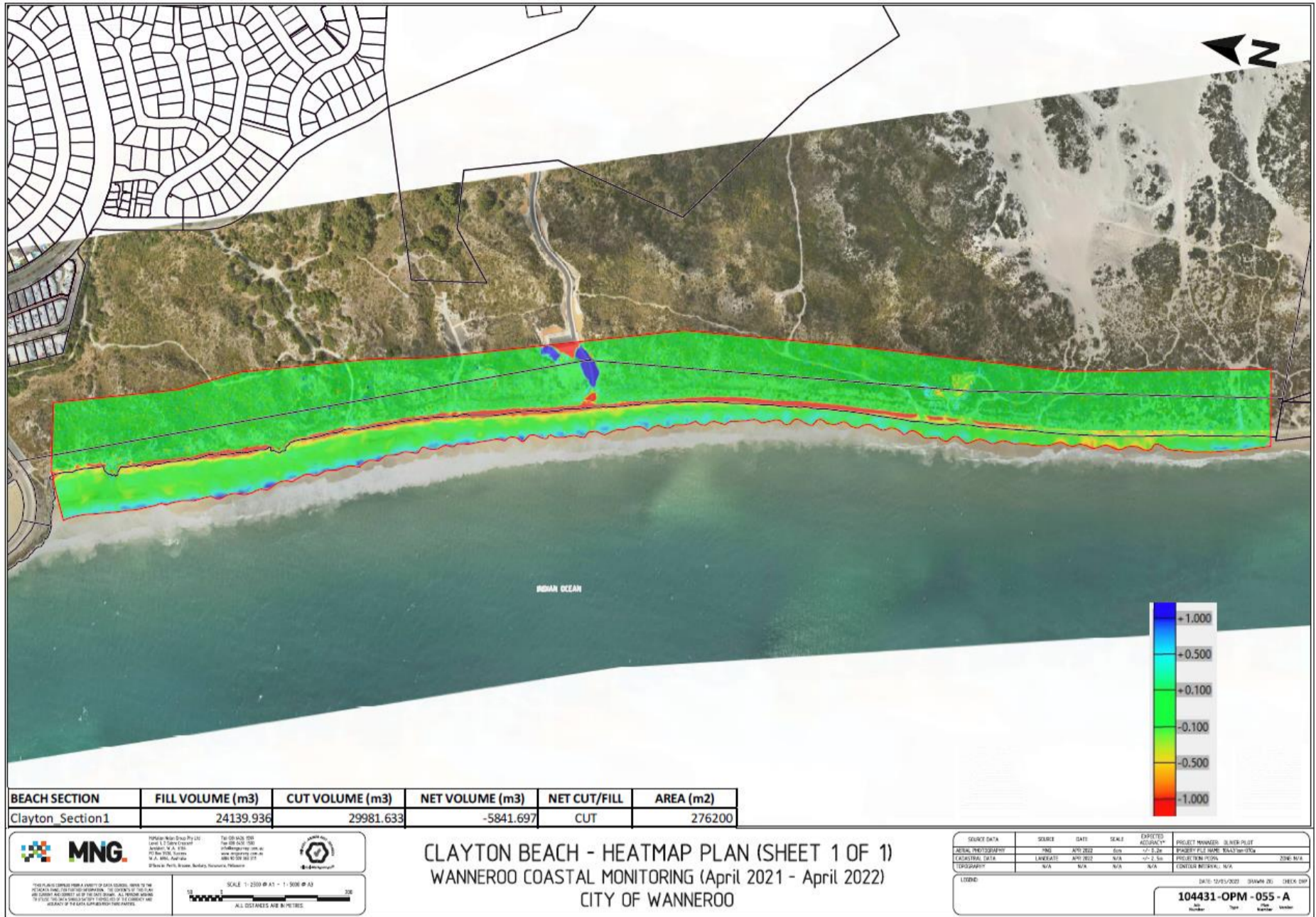
Scale: 1:250 @ A1 - 1:500 @ A2
 ALL DISTANCES ARE IN METRES

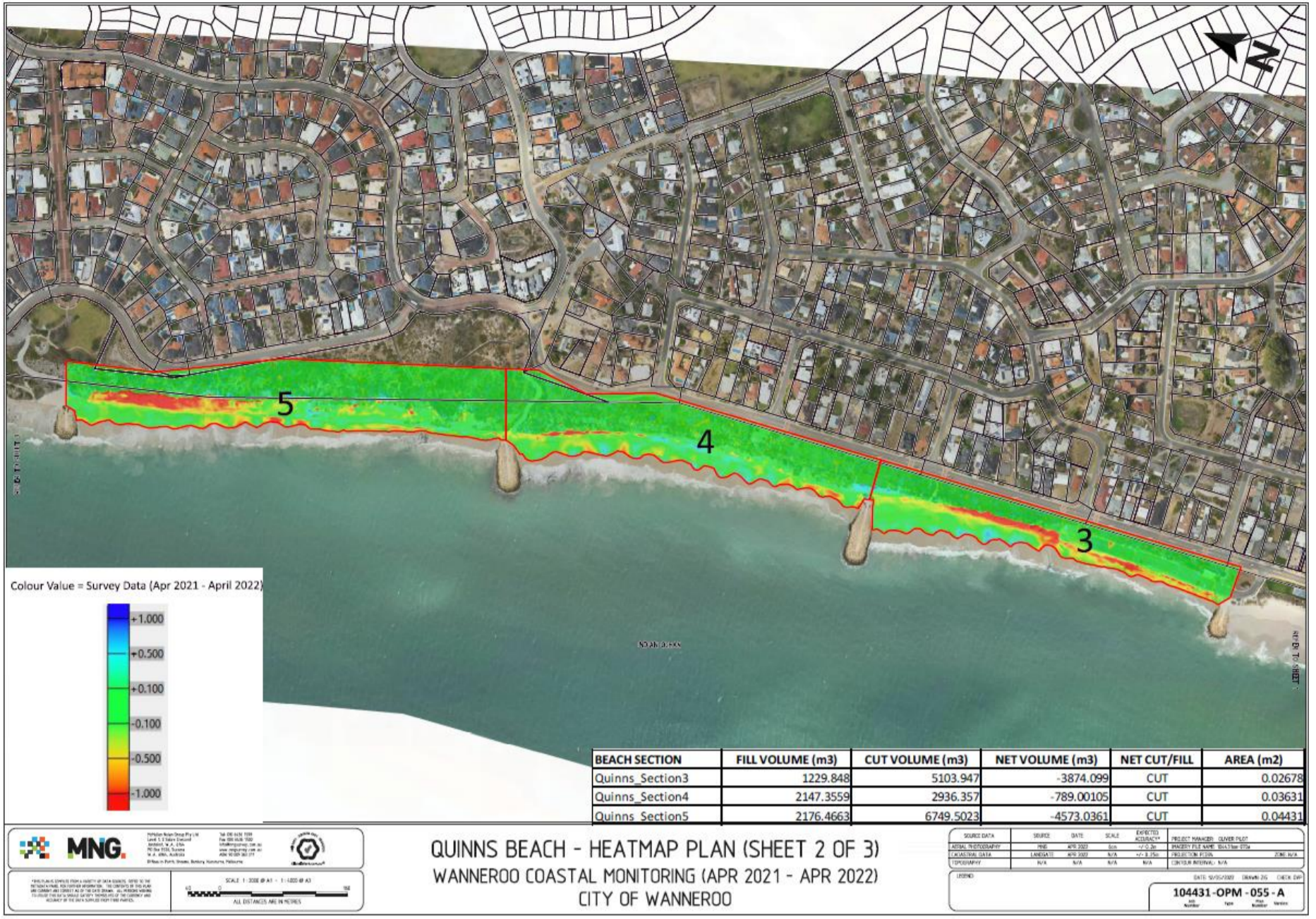
TWO ROCKS - HEATMAP PLAN (SHEET 2 OF 2)
WANNEROO COASTAL MONITORING (OCT 2021 - APR 2022)
 CITY OF WANNEROO

SOURCE DATA	SOURCE	DATE	SCALE	ACCURACY	PROJECT MANAGER	DESIGNER
LOCALITY DATA	NSD	APR 2022	50m	±0.5m	PROJECT MANAGER	DESIGNER
TOPOGRAPHY	LIKASATIS	APR 2022	N/A	±0.25m	PROJECT MANAGER	DESIGNER
	N/A	N/A	N/A	N/A	CONTOUR INTERVAL: 1m	

DATE: 15/05/2022 DRAWN BY: CHECK BY:
104431-OPM-066-A

Beach Volume Changes between April 2021 and April 2022

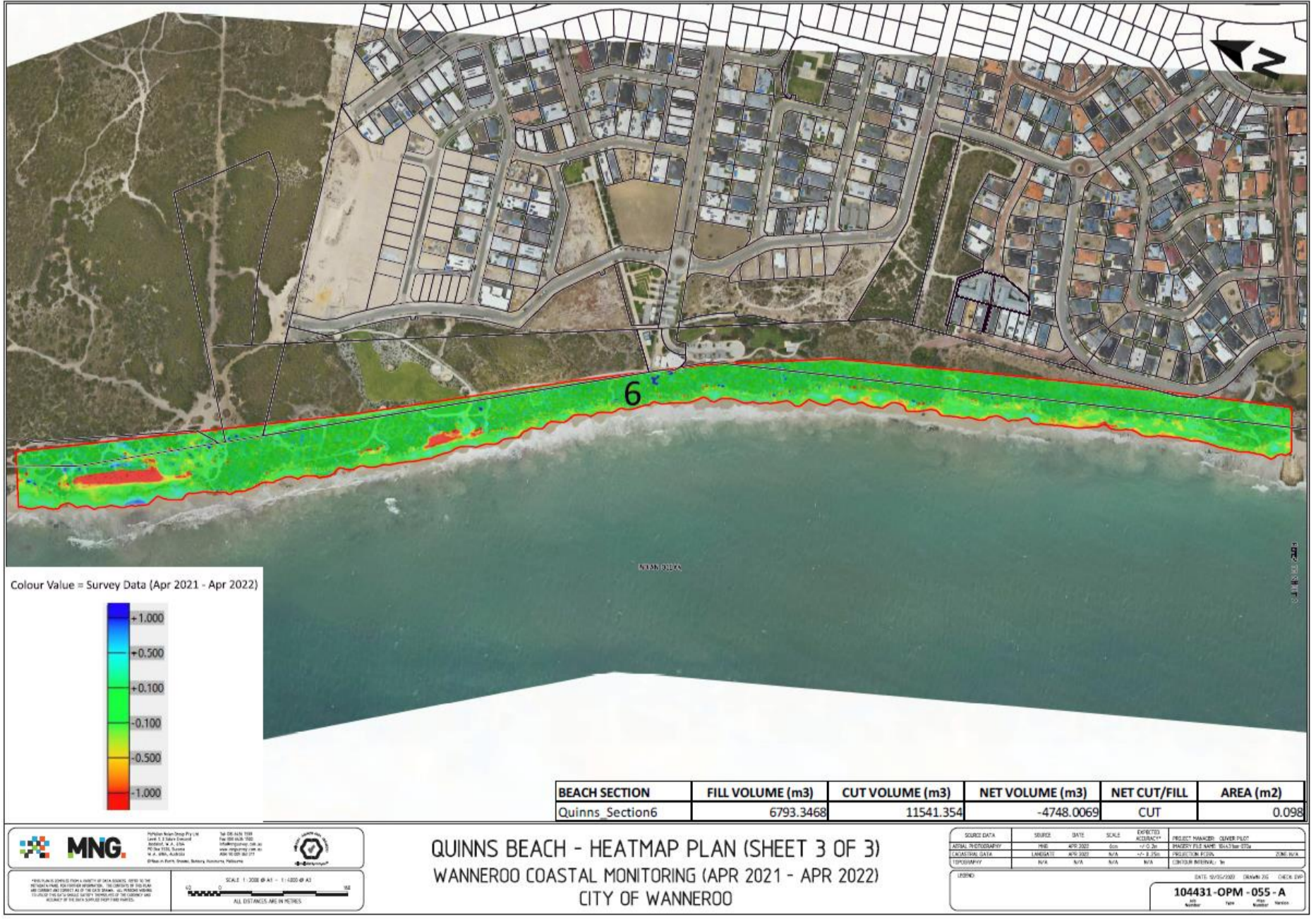




QUINNS BEACH - HEATMAP PLAN (SHEET 2 OF 3)
 WANNEROO COASTAL MONITORING (APR 2021 - APR 2022)
 CITY OF WANNEROO

SOURCE DATA	DATE	SCALE	VERTICAL ACCURACY	PROJECT MANAGER	CLIENT
ASIAL INTERCOMPT	APR 2022	1:1000	±0.20m	PROJECT FILE NAME	WANNEROO
LOCALITY DATA	N/A	N/A	N/A	PROJECT FILE PATH	WANNEROO
TOPOGRAPHY	N/A	N/A	N/A	CURTAIN INTERVAL	N/A

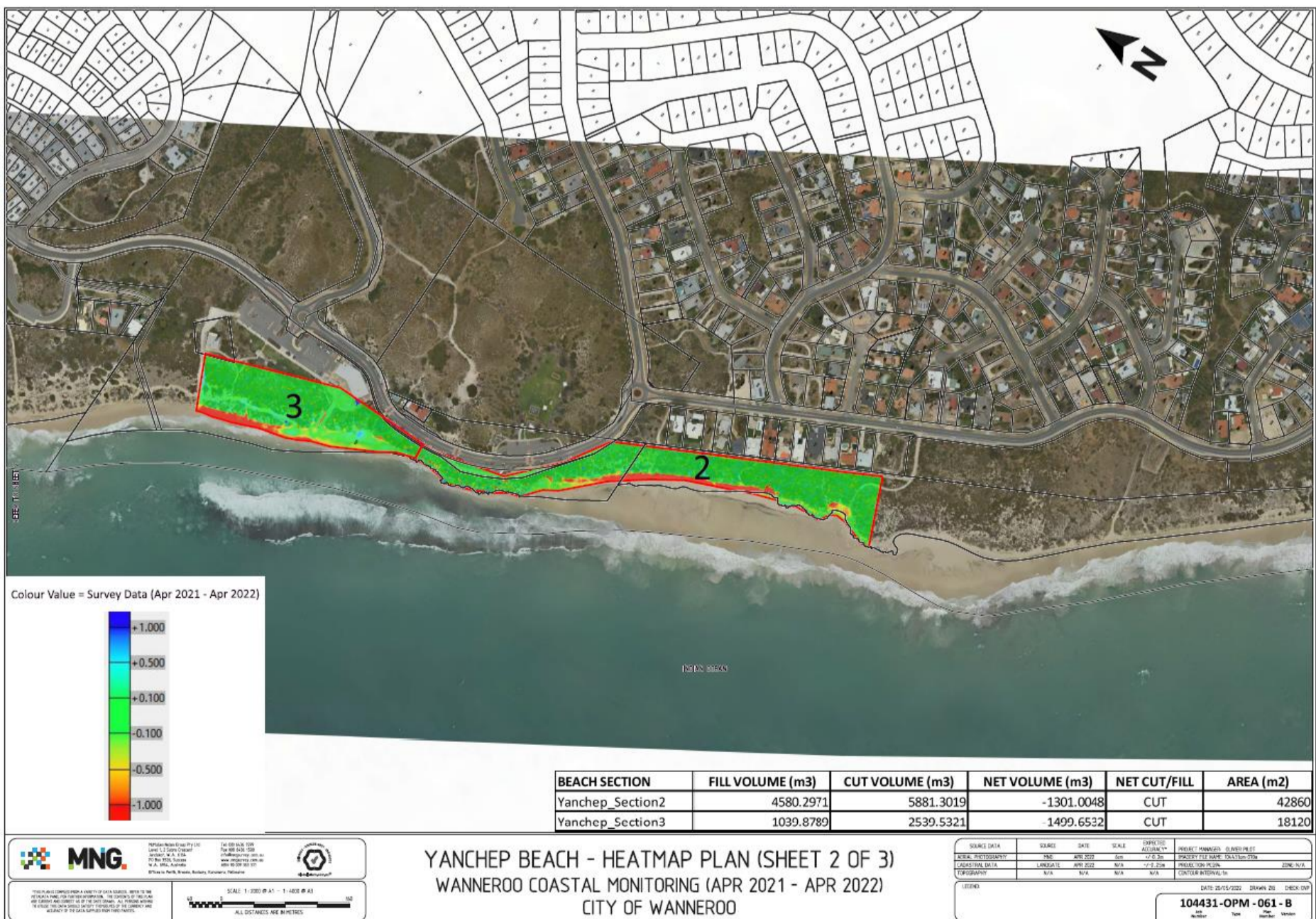
DATE: 01/05/2022 DRAWN BY: CHECK BY:
 104431-OPM-055-A

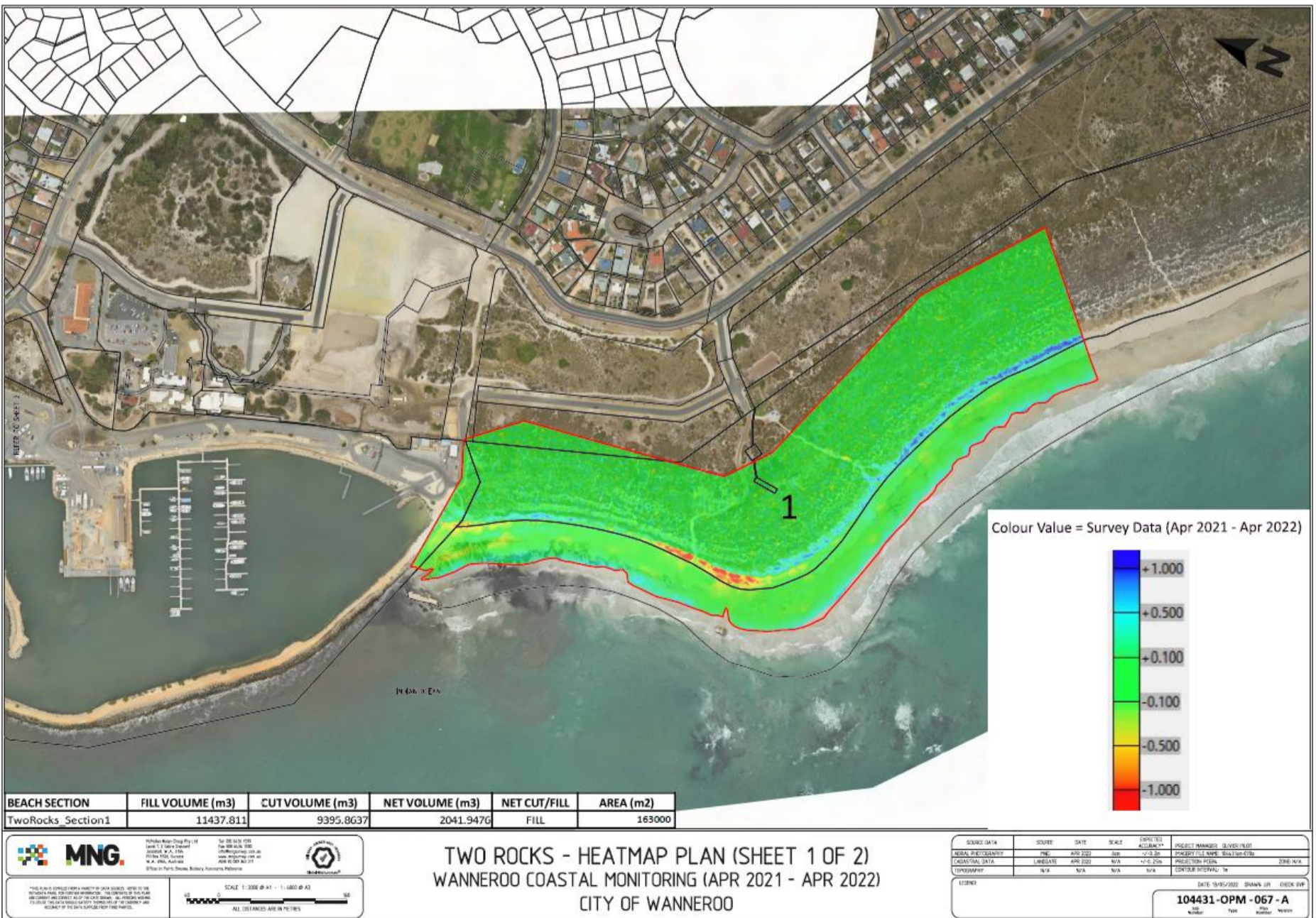
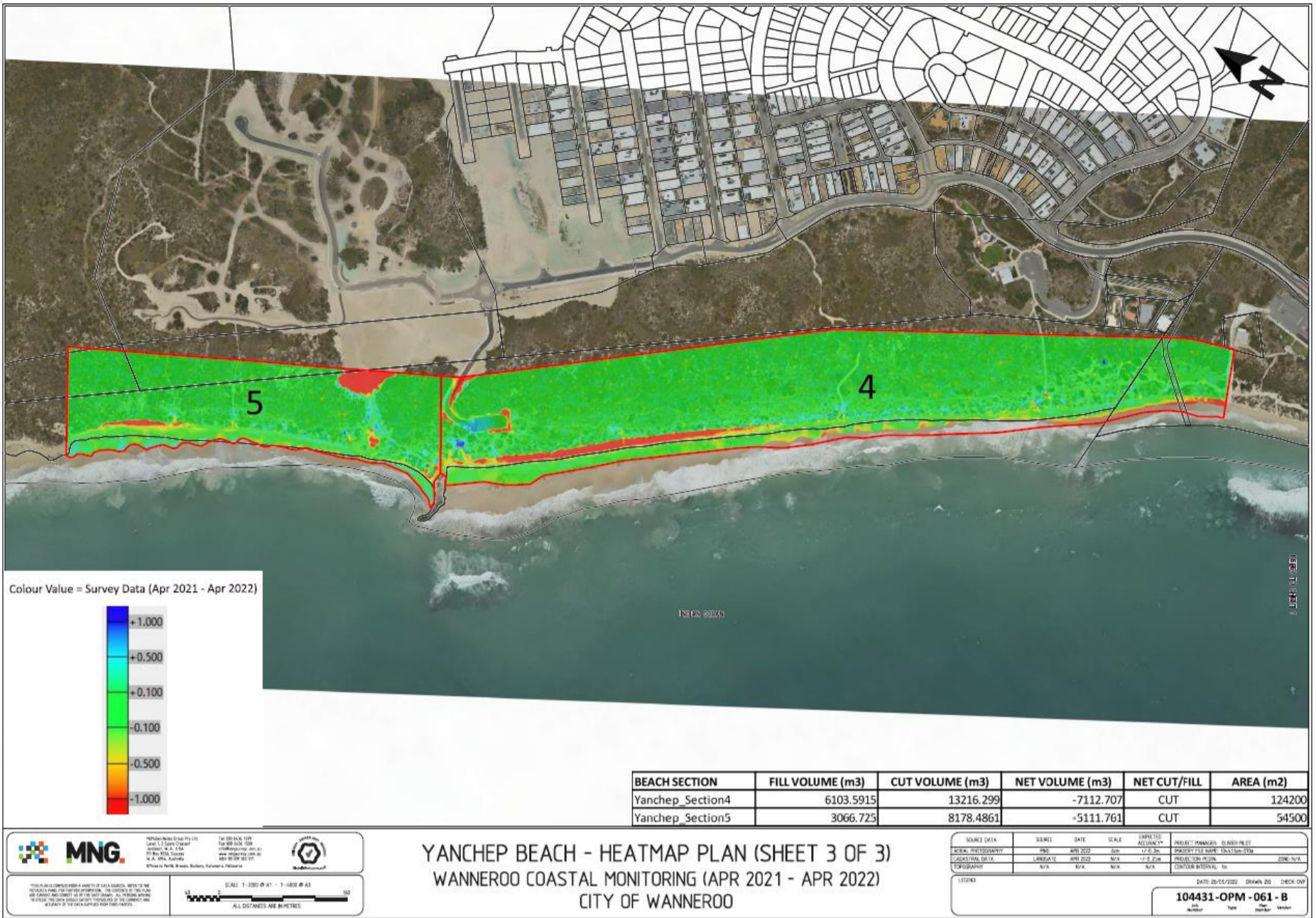


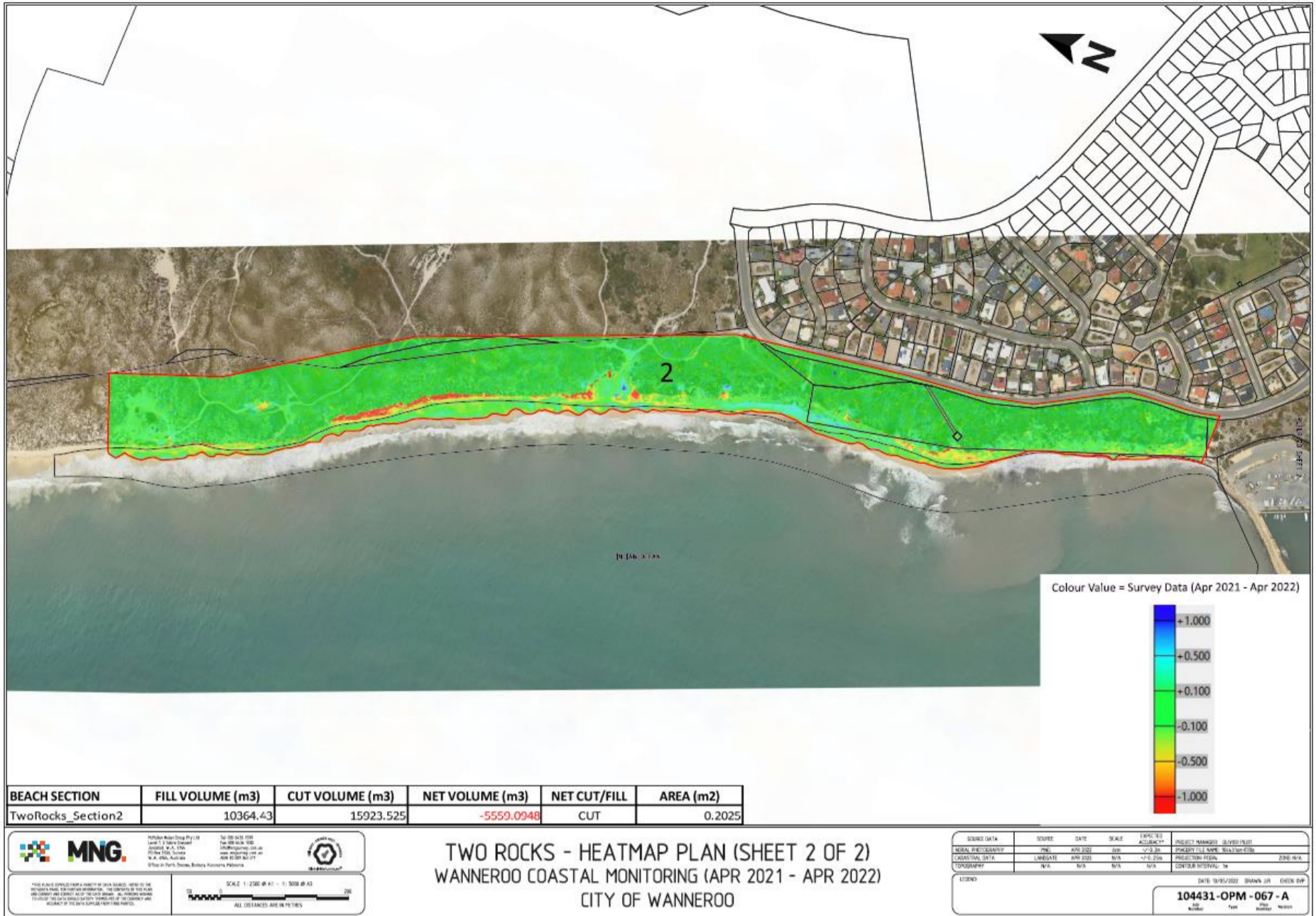
QUINNS BEACH - HEATMAP PLAN (SHEET 3 OF 3)
 WANNEROO COASTAL MONITORING (APR 2021 - APR 2022)
 CITY OF WANNEROO

SOURCE DATA	DATE	SCALE	VERTICAL ACCURACY	PROJECT MANAGER	CLIENT
ASIAL INTERCOMPT	APR 2022	1:1000	±0.20m	PROJECT FILE NAME	WANNEROO
LOCALITY DATA	N/A	N/A	N/A	PROJECT FILE PATH	WANNEROO
TOPOGRAPHY	N/A	N/A	N/A	CURTAIN INTERVAL	N/A

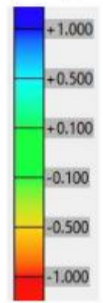
DATE: 01/05/2022 DRAWN BY: CHECK BY:
 104431-OPM-055-A







Colour Value = Survey Data (Apr 2021 - Apr 2022)



BEACH SECTION	FILL VOLUME (m3)	CUT VOLUME (m3)	NET VOLUME (m3)	NET CUT/FILL	AREA (m2)
TwoRocks_Section2	10364.43	15923.525	-5559.0948	CUT	0.2025

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SCALE 1:250 @ A1 - 1:500 @ A3
 ALL DISTANCES ARE IN METRES

TWO ROCKS - HEATMAP PLAN (SHEET 2 OF 2)
WANNEROO COASTAL MONITORING (APR 2021 - APR 2022)
CITY OF WANNEROO

SCOPE	DATE	SCALE	DATE	PROJECT MANAGER	CLIENT
DESIGN	APR 2022	1:250	APR 2022	BRUNNEN	CITY OF WANNEROO
CONSTRUCTION	APR 2022	1:250	APR 2022	BRUNNEN	CITY OF WANNEROO
OPERATION	APR 2022	1:250	APR 2022	BRUNNEN	CITY OF WANNEROO

DATE: 10/05/2022 DRAWN BY: BRUNNEN CHECK BY: BRUNNEN

104431-OPM-067-A