FINAL REPORT:

Agnes Water and Seventeen Seventy Shoreline Erosion Management Plan (SEMP)

April 2020

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The project team acknowledges the Bailai, Gurang, Gooreng Gooreng and Taribeland Bunda people as the Traditional Owners of the land. We pay respect to their Elders past, present and emerging, and acknowledge and respect their continuing culture and the contribution they make to the life and protection of this region.

The project team also would like to acknowledge and thank the Agnes Water and Seventeen Seventy community members who attended the community meetings and provided input towards the Shoreline Erosion Management Plan.

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1 Introduction

1.1 Purpose of a SEMP

Coastal zones are naturally dynamic and complex places that are highly valued by the community. Ongoing interactions occur between waves, winds, tides, rivers and the natural environment. Coastal erosion is a natural process that shapes coastlines over long timeframes. However, erosion processes may become problematic when interacting with communities and built infrastructure. The Queensland State Government states that 'Developed areas impacted by erosion require balanced management to protect infrastructure and preserve coastal values and amenity' (DES 2018). A Shoreline Erosion Management Plan (SEMP) provides councils with a framework to proactively plan for the erosion management of their coastline while ensuring natural coastal processes are maintained. A SEMP is informed by strong technical understanding of the coastal processes, values and knowledge of the stakeholders and community and an appreciation of the means, opportunities and resources of the coastal managers to deliver management actions.

The Agnes Water and Seventeen Seventy SEMP is closely aligned with Strategic Goal 2 "Healthy environment, healthy community" in the Gladstone Regional Council Operational Plan. Under this goal is a commitment by Council to take a leadership role in protecting the environment, using resources efficiently and improving the health and safety of the community. In addressing this goal, SEMPs provide direction for the management of key parts of the coastline, and enable efficient use of Council resources in alignment with community values. SEMPs have now been completed for regionally important sections of the coast at Boyne Island and Tannum Sands, Agnes Water and Seventeen Seventy, and Turkey Beach

1.2 SEMP context

This SEMP has been commissioned by Gladstone Regional Council (GRC) to assist with proactive management of the Agnes Water and Seventeen Seventy shorelines. Council has been supported in the SEMP development process by Alluvium Consulting Australia (Alluvium) in partnership with Jeremy Benn Pacific (JBP) and Natural Capital Economics (NCE).

Agnes Water and the town of Seventeen Seventy are located approximately 80 km south of the city of Gladstone (Figure 1), east and west of the Round Hill Headland (Figure 2). The towns are predominantly known for tourism and Agnes Water is the northernmost surfing beach on the east coast of Australia. Agnes Water has a population of approximately 2,210 residents. There are approximately 69 residents at Seventeen Seventy but a total of 261 dwellings to accommodate holidaymakers.

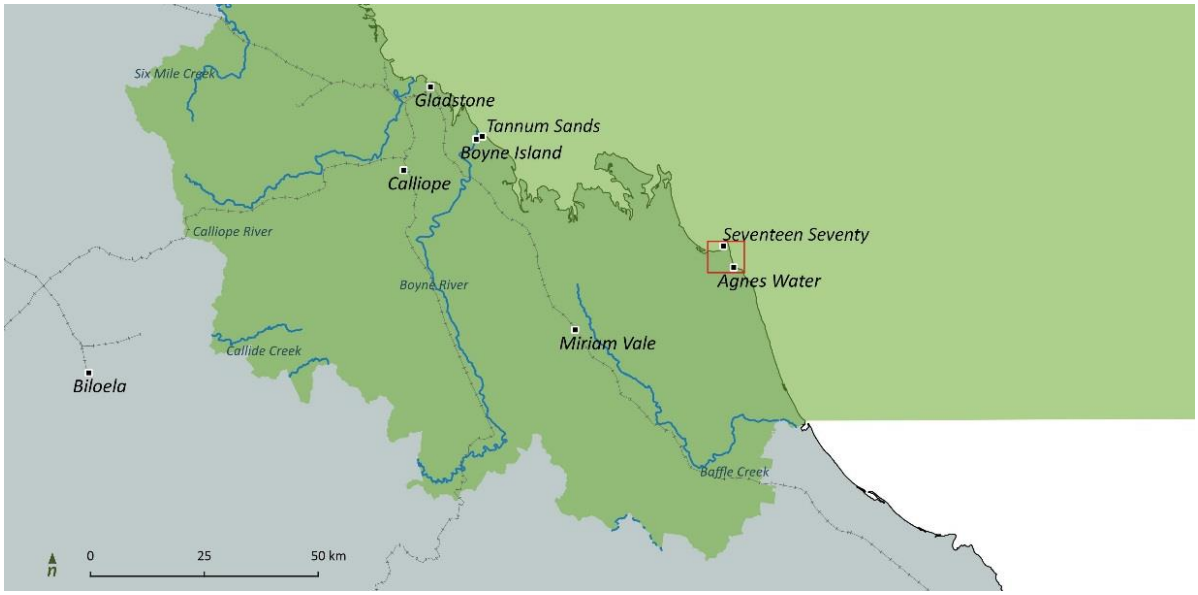


Figure 1. *Study area (shown in red box)*

Figure 2. *View of Round Hill Head looking south with the Agnes Water coastline to the left and Seventeen Seventy to the right* (*https://www.discover1770.com.au/town-information/*)

Over recent years, erosion has been an ongoing concern for the communities at Agnes Water and Seventeen Seventy. The SEMP provides a way forward for Council and the community to proactively manage the shoreline.

Council is also concurrently developing a Coastal Hazard Adaptation Strategy (CHAS) for the region, that will include new technical information relevant to Agnes Water and Seventeen Seventy. The CHAS process will run over 12 months from October 2019 to October 2020 and focuses on long term planning to 2100. The SEMP process has been completed now to ensure Council and the community can have a plan to address immediate issues of concern. The SEMP will be reviewed following completion of the CHAS and new information can be used to refine implementation.

The preparation of the SEMP has been guided by the state guidelines *Preparing a shoreline erosion management plan* (Department of Environmental Science, 2018). The SEMP has been informed by a technical understanding of coastal processes, as well as the values and knowledge of the stakeholders and community, and an appreciation of the means, opportunities and resources of the coastal managers to deliver management actions. Consideration of the legislative context has also been included (Attachment A). The SEMP development has included consultation with Council, State Government and community stakeholders at the relevant stages of the process.

1.3 Plan structure

This SEMP includes a range of technical studies, engagement activities, and a strategic options assessment, which have informed and shaped the management plan. The Plan is structured as follows:

- **Section 2:** Physical context
    - Landscape setting
    - Coastal processes
    - Erosion Prone Area
    - Trends in shoreline change
    - Present day shoreline
    - Trajectory of change and management focus

- **Section 3:** Coastal values
    - Environmental, social, economic
    - Community input
- **Section 4:** Management options and suitability
    - Management objectives
    - Options screening
    - Actions
    - Triggers for change
    - Monitoring and evaluation.

2 Physical context

This chapter of the SEMP provides a summary of the landscape setting and geomorphic context for Agnes Water and Seventeen Seventy, coastal processes that shape the landscape, trends in shoreline changes over the years, the current shoreline condition, and likely trajectory of change.

2.1 Landscape setting

Agnes Water and Seventeen Seventy are situated to the south-east and west (respectively) of the rocky Round Head headland (Figure 3, Figure 4, Figure 5, Figure 6).

The broader coastline to the west of the headland is characterised by predominantly open sandy shores backed by bedrock around headlands (Figure 4). To the east is the tidal zone of Round Hill Creek with a network of low-elevation depositional sandy beach ridges developed as barrier spit features (Figure 4).

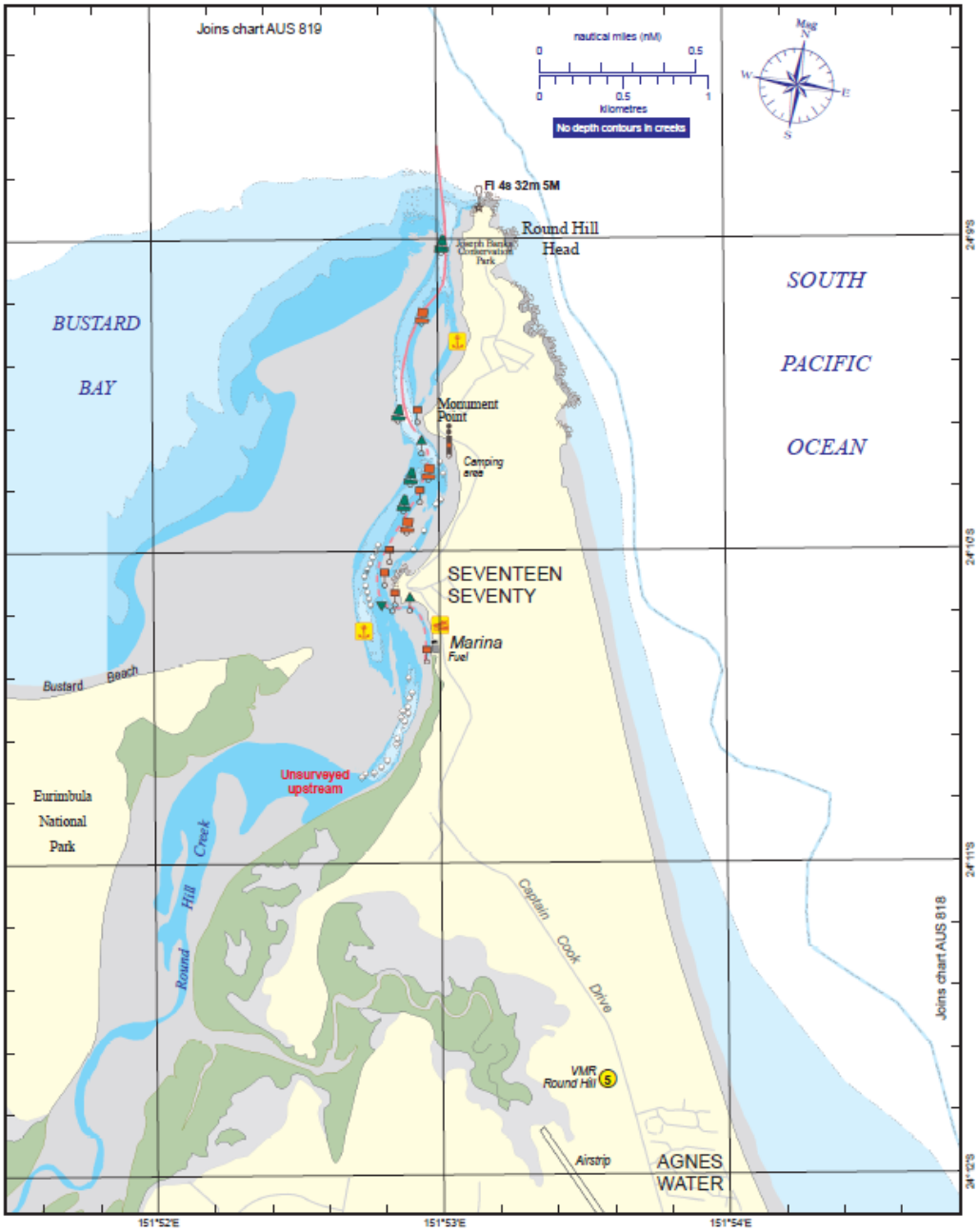


Figure 3. *Seventeen Seventy and Agnes Water navigation chart extract (Maritime Safety Queensland 2014).*

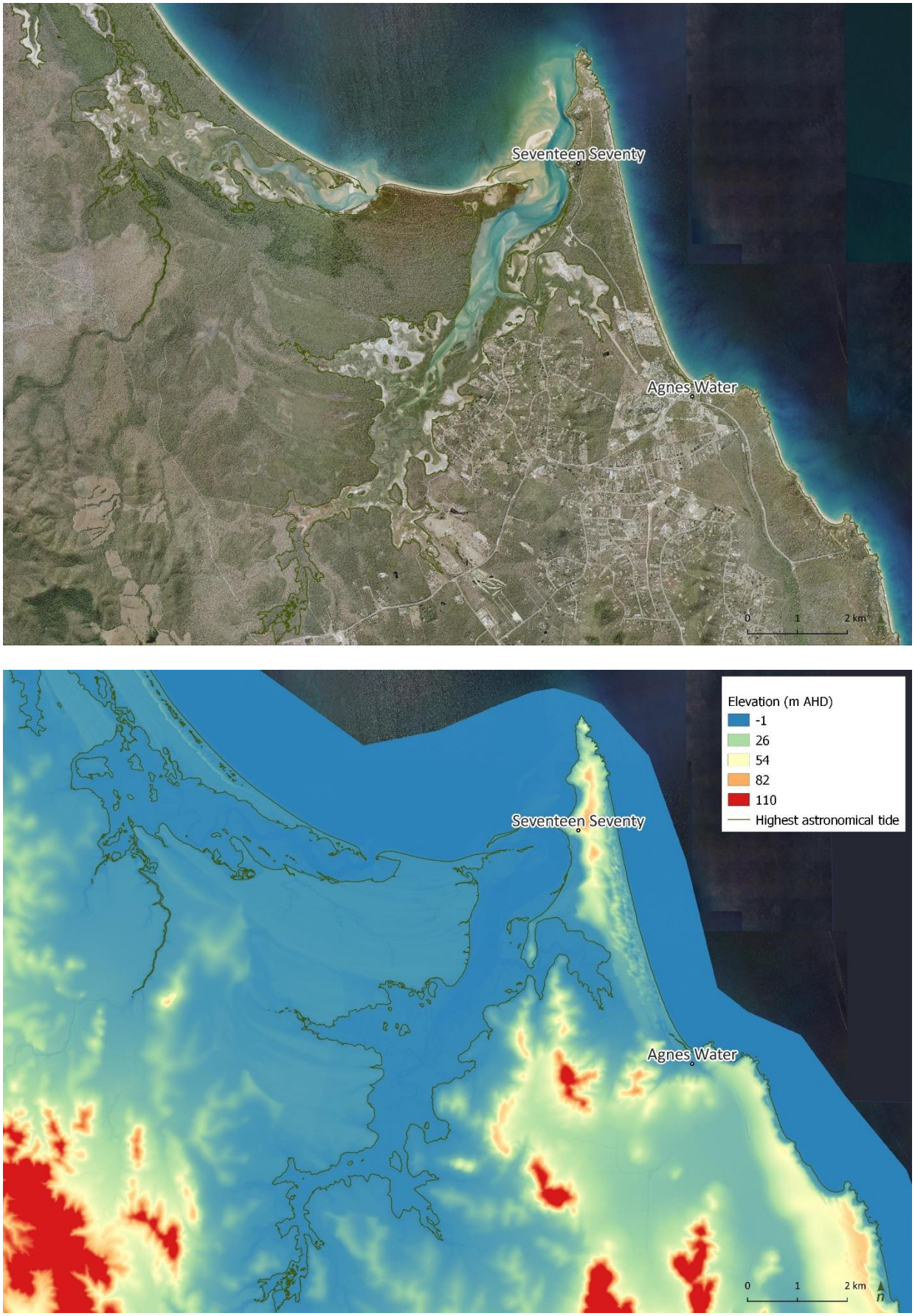


Figure 4. *2017 aerial (top) and elevation (bottom) images of the Agnes Water and Seventeen Seventy coastline and surrounding landscape*

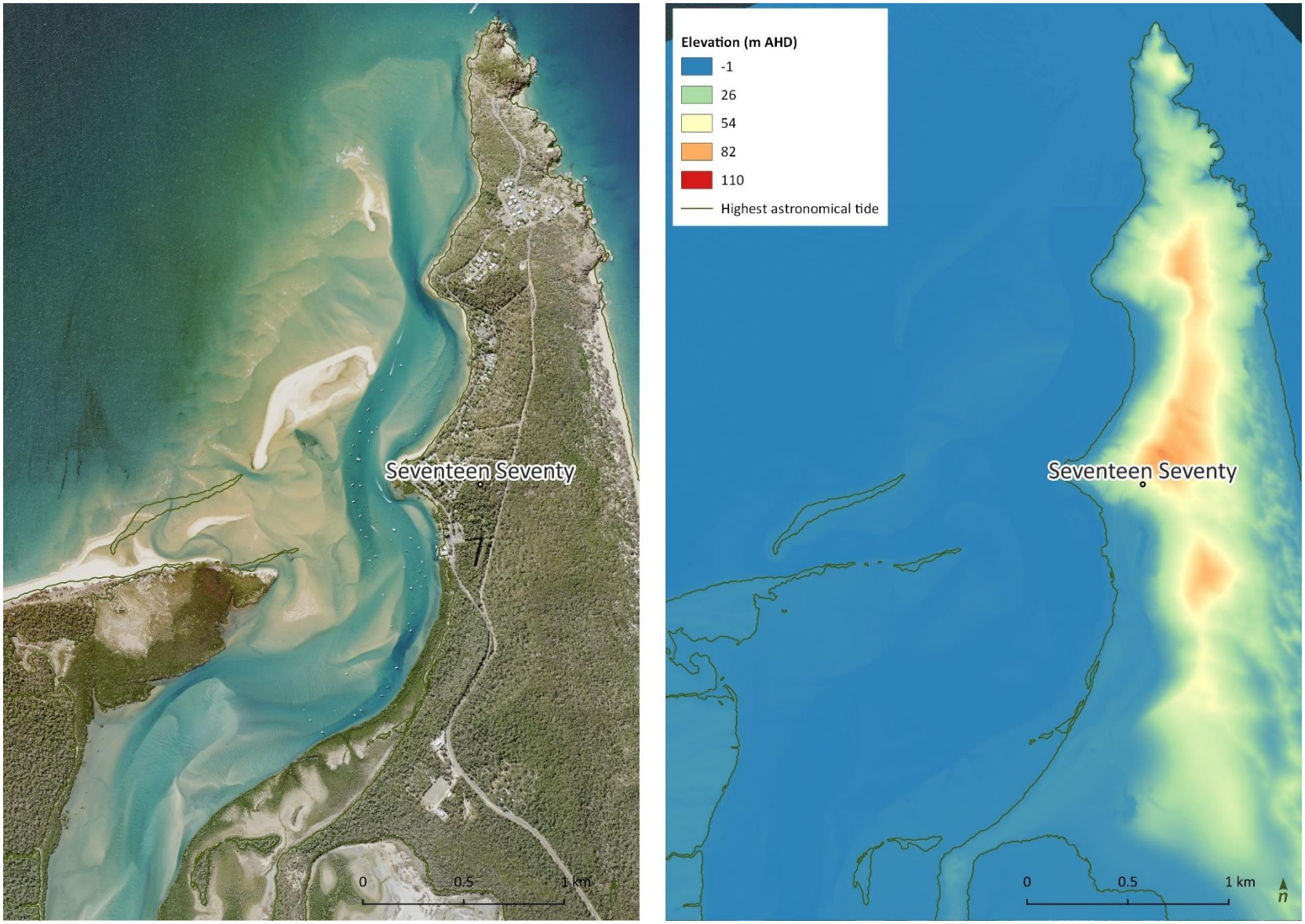


Figure 5. *2017 aerial (left) and elevation (right) images of Seventeen Seventy coastline*

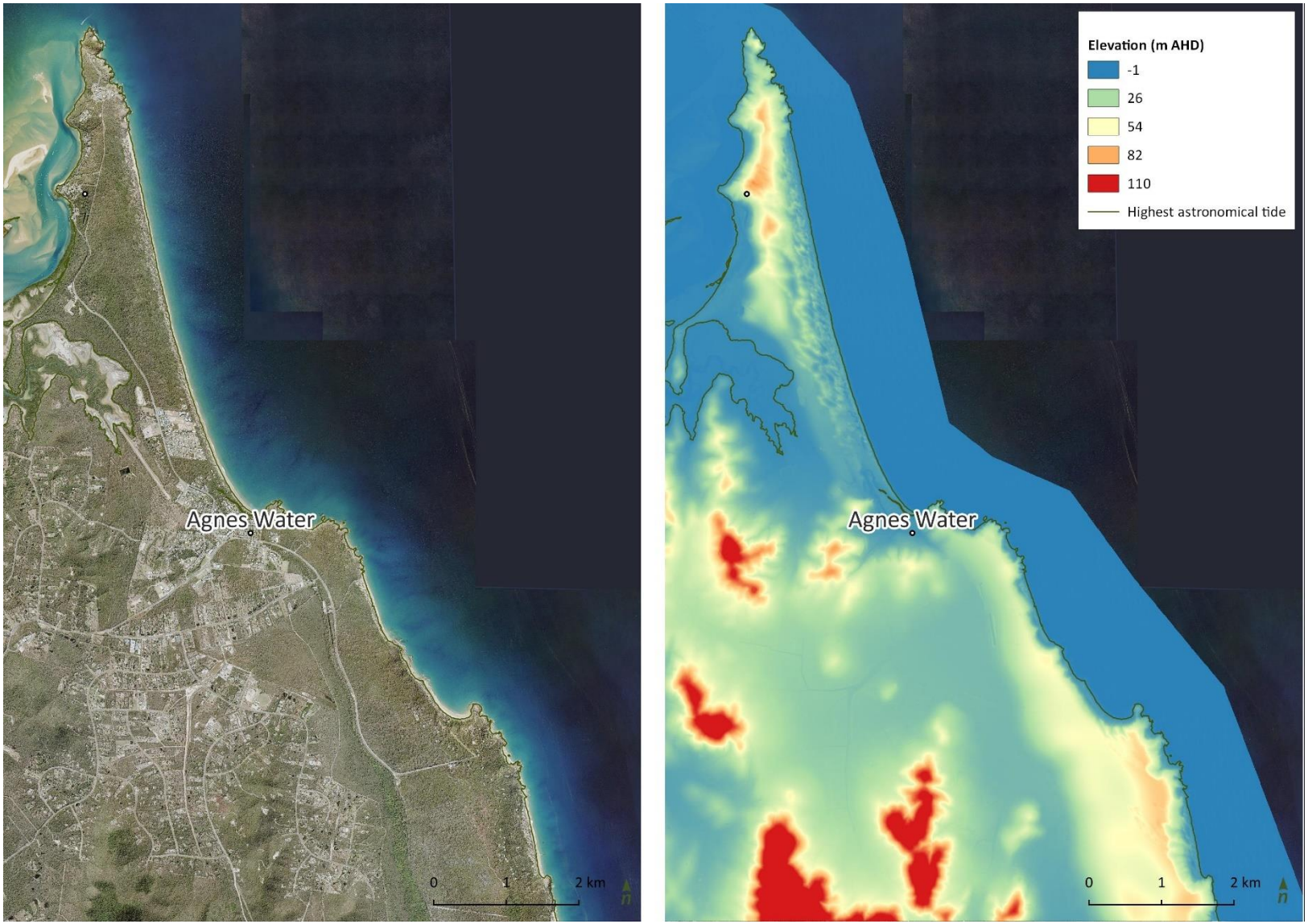


Figure 6. *2107 aerial (left) and elevation (right) images of Agnes Water coastline*

The sandy beach ridges formed as barrier features across the Round Hill Creek estuary/delta zone (Figure 4), are comprised of marine and fluvial derived deposits of Quaternary age, most likely of Holocene origin (formed within last 6,000 years). The ridges of the barrier spit are orientated to the west, extending / transitioning to north-northwest consistent with the prevailing long-shore sediment transport direction.

Sandy beach ridges are composed of fine-grained quartz sands, interspersed with rutile, ilmenite and zircon. Estuarine and deltaic sediments in depositional zones around the tidal creeks include mud, silt and evaporite deposits, and may also contain vegetated black soils.

A key feature of the coastline to the east of Round Hill Headland (north of Agnes Water) is the 4 km (approx.) extent of parabolic dunes. Parabolic dunes are transgressive dunes that build up over underlying rock, typically in exposed open coast environments with a consistent prevailing wind direction. Sand builds up in parabolic arcs (evident in Figure 6) and dune fields can reach significant heights.

The Agnes Water and Seventeen Seventy area is underlain by a geological unit known as the Agnes Water Volcanics. This unit is composed of Triassic felsic volcanics, including rhyolite, andesite and trachyte (GA 2019). Sandy beach ridges, formed during Holocene sea level transgression, are composed fine-grained quartz sands that are dispersed with heavy metals, including rutile, ilmenite and zircon (Ulm 2006). Present-day sediment supply is predominantly from the northern littoral drift, and the waterways to the south of the study area, including Baffle Creek, and the Burnett and Kolan River.

Mangroves span the parts of the Seventeen Seventy shoreline and within Round Hill Creek inlet, and small pockets extend northeast towards Round Hill Head. Vegetation along the Agnes Water shoreline is dominated by grasses, vines and small shrubs and trees, and the vegetation community of the elevated parabolic dunes to the north, and rocky coastline to the south.

2.2 Coastal processes

Tidal planes

Agnes Water and Seventeen Seventy experience a semi-diurnal, macrotidal signature (Figure 7). The tidal range in the Gladstone region is approximately 3 m.

Tidal planes and currents are a dominant driver of changes along the Seventeen Seventy shoreline (at the mouth of the Round Head estuary), but less so for the open coast setting of Agnes Water. Therefore, tidal plane and current information in the following sub-sections is focused on Seventeen Seventy.

Tidal planes have been extracted from the MSQ Tide Tables 2019 and are shown in Table 1. Included in the table are the predicted tides under a climate change scenario for 2100, where an additional 0.8 m has been added.

Table 1. Tide conditions at Seventeen Seventy

Tidal plane	Present day (m, LAT)	Present day (m AHD)	2100 (m AHD)
HAT	3.6	1.3	2.1
MHWS	2.8	0.5	1.3
MHWN	2.2	-0.1	0.7
MSL	2.3	0.1	0.9
AHD	2.3	0.0	0.8
MLWN	1.1	-1.1	-0.3
MLWS	0.5	-1.7	-0.9
LAT	0.0	-2.3	-1.5

Tides have been simulated using a Delft3D numerical model to understand the tidal characteristics (Figure 6). Refer to Appendix A for a full description of the model setup.

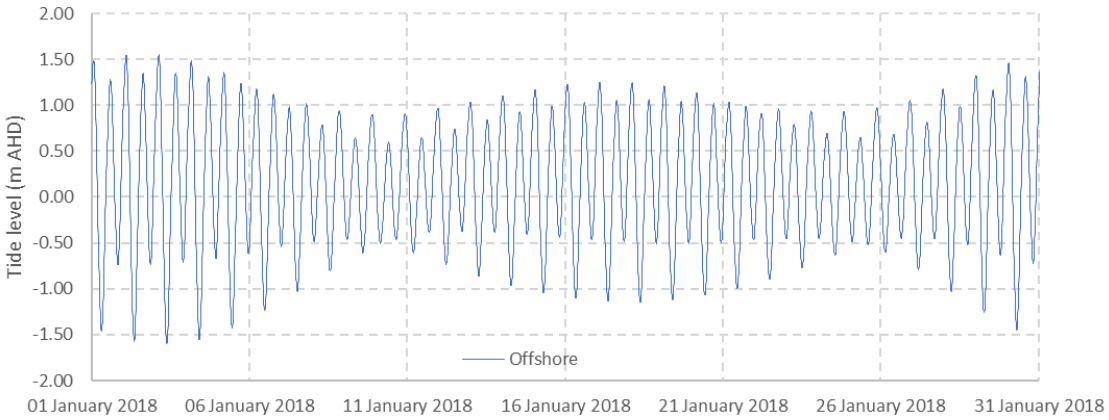


Figure 7. *Tide level simulation at the Round Hill Creek estuary mouth*

Tidal currents

Tidal characteristics have been considered in previous reports to understand dredging and navigation options, such as the Round Hill Creek Channel Options Study (BMT 2019). These past investigations have recorded observations of fast currents and plumes of suspended sediment in the main Round Hill Creek channel, confirming the high mobility of sand in the area, and tidal currents as a key driver of sediment transport.

For this SEMP study, the currents within Round Hill Creek and their implications for the Seventeen Seventy shoreline have been further assessed. In order to understand potential tidal influence on shoreline erosion, a new Delft3D numerical model of Round Hill Creek was developed (refer Attachment A). The Seventeen Seventy coastline experiences complex tidal interactions due to the network of flood and ebb-tide channels and currents situated offshore (Figure 8).

Figure 8. *Modelled tidal patterns during flood tide (left) and ebb tide (right)*

The ebb tide channel runs close to the shoreline, with the stronger currents of the flood tide channel situated further offshore (Figure 9, Figure 8). The ebb tide channel is likely to have a dominant influence on shoreline dynamics along the majority of the Seventeen Seventy coastline. This is particularly the case for the northern and southern ends of the residential shoreline, where the ebb tide channel runs very close to the beach (Figure 9).

Figure 9. *Examples of flood and ebb tide channel locations at Seventeen Seventy*

Wind

The regional wind climate shown in Figure 10 is based on the closest wind stations located in Gladstone and Bundaberg. The wind roses, developed using the BoM AWS data spanning 2010 to 2019, indicate a dominant wind direction from the south-south-east, with intermittent periods from other directions.

The dominant south-east winds are linked to the development of the parabolic dune field north of Agnes Water, and there is potential for wind-generated waves over the long south-westerly fetch at Seventeen Seventy to reach the shoreline (during periods of wind from that direction).

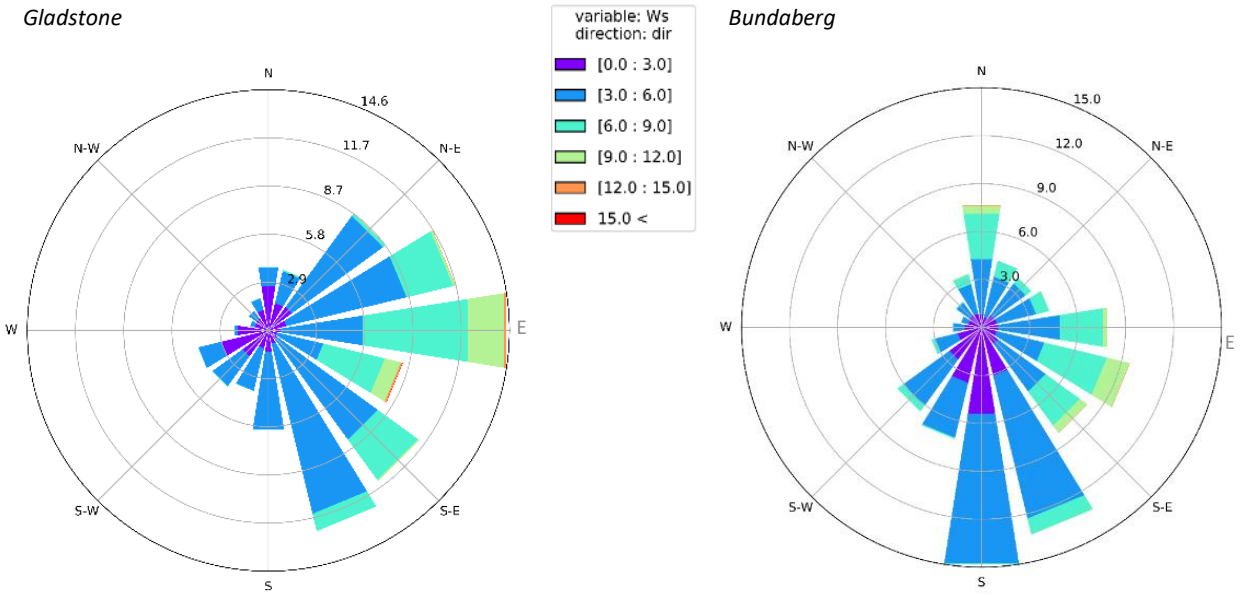


Figure 10. *Wind conditions at Gladstone (left) and Bundaberg (right) (the wind rose shows the occurrence of winds magnitude, direction and frequency of wind)*

Waves and sediment transport

A review of Gladstone and Bundaberg wave buoy data, and development of a SWAN numerical wave model have been completed for this SEMP study (Attachment A). Statistical data analysis and model outputs include an improved understanding of offshore wave conditions, and nearshore wave and storm tide conditions. Outputs (noted in Attachment A, have been used to inform an appreciation of sediment transport rates along the Agnes Water coastline, and present day erosion potential along the residential shorelines of Agnes Water and Seventeen Seventy.

Longshore sediment transport between Agnes Water and Round Hill Head results predominantly from waves breaking at an angle to the shore, which mobilises sand and creates a current in the nearshore area. These processes lead to the transportation of sand in the general direction of the wave action.

Ten years of wave conditions were simulated through the SWAN wave model and used within JBEM (refer Attachment A), in conjunction with the Rosslyn tide gauge records, to estimate sediment transport rate between January 2009 and December 2018. This was calculated at several positions along the coastline between Agnes Water and Round Head Hill. Figure 11 shows a schematic of the longshore sediment transport (LST) pathways, and the following observations are noted:

- At Agnes Water, which is offered protection from southerly swell through coastal headlands, the modelled LST is of the order 11,000 m^3/year towards the north
- As the coastline continues north it becomes further exposed to wave action and is oriented away from the dominant wave direction. The modelled LST increases to over 24,000 m^3/year towards the north.
- Towards the headland, and most exposed section of the coastline (to prevailing wind and greatest fetch), the LST rate increases to between 30,000 to 34,000 m^3/year.

These trends of a dominant northerly sediment transport are consistent with the parabolic dune field and observed sediment accretion from the historical imagery (discussed in Section 2.4).

Daily analysis of the wave and sediment conditions indicate little reverse (southerly) transport, which is limited due to the infrequent northerly waves. Consequently, the southern end of the Agnes Water Main Beach may be prone to periods of sediment deficit leading to recession. Sand can be transported northward where it will build up on the southern side of Round Hill Head or be passed around the headland towards Round Hill creek where it adds to the mobile shoals.

Figure 11. *Estimated longshore sediment transport rates along the Agnes Water coastline m³ per year*

2.3 Erosion Prone Area

2100 State mapping

The Queensland State Government defines Erosion Prone Areas (EPA) for the Queensland Coastline. The EPA indicates areas that may be prone to coastal erosion processes by 2100. This includes open coast erosion and tidal inundation due to sea level rise, based on a storm event with a 1% AEP (annual exceedance probability). The EPA extent for Agnes Water and Seventeen Seventy includes areas likely to be exposed to open coast erosion (sandy beach erodible area) and tidal inundation by 2100 (Figure 12). Tidal inundation includes the area represented by the combined mapping of Highest Astronomical Tide (HAT) plus 0.8 m sea level rise, and a HAT plus 40 m (horizontal) default zone.

Observations from the State 2100 EPA mapping include:

- The majority of the shoreline at Agnes Water and at Seventeen Seventy falls within the 2100 EPA, including areas of residential land use
- The open coast component of the EPA (sandy beach erodible area) is likely to be the dominant component of the EPA affecting residential shorelines, except for southern parts of Seventeen Seventy (where tidal inundation dominates)
- A zone of increased tidal extent is expected around the Round Hill Creek estuary margins.

Longer term adaptation options are being considered in the Coastal Hazard Adaptation Strategy currently being developed for Council. For the SEMP process, the EPA assists to highlight areas that may be increasingly prone to the emerging coastal hazards from present day to 2100.

Present day

For this SEMP study, additional modelling has been completed to estimate the present day erosion volume (storm bite) and width for a 1% AEP storm event for both Agnes Water and Seventeen Seventy.

Modelling of the open coast component of the erosion prone area has been undertaken using the JBP Erosion Prone Area (JEPA) tool (refer Attachment A for approach and results). The outcome of the modelling provides an indication of potential present-day erosion volume (from dunes) and erosion width (measured landward from HAT) for a 1% AEP event (Table 2, Figure 13, Figure 14).

The present day 1% AEP erosion width at Agnes Water is in the order of 35% of the 2100 erosion width component (Table 2), and this is consistent with other trends (present day vs 2100) across QLD.

The present day 1% AEP erosion width at Seventeen Seventy is in the order of 65% of the 2100 erosion width component. The relatively large erosion width at Seventeen Seventy compared to sand volume loss is linked to the shallow beach profile and other elements of the site setting. It is expected that tidal processes and the presence of offshore sand banks will also have a significant influence on dynamics of the site. As such, the present day estimates of potential erosion volumes are indicative only and may be conservative.

Table 2. Summary of short-term, cross-shore erosion width at Agnes Water and Seventeen Seventy

Site	Potential erosion volume (m^3/m) for present day 1%AEP	Potential erosion width from HAT (m) for present day 1% AEP	State open coast erosion calculated component width (m) for 2100 1% AEP
Agnes Water GLR019	9.9	17.6	50 m
Seventeen Seventy (Endeavour Park) GLR021	3.4*	19.1*	30 m

** Lower confidence in modelled outputs due to site setting (tidal processes and offshore sand banks)*

Figure 12. *State 2100 Erosion Prone Area*

Figure 13. *Seventeen Seventy present day 1% AEP modelled erodible width (for State segment GLR021)*

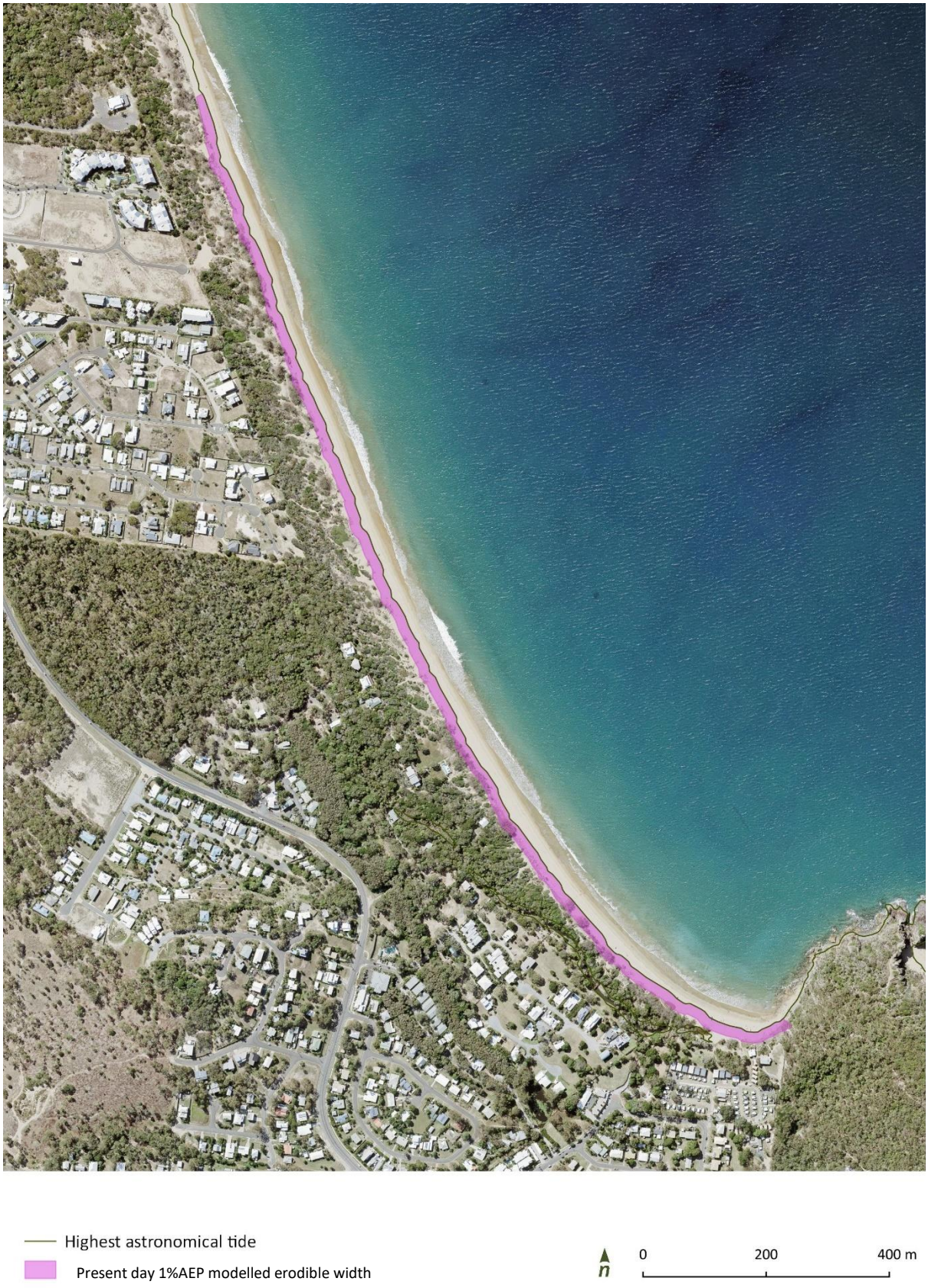


Figure 14. *Agnes Water present day 1%AEP modelled erodible width (for State segment GLR019)*

Observations from the present day potential 1% AEP erosion widths include:

Seventeen Seventy (Figure 13)

- A length of Captain Cook Drive at the northern end of the shoreline is potentially impacted
- The erosion width comes close to Captain Cook Drive in the central area of Endeavour Park
- Foreshore area likely to be impacted including the boardwalk
- No residential properties or other critical infrastructure likely to be impacted.

Agnes Water (Figure 14)

- Erosion width extends across upper beach and into the toe of the vegetated dune system
- May impact on access points
- No residential properties or other critical infrastructure likely to be impacted.

2.4 Trends in shoreline change

Macro changes
The broader coastline of Agnes Water and Seventeen Seventy has been relatively stable over recent decades. However, Round Hill Creek inlet has regularly shifted and changed, as it influenced by fluvial and tidal processes (Figure 15, Figure 16, Figure 17, Figure 18).

Observations from the historical aerial imagery spanning 1959 to 2018 include:

- Regular shifting of tidal channels, sand banks and shoals at the mouth of Round Hill Creek estuary and adjacent to the Seventeen Seventy shoreline
- Significant changes in the alignment of channels at the mouth of Round Hill Creek estuary – linked to dynamic process and likely dredging operations as well
- The progressive development of more defined sand banks offshore (500 m approx.) from the residential shoreline of Seventeen Seventy
- No major losses or gains of sediment at particular locations along the coastline north and south of Agnes Water
- Road and residential development commencing from early 1970s, and expanding to present day extents.

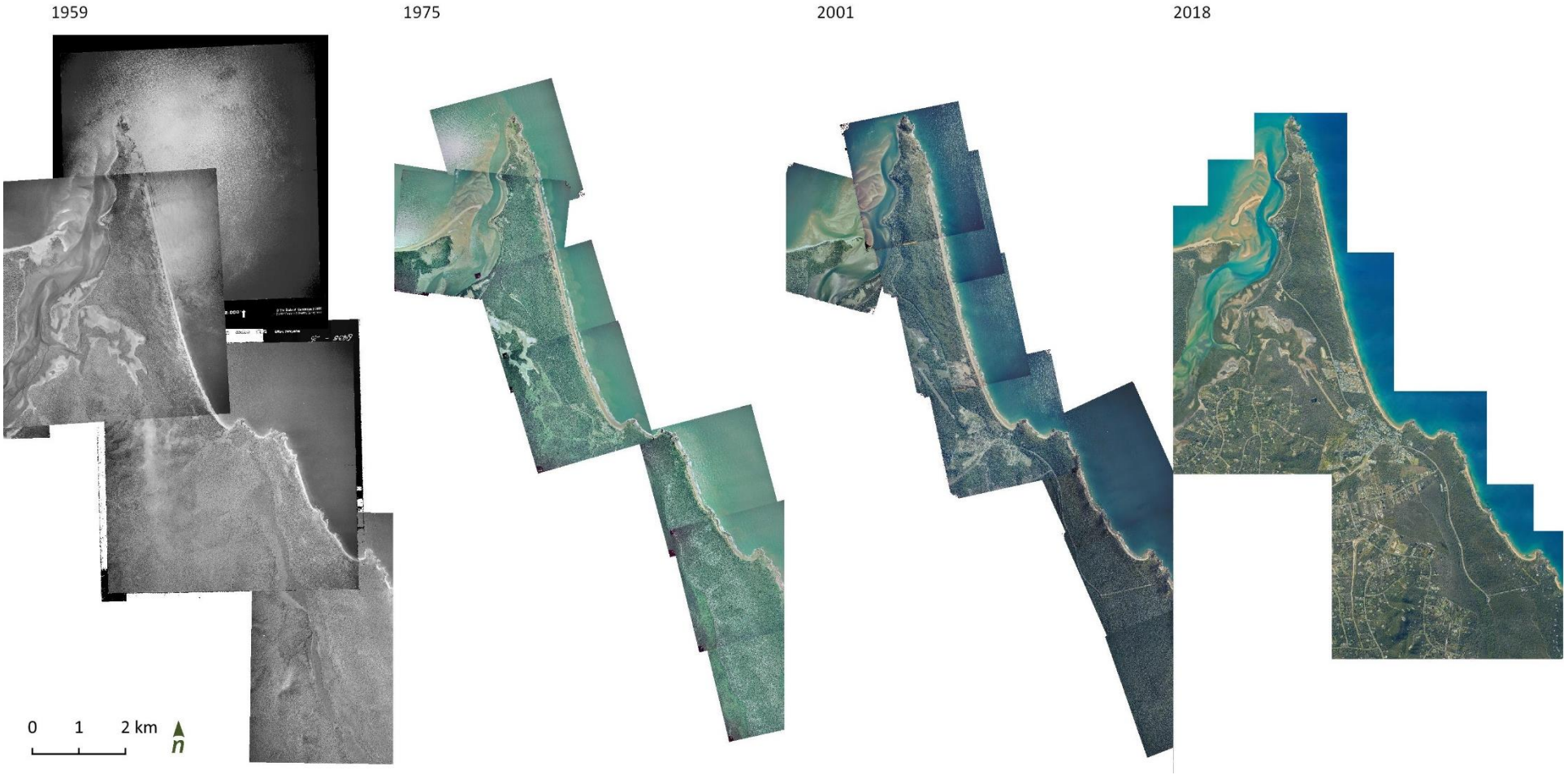


Figure 15. *Historical aerial imagery overview of the coastline (1959 to 2018)*

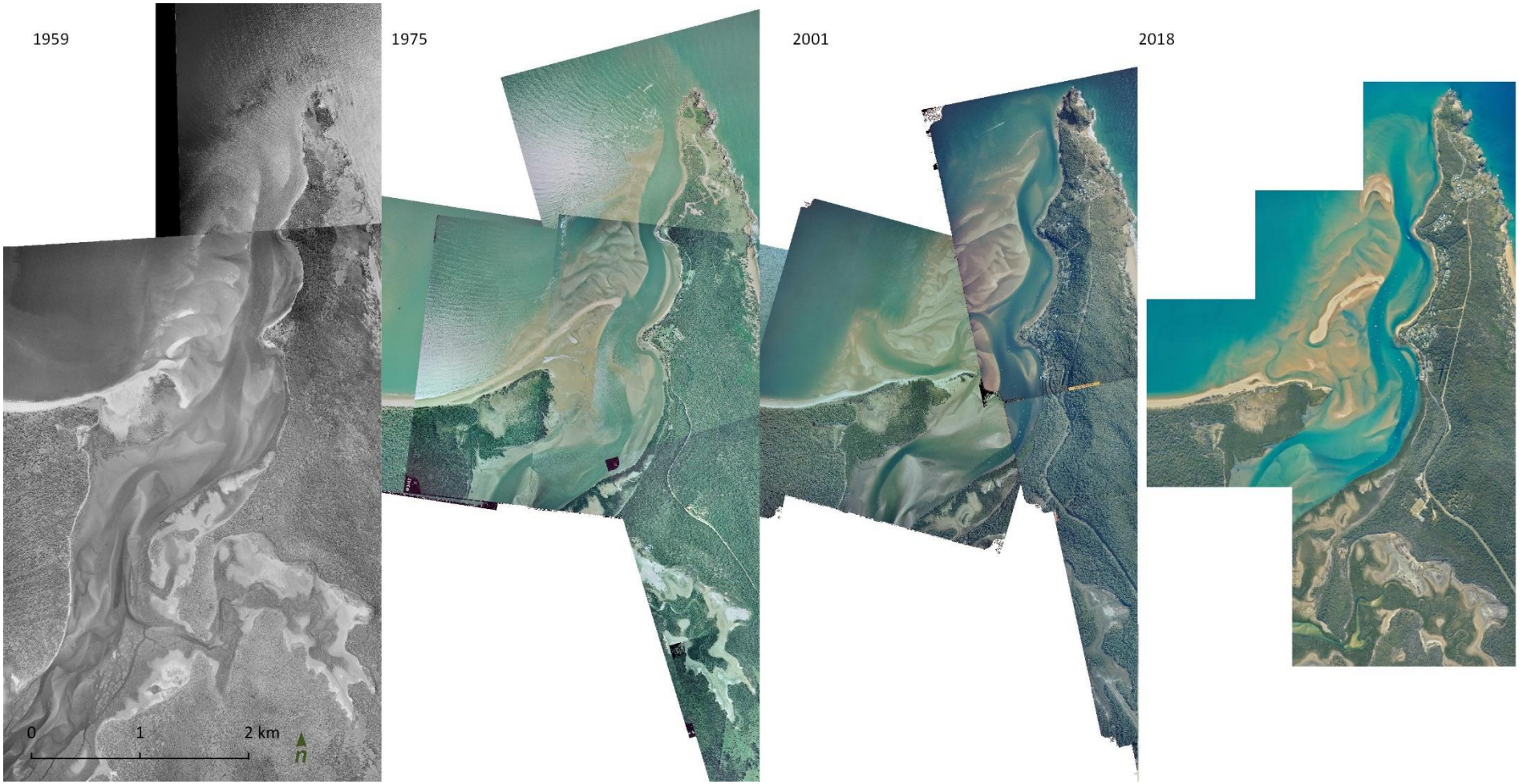


Figure 16. *Historical aerial imagery for Seventeen Seventy (1959 to 2018)*

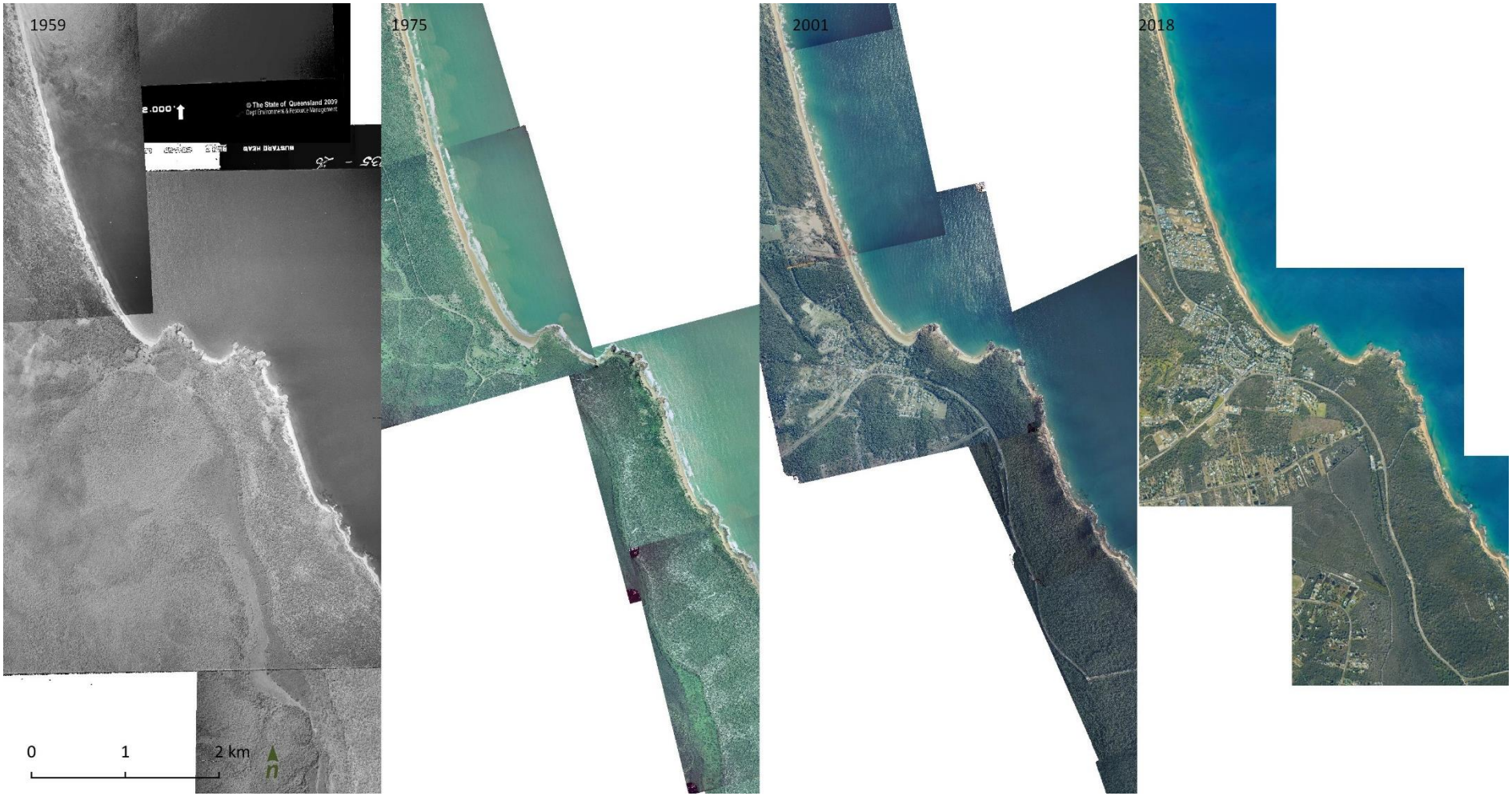


Figure 17. *Historical aerial imagery for Agnes Water Main Beach (1959 to 2018).*

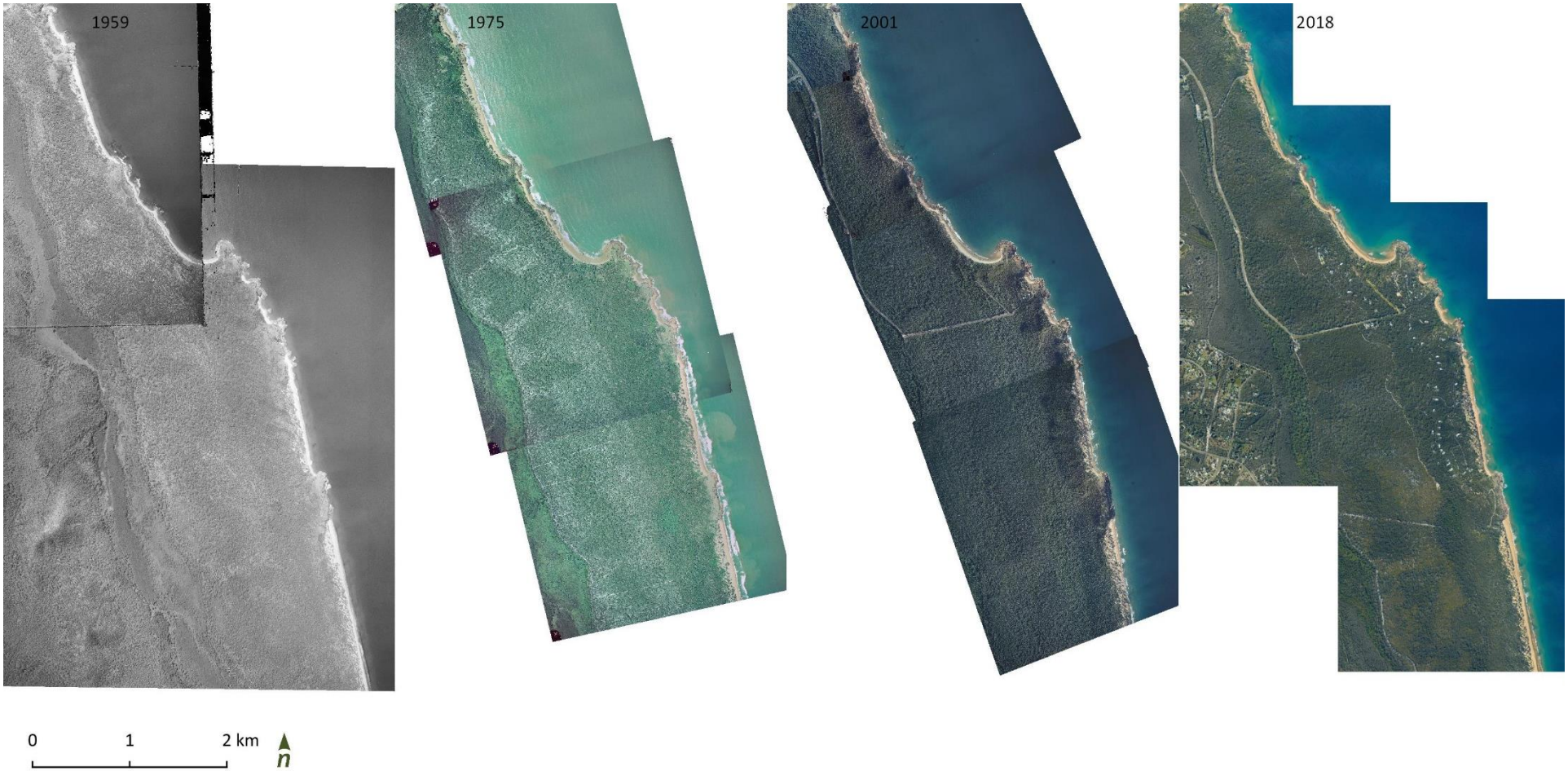


Figure 18. *Historical aerial imagery for south of Agnes Water (1959 to 2018).*

Shoreline movements

The Digital Shoreline Analysis System (DSAS) for ArcGIS was used to identify finer scale historical shoreline changes and trends (see Attachment B for details). Key observations include (refer to Figure 19):

- A trend of moderate incremental recession at the southern end of the Agnes Water coastline, and accretion further north towards Round Head headland. This is consistent with the sediment transport rate estimates along the coastline as previously described.
- Variable pockets of accretion and recession along the sandy pocket beaches of the rocky coastline to the south of Agnes Water.
- A localised area of recession at the northern extent of the Seventeen Seventy shoreline – where the Captain Cook Road runs close to the coast. This is consistent with the area exposed to the 1% AEP event as previously described.
- More broadly, shoreline recession at Seventeen Seventy has slowed from 1975 onwards, and the shoreline has been in a relatively stable position since 2001.

In the areas that have experienced recession, the End Point Rate (EPR) of change (over 1959 – 2018) is relatively moderate, in the order of 0.15 to 0.5 m per year. Linear Regression Rates (LRR) of change are also moderate, with rates in the order of -0.45 to +0.65 m per year. Attachment B provides additional detail on rates of change along the full Seventeen Seventy and Agnes Water shorelines.

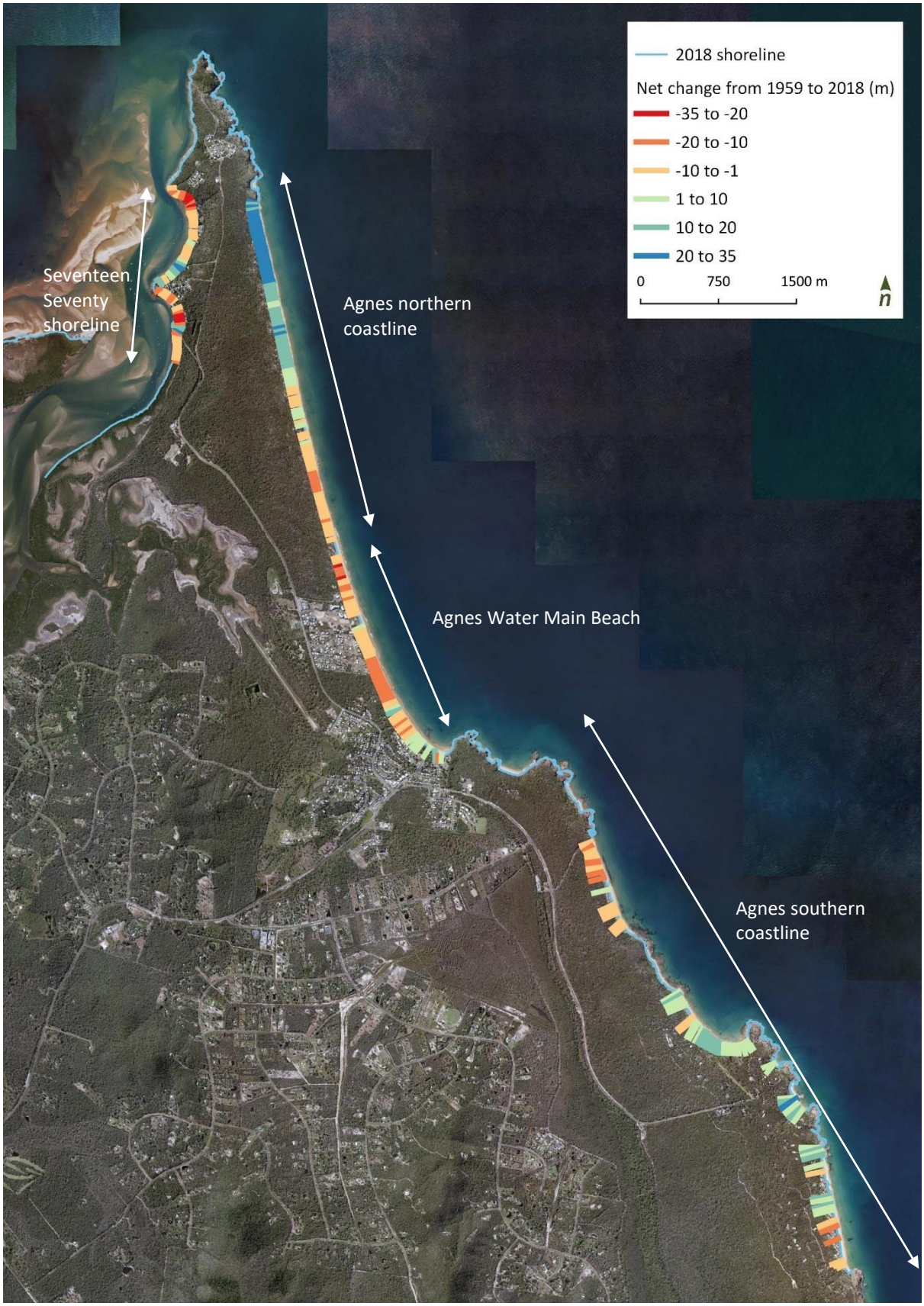


Figure 19. *Net shoreline movement from 1959 to 2018 (m) – seaward accretion (+ve change) or landward recession (-ve change) measured from transects spaced at 20 m intervals along the shoreline*

2.5 Present day shoreline – Agnes Water

Field assessments at Agnes Water and Seventeen Seventy were carried out by Alluvium, JBP and GRC on 7th June 2019 and Alluvium and GRC on 28th August 2019. The main findings following these assessments are summarised below. Additional site-specific notes are included in Attachment C. Sections of shoreline described in the following sections are as noted in Figure 19.

Agnes Water Main Beach (residential shoreline)
Agnes Water Main Beach extends approximately 2 km along the coast, adjacent to areas of residential landuse, including properties and infrastructure located behind and within the dune system.

The wide sandy beach (Figure 20) is backed by elevated vegetated dunes, that are prone to developing a storm bite erosion scarp during large storm events, which can impact on access points (and associated infrastructure).

Coastal management activities to date along this section of shoreline include revegetation of eroded and bare sections of dune, and modifications to beach access points – with a change from past rigid wooden structures towards more flexible measures that can move with the dune and changing profile (ie. chain and timber plank walkways). This approach aids the longevity and functionality of the access point structure, however is also observed to become quite steep in grade after storm activity.

There is currently a setback of 30 m + between residential properties and the active beach along the majority of this section of shoreline. Towards the southern end of the Main Beach most of the land seaward of developed areas is dedicated nature reserve, however there are also a number of freehold properties with boundaries that extend to the beach some with private access points and structures within the dune.

The Surf Life Saving Club (SLSC) is just north of the Agnes Water township with patrols predominantly conducted towards the more highly frequented southern end, near the caravan park and main beach accessway. Dunes within near vicinity of the club are experiencing erosion, with fencing, vegetation and access structures having been lost as a result. There are sections of bare dune, resulting from storm events as well as damage, potentially a result of development behind the dune and informal access.

The southern most section of Agnes Water Main Beach is a Caravan Park and the current mouth of a small coastal creek/lagoon. In front of the caravan park there is evidence of the tide reaching almost up to creek water levels at the time of inspection. Efforts at dune protection and management in the form of palm fronds and branches are being undertaken, as well as signage to deter thoroughfare over the dunes (informal access). This creek entrance relies on natural opening through high creek outflows, and though it was closed during inspection, there was evidence that it had been recently open. Intermittently closed and open lakes and lagoons (ICOLLS) are natural features in the coastal environment, and regularly alter the position of the creek mouth during high flow events.

Figure 20. *Agnes Water main beach looking towards most southern end*

Agnes coastline to the north and south

Northern coastline

To the north of Agnes Water towards the Round Hill headland, is the extensive parabolic dune field previously described. Land behind this section of shoreline remains undeveloped and is listed as National Park and nature/forest reserve. The elevation of primary dunes ranged from ~ 2 m to over 10 m, with some steep sections and some sparsely vegetated areas showing signs of erosion.

Southern coastline

The coastline south of Agnes Water township, through to Red Rocks, includes sand pocket beaches along the rocky coastline including Workman's, Chinamans and Springs Beaches. These beaches are all situated well away from any residential areas/properties.

Workman's Beach (Figure 21) is a pocket beach that is confined by headlands to the north and south and is relatively protected from the offshore coastal processes. The beach has a relatively flat profile with a gentle slope, and is backed by a vegetated slope and a cliff that is 30 to 40 m high. An erosion scarp runs along the length of the beach varying in elevation, approximately 0.2 - 0.3 m in northern end, and 1 to 2 m towards the southern end. Rocky material, up to 10-15 cm diameter, is eroding from sections of the escarpment.

Figure 21. *Workman's Beach south of Agnes Water looking north*

Chinamans Beach is fairly exposed to open coast processes, with steep beach profile resulting from a high energy wave climate. There is a headland to the northern extent of this beach. Chinamans Beach is backed by an approximately 200 m wide sloping vegetated dune. A desalination outfall and pump station are situated at this beach, along with an access road and small carpark. Geofabric bags have been used to limit scouring and protect some of the desalination infrastructure, with some bags currently exposed due to loss of sand.

Figure 22. *Chinamans Beach at Agnes Water looking south*

Springs Beach, further south between Chinamans Beach and prior to Red Rocks headland, has a similar exposure and profile to Chinamans, being high energy, steep beach profile, and backed by wide vegetated dune systems. 4WD only access and thoroughfares for private property mean that this section is likely to be less frequented that other beaches in the area.

Figure 23. *Springs Beach at Agnes Water looking north*

2.6 Present day shoreline - Seventeen Seventy

North of residential shoreline - Round Hill Head to Cooks Landing Place (Monument Point)
The coastline around Round Hill Head itself comprises of rocky cliffs with minimal sand beach. From Round Hill Head towards Cooks Landing Place, the coast remains mostly rocky with small beaches and sand accumulation between outcrops.

Figure 24. *Cooks Landing Place (Monument Point), facing north east towards Round Hill Head*

Residential shoreline - foreshore reserve (Monument Point, 1770 Camping Ground to Seventeen Seventy township)
From Monument Point through to Seventeen Seventy township, there a considerable amount infrastructure within the foreshore reserve, including 1770 Camping Ground, Endeavour Park, boardwalk, picnic facilities, carparks and an amenities block.

South of Monument Point the adjacent road, Captain Cook Drive, has minimal shoulder, (<10 m from the beach) and erosion is evident along a 50 – 100 m extent (corresponding to the area exposed to the 1% AEP

noted previously). Further south at the camping ground, the sandy beach is of relatively low gradient (Figure 25), and mangroves communities are present in sections of the shoreline.

Figure 25. *Foreshore at 1770 Camping Ground, facing north towards Monument Point (Cook's Landing Place*

At Endeavour Park, the beach remains at a low gradient (flat) with scattered mangroves. There is visible erosion, with small scarps evident, undermining of footpath and concrete pad for a picnic table. Some geofabric bags have been placed on a section of the beach to mitigate erosion, and fencing has been constructed around the eroded areas as a safety measure to restrict access. Sections of exposed bedrock underlying the sand are also evident.

Part of the boardwalk (Figure 26) is currently closed due to safety as the foundations have become exposed and a small section has collapsed as a result of scour. Building rubble and rocks have been placed in an effort to armour the erosion scarp and boardwalk foundations.

Figure 26. *Seventeen Seventy boardwalk between Endeavor Park and Seventeen Seventy township, facing south west*

There are several sections of boardwalk that run along the foreshore, from Endeavour Park through to the township. At the township, there is a wider, vegetated and gently sloping foreshore reserve. The timber boardwalk at this location has sections of rock armouring around its foundations, some parts of which have slumped. Boats and kayaks are stored along the reserve – in areas assumed to not be significantly inundated under typical tidal conditions (Figure 27).

Figure 27. *Recreational area along the foreshore at Seventeen Seventy*

Residential shoreline – Marina and adjacent coast

At the Seventeen Seventy Marina, infrastructure includes the boat ramp and the pontoon providing boat launching and boarding facilities, while adjacent buildings house the Volunteer Marine Rescue, a cafe and tourism operators. Rock revetments are used to armour sections of the foreshore. Mangrove communities are present along the shoreline of this section of beach. North of the marina, there is also an informal boat/kayak launching area where the Captain Cook Highway nears the coast.

Figure 28. *Boat ramp and pontoon at Seventeen Seventy Marina, facing north*

2.7 Trajectory of change and management focus

The prevailing coastal processes will continue to drive episodes of erosion along the Agnes Water and Seventeen Seventy shorelines over the coming decades.

With a changing climate and projected sea level rise, the area prone to erosion and tidal inundation, and the magnitude of erosion in storm events, is expected to increase.

Assets and infrastructure at both Agnes Water and Seventeen Seventy are positioned such that erosion has already impacted on key infrastructure. Erosion will continue to have adverse impacts on shoreline amenity, recreation and other social and economic values for the towns and region.

The management focus for the SEMP includes:

- Part A – Seventeen Seventy
- Part B – Agnes Water Main Beach

The overall intent of actions associated with Part A and Part B of the SEMP is to manage erosion in a way that maximises social, economic and environmental benefits for the community.

3 Coastal values

Agnes Water and Seventeen Seventy hold significant environmental, social and economic values to the Gladstone Region, including the Traditional Owners, the communities that reside there, and visitors. This section provides a summary of key values to protect / consider in the management of shoreline erosion processes.

3.1 Environmental values

Agnes Water and Seventeen Seventy are located in close proximity to the Great Barrier Reef and are also surrounded by an abundance of vegetation and native wildlife habitat that is of State and National significance Figure 29.

Figure 29. *State mapped environmental values of Agnes Water and Seventeen Seventy (MSES – Matters of State and Environmental Significance).*

3.2 Cultural values

The Bailai, Gurang, Gooreng Gooreng and Taribeland Bunda People are the Traditional Owners within the Gladstone Region. The coastal region of the Gladstone LGA, including the shoreline from Round Hill Creek mouth to Round Hill Head is held under Native Title. This Native Title hold extends south around the headland towards Agnes Water to the surf club. An additional area is held under Native Title from the headland north of Workman's Beach south to Rocky Point (Figure 30). Indigenous cultural identity is intrinsically linked to the condition of the natural components of the region (GBRMPA 2019).

Figure 30. *Native title boundaries within Agnes Water and Seventeen Seventy.*

3.3 Economic values

The main industry in Agnes Water and Seventeen Seventy is tourism. The towns provide access to the southern GBR and Agnes Water is the northernmost surf beach in Queensland. The annual 1770 Festival celebrates the landing of Captain Cook at Bustard Bay, with a re-enactment of the historic event (Figure 31).

The towns contribute to the broader tourism industry of the Gladstone Region. During the 2017/18 financial year, the total value added to the Gladstone Region economy from tourism was $87.6 million (NIEIR 2018). International tourists accounted for 20 % of the total number of visitors.

Figure 31. *Re-enactment of Captain Cook's landing during the Town of 1770 Festival (https://www.queensland.com/en-au/event/1770-festival)*

3.4 Community input – workshop 1

A community workshop was held on the 27th August 2019. The purpose of the meeting was to:

- Provide an overview of the project, the purpose of the Shoreline Erosion Management Plan and coastal policy setting
- Provide an introduction to coastal processes and hazards, including an introduction to dynamic coastal processes, interactions with the shoreline and built structures and ecosystems, and factors that lead to inundation and erosion (tides, storm surges, waves, overtopping) (Figure 32)
- Gather history, insights and perspectives of the local community in relation to shoreline erosion management

During the meeting, a timeline of events significant to coastal management and development was established (Figure 33) and significant assets, values and issues relating to coastal management were identified (Table 3).

Figure 32. *Discussing coastal processes and identifying values and issues along the shorelines at Agnes Water and Seventeen Seventy*

The values and desired outcomes identified by the community are factored into the objectives for management for the SEMP (Section 4.1). The intent of the SEMP is to ensure that options proposed for managing erosion at Agnes Water and Seventeen Seventy are consistent with the values and desired outcomes of the community and key stakeholders.

Table 3. Assets/values of the Agnes Water coastline, current issues and desired outcomes

Assets/values	
	Recreational fishing
	Boat ramp (including safe access and egress under all tidal conditions)
	Flora and fauna (terrestrial and aquatic), in particular EPBC listed flora and fauna (e.g. turtles)
	Coastal ecosystems (natural beauty)
	Recreational access, aesthetics and beach facilities
	Tourism (economic driver)

Current issues
• Erosion and retreat of dunes following major storm/cyclone events • Anthropogenic and development impacts to sand dunes, tree plantings damaged • Beach fires, weed infestations • Insufficient boat landing facilities • Sand infilling in Round Hill Creek mouth limiting boat access at low tide and detracting visitors • Boardwalk and beach stair access damaged following storm/cyclone events • Infrastructure covering sand • Existing erosion protection is deteriorating • Low pressure sewer system exposed and failing during storm events, resulting in raw sewerage outfall

Desired outcomes
• Protect sand dunes • Protect and enhance habitat and remnant vegetation • Maintain aesthetics and recreation value • Maintain tourism • Maintain historical connection • Maintain fishing access • Protect sand dunes

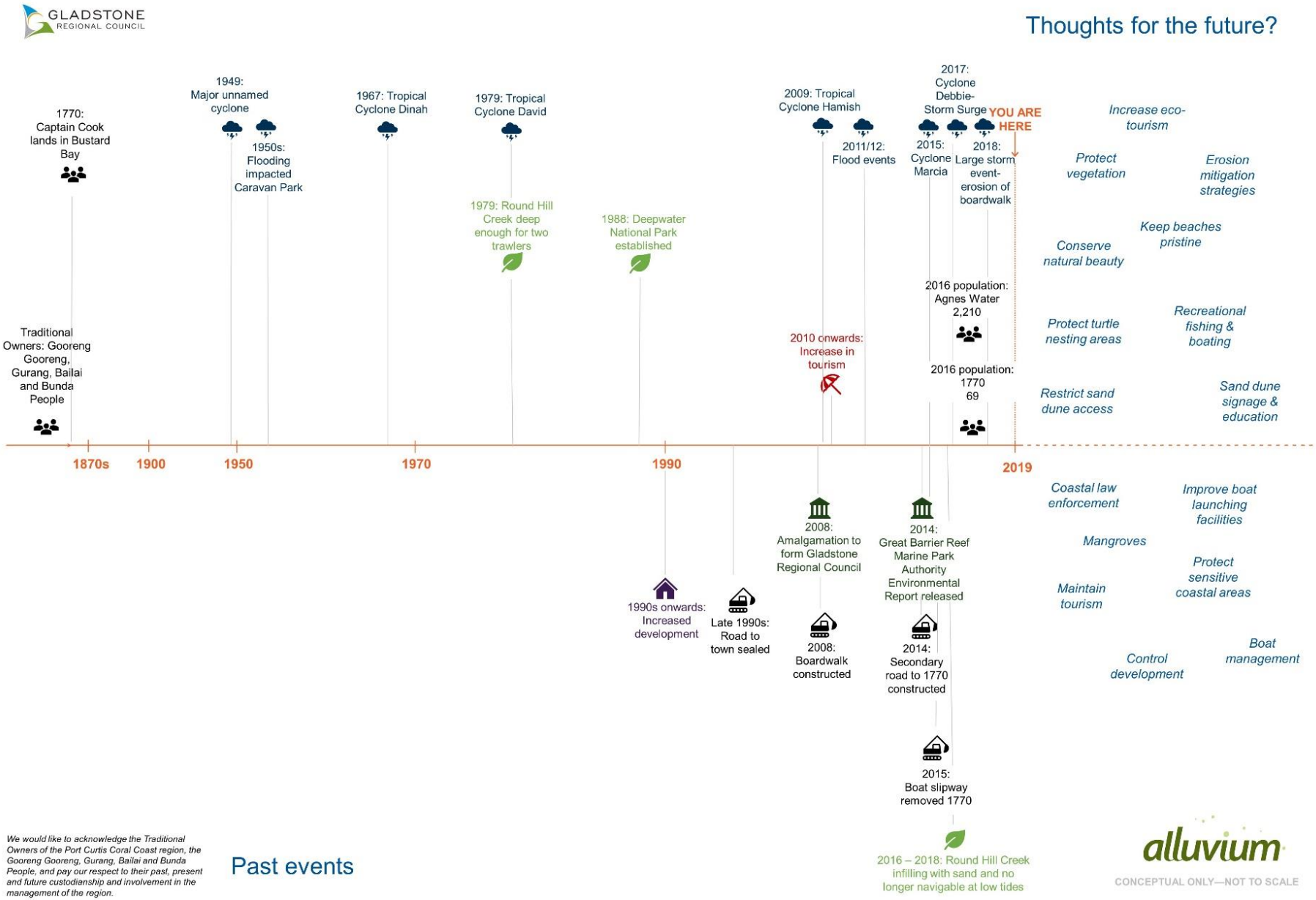


Figure 33. *Agnes Water and Seventeen Seventy - timeline of past events and thoughts for the future - compiled by community stakeholders (August 2019)*

4 Management options and suitability

As noted previously (Section 2.7), two focus areas are defined for this SEMP:

- Part A – Seventeen Seventy
- Part B – Agnes Water Main Beach

The overall intent of actions associated with Part A, Part B of the SEMP is to manage erosion in a way that maximises social, economic and environmental benefits for the community.

General principles for management that apply to all sites include:

- Minimise disturbance to dunes and vegetation, including limiting access points across dunes, and along the dune toe
- Enhance dune vegetation – which assists to trap windblown sand and assist dunes to accrete / build up
- Boost additional dune care actions, including sand fencing and revegetation of dunes, to enhance natural dune building processes between storm events.

In addition to these principles, some additional actions may be required at each site, as noted in the following sections.

4.1 Part A – Seventeen Seventy

Management options and suitability, and proposed actions are considered for two sites along the Seventeen Seventy shoreline.

Site 1 – Captain Cook Drive

Approximately 50 – 100 m of Captain Cook Drive is situated in an area at the northern extent of the Seventeen Seventy shoreline (Figure 34) that is experiencing recession and is exposed to the present day 1% AEP event. This road is the only access road to development areas on the Round Hill headland, and as such is considered a critical asset.

Properly designed revetment protection for the road is likely to be needed here as the last line of defence to protect the road asset.

Indicative cost estimates for the revetment are provided in Table 4. Alternatively, a trial of extending the nourishment volume option from Site 2 (discussed in following section) could be considered, with a plan for routine nourishment in front of the road as well.

Action 1 – Develop detailed design of protection works for the road, and confirm timing (or triggers) for implementation

Table 4. Indicative revetment costs

		m	$/m	$	$	$	$
Location	**Options**	**Length**	**Unit rate**	**Estimated cost**	**Cost w bias (60%)**	**Ten year maintenance cost**	**Construction and maintenance (TOTAL)**
Captain Cook Drive – Northern Endeavour Park	Rock revetment	150	7,000	1,050,000	1,680,000	16,800	1,696,800

Figure 34. *Section of Captain Cook Drive exposed – general extent for revetment works*

Site 2 – Seventeen Seventy main beach

At the Seventeen Seventy main shoreline (Endeavour Park) (Figure 35) the ongoing erosion and tidal inundation concerns observed for the site over the next few decades may require:

- Acceptance of an alternative future state for the shoreline, that may include a gradual transition from a sandy shoreline to increased tidal flats, mangroves, and the transition of some foreshore reserve area over time to tidal area.

  In adapting to this change, the boardwalk could be relocated and/or upgraded during current repairs to exist as a 'wet' feature that can withstand frequent tidal inundation of the foundations, and potentially provide a boardwalk over water experience.

  A 'trigger' for the future establishment of additional protection works (e.g. a seawall as a last line of defence for the road) could also be established.

- AND/OR - Active management to maintain a sandy shoreline, and provide a sandy buffer between the sea and the boardwalk, reserve and road.

  Active management could be part of the long-term management strategy, or for a shorter period of time as part of the transition strategy.

If the preference for implementation of the current SEMP, over the next 20 years, is to actively manage the shoreline to maintain existing use, amenity and provide erosion protection to key assets, then the following options are considered for the main Seventeen Seventy shoreline.

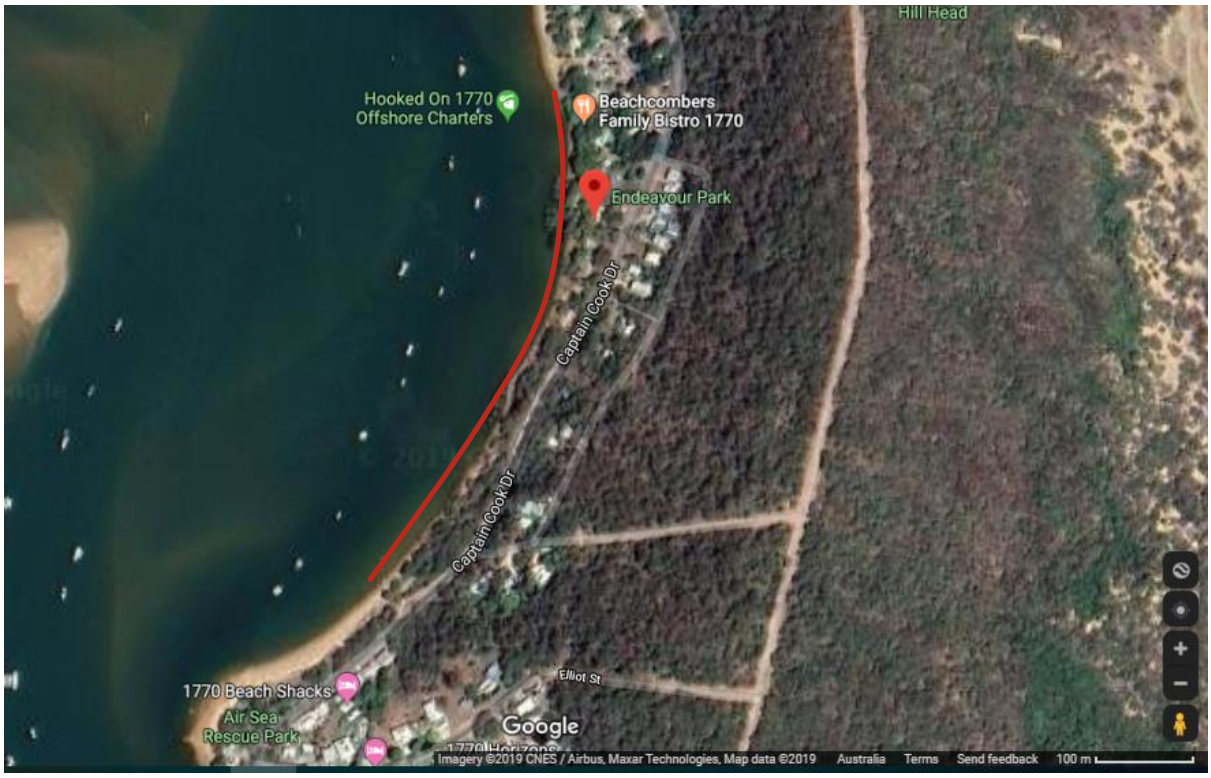


Figure 35. *Seventeen Seventy main shoreline – Endeavour Park – general extent for erosion mitigation works*

There are a range of shoreline erosion management options applied in different contexts across Australia and abroad, however preferred options vary depending on site context and stakeholder preferences.

Seawall / revetment Typically made of rock, concrete, geo-fabric bags or wood, seawalls provide an artificial barrier to erosive processes and protect the coastal assets behind them. They can be either exposed or buried and generally require extensive excavation. A seawall also has limited ability to dissipate energy and generally results in accelerated scour of sand from the base of the wall. Less formal revetments can also be implemented through placement of rock or geo-bags.	 
Groynes Built perpendicular to the coast, groynes can be constructed from a variety of materials, including rock, geo-bags, concrete or wood. Groynes assist with sand retention in areas prone to longshore drift. Sediment is captured on the updrift side, while erosion generally occurs on the downdrift side. Groynes can be formally engineered with excavation, or less formally constructed. They can vary in length, dependent on the sediment transport environment at the site and level of protection required. In some cases, groynes can also be orientated to provide a barrier to wave energy.	  
Breakwater Constructed offshore and generally parallel to the shore, breakwaters dissipate wave energy prior to impacting the beach. Breakwaters are generally constructed of rock or concrete and can be partially or entirely submerged.	
Artificial reef Similar to a breakwater, an artificial reef also reduces the wave energy impacting on the beach. Artificial reefs often have greater habitat value and encourage marine life to establish, mimicking natural reef systems.	
Sand nourishment Sand can be sourced from offshore through dredging or other sources and can be imported or sprayed onto the beach to increase the volume of sand on the beach. Sand can be nourished utilising an external sand source (e.g. river mouth or offshore deposits), or sand scraping can be used to redistribute sand already on the beach. Sand can be shaped to provide a dune system that is stabilised with fencing and vegetation.	 
Vegetation establishment Native coastal vegetation can be sourced and planted to provide stability to a newly established sand dune. This can be through direct seeding or the planting of established vegetation to diffuse wind and wave action and allow for sand retention. Revegetation species will be dependent on the coastal environment, level of protection and salinity.	

A set of criteria were developed for the initial screening of management options. These criteria were informed by stakeholder discussions and input (Section 3.4), and an understanding of the short- and long-term needs and constraints at Seventeen Seventy.

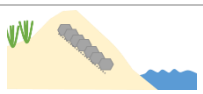
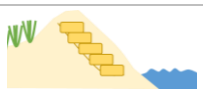
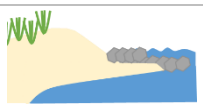
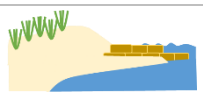
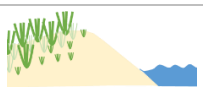
Suitable options for erosion management of the northern point should:

- Be in accord with QLD State Government policy for coastal management.
- Meet necessary planning approvals requirements for the site setting.
- Be feasible for available budgets and funding sources.

- Be in accord with community expectations - The option should align with expectation of local community stakeholders. This includes the values of the site and desired outcomes from management actions.
- Enable prompt action.

An initial screening of the range of options for Seventeen Seventy main shoreline against the criteria is provided in Table 5.

Table 5. Options assessment summary

			Be in accord with State planning policy	Meet planning approvals requirements	Be feasible within budgets and funding sources	Be in accord with community expectations	Enable prompt action
Formal seawall	Rock						
	Geobag						
Formal groyne	Rock						
	Geobag						
Breakwater							
Artificial reef							
Sand nourishment							
Revegetation							

Best meets criteria
May meet criteria
Unlikely to meet criteria

Nourishment, revegetation and the potential to include a series of groynes to assist with sand retention, are considered the most feasible options for the site. Indicative costs are provided in Table 6. The option can be altered to be only nourishment as well. Geobags are preferred for the site as a trial to ensure sand retention occurs as expected. After a period of time (15 – 20 years) groynes could be replaced with rock if desired.

Table 6. Indicative nourishment and geobag groynes cost

			m	$/m		$	$	$/year	$	$
Location	**Options**		**Length**	**Unit rate**	**Unit**	**Estimated cost**	**Cost w bias (60%)**	**Maintenance /year**	**Ten year maintenance cost**	**Construction and maintenance - TOTAL $**
Endeavour park	Sand nourishment & groyne	Sand	10,000	40	$/m^3	400,000	640,000		-	640,000
		Groynes (geobags) @50m spacing	180	5,000	$/m	900,000	1,440,000	14,400	144,000	1,584,000
		Total				**1,300,000**	**2,080,000**	**14,400**	**144,000**	**2,224,000**

The preferred approach for Site 2 at Seventeen Seventy is to:

- Begin planning for the future state of the shoreline with increased tidal inundation, and restore the Boardwalk to sufficient design specifications for that scenario
- Include (if desired) a period (10 years) of sand nourishment, while a transition plan is set in place for the foreshore (if appliable) and as part of the CHAS process
- Trial the addition of geobag groynes (if desired) to assist with retention of placed sand.

Action 2 – Confirm implementation plan for maintaining or transitioning the Seventeen Seventy main shoreline, including detailed designs associated with boardwalk repair/modification, and erosion protection works (beach nourishment, groynes) if applicable

4.2 Part B – Agnes Water Main Beach

At Agnes Water Main Beach, current set back distances between assets (houses, roads) and the active beach are in the order of 50+ m. Erosion does periodically impact beach access points and there is evidence of gradual long term recession at the site.

For the SEMP planning period (5 – 10 years), erosion can be managed by working with the natural coastal processes to restore dunes and encourage growth between storm events.

Erosion at Agnes Water Main Beach can be actively managed through:

A. Minimising disturbance to dune form and vegetation – through management of formal and informal access points.

A range of public and private access points exist along the shoreline (e.g. Figure 36) and the need for these can be reviewed in partnership with the community. The following elements should be part of the access plan developed jointly with the community:

a. Identifying priority public accesses points

b. Identifying access points that could be closed/restricted

c. Access infrastructure/materials – suitability, preference, feasibility

d. Signage - locations, wording

e. Fencing adjacent to access points / dunes - materials, maintenance.

B. **Dune vegetation protection and maintenance to enhance dune building/accretion and recovery after storm events – through minimising disturbance, revegetation, possible sand fencing.**

Priority areas have initially been discussed with the community in a second SEMP workshop to discuss management options (December 2019). Identification of priority areas can be undertaken though a joint planning process between Council and community in the SEMP implementation phase.

Indicative costs for revegetation works along the main beach shoreline, based on up to 1.2 km of priority beach length (Figure 37), would be in the order of $400,000 (mid-range estimate for 1.2 km x 10 m area, Table 7).

C. Active monitoring and maintenance.

A regular monitoring program will be important to confirm rates of erosion/recession, and the impact of SEMP actions to mitigate erosion. This can be included in a stewardship program for the coast. Establishment of regular photo point monitoring, such as the 'Coastsnap' program or less formal photo points, with a view along the main beach extent, can assist to provide regular and easy to collect, and comparable images.

D. Additional nourishment / dune repair after storms.

After severe storm activity, potential nourishment of dunes could also be undertaken. In the first instance scraping up to self-assessable sand volumes (from the intertidal zone/ site based sources) can be completed.

Cost estimates for sand scraping are primarily associated with contract fees for operation of an excavator. Cost estimates using a contractor are in the order of $10 / m^3 plus mobilisation and de-mobilisation costs. An indicative cost associated scraping up to 5,000 m^3 is in the order of $50,000 - $60,000.

Specific actions and implementation of the above elements A – D can be developed in partnership with the community in the form of a joint Council and community stewardship program for the coast. This program

should seek to build on the existing community initiatives around active beach monitoring, dune care, vegetation management and education programs, as well as the initial work completed for the SEMP.

Action 3 – Confirm and implement action plan for shoreline management - including access plan and stewardship program developed in partnership with the community

Figure 36. *Agnes Water Main Beach extent and observed access points – public and signed private access. Note additional informal/unsigned private accesses also exist.*

Table 7. Unit costs (range)

Option	Unit costs			Notes
	Low	Medium	High	
Revegetation (per m^2)	$25	$36	$54	Includes once-off establishment of planting media and planting and initial maintenance of an appropriate species such as sand spinifex (Spinifex sericeous). Ongoing maintenance costs are embedded in existing Council maintenance costs.

Sources: Alluvium (2019) Building a Resilient Coast for the Douglas Shire, Dan Ware and Zsuzsa Banhalmi-Zakar (2017) Funding coastal protection in a changing climate: Lessons from three projects in Australia.

Figure 37. *Potential revegetation areas – inclusive of priority areas noted by community and Council. Prioritisation within these extents to be confirmed as part of SEMP implementation.*

4.3 Community input – workshop 2

A follow up workshop was held 18th December 2019 in Agnes Water (Figure 38). The purpose of the meeting was to:

- Present the findings of the technical assessment
- Canvass any further insights and perspectives of the local community in relation to shoreline erosion management
- Outline the approach to the selection of the management options, including constraints
- Present and gather feedback on the recommended management actions

The comments raised and Alluvium/GRC responses are presented in Attachment E. The main comments surrounding the options presented included:

- General agreement and acceptance of all recommended options
- Support for formalising some access points along Agnes Water main beach
- Community would like more input/consultation around the implementation of the recommended actions

Figure 38. *Community meeting at Agnes Water 18/12/2019*

4.4 Implementation and monitoring

The recommended management actions of this SEMP for implementation, monitoring and review are summarised in Table 8.

Table 8. Actions summary

Action	Description	Timing	Cost*
Action 1 – Develop detailed design of protection works for the Captain Cook Drive, and confirm timing (or triggers) for implementation	Confirm preferred protection approach, detailed design, and timing or triggers for implementation.	End of 2020/21 FY	Consultant support (if applicable) $15,000 - $30,000. Geotechnical assessment additional (if required).

Action	Description	Timing	Cost*
Action 2 – Confirm implementation plan for maintaining or transitioning the Seventeen Seventy main shoreline, including detailed designs associated with boardwalk repair/modification, and erosion protection works (beach nourishment, groynes) if applicable	• Begin planning for the future state of the shoreline with increased tidal inundation, and restore the Boardwalk to sufficient design specifications for that scenario • Include (if desired) a period (10 years) of sand nourishment, while a transition plan is set in place for the foreshore (if appliable) and as part of the CHAS process • Trial the addition of geobag groynes (if desired) to assist with retention of placed sand.	End of 2020/21 FY	Council run (N/A) Consultant support (if applicable) $15,000 - $30,000. Nourishment (if applicable) $600,000 Groynes (if applicable) $900,000
Action 3 – Confirm and implement action plan for Agnes Water Main Beach shoreline management - including access plan and stewardship program developed in partnership with the community	Specific actions associated with implementation of the SEMP can be developed in partnership with the community in the form of a joint Council and community stewardship program for the coast. This program should seek to build on from the existing community initiatives around active beach monitoring, dune care, vegetation management and education programs, as well as the initial work completed for the SEMP.	End of 2020/21 FY	Consultant support (if required) - overall Action Plan ($10,000 - $15,000) Vegetation Up to $400,000 Sand scraping (if applicable) Up to $60,000 Monitoring set up Up to $20,000
Action 4 – Implement monitoring	Monitoring to include: Establishment of monitoring points (photo and depth markers) for monthly beach profile monitoring Establish other required monitoring identified by Action 3.	End of 2020/21 FY	Council/community led (N/A) Consultant support (if applicable) ($5,000 - $10,000) for set up.
	Annual and event-based review of shoreline profile change Annual update of triggers for a SEMP review or change in management.	Annual	Consultant support if applicable ($5,000) – review and summary memo.
Action 5 – SEMP review, evaluation and update	A review of the SEMP every 5 years to confirm and update the plan.	5 years (or earlier if triggered)	Consultant support ($5,00 - $10,000)
	Triggers for an earlier review include: • Accelerated rate of dune erosion/recession – triggering a review of the SEMP actions and effectiveness, and SEMP update. • Erosion of shoreline to within 15 m of critical asset/s (last access road, essential services), triggering the need to review the SEMP and management options, including investigating the feasibility of additional protection measures.		

*Indicative costs only and dependant on desired scope of works

Beach access at Agnes Water

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Attachment A
Legislative context

Legislative context

Coastal management in Queensland is bound by a raft of international, Commonwealth, State and local legislation. The legislation results in a complex structure of rights and responsibilities, particularly surrounding implementation of coastal works. Key legislation relevant to coastal planning within the Gladstone Regional Council LGA is outlined in Figure 39. Any proposed management options will comply with all relevant legislation.

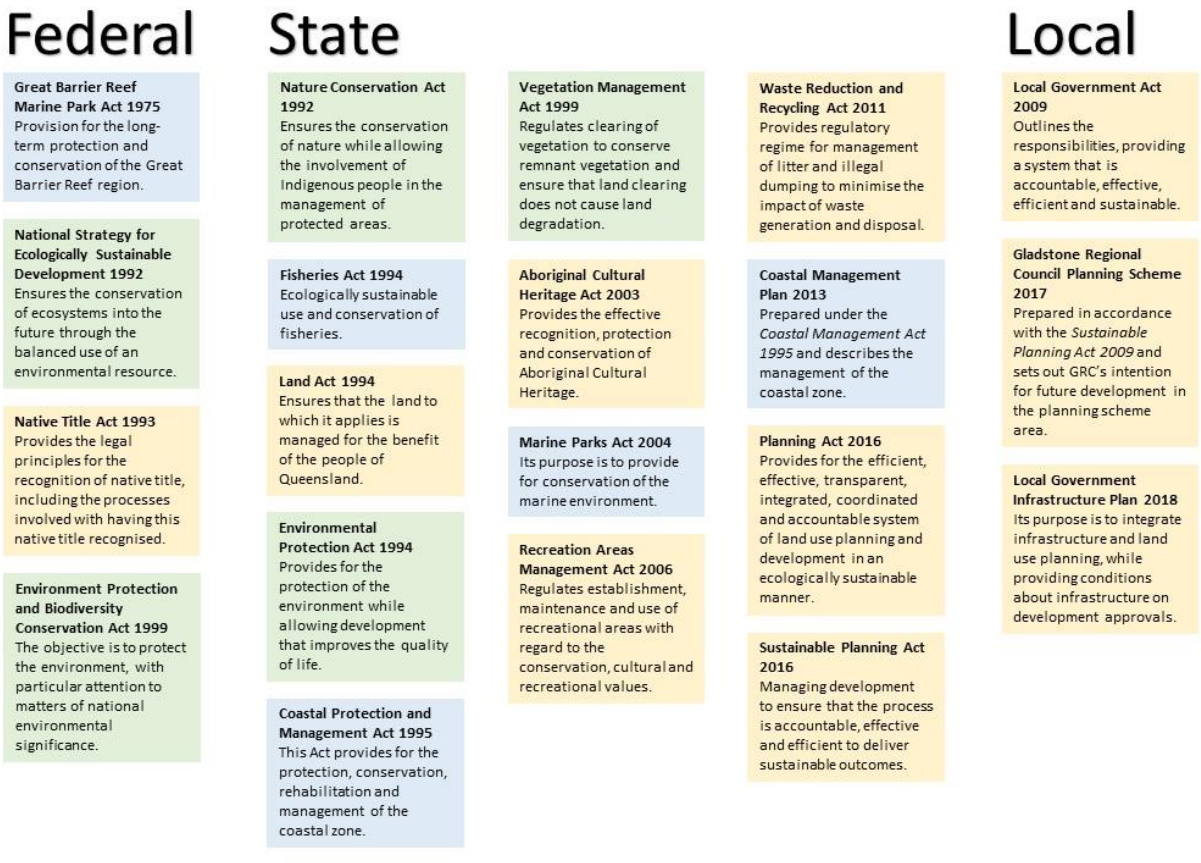

Figure 39. *Summary of the legislation relevant to the Agnes Water and Seventeen Seventy SEMP. (Yellow boxes represent land tenure, title and commercial use plans or Acts, blue boxes represent waterway and coastal plans or Acts, Green boxes represent land, climate, environment and wildlife reforms or plans.*

Approvals processes that may be required for coastal management actions are noted in Table 9.

Table 9. Summary of the approval process for the potential management options (adapted from GU & GHD 2012)

Legislation	Beach nourishment	Revegetation	Buried seawall	Groyne
Coastal Protection and Management Act 1995	✓	✓	✓	✓
Sustainable Planning Act 2016	✓	✓	✓	✓
Fisheries Act 1994	✓	✗	✗	✓
Vegetation Management 1999	✗	✓	✓	✓
Queensland Marine Parks Act 2004	✓	✗	✗	✓
Great Barrier Reef Marine Park Act 1975	✓	✗	✗	✓
Native Title Act 1993	✓	✓	✗	✓

Attachment B
Model information

Coastal process analysis and modelling components

Delft3D numerical model development

Model development

Numerical modelling has been undertaken using Delft3D, an integrated model capable of estimating tides, extreme water levels, currents, cyclones and wave conditions. It is an open-source model. As schematised in Figure 40, several modules of Delft3D can be used within modelling scenarios. For this assessment of coastal processes, the Delft3D-FLOW module was used for hydrodynamic calculations (tides, currents, winds).

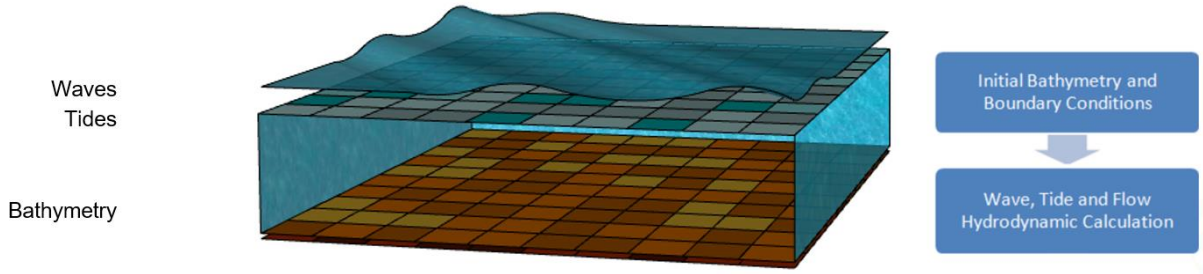

Figure 40. *Delft3D hydrodynamic and wave calculations.*

Modelling extent

The spatial domain of the model spans the nearshore area of Round Hill Creek and continues upstream to the tidal limits. It extends across 4km across the estuary mouth and adjacent foreshore. It and continues around 15km to the inland estuary.

The model was constructed using a curvilinear computational grid with a varying spatial resolution. The model has a grid size of around 25m x 15m along the estuary mouth and Endeavour Park shoreline, which transitions to 50m x 100m grid cells in the upper estuary.

Bathymetry

The bathymetry grid was constructed for each model domain based on several sources of data.

- Offshore data is based on the GBR30 dataset. This is a mosaic of high-density multi-beam data, high-density single-beam data or best scale charted data.
- Above mean sea level, the QLD LiDAR dataset has been used.

This data was processed and merged over the Delft3D grid. Once merged, the grid was inspected to ensure that the locations where datasets intersected did not contain abnormal changes in bathymetry, which could distort coastal processes. Any gaps in the bathymetry were smoothed and averaged with the adjacent grid cell.

Boundary conditions

Tidal conditions throughout the model have been based on tidal harmonics. These were extracted from the TPXO (v7.2) global tidal harmonics database. A double spring-neap tidal cycle was run (spring-neap-spring-neap) to reflect January 2017.

JBP Beach Evolution Model

The JBP Beach Evolution Model (JBEM) considers fetch-limited wave growth as described by Hasselmann[1], depth limitation, tidal interactions and wave breaking based on the Nelson Criterion (1994)[2]. Beach evolution is then modelled for the upper beach using the Kamphuis[3] sediment transport calculations, which builds on to commonly used formulae such as the CERC[4] equation, however, includes the effects of particle diameter, bed slope and wave period.

Wave data analysis, SWAN model and outputs

Seventeen Seventy and Agnes Water are positioned approximately 40km from the closest northern wave buoy at Gladstone, and 80km from the closest southern wave buoy at Bundaberg. The offshore wave climate was analysed at each location to understand the magnitude of recorded wave conditions. The Gladstone wave buoy has data from 2015 - 2019, and the Bundaberg buoy has data over two periods; from 1979 - 1983 and 2009 - 2019. New offshore extreme wave estimates have been produced for the wave data using extreme value analysis. This was analysed using a peaks over threshold (POT) approach to identify 'extreme' events that occurred, assuming a storm duration of 50 hours, and a Generalised Pareto Distribution (GPD) fit to the modelled data. The design offshore wave conditions are presented in the table below, which indicate offshore extreme waves may be between 3-4m.

Return period (1 in X years)	Bundaberg Wave height (m)	Gladstone Wave height (m)
20	2.85	2.81
50	3.00	3.03
100	3.10	3.18
500	3.29	3.51

Extreme wave conditions reaching Seventeen Seventy and Agnes Water have been estimated using a numerical wave model. The model has used SWAN, a third-generation spectral wave model that simulates wave propagation in coastal and inland areas. It accounts for the following physics:

- Wind-wave interactions, which is the transfer of wind energy into wave energy, leading to the growth of waves.
- Shoaling, which is the build-up of energy as a wave enters shallow water, causing an increase in wave height.
- Refraction, which is the change in wave speed as waves propagate through areas of changing depth, causing a change in wave direction.
- Wave breaking, which is the destabilisation of a wave as it enters shallow water, causing broken waves with the characteristic whitewash or foam on the crest.
- Wave dissipation, which limits the size of waves through white-capping, bottom friction and depth-induced breaking.

The spatial domain of the model covers Fraser Island to Townshend Island, and was constructed using a computational grid with a varying spatial resolution. This approach allows for large spacing between grid points in the offshore region where a detailed representation of the deep bathymetry is unnecessary, and more detailed information in the nearshore region. The wave model has been extended beyond the great barrier reef into the deep water in order to capture any waves propagating through the gap that exists north

1 Shoreline Protection Manual (1984). Volume 1. Chapter VI: Wave forecasting for shallow water. Page 3-55.

2 Nelson, R.C., 1994, "Depth limited design wave heights in very flat regions", Coastal Engineering, vol. 23, no. 1-2, pp. 43-59

3 Kamphuis, J.W. 1991. Alongshore sediment transport rate. Journal of Waterway, Port, Coastal and Ocean Engineering, Vol. 117, 624-640

4 USACE, 1984, Shore Protection Manual, CO. Eng. Res. Centre, US Army Corps of Engineers, Vicksburg, MS, USA

of Fraser Island. The offshore boundary of the model is positioned approximately 150km offshore, aligned with the southern end of the Great Barrier Reef and covering a reporting point for a global simulated hindcast wave model, the ERA5. The model resolution at the offshore boundary is 5km, with this decreasing at the coastline to 30m in areas of interest and 500m along the other sections of coastline. The bathymetry has been sourced from the Great Barrier Reef 'Deep Reef' dataset, which has a 30m resolution.

The model was simulating using two different approaches for each community.

1. Agnes Water will be affected by swell waves propagating from the open water. The model offshore boundary was positioned beyond the barrier reef to capture these conditions. At this location an extreme value analysis was undertaken on 40 years of hindcast wave conditions extracted from the ERA5 dataset. The 1% AEP event was subsequently simulated through the model and extracted at Agnes Water.

2. Endeavour Park at Seventeen Seventy will be exposed to small wind-generated waves, forming during north-westerly winds. The SWAN model was forced using design 1% AEP wind conditions from the Australian wind code AS 1170 for Region C. The worst-case wind direction, associated with the longest fetch, was determined to be 310°/N. The worst-case conditions were extracted at Endeavour Park at the -2 mAHD contour.

The present-day nearshore wave and storm tide conditions at Agnes Water and Endeavour Park, Seventeen Seventy are presented in the table below.

Present day, 1% AEP nearshore wave conditions for each community

Location	Wave height (m)	Peak Period (s)	Storm Tide (mAHD)
Agnes Water	2.3	13.1	2.5
Seventeen Seventy	1.2	3.3	2.5

Present day EPA assessment

The JEPA tool estimates the beach equilibrium profile during a storm based on Vellinga (1982):

$$\left(\frac{7.6}{H_{0s}}\right) y = 0.47\left[\left(\frac{7.6}{H_{0s}}\right)^{1.28}\left(\frac{w}{0.0268}\right)^{0.56} x + 18\right]^{0.5} - 2.00$$

Where H_{0S} is equal to significant 'deep water' wave height and w is equivalent to the fall velocity of sand. The input parameters for each calculation include:

- Initial beach profile
- Storm tide level
- Nearshore wave conditions
- Grain-size diameter
- A stability threshold for upward slope of 1:3 has been assumed for the dune scarp component
- A downward slope is fixed at 1:12.5

Using the formula, an erosion distance is measured which balances the storm equilibrium profile and the pre-storm profile. This assumes sand is eroded from the upper beach and is deposited on the lower zone of the beach slope. Above the water level a dune slumping component has been accounted for by assuming a stable post-storm dune slope at a 1:3 gradient. The erosion width is then measured landward of the HAT, all the way to the intersection with the dune escarpment.

Attachment C
Historical shoreline trends analysis

Historical shoreline trends analysis

Method

Historical images, digitised shorelines, and the images were provided by GRC and downloaded from the QImagery website (qimagery.information.qld.gov.au/).

The images selected for analysis spanned 1959 to 2018, and were sourced from the following sets:

- Agnes Area 2018 (resolution: 10cm) *Source: GRC*
- Agnes Area 2010 (resolution: 15cm) *Source: GRC*
- Urangan - St.Lawrence 2001 (scale 1:12,000) *Source: Qimagery*
- Urangan - St.Lawrence 1975 (scale 1:12,000) *Source: Qimagery*
- Bustard Bay 1959 (scale 1:23,800) *Source: Qimagery*

With the exception of 2018 and 2010, the images for all years required georeferencing. Shorelines were digitised immediately seaward of the vegetation line or of any grassed dune areas distinguishable in the historical images. A baseline was drawn along the coast, approximately 50 m inland of the shorelines, as a baseline for casting transects across the digitised shorelines.

Transects were cast and statistics were calculated using the DSAS add-in (version 4.3) to ESRI ArcGIS Desktop (version 10.0). Transects were cast at a spacing of 20 m along the coast. In the statistical analysis, we have focused on the End Point Rate (EPR) and Linear Regression Rate (LRR).

Limitations

While the method is useful in determining approximate rates of recession or accretion there are some limitations. The calculated measures of change, as provided by DSAS, are only as reliable as the accuracy associated with the source materials (quality and coverage of aerial imagery), whereby mapping errors generally increase in older data (Oyedotun 2014). Precise shoreline positions are typically difficult to determine from aerial imagery alone and accuracy is often limited by the imagery resolution and georeferencing. This is particularly relevant when assessing relatively small changes in shoreline position.

Results are considered indicative and transect results are used collectively to understand the general nature of changes along the shoreline over time, and not as specific measures of change for any given transect. The results provide a means to identify trends, the nature of changes along the shoreline over time, and particular areas of interest for management.

Shoreline change

The EPR and LRR results from the digital shoreline assessment indicate the most significant changes in shoreline position are along the open coast between Agnes Water and Round Hill head and at Seventeen Seventy are along the northern ends of the two embayment's, adjacent to the Round Hill Creek entrance (Figure 41). In the map below, negative values (red transects) represent shoreline recession, while positive values (green transects) represent shoreline accretion.

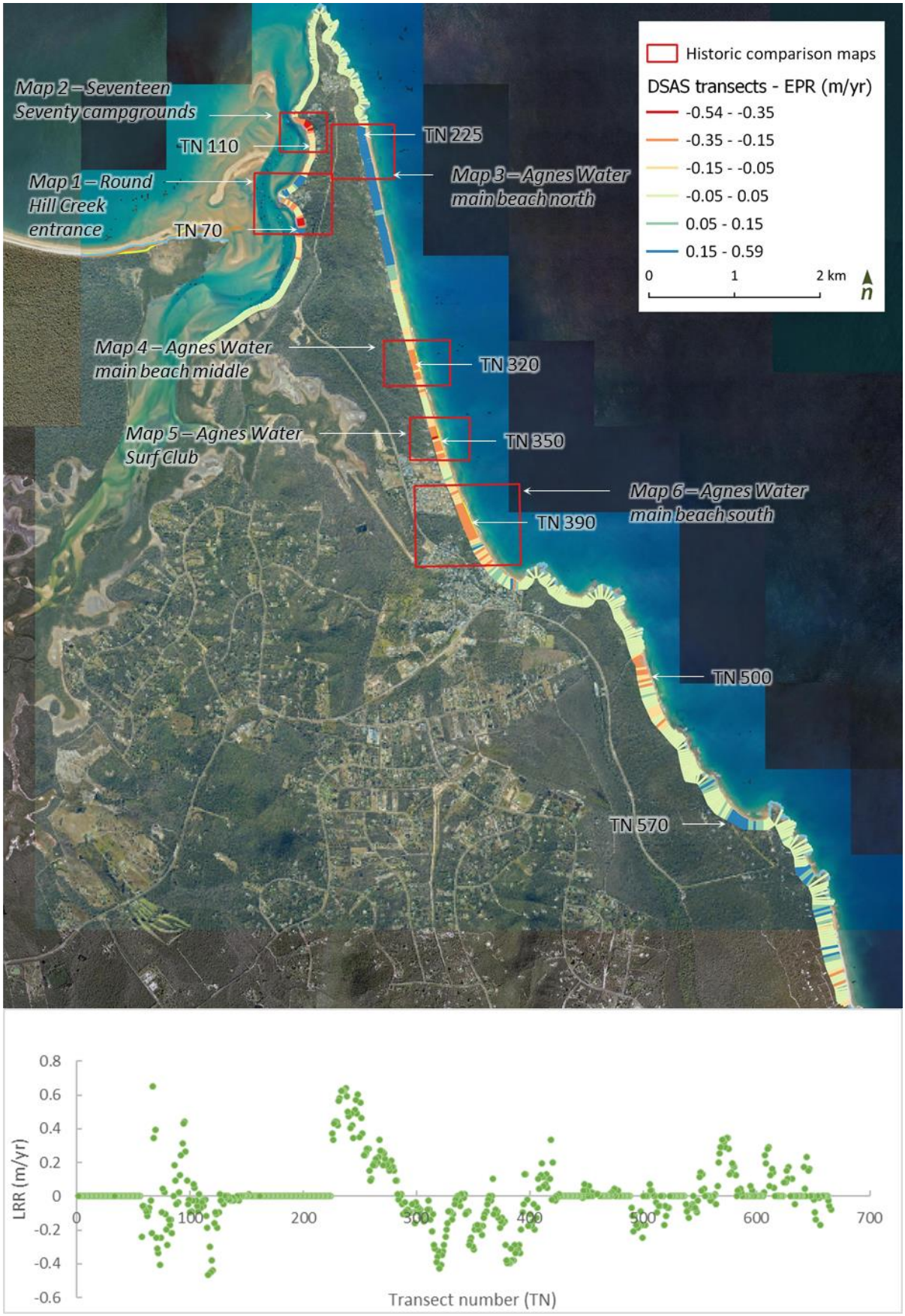

Figure 41. *DSAS transects for Agnes Water and Seventeen Seventy showing End Point Rate (EPR) and Linear Regression Rate (LRR). Red boxes highlight the historic aerial imagery comparison map extents.*

Historic imagery comparison maps were developed for areas showing significant change outlined in Figure 41. It should be noted that the 2010 shoreline was also digitised and used for DSAS analysis but has not been displayed in the historic comparison maps below (Figure 42 to). A summary of the main findings includes:

Map 1 – Round Hill Creek entrance (Figure 42)

- Significant shoreline changes indicated by the DSAS primarily due to the construction of the marina at southern end of the Round Hill Creek entrance and the construction of Captain Cook Drive.
- Moderate EPR at the northern end of the beach of approximately -0.3 m/yr, however most of this change occurred between 1959 and 1975. Shoreline recession of approximately 5m between 1975 and 2018.
- Shoreline accretion of up to 0.37m/yr on the beach north of the rocky outcrop (southern end of the 1770 foreshore)

Map 2 – Seventeen Seventy campgrounds (Figure 43)

- Significant shoreline recession along a section of approximately 300 m at the northern end of the beach. DSAS results indicate and EPR of between – 0.09 m/yr – 0.5 m/yr.
- The most significant change was between 1959 and 1975. Historic imagery analysis indicates recession and a slower rate between 1975 and 2001 and a relatively stable position between 2001 and 2018.
- Shoreline within approximately 5 m of Captain Cook Drive at its closest point.
- Shoreline changes likely to be influenced by the location of the main channel of Round Hill Creek.

Map 3 – Agnes Water Main Beach (north) (Figure 44)

- A net shoreline accretion at the northern end of Agnes Water main beach as indicated by the frontal dune vegetation line.
- EPR of between 0.13 m/yr – 0.5 m/yr, with the most significant change toward the northern end of the beach.

Map 4 – Agnes Water Main Beach (middle) (Figure 45)

- Analysis indicates a period of accretion between 1959 and 1975 followed by a general long-term trend of recession. highlighting the dynamic nature of the open beach system.
- Net shoreline recession of approximately 500 m of beach at an EPR of approximately – 0.29 m/yr.

Map 5 – Agnes Water Main Beach (Surf Club) (Figure 46)

- Analysis indicates a period of accretion between 1959 and 1975 followed by a general long-term trend of recession. highlighting the dynamic nature of the open beach system.
- The most significant change is a section of approximately 150 m of beach where DSAS indicates net shoreline recession at an EPR of – 0.35 m/yr
- A net recession of approximately – 0.16 m/yr of the beach in front of the surf club.

Map 6 – Agnes Water Main Beach (south) (Figure 47***)***

- A general long-term trend of recession of between - 0.15 m/yr to – 0.3 m/yr.
- Accretion between 1959 and 1975 in the central section of the map extent.

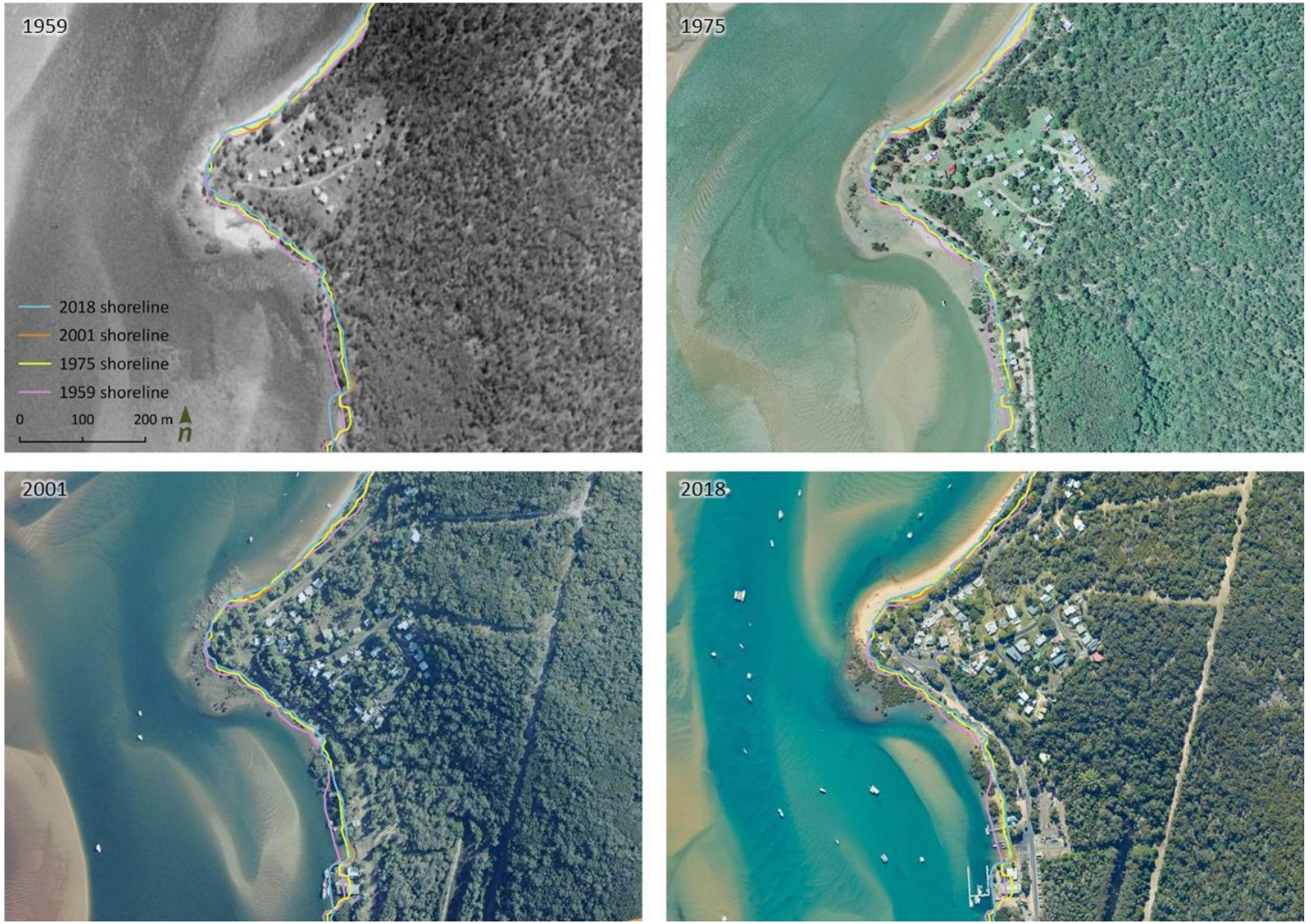

Figure 42. *Historic aerial imagery comparison and shoreline position for Map 1 – Round Hill Creek entrance*.

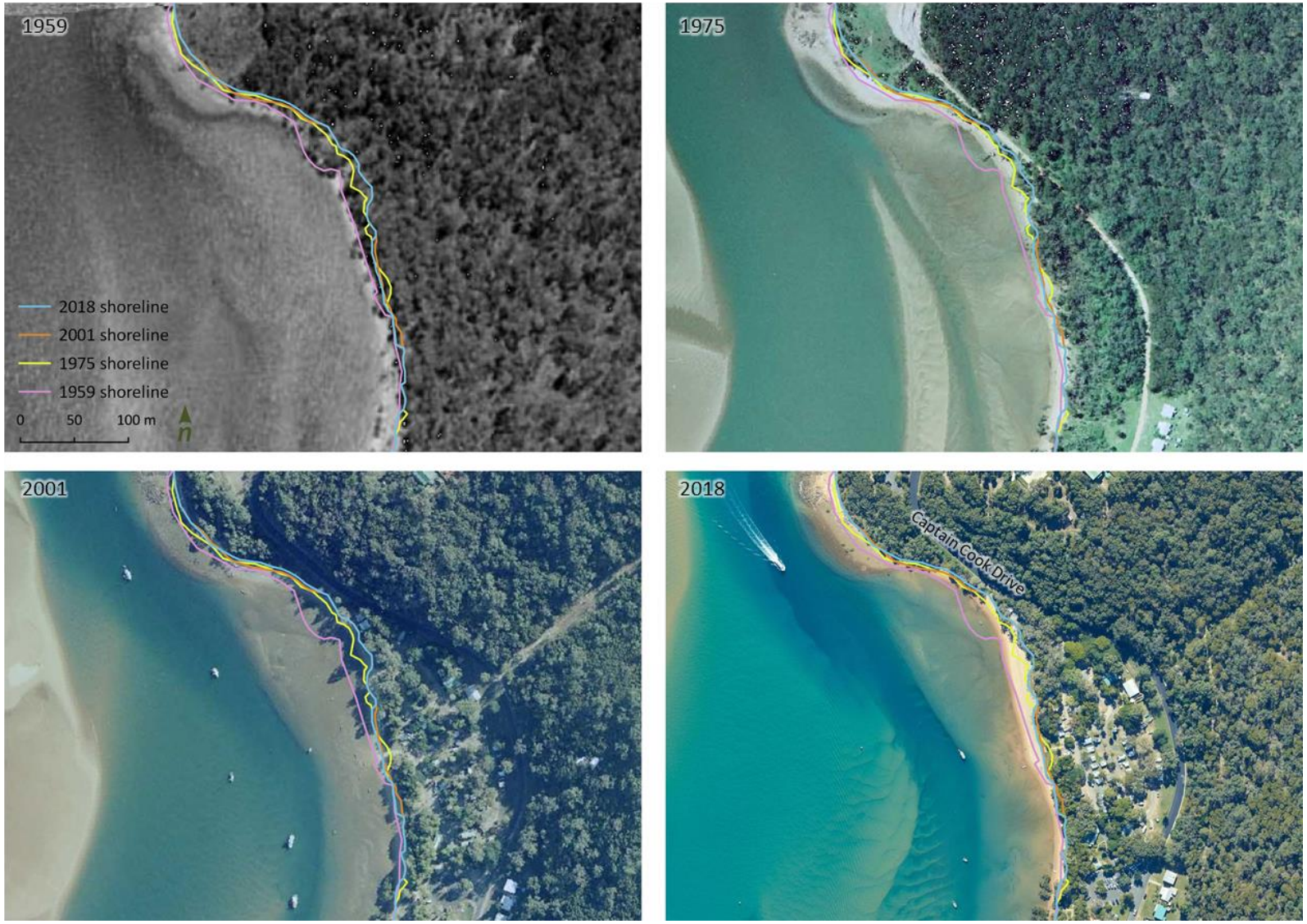

Figure 43. *Historic aerial imagery comparison and shoreline position for Map 2 – Seventeen Seventy campgrounds.*

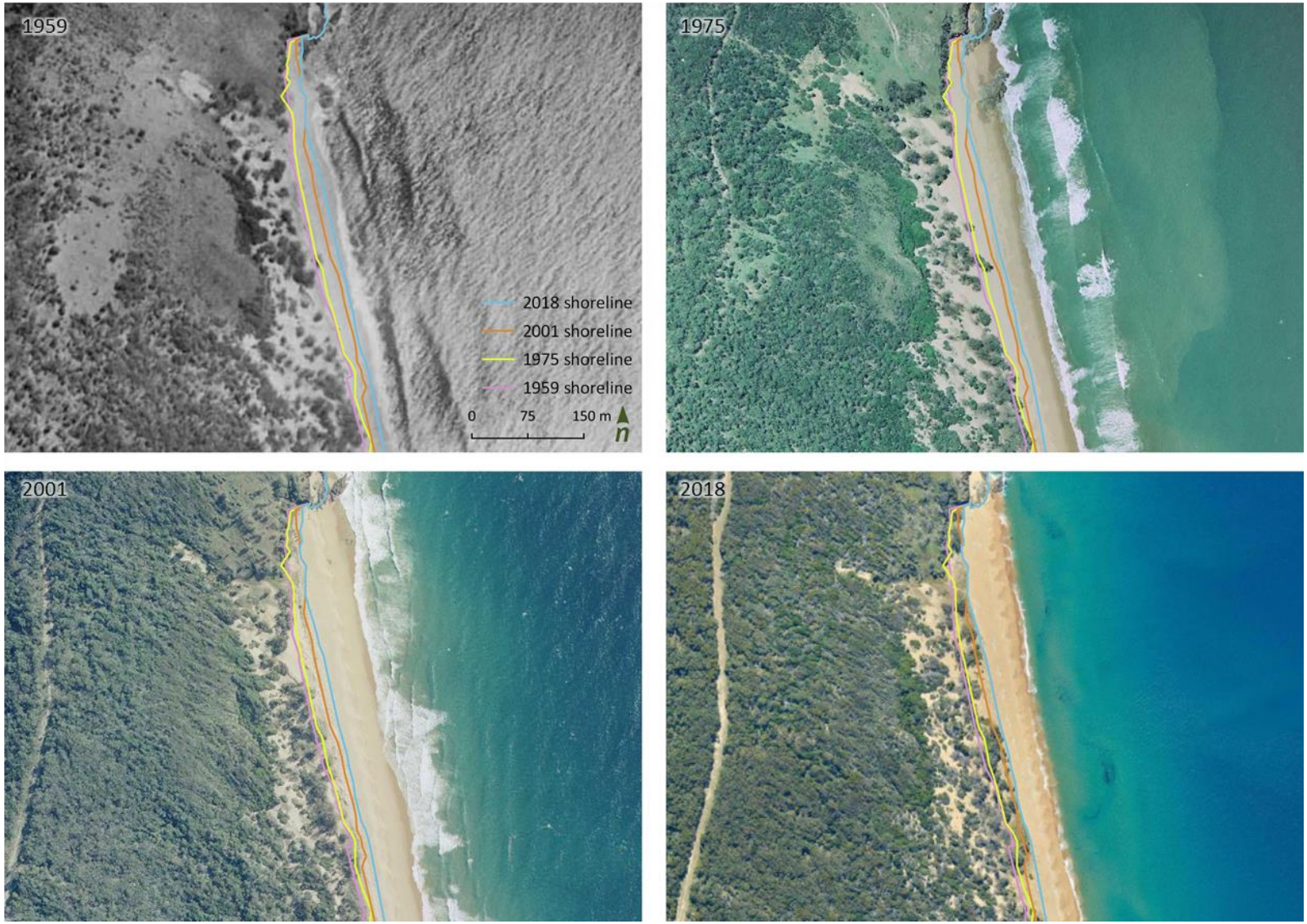

Figure 44. *Historic aerial imagery comparison and shoreline position for Map 3 – Agnes Water Main Beach (north).*

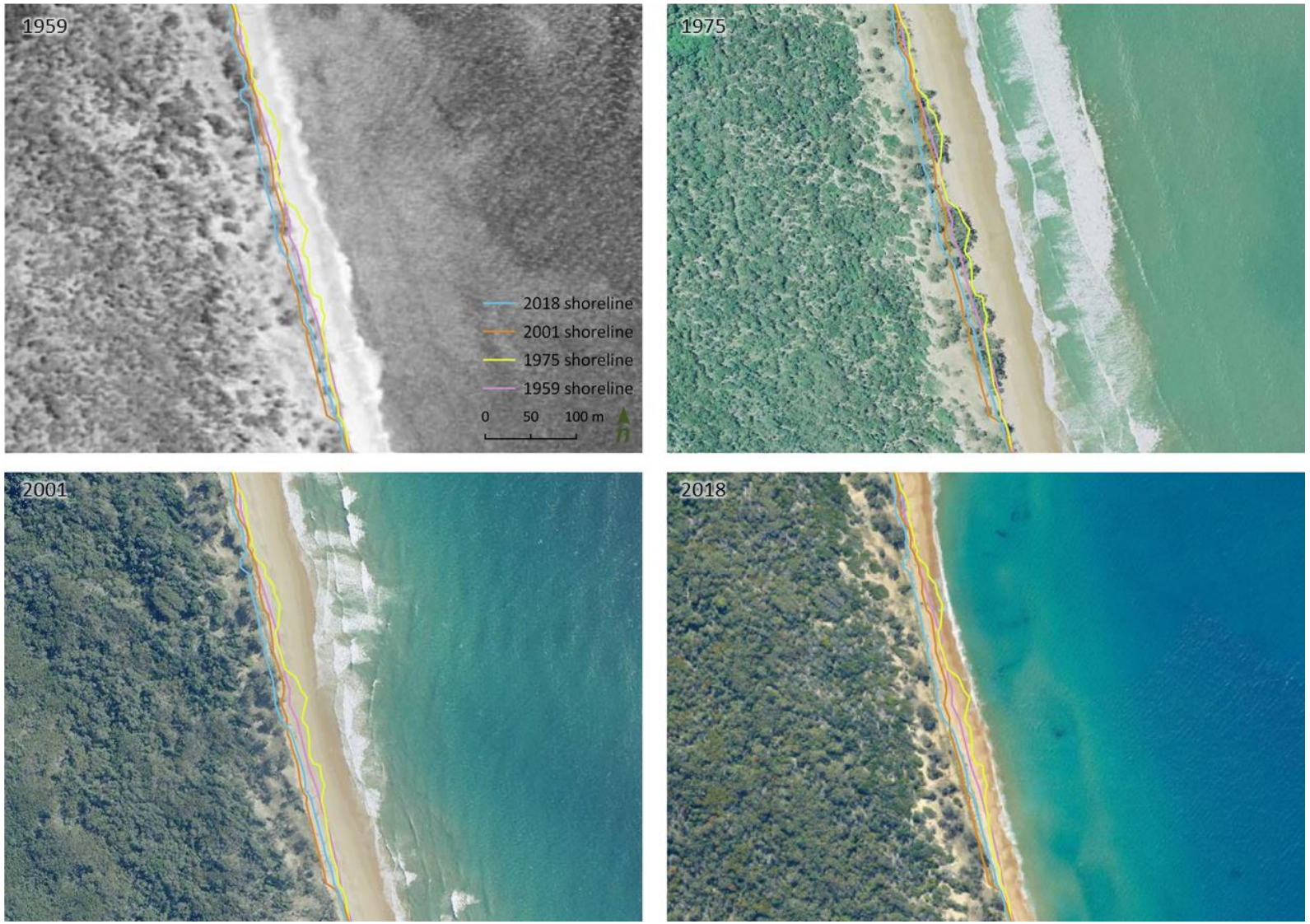

Figure 45. *Historic aerial imagery comparison and shoreline position for Map 4 – Agnes Water Main Beach (middle).*

Figure 46. *Historic aerial imagery comparison and shoreline position for Map 5 – Agnes Water Main Beach (Surf Club).*

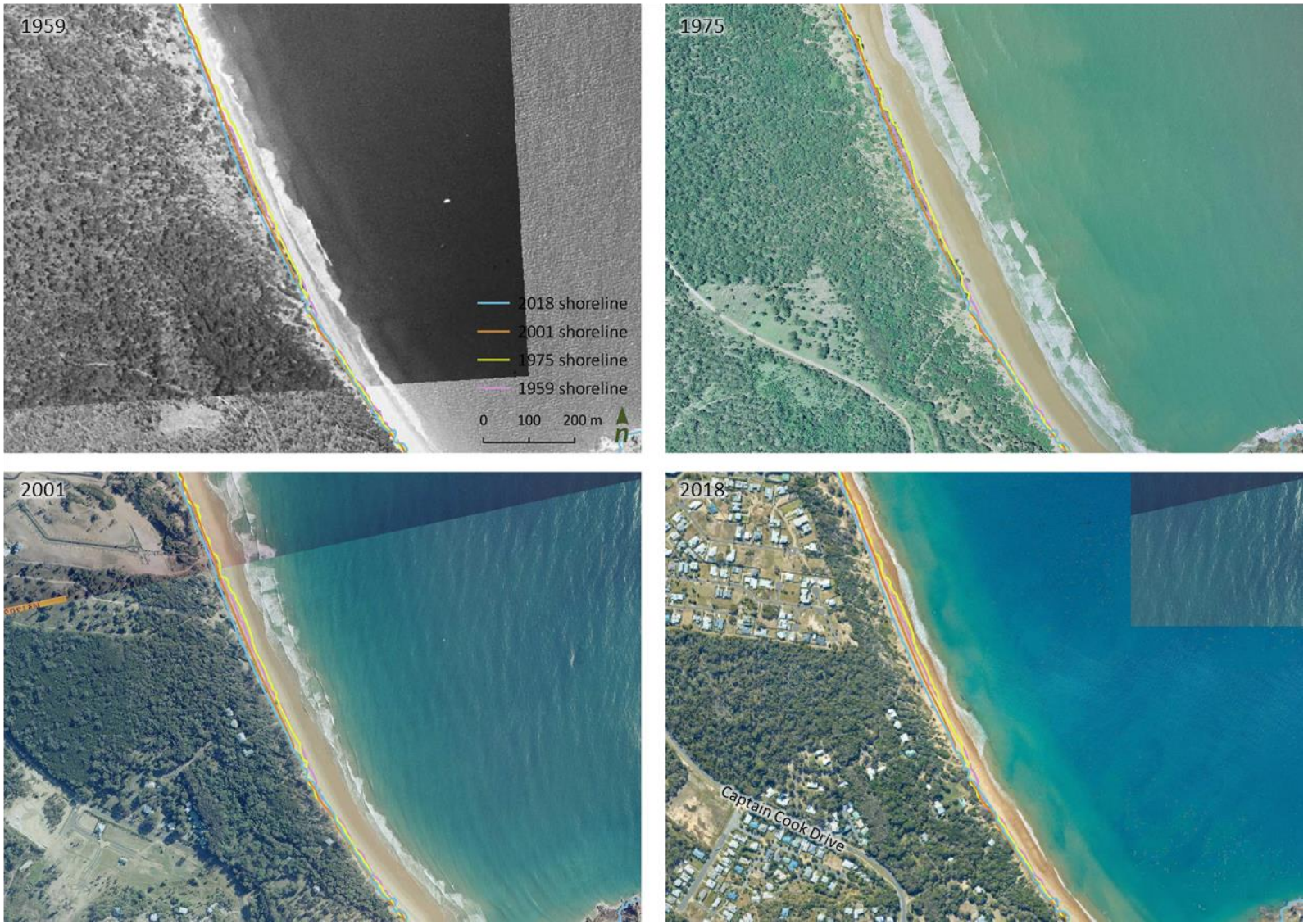

Figure 47. *Historic aerial imagery comparison and shoreline position for Map 6 - Agnes Water Main Beach (south).*

Attachment D
Site condition observations

Site condition observations

Field assessments at Agnes Water and Seventeen Seventy were carried out by Alluvium and JBP on 7th June 2019 and Alluvium and GRC on 27th August 2019. A locality map with street names is shown in Figure 48. Key observations from the site inspections are presented in Figure 49 and Figure 50 and summarised in Table 10 and Table 11.

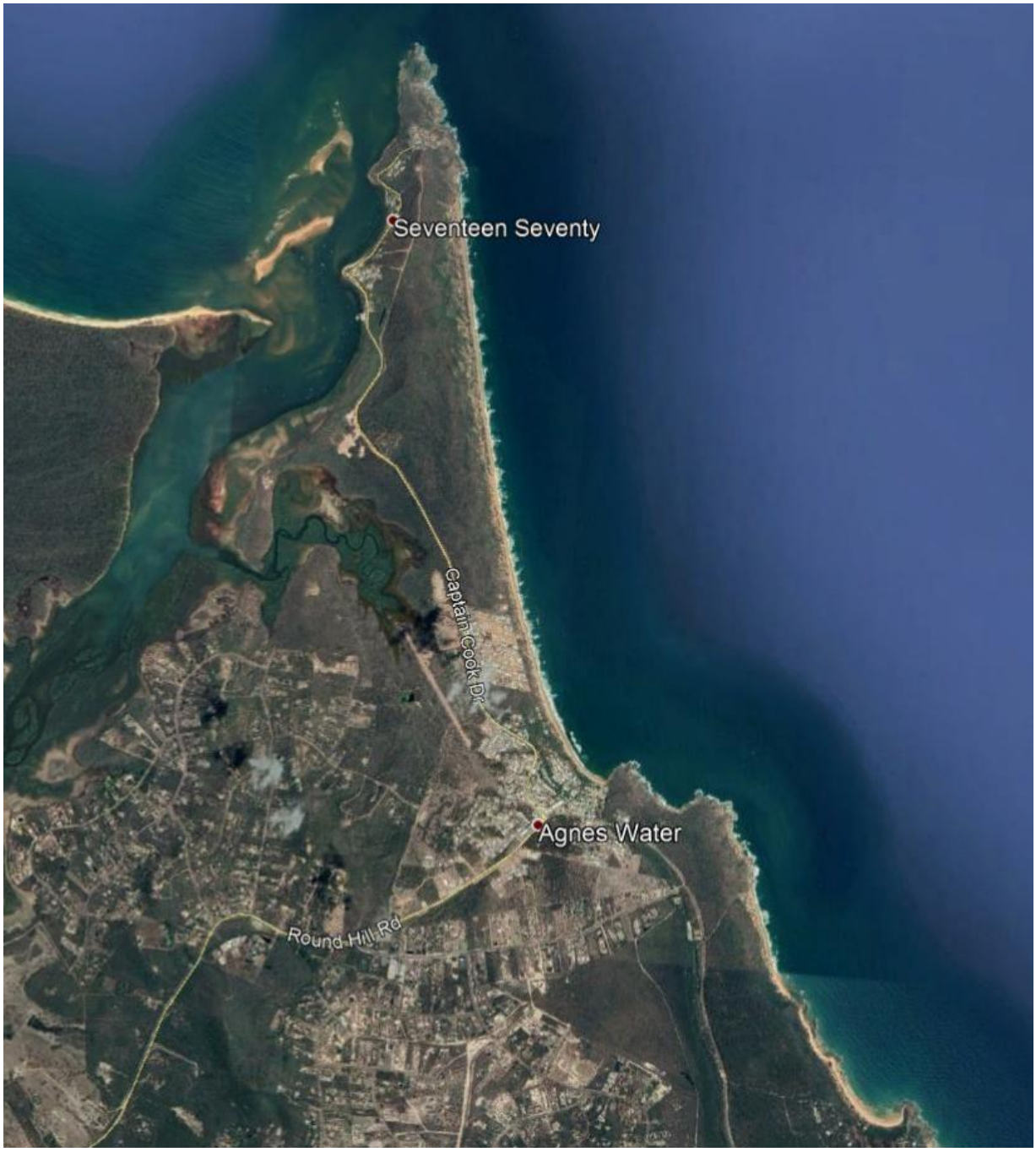

Figure 48. *Locality map with street names.*

Table 10. Summary of present shoreline and infrastructure / asset condition at Agnes Water

Agnes Water	
Existing condition • Beach profile varies from steep in the northern sections to a more gently sloping profile then steepens again towards the south • Dunes behind beach • Erosion scarps • Some vegetation on dunes	**Coastal management and engineering** • Geobags placed around desalination plant infrastructure in an attempt to manage erosion • Revegetation of dunes in places, with fencing in places to deter access • Informal dune protection (palm fronds, branches) and signage to deter thoroughfare
Infrastructure / assets • Desalination plant (offtake and discharge pipe) • Private property behind dunes at Main Beach	

Table 11. Summary of present shoreline and infrastructure / asset condition at Seventeen Seventy

Seventeen Seventy	
Existing condition • Beach slope is gently grading • Visible erosion and scarping, particularly around concrete structures • Mangroves interspersed along the shoreline • Boardwalk and some sections of path damaged or collapsed, foundations exposed	**Coastal management and engineering** • Hazard and formalised fencing around erosion, some sections of beach and pathway • Geofabric bags placed along a small section of beach • Some rubble and building material placed against erosion to armour scarp • Rock armour revetment along some sections of the boardwalk (~100 m length)
Infrastructure / assets • Boardwalk • Marina and boat ramp • Cook's Landing memorial • Picnic areas and amenities block • Caravan park	

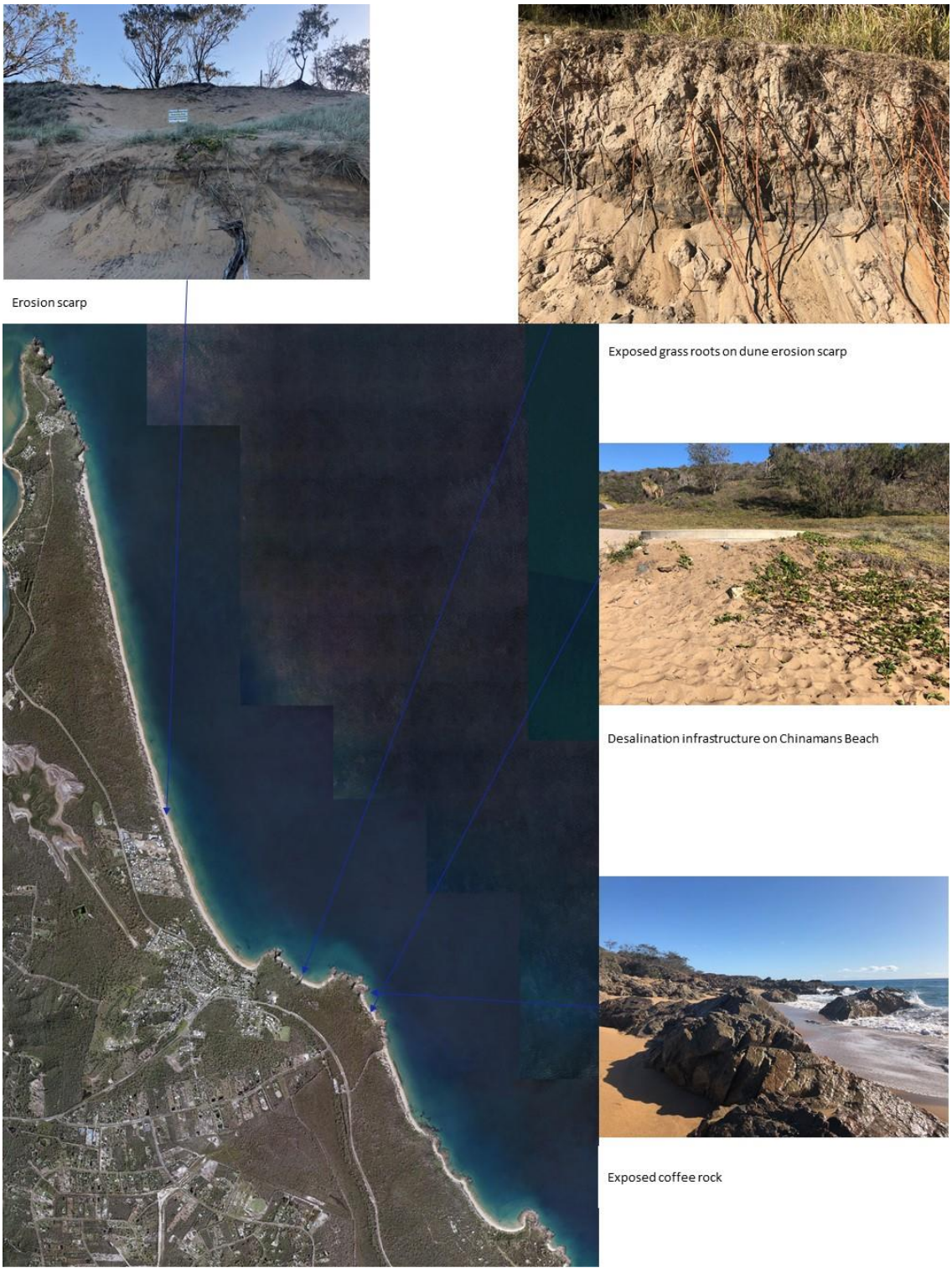

Figure 49. *Summary of key site inspection observations at Agnes Water.*

Additional photos along Agnes Water Main Beach

Geobags to protect the erosion scarp

Section of boardwalk damaged by coastal processes

Erosion scarp with geobags placed to prevent further erosion

Fencing to deter access to damaged path and boardwalk

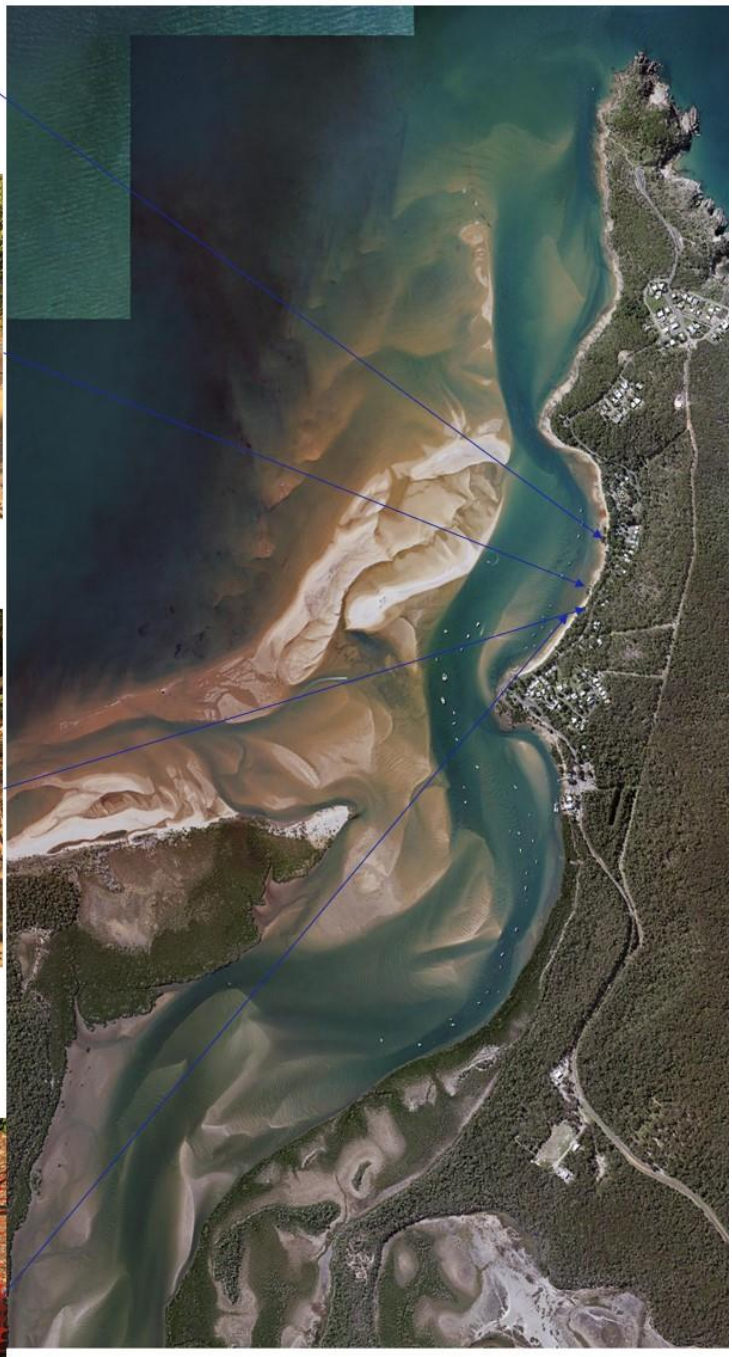

Figure 50. *Summary of key site inspection observations at Seventeen Seventy.*

Attachment E
Workshop 2 responses

Community comment	Alluvium/GRC response
Discussion surround Council's ability to reclaim freehold land along Main Beach. Issue is lack of vegetation maintenance and discontinuity in management approach between council land and freehold land.	Acknowledged that this is a complex issue. Council will look into specifics of land acquisition further. Action Plan will include recommendations for a whole of coast approach and Council will look into how this can be managed with land holders.
Dead trees along 1770 boardwalk, impacting on alternative beach connectivity adjacent to boardwalk at high tide. Dead trees will eventually end up in Round Hill Creek, affecting boat navigability.	Noted. Discussed that there were management options regarding the boardwalk (which were discussed further throughout the meeting).
Support for formalising some access points along Agnes Water main beach.	Undertook a mapping exercise to understand preferred access points and control measures.
Discussion around appropriate signage and messaging – is the language on the existing signage adequate?	Noted and discussed the importance of getting this right.
Community would like more input/consultation around the implementation of the recommended actions.	Discussion around best way to access information on the project and ways for council to better engage with their community.
Beach fires – identified as an issue, suggested formalising beach fire pits.	Noted and parked as a further Council issue.
Suggestions to add objectives around improvement/enhancement rather than just protecting and maintaining.	Noted and agreed.
Question surrounding the potential for including other outcomes into proposed works (e.g. place a footpath on top of structures).	There is opportunity to incorporate these aspects into detailed designs but that will come during the design phase rather than as part of the SEMP.
Concern regarding the materials for the rock structure – i.e. can the structure be in keeping with the surrounds/ locally sourced rock.	There is opportunity to incorporate these aspects into detailed designs but that will come during the design phase rather than as part of the SEMP.
Suggestion of community involvement in management interventions, particularly, school children.	Noted and will be explored as part of the Action Plan, rather than the SEMP. This approach also improves community stewardship and awareness.
Use and learn from the management experience of others, e.g. Sunrise at 1770, local Tradition Owners. Suggestions included: • Don't rush seedling establishment and plant too soon • Aim for long-term success with an on-going commitment to maintenance and monitoring, many plantings in the past have failed • Native species endemic to the area	Noted and agreed. The SEMP will provide the pathway for this to occur.
Increased stakeholder engagement with indigenous groups, particularly within Native Title areas.	Acknowledged and agreed.
People don't like the chain and timber accesses, hard to walk on, uncomfortable, splinters, trip hazard. Maintenance between events is lacking, leading to steepness and safety concerns.	Acknowledged.
More local law enforcement, particularly on weekends. To ensure, adherence to local laws, such as no camping on the beach, access through dune areas and beach fires.	Acknowledged.
General agreement and acceptance of all recommended options.	Acknowledged.

Preference for fencing to be non-intrusive, such as wire fencing.