



Figure A2: Looking north along Seabee wall at southern end of Lagoon Beach



Figure A3: Northern end of Seabee wall at Lagoon Beach, looking north



Figure A4: Sand-filled geotextile containers north of Seabee wall at Lagoon Beach



Figure A5: View of beach erosion escarpment north of Pinetrees boatshed



Figure A6: View south along Lagoon Beach from near access track opposite Board Administration



Figure A7: View north along Lagoon Beach from near from near access track opposite Board Administration

A2.2 Cobbys Beach

General views of Cobbys Beach are provided in Figure A8 to Figure A10.



Figure A8: View to north along Cobbys Beach from near the southern end



Figure A9: View to south along Cobbys Beach from near the centre of beach



Figure A10: View to south along Cobbys Beach from northern end (near airport revetment)

A2.3 Blinky Beach

A general view of Blinky Beach is provided in Figure A11.



Figure A11: View to south at Blinky Beach from crest of dune at accessway

A2.4 Neds Beach

General views of Neds Beach (moving north to south) are provided in Figure A12 to Figure A14.



Figure A12: Northern end of Neds Beach, looking north



Figure A13: Central view of Neds Beach, looking north



Figure A14: Southern end of Neds Beach, looking south

A2.5 Middle Beach

A general view of Middle Beach is provided in Figure A15.



Figure A15: General view of Middle Beach



APPENDIX B

REVIEW OF AERIAL PHOTOGRAPHY AND PHOTOGRAMMETRIC DATA



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B1. BACKGROUND

Aerial photography and photogrammetric data capturing beach conditions along Lagoon Beach and Cobbys Beach (in 1965, 1975, 1984, 2001 and 2011) has been reviewed. The photogrammetric data was provided by the Office of Environment and Heritage, NSW Government.

The photogrammetric data comprised 52 shore-normal beach profiles (numbered from 1 in the north to 52 in the south) arranged into 6 blocks (with a block being a set of parallel profiles), with an alongshore profile spacing of 50m within each block. The location of the profiles is shown in Figure B1 (for the Lagoon Beach and Seabee seawall area) and Figure B2 (for the runway revetment area and Cobbys Beach).

The photogrammetric data was analysed particularly to determine long term beach recession rates. To assess long term recession rates, changes in volume and in the position of various contour levels were determined at each profile over time. This procedure is often denoted as Profile Area Volume (PAV) analysis. Volumes were determined using scripts developed by Haskoning Australia in the software package MATLAB¹.

For the study reported herein, volumes above 0m AHD are given. The volume above 0m AHD was used as it was defined in many profiles without necessity for extrapolation of the profiles seaward, or only required extrapolation over a relatively short distance². However, note that 0m AHD at Lord Howe Island is not equal to mean sea level as on the NSW mainland, but is 1.2m below mean sea level in the Lagoon.

Profiles were generally extrapolated (if required) by continuing the profiles at the same average slope for the block and year as measured between the last two most seaward points in the profiles (generally near 0m AHD). This slope was typically around 1:10 (vertical:horizontal).

In the analysis, the complete profiles (extending to the landward limit) were considered, as well as landward truncations to both a position in the vicinity of the sand/vegetation interface as visible in 2011 aerial photography, and also 10m and 20m further landward. Applying a landward truncation is relevant, as changes to profiles further than 10m landward of the 2011 sand/vegetation interface can mostly be considered to be related to anthropogenic processes such as levelling for development, rather than natural coastal processes.

In addition to volumes, the position of particular elevations (namely 0m, 1m, 2m and 3m AHD) was determined over time.

For each of the profiles, the rate of change of volume above 0m AHD, and the rate of change of position of the particular elevation, was determined. The rates were derived by linear regression, that is by determining the line of best fit (least squares error) in each case³. The advantage of using linear regression, rather than simple differences between the first and last dates of photography, is that errors in predicted rates due to variations in beach states are likely to have been minimised. Rates of change were determined for the entire analysis period (1965 to 2011), as well as investigation being undertaken of changes between each date.

¹ MATLAB is a high-level technical computing language and interactive environment for algorithm development, data visualisation, data analysis, and numerical computation.

² For all data, 73% of profiles extended below 0.5m AHD, and 100% extended below 1m AHD.

³ This does not imply that there were uniform rates of volume or positional change between dates of photography.



Figure B1: Arrangement of photogrammetric profiles at Lagoon Beach and along Seabee seawall

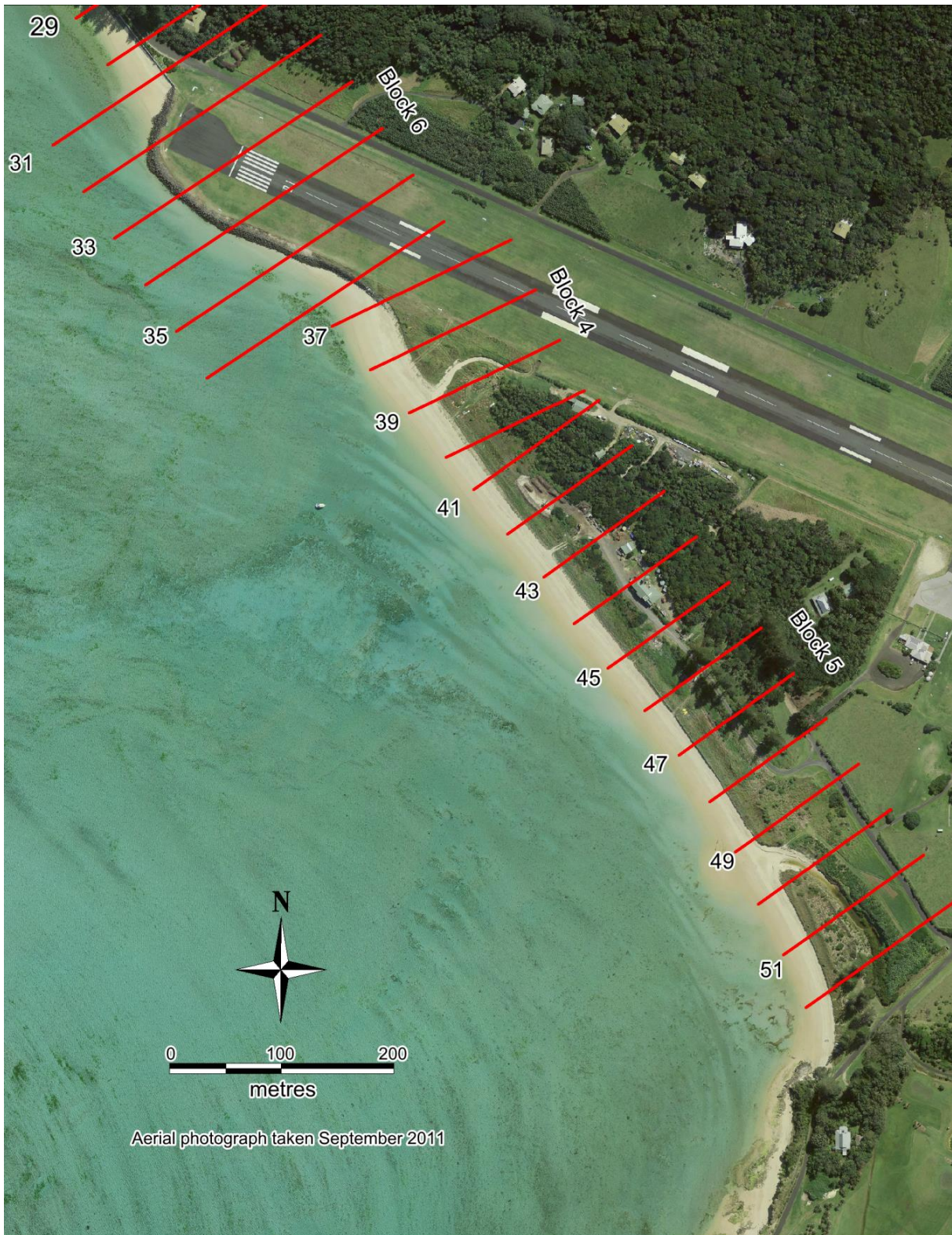


Figure B2: Arrangement of photogrammetric profiles along runway revetment and at Cobbys Beach



B2. DEFINITIONS

The following terms have been adopted herein to describe the short term and long term movements of beaches in the study area:

- **erosion**: the offshore movement of sand from the subaerial⁴ beach during storms, that is a short term loss of subaerial beach volume and short term landward shift of the beach face⁵;
- **accretion**: the opposite of erosion, typically when sand that moved offshore under storm conditions returns to the subaerial beach under milder conditions, increasing the subaerial beach volume and translating the beach face seaward;
- **recession**: a long term progressive (on average) reduction in subaerial beach volume and long term landward shift of the beach face; and
- **progradation**: the opposite of recession, a long term progressive (on average) increase in subaerial beach volume and long term seaward shift of the beach face.

There is some overlap in these terms, for example the process of progradation can be through an excess movement of sand onshore that is typically associated with accretion. Also, when looking at beach changes between various dates, there can be a number of short term cycles of erosion and accretion associated with storms as well as alongshore and windblown movements of sand occurring over this period, leading to recession or progradation. Any beach change over a period of years has been considered as recession or progradation (as the case may be) herein.

In interpreting beach changes over time, it is important to distinguish between natural processes and anthropogenic effects, where possible. For example, about 8,000m³ of sand (sourced from Blinky Beach) was placed along the position of the current Seabee seawall in 1991.

⁴ "Subaerial" literally means "under the air", and this case refers to beach changes above the waterline, as opposed to "subaqueous" changes underwater. Large waves combined with elevated water levels typically remove sand off the upper (subaerial) beach profile and transport this sand offshore.

⁵ This landward shift can be throughout the entire subaerial beach profile, such as landward movement of the shoreline (mean sea level position) and landward movement of an erosion escarpment (dune face).

B3. VOLUME CHANGES AND CONTOUR MOVEMENTS

The rate of change of volume above 0m AHD, and the rate of change of the position of the 1m and 2m AHD contours (both for the 1965 to 2011 period), are depicted in Figure B3 (raw data) and Figure B4 (smoothed data using a running average with a window width of 5⁶) along Lagoon Beach and Cobbys Beach.

For Figure B3 and Figure B4 note that:

- the section covered by the runway revetment was not included in the analysis as this is an anthropogenic reclamation, and being a terminal structure there have not been any significant changes in the subaerial shoreline in this area from 1975 to 2011;
- contour changes at 0m and 3m AHD were generally similar to those shown for 1m and 2m AHD, but were not depicted for clarity; and
- profiles were truncated at 10m landward of the sand/vegetation interface visible in 2011 aerial photography (forming a landward limit to calculations); a comparison of volume calculations using a landward limit at the 2011 sand/vegetation interface is provided in Figure B5.

It is evident that the analysed patterns of volume and contour change were very similar along these beaches. Most areas along Lagoon Beach and Cobbys Beach showed evidence of progradation, but with recession south of the access track opposite the Board Administration office at Lagoon Beach extending to the runway revetment, and recession also immediately south of the runway revetment at Cobbys Beach.

The difference in the volumetric rates for the two landward limit options utilised in Figure B5 indicates that:

- where progradation has been occurring this has been over the full beach profile including the vegetated dunal area (that is, both the sandy beach and vegetated area has been prograding)⁷; and
- where recession has been occurring this has only been seaward of the erosion escarpment (that is, the vegetated area landward of the escarpment has remained stable while the beach area seaward has receded)⁸.

Analysis was also undertaken for a landward profile limit 20m landward of the sand/vegetation interface (except at structures and the northern Lagoon Beach headland near Signal Point, where it is not relevant to extend the limit landward of the fixed structure/cliff). The same pattern of increasing progradation in prograding areas and similar recession in receding areas was generally observed.

⁶ This means that data was averaged using the data point, two points prior and two points following (5 in total).

⁷ As evident with the volume rates for the more landward limit being larger (by about a factor of 2) where progradation has occurred.

⁸ As evident with the volume rates for each landward limit being similar where recession has occurred. This makes physical sense as in some receding areas the dunal area has a fixed structure (namely along the Seabee seawall and at the southern end of the runway revetment), and in other areas the erosion escarpment has been relatively high such that windblown sand may be unable to be transported over the crest of the escarpment into the vegetated area (namely at the southern end of Lagoon Beach).

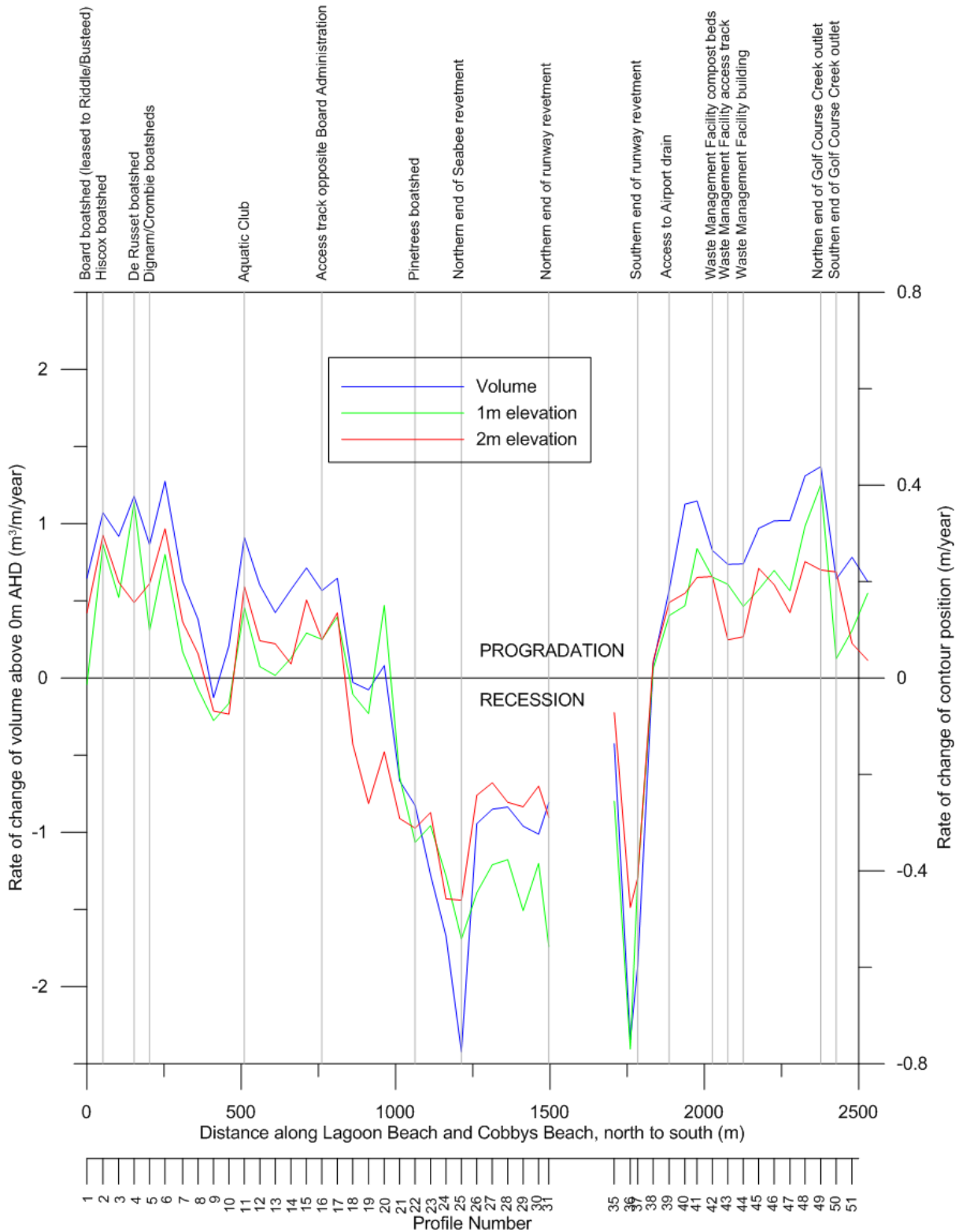


Figure B3: Rate of change of volume above 0m AHD, and rate of change of position of 1m and 2m AHD contours (both for the 1965 to 2011 period), along Lagoon Beach and Cobbys Beach (raw data, landward limit 10m landward of 2011 sand/vegetation interface)

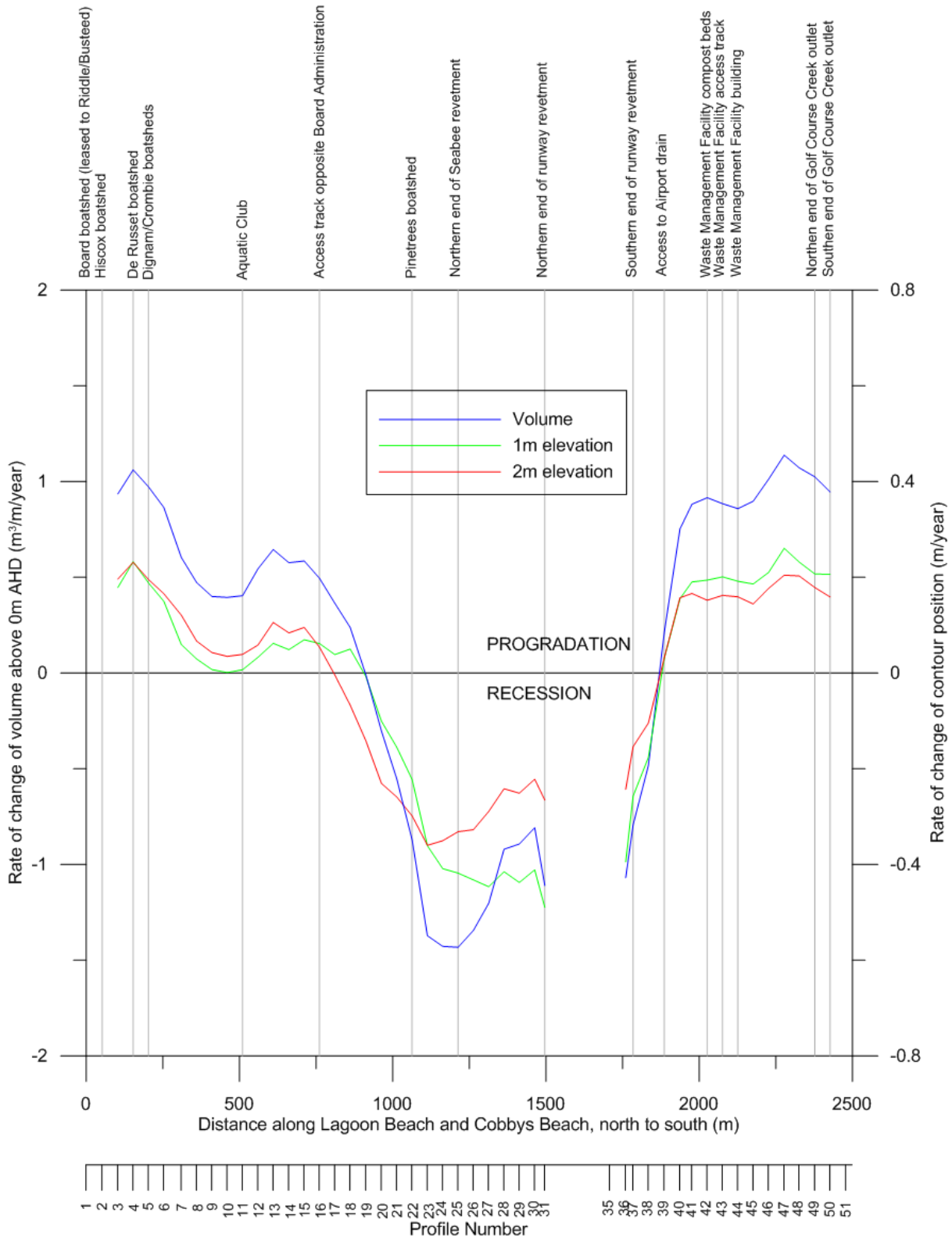


Figure B4: Rate of change of volume above 0m AHD, and rate of change of position of 1m and 2m AHD contours (both for the 1965 to 2011 period), along Lagoon Beach and Cobbys Beach (smoothed data, landward limit 10m landward of 2011 sand/vegetation interface)

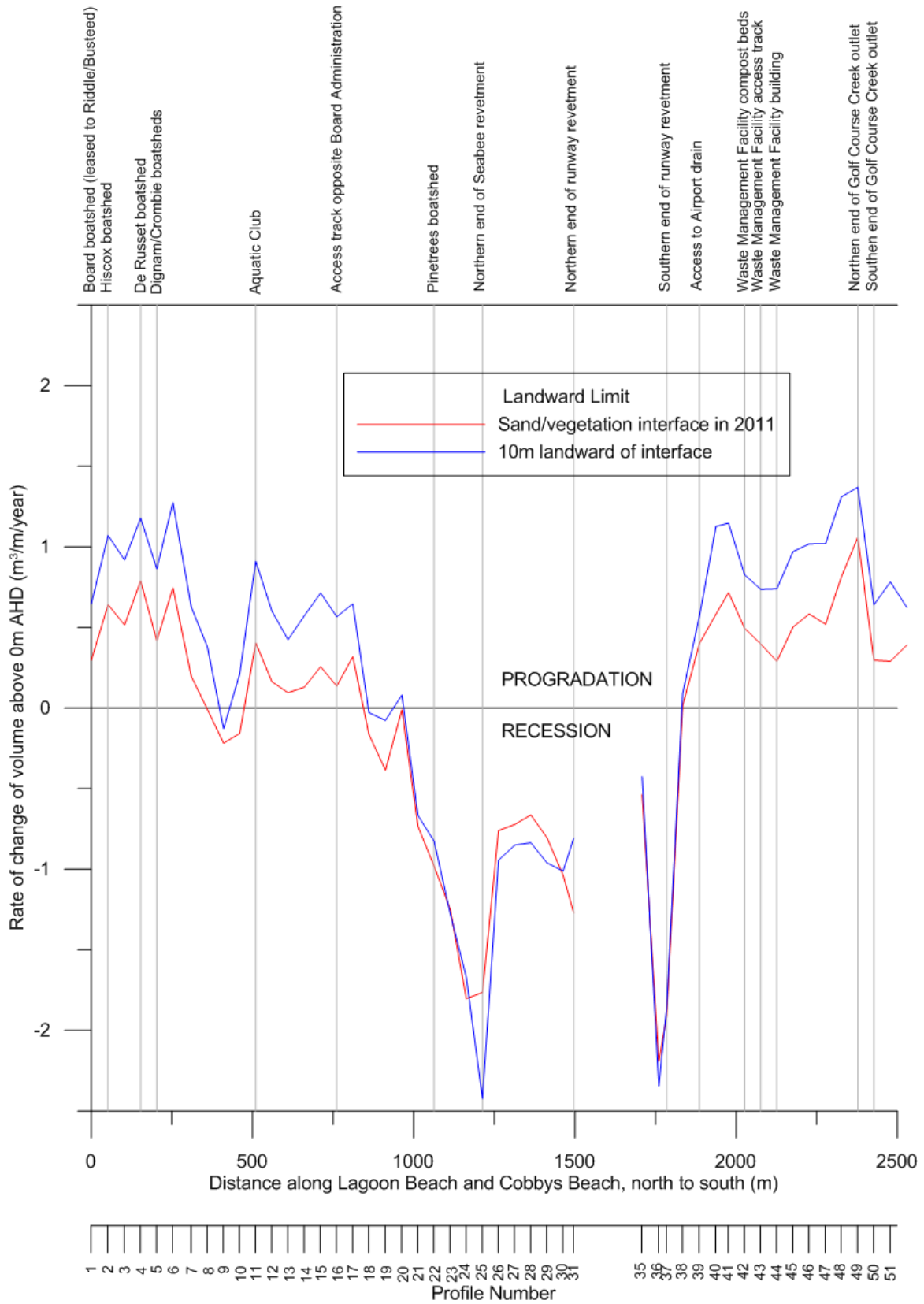


Figure B5: Comparison of volume change analysis for 1965 to 2011 using two different landward profile limits (raw data)

Summaries of the volumetric and positional changes are depicted in Figure B6 (north end of Lagoon Beach), Figure B7 (south end of Lagoon Beach and adjacent to the Seabee seawall) and Figure B8 (Cobbys Beach). These Figures also have the position of 0m and 2m AHD contour levels in 1965 and 2011 depicted, as a useful visualisation of the horizontal movement in these levels over time.

An overall summary of volumetric changes in various compartments along Lagoon Beach and Cobbys Beach is provided in Figure B9. Volumes are given for landward limits at both 10m and 20m landward of the 2011 sand/vegetation interface.

It is evident that from 1965 to 2011, based on linear regression using 5 dates, spatially averaged rates of change were as listed in Table B1. Note that the 10m and 20m limits shown refer to distances of 10m and 20m respectively landward of the sand/vegetation interface as the landward profile limit.

Table B1: Summary of 1965 to 2011 volume and elevation position rates of change along Lagoon Beach and Cobbys Beach (positive is progradation, negative is recession)

Location	Volumetric (m ³ /m/year)		Volumetric (m ³ /year)		Elevation (m/year)
	10m limit	20m limit	10m limit	20m limit	
Northern end of Lagoon Beach (north of 140m north of Pinetrees boatshed)	+0.7	+0.8	+560	+700	+0.1 (0, 1 & 2m AHD)
Southern end of Lagoon Beach (from south of 140m north of Pinetrees boatshed) and adjacent to Seabee seawall	-0.9	-0.8	-540	-520	-0.3 (0, 1 & 2m AHD)
Northern end of Cobbys Beach (80m length south of runway revetment)	-1.5	-1.5	-160	-160	-0.5 (1m elevation) ⁹
Cobbys Beach (from 80m south of runway revetment)	+0.9	+1.1	+620	+770	+0.2 (0, 1 & 2m AHD)

For the 10m limit there was net progradation over the entire area analysed along Lagoon Beach and Cobbys Beach of 480m³/year, and net progradation of 790m³/year for the 20m limit. Therefore, there has been a net infeed of sediment into the compartments depicted in Figure B9. This is considered to be most likely due to onshore transport of sediment from the Lagoon and possibly some alongshore transport of sediment into Cobbys Beach from the south (and also possibly alongshore transport along Lagoon Beach to the north).

To investigate the contribution to the volume changes of the various time periods between photogrammetric dates, plots of volume change in each period were derived as shown in Figure B10. The rates were smoothed using a running average with a window width of 5.

⁹ Rates were -0.6 and -0.3m/year at 0 and 2m elevation respectively.

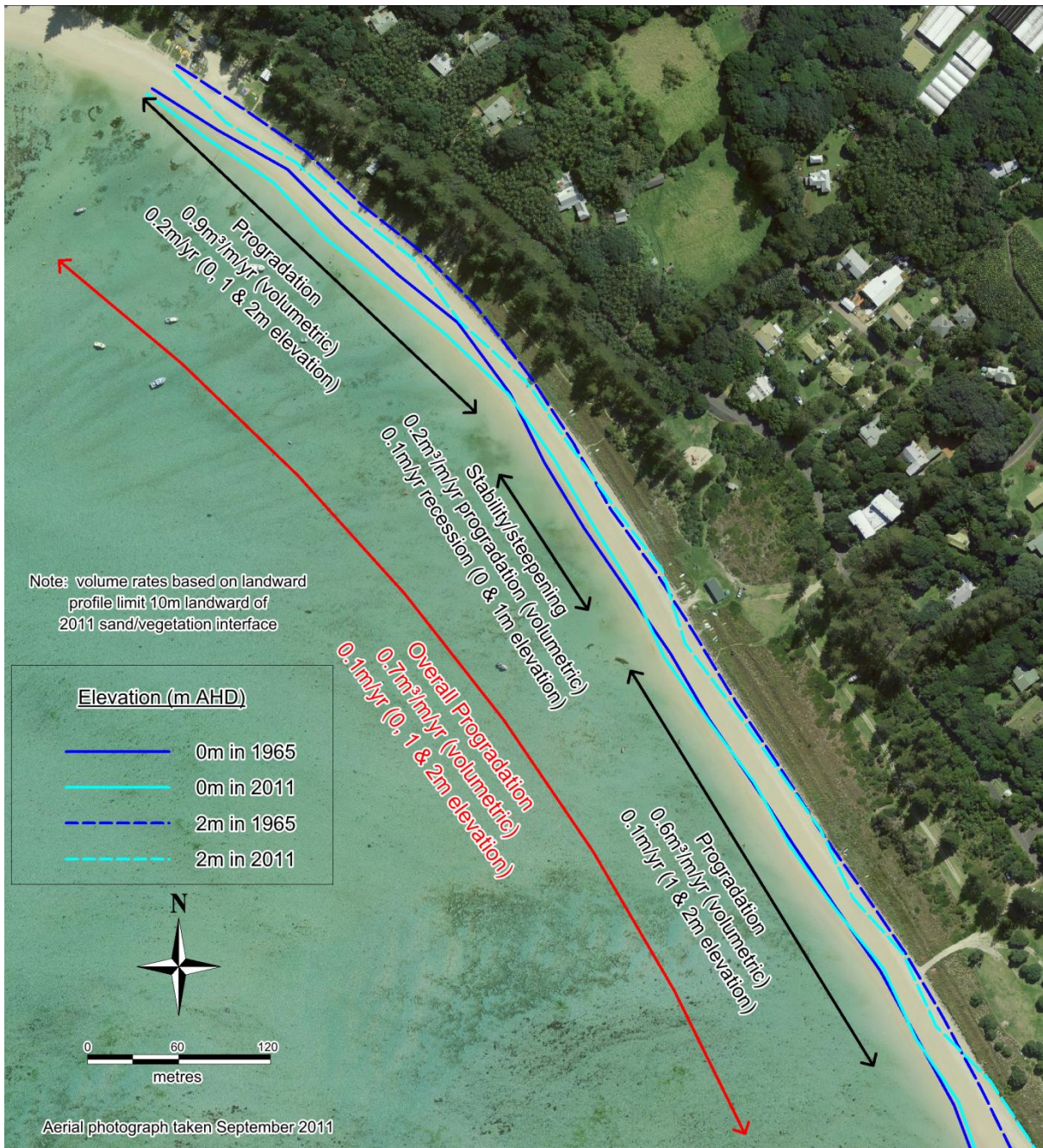


Figure B6: Summary of 1965 to 2011 volume and elevation rates of change along northern end of Lagoon Beach