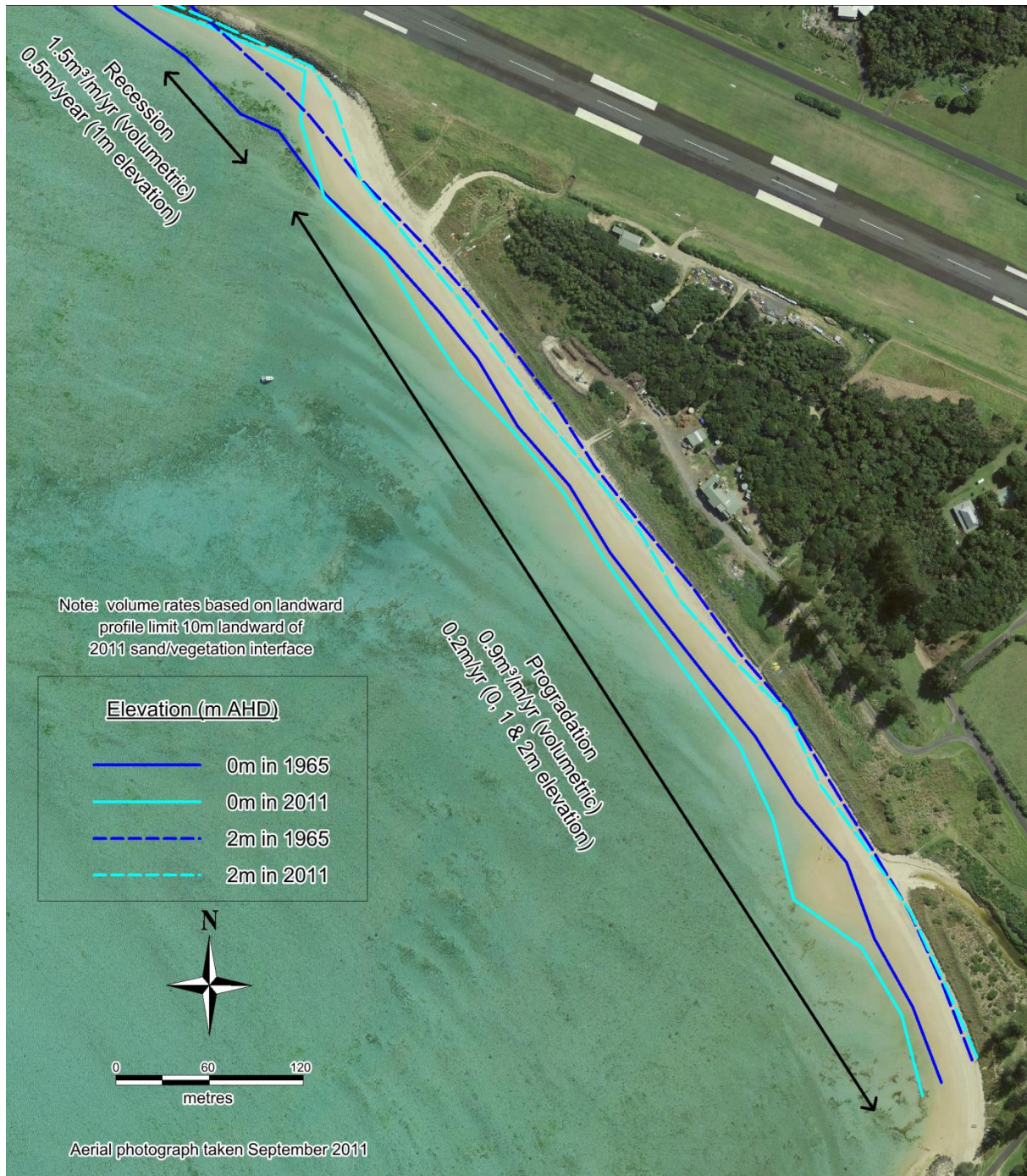


**Figure B7: Summary of 1965 to 2011 volume and elevation rates of change along southern end of Lagoon Beach and adjacent to Seabee seawall**





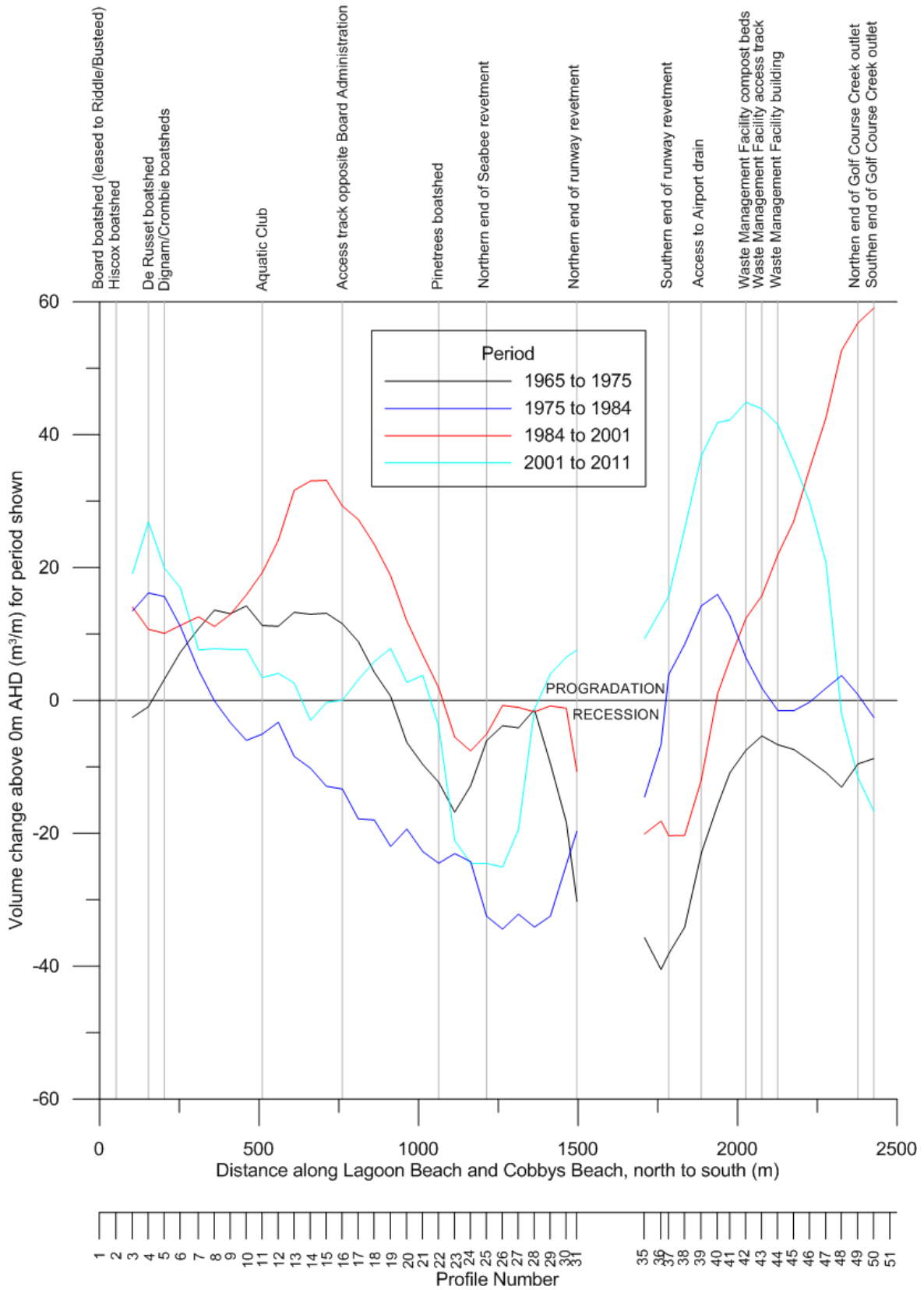
**Figure B8: Summary of 1965 to 2011 volume and elevation rates of change along Cobbys Beach**





**Figure B9: Summary rates of change of volume per year in various compartments along Lagoon Beach and Cobbys Beach (based on 1965 to 2011 rate in compartment)**





**Figure B10: Volume change between each photogrammetric date along Lagoon Beach and Cobbys Beach (smoothed)**

It is evident from Figure B10 that:

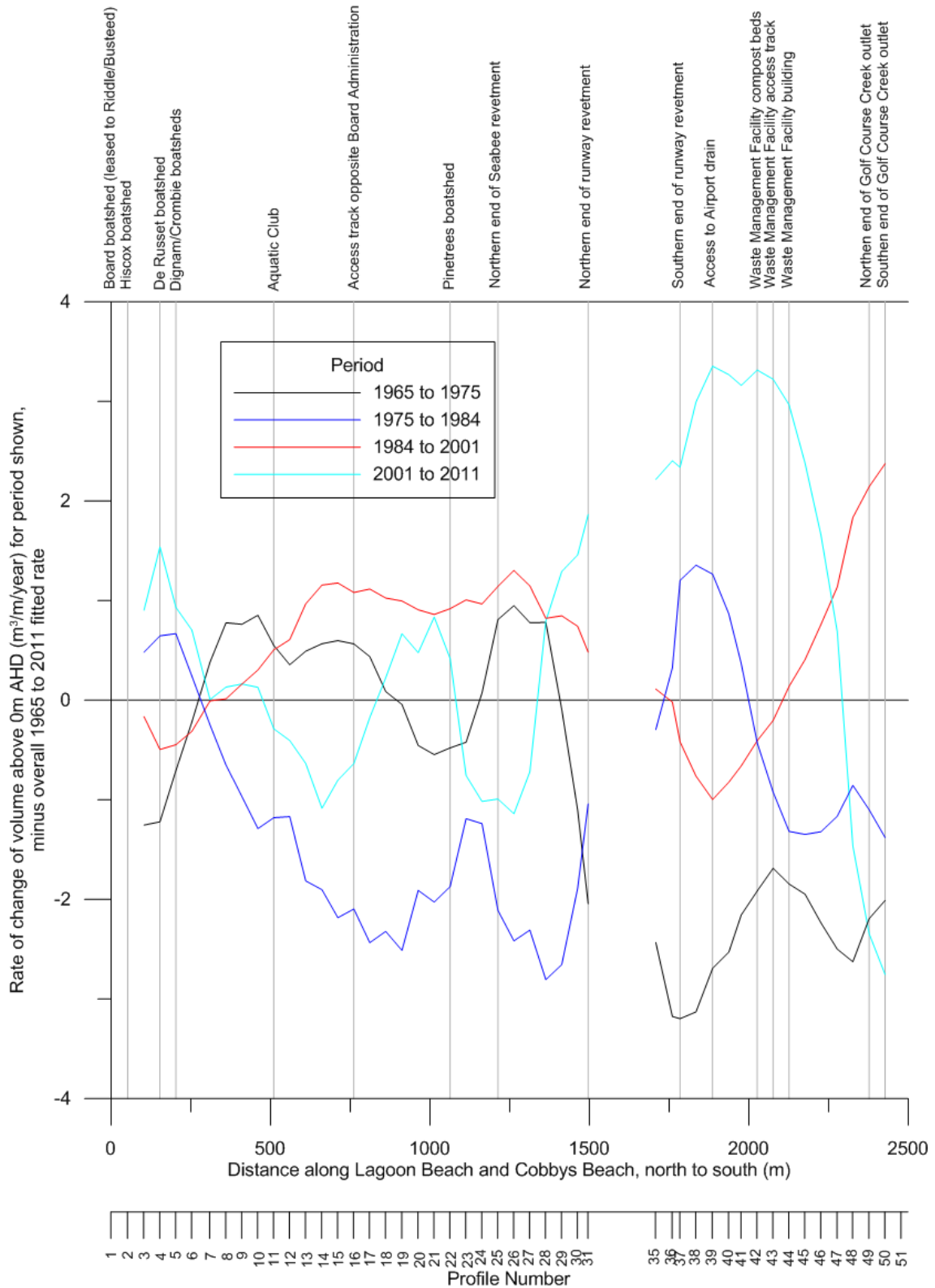
- from 1965 to 1975:
  - there were volume gains to the north of 100m north of Pinetrees boatshed (except not at the northern boatsheds) along Lagoon Beach;
  - there were volume losses along all of Cobbys Beach, particularly north of the Waste Management Facility;
- from 1975 to 1984:
  - there were volume gains at the northern boatsheds and then steadily increasing volume losses moving south to the runway revetment along Lagoon Beach;
  - moving south along Cobbys Beach there were volume losses for 80m south of the runway revetment, then volume gains as far south as the Waste Management Facility, and relative stability further south;
- from 1984 to 2001:
  - there were volume gains along Lagoon Beach to the north of Pinetrees boatshed, and relatively small losses south of that point to the northern end of the runway revetment;
  - there were volume losses over the northern 180m of Cobbys Beach and steadily increasing volume gains south of that point;
- from 2001 to 2011
  - there were volume gains along most of Lagoon Beach to the north of Pinetrees boatshed, and volume losses south of that point to 100m north of the runway revetment (with volume gains over the 100m north of the revetment); and
  - there were volume gains along most of Cobbys Beach, except south of Golf Course (Cobbys) Creek.

Overall, some general patterns emerge, namely:

- increasing volume gain or reducing volume loss moving north of Pinetrees boatshed along Lagoon Beach for most dates; and
- increasing volume gain or reducing volume loss moving south along Cobbys Beach to the Waste Management Facility for most dates.

To further investigate the contribution of the various periods between photogrammetric dates to the overall rates of change, plots of volume rates of change for each period (1965 to 1975, 1975 to 1984, 1984 to 2001, and 2001 to 2011) were derived, with the long term 1965 to 2011 volume rate determined by linear regression (as plotted in Figure B3) then subtracted (see Figure B11). The rates were smoothed using a running average with a window width of 5.

Positive plotted rates mean that a higher rate of progradation occurred for the period than the 1965 to 2011 (long term) rate, or progradation occurred where there had been long term recession. Zero plotted rates mean that there was the same rate of progradation or recession for the period as the long term rate. Negative plotted rates mean that a lower rate of progradation occurred for the period than the long term rate, or recession occurred where there has been long term progradation.



**Figure B11: Rate of change of volume above 0m AHD for various periods, minus overall 1965 to 2011 fitted rate, smoothed**



Key features in Figure B11 include the following:

- cyclic pockets of relative progradation and relative recession along Lagoon Beach from 1965 to 1975, and relative (and large) recession along Cobbys Beach for this period;
- relative (and large) recession from 1975 to 1984 along Lagoon Beach to the northern end of the runway revetment (except at the northern boatsheds), relative progradation for this period immediately south of the runway revetment at Cobbys Beach, and relative recession south of the Waste Management Facility at Cobbys Beach;
- relative progradation from 1984 to 2001 in most areas (except at the northern boatsheds and immediately south of the runway revetment; and
- cyclic pockets of relative progradation and relative recession along Lagoon Beach from 2001 to 2011 (almost mirroring the 1965 to 1975 pattern), and relative (and large) progradation along most of Cobbys Beach (except at the southern end).

#### B4. MOVEMENT OF SAND/VEGETATION INTERFACE

A technique that provides an indication of whether beaches have receded (shifted landwards or reduced in volume) or prograded (shifted seawards or increased in volume) is tracking the position of the sand/vegetation interface over time. Where visible, two interfaces were mapped, namely the incipient sand/vegetation interface (with light coverage of grasses and creepers landward of the interface) and the main frontal dune sand/vegetation interface (more densely vegetated landward). An example of these positions is depicted in Figure B12 (as visible on Lagoon Beach in 2011 near the Dignam/Crombie boatsheds).



**Figure B12: Example definition of incipient and frontal dune sand/vegetation interfaces**

The positions of the 1965 sand/vegetation interfaces at Lagoon Beach overlaid on a 2011 aerial photograph are provided in Figure B13 (northern half) and Figure B14 (southern half). The same information is depicted in Figure B15 for Cobbys Beach. Note that the terms “progradation” and “recession” used in these Figures are taken to be equivalent to seaward and landward migration of the interfaces respectively, for simplicity<sup>10</sup>.

<sup>10</sup> It is possible that this is not always the case, for example that an interface moves landward on a prograding (growing in volume) profile, as vegetation growth can be affected by more factors than just sand volume (such as degree of trampling or rainfall).





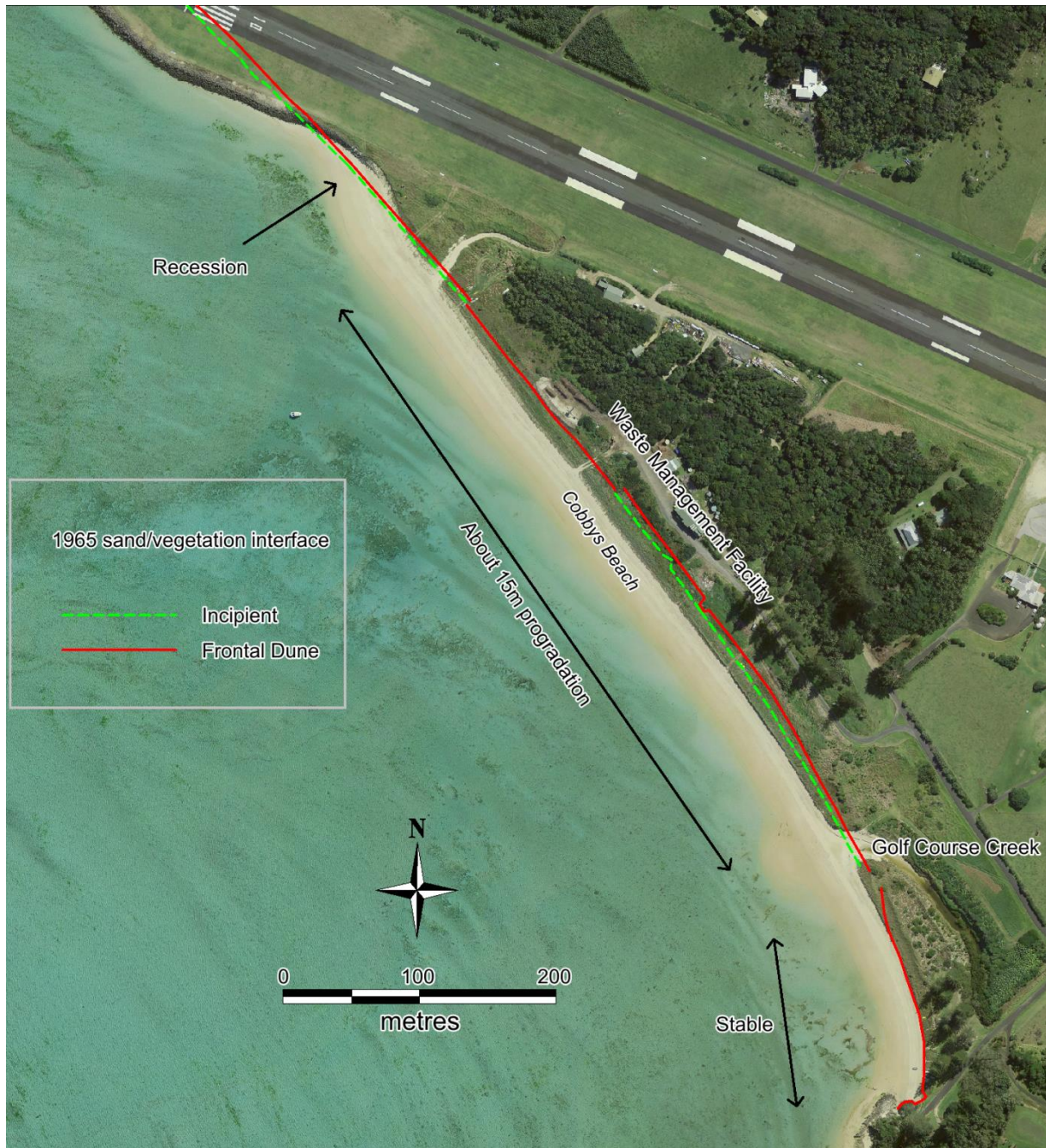
**Figure B13: Position of 1965 sand/vegetation interfaces at northern end of Lagoon Beach overlaid on 2011 aerial photograph**





**Figure B14: Position of 1965 sand/vegetation interfaces at southern end of Lagoon Beach overlaid on 2011 aerial photograph**





**Figure B15: Position of 1965 sand/vegetation interfaces at Cobbys Beach overlaid on 2011 aerial photograph**

It is evident that the sand/vegetation interface has migrated seaward (indicative of progradation) between 1965 and 2011 at most locations along Lagoon Beach and Cobbys Beach, namely:

- about 6m seaward at the northern-western end of Lagoon Beach (north-west of the boatsheds), see Figure B13;

- about 10m to 15 m seaward at the boatsheds at the northern end of Lagoon Beach continuing south past the Aquatic Club to the accessway (Location A in Figure B13) opposite the Board Administration offices (that is, over an alongshore distance of about 840m); and
- about 15m seaward adjacent to the Waste Management Facility and north to the Airport drain accessway and as far south as Golf Course (Cobbys) Creek at Cobbys Beach (that is over an alongshore distance of about 540m), see Figure B15.

Areas where the sand/vegetation interface has migrated landward (indicative of recession) between 1965 and 2011 comprise the following:

- over an alongshore distance of 220m north of the bag wall at Lagoon Beach, including (Figure B14):
  - landward migration of 13m at Pinetrees boatshed;
  - landward migration of 20m immediately north of the bag wall; and
- crenulate shaped landward migration of up to 15m immediately south of the runway revetment at Cobbys Beach, over an alongshore distance of about 80m (Figure B15);

The 1965 and 2011 sand/vegetation interfaces are approximately coincident along Lagoon Beach from about 80m to 210m south of Location A in Figure B14, and south of Golf Course (Cobbys) Creek at Cobbys Beach (Figure B15), indicative of relative stability.

For intermediate dates, it can be noted that:

- there was about 5m landward migration of the sand/vegetation interface between 1975 and 1984 along most of the present Seabee seawall location;
- most (about 75%) of the seaward interface migration north of the Aquatic Club at Lagoon Beach occurred between 1975 and 1984;
- between the Aquatic Club and the southern limit of the “about 10 to 15m progradation” region in Figure B13, about one-third to two-thirds of the seaward interface migration occurred between 1975 and 1984, and the other one-third to two-thirds between 1984 and 2001 (with the larger change for the 1975 to 1984 period in the north, and 1984 to 2001 period in the south);
- the “stable area” in Figure B14 had generally coincident interfaces over the 1965 to 2011 record, except that 1975 was about 5m further landward, particularly in the north;
- most (75%) of the landward migration in the “Recession up to 20m area” at the southern end of Lagoon Beach occurred between 2001 and 2011, for example:
  - at Pinetrees boatshed the interface moved 3m landward from 1965 to 1975, then 3m seaward from 1975 to 1984, then 3m landward from 1984 to 2001, then 10m landward from 2001 to 2011;
  - at the southern end the interface moved 4m landward from 1965 to 1975, then 2m seaward from 1975 to 1984, then 3m landward from 1984 to 2001, then 15m landward from 2001 to 2011;
- the “recession” interface at the northern end of Cobbys Beach moved about 3m seaward between 1965 and 1975, up to about 7m seaward between 1975 and 1984, up to 17m landward between 1984 and 2001, and around 8m landward between 2001 and 2011;
- the “about 15m progradation” interface depicted in Figure B15 at Cobbys Beach has generally progressively moved seawards, namely stable between 1965 and 1975, about 5m seaward at 1984, about 5m further seaward at 2001, and again about 5m further seaward at 2011; and
- the “stable” interface depicted in Figure B15 at Cobbys Beach did migrate about 5m to 10m landward between 1965 and 1975, half recovered by 1984, and fully recovered by 2001.





To summarise, the sand/vegetation interface along most of Lagoon Beach and Cobbys Beach moved about 10m to 15m seaward between 1965 and 2011, with about 75% occurring between 1975 and 1984 at Lagoon Beach and more progressive change at Cobbys Beach. The main exceptions are:

- the “stable” area in Figure B14 which had generally coincident interfaces over the 1965 to 2011 record;
- landward migration over the southern 220m of Lagoon Beach from north of the bag wall (up to 20m at the southern end, and 13m at Pinetrees boatshed), with about 75% occurring between 2001 and 2011; and
- an isolated fillet of landward migration immediately south of the runway on Cobbys Beach, over an alongshore distance of about 80m.

These patterns are generally similar to the volumetric and positional rates of change discussed in Section B3.

## **B5. EXAMPLE OF PROFILE CHANGES AT PINETREES BOATSHED**

A plot of Profile 22 in Figure B1, the closest profile to Pinetrees boatshed (located 14m north of the boatshed), is provided in Figure B16. The five photogrammetric dates are depicted (in 1965, 1975, 1984, 2001 and 2011), as well as a profile derived from a LiDAR (aerial laser) survey completed by NSW Land and Property Information between 25 and 30 October 2012. Note that the zero chainage point is located at the landward extent of the profile depicted in Figure B1. The boatshed position is also shown, but note that its floor level is uncertain.

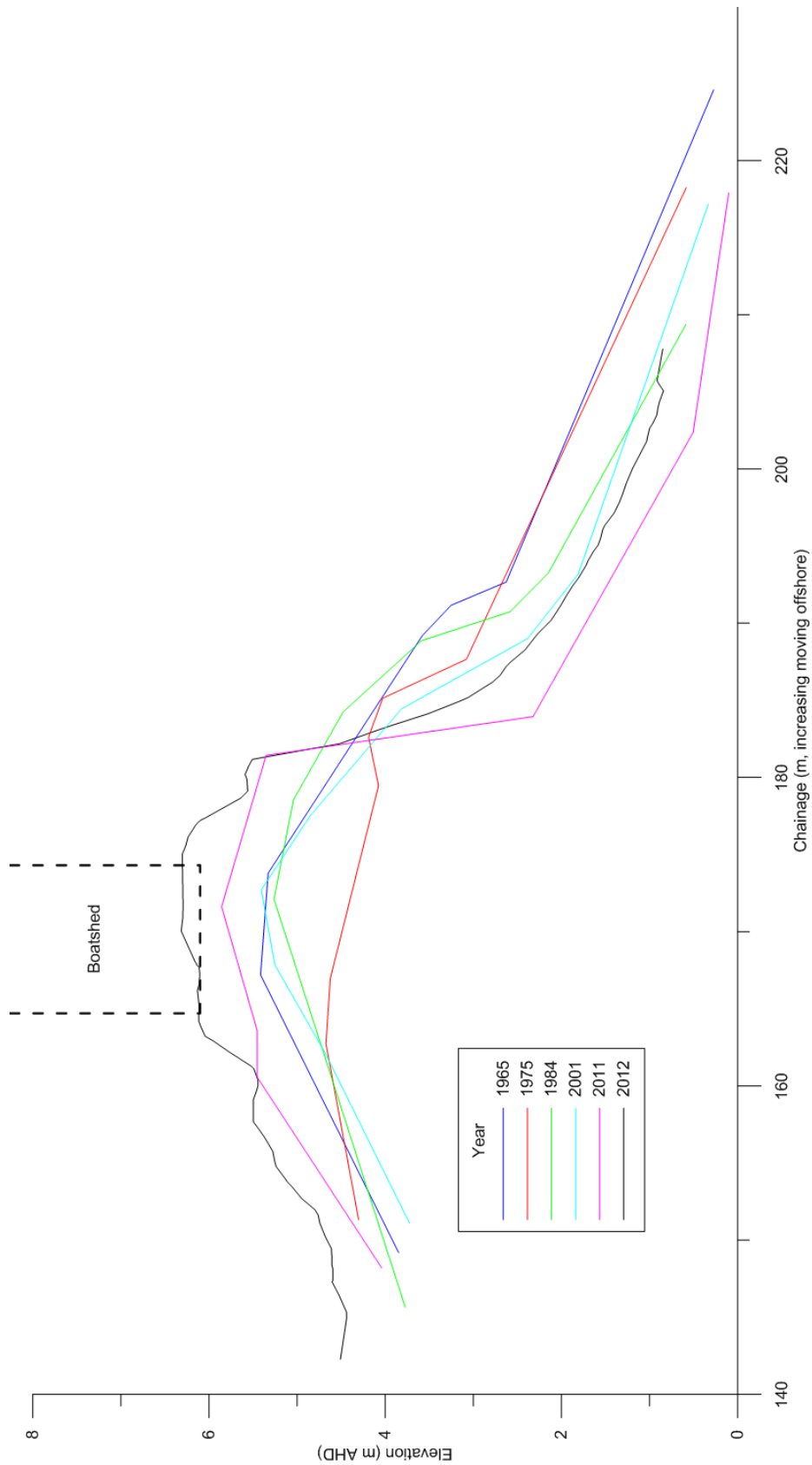
It is evident that beach volumes were reducing between 1975 and 1984, that would not have been visible as forming any erosion escarpment or loss of vegetation in the back beach area. That is, the losses in beach volume between 1975 and 1984 were manifested as a lowering of beach below about 3m AHD and steepening above that, which would only have been visible as a reducing subaerial beach width.

Between 1984 and 2001, the recession was mostly in the upper profile and would have begun to be visible as cutting into the vegetated dune. Between 2001 and 2011, the beach lowered at the seaward end and steepened in the back beach area as a typical erosion profile.

The photogrammetric data is most accurate in exposed beach areas where there is no vegetation. Where there is dense vegetation, the photogrammetric data can lack accuracy. The difference in levels between the 2012 LiDAR data and photogrammetric data evident at the crest of the dune may be related to this. That is, it is unlikely that elevations increased in the dunal area as depicted between 2011 and 2012.

That stated, the general trend of increasing dune crest elevations over time in the photogrammetric data is noteworthy. If this is realistic, this may be indicative of windblown sand being transported over the erosion escarpment and landward into the dunal area, then being trapped by vegetation and increasing the dune crest height. Historical beach scraping practices may have contributed to this process due to mounds of sand being placed at the base of the erosion escarpment, which could then be mobilised and transported into the dune under the dominant south-westerly winds.





**Figure B16: Variation in beach profile near Pinetrees boatshed over time**



## **APPENDIX C**

### **ANALYSIS OF SEDIMENT SAMPLES**





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## C1. BACKGROUND

In August 2012, 64 sediment samples were collected at Lord Howe Island by Haskoning Australia staff, namely at:

- Lagoon Beach (samples L1 to L26);
- Cobbys Beach (denoted as “South Runway Beach” herein, samples SR1 to SR4);
- in the Lagoon waterway (samples W1 to W16);
- Blinky Beach (samples B1 to B6);
- Neds Beach (samples N1 to N8); and
- Middle Beach (samples M1 to M4).

In May 2013, Haskoning Australia collected a further 29 samples from Lagoon Beach along three cross-shore transects, namely:

- at the Douglass Prodiver boatshed at the northern end of Lagoon Beach (Transect A);
- 90m south of the Aquatic Club (Transect B); and
- at Pinetrees boatshed (Transect C).

The sediment sampling locations are depicted in Figure C1 (Lagoon Beach and northern Lagoon waterway), Figure C2 (South Runway Beach and southern Lagoon waterway), Figure C3 (Blinky Beach), Figure C4 (Neds Beach) and Figure C5 (Middle Beach). A brief description of the sample locations is provided in Table C1.

Selected photographs of the sampling are provided in Section C2.

Analysis of selected samples was undertaken by a sedimentologist, Dr Ed Frankel of Vibrosed Analytical (and formerly of the University of Technology Sydney), as discussed in Section C3.

The May 2013 samples were not analysed by Dr Frankel, only being analysed visually. It was evident from visual inspection that the sediment particle size was substantially coarser near the mean water level location on the beach.



**Figure C1: Lagoon Beach and northern Lagoon waterway sediment sampling locations**