

## 8.7 Risk to Assets

The key assets at immediate risk of damage at Lagoon Beach and Cobbys Beach are Pinetrees boatshed and Lagoon Road near the bag wall. Considering 2050 and 2100 timeframes, the boatsheds at the northern end of Lagoon Beach begin to become at risk, as does the Aquatic Club. Without the protection of the Seabee revetment and rock revetment, Lagoon Road and the runway would be at immediate risk of damage, indicating the importance of maintaining these structures.

In August 2012, the erosion escarpment at Pinetrees boatshed was measured as being 7.6m from the seaward face of the structure, with the deck seaward of the boatshed within 1m of the escarpment (Figure 38).



**Figure 38: Erosion escarpment adjacent to deck at Pinetrees boatshed in August 2012**



## 9. CLIFF STABILITY

Woodroffe et al (1995) estimated that the calcarenite cliffs at Neds Beach were formed around 120,000 to 140,000 years ago. They considered that sediments were deposited by aeolian processes and formed over the underlying basalt during the Last Interglacial period (prior to the present Holocene interglacial period) when sea level was 2m to 4m above present levels.

The Neds Beach Calcarenite is composed of well-rounded and polished lithoclasts of coral, coralline algae, shell, foraminifera and microgastropods (Woodroffe et al, 1995). The cliff at the SE end of Neds Beach was considered by Woodroffe et al (1995) to be undergoing active erosion.

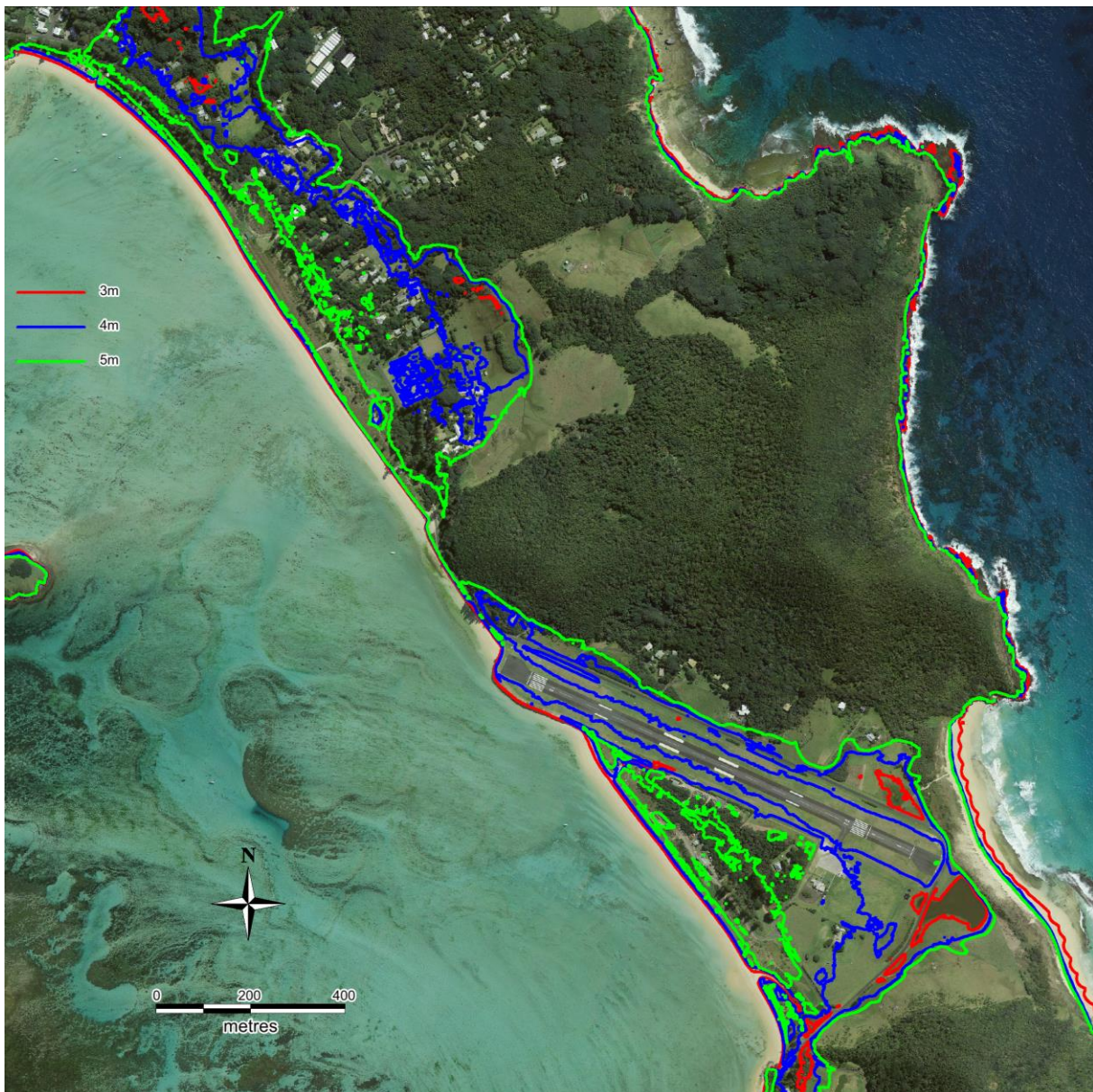
Further discussion on cliff stability is provided in Section 13.4.4.

## 10. COASTAL INUNDATION

Areas below about 3m AHD would be expected to be at particular risk of inundation. There are no areas of infrastructure at Lagoon Beach and Cobbys Beach below that elevation. Areas between 3m and 4m AHD in elevation may become subject to inundation over the long term under sea level rise.

The 3m, 4m and 5m AHD contours along the Lagoon Beach and Cobbys Beach shoreline are depicted in Figure 39.

It is evident that the airport is the most extensive area with elevations around 4m AHD.



**Figure 39: 3m, 4m and 5m AHD contours along the Lagoon shoreline**

## 11. WATERCOURSE ENTRANCE MANAGEMENT

### 11.1 Overall Entrance Management Principles

There were three Intermittently Closed and Open Lakes and Lagoons (ICOLLs) identified in the Brief for consideration with regard to entrance management, namely Old Settlement Creek, Cobbys Creek and Soldiers Creek. Overall entrance management principles that should apply at all of these creeks are outlined below in this Section. Some specific comments on levels and issues at the particular creeks are provided in Sections 11.2, 11.3, and 11.4 respectively.

All these creek systems contain Sallywood Swamp Forest (also known as Lagunaria Swamp Forest), which is a Critically Endangered Ecological Community in NSW (found only at Lord Howe Island). This is a plant community dominated by the Sallywood tree. Other species found in this community include Mangroves, Kentia Palm, Cottonwood Hibiscus and Blackbutt. Sallywood Swamp Forest is found in very limited areas of Lord Howe Island, in low sites that are occasionally inundated (OEH, 2014a).

OEH (2014a) noted that key threats to the Sallywood Swamp Forest were clearing, exposure to winds, tramping by cattle and weed invasion. It is recommended that the Board continues to manage the Sallywood Swamp Forest areas through preventing clearing, providing wind protection, excluding cattle and through weed control.

OEH (2014b) noted that water regimes were a key driver of the existence of Sallywood Swamp Forest community as it occurs in low lying areas, often near the outlets of small creeks. OEH (2014b) also considered that future impacts with rising sea levels were likely to lead to an encroachment of mangroves into the community and necessitate its movement upslope onto existing grazing land, should that be available. It is recommended that the Board investigates opportunities to expand Sallywood Swamp Forest communities upslope where available, in liaison with landowners.

The Sallywood Swamp Forest can be adversely impacted by ingress of saline (ocean) waters into the creek systems (David Kelly, Manager Environment & Community Development, Lord Howe Island Board, personal communication). The Sallywood Swamp Forest is also found in swampy areas, but it is unknown how critical the level and frequency of freshwater inundation is for maintaining the health of the vegetation community<sup>64</sup>.

Where possible, it is recommended that a natural entrance opening regime is maintained, that is no intervention, unless entrance management is required to enhance the Sallywood Swamp Forest or there is a particular need to reduce inundation of infrastructure (but only where this would not adversely impact on the Sallywood Swamp Forest).

The key effect of entrance openings in terms of maintaining the health of the Sallywood Swamp Forest is considered to be the ingress of saline water. If the health of the Sallywood Swamp Forest deteriorates under a natural entrance opening regime (ie with no human intervention in the breakout and closure process), then it would be necessary to intervene in this process to reduce the ingress of saline water. Saline intrusion could be reduced by:

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<sup>64</sup> Scientific/engineering citation databases were searched in an attempt to find literature on the desirable frequency of inundation of Sallywood Swamp Forest, with no relevant information found.

- mechanically closing off an entrance immediately after a breakout event by redistributing sand near the entrance, thus reducing the duration (and hence volume) of saline intrusion; and/or
- maintaining the beach berm level seaward of a creek at a higher level, again by redistributing sand near the entrance, which would reduce the frequency of openings and hence provide fewer opportunities for saline intrusion to occur; and/or
- mechanically opening an entrance (if that was required) on a low to rising tide, which would reduce the efficiency of the breakout process and lead to less entrance scour due to faster equilibration of creek and ocean water levels.

All of the above actions would be counterproductive to any requirements to manage an entrance to reduce inundation levels to protect infrastructure. To manage an entrance for flood mitigation purposes, it would be most effective to:

- maintain the beach berm level seaward of a creek at a lower level (as a 'notch' or 'saddle'), which would increase the frequency of openings and reduce the water level required to induce natural breakout; and/or
- mechanically open an entrance (if that was required) at high tide, which creates the most efficient breakout process as it leads to the longest duration of time that creek levels are higher than the ocean and hence able to drive a seaward flow to drain the creek.

There may be times during extended dry periods when it is desirable to flush creeks that have stagnant pools. This could be achieved by a manual entrance opening, although it must be recognised that this would cause saline water intrusion as ocean waters enter the creek, with some reduction in salinity as fresh groundwater would also enter the creek. It would therefore be necessary to monitor Sallywood Swamp Forest health after any such openings were undertaken, and alter entrance opening practices if required.

It should also be recognised that creek openings introduce suspended sediment and nutrients into the Lagoon, which may impact on coral and seagrass within the Lagoon. For example, plumes of turbid creek water were evident in the Lagoon seaward of the three creeks after rainfall-runoff induced natural openings in August 2012. It is recommended that catchment management practices are adopted to minimise the mobilisation of sediment and nutrients from the surrounding catchments into the creeks during rainfall-runoff.

Given the sensitivity of the Sallywood Swamp Forest to any mechanical entrance opening, it is recommended that:

- there is community education that landowners are not to open creek entrances without Board approval, with legislative changes to make this unlawful if required;
- records are kept by the Board's Administration of the date of natural and mechanical entrance openings and closures;
- berm levels are regularly surveyed, say quarterly;
- water quality within the creek systems is monitored, including salinity levels along the creeks moving downstream to upstream (and variations with depth);
- the health of the Sallywood Swamp Forest is monitored and assessed by the Board's Administration in relation to entrance openings and closures; and
- the entrance opening regime is altered by the Board's Administration as required in terms of maintaining the health of the Sallywood Swamp Forest, protecting infrastructure, and flushing stagnant pools.

If berm levels increase due to sea level rise (which is expected), there may be little change to saline intrusion in the future under a natural entrance opening regime, or even less saline intrusion as opening frequency may reduce (as creek levels would need to be higher to induce natural breakout). However, there are additional complexities in this process such as the potential for rainfall patterns to alter under climate change, and for groundwater to become more saline with sea level rise. This emphasises the importance of continued monitoring of Sallywood Swamp Forest areas into the future.

It may also be possible to reduce saline intrusion by regrading creeks (increasing bed levels in the vicinity of the Sallywood Swamp Forest) or introducing weir or gate like structures downstream of the Sallywood Swamp Forest. Additional investigations would be required to assess the feasibility and environmental impacts of such works.

## 11.2 Old Settlement Creek

At Old Settlement Creek, there is no significant surrounding infrastructure known to require an entrance opening trigger to reduce the risk of flooding, with the lowest nearby structures above 4m AHD<sup>65</sup>. An electrified fence located on the south bank of Old Settlement Creek about 75m north of the entrance (Figure 41) can 'short' out due to inundation, but it is recommended that (in consultation with the leaseholder) the fence design be changed (for example not electrifying the bottom rail and using barbed wire if required) or the fence be relocated to manage this, rather than introducing an opening trigger for this issue alone.

The beach berm at the entrance to Old Settlement Creek was at a level of about 2.6m AHD in an August 2011 survey (provided by the Board), and also in October 2012 LiDAR data. The Sallywood Swamp Forest is located about 300m upstream from the entrance (Figure 41). A photograph of the creek entrance after a rainfall-runoff induced natural opening in August 2012 is provided in Figure 40.

There is a substantial delta of sand formed within the Lagoon seaward of Old Settlement Creek, extending about 70m cross-shore and 110m alongshore, as visible in 2011 aerial photography (Figure 41). Observing 1975, 1984 and 2001 photography, it was evident that:

- in 1975, there was an entrance delta of similar dimensions as present (but located further south-east);
- the 1975 and 1984 entrance positions were similar;
- between 1984 and 2001, the entrance migrated about 50m north-west; and
- the delta also migrated north-west with this creek migration (that is, the delta has been positioned over time to be centred at the creek outlet).

There may be consideration of using this delta as a source of sand for beach nourishment, subject to assessment of sediment properties, environmental assessment and monitoring of effects on coastal processes at Old Settlement Beach. There are likely to be several thousands of cubic metres of sand in the delta that could potentially be removed without adversely impacting on coastline hazards at Old Settlement Beach or other areas. If this was considered, this could be undertaken progressively (with monitoring) to reduce the potential impacts. The fact that the Old Settlement Beach area has a relatively sheltered wave climate means that any impact of removal of delta sand on coastal processes is likely to be limited.

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<sup>65</sup> Note that the deck level over the bridge at Old Settlement Creek is 3.4m AHD.

There are two cattle crossings (muddy tracks) over Old Settlement Creek (see Figure 41) that, due to trampling and associated erosion, may be sources of sediment and nutrients to be mobilised into the creek. It is recommended that there is consideration of works (such as hardening the crossings) to reduce potential mobilisation of sediment in these areas.



**Figure 40: Natural opening of Old Settlement Creek, 31 August 2012**



**Figure 41: Aerial photograph of Old Settlement Creek entrance, with delta evident**



### 11.3 Cobbys Creek

At Cobbys Creek, there is surrounding infrastructure below 4m AHD. This includes the area surrounding a dwelling on Portion 191 which is located south-west of the entrance (Figure 43). The floor level of the dwelling at Portion 191 is unknown, but surrounding ground levels are about 3.4m AHD to the north and south, 3.8m AHD to the east, and 4.0m AHD to the west (based on October 2012 LiDAR data). Lagoon Road is at a level of about 3.8m AHD where it crosses the creek.

The beach berm at the entrance to Cobbys Creek was at a level of about 2.8m to 2.9m AHD in October 2012 LiDAR data. It is understood that there is a Sallywood Swamp Forest community located upstream of where Lagoon Road crosses Cobbys Creek (Figure 43). A photograph of the creek entrance after a rainfall-runoff induced natural opening in August 2012 is provided in Figure 42.

There is a delta of sand formed within the Lagoon seaward of Cobbys Creek, extending about 30m offshore and 60m alongshore, as visible in 2011 aerial photography (Figure 43). The entrance migrated about 30m north from 1965 to 2011, an average rate of about 1.5m/year, although the entrance appears to have been relatively stable since 2001<sup>66</sup>. The delta has only been visible in aerial photography since 2011 (based on examination of 1965, 1975, 1984 and 2001 dates), but this may be a function of entrance closure at the time of earlier photographs, and the delta at Cobbys Beach being a transient feature due to longshore sand transport.

As for Old Settlement Creek, there may be consideration of using the Cobbys Creek delta as a source of sand for beach nourishment. There is likely to be in the order of 1,000m<sup>3</sup> metres of sand in the delta that could potentially be removed without adversely impacting on coastline hazards at Cobbys Beach or other areas.



<sup>66</sup> Based on advice from Board staff, it is understood that some of this migration may have been artificial.

Figure 42: Natural opening of Cobbys Creek, 31 August 2012



Figure 43: Aerial photograph of Cobbys Creek entrance, with delta evident

## 11.4 Soldiers Creek

At Soldiers Creek, the adjacent Lagoon Road is at a level of about 3.3m AHD at its northern arm, and 3.1m AHD (at its lowest point) near its southern arm. Paddocks located adjacent to Lagoon Road in this area are generally at a level of about 3.4m AHD, with some areas as low as 2.7m AHD near the northern arm. Surrounding houses are above 4.0m AHD (all levels based on October 2012 LiDAR data).

The beach berm at the entrance to Soldiers Creek was at a level of about 2.4m AHD in October 2012 LiDAR data. It is understood that there is a Sallywood Swamp Forest community located on the western side of Lagoon Road in the northern arm (Figure 45). A photograph of the creek entrance after a rainfall-runoff induced natural opening in August 2012 is provided in Figure 44.

Given that the Sallywood Swamp Forest at Soldiers Creek is so close to the entrance, there may be limited opportunities to lower berm levels and maintain a viable Sallywood Swamp Forest community at this location. If waterlogging and inundation is an issue for road access and landholdings in this area, there may be consideration of earthworks (cut and fill) in targeted areas to raise ground levels where they are low lying, subject to environmental assessment.

There is a delta of sand formed within the Lagoon seaward of Soldiers Creek, extending about 30m offshore and 30m alongshore, as visible in 2011 aerial photography (Figure 45). Given the surrounding rocks, and that this delta may only be a veneer of sand over rock, using this sand as a beach nourishment source is unlikely to be considered in preference to the Old Settlement Creek and Cobbys Creek sites.



**Figure 44: Natural opening of Soldiers Creek, 31 August 2012**



**Figure 45: Aerial photograph of Soldiers Creek entrance, with delta evident**

## 12. IMMEDIATE MANAGEMENT ACTIONS

### 12.1 Key Coastline Management Issues

The two key coastline management issues at Lord Howe Island are located in the receding area north of the bag wall. The two issues relate to the close proximity of the erosion escarpment to:

- Lagoon Road (the only road access to the Airport from the main settlement area and all areas north of the Airport) and an underground high voltage cable and telecommunications cable; and
- the Pinetrees boatshed (and deck located seaward).

From an overall community and economic perspective, the risk to the road and cables can be considered as the more significant issue. The road and high voltage cable are the responsibility of the Board, while the telecommunications cable is the responsibility of Telstra. The Pinetrees boatshed (an improvement on Permissive Occupancy land) is privately owned.

The Board is proposing to issue a new permissive occupancy for the Pinetrees boatshed site with the following special conditions:

- “that the occupants acknowledge the erosion risk and expressly agree to waive any claim for negligence, against the State of NSW, the Minister and the Lord Howe Island Board, and agree to indemnify the State of NSW, the Minister and the Lord Howe Island Board against any and all actions arising from loss or damage to the structures arising from coastal erosion; and
- that the Permissive Occupancy will be terminated when coastal erosion immediately threatens the structures including the boatshed and decking”.

Should the Permissive Occupancy be granted, it would be necessary for the Board to implement an inspection regime that ensures that it is able to expeditiously identify this circumstance and any remedial actions and accordingly recommend to the Minister that the Permissive Occupancy be terminated (if required).

The receding dunal area at the southern end of Lagoon Beach is understood to be critical habitat for the Lord Howe Island skink (*Oligosoma lichenigera*<sup>67</sup>), which is listed as vulnerable in Schedule 2 of the *Threatened Species Conservation Act 1995*.

The wedge-tailed shearwater (*Puffinus pacificus*<sup>68</sup>), which is a migratory bird, also uses this area to breed. Based on Department of the Environment (2013), this bird arrives at Lord Howe Island between early August and early September, and lays eggs between late November and early December. The young birds fledge (begin to fly) from late April to early May.

Immediate management actions to reduce the risk of undermining at Lagoon Road (for which investigations should be commenced or actions undertaken now) are listed in Section 12.2. Advantages and disadvantages of potential future management actions for this area, that may be considered as part of a Coastal Zone Management Plan (CZMP), are discussed in Section 13.2.

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<sup>67</sup> Formerly *Pseudomoia lichenigerum*.

<sup>68</sup> Also known as *Ardenna pacifica*.

The effects of the actions listed for the Lagoon Road area on coastline hazards at Pinetrees boatshed are discussed in Section 12.3. Potential future actions for the Pinetrees boatshed area, that the Permissive Occupancy holder may consider implementing with consent, are discussed in Section 13.3.

## **12.2 Recommended Immediate Actions to Manage Erosion/Recession Risks to Lagoon Road and Underground Cables**

### *12.2.1 Preamble*

Recommended immediate interim actions to manage erosion/recession risks to Lagoon Road are outlined below, from highest to lowest priority. It should be recognised that these are interim management actions given that a Coastal Zone Management Plan (CZMP), as per Part 4A of the *Coastal Protection Act 1979*, has not been completed for the study area. However, these actions likely to be considered in any future such CZMP.

It is considered that the “do nothing” option is unacceptable given the importance of Lagoon Road and adjacent underground cables, ongoing long term recession in the area, and the likelihood of further recession in the area in the future due to sea level rise.

### *12.2.2 Action 1: Discontinue Beach Scraping*

It is recommended that cross-shore beach scraping (in isolation) is discontinued at Lagoon Beach, and sand is added to the eroding/receding areas at the southern end of the beach (from near Pinetrees boatshed to the bag wall) by:

- undertaking alongshore sand relocation, see Section 12.2.4; and/or
- undertaking beach nourishment, that is using sand sourced externally from Lagoon Beach (such as sand from Blinky Beach), see Section 12.2.5.

In both cases, it is recommended that monitoring of beach profile changes over time is carried out by undertaking surveys along Lagoon Beach. Monitoring should be undertaken in both the source and the placement areas (see Section 12.2.6). Such monitoring would assist in confirming the understanding of coastal processes and informing any future campaigns of alongshore sand relocation and beach nourishment.

### *12.2.3 Action 2: Develop Emergency Action Plan*

Considering the importance of Lagoon Road and adjacent underground cables, and the impact on the Lord Howe Island economy if they were damaged, it is recommended that an investigation is undertaken of the feasibility of emergency protective works. Specifically, this would investigate the feasibility of generating a stockpile of large boulders for use as emergency protective works (to form a randomly placed rock revetment by tipping over the erosion escarpment if required), and the suitability of existing plant and equipment on the island to be used to complete these works. It is considered that rock is the only effective material to use as emergency protection at Lord Howe Island.

Rock near Little Island has been used in the past at Lord Howe Island for protective works. Whatever rock source is selected, some assessment or testing of the rock to determine its suitability (such as mass, shape<sup>69</sup> and durability) for use as protective works would be recommended.

It would also be necessary to ensure planning approvals are in place for such works if they are ever required (see Section 14), and to develop triggers to undertake actions. The investigations should be undertaken expeditiously as Lagoon Road and the adjacent cables would not be able to be protected if threatened in a coastal storm otherwise.

Advantages of emergency rock protection include the following (assuming that suitable rock is available and environmental impacts are found to be acceptable):

- would provide interim protection to the important Lagoon Road asset until long term solutions had been adopted as part of a Coastal Zone Management Plan;
- rock would not need to be placed until (if) required, in response to an agreed trigger;
- relatively simple construction method;
- can be placed during storm conditions; and
- rock could be removed after placement if required.

Disadvantages of emergency rock protection include the following:

- requires stockpiling of rock in advance of a storm;
- potential visual and beach amenity impacts;
- placement would not be under controlled conditions; and
- potential additional localised erosion at ends of the rock protection ('end effects').

#### 12.2.4 Action 3: Alongshore Sand Relocation

Alongshore sand relocation would involve moving sand (alongshore) to the eroding/receding area at the southern end of Lagoon Beach, sourcing from prograding areas at least 150m north of Pinetrees boatshed. The sand would be sourced by scraping a shallow 0.3m thick layer of coarser sediment near the waterline. Sand could also be sourced from where it is building up at the slipway near the boatsheds at the northern end of Lagoon Beach. Where possible, it is better to source coarser sand as this would be less likely to be transported following placement (or would be transported more slowly) compared to finer sand.

The sand should be placed by spreading it over the entire beach profile, for example avoiding placement of large mounds of sand against the erosion escarpment as this may lead to sand being blown into vegetated dunal areas, as discussed in **Appendix B**, Section B4<sup>70</sup>.

Records should be kept by the Board of the dates of each relocation campaign, approximate quantities moved, depth of source sand removed, and source and placement locations (marked on an aerial photograph).

Alongshore sand relocation has the following advantages:

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<sup>69</sup> The rocks near Little Island are relatively rounded, which are less suitable to use as protective works than angular rocks which tend to interlock.

<sup>70</sup> This is different to "longshore and cross-shore beach scraping" as discussed in Section 7.6.3, as it avoids mounding of sediment at the eroding dune face.

- relatively low cost
- likely low environmental impact (and low cumulative impact with ongoing operations);
- able to be undertaken using existing Board plant and equipment;
- improves beach amenity at placement site; and
- can be trialled and monitored to assess effectiveness.

Alongshore sand relocation would need to be ongoing, and the erosion risk to assets may continue unless significant volumes of sand were moved. Planning approvals would need to be in place for these works (see Section 14), with potential environmental impacts on both the source and placement areas considered. It is understood that the Board has a current NSW Marine Parks Permit (of 12 months duration) for “works on the foreshore of the Lord Howe Island Lagoon at Windy Point including relocation of sand for emergency works only” (Permit No. LHIMP/W/2013/002a), which expires on 16 September 2014. This may not allow alongshore sand relocation works in non-emergency periods, so an additional permit may be required as it is recommended that alongshore sand relocation works are carried out outside of emergency periods.

In the past (from 1 July 2011 to 30 June 2012), the Board has had a NSW Marine Parks Permit for “removal of sand adjacent to the LHI slipway [at the northern end of Lagoon Beach] to provide access for vessel maintenance and inspections” (Permit No. LHIMP/W/2011/04), but that this has not been renewed. This only allowed for removal of sand from the specific slipway location at the northern end of Lagoon Beach<sup>71</sup>, and was not a permit for alongshore sand relocation.

#### 12.2.5 Action 4: Beach Nourishment

Beach nourishment would involve adding sand to the southern end of Lagoon Beach (along the boatshed to bag wall area, with a general preference for greater placed volumes further south), using sand derived from a source external to Lagoon Beach.

There is a reasonable sand source at the Blinky Beach dunes. These dunes need to be periodically lowered to meet aviation requirements. It is understood that limited quantities of sand sourced from Blinky Beach dune lowering in 2013 were used to nourish Lagoon Beach (sand was generally pushed seawards from the dune at Blinky Beach rather than being removed, with a stockpile of only 2,000m<sup>3</sup> of removed sand now being available for community use) . Another sand source would be the prograding areas of Cobbys Beach. Where possible, it is better to use coarser sand for beach nourishment as this would be less likely to be transported following placement (or would be transported more slowly) compared to finer sand.

Records should be kept by the Board of the dates of any nourishment campaign, approximate quantities moved, and source and placement locations (marked on an aerial photograph).

The advantages of beach nourishment are similar to those for alongshore sand relocation. As for alongshore sand relocation, beach nourishment would need to be ongoing, the erosion risk to assets may continue unless significant volumes of sand were placed, and planning approvals would need to be in place for the works (see Section 14). A sediment tracing study (Section 12.2.7) would provide valuable insight into the likely movements of nourished sand.

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<sup>71</sup> With sand excavated in areas below (ie seaward of) the high water mark meant to be placed to the side of the rails, and sand excavated in in areas above (ie landward of ) high water mark meant to be removed via a truck and stockpiled for future emergency works (sand nourishment of Windy Point) and community purposes.



#### 12.2.6 Action 5: Beach Profile Surveys

To assess the effectiveness of alongshore sand relocation and beach nourishment, as well as ongoing natural movement of sediment along Lagoon Beach and Cobbys Beach, it would be important to monitor beach changes. This could be completed through regular surveying of shore-normal beach profiles. Monthly surveys would be desirable, or at least quarterly to capture seasonal effects. It would also be beneficial to undertake surveys immediately after significant beach erosion events and during subsequent beach recovery.

It would be convenient to coincide these surveyed profiles with selected photogrammetric profile locations. With reference to the profile locations in **Appendix B**, if possible, the following 22 profile locations should be surveyed: Profiles 1, 5, 9, 11, 14, 17, 19, 21 to 27, 29, 31, 37 to 40, 43 and 47.

Profiles should extend from 5m landward of the sand/vegetation interface (or 5m landward of the top of the erosion escarpment where vegetation is absent) to as far seaward as a low tide wading depth (it is expected that a distance of 50m seaward of the low tide waterline would be captured). All major changes in grade should be captured. It is recommended that levels be gathered to an accuracy of  $\pm 50$  mm. With each profile separately identified, data should be recorded in an ASCII text file or Excel spreadsheet with columns X, Y, Z, chainage and feature, where:

- X and Y are coordinates in metres to the Map Grid of Australia (GDA 94) Zone 57 to at least 1 decimal place;
- Z is elevation in metres AHD to at least 2 decimal places;
- chainage is the distance along the profile from the most landward data point; and
- feature can be used to record relevant information such as the location of the sand/vegetation interface and waterline at a particular time.

The same alignment and landward starting location should be used for a particular surveyed profile over time (that is, ongoing surveys should have the same landward starting location each time a particular profile is surveyed). Coordinates of the photogrammetric profile locations are available to assist in coinciding the survey lines with the photogrammetry.

Use of sand tracing (Section 12.2.7) may reduce some of the requirements for ongoing beach profile surveys.

#### 12.2.7 Action 6: Sand Tracing Study

As outlined herein, the sediment transport patterns in the Lagoon at Lord Howe Island are complex. It is recommended that a sediment tracing study is undertaken to provide a more informed and accurate understanding of where sand is moving and what processes drive this movement. This would involve using inert fluorescent synthetic particles to mimic sand properties, and tracking the movement of these particles from various locations in the Lagoon over say 18 months.

This would assist in determining the relative significance of longshore and cross-shore processes due to tidal, wind-wave and swell-wave transport, with a particular focus on the fate of material transported and eroded from beaches. This would enable an improved understanding of coastal processes to be developed, and would give greater clarity as to the most appropriate long term management actions for the beaches in the Lagoon, for example in terms of potential impacts and likely effectiveness if



constructed. A sediment tracing study would also assist in understanding the long term sustainability of alongshore sand relocation and beach nourishment.

The fluorescent sediment tracing technique is an established and environmentally acceptable technique for measuring sediment transport. It has been applied in many studies in Australia, including a current investigation at Old Bar in NSW which is being funded by OEH and Greater Taree Council and being undertaken by Environmental Tracing Systems Ltd and Haskoning Australia. Other tracing studies in Australia and overseas that have been undertaken include investigations for the US Army Corps of Engineers, Port of Townsville, North Queensland Bulk Ports, and Port Hedland Port Authority. Tracing can be expected to provide a reliable means of determining sediment transport pathways in the Lagoon at Lord Howe Island. Such a study would be expected to cost about \$150,000, depending on the number of placement sites and colours employed, and number of sampling events.

The study would be most valuable if a significant coastal storm event occurred during the tracer deployment. Given that the tracer does not decay, it would be possible to extend the duration of a tracing study as required to capture such an event.

### **12.3 Relevance of Proposed Immediate Management Actions for Managing Risks at Pinetrees Boatshed**

If the management actions for Lagoon Beach (described in Section 12.2) were implemented, this would have the following effects on the Pinetrees boatshed area:

- Action 1 (discontinue beach scraping): this would also be beneficial (cross-shore beach scraping should be discontinued in all areas).
- Action 2 (develop emergency action plan): it would be feasible from a coastal engineering perspective for the Pinetrees owner to undertake emergency rock protection of the boatshed, although it is noted that the deck area may be undermined before any protection could be implemented. However, if this was undertaken, pedestrian access from the boatshed area to and from the beach would be restricted. The Pinetrees owner would need to seek Owner's Consent from the Board if such works were considered, and a Development Application would need to be submitted.
- Action 3 (alongshore sand relocation) and Action 4 (beach nourishment): placing sand from alongshore sand relocation or beach nourishment in the vicinity of Pinetrees boatshed would be beneficial in reducing coastline hazard risks to the boatshed. The Pinetrees owner has contributed to some of the costs of beach scraping carried out by the Board in this area in the past.
- Action 5 (beach profile surveys) and Action 6 (sand tracing study): the beach profile surveys and sand tracing study would assist in the understanding of coastal processes in the vicinity of Pinetrees boatshed.

## 13. POTENTIAL FUTURE MANAGEMENT ACTION OPTIONS

### 13.1 Preamble

A number of potential future long term action options for managing the risk of undermining of Lagoon Road and Pinetrees Boatshed were assessed, as discussed in Section 13.2 and Section 13.3 respectively. Potential future action options for managing other coastline issues at Lord Howe Island are discussed in Section 13.4.

It is expected that these options would be considered and further assessed as part of any future Coastal Zone Management Plan (CZMP) at Lord Howe Island.

### 13.2 Potential Future Action Options at Lagoon Road

#### 13.2.1 *Moving Road and Underground Cables Landward*

If it is found that the risk of damage to Lagoon Road and adjacent cables cannot be managed through alongshore sand relocation and/or beach nourishment (eg if sufficient suitable sand sources cannot be accessed), there could be consideration given to moving Lagoon Road landward. A conceptual layout of a potential relocated road position is provided in Figure 46, assuming adoption of a minimum 20m distance from the 2011 erosion escarpment position (as derived from photogrammetric data) to the relocated road. The total area of relocated road as depicted is about 350m<sup>2</sup>, over a length of about 70m.

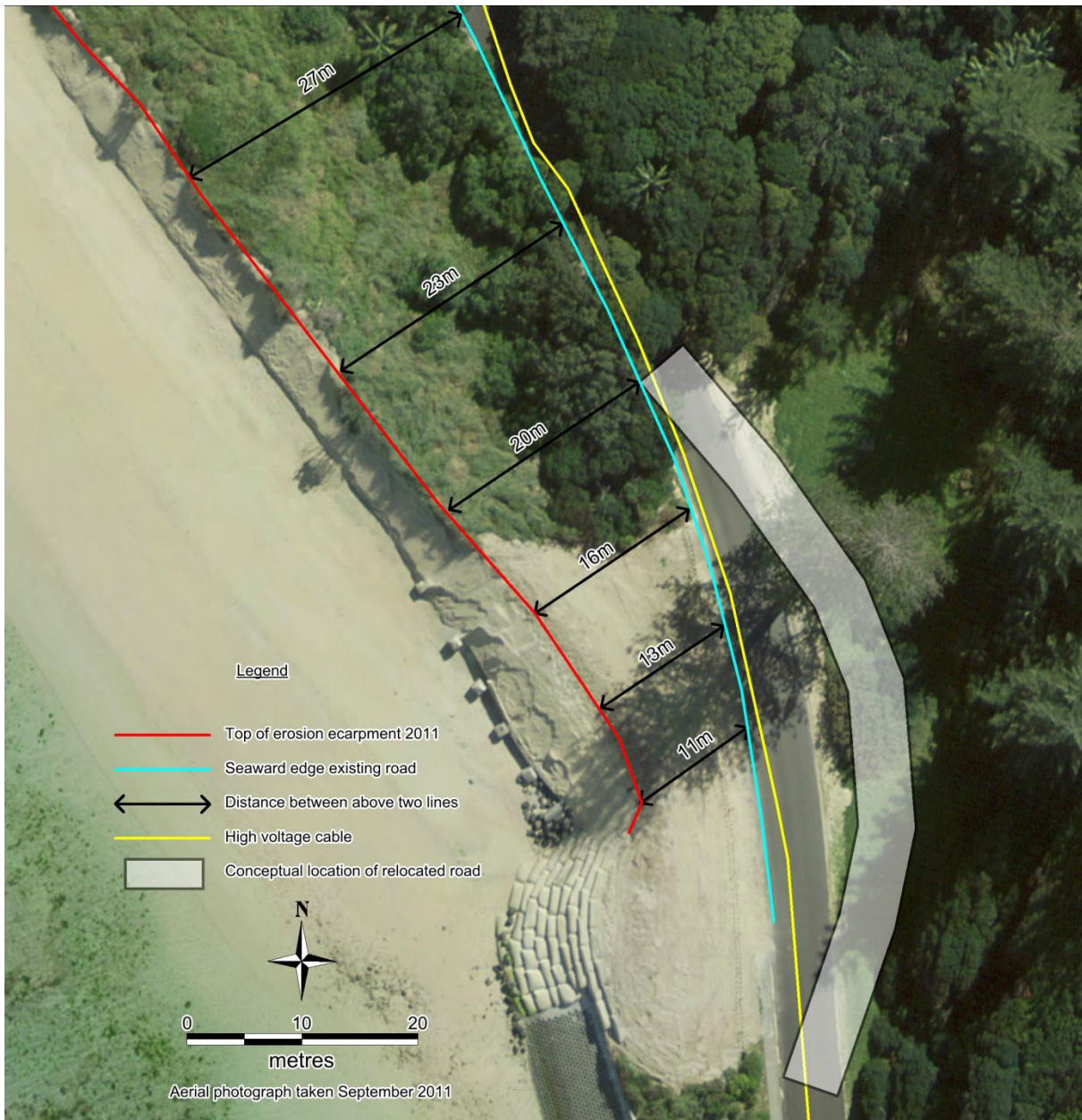
Based on advice from the Board's Administration, the cost of this option would be in the order of \$350,000 (using Board staff and equipment)<sup>72</sup>. A disadvantage of this option (in isolation) would be that there would be no restriction on continuing recession at the southern end of Lagoon Beach. That is, there would be expected to be continuing loss of habitat of the Lord Howe Island skink and wedge-tailed shearwater, and no reduction in coastline hazard risk to Pinetrees boatshed. The relocated road and cables may also be at risk of undermining again in the future if recession continues.

Advantages of the option include:

- relatively low environmental impact;
- minimal visual impact;
- no impact on coastal processes; and
- it provides more time to assess if recession will continue north of the bag wall.

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<sup>72</sup> Haskoning Australia has not independently assessed this costing, although it is noted that a 6m wide road (with concrete kerbs) of the same extent (70m length) as the proposed relocation would cost about \$25,000 in Sydney based on the *Rawlinsons Australian Construction Handbook 2014*.



**Figure 46: Conceptual layout of potential relocated Lagoon Road in vicinity of bag wall**

### 13.2.2 Seawall/Revetment

If it is found that the risk of damage to Lagoon Road cannot be managed through alongshore sand relocation and beach nourishment, and relocation of the road and cables is not considered to be appropriate (for example if it is considered to be more important to protect the currently receding dunal area due to its important habitat, or a suitable route cannot be found), then there may be consideration of a seawall/revetment extending north of the Seabee revetment and bag wall.

The seawall/revetment could be constructed from rock or sand filled geotextile containers (bags), as sloping structures like the existing runway revetment and bag wall. Other construction materials are also possible, such as concrete Seabees (as have been used previously at Lagoon Beach).

The advantage of the seawall/revetment option is that if it was designed and constructed appropriately including coastal engineering input, it would effectively limit further erosion and recession, reducing risk to landward assets and habitat to acceptable levels. However, there are a number of disadvantages to this option:

- visual impact;
- potentially transferring erosion/recession further north; and
- potential loss of beach width adjacent to seawall/revetment if recession continues.

Planning approvals would need to be in place for these works if they are to be implemented, and they would be subject to environmental assessment (see Section 14).

Rock has advantages over bags in having well established design guidelines, longer design life, better tolerance to events exceeding the design event, and faster and simpler construction. Rock is potentially available locally (eg from Little Island), but may become prohibitively expensive to use if it had to be imported to Lord Howe Island. For a bag wall, sand would have to be sourced from accreting areas for filling the bags, as it would not be appropriate to use sand from receding areas of Lagoon Beach given the potential for this to exacerbate recession.

If the most at risk area immediately north of the bag wall was to be protected (over a 30m length), costs would be in the order of \$300,000, assuming local rock or sand was used as applicable (but see Section 1.3 with regard to the limitations of this cost estimate)<sup>73</sup>. Costs would be far greater if rock or sand had to be imported from the mainland.

### 13.2.3 *Potential Options Requiring Additional Investigations (if Considered Warranted)*

#### Groyne

There may be consideration of the construction of a (shore-normal) groyne north of the eroding area located north of the bag wall, in order to attempt to hold sand on the beach (to the south of the groyne) and therefore reduce erosion risks. This could be used in conjunction with beach nourishment. However, additional investigations (eg sediment tracing) would be necessary to determine the likely effectiveness before proceeding further (in particular, the relative significance of longshore sediment transport processes). A groyne placed south of Pinetrees boatshed may also adversely impact on coastline hazards at the boatshed due to downdrift erosion.

Planning approvals would need to be in place for these works if they are to be implemented, and they would be subject to environmental assessment (see Section 14).

#### Offshore Breakwater

There may also be consideration of the construction of a breakwater located offshore of the eroding area north of the bag wall. If effective, this would reduce erosion risk while also allowing beach width to remain. However, this option would be relatively costly (more expensive than a seawall/revetment),

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<sup>73</sup> This estimate was based on a rate of \$10,000/m. A recent detailed cost estimate by Haskoning Australia for a bag wall on the NSW mainland open coast was similar (although it was assumed that a commercial sand source would be used in this case at a cost of \$40/m<sup>3</sup>), and Haskoning Australia has been involved in numerous NSW mainland open coast rock protective works with as-built costs between \$10,000 and \$20,000/m.

and would have to be constructed well above mean sea level to be effective during higher tides and during higher water levels when storms occur. This would have associated visual and environmental impacts, as well as potential impact on adjacent coastal processes. Again, additional investigations (eg sediment tracing) would be necessary to determine likely effectiveness before proceeding further.

Planning approvals would need to be in place for these works if they are to be implemented, and they would be subject to environmental assessment (see Section 14).

### 13.3 Potential Future Action Options at Pinetrees Boatshed

The boatshed could be constructed on piles to reduce the risk of damage from undermining, which could allow the boatshed to remain in its present position at acceptable risk. However, it would be difficult to retrofit piles to the existing structure, and access to the beach from the boatshed would be problematic if erosion/recession continues under the structure (due to the height of the erosion escarpment).

It may also be possible to relocate the boatshed, moving it further landward to reduce the risk of it being undermined. If this was considered, there may also be the option of constructing it on piles to further reduce risk.

It is recognised that the structure may need to be rebuilt if relocation was undertaken, as it may be difficult to relocate intact. Depending on the distance moved, the structure may eventually be at unacceptable risk again in the future (unless constructed on piles, or made relocatable). If the structure was relocated from its current position, some views from near the structure may be lost (as well as proximity to the beach), that may detract from the visitor experience.

An engineered seawall/revetment could be constructed seaward of Pinetrees boatshed, say over a length of about 50m (including extending landward at the ends, to reduce the risk of flanking erosion). Such a structure would reduce the coastline hazard risk to the boatshed to acceptable levels. However, there would be visual impacts if this option was adopted, as well as potential 'end effects' on adjacent areas. Engineered beach access (eg stairs) would be also be required to enable access from the boatshed to the beach.

If there was consideration of the construction of a continuous seawall/revetment extending from the bag wall to Pinetrees boatshed (140m length), costs may be in the order of \$1.4 million (but see Section 1.3 with regard to the limitations of this cost estimate)<sup>74</sup>. There would also be visual impacts, and a potential transferring of erosion further north. There would also be potential loss of beach width adjacent to the seawall/revetment if erosion/recession continued. Engineered beach access (eg stairs) would be required to enable access from the seawall/revetment to the beach.

### 13.4 Other Relevant Management Actions

#### 13.4.1 Maintain Reef Health

The coral reef on the western side of Lord Howe Island is critical to maintaining beaches adjacent to the Lagoon and the Lagoon itself, given that the reef dissipates a large proportion of incoming offshore swell wave energy. The Board and Marine Estate Management Authority should continue supporting

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<sup>74</sup> Also see Footnote 73 on page 70.

research into reef health and implementing measures to improve reef health, such as implementing the onsite wastewater management strategy which has been developed (which includes replacing septic tanks and upgrading secondary treatment systems).

Key long term issues with reef health and structure are whether the reef elevation will increase at the same rate as sea level rise, how the reef may be affected by acidification, and how any changes in the East Australian Current and El Nino / La Nina patterns will affect reef health. Research into how to best adapt the reef to withstand these effects is recommended.

#### 13.4.2 Monitor Sallywood Swamp Forests

As discussed in Section 11, it is recommended that:

- the health of the Sallywood Swamp Forests at Lord Howe Island are monitored in relation to inundation events, to determine if creek opening trigger levels need to be adopted to enhance its viability; and
- a natural entrance opening regime is maintained, unless adoption of a manual water level trigger for opening is required in order to enhance the Sallywood Swamp Forests, or to protect infrastructure (but only where this would not adversely impact on the Sallywood Swamp Forests).

#### 13.4.3 Maintain Dune Vegetation

A healthy coverage of dune vegetation acts to trap windblown sand and prevent blow outs, and hence assists in retaining (and enhancing) available sand volumes on a beach to meet storm demand. This is demonstrated at Blinky Beach (for example), with the dunes there naturally growing in height and volume over time. It is thus recommended that dunal vegetation coverage is maintained at the landward edge of the sandy beaches at Lord Howe Island.

There is a view from some of the Board's Administration that shallow rooted grass species such as Buffalo and Kikuyu lead to greater dune slumping (less binding of sand) in erosion events compared to deeper rooted species. However, it must be recognised that vegetation alone would not resist storm erosion such as being experienced north of the bag wall at Lagoon Beach.

The Board's Administration would prefer the use of the following native species for dunal vegetation: Beach Spinifex (*Spinifex hirsutus*), Knobby Club Rush (*Isolepis nodosa*), Beach Sunflower or Sea Daisy (*Melanthera biflora*), Saltwater Couch (*Sporobolus virginicus*), Pigface (*Carpobrotus glaucescens*), Scented Fan Flower (*Scaevola calendulacea*), Beach Bean or Beach Morning Glory (*Ipomoea pes-caprae* ssp *Brasiliensis*), Beach Pea or Sea Bean (*Vigna marina*), Bully Bush (*Cassinia tenuifolia*), and Berrywood (*Ochrosia elliptica*). The Board's Administration considers that dunal vegetation areas comprising Buffalo or Kikuyu grasses should be progressively rehabilitated with the above listed species.

#### 13.4.4 Signage at Base of Cliff Areas

In the Brief, it was noted that cliff instability had been occurring at Neds Beach, Middle Beach and Signal Point. The observations below were based on an August 2012 site visit. Note that at all three of these sites there was signage (denoted as a "warning sign" below) on which it was stated "Warning, Falling Rocks".

At Neds Beach, the area of historical instability is located at the southern end of the beach. At the time of the site visit, there was a single warning sign located just north of this cliff area (Figure 47). There were some boulders and finer material deposited at the base of the cliff at several locations (known as scree or talus), see Figure 48, but there was no evidence of widespread instability. Immediately north of the area of minor instability (or weathering), the lower portion of the cliff face had some graffiti etched into the cliff face (behind the warning sign in Figure 47).

At Middle Beach, there was evidence of occasional blocks having toppled from the cliff, with a few blocks located adjacent to the base of the cliff. There was a single warning sign located near the alongshore centre of the beach. At the northern end of Middle Beach, there was evidence of a relatively recent minor cliff “failure”, with some small boulders and mainly cobble and finer material deposited along and at the base of the slope as scree/talus, see Figure 49.

At Signal Point, there was evidence of occasional block toppling, with some boulders located at the base of the cliff. Warning signs were noted at the bases of the northern and southern ends of the cliff.



**Figure 47: Cliff area at southern end of Neds Beach, with warning sign evident**





**Figure 48: Area of some cliff instability at southern end of Neds Beach**



**Figure 49: Cliff “failure” at northern end of Middle Beach, 28 August 2012**

The cliff “failures” at Neds Beach, Middle Beach and Signal Point are considered to be mostly related to weathering of the calcarenite, which as noted in Section 4.1 is extremely susceptible to weathering.

To manage the risk to life from falling rocks at these locations it is recommended that:

- there is community education as to possibility of rock falls and the potential danger of being in proximity to the base of these cliffs;
- warning signage includes the warning “do not enter the area near the cliff base” or the like (the existing signage warns of a danger but does not advise an action);
- an additional sign (including the above warning) is installed adjacent to the area depicted in Figure 48 at Neds Beach; and
- additional signage (including the above warning) is installed at the northern and southern entry stairways to Middle Beach.

It is understood that the company Coffey has completed a verbal assessment of slope stability at Neds Beach, Middle Beach and Signal Point based on visual inspection only. Haskoning Australia was not provided with any information deriving from this assessment.

## 14. APPROVALS REQUIRED FOR POTENTIAL WORKS

### 14.1 Works Undertaken by or on Behalf of Board

As noted in Section 12.2.3, it is recommended that the Board develops an Emergency Action Plan for placement of rock protective works to protect Lagoon Road and adjacent underground cables at the southern end of Lagoon Beach. In Section 12.2.4 and 12.2.5 respectively, it was recommended that alongshore sand relocation and beach nourishment were adopted as actions.

In Section 13.2.2, it was noted that there may be future consideration of the construction of a seawall/revetment at the southern end of Lagoon Beach. In Section 13.2.3, other potential options requiring additional investigations (if considered warranted) were listed, namely a groyne and offshore breakwater.

Based on Clause 10(1)(e) of the *Lord Howe Island Local Environmental Plan 2010*, “nothing in this Plan prohibits, requires development consent for, or otherwise restricts the carrying out of environmental protection works by or on behalf of the Board”. Based on Clause 10(3), “environmental protection works means any works associated with the rehabilitation of land towards its natural state or any work to protect land from environmental degradation, and includes vegetation restoration works, wetland protection works, erosion protection works, dune restoration works and the like”. All of the above listed works (placement of emergency rock protective works, alongshore sand relocation, beach nourishment, seawall/revetment, groyne, and offshore breakwater) would be expected to fall within that definition, namely as “erosion protection works”.

Given that development consent would not be required for the works listed above, Part 5 of the *Environmental Planning and Assessment Act 1979* would apply to the works. Completion of an environmental assessment would be required. The environmental assessment would comprise a Review of Environmental Factors (REF), or if significant impacts were expected an Environmental Impact Statement (EIS) would need to be prepared<sup>75</sup>.

The factors to be taken into account when consideration is being given to the likely impact of any of these works on the environment are listed in Clause 228 of the *Environmental Planning and Assessment Regulation 2000*. In addition to this, the following legislation would need to be considered prior to the Board carrying out any works:

- Section 5A of the *Environmental Planning and Assessment Act 1979*;
- *NSW Marine Parks Act 1997*;
- *NSW National Parks and Wildlife Act 1974*;
- *NSW Threatened Species Conservation Act 1995*;
- *NSW Coastal Protection Act 1979*; and
- *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*.

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<sup>75</sup> An REF has no statutory basis, but a determining authority usually decides (as part of standard practice in NSW) whether to require a full EIS by considering a preliminary environmental assessment in the form of an REF.

## 14.2 Works Undertaken by Owner of Pinetrees Boatshed

Should the Permissive Occupancy holders at Pinetrees boatshed want to install protective works, they would need to seek Owner's Consent from the Board<sup>76</sup>, and a Development Application would need to be submitted.

In assessing likely impacts, the Board would need to ensure that the proposal:

- was permissible and an appropriate use of the site according to its zoning;
- complied with the provisions of the *Environmental Planning and Assessment Act 1979*;
- complied with the provisions of the *Lord Howe Island Local Environmental Plan 2010* and any other relevant planning controls for the site;
- had no detrimental environmental impacts upon the locality; and
- had no adverse impact upon adjacent and neighbouring properties (Lord Howe Island Board, 2014).

The Pinetrees boatshed is within a “foreshore area” as defined in the *Lord Howe Island Local Environmental Plan 2010* (Figure 50). The foreshore area means the land between the Foreshore Building Line and the mean high water mark.

Based on Clause 35(2) of the *Lord Howe Island Local Environmental Plan 2010*, development on the foreshore area is prohibited unless:

- (a) the proposed development is in the public interest and does not significantly reduce public access to the foreshore, and
- (b) the bulk and scale of the proposed development will not detract from the visual amenity of the foreshore area, and
- (c) the proposed development addresses any need to restore lost or disturbed plants that are native to the Island, particularly if restoring those plants may enhance visual amenity, and
- (d) there is a demonstrated Island community-based, or marine-based, business need for it, and
- (e) the proposed development will not be adversely affected by, or adversely affect, coastal processes, and
- (f) in the case of proposed development involving the erection of a structure—the purpose of that structure could not practicably be fulfilled by an existing structure, and
- (g) in the case of development proposed to be carried out on land that is also within Zone 9 Marine Park—the proposed development is not inconsistent with any advice about the development that is provided to the consent authority by the Marine Parks Authority.

Therefore, any protective works proposed by the owner of Pinetrees boatshed would need to comply with the above Clauses.

Also, it would be necessary for the Board to ensure that the Pinetrees owner was responsible for continuing maintenance of the works, and removal of the works if required (if they failed or caused significant adverse impacts on adjacent areas), and/or maintenance of beach amenity seaward of the works, as appropriate.

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<sup>76</sup> The Minister has authorised that the Board's Chief Executive Officer can grant owners consent to the lodgement of a development application if the value of the development does not exceed \$2,000,000, the proposal complies with the current Planning instrument, and the development application does not relate to the subdivision of land or creation of a new residential dwelling.



**Figure 50: Foreshore area in vicinity of Pinetrees boatshed**

## 15. CONCLUSIONS

Haskoning Australia Pty Ltd was engaged by the Lord Howe Island Board to complete a Coastal Hazard Definition and Coastal Management Study for Lord Howe Island, as has been set out herein. There are a number of coastline management issues at Lord Howe Island, in particular erosion/recession threatening Lagoon Road (and underground cables) at Lagoon Beach near Windy Point.

Erosion of the Windy Point area has been documented for some time. The road at Windy Point was undermined and rebuilt about six times prior to 1965, and also in 1985. Protective works (such as 44 gallon drums and gabions) were placed at Windy Point in the late 1980's in an attempt to limit this erosion. Ongoing coastal storms over the next few years, and the continuing risk of damage to Lagoon Road, led to the construction of a Seabee revetment at Windy Point in 1999.

An airport was opened at Lord Howe Island in 1974, which included a 70m protrusion of the runway into the Lagoon, protected by a rock revetment. Although some consider that this runway protrusion interrupted longshore sediment transport and caused erosion/recession at Windy Point, it is evident that the area was experiencing erosion prior to the runway construction.

After construction of the Seabee revetment in 1999, erosion began to be experienced to its north, ultimately leading to construction of a sand-filled geotextile container (bag) wall in the eroding area in 2011. However, erosion has continued to the north of the bag wall since that time.

The most southerly coral reef in the world is located at Lord Howe Island, with an average crest level of 1.0m AHD, which is 0.2m below mean sea level in the Lagoon (unlike the Australian mainland, AHD at Lord Howe Island is not equivalent to mean sea level, but is at a level of extreme low tide known as Chart Datum). However, the elevation of reef crests is variable, and wave energy is likely to be focussed on the Windy Point area due to lower reef crests directly offshore from Windy Point.

The Lagoon adjacent to the reef has an average depth of about 2m, but with a much deeper area near Comets Hole, which is likely to act as a sink for sediment moving between the reef crest and shoreline. It has been estimated that sediment began to accumulate over basalt bedrock in the Lagoon about 4,600 years ago, with greater sediment availability after 2,900 years ago as sediment filled sinks in the Lagoon floor and reached a shallow enough depth to be reworked by waves. Increasing westerly wind strength from about 700 years ago, combined with falling sea levels and this lagoon infilling, facilitated increased sediment movement from the reef crest and the Lagoon bed to the western shore of Lord Howe Island. This caused rapid development of beaches about 600 years ago. Sediment may still be moving landward across the Lagoon bed and adding to subaerial beach sediments.

Rates of change of volume per year were determined along Lagoon Beach and Cobbys Beach, based on review of 5 dates of aerial photography and photogrammetric data from 1965 to 2011. It was evident that most of the length of beaches along the Lagoon at Lord Howe Island have been growing in sand volume or moving seaward (prograding). The only two areas reducing in volume or moving landward (receding) are located immediately north and south of the runway revetment, Seabee revetment, and bag wall structures.

Further investigation of the sources and transport direction of sediment in the wider Lagoon would be warranted to inform a longer term understanding of coastal processes and to inform the design of any future beach nourishment campaigns or other works. A preliminary conceptual model of sediment

transport processes that was an attempt to document the observed beach changes and was consistent with observed circulation patterns was developed.

Immediate (as of 2011), 2050 and 2100 Coastline Hazard Lines (defined at the landward edge of the Zone of Slope Adjustment) were delineated herein. The key assets at immediate risk of damage at Lagoon Beach and Cobbys Beach are Pinetrees boatshed and Lagoon Road near the bag wall. Considering 2050 and 2100 timeframes, the boatsheds at the northern end of Lagoon Beach begin to become at risk, as does the Aquatic Club. Without the protection of the Seabee revetment and rock revetment, Lagoon Road and the runway would be at immediate risk of damage, indicating the importance of maintaining these structures.

Immediate management actions to reduce the risk of undermining at Lagoon Road (for which investigations should be commenced or actions undertaken now) were developed as follows:

- discontinue beach scraping;
- develop Emergency Action Plan;
- alongshore sand relocation;
- beach nourishment;
- beach profile surveys; and
- a sand tracing study.

A number of potential future long term action options for managing the risk of undermining of Lagoon Road were also assessed, including moving Lagoon Road and nearby underground cables landward; and construction of a seawall/revetment.

Entrance management of Old Settlement Creek, Cobbys Creek and Soldiers Creek was also considered, particularly in terms of managing Sallywood Swamp Forest (a Critically Endangered Ecological Community) and flooding. Where possible, it was recommended that a natural entrance opening regime be maintained. The key effect of entrance openings in terms of reducing the health of the Sallywood Swamp Forest is the ingress of saline water. Saline intrusion could be reduced by:

- mechanically closing off an entrance immediately after a breakout event; and/or
- maintaining the beach berm level seaward of a creek at a higher level; and/or
- mechanically opening an entrance (if that was required) on a low to rising tide.

All of the above actions would be counterproductive to any requirements to manage an entrance to reduce inundation (flooding) levels to protect infrastructure.

There is a substantial delta of sand formed within the Lagoon seaward of Old Settlement Creek. There may be consideration of using this delta as a source of sand for beach nourishment, subject to detailed assessment. A smaller delta is also present at Cobbys Creek.

Other relevant management actions were developed, namely:

- maintain reef health;
- monitor Sallywood Swamp Forests;
- maintain dune vegetation; and
- install signage at the base of cliff areas.

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# **APPENDIX A**

## **SITE VISIT OBSERVATIONS AND DISCUSSIONS**



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## **A1. BACKGROUND**

Peter Horton and Gary Blumberg of Haskoning Australia visited Lord Howe Island from 27 August to 1 September 2012 inclusive.

In this Appendix, photographs and notes from site observations, and notes from discussions with Island residents and Board staff, are presented. The Appendix is arranged under geographical headings.



## A2. OBSERVATIONS AND DISCUSSIONS

### A2.1 Lagoon Beach

A series of photographs taken from south to north along Lagoon Beach is provided in Figure A1 to Figure A7. Note that the mounded sand visible seaward of the erosion escarpment in Figure A4 and Figure A5 had recently been mechanically placed (it had been sourced by beach scraping from about 100m to 300m north at around the low tide level).



**Figure A1: Southern end of Lagoon Beach at junction between airport revetment and Seabee wall, looking south**