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West Beach Dune Stabilisation: Interim Measures

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1.0 INTRODUCTION

1.1 Background

Adelaide's metropolitan beaches and associated dune systems have been recognised as an important part of the coastal landscape (DEH, 2005). They provide a highly valued recreational facility for Adelaide's residents and visitors, as well as essential protection of adjacent infrastructure (public and private) from ocean inundation and storm surges. They also provide important habitat for Adelaide's coastal flora and fauna.

Sandy coastlines are extremely dynamic, with cyclic patterns of sand accretion (build-up) and erosion. In a natural system where there is a balance between accretion and erosion, sandy coastlines are able to persist, although they will change form and dimensions within natural cycles. The development that has occurred along the Adelaide coastline has greatly modified natural process and beaches can no longer be sustained by these processes (Figure 1). Intervention is now required to keep sand along the metropolitan beaches and within the narrow strip of remnant dunes that remain.

Figure 1: Comparison of sand resources along West Beach in 1968 and 2014. Source: Coastal Protection Board, via InDaily, 10 Jul 2019.

Sand replenishment strategies were introduced to Adelaide's metropolitan beaches in the 1970's and have evolved over time in response to ever-changing natural processes and the introduction of built structures along the shoreline. In 2005 a broad management change was enacted with the establishment of seven management 'cells' along the coastline (DEH, 2005). This has enabled sections of the coastline to receive targeted management actions in line with the landforms, built structures and coastal processes that influence its beach and dunes. The West Beach management cell is Cell 3, extending from the Adelaide Shores Boat Haven (West Beach Boat Ramp) to the River Torrens Outlet (Figure 2).

Cell 3 has been subject to significant, ongoing beach erosion and dune destabilisation in recent decades. In response to this, the State Government is currently enacting a sand replenishment plan for the West Beach cell that is expected to rebuild the beach and maintain sand volumes, providing a store of dune sands over time. This is occurring as part of the government's *Securing the Future of our Coastline* project.

Currently, dune de-stabilisation at West Beach has caused sand blow-outs in parts of the dune system, with mobile sands being transported onto adjacent properties and other infrastructure, causing a nuisance. There are two key problematic areas – Rockingham Street dunes (just north of the West Beach Surf Life Saving Club seawall) and Hamra Avenue dunes (adjacent the West Beach Parks caravan park) (Figure 2).

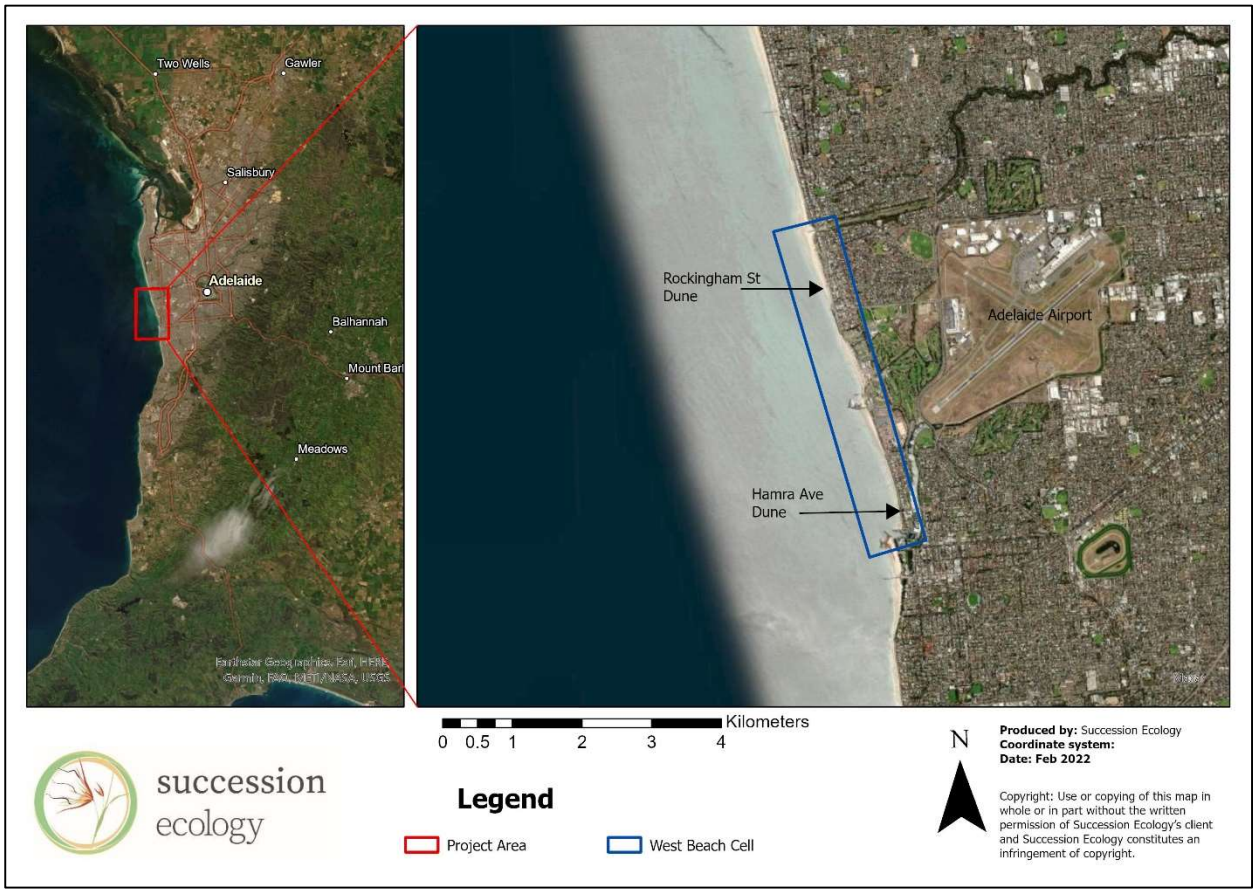


Figure 2: Project location at West Beach, South Australia.

Success Ecology has been engaged by the Department for Environment and Water (DEW) to assist in the management of dunes within the West Beach management cell.

Tasks include:

1. Development and implementation of a plan to stabilise the key erosion points within the Rockingham St and Hamra Ave dunes
2. Development and implementation of a long-term management plan for sections of the dune system within the West Beach management cell.

This report addresses action (1), outlining a strategy to stabilise key erosion points within the Rockingham St and Hamra Ave dunes. It also includes key considerations for action (2), which will be developed into a Management Plan in due course.

1.2 Dune Formation Processes

Dune systems have complex structures and are extremely dynamic, determined by interactions among prevailing winds, sediment supply, wave action, and the broader geomorphology of the area. A typical, natural dune structure is shown in Figure 3. The seaward section of a dune system is predominantly influenced by wave action and ocean deposited sand. It typically consists of the beach berm, the surf zone and a nearshore bar. The landward section of a dune system is predominantly influenced by wind and wind-blown sands, and occasionally influenced by wave action. It consists of an incipient dune (a developing foredune) which can be periodically impacted by wave action and high seas, the foredune which can be impacted by storm events and the hind dunes which are normally the most stable structures in the dune system.

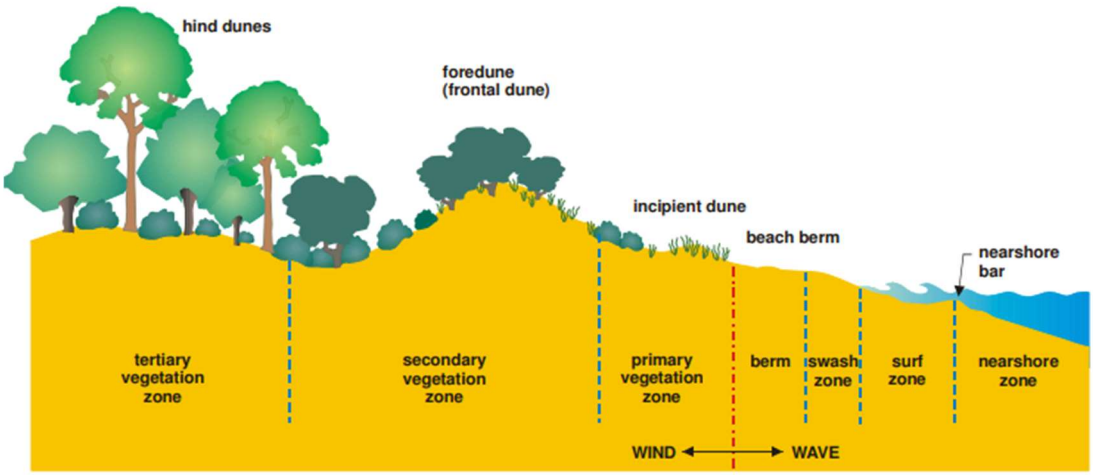


Figure 3: Typical features of a dynamic beach and dune system. Source: DLWC, 2001.

The changes seen on beaches and within dune systems are cyclic. Storm waves remove sand from the beach and dunes and form storm bars nearshore (on Adelaide coastlines these build during summer months; DEH, 2005), whilst calmer conditions allow the deposition of these sands back onto beaches, where wind can then blow the dried sands into the dune system (DLWC, 2001; Figure 4).

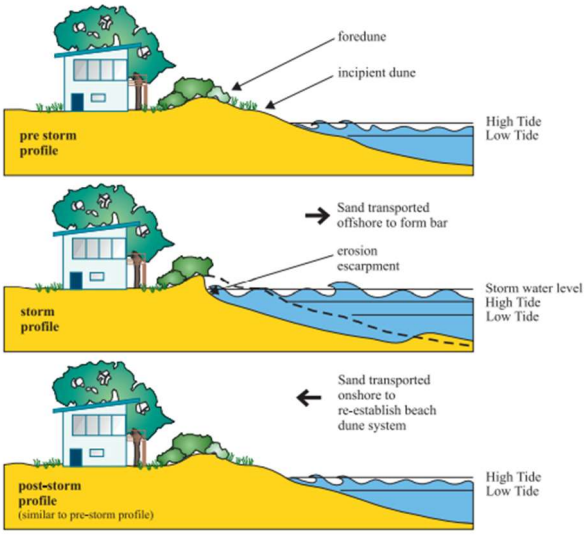


Figure 4: The cycle of beach erosion during storm events and accretion during calm conditions. Source: DLWC, 2001.

Along the coastlines of metropolitan Adelaide, including West Beach, the natural cycles of erosion and accretion (build up) of sands in the dune systems have been interrupted by built structures along shorelines (such as marinas and seawalls) and housing development which covers the vast majority of hind dunes along the coast. Further, the degradation of near-shore seagrass beds over time has lowered the seabed, increasing the velocity and size of waves when they reach the beaches and changed the angle at which waves are hitting the shoreline (DEH, 2005). These factors combine to present a situation where natural processes are significantly disrupted or altered and the erosion of certain sections of beach out-weight the accretion. This has led to net erosion and beach recession in these areas. As such intervention (such as dune stabilisation and sand replenishment) is required to counter this effect, in order to maintain a stable beach and dune system on Adelaide's metropolitan coastline.

1.3 Dune Stabilisation

Sands within dune systems are inherently unstable. They are nutrient poor, highly mobile when not stabilised and have poor water-holding capacity (high porosity). This is particularly true of the foredunes and berm dunes. Hind dunes tend to be more complex, containing better developed soils and more stable vegetation, with little to no interaction with waves (DLWC, 2005; Figure 5). Unstable sands quickly become mobile and wind-blown sand can cause significant nuisance and damage to adjacent property and infrastructure (Figure 6). The maintenance of a uniform protective cover of native coastal vegetation is required to stabilise dune sands and dune structure. Root systems and low-lying vegetative matter trap and hold the sand and moisture, and also support soil development (Page and Thorpe, 2010).

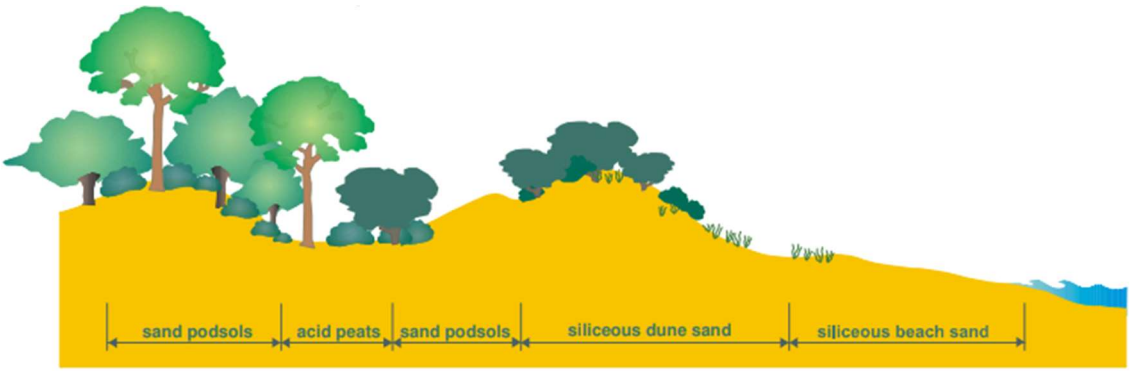


Figure 5: Coastal dune structure with increasing soil development and vegetation stability with distance from ocean. Source: DLWC, 2001.

Figure 6: Mobile sands severely impacting a property at North Beach, Wallaroo, SA.

The vegetation structure within dune systems can be considered to occur in three distinct zones. The Primary zone occurs on the seaward parts of the system amongst the incipient dune and seaward slope of the foredune. This zone can support species such as grasses and creepers. The Secondary zone occurs on the foredune crest and landward slope and can support low to medium shrubs. The foredune is an elevated feature that provides wind deflection near the shoreline. The Tertiary zone occurs amongst the hind dunes and supports taller shrubs and trees. These provide further protection from the wind for successive inland vegetation (Figure 7).

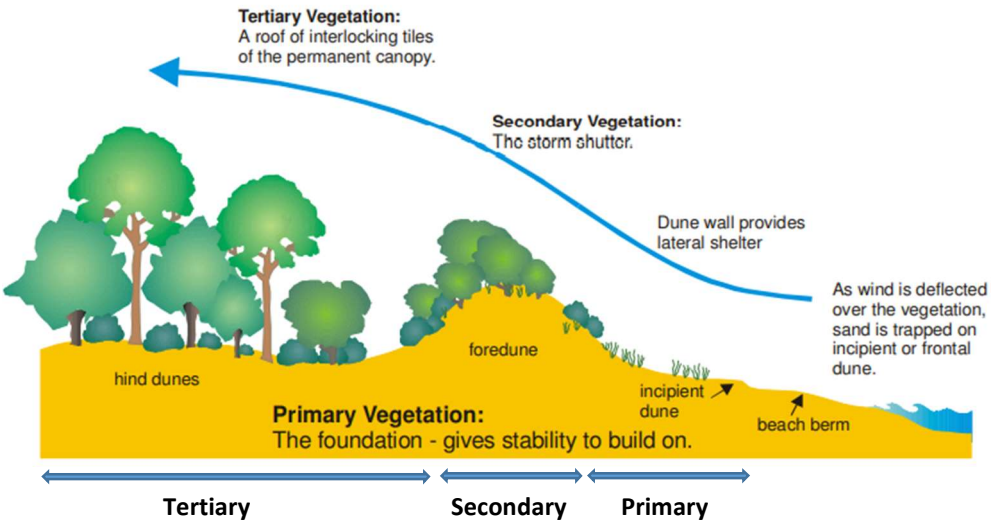


Figure 7: Vegetation zones and the protection provided within a dune system. Source: DLWC, 2001.

When working to stabilise or build dune systems it is important to mimic the natural vegetation structure (DLWC, 2001). Native flora species are the most suitable for dune stabilisation and formation as they can withstand harsh coastal conditions and are adapted to poor nutrient soils. Exotic species have been used in the past, however they can be very detrimental to dune formation and long-term stabilisation, as well as undermine the habitat value of the dune system. For example, introduced sea wheat grass has been used in the past in an attempt to stabilise dunes in Australia, however this species tends to form steeper dunes, which can cause the wind to eddy and remove sand (DLWC, 2001; DEH, 2005). In contrast, a native coastal spinifex, *Spinifex sericeus*, is a coloniser of the foredune forming a wide, stable, flat foredune (DLWC, 2001).

The stabilisation of a foredune system can be enhanced by the presence of incipient dunes. These dunes form seaward of the foredune, from wind-blown sand (Page and Thorpe, 2010). They can build over time and become vegetated with primary zone vegetation. Incipient dunes can help in the protection of the foredune by taking the brunt of wave action, preventing scarping of the foredune during storm events.

2.0 DUNE STABILISATION METHODOLOGY

A number of stabilisation methods are available for use to address mobile sands and dune instability within the West Beach Dune system. A description of these methods, key principles, advantages, and disadvantages are presented below. Selected methodologies are then proposed for application at the Rockingham Street and Hamra Avenue sites in section 4.0. Note that a number of methodologies discussed below are more suitable to consider for longer-term management planning but are included here for context.

2.1 Surface Treatment

Mobile sands on seaward and landward slopes can be stabilised quickly by the application of various surface treatments. These include:

Geotextiles

Geotextiles such as Jute Mesh (Appendix 1), which is specifically designed for sand dune stabilisation, allowing for the trapping of drifting sands and space for plant growth.

- Must be suitable for the slopes encountered/created in the dune system
- Mesh must be loosely woven for plant regeneration and growth
- Must be organic, able to breakdown and form part of the organic matter in the dune system.
- Must be durable enough to allow time for the desired level of plant growth

Seagrass Mulch

Seagrass mulch (wrack) acts as a surface wind barrier whilst also providing structure and a rich source of organic matter within the dune.

- Must be sustainable sourced
- Should be mixed in with the dune sand where possible
- Should be laid thickly to ensure its durability

Brush Mulch

Brush mulch acts as a surface wind barrier, slowing wind speeds over a slope and enhancing sand accretion on a slope. It also provides shelter for developing seedlings, assists in moisture retention and can act as a seed bank (DLWC, 2001).

- Must be sustainable sourced
- Ideal if cut with ripe seed
- Should be laid with the stem anchored facing downslope

Advantages

There are a number of advantages to surface treatments:

- Surface treatment is effective immediately with regards to arresting the mobilisation of loose sand

- Can complement long-term management actions such as stabilisation fencing
- Prepares the sands for revegetation works, enhancing revegetation success

Disadvantages

There are a number of disadvantages to surface treatments:

- Potentially expensive, depending on the material used and transport costs
- Can be aesthetically unpleasant for the time it takes to either breakdown or be covered by vegetation.
- Large amounts of suitable brush can be difficult to source

2.2 Stabilisation fencing

Drift net fencing is a common method for dune creation and sand stabilisation. It is useful for small blow-outs and long-term stabilisation projects (Page and Thorpe, 2010). The fences and netting are designed to capture mobile sands so that they are eventually buried by the sands to form a dune. The forming dunes are then planted out for stabilisation. Principles to consider are:

Blowout stabilisation

The most important areas of a sand blowout to stabilise are the edges, especially the forward edge and other places where the wind is funnelling sand away more quickly (Page and Thorpe, 2010).

Sand erosion/accretion balance

Drift net fencing is most effective in environments with a balance in sand accretion and erosion. It can be used in erosive environments, as long as there is enough sand to blow onto the fences and if prevailing winds blow straight onto the beach (Page and Thorp, 2010).

Fence alignment

Drift net fencing alignment is most effective at capturing sands when placed perpendicular to prevailing winds. This angle, however, may not always be parallel to the shoreline (beach berm), which is the most desirable alignment for fencing (DLWC,2001) particularly when creating or re-forming dune systems in public use areas.

Fence spacing

Sand will accumulate in a zone whose width is 5-10m the height of the fence (DLWC, 2001).

Materials

The Sand Drift Mesh should have a porosity of around 40%.

Fencing posts should be around 1.5m in height, to allow around 1m to show above ground.

High tensile wire to be 2.5mm in width.

Stabilisation

Sands accumulating around fencing should be planted as soon as they have reached the desired height, where possible, to stabilise the loose sands.

Advantages

- Useful as a long-term management action to create or modify the topography of a dune system.
- Cost effective and durable.
- Aesthetically acceptable as a common site on Adelaide's metropolitan beaches.

Disadvantages

- Can take a long time for sand to build up to required levels for stabilisation planting.
- Success is subject to local wind conditions (unless mechanical intervention is used).
- Can result in safety issues if infrastructure becomes exposed or damaged by erosion events.

2.3 Monitoring – Short Term

It is important to ensure short-term actions are effective in achieving the desired outcome, whilst long-term actions are being planned and implemented. Short-term monitoring can include:

- Interviewing affected residents periodically to gauge changes in windblown sand effects on their properties.
- Remotely review dune stabilisation progress via aerial imagery.
- Regular inspection of fencing works to detect any damage from storm events, public interference or erosion points developing under netting.

2.4 Dune reshaping – Long-term Management

Dune re-shaping and formation can be carried out as part of the long-term management plan for a beach and dune system. Drift net fencing (discussed above) can be used to create a wider foredune complex and to prevent the vertical growth of landward dunes (Itzkin et. Al., 2020). This can be desirable for highly erosive sections of coast and in areas where landward dune growth threatens public or private infrastructure. Dune re-shaping can also be carried out with earthmoving equipment, which can fast-track structural formation. Important principles for dune shaping are:

Alignment

Natural dune alignment most commonly runs parallel to a shoreline, although other types of dune formation can occur (Hesp and Walker, 2021). Any formed dunes should match the natural alignment found along the coast and be integrate with adjacent dunes (DLWC, 2001). It should be noted that 'speed-up' across the seaward slope of a foredune is greater for winds blowing perpendicular to the dune, than when blowing at more oblique angles (Hesp et al, 2014).

Slope angle

Natural dune gradients range from zero to 1.5:1 (330, angle of repose, White and Tsoar, 1998) (DLWC, 2001). In general, the gentler the slope the lower the resultant wind speed moving up the slope, and therefore the less the erosion potential. Steep slopes (inflections) should be avoided on the seaward face, as these can cause the wind to eddy and remove more sand, and also facilitate wave incursion (DLWC, 2001).

Surface roughness

Surface cover, such as dune vegetation, will slow wind velocity and erosion potential (Page and Thorpe, 2010).

Dune shape

Seaward facing dune slopes should be flat to slightly convex in shape, to deflect onshore winds in an upward direction – this provides protection on the lee of the dune (DLWC, 2001). Protruding hummocks or steep-sided undulations can concentrate wind flow, and should be avoided (DLWC, 2001).

Dune structure

- Constructing an incipient dune, where there is space, will allow it to take the brunt of wave action providing protection for the foredune whilst vegetation is establishing. The construction of an incipient dune can also be used to reduce the beach fetch which in-turn can reduce the wind speeds that dunes are exposed to.
- The height of planned dunes should consider a number of factors including sea level rise, amenity disruption (where relevant) and associated dune slope.

Vegetation

Disturbance of existing vegetation should be avoided where possible (Page and Thorp, 2010). The timing of dune forming works should consider revegetation requirements. Revegetation works should be carried out on formed dunes as soon as possible.

Accessways

Public accessways through dunes systems should be carefully planned to prevent the creation of wind tunnels and blow-outs. They should be placed at an angle approaching perpendicular to strong prevailing winds.

2.5 Revegetation management – Long-term Management

The revegetation of newly formed or established dunes is critical to long-term dune stability. Where possible, the timing of revegetation works should be planned to coincide not only with the planting season, but when dunes have formed to desired heights and shapes. Principles that apply to revegetation of dunes include:

Review

- Previous revegetation plans, preparation and works.
- Current site condition, priorities for weed control and stabilisation.

Site preparation

Ensure sands are weed free, with adequate moisture content and that bare, loose sands have been protected where possible with a surface treatment.

Revegetation structure:

- Plant species according to succession zones (Primary, Secondary, Tertiary).

- Avoid tunnel affects caused by gaps in plants, particularly clumpy plants, as this can lead to blow-outs.
- Ensure plants are not planted in the swash zone or lower incipient dune, as dune species will not tolerate inundation.

Species selection

Use native, local providence species as much as possible, which are well suited to local conditions. On the seaward side of the foredune, use species that are spreading (such as local *Spinifex* sp) that will produce a flatter dune surface, and avoid taller species that can produce a hummocky form that can potentially increase wind erosion potential (Hesp and Walker, 2021).

Form of plants

Tubestock is suitable for dune plantings and can be supported by direct seeding. The seeding needs to occur on lightly scarified sands and at a time that will be followed by adequate rains.

Monitoring and follow-up

Ensure revegetation works are monitored quarterly and supported by in-fill planting and weed management.

2.6 Monitoring – Long Term Management

It is important to ensure long-term actions are effective in achieving the desired outcome. Monitoring can include:

- Remotely review dune building and stabilisation progress via aerial imagery and photo points
- Regular inspection of revegetation works to gauge the rate of success and plan for future infill planting and weeding.
- Regular inspection of fencing works to detect any damage from storm events, public interference or erosion points developing under netting.
- Interviewing affected residents periodically to gauge changes in wind-blown sand effects on their properties.

3.0 WEST BEACH CONDITION

This section outlines the current condition of dunes and associated issues for the Rockingham Street dunes and the Hamra Avenue (West Beach Parks) dunes.

3.1 Rockingham Street

The dunes located at the end of Rockingham Street at West Beach (Figure 8) contain a moderately vegetated but destabilised foredune. This section of dune is relatively narrow with hind dunes lost to development since the 1930's (Government of SA, 2022), and it is located immediately north of the rock wall established in front of the West Beach Surf Life Saving Club. Due to the narrow width of the dune and its position along the coast, the ongoing erosion from prevailing winds and wave action present a continuing threat to its ongoing integrity. The dune has changed in form, volume and cover over time (Appendix 2), and is currently in moderate to poor condition.

The current foredune has a height of approximately 7m ASL and an approximate slope of 2.5:1, at its steepest. Parts of the crest and landward slope of the foredune has a reasonable cover of coastal vegetation, including *Spinifex sp.* which is a key stabiliser of mobile sands. However, there are a number of gaps in vegetation on the landward slope that are susceptible to sand loss by erosive winds. The seaward slope of the dune is very unstable, with no vegetation and sands becoming mobile when subject to prevailing winds, particularly moderate to strong south-westerly winds (Figure 9; Appendix 3).

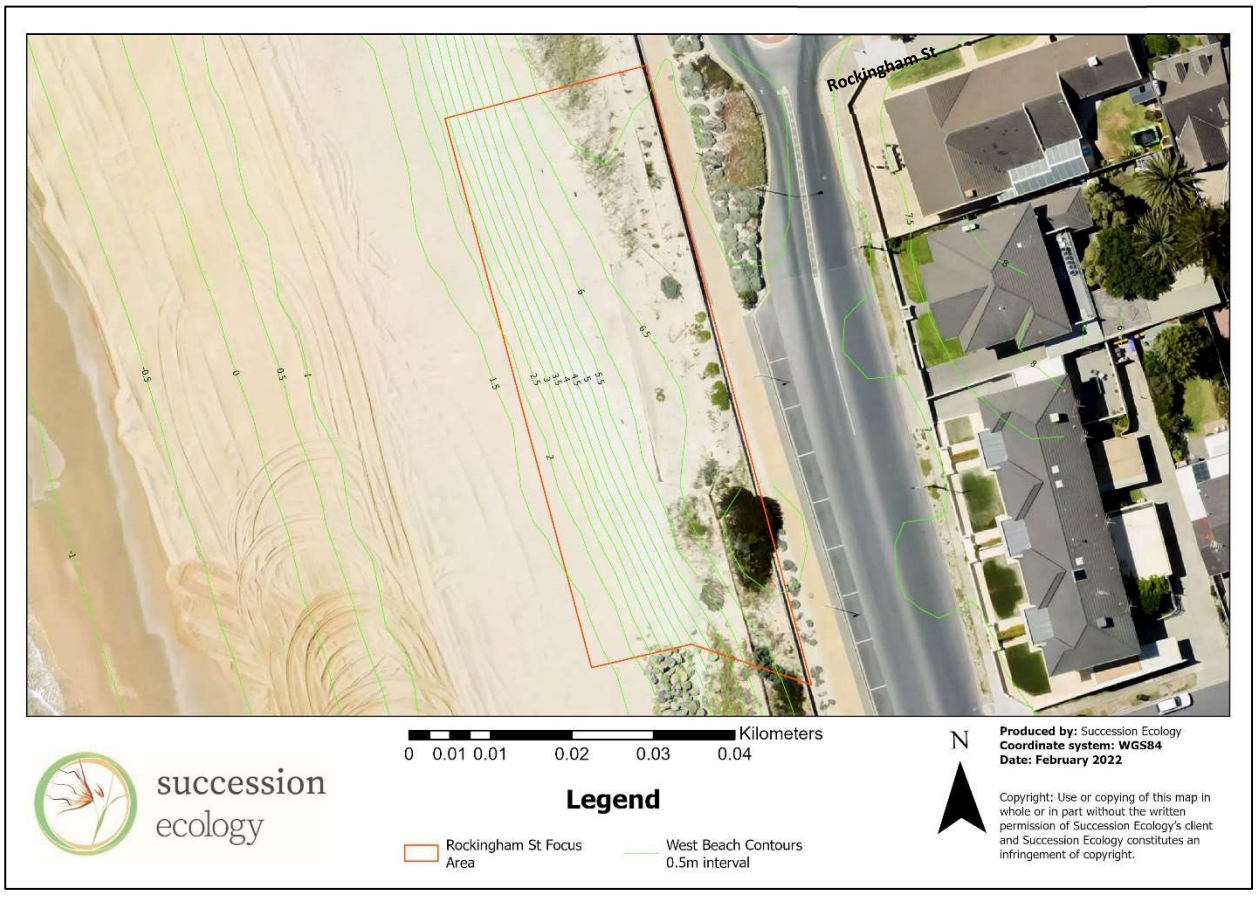


Figure 8: Rockingham Street dune focus area for short-term stabilisation action. Imagery source: Aerometrex, Dec 2021.

Figure 9: Rockingham Street dunes, seaward slope (left) and landward slope (right).

Management of the dune to-date has included a variety of actions, such as sand replenishment of the dune itself and the adjacent beach, installation of drift fencing to capture sands and revegetation works. Most recently approximately 70,000m^3 of quarry sand has been deposited in front of the West Beach Surf Club in late 2021, which has in turn replenished the beach in front of the Rockingham Street dunes. Further replenishment is expected at the Surf Club in early 2022 as part of the State Government's interim measures whilst a permanent sand pumping pipeline system is being constructed. This system will enable a future increase in sand replenishment at West Beach in response to erosion events such as winter storms. Revegetation works have been carried out on the dune crest and landward slope, supported by local council and a local community group.

3.1.1 Current Conditions

The current condition of the dune is causing local issues that require addressing. These include:

- Mobilisation of loose sands during strong wind events being carried onto houses located along Seaview Road, causing an ongoing nuisance
- Regression of the dune as a whole
- Movement of the dune crest further back towards Seaview Road, potentially causing the dune sands to spill over the rock wall adjacent to the footpath
- Further destabilisation of the dune

3.1.2 Addressing Current Issues

To rectify these problems urgent action is needed to stabilise the seaward face of the dune and prevent the movement of loose sands during high wind events.

<u>Priorities for works:</u>

- Stabilise the seaward slope of the foredune to prevent the mobilisation of loose sands from the dune
- Further stabilise the landward slope of the foredune to support revegetation works occurring and prevent further loss of dune volume

<u>Desired outcome</u>

- A significant reduction in nuisance caused by wind-blown sands from the foredune
- Stabilisation of the seaward and landward dune surfaces

3.2 Hamra Avenue (West Beach Parks)

Located at the end of Hamra Avenue at West Beach Parks is a large dune system that has been under steady decline for a number of years (Figure 10; Appendix 2). One area in particular has developed a blowout (a depression formed by wind erosion) overtime and is now causing significant nuisance to adjacent property. This blowout is immediately opposite the Hamra Ave carpark, surrounding a large dune shrub. Coastal blowouts can often form in the foredune where there is low vegetation cover, hummocky or clumpy vegetation cover or where human traffic occurs (Hesp and Walker, 2021). All three factors appear within the Hamra Avenue dunes.

Overall, the dune system is currently in poor condition. The current foredune has a height of approximately 9m ASL (within the focus area) and an approximate slope of 3:1 at its steepest. The seaward slope is relatively steep with mobile sands, and a poorly vegetated crest. Vegetation cover increases a little on the landward slope, with the most stable vegetation occurring on the lower landward slope. The area of blowout extends from the seaward slope, through the crest and to the end of the landward slope in an ENE-WSW alignment. This makes it susceptible to strong prevailing winds (Appendix 3). It is currently being prevented from natural stabilisation due to visitors using the open area as an access to the beach (Figure 11). The southern section of the blowout had a walkway installed to a lookout; this infrastructure has been buried by the depositional lobe of the blowout (Figure 12).

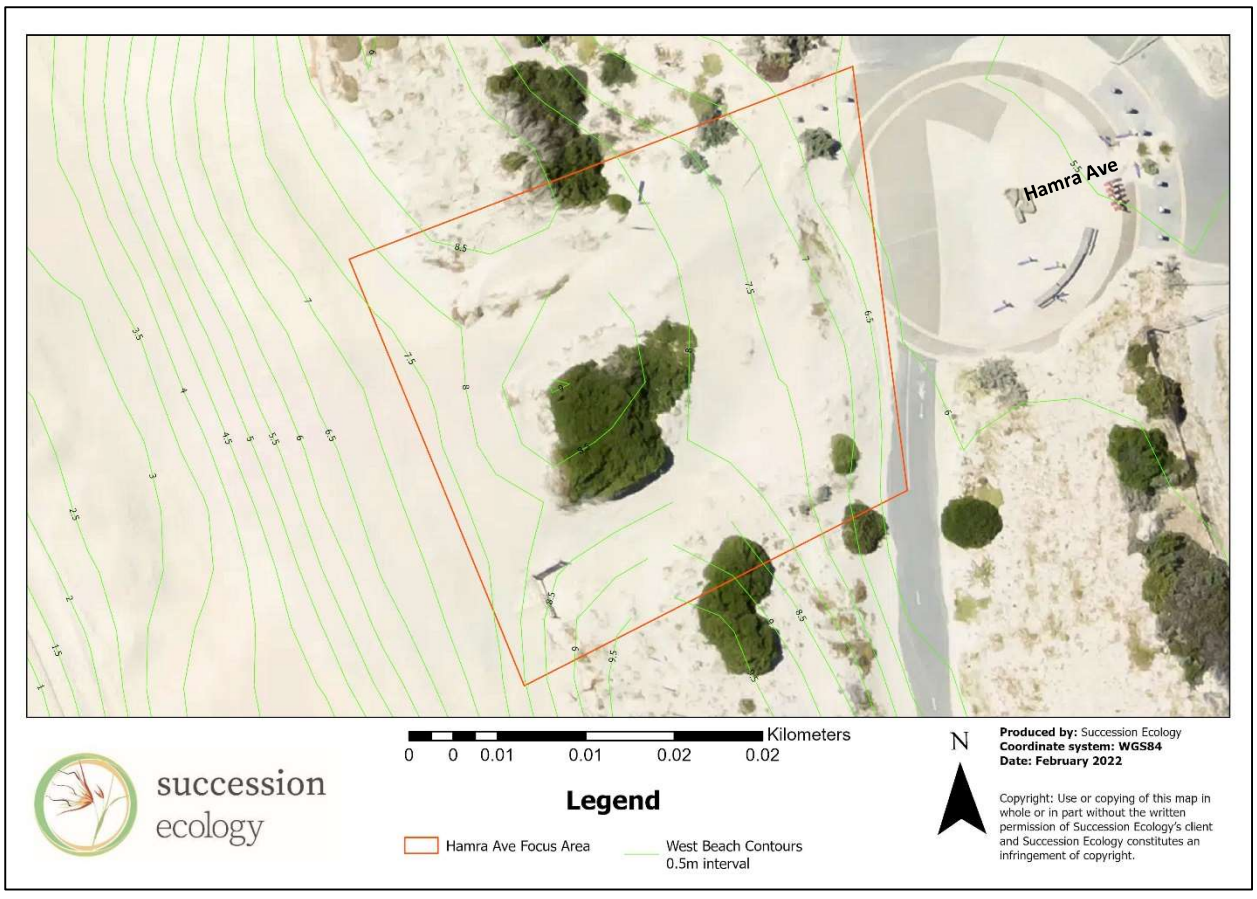


Figure 10: Hamra Avenue dune focus area for short-term stabilisation action. Imagery source: Aerometrex, Dec 2021.

Figure 11: Hamra Avenue dunes. Blowout on landward slope (top) and seaward slope with poorly vegetation crest (bottom).

Figure 12: Protective fencing installed by property owner (top left), mobile sands encroaching on walking/cycling path (top right) and the impacts of mobile sands within the blowout burying a former walkway to a lookout (comparison photos, bottom; Google Earth image 2018 left, and current condition right).

3.2.1 Current Conditions

The current condition of the dune is causing local issues that require addressing. These include:

- Mobilisation of loose sands during strong wind events being carried onto adjacent property along Hamra Avenue, with property owners having to install drift fencing to protect from the blowing sands (Figure 12)
- Mobile sands within the blowout area moving towards Hamra Ave and covering existing infrastructure (eg, the walkway to the lookout; Figure 12)
- Movement of the mobile sands on the landward slope, frequently covering the public walking/cycling path

3.2.2 Addressing Current Issues

To rectify these problems immediate action is needed to stabilise the blowout to significantly decrease the volume of mobile sands affecting adjacent property owners.

<u>Priorities for works</u>

- Stabilise the blowout area to reduce wind-blown sands affecting adjacent property
- Provide options for the re-establishment of access track to beach
- Plan for the long-term stabilisation and rehabilitation of the dune system

<u>Desired outcome</u>

- A significant reduction in nuisance caused by wind-blown sands from the foredune
- Stabilisation of the blowout

4.0 PROPOSED ACTIONS

The stabilisation of the West Beach dunes is being undertaken in a number of phases, as described in Section 1. Mitigation actions proposed here are considered to be short-term actions, to provide immediate relief from current problems within the dunes adjacent to Hamra Avenue and Rockingham Street. They may be reversed or incorporated as needed into the long-term solutions that will be developed to ensure effective management and sustainability of these dunes into the future. The short-term actions recommended here have been developed in consideration of possible long-term actions. Such long-term actions are briefly discussed here, for context.

Estimated costs of each proposed treatment option is provided in Appendix 4.

4.1 Rockingham Street – West Beach

The main issue at the Rockingham Street dunes is the suspension and movement of loose sands onto adjacent properties, during strong prevailing wind events. A number of management options are available for the stabilisation of the Rockingham Street dunes. Below is a discussion of options and recommendations for treatment.

4.1.1 Immediate Action – Dune Stabilisation

Two treatment types are described here, in order of preference. However, a combination of the two could be implemented, in consideration of long-term plans.

Surface Treatment plus Incipient Dune

- Apply a surface treatment to the bare sand on the crest and top 1/3 of the seaward slope. A geotextile treatment such as Jute Mesh will assist in immediate stabilisation of mobile sands on the seaward slope and also support the spread of *Spinifex sp.* on the dune crest.
- Where it is found that bare sands on the landward slope become mobile, it is recommended that a surface treatment be applied to bare sand found on the landward slopes. A geotextile treatment (Jute Mesh) will prevent loss of sand from bare areas, assist in moisture retention and support the growth of revegetated flora within the landward slope.
- Consideration should also be given to applying the jute mesh over the crest of the newly formed incipient dune (see below), in order to provide cover for bare sands in the region that experiences the highest wind speed-up, and to prepare the sands for planting of creepers such as *Spinifex sp.* in the planting season.
- Surface treatment can be installed rapidly with immediate effect and will enable cessation of sand movement whilst more long-term management actions can be put in-place.
- Seagrass wrack may also be used as a surface treatment, although this is likely to be cost prohibitive, given the transport costs from the current source at North Haven (Appendix 4).
- Create a lower incipient dune in front of the main foredune. This dune will interrupt wind flow and slow the winds that hit the main foredune. It will also take the brunt of storm waves, protecting the main dune from repeated wave action. Ideally this would be created mechanically, knowing that the incipient dune is likely to be periodically removed by storm activity. If created by fencing, the exposed or damaged infrastructure could present a public hazard on the beach or in the water (if washed away). A schematic of the cross section of the incipient dune is shown in Figure 13.

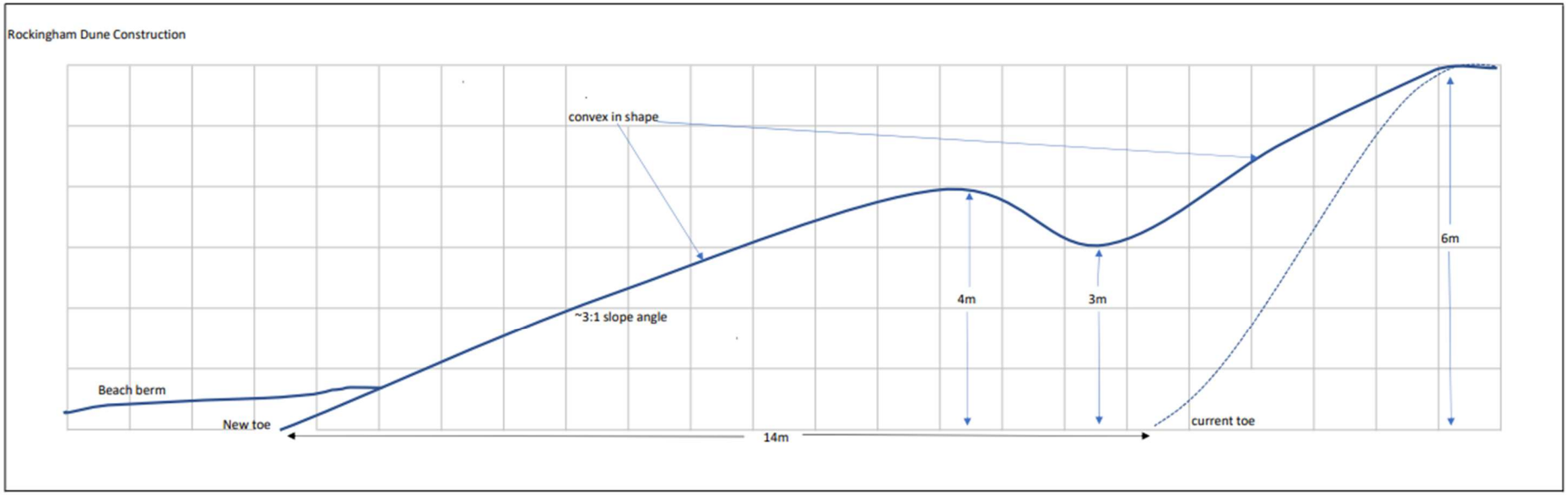


Figure 13: Schematic of proposed incipient dune shape (solid line) in relation to the current dune (dashed line – not to scale)

- Recommended installation areas for surface covering and incipient dune total coverage area are shown in Figure 14, incorporating discussions held with DEW on 16/2/2022. Currently, costings have been based on installation areas of approximately 220m^2 and 480m2 of surface cover for the primary foredune crest and incipient dune crest respectively, and 90m of dune creation (Appendix 4).

Figure 14: Proposed recommended installation areas for Jute Mesh and creation of an incipient dune.

Stabilisation Fencing – Second Preference

- Install a series of sand drift fencing to interrupt and slow wind flow. It is anticipated that this action will take longer to be effective than surface treatment but can be included in longer-term plans for dune stabilisation.
- Fences can be placed in-line with the current dune alignment, in rows from the base of the dune to near the crest.
- The design of fencing rows can be used to gradually lower the slope of the dune face and create an incipient dune, over time.
- It is recommended that this method be used as required in the long-term management of the dune, pending results of monitoring the effectiveness of the constructed incipient dune.

4.1.2 Future Development – Dune Stabilisation

Dune Shaping

- For long-term stability of the dune system, the degree of the seaward slope can be lowered, either mechanically or with the use of drift net fencing to capture sands to change the dune slope. A reduction in slope will slow wind speeds over the dune, reducing sand mobility.
- Maintain an incipient dune in front of the main foredune. This dune will interrupt wind flow and slow the winds that hit the main foredune. It will also take the brunt of storm waves, protecting the main dune from repeated wave action. This could be maintained mechanically or over a longer term with drift net fencing.
- Re-assess after each winter season to ensure incipient dune remains in place.

Revegetation

- Develop a revegetation plan in consideration of past plans and works, and current vegetation condition.
- Provide a surface cover for bare sands, e.g., Jute Mesh to assist in preparing sands for revegetation.
- Revegetation works – weed control, surface preparation, plant out species according to succession zones.
- If required – co-ordinate revegetation works with local council and community groups.
- Ensure revegetation works provide uniform cover, to prevent the development of further blowouts within the reinstated dunes.

Monitoring

- Remotely review dune building and stabilisation progress via aerial imagery and photo points.
- Quarterly inspection of revegetation works to gauge the rate of success and plan for future infill planting and weeding.
- Quarterly inspection of fencing works to detect any damage from storm events, public interference or erosion points developing under netting.
- Interviewing affected residents periodically to gauge changes in wind-blown sand effects on their properties.

4.2 Hamra Avenue – West Beach Parks Dunes

The main issue at the Hamra Avenue dunes is the suspension and movement of loose sands onto adjacent properties, during strong prevailing wind events. A number of management options are available for the stabilisation of the Hamra Avenue dunes. Below is a discussion of options and recommendations for treatment.

4.2.1 Immediate Action - Blowout stabilisation

Sand dune blowouts are depressions or hollows formed by wind erosion. They can occur naturally or be exacerbated by human traffic or disturbance. In natural systems blowouts can be stabilised by natural processes. Such processes include pioneering flora species growing along the walls and floor of the depression, as well as the formation of an incipient dune across the entrance of a blowout, eliminating through-flow of beach sand (Hesp and Walker, 2021). To address the main blowout on the Hamra Ave

dune it is recommended to implement a combination of measures that will mimic (and fast-track) the natural stabilisation processes, to provide rapid stabilisation of shifting sands.

It should be noted that these measures will close the current informal access way that has been created by visitors to the area. As such, if DEW requires an access track to remain in the area a new track can be planned as part of the long-term management of the dune system. It will need to be strategically sited in a north-westerly direction from the end of Hamra Road, so as to be sheltered from strong prevailing south westerly winds.

Sand Capture and Barricade Fencing

- Install drift net fencing across the entrance to the blowout at around crest height, where wind speeds are likely to be highest, to interrupt wind flow through the depression and subsequent sand suspension and movement.
- Place fencing in line with current dune orientation so that any sand building up is integrated into the current dune alignment.
- Install drift net fencing on the landward edge of the dune (to act as a barricade as well as for sand capture) and signage to prevent public access through the blowout and onto the dunes.
- Standard fencing specifications are provided in Appendix 5.
- Recommended installation areas for sand capture fencing are shown in Figure 15. Costings have been based on draft installation areas of approximately 60m of drift net fencing (Appendix 4).

Surface Treatment (where required)

- Where sands are reported to still be mobile despite the sand capture fencing, provide a surface cover to the entrance, floor and walls of the blowout section, to provide surface roughness through the area and slow-down wind speeds. A geotextile such as Jute Mesh, or a brush cover is recommended. Such covering will also help to prepare the sands for re-shaping and planting later in the development, by providing organic material and structure to the sands.
- Recommended installation areas for surface covering are shown in Figure 15. Costings have been based on installation areas of approximately 540m^2 of surface cover

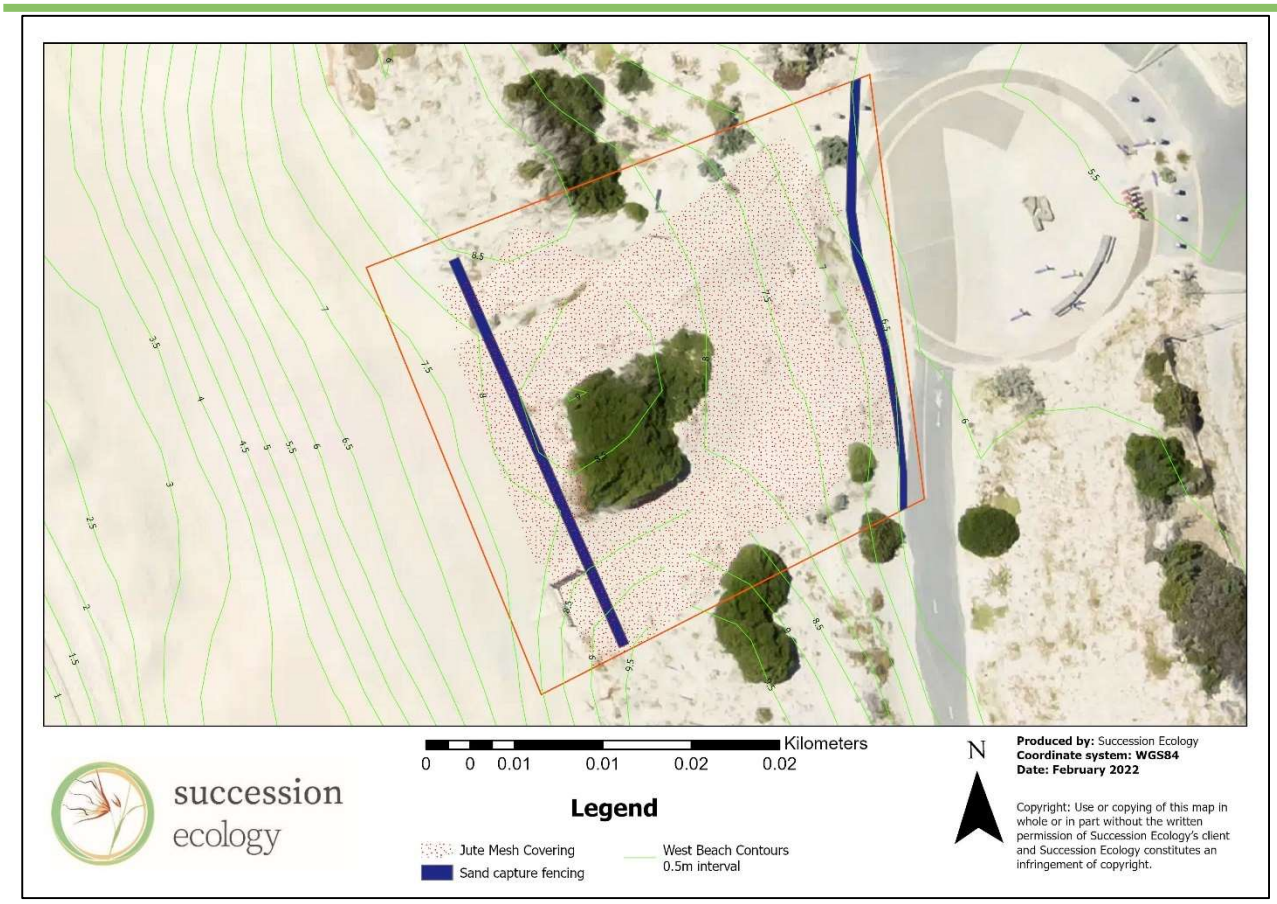


Figure 15: Proposed recommended installation areas for Jute Mesh and sand capture/barricade fencing.

4.2.2 Future Development - Dune re-formation and Stabilisation

Given the sand replenishment work being carried out at West Beach in the first quarter of 2022, DEW may wish to take advantage of the earthmoving equipment on-site to enact some of the dune-shaping actions proposed below. Where this is the case, detailed dune design can become the next priority for works.

Dune Shaping – Seaward (Stoss) Slope

- Re-shape dunes on the seaward slope:
    - Lower the overall peak of the dune by pushing sand down the seaward slope, which will assist in reducing the seaward slope to approx. 4:1. This in turn will aid in slowing wind speeds up the slow and reduce mobilisation of loose sands.
    - Build sand from the base of the current foredune to beyond the shoreline to push back the swash zone, so that and incipient dune can be established near the base of the foredune.
    - Mechanically create, or capture sands to build an incipient dune to act as a buffer to winds and storm surge. Sand drift fencing can be used effectively for this task, given the sand replenishment planned for this beach in the immediate future and long-term.
    - Provide a surface cover for key dune areas (crest and the top 1/3 of stoss slope) to prepare for revegetation.

- If required by DEW, plan an access track from Hamra Ave, angled through dune in a NW direction, to avoid the creation of another blowout.
- Remove all infrastructure associated with the coastal lookout, that cannot be fully buried by earthworks.

Dune Shaping - Landward (Lee) Slopes

- Move un-vegetated sand to fill the depression created by the blowout and create the new crest line consistent with earthworks being planned for the seaward slope. Care is needed around the handrail and other infrastructure that is currently buried by shifting sands.
- Provide surface cover (Jute Mesh, brush or seagrass wrack) over bare sands and infill plant these areas as per revegetation plan.
- Install drift net fencing along the base of dune adjacent to the walking track to prevent any mobile sand from encroaching onto the track.
- Protect all junction boxes of the sand piping system from earthworks, shifting sands and public walkways.

Revegetation

- Develop a revegetation plan in consideration of past plans and works, and current vegetation condition.
- Provide a surface cover for bare sands, e.g., Jute Mesh.
- Revegetation works – weed control, surface preparation, plant out and seed species according to succession zones.
- Ensure revegetation works provide uniform cover to prevent the development of further blowouts within the reinstated dunes.

Monitoring

- Remotely review dune building and stabilisation progress via aerial imagery and photo points
- Quarterly inspection of revegetation works to gauge the rate of success and plan for future infill planting and weeding.
- Quarterly inspection of fencing works to detect any damage from storm events, public interference or erosion points developing under netting.
- Interviewing affected property owners periodically to gauge changes in wind-blown sand effects on their properties.

5.0 CONCLUSION AND RECOMMENDATIONS

Dune de-stabilisation has occurred at a number of locations along the West Beach management cell. This has created sand blowouts in parts of the dune system, with mobile sands being transported onto adjacent properties and other infrastructure, causing a nuisance. There are two key problematic areas – Rockingham Street dunes (just north of the West Beach Surf Life Saving Club seawall) and Hamra Avenue dunes (adjacent the West Beach Parks caravan park).

This document proposes strategies to stabilise these areas in the short-term, with the view to develop long-term management actions that will stabilise the dunes and their function into the future.

Rockingham Street Recommendations

Immediate, short-term

- Apply a surface cover to dune crests to arrest sand movement and prepare the sands for revegetation.
- Build an incipient dune at the base of the main foredune, to slow wind speeds that approach the main dune and to protect against storms and tidal action.

Long-term

- Revegetate the crest, top of the stoss slope and landward slope of the main foredune.
- Maintain the incipient dune to help protect the main foredune from further erosion.
- Monitor effects of all management actions and modify management accordingly.

Hamra Avenue Recommendations

Immediate, short-term

- Build barricade fencing at the base of the landward slope to stop public access to the dune area during the dune stabilisation phase.
- Erect drift net fencing at the opening of the blowout area to disrupt wind flow through the area.
- Where required, apply a surface cover to affected areas to arrest sand movement and prepare the sands for revegetation.

Long-term

- Revegetate the crest, top of the stoss slope and landward slope of the main foredune.
- Re-shape the dune to lower the crest, lower the slope, push the shoreline out, and create and maintain an incipient dune at the base of the main dune to protect it from wind and wave erosion.
- Monitor effects of all management actions and modify management accordingly.

6.0 REFERENCES

Department for Environment and Heritage (2005), *Adelaide's Living Beaches: A Strategy for 2005-2025*. Government of South Australia, Adelaide.

Department of Land and Water Conservation (2001), *Coastal Dune Management.* NSW Government, Newcastle.

Government of South Australia (2022). The Manning Index of South Australia. State Library, Adelaide.

Hesp, P A., Smyth, T.A.G., Nielsen, P., Walker, I.J., Bauer, B.O., Davidson-Arnott, R. (2014). Flow deflection over a foredune. *Geomorphology* (2014), doi: 10.1016/j.geomorph.2014.11.005

Hesp, P.A. and Smyth T.A.G. (2016). Jet flow over foredunes. *Earth Surface Processes and Landforms.* Volume 41, pages 1727-1735.

Hesp, P.A. and Walker I.J. (2021), Eolian Environments: Coastal Dunes V2. *Treatise on Geomorphology.* Volume 11, 2013, pages 328-355.

Itzkin, M., Moore L.J., Ruggiero, P. and Hacker, S.D. (2020). The Effect of Sand Fencing on the Morphology of Natural Dune Systems. *Geomorphology.* Volume 352, 106995.

Page, L. and Thorp, V. (2010), *Tasmanian Coastal Works Manual: A best practice management guide for changing coastlines.* Department of Primary Industries, Parks, Water and Environment, Tasmania.

White, Bruce R. and Tsoar Haim (1998), Slope effect on saltation over a climbing sand dune. *Geomorphology* 22(1998), 159-180.

7.0 APPENDICES

Appendix 1 – Jute Mesh

See Addendum.

Appendix 2 - Changing Dune Condition Over Time

Condition of the Rockingham Street Dunes over time.

Images sourced from Aerometrex.

2002

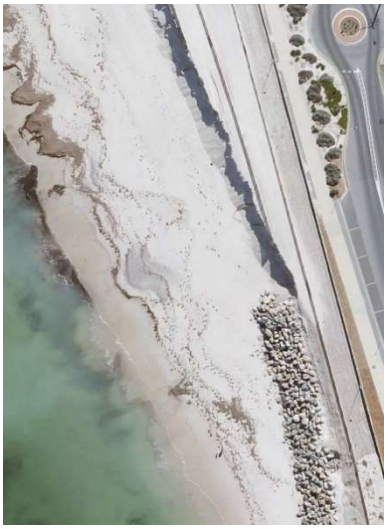
2006

2009

2011

2013

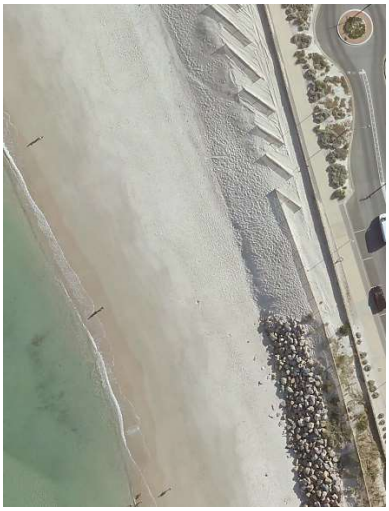
2014



2015

2016

2017

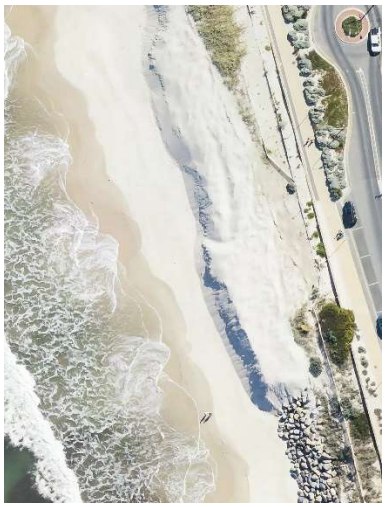


2018

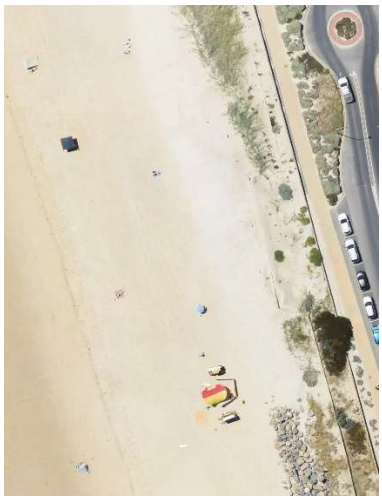
2019

2020

2021 (Nov)



2022 (Jan)



Images sourced from Google Earth

2009

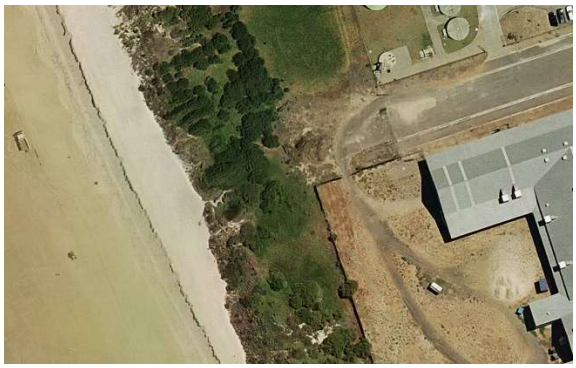
2013

2021

Condition of the Hamra Avenue (West Beach Parks) Dunes over time.

All images sourced from Aerometrex.

2002

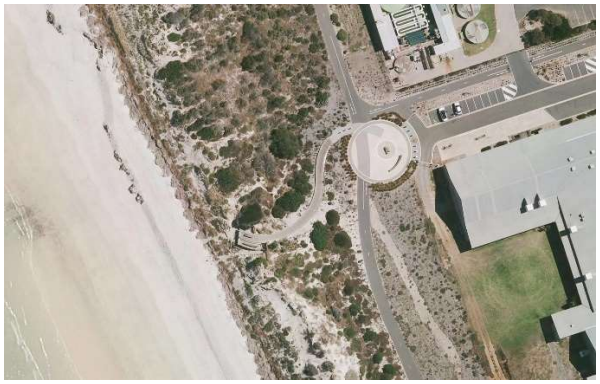


2004

2007

2008

2011



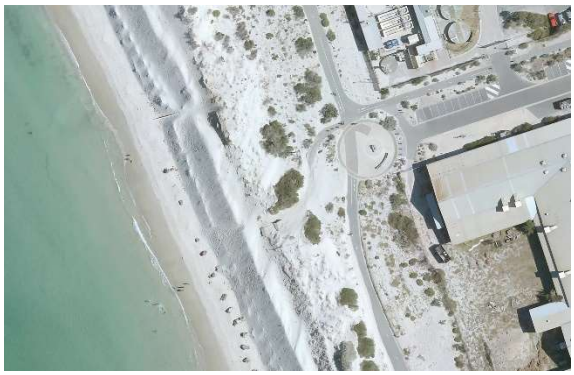
2013

2014

2016

2018

2019

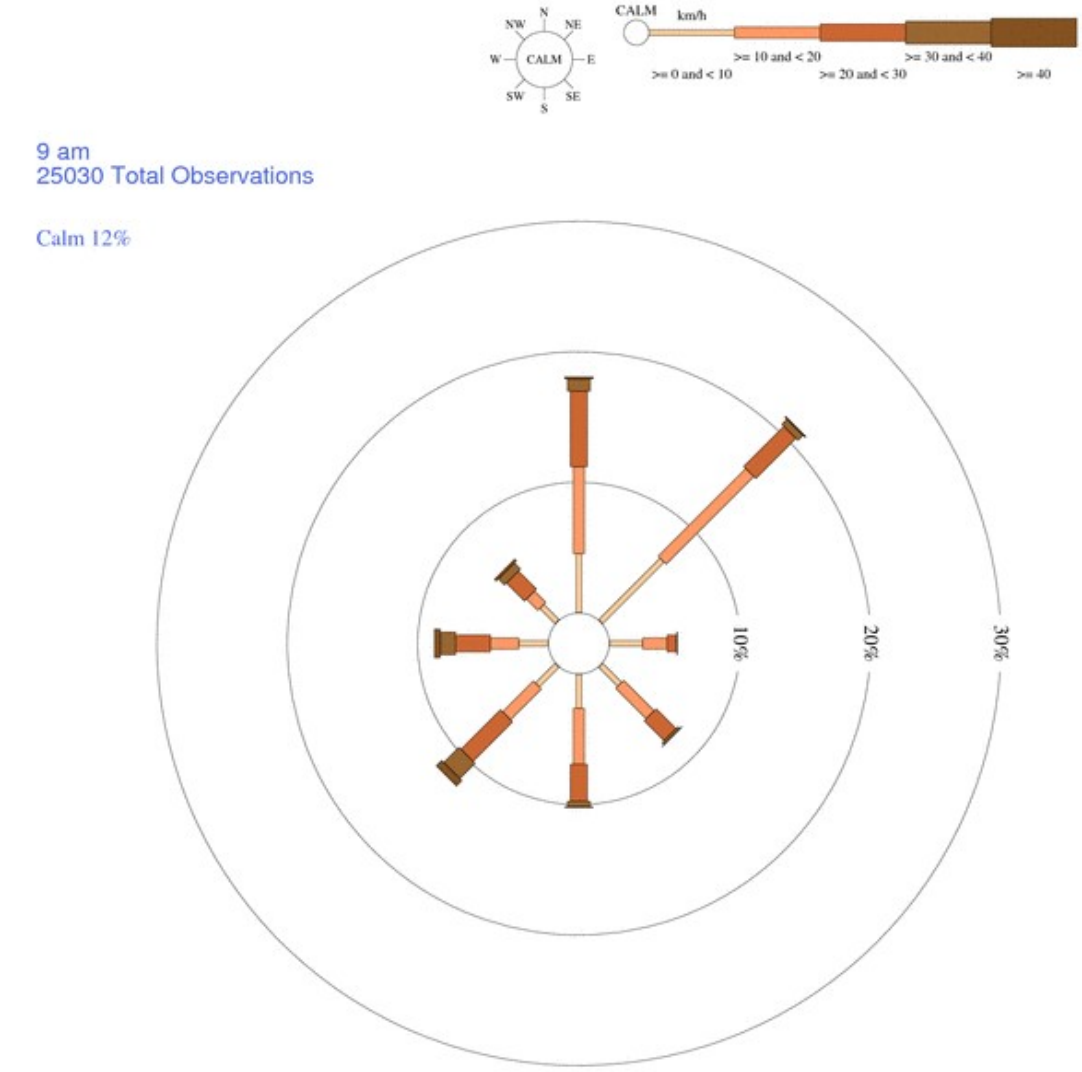


2020

2021 (Sept)

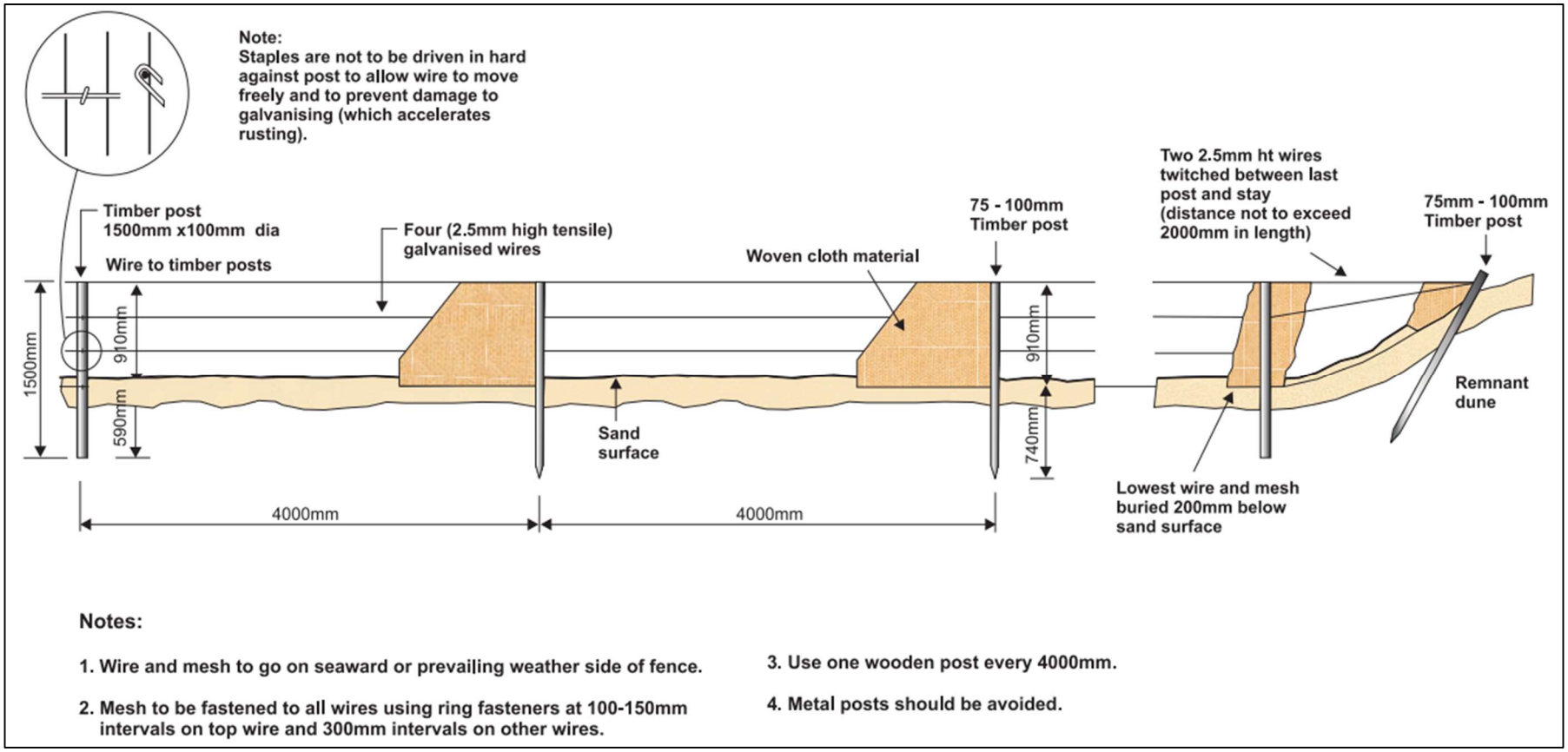
2021 (Dec)

Appendix 3 - Wind Rose from Adelaide Airport



Australian Government
Bureau of Meteorology

Appendix 5 - Standard Drift Net Fencing Design



Source: DLWC, 2001