succession ecology

North Beach Sand Drift Management Plan

PROJECT SPECIFICATIONS

Client:	Copper Coast Council
Client contact:	Müller Mentz
Client email:	mmentz@coppercoast.sa.gov.au
Succession Ecology contact:	Briony Horner
Succession Ecology email:	briony@successionecology.com.au
Prepared by:	Briony Horner
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LIST OF ABBREVIATIONS

AHD	Australian Height Datum
CCC	Copper Coast Council
CPB	Coast Protection Board
DLWC	Department of Land and Water Conservation
WBHOA	Wallaroo Beach House Owners Association
WT	Water Technology

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1.0 INTRODUCTION

1.1 Background

The southern section of North Beach at Wallaroo (within Copper Coast Council, CCC) has been impacted by dune destabilisation processes (Figure 1). This degradation has resulted in wind-blown sand affecting private and public infrastructure (Figure 2). Adverse impacts leading to dune destabilisation are numerous and include the development of a marina and breakwater structures, clearing and development on the dune system, and vehicle access to the beach. Restoring a healthy dune system, while accommodating existing beach uses, would provide protection for adjacent properties against storm surges and wind-blown sand.

The dune system has experienced varying states of repair in the past decade; dune health was in decline, but the system was still functional in April 2017 (Figure 3). A storm surge in 2016 stripped away a portion of the foredune, but satellite imagery shows that the system was beginning to recover. A complete breakdown in many sections of the dune system is evident by late 2018. With the complete loss of vegetative support, sand clearing was used recently to modify and remove the migrating foredune away from many of the impacted properties. This migrating sand has been causing significant damage to infrastructure, inundating the front of several properties (Figure 4). Historical and recent activities (including development activities and large storms) have led to increased sand movement (both erosional and depositional) along the beach as natural coastal processes work to re-build the dune.

Figure 1: North Beach area of Wallaroo in the Copper Coast Council region, and the south section of the beach proposed for sand drift measures, marked in red.

Figure 2: Wind-blown sand impacts private properties (top) and public infrastructure (bottom).

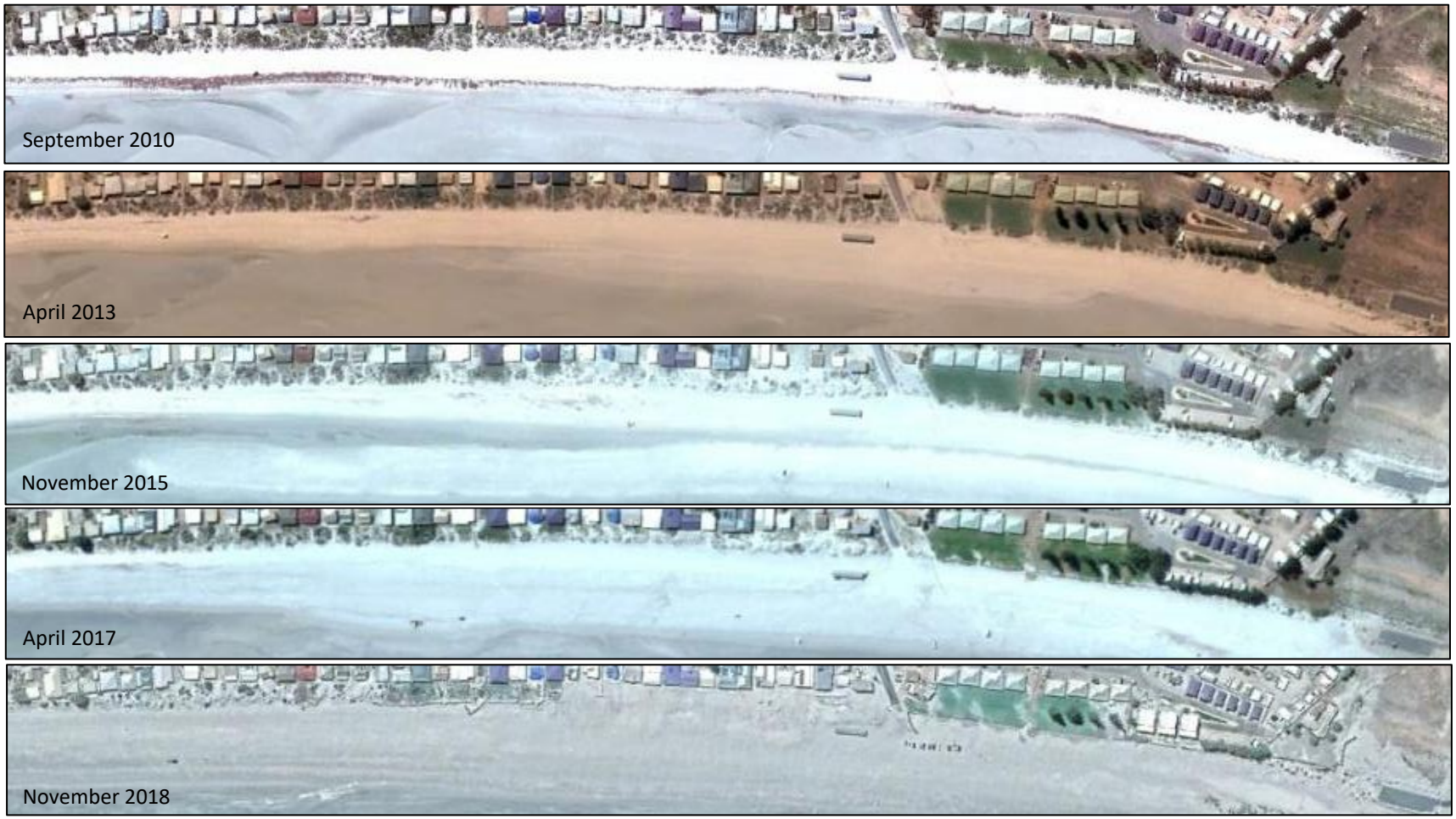


Figure 3: Recent changes in the dune system of North Beach, Wallaroo from 2010 to 2018.

Figure 4: Migrating sand (i.e. "transgressive" dune) impacting a property at North Beach, Wallaroo.

1.2 Sand Drift Management

In order to tackle the impacts of sand drift on the properties at the southern end of North Beach, CCC engaged Water Technology (WT) to conduct a study of the beach and identify management options to address sand drift and erosion issues (Water Technology, May and July 2019). It was recommended that a restored foredune system was required to provide protection against coastal erosion, inundation, and sea level rise for the properties. The engineered parameters of the required dune system included the seaward slope gradient and crest elevation measures (in Australian Height Datum, AHD). In addition to dune shape, the study noted that the reconstructed dune would need to be stabilised to ensure that ongoing sand drift is minimised. Following these findings, coast protection works were proposed for the southern section of North Beach, extending from the Wallaroo Marina to the northern end of Otago Road, approximately 1.1 km (Figure 1).

Two differing methodologies were proposed by Water Technology (Option 1 in May 2019 and Option 2 in July 2019) for the coast protection works. The Coast Protection Board (CPB) recommended that a combination of the two methods be used to address the issues identified on site.

1.3 Community Benefit

Primary benefits of restoring the foredune on the southern section of North Beach include:

a. Reduced sand movement – improve site amenity for residents and visitors and reduce cleaning and property maintenance requirements

b. Property protection – with expected sea level rise and increasing frequency and intensity of storms with climate change, coastal properties will need a buffer for their protection (Figure 5)

c. Biodiversity restoration – dune systems provide habitat for a range of native species that will benefit from the reinstatement of a natural system

d. Community cohesion – previous *ad-hoc* approaches to dune management have created a disjointed ecosystem and community division; a broad and systematic approach to dune restoration will stop the need for individual interventions and reactions to those activities

Figure 5: Storm damage at North Glenelg (left); an intact dune system at Tennyson Beach that absorbs storm damage, enhances amenity and reduces risk of storm damage (right).

2.0 COASTAL SYSTEMS

2.1 Dune Formation Processes

Dune systems of wave-dominated coastal environments have complex structures determined by interactions among prevailing winds, sediment supply, wave action, and the broader geomorphology of the area. Dunes are comprised of sand, which is inherently unstable, nutrient poor and highly mobile; it also has poor water-holding capacity (high porosity). Coastal vegetation stabilises dunes by trapping and holding the sand.

North Beach at Wallaroo has a primary dune (foredune) only; secondary and tertiary dunes were lost to historic development (e.g. Figure 6). Currently, dune vegetation at North Beach is patchy and extensive areas of no vegetation occur there. When vegetation is absent a transgressive dune forms, these dunes can be problematic as they move in a landward direction, inundating coastal properties (Figures 4 and 7).

Figure 6: Historic image of North Beach, Wallaroo in 1930; showing an extensive dune system; image from the State Library of South Australia.

Figure 7: Transgressive dunes are formed when vegetation is absent, the sand is highly mobile and moves inland.

2.2 Dune Stabilisation

Foredunes comprise the transition zone between the land and the sea, they are generated by trapping wind-blown sand particles from the beach face with vegetation. Intact dunes provide a protective structure and buffer for coastal properties. They also act as sand reservoirs that top-up the beach after erosional periods (Figure 8).

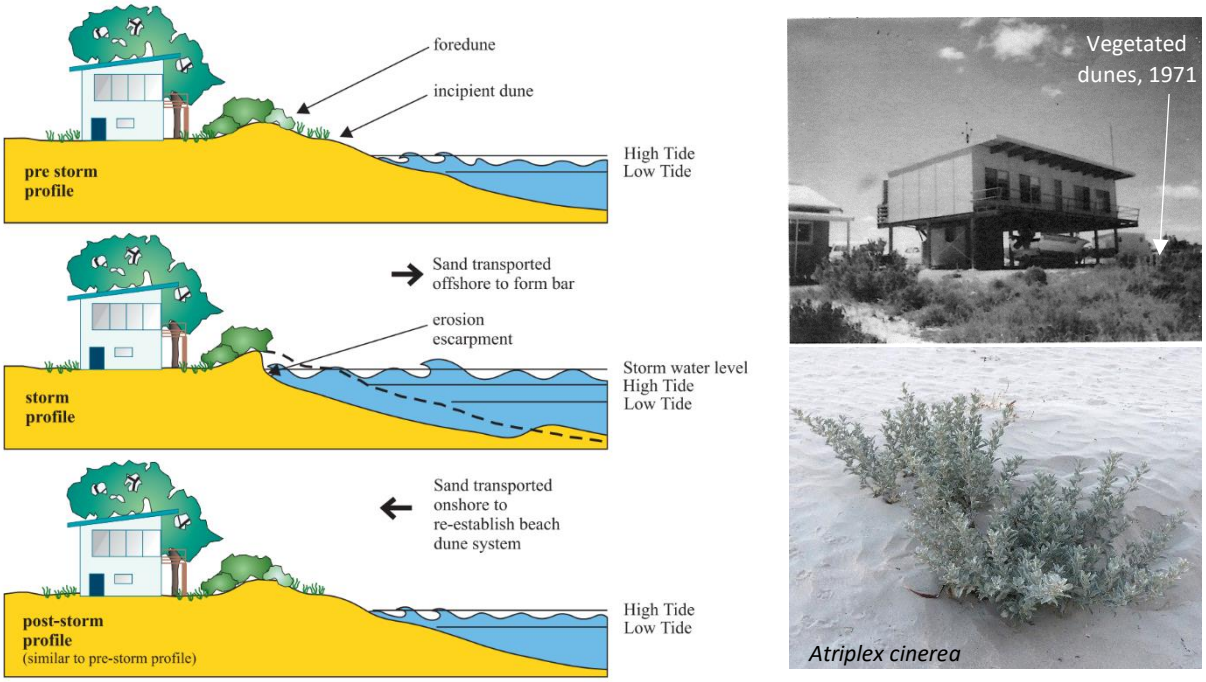


Figure 8: Vegetated dunes will trap airborne sand particles and replenish beaches following storms. Illustration from NSW Department of Land and Water Conservation. Coastal Dune Management – A Manual of Coastal Dune Management and Rehabilitation Techniques; photographs from CCC (top right) and authors (bottom right).

During storm surges, sand is eroded from dunes by wave action and is deposited partly down the beach or in nearshore areas. During periods with onshore winds the sand is transported back from the beach into the dune area. Failure to trap fresh sand blown up from the beach and continued loss of sand from wind erosion decreases the stability and effectiveness of these structures. Destabilised dunes become transgressive and migrate landward (Figure 9).

The prevailing wind direction at North Beach is north and west in winter and south and southwest in summer. These conditions drive northerly currents and longshore sand movement in winter and southerly sand movements in summer. The fine sediment at North Beach (0.117 mm) is readily mobilised with sand naturally migrating in both northerly and southerly directions along the beach front at different times. It is essential that dune management strategies cater for natural sand movements, such as promoting a continuous vegetated dune running parallel to the shoreline. It is important to minimise the physical breaks in the dune, such as pathways, because these will disrupt sand flow and encourage sand to build up or erode from these areas. Dune breaks (including pathways) must also be angled ("dog leg" on seaward side) to minimise problems with sand movements and dune stability.

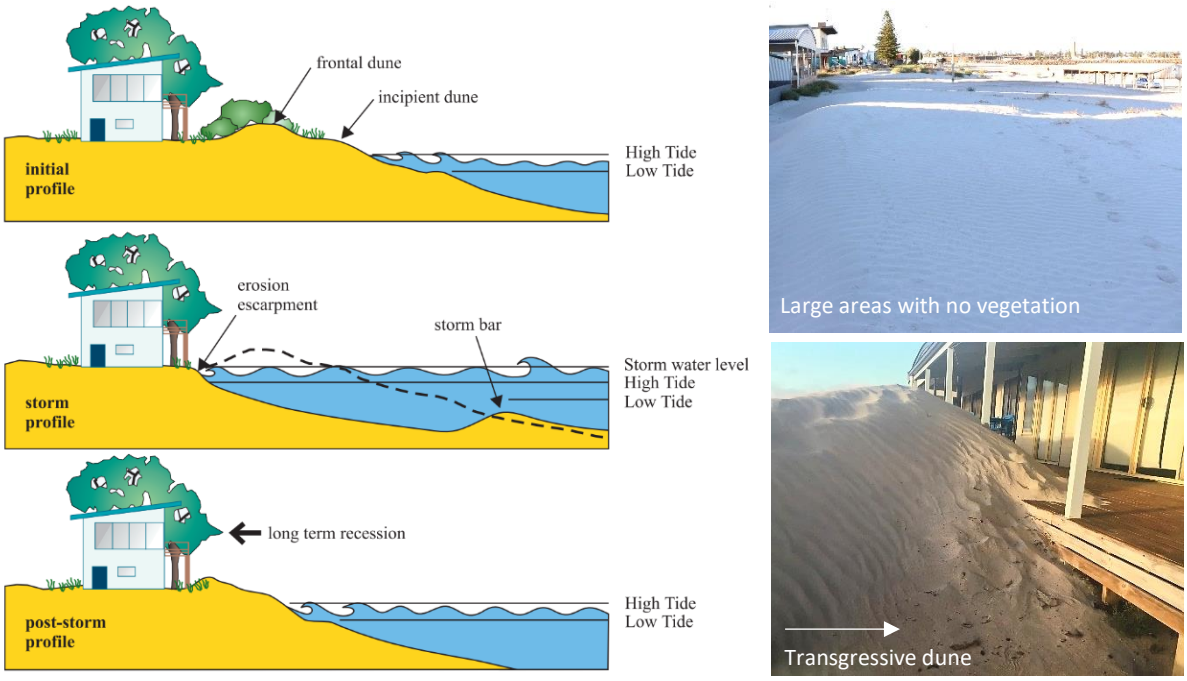


Figure 9: Storms transport sand away from the foredune, if dunes have no vegetation the sand will form a transgressive dune, which moves inland and can impede on properties. Illustration from NSW Department of Land and Water Conservation. Coastal Dune Management – A Manual of Coastal Dune Management and Rehabilitation Techniques; photographs from the authors (top right) and from WBHOA member (bottom right).

2.3 Sea Level Rise

On a geological timeframe, fluctuations in sea level are not unusual and many variations are well documented for the last 400,000 years. However, sea level has been relatively stable for the last 6,500 years, including in recent history when many seaside developments were established. Even with large reductions in carbon emissions, a sea level rise of 30–60 cm is still projected for South Australia from climate change. In addition to rising sea levels, climate change will increase the intensity and frequency of extreme events, including extreme storms. Increases in wave overtopping of protective structures are expected (Figure 10) as well as a dryer climate generally, which inhibits dune vegetation and increases dune mobility (i.e. transgressive dunes).

Figure 10: Pedestrian walkway during September 2016 storm (photo from CCC), and during dry times (March 2020, photo from authors).

2.4 Vegetation

Native coastal plants play a vital role in dune stabilisation. They act to bind dunes together with dense scrambling root systems; they capture wind-blown sand and disrupt surface wind flow to reduce erosion. These plants are specially adapted to tolerate the harsh conditions of coastal environments, thriving in rapidly draining and nutrient poor sand. Coastal vegetation will vary across the dune system with different suites of species occurring at different stages across the dune. The face of the foredune will have low growing species such as spinifex grass (*Spinifex hirsutus*), the dune crest will have low growing to larger species such as coastal saltbush (*Atriplex cinerea*), the back of the foredune will have larger species such as coastal wattle (*Acacia ligulata*). Some species will grow across the entire dune area such as nitre bush (*Nitraria billardierei*).

3.0 SITE ASSESSMENT AND CONSULTATION

A survey of the southern section of North Beach was conducted in March 2020 by Australian UAV (AUAV) (Figure 11). The survey provided detailed elevation maps with site topography (mapped at 0.2 and 0.5 m contours, e.g. Figure 12) with aerial imagery and video of the site. This information was used to plot the existing beach profile against the proposed foredune profile (see Appendix 1: Existing dune system and proposed dune system; Appendix 2: Mapping of fencing and fence height).

Meetings were also held with members of the CCC and WBHOA (Figure 13). The concerns, observations and feedback from all stakeholders were incorporated into the management plan for restoring the site.

Figure 11: AUAV conducted a detailed survey of North Beach, Wallaroo, using two drones.

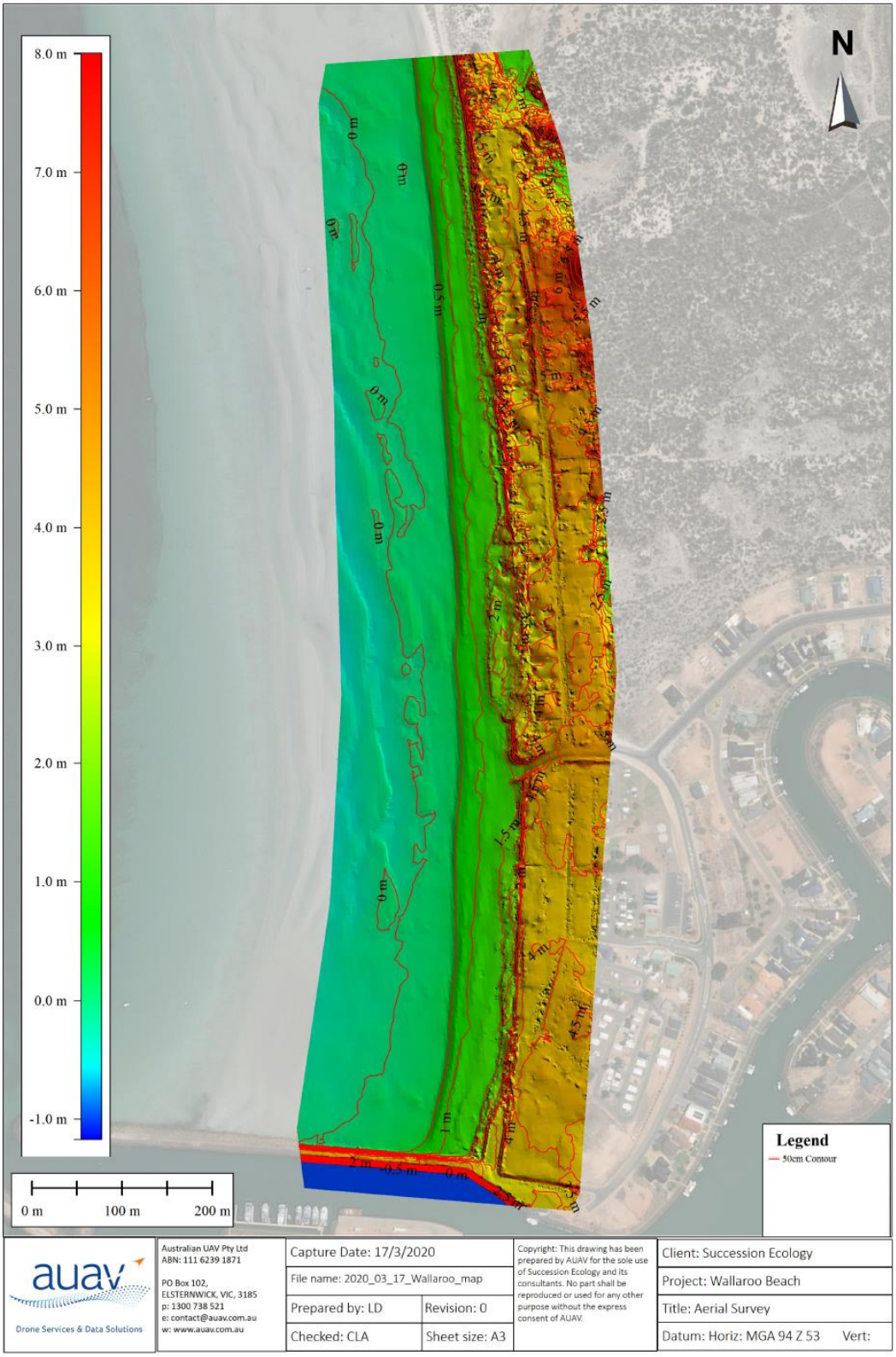


Figure 12: Surveyors map of North beach at Wallaroo showing elevation at 0.5 m intervals (red lines) and at 1 m intervals (shaded spectrum).

Figure 13: Meetings were held at North Beach Wallaroo in March 2020 with members of the Copper Coast Council (top) and WBHOA (Wallaroo Beach House Owners Association; bottom).

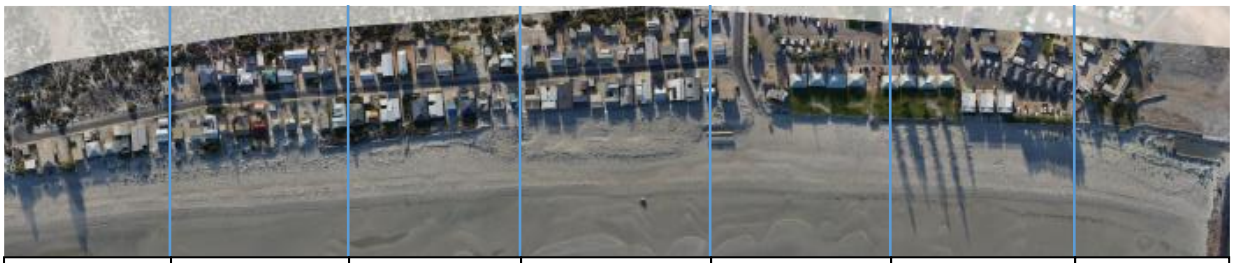
4.0 ESTABLISHING A FOREDUNE

4.1 Methodology

The dune system of the southern section of North Beach at Wallaroo will be restored using a combination of natural and mechanical processes. The mechanical movement of sand will be used initially to define and shape the foredune, building the foundation on which natural processes will follow, continuing the building and stabilisation processes. The rate of natural dune development will be strongly dependent on climatic conditions, prevailing winds, storm events etc. To support these natural processes a series of driftnet fences will be established to capture sand and shape the dune. The fencing will not create a permanent visual impact, rather the aim is for the fences to build dune height, and eventually become engulfed by the sand. These fences will be established, following the specifications in the North Beach Sand Drift Study (Water Technology May 2019). Namely, to build a foredune with a crest height of 3.6 m AHD with seaward slope gradient of 1:5 (every 5 m towards the sea, the dune decreases by 1 m in height) and a smaller toe dune with a crest height of 2.6 m AHD.

For the purposes of designing this project the length of beach from the Marina to the end of Otago Road was divided into seven sections (Figure 14). The landward start of the foredune will be the same height as the base of each house (approximately 3.2 m AHD; Figure 15), it will rise to 3.6 m AHD at 13 m from the front of the houses along Otago Road to Pamir Court (Sections 1 to Section 5). The beach from Pamir Court to the Marina will have the foredune peak located 8 m from the retaining wall and car park (Sections 5 to 7). Maps and graphs of the foredune profile relative to the existing beach profile are available in Appendix 1.

The fencing design will cause some of the existing vegetation to be covered with sand. While covering vegetation appears counterintuitive to stabilising the dune system, these plants will provide sub-surface stabilisation services and organic matter for long-term outcomes. Once established, the foredune will be planted with native vegetation and mulched to improve the integrity of the system and anchor sand. The final dune system will be held together with vegetation and provide a buffer against storm surges and wind-blown sand.



Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7

Figure 14: North Beach at Wallaroo was divided into seven sections for the purposes of mapping recovery activities.

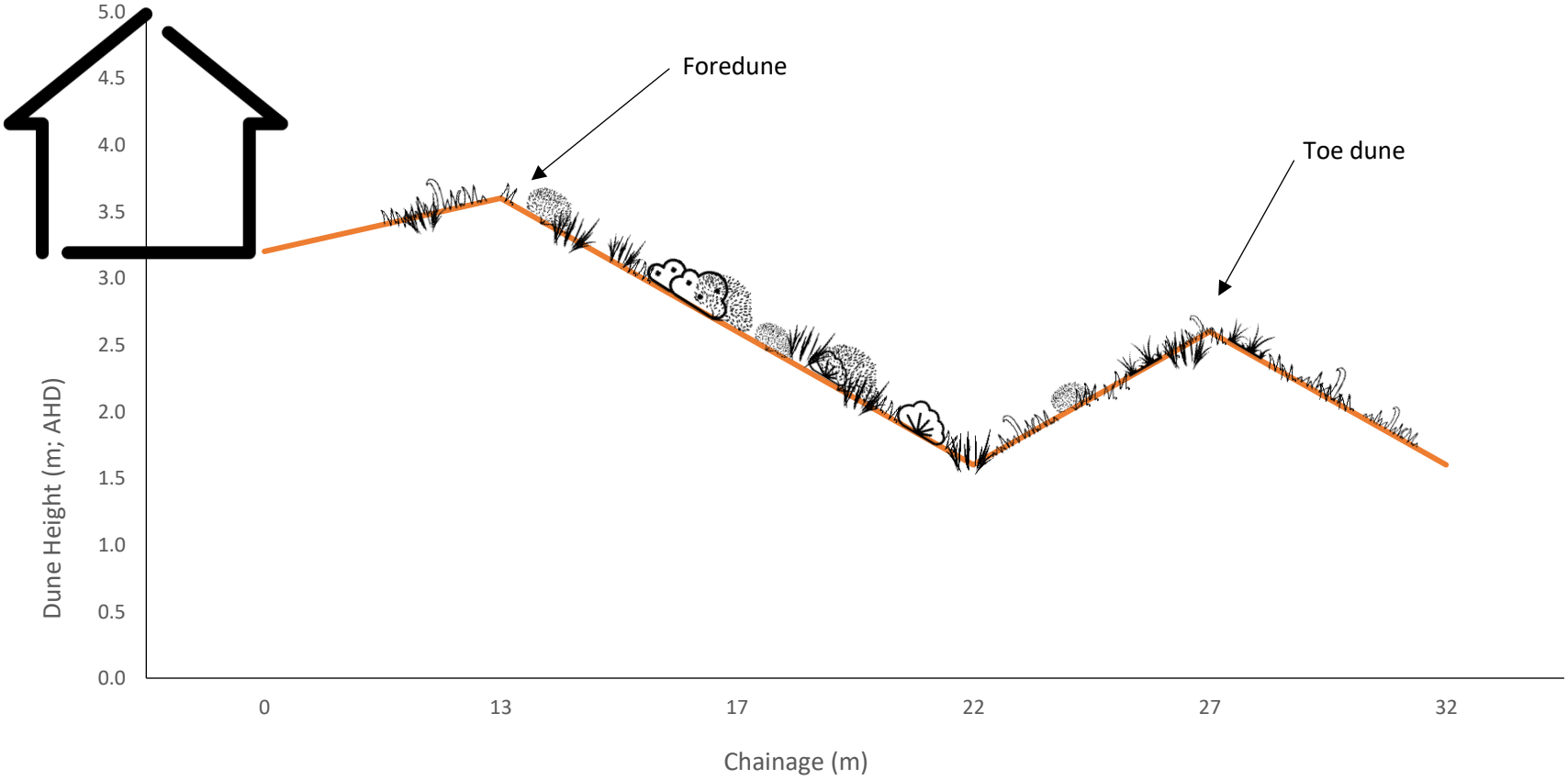


Figure 15: The foredune and toe dune height in relationship to beachfront properties, and low stature native coastal vegetation.

4.2 Dune Recovery Examples

This methodology has been successfully used in projects around Australia and beyond. Some examples include Tennyson Beach in South Australia (https://www.tennyson.org.au/), Budgewoi Beach in NSW (http://www.budgewoibeachdunecare.com.au/index.html and Merimbula Beach in NSW (https://www.environment.nsw.gov.au/resources/coasts/130083Merimbula.pdf).

Figure 16: Successful Spinifex establishment of coastal dunes by the Budgewoi Beach Dune care Program NSW (NSW DLWC 2001).

4.3 Site Preparation

A range of site preparation activities will be required before the fencing can be established on site. These include:

1) Removing existing sand control measures

A range of sand drift and erosion control measures have been established on the site (Figure 17). While these measures have proved effective for some landowners, they create an *ad-hoc*, inconsistent appearance for the beach. In order to provide a uniform approach to the management of the site, improve amenity and support the establishment of a consistent foredune, the existing hay bales and drift fencing will be removed from the site. Landowners will be provided with the option to remove their own bales or leave them as a donation for using to establish the new dune management system. Any remaining bales will be used to mulch the new dunes as they develop. This work will be carried out by CCC under the supervision of Succession Ecology.

Figure 17: Examples of current measures being used by landowners at North Beach, Wallaroo.

2) Moving the public shelter

A public shelter has existed on North Beach at Wallaroo for many years (Figure 18). Currently, the structure is inundated by the foredune and it is in the direct path of the toe dune site. Sand inundation has reduced access to the shelter, which is unlikely to change with time. It is proposed that the shelter be moved toward the beach by around 15 m. The relocation would allow for ease of public use, enable planned dune restoration activities, and encourage vehicle traffic to arc widely around the structure and away from developing dunes. The structure could, at the same time, be upgraded to improve its safety and function for public use. This work will be carried out by CCC.

Figure 18: Relocating this public shelter on North Beach at Wallaroo is recommended.

3) Water outlets

Two water outlets exist along the southern end of North Beach (Figure 19). Access to these outlets will be maintained via small boardwalk structures, built out from and level with the nearby seawall (Figure 19). The boardwalk will also cover the plugs for amenity purposes. This construction will be managed by CCC.

Figure 19: Water outlets at the southern end of North Beach need augmenting to retain access (left). The proposed boardwalk design (right)

4) Tree removal

Several *Casuarina glauca* (swamp sheoak) trees are growing at the northern end of the project area (Figure 20). This species is a declared weed in South Australia under the *Natural Resources Management Act 2004.* These plants present a significant risk to the project; they grow via suckers, inhibit growth of other species, and can become invasive. They have the potential to become a significant pest species in the restored dune system. The removal of these trees will be carried out by CCC.

Figure 20: Casuarina glauca *(swamp sheoak), a declared weed, growing at two properties on the northern end of Otago Road, Wallaroo.*

5) Preliminary shaping of the beach and foredune profile

Some initial sand movement will be required to prepare for establishing the new foredune. These works will remove sand from the areas where it has built up (where dune heights exceed foredune profile) and move it to areas where the foredune profile needs building. In particular, sand removal will target those areas that are problematic to landowners (e.g. Figure 21) and sand deposition in those areas with poor dune profiles (i.e. the southern section of the beach). Vegetative cover on the existing dune varies, some areas have extensive and dense cover, others are sparsely vegetated (Figure 22). Existing vegetation will be preserved where possible; where vegetation is disturbed or covered it will still provide important structural support for the new dune system. Mulch will be used in layers through the sand to provide extra structural support in newly established areas.

Surveys indicate that dune height on the beach North of Pamir Court is close to the planned foredune profile. Minimal sand movement will be required in this section, except for remedial works to remove sand from inundated properties (Appendix 1). The beach south of Pamir Court has a significantly lower foredune profile than is required. This section will require significant deposition and movement of sand to raise the dune profile for fencing activities that will facilitate further dune development. Sand movement and mulching work will be carried out by CCC under the supervision of Succession Ecology.

Figure 21: Houses with a drift of sand in front of them and little vegetation cover.

Figure 22: Areas of dense, patchy and sparse vegetation cover occur on the site.

The total estimated sand to be moved is 842.2 m^3 (Table 1). The sand will be taken from a range of sources with the aim to scalp sand thinly in two areas: 1) where it has built up too much in front of properties in fence blocks 8 to 11 and 2) along the beach front between fence blocks 6 to 17 (Figure 26). Machinery used to move the sand will include a water truck to stabilise sand and reduce windblown sand, a grader to scrape sand from the tide line, an excavator, a dump truck and a smaller digger (skid-steer). The heavier machinery will work mostly on the mid beach where the sand is firm with the dump truck transporting and depositing sand to raise the areas required in preparation for fence construction. Sand will be wet down to hold it in place and create a stable profile for fencing. A small skid steer will be used for sand movements higher up the beach where the sand is soft and vegetation disturbance should be avoided.

Table 1: Soil additions for each fence block allowing for a 2m band of the required height to be established along each fence transect..

Fence Block	Hind			Peak			Mid		
	Height (m)	Length (m)	Sand moved (m^3)	Height adjustment (m)	Length (m)	Sand moved (m^3)	Height adjustment (m)	Length (m)	Sand moved (m^3)
1	0.1	44	8.8	1	52	104	0.1	50	10
2	0	0	0	0.2	51	20.4	0.1	50	10
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0
12	0.4	17	13.6	1	16	32	0.2	90	36
13	0.2	70	28	0.9	71	127.8	0	0	0
14	0	0	0	0.2	63	25.2	0	0	0
15	0.1	50	10	0.9	50	90	0.2	90	36
16	0	0	0	0.5	58	58	0	0	0
17	0	0	0	0.8	134	214.4	0.1	90	18
TOTAL	–	**181**	**60.4**	–	**495**	**671.8**	–	**370**	**110**

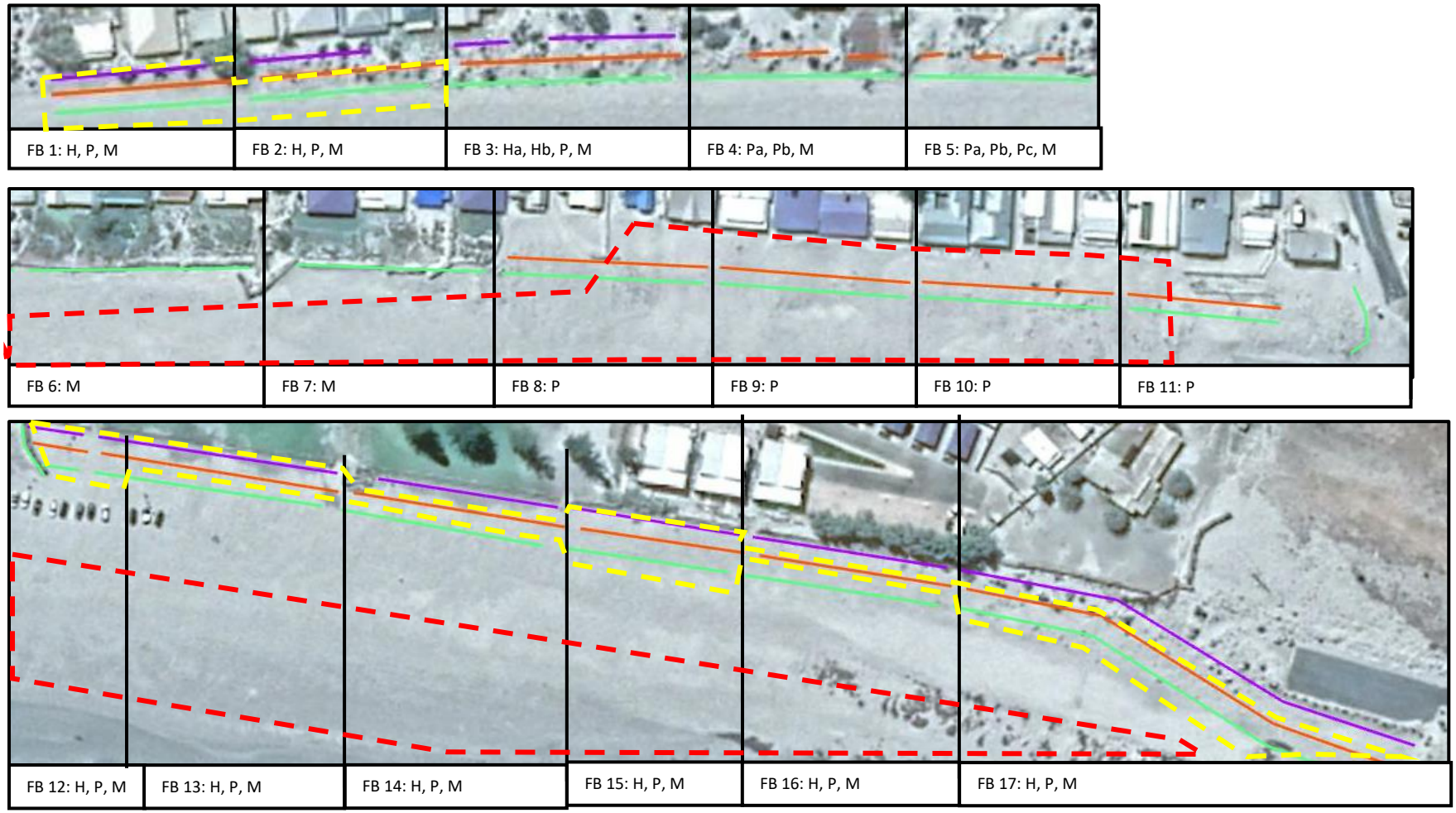


Figure 23: Fencing design allowing for a walkway every 4 houses from the houses on Otago Road and walkways at pre-existing access points south of Pamir Court. The fences cover the hind slope (H; purple), dune peak (P; orange) and mid slope (green). Each fence is divided into a fence block (FB). Sand movement marked to add (yellow dash) and to remove (red dash).

4.4 Drift Fencing

The purpose of drift fencing is to slow wind velocity, capture airborne sand and build dune structures (Figure 24). This process can be used as part of a strategy to re-build a foredune that has been lost from destabilisation processes. The rate at which dune re-building occurs will depend on wind direction and speed. The aim for this project will be to establish the bulk of the foredune within one year. The low dune profile at the southern end of the beach may require an extension to this timeline.

The design for this project will be a standard drift fence using 100 mm diameter posts set 4 m apart connected with high tensile wire mesh and a 900 mm high drift fence (Figures 25 and 26). The height of the fence and end sections above the dune will vary depending on location. As the primary aim is for the fence to be inundated by sand, an additional wing would be added if a box section is used to support the development of a slope at the end of the dune ridge. If the fence abuts a dune slope, an alternative end design will be used to allow the fence to blend into the existing dune (Figure 26).

Figure 24: A staged installation of drift fencing can be used to build a dune.

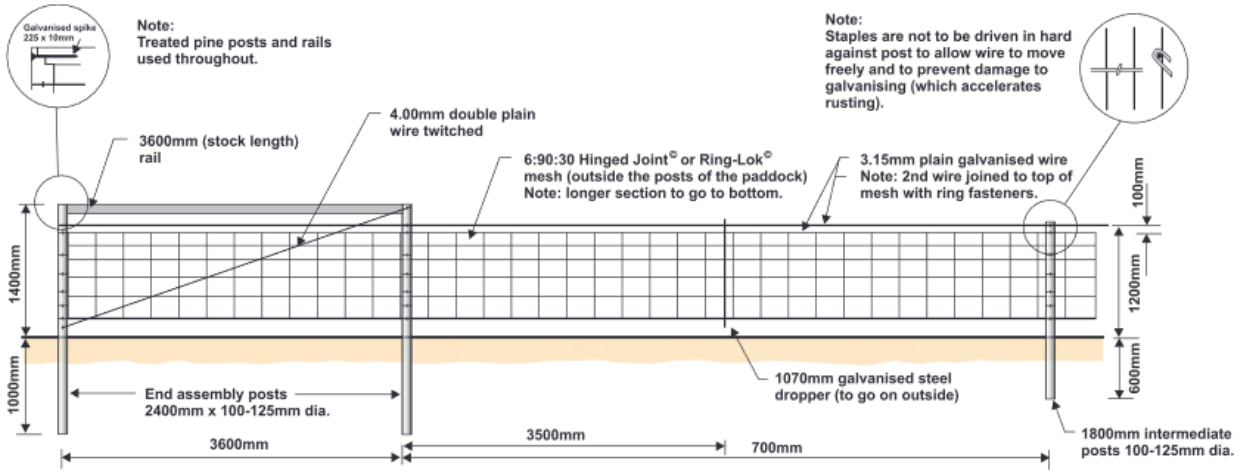


Figure 25: Simple fence design for North Beach dune restoration, Wallaroo.

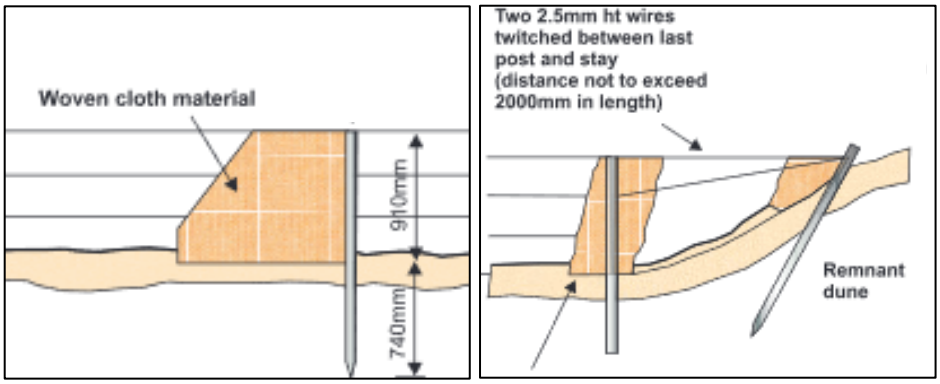


Figure 26: Fencing mesh (left) and alternative fence end design (right).

The fencing design includes establishing fences at the hind slope, peak and mid slope of the foredune. It will cover approximately 2,382 m and will be divided into 17 fence blocks located between the beach access walkways and the road access point at Pamir road (Table 2 and Figure 23). Each block will require different lengths of hind, peak and mid dune fencing. The greatest amount of fencing will be needed south of Pamir Court. Dune elevation from north to south is variable so fence height requirements will also vary based on block elevation. Fencing relative to elevation is estimated in Table 2; fencing details and maps are available in Appendix 2.

The fence will be constructed by a local fencing contractor employed by CCC under the supervision of Succession Ecology.

Table 2: Estimated lengths and heights for sand drift fences within 17 Blocks along North Beach, Wallaroo.

Fence Block	Hind		Peak		Mid	
	Length (m)	Height (cm)	Length (m)	Height (cm)	Length (m)	Height (cm)
1	44	90	52	90	50	90
2	34	50	51	90	50	90
3	36 & 15	50	62	90	63	90
4	–	–	11 & 22	50	59	90
5	–	–	8, 9 & 7	50	50	90
6	–	–	–	–	65	50
7	–	–	–	–	56	50
8	–	–	60	70	60	70
9	–	–	57	50	57	50
10	–	–	57	50	57	50
11	–	–	46	50	46	50
11 roadway	–	–	–	–	23	50
12 roadway	–	–	–	–	17	50
12	17	90	16	90	11	90
13	70	90	71	90	69	80
14	54	60	63	90	61	70
15	50	80	50	90	50	90
16	58	80	58	90	58	70
17	134	50	134	90	134	90
TOTAL	**512 m**		**834 m**		**1,036 m**	

4.5 Planting and Mulching

In order to stabilise the restored dune system, it is vital to establish plant cover. A planting density of at least one plant per m^2 will be used at North Beach. The species selected for this planting include those known to grow well on the site, other dune species that occur in the region and those known to establish rapidly (Table 3; Figure 27).

Table 3: Locally native plant species selected for revegetating the restored dune system of North Beach, Wallaroo.

Growth form	Scientific name	Common name	Position on the foredune		
			Front	Mid	Back
Creeper	*Carpobrotus rossii*	Native pigface	✓	✓	✓
	Threlkeldia diffusa	Coastal bonefruit	✓	✓	✓
Grass	*Distichlis distichophylla*	Emu grass	✓	✓	✓
	Spinifex hirsutus	Hairy spinifex	✓	✓	✓
Shrub	*Atriplex cinerea*	Coast saltbush	✓	✓	✓
	Atriplex paludosa	Marsh saltbush		✓	✓
	Olearia axillaris	Coast daisy-bush		✓	✓
	Rhagodia candolleana	Seaberry saltbush		✓	✓
	Scaevola crassifolia	Cushion fan flower		✓	✓
	Nitraria billardierei	Nitre-bush	✓	✓	✓
Large shrub	*Myoporum insulare*	Common boobialla			✓
	Acacia ligulata	Umbrella bush			✓

Figure 27: Species to be used in the plantings on site include Atriplex cinerea (left) and Nitraria billardierei (right).

The area to be covered by the plantings is around 2.4 Ha. With an average density of one plant per m^2, the planting effort will require 24,000 plants. Planting will be conducted in two stages: 1) preliminary planting to stabilise dune areas that are already at the required foredune profile (approximately 30% of the site with 7,000 plants), and 2) a secondary planting for the remaining dune once it has developed suitably (approximately 70% of the site and 17,000 plants). The first 7,000 plants have already been sourced and will be ready for planting in June 2020. These plants will be well mulched following planting to improve water retention. If no rainfall occurs within three days of planting, they will be watered in manually. Additional watering will be conducted as required over their first year. The secondary planting will occur in June 2021 and will follow the same approach to mulching and watering.

The planting plan will incorporate the ecology of each species and the requirements of the site. Coastal zonation patterns will inform the planting plan, such that rapidly growing grasses (e.g. emu grass and hairy spinifex), which withstand salt spray, strong winds and sand abrasion, will be planted in the most exposed foredune areas. Plant species assemblages then change with distance from beach; low shrubs would be more common in swale and hind dune areas, for example.

Mulch will be added to the foredune as it develops to improve soil stabilisation and moisture holding capacity. It will also be added along the fences as required to anchor captured sand that may otherwise move on away from the dunes. Sources of mulch will include seaweed, existing hay bales on site and possibly brush from areas where vegetation has died back. Additional straw bales will also be purchased as required to bolster mulching activities.

The planting will be carried out by Succession Ecology with CCC providing staff to mulch and water plants following planting.

4.6 Beach Access Walkways

Beach access walkways will be established through the dune systems to guide foot traffic and discourage walking across newly establishing dunes and vegetation. These walkways will occur at existing access points south of Pamir Court and at a frequency of one walkway per four houses north of Pamir road. Walkway frequency north of Pamir Court was greater than recommended by WT (2019) as property owners were concerned that it would be difficult to prevent foot traffic across the dunes by visitors of holiday rentals if beach access points were infrequent.

It is important to specify that beach access tracks would terminate on the beachside in a northward heading "dog-leg" pattern. Seaward access points positioned perpendicular to the foredune would interrupt the flow of sand along the dune and promote wind funnelling and risk of blowouts. The tracks will comprise simple sand trails of about 1-m width (Figure 28). Fencing will run either side of access tracks to encourage people to use them.

Fencing and pathways will be installed by CCC under the supervision of Succession Ecology. Pathway condition will be reviewed during the project to determine whether the frequency is too intensive to support the developing dune.

Figure 28: A sand walkway leading through dunes to beach.

4.7 Temporary Gates

Temporary gates may be required during the dune development phase to prevent wind damage through the breaks in the fence created for walkways. They can be as simple as applying a pallet across the gap in drift fence, and some are already in use (Figure 29). Gates will be installed by CCC as required under the supervision of Succession Ecology.

Figure 29: Pallets are a readily accessible and affordable option for temporary gates that also reduce wind erosion of the dune

4.8 Exclusion Fencing

The developing foredune will be a very fragile environment, its protection will be integral to the success of the project. Eliminating foot and vehicle traffic from the surface will be vital. Exclusion fencing should be established along the seaward and landward sides of the dune restoration areas. The fence could be a simple post and rail or chain fence (Figure 30). Fencing will be installed by CCC under the supervision of Succession Ecology.

Figure 30: Safety bollards used to deter pedestrians from dune restoration activity at Semaphore South.

4.9 Signage and Interpretive Materials

Signage should be displayed alongside the exclusion fencing and in high-use areas to inform the public of the foredune redevelopment project and encourage them to avoid the fragile foredune (Figure 31). Other interpretation materials, such as brochures and community forums, could provide detailed information on the dune ecosystem, the plants and wildlife that they could expect to see. Signage will be designed and installed by Succession Ecology in collaboration with CCC. Other interpretive materials can be designed as required.

Figure 31: Signage to guide people to beach-access pathways (left) and dune restoration information (right).

4.10 Toe Dune

It is recommended that a toe dune fence be installed once the foredune has achieved the desired height. The timing of the installation will then vary across the restoration area, with fence blocks 6 and 7 receiving toe dune fencing after winter in 2020 and the remaining areas receiving fencing in winter 2021. The smaller seaward dune would act as a protective buffer for the foredune. The crest of the toe dune will occur 10 m from the foredune crest, reaching 2.6 m AHD (Figure 15); details on location of toe dune fencing are available in Appendix 1. A toe dune is already forming in some northern sections of the project site. The benefits of a toe dune include:

- Interruption of wind and sand movement from skating over the foredune, creation of additional sand capture opportunity
- Additional protective buffer for properties
- Additional protective structure for the main foredune
- Promotion of a more diverse dune system with inter-dune swale habitat, which some plant and animal species will prefer
- Additional deterrent for vehicles, keeping them further away from important foredune structure
- Working with the natural system of North Beach, the toe dune is already forming

5.0 MONITORING AND MAINTENANCE

The development of the North Beach dune will be monitored quarterly following installation of the fencing. Monitoring will be conducted by Succession Ecology and will enable recording of foredune development, conditions on site, maintenance requirements, storm damage, walkway condition and any other activity required to promote positive foredune development outcomes. Particular attention will be given to monitoring efforts following storm events. A brief report to CCC will present required activities and locations for these works. A 10% budget allowance has been factored into the project for any remedial works required.

Maintenance works by CCC will include:

- **Fence and signage repair** – fences and signs may become damaged by storms, vandalism, and environmental wear; the location and type of fence repairs required will be determined and reported to the CCC to address
- **Sand movement** – supplementary sand movements may be required. For example, storm events can displace large volumes of sand, blow-outs in the dune may occur from walkways, and transgressive dunes may impact some properties before stabilisation works are complete. The nature of the problem and required remedial sand movement will be reported and will be addressed by CCC
- **Mulching** – mulching requirements will be assessed during the monitoring program; identified mulching maintenance will be conducted by CCC as required
- **Plant watering** – watering of planted seedlings will be conducted by CCC for the establishment period. Watering can occur by hand or via an irrigation system (see Section 7.2.1)

6.0 TIMING OF WORKS

The project will be conducted over a 2-year period to allow for dune development and establishment phases. For a detailed project timeline see Table 4. The project activities will be divided into:

1. Coast Protection Works
2. Coast Protection – Post Works

6.1 Coast Protection Works

6.1.1 April to June 2020

Activities required to achieve recovery of the foredune will include:

a) Materials and mobilisation – Purchasing and preparation of materials

b) Site preparation – Sand movement, remediation of previous sand control strategies (re-use of materials where possible)

c) Install drift fencing – Construct drift fencing (hind-slope, peak and mid-slope of the proposed foredune)

d) Stage 1 planting – Preliminary plantings in areas already at the required height (~30% of site and 7,000 plants)

e) Spread mulch – Use of old hay bales and seaweed to provide mulch for the preliminary planting areas to reduce wind erosion in dunes that are at the required height

f) Pathways and gates – to be established at intervals of one per four houses

g) Exclusion fencing – to be established along pathways

h) Signage – designed and installed

6.1.2 July 2020 to June 2021

Activities required to achieve recovery of the foredune will include:

a) Site monitoring and maintenance – conducted quarterly

b) Toe dune fence installed – Construct sand drift fencing

c) Stage 2 planting – Secondary plantings following dune establishment (~70% of site and 17,000 plants)

d) Spread mulch – Use of hay bales and seaweed to provide mulch for planting areas

e) Exclusion fencing – expanded to protect foredune

6.3 Coast Protection – Post Works (July 2021 – June 2022)

6.3.1 Finalisation

On completion of the coastal protection works the Coast and Marine Branch of the CPB will be invited to review the works and assess whether they are satisfied that the works meet the agreed outcomes.

6.3.2 Monitoring and Maintenance

A 12-month monitoring (Succession Ecology) and maintenance (CCC) period will follow the final implementation. These services will include:

a) Quarterly site inspections and reports

b) Watering

c) Sand management

d) Infill planting

e) Fence repair

f) Pathway, fence and signage maintenance

6.3.4 Foredune Management Plan

As part of the handover for this project we propose that a Foredune Management Plan be developed, which would describe management activities that support the continued health and viability of the dune system in the medium- and long-term.

Table 4: The proposed schedule of works for activities outlined within the North Beach Sand Drift Management Plan.

Activity	2020						2021						2022
	A	M	J	J-S	O-D	J-M	A	M	J	J-S	O-D	J-M	A-J
Preliminary Works													
1. Site assessment and design	×												
2. Liaison with partners and stakeholders	×												
3. Materials for application to CPB		×											
4. Plants and equipment orders	×												
Coast Protection Works													
1. Materials and mobilisation	×	x					×	x					
2. Site preparation		×											
3. Install foredune fencing		×											
4. Planting and mulching		×						×					
5. Pathways and gates			×										
6. Exclusion fencing			×										
7. Signage			×										
8. Monitoring and maintenance				×	×	×							
9. Toe dune fencing				×					×				
3.0 Coast Protection – Post Works													
1. Finalisation									×				
2. Monitoring and maintenance										×	×	×	×
3. Foredune Management Plan													×

7.0 RISK ASSESSMENT

A risk assessment is a tool for identifying variables that may impede project success. For the North Beach sand management project, a range of variables have the potential to impact dune development, revegetation, and dust management targets. Potential risks, their likelihood and consequences are detailed in Appendix 3 and Table 6.

7.1 Risk Assessment Outcomes

The primary negative outcomes identified within this risk assessment include (Appendix 1):

1) **Dune structure damage** – from strong winds, waves, dry sand and public access
2) **Sand Drift** – from strong winds and dry sand
3) **Plant losses** – from lack of rainfall, wave damage, and public access
4) **Weed competition** – incursions from surrounding weed populations
5) **Loss of project support** – from financial constraints
6) **Negative publicity** – from failure to reach project targets

7.2 Mitigation Strategies

The identified risks with the greatest threat level to achieving project outcomes were extreme winds and high tides or large waves (Level 4; Table 5). A range of strategies can be applied to mitigate against these risks as well as for other risks of lower threat levels. Mitigating strategies for each of the identified outcomes are described in Table 5.

Table 5: Mitigation strategies for each of the outcomes identified by the Risk Assessment of the North Beach Dune Restoration Project.

Outcome	Risk factors	Mitigation Strategies
1. Dune structure damage	Storm events	• Development of toe dune post-winter • Monitoring and maintenance program • Contingency for remedial works • High planting density and use of mulch • Additional fencing
	Drought	• Plant species selection • Mulch to provide organic material and increase water-holding capacity • Use of irrigation system
	Public access	• Exclusion fencing to deter foot traffic • Signage to encourage desired behaviours • High frequency of walkways to beach enabling ready access • Moving the public shelter so drivers arc around it and away from dunes
2. Sand Drift	Strong winds	• Use of irrigation system • Additional fencing • Development of toe dune post-winter • Monitoring and maintenance program • Contingency for remedial works • High planting density and use of mulch
	Dry Conditions	• Use of irrigation system • Plant species selection • Strategic planting plan • Mulch to provide organic material and increase water-holding capacity
3. Plant losses	Public access	• Exclusion fencing to deter dune access • Signage to encourage desired behaviours
	Severe conditions (including drought and storms)	• Plant species selection • Strategic planting plan • Mulch to provide organic material and increase water-holding capacity • Use of irrigation system • Contingency for remedial planting works
4. Weed Competition	Invasion of dune system	• Selection of competitive native plant species • Monitoring and maintenance program • Planned removal of existing invasive plants on site (e.g. *C. glauca*)
5. Loss of project support	Funding limitations	• Effective project management • Good working relationships with CCC, CPB and the community • Adaptive management approach

Outcome	Risk factors	Mitigation Strategies
6. Negative publicity	Not achieving project targets	• Public engagement and education materials • Media commentary • Contingency for remedial works • Irrigation system to bolster revegetation works • Community consultation

The mitigation strategies identified in Table 5 include some that are already applied in the project design and some that would be applied as required during the project. Those not already described in the project design are described below.

7.2.1 Irrigation

An irrigated sprinkler system is recommended for the North Beach dune restoration project. These systems have been used by the CPB to stabilise dunes elsewhere; note that a section of PVC pipe protects the sprinkler head from abrasion and clogging by sand (Figure 32). The system sprays water out over the dune restoration area to stabilise it during high wind conditions. The system could be activated during any weather conditions that present a risk to the project, including drought.

Automated watering would also reduce work required by CCC to water plants through their establishment phase. An irrigated dune would promote rapid vegetation growth and reduce risk of negative publicity. The system would be run temporarily until the vegetation covers the dune to stabilise it in the longer term.

Figure 32: An irrigated sprinkler system can be used to wet sand and stabilise dunes during strong wind conditions; they also promote rapid vegetation growth.

7.2.2 Increased planting density

The planned planting density is for at least one plant per m^2 (see Section 4.5). It is recommended that planting densities are doubled for high-risk areas. High risk areas include Sections 4, 5, 6 and 7 (available in Figure 14; or Fence Blocks 8 to 17 in Figure 23). Associated efforts will be concentrated for these areas as well, such as mulching and watering plants. The risk of transgressive dunes is greatest for Section 4 because high sand volumes occur there, but there is no anchoring vegetation. Planting will be prioritised in this area in 2020, with a localised increase in planting density of two plants per m^2. Priorities for the other high-risk areas will focus on dune building in 2020. Planting densities will also be maximised in these areas.

7.2.3 Increased exclusion fencing and signage

It is important to deter public access from dune restoration works for their own safety (during works), for the successful development of a stable dune (undisturbed by foot or vehicle traffic), and to promote use of designated beach access points. Temporary exclusion fencing and signage will be used during works on site, it will also be used throughout the project to delineate the walkways and cordon off dune restoration areas from seaward and landward access (Figure 33).

Figure 33: Beach signs for the public are used to notify them of works, communicate the purpose of the works and request certain behaviours (top); clearly delineated pathways and other public infrastructure, such as seating, encourages the desired behaviours (bottom).

7.2.4 Jute matting

The use of jute matting has been considered closely and use of it may be necessary to enhance dune stabilisation in problematic sections (e.g. Section 4 and southwards; Fence Blocks 9 southwards). It is hoped that a combination of hay bale mulch, high plant densities and irrigated sprinkler system will reduce the need for jute matting. The monitoring program will enable the success of existing strategies to be assessed and apply adaptive management strategies to problematic areas.

7.2.5 Toe dune addition post winter

The benefits of establishing a toe dune for the restoration project are available in Section 4.10. Because this dune is the most exposed to wave and wind pressure, its installation will be deferred until after winter (i.e. spring of 2020 for Sections 1–4 and spring 2021 for Sections 5–7). The most severe and erosional storms occur in winter in this area so delaying the installation will reduce risk of damage to the fence and dune processes.

8.0 REFERENCES

NSW Department of Land and Water Conservation (DLWC) 2001, Coastal Dune Management: A Manual of Coastal Dune Management and Rehabilitation Techniques, Coastal Unit, DLWC, Newcastle.

Water Technology (May 2019), North Beach Sand Drift Study – Stage 2 – Second Draft Report. Prepared for Copper Coast Council.

Water Technology (July 2019) North Beach Sand Drift Study – Alternative Implementation Proposal. Prepared for Copper Coast Council.

APPENDIX 1 – EXISTING DUNE SYSTEM AND PROPOSED FOREDUNE SYSTEM

Survey data collected by Australian UAV was captured on Tuesday 17th March 2020. These data were used to create a current image of the site and an elevation map. These attributes are presented for seven sections of the beach for the purposes of presenting a workable layout for proposed dune works (Figure 14). Elevation is mapped at 0.5 m intervals AHD, distance from houses is marked with yellow rulers (2 m interval markers). The proposed foredune peak (orange) and mid slope (green) and toe dune peak (blue) are indicated across the three transects (yellow rulers) on each map. Following each map is three graphs presenting the current (grey) dune profile versus the proposed (orange) dune profile. As the toe dune will be added later in the project schedule no comments on sand movement are provided for this activity.

The transect graphs indicate that:

Section 1:

Sand movement will be required in this section to support fencing. Transect 1 will need to be raised by 0.1 m for the hind-dune fence, 1 m for the dune peak fence and 0.1 m for the mid dune fence. Transect 2 will need to be raised by 0.2 m for the dune peak fence and 0.1 m for the mid dune fence but not for the hind-dune fence. Transect 3 has enough sand to support fencing.

Section 2:

No sand movement will be required to support fencing in this section with some sand being available for use in other areas. A dune peak fence will be required across Transects 4 and 5 but no other fencing will be required.

Section 3:

No sand movement will be required to support fencing in this section with some sand being available for use in other areas. A dune peak fence will be required across Transects 7 to 9 but no other fencing will be required.

Section 4:

No sand movement will be required to support fencing in this section with some sand being available for use in other areas. A dune peak fence will be required across Transects 10 and 11 but no other fencing will be required.

Section 5:

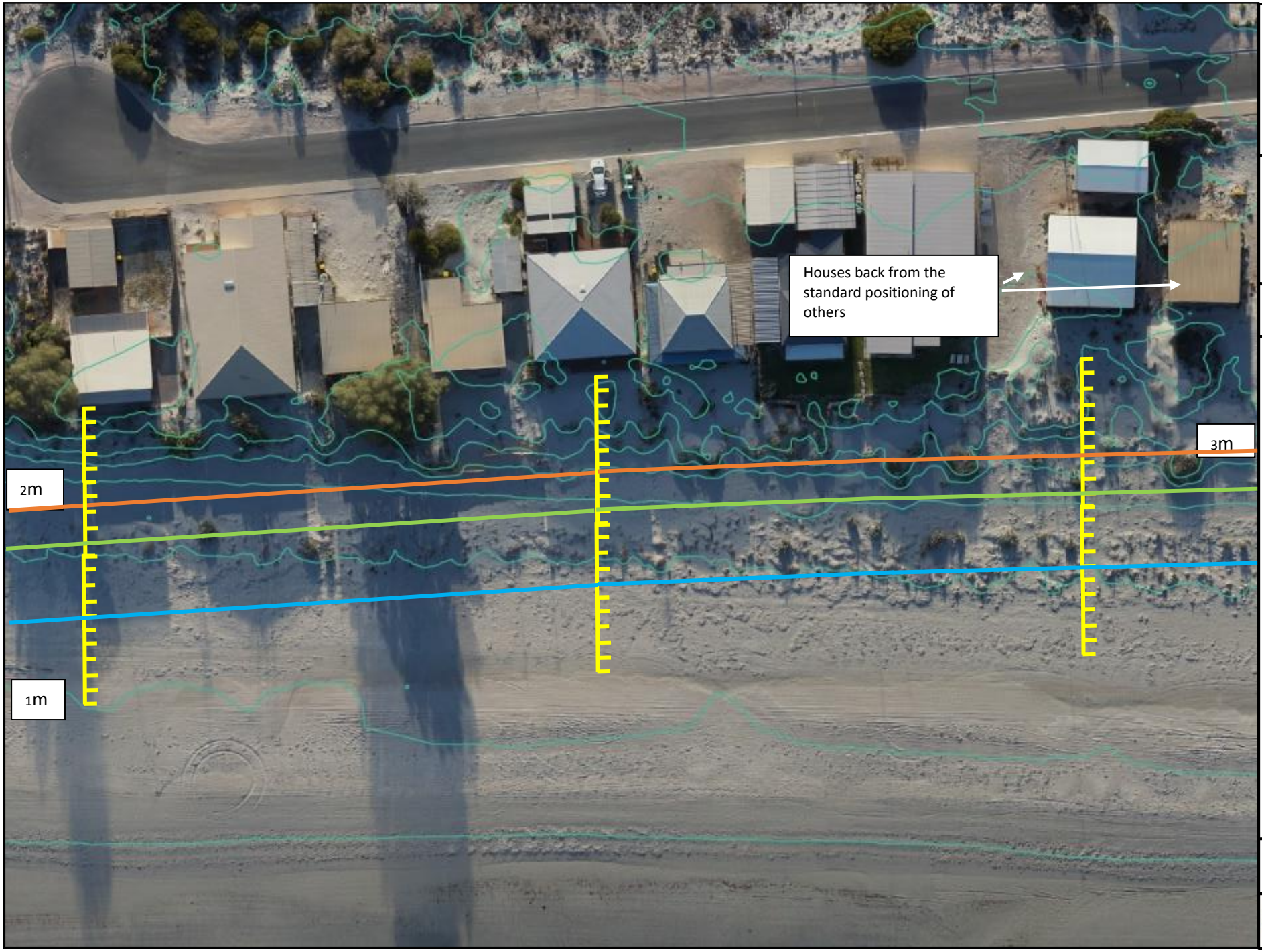
Transect 13 represents the final edge of the Otago road foredune. This section will not require any fencing and could provide sand for use in low areas. The section of beach through Transects 14 and 15 will require significant sand movement to support fencing to build a foredune. Transect 14 will need to be raised by 0.4 m for the hind-dune fence, 1 m for the dune peak fence and 0.2 m for the mid dune fence. Transect 15 will need to be raised by 0.2 m for the hind-dune fence and 0.9 m for the dune peak fence, with enough sand present for the mid dune fence.

Section 6:

The section of beach through Transects 16 to 18 will require significant sand movement to support fencing to build a foredune. Transect 16 will need to be raised by 0.2 m for the dune peak fence but not for the hind-dune fence or mid dune fences. Transect 17 will need to be raised by 0.1 m for the hind-dune fence, 0.9 m for the dune peak fence and 0.2 m for the mid dune fence. Transect 18 will need to be raised by 0.5 m for the dune peak fence with enough sand present for the hind and mid dune fence.

Section 7:

The section of beach through Transects 19 to 21 will require significant sand movement to support fencing to build a foredune. Transect 19 will need to be raised by 1 m for the dune peak fence but not for the hind-dune fence or mid dune fences. Transect 20 will need to be raised by 0.8 m for the dune peak fence and 0.2 m for the mid dune fence but not for the hind-dune fence. Transect 21 will need to be raised by 0.5 m for the dune peak fence with enough sand present to support the hind and mid dune fence.



North Beach Wallaroo

Sand Drift Management Plan

Australian UAV Survey

Captured 17/03/2020

Section 1 Transects 1 – 3

Metric:

Distance from buildings measured in 2m increments:

10m

Dune distance from buildings:

Crest = 13m
Mid-slope = 18m
Toe Dune Peak = 28m

Dune height (AHD):

Dune Peak (3.6m)

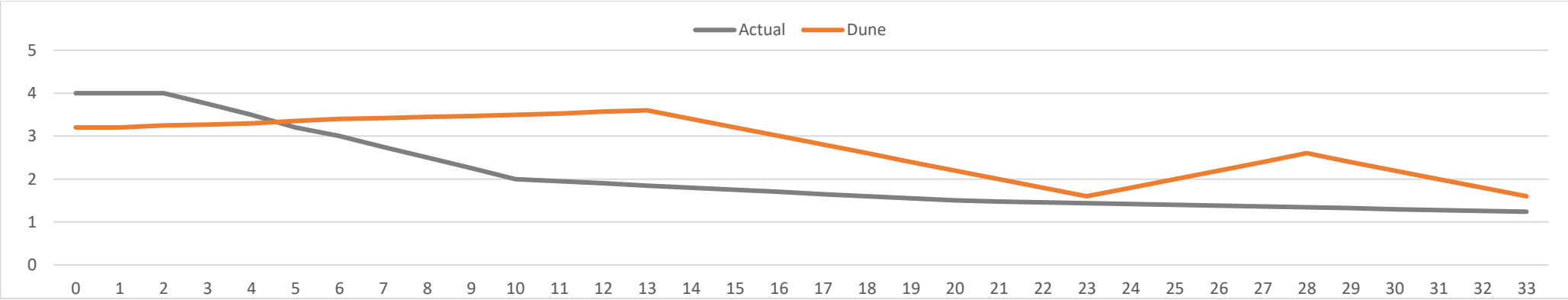
Dune Mid Slope (2.6m)

Toe Dune (2.6m)

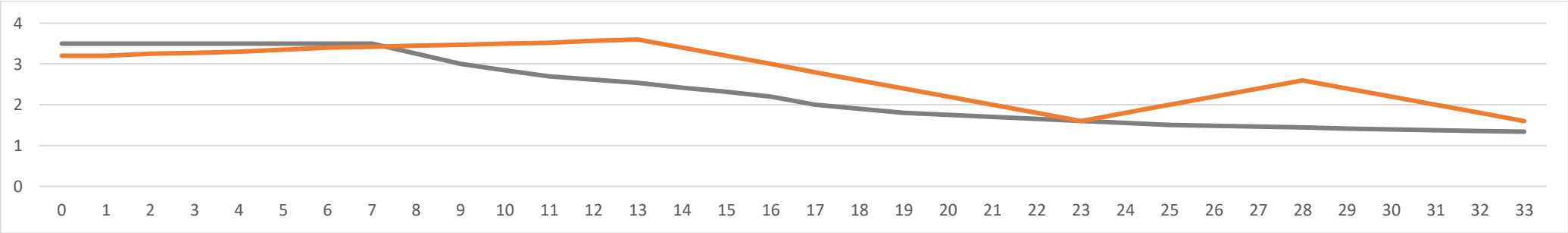
Contours at 50cm

succession ecology

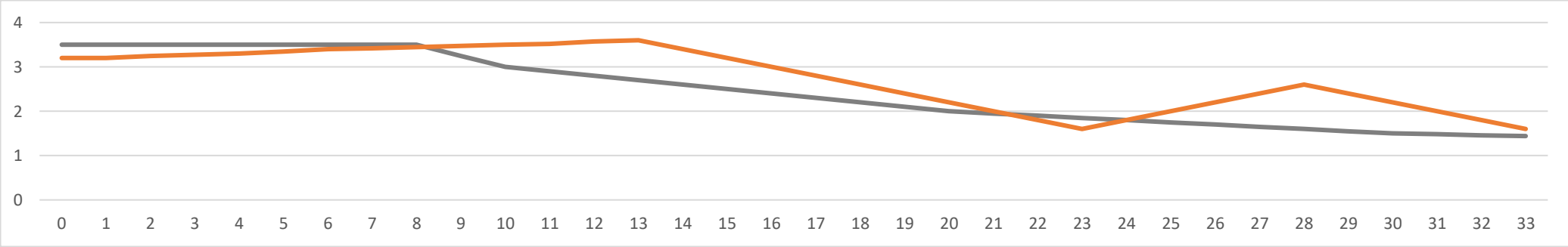
Transect 1



Transect 2



Transect 3



North Beach Wallaroo

Sand Drift Management Plan

Australian UAV Survey

Captured 17/03/2020

Section 2 Transects 4 – 6

Metric:

Distance from buildings measured in 2m increments:

10m

Dune distance from buildings:

Crest = 13m
Mid-slope = 18m
Toe Dune Peak = 28m

Dune height (AHD):

Dune Peak (3.6m)

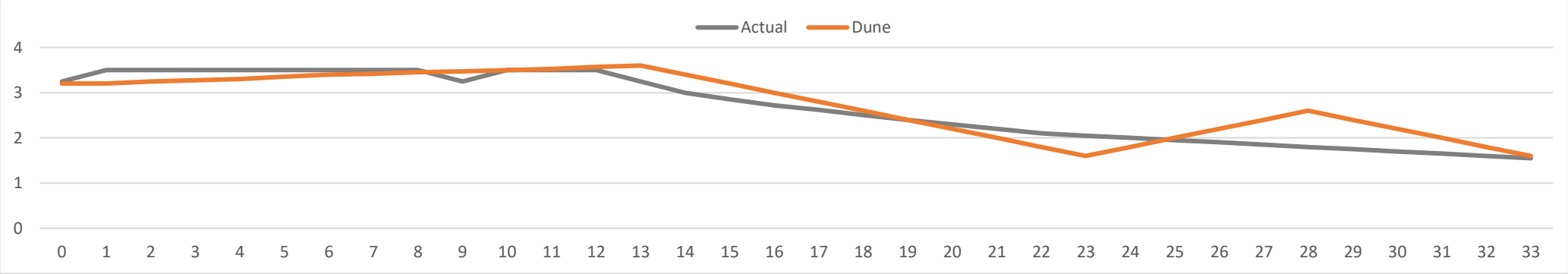
Dune Mid Slope (2.6m)

Toe Dune (2.6m)

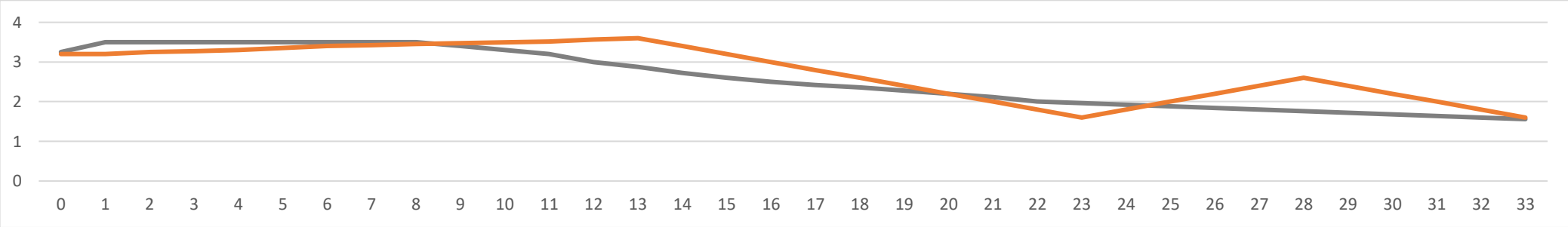
Contours at 50cm

succession ecology

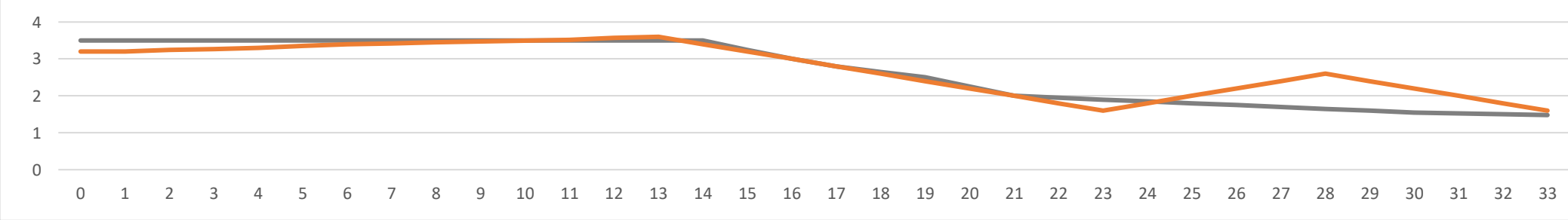
Transect 4



Transect 5



Transect 6



North Beach Wallaroo

Sand Drift Management Plan

Australian UAV Survey

Captured 17/03/2020

Section 3 Transects 7 – 9

Metric:

Distance from buildings measured in 2m increments:

10m

Dune distance from buildings:

Crest = 13m
Mid-slope = 18m
Toe Dune Peak = 28m

Dune height (AHD):

Dune Peak (3.6m)

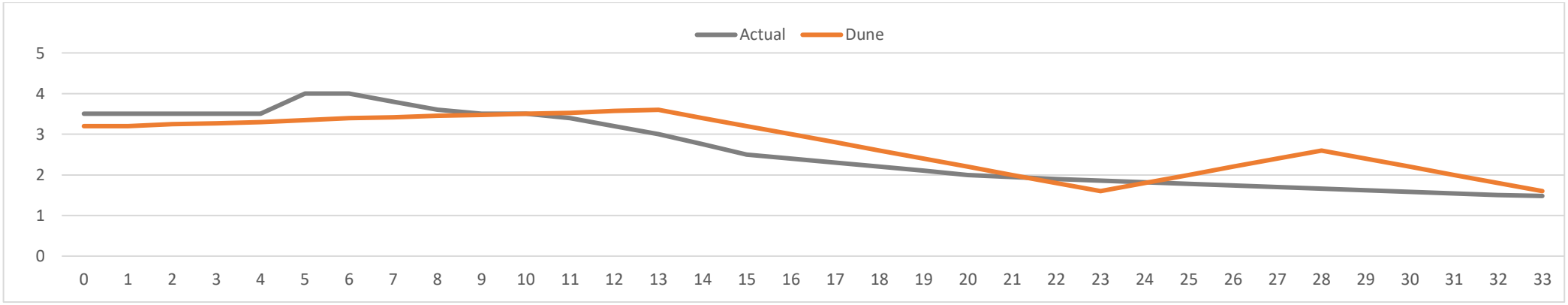
Dune Mid Slope (2.6m)

Toe Dune (2.6m)

Contours at 50cm

succession ecology

Transect 7



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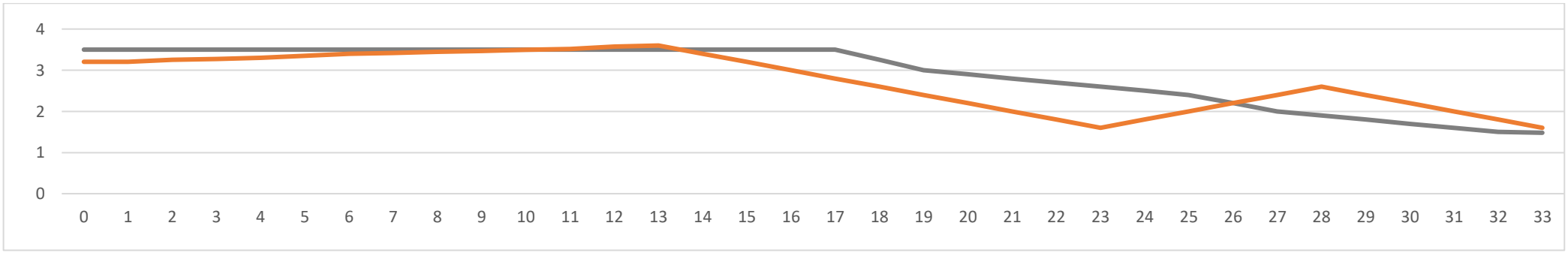
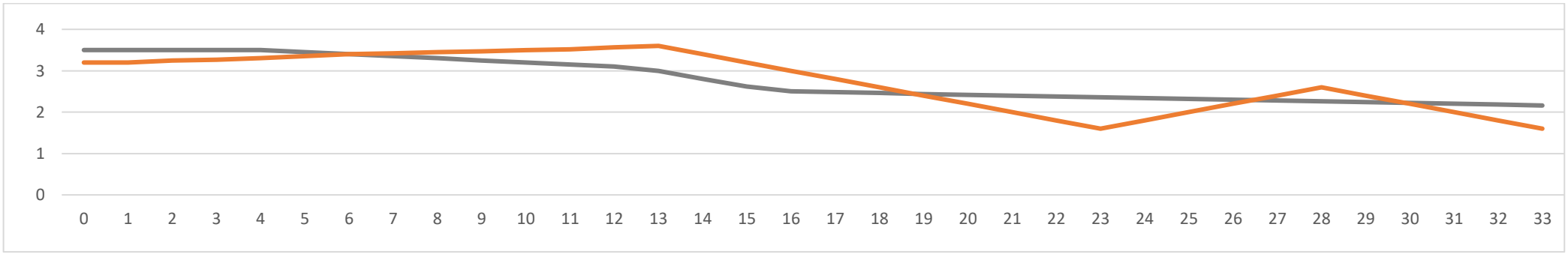


Transect 9



North Beach Wallaroo

Sand Drift Management Plan

Australian UAV Survey

Captured 17/03/2020

Section 4 Transects 10 – 12

Metric:

Distance from buildings measured in 2m increments:

10m

Dune distance from buildings:

Crest = 13m
Mid-slope = 18m
Toe Dune Peak = 28m

Dune height (AHD):

Dune Peak (3.6m)

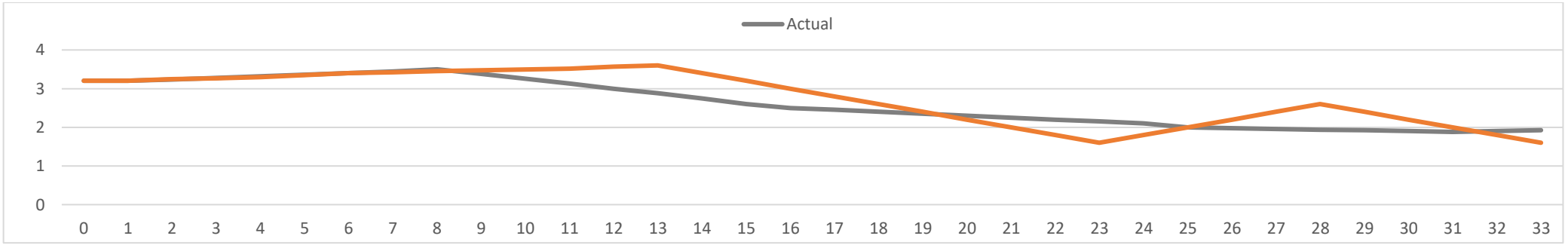
Dune Mid Slope (2.6m)

Toe Dune (2.6m)

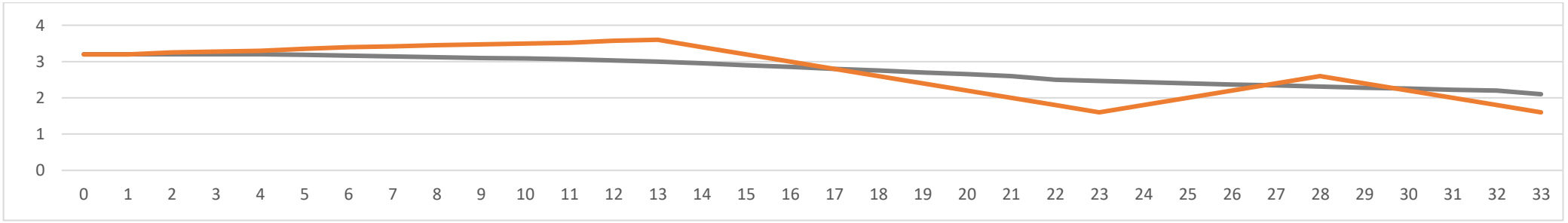
Contours at 50cm

succession ecology

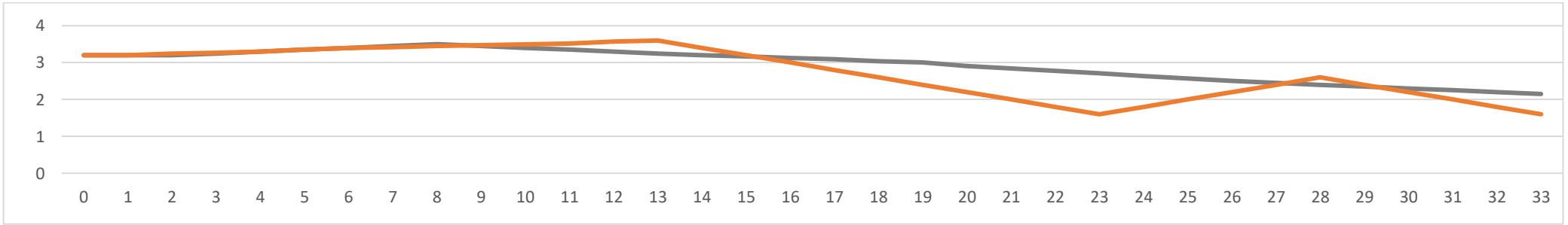
Transect 10

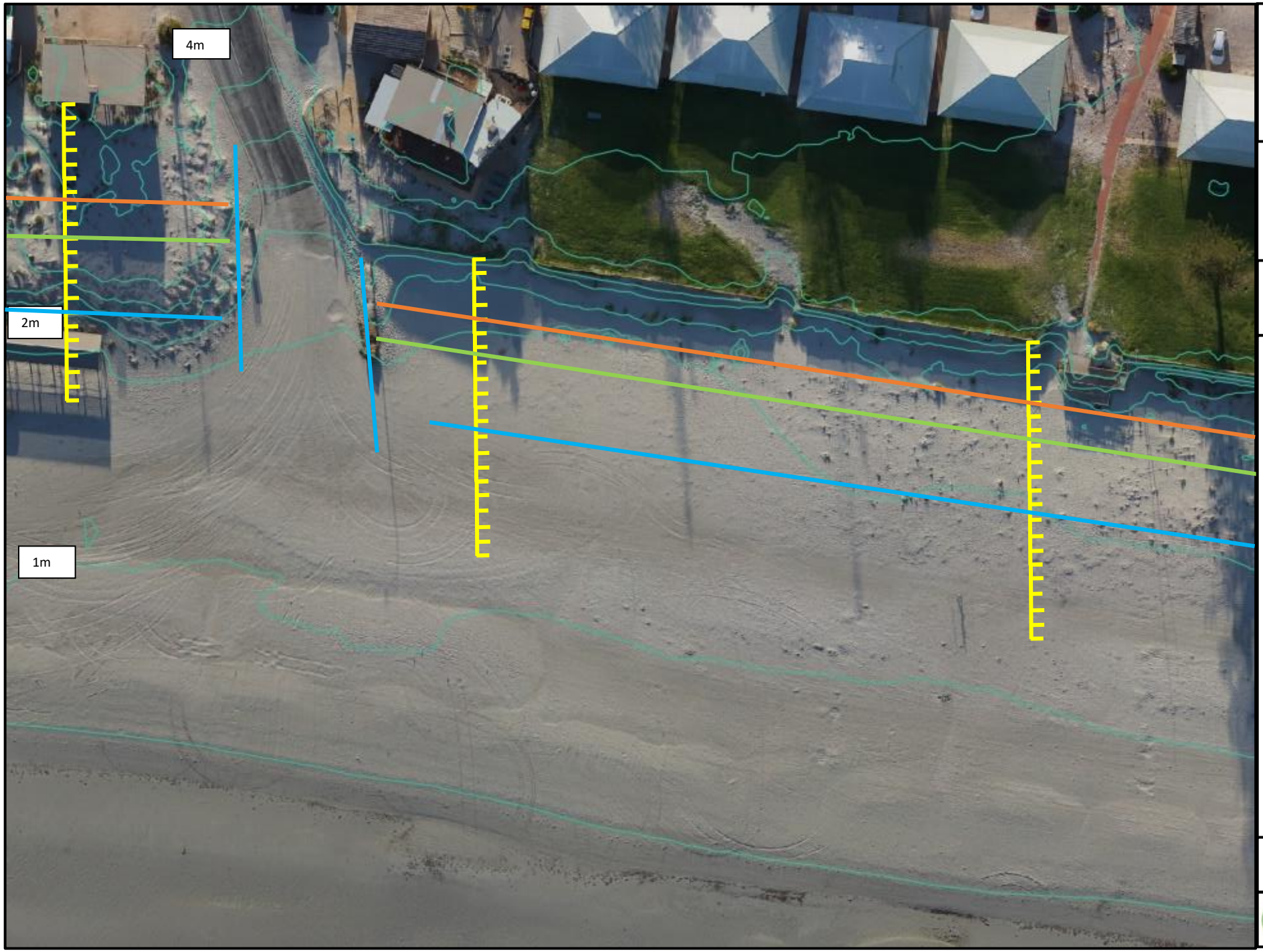


Transect 11



Transect 12





North Beach Wallaroo

Sand Drift Management Plan

Australian UAV Survey

Captured 17/03/2020

Section 5 Transects 13 – 15

Metric:

Distance from buildings measured in 2m increments:

10m

Dune distance from buildings:

Crest = 13m
Mid-slope = 18m
Toe Dune Peak = 28m

Dune height (AHD):

Dune Peak (3.6m)

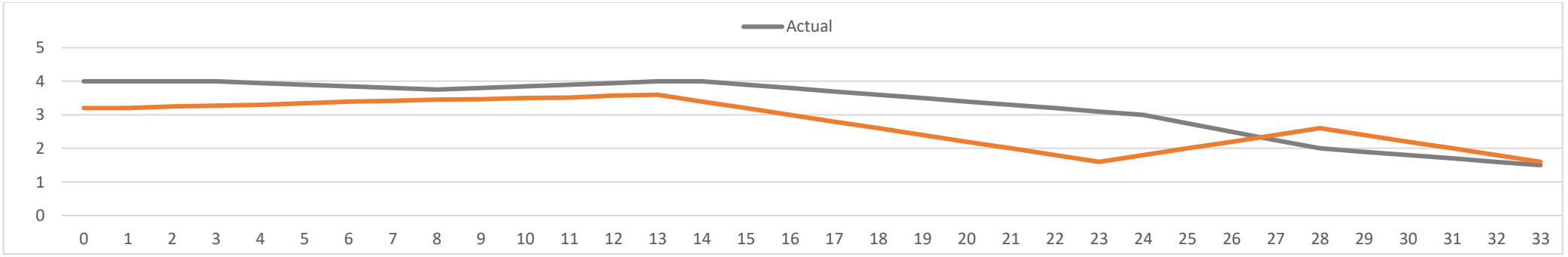
Dune Mid Slope (2.6m)

Toe Dune (2.6m)

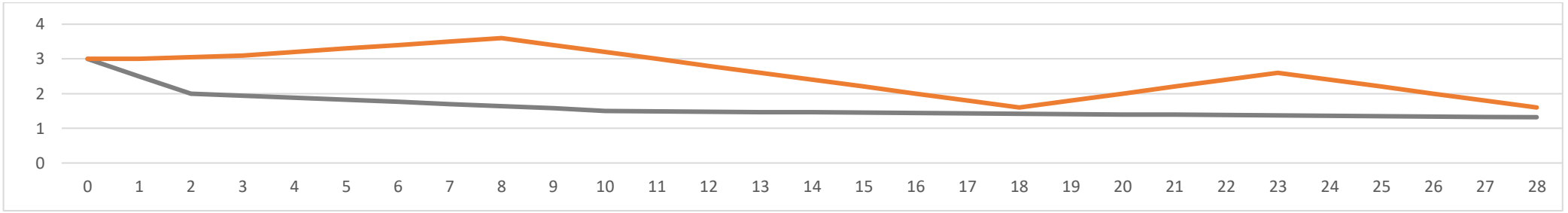
Contours at 50cm

succession ecology

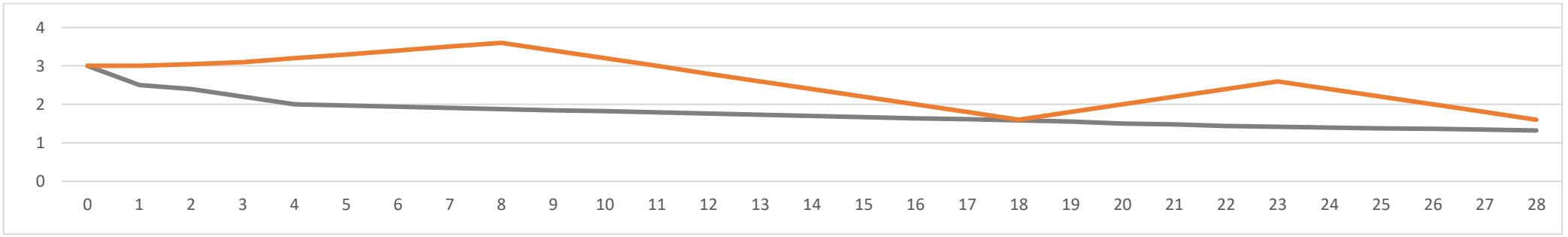
Transect 13

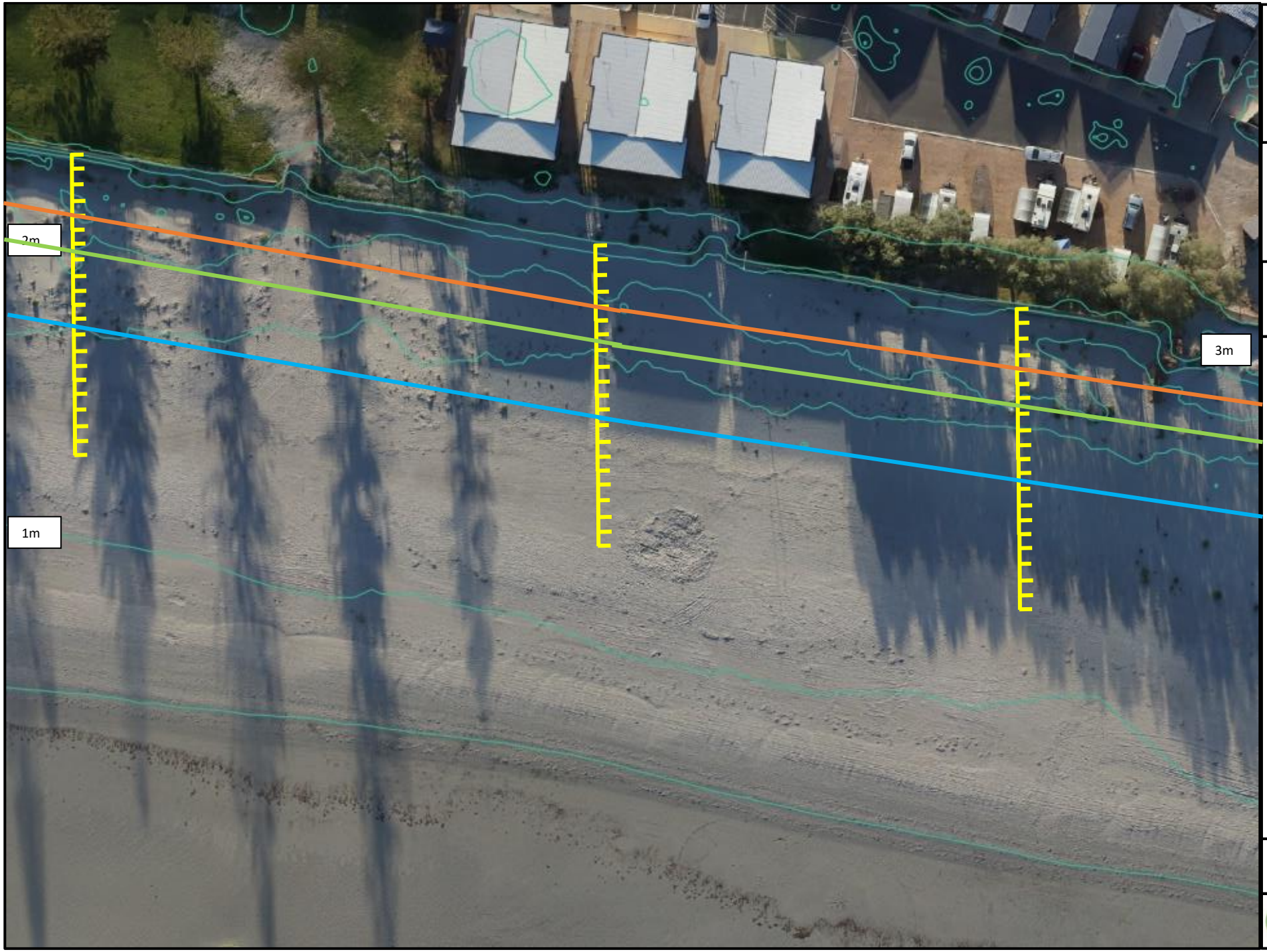


Transect 14



Transect 15





North Beach Wallaroo

Sand Drift Management Plan

Australian UAV Survey

Captured 17/03/2020

Section 6 Transects 16 – 18

Metric:

Distance from buildings measured in 2m increments:

10m

Dune distance from buildings:

Crest = 13m
Mid-slope = 18m
Toe Dune Peak = 28m

Dune height (AHD):

Dune Peak (3.6m)

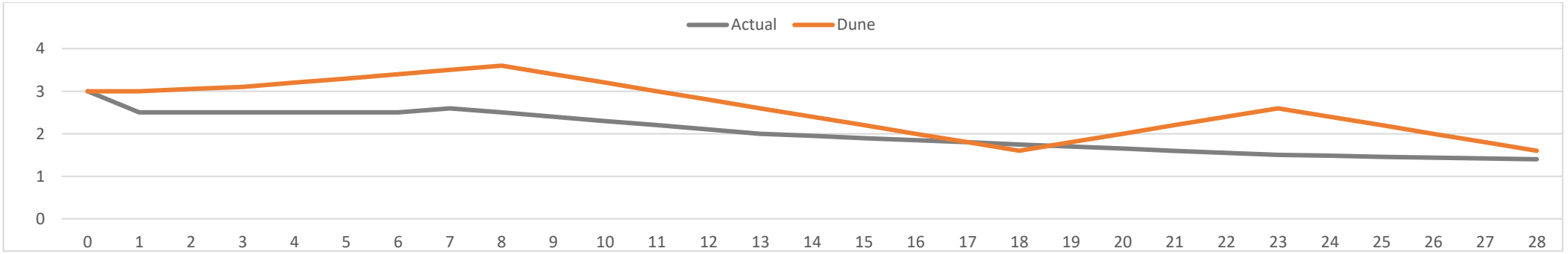
Dune Mid Slope (2.6m)

Toe Dune (2.6m)

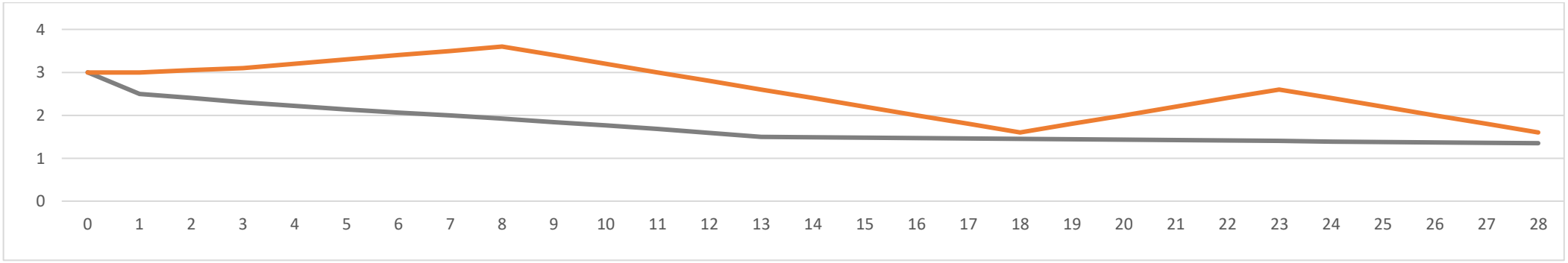
Contours at 50cm

succession ecology

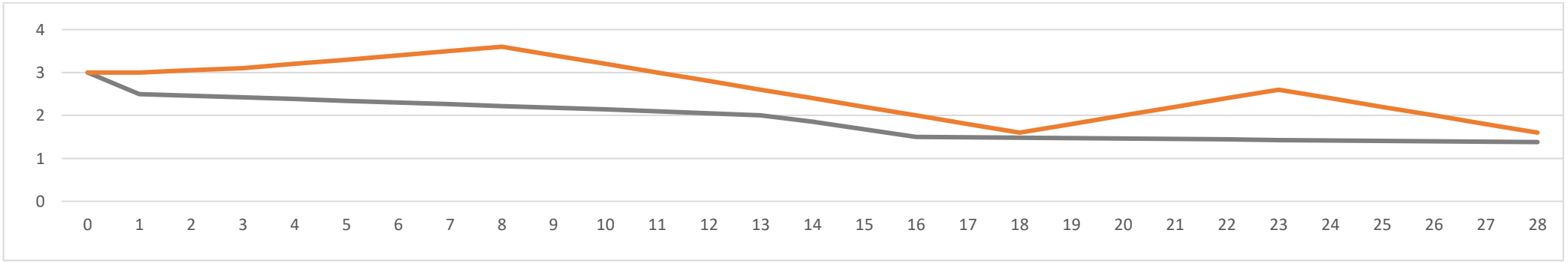
Transect 16



Transect 17



Transect 18



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Section 7 Transects 19 – 21

Metric:
Distance from buildings measured in 2m increments:

10m

Dune distance from buildings:

Crest = 13m
Mid-slope = 18m
Toe Dune Peak = 28m

Dune height (AHD):

Dune Peak (3.6m)

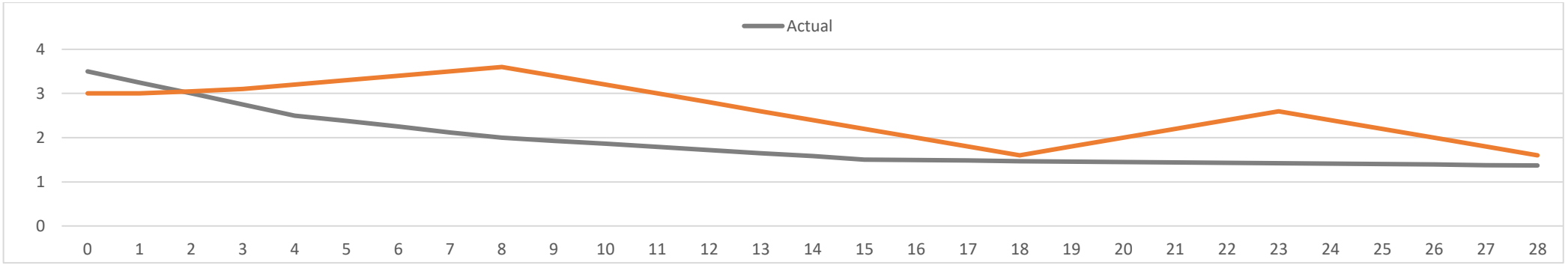
Dune Mid Slope (2.6m)

Toe Dune (2.6m)

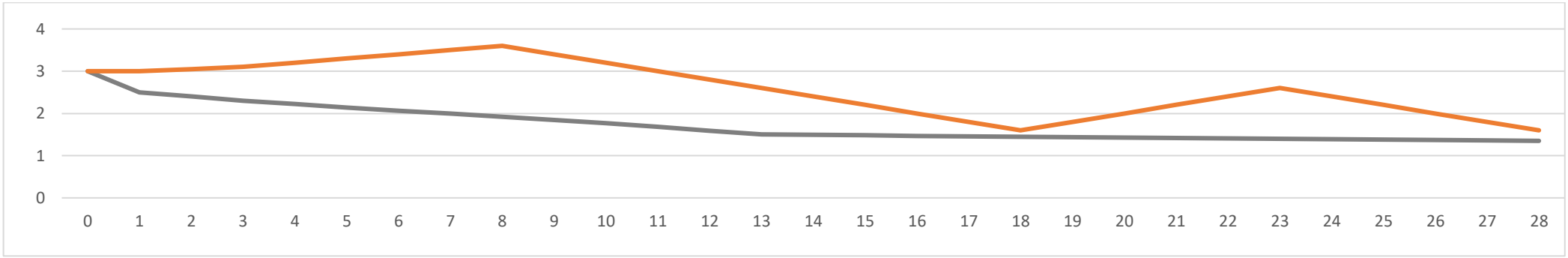
Contours at 50cm

succession ecology

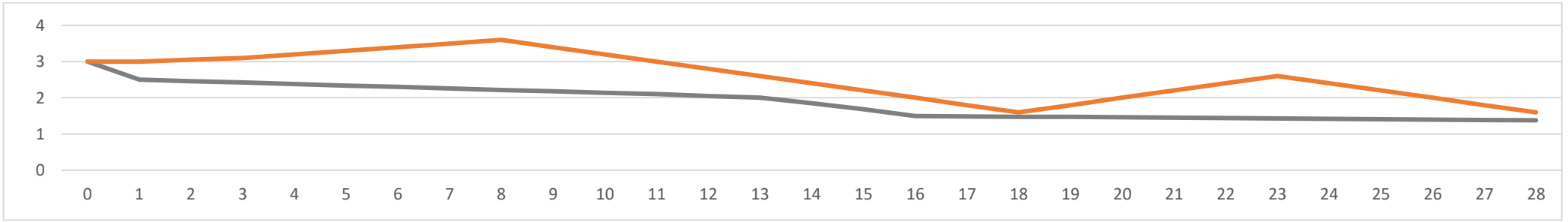
Transect 19



Transect 20

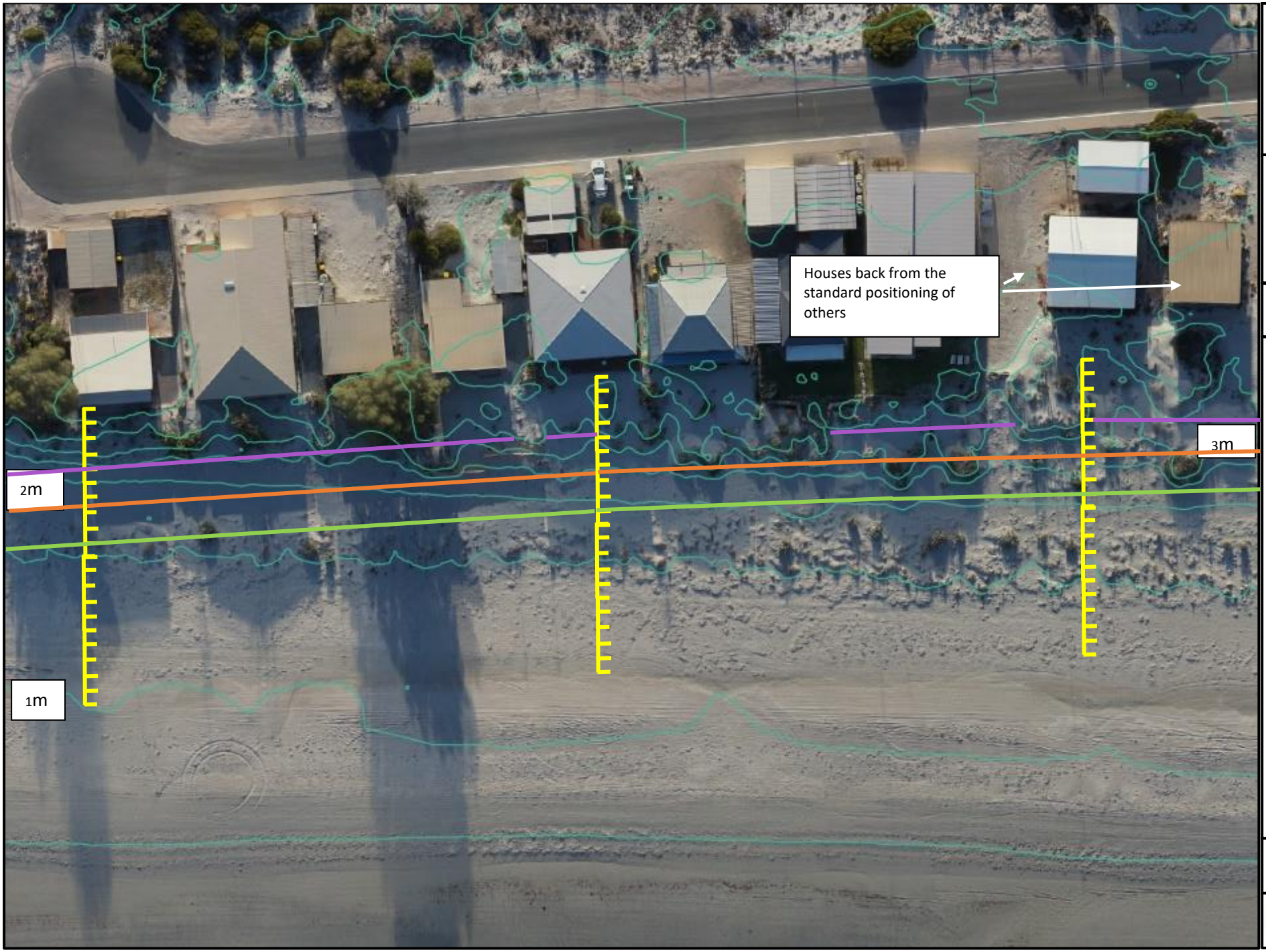


Transect 21



APPENDIX 2 – MAPPING OF FENCING AND FENCE HEIGHTS

Survey data collected by Australian UAV was captured on Tuesday 17th March 2020. These data were used to create a current image of the site and an elevation map. These attributes are presented for seven sections of the beach for the purposes of presenting a workable layout for the proposed dune works (Figure 14). Elevation is mapped at 0.5 m intervals AHD, distance from houses is marked with yellow rulers (2 m interval markers). The fencing required to establish the proposed foredune peak is drawn across the three transects (yellow rulers) on each map. The fencing required is dictated by the height of the existing dune system. The extent and height of the hind slope (purple), peak (orange) and mid-slope (green) fences vary based on the existing beach profile and are presented in the maps below. Approximate measures of their extent and heights are presented in Table 1.



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Captured 17/03/2020

Section 1 Transects 1 – 3

Metric:

Distance from buildings measured in 2m increments:

10m

Dune distance from buildings:

Hind slope = 8m
Peak = 13m
Mid-slope = 18m

Dune height (AHD):

Hind slope (3.4m)

Peak (3.6m)

Mid Slope (2.6m)

Contours at 50cm

succession ecology

North Beach Wallaroo

Sand Drift Management Plan

Australian UAV Survey

Captured 17/03/2020

Section 2 Transects 4 – 6

Metric:

Distance from buildings measured in 2m increments:

10m

Dune distance from buildings:

Hind slope = 8m
Peak = 13m
Mid-slope = 18m

Dune height (AHD):

Hind slope (3.4m)

Peak (3.6m)

Mid Slope (2.6m)

Contours at 50cm

succession ecology

North Beach Wallaroo

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Captured 17/03/2020

Section 3 Transects 7 – 9

Metric:

Distance from buildings measured in 2m increments:

10m

Dune distance from buildings:

Hind slope = 8m
Peak = 13m
Mid-slope = 18m

Dune height (AHD):

Hind slope (3.4m)

Peak (3.6m)

Mid Slope (2.6m)

Contours at 50cm

succession ecology

North Beach Wallaroo

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Australian UAV Survey

Captured 17/03/2020

Section 4 Transects 10 – 12

Metric:

Distance from buildings measured in 2m increments:

10m

Dune distance from buildings:

Hind slope = 8m
Peak = 13m
Mid-slope = 18m

Dune height (AHD):

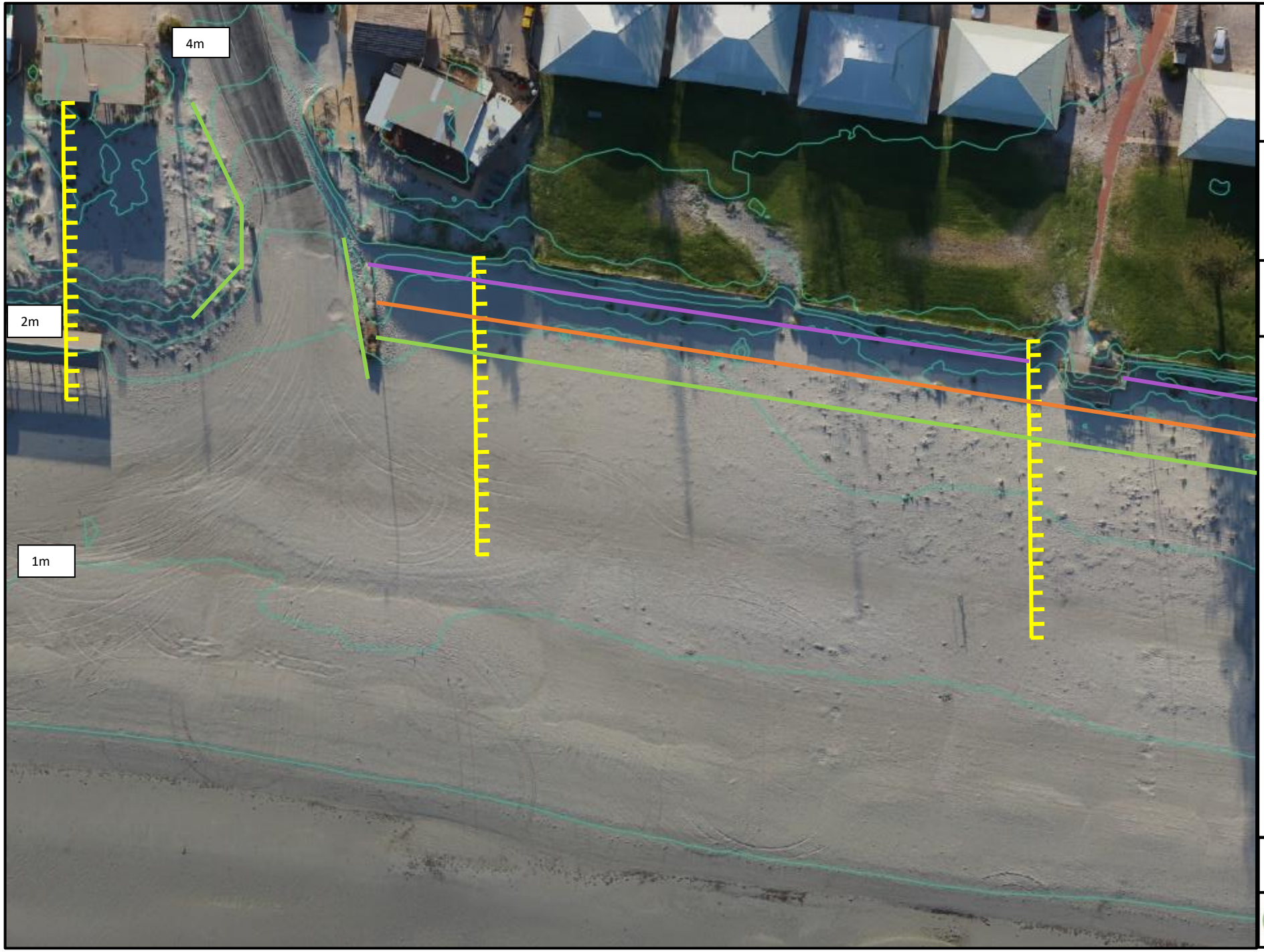
Hind slope (3.4m)

Peak (3.6m)

Mid Slope (2.6m)

Contours at 50cm

succession ecology



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Section 5 Transects 13 – 15

Metric:

Distance from buildings measured in 2m increments:

10m

Dune distance from buildings:

Hind slope = 8m
Peak = 13m
Mid-slope = 18m

Dune height (AHD):

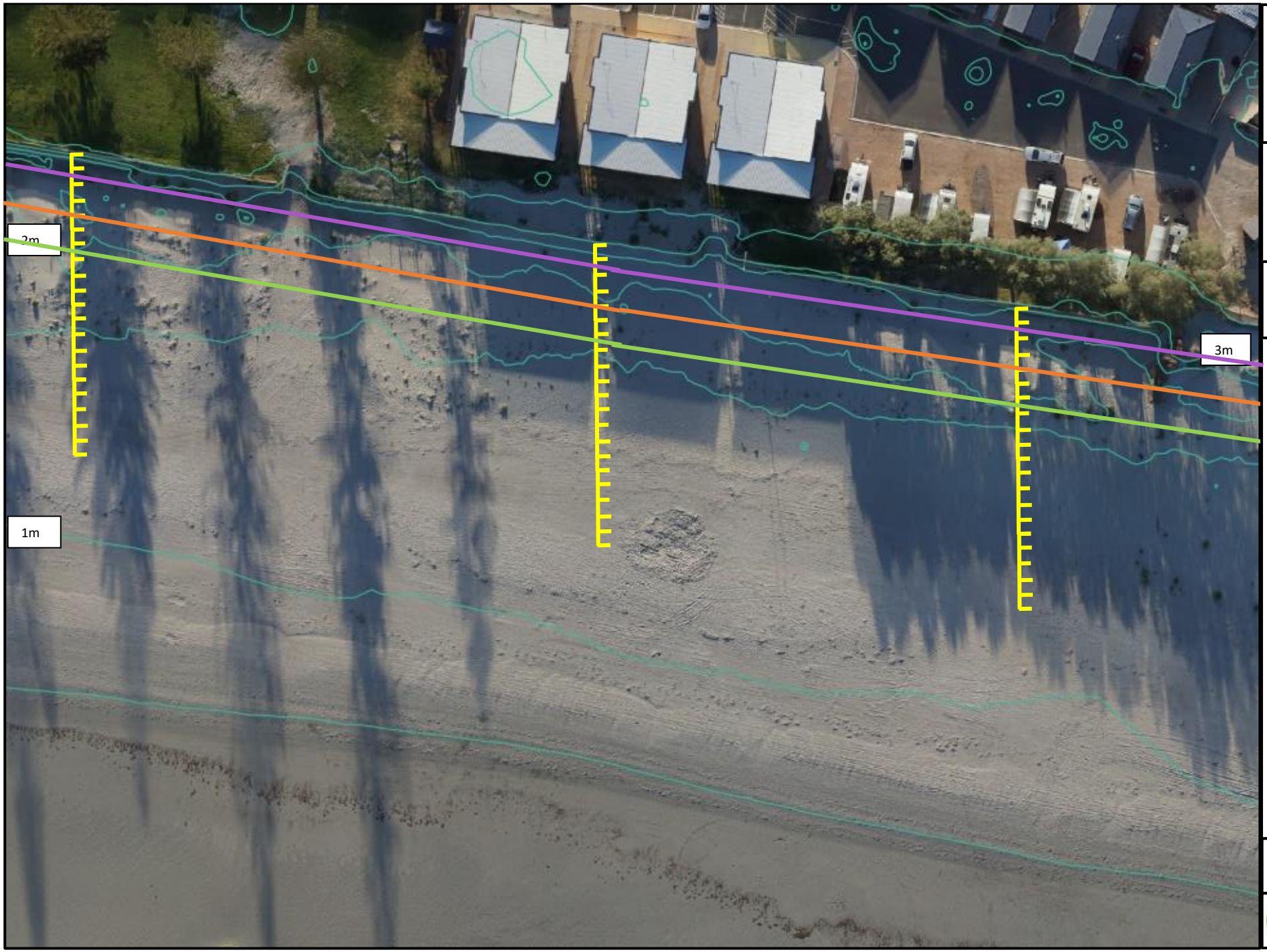
Hind slope (3.4m)

Peak (3.6m)

Mid Slope (2.6m)

Contours at 50cm

succession ecology



North Beach Wallaroo

Sand Drift Management Plan

Australian UAV Survey

Captured 17/03/2020

Section 6 Transects 16 – 18

Metric:

Distance from buildings measured in 2m increments:

10m

Dune distance from buildings:

Hind slope = 8m
Peak = 13m
Mid-slope = 18m

Dune height (AHD):

Hind slope (3.4m)

Peak (3.6m)

Mid Slope (2.6m)

Contours at 50cm

succession ecology

North Beach Wallaroo

Sand Drift Management Plan

Australian UAV Survey

Captured 17/03/2020

Section 7 Transects 19 – 21

Metric:

Distance from buildings measured in 2m increments:

10m

Dune distance from buildings:

Hind slope = 8m
Peak = 13m
Mid-slope = 18m

Dune height (AHD):

Hind slope (3.4m)

Peak (3.6m)

Mid Slope (2.6m)

Contours at 50cm

succession ecology

APPENDIX 3 – RISK ASSESSMENT

Table 6: Risks associated with dune development, revegetation, and dust management of the North Beach at Wallaroo.

Risk	Description	How or when	Outcome	Likelihood	Consequence	Threat Level
Extreme weather events	Extremely strong winds	Conditions are unpredictable and can occur at any time following establishment of dune fencing and planting	• Transient dune development • Damage to residential properties • Desiccation of plants • Negative publicity	Almost Certain	Moderate	4
	High tides/rough seas/ large waves		• Erosion of dune • Destruction of dune fencing • Washing away plants	Possible	Catastrophic	4
	Hailstorms		• Physical damage to plants	Possible	Minor	2
	Prolonged drought		• Dry sand will increase wind erosion risk • Poor survival of plants	Likely	Moderate	3
Unreliable timing of rainfall events	Late or no rain in winter/spring	Rainfall timing is hard to predict in semi-arid regions	• Plants are slow to establish • Increased risk of wind erosion with dry soil	Possible	Moderate	3
	No rain over summer		• Plants struggle to survive	Likely	Moderate	3
Sand Drift	Unwanted movement of sand	Wind blown sand may build in areas that it is not wanted driven by wind and dry conditions	• Transient dune development • Damage to residential properties • Desiccation of plants • Negative publicity	Almost Certain	Moderate	4
Weed infestation	Growth of Weeds of National Significance	Weed species are present in the existing dune system	• Weeds will establish quickly and provide competition for native plants	Possible	Moderate	3

Risk	Description	How or when	Outcome	Likelihood	Consequence	Threat Level
	(WONS) and or regionally significant weeds (*NRM Act 2004*)	and could spread across the dune	• The landowner is obliged to actively manage any declared weeds (*Natural Resources Management Act 2004*)			
	Growth of other weed species		• Weeds will establish quickly and provide competition for native plants	Likely	Minor	2
Public Access	Vandalism of fencing and signage	Access to the site is possible and could occur at any stage during the project	• Fencing and signs will need to be replaced • Increased costs could run above the contingencies allowed for	Possible	Severe	3
	Vehicle access		• Damage to the dune structure • Increased erosion • Loss of plants	Possible	Severe	3
	Foot traffic over the establishing dune		• Damage to the dune structure • Increased erosion • Loss of plants	Likely	Moderate	3
	Pathways are currently set at every 4 houses	Could lead to erosion issues	• Wind erosion • Increased transient dune movement	Possible	Moderate	3
Negative Publicity	Failure of various project activities	If project targets can not be met due to natural or other impediments	• Reduced faith in project outcomes • Loss of public trust	Possible	Moderate	3
Funding	Loss of funding to achieve outcomes	Possible if grant funding is limited and public interest reduces	• Reduced monitoring and maintenance activities could impede outcomes	Unlikely	Moderate	2

Assessment Metric

The threat level matrix (Table 7) provides the level of identified risks, where both consequence and likelihood of risks are categorised. Definitions of the likelihood and consequence scales are available in Tables 8 and 9, respectively.

Table 7: Threat level risk matrix for the dune development, revegetation, and dust management of the North Beach at Wallaroo.

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Severe	Catastrophic
Almost Certain	2	3	4	4	4
Likely	2	2	3	4	4
Possible	1	2	3	3	4
Unlikely	1	1	2	3	3
Rare	1	1	1	2	3

Table 8: The Likelihood Scale for the dune development, revegetation, and dust management of the North Beach at Wallaroo.

	Description	Probability Range	Typical Outcome
Almost Certain	Event is almost certain to occur	91–100%	Expect once in the next year
Likely	Event will probably occur	71–90%	Possibly once in next year
Possible	Event could occur	41–70%	Possibly once in next 2–3 years
Unlikely	In certain circumstances, may occur	11–40%	Possibly once in next 3–5 years
Rare	Extremely low probability of occurring, only likely in exceptional circumstances	0–10%	Unlikely over next 5 or more years

Table 9: The Consequence Scale for the dune development, revegetation, and dust management of the North Beach at Wallaroo.

Level	Environment & Community	Project Targets	Reputation
Catastrophic	Significant environmental exposure with sustained active management response and prolonged external assistance	Project targets threatened indefinitely	Extensive negative local and state media coverage State political commentary
Major	Severe environmental exposure with ongoing active management and temporary external assistance	Project targets threatened for a substantial period	Extended negative local media coverage Local political comment
Moderate	Environmental exposure contained with active management over a substantial period	Some threat to project targets Project is exposed to added cost and maintenance activities	Series of articles in local press
Minor	Environmental exposure contained with temporary active management actions	Some threat to project targets Issues managed by project team	Letters to local press Community comment
Insignificant	Environmental exposure contained immediately	No significant impact on project targets Issues managed by a project team member	Direct or indirect complaints from locals