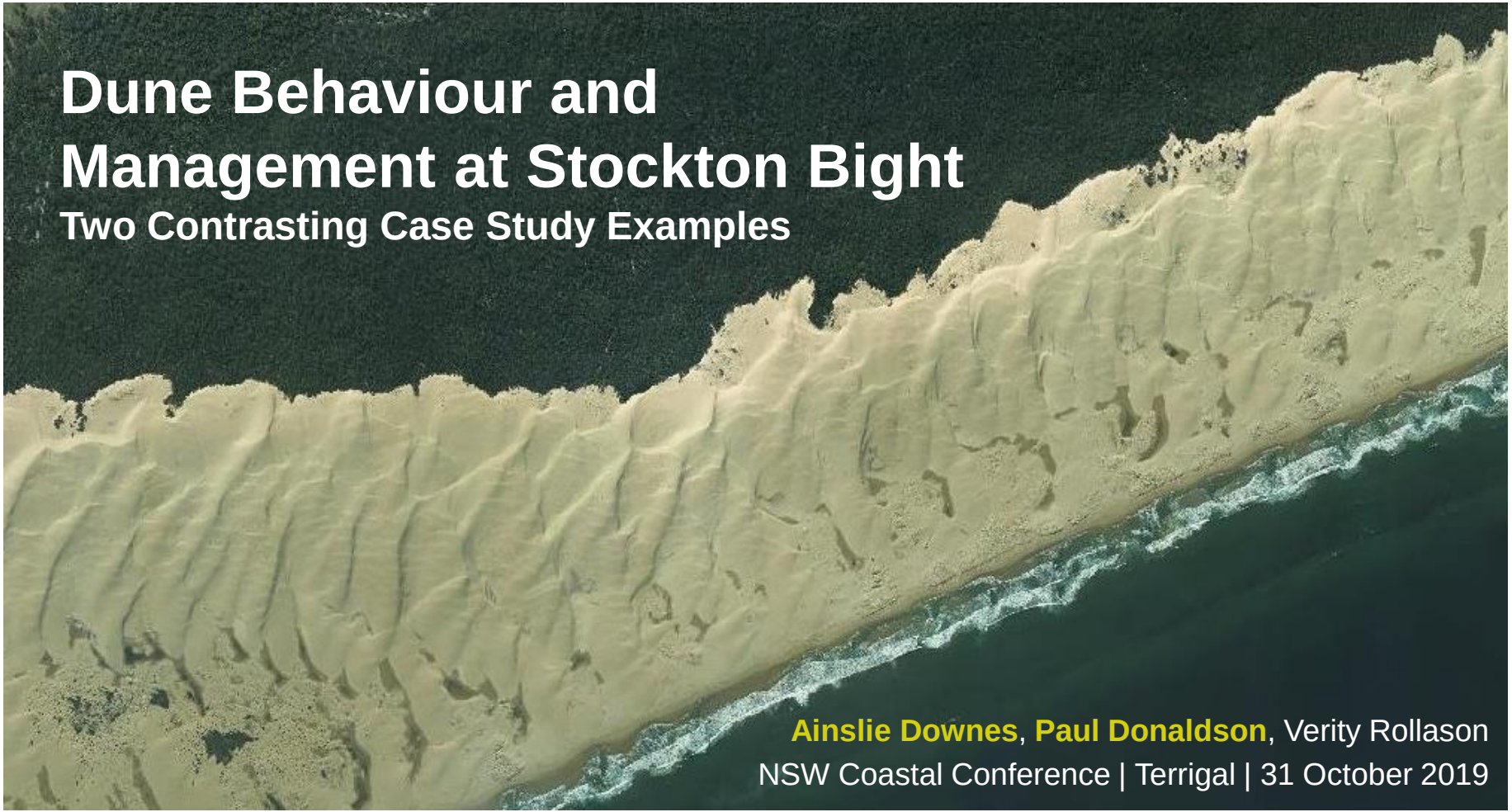


Dune Behaviour and Management at Stockton Bight

Two Contrasting Case Study Examples

Ainslie Downes, **Paul Donaldson**, Verity Rollason

NSW Coastal Conference | Terrigal | 31 October 2019

Outline and Aims

Background to Study

- Technical studies for Newcastle coastline / Stockton Bight dune systems
- Dune management plans prepared for two sites
    - Fort Wallace Site
    - Fern Bay Site

Presentation Outline

- Intro / overview
- Processes, risk, management
- Outcomes, challenges, summary

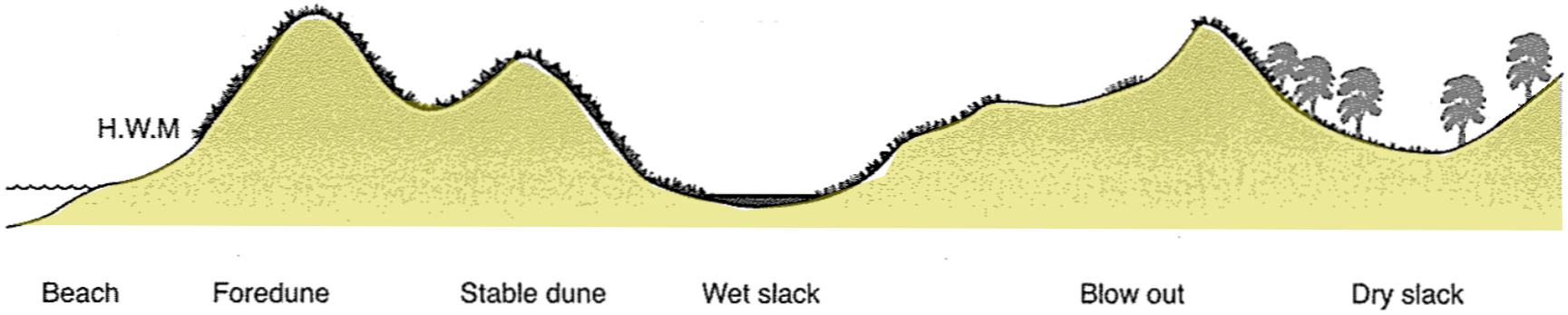
What Are Coastal Sand Dunes?

Accumulations of wind-blow sands, usually associated with beaches and estuaries

- **Dune formation:** Wind conditions (velocity, direction), sediment supply, vegetation and moisture content are important factors

Dune Morphology

- **Primary dunes**: near to the shore; incl. incipient dune & foredunes
- **Secondary dunes**: backshore; incl. foredune ridges, blowouts, transgressive dunes



Schematic Section - Coastal Dunes
Source: Masselink et al. (2003)

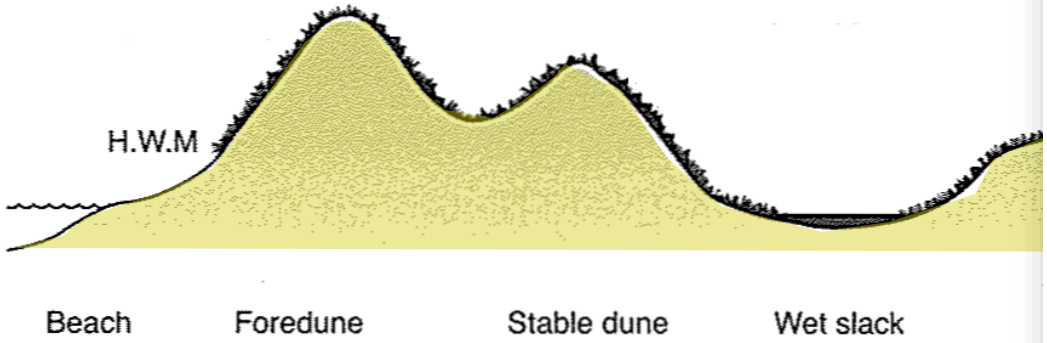
What Are Coastal Sand Dunes?

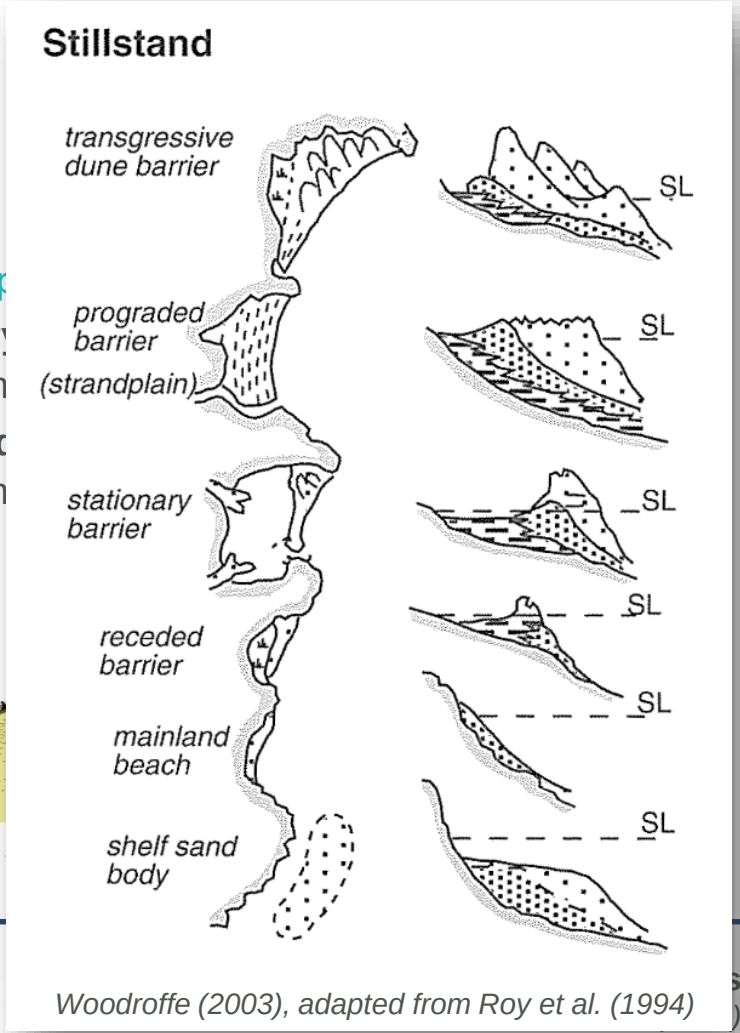
Accumulations of wind-blow sands, usually associated with beaches and estuaries

- **Dune formation:** Wind conditions (velocity, direction), sediment supply, vegetation and moisture content are important factors

Dune Morp

- **Primary** incipien
- **Second** foredun dunes





Woodroffe (2003), adapted from Roy et al. (1994)

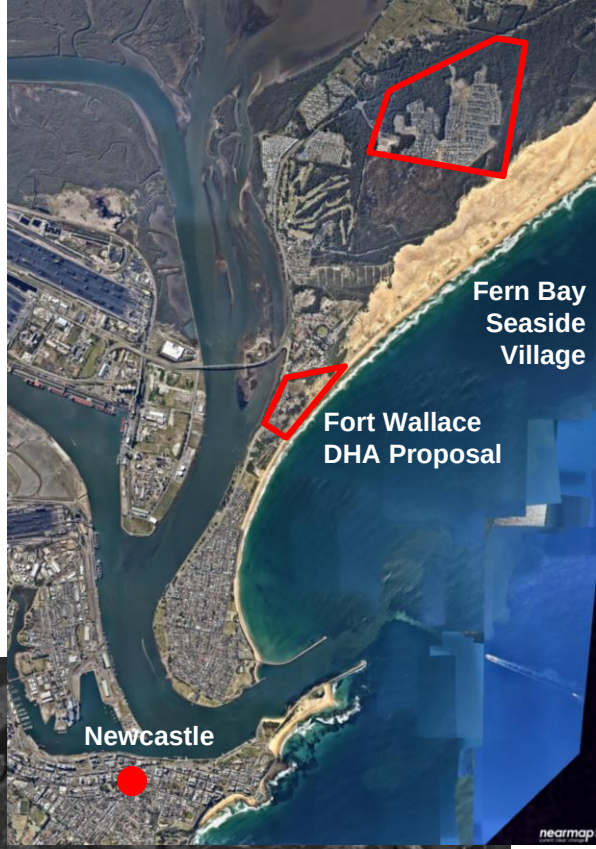
Stockton Bight and Study Sites

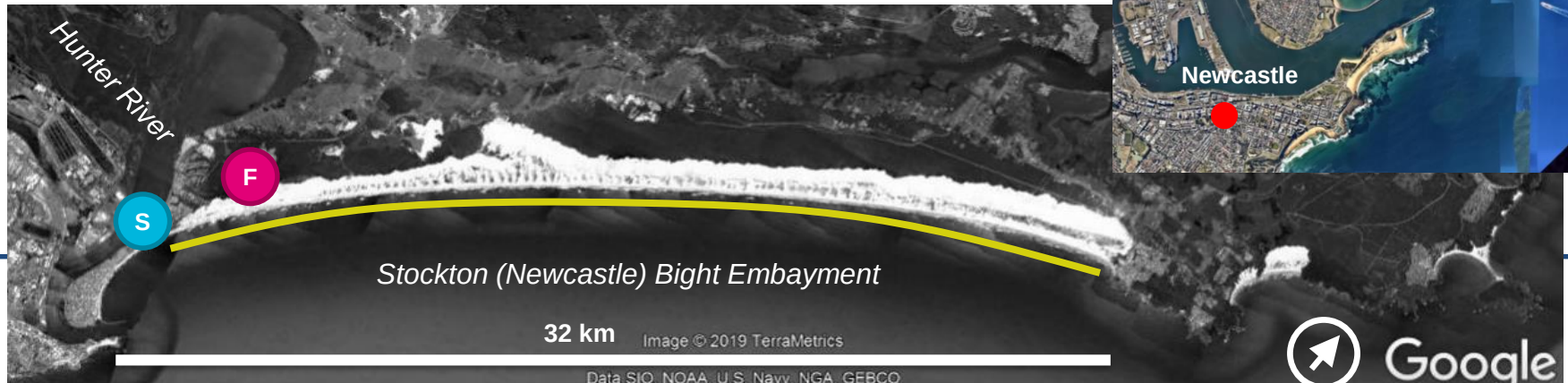
Stockton (Newcastle) Bight

- Transgressive sand dune barrier system, young in geological terms (Holocene)
- Largest active dune system in Sth. Hemi.
- Complex and variable wind regime
- Dominant SE wind climate: NNE-NE greatest transport potential (Nicolas, 2016)

Study Sites

- **Fort Wallace,** *Stockton* ***(S)***
- **Seaside Village**, *Fern Bay* ***(F)***





Fort Wallace - Dunes and Hazards

Beach and Dunes (Local)

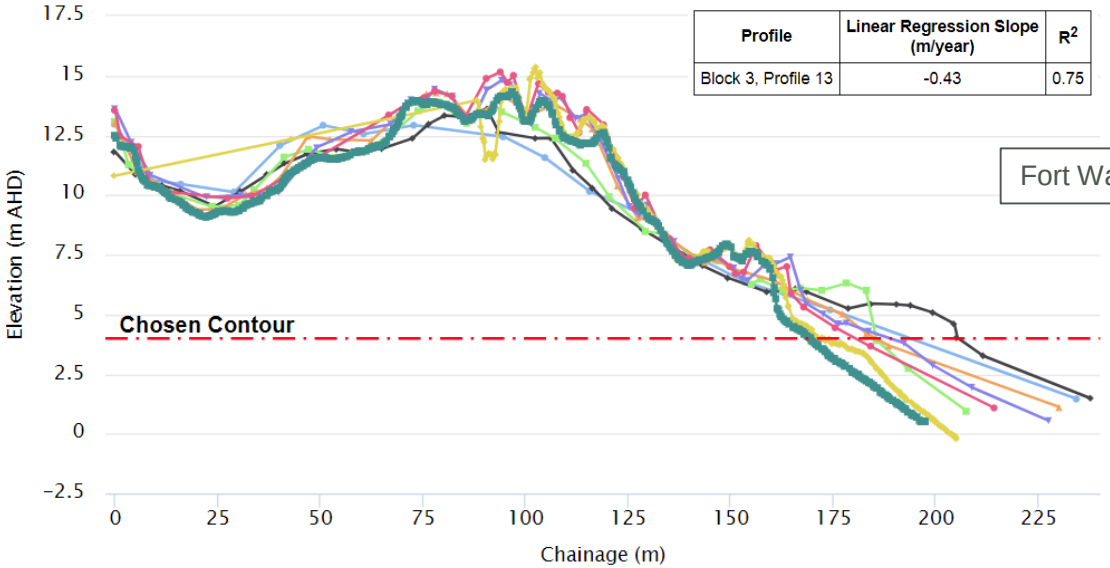
- **High energy (exposed) sandy beach**
- Site on S **margin of transgressive dune** system (~150m wide; ~15m tall)
- Disturbed, patchy vegetation (w. weeds)

Coastal Processes & Hazards (Regional)

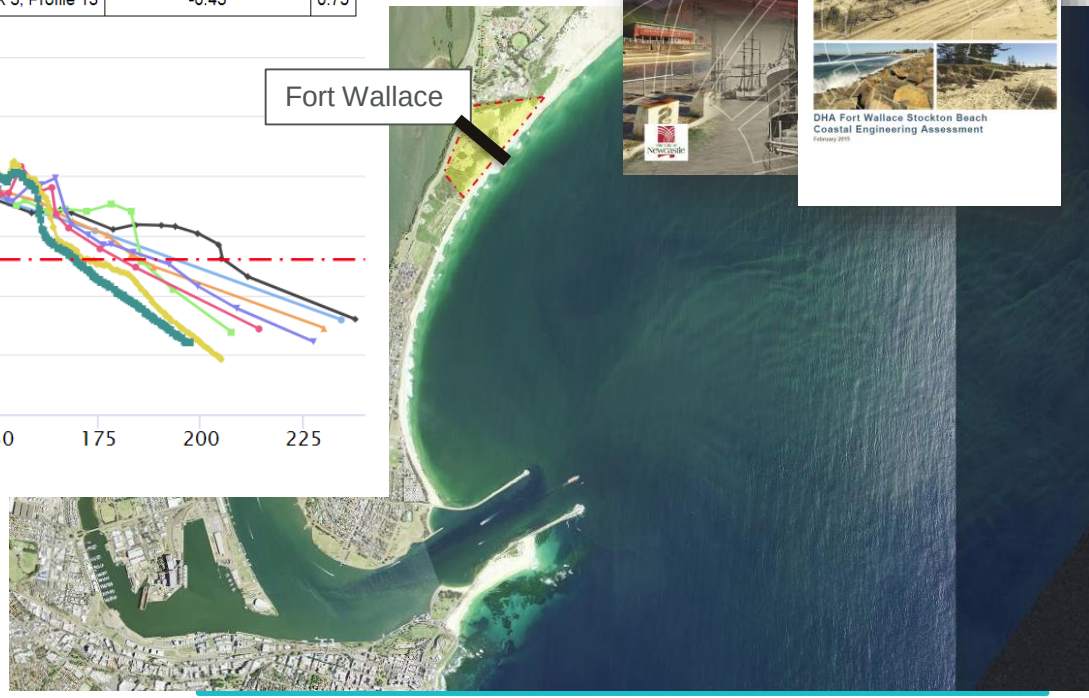
- **Harbour breakwaters**: Interrupt N littoral drift, wave shadowing S corner
- **Major hazards:** historical recession (sediment deficit), beach erosion (now), SLR recession (future)
- **Minor hazards:** dune instability, sand drift (all timeframes)

Fort Wallace Site, Stockton
Source: Six Maps

Cross Section Plots



Profile	Linear Regression Slope (m/year)	R^2
Block 3, Profile 13	-0.43	0.75



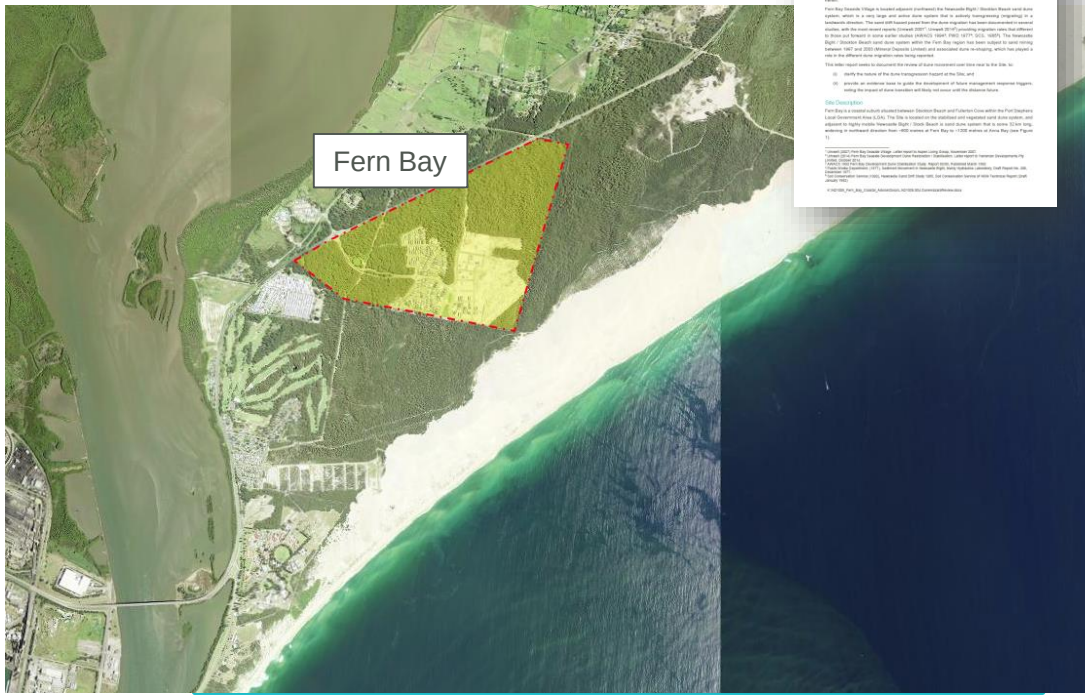
- **Major hazards:** historical recession (sediment deficit), beach erosion (now), SLR recession (future)
- **Minor hazards:** dune instability, sand drift (all timeframes)

Fort Wallace Site, Stockton
Source: Six Maps

Fern Bay - Dunes and Dune Processes

Dune System

- **Highly active transgressive dunes** (~600m wide, 20m tall), dune slip face migrating inland across stabilised vegetated dunes
- **Shoreline building seawards** (N littoral sediment supply)
- **Dune slip face moving landwards** (NNE – NE direction)
- **Deflation basin growing**
- Also, **sand mining impacts** (late ‘90s to early ‘00s) around Fern Bay region



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Source: XXX

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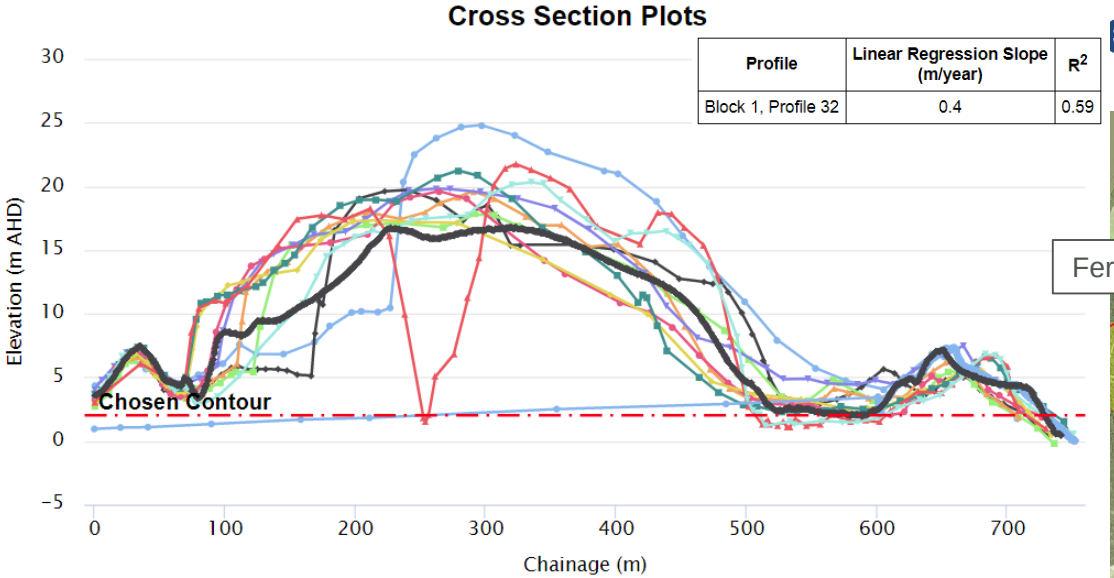
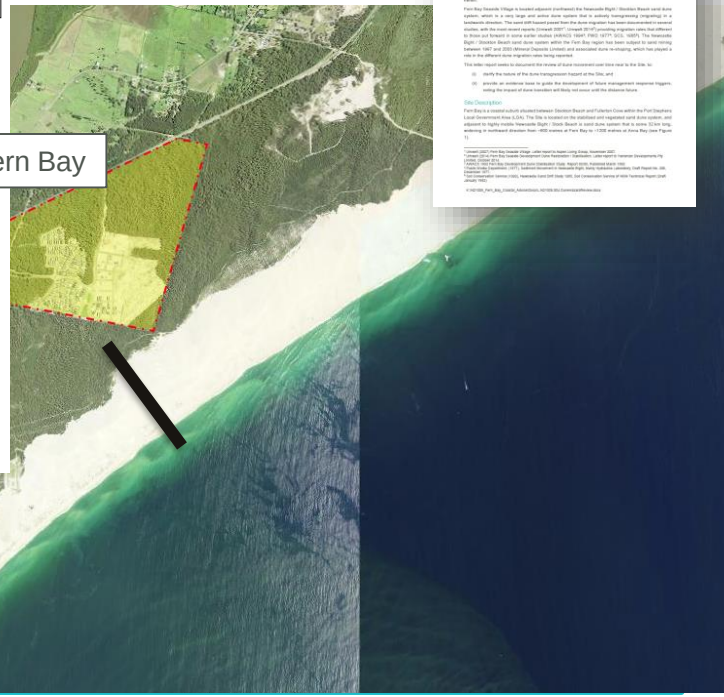


Profile	Linear Regression Slope (m/year)	R^2
Block 1, Profile 32	0.4	0.59



(NNE – NE direction)

- **Deflation basin growing**
- Also, **sand mining impacts** (late ‘90s to early ‘00s) around Fern Bay region

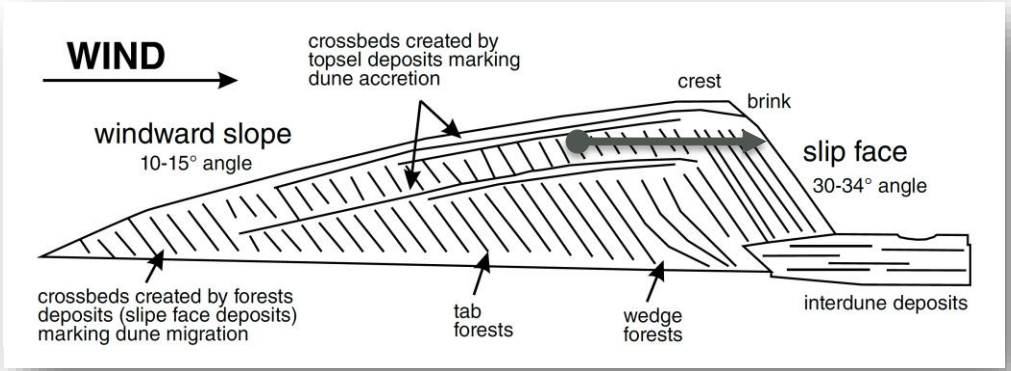
Dunes Transgression / Sand Drift Hazards at Fern Bay

Hazard Classification

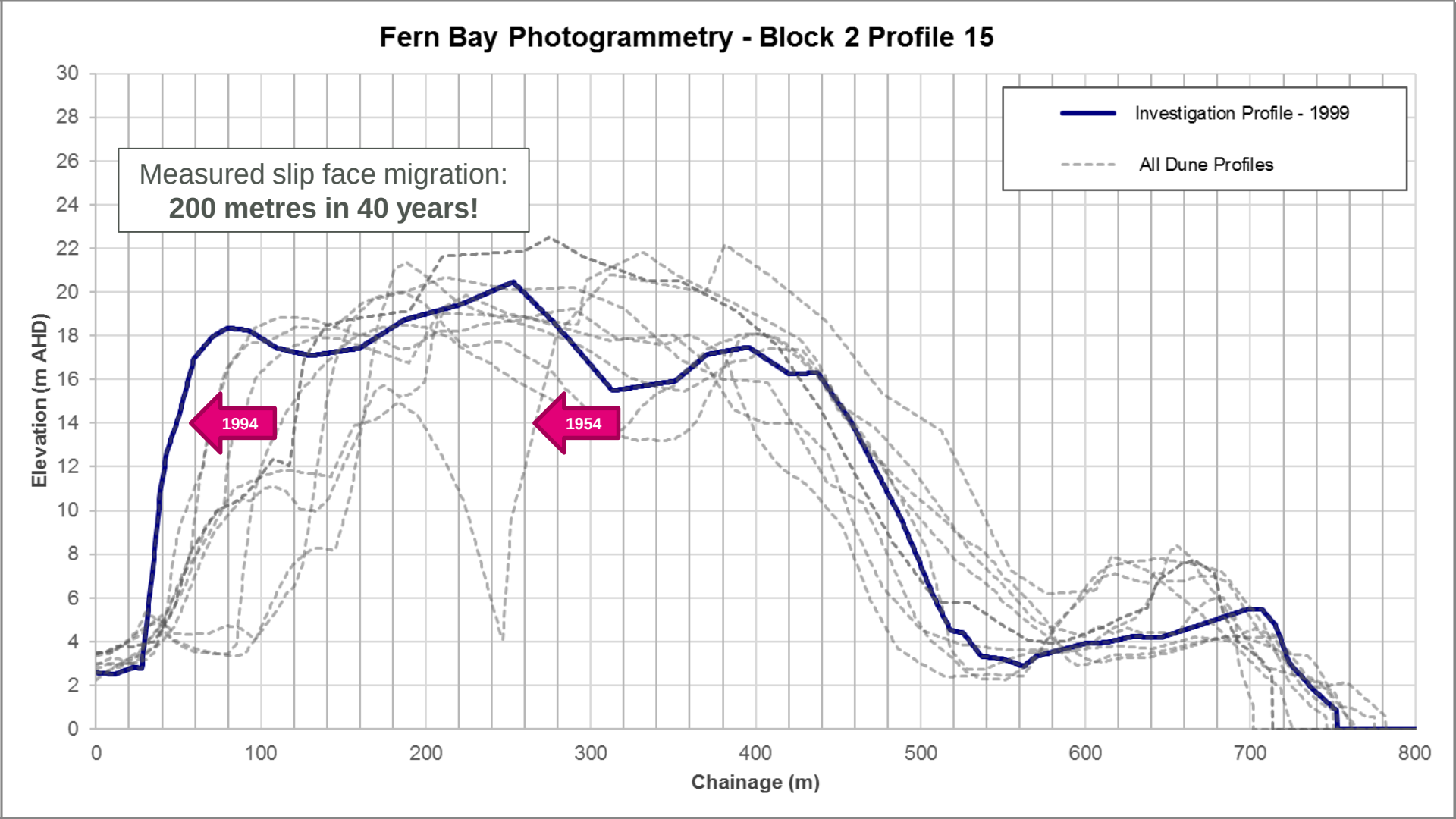
- Sand drift – nuisance hazard (no threat)
- Transgressive dune migration – significant hazard (potential threat)
- Active slip face position indicative of transgression rates

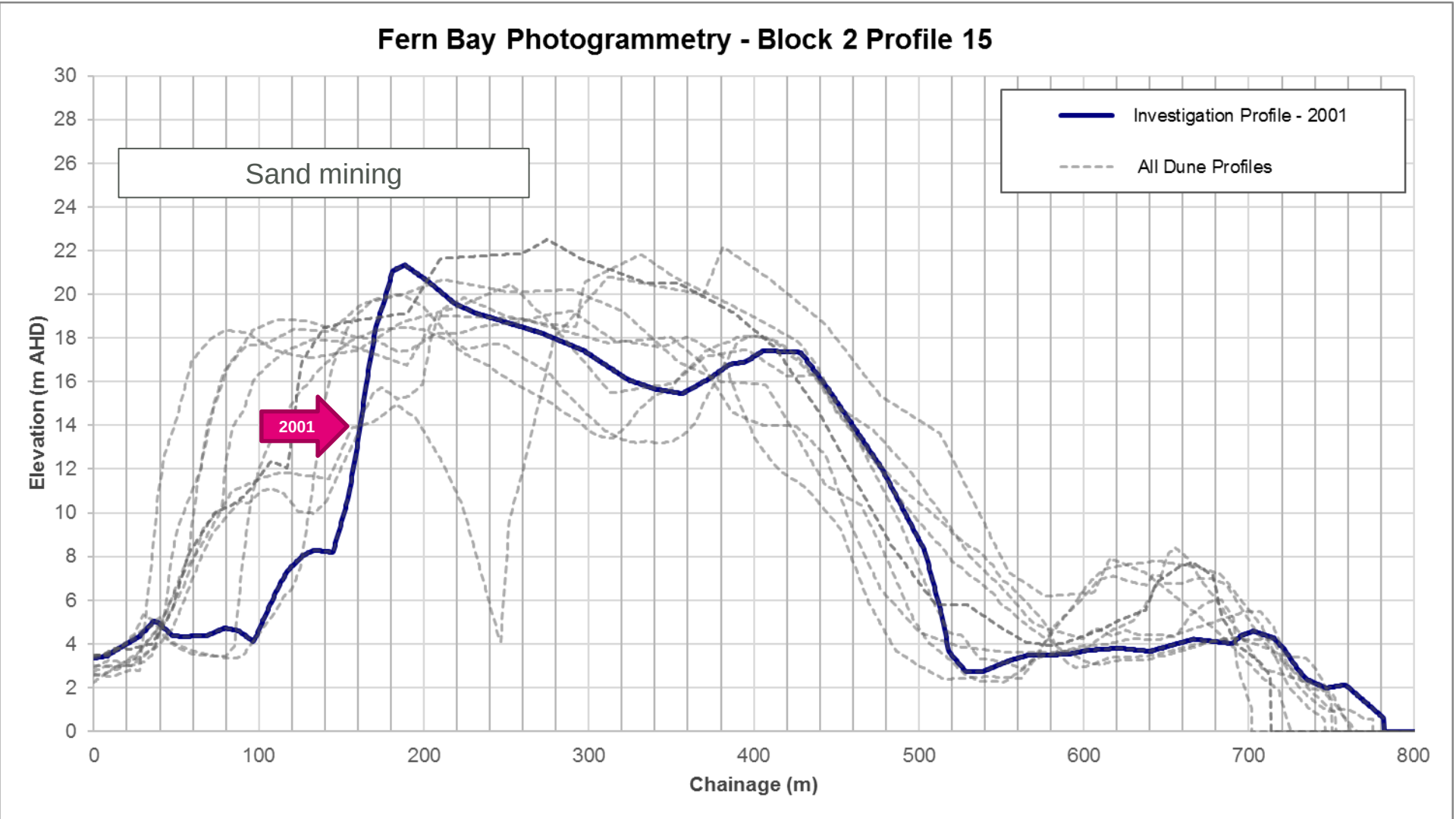
Hazard Assessment

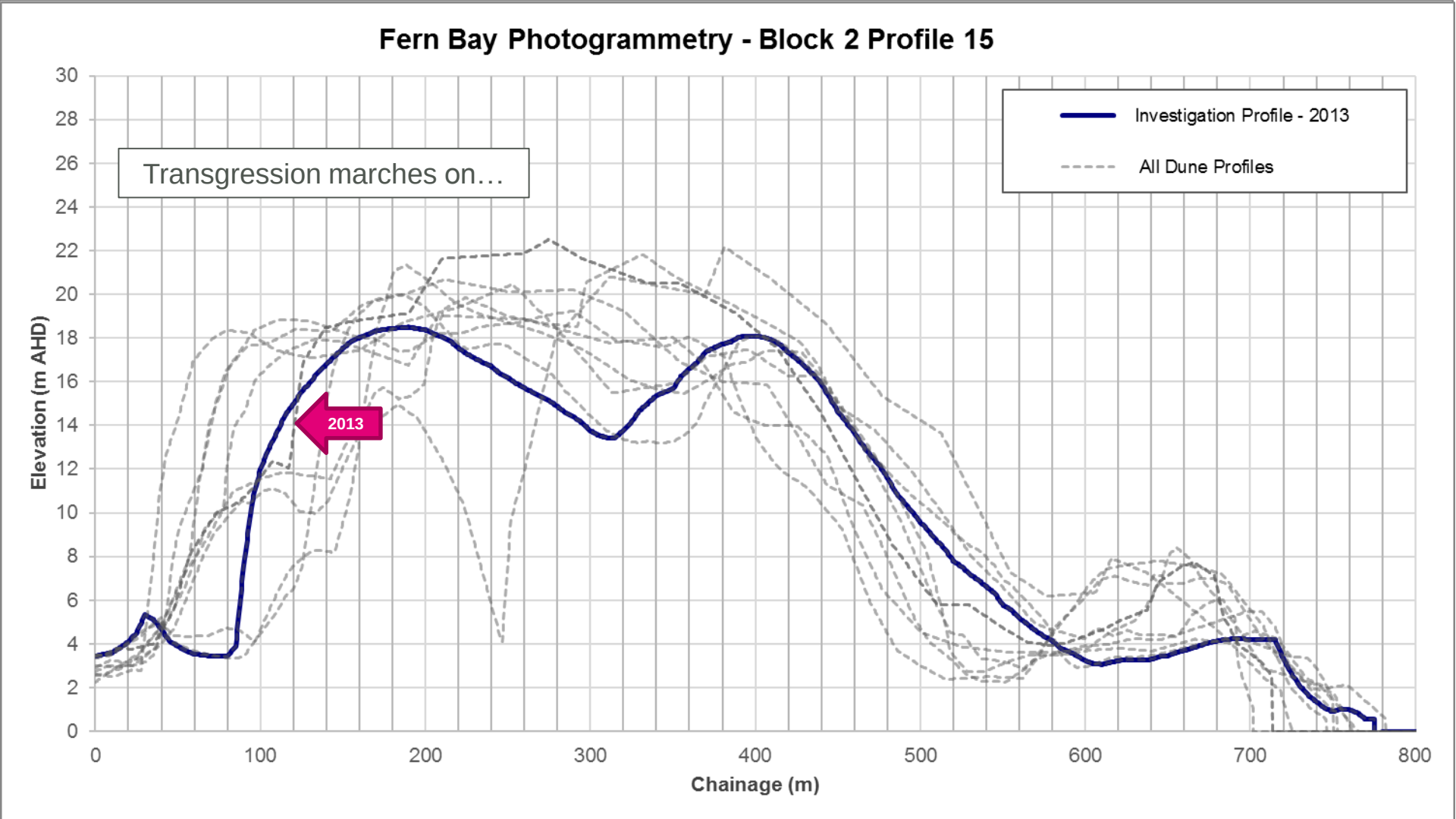
- Profile slip face measurements
- Contour level chosen for each photogram profile (need to avoid vegetated dunes)
- Pre and post mining measurement separated

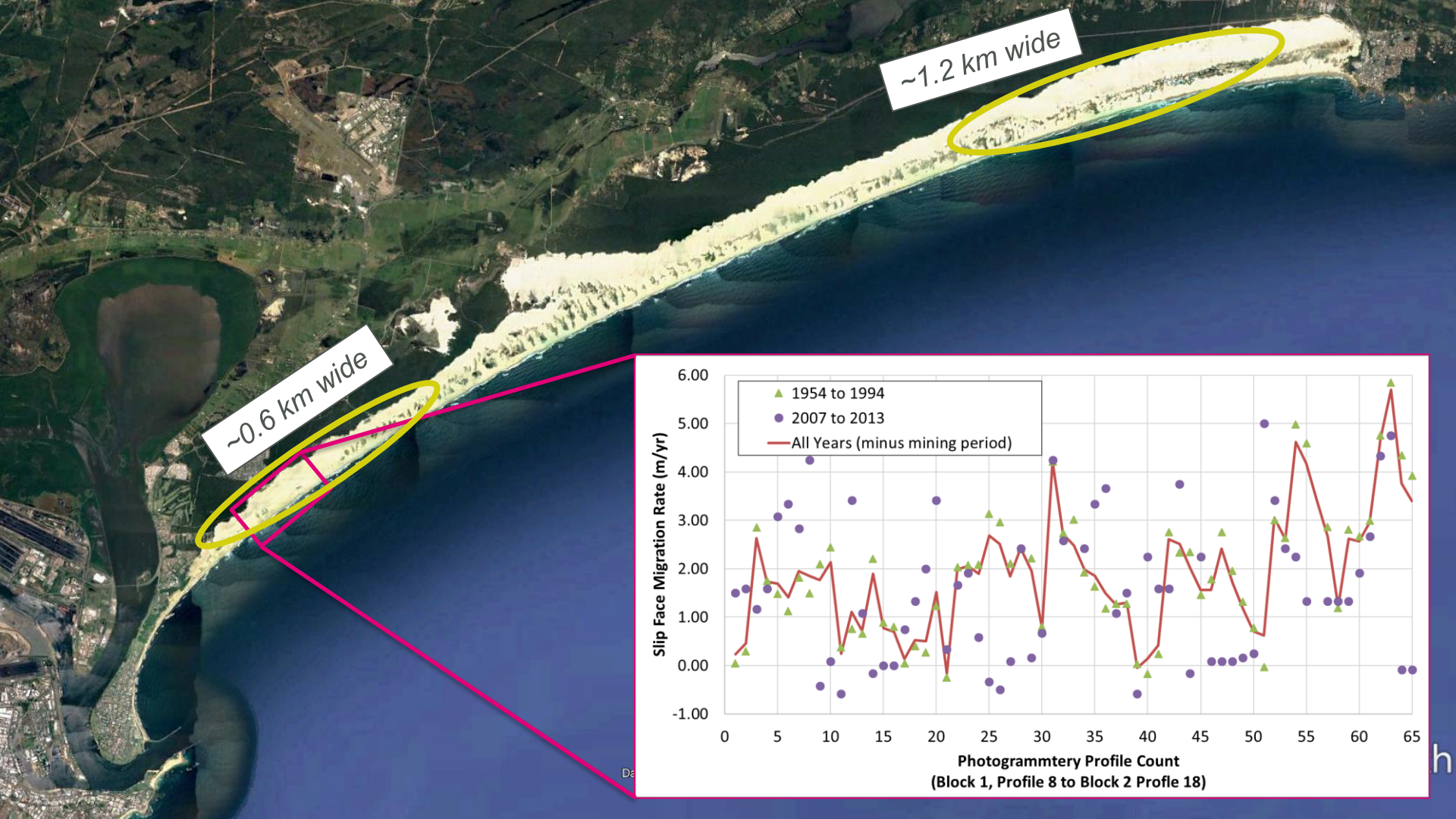


Typical Dune Morphology
Source: Chevron (2011)


Fern Bay Photogrammetry - Block 2 Profile 15
Measured slip face migration:
200 metres in 40 years!
Investigation Profile - 1999
All Dune Profiles
1994
1954
Elevation (m AHD)
Chainage (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
0
100
200
300
400
500
600
700
800


Fern Bay Photogrammetry - Block 2 Profile 15
Sand mining
2001
Investigation Profile - 2001
All Dune Profiles
Elevation (m AHD)
Chainage (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
0
100
200
300
400
500
600
700
800


Fern Bay Photogrammetry - Block 2 Profile 15
Transgression marches on…
Investigation Profile - 2013
All Dune Profiles
2013
Elevation (m AHD)
Chainage (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
0
100
200
300
400
500
600
700
800


~1.2 km wide
~0.6 km wide
1954 to 1994
2007 to 2013
All Years (minus mining period)
Slip Face Migration Rate (m/yr)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
0
5
10
15
20
25
30
35
40
45
50
55
60
65
Photogrammtery Profile Count
(Block 1, Profile 8 to Block 2 Profile 18)

Fort Wallace (Stockton) Development Proposal

Development Proposal

- Site **3.2 km north of Harbour** (& N exiting residential), spanning beach to Fullerton St.
- **Former defence site**
- **Existing**: hummocky dunes, sparsely vegetated (w. weeds), historical structures
- **Proposed**: Rezoning for residential; enviro / reserves (SP2 > R2, E3, RE2)

Constraints

- **Coastline hazards**: aggressive and progressive erosion; future climate risks
  Note: dune movement not a key issue
- Heritage features

Opportunities

- Areas of **undeveloped backbeach land**
- **Restore / improve** degraded dune ecology

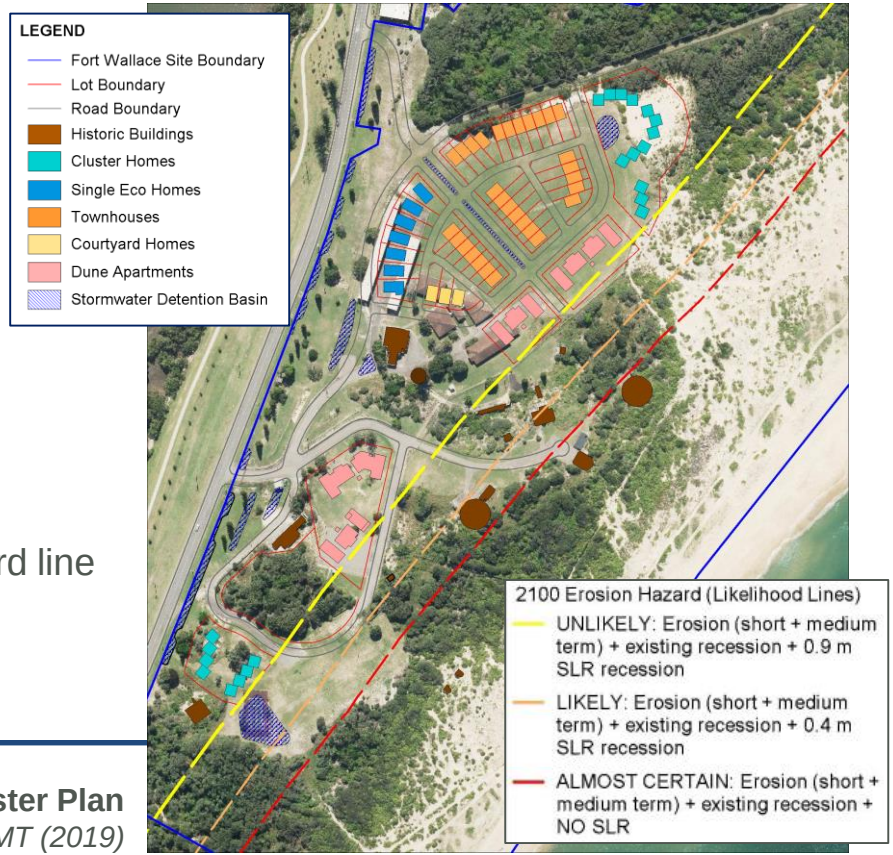
Coastal Risk Management - Fort Wallace (Stockton)

Management Aims and Objectives

- Incorporate coastal hazards into the master planning process
- Implement a program of dune rehabilitation and ongoing dune maintenance on the site

Master Planning

- Hazard and risk guided master planning process (location and form of development)
- All development set back behind unlikely 2100 hazard line
- Higher density housing sited differently
- Good planning outcome!



Fort Wallace Site, Hazard Setbacks & Master Plan
Source: BMT (2019)

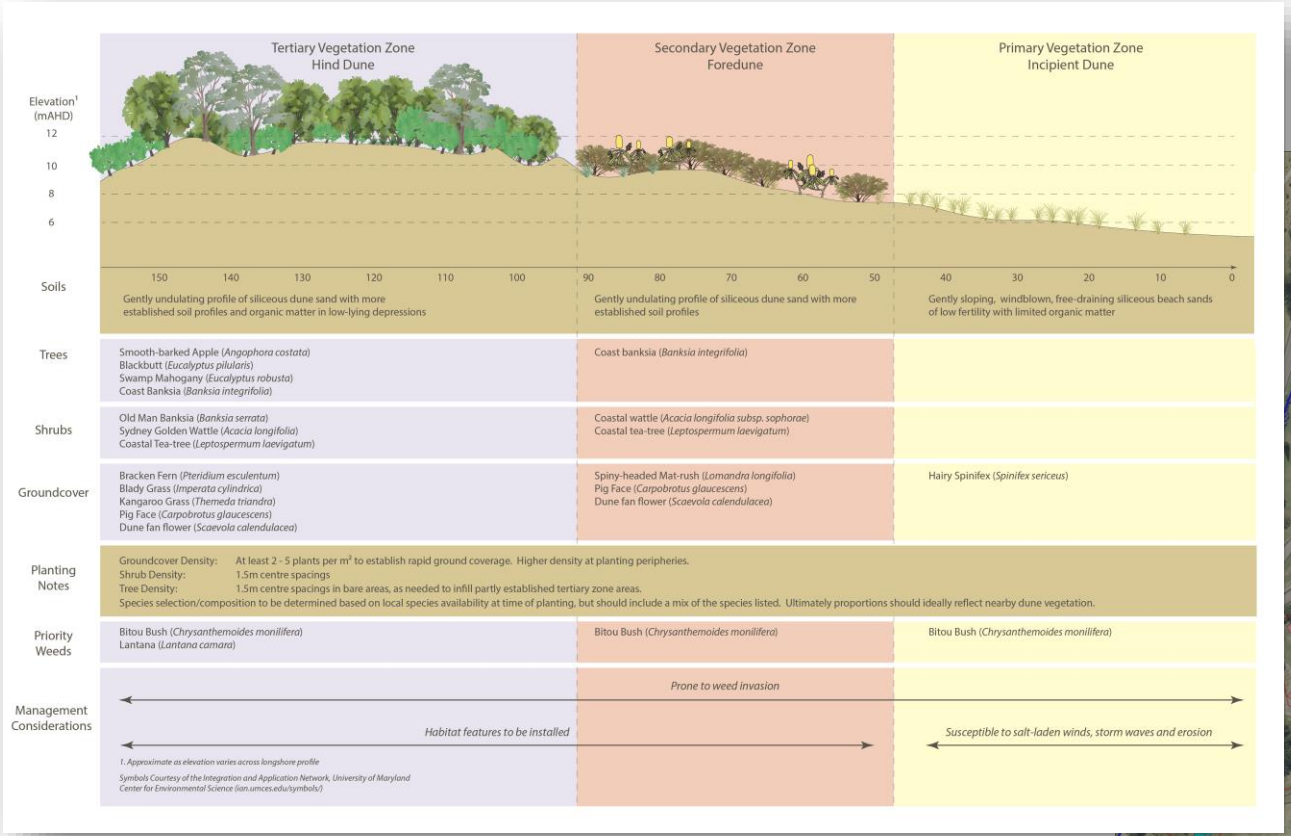
Coastal Risk Management - Fort Wallace (Stockton)

Dune Management Plan (DMP)

- DMP prepared for risk mitigation
- Key outcomes sought:
  - encourage sand capture to buffer for erosion
  - mitigate nuisance sand drift
- Added benefit: remove weeds; improve dune ecology; & encourage ecological stewardship (future local community)
- Short- and medium-term actions
  - Rehabilitation specification for the dunes
  - Ongoing maintenance regime and storm response actions
- Long-term actions:
  - Erosion trigger point to indicate additional actions required

Dune Management Plan for Fort Wallace
Source: BMT (2019)

(Stockton)


Tertiary Vegetation Zone
Hind Dune
Secondary Vegetation Zone
Foredune
Primary Vegetation Zone
Incipient Dune
Elevation[1] (mAHD)
12
10
8
6
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
Soils
Gently undulating profile of siliceous dune sand with more established soil profiles and organic matter in low-lying depressions
Gently undulating profile of siliceous dune sand with more established soil profiles
Gently sloping, windblown, free-draining siliceous beach sands of low fertility with limited organic matter
Trees
Smooth-barked Apple (Angophora costata)
Blackbutt (Eucalyptus pilularis)
Swamp Mahogany (Eucalyptus robusta)
Coast Banksia (Banksia integrifolia)
Coast banksia (Banksia integrifolia)
Shrubs
Old Man Banksia (Banksia serrata)
Sydney Golden Wattle (Acacia longifolia)
Coastal Tea-tree (Leptospermum laevigatum)
Coastal wattle (Acacia longifolia subsp. sophorae)
Coastal tea-tree (Leptospermum laevigatum)
Groundcover
Bracken Fern (Pteridium esculentum)
Blady Grass (Imperata cylindrica)
Kangaroo Grass (Themeda triandra)
Pig Face (Carpobrotus glaucescens)
Dune fan flower (Scaevola calendulacea)
Spiny-headed Mat-rush (Lomandra longifolia)
Pig Face (Carpobrotus glaucescens)
Dune fan flower (Scaevola calendulacea)
Hairy Spinifex (Spinifex sericeus)
Planting Notes
Groundcover Density: At least 2 - 5 plants per m² to establish rapid ground coverage. Higher density at planting peripheries.
Shrub Density: 1.5m centre spacings
Tree Density: 1.5m centre spacings in bare areas, as needed to infill partly established tertiary zone areas.
Species selection/composition to be determined based on local species availability at time of planting, but should include a mix of the species listed. Ultimately proportions should ideally reflect nearby dune vegetation.
Priority Weeds
Bitou Bush (Chrysanthemoides monilifera)
Lantana (Lantana camara)
Bitou Bush (Chrysanthemoides monilifera)
Bitou Bush (Chrysanthemoides monilifera)
Management Considerations
Prone to weed invasion
Habitat features to be installed
Susceptible to salt-laden winds, storm waves and erosion
1. Approximate as elevation varies across longshore profile
Symbols Courtesy of the Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/symbols/)

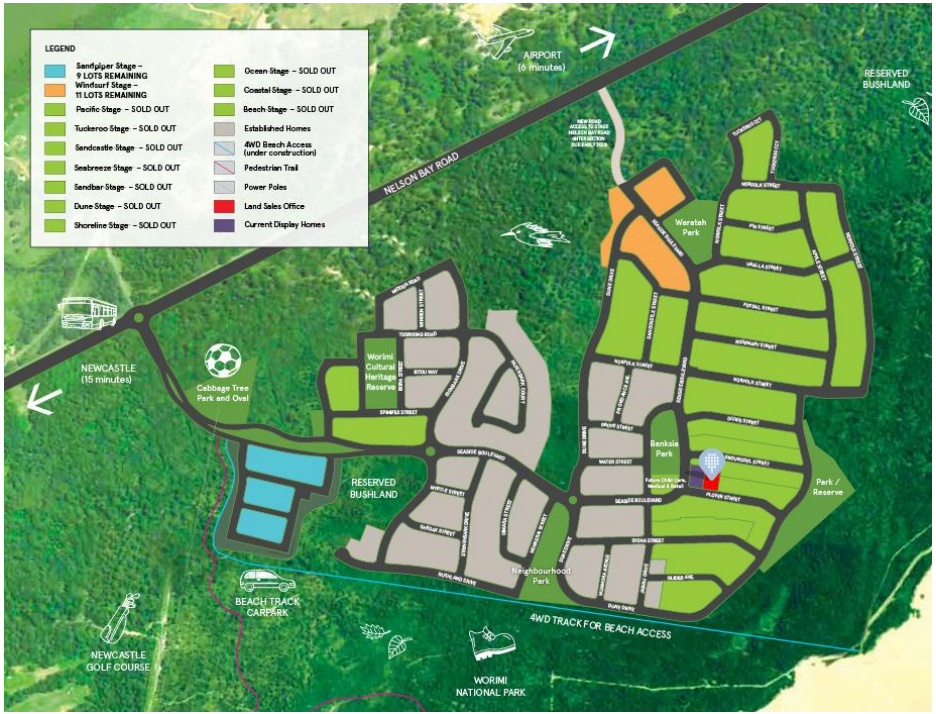
Fern Bay Seaside Village Development Site

Development Proposal

- Site 7km north of Harbour, & nearly 1km landward of the shoreline
- Development on stabilised vegetated dunes, landward of active transgressive dune front
- Surrounded by reserve (Worimi RP & SCA)

Conditions of Consent

- **Dune Management** – prepare Dune Management Plan (DMP) to manage risk, prior to issue of the final subdivision cert.
- DMP to be implemented by the Community Association in *perpetuity!*

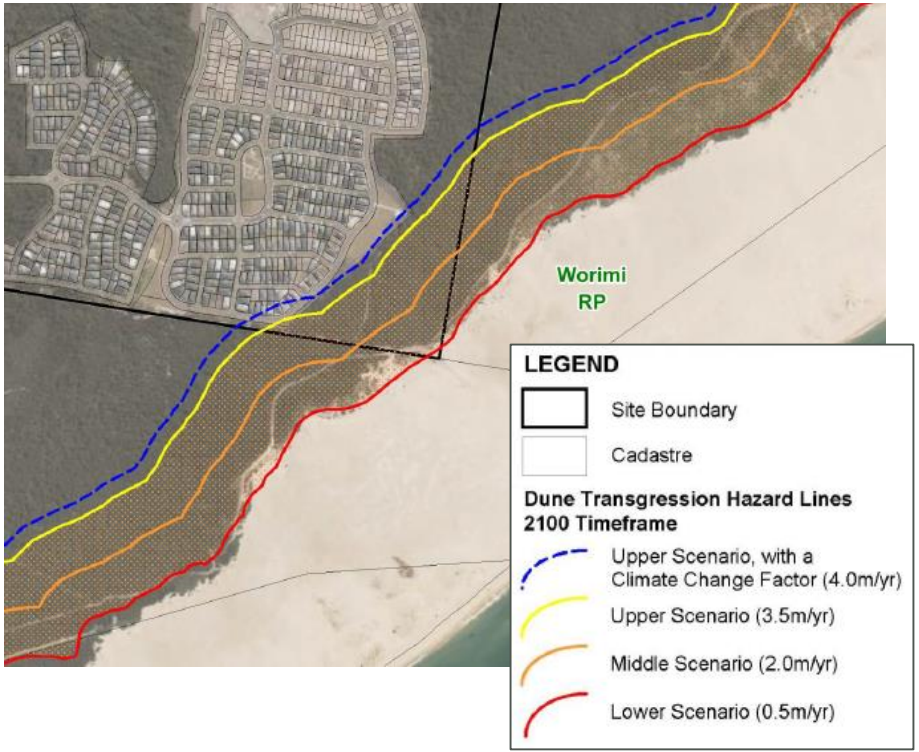


Seaside Village Mater Plan, Fern Bay
Source: Rawson Communities

Coastal Risk – Fern Bay

Dune Transgression Hazards

- Key hazard to consider - transgressive dune potential to engulf development
- (Nuisance) sand drift – minor concern
- Measured transgression rates (region average): 0.4 m/yr to 3.4 m/yr (increasing moving North)
- Adopted rates and timeframe to impacts:
  - *Lower:* 0.5 m/yr, 2615 timeframe
  - *Middle:* 2.0 m/yr, 2165 timeframe
  - *Upper:* 3.5 m/yr, 2100 timeframe
  - *Upper w CC*: 4.0 m/yr, 2090 timeframe



Dune Transgression Hazard Estimates
Source: BMT, 2019

Coastal Risk Management – Fern Bay

Management Aims and Objectives

- Identify appropriate actions and measures required to reduce adverse impacts on the development in the event that the transgressive dunes encroach on the development in the future
- Satisfy conditions of consent dune management requirements

Development Siting

- Differs to Stockton site, very long-term risk to site
- Development setback at significant distance from the shoreline – will not be an issue for many decades, if at all.

Seaside Estate Aerial
Source: Blue Wave Property Strategies

Coastal Risk Management – Dune Management Plan

- Dune Management Plan developed for risk mitigation
- **Trigger based adaptive management plan** was prepared
- Aims of DMP:
  - Avoid modifying natural dune landscape values
  - Understand dune behaviour changes and condition
  - Implement appropriate mitigation measures
- Dune toe migration monitoring regime with various trigger points
  - Monitoring involves surveying dune toe at 10 yearly intervals, with trigger to increase monitoring if/when toe is 80 metres from the development (equivalent to a 20-year timeframe until impact)
- Revegetation not considered appropriate due to active dune values
- Appropriate and permissible future mitigation measures unknown

Fern Bay Dune Management Report
Source: BMT (2019)

Project Challenges – Dune Management

- **Coastal risks** – understanding the physical processes to guide site planning and management
- **Capacity building** – bringing the clients up to speed with coastal processes and risks
- **Community title development** – need to prepare fit for purpose management plans that aren't overly onerus / burdening on the community
- **Cross jurisdictional issues** – Worimi Aboriginal Lands, Council and other neighbouring land owner management goals and plans

Summary

Fort Wallace

Dune Condition and Processes

- Sited on margin of transgressive dunes
- Dune partially vegetated (weeds) and stable

Key Hazard

- Coastal erosion and recession (long-term)

Management Response

- Risk based master planning
- Dune management plan focused on retaining sand and ecological outcomes

Fern Bay

Dune Condition and Processes

- Highly mobile, transgressive dune system
- Development on stable vegetated dunes landward of transgressive dune toe

Key Hazard

- Dune transgression (very long-term)

Management Response

- Trigger based adaptive dune management plan, focused on monitoring landward movement of the transgressive dune toe

Thank you

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