Reversal of Human-induced Dune Erosion Processes - Ōmaro Spit, Coromandel – Revision.

EXECUTIVE SUMMARY:

The continuance of problematic and historically unprecedented erosion issues located within this coastal ecosystem persist solely at the distal north-western extremity of Ōmaro spit, now aggravated even further by impacts from January 2022's ex-Tropical Cyclone Cody. This eroding area has previously received wholly inadequate attention for appropriate diligent restoration of beneficial natural foredune and beach accretion processes over at least the preceding decade. Such simple and affordable remedial activities have demonstrably increased the functional dune width and storm resilience of other nearby Matarangi littoral ecosystems, adjacent to the main beach, Matarangi for example.

Aims and Objectives of the Proposed Plan:

To consult, coordinate and plan readily affordable and sustainable community responses to:

1. Stabilise and then sustainably reverse existing erosion concerns and so progressively expand the natural dune buffer for that largely barren and/or severely eroded coastal margin
2. Ensure any work involves ecologically sound enduring protection of the Ōmaro spit coastal ecosystem
3. Also ensure diligent restoration of the popular Ōmaro spit public walkway, open space, and golf course-land – all of which currently adversely affected by this recent erosion episode
4. Restore the now divided area of shorebird nesting habitat - areas eroded by recent storm forces
5. Achieve the above objectives using proven, sustainable, affordable, and community focussed cost-effective methodologies.

Options Available for Attempting to Control Erosion at Ōmaro Spit:

1. Building timber or rock seawalls
2. Sand nourishment and/or creation of rock (or Geotextile?) groynes
3. Further plantings of European marram, South African Iceplant, Arctotis, Gazania etc
3. Diligent restoration of indigenous foredune plant species following appropriate sand replenishment.

Best Option Discussion:

The most enduring, sustainable, cost effective and affordable option for reversing existing erosion at Ōmaro spit should include a mix of the best natural and least interventionist methodologies. Hence this updated revision suggests that minor localised sand renourishment (where and if necessary; final volumes agreed prior to implementation) PLUS utilisation of diligent restoration of indigenous salt-tolerant (halophyte) foredune plant should be employed in combination. This modern hybrid response will provide the greatest and most sustainable outcomes possible to alleviate community and ecological concerns by reversing the existing dominant erosion processes. Two soft groynes (one at 11m and the second 21m) could latterly be considered in Stage Two plans to provide more reliable dune protection from tidal flows through the Whangapoua harbour entrance if required beyond the low-impact diligent restoration efforts in Stage One. But these unnatural erosion control devices are not considered necessary in 2022.

Modern Matarangi Contexts:

Ōmaro spit is approximately 4km in length, dominated by a relatively linear sandy beach on the open and north-facing Pacific Ocean side, and by a crenulated shoreline bordering the south facing Whangapoua harbour margin. Marks & Nelson (1979) describe this landform as "a series of [natural] dune ridges on the ocean side and a low-lying barrier flat on the harbour side".

These two divergent and distinct exposure settings have created vastly diverse shoreline dynamic systems and demands – a wild and exposed open coast vs sheltered estuarine environs.

The serious and problematic erosion issues located here solely exist at the distal north-western extremity of Ōmaro Spit, where scant attention has previously been provided for beach restoration actions, activities which have demonstrably increased the resilience of other local dune ecosystems.

Most of the eastern beaches of Ōmaro Spit (especially within the north facing Kenwood/Matarangi Drive village zone) have recently received considerable beneficial dune restoration attention, where those renewed dunes are now >30m wider than before restoration. This area was equally exposed to those recently damaging winter storms and 2021 onshore wind/La Niña influences, but their now restored beaches and attendant enhanced ecosystem services ensure their littoral areas remain resilient and protectively intact, even when the storm tide surges have run-up into Kenwood Drive foredune zones – see photo 1 & 2 'Storm Impacts on Restored Matarangi Dunes'.

Photo 1: Both photos - Main Beach, Matarangi Sept 2021. Restored resilient Matarangi foredune ecosystem, increased resistance to storm and sea level rise impacts.

Photo 2: Storm effects are limited on this fully restored and active foredune. Minimal scarping exists even where surges have deposited storm debris high up into this resilient dune.

Photos 1 and 2 above (14 Sept 2021) reveal remarkable transformations towards more natural sand accretionary functions. This has only occurred following replanting of the area shown below with indigenous salt-tolerant foredune plants, as the Kenwood Drive "The Green" **2012** photos **3 & 4** below demonstrate. Those diligently replanted indigenous C_4 salt-tolerant (halophyte) foredune plant species (Jenks 2018) are now beneficially and naturally trapping and stabilising all aeolian sand supplied by normal cross-shore exchange (diabathic) processes, the natural 'fill' function of normal 'Cut and Fill' cycles. Of course, the 'Cut' component of beach and foredune erosion occurs during natural storms that often visit these open shorelines during winter and occasionally again in late summer/early autumn, in tropical cyclone seasons.

Photo 3: Nov 2012: Foredune erosion induced by domination of salt-sensitive non-functional S.A. iceplant.

Photo 4: Nov 2012: This foredune is also dominated by salt-sensitive non-functional plants, e.g. Arctotis, Gazania, kikuyu.

Sand removed by those storms is simply relocated onto offshore storm bars, that in a natural response that increases the subsequent protection of landward beaches by forcing storm waves to break offshore and so spill some of their amassed kinetic energy, thereby reducing erosional impacts when those lower energy waves surge onto shorelines. The erosional effects of existing sea level rise will only increase sand removal from degraded foredunes; however, those impacts are beneficially diminished by the natural, sustainable, and enduring accretionary effects produced by diligent foredune restoration (Jenks & Kouwenhoven 2015).

The exceptionally beneficial but long ignored ecological role of Aotearoa/NZ's (A/NZ) four species of indigenous C4 salt-tolerant foredune plants (see figure 1) is to naturally trap and proficiently stabilise those gradually returned sand particles into expanding foredunes with increased porosity, when brought ashore again by spring/summer calm weather waves (de Lange & Jenks 2007; Müller 2011).

Such sand-return (diabathic) conditions are themselves naturally created by normal spring/summer offshore W to SW winds. These recently researched beneficial and most affordable diligently restored natural sand accretion functions and halophyte status of foredune plants are internationally reported in Springer Nature's Journal of Coastal Conservation (Jenks 2018). The cost benefits and endurance impact of this natural coastal erosion protection option are also published by the IPCC in their 4AR (Jenks et al 2007).

Figure 1 (above): Aotearoa/NZ's Indigenous foredune plant species

A remarkable contrast now exists between those restored, increasingly wide and hence progressively more resilient eastern Matarangi foredune areas shown above, and the affected non-restored eroding areas at the distal north-western end of Ōmaro Spit, where that open space remains dominated by the salt sensitive grass species like East African kikuyu (*Cenchrus clandestinus*). This present dune erosion problem of Ōmaro was also abundantly apparent back in 2012 when photos 5 & 6 (below) were taken. This induced spit erosion most closely resembles the European model of coastal processes, discussed further below.

The obvious prevalence of the non-functional glycophyte European marram grass (that tolerates salt spray – but not salt water) and the similarly non-functional salt sensitive pine species seen here only encourage and intensify additional erosion processes, and do not contribute to effective sand accumulation.

Photo 5: Ōmaro Spit: Nov 2012 – East of photo 6, salt-sensitive marram and S.A. iceplant are already unsuccessfully dominating coastal processes.

Photo 6: Ōmaro Spit: Nov 2012 – West of photo 5, salt-sensitive Pinus species are ineffectually dominating coastal accretion processes – resulting in severe coastal erosion.

Photo 6 (above) reveals the unnaturally wide and flat intertidal beach, where sand removed from the readily eroded dune face is now deposited. An unknown quantity of now mobile sand volume has likely been transported by aeolian saltation during warmer and drier offshore winds to create the also unnaturally wide supratidal but barren beach seen in Zones 1-3 (Map 1 above). That artificially induced movement of mobile sediment has materially impacted on the dune integrity of its source; southwest of Zone 4 (Map 1 above).

Photos 5 and 6 (above) merely represent critical symptoms of the current extent of human-induced erosion problems at Ōmaro Spit, where those predictable erosion impacts are comparable to night following day due to those existing and incontrovertible but poorly acknowledged human impacts. That effect is also demonstrated in the following Google Earth images (below) – see how the extent of the distal spit duneland is continually reducing as erosion is simply marching inland, removing increasing areas of the coastal woody vegetation, undermining, and tossing it onto the newly created beach where a protective dune once stood.

AIMS and OBJECTIVES:

Consult, coordinate and plan a sustainable and enduring community-involved response to -

1. Stabilise and reverse existing erosion concerns to progressively expand that impacted coastal margin
2. Ensure all work involves ecologically sound enduring protection of the Ōmaro spit coastal ecosystem
3. Also ensure enduring restoration of the popular Ōmaro Spit public walkway, open space, and golf course – community land and assets currently adversely affected by the recent erosion episode
4. Restore the area of endemic shorebird nesting habitat recently washed away by those storm forces
5. Achieve the above objectives using proven, sustainable, ecologically sound and community focussed cost-effective methodologies.

Many permanent and absentee Matarangi residents wish to assist with resolving the prevailing dune erosion problems at Ōmaro Spit, existing difficulties that were recently aggravated by winter 2021 La Niña influenced storms and only intensified by ex-Cyclone Cody impacts. While dune and beach erosion issues are generally cyclical in nature, the seriousness of those attrition impacts have compounded over time. That is largely due to those processes not having been readily modified or reversed by diligent and successful foredune restoration activities, like those dune expansion benefits seen along Kenwood and Matarangi Drives. Clearly, in those nearby restored areas, beach and dune accretion here has been naturally and most affordably enhanced, while remaining largely unaltered by those same winter ’21 storms. This dune expansion process is the new vision for Ōmaro Spit.

Those opportunities plus other alternatives are explored below.

OPTIONS AVAILABLE FOR CONTROLLING EROSION AT OMARO SPIT:

1. Building timber or rock seawalls
2. Creation of rock (or geotextile?) groynes
3. Planting more alien species like European marram, South African Iceplant, Arctotis, Gazania etc
4. Diligent restoration of indigenous foredune plant species

OPTION 1 discussion (Seawalls):

Timber seawalls are normally built along eroded dune faces, parallel to damaged beaches. These structures were used in several A/NZ locations after the serious beach erosion created by Cyclone Giselle in 1968 (aka 'The Wahine Storm'). Cheaper timber walls were built at Omaha and Waihi beaches, but they generally failed within a relatively short period - these structures could not withstand the constant wave impacts during winter storms, La Niña impacts (see below) and late summer ex-tropical cyclones.

Those timber walls were then gradually replaced with similarly shore-parallel rock revetments, but at vastly increased expense. In the Waihi beach situation, the first 'new' rock revetment was built in the mid 1970's to replace a failing timber structure. That 'new' rock system was itself replaced again in 2008 (about 30 years later) by another newer rock revetment, due to increasing failures of the previous 'hard' rock structure. The 2008 replacement cost $6million for about 600m of supposed coastal 'protection', or $10,000 per lineal metre of beach. That extremely expensive newest rock revetment does offer some transient comfort to adjacent homeowners, but it also severely limits their access to their previously most precious asset - the beach. And as these structures always do, 'their' beach continues to erode on the seaward side as the true root cause of those erosion issues has not been (and can never be) adequately resolved. That renewed beach erosion is now only accelerated, enabled by wave impact turbulence created by high tide waves breaking directly onto the sea wall, those now unnaturally enhanced turbulent conditions then lift and flush beach sand out to sea with each wave backwash. Therefore, access to the beach is not only restricted, but now 'their' beach quickly becomes a 'wet' beach, with no remaining dry high tide beach sand. Such inflexible rock seawalls are highly likely to require a further and more expensive rebuilds in another 17-20 years. For all these reasons, plus the usual disturbance to the local natural environment, means the time for approval of necessary Resource Consents can be protracted, while the costs for approving any new seawall can be prohibitive. And that beach erosion and regular rebuilding scenario is also the reason why the US Army Corps of Engineers no longer recommends their use on a federal USA basis – see attachment A: 'REUTERS - USACE Short-term Folly of Seawalls'.

OPTION 2 discussion (Rock groynes):

Rock groynes are often located perpendicular to incoming wave action and have been used successfully in a limited number of appropriately planned situations – for example to protect Omaha beach after that failed timber seawall (similarly, also erected in response to the Wahine Storm) was necessarily replaced. A total of three long groynes averaging about 100m long were placed to protect this early and now successfully restored beach ecosystem on the similarly western distal end of Omaha spit. Records are scarce now, but Omaha Spit beach was likely the earliest beach in NZ to be restored with indigenous foredune plants, ostensibly completed in the late 1970's. Professor Bob Dean of the University of Florida's Civil and Coastal Engineering Department ably assisted with the design and creation of this sustainable and enduring project. The 3 wave-perpendicular groynes offer functional protection to Omaha Spit and its attached diligently restored beach ecosystem from the effects of ebb and flood tide flows of the adjacent Whangateau estuary.

That work is so successful, the Omaha Shorebirds Protection Trust has now carefully re-established one of the most successful shorebird enhancement and protection programmes in NZ. In addition, this beach ecosystem is now regarded as dynamically stable, with any regular coastal erosion impacts minimised and promptly self-repaired by the natural sand accumulation attributes of indigenous halophyte foredune plant species. The work at Omaha Beach makes a most useful and agreeable exemplar to emulate at Ōmaro Spit.

However, the rocks used in these groynes are always expensive to utilise, and they also impact on human safety. A more recent option is largely now preferable – incoming wave perpendicular (NOT shore parallel) groynes constructed of softer and more affordable geotextile cloth, and affordably filled with local sand.

OPTION 3 discussion (Planting more marram, lupins etc.):

European marram grass and other alien species were initially utilised as a poorly considered and hasty erosion response in the early 1900's, after the colonial era impacts became dangerously apparent - see attachment B: **HISTORIC COASTAL PERSPECTIVES**. Not one of these plants introduced to NZ can or has succeeded in their expected protection role – to successfully accumulate and stabilise coastal sand volumes. The critical and functional reason behind that universal lack of success has only recently been discovered: none of these alien plants can tolerate extremely common contact with seawater, a functional necessity for any foredune plant normally located so close to the ocean. Most of these introduced alien species variably tolerate salt spray, but not inundation of saltwater (all are salt-sensitive, or non-halophytes).

A second problem with the introduced species is their ecosystem impacts: marram is too dense to effectively trap sand on seaward foredune zones - any sand 'trapping' normally occurs landward of the unnaturally steep and tall dune crest; Californian lupins fix nitrogen which only encourages prolific growth of weed species; SA iceplant increases sand acidity which effectively excludes low-stature indigenous dune plants that naturally excel in alkaline environments; Arctotis and Gazania are likely to be doing the same.

Due to the many identified problems associated with all known introduced alien plants, consideration of their future utilisation is now considered entirely imprudent.

OPTION 4 discussion (Diligent restoration of indigenous foredune plants):

Those indigenous (and recently identified as halophyte) foredune plant species have evolved over many aeons to excel in surviving the many severe natural storms that visit these harsh littoral environments - our beaches, on that thin band of sand between the sea and the land – the golden fringe of NZ. They have persisted on that golden fringe even when sea levels rose 120 metres during the early Holocene period – historically these plants, specialised by evolutionary forces, are nature's true survivors – but they are also regrettably palatable, readily devoured by another new NZ phenomenon – the grazing herbivores also introduced during our colonial era (Jenks 2018) – and see attachment B: **HISTORIC COASTAL PERSPECTIVES.**

But when these specialised indigenous plants are propagated and diligently planted on foredunes, the magic of their amazing salt-tolerant (halophyte) functionality characteristics soon kick-starts their natural sand accumulating and stabilising functions, and their naturally rapid proliferation of any bare beach sand.

These indigenous foredune plants have also been utilised/restored at many other NZ locations, including Nelson, Wellington, Taranaki, BOP, Coromandel and Matarangi locations. Note, an erosion reversal plan utilising indigenous halophyte foredune plant species was prepared and presented to TCDC in 2016 by this author, for diligent restoration of all 16 Mercury Bay beaches in the innovative TCDC coastal management document 'Proven Sustainable Management of Mercury Bay Beaches' (Jenks 2016).

Again, the significant advantages arising from preferential utilisation of these highly adapted indigenous halophyte foredune plants is cited by the IPCC 4th Assessment Report - as the most enduring, sustainable, and least cost option available for coastal protection purposes (Jenks *et al* 2007).

BEST OPTION DISCUSSION:

Comparing all the above information, the most enduring, sustainable, cost-effective, affordable option for use at Ōmaro Spit should include a mix of the following best natural and least interventionist methodologies.

STAGE ONE 2022: 450m of ocean beach – see map 1 below: Ensure satisfactory control of existing environmental weeds in this area (including European marram (*Ammophila arenaria*), Californian tree lupin (*Lupinus arboreus*), South American fleabane (*Conyza sumatrensis*), American Salt-Water Paspalum (*Paspalum vaginatum*)) etc. is most essential to limit future incursions. This activity will be followed by simple but diligent restoration of the existing variably to poorly vegetated 450m long ocean-facing beach in **late autumn 2022** (May-June). This long area of degraded beach possesses four distinct but relatively secure zones, shown on map 1 below.

Zone 1: about 100 m long to the west of the "Conservation Area" sign – the existing kowhangatara (spinifex; *Spinifex sericeus*) here only requires essential weed control plus limited addition of growth promoting fertiliser – to stimulate a rapid response from the existing kowhangatara (spinifex). Some limited interplanting of **200 hinarepe (golden sand tussock; *Poa billardierei*)** plants would assist natural sand trapping processes plus aid vegetation diversity in this secure >60metre wide dune and protected shorebird nesting zone. The existing area landward of the foredune should also be restored to help maintain the new weed free status by utilising **600** of site-appropriate and pre-ordered indigenous **mid-dune plant species** - wiwi (knobby clubrush, *Ficinia nodosa*), anawhata (sand carex, *Carex testacea*), and tarakupenga (sand coprosma, *Coprosma acerosa*). Limited planting of the critically endangered strandline plant Hollway's crystalwort (*Atriplex hollowayi*) seed could additionally be considered seaward of this secure foredune, should supplies be available 2022. These additional indigenous plants will also enhance natural protection for the cryptically camouflaged shorebird chicks from aerial predation, like that from local black-backed gulls (*Larus dominicanus*).

Map 1: Matarangi Beach – Ōmaro Spit: Stage One restoration zones for 2022 (approximated).

Source: Google Earth 2020 – image supplied by Grant Short

Zone 2: about 100m long, to the west of zone 1 - the lesser numbers of existing kowhangatara (spinifex) also require essential weed control plus limited addition of growth promoting fertiliser – to stimulate a rapid response from the existing kowhangatara (spinifex) plants. Some supplementary planting of further kowhangatara and hinarepe (golden sand tussock) would assist natural sand trapping processes and diversity in this relatively secure >40metre wide dune zone; **500 foredune plants** total required. Additionally, the area landward of the foredune should also be restored to help maintain the new weed free status by utilising **600** of site-appropriate and pre-ordered indigenous **mid-dune species** - wiwi (knobby clubrush, *Ficinia nodosa*), anawhata (sand carex, *Carex testacea*), and tarakupenga (sand coprosma, *Coprosma acerosa*).

Zone 3: about 250m long to the west of zone 2 – the moderate dune erosion here has largely self-repaired, but the barren supratidal high tide beach remains exposed to storm-induced erosion. This substantial area requires the main restoration focus, needing **1,500 kowhangatara (spinifex) and hinarepe (golden sand tussock) plants** here. The mid-dune area in this zone is dominated by dune scarping, so limited space is available for normal mid-dune restoration. But where possible, that area should also commence restoration to help maintain the new weed free status by utilising **200** of site-appropriate and pre-ordered indigenous **mid-dune species** - wiwi (knobby clubrush), anawhata (sand carex), and tarakupenga (sand coprosma).

Zone 4: the western-most 50m long limit of that degraded beach – here sand nourishment is deemed necessary, although some natural beach rebuilding occurs sporadically, at an interrupted pace due to the continuing La Niña effects (and its associated Cyclone Cody impacts) overriding the anticipated changes in summer wind directions – to more dominant offshore winds. Initially, approximately only 400-500 cubic metres of intertidal beach sand would be required, placed on a gentle 1:20 slope. Finally, diligent restoration of this newly nourished foredune zone is suggested, with close planting of the upper 5m wide band (@1 plant/m) followed by a wider spaced restoration of the lower 5m wide band (@1 plant/5m) to provide additional sand trapping and stabilising opportunities – a total of **300 foredune plants** are required here. The remaining **100 mid-dune plants** will be utilised landward of the constructed foredune, to provide a buffer to incursions of invasive grasses from the open space above this new dune.

Restoration of natural coastal processes at Ōmaro spit will provide the following advantages:

1. Diligently restore local populations of threatened indigenous functional halophyte foredune species
2. Naturally, sustainably, and affordably increase foredune buffers and beach widths + dynamic stability
3. Encourage re-establishment and enduring reliability of the popular Ōmaro spit walking track
4. Enhance and secure the impacted breeding grounds by important nest elevations for NZ dotterel/tūturiwhatu, and variable oystercatcher/ tōrea pango.
5. Provide affordable and enduring sustainable protection of the open space area
6. Provide a secure fresh translocation site for the critically endangered Holloway’s crystalwort.

Hence it is suggested that diligent techniques for restoration of indigenous (native) salt-tolerant (halophyte) foredune plants be implemented for deployment in Stage One plans (Zones 1-3 inclusive) – in careful combination with some limited sand nourishment at the western spit extremity (Zone 4) of this open space asset. This combined hybrid response will provide the most beneficial, affordable, and sustainable outcomes known to alleviate community and ecological concerns by sustainably reversing existing erosion processes.

Sand nourishment of a 50m long portion of the eroded western extremity beach (Zone 4) is deemed necessary, although natural dune rebuilding has occurred sporadically due to some earlier changes in spring wind directions – from winter La Niña onshore wind conditions to more normal dominant offshore winds. Initially only about 4-500m^3 of adjacent intertidal beach sand is needed to fulfil nourishment requirements, but actual conditions over the remaining period before autumn 2022 will govern the final volumes required. There remains the possibility of some sand being returned by natural diabathic processes to the eroded beach and dune scarp, these volumes beneficially supplied by natural cross-shore exchange ‘Fill’ processes.

But equally, another ex-tropical cyclone or two could occur through late summer/early autumn if La Niña conditions persist, this adding to planning complexities. Based on the earlier 500m^3 estimate, the sand nourishment is likely to cost $3,000, or $2,000 if the volume required falls to 300m^3. Any helpful natural sand repatriation process remains unknown, so any further natural sediment relocations will be carefully monitored and urgently reported.

Finally, diligent restoration of this newly nourished Zone 4 foredune is suggested for autumn 2022, with close planting of the upper 5m wide band (@1 plant/m^2), followed by wider spaced restoration of the next lower 5m wide band (@1 plant/ 5m^2), to provide additional natural sand trapping and stabilising opportunities.

Further, in verified strategies to ensure superior long-term control of invasive weed encroachment into this new and usefully protective foredune zone, it is strongly recommended the most landward 1-metre-wide margin is closely planted with indigenous glycophyte psammophile (salt spray tolerant/sand loving) mid-dune plant species that naturally tolerate a small range of usefully selective herbicides. That weed control buffer consisting of low stature indigenous mid-dune plants (many rated as landscape icons), will also allow for a carefully timed single annual application of environmentally safe Gallant (haloxyfop) grass-specific herbicide to prevent encroachment of this functional new foredune by biologically and functionally harmful weeds like kikuyu and marram plus other commonly invasive grasses.

Follow-up plantings of additional low-stature indigenous mid-dune plants is recommended in years 5 and 10, to ensure the seaward-advancing band of halophyte foredune plants does not leave a barren vegetation vacuum on its landward edge, a widening margin that is likely to then be harmfully occupied by invasive weeds if left in an unnaturally barren state. If this simple and easy maintenance regime is ignored, those alien weeds will eventually infest functional foredune zones, requiring other more serious and costly interventions to maintain the efficient integrity of diligently restored foredunes. Addition of these low-stature indigenous iconic mid-dune plant species not only ‘fills a vacuum’, but they also add considerable interest, colour, and texture to dunes, and revived walking tracks on the back of foredune zones, further enhancing this welcomed and important recreational opportunity. These plants can also be utilised as protective cover by the cryptically camouflaged young of native shorebirds, for shelter from aerial predators.

The indigenous C4 halophyte and thus remarkably functional foredune plants plus the weed controlling mid-dune plants are only likely to cost a total of about $16,000 + GST (includes delivery to site, and supply of essential controlled release fertiliser)

Further details of this most durable, beneficial, sustainable, and cost-effective plan are included in the **‘Sustainable, Enduring Reversal of Human Induced Erosion Pressures’** section, see further below.

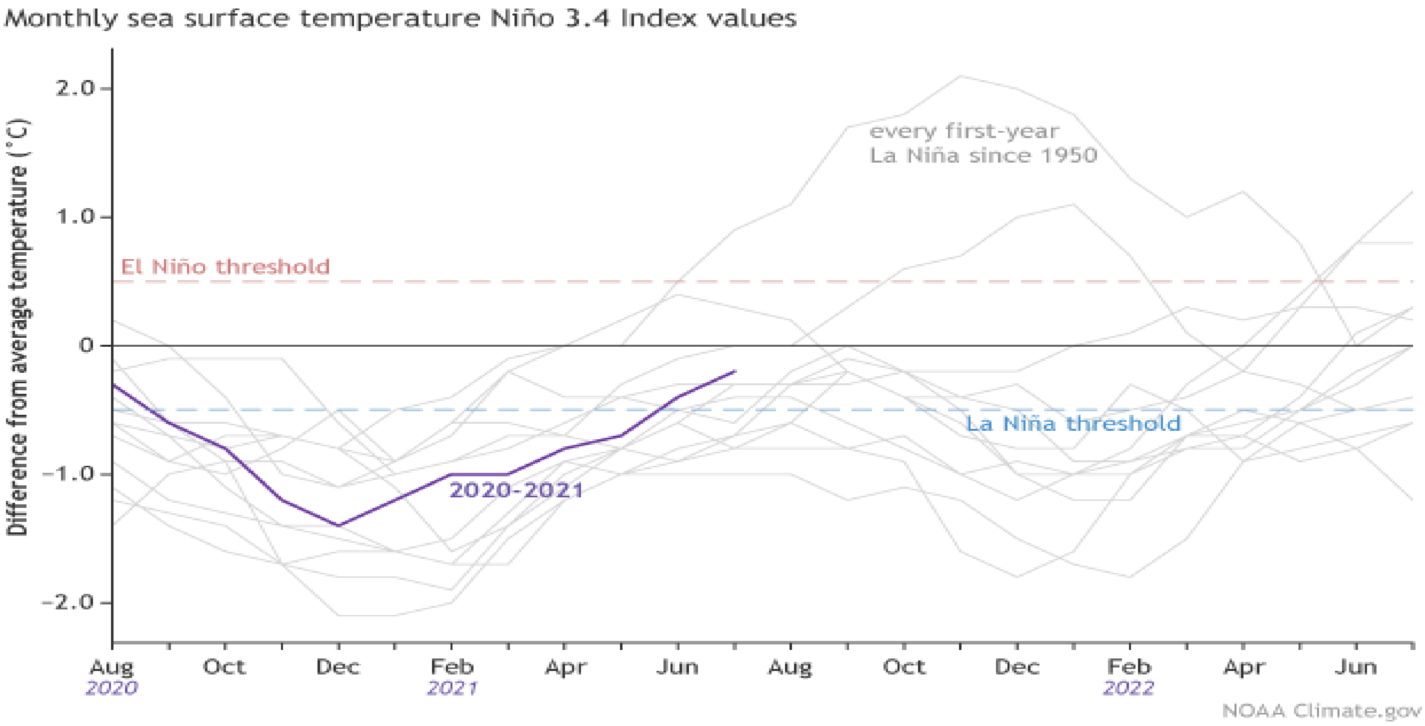
EXISTING IMPACTS STEMMING FROM HISTORICAL INFLUENCES:

In the early 1900’s, Dr Leonard Cockayne was tasked to survey the increasingly problematic eroding dunes of A/NZ. The data from these comprehensive surveys were subsequently presented in his pivotal 1909 and 1911 reports to the NZ Department of Lands. These reports are still available and they clearly reveal this British botanist’s findings – a dune area of 120,000 ha was startlingly already afflicted by human-induced destruction, which amounted to “an alarming 93% of New Zealand’s total 129,000 ha area of this nation’s 1911 dunelands”. Those destructive effects were often unwittingly generated, by a plethora of human harms (intentional fires, grazing etc.) upon indigenous dune plants, native species that had been honed by many aeons of hostile natural storm influences to evolve and excel in their natural role as sand accumulators. These uniquely efficient and functional indigenous (and occasionally endemic) plants had in fact created all the expanding dunefields and the dynamically resilient shorelines that welcomed our early colonial settlers. However, these settlers also unintentionally introduced several influences that destroyed this indigenous vegetation responsible for accumulating and stabilising all available sand, and these 'unwitting' actions then prompted the devastation later reported by Cockayne, as shown above.

Also as discussed above, some local anecdotal information suggests the dunes of Ōmaro Spit (& Matarangi) were similarly affected by analogous harmful colonial activities. This indigenous dune plant destruction model is also supported by local remnants of those unsuitable introduced and non-halophyte alien plants, along with their typical forced or signature deleterious morphological responses - see photos 3-6.

Simply compounding these human-induced impacts was the La Niña weather pattern experienced last summer and winter. That weather anomaly typically induces dominant onshore wind and wave conditions for A/NZ's east coast beaches. Whenever La Niña conditions dominate, all those decimated littoral margins previously either never or improperly restored constantly experience moderate to severe beach erosion pressures. The complete contrast to these impacts also exists locally – upon those diligently restored shores adjacent to Kenwood and Matarangi Drives, utilising those same indigenous sand accumulating and stabilising halophyte foredune plants.

The explanatory La Niña conditions graph is shown below - sourced from NOAA (National Oceanic and Atmospheric Administration, USA), and this contains their July 2021 ENSO update: La Niña Watch.



GRAPH 1 (above): Monthly sea surface temperature anomalies (difference from average) in the El Niño 3.4 region of the tropical Pacific for 2020-21 (purple line) and all other years starting from first-year La Niña winters [Northern Hemisphere] since 1950. Climate.gov graph based on ERSSTv5 temperature data - Source NOAA Climate.gov - USA.

This authoritatively researched and produced graph above indicates that the threshold for La Niña domination was exceeded about October 2020, before slowly returning to the present less severe conditions around June 2021. This reveals that onshore wind and wave conditions were experienced locally all last summer/autumn – dominated by La Niña forced onshore NE & NW weather conditions that typically favour beach (and spit) erosion, especially problematic on this degraded non-restored beach ecosystems.

A recent update from NOAA (11 November 2021) now forecasts existing weak La Niña conditions to persist through the NZ summer and reveals these effects are likely to persist through to autumn 2022, when those conditions are likely to become neutral. "La Niña conditions, which emerged in October 2020, have a 90% chance of persisting through the winter months, and a 50% chance of continuing through spring [in USA]. The forecaster consensus anticipates La Niña to persist longer, potentially returning to ENSO-neutral during

April-June 2022," NOAA said in its outlook. (ENSO-neutral describes a climate pattern that is neither El Niño nor La Niña.)

As those unusual La Niña conditions are now confirmed as weak and currently heading back towards neutral – this update provides a favourable outlook for local beaches and the proposed restoration works at Ōmaro, including beneficial self-repair of minor erosion damage along the more easterly Kenwood Drive beaches.

Further human evidence of induced impacts, which were recently exacerbated by La Niña storm influences, are recorded in the following five Google Earth images, shown in chronological order from 2003 to 2020:

- **Source: Google Earth - images above kindly supplied by Grant Short, Matarangi.**

The five Google Earth satellite photos shown above reveal that over recent years Ōmaro Spit beach has been in a state of constant flux, at least prior to 2003, with large volumes of sand regularly being unnaturally moved merely at the whim of tides and storms, with nil sediment stabilising influences able to be provided or possible due to the long absence of indigenous halophyte foredune plants. However, the dominant alien plants that now barely survive the normal storm surge and high tide after-effects of seawater contact along these NW shorelines demonstrate their complete non-functional status – most often just presenting a slight nuisance value to tidal and storm movement or transport of sub-surface sediments. These foreign and functionally unsuitable species are completely incapable of trapping and stabilising artificially loosened/eroded sand volumes to improve the natural accretion function and resilience of local foredunes.

The only lengthy area providing a direct and beneficial naturally functional contrast is the *c.*3.6km length of successfully restored eastern section of Matarangi beach shown in photos 1 & 2, where significant dune progradation >30m is induced by recent restoration of the indigenous halophyte foredune vegetation shown in Figure 1. In direct divergence, the erosion zone on the NW edge of open space at the distal end of Ōmaro Spit (adjacent to Whangapoua harbour entrance) remains completely barren or is infrequently occupied by salt sensitive alien plant species comprising an eroding beach length of only *c.*500m. This beach/dune area is clearly exposed to the whim of all storms, La Niña dominated weather events plus heavy tidal sand transport influences; and furthermore, this impacted area has remained in this unnaturally barren and fully exposed condition for >18 years. This most recent serious erosion event then should come as no surprise.

Erosion of the distal tip of Ōmaro has exceeded any earlier Holocene erosion event - this conclusion is readily drawn from physical evidence available on site presently – see photos 7 & 8 below.

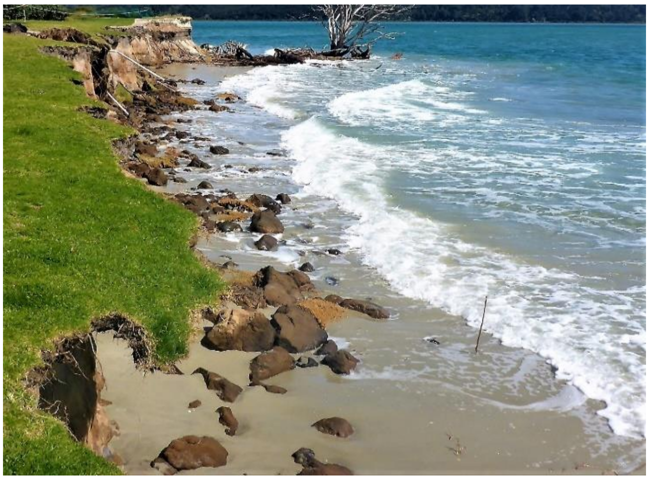


Photo 7: Ōmaro Spit - Sept 2021. 4,000-year BP reddish-brown slightly cemented iron-rich pan layer freshly exposed and now disturbed by ongoing erosion.

Photo 8: Ōmaro Spit - Sept 2021. Regular sub-4,000-year BP stratified depositional sediment layers now freshly exposed by these ongoing and unresolved erosion events.

Marks and Nelson (1979) estimate the geological age of Ōmaro dunes and dune ridges in their seminal technical paper "*Sedimentology and Evolution of Omaro Spit, Coromandel Peninsula*". That document reveals the basal dune ridge formations are composed of "iron-rich, slightly cemented, reddish brown pan" formations that "are over 4,000 years old". The stratified depositional layers overtopping the iron-rich pan are of course composed of younger aeolian material now systematically stratified into the bands shown in photos 7 & 8 above. As these authors state, dune processes during their formation were predominantly those of accretion, with occasional interruptions: "These [dune] structures are typical of aeolian deposition" – and never the scale of erosion that is presently evident. These depositional layers continued to be added and were largely intact over a 4,000 year long history of dominant sand accumulation (accretion) processes, prior to the initiation of very recent storm impacts (in geological time scales), commencing over 10 years ago as earlier human impacts remained completely unresolved (see photos 5 & 6). But previous restoration of the Kenwood and Matarangi Drive dunes ensured enduring protection of that similarly exposed area, but Ōmaro Spit merely remained in an induced erosional state, without any sensible restoration attempted here.

Despite conflicting claims, dune erosion to this calamitous degree is not <u>natural</u>, but it is frequently normalised to fit the European model of all coastal erosion being considered as 'natural' in origin. Rather, these extremely impacting and forced processes are simply normalised by willing acceptance of that fallacious dune response model where long forgotten historic human impacts are dismissed, and frequently 'normalised' – impacts that were in fact initiated globally ~10,000 years BP in the dawn of settled agriculture during the Neolithic revolution (Jenks 2018; Sampath, Beattie and de Freitas 2021).

Hence this present erosional condition was completely avoidable - a local coastal scientist surveyed the issue back in 2014 and suggested no further action be taken: "He explained back then the most appropriate option would be to pull back the [open space] golf course greens to allow for any future [erosion and] landward retreat" (Boyle pers.comm 2021). Such 'do nothing' responses are typical of the European model.

However, the author of this present restoration proposal recognised and reported on options to reverse that 'normalised' but human-induced and increasingly unstable nature of the entire Mercury Bay coastal zone in 2016, including the subject area of Ōmaro Spit, and was consequently requested to provide a sustainable dune restoration plan for all those severely degraded beaches. This detailed restoration plan is titled "Proven Sustainable Management of Mercury Bay Beaches - A five-year full coastal restoration programme covering the period 2016-2020". This logical 2016 restoration plan was unfortunately not effectively or efficiently enacted, so the present problem involving this open space community asset remains completely unresolved.

That innovative and sustainable 2016 restoration plan contains the following useful and even prophetic information, cited here for current reference: "a dangerous 'tipping-point' has been carelessly induced – **where truly natural beach accretion behaviour is dangerously and increasingly replaced by beach erosion** processes encouraged by those continuing and now 'normalised' human impacts" (Jenks 2016).

"This degraded coastal condition represents a new-norm that commonly exists, readily regularised and habitually reported. Most local (and global) dunes, barely persisting today but still perversely expected to increasingly buffer frequent storms and new climate change impacts are, by comparison, merely mounds of loose sand particles, diffidently bound (if at all) by a motley hodgepodge of mediocre, introduced and poor-performing weed species frequently also modified by the grazing of introduced domestic plus feral [herbivorous] mammals, and these tragically ineffectual plants are frequently destroyed by simple sea-water inundation (e.g. marram, lupin, pampas grass, kikuyu, Indian doab, pines etc.). Reality suggests that there should be no shock or surprise when these impacted mounds (the contemporary and even 'iconic dunes' as they are presently and erroneously titled) increasingly suffer from continuing and extensive supposed 'natural erosion'".

"Consequently, those many ostensibly innocent and erroneously-accepted destructive impacts have compounded to create a catastrophic continuum of coastal degradations. Conversely, simple, affordable, and attentive restoration of the original and functional C_4 halophyte foredune flora species convincingly reverses those historic and seriously deleterious biodiversity impacts, and such restorative transformation action increasingly and clearly challenges the notion that beach erosion is always 'natural' in origin" (Jenks 2016).

The species of plants discussed above are the four specialised low stature but sturdy indigenous halophyte foredune plants clearly demonstrated in figure 1 above (plus Holloway's crystalwort), the only known A/NZ (or alien) plant species that will naturally tolerate inundation by quite normal seawater. Their human induced absence has severely limited the functionally critical accumulations of protective sediment supplies that once freely increased the natural resilience of dunes to normal storm and La Niña impacts. This lack of an ecologically sound response has harmfully impacted dune integrity and post-storm accretion capabilities. That resilience and reliable dune integrity are indeed functional necessities in extremely turbulent littoral areas like fluxing harbour entrance channels.

This existing dune degradation issue clearly existing at least since 2003 (see Google Earth images above) has only been exacerbated by continued inactivity. That simple neglect has produced the currently vexing, continuing and unsustainable erosion problems, now requiring artificial movement of sediment just to provide a secure planting environment. Most zones will not require additional sediment supply (see Map 1), but Zone 4 will - these requirements will involve relocating sand from the immediately adjacent intertidal area (below MHWS) of this newly induced erosion zone (see photo 10). Until very recently this same sand was located on the aerial portions of the formerly stable dune immediately adjacent. But normal coastal processes working on this exposed and easily erodible sediment (largely unprotected by normal indigenous halophyte foredune vegetation) plus the impact of recent La Niña storms have forced the artificial relocation of that valuable local sediment from those once stable dunes and to these now mobile adjacent intertidal areas. Diligent restoration of these foredunes will of necessity prevent further sand transport into the Whangapoua harbour, where it will just assist in the unnatural infilling of that large water body, and/or increased navigation risk for boats crossing the Whangapoua bar.

Urgent preferential utilisation and diligent restoration of these indigenous halophyte plants is obviously and directly required here to regulate normal sediment flows and movements once again. Their renewed presence will ensure natural sand accretion and stabilisation processes between storms, will increase dune porosity and resilience, but only after suitable sand is replenished and those new volumes then stabilised.

But one of those foredune species is functionally extinct in the North Island – waiuu-atua, or beach spurge, *Euphorbia glauca.* One of the reasons for this extirpation is a regrettably high palatability, being especially attractive to all livestock and feral rabbits. Other impacts include disturbance by 4WD vehicles on beaches.

Another indigenous beach plant that has long evolved and specialised as a beneficial strandline sand-trapping species also has analogous palatability and responds to unnatural human induced impacts like waiuu-atua – this indigenous halophyte is known as Holloway's crystalwort, or *Atriplex hollowayi*. That species has a Current Conservation Status of 'Threatened – Nationally Critical'. With suitable collaborative input from local mana whenua, and provision of a necessarily secure habitat (free from rabbits and 4WD beach vehicles), attempts should be made to translocate and re-establish this exceptionally rare species at Matarangi. A valued colleague, Associate Professor (Conservation & Biodiversity) Dr. Peter de Lange, wrote the 2001 Conservation Plan (NZ Department of Conservation) for this species - "Considerable conservation effort has been undertaken by the Northland Conservancy of the Department of Conservation following a recovery plan written specifically for this species in 2001. As a result, Holloway's crystalwort has been successfully managed back from the brink of extinction. Plans are underway to reintroduce it to several more southerly locations that fit within its historic range".

Dr. de Lange and its Ngāti Kuri kaitiaki members have agreed by email that the first Aotearoa translocation of this extremely unique and threatened plant to a suitably secure 'southerly' location could be possible for Matarangi, but only with mana whenua agreement, invitation, and ongoing protection. This threatened strandline plant also traps and stabilises sand, it's utilisation will undoubtedly assist in raising and securing nesting areas for A/NZ shorebird species, like the endangered NZ dotterel (tūturiwhatu) on the seaward supratidal margin of restored foredunes.

So, this is the tenor of the community led restoration plans – complete sustainable reversal of existing human-induced erosion pressures of Ōmaro Spit, and utilisation of hybrid natural solutions where possible.

Sustainable, enduring reversal of human induced erosion pressures – Ōmaro spit, coromandel.

A period exceeding 18 years of apparent and comprehensive neglect has created a paucity of suitably elevated sand for immediate commencement of successful beneficial diligent restoration of the far distal end of Ōmaro Point.

Sluggish restoration of Whangapoua beach plus nil replanting on Ōpera and Ōmaro Points has prompted considerable sand bypassing and other unnatural transport relocations of that most critical sediment at these locations, which together, have culminated in this serious but predictable erosion response after the 'most severe' winter storms recently experienced (local anecdotal evidence). Repeated strong onshore La Niña winds from the NE (and NW) quarters PLUS poor environmental management have combined to effectively induce this now severe erosion impact situation.

But note, similarly acute storm responses were not induced on the restored main beach Matarangi dunes – clearly still within the same coastal compartment.

Stage One works (to be implemented autumn 2022) will be divided into 4 separate, more elevated and conjoined zones. Those zones are elucidated in Map 1 (page 7) of this document. Zones 1-3 will only require remedial plantings and some other minor inputs described on that page.

Zone 4 is less elevated so will require some sand nourishment, after the fallen pines are removed from the otherwise barren beach. A maximum volume of sand amounting to ~500m^3 (or less) could be required from adjacent intertidal sources to provide a suitably elevated planting site, this relocated sand to be moved back up against the recently eroded dune scarp, with a 1:20 slope. TCDC may be able to assist with this requirement, as they possess the necessary consent for that procedure.

DILIGENT DUNE RESTORATION PLANTINGS
Only the upper band against the old scarp (50m-long and 5m-wide) will be closely replanted with an appropriate selection of NZ indigenous halophyte foredune species (@ 1 plant/m^2), with indigenous mid-dune and kikuyu controlling plants utilised within the rearmost 1m wide band. Below those intensive planting zones, additional but wider-spaced plantings of the similarly halophyte species will occur (@ 1 plant/5m^2) on the lower 5m wide band. That lower band will assist the early and natural sand trapping/stabilising processes, while also limiting costs plus erosion risks in this possibly more sacrificial zone.

The rearmost 1m wide weed control band requires revegetation @ 3 plants/m^2.
A total of 1,500 indigenous low stature mid-dune and salt-spray tolerant (glycophyte) plants will be utilised in all most landward invasive weed control zones. This effective weed control strategy will also utilise a single annual application of the environmentally safe and selective haloxyfop (Gallant™) herbicide, to actively control inevitable invasions by alien non-salt tolerant weeds (e.g., kikuyu and other pest grass species).

The indigenous psammophile (sand loving), glycophyte (tolerant of <3.5% salt), and haloxyfop tolerant mid-dune plant species to be utilised for this crucial weed control role (and the landward walkway) are:
500 wiwi (knobby clubrush, *Ficinia nodosa*)
500 anawhata (sand carex, *Carex testacea*)
500 tarakupenga (sand coprosma, *Coprosma acerosa*)
1,500 indigenous low-stature mid-dune plants (**NOTE:** all these species grow less than 40cm tall)

The upper foredune zone @ 1 plant/m^2 ; requires a total of 2,000 halophyte foredune plants, composed of
1,700 Kowhangatara (spinifex, *Spinifex sericeus)*
[N/A Pingao (golden sand sedge, *Ficinia spiralis*) - currently not available due to nursery production problems due to Covid lockdown impacts - infill Stage Two plantings 2023]
800 Hinarepe (golden sand tussock, *Poa billardierei*)
2,500 indigenous foredune halophyte plants (**NOTE:** some substitution with pingao is being pursued)

TOTAL INDIGENOUS DUNE PLANTS required
1,500 mid-dune kikuyu-exclusion plants (an equal mix of wiwi, anawhata, and tarakupenga)
1,700 Kowhangatara
[N/A Pingao not available 2022 due to nursery production problems - infill Stage Two plantings 2023]
800 Hinarepe
4,000 plants total

Total costs for supply of these specialised species - about $16,000 + GST (including delivery costs and supply of controlled release fertiliser). Some substitutions with pingao is being arranged as supplies allow.

Follow up plantings of additional low-stature indigenous mid-dune species is recommended in years 5 and 10 after completion of this initial restoration programme, to ensure the new advancing seaward band of halophyte foredune plants does not then create a barren vacuum on its landward edge, a widening margin that is likely to be occupied by invasive weeds if left barren. Mid-dune species such as those discussed above should primarily be considered, but the increasing width of the regenerated dune may warrant inclusion of other similarly suitable and perhaps some other and/or taller species, such as the 20cm high autetaranga (sand daphne, *Pimelea villosa*), 30cm high pohuehue (wire vine, *Muehlenbeckia complexa*), 1.5m tall tauhinu (*Ozothamnus leptophyllus*), 2-3m taupata (mirror leaf, *Coprosma repens*), ti kouka (cabbage tree, *Cordyline australis*) or 1-5m ngaio (*Myoporum laetum*) etc. These natural indigenous mid-dune plants will also provide essential wind shelter for potentially exposed surface sand substrates on the public spit-perimeter walkway.

In efforts to ensure public edification and true empowerment, the most beneficial strategy for encouraging increased understanding and full comprehension of the benefits of utilising diligent restoration of these above species is to invite members of the local community to public information meetings and by creating regular local media items – so locals can learn more about the uniquely beneficial, functional, attractive, and affordable qualities of all these attractive indigenous plants. Community meetings can also provide a record of attendees who can be subsequently contacted for invitations to assist with restoration planting days in mid-autumn 2022. Active community participation in the restoration of these eroded dunes will generate an abiding sense of local ownership and pride in this most sustainable 21st century foreshore defense paradigm.

Analogous diligent foredune restoration programmes should contemporaneously be undertaken on Ōpera Point and finalised on Whangapoua Beach by TCDC, to naturally stabilise those mobile sand volumes.

SCHEDULE OF WORKS:

1. Arrange a prompt peer review of this report – **already achieved.**
2. Installation of temporary sand trapping fences – with thanks to Ray Fanning.
3. Commence the revised sand nourishment programme in autumn, with assistance from TCDC staff.
4. Complete comprehensive weed and rabbit control programmes within these planting zones.
5. Purchase controlled release fertiliser and arrange delivery of the pre-ordered supply of indigenous foredune plants - **autumn 2022**

Restoration of natural coastal processes at Ōmaro Spit will provide the following advantages.

1. enhance local populations of threatened indigenous functional halophyte foredune plant species
2. naturally, sustainably, and affordably increase enduring dune and beach widths + dynamic stability
3. ensure increased opportunities for sustainable harvest of Taonga Raranga Pingao by local weavers
4. enhance secure breeding grounds and important ‘nest’ elevations for NZ dotterel/tūturiwhatu
5. possibly provide a fresh translocation site for the critically endangered Holloway’s crystalwort
6. encourage rapid re-establishment and durability of the popular ‘spit’ walking track
7. provide affordable and enduring sustainable protection of the open space area.

Unresolved harmful human induced effects, winter storms and recent La Niña weather patterns plus Cyclone Cody impacts have all combined to induce unprecedented erosion of Ōmaro Spit, and significantly alter the direction and flow characteristics of the harbour channel(s), unnaturally increasing the sediment volumes of the ebb tide delta, and other sub-tidal areas. The former regular single channel was infilled by a surplus of freshly and unnaturally mobile sediment prompting channel branching, which has made the entrance shallower, more divergent, and more dangerous. The original single channel close to Ōpera Point may require beneficial dredging by Waikato Regional Council to improve navigation safety for small boat owners and return ebb tide flows to the original single outlet channel, and hence away from Ōmaro Spit.

This author has amassed >26 years of successful, beneficial experience with diligent coastal restoration projects utilising naturally functional, indigenous, C_4 halophyte sand accreting foredune plants, even including analogous spit situations. This 'new paradigm' of environmentally ethical work involves continuous improvement and adaptive management principles to ensure the most effective outcome every time. While this advanced ethic has received slow acknowledgement by some traditionalists, this 'disruptive innovation' includes working collaboratively with community, local authorities and iwi groups, plus coastal process academics wherever possible, to provide advanced restoration techniques, the compilation and recording of accumulated data, and the preparation of peer reviewed technical coastal science papers. These long years of dedication to restoration of normal protective coastal processes and ecological enhancement culminated in the awarding of an MNZM in 2011.

One of those above innovations was a collaborative project with Port of Tauranga (POTL) and their highly respected coastal science advisor, Professor Terry Healy - University of Waikato. Back in 1998, it was realised that many large local storm water (SW) drains were exiting onto the beach adjacent to Marine Parade, especially problematic was the Banks Avenue/Tay Street areas, Mt Maunganui. That concentrated collection of SW outlet flows was responsible for effectively 'pumping' sand offshore and thus lowering beach levels whenever intense rainfall from local storms was experienced. The resulting reduction of beach elevations prompted by those flows then just intensified existing dune erosion processes, as any wave runups were vastly enhanced by the resultant flat 'wet' beaches. Dune restoration was achieved more rapidly further away from those SW drains, but much slower where the SW-induced impacts were greatest.

Contemporaneously, large volumes of appropriately coarse, ocean-quality sediment were being dredged (and dumped in deep water) from the open-ocean harbour entrance channel, and this activity was deemed likely to increase as POTL expanded their shipping volumes. Before a new 1999 channel dredging campaign commenced, Healy confirmed that large volumes of sediment would normally and naturally bypass both the harbour entrance and Moturiki (Leisure Island), and so provide the natural sediment source for Mt Maunganui to Pāpāmoa beaches.

The combination of these artificial disruptions (SW drains + dredging impacts + earlier serious dune degradation issues) was discussed with Prof. Healy and BOP Coast Care volunteers. This discussion resulted in a resource consent being prepared and lodged for alternative nearshore deposition of that high quality dredged harbour entrance sand, rather than the then normalised dumping of that 'dredging spoil' into deep water to prevent it being returned to beaches by cross-shore diabathic movement. That consent application was recognised as a far more sustainable use of this naturally sourced sediment, to keep it within normal sand budget requirements. As a result, those former harmfully affected beaches now possess more stable and reliable restored dune processes than was ever possible when that valuable sediment was simply dumped deep out at sea. These restored dunes that now also possess intact sand budgets are still impacted by issues associated with the SW drains, but are now expanding in a seaward direction, with existing expansions exceeding 30m of horizontal growth along the 22km of Mauao to Pāpāmoa shoreline, analogous to Matarangi beach presently. This innovation continues today as the most sustainable natural use of dredged beach sediment in NZ – see Attachment C: **Mount Manganui - TAY ST BEACH accretion,** and Attachment D: **Mount Maunganui - Banks AVE 2020 Reversing human-induced erosion.** Any natural beach and sand budget impacts do count and must be reversed wherever possible – like at Ōmaro.

This novel littoral restoration initiative is becoming increasingly recognised for its important contribution to natural ecosystem values "In the twenty-first century, New Zealand's main approach to dune restoration is centred on re-vegetation using native plant species for stabilizing—rather than fixing—sand. Native plants have greater tolerance to wind, salt spray, sand-blasting, fluctuating temperatures, periodic drought, and poor nutrient conditions than most other species" (Sampath, Beattie & de Freitas 2021).

PROBABILITY OF SUCCESSFUL RESULTS WITH THIS PROPOSED METHODOLGY

Completely analogous and successful beach restoration techniques were utilised 27 years prior at heavily eroded Ohiwa Spit – which shares remarkably similar dune morphologies and processes to Ōmaro Spit. Ohiwa Spit reached infamy back in 1976 when several houses fell onto the eroded beach below. This erosion episode was earlier initiated in 1968 by ex-Cyclone Giselle, better known as 'the Wahine Storm'. See the failed vertical railway iron 'seawall' amongst the waves on the left 1976 photo - now completely buried by the naturally accumulated mass of increasingly stabilised dune sand seen in the right side 1996 photo.

OHIWA BEACH - Changes in management styles and their ensuing positive results for coastal ecosystems

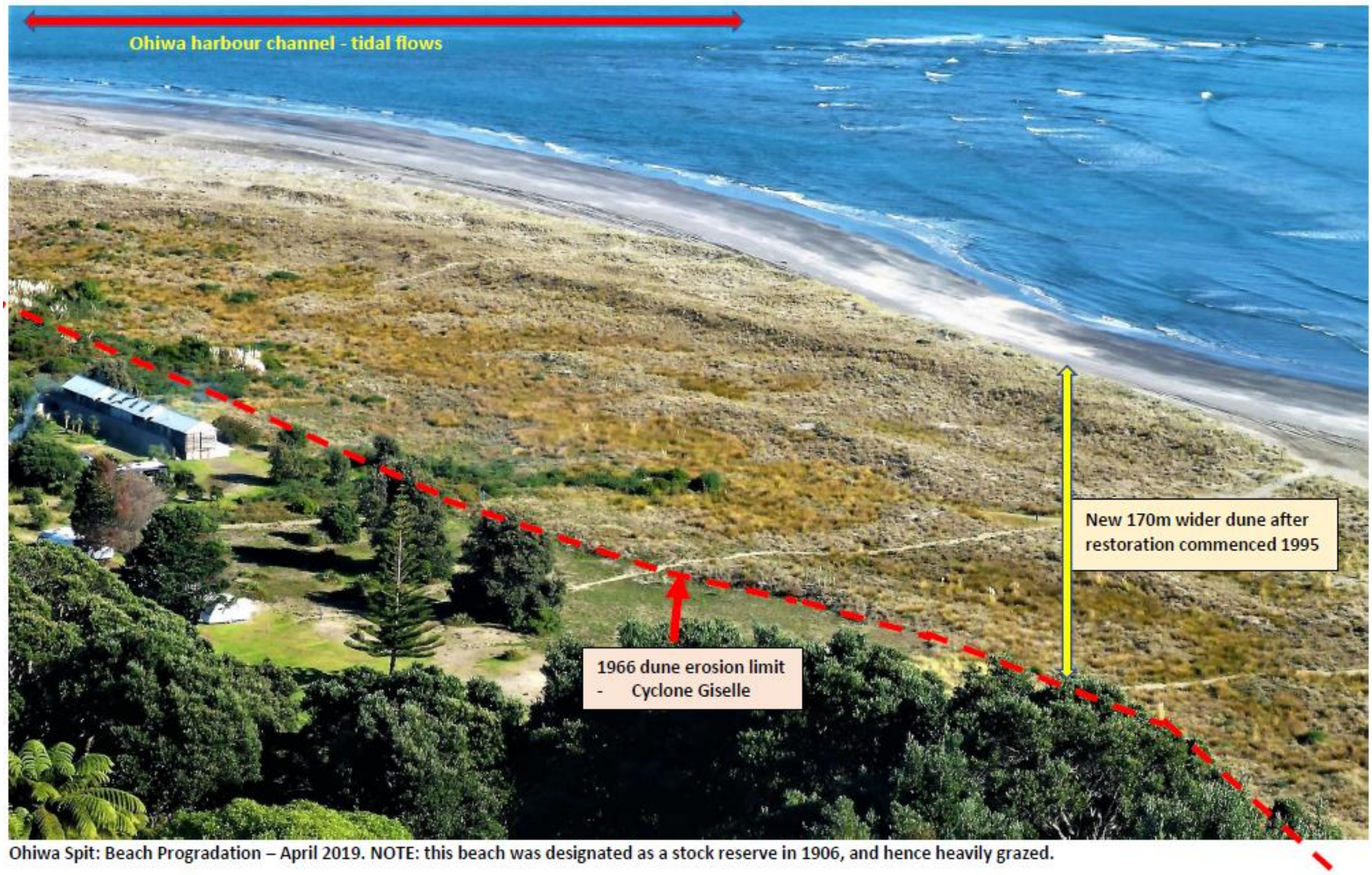
OHIWA BEACH 1976 – this photo reveals the effects of 1968's Cyclone Giselle - more commonly known as "The Wahine Storm". Three houses slid down the above eroded dune scarp into the sea, prompting the local council to build a plainly ineffective vertical railway-line seawall (seen in mid distance), and locals tossed old car bodies into the tide – to 'stop erosion'. But the actual dominant cause of that erosion on this coastal ecosystem was intense livestock grazing on this dune area after it was gazetted as a 'Stock Reserve' in 1906. Stock 'rested 'and grazed here after their long droving trips along the beaches east of Opotiki, removed all functional native foredune plants before their pedestrian journey continued to the Horotiu freezing works. Those sheep and cattle consumed all the palatable and functional indigenous dune plants from this ecosystem, thus damaging native flora & faunal habitats, AND crucially, natural coastal buffer processes. Introduced marram & lupins then invaded the area, but both are salt sensitive species – so those alien plants then prompted significant changes to coastal processes, and so beach erosion was the inevitable consequence. You can still see remnant marram plants at the top of the dune scarp above.

OHIWA BEACH 1996 – photo taken from proximate location to the 1976 photo at left – see the patch of introduced green kikuyu that has now replaced the earlier marram. Beach level has significantly improved (planters are above old car s) now that NZ indigenous salt-tolerant foredune plants again dominate coastal processes here – plants like kowhangatara & pingao. These naturally salt-tolerant (halophyte) plants rapidly colonised this beach after grazing ceased and storms removed most marram & lupins, once again stabilising & storing sand during and after future storm impacts – these native plants function naturally through the most challenging circumstances in this extremely hostile and dynamic ecosystem – the beach. Stock impacts are now permanently removed - droving stock through Opotiki town was banned in 1985, this antiquated practice being replaced by modern transport means - stock trucks. But the second largest grazing threat (feral rabbits) still requires control to minimise their numbers and impacts. Weeds are now readily controlled on dunes. Therefore, this dune is again able to function naturally, so consequently a dramatically wide expansion was quantified here in 2018: the new dune **exceeded 170 metres further seaward** than the 1974 erosion scarp shown at left.

Figure 2: Reversing 1968 Ohiwa Spit erosion

But as detailed above, the probable primary impetus for this disastrous erosion episode was the complete removal by early grazing of the original indigenous halophyte sand trapping and functional foredune plants. The restoration of these functional plants has again assisted to trap and stabilise much of formerly mobile sand volumes, to then create the prograding dune seen on the right 1996 photo above. The true extent of this new protective dune can be seen in the image below.

Similar responses are forecast for the dunes at Ōmaro Spit, with some significant sand trapping and stabilising expected after diligent restoration of the indigenous 'keystone' foredune plants – naturally functional species that regulate sand accretion and porosity processes while minimising dune erosion. These specialised plants also work in tandem with enhancing habitats for indigenous coastal fauna to ensure all complete and 'free' ecosystem services are maximised.



Ohiwa Spit: Beach Progradation – April 2019. NOTE: this beach was designated as a stock reserve in 1906, and hence heavily grazed.

Figure 3: Confirmation of the reversal of 1968 Ohiwa Spit erosion by BOP Regional Council Beach Profile Surveys.

Similarly innovative dune restoration and sand nourishment projects using their locally indigenous halophyte foredune plants are now being utilised by NASA in Florida, and so providing the best protection results for NASA's multi-billion-dollar rocket launch pads at Kennedy Space Center, Cape Canaveral. The following text is sourced from "The Biggest Threat to NASA's Future Is the Ocean" – "Although Kennedy is NASA's most threatened asset, all of the space agency's properties — some $US32 billion (**$41.9 billion**) worth of infrastructure used for scientific research, aeronautics testing, astronaut training, deep space missions and vehicle assembly — face challenges in a changing climate".

"This is a very large concern for our agency as a whole, Toufectis says. And given our growing need to go into space, not just for scientific research, but to harness new resources, colonise other worlds, monitor plus study the one overburdened biosphere we've got, anything that threatens future operations and NASA threatens the entire world".

"Wallops Island [Cape Canaveral] started hardening its defences in earnest in the 1990s, when NASA erected a 6km stone seawall in front of the launch pads. But while the wall initially helped to reduce storm damage, the beach beyond it was soon worn to shreds. **By the mid-2000s, storm waves were breaking directly against the wall, causing those sections to crumble into the sea".** This issue occurs in NZ too.

"And so, in the autumn of 2012 and the winter of 2014, with a $US54 million ($NZ70.8 million) investment from Congress, NASA and the US Army Corps of Engineers dredged around three million cubic metres of sand from offshore, and a new beach was built [and restored] beyond the wall. The impact was sudden and dramatic".

"Majestic sand dunes along a pristine shoreline make for a picturesque landscape. They also serve a crucial role in the natural environment. The effort was celebrated with a ceremony at the site of the restoration effort."

That fresh sand was restored by utilising Florida's own locally indigenous halophyte foredune vegetation, plants that beneficially trap and stabilise local sand just as the equivalent A/NZ foredune plants do here.

Sand accretion data has recently been collated here in A/NZ, on two disparate BOP beaches, and predictably these sand accretion data are mimicked on the local community restored main beach Matarangi restoration sites and even exceeded at the analogous Ohiwa Spit restoration site. The BOP data is presented below in **Table 1: Sand Accretion Data from Diligently Restored BOP Beach Ecosystems:**

Assiduous Dune Restoration Effects: Proven Impacts of Sand Accretion Data - Papamoa Domain & Mt Maunganui Beaches.

1. <u>Papamoa Domain Surf Club</u>: Data collected utilising the innovative Sand Datum Posts, securely placed in June 2008 at the dune toe and 'zero' base-mark. This placement has revealed the following globally-unique information, gathered where indigenous plant species are utilised exclusively to restore natural coastal littoral ecosystem function:

ASSIDUOUS DUNE RESTORATION – PAPAMOA BEACH ECOSYSTEM RESPONSE: 1996 to JUNE 2014

ESTABLISHMENT DETAILS	DUNE DEPTH CHANGES to 2014	DUNE WIDTH CHANGES to 2014	DUNE VOLUME CHANGES to 2014	CHANGES <u>PER ANNUM</u>
1995/96 Plantings: twice only - as natural plant colonisation & proliferation ensued	**1995** – beach was eroding, datum established at zero base-mark	**+30metres** (m) of extra width at present and continuing	Not quantified originally – suitable instruments were not initially available	**Dune width growth +1.6m/year.** This rate of gain continues
2008 Datum Posts added, to quantify changes in sand depth + dune width i.e. **dune volume changes**	**2014: sand accretion 1.0m deep** (recorded after datum post placement 2008)	**+12m seaward** of the original datum post location, and still improving	**>30m^3/lineal m** of beach following the original planting, this gain continues	**Dune volume growth +1.7m^3/year/lineal metre** of beach, and this rate of gain continues

Data collected from the above beach system was analysed, and the derived information provided robust data used in the CLIMsystems Ltd poster prepared for the 'ESRI Users Conference', San Diego 2015. Information from the above case study reveals that diligent dune restoration effects can completely off-set the expected storm surges and impacts of +118cm of sea level rise through to year 2100.

2. **Mount Maunganui, Marine Parade beach**: Very similar results occur at this popular beach-resort town on the northern Tauranga coastline, *c.*12 km NW of Papamoa and on the same coast. Here, the dune was more recently restored (in 2002) but sand datum posts were similarly installed in 2008, and the accumulated sand volume recorded through to 2014 (that accretion rate continues still):

ASSIDUOUS DUNE RESTORATION – MT. MAUNGANUI BEACH ECOSYSTEM RESPONSE: 2002 to JUNE 2014

ESTABLISHMENT DETAILS	DUNE DEPTH CHANGES to 2014	DUNE WIDTH CHANGES to 2014	DUNE VOLUME CHANGES to 2014	CHANGES PER ANNUM
2002 Planting: once only - as natural plant colonisation & proliferation ensued	**2002** – beach was eroding, datum established at zero base-mark	**+20metres** (m) of extra width at present and continuing	Was not quantified originally – suitable instruments were not initially available	**Dune width growth +1.6m/year.** This rate of gain continues
2008 Datum Posts added, to quantify changes in sand depth + dune width i.e. **dune volume changes**	**2014: sand accretion 0.7m depth** (recorded after 2008 datum post placement)	**+8m seaward** of the original datum post location, and still improving	**>14m^3**/lineal m of beach following the original planting, this gain continues	**Dune volume growth +1.2m^3 /year/lineal metre** of beach, and this rate of gain continues

NOTE 1: robust indications of similar improvements to beach processes and sand accretion have been observed at all other successful project sites in NZ. However, due to the limitation of resources available at establishment, precise data is not available from those additional areas – however their photo-records disclose equally compelling results.

NOTE 2: accumulation of significant sand quantum continues unabated – on all diligently restored dunes & beaches.

NOTE 3: intense La Niña episodes during the above periods would have 'normally' induced significant erosion pressures on these exposed east-coast beaches; such impacts occurred on other non-restored beaches in other regions, Coromandel Peninsula for example.

NOTE: the dune expansion data (beyond restoration) recorded above at Papamoa is completely analogous to the experience at Kenwood Drive, Matarangi: where local renewed dune accretion **now exceeds 30m**.

BOP-style Sand Datum Posts (SDPs), as utilised above for quantifying and collating sand accretion data, should also be supplied and utilised at the Ōmaro Spit restoration sites. The collected data can then be similarly utilised by CLIMsystems NZ Ltd in their Coastal Erosion computer model, to increase confidence for dune restoration projects on this and other analogous nearby sites.

STAGE TWO plans: The diligent beach restoration plans detailed for Stage One (above) plus forecast decreasing La Niña conditions will increase natural sand accretion rates for the diligently restored areas after completion. That achievement will ensure these areas are relatively safe from subsequent erosion – with accretionary spill-over of restoration edge effects for those areas adjacent to restored zones. But the rate of accretion/progradation will ultimately depend on the prevailing climatic conditions, especially the timing of a return to neutral for La Niña. The most recent update from NOAA (December 2021) is provided below. As can be seen from that revision, La Niña conditions continue to follow the earlier July 2021 outlook, heading back to neutral conditions around April–June 2022 (or Spring 2022 for northern hemisphere USA).

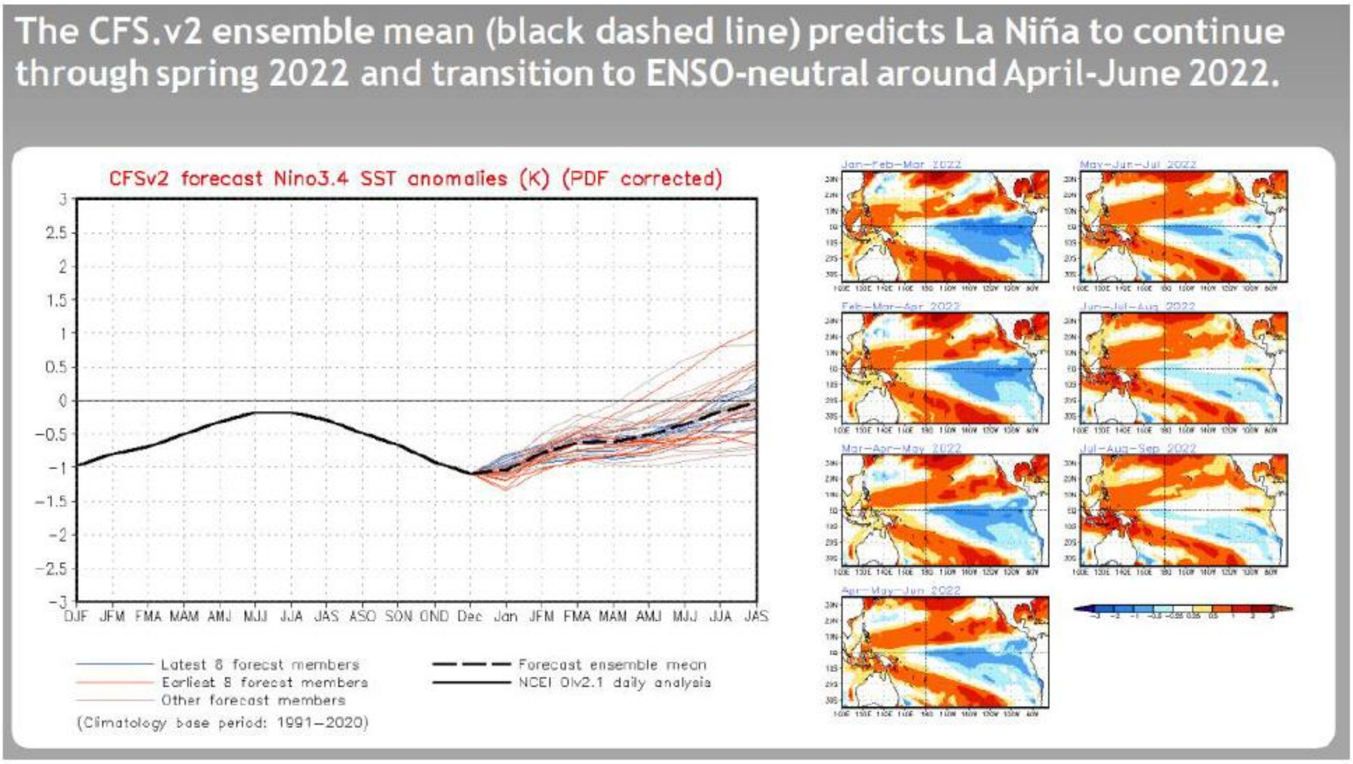
Any further plans for reversing erosion concerns on Ōmaro Spit (especially adjacent to the heavily exposed distal golf course/open space area) ultimately depend on prevailing climate conditions following the expected 'normalisation' of the existing significant La Niña, plus the scale and longevity of accretionary responses following the impacts of community restoration activities in late autumn 2022. There may be some short-term compromise required by users of the golf course/open space, cooperation that will be rewarded by long-term security for the increasingly stable integrity of this open space and its perimeter public walking track.

Should the predicted restoration edge-effects of Stage One come to fruition as anticipated and La Niña conditions return to neutral, then significant natural diabathic return of eroded sand volumes can be expected, leading to simple restoration of the remaining ~200m will be readily accomplished of that returned sand adjacent to the distal end of Ōmaro Spit (adjacent to the Whangapoua channel). That work may possibly require some limited sand push-ups, but only time will provide the true response needed here.

A second possibility could also encompass a revival of the geotextile groyne option, if required and deemed necessary for success later this year for additional consented works in 2023.

NOAA (USA) – updated Dec. 2021 La Niña outlook.

URL: https://www.cpc.ncep.noaa.gov/products/analysis_monitoring/lanina/enso_evolution-status-fcsts-web.pdf



This globally respected updated model of La Niña weather patterns continues to indicate La Niña is heading slowly back to more neutral conditions, by skirting the crucial 0.5 degrees Celsius anomaly during the February-March-April (FMA) period, and then clearly lying within that neutral 0-0.5°C band in June-July- August (JJA) .

GRAPH 2 (above): Updated monthly sea surface temperature anomalies - NOAA.

CONCLUSION:

Diligent and sustainable restoration of local beach ecosystems now benefits from greater than 26 years of proven beneficial progradation responses - these reliably, affordably, and enduringly reverse many of the problems associated with human-induced coastal erosion. This ‘new’ innovative paradigm has been cited by the IPCC in their 4th Assessment Report (Jenks *et al* 2007). Those previous unnatural human inflicted complications (Cockayne 1911) have now been conclusively identified as the ‘true root cause’ of existing beach erosion processes.

While these concepts may appear too pioneering for some, we are on the cusp of creating improved awareness of this simple, most sustainable solution to the world’s coastal erosion problems, difficulties helpfully identified in A/NZ by an early 20th Century British botanist, Dr Leonard Cockayne.

Languid earlier responses have generated severe erosion impacts that have been further aggravated by ex-Tropical Cyclone Cody. These impacts therefore require progressive determined remediation – hence this restoration is planned over two years of implementation – in Stages 1 & 2.

Most recently, Sampath, Beattie & de Freitas (2021) offer local and international support for this new ecological dune refurbishment technology for sustainable and enduring littoral management: "In the twenty-first century, New Zealand's main approach to dune restoration is centred on re-vegetation using native plant species for stabilizing—rather than fixing—sand. Native plants have greater tolerance to wind, salt spray, sand-blasting, fluctuating temperatures, periodic drought, and poor nutrient conditions than most other species". These Lisbon University (Portugal) and Victoria University (Wellington) authors recognise that diligent "restoration efforts have allowed dunes to achieve the [truly] natural character of an active dune system. Thus, ecologist Greg Jenks suggests that this successful, affordable dune restoration work has extensive benefits for other nations experiencing degraded coastal zones" (Sampath, Beattie & de Freitas 2021). Such international support reveals the true worth of diligent dune restoration for Ōmaro Spit.

This ecosystem restoration solution proposed for Ōmaro is underpinned by more than 26 years of most affordable, beneficial, and enduring results on BOP beaches (Jenks *et al* 2007) that include the analogous Ohiwa Spit beach. These reversals of littoral erosion are aided by recent natural storm resilience successes on the restored Matarangi dunes, and with recent analogous international dune restoration advances utilised by NASA at Kennedy Space Centre (with collaboration of a team comprising scientists from US Geological Service, US Army Corps of Engineers and University of Florida) plus other recent technical support from Sampath, Beattie & de Freitas (2021). Some time may be required for more conservative local coastal science professionals to acknowledge these disruptive new but entirely beneficial paradigms for superior coastal management.

Several compelling peer reviewed science papers have been referenced below, but still a baseless conservative hesitancy often persists, much like vaccination hesitancy for proven efficacious Covid-19 treatments. Rational people will soon realise that hesitancy has no place when all the associated risks and benefits are considered. Most of those rational folk will simply decide to proceed and just do it.

Simply put, the same positive rational action should occur regarding approval of this sustainable lowest-cost community-involved proposal for beneficial ecological and enduring open space plus flora/fauna habitat restoration of Ōmaro Spit.

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