GROWING RESILIENCE

Recommendations for Dune Management at North Ocean Beach

PART OF THE **SUNSET NATURAL RESILIENCE PROJECT**

SFEI San Francisco Estuary Institute
ESA
Coastal Conservancy


Growing Resilience:
Recommendations for Dune Management at North Ocean Beach

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Glossary

Backdune
The landward side of a dune (the part that faces away from the ocean).

Backshore
The area between the beach face and the front of the dune, cliff base, wrack line, or any coastal protection structure.

Bathymetry
The topography or morphology of the seafloor and coastal areas.

Beach Face
The sloping section of beach where the swash and backwash of waves occurs.

Brush Matting
Flat placement of unanchored, overlapping branches (tree trimmings) to stabilize the sand surface. Brush matting is temporary, breaking down in a few years and then fully degrading into organic matter.

Constructed Dune
Engineered structures reproducing the form of natural dunes.

Cusps
Small, uniformly-spaced U-shaped embayments on a beach, each separated by protruding ridges.

Dune Blowouts
Unvegetated, wind-eroded troughs or bowl-shaped depressions in foredunes, with depositional dune lobes downwind.

Dune Field
An area covered by extensive sand dunes.

Dune Lobe
The sand eroded by wind from a blowout is deposited immediately downwind to form depositional lobes.

Embryo Foredune
The earliest stage of dune formation, consisting of pioneer colonies of perennial vegetation.

Fetch
Horizontal distance over which wind blows.

Foredune
Shore-parallel dune landforms formed by the interaction between wind transport of beach sand and sand-trapping, burial-tolerant perennial coastal dune vegetation. Foredunes are the primary topographic feature landward of the backshore.

Lag
Coarser sediment, (e.g. pebbles, shells), that persists on a beach after finer particles have been carried along the shore by waves, winds, and currents. Lag deposits are characterized by their greater resistance to erosion and transport compared to the more mobile sand.

Perched Dune
Dune that forms on top of a cliff, pre-existing dune, or embankment.

Ramp
A seaward-facing slope of sand.

Rip Current
A wave-driven current flowing seaward (away from the beach) through the surf zone.

Runnel
Shore-parallel depression between intertidal sand bars (ridges) that fills with water during high tides.

Sand Backpass
Refers to the procedure of excavating sand from north Ocean Beach and placing it at erosion hotspots at South Ocean Beach (south of Sloat Blvd).

Scarp
A steep slope or cliff adjacent to a flat or gently sloping area.

Slipface
The steep, leeward (away from the wind) side of a sand dune which sand grains slide down due to gravity and wind action.

Slump-block
Cohesive mass of sand that has detached or broken away from the main dune structure due to gravity or erosion.

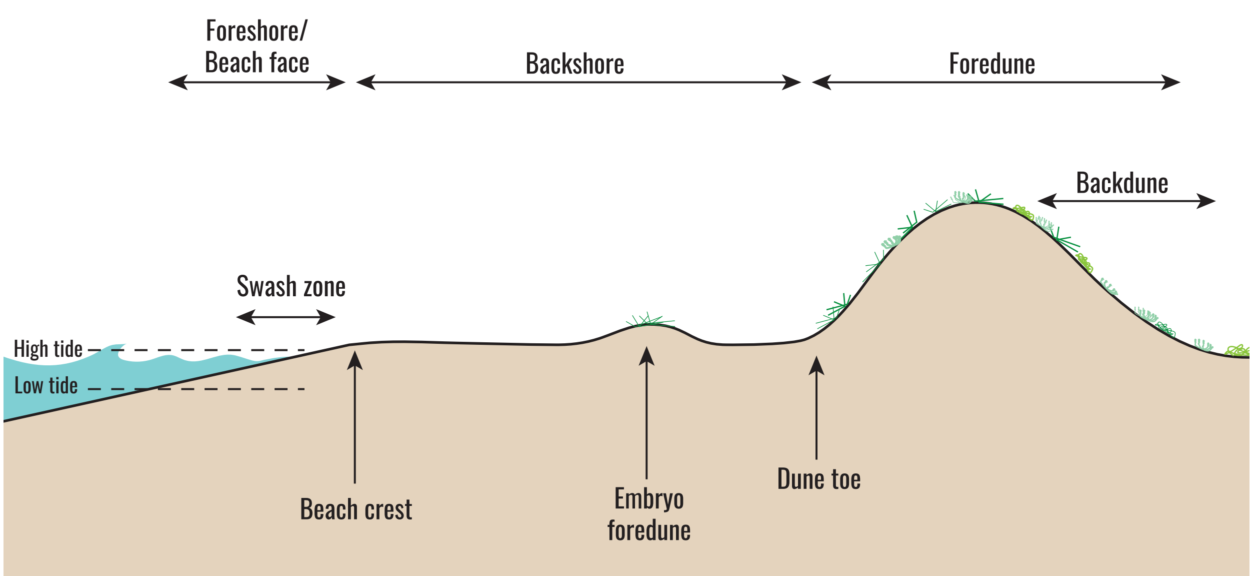
Swash Zone
The area on a beach where waves rush in before retreating back into the ocean.

Toe
The lower, seaward edge of the dune or berm that is closest to the water's edge.

Wave Refraction
The bending of ocean waves as they approach a coastline, caused by the slowing of the wave as the depth decreases.

Wave Focusing
Concentration of wave energy at certain coastal points, often headlands, due to wave refraction.

Wrack Line
The line or band of debris and organic material, such as seaweed, shells, and driftwood, left behind by the highest tide or wave action.



Executive Summary

Ocean Beach faces escalating dune erosion, primarily due to human-induced factors like informal trails causing trampling, leading to blowouts and destabilization of protective vegetation. Areas affected by blowouts experience wind-driven sand accumulation on the Great Highway, posing safety risks for pedestrians and vehicles and requiring costly maintenance. In addition, rising sea levels pose a significant long-term threat, as increased erosion will only add to management challenges.

This report provides a range of strategies to: (1) help minimize sand deposition on the promenade and Great Highway, (2) reduce maintenance costs and effort, (3) create and enhance native dune habitat, (4) facilitate public access to the beach for recreation, and (5) increase the resilience of the shoreline and dunes to sea-level rise and coastal erosion.

Strategies include:

- Engaging the public in education and outreach efforts to increase understanding among residents and beach-goers about the challenges faced at Ocean Beach and the value of a nature-based adaptation solution like dune revegetation.
- Establishing dune-adapted vegetation. Beach wildrye (*Leymus mollis*) and other native species can trap sand and build up dunes to prevent landward migration of blowing sand. Beach wildrye propagation is a critical path item, and enhancement cannot progress without it. Plantings will need two years to propagate, and one year to establish after out-planting, so starting propagation efforts soon is a key first step.
- Changing future sand removal and placement activities by preventing disturbance in the backshore, which inhibits dune formation, and placing sand in the foreshore, where it can be redistributed by waves. After dune vegetation is established, continuing to place sand seaward of the dunes can nourish the beach and dunes and help slow erosion.
- Preventing trampling of dune vegetation. Trampling by pedestrians leads to blowouts and migration of sand onto the Great Highway and promenade. Examples of strategies for preventing trampling include consolidating trail access locations, placing brush matting (cut branches from trees and shrubs) in revegetation areas, and creating educational signage to encourage beach users to stay on trail.
- Increasing collaboration between local City and County of San Francisco agencies and Golden Gate National Recreation Area (including across jurisdictional boundaries) and with residents and beach-goers to enhance stewardship of the beach and dunes.

The following table provides a summary of the existing conditions, main challenges, proposed conceptual design, and near-term implementation actions at each reach of the beach (reaches shown in Figure 1.1).

Reach	Existing Conditions	Main Challenges	Conceptual Design Summary	Near-term Implementation Ideas
A - North of Lincoln Way	• Wide, flat backshore with no foredunes nor vegetation. • Shore accreted 200 feet from 1992-2021, but is unlikely to sustain much additional seaward expansion due to sea-level rise.	• Current grading practices prevent dune formation. • The borrow area for the sand backpass to South Ocean Beach is in the backshore and close to the seawall, preventing dune formation. • Need to reconcile any conceptual design with existing recreational uses.	• Move sand backpass excavation seaward into the runup zone, excavating coarser sand which is better for placement at South Ocean Beach. • Allow a new vegetated foredune to form, creating a sheltered recreational area inland in its lee. Place "driftwood" logs to aid foredune development. • Create pedestrian access paths to reduce vegetation trampling.	• Create updated permits/ practices for backpass mining location in Reach A. • Halt backshore grading. • Allow natural wrack (wood, kelp) to remain on the beach, with the option to also import "driftwood" logs.
B - Lincoln Way to Noriega Street	• Moderately wide beach with high foredunes accreted over constructed sand berms, vegetated primarily with invasive marram grass. • Where vegetated dunes are intact, they prevent onshore sand transport. • Shore accreted 140 feet from 1992-2021, but unlikely to sustain much additional seaward expansion due to sea-level rise.	• Pedestrian trampling of vegetation initiates blowouts; large unvegetated mobile dunes encroach onto Great Highway. • Limited space exists for the further development of embryo foredunes.	• Remove invasive iceplant and marram grass from dunes, regrade blowouts, establish native vegetation with primarily dune-stabilizing beach wildrye. • Create pedestrian access paths to reduce vegetation trampling and plant a dune scrub buffer along Great Highway to reduce access points.	• Place sand cleared from Reach B over iceplant flats near Irving. • Winter: Transplant native beach wildrye from adjacent stands to create self-regenerating beach wildrye propagation bed in the backdune area near Irving St. • Place brush matting in trampling hotspots (e.g. at Judah and Lawton).

Reach	Existing Conditions	Main Challenges	Conceptual Design Summary	Near-term Implementation Ideas
C - Noriega Street to Santiago Street	• Moderate to narrow beach width, relatively stable from 1992-2021. • Wave focusing amplifies erosion in some sections of this reach, with wave runup occasionally reaching the Noriega seawall.	• Wind blows sand onto promenade and Great Highway as sand ramps form against seawall. • There is a narrow zone where embryo foredunes can form. • Annual maintenance activities prevent vegetation establishment and dune formation. • Severe wave events cause erosion and will become more frequent with sea-level rise.	• Create a new foredune ramp seaward of the seawall and stabilize with beach wildrye and other native species. • Place “driftwood” logs in the winter wrack zone to stabilize the dune toe. • Create pedestrian access paths to reduce vegetation trampling.	• Place sand cleared from the Great Highway or promenade in foreshore areas where waves can redistribute it. • Allow natural wrack (wood, kelp) to remain on the beach, with the option to also import “driftwood” logs.
D - Santiago Street to Sloat Boulevard	• Narrow erosional shore with minimal foredunes and a high sand berm • Progressively eroding, with the high tide shoreline receding 100 feet from 1992-2021; erosion is likely to continue or accelerate with sea-level rise. • Iceplant dominates and is ineffective at trapping sand.	• Ongoing erosion threatens roadway and infrastructure. • Limited space for embryo foredunes. • Blowouts and sand movement onto the Great Highway occur due to limited vegetation cover.	• Grade sand over the iceplant-dominated perched dunes and scarp. • Vegetate dunes with beach wildrye and stabilize at the toe with logs. • Once vegetation is established, place sand in the backshore to nourish the dunes and protect the road and infrastructure from wave overtopping. • Consolidate pedestrian access as in other reaches to reduce trampling impacts.	• Place sand cleared from the Great Highway in foreshore areas where it can be remobilized by waves. • Place brush matting in trampling hotspots. • Allow natural wrack (wood, kelp) to remain on the beach, with the option to also import “driftwood” logs.

This report outlines an implementation approach in Chapter 9. The first step is the propagation of beach wildrye, followed by the removal of invasive vegetation, grading, and planting. Once vegetation is established, sand can be placed to nourish the beach and dunes. It is crucial that vegetation is established before sand placement to allow natural processes of sand trapping and accretion to proceed. Successful execution depends on consensus and coordination between managing agencies, a robust public engagement strategy, and a clear adaptive management plan. Regular audits of the management and coordination strategy can contribute to the collaborative process, guiding the determination of future steps in this dynamic coastal management initiative.

Site visit with partners at Ocean Beach, May 30, 2023. Photo by Ellen Plane, SFEI.

1. Introduction

The Sunset Natural Resilience Project (SNRP) comprises six distinct yet interconnected projects in western San Francisco that will enhance the ability of human and natural communities to prepare for climate change impacts. Each project aims to further the biodiversity goals of partner organizations while making the city of San Francisco a more livable and enjoyable space. Ocean Beach is one of the six SNRP sites.

This report provides recommendations for sand management and dune restoration at Ocean Beach north of Sloat Boulevard. Recommendations are based on an assessment of the historical evolution of the dunes, existing conditions and management practices, and the anticipated response of the beach and dunes to sea-level rise. This work builds on the information and vision provided by the Ocean Beach Master Plan (OBMP) (SPUR et al., 2012). The conceptual designs proposed here are particularly relevant to the OBMP's Key Move 4: Restore Dunes along the Middle Reach (defined in the plan as the reach from Lincoln Way to Sloat Blvd). The concepts in this report also build on lessons learned from dune vegetation and management conducted as part of San Francisco's Clean Water Program in the 1980s and from projects elsewhere in California and in Oregon (e.g. Surfers Point, Ventura; Pacifica State Beach). Other documents related to past and current sand management practices are described in Section 3, Agency Jurisdictions and Key Agreements.

The study area covers Ocean Beach from its northern terminus at Point Lobos (where the Cliff House is located) to Sloat Boulevard. The study area is divided into four reaches: A (Cliff House to Lincoln), B (Lincoln to Noriega), C (Noriega to Santiago), and D (Santiago to Sloat; Figure 1.1). This area corresponds to the North and Middle Reaches described in the OBMP. The portion of the beach south of Sloat (referred to as South Reach in the OBMP), where erosion issues are most acute, is covered by the ongoing multi-agency Ocean Beach Climate Change Adaptation Project (San Francisco Water Power Sewer, 2023) and is not covered by the Sunset Natural Resilience Project. However, we do consider the mechanical transport of sand from North Ocean Beach to the south of Sloat to address erosion issues in that area.

This report addresses several key management challenges at Ocean Beach:

1. **Dune erosion.** The existing dunes along Ocean Beach are constructed sand berms capped with naturally deposited dunes, rather than wholly natural coastal dune landforms. They have experienced significant and accelerating erosion in recent years. Erosion has been driven by the creation of informal trails (a.k.a. "social trails" or "use trails") where major streets intersect the Great Highway. The trampling of vegetation destroys protective surface cover and root systems that stabilize the dunes. Wind erosion enlarges bare sand trails over years, forming massive dune blowouts: areas where the wind has removed sand from the dune's surface, creating depressions or openings in the dune. This has led to the growth of large, migrating unvegetated dunes that create a pathway for sand to be blown directly inland from the beach, onto the Great Highway. Trampling, erosion, and blowouts reduce vegetation cover, alter hydrological conditions, and disrupt dune microhabitats which are nesting sites, burrows, food sources, and shelters for a variety of dune organisms. Sand management practices as well as natural processes like erosion, wave focusing and rip currents also contribute to dune erosion.

Figure 1.1. The study area is divided into four reaches: A, B, C, and D. The section of the beach south of Sloat Blvd is outside the study area. The OBMP South Ocean Beach reach is the location of the multi-agency Ocean Beach Climate Change Adaptation Project.

2. **Wind-blown sand.** In portions of the beach without dune features or where there are blowouts, sand is transported inland by the wind and accumulates on the Great Highway and adjacent promenade, interfering with their use by people and cars and causing safety hazards for both. Wind-blown sand on the road also deposits into storm drains, where it causes problems for the city's combined sewer system. After particularly strong wind events, sand can also move further inland, accumulating on nearby neighborhood streets.

3. **Sea-level rise.** Rising sea levels will likely alter wave-driven littoral transport and patterns of beach erosion, resulting in a decrease in the width of the beach seaward of existing hard infrastructure such as seawalls, roadways, and buried utilities. The Ocean Beach Master Plan (SPUR et al., 2012) concluded that the dunes and much of the beach would be eroded by 2070 unless sea-level rise adaptation measures were implemented.

To address these key challenges, it is important to first understand the historical context and the processes driving management decisions and actions at Ocean Beach today. Chapter 2 provides an overview of the historical evolution of beach and dune management at Ocean Beach. Chapter 3 lays out the jurisdictions of each agency and summarizes the key documents and agreements pertinent to future management decisions. Chapter 4 presents general conceptual models explaining the drivers behind today's beach processes, and Chapter 5 goes identifies the main challenges at each of the four reaches identified in Figure 1.1. Chapters 6 and 7 describe management goals, objectives, and strategies in general, and Chapter 8 applies these strategies, describing conceptual designs for each reach of the beach. Finally, Chapter 9 discusses implementation considerations and lays out a possible timeline of actions.

A key management challenge not addressed in this report is the integration of planning for the Great Highway's future with Ocean Beach's future management. Since April 2020, the San Francisco Recreation and Parks Department (RPD)'s Great Highway Pilot Project has closed the Upper Great Highway between Lincoln Way and Sloat Boulevard to car traffic on Friday afternoons, weekends, and holidays, allowing the two-mile segment to transform into a promenade used by pedestrians and bicycles. During weekdays the roadway is open to cars, while pedestrian use is limited to the seaward promenade and the cityside multi-use paved path. This pilot project has been controversial, with strong supporters and opponents in the local community. A separate task of SNRP will examine the future of the Great Highway in terms of enhancing biodiversity planning from Ocean Beach inland to the Sunset District.

2. Historical evolution

PRE-DEVELOPMENT

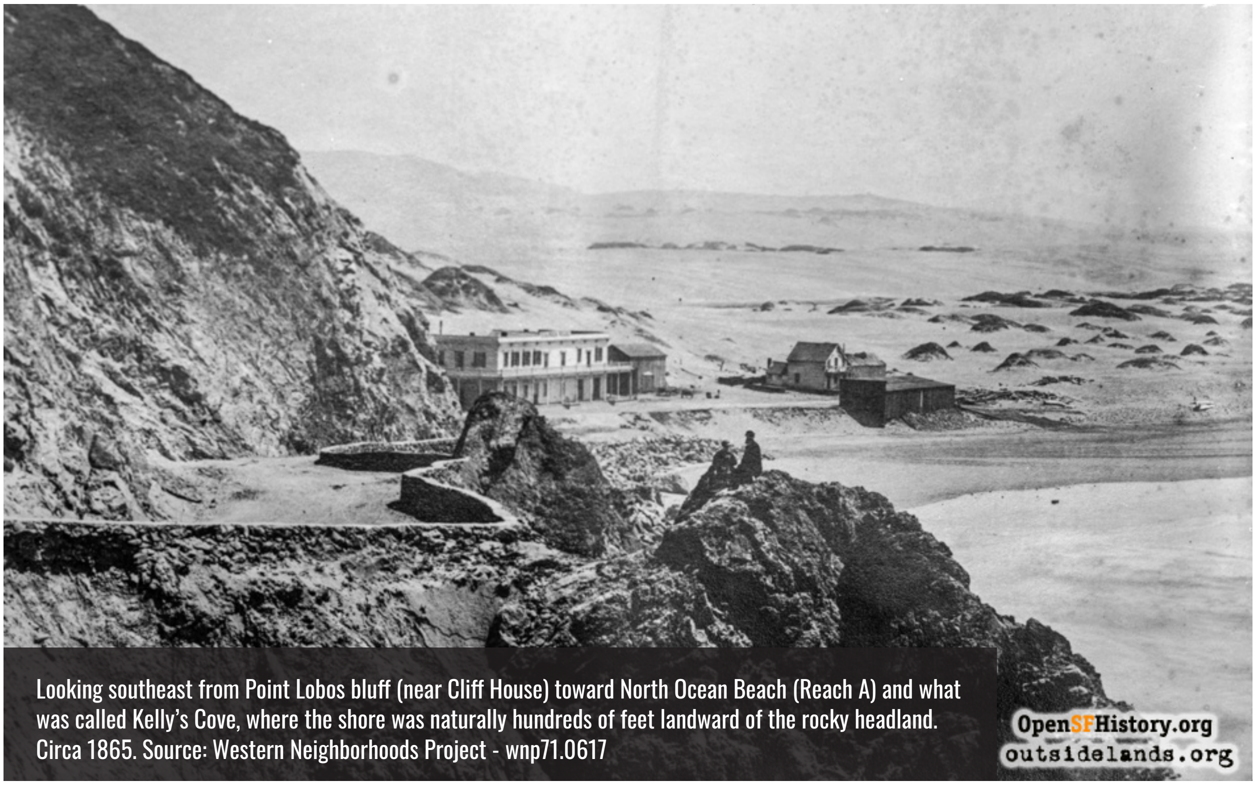
Before the development of San Francisco by Euro-Americans, Ocean Beach was significantly different from its modern form. The beach's backshore transitioned to dune fields that stretched across much of what is now western San Francisco (Hidden Nature SF; San Francisco Estuary Institute et al., 2023). Historically, there was no defined foredune at Ocean Beach; rather, there was direct transport of sand from the beach to the interior dune field (what is now the Sunset District of San Francisco). Broadleaf native forbs (non-grass herbaceous flowering plants) such as beach-bur (*Ambrosia chamissonis*), yellow sand-verbena (*Abronia latifolia*), and silvery beach pea (*Lathyrus littoralis*) formed scattered dome-shaped vegetated dune mounds (Ramaley, 1918).

Mobile dunes landward of Ocean Beach, 1917. (Ramaley, 1918)

LATE 1800s-EARLY 1900s

Stabilization of dunes in western San Francisco began in Golden Gate Park and the Presidio during the 1870s. Due to its ability to build high and narrow foredune ridges under high rates of sand accretion, *Ammophila arenaria* (common names marram grass or European beachgrass) was used for stabilization along Ocean Beach in the vicinity of Golden Gate Park (Reach A) as early as 1905.

Foredunes are different from the dune fields that historically existed at Ocean Beach. Foredunes are the first line of vegetated coastal dunes formed at the back of the beach. They develop from the interaction between wind transport of beach sand and sand-trapping perennial dune vegetation, and regeneration of vegetative cover after sand burial year after year. They can restrict wave runup and release sand back to the beach during storms. Where they existed elsewhere along the pre-development California coast, foredunes stabilized by native vegetation were low, broad dome-shaped dunes; steep rounded hummocks (typical of broadleaf forbs); or broad, undulating ridges or coalesced domes (typical of beach wildrye, *Leymus mollis*).



Looking southeast from Point Lobos bluff (near Cliff House) toward North Ocean Beach (Reach A) and what was called Kelly's Cove, where the shore was naturally hundreds of feet landward of the rocky headland. Circa 1865. Source: Western Neighborhoods Project - wnp71.0617

Sunset dune fields circa 1910. View west from Near 30th and Pacheco. Radio towers visible at the beach. Source: Western Neighborhoods Project - wnp15.641.

The width of Ocean Beach has varied along its length over time. From the mid-1800s to mid-1900s, the shore was pushed seaward several hundred feet by the placement of fill, and the Great Highway was constructed on a berm. The O'Shaughnessy Seawall was constructed in the 1920s to prevent the shore from eroding back to its natural position landward of the Great Highway.

Embankment constructed for the Great Highway near Pacheco Street, 1915. Note the shore embayment characteristic of this location, where a seawall was constructed in the 1990s. (Olmsted & Olmsted, 1979).

View north from foot of Cabrillo St during the second phase of construction of the O'Shaughnessy Seawall. Photo from August 1922. Source: Western Neighborhoods Project - wnp36.02888.

Grass nomenclature

"Marram" or "marram grass" is the common name for the invasive, non-native *Ammophila arenaria.* The vernacular Pacific Northwest and California name for marram grass is European Beachgrass. "American dunegrass" is a common name used for native *Leymus mollis*. Because "beachgrass" and "dunegrass" are similar, habitat-based descriptive names, **this report uses "marram grass" to refer to *Ammophila arenaria*, and the Washington-Alaska-Canadian name "beach wildrye" for native** *Leymus mollis***.** This nomenclature also avoids confusion with American beachgrass (*Ammophila breviligulata*), which is native to the Atlantic coast of the U.S. but is an invasive non-native in Oregon and Washington state.

LATE 1900s

The north end of the beach (Reach A) has accreted substantially from the 1970s to today, likely due to maintenance dredging of the San Francisco Shipping Channel, which is thought to have resulted in increased onshore sand transport to Ocean Beach (B. Battalio, 2014; R. T. Battalio & Trivedi, 1996). Since the 1970s when the dredging practices changed, the north end of the beach has remained wide, unvegetated, and nearly flat with low-relief linear mounds shaped by wind action.

In the 1980s-1990s, San Francisco's combined stormwater and wastewater sewer system was upgraded, which involved realigning the seaward edge of the Great Highway 50 feet landward. Buried rubble was placed at the toe of the embankment supporting the Great Highway. Additionally, a seawall was constructed between Noriega and Santiago cross-streets (Reach C) in response to a natural embayment (area with a recessed shoreline due to wave focusing). Pedestrian access to the beach changed due to this construction; pedestrian tunnels under the Great Highway were closed, and signalized street-level crossings were installed.

As part of the same project, the San Francisco Department of Public Works (DPW) constructed sand berms along Ocean Beach from Lincoln Way to Noriega Street (Reach B). Imported fill material was stabilized by marram grass planted on the seaward face and crest and iceplant (*Carpobrotus edulis*) behind the berms. Both marram grass and iceplant are invasive species. Sand transported from the beach accreted on the seaward face of the berm, although wave runup eroded the dunes, primarily in the southern part of the study area. The dune form created by this project is a steep, narrow, continuous ridge profile that intercepts onshore-blown sand, leading to concentrated deposition in a narrow seaward zone, wih the dune building vertically. Like the marram grass used to stabilize it, this geomorphic form is not native to the California coast.

Many examples of artificial linear marram grass foredune ridges have been created elsewhere in California. Lawson's Landing at the mouth of Tomales Bay, north of Sand Point, is an example of a marram grass foredune with the same grain size range and orientation to dominant winds as Ocean Beach. Other examples of linear marram foredune ridges in California include Limantour Spit, Point Reyes Beach, Bodega Dunes Beach, Funston Beach, and North Pacifica Beach. True "restoration" of California coastal foredunes would mean re-establishing space to allow landward migration of dunes as opposed to the creation of linear foredune ridges that intercept onshore wind-blown sand to protect landward infrastructure or development.

Where it is still intact, Ocean Beach's vegetated foredune created in the 1980s has continued to limit blowing sand, as indicated by the presence of the original and unburied iceplant on the landward side of the berms between Lincoln Way and Judah Street in Reach B. The current state of these constructed dunes, including trampling and erosion issues, is discussed in later chapters.

2000s-PRESENT

Shore management since 2000 has consisted primarily of mitigating windblown sand deposition and increasing sand supply to eroding beaches. Mitigating windblown sand along the Great Highway and hardscaped pedestrian areas involves grading sand away from seawalls, with sand removed from hardscapes often placed in high erosion areas at South Ocean Beach. Fine sand is more prone to wind erosion than coarse sand, and there has been an increase in the proportion of finer-grain sand at Ocean Beach. This may be due to the mobilization of finer sands by the maintenance dredging of offshore channels.

In 2012, the Ocean Beach Master Plan (OBMP), a collaborative multi-agency long-term adaptation plan for the beach, was completed in response to erosion and flood hazards, especially in the context of sea-level rise. The plan has primarily been implemented in South Ocean Beach in response to acute erosion issues. This report focuses on the OBMP's "North Ocean Beach" and "Middle Ocean Beach" reaches (Reach A to D in this report) (Figure 1.1). The OBMP findings for those reaches are summarized below:

- **North Ocean Beach (Reach A):** The beach in the north reach is about 800 feet wide due to increased sand transport from the south. The OBMP recommended no action in this reach to mitigate coastal hazards. Developing vegetated dunes to limit wind-blown sand transport and improve ecology was considered worthy of future investigation, with recognition of potential recreational and management constraints.

- **Middle Ocean Beach (Reach B, C, D):** The shore in this reach has a concave alignment at the high wave focus zone, which conflicts with the straight alignment of the seawall and the Great Highway. Approximately 100,000 cubic yards of sand is estimated to have moved on shore to the beach from the offshore dredge disposal area from the 1970s until 2005. Since 2005, dredging practices have changed and the rate of onshore transport is uncertain. Beach loss is expected by 2050 without intervention. The OBMP recommends the placement of 1.5 million cubic yards of sand to widen the beach and dune berm by 50 feet every 10 to 30 years. The plan also recommends setting the road back by reducing the lanes from four to two if needed as part of a long-term adaptation pathway in response to sea-level rise.

3. Agency jurisdictions

From reviewing agency and department websites, conversing with agency staff, and referencing the OBMP, we have gathered that the jurisdictions form a series of parallel bands, roughly consistent in width, running parallel to the Great Highway. Figure 3.1 shows jurisdictions in Reach A for representative location at Golden Gate Park, and Figure 3.2 shows jurisdictions in Reaches B-D at a representative location at Irving St.

Three agencies have jurisdiction over portions of the study area.

- SF Municipal Transportation Agency (MTA) manages citywide traffic including on the Upper Great Highway (divided highway) and Lower Great Highway (surface street). MTA has been responsible for deploying traffic management tools such as signs and traffic diverters to manage traffic and improve safety during the Great Highway Pilot Project.
- SF Recreation and Parks Department (RPD) - RPD's jurisdiction along Ocean Beach begins at the west curb of Lower Great Highway to 50 feet west of Upper Great Highway. Within their jurisdiction, RPD manages the multi-use north-south trail between Lower Great Highway and

Figure 3.1. Agency jurisdictions, demonstrated at a section of beach in Reach A near Golden Gate Park.

Figure 3.2. Agency jurisdictions, demonstrated at a section of beach in Reach B at Irving Street. Reach C and D jurisdictions are comparable to Reach B.

Upper Great Highway as well as the east-west trails that allow access from the Upper Great Highway to the beach and public restroom facilities. RPD's jurisdiction also includes Golden Gate Park, which is east of the Great Highway between Fulton Street and Lincoln Way.

- National Park Service (NPS) - The Golden Gate National Recreation Area (GGNRA) has jurisdiction over Ocean Beach from the RPD jurisdiction (50 feet west of the western edge of upper Great Highway in Reach B, C, and D, and from the western curb line of the Ocean Beach parking lots in Reach A) to a quarter mile offshore. NPS jurisdiction includes the O'Shaughnessy seawall.The offshore portion of NPS jurisdiction is leased from the CA State Lands Commission.

In addition, two agencies have management responsibilities:

- SF Public Utilities Commission (PUC) - The West Side Transport Box that runs beneath the Upper Great Highway is a key component of the city's combined sewer system and is owned and maintained by PUC. PUC does not have jurisdiction nor management responsibilities on the surface of Ocean Beach but does have an interest in management outcomes due to the impact of blown sand entering the combined sewer system and the potential for erosion of the beach to impact buried assets. For example, PUC has collaborated with NPS to implement several "sand backpass" operations, moving sand from in front of the O'Shaughnessy Seawall (Reach A) to erosion hotspots at South Ocean Beach to protect the critical Lake Merced Transport Tunnel.

- SF Department of Public Works (DPW) - DPW has jurisdiction over the hardscape of the Lower Great Highway and manages maintenance of the Upper Great Highway roadway, median, and Noriega Seawall Promenade (Reaches B, C, and D) through an Memorandum of Understanding (MOU) with RPD. This maintenance includes keeping the Great Highway and promenade clear of sand. DPW also has a special use permit from NPS to remove and relocate wave and windblown sand from the Great Highway back onto Ocean Beach and to perform annual sand management along the Noriega seawall (see Chapter 5). Timing is coordinated with NPS staff to ensure the work does not disturb western snowy plovers on the beach. This permit has been extended several times.

The US Army Corps of Engineers (USACE) has also been involved with sand management at Ocean Beach. Dredged sediment from San Francisco Bay shipping channels is often placed offshore. If the sediment is primarily sand greater than 0.2mm and is placed on or landward of the south arm of the San Francisco Bar, the sand moves onshore by wave action. This movement results in a wider beach primarily in reaches A and B, and occasionally in reaches C and D. A beneficial use project was recently undertaken to bring dredged sand from the San Francisco Main Ship Channel and place it on GGNRA property on the rapidly eroding South Ocean Beach south of Reach D, as opposed to at an offshore disposal site. This initial effort was completed in 2021. The OBMP also called for placement of dredged sand from the shipping channel in Reaches B and C from Lincoln Way to Sloat Boulevard. Future sand placements are being considered per the OBMP and are being planned under the Ocean Beach Climate Change Adaptation Project at South Ocean Beach (Mazzaferro, 2022).

The California Coastal Commission (CCC) is a state agency with primary regulatory jurisdiction along the California coastline, including within 100 feet of the high tide line along Ocean Beach. The CCC plays a crucial role in regulating and overseeing coastal development and land use along the coastline in California (the "Coastal Zone"), including Ocean Beach. The Coastal Zone is defined by the California Coastal Act,and does not include the area of jurisdiction of the SF Bay Conservation and Development Commission.

4. Conceptual Model

Ocean Beach is subject to powerful waves and strong winds shaping its physical form and vegetation. This chapter provides an overview of key processes affecting the beach within the study area.

NATURAL SAND TRANSPORT AND DUNE FORMATION

Ocean Beach receives natural inputs of wave-driven sand from offshore sandbars, building the beach width during summer months when storms are infrequent. During the winter, storms erode the beach and reduce the beach width. For example, a series of El Niño Southern Oscillation (ENSO)-driven storm events in the 1990s caused significant erosion along Ocean Beach, creating wave-cut scarps in the foredunes.

In higher parts of the beach, dry beach sand is transported inland by dominant winds out of the northwest. In the absence of human intervention (mechanical grading), small foredunes would likely develop and store otherwise mobile sand. These foredunes would be eroded by winter storms, releasing sand back to the beach.

Under existing conditions, sand is transported beyond the beach. It accumulates in ramps in front of the seawalls (where present), allowing additional sand to blow over the wall and accumulate on the Great Highway. Where beach sand is blown onshore into the few remaining well-vegetated foredunes, most sand is trapped in the vegetated slope and crest. Where beach sand is blown onshore into trampled, denuded, patchy vegetation or bare blowouts, large migrating dune lobes, often with steep slopes, encroach onto the Great Highway (Figure 4.1). Key locations where dune lobes have developed include Great Highway intersections at Lincoln Way, Judah Street, and Noriega Street. These locations each coincide with a blowout.

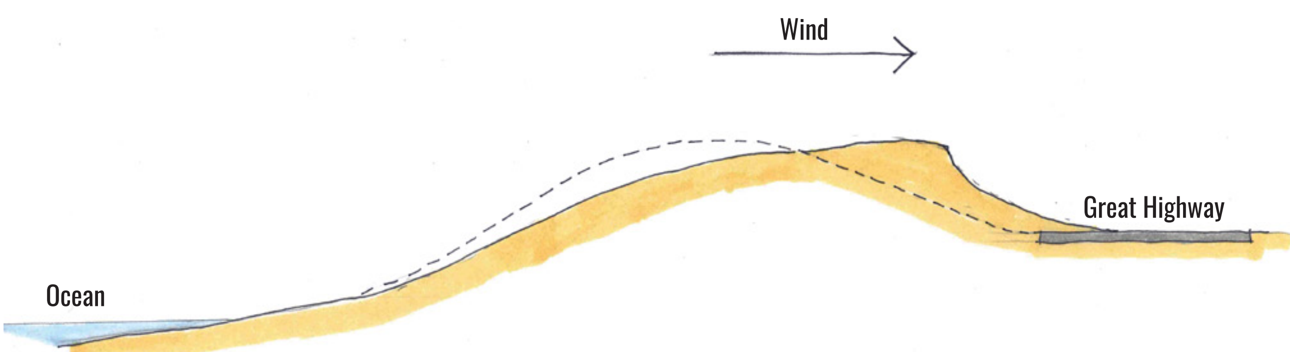


Figure 4.1. Barren dunes migrate landward towards the Great Highway where sand-trapping vegetation cover has been lost from trampling and wind erosion, causing dune blowouts. The dotted line represents an example profile of a vegetated or newly-barren dune, while the shaded dune shows the profile of a barren dune as it migrates landward due to wind erosion.

RIP CURRENTS

Rip currents that form in the nearshore and surf zone affect the width of the beach, erosion patterns, and space available for vegetated foredunes to establish. Rip currents are powerful, localized, and relatively narrow seaward currents that are driven by complex hydrodynamic processes. They typically originate at the shoreline or nearshore regions as a result of wave breaking, changes in seabed topography, and the presence of offshore features such as sandbars and channels. Under certain conditions, rip currents can transport large amounts of sediment offshore when a synergy develops and the rip-wave pattern results in a small embayment where the shoreline erodes.

Wave refraction, starting about 25 miles offshore over the seabed, causes strong wave focus on Ocean Beach. The strongest areas of refraction are in Reaches C and D. Refraction causes a single swell from one direction to cross over itself, which amplifies the wave height, and creates strong seaward rip currents and longshore currents to the north and south. The San Francisco Bar is about three to five miles offshore, about one foot high, and lies below approximately 40-50 feet of water. It is also called the ebb bar, as it is associated with tidal flows out of San Francisco Bay via the Golden Gate. The San Francisco Bar refracts waves and focuses wave energy towards the central area of Ocean Beach. The breaking waves create an onshore flux of water, causing the formation of strong, persistent rip currents that lead to the ephemeral (winter-spring) formation of embayments and a net landward movement of the winter shoreline between the Noriega and Santiago cross-streets (Reach C). The presence of these rip embayments results in a further landward penetration of wave runup and limits the available space for dunes.

VEGETATION STABILIZATION OF SAND

Dune vegetation plays a substantial role in shaping accumulation of beach sand and intercepting its movement inland. Ocean Beach dune vegetation includes one native foredune stabilizer, beach wildrye, and two noxious invasive dune stabilizing species, iceplant and marram grass. These species have unique growth habits based on their biology that shape the surrounding sand:

- Beach wildrye, which has extensively creeping rhizomes, has a wide, creeping habit and creates gently sloped dunes.
- Marram grass, which has short rhizomes, grows in tall bunches, or “tussocks,” that tend to form steeper hummocks of sand.
- Iceplant is found landward of the beach on the fill used to create berms, where it was planted for stabilization purposes and cannot typically grow fast or high enough to survive sand burial.

Both beach wildrye and marram grass thrive in a dune environment where they are intermittently buried by accumulating sand. Because of these species’ high sand trapping efficiency, they can build foredunes vertically in a confined horizontal space. The sand burial tolerance of beach wildrye is second only to marram grass in this region. Planting invasive marram grass is prohibited on NPS lands today.

Vegetated foredunes enhance sand trapping and erosion resilience by capturing sand blown from the beach (Figure 4.2). In winter, waves erode a scarp in the dune, which cuts off the sand supply to the dunes. Later, the scarp slumps, dragging down foredune vegetation that regenerates in place and later becomes buried by wind-blown sand. This process can naturally restore the foredune when erosion rates are slow or intermittent. If the scarp retreat rate exceeds the rate at which slumps revegetate and accumulate wind-blown sand, the foredune self-repair process breaks down. Accelerated shoreline retreat due to sea-level rise means that the dynamic system may not be as able to self-maintain as it was historically.

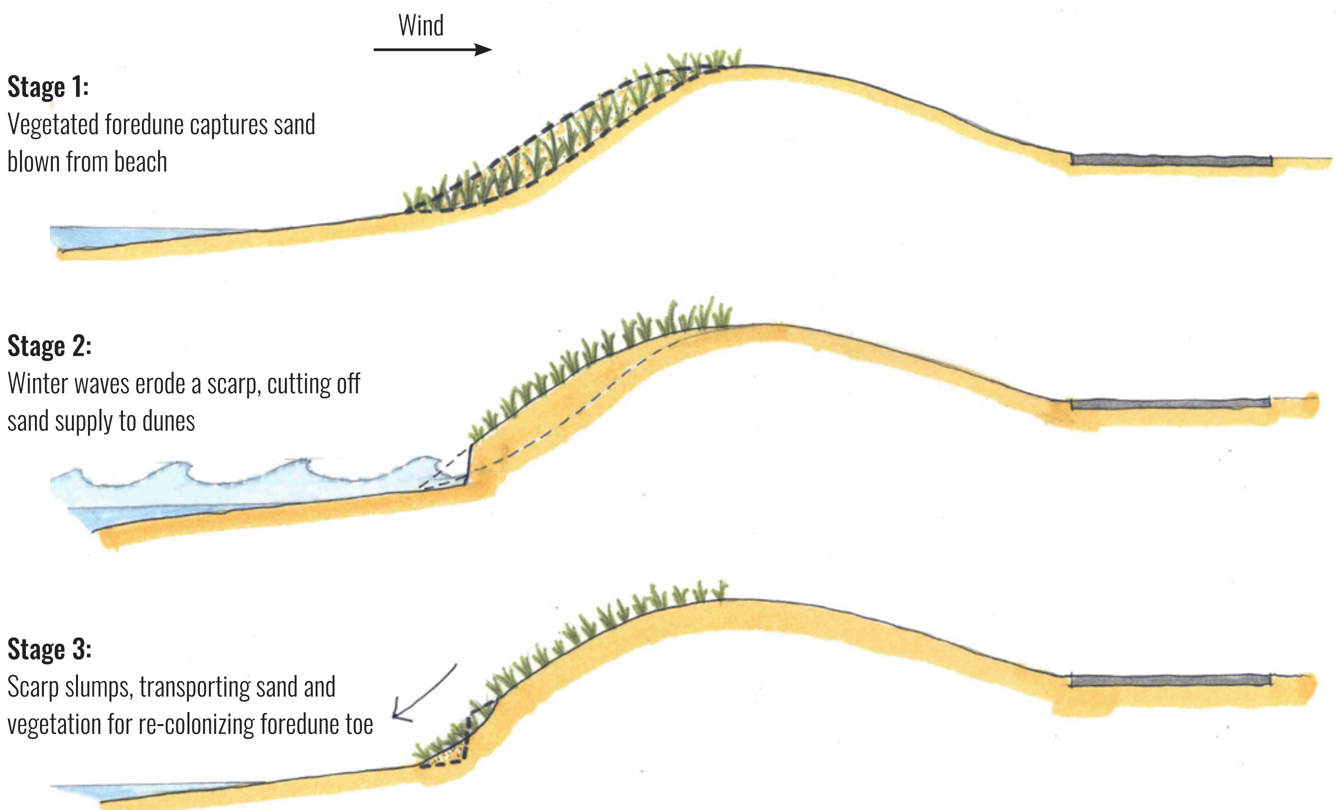


Figure 4.2. Sand trapping and erosion resilience facilitated by a vegetated foredune (slump-block revegetation).

Steep hummocks form as marram grass traps sand (background), and gently sloped, smoother foredunes develop as beach wildrye traps sand (foreground). Photo by Bob Battalio, ESA.

TRAMPLING IMPACTS

Recreation plays a key role in shaping Ocean Beach, primarily through the trampling of vegetation, which leads to erosion of the dunes and increased sand movement. This process is most evident in the evolution of the sand berms that were constructed by DPW in 1985. Following construction, the planted marram grass was protected from disturbance by temporary fencing. However, over time people began crossing the dunes and seeking protection from beach winds, which led to trampled vegetation and the development of informal trails. These trails usually originate from signaled pedestrian crossings on the Great Highway, although smaller trails exist at unsignaled cross streets such as Kirkham Street and Ulloa Street. Most trails seem to provide access over the dunes to the beach, although some are made by pedestrians seeking high points on the dunes to survey the beach and surf. Once established, these trails lead to a fan-shaped area of disturbance seaward of the dunes, as people veer off the trail to either side. This process can be seen in aerial photographs beginning in the late 1990s (Figure 4.3).

The loss of vegetation due to trampling increases the wind transport of sand, transforming fixed dunes into mobile dunes with slipfaces and unvegetated seaward slopes. Sand is blown landward, accumulating in drifts on the promenade and roadway. Continued trampling in the 2000s and 2010s has led to broader gaps in the vegetated dunes and eventually led to permanent blowouts (Figure 4.4). The gaps also gradually oriented to the dominant northwest wind direction, funneling more wind through the gaps and mobilizing more sand, creating a positive feedback loop. Between these blowouts remain the predominantly vegetated foredunes capped with accreting and partially vegetated hummocks. If action is not taken to reduce further trampling, vegetation will continue to be denuded and blowouts will continue to expand, converting much of the existing vegetated foredune area to barren sand.

The beach and foredunes have been subject to wave erosion during this same period, mainly due to El Niño Southern Oscillation events forming wave-cut scarps on the seaward edge of the dunes. However, the co-location of blowouts with pedestrian crossings and the pattern of their evolution indicates that they are primarily caused by trampling. The recent closures of the Great Highway to car traffic (started in 2020 during the COVID-19 pandemic) have led to less constrained use by pedestrians, and increased trampling of dune vegetation has been observed.

SAND MANAGEMENT

Sand is moved within and out of the study area by various agencies to meet recreation, road maintenance, and erosion prevention goals. Dry sand placement on dunes without additional stabilization measures such as re-vegetation or adding a top layer of coarser material can increase sand movement, leading to further dune erosion and loss of vegetation. This compounds the sand inundation problem along the Great Highway. Because management activities are specific to particular reaches of the study area, they are detailed by reach in Chapter 5.

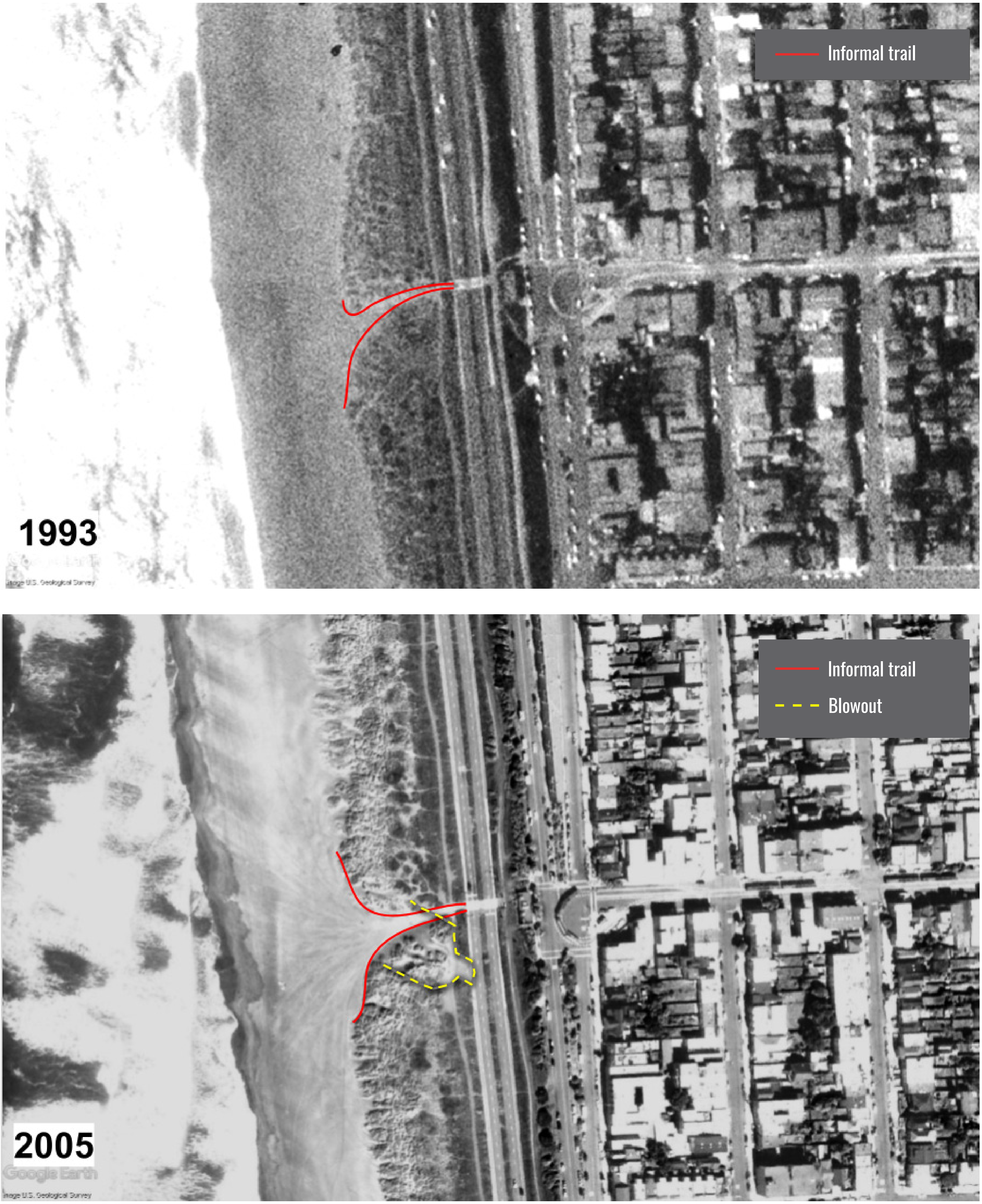


Figure 4.3. Beginning of informal trails through vegetated dunes at Judah Street (1993). Informal trails begin to fan out at Judah Street and a blowout begins to form (2005).

Figure 4.4. Trail mouth widens and blowouts expand at Judah Street (2015), and Judah Street blowout (2021).

5. Existing conditions and management challenges

We have chosen to summarize the existing conditions, dominant physical processes, and main challenges for each reach of the beach separately due to key differences in coastal processes, dune-beach geometry, and backshore conditions. This chapter draws heavily on the work led by Bob Battalio of ESA and is described in more detail in Appendix B. These findings inform the reach-by-reach conceptual designs described in Chapter 8. The four reaches are identified in Figure 1.1.

REACH A - NORTH OF LINCOLN WAY

Existing conditions

Reach A has a wide backshore beach with relatively minimal grade change and no foredunes nor vegetation (Figure 5.1). The beach extends back to the O'Shaughnessy Seawall (Fig 1.1) and is about 700 feet wide, with a winter minimum of about 450 feet. The beach has a homogenous erosion/accretion pattern with no beach cusps, rip embayments, etc. Scour near the seawall can create low points along the landward portion of the beach. Behind the seawall and elevated above the beach are the pedestrian promenade and Great Highway.

Looking north over the O'Shaughnessy Seawall and wide backshore beach toward Cliff House. Reach A near Balboa St. Photo by Jeremy Lowe, SFEI.

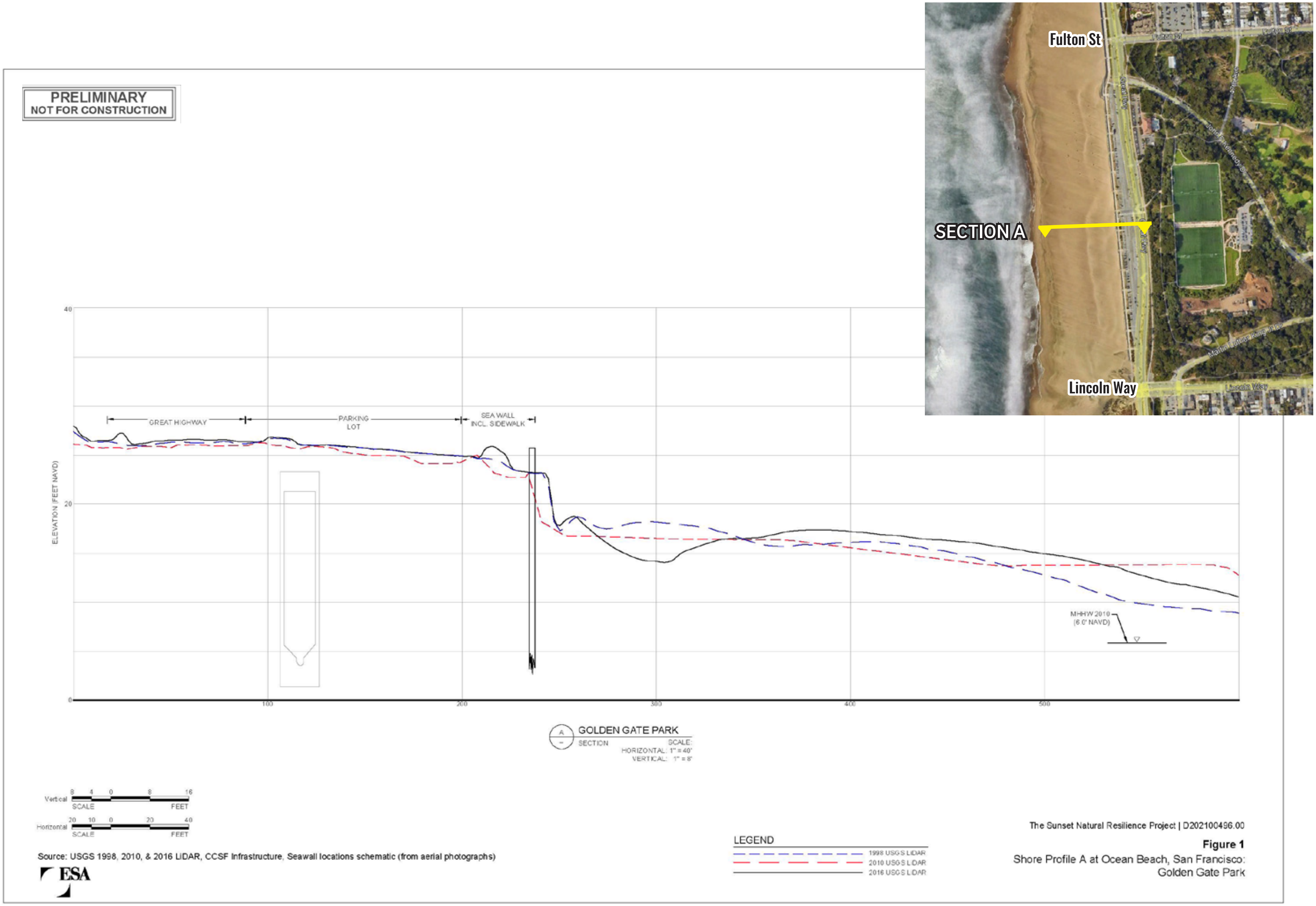


Figure 5.1. Profile of Ocean Beach in Reach A (Golden Gate Park) looking south, showing a wide backshore beach with minimal grade change and no foredunes. The vertical axis has been exaggerated for enhanced readability.

Shoreline change

The shore accreted 200 feet from 1992 to 2021 (an average rate of 6.9 feet per year). It is rare to observe any wave runup at the seawall today due to the increased width of the beach. Our geomorphic interpretation is that the shore accretion is near a maximum due to anticipated sea-level rise (SPUR et al., 2012) and transport to the north past Point Lobos (Battalio, 2014). There is about 400 feet for dunes to persist between the active shore and the seawall.

Current sand management practices

NPS grades sand away from the O'Shaughnessy Seawall annually to prevent sand from blowing onto the promenade and maintain a flat dry beach for recreation. This grading precludes the development of vegetated foredunes in Reach A, although embryo dunes sometimes form in the period between gradings.

Since 2012, sand has been harvested every one to three years from the beach just west of the seawall and transported to South Ocean Beach, south of Sloat Boulevard. This "sand backpass" operation is a collaborative effort between PUC and NPS. The sand from Reach A is placed in an artificial berm to protect the eroding beach scarp south of Sloat Boulevard and the infrastructure behind it. The berm subsequently erodes, releasing sand to the beach and dissipating waves offshore of the fill embankment (where the road and parking exist). Some of this sand moves northward toward North Ocean Beach, resulting in the "backpass" moniker.

Main challenges

We have identified three challenges in Reach A that conceptual designs for dune management can address:

1. Current grading practices prevent dune formation.
2. The borrow area for the sand backpass (close to the seawall) conflicts with dune formation and the borrowed sand is finer, wind-blown sand.
3. Existing recreational uses (e.g., volleyball courts, fire pits) need to be reconciled with dune restoration plans.

REACH B - LINCOLN WAY TO NORIEGA STREET

Existing conditions

Reach B has a moderately wide beach of 300 feet (Figure 5.2). High foredunes have accreted over constructed sand berms and are vegetated primarily with marram grass. This foredune ridge dominates the majority of this reach landward of the beach. The foredunes near Irving Street have been dominated by native beach wildrye since the 1990s (Figure 5.3). Beach wildrye survived with effectively no management for decades; recently, NPS natural resource staff have conducted small-scale removal of marram grass and field-to-field transplants of beach wildrye in Reach B. After well over two decades with only minimal management, the beach wildrye vegetation spread vegetatively, and is performing locally as well as or better than marram grass at preventing sand transport onshore.

The Great Highway segment downwind of the beach wildrye foredune has not been encroached by migrating dunes, as it has around Judah St. Beach wildrye is apparently more resistant to trampling than marram grass (evident due to reduced blowout impacts compared to marram grass-dominated areas). However, both marram- and beach wildrye-covered foredunes are currently subject to substantial trampling damage due to pedestrian access from cross streets. Informal trails have expanded in increasingly large fan-shaped patterns originating at cross streets over the last two decades, eventually resulting in full blowouts transporting sand onto the Great Highway. The largest of these blowouts occurs at Judah Street and extends nearly half a block south to Kirkham Street. Other substantial areas where dunes have mobilized and drift onto the Great Highway occur at Lincoln Way, Lawton Street, and Noriega Street. While the blowouts are mostly caused by expansion of fan-shaped exit points at the main crossings, trampling on informal trails between cross streets also contributes to destabilization of dune vegetation and can increase blowing sand.

The vegetated dune berm in Reach B is approximately 300 feet wide and widening at an average rate of 2.4 feet per year (1992-2021). The berm is wider at the north end of this reach and narrows moving south. The beach accreted about 140 feet from 1992-2021 in the northern part of Reach B, but eroded a comparable amount at the south end of the reach.

Vegetated dune berm at Reach B, looking north from vicinity of Judah St. Photo by Ellen Plane, SFEI.

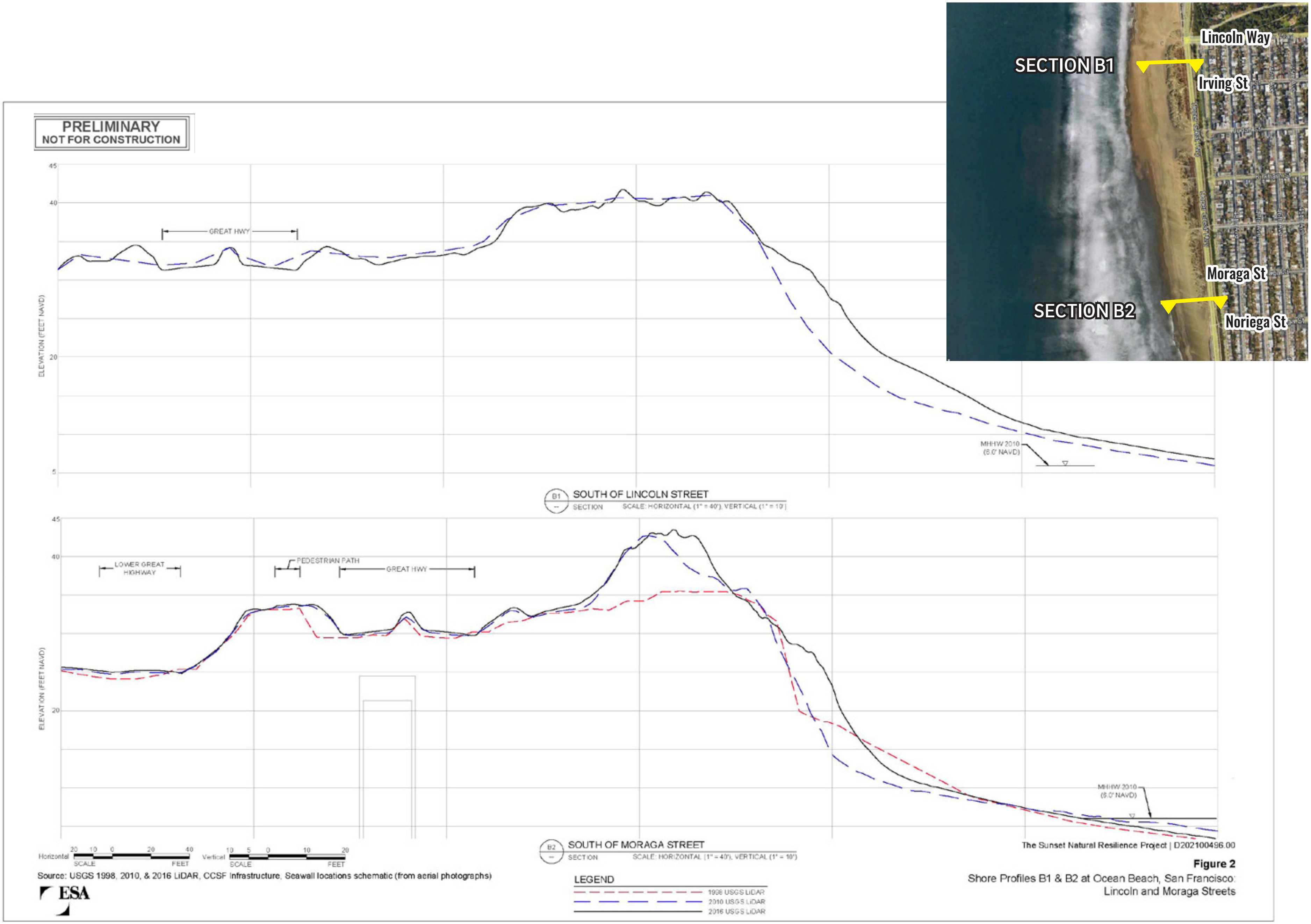


Figure 5.2. Profiles of Ocean Beach in Reach B (south of Lincoln and south of Moraga), looking south, showing the wide and high vegetated dune berm that is the distinctive feature of Reach B. The vertical axes have been exaggerated for enhanced readability.

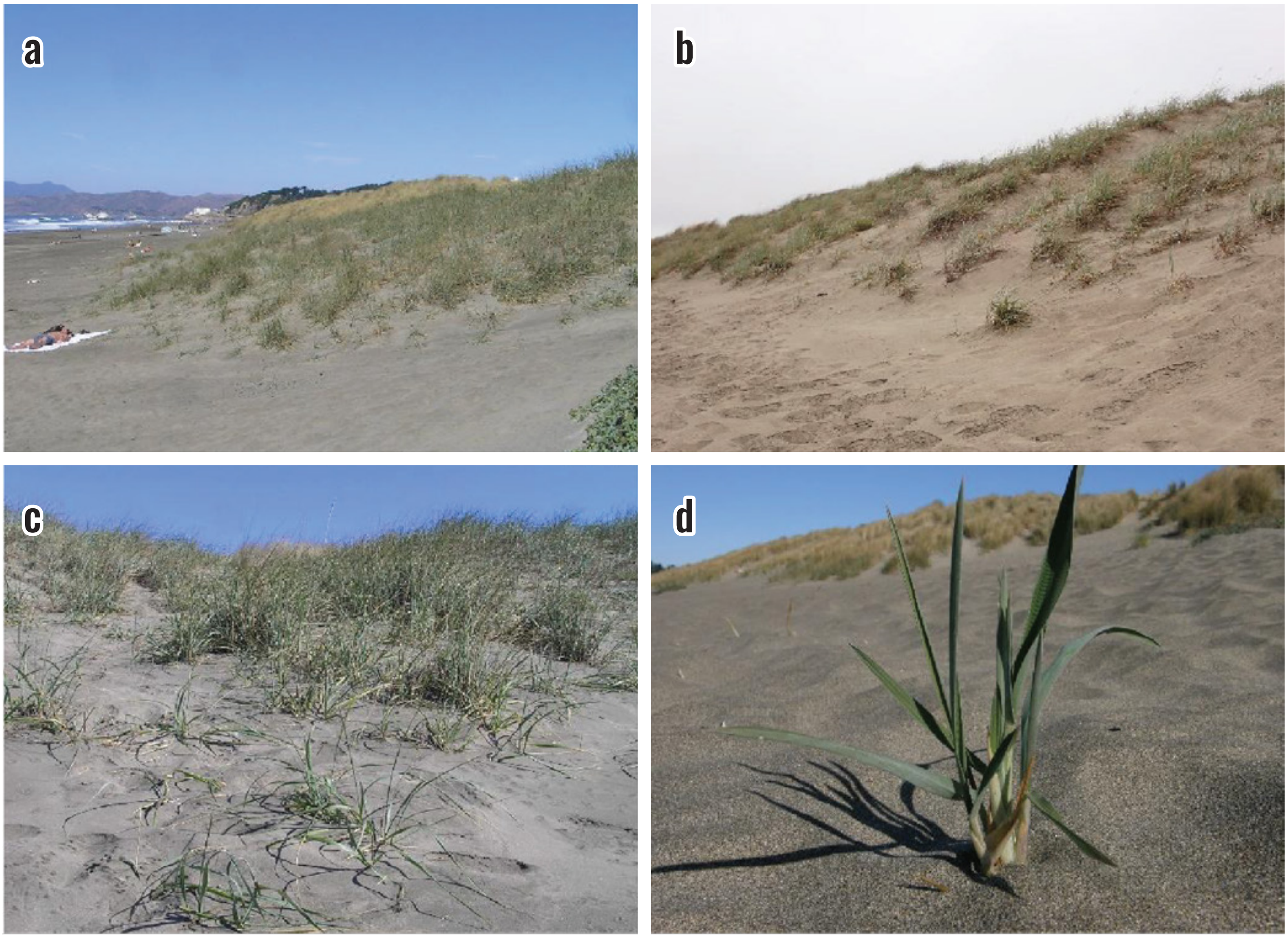


Figure 5.3. (a) Beach wildrye foredune patch near Irving Street in October 2006, over 10 years after establishment in the 1990s. (b) Beach wildrye foredune in July 2022 (matches dimensions and elevations of adjacent marram grass foredunes). (c) Growth habit of beach wildrye: widely spaced, spreading shoot clusters. (d) new beach wildrye shoot cluster emerging from a rhizome tip.

Shoreline change

Despite recent accretion in Reach B, it is unlikely this reach will sustain much additional dune growth seaward due to sea-level rise. Wave refraction due to the offshore bathymetry focuses larger waves between the south end of Reach B and Sloat Boulevard, leading to more erosion in this southern area relative to the northern portion of the Reach B.

Current sand management practices

DPW clears sand from the Great Highway and promenade (such as at the Judah Street blowout), under a 1992 Memorandum of Understanding with RPD. A special use permit from NPS allows DPW to place sand removed from the roadway back onto Ocean Beach. RPD manages sand removal in the multi-use trail running north-south between Lower and Upper Great Highway.

Main challenges

We have identified two challenges in Reach B that conceptual designs for dune management can address:

1. Pedestrian trampling of vegetation initiates blowouts; large unvegetated mobile dunes encroach onto Great Highway.
2. Limited space exists for the further development of embryonic foredunes.

Western snowy plover

The western snowy plover has been a federally listed threatened species since 1993. Western snowy plovers are found at Ocean Beach for about ten months of the year (July to May), where they forage to build up energy reserves for mating season. They are typically found in small depressions in the sand just above the high tide line. They do use sparsely vegetated foredunes but generally avoid tall or dense vegetation that can provide cover for predators. Marram grass has a taller and denser form than beach wildrye, which is low and creeping; therefore, removal of marram grass and expansion of beach wildrye is unlikely to be detrimental to plover. GGNRA has designated a Plover Protection Zone from Stairwell 21 (crosswalk from the Beach Chalet soccer fields at Golden Gate Park) south to Sloat Boulevard. In this zone, dogs must be on leash from July to May, though surveys have shown that most dog walkers do not comply with this rule (National Park Service, 2023., 2008, 2020).

Western snowy plover. Photo by USFWS Pacific Southwest, courtesy Creative Commons.

REACH C - NORIEGA STREET TO SANTIAGO STREET

Existing conditions

The beach in Reach C is moderate to narrow in width (Figure 5.4), and beach width decreases moving south. Beach widths are narrow, about 200-300 feet in summer and about 70-100 feet during the winter. The Noriega Seawall, also called the “New” Seawall, was constructed along this reach from 1988 to 1993. The backshore varies in width and has irregular features, including cusps and rip embayments, and has a high frequency of shell/pebble lag and heavy mineral lag, which reduce wind-blown sand accretion and increase winter storm wave impact. There is minimal vegetation to prevent the mobilization of sand. Sand blowing across the beach accumulates against the seawall, forming a ramp that allows sand to blow over the wall and onto the promenade and roadway. When the backshore beach is wide, western snowy plovers establish high tide roost habitats in this reach.

Clearing sand from the promenade on the Noriega Seawall, July 28, 2022. Photo by Ellen Plane, SFEI.

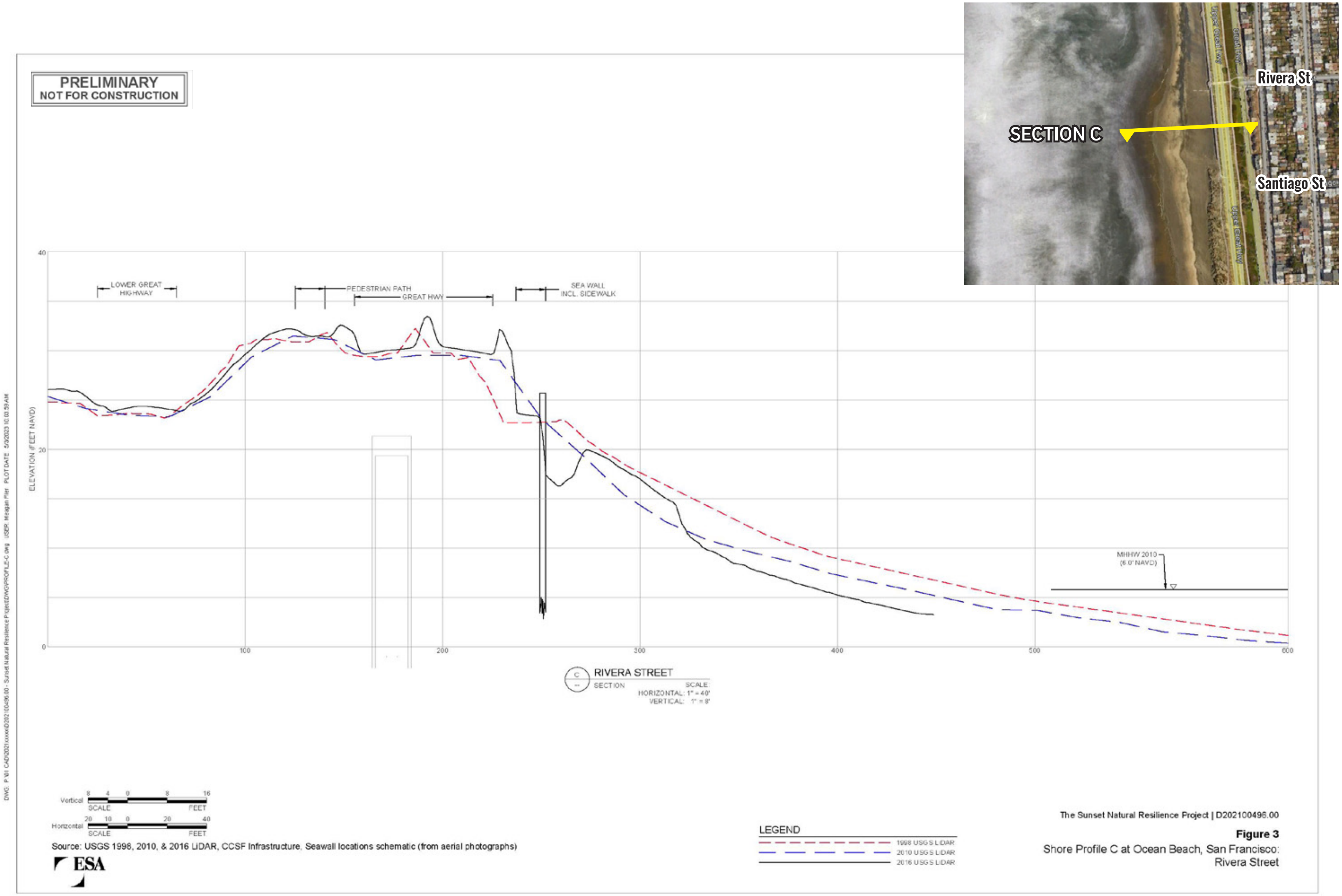


Figure 5.4. Profile of Ocean Beach in Reach C (south of Rivera Street), looking south, showing the lack of foredune and narrower backshore beach than in reaches A and B. The vertical axis has been exaggerated for enhanced readability.

Shoreline change

The average trend in beach width along this reach from 1992-2021 was neutral, with no net accretion nor erosion of the beach. Wave refraction due to the offshore bathymetry results in larger waves roughly from Noriega Street to Sloat Boulevard. Wave focusing causes the high tide shoreline in this area to have a recessed (concave) planform , leading to amplified erosion and the formation of rip embayments during high wave events. During storms, wave runup has reached the seawall; for example, during the storm on January 5, 2023. The artificially wide and unvegetated backshore beach, maintained by sand management as described below, allows for a high rate of wind-blown sand transport from the northwest to the southeast.

Wave runup reached the Noriega Seawall in Reach C on January 5, 2023. Photo by Michael Friedman, ESA.

Current sand management practices

DPW clears sand from the Great Highway and promenade under a 1992 Memorandum of Understanding (MOU) with RPD and places it back on the beach under a special use permit from NPS. DPW also annually clears a 10-30 foot wide excavation zone west of the Noriega seawall to prevent sand from piling up along the seawall and blowing up and over onto the promenade and Great Highway. Excavated sand is placed in a 10-15 foot wide bench with a sloping seaward edge (Figure 5.5). Annual grading in Reach C unintentionally prevents the establishment of vegetated embryo foredunes that would naturally form seaward of the Noriega Seawall, hindering the ability of the beach and dunes to function as a natural and self-sustaining system.

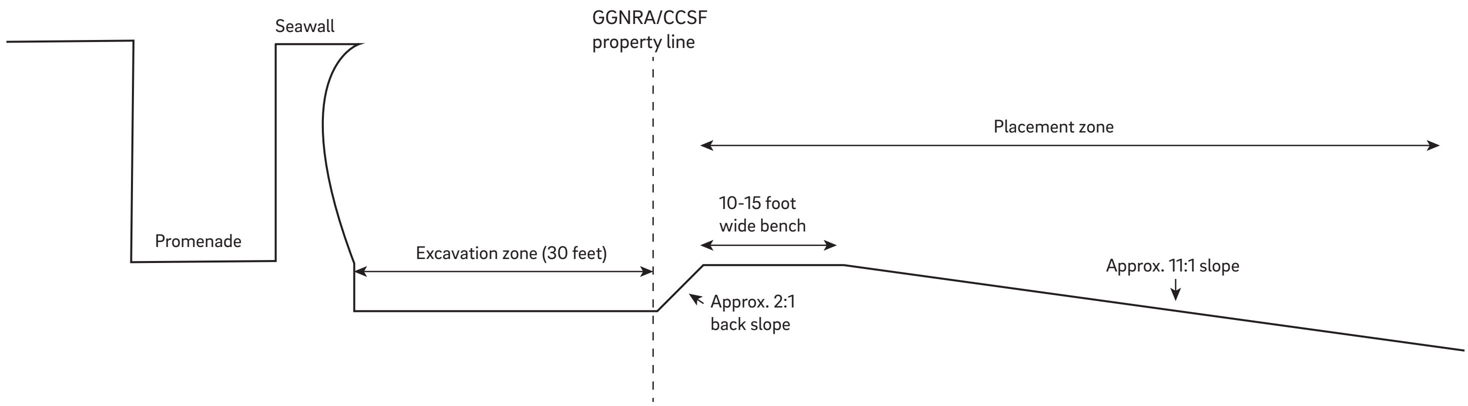


Figure 5.5: Typical Excavation and Placement Diagram in front of the Noriega seawall, as illustrated in NPS Permit # GOGA PLAN_2017_PEPC_66865, Exhibit B.

On a site visit in July 2022, large volumes of non-beach sand were observed by project team members on the beach south of Noriega Street, within the NPS jurisdiction. In conversation with agency staff from NPS and the City and County of San Francisco participating in the Sunset Natural Resilience Project, the origin of the material was not clear.

Main challenges

We have identified four challenges in Reach C that conceptual designs for dune management can address:

1. Sand is transported onto the promenade and Great Highway as dune ramps form against the seawall and wind blows sand into suspension.
2. There is a narrow zone where embryonic foredunes can form.
3. Annual maintenance activities prevent vegetation establishment and dune formation.
4. Severe wave events cause erosion and will become more frequent with sea-level rise.

REACH D - SANTIAGO STREET TO SLOAT BOULEVARD

Existing conditions

Reach D is a narrow erosional shore with a high sand berm (Figure 5.6). The majority of this reach has a narrow beach, only 33-80 feet wide, and minimal foredunes, with the foreshore running up to the toe of the berm. Similar to Reach C, there is variable backshore width, with cusps and rip embayments, and heavy mineral lag soils are common. Erosion due to informal trails also occurs in this reach, particularly at Taraval and Vicente Streets, where sand drifts onto the Great Highway. A short section of seawall, called the Taraval Seawall, was constructed in 1941 and runs from Santiago to Taraval Street. The linear sand berm "dunes" constructed in the 1980s-90s have mostly eroded due to foredune trampling and wave runup, leaving a compacted earth berm covered by a wind-blown sand ramp. Trampling and a period of low sand supply have recently reduced marram grass and increased iceplant dominance in this reach, leading to less resilience to erosion events and reduced ability to trap and intercept onshore-blown sand. This has resulted in increased dune encroachment onto the Great Highway during windstorms.

Shoreline change

Reach D is progressively eroding, with the high tide shoreline receding 100 feet from 1992-2021 and the dune toe eroding an average of 66 feet over the same period. In many places and years there is scarp erosion at the toe of the berm. The sand placed in this reach during the 1980s-1990s was mostly eroded by 2016, leaving behind compacted earth and rubble.

Eroded dune berm south of Taraval Street with rubble exposed, March 11, 2016. Photo by Bob Battalio, ESA.

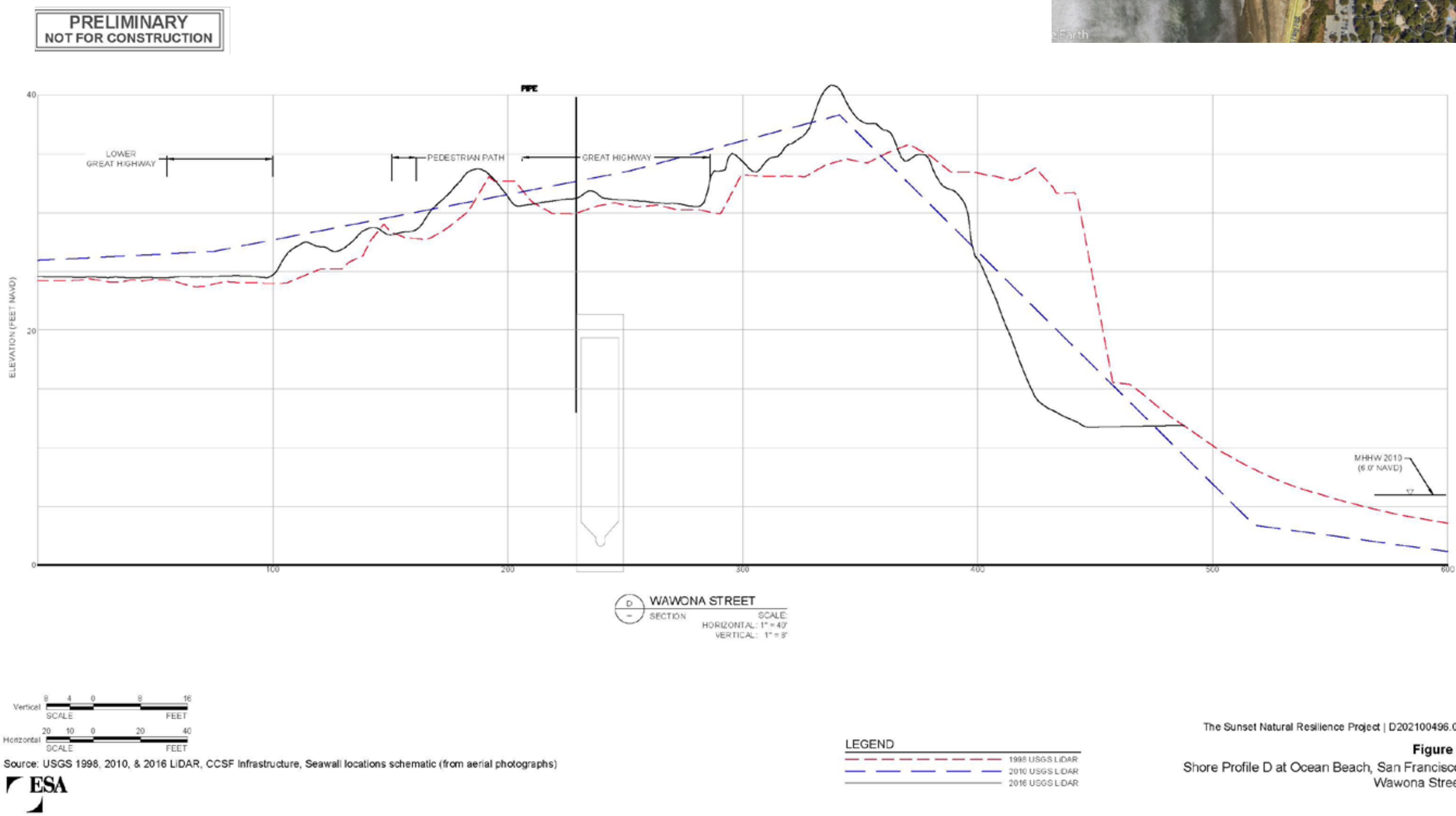


Figure 5.6. Profile of Ocean Beach in Reach D (Wawona St), looking south, showing the foreshore running up to the toe of the high sand berm. The vertical axis has been exaggerated for enhanced readability.

Current sand management practices

DPW clears sand from the Great Highway and promenade under a 1992 Memorandum of Understanding with RPD and places it back on the beach under a special use permit from NPS. RPD manages sand removal from the multi-use trail between Lower and Upper Great Highway.

Main challenges

We have identified four challenges in Reach D that conceptual designs for dune management can address:

1) The narrow beach and berm are eroding progressively over time, and erosion is likely to continue or accelerate with sea-level rise.

2) There is limited space for embryo foredunes.

3) Blowouts and sand movement onto the Great Highway occurs due to limited vegetation cover. Iceplant is dominant in Reach D and ineffective at spreading and trapping sand.

4) Rubble and compacted earth fill are exposed at the base of dunes in winter.

Iceplant dominates on the sand berm in Reach D. Photo by Bob Battalio, ESA.

6. Management goals & objectives

Based on the existing conditions and current challenges described in the preceding sections and conversations with key agency partners, we have identified the following management goals (in no particular order):

- Minimize sand deposition on the promenade and Great Highway,
- Create and enhance native dune habitat to benefit wildlife,
- Facilitate public access to the beach for recreation and guide dune access to designated areas to reduce trampling,
- Reduce maintenance costs and effort, and
- Increase resilience to sea-level rise, storm surge, and coastal erosion.

To achieve these goals, we propose the following objectives:

- Create additional vegetated dunes seaward of the seawalls to trap wind-blown sand by allowing natural accretion of embryonic foredunes, constructing dunes, or a combination of strategies.
- Protect existing and planned dune vegetation from pedestrian trampling; create defined access points for recreational access to the beach.
- Increase collaboration between agencies (including across jurisdicitional boundaries) and with residents and beach-goers to enhance stewardship of the beach and dunes.

Subsequent sections describe possible management strategies and conceptual designs to achieve these goals and objectives.

Representatives from partner agencies walk the beach, May 30, 2023. Photo by Ellen Plane, SFEI.

7. Management strategies

Many of the problems related to sand at Ocean Beach are the result of current management practices and could be addressed by allowing dynamic natural beach and dune processes to progress. First, public education and outreach efforts are needed to ensure there is good understanding among residents and beach-goers about the challenges at Ocean Beach and the value of a nature-based adaptation solution like dune revegetation. Dune-adapted vegetation must be established early in the process; plants can trap sand, build up dunes, reduce blowing sand, provide habitat benefits for wildlife, and slow wave erosion. Beach wildrye propagation is a critical path item, and enhancement cannot progress without it. Plantings will need two years to propagate, and one year to establish after out-planting, so starting propagation efforts soon is a key first step. There may be an opportunity to establish propagation beds at a nearby site (for example, the backdune area near Irving Street in Reach B) where beach wildrye could be grown and transplanted to Ocean Beach. Unlike a traditional nursery, the beach wildrye would not be grown in pots, but grown in the ground, with propagules periodically removed and transported to planting locations.

While beach wildrye propagation progresses, the current sand backpass can be modified to reduce the impacts of excavation and increase erosion mitigation benefits. One key change will be shifting future sand removal and placement activities to prevent disturbance in the backshore area where dunes can form. Sand for the backpass can be borrowed from areas exposed to periodic wave runup (but above the high tide line), where sand is coarser and hence more resistant to wind transport. This coarser sand would be better for placement at South Ocean Beach. Sand removed from the Great Highway and promenade can be placed on the beach (foreshore) instead of on the backshore to allow dunes to develop naturally without causing unintended blowing sand impacts. This will allow backshore areas to remain undisturbed so vegetation can establish and thrive. Leaving wrack on the beach can also speed up the process of dune formation. Multi-agency coordination will be needed to achieve these changes to the backpass operation, including action by NPS and SFPUC.

Examples of fine sand (left) compared to coarse sand (right). Coarser sand is more resistant to wind transport and thus is preferred for placement on Ocean Beach. Photos by Peter Baye.

People are integral to the plan's success. A cultural shift is needed to prevent trampling of dune vegetation by people accessing and recreating at the beach, and volunteers can help with revegetation efforts. Early outreach to residents and beach users is key, as are educational signs to explain the changes at the beach. Many other dune revegetation efforts have employed an educational strategy to encourage users to stay on trail. Local advocacy groups may participate in this effort, and a campaign could be developed to encourage dune stewardship. Sinuous pathways connecting the Great Highway to Ocean Beach and reducing wind-blown sand can be developed using coarse sand and symbolic fencing. Symbolic fencing (usually post and rope or post and cable) does not physically prevent entry, but serves as a visible designation encouraging people to stay out of developing dune areas. Reducing trampling at the top of dunes will allow resilient natural processes like slump-block revegetation to progress. Beach fires, dog walking, and other visitor activities should be accounted for during the outreach and implementation of new management strategies. Public engagement is essential, as changes will impact the visual character and usage of the beach.

These dune revegetation strategies will help achieve the goals outlined in the previous section, including reducing blowing sand and maintenance costs, creating native dune habitat, and increasing resilience to coastal erosion. Pairing dune revegetation with management of pedestrian paths and access points will help revegetation efforts succeed while continuing to allow recreational access to the beach. These strategies will require coordination between federal, state, and city partners. Coordination and identification of funding sources are key next steps.

Wildlife Support

Generally, introducing native plants in urban settings benefits local wildlife, and revegetated foredune areas with reduced occupancy by people and dogs would likely attract and support more wildlife. For example, restoration efforts, combined with restricted recreational use of the dunes at Fort Funston, led to an increase in the diversity of native birds, mammals, reptiles, and amphibians. The dunes may also provide temporary refuge. During winter storms, shorebirds may temporarily take high tide refuge in the sparsely vegetated valleys of the foredune edge. Coyotes may also use vegetated foredunes as cover or corridors. Nevertheless, it is important to be aware of potential complications. Given the plentiful food resources on the beach, the revegetated foredunes could also host nest predators like ravens and gulls. Additionally, urban-adapted mammals such as raccoons, rats, and mice could take advantage of the less disturbed foredunes, possibly dispersing from Golden Gate Park and Sunset.

Above: backshore runnels at Ocean Beach (future borrow area for coarser sand). Photos by Peter Baye and Ellen Plane.
Below: post and cable “symbolic” fencing and trail signage at Pillar Point, Half Moon Bay. Photos by Ellen Plane.

8. Conceptual designs

REACH A - NORTH OF LINCOLN WAY

At Reach A, sand backpass excavation is moved shoreward into the runup zone, a new vegetated foredune is allowed to form in line with the current Reach B vegetated berm, a sheltered recreational area is preserved behind the new foredune, and pedestrian access paths are created to prevent vegetation trampling (Figure 8.1). Initially, embryo foredunes in Reach A would likely be less than three feet high and 20-30 feet wide. Initial dune accretion rates would likely be very uneven, up to 4-8 inches per year in the first one to two years after planting, with widely spaced vegetation patches. Annual maximum vertical dune sand accretion rates under fully established dominant beach wildrye stands would probably not significantly exceed one foot per year. Eventually, lateral spread of efficient sand-trapping beach wildrye vegetation may reach 5-6.5 feet per year. For a more detailed drawing of the conceptual design for Reach A, see Appendix D. Further consultation with agency staff including NPS Law Enforcement and Maintenance staff is needed to refine design concepts.

Excavation troughs for sand backpass

Sand for the backpass to South Ocean Beach is currently excavated close to the O'Shaughnessy Seawall where the sand is fine and mobile. Excavating closer to the ocean in the runup zone would provide natural coarser beach sand less prone to wind transport and promote dune formation in the backshore (Figure 8.2). The coarser sand will perform better at the South Ocean Beach placement area because it is less mobile than the finer sands placed there now, meaning that wind-blown transport will be reduced and wave-driven transport will be slowed. Regulatory requirements may be less burdensome for excavation locations above the high tide line, and it is possible to excavate above the high tide line in areas that are still within the wave runup zone where coarse sediment deposits. An additional benefit of excavating just above the high tide line is that excavation troughs may also trap onshore blown sand and reduce local wind fetch. This could reduce the amount of windblown sand migrating across the beach toward the Great Highway. The excavation troughs would emulate natural backshore runnels: elongated pools that form on the beach during particularly high tides. The existing beach access point at Lincoln Way could be used for equipment access to the beach.

New vegetated foredune zone

A new foredune zone is established seaward of the O'Shaughnessy seawall in line with the existing foredune ridge at Reach B (Lincoln Way to Noriega Street) (approximately 150-225' west of the seawall) (Figure 8.3) . After public education and outreach efforts, planting and establishing vegetation is the first step; once vegetation is established, then sand will begin to accrete and form the foredune. Beach wildrye can serve as pioneer vegetation, along with additional native San Francisco broadleaf foredune species like beach-bur (*Ambrosia chamissonis*), yellow sand-verbena (*Abronia latifolia*), and silvery beach pea (*Lathyrus littoralis*). These forbs naturally establish embryo foredunes in the beach backshore, starting at the winter wrack line. Winter is the natural time for seedling establishment due to the high moisture in the wet season (see Chapter 9 for more planting information). Once established, the new foredunes will intercept and accrete sand, reducing blown sand and extreme storm wave runup.

Figure 8.1. Concept design summary for Reach A. Elements can be adjusted based on management and recreational priorities; for instance, spacing of excavation troughs is flexible, and the density of pedestrian access paths can be shifted to accommodate more designated dune-crossing trails in areas with higher foot traffic or fewer trails in areas with lower foot traffic.

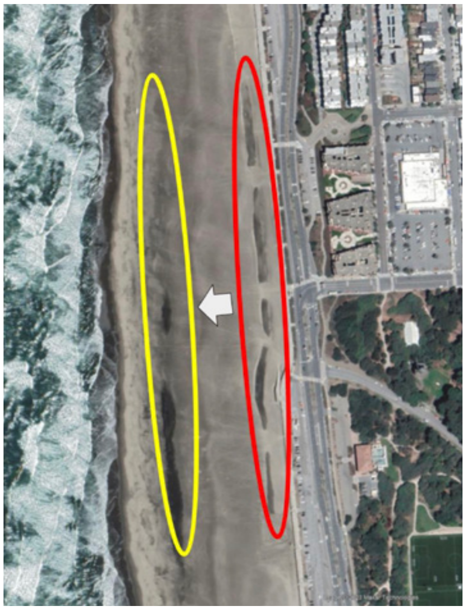


Figure 8.2 The backpass excavation is moved shoreward from the current location just seaward of the seawall (excavation pits visible in aerial photo) to the runup zone above the high tide line.

Figure 8.3. Diagram of natural sand transport processes along Ocean Beach. Regular beach grading north of Lincoln interrupts these processes and limits the natural development of embryo foredunes.

Pedestrian access

Without careful management of pedestrian access, vegetation trampling will inhibit foredune formation. To reduce trampling, new pedestrian corridors are established perpendicular to the dominant northwest wind direction to prevent blowouts. Coarse sand mined from San Francisco Bay, which is less mobile, would be placed on the paths. While all stairwells would remain open to access the beach area behind the dunes, the number of shore access points through the dunes could be consolidated, for example with one dune-crossing path for approximately every three stairwells. Symbolic fencing and brush matting can be used to prevent dune crossing and trampling outside the designated paths. Brush matting is a temporary material that degrades in place. Brush can be sourced from Golden Gate Park trimmings (e.g. from eucalyptus, acacia, Monterey cypress) that would otherwise be chipped. There is potential that brush matting could be piled as fuel for beach fires, which could pose a management challenge if used near fire pits. Educational signs can be included in high pedestrian traffic areas to explain the purpose of the new pathways and brush matting and encourage beach-goers to be good stewards of the dune revegetation project. Signs could be placed at the parking lot, along the dune revegetation zone, and at both ends of the dune-crossing trails. Where trampling occurs, maintenance will be required to replace brush matting and prevent further damage.

Log placement

Imported "driftwood" can be used as a sand trap to aid foredune development. Driftwood deposits naturally support development of embryo foredunes by allowing shadow dunes to form downwind in their lee. Local treefall (e.g., eucalyptus, Monterey cypress) could emulate the role of driftwood on the beach. When buried with sand, they are unlikely to pose a predation risk to western snowy plovers, since they would not be high enough above the beach surface to serve as elevated perches for ravens and other predators. Logs can be approximately 1-2 feet in diameter and 15-20 feet in length, with log stakes used to prevent rolling but allowing release during extreme waves or tides. Driftwood logs are a common feature on state beaches with similar public recreational uses ranging from Waddell Beach (Santa Cruz County) to San Gregorio Beach (San Mateo County), and from Mendocino north. Logs can be placed roughly parallel to the shoreline to protect the dune toe. On each path's western entry/exit point, the logs can be placed roughly parallel to the path to prevent fan-shaped informal trails from forming and help prevent northwest winds from blowing sand onto the paths. These logs would be too large to be used as firewood. For detailed drawings regarding log placement, see Appendix D.

Wind-sheltered recreational zone

Behind the new foredune zone, there will be space (over 100 feet in width) on the beach in Reach A for recreational use (Figure 8.4). The bare area behind the dunes will be sheltered from the wind and compatible with recreational uses like volleyball and beach fires. Maintenance of this area is likely similar to existing requirements at Reach A.

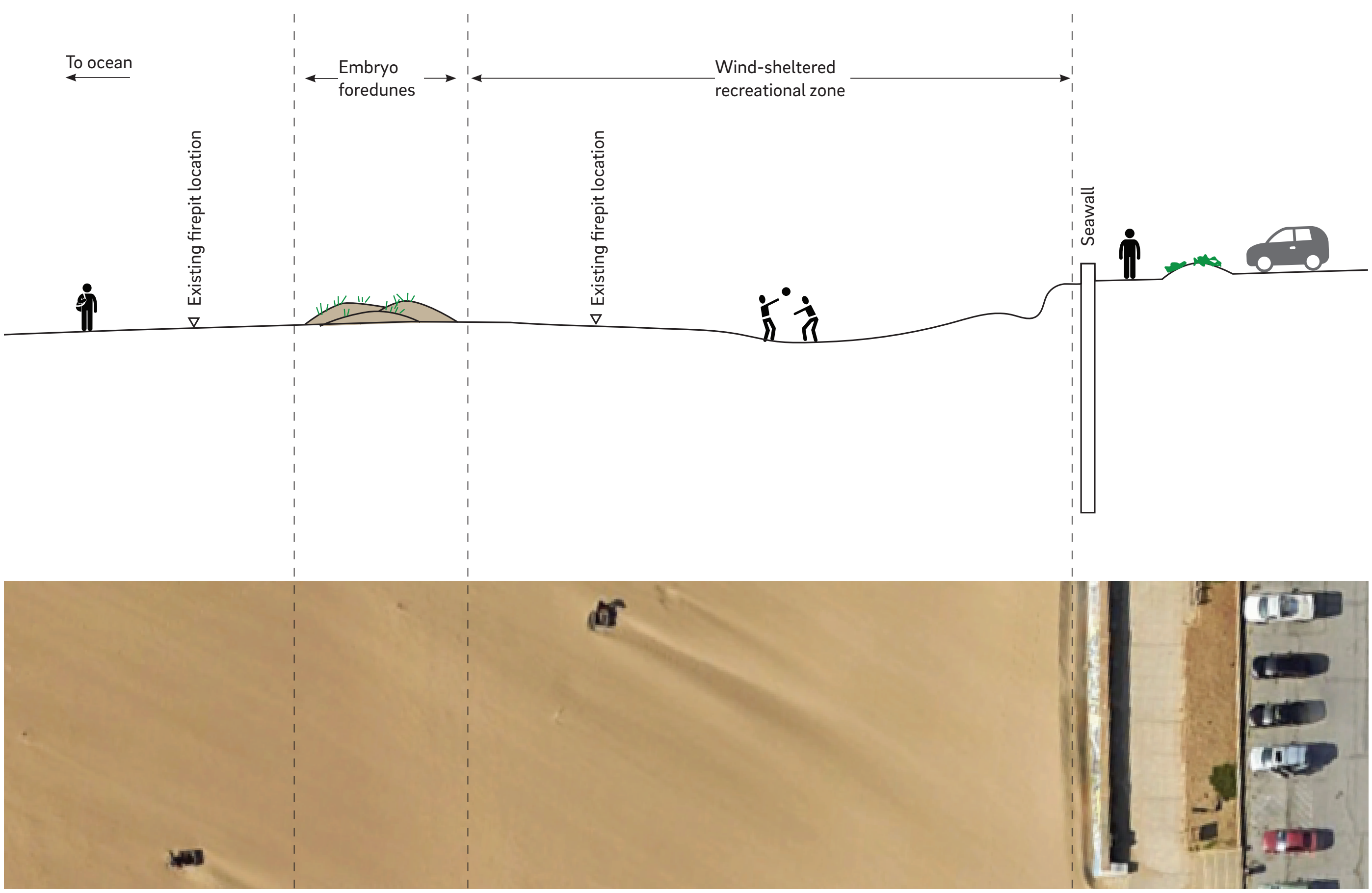


Figure 8.4. The embryo foredune zone would be approximately in line with the existing locations of the fire pits in Reach A, with the wind-sheltered recreational landward.

Timing and implementation

Cultivation of beach wildrye to plant in the new foredune zone is a critical path item; propagation takes two years and another year to establish once planted. Beach wildrye establishes from dormant winter vegetative fragments of shoots with buds. It may be possible to harvest some beach wildrye from Reach B and/or to explore the possibility of applying local California traditional ecological knowledge about sedge harvesting beds to grow self-replenishing supplies of beach wildrye in the backdune area near Irving Street in Reach B or at Golden Gate Park. On-site wildrye propagation beds would be extremely useful for expediting implementation. An on-site growing location must be in the maritime sand and fog zone where beach wildrye thrives. Planting of transplants collected from nearby donor areas must be timed in late fall or early winter to coincide with rains (when soil is already wet). More details on planting are provided in Chapter 9. Each section of the reach that is planted can help provide propagules to plant in other sections or reaches.

Iceplant flats in the backdune area near Irving Street are a potential location to develop on-site beach wildrye propagation beds. Photo by Bob Battalio, ESA.

REACH B - LINCOLN WAY TO NORIEGA STREET

At Reach B, rehabilitation efforts can convert the current degenerated dunes into a vibrant native dune ecosystem (Figure 8.5). Iceplant and marram grass are removed, blowouts regraded, and native vegetation established. Intentional management of pedestrian access and crossings enhance the recreational experience while preventing vegetation trampling and blowing sand impacts. For a more detailed drawing, including a cross-section and a detailed plant palette, see Appendix D.

Foredune rehabilitation (active deposition zone)

To maintain resilience to wave erosion and reduce wind erosion, foredune rehabilitation is needed in Reach B. Beach wildrye and associated broadleaf species (beach-bur, yellow sand-verbena, and silvery beach pea, if approved by NPS), can be planted among brush matting.

Managing trampling damage to vegetation is important throughout this reach, particularly in the higher erosion area south of Lawton Street (see "pedestrian access" section for details). If vegetation is successfully established, it can be resilient to repeated wave erosion events and recolonize through slump-block revegetation after a scarp forms.

Backdune rehabilitation (stabilized zone)

Invasive iceplant and marram grass can be removed by scraping and placing vegetation in pits capped with sand. Pits should be at least 3 feet deep to prevent regrowth. Sand in the backdunes can then be regraded to cover old exposed fill material, smooth out blowouts, and cover unvegetated dune hummocks. The backdune would be graded to create a gentle backslope up to the dune crest, typical of a natural, vegetated foredune. Brush matting can be placed on top of the sand for temporary stabilization and to reduce trampling. This process should be completed during the fall in time for the wet season planting of beach wildrye and associated broadleaf pioneer species. Following planting, it is important to reduce trampling to allow vegetation establishment. When wind-driven blowouts occur, they can be stabilized with brush matting and revegetated. The grading and planting process will occur during a season when snowy plover use the beach; however, the plovers are typically are found on the beach and so the backdune efforts are unlikely to impact them.

Once planted, the backdune area at Reach B near Irving Street could serve as a source population of beach wildrye, allowing propagation for use in planting other reaches. See Chapter 9 (implementation considerations) for more information about this pilot project idea.

Once vegetation is established, additional co-dominant dune species like dune sage (*Ambrosia chamissonis*), clonal grasses like Douglas's dune bluegrass (*Poa douglasii*), and other species can be planted in low-accretion areas of the backdune to provide additional habitat and stabilization benefits. See Appendix A for appropriate plant species.

Dune scrub buffer

To reduce the development of new informal trails and encourage beach access at designated points, a band of thick dune scrub can be planted as a buffer zone between the dunes and the Great Highway. The dune scrub buffer would also create a backstop for the blowing sand. This scrub zone

Figure 8.5. Concept design summary for Reach B. Reach B design elements focus on revitalizing the existing dunes and guiding pedestrian access to designated locations to reduce trampling.


Yellow bush lupine at Bodega Head State Park, Sonoma County. Photo by David A. Hofmann, courtesy Creative Commons.

can be 10-15 feet wide and include shrubs like silvery Chamisso lupine (*Lupinus chamissonis*), yellow bush lupine (*Lupinus arboreus*), and mock-heather (*Ericameria ericoides*), and annual forbs like wild heliotrope (*Phacelia distans*) (see the cross-section in Appendix D). Chamisso lupine is fast-growing and spreading and will establish a thick, soft scrub. After establishment, the dune scrub buffer would be self-sustaining. Watering is not required and management of the dune scrub buffer would be limited to occasional non-native species removal.

Pedestrian access

As in Reach A, entrance points are consolidated, coarse sand is placed on paths to prevent wind erosion, and paths are oriented perpendicular to the dominant northwest wind. Symbolic fencing, brush matting, and educational signs encourage beach-goers to stay on the designated paths.

Viewpoints

Pedestrians tend to seek out topographic high points in the dunes to get a good view of the beach, scope out surfing locations, or take photos. Designated viewpoints can be established at high points to encourage users to visit specific locations rather than trampling vegetation off-trail to seek out new ones. Coarse sand can be placed at these viewpoints, along with symbolic fencing and signage to designate them as appropriate scenic viewing locations.

Timing and implementation

As in Reach A, propagation of beach wildrye is the critical path item. Timing is important in this reach, with marram grass and iceplant removal in fall followed by planting in winter. Multiple phases over multiple years may be needed, with small pilot sites undertaken in the first years and expanding over time to cover the full reach. Another early action that can be undertaken is placing brush matting and educational signage south of Lawton Street, where erosion rates are higher. This section can also be prioritized for early planting.

REACH C - NORIEGA STREET TO SANTIAGO STREET

In Reach C, major vegetative stabilization work is needed, similar to the Judah St crossing in Reach B. A new foredune ramp can be established seaward of the seawall and vegetatively stabilized with native species, if trampling is prevented by concentrating dune-crossings onto designated paths (Figure 8.6). Reducing active sand management activities in this reach can allow natural processes (accretion by dune vegetation) to perform erosion control instead of mechanical removal and placement. See Appendix D for a more detailed drawing.

New foredune zone

The trough immediately seaward of the seawall can be filled with sand and graded to create a gentle slope up to the seawall. This ramp must then be planted with the key dune species identified for other reaches: beach wildrye and others (see Appendix D). It is essential to allow vegetation to establish and create foredunes without disturbance from grading equipment or pedestrian trampling. The seaward side of the new foredune will trap sand and accrete, then erode in episodic storm events. The landward foredune zone provides a source of post-storm recovery vegetation. After a major storm erosion event, rhizomes will re-spread and accrete sand again. The educational signs in Reach C could explain this dynamic process to explain why the dunes may look different at different times of year. In the meantime, brush matting can be placed after an erosion event to mitigate any blown sand.

Pedestrian access

As in Reaches A and B, entrance points are consolidated, coarse sand is placed on paths to prevent wind erosion, and paths are oriented perpendicular to the dominant northwest wind. Symbolic fencing, brush matting, and educational signs are used to encourage beach-goers to stay on designated paths. Logs can be placed parallel to paths at the beach side outlets to reduce fan-shaped informal trails and sand blowing into the path.

Log placement

As in Reach A, imported “driftwood” logs (e.g., eucalyptus, Monterey cypress treefall from Golden Gate Park and other locations) can be placed in the winter wrack zone to stabilize the dune toe and allow the formation of shadow dunes in the lee of the logs. See Reach A description regarding log dimensions and placement. This action will require multi-agency cooperation, with action by RPD and NPS.

Sand placement option

If a location is needed for sand placement in the near term (for example, after removal from the Great Highway or promenade), the rip embayment in Reach C could be a logical location. Rather than placing fine sand in the backshore where it will disturb revegetation efforts and likely blow back into the road, it can be placed below (or within a short distance above) the high tide line in the swash zone where waves can redistribute it. This is a more dynamic and less error-prone strategy than the present placement locations closer to the highway

Figure 8.6. Concept design summary for Reach C, focusing on vegetative stabilization in a new foredune zone.

Timing and implementation

Revegetation can progress from north to south from the existing beach wildrye population in the vegetated dunes in Reach B. As in the other reaches, propagation of beach wildrye two years ahead of time and planting during the winter are the key timing considerations.

Sand migrating onto the Great Highway at Noriega St, looking south across Reach C. Photo by Ellen Plane, SFEI.

REACH D - SANTIAGO STREET TO SLOAT BOULEVARD

A variety of management strategies are possible at Reach D (Figure 8.7). First, sand can be graded into a ramp and a cap over the iceplant-dominated perched dunes and scarp that exist today. After grading, the dunes can be vegetated with beach wildrye and other native species and stabilized at the toe with imported “driftwood.” Once vegetation is established, backshore sand placement can help nourish the dunes and protect the road and infrastructure from wave overtopping.

Vegetated foredune ramp / berm cap

The current iceplant hummocks over the old Great Highway and 1984 berm do not trap sand efficiently. Iceplant can be replaced with more suitable and efficient native sand-trapping vegetation. Iceplant should be removed by scraping, then buried in pits (see Reach B description for more detail). Sand can be graded to form an undulating cap over the existing berm, with a gentle slope at the toe of the berm. Then this cap and ramp can be vegetated with beach wildrye and associated pioneer foredune species. As in other reaches, grading should take place in the fall, along with placement of brush matting for temporary erosion control. Then, planting occurs in the winter rainy season. Vegetation establishment is the key first step at Reach D and must occur before sand backpass placement to maximize trapping and accretion.

Dune scrub buffer

As in the other non-seawall reach (Reach B), a 10-15 foot wide buffer zone of dune scrub (e.g., lupine, mock-heather, and others) is planted along Great Highway to encourage access at designated paths and help prevent blowing sand from reaching the road. These dune-adapted plants grow well in sandy soils. Brush matting can be placed during establishment to prevent trampling impacts before the plants grow to form a more substantial barrier.

Pedestrian access

As in Reaches A, B, and C, entrance points are consolidated, coarse sand is placed on paths to prevent wind erosion, and paths are oriented perpendicular to the dominant northwest wind. Symbolic fencing, brush matting, and educational signs are used to encourage beach-goers to stay on the designated paths. Logs can be placed parallel to paths at the beach-side outlets to reduce fan-shaped informal trails and sand blowing into the path.

Log placement

Large wood can be left in place on the beach (if non-creosote) and more fallen wood brought in as artificial “driftwood” to form small log complexes and protect the dune toe as an interim measure while the beach wildrye propagule stock is built up. See Reach A description regarding dimensions and placement for imported logs.

Sand placement

After successful establishment of vegetation, placement of backpassed sand can be extended northward from South Ocean Beach up to Wawona Street. The material mined from the new foreshore location (see Reach A description) will be coarser sand more suitable for dune formation

Figure 8.7. Concept design summary for Reach D. Once vegetation is established, backshore sand placement can help nourish the dunes.

and less prone to blowing. However, this Reach D placement zone could also be appropriate for placement of any blown sand removed from the Great Highway and promenade.

Using the nourishment plan in the Ocean Beach Master Plan as a guide, sand can be placed as a flat-top berm, extending approximately 50 feet out into the surf zone from the beach crest and approximately 50 feet seaward from the dune face. This sand placement is expected to occur less frequently than the existing sand backpass but entail a larger volume of sand, essentially rebuilding and resetting the shore. Sand would migrate out somewhat farther into the surf zone due to wave action. The sand placed here will be trapped by the newly vegetated dunes and help protect the road and infrastructure from erosion.

Windblown sand salvaged from the Great Highway can be accommodated with additional measures to mitigate wind blown transport. Access for sand placement can be via the Sloat-Great Highway intersection. An agreement between the City and County of San Francisco and NPS will be required to accommodate the placement of wind blown sand on the beach at Reach D.

Timing and implementation

Sequencing is key at Reach D. As in other reaches, it is essential to start propagation of beach wildrye and other dune plants as soon as possible. Next, logs can be placed as a temporary stabilization measure. Once beach wildrye is available in sufficient quantities to stabilize graded sand areas, iceplant scraping, sand grading, and planting can commence in fall, ahead of rains. Finally, once vegetation is established, backpassed sand from Reach A can be placed in the backshore. Timing of this sand placement will need to be coordinated with other sand placement activities at South Ocean Beach.

Large wood on the beach in Reach D, late winter 2023. Photo by Bob Battalio, ESA.

9. Implementation Considerations

A general sequence of events, as described in the preceding chapters, is:

1. vegetation propagation
2. invasive removal and grading
3. planting and vegetation establishment
4. sand nourishment (at Reach D).

The actual timing of implementation in the various reaches will depend on management decisions by the various managing agencies. The following section provides a possible implementation timeline.

YEAR 1

» COORDINATION

- Create updated inter-agency coordination strategy. Identify key roles and responsibilities for each agency to execute the plan.
- Solicit feedback from key user groups to refine management strategies.
- Start coordinated public outreach and education effort to get the word out about dune revegetation efforts.
- Work with local stewardship groups to onboard volunteers for planting and education efforts.

» MANAGEMENT

- Create updated permits/practices for backpass mining location in Reach A. Change backpass mining location to runup zone (if applicable in Year 1) and halt backshore grading.
- Place any sand cleared from roads in rip embayment in Reach C or in other foreshore areas where it can be remobilized by waves, especially in Reach D where dune erosion is severe. Continue in future years.
- Allow natural wrack (untreated wood, kelp) to remain on the beach. Continue in future years.

» REVEGETATION (PILOT PROJECT)

- Fall: Place sand cleared from Reach B over iceplant flats near Irving St (3 ft deep) to smother iceplant and create sand platform for beach wildrye bed.
- Winter: Transplant from adjacent native foredune beach wildrye stands to create self-regenerating beach wildrye propagation bed in the backdune area at Reach B near Irving St (see Propagation and Planting box).
- Any season: Place brush matting preventatively in trampling hotspots (e.g. at Judah and Lawton) before windstorms and dune blowout activity occur.

YEAR 2

» COORDINATION

- Assess and improve inter-agency coordination and adaptive management strategy.
- Expand education and outreach efforts.

» MANAGEMENT

- Reach A: Change backpass mining location to runup zone (if applicable in Year 2). Continue in future years.

» REVEGETATION (PILOT EXPANSION)

- Winter: Expand beach wildrye propagation beds in Reach B.
- Any season: Place brush matting in trampling hotspots (Reaches B and D).
- Any season: Develop paths, symbolic fencing, and viewpoints (Reach B).
- Any season: Import “driftwood” logs (Reaches A, C, and/or D).

YEAR 3

» COORDINATION

- Assess and improve inter-agency coordination and adaptive management strategy.

» REVEGETATION (EXPANDED IMPLEMENTATION)

- Fall: Remove invasive plants and grade sand in Reaches B and D.
- Winter: Plant in Reaches A, B, and D (note that embryo foredune planting, as suggested for Reach A, could occur earlier than Year 3; advance propagation of beach wildrye is not required as only low transplant densities are needed to initiate foredune development).
- Any season: Place brush matting in trampling hotspots (Reaches A, B, and D).
- Any season: Develop paths, symbolic fencing, and viewpoints (Reaches A, B, and D).
- Any season: Import "driftwood" logs (Reaches A, C, and/or D).

YEAR 4

» COORDINATION

- Assess and improve inter-agency coordination and adaptive management strategy.

» REVEGETATION (EXPANDED IMPLEMENTATION)

- Fall: Regrade sand in Reach C.
- Winter: Plant in Reach C (harvest from propagation beds as well as Reaches A and B).

YEAR 5

» COORDINATION

- Assess and improve inter-agency coordination and adaptive management strategy

» MANAGEMENT

- Place backpass sand as a flat-top berm in Reach D to widen the beach and dunes.

» REVEGETATION (EXPANDED IMPLEMENTATION)

- Winter: Plant additional native vegetation in all reaches.

Changes to the current management regime may increase the pace and effectiveness of implementation. Key to implementation is agreement and coordination between the managing agencies, with regular engagement and surveys to assess which parts of the collaboration are working and which need improvement. One idea is to create a new coordination position for Ocean Beach to coordinate between the multiple overlapping agency jurisdictions and seek cooperatively funded and implemented projects. Working together on regular audits of the management and coordination strategy can help determine next steps.

Propagation and Planting

Planting a source bed of beach wildrye, plus light thinning of existing stands, would support the expansion of vegetative stabilization projects at Ocean Beach. Existing stands at Reach B are large and could be thinned 1-2% with negligible impact, and thinning could be compensated by light applications of fertilizer. During the winter, beach wildrye tillers (shoots growing from the base of a grass plant) and rhizomes (underground stems running horizontally) can be divided and harvested from a source bed, then transplanted. Transplanting must occur during winter when soils are already wet. Drought would preclude transplant, as survivorship would be inhibited by drought conditions.

Transplants should be buried in the sand about 10 centimeters. Setting each transplant over an organic matter patch with added nitrogen would accelerate establishment. Where outplanted for continuous stabilization plantings, 2-3 foot centers is a reasonable density. Outplantings for embryo foredune development in Reach A can be much more sparse. After transplant, brush matting should be placed for temporary surface stabilization.

Little additional management is needed beyond occasional invasive species management. Marram and iceplant are the main weeds that would require management in newly planted beach wildrye areas. Iceplant is easily weeded at its seedling-juvenile first year stage, and marram spreads slowly (it has not displaced beach wildrye at Irving in thirty years).

This report recommends including broadleaf species in addition to beach wildrye in the vegetative stabilization areas. The quantity of founder plants for the broadleaf species is flexible. Even if plantings are limited in number and spaced widely, they will spread clonally from founder plants. Broadleaf species could be grown by coastal nurseries for planting at Ocean Beach. Spacing would depend on availability of stock.

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