Malibu Living Shoreline Project

Implementation and Monitoring Plan

May 2020

Prepared for:

- California Coastal Commission
- Los Angeles County Department of Beaches and Harbors
- City of Malibu
- California State Coastal Conservancy

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Timing of Operations: The Malibu Living Shoreline Project will begin implementation likely in Fall 2020 once a Coastal Development Permit through the City of Malibu's Local Coastal Program has been approved and will be contingent on COVID-19 local and state restriction lifts. Outreach and baseline monitoring efforts are ongoing. The project will be scientifically monitored for a period of no less than five years post-implementation.

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Prepared for:

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In addition to the partners listed above, we are also grateful for the many proponents and advocates for this project, including but not limited to: former Malibu Mayor and Councilmember Skylar Peak, Councilmember Jefferson "Zuma Jay" Wagner, Audubon Society, US Fish and Wildlife Service, United States Geological Survey, University of Southern California Sea Grant Program, Loyola Marymount University's Coastal Research Institute, University of California Santa Barbara, Cooper Ecological Monitoring, Inc., Coastal Restoration Consultants, Inc., Heal the Bay, Tijuana River National Estuarine Research Reserve, US Environmental Protection Agency, Resource Conservation District of Santa Monica Mountains, and local residents and visitors to the site. This support will allow us to explore nature-based adaptation ("living shoreline") protection measures to combat climate change, while bringing back an important coastal habitat to the Los Angeles region.

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Photograph of non-native iceplant in project area (bright green/orange) with native beach bur in the middle (light blue-green) in the Zuma Beach project area.

Introduction

Background

Los Angeles County beaches are some of the most recognizable and popular beaches in the world. They feature expanses of sand, cliffs, tidepools, and marine life; and they hold many recreational opportunities for the millions of people who visit the vast coastline each year. In recent years, over 70 million people have visited beaches in Los Angeles County annually. Although sandy beaches traditionally have been and continue to be managed primarily as recreation areas, they are also important natural ecosystems that link marine and terrestrial environments and are considered a major habitat. The protection of sandy beaches and an understanding of their condition has become increasingly important in their relationship to sea level rise and coastal resilience.

Beaches are broadly recognized and highly valued as cultural and economic resources for coastal regions (Dugan et al. 2015). However, their value as ecosystems is often less appreciated. Southern California beach systems and associated wildlife are highly impacted by threats such as erosion, interrupted sediment transport, beach replenishment with non-natural sediment, pollution, and loss of natural morphology due to grooming and other maintenance activities, which has led to the extirpation and extinction of many native species and loss of important ecosystem functions (Dugan et al. 2003, Dugan and Hubbard 2009, Hubbard et al. 2013). Dunes and other beach habitats are critical in managing sand transport to create resilient beach morphologies, which naturally adapt to climate change impacts. These systems can also offer a nature-based adaptation approach, or "living shoreline", form of protection for our coastlines. By restoring natural processes to impacted beach systems, we will improve their ecological and utilitarian functions, and serve as a model for similar projects statewide.

Since the 1960s, many of the beaches in the Los Angeles area have been subjected to the continuous removal of natural features as they begin to develop. Additional impacts have occurred from development such as roads and highways, homes, and other types of infrastructure. However, when beaches are allowed to maintain or create natural features, such as low dunes away from active recreation areas, they provide a cost-effective buffer to storm surges and other regular, predictable threats, including sea level rise and increased erosion. As a vital part of our coastline, beaches and dunes support and protect our homes, roads, and infrastructure, providing a natural buffer from sea level rise (SLR) as well as from tidal and wave action from the ocean.

In April 2016, Los Angeles County published the LA County Public Beach Sea-Level Rise Vulnerability Assessment, made possible by a grant from the California State Coastal Conservancy. This assessment identified public beach facility assets at Zuma and Point Dume County Beaches, where the proposed Malibu Living Shoreline Project will occur. Collectively there are 33 assets, including a concession, multiple lifeguard buildings, a maintenance yard, parking lots, restrooms, and an access road at Zuma and Point Dume County Beaches. These assets comprise the essential components that are needed to support and promote safe public beach recreation opportunities. The study identified that if no protection measures are implemented, assets at Zuma and Point Dume County Beaches will be vulnerable to inundation damage under high sea-level rise projections. Additionally, with no shoreline protection measures implemented, the analysis suggests that Zuma and Point Dume County Beaches could lose up to 50% of beach by 2040, and up to 70% of beach by 2100. The Malibu Living Shoreline

Project provides a cost-effective and low-impact solution to increase the resiliency of the shoreline at Zuma and Point Dume County Beaches.

Historically, large expanses of dunes once covered the coastal zone at both Zuma and Point Dume County Beaches (Figures 1 and 2). Due to urbanization, an increase in development, and beach grooming (raking) practices, the majority of these historical dunes have disappeared. The Los Angeles County Department of Beaches and Harbors (LACDBH) has built up some sand dunes in recent years to protect coastal infrastructure at Zuma and Point Dume Beaches in Malibu, but they are largely covered by monocultures of non-native, invasive species such as iceplant (e.g., *Carpobrotus edulis*).

Historical Ecology

Historical ecology is the study of how humans have interacted with natural landscapes over time. A basic tenant of this field is that different societies alter ecological landscapes in different ways. The greater Malibu area was part of the Rancho Topanga Malibu Sequit, a Spanish land grant made in 1805 to Jose Bartolome Tapia. The approximately 14,000-acre rancho stretched along the coast from about Topanga Canyon to Point Mugu and from the coast to the first high ridge of the Santa Monica Mountains. The first detailed map of the Malibu coast was published in 1857 as part of the United States Coast Survey (Figures 1 and 2).

Today's Pacific Coast Highway was first opened as a county road in 1921, and then improved to a state highway in 1929. The building of roads brought some of the early major impacts to dunes, creeks, and beaches along the Malibu coast. With the building of the road, came coastal development in the 1930's and 40's. In 1941, Los Angeles County foreclosed on a large property at Zuma Beach for taxes due, and in the ensuing years, replaced a large area of dune habitat with an extensive parking lot. A road and parking lot were built on top of dunes in the mid-to-late 1940's at Point Dume Beach as well. Subsequent facilities such as additional parking lots, bathrooms, lifeguard facilities, and other recreational use development were added over subsequent decades, leading to existing site conditions which include 26 public beach facilities at Zuma Beach (i.e., two concession stands, two lifeguard buildings, one maintenance yard, 12 parking lots, and nine restrooms) and seven at Point Dume Beach (i.e., two lifeguard buildings, one parking lot, three restrooms, and an access road) (LACDBH 2016).

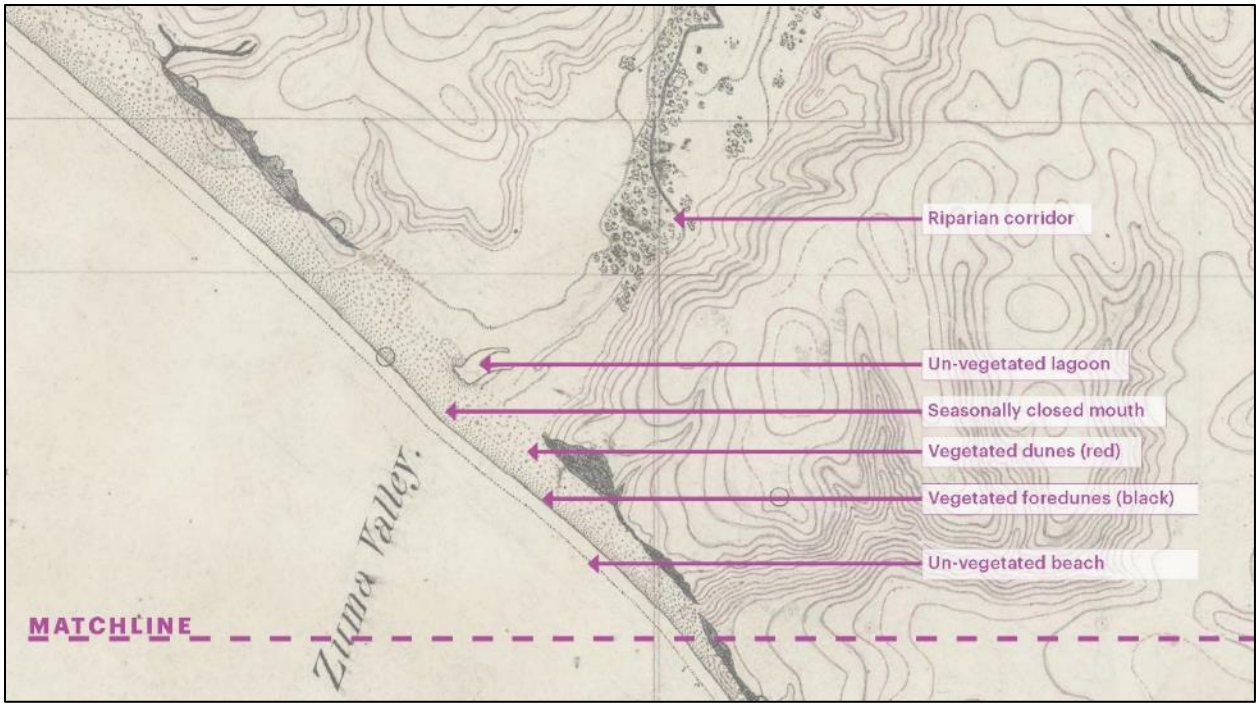

Figure 1. 1857 Coast Survey of Zuma Lagoon and vicinity (replicated from Rios and CRC 2019). Vegetated foredunes are indicated by a black line and vegetated dunes are 'red' speckles on the map.

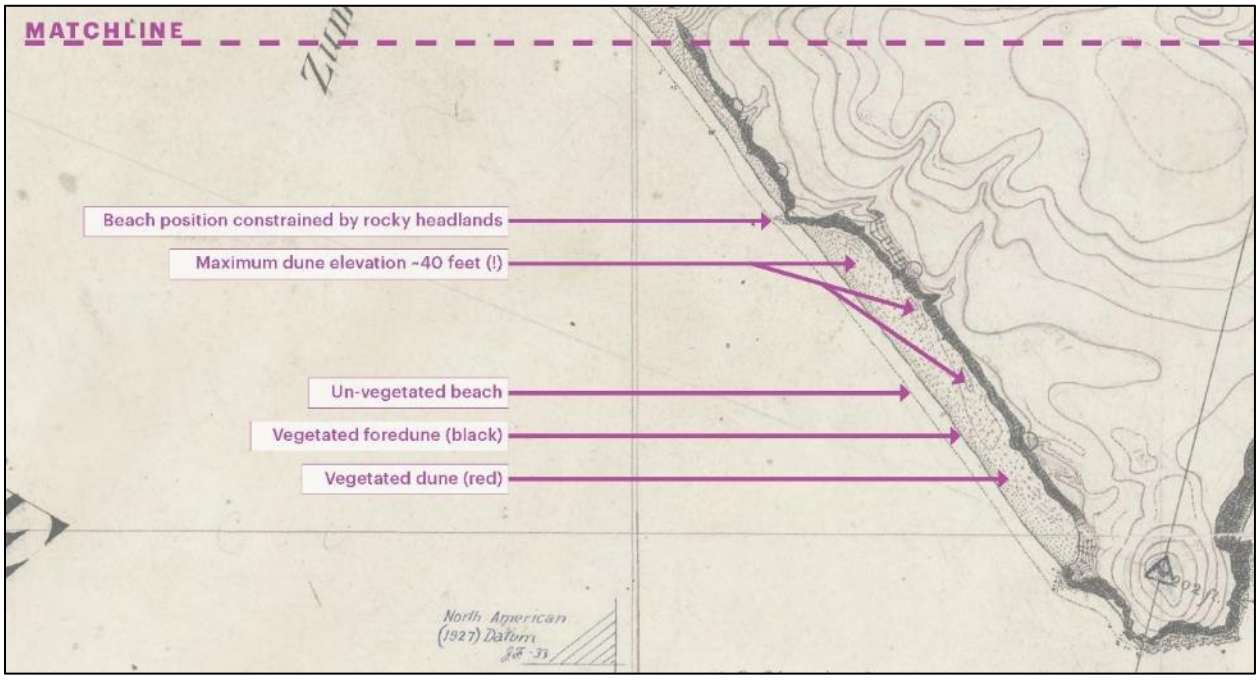

Figure 2. 1857 Coast Survey of Point Dume Beach and vicinity (replicated from Rios and CRC 2019). Vegetated foredunes are indicated by a black line and vegetated dunes are 'red' speckles on the map.

Project Goals

This pilot project aims to restore approximately three acres of sandy coastal habitats located on the beaches of Malibu by utilizing existing sediments to transform a portion of the current beach into a sustainable coastal strand and foredune habitat complex resilient to sea level rise. As an alternative to traditional hardscaping options, this project will evaluate a living, restored shoreline with a diverse wildlife community as an alternate approach to combat climate change. Three specific goals of the Malibu Living Shorelines Restoration Project include: increasing the resiliency of the shoreline through the restoration of sandy beach and foredune habitat, implementing nature-based adaptation, or 'living shoreline', protection measures against sea level rise and coastal storms, and increasing engagement of the community through enhanced beach experiences, outreach, and education. Encouraging natural accretion of sand will build topography and increase elevation across the upper shore to store sand. This will help alleviate the effects of large winter storms and in the long-term, sea level rise. Intact and native dune systems are more resilient to disturbance than degraded systems.

This project aims to enhance the existing dunes by replacing the invasive plants with native dune species as well as enhancing the footprint of ungroomed areas (Figure 3). After seeding and planting vegetation, sandy coastal strand habitats and foredunes would naturally develop, which will then support higher levels of the ecological community (e.g., invertebrates, birds). Scientific literature highlights the need for ecosystem-level, rather than species-level, beach restoration planning to achieve the greatest ecological benefits (e.g., Schlacher et al. 2008). The ecosystem benefits that living shorelines projects provide are not limited to a narrow time period but continue over time as the shoreline establishes, compared to hard shorelines that require maintenance and often result in the loss of beach.

This demonstration site will also serve as a model for the region, showing that heavy recreational use of beaches and meaningful habitat restoration are not incompatible goals. It will provide not only a scientific basis to develop guidelines and protocols but an integrated, locally-based program for increasing the usefulness of natural environments in a developed area. It will evaluate "soft" nature-based, low-cost, natural living shoreline protection from sea-level rise and storms while providing public benefits and enhancing natural resource values.

Additionally, this project will help reestablish an appreciation that has been lost in the Los Angeles region of a natural, functioning beach ecosystem and the site will provide educational and recreational opportunities including interpretive signage and pathways for people to interact with the site. In addition to reducing coastal hazards and protecting nesting birds, this project will encourage nature-based tourism and increase community awareness of living shorelines while still allowing all other existing recreational uses of the beach to continue. All of these benefits are expected while having low-to-no impact on existing recreational uses of the beach.

Figure 3. Representative site photographs from Zuma Beach adjacent to the lagoon (above) and Point Dume Beach adjacent to the parking lot (below).

Site Description

Both Zuma Beach and Point Dume Beach reside in the City of Malibu and are managed by the Los Angeles County Department of Beaches and Harbors. Historically, dune systems were a prominent feature of this area; over time with increased development and urbanization, these dune features disappeared. The project site consists of approximately three total acres of sandy beach and foredune restoration. Restoration activities are proposed on just over one acre at the Zuma Beach site, adjacent to Zuma Lagoon, and approximately two acres at the Point Dume Beach site (Figure 4).

Figure 4. Overview map of both restoration areas as part of the Malibu Living Shoreline Project (Rios and CRC 2019).

Zuma Beach and Upland Transition Habitats

The dune system present at Zuma Beach adjacent to Zuma Lagoon is largely overrun by invasive vegetation, including large monocultures of invasive iceplant (*C. edulis*), searocket (*Cakile maritima*), and non-native grasses such as Bermuda grass (*Cynodon dactylon*). Small patches of native beach bur (*Ambrosia chamissonis*) were identified during vegetation assessments, but the areas designated for restoration in this system are largely covered by non-native plants. Existing native vegetation will be protected, while non-native plants are targeted for removal. This site is dynamic over time with strong fluvial, aeolian, and marine processes at work (Rios and CRC 2019). As this site includes some upland transition habitats, there may be some shifting of plant communities over time, which is expected. Current grooming practices preclude expansion of the existing dune footprint, but new opportunities for enhanced beach are one component of the restoration project.

Major habitats in the restoration area for Zuma Beach include upland transition, back dune, southern foredune, and mechanically groomed beach (Figure 5a). Back dunes and upland transition habitats on site occur on sandy soils that are sufficiently stabilized (i.e., little or no blowing sand) due to their position in the lee of foredunes. The lack of sand movement leads to a buildup of nutrients and inclusion of some fine sediments (i.e., silt, clay, or organic components) in the soil. This soil structure allows for the potential to restore a wide range of native forbs and shrub species not found in foredunes or coastal strand areas. In Figure 5b, the top photograph foreground is a mix of native and non-native species in a more stabilized dune area, with iceplant in the background. The bottom photograph is closer to the transition habitat area and is dominated by iceplant.

Current plant communities in the upland shrub area include large monocultures of invasive iceplant, non-native grasses, and invasive Ngaio tree (*Myoporum laetum*). Current plant communities in the back dune habitat are predominantly iceplant, with interspersed patches of carnation spurge (*Euphorbia terracina*) and Bermuda grass. There are a few patches of beach bur and beach saltbush (*Atriplex leucophylla*) intermixed that will be protected during restoration activities. Southern foredune habitats occur on fine to coarse sand that is subject to aeolian processes and disturbances. The plant communities in the southern foredunes include some native plants (e.g., beach bur and beach evening primrose, *Camissoniopsis cheiranthifolia*) and non-native plants (e.g., Bermuda grass, European sea rocket, iceplant). Removal of non-native plants in this habitat will allow for native plant germination and expansion. Groomed beach areas currently have no vegetation and are frequently smoothed and raked by mechanical equipment.

The Zuma Beach restoration site is directly adjacent to Zuma Lagoon which is designated critical habitat for the federally endangered tidewater goby (USFWS 2013), though none have been present in annual surveys conducted since 2005 (R. Dagit, pers. comm 2020; Dagit et al. 2018). The “specific physical or biological features” essential to tidewater goby conservation include saline aquatic habitats such as lagoons, estuaries, and backwater marshes (USFWS 2013). The restoration is unlikely to affect the potential for tidewater gobies to populate the site, as wetland and aquatic habitat restoration is not a component of this restoration plan. Similarly, the restoration project will not alter the sandbar in front of the mouth of the lagoon. However, the Federal Register (Vol. 78, No. 25) identifies sea level rise as a threat to the species, so there may be indirect benefits through habitat preservation in the form of increased coastal resiliency.

Additional adjacent habitats include riparian areas dominated by arroyo willow (*Salix lasiolepis*), emergent brackish wetland dominated by California tule (*Schoenoplectus californicus*), and other habitats. For additional details on the biological community of the restoration area and surrounding habitats, refer to the supplemental "Baseline Assessment and Site Characterization" document (CRC and TBF 2020).

Additionally, western snowy plovers, a federally threatened species of bird, are known to inhabit roosting sites on northern Zuma Beach. Individuals show high site fidelity and have been observed returning to Los Angeles County to the same beach for as many as six years (Ryan and Vigallon 2010). Beach grooming is one of the key impacts to plovers both directly through mortality and indirectly through habitat restrictions (Ryan et al. 2017). Roost population counts are generally highest between August and March. This beach and the roosting area are within Western Snowy Plover Critical Habitat Subunit CA-43 (USFWS 2012). "Physical or biological features" essential to the conservation of the species are identified (in part) as dune-backed beaches, sparsely vegetated dunes, and beaches at creek and river mouths (USFWS 2012). However, the Zuma Beach plover roost site is northwest from the proposed restoration area by approximately 1,300 meters and the restoration project is unlikely to directly affect the Zuma Beach population.

However, the project has the potential to provide future indirect benefits for the plovers, once restored, and will be carefully monitored over time for any changes or movements in the roosting plover populations. See the supplemental "Baseline Assessment and Site Characterization" document (CRC and TBF 2020) for additional information and "Conservation Measures" below for additional protection measures to be conducted during restoration activities.

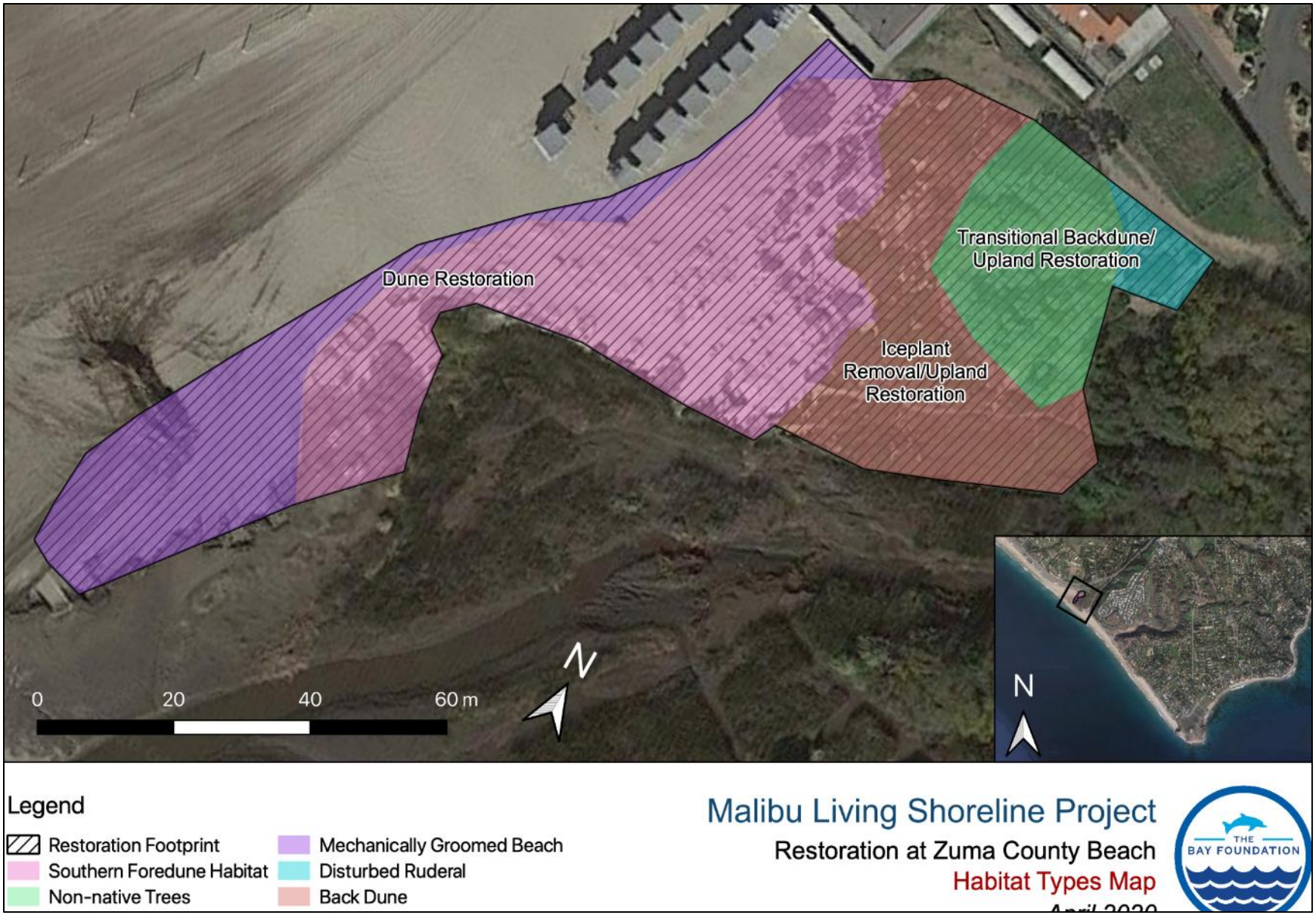

Figure 5a. Map of Zuma Beach and upland transition restoration areas and summary habitat information.

Figure 5b. Representative photographs from Zuma Beach and transition habitats.

Point Dume Beach

The project area at Point Dume is comprised of small, sporadic and patchy dunes lining the edge of the beach and buffering the parking lot (Figures 6a-d). The site historically supported foredune, dune, and back dune habitats in front of the bluffs. Almost no native coastal strand or foredune vegetation species can be found here, with several exceptions of small intermixed native plant patches, and those areas that are vegetated are covered with non-native, invasive species such as iceplant and sea rocket (Cal-IPC 2020). The condition of this dune habitat is poor and restoration activities would increase ecosystem values, critical habitat, and the ability of these areas to build healthy and stable dune ecosystems to protect against sea level rise. Additionally, the dunes would serve to protect existing beach infrastructure such as parking lots, restrooms, and lifeguard facilities. There is sufficient sand supply and natural wind and wave conditions to restore natural processes that support dunes (Rios and CRC 2019). Both sites border the 16-square mile Point Dume State Marine Protected Area, and US Fish and Wildlife Service has also designated this area as critical habitat for the federally threatened western snowy plover.

Figure 6a. Representative photograph of patchy dune system at Point Dume Beach adjacent to a parking lot with two lifeguard towers in the background.

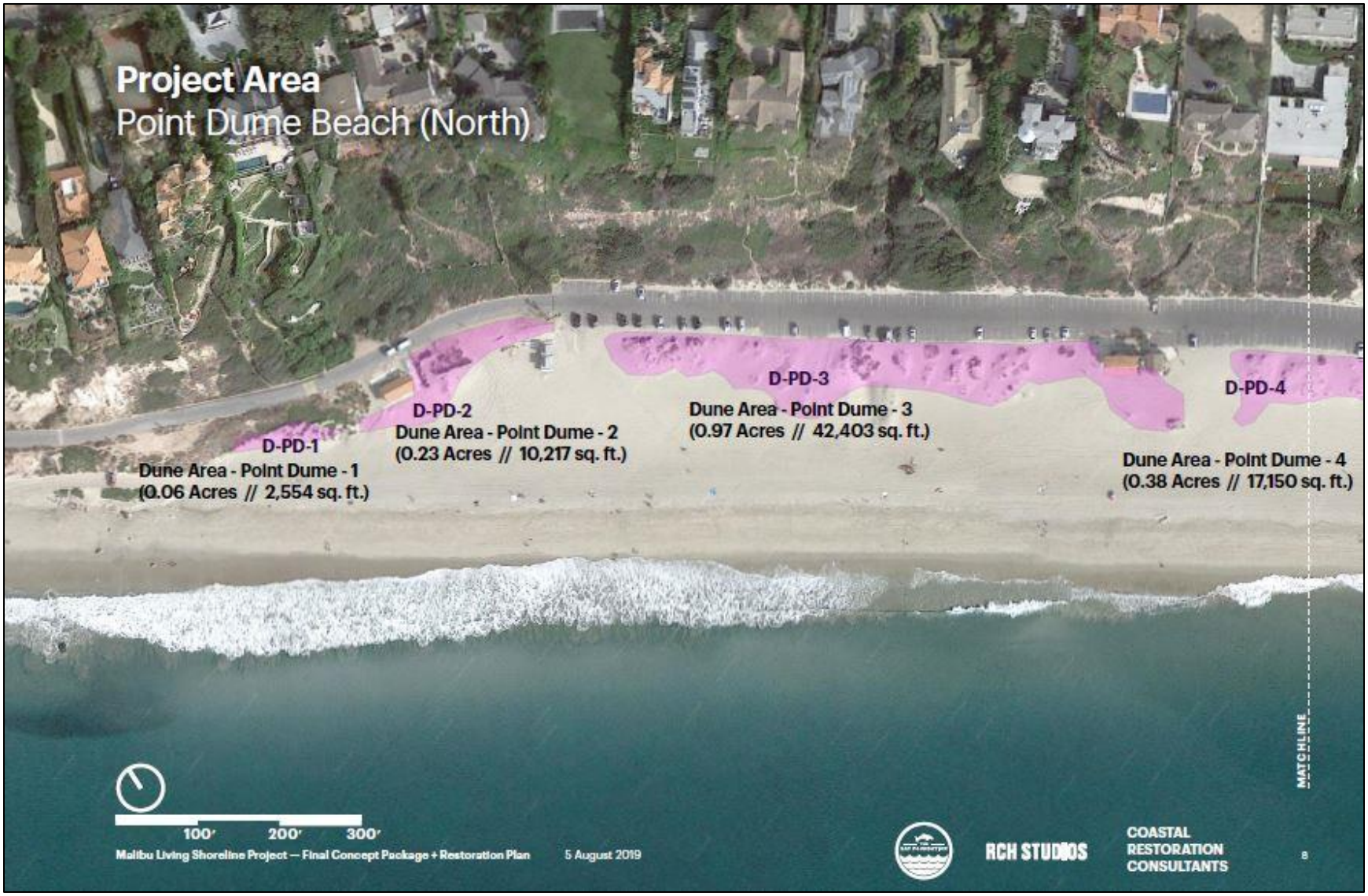

Figure 6b. Map of existing dune patches at within the project area at Point Dume Beach in Malibu, CA (northern half).

Figure 6c. Map of existing dune patches at within the project area at Point Dume Beach in Malibu, CA (southern half).

Figure 6d. Representative photographs from Point Dume Beach (north, top; south, bottom).

Project Description Summary

The project aims to restore just over three acres of impacted beach and foredune habitat into a healthy living shoreline that will provide rare coastal habitat, ecosystem services, and adaptation measures for coastal storms and sea level rise (Figure 7). This pilot project will use a combination of native plants and seeds and strategically placed fencing, wooden slats, symbolic pathways, and signage as part of the implementation plan. Encouraging accretion of sand through native vegetation, sand fences, and wooden slats will build topography and increase elevation across the upper shore to store sand. This will help alleviate the effects of large winter storms and in the long-term, sea level rise. Intact and native dune systems are more resilient to disturbance than degraded systems.

The proposed restoration sites at Zuma Beach and Point Dume Beach have good potential for supporting more natural coastal habitats because they retain relatively intact coastal processes, e.g., wind transport, space, sediment flux. The remnant coastal dunes at Zuma Beach and Point Dume Beach seem to have somewhat stable sediment fluxes and are perhaps the best examples of natural dunes in the 17 mile long (27 km) Zuma Littoral Cell (Griggs and Patsch 2018), which lies between Point Mugu and Point Dume. On the other hand, the proposed restoration areas are currently under pressure from non-native vegetation, mechanized grooming, compromised sediment supplies from up-coast sources, and other impacts.

This section contains summary project descriptions for each of the two restoration locations included as part of this project (i.e., Zuma Beach and Point Dume Beach), as well as 'before' photographs and 'after' artistic renderings of the project areas post-restoration from the same locations. Detailed implementation methods are included in the subsequent report section.

Figure 7. Overview map of the project sites adjacent to Zuma Lagoon and at Point Dume Beach in Malibu, CA.

Zuma Beach and Transition Habitats

Proposed restoration activities at Zuma County Beach include restoring approximately one acre of sandy beach and dune habitat complex adjacent to Zuma Lagoon (Figure 8). Currently the habitat is overrun by invasive non-native plant species, primarily large monocultures of iceplant (*C. edulis*). The lower portion of the restoration area is located on beach habitats adjacent to the lagoon, and they are highly dynamic. Between 2017-2019, the area changed shape during the rainy season, such that older aerial photos show the dunes in a different location than the current area. Thus, this design will embrace the dynamic nature of the site with the understanding that project outcomes are subject to disturbance. Restoration activities will aim to manually remove non-native invasive species on site (Figure 9a). Invasive species will be disposed offsite into green waste. Symbolic pathways (white lines with red dots in Figure 8) and interpretive signage will be installed throughout the site to allow native vegetation to grow and encourage visitors to use the site in a sustainable manner (Figure 9b). The majority of the site will be seeded and planted with native coastal strand and foredune species, with the northern portion also including coastal scrub plants. Restoration details by habitat type are included in the subsequent section of this document: “Malibu Living Shoreline Project: Implementation and Monitoring Plan”.

Point Dume Beach

Proposed restoration activities at Point Dume County Beach will restore approximately two acres of sandy beach and foredune habitat and will include non-native invasive species removal, seeding with native coastal dune species, several strategically placed segments of slatted sand fending and “biomimicry wooden stakes” to optimize sand capture, and strategic placement of short symbolic pathways leading from the parking lot to the front beach area (Figures 10a and 10b). Interpretive signage will be a component of restoration activities and included at both the Zuma and Point Dume project sites. Figure 11a is a photograph of the existing view of Point Dume Beach from the bluff, and Figure 11b is an artistic rendering of the potential future of the site post-restoration. Figure 12 is a graphic representation of an existing and proposed dune section at Point Dume Beach. Note the target dune crest shifting oceanward of the parking lot over time to facilitate sand retention. Appendix A contains graphics for the four proposed interpretive signs (two for each site).

The Bay Foundation (TBF) aims to utilize the Los Angeles Conservation Corps to aid in on-the-ground restoration activities. Following the completion of project implementation, TBF will coordinate and lead five years of post-restoration monitoring and maintenance and, if necessary, perform adaptive management actions to ensure the success of the restoration project such as trash or non-native vegetation removal (see also “Adaptive Management” later in this document). Further, post-restoration outreach will continue to maximize community involvement in the site and identify stewardship and educational opportunities as well as continue to explore other partnerships such as with Audubon Society. A future phase (‘Phase 2’) of dune restoration may be possible in Point Dume South, but is not planned at this time as part of this project and thus is not included in this restoration plan document.

Figure 8. Map of the final site design for the one-acre footprint adjacent to Zuma Lagoon.

Figure 9a. Photograph of existing view of Zuma Lagoon taken in ecotone E-Z-1 (see map above) and dominated by iceplant.

Figure 9b. Artistic rendering of ecotone E-Z-1 in post-restoration conditions adjacent to Zuma Lagoon approximately five years after restoration.

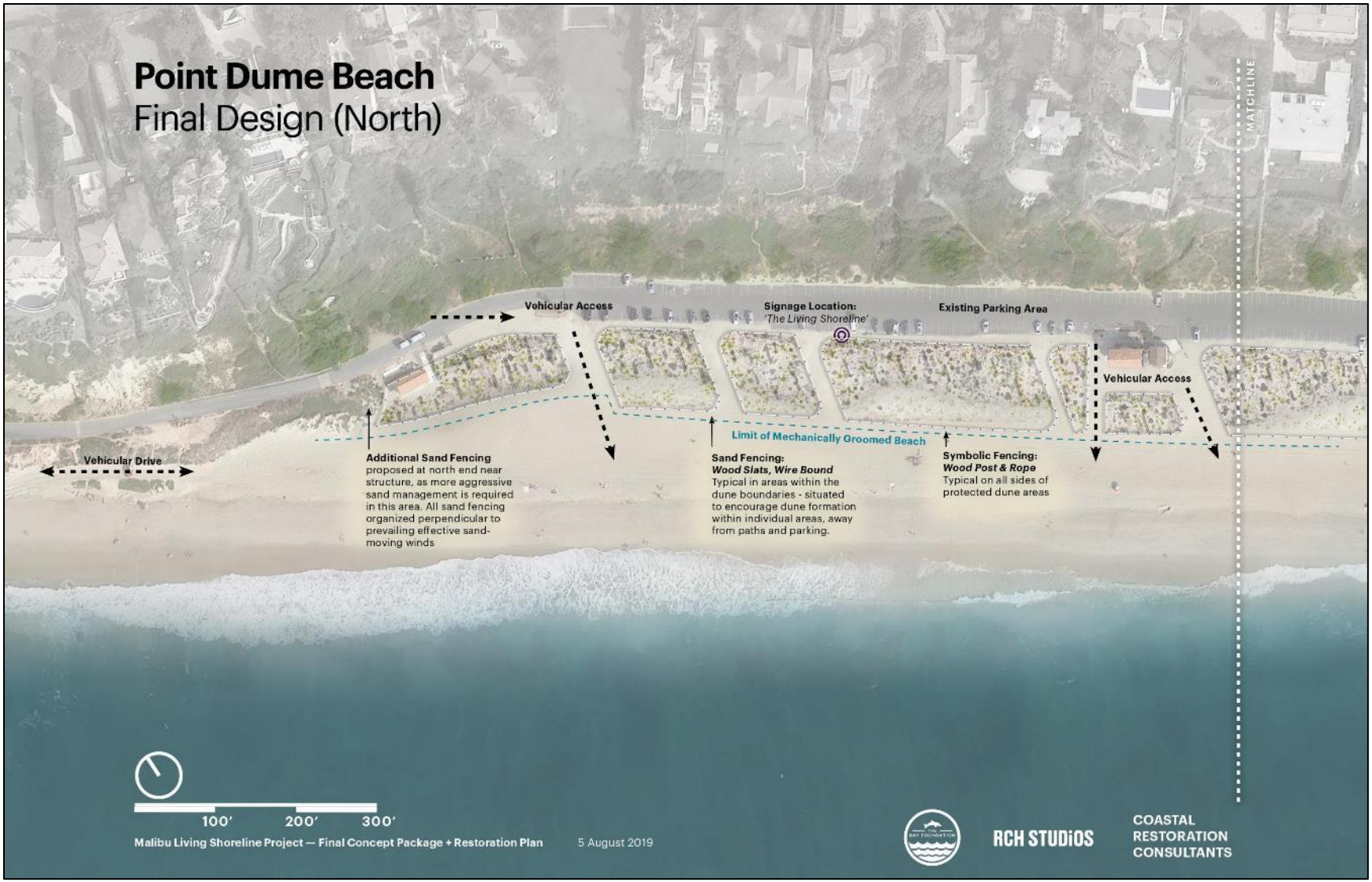

Figure 10a. Map of the final site design for the Point Dume Beach restoration area (north half).

Figure 10b. Map of the final site design for the Point Dume Beach restoration area (south half, Phase 1).

Figure 11a. Photograph of existing view of Point Dume Beach with some foredune dunes dominated by iceplant.

Figure 11b. Artistic rendering of Point Dume Beach (phase 1) post-restoration conditions approximately five years after restoration.

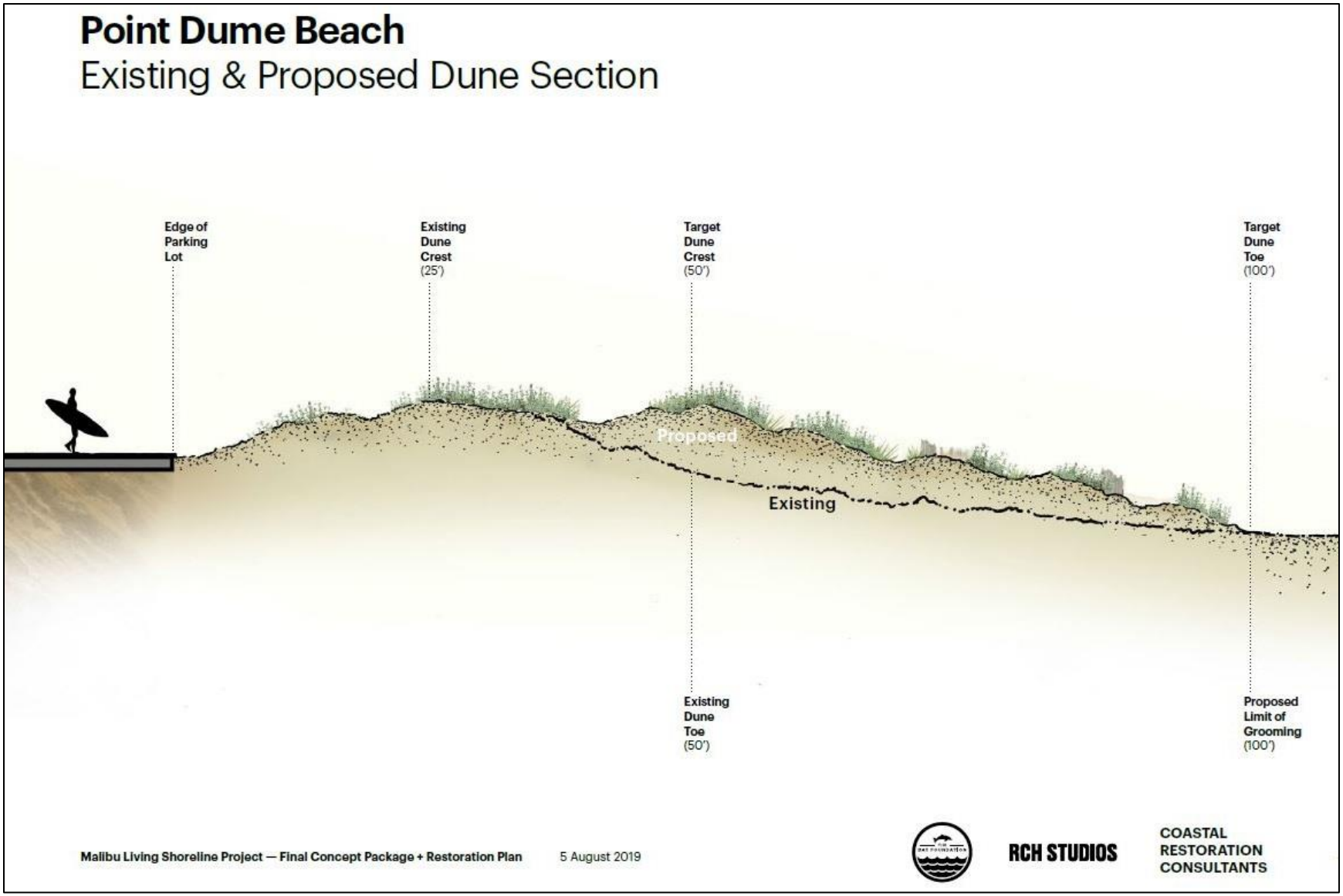

Figure 12. Graphic representation of an existing and proposed dune section at Point Dume Beach.

Coastal Processes

Seeded and planted specialized foredune vegetation will grow and develop and begin trapping sand transported by wind. Wind-driven sand will bump into vegetation, fall, and accrete, increasing the elevation of the plant hummocks and dunes over time. Subsequently, the vegetation will continue to grow and develop on top of the newly accreted vegetated sand hummocks. Because beach dunes accrete sediment being transported from the ocean, they will continue to grow concurrently with rising sea levels. This process can continue as long as the vegetation community is robust and healthy. This process has repeatedly been demonstrated in the scientific literature as well as in pilot projects in other California Counties, such as the Surfer's Point restoration project in Ventura County, the Santa Monica Beach Restoration Pilot Project in Los Angeles County, and the Cardiff Dune Restoration Project in San Diego County.

Additional processes such as beach erosion occur seasonally in southern California in the winter months, and the project will be designed specifically to maximize the potential for the beach to retain sediment in the long-term. Intact systems in areas with adequate sand supply and with large seed banks have the capacity to regenerate vegetation cover and then re-build dunes by trapping wind-blown sand.

Permitting

TBF, in coordination with the City of Malibu and LACDBH, will obtain the necessary permits to implement the Malibu Living Shoreline Project. The project has been brought before the City Council of the City of Malibu twice, with additional special presentations at an Environmental Subcommittee Meeting, beach walk outreach events, and other public venues. This document is part of TBF's application through the City of Malibu (in partnership with LACDBH) for a Coastal Development Permit (CDP) issued by the California Coastal Commission. This project fits within City of Malibu's Local Coastal Program and has been enthusiastically supported by City Councilmembers as a demonstration pilot project for the region. While not a building or construction project, this project does have the potential to affect beach activities and as such requires a public process. Subsequent to CDP permit approval, TBF will apply for a right of entry permit with LACDBH. At the time of drafting this document, City of Malibu Departments of Public Works, Planning, Biology, and Engineering have reviewed and signed the CDP application. Additionally, a CEQA exemption will be filed and obtained by the City.

Lastly, coordination and communications are ongoing with federal and state agencies with an interest in this project, beach management, and/or wildlife (e.g., US Fish and Wildlife Service). US Fish and Wildlife Service provided recommendations for conservation measures as a component of the adaptive management section of this document. All annual reports for this project will be made publicly available on The Bay Foundation's website: www.santamonicabay.org.

Implementation and Restoration Plan

Through habitat restoration and the installation of symbolic pathways and interpretive signage, the site will provide new opportunities to enhance recreational beach experiences, including opportunities to observe native dune plants growing and flowering, bird watching, and to simply enjoy the scenery. Detailed maps with project implementation components can be found above in Figures 7-12. Narrative details on project implementation strategies, components, specific methods, and vegetation species can be found in the subsections below.

Project implementation is scheduled to begin in fall 2020 and may require up to six months. Pre-restoration monitoring is ongoing, and the project implementation will be followed by post-restoration monitoring for a time period of no less than five years. TBF has a long-term commitment to post-implementation monitoring, maintenance, and adaptive management, if needed. Maintenance may include removing or replacing fencing, removing non-native vegetation, spot watering, and picking up trash. For more information, details, artistic renderings, and links to public documents and photographs, please visit the project website: https://www.santamonicabay.org/explore/beaches-dunes-bluffs/beach-restoration/malibu-living-shorelines-project/.

The remainder of this restoration plan outlines the appropriate techniques for restoring more natural foredune, back dune, and riparian habitats at the project site. These techniques were developed in consideration of the following set of goals and were informed by project partners:

1. Increase the resiliency of the shoreline through the restoration of sandy beach and foredune habitat and topography;
2. Implement nature-based living shoreline protection measures against sea level rise and coastal storms; and
3. Increase engagement of the community through enhanced beach experiences, outreach, and education.

There are multiple potential approaches to meeting these goals at the project site. The most appropriate approach seeks to optimize the accomplishment of these goals in light of the historical ecology, current conditions, and opportunities and constraints of the sites. Objectives include:

1. Reduce cover of non-native plants;
2. Increase cover of native dune plants;
3. Stabilize blowing sand to build dune topography and decrease nuisance sand (e.g., parking lots);
4. Use strategies that allow for potential future phases of implementation if desired;
5. Enhance recreation with wildflowers, wildlife, and pedestrian paths through dunes; and
6. Engage the public through interpretive signage and educational tours.

Restoration Techniques

The following descriptions of techniques for restoring more natural coastal habitats includes proven strategies that have been employed elsewhere in southern California by TBF, CRC, and other partners or

scientific colleagues. Also presented are some approaches that were developed with the specific opportunities and constraints of the project site in mind and one novel approach that is currently being tested at the Cardiff Dune Restoration Project in San Diego County. Approaches include perimeter fencing and symbolic pathways, dune restoration through invasive plant removal and native seeding/planting, interpretive signage, sand fencing to facilitate sand stabilization and plant growth, and adaptive management strategies.

Perimeter Fencing and Established Trail Systems

Boundaries will be defined and established at both sites using symbolic fencing. Symbolic post and rope fence utilizing sustainable materials to the highest extent possible will be installed around most of the perimeter of the project site. This perimeter establishment will serve several purposes, including delineating areas to be restricted from mechanical grooming, encouraging safe recreational activities, and minimizing excessive disturbance to the dune areas, especially during establishment. The fenced area will be consistent with project permits, goals and management objectives. Post and rope fencing will be used consistent with park guidelines.

Symbolic Pathways and Interpretive Signage

Symbolic post and rope fence utilizing sustainable materials to the highest extent possible will also be installed through several cross-cutting trails to formally delineate project trails. This will be an improvement both for recreation purposes as well as native habitat protection as compared to the random and unmaintained pathways that currently exist from the parking lots through the dunes to the ocean. The post and rope fence will be no more than 36 inches (3 feet) in height and designed to be removable in the event of significant storm events or emergencies.

Interpretive signs or exhibits offer stories that are designed to stimulate visitors' interest while challenging their imaginations, and present new perspectives on familiar topics. Four interpretive signs were designed by Rios Clemente Hale Studios and will be installed with two at the Zuma Beach site and two at the Point Dume site. Review and input was provided by The Bay Foundation, LACDBH, City of Malibu, Coastal Conservancy, and others. Interpretive sign graphics are included as Appendix A. Each sign has its own theme and storyline. Interpretive signs will help visitors and beachgoers understand the importance of the dune system for plants and wildlife, but also as buffers to help improve our coastal resiliency to storm erosion and sea level rise. Signs were developed specifically for use in the restoration area to help engage the public with the site and to facilitate a unique opportunity for education and recreation on their way to the beach.

Dune Restoration

One of the primary goals in increasing resiliency at the site is to trap more of the blowing sand in the upper beach area and to increase topography and elevations in key areas. There are several options for repairing damaged dunes and increasing resilience to rising sea level by building topography. These will be used both individually and in combination, depending on the specific area.

1. Sand fencing. Sand fencing is a proven technique for stabilizing areas with high levels of blowing sand and will be most effective in the coastal strand areas and in strategic locations in the Point Dume restoration area. Sand fencing can be effectively mixed with re-vegetation techniques to

delineate restoration areas, slow sand movement, build topography and create areas suitable for plant establishment. Short lengths of sand fencing (approximately 5-10 ft) will be installed perpendicular to predominant wind direction to enhance rapid dune establishment, and in strategic locations to reduce potential for erosion (e.g., northwestern Point Dume boundary). Sand fencing will be evaluated over time and may be eventually removed through adaptive management once the dunes are stabilized (see "Adaptive Management" section below).

2. Wooden slats or "Biomimicry Stakes". Recently, groups on the east coast of the United States have been using groupings of wooden slats, or biomimicry stakes, instead of fencing to build topography in degraded dunes. This technique is being tested at Cardiff State Beach and at the mouth of the Tijuana River Estuary. Preliminary results at Cardiff Beach suggest promise for this method, though further assessments and testing are warranted. Groups of wooden slats will be installed primarily at the Point Dume location in conjunction with strategic sand fencing to maximize sand retention and encourage plant growth. Wooden slats will not be permanent and will be raised over time and eventually removed through adaptive management of the site once plants are established.
3. Re-vegetation. Native dune plants are the best sustainable long-term choice for building coastal dunes in California and elsewhere. There are situations in which some form of sand stabilization may help in the establishment phase (see 1 and 2). California native dune plants also benefit greatly from protection from driving and trampling, so directing foot and vehicle traffic around vegetated areas is important. Re-vegetation will occur in all areas through seeding and planting.

Invasive Non-Native Species Control

To successfully expand native plant populations within the project area, certain non-native plants will need to be controlled and/or eradicated. Non-native plants will be managed for a minimum of five years post-restoration, though additional maintenance may be necessary after that time period and will be determined by TBF through systematic scientific surveys upon completion of the five years of monitoring.

1. Ice plant (*Carpobrotus edulis*, Cal-IPC Rating: High). Removed by hand with support from Los Angeles Conservation Corps workers and volunteers. It will be turned upside down on site for mulch (upland shrub habitats) or off-hauled in green waste dumpsters (beach habitats).
2. Bermuda grass (*Cynodon dactylon*, Cal-IPC Rating: Moderate). Manually removed, with subsequent follow up for regrowth.
3. European Sea rocket (*Cakile maritima*, Cal-IPC Rating: Limited). Annually hand-pull large plants before seed drops in April and May.
4. Carnation spurge (*Euphorbia terracina*, Cal-IPC Rating: Limited). Hand-pull before seed production will be used for small patches. Repeat several times over the growing season (2 to 3 week intervals), and for several years. Use gloves when handling leafy spurge due to the irritating effects of latex sap.
5. Myoporum (*Myoporum laetum*, Cal-IPC Rating: Moderate). Cut existing standing wood (trained chainsaw operators only). Remove material from site. Treat stumps by applying herbicide as described at Cal-IPC website.

Re-vegetation Strategies

In sand dune areas, the most effective strategy for re-introducing native species is to seed the areas in the late fall and to let seed germinate with winter rains. Upland shrub areas will also be planted with container stock. Timing is very important. Irrigation is not likely to be needed in most areas, but spot spraying with a water truck is proposed as an adaptive management strategy, especially in the back dune areas with upland shrub species.

The following re-vegetation strategies will take place:

1. Seed sandy beach and dune areas with primary dune forming plants. Seed dune areas with red sand verbena, beach bur, beach saltbush, and beach evening primrose. Use seeding rates per S&S Seeds. Prepare the sand surface using a rock rake (leave deep grooves). Scatter seeds by hand and bury seeds by raking again with rock rakes. It is important to prevent driving and trampling in seeded areas.
2. Most dune plant seeds remain viable for years. Germination rates are low in any given year. If year one performance is poor because of very low rainfall (less than 6 inches), consider re-starting in the second year with the same seed in the ground.
3. Add California poppy (coastal variety) seed and other native annual coastal dune species after primary dune vegetation exceeds 10% cover and sand is relatively stable.

Implementation of this project will occur primarily during the winter/rainy season to allow for natural germination and establishment of native seeds during the winter rains. The proposed project is not anticipated to adversely affect the seasonal California grunion run and egg incubation period which ranges from 1 March through 31 August. Best beach management practices that restrict beach grooming (raking) during grunion spawning will continue as before.

Native Plants: Seeding and Container Stock

Hand seeding will occur in the coastal strand and foredune habitats at Zuma Beach as well as all dune areas at the Point Dume site. A mix of container stock and seeding will occur in the back dunes/upland transition areas at Zuma Beach and in low densities along the Point Dume restoration areas to expedite plant growth (Table 1). Seed will be sourced from S&S Seeds, who have over 30 years of experience with California native wildland seed and have provided seed for coastal dune, bluff, and wetland habitat restoration projects across all of California. TBF consulted with experts and S&S Seeds to develop a specialized plant palette and custom seed mix design specific to the various habitats on site. Existing site conditions and microhabitats (e.g., soil conditions) were also taken into account, especially accounting for species that were presently established, though in very low densities (i.e., densities preclude collection of on-site seed without impacts). Container stock plants identified in Table 1 will be hand planted across the habitats identified in the table.

Table 1. Native plant species by site and habitat type.

Site Location	Habitat Type	Species for Seeding	Container Stock Species
Zuma Beach	Coastal Strand and Foredune	*Abronia maritima*, *Ambrosia chamissonis*, *Atriplex leucophylla*, *Calystegia soldanella*, *Camissoniopsis cheiranthifolia*	N/A
Zuma Beach	Back Dune	*Abronia umbellata*, *Camissoniopsis cheiranthifolia*, *Ericameria ericoides*, *Eriogonum parvifolium*, *Eschscholzia californica* (coastal variety), *Heliotropium curassavicum*, *Isocoma menziesii*, *Lupinus chamissonis*	*Abronia maritima*, *Ericameria ericoides*, *Eriogonum parvifolium*, *Lupinus chamissonis*
Zuma Beach	Upland Transition	*Artemisia californica*, *Atriplex lentiformis*, *Baccharis pilularis*, *Croton californicus*, *Encelia californica*, *Ericameria ericoides*, *Heliotropium curassavicum*, *Leptosyne gigantea*, *Malvella leprosa*	*Artemisia californica*, *Atriplex lentiformis*, *Leptosyne gigantea*, *Rhus integrifolia*
Point Dume	Established Foredunes and Coastal Strand	*Abronia maritima*, *Ambrosia chamissonis*, *Atriplex leucophylla*, *Calystegia soldanella*, *Camissoniopsis cheiranthifolia*	*Abronia maritima*, *Ambrosia chamissonis*, *Atriplex leucophylla*

Container stock plants will help expedite growth in key areas such as the established dunes in the Point Dume restoration areas. This will allow for maximum sand retention in the pre-existing dune areas. Similarly, planting in the backdunes and upland transition areas will enhance native cover to help preclude non-native invaders from returning.

Table 2 outlines the five key dune species included in the custom seed mix for the primary foredune and coastal strand habitat seeding for both restoration sites, along with the proposed seeding rate and number of pure live seeds per pound. Each of the first four "dune forming" coastal strand habitat plant species are discussed in detail below. The fifth species listed in the table, beach morning glory (*Calystegia soldanella*), was recommended for inclusion by US Fish and Wildlife Service and is a perennial native, though not a typical "dune former" species. Native plant species characteristics and growing pattern information was retrieved from CalFlora (www.calflora.org), S&S Seeds databases, and Rancho Santa Ana Botanic Garden. The combined seed mix with all five species will be distributed across the restoration site using a broadcast hand seeder. The combined seed mix will be spread at a rate of 21.1 pounds per acre and will be immediately raked into the sand.

Table 2. Custom seed mix design for coastal strand and foredune habitats by species. Asterisk indicates an additional plant species recommended by USFWS and not included in the S&S seed mix.

Species Name	Common Name	Lbs / Acre	Number of Pure Live Seeds / Lb.
Camissoniopsis cheiranthifolia	beach evening primrose	0.10	2,441,000
Abronia maritima	sand verbena	12.00	16,000
Ambrosia chamissonis	beach bur sage	6.00	40,000
Atriplex leucophylla	sea scale	2.00	73,600
Calystegia soldanella *	beach morning glory	1.00	13,500

Camissoniopsis cheiranthifolia (beach evening primrose) is a perennial native to California and is a low-lying shrub that provides good ground cover and soil/dune stabilization. This plant species is native to open dunes and sandy soils, growing prostrate along the beach surface and forming mats. Typically blooming from as early as January to the end of August, beach evening primrose features small solitary bright yellow flowers, and is tolerant to low water conditions, surviving year round on seasonal winter rains and ocean spray (Figure 4).

Figure 4. *Camissoniopsis cheiranthifolia* (beach evening primrose) [CalFlora: L. Watson 2007 (Left) and J. Pawek 2013 (right)].

Abronia maritima (Sand verbena) is a beach-adapted perennial, native to the coastlines of southern California, including the Channel Islands, and northern Baja California. Sand verbena is a mat-like herb growing under 1 foot, with fleshy leaves, and clustered pink to purple flowers which bloom in the Spring and Summer (Figure 5). Sand verbena was chosen for its association with fore-dune habitats and ability to stabilize sand and create small dunes as well as its characteristics of high salt tolerance and low water requirements. This species is also listed in the California Native Plant Society's Rare Plant Rank as a List 4.2 species (CNPS 2020).

Figure 5. *Abronia maritima* (Sand verbena) [CalFlora: G.A. Monroe 2010 (Left) and L. Watson 2007 (right)].

Ambrosia chamissonis (beach bur sage) is a low-lying perennial herb native to California's coastline. This plant species is commonly found along the coastline and dune environments and produces tiny clustered blooms from June to July (Figure 6). Beach bur sage has a high salt tolerance, low water requirement, and is conducive for sand stabilization and dune formation.

Figure 6. *Ambrosia chamissonis* (beach bur sage) [CalFlora: N. Kramer 2008 (left) and M. Bors 2008 (right)].

Atriplex leucophylla (sea scale) is a perennial herb native to the sandy beaches and dunes of the California coastline. Like the other species in the seed pallet, sea scale has a high salt tolerance and low water requirement, with the capability of surviving harsh dynamic coastal environments. Sea scale forms low-lying mats that spread up to 3 feet and blooms from April to October with tiny inconspicuous green flowers (Figure 7).

Figure 7. *Atriplex leucophylla* (sea scale) [CalFlora: (left) and Z. Akulova 2015 (right)].

Water Truck

The upland transition and backdune areas may require supplemental irrigation in the first growing season for good initial plant establishment, especially for areas with container stock. In particular, upland habitats in the northwestern portion of the Zuma Beach site may require supplemental irrigation, depending on rain events that occur after planting. If rain does not occur for the first 2-3 weeks following planting, planted container stock will be watered by hose from a water truck parked in the parking lots adjacent to the sites. This may be repeated every 2-3 weeks during the wet season until rainfall occurs (>0.25 in) or plants become fully established.

Conservation Measures

Care will be taken throughout the restoration process to protect native species and wildlife. One of the objectives of this project is to enhance the habitat areas for native species. As this is a hand-restoration project with no heavy equipment and no sediment/soil movement, impacts to wildlife should not occur. Access to the site will be through predefined trail systems and parking will be on established existing parking lots. No beach driving will occur as part of this project. Additionally, all restoration activities will have a biological monitor present who is familiar with native and rare plant species and wildlife. Pre-restoration surveys will occur by a qualified biologist immediately prior to implementation activities.

As non-native plants are removed by hand, they will be gently shaken to make sure that as much sand as possible is left in place. If wildlife is visually seen, it will be left alone and avoided. Pre-implementation bird and wildlife surveys will be conducted, especially for the upland transition areas. No work is proposed in bird nesting season, but pre-implementation surveys will confirm site use by species.

Native plants that are co-occurring in the project sites will be protected and left in place to encourage expansion and continued establishment. No native plants will be removed as part of this project. No rare plant species have been identified on site, but if any are found in the course of restoration activities, they will be flagged, marked with GPS, and avoided. Additional pre-implementation

vegetation assessment surveys will be conducted directly prior to restoration activities in case additional vegetation species establish after the finalization of this document.

Federally threatened western snowy plovers are known to be on site in the beach areas periodically, both in the winter season and with the establishment of several nests over the last few years during nesting season (see baseline assessment and site characterization document for more details). While the footprint for this restoration project is outside of the common plover roosting and breeding areas for this beach location, conservation measures will still be in effect for any activities (i.e., implementation, scientific monitoring, and site maintenance). Additionally, no work will occur in plover nesting season, and care will be taken to avoid all plovers during all work and scientific monitoring. If plovers are present, restoration activities will not occur where they are present.

A list of additional wildlife and plants with special status listing is prepared as Appendix B. Data were downloaded from the California Natural Diversity Database (CNDDB) hosted by California Department of Fish and Wildlife on 10 April 2020 for the Zuma Quad (https://wildlife.ca.gov/Data/CNDDB). While no listed or special status species have been identified in the project area to date, see Appendix B and also "Conservation Measures" in the Implementation and Monitoring Plan for additional avoidance protocol details such as pre-restoration bird and wildlife surveys. The full list contains two amphibians, 14 birds, one bryophyte, one fish, five insects, five mammals, six reptiles, 23 plants, and one plant community

Lastly, care will be taken to avoid dune erosion in areas that have established dunes once iceplant is removed. Seeding and planting will happen within one week of iceplant removal, sooner if possible. Erosion control matting may be used, if heavy winds are expected or if sand begins to transport onto the parking lots or other nuisance areas.

Adaptive Management

Adaptive management is a tool for achieving success where there is uncertainty as to what actions will be needed to accomplish specific goals. As systems like Zuma Lagoon and Point Dume Beach are inherently dynamic, with high levels of visitation and changing management strategies, an adaptive management approach will lead to better outcomes in the long-term. Adaptive management may be implemented based on the success of the project as interpreted by TBF, beach managers, LACDBH, and the City of Malibu. The monitoring components and resulting data will be integral in determining the success of the project both from a socio-economic and ecological perspective. Scientific monitoring will also serve to inform progress towards restoration objectives and success criteria.

TBF, with the help of our existing volunteer internship program, will also undertake a hands-on, community-level maintenance strategy without the use of mechanized equipment, including trash removal and invasive species removal throughout the implementation of the project and for a duration of no less than five years afterwards. Subsequent site maintenance, if needed, will be conducted by TBF, volunteers, LACDBH, or other partners and project supporters. Evaluation of the project will occur annually via an annual report for five years post-restoration. The report will be provided to LACDBH, City of Malibu, and California Coastal Commission and will be made publicly available on TBF's website.

Scientific Monitoring

Accurate and robust scientific monitoring is a vital part of any restoration project. Monitoring includes observations of post-implementation site condition which will assess plant installation as well as other restoration components (e.g., sand fencing). Monitoring also informs adaptive management actions (e.g., non-native plant cover that may need to be controlled), tracks the project towards meeting success criteria over time, and compares the site to 'control' conditions in adjacent areas that have had no restoration actions. Lastly, opportunistic research will be conducted in partnership with Loyola Marymount University's Coastal Research Institute and other universities.

Monitoring is used to assess successful project implementation; for example, in this project, monitoring will allow a topographic assessment of dune growth to combat sea level rise. TBF will be implementing a biological, physical, and human use monitoring plan before the restoration to collect baseline data, for the duration of the restoration project, and several years afterwards to assess success. Additional "control" data in unrestored adjacent beach areas will be collected as part of a before-after-control-impact ecological assessment monitoring program. Specialist ecological and restoration scientists are partners and advisors for this project, and their expertise will be used to advise both the monitoring program and its evaluation. Data will be collected for up to five years to evaluate the ecological health of the created dune ecosystem and its potential for long-term adaptation to accelerated rates of sea level rise.

A rigorous scientific monitoring plan will allow for the evaluation of completed restoration activities. Table 3 summarizes the monitoring sampling design. It lists eight major parameters, the primary protocol(s) which will be implemented for each parameter, and the frequency of implementation. It should be noted that the frequency of implementation of each protocol listed in Table 3 is the minimum frequency which will be undertaken. Opportunistic additions of new survey methods, additional research, and increased frequency of surveys will be conducted when possible and with additional future funding. TBF has a long history of partnership with Loyola Marymount University and other universities that helps facilitate cost-effective data collection. All data collected by TBF and their partners will have results summarized and reported in Annual Reports that will be made publicly available on TBF's website: www.santamonicabay.org for a period of time no less than five years.

Pre-restoration baseline monitoring will occur prior to the implementation of the restoration project to allow a comparison of the pre- and post-project conditions of the area. Ongoing implementation monitoring will occur throughout the duration of the restoration activities to adaptively manage and avoid impacts to any existing native plant and wildlife species. Post-restoration monitoring will occur after restoration activities are concluded and will allow a scientific evaluation of the successes and challenges of the implementation strategies. Additionally, post-restoration data will contribute meaningful information towards adaptively implementing re-vegetation activities. It will allow for a thorough scientific evaluation of restoration efforts. When possible, additional data will be collected and partnerships with universities and other entities will be undertaken to supplement research efforts and obtain more frequent datasets. Results will be disseminated in public annual reports, scientific presentations and conferences, potential future manuscripts, to local communities via presentations and speaking to Malibu City Council, and via webinars.

Figure 8. Photograph of dune monitoring students and professors from LMU's Coastal Research Institute.

Table 3. Description of protocols to be implemented during pre-restoration baseline monitoring, post-restoration evaluation monitoring, and their minimum frequency of occurrence.

Parameter	Protocol	Minimum Frequency
Photo Point	Fixed geospatial and bearing photo locations throughout sites	Semi-annually
Wrack Cover	Percent cover, composition by species, average depth	Semi-annually
Vegetation Cover and Seedling Density (if present)	Selective mapping, fixed cover class quadrats along t-sects; fixed quadrat density counts for seedlings	Semi-annually
Avifauna (+ pollinator presence)	Visual presence / behavior surveys; identified plover nesting will immediately halt activities and USFWS will be notified	Semi-annually, with increased frequency if snowy plovers are present
Physical Characteristics	Elevation profiles and cross-sections, beach width, beach slope	Semi-annually
Weather Conditions	Air temperature, precipitation, and tide gauge data (NOAA)	As publicly available data sets are posted online
Sediment Grain Size	Sieve method	Annually
Human Use, Volunteer Data, and Site Checklist	Visual presence / activity checklist; date and metrics of events and tours; site checklist; sign check and maintenance	Semi-annually

Individual Protocol Details

Each of the following subsections summarizes an individual protocol to be implemented as part of the monitoring program. For in depth details on objectives, equipment, field preparation, field methods, quality control check procedures, and datasheets, refer to the individual Standard Operating Procedures listed below within the California Estuarine Wetland Monitoring Manual, publicly available for free download: http://www.santamonicabay.org/california-estuarine-wetlands-monitoring-manual-level-3/. Additionally, some protocols were adopted from Dugan et al. 2015 Final Report: Baseline Characterization of Sandy Beach Ecosystems along the South Coast of California.

Photo-Point

Photo point monitoring will occur to identify major site changes or project-level changes as a result of the restoration activities with a semi-annual frequency (e.g., native vegetation growth, plant hummock formation). Survey methods are described in detail in SOP 7.2 Level 2 Photo Point (TBF 2015a). A minimum of six permanent photo point locations will be established during baseline monitoring and the locations recorded using a GPS. Photographs can be used as qualitative assessments of broad-scale changes following restoration activities and dune development over time.

Wrack Cover

Wrack, or plants and algae that have washed ashore, surveys will be conducted to determine the percent cover, composition by species, and average depth of macrophyte wrack in the wash zone area directly in front of the restoration site and control site. As the project does not extend to the high tide line or swash zone, it is unlikely to have an effect or change on the wrack composition. However, wrack is reommended as a survey assessment because it is an important component of the beach trophic system as a whole and can provide support for invertebrates and foraging birds. A total of six line-intercept transects will be surveyed, consisting of two transects each in the wash zone directly in front of the two restoration sites (four total) and two transects in the wash zone of the control areas (outside the project area). These transects will also record any trash, tar, driftwood, or other detritus in a similar manner. Surveys will occur prior to restoration implementation, and will be continued semi-annually for a period no less than five years. The wash zone is a dynamic area, therefore, exact transect locations may vary over surveys. As beach topography varies considerably between summer and winter weather conditions, semi-annual surveys will be timed at minimum during those seasons.

Vegetation Cover

Vegetation cover surveys can be used to provide a wide range of information and data, including: summarizing the prevalence of native and non-native plant cover, determining species cover, relative species richness and diversity, and assessing canopy height. The primary objective of the transect- and quadrat-level cover surveys for this project is to assess the approximate cover of native coastal strand vegetation semi-annually over time. A minimum of two transects in each site (i.e., Zuma Beach and Point Dume Beach) and two transects outside, but adjacent to, the project area (control transects) will be surveyed.

The transect survey methods are described, along with field data sheets, in SOP 3.2 Vegetation Cover Surveys (TBF 2015b). Line-Intercept Transects document every species observed directly below the

transect tape where the vegetation crosses a minimum of 0.01 m (or 1 cm). This transect survey method is useful when collecting vegetation cover data in patchy habitats or those with a significant amount of bare ground (or sand). Line-intercept data will be summed by species and divided by the total length of transect to determine percent cover for each transect. Cover Class Quadrat surveys will be conducted using 1 m^2 PVC quadrats subdivided into 16 sub-quadrats. Ten fixed-location quadrats will be surveyed along each transect. Seedling density will be speciated if possible and quantified along a subset of transects and quadrats. This quantitative assessment method will allow for a post-restoration evaluation of germination success of native coastal strand and foredune plant species. Cover class species data will be analyzed using the median of each Daubenmire cover category and averaged to determine percent cover within each transect with variability represented as standard deviation or error (TBF 2015b). Photographs of a subset of quadrats will also be collected concurrently. Additional visual estimates of cover in mapped areas may also be conducted.

Avifauna (and Pollinator Presence)

The presence and distribution of avifauna within an ecosystem is often used as an index of habitat quality due to their diet and vulnerability to environmental conditions (Conway 2008). Avifauna data are useful to characterize representative avian assemblages and spatial distributions within a particular area. Bird survey methods are described in detail, along with field data sheets, in SOP 5.1 Bird Abundance-Activity (TBF 2015d). The primary purpose of avifauna surveys for this project is to provide a general understanding of the bird community and activity in the restoration area. It is not intended to provide statistical results; rather, its goal is to generally characterize bird species utilizing the site.

Bird surveys will be conducted semi-annually and will include observational species presence and activity/behavior. Additionally, breeding or nesting activity of birds will be recorded and, if present, will require the immediate postponement of any restoration or monitoring activities within the project area. LA Audubon Society has offered to help with supplemental plover surveys. If plover nests are identified, appropriate agencies such as US Fish and Wildlife Service (USFWS) will be immediately notified. Any data collected will also be shared with Audubon Society and USFWS. Lastly, presence of various species of pollinators such as butterflies or bees will also be recorded as part of these surveys.

Physical Characteristics

Physical characteristics will be collected using techniques described in detail in Dugan et al. 2015. To physically characterize the beach, surf, and swash zones, measurements will be taken along a transect of the beach width from the inland edge at a fixed location such as a parking lot edge to the lowest intertidal level exposed by swash, locations of the water table outcrop (WTO) and high tide strand line (HTS). Elevation profiles will also be conducted along these transects. A high-resolution Trimble GPS (or equivalent) will be used to calculate GPS location and approximate elevation at several points along each transect for reference. These measurements will be collected along at least three transects at Point Dume, one at Zuma Beach, and along two transects outside the project area as controls.

Weather Conditions

Average air temperature and precipitation data will be downloaded annually for Zuma Beach from NOAA weather, if available (closest weather station is Leo Carrillo State Beach). Precipitation data from LA County Department of Public Works are also available, though the Malibu Fire Station is the closest

station and may not completely accurately reflect the site-specific precipitation total values (https://dpw.lacounty.gov/wrd/rainfall/). Additional data from variables such as humidity or barometric pressure may also be accessed and summarized in Annual Reports, if available.

Sediment Grain Size

Sediment grain size will be collected annually to detect long-term shifts in grain size composition using techniques described in detail in Dugan et al. 2015. Average sediment grain size will be determined from sand samples taken at the WTO in the restoration area along each transect. Sediments will be rinsed in fresh water to remove salt residue, dried to constant weight and then shaken through a series of sieves with a variety of screen aperture size (in microns) to determine the relative abundance and proportion of sand in each size class (phi).

Human Use, Volunteer Event Data, Site Checklist

Volunteer event data will be collected for all public restoration events or tours, including the date of the event, the number of participants, hours worked, and any incidental useful supplemental information such as the school and age group, zip code if possible, other demographics, etc. Human use and activity of the site and surrounding areas will be recorded at a minimum of semi-annually. These data may also be supplemented by other metrics such as LACDBH or County lifeguard visitor count data.

In addition, any vehicle tracks on the beach, including grooming marks and other tracks such as footprints or animal tracks will be noted. The physical characteristic surveys will also include a "site checklist" which will collect data on things like interpretive sign condition, trash presence and type, etc. As beach topography varies considerably between summer and winter weather conditions, semi-annual surveys will be timed at minimum during those seasons.

Additional Studies

In addition to the protocols and surveys listed above, TBF and their partners will pursue supplemental funding for additional specialized surveys such as invertebrates, grunion, sand deposition studies, or more frequent implementation of the above protocols.

Success Criteria

Setting appropriate performance criteria for restoration projects, and assuring those criteria are met, helps assure that the ecological benefits of the project are realized. Performance criteria should focus on measuring the extent to which appropriate physical and biological ecosystem processes have been restored in the short-term and how they might be expected to be self-sustaining in the long-term. Additionally, performance criteria should be sufficient for measuring whether or not the project goals have been achieved. Performance criteria should be quantitative and measurable.

Restoration success criteria are intended to support the project goals and assist in information sharing throughout California and beyond for living shoreline projects. Additionally, criteria can inform the need for adaptive management. The following table summarizes the restoration success criteria associated with this project over time (Table 4).

Table 4. Success criteria for the Malibu Living Shoreline Project.

Criteria Parameter	Quantifiable Metric	5-Year Target
Non-native vegetation	Absolute cover as assessed along transects within the restoration areas and compared to the controls	Reduced (or absent) non-native cover within restoration area compared to baseline and controls (<15% absolute cover non-natives; <5% absolute cover of highly invasive non-natives as determined by CalIPC)
Native vegetation	Absolute cover as assessed along transects within the restoration areas and compared to the controls; species richness	Increase in native cover and native species richness (total) within restoration areas compared to baseline and controls; minimum absolute native cover of 15% (coastal strand and foredune), 20% (backdune), 30% (upland transition)
Native / Non-native ratio	Relative cover as assessed along transects within the restoration areas	Minimum of 85/15% ratio of native to non-native relative plant cover
Topography change	Change in elevation profiles and dune heights along restoration transects	Stable dune system over time without long-term erosion (incorporating seasonal change); shift in berm crest towards ocean compared to baseline and accretion over time
Community participation	Number of volunteers (and hours worked) annually during restoration events, outreach events, tours, and public meeting participation	Minimum of 50 people directly or virtually engaged annually for five years (> 250 total)

Maintenance

Site visits will be conducted semi-annually (at minimum) for a period of no less than five years to visually assess the restoration progress and evaluate the need for maintenance activities. Additional site visits or monitoring will be conducted opportunistically, or if additional funding is identified. Additionally, adaptive management considerations may require more frequent site visits which will be undertaken by TBF or partners. TBF is resolutely committed to the long-term ecological and physical health of the site.

The overall condition of the restoration areas will be noted, along with detailed observations including presence of invasive species re-growth or environmental stressors (e.g., prolonged dry periods). Photographic documentation of any observations of concern will occur. If invasive vegetation is found in a restored area, adaptive management steps such as weed removal by hand may need to be taken. Similarly, litter or trash collection and removal from site will be conducted at least semi-annually or more frequently as needed (especially in the summer months).

After perennial vegetation becomes established, it may be beneficial to the site and overall site biodiversity to consider supplementing the plant palette with additional annual native plant species (e.g., *Camissoniopsis bistorta, Chaenactis glabriuscula,* or *Abronia umbellata*). Vegetation cover will be analyzed at least annually to determine if additional supplemental seeding or planting should be considered or if additional diversity would be ecologically beneficial. Cover will be evaluated against the established success criteria (above). Need for supplemental vegetation will be determined by project partners and in consultation with the California Coastal Commission.

Reporting

Collected data will be entered into excel (or equivalent) datasheets, and quality control checks will be performed by a different qualified individual. A publicly available annual report will be compiled and produced at the culmination of each year of work up to a minimum of five years, in accordance with the requirements of the final issued permits. Reporting will help track monitoring data over time and inform adaptive management actions (e.g., non-native plant cover that may need to be controlled). Additionally, reporting will track the project towards meeting defined success criteria over time, and compare the site to 'control' conditions in adjacent areas that have had no restoration actions.

The Annual Reports will be published on The Bay Foundation's website: www.santamonicabay.org, and submitted to Coastal Commission, Coastal Conservancy, LACDBH, and City of Malibu. Each Annual Report will contain summary details on restoration activities (Year 1 only) and monitoring results (all years) as well as photographs documenting the site over time. Annual reports will be published for a minimum of five years after implementation.

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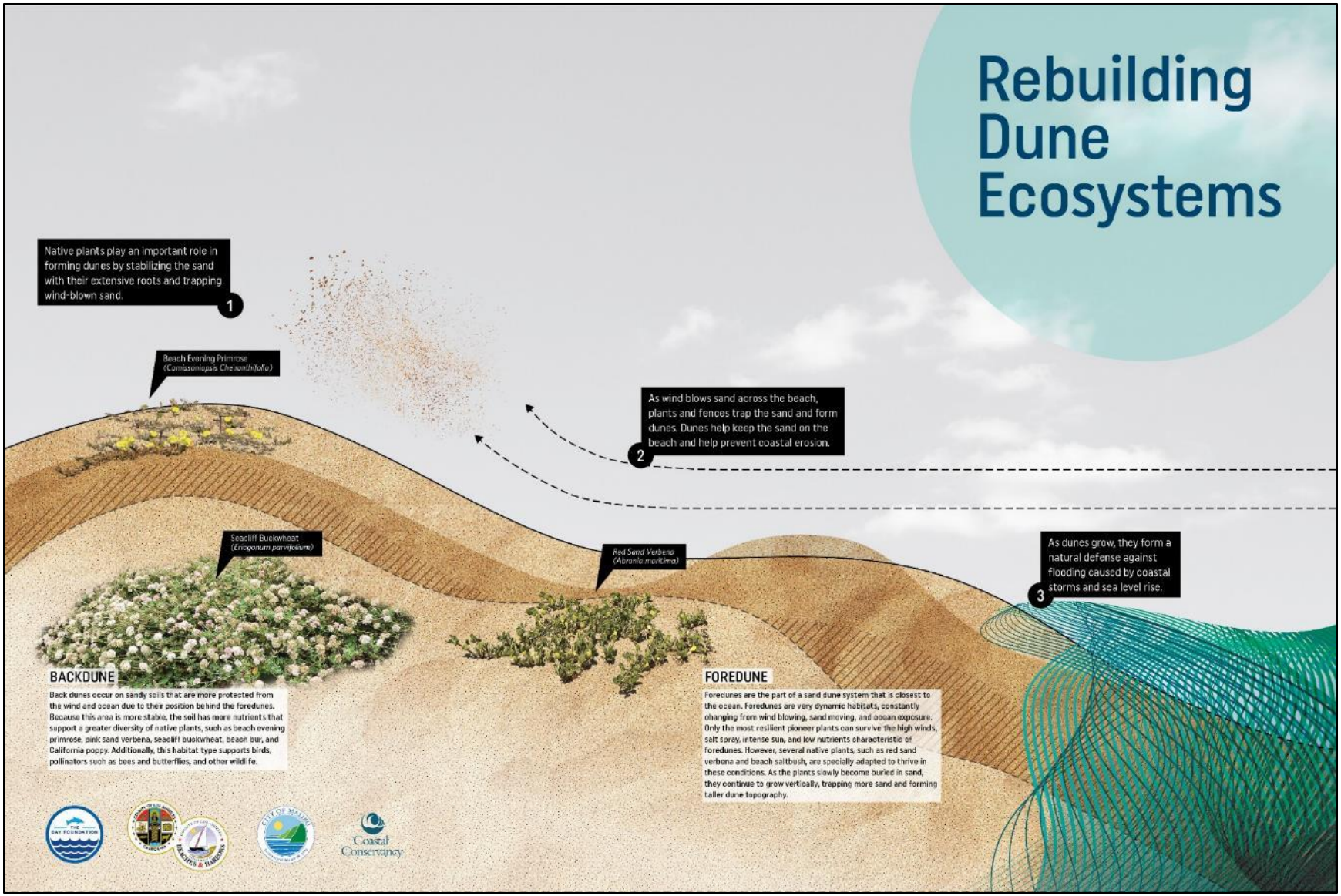
Appendix A – Final Interpretive Signs for the Malibu Living Shoreline Project



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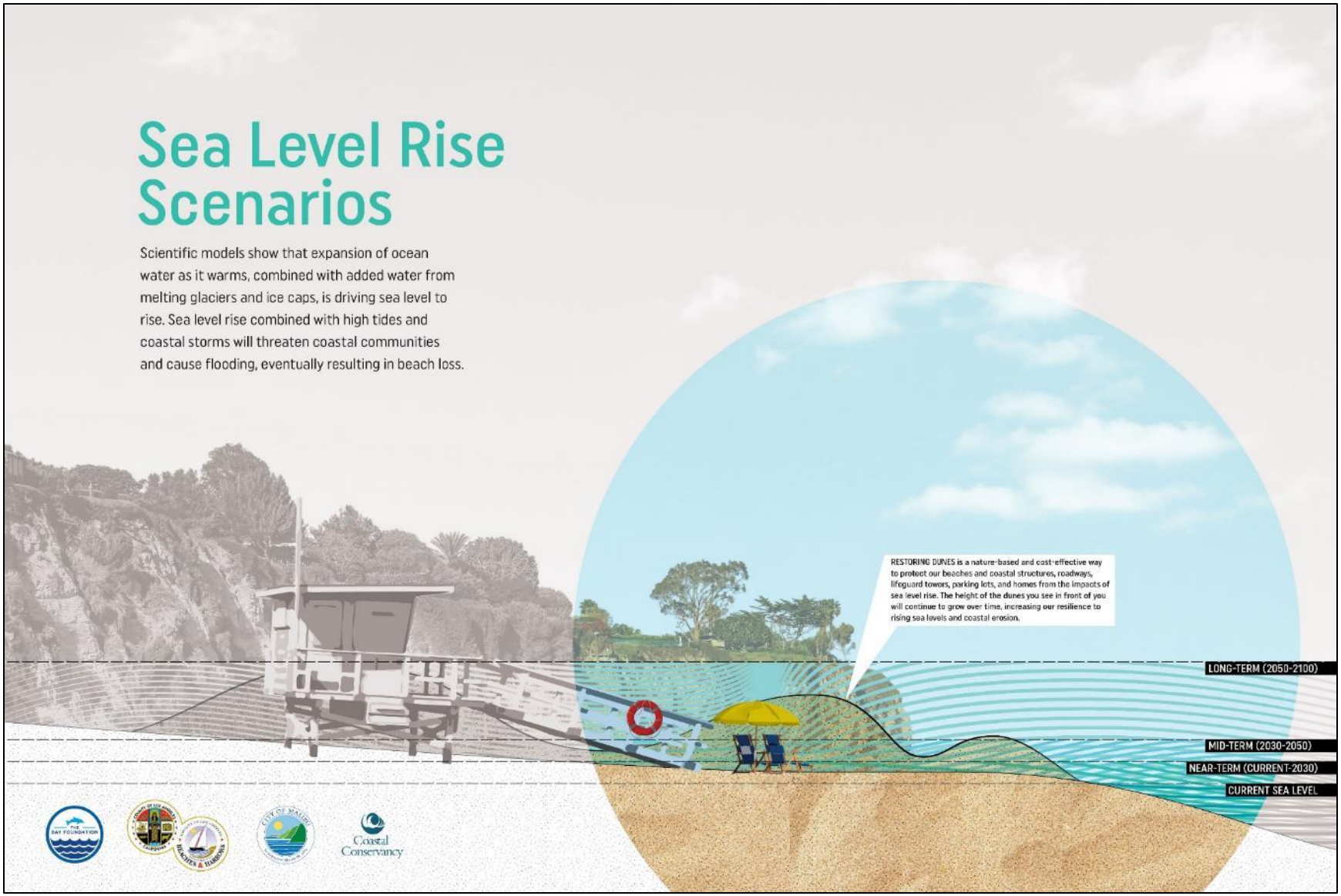

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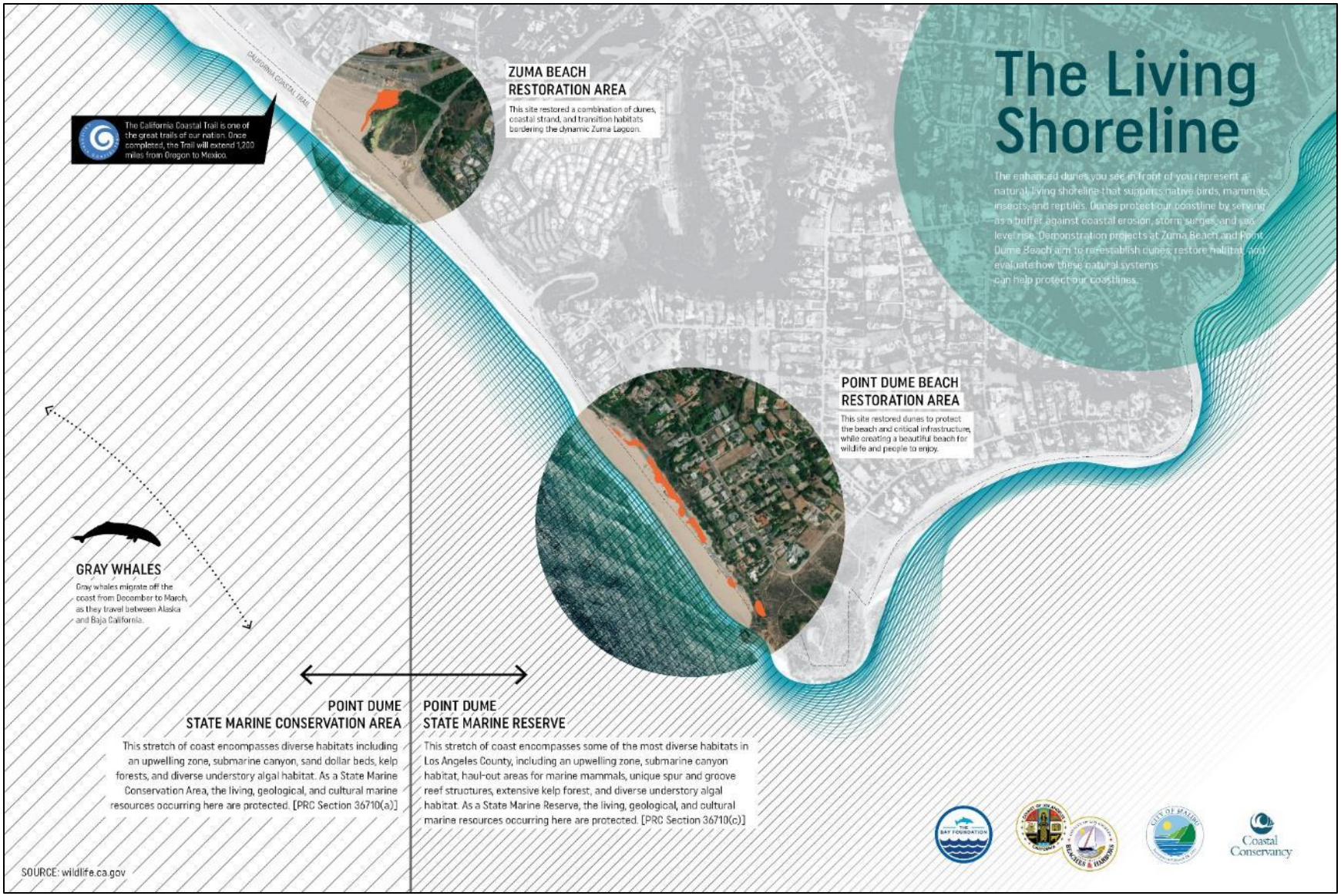

Appendix B – CNDDB List for Zuma Quad with Additional Observation Notes and Conservation Measures

Category	Scientific Name	Common Name	Federal Status	State Status	CDFW Status	CA Rare Plant Rank	Notes	Conservation Measures
Amphibians	*Rana draytonii*	California red-legged frog	Threatened	None	SSC	N/A	No wetland habitat in project area; unlikely to occur	Pre-restoration wildlife survey
Amphibians	*Taricha torosa*	Coast Range newt	None	None	SSC	N/A	No wetland habitat in project area; unlikely to occur	Pre-restoration wildlife survey
Birds	*Accipiter cooperii*	Cooper's hawk	None	None	WL	N/A	Known to be adjacent to project area; possible foraging within project area	Pre-restoration bird survey
Birds	*Aquila chrysaetos*	golden eagle	None	None	FP; WL	N/A	Unlikely to occur in project area	Pre-restoration bird survey
Birds	*Synthliboramphus scrippsi*	Scripps's murrelet	Candidate	Threatened	-	N/A	Unlikely to occur in project area	Pre-restoration bird survey
Birds	*Ardea herodias*	great blue heron	None	None	-	N/A	Known to be adjacent to project area; possible foraging within project area	Pre-restoration bird survey
Birds	*Charadrius alexandrinus nivosus*	western snowy plover	Threatened	None	SSC	N/A	Known to be adjacent to project area (~1,300 m); possible foraging within project area	Pre-restoration bird survey
Birds	*Gavia immer*	common loon	None	None	SSC	N/A	Known to be adjacent to project area	Pre-restoration bird survey
Birds	*Riparia riparia*	bank swallow	None	Threatened	-	N/A	Unlikely to occur in project area	Pre-restoration bird survey
Birds	*Agelaius tricolor*	tricolored blackbird	None	Threatened	SSC	N/A	Unlikely to occur in project area	Pre-restoration bird survey
Birds	*Hydroprogne caspia*	Caspian tern	None	None	-	N/A	Known to be adjacent to project area; possible foraging within project area	Pre-restoration bird survey

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Category	Scientific Name	Common Name	Federal Status	State Status	CDFW Status	CA Rare Plant Rank	Notes	Conservation Measures
Birds	*Larus californicus*	California gull	None	None	WL	N/A	Known to be adjacent to project area; possible foraging within project area	Pre-restoration bird survey
Birds	*Baeolophus inornatus*	oak titmouse	None	None	-	N/A	Unlikely to occur in project area	Pre-restoration bird survey
Birds	*Setophaga petechia*	yellow warbler	None	None	SSC	N/A	Unlikely to occur in project area	Pre-restoration bird survey
Birds	*Pelecanus occidentalis californicus*	California brown pelican	Delisted	Delisted	FP	N/A	Known to be adjacent to project area	Pre-restoration bird survey
Birds	*Phalacrocorax auritus*	double-crested cormorant	None	None	WL	N/A	Known to be adjacent to project area	Pre-restoration bird survey
Fish	*Eucyclogobius newberryi*	tidewater goby	Endangered	None	SSC	N/A	No wetland or lagoon habitat in project area; unlikely to occur	No measures needed
Insects	*Trimerotropis occidentiloides*	Santa Monica grasshopper	None	None	-	N/A	Unlikely to occur in project area	Careful hand removal of invasive vegetation
Insects	*Bombus crotchii*	Crotch bumble bee	None	Candidate Endangered	-	N/A	Identified in riparian area southeast of project area	Careful hand removal of invasive vegetation
Insects	*Atractelmis wawona*	Wawona riffle beetle	None	None	-	N/A	Unlikely to occur in project area	Careful hand removal of invasive vegetation
Insects	*Danaus plexippus pop. 1*	monarch - California overwintering population	None	None	-	N/A	Identified adjacent to project area	Pre-restoration wildlife survey
Insects	*Euphydryas editha quino*	quino checkerspot butterfly	Endangered	None	-	N/A	Unlikely to occur in project area	Pre-restoration wildlife survey

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Category	Scientific Name	Common Name	Federal Status	State Status	CDFW Status	CA Rare Plant Rank	Notes	Conservation Measures
Mammals	*Eumops perotis californicus*	western mastiff bat	None	None	SSC	N/A	Unlikely to occur in project area	Pre-restoration wildlife survey
Mammals	*Taxidea taxus*	American badger	None	None	SSC	N/A	Unlikely to occur in project area	Pre-restoration wildlife survey
Mammals	*Lasiurus blossevillii*	western red bat	None	None	SSC	N/A	Unlikely to occur in project area	Pre-restoration wildlife survey
Mammals	*Lasiurus cinereus*	hoary bat	None	None	-	N/A	Unlikely to occur in project area	Pre-restoration wildlife survey
Mammals	*Myotis yumanensis*	Yuma myotis	None	None	-	N/A	Unlikely to occur in project area	Pre-restoration wildlife survey
Reptiles	*Anniella stebbinsi*	California legless lizard	None	None	SSC	N/A	Closest reported observation is the Point Dume bluff above and east of the project area	Pre-restoration wildlife survey
Reptiles	*Diadophis punctatus modestus*	San Bernardino ringneck snake	None	None	-	N/A	Unlikely to occur in project area	Pre-restoration wildlife survey
Reptiles	*Emys marmorata*	western pond turtle	None	None	SSC	N/A	Unlikely to occur in project area	Pre-restoration wildlife survey
Reptiles	*Thamnophis hammondii*	two-striped gartersnake	None	None	SSC	N/A	Identified adjacent to project area	Pre-restoration wildlife survey
Reptiles	*Phrynosoma blainvillii*	coast horned lizard	None	None	SSC	N/A	Unlikely to occur in project area	Pre-restoration wildlife survey
Reptiles	*Aspidoscelis tigris stejnegeri*	coastal whiptail	None	None	SSC	N/A	Unlikely to occur in project area	Pre-restoration wildlife survey
Community	*Southern Sycamore Alder Riparian Woodland*	Southern Sycamore Alder Riparian Woodland	None	None	-	N/A	Not identified within project area	No measures needed

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Category	Scientific Name	Common Name	Federal Status	State Status	CDFW Status	CA Rare Plant Rank	Notes	Conservation Measures
Bryophytes	*Tortula californica*	California screw moss	None	None	-	1B.2	Not identified within project area	Pre-restoration plant survey
Plants	*Baccharis malibuensis*	Malibu baccharis	None	None	-	1B.1	Not identified within project area	Pre-restoration plant survey
Plants	*Deinandra minthornii*	Santa Susana tarplant	None	Rare	-	1B.2	Not identified within project area	Pre-restoration plant survey
Plants	*Pentachaeta lyonii*	Lyon's pentachaeta	Endangered	Endangered	-	1B.1	Not identified within project area; one identification northeast of project area in Zuma Canyon	Pre-restoration plant survey
Plants	*Atriplex coulteri*	Coulter's saltbush	None	None	-	1B.2	Not identified within project area	Pre-restoration plant survey
Plants	*Dudleya blochmaniae ssp. blochmaniae*	Blochman's dudleya	None	None	-	1B.1	Not identified within project area	Pre-restoration plant survey
Plants	*Dudleya cymosa ssp. agourensis*	Agoura Hills dudleya	Threatened	None	-	1B.2	Not identified within project area, closest identification in Point Dume bluff area	Pre-restoration plant survey
Plants	*Dudleya cymosa ssp. marcescens*	marcescent dudleya	Threatened	Rare	-	1B.2	Not identified within project area	Pre-restoration plant survey
Plants	*Astragalus brauntonii*	Braunton's milk-vetch	Endangered	None	-	1B.1	Not identified within project area; possibly in bluffs above Dume Cove east of project area	Pre-restoration plant survey
Plants	*Quercus dumosa*	Nuttall's scrub oak	None	None	-	1B.1	Not identified within project area	Pre-restoration plant survey
Plants	*Juglans californica*	southern California black walnut	None	None	-	4.2	Not identified within project area	Pre-restoration plant survey

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Plants	*Lepechinia fragrans*	fragrant pitcher sage	None	None	-	4.2	Not identified within project area	Pre-restoration plant survey
Plants	*Calochortus catalinae*	Catalina mariposa-lily	None	None	-	4.2	Not identified within project area	Pre-restoration plant survey
Plants	*Calochortus clavatus var. gracilis*	slender mariposa-lily	None	None	-	1B.2	Not identified within project area	Pre-restoration plant survey
Plants	*Calochortus plummerae*	Plummer's mariposa-lily	None	None	-	4.2	Not identified within project area, but possibly adjacent	Pre-restoration plant survey
Plants	*Lilium humboldtii ssp. humboldtii*	Humboldt lily	None	None	-	4.2	Not identified within project area	Pre-restoration plant survey
Plants	*Calandrinia breweri*	Brewer's calandrinia	None	None	-	4.2	Not identified within project area	Pre-restoration plant survey
Plants	*Camissoniopsis lewisii*	Lewis' evening-primrose	None	None	-	3	Not identified within project area	Pre-restoration plant survey
Plants	*Navarretia ojaiensis*	Ojai navarretia	None	None	-	1B.1	Not identified within project area	Pre-restoration plant survey
Plants	*Chorizanthe parryi var. parryi*	Parry's spineflower	None	None	-	1B.1	Not identified within project area	Pre-restoration plant survey
Plants	*Eriogonum crocatum*	conejo buckwheat	None	Rare	-	1B.2	Not identified within project area	Pre-restoration plant survey
Plants	*Cercocarpus betuloides var. blancheae*	island mountain-mahogany	None	None	-	4.3	Not identified within project area	Pre-restoration plant survey
Plants	*Horkelia cuneata var. puberula*	mesa horkelia	None	None	-	1B.1	Not identified within project area	Pre-restoration plant survey
Plants	*Thelypteris puberula var. sonorensis*	Sonoran maiden fern	None	None	-	2B.2	Not identified within project area	Pre-restoration plant survey