SEAL COVE GEOLOGIC STUDY
Seal Cove Neighborhood - Moss Beach Community, San Mateo California

Prepared for:
County of San Mateo
Planning and Building Department

December 2025

COTTON, SHIRES AND ASSOCIATES, INC.
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December 11, 2025
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By Email: qtodzo@smcgov.org

Quinn Todzo
SAN MATEO COUNTY
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SUBJECT: **Seal Cove Geologic Study**
RE: Seal Cove Neighborhood
Moss Beach Community, San Mateo County, California

Dear Mr. Todzo:

Cotton, Shires and Associates, Inc. (CSA) is pleased to submit the following report to San Mateo County in which we describe our completed scope of work including document compiling and reviewing, field surveying and mapping, map preparing, and geologic and geotechnical evaluating for an update of the 1980 William Cotton and Associates (WCA) Geologic Analysis of the Seal Cove Area, County of San Mateo, California. This study was performed in accordance with our revised proposal to San Mateo County, most recently dated May 20, 2025.

We have also prepared various maps (topographic and hillshade, fault trench location, boring location, landslide features, and drainage), and tables of the investigation reports compiled and reviewed for our study. Finally, we have provided responses to the questions provided by the DPW.

We appreciate the opportunity to have been of service to you on this project. If you have any questions regarding this report, please feel free to call us.

Sincerely,
COTTON, SHIRES AND ASSOCIATES, INC.

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Table of Contents

Table of Contents (cont.)

SEAL COVE GEOLOGIC STUDY
Seal Cove Neighborhood
Moss Beach Community, San Mateo County, California

1.0 INTRODUCTION

1.1 Project Description

In this report, Cotton, Shires and Associates, Inc. (CSA) is pleased to present to San Mateo County (SMC) the results of our geologic study of the Seal Cove Neighborhood, in the Moss Beach Community of San Mateo County, California (Figure 1). This study is an update to the 1980 William Cotton and Associates (WCA) Geologic Analysis of the Seal Cove Area.

The Seal Cove neighborhood contains several geologic hazards including an active landslide complex, surface fault rupture hazards associated with the Seal Cove Fault (recognized by the State), and rapid failure of the high coastal bluff.

We understand that SMC has been notified of recent distress in the Seal Cove neighborhood, likely related to landslide movement, including in the vicinity of San Lucas Avenue between Ocean Boulevard and Del Mar Avenue. SMC staff observed recent distress, including *" . . road subsidence and damage, multiple water main breaks, and property damage."* In addition, SMC staff noted that some of the reported *" . . distress appears in areas within Hazard Zones 2 and 3, eastward of the 1980 mapped landslide."* We also understand that since the 1980 WCA report, a portion of Ocean Boulevard was closed around 2006 due to landslide movement between San Lucas Avenue to the south and Los Banos Avenue to the north.

1.2 Purpose and Scope of Work

The purpose of this study is to update the previous 1980 WCA Geologic Analysis study, reevaluate the current geologic hazards impacting the Seal Cove neighborhood, provide the County with updated maps showing the current locations of landslide scarps and movement, our understanding of fault traces, and address various questions from the Department of Public Works (DPW).

The specific scope of work performed for our investigation included the following tasks:

1) Compile documents, historic aerial photographs;
2) Prepare a topographic base map;
3) Review and catalog compiled documents;
4) Evaluate compiled documents;
5) Transfer information from compiled documents to CAD files;
6) Complete site reconnaissance;
7) Prepare landslide map and surface drainage map based on site reconnaissance;
8) Complete a drone survey of the bluff face and landslide-impacted streets;
9) Prepare maps of previously completed exploratory fault trenches and geotechnical investigations;
10) Revise 1980 Geotechnical Hazard Zones Map;
11) Formulate geologic and geotechnical responses to DPW questions;
12) Prepare this report.

2.0 PHYSICAL AND GEOLOGIC SETTING

2.1 Terrain

The site topography and features discussed in this section are shown on Figure 3, 2023 LiDAR Topographic Map. The Seal Cove neighborhood is situated on a relatively level marine terrace, ranging in elevation from approximately 75 feet to 125 feet. The western side of the neighborhood is surrounded by a very steep, roughly 80- to 90-foot-high coastal bluff. The northern and southern edges of the Seal Cove neighborhood are adjacent to the Fitzgerald Marine Reserve and Pillar Point Bluff, respectively.

The southern portion of Seal Cove (south of Los Banos Avenue) is bordered by a 30- to 50-foot escarpment to the east that trends northwest-southeast. This escarpment is associated with a mapped trace of the San Gregorio/Seal Cove Fault (Seal Cove Fault). The escarpment dissipates to flat terrain north of Los Banos Avenue (known as the Seal Cove wind gap), where the neighborhood is relatively flat. The escarpment reemerges north of the Seal Cove wind gap, approximately 560 feet north of Cypress Avenue.

2.2 Geologic Setting

Seal Cove is located within the Coast Ranges geomorphic province. The Pacific Ocean borders the Coast Ranges geomorphic province to the west and the Great Valley geomorphic province to the east. In general, the Coast Ranges geomorphic province is comprised of mountain ranges and valleys that trend northwest, subparallel to the San Andreas Fault. The Seal Cove area lies on the Pacific tectonic plate approximately 7.0 miles southwest of the San Andreas Fault. This major transform boundary separates the Pacific Plate from the North American tectonic plate.

The Seal Cove area is mapped as being underlain by marine terrace deposits (Qmt) (See Figure 2- Pampeyan, 1998). The Purisima Formation (Tp) and a massive, coarse-grained igneous rock of the Montara Quartz Diorite (Kg) (WCA, 1980) underlie the marine terrace deposits.

Resistant layers of the Purisima Formation can be observed in the intertidal zone at low tide, along the base of the adjacent bluffs. The bluffs along the Seal Cove neighborhood expose poorly consolidated sandstone, shale, and siltstone that have been fractured and weathered through tectonic movement and erosion. The combination of wave action and tectonic movement throughout the area has continued to shape the coastline along Seal Cove, contributing to landsliding and bluff retreat. Local geologic maps have identified several active landslides along the adjacent sea bluff.

2.3 Seismic Setting

The Seal Cove neighborhood is situated in an area of high seismicity. The San Gregorio Fault/Seal Cove Fault is mapped through the neighborhood. Published estimates of slip rates along the fault range from 1.0 to 3.0 mm/yr to 13.0 to 16.0 mm/yr. Various traces of this fault have been encountered in local fault trench investigations. The San Gregorio

Fault is a complex system of strike-slip faults that run along the California coast from Bolinas (north) to Point Arguello (south). The San Gregorio Fault is predominantly an offshore fault, with few onshore occurrences including Seal Cove, along the Santa Cruz Mountains, Big Sur, and San Simeon. The active San Andreas Fault is located approximately 7.0 miles to the southwest.

Earlier studies of the San Gregorio Fault's movement in the Seal Cove area show that the fault zone is a complex system of high-angle dextral (right lateral) strike-slip and west-vergent reverse faults (Simpson, 1997). This indicates the movement along the fault is oblique, and occurring both laterally and vertically. However, the exact movement of the fault throughout the area remains largely unknown and poorly understood. Simpson also concluded that the fault bends to the west through the Seal Cove wind gap.

The 1997 Simpson study concluded that the most recent fault rupture event and the penultimate fault rupture event were exposed in their exploratory fault trench. The location of the 1997 Simpson fault trench is shown on Figure 5 (at the north end of the study area). Simpson, utilized radiometric dating techniques, stratigraphic, and ethnostratigraphic (midden deposit) relationships to estimate the age of the most recent and penultimate fault rupture. Based on their analysis Simpson concluded that the most recent event occurred between 1270 AD and 1775 AD (250 to 755 years before present) and the penultimate event occurred between 620 AD and 1400 AD (625 to 1405 years before present). Finally, the Simpson study concluded that the most recent event was located near the western end of their trench (Figure 5), approximately 200 feet west of the projected east facing escarpment fault position. We note that the orientation of the most recent fault rupture event and the projection of the fault trace to the south align with the headscarp of the northern portion of the active landslide.

A few portions of the neighborhood are located within a California Geological Survey liquefaction hazard zone, and the entire sea bluff is in an earthquake-induced landslide hazard zone. As previously described, the San Gregorio Fault/Seal Cove Fault passes through the neighborhood. Consequently, much of the neighborhood is located within a State-designated Alquist Priolo/ Fault Rupture Zone of Required Investigation.

3.0 <u>SITE CONDITIONS</u>

3.1 <u>Surface Conditions</u>

The Seal Cove neighborhood in San Mateo County is situated in a suburban area characterized by single-family residences, accessible via narrow paved roads. Most of the parcels are developed with single-family residences.

In 1908, the Seal Cove neighborhood was subdivided into residential parcels. The existing parcels and street layouts have remained essentially unchanged since their initial establishment. Since then, the development of single-family homes has continued, with increasing restrictions as geologic hazards are updated.

Topographic features along the active landslide's boundary have periodically been paved over and incorporated into development on various properties (retaining walls, above-ground pipes, etc.).

Existing drainage throughout the Seal Cove Neighborhood includes ditches, gutters, culverts, and catch basins on private property and County right of way. Generally, surface water is conveyed east and west via paved and unlined ditches and swales toward relatively few catch basins. Surface water that flows toward the west, where controlled, is either gathered in catch basins at the Moss Beach Distillery parking area or in a catch basin near the southern end of Ocean Boulevard before discharging onto the bluff or the beach. We note that in one area, near 556 Madrone Avenue, the concentrated surface water flows overland across the bluff and on to the beach, and this flow has resulted in the development of an erosion gully on the bluff face (see Figure 8). Based on our review of historical aerial photos, it appears that the eroded gully existed prior to the development of the neighborhood.

3.2 <u>Landslides</u>

The limits of the active landslide complex, based on our recent mapping, are shown on Figure 6. The active landslide complex in Seal Cove has caused road closures, abandoned homes, broken sewer lines, broken water mains, and caused various other issues affecting the neighborhood's development. Ocean Boulevard was closed around 2006 from Los Banos Avenue to the north to San Lucas Avenue to the south, and has since been severely impacted by the landslide, becoming overgrown with vegetation, dropping in elevation, and shifting westward. At the intersection of San Lucas Avenue and Del Mar Avenue, a series of separations, depressions, and cracks has led to the closure of San Lucas Avenue from Del Mar Avenue to Ocean Boulevard. According to San Mateo County, the closure happened in March of 2025. During this period, the County also reported multiple water pipeline breaks and leaks in the area.

The damage to homes caused by the landslide is visible from the streets throughout the neighborhood. Depressions that run roughly northwest to southeast can be seen affecting foundations, driveways, and residences. Several homes near Ocean Boulevard have been previously red-tagged by the County and are no longer occupied.

4.0 COMPILED DOCUMENTS AND REVIEW

In this section, we present the findings from our review of documents and reports sourced from San Mateo County, our office files, and online databases. The materials we examined included geotechnical investigations, geological reports, fault investigations, soil assessments, construction plans, aerial photographs, drainage maps, and LiDAR data. A summary of the reviewed documents and data is provided in Appendix B, and select monitoring reports are provided in Appendix C.

4.1 Previous Geological and Geotechnical Investigation Reports

As part of our study, we reviewed a total of 74 documents, reports, and studies obtained from San Mateo County records, our office files, and publicly available online records. Within these documents, we categorized 74 fault trenches and test pits, 74 exploratory borings, and 3 inclinometers. The locations of exploratory borings and inclinometers are shown on Figure 4 and the locations of exploratory fault trenches are shown on Figure 5.

The site maps included in the reviewed documents were georeferenced to county parcel data to locate subsurface investigations (fault trenches, borings, etc.) and geomorphic features on our maps.

4.1.1 **<u>Landslide Evaluations</u>** – A handful of reviewed geotechnical and geologic reports discussed active landslides across Seal Cove. Topics related to landslides, such as surface cracks, foundation settlement, coastal erosion, and mitigation efforts, were included in the reviewed documents. In general, the lot specific reports do not include a scope of work sufficient to add significant knowledge to our understanding of the larger landslide complex.

The most thorough documentation and evaluation of the large landslide complex are presented in the F. Beach Leighton and Associates, 1971, Engineering Geologic Report of the Seal Cove – Moss Beach Area, and the William Cotton and Associates, 1980, Geologic Analysis of the Seal Cove Area. The 1971 Leighton report included detailed geologic mapping, 17 large-diameter borings, and 9 small-diameter borings. The William Cotton and Associates (WCA) study included additional geologic mapping and builds on the Leighton report. Based on their analysis, WCA concluded *"Detailed surface mapping and subsurface drill hole data strongly suggest that the mode or style of slope failure can be characterized as (1) progressing from the north to the south and (2) undergoing rotational failure along a concave upward basal rupture surface."* Observations during our site reconnaissance and the recent southward landslide enlargement validates the WCA conclusions regarding the mode of slope failure of the large landslide complex.

4.1.2 **<u>Inclinometer Monitoring</u>** – A total of three inclinometers were documented within our study (Figure 4, Appendix C). Two inclinometers (BAGG/SI-1 and SI-2), located at 96 Terrace Avenue, were monitored for six months between March and September 2020. The results of these inclinometers are conflicting, because they appear to show opposite movement vectors. BAGG/SI-1 recorded movement towards the east, while BAGG/SI-2 recorded movement towards the west. The expected movement of the landslide in this area would be towards the west. Due to the short timeframe that the two BAGG inclinometers were monitored in conjunction with the contradictory displacement directions, we have concluded that the BAGG inclinometers do not contribute to our understanding of the large landslide complex.

The inclinometer at 105 San Lucas Avenue (PR/SI-1) was installed by Peters and Ross in October 2019, monitored until December 2024, and subsequently sheared off by landslide displacement in 2025 (as communicated by San Mateo County). This inclinometer was monitored annually and recorded displacement at depths from 2 to 8 feet and deeper displacement zones from 46 to 48 feet and 52 to 58 feet. Visible scarps are located just west of the slope inclinometer and we interpret the 8+ inches of total movement between depths 2 to 8 feet the result of a shallow failure of the precipitous scarp. The total displacement at the deepest zone, between depths of 52 and 58 feet, was approximately 1.0 inch and the majority of this displacement occurred between December 2022 and December 2024. Based on the inclinometer plots, we assume that the inclinometer casing was sheared off at a depth of 8 feet due to shallow movement; however, we have not been provided with any documentation to confirm our assumption. We also note that the inclinometer plots indicate that a bias correction was applied. A bias correction is often utilized when the raw cumulative displacement plot exhibits an overall tilt from one reading to the next; however, if the inclinometer casing was installed above/shallower than the basal rupture surface, the bias shift could be removing a real tilt caused by backward rotation of the landslide.

4.1.3 <u>Groundwater and Piezometer Monitoring</u> – In addition to the inclinometer at 105 San Lucas Avenue, the Consultant (Peters and Ross) also installed two vibrating wire piezometers. The vibrating wire piezometers were attached to the inclinometer casing and installed at depths of 45.5 feet (upper) and 95.5 feet (lower). The piezometers were connected to a data logger and recorded a relatively complete record of groundwater levels from October 2019 through December 2024 (five rainy seasons). Both the lower and upper piezometer recorded similar groundwater depths and fluctuated in unison during this time. Precipitation records indicate that there were two drought years (2019/2020 and 2020/2021), two average rainfall years (2021/2022 and 2023/2024) and one above average rainfall year (2022/2023). During the drought years the piezometers recorded groundwater depths that ranged from approximately 31 feet to 38 feet, and during the average and above average rainfall years the groundwater depths ranged from approximately 21 feet to 37 feet. The groundwater exhibited a direct and relatively immediate response to precipitation events and a gradual drawdown during dry periods.

We have plotted precipitation data with the Peters and Ross plot of the piezometer data in Appendix C.

Groundwater was identified at one of the 21 locations represented by the lot specific geotechnical borings drilled in the area. Shallow groundwater was identified in a geologic investigation at 160 Los Banos Avenue (Don Hillebrandt, 1985). In general, the borings associated with lot specific geotechnical investigations were shallow (10 to 20 feet), consequently, the lack of groundwater identified in these borings is not surprising. Conversely, the borings drilled by Leighton in their 1971 investigation were deeper (up to 60 feet) and groundwater was encountered in the majority of these borings, typically perched at the terrace deposit/Purisima contact. Leighton notes that the groundwater observed was higher in the south side of the study area than the north and postulates that groundwater flows to the north towards the Seal Cove wind gap.

4.1.4 **Survey Monitoring** – CSA has been performing survey monitoring of the landslide displacement in the vicinity of the Moss Beach Distillery since 1997. We have calculated a total of 79.0 inches of displacement (66.5 inches horizontally and 42.7 vertically) between 1997 and 2025. Prior to CSA's monitoring effort, County Surveyors performed monitoring in the area beginning in 1972. As part of our survey monitoring we have incorporated the County's monitoring results to estimate a long-term displacement rate. We have calculated an average annual long-term displacement rate of 2.7 inches horizontally and 1.6 inches vertically (downward) since monitoring began in 1972. Based on our most recent monitoring the annual rate between 2023 and 2025 has increased to 3.3 inches horizontally and 2.7 inches vertically. This increased rate followed two years of average and one year of above average rainfall in the area and coincided with the southeastern progression of the landslide to San Lucas Avenue.

4.1.5 **Fault Traces** – We reviewed fault trenches and test pits included within each of the reviewed documents. Using the consultant's trench/test pit logs, we documented the orientation, width, materials, and characteristics of the mapped fault traces. We noted fault traces in 43 percent of the reviewed fault trench logs, with some logs recording more than one trace in each trench.

Generally, the fault traces logged by consultants trended northwest-southeast and were vertically oriented. Typical characteristics of fault traces included gouge zones, clay seams, and offset layers of materials.

After plotting orientations of fault traces throughout each reviewed trench log and test pit, we connected fault traces from trench to trench where linear projections of the reported fault orientations could be made. The majority of the fault investigations have been completed north of Orval Avenue and south of San Lucas Avenue, consequently, there is a dearth of fault information in the central portion of the study area. The fault trench locations, identified fault locations and fault orientations are presented on Figure 5, Exploratory Fault Trench Location Map.

Typical fault setback distances for habitable structures recommended by the investigating consultants ranged from 5.0 to 50.0 feet, with the most frequently recommended setback being 10 feet.

Various fault shadow studies have been completed in Seal Cove, but only a few included reference fault trench logs in the submitted reports. Therefore, our assessment of these shadow studies is limited to the trench logs that we have reviewed.

4.1.6 Other Geotechnical Hazards – Previous studies and reports have identified other geotechnical hazards within Seal Cove, including potentially expansive soils, poor surface drainage, and shallow groundwater. In our study, we reviewed exploratory borings from consultants' reports, focusing on groundwater depths (discussed in Section 4.1.3), slide planes, geologic contacts, and earth materials encountered.

Laboratory testing was performed on samples from 40 percent of the reviewed borings, with Atterberg tests completed on samples from the ground surface to 20 feet below ground level. Reported liquid limits ranged from 21 to 54, with an average of 34. Reported plasticity indices ranged from 4 to 34, with an average of 14.

4.2 Maps and Aerial Photographs

We reviewed multiple sets of aerial photographs ranging from 1941 to 2025. These aerial photographs were provided by the San Mateo County Planning Department and additional air photos were obtained through University of Santa Barbara's (UCSB) online Air Photo Database. High resolution orthophotos from 2014 through 2025 obtained from Nearmap were also reviewed.

In our analysis of these photograph sets, we were able to review changes that have occurred in the landslide topography and terrain throughout Seal Cove. These photographs served as a basis for our bluff retreat calculations (see Section 7.3) and provided insight into the development of Seal Cove since the establishment of the residential parcels and road alignments.

4.3 Topographic Base Map

A topographic base map (Figure 3) was created using publicly available Light Detection and Ranging (LiDAR) data (USGS 1 Meter 10x54y416 CA_CaliforniaGaps_B23: U.S. Geological Survey.) LiDAR for the data set was collected between September 5, 2023 and December 11, 2023. The map features a hillshade representation and topographic contours, allowing for the visualization of terrain in the Seal Cove area. This map functions as a foundational layer for our compilation of all the reviewed data, site reconnaissance mapping, and geologic interpretation of geomorphic and topographic features related to landsliding and faulting.

4.4 County GIS Drainage Map

San Mateo County provided a drainage map for the Seal Cove neighborhood that shows the various drainage infrastructure throughout the area. We reviewed this data using the online viewer, which included approximate locations for drainage features such as storm drains, culverts, ditches, catch basins, and pipes. The County data also featured elevation profiles along ditches and pipes, enabling us to analyze drainage directions and where water might be diverted or pool as it flows through the neighborhood.

We transferred the approximate locations of these drainage features to our topographic base map. During our site reconnaissance, we attempted to locate mapped catch basins, inlets, outlets, ditches, and pipes. Then, we compared our field findings to the County-provided data to assess its accuracy.

There were multiple areas with unclear drainage patterns, particularly north of Los Banos Avenue and inland from Beach Way. Along these streets, the elevation profiles provided for drainage pipes and ditches fluctuated significantly, indicating a lack of clear drainage direction.

We found that the County drainage map is missing data for several catch basins and drainage ditches. The County GIS generally includes County maintained facilities and not privately maintained facilities. Additionally, multiple points on the County-provided map indicated that a drainage infrastructure was present at a specific location, but we were unable to locate this feature during our site reconnaissance. See Section 5.3 for a more detailed description of the drainage features observed during our site reconnaissance.

5.0 SITE RECONNAISSANCE

We completed a detailed site reconnaissance for this study through multiple trips to Seal Cove between May 6, 2025, and August 17, 2025. During our site visits, we mapped landslide features, fault indications, geologic bedding orientations, damaged infrastructure, and topographic features. We were able to gain access to several of the private properties that displayed exterior damage from the landslide through granted access from San Mateo County and the homeowners.

We mapped geomorphic features using our Trimble GPS equipment when sufficient satellite coverage was available and manually mapped features on topographic maps when satellite coverage was insufficient.

During low tide, we walked along the beach to measure the bedding orientations of distinct layers of the Purisima Formation and to record signs of erosion and landsliding along the sea bluff. Competent layers of the Purisima Formation can be clearly observed in the wave action zone of the beach during low tide. The sea bluff is composed of unsaturated Purisima Formation, where the clay content of the rock has shrunk, resulting in significant weathering and complex fracture systems. Roughly 20 feet of terrace deposits overlie the Purisima Formation bedrock at the top of the bluff. Generally, the measured bedding of the Purisima Formation trends northwest to southeast and dips between 20 and 60 degrees towards the northeast.

We observed several sites at the base of the coastal bluffs that contained remnants of infrastructure, originally situated on top of the bluffs, that were displaced during failures associated with bluff retreat (see Appendix D, Photo 5). The materials we noted included concrete foundations, wooden beams, concrete blocks, bricks, and metal.

5.1 Landslide Features

Common geomorphic features associated with landslides were observed within Seal Cove, including scarps, grabens (depressions), tension cracks, separations, and sinkholes. Exposures of these features are easily traceable along Ocean Boulevard and intersecting roads due to the lack of vegetation and pavement distress. The northern and southern boundaries of the active landslide are Cypress Avenue and San Lucas Avenue, respectively. The exact southern terminus of the landslide is uncertain, but is located somewhere between San Lucas Avenue and Madrone Avenue. We were unable to gain access to the residences in this block of Seal Cove for detailed mapping.

North of Orval Avenue, the eastern boundary of the landslide is a 40- to 50-foot steep slope (scarp) that parallels Beach Way to the west. From Beach Way, we observed scarps and cracking of the pavement on Terrace Avenue (a private driveway located opposite Alton Avenue) below the scarp. We interpret this high scarp and relatively low coastal bluff as representing the oldest block of the active landslide complex. Southern progression of the landslide has incorporated additional land to the south, most recently San Lucas Avenue.

The eastern margin of the landslide crosses the front yard of 100 Orval Avenue (intersection of Beach Way and Park Avenue) and continues south through the northern edge of the Moss Beach Distillery parking lot and forms a 10-foot-tall scarp that slopes towards the restaurant. This scarp continues through 125 and 116 Los Banos Avenue. Depressions, cracks, and minor scarps were observed within the Moss Beach Distillery parking lot. At 795 Park Avenue, we observed a power pole leaning towards the northwest at an angle of approximately 10 degrees. The adjacent pole to the northwest is located within the active landslide boundary near the scarp east of Moss Beach Distillery and displacement of the landslide is likely causing the observed tilt in the pole adjacent to 795 Park Avenue.

The upslope (eastern) margin of the landslide appears to step west between 116 Los Banos Avenue and 131 La Grande Avenue where it forms a 6 foot tall scarp. The scarp can be traced to the south where it becomes a depression that crosses La Grande Avenue at 116 La Grande Avenue.

Previous mapping indicates that the eastern margin of the landslide steps west again between La Grande and San Lucas Avenue. We were unable to access the properties between La Grande and San Lucas Avenue to evaluate whether this westward step is still present, however due to the new distress observed on San Lucas Avenue we have projected the landslide limits to connect the eastern most distress on La Grande and San Lucas Avenue directly without the westward step.

San Lucas Avenue displays a series of scarps and grabens from Del Mar Avenue to Ocean Boulevard. The eastern most depression/graben at the intersection of San Lucas Avenue and Del Mar Avenue was filled with sand by the County in March of 2025 after intense separation and the formation of sinkholes through the asphalt. This same depression extends along the western side of 105 San Lucas Avenue and turns into a tall vegetated scarp to the north.

Prominent scarps along Ocean Boulevard range in height from 0.5 to 7 feet, and alternate in slope direction, sloping both inland and toward the bluff. As identified within the WCA 1980 study, the active landslide is characterized by progression from north to south and the mode of failure is a rotational failure along a concave-upward basal rupture surface.

Based on comparisons to previous studies and aerial photos, the landslide has progressed southeast between La Grande Avenue and San Lucas Avenue. The landslide distress along San Lucas Avenue has moved approximately 70 feet southeast since the 1980 study. The landslide, in this area, now extends approximately 250 to 400 feet inland from the bluff edge. In addition, the height of the scarps along Ocean Boulevard have increased significantly. North of La Grande Avenue, the magnitude of landslide distress has increased but the eastern (inland) limits of the landslide have remained remarkably consistent.

There are no prominent features along the face of the sea bluff that indicate the basal slide plane of the landslide. Thus, the landslide likely extends deeper than (below) the sea bluff height (80 to 90 feet) and toes out off-shore into the ocean.

5.2 Fault Trace Indications

The most significant geomorphic expression of faulting in the area is the high east-facing escarpment just east of Seal Cove along Airport Street. However, additional fault traces throughout the Seal Cove neighborhood have been identified in exploratory fault trenches. After reviewing previous geologic and geotechnical reports and identifying fault traces throughout the neighborhood, we walked along the mapped traces to identify any observable features associated with the faulting. Minor settlement was observed through the driveway of 50 Bernal Avenue, following the orientation of the mapped fault traces that were identified within the address's geologic investigation. Similarly, minor settlement in the driveway at 130 Beach Way followed the mapped fault trace based on the adjacent address's reports.

5.3 Surface Drainage

During our site reconnaissance, we observed various surface drainage structures and noted drainage patterns. Determining who owns or is responsible for any of these improvements is beyond the scope of our investigation. We also compared the provided San Mateo County drainage maps with observed infrastructure. Several ditches shown on the County drainage map and identified in the field were either partially filled with debris, did not drain to a proper inlet or outlet system, or pooled in low-lying areas. Some storm drain inlets and outlets listed on the County's map could not be located during our site visit, or they are incorrectly positioned on the map.

We also observed multiple ditches throughout the neighborhood that were not included within the county's drainage map. Additionally, we observed areas of pooled water, partially blocked storm drain inlets on private property (overgrown with grass and debris), and gullied areas along the bluff face.

Many of the storm drain ditches divert water directly to the edge of the sea bluff, along Ocean Boulevard, where they drain directly over the edge and, in places, have created erosion gullies that have begun to recede towards the roadway. These gullies were observed near the intersection of Madrone Avenue and Ocean Boulevard, just west of the roadway near the mailboxes, as well as at the intersection of Bernal Avenue and Ocean Boulevard. Based on our review of historical aerial photos, it appears that the eroded gully existed prior to the development of the neighborhood. We were unable to locate the inlet and outlet marked on County maps, in the vicinity of the Bernal Avenue and Ocean Boulevard intersection. Based on our review of aerial photos from recent years, it appears that the outlet pipe was destroyed sometime during the 2022/23 winter. The area around this inlet is eroded and gullied.

We have plotted estimated overall drainage directions, based on the roadway topography, and the pipes, culverts and drop inlets on Figure 8, Surface Drainage Map.

6.0 DRONE SURVEY

A drone survey was conducted as part of this study on June 25, 2025. We generated an ortho-rectified aerial photograph (orthophoto), a georeferenced image of the ground surface, using high-resolution aerial imagery of the study area. This orthophoto provides a detailed record of the ground conditions, topographic features, and the position of the bluff, serving as a baseline for future evaluations. In addition, a dense point cloud was generated from the drone images. Drone flights in the future, and their resulting data sets, may be used to compare and measure bluff retreat, erosion rates, and changes in landslide geomorphology.

7.0 GEOLOGIC EVALUATION

Based on our review of existing published documents, reports, subsurface exploration, aerial photographs, and our site reconnaissance we have evaluated the three major geologic hazards that impact the Seal Cove neighborhood; active landslides, faulting, and bluff retreat.

7.1 Landslides

The large active landslide complex impacting the Seal Cove neighborhood is a north to south progressing rotational failure along a concave-upward basal rupture surface. Our interpretation of the current limits of the landslide is shown on Figure 6. The landslide displaces Purisima Formation bedrock and the overlying terrace deposits and the base of the landslide is understood to be within the Purisima Formation bedrock. Observations of the bedrock outcrops at the base of the coastal bluffs and descriptions from the large and small-diameter exploratory borings indicate that the Purisima Formation in this area consists of thin-bedded, highly fractured siltstone, shale and sandstones. In general, the Purisima Formation bedding planes dip to the east, into the slope, however the numerous fractures and joint sets appear to be concentrated enough to have allowed a rupture surface to develop across bedding planes. The basal rupture surface of the landslide is not well defined, however, WCA and Leighton have postulated that the landslide toes out at the base of the coastal bluff or offshore, relatively close to the bluff; however, as we previously indicated, we did not observe signs of a landslide toe at the base of the bluff during our site reconnaissance. Based on WCA and Leighton’s interpretation, the depth of the landslide is approximately 100 feet below the ground surface at its deepest.

The recent expansion of the landslide to the southeast confirms the north to south progressing nature of the landslide. We anticipate that the landslide will continue to progress to the southeast along a line roughly parallel to the coastal bluff. Comparison of the 1971 and 1980 landslide mapping with the current conditions (Figure 12) indicates that the northern portion of the landslide has not propagated to the east (inland) since 1971, specifically, the eastern limits of mapped distress north of La Grande Avenue have remained consistent for the past 54 years. Based on the location and orientation of the most recent Seal Cove Fault rupture, as described by Simpson in their 1997 study, the eastern (inland) limit of the landslide may be controlled by the location of the most recent fault rupture. The fault may be providing a releasing joint that the landslide is preferentially following. We anticipate that in the long term (hundreds to thousands of years) the landslide will continue to propagate southward until its inland margin exits the bluff face or reaches the next major landslide approximately 2,000 feet to the south.

Long term displacement rates of the landslide measured since 1972 indicate the landslide, in the vicinity of the Moss Beach Distillery, displaces an average of 2.7 inches horizontally and 1.6 inches vertically (downward) per year. Recent measurements, between 2023 and 2025 recorded an increased displacement rate of 3.3 inches horizontal and 2.7 inches vertical per year. This rate increase is coincident with the increased distress and southeast expansion of the landslide in the San Lucas Avenue area and follows three years of average and above average precipitation. While the distress in the San Lucas Avenue area accelerated recently, we note that roadway distress in this area can be seen in Google street view images as far back as 2011.

It should be understood that shaking from a major earthquake on one of the Bay Area faults or rupture of the Seal Cove Fault could trigger immediate landslide movement, or a rapid acceleration and potentially significant southward expansion of the landslide. If the Seal Cove Fault ruptures along one of the eastern traces identified in the exploratory trenches, rather than the more westerly trace identified by Simpson as the most recent event, the landslide could expand significant distances to the east (inland) beyond its present limits.

7.2 Faulting

Fault traces have been identified in various exploratory trenches within the Seal Cove neighborhood. Based on the distribution of the fault traces we consider the Seal Cove Fault in this area to be defined as a broad zone of surface faulting rather than a discrete fault and the ground surface. Based on the 1997 Simpson study the fault has accumulated 3 to 24 feet of elastic strain since the most recent rupture. Given the potential for 3 to 24 feet of displacement, the fault poses a significant risk to existing infrastructure and future development in the area.

7.3 Bluff Retreat

We utilized the 1965 aerial photographs to generate an ortho-rectified photo of the Seal Cove area. Developing the ortho-rectified image allowed us to make more precise measurements of the historic top of bluff position with respect to the current position of the top of bluff defined by the 2023 LiDAR topography and June 25, 2025 drone based orthophoto. The distance between the 1965 top of bluff and the current top of bluff was measured at several locations throughout the study area to calculate the magnitude of bluff retreat over the 60 year period (1965-2025). The calculated bluff retreat rates are shown on Figure 7. Based on our evaluation, we calculated an average retreat of 60 feet along the bluff south of the limits of the landslide (south of San Lucas Avenue to Bernal Avenue). This results in a 60-year average retreat rate of 1-foot per year. It should be understood that coastal bluff retreat is episodic by nature and it is likely that the measured 60 feet of bluff retreat occurred in relatively few rapid failures followed by significant periods of quiescence. It should be noted that we did not factor sea level rise into our evaluation.

The bluffs within the landslide, between the Moss Beach Distillery and the southern margin of the landslide have experienced less retreat, however the retreat rate within the landslide increases to the south (south of La Grande Avenue). At least a partial cause of the reduced retreat rate within the northern portion of the landslide complex, where we have monitoring data, is that the seaward displacement of the landslide moves the top of bluff west each year, masking some of the eastward migration of the top of bluff caused by bluff retreat. The low bluffs north of the Moss Beach Distillery, within the study area, have experienced relatively little retreat since 1965.

Utilizing the recent (2014 to 2017) high resolution orthophotographs we observed approximately 20 feet of bluff retreat along isolated sections of Ocean Boulevard, south of the southern landslide margin, during the wet winters of 2016/2017 and 2022/2023. In addition, we observed bluff failures during these wet winters adjacent to 686 Ocean Boulevard the last residence remaining west of Ocean Boulevard.

8.0 <u>HAZARD MAP PREPARATION</u>

Based on our geologic evaluation of the current state of the geotechnical hazards that impact the Seal Cove neighborhood we have revised the Geotechnical Hazards Zone Map originally produced by WCA in 1980. The revised Geotechnical Hazards Zone Map and Geotechnical Hazards Zone Explanation are shown on Figures 9 and 10, respectively. In general, we concur with the previous characterization, risk assessment and recommended geologic and geotechnical investigations for each of the three zones originally proposed by WCA. The significant modifications made to the Geotechnical Hazards Zone Map are the southeastern expansion of Zone 1 and 2 in the vicinity of San Lucas Avenue to account for the southeastern expansion of the active landslide and the northeastern expansion of Zones 1 and 2 along Ocean Boulevard in the vicinity of Precita Avenue to account for the coastal bluff retreat that has occurred since the WCA 1980 study.

Below we present the characterization, risk assessment and recommended geologic and geotechnical investigations for Geotechnical Hazard Zones 1 through 3:

Zone 1 - Includes all lands located along the western coastal bluff that are adversely affected by active landslide processes and bluff erosion. The eastern limit of Zone 1 includes a 50 to 70 foot setback from the limit of active landslide features to account for anticipated continued migration of the landslide. Lands within Zone 1 should be considered unstable. It is anticipated that slow progressive landsliding and rapid coastal bluff retreat will continue to result in distress to existing residential improvements, roadways and utilities in Zone 1.

<u>Risk Assessment</u> - Risk to development in this zone is considered to be extremely high. It is reasonable to conclude that slow progressive landsliding and coastal bluff retreat will continue, resulting in structural and property damage. This is especially true for structures or utilities located astride active surface breaks. The risk of rapid catastrophic slope failure of the high, steep portion of the coastal bluff is high. If parcels west of Ocean

Boulevard in Zone 1 are developed such an event could involve the loss of life as well as significant property damage. The feasibility of reducing the risk associated with slope instability to acceptable levels in Zone 1 is extremely low.

We recommended that no new development and no additions of habitable space to existing structures (i.e. increase of bedrooms and bathrooms) be approved in Zone 1.

We recommend that as a condition of approval for any improvements or additions to existing structures in Zone 1 the proposed improvements include improvements to foundations and/or other structural improvements that increase the strength of the existing structure and reduce the risk of collapse of the structure.

<u>Recommended Geologic and Geotechnical Investigations</u> - No investigation deemed feasible to warrant approval of new development due to the severity of the instability.

Zone 2 - Includes all lands within a 100-foot wide zone located immediately adjacent to the zone of active landsliding and accelerated costal bluff erosion (i.e. Zone 1) and areas located within the San Mateo County Local Coastal Program *"areas of demonstration of stability".* The position of the eastern boundary of this zone is established in part by the intersection of the ground surface and a plane inclined at 20° originating from the base of the high coastal bluff located west of Ocean Boulevard. This method of establishing the area potentially impacted by coastal bluff retreat/instability is consistent with the San Mateo County Local Coastal Program Policies (September, 2021).

<u>Risk Assessment</u> - Risk of slope instability or fault hazards to impact development in Zone 2 is considered to be moderate to high. The timing of eastward/southward progression of the active landsliding is difficult to predict with reliable accuracy. The likelihood of eliminating the slope

stability risk is very low, however it may be possible to significantly reduce the impact to proposed improvements by thoroughly characterizing the hazard during engineering geologic and geotechnical investigations and adhering to recommended setbacks or implementing recommended mitigation alternatives.

The feasibility of reducing the fault hazard risks to acceptable levels in this zone is considered high. This can be accomplished by careful siting of homes away from active· faults, using careful structural and foundation design and adequate surface drainage plans. However, it is possible that some residential parcels will be judged unbuildable due to high seismic hazards.

We recommend no development be allowed in this zone until stability/safety is clearly demonstrated by the required engineering geologic, geotechnical, and fault hazard investigations.

Recommended Geologic and Geotechnical Investigations - Engineering geologic investigation by a certified engineering geologist and a geotechnical investigation by a registered civil engineer, or a combined equivalent of the above. Scope of both investigations should be directed toward a detailed evaluation of the potential landslide hazards in this zone. In most cases, landslide studies will require extensive subsurface work in order to provide the necessary technical data to conduct a detailed slope stability analysis. The geotechnical analysis should provide acceptable factors of safety to clearly demonstrate stability before new development is allowed in this zone.

Scope of engineering geologic investigation should also address the seismic hazards related to the master and branching traces of the Seal Cove fault. Particular emphasis of the engineering geologic investigations. should be placed on the evaluation of possible surface faulting. Investigative techniques within this area will require the use of subsurface trenching unless clear evidence is established, based on previous fault trenches that shadow the property, that show that no active fault crosses the parcel in question.

Zone 3 - Includes all lands located outside of the areas affected by active or potential landslides. Zone 3 properties are impacted by potential fault hazards.

Risk Assessment - Risk to development in this zone is considered to be low to moderate. The major geologic hazard in this zone is the risk of surface faulting along the master fault trace and several, branching fault traces of the Seal Cove fault. These faults are considered active by the State and are capable of producing damaging surface faulting, strong ground shaking and ground failure.

The relative risk associated with poor surface drainage and potentially expansive soils is generally regarded as moderate to locally high.

The feasibility of reducing the risks to acceptable levels in this zone is considered high. This can be accomplished by careful siting of homes away from active· faults, using careful structural and foundation design and adequate surface drainage plans. However, it is possible that some residential parcels will be judged unbuildable due to high seismic hazards. Development should be allowed in Zone 3 on parcels found to be free of hazardous conditions by the required geotechnical/geologic investigations.

Recommended Geologic and Geotechnical Investigations - Engineering geologic investigation by a certified engineering geologist and a geotechnical investigation by a registered civil engineer, or a combined equivalent of the above. Scope of engineering geologic investigation should address the seismic hazards related to the master and branching traces of the Seal Cove fault. Particular emphasis of the engineering geologic investigations should be placed on the evaluation of possible surface faulting. Investigative techniques within this area will require the use of subsurface trenching unless clear evidence is established, based on nearby previous fault trenches that shadow the property, that show that no active fault crosses the parcel in question. The geotechnical investigation should address, but not necessarily be confined to, the following items: site preparation and grading, surface drainage, and design parameters for residential foundations.

Several properties were incorporated into Zone 1 and Zone 2 due to the revision to the map. To illustrate which properties were impacted we have prepared Figure 11, Area of Hazard Zone Changes.

9.0 GEOTECHNICAL EVALUATION OF DPW SPECIFIC QUESTIONS

Based on our recent document review and site reconnaissance, we developed the following responses to the previously provided corresponding DPW questions:

- *Current, short-term, and future risk levels of the roadways in the Seal Cove study area;*

  Figure 13, Roadway Risk-Level Map, shows the location of the road segments described in this section.

  Various roadways in the Seal Cove Study area have a high short-term risk of being distressed by the ongoing landslide movement, including portions of the following (from north to south):

  - Beach Way (between Ocean Blvd and Orval Ave)
  - Los Banos Ave (west of 116 Los Banos Ave)
  - La Grande Ave (west of 136 La Grande Ave)
  - San Lucas Ave (west of 105 San Lucas Ave)
  - Ocean Blvd (north of 885 Ocean Blvd)

  Roadway segments that have a high long term (future) risk include:

  - Ocean Blvd (south of 885 Ocean Blvd) due to potential rapid bluff retreat;
  - Madrone Ave. (adjacent to 556 Madrone Ave) due to potential southward progression of the landslide;

- All roadways in the study area have a risk of significant damage due to potential rupture of the Seal Cove Fault.

- *Future landslide movement impacts on roadways, infrastructure (utilities), and public safety;*

  Future landslide impacts to the roadways and utilities include the following:
  - Pavement Cracks;
  - Vertical Drops/Scarps;
  - Separations/Open Cracks;
  - Broken Water Pipelines;
  - Broken Sewer Pipelines;
  - Leaning/Distressed Overhead Utility Poles
  - Broken Gas Pipelines
  - Broken Storm Drain Pipes

  The risks to public safety associated with landslide movement cover the spectrum from minor (slips trips and falls associated with open ground cracks) to moderate (falls associated with precipitous scarps over 6 feet in height) to significant life safety concerns associated with rapid bluff retreat or catastrophic failure of structures due to rapid acceleration of the landslide during seismic events. In addition, it should be understood that continued roadway distress may delay or prevent first responders from accessing certain properties.

- *Surface drainage conditions, and potential drainage improvement alternatives;*

  Roadway drainage improvements designed to reduce the volume of surface water that potentially infiltrates into landslide will provide some benefit to landslide stability; however, given the magnitude of the landslide, the surface area of the roadways compared to the rest of the neighborhood, and the historical displacement rates, we anticipate that surface drainage improvements will have only a minor impact on the stability of the landslide. Furthermore, based on our monitoring at the Moss Beach Distillery, the landslide moves during wet years and during drought years; however, the magnitude of movement appears to increase following wetter years. We understand that the drainage patterns throughout Seal Cove follow the natural topography, and there is no underground storm drain system throughout the neighborhood. We also understand that the drainage patterns and infrastructure throughout the neighborhood (i.e. driveway culverts, ditches, gutters, etc.) are often located on private property and are the responsibility of the property owner to maintain.

We further understand that there are limitations placed on stormwater drainage discharge towards the bluff due the Seal Cove area being located in a designated "Area of Special Biological Significance" as part of the Fitzgerald Marine Reserve; however, there are several existing catch basins in the Seal Cove neighborhood that are collected into culverts and discharge onto the bluff.

Installation of additional catch basins and culverts throughout the landslide area would likely reduce the potential for storm runoff water to infiltrate into the landslide, which would typically be beneficial to reducing landslide movement, provided that the discharge location was suitably located off of the landslide.

During our site reconnaissance, we observed inlets and catch basins overgrown with grass and debris. We recommend that proper maintenance of the drainage infrastructure be implemented to reduce the potential for rainwater to overflow and infiltrate into the landslide material. Determining who owns or is responsible for any of these improvements is beyond the scope of our investigation.

We also observed an area that appears to be a "closed depression" with poor drainage located in the northern portion of the neighborhood (See Figure 8).

- *Roadway usage, maintenance, and modifications for roads in the Seal Cove study area, to "minimize further damage."*

Roadway usage, maintenance and modifications likely have had minimal adverse effects on the stability of the landslide. Continued crack sealing of open fractures will reduce the potential for surface water to enter the landslide, however, with a landslide of this magnitude these crack sealing efforts will likely result in only marginal gains in stability.

- *Landslide movement thresholds for roadway closures and utility relocations;*

  Observations of the surficial distress including cracked pavements, and utility breaks are beneficial for tracking rate of movement and location of the landslide headscarp. During our evaluation, we observed that cracks originally mapped in the 1980 report later developed into scarps and that observed cracks indicate the likely location of future landslide propagation.

  The County could consider confirmation of movement exceeding 400% of the limits of precision of the monitoring instrument and methods in previously unaffected areas as an indication that the landslide is progressing into these areas and additional distress is likely. It should be understood that the magnitude of movement necessary to confirm landslide progression will vary depending on monitoring instrumentation type and methods. Once landslide progression is observed the County should develop a road closure and utility relocation plan. Assessing the timing of road closures and utility relocation with respect to the impact on the residents of the area is beyond our expertise, however, the County should understand that the magnitude of existing roadway distress and any future distress associated with southward progression of the landslide could rapidly increase during a seismic event or during/following very wet winters.

  The County should consider required access of emergency vehicles when evaluating thresholds for roadway closures.

- *Specific roadway segments that have the highest risk and will likely require abandonment;*

  Based on our recent study, we have identified the following roadway segments that have the highest risk and will likely require future abandonment (from north to south):

  - Ocean Blvd. (from Park Ave. to the Distillery Parking Lot)

- Los Banos Ave. (west of 116 Los Banos Ave.)
- La Grande Ave. (west of 136 La Grande Ave.)
- San Lucas Ave (west of 105 San Lucas Avenue)
- Ocean Blvd. (north of 885 Ocean Blvd.)

- *Feasibility of a long-term landslide stabilization;*

  Based on our experience, the costs for an investigation and construction of stabilization measures (walls, drawdown wells, etc.) will be very high. In addition, a mitigation project will likely require taking of private land (eminent domain). The current characterization of the landslide is incomplete and very little is known about the basal rupture surface and the groundwater regime. In our experience an investigation to thoroughly characterize a landslide of this magnitude will require dozens of deep exploratory borings equipped with inclinometers and piezometers followed by a period of monitoring and potentially more subsurface exploration once the depth of movement is identified. In addition, analysis of the landslide following thorough characterization may conclude that mitigation alternatives are cost prohibitive. For a rough estimate of landslide investigation and stabilization costs, we understand that in the past two years, the City of Rancho Palos Verdes, in Southern California, has spent approximately $48 million related to their ongoing landslide stabilization effort including supplemental investigations, dewatering, and repairing roadways and sewer pipe lines. It is important to note that prior to the recent City expenditures the landslide had been extensively investigated with numerous deep exploratory borings, lab testing, and instrumentation, and an array of surface monuments has been monitored at the site for over 30 years. In addition, we note that the landslide is still moving at a rate approximately 20 to 30 times greater than the Seal Cove Landslide.

- *Monitoring alternatives to measure and track landslide movement.*

  Typical landslide monitoring instruments include:

  - Slope Inclinometers;
  - Shape Arrays ;

- Survey Arrays;
- Cloud to Cloud comparison of dense point clouds derived from LiDAR or photogrammetry of drone captured aerial images; and
- Periodic Visual Observations.

Slope inclinometers and shape arrays are typically installed in a subsurface hole or trench and need to extend below the basal landslide plane of movement. Both require periodic monitoring and comparing to an initial baseline reading, and provide displacement depth, rate and direction. The shape array can be monitored remotely, provided there is access to electricity, while the slope inclinometer requires on-site monitoring. The slope inclinometer can provide monitoring up to about 3 inches of discrete deformation, while the shape array can reportedly accommodate greater displacements. However, it should be understood that the total magnitude of discrete displacement that a shape array can accommodate is dependent on the location of the displacement with respect to the individual joints within the shape array. Both inclinometers and shape arrays provide high precision data about the depth, rate, and direction of landslide movement, however they each have a high installation cost, the data is limited to the location where they are installed, and have a limited life span (only a couple of years based on the historical displacement rate).

Traditional survey arrays (measured by total station or GNSS) and cloud to cloud comparison of dense point clouds from LiDAR or photogrammetry of drone captured aerial images are ground surface based monitoring systems. Monitoring of traditional survey arrays and drone flights both require periodic site visits. Traditional survey arrays can provide rate and direction of surface displacement, but not to the detail that the subsurface monitoring can. Cloud to cloud comparison can provide a magnitude of change in the ground surface but not a horizontal direction. Surface based monitoring can provide additional data to characterize the lateral limits and potential differing rates of the landslide but do not add information regarding the depth of displacement. In addition, there is no way to differentiate local, shallow displacement, from the deeper basal rupture surface displacement of the landslide utilizing surface monitoring methods alone. Traditional survey arrays likely have a limit of precision of approximately ½ inch but are limited to providing data at the locations they are installed. Cloud to cloud comparisons have a limit of precision of several inches but have the benefit of capturing and evaluating data for the entire site which allows the identification of new areas of displacement that may not have been identified when installing fixed location monitoring systems (i.e. inclinometers, shape arrays, traditional survey arrays).

10.0 CONCLUSIONS AND RECOMMENDATIONS

The Seal Cove neighborhood is constrained by three major geologic/geotechnical hazards: 1) active landslides; 2) faulting; and 3) rapid failure of coastal bluffs.

10.1 Active Landslide

The active landslide complex has been displacing at an average rate of 2.7 inches horizontally and 1.6 inches vertically (downward) since monitoring began in 1972, however, in the last two years that annual rate has increased to 3.3 inches horizontally and 2.7 inches vertically. This increased rate followed two years of average and one year of above average rainfall in the area and coincided with the southeastern progression of the landslide to San Lucas Avenue. We note that minor distress was observed along San Lucas Avenue as early as 2011 but the observed distress greatly accelerated in the past two years. We anticipate that southeastern progression of the landslide will continue in the future, however, based on our observations, and in the absence of a triggering seismic event, we do not anticipate significant eastward (inland) migration of the landslide.

While there is a long history of survey monitoring of the landslide at the Moss Beach Distillery location, monitoring along the majority of the landslide has been negligible. We recommend that the County develop a monitoring program that will document the landslide displacement rates across the footprint of the entire landslide. This would be especially beneficial along the southeastern margin of the landslide where there is recent distress and no monitoring data to compare current rate of movement to historic rates. In addition, currently stable areas adjacent to the landslide should be monitored to evaluate signs of landslide progression. As previously indicated, it appears that the northern limits of the landslide have not changed since 1980; however, the southeastern margin of the landslide appears to have enlarged.

A robust monitoring plan would initially include several monitoring systems including deep inclinometers and surface monitoring to evaluate the relationship between basal rupture surface displacement and surface displacements. Once a correlation between the basal rupture surface displacement and surface displacement has been established, basal rupture surface displacements can be estimated based on surface displacements alone. Deep inclinometers are costly to install and will likely have a limited effective life based on the observed surface displacement rates (one to three years), consequently, it may be more cost effective to establish a surface monument monitoring program, after the depth of landsliding has been characterized.

The County could consider a phased monitoring approach, starting with periodic drone flights to compare dense point clouds to our initial drone flight. But it should be understood that the drone flights provide regional data, and only limited visual displacement information. Unfortunately, drone based surveys do not easily provide detailed rates of movement or detect minor movement. Ideally, a drone based monitoring would be combined with a higher precision monitoring system such as a periodic total station or GNSS survey monument array. It has been our experience that a program which includes redundancy provides the most useful monitoring data, because frequently one wants to confirm the measurements of one system with another.

If landslide mitigation is being considered in the future, then we suggest also installing piezometers to model the groundwater depth across the landslide.

We recommend that the County work with the homeowner at 105 San Lucas Avenue to facilitate continued monitoring/continuous data logging of the piezometers installed in 2019. Data loggers could be downloaded semiannually to minimize the need to access the property.

Roadway drainage improvements designed to reduce the volume of surface water that infiltrates into landslide will provide some benefit to landslide stability, however, given the magnitude of the landslide, the surface area of the roadways compared to the rest of the neighborhood, and the historical displacement rates, we anticipate that surface drainage improvements will have only a minor effect on the stability of the landslide.

We recommend that revisions to the Geotechnical Hazards Zone Map be adopted by the County to account for the southeastern progression of the active landslide.

10.2 Faulting

Numerous exploratory fault trenches have been completed since the initial Geotechnical Hazards Zone Map was prepared in 1980. Given the distribution of fault traces identified in the trenches, the Seal Cove Fault should be considered to be a broad zone of potential surface rupture hazards in the Seal Cove neighborhood rather than a discrete fault. Based on the 1997 Simpson study, the fault has accumulated 3 to 24 feet of elastic strain since the most recent rupture. Given the potential for 3 to 24 feet of displacement, the fault poses a significant risk to existing infrastructure and future development in the area. We recommend that the County continue to require fault investigations, including exploratory trenches, prior to approval of new development in Zones 2 and 3.

We recommend that revisions to the Geotechnical Hazards Zone Map be adopted by the County and that Consultants utilize the fault investigation information compiled on the revised map when advising residents and designing subsurface exploration programs.

10.3 Rapid Failure of Coastal Bluffs

Rapid failure of the high coastal bluffs continues to be a hazard in the Seal Cove neighborhood. Residents along Ocean Boulevard should be aware of the hazard and the County should monitor the roadway following significant storms and high swells. Improvements to surface drainage should be implemented to minimize the incision of the bluffs caused by concentrated, overland surface flow across the bluff along Ocean Boulevard.

We recommend that revisions to the Geotechnical Hazards Zone Map be adopted by the County to account for the bluff retreat that has occurred since the previous map was produced in 1980.

11.0 INVESTIGATION LIMITATIONS

Our services consist of professional opinions and recommendations made in accordance with generally accepted engineering geology and geotechnical engineering principles and practices. No warranty, expressed or implied, or merchantability of fitness, is made or intended in connection with our work, by the proposal for consulting or other services, or by the furnishing of oral or written reports or findings.

This report is based solely on reconnaissance-level geologic evaluations and review of geologic and geotechnical investigations performed by other Consultants and is without benefit of subsurface exploration and/or laboratory testing. Such additional work would be necessary to provide recommendations to stabilize the landslides.

12.0 REFERENCES

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Aerial Photographs

Date	Flight	Frame
3/23/41	6660	6
3/23/41	6660	7
5/27/56	DOB-1R	2
5/27/56	DOB-1R	4
5/17/65	SM	12-91
5/17/65	SM	12-92
6/30/70	2946-13	1
6/30/70	2946-13	2
6/30/70	2946-13	3
6/16/01	HM-2001-USA-3042	219
6/16/01	HM-2001-USA-3042	220

APPENDIX A

Figures 1 - 13

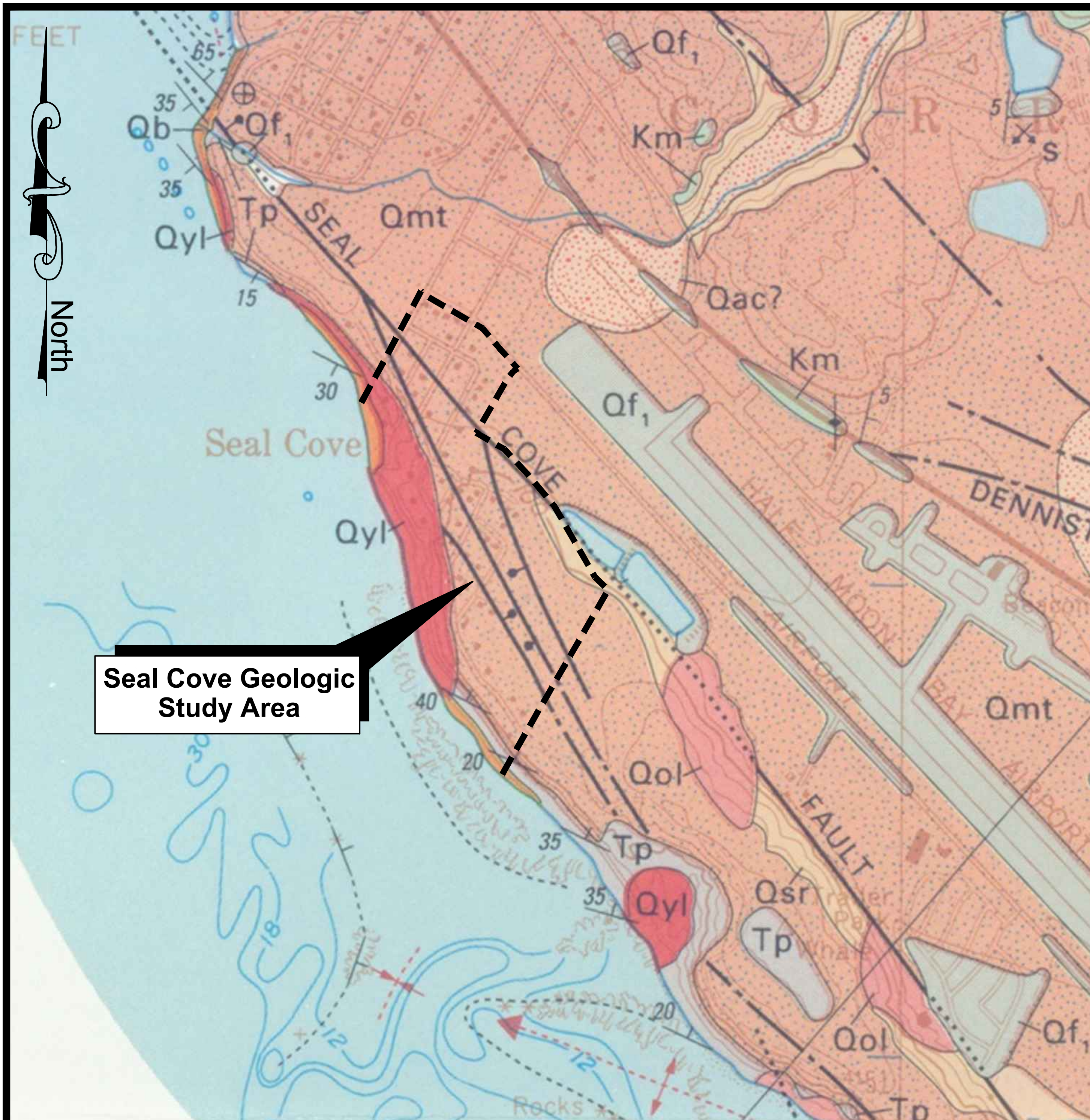
Source: USGS Topoview Terrain Base Map

Source: Montara Mountain OE W Quadrangle, California- San Mateo County 7.5-Minute Series, USGS, 2021

COTTON, SHIRES AND ASSOCIATES, INC.
CONSULTING ENGINEERS AND GEOLOGISTS

SITE LOCATION MAP
Seal Cove Geologic Study
SEAL COVE NEIGHBORHOOD, MOSS BEACH COMMUNITY
SAN MATEO COUNTY, CALIFORNIA

GEO/ENG BY CSS	SCALE 1"=100'	PROJECT NO. E6195
APPROVED BY DTS/AM	DATE December 2025	FIGURE NO. 1



DESCRIPTION OF MAP UNITS

- Qmt — Marine Terrace Deposits
- Qb — Beach deposits
- Qsr — Slope wash, ravine fill, and colluvium
- Km — Granitic rock of Montara Mountain
- Tp — Purisima Formation
- Qyl — Younger landslide deposits
- Qol — Older landslide deposits
- Qf_1 — Artificial Fill (Unit 1)
- Qac — Coarse-grained alluvium
- **Contact**- dashed where approximate, dotted where concealed
- **Fault**- dashed where approximate, small dashes where inferred, dotted where concealed, queried where location is uncertain
- **Syncline**
- **Anticline**
- 30 **Strike and dip of beds**
- **Horizontal bed**

Source: Pampeyan, E.H., Geologic Map of the Montara Mountain and San Mateo 7-1/2' Quadrangles, San Mateo County, California, 1981

0 500 1000 2000
(feet)

COTTON, SHIRES AND ASSOCIATES, INC.
CONSULTING ENGINEERS AND GEOLOGISTS

REGIONAL GEOLOGIC MAP
Seal Cove Geologic Study
SEAL COVE NEIGHBORHOOD, MOSS BEACH COMMUNITY
SAN MATEO COUNTY, CALIFORNIA

GEO/ENG BY	SCALE	PROJECT NO.
CSS	1"=100'	E6195
APPROVED BY	DATE	FIGURE NO.
DTS/AM	December 2025	2

EXPLANATION

Map Symbols

- San Mateo County Parcels
- Major Contour Line — Major Contour Interval = 25 feet
- Minor Contour Line — Minor Contour Interval = 5 feet
- Top of Coastal Bluff
- Limits of East Facing Escarpment
- Seal Cove Wind Gap

NOTE: Topography and Hillshade derived from publicly available DEM *"U.S. Geological Survey, 20250820, USGS 1 Meter 10 x54y416 CA_CaliforniaGaps_B23: U.S. Geological Survey"*. LiDAR for data set collected between September 5, 2023 and December 11, 2023.

COTTON, SHIRES AND ASSOCIATES, INC.
CONSULTING ENGINEERS AND GEOLOGISTS

2023 LiDAR TOPOGRAPHIC MAP
Seal Cove Geologic Study
SEAL COVE NEIGHBORHOOD, MOSS BEACH COMMUNITY
SAN MATEO COUNTY, CALIFORNIA

GEO/ENG BY	SCALE	PROJECT NO.
CSS	1"=100'	E6195
APPROVED BY	DATE	FIGURE NO.
DTS/AM	December 2025	3

EXPLANATION

Consultant Legend

ARSA = Abel R. Soares and Associates
AT = Atlas
BEA = Buckley Engineering Associates
CCI = Cleary Consultants
CSA = Cotton, Shires and Associates
DHA = Don Hildebrand Associates
EIC = Earth Investigation Consultants
FLA = Frank Lee Associates
GF = GeoForensics
GS = GeoSphere
HAY = Hayes
HMT = Harlan Miller Tait
JCP = J.C. Penderghast
LEE = Lee Engineers
MUR = Murray Engineers Inc.
PR = Peters and Ross
PRA = Purcell Rhoades and Associates
R = Romig Engineers
SEY = Stanley E. Yorke
SFC = Steven F. Connelly
SP = Sigma Prime Geosciences
WT = Wayne Ting and Associates

Map Symbols

17 — Large Diameter Exploratory Boring (Leighton and Associates, 1971)

25 — Small Diameter Exploratory Boring (Leighton and Associates, 1971)

Boring Designation / Consultant — CSA/B-2 — Exploratory Boring Location (Consultant/Boring Designation)

PR/SI-1 — Inclinometer Location (Consultant/Boring Designation)

COTTON, SHIRES AND ASSOCIATES, INC.
CONSULTING ENGINEERS AND GEOLOGISTS

GEOTECHNICAL BORING LOCATION MAP
Seal Cove Geologic Study
SEAL COVE NEIGHBORHOOD, MOSS BEACH COMMUNITY
SAN MATEO COUNTY, CALIFORNIA

GEO/ENG BY	SCALE	PROJECT NO.
CSS	1"=100'	E6195
APPROVED BY	DATE	FIGURE NO.
DTS/AM	December 2025	4

EXPLANATION

Consultant Legend

ARSA = Abel R. Soares and Associates
AT = Atlas
BEA = Buckley Engineering Associates
BLA = Beach Leighton and Associates
CCI = Cleary Consultants
CSA = Cotton, Shires and Associates
DHA = Don Hildebrand Associates
EIC = Earth Investigation Consultants
FLA = Frank Lee Associates
GF = GeoForensics
GS = GeoSphere
HAY = Hayes
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PRA = Purcell Rhoades and Associates
R = Romig Engineers
SEY = Stanley E. Yorke
SFC = Steven F. Connelly
SP = Sigma Prime Geosciences
WT = Wayne Ting and Associates

Map Symbols

Exploratory Fault Trench and Designation

Exploratory Fault Trench; log not available

Location of Identified Fault in Exploratory Fault Trench

Orientation of Fault Identified in Exploratory Trench (projected 75 feet each way)

California Geologic Survey Alquist-Priolo Location of Primary Fault Trace, Montara Mountain Quadrangle, Official Map Released 1982

California Geologic Survey Alquist-Priolo Zone of Required Investigation - Montara Mountain Quadrangle, Official Map Released 1982

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EXPLORATORY FAULT TRENCH LOCATION MAP
Seal Cove Geologic Study
SEAL COVE NEIGHBORHOOD, MOSS BEACH COMMUNITY
SAN MATEO COUNTY, CALIFORNIA

GEO/ENG BY	SCALE	PROJECT NO.
CSS	1"=100'	E6195
APPROVED BY	DATE	FIGURE NO.
DTS/AM	December 2025	5

COTTON, SHIRES AND ASSOCIATES, INC.
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LANDSLIDE AND BLUFF FAILURE MAP
Seal Cove Geologic Study
SEAL COVE NEIGHBORHOOD, MOSS BEACH COMMUNITY
SAN MATEO COUNTY, CALIFORNIA

GEO/ENG BY	SCALE	PROJECT NO.
CSS	1"=100'	E6195
APPROVED BY DTS/AM	DATE December 2025	FIGURE NO. 6

EXPLANATION

Map Symbols

- 2025 Top of Bluff
- 1965 Top of Bluff
- San Mateo County Parcels
- Major Contour Line (Major Contour Interval = 25 feet)
- Minor Contour Line (Minor Contour Interval = 5 feet)
- Limit of Landslide Complex
- Scarp
- Depression/Trench
- Tension Crack

RETREAT RATES

Minimum Rate (ft/yr)	Maximum Rate (ft/yr)	Color
0.00	0.20	purple
0.20	0.40	blue
0.40	0.60	teal
0.60	0.80	green
0.80	1.00	yellow
1.00	1.20	pink

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BLUFF RETREAT 1965-2025
Seal Cove Geologic Study
SEAL COVE NEIGHBORHOOD, MOSS BEACH COMMUNITY
SAN MATEO COUNTY, CALIFORNIA

GEO/ENG BY	SCALE	PROJECT NO.
CSS	1"=100'	E6195
APPROVED BY DTS/AM	DATE December 2025	FIGURE NO. 7


Catch Basin
15" RCP
12" CMP
Closed Depression
Area of Poor Drainage
Airport St
Los Banos Ave
Orval Ave
Marine Ave
Alton Ave
Cypress Ave
Park Way
Beach Way
Park Ave
San Ramon Ave
San Lucas Ave
La Grande Ave
Madrone Ave
Del Mar Ave
Precita Ave
Alvarado Ave
Decota Ave
Bernal Ave
Ocean Blvd
18" HDPE
Catch Basins
Inlet
Outlet,
Destroyed
2022/2023
Eroded Gully
North
0 50 100 200
(feet)
EXPLANATION
Map Symbols
Active Landslide Complex
Drainage area contributing surface water to landslide
Surface Drainage Direction
Drainage Pipe
Closed Depression - Area of Poor Draiange
San Mateo County Parcels
COTTON, SHIRES AND ASSOCIATES, INC.
CONSULTING ENGINEERS AND GEOLOGISTS
SURFACE DRAINAGE MAP
Seal Cove Geologic Study
SEAL COVE NEIGHBORHOOD, MOSS BEACH COMMUNITY
SAN MATEO COUNTY, CALIFORNIA
GEO/ENG BY CSS
SCALE 1"=100'
PROJECT NO. E6195
APPROVED BY DTS/AM
DATE December 2025
FIGURE NO. 8

California Geologic
Survey Alquist-Priolo
Fault Location
(Montara Mountain
Quadrangle)
ZONE 3
ZONE 3
ZONE 2
ZONE 1
Airport St
Los Banos Ave
San Ramon Ave
Bernal Ave
Del Mar Ave
Alvarado Ave
Precita Ave
Park Ave
San Lucas Ave
Madrone Ave
Decota Ave
Orval Ave
Park Way
Marine Ave
Alton Ave
Cypress Ave
Beach Way
Ocean Blvd
La Grande Ave
Ocean Blvd
Simpson,
1997 Study
North
0 50 100 200
(feet)
NOTE TO USERS:
The map is primarily designed for use by geologists, engineers and planners and is not intended to be a substitute for detailed site specific geotechnical investigations.
EXPLANATION
Geotechnical Hazard Zones*
Zone 1- Unstable active landslide and unstable steep coastal bluff
Zone 2- Area of potential eastward and southward landslide progression and area of potential future coastal bluff failure. Also constrained by fault hazards.
Zone 3- Not impacted by landslide and coastal bluff instability hazard. Primary geotechnical constraint is fault hazard.
* See Figure 10, Geotechnical Hazard Zone Explanation, for through description of hazard zones, risk assessment, and recommended scope of investigation.
Map Symbols
Scarp
Depression/Trench
Tension Crack
Exploratory Fault Trench
Exploratory Fault Trench; log not available
Location of Identified Fault in Exploratory Fault Trench
Orientation of Fault Identified in Exploratory Trench (projected 75 feet each way)
California Geologic Survey Alquist-Priolo Location of Primary Fault Trace
Direction of Landslide and Fault Displacement
ZONE 2
ZONE 1
Limit of Geotechnical Hazard Zone
San Mateo County Parcels
Major Contour Line
Major Contour Interval = 25 feet
Minor Contour Line
Minor Contour Interval = 5 feet
COTTON, SHIRES AND ASSOCIATES, INC.
CONSULTING ENGINEERS AND GEOLOGISTS
GEOTECHNICAL HAZARDS ZONE MAP
Seal Cove Geologic Study
SEAL COVE NEIGHBORHOOD, MOSS BEACH COMMUNITY
SAN MATEO COUNTY, CALIFORNIA
GEO/ENG BY
CSS
SCALE
1"=100'
PROJECT NO.
E6195
APPROVED BY
DTS/AM
DATE
December 2025
FIGURE NO.
9

GEOTECHNICAL HAZARD ZONE	RISK ASSESSMENT	RECOMMENDED GEOTECHNICAL INVESTIGATIONS
Zone 1 Includes all lands located along the western coastal bluff that are adversely affected by active landslide processes and bluff erosion. The eastern limit of Zone 1 includes a 50 to 70 foot setback from the limit of active landslide features to account for anticipated continued migration of the landslide. Lands within Zone 1 should be considered **unstable**. It is anticipated that slow progressive landsliding and rapid coastal bluff retreat will continue to result in distress to existing residential improvements, roadways and utilities in Zone 1.	Risk to development in this zone is considered to be extremely high. It is reasonable to conclude that slow progressive landsliding and coastal bluff retreat will continue, resulting in structural and property damage. This is especially true for structures or utilities located astride active surface breaks. The risk of rapid catastrophic slope failure of the high, steep portion of the coastal bluff is high. If parcels west of Ocean Boulevard in Zone 1 are developed such an event could involve the loss of life as well as significant property damage. The feasibility of reducing the risk associated with slope instability to acceptable levels in Zone 1 is extremely low. **We recommended that no new development and no additions of habitable space to existing structures (i.e. increase of bedrooms and bathrooms) be approved in Zone 1.** We recommend that as a condition of approval for any improvements or additions to existing structures in Zone 1 the proposed improvements include improvements to foundations and/or other structural improvements that increase the strength of the existing structure and reduce the risk of collapse of the structure.	No investigation deemed feasible due to the severity of the instability.
Zone 2 Includes all lands within a 100-foot wide zone located immediately adjacent to the zone of active landsliding and accelerated costal bluff erosion (i.e. Zone 1) and areas located within the San Mateo County Local Coastal Program *"areas of demonstration of stability"*. The position of the eastern boundary of this zone is established in part by the intersection of the ground surface and a plane inclined at 20° originating from the base of the high coastal bluff located west of Ocean Boulevard. This method of establishing the area potentially impacted by coastal bluff retreat/instability is consistent with the San Mateo County Local Coastal Program Policies (September, 2021).	Risk of slope instability or fault hazards to impact development in Zone 2 is considered to be moderate to high. The timing of eastward/southward progression of the active landsliding is difficult to predict with reliable accuracy. The likelihood of eliminating the risk is very low, however it may be possible to significantly reduce the impact to proposed improvements by thoroughly characterizing the hazard during engineering geologic and geotechnical investigations and adhering to recommended setbacks or implementing recommended mitigation alternatives. The feasibility of reducing the fault hazard risks to acceptable levels in this zone is considered high. This can be accomplished by careful siting of homes away from active· faults, using careful structural and foundation design and adequate surface drainage plans. However, it is possible that some residential parcels will be judged unbuildable due to high seismic hazards. We recommend no development be allowed in this zone until stability is clearly demonstrated by the required engineering geologic, geotechnical, and fault hazard investigations.	Engineering geologic investigation by a certified engineering geologist and a geotechnical investigation by a registered civil engineer, or a combined equivalent of the above. Scope of both investigations should be directed toward a detailed evaluation of the potential landslide hazards in this zone. In most cases, landslide studies will require extensive subsurface work in order to provide the necessary technical data to conduct a detailed slope stability analysis. The geotechnical analysis should provide acceptable factors of safety to clearly demonstrate stability before new development is allowed in this zone. Scope of engineering geologic investigation should also address the seismic hazards related to the master and branching traces of the Seal Cove fault. Particular emphasis of the engineering geologic investigations. should be placed on the evaluation of possible surface faulting. Investigative techniques within this area will require the use of subsurface trenching and possibly geophysical traverses unless clear evidence is established, based on previous fault trenches that shadow the property, that show that no active fault crosses the parcel in question.
Zone 3 Includes all lands located outside of the areas affected by active or potential landslides. Zone 3 properties are impacted by potential fault hazards.	Risk to development in this zone is considered to be low to moderate. The major geologic hazard in this zone is the risk of surface faulting along the master fault trace and several, branching fault traces of the Seal Cove fault. These faults are considered active by the State and are capable of producing damaging surface faulting, strong ground shaking and ground failure. The relative risk associated with poor surface drainage and potentially expansive soils is generally regarded as moderate to locally high. The feasibility of reducing the risks to acceptable levels in this zone is considered high. This can be accomplished by careful siting of homes away from active· faults, using careful structural and foundation design and adequate surface drainage plans. However, it is possible that some residential parcels will be judged unbuildable due to high seismic hazards. Development should be allowed in Zone 3 on parcels found to be free of hazardous conditions by the required geotechnical investigations.	Engineering geologic investigation by a certified engineering geologist and a geotechnical investigation by a registered civil engineer, or a combined equivalent of the above. Scope of engineering geologic investigation should address the seismic hazards related to the master and branching traces of the Seal Cove fault. Particular emphasis of the engineering geologic investigations should be placed on the evaluation of possible surface faulting. Investigative techniques within this area will require the use of subsurface trenching unless clear evidence is established, based on previous fault trenches that shadow the property, that show that no active fault crosses the parcel in question. The geotechnical investigation should address, but not necessarily be confined to, the following items: site preparation and grading, surface drainage, and design parameters for residential foundations.

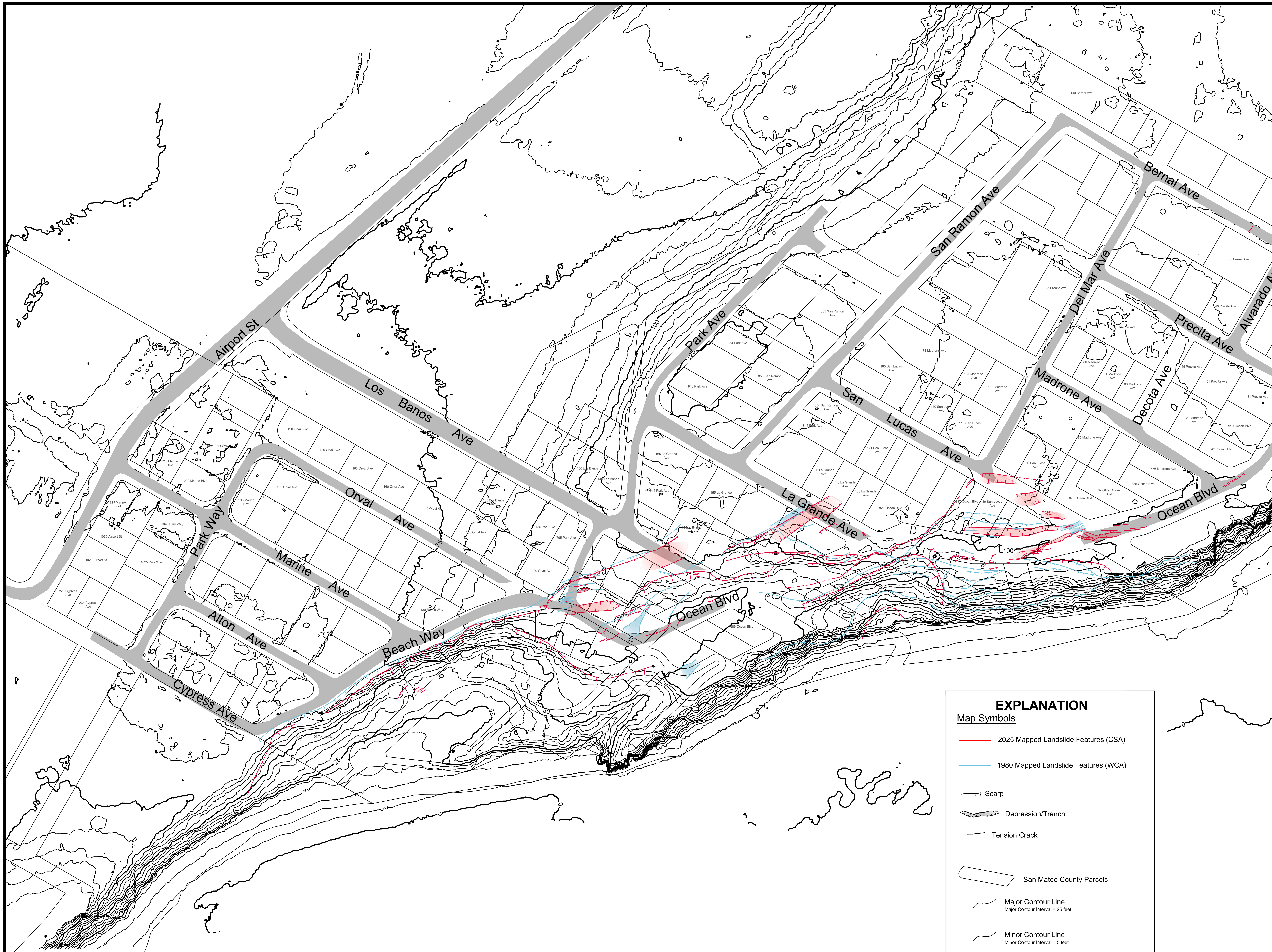
NOTE TO USERS:
The map is primarily designed for use by geologists, engineers and planners and is not intended to be a substitute for detailed site specific geotechnical investigations.

COTTON, SHIRES AND ASSOCIATES, INC.
CONSULTING ENGINEERS AND GEOLOGISTS

GEOTECHNICAL HAZARDS ZONE EXPLANATION
Seal Cove Geologic Study
SEAL COVE NEIGHBORHOOD, MOSS BEACH COMMUNITY
SAN MATEO COUNTY, CALIFORNIA

GEO/ENG BY	SCALE	PROJECT NO.
CSS	1"=100'	E6195
APPROVED BY	DATE	FIGURE NO.
DTS/AM	December 2025	10


Airport St
Los Banos Ave
Park Ave
San Ramon Ave
Bernal Ave
Del Mar Ave
Alvarado Ave
Precita Ave
Madrone Ave
Decota Ave
San Lucas Ave
La Grande Ave
Ocean Blvd
Orval Ave
Marine Ave
Park Way
Alton Ave
Beach Way
Cypress Ave
Ocean Blvd
Previous (1980) Inland Limit of Zone 2
Previous (1980) Inland Limit of Zone 1
North
0 50 100 200
(feet)
EXPLANATION
Area of 2025 Expansion of Hazard Zone 1
Area of 2025 Expansion of Hazard Zone 2
Previous (1980) Inland Limit of Hazard Zone 1
Previous (1980) Inland Limit of Hazard Zone 2
COTTON, SHIRES AND ASSOCIATES, INC.
CONSULTING ENGINEERS AND GEOLOGISTS
AREAS OF HAZARD ZONE CHANGES
Seal Cove Geologic Study
SEAL COVE NEIGHBORHOOD, MOSS BEACH COMMUNITY
SAN MATEO COUNTY, CALIFORNIA
GEO/ENG BY CSS
SCALE 1"=100'
PROJECT NO. E6195
APPROVED BY DTS/AM
DATE December 2025
FIGURE NO. 11



COTTON, SHIRES AND ASSOCIATES, INC.
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1980 AND 2025 LANDSLIDE MAPPING

Seal Cove Geologic Study

SEAL COVE NEIGHBORHOOD, MOSS BEACH COMMUNITY
SAN MATEO COUNTY, CALIFORNIA

GEO/ENG BY	SCALE	PROJECT NO.
CSS	1"=100'	E6195
APPROVED BY	DATE	FIGURE NO.
DTS/AM	December 2025	12

COTTON, SHIRES AND ASSOCIATES, INC.
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ROADWAY RISK-LEVEL MAP
Seal Cove Geologic Study
SEAL COVE NEIGHBORHOOD, MOSS BEACH COMMUNITY
SAN MATEO COUNTY, CALIFORNIA

GEO/ENG BY	SCALE	PROJECT NO.
CSS	1"=100'	E6195
APPROVED BY	DATE	FIGURE NO.
DTS/AM	December 2025	13

APPENDIX B

Spreadsheet of Geological and Geotechnical Reports Reviewed

Table 1: Reviewed Documents

Address	APN	Date	Consultant	City File #	City Permit	Consultant's Project #
0 Cypress Avenue	037-221-020, 030	12/19/2017	Sigma Prime	9A-139, 91-140	PLN2020-00070	16-128
150 Cypress Avenue	037-221-150	1982	JCP	9A-140	BLD2015-00036	JCP-946
140 Cypress Avenue	037-221-140	19??	Stanley E. Yorke	8A-8	-	0661?
221 Cypress	037-200-090	6/1/1989	Harlan Miller Tait	9A-164	BLD89-00147	917.01
151 Alton	037-221-080, 090, 100	12/5/1988	JCP	9A-155	-	JCP-2486
120 Alton	037-222-220	5/7/2002	GeoForensics	-	BLD2001-01565	-
120 Alton	037-222-220	4/19/2002	Steven F. Connelly	9A-244	BLD2001-01565	209
145 Marine Boulevard	037-222-160	1/22/1983	Perry R. Wood	9A-49	-	604-80-83
145 Marine Boulevard	037-222-160	5/29/1980	Perry R. Wood	9A-49	-	604-80
148 Marine Boulevard	037-223--03, 04	4/2/1981	JCP	9A-54	-	JCP-726
191 Marine Boulevard	037-222-200	5/29/2014	Sigma Prime	9A-93	BLD-2000-1444, BLD2004-01296	14-110
191 Marine Boulevard	037-222-120	1983	JCP	9A-93	BLD2000-1444	JCP-1079
160 Marine Boulevard	037-223-190	1981	JCP	9A-66	-	JCP-716
175 Marine Boulevard	037-222-230	5/12/2017	Michelucci and Associates, Inc.	-	BLD2016-01322	16-4614
196 marine Boulevard	037-223-090	12/11/2002	GeoForensics	9A-250		
112 Orval Avenue	037-224-020	3/8/2018	Geosphere	-	BLD2020-01713	91-04233-A
175 Orval Avenue	037-223-110	1/14/2008	Hoexter Consulting	-	BLD2017-01438	G-179-02A-735A
135 Orval Avenue	037-223-240	5/9/2001	GeoForensics	9A-150	BLD2002-00619	201061
131 Orval Avenue	037-223-230	1987	JCP	-	-	JCP-2048
159 Orval Avenue	037-223-140	5/29/1980	Perry R. Wood	9A-52	-	605-80
140 Beach Way	037-215-070	2/27/1991	CSA	-	-	G1270
120-150 Beach Way	037-215-100, 037-214-050	7/25/2023	CSA	9A-304	BLD2024-00381	E6022
1011 Park Way	037-225-010	6/15/2017	Sigma Prime	-	BLD2016-02502	-
825 Park Avenue	037-256-180	1/1/1977	JCP	9A-32	-	JCP-137
836 Park Avenue	037-259-010	2/22/2019	Geosphere	-	BLD2024-00466, BLD2024-01784, PLN2022-00217	91-04555-A (2912)
880 Park Avenue	037-259-310	7/30/2020	Sigma Prime	-	PLN2019-00472, BLD2020-00634	19-135
106 Los Banos Avenue	037-255-290	4/23/2020	Sigma Prime	9A-296	BLD2020-00296, BLD2020-00890	20-104
125 Los Banos Avenue	037-252-040	12/3/2014	Murray	-	BLD2015-00958	2083-1R1
160 Los Banos Avenue	037-256-130	1/21/1985	Don Hillebrandt Associates	9A-135	BLD2011-00784	1544-1
160 Los Banos Avenue	037-256-130	3/12/2010	Wayne Ting	9A-135	BLD2011-00784	2856
955 Ocean Boulevard	037-278-010	9/23/2020	Sigma Prime	-	BLD2022-00682	20-136
989 Ocean Boulevard	037-278-090	11/30/2020	Louis A. Richardson	-	-	1094.12

989 Ocean Boulevard	037-278-090	12/3/2020	Frank Lee and Associates	-	BLD2021-01681	11913-51
127 La Grande Avenue	037-255-260	8/10/2023	Sigma Prime	-	PLN2024-00158	23-170
131 La Grande Avenue	037-255-280	10/25/1987	GeoForensics	9A-12	BLD97-1207	97311
131 La Grande Avenue	037-255-280	6/29/1976	Abel R. Soares and Associates	9A-12	BLD97-1207	159-1
146 La Grande Avenue	037=258-260	7/5/2017	Sigma Prime	-	BLD2018-00656	15-143
845 San Ramon Avenue	037-259-200	11/17/2006	Earth investigations Consultants	-	-	2161.01.00
845 San Ramon Avenue	037-259-200	10/11/2019	Geosphere	-	PLN2024-00131, BLD2019-02355	91-04338-A (2161)
847 San Ramon Avenue	037-259-220	7/6/1976	Abel R. Soares and Associates	9A-28	-	19-3
863 San Ramon	037-259-170	12/14/2000	Buckley Engineering Associates	9A--221	-	99176.8
871 San Ramon Avenue	037-259-270	5/3/1976	Purcell, Rhoades and Associates	9A-11	-	675-1
991 San Ramon Avenue	037-287-030	2/16/2001	Purcell, Rhoades and Associates	-	-	07-212/7506-01
5 Precita Avenue (898 San Ramon)	037-284-190	1/5/2017	Lee Engineers	-	-	-
98 San Lucas Avenue	037-275-130	6/11/2003	Sigma Prime	9A-260	BLD2003-01254	01-125
98 San Lucas Avenue	037-275-130	10/12/2001	Sigma Prime	9A-260	BLD2003-01254	01-125
105 San Lucas Avenue	037-258-240	6/12/2017-12/23/2024	Peters and Ross	-	BLD2016-00745, BLD2023-00586	16129.001
111 San Lucas Avenue	037-258-210	8/16/1979	JCP	-	BLD2018-02003	JCP-500
131 San Lucas Avenue	037-258-220	4/27/2023	Bay Area Underpinning	-	BLD2020-01858, BLD2020-01181, BLD2023-01062	-
50 Madrone Avenue	037-276-130	8/30/1977	Purcell, Rhoades and Associates	10A-2	-	674
90 Madrone Avenue	037-277-160	12/4/2020	Sigma Prime	-	BLD2021-00450	13-121
99 Madrone Avenue	037-275-150	12/12/1989	JCP	-	-	JCP-2767
150 Madrone Avenue	037-284-170	7/1/1987	JCP	-	-	JCP-2113
150 Madrone Avenue	037-284-170	7/20/1998	Buckley Engineering Associates	-	-	98363.1
90 Precita Avenue	037-281-120	6/22/1978	PSC Associates	-	-	A78114
66 Precita Avenue	037-281-150	6/20/1978	PSC Associates	10A-3	-	A78113
25 Bernal Avenue	037-278-070	8/17/2022	Michelucci and Associates, Inc.	10A-44	BLD2014-01181	-
30 Bernal Avenue	037-279-060	1986	JCP	-	-	JCP-1720
30 Bernal Avenue	037-279-060	8/25/2016	Romig	-	BLD2019-02762	4669-1
50 Bernal Avenue	037-282-080	3/1/1985	JCP	-	-	JCP-1420
55 Bernal Avenue	037-278-040	7/21/2021	Sigma Prime	-	BLD2023-01830	21-172
70-90 Bernal Avenue	037-282-090, 100	12/11/1983	PSC Associates	-	-	A79146
70 Bernal Avenue	037-282-090	9/15/1983	PSC Associates	10A-6	-	A822127-01
75 Bernal Avenue	037-281-160	9/1/1979	Hayes	10A-5	-	-
121 Bernal Avenue	037-285-100	7/6/1984	P.R. Wood	-	-	1003-84
123 Bernal Avenue	037-285-190	2/14/2014, 2/15/2015	Sigma Prime	10A-45	BLDG2014-02237	13-153
140 Precita Ave	037-277-150	1989	M.J. King	-	-	-
140 Precita Ave	037-277-150	1984	Wood	-	-	1004-84
100 Del Mar	037-277-150	?	JCP	10A-25	-	JCP-1650
234 Nevada Street	037-113-130	7/1/2002	Romig	AP-3225	BLD2002-01165	907-1
96 terrace Avenue	037-211-010	11/16/2022	Atlas, BAGG Engineers	-	PLN2021-00447	91-64277-A (3322)

96 terrace Avenue	037-211-010	4/18/2024	Lea & Braze Engineering	-	PLN2021-00447	2211871 CI
Fitzgerald Marine Preserve	037-196-100	2/22/1990	Cleary	9A-166	-	4332, 633.`
Moss Beach Distillery, 140 Beach Way	037-215-070	8/8/1995	William Cotton and Associates	-	-	E3315

Table 2: Reviewed Trenches and Test Pits

Address	APN #	Date	Consultant	Trench	Map Label	Fault Trace (Y/N)
0 Cypress Avenue	037-221-020, 030	12/19/2017	Sigma Prime	Trench 1	SP/T-1	Y
150 Cypress Avenue	037-221-150	1982	JCP	T-1	JCP/T-1	Y
				TP-1	JCP/TR-1	
221 Cypress	037-200-090	6/1/1989	Harlan Miller Tait	1	HMT/T-1	N
				2	HMT/T-2	N
				3	HMT/T-3	N
				4	HMT/T-4	N
				5	HMT/T-5	N
151 Alton	037-221-080, 090, 100	12/5/1988	JCP	1	JCP/T-1	N
				2	JCP/T-2	Y
				3	JCP/T-3	Y
120 Alton	037-222-220	4/19/2002	Steven F. Connelly	1	SFC/T-1	N
145 Marine Boulevard	037-222-160	1/22/1983	Perry R. Wood	Trench 1	PRW/T-1	Y
				Trench 2	PRW/T-2	Y
148 Marine Boulevard	037-223--03, 04	4/2/1981	JCP	1	JCP/T-1	Y
				2	JCP/T-2	N
191 Marine Boulevard	037-222-200	5/29/2014	Sigma Prime	1	SP/T-1	Y
191 Marine Boulevard	037-222-120	1983	JCP	1	JCP/T-1	Y
160 Marine Boulevard	037-223-190	1981	JCP	TR-1	JCP/T-1	Y
				TR-2	JCP/T-2	Y
112 Orval Avenue	037-224-020	3/8/2018	Geosphere	1	GS/T-1	N
175 Orval Avenue	037-223-110	1/14/2008	Hoexter Consulting	1* (NO LOGS)		
131 Orval Avenue	037-223-230	1987	JCP	TP-1	JCP/TP-1	Y
				TR-1	JCP/T-1	Y
159 Orval Avenue	037-223-140	5/29/1980	Perry R. Wood	1	PRW/T-1	N
				2	PRW/T-2	Y
				3	PRW/T-3	Y
825 Park Avenue	037-256-180	1/1/1977	JCP	Trench 1	JCP/T-1	N
880 Park Avenue	037-259-310	7/30/2020	Sigma Prime	Trench 1	SP/T-1	Y
				Trench 2	SP/T-2	Y
131 La Grande Avenue	037-255-280	6/29/1976	Abel R. Soares and Associates	Trench 1	ARSA/T-1	N
146 La Grande Avenue	037=258-260	7/5/2017	Sigma Prime	Trench 1	SP/T-1	N
847 San Ramon Avenue	037-259-220	7/6/1976	Abel R. Soares and Associates	T-1	ARSA/T-1	N
871 San Ramon Avenue	037-259-270	5/3/1976	Purcell, Rhoades and Associates	T-1	PRA/T-1	Y (2)
				T-2	PRA/T-2	Y (4)
991 San Ramon Avenue	037-287-030	2/16/2001	Purcell, Rhoades and Associates	TR-1	JCP/T-1	Y
				TR-2	JCP/T-2	N
				TP-1	JCP/TP-1	Y (NO LOGS)
111 San Lucas Avenue	037-258-210	8/16/1979	JCP	Test Pit 1	JCP/TP-1	N
				Trench 1	JCP/T-1	N
50 Madrone Avenue	037-276-130	8/30/1977	Purcell, Rhoades and Associates	Trench 1	PRA/T-1	N

150 Madrone Avenue	037-284-170	7/20/1998	JCP	TR-1	JCP/T-1	N
				TR-2	JCP/T-2	Y
				TR-3	JCP/T-3	N
		7/20/1998	Buckley Engineering Associates	Trench 2	BEA/T-2	N
90 Precita Avenue	037-281-120	6/22/1978	PSC Associates	Trench 1A	PSC/T-1A	Y
				Trench 1	PSC/T-1	N
				Trench 4	PSC/T-4	N
66 Precita Avenue	037-281-150	6/20/1978	PSC Associates	Trench 2	PSC/T-2	N
				Trench 3	PSC/T-3	N
30 Bernal Avenue	037-279-060	1986	JCP	Trench 1	JCP/T-1	N
				Trench 2	JCP/T-2	N
				Trench 3	JCP/T-3	N
123 Bernal Avenue	037-285-190	2/14/2014, 2/15/2015	Sigma Prime	Trench 1	SP/T-1	N (NO LOGS)
96 terrace Avenue	037-211-010	11/16/2022	Atlas, BAGG trenches	1	BAGG/T-2	N
Fitzgerald Marine Preserve	037-196-100	2/22/1990	Cleary	Trench 1	CCI/T-1	Y
75 Bernal Avenue	037-281-160	9/1/1979	Hayes	T-1	HAY/T-1	Y (2)
50 Bernal Avenue	037-282-080	3/1/1985	JCP	T-1	JCP/T-1	Y (2)
				TP-2	JCP/TP-1	Y
70 Bernal Avenue	037-282-090	9/15/1983	PSC Associates	T-1	PSC/T-1 (70 Bernal)	N
				T-4	PSC/T-2 (70-90 Bernal)	N
70-90 Bernal Avenue	037-282-090, 100	12/11/1983	PSC Associates	Trench 1	PSC/T-1 (70-90)	N
				Trench 2	PSC/T-2 (70-90)	Y
				Trench 3	PSC/T-3 (70-90)	
				Trench 4	PSC/T-4 (70-90)	N
100 Del Mar Avenue	037-277-150	?	JCP	T-1A,B	JCP/T-1A,B	N (no logs)
140 Precita Avenue	037-277-150	1989	M.J. King	T-1	MJK/T-1	N
				T-2	MJK/T-2	N
		1984	Wood	T-3	PRW/T-3	Y
				T-4	PRW/T-4	N
				T-5	PRW/T-5	Y

Table 3: Reviewed Borings

Address	APN	Report Date	Consultant	Boring	Map Designation	Depth of Boring (feet)
234 Nevada Street	037-113-130	7/1/2002	Romig	EB-1	R/EB-1	36.5
120-150 Beach Way	037-215-100, 037-214-050	7/25/2023	CSA	SD-1	CSA/SD-1	19.2
				SD-2	CSA/SD-2	20.6
112 Orval Avenue	037-224-020	3/8/2018	Geosphere	B-1	GS/B-1	9.5
				B-2	GS/B-2	9.5
125 Los Banos Avenue	037-252-040	12/3/2014	Murray	B-1	MUR/B-1	12
				B-2	MUR/B-2	14.8
				B-3	MUR/B-3	12
				B-4	MUR/B-4	6
127 La Grande Avenue	037-255-260	8/10/2023	Sigma Prime	B-1	SP/B-1	12
				B-2	SP/B-2	12
106 Los Banos Avenue	037-255-290	4/23/2020	Sigma Prime	B-1	SP/B-1	12
				B-2	SP/B-2	12
				B-3	SP/B-3	8
160 Los Banos Avenue	037-256-130	1/21/1985	Don Hillebrandt Associates	B-1	DHA/B-1	15
				B-2	DHA/B-2	10
				B-3	DHA/B-3	15
				B-4	DHA/B-4	15
				B-5	DHA/B-5	10
160 Los Banos Avenue	037-256-130	3/12/2010	Wayne Ting	B-1	WT/B-1	13.5
836 Park Avenue	037-259-010	2/22/2019	Geosphere	B-1	GS/B-1	9.5
				B-2	GS/B-2	9.5
				B-3	GS/B-3	9.5
845 San Ramon Avenue	037-259-200	11/17/2006	Earth investigations Consultants	B-1	EIC/B-1	5
				B-2	EIC/B-2	11
				B-3	EIC/B-3	7
845 San Ramon Avenue	037-259-200	10/11/2019	Atlas	B-1	AT/B-1	9
847 San Ramon Avenue	037-259-220	7/6/1976	Soares and Associates	S-1	ARSA/S-1	5
				S-2	ARSA/S-2	4
880 Park Avenue	037-259-310	7/30/2020	Sigma Prime	B-1	SP/B-1	8
				B-2	SP/B-2	10
98 San Lucas Avenue	037-275-130	6/11/2003	Sigma Prime	B-1	SP/B-1	12
				B-2	SP/B-2	12
99 Madrone Avenue	037-275-150	12/12/1989	JCP	B-1	JCP/B-1	4
				B-2	JCP/B-2	3
				B-3	JCP/B-3	3.5
90 Madrone Avenue	037-277-160	12/4/2020	Sigma Prime	B-1	SP/B-1	9.5
				B-2	SP/B-2	9.5
955 Ocean Boulevard	037-278-010	9/23/2020	Sigma Prime	B-1	SP/B-1	48.5
				B-2	SP/B-2	15
55 Bernal Avenue	037-278-040	7/21/2021	Sigma Prime	B-1	SP/B-1	12
				B-2	SP/B-2	10
989 Ocean Boulevard	037-278-090	12/3/2020	Frank Lee and Associates	1	FLA/B-1	28.5
30 Bernal Avenue	037-279-060	8/25/2016	Romig	EB-1	R/EB-1	20
				EB-2	R/EB-2	18
5 Precita Avenue (898 San Ramon)	037-284-190	1/5/2017	Lee Engineers	TB-1	LEE/TB-1	25
				TB-2	LEE/TB-2	15

123 Bernal Avenue	037-285-190	2/14/2014, 2/15/2015	Sigma Prime	B-1	SP/B-1	9.5
				B-2	SP/B-2	no log
Bernal and Park Avenue	-	9/24/1971	F. Beach Leighton and Associates	B-1	B-1	25.5
Ocean Ave. at Bernal	-	9/25/1971	F. Beach Leighton and Associates	B-2	B-2	39
Madrone at Del Mar Avenue	-	9/24/1971	F. Beach Leighton and Associates	B-3	B-3	15.5
Ocean Ave. between Madrone and San Lucas	-	9/24/1971	F. Beach Leighton and Associates	B-4	B-4	49.25
Ocean Ave. between San Lucas and La Grande	-	9/24/1971	F. Beach Leighton and Associates	B-5	B-5	51
Ocean Ave. between La Grande and Los Banos	-	9/24/1971	F. Beach Leighton and Associates	B-6	B-6	50
La Grande Ave. and San Ramon Ave.	-	9/24/1971	F. Beach Leighton and Associates	B-7	B-7	25.25
Los Banos at Park Ave	-	9/24/1971	F. Beach Leighton and Associates	B-8	B-8	46
100'±SE of Galway Bay Inn	-	9/28/1971	F. Beach Leighton and Associates	B-9	B-9	61
Opposite Torres' House	-	9/24/1971	F. Beach Leighton and Associates	B-10	B-10	24
Orval, South of Park	-	9/27/1971	F. Beach Leighton and Associates	B-11	B-11	30
200' SE of La Grande on Park	-	9/27/1971	F. Beach Leighton and Associates	B-12	B-12	43.5
Redondo Ave. 200' E of Monterey	-	9/28/1971	F. Beach Leighton and Associates	B-13	B-13	41
San Lucas and Ocean Ave.	-	9/23/1971	F. Beach Leighton and Associates	B-14	B-14	30
Lst West of No. 1	-	9/28/1971	F. Beach Leighton and Associates	B-15	B-15	24
bernal Ave. 120' S of Del Mar Ave.	-	9/28/1971	F. Beach Leighton and Associates	B-16	B-16	24
Bernal Ave. 60' N of Del Mar Ave.	-	9/28/1971	F. Beach Leighton and Associates	B-17	B-17	21
Bernal @ Del Mar, 1/2 way betweeen borings 16 and 17	-	10/6/1971	F. Beach Leighton and Associates	B-18	B-18	60
Intersection of San Ramon and Madrone	-	10/6/1971	F. Beach Leighton and Associates	B-19	B-19	40
100' S of B-19	-	10/6/1971	F. Beach Leighton and Associates	B-20	B-20	40
Los Banos 100' NE of Boring 8	-	10/6/1971	F. Beach Leighton and Associates	B-21	B-21	55
Los Banos 100' NE of Ocean	-	10/6/1971	F. Beach Leighton and Associates	B-22	B-22	50
Intersection of Orval and Beaach	-	10/6/1971	F. Beach Leighton and Associates	B-23	B-23	55
5' SE of Intersection of Orval and Park	-	10/7/1971	F. Beach Leighton and Associates	B-24	B-24	55

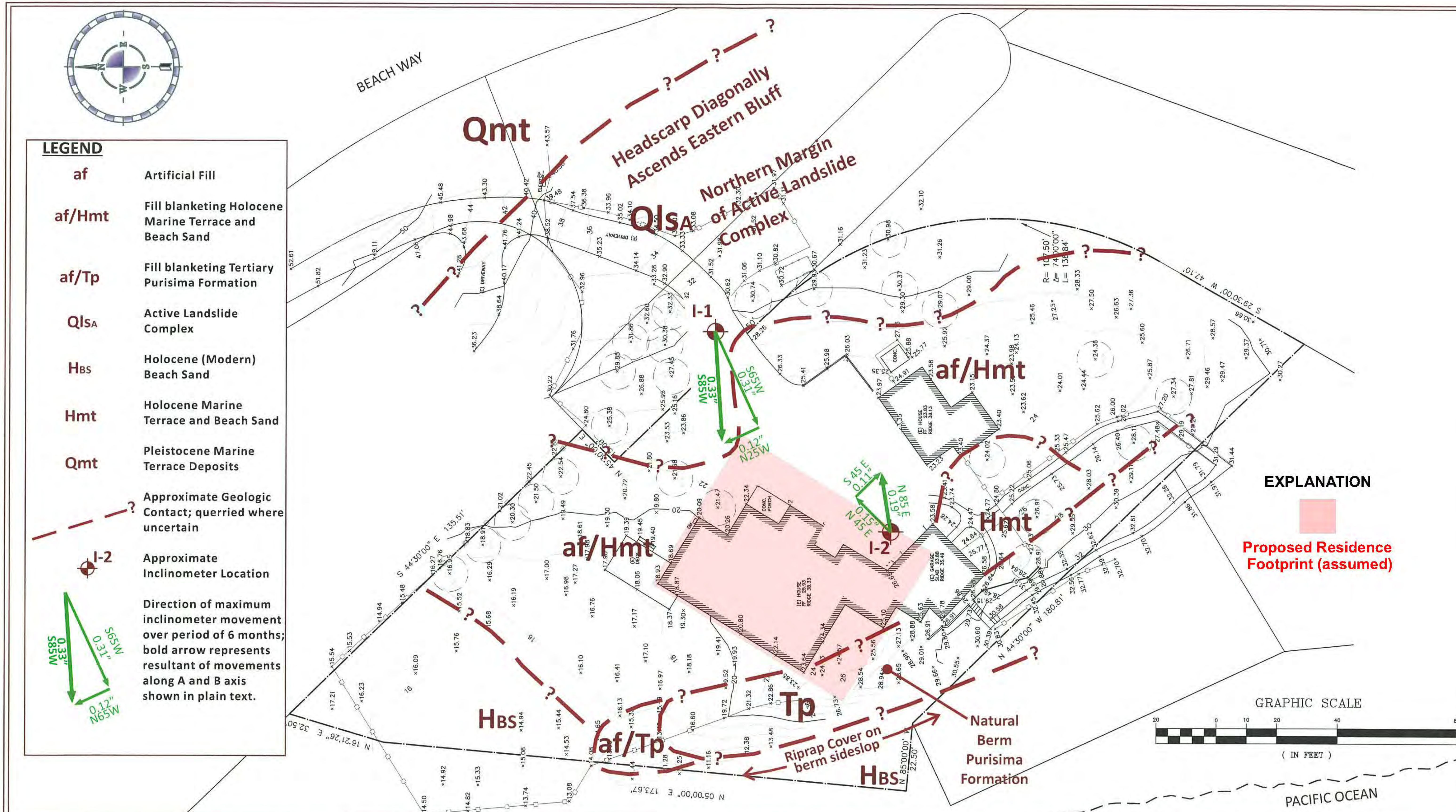
On Marine 100' NE of Beach	-	10/7/1971	F. Beach Leighton and Associates	B-25	B-25	55
On the strand between View and Newport Ave., Doelger Property	-	10/7/1971	F. Beach Leighton and Associates	B-26	B-26	49

Table 4: Reviewed Inclinometers

Address	Consultant	Inclinometer Designation	Map Designation	Period of monitoring	Annual Displacement (inches)	Direction of Movement
96 Terrace Avenue	BAGG Engineers	I-1	BAGG/SI-1	3/6/2020-9/1/2020	0.38	S85W
	BAGG Engineers	I-2	BAGG/SI-2	3/6/2020-9/1/2020	0.66	N85E
105 San Lucas	Peters and Ross	SI-1	PR/SI-1	10/30/2019-12/13/2024	0.23	W
					0.10	N

APPENDIX C

Landslide Monitoring
BAGG Slope Inclinometers, Peters & Ross Monitoring Data,
and CSA's 2025 Moss Beach Distillery Monitoring Report



Base: *Preliminary Boundary and Topographic Survey Map, 96 Terrace Avenue, Moss Beach, CA 94018, APN: 037-211-010,* by SMP Engineers, Project No. 2019036, dated 05/24/2019. Added notes and mapping are approximate and based on field observations, review of available geologic and geotechnial literature, and findings of exploratory borings and trenches, and inclinometer data.

ENGINEERING GEOLOGIC AND GEOTECHNICAL ENGINEERING INVESTIGATION
PROPOSED GUPTA RESIDENCE
96 TERRACE AVENUE
MOSS BEACH, CALIFORNIA
APN: 037-211-010

BAGG ENGINEERS

MAP OF INCLINOMETER MOVEMENT

JOB NUMBER:	SCALE:	DATE:	PLATE
GUPMU-19-02	1" ≈ 30'	SE{TEMBER 2020	A-1

Peters & Ross

Geotechnical & Geoenvironmental

Consultants

December 23, 2024
Project No. 20113.001

Mr. Quinn Todzo, Geotechnical Engineer
County of San Mateo Planning and Building
455 County Center, 2nd Floor
Redwood City, CA 94063

Item 27 - Slope Monitoring
Annual Summary Report for 105 San Lucas Avenue in Moss Beach, California
PLN2016-00327 Letter of Decision dated October 18, 2018
Building Permit BLD2016-00745

Dear Mr. Todzo:

In accordance with Item 27 of the October 18, 2018 Letter of Decision (PLN2016-00327) Peters & Ross has prepared the following annual slope monitoring summary letter.

The site geology at 105 San Lucas Avenue was presented in our report dated July 15, 2016, and in our revision dated October 17, 2016. Peters & Ross included a portion of the geologic map prepared by Baldwin-Wright Inc. dated April 20, 1989 on the attached Figure 1 (Site Plan). Also attached is their Plate 4 which shows Geologic Cross Section A-A'.

The installation of a 100 foot deep inclinometer and two vibrating wire piezometers was documented in our installation letter dated November 9, 2019. The 2.75 inch ABS casing and vibrating wire inclinometers were obtained from Slope Indicator. Based on the Baldwin-Wright mapping of the large landslide along Ocean Boulevard, we set the A_0 (+ direction) azmuth of the slope indicatior casing to 264 degrees (W6^{0}S) during its installation. The location of the installed inclinometer SI-1, as well as the positive A and B directions, are all shown on Figure 1.

Peters & Ross continues to use a Slope Indicator Digitilt AT System to collect slope movement data with a precision of +/- 0.3 inches over 100 feet. The Digitilt AT System is designed to collect data in both the A and B directions in one pass. Each data set consists of two passess. The first pass is made in the A_0 direction and the second pass in the A_{180} direction. The two passess are then summed and these results are used to assess the accuracy of the data set and to assess the health of the Digitilt sensor. As recommended by Slope Indicator, two data sets are obtained during each reading. As noted in our January 4, 2021 letter, a baseline reading was obtained on October 30, 2019.

For the 2024 period, inclinometer readings were obtained on April 11, 2024, August 28, 2024, and December 13, 2024. The slope movement data was processed using the computer program DigiPro2 by Slope Indicator. A profile change plot is presented in Figure 2. Data from the vibrating wire piezometers is collected hourly using a Slope Indicator Mini Logger. The computer software program VW MiniLogger 2 was used to download the data and an excel spread sheet was used to plot the data relative to the SI-1 ground surface elevation of 102 feet as shown on Figure 3. After each set of quarterly readings, a visual inspection form was submitted to the County.

Results

The 2024 inclinometer readings (see Figure 2) showed that the movement of the deeper zone (a depth of 45 to 55 feet below the ground surface) was only half (0.3") of what it was during the 2023 readings (0.6"). Figure 3 shows the ground water measurements. Note that two peaks in the groundwater were measured during 2023 compared to a single peak that occurred in February 2024. Peters & Ross will continue to monitor these zones. Based on the Transportation Research Board *Special Report 247*, the observed velocity of the landslide between December 2023 to December 2024 is considered very slow and this movement virtually ceased during the dry season.

Based on our observations of the rate of movement of this landslide, it is Peters & Ross opinion that movement at the surface is a direct result of movement of the deeper landslide. Therefore, Peters & Ross recommends that consideration be given to eliminating quarterly monitoring in 2025 and replacing it with semi annual monitoring on April 15 and October 15 to coincide with the "rainy season". Additionally, Peters & Ross would monitor the site after 75 year storm events and/or significant earthquakes. Please call if you have any questions.

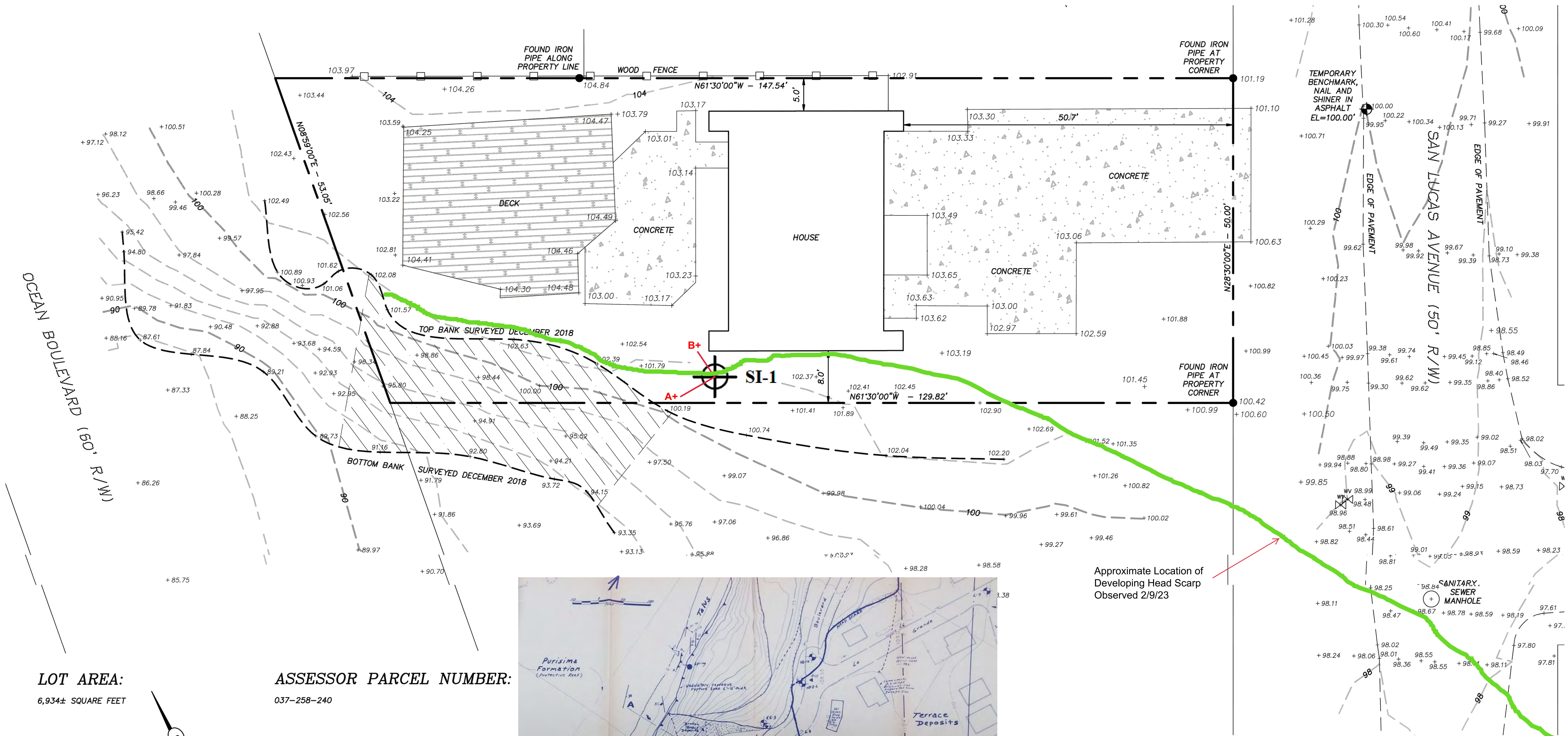
Very truly yours,
PETERS & ROSS

Peter K. Mundy, P.E., G.E.
Geotechnical Engineer 2217

REGISTERED PROFESSIONAL ENGINEER
PETER K. MUNDY
No. 2217
Expires 3/25
GEOTECHNICAL
STATE OF CALIFORNIA

REV	DESCRIPTION	DATE	APPROVED

REVISIONS



LOT AREA:

6,934± SQUARE FEET

ASSESSOR PARCEL NUMBER:

037–258–240

GRAPHIC SCALE

8 0 4 8 16 32

(IN FEET)
1 inch = 8 ft.

NOTES:

1. THE BASE FOR THESE DRAWINGS IS A TOPOGRAPHIC MAP AND SURVEY DONE BY DMG ENGINEERING DATED DECEMBER 2018.
2. REFER TO GRADING AND DRAINAGE PLAN PREPARED BY PRECISION ENGINEERING DATED 6/6/16 WITH LATEST REVISION DATED 6/12/17

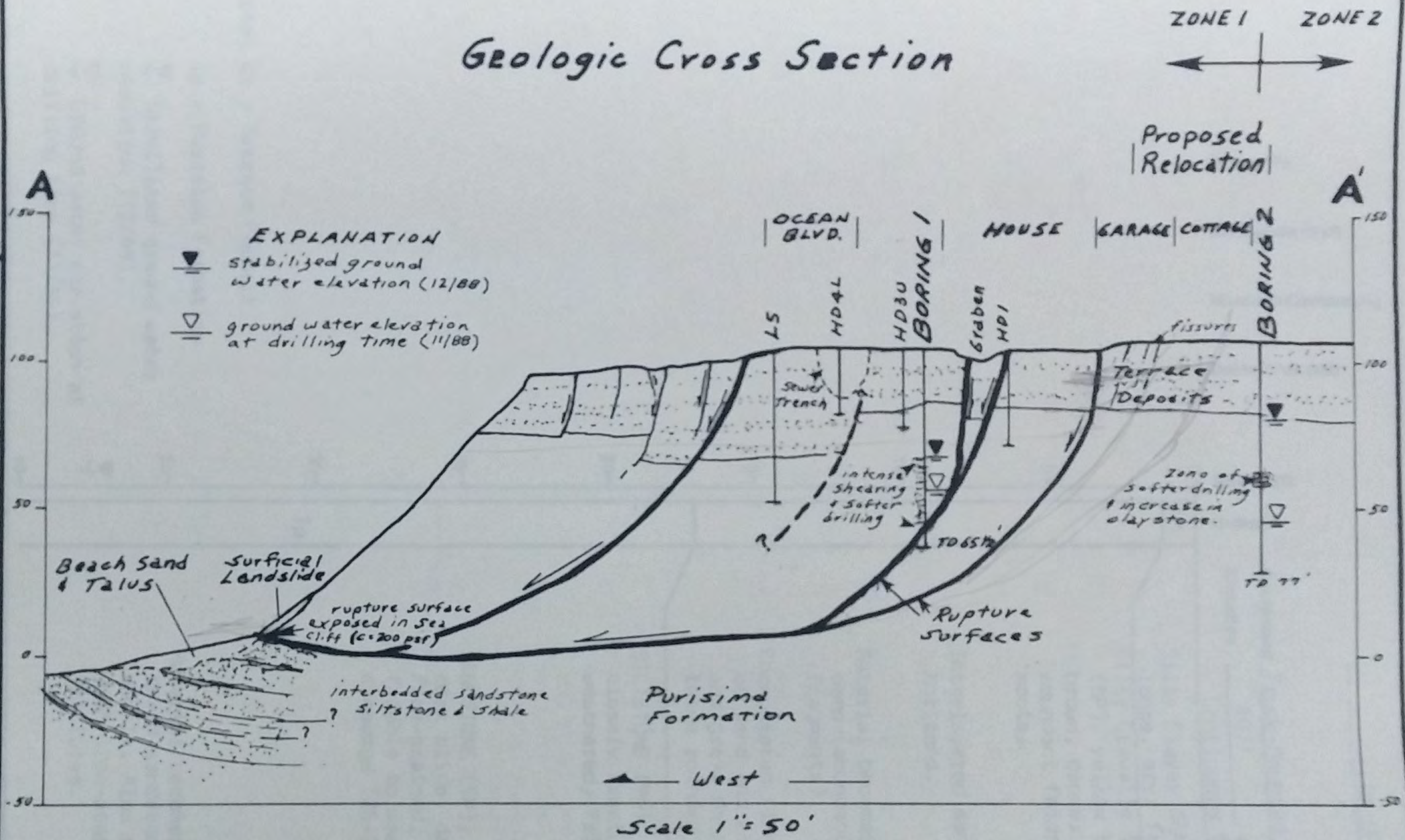
Peters & Ross
Geotechnical and Geoenvironmental Consultants
114 Hopeco Road
Pleasant Hill, CA 94523
tel. (925) 942–3629
fax. (925) 655–1700
PetersRoss@aol.com

Slope Inclinometer Location SI-1

Figure 1 - Site Plan

105 San Lucas Avenue
Moss Beach, California

Designed By: P. Mundy	Project No.: 20113.001	Prepared For: Mrs. E. Lynette Mullens	
Drawn By: C. Flores			
Checked By: P. Mundy	Scale: AS NOTED	Date: 12/13/2024	Sheet: 1 of 1



Baldwin – Wright, Inc.
GEOTECHNICAL CONSULTANTS

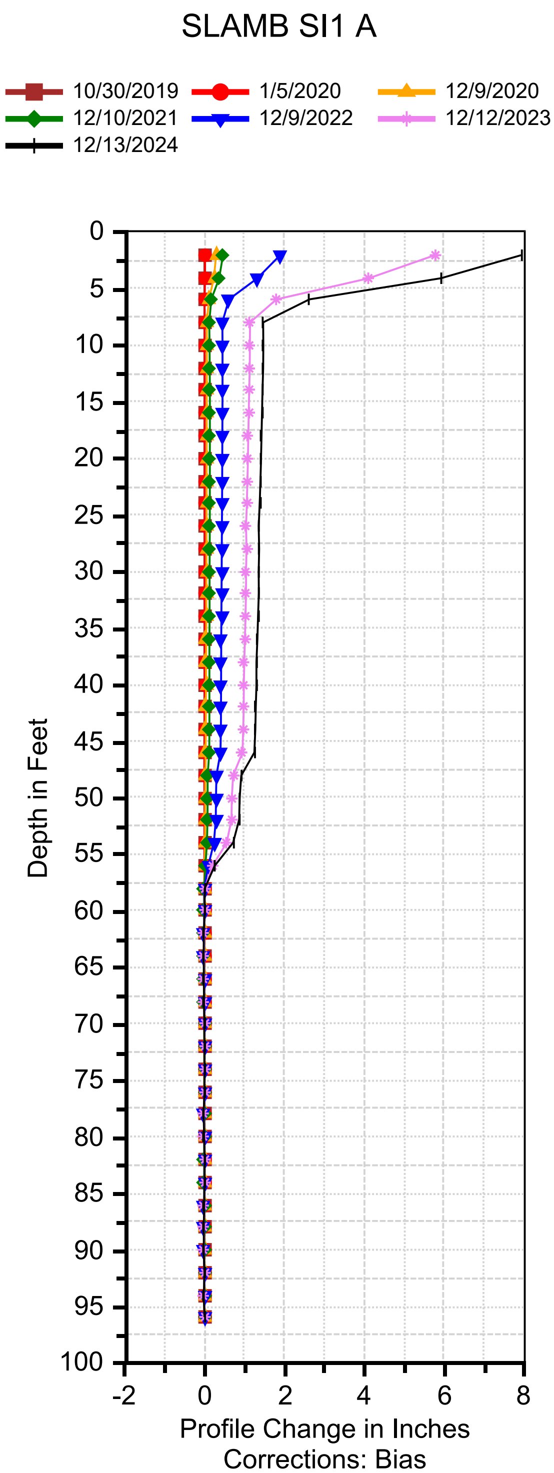
Job No. 1243.01.00
Approved
Date 4/20/89

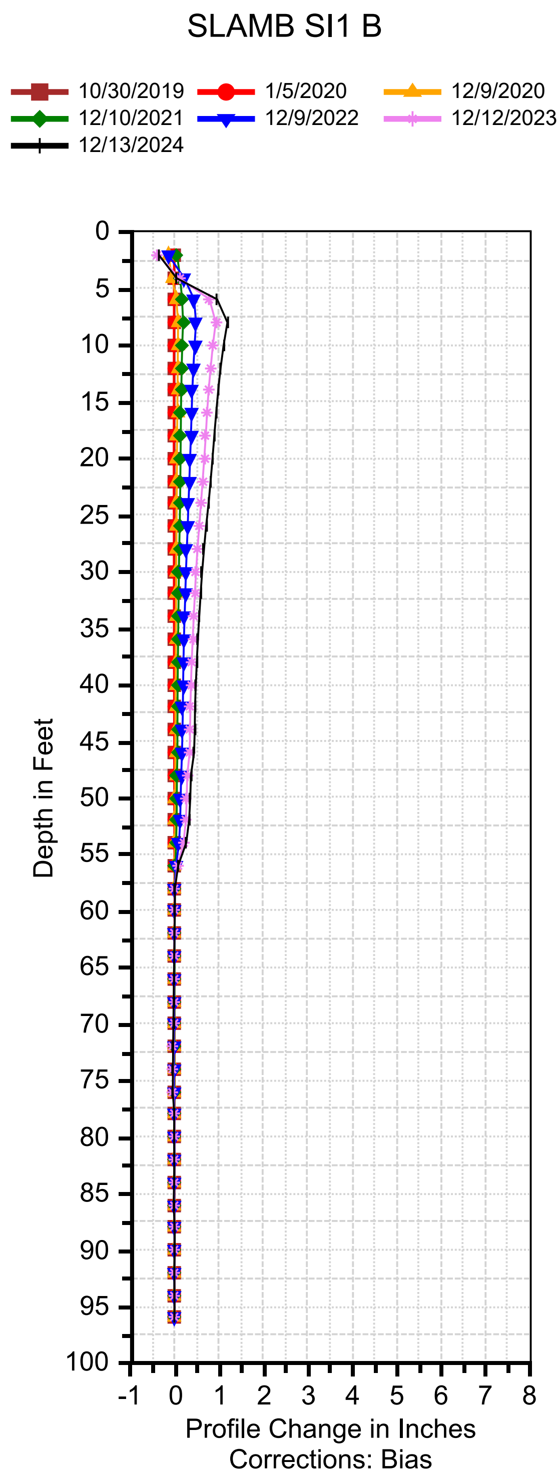
Geologic Cross Section A–A'
837 Ocean Boulevard
Seal Cove, California

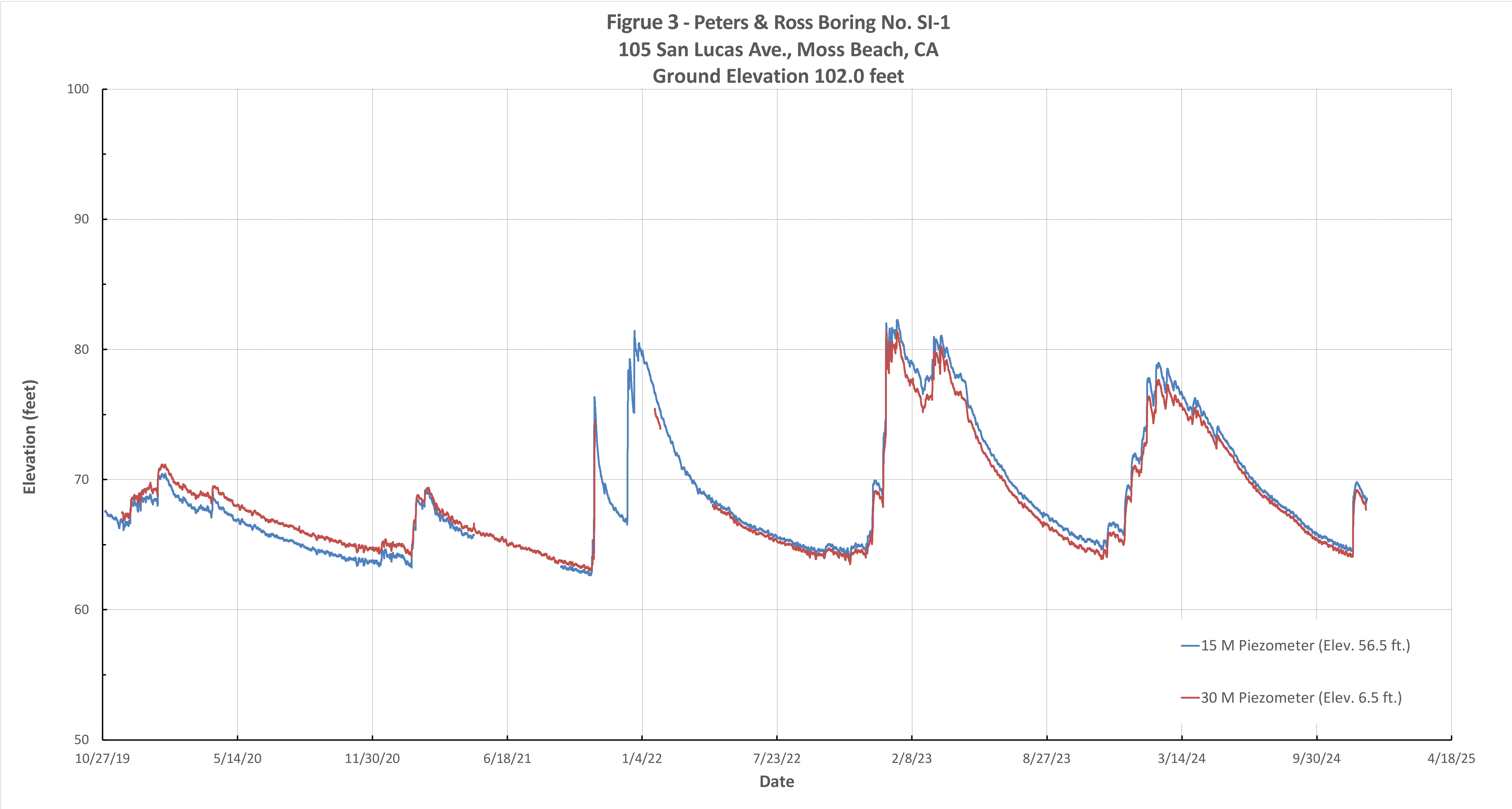
Plate **4**

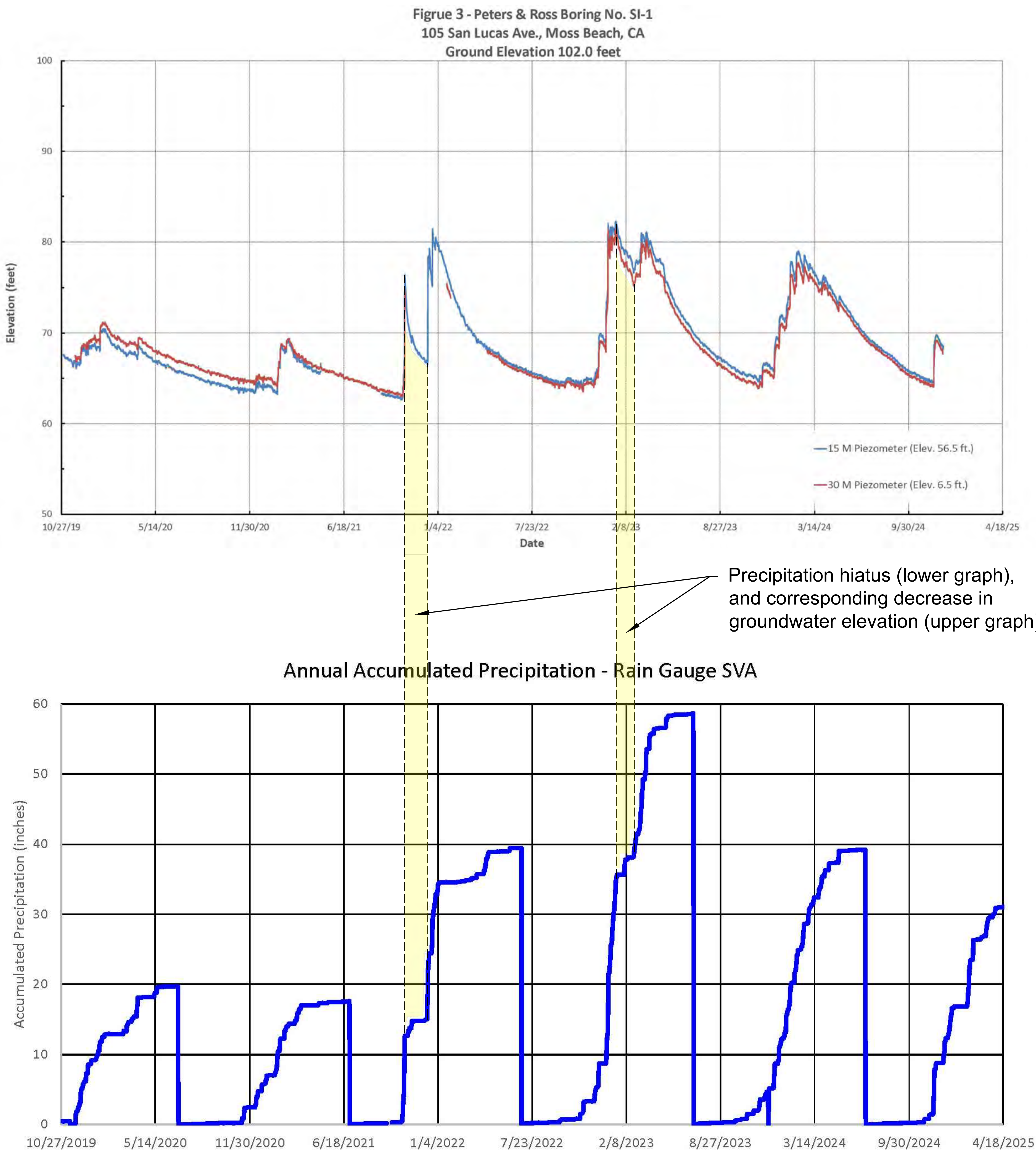
Peters & Ross
Geotechnical and Geoenvironmental Consultants
114 Hopeco Road
Pleasant Hill, CA 94523
tel. (925) 942-3629
fax. (925) 665-1700
PetersRoss@aol.com

Figure 2
105 San Lucas Avenue
Moss Beach, California
Inclinometer SI-1
Project No. 20113.001






Figrue 3 - Peters & Ross Boring No. SI-1
105 San Lucas Ave., Moss Beach, CA
Ground Elevation 102.0 feet
Elevation (feet)
100
90
80
70
60
50
10/27/19
5/14/20
11/30/20
6/18/21
1/4/22
7/23/22
2/8/23
8/27/23
3/14/24
9/30/24
4/18/25
Date
15 M Piezometer (Elev. 56.5 ft.)
30 M Piezometer (Elev. 6.5 ft.)



COTTON, SHIRES AND ASSOCIATES, INC.
CONSULTING ENGINEERS AND GEOLOGISTS

PIEZOMETER AND PRECIPITATION PLOT
Seal Cove Geologic Study
SEAL COVE NEIGHBORHOOD, MOSS BEACH COMMUNITY
SAN MATEO COUNTY, CALIFORNIA

GEO/ENG BY AM	SCALE N/A	PROJECT NO. E6195
APPROVED BY DTS	DATE September 2025	FIGURE NO. C-1

May 21, 2025
E6472
By Email bev@mossbeachdistillery.com

Ms. Beverly Anolin
140 Beach Way
Moss Beach, California 94038

SUBJECT: **Landslide Monitoring Program - 2025 Annual Landslide Monitoring Report**
RE: Moss Beach Distillery
San Mateo County, California

Dear Ms. Anolin:

In accordance with our proposal to you dated April 7, 2025, Cotton, Shires and Associates, Inc. (CSA) is providing you with this report and accompanying illustrations that summarize our 2025 Annual Landslide Monitoring Report for the Moss Beach Distillery Landslide Monitoring Program. The monitoring program is a condition of the Moss Beach Distillery Use Permit required by the County of San Mateo. In this report, we describe the long-term survey monitoring system installed and monitored at the site and summarize the results of our May 6, 2025 monitoring of survey monuments.

MONITORING SYSTEM

The locations of the active Moss Beach Distillery survey monuments are shown on the attached Figure 1, Survey Monument and Displacement Map. The following describes the various active survey monuments, and describes when and where they were installed:

Survey Monuments Assumed to be Stable

SS-1: Survey Station (Base Station), located in the pavement roadway, at the intersection of Park Ave. and Los Banos Lane. Established by San Mateo County in 1972.

SS-2: Survey Station (Base Station), installed in the pavement roadway, at the intersection of Orval Ave. and Beach Way. Established by CSA on 09/24/2020.

BS-1: Back sight monument for SS-1 (basis of bearings for SS-1), located in the pavement roadway along Los Banos Ave, directly north (survey monitoring coordinate system north) of SS-1. Established by San Mateo County in 1972, first monitored by CSA on 5/1/1996.

BS-2: Back sight monument for SS-2 (basis of bearing for SS-2), located in the pavement roadway along beach way, north of SS-2. Established by CSA on 9/24/2020 from SS-2.

CP-2: Second control point monument, located in the pavement roadway at the southeast corner of the intersection of La Grand Ave. and Park Ave. Established by CSA on 5/1/1996.

CP-4: Fourth control point monument, located in the pavement roadway east of the intersection of Los Banos Lane and Park Avenue to serve as a replacement for CP-3. Established by CSA on 12/7/2023.

Array-1: A nail embedded in the pavement located above the landslide headscarp on Park Avenue, west of SS-1. Established by CSA on 5/1/1996.

Survey Monuments Within Active Slide

Bldg-3: The northernmost bolt on the Moss Beach Distillery roof vent. This was established by CSA on 7/20/2011.

Bldg-6: The bolt along the northeast corner of the Moss Beach Distillery building with a metal strap hanging off it. Established by CSA on 9/24/2020 from SS-2.

Array-3: A nail embedded in the roadway in the middle of the intersection of Park Avenue and Beach Way. This monument was established by CSA on 8/15/2018.

Slide-6: A bolt in the "Beach Way" road sign at the northeast corner of Beach Way and Park Avenue. Established by CSA on 8/15/2018. This bolt is located below the Slide-5 bolt in the same road sign but not altered when the sign was replaced.

Slide-7: A bolt in the "End Roadway" sign at the end along Los Banos Lane, south of SS-1. Established 12/7/2023 after replacement of the sign.

Array-4: A nail embedded in the roadway at the front of Moss Beach Distillery. This nail was established by CSA on 12/7/2023 utilizing our survey grade integrated GNSS system (GPS).

Array-5: A nail embedded in the parking lot near the entrance from Ocean Blvd. This nail was established by CSA on 12/7/2023 utilizing our survey grade integrated GNSS system (GPS).

Array-6: A nail embedded at the southwest end of the parking lot extending from Ocean Blvd. This nail was established by CSA on 12/7/2023 utilizing our survey grade integrated GNSS system (GPS).

The survey procedure utilized for monitoring initially involved survey monitoring all of the monuments from Setup Station SS-1. The methodology included setting up a total station theodolite over the Setup Station SS-1, and setting the instrument orientation utilizing County monument BS-1 located north of Figure 1 in the center of Los Banos Lane. This line of sight from SS-1 to BS-1 was assumed to have an azimuth of 0.0 degrees (i.e., was assumed to be oriented due north). The positions of control points located off the landslide were then surveyed to estimate the limit of precision for the survey method employed. These included Control Points CP-1 and CP-2 (located near the intersection of La Grand Avenue and Park Avenue), and Array-1 (located above the landslide headscarp on Park Avenue). We note that CP-1 is no longer visible as it is now obscured by vegetation. In addition, it appears CP-3 was destroyed sometime between 2022 and 2023; however, we installed a new control point in 2023, CP-4, to serve as a replacement for CP-3. After surveying the accessible Control Point (Array-1), points on the landslide, Bldg-3 (a bolt located on a circular roof vent of the Moss Beach Distillery building), Array-3 (a nail embedded in the pavement near the intersection of Beach Way and Park Avenue), Slide-6 (a bolt on the "Beach Way" road sign), and Slide-7 (bolt on "End Roadway" sign) were surveyed to determine the relative movement of the landslide.

After all the survey monuments were recorded, the theodolite was reset over SS-1, and the process was repeated two more times, for a total of three survey measurements of each monument.

Eight monuments that had previously been used to monitor displacement of the landslide can no longer be surveyed either due to sightline obstruction (vegetation) or destruction of the monument. These monuments included: Bldg-1, Bldg-2, Bldg-4, Bldg-5, Slide-3, Slide-4, Slide-5, and Slide-6.

Due to the loss of most of the original survey monuments located on the landslide that are monitored from SS-1, we added a new monument, Array-3 in 2018. In addition, we initialized survey monitoring of several cultural features (from SS-1) located on various parts of the landslide (i.e., bolt heads, and signs) to independently confirm landslide movement rates using the reflectorless capabilities of our total station system (the system is capable of measuring laser signal returns from objects without needing a prism reflector).

In 2020, due to the increasing growth of vegetation obscuring survey monitoring points from Setup Station SS-1, we installed a second Setup Station, SS-2, and Back-Sight monument, BS-2. The second setup station allows for monitoring of additional building points (Bldg-4, Bldg-5, and Bldg-6) located on the northeast wall of the Moss Beach Distillery. In 2023 we installed new monitoring points on the slide (Array-4, Array-5, and Array-6) to be monitored from SS-2. The survey monitoring methodology used at setup

SS-2 is the same as the method used at SS-1 (i.e. set orientation using BS-2 and complete a total of three survey measurements of each target).

In 2023 all existing ground monuments were surveyed for the first time using our survey grade integrated GNSS system (GPS system). As this marks our second year monitoring monuments with GPS-derived positions (real-world coordinates), we are able to compare displacement rates between our two methods (Total Station Theodolite and GPS). As we continue to use our GPS system to record the coordinates of our ground-based monuments, we anticipate uncovering shifts that might have been overlooked if our setup stations were also in motion. Previously, we assumed these stations to be fixed. This advancement will produce more accurate overall displacement measurements in the years that follow. The GPS coordinates of the ground-based monuments, based on NAD83/CA Zone 3, are detailed in Table 4.

SURVEY RESULTS

The averages of the three readings for each of the survey monuments measured from SS-1 (Array-1, Array-3, CP-2, CP-4, Slide-6, and Slide 7) and the survey monuments measured from SS-2 (BS-2, Bldg-3, Bldg-6, Array-4, Array-5, and Array-6) are compared to previous average readings, and the results are tabulated in Table 1 and Table 2, attached. The incremental (2023-2025) horizontal displacement rate and directions of displacement are shown as vectors on Figure 1. As expected, the monuments located on the building (Bldg-3, Bldg-6) continued to move in a westerly direction, steadily downslope toward the ocean (see Figure 1). The results of our recent survey measurements indicate that since our previous monitoring in 2023, the landslide and Moss Beach Distillery Building have displaced 6.0 inches, (4.6 inches horizontally and 3.8 inches vertically) at a rate of 4.1 to 4.2 inches/year. Since monitoring points were established on the building in 1997, the building has displaced approximately 66.5 inches horizontally and 42.7 inches vertically. The other monuments located on the landslide and west of the ground cracks adjacent to Ocean Blvd (Array-4 through Array 6) exhibited displacement rates similar to what was observed at the Moss Beach Distillery Building from 2023-2025. We note that the monuments located on the slide but east of the Ocean Blvd. cracks (Array-3, Slide-6 and Slide-7) also continue to move toward the ocean but at significantly lower rates than the monuments west of the Ocean Blvd. cracks. The monuments located off the landslide (Array-1) indicate that the limit of precision for the total station theodolite monitoring methods and equipment utilized is approximately ±0.1 inch (see Figure 1 and Table 1).

The GPS data for each of the ground-based monuments are compared to previous data, and the results are tabulated in Table 3, attached. The incremental (2023-2025) horizontal displacement rates and directions of these monuments are shown as vectors on

Figure 2. The GPS rates are generally in agreement with the rates and direction from our total station data. We are unable to take data on our reflectorless points (Bldg-3, Bldg-6), and therefore were unable to acquire GPS rates for the points located on the distillery building, however, the GPS rates for Array-4, Array-5, and Array-4 (good analogs of building displacement) are similar to the total station theodolite rates for Bldg-3 and Bldg-6. The results of our recent GPS survey indicate that since our previous monitoring in 2023, the landslide has displaced 5.3 inches (4.7 inches horizontally and 2.5 inches vertically) at a rate of 3.8 inches/year (rates based on Array-4 displacement). The monuments located off the landslide (Array-1, CP-2, CP-4) indicate that the limit of precision for the GPS monitoring methods and equipment utilized is approximately ±1.0 inch (see Figure 2 and Table 3). The average historic horizontal rate and direction of landslide movement based on total station monitoring is depicted on Figure 3.

To compare movements from the current monitoring visit to our previous monitoring visit, the movement measured at survey point Bldg-3 and rainfall have been plotted versus time on the attached Figure 4, Landslide Displacement and Rainfall. The red (horizontal displacement) and blue (vertical displacement) dashed lines on Figure 4 are long term displacement estimates that were projected based on the 1972 through 1986 County monitoring data. These projected rates were roughly 2.7 and 1.6 inches per year for horizontal and vertical movement, respectively. These long-term rates remained relatively consistent through 2006. Following 2006, extended periods of drought separated by isolated years of average to above average rainfall has resulted in an overall decrease in the landslide displacement rate. We note that while the overall landslide displacement rate has decreased since 2006 individual periods have matched or exceeded the historical displacement rate. Notable examples include the monitoring periods from 2009 to 2011, 2016 to 2018, and 2022 to 2025.

CONCLUSIONS

Over the current monitoring period from December 7, 2023, to May 6, 2025, the active landslide underlying the Moss Beach Distillery building displaced approximately 4.6 inches in the horizontal direction (toward the ocean), and 3.8 inches in the vertical direction (downward). The annual movement rates have decreased slightly since our previous monitoring in 2023 but are still higher than the historic (1972-2006) annual rates.

While in general, these rates align with the long-term trends of horizontal and vertical building movement, this specific period did witness higher rates than average. Since the last two monitoring periods had greater displacement rates on average, it is crucial to closely monitor whether these latest rates evolve into a sustained trend. Our recent monitoring indicates that the rate of landslide movement in the immediate Moss Beach Distillery area has not changed significantly in the past year-and-a-half; however, based on the recent acceleration of landslide movement to the south, we consider that there is a moderate risk that accelerated landslide movement could propagate to the north, and impact the restaurant. We have not evaluated the stability of the landslide under seismic conditions.

RECOMMENDATIONS

We recommend that monitoring of the landslide continue on an annual basis; however, if signs of accelerated landslide movement are observed, CSA should be contacted to complete a site reconnaissance. We also recommend the Moss Beach Distillery hire a structural engineer to evaluate the structural integrity of the building.

LIMITATIONS

Our services consist of professional opinions and recommendations made in accordance with generally accepted engineering geology and geotechnical engineering principles and practices. No warranty, expressed or implied, or merchantability of fitness, is made or intended in connection with our work, by the proposal for consulting or other services, or by the furnishing of oral or written reports or findings.

We appreciate the opportunity to have been of service to you. If you have any questions regarding this letter, please call.

Very truly yours,
COTTON, SHIRES AND ASSOCIATES, INC.

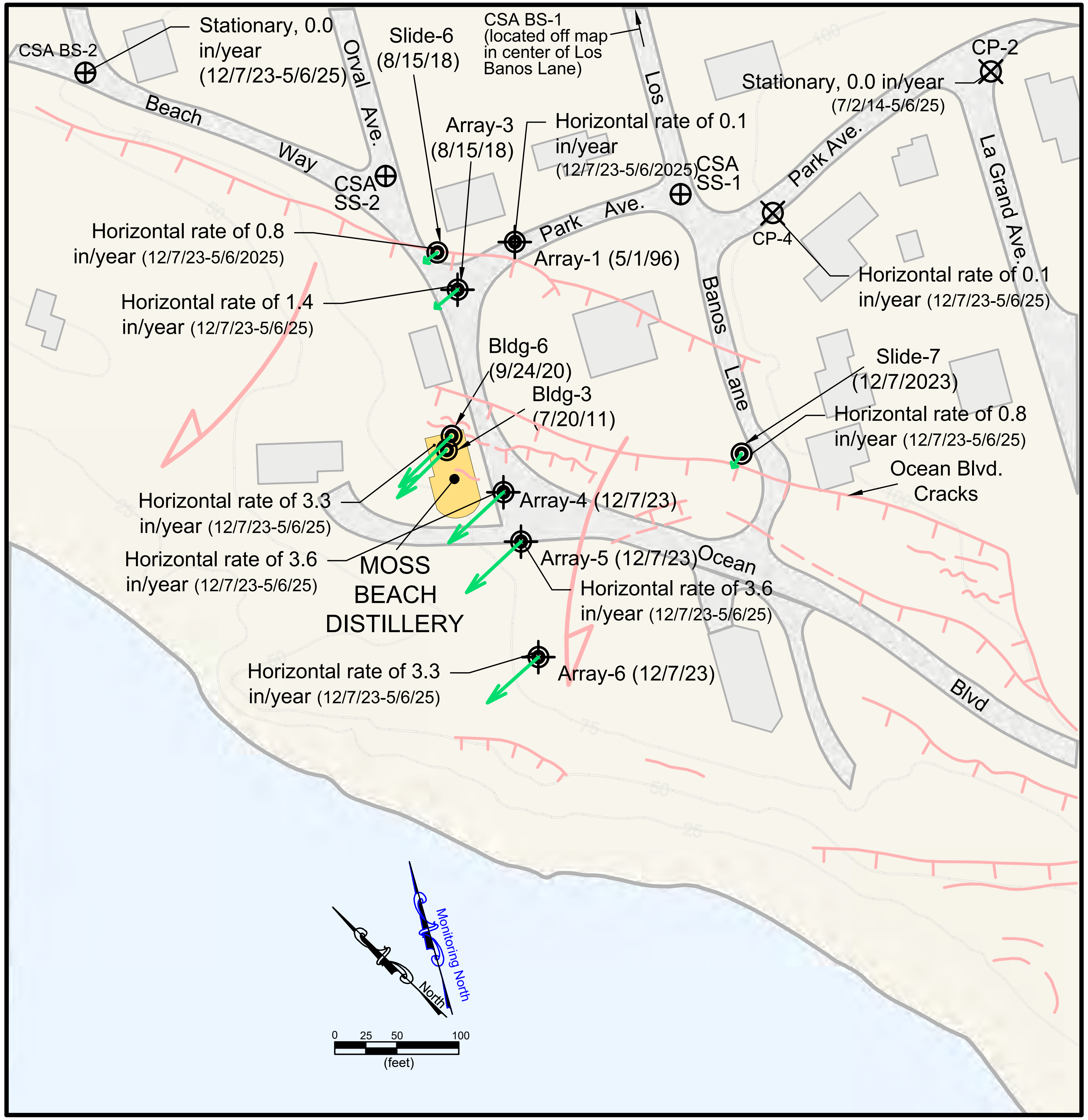
David T. Schrier
Principal Geotechnical Engineer

REGISTERED PROFESSIONAL ENGINEER
DAVID T. SCHRIER
NO. 2334
EXP. 12/31/23
GEOTECHNICAL
STATE OF CALIFORNIA

DTS:CSS:JD:AM

Attachments:
Figures 1 (Total Station Horizontal Rates Map 2023-2025)
Figure 2 (GPS Horizontal Displacement Rates Map 2023-2025)
Figure 3 (Historic Horizontal Rates Map)
Figure 4 (Landslide Displacement and Rainfall)
Table 1 (Station 1 Survey Results)
Table 2 (Station 2 Survey Results)
Table 3 (GPS Survey Results)
Table 4 (Survey Initiation Data)

cc: San Mateo County Planning Department



EXPLANATION

- Active landslide ground cracks (Leighton & Associates, 1971)
- CSA SS-2 — Survey monitoring station. SS-1 was set up in 1996, SS-2 was installed on 9/24/20 (nails in street).
- BS-2 — Survey monitoring back sight. BS-1 was set up in 1996, BS-2 was installed on 9/24/20 (nails in street)
- Bldg-3 — Landslide survey monument. Bldg-3 was initiated on 7/20/11 (vent bolt)
- Array-6 — Landslide nail array monument. Array-1 and Array-2 were installed in 1996. Array-3 was installed on 8/15/2018, Array-4 to Array-6 were installed in 2023 (nails in street)
- CP-4 — Control point monuments. CP-1 and CP-2 were installed in 1996, CP-3 was installed in 1999, CP-4 was installed in 2023 (nails in street)
- Slide-7 — Landslide reflectorless monitoring point. Slide-7 was established 12/7/23 (bolt on road sign)
- 11/10/2022 — Horizontal Rate Vector (shown at vector head, 1 inch = 5 inches of horizontal displacement/year)
- Active landslide movement direction

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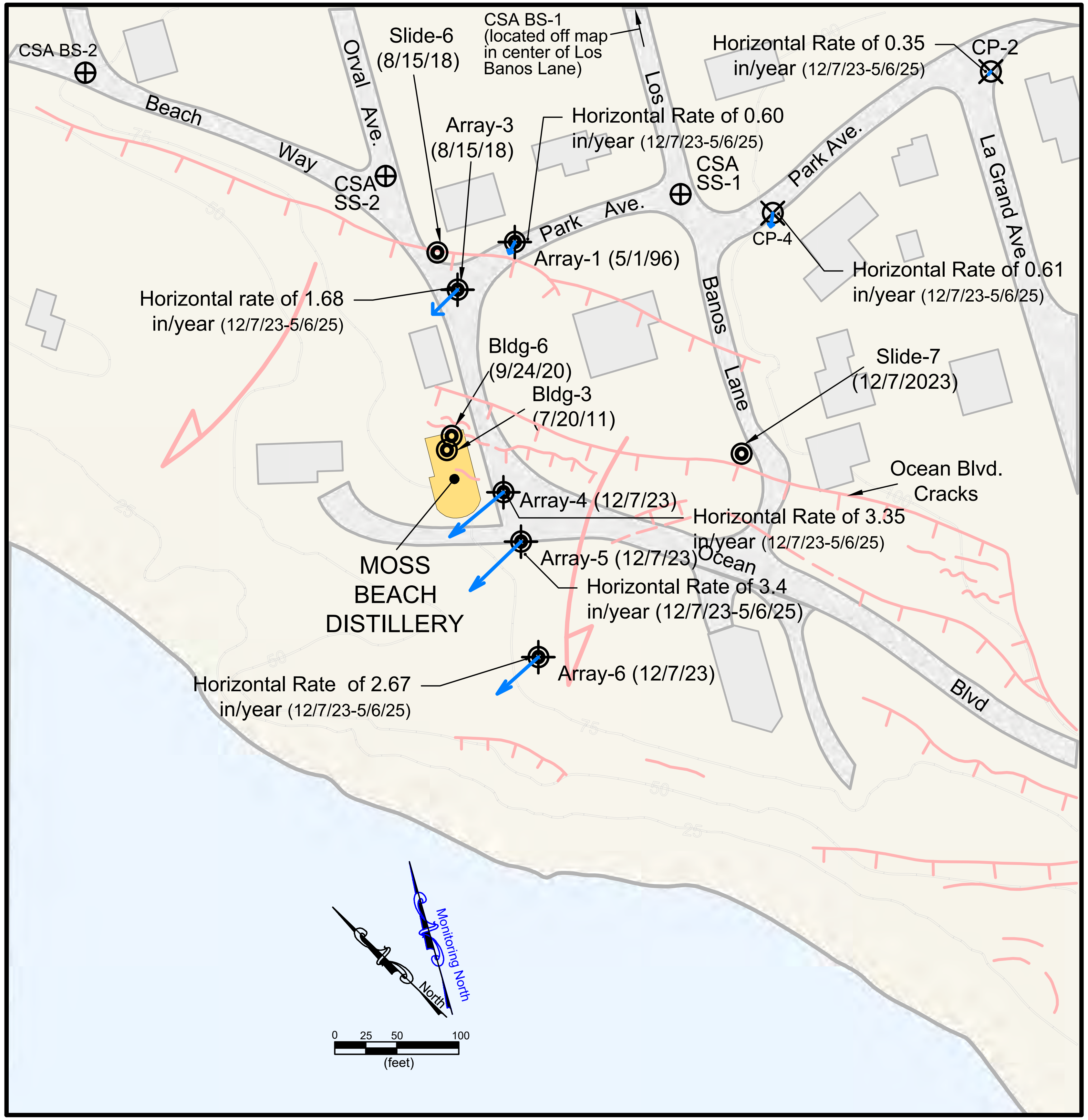
TOTAL STATION HORIZONTAL RATES MAP
2023-2025
LANDSLIDE MONITORING PROGRAM, MOSS BEACH DISTILLERY
SAN MATEO COUNTY, CALIFORNIA

GEO/ENG BY	SCALE	PROJECT NO.
CSS	1"=100'	E6472
APPROVED BY	DATE	FIGURE NO.
DTS	MAY 2025	1



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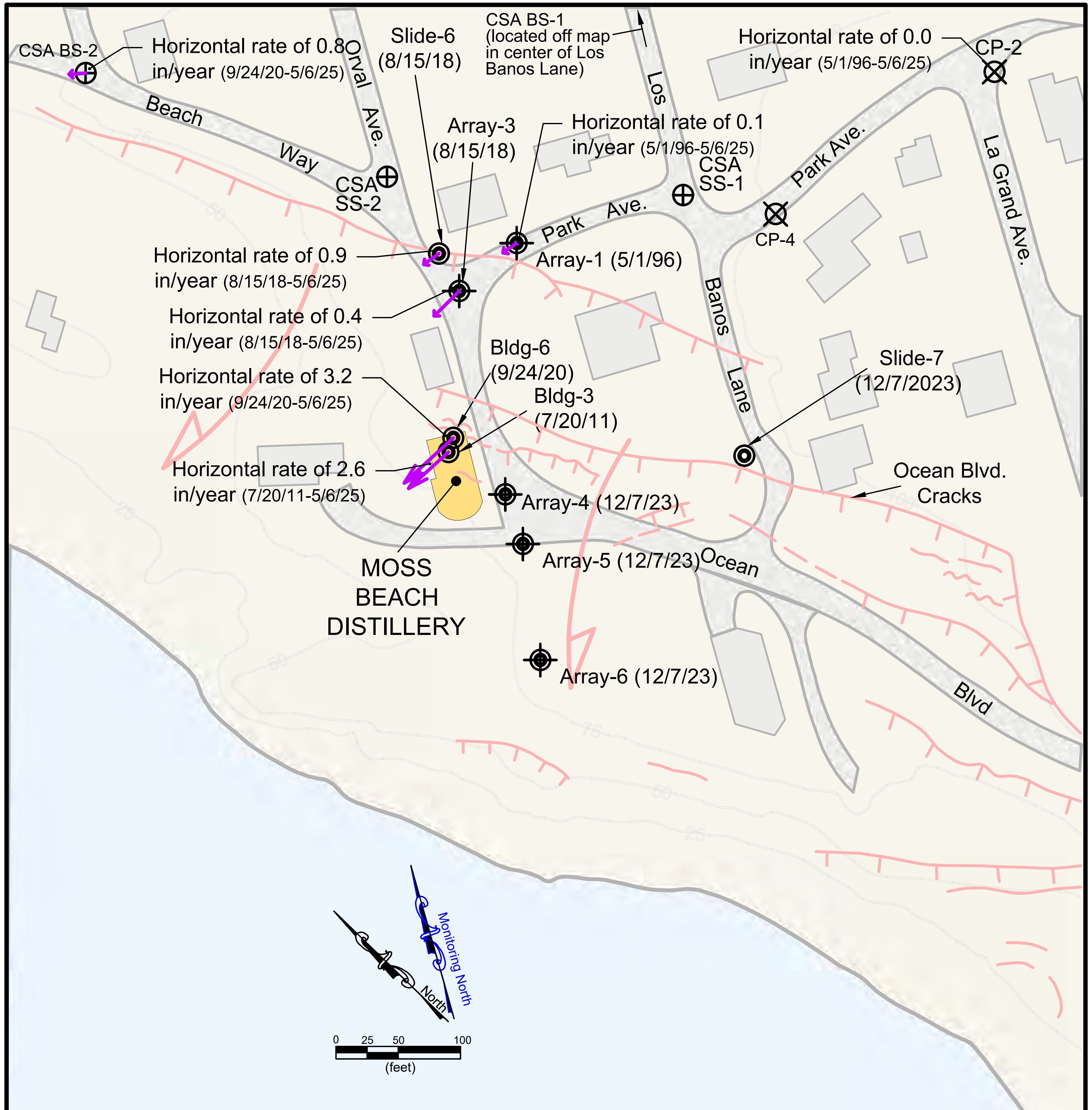
GPS HORIZONTAL RATES MAP 2023-2025
LANDSLIDE MONITORING PROGRAM
MOSS BEACH DISTILLERY
SAN MATEO COUNTY, CALIFORNIA

GEO/ENG BY	SCALE	PROJECT NO.
CSS	1"=100'	E6472
APPROVED BY	DATE	FIGURE NO.
DTS	MAY 2025	2



EXPLANATION

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Active landslide movement direction

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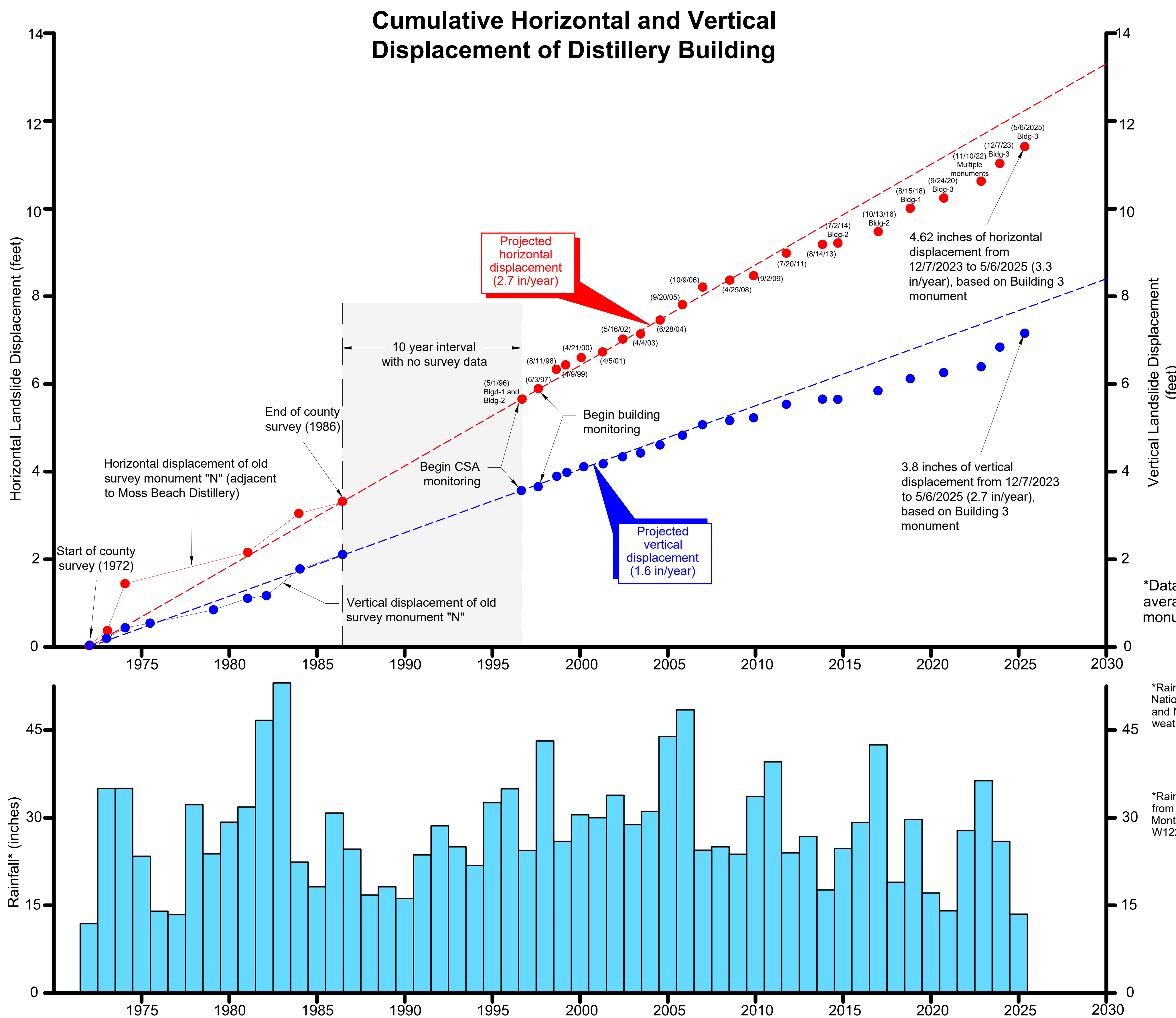
HISTORIC HORIZONTAL RATES MAP
LANDSLIDE MONITORING PROGRAM
MOSS BEACH DISTILLERY
SAN MATEO COUNTY, CALIFORNIA

GEO/ENG BY CSS	SCALE 1"=100'	PROJECT NO. E6472
APPROVED BY DTS	DATE MAY 2025	FIGURE NO. 3



*Data up to 7/2/14 based on average of 2 building monuments

*Rainfall data from 1972 to 2001 collected from the National Climatic Data Center, National Weather Service, and National Oceanic and Atmospheric Administration weather stations:

- Half Moon Bay
- Pacifica 4SSE
- Pacifica 2S
- San Gregorio

*Rainfall data from 2002 to December 2025 collected from the Alta Vista Water Treatment and Storage Facility, Montara, California (Lat. N37°32'54.02", Long. W122°29'53.33", NAD27, Elev. 475 feet)

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LANDSLIDE DISPLACEMENT AND RAINFALL

LANDSLIDE MONITORING PROGRAM
MOSS BEACH DISTILLERY
SAN MATEO COUNTY, CALIFORNIA

GEO/ENG BY	SCALE	PROJECT NO.
CSS	AS SHOWN	E6472
APPROVED BY DTS	DATE MAY 2025	FIGURE NO. 4

TABLE 1

SS-1 Survey Results

Monument	2023-2025 Displacement			2023-2025 Rate			Baseline Reading to 2025 Vectors			Baseline Reading to 2025 Rate		
	Horiz. Disp. (inches)	Vert. Disp. (inches)	Total Disp. (inches)	Horiz. Rate (in./year)	Vert. Rate (in./year)	Total Rate (in./year)	Horiz. Disp. (inches)	Total Disp. (inches)	**Azimuth of Displacement	Horz. Rate (in./Year)	Vert. Rate (in./Year)	Total Rate (in./year)
Off Landslide												
Array-1	0.1	-0.1	0.1	0.1	-0.1	0.1	0.2	1.7	190	0.0	-0.1	0.1
CP-2^	0.1	0.8	0.8	4.6	0.1	0.1	0.3	0.8	147	0.0	0.0	0.0
CP-4	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	110	0.1	0.1	0.1
On Landslide												
Array-3	2.0	-0.6	2.1	1.4	-0.4	1.5	9.0	12.1	234	0.4	-0.3	0.5
Slide 6	1.1	-2.5	2.8	0.8	-1.8	2.0	5.8	9.6	232	0.9	-1.1	1.4
Slide 7	1.1	-2.1	2.3	0.8	-1.5	1.7	1.1	-2.1	213	0.8	-1.5	1.7

^CP-2 was last surveyed in 2014 due to an obstruction from trees, but was visible in 2025. Discplacement shown is a comparison between 2014 and 2025 data.

TABLE 2

SS-2 Survey Results

Monument	2023-2025 Displacement			2023-2025 Rate			Baseline Reading to 2025 Vectors			Baseline Reading to 2025 Rate		
	Horiz. Disp. (inches)	Vert. Disp. (inches)	Total Disp. (inches)	Horiz. Rate (in./year)	Vert. Rate (in./year)	Total Rate (in./year)	Horiz. Disp. (inches)	Total Disp. (inches)	**Azimuth of Displacement	Horz. Rate (in./Year)	Vert. Rate (in./Year)	Total Rate (in./year)
Off Landslide												
BS-2	0.0	0.3	0.3	0.0	0.2	0.2	3.7	3.8	261	0.8	-0.2	0.8
On Landslide												
Bldg-3	4.6	-3.8	6.0	3.3	-2.7	4.2	28.9	33.7	227	2.6	-1.5	3.0
Bldg-6	5.1	-2.8	5.8	3.6	-2.0	4.1	14.8	17.6	227	3.2	-2.1	3.8
Array-4	5.2	-3.3	6.2	3.7	-2.3	4.4	5.2	6.2	225	3.7	-2.3	4.4
Array-5	5.1	-3.2	6.0	3.6	-2.2	4.2	5.1	6.0	223	3.6	-2.2	4.2
Array-6	4.7	-1.8	5.1	3.3	-1.3	3.6	4.7	5.1	227	3.3	-1.3	3.6

TABLE 3

GPS Survey Results

Monument	2023-2025 Displacement			2023-2025 Rates			
	Horiz. Disp. (inches)	Vert. Disp. (inches)	Total Disp. (inches)	Horiz. Rate (in./year)	Vert. Rate (in./year)	Total Rate (in./year)	**Azimuth of Displacement
Off Landslide							
BS-1	0.35	0.94	1.00	0.2	0.7	0.7	226
Array-1	0.85	0.68	1.09	0.6	0.5	0.8	207
CP-2	0.50	0.79	0.93	0.4	0.6	0.7	247
CP-4	0.87	0.40	0.95	0.6	0.3	0.7	199
On Landslide							
Array 3	2.4	-1.1	2.6	1.7	-0.8	1.8	234
Array 4	4.7	-2.5	5.3	3.3	-1.7	3.8	228
Array 5	4.8	-2.3	5.3	3.4	-1.6	3.8	231
Array 6	3.8	-0.8	3.9	2.7	-0.6	2.7	229

**Note: Azimuth is relative to survey monitoring north. To convert to geographic north rotate 30 degrees counterclockwise.

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TABLE 4

Initial Baseline Readings

Station 1 Setup

	Initial Data							
Monument	**X**	**Y**	**Z**	**original date**	**current date**	**days**	**yrs**	**status**
bs-1	1000.000	1711.530	74.520	5/1/1996	5/6/2025	10597	29	monitored
cp-1	1227.240	1005.031	127.410	5/1/1996	5/6/2025	10597	29	obscured
cp-2	1261.750	1013.140	122.920	5/1/1996	5/6/2025	10597	29	monitored
cp-3	1067.043	959.623	106.550	4/9/1999	5/6/2025	9524	26	destroyed
cp-4	1060.890	958.646	106.088	12/7/2023	5/6/2025	516	1	monitored
array-1	870.980	995.420	94.530	5/1/1996	5/6/2025	10597	29	monitored
array-2	836.152	960.520	88.170	5/1/1996	5/6/2025	10597	29	destroyed
slide-3	808.459	996.112	93.156	4/9/1999	5/6/2025	9524	26	monitored
bldg-1	779.154	862.551	94.960	6/3/1997	5/6/2025	10199	28	obscured
bldg-2	747.800	862.379	96.108	6/3/1997	5/6/2025	10199	28	obscured
bldg-3	765.371	859.399	101.745	7/20/2011	5/6/2025	5039	14	monitored
array-3	797.325	961.767	85.103	8/15/2018	5/6/2025	2456	7	monitored
slide-4	995.182	786.952	103.161	8/15/2018	5/6/2025	2456	7	obscured
slide-5	815.142	989.498	96.049	8/15/2018	5/6/2025	2456	7	destroyed
slide-6	815.142	989.498	96.049	8/15/2018	5/6/2025	2456	7	monitored

Station 2 Setup

	Initial Data							
Monument	**X**	**Y**	**Z**	**original date**	**current date**	**days**	**yrs**	**status**
bs-2	575.0708	1212.9008	81.2918	9/24/2020	5/6/2025	1685	5	monitored
bldg-4	744.4343	859.5875	97.4622	9/24/2020	5/6/2025	1685	5	obscured
bldg-5	726.4673	859.0403	93.5652	9/24/2020	5/6/2025	1685	5	obscured
bldg-6	771.5890	859.0196	95.6053	9/24/2020	5/6/2025	1685	5	monitored
array-4	804.9960	816.9357	77.3720	12/7/2023	5/6/2025	516	1	monitored
array-5	805.7615	787.6311	76.6557	12/7/2023	5/6/2025	516	1	monitored
array-6	830.9367	636.4499	79.4612	12/7/2023	5/6/2025	516	1	monitored

GPS Setup

	Initial Data*							
Monument	**X**	**Y**	**Z**	**original date**	**current date**	**days**	**yrs**	**status**
array-1	870.9943	995.3938	94.301	12/7/2023	5/6/2025	516	1	monitored
array-3	796.9117	961.4569	84.486	12/7/2023	5/6/2025	516	1	monitored
array-4	805.0071	816.924	77.372	12/7/2023	5/6/2025	516	1	monitored
array-5	805.7743	787.6178	76.663	12/7/2023	5/6/2025	516	1	monitored
array-6	830.8474	636.4317	79.456	12/7/2023	5/6/2025	516	1	monitored
CP-2	1261.7197	1013.1039	122.818	12/7/2023	5/6/2025	516	1	monitored
CP-4	1060.8808	958.6209	106.016	12/7/2023	5/6/2025	516	1	monitored
SS-1	1000	1000	100	12/7/2023	5/6/2025	516	1	monitored
BS-1	999.9791	1711.489	74.477	12/7/2023	5/6/2025	516	1	monitored
SS-2	780.0383	1063.4578	91.375	5/6/2025	5/6/2025	0	0	new
BS-2	574.958	1213.0559	81.281	5/6/2025	5/6/2025	0	0	new
GPS BASE	775.6327	1071.0999	91.051	12/7/2023	5/6/2025	516	1	monitored

*Initial GPS data was shifted to match project coordinates from total station data. SS-1 is assumed to be (1000,1000,100) with BS-1 as north

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APPENDIX D

Photographs of Roadway Distress

Photo 1: Scarp along Ocean Boulevard, between San Lucas Avenue and La Grande Avenue. Photo is taken facing toward the south. Height of scarp is 3-7 feet, with the downslope side facing inland (away from the sea bluff). Date of Photo: June 25, 2025

Photo 2: Scarp at the intersection of La Grande Avenue and Ocean Boulevard. Photo is taken facing southeast. Height of the scarp is 4-6 feet, with the downslope side facing the sea bluff. The asphalt above the scarp is sloped inland. Date of photo: June 25, 2025

Photo 3: Scarp in Moss Beach Distillery parking lot, east of the restaurant. Photo taken facing southeast. Date of photo: June 25, 2025.

Photo 4: Graben, cracking, and sink hole (left) along San Lucas Avenue between Ocean Boulevard and Del Mar Avenue. Photo taken facing north. Date of photo: June 25, 2025.

Photo 5: Collapsed foundation, originally atop the sea bluff, now along the beach between San Lucas Avenue and La Grande Avenue. Photo taken facing north. Date of photo: July 27, 2025.