Project SM10391.1
24 April 2015

OWEN LAWLOR
Moss Beach Associates LLC
C/O Lawlor Land Use
612 Spring Street
Santa Cruz, CA 95060-2030

Subject: Coastal Bluff Recession Study

Reference: Juliana Avenue and Vallemar Street
Moss Beach, California
San Mateo County APN's 37-08-23, 24, 25, 26, 27, 28 and 29

Dear Mr. Lawlor:

Below is our report from Phase1 of our Coastal Bluff Recession Study that we have recently completed at your request, for the property bordering Juliana Avenue and Vallemar Street in Moss Beach, California. We understand that Moss Beach Associates LLC is proposing to develop 6 or 7 new homes there.

The referenced property is a beautiful piece of property with almost 500 feet of oceanfront and includes 7 lots of record. The purpose of this report is to address future coastal bluff recession at the property and it's impact on the development over the proposed 50 year design life. We have reviewed the project designs you provided to us in 2012 through 2015, including the renderings by Larry Pearson.

Summary:

We have evaluated the historical coastal bluff recession rates at Juliana Avenue and Vallemar Street in Moss Beach, California. We also estimated the slope stability of the coastal bluff, including the influence of an earthquake that could cause recession.

During our study, we obtained and reviewed several sets of historical vertical aerial and satellite photographs from 1986 through 2013. In addition we obtained the original subdivision map survey of the property from May 1908. We visited the site, observed the geologic conditions and made measurements from the seaward edge of the existing home out to the top edge of the coastal bluff. We worked with Gary Ifland of Ifland Surveys, who prepared a detailed topographic map. From our comparison of the surveyed 2014 bluff edge position with that on the 1908 subdivision map, it appears that

the coastal bluff has receded inland up to 48 feet since 1908, which is a long term historical bluff recession rate of about 0.45 feet per year. From comparison of vertical aerial photography taken in 1986 and the 2014 survey, it appears that about 10 to 18 feet of bluff recession occurred in that time period which is a long term historical bluff recession rate of about 0.36 to 0.64 feet per year. Accelerating future sea level rise rates may result in possible increased future recession rates (compared to average historical recession rates).

In our opinion, the best way to predict future bluff recession and evaluate coastal recession risk is to use long term historical average annual erosion rates as a minimum.

That would suggest that a minimum of 22.5 feet of bluff recession will occur at the subject property in the next 50 years. Future bluff recession may occur at faster rates because the rate at which sea level is rising is accelerating. Based on the analysis we have completed to date, we are unable to accurately predict how much future bluff recession rates will increase due to sea level rise. If the noted historical recession rates increased by 25 % because of accelerating sea level rise, that would suggest that 28 feet of recession will occur at the subject property in the next 50 years.

We have depicted an estimated 50 year coastal bluff recession setback line on the topographic map prepared by Ifland Surveys, and have shown the locations of the presently proposed homes on that map. All of the proposed homes are located landward of the estimated 50 year coastal bluff recession setback line.

The California Coastal Commission requires consideration of historical recession rates, future increases in recession rates due to sea level rise and potential bluff instability if and when they evaluate bluff setbacks relative to Coastal Development Permit applications. San Mateo County requires evaluation of a minimum 50 year coastal recession setback line and prohibits development seaward of that line.

Analysis:

We completed the following tasks in our scope of services:

1) Conducted preliminary and administrative work to plan the investigation and study.

2) Reviewed the pertinent documentation in the files you provided to usincluding the renderings by Larry Pearson.

3) Made a preliminary site visit.

4) Obtained an APN map.

5) Obtained the recorded subdivision map.

6) Reviewed site geology.

7) Obtained a recent digital aerial photo.

8) Obtained 1986 historical vertical aerial photos, satellite imagery from Google Earth from 1993 through 2014, and oblique aerial photography from 1972 through 2013 from www.californiacoastline.org

9) Reviewed the 2014 topographic map by Ifland surveys. Worked with Ifland Surveys to survey the bluff edge and bluff edge conditions.

10) Digitally overlaid the Subdivision Map on the 2014 topographic map.

11) Digitally overlaid the historical aerial photograph from 1986 on the 2014 topographic map.

12) Trace the historical bluff edges and the current bluff edge and evaluate historical long term bluff recession rates (average feet or inches per year).

13) Prepared four geologic cross sections.

14) Evaluated bluff recession causation

15) Assessed future sea level rise requirements.

16) Evaluated the influence of future sea level rise on future bluff recession rates.

17) Qualitatively evaluated slope stability as it pertains to future bluff recession rates.

18) Recommended a future bluff recession rate for future development, based on 50 years of future bluff recession, including future sea level rise and bluff instability factors.

19) Drew a recommended 50 year development setback line on the 2014 topographic survey map prepared by Ifland Engineers (Appendix C of this report).

20) Prepared this report.

Historical Bluff Recession

We obtained aerial and satellite photography of the site from 1972 through 2013. We scanned and enlarged each historical photograph and then compared the position of the top edge of the coastal bluff on selected aerial photographs and the centerline of each nearby street as well as reference points on nearby homes in the vicinity of the subject property. We then enlarged each photograph to be the same scale.

We attempted to overlay various historical vertical images; in order to look at the historical changes in the bluff edge. There was poor agreement in the registration of some of the various images. Some of the photos were distorted and unusable for this purpose, probably because the photographs were not truly vertical views of the property because the airplane camera was at a slightly oblique angle at the time of the photograph. The 1986 vertical aerial photograph, which is included in Appendix A, appeared to be most useful for evaluation of historical bluff recession, and were relatively free of distortion and tree shadow coverage. From comparison of the vertical aerial photography taken in 1986 with the conditions found and our 2014 field measurements, it appears that about 10 to 18 feet of bluff recession occurred in that time period which is a long term historical bluff recession rate of about 0.36 to 0.64 feet per year.

We also obtained a 1 inch = 100 foot scale map of "Moss Beach Heights", that is a subdivision map dated 1908 and a partial copy is included in Appendix B. This subdivision map shows the subdivision of this part of the Moss Beach area, and most importantly for our purposes shows the top edge of the coastal bluff where it existed in 1908. By field measurements at the site, we compared the position of the top edge of the coastal bluff in 2014 relative to the position shown on the 1908 surveyed subdivision map. From our comparison of the surveyed bluff edge position in 1908 compared to the current bluff edge position, it appears that the coastal bluff has receded landward up to 48 feet since 1908, which is a long term historical bluff recession rate of about 0.45 feet per year.

The faster rates from 1986 to 2014 (compared to the 1908 to 2014 rate) in part of the property frontage may be a result of the short time period being used for measurement; which include the erosion episode resulting from the extreme coastal storms that occurred in the El Nino year of 1998.

In two areas of the bluff edge, shallow (1-2 feet deep) gullies extend inland from the bluff edge, masking the bluff edge position derived from coastal erosion related to the oceanfront environment. These gullies appear to be from overland storm runoff. Development should incorporate best management drainage control practices to reduce future rilling or gullying.

If historical long term average annual erosion rates from 1908 to 2014 were to continue into the future for 50 years at 0.45 feet per year, the top of the coastal bluff in 2065 would be 22.5 feet inland from where it is now. It is important to note that coastal bluff recession occurs episodically and not at a constant rate. It is more likely that 2 or 3 or 5 or even 10 feet of recession will happen at one time any given point on the coastal bluff, than a few inches per year each and every year will occur.

Sea Level has risen and the rate at which it is rising is accelerating. In general, sea level rise tends to make future coastal bluff recession rates faster than measured historical coastal bluff recession rates.

Future Sea Level Rise

The State of California, through the California Ocean Protection Council agency, has adopted the following sea level rise projections using the year 2000 as a base line:

Sea Level Rise Amounts Adopted by the State of California (2011)		
Year	Average of Models	Range of Models
2030	7 in (0.6 Feet)	5 to 8 inches
2050	14 in (1.2 Feet)	10 to 17 inches
2070	Low 23 inches	17 to 27 inches
	Medium 24 inches (2.0 Feet)	18 to 29 inches
	High 27 inches	20 to 32 inches
2100	Low 40 inches	31 to 50 inches
	Medium 47 inches (4.0 Feet)	37 to 60 inches
	High 55 inches	43 to 69 inches

The data adopted by the State of California in 2011 indicates 40 to 55 inches of sea level rise should be planned for by 2100. This equates to between 3.4 to 5.5 feet of sea level increase by 2100. We have graphed the State of California data. Interpolating that data for 2065 (50 years from now), results in a projection of 21 to 24 inches of sea level rise should be planned for by 2065. This equates to between 1.7 to 2.0 feet of sea level increase by then.

The National Research Council prepared a 2012 report entitled Sea Level Rise for the Coasts of California, Oregon and Washington: Past, Present and Future. This report stated the following sea level rise projections for areas South of Cape Mendocino using the year 2000 as a base line:

Sea Level Rise Amounts from the National Research Council (2012)	
Year	Sea Level Rise
2050	Lower Range 5 inches
	Higher Range 24 inches
2100	Lower Range 16 inches
	Higher Range 66 inches

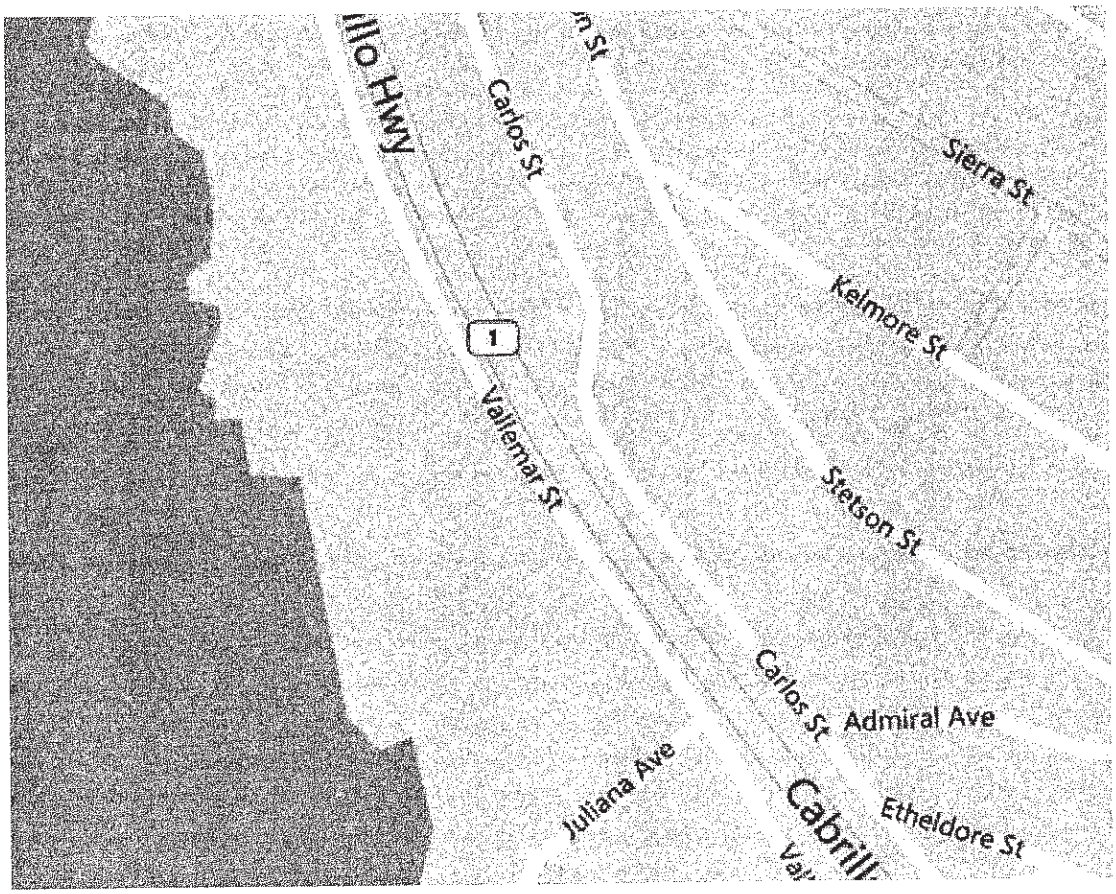
The 2012 NRC projections of sea level rise appear to be more uncertain than the 2011 State of California projections; that is the low range estimates are lower and the high range estimates are higher. Utilizing a linear interpolation, the 2012 NRC projections suggest that 8 to 37 inches of sea level rise should be planned for by 2065.

Sea level rise will cause faster rates of bluff recession than have occurred historically. The degree to which sea level rise will cause coastal bluff rates to increase is not agreed upon by all geologists.

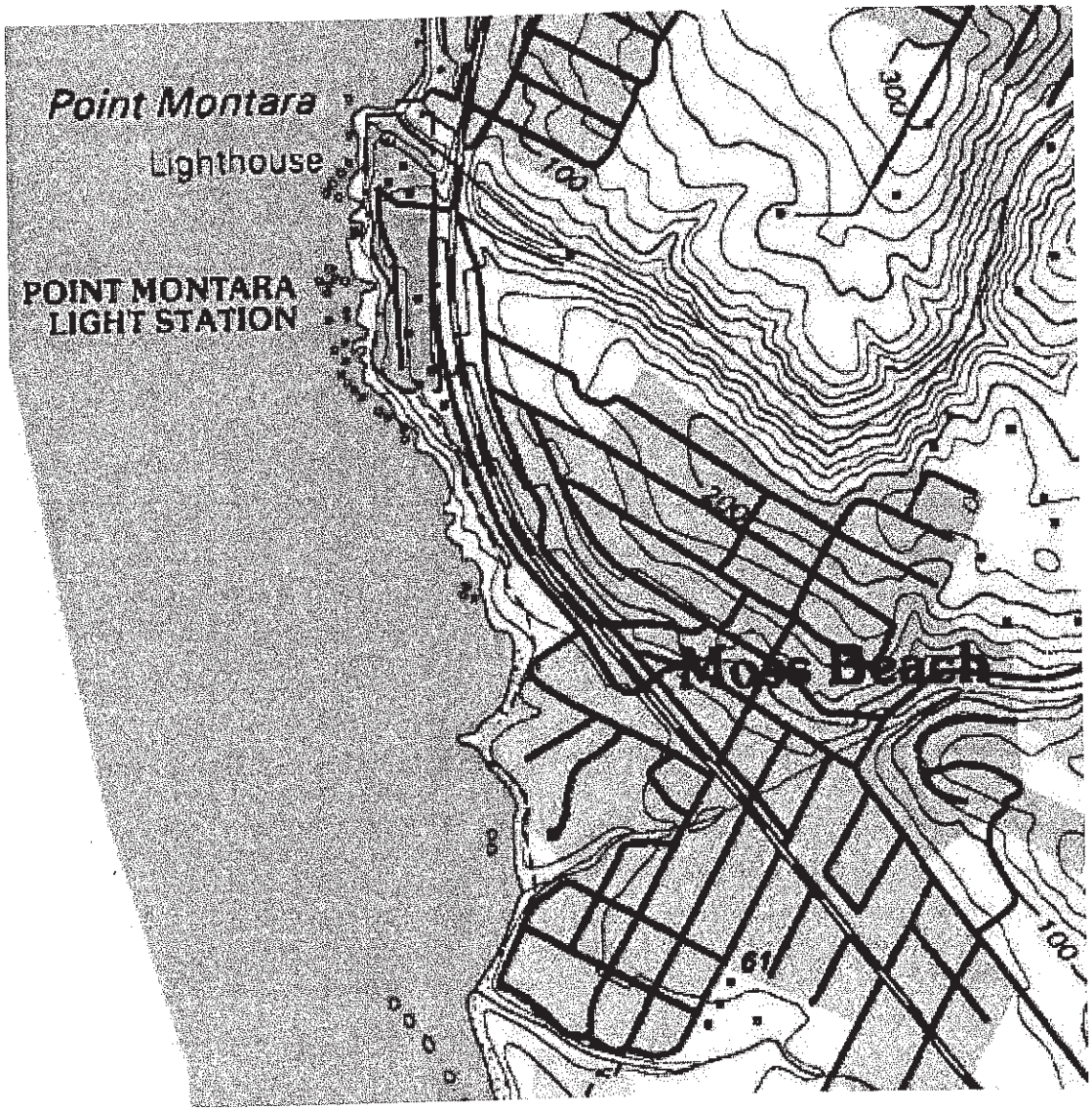
Future bluff recession may occur at faster rates because the rate at which sea level is rising is accelerating. Based on the analysis we have completed to date, we are unable to accurately predict how much future bluff recession rates will increase due to sea level rise. Nobody really knows. If the noted historical recession rates increased by 25 % because of accelerating sea level rise, that would suggest that a minimum of 28 feet of recession will occur at the subject property in the next 50 years.

Bluff Geology and Future Bluff Recession Discussion

The referenced property is situated just upcoast from the City of Half Moon Bay, in Moss Beach.



Vicinity Map of Juliana Avenue and Vallemar Street in Moss Beach

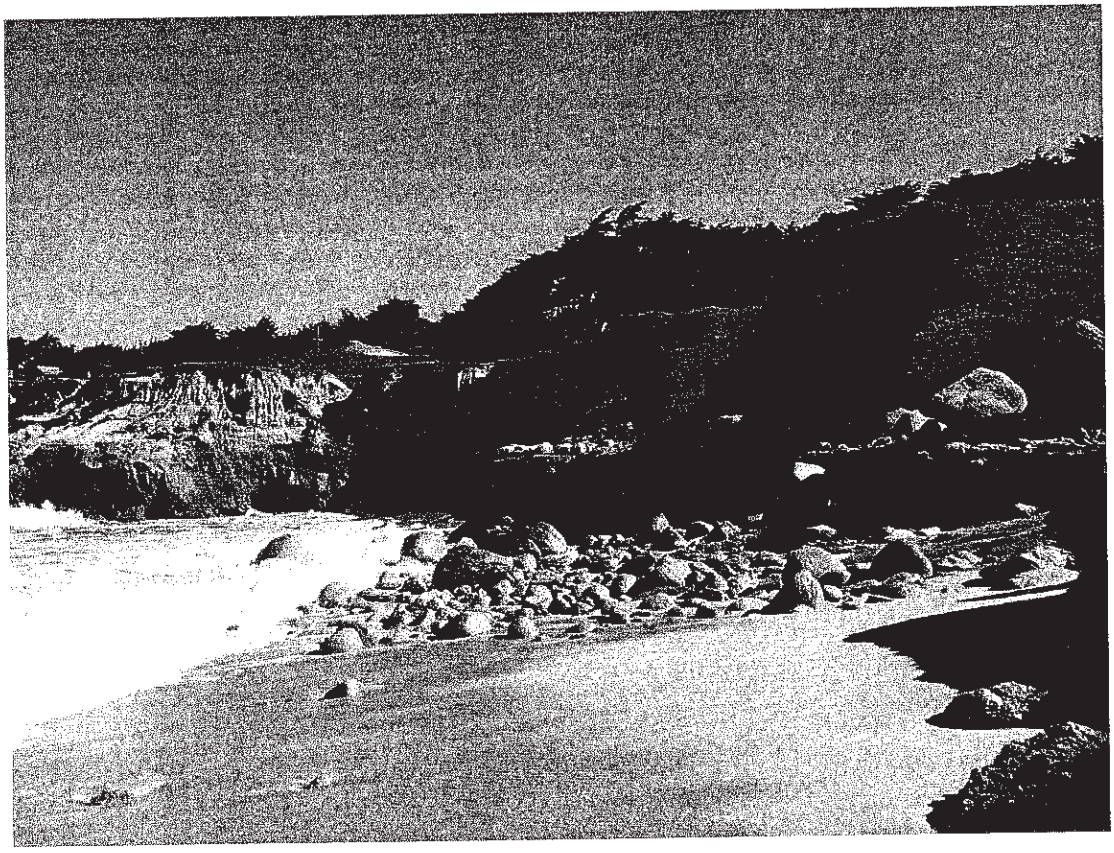


Topographic Map of Juliana Avenue and Vallemar in Moss Beach

April 15, 2013 Vertical Image of Site
Copyright Google Earth

2010 Oblique Aerial Photo of Site
Copyright www.californiacoastline.org

Photographs of the bluff face at the property are shown below:



Bluff Face Looking Upcoast

Bluff Face Looking Downcoast

We observed the bluff from the ocean to the building site. The level bluff top area where the oceanfront homes will be located is 42 to 55 feet above sea level. The upper bluff face is steeply inclined downward and is composed of marine terrace deposits (Qmt), which are approximately 22 to 26 feet thick where exposed in the bluff face. Below the terrace deposits, the lower bluff below approximately elevation 20 is composed of hard erosion resistant bedrock, which is nearly vertical, consisting of granitic rock (Kgr). The bedrock is erosion resistant and therefore the upper bedrock surface forms an exposed rough horizontal bench where the more erodible upper terrace deposits have receded more than the bedrock. Along the downcoast half of the site, seaward of the base of the bluff is a thin deposit of cobbles and beach sand that is often covered by ocean water or wave runup. The beach width varies significantly based on tidal conditions and ocean wave runup.

One form of bluff recession is caused by rainfall or wave splash or spray that erodes the bluff face. Slope instability (landsliding) along the coastal bluff face is another form of the coastal erosion process that results in landward recession of the top edge of the coastal bluff. Coastal bluff landslides are caused either by undermining of the base of the bluff or from saturation of the bluff edge or bluff face. Because the upper part of the bluff is composed primarily of relatively weak sedimentary deposits (terrace deposits), the failure mechanism from landsliding is typically tabular or consists of very shallow, large radius, circular arc type failure. Field observations of the geology and geomorphology of the bluff suggest that terrace deposits in the bluff face are generally stable at a 1:1 to 1.25:1 (H:V) gradient. The top half of the bluffs in the upcoast half of the property are flatter because they are protected by a bedrock outcrop in the bottom half. The top half of the bluffs in the downcoast half of the property are steeper because they are unprotected by a bedrock outcrop in the bottom half and more exposed to erosion. Under worst case seismic conditions, qualitative evaluation suggests the terrace deposits are probably stable at a 1.5:1 (H:V) gradient. A complete evaluation of site stability is beyond the scope of this report; such an evaluation would require additional work, including subsurface exploration, laboratory testing, and quantitative slope stability analysis. More detailed quantitative analysis would be required to assess that.

In our opinion, the best way to predict future bluff recession and evaluate coastal recession risk is to use long term historical average annual erosion rates as a minimum. That would suggest that a minimum of 22.5 feet of recession will occur at the subject property in the next 50 years. In addition to those minimums, we recommend that the influence of rising sea level be considered, which would accelerate those rates. Based on the analysis we have completed to date, we are unable to accurately predict how much future bluff recession rates will increase due to sea level rise, but can make an estimate. In order to allow for the possibility that future accelerating sea level rise will increase the long term average annual, rate of recession, we recommend that the average annual historical recession rate be increased by 25 percent, in order to estimate an average annual future recession rate during the next 100 years. That would suggest that an additional 5.5 feet of recession will occur at the subject property in the next 50 years as a result of accelerating sea level rise.

Based on bluff face slope gradients at the property, and observations of the geology we recommend that projected future bluff edge recession be measured from where the bluff is considered to be stable. Projected future recession should be added inland of this to arrive at an estimated 50 year coastal recession setback line on the property.

We have prepared a drawing that shows an Estimated 50 Year Future Coastal Bluff Recession Setback that depict the setback in plan view on a 2014 topographic base map prepared by Ifland Surveys (Appendix C). The Setback was developed based on where an estimated projected failure of the bluff face to a 1.5 to 1.0 (H to V) stable gradient would come to (varying from 0 to about 25 feet back from the existing bluff edge; depending on existing bluff face gradient), then an additional 22.5 feet of recession to account for 50 years of future coastal erosion at the historical rate that recession has occurred at since 1908, plus an additional 5.5 feet of recession to account for accelerating bluff recession resulting from accelerating sea level rise. The 5.5 feet represents a 25% acceleration in the long term historical recession rate at this site. As a result the total Estimated 50 Year Future Coastal Bluff Recession Setback is predicted to be 28 feet landward of where the bluff would be stable based on the 1.5 to 1 (H to V) gradients discussed above. This results in a total Estimated 50 Year Future Coastal Bluff Recession Setback line 28 to 56 feet inland of the existing top edge of the bluff, as shown on the 2014 topographic base map prepared by Ifland Surveys in Appendix C.

We note that our analysis considers the influence of both slope instability and coastal recession. It accounts for 50 years of recession that causes the bluff face to recede landward uniformly, then an episode of slope instability in the 50th year that flattens the bluff face to a 1. 5 to 1 (H:V) gradient in areas that have been oversteepened by active recent erosion. It is statistically unlikely that an episode of slope instability will occur exactly in the 50th year; this makes the analysis conservative. Because the historical recession rates used herein were calculated using the position of the top edge of the bluff, those calculated rates include the influence of both slope instability and coastal erosion. This adds a second degree of conservatism to the setback line we have presented, since it considers the influence of slope instability and coastal erosion in an additive manner.

The California Coastal Commission requires consideration of historical recession rates, future increases in recession rates due to sea level rise and potential bluff instability if and when they evaluate bluff setbacks relative to Coastal Development Permit applications. San Mateo County requires evaluation of a 50 year coastal recession setback line and regulates development seaward of that line.

We recommend that if new development (as defined in the County Ordinances) is proposed, that it be setback landward of the Estimated 50 Year Future Coastal Bluff Recession Setback, which we believe is the distance necessary to provide a stable building site over a 50-year lifetime of the proposed structure.

We also recommend that mitigating measures (i.e., landscaping and drainage control) be used and maintained to avoid increased erosion at the property.

Limitations

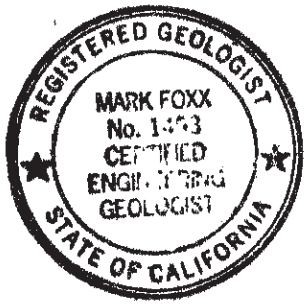
Because of uncertainties that are inherent in the analysis and are beyond the control of HKA, no guarantee or warranty is possible that future recession will occur at the rate predicted. Greater or lesser erosion and recession may occur. In any case, damage to improvements should be expected at some point in the far future. This study should not be used in lieu of appropriate insurance coverage. The owners and occupants of the coastal improvements shall accept the risk of that damage, and HKA recommends that they should purchase appropriate insurance to mitigate the inherent risk.

If you have any questions or concerns, please call us at (831) 722-4175 Ext. 0, and we will be happy to discuss them.

Respectfully submitted,

HARO, KASUNICH AND ASSOCIATES, INC.

Mark Foxx
CEG 1493



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Attachments:

Appendix A: 1986 Vertical Aerial Photograph
Appendix B. 1908 Moss Beach Heights Subdivision Map
Appendix C. 2014 Topographic Map and Cross Sections Showing Estimated 50 Year Future Coastal Bluff Recession Setback

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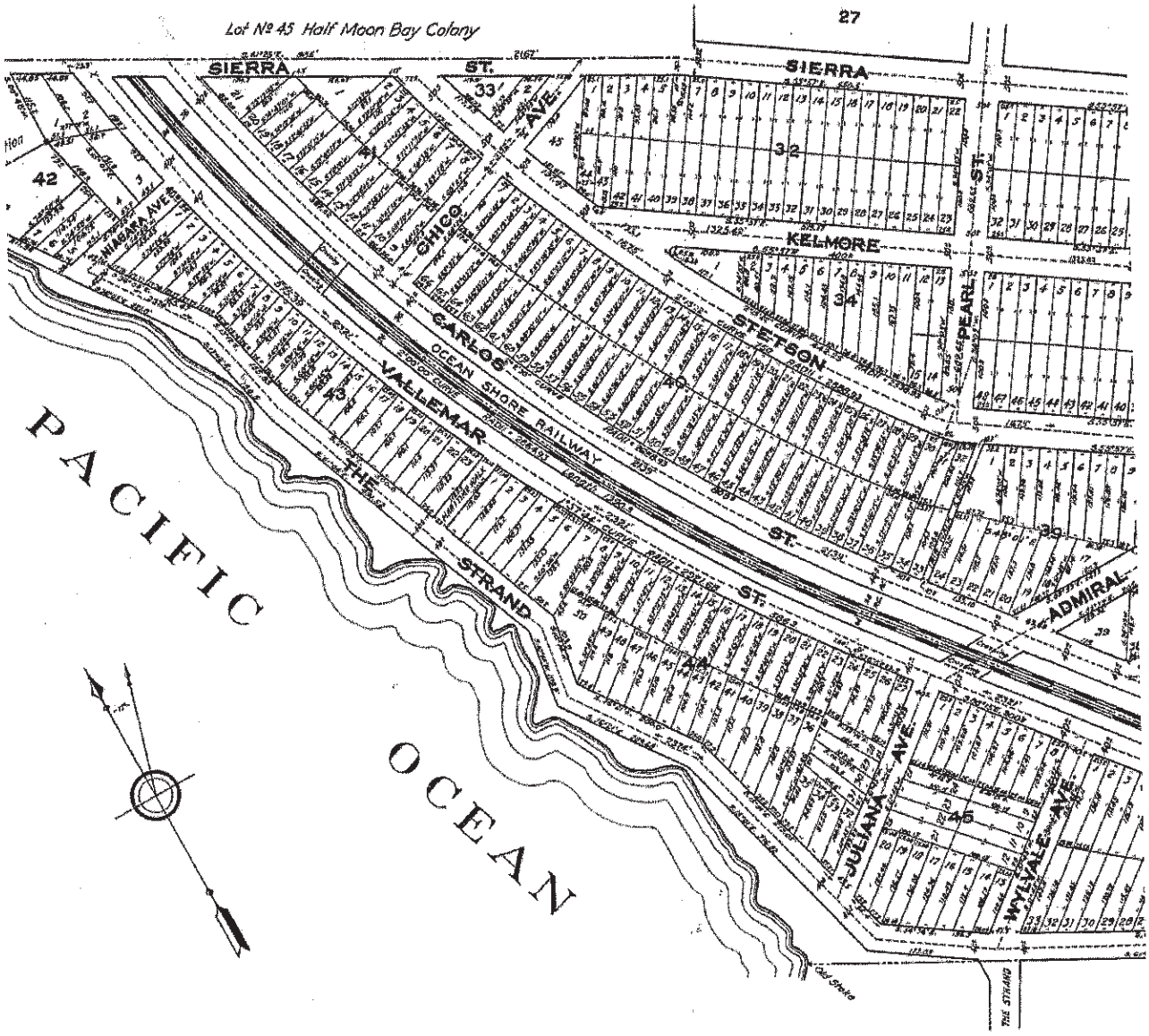
1 to File

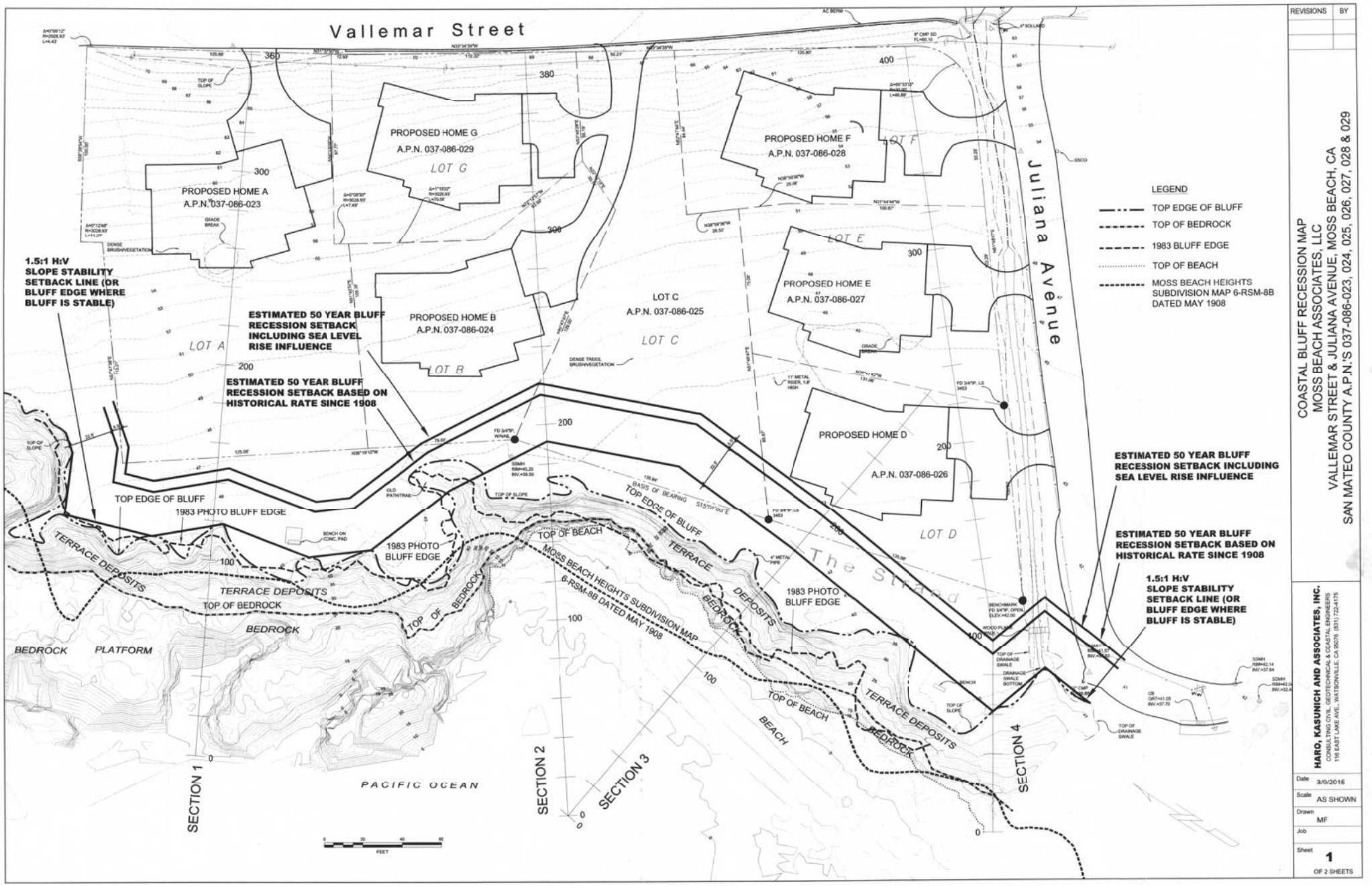
Appendix A
3-26-1986 Vertical Aerial Photograph

Appendix B
1908 Moss Beach Heights Subdivision Map



Appendix C

2014 Topographic Base Map and Cross Sections by Ifland Surveys Showing Estimated 50 Year Future Coastal Bluff Recession Setback



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COASTAL BLUFF RECESSION MAP
MOSS BEACH ASSOCIATES, LLC
VALLEMAR STREET & JULIANA AVENUE, MOSS BEACH, CA
SAN MATEO COUNTY A.P.N.'S 037-086-023, 024, 025, 026, 027, 028 & 029

HARO, KASUNICH AND ASSOCIATES, INC.
CONSULTING CIVIL, GEOTECHNICAL & COASTAL ENGINEERS
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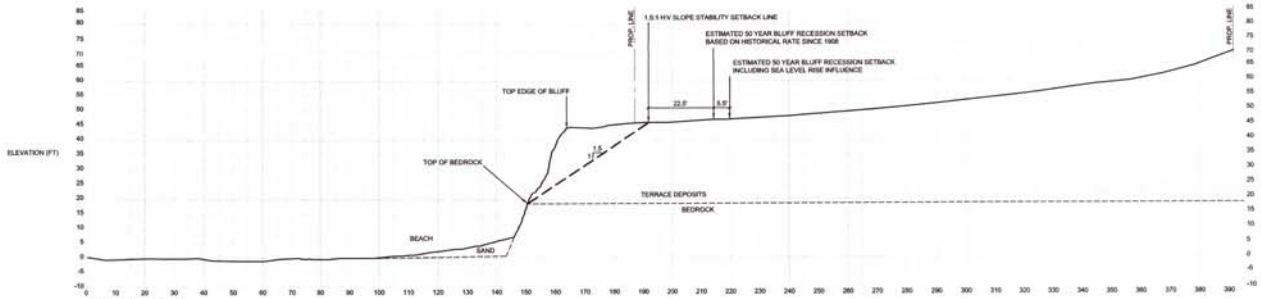

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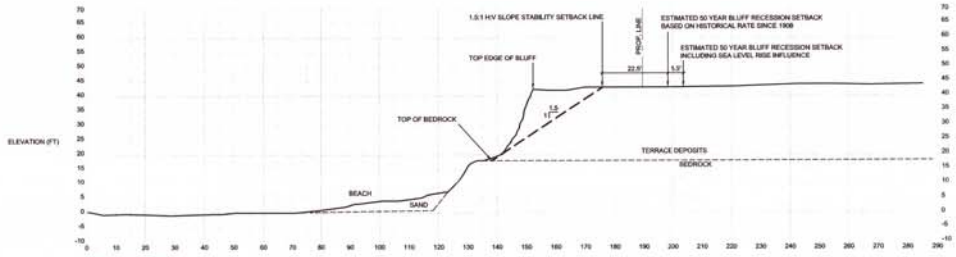

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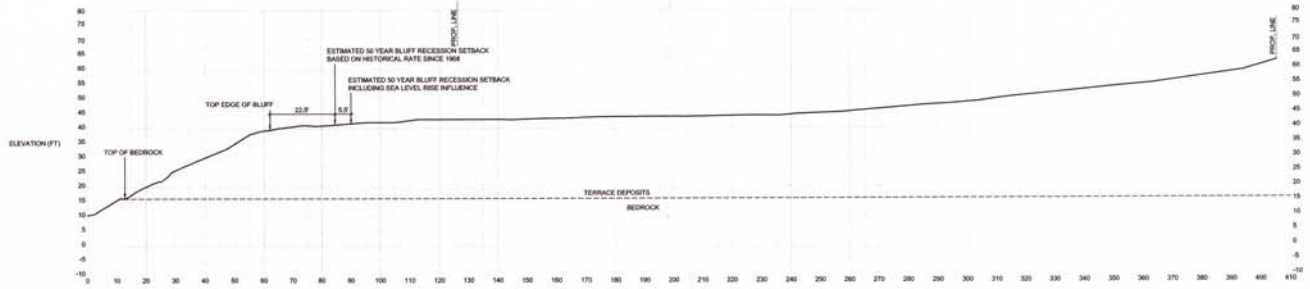

SECTION 4

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COASTAL BLUFF RECESSION CROSS SECTIONS
MOSS BEACH ASSOCIATES, LLC
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