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October 15, 1971

TO: County of San Mateo
Attention: Mr. S. H. Cantwell, Jr., County Engineer

FROM: F. Beach Leighton & Associates

SUBJECT: Final Engineering Geologic Report of the Seal Cove - Moss Beach Area, County of San Mateo

In accordance with the agreement with the County of San Mateo for engineering geology services (dated September 7, 1971), and in fulfillment of Resolution 29451 that authorized these services on the same date, the final geologic report is hereby submitted. We are transmitting to the County Engineer's office on this date, one reproducible original and 10 copies of the text and exhibits.

The final report succeeds the interim geologic report that was delivered October 1, 1971. The three principal divisions of the final report consists of (1) the non-technical text, (2) the technical text and supporting data in the Appendix, and (3) exhibits that support both the non-technical and technical sections.

We will be willing at any time to explain any elements connected with the investigation and to present our findings by means of kodachrome slides. Should any questions arise, please do not hesitate to phone.

Respectfully submitted,

F. Beach Leighton

F. Beach Leighton
Consulting Engineering Geologist (EG 599)

/jm

GEOLOGIC REPORT
OF
SEAL COVE - MOSS BEACH AREA

October 15, 1971

by (F. Beach)
F. Beach Leighton & Associates

Prepared for
THE COUNTY OF SAN MATEO
in Accordance with Resolution 29451

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CONCLUSIONS AND RECOMMENDATIONS

General Statement

This study demarcates four zones of varying stability that will require different approaches in planning, investigation, development and regulations. Much more geologic-soils information will be necessary to evaluate individual sites, including the feasibility of correcting problems, but these evaluations should be based on the areal geology presented in this report, as well as conditions within an individual property or group of properties.

Recommendations

1. Lots in Zone 4 can be released from the Moratorium from a geologic standpoint.

2. Future development in Zones 1, 2 and 3 should be allowed only after completion of detailed geologic-soils investigations as indicated by zone on the Preliminary Geologic Stability Map. Investigations required are as follows:

   Zone 1 - MOST SEVERE INSTABILITY - Feasibility of correction (and investigation) extremely doubtful.

   Zone 2 - UNSTABLE - Detailed subsurface investigations will be necessary to analyze instability.

   Zone 3 - DEGREE OF INSTABILITY QUESTIONABLE - Detailed subsurface investigations will be necessary to determine degree of stability.

   Zone 4 - MOST STABLE - Conventional investigations will probably be adequate.

3. Geologic-soils reports for Zones 1, 2 and 3 should include recommendations regarding:

   a. Geometry of landslides and potential landslides.

   b. Slope stability analysis for potentially adverse slopes, incorporating anticipated seismic factors.

   c. Rate of cliff retreat in relationship to the useful life of man-made structures.

   d. Seismic hazards, including potential ground rupture and anticipated shaking from nearby active and potentially active faults, including the configuration and degree of activity of each fault branch.

   e. Foundation conditions, including the influence of ground water.

   f. Drainage, both surface and subsurface.

4. Special attention during future investigations should be given to certain aspects of Zones 1, 2 and 3.

Zone 1 - Sliding constitutes a serious hazard to life and property in this zone.

Zone 2 - Because the cliff area shown as UNSTABLE is underlain by the same geologic materials and geologic structure as the large landslide area located south of the property, it may also be subject to the spread of massive landsliding and should be so evaluated by detailed investigations.

Zone 3 - Major questions remain to be investigated and evaluated in this zone, as it will be necessary to ascertain whether the problems in this zone will have to be treated as Zone 2 problems or Zone 4 problems.

NONTECHNICAL SECTION

The Problem

Geologic processes of faulting, landsliding and other mass movements constitute an imminent hazard to life and property in parts of the subject area. Ruptures of the earth and accompanying movements of man-made structures testify to the current activity of these processes. This geologic investigation has been undertaken to determine the extent of the hazard to life and property, and the geologic conditions controlling the hazard. The basic objective has been to establish geologic guidelines for the safety of the lives and property of the residents and for the continued safe development of the area.

Investigative Work Sequence

1. Stereoscopic study of vertical aerial photographs that span the time interval 1930-1970 and the preparation of photogeologic maps.

2. Geologic field mapping utilizing newly available large-scale topographic maps and photomaps.

3. Subsurface exploration by trenching and drilling, including descent in many of the holes to observe and measure key features in the earth materials.

4. Analysis of geologic data and preparation of maps, cross-sections, tables and diagrams.

5. Measuring the extent and rate of sea cliff retreat from aerial photos taken between 1941 and 1970.

6. Conducting a house-to-house survey of property damage and the relationship of this damage to geologic conditions.

7. Compilation of the report and completion of the geologic exhibits.

Key Illustrations in the Nontechnical Section

Photographs of Trench Walls

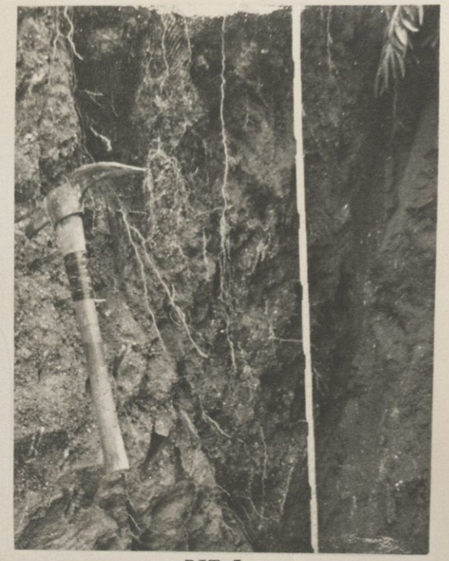
Sequence of Sea Cliff Retreat

Schematic Cross-Section

Preliminary Geologic Stability Map

PIT 5

9-24-71 B.D. Photo 1
Looking south at active scarp (between mattock & ruler, behind ice plant)

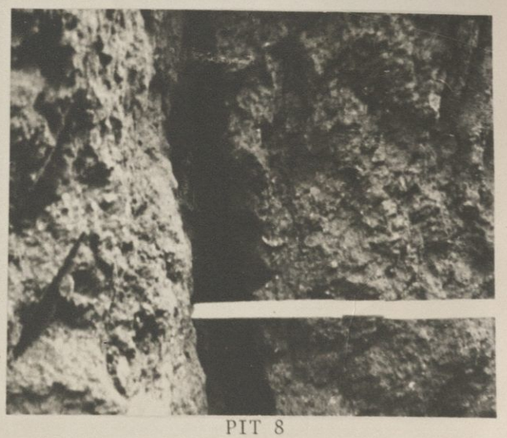


PIT 5

9-24-71 B.D. Photo 2
Close-up of view in Photo 1. Active scarp is down on right and filled with soil debris. Qt to left of scarp line.

PIT 8

9-24-71 B.D. Photo 3
Open crack (1-1/2") along scarp line on Los Banos St. Qt on left, soil on right.



PIT 8

9-24-71 L.C. Photo 4
Close-up of Photo 3 showing 1-1/2" open crack which forms scarp at ground surface.

EXHIBIT F

Summary of Geologic Conditions

Terrain conditions in the Seal Cove - Moss Beach Study Area vary in severity from major geologic instability problems along the sea cliff front, to minimal soils-related foundation problems in the most stable inland areas. These adverse geologic conditions include the following:

- Landsliding

  Existing active landslide masses that threaten man-made structures. Approximately 75% of the sea cliff is involved in active failure. Surface breaks, slumps, landslides and local mass movements are recurring evidences of the highly fractured and faulted condition of earth materials that underlie the study area.

- Sea Cliff Erosion

  Continuing rapid erosion of the base of the sea cliff. Actual measurement from aerial photographs indicate an average retreat of 1 foot yearly over the 29 year control period.

- Ground Water

  A shallow ground-water zone underlies much of the area, as revealed by the subsurface exploration program. This adversely affects slope stability, seismic stability and surface drainage.

- Expansive Soils

  A well-developed potentially expansive soil covers much of the area. Special treatment will be required to avoid potential damage to new structures.

- Seismic Hazards

  Seismic hazards within the study area consist principally of (1) possible ground rupture along the Seal Cove Fault with potential reactivation of secondary faults, (2) strong ground motion (shaking) and (3) ground failure (landsliding) along the sea cliff area. These hazards would be amplified by the perched water table and associated water-saturated sediments.

Sea Cliff Retreat

The sea cliff is remarkably straight in view of the wide range in composition and structure of the materials exposed in the cliffs. Some major recessions in the cliff face mark areas of major landsliding as illustrated by Cross-Section D-D'. Other areas of rapid retreat are where beach areas narrow, and where wave impact and channel runoff impinge.

Many descriptions of sea cliff retreat are based on short-term events and suppositions rather than on documented evidence. Misleading is the fact that sea cliffs are commonly extremely bold and steep, implying that this is an indication of both strength and durability. Residents in a sea cliff area are likely to conclude that because the sea cliff has been there for years and years and is still standing near-vertical, it is stable and will continue to be stable. On the other hand, residents may have exaggerated opinions of the rate of retreat because the cliff crumbles away as much as 10± horizontal feet during one wet season even after 50± years of negligible erosion. Both extremes are inaccurate suppositions as applied to the sea cliffs of the Seal Cove area.

Most sea cliff retreat in the subject area takes place during the storm season, particularly when storms and high surf occur during high tides. In the intervening seasons, weathering and erosion prepare portions of the cliff for consumption by vigorous wave attack. The terrace deposits and other surficial materials are relatively permeable as compared to the underlying bedrock exposed in the cliffs. Consequently, ground water tends to collect at the boundary and emerge as seepages on the cliff face. This further weakens those sections of the cliff promoting sliding and sloughing. Slide and slough debris tend to collect at the base of the slopes and protect the slopes from active erosion for a short time; however, one period of high waves can chew up this material and carry it away.

An analysis of aerial photographs taken over a 29-year period reveals that the average rate of cliff retreat over this period has been approximately 1 foot per year. The rate of retreat has increased in recent years; since 1965 it has been 3 to 4 feet per year. More detailed data are presented in the table in the Appendix.

The excellent exposures along the Seal Cove sea cliff suggest that its stability can readily be evaluated from measuring the geologic structures in the cliff. However, some rock sections in the cliff appear stable that are actually exposed surfaces of geometrical defects to be found inland. Many of these defects can be detected only by detailed subsurface exploration inland and by relating the geometry of these materials in the subsurface to the geometry in the sea cliff.

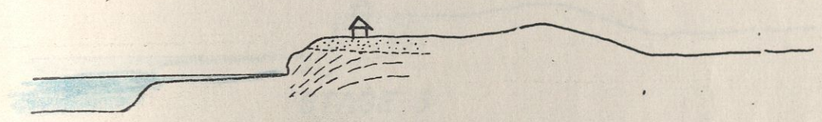
A typical sequence in the retreat of the sea cliff at Seal Cove is shown by the two pages of Exhibit E that follow. Six stages in the retreat process are shown, stages that have repeated themselves many times. Remedial steps that might be taken to prevent unhappy consequences of the type shown are presented in the Conclusions and Recommendations.

SEQUENCE OF
SEA CLIFF RETREAT

STAGE 1

NATURALLY STABLE SEA CLIFF

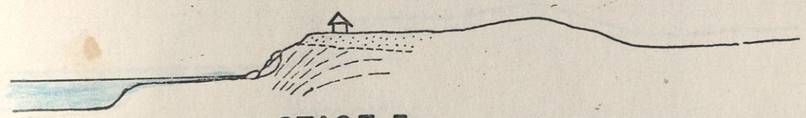
The sea cliff is at its natural angle of repose and is protected from the surf by a mass of beach sand.



STAGE 2

REMOVAL OF BEACH SAND AND OVERSTEEPENING CLIFF

The beach sand has been removed by the wave and currents exposing the wave-cut bench. Wave action during storms, aided by runoff and small-scale sloughing, has oversteepened the cliff, forming a notch and removing support from the bedrock.



STAGE 3

LANDSLIDING

The unsupported bedrock fails, aided by the infiltration of water which soaks through the permeable terrace capping beneath the residence to the bedrock.

EXHIBIT E

STAGE 4

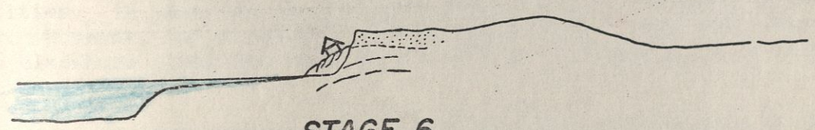
REMOVAL OF LANDSLIDE DEBRIS

The slide materials are removed by wave erosion exposing unsupported bedrock and initiating another cliff retreat cycle.

STAGE 5

CRACKING AND INCIPIENT SLIDING

Cracks develop in the unsupported bedrock beneath the residence damaging the residence. The slide block may fail piecemeal or in a block-glide manner.



STAGE 6

LANDSLIDING AND RESIDENTIAL DESTRUCTION

The cliff area fails, carrying the residence with it. If this occurs rapidly, occupants can be seriously injured.

EXHIBIT E

Zones of Geologic Stability

The Preliminary Geologic Stability Map at the end of this nontechnical section is the chief product of this investigation. It is an interpretive geologic map that divides the subject area into four zones on the basis of geologic problems and the types of future terrain investigations believed to be needed prior to further planning and development in the area.

The Schematic Cross-Section illustrates the depth relationships of the geologic problems and assignment of stability ratings for each problem area. The ranking of the four zones are: Zone 1 - MOST SEVERE INSTABILITY; Zone 2 - UNSTABLE; Zone 3 - DEGREE OF INSTABILITY QUESTIONABLE; and Zone 4 - MOST STABLE. Criteria used for differentiating the four zones are as follows:

Zone 1 is the zone of MOST SEVERE INSTABILITY. It is the most critical zone, because both life and dwellings are believed to be threatened by rapid mass movements. Criteria include areas of rapid erosional retreat, severe ground breaking, unsupported planar elements projected up-slope landward of the cricital areas, and cliff-top residential properties damaged by these geologic processes.

Zone 2 refers to UNSTABLE areas which do not appear to presently threaten both life and dwellings by rapid mass movements. These unstable areas include existing hazards of landslides, incipient ground failures, major ground breaks, active faulting and a high ground-water table. Potential hazard areas within this zone include those with unsupported planar surfaces projected up-slope, high rates of erosional retreat by wave action and surface runoff, severely broken and weak earth materials, and combinations of these. Criteria for placement of Zone 2 boundaries include residential properties damaged by geologic processes and utilities that have been ruptured, as well as the boundaries of natural features, both existing and projected.

Zone 3 includes those areas in which the degree of stability has not been ascertained and in which stability appears to be transitional between UNSTABLE and MOST STABLE. In these areas there has been insignificant damage to buildings and utilities. In addition, no strong evidence is known of recent geologic activity. However, these areas lie within geometrical blocks that have proven unstable elsewhere along the coast as a result of what appear to be similar geologic conditions.

Zone 4 is the MOST STABLE zone. This zone lacks the criteria of Zones 1, 2 and 3. It lies landward of the unstable coastal zone and outside known active fault zones. Zone 4 areas are generally either flatlands, general slopes, or both.