Engineering Geologic Evaluation
Sunken City / Point Fermin Landslide

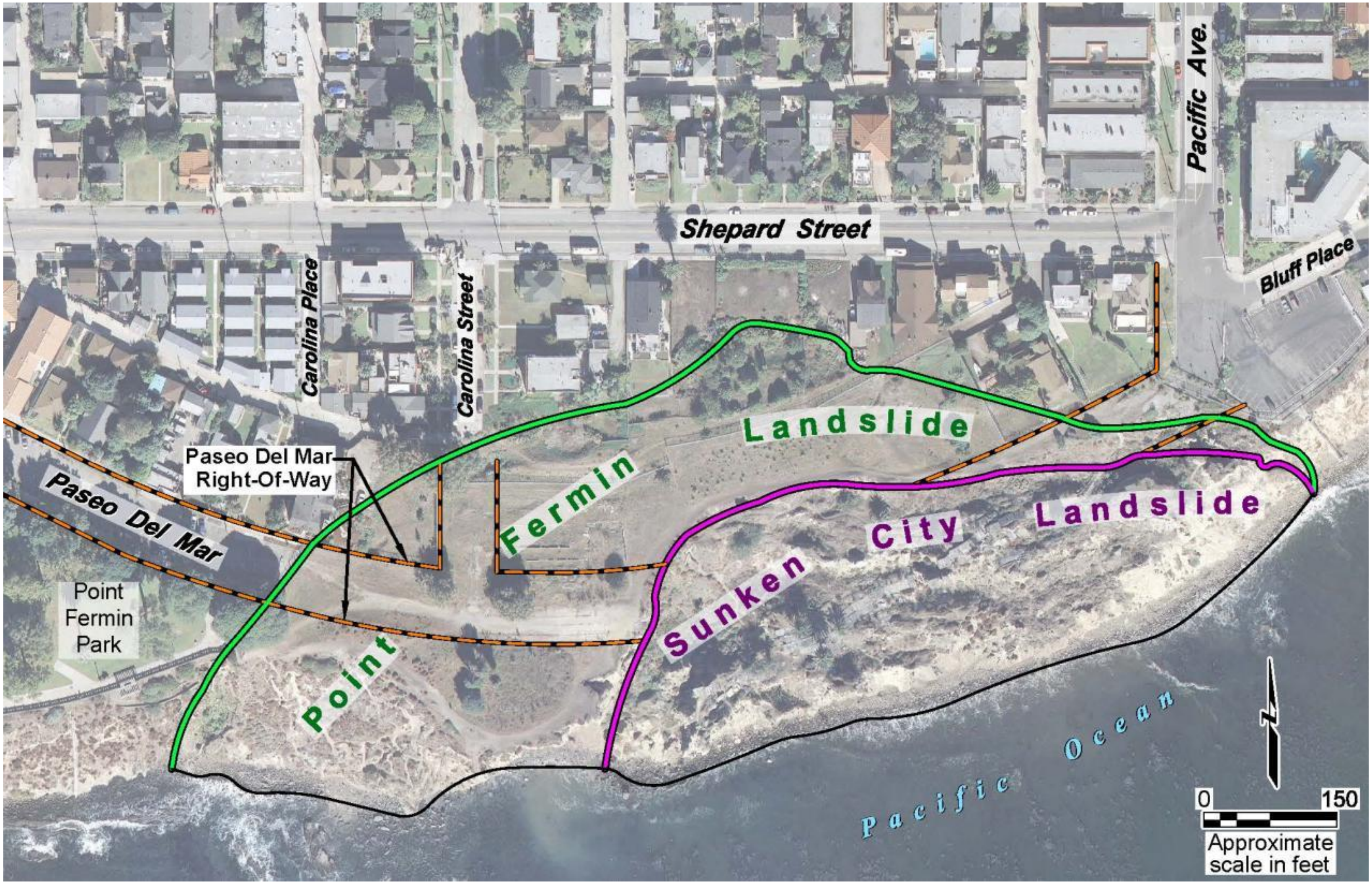
amec foster wheeler

Potential Ground Failure Safety Issues Associated with Public Use of the Landslide Area

Summary Outline

1. Landslide Chronology / History
2. Observed Conditions and Geologic Mapping
3. Landslide Cross-Sections and Stability Analyses
4. Primary Existing Trails and Ground Failure Hazard Zones
5. Possible Mitigation Measures for Ground Failure Hazard Zones and to Minimize the Rate and Severity of Future Landslide Movement

Site Plan


Shepard Street
Pacific Ave.
Bluff Place
Carolina Place
Carolina Street
Paseo Del Mar
Right-Of-Way
Paseo Del Mar
Point
Fermin
Park
Point Fermin Landslide
Sunken City Landslide
Pacific Ocean
0
150
Approximate
scale in feet

1921- Existing Development Prior to Landslide

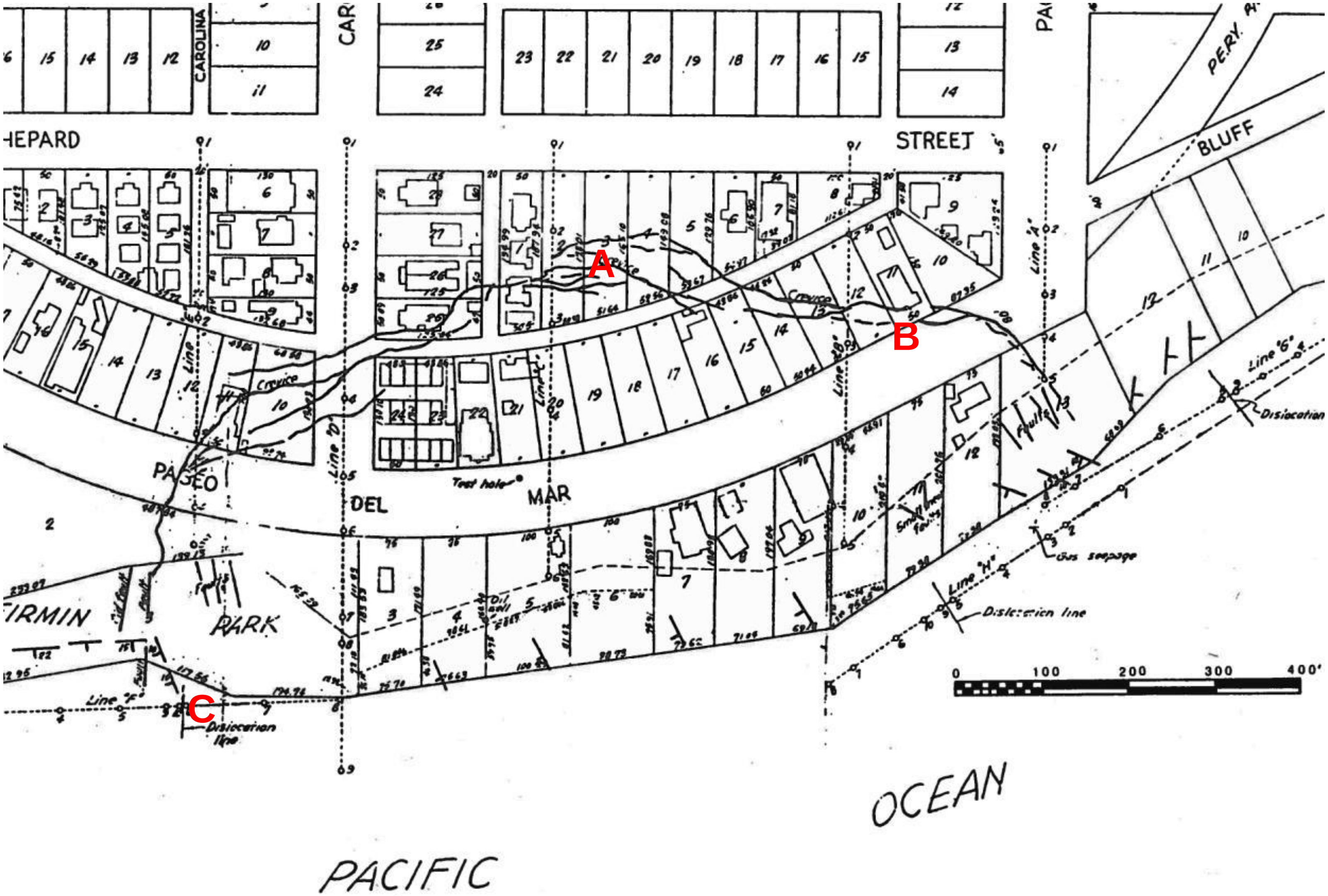
1929 Point Fermin Landslide Movement

- Landslide movement is first recognized in January 1929 when water and gas line breaks occur under the Ocean View Inn, adjacent to the current terminus of Paseo Del Mar at the steel fence/gate;

- In the following months, other utility breaks and cracks in the ground occurred, forming a broad arc extending across Carolina Street, along and through several residences and seaward back across Paseo Del Mar near the intersection with Pacific Avenue;

- Geologic studies of the landslide area were conducted on behalf of the City of Los Angeles Engineering Department by F.L. Ransome (5-7-1929) and R. Arnold, et al (8-28-1929)

1929 Geologic Map (Arnold, et al)



1929 Back or Head of the Landslide Block

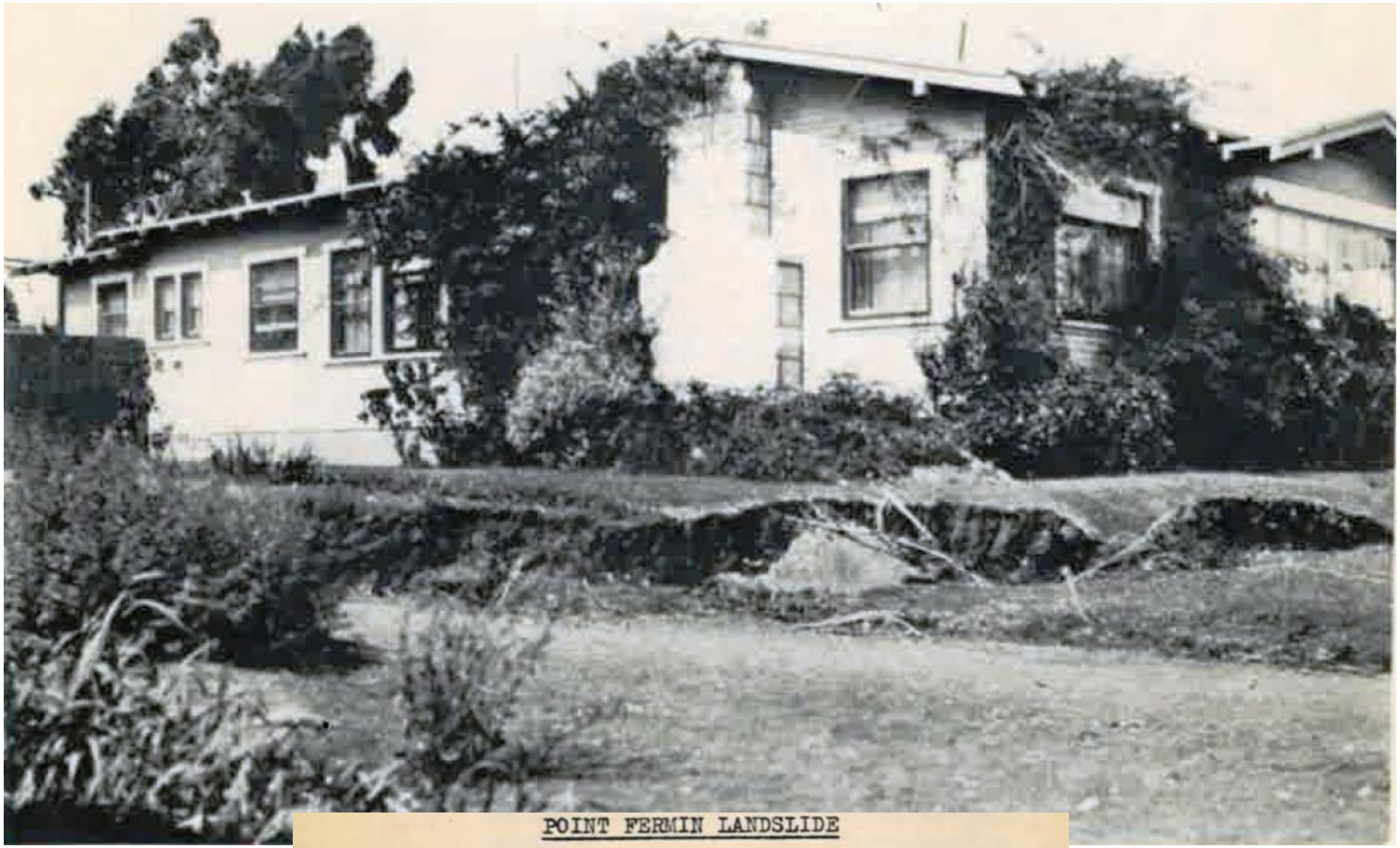
POINT FERMIN LANDSLIDE

Photograph A.

Looking west along the major fissure at the point of greatest displacement near the middle of the crescent. Considerable filling material has been dumped in the crevice at this point.

Photo by Ralph Arnold, Aug. 22, 1929.

1929 Head of Landslide Near Pacific Avenue



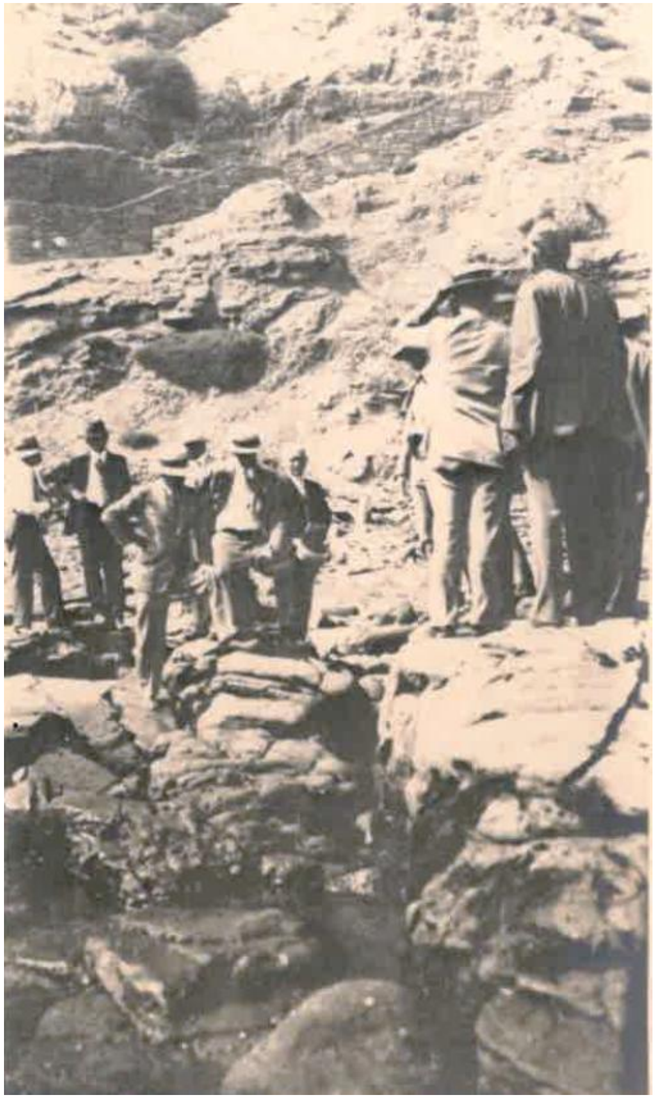
POINT FERMIN LANDSLIDE

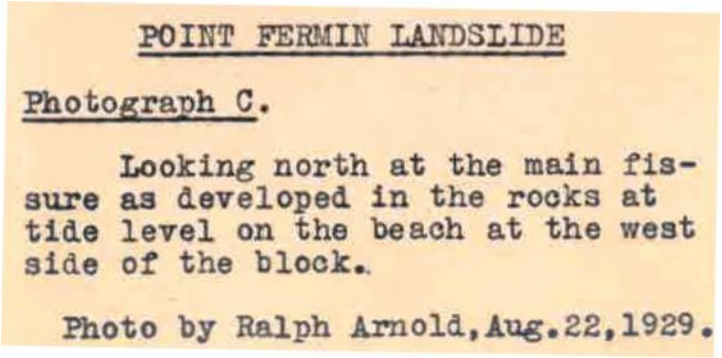
Photograph B.

Looking northeast at the main crevice near the eastern end of fissure.

Photo by Ralph Arnold, Aug. 22, 1929.

1929 Displacement of Bedrock in the Intertidal Zone on the West Side of the Landslide Block



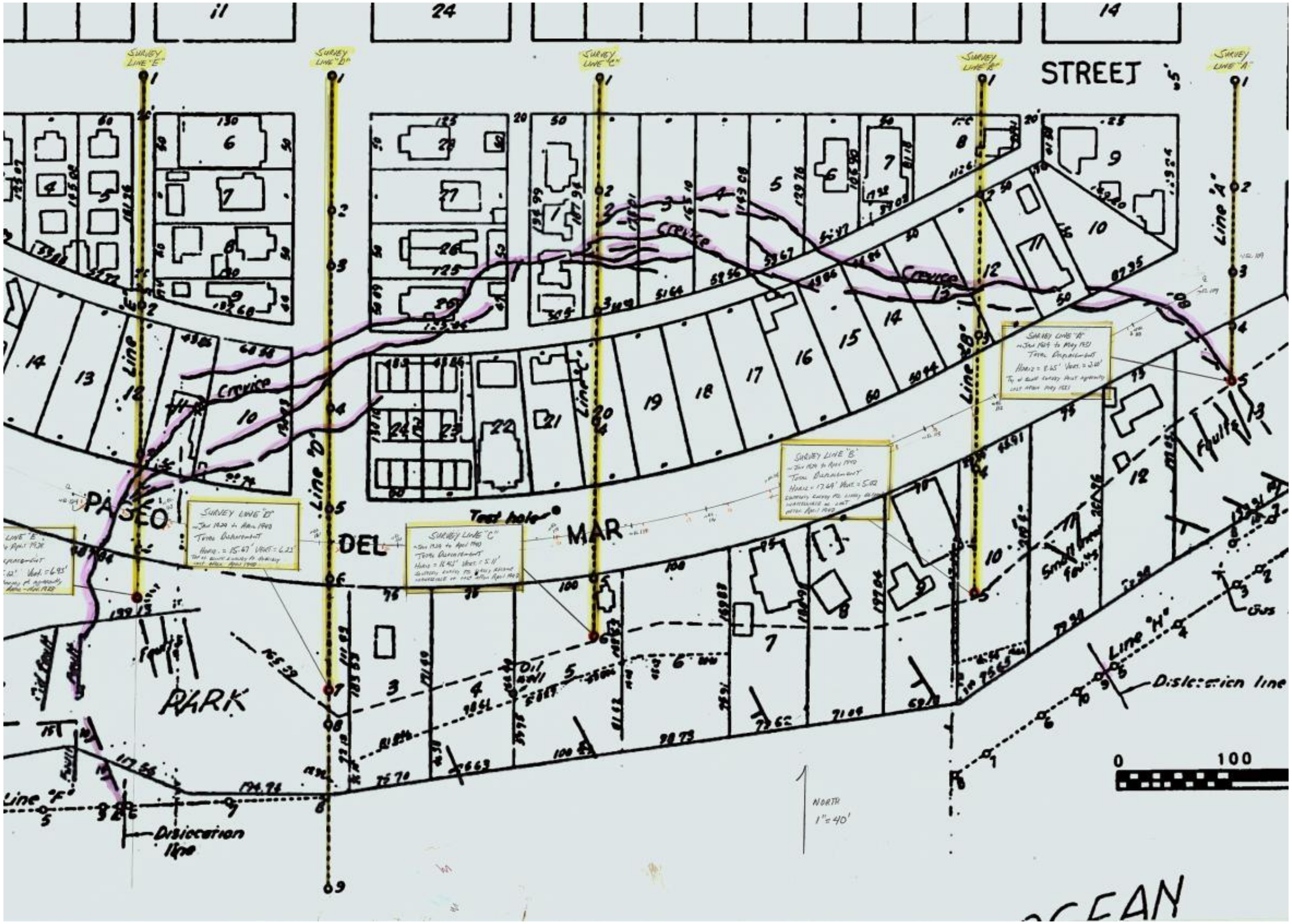

POINT FERMIN LANDSLIDE

Photograph C.

Looking north at the main fissure as developed in the rocks at tide level on the beach at the west side of the block.

Photo by Ralph Arnold, Aug.22,1929.

1929 through April 1940
Survey Measurements of Slide Movement



1929 through April 1940
Survey Measurements of Slide Movement

- Survey measurements of the Point Fermin Landslide indicate it was moving slowly, but more or less continuously between 1929 through April 1940 at a typical rate ranging from about 1 to 6 inches per month;

- The faster rates of movement typically occurred during and following the winter rainy season;

- The total horizontal displacement measured during that 11 year time period was about 16 to 18 feet and the ground surface across the top of the slide mass dropped about 5 to 8 feet;

- Survey measurements abruptly ended in April 1940 when slide movement accelerated and the "Sunken City" portion of the Point Fermin Landslide developed.

1932 - View East along Paseo Del Mar at Westerly Point Fermin Landslide Boundary

1932 - View East along Paseo Del Mar at Easterly Point Fermin Landslide Boundary

1932 - Ground Fissure or Crevice at the back of the Eastern Portion of the Point Fermin Landslide

1932 - Westerly Boundary of Landslide at the Ocean Shoreline

April 1940 – the Sunken City Landslide Developed in the Southeastern Portion of the Point Fermin LS

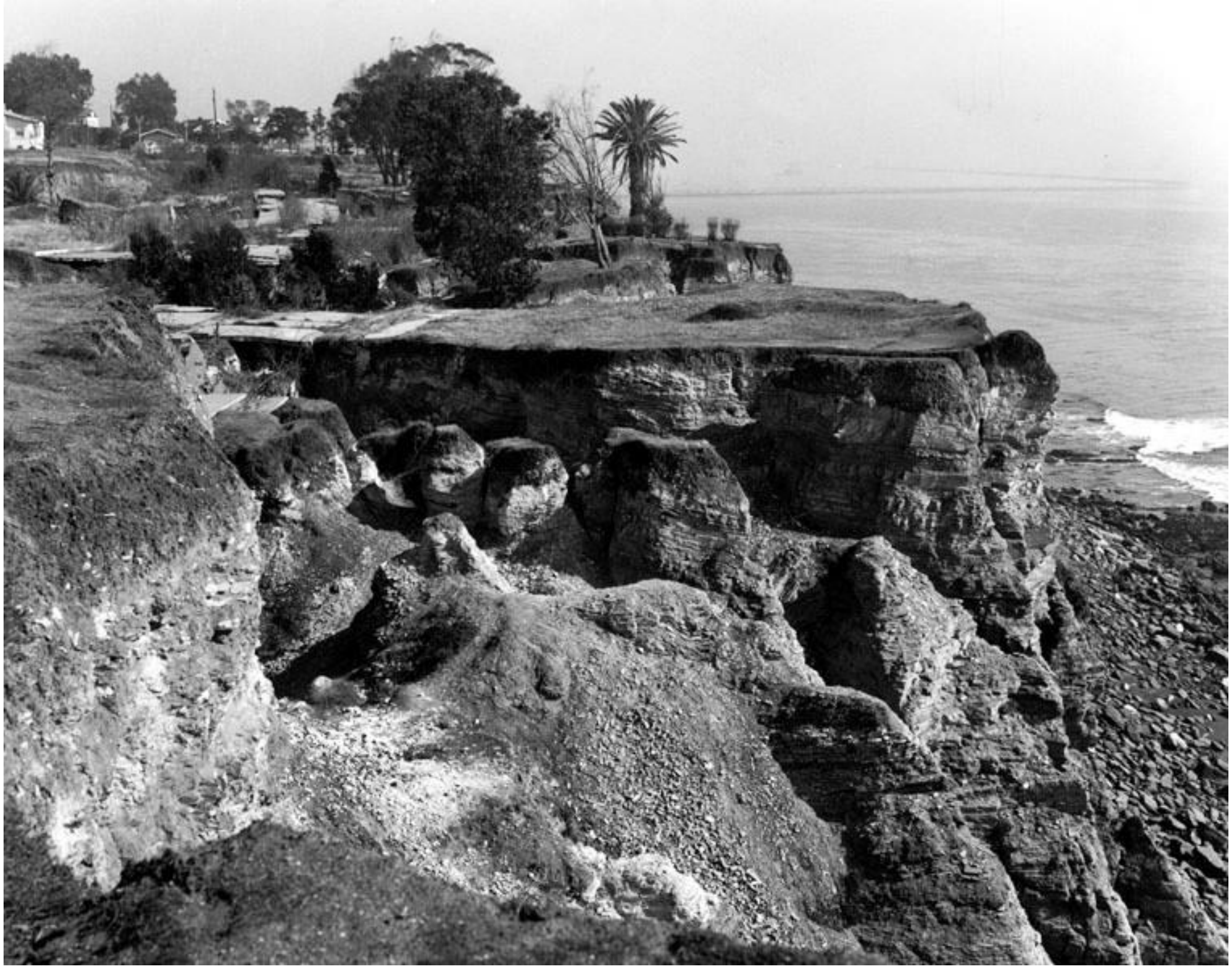
- The 1940-41 rainfall year was the wettest on record at that time (i.e., since 1883-84), with an annual total of approximately 33 inches of rain;

- A dissipating hurricane reportedly made landfall in southern California in September 1939; high surf conditions out of the South were recorded, including large waves that destroyed the outer 300 feet of the Huntington Beach Pier; the subject area faces directly South;

- The combined effects of high rainfall/groundwater conditions and coastal erosion along the toe of the slide mass apparently precipitated acceleration of the slide movement and formation of the Sunken City portion of the landslide.

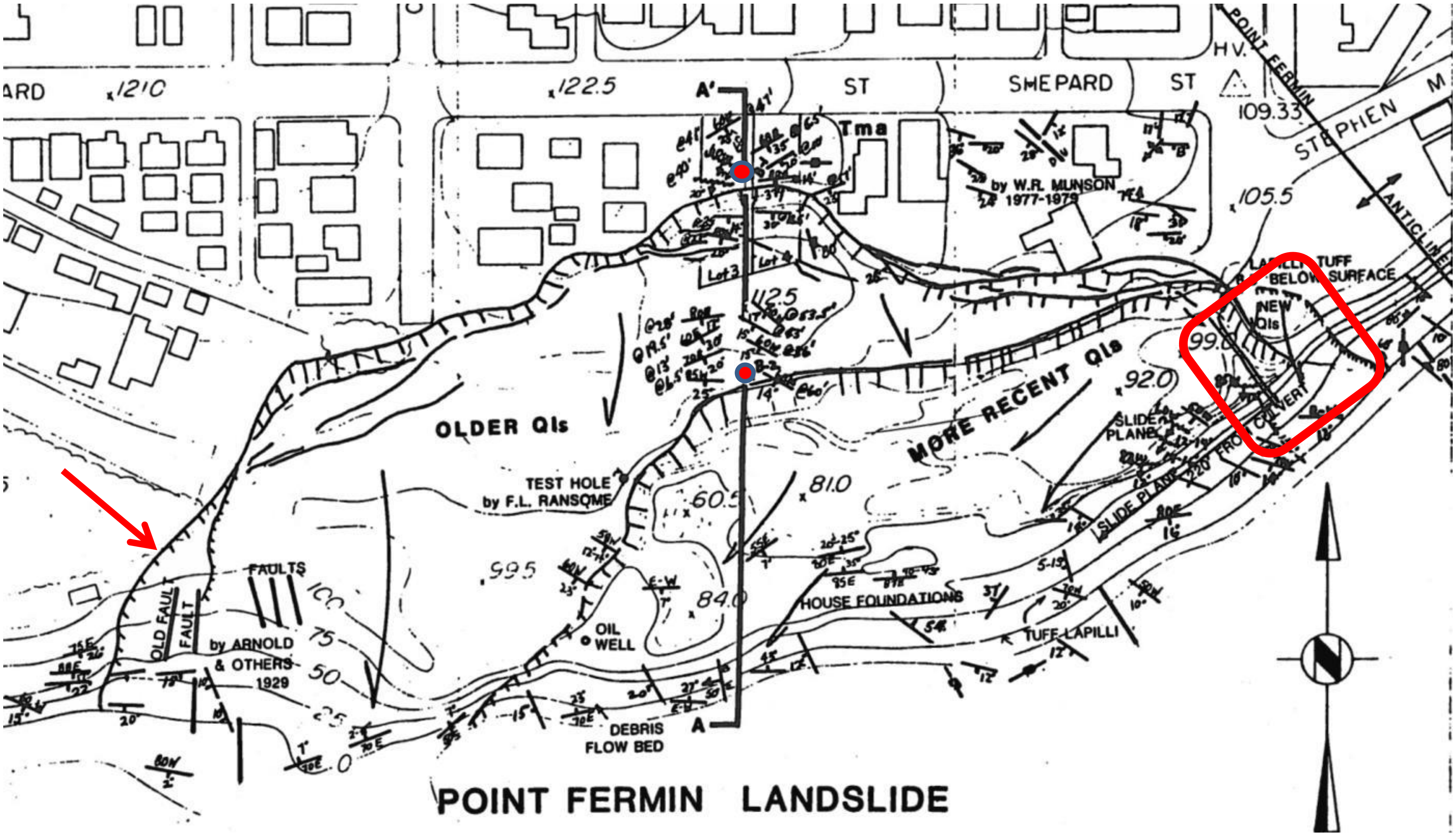
1941 – Sunken City Portion of the Landslide

Circa 1942 - Sunken City Landslide Area



Circa 1942 - Sunken City Landslide Area

1986 Geologic Map by Mike Scullin CEG Showing Local Areas of Landslide Enlargement



Landslide Activity 1940s to Present

- No additional surveys or other types of monitoring of the landslide after April 1940 are known to be available;
- Geologists working in the area in the early 1980s indicate that noticeable active movement of the Sunken City portion of the landslide was occurring at that time;
- Comparisons of the original Paseo Del Mar R.O.W. to the location of the existing road pavement suggests that on the order of about 5 to 10 feet of additional horizontal displacement has occurred on the Point Fermin Landslide since 1940 and up to about 130 feet of displacement has occurred on the Sunken City Landslide (largest displacements in the west);
- Recent personal observations in December 2015 and early March 2016 indicated significant erosion had occurred in the interim along the toe of the slide area in response to relatively high surf conditions; the observed conditions were consistent with active movement of the Sunken City portion of the landslide.

March 2016 - Sunken City Landslide Bluff Face and Beach Debris Piles

The Point Fermin Landslide is Described as a "Translational" or "Block Glide" Landslide

- Displacement of the Pt. Fermin landslide originally occurred as a relatively coherent block or rock mass that moved seaward along weak strata/bedding in the underlying bedrock that are tilted towards the ocean (this is known as a translational or block glide landslide);

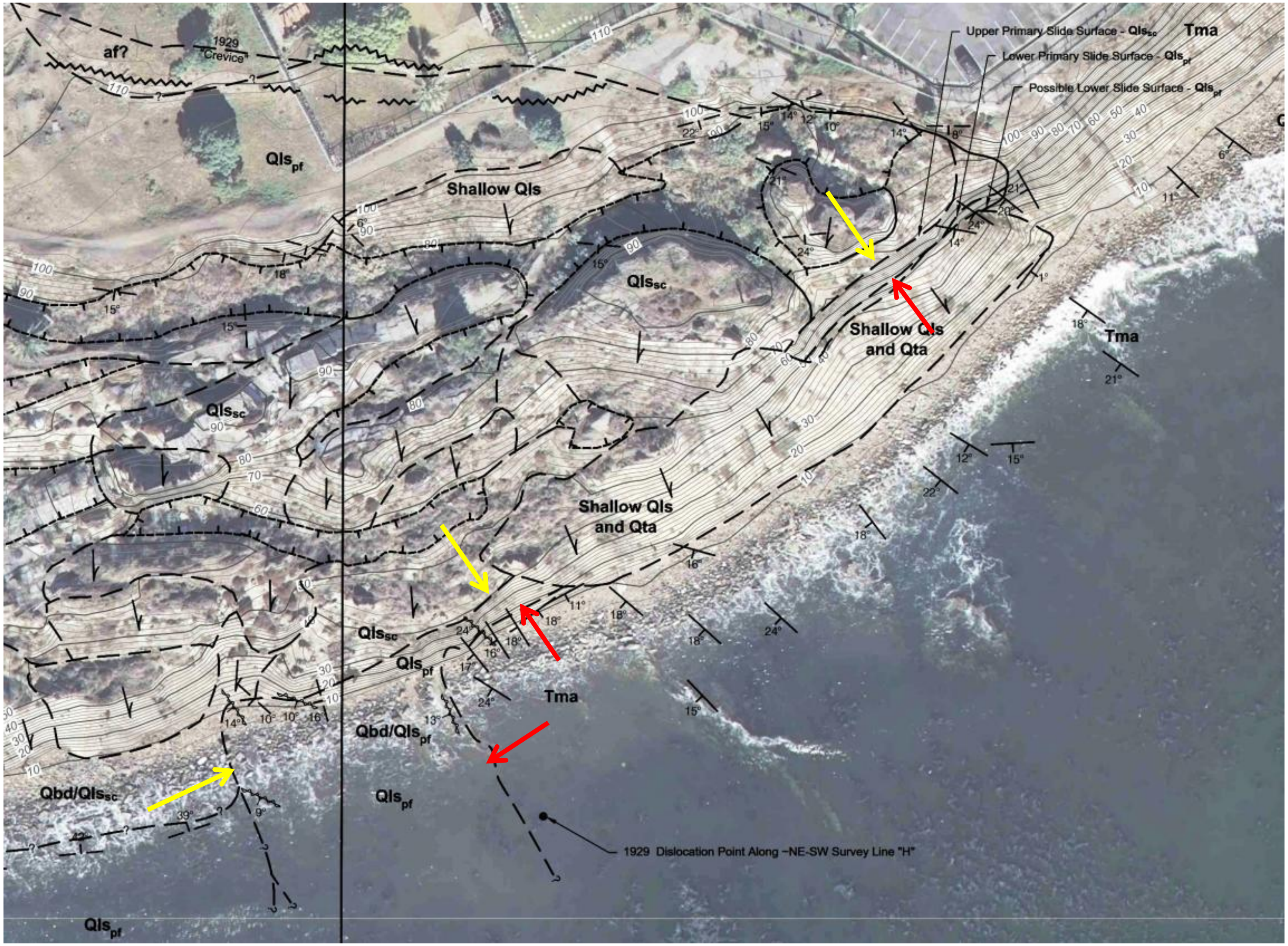
- The seaward tilt of the bedrock strata and the presence of weak bentonite clay beds are the physical properties that control the location and extent of the landsliding;

- These conditions can be likened to an old deck of sticky playing cards with some slippery new cards at the bottom of the deck – when the deck of cards is tilted slightly the block of sticky cards slides down the inclination of the slippery new cards near the base;

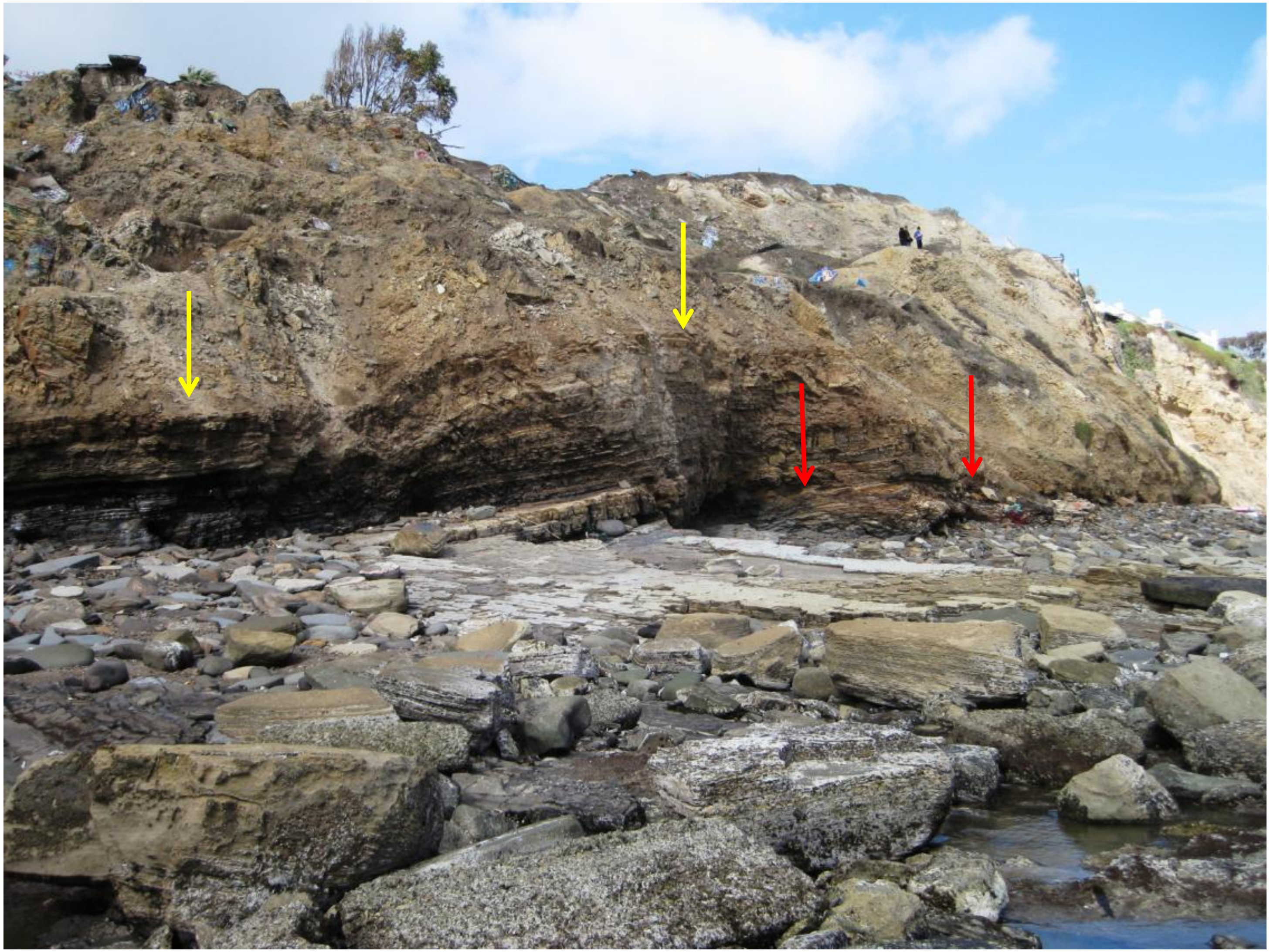
- Bentonite clay beds form the base of both the larger, deeper Point Fermin Landslide and the smaller, shallower Sunken City landslide.

2016 Geologic Map Amec Foster Wheeler

2016 Geologic Map Excerpt Showing the Exposed Base of Sunken City and Point Fermin Landslides



Exposed Base of Pont Fermin Landslide (red arrows) and Sunken City Landslide (yellow arrows)



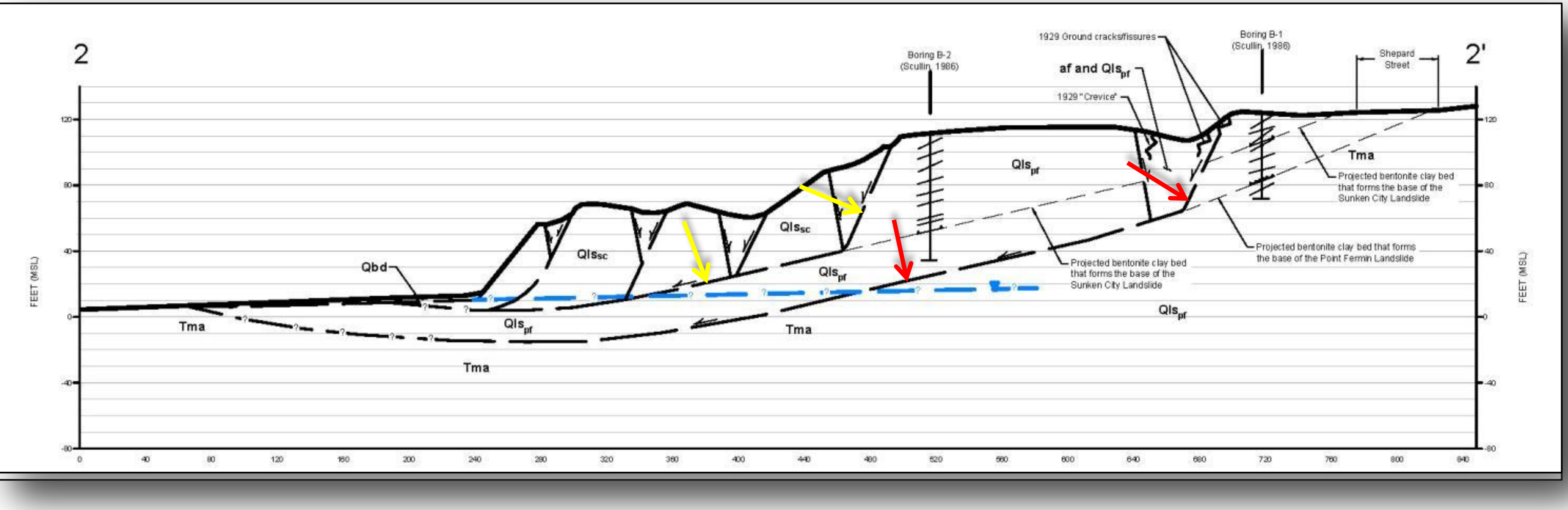
Destabilizing Effects of Groundwater and Coastal Bluff Erosion

- Elevated groundwater levels create water pressure on the base of the slide and also reduce the strength of the bentonite clay, thus reducing the frictional resistance to sliding;

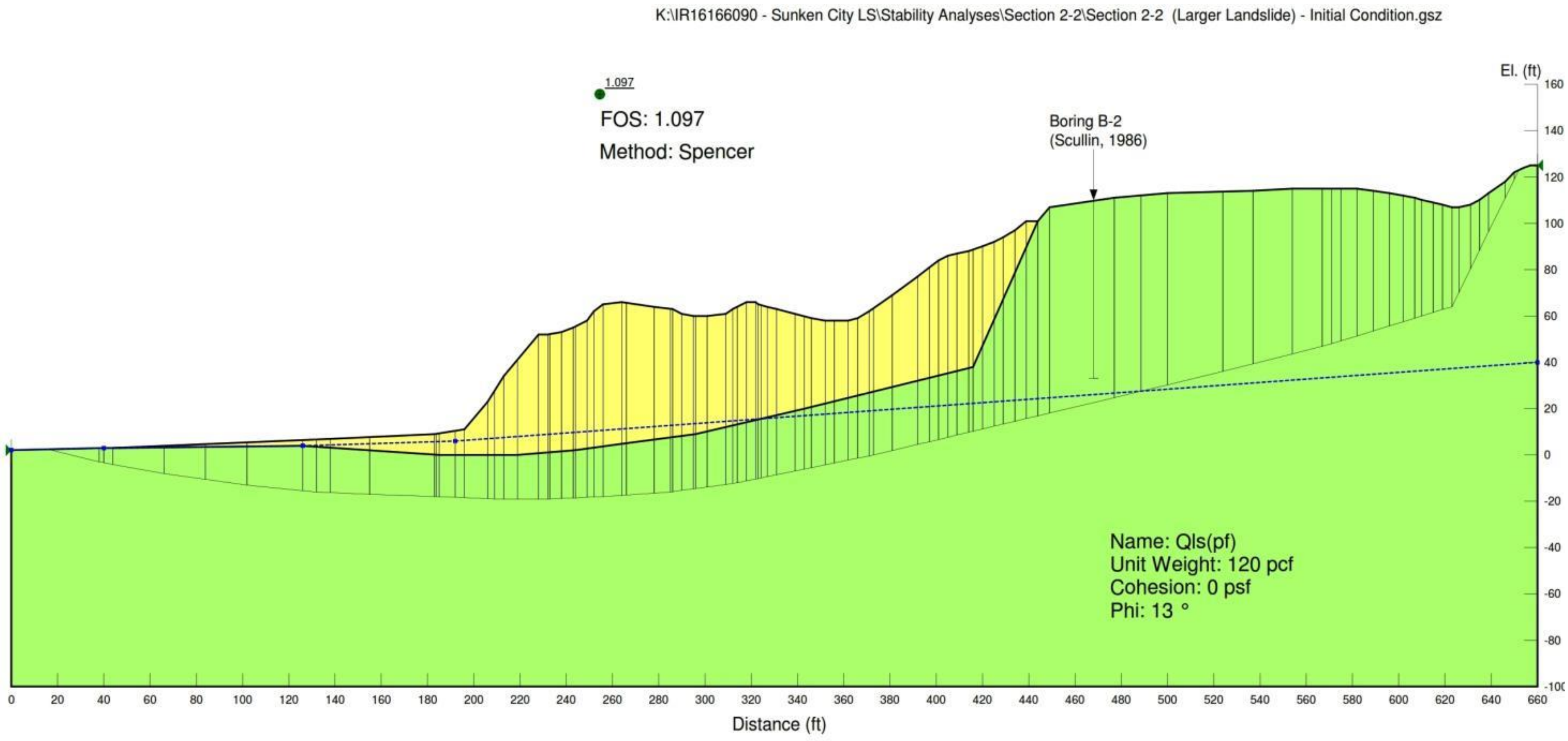
- Rainfall, and particularly intense rainfall, also has the potential to create water pressure in the numerous cracks and fissures within the landslide, further destabilizing the slide mass – this destabilizing condition is probably most critical in the relatively high, steep fracture blocks present in the bluff along the ocean shoreline;

- Wave erosion along the shoreline continually undercuts the bluff and toe of the landslide, creating over-steepened conditions that fail/fall and are continually reestablished as the slide moves seaward (this can be likened to a very slow moving conveyor belt of landslide blocks/debris that are continually being removed by the wave erosion).

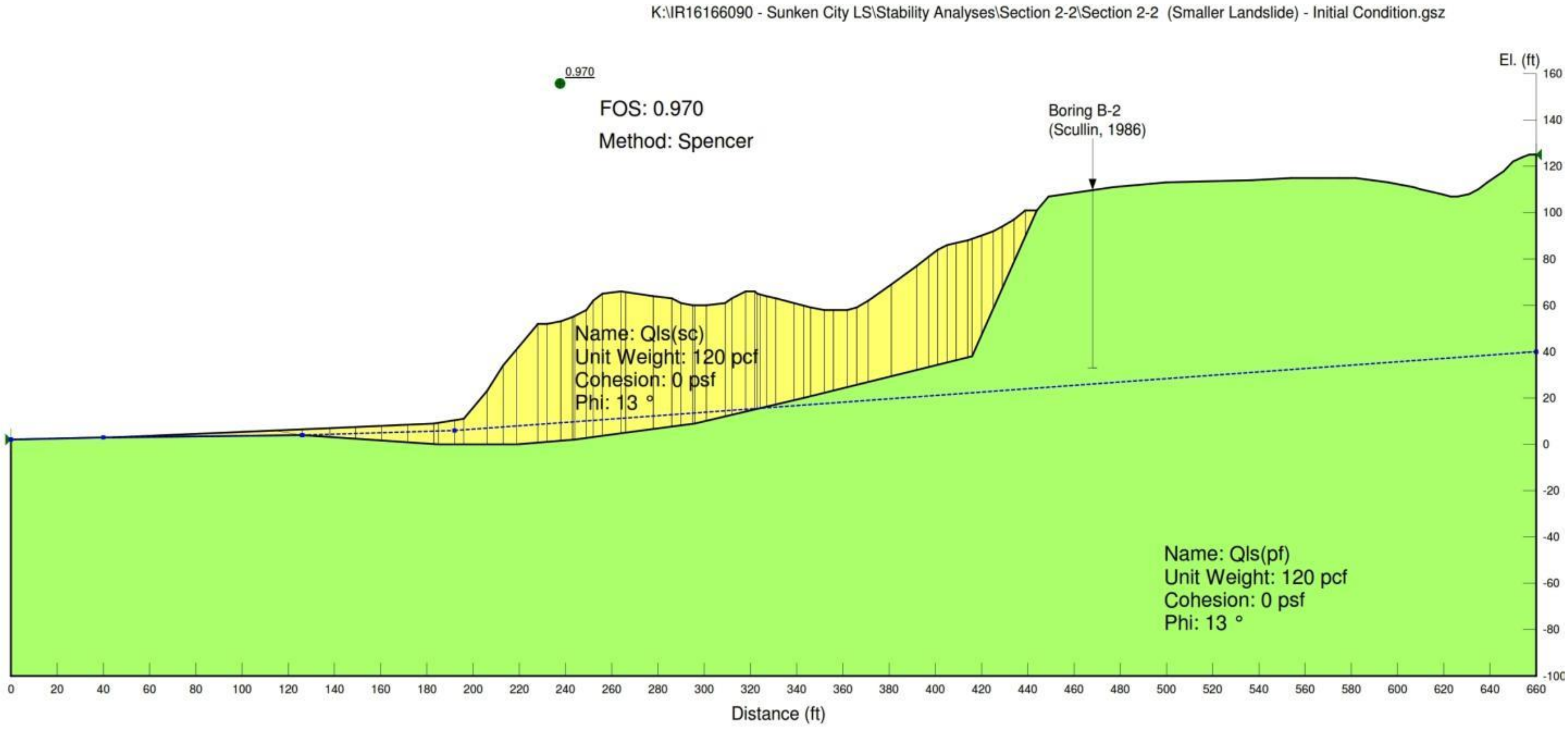
Geologic Cross-Section 2 – 2' Near the Center of the Landslide Area (Point Fermin LS: red arrows, Sunken City LS: yellow arrows)



Calculated Phi-Angle for Near-Equilibrium Condition: PFLS Section 2-2’ (Phi = 13 degrees)

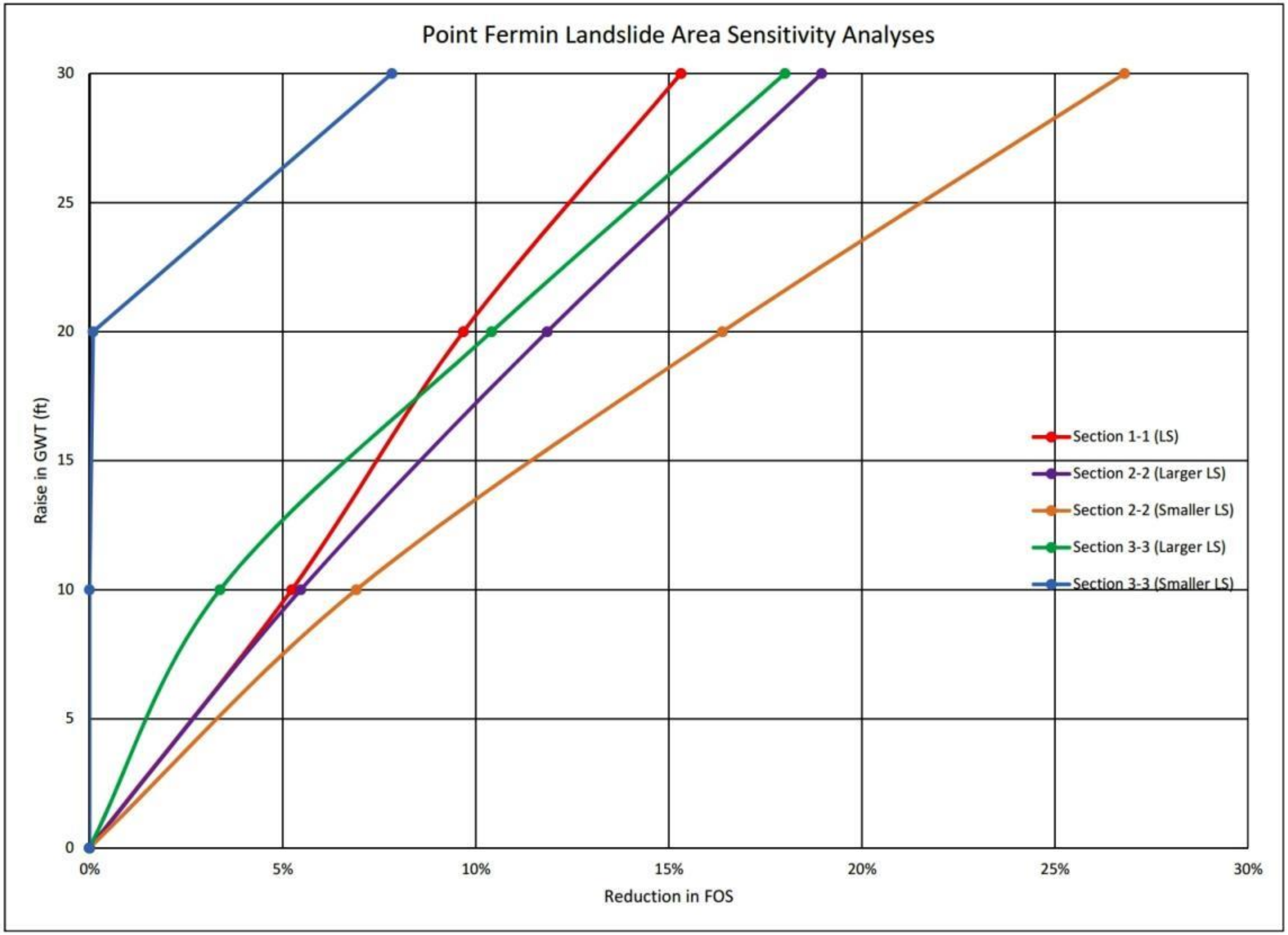


Calculated Phi-Angle for Near-Equilibrium Condition: SCLS Section 2-2’ (Phi = 13 degrees)



Sensitivity Evaluation of Rising Groundwater Levels on the Calculated F.S.

Section 2-2’: a 20-foot rise in GW reduces F.S. 12% and 17%, respectively, for the PFLS and SCLS,



Primary Trails and Ground Failure Hazard Zones Map, Showing Displaced Concrete Road Slabs

Explanation and Definitions for Primary Trails and Ground Failure Hazards Map

Explanation

Approximate location of primary existing trail

Approximate location of remnant concrete slabs from Paseo Del Mar roadway

North side of Paseo Del Mar roadway Right-of-Way

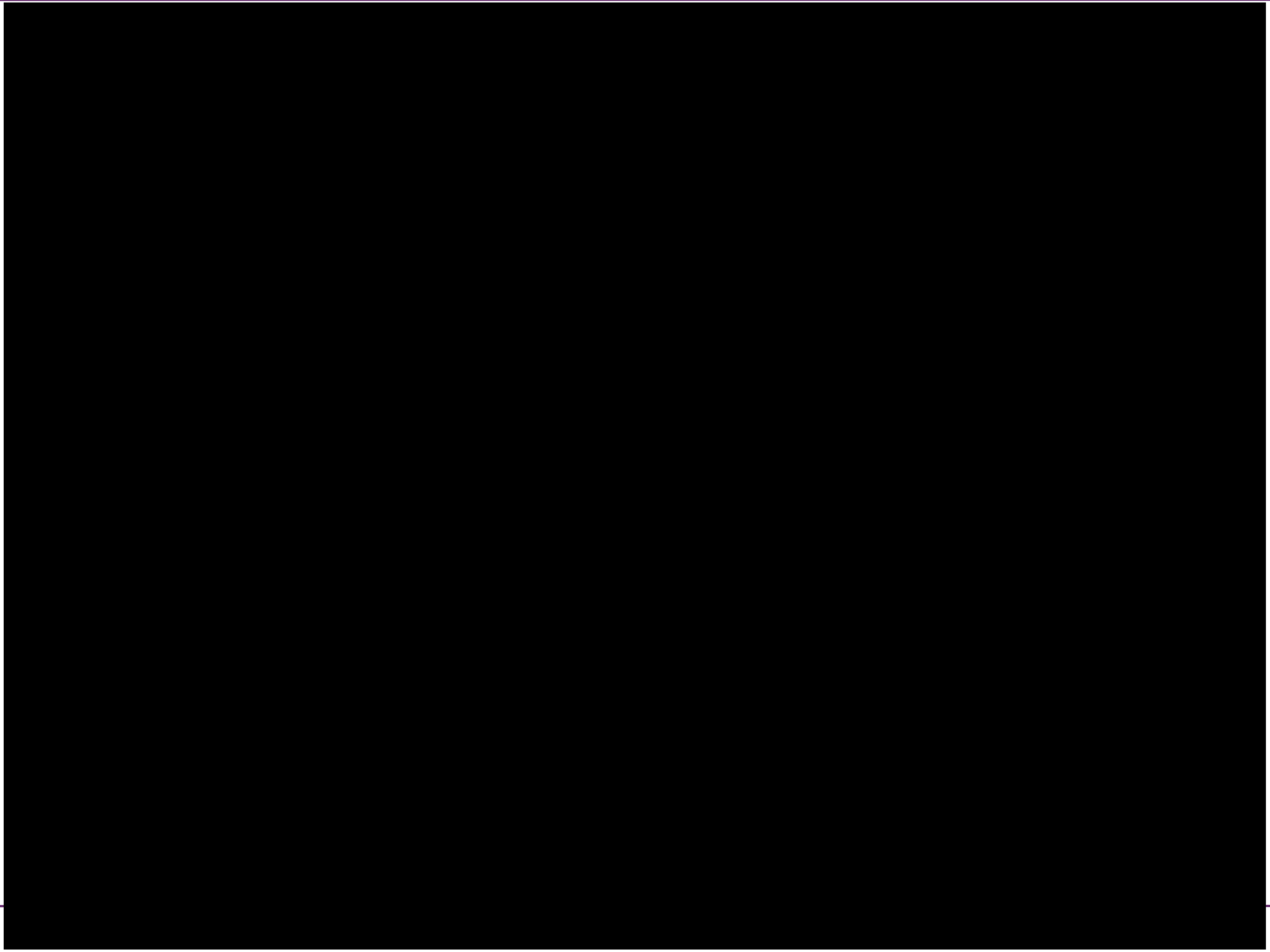
POINT FERMIN LANDSLIDE AREA - GROUND FAILURE HAZARD ZONES

EXTREME HAZARD ZONE - the presence of pervasive dilated fracturing within the bedrock comprising these relatively high, very steep slopes indicates a potential for life-threatening catastrophic failure that could occur at any time, affecting both the area above/behind, and also below the slope.

HIGH HAZARD ZONE - disturbance of the bedrock fabric from the extended period of ground movement within the landslide makes these relatively steep slope areas highly susceptible to shallow failure and/or rockfalls, primarily affecting areas on or below the slope.

HAZARD ZONE - relatively large horizontal and vertical ground displacements within these portions of the landslide have broken the slide mass into a myriad of blocks with intervening ground cracks and extensional zones, thus reducing much of the bedrock to rocky or blocky debris; these ground cracks and extensional zones are subject to local ground collapse and the slide debris is subject to shallow failure in areas with significant slope gradients.

3D Model of the Landslide Area Graphically Illustrating the Ground Failure Hazard Areas



3D Model of the Landslide Area Graphically Illustrating the Ground Failure Hazard Areas

Pix4D 3D model of Point Fermin Landslide, Rancho Palos Verde.mp4

Pix4D 3D model of Point Fermin Landslide, Rancho Palos Verde_1.wmv

Extreme Ground Failure Hazard Zones

Extreme Ground Failure Hazard Zones

Extreme Ground Failure Hazard Zones

Extreme Ground Failure Hazard Zones

Possible Mitigation Measures for Extreme and High Hazard Ground Failure Zones Along the Ocean Shoreline

- In general, because of their location on relatively high, very steep slopes, the only potential mitigation measures for the Extreme and High Hazard Zones along the ocean shoreline are avoidance or removal;

- It must be recognized that any proposed grading removal involves significant safety concerns that would need to be addressed and the longevity of these mitigation measures would be limited by the effects of continuing wave erosion;

- Coastal permitting issues may also severely constrain or prohibit mitigation grading of the existing bluff slopes;

- The possible legal ramifications of grading modification of what through time will likely continue to be an unsafe area will also need to be considered.

Possible Mitigation Measures for Extreme and High Hazard Ground Failure Zones Inland from the Ocean Shoreline

- Extreme and High Hazard Zones inland from the ocean shoreline are much more amenable to grading mitigation measures that would primarily consist of regrading these relatively steep slope areas to gradients shallower than 1:1 (H:V); this is sometimes referred to as a "slope layback";

- A slope layback will not be possible in most of the High Hazard Zone at the easterly extremity of the landslide area because of the proximity of the adjoining offsite parking area; installation of a tieback shoring wall at this location could be considered, which will also control additional northeastward enlargement of the landslide area;

Possible Mitigation Measures for Ground Failure Hazard Zones Along the Ocean Shoreline

- In general, delineated Hazard Zone slope areas along the ocean shoreline are subject to local shallow slope failure and include local open ground cracks/extensional zones; the most reasonable hazard mitigation for these areas is avoidance because of the steepness of the slopes is generally not compatible with public access, particularly along the toe of the slope at the ocean shoreline where continuous wave erosion has created very steep slopes;

- In the event future construction of a temporary public access trail is considered along a portion of the slope with a relatively low slope gradient, the stability of the trail and adjoining slopes should be addressed, including also some type of ground reinforcement to bridge existing open ground cracks/extensional zones; the effects of continuous wave erosion along the base of the slope will also need to be addressed in some manner.

Possible Mitigation Measures for Ground Failure Hazard Zones Inland from the Ocean Shoreline

- Hazard Zones inland from the ocean shoreline are much more amenable to grading mitigation measures that would primarily consist of regrading locally steep slope areas to gradients shallower than 1:1 or 1.5: 1 (H:V), depending on the location and material types comprising the slopes;

- It is assumed that future construction of temporary public access trails will be considered for these areas; in addition to appropriate slope laybacks, remedial grading should include some type of ground reinforcement to bridge existing open ground cracks/extensional zones.

General Recommendations for Mitigation of the Rate and Severity of Future Landslide Movement

- It should be recognized that the subject site is an active landslide area; although the rate of movement may not be noticeable in the short term, there is no physical mechanism for this landslide area to stabilize itself, particularly in consideration of continual wave erosion that is occurring along the ocean shoreline;

- Specific provisions should be developed and implemented to enhance drainage conditions within and surrounding the landslide area to minimize infiltration of rainfall and surface water runoff; any uncontrolled runoff over the bluff edge, or over the scarps that form the boundaries of the slide areas should also be eliminated; of particular concern is runoff from the upland areas northerly of the slide area;

- Specific provisions should be developed for routine monitoring and maintenance of the water, sewer and storm drain lines in the areas within a radius of about 200 to 300 feet surrounding the boundaries of the slide area; any existing lines within the slide area should be removed or appropriately sealed and abandoned.

General Recommendations for Monitoring Future Landslide Movement

- Considering the potential for public use of the landslide area, some provisions should be made to monitor current and future landslide movement;

- Survey monitoring points should be established within the landslide area to monitor their position/location relative to “no movement” datum monuments well beyond the limits of the mapped landsliding; monitoring points should also be established around the perimeter of the landslide area, both within and beyond the surface projection of the bentonite bed that forms the base of the Point Fermin Landslide (see Geologic Cross-Sections);

- Some consideration should also be given to installation of inclinometers to monitor subsurface movement along the base of both landslide slip planes.

Questions and Discussion