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

June 23, 2016
G5056

TO: Sam Herzberg
Senior Planner
SAN MATEO COUNTY PARKS DEPARTMENT
455 County Center, 4th Floor
Redwood City, California 94063

SUBJECT: **Geotechnical Hazard Assessment**
RE: Pillar Point Bluffs and California Coastal Trail
County of San Mateo, California

DISCUSSION

In conformance with our proposal dated May 24, 2016, we have completed an assessment of geotechnical hazards to the trail system at Pillar Point extending from the parking lot at Pillar Point Marsh to the northern terminus of the Jean Lauer Trail at Bernal Avenue. Our focus has been on the trail systems located on the top of the bluff, but we also completed a brief reconnaissance of probable pedestrian routes along the local beach. We have also considered previous data regarding landsliding and coastal bluff retreat within the community of Seal Cove primarily from Bernal Avenue to San Lucas Avenue.

SCOPE OF WORK

We have compiled and reviewed published maps and reports from our office files including data from a Leighton and Associates hazard study of the Seal Cove area completed in 1971, a U.S. Geological Survey Open-File Report (98-41) regarding 1982-83 El Niño Coastal Erosion in San Mateo County and other monitoring data regarding the development and movement of landslides in Seal Cove. In addition, our work has included the following tasks:

- **Aerial photographs** – We have examined site historic aerial photographs available from Californiacoastlines.org dating back to 1972 and images from Google Earth dating from 1993 to April 2016. We have reviewed data regarding studies of Seal Cove bluff retreat rates from 1866 to 1972, and 1910 to 1971 that were also based partly on historic photographs.

- **Reconnaissance/Geologic Map** – We have observed conditions and mapped identified landslides and zones of active ground cracking/fissuring extending along the bluff edge from Bernal Avenue to the southern radar facility. We also completed a reconnaissance of the adjacent beaches to check for evidence of rockfall and landslide toe displacements.

- **Base Map** – We have prepared a base map for data presentation utilizing a recent aerial photograph with an overly of topographic contours. Detailed field data was collected on several individual sheets of April 5, 2016, color photographs (approximately 1 inch = 100 feet) that accurately displayed existing site trees and complex path and trail networks.

- **Reporting** – We have summarized our observations and recommendations in this document that includes an attached geotechnical hazards map.

GEOLOGIC SETTING

Pillar Point, and the adjoining relatively high ground extending to the northwest, is located on uplifted block of ground bordered on the east by a 50-foot high, east-facing escarpment formed by the active Seal Cove-San Gregorio Fault and on the west by a precipitous sea cliff. The uplifted block is mantled by marine terrace deposits that are underlain by Purisima Formation bedrock that dips steeply to the east. Local bluffs expose steep beds of sandstone, siltstone and extensive landslide deposits in some areas. We observed several failures of the upper bluff that appear to be confined to the capping terrace deposits, and it is possible that perched groundwater may accumulate at the terrace deposit/bedrock contact. We also observed active deep landsliding with basal rupture surfaces apparent near beach level.

The height and steepness of local bluffs reflects the local balance between erosional power of the near-shore marine processes, and the erosional resistance of the cliff forming materials. Overall, the local coastline appears to be sand deficient and only locally do a few broad beaches protect the sea cliffs from wave erosion. From our review of site aerial photographs from 1972 to present, it appears that there has been a significant narrowing and reduction of protective beaches over the last 40 years in this area. Surface drainage from the top of bluff may aggravate bluff instability at specific locations. However, we did not observe areas where relatively simple improvements could substantially improve overall bluff stability.

EROSION RATES

Based on our evaluation of local bluff retreat rates, it is apparent that decades can pass with little erosion followed by short intervals where several feet of bluff may be lost in a single winter season. Preparing estimates of average retreat rates requires considering long periods of relatively benign conditions followed by short periods of catastrophic bluff collapse such as those experienced locally in 1982-83, 1998, 2010, and 2016. Often significant periods of rapid retreat are initiated by El Niño conditions. After cliffs are temporarily over-steeped by a significant storm season, bluff instability may be adversely impacted for several years as bluffs progressively fail back to more stable inclinations. During our recent site reconnaissance, we observed several areas where tension cracking and fissuring has occurred within 5 to 15 feet of the top of bluff. The observed cracking is caused by a gradual detachment process leading to large blocks of ground eventually failing from the top edge of bluff.

As allowed by identifiable site trees that have persisted from 1993 to present, we have measured bluff retreat rates from aerial photographs at 3 representative locations along the existing bluff trail over the last 23 years. Along the northern trail segment, we obtained an average rate of 0.5 feet/year, over the middle trail area an average rate of 1.3 feet/year, and over the southern portion of the trail 0.6 feet/year (source data is included in Appendix A). As a comparison to other local bluff retreat rates, we understand that coastal bluffs from Bernal Avenue to San Lucas Avenues have an average retreat rates of 0.4 feet/year from 1910-1971 and specific bluffs at Moss Beach have an average retreat rate of 1.6 feet/year (1866-1972).

Given the extensive bluff failures that were locally observed from this last winter and possible recent acceleration of coastal retreat rates along the San Mateo coastline (that may be related to rising sea levels and changes in wave patterns caused by changing climate and currents), we believe it is prudent to plan trail alignments based on a conservative average local bluff retreat rate of 1.5 feet/year.

LANDSLIDING

Observed top of bluff tension cracks and fissures, often combined with vertical displacements ranging from 0.5 inch to 2.5 feet, are an indication of incipient landsliding whereby blocks of ground will ultimately become fully detached and fail towards the beach. Existing paths which extend to the west of prominent tension cracks or fissures should be deemed hazardous and unsuitable for continued public access. Plates 1 and 2 present the results of our reconnaissance geologic mapping and indicate where fresh active margins of ground displacement were observed (red). The mapping of features in blue indicate where dormant (previous to 2016) landslides were observed.

Regarding public beach use, we identified several areas where piles of relatively fine talus debris have been deposited near the toe of bluff. Apparently, many areas of unstable upper terrace deposits and over-steepened bedrock produce slope failures composed of friable or relatively small size clasts typically less than 1 inch in size. In addition, we have identified two areas where large intact rock blocks (0.5 to 4 feet in diameter) have fallen from the local cliffs. Other areas of active rock block failure may exist where fallen blocks have been removed by wave action. New sources of rockfall are possible at locations that are not fully predictable. In general, we judge the rockfall hazard at the base of the local bluffs to range from low to high depending on specific bluff slope conditions.

We also observed signs of past dormant and active deep-seated landsliding in the vicinity of Jean Lauer Trail and adjoining bluffs to the southwest. This trail system essentially encompasses a very large and old landslide complex that has partially reactivated during the 2015-16 winter season. We observed open ground fissures along prominent graben features within the northern half of the landslide complex. Active landsliding has occurred along the southeastern edge of this landslide undermining a portion of an adjacent trail. Another portion of the landslide complex (northwestern corner) displays active deep-seated displacement of ground over an area of approximately 30,000 square feet. Active basal shear surfaces were observed at beach level in this vicinity.

Based primarily on local topography and observed signs of active displacement, we have delineated the apparent margin of this landslide complex on Plate 2. From observation of historic aerial photographs, we estimated that the eastern edge of this landslide is enlarging at a relatively slow average rate of 0.1 feet/year or 5 feet over a period of 50 years. Due to the imprecision in defining an accurate boundary around the entire landslide feature, we are recommending a 20 foot wide Long Term Hazard Zone adjacent to the apparent eastern margin of this feature.

TRAIL CONDITIONS

As noted above, the winter of 2015-2016 was especially damaging to the bluffs north of Pillar Point. During our site reconnaissance, we observed many areas of active landsliding including slivers of ground from 2 to 15 feet in width failing from the top of local bluffs. We estimate that failure surfaces of detached blocks typically daylight into the face of bluff in the range of 5 to 30 feet vertical from the current top of bluff. In addition, we observed signs of deep landsliding (northern portion of trail system with displacement depths greater than 40 feet) where low angle basal failure surfaces were evident near the base of the bluffs. We anticipate such deep-seated failures to move relatively slow (less than a few inches per day). In contrast, smaller detached blocks at

the top of bluff have the potential for catastrophic failure and near vertical fall distances on the order of 100 feet.

CONCLUSIONS AND RECOMMENDATIONS

Portions of the existing trail system along the top of the Pillar Point bluff have a high risk of being undermined by landsliding associated with bluff retreat. The 2015-2016 winter conditions have triggered significant bluff retreat, and areas that are now partially undermined will likely experience further instability and possible catastrophic failure in the upcoming months or following winter seasons. Other portions of the trail/path system located very close to the bluff may currently appear stable but are in fact next in line for slope failure. Given average potential long term top of bluff retreat on the order of 1.5 feet/year, we recommend consideration of closing off and abandoning various existing bluff trails/paths. The general locations of trail segments for consideration to be abandoned are those paths within the Short Term Hazard Zone (yellow) delineated on Plates 1 and 2. We suggest that specific trail segments to be closed be identified in the field with supplemental geotechnical input regarding the highest risk areas. There is a complex bluff top network of trails and casual paths that are difficult to accurately depict or recognize on the utilized base map resulting in the need for field identification of specific closures.

To replace trail segments that are to be closed, we recommend consideration of establishing new trails or utilizing existing alternative trails that are located east of the Short Term Hazard Zone (based on a 10-year life span). For the permanent California Coastal Trail (life span of 50 years or more), we recommend that the Long Term Hazard Zone (green) be observed. As a basic trail layout strategy for the top of the Pillar Point bluff vicinity, we recommend consideration of constructing observation points that are spurs off of a trunk trail with outlooks that observe at least the Short Term Hazard Zone. Observation points would ideally be surrounded on the west side by appropriate safety barriers (possibly a wood rail fence). It should be understood that spur trails to overlooks may require shortening and maintenance in the future as additional bluff retreat occurs. We recommend that geotechnical consultation be provided as a revised trail layout plan is prepared to verify that favorable observation points are selected.

Regarding safety of beach use, we recommend that additional signage be considered advising the public of the potential hazard of periodic rockfall from steep cliffs along with the advisability of staying well back from the base of bluffs. The presence of talus deposits or angular blocks of rock near the back beach should be understood as a warning sign of ongoing rockfall hazard.

LIMITATIONS

This geologic and geotechnical evaluation has been performed to provide technical advice to assist the County in determining appropriate actions. Our services have been limited to review of technical documents, photographic monitoring of the property, and visual site observations. Our opinions and conclusions are made in accordance with generally accepted principles and practices of the geotechnical profession. This warranty is in lieu of all other warranties, either expressed or implied.

Respectfully submitted,

COTTON, SHIRES AND ASSOCIATES, INC.

Ted Sayre
Principal Engineering Geologist
CEG 1795

David T. Schrier
Principal Geotechnical Engineer
GE 2334

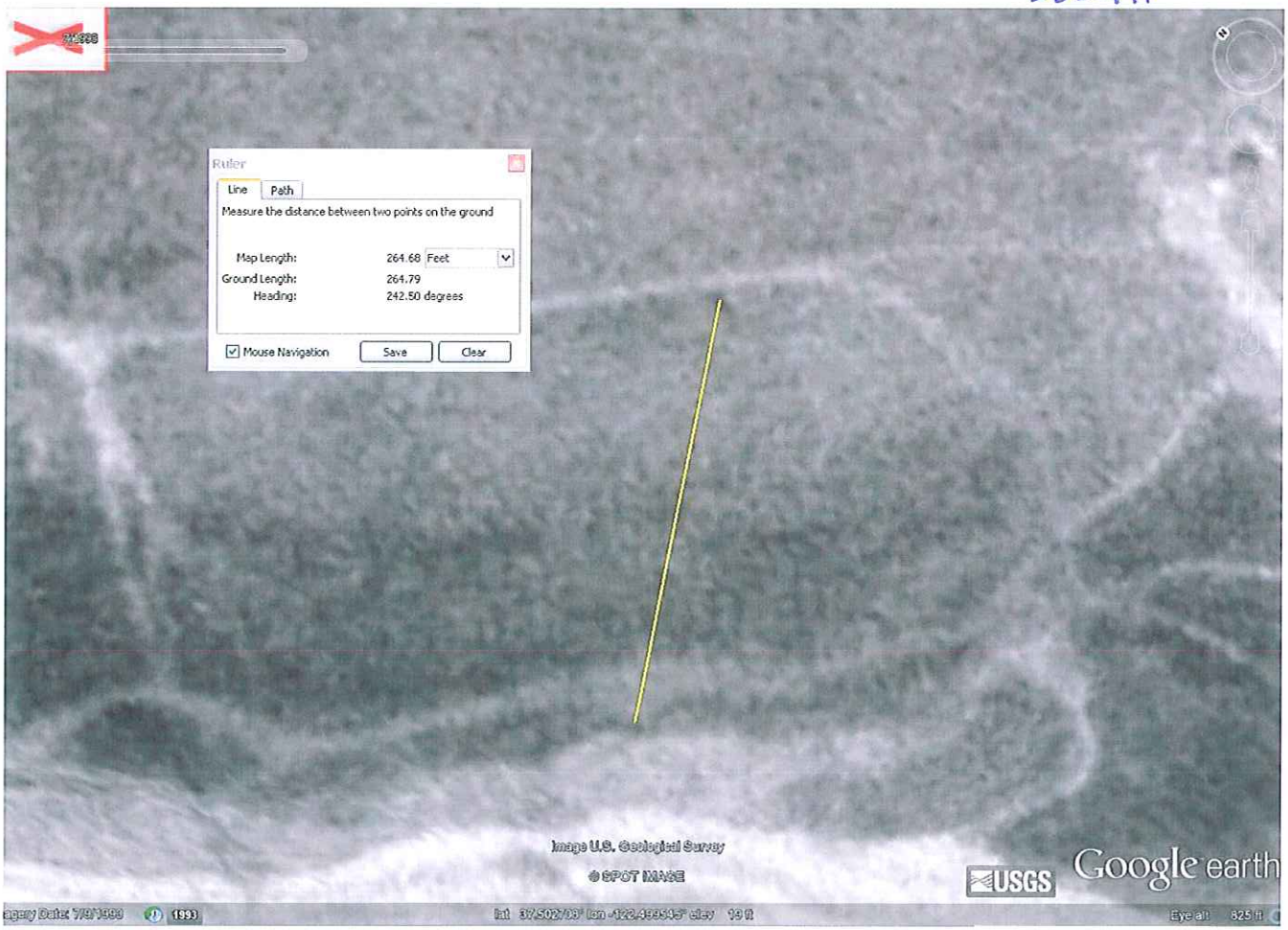
TS:DTS:kc

Attachments: Plates 1 and 2
Appendix A – Measurement Data

Appendix A


4/2016
1991
2016
Ruler
Line
Path
Measure the distance between two points on the ground
Map Length: 250.64 Feet
Ground Length: 250.65
Heading: 249.16 degrees
Mouse Navigation
Save
Clear
© SPOT IMAGE
USGS
Google earth
1993
Eye alt 825 ft

SOUTH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Line
Path
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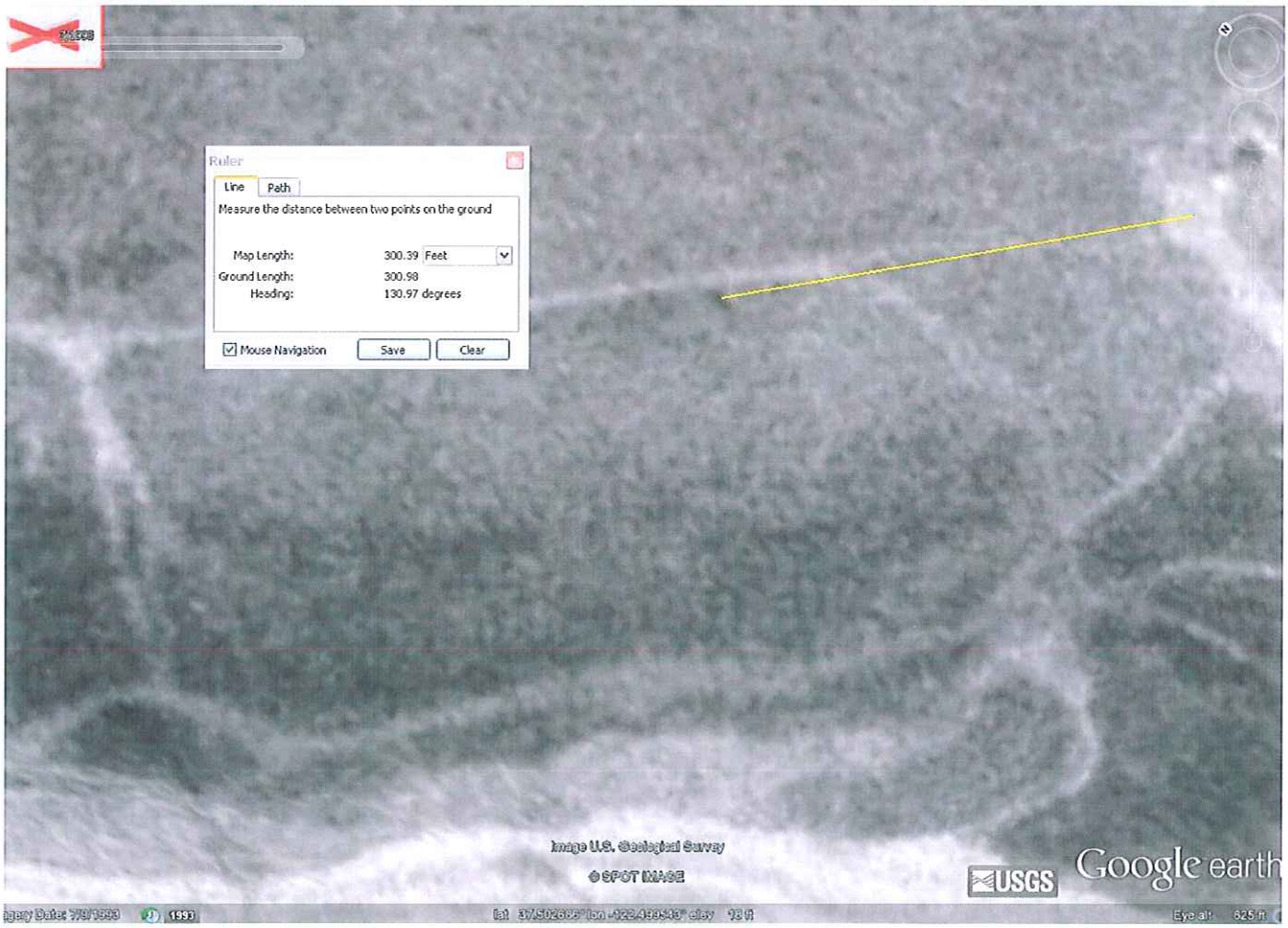
Map Length: 264.68 Feet
Ground Length: 264.79
Heading: 242.50 degrees
Mouse Navigation
Save
Clear
Image U.S. Geological Survey
© SPOT IMAGE
USGS
Google earth
1993
Eye alt 825 ft

SOUTH - CONTROL

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Line
Path
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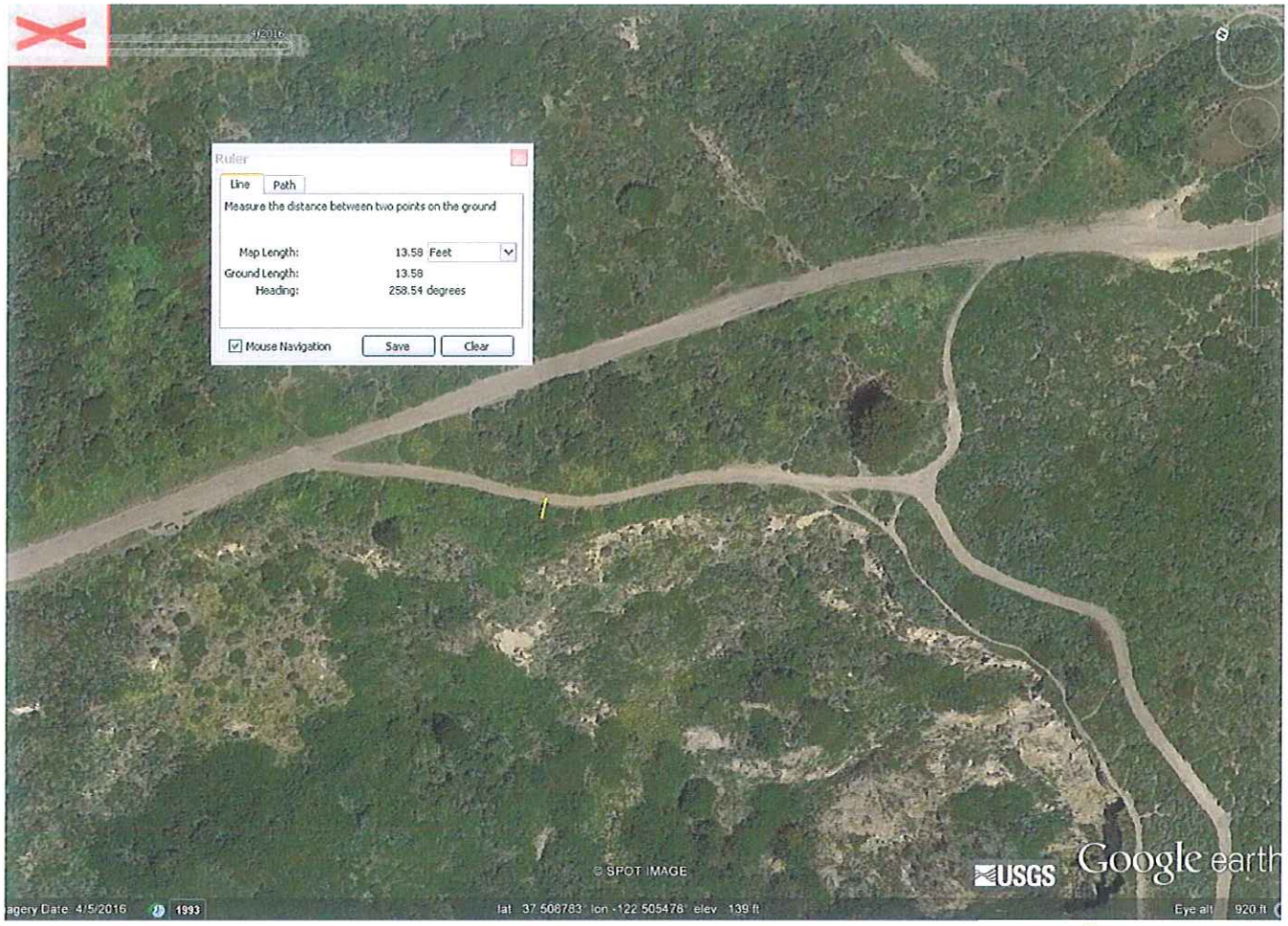
Mouse Navigation
Save
Clear
© SPOT IMAGE
USGS
Google earth
1993
lat 37.505732° lon -122.503753° elev 2 ft
Eye alt 959 ft

MIDDLE


Ruler
Line
Path
Measure the distance between two points on the ground
Map Length: 66.67 Feet
Ground Length: 69.45
Heading: 215.72 degrees
Mouse Navigation
Save
Clear
Image U.S. Geological Survey
© SPOT IMAGE
USGS
Google earth
1993

MIDDLE - CONTROL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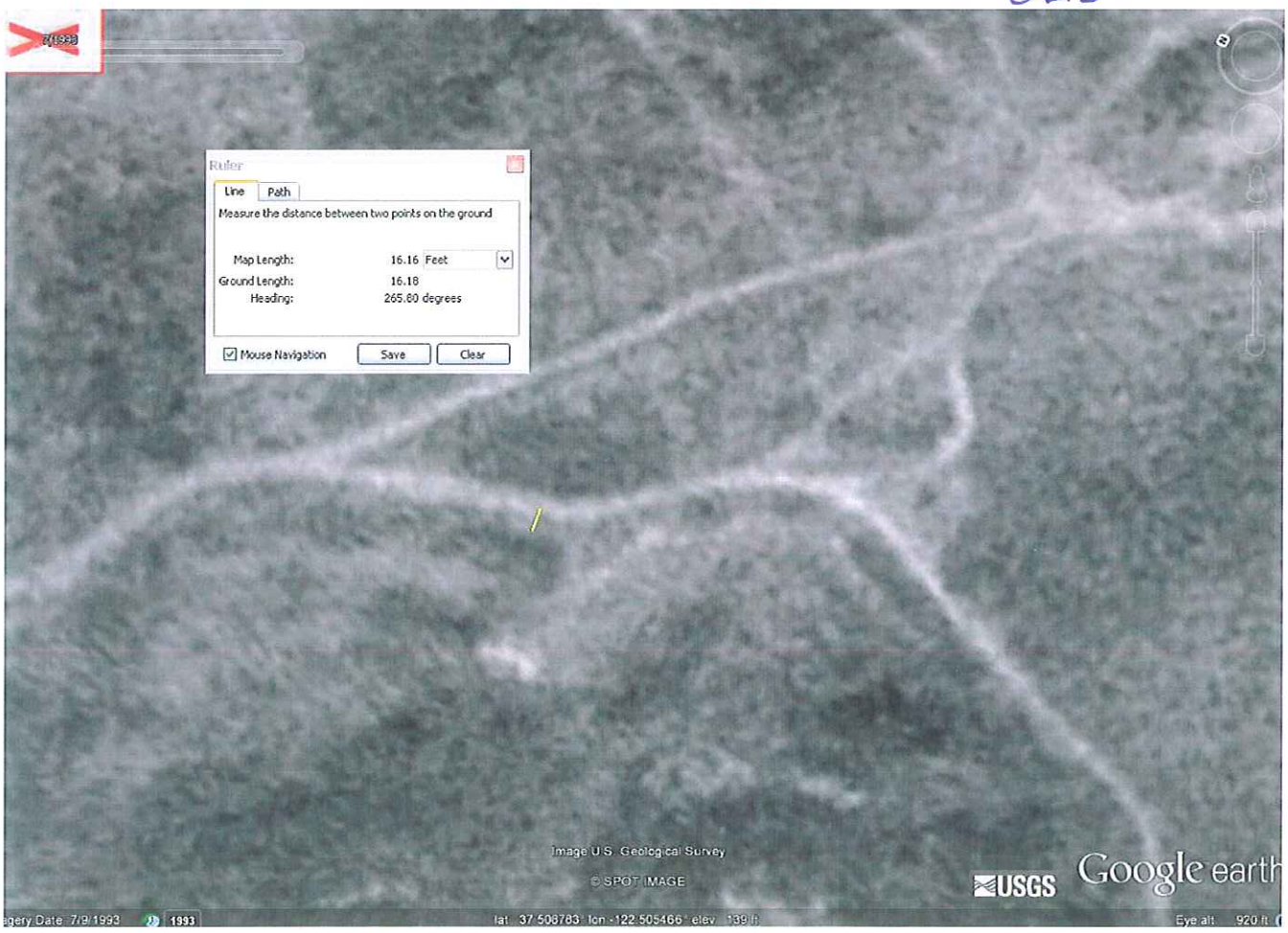
Mouse Navigation
Save
Clear
© SPOT IMAGE
USGS
Google earth
Imagery Date: 4/5/2016
1993
lat 37.508783 lon -122.505478 elev 139 ft
Eye alt 920 ft

OLS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Ground Length: 16.18
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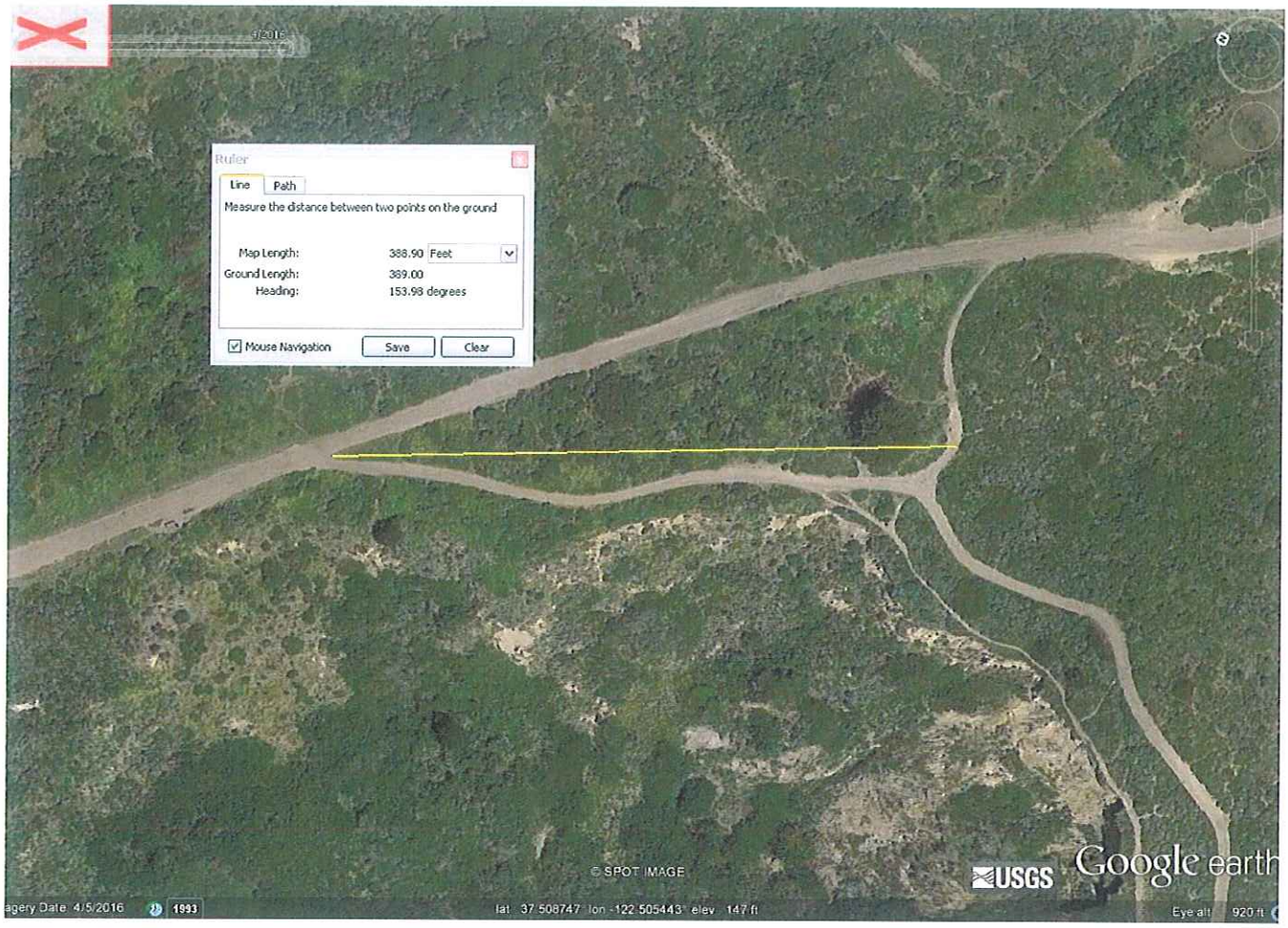
Image U.S. Geological Survey
© SPOT IMAGE
USGS
Google earth
1993
lat 37.508783 lon -122.505466 elev 139 ft
Eye alt 920 ft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Clear
© SPOT IMAGE
USGS
Google earth
Imagery Date: 4/5/2016
1993
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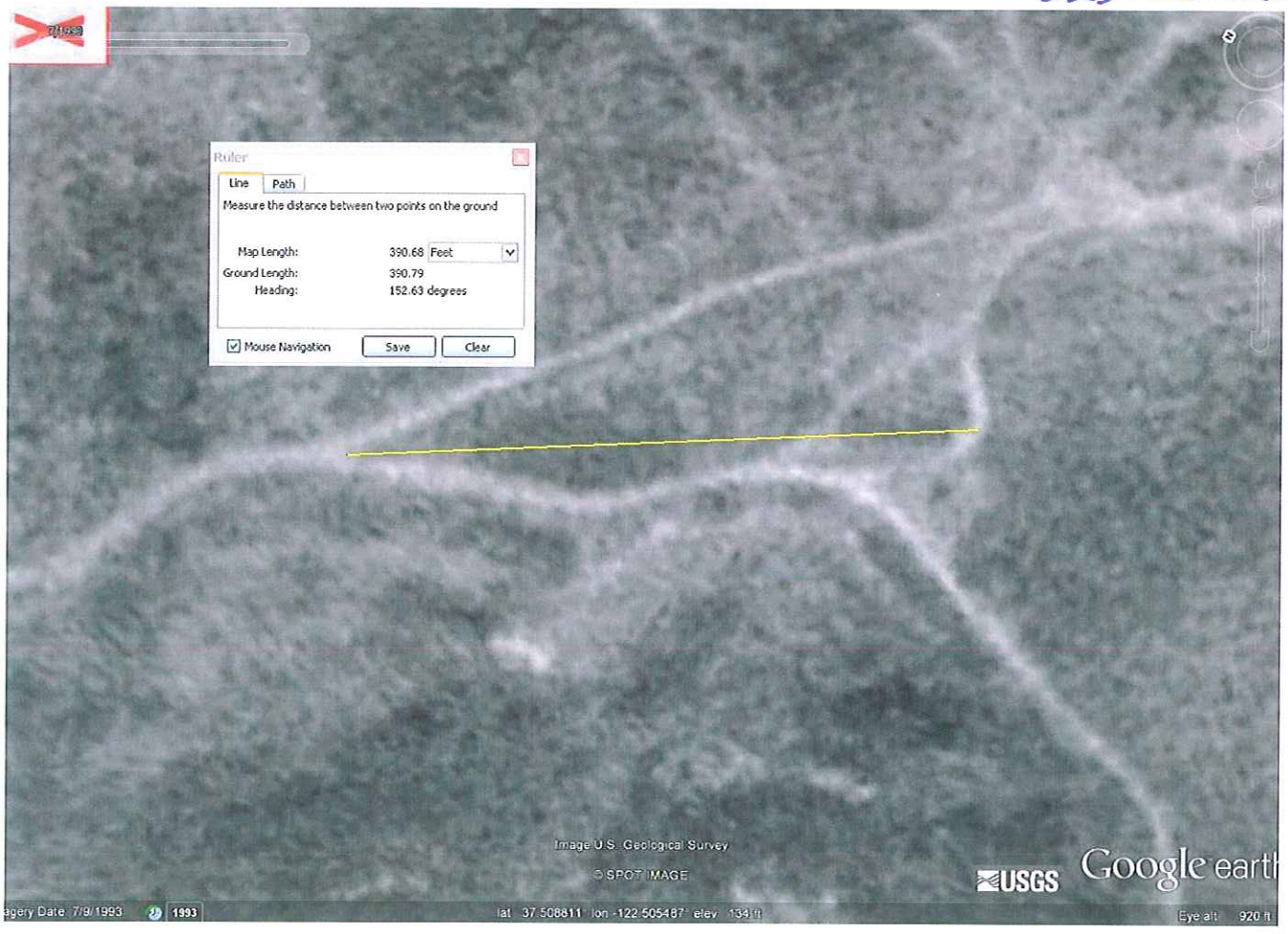
Eye alt 920 ft

OLS - CONTROL


Ruler
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Path
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Map Length: 390.68 Feet
Ground Length: 390.79
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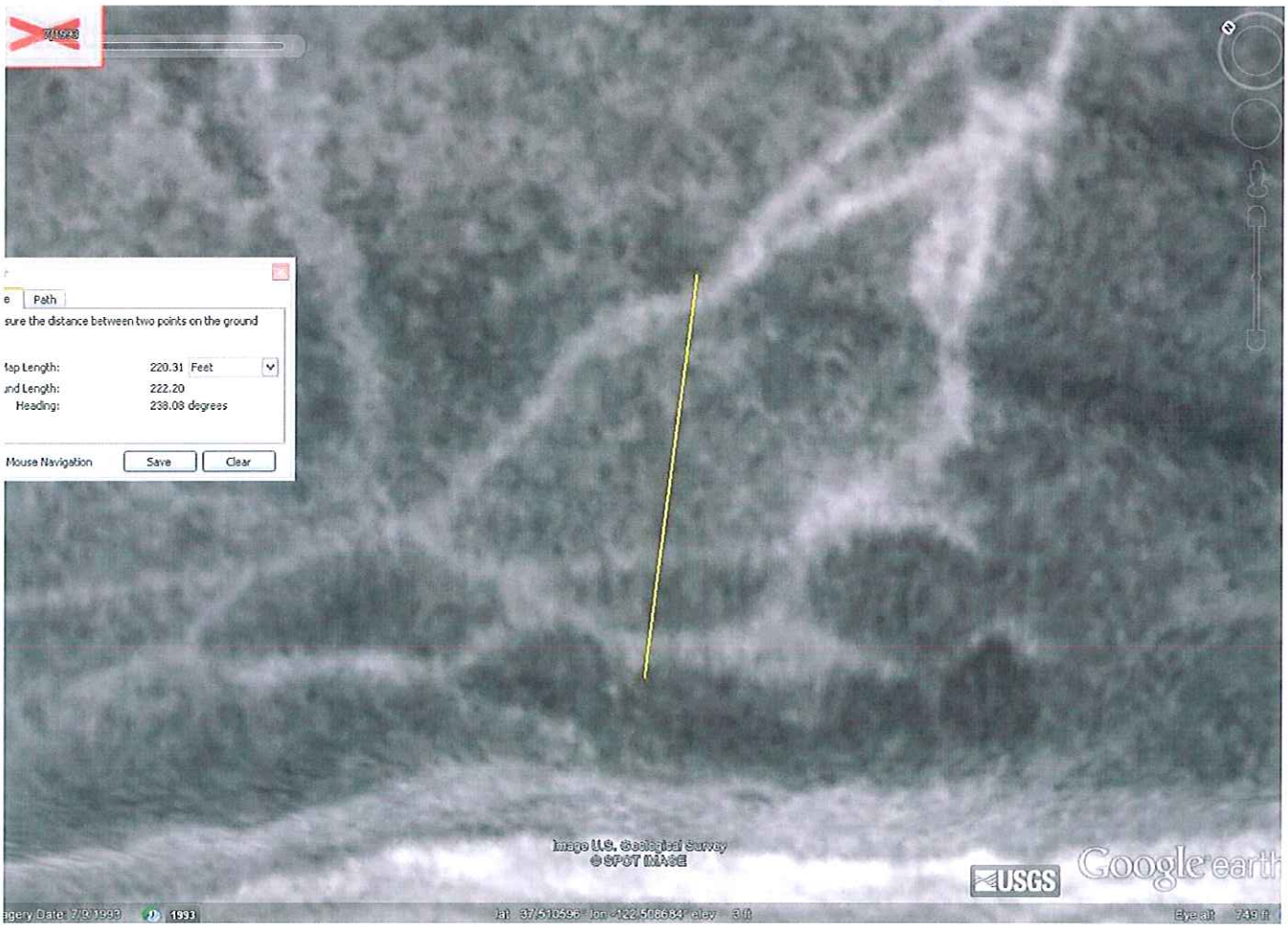
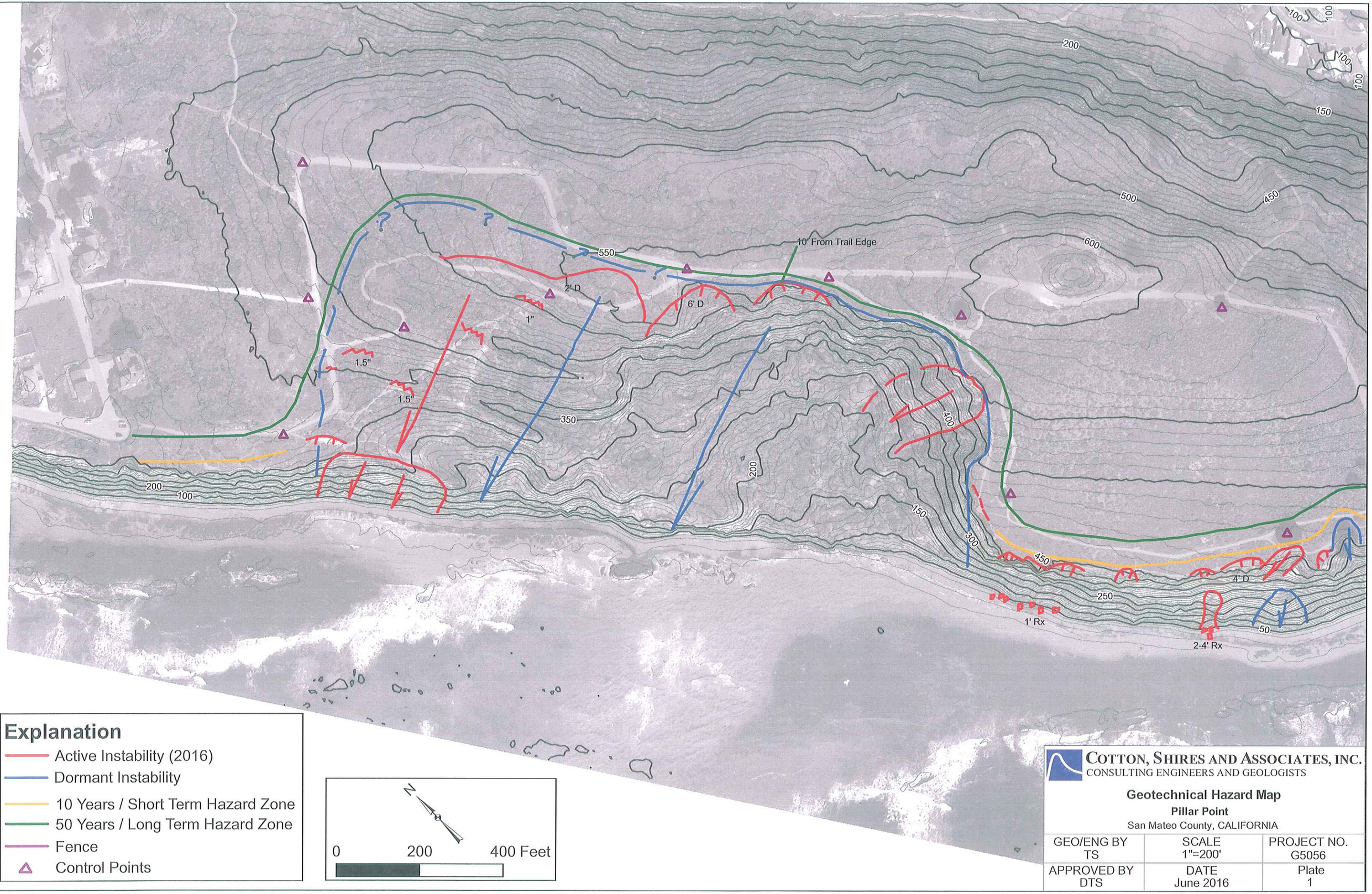
Mouse Navigation
Save
Clear
Image U.S. Geological Survey
© SPOT IMAGE
USGS
Google earth
Imagery Date: 7/9/1993
1993
lat 37.508811° lon -122.505487° elev 134 ft
Eye alt 920 ft


Path
ssure the distance between two points on the ground
Map Length: 208.98 Feet
ound Length: 210.68
Heading: 242.85 degrees
Mouse Navigation
Save
Clear
© SPOT IMAGE
USGS
Google earth
Imagery Date: 4/5/2016
1993
lat 37.510568° lon -122.508661° elev 4 ft
Eye alt 749 ft

NORTH


Path
sure the distance between two points on the ground
Map Length: 220.31 Feet
ound Length: 222.20
Heading: 238.08 degrees
Mouse Navigation
Save
Clear
Image U.S. Geological Survey
© SPOT IMAGE
USGS
Google earth
1993
Eye alt 749 ft



Explanation

- Active Instability (2016)
- Dormant Instability
- 10 Years / Short Term Hazard Zone
- 50 Years / Long Term Hazard Zone
- Fence
- Control Points

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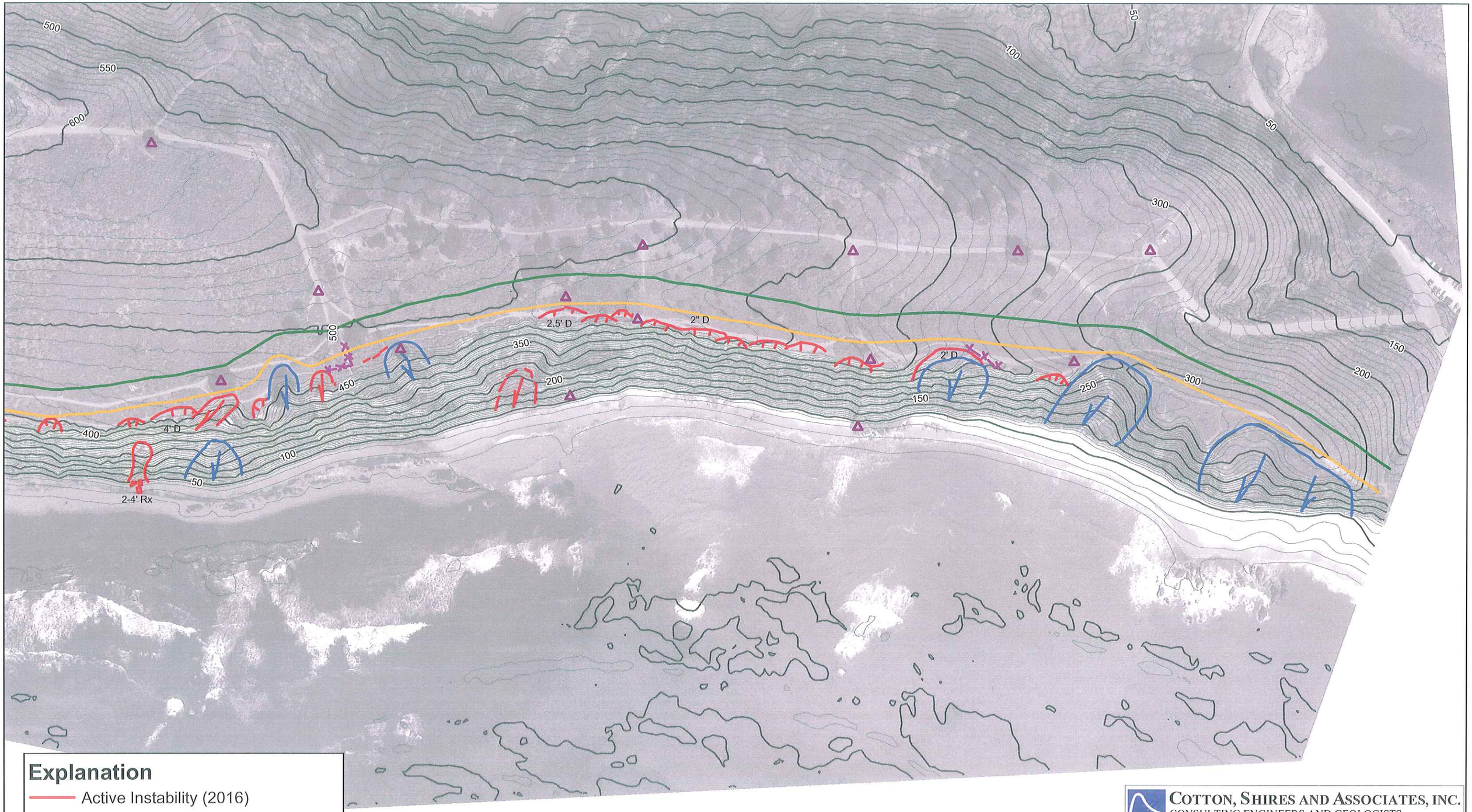
Geotechnical Hazard Map
Pillar Point
San Mateo County, CALIFORNIA

GEO/ENG BY TS	SCALE 1"=200'	PROJECT NO. G5056
APPROVED BY DTS	DATE June 2016	Plate 1



Explanation

- Active Instability (2016)
- Dormant Instability
- 10 Years / Short Term Hazard Zone
- 50 Years / Long Term Hazard Zone
- Fence
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N

0 200 400 Feet

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Geotechnical Hazard Map
Pillar Point
San Mateo County, CALIFORNIA

GEO/ENG BY	SCALE	PROJECT NO.
TS	1"=200'	G5056
APPROVED BY	DATE	Plate
DTS	June 2016	2