Sigma Prime Geosciences, Inc.
Effective Solutions

GEOTECHNICAL STUDY

MUKAEDA PROPERTY
CYPRESS AVENUE
MOSS BEACH, CALIFORNIA

PREPARED FOR:
RANDY MUKAEDA
105 ROSA FLORA CIRCLE
SOUTH SAN FRANCISCO, CA 94080

PREPARED BY:
SIGMA PRIME GEOSCIENCES, INC.
332 PRINCETON AVENUE
HALF MOON BAY, CALIFORNIA 94019

JUNE 2020

Sigma Prime Geosciences, Inc.
Effective Solutions

June 24, 2020

Randy Mukaeda
105 Rosa Flora Circle
South San Francisco, CA 94080

Subject: Geotechnical Report for Proposed Construction at Cypress Avenue, Moss Beach, California. (APN's: 037-221-020,030)
Sigma Prime Job No. 16-128; PLN2020-00070

Dear Mr. Mukaeda:

As per your request, we have performed a geotechnical study for the proposed construction at Cypress Avenue in Moss Beach, California. The accompanying report summarizes the results of our field study and engineering analyses, and presents geotechnical recommendations for the planned improvements.

Thank you for the opportunity to work with you on this project. If you have any questions concerning our study, please call.

Yours,

Sigma Prime Geosciences, Inc.

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1. INTRODUCTION

We are pleased to present this geotechnical study report for the proposed construction located at Cypress Avenue in Moss Beach, California, at the location shown in the vicinity map in Figure 1. The purpose of this investigation was to evaluate the subsurface conditions at the site, and to provide geotechnical design recommendations for the proposed construction.

1.1 PROJECT DESCRIPTION

We understand that you plan to construct a new two-story home. Structural loads are expected to be relatively light as is typical for this type of construction.

1.2 SCOPE OF WORK

In order to complete this project we have performed the following tasks:

- Reviewed published information on the geologic and seismic conditions in the site vicinity;
- Subsurface study consisting of a fault trench across the property
- Engineering analysis and evaluation of the subsurface data to develop geotechnical design criteria; and
- Preparation of this report presenting our recommendations for the proposed improvements.

2. FINDINGS

2.1 GENERAL

The site reconnaissance and fault trench investigation were performed in July, 2016. The fault trench was 89 feet long. 2 feet wide, and about 10 feet deep. It's location is shown in Figure 2, with a trench log and explanation in Figures 3 and 4.

2.2 SITE CONDITIONS

At the time of our study, the lot was undeveloped. The lot is very flat and covered with grass. There is a drainage ditch down the middle of the lot that drains runoff from the developed property to the south.

2.3 REGIONAL AND LOCAL GEOLOGY

Based on Brabb et. al. (1998), the site vicinity is primarily underlain by Pleistocene-age marine terrace deposits. These deposits are described as poorly consolidated sand and gravel. The marine terrace deposits are underlain by the mudstone of the Purissima formation. Based on the contact between the two units exposed in the nearby sea cliff, the depth to the Purissima formation is estimated to be about 25 feet.

2.4 SITE SUBSURFACE CONDITIONS

Based on the fault trench, the subsurface conditions consist of 1.5 feet of stiff clay topsoil, overlying about 6 feet of very stiff sandy clay. The topsoil has moderate to high plasticity, with a plasticity index of 24. Below the sandy clay, the soil grades sandier to a clayey sand. There are two gravelly clay marker beds. The stratigraphy is described in more detail in Section 3.2.1 below.

2.5 GROUNDWATER

Groundwater was encountered in the trench at a depth of 9.5 feet. Groundwater is not expected to have an impact on the construction.

2.6 FAULTS AND SEISMICITY

The site is in an area of high seismicity, with active faults associated with the San Andreas fault system. The closest active fault to the site is the San Gregorio-Seal Cove fault, located perhaps as close as about 10 feet from the northwest corner of the property. The best estimate of the fault location is discussed in Section 3.2.1 below.

Other faults most likely to produce significant seismic ground motions include the San Andreas, Hayward, Rodgers Creek, and Calaveras faults. Selected historical earthquakes in the area with an estimated magnitude greater than 6-1/4, are presented in Table 1 below.

TABLE 1
HISTORICAL EARTHQUAKES

Date	Magnitude	Fault	Locale
June 10, 1836	6.5[1]	San Andreas	San Juan Bautista
June 1838	7.0[2]	San Andreas	Peninsula
October 8, 1865	6.3[2]	San Andreas	Santa Cruz Mountains
October 21, 1868	7.0[2]	Hayward	Berkeley Hills, San Leandro
April 18, 1906	7.9[3]	San Andreas	Golden Gate
July 1, 1911	6.6[4]	Calaveras	Diablo Range, East of San Jose
October 17, 1989	7.1[5]	San Andreas	Loma Prieta, Santa Cruz Mountains

(1) Borchardt & Toppozada (1996)
(2) Toppozada et al (1981)
(3) Petersen (1996)
(4) Toppozada (1984)
(5) USGS (1989)

2.7 2019 CBC EARTHQUAKE DESIGN PARAMETERS

Based on the 2019 California Building Code (CBC) and our site evaluation, we recommend using Site Class Definition D (stiff soil) for the site. The other pertinent CBC seismic parameters are given in Table 2 below.

Table 2
CBC SEISMIC DESIGN PARAMETERS

S_S	S_1	S_{MS}	S_{M1}	S_{DS}	S_{D1}
2.124	0.869	2.124	null	1.416	null

Because the S_1 value is greater than 0.75, Seismic Design Category E is recommended, per CBC Section 1613.5.6. The values in the table above were obtained from a USGS software program which provides the values based on the latitude and longitude of the site, and the Site Class Definition. The latitude and longitude were 37.5200 and –122.5132, respectively, and were accurately obtained from Google Earth™. These same values can be obtained directly from maps in the CBC, however the scale of the map makes it impractical to achieve satisfactory accuracy. The map in the CBC was derived from the same work that led to the USGS software. The remaining parameters were also obtained by the same USGS program.

3. CONCLUSIONS AND RECOMMENDATIONS

3.1 GENERAL

It is our opinion that, from a geotechnical viewpoint, the site is suitable for the proposed construction, provided the recommendations presented in this report are followed during design and construction. Detailed recommendations are presented in the following sections of this report.

Because subsurface conditions may vary from those encountered at the location of our trench, and to observe that our recommendations are properly implemented, we recommend that we be retained to 1) Review the project plans for conformance with our report recommendations and 2) Observe and test the earthwork and foundation installation phases of construction.

3.2 GEOLOGIC HAZARDS

We reviewed the potential for geologic hazards to impact the site, considering the geologic setting, and the soils encountered during our investigation. The results of our review are presented below:

- Fault Rupture – See discussion below.

- Ground Shaking - The site is located in an active seismic area. Moderate to large earthquakes are probable along several active faults in the greater Bay Area over a 30 to 50 year design life. Strong ground shaking should therefore be expected several times during the design life of the structure, as is typical for sites throughout the Bay Area. The improvements should be designed and constructed in accordance with current earthquake resistance standards.

- Differential Compaction - Differential compaction occurs during moderate and large earthquakes when soft or loose, natural or fill soils are densified and settle, often unevenly across a site. Due to the stiff and dense nature of the underlying marine terrace deposits, the likelihood of significant damage to the structure from differential compaction is low.

- Liquefaction - Liquefaction occurs when loose, saturated sandy soils lose strength and flow like a liquid during earthquake shaking. Ground settlement often accompanies liquefaction. Soils most susceptible to liquefaction are saturated, loose, silty sands, and uniformly graded sands. Loose silty sands were not encountered at the site and are not typically present in the marine terrace deposits. Therefore, in our opinion, the likelihood of liquefaction occurring at the site is low.

3.2.1 Fault Study

The Seal Cove fault is thought to exist very close to the subject property. Therefore, prior to trenching, we performed a desk study to identify evidence of faulting in the area. The Seal Cove fault is a section of the San Gregorio fault system and is often identified in the study area as the San Gregorio fault. The Seal Cove fault is an active fault with up to 156 kilometers of cumulative total displacement (Clark, et al, 1984). The fault is considered capable of a magnitude of up to M7-1/4. (Simpson, et al, 1997). The slip rate of the fault is estimated to be at least 4.5 mm/yr, and possible as high as 7 to 10 mm/yr (Koehler et al, 2005). The recurrence interval between maximum seismic events is estimated to be 1037 to 2205 years (Koehler et al, 2005).

We reviewed 16 fault studies on neighboring properties. A parcel map of the area, showing the locations of the studies, and the associated fault trenches and features identified as fault traces, is shown in Figure 6. The 16 fault studies, numbered in the reference section from 1 to 16, are identified on the corresponding parcels.

As Figure 6 shows, the most likely main trace of the fault borders the west side of the neighborhood, as identified in 3 of the studies (Numbers 9, 12, and 13). The other identified fault traces to the east are scattered and discontinuous, with no obvious major fault characteristics.

A study of the trench logs in all 16 studies reveals a striking difference between the 3 studies along the main trace, and the remaining studies to the east. The trench logs on the properties to the east describe somewhat vague features in which the suspected fault showed little or no evidence of major displacement. For example, the trench study number 8 shows the fault as a narrow feature with no real description. (The description is limited to, “Fault trace oriented N 20^{O} N [sic]”.) On either side of the fault, the soil consists of sandy clay marine terrace material, with no difference in lithology. Every other fault study on the properties to the east has similar vague descriptions of the fault, with no change in lithology from one side of the fault to the other. At the corner of Alton Avenue and Park Way, two different studies were performed (study numbers 2 and 10), with no correlation in the locations of identified fault traces. In addition, the trends of the faults differed by 20 degrees. In both studies, the lithology did not change across the fault traces. The width of the fault in some cases was 2 inches.

Sigma Prime performed studies on two lots to the east, numbers 15 and 16. In both we identified a minor fault trace with up to 1 foot of vertical off-set. It should be noted that for study number 15, which we performed on the same site for study number 8, we identified an obvious fault trace that the previous study by others did not identify. We also could not find any evidence of the fault that they did identify, even though our trench was just a few feet away from the older trench.

The 3 studies to the west included fault trench logs with completely different findings. In all cases, the identified fault was much wider, measured in feet, as opposed to, typically, 2 to 4 inches. In addition, the lithology on one side of the fault was different from the lithology on the other side.

The most detailed study was performed by Simpson et al (1997) (study #12), in a study that was funded by the National Earthquake Hazard Reduction Program (NEHRP). The research group that performed the study is among the world leaders in fault evaluations. One of the most important findings of their study, besides identifying timing and maximum potential of the fault, was their conclusion that the mapped fault trace should be moved to the west, where it is shown in Figure 6. They dismissed the other studies to the east, in the following paragraph on page 1161:

> *Prior to this study, the precise location of the San Gregorio Fault within the Seal Cove gap was poorly constrained because of a lack of a large, distinct scarp or other well-defined geomorphic features. In this study, we refine the location of the fault across the gap based on the results of our trenching study, a compilation of previous trenching studies, and detailed assessment of subtle geomorphic features. Previous mapping of the San Gregorio fault shows the fault as a straight projection across the Seal Cove gap between the large east-facing scarps to the north and south…. Our review of consultant reports, however, suggests that the fault arcs westward across the topographic gap at Seal Cove. This alignment is coincident with a 1.5- to 6-m-high east-facing scarp that can be traced across the entire gap. Our trench, as well as previous consultant trenches across this scarp, shows a distinct lithologic break across the fault indicative of significant cumulative displacement. Conversely, consultant trenches across the previously mapped straight-line projection of the fault revealed only fractures and secondary faults with minor displacements that do not juxtapose dissimilar strata.*

The Simpson paper lists only 2 consultant studies in their reference list among the 13 other studies we reviewed. The 11 additional studies that we obtained only confirmed their conclusions in every case.

Figure 6 also shows the original location of the main fault trace, based on the Alquist-Priolo Special Studies Zone map, compiled by the State of California. This is the location that Simpson et al concluded was erroneous. Further evidence to support the incorrect placement of the fault occurs in many of the reports we reviewed. As Figure 6 shows, several of the trenches by other consultants should have crossed the main trace of the fault. Most notably, the property along Cypress Avenue (Reference #7) should have revealed a major seismic feature. Instead, the trench log describes minor, 2 to 4 inch wide fractures with no changes in lithology.

Based on our desk study, it appears very likely that the Seal Cove fault follows the westward trend shown in Figure 6. The features mapped to the east are ground fractures and other minor ground disruptions likely associated with past seismic events. Some of these features may be the result of no more than a few inches of displacement at a time when the causative seismic event resulted in several feet of displacement along the main fault trace. Future events may produce similar ground disruptions in the neighborhood, either at the same locations, or at other, new locations.

Fault Trench On Subject Property

We excavated an 89-foot long by 10-foot deep trench across the subject property, at the location shown in Figure 2. A log of the trench is shown in Figure 3, with lithologic descriptions in Figure 4, and photographs in Figures 5a through 5c. We found evidence of a minor trace fault in the west end of the trench. The trench revealed a soil column entirely within the marine terrace deposit. There was a well-developed soil column, with a distinct dark brown A-horizon and a distinct orange-brown B-horizon (Units 1 and 3 in the trench log). Below the B-horizon (unit 4), the soil is grades sandier, to a sandy clay, consistent with the marine terrace deposits.

Besides the three main lithologic units, there is a thin gravelly clay marker bed that extends across most of the trench. It pinches out before it makes contact with the fault trace and is undisturbed. The fault trace feature consists of a tension crack that is in-filled with topsoil from above and an olive-brown clay. There is no vertical offset of the adjacent lithologic units and differing lithologic units are not juxtaposed. There are no shears or slickensides in the clay. This feature appears to be a minor secondary fault trace.

Based on our studies, there is no major trace of the Seal Cove fault on the property. However, there is a minor trace that should require a 10-foot offset. The main trace is estimated to be as little as 10 feet west of the northwest corner of the property, as shown in Figure 6. The trace shown in Figure 6 is derived by connecting the mapped traces located in trenches to the north and south. The location is very approximate, since the trenches were somewhat far away. However, our fault trench on the property clearly showed that the main trace is not on the property.

3.3 EARTHWORK

3.3.1 Clearing & Subgrade Preparation

All deleterious materials, including topsoil, roots, vegetation, designated utility lines, etc., should be cleared from the building area. The actual stripping depth required will depend on site usage prior to construction, and should be established by the Contractor during construction. Topsoil may be stockpiled separately for later use in landscaping areas.

3.3.2 Compaction

Scarified surface soils that will support foundations should be moisture conditioned to 3-5 percent above the optimum moisture content and compacted to at least 95 percent of the maximum dry density, as determined by ASTM D1557-78. All trench backfill should also be moisture conditioned to 3-5 percent above the optimum moisture content and compacted to at least 90 percent of the maximum dry density. The upper 3 feet of trench backfill below foundations or paved areas should be compacted to 95 percent of the maximum dry density.

3.3.3 Surface Drainage

The finish grades should be designed to drain surface water away from foundations and slab areas, to suitable discharge points. Slopes of at least 2 percent within 10 feet of the structures are recommended, as per the CBC. Ponding of water should not be allowed adjacent to the structure.

3.4 FOUNDATIONS

We recommend a mat slab foundation. The mat slab should be at least 5 inches thick and underlain by at least 12-inches of non-expansive granular fill. Where floor wetness would be detrimental, a vapor barrier, such as Stego wrap or equivalent should be used. The slabs should be structurally tied to the perimeter footings, either as a continuous pour or separate pours with dowels connecting the two, or an equivalent method.

All slabs should be reinforced to provide structural continuity and to permit spanning of areas of earthquake-induced ground deformation. The slabs should be capable of spanning 10 feet, point to point, and should cantilever a minimum of 3 feet.

The perimeter of the slab should be thickened with footings at least 15 inches wide and extending at least 6 inches below the cut for the interior slabs. Load bearing interior walls should also be founded on thicker slab sections of the same dimensions. The excavation for the footings may slope up to the interior slabs at a slope of 1:1. An allowable bearing capacity of 2500 psf may be used in design.

3.4.1 Lateral Loads

Resistance to lateral loads may be provided by passive pressure acting against the sides of the footings, below a depth of 1 foot. We recommend that an equivalent fluid pressure of 350 pcf be used in design. A skin friction value of 0.3 may be used.

3.4.2 Garage Slab-on-Grade

The garage slab-on-grade should be constructed as a free-standing slab, structurally isolated from surrounding grade beams or footings. We recommend that the slab-on-grade be underlain by at least 6 inches of non-expansive fill. The fill should consist of ½- to ¾-inch clean crushed rock. Where floor wetness would be detrimental, a vapor barrier, such as Stego wrap or equivalent should be used.

3.5 CONSTRUCTION OBSERVATION AND TESTING

The earthwork and foundation phases of construction should be observed and tested by us to 1) Establish that subsurface conditions are compatible with those used in the analysis and design; 2) Observe compliance with the design concepts, specifications and recommendations; and 3) Allow design changes in the event that subsurface conditions differ from those anticipated. The recommendations in this report are based on a limited number of borings. The nature and extent of variation across the site may not become evident until construction. If variations are then exposed, it will be necessary to reevaluate our recommendations.

4. LIMITATIONS

This report has been prepared for the exclusive use of the property owner for specific application in developing geotechnical design criteria for the currently planned construction at Cypress Avenue in Moss Beach, California. We make no warranty, expressed or implied, except that our services were performed in accordance with geotechnical engineering principles generally accepted at this time and location. The report was prepared to provide engineering opinions and recommendations only. In the event that there are any changes in the nature, design or location of the project, or if any future improvements are planned, the conclusions and recommendations contained in this report should not be considered valid unless 1) The project changes are reviewed by us, and 2) The conclusions and recommendations presented in this report are modified or verified in writing.

The analyses, conclusions and recommendations contained in this report are based on site conditions as they existed at the time of our study; the currently planned improvements; review of previous reports relevant to the site conditions; and laboratory results. In addition, it should be recognized that certain limitations are inherent in the evaluation of subsurface conditions, and that certain conditions may not be detected during a study of this type. Changes in the information or data gained from any of these sources could result in changes in our conclusions or recommendations. If such changes do occur, we should be advised so that we can review our report in light of those changes.

5. REFERENCES

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N

0 1000

Scale - feet

Sigma Prime Geosciences, Inc.	Figure 1
	Date: 12/19/17
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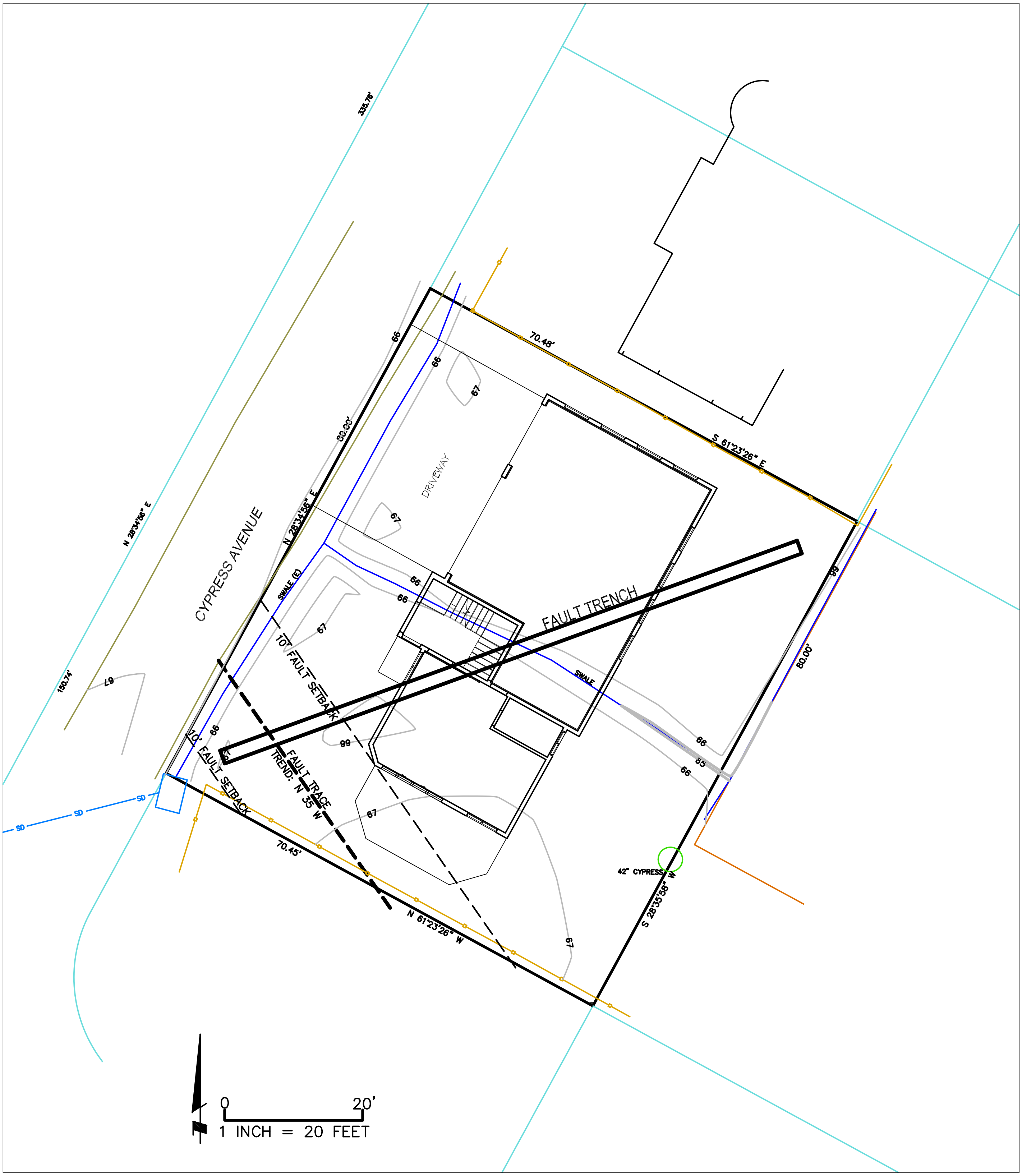
Location Map

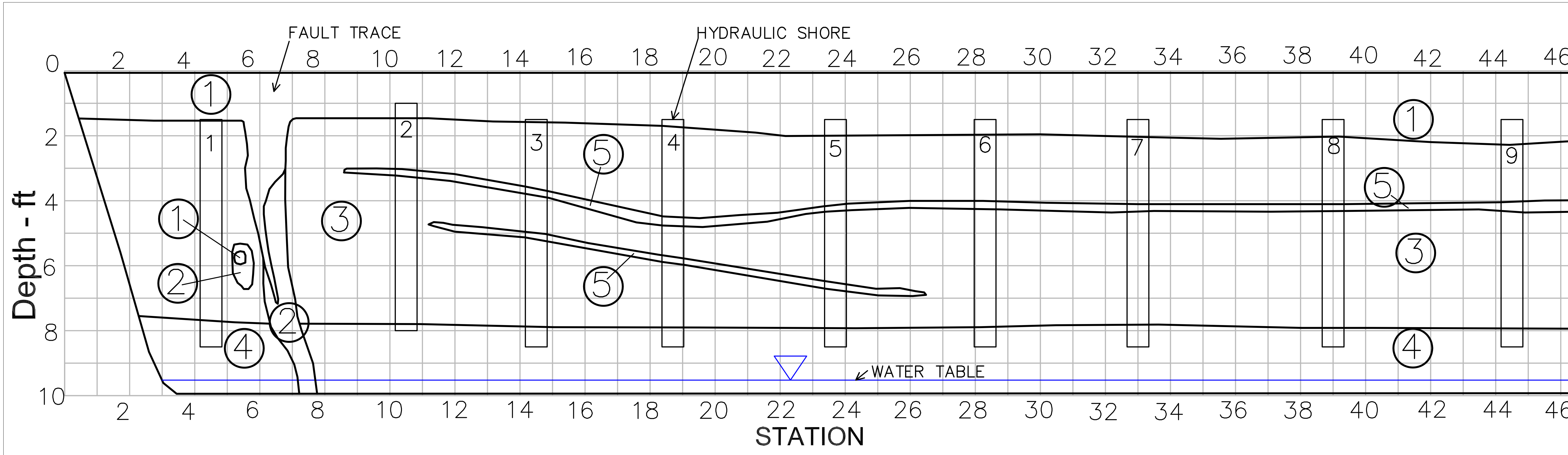
Mukaeda Property, Cypress Ave., Moss Beach

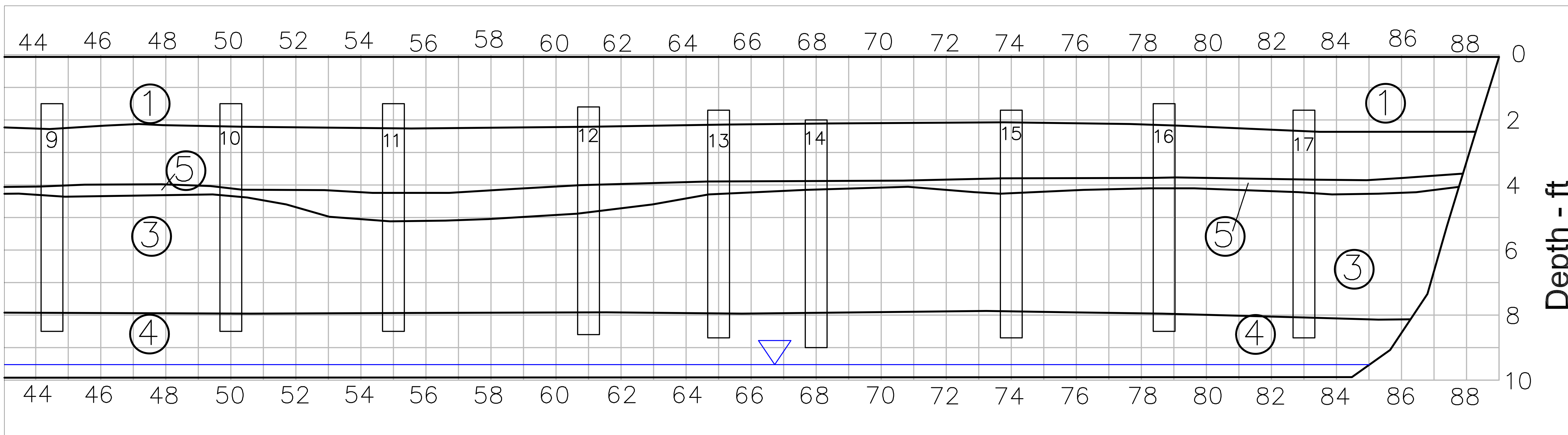


Sigma Prime Geosciences, Inc.	Figure	2
	Date:	12/19/17
	Job No.:	16-128

Site Map

Mukaeda Property, Cypress Ave., Moss Beach





1"=3'   LOOKING AT NORTH WALL: TRENCH TRENDS N 70 E

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Figure	3
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Trench Log

Mukaeda Property, Cypress Ave., Moss Beach

EXPLANATION

1. CLAY (CL) (Topsoil, A-Horizon): dark brown; moist. 1" to 3" caliche at base of unit.

2. CLAY (CL): olive-brown; very stiff; moist. No shears or slickensides.

3. SANDY CLAY (CL) (B-Horizon): yellowish brown; very stiff; moist.
   Gradual change to:

4. CLAYEY SAND (SC) (C-Horizon): yellowish brown; dense; moist.

5. GRAVELLY CLAY (CL) : orange-brown; very stiff; moist. (Marker Bed)

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Fault Trench Explanation
Mukaeda Property, Cypress Ave., Moss Beach

Looking East

Looking West

Sigma Prime Geosciences, Inc.	Figure	5a
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Photos

Mukaeda Property, Cypress Ave., Moss Beach

Fault trace at Shore #1

Fault trace at Shore #1

Sigma Prime Geosciences, Inc.

Figure	5b
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Photos

Mukaeda Property, Cypress Ave., Moss Beach

Fault trace at Shore #1

Typical Lithology at Shore #10

Sigma Prime Geosciences, Inc.	Figure	5c
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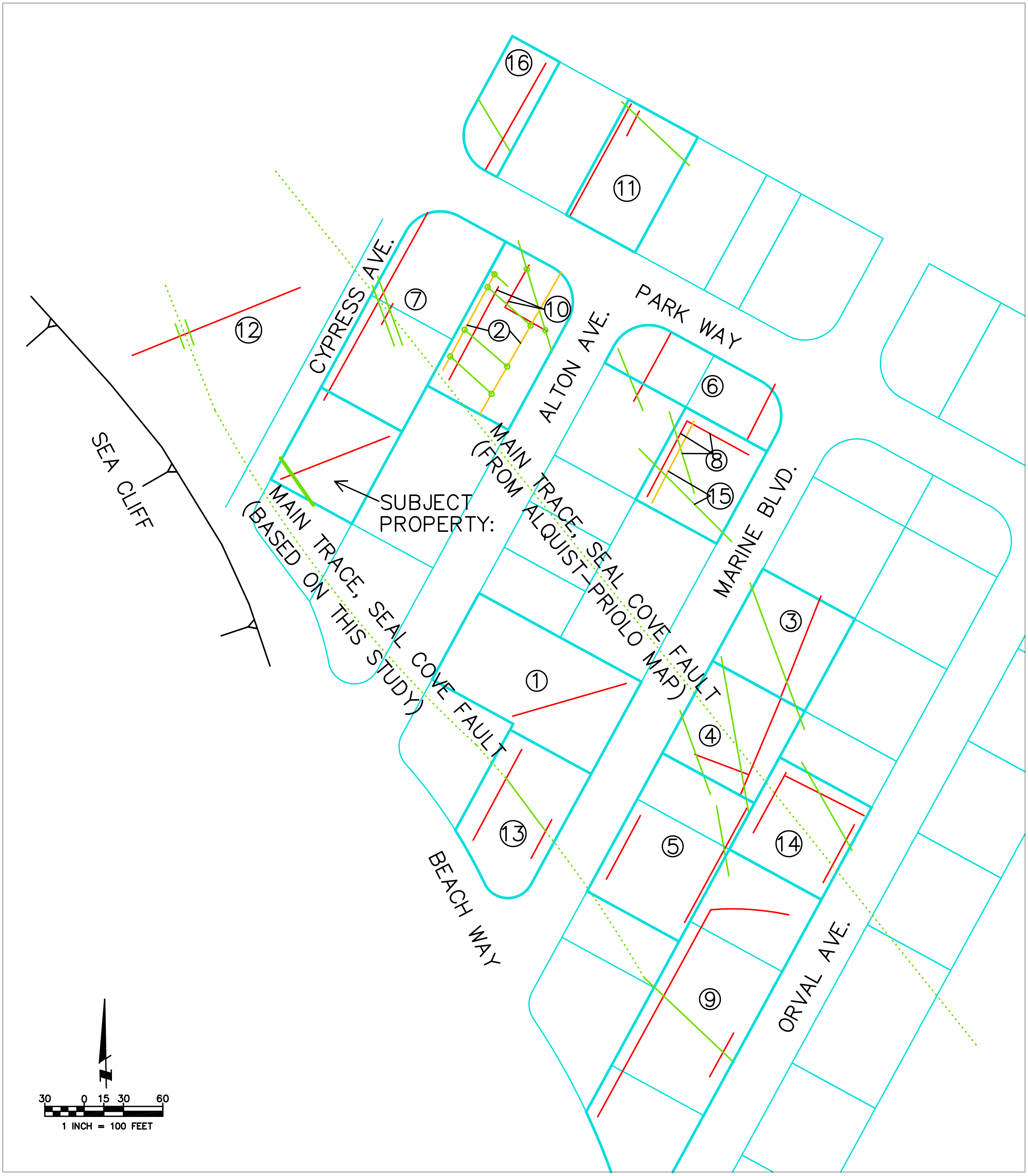
Photos

Mukaeda Property, Cypress Ave., Moss Beach



EXPLANATION

or:	Fault Trench
	Feature Identified as a Fault Trace
3	Consultant's Report in Reference List

Sigma Prime Geosciences, Inc.

Figure	6
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Faulting in Study Area

Mukaeda Property, Cypress Ave., Moss Beach