Crawford & Associates, Inc.
Geotechnical Engineering, Design and Construction Services
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October 9, 2017
CAInc File No. 16-337.2

Mr. Howard Dashiell, PE
Mendocino County Department of Transportation
340 Lake Mendocino Drive
Ukiah, CA 95482

Subject: **Geotechnical Memorandum**
Branscomb Road (CR 429) Failure at MP 17.21
Mendocino County, California

Dear Mr. Dashiell,

Crawford & Associates, Inc. (CAInc) prepared this Geotechnical Memorandum for the Branscomb Road Failure at Milepost (MP) 17.21 in accordance with Project Work Order No. 2 under Mendocino County Board of Supervisors (BOS) Agreement 16-099 and Mendocino County Department of Transportation (MCDOT) Agreement 16-0048, made on December 06, 2016. This memo provides repair alternatives and recommendations for permanent road repair with a soldier pile tieback wall.

Please contact us if you have questions or require additional information.

Sincerely,

Crawford & Associates, Inc.,

Reviewed By,

Ryan Houghton, PE
Project Engineer

Rick Sowers, PE, CEG
Principal

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1 INTRODUCTION

This Geotechnical Memorandum summarizes the results of our geotechnical investigation completed at the Branscomb Road (CR 429) Failure at MP 17.21. This work was completed in accordance with Work Order No. 2 agreement with Mendocino County Department of Transportation (MCDOT) and summarizes the site earth materials and their properties, evaluates alternative repair options, and provides recommendations for permanent repair with a soldier pile tieback wall.

2 GEOTECHNICAL SERVICES

To prepare this report, Crawford & Associates (CAInc):

- Discussed the project with MCDOT.
- Reviewed published topographic, geologic, and landslide mapping of the site.
- Reviewed MCDOT survey data, received via electronic transfer on June 5, 2017.
- Performed surface geologic reconnaissance of the site and immediate vicinity.
- Drilled and sampled three roadway-level test borings on June 13-14, 2017.
- Performed laboratory testing and geotechnical engineering analysis in support of the recommendations contained herein.

3 PROJECT DESCRIPTION

3.1 PROJECT LOCATION

The project is located on Branscomb Road (CR 429) at MP 17.21, approximately 8 miles southwest of Laytonville, off of US 101. Site latitude is approximately 39.625104° and longitude -123.561813°, per Google Earth. See Figure 1 for Vicinity Map.

3.2 SITE DESCRIPTION

Branscomb Road at this location traverses a steep (generally >1.5H:1V), southeast-facing slope, approximately 40 feet above the South Fork Eel River. The river at this location flows southwesterly and makes sharp turn at the site, impacting the bank and undercutting the slope.

The road is a paved, two-lane section approximately 24 feet wide and established in a combination cut/fill section. Inboard cuts are approximately 10-15 feet high. Approximate site elevation is 1760 feet per USGS topographic mapping; a topographic survey by MCDOT [1] used an assumed elevation 1000.00 (CP-1) for this project.

The subject road failure has resulted in the complete loss of the outboard fill section and paved shoulder, as well as some minor encroachment into the travel lane, for a distance of approximately 74 feet The head scarp is nearly vertical and up to about 10 feet high; the slope then flattens to approximately 1.5:1 down to the river.

The road gradient, based on the topography survey provided by MCDOT, descends about 4.5% west to east, with a cross slope of nearly 10% from the inboard to out board lane. Surface runoff is collected west of the site in an inboard, unlined ditch that flows into a cross culvert that discharges just west of the slide. The inboard ditch continues through the slide area and we observed a small culvert outlet at

[1] CAD drawings of Topographic Survey completed by MCDOT received electronically on 06/05/2017

the east end of the slide and downslope from the road, but no inlet could be located. There is an asphalt berm along the outboard lane that collects sheet flow from the road and conveys it east of the site.

No sloughing of the inboard cut slope was observed at the site, but the inboard ditch contained significant amounts of debris reducing its capacity and possibly directing sheet-flow across the road (toward the failure area) during periods of high intensity rainfall. There was also some asphalt cracking within the outboard lane, which would have led to additional water infiltrating into the failed fill section. A large downed tree within the slide area may have contributed to the slope failure by removing support for the fill section.

See Figure 1 for the regional topography in the vicinity of the site and Figure 2 for local site topography and location of the borings.

4 GEOLOGIC SETTING

4.1 REGIONAL GEOLOGY

The project site lies within the Coast Ranges Geomorphic Province, characterized by a series of northwest trending mountain ranges sub-parallel to the San Andres Fault. The Coast Ranges is composed of thick Mesozoic and Cenozoic sedimentary strata. The northern Coast Ranges are dominated by the irregular, knobby, landslide-topography of the Franciscan Complex. Regional geologic mapping[2] shows the site as being underlain by Jurassic-Cretaceous age Franciscan Formation (KJf) rock, which consist of sandstone, shale, chert, and conglomerate typically within a highly sheared matrix.

See Figure 3 for a Regional Geologic Map.

4.2 SITE GEOLOGY AND LANDSLIDE MAPPING

Local geologic and landslide mapping of the Cahto Peak[3] and Sherwood Peak[4] 7.5-minute quadrangle maps show the site as being underlain by Tertiary-Cretaceous age Franciscan Mélange (fm) rock, which is described as a pervasively sheared argillaceous (shale) matrix surrounding individual blocks of sandstone, greenstone, chert, schist, serpentine, and serpentinized ultramafic rocks of varying size. The sheared shale matrix is noted as being unstable and prone to landsliding. Just east of the site is a thrust fault that serves as the boundary between the Franciscan Mélange rock and Coastal Belt Franciscan (TKfs) rock. The Coastal Belt unit is described as well-consolidated, clastic sedimentary rocks (sandstone, shale, and conglomerate). Serpentine and serpentinized ultramafic rocks are mapped approximately 1000 to 2000 feet west of the site. The rock observed within the cut-slope at the site was typically very intensely fractured, weathered to decomposed sandstone and shale, consistent with the mapping of the area.

There are no mapped landslides within the immediate site vicinity. Several landslides of varying size are mapped west of the site and are predominately translational/rotational in nature. No current slope

[2] Jennings, C.W. and Strand, R.G. (1960), Geologic Map of California: Ukiah Sheet, California Division of Mines and Geology, Scale 1:250,000
[3] Kilbourne, R.T. (1983), Geology and Geomorphic Features Related to Landsliding, Cahto Peak 7.5' Quadrangle, OFR 83-39, California Division of Mines and Geology, Scale 1:24,000
[4] Kilbourne, R.T. (1983), Geology and Geomorphic Features Related to Landsliding, Sherwood Peak 7.5' Quadrangle, OFR 83-38, California Division of Mines and Geology, Scale 1:24,000

distress was observed beyond the project slide limits; however, small amounts of rock slope protection (RSP) have been placed on the cut slope at several locations within a few hundred feet of the site. We did not observe evidence of springs or large-scale, global instability at the site.

See Figure 4A and 4B for site Landslide and Geologic Map and corresponding legend.

4.3 FAULTS AND SEISMIC ACTIVITY

Based on California Geologic Survey (CGS) fault data[5], the nearest faults to the site are unnamed Pre-Quaternary faults (no activity in last 1.6 million years) located approximately 2500 feet southeast and southwest of the site. The nearest active fault (defined as surface displacement within the last 11,000 years) is a part of the north section of the Maacama Fault Zone, located approximately 4.5 miles east of the site. The site is located in an area with risks of strong seismic ground motions, having a peak ground acceleration (PGA) of approximately 0.59g[6].

See Figure 5 for Fault Activity Map.

5 SUBSURFACE CONDITIONS

5.1 EXPLORATION

CAInc retained Geo-Ex Subsurface Exploration to drill and sample three roadway-level test borings (B1 – B3) to a maximum depth of 60.33 feet below the ground surface (bgs), corresponding to an elevation of 940.53. Drilling was conducted from 06/13/17 to 06/14/17. See Figure 2 for the Exploration Location Map.

Geo-Ex used a CME-75 high-torque truck-mounted drill rig to complete the test borings using a combination of 7.25-inch O.D. hollow-stem auger and 3.87-inch rotary wash drilling equipment. For the rotary wash drilling two different drill bits were used, a tungsten carbide tricone bit and diamond core bit. The diamond core bit was used to facilitate quicker sampling, not because it was required to drill through material. Auger refusal was reached in the rock unit of B3 at approximately 30 feet bgs. B1 and B2 were switched to rotary wash drilling before auger refusal was reached. Drilling with the tricone bit was noted as becoming "hard" (typically characterized as near maximum drill rig effort and audible drill chatter/screeching) within B1, B2, and B3 at 41 feet, 28 feet, and 35 feet bgs respectively.

Soil samples were recovered by means of a 2.0-inch O.D. "Standard Penetration" split-spoon sampler with 1.4-inch stainless steel liners and a 3.0-inch O.D. "Modified California" split-spoon sampler with 2.4-inch stainless steel liners. Both samplers were advanced with standard 350 ft-lb striking force using a 140 lb. automatic hammer and a drop height of 30 inches. An energy hammer analysis was not performed specific to this project/site, but a calibration test performed on 10/30/2012 indicates an efficiency of 70%. Sampler penetration resistance was recorded to provide a field measure of relative densities and can be correlated to soils strength and bearing characteristics. The field-recorded (uncorrected) blow counts are shown on the boring logs provided in Appendix A.

CAInc logged all the test borings consistent with the Unified Soil Classification System (USCS) and the Caltrans 2010 Logging Manual. Selected portions of recovered soil drive samples were retained in

[5] California Geologic Survey, 2010 Fault Activity Map of California, GIS data
[6] USGS Unified Hazard Tool (2014 data), assuming Site Class C/D and a return period of 475 years (10% in 50 years)

sealed containers for laboratory testing and reference. Groundwater observations were recorded during drilling operations when drilling technique allowed. At completion, the borings were cement grout backfilled with inspection from Mendocino County Environmental Health Division Field Inspector.

5.2 SOIL DESCRIPTION

Based on the test boring data, we divide the subsurface soils into two general material units, as described in Table 1. Refer to the boring logs in Appendix A for more specific soil/rock descriptions, boring details and elevations.

Table 1: Subsurface Soils

Unit	Location	Depth Range (bgs, ft)	Soil Description
1	B1/B2 (Soldier Piles)	0 to 20	**Fill and/or Native Residual Soil** - Stiff to very stiff, brown to bluish-gray lean clay to silty clay with varying amounts of sand and gravel. Also layers of brown, medium dense clayey sand and clayey gravel. Pocket Penetrometer[1] (PP) tests on samples ranges from 1.0 to +4.5 tsf, field SPT Blow Counts[2] (N) ranges from 7 – 24 blows per foot (bpf).
	B3 (Anchor Piles)	0 to 5.5	
2	B1/B2 (Soldier Piles)	20 to 60.33	**Weathered Rock** - Decomposed to intensely weathered, very intensely fractured shale and greywacke sandstone. Scattered throughout are fragments of moderately to slightly weathered greywacke rock. Rock color predominately dark gray with minor amounts of brownish gray and bluish gray. PP tests on samples typically 3.0 to +4.5 tsf with N>50 bpf (typically reaching blow count refusal[2] towards the bottom of borings.) B3 contained a distinct soft layer (N=9 bpf) from 18' to 23'.
	B3 (Anchor Piles)	5.5 to 42.5	

Note: 1. Pocket Penetrometer (PP) is a field measure for approximating the unconfined compressive strength of soil.
2. Field SPT Blow Counts (N) is a measure of Standard Penetration Test blows per foot. Refusal defined as 50 blows in less than 6".

5.3 GROUNDWATER

Free groundwater was encountered within the augered portions of the test borings in both B1 and B3 for this study. Groundwater could not be checked in B2 since rotary wash drilling was used for the entire boring. The ground water depth varied from 6.5 feet bgs in B3 to 14 feet bgs in B1. This likely represents perched groundwater overlying the weathered rock. We interpret groundwater within the rock unit to be variable and controlled by the degree of weathering and fracturing, but may locally yield significant volumes of water. Groundwater levels in general will fluctuate due to changes in precipitation, seasonal fluctuations, and other factors.

6 LABORATORY TESTING

CAInc completed the following laboratory tests on representative soil samples obtained from the test borings:

- Moisture Content/Unit Weight (ASTM D2216/2937)
- Particle Size Analysis (ASTM D422)
- Plasticity Index (ASTM D4318)
- Unconfined Compression (ASTM D2166)
- Sulfate/Chloride Content (CTM 417/422)

- pH/Minimum Resistivity (CTM 643)

Table 2 below summarizes the material properties determined from lab testing of the underlying soil/rock units.

Table 2: Material Properties

Material Unit	In-Situ Densities (Total - pcf)	Moisture Content (%)
1	122.8 – 130.8 (Avg. = 129.0)	12.6 – 24.8 (Avg. = 18.3)
2	119.4 – 146.7 (Avg. = 138.0)	11.7 – 16.8 (Avg. = 13.5)

Four unconfined compression test were completed and resulted in a range of 202 psf to 1,138 psf. We consider the lower range of values to reflect fractured rock within the samples and not representative of the in-situ rock strength.

A chemical analysis was completed on one sample for corrosion potential. See Table 3 below for summary of test results.

Table 3: Soil Corrosion Test Summary

Boring-Sample No.	Depth (ft)	pH	Minimum Resistivity (ohm-cm)	Chloride Content (ppm)	Sulfate Content (ppm)
B1-3	15.0	5.62	1,920	5.3	1.7

According to Caltrans Corrosion Guidelines, a site is considered to be corrosive to foundation elements (concrete/steel) if one or more of the following conditions exist: Chloride concentration is greater than or equal to 500 ppm, sulfate concentration is greater than or equal to 2000 ppm, minimal resistivity of 1000 ohm-cm or less, or the pH is 5.5 or less. Based on the test results above and Caltrans guidelines, site soils are considered non-corrosive to concrete/steel foundation elements. These tests are only an indicator of soil corrosivity and the designer should consult with a corrosion engineer if these values are considered significant.

See Appendix B for a complete summary of Laboratory Testing Results.

7 CONCLUSIONS

The road failure occurred primarily within residual soil and/or fill material. We conclude the primary causes of slope failure to be the inherent weakness of the fill, the high degree of saturation from seasonal storm water infiltration during this past very wet winter, and the undermining of the slope by the river below. Without remedial work, expect additional slope movement during future wet seasons, with possible progression both head-ward and laterally.

The USDOT FHWA Damage Assessment Form (DAF) provided by the County specifies a 94' long soldier pile wall with tiebacks and sub-drains as the preferred road repair option. We also considered a

Mechanically Stabilized Earth (MSE) wall and RSP Fill Slope for permanent repair. The following summarizes the key elements of each option.

1. **Soldier Pile Tieback Wall:**
   - Drill vertical soldier piles and anchor piles into the weathered/decomposed rock.
   - Install tiebacks from soldier piles to anchor piles for control of lateral stresses.
   - Construct lagging and/or facing elements to support backfill.
   - Provide sub-drainage behind the wall for control of hydrostatic forces.
   - Control surface runoff to direct water away from the slide area.
   - Reconstruct pavement section.

2. **Mechanically Stabilized Earth (MSE) Wall:**
   - Excavate and remove disturbed slide materials within the wall area.
   - Establish base of wall into the weathered/decomposed sedimentary rock, as verified by CAInc.
   - Construct the wall and new embankment using new cut from the excavation.
   - Install sub-drainage behind the wall, with gravity relief.
   - Control surface runoff to direct water away from the slide area.
   - Reconstruct pavement section.

3. **RSP (Rock Slope Protection) Fill Slope:**
   - Excavate a minimum 8-foot wide key at the base of the slope, with a temporary back-slope about 0.75:1.
   - Place rock slope protection (e.g. 1-ton rock) with filter fabric backing and a 1:1 finished slope.
   - Provide toe drain with gravity outlet.
   - Control surface runoff to direct water away from the slide area.
   - Reconstruction pavement section.

We consider other options less appropriate for this site. The existing slopes are too steep for a typical 2:1 (H:V) reconstructed embankment section. Rigid wall systems, such as reinforced concrete cantilever wall, are not recommended due to height requirements and limited tolerance for movement. Significant road realignment and/or significant grade changes are not viable due to the existing curvature, steep road grade and high cuts already present at the site.

8 RECOMMENDATIONS

We recommend the soldier pile tieback wall option. This option will achieve secure support within the rock and provide lateral resistance to active pressures. Additionally, this option will limit the environmental impact downslope of the failure. See Figure 6 for typical section of tieback wall.

The MSE wall and RSP Fill options would be at least 25 feet high to engage the stable Unit 2 rock, thus require significant excavations likely extending beyond the County Right-of-Way, as well as having a greater environmental impact within the project vicinity.

The following summarizes our recommended active and passive Equivalent Fluid Pressures (EFP) for design of the soldier pile tieback wall. Include traffic loading in determination of design wall pressures.

- An active EFP of 40 pcf/ft for imported structural backfill meeting Caltrans 2015 Specifications[7]
- An active EFP of 50 pcf/ft for native backfill materials
- A passive EFP of 500 pcf/ft for the weathered rock unit

The passive resistance of the piles embedded into weathered rock can be applied to an effective pile width of 3x the pile diameter, provided that the pile spacing is greater than the effective pile width.

We consider cast-in-drilled-hole (CIDH) piles with a minimum diameter of 24 inches appropriate for this project. For design, consider the piles essentially "fixed" at 3 feet below the rock line. Provide additional lateral capacity by installing an H-pile "core", or other reinforcement, within the pile excavations. Place concrete in clean, dry excavations, as soon as possible after completion of drilling. We expect that groundwater seepage into the pile excavations can be controllable by pumping, if necessary, for dry-season construction (e.g., late summer to early fall).

Retain the backfill between the soldier piles with wood lagging and/or concrete facing placed between the H-pile flanges. Provide wall drainage by means of either (1) a permeable material section (e.g., Class-2 Permeable Material per Caltrans Section 68), wrapped in filter fabric, (2) permeable backfill (e.g., clean drain rock) with filter fabric backing, or (3) prefabricated drainage panel attached behind the wall. Provide a perforated gravity drainpipe located behind the bottom of the wall.

We recommend the soldier piles achieve a minimum 20 feet of embedment below the pile fixity point into the weathered rock unit. The wall length should extend a minimum of 10 feet beyond the extents of the slide limits, which the DAF specified 94 foot long wall meets. For a wall positioned as shown in Figure 6, the estimated rock surface near the center of the slide is elevation 979 feet (per assumed project datum), corresponding to a minimum pile tip elevation of 956 feet. Minimum pile tip elevation assumes 3 feet from estimated rock line to pile fixity point and 20 feet of embedment. The pile tip elevations will vary along the line of wall, generally parallel to the road grade. For a 94 ft long wall, we estimate the tip elevations will vary linearly from about elev. 958 ft at the west end to 955 ft at the east end.

Resist lateral wall forces with horizontal tieback rods connected to CIDH anchor piles drilled along the inboard side of the road. Embed the anchor piles a minimum of 20 feet below the pile fixity point into the weathered rock unit. The estimated rock surface below the inboard edge of the road at the center of the slide is at elevation 996 feet, corresponding to a minimum pile tip elevation of 973 feet. We have neglected potential resistance provided by the soft layer identified in B3 from 18 feet to 23 feet. The pile tip elevations will vary along the line of wall, generally parallel to the road grade.

Variations in the rock surface may be nonlinear and change abruptly; therefore, the final tip elevations should be made on the basis of specific field review by a CAInc representative.

We recommend construction of a trenched under-drain (e.g., per Caltrans "Standard Plans") along the inner road area to intercept shallow seepage. Construct the under-drain to minimum depth 5 feet below road grade and backfill with permeable material enclosed in filter fabric. Place low permeability soil (compacted structure backfill or cohesive native soil) within the uppermost 6 inches to prevent surface water from entering the under-drain. See Figure 6 for typical section of tieback wall.

[7] Material assumed to be fully drained with unit weight of 120 pcf and friction angle of 34 deg. per Caltrans

9 RISK MANAGEMENT

Our experience and that of our profession clearly indicates that the risks of costly design, construction, and maintenance problems can be significantly lowered by retaining the geotechnical engineer of record to provide additional services during design and construction.

For this project, CAInc should be retained to:

- Review and provide comments on the civil plans, grading/foundation plans, and specifications prior to construction.
- Monitor construction to check and document our report assumptions. At a minimum, CAInc should monitor initial pile excavations and sub-drainage requirements.
- Update this report if design changes occur, two years or more lapses between this report and construction, and/or site conditions have changed.

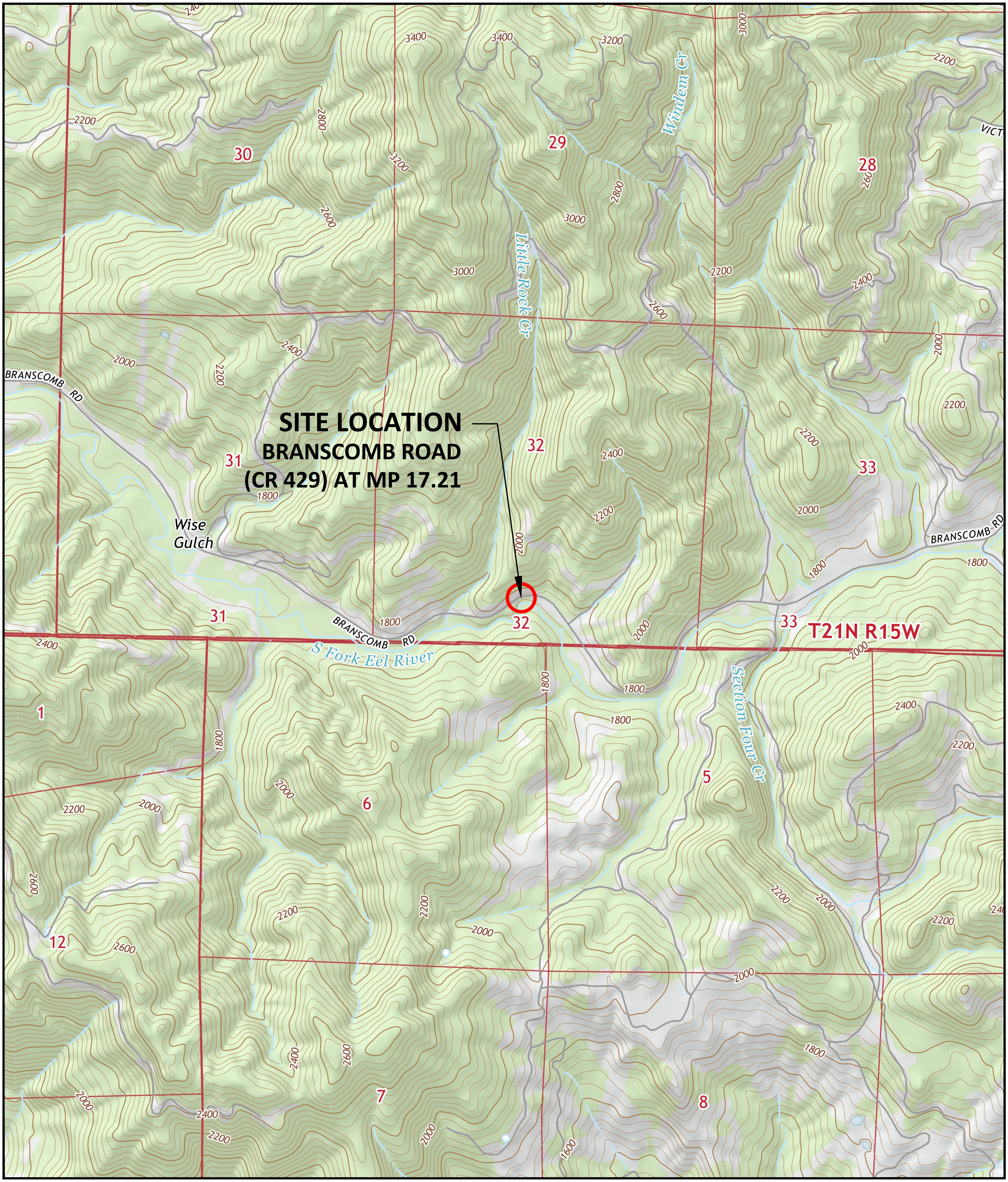
10 LIMITATIONS

CAInc performed these services in accordance with generally accepted geotechnical engineering principles and practices currently used in this area. This report is based on the current site and project conditions and should be used only for the evaluation and design of repair alternative for the Branscomb Road slope failure at MP 17.21.

It is assumed the soil/rock and groundwater conditions interpreted/encountered in the borings provided in Appendix A are representative of the subsurface conditions at the site. Actual conditions between explorations could be different. The interface shown between soil/rock materials on the boring logs is approximate. The transition between materials may be abrupt or gradual. Recommendations are based on the final logs, which represent our interpretation of the field logs and general knowledge of the site and geological conditions.

Modern design and construction is complex and it is common to experience changes and delays. The owner should set aside a reasonable contingency fund based on complexities and cost estimates to cover changes and delays.

FIGURES



NORTH

Map Sources:

1. *USGS 7.5' Topographic Maps 2015, Cahto Peak, Mendocino County, California, Scale 1:24000*
2. *USGS 7.5' Topographic Maps 2015, Sherwood Peak, Mendocino County, California, Scale 1:24000*

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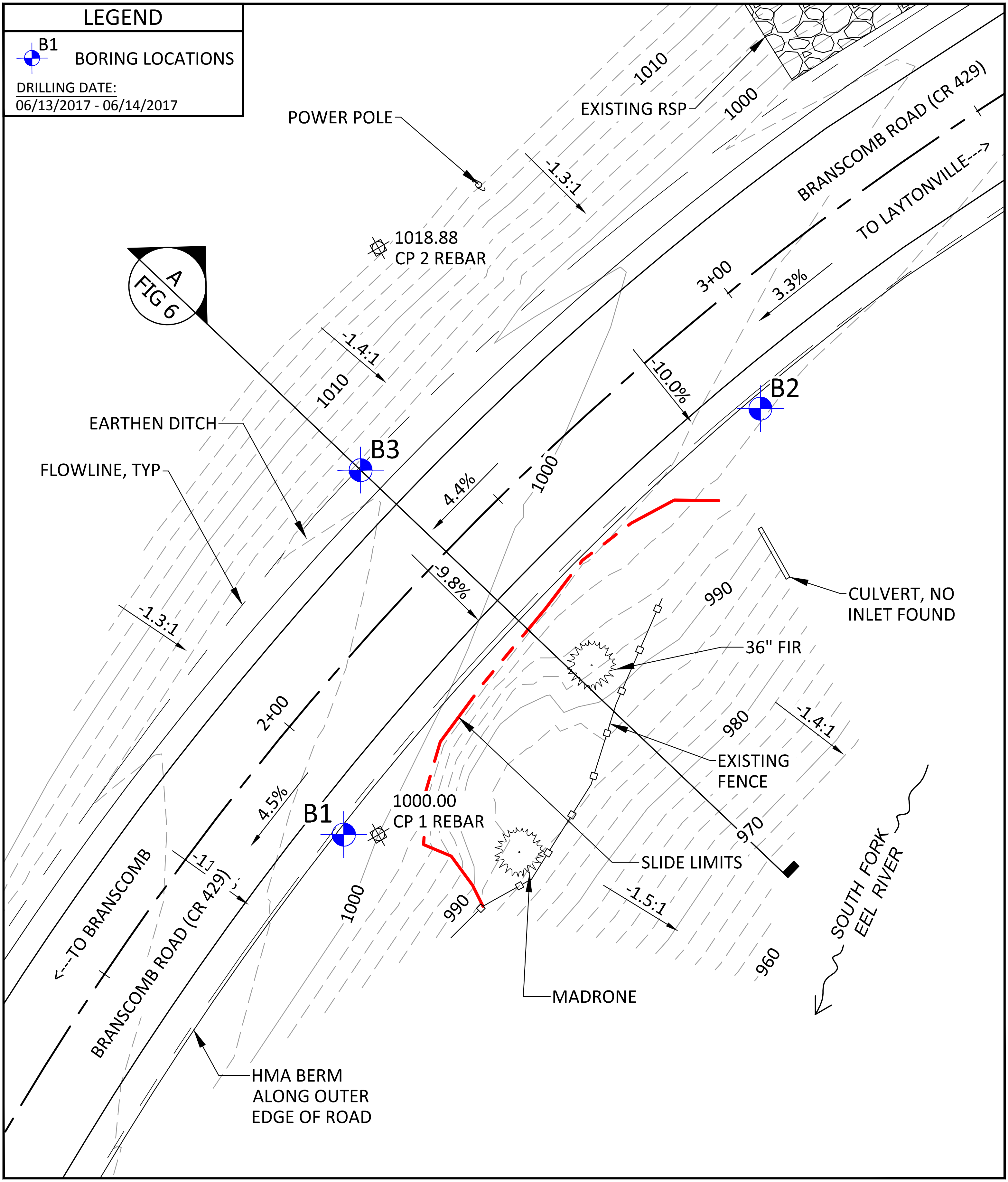
GEOTECHNICAL INVESTIGATION
BRANSCOMB ROAD (CR 429)
FAILURE AT MP 17.21

MENDOCINO COUNTY, CA

Figure 1
Vicinity Map

Proj. No: 16-337.2
Scale: 1" = 2,000'
Date: 05/26/2017

Path: \\psf\Home\Box Sync\Projects\16-337.X Mendocino 2016 Quadrennial Support Project\16-337.2 Branscomb Road (CR 429) at MP 17.21\CAD\16-337.2-Branscomb Road at MP 17.21.dwg Plot Date: May 24, 2017 at 6:29pm



NORTH

Map Source:
Base map provided by MCDOT via electronic transfer, 06/05/2017

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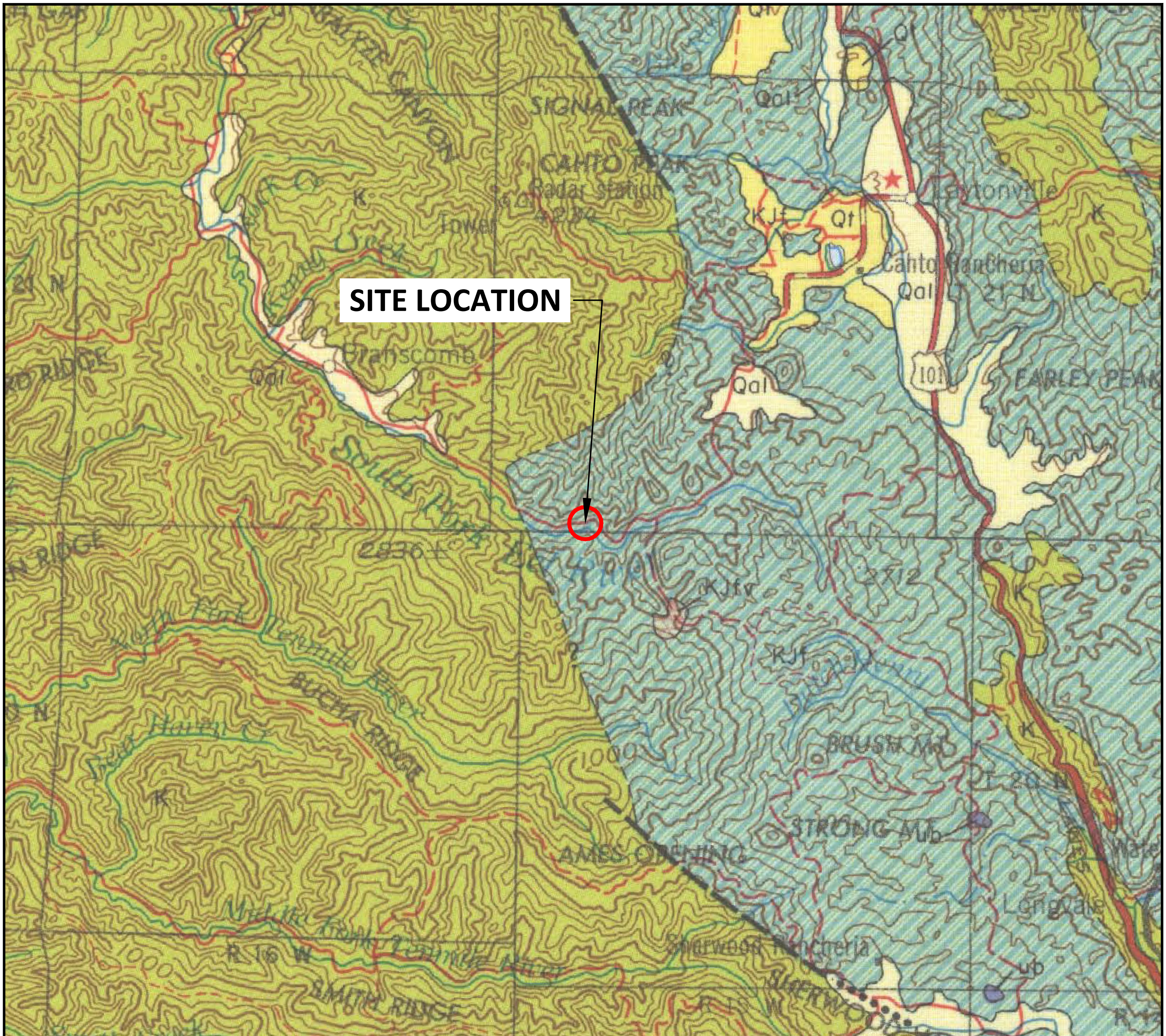
GEOTECHNICAL INVESTIGATION
BRANSCOMB ROAD (CR 429)
FAILURE AT MP 17.21

MENDOCINO COUNTY, CA

Figure 2
Exploration Location Map

Proj. No: 16-337.2
Scale: 1" = 20'
Date: 05/26/2017

Path: \\psf\Home\Box Sync\Projects\16-337.X Mendocino 2016 Quadrennial Support Project\16-337.2 Branscomb Road (CR 429) at MP 17.21\CAD\16-337.2-Branscomb Road at MP 17.21.dwg Plot Date: Jul 12, 2017 at 6:31pm



LEGEND

Geologic Formations

K — **Undivided Marine Sedimentary Rocks (Cretaceous) -** *sandstone, shale, and conglomerate*

KJf — **Franciscan Formation (Jurassic-Cretaceous) -** *sandstone, shale, chert, and conglomerate; locally small areas of greenstone, limestone, basalt, schist, and related metamorphic rocks*

CONTACT
(Dashed where approximately located, gradational or inferred)

FAULT
(Dashed where approximately located)

NORTH

Map Source:
Jennings, C.W. and Strand, R.G., 1960, Geologic Map of California, Ukiah Sheet, California Division of Mines and Geology, Scale 1:250,000

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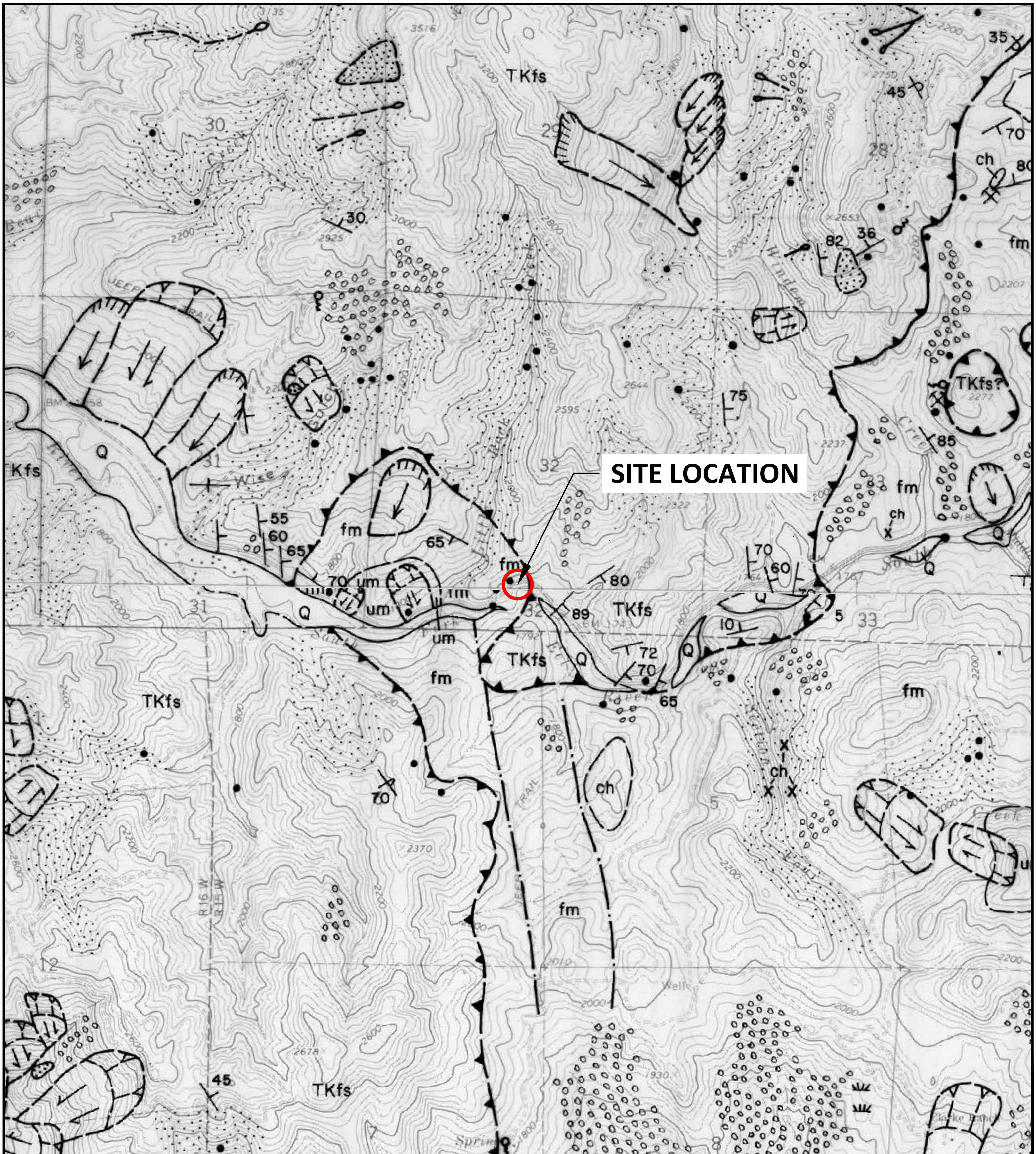
GEOTECHNICAL INVESTIGATION
BRANSCOMB ROAD (CR 429)
FAILURE AT MP 17.21

MENDOCINO COUNTY, CA

Figure 3
Regional Geologic Map

Proj. No: 16-337.2
Scale: 1" = 10,000'
Date: 05/26/2017

Path: \\psf\Home\Box Sync\Projects\16-337.X Mendocino 2016 Quadrennial Support Project\16-337.2 Branscomb Road (CR 429) at MP 17.21\CAD\16-337.2-Branscomb Road at MP 17.21.dwg Plot Date: May 24, 2017 at 4:34pm



SEE FIGURE 4B FOR MAP LEGEND

NORTH

Map Source:

1. Kilbourne, R.T., 1983, Geology and Geomorphic Features Related to Landsliding, Cahto Peak 7.5' Quadrangle, OFR 83-39, California Division of Mines and Geology, Scale 1:24000

2. Kilbourne, R.T., 1983, Geology and Geomorphic Features Related to Landsliding, Sherwood Peak 7.5' Quadrangle, OFR 83-38, California Division of Mines and Geology, Scale 1:24000

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GEOTECHNICAL INVESTIGATION
BRANSCOMB ROAD (CR 429)
FAILURE AT MP 17.21

MENDOCINO COUNTY, CA

Figure 4A
Landslide and Geologic Map

Proj. No: 16-337.2
Scale: 1" = 2,000'
Date: 05/26/2017

Path: \\psf\Home\Box Sync\Projects\16-337.X Mendocino 2016 Quadrennial Support Project\16-337.2 Branscomb Road (CR 429) at MP 17.21\CAD\16-337.2-Branscomb Road at MP 17.21.dwg Plot Date: May 24, 2017 at 5:19pm

EXPLANATION

TRANSLATIONAL/ROTATIONAL SLIDE: relatively cohesive slide mass with a failure plane that is deep-seated in comparison to that of a debris slide of similar areal extent; sense of motion along slide plane is linear in a translational slide and arcuate or "rotational" in a rotational slide; complex versions with rotational heads and translation or earthflows downslope are common; translational movement along a planar joint or bedding discontinuity may be referred to as a block glide; indicates scarp, ⟸ indicates direction of movement; solid where active, dashed where dormant, queried where uncertain.

EARTHFLOW: mass movement resulting from slow to rapid flowage of saturated soil and debris in a semiviscous, highly plastic state; after initial failure, the flow may move, or creep, seasonally in response to destabilizing forces; indicates scarp, ⟵ indicates direction of movement; solid where active, dashed where dormant.

DEBRIS SLIDE: unconsolidated rock, colluvium, and soil that has moved slowly to rapidly downslope along a relatively steep (generally greater than 65 percent), shallow translational failure plane; forms steep, unvegetated scars in the head region and irregular hummocky deposits (when present) in the toe region; scars likely to ravel and remain unvegetated for many years; revegetated scars recognized by steep, even-faceted slope and light-bulb shape; includes scarp and slide deposits; solid where active, dashed where dormant.

DEBRIS FLOW/TORRENT TRACK: long stretches of bare, generally unstable stream channel banks scoured and eroded by the extremely rapid movement of water-laden debris; commonly triggered by debris sliding in the upper part of the drainage during high intensity storms; scoured debris may be deposited downslope as a tangled mass of organic material in a matrix of rock and soil; debris may be reactivated or washed away during subsequent events; solid where active, dashed where dormant.

DEBRIS SLIDE SLOPE: geomorphic feature characterized by steep (generally greater than 65 percent), usually well-vegetated slopes that have been sculpted by numerous debris slide events; vegetated soils and colluvium above shallow soil/bedrock interface may be disrupted by active debris slides or bedrock exposed by former debris sliding; slopes near angle of repose may be relatively stable except where weak bedding planes and extensive bedrock joints and fractures parallel slope.

• **ACTIVE SLIDE:** too small to delineate at this scale.

DISRUPTED GROUND: irregular ground surface caused by complex landsliding processes resulting in features that are indistinguishable or too small to delineate individually at this scale; also may include areas affected by downslope creep, expansive soils, and/or gully erosion; boundaries usually are indistinct.

Qf **ALLUVIAL FAN DEPOSITS (Holocene):** fan-shaped deposits of unconsolidated, poorly sorted sand and gravel; found in lowlands at the mouth of steep drainage canyons; deposits may represent material transported by debris torrents.

Q **ALLUVIUM (Holocene):** unconsolidated, fine-grained sand and silt along modern river flood plains; minor amounts of gravel in channel areas.

Qo **OLDER ALLUVIUM (Holocene-Pleistocene):** flat-lying, compact but uncemented, river and lake deposits ranging from boulder conglomerate and breccia to fine sand and silt; coarser facies more common at base and along edge of deposit near contact with upland areas of Franciscan melange (fm); sediments appear to represent basin filling in a lake formed by landslide blockage of Ten Mile River drainage in Sec 21, T22N, R15W in Cahto Peak quadrangle to the north.

TKfs **COASTAL BELT FRANCISCAN (Tertiary-Cretaceous):** well consolidated, clastic sedimentary rocks; includes arkosic sandstone, pebble conglomerate and shale with small amounts of limestone; sandstone and conglomerate units tend to form ridges; streams generally lie in less competent sheared shale.

fm **FRANCISCAN MELANGE (Tertiary-Cretaceous):** pervasively sheared argillaceous matrix surrounding pebble-sized to individually mappable blocks of sandstone, greenstone, chert, schist, serpentine and serpentinized ultramafic rocks; the highly erodible, sheared shale matrix generally is unstable and prone to landsliding, even on gentle slopes; locally, the melange is indistinguishable from fault gauge.

ch chert

um serpentine and serpentinized ultramafic rocks

RATES OF LANDSLIDE MOVEMENT*

10 ft/sec or more	= extremely rapid
1 ft/min-10 ft/sec	= very rapid
5 ft/day-1 ft/min	= rapid
5 ft/mo-5 ft/day	= moderate
5 ft/yr-5 ft/mo	= slow
1 ft/5yr-5 ft/yr	= very slow
1 ft/5yr or less	= extremely slow

*Modified from: Varnes, D.J., 1978, Slope movement types and processes *in* Landslides: Analysis and Control, Transportation Research Board, National Academy of Sciences, Washington, D.C., Special Report 176, Figure 2.1.

LITHOLOGIC CONTACT: solid where well located, dashed where approximately located.

x **ROCK OUTCROP:** too small to delineate at this scale.

FAULT: solid where well located, dashed where approximately located; usually associated with highly sheared, landslide-prone fault gauge.

THRUST FAULT: solid where well located, dashed where approximately located; barbs on upper plate.

LINEAMENT: linear feature of unknown origin observed on aerial photographs; usually associated with erodible rock units.

SHEAR ZONE: sheared, crushed and usually erodible rock associated with fault zones; may represent a geologic contact.

50 **STRIKE AND DIP OF BEDDING**

70 **STRIKE AND DIP OF OVERTURNED BEDDING**

SPRING

MARSH

REFERENCES

California Department of Forestry, 1981, Cal Aero Photos: Photos CDF-ALL-UK; Flight 6/3/81; Frames 16-1 to 16-9, 18-1 to 18-9, and 20-1 to 20-9; black and white, scale 1:24,000.

California Division of Mines and Geology, 1976-1983, Geologic review of Timber Harvesting Plans: Unpublished field studies conducted for the California Department of Forestry.

Durham, J., 1979, Geologic map, Branscomb 15-minute quadrangle: California Department of Forestry, Title II Geologic Data Compilation Project, unpublished, scale 1:62,500.

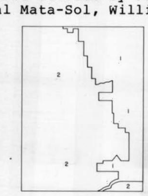
Kleist, J.R., 1974, Geology of the Coastal Belt Franciscan Complex, near Ft. Bragg, California: University of Texas at Austin, unpublished Ph.D. thesis, 133 p., map scale 1:62,500.

Pampeyan, E.H., Harsh, P.W., and Coakley, J.M., 1981, Preliminary map showing recently active breaks along the Maacama fault zone between Laytonville and Hopland, Mendocino County, California: United States Geological Survey, Miscellaneous Field Studies Map, MF-1217, scale 1:24,000.

SOURCES OF GEOLOGIC DATA

Geologic data was compiled from aerial photo interpretation, field reconnaissance, and the modification of published and unpublished geologic maps listed in references above. The author was assisted in field and office studies by Janet Hollibaugh, Peter H. Griffith, Anibal Mata-Sol, William McIlvride and Charles Smith.

1. Mapping from aerial photo interpretation, previously existing geologic data, and reconnaissance level field checking.
2. Mapping from aerial photo interpretation and previously existing geologic data; field access denied.

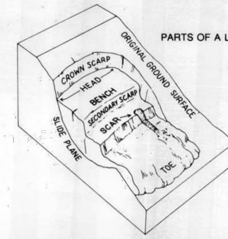


ACTIVITY OF LANDSLIDES

Active or probably active - presently moving or recently moved. Distinct topographic slide features present i.e., sharp barren scarps, cracks, jackstrawed trees. Major revegetation has not occurred.

Dormant - little evidence of recent movement. Slide features modified by weathering and erosion. Vegetation generally well established. Some mass movements may have developed under climatic conditions different from today. Causes of failure may remain and movement could be renewed.

PARTS OF A LANDSLIDE



SEE FIGURE 4A FOR MAP

NORTH

Map Source:

1. Kilbourne, R.T., 1983, Geology and Geomorphic Features Related to Landsliding, Cahto Peak 7.5' Quadrangle, OFR 83-39, California Division of Mines and Geology, Scale 1:24000

2. Kilbourne, R.T., 1983, Geology and Geomorphic Features Related to Landsliding, Sherwood Peak 7.5' Quadrangle, OFR 83-38, California Division of Mines and Geology, Scale 1:24000

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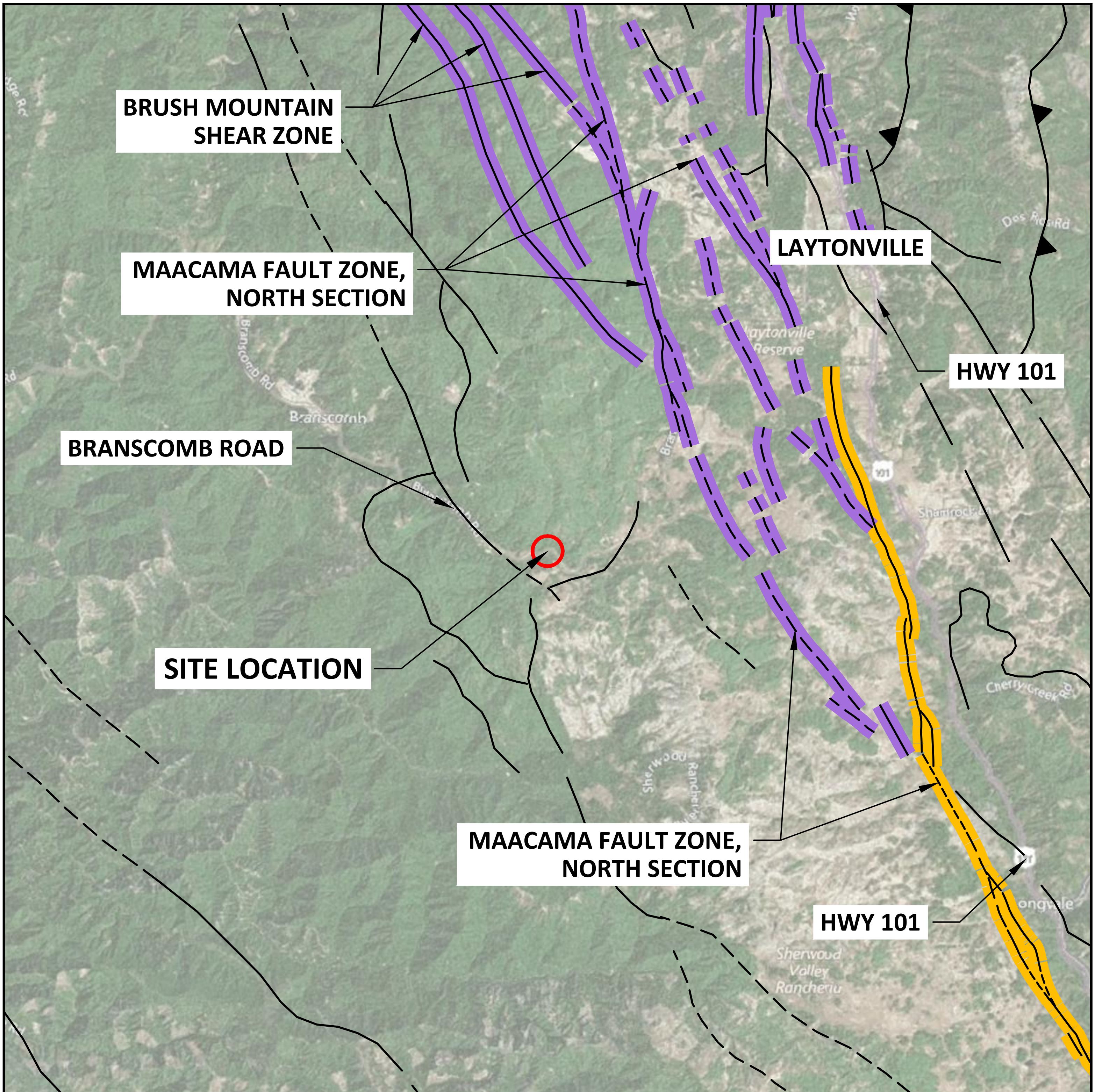
GEOTECHNICAL INVESTIGATION
BRANSCOMB ROAD (CR 429)
FAILURE AT MP 17.21

MENDOCINO COUNTY, CA

Figure 4B
Landslide and Geologic Map Legend

Proj. No:	16-337.2
Scale:	N/A
Date:	05/26/2017



LEGEND

CGS Faults (Last Activity Age)	CGS Faults (Last Activity Age)	Fault Location
<200 years (Historic)	<1.6 million years (Quaternary)	Certain
<11,700 years (Holocene)	>1.6 million years (Pre-Quaternary)	Approx. or Inferred
<700,000 years (Late Quaternary)	Thrust Fault	Concealed

NORTH

Map Sources:

1. Base map via AutoCAD Civil 3D geolocation tool

2. Fault data via CGS Fault Activity Map of California 2010 GIS data

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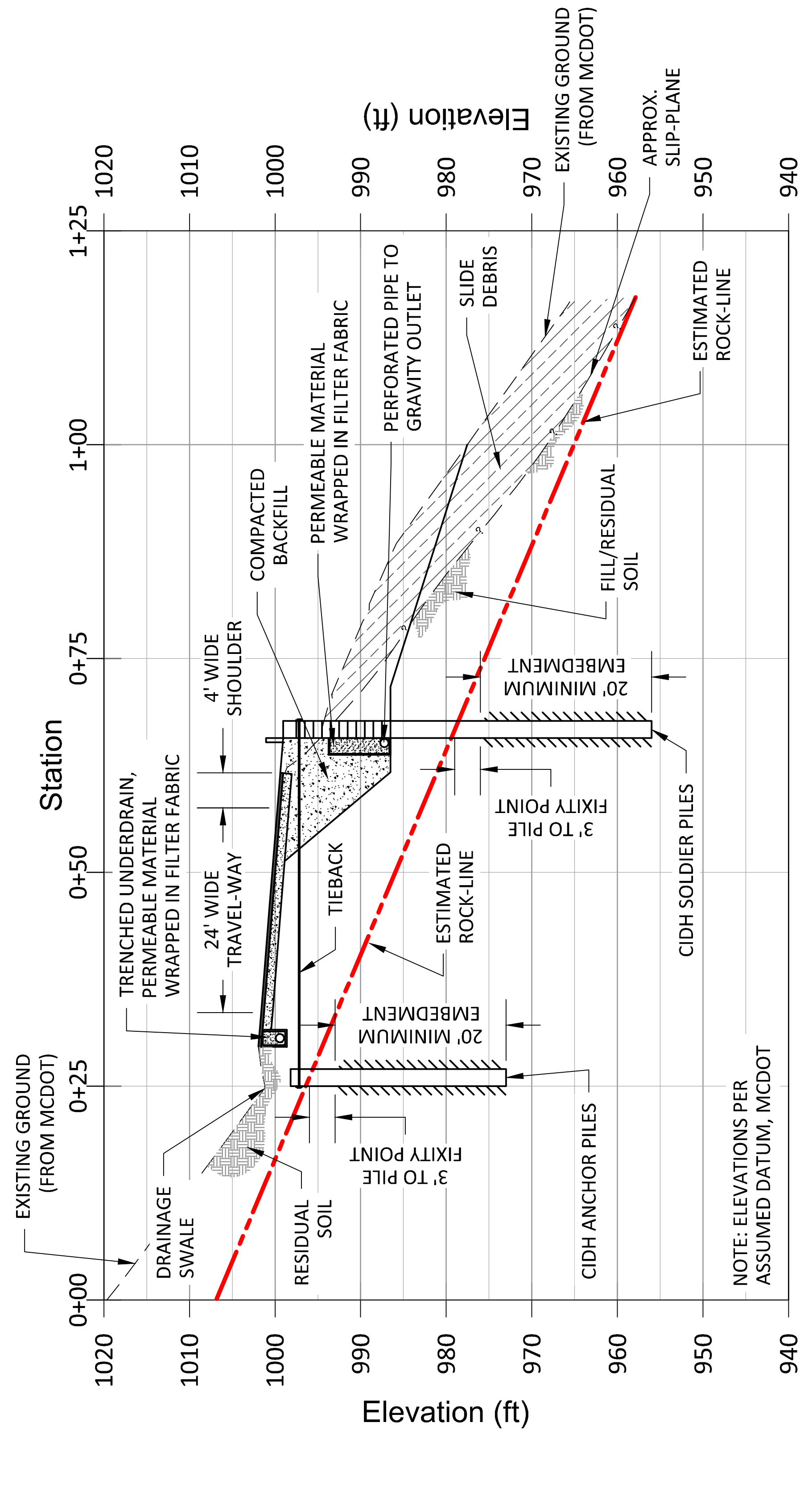
GEOTECHNICAL INVESTIGATION
BRANSCOMB ROAD (CR 429)
FAILURE AT MP 17.21

MENDOCINO COUNTY, CA

Figure 5
Fault Activity Map

Proj. No: 16-337.2
Scale: 1" = 10,000'
Date: 05/26/2017

Path: \\psf\Home\Box Sync\Projects\16-337.X Mendocino 2016 Quadrennial Support Project\16-337.2 Branscomb Road (CR 429) at MP 17.21\CAD\16-337.2-Branscomb Road at MP 17.21.dwg Plot Date: May 25, 2017 at 2:14pm



Typical Section of Tieback Wall

NORTH

Data Source:
Existing ground surface area provided by MCDOT via electronic transfer on 06/05/2017

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GEOTECHNICAL INVESTIGATION
BRANSCOMB ROAD (CR 429)
FAILURE AT MP 17.21

MENDOCINO COUNTY, CA

Figure 6
Typical Section of Tieback Wall

Proj. No: 16-337.2
Scale: 1" = 20'
Date: 05/26/2017

APPENDIX A

BORING LOG LEGEND
BORING LOGS

GROUP SYMBOLS AND NAMES

Graphic / Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)
GM	SILTY GRAVEL SILTY GRAVEL with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL
SP	Poorly graded SAND Poorly graded SAND with GRAVEL
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)
SM	SILTY SAND SILTY SAND with GRAVEL
SC	CLAYEY SAND CLAYEY SAND with GRAVEL
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL
PT	PEAT
	COBBLES COBBLES and BOULDERS BOULDERS

Graphic / Symbol	Group Names
CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY elastic ELASTIC SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND

FIELD AND LABORATORY TESTS

C	Consolidation (ASTM D 2435)
CL	Collapse Potential (ASTM D 4546)
CP	Compaction Curve (CTM 216)
CR	Corrosion, Sulfates, Chlorides (CTM 643, CTM 417, CTM 422)
CU	Consolidated Undrained Triaxial (ASTM D 4767)
DR	Drained Residual Shear Strength (ASTM D 6467)
DS	Direct Shear (ASTM D 3080)
EI	Expansion Index (ASTM D 4829)
M	Moisture Content (ASTM D 2216)
OC	Organic Content (ASTM D 2974)
P	Permeability (CTM 220)
PA	Particle Size Analysis (ASTM D 422)
PI	Liquid Limit, Plastic Limit, Plasticity Index (AASHTO T 89, AASHTO T 90)
PL	Point Load Index (ASTM D 5731)
PM	Pressure Meter
R	R-Value (CTM 301)
SE	Sand Equivalent (CTM 217)
SG	Specific Gravity (AASHTO T 100)
SW	Swell Potential (ASTM D 4546)
UC	Unconfined Compression - Soil (ASTM D 2166) Unconfined Compression - Rock (ASTM D 7012-C)
UU	Unconsolidated Undrained Triaxial (ASTM D 2850)
UW	Unit Weight (ASTM D 7263)

SAMPLER GRAPHIC SYMBOLS

- Standard Penetration Test (SPT)
- Standard California Sampler (ID 2.5 in.)
- Modified California Sampler (ID 2.0 in.)
- Shelby Tube
- Piston Sampler
- NX Rock Core
- HQ Rock Core
- Bulk Sample
- Other (see remarks)

DRILLING METHOD SYMBOLS

- Auger Drilling
- Rotary Drilling
- Dynamic Cone or Hand Driven
- Diamond Core

WATER LEVEL SYMBOLS

- First Water Level Reading (during drilling)
- Static Water Level Reading (short-term)
- Static Water Level Reading (long-term)

REFERENCE: Caltrans Soil and Rock Logging, Classification, and Presentation Manual (2010) with Errata Sheet (2015).

CONSISTENCY OF COHESIVE SOILS

Descriptor	Unconfined Compressive Strength (tsf)	Pocket Penetrometer (tsf)	Torvane (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 - 0.50	0.25 - 0.50	0.12 - 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 - 1.0	0.50 - 1.0	0.25 - 0.50	Can be penetrated several inches by thumb with moderate effort
Stiff	1.0 - 2.0	1.0 - 2.0	0.50 - 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2.0 - 4.0	2.0 - 4.0	1.0 - 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

APPARENT DENSITY OF COHESIONLESS SOILS

Descriptor	SPT N_{60} (blows / 12 inches)
Very Loose	0 - 5
Loose	5 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	> 50

MOISTURE

Descriptor	Criteria
Dry	No discernable moisture
Moist	Moisture present, but no free water
Wet	Visible free water

PERCENT OR PROPORTION OF SOILS

Descriptor	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

SOIL PARTICLE SIZE

Descriptor		Size
Boulder		> 12 inches
Cobble		3 to 12 inches
Gravel	Coarse	3/4 inch to 3 inches
	Fine	No. 4 Sieve to 3/4 inch
Sand	Coarse	No. 10 Sieve to No. 4 Sieve
	Medium	No. 40 Sieve to No. 10 Sieve
	Fine	No. 200 Sieve to No. 40 Sieve
Silt and Clay		Passing No. 200 Sieve

PLASTICITY OF FINE-GRAINED SOILS

Descriptor	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled, and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll, and not much time is required to reach the plastic limit; it cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

CEMENTATION

Descriptor	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

REFERENCE: Caltrans Soil and Rock Logging, Classification, and Presentation Manual (2010).

ROCK GRAPHIC SYMBOLS
IGNEOUS ROCK
SEDIMENTARY ROCK
METAMORPHIC ROCK

BEDDING SPACING

Descriptor	Thickness or Spacing
Massive	> 10 ft
Very thickly bedded	3 ft - 10 ft
Thickly bedded	1 ft - 3 ft
Moderately bedded	4 in - 1 ft
Thinly bedded	1 in - 4 in
Very thinly bedded	1/4 in - 1 in
Laminated	< 1/4 in

WEATHERING DESCRIPTORS FOR INTACT ROCK

	Diagnostic Features					
	Chemical Weathering-Discoloration-Oxidation		Mechanical Weathering and Grain Boundary Conditions	Texture and Solutioning		
Descriptor	**Body of Rock**	**Fracture Surfaces**		**Texture**	**Solutioning**	**General Characteristics**
Fresh	No discoloration, not oxidized	No discoloration or oxidation	No separation, intact (tight)	No change	No solutioning	Hammer rings when crystalline rocks are struck.
Slightly Weathered	Discoloration or oxidation is limited to surface of, or short distance from, fractures; some feldspar crystals are dull	Minor to complete discoloration or oxidation of most surfaces	No visible separation, intact (tight)	Preserved	Minor leaching of some soluble minerals may be noted	Hammer rings when crystalline rocks are struck. Body of rock not weakened.
Moderately Weathered	Discoloration or oxidation extends from fractures usually throughout; Fe-Mg minerals are "rusty"; feldspar crystals are "cloudy"	All fracture surfaces are discolored or oxidized	Partial separation of boundaries visible	Generally preserved	Soluble minerals may be mostly leached	Hammer does not ring when rock is struck. Body of rock is slightly weakened.
Intensely Weathered	Discoloration or oxidation throughout; all feldspars and Fe-Mg minerals are altered to clay to some extent; or chemical alteration produces in situ disaggregation (refer to grain boundary conditions)	All fracture surfaces are discolored or oxidized; surfaces are friable	Partial separation, rock is friable; in semi-arid conditions, granitics are disaggregated	Altered by chemical disintegration such as via hydration or argillation	Leaching of soluble minerals may be complete	Dull sound when struck with hammer; usually can be broken with moderate to heavy manual pressure or by light hammer blow without reference to planes of weakness such as incipient or hairline fractures or veinlets. Rock is significantly weakened.
Decomposed	Discolored of oxidized throughout, but resistant minerals such as quartz may be unaltered; all feldspars and Fe-Mg minerals are completely altered to clay		Complete separation of grain boundaries (disaggregated)	Resembles a soil; partial or complete remnant rock structure may be preserved; leaching of soluble minerals usually complete		Can be granulated by hand. Resistant minerals such as quartz may be present as "stringers" or "dikes".

Note: Combination descriptors (such as "slightly weathered to fresh") are used where equal distribution of both weathering characteristics is present over significant intervals or where characteristics present are "in between" the diagnostic feature. However, combination descriptors should not be used where significant identifiable zones can be delineated. Only two adjacent descriptors shall be combined. "Very intensely weathered" is the combination descriptor for "decomposed to intensely weathered".

PERCENT CORE RECOVERY (REC)

$$\frac{\Sigma \text{ Length of the recovered core pieces (in.)}}{\text{Total length of core run (in.)}} \times 100$$

ROCK QUALITY DESIGNATION (RQD)

$$\frac{\Sigma \text{ Length of intact core pieces > 4 in.}}{\text{Total length of core run (in.)}} \times 100$$

Note: RQD* indicates soundness criteria not met

ROCK HARDNESS

Descriptor	Criteria
Extremely Hard	Specimen cannot be scratched with pocket knife or sharp pick; can only be chipped with repeated heavy hammer blows
Very hard	Specimen cannot be scratched with pocket knife or sharp pick; breaks with repeated heavy hammer blows
Hard	Specimen can be scratched with pocket knife or sharp pick with heavy pressure; heavy hammer blows required to break specimen
Moderately Hard	Specimen can be scratched with pocket knife or sharp pick with light or moderate pressure; breaks with moderate hammer blows
Moderately Soft	Specimen can be grooved 1/16 in. with pocket knife or sharp pick with moderate or heavy pressure; breaks with light hammer blow or heavy hand pressure
Soft	Specimen can be grooved or gouged with pocket knife or sharp pick with light pressure, breaks with light to moderate hand pressure
Very Soft	Specimen can be readily indented, grooved, or gouged with fingernail, or carved with pocket knife; breaks with light manual pressure.

FRACTURE DENSITY

Descriptor	Criteria
Unfractured	No fractures
Very Slightly Fractured	Core lengths greater than 3 ft.
Slightly Fractured	Core lengths mostly from 1 ft. to 3 ft.
Moderately Fractured	Core lengths mostly from 4 in. to 1 ft.
Intensely Fractured	Core lengths mostly from 1 in. to 4 in.
Very Intensely Fractured	Mostly chips and fragments.

REFERENCE: Caltrans Soil and Rock Logging, Classification, and Presentation Manual (2010).

LOG OF BORING B1

PROJECT NO: 16-337.2
PROJECT: Branscomb Road Failure MP 17.21
LOCATION: Branscomb Road, Laytonville
CITY/COUNTY: Mendocino
CLIENT: MCDOT
LOGGED BY: RRH
DEPTH OF BORING: 60.33 (ft)

BEGIN DATE: 6/13/17
COMPLETION DATE: 6/14/17
SURFACE ELEVATION: 1000.86 (ft)*
SURFACE CONDITION: Grass
WATER DEPTH: 14 (ft)
READING TAKEN: 6/14/17
HAMMER EFFICIENCY: 70 (%)

DRILLING CONTRACTOR: Geo-Ex Subsurface Exploration
DRILLING METHOD: Hollow-Stem Auger, Rotary Wash
DRILL RIG: CME 75 (Truck Rig)
HAMMER TYPE: Automatic, 140 lbs, 30" drop
SAMPLER TYPE & SIZE: SPT (ID 1.4") and CAL (ID 2.4")
BOREHOLE DIAMETER: 7.25" (Auger) and 3.87" (Rotary)
BACKFILL METHOD: Portland Type I/II Cement Grout

FIELD											LABORATORY							
ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	PLASTIC LIMIT	LIQUID LIMIT	MOISTURE (%)	D. DENSITY (PCF)	% PASSING 200 SIEVE	DRILL METHOD	CASING DEPTH	REMARKS
	0							CLAYEY SAND (SC); medium dense; brown; moist; about 7% GRAVEL; about 58% SAND; about 35% low to medium plasticity fines [FILL].										
	1																	
999	2																	
	3																	
997	4		1	7 9 12	21				67				17.6	104.4	35			
	5																	
995	6																	
	7							CLAYEY SILT with SAND (ML/CL); stiff; bluish gray; moist; low plasticity fines.										
993	8																	
	9		2	3 7 10	17	1.5 2.0			72		28	44	24.8	104.1				
991	10																	
	11																	
989	12							Lean CLAY with GRAVEL (CL); very stiff; bluish gray to brown; moist; medium plasticity fines.										
	13																	
987	14		3	4 9 9	18	3.0 3.0			78				19.3	109.1				Chemical Analysis pH = 5.62 Min Resist. = 1920 ohm-cm Chloride = 5.3 ppm Sulfate-S = 1.7 ppm
	15																	
985	16																	
	17																	
983	18																	
	19		4	11 15 20	35	4.5 4.5		Hard; brown.	39				16.8	110.9				
981	20							SEDIMENTARY ROCK (SHALE), dark gray, decomposed, very intensely fractured, (silty clay matrix) [FRANCISCAN FORMATION].										
	21																	
979	22																	

ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	PLASTIC LIMIT	LIQUID LIMIT	MOISTURE (%)	D. DENSITY (PCF)	% PASSING 200 SIEVE	DRILL METHOD	CASING DEPTH	REMARKS
								SEDIMENTARY ROCK (Shale) *(continued)*.										
977	24		5	9 13 15	28	2.0 3.0		Very intensely weathered.	83				12.3	106.3				
	25																	
975	26																	Switch to rotary drilling with a 3-7/8" Tricone Bit
	27																	
973	28		6	13 13 22	35	3.0 4.0		Decomposed, with moderately weathered Greywacke fragments within matrix.	83				11.7	131.3				
	29																	
971	30																	
	31																	
969	32																	
	33		7	9 16 23	39	3.5 2.0			72				12.1	125.6				
967	34																	
	35																	
965	36																	
	37																	
963	38		8	18 29 38	67	4.0 >4.5			89				13.1	127.9				
	39																	
961	40																	
	41																	Drilling becomes hard to very hard at 41'
959	42																	
	43		9	16 25 32	57	>4.5 >4.5		Intensely weathered, very intensely fractured, with moderately weathered Greywacke fragments within matrix and lenses of decomposed Shale.	78									
957	44																	
	45																	
955	46																	
	47																	
953	48		10	17 26 33	59	4.0 >4.5			61				12.7	125.8				
	49																	Switch to a 3-7/8" Diamond Core Bit in order to sample without having to remove drill bit
951	50																	

ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	PLASTIC LIMIT	LIQUID LIMIT	MOISTURE (%)	D. DENSITY (PCF)	% PASSING 200 SIEVE	DRILL METHOD	CASING DEPTH	REMARKS
949	52																	
	53																	
947	54																	
	55		11	15 50/6"	50/6	>4.5 >4.5			100									
945	56																	
	57																	
943	58																	
	59																	
941	60		12	50/4"	REF				100									
	61							Bottom of borehole at 60.3 ft bgs Backfilled with cement grout, no field inspection required per MCDEH Inspector Will Nalty *Elevation Reference: CP-1, assumed Elev. 1000.00 per MCDOT Datum										
939	62																	
	63																	
937	64																	
	65																	
935	66																	
	67																	
933	68																	
	69																	
931	70																	
	71																	
929	72																	
	73																	
927	74																	
	75																	
925	76																	
	77																	
923	78																	

LOG OF BORING B2

PROJECT NO: 16-337.2
PROJECT: Branscomb Road Failure MP 17.21
LOCATION: Branscomb Road, Laytonville
CITY/COUNTY: Mendocino
CLIENT: MCDOT
LOGGED BY: RRH
DEPTH OF BORING: 35.08 (ft)

BEGIN DATE: 6/14/17
COMPLETION DATE: 6/14/17
SURFACE ELEVATION: 996.39 (ft)*
SURFACE CONDITION: Grass
WATER DEPTH: N/A, Drill Method (ft)
READING TAKEN: 6/14/17
HAMMER EFFICIENCY: 70 (%)

DRILLING CONTRACTOR: Geo-Ex Subsurface Exploration
DRILLING METHOD: Rotary Wash
DRILL RIG: CME 75 (Truck Rig)
HAMMER TYPE: Automatic, 140 lbs, 30" drop
SAMPLER TYPE & SIZE: SPT (ID 1.4") and CAL (ID 2.4")
BOREHOLE DIAMETER: 3.87"
BACKFILL METHOD: Portland Type I/II Cement Grout

FIELD											LABORATORY							
ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	PLASTIC LIMIT	LIQUID LIMIT	MOISTURE (%)	D. DENSITY (PCF)	% PASSING 200 SIEVE	DRILL METHOD	CASING DEPTH	REMARKS
	0							GRAVELLY lean CLAY with SAND (CL); very stiff; brown; moist; medium plasticity fines [FILL].										Use a 3-7/8" Diamond Core Bit in order to sample without having to remove drill bit
	1																	
994	2																	
	3																	
992	4																	
	5		1	5 8 12	20	4.0 4.0			83				21.7	105.4				
990	6							Lean CLAY with SAND (CL); very stiff; brown; moist; medium plasticity fines.										
	7																	
988	8																	
	9																	
986	10		2	5 6 9	15	2.0 2.5		Stiff; with fine gravel.	78		27	45						
	11							Stiff to very stiff; dark gray.										
984	12																	
	13																	
982	14																	
	15		3	3 4 3	7	1.5 1.0		Stiff.	100				22	107.2				
980	16							SANDY lean CLAY (CL); stiff; dark gray; moist; low to medium plasticity fines.										
	17																	
978	18							SEDIMENTARY ROCK (SHALE), dark gray, very intensely weathered, soft, very intensely fractured, with moderately weathered Greywacke fragments within Shale matrix (up to 1" in size) [FRANCISCAN FORMATION].										
	19																	
976	20		4	9 13 20	33	2.0 >4.5			56				14.9	121.3				
	21																	
974	22																	

ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	PLASTIC LIMIT	LIQUID LIMIT	MOISTURE (%)	D. DENSITY (PCF)	% PASSING 200 SIEVE	DRILL METHOD	CASING DEPTH	REMARKS
								SEDIMENTARY ROCK (Shale) *(continued)*.										
972	24																	
	25		5	12 19 26	45	>4.5 >4.5			56									
970	26																	
	27																	Losing circulation/water, Diamond Core Bit clogging with fractured rock cuttings, switch to rotary drilling with a 3-7/8" Tricone Bit Very hard drilling, drill rig chatter at 28'
968	28																	
	29																	
966	30		6	50/2"	REF				0									
	31																	
964	32																	Extremely hard drilling at 32.5'
	33																	
962	34							Moderately weathered Graywacke pieces (1" in size).										
	35		7	50/1"	REF			Bottom of borehole at 35.1 ft bgs Backfilled with cement grout, no field inspection required per MCDEH Inspector Will Nalty *Elevation Reference: CP-1, assumed Elev. 1000.00 per MCDOT Datum	100									
960	36																	
	37																	
958	38																	
	39																	
956	40																	
	41																	
954	42																	
	43																	
952	44																	
	45																	
950	46																	
	47																	
948	48																	
	49																	
946	50																	

LOG OF BORING B3

PROJECT NO: 16-337.2
PROJECT: Branscomb Road Failure MP 17.21
LOCATION: Branscomb Road, Laytonville
CITY/COUNTY: Mendocino
CLIENT: MCDOT
LOGGED BY: RRH
DEPTH OF BORING: 42.5 (ft)

BEGIN DATE: 6/13/17
COMPLETION DATE: 6/13/17
SURFACE ELEVATION: 1001.22 (ft)*
SURFACE CONDITION: Baserock
WATER DEPTH: 6.5 (ft)
READING TAKEN: 6/13/17
HAMMER EFFICIENCY: 70 (%)

DRILLING CONTRACTOR: Geo-Ex Subsurface Exploration
DRILLING METHOD: Hollow-Stem Auger, Rotary Wash
DRILL RIG: CME 75 (Truck Rig)
HAMMER TYPE: Automatic, 140 lbs, 30" drop
SAMPLER TYPE & SIZE: SPT (ID 1.4") and CAL (ID 2.4")
BOREHOLE DIAMETER: 7.25" (Auger) and 3.87" (Rotary)
BACKFILL METHOD: Portland Type I/II Cement Grout

ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	DESCRIPTION	RECOVERY(%)	RQD (%)	PLASTIC LIMIT	LIQUID LIMIT	MOISTURE (%)	D. DENSITY (PCF)	% PASSING 200 SIEVE	REMARKS
	0						CLAYEY GRAVEL with SAND (GC); medium dense; brown; moist; about 49% GRAVEL; about 36% SAND; about 15% medium plasticity fines.								
999	2														
997	4	SPT	1	7 11 13	24			67				12.6	115.3	15	
995	6						SEDIMENTARY ROCK (SHALE), bluish gray, decomposed [FRANCISCAN FORMATION].								Decomposed rock in tip of sampler
993	7.5						SEDIMENTARY ROCK (GREYWACKE SANDSTONE), brownish gray, moderately weathered, very intensely fractured, within a bluish gray Shale matrix.								
991	9	SPT	2	13 37 30	67			67							
989	12.5						SEDIMENTARY ROCK (SHALE), dark gray, very intensely weathered, very intensely fractured, with seams of decomposed Shale.								
987	14	CAL	3	10 22 35	57	4.5 4.5		72				13	125.2		
985	16														
983	18														Start of soft drilling at 18'
981	19	SPT	4	6 5 4	9		Decomposed.	0							No recovery, re-drive with SPT to retrieve sample
979	22														

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(916) 455-4225

PROJECT NUMBER: 16-337.2
PROJECT: Branscomb Road Failure MP 17.21
BORING: B3
ENTRY BY: RRH
CHECKED BY: RDS

ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	PLASTIC LIMIT	LIQUID LIMIT	MOISTURE (%)	D. DENSITY (PCF)	% PASSING 200 SIEVE	DRILL METHOD	CASING DEPTH	REMARKS
								SEDIMENTARY ROCK (Shale) *(continued)*.										End of soft drilling at 23'
977	24		5	10 16 19	35	>4.5 >4.5		Very intensely weathered, with moderately weathered Greywacke fragments within Shale matrix (coarse sand to fine gravel in size).	89				12.2	119.2				
	25																	
975	26																	
	27																	
973	28																	Very hard drilling at 28'
	29		6	50/3"	REF				100									
971	30																	Auger refusal at 30', switch to rotary drilling with a 3-7/8" Tricone Bit, unable to drive casing into rock (poor circulation)
	31																	
969	32																	
	33																	
967	34		7	50/1"	REF				0									
	35																	Very hard drilling with Tricone Bit
965	36																	
	37																	
963	38																	
	39																	
961	40																	
	41																	
959	42		8	50/0"	REF			Bottom of borehole at 42.5 ft bgs Backfilled with cement grout, field inspected by MCDEH Inspector Will Nalty *Elevation Reference: CP-1, assumed Elev. 1000.00 per MCDOT Datum										
	43																	
957	44																	
	45																	
955	46																	
	47																	
953	48																	
	49																	
951	50																	

APPENDIX B

LABORATORY AND FIELD TEST RESULTS SUMMARY

Job: **Branscomb Road (CR 429) Slide at MP 17.21**
Job No: **16-337.2**
Date: **7/6/17**

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Laboratory/Field Test Summary

						Moisture/Density			Classification							Strength		Chemical Analysis			
									Atterberg Limits												
	Boring I.D.	Sample I.D.	Sample Depth (ft)	USCS Class.	Blow Counts N_{60} (bpf)	Dry Density (pcf)	Moist. Content (%)	Wet Density (pcf)	Liquid Limit	Plastic Limit	Plasticity Index	Gravel (%)	Sand (%)	Fines (%)	Organic Content (%)	Pocket Pent. (tsf)	Uncon. Comp. (psf)	pH	Min. Resist. (ohm-cm)	Chloride (ppm)	Sulfate-S (ppm)
Soldier Pile Wall	B1	1	5.0	SC	16	104.4	17.6	122.8				7	58	35							
	B1	2	10.0	ML/CL	13	104.1	24.8	129.9	44	28	16					1.5 - 2.0					
	B1	3	15.0	CL	14	109.1	19.3	130.2								3.0		5.62	1,920	5.3	1.7
	B1	4	20.0	D. Rock	27	110.9	16.8	129.5								4.5					
	B1	5	24.5	D. Rock	33	106.3	12.3	119.4								2.0 - 3.0	418				
	B1	6	28.0	D. Rock	41	131.3	11.7	146.7								3.0 - 4.0					
	B1	7	33.0	D. Rock	46	125.6	12.1	140.8								2.0 - 3.5	1,138				
	B1	8	38.0	D. Rock	78	127.9	13.1	144.7								4.0 - >4.5					
	B1	9	43.0	D. Rock	67											>4.5					
	B1	10	48.0	D. Rock	69	125.8	12.7	141.8								4.0 - >4.5					
	B1	11	55.0	D. Rock	50/6"											>4.5					
	B1	12	60.0	D. Rock	REF																
	B2	1	5.5	CL	23	105.4	21.7	128.3								4.0					
	B2	2	10.5	CL	18				45	27	18					2.0 - 2.5					
	B2	3	15.5	CL	8	107.2	22.0	130.8								1.0 - 1.5					
	B2	4	20.5	D. Rock	39	121.3	14.9	139.4								2.0 - >4.5	518				
	B2	5	25.5	D. Rock	53											>4.5					
	B2	6	30.0	D. Rock	REF																
	B2	7	35.0	D. Rock	REF																
Anchor Piles	B3	1	5.0	GC	18	115.3	12.6	129.8				49	36	15							
	B3	2	10.0	D. Rock	51																
	B3	3	14.5	D. Rock	67	125.2	13.0	141.5								4.5					
	B3	4	20.0	D. Rock	7																
	B3	5	24.5	D. Rock	41	119.2	12.2	133.7								>4.5	202				
	B3	6	29.0	D. Rock	REF																
	B3	7	34.0	D. Rock	REF																
	B3	8	42.5	D. Rock	REF																

Note: We consider the lower range of values to reflect fractured rock within the samples and not representative of the in-situ rock strength.

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Project Name: Branscomb Road at MP 17.21
CAInc File No: 16-337.2
Date: 6/26/17
Technician: MEA

MOISTURE-DENSITY TESTS - D2216

	1	2	3	4	5
Sample No.	B1-1	B1-2	B1-3	B1-4	B1-5
USCS Symbol	SC	CL	CL	CL/Rock	Rock
Depth (ft.)	5	10	15	20	24.5
Sample Length (in.)	5.315	5.656	5.833	5.974	3.030
Diameter (in.)	2.378	2.383	2.388	2.382	1.390
Sample Volume (ft^3)	0.01366	0.01460	0.01512	0.01541	0.00266
Total Mass Soil+Tube (g)	1031.4	1148.8	1168.3	1181.4	144.0
Mass of Tube (g)	270.7	288.2	275.4	276.5	0.0
Tare No.	R4	D3	E3	C16	D1
Tare (g)	126.7	13.7	13.9	13.7	13.9
Wet Soil + Tare (g)	408.5	75.1	74.0	82.7	69.4
Dry Soil + Tare (g)	366.3	62.9	64.3	72.8	63.4
Dry Soil (g)	239.6	49.2	50.3	59.1	49.4
Water (g)	42.2	12.2	9.7	9.9	6.1
Moisture (%)	**17.6**	**24.8**	**19.3**	**16.8**	**12.3**
Dry Density (pcf)	**104.4**	**104.1**	**109.1**	**110.9**	**106.3**

Notes:

Crawford & Associates, Inc.
Geotechnical Engineering, Design and Construction Services

Project Name: Branscomb Road at MP 17.21
CAInc File No: 16-337.2
Date: 6/27/17
Technician: MEA

MOISTURE-DENSITY TESTS - D2216

	1	2	3	4	5
Sample No.	B1-6	B1-8	B1-10	B2-1	B2-3
USCS Symbol	Rock	Rock	Rock	CL	CL
Depth (ft.)	28	38	48	5.5	15.5
Sample Length (in.)	5.736	5.710	4.752	5.521	5.587
Diameter (in.)	1.399	1.420	1.409	1.416	1.411
Sample Volume (ft^3)	0.00510	0.00523	0.00429	0.00503	0.00506
Total Mass Soil+Tube (g)	461.9	466.1	395.0	416.7	421.3
Mass of Tube (g)	122.4	122.6	119.3	123.9	121.4
Tare No.	C8	C2	G22	H21	D7
Tare (g)	13.6	13.7	13.6	13.3	13.7
Wet Soil + Tare (g)	76.2	86.9	83.2	84.8	80.6
Dry Soil + Tare (g)	69.6	78.4	75.4	72.1	68.5
Dry Soil (g)	56.0	64.7	61.8	58.7	54.9
Water (g)	6.6	8.5	7.8	12.8	12.0
Moisture (%)	**11.7**	**13.1**	**12.7**	**21.7**	**22.0**
Dry Density (pcf)	**131.3**	**127.9**	**125.8**	**105.4**	**107.2**

Notes:

Crawford & Associates, Inc.
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Project Name: Branscomb Road at MP 17.21
CAInc File No: 16-337.2
Date: 6/27/17
Technician: MEA

MOISTURE-DENSITY TESTS - D2216

	1	2	3	4	5
Sample No.	B2-4	B3-1	B3-3	B3-5	
USCS Symbol	Rock	GC	Rock	Rock	
Depth (ft.)	20.5	5	14.5	24.5	
Sample Length (in.)	4.197	5.107	5.171	2.931	
Diameter (in.)	1.415	2.385	1.403	1.405	
Sample Volume (ft^3)	0.00382	0.01320	0.00463	0.00263	
Total Mass Soil+Tube (g)	363.1	1050.6	422.8	159.5	
Mass of Tube (g)	121.6	272.9	126.1	0.0	
Tare No.	H7	P3	G20	A6	
Tare (g)	13.2	127.9	13.6	13.7	
Wet Soil + Tare (g)	77.8	606.6	94.7	108.5	
Dry Soil + Tare (g)	69.5	553.0	85.4	98.2	
Dry Soil (g)	56.2	425.1	71.8	84.6	
Water (g)	8.4	53.6	9.3	10.3	
Moisture (%)	**14.9**	**12.6**	**13.0**	**12.2**	
Dry Density (pcf)	**121.3**	**115.3**	**125.2**	**119.2**	

Notes:

Crawford & Associates, Inc.
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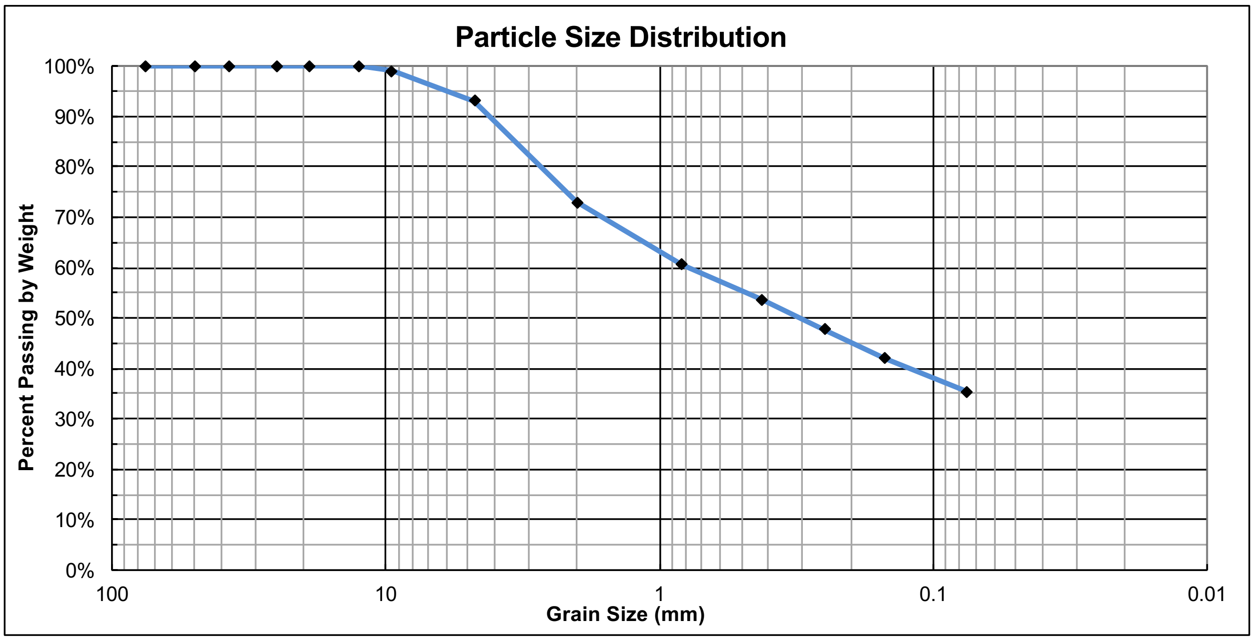
Project Name: Branscomb Road at MP 17.21
CAInc File No: 16-337.2
Date: 6/27/17
Technician: MEA
Sample ID: B1-1
Depth: 5.0'
USCS Classification: Clayey SAND

ASTM 6913 - Method A



% Cobble	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt/Clay
	0	7	20	19	19	
0	**7**		**58**			**35**

		Sieve #	Opening mm	Cummulative Mass Retained (g)	% Passing %
Cobbles		**3"**	75	0.0	100%
Gravel	Coarse	**2"**	50	0.0	100%
		1-1/2"	37.5	0.0	100%
		1"	25.0	0.0	100%
		3/4"	19.0	0.0	100%
	Fine	**1/2"**	12.5	0.0	100%
		3/8"	9.50	2.5	99%
		#4	4.75	16.5	93%
Sand	Coarse	**#10**	2.00	64.9	73%
	Medium	**#20**	0.825	94.5	61%
		#40	0.425	110.9	54%
	Fine	**#60**	0.250	125.3	48%
		#100	0.150	139.1	42%
		#200	0.075	154.8	35%

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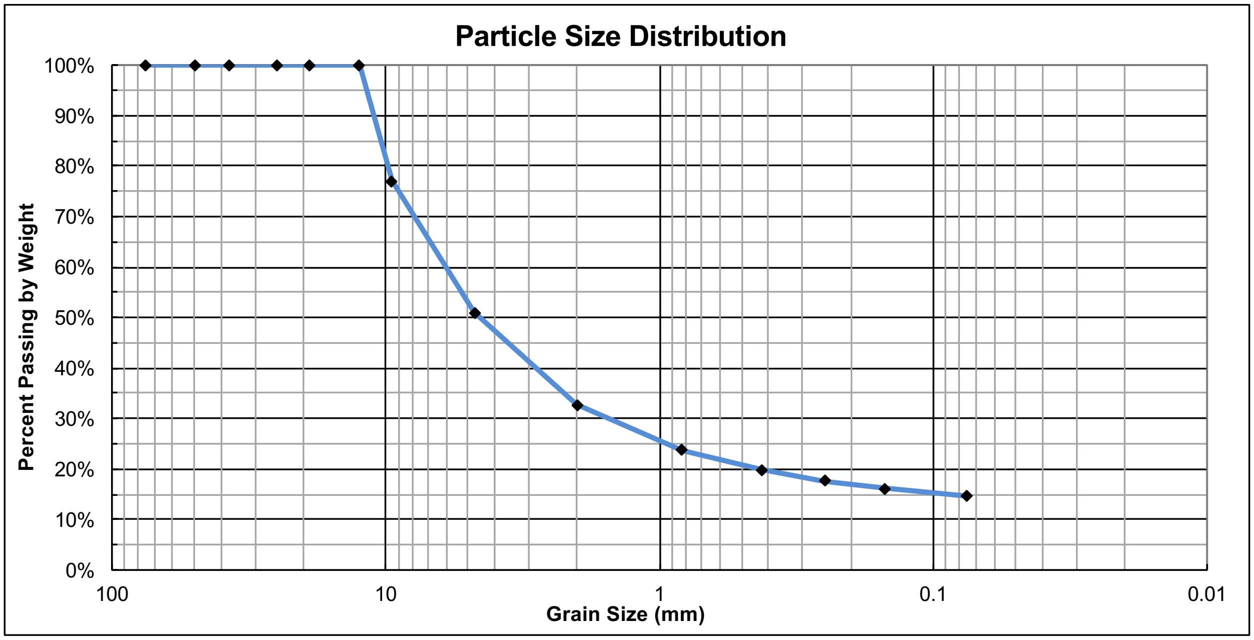
Project Name: Branscomb Road at MP 17.21
CAInc File No: 16-337.2
Date: 6/27/17
Technician: MEA
Sample ID: B3-1
Depth: 5.0'
USCS Classification: Clayey GRAVEL with SAND

ASTM 6913 - Method A



% Cobble	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt/Clay
	0	49	18	13	5	
0	**49**		**36**			**15**

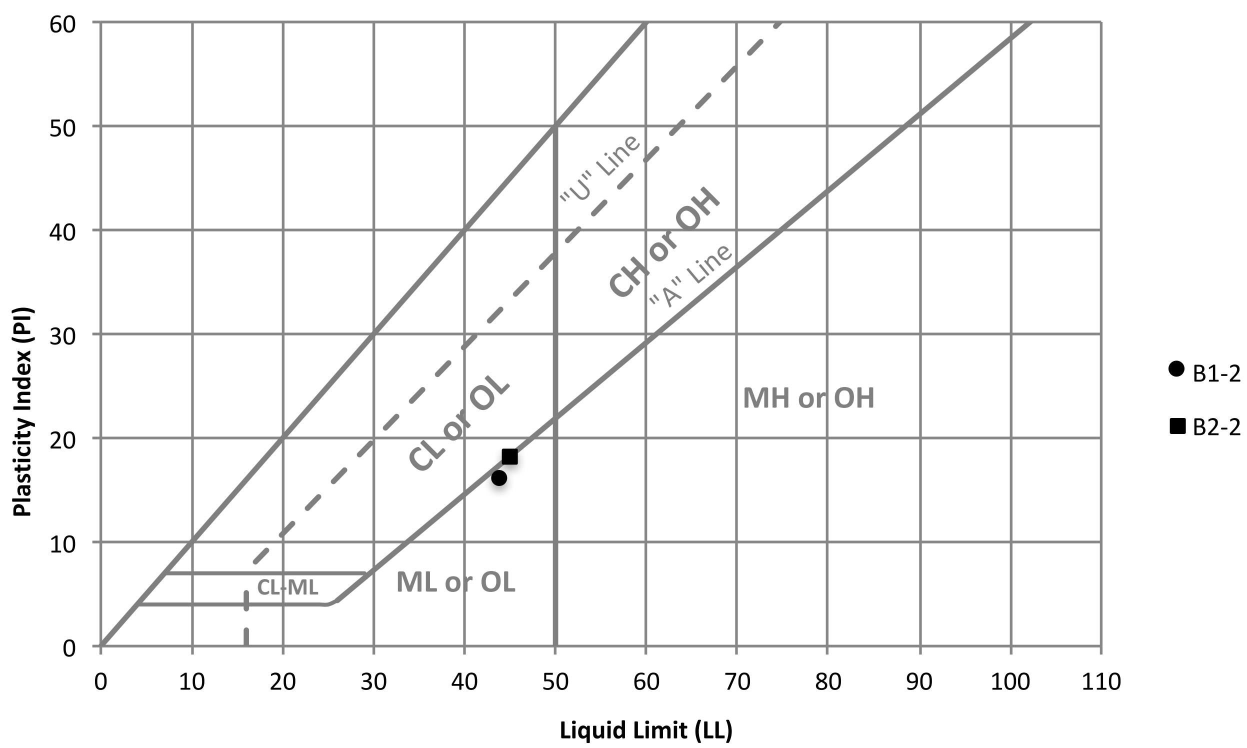
		Sieve #	Opening mm	Cummulative Mass Retained (g)	% Passing %
Cobbles		**3"**	75	0.0	100%
Gravel	Coarse	**2"**	50	0.0	100%
		1-1/2"	37.5	0.0	100%
		1"	25.0	0.0	100%
		3/4"	19.0	0.0	100%
	Fine	**1/2"**	12.5	0.0	100%
		3/8"	9.50	97.7	77%
		#4	4.75	208.2	51%
Sand	Coarse	**#10**	2.00	286.2	33%
	Medium	**#20**	0.825	324.0	24%
		#40	0.425	340.6	20%
	Fine	**#60**	0.250	350.0	18%
		#100	0.150	356.4	16%
		#200	0.075	362.9	15%

Crawford & Associates, Inc.
Geotechnical Engineering, Design and Construction Services

Project Name: Branscomb Road at MP 17.21
CAInc File No: 16-337.1
Date: 6/30/17
Technician: CAP

Plastic Index - ASTM D4318

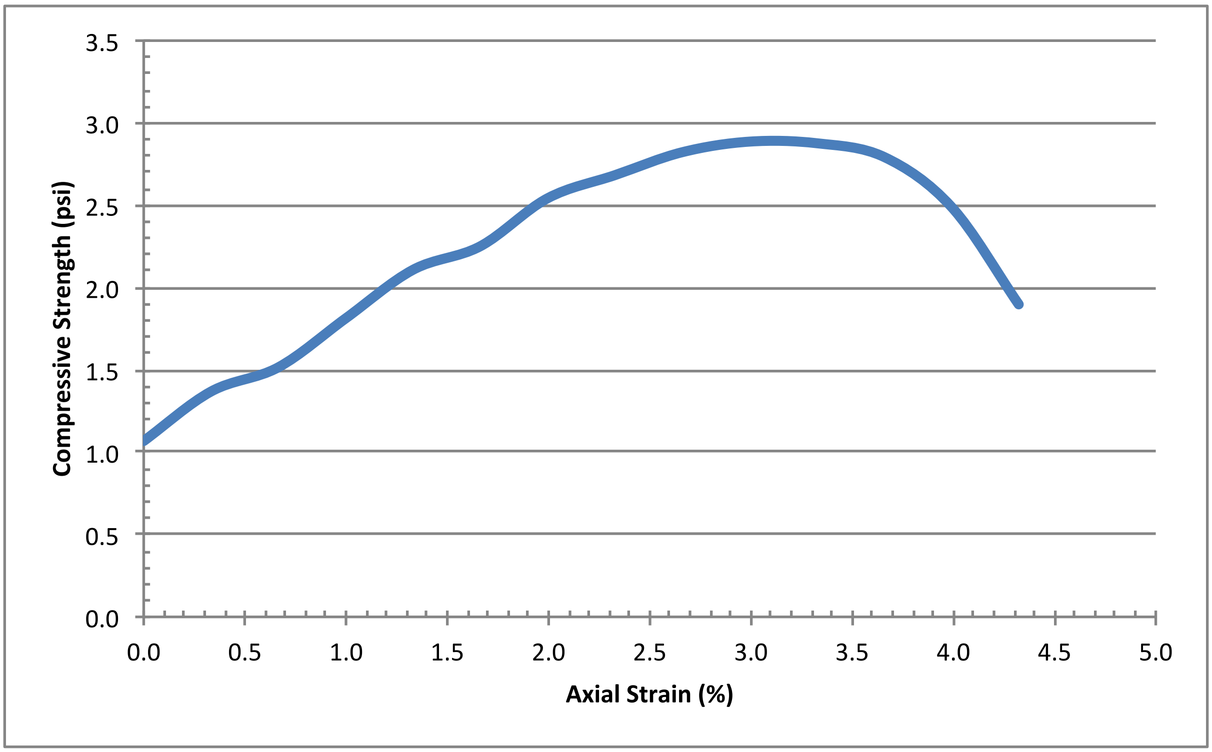
Sample ID	Depth (ft)	Liquid Limit	Plastic Limit	PI
B1-2	10.0	44	28	16
B2-2	10.5	45	27	18



Plasticity Chart

Project Name: Branscomb Road at MP 17.21
CAInc File No: 16-337.2
Date: 6/27/17
Technician: HFW
Sample ID: B1-5 Depth: 24.5'
USCS Classification: Rock

UNCONFINED COMPRESSION TEST - D2166



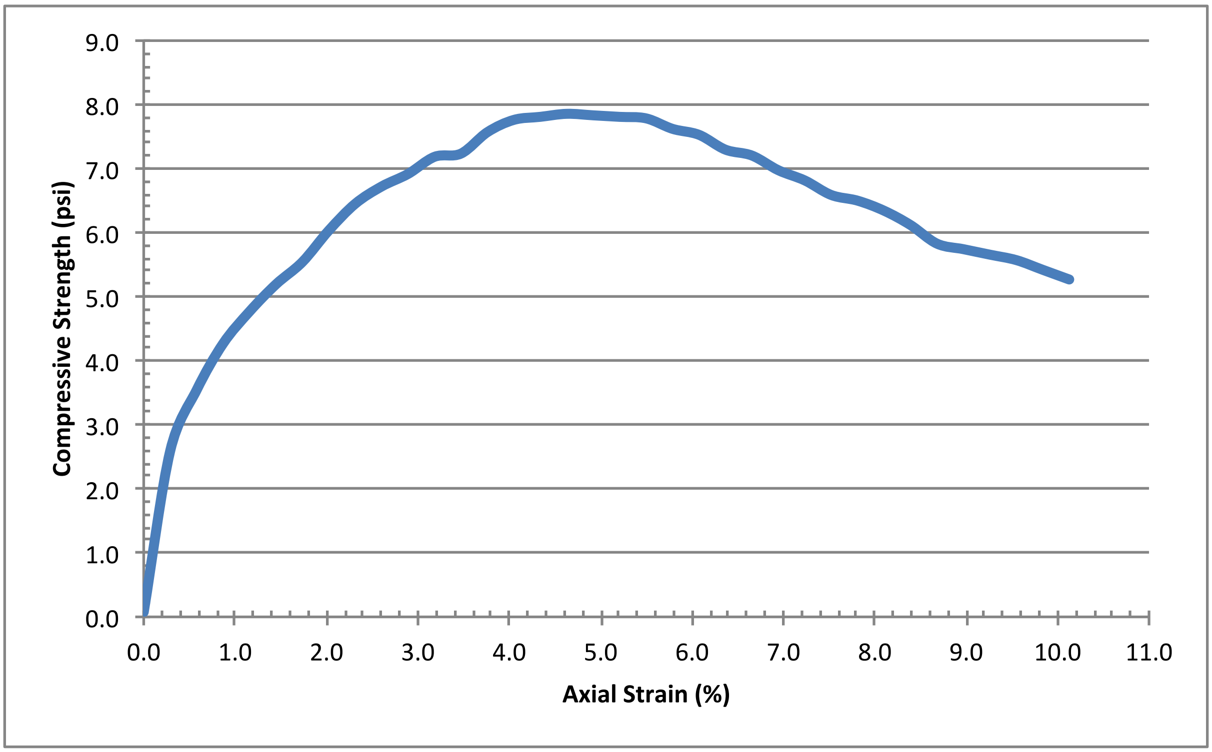
Dry Density (pcf)	**106.5**
Water Content (%)	**12.3**
Unconfined Compressive Strength (psi)	**2.9**
Unconfined Compressive Strength (psf)	**418**
Average Height	3.026
Average Diameter	1.390
Rate of strain (%)	1.0
Strain at Failure (%)	3.0

Notes:

Crawford & Associates, Inc.
Geotechnical Engineering, Design and Construction Services

Project Name:	Branscomb Road at MP 17.21
CAInc File No:	16-337.2
Date:	6/27/17
Technician:	MEA
Sample ID:	B1-7 Depth: 33.0'
USCS Classification:	Rock

UNCONFINED COMPRESSION TEST - D2166

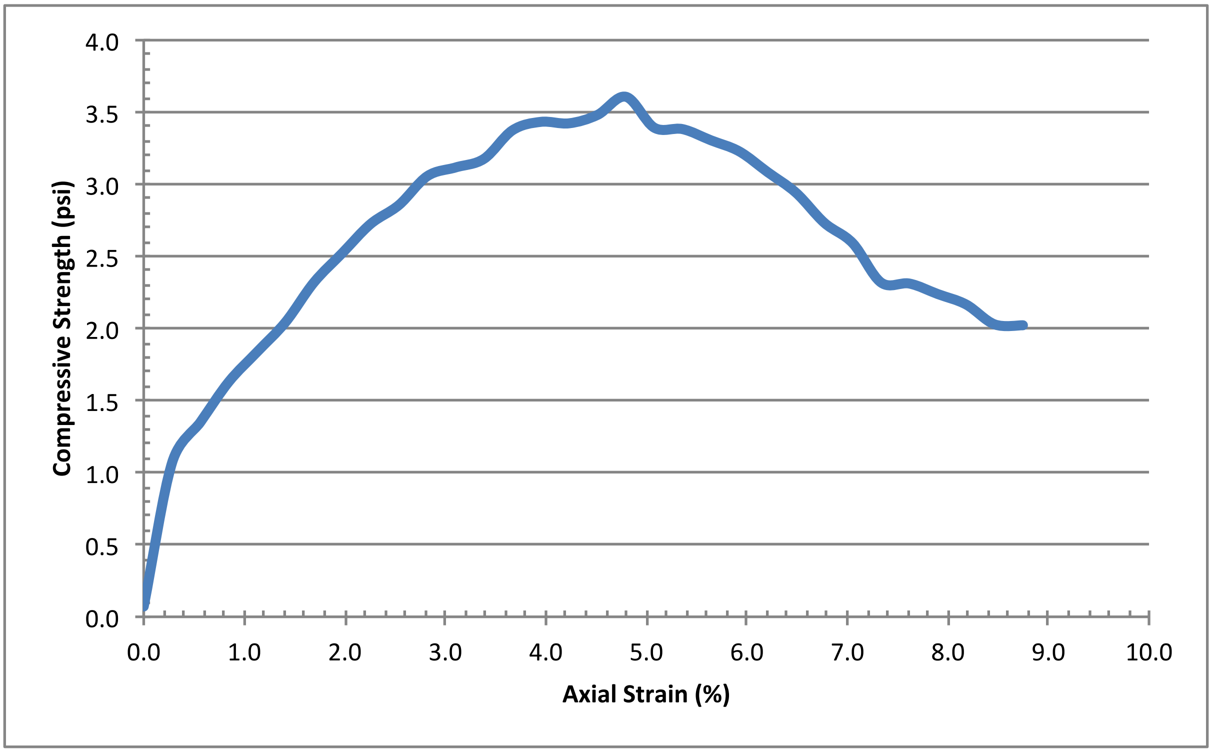


Dry Density (pcf)	**125.6**
Water Content (%)	**12.1**
Unconfined Compressive Strength (psi)	**7.9**
Unconfined Compressive Strength (psf)	**1138**
Average Height	3.477
Average Diameter	1.409
Rate of strain (%)	1.0
Strain at Failure (%)	4.6

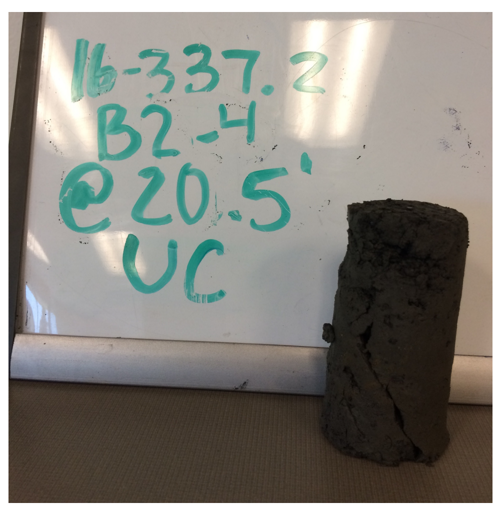
Notes:

Project Name: Branscomb Road at MP 17.21
CAInc File No: 16-337.2
Date: 6/29/17
Technician: HFW
Sample ID: B2-4 Depth: 20.5'
USCS Classification: Rock

UNCONFINED COMPRESSION TEST - D2166



Dry Density (pcf)	**121.2**
Water Content (%)	**11.6**
Unconfined Compressive Strength (psi)	**3.6**
Unconfined Compressive Strength (psf)	**518**
Average Height	3.566
Average Diameter	1.436
Rate of strain (%)	1.0
Strain at Failure (%)	4.8

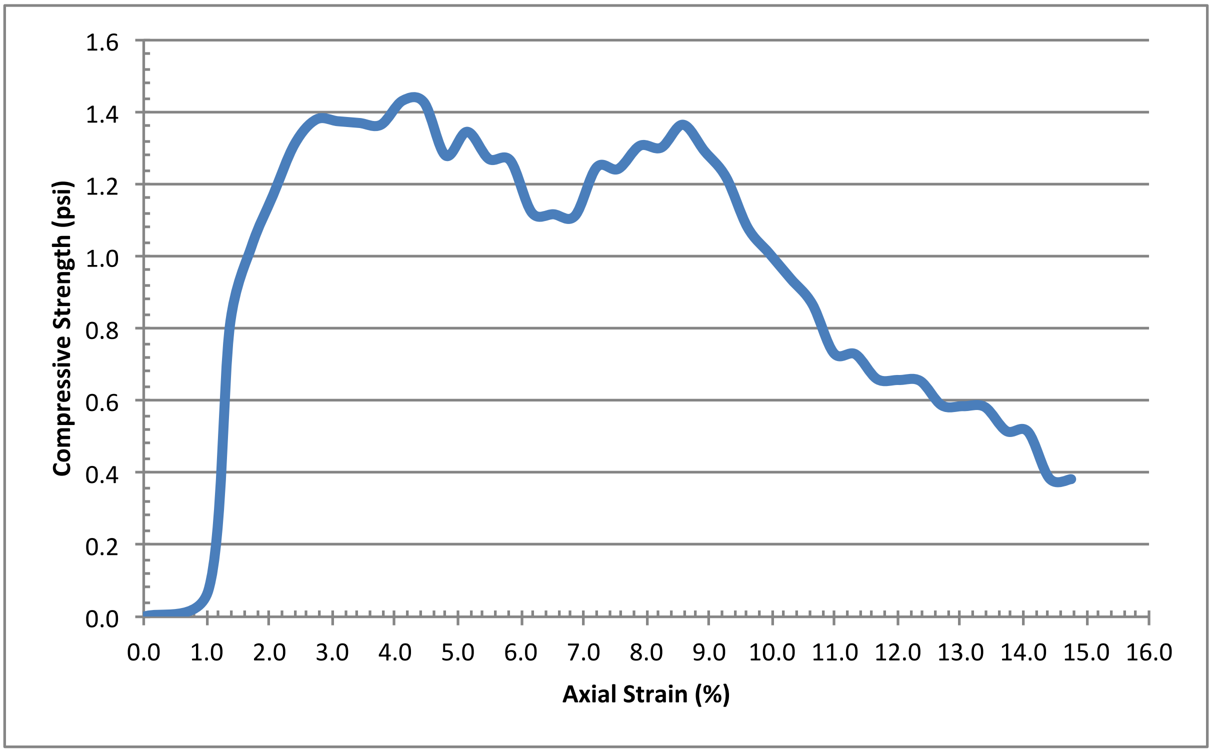


Notes:

Crawford & Associates, Inc.
Geotechnical Engineering, Design and Construction Services

Project Name: Branscomb Road at MP 17.21
CAInc File No: 16-337.2
Date: 6/27/17
Technician: HFW
Sample ID: B3-5   Depth: 24.5'
USCS Classification: Rock

UNCONFINED COMPRESSION TEST - D2166



Dry Density (pcf)	**119.2**
Water Content (%)	**12.2**
Unconfined Compressive Strength (psi)	**1.4**
Unconfined Compressive Strength (psf)	**202**
Average Height	2.931
Average Diameter	1.405
Rate of strain (%)	1.0
Strain at Failure (%)	4.1

Notes:

Sunland Analytical
11419 Sunrise Gold Cir.#10
Rancho Cordova, CA 95742
(916) 852-8557

Date Reported 06/30/17
Date Submitted 06/26/17

To: Keiko Lewis
Crawford and Associates Inc.
4020 Rocklin Rd, Ste 1
Rocklin, CA, 95677

From: Gene Oliphant, Ph.D. \ Randy Horney
General Manager \ Lab Manager

The reported analysis was requested for the following:
Location : 16-227.2 BRANSCOMB Site ID: B1-3 @ 15 FT
Thank you for your business.

* For future reference to this analysis please use SUN # 74577 - 155640

EVALUATION FOR SOIL CORROSION

Soil pH	5.62	
Minimum Resistivity	1.92	ohm-cm (x1000)
Chloride	5.3 ppm	0.0005 %
Sulfate-S	1.7 ppm	0.0002 %

METHODS:
pH and Min.Resistivity CA DOT Test #643 Mod.(Sm.Cell)
Sulfate CA DOT Test #417, Chloride CA DOT Test #422