Crawford & Associates, Inc.
Geotechnical Engineering, Design and Construction Services
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May 19, 2017
CAInc File No. 16-337.3

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

Subject: **Geotechnical Memorandum**
Orr Springs Road (CR 223) Slide at MP 39.20 – Permanent Repair
Mendocino County, California

Dear Mr. Dashiell,

Crawford & Associates, Inc. (CAInc) prepared this Geotechnical Memorandum for the Orr Springs Road Slide at Milepost (MP) 39.20 in accordance with Project Work Order No. 3 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 repair with a soldier pile tieback wall.

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

Sincerely,

Crawford & Associates, Inc.,

Ryan Houghton, MS, EIT
Project Engineer

Reviewed By,

Rick Sowers, PE, CEG
Principal

REGISTERED PROFESSIONAL ENGINEER
RICHARD D. SOWERS
C38788
CIVIL
STATE OF CALIFORNIA

PROFESSIONAL GEOLOGIST
RICHARD D. SOWERS
No. 1104
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

Taber
Since 1954

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX A

APPENDIX B

1 INTRODUCTION

This Geotechnical Memorandum summarizes the results of our geotechnical investigation completed at the Orr Springs Road (CR 223) Slide at MP 39.20. This work was completed in accordance with Work Order No. 3 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 geologic and topographic mapping of the site.
- Reviewed the subsurface exploration, surface geologic reconnaissance, and laboratory testing completed under Work Order #1 for this site.
- Performed geotechnical engineering analysis in support of the recommendations contained herein.

3 PROJECT DESCRIPTION

3.1 PROJECT LOCATION

The project is located on Orr Springs Road (CR 223) at MP 39.20, approximately 3.5 miles northwest of the City of Ukiah. Site latitude is approximately 39.194407° and longitude -123.269657°, per Google Earth. See Figure 1 for Vicinity Map.

3.2 SITE DESCRIPTION

Orr Springs Road at this location traverses a moderately steep, northeast-facing slope near the crest of a northwest-trending ridge. The road is a paved, two-lane section approximately 20 feet wide and established in a combination cut/fill section. Inboard cuts are approximately 5-10 feet high and decrease to the west, where the road eventually transitions into a full-fill section. Existing slope gradients in the project vicinity range from approximately 1.5:1 to 1:1. Approximate elevation of the site is 1920 feet per USGS topographic mapping and 1010 feet per MCDOT topographic survey[1] of the site. The MCDOT survey is based on a local control point with assumed elevation (CP 1, elev. 1000.00 feet) located at the center of the road just east of the failure area.

The subject road failure has resulted in the complete loss of the outboard (west-bound) lane and over half of the inboard (east-bound) lane for a distance of approximately 55 feet and maximum depth of 16 feet. The west half of the head-scarp is approximately 10-15 feet high, with a 5 to 6 foot nearly vertical face directly below the road grade and then transitioning to 1:1 sloped face thereafter. The east half is approximately 8 feet high with a constant 1.5:1 slope face directly below the road grade. The toe of the slide is approximately 44 feet from the head-scarp and consists of a large mound of slide debris. Immediately down-slope of the road failure, significant erosion of the existing slopes has been caused by the slide. The erosion extends down the entire slope, approximately 300 feet horizontally, until it reaches a private dirt road running along an unnamed tributary to Hensley Creek. Near the bottom of the slope, the erosion cuts are as deep as 8 to 10 feet.

[1] CAD drawings of Topographic Survey completed by MCDOT received electronically on 03/13/17

The road gradient, based on the topography survey provided by MCDOT, descends about 10% west to east. Surface runoff is collected west of the site in an inboard, unlined ditch/culvert system and discharges east of the road failure. Sloughing of the inboard cut slope was observed west of the slide, which was blocking the flow-line of the ditch and an upstream culvert appeared at least partial blocked. Blockages within the road drainage conveyance system may have forced sheet-flow across the road (toward the failure area) during periods of high intensity rainfall. The County has placed a Bailey bridge across the slide area to provide temporary access.

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

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.

4.2 SITE GEOLOGY

The Geologic Map of California: Ukiah Sheet[2] shows the site as being underlain by Undivided Marine Sedimentary Rocks (Cretaceous), which consist of sandstone, shale, and conglomerate. Approximately 3500 feet northeast of the site lay rock of the Franciscan Formation (Jurassic-Cretaceous.) Rock out-crops within the inboard road cut at the site and west of the site, showed intensely fractured, weathered to decomposed brown sandstone, consistent with the mapped marine sedimentary rocks. Additionally, approximately 200 feet down-slope of the road failure, the eroded slope exposes small areas of fresh to slightly weathered rock within the bottom of the deepest erosion cuts (8 to 10 feet below the original ground); this rock appears to be moderately fractured, bluish-gray sandstone (greywacke.)

See Figure 3 for a Regional Geologic Map.

4.3 FAULTS AND SEISMIC ACTIVITY

Based on California Geologic Survey (CGS) fault data[3], the nearest fault to the site is an unnamed Pre-Quaternary fault (no activity in last 1.6 million years) located approximately 3500 feet northeast of the site. It coincides with the boundary between the Undivided Marine Sedimentary rock formation of the site and the Franciscan Formation rock. The nearest active fault (defined as surface displacement within the last 11,000 years) is the north section of the Maacama Fault Zone, located approximately 3.5 miles east of the site. Portions of this fault have been active as recently as within the last 200 years. The site is located in an area with risks of strong seismic ground motions, having a peak ground acceleration (PGA) of approximately 0.49g[4].

See Figure 4 for Fault Map.

[2] Jennings, C.W. and Strand, R.G., (1960), Geologic Map of California: Ukiah Sheet
[3] California Geologic Survey, Fault Activity Map of California, 2010
[4] USGS Unified Hazard Tool (2014 data), assuming Site Class C and a return period of 475 years (10% in 50 years)

5 SUBSURFACE CONDITIONS

5.1 EXPLORATION

CAInc retained Geo-Ex Subsurface Exploration (GEOEX) to drill and sample three roadway-level test borings (B1 – B3) to a maximum depth of 61.5 feet below the ground surface (bgs.) These borings were supplemented by two on-slope test borings (HA4 – HA5) hand-augered by CAInc to a maximum depth of 6.3 feet bgs. Drilling of B1 – B3 took place from 03/22/17 – 03/23/17 and HA4 – HA5 were completed on 04/05/17. See Figure 2 for Exploration Location Map.

GEOEX used a CME-75HT track-mounted drill rig to complete the road-level test borings using a combination of 4-inch solid-stem auger and 3.8-inch rotary wash drilling equipment. Auger refusal was reached in the rock unit of B1 and B3 at 15 feet and 20 feet bgs respectively. B2 was drilled entirely using rotary wash methods. The borings were all drilled to the completion depth with standard rotary wash drilling equipment.

Soil samples were recovered by means of a 2.0-inch O.D. "Standard Penetration" split-spoon sampler without liners and a 3.0-inch O.D. "Modified California" split-spoon sampler with stainless steel liners. Both samplers were advanced with standard 350 ft-lb striking force using an automatic hammer. Hammer efficiency is assumed to be 80% for this project. 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 samples were retained in sealed containers for laboratory testing and reference. Groundwater observations were recorded during drilling operations when drilling technique allowed. At completion, the road-level borings were cement grout backfilled with inspection from Mendocino County Environmental Health Division Field Inspectors. On-slope hand-augered borings were backfilled with soil cuttings.

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

Material Unit	Boring Location	Depth Range (bgs, ft)	Soil Description
1	Road-Level	0 to 6.0-8.0	Very stiff, reddish-brown to brown sandy lean clay with gravel; dense, brown, silty, clayey sand with gravel and clayey gravel with sand. Pocket Penetrometer[1] (PP) tests on samples ranges from 3.25 to >4.5 tsf, field SPT Blow Counts[2] (N) ranges from 35 – 47 blows per foot (bpf). Represents fill and/or residual native soil.
	On-slope	0 to 2.5-5.5	
2	Road-Level	6.0-8.0 to 61.5	Decomposed to moderately weathered, very soft to moderately hard sandstone with varying amounts of intact weathered rock fragments ranging in size from coarse sand to coarse gravel. Rock color predominately reddish-brown and brownish-gray with minor amounts of light brown and blackish gray. PP tests on samples predominately >4.5 tsf with N>50 bpf (typically reaching blow count refusal[2].) Occasional, isolated layers encountered with PP test range of 2.5-4.25 tsf and N range between 33-41 bpf.
	On-slope	2.5-5.5 to 6.3	

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".

A nearly vertical face of the head-scarp showed various layers associated with the road section. Below the current road structural section (HMA over AB), which is approximately 0.5 feet thick at this location, is a 2.75 foot layer of hard gravelly clay with Pocket Penetrometer readings of >4.5 tsf. Underlying the clay layer is a distinct 0.75 foot layer of gray base-rock, which is likely an older road section. Below the old road section is reddish-brown sandy silt; the upper portion (1 ft) is hard/cemented in consistency (PP>4.5 tsf) and then proceeds to grade to a stiff consistency (PP=1.5-2 tsf.)

5.3 GROUNDWATER

Free groundwater was not encountered within the augered portions of the test borings for this study. Groundwater could not be checked when using rotary wash drilling due to drilling fluid. We expect that seasonal groundwater could be present during the winter months within the upper 10-20 ft, possibly as perched groundwater overlying the decomposed 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 (%)	Unconfined Compression Strength (psf)
1	132.1 – 138.4 (Avg. = 135.3)	9.1 – 15.1 (Avg. = 12.1)	3,467
2	133.4 – 152.0 (Avg. = 142.8)	5.0 – 15.5 (Avg. = 9.9)	1,103 – 9,039 (Avg. = 4,817)

Chemical analysis was completed on two samples 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)
B1-4	20.0	7.15	5,630	10.3	16.0
B2-4	20.0	5.61	7,240	4.9	7.5

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, as well as the uppermost portion of the soft decomposed sandstone. We conclude the primary causes of slope failure to be the inherent weakness of the fill and intensely weathered sandstone, the high degree of saturation from seasonal storm water infiltration during this past very wet winter, and possible internal seepage pressures – including seepage from within the underlying weathered rock. 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 an 82’ long soldier pile wall with tiebacks 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 sedimentary 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.

8 RECOMMENDATIONS

We recommend the soldier pile tieback wall option. This option will achieve secure support within the sedimentary rock and provide lateral resistance to active pressures. Additionally, based on conversations with the County, this option allows for Orr Springs Road (a Major Collector) to remain open during construction, as well as limiting the environmental impact downslope of the failure. See Figure 5 for typical section of tieback wall.

The MSE wall and RSP Fill options would require significant excavations, likely extending beyond the County Right-of-Way, as well as having a greater environmental impact within the project vicinity. Additionally, these two options would require a road closure during construction.

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[5]

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

- An active EFP of 50 pcf/ft for native backfill materials
- A passive EFP of 560 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 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 82 foot long wall meets. For a wall positioned as shown in Figure 5, the estimated rock surface near the center of the slide is at elevation 989 feet (per assumed project datum), corresponding to a minimum pile tip elevation of 969 feet. The pile tip elevations will vary along the line of wall, generally parallel to the road grade.

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 15 feet 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 998 feet, corresponding to a minimum pile tip elevation of 983 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 underdrain (e.g., per Caltrans “Standard Plans”) along the inner road area to intercept shallow seepage. Construct the underdrain 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 underdrain. See Figure 5 for typical section of tieback wall.

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.

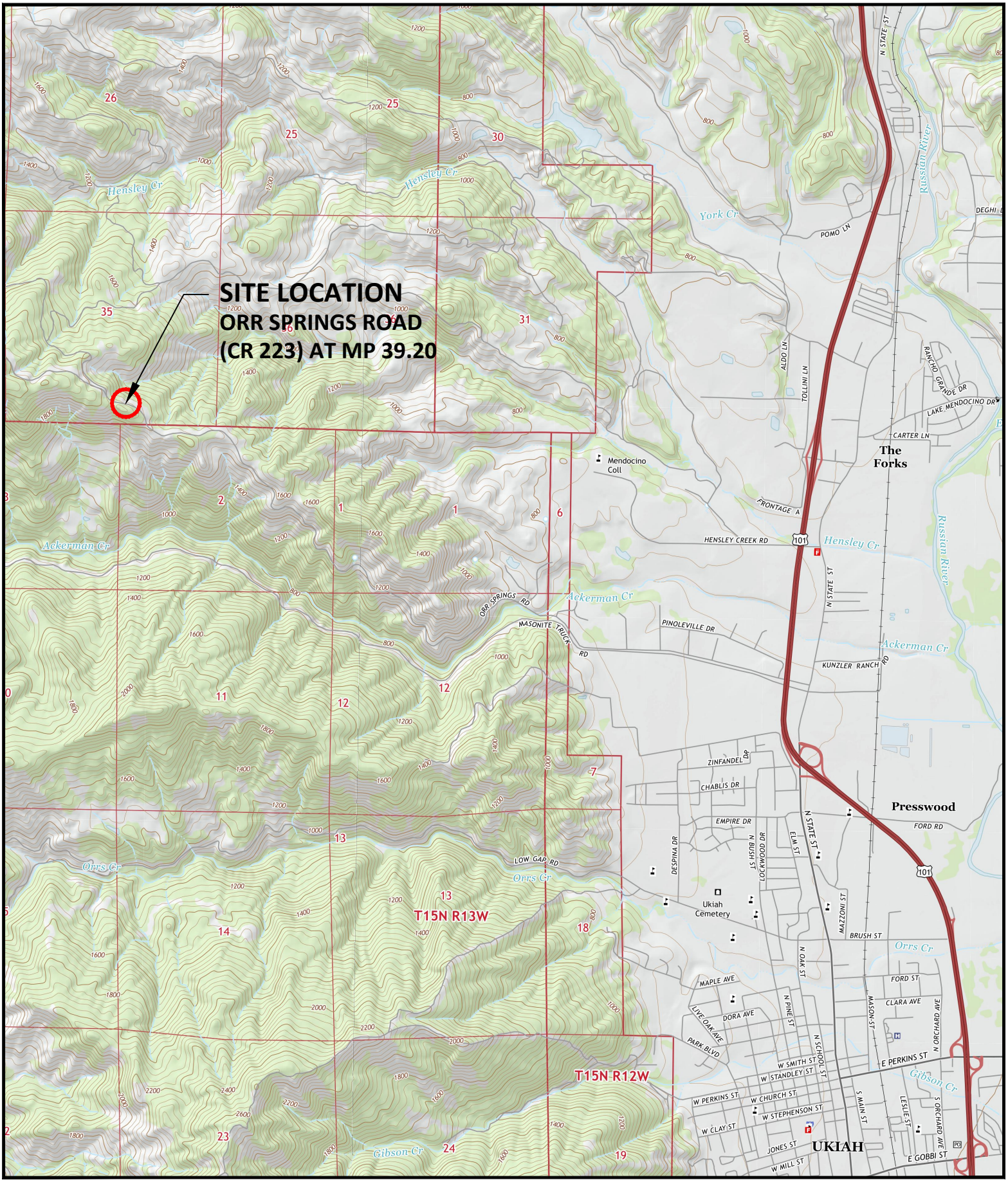
10 LIMITATIONS

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 Orr Springs Road slope failure at MP 39.20.

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:

-USGS, Orrs Springs, Mendocino Co., CA, 2015
7.5 Minute Quadrangle Map Series, Scale 1:24,000.

-USGS, Ukiah, Mendocino Co., CA, 2015
7.5 Minute Quadrangle Map Series, Scale 1:24,000.

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GEOTECHNICAL INVESTIGATION
ORR SPRINGS ROAD (CR 223)
SLIDE AT MP 39.20

MENDOCINO COUNTY, CA

Figure 1
Vicinity Map

Proj. No: 16-337.3
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Date: 05/15/2017

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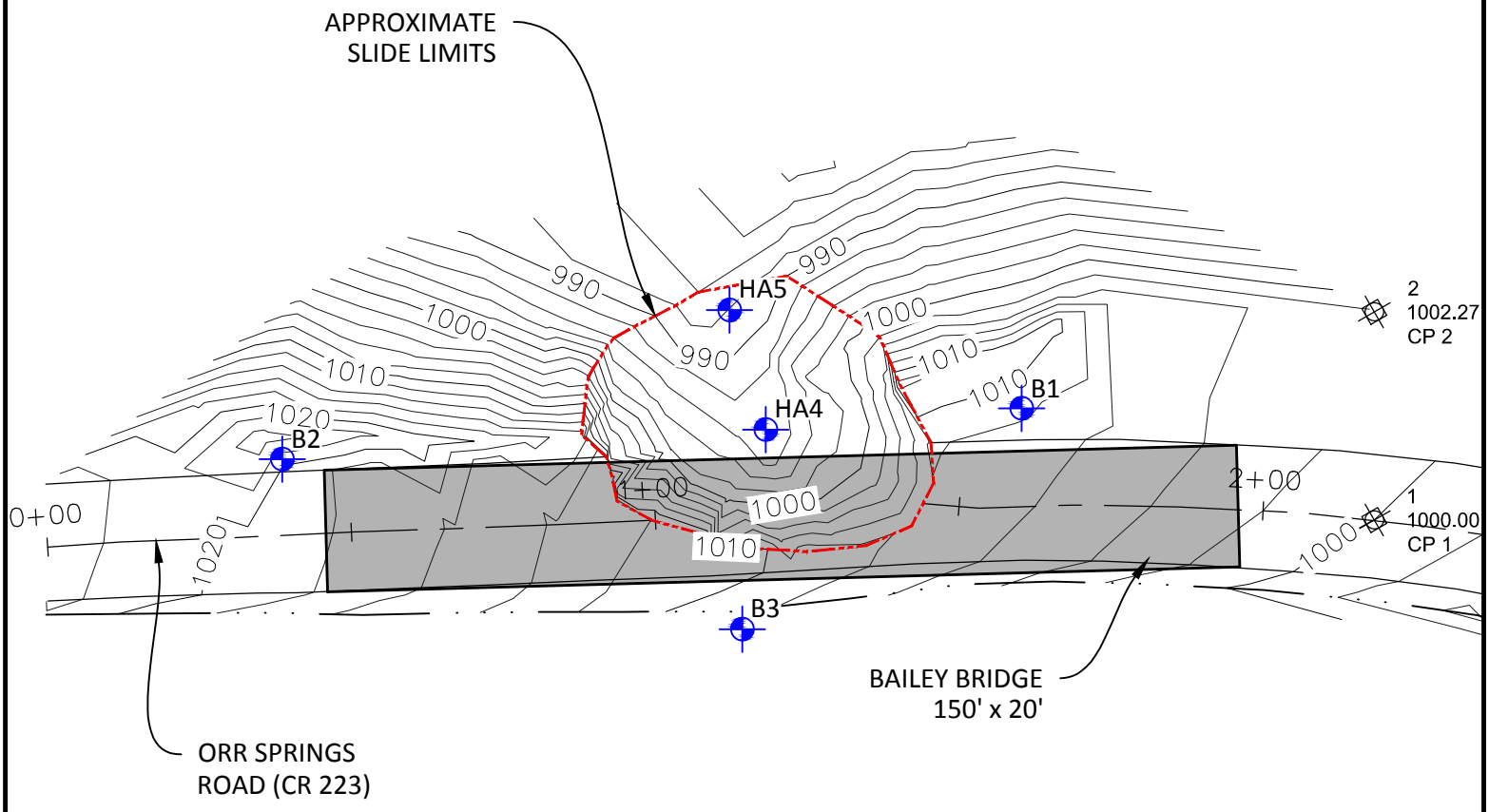
LEGEND

B-1 BORING LOCATIONS

DRILLING DATES:
03/22/2017 - 03/23/2017 AND 04/05/2017



NORTH

Map Source:
-Base map provided by MCDOT via electronic transfer on 03/13/17.

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GEOTECHNICAL INVESTIGATION
ORR SPRINGS ROAD (CR 223)
SLIDE AT MP 39.20

MENDOCINO COUNTY, CA

Figure 2
Exploration Location Map

Proj. No:	16-337.3
Scale:	1"=30'
Date:	05/15/2017

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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*

ub — **Mesozoic Ultra-basic Intrusive Rocks (Jurassic-Cretaceous) -** *serpentine and peridotite*

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
ORR SPRINGS ROAD (CR 223)
SLIDE AT MP 39.20

MENDOCINO COUNTY, CA

Figure 3
Geologic Map

Proj. No: 16-337.3
Scale: 1"=10,000'
Date: 05/15/2017

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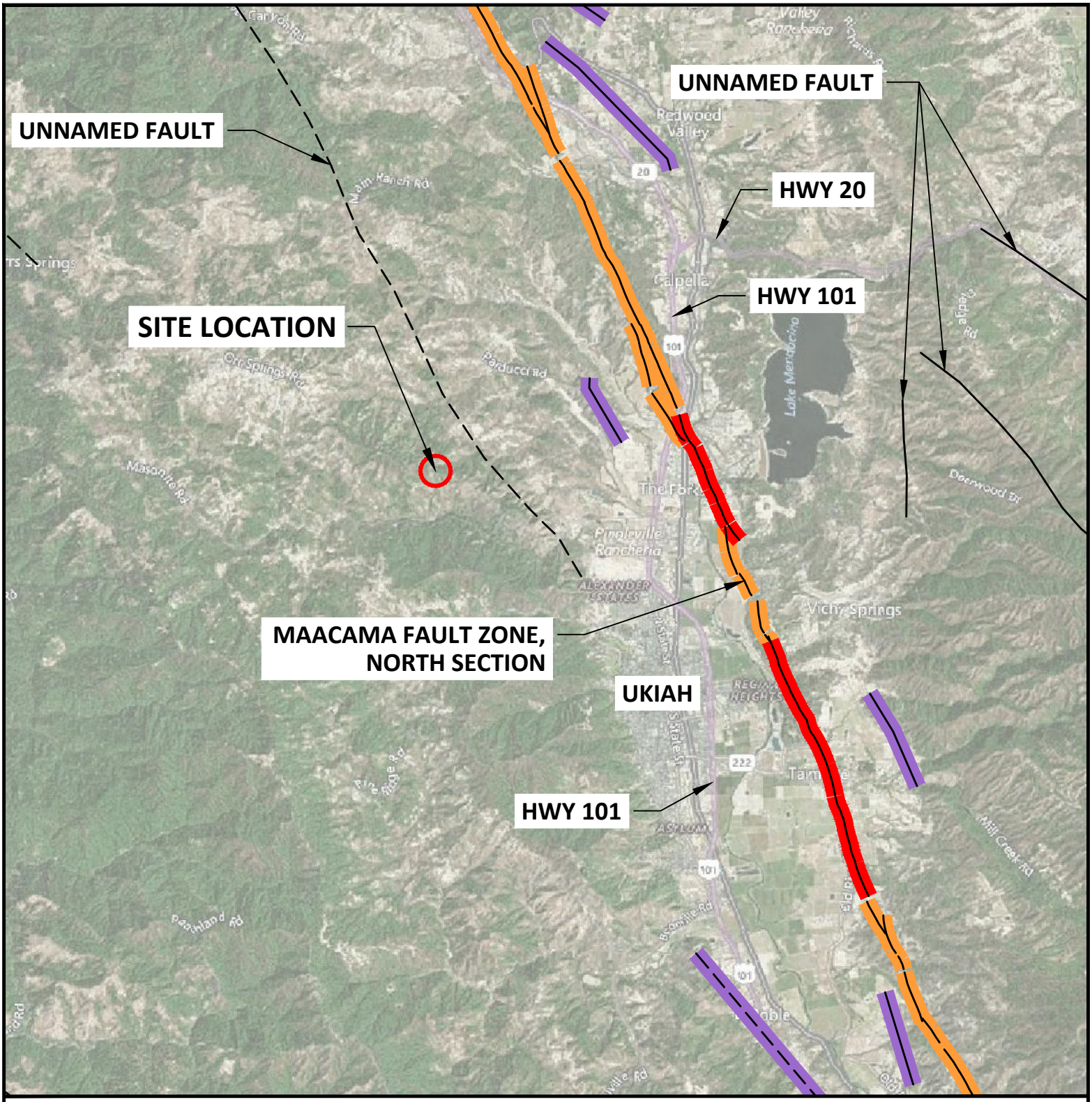

LEGEND

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)		Concealed

NORTH

Map and Data Sources:
-Base map via AutoCAD Civil3D Geolocation Map tool

-Fault data via GIS of CGS Fault Activity Map of California (2010)

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GEOTECHNICAL INVESTIGATION
ORR SPRINGS ROAD (CR 223)
SLIDE AT MP 39.20

MENDOCINO COUNTY, CA

Figure 4
Fault Map

Proj. No: 16-337.3
Scale: 1"=10,000'
Date: 05/15/2017

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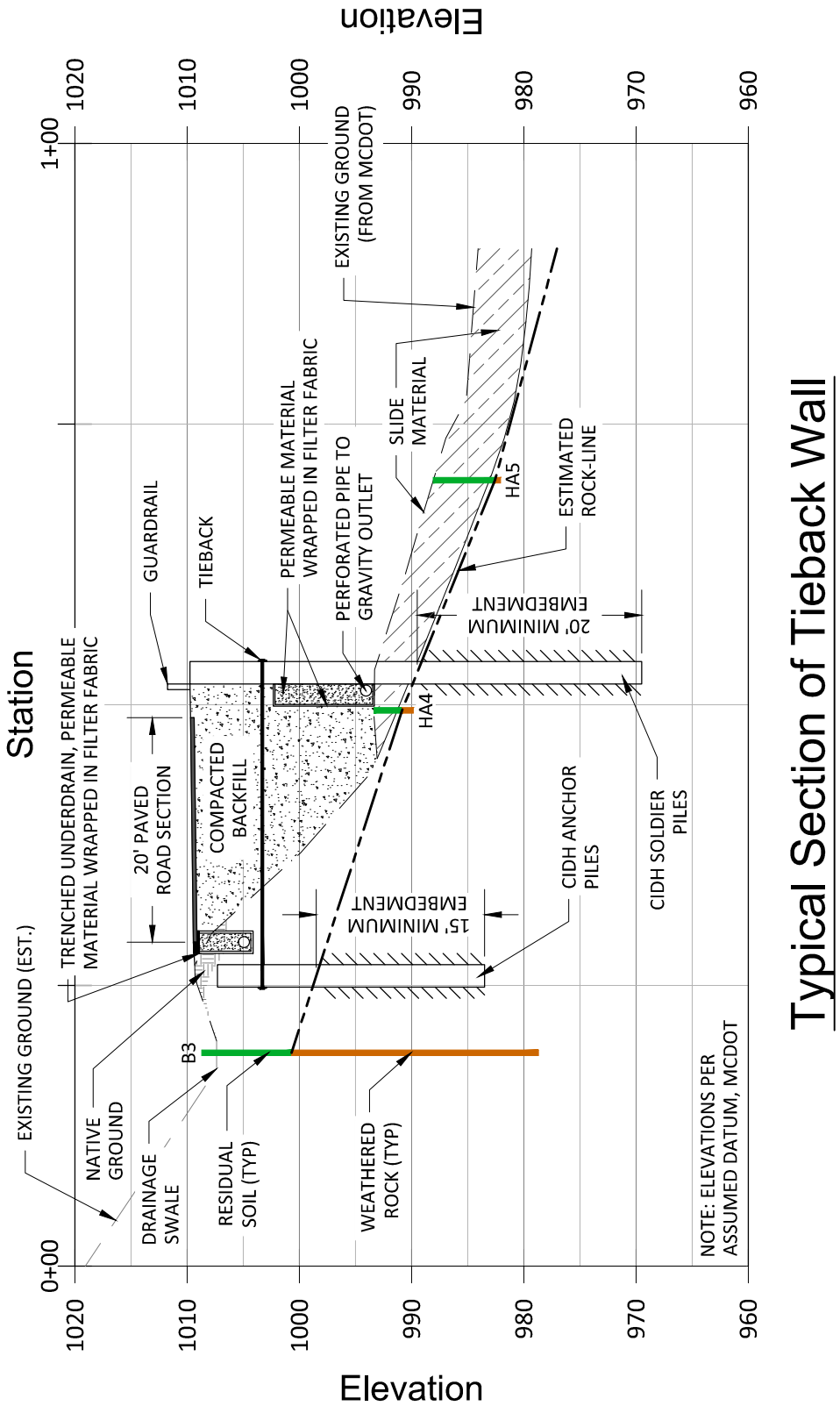

Typical Section of Tieback Wall

NORTH

Data Source:
-Existing ground surface within slide area provided by MCDOT via electronic transfer on 03/13/17.

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GEOTECHNICAL INVESTIGATION
ORR SPRINGS ROAD (CR 223)
SLIDE AT MP 39.20

MENDOCINO COUNTY, CA

Figure 5
Typical Section of Tieback Wall

Proj. No:	16-337.3
Scale:	1" = 15'
Date:	05/15/2017

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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).

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Boring Record Legend

Soil Legend

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)

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

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).

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Boring Record Legend

Rock Legend

LOG OF BORING B1

PROJECT NO: 16-337.3
PROJECT: Orr Springs Rd Slide MP 39.20
LOCATION: Orr Springs Rd, Ukiah
CITY/COUNTY: Mendocino
CLIENT: MCDOT
LOGGED BY: RH
DEPTH OF BORING: 60.08(ft)

BEGIN DATE: 3/22/17
COMPLETION DATE: 3/23/17
SURFACE ELEVATION: 1008.6(ft)
SURFACE CONDITION: Soil/Gravel
WATER DEPTH: Not Encountered(ft)
READING TAKEN: 3/22/17
HAMMER EFFICIENCY: 80(%)

DRILLING CONTRACTOR: Geo-Ex Subsurface Exploration
DRILLING METHOD: Solid-Stem Auger, Rotary Wash
DRILL RIG: CME 75HT (Track Rig)
HAMMER TYPE: Automatic, 140 lbs, 30" drop
SAMPLER TYPE & SIZE: SPT (ID 1.4") and CAL (ID 2.4")
BOREHOLE DIAMETER: 4" (Auger) and 3.8" (Rotary)
BACKFILL METHOD: 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
	1							CLAYEY GRAVEL with SAND (GC); dense; reddish brown; moist; low to medium plasticity fines.									
1007	2																
	3																
1005	4																
	5		1	6 15 25	40	>4.5			67								
1003	6										19	37	9.1	126.9	24		Intact rock fragments in sampler tip
	7							SEDIMENTARY ROCK (SANDSTONE), brownish gray, decomposed, very soft, very intensely fractured, (Sandy clay matrix with fragments of moderately to intensely weathered intact rock, size of rock ranges from coarse sand to >1") [DECOMPOSED BEDROCK].									
1001	8																
	9																
999	10		2	38 50/5"	50/5	>4.5			73				7.7	123.9			Unconfined Comp. Test UC = 4,310 psf
	11																
997	12																
	13																
995	14																
	15		3	50/5"	REF	>4.5			80								At 15', switch from auger to rotary wash
993	16																
	17																
991	18																
	19																
989	20		4	17 50/6"	50/6				33				11.4				Chemical Analysis pH = 7.15 Min Resist. = 5630 ohm-cm Chloride = 10.3 ppm Sulfate-S = 16.0 ppm
	21																
987	22																Audible drill "screeching/grinding" sporadically throughout rest of hole
	23																

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ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	LABORATORY: PLASTIC LIMIT	LABORATORY: LIQUID LIMIT	LABORATORY: MOISTURE (%)	LABORATORY: D. DENSITY (PCF)	LABORATORY: % PASSING 200 SIEVE	DRILL METHOD / CASING DEPTH	REMARKS
								SEDIMENTARY ROCK (Sandstone) *(continued)*.									
	25		5	16 26 41	67				33								Quartzite fragments
983	26																
	27																
981	28																
	29																Hard drilling
979	30		6	41 50/3"	50/3				78				9.8	132.7			Unconfined Comp. Test UC = 1,103 psf
	31																
977	32																
	33																Hard drilling
975	34																
	35		7	50/4"	REF			Intensely to moderately weathered, moderately soft to moderately hard.	50								Intact rock pieces of 1" to 1.3" within sampler
973	36																
	37																
971	38																
	39																
969	40		8	50/3"	REF				67				5				
	41																
967	42																
	43																Hard drilling
965	44																
	45		9	50/1"	REF				100								
963	46																
	47																
961	48																
	49																
959	50		10	50/4"	REF				50								
	51																
957	52																
	53																

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PROJECT NUMBER: 16-337.3
PROJECT: Orr Springs Rd Slide MP 39.20
BORING: B1
ENTRY BY: RH
CHECKED BY: RS

ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	LABORATORY: PLASTIC LIMIT	LABORATORY: LIQUID LIMIT	LABORATORY: MOISTURE (%)	LABORATORY: D. DENSITY (PCF)	LABORATORY: % PASSING 200 SIEVE	DRILL METHOD / CASING DEPTH	REMARKS
955	54																
	55		11	50/4"	REF			Decomposed, very soft, with moderately to intensely weathered intact rock fragments within matrix.	75								
953	56																
	57																
951	58																
	59																
949	60		12	50/1"	REF			Bottom of borehole at 60.1 ft bgs	100								
	61							No groundwater encountered									
947	62							Backfill with cement grout, field inspection by MCDEH Inspector Gary Leonard									
	63																
945	64																
	65																
943	66																
	67																
941	68																
	69																
939	70																
	71																
937	72																
	73																
935	74																
	75																
933	76																
	77																
931	78																
	79																
929	80																
	81																
927	82																

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PROJECT NUMBER: 16-337.3
PROJECT: Orr Springs Rd Slide MP 39.20
BORING: B1
ENTRY BY: RH
CHECKED BY: RS SHEET 3 of 3

LOG OF BORING B2

PROJECT NO: 16-337.3
PROJECT: Orr Springs Rd Slide MP 39.20
LOCATION: Orr Springs Rd, Ukiah
CITY/COUNTY: Mendocino
CLIENT: MCDOT
LOGGED BY: RH
DEPTH OF BORING: 61.5(ft)

BEGIN DATE: 3/23/17
COMPLETION DATE: 3/23/17
SURFACE ELEVATION: 1021.0(ft)
SURFACE CONDITION: Baserock
WATER DEPTH: Not Encountered(ft)
READING TAKEN: 3/23/17
HAMMER EFFICIENCY: 80(%)

DRILLING CONTRACTOR: Geo-Ex Subsurface Exploration
DRILLING METHOD: Rotary Wash
DRILL RIG: CME 75HT (Track Rig)
HAMMER TYPE: Automatic, 140 lbs, 30" drop
SAMPLER TYPE & SIZE: SPT (ID 1.4") and CAL (ID 2.4")
BOREHOLE DIAMETER: 3.8" (Rotary)
BACKFILL METHOD: 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
	1							SANDY lean CLAY with GRAVEL (CL); very stiff; reddish brown; moist; low to medium plasticity fines.									
1019	2																
	3																
1017	4																
	5		1	10	47				56								
				22		3.25											
1015	6			25		>4.5							5.4	144.2			
	7							SEDIMENTARY ROCK (SANDSTONE), brown, decomposed, very soft, very intensely fractured, (Sandy clay matrix with fragments of moderately to intensely weathered intact rock, size of rock ranges from coarse sand to >1") [DECOMPOSED BEDROCK].									
1013	8																
	9																
1011	10		2	13	73				44				8.5	130.1			Unconfined Comp. Test UC = 9,039 psf
				28		>4.5											
	11			45													
1009	12																
	13																
1007	14																
	15		3	28	98/11				47				8.3	130.7			
				48		2.5											
1005	16			50/5"		>4.5											
	17																Audible drill "screeching/grinding" sporadically throughout rest of hole
1003	18																
	19																
1001	20		4	6	33				50								Chemical Analysis pH = 5.61 Min Resist. = 7240 ohm-cm Chloride = 4.9 ppm Sulfate-S = 7.5 ppm
	21			15		3.25											
				18													
999	22																
	23																

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PROJECT NUMBER: 16-337.3
PROJECT: Orr Springs Rd Slide MP 39.20
BORING: B2
ENTRY BY: RH
CHECKED BY: RS

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 (Sandstone) *(continued)*.									
	25		5	29 31 37	68				56				15.5				Increasing amount of intact rock fragments
995	26																
	27																
993	28																
	29																
991	30		6	13 50/4"	50/4	>4.5			50								
	31																
989	32																
	33																
987	34																
	35		7	47 36 34	70	>4..5		Brownish gray, with scattered moderately to slightly weathered rock fragments.	56				10.6				
985	36																
	37																
983	38																
	39																
981	40		8	13 30 27	57	>4.5			61								Increasing amount of intact rock fragments, some containing quartz veins
	41																
979	42																
	43																
977	44																
	45		9	9 16 19	35	>4.5			39				10.3				Only a few coarse sand size rock fragments
975	46																
	47																
973	48																
	49																
971	50		10	16 50/3"	50/3				33								
	51																
969	52																
	53																

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PROJECT NUMBER: 16-337.3
PROJECT: Orr Springs Rd Slide MP 39.20
BORING: B2
ENTRY BY: RH
CHECKED BY: RS

ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	LABORATORY: PLASTIC LIMIT	LIQUID LIMIT	MOISTURE (%)	D. DENSITY (PCF)	% PASSING 200 SIEVE	DRILL METHOD / CASING DEPTH	REMARKS
967	54																
	55																
		X	11	19 32 32	64			Grayish black, with moderately weathered rock fragments.	28								
965	56																
	57																
963	58																
	59																
961	60																
	61	X	12	14 45 47	92				0								
959	62							Bottom of borehole at 61.5 ft bgs No groundwater encountered Backfill with cement grout, no field inspection required per phone call with MCDEH Inspector Gary Leonard									
	63																
957	64																
	65																
955	66																
	67																
953	68																
	69																
951	70																
	71																
949	72																
	73																
947	74																
	75																
945	76																
	77																
943	78																
	79																
941	80																
	81																
939	82																

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PROJECT NUMBER: 16-337.3
PROJECT: Orr Springs Rd Slide MP 39.20
BORING: B2
ENTRY BY: RH
CHECKED BY: RS

LOG OF BORING B3

PROJECT NO: 16-337.3
PROJECT: Orr Springs Rd Slide MP 39.20
LOCATION: Orr Springs Rd, Ukiah
CITY/COUNTY: Mendocino
CLIENT: MCDOT
LOGGED BY: RH
DEPTH OF BORING: 30.08(ft)

BEGIN DATE: 3/22/17
COMPLETION DATE: 3/22/17
SURFACE ELEVATION: 1008.6(ft)
SURFACE CONDITION: Soil/Gravel
WATER DEPTH: Not Encountered(ft)
READING TAKEN: 3/22/17
HAMMER EFFICIENCY: 80(%)

DRILLING CONTRACTOR: Geo-Ex Subsurface Exploration
DRILLING METHOD: Solid-Stem Auger, Rotary Wash
DRILL RIG: CME 75HT (Track Rig)
HAMMER TYPE: Automatic, 140 lbs, 30" drop
SAMPLER TYPE & SIZE: SPT (ID 1.4") and CAL (ID 2.4")
BOREHOLE DIAMETER: 4" (Auger) and 3.8" (Rotary)
BACKFILL METHOD: Cement Grout

ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	LABORATORY: PLASTIC LIMIT	LIQUID LIMIT	MOISTURE (%)	D. DENSITY (PCF)	% PASSING 200 SIEVE	DRILL METHOD / CASING DEPTH	REMARKS
	0							SILTY, CLAYEY SAND with GRAVEL (SC-SM); dense; reddish brown; moist; low plasticity fines; scattered rock fragments.									
1007	2																
1005	4																
	5		1	13 15 20	35	>4.5			56		22	28	15.1	114.8	24		Unconfined Comp. Test UC = 3,467 psf
1003	6																
1001	8							SEDIMENTARY ROCK (SANDSTONE), moderate reddish brown, decomposed, very soft, very intensely fractured, (Sandy clay matrix with fragments of moderately to intact rock, size of rock varies from coarse sand to fine grave) [DECOMPOSED BEDROCK].									
999	10		2	16 20 21	41	3.25			100								
997	12																
995	14																
	15		3	50/3"	REF				100				12.4				
993	16																
991	18																Audible drill "screeching"
989	20		4	50/1"	REF			Light brown, intensely to moderately weathered.	100								At 20', switch from auger to rotary wash (no casing) Sampler contained fine gravel size rock fragments with dry fine sand (rock pulverized by auger)
987	22																
	23																

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PROJECT NUMBER: 16-337.3
PROJECT: Orr Springs Rd Slide MP 39.20
BORING: B3
ENTRY BY: RH
CHECKED BY: RS

ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	LABORATORY: PLASTIC LIMIT	LIQUID LIMIT	MOISTURE (%)	D. DENSITY (PCF)	% PASSING 200 SIEVE	DRILL METHOD / CASING DEPTH	REMARKS
								SEDIMENTARY ROCK (Sandstone) *(continued)*.									
	25		5	42 50/5"	50/5	4.25		Grayish brown, decomposed, with scattered moderately weathered rock fragments within matrix.	82				14				
983	26																
	27																
981	28																
	29																
979	30		6	50/1"	REF			Bottom of borehole at 30.1 ft bgs	0								
	31							No groundwater encountered									
977	32							Backfill with cement grout, field inspection by MCDEH Inspector Will Nalty									
	33																
975	34																
	35																
973	36																
	37																
971	38																
	39																
969	40																
	41																
967	42																
	43																
965	44																
	45																
963	46																
	47																
961	48																
	49																
959	50																
	51																
957	52																
	53																

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PROJECT NUMBER: 16-337.3
PROJECT: Orr Springs Rd Slide MP 39.20
BORING: B3
ENTRY BY: RH
CHECKED BY: RS

LOG OF BORING HA4

PROJECT NO: 16-337.3
PROJECT: Orr Springs Rd Slide MP 39.20
LOCATION: Orr Springs Rd, Ukiah
CITY/COUNTY: Mendocino
CLIENT: MCDOT
LOGGED BY: RH
DEPTH OF BORING: 3.5(ft)

BEGIN DATE: 4/5/17
COMPLETION DATE: 4/5/17
SURFACE ELEVATION: 993.3(ft)
SURFACE CONDITION: Slide Debris
WATER DEPTH: Not Encountered(ft)
READING TAKEN: 04/05/17
HAMMER EFFICIENCY: N/A(%)

DRILLING CONTRACTOR: Crawford & Associates, Inc.
DRILLING METHOD: Hand Auger
DRILL RIG: N/A
HAMMER TYPE: N/A
SAMPLER TYPE & SIZE: BULK
BOREHOLE DIAMETER: 4"
BACKFILL METHOD: Cuttings

ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	LABORATORY: PLASTIC LIMIT	LIQUID LIMIT	MOISTURE (%)	D. DENSITY (PCF)	% PASSING 200 SIEVE	DRILL METHOD	CASING DEPTH	REMARKS
								SANDY lean CLAY (CL); soft; reddish brown; wet; scattered gravel.										
	1		1						100									
991	2							SANDY SILT (ML); light yellowish brown; moist; scattered coarse sand to fine gravel.										
	3		2					SEDIMENTARY ROCK (SANDSTONE), light brown, decomposed, with weathered rock fragments.	100									
989	4							Bottom of borehole at 3.5 ft bgs										Auger refusal at 3.5'
	5							No groundwater encountered										
987	6							Backfill with cuttings										
	7																	
985	8																	
	9																	
983	10																	
	11																	
981	12																	
	13																	
979	14																	
	15																	
977	16																	
	17																	
975	18																	
	19																	
973	20																	
	21																	
971	22																	
	23																	
969	24																	

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PROJECT NUMBER: 16-337.3
PROJECT: Orr Springs Rd Slide MP 39.20
BORING: HA4
ENTRY BY: RH
CHECKED BY: RS SHEET 1 of 1

LOG OF BORING HA5

PROJECT NO: 16-337.3
PROJECT: Orr Springs Rd Slide MP 39.20
LOCATION: Orr Springs Rd, Ukiah
CITY/COUNTY: Mendocino
CLIENT: MCDOT
LOGGED BY: RH
DEPTH OF BORING: 6.25(ft)

BEGIN DATE: 4/5/17
COMPLETION DATE: 4/5/17
SURFACE ELEVATION: 988.1(ft)
SURFACE CONDITION: Slide Debris
WATER DEPTH: Not Encountered(ft)
READING TAKEN: 04/05/17
HAMMER EFFICIENCY: N/A(%)

DRILLING CONTRACTOR: Crawford & Associates, Inc.
DRILLING METHOD: Hand Auger
DRILL RIG: N/A
HAMMER TYPE: N/A
SAMPLER TYPE & SIZE: BULK
BOREHOLE DIAMETER: 4"
BACKFILL METHOD: Cuttings

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
988	0							SANDY lean CLAY (CL); soft; brown; wet.										
986	2																	
984	4																	
982	6							SEDIMENTARY ROCK (SANDSTONE), grayish brown, decomposed, with scattered weathered rock fragments.										Auger refusal at 6.25'
								Bottom of borehole at 6.3 ft bgs										
								No groundwater encountered										
980	8							Backfill with cuttings										
978	10																	
976	12																	
974	14																	
972	16																	
970	18																	
968	20																	
966	22																	
964	24																	

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PROJECT NUMBER: 16-337.3
PROJECT: Orr Springs Rd Slide MP 39.20
BORING: HA5
ENTRY BY: RH
CHECKED BY: RS

APPENDIX B

Laboratory and Field Test Results Summary

Job: **Orr Springs Road (CR 223) Slide at MP 39.20**
Job No: **16-337.1**
Date: **4/26/17**

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Laboratory/Field Test Summary

Boring I.D.	Sample I.D.	Sample Depth (ft)	USCS Class.	Blow Counts $(N_1)_{60}$ (bpf)	Moisture/Density			Classification							Strength			Chemical Analysis			
					Dry Density (pcf)	Moist. Content (%)	Wet Density (pcf)	Atterberg Limits			Gravel (%)	Sand (%)	Fines (%)	Organic Content (%)	Pocket Pen. (tsf)	Uncon. Comp. (psf)	Point Load (psf)	pH	Min. Resist. (ohm-cm)	Chloride (ppm)	Sulfate-S (ppm)
								Liquid Limit	Plastic Limit	Plasticity Index											
B1	1	6.0	GC	48	126.9	9.1	138.4	37	19	18	43	33	24		>4.50						
B1	2	10.0	D. Rock	50/5"	123.9	7.7	133.4								>4.50	4,310					
B1	3	15.0	D. Rock	REF											>4.50						
B1	4	20.0	D. Rock	50/6"		11.4												7.15	5,630	10.3	16.0
B1	5	25.0	D. Rock	74																	
B1	6	30.0	D. Rock	50/3"	132.7	9.8	145.7									1,103					
B1	7	35.0	D. Rock	REF																	
B1	8	40.0	D. Rock	REF		5.0															
B1	9	45.0	D. Rock	REF																	
B1	10	50.0	D. Rock	REF																	
B1	11	55.0	D. Rock	REF																	
B1	12	60.0	D. Rock	REF																	
B2	1	6.0	D. Rock	57	144.2	5.4	152.0								4.00						
B2	2	10.0	D. Rock	73	130.1	8.5	141.2								>4.50	9,039					
B2	3	15.0	D. Rock	98/11"	130.7	8.3	141.5								3.50						
B2	4	20.0	D. Rock	40											3.25			5.61	7,240	4.9	7.5
B2	5	25.0	D. Rock	76		15.5															
B2	6	30.0	D. Rock	50/4"											>4.50						
B2	7	35.0	D. Rock	67		10.6									>4.50						
B2	8	40.0	D. Rock	51											>4.50						
B2	9	45.0	D. Rock	30		10.3									>4.50						
B2	10	50.0	D. Rock	50/3"																	
B2	11	55.0	D. Rock	48																	
B2	12	60.0	D. Rock	66																	
B3	1	6.0	SC-SM	42	114.8	15.1	132.1	28	22	6	25	51	24		>4.50	3,467					
B3	2	10.0	D. Rock	63											3.25						
B3	3	15.0	D. Rock	REF		12.4															
B3	4	20.0	D. Rock	REF																	
B3	5	25.0	D. Rock	50/5"		14.0									4.25						
B3	6	30.0	D. Rock	REF																	

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Geotechnical Engineering, Design and Construction Services

Project Name: Orr Spring Road Slide
CAInc File No: 16-337.1
Date: 4/6/17
Technician: HFW & CAP

MOISTURE-DENSITY TESTS - D2216

	1	2	3	4	5
Sample No.	B1-1	B2-1	B2-3		
USCS Symbol	GC	D. Rock	D. Rock		
Depth (ft.)	6'	6'	16'		
Sample Length (in.)	5.209	4.209	5.640		
Diameter (in.)	2.350	2.388	2.404		
Sample Volume (ft^3)	0.01307	0.01091	0.01481		
Total Mass Soil+Tube (g)	1103.0	967.8	1227.7		
Mass of Tube (g)	282.0	215.4	276.1		
Tare No.	R13	B14	C15		
Tare (g)	129.8	21.0	20.7		
Wet Soil + Tare (g)	553.6	92.8	76.3		
Dry Soil + Tare (g)	518.2	89.1	72.0		
Dry Soil (g)	388.4	68.2	51.3		
Water (g)	35.4	3.7	4.3		
Moisture (%)	**9.1**	**5.4**	**8.3**		
Dry Density (pcf)	**126.9**	**144.2**	**130.7**		

Notes:

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

Project Name: Orr Spring Road Slide
CAInc File No: 16-337.1
Date: 4/5/17
Technician: HFW

MOISTURE TESTS - D2216

	1	2	3	4	5
Sample No.	B1-4	B1-8	B2-5	B2-7	B2-9
USCS Symbol	D. Rock	D. Rock	D. Rock	D. Rock	D. Rock
Depth (ft.)	20	40	25	35'	45'
Tare No.	H3	D9	B12	D2	D1
Tare (g)	13.4	20.9	13.6	13.9	21.1
Wet Soil + Tare (g)	96.7	105.0	129.7	95.8	100.0
Dry Soil + Tare (g)	88.2	101.0	114.2	87.9	92.7
Dry Soil (g)	74.8	80.1	100.5	74.1	71.6
Water (g)	8.5	4.0	15.6	7.9	7.4
Moisture (%)	**11.4**	**5.0**	**15.5**	**10.6**	**10.3**

Notes:

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

Project Name: Orr Spring Road Slide
CAInc File No: 16-337.1
Date: 4/5/17
Technician: HFW

MOISTURE TESTS - D2216

	1	2	3	4	5
Sample No.	B3-3	B3-5			
USCS Symbol	D. Rock	D. Rock			
Depth (ft.)	15	25			
Tare No.	D7	A19			
Tare (g)	13.7	13.6			
Wet Soil + Tare (g)	102.9	138.0			
Dry Soil + Tare (g)	93.0	122.7			
Dry Soil (g)	79.3	109.0			
Water (g)	9.8	15.3			
Moisture (%)	**12.4**	**14.0**			

Notes:

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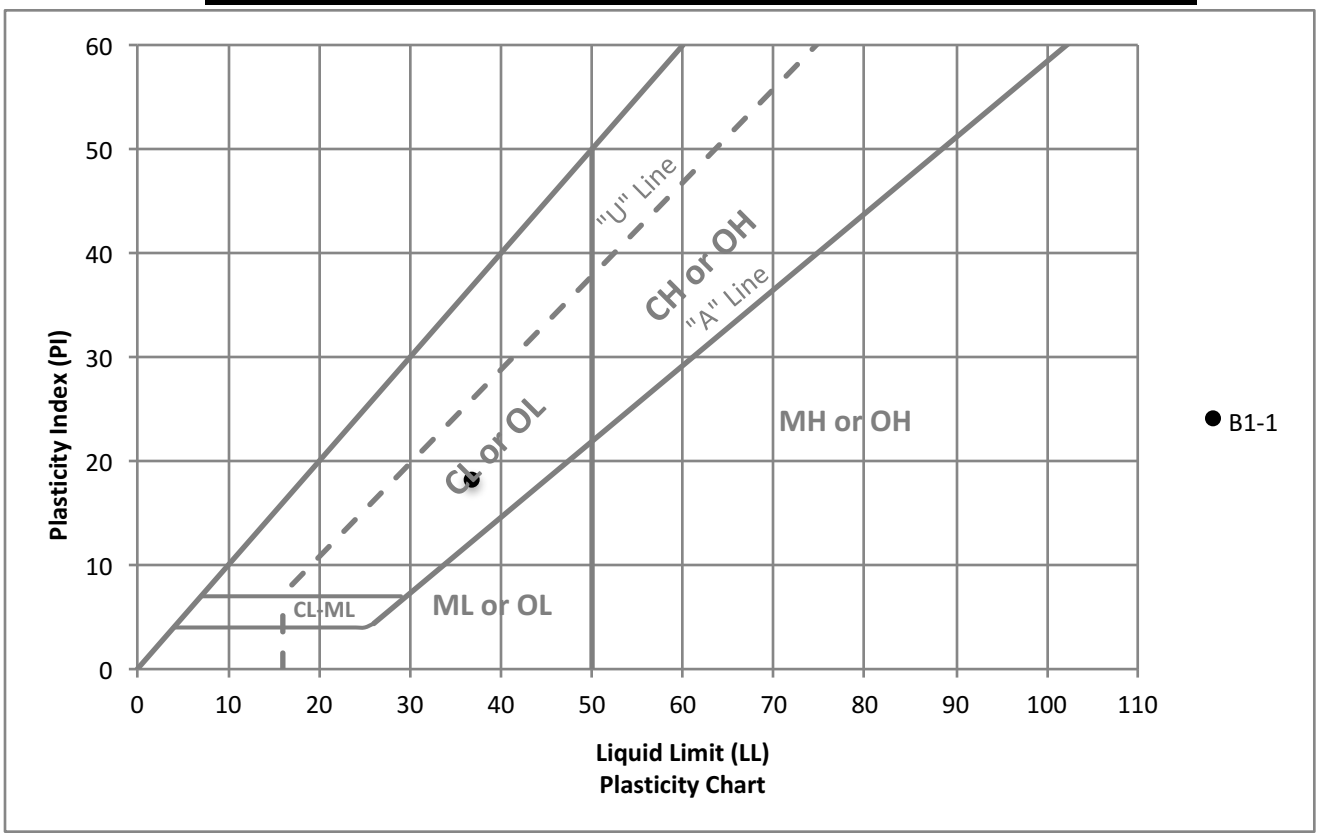
Geotechnical Engineering, Design and Construction Services

Project Name: Orr Spring Road Slide
CAInc File No: 16-337.1
Date: 4/13/17
Technician: KKL

Plastic Index - ASTM D4318

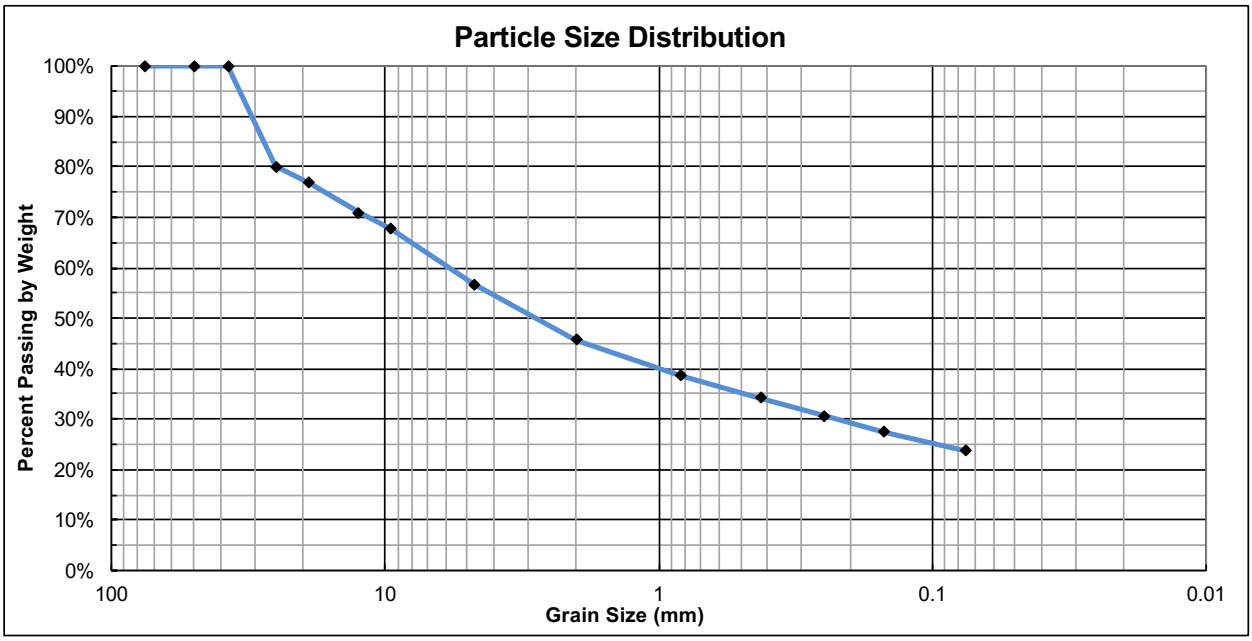
Sample ID	Depth (ft)	Liquid Limit	Plastic Limit	PI
B1-1	6	37	19	18



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

Project Name: Orr Spring Road Slide
CAInc File No: 16-337.1
Date: 4/6/17
Technician: HFW
Sample ID: B1-1
Depth: 6'
USCS Classification: Clayey GRAVEL with SAND

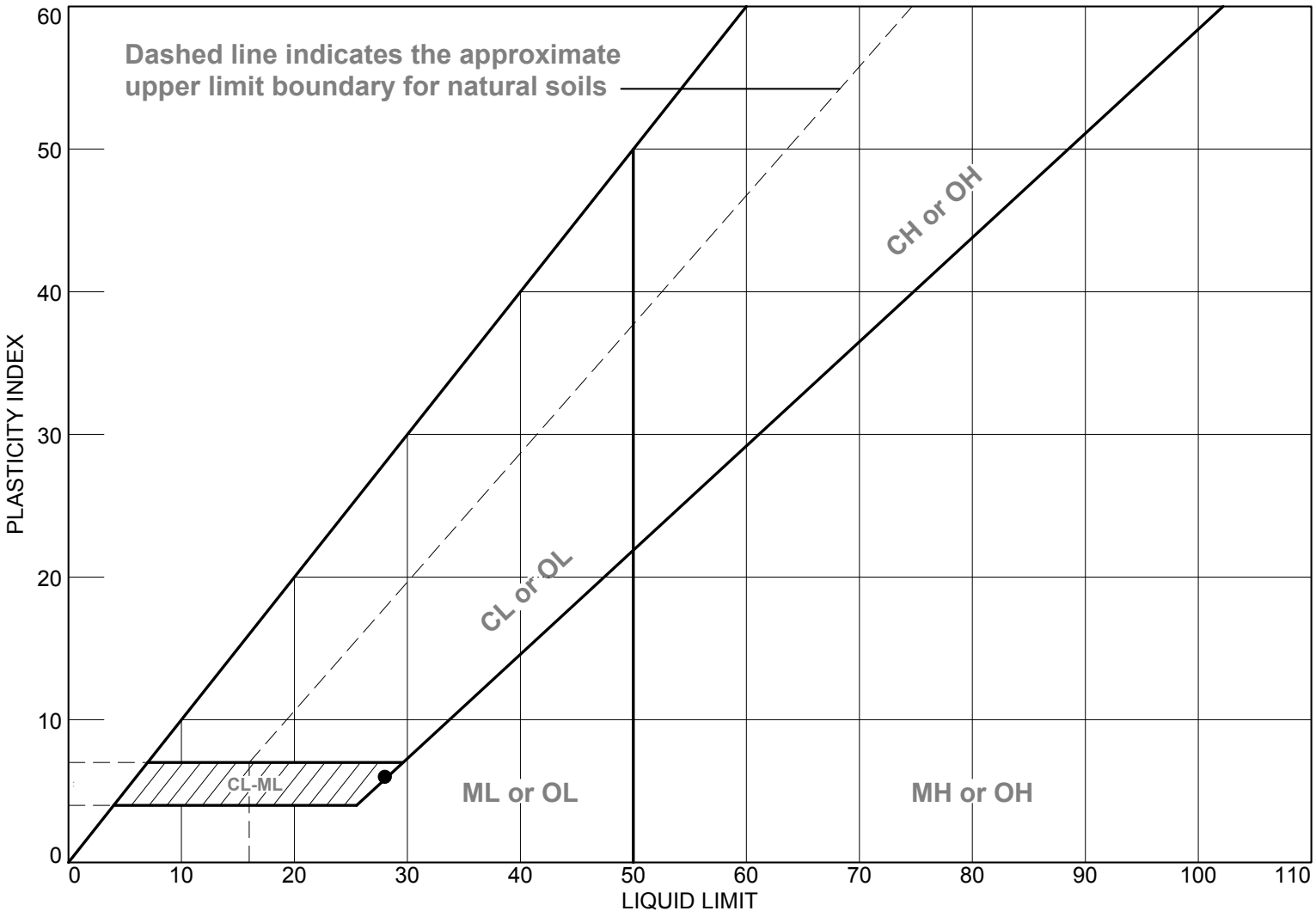
ASTM 6913 - Method A



% Cobble	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt/Clay
	23	20	11	12	10	
0	**43**		**33**			**24**

		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	77.3	80%
		3/4"	19.0	89.7	77%
	Fine	**1/2"**	12.5	112.7	71%
		3/8"	9.50	125.1	68%
		#4	4.75	168.0	57%
Sand	Coarse	**#10**	2.00	210.5	46%
	Medium	**#20**	0.825	238.1	39%
		#40	0.425	255.3	34%
	Fine	**#60**	0.250	269.1	31%
		#100	0.150	281.5	28%
		#200	0.075	296.5	24%

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA								
SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●		B3-1	6		22	28	6	SC-SM

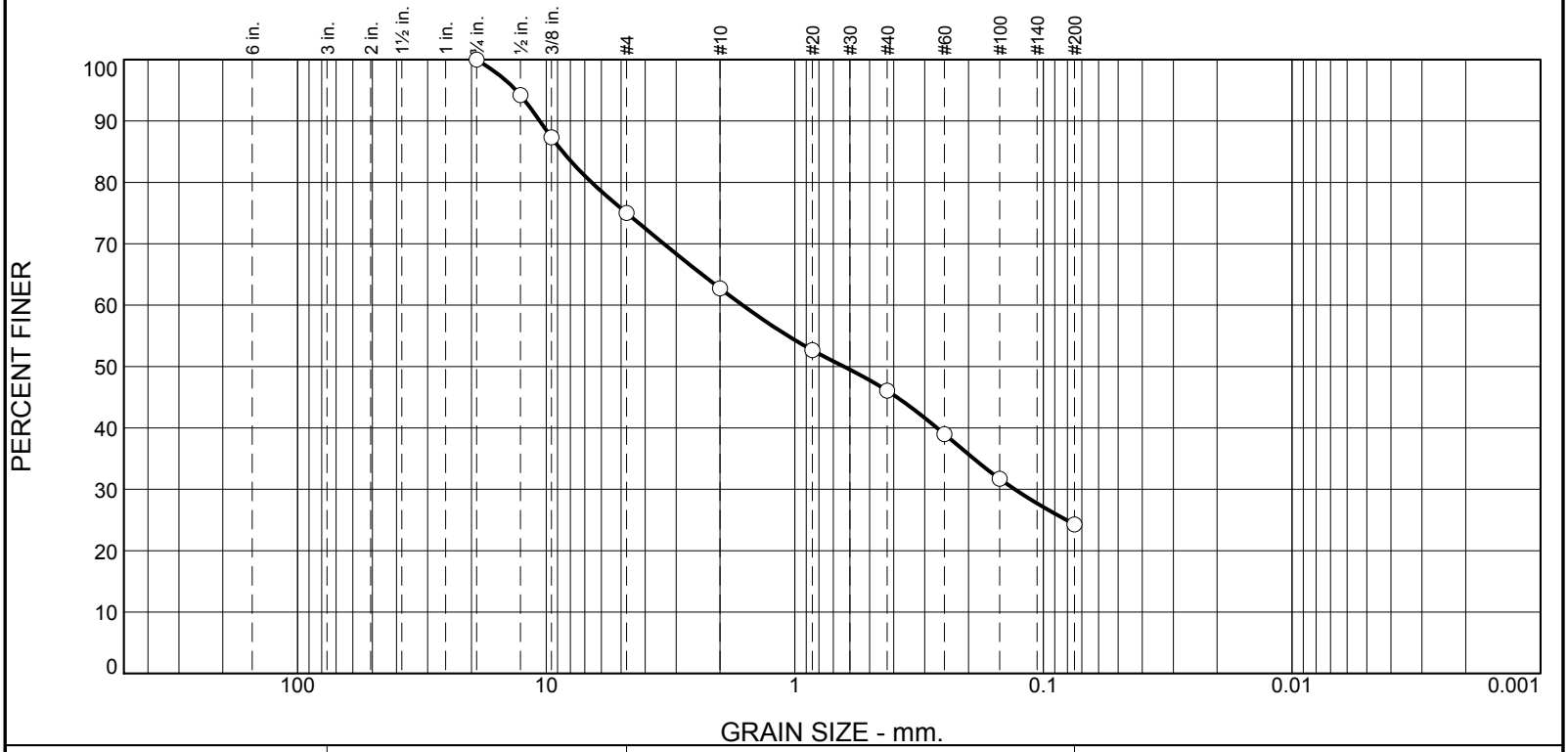
GEOCON CONSULTANTS, INC.

Client: Crawford and Associates
Project: Crawford 16-337.1

Project No.: S9763-05-92 **Figure**

Tested By: DI **Checked By:** MR

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	25.0	12.3	16.6	21.8	24.3	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.75	100.0		
.5	94.2		
.375	87.3		
#4	75.0		
#10	62.7		
#20	52.7		
#40	46.1		
#60	39.0		
#100	31.7		
#200	24.3		

* (no specification provided)

Material Description

Strong Brown silty, clayey sand with gravel

Atterberg Limits (ASTM D 4318)

PL= 22 **LL=** 28 **PI=** 6

Classification

USCS (D 2487)= SC-SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 10.6158 D_{85}= 8.5862 D_{60}= 1.6227
D_{50}= 0.6351 D_{30}= 0.1305 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 4/12-17/17

Tested By: MR/DI

Checked By: MR

Title: Lab Manager

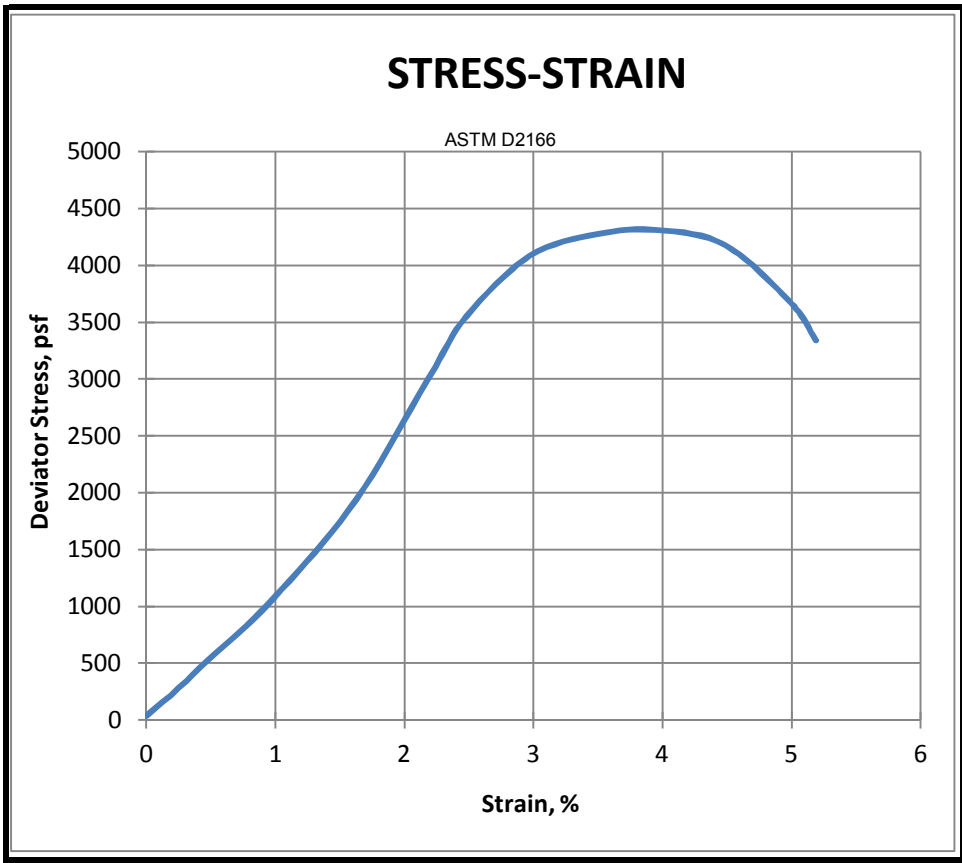
Sample Number: B3-1 **Depth:** 6 **Date Sampled:**

GEOCON CONSULTANTS, INC.

Client: Crawford and Associates

Project: Crawford 16-337.1

Project No: S9763-05-92 **Figure**



Failure Photo

Sample Description	
Boring Number	B1-2
Sample Depth (feet)	11.00
Material Description	Dark olive Clayey SAND
Initial Conditions at Start of Test	
Height (inch) average of 3	4.86
Diameter (inch) average of 3	2.39
Moisture Content (%)	7.7
Dry Density (pcf)	123.9
Estimated Specific Gravity	2.7
Saturation (%)	58.1
Shear Test Conditions	
Strain Rate (%/min)	0.9925
Major Principal Stress at Failure (psf)	4310
Strain at Failure (%)	4.0
Test Results	
Unconfined Compressive Strength (tons/ft^2)	2.2
Unconfined Compressive Strength (lbs/ft^2)	4310
Shear Strength (tons/ft^2)	1.1
Shear Strength (lbs/ft^2)	2155

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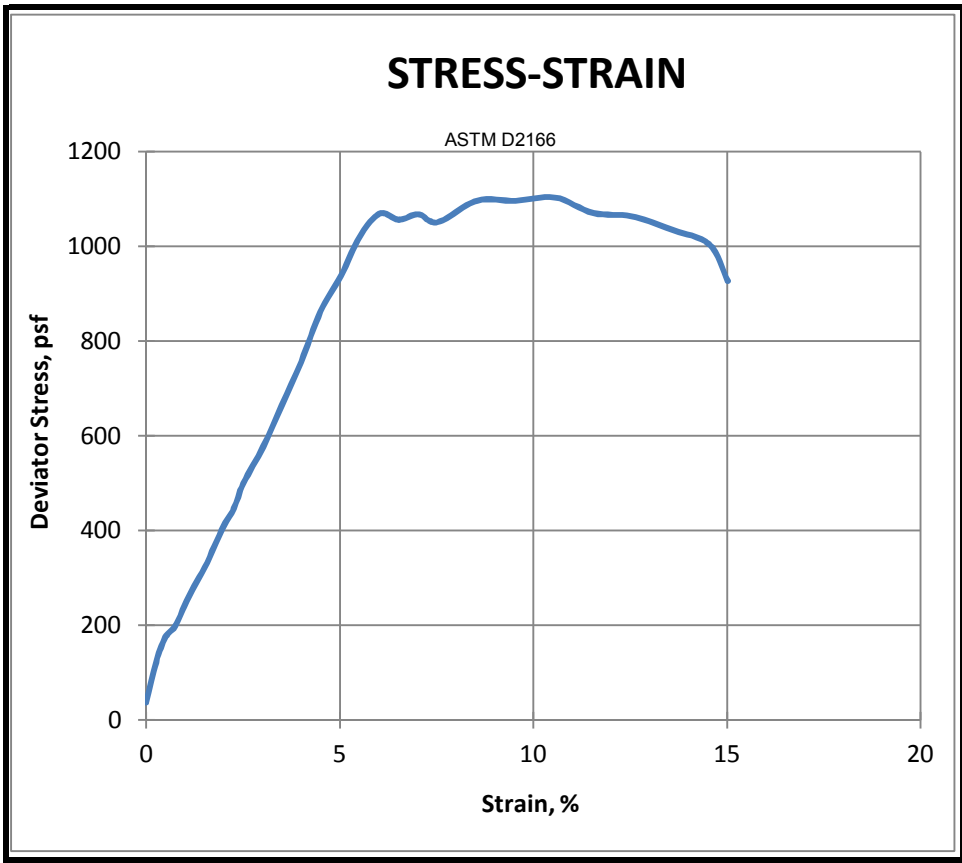
Unconfined Compressive Strength (ASTM D2166)

Project: Crawford 16-337.1
Location:
Number: S9763-05-92
Figure:



Failure Photo

Sample Description	
Boring Number	B1-6
Sample Depth (feet)	30.00
Material Description	Dark gray lean Clay with gravel
Initial Conditions at Start of Test	
Height (inch) average of 3	4.65
Diameter (inch) average of 3	2.40
Moisture Content (%)	9.8
Dry Density (pcf)	132.7
Estimated Specific Gravity	2.7
Saturation (%)	98.7
Shear Test Conditions	
Strain Rate (%/min)	1.0003
Major Principal Stress at Failure (psf)	1100
Strain at Failure (%)	10.6
Test Results	
Unconfined Compressive Strength (tons/ft^2)	0.6
Unconfined Compressive Strength (lbs/ft^2)	1103
Shear Strength (tons/ft^2)	0.3
Shear Strength (lbs/ft^2)	552

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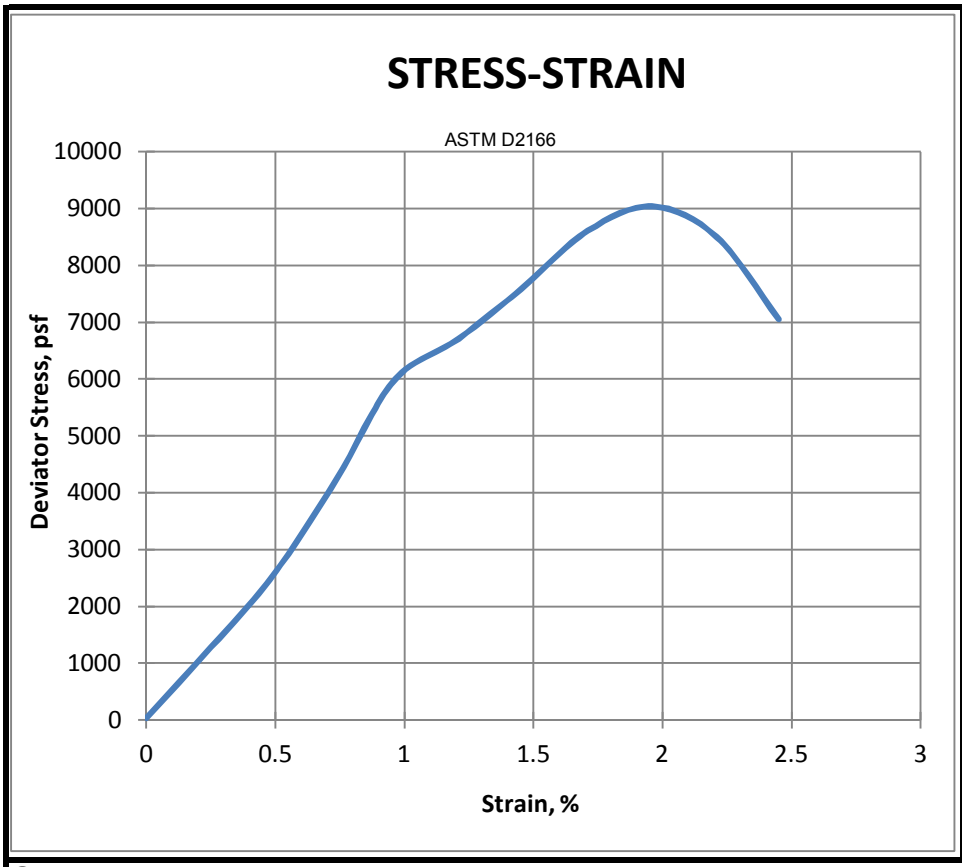
Unconfined Compressive Strength (ASTM D2166)

Project: Crawford 16-337.1
Location:
Number: S9763-05-92
Figure:



Failure Photo

Sample Description	
Boring Number	B2-2
Sample Depth (feet)	11.00
Material Description	Olive lean CLAY with gravel
Initial Conditions at Start of Test	
Height (inch) average of 3	4.73
Diameter (inch) average of 3	2.41
Moisture Content (%)	8.5
Dry Density (pcf)	130.1
Estimated Specific Gravity	2.7
Saturation (%)	77.5
Shear Test Conditions	
Strain Rate (%/min)	0.9789
Major Principal Stress at Failure (psf)	9040
Strain at Failure (%)	2.0
Test Results	
Unconfined Compressive Strength (tons/ft^2)	4.5
Unconfined Compressive Strength (lbs/ft^2)	9039
Shear Strength (tons/ft^2)	2.3
Shear Strength (lbs/ft^2)	4519

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Telephone: (916) 852-9118
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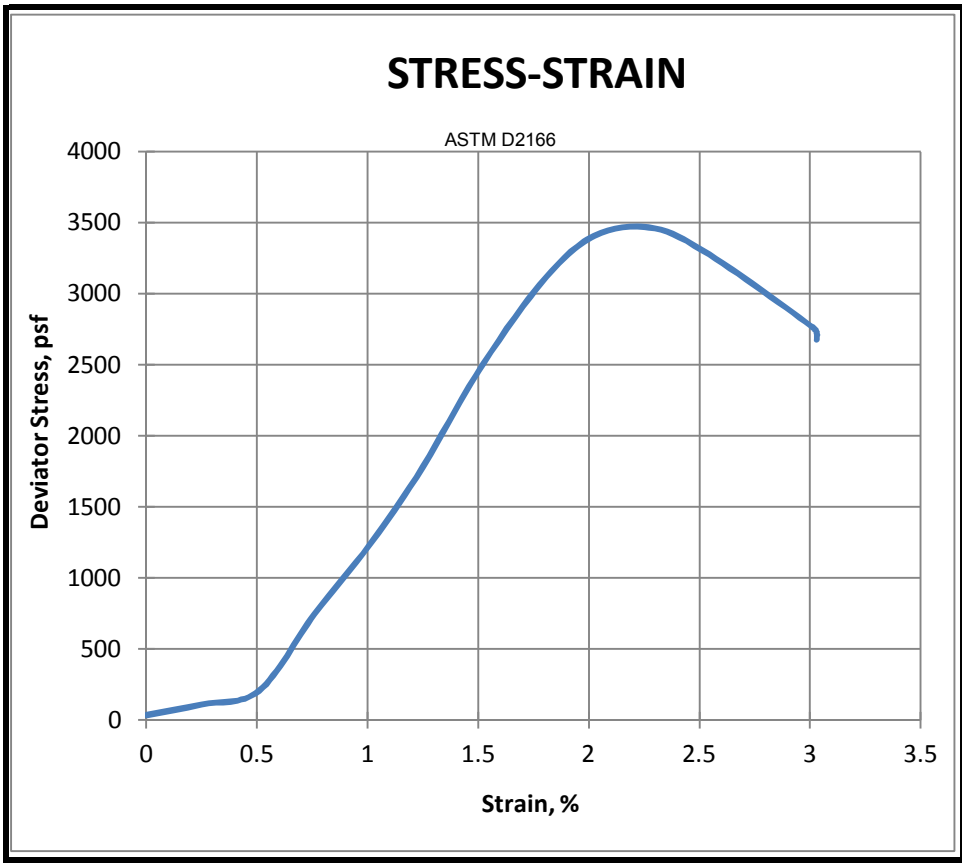
Unconfined Compressive Strength (ASTM D2166)

Project: Crawford 16-337.1
Location:
Number: S9763-05-92
Figure:



Failure Photo

Sample Description	
Boring Number	B3-1
Sample Depth (feet)	6.00
Material Description	Black and dark yellowish brown lean CLAY
Initial Conditions at Start of Test	
Height (inch) average of 3	5.00
Diameter (inch) average of 3	2.39
Moisture Content (%)	15.1
Dry Density (pcf)	114.8
Estimated Specific Gravity	2.7
Saturation (%)	87.2
Shear Test Conditions	
Strain Rate (%/min)	0.9691
Major Principal Stress at Failure (psf)	3470
Strain at Failure (%)	2.3
Test Results	
Unconfined Compressive Strength (tons/ft^2)	1.7
Unconfined Compressive Strength (lbs/ft^2)	3467
Shear Strength (tons/ft^2)	0.9
Shear Strength (lbs/ft^2)	1734

GEOCON CONSULTANTS, INC.
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Unconfined Compressive Strength (ASTM D2166)

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Figure:

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

Date Reported 04/12/17
Date Submitted 04/06/17

To: Hailey Wagenman
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 : ORRSPRING ROAD SLIDE Site ID: B1-4@20FT
Thank you for your business.

* For future reference to this analysis please use SUN # 73949 - 154203

EVALUATION FOR SOIL CORROSION

Soil pH	7.15	
Minimum Resistivity	5.63	ohm-cm (x1000)
Chloride	10.3 ppm	0.001 %
Sulfate-S	16.0 ppm	0.0016 %

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

Sunland Analytical
11419 Sunrise Gold Cir.#10
Rancho Cordova, CA 95742
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General Manager \ Lab Manager

The reported analysis was requested for the following:
Location : ORRSPRING ROAD SLIDE Site ID: B2-4@20FT
Thank you for your business.

* For future reference to this analysis please use SUN # 73949 - 154204

EVALUATION FOR SOIL CORROSION

Soil pH	5.61	
Minimum Resistivity	7.24	ohm-cm (x1000)
Chloride	4.9 ppm	0.0005 %
Sulfate-S	7.5 ppm	0.0008 %

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