FIGURE 1

TETRA TECH 21700 Copley Drive, Suite 200, Diamond Bar, CA 91765 TEL 909.860.7777 www.tetratech.com	Bridge Replacement - Dola, Lanzit PROJECT LOCATION MAP	JOB NO. coSB 23-03E DATE JUN 2023 DRAWN BY MKM CHECKED BY FC

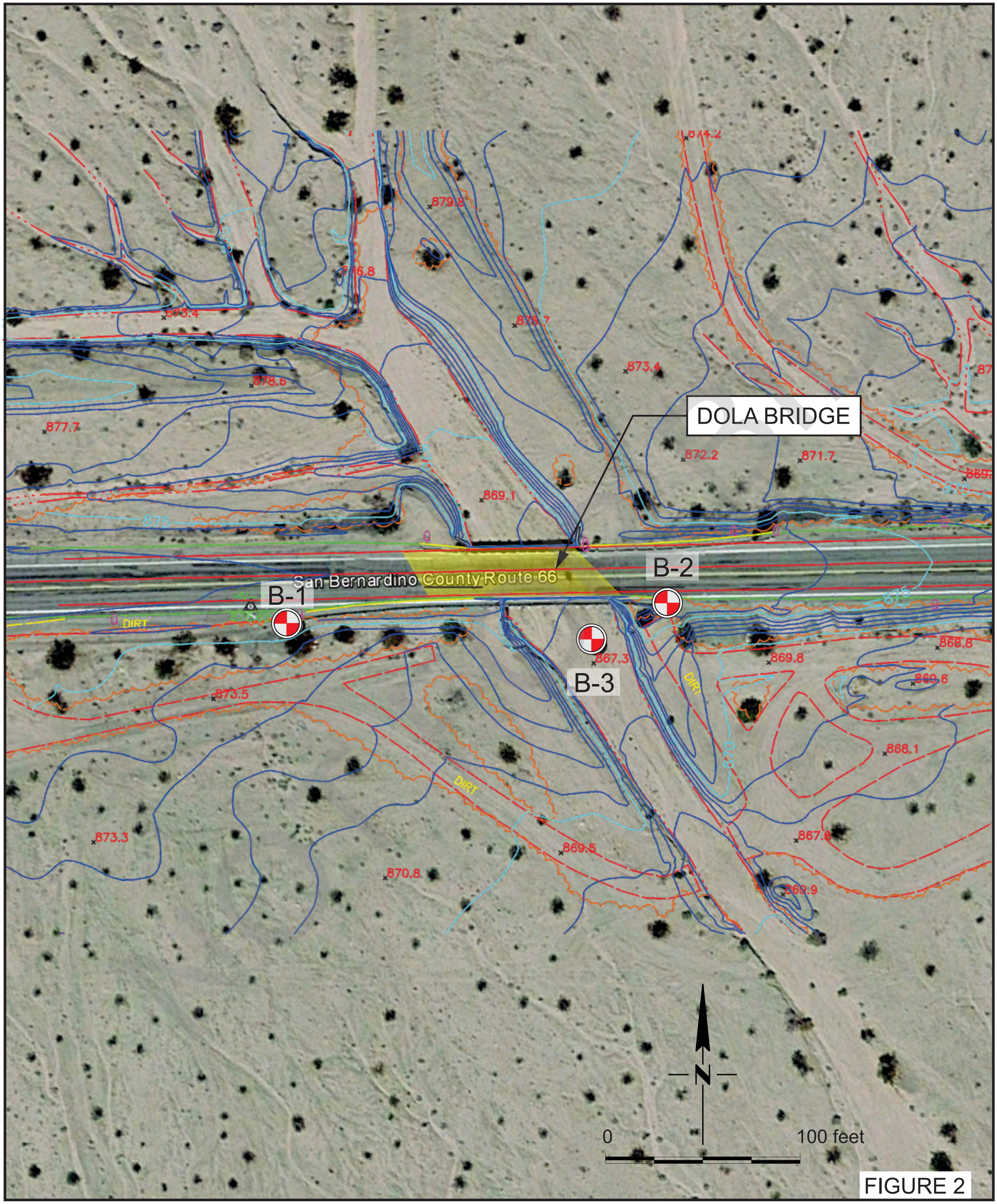


FIGURE 2

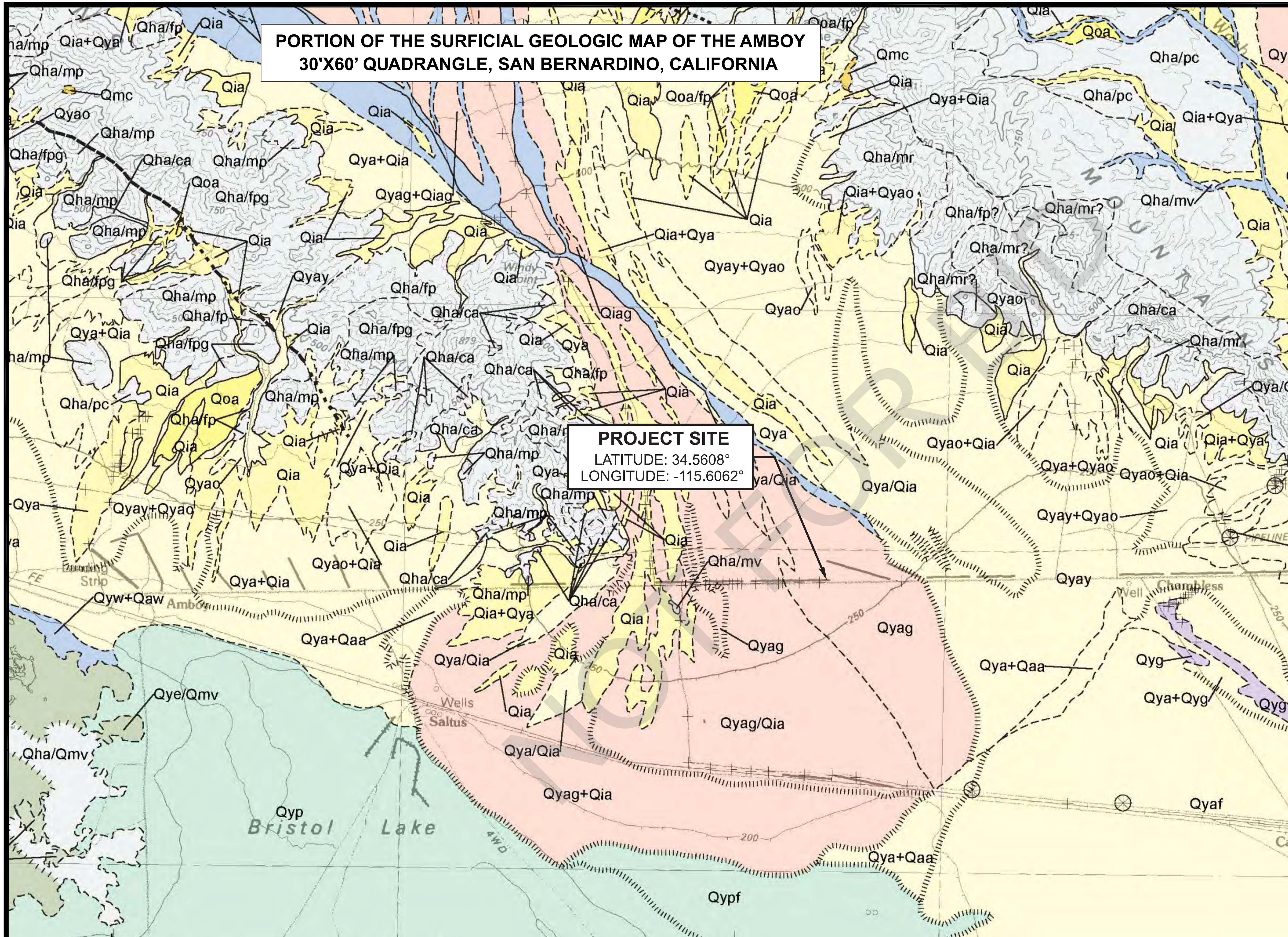
TETRA TECH

21700 Copley Drive, Suite 200, Diamond Bar, CA 91765
TEL 909.860.7777 www.tetratech.com

Bridge Replacement - Dola, Lanzit

BORING LOCATION MAP
DOLA BRIDGE

JOB NO.	coSB 23-03E
DATE	JUN 2023
DRAWN BY	MKM
CHECKED BY	FC



SURFICIAL DEPOSITS

ANTHROPOGENIC DEPOSITS

- ml — Made land

ALLUVIAL DEPOSITS

- Qaa — Active alluvial fan deposit (Holocene)
- Qaag — Active alluvial deposit composed of grus
- Qya — Young alluvial fan deposit (Holocene and latest Pleistocene)
- Qyay — Younger young alluvial fan deposit (Holocene)
- Qyad — Young alluvial fan composed of debris-flow deposits (Holocene and latest Pleistocene)
- Qyaf — Young alluvial fan composed of fine-grained deposits (Holocene and latest Pleistocene)
- Qyao — Older young alluvial fan deposit (Holocene and latest Pleistocene)
- Qyag — Young alluvial fan deposit composed of grus (Holocene and latest Pleistocene)
- Qyaog — Older young alluvial fan deposit composed of grus (Holocene and latest Pleistocene)
- Qia — Intermediate alluvial fan deposit (late to middle Pleistocene)
- Qiad — Intermediate alluvial fan composed of debris-flow deposits (late to middle Pleistocene)
- Qiag — Intermediate alluvial fan deposit composed of grus (late to middle Pleistocene)
- Qiao — Older intermediate alluvial fan deposit (late to middle Pleistocene)
- Qiaog — Older intermediate alluvial fan deposit composed of grus (late to middle Pleistocene)
- Qoa — Old alluvial fan deposit (middle to early Pleistocene)
- Qoad — Old alluvial fan composed of debris-flow deposits (middle to early Pleistocene)
- Qoag — Old alluvial fan deposit composed of grus (middle to early Pleistocene)
- QToa — Extremely old alluvial fan deposit (early Pleistocene to Pliocene)

WASH DEPOSITS

- Qaw — Active wash deposit (Holocene)
- Qawg — Active wash deposit composed of grus (Holocene)
- Qyw — Young wash deposit (Holocene and latest Pleistocene)
- Qywg — Young wash deposit composed of grus (Holocene and latest Pleistocene)
- Qiw — Intermediate wash deposit (late to middle Pleistocene)

EOLIAN DEPOSITS

- Qae — Active eolian sand deposit (Holocene)
- Qaed — Active eolian sand dune deposit (Holocene)
- Qye — Young eolian sand deposit (Holocene and latest Pleistocene)
- Qyed — Young eolian sand dune deposit (Holocene and latest Pleistocene)
- Qyer — Young eolian sand ramp deposit (Holocene and latest Pleistocene)
- Qyes — Young eolian sand sheet deposit (Holocene and latest Pleistocene)
- Qie — Intermediate eolian sand deposit (late to middle Pleistocene)

MIXED EOLIAN AND ALLUVIAL DEPOSITS

- Qyea — Young mixed eolian sand and alluvial deposit (Holocene and latest Pleistocene)
- Qyae — Young mixed alluvial and eolian sand deposit (Holocene and latest Pleistocene)
- Qiea — Intermediate mixed eolian sand and alluvial deposit (late to middle Pleistocene)
- Qiae — Intermediate mixed alluvial and eolian sand deposit (late to middle Pleistocene)

PLAYA DEPOSITS

- Qyp — Young playa deposit (Holocene and latest Pleistocene)
- Qypf — Young playa fringe deposit (Holocene and latest Pleistocene)

Map Reference:

USGS, 2010, David R Bedford, David M Miller, and Geoff A Phelps Surficial Geologic Map of the Amboy 30'x60' Minute Quadrangle, California.

0 — 6 Mile

Contour Interval 50 Feet

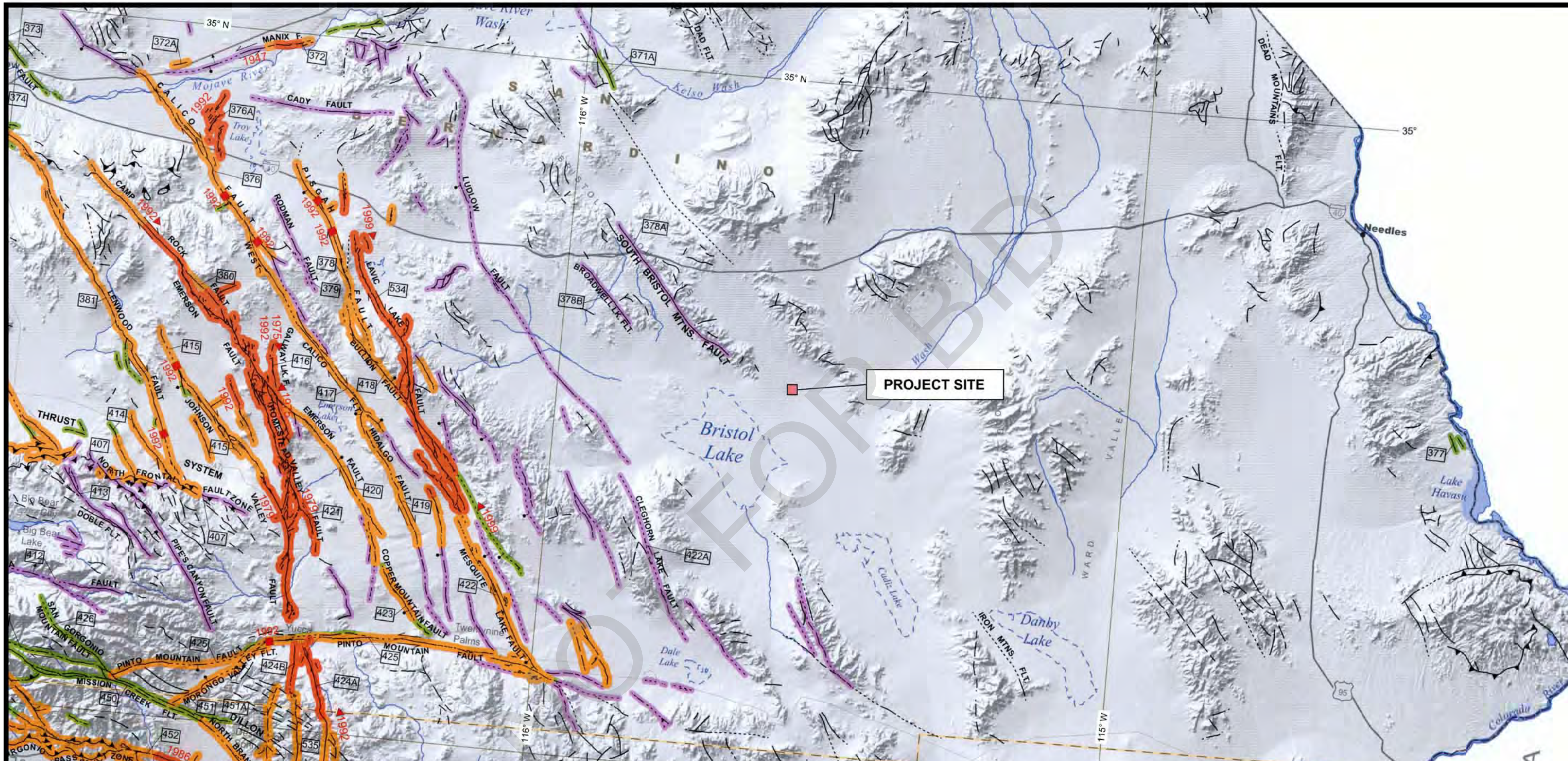
Figure 3

REGIONAL GEOLOGIC MAP

TETRA TECH
21700 Copley Drive, Suite 200
, Diamond Bar, CA 91765
TEL 909.860.7777 www.tetratech.com

Project Name: Bridge Replacement - Dola, Lanzit

Project Number: coSB 23-03E | Date: JUNE 2023



Reference: Excerpt of *Jennings, C.W., and Bryant, W.A., 2010, Fault activity map of California: California Geological Survey, Data Map No. 6, map scale 1:750,000.*

Used by permission from California Geological Survey.

0 10 20 30 40 50

SCALE IN MILES

EXPLANATION

Geologic Time Scale			Years Before Present (Approx.)	Fault Symbol	Recency of Movement	Description: On Land	Description: Offshore
Quaternary	Late Quaternary	Historic				Displacement during historic time (e.g. San Andreas fault 1906). Includes areas of known fault creep.	
			200				
Quaternary	Late Quaternary	Holocene			? ? ?	Displacement during Holocene time.	Fault offsets seafloor sediments or strata of Holocene age.
			11,700				
Quaternary	Late Quaternary	Pleistocene			? ?	Faults showing evidence of displacement during late Quaternary time.	Fault cuts strata of Late Pleistocene age.
			700,000				
Quaternary	Early Quaternary	Pleistocene			?	Undivided Quaternary faults – most faults in this category show evidence of displacement during the last 1,600,000 years; possible exceptions are faults which displace rocks of undifferentiated Plio-Pleistocene age.	Fault cuts strata of Quaternary age.
			1,600,000				
Pre-Quaternary			4.5 bya (Age of Earth)	—		Faults without recognized Quaternary displacement or showing evidence of no displacement during Quaternary time. Not necessarily inactive	Fault cuts strata of Pliocene or older age.

MAP SYMBOLS

- Triangle - termination point data.
- Square – fault creep slippage.
- Hachure – linear extent of fault creep (other symbols – see below)
- Approximately located trace
- --? Location uncertain
- Bar and ball on downthrown side
- Arrows along fault indicate relative or apparent direction of lateral movement
- Direction of fault dip
- Low angle fault (barbs on upper plate)
- 171 Numbers refer to annotations listed in explanatory text of map.

Figure 4

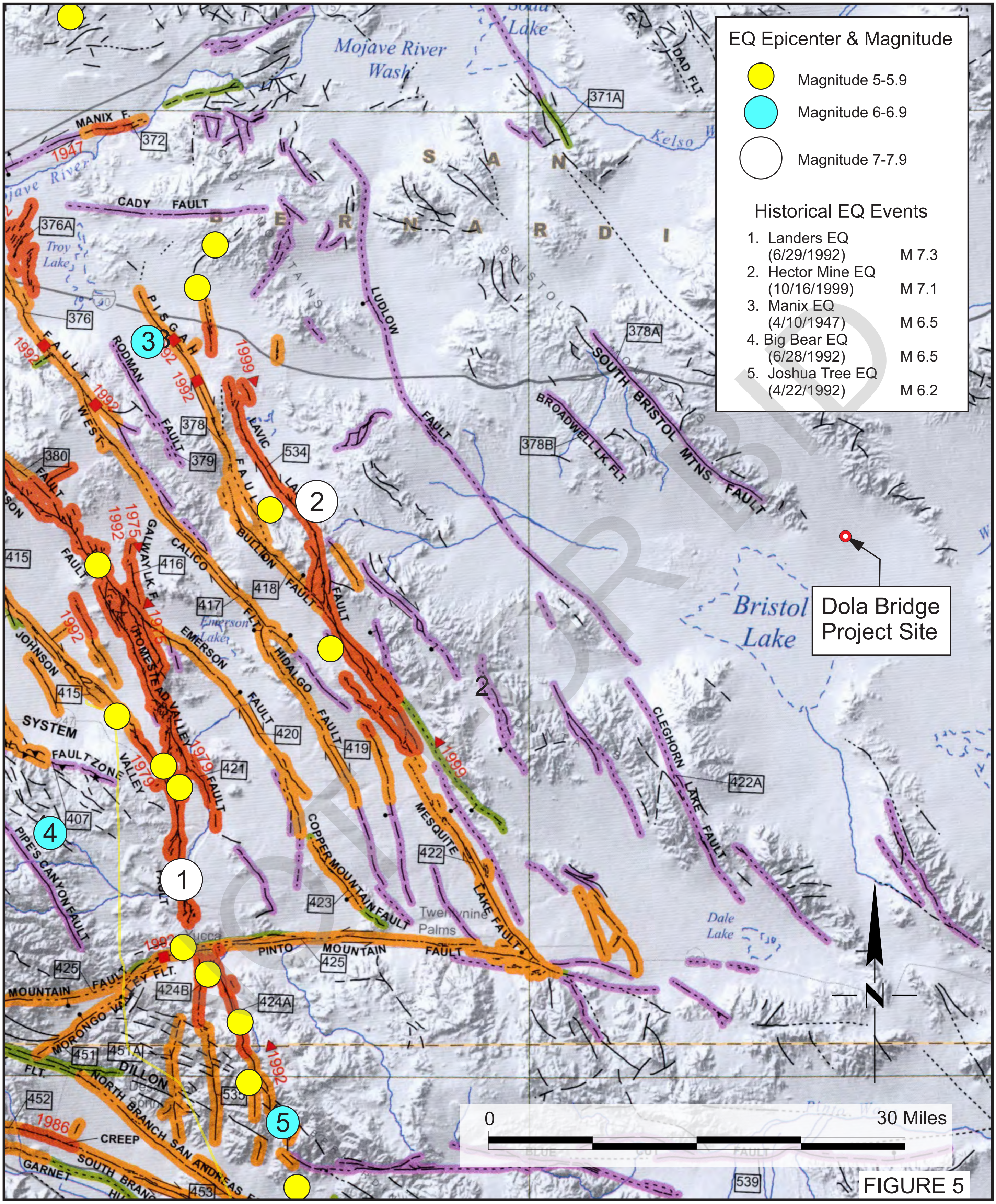
REGIONAL FAULT MAP

TETRA TECH
21700 Copley Drive, Suite 200
, Diamond Bar, CA 91765
TEL 909.860.7777 www.tetratech.com

Project Name: Bridge Replacement - Dola, Lanzit

Project Number: coSB 23-03E

Date: JUNE 2023



TETRA TECH

21700 Copley Drive, Suite 200, Diamond Bar, CA 91765
TEL 909.860.7777 www.tetratech.com

Bridge Replacement - Dola, Lanzit

QUATERNARY EARTHQUAKE EPICENTER MAP

JOB NO.	coSB 23-03E
DATE	JUN 2023
DRAWN BY	MKM
CHECKED BY	FC

Appendix A

Borings Logs

Project: **San Bernardino County**	# Log of Boring B-1
Project Location: **Dola Bridge, Route 66**	**Sheet 1 of 1**
Project Number: **cSB 14-01**	

Date(s) Drilled	**05-19-2014**	Logged By	**AHM**	Checked By	**FC**
Drilling Method	**HSA**	Drill Bit Size/Type	**8-inch**	Total Depth of Borehole	**51.5 feet bgs**
Drill Rig Type	**CME 75**	Drilling Contractor	**Jet Drilling**	Approximate Surface Elevation	**876.6 ft. above msl**
Groundwater Level and Date Measured	**Not encountered**	Sampling Method(s)	**Bulk, Modified California, SPT**	Hammer Data	**140 lbs. dropped 30 inches, automatic hammer. Efficiency 75%**
Borehole Backfill	**Cuttings and tamped**	Location	**Dola Bridge west abutment south side of road: Lattitude: 34.560767 Longitude: -115.606603**		

Elevation (feet)	Depth (feet)	Sample Number	Sampling Resistance, # blows	USCS Symbol	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	REMARKS AND OTHER TESTS
876.6	0	SK-1		SP	[EMBANKMENT FILL] (af) Poorly graded SAND, light brown, (7.5 YR 6/3), dry, trace of gravel and cobbles, cobbles up to 4 inches			Hand augered to 5 feet, SO4=6 ppm, CL=1 ppm, pH=7.7, minimum resistivity= 16,200
		R-1						Direct Shear
871.6	5	R-2	25-37-45		... dense	2.4	116	
		R-3A		SP	[NATIVE] Younger Alluvium (Qy) Poorly graded SAND with gravel, light brown (7.5 YR 6/3), dry, very dense, trace of cobbles			Direct Shear
		SPT-3	19-22-36					
866.6	10	R-4	2-35-40			2.9	117	
		SPT-5	12-28-25	GM	Silty GRAVEL with sand, light brown (7.5 YR 6/3) dry, very dense			
861.6	15	R-6	23-28-39	SM	Silty SAND, very pale brown (10 YR 7/4), dry, dense, trace of silt			
		SPT-7	11-14-20		... (18.5 ft) trace of gravel up to 1 inch			
856.6	20	R-8	18-25-27		... (20 ft) medium dense			
851.6	25	SPT-9	14-18-23		... (25 ft) dense			
				SP-SM	Poorly graded SAND with Silty and Gravel, light yellow (10YR 6/8), dry, dense			
846.6	30	R-10	18-25-28	SP	Poorly graded SAND, light yellow brown (10YR 6/4), dry to damp, medium dense, trace of gravel			
841.6	35	SPT-11	20-25-38					
				SM	Silty fine SAND, light yellow brown (10 YR 6/4), dry, very dense			
836.6	40	R-12	20-24-25		... (40 ft) with gravel, light brown (7.5 YR 6/3), dry, medium dense			
831.6	45	SPT-13	16-18-19		... (45 ft) damp, dense, trace of silt			
				SP	Poorly graded SAND with gravel, pale brown (10 YR 6/3), dry to damp, dense, gravel up to 1 inch			
826.6	50	R-14	18-25-38					
					Bottom of boring at 51.5 feet below ground surface.			
821.6	55							

Project: **San Bernardino County**	**Log of Boring B-2**
Project Location: **Dola Bridge, Route 66**	**Sheet 1 of 1**
Project Number: **cSB 14-01**	

Date(s) Drilled **05-19-2014**	Logged By **AHM**	Checked By **FC**
Drilling Method **HSA**	Drill Bit Size/Type **8-inch**	Total Depth of Borehole **43 feet bgs**
Drill Rig Type **CME 75**	Drilling Contractor **Jet Drilling**	Approximate Surface Elevation **876 ft. above msl**
Groundwater Level and Date Measured **Not encountered**	Sampling Method(s) **Bulk, Modified California, SPT**	Hammer Data **140 lbs. dropped 30 inches, automatic hammer, Efficiency 75%**
Borehole Backfill **Cuttings and tamped**	Location **Dola Bridge east abutment south side of road: Lattitude: 34.560795 Longitude: -115.605970**	

Elevation (feet)	Depth (feet)	Sample Number	Sampling Resistance, # blows	USCS Symbol	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	REMARKS AND OTHER TESTS
876	0			SP-SM	[EMBANKMENT FILL] (af) Poorly graded SAND with silt and gravel, light brown (7.5 YR 614), dry			Hand augered to 5 feet
		SK-1						
871	5	R-2A						Direct Shear
		SPT-2	5-12-16		... (5 ft) medium dense			
		R-3	18-25-29	SP	[NATIVE] Younger Alluvium (Qy) Poorly graded SAND with gravel, light brown (7.5 YR 6/3), dry, medium dense	2.3	117	
866	10	R-4A				3.7	116	
		SPT-4	11-14-15		... (11 ft) very dense, trace of fine silt			
		R-5	25-37-40		... (13 ft) dense, trace of gravel			
861	15	SPT-6	12-18-26	SP-SM	Poorly graded SAND with silt, dry, light brown (7.5 YR 6/4), dry, very dense			
		R-7	29-30-50	SP	Poorly graded SAND, light yellow brown (7.5 YR 6/4) dry, dense, trace of gravel			
856	20	SPT-8	50/3"	Cobbles	COBBLE and GRAVEL zone between 20-25 feet			Cobble fragments in cuttings, difficult drilling, little to no recovery of samples to TD
851	25	SPT-9	50/4"	GP	Poorly graded GRAVEL, pale yellow (2.5 YR 7/3), dry, very dense			
846	30	R-10	50/3"	SP-SM	Poorly graded SAND with silt and gravel, light yellowish brown (10 YR 6/4), dry, very dense, trace of cobble fragments			
				Cobbles	COBBLES			
841	35	SPT-11	100/2"		... (35 ft) as above			
836	40	R-12	80/4"		... (40 ft) as above			
					Bottom of boring at 43 feet below ground surface. Refusal on cobbles.			
831	45							
826	50							
821	55							

Project: **San Bernardino County**	**Log of Boring B-3**
Project Location: **Dola Bridge, Route 66**	**Sheet 1 of 1**
Project Number: **cSB 14-01**	

Date(s) Drilled **3/20/2015**	Logged By **AHM**	Checked By **FC**
Drilling Method **HSA**	Drill Bit Size/Type **8-inch**	Total Depth of Borehole **51.5 feet bgs**
Drill Rig Type **CME 75**	Drilling Contractor **Jet Drilling**	Approximate Surface Elevation **867.3 ft. above msl**
Groundwater Level and Date Measured **Not encountered**	Sampling Method(s) **Bulk, Modified California, SPT**	Hammer Data **140 lbs. dropped 30 inches, CME automatic hammer, Efficiency 75%**
Borehole Backfill **Cuttings and tamped**	Location **South side of road in the wash: Lattitude: 34.56074 Longitude: -115.60609**	

Elevation (feet)	Depth (feet)	Sample Number	Sampling Resistance, # blows	USCS Symbol	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	REMARKS AND OTHER TESTS
867.3	0	R-1	4-10-12	SW	[NATIVE] Active Alluvium (Qa) Well graded SAND, light yellowish brown (10YR 6/4), damp, medium dense, trace of gravel and cobbles			
		R-2 SK-3	2-3-7			3.3	116	SO4= 14ppm, G=16%, S=79%, F=5%
862.3	5	SPT-4	7-9-10		... (2 ft) brown (10YR 5/3), loose			G=6%, S=85%, F=9%
		R-5	12-15-30	SW-SM	[NATIVE] Younger Alluvium (Qy) Well graded SAND with Silt, brown (10YR 4/3), damp, medium dense	3.4	116	
		SPT-6	6-8-15					
857.3	10	R-7	17-25-21	SP	Poorly graded SAND, brown (10YR 6/3), dry to damp, medium dense, trace of gravel	2.6	111	Direct Shear
		SPT-8	12-18-29	SW-SM	... (12 ft) with gravel Well graded SAND with Silt, brown (10YR 6/3), dry to damp, dense			G=20%, S=74%, F=7%
852.3	15	R-9	15-25-39			3.5	116	
		SPT-10	10-15-18		... (17 ft) light yellowish brown (10YR 6/4)			
847.3	20	R-11	23-28-25		... (20 ft) brown to light brown (10YR 7/4)	3.8	107	Direct Shear
842.3	25	SPT-12	8-10-12	SW-SM	Well graded SAND with SIlt, brownish yellow (10YR6/6), dry to damp, medium dense, trace of gravel			G=9%, S=83%, F=8%
837.3	30	R-13	18-25-28	SW	Well graded SAND, yellowish brown (10YR 6/8), damp, dense, trace of gravel	3.4	111	Direct Shear
832.3	35	SPT-14	10-15-17	SP	Poorly graded SAND, yellowish brown (10YR 6/8), damp, dense, trace of gravel			
827.3	40	SPT-15	16-22-25	SP-SM	Poorly graded Sand with Silt and Gravel, yellowish brown (10YR 6/8), damp, dense			
822.3	45	SPT-16	12-20-19	SW	Well graded SAND, pale brown (10YR 6/3), damp, dense, trace of gravel			
817.3	50	SPT-17	11-15-20		... (50 ft) as above			
					Bottom of boring at 51.5 feet below ground surface			
812.3	55							

Project: **San Bernardino County**	Key to Log of Boring
Project Location: **Dola Bridge, Route 66**	**Sheet 1 of 1**
Project Number: **cSB 14-01**	

Elevation (feet)	Depth (feet)	Sample Type	Sample Number	Sampling Resistance, # blows	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	REMARKS AND OTHER TESTS
1	2	3	4	5	6	7	8	9	10	11

COLUMN DESCRIPTIONS

1. Elevation (feet): Elevation (MSL, feet).
2. Depth (feet): Depth in feet below the ground surface.
3. Sample Type: Type of soil sample collected at the depth interval shown.
4. Sample Number: Sample identification number.
5. Sampling Resistance, # blows: Number of blows to advance driven sampler one foot (or distance shown) beyond seating interval using the hammer identified on the boring log.
6. USCS Symbol: USCS symbol of the subsurface material.
7. Graphic Log: Graphic depiction of the subsurface material encountered.
8. MATERIAL DESCRIPTION: Description of material encountered. May include consistency, moisture, color, and other descriptive text.
9. Water Content, %: Water content of the soil sample, expressed as percentage of dry weight of sample.
10. Dry Unit Weight, pcf: Dry weight per unit volume of soil sample measured in laboratory, in pounds per cubic foot.
11. REMARKS AND OTHER TESTS: Comments and observations regarding drilling or sampling made by driller or field personnel.

FIELD AND LABORATORY TEST ABBREVIATIONS

MATERIAL GRAPHIC SYMBOLS

Cobbles

Silty GRAVEL (GM)

Poorly graded GRAVEL (GP)

Silty SAND (SM)

Poorly graded SAND (SP)

Poorly graded SAND with Silt (SP-SM)

Well graded SAND (SW)

Well graded SAND with Silt (SW-SM)

TYPICAL SAMPLER GRAPHIC SYMBOLS

Auger sampler

Bulk Sample

Bulk and Ring

Bulk sample

3-inch-OD California w/ brass rings

CME Sampler

Grab Sample

2.5-inch-OD Modified California w/ brass liners

Pitcher Sample

2-inch-OD unlined split spoon (SPT)

Shelby Tube (Thin-walled, fixed head)

OTHER GRAPHIC SYMBOLS

Water level (at time of drilling, ATD)

Water level (after waiting)

Minor change in material properties within a stratum

Inferred/gradational contact between strata

—?— Queried contact between strata

GENERAL NOTES

TETRA TECH BAS GEOSCIENCE

Appendix B

Results of Laboratory Testing

HUSHMAND ASSOCIATES, INC.
Geotechnical and Earthquake Engineers

MOISTURE CONTENT AND DRY DENSITY OF RING SAMPLES

Client: Tetra Tech
Project Name: Dola Bridge, Route 66 (San Bernardino County)
Project No.: cSB 14-01

HAI Project No.: TRT-15-009
Performed by: SE/KL
Checked by:
Date: 4/1/2015

Boring No.		**B-3**	**B-3**	**B-3**
Sample No.		**R-7**	**R-11**	**R-13**
Depth (ft)		**11-11.5**	**21-21.5**	**31-31.5**
Total wt of rings and soil	gr	576.99	894.04	911.49
Height of sample	in	3.00	5.00	5.00
Diameter of sample	in	2.36	2.42	2.42
Volume of sample	cu.ft	0.0076	0.0133	0.0133
Weight of rings	gr	186.01	220.65	220.65
Weight of soil	lbs.	0.862	1.485	1.523
Wet Density	pcf	113.5	111.5	114.4
Container No.		200	35	53
Weight of cont.+ wet soil	gr	95.18	98.62	111.26
Weight of cont.+ dry soil	gr	92.89	95.15	107.75
Weight of container	gr	6.38	4.96	5.30
Weight of water	gr	2.29	3.47	3.51
Weight of dry soil	gr	86.51	90.19	102.45
Moisture Content	**%**	**2.6**	**3.8**	**3.4**
Dry Density	**pcf**	**110.6**	**107.4**	**110.6**

TETRA TECH BAS
GEOSCIENCE

MOISTURE CONTENT AND DENSITY

ASTM D2937

Job Name:	Dola Bridge	**Date Sampled:**	3/20/2015
Job Number:	CSB-14-01	**Date Completed:**	4/14/2015
Tested By:	MG	**Note:**	Page 1

Boring / Test Pit / Trench		**B-1**	**B-1**	**B-2**	**B-2**	**B-3**	**B-3**	**B-3**		
Sample Number		**R-2**	**R-4**	**R-3**	**R-4**	**R-3**	**R-5**	**R-9**		
Sample Depth	*feet*	**5-5.5**	**10-10.5**	**7.5-8**	**10-10.5**	**3-3.5**	**7-7.5**	**16-16.5**		
USCS Soil Description		Reddish Yellow Native(SM)	Reddish Yellow Native (SP)	Reddish Yellow Native (SM)	Reddish Yellow Native (SP)	Reddish Yellow Native (SW)	Reddish Yellow Native (SM)	Reddish Yellow Native (SP-SM)		
Number of Rings		6	6	6	6	6	6	6		
Total Weight Rings + Soil	*grams*	1115.60	1126.40	1119.30	1125.70	1122.70	1122.60	1124.40		
* Volume of Rings	*ft^3*	0.0159	0.0159	0.0159	0.0159	0.0159	0.0159	0.0159		
* Weight of Rings	*grams*	255.36	255.36	255.36	255.36	255.36	255.36	255.36		
* Weight of Soil	*grams*	860.24	871.04	863.94	870.34	867.34	867.24	869.04		
* Wet Density	*pcf*	118.94	120.44	119.45	120.34	119.92	119.91	120.16		
	Container ID	P4	P17	P14	P31	P10	P1	P29		
Tare	*grams*	9.1	9.3	9.2	9.4	9.2	8.6	9.3		
Wet Soil + Tare	*grams*	287.9	330.1	321.4	317.4	316	434.3	297.1		
Dry Soil + Tare	*grams*	281.4	321.2	314.5	306.3	306.1	420.5	287.4		
* Weight of Water	*grams*	6.5	8.9	6.9	11.1	9.9	13.8	9.7		

*** Dry Density**	***pcf***	**116.2**	**117.1**	**116.8**	**116.0**	**116.1**	**116.0**	**116.1**		
*** Moisture Content**	**%**	**2.4**	**2.9**	**2.3**	**3.7**	**3.3**	**3.4**	**3.5**		
Assumed/Measured Gs		2.65	2.65	2.65	2.65	2.65	2.65	2.65		
* Saturation	*%*	14.9	18.3	14.4	23.3	20.8	20.9	21.8		

TETRA TECH BAS

GRAIN SIZE DISTRIBUTION ANALYSIS

ASTM C136/C117/D422

Job Name: Dola Bridge

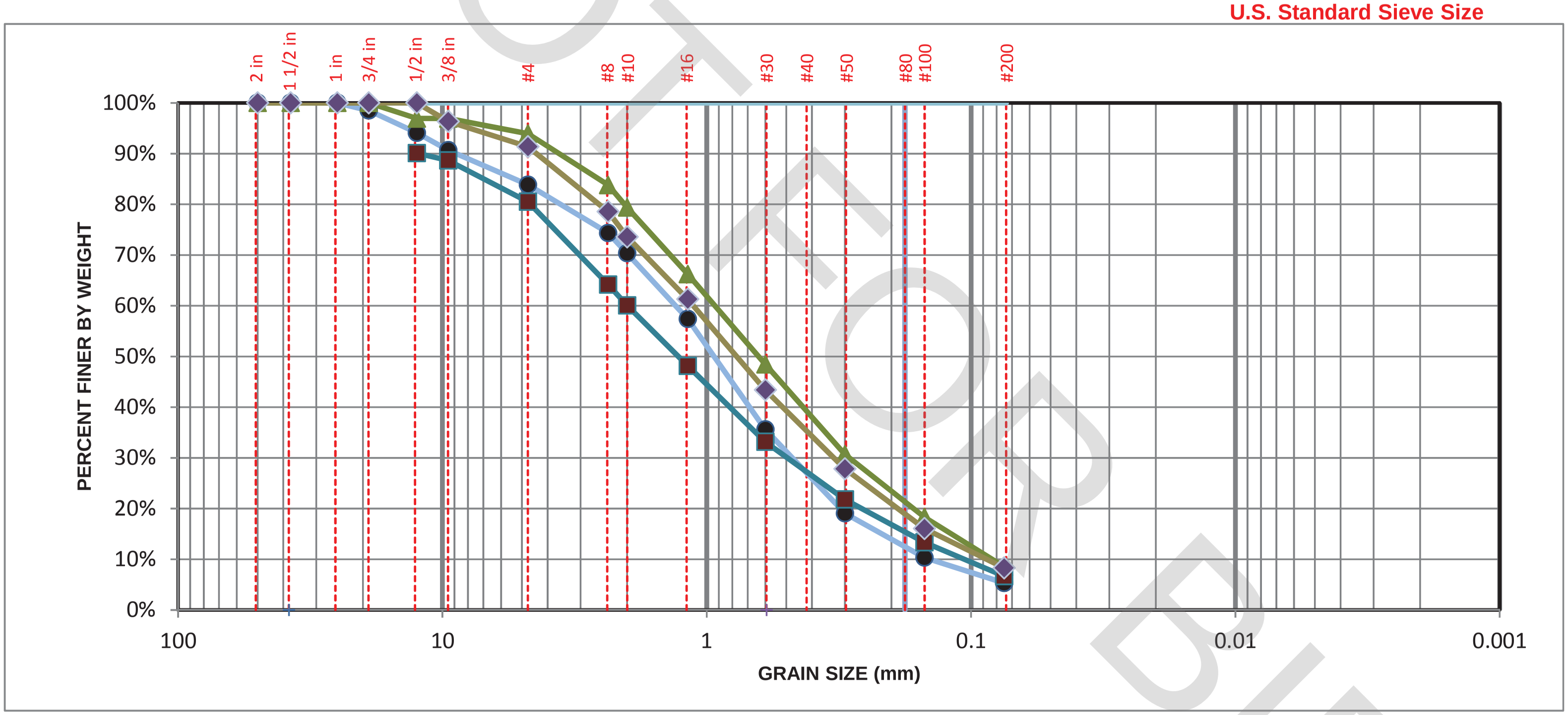
Job Number: CSB-14-01

Address:

Date Sampled: March 20, 2015

Tested By : MG

Date Completed: April 7, 2015



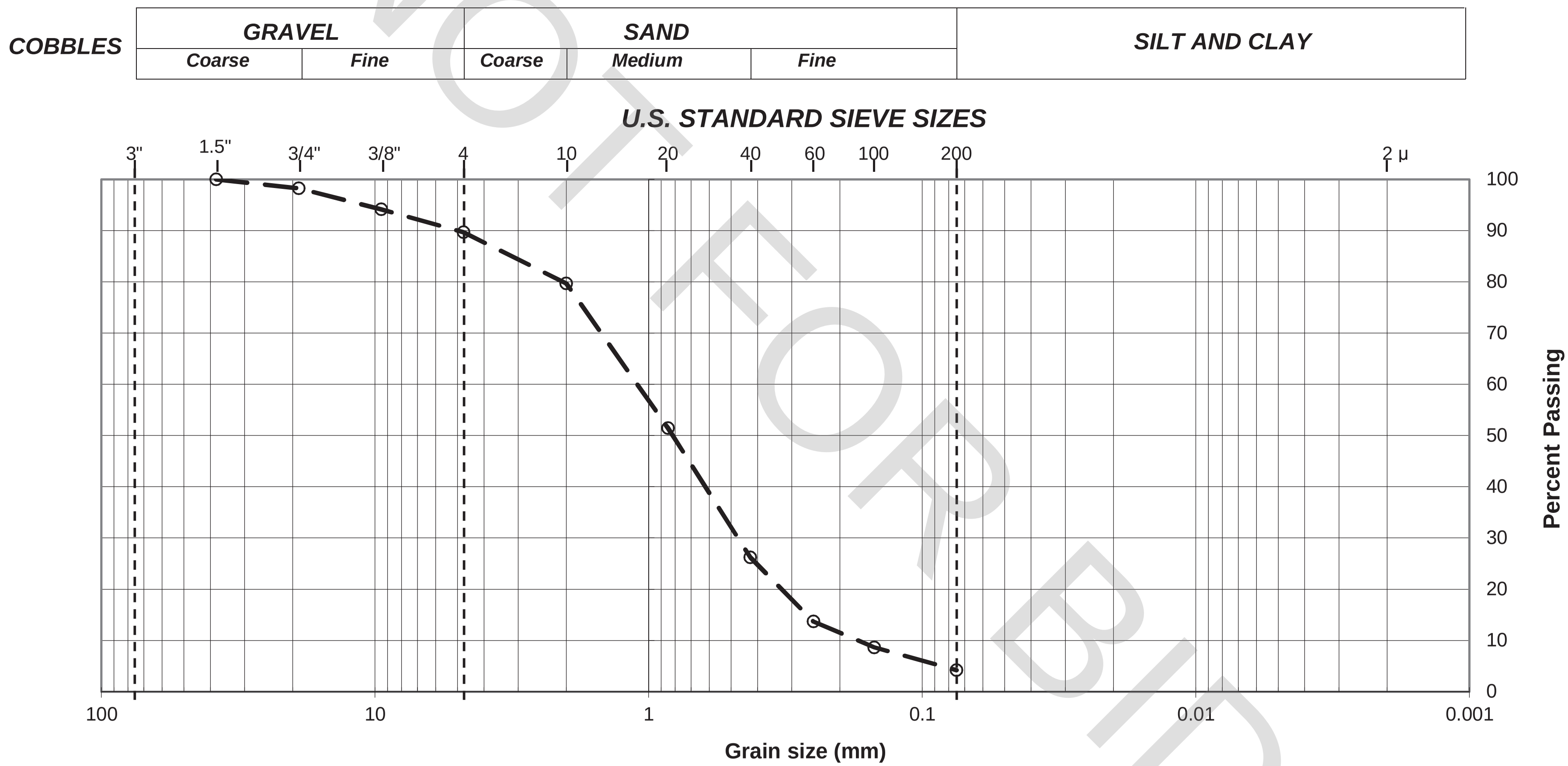
Symbol	Boring No.	Sample #	Deph (feet)	LL	PI	USCS	Gravel	Sand	Fines	2µ
●	B-3	SK-3	0-6	N/A	N/A	**SW**	**16%**	**79%**	**5%**	**N/A**
▲	B-3	R-5	7-7.5	N/A	N/A	**SW-SM**	**6%**	**85%**	**9%**	**N/A**
■	B-3	SPT-8	12.5-14	N/A	N/A	**SW-SM**	**20%**	**74%**	**7%**	**N/A**
◆	B-3	SPT-12	25-26.5	N/A	N/A	**SW-SM**	**9%**	**83%**	**8%**	**N/A**

HUSHMAND ASSOCIATES, INC.
Geotechnical and Earthquake Engineers

PARTICLE-SIZE ANALYSIS OF SOILS
(ASTM D422)

Client: Tetra Tech
Project Name: Dola Bridge, Route 66 (San Bernardino County)
Project No.: cSB 14-01

HAI Project No.: TRT-15-009
Tested by: SE/KL
Checked by: NB
Date: 4/6/2015



Sample No.	Symbol	USCS	% Gravel	% Sand	% Fines
B-3 SK-3 @ 0-6'	○	Brown, Well Graded Sand (SW)	10.3	85.5	4.2

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Geotechnical and Earthquake Engineers

DIRECT SHEAR TEST

(ASTM D3080)

HAI Pr No.: TRT-15-011
Tested by: KL/SE
Checked by: NB
Date: 4/16/2015

Client: **Tetra Tech**
Project Name: **Dola Bridge, Route 66 (San Bernardino County)**
Project Number: **cSB 14-01**

Boring No.: **B-1**

Sample No.: **R-1**

Depth (ft): **2.5-3'**

Soil description: Brown, Poorly Graded Sand with Silt (SP-SM)

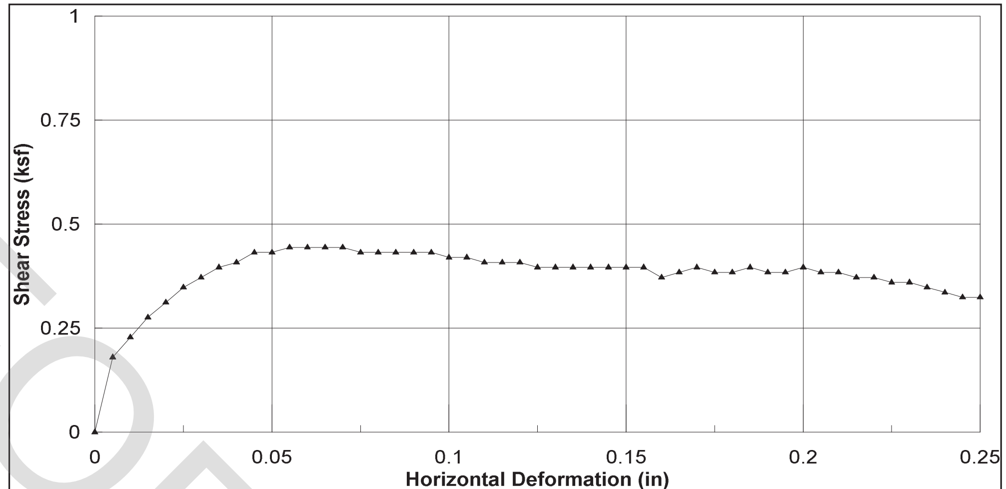
Sample type: Undisturbed Ring

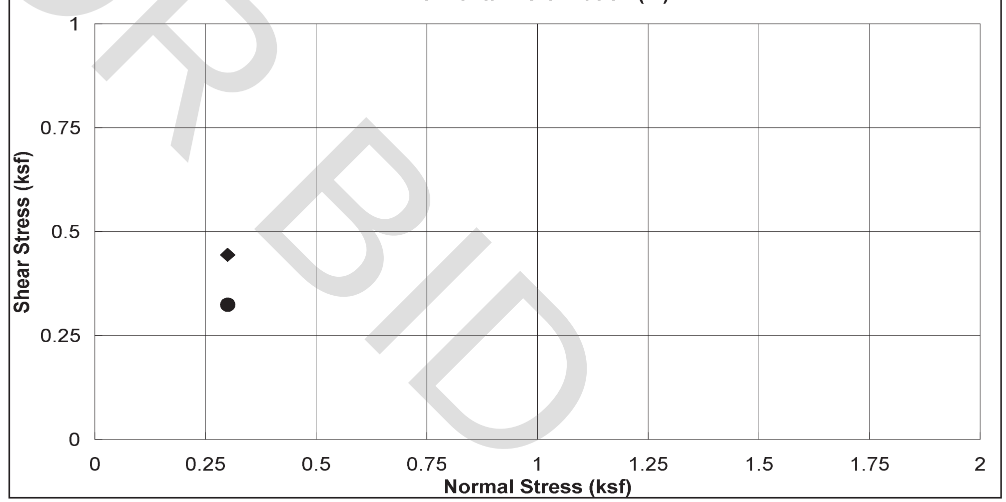
Type of test: Consolidated, Drained

	▲
Normal Stress (ksf)	0.3
Deformation Rate (in/min)	0.0025

Peak Shear Stress (ksf) ◆	0.44
Shear stress @ end of test (ksf) ●	0.32

Initial height of sample (in)	1
Height of sample before shear (in)	0.9996
Diameter of sample (in)	2.42
Initial Moisture Content (%)	1.8
Final Moisture Content (%)	13.0
Dry Density (pcf)	115.5
Final Saturation (%)	82.2





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DIRECT SHEAR TEST

(ASTM D3080)

HAI Pr No.: TRT-15-011
Tested by: KL/SE
Checked by: NB
Date: 4/16/2015

Client: **Tetra Tech**
Project Name: **Dola Bridge, Route 66 (San Bernardino County)**
Project Number: **cSB 14-01**

Boring No.: **B-1**

Sample No.: **R-3** A

Depth (ft): **7.5-8'**

Soil description: Light Brown, Poorly Graded Sand with Silt (SP-SM)

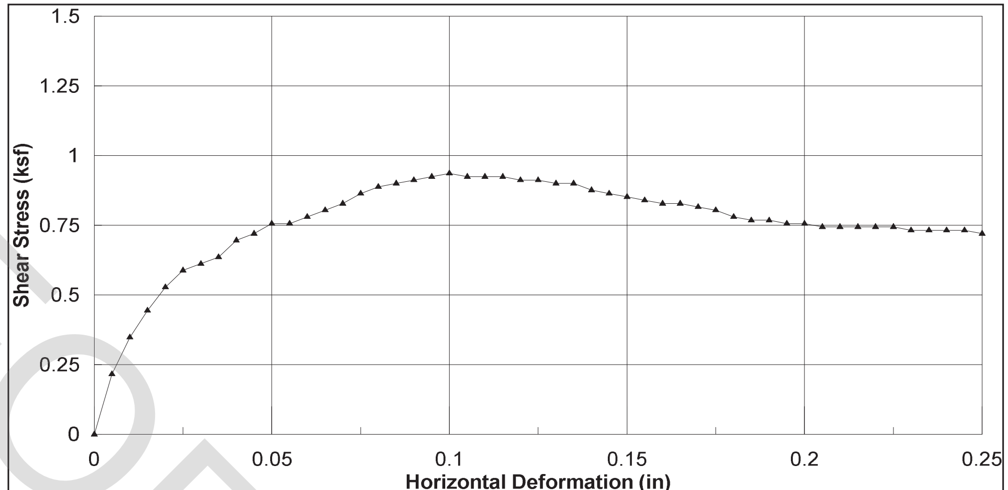
Sample type: Undisturbed Ring

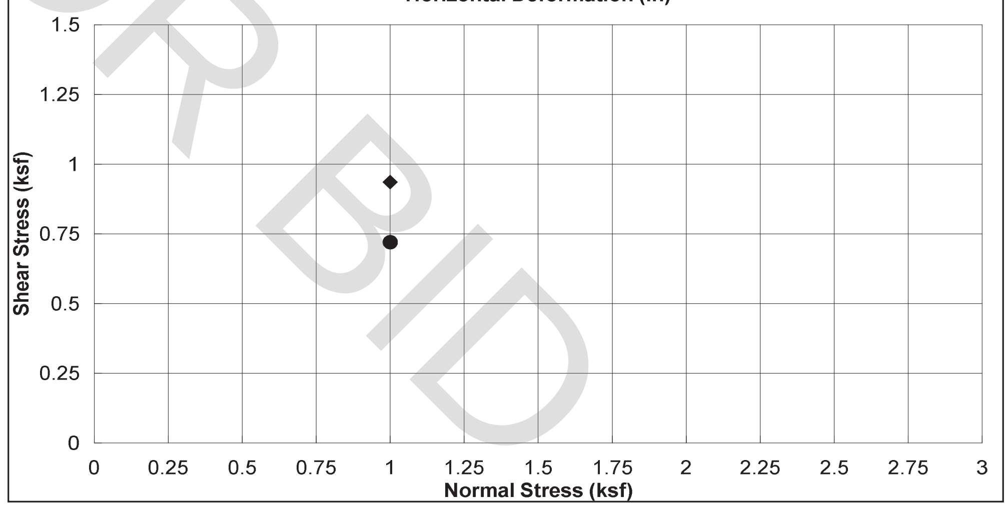
Type of test: Consolidated, Drained

	▲
Normal Stress (ksf)	**1**
Deformation Rate (in/min)	**0.0025**

Peak Shear Stress (ksf) ◆	**0.94**
Shear stress @ end of test (ksf) ●	**0.72**

Initial height of sample (in)	**1**
Height of sample before shear (in)	**0.9802**
Diameter of sample (in)	**2.42**
Initial Moisture Content (%)	**1.2**
Final Moisture Content (%)	**12.6**
Dry Density (pcf)	**113.1**
Final Saturation (%)	**78.9**





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DIRECT SHEAR TEST

(ASTM D3080)

HAI Pr No.: TRT-15-011
Tested by: KL/SE
Checked by: NB
Date: 4/16/2015

Client: **Tetra Tech**
Project Name: **Dola Bridge, Route 66 (San Bernardino County)**
Project Number: **cSB 14-01**

Boring No.: **B-2**

Sample No.: **R-2** A

Depth (ft): **5-5.5'**

Soil description: Brown, Poorly Graded Sand with Silt (SP-SM)

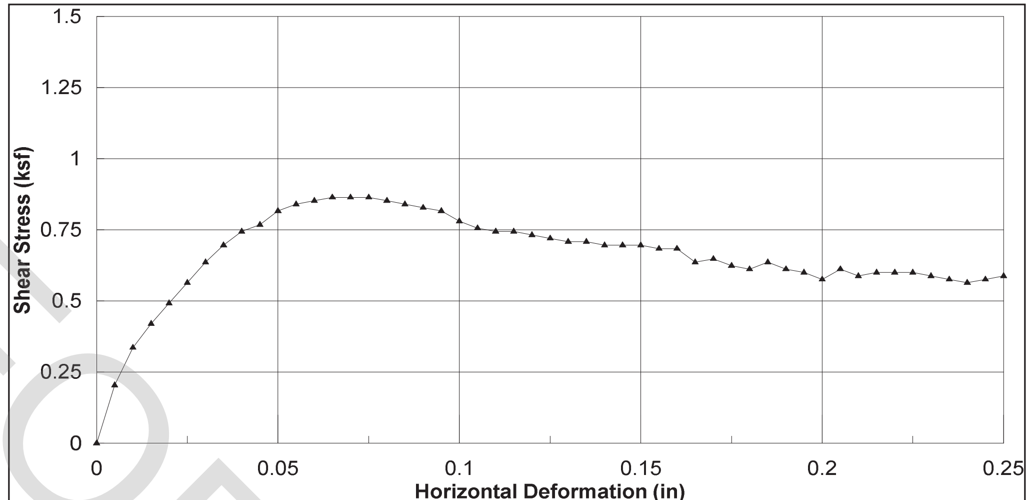
Sample type: Undisturbed Ring

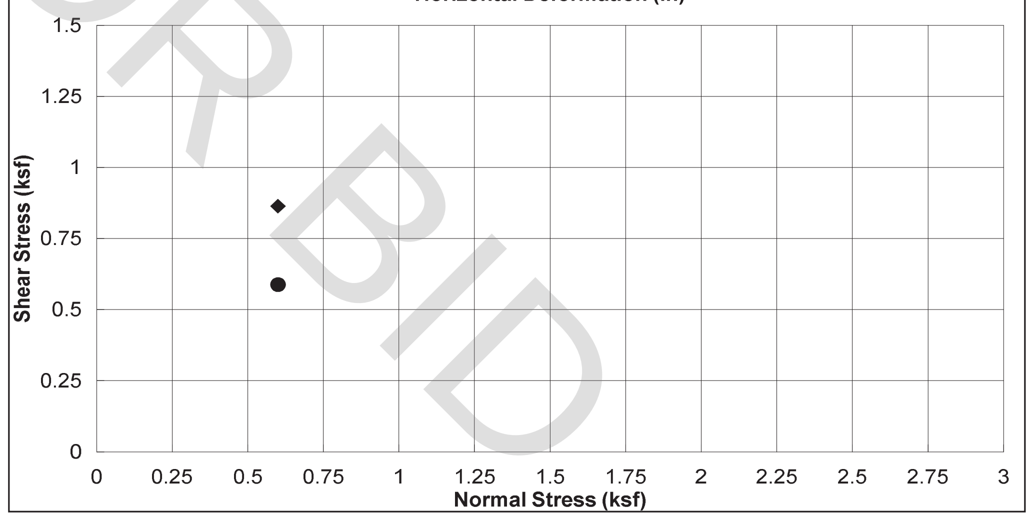
Type of test: Consolidated, Drained

	▲
Normal Stress (ksf)	**0.6**
Deformation Rate (in/min)	**0.0025**

Peak Shear Stress (ksf) ◆	**0.86**
Shear stress @ end of test (ksf) ●	**0.59**

Initial height of sample (in)	**1**
Height of sample before shear (in)	**1.0000**
Diameter of sample (in)	**2.42**
Initial Moisture Content (%)	**6.3**
Final Moisture Content (%)	**13.3**
Dry Density (pcf)	**115.5**
Final Saturation (%)	**84.1**





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Geotechnical and Earthquake Engineers

DIRECT SHEAR TEST

(ASTM D3080)

HAI Pr No.: TRT-15-009
Tested by: KL/SE
Checked by: NB
Date: 4/6/2015

Client: **Tetra Tech**
Project Name: **Dola Bridge, Route 66 (San Bernardino County)**
Project Number: **cSB 14-01**

Boring No.: **B-3**

Sample No.: **R-7**

Depth (ft): **11-11.5'**

Soil description: Light Brown, Poorly Graded Sand with Silt and Gravel (SP-SM)

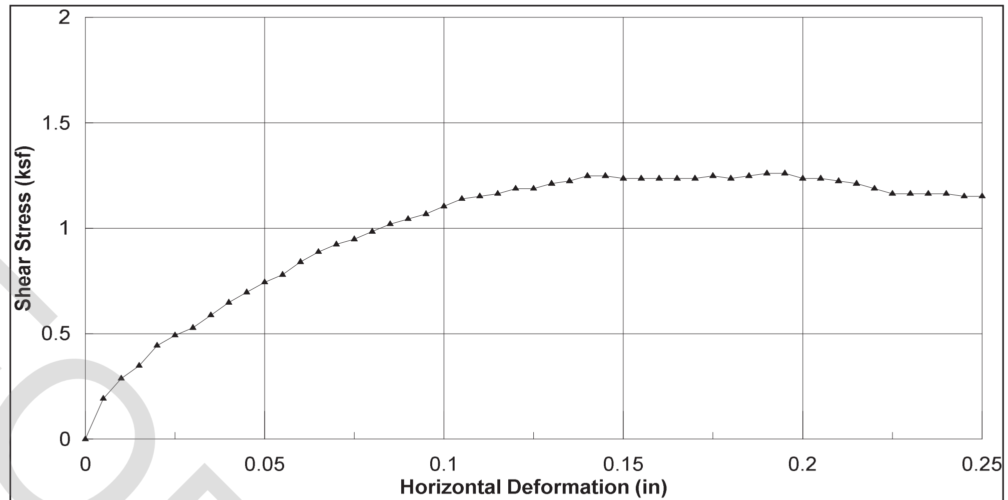
Sample type: Undisturbed Ring

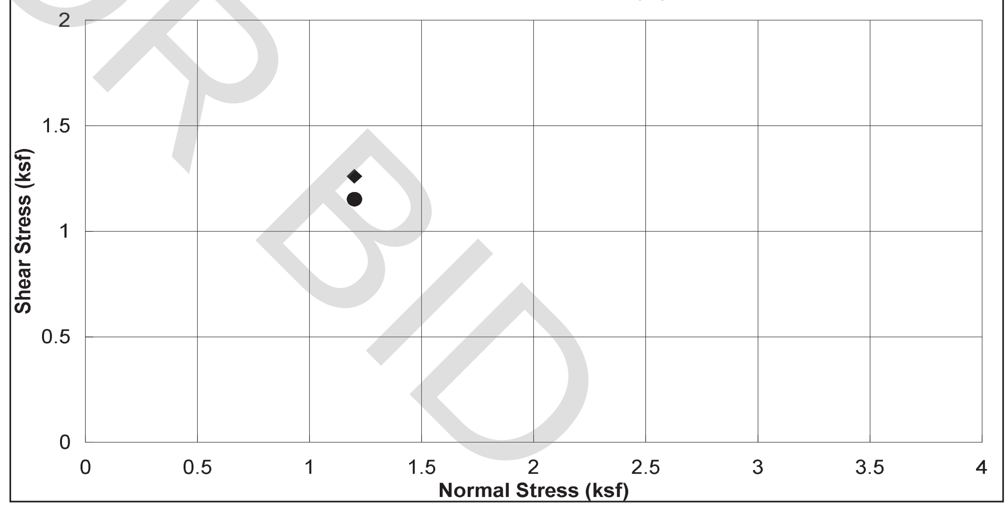
Type of test: Consolidated, Drained

	▲
Normal Stress (ksf)	**1.2**
Deformation Rate (in/min)	**0.0025**

Peak Shear Stress (ksf) ◆	**1.26**
Shear stress @ end of test (ksf) ●	**1.15**

Initial height of sample (in)	**1**
Height of sample before shear (in)	**0.9607**
Diameter of sample (in)	**2.36**
Initial Moisture Content (%)	**2.6**
Final Moisture Content (%)	**14.2**
Dry Density (pcf)	**109.9**
Final Saturation (%)	**81.2**





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Geotechnical and Earthquake Engineers

DIRECT SHEAR TEST

(ASTM D3080)

HAI Pr No.: TRT-15-009
Tested by: KL/SE
Checked by: NB
Date: 4/6/2015

Client: **Tetra Tech**
Project Name: **Dola Bridge, Route 66 (San Bernardino County)**
Project Number: **cSB 14-01**

Boring No.: **B-3**

Sample No.: **R-11**

Depth (ft): **21-21.5'**

Soil description: Light Reddish Brown, Poorly Graded Sand (SP)

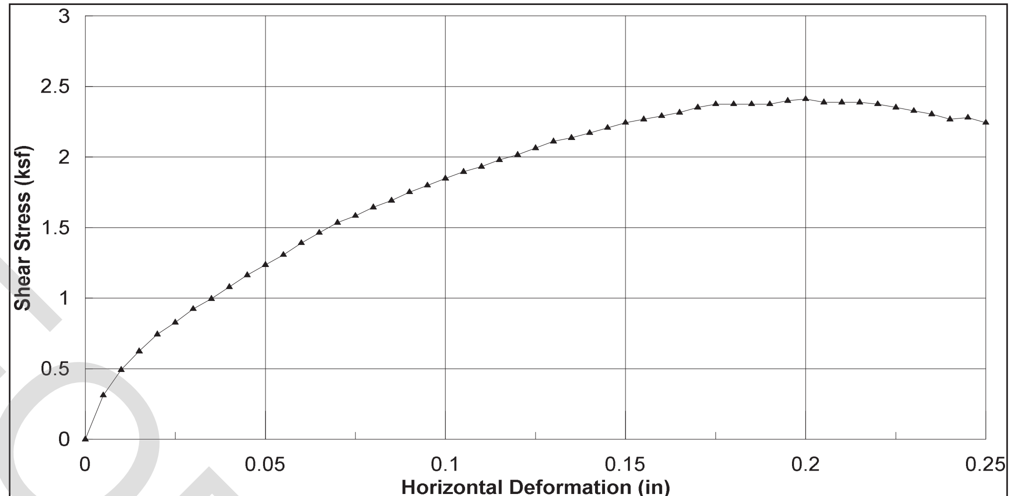
Sample type: Undisturbed Ring

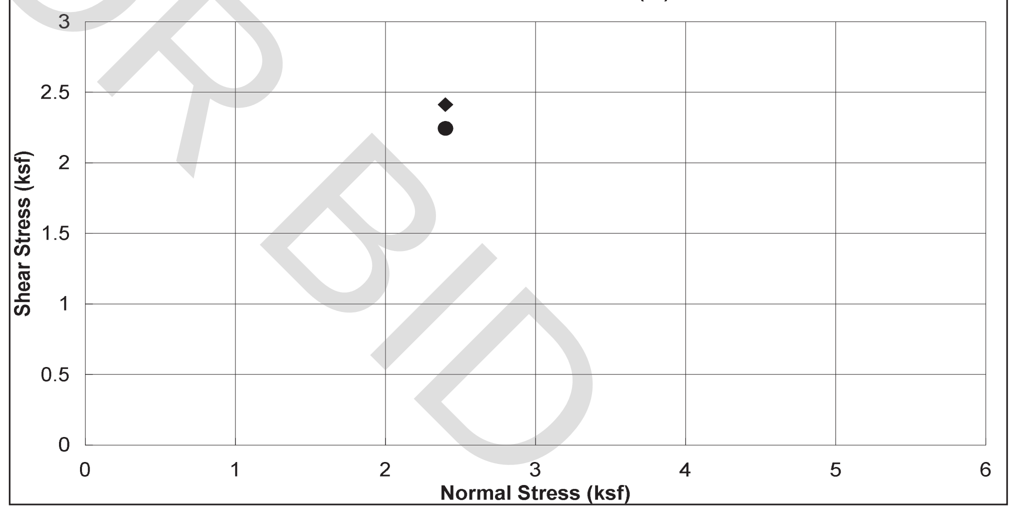
Type of test: Consolidated, Drained

	▲
Normal Stress (ksf)	**2.4**
Deformation Rate (in/min)	**0.0025**

Peak Shear Stress (ksf)	◆	**2.41**
Shear stress @ end of test (ksf)	●	**2.24**

Initial height of sample (in)	**1**
Height of sample before shear (in)	**0.9569**
Diameter of sample (in)	**2.42**
Initial Moisture Content (%)	**3.8**
Final Moisture Content (%)	**15.2**
Dry Density (pcf)	**106.7**
Final Saturation (%)	**83.2**





DIRECT SHEAR TEST

(ASTM D3080)

HUSHMAND ASSOCIATES, INC.
Geotechnical and Earthquake Engineers

HAI Pr No.: TRT-15-009
Tested by: KL/SE
Checked by: NB
Date: 4/6/2015

Client: **Tetra Tech**
Project Name: **Dola Bridge, Route 66 (San Bernardino County)**
Project Number: **cSB 14-01**

Boring No.: **B-3**

Sample No.: **R-13**

Depth (ft): **31-31.5'**

Soil description: Light Reddish Brown, Well Graded Sand (SW)

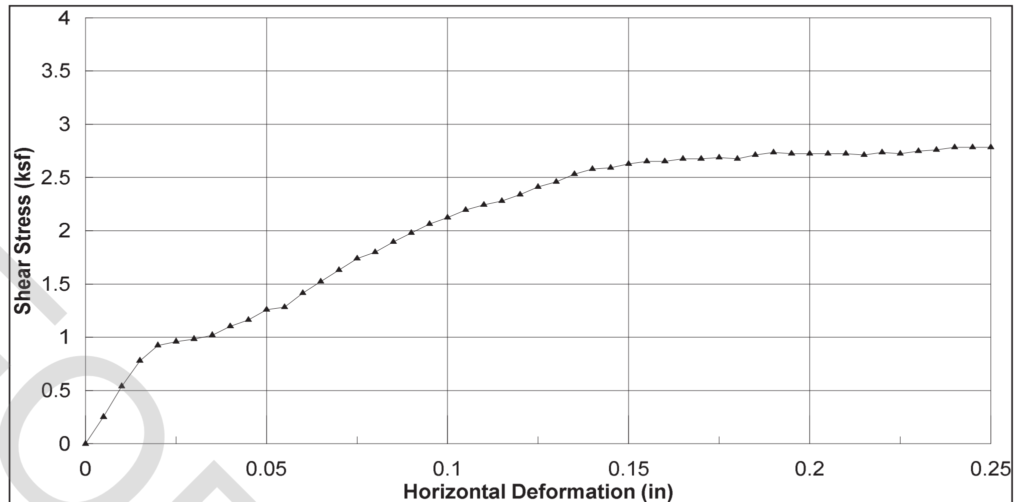
Sample type: Undisturbed Ring

Type of test: Consolidated, Drained

	▲
Normal Stress (ksf)	**3.6**
Deformation Rate (in/min)	**0.0025**

Peak Shear Stress (ksf) ◆	**2.78**
Shear stress @ end of test (ksf) ●	**2.78**

Initial height of sample (in)	**1**
Height of sample before shear (in)	**0.9279**
Diameter of sample (in)	**2.42**
Initial Moisture Content (%)	**3.4**
Final Moisture Content (%)	**11.9**
Dry Density (pcf)	**106.2**
Final Saturation (%)	**72.5**



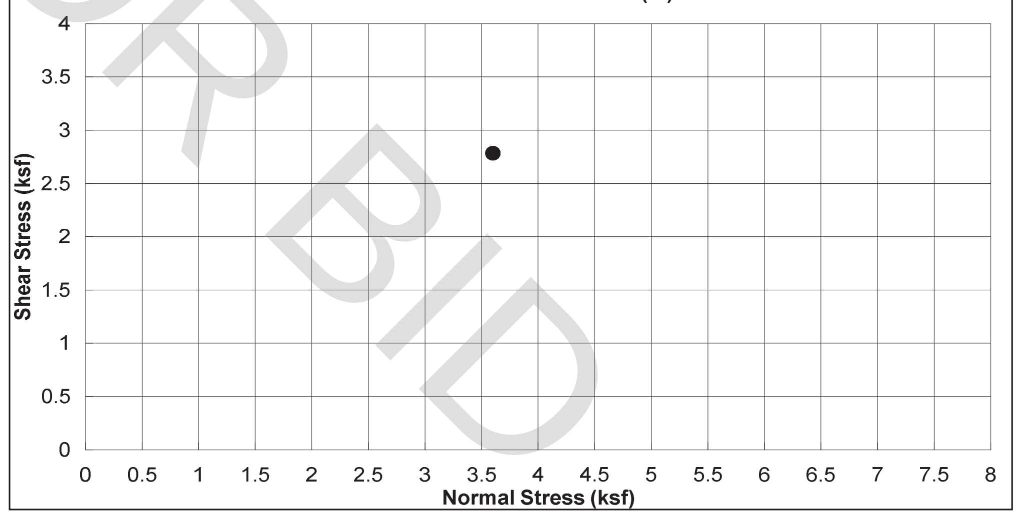


Table 1 - Laboratory Tests on Soil Samples

Hushmand Associates
DOLA Bridge, Route 66
Your #TRT-15-011, HDR Lab #15-0296LAB
17-Apr-15

Sample ID			B-1 SK-1
Resistivity		**Units**	
as-received		ohm-cm	>4,400,000
minimum		ohm-cm	16,200
pH			7.7
Electrical Conductivity		mS/cm	0.04
Chemical Analyses			
Cations			
calcium	Ca^{2+}	mg/kg	48
magnesium	Mg^{2+}	mg/kg	2.9
sodium	Na^{1+}	mg/kg	3.0
potassium	K^{1+}	mg/kg	21
Anions			
carbonate	CO_3^{2-}	mg/kg	20
bicarbonate	HCO_3^{1-}	mg/kg	24
fluoride	F^{1-}	mg/kg	0.5
chloride	Cl^{1-}	mg/kg	1.0
sulfate	SO_4^{2-}	mg/kg	6.0
phosphate	PO_4^{3-}	mg/kg	1.6
Other Tests			
ammonium	NH_4^{1+}	mg/kg	0.4
nitrate	NO_3^{1-}	mg/kg	7.3
sulfide	S^{2-}	qual	na
Redox		mV	na

Minimum resistivity per CTM 643, Chlorides per CTM 422, Sulfates per CTM 417
Electrical conductivity in millisiemens/cm and chemical analysis were made on a 1:5 soil-to-water extract.
mg/kg = milligrams per kilogram (parts per million) of dry soil.
Redox = oxidation-reduction potential in millivolts
ND = not detected
na = not analyzed

431 West Baseline Road · Claremont, CA 91711
Phone: 909.962.5485 · Fax: 909.626.3316

Table 1 - Laboratory Tests on Soil Samples

Hushmand Associates
DOLA Bridge Route 66
Your #TRT-15-009, HDR Lab #15-0258LAB
1-Apr-15

Sample ID			B-3 SK-3 @ 0-6' SM-SW
Resistivity		**Units**	
as-received		ohm-cm	na
saturated		ohm-cm	na
pH			na
Electrical Conductivity		mS/cm	0.05
Chemical Analyses			
Cations			
calcium	Ca^{2+}	mg/kg	na
magnesium	Mg^{2+}	mg/kg	na
sodium	Na^{1+}	mg/kg	na
potassium	K^{1+}	mg/kg	na
Anions			
carbonate	CO_3^{2-}	mg/kg	na
bicarbonate	HCO_3^{1-}	mg/kg	na
fluoride	F^{1-}	mg/kg	na
chloride	Cl^{1-}	mg/kg	na
sulfate	SO_4^{2-}	mg/kg	14
phosphate	PO_4^{3-}	mg/kg	na
Other Tests			
ammonium	NH_4^{1+}	mg/kg	na
nitrate	NO_3^{1-}	mg/kg	na
sulfide	S^{2-}	qual	na
Redox		mV	na

Electrical conductivity in millisiemens/cm and chemical analysis were made on a 1:5 soil-to-water extract.
mg/kg = milligrams per kilogram (parts per million) of dry soil.
Redox = oxidation-reduction potential in millivolts
ND = not detected
na = not analyzed

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Appendix C

Dynamic Settlement Analyses

SPT LIQUEFACTION SUSCEPTIBILITY AND EARTHQUAKE INDUCED SETTLEMENT

You must input all fields highlighted in blue | Insert or delete rows only immediately above the red row.

Boring: B-1

M 6.4 ==> MSF 1.500
PGA 0.25

This spreadsheet is suitable only for evaluation of liquefaction of SANDs.

If fines content greater than 50% is input, sensitivity of the fine-grained soils will be evaluated.

P_{atm} = 100 kPa
= 2088.54 psf
σ_{ref} = 2000 psf
M_{base} 7.5

Boring Data / Earthquake Loading

Depth to Layer Top	Depth to Layer Bottom	Groundwater present ? yes / no	Layer Thickness	Depth to layer middle	Depth to layer middle	SPT - N	Fines % (if %f > 50% NO LIQUEFACTION is assumed)	Dry Unit Wt	Moisture Content	Total Unit Wt	Total Stress @ layer middle	Pore Pressure @ layer middle	Pore Pressure @ layer bottom	Effective Stress @ layer middle	Test for first groundwater	Cyclic Stress Ratio CSR: r_d	CSR	$CSR_{7.5}$
feet	feet		feet	feet	meters		%	pcf	%	pcf	psf	psf	psf	psf				
0	5	no	5.0	2.5	0.8	49	3.0	116	3.0	119.5	299	0.0	0.0	299	n/a	0.996	0.162	0.108
5	10	no	5.0	7.5	2.3	50	3.0	116	3.0	119.5	896	0.0	0.0	896	n/a	0.985	0.160	0.107
10	15	no	5.0	12.5	3.8	50	10.0	116	3.0	119.5	1494	0.0	0.0	1494	n/a	0.974	0.158	0.105
15	20	no	5.0	17.5	5.3	34	20.0	116	3.0	119.5	2091	0.0	0.0	2091	n/a	0.963	0.156	0.104
20	25	no	5.0	22.5	6.9	31	20.0	116	3.0	119.5	2688	0.0	0.0	2688	n/a	0.950	0.154	0.103
25	30	no	5.0	27.5	8.4	41	3.0	116	3.0	119.5	3286	0.0	0.0	3286	n/a	0.932	0.151	0.101
30	35	no	5.0	32.5	9.9	32	20.0	116	3.0	119.5	3883	0.0	0.0	3883	n/a	0.907	0.147	0.098
35	40	no	5.0	37.5	11.4	63	20.0	116	3.0	119.5	4481	0.0	0.0	4481	n/a	0.872	0.142	0.094
40	45	no	5.0	42.5	13.0	22	20.0	116	3.0	119.5	5078	0.0	0.0	5078	n/a	0.828	0.135	0.090
45	50	no	5.0	47.5	14.5	37	5.0	116	3.0	119.5	5675	0.0	0.0	5675	n/a	0.778	0.126	0.084
50	55	no	5.0	52.5	16.0	38	3.0	116	3.0	119.5	6273	0.0	0.0	6273	n/a	0.728	0.118	0.079

Derivation of $(N_1)_{60,cs}$

SPT Readings and Corrections
convert California sampler blowcounts into SPT and use SPT blowcounts only

Correction	Input	Value	Factor	Value
Correction for borehole diameter	D_B (in)	4	C_B	1.00
Correction for sampling method		no liner	C_S	1.2
Correction for energy ratio			C_E	1.37
Correction for rod length	$r_{stickup}$ (ft)	3	see C_R	
Correction for effective overburden pressure			see C_N	
Correction for % fines			see α, β	

Derivation of $(N_1)_{60,cs}$ / Soil Earthquake Resistance / Factor of Safety

Depth to Layer Top	C_N	rod length	C_R	$(N_1)_{60}$	α	β	$(N_1)_{60,cs}$	K_σ	$CRR_{SPT,CS}$	$CRR_{SPT,CS}$	$CRR_{SPT,CS,K\sigma}$	$FS_{SPT.cs,K\sigma}$	Interpreted Factor of Safety against liquefaction	Liquefiable thickness	for plotting only
feet		m	%						Idriss	Rauch				ft	
0	2.000	1.7	0.75	120.8	0.000	1.000	120.8	1.000	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
5	1.527	3.2	0.75	94.1	0.000	1.000	94.1	1.000	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
10	1.183	4.7	0.85	82.6	0.869	1.022	85.3	1.000	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
15	0.999	6.2	0.95	53.1	3.615	1.079	60.9	0.995	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
20	0.881	7.8	0.95	42.7	3.615	1.079	49.7	0.952	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
25	0.797	9.3	0.95	51.1	0.000	1.000	51.1	0.914	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
30	0.733	10.8	1.00	39	3.615	1.079	45.3	0.880	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
35	0.683	12.3	1.00	71	3.615	1.079	79.9	0.850	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
40	0.641	13.9	1.00	23	3.615	1.079	28.7	0.823	0.371	0.395	0.325	3.62	Not liquefiable - no groundwater	0.00	5.00
45	0.607	15.4	1.00	37	0.000	1.000	36.9	0.798	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
50	0.577	16.9	1.00	36	0.000	1.000	36.0	0.776	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00

Cyclic Resistance Ratio CRR

Factor of Safety against Liquefaction
Total evaluated profile thickness 55.00 feet
Profile thickness susceptible to liquefaction 0.00 feet
not interpreted

EARTHQUAKE-INDUCED SETTLEMENT OF SATURATED SAND

Earthquake-induced Settlement of Saturated Sand (fines < 50%)
by Tokimatsu and Seed

Total liquefaction settlement 0.00 inches

Fines% Correction for Tokimatsu & Seed	$(N_1)_{60,cs,stlmnt}$	$CSR_{7.5}$	ε_v	Δz	$S_i = \varepsilon_{vi}\ \Delta z_i$	S_{cumul}
			%	feet	in	inches
0.00	100.0	0.108	0.00	5.00	no GW	0.00
0.00	94.1	0.107	0.00	5.00	no GW	0.00
3.00	85.6	0.105	0.00	5.00	no GW	0.00
5.00	58.1	0.104	0.00	5.00	no GW	0.00
5.00	47.7	0.103	0.00	5.00	no GW	0.00
0.00	51.1	0.101	0.00	5.00	no GW	0.00
5.00	43.6	0.098	0.00	5.00	no GW	0.00
5.00	75.7	0.094	0.00	5.00	no GW	0.00
5.00	28.2	0.090	0.00	5.00	no GW	0.00
3.00	39.9	0.084	0.00	5.00	no GW	0.00
0.00	36.0	0.079	0.00	5.00	no GW	0.00

EARTHQUAKE-INDUCED SETTLEMENT OF DRY SAND

Earthqauke-induced Settlement of Dry Sand (fines < 50%)
by Daniel Pradel

Total settlement of dry sand 0.04 inches

Multidirectional effect coeffiecient B 2
Equivalent number of cycles N_c 6.68

K_o	σ_m	G_{max}	r_d	τ_{av}	a	b	γ	ε_{15}	ε_{Nc}	Δz	$S_i = \varepsilon_{vi}\ \Delta z_i$	S_{cumul}
		psf		psf						feet	in	in
0.50	199	1395069	0.999	49	0.128	25545	0.004%	0.000%	0.000%	5.00	0.00	0.00
0.50	597	2223253	0.994	145	0.136	13214	0.008%	0.001%	0.001%	5.00	0.00	0.00
0.50	996	2777406	0.985	239	0.143	9726	0.010%	0.002%	0.001%	5.00	0.00	0.00
0.50	1394	2937438	0.970	330	0.151	7948	0.013%	0.004%	0.002%	5.00	0.00	0.01
0.50	1792	3112139	0.952	416	0.159	6835	0.016%	0.005%	0.004%	5.00	0.00	0.01
0.50	2190	3472005	0.930	496	0.167	6060	0.017%	0.006%	0.004%	5.00	0.00	0.01
0.50	2589	3626007	0.905	571	0.174	5482	0.019%	0.007%	0.005%	5.00	0.01	0.02
0.50	2987	4708135	0.877	638	0.182	5031	0.016%	0.003%	0.002%	5.00	0.00	0.02
1.50	6771	5035188	0.847	699	0.256	3079	0.015%	0.010%	0.007%	5.00	0.01	0.03
2.50	11351	7093012	0.816	753	0.345	2258	0.011%	0.005%	0.004%	5.00	0.00	0.04
3.50	16727	8543771	0.784	799	0.449	1790	0.010%	0.005%	0.003%	5.00	0.00	0.04

Settlement Distribution

Layer settlement (compression) both liquefied and dry sand | Distribution of Earthquake-induced settlement (top of layer) — Surface settlement 0.04

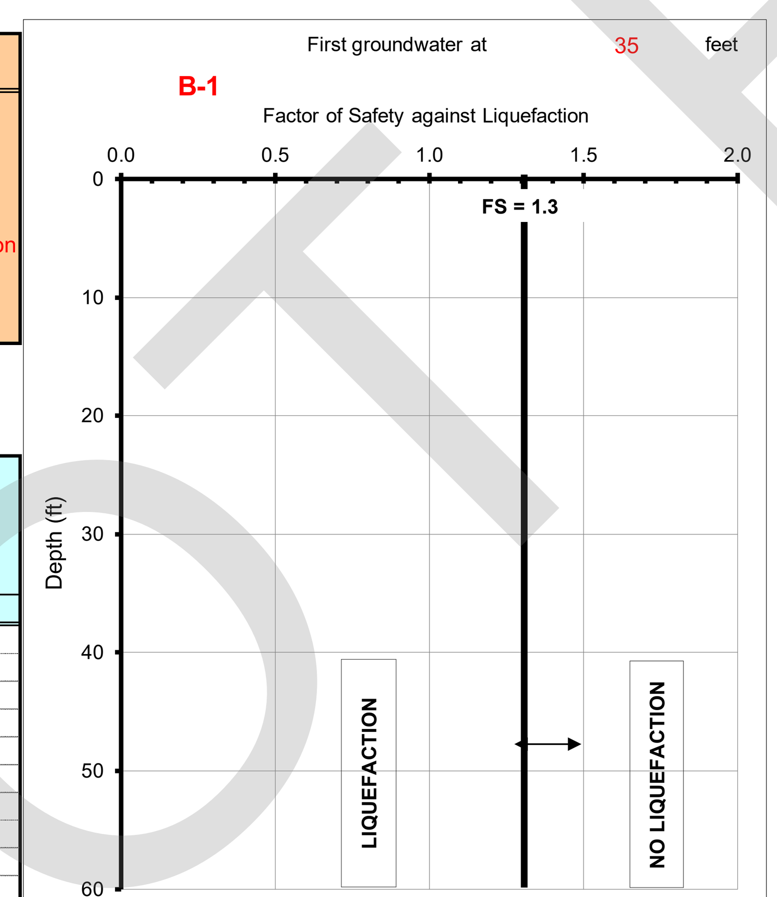
S_{layer}	S_{cumul}
in	in
0.00	0.04
0.00	0.04
0.00	0.04
0.00	0.04
0.00	0.03
0.00	0.03
0.01	0.03
0.00	0.02
0.01	0.02
0.00	0.01
0.00	0.00

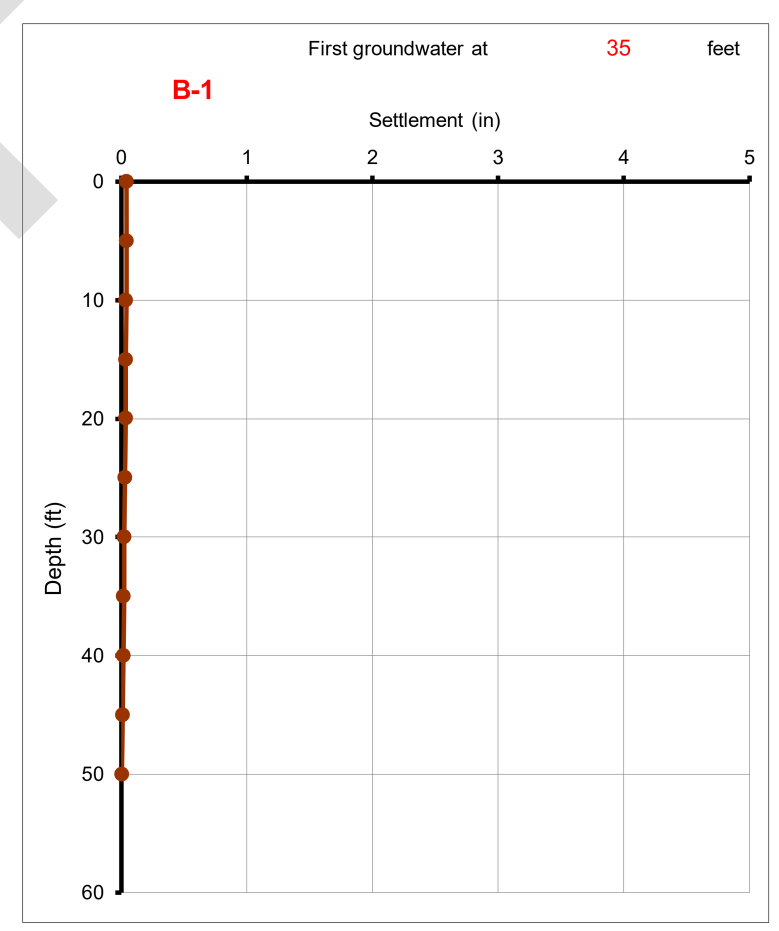
Boring B-1 — Summary of analysis

Total liquefaction settlement	0.00	inches
Total dry sand settlement	0.04	inches
Total earthquake-induced settlement	**0.04**	inches
Number of evaluated intervals	11	
Number of potentially liquefiable intervals	0	
Average Factor of Safety	no liquefaction	
Depth to first groundwater	0.00	feet
Total thickness of evaluated profile	55.00	feet
Profile thickness susceptible to liquefaction	0.00	feet

Earthquake loading: M 6.4
PGA 0.25

Depth to Layer Top	Depth to Layer Bottom	SPT - N	Fines %	$FS_{SPT.cs,K\sigma}$	Interpreted Factor of Safety against liquefaction	Settlement
feet	feet					in
0	5	49	3	no liq	Not liquefiable - no groundwater	0.00
5	10	50	3	no liq	Not liquefiable - no groundwater	0.00
10	15	50	10	no liq	Not liquefiable - no groundwater	0.00
15	20	34	20	no liq	Not liquefiable - no groundwater	0.00
20	25	31	20	no liq	Not liquefiable - no groundwater	0.00
25	30	41	3	no liq	Not liquefiable - no groundwater	0.00
30	35	32	20	no liq	Not liquefiable - no groundwater	0.01
35	40	63	20	no liq	Not liquefiable - no groundwater	0.00
40	45	22	20	3.62	Not liquefiable - no groundwater	0.01
45	50	37	5	no liq	Not liquefiable - no groundwater	0.00
50	55	38	3	no liq	Not liquefiable - no groundwater	0.00





SPT LIQUEFACTION SUSCEPTIBILITY AND EARTHQUAKE INDUCED SETTLEMENT

You must input all fields highlighted in blue | Insert or delete rows only immediately above the red row.

Boring: B-2 | M 6.4 | PGA 0.25 | ==> | MSF 1.500

This spreadsheet is suitable only for evaluation of liquefaction of SANDs.

If fines content greater than 50% is input, sensitivity of the fine-grained soils will be evaluated.

P_{atm} = 100 kPa
= 2088.54 psf
σ_{ref} = 2000 psf
M_{base} 7.5

Boring Data

Depth to Layer Top	Depth to Layer Bottom	Groundwater present ? yes / no	Layer Thickness	Depth to layer middle	Depth to layer middle	SPT - N	Fines % (if %f > 50% NO LIQUEFACTION is assumed)	Dry Unit Wt	Moisture Content	Total Unit Wt	Total Stress @ layer middle	Pore Pressure @ layer middle	Pore Pressure @ layer bottom	Effective Stress @ layer middle	Test for first groundwater
feet	feet		feet	feet	meters		%	pcf	%	pcf	psf	psf	psf	psf	
0	5	no	5.0	2.5	0.8	28	3.0	116	3.0	119.5	299	0.0	0.0	299	n/a
5	10	no	5.0	7.5	2.3	28	3.0	116	3.0	119.5	896	0.0	0.0	896	n/a
10	15	no	5.0	12.5	3.8	29	10.0	116	3.0	119.5	1494	0.0	0.0	1494	n/a
15	20	no	5.0	17.5	5.3	44	20.0	116	3.0	119.5	2091	0.0	0.0	2091	n/a
20	25	no	5.0	22.5	6.9	50	20.0	116	3.0	119.5	2688	0.0	0.0	2688	n/a
25	30	no	5.0	27.5	8.4	50	3.0	116	3.0	119.5	3286	0.0	0.0	3286	n/a
30	35	no	5.0	32.5	9.9	50	20.0	116	3.0	119.5	3883	0.0	0.0	3883	n/a
35	40	no	5.0	37.5	11.4	100	20.0	116	3.0	119.5	4481	0.0	0.0	4481	n/a
40	45	no	5.0	42.5	13.0	80	20.0	116	3.0	119.5	5078	0.0	0.0	5078	n/a
45	50	no	5.0	47.5	14.5	50	5.0	116	3.0	119.5	5675	0.0	0.0	5675	n/a
50	55	no	5.0	52.5	16.0	50	3.0	116	3.0	119.5	6273	0.0	0.0	6273	n/a

Earthquake Loading / Derivation of $(N_1)_{60,cs}$

Cyclic Stress Ratio CSR

SPT Readings and Corrections

convert California sampler blowcounts into SPT and use SPT blowcounts only

Correction				
Correction for borehole diameter	D_B (in)	4	C_B	1.00
Correction for sampling method		no liner	C_S	1.2
Correction for energy ratio			C_E	1.37
Correction for rod length	$r_{stickup}$ (ft)	3	see C_R	
Correction for effective overburden pressure			see C_N	
Correction for % fines			see α, β	

Depth to Layer Top (feet)	r_d	CSR	$CSR_{7.5}$	C_N	rod length (m)	C_R (%)	$(N_1)_{60}$	α	β	$(N_1)_{60,cs}$
0	0.996	0.162	0.108	2.000	1.7	0.75	69.0	0.000	1.000	69.0
5	0.985	0.160	0.107	1.527	3.2	0.75	52.7	0.000	1.000	52.7
10	0.974	0.158	0.105	1.183	4.7	0.85	47.9	0.869	1.022	49.8
15	0.963	0.156	0.104	0.999	6.2	0.95	68.7	3.615	1.079	77.8
20	0.950	0.154	0.103	0.881	7.8	0.95	68.8	3.615	1.079	77.9
25	0.932	0.151	0.101	0.797	9.3	0.95	62.3	0.000	1.000	62.3
30	0.907	0.147	0.098	0.733	10.8	1.00	60	3.615	1.079	68.7
35	0.872	0.142	0.094	0.683	12.3	1.00	112	3.615	1.079	124.8
40	0.828	0.135	0.090	0.641	13.9	1.00	84	3.615	1.079	94.7
45	0.778	0.126	0.084	0.607	15.4	1.00	50	0.000	1.000	49.9
50	0.728	0.118	0.079	0.577	16.9	1.00	47	0.000	1.000	47.4

Soil Earthquake Resistance / Factor of Safety

Cyclic Resistance Ratio CRR

Factor of Safety against Liquefaction

Total evaluated profile thickness 55.00 feet
Profile thickness susceptible to liquefaction 0.00 feet

Depth to Layer Top (feet)	K_σ	$CRR_{SPT,CS}$ Idriss	$CRR_{SPT,CS}$ Rauch	$CRR_{SPT,CS,K\sigma}$	not interpreted $FS_{SPT.cs,K\sigma}$	Interpreted Factor of Safety against liquefaction	Liquefiable thickness (ft)	for plotting only
0	1.000	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
5	1.000	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
10	1.000	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
15	0.995	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
20	0.952	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
25	0.914	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
30	0.880	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
35	0.850	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
40	0.823	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
45	0.798	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
50	0.776	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00

EARTHQUAKE-INDUCED SETTLEMENT OF SATURATED SAND

Earthquake-induced Settlement of Saturated Sand (fines < 50%)
by Tokimatsu and Seed

Total liquefaction settlement 0.00 inches

Fines% Correction for Tokimatsu & Seed	$(N_1)_{60,cs,stlmnt}$	$CSR_{7.5}$	ε_v	Δz	$S_i = \varepsilon_{vi}\ \Delta z_i$	S_{cumul}
			%	feet	in	inches
0.00	69.0	0.108	0.00	5.00	no GW	0.00
0.00	52.7	0.107	0.00	5.00	no GW	0.00
3.00	50.9	0.105	0.00	5.00	no GW	0.00
5.00	73.7	0.104	0.00	5.00	no GW	0.00
5.00	73.8	0.103	0.00	5.00	no GW	0.00
0.00	62.3	0.101	0.00	5.00	no GW	0.00
5.00	65.3	0.098	0.00	5.00	no GW	0.00
5.00	100.0	0.094	0.00	5.00	no GW	0.00
5.00	89.3	0.090	0.00	5.00	no GW	0.00
3.00	52.9	0.084	0.00	5.00	no GW	0.00
0.00	47.4	0.079	0.00	5.00	no GW	0.00

EARTHQUAKE-INDUCED SETTLEMENT OF DRY SAND

Earthqauke-induced Settlement of Dry Sand (fines < 50%)
by Daniel Pradel

Total settlement of dry sand 0.03 inches

Multidirectional effect coeffiecient B 2
Equivalent number of cycles N_c 6.68

K_o	σ_m	G_{max}	r_d	τ_{av}	a	b	γ	ε_{15}	ε_{Nc}	Δz	$S_i = \varepsilon_{vi}\ \Delta z_i$	S_{cumul}
		psf		psf						feet	in	in
0.50	199	1157687	0.999	49	0.128	25545	0.005%	0.001%	0.001%	5.00	0.00	0.00
0.50	597	1832567	0.994	145	0.136	13214	0.010%	0.003%	0.002%	5.00	0.00	0.00
0.50	996	2321959	0.985	239	0.143	9726	0.013%	0.004%	0.003%	5.00	0.00	0.01
0.50	1394	3186572	0.970	330	0.151	7948	0.012%	0.002%	0.002%	5.00	0.00	0.01
0.50	1792	3615733	0.952	416	0.159	6835	0.013%	0.003%	0.002%	5.00	0.00	0.01
0.50	2190	3709421	0.930	496	0.167	6060	0.016%	0.004%	0.003%	5.00	0.00	0.01
0.50	2589	4166834	0.905	571	0.174	5482	0.016%	0.004%	0.003%	5.00	0.00	0.02
0.50	2987	5461182	0.877	638	0.182	5031	0.013%	0.001%	0.001%	5.00	0.00	0.02
1.50	6771	7498975	0.847	699	0.256	3079	0.010%	0.002%	0.001%	5.00	0.00	0.02
2.50	11351	7841800	0.816	753	0.345	2258	0.010%	0.003%	0.002%	5.00	0.00	0.02
3.50	16727	9362124	0.784	799	0.449	1790	0.009%	0.003%	0.002%	5.00	0.00	0.03

Settlement Distribution

Layer settlement (compression) both liquefied and dry sand S_{layer} (in)	Distribution of Earthquake-induced settlement (top of layer) Surface settlement 0.03 S_{cumul} (in)
0.00	0.03
0.00	0.02
0.00	0.02
0.00	0.02
0.00	0.02
0.00	0.01
0.00	0.01
0.00	0.01
0.00	0.01
0.00	0.01
0.00	0.00

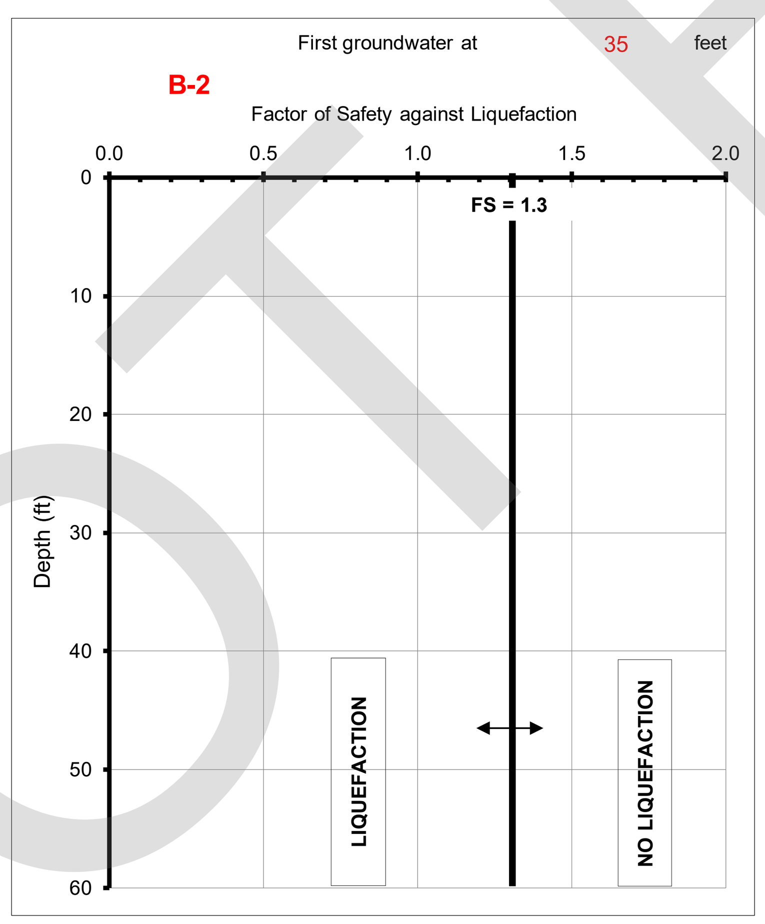
Summary of analysis

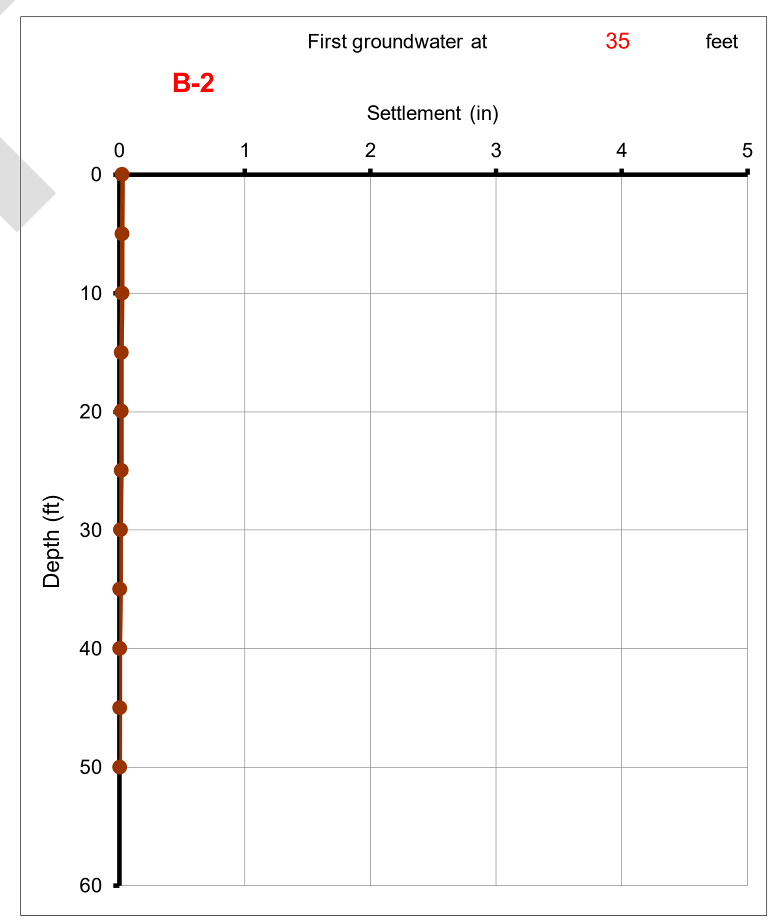
Boring B-2

Total liquefaction settlement	0.00 inches
Total dry sand settlement	0.03 inches
Total earthquake-induced settlement	0.03 inches
Number of evaluated intervals	11
Number of potentially liquefiable intervals	0
Average Factor of Safety	no liquefaction
Depth to first groundwater	0.00 feet
Total thickness of evaluated profile	55.00 feet
Profile thickness susceptible to liquefaction	0.00 feet

Earthquake loading: M 6.4, PGA 0.25

Depth to Layer Top	Depth to Layer Bottom	SPT - N	Fines %	$FS_{SPT.cs,K\sigma}$	Interpreted Factor of Safety against liquefaction		Settlement
feet	feet						in
0	5	28	3	no liq	Not liquefiable	- no groundwater	0.00
5	10	28	3	no liq	Not liquefiable	- no groundwater	0.00
10	15	29	10	no liq	Not liquefiable	- no groundwater	0.00
15	20	44	20	no liq	Not liquefiable	- no groundwater	0.00
20	25	50	20	no liq	Not liquefiable	- no groundwater	0.00
25	30	50	3	no liq	Not liquefiable	- no groundwater	0.00
30	35	50	20	no liq	Not liquefiable	- no groundwater	0.00
35	40	100	20	no liq	Not liquefiable	- no groundwater	0.00
40	45	80	20	no liq	Not liquefiable	- no groundwater	0.00
45	50	50	5	no liq	Not liquefiable	- no groundwater	0.00
50	55	50	3	no liq	Not liquefiable	- no groundwater	0.00





B-3

SPT LIQUEFACTION SUSCEPTIBILITY AND EARTHQUAKE INDUCED SETTLEMENT

You must input all fields highlighted in blue | Insert or delete rows only immediately above the red row.

This spreadsheet is suitable only for evaluation of liquefaction of SANDs.

If fines content greater than 50% is input, sensitivity of the fine-grained soils will be evaluated.

Boring: B-3 M 6.4 PGA 0.25 ==> MSF 1.500

P_{atm} = 100 kPa
= 2088.54 psf
σ_{ref} = 2000 psf
M_{base} 7.5

Boring Data / Earthquake Loading

Depth to Layer Top	Depth to Layer Bottom	Groundwater present ? yes / no	Layer Thickness	Depth to layer middle	Depth to layer middle	SPT - N	Fines % (if %f > 50% NO LIQUEFACTION is assumed)	Dry Unit Wt	Moisture Content	Total Unit Wt	Total Stress @ layer middle	Pore Pressure @ layer middle	Pore Pressure @ layer bottom	Effective Stress @ layer middle	Test for first groundwater	r_d	CSR	$CSR_{7.5}$
feet	feet		feet	feet	meters		%	pcf	%	pcf	psf	psf	psf	psf				
0	5	no	5.0	2.5	0.8	13	3.0	116	3.0	119.5	299	0.0	0.0	299	n/a	0.996	0.162	0.108
5	10	no	5.0	7.5	2.3	21	5.0	116	3.0	119.5	896	0.0	0.0	896	n/a	0.985	0.160	0.107
10	15	no	5.0	12.5	3.8	28	5.0	116	3.0	119.5	1494	0.0	0.0	1494	n/a	0.974	0.158	0.105
15	20	no	5.0	17.5	5.3	33	5.0	116	3.0	119.5	2091	0.0	0.0	2091	n/a	0.963	0.156	0.104
20	25	no	5.0	22.5	6.9	32	5.0	116	3.0	119.5	2688	0.0	0.0	2688	n/a	0.950	0.154	0.103
25	30	no	5.0	27.5	8.4	22	5.0	116	3.0	119.5	3286	0.0	0.0	3286	n/a	0.932	0.151	0.101
30	35	no	5.0	32.5	9.9	32	3.0	116	3.0	119.5	3883	0.0	0.0	3883	n/a	0.907	0.147	0.098
35	40	no	5.0	37.5	11.4	32	3.0	116	3.0	119.5	4481	0.0	0.0	4481	n/a	0.872	0.142	0.094
40	45	no	5.0	42.5	13.0	47	5.0	116	3.0	119.5	5078	0.0	0.0	5078	n/a	0.828	0.135	0.090
45	50	no	5.0	47.5	14.5	39	3.0	116	3.0	119.5	5675	0.0	0.0	5675	n/a	0.778	0.126	0.084
50	55	no	5.0	52.5	16.0	35	3.0	116	3.0	119.5	6273	0.0	0.0	6273	n/a	0.728	0.118	0.079

Cyclic Stress Ratio CSR

Derivation of $(N_1)_{60,cs}$

SPT Readings and Corrections
convert California sampler blowcounts into SPT and use SPT blowcounts only

Correction				
Correction for borehole diameter	D_B (in)	4	C_B	1.00
Correction for sampling method		no liner	C_S	1.2
Correction for energy ratio			C_E	1.37
Correction for rod length	$r_{stickup}$ (ft)	3	see C_R	
Correction for effective overburden pressure			see C_N	
Correction for % fines			see α, β	

Soil Earthquake Resistance / Factor of Safety

Cyclic Resistance Ratio CRR

Factor of Safety against Liquefaction

Total evaluated profile thickness 55.00 feet
Profile thickness susceptible to liquefaction 0.00 feet

C_N	rod length	C_R	$(N_1)_{60}$	α	β	$(N_1)_{60,cs}$	K_σ	$CRR_{SPT,CS}$	$CRR_{SPT,CS}$	$CRR_{SPT,CS,K\sigma}$	$FS_{SPT,cs,K\sigma}$ (not interpreted)	Interpreted Factor of Safety against liquefaction	Liquefiable thickness	for plotting only
	m	%						Idriss	Rauch				ft	
2.000	1.7	0.75	32.1	0.000	1.000	32.1	1.000	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
1.527	3.2	0.75	39.5	0.000	1.000	39.5	1.000	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
1.183	4.7	0.85	46.3	0.000	1.000	46.3	1.000	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
0.999	6.2	0.95	51.5	0.000	1.000	51.5	0.995	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
0.881	7.8	0.95	44.1	0.000	1.000	44.1	0.952	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
0.797	9.3	0.95	27.4	0.000	1.000	27.4	0.914	0.333	0.350	0.320	3.17	Not liquefiable - no groundwater	0.00	5.00
0.733	10.8	1.00	39	0.000	1.000	38.6	0.880	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
0.683	12.3	1.00	36	0.000	1.000	35.9	0.850	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
0.641	13.9	1.00	50	0.000	1.000	49.6	0.823	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
0.607	15.4	1.00	39	0.000	1.000	38.9	0.798	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00
0.577	16.9	1.00	33	0.000	1.000	33.2	0.776	no liq	no liq	no liq	no liq	Not liquefiable - no groundwater	0.00	5.00

EARTHQUAKE-INDUCED SETTLEMENT OF SATURATED SAND

Earthquake-induced Settlement of Saturated Sand (fines < 50%)
by Tokimatsu and Seed

Total liquefaction settlement 0.00 inches

Fines% Correction for Tokimatsu & Seed	$(N_1)_{60,cs,stlmnt}$	$CSR_{7.5}$	ε_v	Δz	$S_i = \varepsilon_{vi}\,\Delta z_i$	S_{cumul}
			%	feet	in	inches
0.00	32.1	0.108	0.00	5.00	no GW	0.00
3.00	42.5	0.107	0.00	5.00	no GW	0.00
3.00	49.3	0.105	0.00	5.00	no GW	0.00
3.00	54.5	0.104	0.00	5.00	no GW	0.00
3.00	47.1	0.103	0.00	5.00	no GW	0.00
3.00	30.4	0.101	0.00	5.00	no GW	0.00
0.00	38.6	0.098	0.00	5.00	no GW	0.00
0.00	35.9	0.094	0.00	5.00	no GW	0.00
3.00	52.6	0.090	0.00	5.00	no GW	0.00
0.00	38.9	0.084	0.00	5.00	no GW	0.00
0.00	33.2	0.079	0.00	5.00	no GW	0.00

EARTHQUAKE-INDUCED SETTLEMENT OF DRY SAND

Earthqauke-induced Settlement of Dry Sand (fines < 50%)
by Daniel Pradel

Total settlement of dry sand 0.06 inches

Multidirectional effect coeffiecient B 2
Equivalent number of cycles N_c 6.68

K_o	σ_m	G_{max}	r_d	τ_{av}	a	b	γ	ε_{15}	ε_{Nc}	Δz	$S_i = \varepsilon_{vi}\,\Delta z_i$	S_{cumul}
		psf		psf						feet	in	in
0.50	199	896459	0.999	49	0.128	25545	0.007%	0.004%	0.003%	5.00	0.00	0.00
0.50	597	1665014	0.994	145	0.136	13214	0.011%	0.005%	0.003%	5.00	0.00	0.01
0.50	996	2265326	0.985	239	0.143	9726	0.013%	0.005%	0.003%	5.00	0.00	0.01
0.50	1394	2777956	0.970	330	0.151	7948	0.014%	0.005%	0.003%	5.00	0.00	0.02
0.50	1792	2989884	0.952	416	0.159	6835	0.017%	0.007%	0.005%	5.00	0.01	0.02
0.50	2190	2821428	0.930	496	0.167	6060	0.022%	0.015%	0.011%	5.00	0.01	0.03
0.50	2589	3438075	0.905	571	0.174	5482	0.020%	0.009%	0.006%	5.00	0.01	0.04
0.50	2987	3606056	0.877	638	0.182	5031	0.022%	0.011%	0.007%	5.00	0.01	0.05
1.50	6771	6043816	0.847	699	0.256	3079	0.013%	0.004%	0.003%	5.00	0.00	0.05
2.50	11351	7218565	0.816	753	0.345	2258	0.011%	0.005%	0.003%	5.00	0.00	0.06
3.50	16727	8312766	0.784	799	0.449	1790	0.010%	0.006%	0.004%	5.00	0.00	0.06

Settlement Distribution

Layer settlement (compression) both liquefied and dry sand | Distribution of Earthquake-induced settlement (top of layer) — Surface settlement 0.06

S_{layer}	S_{cumul}
in	in
0.00	0.06
0.00	0.06
0.00	0.05
0.00	0.05
0.01	0.05
0.01	0.04
0.01	0.03
0.01	0.02
0.00	0.01
0.00	0.01
0.00	0.00

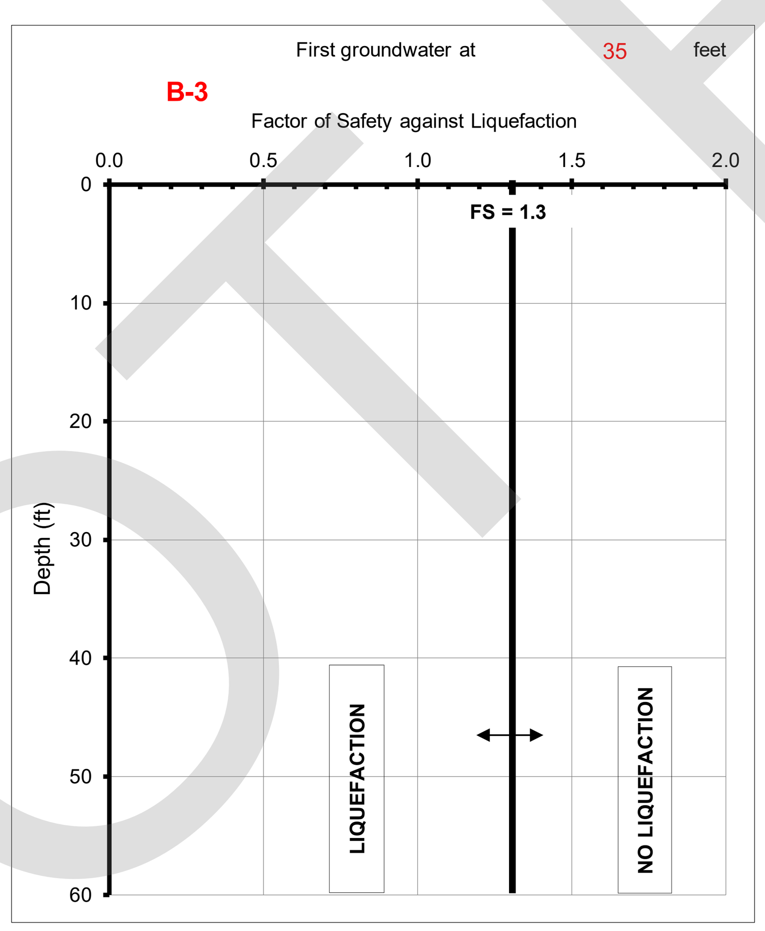
Summary of analysis

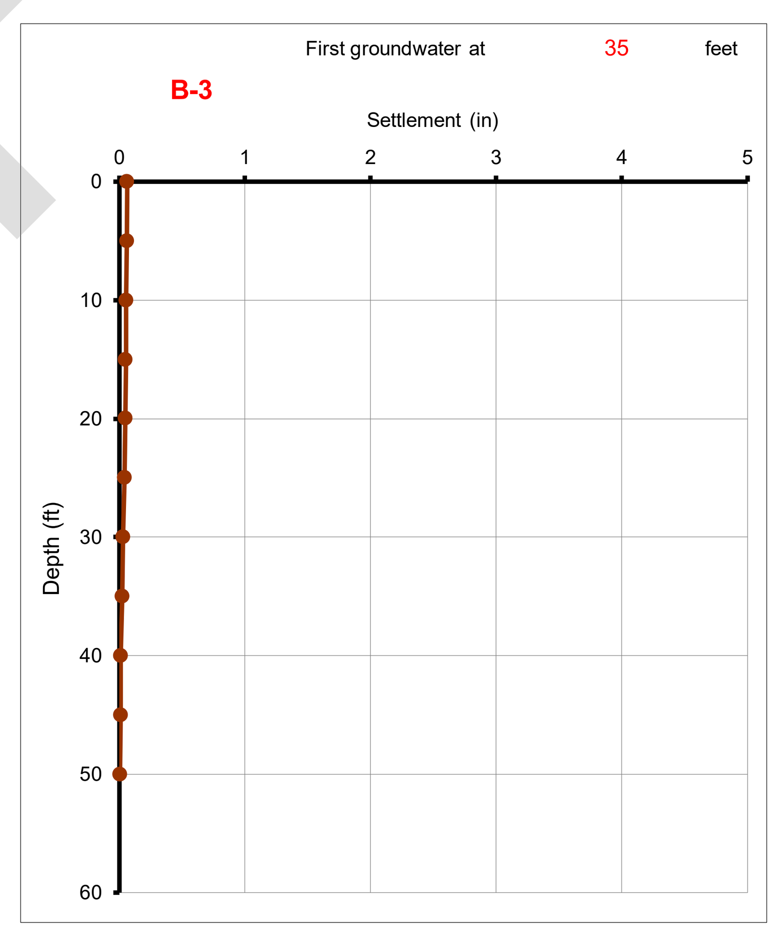
Boring B-3

Total liquefaction settlement	0.00 inches
Total dry sand settlement	0.06 inches
Total earthquake-induced settlement	0.06 inches
Number of evaluated intervals	11
Number of potentially liquefiable intervals	0
Average Factor of Safety	no liquefaction
Depth to first groundwater	0.00 feet
Total thickness of evaluated profile	55.00 feet
Profile thickness susceptible to liquefaction	0.00 feet

Earthquake loading: M 6.4, PGA 0.25

Depth to Layer Top	Depth to Layer Bottom	SPT - N	Fines %	$FS_{SPT,cs,K\sigma}$	Interpreted Factor of Safety against liquefaction		Settlement
feet	feet						in
0	5	13	3	no liq	Not liquefiable	- no groundwater	0.00
5	10	21	5	no liq	Not liquefiable	- no groundwater	0.00
10	15	28	5	no liq	Not liquefiable	- no groundwater	0.00
15	20	33	5	no liq	Not liquefiable	- no groundwater	0.00
20	25	32	5	no liq	Not liquefiable	- no groundwater	0.01
25	30	22	5	3.17	Not liquefiable	- no groundwater	0.01
30	35	32	3	no liq	Not liquefiable	- no groundwater	0.01
35	40	32	3	no liq	Not liquefiable	- no groundwater	0.01
40	45	47	5	no liq	Not liquefiable	- no groundwater	0.00
45	50	39	3	no liq	Not liquefiable	- no groundwater	0.00
50	55	35	3	no liq	Not liquefiable	- no groundwater	0.00





Appendix D

Spreadsheets with Calculations of Axial CIDH Pile Capacities

PROJECT SITE	DOLAT BRIDGE - CIDH Piles	
SOIL PROFILE (BORING) BEGINS AT ELEVATION	869.5	feet
PILE BEGINS AT GROUND ELEVATION	869.5	feet
SCOUR DEPTH CONSIDERED	6.5	feet
LIMIT STATE CONSIDERED	Strength	

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Boring:	B-3

Resistance Factor for Side Friction	0.7
Resistance Factor for End Bearing	0.5
Reduction Factor for Caving or poor construction	1.00
Reduction Factor for Group Effects	0.76

Overburden at Ground Surface for Limit State	0	psf
PILE SHAPE	circular	
Pile Side (Only for Square or Octagonal Piles)		feet
For other piles (perimeter)	6.283185	feet
For other piles (area)	3.141593	ft2
Information for Round Piles to be provided below:		
Pile Diameter (top)	2	feet
Pile Diameter (tip)	2	feet
Specified Length of Pile	53	feet
Estimated Initial Pile Tip Elevation	824.5	feet
Stick Up Length	8	feet
Taper Angle ω	0.000	deg
Pile Embedment Depth into bearing stratum	2	feet
Predrilling Reduction fraction for side resistance<1.0	1	

Octagon Calculator		
Given total width=	1.25	ft
Octagon Side=	0.517767	ft

Group Design Load	1066	kips
Pile Group Width	2	feet
Pile Group Length	39.26	feet

SPT Corrections convert California sampler blowcounts into SPT and use SPT blowcounts only				
Correction for borehole diameter	D_B (in)	4	C_B	1.00
Correction for sampling method		no liner	C_S	1
Correction for energy ratio			C_E	1.25
Correction for rod length	$r_{stickup}$ (ft)	3	see C_R	

Elevation at Top of Layer	Elevation at bottom of Layer	Depth to Layer Top	Depth to Layer Bottom	Groundwater present during drilling? yes / no	Groundwater present for Limit State Considered ? yes / no	Predrilling? Yes/no	Layer Thickness	Depth to middle of layer		SPT - N	Total Unit Wt during Drilling	Total Unit Wt for modeled Limit State	Soil Type	Su (for clays and silts)	Rod length	Cr	Corrected SPT - N	Corrected SPT - N (max 50)	Angle of friction	m	Cn	Corrected SPT - N (Overburden) MIDDLE LAYER	To compute Cn: Pore Pressure @ layer middle
feet	feet	feet	feet	yes/no	yes/no	yes/no	feet	feet	meters	blowcounts	pcf	pcf		psf	m	%	blowcount	blowcount	degrees			blowcount	psf
869.5	867.5	0	2	no	no	no	2	1	0.3	13	120	0.001	Sand		1.2	0.75	12	12	31	0.43	3.48	21	0
867.5	866.5	2	3	no	no	no	1	2.5	0.8	6	120	0.001	Sand		1.7	0.75	6	6	29	0.55	2.91	10	0
866.5	865.5	3	4	no	no	no	1	3.5	1.1	6	120	0.001	Sand		2.0	0.75	6	6	29	0.55	2.42	10	0
865.5	864.5	4	5	no	no	no	1	4.5	1.4	19	120	0.001	Sand		2.3	0.75	18	18	32	0.37	1.65	29	0
864.5	863.5	5	6	no	no	no	1	5.5	1.7	19	120	0.001	Sand		2.6	0.75	18	18	32	0.38	1.56	28	0
863.5	862.5	6	7	no	no	no	1	6.5	2.0	21	120	0.001	Sand		2.9	0.75	20	20	33	0.37	1.45	29	0
862.5	861.5	7	8	no	yes	no	1	7.5	2.3	21	120	120	Sand		3.2	0.75	20	20	33	0.38	1.39	27	0
861.5	860.5	8	9	no	yes	no	1	8.5	2.6	23	120	120	Sand		3.5	0.75	22	22	33	0.38	1.31	28	0
860.5	859.5	9	10	no	yes	no	1	9.5	2.9	23	120	120	Sand		3.8	0.75	22	22	33	0.38	1.27	27	0
859.5	858.5	10	11	no	yes	no	1	10.5	3.2	28	114	114	Sand		4.1	0.85	30	30	36	0.33	1.19	35	0
858.5	857.5	11	12	no	yes	no	1	11.5	3.5	28	114	114	Sand		4.4	0.85	30	30	36	0.33	1.16	34	0
857.5	856.5	12	13	no	yes	no	1	12.5	3.8	28	114	114	Sand		4.7	0.85	30	30	36	0.34	1.13	34	0
856.5	855.5	13	14	no	yes	no	1	13.5	4.1	47	114	114	Sand		5.0	0.85	50	50	41	0.24	1.07	50	0
855.5	854.5	14	15	no	yes	no	1	14.5	4.4	47	114	114	Sand		5.3	0.85	50	50	41	0.24	1.05	50	0
854.5	853.5	15	16	no	yes	no	1	15.5	4.7	38	120	120	Sand		5.6	0.85	40	40	38	0.29	1.04	42	0
853.5	852.5	16	17	no	yes	no	1	16.5	5.0	38	120	120	Sand		5.9	0.85	40	40	38	0.29	1.02	41	0
852.5	851.5	17	18	no	yes	no	1	17.5	5.3	33	120	120	Sand		6.2	0.95	39	39	38	0.30	1.01	39	0
851.5	850.5	18	19	no	yes	no	1	18.5	5.6	33	120	120	Sand		6.5	0.95	39	39	38	0.31	0.99	39	0
850.5	849.5	19	20	no	yes	no	1	19.5	5.9	33	120	120	Sand		6.8	0.95	39	39	38	0.31	0.97	38	0
849.5	848.5	20	21	no	yes	no	1	20.5	6.2	32	111	111	Sand		7.1	0.95	38	38	38	0.32	0.96	36	0
848.5	847.5	21	22	no	yes	no	1	21.5	6.5	32	111	111	Sand		7.4	0.95	38	38	38	0.32	0.94	36	0
847.5	846.5	22	23	no	yes	no	1	22.5	6.8	32	111	111	Sand		7.7	0.95	38	38	38	0.33	0.93	35	0
846.5	845.5	23	24	no	yes	no	1	23.5	7.1	32	111	111	Sand		8.0	0.95	38	38	38	0.33	0.92	35	0
845.5	844.5	24	25	no	yes	no	1	24.5	7.4	32	111	111	Sand		8.3	0.95	38	38	38	0.33	0.90	34	0
844.5	843.5	25	26	no	yes	no	1	25.5	7.7	22	111	111	Sand		8.6	0.95	26	26	35	0.42	0.87	23	0
843.5	842.5	26	27	no	yes	no	1	26.5	8.0	22	111	111	Sand		8.9	0.95	26	26	35	0.42	0.85	22	0
842.5	841.5	27	28	no	yes	no	1	27.5	8.3	22	111	111	Sand		9.2	0.95	26	26	35	0.42	0.84	22	0
841.5	840.5	28	29	no	yes	no	1	28.5	8.6	22	111	111	Sand		9.5	0.95	26	26	35	0.43	0.83	22	0
840.5	839.5	29	30	no	yes	no	1	29.5	8.9	22	111	111	Sand		9.8	0.95	26	26	35	0.43	0.81	21	0
839.5	838.5	30	31	no	yes	no	1	30.5	9.2	35	115	115	Sand		10.1	1	44	44	39	0.32	0.85	37	0
838.5	837.5	31	32	no	yes	no	1	31.5	9.5	35	115	115	Sand		10.4	1	44	44	39	0.32	0.84	37	0
837.5	836.5	32	33	no	yes	no	1	32.5	9.8	35	115	115	Sand		10.7	1	44	44	39	0.32	0.83	36	0
836.5	835.5	33	34	no	yes	no	1	33.5	10.1	35	115	115	Sand		11.0	1	44	44	39	0.32	0.82	36	0
835.5	834.5	34	35	no	yes	no	1	34.5	10.4	32	115	115	Sand		11.3	1	40	40	38	0.35	0.80	32	0
834.5	833.5	35	36	no	yes	no	1	35.5	10.7	32	115	115	Sand		11.6	1	40	40	38	0.35	0.79	32	0
833.5	832.5	36	37	no	yes	no	1	36.5	11.0	32	115	115	Sand		11.9	1	40	40	38	0.35	0.78	31	0
832.5	831.5	37	38	no	yes	no	1	37.5	11.3	32	115	115	Sand		12.2	1	40	40	38	0.36	0.77	31	0
831.5	830.5	38	39	no	yes	no	1	38.5	11.6	32	115	115	Sand		12.5	1	40	40	38	0.36	0.77	31	0
830.5	829.5	39	40	no	yes	no	1	39.5	11.9	32	115	115	Sand		12.8	1	40	40	38	0.36	0.76	30	0
829.5	828.5	40	41	no	yes	no	1	40.5	12.2	47	115	115	Sand		13.1	1	59	50	41	0.25	0.82	48	0
828.5	827.5	41	42	no	yes	no	1	41.5	12.5	47	115	115	Sand		13.4	1	59	50	41	0.25	0.81	48	0
827.5	826.5	42	43	no	yes	no	1	42.5	12.8	47	115	115	Sand		13.7	1	59	50	41	0.26	0.81	47	0
826.5	825.5	43	44	no	yes	no	1	43.5	13.1	47	115	115	Sand		14.0	1	59	50	41	0.26	0.80	47	0
825.5	824.5	44	45	no	yes	no	1	44.5	13.4	47	115	115	Sand		14.3	1	59	50	41	0.26	0.79	47	0
824.5	823.5	45	46	no	yes	no	1	45.5	13.7	39	115	115	Sand		14.6	1	49	49	40	0.32	0.75	36	0
823.5	822.5	46	47	no	yes	no	1	46.5	14.0	39	115	115	Sand		14.9	1	49	49	40	0.32	0.74	36	0
822.5	821.5	47	48	no	yes	no	1	47.5	14.3	39	115	115	Sand		15.2	1	49	49	40	0.32	0.73	36	0
821.5	820.5	48	49	no	yes	no	1	48.5	14.6	39	115	115	Sand		15.5	1	49	49	40	0.33	0.73	35	0
820.5	819.5	49	50	no	yes	no	1	49.5	14.9	39	115	115	Sand		15.8	1	49	49	40	0.33	0.72	35	0
819.5	818.5	50	51	no	yes	no	1	50.5	15.2	35	115	115	Sand		16.1	1	44	44	39	0.36	0.69	30	0
818.5	817.5	51	52	no	yes	no	1	51.5	15.5	35	115	115	Sand		16.4	1	44	44	39	0.36	0.69	30	0
817.5	816.5	52	53	no	yes	no	1	52.5	15.8	35	115	115	Sand		16.7	1	44	44	39	0.36	0.68	30	0
816.5	815.5	53	54	no	yes	no	1	53.5	16.1	35	115	115	Sand		17.0	1	44	44	39	0.37	0.67	30	0
815.5	814.5	54	55	no	yes	no	1	54.5	16.4	35	115	115	Sand		17.3	1	44	44	39	0.37	0.67	29	0
814.5	813.5	55	56	no	yes	no	1	55.5	16.7	37	115	115	Sand		17.6	1	46	46	40	0.36	0.67	31	0
813.5	812.5	56	57	no	yes	no	1	56.5	17.0	37	115	115	Sand		17.9	1	46	46	40	0.36	0.67	31	0
812.5	811.5	57	58	no	yes	no	1	57.5	17.3	37	115	115	Sand		18.2	1	46	46	40	0.36	0.66	31	0
811.5	810.5	58	59	no	yes	no	1	58.5	17.6	37	115	115	Sand		18.5	1	46	46	40	0.36	0.66	30	0
810.5	809.5	59	60	no	yes	no	1	59.5	17.9	37	115	115	Sand		18.8	1	46	46	40	0.36	0.65	30	0
809.5	808.5	60	61	no	yes	no	1	60.5	18.2	37	115	115	Sand		19.1	1	46	46	40	0.36	0.65	30	0
808.5	807.5	61	62	no	yes	no	1	61.5	18.5	37	115	115	Sand		19.4	1	46	46	40	0.37	0.64	30	0
807.5	806.5	62	63	no	yes	no	1	62.5	18.8	37	115	115	Sand		19.7	1	46	46	40	0.37	0.64	29	0
806.5	805.5	63	64	no	yes	no	1	63.5	19.1	37	115	115	Sand		20.0	1	46	46	40	0.37	0.63	29	0
805.5	804.5	64	65	no	yes	no	1	64.5	19.4	37	115	115	Sand		20.3	1	46	46	40	0.37	0.63	29	0
804.5	803.5	65	66	no	yes	no	1	65.5	19.7	37	115	115	Sand		20.6	1	46	46	40	0.37	0.62	29	0
803.5	802.5	66	67	no	yes	no	1	66.5	20.0	37	115	115	Sand		20.9	1	46	46	40	0.37	0.62	29	0
802.5	801.5	67	68	no	yes	no	1	67.5	20.3	37	115	115	Sand		21.2	1	46	46	40	0.37	0.61	28	0
801.5	800.5	68	69	no	yes	no	1	68.5	20.6	37	115	115	Sand		21.5	1	46	46	40	0.38	0.61	28	0
800.5	799.5	69	70	no	yes	no	1	69.5	20.9	37	115	115	Sand		21.8	1	46	46	40	0.38	0.60	28	0

Elevation at Top of Layer	To compute Cn: Pore Pressure @ layer bottom	Effective Stress @ layer middle	Effective Stress @ layer bottom	Angle of friction (with correction for Cn) φ	To compute Stresses for Limit State: Pore Pressure @ layer middle	Pore Pressure @ layer bottom	Effective Stress @ layer middle	Effective Stress @ layer bottom	Pile Diameter at top of layer For Circular Piles	Pile Diameter at bottom of layer For Circular Piles	FHWA-HI-10-016(Beta and Alpha Methods): Beta	alpha	Fsn	Rsn	Factored Rsn for predrill	Cumulative Rsn	Nc	Base Resistance qbn	Base Resistance Qbn	Factored Cumulative Rsn	Factored Qbn	Total Q	Settlement
feet	psf	psf	psf	degrees	psf	psf	psf	psf	feet	feet			psf	kips	kips	kips		ksf	kips	Kips	Kips	Kips	(inches)
869.5	0	120	240	33	0	0	0.001	0.002	2.000	2.000	2.218	N/A	0	0	0	0	N/A	7	21	0	11	N/A	N/A
867.5	0	300	360	30	0	0	0.0025	0.003	2.000	2.000	1.721	N/A	0	0	0	0	N/A	7	21	0	11	N/A	N/A
866.5	0	420	480	30	0	0	0.0035	0.004	2.000	2.000	1.721	N/A	0	0	0	0	N/A	21	67	0	34	N/A	N/A
865.5	0	540	600	35	0	0	0.0045	0.005	2.000	2.000	2.680	N/A	0	0	0	0	N/A	21	67	0	34	N/A	N/A
864.5	0	660	720	35	0	0	0.0055	0.006	2.000	2.000	2.584	N/A	0	0	0	0	N/A	24	74	0	37	N/A	N/A
863.5	0	780	840	35	0	0	0.0065	0.007	2.000	2.000	2.632	N/A	0	0	0	0	N/A	24	74	0	37	N/A	N/A
862.5	0	900	960	35	31.2	62.4	28.807	57.607	2.000	2.000	2.561	N/A	36	0	0	0	N/A	26	81	0	41	31	1.354428
861.5	0	1020	1080	35	93.6	124.8	86.407	115.207	2.000	2.000	2.619	N/A	112	1	1	1	N/A	26	81	1	41	31	1.405583
860.5	0	1140	1200	35	156	187.2	144.007	172.807	2.000	2.000	2.562	N/A	181	1	1	2	N/A	36	112	1	56	44	1.088171
859.5	0	1257	1314	37	218.4	249.6	198.607	224.407	2.000	2.000	2.695	N/A	282	2	2	4	N/A	36	112	3	56	45	1.116731
858.5	0	1371	1428	37	280.8	312	250.207	276.007	2.000	2.000	2.318	N/A	303	2	2	6	N/A	36	112	4	56	46	1.144651
857.5	0	1485	1542	37	343.2	374.4	301.807	327.607	2.000	2.000	2.051	N/A	321	2	2	8	N/A	60	188	5	94	76	0.767984
856.5	0	1599	1656	40	405.6	436.8	353.407	379.207	2.000	2.000	2.634	N/A	537	3	3	11	N/A	60	188	8	94	77	0.767984
855.5	0	1713	1770	40	468	499.2	405.007	430.807	2.000	2.000	2.413	N/A	564	4	4	15	N/A	48	152	10	76	66	0.912404
854.5	0	1830	1890	39	530.4	561.6	459.607	488.407	2.000	2.000	1.953	N/A	499	3	3	18	N/A	48	152	12	76	67	0.928781
853.5	0	1950	2010	39	592.8	624	517.207	546.007	2.000	2.000	1.801	N/A	515	3	3	21	N/A	47	148	15	74	67	0.973409
852.5	0	2070	2130	38	655.2	686.4	574.807	603.607	2.000	2.000	1.637	N/A	513	3	3	24	N/A	47	148	17	74	69	0.990236
851.5	0	2190	2250	38	717.6	748.8	632.407	661.207	2.000	2.000	1.534	N/A	525	3	3	28	N/A	47	148	19	74	71	1.00687
850.5	0	2310	2370	38	780	811.2	690.007	718.807	2.000	2.000	1.445	N/A	537	3	3	31	N/A	46	143	22	72	71	1.055744
849.5	0	2425.5	2481	37	842.4	873.6	743.107	767.407	2.000	2.000	1.344	N/A	530	3	3	34	N/A	46	143	24	72	73	1.071681
848.5	0	2536.5	2592	37	904.8	936	791.707	816.007	2.000	2.000	1.287	N/A	539	3	3	38	N/A	46	143	26	72	74	1.087487
847.5	0	2647.5	2703	37	967.2	998.4	840.307	864.607	2.000	2.000	1.236	N/A	547	3	3	41	N/A	46	143	29	72	76	1.103172
846.5	0	2758.5	2814	37	1029.6	1060.8	888.907	913.207	2.000	2.000	1.189	N/A	554	3	3	45	N/A	46	143	31	72	78	1.118745
845.5	0	2869.5	2925	37	1092	1123.2	937.507	961.807	2.000	2.000	1.147	N/A	562	4	4	48	N/A	31	98	34	49	63	1.696463
844.5	0	2980.5	3036	34	1154.4	1185.6	986.107	1010.407	2.000	2.000	0.881	N/A	409	3	3	51	N/A	31	98	35	49	64	1.724585
843.5	0	3091.5	3147	34	1216.8	1248	1034.707	1059.007	2.000	2.000	0.855	N/A	415	3	3	53	N/A	31	98	37	49	66	1.752531
842.5	0	3202.5	3258	33	1279.2	1310.4	1083.307	1107.607	2.000	2.000	0.831	N/A	421	3	3	56	N/A	31	98	39	49	67	1.780312
841.5	0	3313.5	3369	33	1341.6	1372.8	1131.907	1156.207	2.000	2.000	0.809	N/A	427	3	3	59	N/A	31	98	41	49	69	1.807936
840.5	0	3424.5	3480	33	1404	1435.2	1180.507	1204.807	2.000	2.000	0.788	N/A	432	3	3	61	N/A	53	165	43	82	95	1.032228
839.5	0	3537.5	3595	38	1466.4	1497.6	1231.107	1257.407	2.000	2.000	1.048	N/A	690	4	4	66	N/A	53	165	46	82	98	1.044241
838.5	0	3652.5	3710	37	1528.8	1560	1283.707	1310.007	2.000	2.000	1.019	N/A	697	4	4	70	N/A	53	165	49	82	100	1.056206
837.5	0	3767.5	3825	37	1591.2	1622.4	1336.307	1362.607	2.000	2.000	0.991	N/A	703	4	4	74	N/A	53	165	52	82	102	1.068126
836.5	0	3882.5	3940	37	1653.6	1684.8	1388.907	1415.207	2.000	2.000	0.965	N/A	710	4	4	79	N/A	48	151	55	75	99	1.198892
835.5	0	3997.5	4055	36	1716	1747.2	1441.507	1467.807	2.000	2.000	0.888	N/A	656	4	4	83	N/A	48	151	58	75	101	1.21285
834.5	0	4112.5	4170	36	1778.4	1809.6	1494.107	1520.407	2.000	2.000	0.867	N/A	661	4	4	87	N/A	48	151	61	75	104	1.226761
833.5	0	4227.5	4285	36	1840.8	1872	1546.707	1573.007	2.000	2.000	0.848	N/A	667	4	4	91	N/A	48	151	64	75	106	1.240629
832.5	0	4342.5	4400	36	1903.2	1934.4	1599.307	1625.607	2.000	2.000	0.829	N/A	673	4	4	96	N/A	48	151	67	75	108	1.254456
831.5	0	4457.5	4515	36	1965.6	1996.8	1651.907	1678.207	2.000	2.000	0.811	N/A	678	4	4	100	N/A	48	151	70	75	110	1.268244
830.5	0	4572.5	4630	36	2028	2059.2	1704.507	1730.807	2.000	2.000	0.795	N/A	683	4	4	104	N/A	60	188	73	94	127	0.798234
829.5	0	4687.5	4745	40	2090.4	2121.6	1757.107	1783.407	2.000	2.000	0.940	N/A	954	6	6	110	N/A	60	188	77	94	130	0.804476
828.5	0	4802.5	4860	40	2152.8	2184	1809.707	1836.007	2.000	2.000	0.922	N/A	964	6	6	116	N/A	60	188	81	94	133	0.81071
827.5	0	4917.5	4975	40	2215.2	2246.4	1862.307	1888.607	2.000	2.000	0.905	N/A	974	6	6	122	N/A	60	188	86	94	137	0.81694
826.5	0	5032.5	5090	40	2277.6	2308.8	1914.907	1941.207	2.000	2.000	0.889	N/A	983	6	6	129	N/A	60	188	90	94	140	0.823164
825.5	0	5147.5	5205	40	2340	2371.2	1967.507	1993.807	2.000	2.000	0.873	N/A	989	6	6	135	N/A	59	184	94	92	142	1.05492
824.5	0	5262.5	5320	37	2402.4	2433.6	2020.107	2046.407	2.000	2.000	0.803	N/A	862	5	5	140	N/A	59	184	98	92	144	1.064284
823.5	0	5377.5	5435	37	2464.8	2496	2072.707	2099.007	2.000	2.000	0.789	N/A	866	5	5	146	N/A	59	184	102	92	147	1.073636
822.5	0	5492.5	5550	37	2527.2	2558.4	2125.307	2151.607	2.000	2.000	0.776	N/A	871	5	5	151	N/A	59	184	106	92	150	1.082977
821.5	0	5607.5	5665	37	2589.6	2620.8	2177.907	2204.207	2.000	2.000	0.763	N/A	876	6	6	157	N/A	59	184	110	92	153	1.092308
820.5	0	5722.5	5780	37	2652	2683.2	2230.507	2256.807	2.000	2.000	0.751	N/A	880	6	6	162	N/A	53	165	113	82	149	1.266081
819.5	0	5837.5	5895	36	2714.4	2745.6	2283.107	2309.407	2.000	2.000	0.692	N/A	797	5	5	167	N/A	53	165	117	82	152	1.27754
818.5	0	5952.5	6010	36	2776.8	2808	2335.707	2362.007	2.000	2.000	0.682	N/A	801	5	5	172	N/A	53	165	121	82	154	1.288985
817.5	0	6067.5	6125	36	2839.2	2870.4	2388.307	2414.607	2.000	2.000	0.672	N/A	806	5	5	177	N/A	53	165	124	82	157	1.300417
816.5	0	6182.5	6240	35	2901.6	2932.8	2440.907	2467.207	2.000	2.000	0.662	N/A	810	5	5	182	N/A	53	165	128	82	160	1.311836
815.5	0	6297.5	6355	35	2964	2995.2	2493.507	2519.807	2.000	2.000	0.653	N/A	814	5	5	187	N/A	56	174	131	87	166	1.2307
814.5	0	6412.5	6470	36	3026.4	3057.6	2546.107	2572.407	2.000	2.000	0.665	N/A	861	5	5	193	N/A	56	174	135	87	169	1.240976
813.5	0	6527.5	6585	36	3088.8	3120	2598.707	2625.007	2.000	2.000	0.656	N/A	865	5	5	198	N/A	56	174	139	87	172	1.251245
812.5	0	6642.5	6700	36	3151.2	3182.4	2651.307	2677.607	2.000	2.000	0.648	N/A	869	5	5	204	N/A	56	174	143	87	175	1.261506
811.5	0	6757.5	6815	36	3213.6	3244.8	2703.907	2730.207	2.000	2.000	0.640	N/A	873	5	5	209	N/A	56	174	146	87	178	1.271761
810.5	0	6872.5	6930	36	3276	3307.2	2756.507	2782.807	2.000	2.000	0.631	N/A	877	6	6	215	N/A	56	174	150	87	180	1.28201
809.5	0	6987.5	7045	36	3338.4	3369.6	2809.107	2835.407	2.000	2.000	0.624	N/A	881	6	6	220	N/A	56	174	154	87	183	1.292253
808.5	0	7102.5	7160	36	3400.8	3432	2861.707	2888.007	2.000	2.000	0.616	N/A	885	6	6	226	N/A	56	174	158	87	186	1.30249
807.5	0	7217.5	7275	35	3463.2	3494.4	2914.307	2940.607	2.000	2.000	0.609	N/A	889	6	6	231	N/A	56	174	162	87	189	1.312722
806.5	0	7332.5	7390	35	3525.6	3556.8	2966.907	2993.207	2.000	2.000	0.602	N/A	893	6	6	237	N/A	56	174	166	87	192	1.32295
805.5	0	7447.5	7505	35	3588	3619.2	3019.507	3045.807	2.000	2.000	0.595	N/A	896	6	6	243	N/A	56	174	170	87	195	1.333173
804.5	0	7562.5	7620	35	3650.4	3681.6	3072.107	3098.407	2.000	2.000	0.588	N/A	900	6	6	248	N/A	56	174	174	87	198	1.343392
803.5	0	7677.5	7735	35	3712.8	3744	3124.707	3151.007	2.000	2.000	0.582	N/A	904	6	6	254	N/A	56	174	178	87	201	1.353607
802.5	0	7792.5	7850	35	3775.2	3806.4	3177.307	3203.607	2.000	2.000	0.576	N/A	907	6	6	260	N/A	56	174	182	87	204	1.363818
801.5	0	7907.5	7965	35	3837.6	3868.8	3229.907	3256.207	2.000	2.000	0.570	N/A	911	6	6	265	N/A	56	174	186	87	207	1.374026
800.5	0	8022.5	8080	35	3900	3931.2	3282.507	3308.807	2.000	2.000	0.564	N/A	915	6	6	271	N/A	#DIV/0!	#DIV/0!	190	#DIV/0!	#DIV/0!	#DIV/0!

PROJECT SITE	DOLAT BRIDGE - CIDH Piles	
SOIL PROFILE (BORING) BEGINS AT ELEVATION	869.5	feet
PILE BEGINS AT GROUND ELEVATION	869.5	feet
SCOUR DEPTH CONSIDERED	11	feet
LIMIT STATE CONSIDERED	Service	

Overburden at Ground Surface for Limit State	0	psf
PILE SHAPE	circular	
Pile Side (Only for Square or Octagonal Piles)		feet
For other piles (perimeter)	6.283185	feet
For other piles (area)	3.141593	ft2
Information for Round Piles to be provided below:		
Pile Diameter (top)	2	feet
Pile Diameter (tip)	2	feet
Specified Length of Pile	53	feet
Estimated Initial Pile Tip Elevation	824.5	feet
Stick Up Length	8	feet
Taper Angle ω	0.000	deg
Pile Embedment Depth into bearing stratum	2	feet
Predrilling Reduction fraction for side resistance<1.0	1	

Octagon Calculator		
Given total width=	1.25	ft
Octagon Side=	0.517767	ft

Group Design Load	701	kips
Pile Group Width	2	feet
Pile Group Length	39.26	feet

Boring:	B-3

Resistance Factor for Side Friction	1
Resistance Factor for End Bearing	1
Reduction Factor for Caving or poor construction	1.00
Reduction Factor for Group Effects	0.76

SPT Corrections convert California sampler blowcounts into SPT and use SPT blowcounts only				
Correction for borehole diameter	D_B (in)	4	C_B	1.00
Correction for sampling method		no liner	C_S	1
Correction for energy ratio			C_E	1.25
Correction for rod length	$r_{stickup}$ (ft)	3	see C_R	

Elevation at Top of Layer	Elevation at bottom of Layer	Depth to Layer Top	Depth to Layer Bottom	Groundwater present during drilling? yes / no	Groundwater present for Limit State Considered ? yes / no	Predrilling? Yes/no	Layer Thickness	Depth to middle of layer		SPT - N	Total Unit Wt during Drilling	Total Unit Wt for modeled Limit State	Soil Type	Su (for clays and silts)	Rod length	Cr	Corrected SPT - N	Corrrected SPT - N (max 50)	Angle of friction	m	Cn	Corrrected SPT - N (Overburden) MIDDLE LAYER
feet	feet	feet	feet	yes/no	yes/no	yes/no	feet	feet	meters	blowcounts	pcf	pcf		psf	m	%	blowcount	blowcount	degrees			blowcount
869.5	867.5	0	2	no	no	no	2	1	0.3	13	120	0.001	Sand		1.2	0.75	12	12	31	0.43	3.48	21
867.5	866.5	2	3	no	no	no	1	2.5	0.8	6	120	0.001	Sand		1.7	0.75	6	6	29	0.55	2.91	10
866.5	865.5	3	4	no	no	no	1	3.5	1.1	6	120	0.001	Sand		2.0	0.75	6	6	29	0.55	2.42	10
865.5	864.5	4	5	no	no	no	1	4.5	1.4	19	120	0.001	Sand		2.3	0.75	18	18	32	0.37	1.65	29
864.5	863.5	5	6	no	no	no	1	5.5	1.7	19	120	0.001	Sand		2.6	0.75	18	18	32	0.38	1.56	28
863.5	862.5	6	7	no	no	no	1	6.5	2.0	21	120	0.001	Sand		2.9	0.75	20	20	33	0.37	1.45	29
862.5	861.5	7	8	no	no	no	1	7.5	2.3	21	120	0.001	Sand		3.2	0.75	20	20	33	0.38	1.39	27
861.5	860.5	8	9	no	no	no	1	8.5	2.6	23	120	0.001	Sand		3.5	0.75	22	22	33	0.38	1.31	28
860.5	859.5	9	10	no	no	no	1	9.5	2.9	23	120	0.001	Sand		3.8	0.75	22	22	33	0.38	1.27	27
859.5	858.5	10	11	no	yes	no	1	10.5	3.2	28	114	114	Sand		4.1	0.85	30	30	36	0.33	1.19	35
858.5	857.5	11	12	no	yes	no	1	11.5	3.5	28	114	114	Sand		4.4	0.85	30	30	36	0.33	1.16	34
857.5	856.5	12	13	no	yes	no	1	12.5	3.8	28	114	114	Sand		4.7	0.85	30	30	36	0.34	1.13	34
856.5	855.5	13	14	no	yes	no	1	13.5	4.1	47	114	114	Sand		5.0	0.85	50	50	41	0.24	1.07	50
855.5	854.5	14	15	no	yes	no	1	14.5	4.4	47	114	114	Sand		5.3	0.85	50	50	41	0.24	1.05	50
854.5	853.5	15	16	no	yes	no	1	15.5	4.7	38	120	120	Sand		5.6	0.85	40	40	38	0.29	1.04	42
853.5	852.5	16	17	no	yes	no	1	16.5	5.0	38	120	120	Sand		5.9	0.85	40	40	38	0.29	1.02	41
852.5	851.5	17	18	no	yes	no	1	17.5	5.3	33	120	120	Sand		6.2	0.95	39	39	38	0.30	1.01	39
851.5	850.5	18	19	no	yes	no	1	18.5	5.6	33	120	120	Sand		6.5	0.95	39	39	38	0.31	0.99	39
850.5	849.5	19	20	no	yes	no	1	19.5	5.9	33	120	120	Sand		6.8	0.95	39	39	38	0.31	0.97	38
849.5	848.5	20	21	no	yes	no	1	20.5	6.2	32	111	111	Sand		7.1	0.95	38	38	38	0.32	0.96	36
848.5	847.5	21	22	no	yes	no	1	21.5	6.5	32	111	111	Sand		7.4	0.95	38	38	38	0.32	0.94	36
847.5	846.5	22	23	no	yes	no	1	22.5	6.8	32	111	111	Sand		7.7	0.95	38	38	38	0.33	0.93	35
846.5	845.5	23	24	no	yes	no	1	23.5	7.1	32	111	111	Sand		8.0	0.95	38	38	38	0.33	0.92	35
845.5	844.5	24	25	no	yes	no	1	24.5	7.4	32	111	111	Sand		8.3	0.95	38	38	38	0.33	0.90	34
844.5	843.5	25	26	no	yes	no	1	25.5	7.7	22	111	111	Sand		8.6	0.95	26	26	35	0.42	0.87	23
843.5	842.5	26	27	no	yes	no	1	26.5	8.0	22	111	111	Sand		8.9	0.95	26	26	35	0.42	0.85	22
842.5	841.5	27	28	no	yes	no	1	27.5	8.3	22	111	111	Sand		9.2	0.95	26	26	35	0.42	0.84	22
841.5	840.5	28	29	no	yes	no	1	28.5	8.6	22	111	111	Sand		9.5	0.95	26	26	35	0.43	0.83	22
840.5	839.5	29	30	no	yes	no	1	29.5	8.9	22	111	111	Sand		9.8	0.95	26	26	35	0.43	0.81	21
839.5	838.5	30	31	no	yes	no	1	30.5	9.2	35	115	115	Sand		10.1	1	44	44	39	0.32	0.85	37
838.5	837.5	31	32	no	yes	no	1	31.5	9.5	35	115	115	Sand		10.4	1	44	44	39	0.32	0.84	37
837.5	836.5	32	33	no	yes	no	1	32.5	9.8	35	115	115	Sand		10.7	1	44	44	39	0.32	0.83	36
836.5	835.5	33	34	no	yes	no	1	33.5	10.1	35	115	115	Sand		11.0	1	44	44	39	0.32	0.82	36
835.5	834.5	34	35	no	yes	no	1	34.5	10.4	32	115	115	Sand		11.3	1	40	40	38	0.35	0.80	32
834.5	833.5	35	36	no	yes	no	1	35.5	10.7	32	115	115	Sand		11.6	1	40	40	38	0.35	0.79	32
833.5	832.5	36	37	no	yes	no	1	36.5	11.0	32	115	115	Sand		11.9	1	40	40	38	0.35	0.78	31
832.5	831.5	37	38	no	yes	no	1	37.5	11.3	32	115	115	Sand		12.2	1	40	40	38	0.36	0.77	31
831.5	830.5	38	39	no	yes	no	1	38.5	11.6	32	115	115	Sand		12.5	1	40	40	38	0.36	0.77	31
830.5	829.5	39	40	no	yes	no	1	39.5	11.9	32	115	115	Sand		12.8	1	40	40	38	0.36	0.76	30
829.5	828.5	40	41	no	yes	no	1	40.5	12.2	47	115	115	Sand		13.1	1	59	50	41	0.25	0.82	48
828.5	827.5	41	42	no	yes	no	1	41.5	12.5	47	115	115	Sand		13.4	1	59	50	41	0.25	0.81	48
827.5	826.5	42	43	no	yes	no	1	42.5	12.8	47	115	115	Sand		13.7	1	59	50	41	0.26	0.81	47
826.5	825.5	43	44	no	yes	no	1	43.5	13.1	47	115	115	Sand		14.0	1	59	50	41	0.26	0.80	47
825.5	824.5	44	45	no	yes	no	1	44.5	13.4	47	115	115	Sand		14.3	1	59	50	41	0.26	0.79	47
824.5	823.5	45	46	no	yes	no	1	45.5	13.7	39	115	115	Sand		14.6	1	49	49	40	0.32	0.75	36
823.5	822.5	46	47	no	yes	no	1	46.5	14.0	39	115	115	Sand		14.9	1	49	49	40	0.32	0.74	36
822.5	821.5	47	48	no	yes	no	1	47.5	14.3	39	115	115	Sand		15.2	1	49	49	40	0.32	0.73	36
821.5	820.5	48	49	no	yes	no	1	48.5	14.6	39	115	115	Sand		15.5	1	49	49	40	0.33	0.73	35
820.5	819.5	49	50	no	yes	no	1	49.5	14.9	39	115	115	Sand		15.8	1	49	49	40	0.33	0.72	35
819.5	818.5	50	51	no	yes	no	1	50.5	15.2	35	115	115	Sand		16.1	1	44	44	39	0.36	0.69	30
818.5	817.5	51	52	no	yes	no	1	51.5	15.5	35	115	115	Sand		16.4	1	44	44	39	0.36	0.69	30
817.5	816.5	52	53	no	yes	no	1	52.5	15.8	35	115	115	Sand		16.7	1	44	44	39	0.36	0.68	30
816.5	815.5	53	54	no	yes	no	1	53.5	16.1	35	115	115	Sand		17.0	1	44	44	39	0.37	0.67	30
815.5	814.5	54	55	no	yes	no	1	54.5	16.4	35	115	115	Sand		17.3	1	44	44	39	0.37	0.67	29
814.5	813.5	55	56	no	yes	no	1	55.5	16.7	37	115	115	Sand		17.6	1	46	46	40	0.36	0.67	31
813.5	812.5	56	57	no	yes	no	1	56.5	17.0	37	115	115	Sand		17.9	1	46	46	40	0.36	0.67	31
812.5	811.5	57	58	no	yes	no	1	57.5	17.3	37	115	115	Sand		18.2	1	46	46	40	0.36	0.66	31
811.5	810.5	58	59	no	yes	no	1	58.5	17.6	37	115	115	Sand		18.5	1	46	46	40	0.36	0.66	30

FHWA-HI-10-016(Beta and Alpha Methods)

Elevation at Top of Layer	To compute Cn: Pore Pressure @ layer middle	Pore Pressure @ layer bottom	Effective Stress @ layer middle	Effective Stress @ layer bottom	Angle of friction (with correction for Cn) φ	To compute Stresses for Limit State: Pore Pressure @ layer middle	Pore Pressure @ layer bottom	Effective Stress @ layer middle	Effective Stress @ layer bottom	Pile Diameter at top of layer For Circular Piles	Pile Diameter at bottom of layer For Circular Piles	Beta	alpha	Fsn	Rsn	Factored Rsn for predrill	Cumulative Rsn	Nc	Base Resistance qbn	Base Resistance Qbn	Factored Cumulative Rsn	Factored Qbn	Total Q	Settlement
feet	psf	psf	psf	psf	degrees	psf	psf	psf	psf	feet	feet			psf	kips	kips	kips		ksf	kips	Kips	Kips	Kips	(inches)
869.5	0	0	120	240	33	0	0	0.001	0.002	2.000	2.000	2.218	N/A	0	0	0	0	N/A	7	21	0	21	N/A	N/A
867.5	0	0	300	360	30	0	0	0.0025	0.003	2.000	2.000	1.721	N/A	0	0	0	0	N/A	7	21	0	21	N/A	N/A
866.5	0	0	420	480	30	0	0	0.0035	0.004	2.000	2.000	1.721	N/A	0	0	0	0	N/A	21	67	0	67	N/A	N/A
865.5	0	0	540	600	35	0	0	0.0045	0.005	2.000	2.000	2.680	N/A	0	0	0	0	N/A	21	67	0	67	N/A	N/A
864.5	0	0	660	720	35	0	0	0.0055	0.006	2.000	2.000	2.584	N/A	0	0	0	0	N/A	24	74	0	74	N/A	N/A
863.5	0	0	780	840	35	0	0	0.0065	0.007	2.000	2.000	2.632	N/A	0	0	0	0	N/A	24	74	0	74	N/A	N/A
862.5	0	0	900	960	35	0	0	0.0075	0.008	2.000	2.000	2.561	N/A	0	0	0	0	N/A	26	81	0	81	N/A	N/A
861.5	0	0	1020	1080	35	0	0	0.0085	0.009	2.000	2.000	2.619	N/A	0	0	0	0	N/A	26	81	0	81	N/A	N/A
860.5	0	0	1140	1200	35	0	0	0.0095	0.01	2.000	2.000	2.562	N/A	0	0	0	0	N/A	36	112	0	112	N/A	N/A
859.5	0	0	1257	1314	37	31.2	62.4	25.81	51.61	2.000	2.000	3.035	N/A	41	0	0	0	N/A	36	112	0	112	N/A	N/A
858.5	0	0	1371	1428	37	93.6	124.8	77.41	103.21	2.000	2.000	2.978	N/A	120	1	1	1	N/A	36	112	1	112	86	0.752721
857.5	0	0	1485	1542	37	156	187.2	129.01	154.81	2.000	2.000	2.926	N/A	196	1	1	2	N/A	60	188	2	188	145	0.505025
856.5	0	0	1599	1656	40	218.4	249.6	180.61	206.41	2.000	2.000	3.859	N/A	402	3	3	5	N/A	60	188	5	188	147	0.505025
855.5	0	0	1713	1770	40	280.8	312	232.21	258.01	2.000	2.000	3.450	N/A	463	3	3	8	N/A	48	152	8	152	122	0.599996
854.5	0	0	1830	1890	39	343.2	374.4	286.81	315.61	2.000	2.000	2.624	N/A	419	3	3	10	N/A	48	152	10	152	124	0.610765
853.5	0	0	1950	2010	39	405.6	436.8	344.41	373.21	2.000	2.000	2.321	N/A	442	3	3	13	N/A	47	148	13	148	122	0.640112
852.5	0	0	2070	2130	38	468	499.2	402.01	430.81	2.000	2.000	2.042	N/A	447	3	3	16	N/A	47	148	16	148	124	0.651178
851.5	0	0	2190	2250	38	530.4	561.6	459.61	488.41	2.000	2.000	1.866	N/A	465	3	3	19	N/A	47	148	19	148	127	0.662116
850.5	0	0	2310	2370	38	592.8	624	517.21	546.01	2.000	2.000	1.724	N/A	481	3	3	22	N/A	46	143	22	143	125	0.694256
849.5	0	0	2425.5	2481	37	655.2	686.4	570.31	594.61	2.000	2.000	1.578	N/A	478	3	3	25	N/A	46	143	25	143	128	0.704736
848.5	0	0	2536.5	2592	37	717.6	748.8	618.91	643.21	2.000	2.000	1.493	N/A	489	3	3	28	N/A	46	143	28	143	130	0.71513
847.5	0	0	2647.5	2703	37	780	811.2	667.51	691.81	2.000	2.000	1.420	N/A	499	3	3	31	N/A	46	143	31	143	132	0.725444
846.5	0	0	2758.5	2814	37	842.4	873.6	716.11	740.41	2.000	2.000	1.354	N/A	508	3	3	34	N/A	46	143	34	143	135	0.735685
845.5	0	0	2869.5	2925	37	904.8	936	764.71	789.01	2.000	2.000	1.296	N/A	517	3	3	37	N/A	31	98	37	98	103	1.115592
844.5	0	0	2980.5	3036	34	967.2	998.4	813.31	837.61	2.000	2.000	0.980	N/A	375	2	2	40	N/A	31	98	40	98	105	1.134085
843.5	0	0	3091.5	3147	34	1029.6	1060.8	861.91	886.21	2.000	2.000	0.946	N/A	383	2	2	42	N/A	31	98	42	98	107	1.152462
842.5	0	0	3202.5	3258	33	1092	1123.2	910.51	934.81	2.000	2.000	0.915	N/A	389	2	2	45	N/A	31	98	45	98	109	1.17073
841.5	0	0	3313.5	3369	33	1154.4	1185.6	959.11	983.41	2.000	2.000	0.886	N/A	396	2	2	47	N/A	31	98	47	98	111	1.188896
840.5	0	0	3424.5	3480	33	1216.8	1248	1007.71	1032.01	2.000	2.000	0.859	N/A	402	3	3	50	N/A	53	165	50	165	163	0.678791
839.5	0	0	3537.5	3595	38	1279.2	1310.4	1058.31	1084.61	2.000	2.000	1.150	N/A	651	4	4	54	N/A	53	165	54	165	166	0.686691
838.5	0	0	3652.5	3710	37	1341.6	1372.8	1110.91	1137.21	2.000	2.000	1.112	N/A	658	4	4	58	N/A	53	165	58	165	169	0.694559
837.5	0	0	3767.5	3825	37	1404	1435.2	1163.51	1189.81	2.000	2.000	1.078	N/A	666	4	4	62	N/A	53	165	62	165	173	0.702398
836.5	0	0	3882.5	3940	37	1466.4	1497.6	1216.11	1242.41	2.000	2.000	1.046	N/A	673	4	4	66	N/A	48	151	66	151	165	0.788389
835.5	0	0	3997.5	4055	36	1528.8	1560	1268.71	1295.01	2.000	2.000	0.958	N/A	622	4	4	70	N/A	48	151	70	151	168	0.797568
834.5	0	0	4112.5	4170	36	1591.2	1622.4	1321.31	1347.61	2.000	2.000	0.932	N/A	629	4	4	74	N/A	48	151	74	151	171	0.806716
833.5	0	0	4227.5	4285	36	1653.6	1684.8	1373.91	1400.21	2.000	2.000	0.909	N/A	635	4	4	78	N/A	48	151	78	151	174	0.815836
832.5	0	0	4342.5	4400	36	1716	1747.2	1426.51	1452.81	2.000	2.000	0.886	N/A	642	4	4	82	N/A	48	151	82	151	177	0.824929
831.5	0	0	4457.5	4515	36	1778.4	1809.6	1479.11	1505.41	2.000	2.000	0.866	N/A	648	4	4	86	N/A	48	151	86	151	180	0.833996
830.5	0	0	4572.5	4630	36	1840.8	1872	1531.71	1558.01	2.000	2.000	0.846	N/A	654	4	4	90	N/A	60	188	90	188	212	0.524918
829.5	0	0	4687.5	4745	40	1903.2	1934.4	1584.31	1610.61	2.000	2.000	1.005	N/A	919	6	6	96	N/A	60	188	96	188	216	0.529022
828.5	0	0	4802.5	4860	40	1965.6	1996.8	1636.91	1663.21	2.000	2.000	0.984	N/A	930	6	6	102	N/A	60	188	102	188	221	0.533122
827.5	0	0	4917.5	4975	40	2028	2059.2	1689.51	1715.81	2.000	2.000	0.964	N/A	940	6	6	108	N/A	60	188	108	188	225	0.537218
826.5	0	0	5032.5	5090	40	2090.4	2121.6	1742.11	1768.41	2.000	2.000	0.945	N/A	951	6	6	114	N/A	60	188	114	188	230	0.541311
825.5	0	0	5147.5	5205	40	2152.8	2184	1794.71	1821.01	2.000	2.000	0.926	N/A	957	6	6	120	N/A	59	184	120	184	231	0.693714
824.5	0	0	5262.5	5320	37	2215.2	2246.4	1847.31	1873.61	2.000	2.000	0.848	N/A	832	5	5	125	N/A	59	184	125	184	235	0.699871
823.5	0	0	5377.5	5435	37	2277.6	2308.8	1899.91	1926.21	2.000	2.000	0.832	N/A	837	5	5	130	N/A	59	184	130	184	239	0.706021
822.5	0	0	5492.5	5550	37	2340	2371.2	1952.51	1978.81	2.000	2.000	0.816	N/A	842	5	5	136	N/A	59	184	136	184	243	0.712164
821.5	0	0	5607.5	5665	37	2402.4	2433.6	2005.11	2031.41	2.000	2.000	0.802	N/A	847	5	5	141	N/A	59	184	141	184	247	0.7183
820.5	0	0	5722.5	5780	37	2464.8	2496	2057.71	2084.01	2.000	2.000	0.788	N/A	852	5	5	146	N/A	53	165	146	165	237	0.832573
819.5	0	0	5837.5	5895	36	2527.2	2558.4	2110.31	2136.61	2.000	2.000	0.724	N/A	771	5	5	151	N/A	53	165	151	165	240	0.840108
818.5	0	0	5952.5	6010	36	2589.6	2620.8	2162.91	2189.21	2.000	2.000	0.713	N/A	776	5	5	156	N/A	53	165	156	165	244	0.847635
817.5	0	0	6067.5	6125	36	2652	2683.2	2215.51	2241.81	2.000	2.000	0.702	N/A	781	5	5	161	N/A	53	165	161	165	248	0.855152
816.5	0	0	6182.5	6240	35	2714.4	2745.6	2268.11	2294.41	2.000	2.000	0.691	N/A	785	5	5	166	N/A	53	165	166	165	251	0.862662
815.5	0	0	6297.5	6355	35	2776.8	2808	2320.71	2347.01	2.000	2.000	0.681	N/A	790	5	5	171	N/A	56	174	171	174	262	0.809306
814.5	0	0	6412.5	6470	36	2839.2	2870.4	2373.31	2399.61	2.000	2.000	0.693	N/A	837	5	5	176	N/A	56	174	176	174	266	0.816064
813.5	0	0	6527.5	6585	36	2901.6	2932.8	2425.91	2452.21	2.000	2.000	0.683	N/A	841	5	5	181	N/A	56	174	181	174	270	0.822817
812.5	0	0	6642.5	6700	36	2964	2995.2	2478.51	2504.81	2.000	2.000	0.674	N/A	845	5	5	187	N/A	56	174	187	174	274	0.829565
811.5	0	0	6757.5	6815	36	3026.4	3057.6	2531.11	2557.41	2.000	2.000	0.665	N/A	850	5	5	192	N/A	56	174	192	174	279	0.836308

PROJECT SITE	DOLAT BRIDGE - CIDH Piles	
SOIL PROFILE (BORING) BEGINS AT ELEVATION	869.5	feet
PILE BEGINS AT GROUND ELEVATION	869.5	feet
SCOUR DEPTH CONSIDERED	6.5	feet
LIMIT STATE CONSIDERED	Strength	

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Boring:	B-3

Resistance Factor for Side Friction	0.7
Resistance Factor for End Bearing	0.5
Reduction Factor for Caving or poor construction	1.00
Reduction Factor for Group Effects	0.76

Overburden at Ground Surface for Limit State	0	psf
PILE SHAPE	circular	
Pile Side (Only for Square or Octagonal Piles)		feet
For other piles (perimeter)	6.283185	feet
For other piles (area)	3.141593	ft2
Information for Round Piles to be provided below:		
Pile Diameter (top)	2	feet
Pile Diameter (tip)	2	feet
Specified Length of Pile	53	feet
Estimated Initial Pile Tip Elevation	824.5	feet
Stick Up Length	8	feet
Taper Angle ω	0.000	deg
Pile Embedment Depth into bearing stratum	2	feet
Predrilling Reduction fraction for side resistance<1.0	1	

Octagon Calculator	
Given total width=	1.25 ft
Octagon Side=	0.517767 ft

Group Design Load	1050	kips
Pile Group Width	2	feet
Pile Group Length	39.26	feet

SPT Corrections convert California sampler blowcounts into SPT and use SPT blowcounts only				
Correction for borehole diameter	D_B (in)	4	C_B	1.00
Correction for sampling method		no liner	C_S	1
Correction for energy ratio			C_E	1.25
Correction for rod length	$r_{stickup}$ (ft)	3	see C_R	

Elevation at Top of Layer	Elevation at bottom of Layer	Depth to Layer Top	Depth to Layer Bottom	Groundwater present during drilling? yes / no	Groundwater present for Limit State Considered ? yes / no	Predrilling? Yes/no	Layer Thickness	Depth to middle of layer		SPT - N	Total Unit Wt during Drilling	Total Unit Wt for modeled Limit State	Soil Type	Su (for clays and silts)	Rod length	Cr	Corrected SPT - N	Corrected SPT - N (max 50)	Angle of friction	m	Cn	Corrected SPT - N (Overburden) MIDDLE LAYER
feet	feet	feet	feet	yes/no	yes/no	yes/no	feet	feet	meters	blowcounts	pcf	pcf		psf	m	%	blowcount	blowcount	degrees			blowcount
869.5	867.5	0	2	no	no	no	2	1	0.3	13	120	0.001	Sand		1.2	0.75	12	12	31	0.43	3.48	21
867.5	866.5	2	3	no	no	no	1	2.5	0.8	6	120	0.001	Sand		1.7	0.75	6	6	29	0.55	2.91	10
866.5	865.5	3	4	no	no	no	1	3.5	1.1	6	120	0.001	Sand		2.0	0.75	6	6	29	0.55	2.42	10
865.5	864.5	4	5	no	no	no	1	4.5	1.4	19	120	0.001	Sand		2.3	0.75	18	18	32	0.37	1.65	29
864.5	863.5	5	6	no	no	no	1	5.5	1.7	19	120	0.001	Sand		2.6	0.75	18	18	32	0.38	1.56	28
863.5	862.5	6	7	no	no	no	1	6.5	2.0	21	120	0.001	Sand		2.9	0.75	20	20	33	0.37	1.45	29
862.5	861.5	7	8	no	yes	no	1	7.5	2.3	21	120	120	Sand		3.2	0.75	20	20	33	0.38	1.39	27
861.5	860.5	8	9	no	yes	no	1	8.5	2.6	23	120	120	Sand		3.5	0.75	22	22	33	0.38	1.31	28
860.5	859.5	9	10	no	yes	no	1	9.5	2.9	23	120	120	Sand		3.8	0.75	22	22	33	0.38	1.27	27
859.5	858.5	10	11	no	yes	no	1	10.5	3.2	28	114	114	Sand		4.1	0.85	30	30	36	0.33	1.19	35
858.5	857.5	11	12	no	yes	no	1	11.5	3.5	28	114	114	Sand		4.4	0.85	30	30	36	0.33	1.16	34
857.5	856.5	12	13	no	yes	no	1	12.5	3.8	28	114	114	Sand		4.7	0.85	30	30	36	0.34	1.13	34
856.5	855.5	13	14	no	yes	no	1	13.5	4.1	47	114	114	Sand		5.0	0.85	50	50	41	0.24	1.07	50
855.5	854.5	14	15	no	yes	no	1	14.5	4.4	47	114	114	Sand		5.3	0.85	50	50	41	0.24	1.05	50
854.5	853.5	15	16	no	yes	no	1	15.5	4.7	38	120	120	Sand		5.6	0.85	40	40	38	0.29	1.04	42
853.5	852.5	16	17	no	yes	no	1	16.5	5.0	38	120	120	Sand		5.9	0.85	40	40	38	0.29	1.02	41
852.5	851.5	17	18	no	yes	no	1	17.5	5.3	33	120	120	Sand		6.2	0.95	39	39	38	0.30	1.01	39
851.5	850.5	18	19	no	yes	no	1	18.5	5.6	33	120	120	Sand		6.5	0.95	39	39	38	0.31	0.99	39
850.5	849.5	19	20	no	yes	no	1	19.5	5.9	33	120	120	Sand		6.8	0.95	39	39	38	0.31	0.97	38
849.5	848.5	20	21	no	yes	no	1	20.5	6.2	32	111	111	Sand		7.1	0.95	38	38	38	0.32	0.96	36
848.5	847.5	21	22	no	yes	no	1	21.5	6.5	32	111	111	Sand		7.4	0.95	38	38	38	0.32	0.94	36
847.5	846.5	22	23	no	yes	no	1	22.5	6.8	32	111	111	Sand		7.7	0.95	38	38	38	0.33	0.93	35
846.5	845.5	23	24	no	yes	no	1	23.5	7.1	32	111	111	Sand		8.0	0.95	38	38	38	0.33	0.92	35
845.5	844.5	24	25	no	yes	no	1	24.5	7.4	32	111	111	Sand		8.3	0.95	38	38	38	0.33	0.90	34
844.5	843.5	25	26	no	yes	no	1	25.5	7.7	22	111	111	Sand		8.6	0.95	26	26	35	0.42	0.87	23
843.5	842.5	26	27	no	yes	no	1	26.5	8.0	22	111	111	Sand		8.9	0.95	26	26	35	0.42	0.85	22
842.5	841.5	27	28	no	yes	no	1	27.5	8.3	22	111	111	Sand		9.2	0.95	26	26	35	0.42	0.84	22
841.5	840.5	28	29	no	yes	no	1	28.5	8.6	22	111	111	Sand		9.5	0.95	26	26	35	0.43	0.83	22
840.5	839.5	29	30	no	yes	no	1	29.5	8.9	22	111	111	Sand		9.8	0.95	26	26	35	0.43	0.81	21
839.5	838.5	30	31	no	yes	no	1	30.5	9.2	35	115	115	Sand		10.1	1	44	44	39	0.32	0.85	37
838.5	837.5	31	32	no	yes	no	1	31.5	9.5	35	115	115	Sand		10.4	1	44	44	39	0.32	0.84	37
837.5	836.5	32	33	no	yes	no	1	32.5	9.8	35	115	115	Sand		10.7	1	44	44	39	0.32	0.83	36
836.5	835.5	33	34	no	yes	no	1	33.5	10.1	35	115	115	Sand		11.0	1	44	44	39	0.32	0.82	36
835.5	834.5	34	35	no	yes	no	1	34.5	10.4	32	115	115	Sand		11.3	1	40	40	38	0.35	0.80	32
834.5	833.5	35	36	no	yes	no	1	35.5	10.7	32	115	115	Sand		11.6	1	40	40	38	0.35	0.79	32
833.5	832.5	36	37	no	yes	no	1	36.5	11.0	32	115	115	Sand		11.9	1	40	40	38	0.35	0.78	31
832.5	831.5	37	38	no	yes	no	1	37.5	11.3	32	115	115	Sand		12.2	1	40	40	38	0.36	0.77	31
831.5	830.5	38	39	no	yes	no	1	38.5	11.6	32	115	115	Sand		12.5	1	40	40	38	0.36	0.77	31
830.5	829.5	39	40	no	yes	no	1	39.5	11.9	32	115	115	Sand		12.8	1	40	40	38	0.36	0.76	30
829.5	828.5	40	41	no	yes	no	1	40.5	12.2	47	115	115	Sand		13.1	1	59	50	41	0.25	0.82	48
828.5	827.5	41	42	no	yes	no	1	41.5	12.5	47	115	115	Sand		13.4	1	59	50	41	0.25	0.81	48
827.5	826.5	42	43	no	yes	no	1	42.5	12.8	47	115	115	Sand		13.7	1	59	50	41	0.26	0.81	47
826.5	825.5	43	44	no	yes	no	1	43.5	13.1	47	115	115	Sand		14.0	1	59	50	41	0.26	0.80	47
825.5	824.5	44	45	no	yes	no	1	44.5	13.4	47	115	115	Sand		14.3	1	59	50	41	0.26	0.79	47
824.5	823.5	45	46	no	yes	no	1	45.5	13.7	39	115	115	Sand		14.6	1	49	49	40	0.32	0.75	36
823.5	822.5	46	47	no	yes	no	1	46.5	14.0	39	115	115	Sand		14.9	1	49	49	40	0.32	0.74	36
822.5	821.5	47	48	no	yes	no	1	47.5	14.3	39	115	115	Sand		15.2	1	49	49	40	0.32	0.73	36
821.5	820.5	48	49	no	yes	no	1	48.5	14.6	39	115	115	Sand		15.5	1	49	49	40	0.33	0.73	35
820.5	819.5	49	50	no	yes	no	1	49.5	14.9	39	115	115	Sand		15.8	1	49	49	40	0.33	0.72	35
819.5	818.5	50	51	no	yes	no	1	50.5	15.2	35	115	115	Sand		16.1	1	44	44	39	0.36	0.69	30
818.5	817.5	51	52	no	yes	no	1	51.5	15.5	35	115	115	Sand		16.4	1	44	44	39	0.36	0.69	30
817.5	816.5	52	53	no	yes	no	1	52.5	15.8	35	115	115	Sand		16.7	1	44	44	39	0.36	0.68	30
816.5	815.5	53	54	no	yes	no	1	53.5	16.1	35	115	115	Sand		17.0	1	44	44	39	0.37	0.67	30
815.5	814.5	54	55	no	yes	no	1	54.5	16.4	35	115	115	Sand		17.3	1	44	44	39	0.37	0.67	29
814.5	813.5	55	56	no	yes	no	1	55.5	16.7	37	115	115	Sand		17.6	1	46	46	40	0.36	0.67	31
813.5	812.5	56	57	no	yes	no	1	56.5	17.0	37	115	115	Sand		17.9	1	46	46	40	0.36	0.67	31
812.5	811.5	57	58	no	yes	no	1	57.5	17.3	37	115	115	Sand		18.2	1	46	46	40	0.36	0.66	31
811.5	810.5	58	59	no	yes	no	1	58.5	17.6	37	115	115	Sand		18.5	1	46	46	40	0.36	0.66	30
810.5	809.5	59	60	no	yes	no	1	59.5	17.9	37	115	115	Sand		18.8	1	46	46	40	0.36	0.65	30
809.5	808.5	60	61	no	yes	no	1	60.5	18.2	37	115	115	Sand		19.1	1	46	46	40	0.36	0.65	30
808.5	807.5	61	62	no	yes	no	1	61.5	18.5	37	115	115	Sand		19.4	1	46	46	40	0.37	0.64	30
807.5	806.5	62	63	no	yes	no	1	62.5	18.8	37	115	115	Sand		19.7	1	46	46	40	0.37	0.64	29
806.5	805.5	63	64	no	yes	no	1	63.5	19.1	37	115	115	Sand		20.0	1	46	46	40	0.37	0.63	29
805.5	804.5	64	65	no	yes	no	1	64.5	19.4	37	115	115	Sand		20.3	1	46	46	40	0.37	0.63	29
804.5	803.5	65	66	no	yes	no	1	65.5	19.7	37	115	115	Sand		20.6	1	46	46	40	0.37	0.62	29
803.5	802.5	66	67	no	yes	no	1	66.5	20.0	37	115	115	Sand		20.9	1	46	46	40	0.37	0.62	29
802.5	801.5	67	68	no	yes	no	1	67.5	20.3	37	115	115	Sand		21.2	1	46	46	40	0.37	0.61	28
801.5	800.5	68	69	no	yes	no	1	68.5	20.6	37	115	115	Sand		21.5	1	46	46	40	0.38	0.61	28
800.5	799.5	69	70	no	yes	no	1	69.5	20.9	37	115	115	Sand		21.8	1	46	46	40	0.38	0.60	28

Elevation at Top of Layer	To compute Cn					To compute Stresses for Limit State						FHWA-HI-10-016(Beta and Alpha Methods)												
	Pore Pressure @ layer middle	Pore Pressure @ layer bottom	Effective Stress @ layer middle	Effective Stress @ layer bottom	Angle of friction (with correction for Cn) φ	Pore Pressure @ layer middle	Pore Pressure @ layer bottom	Effective Stress @ layer middle	Effective Stress @ layer bottom	Pile Diameter at top of layer For Circular Piles	Pile Diameter at bottom of layer For Circular Piles	Beta	alpha	Fsn	Rsn	Factored Rsn for predrill	Cumulative Rsn	Nc	Base Resistance qbn	Base Resistance Qbn	Factored Cumulative Rsn	Factored Qbn	Total Q	Settlement
feet	psf	psf	psf	psf	degrees	psf	psf	psf	psf	feet	feet			psf	kips	kips	kips		ksf	kips	Kips	Kips	Kips	(inches)
869.5	0	0	120	240	33	0	0	0.001	0.002	2.000	2.000	2.218	N/A	0	0	0	0	N/A	7	21	0	11	N/A	N/A
867.5	0	0	300	360	30	0	0	0.0025	0.003	2.000	2.000	1.721	N/A	0	0	0	0	N/A	7	21	0	11	N/A	N/A
866.5	0	0	420	480	30	0	0	0.0035	0.004	2.000	2.000	1.721	N/A	0	0	0	0	N/A	21	67	0	34	N/A	N/A
865.5	0	0	540	600	35	0	0	0.0045	0.005	2.000	2.000	2.680	N/A	0	0	0	0	N/A	21	67	0	34	N/A	N/A
864.5	0	0	660	720	35	0	0	0.0055	0.006	2.000	2.000	2.584	N/A	0	0	0	0	N/A	24	74	0	37	N/A	N/A
863.5	0	0	780	840	35	0	0	0.0065	0.007	2.000	2.000	2.632	N/A	0	0	0	0	N/A	24	74	0	37	N/A	N/A
862.5	0	0	900	960	35	31.2	62.4	28.807	57.607	2.000	2.000	2.561	N/A	36	0	0	0	N/A	26	81	0	41	31	1.334099
861.5	0	0	1020	1080	35	93.6	124.8	86.407	115.207	2.000	2.000	2.619	N/A	112	1	1	1	N/A	26	81	1	41	31	1.384486
860.5	0	0	1140	1200	35	156	187.2	144.007	172.807	2.000	2.000	2.562	N/A	181	1	1	2	N/A	36	112	1	56	44	1.071839
859.5	0	0	1257	1314	37	218.4	249.6	198.607	224.407	2.000	2.000	2.695	N/A	282	2	2	4	N/A	36	112	3	56	45	1.09997
858.5	0	0	1371	1428	37	280.8	312	250.207	276.007	2.000	2.000	2.318	N/A	303	2	2	6	N/A	36	112	4	56	46	1.12747
857.5	0	0	1485	1542	37	343.2	374.4	301.807	327.607	2.000	2.000	2.051	N/A	321	2	2	8	N/A	60	188	5	94	76	0.756457
856.5	0	0	1599	1656	40	405.6	436.8	353.407	379.207	2.000	2.000	2.634	N/A	537	3	3	11	N/A	60	188	8	94	77	0.756457
855.5	0	0	1713	1770	40	468	499.2	405.007	430.807	2.000	2.000	2.413	N/A	564	4	4	15	N/A	48	152	10	76	66	0.89871
854.5	0	0	1830	1890	39	530.4	561.6	459.607	488.407	2.000	2.000	1.953	N/A	499	3	3	18	N/A	48	152	12	76	67	0.914841
853.5	0	0	1950	2010	39	592.8	624	517.207	546.007	2.000	2.000	1.801	N/A	515	3	3	21	N/A	47	148	15	74	67	0.958798
852.5	0	0	2070	2130	38	655.2	686.4	574.807	603.607	2.000	2.000	1.637	N/A	513	3	3	24	N/A	47	148	17	74	69	0.975373
851.5	0	0	2190	2250	38	717.6	748.8	632.407	661.207	2.000	2.000	1.534	N/A	525	3	3	28	N/A	47	148	19	74	71	0.991758
850.5	0	0	2310	2370	38	780	811.2	690.007	718.807	2.000	2.000	1.445	N/A	537	3	3	31	N/A	46	143	22	72	71	1.039898
849.5	0	0	2425.5	2481	37	842.4	873.6	743.107	767.407	2.000	2.000	1.344	N/A	530	3	3	34	N/A	46	143	24	72	73	1.055596
848.5	0	0	2536.5	2592	37	904.8	936	791.707	816.007	2.000	2.000	1.287	N/A	539	3	3	38	N/A	46	143	26	72	74	1.071164
847.5	0	0	2647.5	2703	37	967.2	998.4	840.307	864.607	2.000	2.000	1.236	N/A	547	3	3	41	N/A	46	143	29	72	76	1.086614
846.5	0	0	2758.5	2814	37	1029.6	1060.8	888.907	913.207	2.000	2.000	1.189	N/A	554	3	3	45	N/A	46	143	31	72	78	1.101953
845.5	0	0	2869.5	2925	37	1092	1123.2	937.507	961.807	2.000	2.000	1.147	N/A	562	4	4	48	N/A	31	98	34	49	63	1.671001
844.5	0	0	2980.5	3036	34	1154.4	1185.6	986.107	1010.407	2.000	2.000	0.881	N/A	409	3	3	51	N/A	31	98	35	49	64	1.6987
843.5	0	0	3091.5	3147	34	1216.8	1248	1034.707	1059.007	2.000	2.000	0.855	N/A	415	3	3	53	N/A	31	98	37	49	66	1.726227
842.5	0	0	3202.5	3258	33	1279.2	1310.4	1083.307	1107.607	2.000	2.000	0.831	N/A	421	3	3	56	N/A	31	98	39	49	67	1.75359
841.5	0	0	3313.5	3369	33	1341.6	1372.8	1131.907	1156.207	2.000	2.000	0.809	N/A	427	3	3	59	N/A	31	98	41	49	69	1.7808
840.5	0	0	3424.5	3480	33	1404	1435.2	1180.507	1204.807	2.000	2.000	0.788	N/A	432	3	3	61	N/A	53	165	43	82	95	1.016735
839.5	0	0	3537.5	3595	38	1466.4	1497.6	1231.107	1257.407	2.000	2.000	1.048	N/A	690	4	4	66	N/A	53	165	46	82	98	1.028568
838.5	0	0	3652.5	3710	37	1528.8	1560	1283.707	1310.007	2.000	2.000	1.019	N/A	697	4	4	70	N/A	53	165	49	82	100	1.040353
837.5	0	0	3767.5	3825	37	1591.2	1622.4	1336.307	1362.607	2.000	2.000	0.991	N/A	703	4	4	74	N/A	53	165	52	82	102	1.052094
836.5	0	0	3882.5	3940	37	1653.6	1684.8	1388.907	1415.207	2.000	2.000	0.965	N/A	710	4	4	79	N/A	48	151	55	75	99	1.180897
835.5	0	0	3997.5	4055	36	1716	1747.2	1441.507	1467.807	2.000	2.000	0.888	N/A	656	4	4	83	N/A	48	151	58	75	101	1.194645
834.5	0	0	4112.5	4170	36	1778.4	1809.6	1494.107	1520.407	2.000	2.000	0.867	N/A	661	4	4	87	N/A	48	151	61	75	104	1.208348
833.5	0	0	4227.5	4285	36	1840.8	1872	1546.707	1573.007	2.000	2.000	0.848	N/A	667	4	4	91	N/A	48	151	64	75	106	1.222008
832.5	0	0	4342.5	4400	36	1903.2	1934.4	1599.307	1625.607	2.000	2.000	0.829	N/A	673	4	4	96	N/A	48	151	67	75	108	1.235628
831.5	0	0	4457.5	4515	36	1965.6	1996.8	1651.907	1678.207	2.000	2.000	0.811	N/A	678	4	4	100	N/A	48	151	70	75	110	1.249209
830.5	0	0	4572.5	4630	36	2028	2059.2	1704.507	1730.807	2.000	2.000	0.795	N/A	683	4	4	104	N/A	60	188	73	94	127	0.786253
829.5	0	0	4687.5	4745	40	2090.4	2121.6	1757.107	1783.407	2.000	2.000	0.940	N/A	954	6	6	110	N/A	60	188	77	94	130	0.792401
828.5	0	0	4802.5	4860	40	2152.8	2184	1809.707	1836.007	2.000	2.000	0.922	N/A	964	6	6	116	N/A	60	188	81	94	133	0.798542
827.5	0	0	4917.5	4975	40	2215.2	2246.4	1862.307	1888.607	2.000	2.000	0.905	N/A	974	6	6	122	N/A	60	188	86	94	137	0.804678
826.5	0	0	5032.5	5090	40	2277.6	2308.8	1914.907	1941.207	2.000	2.000	0.889	N/A	983	6	6	129	N/A	60	188	90	94	140	0.810809
825.5	0	0	5147.5	5205	40	2340	2371.2	1967.507	1993.807	2.000	2.000	0.873	N/A	989	6	6	135	N/A	59	184	94	92	142	1.039086
824.5	0	0	5262.5	5320	37	2402.4	2433.6	2020.107	2046.407	2.000	2.000	0.803	N/A	862	5	5	140	N/A	59	184	98	92	144	1.048309
823.5	0	0	5377.5	5435	37	2464.8	2496	2072.707	2099.007	2.000	2.000	0.789	N/A	866	5	5	146	N/A	59	184	102	92	147	1.057521
822.5	0	0	5492.5	5550	37	2527.2	2558.4	2125.307	2151.607	2.000	2.000	0.776	N/A	871	5	5	151	N/A	59	184	106	92	150	1.066722
821.5	0	0	5607.5	5665	37	2589.6	2620.8	2177.907	2204.207	2.000	2.000	0.763	N/A	876	6	6	157	N/A	59	184	110	92	153	1.075913
820.5	0	0	5722.5	5780	37	2652	2683.2	2230.507	2256.807	2.000	2.000	0.751	N/A	880	6	6	162	N/A	53	165	113	82	149	1.247078
819.5	0	0	5837.5	5895	36	2714.4	2745.6	2283.107	2309.407	2.000	2.000	0.692	N/A	797	5	5	167	N/A	53	165	117	82	152	1.258365
818.5	0	0	5952.5	6010	36	2776.8	2808	2335.707	2362.007	2.000	2.000	0.682	N/A	801	5	5	172	N/A	53	165	121	82	154	1.269638
817.5	0	0	6067.5	6125	36	2839.2	2870.4	2388.307	2414.607	2.000	2.000	0.672	N/A	806	5	5	177	N/A	53	165	124	82	157	1.280898
816.5	0	0	6182.5	6240	35	2901.6	2932.8	2440.907	2467.207	2.000	2.000	0.662	N/A	810	5	5	182	N/A	53	165	128	82	160	1.292147
815.5	0	0	6297.5	6355	35	2964	2995.2	2493.507	2519.807	2.000	2.000	0.653	N/A	814	5	5	187	N/A	56	174	131	87	166	1.212228
814.5	0	0	6412.5	6470	36	3026.4	3057.6	2546.107	2572.407	2.000	2.000	0.665	N/A	861	5	5	193	N/A	56	174	135	87	169	1.22235
813.5	0	0	6527.5	6585	36	3088.8	3120	2598.707	2625.007	2.000	2.000	0.656	N/A	865	5	5	198	N/A	56	174	139	87	172	1.232464
812.5	0	0	6642.5	6700	36	3151.2	3182.4	2651.307	2677.607	2.000	2.000	0.648	N/A	869	5	5	204	N/A	56	174	143	87	175	1.242572
811.5	0	0	6757.5	6815	36	3213.6	3244.8	2703.907	2730.207	2.000	2.000	0.640	N/A	873	5	5	209	N/A	56	174	146	87	178	1.252673
810.5	0	0	6872.5	6930	36	3276	3307.2	2756.507	2782.807	2.000	2.000	0.631	N/A	877	6	6	215	N/A	56	174	150	87	180	1.262768
809.5	0	0	6987.5	7045	36	3338.4	3369.6	2809.107	2835.407	2.000	2.000	0.624	N/A	881	6	6	220	N/A	56	174	154	87	183	1.272857
808.5	0	0	7102.5	7160	36	3400.8	3432	2861.707	2888.007	2.000	2.000	0.616	N/A	885	6	6	226	N/A	56	174	158	87	186	1.282941
807.5	0	0	7217.5	7275	35	3463.2	3494.4	2914.307	2940.607	2.000	2.000	0.609	N/A	889	6	6	231	N/A	56	174	162	87	189	1.293019
806.5	0	0	7332.5	7390	35	3525.6	3556.8	2966.907	2993.207	2.000	2.000	0.602	N/A	893	6	6	237	N/A	56	174	166	87	192	1.303093
805.5	0	0	7447.5	7505	35	3588	3619.2	3019.507	3045.807	2.000	2.000	0.595	N/A	896	6	6	243	N/A	56	174	170	87	195	1.313163
804.5	0	0	7562.5	7620	35	3650.4	3681.6	3072.107	3098.407	2.000	2.000	0.588	N/A	900	6	6	248	N/A	56	174	174	87	198	1.323228
803.5	0	0	7677.5	7735	35	3712.8	3744	3124.707	3151.007	2.000	2.000	0.582	N/A	904	6	6	254	N/A	56	174	178	87	201	1.33329
802.5	0	0	7792.5	7850	35	3775.2	3806.4	3177.307	3203.607	2.000	2.000	0.576	N/A	907	6	6	260	N/A	56	174	182	87	204	1.343348
801.5	0	0	7907.5	7965	35	3837.6	3868.8	3229.907	3256.207	2.000	2.000	0.570	N/A	911	6	6	265	N/A	56	174	186	87	207	1.353403
800.5	0	0	8022.5	8080	35	3900	3931.2	3282.507	3308.807	2.000	2.000	0.564	N/A	915	6	6	271	N/A	#DIV/0!	#DIV/0!	190	#DIV/0!	#DIV/0!	#DIV/0!

PROJECT SITE	DOLAT BRIDGE - CIDH Piles	
SOIL PROFILE (BORING) BEGINS AT ELEVATION	869.5	feet
PILE BEGINS AT GROUND ELEVATION	869.5	feet
SCOUR DEPTH CONSIDERED	11	feet
LIMIT STATE CONSIDERED	Service	

Boring:	B-3

Resistance Factor for Side Friction	1
Resistance Factor for End Bearing	1
Reduction Factor for Caving or poor construction	1.00
Reduction Factor for Group Effects	0.76

Overburden at Ground Surface for Limit State	0	psf
PILE SHAPE	circular	
Pile Side (Only for Square or Octagonal Piles)		feet
For other piles (perimeter)	6.283185	feet
For other piles (area)	3.141593	ft2
Information for Round Piles to be provided below:		
Pile Diameter (top)	2	feet
Pile Diameter (tip)	2	feet
Specified Length of Pile	53	feet
Estimated Initial Pile Tip Elevation	824.5	feet
Stick Up Length	8	feet
Taper Angle ω	0.000	deg
Pile Embedment Depth into bearing stratum	2	feet
Predrilling Reduction fraction for side resistance<1.0	1	

Octagon Calculator	
Given total width=	1.25 ft
Octagon Side=	0.517767 ft

Group Design Load	684	kips
Pile Group Width	2	feet
Pile Group Length	39.26	feet

SPT Corrections convert California sampler blowcounts into SPT and use SPT blowcounts only				
Correction for borehole diameter	D_B (in)	4	C_B	1.00
Correction for sampling method		no liner	C_S	1
Correction for energy ratio			C_E	1.25
Correction for rod length	$r_{stickup}$ (ft)	3	see C_R	

Elevation at Top of Layer	Elevation at bottom of Layer	Depth to Layer Top	Depth to Layer Bottom	Groundwater present during drilling? yes / no	Groundwater present for Limit State Considered ? yes / no	Predrilling? Yes/no	Layer Thickness	Depth to middle of layer		SPT - N	Total Unit Wt during Drilling	Total Unit Wt for modeled Limit State	Soil Type	Su (for clays and silts)	Rod length	Cr	Corrected SPT - N	Corrrected SPT - N (max 50)	Angle of friction	m	Cn	Corrrected SPT - N (Overburden) MIDDLE LAYER
feet	feet	feet	feet	yes/no	yes/no	yes/no	feet	feet	meters	blowcounts	pcf	pcf		psf	m	%	blowcount	blowcount	degrees			blowcount
869.5	867.5	0	2	no	no	no	2	1	0.3	13	120	0.001	Sand		1.2	0.75	12	12	31	0.43	3.48	21
867.5	866.5	2	3	no	no	no	1	2.5	0.8	6	120	0.001	Sand		1.7	0.75	6	6	29	0.55	2.91	10
866.5	865.5	3	4	no	no	no	1	3.5	1.1	6	120	0.001	Sand		2.0	0.75	6	6	29	0.55	2.42	10
865.5	864.5	4	5	no	no	no	1	4.5	1.4	19	120	0.001	Sand		2.3	0.75	18	18	32	0.37	1.65	29
864.5	863.5	5	6	no	no	no	1	5.5	1.7	19	120	0.001	Sand		2.6	0.75	18	18	32	0.38	1.56	28
863.5	862.5	6	7	no	no	no	1	6.5	2.0	21	120	0.001	Sand		2.9	0.75	20	20	33	0.37	1.45	29
862.5	861.5	7	8	no	no	no	1	7.5	2.3	21	120	0.001	Sand		3.2	0.75	20	20	33	0.38	1.39	27
861.5	860.5	8	9	no	no	no	1	8.5	2.6	23	120	0.001	Sand		3.5	0.75	22	22	33	0.38	1.31	28
860.5	859.5	9	10	no	no	no	1	9.5	2.9	23	120	0.001	Sand		3.8	0.75	22	22	33	0.38	1.27	27
859.5	858.5	10	11	no	yes	no	1	10.5	3.2	28	114	114	Sand		4.1	0.85	30	30	36	0.33	1.19	35
858.5	857.5	11	12	no	yes	no	1	11.5	3.5	28	114	114	Sand		4.4	0.85	30	30	36	0.33	1.16	34
857.5	856.5	12	13	no	yes	no	1	12.5	3.8	28	114	114	Sand		4.7	0.85	30	30	36	0.34	1.13	34
856.5	855.5	13	14	no	yes	no	1	13.5	4.1	47	114	114	Sand		5.0	0.85	50	50	41	0.24	1.07	50
855.5	854.5	14	15	no	yes	no	1	14.5	4.4	47	114	114	Sand		5.3	0.85	50	50	41	0.24	1.05	50
854.5	853.5	15	16	no	yes	no	1	15.5	4.7	38	120	120	Sand		5.6	0.85	40	40	38	0.29	1.04	42
853.5	852.5	16	17	no	yes	no	1	16.5	5.0	38	120	120	Sand		5.9	0.85	40	40	38	0.29	1.02	41
852.5	851.5	17	18	no	yes	no	1	17.5	5.3	33	120	120	Sand		6.2	0.95	39	39	38	0.30	1.01	39
851.5	850.5	18	19	no	yes	no	1	18.5	5.6	33	120	120	Sand		6.5	0.95	39	39	38	0.31	0.99	39
850.5	849.5	19	20	no	yes	no	1	19.5	5.9	33	120	120	Sand		6.8	0.95	39	39	38	0.31	0.97	38
849.5	848.5	20	21	no	yes	no	1	20.5	6.2	32	111	111	Sand		7.1	0.95	38	38	38	0.32	0.96	36
848.5	847.5	21	22	no	yes	no	1	21.5	6.5	32	111	111	Sand		7.4	0.95	38	38	38	0.32	0.94	36
847.5	846.5	22	23	no	yes	no	1	22.5	6.8	32	111	111	Sand		7.7	0.95	38	38	38	0.33	0.93	35
846.5	845.5	23	24	no	yes	no	1	23.5	7.1	32	111	111	Sand		8.0	0.95	38	38	38	0.33	0.92	35
845.5	844.5	24	25	no	yes	no	1	24.5	7.4	32	111	111	Sand		8.3	0.95	38	38	38	0.33	0.90	34
844.5	843.5	25	26	no	yes	no	1	25.5	7.7	22	111	111	Sand		8.6	0.95	26	26	35	0.42	0.87	23
843.5	842.5	26	27	no	yes	no	1	26.5	8.0	22	111	111	Sand		8.9	0.95	26	26	35	0.42	0.85	22
842.5	841.5	27	28	no	yes	no	1	27.5	8.3	22	111	111	Sand		9.2	0.95	26	26	35	0.42	0.84	22
841.5	840.5	28	29	no	yes	no	1	28.5	8.6	22	111	111	Sand		9.5	0.95	26	26	35	0.43	0.83	22
840.5	839.5	29	30	no	yes	no	1	29.5	8.9	22	111	111	Sand		9.8	0.95	26	26	35	0.43	0.81	21
839.5	838.5	30	31	no	yes	no	1	30.5	9.2	35	115	115	Sand		10.1	1	44	44	39	0.32	0.85	37
838.5	837.5	31	32	no	yes	no	1	31.5	9.5	35	115	115	Sand		10.4	1	44	44	39	0.32	0.84	37
837.5	836.5	32	33	no	yes	no	1	32.5	9.8	35	115	115	Sand		10.7	1	44	44	39	0.32	0.83	36
836.5	835.5	33	34	no	yes	no	1	33.5	10.1	35	115	115	Sand		11.0	1	44	44	39	0.32	0.82	36
835.5	834.5	34	35	no	yes	no	1	34.5	10.4	32	115	115	Sand		11.3	1	40	40	38	0.35	0.80	32
834.5	833.5	35	36	no	yes	no	1	35.5	10.7	32	115	115	Sand		11.6	1	40	40	38	0.35	0.79	32
833.5	832.5	36	37	no	yes	no	1	36.5	11.0	32	115	115	Sand		11.9	1	40	40	38	0.35	0.78	31
832.5	831.5	37	38	no	yes	no	1	37.5	11.3	32	115	115	Sand		12.2	1	40	40	38	0.36	0.77	31
831.5	830.5	38	39	no	yes	no	1	38.5	11.6	32	115	115	Sand		12.5	1	40	40	38	0.36	0.77	31
830.5	829.5	39	40	no	yes	no	1	39.5	11.9	32	115	115	Sand		12.8	1	40	40	38	0.36	0.76	30
829.5	828.5	40	41	no	yes	no	1	40.5	12.2	47	115	115	Sand		13.1	1	59	50	41	0.25	0.82	48
828.5	827.5	41	42	no	yes	no	1	41.5	12.5	47	115	115	Sand		13.4	1	59	50	41	0.25	0.81	48
827.5	826.5	42	43	no	yes	no	1	42.5	12.8	47	115	115	Sand		13.7	1	59	50	41	0.26	0.81	47
826.5	825.5	43	44	no	yes	no	1	43.5	13.1	47	115	115	Sand		14.0	1	59	50	41	0.26	0.80	47
825.5	824.5	44	45	no	yes	no	1	44.5	13.4	47	115	115	Sand		14.3	1	59	50	41	0.26	0.79	47
824.5	823.5	45	46	no	yes	no	1	45.5	13.7	39	115	115	Sand		14.6	1	49	49	40	0.32	0.75	36
823.5	822.5	46	47	no	yes	no	1	46.5	14.0	39	115	115	Sand		14.9	1	49	49	40	0.32	0.74	36
822.5	821.5	47	48	no	yes	no	1	47.5	14.3	39	115	115	Sand		15.2	1	49	49	40	0.32	0.73	36
821.5	820.5	48	49	no	yes	no	1	48.5	14.6	39	115	115	Sand		15.5	1	49	49	40	0.33	0.73	35
820.5	819.5	49	50	no	yes	no	1	49.5	14.9	39	115	115	Sand		15.8	1	49	49	40	0.33	0.72	35
819.5	818.5	50	51	no	yes	no	1	50.5	15.2	35	115	115	Sand		16.1	1	44	44	39	0.36	0.69	30
818.5	817.5	51	52	no	yes	no	1	51.5	15.5	35	115	115	Sand		16.4	1	44	44	39	0.36	0.69	30
817.5	816.5	52	53	no	yes	no	1	52.5	15.8	35	115	115	Sand		16.7	1	44	44	39	0.36	0.68	30
816.5	815.5	53	54	no	yes	no	1	53.5	16.1	35	115	115	Sand		17.0	1	44	44	39	0.37	0.67	30
815.5	814.5	54	55	no	yes	no	1	54.5	16.4	35	115	115	Sand		17.3	1	44	44	39	0.37	0.67	29
814.5	813.5	55	56	no	yes	no	1	55.5	16.7	37	115	115	Sand		17.6	1	46	46	40	0.36	0.67	31
813.5	812.5	56	57	no	yes	no	1	56.5	17.0	37	115	115	Sand		17.9	1	46	46	40	0.36	0.67	31
812.5	811.5	57	58	no	yes	no	1	57.5	17.3	37	115	115	Sand		18.2	1	46	46	40	0.36	0.66	31
811.5	810.5	58	59	no	yes	no	1	58.5	17.6	37	115	115	Sand		18.5	1	46	46	40	0.36	0.66	30

Elevation at Top of Layer	To compute Cn				Angle of friction (with correction for Cn) φ	To compute Stresses for Limit State				Pile Diameter at top of layer For Circular Piles	Pile Diameter at bottom of layer For Circular Piles	FHWA-HI-10-016(Beta and Alpha Methods)											Total Q	Settlement
	Pore Pressure @ layer middle	Pore Pressure @ layer bottom	Effective Stress @ layer middle	Effective Stress @ layer bottom		Pore Pressure @ layer middle	Pore Pressure @ layer bottom	Effective Stress @ layer middle	Effective Stress @ layer bottom			Beta	alpha	Fsn	Rsn	Factored Rsn for predrill	Cumulative Rsn	Nc	Base Resistance qbn	Base Resistance Qbn	Factored Cumulative Rsn	Factored Qbn		
feet	psf	psf	psf	psf	degrees	psf	psf	psf	psf	feet	feet			psf	kips	kips	kips		ksf	kips	Kips	Kips	Kips	(inches)
869.5	0	0	120	240	33	0	0	0.001	0.002	2.000	2.000	2.218	N/A	0	0	0	0	N/A	7	21	0	21	N/A	N/A
867.5	0	0	300	360	30	0	0	0.0025	0.003	2.000	2.000	1.721	N/A	0	0	0	0	N/A	7	21	0	21	N/A	N/A
866.5	0	0	420	480	30	0	0	0.0035	0.004	2.000	2.000	1.721	N/A	0	0	0	0	N/A	21	67	0	67	N/A	N/A
865.5	0	0	540	600	35	0	0	0.0045	0.005	2.000	2.000	2.680	N/A	0	0	0	0	N/A	21	67	0	67	N/A	N/A
864.5	0	0	660	720	35	0	0	0.0055	0.006	2.000	2.000	2.584	N/A	0	0	0	0	N/A	24	74	0	74	N/A	N/A
863.5	0	0	780	840	35	0	0	0.0065	0.007	2.000	2.000	2.632	N/A	0	0	0	0	N/A	24	74	0	74	N/A	N/A
862.5	0	0	900	960	35	0	0	0.0075	0.008	2.000	2.000	2.561	N/A	0	0	0	0	N/A	26	81	0	81	N/A	N/A
861.5	0	0	1020	1080	35	0	0	0.0085	0.009	2.000	2.000	2.619	N/A	0	0	0	0	N/A	26	81	0	81	N/A	N/A
860.5	0	0	1140	1200	35	0	0	0.0095	0.01	2.000	2.000	2.562	N/A	0	0	0	0	N/A	36	112	0	112	N/A	N/A
859.5	0	0	1257	1314	37	31.2	62.4	25.81	51.61	2.000	2.000	3.035	N/A	41	0	0	0	N/A	36	112	0	112	N/A	N/A
858.5	0	0	1371	1428	37	93.6	124.8	77.41	103.21	2.000	2.000	2.978	N/A	120	1	1	1	N/A	36	112	1	112	86	0.734466
857.5	0	0	1485	1542	37	156	187.2	129.01	154.81	2.000	2.000	2.926	N/A	196	1	1	2	N/A	60	188	2	188	145	0.492777
856.5	0	0	1599	1656	40	218.4	249.6	180.61	206.41	2.000	2.000	3.859	N/A	402	3	3	5	N/A	60	188	5	188	147	0.492777
855.5	0	0	1713	1770	40	280.8	312	232.21	258.01	2.000	2.000	3.450	N/A	463	3	3	8	N/A	48	152	8	152	122	0.585445
854.5	0	0	1830	1890	39	343.2	374.4	286.81	315.61	2.000	2.000	2.624	N/A	419	3	3	10	N/A	48	152	10	152	124	0.595953
853.5	0	0	1950	2010	39	405.6	436.8	344.41	373.21	2.000	2.000	2.321	N/A	442	3	3	13	N/A	47	148	13	148	122	0.624589
852.5	0	0	2070	2130	38	468	499.2	402.01	430.81	2.000	2.000	2.042	N/A	447	3	3	16	N/A	47	148	16	148	124	0.635386
851.5	0	0	2190	2250	38	530.4	561.6	459.61	488.41	2.000	2.000	1.866	N/A	465	3	3	19	N/A	47	148	19	148	127	0.646059
850.5	0	0	2310	2370	38	592.8	624	517.21	546.01	2.000	2.000	1.724	N/A	481	3	3	22	N/A	46	143	22	143	125	0.677419
849.5	0	0	2425.5	2481	37	655.2	686.4	570.31	594.61	2.000	2.000	1.578	N/A	478	3	3	25	N/A	46	143	25	143	128	0.687646
848.5	0	0	2536.5	2592	37	717.6	748.8	618.91	643.21	2.000	2.000	1.493	N/A	489	3	3	28	N/A	46	143	28	143	130	0.697787
847.5	0	0	2647.5	2703	37	780	811.2	667.51	691.81	2.000	2.000	1.420	N/A	499	3	3	31	N/A	46	143	31	143	132	0.707851
846.5	0	0	2758.5	2814	37	842.4	873.6	716.11	740.41	2.000	2.000	1.354	N/A	508	3	3	34	N/A	46	143	34	143	135	0.717844
845.5	0	0	2869.5	2925	37	904.8	936	764.71	789.01	2.000	2.000	1.296	N/A	517	3	3	37	N/A	31	98	37	98	103	1.088538
844.5	0	0	2980.5	3036	34	967.2	998.4	813.31	837.61	2.000	2.000	0.980	N/A	375	2	2	40	N/A	31	98	40	98	105	1.106582
843.5	0	0	3091.5	3147	34	1029.6	1060.8	861.91	886.21	2.000	2.000	0.946	N/A	383	2	2	42	N/A	31	98	42	98	107	1.124514
842.5	0	0	3202.5	3258	33	1092	1123.2	910.51	934.81	2.000	2.000	0.915	N/A	389	2	2	45	N/A	31	98	45	98	109	1.142339
841.5	0	0	3313.5	3369	33	1154.4	1185.6	959.11	983.41	2.000	2.000	0.886	N/A	396	2	2	47	N/A	31	98	47	98	111	1.160064
840.5	0	0	3424.5	3480	33	1216.8	1248	1007.71	1032.01	2.000	2.000	0.859	N/A	402	3	3	50	N/A	53	165	50	165	163	0.66233
839.5	0	0	3537.5	3595	38	1279.2	1310.4	1058.31	1084.61	2.000	2.000	1.150	N/A	651	4	4	54	N/A	53	165	54	165	166	0.670038
838.5	0	0	3652.5	3710	37	1341.6	1372.8	1110.91	1137.21	2.000	2.000	1.112	N/A	658	4	4	58	N/A	53	165	58	165	169	0.677716
837.5	0	0	3767.5	3825	37	1404	1435.2	1163.51	1189.81	2.000	2.000	1.078	N/A	666	4	4	62	N/A	53	165	62	165	173	0.685364
836.5	0	0	3882.5	3940	37	1466.4	1497.6	1216.11	1242.41	2.000	2.000	1.046	N/A	673	4	4	66	N/A	48	151	66	151	165	0.76927
835.5	0	0	3997.5	4055	36	1528.8	1560	1268.71	1295.01	2.000	2.000	0.958	N/A	622	4	4	70	N/A	48	151	70	151	168	0.778226
834.5	0	0	4112.5	4170	36	1591.2	1622.4	1321.31	1347.61	2.000	2.000	0.932	N/A	629	4	4	74	N/A	48	151	74	151	171	0.787153
833.5	0	0	4227.5	4285	36	1653.6	1684.8	1373.91	1400.21	2.000	2.000	0.909	N/A	635	4	4	78	N/A	48	151	78	151	174	0.796051
832.5	0	0	4342.5	4400	36	1716	1747.2	1426.51	1452.81	2.000	2.000	0.886	N/A	642	4	4	82	N/A	48	151	82	151	177	0.804923
831.5	0	0	4457.5	4515	36	1778.4	1809.6	1479.11	1505.41	2.000	2.000	0.866	N/A	648	4	4	86	N/A	48	151	86	151	180	0.81377
830.5	0	0	4572.5	4630	36	1840.8	1872	1531.71	1558.01	2.000	2.000	0.846	N/A	654	4	4	90	N/A	60	188	90	188	212	0.512188
829.5	0	0	4687.5	4745	40	1903.2	1934.4	1584.31	1610.61	2.000	2.000	1.005	N/A	919	6	6	96	N/A	60	188	96	188	216	0.516193
828.5	0	0	4802.5	4860	40	1965.6	1996.8	1636.91	1663.21	2.000	2.000	0.984	N/A	930	6	6	102	N/A	60	188	102	188	221	0.520193
827.5	0	0	4917.5	4975	40	2028	2059.2	1689.51	1715.81	2.000	2.000	0.964	N/A	940	6	6	108	N/A	60	188	108	188	225	0.52419
826.5	0	0	5032.5	5090	40	2090.4	2121.6	1742.11	1768.41	2.000	2.000	0.945	N/A	951	6	6	114	N/A	60	188	114	188	230	0.528184
825.5	0	0	5147.5	5205	40	2152.8	2184	1794.71	1821.01	2.000	2.000	0.926	N/A	957	6	6	120	N/A	59	184	120	184	231	0.676891
824.5	0	0	5262.5	5320	37	2215.2	2246.4	1847.31	1873.61	2.000	2.000	0.848	N/A	832	5	5	125	N/A	59	184	125	184	235	0.682899
823.5	0	0	5377.5	5435	37	2277.6	2308.8	1899.91	1926.21	2.000	2.000	0.832	N/A	837	5	5	130	N/A	59	184	130	184	239	0.688899
822.5	0	0	5492.5	5550	37	2340	2371.2	1952.51	1978.81	2.000	2.000	0.816	N/A	842	5	5	136	N/A	59	184	136	184	243	0.694893
821.5	0	0	5607.5	5665	37	2402.4	2433.6	2005.11	2031.41	2.000	2.000	0.802	N/A	847	5	5	141	N/A	59	184	141	184	247	0.700881
820.5	0	0	5722.5	5780	37	2464.8	2496	2057.71	2084.01	2.000	2.000	0.788	N/A	852	5	5	146	N/A	53	165	146	165	237	0.812382
819.5	0	0	5837.5	5895	36	2527.2	2558.4	2110.31	2136.61	2.000	2.000	0.724	N/A	771	5	5	151	N/A	53	165	151	165	240	0.819735
818.5	0	0	5952.5	6010	36	2589.6	2620.8	2162.91	2189.21	2.000	2.000	0.713	N/A	776	5	5	156	N/A	53	165	156	165	244	0.827079
817.5	0	0	6067.5	6125	36	2652	2683.2	2215.51	2241.81	2.000	2.000	0.702	N/A	781	5	5	161	N/A	53	165	161	165	248	0.834414
816.5	0	0	6182.5	6240	35	2714.4	2745.6	2268.11	2294.41	2.000	2.000	0.691	N/A	785	5	5	166	N/A	53	165	166	165	251	0.841741
815.5	0	0	6297.5	6355	35	2776.8	2808	2320.71	2347.01	2.000	2.000	0.681	N/A	790	5	5	171	N/A	56	174	171	174	262	0.78968
814.5	0	0	6412.5	6470	36	2839.2	2870.4	2373.31	2399.61	2.000	2.000	0.693	N/A	837	5	5	176	N/A	56	174	176	174	266	0.796274
813.5	0	0	6527.5	6585	36	2901.6	2932.8	2425.91	2452.21	2.000	2.000	0.683	N/A	841	5	5	181	N/A	56	174	181	174	270	0.802863
812.5	0	0	6642.5	6700	36	2964	2995.2	2478.51	2504.81	2.000	2.000	0.674	N/A	845	5	5	187	N/A	56	174	187	174	274	0.809447
811.5	0	0	6757.5	6815	36	3026.4	3057.6	2531.11	2557.41	2.000	2.000	0.665	N/A	850	5	5	192	N/A	56	174	192	174	279	0.816027

TETRA TECH

Geotechnical Engineering ● Engineering Geology

Foundation Report
Lanzit Ditch Bridge
County Local Bridge No. 82
Caltrans State Bridge No. 54C0286
San Bernardino County, California

Prepared for: County of San Bernardino
Transportation Design Division
825 East Third Street
San Bernardino, CA 92415-0835

Prepared by: Tetra Tech
21700 Copley Drive, Suite 200
Diamond Bar, California 91765

November 22, 2023
Project No. coSB 23-03E

TETRA TECH

Project No. coSB 23-03E
November 22, 2023

Mr. Noel Mondragon
County of San Bernardino
Transportation Design Division
825 East Third Street
San Bernardino, CA 92415-0835

SUBJECT: LANZIT DITCH BRIDGE FOUNDATION REPORT
National Trails Highway SR66
San Bernardino County, California
2.8 miles East of Kelbaker Road

Dear Mr. Mondragon:

Presented herein is Tetra Tech's Foundation Report for the replacement of the existing timber Lanzit Ditch Bridge, County Local Bridge No. 82, Caltrans State Bridge No. 54C0286, located in San Bernardino County, with a new concrete bridge. This report summarizes Tetra Tech's scope of work, project description, seismic design recommendations, and provides recommendations for bridge foundations, and structural design.

We appreciate the opportunity to provide our professional services on this project. If you have any questions regarding this report or if we can be of further service, please do not hesitate to contact the undersigned.

Respectfully submitted,
Tetra Tech BAS, Inc

Fernando Cuenca, Ph.D., G.E.
Senior Engineer

Peter Skopek, Ph.D., G.E.
Principal Engineer

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Appendices

1. INTRODUCTION

This Foundation Report (FR) presents the results of Tetra Tech's geotechnical engineering evaluation and geotechnical design recommendations for the construction of the replacement Lanzit Ditch Bridge, County Local Bridge No. 82, Caltrans State Bridge No. 54C0286, located in San Bernardino County (see Figure 1 – Project Location Map). The existing timber bridge was built in 2017, and the proposed project entails its removal and replacement with a new, longer, reinforced concrete bridge.

The purpose of this study was to provide recommendations for the design and construction of the proposed replacement bridge. This report presents our findings, conclusions, and foundation design recommendations.

2. SCOPE OF SERVICES

Tetra Tech's scope of services for this project consisted of the following tasks:

- Review of available background data, geologic maps, and seismic hazard maps relevant to the subject site.

- Review of local seismic sources and development of a Design Acceleration Response Spectrum (ARS) for the site.

- Engineering evaluation of the geotechnical data collected to develop geotechnical recommendations for the design and construction of the proposed structure. Consideration including the following items:

    - An evaluation of the liquefaction potential and dynamic settlement of the on-site granular materials.
    - Recommendations for the design of Cast-In-Drilled-Hole (CIDH) pile foundation systems for the bents including axial resistance, lateral resistance parameters, and settlement estimates.
    - Recommendations for the design of footing foundations for the abutments including allowable bearing pressures and settlement estimates.
    - An evaluation of the corrosion potential of the on-site soils to buried concrete.

- Preparation of this report, including conclusions, and geotechnical recommendations for the design and construction of the proposed project.

3. PROPOSED DEVELOPMENT AND SITE DESCRIPTION

The existing Lanzit Ditch Bridge is located in the county of San Bernardino on Route 66 (a.k.a National Trails Highway), approximately 11.3 miles south of I-40, 8.6 miles east of the city of Amboy, and approximately 2.8 miles east of the intersection with Kelbaker Road. The bridge is spans from Station 49+17.54 to Station 49+95.23, i.e., is about 78 feet long. The bridge is constructed of timber and was completed in 2017. The approximate location of the project area is shown on Figure 1.

The proposed concrete bridge will replace the existing timber bridge and will match the existing skew angle of 30 degrees and effective roadway width of 30 feet (total width of 34 feet). The new bridge will be 100 feet long (from Station 48+95.23 to Station 49+95.23) as it will extend the existing bridge abou22 feet to the west. The replacement bridge will consist of 3 spans, which from west to east will be 33.5, 33, and 33.5 feet long, respectively. The abutments will be supported on concrete footings about 10 feet wide by 41.3 feet long, and the 2 bents will be supported on a single row of 6 CIDH piles 24 inches in diameter spaced 6.5 feet on-center. The 2(H):1(V) abutment slopes will be protected from scour with a riprap revetment extending below the streambed. The new bridge grading will include westward widening of the Lanzit Ditch as well as excavations for the construction of the abutment foundations and the riprap revetment.

4. FIELD EXPLORATION AND LABORATORY TESTING

4.1. Field Exploration

The subsurface soil and groundwater conditions at the site were explored on May 20, 2014, and March 20, 2015 and included drilling, logging, and sampling of 3 hollow stem auger borings designated as B-1, B-2, and B-3 (see Figure 2 – Boring Location Map). This exploration was performed for the design of the existing timber bridge, but the collected data and findings are directly applicable to the design of the proposed concrete bridge.

The borings were excavated using a limited access truck-mounted CME 75 drill rig equipped with an 8-inch diameter hollow stem auger. Soil borings B-1 through B-3 were excavated to a depth of approximately 51.5 feet.

Both driven ring-type and bulk samples were retrieved at selected depths during drilling. The driven samples were collected utilizing a 2.5-inch-outside diameter California-type sampler driven by a 140-pound automatic trip hammer with a drop of 30 inches. Standard Penetration Testing (SPT) was also performed using the same hammer and drop in general accordance with ASTM D1586. The hammer efficiency was estimated from AASHTO (2012) Section 10.4.6.2.4 to be about 75 percent.

The soil borings were surface-logged by a California Professional Geologist, who also prepared the recovered samples for subsequent reference and laboratory testing. At the completion of drilling, the borings were backfilled with tamped soil cuttings. The soil boring logs are presented in Appendix A.

4.2. Laboratory Testing

Laboratory tests were performed on selected samples recovered from the boring to aid in the classification of soils and to evaluate pertinent engineering properties of the foundation soils. The following tests were performed:

- In-situ Moisture Content and Dry Density, ASTM D2937;
- Percent Passing #200 Sieve, ASTM D1140;
- Grain Size Distribution, ASTM D422;
- Atterberg Limits, ASTM D4318;
- Direct Shear Strength, ASTM D3080;

Testing was performed in general accordance with the referenced ASTM Standards, UBC, and California Test Methods. Results of all laboratory tests are presented in Appendix B. For convenient referral to the soil profile, selected laboratory results, including moisture and density determinations, have also been included on the boring logs in Appendix A.

5. GEOLOGIC CONDITIONS

5.1. Regional Geology

Regionally the subject site is located within the eastern Mojave Desert portion of San Bernardino County, California. This region is known as the Mojave Desert Geomorphic Province (MDGP), which is characterized by a series of structural and topographic basins bounded by relatively linear mountain ranges. The MDGP exists throughout eastern and southeastern California, Nevada, and western to southern Arizona. The alternating mountains and valley topography primarily resulted from extensional (pulling apart) tectonics that occurred during the Miocene (5.3 to 23 million years ago). Most of the valleys within the MDGP are truly basins collecting sediments eroded from the local mountain ranges. Streams remain trapped within the MDGP basins and do not terminate to the Pacific Ocean and/or Gulf of California (Sea of Cortez). All surface water flow and groundwater flow within basin drainages remains within the hydraulically closed basins, eventually flowing to playas at the lowest elevations, creating dry lakes where flows gather, become saline, and evaporate. Bristol Lake, located 5 miles southwest of the subject site, is the nearest closed basin.

Based on the regional mapping published by the USGS (Bedford and Miller, 2010) (see Figure 3 – Regional Geology Map), the subject site is mostly covered by surficial Quaternary younger alluvial fan deposits (Qyag) that rest on late to middle Pleistocene intermediate alluvial fan deposits (Qia). The surficial materials are typically made up of loose to moderately dense poorly to well graded sand and gravel clasts derived from granitic sources that have weathered to grus and that have been eroded from the surrounding mountains and deposited on a centennial to millennial basis. The late to middle Pleistocene sediments generally consist of dense well to poorly graded sands, gravels, and cobbles characterized by surfaces abandoned for tens of thousands of years. These Quaternary sediments rest on Tertiary volcanic and fanglomerate units and Archean to Jurassic granitic and metamorphic rocks. A geologic map with description of the main surficial geologic units within the subject site is shown on Figure 3 – Regional Geology Map.

5.2. Site Specific Geology

The site geology is characterized by surficial younger alluvial deposits. Locally, these fan deposits are sub-classified by their age of deposition and predominance of clay, silt, sand, and gravels. Based upon the findings from our subsurface investigation, the project site at the bridge abutments is mantled by artificial fill soils (af). Beneath the artificial fill, younger alluvial (Qy) soils of sand and gravel, were encountered to the base of the explorations. Within the ditch area beneath the bridge, active alluvium (Qa) soils of loose channelized sand deposits were encountered. Generalized descriptions of the encountered units are provided below. Detailed descriptions of the encountered soil conditions are presented on the boring logs in Appendix A.

5.3. Fill

Artificial embankment road fill (af) associated with Route 66 roadway and associated bridge embankments was encountered in the 2roadway borings (B-1 and B-2) to depths ranging from 5 to 9 feet below ground surface. The fills consisted of light brown to brown, medium dense to dense poorly graded sands to poorly graded sands with silt and gravels that were typically dry.

5.4. Active Alluvium

Active alluvial deposits were encountered in stream ditch area below the bridge (boring B-3) to a depth of 2 feet. These soils consisted of pale brown, loose well graded sands. These soils were observed to be damp, due to previous week's winter storm.

5.5. Younger Alluvium

Younger alluvial soils were encountered below the fill soils and active alluvial soils. They typically consisted of medium dense to very dense silty sand to sands, poorly graded sand with silt and gravel, and silty gravel with sand. The soils were typically pale brown to light brown to yellowish brown in color. These younger alluvial soils extended to the total depth of the exploratory borings.

5.6. Groundwater

Mapping by the State of California and Cadiz Groundwater Modeling and Impact Analysis, prepared by Geoscience, 2011, indicates that the groundwater level near the site is estimated to be deeper than 700 feet. Groundwater was not encountered in any of the borings undertaken in this exploration. It should be noted that groundwater levels may fluctuate due to seasonal variations, rainfall, irrigation, or other factors. Evaluation of such factors is beyond the scope of our services.

6. ENGINEERING SEISMOLOGY

6.1. General Seismic Setting

The Southern California region is known to be seismically active. Earthquakes occurring within approximately 60 miles of the site are generally capable of generating ground shaking of engineering significance to the proposed construction. The project area is located in the general proximity of several holocene-active faults, as shown on Figure 4 – Regional Fault Map. Holocene-active faults are defined as those that have experienced surface displacement within Holocene period (approximately the last 11,700 years).

The project site is located in eastern margin of the Eastern California Shear Zone, a broad seismically active region dominated by northwest trending right-lateral strike-slip faulting. Several named fault zones showing evidence of Quaternary movement have been identified and are illustrated on the generalized fault map on Figure 5 - Quaternary Faults and Earthquake Epicenter Map. Superimposed on this map are recorded earthquake epicenters recorded by the USGS between 1900 and 2023. The closest faults (not known to be active) to the subject site mapped by the CGS are the South Bristol Mountains fault and the Broadwell Lake fault. These faults are found at approximately 7 and 18 miles northwest of the subject site, respectively.

Very few earthquake epicenters have been recorded in the immediate area of the subject site. A large amount of seismic activity and associated events with their epicenters have been recorded west of the project site at a distance of about 35 miles, as shown in Figure 5. There have been 5 notable historic earthquakes in Southern California of significance to the subject site that are shown in Table 1. The most notable historic earthquakes occurred in 1992 (Landers earthquake) and 1999 (Hector Mine earthquake). The Landers earthquake is considered one of the 4 largest earthquakes to have occurred in Southern California in the past century.

Table 1
Significant Historical Earthquakes

Year	Date	Location	Mag.	Approximate Epicenter Location	EQ Name	Distance from Site
1999	16-Oct	Hector Mine	7.1	34.59°N, -116.27°W	Hector Mine	38.5 miles W
1992	28-Jun	Big Bear	6.5	34.17°N, -116.83°W	Big Bear	75.7 miles SW
1992	29-Jun	Landers Region	7.3	34.21°N, -116.44°W	Landers	53.5 miles SW
1992	23-Apr	Joshua Tree	6.2	33.96°N, -116.32°W	Joshua Tree	56.7 miles SW
1947	10-Apr	Newberry Springs	6.5	34.98°N -116.55°W	1947 Manix	61 miles NW

6.2. Seismic Hazards and Potential for Surface Fault Rupture

The engineering seismology study for the subject site included reviewing local and regional fault maps and the review of historical earthquake data. Specifically, the following engineering seismology issues were addressed:

6.2.1. Seismic Hazard Zones

Maps of seismic hazard zones are issued by the California Geological Survey (CGS, formerly California Department of Conservation, Division of Mines and Geology (CDMG)) in accordance with the Seismic Hazards Mapping Act enacted in April 1997. The intent of the Seismic Hazards Mapping Act is to provide for a statewide seismic hazard mapping and technical advisory program to assist cities and counties in developing compliance requirements to protect the public health and safety from the effects of strong ground shaking, liquefaction, landslides, or other ground failure and other seismic hazards caused by earthquakes.

Based on the review of available Maps of Seismic Hazard Zones in the State of California developed by the State of California Department of Conservation (https://maps.conservation.ca.gov/cgs/EQZApp/app/), the proposed development is located in an area that has not yet been mapped for susceptibility to the hazard of liquefaction or earthquake-induced landslides.

6.2.2. Surface Fault Rupture

Official Maps of Earthquake Fault Zones were reviewed to evaluate the location of the project site relative to active fault zones. Earthquake Fault Zones (known as Special Studies Zones prior to 1994) have been established in accordance with the Alquist-Priolo Special Studies Zones Act enacted in 1972. The Act directs the State Geologist to delineate the regulatory zones that encompass surface traces of active faults that have a potential for future surface fault rupture. The purpose of the Alquist-Priolo Act is to regulate development near active faults in order to mitigate the hazard of surface fault rupture.

Based on a review of Fault Maps from the Department of Conservation (https://maps.conservation.ca.gov/cgs/EQZApp/app/) the site is not located within a designated Earthquake Fault Zone for fault surface rupture hazard. The closest Earthquake Fault Zones with surface rupture hazard to the subject site mapped by the CGS are the Lavic Lake Fault Zone and the Pisgah-Bullion Fault Zone. These fault zones are both found at approximately 36 miles west and southwest of the subject site, respectively.

Surface traces of active or potentially active faults are not known to pass directly through or towards the site. Neither our field exploration nor literature review disclosed an active fault trace projecting to the ground surface in the project area. Therefore, the potential for surface rupture due to faulting occurring beneath the site during the design life of the proposed development is considered low.

6.2.3. Seismogenic Sources

The principal seismic hazard at the subject site is the potential for ground shaking associated with large earthquakes on distant faults. Of these, the most important is the San Andreas Fault Zone, an active fault of regional significance located approximately 70 miles southwest of the subject site.

In addition to the San Andreas Fault Zone, other regional fault zones that have been active in Holocene time include the Lavic Lake Fault Zone and the Pisgah-Bullion Fault Zone (mentioned above) and the Bullion Mountain and Calico-Hidalgo Fault Zones. The latter 2 fault zones are located approximately 34 and 41 miles west of the project area, respectively. The maximum earthquake magnitudes on these faults are estimated to be similar or slightly higher than those on the San Andreas Mojave Fault Zone (M_w 7.1). However, the recurrence interval of large earthquakes in the Eastern California Shear Zone is considered to be on the order of thousands of years. Therefore, the potential for a seismic event along these faults during the design life of the project is considered to be low.

The Ludlow Fault Zone is located approximately 26 miles west of the project area. The Ludlow Fault Zone has displaced alluvium as young as late Pleistocene but not Holocene. As shown in Figure 4, the Ludlow, Sheephole and Cleghorn Lakes and Cleghorn Pass Fault Zones appear to be associated with a relatively high amount of micro-seismic activity, however, none of these fault zones are classified as active, and none trend toward the subject site.

6.3. Design Acceleration Response Spectrum

Per Caltrans Seismic Design Criteria (Version 2, 2019), the Design Acceleration Response Spectrum (ARS) is defined as a probabilistic spectrum developed for ground motions with a probability of exceedance of 5 percent in 50 years (or 975-year return period). The design ARS was developed using the Caltrans ARS online tool v.3.1.0 (https://arsonline.dot.ca.gov/). The probabilistic spectrum was developed using the following parameters:

- The site coordinates for the Lanzit bridge of N34.5610º, W-115.5942º;

- Site Class D based on a shear wave velocity of 310 m/s. This shear wave velocity was estimated based on the correlation with Standard Penetration Test (SPT) blowcounts presented in a 2010 UCLA study, and included in the Caltrans Geotechnical Manual, Design Acceleration Response Spectrum" (Caltrans, January 2021). Since there was no information available beyond the maximum depth of exploration, the characteristic value of Vs_{30} for the upper 100 feet (30 meters) was computed by extrapolation using the David and Boore (2004) formula, included in the same document. It is noted that the blowcounts at the maximum depth of exploration (50 feet) indicate the presence of dense to very dense sands. It is possible that the likely denser soils below the depth could result in changing the site from Site Class D to Class C. However, since the investigation for this study did not extend to such depths, Site Class D was conservatively assumed in the analyses.

- No adjustments were made for near fault-factors since the bridge is located more than 10 miles from t any active faults in the area; no directivity adjustments were applied either as there are no near active faults or active faults that project towards the site.

- Basin amplification factors were not applied since the Lanzit Ditch basin is expected to be less than 1.9 miles deep, which is the minimum depth to bedrock considered to apply basin factors.

Figure 6 – Design ARS, presents the developed design ARS. The tabulated values of the recommended Design ARS are summarized in Table 2.

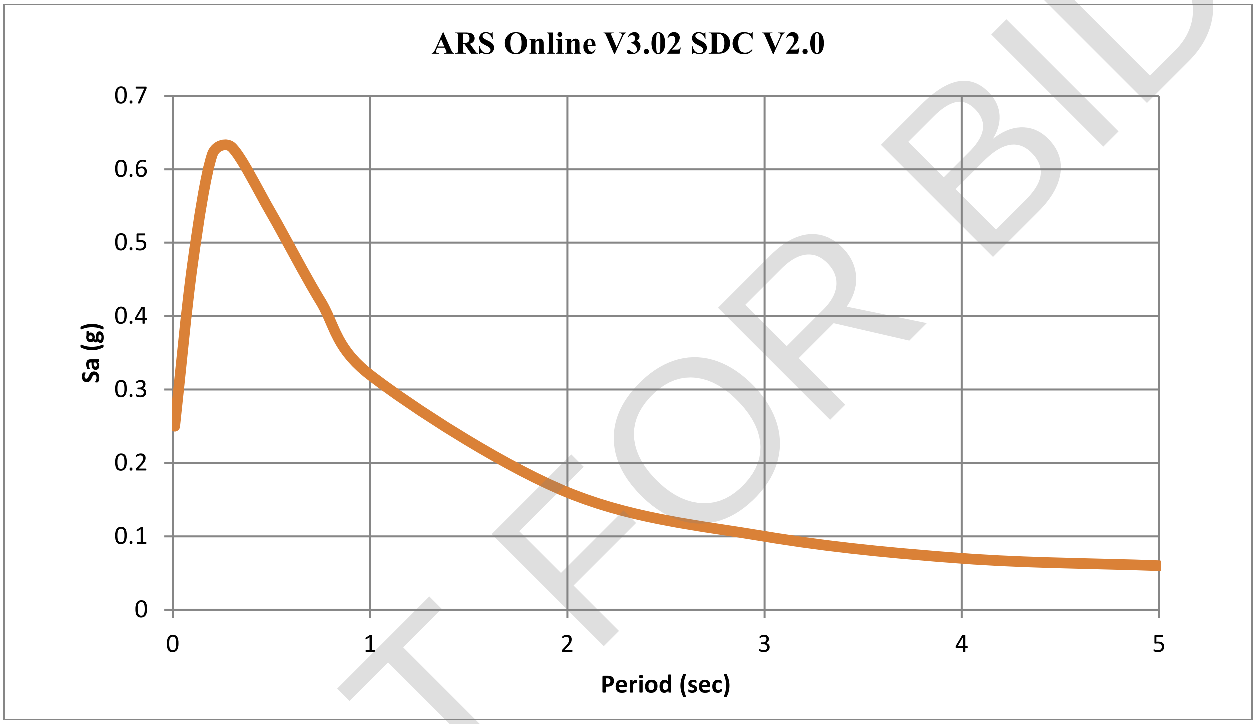

Figure 6. Design ARS

Table 2
Tabulated Values for Design ARS

Period (sec)	Spectral Acceleration $RotD_{50}$ (g)
0.01	0.25
0.1	0.47
0.2	0.62
0.3	0.63
0.5	0.54
0.75	0.42
1	0.32
2	0.16
3	0.1
4	0.07
5	0.06

6.4. Liquefaction Potential, Seismic Sensitivity, and Dynamic Settlement

Liquefaction and the associated loss of strength can be caused by ground shaking during earthquakes. Research and historical data indicate that loose, relatively clean granular soils and low plasticity silts are susceptible to liquefaction and dynamic settlement whereas the stability of the majority of clayey silts, silty clays and clays is not typically adversely affected by ground shaking. Liquefaction is generally known to occur in saturated or near-saturated cohesionless soils at depths shallower than about 50 feet.

6.4.1. Soil Description

Evaluation of liquefaction potential for the on-site materials was performed based on soil stratigraphy encountered in our field explorations. Based purely on apparent relative density, isolated lenses of soils susceptible to liquefaction were identified only at exploratory boring B-3 between the depths of approximately 5 to 10 feet. The materials consisted of medium dense sands with SPT uncorrected blowcounts ranging from 7 to 26 per foot. However, when these blowcounts were corrected for hammer energy efficiency, the blowcounts fall above or right at the limit where liquefaction is not considered to be an issue per AASHTO (2017) Section 10.5.4.2 when soils with corrected blowcounts greater than 25 blows per foot are not considered to be susceptible to liquefaction.

6.4.2. Groundwater Level

Mapping by the State of California and Cadiz Groundwater Modeling and Impact Analysis, prepared by Geoscience (2011), indicates that the groundwater level near the site is estimated to be deeper than 700 feet. Groundwater was not encountered in any of the borings undertaken in this exploration. AASHTO (2017) considers that if the groundwater level is anticipated to be deeper than 50 feet the site is not susceptible to liquefaction.

6.4.3. Seismic Demand for Liquefaction and Dynamic Settlement Analyses

The seismic demand to evaluate liquefaction and dynamic settlements is established by ASSHTO (2012) Section 10.5.4.2 based on ground motions with a 975-year return period (i.e., five percent in 50 years). Based on the USGS Seismic Hazard Interactive Deaggregation website (https://earthquake.usgs.gov/hazards/interactive/) for site coordinates Latitude 34.5610º N and Longitude -115.5942º W the $RotD_{50}$ peak ground acceleration (PGA) for the site was estimated to be approximately 0.25g for a Site Class D (assumed V_{s30} = 310 m/s). This ground motion corresponds to a predominant earthquake magnitude of M_w 6.4 located at a distance of approximately 10.9 km. These ground motion parameters were used in the dynamic settlement analyses.

6.4.4. Evaluation of Liquefaction and Loss of Strength Potential

The liquefaction potential was evaluated based on the liquefaction design requirements presented in AASHTO (2017) Section 10.5.4.2. Liquefaction is not considered a hazard at the site because the groundwater depth is greater than 50 feet.

It is noted and recognized that the groundwater levels will be affected by occasional seasonal flooding. However, the likelihood of simultaneous occurrence of a triggering seismic event and flooding is considered low and thus liquefaction is still not considered a hazard at the site.

Since the liquefaction potential is considered to be negligible, the potential for lateral spreading, or slope instability caused by flow failure are also considered to be negligible.

6.4.5. Seismically Induced Settlement

Seismically induced settlement can occur in both dry and saturated soils when loose to medium-dense granular soils undergo volumetric changes during ground shaking. Dynamic settlement can occur in saturated soils due to liquefaction or in dry soils due to densification of the soil matrix. As discussed above, the on-site soils are not susceptible to liquefaction, and therefore liquefaction-induced settlement is not anticipated. The potential for dry dynamic settlement was calculated using the procedures outlined in the Pradel (1998a and 1998b). Table 3 presents the results of the dynamic settlement estimates based on the information collected from soil borings B-1 through B-3.

Table 3
Results of Dry Seismic Settlement Analyses

<table>
<tr><th>Boring No.</th><th>Settlement of Dry Sands (inches)</th></tr>
<tr><td>B-1</td><td rowspan="3">negligible</td></tr>
<tr><td>B-2</td></tr>
<tr><td>B-3</td></tr>
</table>

As shown in Table 3, the combined seismically induced settlement of the on-site soils was calculated to be negligible. It is our opinion that the seismically induced settlement will not adversely impact the proposed bridge. The seismically induced settlement analyses are presented in Appendix C.

7. DESIGN RECOMMENDATIONS

7.1. General

Based on the results of the field exploration and engineering analyses, it is Tetra Tech's opinion that the proposed construction utilizing CIDH piles at the bents and spread footings at the abutments is feasible from a geotechnical standpoint, provided that the recommendations contained in this report are incorporated into the design plans and implemented during construction.

The design recommendations presented below are based on Tetra Tech's current understanding of the project. Once the project configuration is finalized and the design is complete, Tetra Tech should review the plans and specifications to evaluate if the geotechnical design recommendations have been incorporated as intended.

7.2. Clearing and Grubbing and Site Preparation

Prior to commencement of the earthwork, the construction area should be cleared of vegetation, trash, debris, and the existing structures including the existing bridge foundations, deadman and deadman tierods, and abutment slope protection. Any subterranean installations not to be preserved should be abandoned per the Geotechnical Engineer's recommendations and in accordance with applicable regulations. The existing rock slope protection not interfering with the proposed construction may remain in place in place.

Disturbed soils at structural and non-structural areas will likely occur after demolition of existing site improvements. These soils should be overexcavated and recompacted to the total depth of the disturbed material. The specific type of remediation and associated area limits will need to be evaluated in the field by the Geotechnical Engineer.

All structural backfill associated with the replacement of overexcavated soils, and all the structural backfill to be placed in the zone between the abutment foundations/walls and the approach embankments should have a Sand Equivalent of at least 20, comply with the gradation requirements presented in Table 4, and be compacted at least the optimum moisture content to at least 95 percent relative compaction per ASTM D1557. It is anticipated that the existing embankment materials and native soils can be used in the new construction.

The upper 2.5 foot of soils below finished grade within the width of the travelled way plus 3 feet on each side should be processed and compacted to at least 95 percent relative compaction.

Table 4
Structural Backfill Gradation Requirements (95% compaction)

Sieve Size	Percent Passing
3"	100
No. 4	35-100
No. 30	20-100

Except for materials mentioned above, any other embankment fill including fill placed to achieve finish grade or subgrade, utility trench backfill, and backfill of the riprap slope protection at the streambed shall comply with the gradation requirements presented in Table 5 and be compacted at least the optimum moisture content to at least 90 percent relative compaction per ASTM D1557.

Table 5
Structural Backfill Gradation Requirements (90% compaction)

Sieve Size	Percent Passing
3"	100

Excavated on-site soils may be re-used as compacted fill provided they are free of organics, deleterious materials, debris and particles over 3 inches in largest dimension. Locally, particles up to 6 inches in largest dimension may be incorporated in the fill soils based on specific approval and placement recommendations provided by the geotechnical engineer during grading.

In the event that any soil materials (including backfill or base course materials) are imported to the site, such soils should be sampled, tested, and approved by the geotechnical engineer prior to arrival on-site. In general, any soils imported to the site for use as fill should be predominantly granular and have an Expansion Index less than 20. Additional recommendations for site grading are provided in the "General Site Grading Recommendations" section of this report.

7.3. Rock Slope Protection (Riprap Revetment)

The rock slope protective cover to minimize scour problems at the abutments must comply with the rock gradation requirements and method placement specifications presented in the Caltrans Standard Specifications (2022) Section 72-2.

7.4. Temporary Slope and Trench Excavations

The on-site soils are not expected to pose unusual excavation difficulties, and therefore, conventional earth-moving equipment may be used. Localized sloughing/raveling of exposed soil intervals should be anticipated. All trench excavations should be performed in accordance with Cal/OSHA regulations. The on-site soils may be considered a Type C soil, as defined by the current Cal/OSHA soil classification.

Unsurcharged excavations: Sides of temporary, unsurcharged excavations less than 20 feet deep should be sloped back at an inclination of 1.5(H):1(V) or flatter. Where space for sloped sides is not available, shoring will be necessary. This office can provide appropriate shoring recommendations, once the excavation configuration is known.

Surcharge setback recommendations: Stockpiled (excavated) materials should be placed no closer than 4 feet from the top of the trench. A greater setback may be necessary when considering surcharge loads such as heavy vehicles, concrete trucks and cranes. Tetra Tech should be advised of such heavy vehicle loadings so that specific setback requirements can be established for the used equipment. Alternatively, a shoring system may be designed to allow reduction in the setback distance.

7.5. Embankment Slope Stability

The stability of the side slopes of the embankment was evaluated based on the proposed configuration of a 2(H):1(V) slope and a maximum slope height of 7 feet. The soil properties for the embankment include an angle of friction of 34°, cohesion of 50 psf and a unit weight of 120 pcf. The static Factor of Safety was computed as 2.2 for dry conditions and 2.8 for submerged conditions.

7.6. Scour Evaluation

Scour is the process of erosion of the streambed or bank material due to flowing water. The total scour to be expected at a bridge location is the sum of long-term degradation, contraction scour, and local scour.

Aggradation and degradation are long-term streambed elevation changes due to natural or man-induced causes which can affect the reach of the river where the bridge is located. Aggradation involves the process of deposition of material eroded from the channel or watershed upstream of the bridge, and it is not considered a component of total scour. Degradation involves erosion of the streambed over relatively long reaches due to a deficit in sediment supply from upstream and contributes to total scour. For this bridge the degradation scour has been assumed to be negligible per the County of San Bernardino.

Contraction scour is a lowering of the streambed across all or most of the channel width at the bridge due to contraction of the flow and the associated increase in flow velocity.

Local scour involves removal of material from around piers and abutments due to acceleration of flow and resulting vortices created by obstructions to the flow.

The evaluation of the contraction scour and the local scour was performed by the County of San Bernardino and the results are summarized in Table 6.

Table 6
Scour Analysis

Limit State	Contraction Scour (feet)	Local Scour (feet)	Total Scour[1] (feet)
Strength (construction) (100-year flood)	1.9	2.3	4.2
Service (100-year flood)	1.9	4.6	6.5
Extreme Event I (100-year flood)[2]	1.0	2.3	3.3
Extreme Event II (check flood)[3]	1.9	4.6	6.5

Notes:
1 Total scour is the sum of the contraction scour and the local scour for each Limit State.
2 For the extreme event I limit state half of the total scour is to be considered in conjunction with the earthquake loads.
3 Per AASHTO (2017) Section 3.4.1, the case of check floods should not be combined with other loadings

7.7. Bent CIDH Pile Foundation

The bents for the proposed bridge may be supported on 24-inch-diameter CIDH piles. The foundation design data and foundation loads as provided by the structural engineer are presented in Tables 7 and 8.

Table 7
24-inch CIDH Pile Design Data
Permissible Settlement under Service Load … 1 inch
No. of Piles per Support … 6

Support No.	Elevation (feet)			Pile Cap Size (feet)	
	Finished Grade	Bottom of Cap	Cut-Off	B	L
Pier 2	823.50	830.3	816.50	4	39.26
Pier 3		830.1			

Table 8
Pile Design Factored Loads in kips

Support No.	Service-I Limit State		Strength Limit State (Controlling Group)		Extreme Event Limit State	
	Total Load	Permanent Load	Compression	Tension	Compression	Tension
	Per Support / Max. per pile	Per Support	Per Support / Max. per pile			
Pier 2	704 / 120	376	1,052 / 193	Not applicable		
Pier 3	687 / 117	359	1,030 / 190			

7.7.1. Static Axial Capacity

The considered foundations at each bent include a single row of 6 CIDH piles spaced 3 pile diameters on-center. The static axial capacity of CIDH piles was estimated based on SPT N values using the beta method outlined in Section 10.3 of FWHA GEC 010 (2010).

Pile tip elevations were calculated for the required pile capacity at the bents. For each Limit State, the soil above the scour depth was assumed to be completely removed and the groundwater was assumed to be at the streambed elevation. The upper 10 feet of soil below the finished grade was conservatively assumed to be composed of recompacted native soils. Copies of pile capacities calculations including the utilized strength parameters used for each Limit State are provided in Appendix D.

Table 9A
Design CIDH Pile Tip Elevations

Support Location	Pile Type	Cut-off Elev. (ft)	Service-I Limit State Load per Support (kips)		c Total Permissible Settlement (inches)	Required Factored Nominal Resistance (kips)				Pile Tip Elevations (ft)	
						Strength/ Construction		Extreme Event			
			Total	Permanent		a1 Comp (ϕ_{qs}=0.7, ϕ_{qp}=0.5)	b1 Tension (ϕ=0.7)	a2 Comp (ϕ=1.0)	b2 Tension (ϕ=1.0)	Design	Specified
Pier 2	24-inch CIDH	816.5	704	376	1	193	-	-	-	765.5 (a1) - (b1) 806.5 (c) 785 (d)	763.5
Pier 3			687	359		190	-	-		768.5 (a1) - (b1) 806.5 (c) 785 (d)	766.5

Notes:

1. Design tip elevations are controlled by: (a1) compression (Strength Limit), (b1) Tension (Strength Limit), (a2) Compression (Extreme Event), (b2) Tension Extreme Event, (c) Settlement, (d) Lateral Load
2. The specified tip elevation shall not be raised. Per Caltrans Geotechnical Manual (2021) the specified tip elevation should be lowered a minimum of 2 feet below the calculated bottom of the side resistance zone to account for limitations in the pile integrity testing methods. Thus, the specified tip elevations are 2 feet lower than the controlling tip elevations.
3. Design tip elevation for Lateral Load provided by SD.

The design and specified pile tip elevations are presented in Table 9A. Per Caltrans Geotechnical Manual (2021) the specified tip elevation should be lowered a minimum of 2 feet below the calculated bottom of the side resistance zone to account for limitations in the pile integrity testing methods. Thus, the specified tip elevations are 2 feet lower than the controlling tip elevations. The pile data is also summarized in Table 9B.

The pile capacities and estimated tip elevations consider pile group effects by modifying the axial capacity of each individual pile by a reduction factor of 0.76 based on the on-center pile spacing of 3 diameters as required by Section 14.4.1.2 of FHWA GEC 010 (2010).

Table 9B
Pile Data Table

Support No.	Pile Type	Nominal Resistance (kips)		Pile Tip Elevations (ft)	
		Compression	Tension	Design	Specified
Pier 2	24-inch CIDH	320	-	765.5 (a1) - (b1) 806.5 (c) 785 (d)	763.5
Pier 3		316	-	768.5 (a1) - (b1) 806.5 (c) 785 (d)	766.5

7.7.2. p-y Curve Soil Parameters

Table 10 presents the recommended soil parameters to be used with LPile software for the analysis and design of laterally loaded piles. The provided parameters are conservatively estimated assuming that the soils are fully saturated.

As indicated in Note 3 in Table 10, scour and soil disturbance effects may be modeled in LPile by specifying a near-zero p-multiplier (i.e., 10^{-06}) which effectively eliminates any soil lateral resistance, and by specifying a negligible unit weight (i.e., 10^{-06} pcf) so that the soils within the scour/disturbance interval do not provide any overburden surcharge to the soils below.

The presented parameters and elevations are deemed applicable for both bent locations. It is recognized that the parameters are based on investigation carried out within the within the existing streambed while the new Bent #2 will be located farther west in the area of the existing west abutment where the soils could be possibly less impacted by the flood flows. However, in the absence of appropriate data the presented parameters are deemed appropriately conservative.

Table 10
p-y Curve Parameters for LPile Analyses [1]

Elevation[2] (ft)	Depth (ft)	ϕ (deg)	k (pci)	Effective Unit Weight[3] (pcf)	p-multiplier[3]
823.5-821.5	0 – 2 (near surface disturbance zone)	33	60	10^{-06}	10^{-06}
821.5-814	2 – 9.5	33	60	58	1
814-809	9.5-14.5	37	105	62.2	
809-804	14.5-19.5	38	120		
804-799	19.5-24.5	36	90		
799-794	24.5-29.5	37	105	50.1	
794-773.5	29.5-50	39	140	52	

Notes:
1. API Sand soil model to be used for all layers
2. Ground surface (i.e., finished grade / streambed) elevation of 823.50 feet provided by Dokken
3. Within the 2-foot disturbance depth and the scour depth for each Limit State use an effective unit weight of 10^{-6} pcf and a p-multiplier of 10^{-6}

The parameters provided in Table 10 are for a single pile subjected to lateral load. Since closely spaced piles are considered, the lateral load capacity should be reduced to consider the pile group interaction as discussed below.

For lateral load parallel to the pile bent row, there would be a reduction of the lateral load capacity if the center-to-center spacing between piles is less than 8 times the diameter (D) of a single pile. The p-multipliers presented in Table 11a are recommended by Caltrans California Amendments to AASHTO LRFD Bridge Design Specifications (2022), Section 10.7.2.4. These p-multipliers for the leading pile row, 2nd, and 3rd and subsequent pile rows, should be used in by multiplying the p-multipliers provided in Table 10.

Table 11a
Pile p-multipliers for Closely Spaced Piles
Static Loading Parallel with the Pile Row

Pile Center to Center spacing (in the direction of loading)	p-multiplier		
	Row 1	Row 2	Row 3 and higher
2 D	0.60	0.35	0.25
3 D	0.75	0.55	0.40
5 D	1.00	0.85	0.70
7 D	1.0	1.0	0.90

For lateral load is normal (perpendicular) to the pile row, there would be a reduction of the lateral load capacity if the center-to-center spacing between piles is less than 4 times the diameter of a single pile. The p-multipliers presented in Table 11b are recommended by Caltrans California Amendments to AASHTO LRFD Bridge Design Specifications (2022), Section 10.7.2.4. These p-multipliers should be used by multiplying the p-multipliers provided in Table 10.

Table 11b
Pile p-multipliers for Closely Spaced Piles
Static Loading Perpendicular to the Pile Row

Pile Center to Center spacing (in the direction perpendicular to the loading)	**p-multiplier**
2.5 D	0.8
3 D	0.9
4 D	1.0

Under cyclic conditions (earthquake loading), FHWA-NHI-11-032 (2011) Section 10.6.4 recommends for lateral load parallel to a pile row p-multipliers as shown in Table 11c. These p-multipliers should be used by multiplying these p-multipliers with the scour/disturbance zone p-multipliers listed in Table 10. The p-multipliers provided in Table 11a should not be used because the shading effect is already included in the cyclic p-multipliers.

Table 11c
Pile p-multipliers for Closely Spaced Piles
Cyclic Loading Parallel with the Pile Row

Pile Center to Center spacing (in the direction of loading)	**p-multiplier**
3 D	0.5
4 D	0.7
5 D	0.9

7.7.3. Pile Construction Recommendations

The performance and capacities of CIDH piles can be significantly influenced by the used construction methods and procedures. Construction methods that create large zones of disturbance around the drilled pile boreholes can lead to lower-than-expected skin friction and/or lateral support. Therefore, it is recommended that an experienced contractor be retained for installation of the CIDH piles.

The pile construction will include the drilling of 24-inch-diameter boreholes. It is anticipated that conventional drilling equipment can be used considering that the exploratory borings were previously excavated with a regular hollow stem auger without excessive effort. It is expected that groundwater will likely not be encountered as long as the drilling is performed during the dry season and therefore, it is not expected to impact the drilling progress. However, it is expected that some zones of coarse-grained materials may cave during drilling. Consequently, the Contractor should be prepared to address and minimize the impact of such adverse conditions. Since the CIDH axial pile capacity relies on the end bearing, it will be necessary for the Contractor to remove any disturbed materials from the bottom of the pile hole.

The CIDH piles should be checked for alignment and plumbness. The amount of acceptable misalignment of a pile is approximately 2 to 3 inches from the exact location and it is usually acceptable to be out of plumb 1 inch over 10 feet of the length of the pile.

Tremie method of concrete placement should be used so that the concrete delivery begins at the bottom of the hole and is always below the rising level of concrete so that all water and/or drilling fluid is removed from the boring. The concrete should be first placed to develop a minimum head of 5 feet of concrete above the bottom of the tremie and then the tremie pipe can be withdrawn in step with the placement of concrete, always maintaining a head of concrete of at least 5 feet above the delivery point. If casing is used, the pipe should be pulled by keeping a positive concrete head above the bottom of the casing. The concrete should not be allowed to fall freely more than 5 feet and to prevent concrete from striking the walls of the borehole possibly causing caving and contamination of the concrete with sloughed material. Concrete should be placed and vibrated throughout the full length of the pile so that voids in pile concrete are minimized. The pile drilling, the steel cage installation, and the concrete pour should be completed within the same day, that is, pile excavations should not be left open overnight.

7.8. Abutment Footing Foundations

At the abutments the bridge will be supported on supported on an abutment wall supported on buried concrete pad footing. The abutment design configuration data are provided in Table 12.

Table 12
Abutment Foundation Design Data

Support No.	Finished Grade Elevation (feet)	Bottom of Footing Elevation (feet)	Footing Dimensions (ft)		Permissible Settlement under Service Load (in)
			B	L	
Abut 1 (west)	826.3	814	10	41.7	1
Abut 4 (east)	824.5				

The anticipated loads on the abutment foundations provided by Dokken are summarized in Tables 13a through 13d, and the foundation bearing pressures are provided in Table 14.

Table 13a
Abutment Service I Limit State Loads
Total Loads

Support No.	PTOTAL Gross (kips)	PTOTAL (kips) Net	Mx (kips-ft)	My (kips-ft)	Vx (kips)	Vy (kips)
Abut 1	1,339	827	651	0	0	487
Abut 4	1,319	827	532	0	0	464

Table 13b
Abutment Service I Limit State Loads
Permanent Loads

Support No.	PPERMAN Net (kips)	Mx (kips-ft)	My (kips-ft)	Vx (kips)	Vy (kips)
Abut 1	682	109	0	0	459
Abut 4	683	105	0	0	435

Table 13c
Abutment Strength, Construction Limit State Loads

Support No.	PTOTAL Gross (kips)	Mx (kips-ft)	My (kips-ft)	Vx (kips)	Vy (kips)
Abut 1	1,733	966	0	0	675
Abut 4	1,703	837	0	0	639

Table 13d
Abutment Extreme Event Limit State Loads

Support No.	PTOTAL Gross (kips)	Mx (kips-ft)	My (kips-ft)	Vx (kips)	Vy (kips)
Abut 1	Not applicable				
Abut 4					

Table 14
Abutment Bearing Stresses

Support No.	Service Limit State		Strength Limit State		Extreme Event Limit State	
	B' (feet)	Bearing Stress (ksf)	B' (feet)	Bearing Stress (ksf)	B' (feet)	Bearing Stress (ksf)
Abut 1	9.0	4.1	8.9	5.4	Not applicable	
Abut 4	9.1	3.9	9.0	5.2		
B' – Effective Width						

7.8.1. Bearing Capacity

The foundation design recommendations for the footings at the abutments are provided in Table 15. It is assumed the rock slope protection remains in place during the design storm event and so no scour will take place at the abutments. Furthermore, it is assumed that the soils are fully saturated.

Table 15
Abutment Foundation Design Recommendations

Support Location	Footing Size (feet)		Bottom of Footing Elevation (feet)	Minimum Footing Embedment Depth (feet)	Total Permissible Support Settlement (inches)	Service Limit State	Strength Limit State *(ϕb=0.45)*	Extreme Event Limit State *(ϕb=1.0)*
	B	L				Permissible Net Contact Stress (ksf)	Factored Gross Nominal Bearing Resistance (ksf)	Factored Gross Nominal Bearing Resistance (ksf)
Abut 1	10	41.7	814	9.5	1	4.1 (B' = 9.0 feet)	10 (B'=8.9 feet)	Not applicable
Abut 4						3.9 (B' = 9.1 feet)	10 (B'=9.0 feet)	

Additional geotechnical design parameters for the abutment footings are provided in Table 16.

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Table 16
Additional Design Parameters
Abutment Footings

Allowable Coefficient of Friction (incorporates ϕ_T= 0.8)	• 0.44 mass concrete on soil • 0.32 formed concrete on soil
Allowable Lateral Passive Resistance (incorporates ϕ_{ep} = 0.5)	• 110 pcf (EFD, equivalent fluid density, for saturated compacted fill with ϕ=34°) • The passive resistance derived from the upper 12 inches should be neglected.
Allowable Combined Lateral Resistance	• Total allowable resistance to lateral loads can be calculated by combining lateral resistance due to friction at the base and lateral passive resistance. • Passive resistance values may be increased by one-third when considering transient wind or seismic loading

7.8.2. Lateral Pressures on Abutment and Wing Walls

The space behind the abutment/wing walls will be backfilled with engineered fill. The following lateral loads need to be considered for both the abutment walls and the wing walls:

- Geostatic loads after backfill placement;
- Surcharge loads due to embankment and pavement placed above the top of the abutment/wing wall;
- Traffic loads; and,
- Seismically induced loads.

These loads are to be applied to the abutment and wing walls between the bottom of the footing and the top of the wall and be factored by appropriate loading factors for each Limit State.

For the design it is assumed that the embankment fill behind the abutment and wing walls is saturated but no pore pressures develop behind the wall as the design should include a backdrain system consisting of a geocomposite drain connected to a collector pipe to convey the water to a proper outlet. If drainage behind the abutment/wing walls cannot be provided, the walls should be designed to account for full hydrostatic pressure in addition to all the other lateral earth pressures calculated based on buoyant unit weights. The individual lateral loading components should be computed as indicated in the following sections. These loads need to be considered with the appropriate load factors for the different Limit States as indicated in Table 17 per AASHTO (2017) Section 3.4.

Table 17
Factored Load Combinations Involving Earth Loads

Load Combination Limit State	EH_1, EH_2, ES	LS	EQ
Strength I	γ_{pEH}•EH_2 + γ_{pES} •ES	1.75•LS	-
Strength II	γ_{pEH}•EH_2 + γ_{pES} •ES	1.35•LS	-
Strength III	γ_{pEH}•EH_2 + γ_{pES} •ES	-	-
Strength IV	γ_{pEH}•EH_2 + γ_{pES} •ES	-	-
Strength V	γ_{pEH}•EH_2 + γ_{pES} •ES	1.35•LS	-
Extreme Event I	γ_{pEH}•EH_2 + γ_{pES} •ES	0.5•LS	1.0•EQ
Extreme Event II	γ_{pEH}•EH_2 + γ_{pES} •ES	0.5•LS	-
Service I	1.0•EH_2 + 1.0•ES	1.0•LS	-
Service II	1.0•EH_2 + 1.0•ES	1.30•LS	-
Service III	1.0•EH_2 + 1.0•ES	0.80•LS	-
Service IV	1.0•EH_2 + 1.0•ES	-	-
Fatigue I	-	1.50•LS	-
Fatigue II	-	0.75•LS	-

Where:
EH_2 is the horizontal Earth Pressure after backfill placement
ES is the Earth Surcharge
LS is the Live Load Surcharge due to vehicular traffic
EQ is the Earthquake Seismic Increment
γ_{pEH} is the limit state coefficient and has a maximum value of 1.35 and a minimum of 0.90
γ_{pES} is the limit state coefficient has a maximum value of 1.5 and a minimum of 0.75
This Table only presents the load components and factors applicable to earth loads. Other loads and load combinations must be considered by the designer in accordance with AASHTO Section 3.4.

7.8.2.1. Lateral Geostatic Earth Pressure (EH_2)

The walls will be loaded laterally by the backfill as indicated by the expression below:

$$\boldsymbol{P_{TOTALGeostatic} = 0.5 * K_l * \gamma * H_w^2} \text{ (lbf/ft of wall length)}$$

where: K_l … for wingwalls use active pressure coefficient for the engineered backfill soils considering a level grade behind the wall of 0.28; for diaphragm abutment walls use at-rest pressure coefficient for the engineering backfill soils considering a level grade behind the wall of 0.44;

γ … unit weight of the embankment soil behind the abutment/wing wall; use 125 pcf;

H_w … abutment/wing wall height above the bottom of footing elevation.

The lateral earth pressure distribution is triangular as shown in Figure 7 – Loading Diagram of Geostatic Pressures on Abutment/Wing Wall, and the maximum ordinate for the lateral earth pressures p_l can be determined as follows:

$$p_a = \frac{2P_{TOTALGeostatic}}{H_w} = K_l \gamma H_w$$

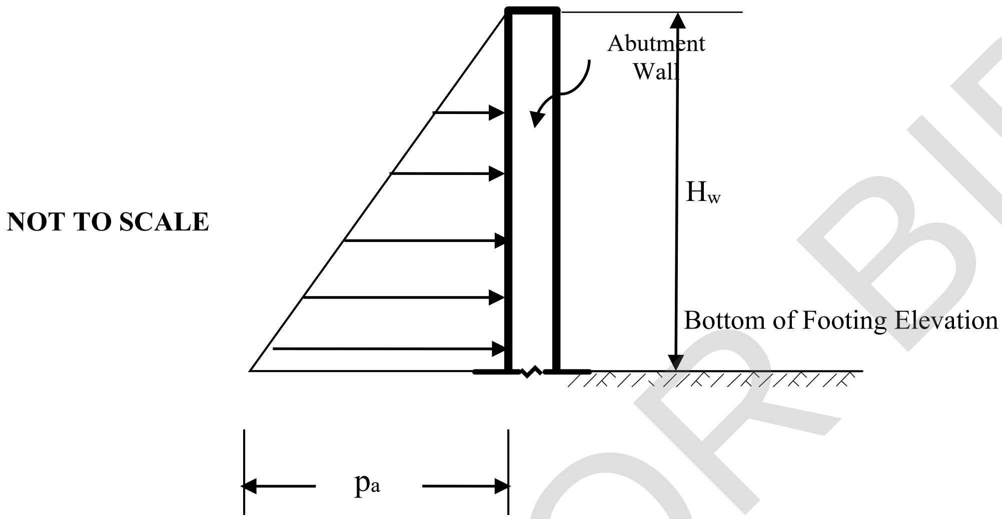

Figure 7. Loading Diagram of Geostatic Pressures on Abutment/Wing Wall

7.8.2.2. Lateral Pressure due to the Embankment above Top of Wall (ES)

The total force due to the embankment and pavement section surcharge can be calculated as shown below:

$$P_{TOTAL\ Embankment} = K_l\ \gamma\ H_{Embankment}\ H_w \quad \text{(lbf/ft of wall width)}$$

Where:

- K_l … for wingwalls use active pressure coefficient for the engineered embankment soils considering a level grade behind the wall; use 0.28; for diaphragm abutment walls use at-rest pressure coefficient for the engineering embankment soils considering a level grade behind the wall; use 0.44;
- γ … unit weight of the embankment soil behind the wall; use 125 pcf;
- $H_{Embankment}$ … height of the embankment (including pavement section) above the top of the wall;
- H_w … wall height above the bottom of footing elevation.

The lateral earth pressure distribution is uniform rectangular as depicted in Figure 8 – Loading Diagram of Lateral Earth Pressures Induced by the Embankment Surcharge behind the Abutment/Wing Wall, and the pressure diagram ordinate p_a can be determined as follows:

$$p_a = K_l \gamma H_{Embankment}$$

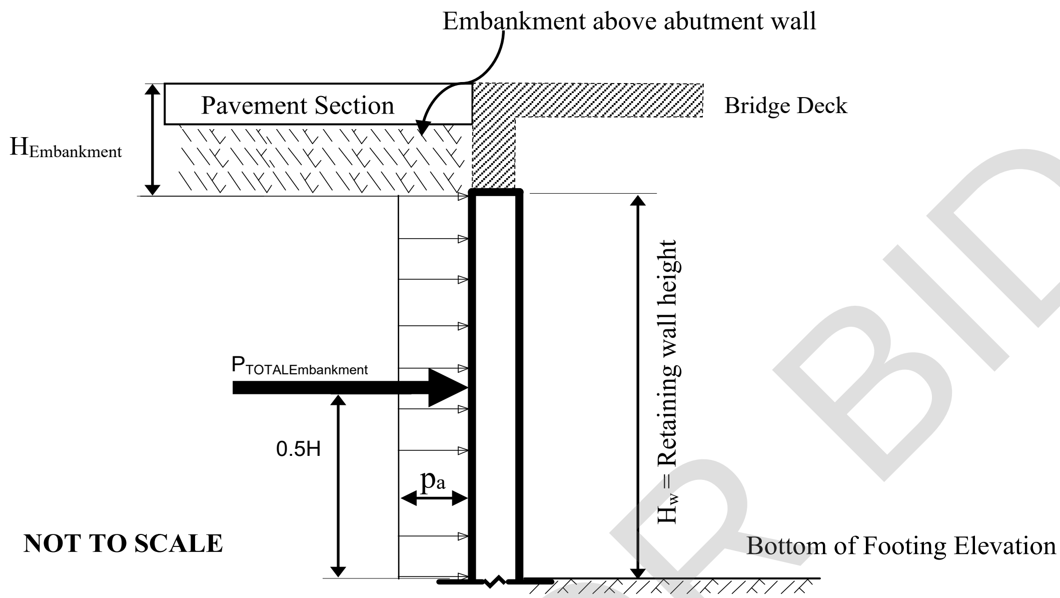

Figure 8. Loading Diagram of Lateral Earth Pressures Induced by the Embankment Surcharge behind the Abutment/Wing Wall

7.8.2.3. Lateral Pressure due to the Live Load Surcharge (LS)

The total force due to the vehicular traffic loading is determined based on the AASHTO LRFD Bridge Design Specifications (2017) Section 3.11.6.4 as an equivalent surcharge load. The total force due to the live load surcharge can be calculated as shown below:

$$P_{TOTAL\,Traffic} = K_l \, \gamma \; H_{Traffic} \; H_w \quad \text{(lbf/ft of wall width)}$$

Where: K_l … for wingwalls use active pressure coefficient for the engineered embankment soils considering a level grade behind the wall; use 0.28; for diaphragm abutment walls use at-rest pressure coefficient for the engineering embankment soils considering a level grade behind the wall, use 0.44;

γ … unit weight of the embankment soil behind the wall; use 125 pcf;

$H_{Traffic}$ … equivalent height of soil for vehicular traffic; use 4 feet for loading on abutment/wing walls perpendicular to traffic and 2 feet for walls parallel to traffic;

H_w …wall height above the bottom of footing elevation.

The lateral earth pressure distribution is uniform rectangular as depicted in Figure 9 – Loading Diagram of Lateral Earth Pressures Induced by Traffic Loading, and the pressure diagram ordinate p_a can be determined as follows:

$$p_a = K_l \gamma H_{Traffic}$$

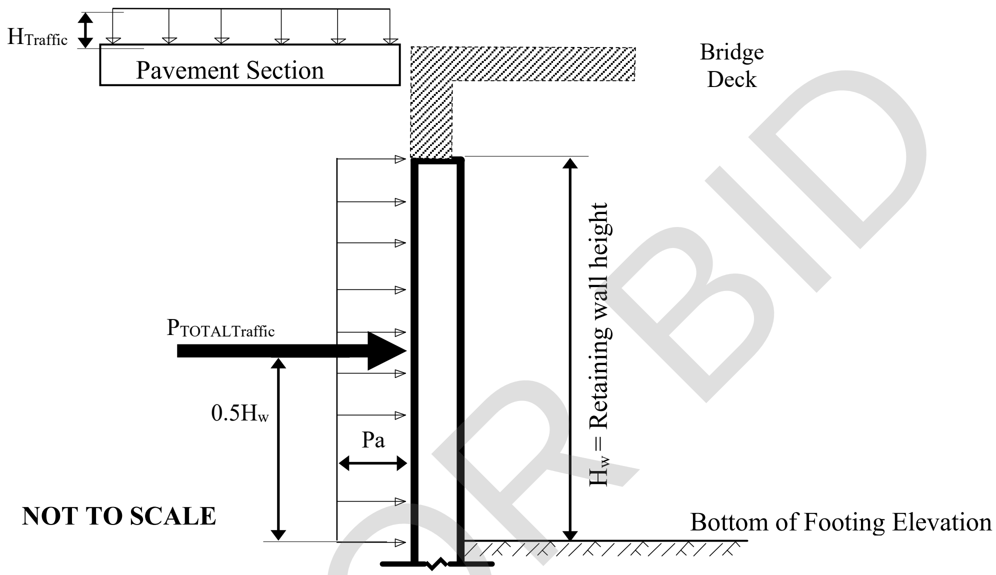

Figure 9. Loading Diagram of Lateral Earth Pressures Induced by Traffic Loading

7.8.2.4. Lateral Earth Pressure Increment due to Seismic Loading (EQ)

The Mononobe-Okabe (1929, 1926) approach was used to determine the coefficient of active seismic pressure on the abutment/wing wall and for subsequent calculation of the total (geostatic + seismic increment) lateral load. A horizontal seismic coefficient k_h of 0.33 was used as recommended by AASHTO (2017) Section 11.6.5.3 for non-yielding walls. This total lateral load includes the effects of the seismically induced loading from the wall backfill as well as the embankment above the top of the abutment/wing wall and can be computed as follows:

$$P_{TOTAL\ SEISMIC} = 0.5\,\gamma\, Ka''\, H^2 \quad \text{(lbf/ft of wall width)}$$

Where: K_a'' … total seismic coefficient of active earth pressure for the embankment soils calculated using the Mononobe-Okabe approach for a horizontal seismic coefficient of 0.33; use 0.52 for a backfill friction angle of 34° and an interface angle of friction δ of 0°;

γ … unit weight of the embankment soil behind the abutment/wing wall; use 125 pcf;

H … total height of soil retained above the bottom of the footing elevation, $H_{embankment} + H_w$ as depicted in Figure 10.

The total lateral earth pressure distribution is triangular (similar to Figure 7), and the maximum ordinate for the lateral earth pressures p_a for the seismic case, can be determined as follows:

$$p_a = 2\frac{P_{TOTAL\ SEISMIC}}{H}$$

Because the net seismic increment load due to the soil retained behind and above the top of the wall is required for the LRFD procedure rather than the total seismic lateral load, the seismic increment can be computed by subtracting the active static force from the total lateral seismic force and redistributing into a uniform rectangular distribution as shown in Figure 10 – Loading Diagram of Seismic Pressure Increment of Earth Pressure. The net seismic increment force can be computed as follows:

$$P_{SEISMIC\ increment} = 0.5\,\gamma\,K_a^{"}H^2 - 0.5\gamma K_a H^2 = 15.7\,H^2 \quad \text{(lbf/ft of wall width)}$$

Where: K_a … coefficient of active earth pressure for the embankment soils; use 0.28

$K_a^{"}$… total seismic coefficient of active earth pressure for the embankment soils calculated using the Mononobe-Okabe approach for horizontal seismic coefficient 0.33; use 0.52 for a backfill friction angle of 34° and an interface angle of friction δ of 0°.

The uniform rectangular seismic increment distribution ordinate p_a can be determined as follows:

$$\boldsymbol{p_a = 15.7\,\frac{H^2}{H_w}}$$

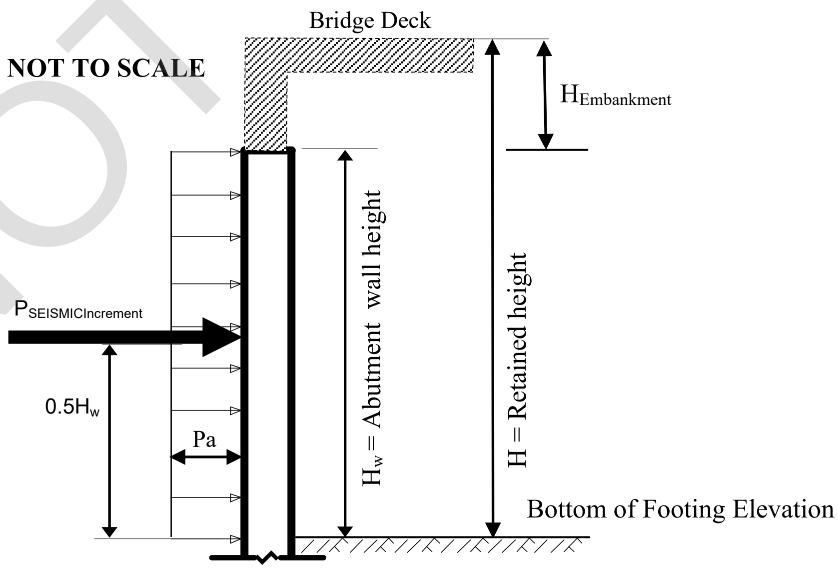

Figure 10. Loading Diagram of Seismic Pressure Increment of Earth Pressures

7.8.2.5. Passive Lateral Resistance

The maximum passive force resisting the movement of a diaphragm abutment (*dia*) in the longitudinal direction can be computed according to Caltrans Seismic Design Criteria (2019) Section 6.3 as follows:

$$P_{dia} = w_{dia} * e^{-\theta/45} * \frac{5.5 * h_{dia}{}^{2.5}}{1+2.37\ h_{dia}} \text{ (kips)}$$

Where: w_{dia} … abutment width along the skew direction in feet;
h_{dia} … height of the diaphragm abutment in feet;
θ … abutment skew angle (degrees);

The abutment stiffness for fill material meeting the requirements of Caltrans Standard Specifications (2022) can be computed as follows:

$$K_{dia} = w_{dia} * (5.5 * h_{dia} + 20) * e^{-\theta/45} \text{ (kips/inch)}$$

Bridge abutments are only effective in compression. The structural designer will have to consider the contributions of other structural elements in the longitudinal direction.

The magnitude of the transverse stiffness can be taken into consideration by the structural designer in accordance with SDC Caltrans (2019) as described in Section 6.3.2.

7.9. Soil Corrosion

The corrosion potential of the on-site materials to buried steel and concrete was evaluated based on the testing carried out for the accompanying project at the Dola Ditch Bridge. Based on our observations the soils at both bridge locations are considered to be similar. Laboratory testing performed on representative soil samples from the Dola Ditch Bridge is presented in Table 18 below.

The corrosion potential of the on-site materials to buried concrete and steel was evaluated in accordance with Caltrans corrosive environment evaluation criteria. Caltrans considers a site to be corrosive, if at least one of the following conditions exists:

- Chloride content ≥ 500 ppm;
- Soluble sulphate content ≥ 2,000 ppm;
- pH ≤ 5.5.

Minimum resistivity serves only as an indicator parameter for the possible presence of soluble salts and thus higher propensity for corrosion.

Table 18
Corrosivity Results

Location	Sample ID	Depth	Minimum Resistivity (ohm-cm)	pH	Soluble Sulfate Content / Sulfate Exposure CTM 417
B-1 (Dola)	SK-1	0 – 5 feet	16,200	7.7	6 ppm
B-3 (Dola)	SK-3	0 – 6 feet	Not tested	Not tested	14 ppm

Observations and laboratory tests indicate that based on the Caltrans' criteria the soils at the site are not considered corrosive. The corrosion potential of the on-site soils should be verified during construction for each encountered soil type. Any imported fill materials should be tested to confirm that their corrosion potential is not more severe than those assumed herein.

8. GENERAL SITE GRADING RECOMMENDATIONS

The intent of this section is to provide general information regarding the site grading. Site grading operations should conform with applicable local building and safety codes and to the rules and regulations of those governmental agencies having jurisdiction over the subject construction.

The grading contractor is responsible for notifying governmental agencies, as required, and the Geotechnical Engineer of Record at the start of site cleanup, at the initiation of grading, and any time that grading operations are resumed after an interruption. Each step of the grading should be accepted by the Geotechnical Engineer of Record, and where required, should be approved by the applicable governmental agencies prior to proceeding with subsequent work.

The following site grading recommendations should be regarded as minimal. The site grading recommendations should be incorporated into the project plans and specifications.

1. Prior to grading, existing vegetation, trash, surface structures and debris should be removed and disposed off-site at a legal dumpsite. Any existing utility lines, or other subsurface structures which are not to be utilized, should be removed, destroyed, or abandoned in compliance with current governmental regulations.

2. Subsequent to cleanup operations, and prior to initial grading, a reasonable search should be made for subsurface obstructions and/or possible loose fill or detrimental soil types. This search should be conducted by the contractor, with advice from and under the observation of a representative of the geotechnical engineer of record.

3. Prior to installation of foundations or any placement of fill, the site should be prepared in accordance with the recommendations presented in the section "Site Preparation" of this report. All undocumented fill or disturbed soils within the construction area should be removed and processed as recommended by the Geotechnical Engineer of Record.

4. The exposed subgrade and/or excavation bottom for the abutment footings should be observed and approved by the Geotechnical Engineer of Record for conformance with the intent of the recommendations presented in this report and prior to any further construction or fill placement. It should be understood that the actual encountered conditions may warrant excavation and/or subgrade preparation beyond the extent recommended and/or anticipated in this report.

5. On-site inorganic granular soils that are free of debris or contamination are considered suitable for placement as compacted fill.

6. Any imported fill material required for backfill or grading should be tested and approved prior to delivery to the site.

7. Visual observations and field tests should be performed during grading and pile and foundations construction by the Geotechnical Engineer of Record.

8. Wherever, in the opinion of the Geotechnical Engineer of Record, an unsatisfactory geotechnical grading or foundation condition is being created in any area, the work should not proceed in that area until the condition has been corrected.

9. DESIGN REVIEW AND CONSTRUCTION MONITORING

Geotechnical review of plans and specifications and participation during construction are an integral part of the geotechnical design practice. The following sections present our recommendations relative to the review of construction documents and the monitoring of construction activities.

9.1. Plans and Specifications

Upon completion, the civil and structural design plans and specifications should be reviewed and approved by Tetra Tech prior to submittal for issuance of grading and construction permit and prior to bidding of construction tasks as the geotechnical recommendations may need to be re-evaluated based on the actual design configuration and loads. This review is necessary to evaluate whether the recommendations contained in this report have been incorporated into the project plans and specifications as intended.

9.2. Construction Monitoring

The objective of the construction quality assurance (CQA) is to assist in the construction of the soils and soils-structure interaction components of the project. Continuous observation of site excavation, processing and assessment of fill materials, fill placement, foundation installation, and other site grading operations by the Geotechnical Engineer should be implemented during construction to allow for evaluation of the geotechnical-related conditions as they are encountered. This process provides the Geotechnical Engineer with the opportunity to recommend appropriate revisions as needed.

9.2.1. Grading Observations

The Geotechnical Engineer should observe the excavation, subgrade preparation for foundations, pavements, and fill placement so that appropriate modifications to the design, extent, or procedure may be provided, as necessary, should conditions encountered during grading differ from the design assumptions. The grading observations by the Geotechnical Engineer are also recommended to assist the Contractor in obtaining the proper moisture content and required degree of compaction.

9.2.2. Foundation Subgrade Observations

The Geotechnical Engineer should observe and evaluate the presence of satisfactory materials at the foundation subgrade. The foundations excavations should be observed by the Geotechnical Engineer to verify if soft or loose soils or other unsatisfactory materials are encountered, and whether or not such materials should be removed and replaced with compacted fill prior to pouring the foundation.

9.2.3. CIDH Pile Installation Observations

The installation of the CIDH piles should be carried out under the continuous observation of the Geotechnical Engineer to verify the installation configuration, design assumptions and conformance with the intent of the recommendations contained herein, and to provide additional recommendations as appropriate.

CIDH pile acceptance testing should also be performed in accordance with California Test 233 (Caltrans, 2005), "Method of Ascertaining the Homogeneity of Concrete in CIDH Piles Using the Gamma-Gamma Test Method".

9.2.4. Pavement Construction Observations

Preparation of the pavement subgrade and the placement of base course and pavement sections should be observed by the Geotechnical Engineer. Careful observation is recommended to evaluate that the pavement subgrade is uniformly compacted, and the recommended pavement and base course thicknesses are achieved.

10. LIMITATIONS

The recommendations and opinions expressed in this report are based on Tetra Tech's review of background documents and on information obtained from limited field explorations and the associated laboratory testing. It should be noted that this study did not evaluate the possible presence of hazardous materials on any portion of the site.

Due to the limited nature of the field explorations, conditions not observed and described in this report may be present on the site. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation and laboratory testing can be performed upon request. It should be understood that conditions different from those anticipated in this report may be encountered during construction operations, for example, the extent of unsuitable soil and the associated additional effort required to mitigate them or a presence of difficult grading or drilling conditions.

Site conditions, including groundwater level, can change with time as a result of natural processes or the activities of man at the subject site or at nearby sites. Changes to the applicable laws, regulations, codes, and standards of practice may occur as a result of government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Tetra Tech has no control. Therefore, this report should reviewed and recertified if it were to be used for a project design commencing more than 1 year after the date of issuance of this report.

Tetra Tech's recommendations for this site are, to a high degree, dependent upon appropriate quality control of subgrade preparation, fill placement, and foundation construction. Accordingly, the recommendations are made contingent upon the opportunity for Tetra Tech to observe grading operations and foundation excavations for the proposed construction. If parties other than Tetra Tech are engaged to provide such services, such parties are automatically assuming complete responsibility as the Geotechnical Engineer of Record for the project and are deemed concurring with the recommendations in this report or are obligated to provide alternative recommendations.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Tetra Tech should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document. Reliance by others on the data presented herein or for purposes other than those stated in the text is authorized only if so permitted in writing by Tetra Tech. It should be understood that such an authorization may incur additional expenses and charges.

Tetra Tech has endeavored to perform its evaluation using the degree of care and skill ordinarily exercised under similar circumstances by reputable geotechnical professionals with experience in this area in similar soil conditions. No other warranty, either expressed or implied, is made as to the conclusions and recommendations contained in this report.

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Figures

FIGURE 1

TETRA TECH 21700 Copley Drive, Suite 200, Diamond Bar, CA 91765 TEL 909.860.7777 www.tetratech.com	Bridge Replacement - Dola, Lanzit PROJECT LOCATION MAP	JOB NO. coSB 23-03E DATE JUN 2023 DRAWN BY MKM CHECKED BY FC

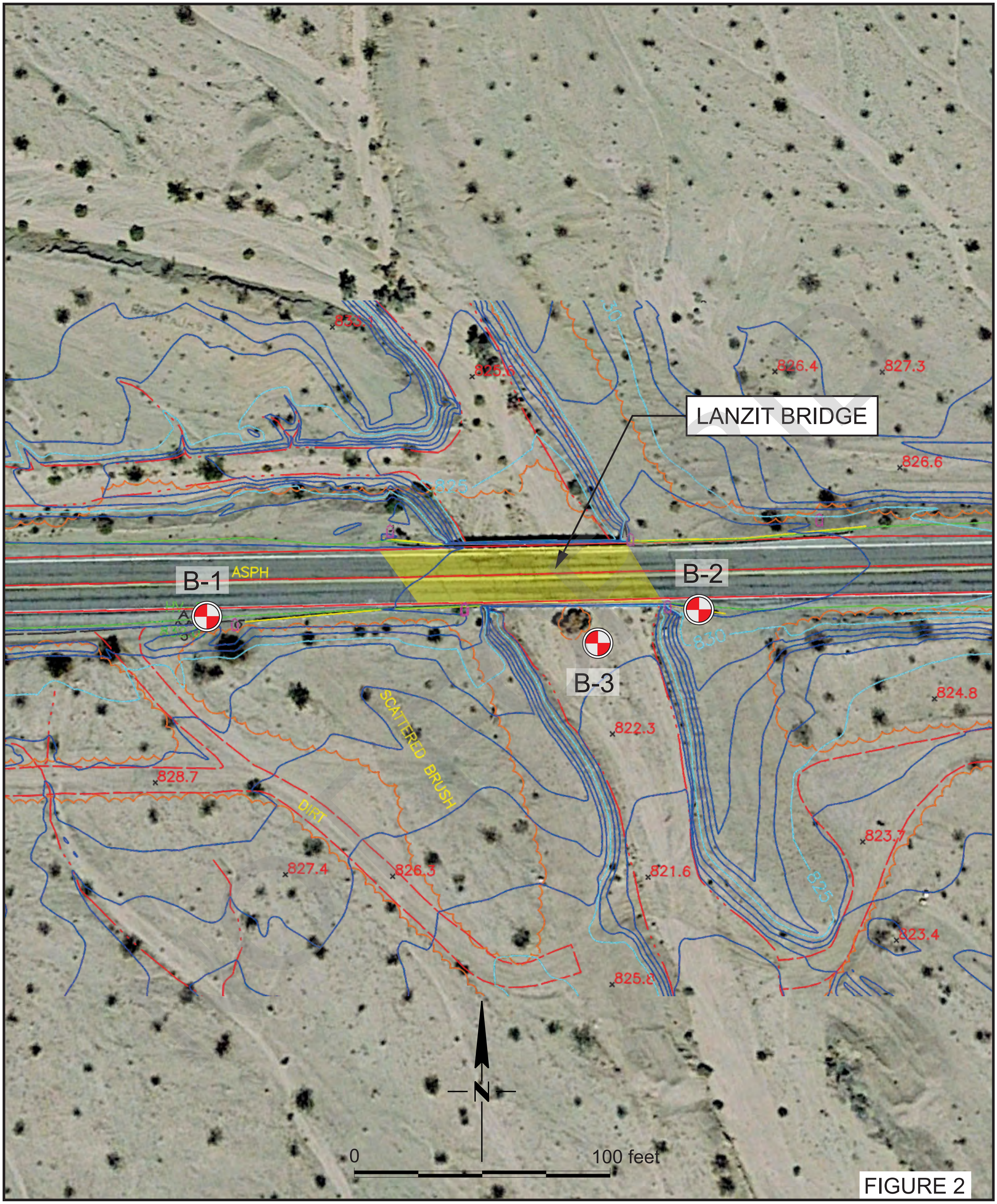

FIGURE 2

TETRA TECH

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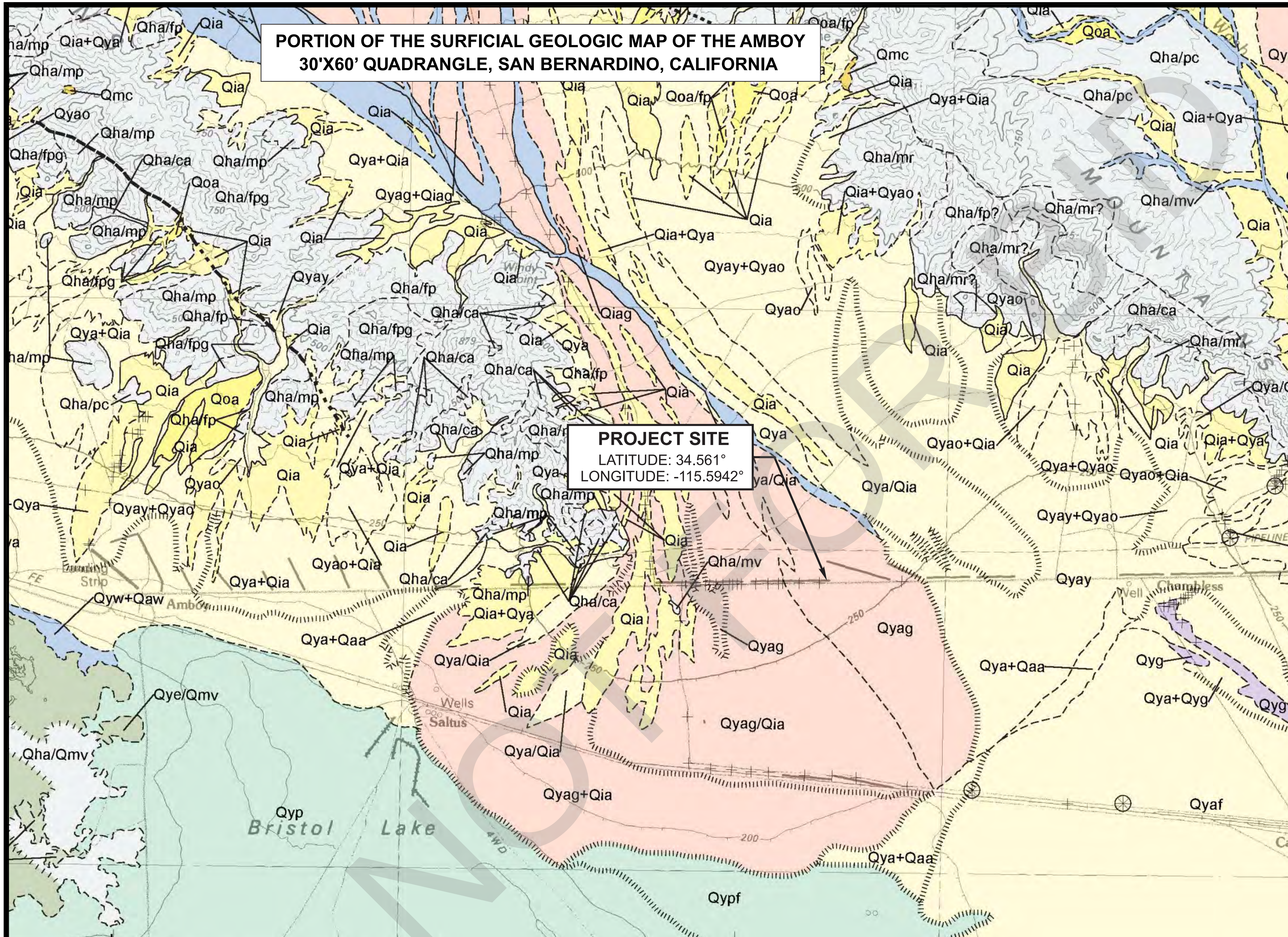
Bridge Replacement - Dola, Lanzit

BORING LOCATION MAP
LANZIT BRIDGE

JOB NO.	coSB 23-03E
DATE	JUN 2023
DRAWN BY	MKM
CHECKED BY	FC



SURFICIAL DEPOSITS

ANTHROPOGENIC DEPOSITS

ml	Made land

ALLUVIAL DEPOSITS

Qaa	Active alluvial fan deposit (Holocene)
Qaag	Active alluvial deposit composed of grus
Qya	Young alluvial fan deposit (Holocene and latest Pleistocene)
Qyay	Younger young alluvial fan deposit (Holocene)
Qyad	Young alluvial fan composed of debris-flow deposits (Holocene and latest Pleistocene)
Qyaf	Young alluvial fan composed of fine-grained deposits (Holocene and latest Pleistocene)
Qyao	Older young alluvial fan deposit (Holocene and latest Pleistocene)
Qyag	Young alluvial fan deposit composed of grus (Holocene and latest Pleistocene)
Qyaog	Older young alluvial fan deposit composed of grus (Holocene and latest Pleistocene)
Qia	Intermediate alluvial fan deposit (late to middle Pleistocene)
Qiad	Intermediate alluvial fan composed of debris-flow deposits (late to middle Pleistocene)
Qiag	Intermediate alluvial fan deposit composed of grus (late to middle Pleistocene)
Qiao	Older intermediate alluvial fan deposit (late to middle Pleistocene)
Qiaog	Older intermediate alluvial fan deposit composed of grus (late to middle Pleistocene
Qoa	Old alluvial fan deposit (middle to early Pleistocene)
Qoad	Old alluvial fan composed of debris-flow deposits (middle to early Pleistocene)
Qoag	Old alluvial fan deposit composed of grus (middle to early Pleistocene)
QToa	Extremely old alluvial fan deposit (early Pleistocene to Pliocene)

WASH DEPOSITS

Qaw	Active wash deposit (Holocene)
Qawg	Active wash deposit composed of grus (Holocene)
Qyw	Young wash deposit (Holocene and latest Pleistocene)
Qywg	Young wash deposit composed of grus (Holocene and latest Pleistocene)
Qiw	Intermediate wash deposit (late to middle Pleistocene)

EOLIAN DEPOSITS

Qae	Active eolian sand deposit (Holocene)
Qaed	Active eolian sand dune deposit (Holocene)
Qye	Young eolian sand deposit (Holocene and latest Pleistocene)
Qyed	Young eolian sand dune deposit (Holocene and latest Pleistocene)
Qyer	Young eolian sand ramp deposit (Holocene and latest Pleistocene)
Qyes	Young eolian sand sheet deposit (Holocene and latest Pleistocene)
Qie	Intermediate eolian sand deposit (late to middle Pleistocene)

MIXED EOLIAN AND ALLUVIAL DEPOSITS

Qyea	Young mixed eolian sand and alluvial deposit (Holocene and latest Pleistocene)
Qyae	Young mixed alluvial and eolian sand deposit (Holocene and latest Pleistocene)
Qiea	Intermediate mixed eolian sand and alluvial deposit (late to middle Pleistocene)
Qiae	Intermediate mixed alluvial and eolian sand deposit (late to middle Pleistocene)

PLAYA DEPOSITS

Qyp	Young playa deposit (Holocene and latest Pleistocene)
Qypf	Young playa fringe deposit (Holocene and latest Pleistocene)

Map Reference:

USGS, 2010, David R Bedford, David M Miller, and Geoff A Phelps
Surficial Geologic Map of the Amboy 30'x60' Minute Quadrangle, California.

LOCATION MAP

0 — 6 Mile

Contour Interval 50 Feet

Figure 3

REGIONAL GEOLOGIC MAP

TETRA TECH
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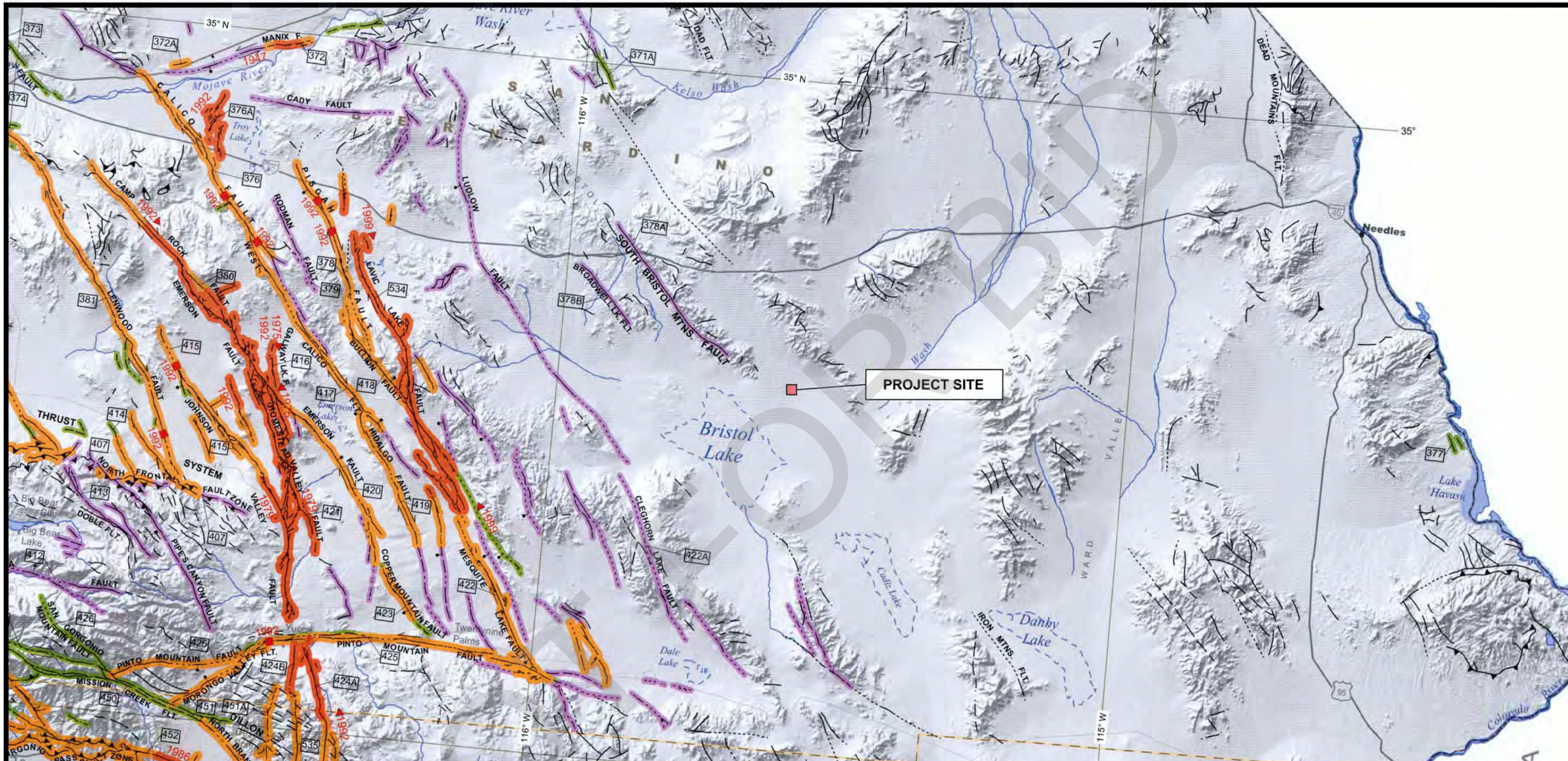

Reference: Excerpt of *Jennings, C.W., and Bryant, W.A., 2010, Fault activity map of California: California Geological Survey, Data Map No. 6*, map scale 1:750,000.

Used by permission from California Geological Survey.

0 10 20 30 40 50

SCALE IN MILES

EXPLANATION

Geologic Time Scale			Years Before Present (Approx.)	Fault Symbol	Recency of Movement	DESCRIPTION: ON LAND	DESCRIPTION: OFFSHORE	MAP SYMBOLS
Quaternary	Late Quaternary	Historic				Displacement during historic time (e.g. San Andreas fault 1906). Includes areas of known fault creep.		Triangle - termination point data. Square – fault creep slippage. Hachure – linear extent of fault creep (other symbols – see below)
		Holocene	200			Displacement during Holocene time.	Fault offsets seafloor sediments or strata of Holocene age.	Approximately located trace; Location uncertain
		Pleistocene	11,700			Faults showing evidence of displacement during late Quaternary time.	Fault cuts strata of Late Pleistocene age.	Bar and ball on downthrown side
	Early Quaternary		700,000			Undivided Quaternary faults – most faults in this category show evidence of displacement during the last 1,600,000 years; possible exceptions are faults which displace rocks of undifferentiated Plio-Pleistocene age.	Fault cuts strata of Quaternary age.	Arrows along fault indicate relative or apparent direction of lateral movement; Direction of fault dip; Low angle fault (barbs on upper plate)
Pre-Quaternary			1,600,000 – 4.5 bya (Age of Earth)			Faults without recognized Quaternary displacement or showing evidence of no displacement during Quaternary time. Not necessarily inactive	Fault cuts strata of Pliocene or older age.	171 Numbers refer to annotations listed in explanatory text of map.

Figure 4

REGIONAL FAULT MAP

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Project Number: coSB 23-03E

Date: JUNE 2023