Appendix E1

Geotechnical Engineering Report - Lassen Facility

WallaceKuhl & ASSOCIATES | A Universal Engineering Sciences Company

Geotechnical Engineering Report

GOLDEN STATE NATURAL RESOURCES LASSEN COUNTY

Nubieber, Lassen County, California

WKA No. 4630.2200118.0000

September 13, 2022

Prepared for:

Golden State Natural Resources

1215 K Street, Suite 1650

Sacramento, California 95814

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WallaceKuhl & ASSOCIATES
A Universal Engineering Sciences Company

Corporate Office
3050 Industrial Boulevard
West Sacramento, CA 95691
916.372.1434 phone
916.372.2565 fax

Stockton Office
3422 West Hammer Lane, Suite D
Stockton, CA 95219
209.234.7722 phone
209.234.7727 fax

Geotechnical Engineering Report
GOLDEN STATE NATURAL RESOURCES LASSEN COUNTY
551000 Roosevelt Avenue
Nubieber, Lassen County, California
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INTRODUCTION

We have completed a geotechnical engineering study for the proposed pellet processing facility to be constructed at 551000 Roosevelt Avenue in Nubieber, Lassen County, California. The purpose of our study has been to explore the existing site, soil, and groundwater conditions, and to provide geotechnical engineering conclusions and recommendations for the design and construction of the proposed improvements. This report presents the results of our study.

Scope of Services

Our scope of services for this project included the following tasks:

1. Perform a site reconnaissance;
2. Review of historic United States Geological Survey (USGS) topographic maps, historical aerial photographs, various geologic maps, and available groundwater information;
3. Perform subsurface explorations, including the drilling and sampling of eight soil borings to depths ranging from about 10 to 21½ feet below the existing ground surface (bgs);
4. Perform laboratory testing of selected soil samples to determine engineering properties of the soil encountered;
5. Perform engineering analyses; and,
6. Preparation of this report.

Figures and Attachments

This report contains a Vicinity Map as Figure 1; a Site Plan showing the boring locations as Figure 2; and the Logs of Soil Borings as Figures 3 through 10. An explanation of the symbols and classification system used in developing the exploration logs is contained on Figure 11. A graphical illustration of the calculated capacities versus depth for piers is provided in Figure 12. Appendix A contains general information regarding project concepts, the exploratory methods used during our field investigation, and the laboratory test results that are not included on the logs. Appendix B contains *Guide Earthwork Specifications* that may be used in the preparation of contract documents. Appendix C contains the results of the pier deflection, shear, and moment diagrams from LPILE.

Proposed Development

We understand the proposed pellet processing facility will include the design and construction of a dry hammer mill building, pellet mill building, dryer system, overhead conveyor system, and roundwood storage areas. The proposed buildings are anticipated to be single-story structures constructed of either wood-framed or concrete block walls with interior concrete slabs-on-grade floors. The overhead system is anticipated to be a steel structure supported on isolated spread footings or drilled piers. Structural loads for the buildings and conveyor system are anticipated to be light to moderately heavy. Associated improvements will include the construction of underground utilities, exterior flatwork, and asphalt concrete paved areas.

We anticipate that associated improvements may include underground utilities, various exterior flatwork, low retaining walls and paved parking and drive aisles subjected to heavy wheel loads.

Grading plans were not provided to us; however, based on the existing site topography, we anticipate maximum excavations and fills on the order of two to four feet for development of the site.

FINDINGS

Site Description

The project site is located at 551000 Roosevelt Avenue in Nubieber, Lassen County, California and consists of two parcels identified as Lassen County Assessor's Parcel Numbers 001-270-086-000 and 001-270-026-000. The site is bounded to the north by Lassen State Highway 299; to the south by vacant, undeveloped land, to the east by Babcock Road and Gateway Subdivision railroad line; and to the west by existing agricultural land and facility of Helena Chemical Company. The property is relatively flat with the northern portion about a few feet higher and gently sloping down to the southern half. Based on review of the USGS 7.5 *Minute Topographic Map of the Bieber Quadrangle, California* – *Lassen County,* dated 2018 the property has an average surface elevation of about +4120 feet relative to the North American Vertical Datum of 1988 (NAVD88).

At the time of our field reconnaissance, most of the site was vacant and covered in a low to moderate growth of volunteer grass and weeds. An unpaved gravel access road (Babcock Road) and overhead utilities adjacent to Babcock Road runs from west to east near the center of the site. Railroad lines and a shallow drainage ditch were also observed near the center of the site. The drainage ditch was dry at the time of our field explorations. An elevated water storage tank and what appears to be a train loading facility occupied the northern end of the site. A fire break line was observed around the perimeter of the southern portion of the site. The upper foot of soil, south of Babcock Road appeared to have been disced and were in a relatively soft condition. Desiccation cracks were observed throughout the northern half of the property.

Historic Aerial Photograph Review

We reviewed historical aerial photographs of the site from Google Earth Pro software (Google, 2018) and the website www.HistoricalAerials.com. Photographs were available from 1960 through 2021. Based on review of the available photographs, most of the site is vacant and empty since at least 1960. The existing railroad line, Babcock Road, and loading facility can be seen in the photograph of 1960. The photographs revealed the site has essentially remained the same between 1960 and 2021. The facilities west adjacent to the project site can first be seen in an aerial photograph of 1993. The site conditions at the time of our site reconnaissance were similar to the most recent aerial photograph from 2021.

General Site Geology

The site is located within the Modoc Plateau. The Modoc Plateau is a volcanic table land (elevation 4,000- 6,000 feet above sea level) consisting of a thick accumulation of lava flows and tuff beds along with many small volcanic cones. Occasional lakes, marshes, and sluggishly flowing streams meander across the plateau. The plateau is cut by many north-south faults. The province is bound indefinitely by the Cascade Range on the west and the Basin and Range on the east and south.

The local geology has been mapped by various authors. The maps reviewed differ in scale and detail but agree that the site is underlain by Quaternary aged (within the last 2.5 million years) lake deposits.

Subsurface Soil Conditions

The subsurface soil conditions at the project site were explored on July 14, 2022, by drilling and sampling eight soil borings to depths ranging from about 10 to 21½ feet bgs. The approximate soil boring locations are presented in Figure 2.

The near-surface soils encountered generally consist of very stiff to hard, variably cemented, brown, lean clay or dark brown, fat clay in the upper four to eight feet at the boring locations.

Beneath the clays were medium to very dense, silty sand with fine gravel. At Borings D1, D2, D3, and D5, the sand layer was underlain by stiff to very stiff, lean clay to the maximum depth explored of 21½ feet below ground surface (bgs).

For specific information regarding the soil conditions at a specific boring location, please refer to the Logs of Soil Borings, Figures 3 through 10.

Groundwater

Groundwater was encountered during our field explorations on July 14, 2022 at depths ranging from approximately 7 to 10 feet bgs. Please note the borings may not have been left open long enough for groundwater to reach static equilibrium.

To supplement our groundwater data, we reviewed available groundwater information at the California Department of Water Resources (DWR) website. The DWR periodically monitors groundwater levels in wells across the state. Their website shows a well located approximately ½-mile northwest of the project site as shown in Figure 1. The well is identified as Well No. 38N07E32A002M with a ground surface elevation of about +4119 feet NAVD 88, which is similar to the project site. Groundwater data for this well was recorded from September 15, 1959 to at least October 28, 2021. Data shows the highest recorded groundwater elevation was about +4118 feet NAVD 88 at the well on March 22, 1999, which is at about one foot below ground surface elevation. The lowest recorded groundwater elevation was about +4106 feet NAVD 88 at the well on October 15, 1987, which is about 12 feet bgs at the well. The most recent groundwater elevation recorded was about +4110 feet NAVD 88 at the well on October 28, 2021 which is about 8 feet bgs at the well.

CONCLUSIONS

Bearing Capacity and Anticipated Settlements

Based upon our field and laboratory testing, it is our opinion the near-surface native soils are capable of supporting the planned structures and associated improvements provided the recommendations of this report are followed (i.e., scarification, moisture conditioning, and compaction).

New engineered fills composed of native soils or approved imported soils constructed in accordance with our recommendations should also be capable of supporting foundations, slab-on-grade concrete, and pavements at the site. We anticipate total settlement on the order of one inch for the structures and about ½ inch differential settlement over 50 lineal feet.

The project site is in an area of Lassen County that receives an annual snowfall on the order of two to five feet (https:www.bestplaces.net/climate/city/California/nubieber). Review of available information by the United States Department of Agriculture, Natural Resource Conservation Service, the project area is mapped as susceptible to low to high frost heave. Frost heave is the upward thrust of ground or pavement caused by freezing moist soil. Common methods of reducing the potential of frost heave may include construction of building pads with granular, non-expansive soil; deepening foundations to bear below the anticipated frost depth; or chemical stabilization of near-surface clays with high-calcium quicklime. Recommendations to mitigate for potential frost heave have been provided in this report.

2019 CBC/ASCE 7-22 Seismic Design Parameters

The 2019 *California Building Code* (CBC) references the American Society of Civil Engineers (ASCE) Standard 7-16 for seismic design. We understand that ASCE 7-22 was recently published which is intended to supersede ASCE 7-16. At the time this report was prepared, the specific version governing design code has not been determined. Therefore, we are providing the following seismic design parameters summarized in Tables 1 and 2 that are based on the ASCE 7-16 and ASCE 7-22, respectively, to assist with the structural design of this project.

The seismic design parameters provided in Table 1 were determined based on a Site Class D and the latitude and longitude for the central portion of the site using the web interface developed by the *Structural Engineers Association of California* (SEAOC) and *California Department of Health Care Access and Information* (HCAi). Since S_1 is greater than 0.2 g, the coefficient values F_v, S_{M1}, and S_{D1} presented in Table 1 are valid for this project, provided the requirements in Exception Note No. 2 of Section 11.4.8 of *ASCE 7-16* apply. If not, a site-specific ground motion hazard analysis is required for this project. Based on our experience with similar projects, we anticipate the proposed structures will meet the exception. However, the project structural engineer should verify the exception is met.

TABLE 1
2019 CBC/ASCE 7-16 SEISMIC DESIGN PARAMETERS

Latitude: 41.0909° N Longitude: 121.1757° W	ASCE 7-16 Table/Figure	2019 CBC Table/Figure	Factor/Coefficient	2019 CBC Values
0.2-second Period MCE	Figure 22-1	Figure 1613.2.1(1)	S_S	0..669 g
1.0-second Period MCE	Figure 22-2	Figure 1613.2.1(2)	S_1	0.262 g
Soil Class	Table 20.3-1	Section 1613.2.2	Site Class	D

TABLE 1
2019 CBC/ASCE 7-16 SEISMIC DESIGN PARAMETERS

Latitude: 41.0909° N Longitude: 121.1757° W	ASCE 7-16 Table/Figure	2019 CBC Table/Figure	Factor/Coefficient	2019 CBC Values
Site Coefficient	Table 11.4-1	Table 1613.2.3(1)	F_a	1.27
Site Coefficient	Table 11.4-2	Table 1613.2.3(2)	F_v	2.08*
Adjusted MCE Spectral Response Parameters	Equation 11.4-1	Equation 16-36	S_{MS}	0.85 g
	Equation 11.4-2	Equation 16-37	S_{M1}	0.54* g
Design Spectral Acceleration Parameters	Equation 11.4-3	Equation 16-38	S_{DS}	0.56 g
	Equation 11.4-4	Equation 16-39	S_{D1}	0.36* g
Seismic Design Category	Table 11.6-1	Table 1613.2.5(1)	Risk Category I – IV	D
	Table 11.6-2	Table 1613.2.5(2)	Risk Category I – IV	D

Notes: MCE = Maximum Considered Earthquake; g = gravity
* = The value is valid since the requirements in Exception Note No. 2 in Section 11.4.8 of ASCE 7-16 are met.

The seismic design parameters provided in Table 2 have been determined based on the site location and the web interface developed by ASCE (https://asce7hazardtool.online/).

TABLE 2
ASCE 7-22 SEISMIC DESIGN PARAMETERS

Latitude: 41.0909° N Longitude: 121.1757° W	ASCE 7-22 Table/Figure	Factor/ Coefficient	Risk Category I-IV
0.2-second Period MCE_R	N/A	S_S	0.93 g
1.0 second Period MCE_R	N/A	S_1	0.28 g
Soil Class	Table 20.2-1	Site Class	D
Adjusted MCE_R Spectral Response Parameters	Figure 22-1	S_{MS}	1.17 g
	Figure 22-2	S_{M1}	0.69 g
Design Spectral Acceleration Parameters	Equation 11.4-1	S_{DS}	0.78 g
	Equation 11.4-2	S_{D1}	0.46 g

Note: MCE_R = Risk-Targeted Maximum Considered Earthquake
g = gravity

Soil Expansion Potential

Laboratory tests performed on two samples of near surface soils revealed that these materials possess relatively medium to high plasticity indexes when tested in accordance with ASTM D4318 test method (see Figure A1). Additional laboratory testing of soils collected at the boring locations revealed the near-surface clay soils possess “medium” to “high” expansion potential when tested in accordance with ASTM D4829 test method (see Figures A2 through A4).

Based on the laboratory test results, we conclude the near-surface clays can exert significant expansion pressures on building foundations, interior floor slabs, exterior flatwork, and pavements. Specific recommendations to reduce the effects of expansive soils are presented in this report.

Soil Suitability for Engineered Fill Construction

The on-site soils are considered suitable for use as engineered fill provided the materials do not contain significant amounts of organic concentrations, deleterious material, particles larger than three inches in maximum dimension, and are at a suitable moisture content to achieve the desired degree of compaction.

Excavation Conditions

The on-site surface and near-surface soils should be readily excavatable with conventional construction equipment, except that the variably cemented soils may be slower to excavate, but special excavation equipment is not anticipated. Based on the borings performed at the site, excavations associated with shallow trenches for foundations and utilities, and other excavations less than five feet deep associated with the planned construction, should stand vertically for short periods of time (i.e., less than one day) required for construction, unless cohesionless, saturated or disturbed soils are encountered. Minor sloughing and "running" conditions could occur if the soils are saturated, or where zones of clean (cohesionless) sands are encountered, especially when subjected to construction vibrations or allowed to dry significantly.

Excavations deeper than five feet that will be entered by workers should be sloped, braced, or shored in accordance with current California Occupational Safety and Health Administration (Cal/OSHA) regulations. The contractor must provide an adequately constructed and braced shoring system in accordance with federal, state, and local safety regulations for individuals working in an excavation that may expose them to the danger of moving ground.

After excavations/trenches have been properly dewatered, the soils within the excavation sidewalls will remain in a saturated condition and potentially create unstable conditions that can result in caving or sloughing. The presence of cohesionless or disturbed soils may also create unstable conditions that can also result in caving or sloughing. Therefore, the contractor should be prepared to brace and/or shore these excavations as needed. Excavations/trenches left open for more than a day may also be susceptible to caving or sloughing; therefore, such excavations should be evaluated by the contractor on a daily basis and determine if it is necessary to brace or shore the excavations.

Temporarily sloped excavations less than 20 feet deep should be constructed no steeper than a one and a half horizontal to one vertical (1½ H:1V) inclination, if properly dewatered. Temporary slopes likely will stand at this inclination for the short-term duration of construction, provided significant pockets of loose and/or saturated granular soils are not encountered. Flatter slopes would be required if these conditions are encountered.

Excavated materials should not be stockpiled directly adjacent to an open trench to prevent surcharge loading of the trench sidewalls. Excessive truck and equipment traffic also should be avoided near open trenches. If material is stored or heavy equipment is operated near an excavation, stronger shoring would be needed to resist the extra pressure due to the superimposed loads.

<u>Groundwater Effect on Development</u>

Based on our field explorations, excavations that extend deeper than about seven feet below existing grades could encounter groundwater and require dewatering. However, historic groundwater data indicates that groundwater could be at about one foot below ground surface. Groundwater monitoring wells could be installed in different areas of the site prior to construction to evaluate actual groundwater levels before and during construction.

If groundwater is encountered during construction, the use of sumps, submersible pumps, deep wells or a well point system could be used as methods to lower the groundwater level at least three feet below the bottom of excavations. The dewatering method used should depend on the soil conditions, depth of the excavation and amount of groundwater present within the excavation. Dewatering, if required, should be the contractor’s responsibility. The dewatering system should be designed and constructed by a qualified dewatering contractor with local experience.

Groundwater removed during construction dewatering operations, if necessary, should be disposed of as required under permit issued by the appropriate regulatory agency. Monitoring and/or dewatering wells, if required should be properly abandoned and backfilled in accordance with the governing agency’s requirements.

Pavement Subgrade Quality

Laboratory tests indicate that the anticipated clay subgrade soils possess Resistance ("R") values of 5 and 10 when tested in accordance with California Test 301 (Figure A5). Based on these test results, it is our opinion that the anticipated clay subgrade soils are considered poor quality materials for support of asphalt concrete pavements and will require thicker pavement sections to compensate for the lower strength of the soils.

We anticipate that the on-site clay soils will react well with the addition of quicklime (dolomitic or high calcium). The lime-treatment of native clays can be an effective and economical method to increase the quality of the pavement subgrade soils to support pavements; to reduce the moisture content of near-saturated soils, enabling construction to proceed during or shortly after the rainy season; to reduce the expansive characteristics of the clays for exterior flatwork construction; and mitigate the effects of potential freeze-thaw cycles.

The performance of lime-stabilized soils is very dependent on uniform mixing of the quicklime into the subgrade soils and providing a proper curing period following compaction. An experienced soil stabilization contractor combined with a comprehensive quality control program are essential to achieve satisfactory results with lime-stabilized subgrades.

Soil Corrosion Potential

Two representative samples were submitted to Sunland Analytical Lab of Rancho Cordova, California for testing to determine minimum resistivity, pH, and chloride and sulfate concentrations to help evaluate the potential for corrosive attack upon reinforced concrete and buried metal. The results of the corrosivity testing are summarized in Table 3. Copies of the corrosion test reports are presented in Figures A7 and A8.

TABLE 3
SOIL CORROSIVITY TESTING

Analyte	Test Method	Sample Identification	
		D3 (0-3’)	D6 (0-3’)
pH	CA DOT 643 Modified*	7.45	5.96
Minimum Resistivity	CA DOT 643 Modified*	320 Ω-cm	990 Ω-cm
Chloride	CA DOT 422	570.1 ppm	3.7 ppm
Sulfate	CA DOT 417	433.0 ppm	26.3 ppm

Notes: * = Small cell method; Ω-cm = Ohm-centimeters; ppm = Parts per million

The California Department of Transportation Corrosion and Structural Concrete Field Investigation Branch, 2021 Corrosion Guidelines (Version 3.2), considers a site to be corrosive to foundation elements if one or more of the following conditions exists for the representative soil and/or water samples taken: has a chloride concentration greater than or equal to 500 ppm, sulfate concentration greater than or equal to 2000 ppm, or the pH is 5.5 or less. Based on this criterion, the on-site soils tested are considered corrosive to steel reinforcement properly embedded within Portland cement concrete (PCC). The relatively high chloride concentration indicates that corrosion resistance concrete mix designs may be required to mitigate the effects of chloride diffusion in concrete. The low resistivity may also indicate a higher corrosion potential to metal in direct contact with soil.

Table 19.3.1.1 – *Exposure Categories and Classes*, American Concrete Institute (ACI) 318-19, Section 4.2, as referenced in Section 1904.1 of the 2019 CBC, indicates the severity of sulfate exposure for the sample tested is *S1 - Moderate*. In addition, due to the potential freezing and thawing in the project area, concrete foundations should be designed for exposure class “F2” conditions. Ordinary Type II Portland cement is considered suitable for use on this project, assuming a minimum concrete cover as detailed in ACI 318-19, Section 7.7 is maintained for all reinforcement.

Wallace-Kuhl & Associates are not corrosion engineers. Therefore, if it is desired to further define the soil corrosion potential at the site, a corrosion engineer should be consulted.

<u>Groundwater and Seasonal Moisture</u>

Infiltrating surface run-off water from irrigation and/or seasonal moisture during the winter and spring months will create saturated surface soil conditions. It is probable that construction operations attempted following the onset of winter rains, prior to prolonged drying periods will be hampered by high soil moisture contents. Such soils, intended for use as engineered fill, will require a prolonged period of dry weather and aeration to reach a moisture content suitable for proper compaction.

Seasonal moisture and landscape irrigation will result in high soil moisture contents below interior floor slabs throughout their lifetime. It is likely that floor slab subgrade soils will become wet to near saturated at some time during the life of structures built at the site. This is a certainty when slabs are constructed during the wet season or where constantly wet ground, or poor drainage conditions exist adjacent to structures. Moisture vapor penetration should be a significant consideration in interior floor slab design and construction.

RECOMMENDATIONS

General

The recommendations presented below are appropriate for typical construction in the late spring through fall months. The on-site soils typically become very moist and wet following rainfall in the winter and early spring months, and often are not suitable for earthwork without drying by aeration, chemical treatment, or geogrid stabilization. Should the construction schedule require work to start or continue during the wet months, additional recommendations can be provided, as conditions warrant.

A representative of the Geotechnical Engineer should be present during all earthwork and ground improvement construction operations to evaluate compliance with the recommendations presented in this report and the project plans and specifications. The Geotechnical Engineer of Record referenced herein should be considered the Geotechnical Engineer that is retained to provide geotechnical engineering observation and testing services during construction.

Site Clearing

Prior to grading, the construction areas should be cleared of all surface trash, rubble, deleterious debris, to expose firm and stable soils, as determined by the Geotechnical Engineer’s representative. The area of removal should extend at least five feet beyond the building pads and at least two feet beyond any exterior flatwork or pavements, where practical. All resulting rubble and debris should be removed from the site.

On-site water wells were not noted at the site during our field exploration. However, if any wells are discovered, they should be properly abandoned in accordance with accordance with the governing agency’s requirements.

Any existing underground utilities designated to be removed or relocated should include all trench backfill and bedding materials. The resulting excavations should be restored with engineered fill placed and compacted in accordance with the recommendations included in this report.

Existing surface vegetation and organically laden soil within construction areas should be removed by stripping. Debris from the stripping should not be used in general fill construction areas supporting the proposed structures, concrete slabs, or pavements. Strippings may be stockpiled for later use or disposed of offsite. With prior approval from the Geotechnical Engineer, strippings may be used in landscape areas, provided they are kept at least five feet from the building pads, pavements, concrete slabs and other surface improvements, moisture conditioned, and compacted.

Discing of the organics into the surface soils may be a suitable alternate to stripping, depending on the condition and quantity of the organics at the time of grading. The decision to utilize discing in lieu of stripping should be made by the Geotechnical Engineer, or their representative, at the time of earthwork construction. Discing operations, if approved, should be observed by the Geotechnical Engineer's representative and be continuous until the organics are adequately mixed into the surface soils to provide a compactable mixture of soil containing minor amounts of organic matter. Pockets or concentrations of organics will not be allowed.

On-site drainage ditches or swales should be fully drained of water and cleaned of organics. Saturated and unstable soils exposed should be removed to expose firm, native materials, as determined by our representative. These soils will likely be saturated and will require aeration and a period of drying to allow proper compaction. Organically contaminated soils will not be suitable for use in engineered fill construction.

Depressions resulting from site clearing operations, as well as any loose, soft, disturbed, saturated, or organically contaminated soils, as identified by the Geotechnical Engineer's representative should be cleaned out to firm, undisturbed soils and the excavation should be widened, as necessary, to allow access with compaction equipment. Depressions should be backfilled with engineered fill placed and compacted in accordance with the recommendations of this report. It is important that the Geotechnical Engineer's representative be present during site clearing operations to verify adequate removal of the surface and subsurface items, as well as the proper backfilling of resulting excavations.

Subgrade Preparation

Following site clearing activities, areas to receive fill or remain at-grade should be processed (i.e., scarified/blended) to a depth of at least 12 inches, thoroughly moisture conditioned to at least two percent above the optimum moisture content, and uniformly compacted to at least 90 percent relative compaction. Relative compaction should be based on the maximum dry density as determined in accordance with the ASTM D1557 Test Method. All soils supporting interior and exterior slab-on-grade concrete should be uniformly compacted to 90 percent of the ASTM D1557 maximum dry density.

It is possible that soils present at the bottom of excavations associated with site clearing activities will initially be too wet to properly compact and will require a period of drying and/or considerable aeration for the soils to dry to a workable moisture content. Alternative recommendations to stabilize the bottom of excavations can be evaluated upon request based on actual field conditions. Removal and replacement of the unstable soils, chemical treatment, and/or the use of geogrids is typically recommended to stabilize soil subgrades during construction.

To help identify unstable pavement subgrades, a proof-roll test should be performed on the exposed subgrades prior to placement of any fill beneath pavements with a fully loaded water truck. The proof-roll test should be observed by the Geotechnical Engineer. If proof-roll testing exposes unstable conditions, stabilization measures (e.g., over-excavation and replacement of unstable areas) or additional compaction may be required at the discretion of the Geotechnical engineer.

Subgrade preparation operations should extend at least five feet beyond the building pads and at least two feet beyond any exterior flatwork or pavements, where practical. Compaction of all soil subgrades should be performed using a heavy, self-propelled, sheepsfoot compactor capable of achieving the required compaction and must be performed in the presence of the Geotechnical Engineer's representative who will evaluate the performance of subgrade under compactive load. Difficulty in achieving subgrade compaction may be an indication of loose, soft, or unstable soil conditions associated with prior site use. If these conditions exist, the loose, soft, or unstable materials should be excavated to firm and stable soil conditions. The resulting excavations should be backfilled with engineered fill placed and compacted in accordance with the recommendations in this report.

<u>Engineered Fill Construction</u>

To mitigate the significant shrinking and swelling potential of the surface and near-surface clay soils present at the site, at least 12 inches of imported, compactable, very low-expansive (Expansion Index ≤ 20) granular soils will be required beneath all interior floor slabs and exterior flatwork. Alternatively, chemical amendment of on-site clay soils (e.g., lime-treatment) could also be considered to reduce the shrinking and swelling potential of on-site or imported clays. If the lime-treatment alternative is selected, the upper 12 inches of final soils subgrades for all interior floor slabs and exterior flatwork should be constructed as described in the <u>Lime-Treatment Alternative</u> section of this report. Interior and exterior concrete slab-on-grade final soil subgrade is defined as the surface in which aggregate base or capillary break materials are placed.

On-site soils are considered suitable for engineered fill construction in structural areas provided these materials do not contain rubbish, rubble greater than three inches, and significant organic concentrations. However, due to their significant expansion potential, on-site clay soils should not be used in fills within the upper 12 inches of final soil subgrade beneath interior floor-slabs and exterior flatwork, as defined above, unless the clay soils are lime-treated as described in the Lime-Treatment Alternative section of this report.

Imported fill materials to be used in the upper 12 inches of soil subgrade beneath interior floor slab and exterior flatwork should be compactable, well-graded, granular soils with a Plasticity Index of 15 or less when tested in accordance with ASTM D4318; an Expansion Index of 20 or less when tested in accordance with ASTM D4829; and should not contain particles greater than three inches in maximum dimension.

In addition, except for imported aggregate base and bedding/initial fill materials for underground utility construction, the contractor should provide appropriate documentation for all imported fill materials that designates the import materials do not contain known contaminants per Department of Toxic Substances Control's guidelines for clean imported fill material (DTSC, 2001), and have corrosion characteristics within acceptable limits. Imported soils should be approved by the Geotechnical Engineer prior to being transported to the site.

Engineered fill should be placed in lifts not exceeding six inches in compacted thickness with each lift being thoroughly moisture conditioned to at least two percent above the optimum moisture content for clay soils and to the optimum moisture content for granular soils, maintained in that condition, and uniformly compacted to not less than 90 percent of the ASTM D1557 maximum dry density.

The upper 12 inches of building pads and those areas supporting exterior flatwork should consist of granular, non-expansive soil or granular import material that is thoroughly moisture conditioned to at the optimum moisture content and uniformly compacted to not less than 90 percent of the ASTM D1557 maximum dry density, regardless of whether final grade is achieved by excavation, filling or left at existing grades. Building pads should extend five feet beyond the outside edge of perimeter foundations.

The upper 12 inches of final pavement untreated or chemically treated subgrades should be processed, thoroughly moisture conditioned to at least two percent above the optimum moisture content, and uniformly compacted to at least 95 percent of the ASTM D1557 maximum dry density, regardless of whether final elevation is achieved by filling, excavation, or is left at existing grade.

Permanent excavation and fill slopes should be constructed no steeper than two horizontal to one vertical (2H:1V) and should be vegetated as soon as practical following grading to minimize erosion. As a minimum, the following erosion control measures should be considered: placement of straw bale sediment barriers or construction of silt filter fences in areas where surface run-off may be concentrated. Any slopes should be over-built and cutback to design grades and inclinations.

The Geotechnical Engineer's representative should be present on a regular basis during all earthwork operations to observe and test the engineered fill and to verify compliance with the recommendations of this report and the project plans and specifications.

Lime-treatment Alternative

As an alternative to the use of imported, very low-expansive (Expansion Index ≤ 20), granular soils beneath interior and exterior concrete slabs-on-grade, amendment of the on-site or approved imported clay soils with lime is expected to mitigate the effect of expansion pressures on interior and exterior concrete slabs-on-grade produced by untreated clay soils. Based on our experience with similar soils, the clay soils encountered at the site and imported clay soils are anticipated to react well with the addition of quicklime (high-calcium or dolomitic). If lime-treatment of on-site or approved imported clay soils is selected for the final soil subgrade beneath interior and exterior concrete slabs-on-grade, we recommend the final soil subgrade elevation beneath interior concrete slabs and exterior flatwork is mixed with lime at a minimum spread rate of at least 4½ pounds of quicklime per square foot of treated soil, at a depth sufficient to produce a compacted lime-treated layer 12 inches thick. Lime should be mixed into the soil, allowed to cure for a period of 12 to 72 hours, remixed, moisture conditioned and compacted. Following the second re-mix and compaction, the soil-lime mixture should be allowed to mellow for a period of at least 36 hours.

Lime-treatment of clay subgrade soils should be performed in general conformance with Section 24 of the *Caltrans Standard Specifications*, latest edition. Lime-treated soil beneath interior and exterior concrete slabs-on-grade should be compacted to at least 90 percent relative compaction at no less than two percent over the optimum moisture content and maintained in that condition until covered by capillary break gravel or aggregate base. Treatment of more than 12 inches of soil may require the use of a mixing table and compaction of the treated soils in lifts. The contractor must use equipment that will provide uniform and complete compaction of the entire lime-treated section.

If the near surface soils are to be lime-treated, the scarification and compaction procedures outlined in the Subgrade Preparation section of this report are not required within the upper 12 inches of the final subgrade, prior to lime-treatment.

Utility Trench Backfill

Utility trench backfill should be mechanically compacted as engineered fill in accordance with the following recommendations. Bedding of utilities and initial backfill around and over the pipe should conform to the manufacturer's recommendations for the pipe materials selected and applicable sections of the governing agency standards. If open-graded, crushed rock is used as bedding or initial backfill, an approved geotextile filter fabric should be used to separate the crushed rock from finer-grained soils. The intent of geotextile filter fabric is to prevent soil from migrating into the crushed rock (piping), which could result in trench settlement.

The on-site native soils (in lieu of select gravel or sand backfill) should be used as backfill for utility trenches located within the building footprints and extending at least five feet beyond the perimeter foundations to minimize water transmission beneath the structures. Utility trench backfill should be placed in thin lifts, moisture conditioned to at least two percent above the optimum moisture content and mechanically compacted to at least 90 percent of the ASTM D1557 maximum dry density. The lift thickness will depend on the type of compaction equipment used to compact the trench backfill.

Backfill for the upper 12 inches of trenches must match the quality of the adjacent materials. That is, if the upper 12 inches of subgrades for the building pad, exterior flatwork, or pavements consists of chemically treated soils, the upper 12 inches of trench backfill should consist of controlled density fill (CDF) or aggregate base. Chemically treated soils removed from excavations are not suitable for use as replacement for the soil treated in place. However, the chemically treated soils removed from excavations may be used as deeper trench backfill if approved by the Geotechnical Engineer.

Underground utility trenches, which are aligned nearly parallel with foundations, should be at least three feet from the outer edge of foundations. Trenches should not encroach into the zone extending outward at a 1H:1V inclination below the bottom of the foundations. Additionally, trenches near foundations should not remain open longer than 72 hours to prevent drying of the soils. The intent of these recommendations is to prevent loss of both lateral and vertical support of foundations, resulting in possible settlement.

Foundation Design

Based on the findings of our study and laboratory test results, it is our opinion that the proposed single-story structures can be supported on shallow conventional foundations or post-tensioned (PT) slab systems. In our experience, post-tensioned slabs typically provide better support with respect to mitigating the expansive characteristics of the on-site clays and reduce the risk of future foundation movements. Since we provided recommendations to use granular, non-expansive soil in the upper 12 inches of building pads, we have assumed that PT slabs are not being considered at this time. Recommendations for PT slabs can be provided upon request.

In addition to the expansive native clay soils at the site, we anticipate that structural foundations may be susceptible to frost heave. Recommendations to include frost heave loads have been provided below.

Shallow Conventional Foundations

The proposed structures and equipment may be supported upon continuous and/or isolated spread foundations embedded at least 24 inches below lowest adjacent soil grade, provided the subgrade has been prepared in accordance with the recommendations included in this report. Lowest soil grade is defined as either the adjacent exterior soil grade or the soil subgrade beneath the building, whichever is lower. A continuous, reinforced foundation should be utilized for the perimeter of the buildings to act as a “cut-off” to help minimize moisture infiltration and variations beneath the interior slab-on-grade areas of the buildings. Continuous foundations should maintain a minimum width of 24 inches and isolated spread foundations should be at least 24 inches in plan dimension.

Foundations bearing on engineered fill may be sized for maximum allowable “net” soil bearing pressure of 3,000 pounds per square foot (psf) for dead plus live load. A one-third increase in the allowable bearing pressures may be applied when considering short-term loading due to wind or seismic forces. The weight of the foundation concrete extending below lowest adjacent soil grade may be disregarded in sizing computations.

All foundations should be adequately reinforced to provide structural continuity, mitigate cracking, and permit spanning of local soil irregularities. The structural engineer should determine final foundation reinforcing requirements.

Resistance to lateral foundation displacement may be computed using an allowable friction factor of 0.30, which may be multiplied by the effective vertical load on each foundation. Additional lateral resistance may be computed using an allowable passive earth pressure equivalent to a fluid pressure of 300 psf per foot of depth, acting against the vertical projection of the foundation. These two modes of resistance should not be added together unless the frictional component is reduced by 50 percent since full mobilization of the passive resistance requires some horizontal movement, effectively reducing the frictional resistance. We recommend that all foundation excavations be observed by the Geotechnical Engineer’s representative prior to placement of reinforcement and concrete to verify firm bearing materials are exposed.

Drilled Piers

Equipment anticipated to be supported on cast-in-drilled-holes (CIDH), commonly referred to as drilled piers should be at least 24 inches in diameter and extend to a minimum depth of 15 feet below existing grades. The final drilled pier dimensions should be determined by the project Structural Engineer based on structural loads.

Drilled piers may be designed utilizing the following maximum allowable loads per pile with appropriate factor of safety (F.S.) as summarized in Table 4. Alternate capacities for piers of different dimensions can be provided upon request. The factors of safety used to determine the allowable capacities presented below are based on our experience with similar projects and current industry standards. For design purposes, the factor of safety for the dead load condition only may be modified by the Structural Engineer if considered appropriate. CIDH pier concrete should achieve a minimum compressive strength of 4,000 pounds per square inch (psi) when tested in accordance with ASTM C109.

TABLE 4
ALLOWABLE PIER CAPACITIES

Loading Conditions		24-inch-diameter, CIDH Pier	
		Allowable Pier Capacity (kips)	Ultimate Pier Capacity (kips)
Axial Compression	DL (F.S. = 3)	18	54
	DL + LL (F.S. = 2)	27	54
	Total Load (F.S. = 1.5)	36	54
Axial Uplift (Tension)	Total Load (F.S. = 2)	8	16*
Lateral Load (½-inch deflection)	Free Head: (F.S. = 1.5)	11	17

Notes: DL = Dead Load
LL = Live Load
F.S. = Factor of Safety
* = does not include frost heave uplift

For preliminary design, we modeled a single, reinforced 24-inch-diameter pier for “free-head” and “fixed-head” conditions subjected to a pier head deflection of ½-inch under static conditions. Pier fixity may be determined by utilizing the deflection, shear and moment diagrams included in Appendix C. A copy of the L-Pile output files can be provided upon request.

Near surface soils exposed to freezing conditions may experience frost heave. Piers subjected to adfreeze stresses (frost heave) should be factored into the design of the pile so that the total resisting forces exceed the uplift forces due to frost heave and other factors. Review of data presented by L. Domaschuk[1] indicates that concrete columns can experience adfreeze pressure on the order of 2000 to 3000 psf in clay soils. For design purposes, we recommend an adfreeze pressure of 2500 psf applied over the upper one foot multiplied by the pile circumference. Methods of mitigating adfreeze pressures include deepening the drilled piers or increasing the size of the footings.

Uplift resistance of pier foundations may be computed using the following resisting forces, where applicable: 1) weight of the pier concrete (150 pounds per cubic foot [pcf]) and 2) an allowable skin friction of 300 psf applied over the shaft area of the pier. Increased uplift resistance can be achieved by increasing the diameter of the pier or increasing the depth. The upper one foot of skin friction should be disregarded unless the pier is completed surrounded by slab concrete for a distance of at least three feet from the edge of the foundation pier.

Based on historic groundwater information, groundwater will likely be encountered during drilling and drilling with bentonite slurry and/or temporary casing will be required. If bentonite slurry is used or groundwater cannot not be controlled by bailing or submersible pumps such that more than six inches of water accumulates at the bottom of the pier excavation, concrete should be placed using a tremie. For the tremie method of concrete placement, the drilled pier concrete should have a design slump of six to eight inches, and a maximum aggregate size of ¾-inch. These required slump values should be obtained by using plasticizers or water-reducing agents. Addition of water on-site to establish the recommended slump should not be allowed.

When extracting temporary casings or tremie methods from the excavations, care should be taken to maintain a head of concrete to prevent infiltrations of water and soil into the shaft area. The head of concrete should always be greater than the head of water trapped outside the pier or tremie, considering the difference in unit weights of concrete and water.

<u>Interior Floor Slabs</u>

Interior concrete slab-on-grade floors can be supported upon very low-expansive, imported soil or lime-treated soil subgrade prepared in accordance with the recommendations in this report. Slabs-on-grade should be at least four inches thick, and final thickness, reinforcement and joint spacing should be determined by the slab designer. Proper and consistent location of the

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[1] Domaschuk, L., (1982). Frost heave forces on embedded structural units, *Department of Civil Engineering, University of Manitoba, Winnipeg, Canada, Proceedings of the 4th Canadian Permafrost Conference*, National Research Council, Canada 1982.

reinforcement near mid-slab is essential to its performance. The risk of uncontrolled shrinkage cracking is increased if the reinforcement is not properly located within the slab. Temporary loads exerted during construction from vehicle traffic, cranes, forklifts, other construction equipment, storage of palletized construction materials, etc. should be considered in the design of the thickness and reinforcement of the interior concrete slabs-on-grade.

Floor slabs should be underlain by a layer of free-draining crushed rock, serving as a deterrent to migration of capillary moisture. The crushed rock layer should be at least four inches thick and graded such that 100 percent passes a one-inch sieve and none passes a No. 4 sieve. Additional moisture protection may be provided by placing a vapor retarder membrane (at least 10-mils thick) directly over the crushed rock. The membrane should meet or exceed the minimum specifications as outlined in ASTM E1745 and be installed in strict conformance with the manufacturer's recommendations.

Floor slab areas that will be subjected to any vehicle/forklift traffic, frost heave, as well as floor slab areas to support palletized construction materials, cranes and/or any other relatively heavy construction equipment or machinery, should be supported by at least six inches of Class 2 aggregate base. The aggregate base should be compacted to at least 95 percent relative compaction to provide adequate support capacity. The aggregate base should be placed over the 12 inches of low-expansion potential imported soil, or lime treated soil.

Floor slab construction practice over the past 30 years or more has included placement of a thin layer of dry sand or pea gravel over the vapor retarder membrane. The intent of the sand/pea gravel is to aid in the proper curing of the slab concrete. However, during the wet seasons moisture can become trapped in the sand or pea gravel, which can lead to excessive moisture vapor emissions from floor slabs. Consequently, we consider use of the sand/pea gravel layer as optional. The concrete curing benefits should be weighed against efforts to reduce slab moisture vapor transmission.

Moisture Penetration Resistance

It is likely that floor slab subgrade soils will become very moist or wet at some time during the life of the structures. This is a certainty when slabs are constructed during the wet season or when constantly wet ground or poor drainage conditions exist adjacent to structures. For this reason, it should be assumed that interior slabs with moisture-sensitive floor coverings or coatings will require protection against moisture or moisture vapor penetration through the slabs.

It is emphasized that the crushed rock/grave and the vapor retarder membrane suggested above provides only a limited, first line of defense against soil-related moisture issues and will not "moisture proof" the slab. Nor do these measures provide an assurance that slab moisture transmission levels will achieve tolerable levels to prevent damage to floor coverings or other building components. If increased protection against moisture vapor penetration is desired, a concrete moisture protection specialist should be consulted. The design team should consider all available measures for slab moisture protection. It is commonly accepted that maintaining the lowest practical water-cement ratio in the slab concrete is one of the most effective ways to reduce future moisture vapor penetration of the completed slabs.

Exterior Flatwork

The upper 12 inches of final soil subgrade for exterior concrete flatwork areas (18 inches for swimming deck slabs) should consist of approved, imported, compactable, very low-expansive (Expansion Index ≤ 20) granular soils or lime-treated on-site or approved imported clay soils placed and compacted in accordance with the Engineered Fill Construction recommendations included in this report. Exterior flatwork subgrade soils should be maintained in a moist condition and protected from disturbance.

Exterior flatwork should be underlain by at least four inches of Class 2 Aggregate Base compacted to at least 95 percent relative compaction. The aggregate base can be included in the 12 inches of very-low expansive granular soils (not lime-treated soils), or the very-low expansive layer can be completely composed of Class 2 Aggregate Base. If the upper 12 inches of final soils subgrade for exterior flatwork will consist of lime-treated clay soils, the four inches of aggregate base should be placed over the lime-treated soils.

Exterior flatwork concrete should be at least four inches thick. Consideration should be given to thickening the edges of the slabs at least twice the slab thickness where wheel traffic is expected over the slabs. Expansion joints should be provided to allow for minor vertical movement of the flatwork. Exterior flatwork should be constructed independent of other structural elements by the placement of a layer of felt material between the flatwork and the structural element. The slab designer should determine the final thickness, strength and joint spacing of exterior slab-on-grade concrete. The slab designer should also determine if slab reinforcement for crack control is required and determine final slab reinforcing requirements.

Areas adjacent to exterior flatwork should be landscaped to maintain more uniform soil moisture conditions adjacent to and under flatwork. We recommend final landscaping plans not allow fallow ground adjacent to exterior concrete flatwork.

Practices recommended by the Portland Cement Association (PCA) for proper placement, curing, joint depth and spacing, construction, and placement of concrete should be followed during exterior concrete flatwork construction.

Retaining Walls

Retaining walls, if planned, that will be allowed to slightly rotate about their base (unrestrained at the top or sides) should be capable of resisting an "active" lateral earth pressure equal to an equivalent fluid pressure of 40 psf per foot of wall backfill for horizontal backfill and fully drained conditions. Retaining walls that are fixed at the top should be capable of resisting an "at-rest" lateral earth pressure equal to an equivalent fluid pressure of 60 psf per foot of wall backfill, again assuming horizontal granular backfill and fully drained conditions. Walls supporting sloping backfill, up to a two horizontal to one vertical (2H:1V) inclination, should be designed adding an additional 20 psf per foot of wall to the pressures presented above.

The calculated modified peak ground acceleration (PGA_M) of the site is 0.383g based on the 2019 CBC from the web interface developed by the SEAOC and HCAi. Based on recent research[2], the seismic increment of earth pressure may be neglected if the maximum ground acceleration if 0.4g or less. Therefore, the seismic increment of lateral earth pressure may be neglected.

Retaining walls may be supported on a continuous foundation extending at least 24 inches below lowest adjacent soil grade. Continuous footings for retaining walls may be designed based upon the recommendations contained in the Shallow Conventional Foundation section of this report. Appropriate setbacks for structures constructed behind the walls should be maintained so that such structures do not surcharge the walls. To utilize the full allowable passive resistance, the minimum horizontal distance from the base of the wall footing to the face of a graded slope in front of the wall should be at least five feet.

Retaining walls will experience additional surcharge loading if vehicles are parked, equipment is stored, or foundations are within a one horizontal to one vertical (1H:1V) projection from the bottom of the retaining wall. Surcharge loading under these circumstances should be evaluated by the wall designer on a case-by-case basis and be included in the design of the wall, in addition to the lateral earth pressures described above. The surcharge load distribution, magnitude of the surcharge resultant force to be applied on the wall and the location of where the resultant force should be applied will depend on the specific surcharge load type (e.g., point load, distributed load, etc.) and the distance away from the retaining wall.

Backfill behind retaining walls should be fully drained to prevent the build-up of hydrostatic pressure behind the wall. Retaining walls should be provided a drainage blanket of Class 2 permeable material, *Caltrans Standard Specifications*, Section 68-2.02F(3), at least one-foot-

[2] Lew, M., Sitar, N., and Al Atik, L. (2010). “Seismic Earth Pressures: Fact or Fiction.” Invited Keynote Paper, Earth Retention Conference, ER 2010, ASCE, Seattle.

wide extending from the base of wall to within one foot of the top of the wall. The top foot above the drainage layer should consist of compacted on-site materials, unless covered by a concrete slab or pavement. Weep holes or perforated pipe, as appropriate, should be provided at the base of the wall to collect accumulated water. Drainpipes, if used, should slope to discharge at no less than a one percent fall to suitable drainage facilities. Open-graded ½- to ¾-inch crushed rock may be used in lieu of the Class 2 permeable material, if the rock and drainpipe are completely enveloped in an approved non-woven, geotextile filter fabric. Alternatively, geotextile drainage composites such as MiraDRAIN® may be used in lieu of the drain rock layer. If used, geocomposite drain panels should be installed in accordance with the manufacturer's recommendations.

Structural backfill materials for retaining walls (other than the drainage layer) should consist of non-expansive (Expansion Index less than 20), compactable granular material that does not contain significant quantities of rubbish, rubble, organics, and rock over six inches in size. Clays, pea gravel and/or crushed rock are not considered suitable backfill materials for retaining walls. Structural backfill should be placed in lifts not exceeding eight inches in compacted thickness, moisture conditioned to at least the optimum moisture content, and should be mechanically compacted to at least 90 percent relative compaction.

Site Drainage

Final site grading should be accomplished to provide positive drainage of surface water away from the buildings and prevent ponding of water adjacent to foundations, slabs, or pavements. The subgrade adjacent to the buildings should be sloped away from the building at a minimum two percent gradient for at least five feet, where possible. All roof drains should be connected to non-perforated rigid pipes, which in-turn are connected to available drainage features that convey water away from the buildings and foundations or discharging the drainage onto paved or hard surfaces that slope away from the buildings. Landscape berms, if planned, should not be constructed in such a manner as to promote drainage toward the buildings.

Pavement Design

Based on laboratory test results and our experience with similar soils, it is our opinion an R-value of five is appropriate for design of pavements at the site supported on untreated subgrades. The on-site clay soils are anticipated to react well with the addition of quicklime (high-calcium or dolomitic), as well as enhance the support characteristics of the subgrade to resist freeze-thaw cycles and allow for a reduction in the aggregate base section. If the soils are lime-treated, an R-value of 40 can be used for design.

The pavement sections presented in Table 4 have been calculated using traffic indices assumed to be appropriate for the project. The procedures used for pavement design are in general conformance with Chapters 600 to 670 of the *California Highway Design Manual*, dated July 1, 2020. The project civil engineer should determine the appropriate traffic index and pavement section based on anticipated traffic conditions. If needed, we can provide alternative pavement sections for different traffic indices.

TABLE 4
PAVEMENT DESIGN ALTERNATIVES

Traffic Index (TI)	Typical Pavement Use	Untreated Subgrade R-value = 5			Lime-Treated Subgrade Soils (a) R-value = 40		
		Type A Asphalt Concrete (inch)	Class 2 Aggregate Base (inch)	Portland Cement Concrete (inch)	Type A Asphalt Concrete (inch)	Class 2 Aggregate Base (inch)	Portland Cement Concrete (inch)
4.5	Automobile Parking Only	2½	9	--	2½	4	--
		3*	8	--	3*	4	--
		--	4	4	--	4	4
5.5	Automobile Drive Lanes	2½	13	--	2½	7	--
		3*	12	--	3*	5	--
		--	4	5	--	5	4
6.5	Automobile, Light Delivery Truck and Fire Lanes	3	16	--	3	8	--
		4*	14	--	4*	6	--
		--	6	6	--	6	4
7.0	Trash Enclosures and Moderate Delivery Truck Traffic	3	18	--	3	9	--
		4*	15	--	4*	7	--
		--	7	6	--	6	5
8.0	Heavy Truck Traffic Lanes	4	19	--	4	10	--
		5*	18	--	6*	8	--
		--	7	7	--	6	6

Notes: * = Asphalt concrete thickness contains the Caltrans safety factor.
(a) = Lime-treated subgrade should be at least 12 inches thick and possess a minimum R-value of 40 when testing in accordance with California Test 301.

We emphasize that the performance of pavements is critically dependent upon uniform and adequate compaction of the soil subgrade, as well as all engineered fill and utility trench backfill within the limits of the pavements. We recommend that pavement subgrade preparation (i.e., scarification, moisture conditioning and compaction) be performed after underground utility construction is completed and just prior to aggregate base placement. The upper six inches of untreated and chemically treated pavement subgrade soils should be compacted to at least 95 percent relative compaction at no less than two percent above the optimum moisture content. All aggregate base should be compacted to at least 95 percent of the ASTM D1557 maximum dry density.

Pavement subgrades should be stable and unyielding under heavy wheel loads of construction equipment. To help identify unstable subgrades within the pavement limits, a proof-roll should be performed with a fully loaded water truck (or equivalent) on the exposed subgrades prior to placement of aggregate base. The proof-roll should be observed by the Geotechnical Engineer's representative.

It has been our experience that pavement failures may occur where a non-uniform or disturbed subgrade soil condition is created. Subgrade disturbances can result if pavement subgrade preparation is performed prior to underground utility construction and/or if a significant period passes between subgrade preparation and placement of aggregate base. Therefore, we recommend that final pavement subgrade preparation (i.e., scarification, moisture conditioning, and compaction) be performed just prior to aggregate base placement.

In the summer heat, high axle loads coupled with shear stresses induced by sharply turning tire movements can lead to failure in asphalt concrete pavements. Therefore, consideration should be given to using Portland cement concrete (PCC) pavements in areas subjected to concentrated heavy wheel loading, such as entry driveways, in front of trash enclosures, and/or in storage/unloading areas. Alternate PCC pavement sections have been provided above in Table 4.

Efficient drainage of all surface water to avoid infiltration and saturation of the supporting aggregate base and subgrade soils is important to pavement performance. Weep holes could be provided at drainage inlets, located at the subgrade-aggregate base interface, to allow accumulated water to drain from beneath the pavements.

Lime-treatment of Pavement Subgrade Soils

If lime-treatment of subgrade soils is selected, the lime-treatment of subgrade soils should be performed in general conformance with Section 24 of the *Caltrans Standard Specifications*, latest edition. Please note that sandy soils, if encountered, will likely require blending with clayey soils before amendment with quicklime will be effective.

If lime-treatment of pavement subgrades is selected, we recommend a minimum spread rate of at least 4½ pounds of high calcium quicklime per square foot of treated soil, at a depth sufficient to produce a compacted lime-treated layer 12 inches thick. After the materials have been thoroughly mixed and re-mixed, the soil-lime mixture should be compacted to at least 95 percent relative compaction at a moisture content at least two to four percent over optimum conditions. Compaction should be achieved using a heavy, self-propelled sheepsfoot compactor such as a Rex compactor. The lime-treated subgrade soils should have a minimum “mellowing period” of 36 hours prior to placement of aggregate base and asphalt concrete. The actual mellowing period for the lime-treated subgrade soils shall be determined by Geotechnical Engineer’s representative.

Drought Considerations

The State of California can experience extended periods of severe drought conditions. The ability for landowners to use irrigation as a means for maintaining landscape vegetation and soil moisture can be inhibited for unpredictable periods of time. For this reason, landscape and hardscape systems for this development should be carefully planned to prevent the desiccation of soils under and near foundations and slabs. Trees with invasive shallow root systems should be avoided. No trees or large shrubs that could remove soil moisture during dry periods should be planted within five feet of any foundation or slab. Fallow ground adjacent to foundations must be avoided.

Geotechnical Engineering Construction Observation Services

Wallace-Kuhl & Associates be retained to review the final plans and specifications to verify that the intent of our recommendations has been implemented in those documents.

Site preparation should be accomplished in accordance with the recommendations of this report. Geotechnical testing and observation during construction is considered a continuation of our geotechnical engineering investigation. Wallace-Kuhl & Associates should be retained to provide testing and observation services during site clearing, preparation, earthwork, and foundation construction at the project site to verify compliance with this geotechnical report and the project plans and specifications, and to provide consultation as required during construction. These services are beyond the scope of work authorized for this study; however, we can submit a proposal to provide these services upon request.
In the event that Wallace-Kuhl & Associates is not retained to provide geotechnical engineering observation and testing services during construction, the Geotechnical Engineer retained to

provide these services should indicate in writing that they agree with the recommendations of this report or prepare supplemental recommendations as necessary. A final report by the Geotechnical Engineer providing construction testing services should be prepared upon completion of the project.

LIMITATIONS

Our recommendations are based upon the information provided regarding the proposed project, combined with our analysis of site conditions revealed by our field explorations and associated laboratory testing programs. We have used engineering judgment based upon the information provided and the data generated from our study. This report has been prepared in substantial compliance with generally accepted geotechnical engineering practices that exist in the area of the project at the time the report was prepared. No warranty, either express or implied, is provided.

If the proposed construction is modified or re-sited; or, if it is found during construction that subsurface conditions differ from those we encountered at the boring locations, we should be afforded the opportunity to review the new information or changed conditions to determine if our conclusions and recommendations must be modified.

We emphasize that this report is applicable only to the proposed construction and the investigated site and should not be utilized for construction on any other site. The conclusions and recommendations of this report are considered valid for a period of two years. If design is not completed and construction has not started within two years of the date of this report, the report must be reviewed and updated, if necessary.

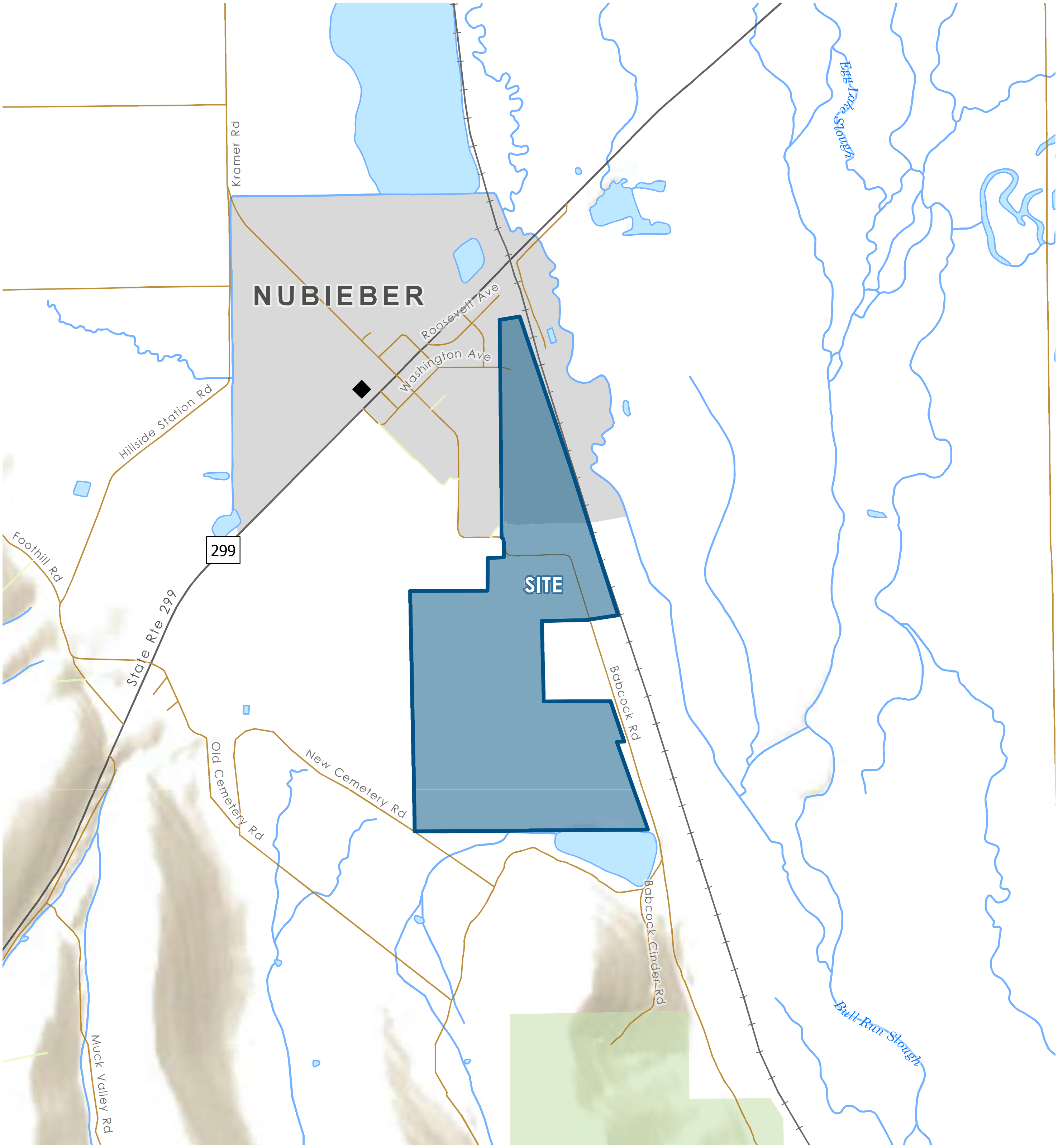
Wallace – Kuhl & Associates

Guang H. Zhu
Staff Engineer

Michael M. Watari
Principal Engineer

GHZ:MMW:/ghz

FIGURES



◆ Approximate Location of Monitoring Well

N

0 1,000 2,000
Feet

Spatial Data provided by Esri, NOAA, and USGS.
Projection: NAD 1983 2011 StatePlane California I FIPS 0401 Ft US

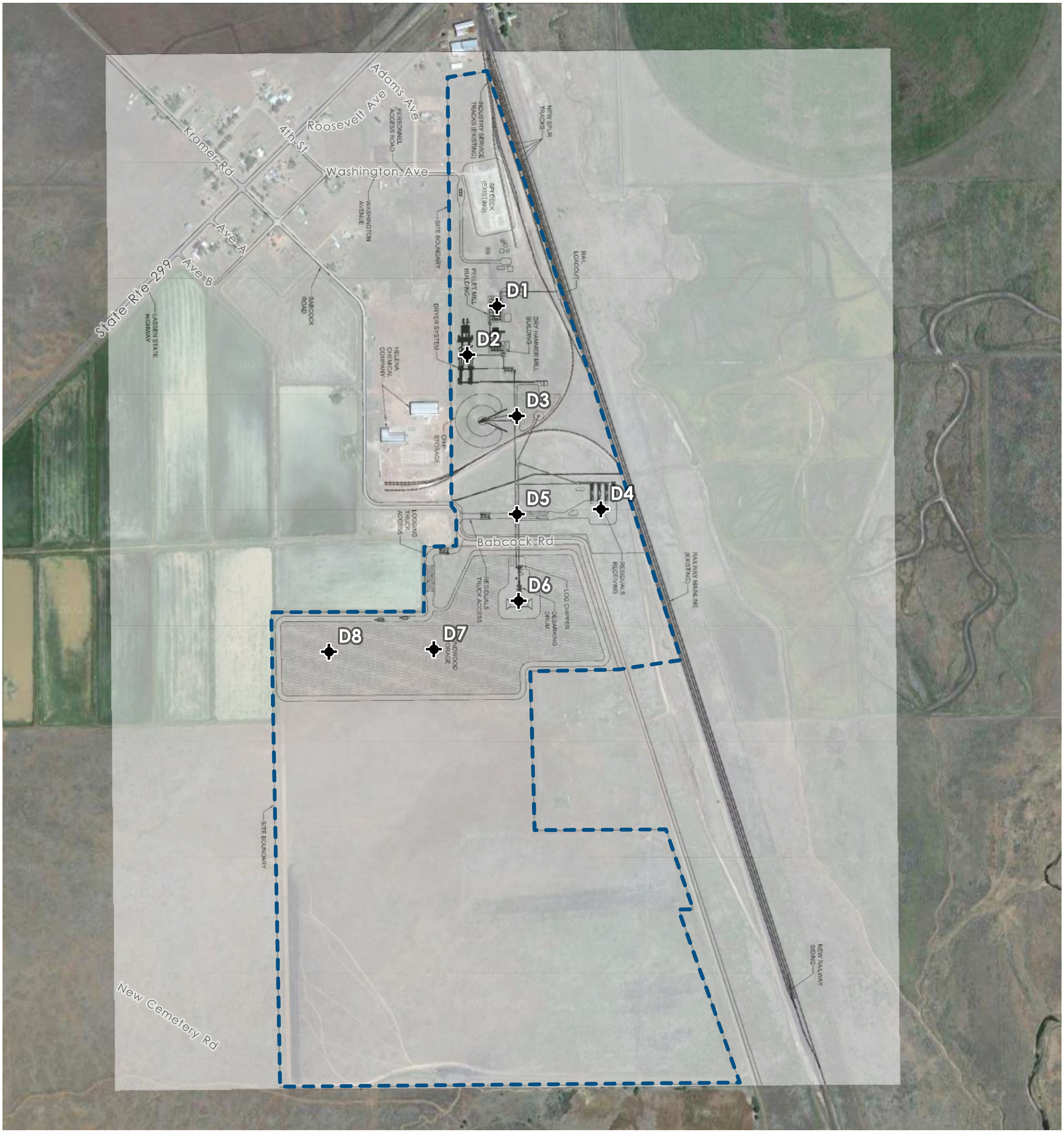
WallaceKuhl & ASSOCIATES
A Universal Engineering Sciences Company

VICINITY MAP

GOLDEN STATE NATURAL RESOURCES LASSEN COUNTY

Nubieber, Lassen County, California

FIGURE	1
DRAWN BY	RWO
CHECKED BY	GHZ
PROJECT MGR	MMW
DATE	09/2022
4630.2200118.0000	



Approximate Soil Boring Location

Approximate Site Boundary

N

0 500 1,000

Feet

Aerial imagery provided by Esri.
Site Plan adapted from a drawing provided by
Nexus Program Management Group, dated 2/18/2022.
Projection: NAD 1983 2011 StatePlane California I FIPS 0401 Ft US

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SITE PLAN

GOLDEN STATE NATURAL RESOURCES LASSEN COUNTY

Nubieber, Lassen County, California

FIGURE	2
DRAWN BY	RWO
CHECKED BY	GHZ
PROJECT MGR	MMW
DATE	09/2022

4630.2200118.0000

Project: Golden State Natural Resources Lassen County **Project Location: Nubieber, Lassen County, California** **WKA Number: 4630.2200118.0000**	**LOG OF SOIL BORING D1** Sheet 1 of 1

Date(s) Drilled	**7/14/22**	Logged By	**GHZ**	Checked By	**MMW**
Drilling Method	**Hollow Stem Auger**	Drilling Contractor	**V&W Drilling**	Total Depth of Drill Hole	**21.5 feet**
Drill Rig Type	**CME 55**	Diameter(s) of Hole, inches	**7"**	Approx. Surface Elevation, ft MSL	**4118.0**
Groundwater Depth [Elevation], feet	**8.0 [4110.0]**	Sampling Method(s)	**2.0" Modified California with 6-inch sleeve**	Drill Hole Backfill	**Soil Cuttings**
Remarks	**Bulk (0-2'); PI = 33, EI = 105**			Driving Method and Drop	**140lb auto. hammer with 30" drop**

ELEVATION, feet	DEPTH, feet	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE NUMBER	NUMBER OF BLOWS	MOISTURE CONTENT, %	DRY UNIT WEIGHT, pcf	ADDITIONAL TESTS
	0	Dark brown, moist, hard, fat CLAY (CH)	D1 (0-2')				PI = 33, EI = 105
			D1-1I	25	26	82	PP = 4.5+ tsf
4115	2.5	Light brown, moist, hard, strongly cemented, sandy lean CLAY (CL)					
			D1-2I	77	25	88	
	5						
	7	Dark brown, moist, dense, silty fine to coarse SAND (SM) with fine gravel					
4110	8	wet					
			D1-3I	45	13	112	
	10						
4105							
	15						
4100							
	20	Grayish brown, moist, stiff, silty lean CLAY (CL)	D1-4I	10			PP = 1.75 tsf

Boring was terminated at approximately 21½ feet below existing ground surface.
Groundwater encountered at approximately 8 feet below existing ground surface.

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FIGURE 3

Project: Golden State Natural Resources Lassen County Project Location: Nubieber, Lassen County, California WKA Number: 4630.2200118.0000	# LOG OF SOIL BORING D2 Sheet 1 of 1

Date(s) Drilled	7/14/22	Logged By	GHZ	Checked By	MMW
Drilling Method	Hollow Stem Auger	Drilling Contractor	V&W Drilling	Total Depth of Drill Hole	21.5 feet
Drill Rig Type	CME 55	Diameter(s) of Hole, inches	7"	Approx. Surface Elevation, ft MSL	4118.0
Groundwater Depth [Elevation], feet	7.0 [4111.0]	Sampling Method(s)	2.0" Modified California with 6-inch sleeve	Drill Hole Backfill	Soil Cuttings
Remarks				Driving Method and Drop	140lb auto. hammer with 30" drop

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE NUMBER	NUMBER OF BLOWS	TEST DATA: MOISTURE CONTENT, %	DRY UNIT WEIGHT, pcf	ADDITIONAL TESTS
			Dark brown, moist, hard, fat CLAY (CH) with sand						
4115					D2-1I	31	28	81	PP = 4.5+ tsf
			Brown, moist, medium dense, silty fine to medium SAND (SM)						
	5				D2-2I	31	25	73	
4110									
	10		dark brown, wet, fine to coarse sand, with fine gravel		D2-3I				
4105									
	15								
4100									
			Dark brown, moist, very stiff, silty lean CLAY (CL)						
	20				D2-4I	8			PP = 2.0 tsf

Boring was terminated at approximately 21½ feet below existing ground surface.
Groundwater encountered at approximately 7 feet below existing ground surface.

Project: Golden State Natural Resources Lassen County
Project Location: Nubieber, Lassen County, California
WKA Number: 4630.2200118.0000

LOG OF SOIL BORING D3

Date(s) Drilled	7/14/22	Logged By	GHZ	Checked By	MMW
Drilling Method	Hollow Stem Auger	Drilling Contractor	V&W Drilling	Total Depth of Drill Hole	20.0 feet
Drill Rig Type	CME 55	Diameter(s) of Hole, inches	7"	Approx. Surface Elevation, ft MSL	4120.0
Groundwater Depth [Elevation], feet	7.0 [4113.0]	Sampling Method(s)	2.0" Modified California with 6-inch sleeve	Drill Hole Backfill	Soil Cuttings
Remarks	Bulk (0-3'); EI = 111, CR			Driving Method and Drop	140lb auto. hammer with 30" drop

ELEVATION, feet	DEPTH, feet	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE NUMBER (SAMPLE DATA)	NUMBER OF BLOWS (SAMPLE DATA)	MOISTURE CONTENT, % (TEST DATA)	DRY UNIT WEIGHT, pcf (TEST DATA)	ADDITIONAL TESTS (TEST DATA)
	0	Dark brown, moist, hard, sandy fat CLAY (CH)					
			D3 (0-3')				EI = 111, CR
			D3-1I	41	28	82	PP = 4.5+ tsf UCC = 2.0 tsf
4115	5						
		Brown, moist, very dense, silty fine to coarse SAND (SM)	D3-2I	53	21	99	
	7 ▼						
4110	10						
		wet, dense	D3-3I	43			
4105	15						
		Brown, wet, lean CLAY (CL)					
4100	20						

Boring was terminated at approximately 20 feet below existing ground surface.
Groundwater encountered at approximately 7 feet below existing ground surface.

Project: Golden State Natural Resources Lassen County
Project Location: Nubieber, Lassen County, California
WKA Number: 4630.2200118.0000

LOG OF SOIL BORING D4

Date(s) Drilled	**7/14/22**	Logged By	**GHZ**	Checked By	**MMW**
Drilling Method	**Hollow Stem Auger**	Drilling Contractor	**V&W Drilling**	Total Depth of Drill Hole	**11.5 feet**
Drill Rig Type	**CME 55**	Diameter(s) of Hole, inches	**7"**	Approx. Surface Elevation, ft MSL	**4118.0**
Groundwater Depth [Elevation], feet	**9.0 [4109.0]**	Sampling Method(s)	**2.0" Modified California with 6-inch sleeve**	Drill Hole Backfill	**Soil Cuttings**
Remarks	**Bulk (0-3'); RV = 10**			Driving Method and Drop	**140lb auto. hammer with 30" drop**

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE NUMBER	NUMBER OF BLOWS	TEST DATA: MOISTURE CONTENT, %	DRY UNIT WEIGHT, pcf	ADDITIONAL TESTS
			Dark brown, moist, hard, fat CLAY (CH) with sand						
					D4 (0-3')				RV = 10
4115					D4-1I	42	33	84	PP = 4.5 tsf
			Brown, moist, very stiff, sandy lean CLAY (CL)						
	5								
					D4-2I	25	28	89	PP = 3.0 tsf
4110									
			Dark brown, wet, dense, silty fine to coarse SAND (SM) with fine gravel	▼					
	10								
					D4-3I	43			

Boring was terminated at approximately 11½ feet below existing ground surface.
Groundwater encountered at approximately 8½ feet below existing ground surface.

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FIGURE 6

Project: Golden State Natural Resources Lassen County
Project Location: Nubieber, Lassen County, California
WKA Number: 4630.2200118.0000

LOG OF SOIL BORING D5

Date(s) Drilled	7/14/22	Logged By	GHZ	Checked By	MMW
Drilling Method	Hollow Stem Auger	Drilling Contractor	V&W Drilling	Total Depth of Drill Hole	20.0 feet
Drill Rig Type	CME 55	Diameter(s) of Hole, inches	7"	Approx. Surface Elevation, ft MSL	4119.0
Groundwater Depth [Elevation], feet	8.5 [4110.5]	Sampling Method(s)	2.0" Modified California with 6-inch sleeve	Drill Hole Backfill	Soil Cuttings
Remarks				Driving Method and Drop	140lb auto. hammer with 30" drop

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE	SAMPLE NUMBER	NUMBER OF BLOWS	MOISTURE CONTENT, %	DRY UNIT WEIGHT, pcf	ADDITIONAL TESTS
			Dark brown, moist, hard, fat CLAY (CH)						
					D5-1I	34	26	79	PP = 4.5+ tsf
			Brown, moist, stiff, lean CLAY (CL) with sand						
4115					D5-2I	20	37	75	PP = 1.75 tsf UCC = 0.5 tsf
	5								
			Dark brown, moist, medium dense, silty fine SAND (SM)						
			wet						
4110					D5-3I	19			TC
	10								
4105					D5-4I	87			
	15								
			Dark brown, wet, stiff, lean CLAY (CL)						
4100					D5-5I	16			PP = 1.5 tsf
	20								

Boring was terminated at approximately 20 feet below existing ground surface.
Groundwater encountered at approximately 8½ feet below existing ground surface.

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FIGURE 7

Project: Golden State Natural Resources Lassen County
Project Location: Nubieber, Lassen County, California
WKA Number: 4630.2200118.0000

LOG OF SOIL BORING D6

Date(s) Drilled	**7/14/22**	Logged By	**GHZ**	Checked By	**MMW**
Drilling Method	**Hollow Stem Auger**	Drilling Contractor	**V&W Drilling**	Total Depth of Drill Hole	**21.5 feet**
Drill Rig Type	**CME 55**	Diameter(s) of Hole, inches	**7"**	Approx. Surface Elevation, ft MSL	**4120.0**
Groundwater Depth [Elevation], feet	**9.0 [4111.0]**	Sampling Method(s)	**2.0" Modified California with 6-inch sleeve**	Drill Hole Backfill	**Soil Cuttings**
Remarks	**Bulk (0-3'); PI = 21, EI = 82, CR**			Driving Method and Drop	**140lb auto. hammer with 30" drop**

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: SAMPLE NUMBER	SAMPLE DATA: NUMBER OF BLOWS	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
			Brown, moist, hard, lean CLAY (CL) with sand		D6(0-3')				PI = 21, EI = 82, CR
					D6-1I	16			PP = 4.5 tsf
4115	5		Brown, moist, medium dense, silty fine SAND (SM)		D6-2I	12			
4110	10		wet, dense, fine to coarse sand, with fine gravel		D6-3I	42			
4105	15		dark brown, very dense		D6-4I	62			
4100	20		dark grayish brown		D6-5I	55			

Boring was terminated at approximately 15 feet below ground surface.
Groundwater encountered at approximately 9 feet below existing ground surface.

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FIGURE 8

Project: Golden State Natural Resources Lassen County	LOG OF SOIL BORING D7
Project Location: Nubieber, Lassen County, California	Sheet 1 of 1
WKA Number: 4630.2200118.0000	

Date(s) Drilled	7/14/22	Logged By	GHZ	Checked By	MMW
Drilling Method	Hollow Stem Auger	Drilling Contractor	V&W Drilling	Total Depth of Drill Hole	10.0 feet
Drill Rig Type	CME 55	Diameter(s) of Hole, inches	7"	Approx. Surface Elevation, ft MSL	4119.0
Groundwater Depth [Elevation], feet	10.0 [4109.0]	Sampling Method(s)	2.0" Modified California with 6-inch sleeve	Drill Hole Backfill	Soil Cuttings
Remarks	Bulk (0-2'); RV = 5			Driving Method and Drop	140lb auto. hammer with 30" drop

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: SAMPLE NUMBER	SAMPLE DATA: NUMBER OF BLOWS	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
			Dark brown, moist, very stiff, fat CLAY (CH)		D7 (0-2')				RV = 5
					D7-1I	27	34	78	
4115			Brown, moist, hard, lean CLAY (CL); with calcification		D7-2I	39	37	82	
	5								
			Brown, miost, medium dense, silty fine SAND (SM)						
4110					D7-3I	20			
	10								

Boring was terminated at approximately 10 feet below existing ground surface.
Groundwater encountered at approximately 10 feet below existing ground surface.

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FIGURE 9

Project: Golden State Natural Resources Lassen County
Project Location: Nubieber, Lassen County, California
WKA Number: 4630.2200118.0000

LOG OF SOIL BORING D8

Date(s) Drilled	**7/14/22**	Logged By	**GHZ**	Checked By	**MMW**
Drilling Method	**Hollow Stem Auger**	Drilling Contractor	**V&W Drilling**	Total Depth of Drill Hole	**11.5 feet**
Drill Rig Type	**CME 55**	Diameter(s) of Hole, inches	**7"**	Approx. Surface Elevation, ft MSL	**4119.0**
Groundwater Depth [Elevation], feet	**10.0 [4109.0]**	Sampling Method(s)	**2.0" Modified California with 6-inch sleeve**	Drill Hole Backfill	**Soil Cuttings**
Remarks	**Bulk (0-3')**			Driving Method and Drop	**140lb auto. hammer with 30" drop**

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE	SAMPLE NUMBER	NUMBER OF BLOWS	MOISTURE CONTENT, %	DRY UNIT WEIGHT, pcf	ADDITIONAL TESTS
			SAMPLE DATA				TEST DATA		
			Dark brown, moist, hard, fat CLAY (CH)						
					D8(0-3')				
			with sand		D8-1I	36	31	89	PP = 4.5+ tsf
4115			Dark brown, moist, medium dense, silty fine SAND (SM)						
	5				D8-2I	25	30	87	
4110									
	10		wet, fine to coarse, with fine gravel		D8-3I	39			
			Boring was terminated at approximately 11½ feet below existing ground surface. Groundwater encountered at approximately 10 feet below existing ground surface.						

FIGURE 10

UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2487)

MAJOR DIVISIONS		USCS[4]	CODE	CHARACTERISTICS
COARSE GRAINED SOILS (More than 50% of soil > no. 200 sieve size)	GRAVELS[1] (More than 50% of coarse fraction > no. 4 sieve size)	GW		Well-graded gravels or gravel - sand mixtures, trace or no fines
		GP		Poorly graded gravels or gravel - sand mixtures, trace or no fines
		GM		Silty gravels, gravel - sand - silt mixtures, containing little to some fines [2]
		GC		Clayey gravels, gravel - sand - clay mixtures, containing little to some fines [2]
	SANDS[1] (50% or more of coarse fraction < no. 4 sieve size)	SW		Well-graded sands or sand - gravel mixtures, trace or no fines
		SP		Poorly graded sands or sand - gravel mixtures, trace or no fines
		SM		Silty sands, sand - gravel - silt mixtures, containing little to some fines [2]
		SC		Clayey sands, sand - gravel - clay mixtures, containing little to some fines [2]
FINE GRAINED SOILS (50% or more of soil < no. 200 sieve size)	SILTS & CLAYS LL < 50	ML		Inorganic silts, gravely silts, and sandy silts that are non-plastic or with low plasticity
		CL		Inorganic lean clays, gravelly lean clays, sandy lean clays of low to medium plasticity [3]
		OL		Organic silts, organic lean clays, and organic silty clays
	SILTS & CLAYS LL ≥ 50	MH		Inorganic elastic silts, gravelly elastic silts, and sandy elastic silts
		CH		Inorganic fat clays, gravelly fat clays, sandy fat clays of medium to high plasticity
		OH		Organic fat clays, gravelly fat clays, sandy fat clays of medium to high plasticity
HIGHLY ORGANIC SOILS		PT		Peat
ROCK		RX		Rocks, weathered to fresh
FILL		FILL		Artificially placed fill material

OTHER SYMBOLS

- = Drive Sample: 2-1/2" O.D. Modified California sampler
- = Drive Sampler: no recovery
- = SPT Sampler
- = Initial Water Level
- = Final Water Level
- — — — = Estimated or gradational material change line
- ——— = Observed material change line

Laboratory Tests

CR = Corrosion
PI = Plasticity Index
EI = Expansion Index
UCC = Unconfined Compression Test (TSF)
TR = Triaxial Compression Test
GR = Gradational Analysis (Sieve/Hydro)
FC = Wash (Fines Content)
PP = Pocket Penetrometer Test (TSF)
PID = Photo Ionization Detector Test (PPM)
RV = Resistance ("R") Value

REF = Refusal (>50 blows in 6 inches)

GRAIN SIZE CLASSIFICATION

CLASSIFICATION	RANGE OF GRAIN SIZES	
	U.S. Standard Sieve Size	Grain Size in Millimeters
BOULDERS (b)	Above 12"	Above 300
COBBLES (c)	12" to 3"	300 to 75
GRAVEL (g) coarse fine	3" to No. 4 3" to 3/4" 3/4" to No. 4	75 to 4.75 75 to 19 19 to 4.75
SAND coarse medium fine	No. 4 to No. 200 No. 4 to No. 10 No. 10 to No. 40 No. 40 to No. 200	4.75 to 0.075 4.75 to 2.00 2.00 to 0.425 0.425 to 0.075
SILT & CLAY	Below No. 200	Below 0.075

Trace - Less than 5 percent
Few - 5 to 10 percent
Little - 15 to 25 percent
Some - 35 to 45 percent
Mostly - 50 to 100 percent

* Percents as given in ASTM D2488

NOTES:

1. Coarse grained soils containing 5% to 12% fines, use dual classification symbol (ex. SP-SM).
2. If fines classify as CL-ML (4<PI<7), use dual symbol (ex. SC-SM).
3. Silty Clays, use dual symbol (CL-ML).
4. Borderline soils with uncertain classification list both classifications (ex. CL/ML).

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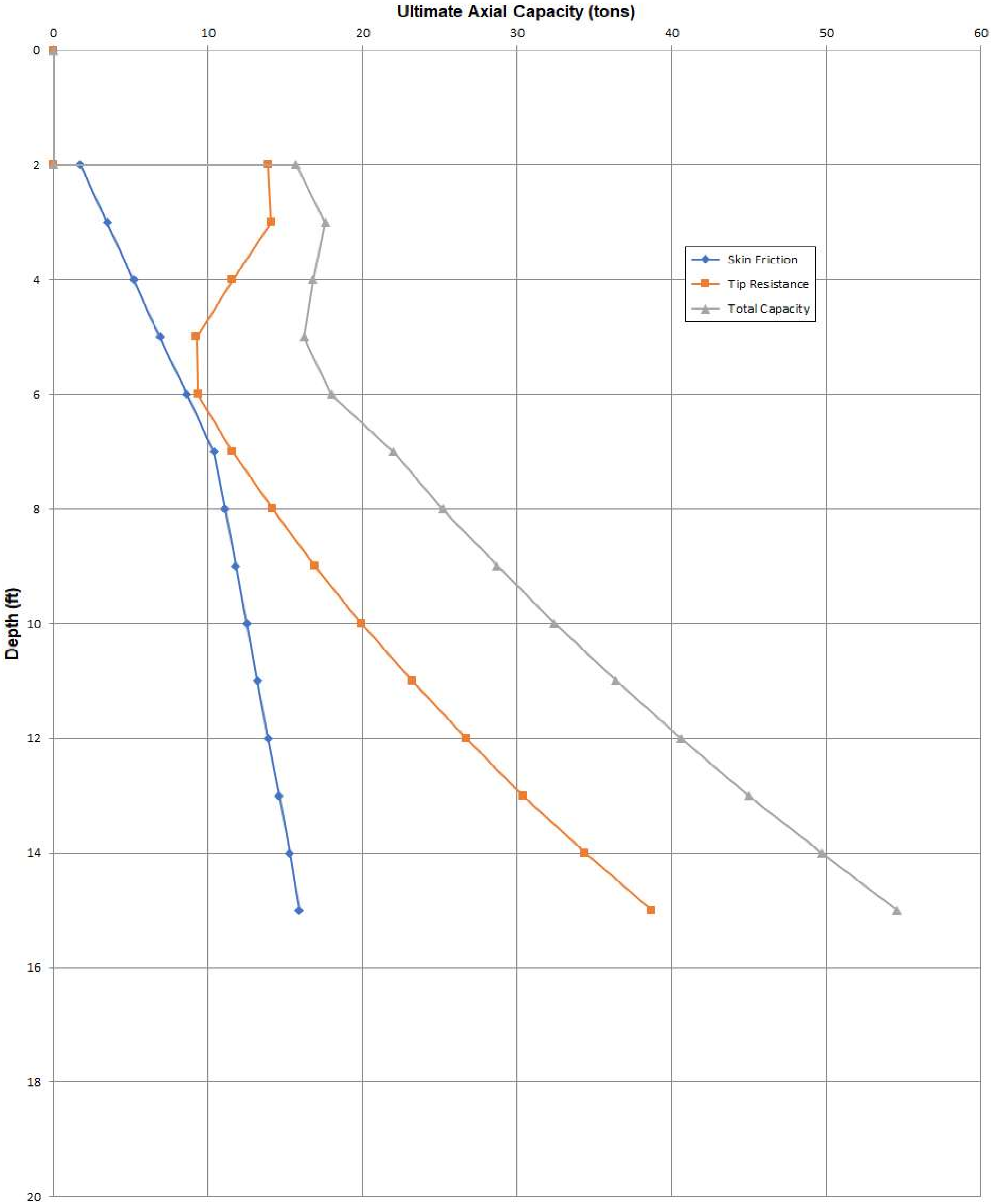
UNIFIED SOIL CLASSIFICATION SYSTEM

GOLDEN STATE NATURAL RESOURCES LASSEN COUNTY

Nubieber, Lassen County, California

FIGURE	11
DRAWN BY	RWO
CHECKED BY	GHZ
PROJECT MGR	MMW
DATE	09/2022
4630.2200118.0000	



PILE CAPACITY RESULTS

GOLDEN STATE NATURAL RESOURCES LASSEN COUNTY

Nubieber, Lassen County, California

FIGURE	12
DRAWN BY	GHZ
CHECKED BY	MMW
PROJECT MGR	MMW
DATE	09/2022

4630.2200118.0000

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APPENDIX A

General Project Information, Laboratory Testing and Results

APPENDIX A

A. GENERAL INFORMATION

The performance of a geotechnical engineering study for the pellet processing facility to be constructed at 551000 Roosevelt Avenue in Nubieber, Lassen County, California, was authorized by Mr. Kevin Cann with Golden State Natural Resources on June 28, 2022. Authorization was for a study as described in our proposal letter dated June 10, 2022 sent to our client whose mailing address 1215 K Street, Suite 1650 in Sacramento, California 95814; telephone (209) 617-1402.

B. FIELD EXPLORATION

Eight soil borings (D1 through D8) were performed on July 14, 2022 to depths ranging from about 10 to 21½ feet below existing site grades utilizing a CME-55 truck-mounted drilling rig equipped with seven-inch-diameter hollow stem augers provided by V&W Drilling of Galt, California. At various intervals soil samples were recovered with a 2½-inch outside diameter (O.D.), 2-inch inside diameter (I.D.), modified California split-spoon sampler. The sampler was driven by an automatic 140-pound hammer freely falling 30 inches. The number of blows of the hammer required to drive the 18-inch-long samplers each six-inch interval was recorded. The sum of the blows required to drive the sampler the lower 12-inch interval is designated the penetration resistance or "blow count" for that particular drive.

The modified California samples were retained in 2-inch-diameter by 6-inch-long, thin-walled brass tubes contained within the sampler. After recovery, the field representative visually classified the soil recovered in the tubes. After the samples were classified, the ends of the tubes were sealed to preserve the natural moisture contents.

In addition to the driven samples, representative bulk samples of near-surface soils also were collected and retained in plastic bags. Driven and bulk samples were taken to our laboratory for additional soil classification and selection of samples for testing.

Descriptions of the soils encountered at the boring locations are presented on Figures 3 through 10. An explanation of the Unified Soil Classification System symbols used in the descriptions is presented on Figure 11.

C. LABORATORY TESTING

Selected soil samples were tested to determine dry unit weight (ASTM D2937), natural moisture content (ASTM D2216), and unconfined compressive strength (ASTM D2166). The results of these tests are included on the boring logs at the depth each sample was obtained.

Two representative near-surface samples were subjected to Atterberg Limits tests (ASTM D4318). The results of this test are presented in Figure A1.

Three representative near-surface soil samples were tested for Expansion Index (ASTM D4829) with results presented in Figures A2 through A4.

Two representative samples of near-surface soil were subjected to Resistance-value ("R") testing in accordance with California Test 301. The results of the R-value tests are presented in Figure A5.

One relatively undisturbed sample of near-surface soil was subjected to a triaxial shear test (ASTM D4767). The results of this test are presented in Figure A6.

Two samples of the near-surface soil were submitted to Sunland Analytical to determine the soil pH, minimum resistivity (California Test 643), Sulfate concentration (California Test 417) and Chloride concentration (California Test 422). The results of these tests are presented in Figures A7 and A8.

APPENDIX B

Guide Earthwork Specifications

APPENDIX B

GUIDE EARTHWORK SPECIFICATIONS

GOLDEN STATE NATURAL RESOURCES LASSEN COUNTY

Nubieber, Lassen County, California

WKA No. 4630.2200118.0000

PART 1: GENERAL

1.1 SCOPE

a. General Description

This item shall include all clearing and site demolition, preparation of land to be filled, filling, soil treatment, spreading, compaction, observation and testing of the fill, and all subsidiary work necessary to complete the grading of the buildings and pavement areas to conform with the lines, grades and slopes as shown on the accepted Drawings.

b. Related Work Specified Elsewhere

(1) Trenching and backfilling for sanitary sewer system: Section ____.

(2) Trenching and backfilling for storm sewer system: Section ____.

(3) Trenching and backfilling for underground water, natural gas, and electrical supplies: Section ____.

c. Geotechnical Engineer

Where specific reference is made to "Geotechnical Engineer," this designation shall be understood to include both the Geotechnical Engineer and a field representative of the Geotechnical Engineer.

1.2 PROTECTION

a. Adequate protection measures shall be provided to protect workmen and passers-by at the site. Streets and adjacent property shall be fully protected throughout the operations.

b. In accordance with generally accepted construction practices, the Contractor shall be solely and completely responsible for working conditions at the job site, including safety of all persons and property during performance of the work. This requirement shall apply continuously and shall not be limited to normal working hours.

c. Any construction review of the Contractor's performance conducted by the Geotechnical Engineer is not intended to include review of the adequacy of the Contractor's safety measures, in, on or near the construction site.

d. Adjacent streets, sidewalks and properties shall be kept free of mud, dirt or similar nuisances resulting from earthwork operations.

e. Surface drainage provisions shall be made during the period of construction in a manner to avoid creating a nuisance to adjacent areas.

f. The site and adjacent influenced areas shall be watered as required to suppress dust nuisance.

1.3 GEOTECHNICAL REPORT

a. A *Geotechnical Engineering Report* (WKA No. 4630.2200118.0000, dated September 13, 2022) has been prepared for this site by Wallace-Kuhl & Associates of West Sacramento, California [(916) 372-1434]. A copy is available for review at the office of Wallace-Kuhl & Associates.

b. The information contained in this report was obtained for design purposes only. The contractor is responsible for any conclusions he/she may draw from this report; should he/she prefer not to assume such risk, the contractor should employ their own experts to analyze available information and/or to make additional borings upon which to base his conclusions, all at no cost to the Owner.

1.4 EXISTING SITE CONDITIONS

The Contractor shall become acquainted with all site conditions. If unshown active utilities are encountered during the work, the Architect shall be promptly notified for instructions. Failure to notify will make the Contractor liable for damage to these utilities arising from Contractor's operations subsequent to his discovery of such unshown utilities.

1.5 SEASONAL LIMITS

Fill material shall not be placed, spread or rolled during unfavorable weather conditions. When the work is interrupted by heavy rains, fill operations shall not be resumed until field tests indicated that the moisture contents of the subgrade and fill materials are satisfactory.

PART 2: PRODUCTS

2.1 MATERIALS

a. All fill shall be of approved local materials from required excavations, supplemented by imported fill, if necessary. Approved local materials are defined as local soils that do not contain significant quantities of rubble, rubbish, and vegetation, and having been tested and approved by the Geotechnical Engineer prior to use.

b. All imported fill materials shall be approved by the Geotechnical Engineer prior to being transported to the site. All fill material also shall be free of particles not exceeding three inches (3") in maximum dimension, not contain known contaminants and be within acceptable corrosion limits, with appropriate documentation provided by the contractor.

c. Imported fill materials to be used in the upper twelve inches (12”) of soil subgrade beneath interior floor slabs and exterior flatwork, as defined in the *Geotechnical Engineering Report*, shall be compactable, well-graded, granular soils with a Plasticity Index not exceeding fifteen (15) when tested in accordance with ASTM D4318 and an Expansion Index not exceeding twenty (20) when tested in accordance with ASTM D4829.

d. Imported fill materials to be used deeper than the twelve inches (12”) of the final soil subgrade elevation beneath interior floor slabs or exterior flatwork, as defined in the *Geotechnical Engineering Report*, within pavement areas, or to be lime-treated can consist of locally derived clay soils provided they are similar to but less expansive than native soil and does not contain particles greater than three inches in maximum dimension.

e. Materials to be lime-treated shall be on-site or approved imported clay soils free from significant quantities of rubble, rubbish and vegetation and shall have been tested and approved by the Geotechnical Engineer.

f. Capillary barrier material under floor slabs shall be provided to the thickness shown on the Drawings. This material shall be clean gravel or crushed rock of one-inch (1") maximum size, with less than five percent (5%) material passing a Number Four (#4) sieve.

g. Lime used for stabilization shall be high-calcium or dolomitic quicklime conforming to the definitions in ASTM Designation C977.

1) When sampled by the Geotechnical Engineer from the lime spreader or during the spreading operations, the sample of lime shall conform to the following requirements:

Lime Quality

Property	ASTM Designation	Requirements
Available calcium and magnesium oxide [minimum percent (%)]	C25 or C1301 & C1271	High calcium quicklime: CaO > 90% Dolomitic quicklime: CaO > 55% & CaO + MgO > 90%
Loss on ignition [maximum percent (%)]	C25	7% (total loss) 5% (carbon dioxide) 2% (free moisture)
Slaking Rate [degrees Celsius (°C)]	C110	30°C rise in 8 minutes

2) When dry sieved in a mechanical sieve shaker for 10 minutes ±30 seconds, a 0.5 pound (lb) test sample of quicklime shall conform to the following grading requirements:

Lime Grading

Sieve Sizes	Percentage Passing
3/8-inch	98 - 100

h. The burden of proof as to quality and suitability of alternatives shall be upon the Contractor and/or Supplier and he shall furnish test data and all information necessary, as required by the Geotechnical Engineer. Written request for alternatives, accompanied by complete data as to the quality and suitability of the material shall be made in ample time to permit testing and approval without delaying the work. The Geotechnical Engineer shall be the sole judge as to the quality and suitability of alternatives and his decision shall be final. Documentation shall be provided to the Geotechnical Engineer no later than two weeks before the alternative material is imported to the site.

i. Lime from more than one source or of more than one type may be used on the same project but the different limes shall not be mixed.

j. The lime shall be protected from moisture until used and shall be sufficiently dry to flow freely when handled.

k. Water for use in subgrade stabilization shall be clean and potable and shall be added during mixing, remixing, and compaction operations, and during the curing period to keep the cured material moist until covered.

l. Other products, such as aggregate base, asphalt concrete and related asphaltic seal coats, tack coat, etc., shall comply with the appropriate provision of the State of California (Caltrans) Standard Specifications, latest edition.

PART 3: EXECUTION

3.1 LAYOUT AND PREPARATION

Lay out all work, establish grades, locate existing underground utilities, set markers and stakes, set up and maintain barricades and protection of utilities--all prior to beginning actual earthwork operations.

3.2 CLEARING, GRUBBING, AND PREPARING BUILDING PAD, AND PAVEMENT AREAS

a. All surface and other sub-surface items at the site, including utilities and associated backfill, vegetation, debris, and other items encountered during site work and deemed unacceptable by the Geotechnical Engineer, shall be removed and disposed of so as to leave the disturbed areas with a neat and finished appearance, free from unsightly debris. All demolition debris shall be hauled off site.

b. If any wells, septic systems or tanks are encountered at the site, they shall be properly abandoned in accordance with governing agency’s requirements.

c. Excavations and depressions resulting from the removal of such items, as determined by the Geotechnical Engineer, shall be cleaned out to firm, undisturbed soils and backfilled with suitable materials in accordance with these specifications.

d. All structural areas (building pads, pavements, exterior flatwork, etc.) shall be stripped of vegetation and organically laden topsoil. With prior approval of our office, stripping may be used in landscaped areas, provided they are kept at least five feet (5') from buildings pads and other structural improvements, moisture conditioned and compacted.

e. Existing ditches or swales shall be fully drained of water and cleaned of organics prior to site grading.

f. Compaction operations for all soil subgrades shall be undertaken with a heavy, self-propelled, sheepsfoot compactor capable of achieving the compaction requirements included in the Geotechnical Engineering Report.

g. When the moisture content of the fill material is less than the optimum moisture content for granular/silty soils or at least two percent (2%) above the optimum moisture content for clay soils as defined by the ASTM D1557 Compaction Test, water shall be added until the proper moisture content is achieved.

h. When the moisture content of the subgrade is too high to permit the specified compaction to be achieved, the subgrade shall be aerated by blading or other methods until the moisture content is satisfactory for compaction.

i. Site clearing and subgrade preparation operations shall extend at least five feet (5') beyond the building pads and at least two feet (2') beyond exterior flatwork areas, pavements and any other structural areas.

j. Compaction operations shall be performed in the presence of the Geotechnical Engineer who will evaluate the performance of the materials under compactive load. Loose, soft, and saturated soils and unstable soil deposits, as determined by the Geotechnical Engineer, shall be excavated to expose a firm base and grades restored with engineered fill in accordance with these specifications.

3.3 CONSTRUCTION OF UNTREATED SUBGRADES

a. The selected soil fill material shall be placed in layers which when compacted shall not exceed six inches (6") in compacted thickness. Each layer shall be spread evenly and shall be thoroughly mixed during the spreading to promote uniformity of material in each layer.

b. When the moisture content of the fill material is less than the optimum moisture content for granular soils or at least two percent (2%) above the optimum moisture content for clay soils, as defined by the ASTM D1557 Compaction Test, water shall be added until the proper moisture content is achieved.

c. When the moisture content of the fill material is too high to permit the specified degree of compaction to be achieved, the fill material shall be aerated by blading or other methods until the moisture content is satisfactory..

d. After each layer has been placed, mixed and spread evenly, it shall be thoroughly compacted to not less than ninety percent (90%) of maximum dry density as determined by the ASTM D1557 Compaction Test. Compaction shall be undertaken with equipment capable of achieving the specified density and shall be accomplished while the fill material is at the required moisture content. Each layer shall be compacted over its entire area until the desired density has been obtained.

e. The fill operations shall be continued until the fills have been brought to the slopes and grades shown on the accepted Drawings.

3.4 LIME-STABILIZED SUBGRADE CONSTRUCTION

a. On-site or approved imported clay material, or sand/silt material blended with clay materials, to be treated shall be placed at a moisture content at least two percent (2%) over optimum moisture as defined by the ASTM D1557 Compaction Test.

b. Material to be treated shall be scarified and thoroughly broken up to the full depth and width to be stabilized. The material to be treated shall contain no rocks or solids larger than one and one-half inches (1½") in maximum dimension.

c. Mixing lime-treated material shall consist of the following:

1) Lime shall be added to the material to be treated at a rate of no less than four and a half pounds (4½ lbs.) of lime per square foot of treated soil, at a depth sufficient to produce a compacted lime-treated layer twelve inches (12”) thick, or six and three quarter pounds (6¾ lbs.) of lime per square foot of treated soil, at a depth sufficient to produce a compacted lime-treated layer eighteen inches (18”) thick.

2) Lime shall be spread by equipment that will uniformly distribute the required amount of lime for the full width of the prepared material. The rate of spread per linear foot of blanket shall not vary more than five percent (5%) from the designated rate.

3) The spread lime shall be prevented from blowing by suitable means selected by the Contractor. Quicklime shall not be used to make lime

slurry. The spreading operations shall be conducted in such a manner that a hazard is not present to construction personnel or the public. All lime spread shall be thoroughly ripped in, or mixed into, the soil the same day lime spreading operations are performed.

4) The distance which lime may be spread upon the prepared material ahead of the mixing operation shall be determined by the Geotechnical Engineer.

5) No traffic other than the mixing equipment will be allowed to pass over the spread lime until after the completion of mixing.

6) Mixing equipment shall be equipped with a visual depth indicator showing mixing depth, an odometer or foot meter to indicate travel speed and a controllable water additive system for regulating water added to the mixture.

7) Mixing equipment shall be of the type that can mix the full depth of the treatment specified and leave a relatively smooth bottom of the treated section. Mixing and re-mixing, regardless of equipment used, will continue until the material is uniformly mixed (free of streaks or pockets of lime), moisture is at approximately two percent (2%) over optimum, and the mixture complies with the following requirements:

Minimum Sieve Size	Percent Passing
1-1/2"	100
1"	95
No. 4	60

8) Non-uniformity of color reaction when the treated material, exclusive of one inch or larger clods, as tested with the standard phenolphthalein alcohol indicator, will be considered evidence of inadequate mixing.

9) Lime-treated material shall not be mixed or spread while the atmospheric temperature is below 35 degrees Fahrenheit (35°F).

10) Remixing of the treated soils shall be performed no sooner than twelve (12) hours after the initial mixing, and no later than seventy-two (72) hours after the initial mixing. The entire mixing operation shall be completed within seventy-two

(72) hours of the initial spreading of lime, unless otherwise permitted by the Geotechnical Engineer.

d. Spreading and compacting of lime-treated material shall consist of the following:

1) The treated mixture shall be spread to the required width, grade, and cross-section. The maximum compacted thickness of a single layer may be determined by the Contractor provided he can demonstrate to the Geotechnical Engineer that his equipment and method of operation will provide uniform distribution of the lime and the required compacted density throughout the layer. If the Contractor is unable to achieve uniformity and density throughout the thickness selected, he shall rework the affected area using thinner lifts until a satisfactory treated subgrade meeting the distribution and density requirements is attained, as determined by the Geotechnical Engineer, at no additional cost to the Owner.

2) The finished thickness of the lime-treated material shall not vary more than one-tenth foot (0.1') from the planned thickness at any point.

3) The lime-treated soils shall be compacted to a relative compaction of not less than ninety five percent (95%) for pavements as determined by the ASTM D1557 Compaction Test.

4) Initial compaction shall be performed by means of a sheepsfoot or segmented wheel roller. Final rolling shall be by means of steel-tired or pneumatic-tired rollers.

5) Areas inaccessible to rollers shall be compacted to meet the minimum compaction requirement by other means satisfactory to the Geotechnical Engineer.

6) Final compaction shall be completed within thirty-six (36) hours of initial mixing, and within four (4) hours of final mixing. The surface of the finished lime-treated material shall be the grading plane and at any point shall not vary more than eight one hundredths of a foot (0.08') foot above or below the grade established by the Civil Engineer except that when the lime-treated material is to be covered by material which is paid for by the cubic yard the surface of the finished lime-treated material shall not extend above the grade established by the Civil Engineer.

7) Before final compaction, if the treated material is above the grade tolerance specified in this section, uncompacted excess material may be

removed and used in areas inaccessible to mixing equipment. After final compaction and trimming, excess material shall be removed and disposed of off-site. The trimmed and completed surface shall be rolled with steel or pneumatic-tired rollers. Minor indentations may remain in the surface of the finished material so long as no loose material remains in the indentations.

8) At the end of each day's work, a construction joint shall be made in thoroughly compacted material and with a vertical face. After a partial-width section has been completed, the longitudinal joint against which additional material is to be placed shall be trimmed approximately three inches (3") into treated material, to the neat line of the section, with a vertical edge. The material so trimmed shall be incorporated into the adjacent material to be treated.

9) An acceptable alternate to the above construction joints, if the treatment is performed with cross shaft rotary mixers, is to actually mix three inches (3") into the previous day's work to assure a good bond to the adjacent work.

3.5 FINAL SUBGRADE PREPARATION USING UNTREATED SOILS

a. Final subgrade for building pads and exterior flatwork areas shall be constructed in accordance with Section 3.2 and Section 3.3 of these specifications. Clay soils shall not be used in fills within the upper twelve inches (12”) of the final subgrade for all building pad and exterior flatwork areas, unless the lime-treatment alternative included in the *Geotechnical Engineering Report* is selected. The upper twelve inches (12") of final subgrade for the building pad and exterior flatwork areas shall consist of imported, compactable, very-low expansive (Expansion Index equal to or less than 20), granular soil, be brought to a uniform moisture content not less than the optimum moisture content, and shall be uniformly compacted to not less than ninety percent (90%) as determined by ASTM D1557 Compaction Test.

b. Final subgrade for pavements, shall be constructed in accordance with Section 3.2 and Section 3.3 of these specifications. The upper twelve inches (12”) of untreated final pavement subgrades shall be brought to a uniform moisture content of at least two percent (2%) above the optimum moisture content, and shall be uniformly compacted to not less than ninety-five percent (95%) as determined by ASTM D1557 Compaction Test, regardless of whether final subgrade elevations are attained by filling, excavation or are left at existing grades.

3.6 FINAL SUBGRADE PREPARATION USING TREATED SOILS

A. Final subgrade for building pad and exterior flatwork areas using treated soils shall be constructed in accordance with Section 3.2 and Section 3.4 of these specifications. If the lime-treatment alternative is selected for finals subgrade of building pad and exterior flatwork areas, the upper twelve inches (12”) of treated final subgrades shall be brought to a uniform moisture content of at least two percent (2%) above the optimum moisture content, and shall be uniformly compacted to not less than ninety percent (90%) as determined by ASTM D1557 Compaction Test, regardless of whether final subgrade elevations are attained by filling, excavation or are left at existing grades.

B. Final subgrade for pavements, using treated soils shall be constructed in accordance with Section 3.2 and Section 3.4 of these specifications. If the lime-treatment alternative is selected for pavement subgrades, the upper twelve inches (12”) of treated pavement subgrades shall be brought to a uniform moisture content of at least two percent (2%) above the optimum moisture content, and shall be uniformly compacted to not less than ninety-five percent (95%) as determined by ASTM D1557 Compaction Test, regardless of whether final subgrade elevations are attained by filling, excavation or are left at existing grades.

3.7 TESTING AND OBSERVATION

a. Grading operations, including lime-treatment of subgrades, shall be observed by the Geotechnical Engineer, serving as the representative of the Owner.

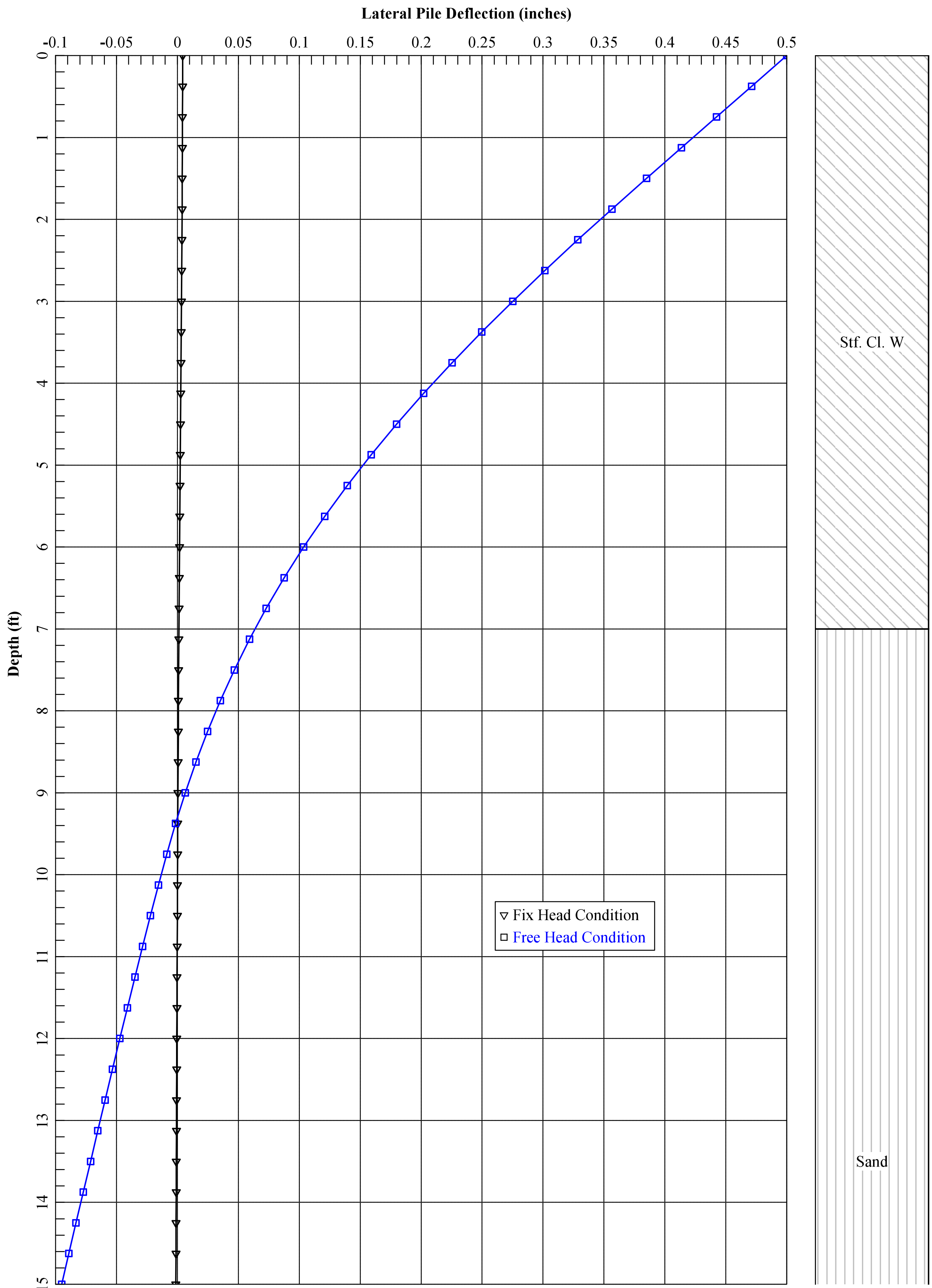
b. Field density tests shall be made by the Geotechnical Engineer after compaction of each layer of fill. Additional layers of fill shall not be spread until the field density tests indicate that the minimum specified density has been obtained.

c. Earthwork shall not be performed without the notification or approval of the Geotechnical Engineer. The Contractor shall notify the Geotechnical Engineer at least two (2) working days prior to commencement of any aspect of the site earthwork..

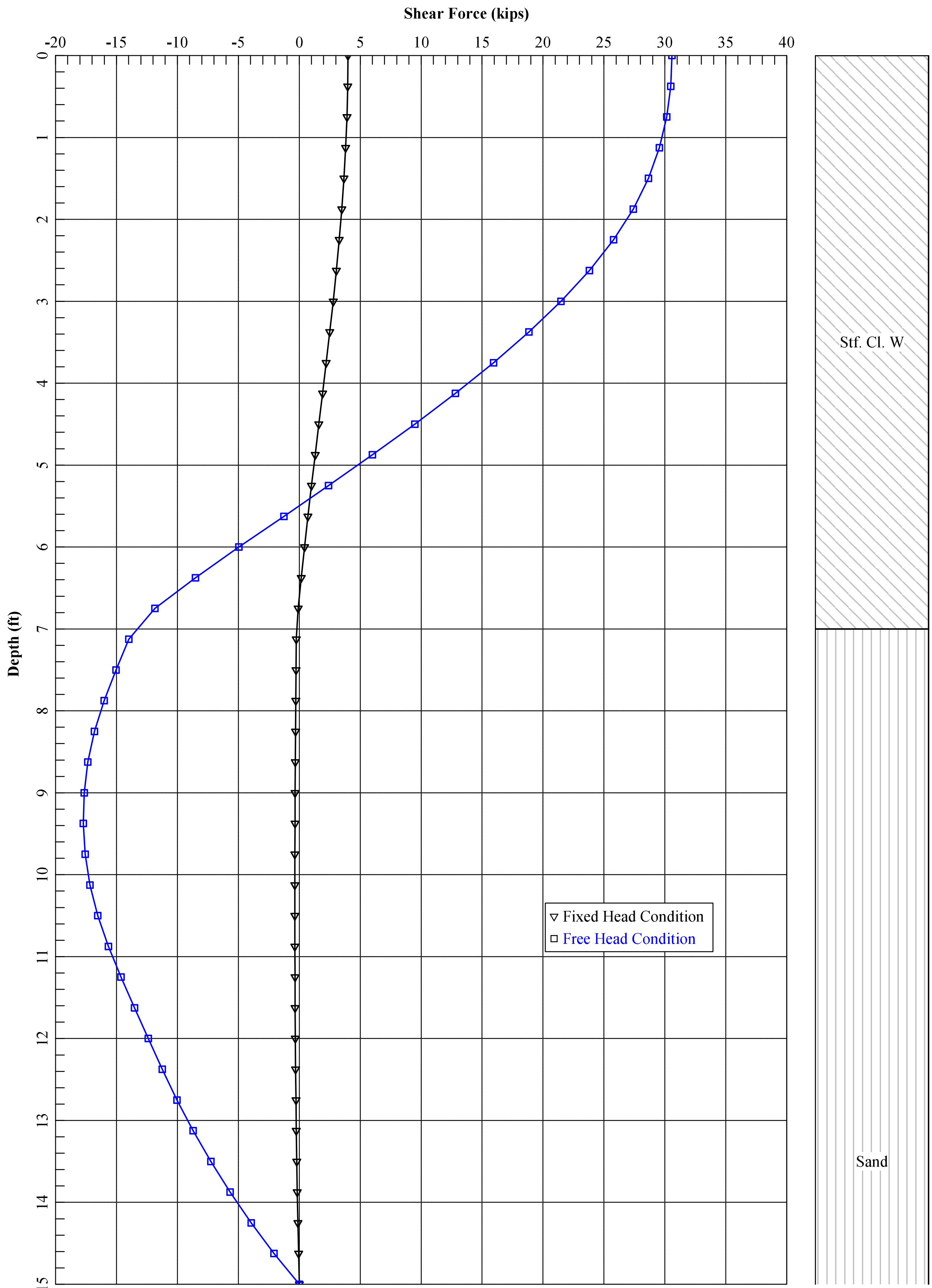
d. If the Contractor should fail to meet the technical or design requirements embodied in this document and on the applicable plans, the necessary readjustments shall be made by the Contractor until all work is deemed satisfactory, as determined by the Geotechnical Engineer and the Architect/Engineer. No deviation from the specifications shall be made except upon written approval of the Geotechnical Engineer or Architect/Engineer.

APPENDIX C

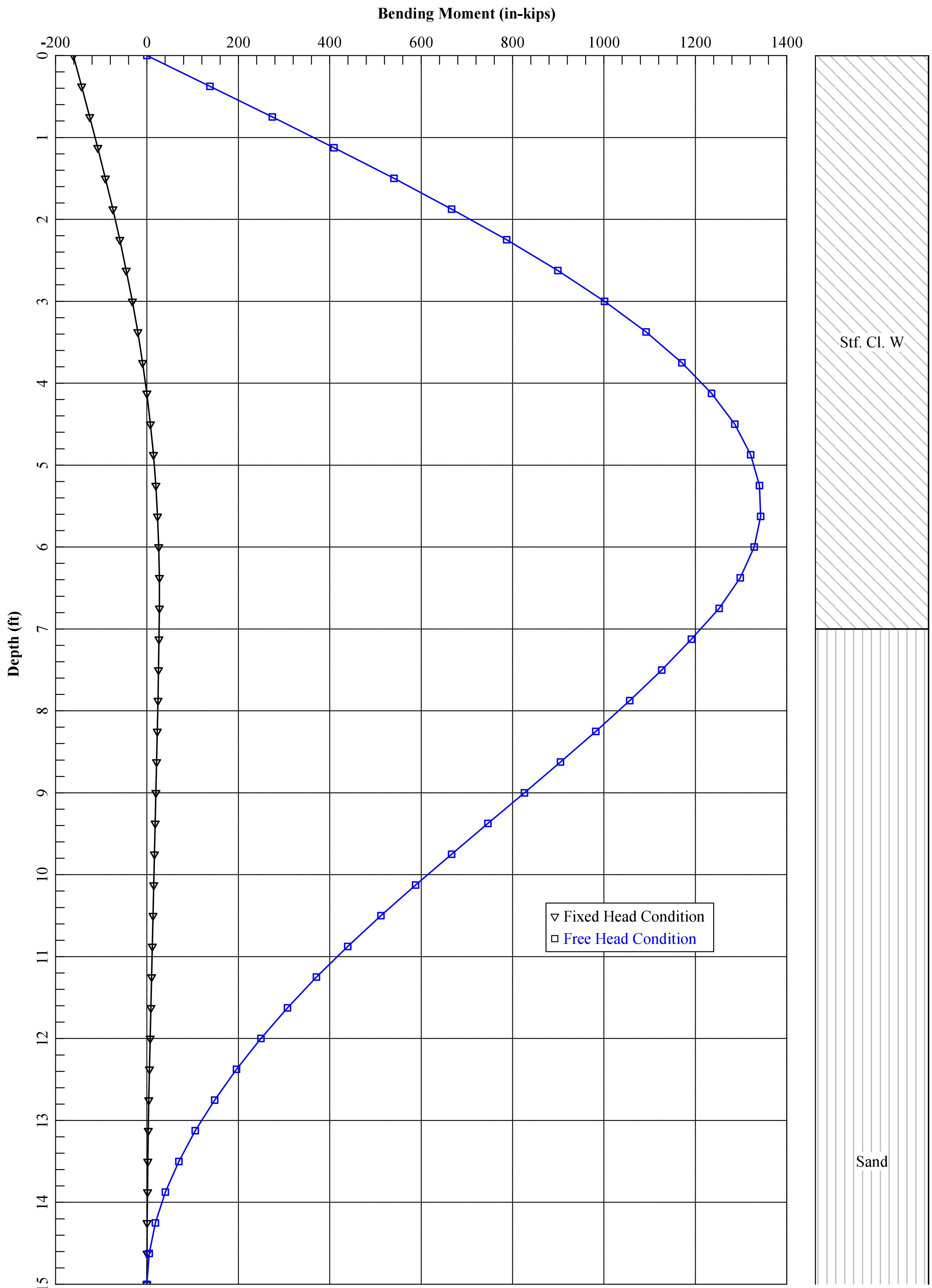
L-PILE Output Diagrams



Lateral Pile Deflection (inches)
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Fix Head Condition
Free Head Condition
Stf. Cl. W
Sand



Shear Force (kips)
-20
-15
-10
-5
0
5
10
15
20
25
30
35
40
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Fixed Head Condition
Free Head Condition
Stf. Cl. W
Sand


Bending Moment (in-kips)
-200
0
200
400
600
800
1000
1200
1400
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Fixed Head Condition
Free Head Condition
Stf. Cl. W
Sand