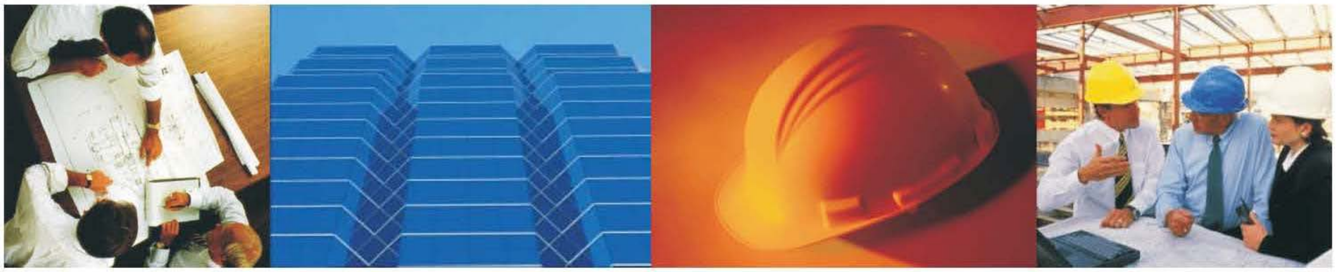

GEOTECHNICAL ENGINEERING INVESTIGATION

FOR

PROPOSED ROCKLIN FIRE STATION NO. 23

NORTHEAST OF RUHKALA ROAD AND PACIFIC STREET

ROCKLIN, CA

PREPARED FOR

Mr. Dennis Dong
Calpo Hom & Dong Architects
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Sacramento, CA 95818

By

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Project No.: 2677-01
March 8, 2017

MatriScope
Engineering Laboratories, Inc.

March 8, 2017 **MEL File No.: 2677-01**

Mr. Dennis Dong
Calpo Hom & Dong Architects
2120 20th Street, #1
Sacramento, CA 95818

Subject: **Geotechnical Engineering Investigation**
Proposed Rocklin Fire Station No. 23
Northeast of Ruhkala Road and Pacific Street
Rocklin, CA

Dear Mr. Dong:

In accordance with your authorization, MatriScope Engineering Laboratories, Inc. (MatriScope) has performed a geotechnical engineering investigation for the proposed Rocklin Fire Station No. 23 project located northeast of Ruhkala Road and Pacific Street, Rocklin, California. The purpose of our investigation was to explore and evaluate the subsurface conditions at various locations at the site in order to develop geotechnical engineering recommendations for use in the project design and construction.

The attached report presents the results of our data review, field exploration, laboratory testing, and engineering analysis. Based on our investigation, it is our professional opinion the proposed project may be constructed at the subject site provided the recommendations contained in the attached report are implemented into project design and construction.

It is imperative that MatriScope be provided the opportunity to review, in advance of construction, the civil and foundation plans related to grading and building construction to assure the recommendations contained herein are appropriate for the proposed development.

Recommendations provided herein are contingent on the provisions outlined in the ADDITIONAL SERVICES and LIMITATIONS sections of this report. The project Client and Owner should become familiar with these provisions in order to assess further involvement by MatriScope and other potential impacts to the proposed project.

Thank you for the opportunity of providing our services for this project. If you have questions regarding this report or if we may be of further assistance, please contact our office.

Respectfully Submitted,
MatriScope Engineering Laboratories, Inc.

Randall L. Leong

REGISTERED PROFESSIONAL ENGINEER
RANDALL L. LEONG
No. 30,618
Expires 3/31/2018
CIVIL
STATE OF CALIFORNIA

Randall L. Leong, C.E., G.E.
Senior Geotechnical Engineer

Timothy Peel, E.I.T.
Project Engineer

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GEOTECHNICAL ENGINEERING INVESTIGATION

PROPOSED ROCKLIN FIRE STATION NO. 23

NORTHEAST OF RUHKALA ROAD AND PACIFIC STREET

ROCKLIN, CA

1. INTRODUCTION

1.1 GENERAL

The proposed Rocklin Fire Station No. 23 site is located northeast of the intersection of Ruhkala Road and Pacific Street in Rocklin, California. The site is bounded on the west by Pacific Street, vacant land that is part of Quarry Park on the east, and vacant unused land on the north and south sides. Beyond the vacant land to the north are vacant structures and a large quarry pit, and beyond the vacant land to the south is a veterinary clinic and Ruhkala Road. This report contains the results of our geotechnical engineering investigation for the proposed development. The site location relative to the vicinity of the site is shown on Plate 1.

This report includes recommendations related to the geotechnical aspects of project design and construction. Conclusions and recommendations presented in this report are based on the subsurface conditions encountered at the locations of our field exploration and the provisions and requirements outlined in the ADDITIONAL SERVICES and LIMITATIONS sections of this report. Recommendations presented herein should not be extrapolated to other areas or used for other projects without prior review by MatriScope Engineering Laboratories, Inc. (MatriScope).

1.2 PROPOSED CONSTRUCTION

The preliminary project design (prepared by Calpo Hom & Dong Architects, Inc., e-mailed to us on February 18, 2017) includes construction of a new fire station consisting of a wooden structure main building and fire engine garage, security fencing, an access road connecting to Pacific Street and other associated improvements. We understand that most of the site’s paving will be concrete for the fire engines, with some asphalt paving for public parking. Grading plans were not available at the time of this report preparation.

The overall slope appears to be downward towards the south and southeast and contains an elevation difference of approximately 10 to 15 feet. Based on our understanding, the proposed building location will have earthwork cut and fill up to 3 to 4 feet in depth. The northeast corner of the site, in the area of the proposed driveway, access road and surrounding area will have excavation required of up to approximately 10 feet.

1.3 PURPOSE AND SCOPE OF SERVICES

Our field investigation was performed to explore and evaluate subsurface conditions at various locations at the site in order to develop recommendations related to the geotechnical aspects of project design and construction. This report summarizes the results of our services including:

- A description of the proposed project
- A description of the site surface, subsurface and groundwater conditions observed during our field investigation
- Geohazards report evaluation
- Recommendations related to the geotechnical aspects of:
  - Site preparation and earthwork construction
  - Utility trench excavations and backfill
  - Spread footing design and construction
  - 2016 CBC seismic design coefficients for use in structural analysis
  - Concrete slab-on-grade
  - Concrete sidewalks/flatwork
  - Concrete/Asphalt Concrete Pavements
  - Surface drainage and moisture protection

2. SITE REVIEW

2.1 RECONNAISSANCE

An initial site reconnaissance was performed on November 10, 2016 to observe surface conditions that may affect the geotechnical aspects of the project and to note areas of obvious geotechnical concerns, if any. During the site reconnaissance we witnessed stockpiles of loose silty clay fill near the project site from an unidentified off-site project. Surface water was present at the time of this reconnaissance at the bottom of slopes due to seasonal rains.

2.2 SUBSURFACE EXPLORATION

A subsurface exploration at the site was performed to investigate and sample soils beneath the site on February 16, 2017. Two (2) exploratory borings (B1 and B2) were advanced to approximate depths of 10.5 to 15.5 feet below the existing ground surface and a test pit (TP1) was dug by hand to approximately 2.5 feet below the ground surface until bedrock was encountered. Auger refusal was encountered in both borings. The borings were drilled with a track-mounted drill rig equipped with continuous flight augers. Approximate locations of exploratory borings and the test pit are shown on Plate 2. Borings and test pit were located in the field by visual sighting and/or pacing from existing site features. Therefore, the location of borings and test pit shown on Plate 2 should be considered approximate and may vary from the locations at the site.

After completion of drilling, the bore holes and test pit were backfilled with soil generated during the drilling. The obtained soil samples were sealed and transported to our Sacramento laboratory for visual examination and testing.

3. SITE CONDITIONS

3.1 SURFACE AND SUBSURFACE CONDITIONS

The site is currently vacant with scattered trees, surface vegetation and outcroppings observed. The surface is irregular, partly due to the past placement of fill materials including boulders was observed in various locations. Abandoned rail ties and spurs believed to be the part of nearby quarrying operations were also observed traversing the site, exposed in some areas and overlain by fill material in others. The site grade, in general, slopes downward toward south and southeast.

The site subsurface soils consist mainly of poorly graded sand in both borings, down to the bottom of the borings and test pit where bedrock was encountered. The exception being the top 7 to 8 feet of soils in Boring B2 was light brown silty clay fill.

3.2 GROUNDWATER

At the time of our field investigation, surface water was present at the site at the bottom of slopes due to the heavy rainfall preceding the investigation. Perched water directly above bedrock was encountered in both borings before refusal. It should be noted that soil moisture conditions within the site will vary depending on rainfall, and/or runoff conditions not apparent at the time of our field investigation. It is common that the soil moisture conditions will change seasonally.

A discussion of the field investigation and laboratory testing programs is presented in Appendix A of this report. Detailed descriptions of the subsurface conditions encountered during our field investigation are presented on the Logs of Borings Plates A2 to A4 of the appendix.

4. GEOLOGIC HAZARDS

4.1 GENERAL

The geohazards study was performed by Youngdahl Consulting Group, Inc. in accordance with requirements listed in the California Geological Survey (CGS) Note 48 Checklist (CGS, 2013). The findings of this geohazards study are briefly summarized in this section of this report. The complete geohazards study report is included as Appendix B of this report.

4.2 GEOHAZARDS FINDINGS

The nearest active fault was identified as the Dunnigan Hills Fault, approximately 38 miles west of the site. The closest source of historical seismicity to the site in the past 200 years was the 6.6 magnitude earthquake approximately 3 ½ miles north of Vacaville, California in 1892. Based on the 2001 FEMA Flood Maps, the site is located outside the 500-year floodplain.

Due to the absence of a permanently elevated groundwater table, the relatively low seismicity of the area, and the shallow depths to bedrock, the potential for seismically induced damage due to liquefaction, surface ruptures, and settlement is considered negligible. No potential landslides, flooding or other geological hazards are identified at the site.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 GENERAL

It is our professional opinion the proposed structures may be supported on newly compacted engineered fill or competent undisturbed site soils provided the recommendations contained in the attached report are implemented into project design and construction.

5.2 EXPANSIVE SOILS

Based on the result of visual examination of near-surface soil samples obtained from the subject site, the site soils are considered as having very low expansion potential.

5.3 SOIL CORROSIVITY

Laboratory test was performed for soil corrosivity parameters (minimum resistivity, pH, chloride and sulfate) on one selected soil sample. Based on the test results of minimum resistivity (56,280 ohm-cm), the tested soil is not considered to be having high corrosive potential to buried metallic improvements. The results of pH (5.70), chloride (4.4 ppm) and sulfate (5.8 ppm) tests do not indicate significant corrosive potential to buried concrete structures and, therefore, Type II cement may be used. All underground utility lines should be corrosion-protected per recommendations of a corrosion engineer, if required.

We have provided the above preliminary corrosion test results. These test results are only indicator parameters of potential soil corrosivity for the sample tested. Other soils found on the site may be more, less, or of a similar corrosive nature.

SITE PREPARATION

5.3.1 Stripping, Grubbing and Tree Removal

Prior to general site grading, existing vegetation, trees designated to be removed, organic topsoil, railroad tracks and any other debris should be stripped and disposed of outside the construction limits along with any boulders or rocks larger than 3-inches in diameter. The topsoil (less any debris) to be stripped and be stockpiled and reused for landscape purposes; however, this material should not be incorporated into any engineered fill.

Tree removal should include the root system and all surface roots larger than ½-inch in diameter. Excavations resulting from tree removal should be cleaned of loose or disturbed material (including all previously-placed backfill) and dish-shaped (with sides sloped 3 (h): 1(v) or flatter) to permit access for compaction equipment.

5.3.2 Removal, Scarification and Compaction

Preparation of the subgrade exposed by excavation and requirements for engineered fill should be in accordance with recommendations provided below (see ENGINEERED FILL section of this report). The bottom of removal areas should be observed and approved by the geotechnical engineer or his representative prior to scarification and compaction. As indicated previously, loosely placed silty clay fill was observed in the 7 to 8 feet of soil within existing grade at B1. Following rough grading and site stripping, the loosely placed fill material within the proposed building, pavement/concrete, and flatwork/sidewalk areas and surrounding areas should be removed to firm competent soils.. We anticipate most of the fill material to be removed during rough grading as cuts of up to approximately 10 feet is expected. However, the extent of the loose fill is unknown and should be determined.

Following the removal of loosely placed fill material, the subgrade soils in the proposed building, pavement/concrete flatwork/sidewalk areas should be removed to a depth of at least 12 inches below the design finish subgrade soil elevation. Exposed excavation bottoms should be scarified to a depth of at least 8 inches; uniformly moisture-conditioned and compacted as required in the ENGINEERED FILL section. The scarification and compaction of the site soils should extend to a horizontal distance of at least 5 feet beyond the outer edges of foundations and at least 2 feet beyond the edge of pavement/concrete flatwork/sidewalk.

After the excavation bottom is approved by the geotechnical engineer or his representatives, the excavation should be backfilled with engineered fill to the design finish subgrade elevation. The scarification and compaction of the site soils should extend to a horizontal distance of at least 5 feet beyond the outer edges of foundations and at least 2 feet beyond the edge of pavement/concrete flatwork/sidewalk.

5.4 ENGINEERED FILL

5.4.1 Materials

All engineered fill soils (on-site and imported soils) should be nearly-free of organic, rubble, rubbish, deleterious debris, clay with high plasticity or contaminated materials.

<u>On-Site Soils</u>

In general, on-site soils (with a 3-inch maximum particle size) similar to those encountered in our borings may be used as engineered fills within the proposed building pads, pavement, concrete flatwork and sidewalk areas. On-site soils may be used as engineered fills provided they are adequately moisture-conditioned and compacted during placement as recommended in the COMPACTION CRITERIA section.

<u>Imported Soils</u>

All imported fill materials to be used for engineered fill should be sampled and tested by the project Geotechnical Engineer prior to being transported to the site. As a minimum, all imported fill should be free of contamination and be granular with a 3-inch maximum particle size, an Expansion Index less than 20 and less than 30 percent passing the number 200 sieve; essentially non-plastic. Imported gravel fill should be, as a minimum, washed gravel, with a 1-inch maximum particle size and less than 5 percent passing the number 200 sieve.

5.4.2 Compaction Criteria

Soils scarified and material to be used for engineered fill should be uniformly moisture-conditioned near the optimum moisture content, placed in horizontal lifts less than 8 inches in loose thickness, and compacted to at least 95 percent relative compaction as determined by the current ASTM D1557. The upper 12 inches of subgrade soils in the parking/driveway areas and aggregate base (AB) materials should be compacted to a minimum of 95 percent relative compaction.

Should site grading be performed during or subsequent to wet weather, near-surface site soils may be significantly above the optimum moisture content. Additionally, it is common to encounter wet, unstable soils upon site excavation as a result of subsurface moisture becoming trapped above relatively impervious bedrock. This condition could hamper equipment maneuverability and efforts to compact site soils to the recommended compaction criteria. Disking to aerate, chemical treatment, replacement with drier material, stabilization with a geotextile fabric or grid, or other methods may be required to reduce excessive soil moisture and facilitate earthwork operations.

5.5 TEMPORARY EXCAVATION

The site consists mainly of bedrock underlying native and fill soils, with outcroppings and boulders observed during our field exploration. The grading contractor should choose his appropriate grading equipment accordingly. All excavations must comply with applicable local, state, and federal safety regulations including the current OSHA Excavation and Trench Safety Standards. Construction site safety generally is the sole responsibility of the Contractor, who shall also be solely responsible for the means, methods, and sequencing of construction operations. We are providing the information below solely as a service to our client. Under no circumstances should the information provided be interpreted to mean that MatriScope is assuming responsibility for construction site safety or the Contractor's activities; such responsibility is not being implied and should not be inferred.

During wet weather, earthen berms or other methods should be used to prevent runoff water from entering all excavations. All runoff water and/or groundwater encountered within the excavation(s) should be collected and disposed of outside the construction limits. Plastic sheets or shotcrete skin coat should be applied to the slope faces to limit raveling during wet weather or any surface water run-off.

5.6 TRENCH PREPARATION AND BACKFILL

5.6.1 Subgrade Preparation

Prior to placement of utility bedding, the exposed subgrade at the bottom of trench excavations should be examined to detect soft, loose, or unstable areas. Loose materials at trench bottoms resulting from excavation disturbance should be removed to firm material. If extensive soft or unstable areas are encountered, these areas should be over-excavated to a depth of at least 2 feet or to a firm base and be replaced with additional bedding material. Where excavations cross the existing trench backfill materials, the need for and extent of over-excavation or stabilization measures should be evaluated by the Geotechnical Engineer on a case-by-case basis.

5.6.2 Backfill Materials

Pipe zone backfill (i.e., material beneath and in the immediate vicinity of the pipe) should consist of clean washed sand and/or crushed rock. If crushed rock is used for pipe zone backfill, we recommend it should have a maximum particle size less 1 inch and have less than 5 percent passing No. 200 U.S. sieve. Where crushed rock is used, the material should be completed surrounded by a non-woven filter fabric such as Mirafi 140N or equivalent. Recommendations provided above for pipe zone backfill are minimum requirements only. More stringent material specifications may be required to fulfill local codes and/or bedding requirements for specific types of pipes. We recommend the project Civil Engineer develop these material specifications based on planned pipe types, bedding conditions, and other factors beyond the scope of this study.

Trench zone backfill (i.e., material placed between the pipe zone backfill and finished subgrade) may consist of native soil and approved imported fill material that meets the requirements provided above for engineered fill.

5.6.3 Compaction Criteria

All trench backfill should be placed and compacted in accordance with recommendations provided above for engineered fill. Mechanical compaction is recommended; ponding or jetting should not be allowed, especially in areas supporting structural loads or beneath concrete slabs supported-on-grade, pavements, or other improvements.

5.7 SPREAD FOOTINGS

5.7.1 Allowable Bearing Pressures

We recommend spread footings constructed of reinforced concrete and founded on undisturbed competent on-site soils or newly constructed engineered fills as recommended in the SITE PREPARATION section of this report be used for support of the proposed building. Bedrock is not anticipated in foundation excavation. Footings should be a minimum of 12 inches wide and embedded a minimum of 12 inches below the lowest final adjacent subgrade. The structural engineer should evaluate the need for reinforcement of foundation based on the anticipated loads. As a minimum, continuous foundations should be reinforced with a minimum of four No. 4 reinforcing bars, placed two each near the top and bottom, to provide structural continuity and allow the foundations to span isolated soil irregularities.

An allowable bearing pressure of 2,500 pounds per square foot (psf) may be used for spread foundations with the above minimum dimensions. The allowable bearing pressure provided above is a net value; therefore, the weight of the foundation (which extends below grade) may be neglected when computing dead loads. The allowable bearing pressure applies to dead plus live loads and may be increased by 1/3 for short-term loading due to wind or seismic forces.

5.7.2 Estimated Settlements

Total settlement of an individual foundation will vary depending on the plan dimensions of the foundation and the actual load supported. Based on anticipated foundation dimensions and loads, we estimate maximum settlement of foundations designed and constructed in accordance with the preceding recommendations to be less than one inch. Differential settlement between similarly loaded, adjacent footings is expected to be less than 1/2 inch. Settlement of all foundations is expected to occur rapidly and should be essentially complete shortly after initial application of the loads.

5.7.3 Lateral Resistance

Resistance to lateral loads (including those due to wind or seismic forces) may be provided by frictional resistance between the concrete foundations and the bottom of foundations, and by passive soil pressure against the sides of the foundations. A coefficient of friction of 0.35 may be used between cast-in-place concrete foundations and the bottom of foundations. Additional allowable passive pressure available may be taken as equivalent to the pressure exerted by a fluid weighing 300 pounds per cubic foot (pcf). These two modes of resistance should not be added unless the frictional component is reduced by 50 percent, since full mobilization of the passive resistance requires some horizontal movement, which significantly diminishes the frictional resistance.

5.7.4 Construction Considerations

Prior to placing steel or concrete, footing excavations should be cleaned of all debris, loose or soft soil, and water. All footing excavations should be observed by the project Geotechnical Engineer or his representatives just prior to placing steel or concrete to verify the recommendations contained herein are implemented during construction.

5.7.5 California Building Code Seismic Design Parameters

Structures should be designed for lateral force requirements as set forth in Chapter 16 of the 2016 California Building Code (CBC). We recommend the following parameters in Table 1 on the next page:

Table 1
2016 CBC Seismic Design Parameters

Seismic Design Parameter	Symbol	Recommended Value
Mapped Spectral Acceleration at Short Period	S_S	0.487g
Mapped Spectral Response at 1-second Period	S_1	0.245g
Site Class	A-F	C
Site Coefficient at Short Period	F_a	1.200
Site coefficient at 1-Second Period	F_v	1.555
Spectral Response Acceleration	S_{MS}	0.584g
	S_{M1}	0.382g
Design Spectral Response Accelerations	S_{DS}	0.389g
	S_{D1}	0.254g
Long-Period Transition Period	T_L	12 seconds
MCE_G Peak Ground Acceleration Adjusted for Site Class Effects	PGA_M	0.19g
Site coordinates: Latitude 38.78786 degrees North Longitude 121.23647 degrees West		

5.8 INTERIOR CONCRETE SLABS-ON-GRADE

Conventional concrete slab-on-grade floors are suitable for building pads provided excavations and subgrades are prepared as recommended in section titled SITE PREPARATION. Slab thickness and reinforcement should be determined by the structural engineer based on the anticipated loading, especially in areas anticipated to support fire engine loading. However, slabs should be at least 4 inches thick and reinforced with No. 3 reinforcing bars on 18 inches or No. 4 bars on 24 inches center-to-center spacing each way, placed at mid-slab depth. Proper and consistent location of the reinforcement at 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.

5.8.1 Subgrade Preparation

Prior to constructing interior concrete slabs supported-on-grade, surficial soils should be processed as recommended in the SITE PREPARATION and ENGINEERED FILL sections of this report. Scarification and compaction may not be required if concrete slabs are to be placed directly on undisturbed engineered fill compacted during site preparation, or within earthwork cut areas consisting of competent soils or bedrock and if approved by the project Geotechnical Engineer or his representatives during construction.

5.8.2 Rock Capillary Break

In order to provide enhanced subgrade support, we recommend the compacted subgrade be overlain with a minimum 4-inch thickness of compacted crushed rock. If this layer is desired to also serve as a capillary break, there should be less than 5 percent by weight passing the No. 4 sieve size. A capillary break may reduce the potential for soil moisture migrating upwards toward the slab.

5.8.3 Construction Considerations

Subsurface moisture and moisture vapor naturally migrate upward through the soil and, where the soil is covered by a building or pavement, this subsurface moisture will collect. To reduce the impact of this subsurface moisture and the potential impact of introduced moisture (such as landscape irrigation or plumbing leaks) the current industry standard is to place a vapor retarder on the compacted crushed rock layer (described above). This membrane typically consists of visquene or polyvinyl plastic sheeting at least ten (10) mil in thickness. The plastic sheet membrane should meet or exceed the minimum specifications for plastic water vapor retarders as outlined in ASTM E1745.

It should be noted that although capillary break and vapor barrier systems are currently the industry standard, this system may not be completely effective in preventing floor slab moisture problems. These systems will not "moisture proof" the floor slab nor will it assure floor slab moisture transmission rates will meet floor-covering manufacturer standards. The design and construction of such systems are dependent on the proposed use and design of the proposed building and all elements of building design and function should be considered in the slab-on-grade floor design. Building design and construction may have a greater role in perceived moisture problems since sealed buildings/rooms or inadequate ventilation may result in excessive moisture in a building and affect indoor air quality.

Special precautions must be taken during the placement and curing of all concrete slabs. Excessive slump (high water-cement ratio) of the concrete and/or improper curing procedures used during either hot or cold weather conditions could lead to excessive shrinkage, cracking, or curling in the slabs. High water-cement ratio and/or improper curing also greatly increase the water vapor permeability of concrete. We recommend that all concrete placement and curing operations be performed in accordance with the current edition of American Concrete Institute (ACI) Manual.

5.9 EXTERIOR CONCRETE SIDEWALKS AND FLATWORK

Concrete sidewalks and flatwork should be a minimum of 4 inches thick and may be underlain by compacted engineered fills as recommended in the SITE PREPARATION and ENGINEERED FILL sections of this report. Scarification and compaction may not be required if exterior slabs are to be placed directly on undisturbed engineered fill compacted during site preparation, or within earthwork cut areas consisting of competent soils or bedrock and if approved by the project Geotechnical Engineer or his representatives during construction.

5.10 PAVEMENT

5.10.1 Portland Cement Concrete Pavement

MatriScope recommends that the project structural engineer, taking into consideration the anticipated required loading for fire response equipment, should determine the actual design pavement sections and reinforcements for concrete pavement. All pavement subgrades should be compacted Caltrans Class 2 Aggregate Base (AB) and prepared as recommended in the SITE PREPARATION and ENGINEERED FILL sections of this report.

5.10.2 Asphalt Concrete Pavement

Resistance value (R-value) test was performed on one sample in accordance with ASTM Test Method D2488. Result of the test indicates the site soils have an R-value of 43. A design R-value of 30 was used in the design to account for the variance of subgrade materials which may be encountered during construction. All pavement subgrades should be prepared as recommended in the SITE PREPARATION and ENGINEERED FILL sections of this report. Aggregate bases (AB) should be compacted to a minimum of 95 percent relative compaction in accordance with ASTM D1557.

Asphalt concrete pavement structural sections presented in the Table 2 below are based on the R-value of 30 and current Caltrans design procedures. Automobile traffic indexes should be reviewed by the project Owner, Architect, and/or Civil Engineer to evaluate their suitability for this project. Changes in the actual traffic indexes will affect the corresponding pavement sections.

Table 2
Recommended Asphalt Concrete Pavement Sections
(R-Value = 30)

Assumed Traffic Index	Asphalt Concrete (inch)	Caltrans Class 2 Aggregate Base (inch)
4	3	4
5	3	6
6	3	9

Asphalt paving materials, placement methods and compaction should meet the current Caltrans specifications for asphalt concrete.

5.10.3 Construction Consideration

The above pavement recommendations should be incorporated into project plans and specifications by the project engineer. These recommendations are not intended to be used as a specification for construction. Adequate drainage should be provided such that the subgrade soils and aggregate base materials are not allowed to become wet.

Proof Rolling

Regardless the field soil compaction test results, we recommend a heavy, rubber-tired vehicle (typically a loaded water truck) be used to proof-roll testing the load/deflection characteristics of the finished subgrade materials. If the tested surface shows a visible deflection (pumping) from the wheel track at the time of loading, or a visible crack remains after loading, corrective measures should be implemented. Such measures could include disking to aerate, chemical treatment, replacement with drier material, or other methods. We recommend MatriScope be retained to assist in developing which method (or methods) would be applicable for this project.

Variations in Subgrade Materials

Pavement sections provided above are based on the soil conditions encountered during our field investigation, our assumptions regarding final site grades, and limited laboratory testing. In the event actual pavement subgrade materials are significantly different than those tested for this study, we recommend representative subgrade samples be obtained and additional R-value tests performed. Should the results of these tests indicate a significant difference, the design pavement section(s) provided above may need to be revised.

5.11 SITE DRAINAGE AND MOISTURE PROTECTION

Foundation, slab and pavement performance depends greatly on how well runoff waters drain from the site. This drainage should be maintained both during construction and over the entire life of the project. The ground surface around structures should be graded so that water flows rapidly away from structures and slopes without ponding. The surface gradient needed to do this depends on the landscaping type. In general, pavement and lawns within five feet of buildings should slope away at gradients of at least two percent. Densely vegetated areas should have minimum gradients of 5 percent away from buildings in the first five feet if it is practical to do so. Adequate drainage (both surface and subsurface) should be provided such that the subgrade soils and aggregate base materials are not allowed to become wet.

Planters should be built so that water exiting from them will not seep into the foundation areas or beneath slabs and pavement. In general, the elevation of exterior grades should not be higher than the elevation of the subgrade beneath the slab to help prevent water intrusion beneath slabs. In any event, maintenance personnel should be instructed to limit irrigation to the minimum actually necessary to properly sustain landscaping plants. Should excessive irrigation, waterline breaks, or unusually high rainfall occur, saturated zones and "perched" groundwater may develop. Consequently, the site should be graded so that water drains away readily without saturating the foundation or beneath slabs and pavement. Potential sources of water, such as water pipes, drains, garden sprinklers, and the like, should be frequently examined for signs of leakage or damage. Any such leakage or damage should be promptly repaired.

All utility trenches should be backfilled with compacted non-pervious fill material. Special care should be taken during installation of sub-floor water and sewer lines to reduce the possibility of leaks.

6. ADDITIONAL SERVICES

6.1 PLANS AND SPECIFICATIONS REVIEW

We recommend that the ninety-five (95) percent complete plans and specifications should be reviewed by MatriScope in order to assure that our earthwork and foundation recommendations have been properly interpreted and implemented during design. In the event MatriScope is not retained to perform this recommended review, we will assume no responsibility for misinterpretation of our recommendations.

6.2 CONSTRUCTION OBSERVATION AND TESTING

All earthworks during construction should be monitored by a representative from MatriScope, including site preparation, placement of all engineered fill, trench backfill and wall backfill, construction of slab and roadway subgrade, and all foundation excavations. It is essential that the finished subgrade and footing excavation in all areas to receive engineered fill or to be used for the future support of structures, concrete slabs-on-grade or pavement sections be observed and approved by the Project Geotechnical Engineer or a representative from MatriScope prior to placement of engineered fill or concrete pouring for building pad and slab-on-grade.

The purpose of these services would be to provide MatriScope the opportunity to observe the soil conditions encountered during construction, evaluate the applicability of the recommendations presented in this report to the soil conditions encountered, and recommend appropriate changes in design or construction procedures if conditions differ from those described herein.

7. LIMITATIONS

Recommendations contained in this report are based on our field observations and subsurface explorations, limited laboratory tests, and our present knowledge of the proposed construction. It is possible that soil conditions could vary between or beyond the points explored. If soil conditions are encountered during construction which differ from those described herein, we should be notified immediately in order that a review may be made and any supplemental recommendations provided. If the scope of the proposed site development changes from that described in this report, our recommendations should also be reviewed.

We have prepared this report in substantial accordance with the generally accepted geotechnical engineering practice as it exists in the site area at the time of our study. No warranty is expressed or implied. The recommendations provided in this report are based on the assumption that an adequate program of tests and observations will be conducted by MatriScope during the construction phase in order to evaluate compliance with our recommendations. Other standards or documents referenced in any given standard cited in this report, or otherwise relied upon by the author of this report, are only mentioned in the given standard; they are not incorporated into it or “included by reference”, as that latter term is used relative to contracts or other matters of law.

This report may be used only by the client and only for the purposes stated, within a reasonable time from its issuance. Land use, site conditions (both on site and off site) or other factors may change over time, and additional work may be required with the passage of time. Any party other than the client who wishes to use this report shall notify MatriScope of such intended use. Based on the intended use of the report, MatriScope may require that additional work be performed and that an updated report be issued. Non-compliance with any of these requirements by the client or anyone else will release MatriScope from any liability resulting from the use of this report by any unauthorized party.

Site Vicinity Map

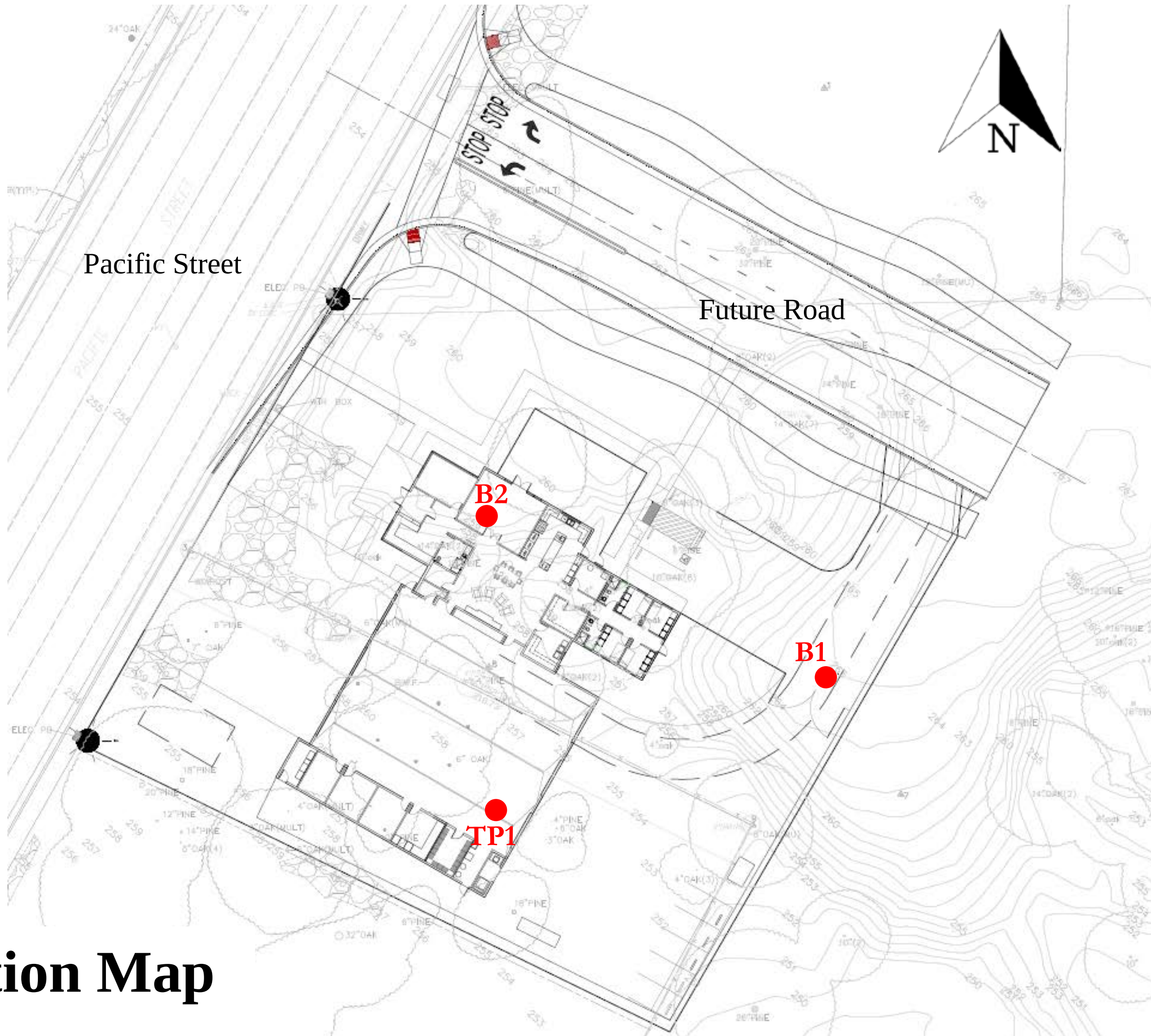
MatriScope Engineering Laboratories, Inc.	601 Bercut Drive Sacramento, CA 95811 Phone: (916) 375-6700 Fax: (916) 447-6702 www.matriscope.com	Project No.:	2677-01	Plate 1
		Project Name:	Proposed Rocklin Fire Station No. 23	
		Location:	Northeast of Ruhkala Road and Pacific Street, Rocklin, CA	
		Date:	03/08/2017	

Legend:

B1 **Approximate Boring Location**

TP1 **Approximate Test Pit Location**

Base Map:
Prepared by Calpo Hom & Dong Artichects



Boring Location Map

MatriScope Engineering Laboratories, Inc.	601 Bercut Drive Sacramento, CA 95811 Phone: (916) 375-6700 Fax: (916) 447-6702 www.matriscope.com	Project No.:	2677-01	**Plate** 2
		Project Name:	Proposed Rocklin Fire Station No. 23	
		Location:	Northeast of Ruhkala Road and Pacific Street, Rocklin	
		Date:	03/08/2017	

APPENDIX A

APPENDIX A

FIELD INVESTIGATION AND LABORATORY TESTING

FIELD INVESTIGATION

General

The subsurface conditions at the site were explored on February 16, 2017 by drilling 2 borings to a maximum depth of 15.5 feet below existing ground surface. Borings were drilled using a track-mounted drill rig equipped with 4-inch-diameter continuous flight augers and a test pit was dug by hand. The locations of borings and test pit performed for this investigation are shown on Plate 2 of the report.

Borings and test pit were located in the field by visual sighting and/or pacing from existing site features. Therefore, the location of borings and test pit shown on Plate 2 should be considered approximate and may vary from the locations at the site.

Our representative maintained logs of the borings and test pit, visually classified soils encountered in accordance with the Unified Soil Classification System (see Plate A1), and obtained relatively undisturbed and bulk samples of the subsurface materials. Logs of Borings and Test Pit are presented on Plates A2 to A4.

Sampling Procedures

Soil samples were obtained from the boreholes using a Modified California Sampler driven 18 inches (unless otherwise noted) into undisturbed soil using a 30-inch drop of a 140-pound hammer. Blow counts were recorded at 6-inch intervals for each sample attempt and are reported on the logs in terms of blows-per-foot for the last foot of penetration. Soil samples obtained from the borings were packaged and sealed in the field to reduce moisture loss and disturbance, and returned to our laboratory for further testing.

LABORATORY TESTING

General

Laboratory tests were performed on selected samples to aid in soil classification and to evaluate physical properties of the soils which may affect the geotechnical aspects of project design and construction. A description of the laboratory testing program is presented below.

Moisture Content and Dry Unit Weight

Moisture content and dry unit weight tests were performed to evaluate moisture-conditioning requirements during site preparation and earthwork grading. Moisture content was evaluated in general accordance with ASTM (American Society for Testing and Materials) Test Method D2216; dry unit weight was evaluated using procedures ASTM D2937. Results of these tests are presented on the logs of Borings.

Atterberg Limits

Atterberg Limits (Liquid Limit and Plasticity Limit) test was performed to aid in soil classification and to evaluate the plasticity characteristics of the material. Tests were performed in general accordance with ASTM Test Method D4318. Results of these tests are summarized in Table A1 below. The laboratory test report is attached.

Table A1
Atterberg Limits Test Summary

Boring No.	Sample Depth (feet)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Unified Soil Classification
B1	5	24	18	6	CL-ML

R-Value

Resistance value (R-value) test was performed on one bulk soil sample obtained from the site to evaluate pavement support characteristics of the near-surface site soils. Test procedures were in general accordance with ASTM D2488. The result of R-value test is shown in Table A2. The laboratory test report is attached.

Table A2
R-Value Test Result

Boring No.	Sample Depth (feet)	R-Value
B1	0-5	43

Compaction

Compaction test was performed on one near-surface bulk soil sample to determine maximum dry density and optimum moisture content for use in evaluation of field soil compaction compliance during earthwork construction. Test procedures were in general accordance with ASTM D1557. The compaction test Results are summarized in Table A3 and the laboratory test reports are attached.

Table A3
Compaction Test Result

Boring No.	Material Description	Sample Depth (feet)	Maximum Dry Density (pcf)	Optimum Moisture (%)
B2	Poorly-graded Sand (SP)	0-5	121.3	10.5

Soil Corrosivity

One soil sample was subjected to chemical analysis for the purpose of corrosion assessment. The tests were performed in accordance with California Test Methods 643, 422, and 417 for pH and minimum resistivity, soluble chlorides, and soluble sulfates, respectively. The test results are presented in Table A4. The laboratory test report is attached in this appendix.

Table A4
Soil Corrosivity Test Results

Boring No.	Sample Depth (feet)	pH	Minimum Resistivity (Ohm-Cm)	Water Soluble Chloride (ppm)	Water Soluble Sulfates (ppm)
B2	5	5.70	56,280	4.4	5.8

The 2003 California Department of Transportation (Caltrans) Corrosion Guidelines considers a site to be corrosive if water-soluble chloride content is 500 ppm or greater, sulfate concentration is 2,000 ppm or greater, or pH is 5.5 or less. The soil resistivity serves as an indicator parameter for possible presence of soluble salts. A minimum soil resistivity value less than 1,000 ohm-cm indicates the possible presence of higher quantities of soluble salts and a higher corrosion potential.

We have provided the above preliminary corrosion test results. These test results are only indicator parameters of potential soil corrosivity for the sample tested. Other soils found on the site may be more, less, or of a similar corrosive nature.

LIST OF ATTACHMENTS

Plate A1 to A4: Unified Soil Classification System and Log of Boring B1 to B2 and Test Pit TP1
Atterberg Limits Test Report
Resistance Value (R-Value) Test Report
Compaction Test Report
Soil Corrosivity Test Summary Report

SOIL CLASSIFICATION CHART

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

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PLATE

A-1

LOG OF BORING

Project Rocklin Fire Station No. 23		**Sheet no.** 1 of 1	**Hole Number** **B1**	
Site NE of Ruhkala Road and Pacific Street		**Project Number** 2677-01	**Logged By** Tim Peel	**Checked By** Randall Leong
Started 2/16/2017	**Completed** 2/16/2017	**Driller** Taber Drilling	**Boring Dia.** 4"	**Total Depth** 15.5'
Drill Method Continuous Flight Auger		**Drill Equipment** CME 55	**Ground Elev.** 264' AMSL	**Depth/Elev. Groundwater** N/A
Sample Type Modified California Sampler		**Notes**		

SAMPLE NUMBER	BLOWS/FT	MOISTURE (%)	DRY DENSITY (pcf)	PENETROMETER (tsf)	DEPTH (feet)	DESCRIPTION AND CLASSIFICATION
					0	FILL Silty Clay (CL-ML), light brown, medium stiff, slightly moist
MC-1-1	8	15.8				
MC-1-2	9	15.5	111.4		5	reddish brown, PI=6
MC-1-3	35					Poorly-Graded Sand (SP), dark gray, very dense, moist
						light brown
MC-1-4	36				10	
						gray, wet and loose
MC-1-5	50/1"				15	Perched Water
						Boring was ended at 15.5 feet due to refusal.
					20	
					25	

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PLATE
A2

LOG OF BORING

Project Rocklin Fire Station No. 23		**Sheet no.** 1 of 1	**Hole Number** **B2**	
Site NE of Ruhkala Road and Pacific Street		**Project Number** 2677-01	**Logged By** Tim Peel	**Checked By** Randall Leong
Started 2/16/2017	**Completed** 2/16/2017	**Driller** Taber Drilling	**Boring Dia.** 4"	**Total Depth** 15.5'
Drill Method Continuous Flight Auger		**Drill Equipment** CME 55	**Ground Elev.** 259' AMSL	**Depth/Elev. Groundwater** N/A
Sample Type Modified California Sampler		**Notes**		

SAMPLE NUMBER	BLOWS/FT	MOISTURE (%)	DRY DENSITY (pcf)	PENETROMETER (tsf)	DEPTH (feet)	GRAPHIC LOG	SAMPLE TYPE	DESCRIPTION AND CLASSIFICATION
					0			FILL Poorly-Graded Sand (SP) with some clay, brown, medium dense, very moist
MC-2-1	50/5"	15.2			2			Sampler hit wooden railroad tie
					3			Poorly-Graded Sand (SP), brown, medium dense, very moist
MC-2-2	66/10"	17.0	100.7		5			
					9			gray
MC-2-3	50/1"				10			Perched Water
					10.5			Boring was ended at 10.5' due to refusal.
					15			
					20			
					25			

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PLATE
A3

LOG OF TEST PIT

Project Rocklin Fire Station No. 23	**Sheet no.** 1 of 1	**Hole Number** **TP1**	
Site NE of Ruhkala Road and Pacific Street	**Project Number** 2677-01	**Logged By** Tim Peel	**Checked By** Randall Leong
Started 2/16/2017 / **Completed** 2/16/2017	**Driller**	**Boring Dia.**	**Total Depth** 2.5'
Dig Method Shovel	**Drill Equipment**	**Ground Elev.** 256' AMSL	**Depth/Elev. Groundwater** N/A
Sample Type	**Notes**		

SAMPLE NUMBER	BLOWS/FT	MOISTURE (%)	DRY DENSITY (pcf)	PENETROMETER (tsf)	DEPTH (feet)	GRAPHIC LOG	SAMPLE TYPE	DESCRIPTION AND CLASSIFICATION
					0–2.5			Poorly-Graded Fine Sand (SP), brown, loose, very moist
					2.5			Test pit ended at 2.5' due to refusal.
					5			
					10			
					15			
					20			
					25			

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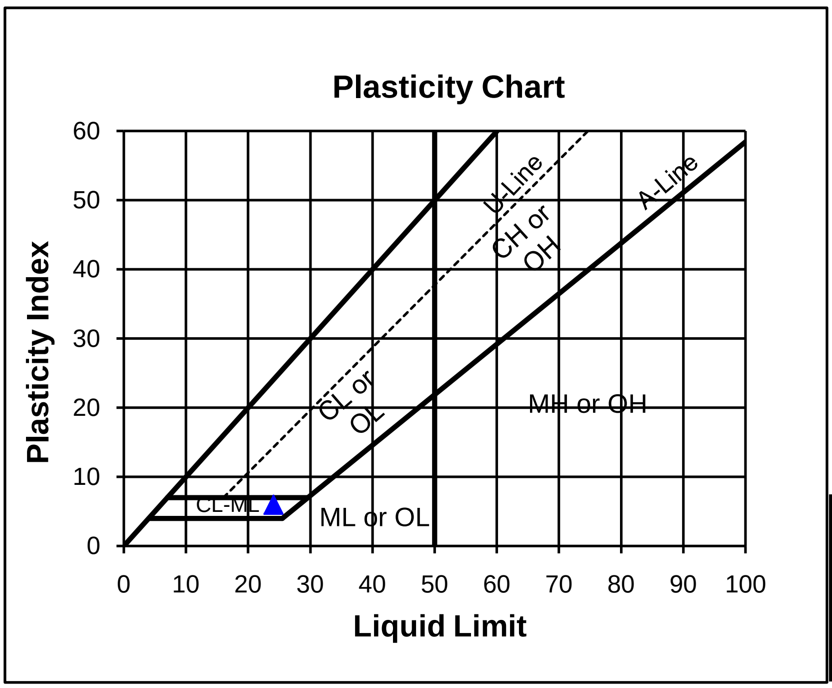
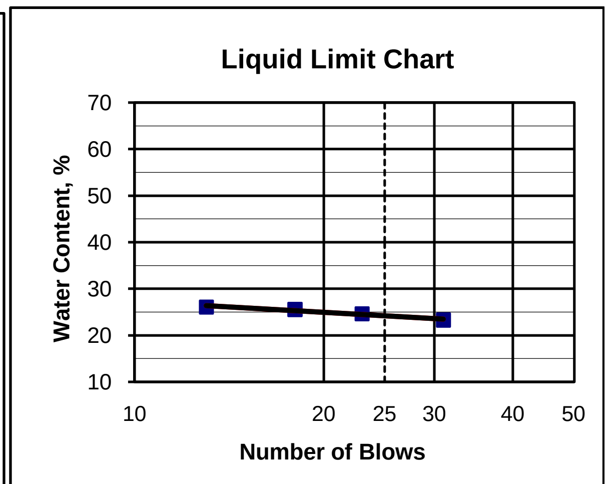
LIQUID AND PLASTIC LIMITS AND PLASTICITY INDEX OF SOILS (ASTM D4318)

Project	DSA File No.	DSA/LEA No.	DSA App. No.	Job No.	Date
Rocklin Fire Station No. 23				2677-01	02/22/17
Address: NE of Ruhkala Rd and Pacific St, Rocklin	Lab ID. 17016	Total Wt. *(g)*	Retained #4 *(g)*	Retained #40 *(g)*	Retained #200 *(g)*
Material Description: Light Brown Silty Clay	Sampling Location: B1-5'	Sample Date: 02/16/17	Retained #4 *(%)*	Retained #40 *(%)*	Retained #200 *(%)*

	Plastic Limit		Liquid Limit			
A. Run Number	1	2	A	B	C	D
B. Tare Number	f1	i2	q2	z11	f	h
C. Wt. of Wet Soil + Tare *(g)*	20.2	20.1	31.8	31.5	33.2	36.6
D. Wt. of Dry Soil + Tare *(g)*	19.5	19.4	29.7	29.6	31.0	33.9
E. Wt. of Tare *(g)*	15.6	15.4	22.1	22.2	22.3	22.2
F. Wt. of Water *(g)*	0.7	0.7	2.0	1.9	2.2	2.7
G. Wt. of Dry Soil *(g)*	3.9	4.0	7.7	7.4	8.8	11.7
H. Moisture *(%)*	**18.1**	**18.1**	26.1	25.5	24.7	23.3
I. Number of Blows			**13**	**18**	**23**	**31**





Liquid And Plastic Limits		Unified Soil Classification
LL.	24	CL-ML
PL.	18	
PI.	6	

Remarks	**Existing Fill**

Technician	Soussan	Professional Engineer	Randall L. Leong

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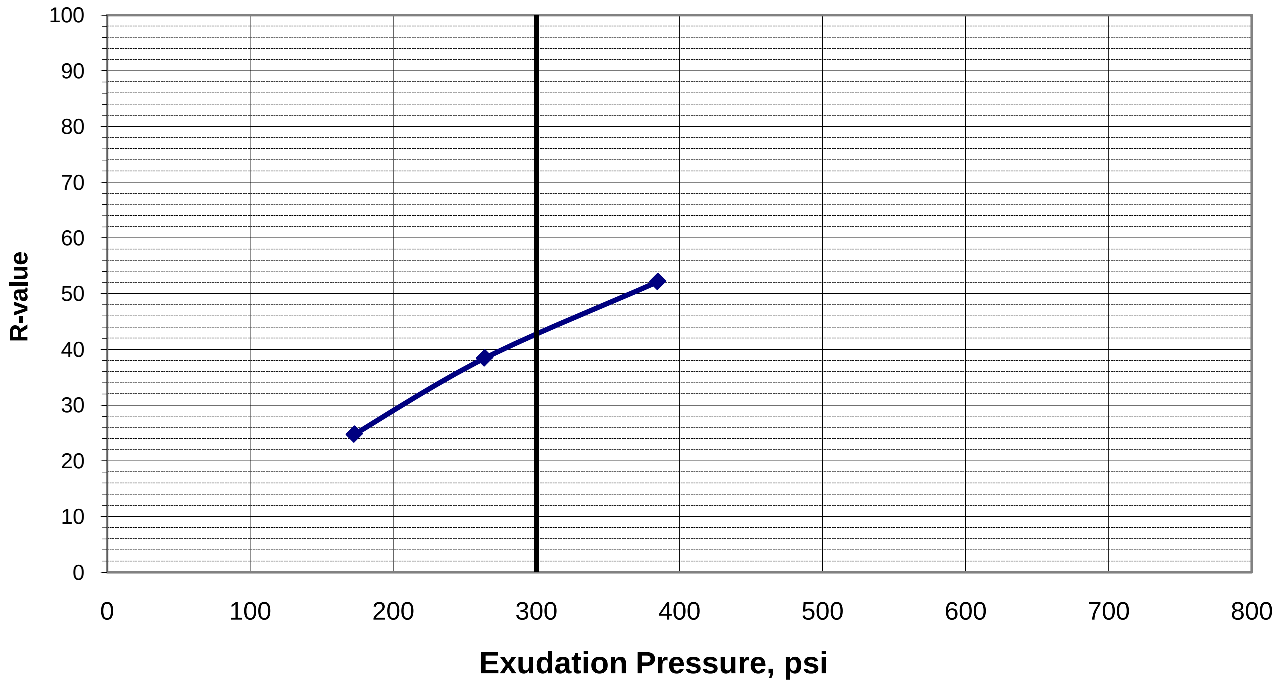
R-value Test Report
(ASTM D2844 / CTM 301)



Job No.:	2677-01	**Date:**	02/27/17
Client:	Calpo Hom & Dong Architects	**Tested:**	S Lee
Project:	Rocklin Fire Station No. 23	**Reduced:**	
Sample:	B1: 0'-5'	**Checked:**	
Soil Type:	Light Brown Silty Clay		

Initial Moisture,	5.9%
R-value by Stabilometer	**43**
Expansion Pressure	**psf**

Specimen Number	A	B	C	D
Exudation Pressure, psi	385	264	173	
Prepared Weight, grams	1200	1200	1200	
Final Water Added, grams/cc	50	60	70	
Weight of Soil & Mold, grams	2997.5	2927.9	2949.6	
Weight of Mold, grams	1181.1	1876.3	1855.1	
Height After Compaction, in.	2.47	2.41	2.4	
Moisture Content, %	10.3	11.2	12.1	
Dry Density, pcf	201.9	118.8	123.2	
Expansion Pressure, psf	346.4	164.5	121.2	
Stabilometer @ 1000				
Stabilometer @ 2000	55.6	78.4	100	
Turns Displacement	4.17	3.79	4.18	
R-value	52	38	25	

Remarks:

Existing Fill Soils (CL-ML)

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COMPACTION CHARACTERISTICS OF SOIL (ASTM D1557)

LABORATORY COMPACTION TEST

JOB NO.	LAB ID.	DSA/LEA NO.	DSA FILE NO.	DSA APPLICATION NO.	REPORT DATE
2677-01					2/22/2017

PROJECT	MATERIAL DESCRIPTION
Rocklin Fire Station No. 23	Brown Sand with some Clay

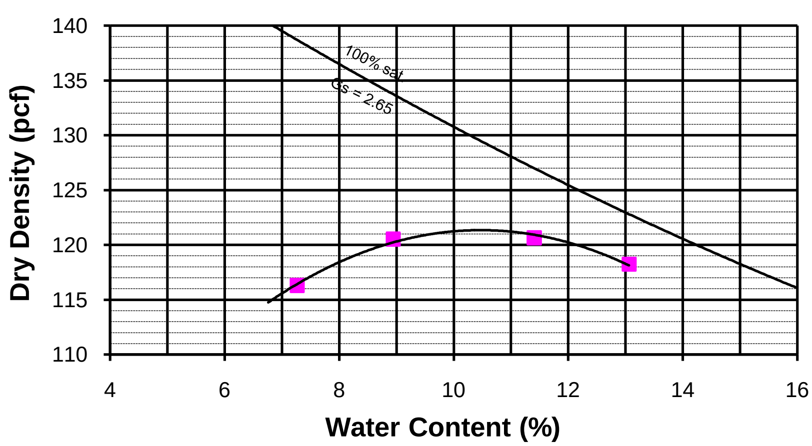
ADDRESS	PROCEDURE	SIEVE_Oversize	OVERSIZE < 5 %
Northeast of Ruhkala Road and Pacific Street, Rocklin, CA	B	3/8"	Yes

TOTAL WT. *(g)* USED IN PROCESSING	WT. *(g)* Oversize	DRY *(g)* Oversize	DRY *(g)* Finer	TOTAL *%* Oversize	TOTAL *%* Finer	SG_Oversize

SAMPLING LOCATION	SAMPLE DATE	DIA. OF MOLD (in.)	LAYERS	BLOWS / LAYER	HAND TAMPER	MECHANICAL TAMPER
B2: 0'-5'	2/16/17	4	5	25	☐	☑

A. WATER ADDED *(CC)*	**0**	**50**	**100**	**150**	**Finer**	**Oversize**
B. MOLD NUMBER						
C. WT. OF WET SOIL + MOLD *(gm)*	3930.5	4029.5	4076.4	4065.9		
D. WT. OF MOLD *(gm)*	2046.8	2046.8	2046.8	2046.8		
E. WT. OF WET SOIL *(gm)*	1883.7	1982.7	2029.6	2019.1		
F. VOLUME OF MOLD *(ft^3)*	0.033	0.033	0.033	0.033		
G. WET DENSITY *(pcf)*	124.7	131.3	134.4	133.7		
H. CONTAINER NO.	**p60**	**49**	**l12**	**b**		
I. WT. OF WET SOIL + TARE *(gm)*	843.2	794.1	845.1	782.0		
J. WT. OF DRY SOIL + TARE *(gm)*	805.2	747.5	787.6	716.1		
K. WT. OF TARE *(gm)*	282.0	226.2	283.5	211.4		
L. WT. LOSS *(gm)*	38.0	46.6	57.5	65.9		
M. WT. OF DRY SOIL *(gm)*	523.2	521.3	504.1	504.7		
N. MOISTURE *(%)*	**7.3**	**8.9**	**11.4**	**13.1**		
O. DRY DENSITY *(pcf)*	**116.3**	**120.5**	**120.6**	**118.3**		

Compaction Curve



TEST RESULTS	
OPTIMUM WATER CONTENT %	**10.5**
MAXIMUM DRY DENSITY pcf	**121.3**

ROCK CORRECTED TEST RESULTS	
OPTIMUM WATER CONTENT %	
MAXIMUM DRY DENSITY pcf	

REMARKS:

Technician	Soussan	Professional Engineer	Randall L. Leong

Sunland Analytical

11419 Sunrise Gold Circle, #10
Rancho Cordova, CA 95742
(916) 852-8557

Date Reported 03/01/2017
Date Submitted 02/23/2017

To: Steve Lee
Matriscope Engineering Laboratories
601 Bercut
Sacramento, CA 95811

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

The reported analysis was requested for the following location:
Location : 2677-01 FIRE STAT.33 Site ID : B2-5.
Thank you for your business.

* For future reference to this analysis please use SUN # 73668-153647.

EVALUATION FOR SOIL CORROSION

Soil pH	5.70		
Minimum Resistivity	56.28	ohm-cm (x1000)	
Chloride	4.4 ppm	00.00044	%
Sulfate	5.8 ppm	00.00058	%

METHODS
pH and Min.Resistivity CA DOT Test #643
Sulfate CA DOT Test #417, Chloride CA DOT Test #422

APPENDIX B