GEOTECHNICAL FEASIBILITY REPORT
1515 4th STREET APARTMENTS
SAN RAFAEL, CALIFORNIA

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Job No. 502.305

Prepared for:
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CERTIFICATION

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1.0 INTRODUCTION

This report presents the results of our Geotechnical Feasibility Report for the planned apartment building located at 1515 4th Street in San Rafael, California. As shown on Figure 1, the project site on the western extent of downtown San Rafael and is bounded by 4th Street to the north, Shaver Street to the west and E Street to the east. The southern property line is adjacent to existing, multi-story, office buildings.

Our work was performed in accordance with our Agreement for Professional Services dated October 6, 2021. The purpose of our services was to evaluate the geotechnical feasibility of the proposed improvements. The scope of our services includes:

- Review of readily available, published public geologic mapping and geotechnical background information from our files.
- Evaluation of relevant geologic hazards including seismic shaking, liquefaction, flooding, settlement, and other hazards.
- Preparing a Geotechnical Feasibility report which summarizes the evaluation of relevant geologic hazards, and preliminary geotechnical recommendations and design criteria.

This report completes our Phase 1 services for the project. Subsequent phases of work may include subsurface exploration and laboratory testing as part of design level investigation; geotechnical plan review; and observation and testing of geotechnical-related work items during construction.

2.0 PROJECT DESCRIPTION

Based on our review of preliminary plans and discussions with the project team, we understand the project consists of demolishing the existing structure and parking lot and constructing a 7-story apartment structure that will encompass the entire property (approximately 38,500 square feet), as shown on Figure 2. Additionally, two stories of subterranean parking will be constructed under the entirety of the proposed structure. The subterranean parking levels will require excavations up to approximately 20-feet along the northern property line tapering to a few feet deep along the southern property line.

3.0 SITE CONDITIONS

The project site is located within the Coast Ranges geomorphic province of California. It is typified by generally northwest-trending ridges and intervening valleys that formed as a result of movement along a group of northwest-trending fault systems, including the San Andreas Fault. Bedrock geology within the San Francisco Bay area is dominated by sedimentary, igneous, and metamorphic rocks of the Jurassic-Cretaceous age Franciscan Complex. Most of Franciscan rock types are composed of sandstone and pervasively sheared shale. It also includes less common rocks such as chert, serpentinite, basalt, greenstone, and exotic low- to high-grade metamorphic rocks, including phyllite, schist, and eclogite.

3.1 Regional Geology

As shown on the Regional Geology Map (Rice, Strand, and Smith, 1976), Figure 3, the site is underlain by alluvial deposits (map symbol Qa). Typically, alluvium consists of unconsolidated sand, gravel, silt, and clay deposited by streams. The hillsides located to the north and south of the project site are mapped as Franciscan Mélange and Cretaceous sandstone, respectively. These mapped rock types most likely underly the alluvial deposits.

3.2 Seismicity

The project site is located within the seismically active San Francisco Bay Area and will therefore experience the effects of future earthquakes. Earthquakes are the product of the build-up and sudden release of strain along a "fault" or zone of weakness in the earth's crust. Stored energy may be released as soon as it is generated, or it may be accumulated and stored for long periods of time. Individual releases may be so small that they are detected only by sensitive instruments, or they may be violent enough to cause destruction over vast areas.

Faults are seldom single cracks in the earth's crust but are typically composed of localized shear zones which link together to form larger fault zones. Within the Bay Area, faults are concentrated along the San Andreas Fault and Hayward Fault Zones. The movement between rock formations along either side of a fault may be horizontal, vertical, or a combination, and is radiated outward in the form of energy waves. The amplitude and frequency of earthquake ground motions partially depends on the material through which it is moving. The earthquake force is transmitted through hard rock in short, rapid vibrations, while this energy becomes a long, high-amplitude motion when moving through soft ground materials, such as Bay Mud.

3.2.1 Regional Active Faults

An "active" fault is one that shows displacement within the last 11,000 years (i.e., Holocene) and has a reported average slip rate greater than 0.1 mm per year. The California Division of Mines and Geology has mapped various active and inactive faults in the region. These faults are shown in relation to the project site on the attached Active Fault Map, Figure 4. The nearest known active faults are the San Andreas and Hayward/Rodgers Creek Faults, which are located roughly 14.3 kilometers southwest and 14.4 kilometers northeast of the site, respectively.

3.2.2 Historic Fault Activity

Numerous earthquakes have occurred in the region within historic times. The results of our USGS earthquake search catalogue indicates that at least 9 earthquakes with a Richter Magnitude of 5.0 or larger have occurred within 100 kilometers (62 miles) of the site between 1900 and 2014. The approximate locations of earthquakes with a Magnitude greater than 2.0 from 1985 to 2014 are shown on the Historic Earthquake Map, Figure 5.

3.2.3 Probability of Future Earthquakes

The site will likely experience moderate to strong ground shaking from future earthquakes originating on any of several active faults in the San Francisco Bay region. The historical records do not directly indicate either the maximum credible earthquake or the probability of such a future event. To evaluate earthquake probabilities in California, the USGS has assembled a group of researchers into the "Working Group on California Earthquake Probabilities" (USGS 2003, 2008, 2013) to estimate the probabilities of earthquakes on active faults. These studies have been published cooperatively by the USGS, CGS, and Southern California Earthquake Center (SCEC) as the Uniform California Earthquake Rupture Forecast, Versions 1, 2, and 3. In these studies, potential seismic sources were analyzed considering fault geometry, geologic slip rates, geodetic strain rates, historic activity, micro-seismicity, and other factors to arrive at estimates of earthquakes of various magnitudes on a variety of faults in California.

Conclusions from the most recent UCERF3 and USGS indicate the highest probability of an earthquake with a magnitude greater than 6.7 originating on any of the active faults in the San Francisco Bay region by 2043 is assigned to the Hayward/Rodgers Creek Fault system, with a probability of 33 percent. The nearest active fault, the San Andreas Fault located approximately 14.3 kilometers southwest of the site and is assigned a probability of 22 percent. Additional studies by the USGS regarding the probability of large earthquakes in the Bay Area are ongoing. These current evaluations include data from additional active faults and updated geological data.

3.3 Surface Conditions

The project site encompasses an approximately 38,500-square feet (0.8-acre), L-shaped, parcel that is bounded by 4th Street to the north, Shaver Street to the west and E Street to the east. Elevations on the project site slope gently from +54-feet on the northeast corner down to +44-feet on the southwest corner. The site is currently developed with a vacant, one-story bank structure that is surrounded by asphalt parking areas. Concrete retaining walls border the western and southern property lines that approach 10-feet in height. The southern retaining wall is performing poorly with large sections that are severely cracked and leaning.

3.4 Anticipated Subsurface Conditions

Based on geologic mapping, and our experience in this area of downtown San Rafael, we anticipate the subsurface conditions will include clayey alluvial deposits overlying weathered bedrock. Weathered bedrock is anticipated at depths between 10- and 20-feet below the ground surface. Groundwater conditions in the general vicinity is anticipated to be within the upper 10-feet.

4.0 GEOLOGIC HAZARDS

This section summarizes our review of commonly considered geologic hazards and discusses their potential impacts on the planned improvements. The primary geologic hazard which could affect the proposed development is strong seismic ground shaking from future earthquakes in the San Francisco Bay region and liquefaction. Other geologic hazards are judged less than significant regarding the proposed project. Geologic hazards, potential impacts and mitigation measures are discussed in further detail in the following sections.

4.1 Fault Surface Rupture

Under the Alquist-Priolo Earthquake Fault Zoning Act, the California Division of Mines and Geology (now known as the California Geological Survey) produced 1:24,000 scale maps showing known active and potentially active faults and defining zones within which special fault studies are required. The nearest known active faults to the site are the San Andreas and Rodgers Creek Faults, located approximately 14.3 southwest and 14.4 kilometers northeast, respectively. The site is not located within an Alquist-Priolo Special Studies Zone. Therefore, we judge the potential for fault surface rupture in the development area to be low.

Evaluation: *Less than significant.*
Recommendation: *No mitigation measures are required.*

4.2 Seismic Shaking

The site will likely experience seismic ground shaking similar to other areas in the seismically active Bay Area. The intensity of ground shaking will depend on the characteristics of the causative fault, distance from the fault, the earthquake magnitude and duration, and site-specific geologic conditions. Estimates of peak ground accelerations are based on either deterministic or probabilistic methods.

4.2.1 Deterministic Seismic Hazard Analysis

Deterministic methods use empirical attenuation relations that provide approximate estimates of median peak ground accelerations. A summary of the active faults that could most significantly affect the planning area, their maximum credible magnitude, closest distance to the center of the planning area, probable peak ground accelerations, and 84th percentile peak ground accelerations are summarized in Table 1. The calculated accelerations should only be considered as reasonable estimates. Many factors (e.g., soil conditions, orientation to the fault, etc.) can influence the actual ground surface accelerations.

Table 1 – Deterministic Peak Ground Accelerations for Active Faults

Fault	*Magnitude*[1]	*Distance*[2]	*Median PGA*[3,4]	*84% PGA*[2,4]
San Andreas Fault: SAN+SAP+SAP+SAS	8.0	14.3 km	0.28 g	0.51 g
Hayward Fault: RC+HN+HS+HE	7.6	14.4 km	0.22 g	0.40 g
San Gregorio	7.4	15.3 km	0.25 g	0.45 g
Rodgers Creek – Healdsburg Fault	7.3	23.0 km	0.16 g	0.28 g
West Napa	6.6	32.4 km	0.08 g	0.14 g

Notes:

1. Values determined using USGS Earthquake Scenario Map (BSSC 2014), accessed 2021.
2. Google Earth – KML Files showing Quaternary Faults & Folds in the US obtained from USGS
3. Values determined using V_{S30} = 2,500 ft/s based on the anticipated shallow bedrock subsurface conditions.
4. Abrahamson, Silva & Kamai (2014), Boore, Stewart, Seyhan & Atkinson (2014), Campbell & Bozorgnia (2014), and Chiou & Youngs (2014) NGA models.

Key:
RC – Rodgers Creek – Healdsburg Fault
HN – Hayward Fault, Northern Section
HS – Hayward Fault, Southern Section
HE – Hayward Fault, Southern Extension
SAO – San Andreas Fault, Offshore
SAN – San Andreas Fault, North Coast
SAP – San Andreas Fault, Peninsula
SAS – San Andreas Fault, Santa Cruz Mountains

4.2.2 Probabilistic Seismic Hazard Analysis

Probabilistic Seismic Hazard Analysis analyzes all possible earthquake scenarios while incorporating the probability of each individual event to occur. The probability is determined in the form of the recurrence interval, which is the average time for a specific earthquake acceleration to be exceeded. The design earthquake is not solely dependent on the fault with the closest distance to the site and/or the largest magnitude, but rather the probability of given seismic events occurring on both known and unknown faults.

We calculated the peak ground acceleration for two separate probabilistic conditions; the 2 percent chance of exceedance in 50 years (2,475-year statistical return period) and the 10 percent chance of exceedance in 50 years (475-year statistical return period). The peak ground acceleration values were calculated utilizing the USGS Unified Hazard Tool (USGS, 2021). The results of the probabilistic analyses are presented below in Table 2.

Table 2 – Probabilistic Peak Ground Accelerations for Active Faults[1]

Probability of Exceedance	***Return Period***	***Magnitude***	***PGA (g)***
2% in 50 years	2,475 years	7.7	0.71 g
10% in 50 years	475 years	7.6	0.40 g

Notes:

1. Reference: USGS Unified Hazard Tool accessed, 2021.

Ground shaking can result in structural failure and collapse of structures or cause non-structural building elements (such as light fixtures, shelves, cornices, etc.) to fall, presenting a hazard to building occupants and contents. Compliance with provisions of the most recent version of the California Building Code (2019 CBC) should result in structures that do not collapse in an earthquake. Damage may still occur, and hazards associated with falling objects or non-structural building elements will remain.

The potential for strong seismic shaking at the project site is high. Due to their proximity and historic rates of activity, the San Andreas and Hayward-Rodgers Creek Faults present the highest potential for severe ground shaking. The significant adverse impact associated with strong seismic shaking is potential damage to structures and improvements.

Evaluation: *Less than significant with mitigation.*

Recommendation: *Minimum mitigation includes design of new structures in accordance with the provisions of the 2019 California Building Code or subsequent codes in effect when final design occurs. Additional subsurface exploration and analysis will be required to provide seismic design criteria.*

4.3 Liquefaction and Related Effects

Liquefaction refers to the sudden, temporary loss of soil strength during strong ground shaking. The strength loss occurs as a result of the build-up of excess pore water pressures and subsequent reduction of effective stress. While liquefaction most commonly occurs in saturated, loose, granular deposits, recent studies indicate that it can also occur in materials with relatively high fines content provided the fines exhibit lower plasticity. The effects of liquefaction can vary from cyclic softening, resulting in limited strain potential, to post liquefaction settlements and lateral ground movements.

The anticipated subsurface conditions include variable alluvial deposits overlying weathered bedrock. Alluvial deposits typically consist of layers of clayey, sandy, and gravelly soils with the granular layers being potentially susceptible to liquefaction. Liquefaction susceptibility mapping by the Association of Bay Area Governments (MarinMap.org, accessed 2021) indicates that the project site has a moderate to low liquefaction potential, as shown on Figure 6. Considering we anticipate weathered bedrock is located within the upper 20-feet below the ground surface and the current project includes constructing 2-levels of below grade parking that will require excavations roughly 5- to 20-feet, the potential for liquefiable soils below the structure is low.

Evaluation: *Less than significant with mitigation.*
Recommendation: *A subsurface exploration, including laboratory testing, should be performed to fully evaluate the liquefaction risk at the project site. Mitigation measures will be dependent on the results of a subsurface exploration and laboratory testing and liquefaction analysis.*

4.4 Settlement

Significant settlement can occur when new loads are placed over soft, compressible clays or loose granular soils or significant structural loads are transferred to the underlying soils. We do not anticipate soft compressible soils (i.e., Bay Mud, lacustrine deposits, marsh deposits, etc.) will underlie the project site; however, we anticipate the foundation loads will be significant. These loads can cause the underlying soils to consolidate, resulting in surface settlements. However, we anticipate excavations roughly 5- to 20-feet will be required to construct the 2-levels of subterranean parking levels and the proposed structure will most likely span between bedrock and alluvial soils that can result in differential settlements. Therefore, differential settlement is considered a moderate hazard at the project site.

Evaluation: *Less than significant with mitigation.*
Recommendation: *A subsurface exploration, including laboratory testing, should be performed to fully evaluate the settlement risk at the project site. Mitigation measures will be dependent on the results of a subsurface exploration and laboratory testing and settlement analysis. We anticipate mitigation will include utilizing shallow foundations to support the structure where bedrock is at or near the excavated surface. A deep foundation system (i.e., drilled piers, piles, etc.) that extend through the alluvial soils and bear on the underlying weathered bedrock will be utilized where the overlying soils are thicker.*

4.5 Seismic Densification

Seismic ground shaking can induce settlement in unsaturated, loose, granular soils. Settlement occurs as the loose soil particles rearrange into a denser configuration when subjected to seismic ground shaking. Varying degrees of settlement can occur throughout a deposit, resulting in differential settlement of structures founded on such deposits. We do not anticipate encountering loose, dry granular soils below the bearing soil strata. However, a subsurface exploration should be performed to verify unsaturated, loose, granular soils do not underly the site.

Evaluation: *Less than significant with mitigation.*
Recommendation: *A subsurface exploration, including laboratory testing, should be performed to fully evaluate the seismic densification risk at the project site. Mitigation measures will be dependent on the results of lab testing and analysis.*

4.6 Expansive Soils

Soil expansion occurs when clay particles interact with water causing seasonal volume changes in the soil matrix. The clay soil swells when saturated and then contracts when dried. This phenomenon generally decreases in magnitude with increasing confinement pressures at increasing depths. These volume changes may damage lightly loaded foundations, concrete slabs, pavements, retaining walls and other improvements. Expansive soils also cause soil creep on sloping ground. Near surface soils are likely to include silts and clays that may be prone to expansive behavior. However; these soils, if encountered, would most likely be removed from the project site to construct the subterranean parking levels. Therefore, the risk of expansive soil affecting the proposed improvements appears low.

Evaluation: *Less than significant with mitigation.*
Recommendation: *A subsurface exploration, including laboratory testing, should be performed to fully evaluate the expansive soil risk at the project site. Mitigation measures will be dependent on the results of lab testing.*

4.7 Erosion

Sandy soils on moderately steep slopes or clayey soils on steep slopes are susceptible to erosion when exposed to concentrated surface water flow. The potential for erosion is increased when established vegetation is disturbed or removed during normal construction activity.

The project site is relatively flat. Additionally, the preliminary proposed improvement plans indicate that the entirety of the property will be developed with the apartment building, pavements, or concrete flatwork. Therefore, erosion is not considered to be a significant geologic hazard.

Evaluation: *Less than significant.*
Recommendation: *Designing a site drainage system for the maximum credible rainfall event, and to collect surface water and discharging it into an established storm drainage system. The project Civil Engineer is typically responsible for designing the site drainage system and, an erosion control plan should be developed prior to construction per the current guidelines of the California Stormwater Quality Association's Best Management Practice Handbook.*

4.8 Flooding

The project site is located at about at elevations approximately +54 and +44-feet and mapped at the edge of a 500-year flood hazard zone (MarinMap.org, 2021), as shown on Figure 7. Therefore, large scale flooding is considered a low hazard to the inhabitable spaces at the project site. However, two levels of subterranean parking proposed may be susceptible to localized flooding. Additionally, changes to existing grades and drainage patterns associated with site development can result in localized flooding. Therefore, the risk of flooding at the project site is low to moderate.

Evaluation: *Less than significant with mitigation.*
Recommendation: *The project Civil Engineer is responsible for site drainage and should evaluate localized flooding potential and provide appropriate mitigation. Additionally, finished floor elevations should be above potential flood levels.*

4.9 Tsunami and Seiche

Seiche and tsunamis are short duration, earthquake-generated water waves in large, enclosed bodies of water and the open ocean, respectively. The extent and severity of a seiche or tsunami would be dependent upon ground motions and fault offset from nearby active faults. Tsunami hazard mapping of the project area (MarinMap.org, 2021) indicates the site is not located within an area that is susceptible to tsunami inundation. Therefore, the likelihood of inundation by seiche or tsunami is low.

Evaluation: *Less than significant.*
Recommendation: *No mitigation measures are required.*

5.0 PRELIMINARY CONCLUSIONS AND RECOMMENDATIONS

Based on the results of our investigation, we conclude the site conditions are suitable for the proposed development. The primary geotechnical considerations for the project will include designing the improvements to resist strong seismic ground shaking, potential differential settlement, potential liquefaction, and excavation safety. Additional discussion and preliminary conclusions and recommendations addressing these, and other considerations are presented in the following sections.

5.1 Seismic Design

Minimum mitigation of ground shaking includes seismic design of new structures in conformance with the provisions of the most recent edition (2019) of the California Building Code. The magnitude and character of these ground motions will depend on the earthquake and the site response characteristics. Based on the anticipated site grading, subsurface conditions, and proximity of active faults, we recommend the CBC coefficients and site values shown in Table 3 be used to preliminarily calculate the design base shear of new structures as applicable. The values presented in Table 3 should be confirmed based on supplemental subsurface exploration and laboratory testing.

Table 3 – Preliminary 2019 California Building Code Seismic Design Criteria

Parameter	Design Value
Site Class	B
Site Latitude, Longitude	37.9734°, 122.5340°
Spectral Response (short), S_S	1.50 g
Spectral Response (1-sec), S_1	0.60 g
Site Coefficient, F_a	1.0
Site Coefficient, F_V	1.0

Reference: SEAC/OSHPD Seismic Design Maps, accessed 2021.

Depending on the building period, supplemental exploration and updated liquefaction analyses performed during the design-level investigation, the soil site class may be Site Class “F” (liquefiable soils) requiring a site-specific seismic response evaluation.

5.2 Site Grading

Significant grading (cut or fill placement) is anticipated to develop the project site. Site grading will consist of excavations up to 20-feet deep on the north side of the project site to construct the subterranean parking levels. Earthwork should be performed in accordance with the recommendations and criteria outlined in the following sections.

5.2.1 Site Preparation

Clear pavements, old foundations, over-sized debris, and organic material from areas to be graded. Debris, rocks larger than six inches, and vegetation are not suitable for structural fill and should be removed from the site. Existing foundations and utilities which are to be abandoned as part of the work should be removed from structural areas. In non-structural areas, utilities could be abandoned in place provided cement grout completely fills any void in the utility.

Where fills or other structural improvements are planned, the subgrade surface should be scarified to a depth of 8 inches, moisture conditioned to above the optimum moisture content, and compacted to at least 90 percent relative compaction. Relative compaction refers to the in-place dry density of soil expressed as a percentage of the maximum dry density, as determined by ASTM D1557. Subgrade preparation should extend a minimum of 5 feet beyond the planned building envelope in all directions. The subgrade should be firm and unyielding when proof-rolled with heavy, rubber-tired construction equipment. If soft, wet, or otherwise unsuitable materials are encountered at subgrade elevation during construction, we can provide supplemental recommendations to address the specific condition. If weathered bedrock is exposed at the subgrade level, ripping and recompacting is not required with the approval of the geotechnical engineer.

5.2.2 Excavations

Based on geologic mapping, site excavations will likely encounter unconsolidated alluvial soil deposits containing clay, silt, sand, and gravel. Weathered bedrock should be anticipated within the upper 20-feet and will likely be encountered during excavation. Soils and highly weathered bedrock encountered should be “diggable” with standard excavation equipment (i.e., excavators, back-hoes, etc.). However, more competent and less weathered bedrock should be anticipated that may require hard rock excavation equipment (i.e., hoe-ram, large teeth excavators, etc.).

We anticipate onsite subsurface soils generally classify as OSHA Type C while weathered bedrock will classify as OSHA Type A. Temporary support of excavations will be required to ensure the safety of workers and to reduce the potential for failure of the excavation sidewalls and damage to surrounding improvements. Excavation stability and the structural design of temporary shoring should be made the sole responsibility of the Contractor. For excavation deeper than 5 feet, the design of temporary dewatering systems should be made the sole responsibility of the Contractor.

5.2.3 Fill Materials, Placement and Compaction

Fill materials should consist of non-expansive materials that are free of organic matter, have a Liquid Limit of less than 40 (ASTM D 4318), a Plasticity Index of less than 15 (ASTM D 4318), and a minimum R-value of 20 (California Test 301). The fill material should contain less than 50 percent of particles passing a No. 200 sieve and should have a maximum particle size of 4 inches. Onsite soils may be suitable for use as fill provided, they meet the criteria specified above. Any imported fill material needs to be tested to determine its suitability.

Fill materials should be moisture conditioned to above the optimum moisture content prior to compaction. Properly moisture conditioned fill materials should subsequently be placed in loose, horizontal lifts of 8 inches-thick or less and uniformly compacted to at least 90 percent relative compaction. Where fill thicknesses are greater than 5 feet, fill materials should be compacted to at least 92 percent relative compaction. In pavement areas, the upper 12 inches of fill should be compacted to at least 95 percent relative compaction. The maximum dry density and optimum moisture content of fill materials should be determined in accordance with ASTM D1557.

5.3 Preliminary Foundation Design

Based on our experience with similar projects in the general vicinity of the project site, we judge the proposed 7-story apartment building should be supported on a foundation system that bears on the anticipated underlying weathered bedrock. Shallow foundations may be utilized where weathered bedrock is exposed at, or near, the ground surface. Drilled piers will likely be required to extend through deeper soils and embed into the weathered bedrock. We will provide additional foundation recommendations and design criteria in the design level geotechnical investigation report.

5.4 Retaining Walls

Retaining walls may be required to support the subterranean parking levels. These walls should be supported on a foundation system as described above. Walls free to rotate at the top, (i.e., "unrestrained") and walls structurally connected at the top (i.e., "restrained"). If retaining walls will be greater than 10-feet in retained height tie-backs may be utilized to reduce foundation depths. Additionally, retaining walls greater than 5-feet should not be constructed without temporary cut slopes or shoring.

Drainage shall be provided for all retaining walls taller than two feet. Either Caltrans Class 1B permeable material within filter fabric or Caltrans Class 2 permeable material can be used. The seepage should be collected in a 4-inch perforated PVC drain line at the base of the wall. The permeable material shall extend at least 12 inches from the back of the wall and be continuous from the bottom of the wall to within 12 inches of the ground surface. Alternatively, drainage panels, such as Mirifi 100N, may be utilized. Additionally, waterproofing should be constructed behind retaining walls that abut interior space and considered for the parking levels. The Project Architect and/or waterproofing expert should design the waterproofing system.

5.5 Interior Concrete Slabs-On-Grade

Reinforced concrete slab-on-grade floors are judged to be appropriate for the site conditions. The concrete slabs-on-grade may be poured monolithically or separated with a cold joint. We recommend that interior concrete slabs have a minimum thickness of 5 inches and be reinforced with steel reinforcing bars (not mesh) with rebar extending through crack control joints. Slabs should be placed on a moist subgrade to reduce potential for future expansive behavior. The project Structural Engineer should specifically design the concrete slabs, including locations of crack control joints. Under slab drainage should also be considered below the subterranean garage to alleviate buoyancy effects and reduce potential moisture infiltration.

To reduce the potential for moisture to move upward through the slab, a four-inch layer of clean, free draining, ¾-inch angular gravel should be placed beneath interior concrete slabs to form a capillary moisture break. The gravel must be placed on a properly moisture conditioned and compacted subgrade that has been approved by the Geotechnical Engineer. A plastic membrane vapor barrier, 15 mils or thicker, should be placed over the compacted base rock. The vapor barrier shall meet the ASTM E1745 Class A requirements and be installed per ASTM E1643. Eliminating the capillary moisture break and/or plastic vapor barrier may result in excess moisture intrusion through the floor slabs resulting in poor performance of floor coverings, mold growth, or other adverse conditions.

We note that over time, placing sand between the vapor barrier and concrete is becoming less common because of elevated interior moisture contents. If sand is used, it should be dry, and if it is not used, the slab should be carefully designed with a lower water-cement ratio (generally less than 0.45) since eliminating the sand can cause cracking or "curling" of the new concrete. For slabs that are not sensitive to moisture vapor, we recommend at least four inches of Class 2 aggregate base (Caltrans, 2015) compacted to 95 percent relative compaction.

5.6 Exterior Concrete Slabs

Exterior concrete walkway slabs and other concrete slabs that are not subjected to vehicle loads should be a minimum of 4 inches thick and underlain with 4 inches or more of Class 2 aggregate base. The aggregate base should be moisture conditioned to near optimum and compacted to at least 95 percent relative compaction. The upper 8 inches of subgrade on which aggregate base is placed should be prepared as previously discussed under Section 5.2.

Where improved performance is desired (i.e., reduced risks of cracking or small movements), exterior slabs can be thickened to 5 inches and reinforced with steel reinforcing bars (not welded wire mesh). We recommend crack control joints no farther than 10 feet apart in both directions and that the reinforcing bars extend through the control joints. Some movement or offset at sidewalk joints should be expected as the underlying soils expand and shrink from seasonal moisture changes.

5.7 Site and Foundation Drainage

New grading could result in adverse drainage patterns causing water to pond around the development. Careful consideration should be given to design of finished grades at the site. We recommend that the building areas be raised slightly and that the adjoining landscaped areas be sloped downward at least 0.25 feet for 5 feet (5 percent) from the perimeter of building foundations. Where hard surfaces, such as concrete or asphalt adjoin foundations, slope these surfaces at least 0.10 feet in the first 5 feet (2 percent).

Roof gutter downspouts may discharge onto the pavements but should not discharge onto landscaped areas immediately adjacent to the buildings. Provide area drains for landscape planters adjacent to buildings and collect downspout discharges into a tight pipe collection system that discharges well away from the building foundations. Site drainage should be discharged away from the building area and outlets should be designed to reduce erosion. Site drainage improvements should be connected into an established storm drainage system.

5.8 Underground Utilities

Excavations for utilities will likely encounter unconsolidated alluvial soils deposits containing variable amounts of clay, silt, sand, and gravel. Groundwater may be encountered at shallow depths. Trench excavations having a depth of 5 feet or more must be excavated and shored in accordance with OSHA regulations, as discussed in Section 5.2.2.

Unless otherwise recommended by the pipe manufacturer, pipe bedding and embedment materials should consist of well-graded sand with 90 to 100 percent of particles passing the No. 4 sieve and no more than 5 percent finer than the No. 200 sieve. Crushed rock or pea gravel may also be considered for pipe bedding. Provide the minimum bedding thickness beneath the pipe in accordance with the manufacturer’s recommendations (typically 3 to 6 inches). Trench backfill may consist of on-site soils, provided that the soil meets the fill criteria outlined in Section 5.2.3 or imported aggregate baserock. Trench backfill should be moisture conditioned and placed in thin lifts and compacted to at least 90 percent. Use equipment and methods that are suitable for work in confined areas without damaging utility conduits.

6.0 SUPPLEMENTAL GEOTECHNICAL SERVICES

We should perform a design level geotechnical investigation on the project site prior to structural design. Our services will include soil borings to confirm the anticipated subsurface conditions and to collect select soil samples for laboratory testing to determine the pertinent engineering properties. We will summarize the results of our subsurface exploration in a report that will include the results of our subsurface exploration and laboratory testing and will include seismic and foundation design criteria.

As project plans near completion, we should review them to ensure that the intent of our recommendations has been sufficiently incorporated. During construction, we should be present intermittently to observe and test the geotechnical portions of the work. The purpose of our observation and testing is to confirm that site conditions are as anticipated, to adjust our recommendations and design criteria if needed, and to confirm that the Contractor's work is performed in accordance with the project plans and specifications.

7.0 LIMITATIONS

We believe this report has been prepared in accordance with generally accepted geotechnical engineering practices in Sonoma County at the time the report was prepared. This report has been prepared for the exclusive use of the project Owner (Monahan Pacific Corporation) and/or their assignees specifically for this project. No other warranty, expressed or implied, is made. Our evaluations and recommendations are based on the data obtained during our subsurface exploration program and our experience with soils in this geographic area.

Our approved scope of work did not include an environmental assessment of the site. Consequently, this report does not contain detailed information regarding the presence or absence of toxic or hazardous wastes.

The evaluations and recommendations do not reflect variations in subsurface conditions that may exist between boring locations or in unexplored portions of the site. Should such variations become apparent during construction, the general recommendations contained within this report will not be considered valid unless MPEG is given the opportunity to review such variations and revise or modify our recommendations accordingly. No changes may be made to the general recommendations contained herein without the written consent of MPEG.

We recommend that this report, in its entirety, be made available to project team members, designers, contractors, and subcontractors for informational purposes and discussion. We intend that the information presented within this report be interpreted only within the context of the report as a whole. No portion of this report should be separated from the rest of the information presented herein. No single portion of this report shall be considered valid unless it is presented with and as an integral part of the entire report.

8.0 LIST OF REFERENCES

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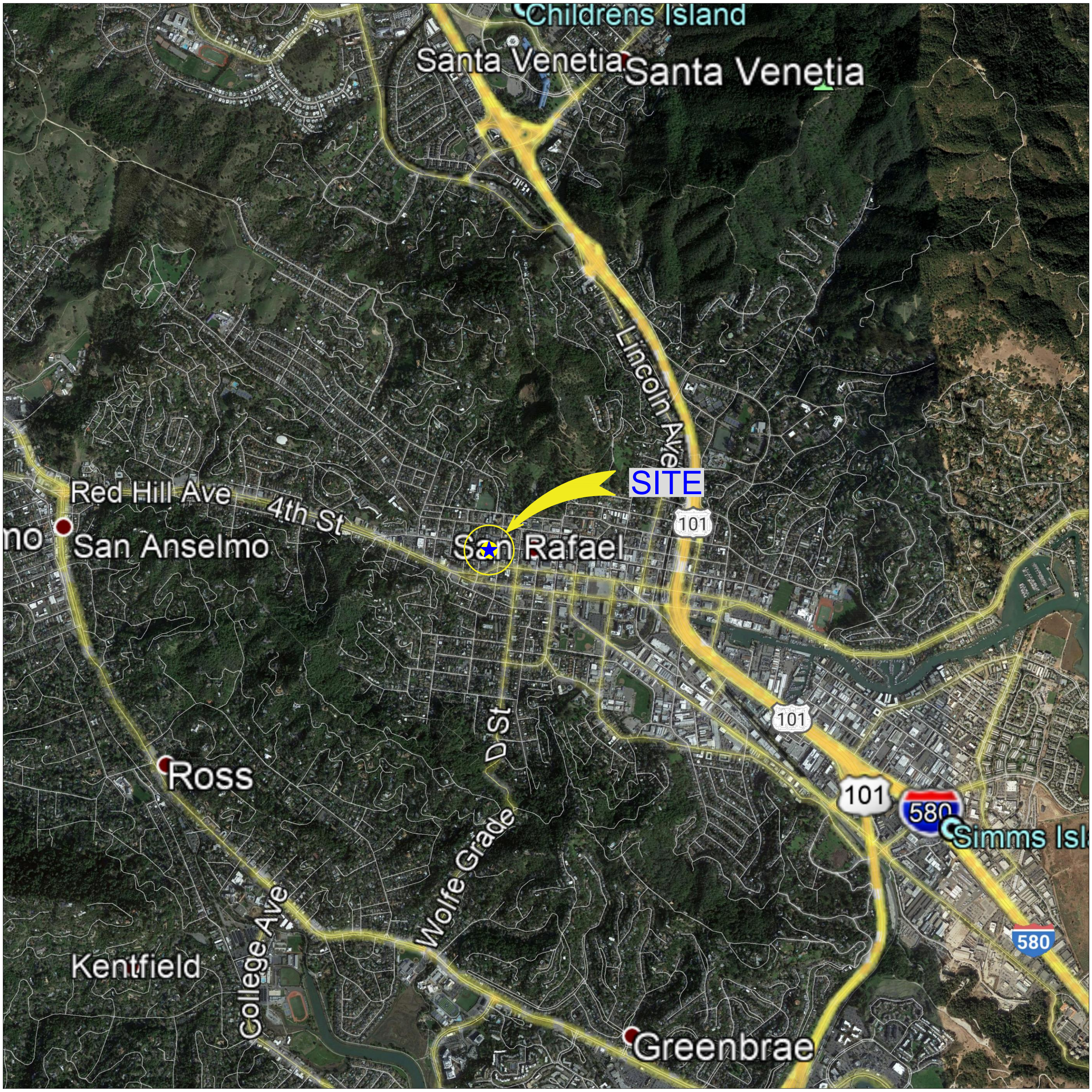

SITE COORDINATES
LAT. 37.9734°
LON. -122.5340°

SITE LOCATION

N.T.S.

NORTH

REFERENCE: Google Earth, 2021

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SITE LOCATION MAP

1515 Fourth Street
San Rafael, California

Project No. 502.305 Date: 10/14/2021

Drawn MMT
Checked

1
FIGURE

SITE PLAN

SCALE

0 30 60 120 FEET

NORTH

REFERENCE: 1515 Fourth Street Associates, LLC, "Site Plan" Sheet 001, 10/01/2021.

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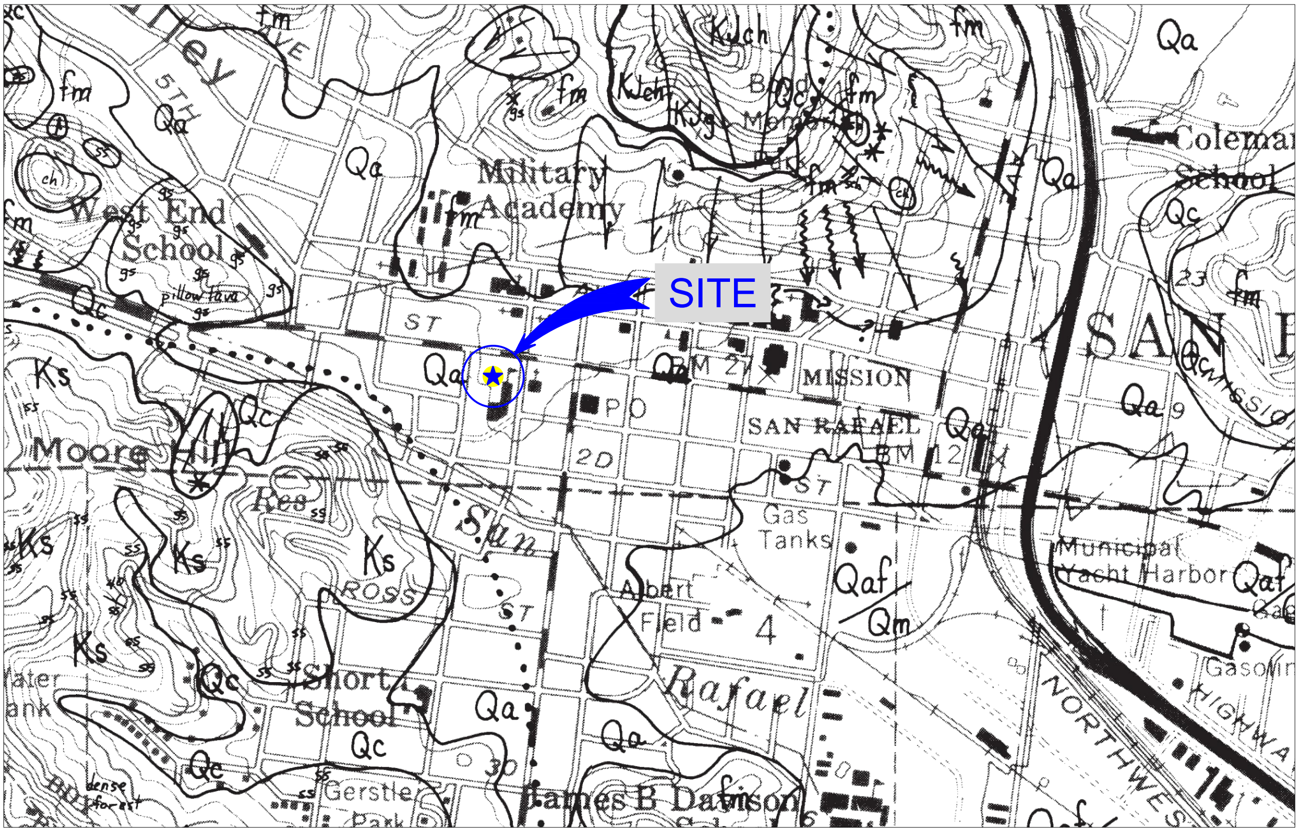
SITE PLAN

1515 Fourth Street
San Rafael, California

Project No. 502.305 Date: 10/14/2021

Drawn MMT
Checked

2
FIGURE



REGIONAL GEOLOGIC MAP

NORTH

LEGEND AND KEY TO MAP SYMBOLS

Qc - **Colluvium (Quaternary)**
Unsorted deposits of gravel, clay, sand, and silts at the base of hillsides due to the weathering process of slopes.

Qaf/Qm - **Artificial Fill over Marine and Marsh Deposits, Bay Mud (Quaternary)**
Bay Mud, including organic material, silty mud, silt, and sand, overlain by artificial fill.

Qa - **Alluvium (Quaternary)**
Unconsolidated sand, gravel, silt and clay deposited by streams.

fm - **Franciscan Melange**
Highly sheared weathered bedrock consisting of variying amounts of sandstone, siltstone, chert, greenstone and conglomerate. Intermittent competent rock is sometimes present within the weathered bedrock matrix.

KJch - **Chert (Cretaceous and Jurassic)**
Chert with shale interbeds. Chert is thin bedded, closely fractured, and parts along bedding planes.

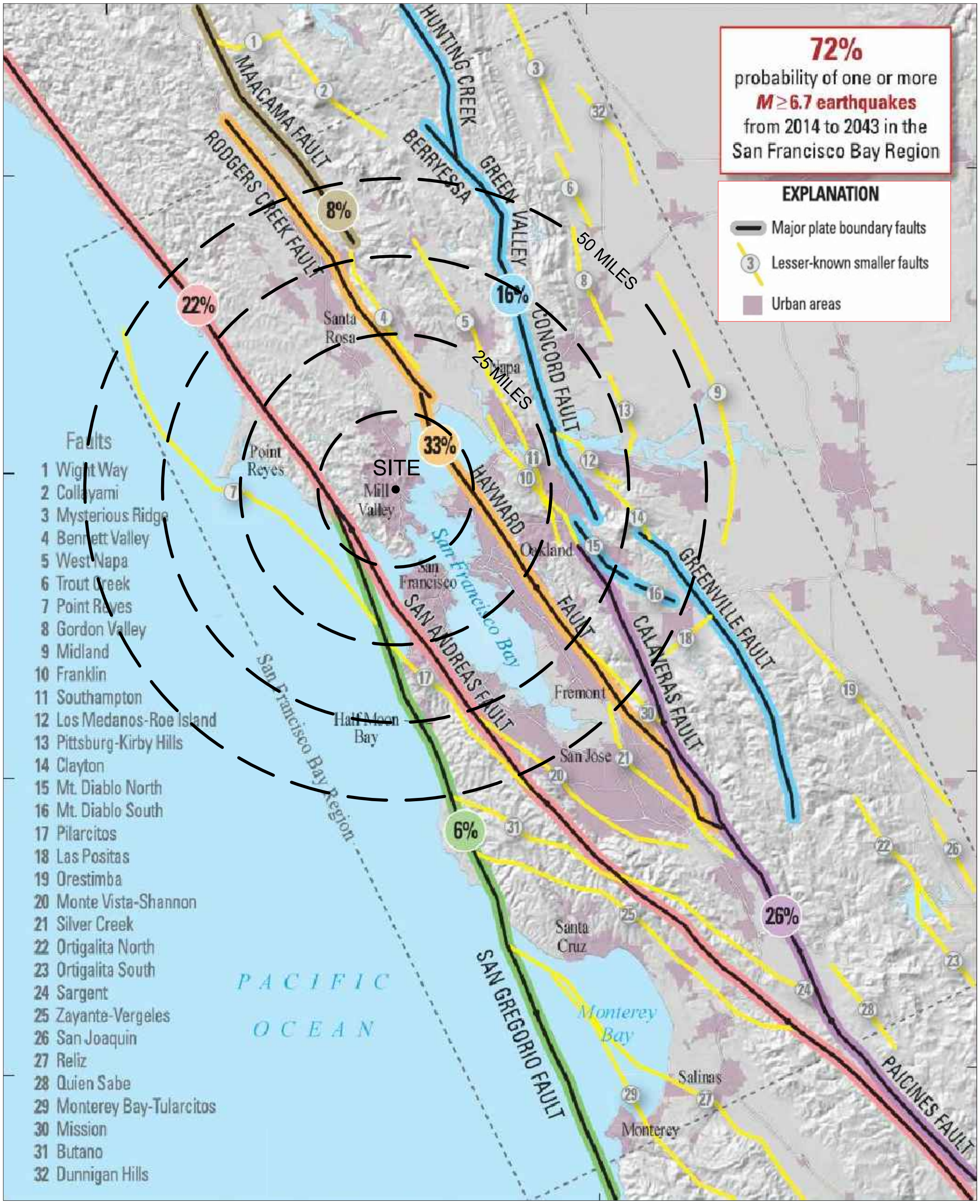
Ks - **Sandstone and Shale (Cretaceous)**
Consists of pillow lava and less abundant tuff, breccia, and intrusive basalt, diabase, and rare gabbro.

——— Geologic contact, dashed where approximate, dotted where concealed.

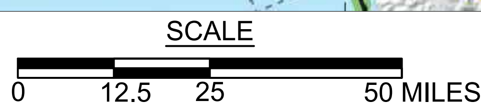
— — — Fault contact, dashed where approximate, dotted where concealed.

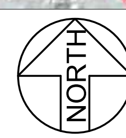
REFERENCE: Rice, S.J. Strand, R.G., and Smith, T.C. (1976), “Geology of the Eastern Part of the San Rafael Area, Marin County, California” in Geology of the Eastern Part of the San Rafael Area, Marin County, California”, California Department of Conservation, Division of Mines and Geology Open-File Report 76-22, Plate 1C, Map Scale 1:12,000.

MPEG MILLER PACIFIC ENGINEERING GROUP	504 Redwood Blvd. Suite 220 Novato, CA 94947 T 415 / 382-3444 F 415 / 382-3450 www.millerpac.com	REGIONAL GEOLOGIC MAP		
 FILENAME: 502.305 Figures.dwg		1515 Fourth Street San Rafael, California Project No. 502.305 Date: 10/14/2021	Drawn MMT Checked	3 FIGURE



SITE COORDINATES
LAT. 37.9734°
LON. -122.5340°





DATA SOURCE:
1) U.S. Geological Survey, U.S. Department of the Interior, "Earthquake Outlook for the San Francisco Bay Region 2014-2043", Map of Known Active Faults in the San Francisco Bay Region, Fact Sheet 2016-3020, Revised August 2016 (ver. 1.1).

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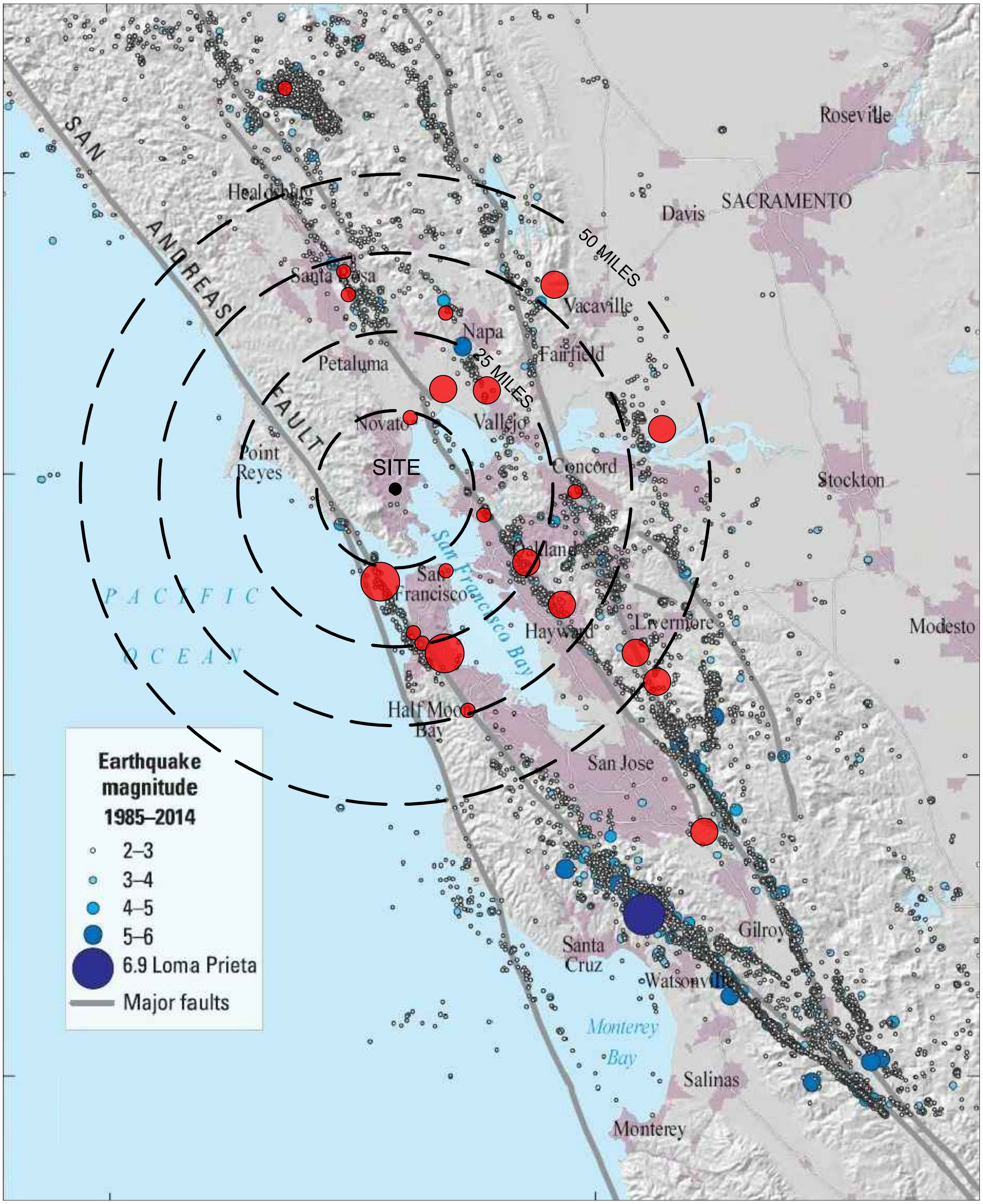
ACTIVE FAULT MAP

1515 Fourth Street
San Rafael, California

Project No. 502.305 Date: 10/14/2021

Drawn MMT
Checked

4
FIGURE



SITE COORDINATES
LAT. 37.9734°
LON. -122.5340°

SCALE
0 12.5 25 50 MILES

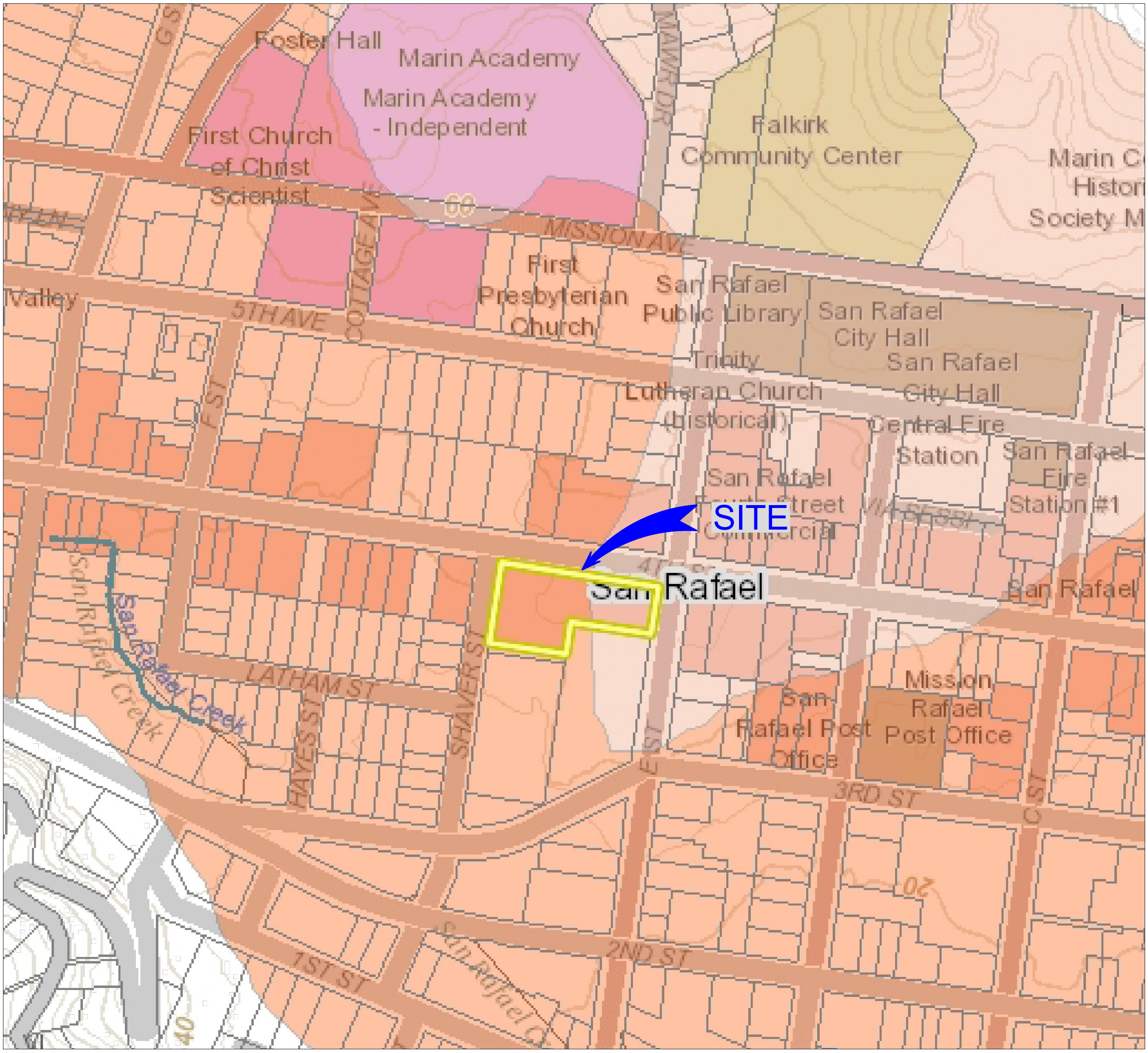
NORTH

LEGEND & DATA SOURCE:

See legend above. U.S. Geological Survey, U.S. Department of the Interior, "Earthquake Outlook for the San Francisco Bay Region 2014-2043", Map of Known Active Faults in the San Francisco Bay Region, Fact Sheet 2016-3020, Revised August 2016 (ver. 1.1).

Large circles indicate earthquakes M>7.0, medium circles indicate 6.0<M<7.0 and small circles indicate 5.0<M<6.0 .U.S. Geological Survey, Earthquake Catalog Search, https://earthquake.usgs.gov/earthquakes/search/. Earthquakes between 1830 and 2021.

MPEG MILLER PACIFIC ENGINEERING GROUP	504 Redwood Blvd. Suite 220 Novato, CA 94947 T 415 / 382-3444 F 415 / 382-3450 www.millerpac.com	HISTORIC EARTHQUAKE MAP		
A CALIFORNIA CORPORATION, © 2020, ALL RIGHTS RESERVED FILENAME: 502.305 Figures.dwg		1515 Fourth Street San Rafael, California Project No. 502.305 Date: 10/14/2021	Drawn MMT Checked	5 FIGURE



LIQUEFACTION SUSCEPTIBILITY MAP

No Scale

Liquefaction

- Very High
- High
- Moderate
- Low
- Very Low

NORTH

Reference: MarinMap.org, accessed 2021

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LIQUEFACTION SUSCEPTIBILITY MAP

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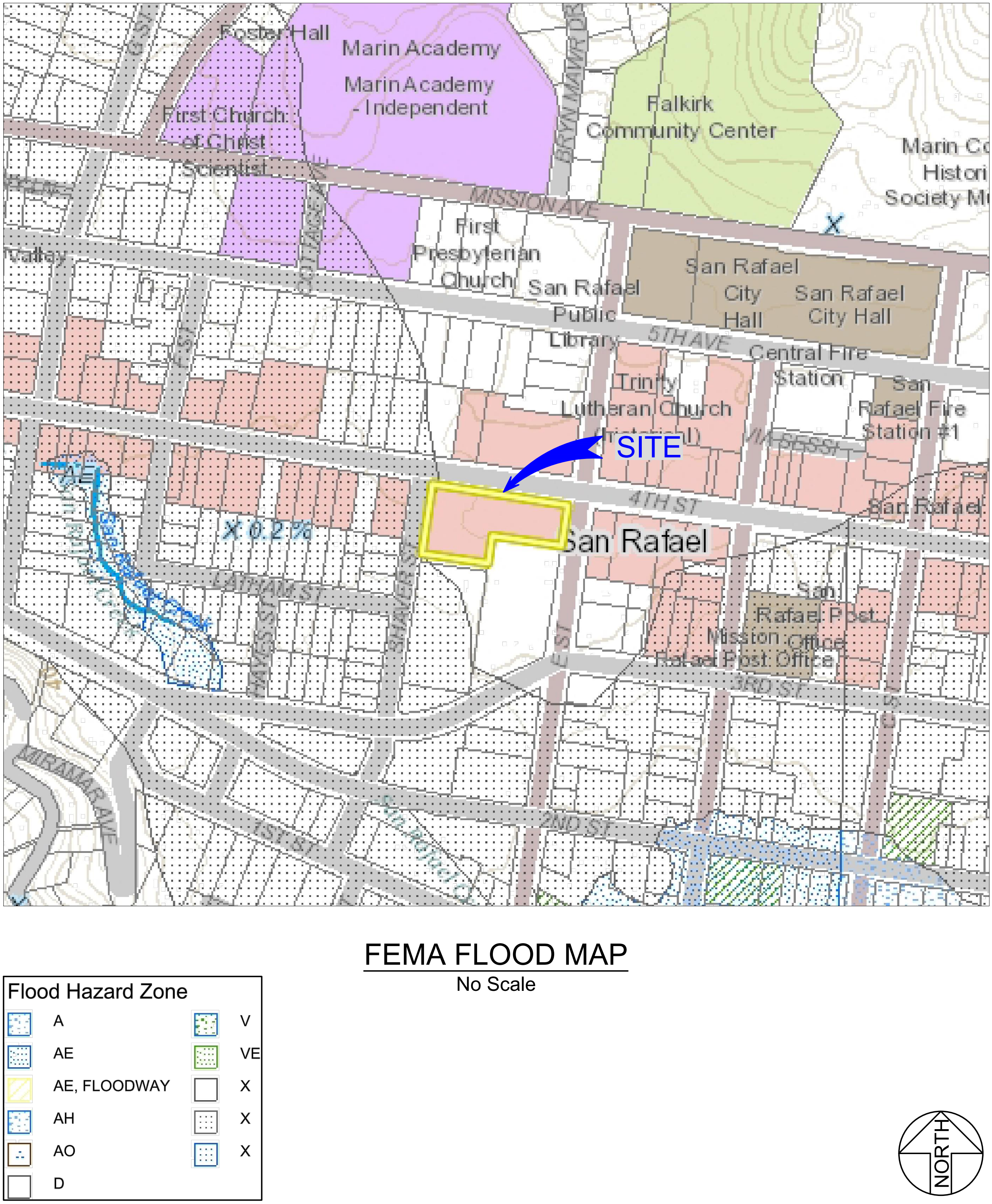
6
FIGURE



FEMA FLOOD MAP

No Scale

Reference: MarinMap.org, accepted 2021

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FEMA FLOOD MAP

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Project No. 502.305 Date: 10/14/2021

Drawn MMT
Checked

7
FIGURE