GEOTECHNICAL CONSULTANTS, INC.
Geotechnical Engineering • Geology • Hydrogeology

PLANNING LEVEL GEOTECHNICAL STUDY
800 MHZ PUBLIC SAFETY RADIO REPLACEMENT PROJECT
1 CHRISTMAS TREE POINT ROAD
SAN FRANCISCO, CALIFORNIA

December 2014

Prepared for:

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TABLE OF CONTENTS

TABLES

FIGURES

1.0 INTRODUCTION

This report presents a planning level geotechnical assessment of the site and anticipated foundation alternatives for the proposed replacement radio tower under consideration as part of the City and County of San Francisco (CCSF) 800MHz Public Safety Radio Replacement Project. The project aims to provide a replacement radio system that must meet public safety standards for performance and reliability and provide a robust radio communications for the next 10 to 20 years (CCSF, 2013). The facility is located at 1 Christmas Tree Point Road (at the intersection of Twin Peaks Boulevard) in San Francisco, California. The project location is shown on ***Figure 1 – Project Location Map.*** This report was developed in accordance with *Task Order No. 1 – Scope Change 3 - Twin Peaks*, of our Geotechnical Consulting Services Subconsultant Agreement with Jacobs Engineering Group, Inc. (11/11/2014, Jacobs Project No. W8X91401).

We understand that the project proposes to install a new ±180 foot high radio tower at one of two site locations under consideration: 1) Option #1 located approximately 25 feet southwest of the existing Tower #3, and 2) Option #2 approximately 20 feet northeast of the existing Tower #3. Design details such as tower loads etc. are not known to us at this time.

Our geotechnical assessment include geologic and geotechnical conditions, and potential seismic geo-hazards at the proposed radio tower site, geotechnical parameters for seismic design, and preliminary (planning/permitting level) foundation considerations. Our geotechnical study presented here is limited to a review of available resources including previous soil investigation reports in the site vicinity, and maps and reports published by the United States Geological Survey (USGS) and California Geological Survey (CGS). Site exploration and/or design level assessments were not part of our scope. Key reports that contain geotechnical and geological information relevant to the radio tower site include:

- Trans Pacific Geotechnical Consultants, Inc. (TPGC), 1997, "Report, Geotechnical Consultation, Proposed Antenna, Christmas Tree Point Radio Communication Center, Twin Peaks Boulevard, San Francisco, California," December 4.
- TPGC, 1997, "Supplementary Report, Geotechnical Consultation, Proposed Antenna, Christmas Tree Point Radio Communication Center, Twin Peaks Boulevard, San Francisco, California," December 17.
- Geotechnical Consultants, Inc. (GTC), 2012, Geotechnical Report, Auxiliary Water Supply System (AWSS), Twin Peaks Reservoir, San Francisco, California," May.

FIGURE 1 – PROJECT LOCATION MAP

2.0 SITE SETTING

2.1 SITE CONDITIONS

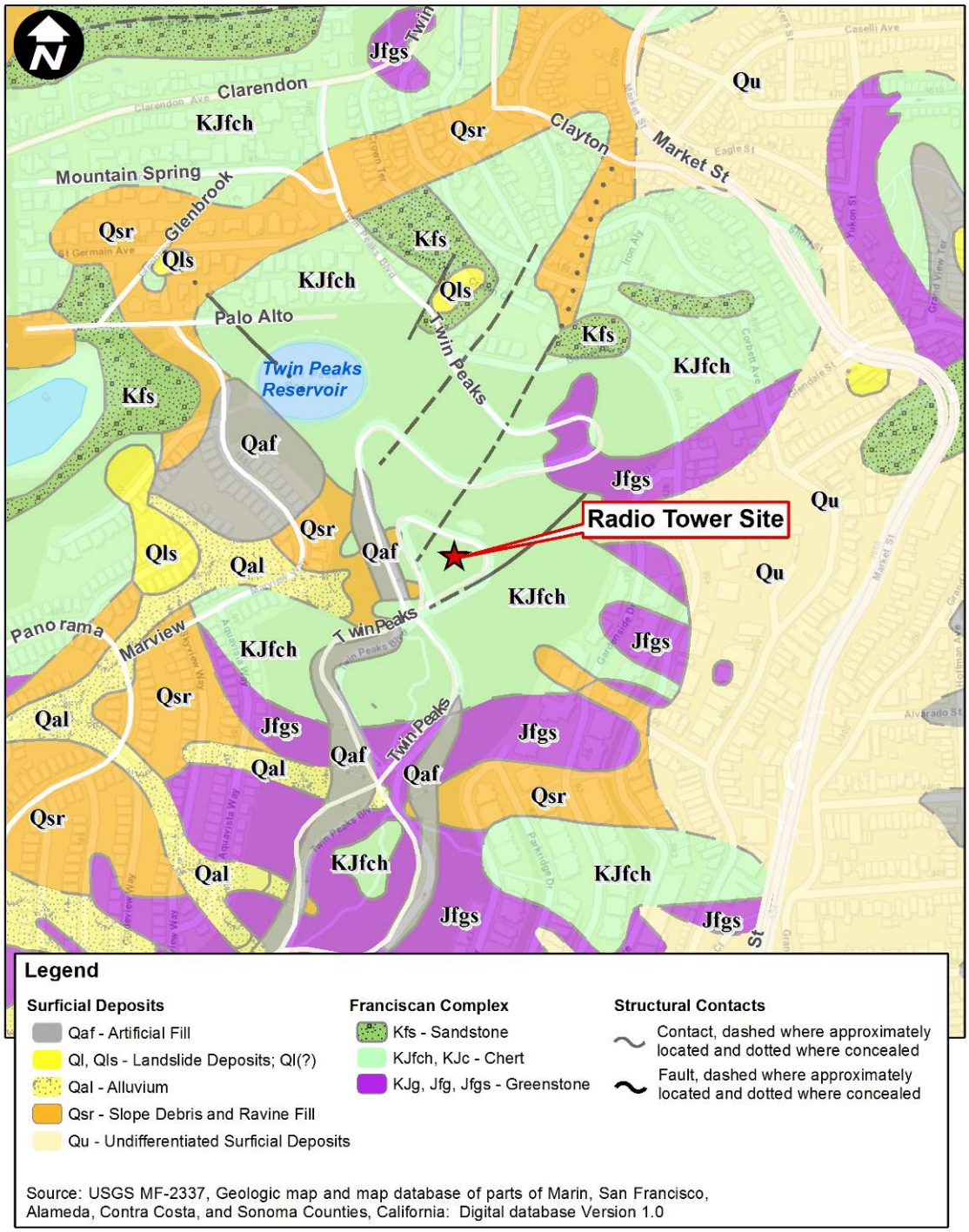
Surface Conditions. The radio tower site at 1 Christmas Tree Point Road is located at the top of Twin Peaks at approximate ground surface elevation of +860 feet (San Francisco City Datum). The existing facility is enclosed by a chain link fence that follows the perimeter of the site. Existing facilities include a one-story building (control room), antennas (including two approximately 150 foot high antennas), a paved service area, and landscaped areas on the north and east sides of the control room building.

Subsurface Conditions. Based on available geotechnical information, most of the existing radio tower site, including the proposed Option #1 and Option #2 radio tower locations, is underlain by a few feet of colluvium/residual soil, followed by Franciscan Complex bedrock comprising weathered and fractured chert. In the landscaped area to the north and east of the existing control room building, bedrock is overlain by a thicker layer of artificial fill ranging from approximately 5 to 15 feet deep, comprising silty fine sand with chert rock fragments. Groundwater is expected to be greater than 35 feet below the ground surface, although seepage through the fractured bedrock caused by transient flow of groundwater (e.g. infiltration during the wet season) may be encountered at shallower depths.

2.2 SITE GEOLOGY

The local geologic conditions at the radio tower site are shown on ***Figure 2 – Local Geologic Map.*** The radio tower site is located on North Twin Peak east of Mount Sutro. These peaks along with all other peaks in north central highland area of San Francisco are comprised of chert, sandstone and minor greenstone of the Franciscan Complex (Schlocker, 1974). Bedrock in the hillside area is overlain by unconsolidated colluvium (slope and ravine deposits of Schlocker, 1974) and artificial fill. Chert with very thin shale interbeds is exposed in the road cuts along Twin Peaks Blvd. just west of the radio rower site. The chert unit consists of thin bedded chert with minor thin interbeds of fissile shale. Chert beds range overall from ½ to 6 inches thick and tend to occur in units comprised of very thin beds (½ to 2 inches) and medium beds (3 to 6 inches). The chert beds are generally fractured to highly fractured (spacing less than 2 inches) with fractures oriented normal to bedding.

FIGURE 2 – LOCAL GEOLOGIC MAP



2.3 SEISMIC SETTING AND LOCAL FAULTING

Strong ground shaking at the radio tower site could occur as a result of an earthquake on any one of the active regional faults shown in ***Figure 3 – Regional Active Fault Map***. Active faults in California have been divided into activity categories by the California Geological Survey based on their predicted activity and ability to generate strong earthquakes; "Type A" faults which generally have higher and more well defined slip rates and well defined recurrence intervals and "Type B" faults with well-defined slip rates but poorly constrained recurrence intervals. "Type A" faults are commonly considered more active (generally with higher slip rates) and/or capable of generating larger earthquakes than "Type B" faults. Both "Type A" and "Type B" faults that are mapped in the vicinity of the project site are summarized in ***Table 1 – Significant Active and Potentially Active Faults***.

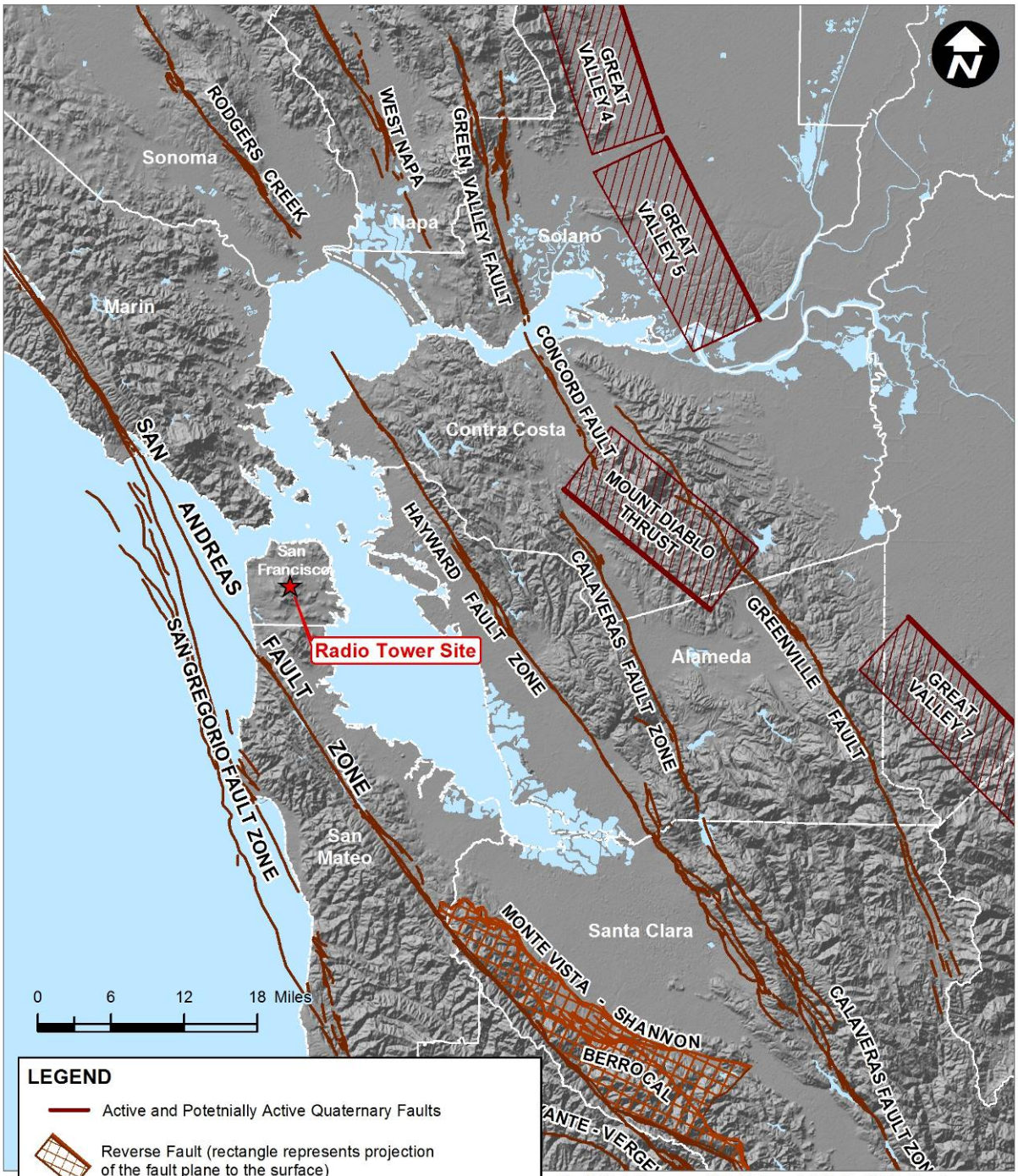
TABLE 1 – SIGNIFICANT ACTIVE AND POTENTIALLY ACTIVE FAULTS

Fault	Distance to Fault [1]		Estimated Earthquake Magnitude [2]	30-Year Probability of M>6.7 Earthquake [3] (%)
	(km)	(miles)		
Active Type A Faults				
N. San Andreas Segments: Offshore, N. Coast, Peninsula, Santa Cruz (SAO+SAN+SAP+SAS)	7.4	4.6	7.9	21
Hayward – Rodgers Creek: Rodgers Creek, N. & S. Sections (RC+HN+HS)	21.6	13.4	6.9	31
Calaveras Segments: N., Central, & S. (CN+CC+CS)	39.1	24.3	6.9	
Potentially Active Type B Faults				
San Gregorio Connected	13.5	8.4	7.5	-

Notes:

1. Fault-to-site distances based on the 2008 updated National Seismic Hazard Mapping program (Petersen et al., 2008) and companion interactive seismic de-aggregation site at URL https://geohazards.usgs.gov/deaggint/2008.
2. Maximum Moment Magnitude based on California Geological Survey (CGS) fault parameters as updated in 2002 (Cao et al., 2003), and/or as suggested by the SFPUC's General Seismic Requirements – Appendix A (SFPUC, 2009).
3. 30-year probability of M>6.7 earthquake based on 2007 Working Group on California Earthquake Probabilities (WGCEP, 2008).

FIGURE 3 – REGIONAL ACTIVE FAULT MAP



Fault Data Sources: U.S.G.S. and C.G.S., 2010, Quaternary fault and fold database for the United States; and Cao, et. al., 2003, The Revised 2002 California Probabilistic Seismic Hazard Maps,

3.0 GEOLOGIC HAZARDS AND SEISMIC DESIGN CONSIDERATIONS

As the radio tower site is located in seismically active San Francisco, the proposed replacement tower and its appurtenant structures/facilities may be subjected to permanent ground deformations (PGDs) and/or structural damage associated with a number of potential geologic hazards, including fault rupture, strong ground shaking, liquefaction, and landsliding. These geologic hazards and their potential impact on the proposed project are discussed as follows:

- ***Faults Rupture.*** As shown on ***Figure 2***, a series of fault traces are mapped in the near vicinity of the radio tower site. These faults are not through-going bedrock faults and are not considered to be active faults by the California Geologic Survey. As such, the hazard posed by ground rupture due to fault offset at the project site is considered to be very low.

- ***Strong Ground Shaking.*** As discussed in ***Section 2***, the radio tower is located in the vicinity of a number of active faults, including the San Andreas Fault (4.6 miles) and the Hayward fault (13 miles). These faults are considered capable of generating earthquakes of maximum moment magnitude ranging from Mw 6.9 (Hayward fault) to Mw 7.9 (San Andreas Fault), which can result in strong ground shaking at the project site. Seismic ground motion design parameters to be used for code-based design (2013 CBC, which adopts the seismic design criteria in ASCE7-10) are shown in ***Table 2 – ASCE 7-10 Seismic Design Parameters.***

TABLE 2 – ASCE 7-10 SEISMIC DESIGN PARAMETERS

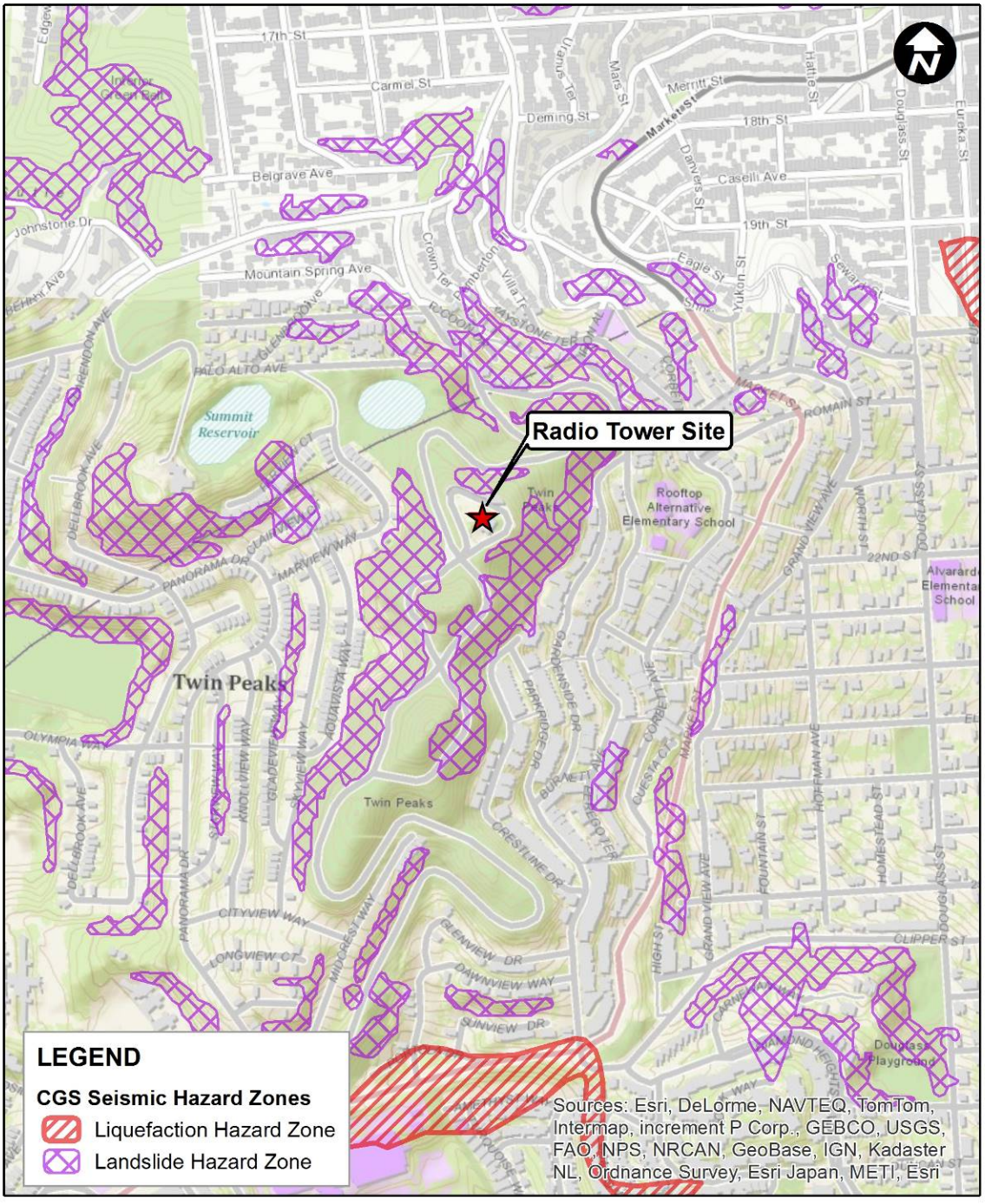
Site/Design Parameters	Site Class	B
Mapped Spectral Acceleration	PGA (g)	0.94
	S_S at 0.2-second (g)	2.43
	S_1 at 1-second (g)	1.17
Site Adjustment Factors	Site Coefficient F_{PGA}	1.0
	Site Coefficient F_a	1.0
	Site Coefficient F_v	1.5
Site Adjusted Spectral Acceleration	S_{MS} (g) (= F_a x S_S)	2.43
	S_{M1} (g) (= F_v x S_1)	1.75
Design Spectral Acceleration	PGA (g)	0.62
	S_{DS} = 2/3 x S_{MS} (g)	1.62
	S_{D1} = 2/3 x S_{M1} (g)	1.17

- ***Liquefaction.*** As shown on ***Figure 4 – Mapped Seismic Hazard Zones,*** the radio tower is not mapped within a liquefaction hazard zone by the California Geologic Survey, as most of the site is underlain by Franciscan Complex rock that is not susceptible to liquefaction. Furthermore, phreatic groundwater is not anticipated within the upper 35 feet below ground surface so that soil layers overlying bedrock (e.g. landscape area fill, colluvium, etc.) will not be susceptible to liquefaction.

- ***Seismic Settlement.*** Most of the radio tower site is underlain by formational rock that is not susceptible to seismic settlement. The artificial fill materials underlying the north and east portion of the radio tower site are relatively loose (as described by TPGC, 1997) and will likely experience seismic settlement when subjected to strong ground shaking, typically on the order of 2 to 3 percent of the total fill thickness. It is therefore recommended that any proposed radio tower located in the landscaped area to the north and east of the existing control room building be founded on/within the underlying competent Franciscan Formation bedrock.

- ***Landsliding.*** The radio tower site at the top of rocky hillside terrain in San Francisco's Twin Peaks area has been mapped by the California Geologic Survey to contain slopes that are potentially susceptible to permanent ground displacement caused by earthquake-induced landslides. These areas of potential landsliding are shown on ***Figure 4 – Mapped Seismic Hazard Zones***. The mapped landslide hazard zones to the north and east of the radio tower site (***Figure 4)*** comprise steep hillside slopes that expose thinly bedded and fractured Franciscan Complex chert. These hillside slopes surrounding the radio tower site will likely continue to experience deterioration by means of raveling and shallow landsliding as the exposed chert bedrock on the slopes continue to slowly degrade due to weathering. However, these modes of long-term slope deterioration will occur over a period of time much longer than the practical operating life of the antenna tower. The occurrence of a major seismic event may induce shallow landslides and slope raveling, but it is not anticipated that the magnitude of these ground deformations would have an impact on the radio tower site from a single seismic event.

FIGURE 4 – MAPPED SEISMIC HAZARD ZONES



Data Sources: CGS, 2001. Seismic Hazard Mapping Program, Official Map of Seismic Hazard Zones, City of San Francisco

4.0 FOUNDATIONS

Based on our review of existing available geologic/geotechnical information and data, we anticipate that the proposed radio tower will be supported on cast-in-place concrete drilled shafts to provide resistance to compression, uplift, and lateral loads. Drilled shafts provide resistance to compression and uplift forces, as they can derive skin friction resistance from their surface area contact with surrounding formational soil/rock as well as significant end-bearing capacity against the Franciscan Complex chert underlying the radio tower site.

For initial estimating of drilled shaft sizes (diameter and length) for planning purposes, drilled shaft axial capacity may be estimated using an allowable unit skin friction capacity on the order of 2,000 psf, and an allowable end bearing capacity on the order of 10,000 psf. The frictional and end-bearing components can be summed to evaluate the axial compressive capacity of the drilled shaft. Uplift forces imposed on drilled shafts may be resisted by the weight (buoyant if submerged) of the shafts and by the frictional resistance mobilized along the shaft wall surface. For uplift, we recommend that 75% of the allowable unit skin friction (i.e. 1,500 psf) be assumed. Drilled shafts should be socketed at least 10 feet into weathered bedrock. Resistance of such drilled shafts to lateral loads should be evaluated during the design phase of the project. The planning-level recommendations presented herein should be confirmed/updated during project design.

5.0 CLOSURE

The assessments presented herein are based upon review of relevant investigations conducted in the project vicinity by others, and review of available geologic and seismic hazard maps of the region. These conclusions and opinions are intended to be used solely by the Jacobs Engineering Group and its consultants in their initial planning for the radio tower replacement project, and not for any other purpose. Additional subsurface investigation for the project may be warranted during project design. This report was prepared for the purposes of planning/permitting, and should not be used for final design and/or construction. This report is based on the data and information available to us at the time of this submittal, and the project as described. Should additional data become available that could potentially impact the findings, opinions, and other information presented in this report, we should be given the opportunity to evaluate such data and to modify this report as appropriate.

The recommendations presented in this report are professional opinions based on our understanding of the described project. The findings and professional opinions presented in this

report are presented within the limits prescribed by the client, in accordance with generally accepted professional engineering and geologic practices. There is no other warranty, either express or implied.

Prepared by:
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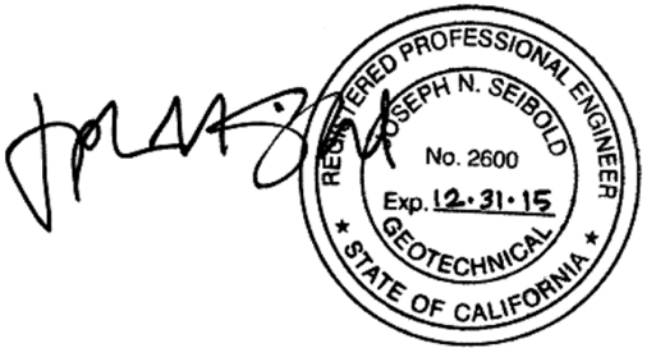

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