Geotechnical Evaluation
Canyon Hills Project
City of Los Angeles, California

March 24, 2003

PN 00189-00

Prepared For:

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ZEISER
KLING
Consultants, Inc.

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Mr. Christopher A. Joseph
Christopher A. Joseph & Associates
11849 West Olympic Blvd., Suite 101
Los Angeles, CA 90064

Subject: Geotechnical Evaluation, Canyon Hills Project, City of Los Angeles, California.

Dear Mr. Joseph:

In accordance with your request and authorization, Zeiser Kling Consultants, Inc. (ZKCI) has completed a geotechnical feasibility evaluation for the proposed Canyon Hills project in the City of Los Angeles, California. The accompanying report presents our findings, conclusions and recommendations regarding the existing geotechnical conditions and their potential constraints on the design of the proposed development.

Geotechnical services are provided by ZKCI in accordance with generally accepted professional engineering and geologic practice in the area where these services are to be rendered. Client acknowledges that the present standard in the engineering and geologic and environmental profession does not include a guarantee of perfection and, except as expressly set forth in the Conditions above, no warranty, expressed or implied, is extended by ZKCI.

Geotechnical reports are based on the project description and proposed scope of work as described in the proposal. Our conclusions and recommendations are based on the results of the field, laboratory, and office studies, combined with an interpolation and extrapolation of soil conditions as described in the report. The results reflect our geotechnical interpretation of the limited direct evidence obtained. Our conclusions and recommendations are made contingent upon the opportunity for ZKCI to continue to provide geotechnical services beyond the scope in the proposal to include all geotechnical services. If parties other than ZKCI are engaged to provide such services, they must be notified that they will be required to assume complete responsibility for the geotechnical work of the project by concurring with the recommendations in our report or by providing alternate recommendations.

All locations of borings/exploratory trenches, cut/fill transitions, limits of fill, verification of overexcavations, contacts, elevations, etc., are represented herein to the best of our abilities. The approximate locations depicted on all plates and figures are based upon available control as provided in the field by others. Where no information was provided by others, locations were approximated using limited measuring methods and crude instrumentation.

We do not verify the locations or elevations reported herein as accurate in survey or void of error. ZKCI assumes no responsibility for any future costs associated with errors in the area of survey.

It is the readers' responsibility to verify the correct interpretation and intention of the recommendations presented herein. ZKCI assumes no responsibility for misunderstandings or improper interpretations that result in unsatisfactory or unsafe work products. It is the readers' further responsibility to acquire copies of any supplemental reports, addenda or responses to public agency reviews that may supersede recommendations in this report.

We appreciate the opportunity to be of service to you and the project team. Should you have any questions regarding the content of this report, please do not hesitate to contact our office.

Sincerely,

ZEISER KLING CONSULTANTS, INC.

James M. Lancaster, Jr.
Associate Engineering Geologist
C.E.G. 1927
Expires 6/30/04

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Matthew G. Rogers
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ATTACHMENTS

1.0 INTRODUCTION

This report summarizes the geotechnical evaluation conducted by Zeiser Kling Consultants, Inc. for the Draft Environmental Impact Report for the proposed Canyon Hills project (the "DEIR"). The purpose of this report is to evaluate general geologic and geotechnical site conditions and constraints, as well as more focused constraints as they pertain to the proposed development plans, for discussion and use in the DEIR. This report was prepared in accordance with (a) guidelines for environmental impact reports prepared by the California Geologic Survey (CDMG Note 46, 1982) and (b) the City of Los Angeles General Plan. Applicable provisions in the City of Los Angeles Building Code relating to geotechnical aspects of the project were also used in this evaluation.

During the course of our investigation, many data sources were utilized for the evaluation of the project site and the "Duke" Property, including published geologic maps, previous studies of the project area by CalTrans, and the geotechnical report for the adjacent "Duke" Property. In order to augment and verify existing data, and address the current development proposal, detailed site-specific geologic mapping and subsurface exploration were conducted as part of this study.

This report presents our evaluation of the geologic and geotechnical characteristics of the project site and the "Duke" Property, including soil and bedrock characteristics, seismic considerations, mineral resources, waste disposal, slope and foundation stability, excavatability, groundwater, erosion, land subsidence and volcanic hazards. Geotechnical conditions and locations of site exploration are depicted on the attached Plates and Geotechnical Cross-sections.

2.0 PROJECT SITE DESCRIPTION

The project site is irregular in shape and consists of approximately 887 acres on the northwest flank of the Verdugo Mountains. The project site is bisected by the Foothill Freeway (Interstate 210) and is bounded by La Tuna Canyon Road to the south and an existing community and open space to the north, east and west. The existing community was apparently developed in the 1940s to 1970s and at least partially utilizes onsite private sewage disposal systems for sewage disposal. A Southern California Edison transmission right-of-way bisects the northern area of the project site. The "Duke" Property referred to in this report is located adjacent to the eastern portion of the project site, and is sometime referred to as "Hillview Estates" or Vesting Tentative Tract Map No. 48754 (the "Duke Property").

The project site location is depicted on the Site Location Map (Figure 1). The project site is steep, hilly terrain with local relief changes upwards of 900 vertical feet. Land elevations range approximately from 1,160 to 2,064 feet above sea level. Natural slope gradients roughly range from 3:1 (horizontal:vertical) to as steep as 0.75:1 (horizontal:vertical). Steep "V" shaped canyons are abundant throughout the project site.

In general, the majority of the project site can only be accessed on foot due to the rugged terrain consisting of canyons, peaks, ridgelines, and locally dense vegetation. Vehicular access is limited to only portions of the northernmost part of the project site via private dirt roads. A dirt road (Verdugo Crestline Road) provides limited access to the Southern California Edison power poles and several private residences.

3.0 PROPOSED DEVELOPMENT

The proposed Canyon Hills project includes the development of 280 single-family homes to be clustered on approximately 194 acres of the 887-acre project site. Approximately 211 homes will be constructed on approximately 142 acres north of Interstate 210 ("Development Area A"). The remaining 69 homes will be constructed on approximately 52 acres south of Interstate 210 ("Development Area B"). Approximately 693 acres of the project site, including a large swath of land west of the two Development Areas, will be preserved as permanent open space. The 280 Lot Site Plan by the Templeton Planning Group was utilized as the base map for this geotechnical study (Appendix A, Plan References).

The above-described Development Areas include park and recreation areas, tot lots, debris basins/urban runoff areas, two water tanks, and open space. The proposed development also includes the construction of a network of private roads within the proposed Development Areas with project access from existing public roadways. In addition, an equestrian park is proposed on the project site west of Development Area B adjacent La Tuna Canyon Road

Within Development Area A, there is one proposed primary access point from La Tuna Canyon Road north of Interstate 210. This access road parallels Interstate 210 within the project site. An emergency access is planned from the community of Tujunga by way of Verdugo Crestline Road or Inspiration Way.

Within Development Area B, there are two proposed primary access points from La Tuna Canyon Road utilizing bridges to span the La Tuna Canyon drainage course. As mentioned above, the proposed project includes plans for an equestrian park along La Tuna Canyon Road with an associated equestrian trail in the Development Area B.

The grading concept for the proposed development is illustrated on Plate 1. Proposed grading for the project site will generally consist of cuts and fills to create building pads, roadways and slopes. Cut slopes with gradients up to 1.5:1 (horizontal:vertical) and up to 100 feet in height are proposed. Fill slopes are proposed to heights of up to 200 feet at slope gradients up to 2:1 (horizontal:vertical). Several retaining walls are also proposed within both Development Areas A and B in order to achieve design grades.

One of the alternates that will be examined in the DEIR includes the same proposed development of 280 single-family homes, but with access to Development Area A through the Duke Property instead of along an access road paralleling Interstate 210. The grading concept for this alternative access is depicted on Plate 2.

4.0 SCOPE OF WORK

Our scope of work was developed in order to utilize existing data, take into account the nature of hard rock materials comprising site bedrock, and develop a model of the geologic framework of the project site. Specific geotechnical issues investigated include general bedrock and soil characteristics, slope stability, groundwater conditions, seismic considerations, mineral resources, waste disposal, slope and foundation stability, bedrock excavation characteristics, groundwater, erosion, land subsidence and volcanic hazards.

Based on the limited vehicular access, rugged terrain, and anticipated shallow hard bedrock conditions, mechanical exploration techniques, including drilling and trenching with heavy equipment, would be extremely difficult to carry out on the project site. Among other things, extensive grading and alteration of the existing topography would be required to create the access roads and drill pads that would be necessary to undertake that type of subsurface exploration program.

Notwithstanding these significant physical constraints, and the wealth of information already available regarding subsurface conditions on and in the vicinity of the project site and the Duke Property, this firm determined that a subsurface exploration program was appropriate to evaluate subsurface conditions in accordance with the standard of practice within our industry. We determined that a seismic survey would best evaluate the hardness of the rock and the depth to unexcavatability. In order to accomplish a physical subsurface exploration, we met with the City of Los Angeles Department of Building and Safety ("Building and Safety") to consider alternative methods of exploration.

Based on discussions with Building and Safety, the exploration program was developed in order to avoid impact to the project site. The program utilizes surface geologic mapping of numerous bedrock exposures throughout the project site augmented with hand-dug test excavations within the proposed Development Areas. Hollow-stem auger borings were excavated in the few areas that were accessible by vehicle to further verify subsurface conditions.

Our general scope of work included:

- Review of published regional geologic and geotechnical literature and maps, as described in Section 7.0;
- Review of historical aerial photographs for the project site, the Duke Property and surrounding areas, as discussed in Section 7.0 (aerial photographs reviewed are summarized in Appendix A);
- Review of site-specific geotechnical reports of previous investigations for the project site, the Duke Property and surrounding areas, as discussed in Section 5.0;
- Geologic reconnaissance to assess general conditions, including access, terrain, and survey site improvements;

- Attending meetings with Building and Safety and the City's Deputy Advisory Agency;
- Performance of a seismic refraction survey of the proposed Development Areas. The report for the seismic refraction survey is included as Appendix E;
- Performance of a field exploration program, including geologic surface mapping, excavation of 33 hand-dug test pits, drilling of two hollow-stem borings, focusing on the proposed Development Areas;
- Performance of laboratory testing of collected samples to augment soil and rock identification from the field exploration and determine soil strength parameters, as presented in Appendix H;
- Conducting a detailed evaluation of the bedrock structure and orientation utilizing stereonet analysis of joint sets, bedding, and foliation to evaluate natural and manufactured slope stability within the proposed Development Areas;
- Evaluating seismicity for the project site for the "maximum probable event" using probabilistic seismic hazard analyses. Evaluating project seismicity utilizing regional and site-specific fault activity information from published sources;
- Review of public comments in response to the Notice of Preparation for the DEIR and at a scoping meeting conducted by the City of Los Angeles Department of City Planning on September 23, 2002;
- Compilation and analysis of the collected data and subsequent evaluation of these findings from a geotechnical perspective relative to the proposed project; and
- Preparation of this report summarizing our findings, conclusions and mitigation measures for the proposed development.

5.0 PREVIOUS GEOTECHNICAL INVESTIGATIONS

Information and evaluations developed for this report are based in part on previous studies conducted on areas either adjacent to or near the project site. This information has been supplemented by published references. The information gathered was used as a basis for this firm's preliminary site studies. Below is a summary of information that is relevant to the project site. All references utilized in preparation of this report are summarized in Appendix A.

In February 1968, CalTrans produced a project report titled, "Complete Materials Report for the Proposed Construction of the Route 210 Freeway from Sunland Boulevard to West City Limits of Glendale". In this report, pertinent data regarding the Interstate 210 freeway construction was summarized and presented for a section of freeway roughly 4.6 miles long. Since the freeway alignment bisects the project site, it was utilized for the preparation of this report. Important data contained in the report includes detailed descriptions of soil and rock types, geologic features of the freeway alignment, as well as storm drain culverts beneath the freeway embankment.

The Duke Property is located adjacent to the eastern portion of the project site. As part of the development process for the Duke project, Pacific Soils Engineering, Inc. produced a report titled, "Preliminary Geologic/Soil Engineering Investigation for Tentative Tract 48754, 7201 La Tuna Road, City of Los Angeles, California", dated June 21, 1990. That report was based on review of referenced reports and field exploration consisting of nine mechanically dug exploratory trenches to depths of 4 to 7 feet, two hand-dug test pits to a depth of two feet, a seismic refraction survey, and field mapping. The report also contains pertinent data such as slope stability calculations, and onsite materials laboratory testing data.

In 1991, the Dibblee Geological Foundation published their map number DF-32 "Geologic Map of the Sunland and Burbank (North Half) Quadrangles". This map is a compilation of mapping by previous investigators for the area. It includes regional geologic information regarding the project site and surrounding area.

The California Geologic Survey produced a report titled, "Seismic Hazard Evaluation of the Burbank 7.5-Minute Quadrangle, Los Angeles County, California (Open-File Report 98-07)", in 1998. This investigation encompassed an area that includes the project site and the Duke Property. Pertinent information was extracted and incorporated within this report with regards to areas delineated as potential seismic hazards and earthquake-induced landslides. The Seismic Hazard Map for the Burbank Quadrangle dated March 25, 1999 was the result of this study.

The Alquist-Priolo Earthquake Fault Zone maps for the Burbank and Sunland quadrangles (which includes the project site and the Duke Property) depict known fault ruptures from previous earthquakes, as well as recommended fault setback zones from known active faults.

The City of Los Angeles General Plan Safety Element (1996) also includes maps for fault rupture hazard zones, landslide hazard zones, and liquefaction hazard zones.

The California Department of Water Resources Bulletin 118, "California's Groundwater" identifies groundwater basins throughout the State, including the project site and the Duke Property. This publication was utilized to provide information regarding groundwater resources.

6.0 SITE EXPLORATION

The process of site exploration was conducted in numerous phases over an extended period from June 2001 to the present, with each phase utilizing results of the prior phase of information gathered to further focus the next phase of exploration. Review of aerial photographs, prior studies, regional maps, site reconnaissance and seismic surveys were all used to develop a preliminary characterization of the project site. This initial characterization indicated thin soil cover, sparse alluvial material, hard bedrock and steep-sided canyons that expose abundant bedrock material. This characterization of the project site was used to direct locations and areas of geologic interest prior to executing the exploration plan.

Based on discussions with Building and Safety, the exploration program was developed in order to avoid impact to the project site. The program utilizes surface geologic mapping of numerous bedrock exposures throughout the project site augmented with hand-dug test excavations within the proposed Development Areas. Hollow-stem auger borings were excavated in the few areas that were accessible by vehicle to further verify subsurface condition.

As discussed above, the subsurface exploration consisted of drilling two hollow-stem auger borings and excavation of 33 hand-dug test pits. One hollow–stem auger boring was located in Development Area A adjacent to the Verdugo Crestline Road, and one boring was located in Development Area B adjacent to La Tuna Canyon. Hand-excavated test pits were located throughout the proposed Development Areas to evaluate areas of geotechnical interest. The site exploration was conducted under the guidance of on-staff Certified Engineering Geologists. Boring and test pit logs from the subsurface exploration are attached in Appendix B of this report. Locations of exploration points are plotted on Plates 1 and 2.

The 33 hand-excavated test pits were located throughout the Development Areas to provide additional subsurface information and to augment surface geologic mapping. The test pits were 1 foot to 7.5 feet in depth. It should be noted that the same geologic data can be obtained from either a hand-dug test pit or a mechanically-excavated test pit. It was decided for this investigation that the hand-dug test pits were the most reasonable method for excavation based on the physical constraints of the project site. Test pit logs are attached in Appendix B of this report.

Hollow-stem auger borings were advanced using a CME 75 truck-mounted drill rig equipped with 8-inch diameter augers, and using a standard 140-pound automatic trip hammer with a 30-inch drop to drive the sampler. Hollow-stem borings were advanced to depths of approximately 35 feet and 41 feet, where they encountered refusal. Refusal is defined as the point where the drilling rig can no longer advance due to hard bedrock conditions. In-situ representative earth material samples were retrieved at five-foot intervals, recorded, sealed, and transported to our laboratory for analysis. The borings were surface logged by a staff geologist from our office. Boring logs are attached in Appendix B of this report.

Seismic refraction survey data was collected from six survey lines within the proposed Development Areas. Seismic refraction survey is a scientific method used to determine relative hardness of earth units by measuring relative velocity of sound waves through earth materials. Because of the limited access to the project site, the survey was conducted with hand-carried equipment. The seismic survey lines were located in areas of either proposed deep cuts or proposed cut slopes. The total length of seismic survey lines was 1,338 feet. Locations of seismic survey lines are depicted on Plates 1 and 2. Results of seismic refraction surveys are discussed in Section 7.7. A more detailed description of seismic refraction survey methodology is included with the seismic refraction survey report, attached as Appendix E.

In its preliminary work for Interstate 210, CalTrans prepared a materials report in 1968 for the proposed freeway route. As part of the materials report, numerous borings were excavated along the alignment of the freeway and within the project site. A few of these borings also included downhole seismic refraction data. As part of additional work conducted during construction, CalTrans excavated additional borings within drainage culverts under the proposed freeway grade as documented in their 1977 as-built materials report. Over 60 borings were located within the project site. The approximate location of these borings are illustrated on Plates 1 and 2.

Pacific Soils Engineering, Inc. investigated the proposed Duke Property in 1990. It appears that the consultant had similar concerns regarding site accessibility and drilling access for subsurface exploration. As a result, the Duke geotechnical investigation included seismic refraction surveys, 9 mechanically-excavated trenches ranging in depth up to 7 feet and 2 hand–excavated trenches to a depth of 2 feet, and geologic mapping of surface bedrock exposures. Trenches and seismic survey lines were located along existing ridge-top fire roads were access was available. The approximate locations of the exploration are illustrated on Plates 1 and 2. Based on the geotechnical study of the Duke Property, it appears that the geologic conditions there are essentially the same as those observed within the project site. Therefore, the analysis below of the project site should generally apply with equal force to the Duke Property.

The boring and trench logs of the exploration data from previous investigations discussed in Section 5.0 are attached as Appendices C (Duke) and D (CalTrans), respectively.

7.0 EXISTING CONDITIONS

7.1 Topography

The project site is steep, hilly terrain with distinctive ridgelines dropping sharply into deep "V" shaped canyons. The northern portion of the project site includes a prominent east-west trending ridgeline, and several steep tributary ridgelines trending in a north-south direction. The southern portion of the project site is dominated by north-south trending ridgelines and intervening canyons. The La Tuna Canyon drainage is the predominant topographic feature of the southern portion of the project site and drains to the west to the San Fernando Valley. The local relief changes up to of 900 vertical feet. Land elevations range approximately from 1,160 to 2,064 feet above sea level. Natural slope gradients roughly range from 3:1 to as steep as .75:1 (horizontal: vertical). Steep "V" shaped canyons are abundant throughout the project site.

7.2 Previous Grading

The project site lies both to the north and south of Interstate 210. The portion of Interstate 210 adjacent to the project site was constructed in the early 1970s. Several cut and fill areas with large embankments were constructed in conjunction with the Interstate 210 construction. CalTrans artificial fill is addressed in Section 7.3.2.1. Various minor access roads and "leveled" areas exist mainly concentrated in Development Area A, the northern portion of the project site. Regional Southern California Edison electrical transmission lines with access roads bisect Development Area A from east to west. Our observations indicate that cut and fill grading was used to create the pads for these transmission line towers.

7.3 Geologic Setting

7.3.1 Regional Geology

The Canyon Hills project site lies near the northern edge of the Los Angeles Basin within the northwestern flank of the Verdugo Mountains. These mountains are a portion of the Transverse Ranges geomorphic province of Southern California. The Transverse Ranges are characterized by east-west trending geologic structures, as opposed to prevailing northwest-southeast structural trends that dominate elsewhere in the State. The Verdugo Mountains are characterized primarily of Mesozoic or older age crystalline metamorphic and igneous basement rocks.

Quaternary age alluvial deposits, including stream terrace deposits and older alluvium, as well as recent alluvium occur in present-day stream courses. Man-made artificial fill is also common within developed portions of the Verdugo Mountains.

The Verdugo Mountains were most likely elevated above sea level in middle Pliocene time (approximately 5 million to 1.6 million years ago). Uplift of the Verdugo Mountains has continued to the present day. The mountains have been thrust up to the south and eroded to form the present mountain range. Terrace deposits, representing the uplifted remnants of older alluvium, exist at various elevations up to 2,800 feet, indicating that the range has undergone intermittent uplift during Pleistocene time (1.6 million to 11,000 years ago).

The Verdugo Mountains are surrounded by several known active fault zones that collectively comprise an active thrust belt. To the north and east, the Verdugo Mountains are in close proximity to the Sierra Madre Fault Zone. To the south and east, the Raymond Hill Fault Zone and the Verdugo-Eagle Rock Fault Zone exist within close proximity to the project site. In recent geologic time, considerable uplift and compression of Mesozoic bedrock blocks occurred along the fault zones that produced the linear features expressed as alternating regional valleys and ranges. The recent and high rate of bedrock uplift is apparent by the steep and narrow "V" shaped gorges typical of these mountainous areas.

7.3.2 Local Geology

Onsite geology consists of numerous surficial and bedrock units. The surficial units consist of artificial fill, topsoil/colluvial soils, recent alluvium, and landslide debris. Bedrock units consist of sedimentary and volcanic Topanga formation and basement igneous rock, including granite, quartz diorite, and metamorphic gneisses. As described above, the structure of the project site and the Verdugo Mountains is a direct result of uplift and exposure of the Mesozoic bedrock units. Sympathetic faulting and fracturing of the bedrock throughout the Verdugo Mountains has developed as a result of the uplift. These sympathetic faults are considered inactive (>1.6 million years old). The approximate limits of the respective surficial and bedrock units are illustrated on the accompanying Plates 1 and 2.

7.3.2.1 Surficial Units

Artificial Fill (Af)

Most fill encountered on the project site is associated with materials generated from Interstate 210 construction of fill embankments (see Plate 1 and Plate 2). The CalTrans artificial fill embankments/slopes found onsite are brown silty sands with some gravel and cobbles. These slopes range in height roughly from tens of feet to approximately 250 feet with fill depths up to approximately 270 feet thick. Artificial fill widths vary from approximately 50 feet to about 460 feet. Artificial fill lengths (dimension parallel to Interstate 210) range approximately from 100 to 4,000 feet. In general, the majority of “large” fill slopes are on the southern boundary of Interstate 210 (the northern portion of Development Area B) and are south facing with respect to orientation.

Other minor artificial fills are associated with dirt road construction and Southern California Edison transmission tower pad construction.

Topsoil/Colluvium (Qcol)

Topsoil and colluvium within the project site consists of a relatively thin mantle of soil above the onsite bedrock materials. Generally, the topsoil and colluvial deposits were less than two feet in thickness. These materials consisted of fine to medium grained silty sands that were generally loose to medium dense and dry to damp.

Alluvium (Qa)

Alluvial materials within the project site are confined to stream deposited materials consisting of brown clays, silts, and sands with gravel and cobbles. Generally, the alluvial materials are very minor with occurrences in canyon drainage bottoms. The only area of significant alluvial materials is in the southern portion of the project site, within the proposed equestrian park (Plate 1).

Landslide Debris (Qls)

Landslide debris is a general term used to describe the results of a variety of processes and landforms involving the downslope movement of earth material due to gravity. This term can describe existing surficial slumps, mud and debris flows, rock fall, soil creep, or other movement of bedrock.

Within the project site, the existing landslide materials are the result of prior accumulations of loose rock and debris flowing down canyon from steeper slopes above, and steeper slope areas undercut by stream erosion. The debris flows typically occur during periods of heavy rainfall and/or in association with ground shaking caused by earthquakes. These materials are composed mainly of brown silty sands with some gravel, cobbles, and boulders. The areas mapped on the project site that contain landslide debris (commonly referred to as "landslides" or "landslide areas") are typically less than 20 feet in thickness and exist at the base of steeper slopes. The landslides' consistency is generally loose and unsuitable for the support of fill embankments or engineered improvements. The approximate boundaries of the landslide areas are illustrated on Plates 1 and 2.

7.3.2.2 Bedrock Units

Topanga Formation – Sandstone/Conglomerate (Ttusg)

The upper Topanga Formation (Ttusg) consists of massive sandstone with pebble-cobble-boulder conglomerate beds of mostly granitic detritus. Bedding of this formation generally dips steeply to the northwest. This geologic unit can also include thin lenses of semi-siliceous shale. Exposures of this formation are limited to the extreme northwest corner of the project site, outside of the proposed Development Areas.

Topanga Formation - Volcanic Flows/Breccia (Tvb)

Topanga volcanic rocks (Tvb) consist of basaltic to mafic andesitic flows and flow-breccias. They are dark brown to black in color and in some areas, vesicular structures can occur and when weathered, they tend to be incoherent. This formation can be correlated with the Conejo Volcanics of the Santa Monica Mountains. This formation outcrops in a small band in the northwest corner of the project site, outside of the proposed Development Areas.

Leucocratic Granitic Rocks (gr)

Granitic rock (gr), formed during the late Mesozoic (Cretaceous), is nearly white in color, massive, and consists of medium to fine-grained granitic rocks mostly comprised of quartz monzonite-granodiorite. This unit complexly intrudes into the quartz diorite (qd) and gneiss (gn). In general, this crystalline basement formation is made up of quartz, potassic feldspar, and sodic plagioclase feldspar, with sparse biotite. Where abundant mixing of the units occurred within the project site, the granitic materials were mapped as part of the quartz diorite (qd). This formation is sparsely located throughout the northern portion of the project site, and within the western and southern portions of Development Area A. General foundation characteristics of this formation indicate good to very good bearing characteristics, low to very low potential for settlement, and high compressive strength. This formation, as observed, is highly weathered near the surface, with the degree of weathering decreasing with depth.

Quartz Diorite (qd)

Quartz Diorite (qd) is the predominant geologic bedrock terrain contained within the project site. It is gray in color, medium-grained quartz diorite with variations to diorite where the rock unit contains less quartz minerals. The quartz diorite is composed of quartz minerals, sodic plagioclase, feldspar, biotite, and hornblende. Roughly, 70 percent of the project site, and over 90 percent of the proposed Development Areas, is comprised of this geologic unit, which in some areas is complexly intruded by the aforementioned Leucocratic Granitic unit (gr). Foundation characteristics of quartz diorite indicate good to very good bearing characteristics, low to very low potential for settlement, and high compressive strength. This formation, as observed, is highly weathered near the surface, with the degree of weathering decreasing with depth.

Gneissic Rocks (gn)

Gneiss consists of granitic rocks and quartz diorite metamorphosed under conditions of high temperature and pressure. Gneissic Rocks (gn), are generally found in the western portion of the project site. Small, localized pockets are located within the proposed Development Areas and are predominantly dark gray biotite-quartz-feldspar gneiss. This geologic unit ranges from thin layered gneiss to somewhat incoherent gneissoid quartz diorite or biotite diorite. Foundation characteristics of the gneissic rocks indicate good to very good bearing characteristics, low to very low potential for settlement, and high compressive strength. This formation, as observed, is highly weathered near the surface, with the degree of weathering decreasing with depth.

7.4 Geologic Structure

7.4.1 Bedding and Foliation

Bedding is defined as a continuous planar fabric as a result of layering during deposition of sedimentary rock. Bedding planes are preserved in the fabric of the rock structure as it undergoes further deposition, folding and faulting. Similarly, as igneous and metamorphic rocks are subjected to intense heat and pressure, minerals will align themselves in a fashion similar to bedding. This planar fabric of mineral alignment is defined as foliation. Foliation was mapped where observed within the gneissic bedrock materials. The existence of bedding and/or foliation are critical existing features of bedrock units which influence the stability of both natural and manufactured slopes. The orientation of these planar surfaces is a key factor to be considered during the analysis of slope stability.

7.4.2 Folding

The Transverse Range Province, of which the Los Angeles Basin is a part, is the result of uplift caused by the relative movement of the Pacific Plate and the North American Plate along the San Andreas Fault. Tectonic forces between the two crustal plates caused compression of the bedrock wherein large bedrock blocks were "bowed" in an anticlinal (convex upward) fashion to accommodate compressive forces. Compressive forces have also been accommodated within thrust faults throughout the Los Angeles Basin and surrounding areas.

Folding is indicated within the project site as the reflection of uplift of the Verdugo Mountains. Sympathetic (inactive) faulting, jointing, and fracturing of the hard granitic bedrock materials is also a result of the general uplift and compressive folding observed throughout the northern Los Angeles Basin and surrounding area.

7.4.3 Faulting and Seismicity

Southern California is a tectonically active region. Tectonic activity will typically create stress and strain within rock units that is relieved by fracturing and faulting within the bedrock materials. A fault is defined as a fracture within rock upon which there has been an observable amount of displacement. Fracturing or jointing is defined as a break within the rock structure that has not experienced displacement. Faulting can include major sutures within the earth's crust that can produce earthquakes to smaller features that have experienced sympathetic movement due to movement on major faults, to joints and fractures that have not experienced displacement.

As a result of damage due to the 1971 San Fernando earthquake, the State of California enacted the Alquist-Priolo Act. The Act required the State Geologist to map known faults and determine relative activity of the fault. As such, the California Geologic Survey has created definitions for active, potentially active and inactive fault zones. An **active fault** is defined as a well-defined fault that has exhibited surface displacement during the Holocene (recent) time (approximately the last 11,000 years). A **potentially active** fault is defined as having a history of movement within the Pleistocene time (between 11,000 to 1.6 million years ago). An **inactive** fault is defined as any fault that has not experienced movement in the last 1.6 million years.

The fault systems discussed below in proximity to the project site are all active faults also classified as strike-slip, reverse, thrust and blind thrust faults. These classifications are irrespective of the fault activity and are based on the general sense of displacement and type of movement on the fault. A strike-slip fault has motion that is parallel to the direction or trend of the fault's surface trace. A reverse fault has displacement that is sub-vertical with one side of the fault moving over and above the other side. If a reverse fault has a dip angle of less than 45 degrees, it is called a thrust fault. A thrust fault which terminates before it reaches the surface is referred to as a blind thrust fault. When a blind thrust fault produces movement it may produce uplift of the ground above, but does not produce a clear surface rupture.

The faults mapped as part of the Alquist-Priolo Act only depict visible faults that have ruptured the ground surface. However, it is the quakes along faults that do not break the surface, or blind thrust faults, such as the fault that is associated with the Northridge and Whittier Narrows earthquake, that increasingly are becoming the focus of study within the Los Angeles Basin. The effect of such faults may dominate the geology of the region in a way not previously known. The Alquist-Priolo fault rupture hazard zones, together with known blind thrust faults, are depicted within the Safety Element of the City of Los Angeles General Plan.

In particular, potential fault rupture zones are depicted on both the Fault Rupture Study Areas Map (Exhibit A) in the Safety Element of the City of Los Angeles General Plan and the State of California Alquist-Priolo Fault Rupture Hazard Maps of the Burbank and Sunland Quadrangle. The project site is not located within either the City or State delineated zones for fault rupture. None of the faults or fault zones with surface rupture potential identified on these maps cross or intersect the project site or the adjacent Duke Property. Based on review of referenced data, field mapping, exploration and aerial photo review of the project site, the project site does not exhibit surface expression that indicates the presence of active or potentially active faulting onsite or in the immediate vicinity of the project site. The project site does contain some minor inactive sympathetic faults, as well as jointing and fracturing of the bedrock materials, as discussed above. These geologic features are illustrated on Plates 1 and 2.

Generally, the major faults beyond the immediate vicinity of the project site within the regional area trend northwest and are parallel to the San Andreas Fault, which is the largest regional fault. Numerous active and potentially active fault systems exist in regional proximity to the project site. Below is a brief summary of the active fault systems that may produce seismic events that could affect the project site.

The **Verdugo** fault is located approximately 2 miles south of the project site at the southern base of the Verdugo Mountains. It generally parallels the Sierra Madre fault zone, dips to the northeast and has a general trend of direction from northwest to southeast. It is believed that this fault zone was responsible for the uplift of the Verdugo Mountains relative to the San Fernando Valley. The Verdugo fault is considered a thrust or reverse fault with most portions of the surface expression of the fault buried by alluvium at the southern base of the Verdugo Mountains. Portions of this fault as close as two miles from the project site have been classified as active by the California Geologic Survey.

The **Sierra Madre** fault zone is located approximately 1.5 miles to the east and northeast of the project site at the base of the San Gabriel Mountains. The fault dips to the north below the San Gabriel Mountains. It is largely buried beneath alluvial material derived from the San Gabriel Mountains. The Sierra Madre fault is classified as a thrust fault, and is considered active by the California Geologic Survey.

The **San Fernando** fault zone is located approximately 2 miles to the northwest of the project site. It is generally considered to be an extension of the Sierra Madre fault zone. This fault zone is believed to be a thrust fault that primarily dips steeply to the north with respect to rupture surfaces. This fault was responsible for the February 9, 1971 “San Fernando” earthquake (Mw 6.6). Surface rupture mapped in 1971 at the base of the San Gabriel Mountains was observed as close as two miles from the project site.

The **San Gabriel** fault zone, located approximately 5 miles north of the project site, is a steep north dipping active fault zone. It is approximately 84 miles long and is mapped as part of the San Andreas system. Similarly, the San Gabriel fault zone shows predominately right lateral strike-slip displacement. This system has also experienced varying vertical displacement, with the north side up in some places and down in others. The San Gabriel Fault has experienced some minor activity in recent geologic times and does display a few youthful breaks. Some Pleistocene deposits and stream courses have been affected by movement on this fault. The San Gabriel Fault is considered active by the California Geologic Survey.

The **Hollywood** fault is generally considered a westward extension of the **Raymond Hill** fault. The Raymond Hill fault zone traverses roughly from South Pasadena to just east of Monrovia with the Hollywood fault traversing the area of Glendale to Beverly Hills. These faults are approximately 8 miles south and southeast of the project site. The Hollywood and Raymond Hill Faults are considered active by the California Geologic Survey.

The **Northridge Fault**, the causative fault for the 1994 Northridge Earthquake, is believed to be a buried or “blind” thrust associated with the Oak Ridge Fault system that extends westward to Santa Paula. The blind thrust portion of the fault is of unknown length due to the lack of surface expression. As such, the fault does not present a surface rupture hazard to the project site, but is capable of generating future seismic activity. This fault is approximately 7 miles west of the project site.

The **Elysian Park Thrust System** underlies the central Los Angeles Basin and describes a series of northwest-southeast trending folds that overlie blind thrust faults. Regional seismicity indicates that these blind thrust faults are active, and include the fault ramp that produced the 1987 Whittier Narrows magnitude 6.0 earthquake. These subsurface faults are not exposed at the surface, and do not pose a fault rupture hazard to the project site. However, as demonstrated by the 1987 earthquake, the fault system is capable of generating future seismic activity This fault is approximately 11 miles south of the project site.

The **San Andreas** fault zone, located approximately 25 miles north of the project site, is a major geologic structural element in California, and represents the boundary between the Pacific and North American tectonic plates. It strikes roughly west-northwest in the region closest to the project site and has a dip that is close to vertical. The entire fault system is over 750 miles long with a right lateral strike-slip sense of movement. The most recent large-scale seismic event of the southern portion of the San Andreas fault occurred in 1857.

7.4.4 Seismic Hazards

Seismic Shaking: The project site would be subject to ground motions induced by the movement along active faults, as discussed above. Earthquake magnitudes are typically characterized by the "Moment Magnitude" (M_w). The moment magnitude is a relative measure of the energy released by a given earthquake. Ground motions are typically summarized and represented by the Peak Ground Acceleration ("PGA"). The PGA is defined as the peak acceleration of a specific site due to a given earthquake.

The California Geologic Survey (formerly the California Division of Mines and Geology, CDMG) performed a probabilistic seismic hazard assessment for the State of California in 1996 (CGS OFR 96-08). The methodology for performing the assessment is also detailed in the 1996 document. As part of their methodology, the Geologic Survey delineated earthquake sources, defined the potential distribution of seismicity for each of the sources, and calculated the potential ground motions.

The City of Los Angeles Building Code (LABC) is based on the 2001 California Building Code (CBC) and 1997 Uniform Building Code (UBC). The LABC indicates that the design PGA at a site is to be calculated for a probability of exceedance of 10 percent in a 50-year exposure period, equivalent to a 475-year recurrence interval. Based on the above parameters, the magnitude resulting from this probabilistic analysis is referred to as the Maximum Probable Event (MPE). MPEs for the faults discussed in the previous section are presented in Table 1 below as Maximum Earthquake Magnitude (M_w). The PGA (i.e., ground motion) that would be experienced at the project site is calculated by inputting the MPE magnitude into a statistical attenuation relation equation that calculates energy loss as a result of distance from the seismic event. Generally, the closest fault system will produce the highest ground motion. Results of this analysis are listed below.

TABLE 1
Summary of Seismic Sources

Fault Name	**Type of Faulting**	**Distance from project site (miles)**	**Maximum Earthquake Magnitude(M_w^1)**	**Peak Ground Acceleration g^2**
Verdugo	Reverse	2.0	6.7	0.82
Sierra Madre	Reverse	1.5	7.0	0.61
San Fernando	Thrust	2.0	6.7	0.44
San Gabriel	Right-Lateral Strike Slip	5.0	7.0	0.33
Hollywood/ Raymond Hill	Left-Lateral Reverse	7.8/8.4	6.4/6.5	0.26
Northridge Blind Thrust	Blind Thrust	6.8	6.5	0.35
Elysian Park	Blind Thust	11.4	6.7	0.17
San Andreas	Left-lateral Strike Slip	25.0	6.8-8.0	0.15

1) Moment Magnitude
2) Percentage of Gravity calculated by Borzongia, Campbell, Niazi, attenuation relation (1999).

In order for engineered structures to withstand the PGAs summarized above, design procedures contained within the LABC provide the parameters set forth in Table 2 below to be input into the design of structures within the proposed Development Areas. The procedures contained within the LABC incorporate the known seismic framework of the region, the relative activity of nearby faults, and the proximity of the project site to active faults to determine the parameters to be used in structural engineering calculations. The design fault is chosen based on the largest PGA for the project site (Table 1). The Seismic Source Type for a chosen design fault has been defined by the California Geologic Survey (CGS OFR 96-08) and in Table 16-U, LABC. The proximity of the project site to the design fault (near source distance) and soil and bedrock conditions beneath the project site (soil profile) are used to determine the Near-Source Factors (**N_a** and **N_v**), which in turn are used to calculate the Seismic Coefficients (**C_a** and **C_v**) for the project site. These parameters are used by structural engineers in the design of structures to withstand earthquake forces. A listing of the design parameters are listed in Table 2.

TABLE 2
2002 City of Los Angeles Building Code Parameters[1]

Design Fault	**Verdugo**
Seismic Source Type	**Type B**
Near-Source Distance	**2-km**
Seismic Zone	**4 (z = 0.4)**
Soil Profile (Table 16-J, LABC)	S_B
Near-Source Factor N_a (Table 16-S, LABC)	**1.5**
Near-Source Factor N_v (Table 16-T, LABC)	**2.0**
Seismic Coefficient C_a (Table 16-Q, LABC)	**0.40**
Seismic Coefficient C_v (Table 16-R, LABC)	**0.40**

[1] **2002 City of Los Angeles Building Code, Chapter 16**

Liquefaction: The term liquefaction refers to a phenomena that occurs when saturated, loose granular soils experience a temporary loss of strength when subjected to seismic ground vibrations. This loss of strength occurs when an increase of water pressure within the soil matrix exceeds the soil overburden pressure, and therefore liquefies the soil matrix. For liquefaction to occur, three conditions are required:

- Ground shaking of significant magnitude and duration
- Groundwater conditions sufficient to create saturated soil conditions
- Loose cohesionless soils.

Liquefaction does not directly pose a hazard to life, but the settlements and lateral ground displacements it may cause can severely damage or destroy structures or cause landslides that in turn could pose a hazard to life or property.

As part of the State of California Seismic Hazard Mapping program, the California Geologic Hazard Mapping program created seismic hazard maps to identify liquefaction hazards on an aerial basis. The project site and the Duke Property fall within the Burbank and Sunland Quadrangles. Based on the most recent version of these maps, neither the project site nor the Duke Property is shown as a liquefaction hazard area. The Areas Susceptible to Liquefaction plate (Exhibit B) of the City of Los Angeles General Plan Safety Element also depicts areas of potential liquefaction hazard. There are no potential liquefaction hazard areas included within the project site or the Duke Property.

Seismically-Induced Settlement: Seismic shaking of loose sands and gravels, including those subject to liquefaction as well as unsaturated granular materials, may result in settlement. Seismically-induced settlement is especially pronounced when liquefaction occurs simultaneously with seismic settlement. Materials prone to seismically induced settlement were not observed within the project site boundaries or the Duke Property.

Seismically-Induced Landsliding: Just as man-made structures can be damaged by severe shaking from an earthquake, natural slopes can weaken and fail and cause damage to buildings and site improvements. Although most types of earthquake-induced landslides pose some hazard to human life and property, historical evidence shows that the predominant hazards to life safety come from rock avalanches, rock falls, and rapid soil flows.

Approximately 50 percent of the natural slopes within the project site and the Duke Property are located within an Earthquake Induced Landslide Hazard Zone as delineated on the State of California Seismic Hazard Maps, Burbank and Sunland Quadrangle. According to California Geologic Survey, Special Publication 118, the zones are defined as "areas meeting one or more of the following criteria":

- Areas known to have experienced earthquake-induced slope failure during historic earthquakes;
- Areas identified as having past landslide movement, including both landslide deposits and source areas; and
- Areas where the California Geologic Survey's analysis of geologic and geotechnical data indicate that the geologic materials are susceptible to earthquake-induced slope failures.

Based on our geologic mapping of the project site, it does not appear that the project site suffered considerable earthquake-induced landslides as a result of the 1971 San Fernando or 1994 Northridge earthquakes or other historic earthquakes of lesser magnitudes. Within the project site boundaries, rock fall would be the most likely form of earthquake-induced slope failure. A rock fall is defined as a free fall of rock fragments of various sizes detached from a slope. The fall may be combined with rolling and leaping of fragments, which may be broken into pieces in the process. Specifically, rock fragments might detach and roll downslope onto homes and other improvements below. Eight areas of potential seismically-induced rock fall have been identified within the project Development Areas (see Plate 1). These eight areas of potential seismically-induced rock fall are all located within an Earthquake Induced Landslide Hazard Zone, as discussed above.

7.4.5 Landslides

The Dibblee Foundation Map for the Sunland and Burbank (north ½) Quadrangles (Appendix A, Text Reference 19) does not identify any landslides within the project site or the Duke Property. The State of California Seismic Hazards Zone map designates some of the natural slopes as areas with potential for "Earthquake-Induced Landslides". The Landslide Inventory & Hillside Areas plan (Exhibit C) in the City of Los Angeles General Plan Safety Element indicates that the project site is within a hillside area. However, there are no bedrock or probable bedrock landslide sites within the project site identified on Exhibit C.

Within the project site, landslide materials are due to accumulations of loose rock and debris flowing down canyon from steeper slopes above, and steeper slope areas undercut by stream erosion. These debris flows typically occur during periods of heavy rainfall and/or in association with ground shaking caused by earthquakes. Landslides mapped within the project site are typically less than 20 feet in thickness and exist at the base of steeper slopes generating loose rock debris. The landslides consistency is generally loose and unsuitable for the support of fill embankments or engineered improvements. The approximate landslide boundaries are illustrated on the Geotechnical Maps (Plates 1 and 2). A summary of each landslide is presented in the Table 3 below. Landslides 4, and 7 through 9 are not within proposed Development Areas. Landslides 1 through 3, 5, 6, 10 and 11 are within proposed Development Areas and will require mitigation during grading.

TABLE 3
Summary of Landslides

Landslide Designation	Approximate Depth	Approximate Width	Approximate Height	General Trend
1	10-20’	250’	100’	NW
2	10-20’	370’	130’	S
3	10’	30’	50’	W
4	10’	40’	70’	W
5	10’	70’	60’	NW
6	10’	40’	70’	S
7	10’	75’	120’	SW
8	10’	90’	100’	S
9	10’	150’	60’	SW
10	10’	50’	150’	SW
11	10-20’	310’	80’	S

7.5 SLOPE STABILITY

7.5.1 Cut and Natural Slope Stability

Bedrock Fabric Stability Analysis: As noted in the physical descriptions and structure descriptions of the bedrock materials on the project site, the materials have undergone stress and strain resulting in fracturing and jointing of the bedrock. In the absence of bedding features, rock structure is controlled by faulting, jointing, and foliation. The orientation of these planar surfaces is a key factor to be considered during the analysis of the slope stability of the project site and proposed Development Areas.

During our field mapping and subsurface exploration phase of our work, these planar surface orientations were measured, located, and recorded on geologic maps and trench logs. The method of analysis of these features included tabulating the orientation of planar surfaces to evaluate where these surfaces might intersect with adverse orientation for slope stability. The method of analysis also included the use of a stereonet procedure. A stereonet is a two-dimensional process to interpret three-dimensional representations of planar surfaces. This can in turn be used to determine the stability of intersecting planar features. The first step in this process was a review of aerial photographs and site topography to determine areas of similar structural characteristics. These were identified by the "sectors" contained within the table below. The locations of the sectors are illustrated on the Stereonet Sector Map (Figure 3).

The major orientation patterns of bedrock jointing and foliation within bedrock sectors were collected from this investigation, previous investigations, and published geologic maps and is entered into the computer program SpheriSat 2. This computer program determines the major orientations as a density distribution of the plotted structural element pole projections utilizing the Gaussian counting model on an equal area Schmidt stereograph. From the density distribution we were able to determine the most prominent planar orientations of the planar surfaces. Planar surfaces trends are identified by a compass bearing direction (strike) and an inclination in degrees (dip) from an imaginary horizontal planar surface (e.g., strike N (North) 13 (degrees) E (east) and dip 59 (degrees) NE (northeast). Therefore the first Prominent Planar Trend in Sector I is oriented in a compass direction 13 degrees east from north with an inclination of 59 degrees down from the horizontal toward the southeast. The results of the point density distribution analysis are presented in Table 4 below. The analyzed plots are presented in Appendix F.

TABLE 4
Point Density Distribution Analyses Results

Sector Number	Structural Element	Number of Attitudes Analyzed	Prominent Planar Trend(s) Strike, Dip
I	Jointing	38	N13E, 59SE
			N68W, 47SW
			N12W, 74SW
			N22W, 80NE
II	Jointing	31	N54E, 66SE
			N62W, 46SW
			E-W, 71N
	Foliation	14	N-S, 57W
			N49E, 63NW
			N44E, 88NW
III	Jointing	94	N72W, 88SW
			N31W, 56SW
			N10W, 72SW
			N14E, 79NW
IV	Jointing	130	E-W, 52S
			N26E, 65SE
			N10E, 43SE
			N62W, 58SW
			N14W, 59SW
	Foliation	14	N2W, 64NE
V	Jointing	94	E-W, 90
			E-W, 58S
			N72E, 45SE

After determining the prominent compass orientation of planar surfaces, we next determined the resultant compass orientation of these intersecting planar surfaces within individual sectors. The direction and inclination (plunge) of intersecting planar surfaces are characterized by their own strike and dip compass orientations. The compass orientation of the intersecting planar surfaces is a key factor to be considered during the analysis of the stability of natural and manufactured slopes. Within individual sectors, we anticipate that slopes oriented subparallel to the inclination (dip) direction of the intersecting planes would potentially be adversely affected by potential slope failures. Table 5 below identifies compass orientations of slopes that may be affected by these inclined intersecting planes. As such, natural and proposed cut slopes within the Development Areas perpendicular to and sloping in the direction of the trend presented in the above table would potentially be subject to slope instabilities.

TABLE 5
Potential Adverse Slope Orientations

Sector Number	Direction of Intersecting Joint sets	Plunge of Intersecting Joint Sets	Slopes Affected
I	S3E	45°	South facing
II	N62W S34W	38° 48°	Southwest facing Northwest facing
III	S7W	52°	South facing
IV	S to SE	45°	South to southeast facing
V	S42E	43°	Southeast facing

Table 5 indicates that south facing cut and natural slopes in all five Sectors of the Development Areas (as shown on Figure 3) are subject to potential slope instabilities. In addition, west and northwest facing slopes in Sector II, southeast facing slopes in Sectors IV and V have adverse orientations in relation to jointing and would be subject to potential slope instabilities

7.5.2 Fill Slope Stability

Fill slopes constructed of excavated and recompacted earth materials are proposed to a maximum height of approximately 200 feet. Slope stability analyses of these configurations utilizing shear strength testing of soil materials from within the proposed Development Areas indicates that current slopes, as shown in the current development plan meet LABC Criteria of a 1.5 factor of safety under static loading conditions. Analyses of fill slope stability are included in Appendix G.

7.6 Excavatability

Excavatability or "rippability" refers to the hardness and ability of conventional earthmoving equipment to excavate earth materials within the project site. Excavatability surveys evaluate bedrock hardness generally by measuring a shear wave velocity through the bedrock formation with a higher velocity representing more resistant bedrock material. This is compared through empirical relations to determine relative ease of excavation for differing types of earthmoving equipment.

Onsite bedrock materials appear to be highly weathered and fractured where observed during our field observations at the ground surface. The results of the seismic refraction survey generally indicate that the bedrock materials encountered to the depths explored exhibit relatively low seismic velocities corresponding to easily excavatable rock. Comparing the seismic velocities above, with the Rock Rippability Classification table contained in the attached seismic survey report (Appendix E) suggests that the bedrock materials can be excavated with conventional earthworking equipment to surveyed depths. Table 6 below is a summary of the results of the seismic refraction survey perform within the Development Areas.

TABLE 6
SUMMARY OF SEISMIC REFRACTION SURVEY

Line	Depth of Survey (bgs)[1]	General Depth of Proposed Cut	Maximum Average Velocity to Survey Depth
1	60 feet	60 feet	2,501 feet/sec
2	80 feet	80 feet	2,567 feet/sec
3	80 feet	80 feet	2,808 feet/sec
4	80 feet	70 to 80 feet	3,515 feet/sec
5	60 feet	60 feet	2,373 feet/sec
6	80 feet	80 to 95 feet	3,642 feet/sec

1) bgs = below ground surface

Seismic data obtained from the Pacific Soils Engineering report for the Duke Property indicates average velocities of between approximately 2800 feet/second to 4,000 feet/second to 60 feet in depth. These velocities are similar to the velocities shown in the Table 6 above. It should be noted that although CalTrans documentation indicated similar velocities to those indicated by our study and the Pacific Soils Engineering study, some localized blasting was required during the construction of Interstate 210 to achieve proposed cuts.

It should be noted that the measured velocities are averages of the subsurface materials encountered and that significant local variations, such as fracture spacing, frequency and orientation in bedrock materials may be encountered. Therefore, based on the data, the majority of the bedrock can be excavated without blasting. However, due to these expected variations, small, localized areas may still require blasting due to the variability of the onsite bedrock conditions.

7.7 Groundwater

Based on a recent report by the California Department of Water Resources (Bulletin 118, "California's Groundwater"), the project site is located within an elevated area between the San Gabriel groundwater basin and the San Fernando Valley groundwater basin. The project site and the Verdugo Mountains are not within either basin due to their relative elevation above the basins.

Locally, groundwater was encountered during the construction of Interstate 210 as discussed in the As-Built Materials report prepared after freeway construction was completed (Appendix D). Generally, the groundwater was located in the drainage area of La Tuna Canyon and subsidiary canyons draining into it. The depth of ground water ranged from 18 to 60 feet below the surface where encountered. This water was considered isolated to the tributary drainages through the site and not representative of a true groundwater "table" as found within the larger groundwater basins. No groundwater was encountered in our exploratory excavations.

8.0 GEOTECHNICAL IMPACTS AND MITIGATION

In accordance with Appendix G of the State CEQA Guidelines, the proposed project could have a significant environmental impact if it would:

(a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

  (i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault.

  (ii) Strong seismic ground shaking.

  (iii) Seismic-related ground failure, including liquefaction.

  (iv) Landslides.

(b) Result in substantial soil erosion or the loss of topsoil.

(c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse.

(d) Be located on expansive soil, as defined in Table 18-1-B of the California Building Code (2001), creating substantial risks to life or property.

(e) Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water.

In addition to the above, the California Geologic Survey has also incorporated the following potential impacts within their "Guidelines for Preparation of Geologic Sections of Environmental Impact Reports" (CDMG Note 46, 1982):

1. Flooding due to Dam or Levee Failure
2. Loss of Mineral Resources
3. Excavation and Blasting
4. Impacts due to seiches
5. Impacts due to tsunami
6. Volcanic Hazards.

The project impacts focus on the project site, but the analysis is generally applicable with equal force to the Duke Property.

8.1 Seismic Impacts

In general, seismic exposure at the project site is typical of the Southern California region. Possible sources or causes of earthquake-related damages are addressed below.

8.1.1 Rupture of Known Earthquake Fault

The project site does not lie within an Alquist-Priolo Special Studies Zone, nor is the project site within an active fault zone as defined by the City of Los Angeles General Plan Safety Element Fault Rupture Study Areas. No known active or potentially active faults cross the project site. Faults encountered within the project site are considered sympathetic to tectonic movement on major earthquake-producing faults. Evidence of movement on these sympathetic faults within the last 1.6 million years that would indicate an active or potentially active fault was not encountered during our exploration of the site. Therefore, the proposed project would not expose people or structures to potential substantial adverse effects involving rupture of a known earthquake fault.

<u>Mitigation Measures</u> – None.

8.1.2 Seismic Ground Shaking

As with all properties in the seismically active Southern California region, the project site is susceptible to ground shaking during a seismic event. Potential impacts from seismic ground shaking are present throughout Southern California and would be of comparable intensity at the project site as it would be for large parts of the City of Los Angeles and the region. The proposed homes and infrastructure that comprise the project will be designed in accordance with the seismic parameters set forth in Table 2 of this report, which incorporate the known seismic framework of the region, the relative activity of nearby faults, the proximity of the project site to active faults (or "near-source" effects), and soil and bedrock conditions beneath the project site. Compliance with the LABC utilizing the parameters set forth in Table 2 will reduce seismic risks to an acceptable level. Therefore, the proposed project would not expose people or structures to potential substantial adverse effects relating to strong seismic ground shaking.

<u>Mitigation Measures</u> – None.

8.1.3 Seismic-Related Ground Failure and Liquefaction

The project site is not within any area considered subject to liquefaction or seismic settlement as delineated by the State of California Seismic Hazard Maps, or the City of Los Angeles General Plan Safety Element. In any event, surficial earth materials within the proposed Development Areas that may be susceptible to liquefaction will be removed in accordance with normal grading procedures. The proposed project will not exposed people or structures to potential substantial adverse effects involving liquefaction or other seismic-related ground failure. Materials prone to seismically induced settlement were not observed within the project site or the Duke Property.

Mitigation Measures – None.

8.1.4 Seismically-Induced Landslides and Rock Fall

The project site is dominated by steep canyons composed primarily of weathered and jointed bedrock. Based on our geologic mapping of the project site, it does not appear that the project site has suffered considerable earthquake-induced landslides as a result of historic earthquakes. Within the project site boundaries, rock fall would be the most likely form of earthquake-induced landslide. Seismically-induced rock fall describes rock fragments loosened due to shaking related to an earthquake.

As set forth in Section 7.4.4, above, there are eight areas of potential seismically-induced rock fall in the Development Areas (see Plate 1). These eight areas are all located in an Earthquake Induced Landslide Hazard Zone, as discussed in Section 7.4.4, above. There are approximately 21 proposed homes in exposed locations beneath those eight areas. Although our geologic mapping of the project site indicates that no significant earthquake-induced landslides occurred in these areas as the result of historic earthquakes, the potential for significant property damage or potential loss of life exists if such a landslide did occur. Therefore, the proposed project could expose people or structures to potential substantial adverse effects as the result of seismically-induced rock fall, and is therefore considered a significant impact. However, incorporation of the mitigation measures presented below will reduce this potentially significant impact to a less than significant level.

Seismically-induced landslides other than those caused by rockfall described in section 7.4.4 are addressed by the LABC and Grading Code and are therefore not considered to represent a significant impact to the site.

Mitigation Measures – In areas with rock fall potential (see Plate 1), the mitigation should incorporate setback zones from potential rock fall areas. In areas where proposed structures may encroach within the setback area, rock fall containment devices should be incorporated into the design. Examples of such devices include debris fences or walls, rock bolting and netting, or rock fall containment basins.

8.1.5 Tsunami

A tsunami is a sea wave caused by a submarine earthquake, landslide, or volcanic eruption. Tsunami can cause catastrophic damage to shallow and or exposed coastline. The project site is located approximately 40 miles inland from the Pacific Ocean, and is at an elevation sufficiently above sea level to preclude affects of tsunami. Therefore, the potential for tsunami to affect the project site is considered non-existent.

<u>Mitigation Measures</u> – None.

8.1.6 Seiches

Seiches are changes or oscillations of water levels within a confined body of water due to fluctuations in the atmosphere, tidal currents, or earthquakes. The effect of this phenomenon is a "standing wave" that would occur in a body of water that would occur when influenced by the external stimulus. No lakes, reservoirs, or other large confined bodies of water are in close proximity of the project site. Therefore, the potential for seiches to affect the project is considered non-existent.

<u>Mitigation Measures</u> – None.

8.2 Soil Erosion or Loss of Topsoil

The graded and natural areas of the proposed project will be subject to erosion, sedimentation during, and following grading of the Development Areas. The City of Los Angeles Grading Code, as well as the provisions of the Federal Clean Water Act regulations, requires that erosion be controlled and minimized through the use of Best Management Practices, and appropriate flood and storm drainage control systems. Compliance with those codes and regulations will reduce soil erosion and loss of topsoil to acceptable levels. Therefore, the proposed project would not result in substantial soil erosion or loss of topsoil.

<u>Mitigation Measures</u> – None.

8.3 Project Site Stability

8.3.1 Landslides

The proposed development may be subject to slope and/or foundation instability due to landslides. As discussed in Section 7.4.5, above, Landslides 1 through 3, 5, 6, 10 and 11 are located within areas of proposed development (see Plate 1).

Approximately 10 of the proposed homes are located within or adjacent to these landslide areas. Without mitigation, the potential exposure would constitute a significant environmental impact. However, incorporation of the mitigation measures presented below would reduce this potentially significant impact to a less than significant level. Landslides 4 and 7 through 9 would not expose people or structures to landslides because they are not located in proximity to any of the proposed homes or infrastructure.

Mitigation Measures – Appropriate mitigation measures include grading to buttress existing landslides and the installation of subdrainage systems to mitigate the build-up of subsurface water, thereby increasing the stability of the slopes. At a minimum, slopes prone to landsliding should be provided with a minimum keyway width of one-half of the slope height (with a minimum width of 12 feet), and a buttress fill to provide a final slope gradient of 2 to 1 (horizontal to vertical) in accordance with the LABC.

As discussed above, Landslides 4 and 7 through 9 will not require mitigation. Landslide 1 should be stabilized during grading or removed. A cut slope proposed into Landslide 2 will require stabilization of the slope and a partial removal of the landslide mass. Landslide 3 should include a shear key for the outside edge of the roadway above. Landslides 5 and 6 should be removed during grading. The outside edge of the lot above Landslide 10 will require a shear key to proposed building pads above. Landslide 11 will require a partial excavation of the landslide mass to provide support for the adjacent fill slope. The recommended mitigation set forth above would be accomplished during grading using standard grading techniques in accordance with the LABC, which would reduce risks from landslides to an acceptable level. Therefore, the proposed project, as mitigated, would have a less than significant impact with regard to landslides.

8.3.2 Mudflows

The primarily granular character of the surficial materials within the Development Areas is not conducive to the development of mud and debris flow. Therefore, mud and debris flow is not considered to be significant impact.

Mitigation Measures – None.

8.3.3 Proposed Cut Slopes

The grading of south and northwest facing cut slopes for the proposed project may result in slope and/or foundation instability, as discussed in Section 7.5.1, above. The majority of the proposed cut slopes on the project site will expose highly weathered and/or highly jointed bedrock, which will be susceptible to possible surficial failure or deep-seated slope failures and will require stabilization measures. Proposed cut slopes range in height from tens of feet to roughly 100 feet (vertical relief). As indicated in section 7.5.1, above, all five Sectors of the Development Areas (as shown on Figure 3) are subject to potential slope instabilities. In addition, west and northwest facing slopes in Sector II, and southeast facing slopes in Sectors IV and V, have adverse orientations in relation to jointing and would be subject to potential slope instabilities. Slope instability could lead to slope failures that would pose a hazard to property and life safety. Therefore, this is considered a potentially significant impact. However, incorporation of the mitigation measures set forth below would reduce this potentially significant impact to a less than significant level.

Mitigation Measures – Most cut slopes will require replacement with a stabilization fill slope or buttress fill slope with a maximum slope gradient of 2:1 (horizontal:vertical). Any slope that cannot be rebuilt as a 2:1 or flatter shall be rebuilt as a reinforced slope or lessened to a 2:1 gradient with retaining walls.

Temporary back cut slopes associated with remedial grading of stabilization fills and buttress slopes shall not exceed a slope gradient of 1.5:1 (horizontal:vertical), and shall more typically maintain a slope gradient of 2:1. Fill widths at the top of the proposed slopes shall maintain a minimum width of 15 feet. Buttress and stabilization fills shall be built with keyways with a minimum width of one-half the slope height (with a minimum width of 12 feet) and supplied with subdrainage to preclude buildup of water. Design and grading construction of the proposed cut slopes shall conform with the LABC.

8.3.4 Cut Pads

The majority of the cut pads proposed in the development plan are situated along ridgelines with a portion of the proposed cut pad extending to the natural slope face. These pads are anticipated to expose one or a combination of the following conditions:

- highly sheared, jointed or fractured bedrock
- unsuitable topsoil and/or highly weathered bedrock
- materials with different settlement characteristics
- hard rock with difficult excavation characteristics.

The LABC requires that potentially adverse bedrock conditions be mitigated by appropriate foundations or remedial grading to address potential differential settlement. Grading of cut pads in accordance with the LABC is not considered to be a significant impact.

Mitigation Measures – None.

8.3.5 Proposed Fill Slopes

In accordance with the LABC, proposed fill slopes within the proposed Development Areas will be required to meet a minimum factor of safety of 1.5, and be stable under seismic loading conditions. Any portion of a proposed fill slope with a gradient steeper than 2:1 should be reinforced with geogrid or lessened to a 2:1 gradient with retaining walls. Grading of fill slopes in accordance with the LABC is not considered a significant impact.

<u>Mitigation Measures</u> – None.

8.3.6 Compressible Earth Materials

In accordance with LABC requirements, compressible earth materials are to be removed and replaced as compacted fill. The proposed project will avoid the compressible fills placed on the project site in connection with the construction of Interstate 210. Therefore, the existence of compressible earth materials is not considered to be a significant impact.

<u>Mitigation Measures</u> – None.

8.3.7 Land Subsidence

Land subsidence is the gradual sinking or downward warping of the earth's surface due to a variety of possible circumstances and or activities that include mining, and the removal of oil or groundwater. No potential land subsidence-related circumstances and or activities are suspected to occur on the project site, nor have they in the past. Therefore, no potential for land subsidence exists.

<u>Mitigation Measures</u> – None.

8.4 Expansive Earth Materials

Expansive soils generally contain clay minerals that absorb moisture and cause the material to "swell" or increase in volume. Likewise, when expansive soils dry out, they tend to shrink or decrease in volume. Volume changes associated with changes in the moisture content of near surface soils can cause uplift or heave of the ground surface. Less commonly, settlement can occur when they lose moisture or dry out. Expansive earth materials are not known to be present within the project site. Therefore, the existence of expansive earth materials is not considered to be a significant impact.

<u>Mitigation Measures</u> – None.