5.5 Geology and Soils

5.5.1 Methodology

This chapter is based on the information contained in the "Geotechnical Feasibility Report, La Floresta Development (Former Unocal Hartley Center), 376 South Valencia Avenue, Brea, California, November 14, 2005" and the "Geotechnical Feasibility Report, Birch Hills Golf Course Development, Southwest Corner of Birch Street and Kraemer Boulevard, Brea, California, November 18, 2005," both prepared by Albus-Keefe & Associates, Inc. These reports are provided in the Technical Appendix. The Public Safety Element of the Brea General Plan also provides an overview of geologic conditions and hazards in the city. The General Plan Geologic and Seismic Hazards Map is shown in Exhibit 5.5-1.

5.5.2 Setting

PROJECT SITE CONDITIONS

Both Sites

Regionally, the Project sites lie within the northeastern portion of the Los Angeles basin within the Peninsular Ranges Geomorphic Province. More specifically, the sites are situated near the base of the south-central Puente Hills. The Puente Hills is a structural unit of Upper Miocene-age sedimentary rocks that has been uplifted between the Whittier fault zone and the Chino fault zone. The La Habra syncline is a structural feature positioned south of and nearly parallel to the southern edge of the Puente Hills. The study area is situated within the lowlands of this structural feature, which lies between the hills to the north and the Coyote Hills uplift to the south.

Uplift of the Puente Hills in the Late Pleistocene and Holocene has created geomorphic landforms within the hills and lowlands to the south that have episodically been eroded and infilled with various generations of alluvium. Thick accumulations of these deposits underlie the Project sites.

Faulting and Seismicity

Regional Faulting

Several large active fault systems are located in relative close proximity to the Project sites. Seismic activity on these larger fault systems has for the most part controlled the geologic structure in the region. The closest known active fault systems to the sites include the Whittier fault, the Puente Hills Blind Thrust fault, the Chino fault, the San Jose fault, the Elsinore fault, the Sierra Madre fault, and the Cucamonga fault.

Site Specific Faulting

No evidence of faulting was observed or reported within or directly adjacent to either of the Project sites. Based on a review of the referenced publications and seismic data, no faults are known to extend through or immediately adjacent to the sites, nor do the sites lie within an "Earthquake Fault Zone" as defined by the State of California in the Alquist-Priolo Earthquake Fault Zoning Act (see Exhibit 5.5-1 and Exhibit 5.5-2).

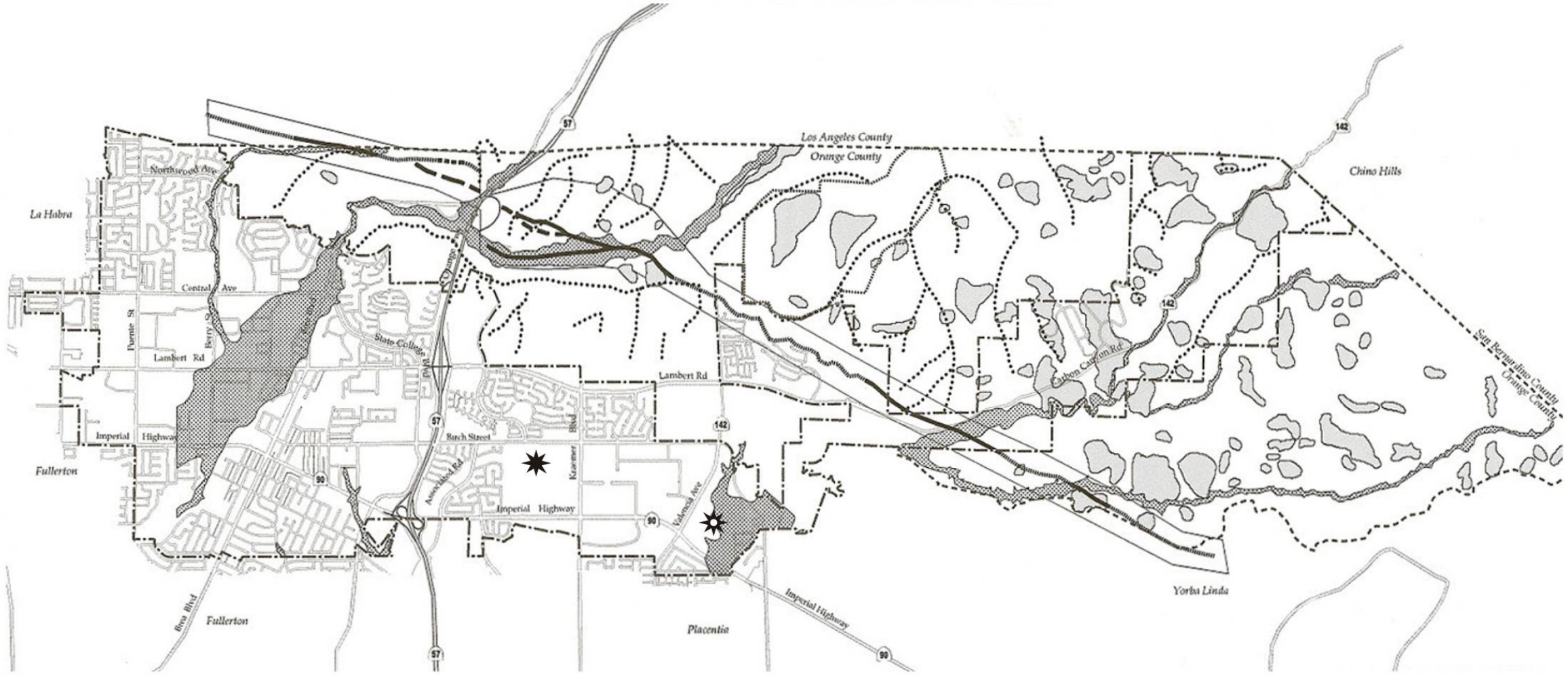
Landslides

No conditions were observed that would suggest the Project sites are prone to landsliding. The sites are not located within an area identified by the California Geologic Survey (CGS) as having potential for seismic slope instability.

La Floresta Village Site

Pleistocene-age terrace deposits (Qt) and Quaternary-age alluvium (Qal) underlie the La Floresta Village site. These deposits are generally mantled by compacted artificial fill, non-engineered artificial fill (Qaf), and topsoil. The Pleistocene-age terrace deposits are located along the elevated western and northern margins of the site. These deposits, which are essentially uplifted and partially eroded older alluvial deposits, consist of yellowish to reddish brown clayey silt, sandy silt, silty sand, clayey sand, and sands that are damp to moist, firm to stiff, and dense. The younger alluvial deposits underlie the low-lying areas of the site and are estimated to be over 100 feet in maximum thickness. These deposits consist of various shades of brown and gray colored clayey to sandy silt, silty clay, clayey sand, silty sand, and sands that are dry to very moist, soft to firm, and medium dense to dense. Relatively undisturbed areas of the site are generally underlain by a 2-foot to 4-foot thick mantle of topsoil. The topsoil materials, depending on the underlying parent materials, generally consist of grayish brown colored clayey and silty sands and sandy silts that are dry to moist, soft to firm, medium dense, and porous. Compacted artificial fill materials are present within various portions of the site and are generally coincident with structures associated with the previous research center and with backfilling of environmental remediation excavations in the northeasterly portion of the site. These fills generally vary from a few feet to up to 15 feet or more in thickness and consist of locally derived materials that are damp to moist, stiff, and dense. Non-engineered (or undocumented) artificial fill is also widely scattered throughout the site. Owing to the long history of development of the site, the nature of these fills is quite variable. Only those fills of significant extent are indicated on the Geologic Map (see Exhibit 5.5-3).

City of Brea: Geologic and Seismic Hazards



Legend

Seismic Hazards

Legend

- City Boundary
- Sphere of Influence

Seismic Hazards

- Accurate Fault Location
- Approximate Fault Location
- Concealed Fault
- Inferred
- Alquist-Priolo Earthquake Fault Zone
- Liquefaction

Areas where historic occurrence of liquefaction, or local geological, geotechnical and groundwater conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resource Code Section 2693c would be required

- Mapped Landslides
- Major Ridgelines

- La Floresta Village
- Birch Hills Golf Course

Source: City of Brea - Earth Consultants Internation, January 2002;
California Division of Mines and Geology, 1980, 1991, and 1998.

Not to Scale
Exhibit 5.5-1

CONEXUS

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Hydrogeologic Setting

The La Floresta Village site lies within the La Habra-Yorba Linda Basin, a gently down-warped trough lying between the Puente Hills to the north and the Coyote Hills to the south. This hydrogeologic area is located in the northern portion of the Coastal Plain of Orange County and is bounded by the Norwalk Fault zone and the Whittier Fault. Aquifers within the basin occur in relatively thin sediments that are deposited on non-water bearing rocks adjacent to the Puente Hills.

Shallow perched groundwater was not encountered during supplemental geotechnical investigation to the depths explored (51 feet), nor was it encountered within the site during previous investigations by others. Research indicates that groundwater beneath the site is in excess of 100 feet of the existing ground surface.

Birch Hills Site

Upper Pleistocene-age non-marine sediments assigned to the La Habra Formation underlie the entire Birch Hills site and are locally exposed on the hilltops. These deposits consist primarily of interbedded sequences of brown, gray brown, and yellow brown colored clayey sandstone, silty sandstone, sandstone, clayey siltstone, and silty claystone. Generally, these deposits are damp to moist, moderately hard, thinly bedded to massive and moderately to highly fractured. Overlying the La Habra Formation are surficial units consisting of late Pleistocene to early Holocene age older alluvial deposits, recent alluvium, colluvium, topsoil, and various artificial fills. The older alluvial deposits generally consist of brown, yellow brown, and gray brown colored sands, silty sands, clayey sands and clayey silt. These deposits are typically damp to very moist, medium dense to very dense, and/or stiff to very stiff, and contain scattered gravel, cobbles, and siltstone rock fragments. The recent alluvium, colluvium, and topsoil materials generally consist of various mixtures of brown to gray brown colored sands, silts, and clays and are typically damp to very moist, loose to medium dense, and or soft to firm and porous. The artificial fill materials, which are generally associated with the construction of the golf course, the abandoned railroad easement, and the Loftus Channel, consist primarily of locally derived mixtures of sands, silts and clays (see Exhibit 5.5-3, page 5.5-9).

Hydrogeologic Setting

The Birch Hills site lies within the La Habra-Yorba Linda Basin, a gently down-warped trough lying between the Puente Hills to the north and the Coyote Hills to the south. This hydrogeologic area is located in the northern portion of the Coastal Plain of Orange County and is bounded by the Norwalk Fault zone and the Whittier Fault. Aquifers within the basin occur in relatively thin sediments that are deposited on non-water-bearing rocks adjacent to the Puente Hills.

Research of referenced investigation reports by others indicates that groundwater levels were encountered at depths in excess of 30 feet below the ground surface.

REGULATORY SETTING

Both Sites

City of Brea General Plan: Public Safety Element

The Public Safety Element of the General Plan contains policies that are applicable to the Project, as identified below.

Public Safety Element Policies

- *Policy PS-8.1: Minimize the potential damage to structures and loss of life that may result from an earthquake.*
- *Policy PS-8.2: Require seismic safety standards for construction of all new buildings.*
- *Policy PS-8.3: Continue to require geological and geotechnical investigations of all new developments in areas of potential seismic or geologic hazards as part of the environmental and development review process.*
- *Policy PS-8.4: Require that careful, site-specific evaluations based on detailed surface and subsurface geotechnical studies be conducted in areas where landslides are suspected or known to occur.*
- *Policy PS-8.5: Participate in Federal, State, and local earthquake preparedness and emergency response programs.*

Other Applicable Regulations

Alquist-Priolo Earthquake Fault Zoning Act

The State of California, per the requirements of the Alquist-Priolo Earthquake Fault Zoning Act, requires the delineation of earthquake fault zones along faults that are sufficiently active and well-defined. The Act requires cities and counties to withhold development permits for sites within an earthquake fault zone until geologic investigations demonstrate that the sites are not threatened by surface displacements from future faulting. In Brea, the Whittier fault meets this definition, and the fault zone boundaries shown in Exhibit 5.5-1 (page 5.5-3) reflect state-delineated boundaries.

La Floresta Village: Local Geologic Setting

Source: Albus-Keefe & Associates, Inc., November 2005

Not to Scale
Exhibit 5.5-2

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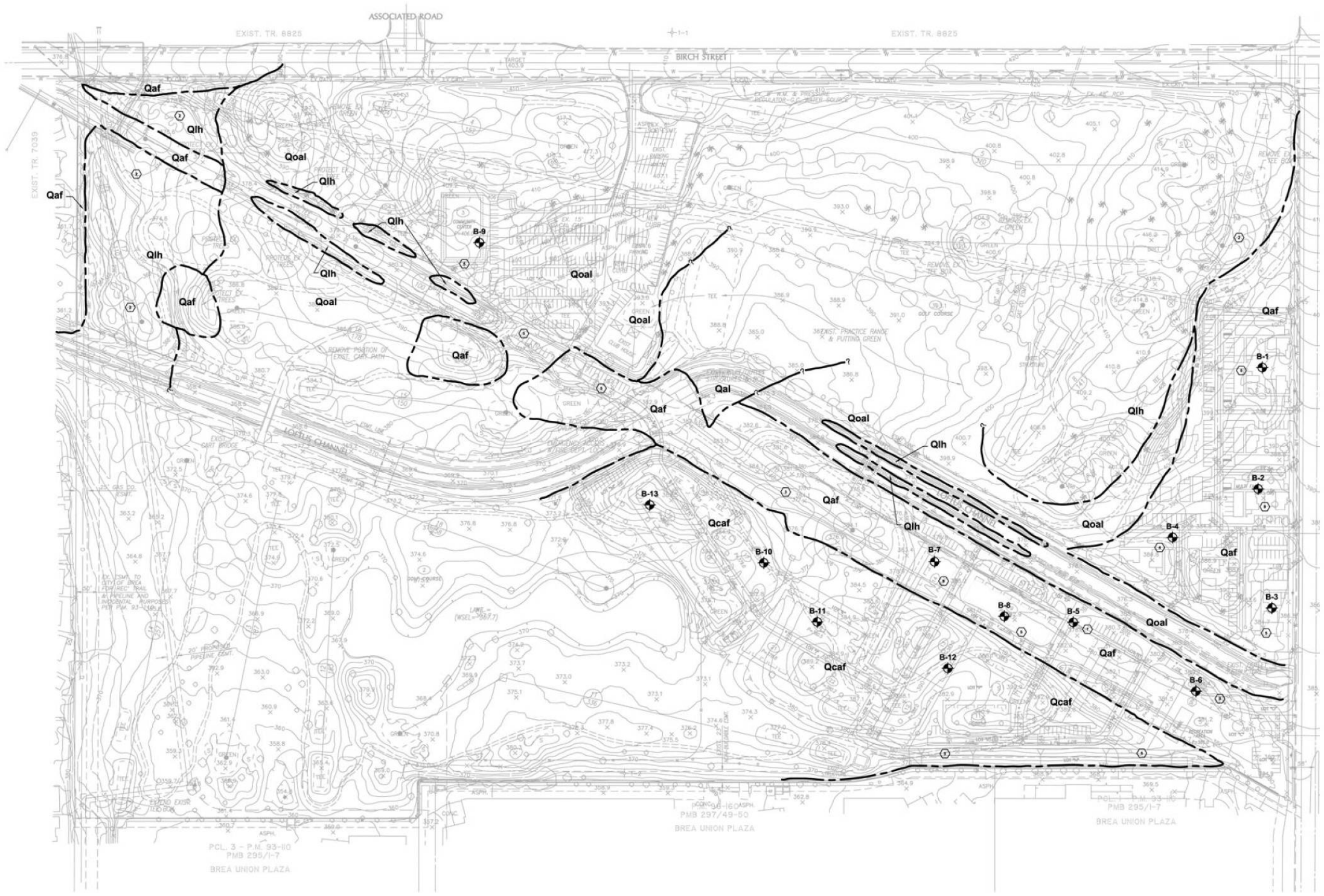
Birch Hills: Local Geologic Setting



Source: Albus-Keefe & Associates, Inc., June 9, 2006

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Exhibit 5.5-3

CONEXUS

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5.5.3 Thresholds of Significance

According to Appendix G of the CEQA Guidelines, a project will normally have a significant adverse environmental impact on geology and soils if it will:

- *Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:*
    1. *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.*
    2. *Strong seismic ground shaking.*
    3. *Seismic-related ground failure, including liquefaction.*
    4. *Landslides*
- *Result in substantial soil erosion or the loss of topsoil.*
- *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.*
- *Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property.*
- *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.*

The NOP (Appendix A) determined that the following issues would either have no impacts or impacts that are less than significant. However, these issues were addressed in the geotechnical studies performed for the proposed project, and the results are summarized in the Impacts section below in order to provide a complete summary of the technical reports.

- 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.
- Seismic-related ground failure, including liquefaction (Birch Hills site only)
- Landslides
- Result in substantial soil erosion or the loss of topsoil.
- 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.

Geology and Soils impacts could also be considered significant if aspects of the project were found to be inconsistent with applicable plans and policies as outlined in the preceding sub-section. Thus the following threshold is added:

- *Substantially conflict with applicable plans and regulations as presented in Section 5.5.2 under Regulatory Setting.*

5.5.4 Project Impacts and Mitigation Measures

CONSISTENCY WITH APPLICABLE REGULATIONS AND PLANS

City of Brea General Plan: Public Safety Element

Both Sites

The project would conform to all General Plan policies listed under Regulatory Setting in Section 5.5.2. Existing law requires that all grading and construction comply with Uniform Building Code standards for seismic safety. In addition, detailed geotechnical studies have been conducted for both sites, and findings are summarized in this discussion. Mitigation Measure GEO-1 would require that these studies be reviewed and approved by the City Engineer and all recommendations from these studies be incorporated into grading and building plans. (Please see additional discussion of specific impacts in sections below.)

Level of Significance: Potentially significant.

Mitigation Measures:

GEO-1 Geotechnical Investigation

Prior to approval of a final subdivision map or issuance of a grading permit the applicant shall submit a site-specific geotechnical investigation report prepared by a licensed engineering geologist in conformance with the City Grading and Excavation Code and meeting the approval of the City Engineer. All recommendations of the report shall be based on surface and subsurface mapping, laboratory testing, and analysis, and shall be incorporated into the final grading plans. The report shall address the following issues:

- *Site clearing and preparation*
- *Identification of faults and traces*
- *Full characterization of on-site soils*
- *Mitigation options for removal of in-ground improvement (or structure design mitigation) of uncompacted fill, compressible soils, expansive soils, corrosive soils, and liquefiable soils*
- *Foundation design*
- *Slope stability*
- Subdrains

Level of Significance after Mitigation: Less than significant

Alquist-Priolo Earthquake Fault Zoning Act

Both Sites

There are no Alquist-Priolo Zones on or immediately adjacent to either site, therefore no significant impacts would occur (see Exhibit 5.5-1, page 5.5-3).

Level of Significance: Less than significant.

Mitigation Measures: None required.

Level of Significance after Mitigation: Not applicable.

IMPACTS RELATED TO SEISMIC ACTIVITY, SLOPE STABILITY, SOILS AND GROUNDWATER CONDITIONS

Both Sites

Ground Rupture

No active faults are known to project through the Project sites nor do the sites lie within the bounds of an "Earthquake Fault Zone" as defined by the State of California in the Alquist-Priolo Earthquake Fault Zoning Act. As such, the potential for ground rupture due to fault displacement beneath the sites is considered low, and potential impacts would be less than significant.

Ground Shaking

The Project sites are located in a seismically active area that has historically been affected by moderate to occasionally high levels of ground motion. The sites lie in relatively close proximity to several active faults; therefore, during the life of the proposed development, the properties will probably experience moderate to occasionally high ground shaking from these fault zones, as well as some background shaking from other seismically active areas of the southern California region. Design of proposed structures in accordance with the current UBC is anticipated to mitigate potential impacts from ground shaking to a level that is less than significant (see Mitigation Measure GEO-1 (page 5.5-12)).

Landsliding

No conditions were observed that would suggest the Project sites are prone to landsliding. The sites are not located within an area identified by the California Geologic Survey (CGS) as having potential for seismic slope instability. Geologic hazards associated with landsliding are not anticipated at the sites. Proposed grading of the sites is unlikely to expose adverse geologic conditions. However, adverse geologic conditions could be readily mitigated with stabilization and/or buttress fills. All grading and construction must conform to the requirements of the Uniform Building Code, with any locally adopted amendments. Mitigation Measure GEO-1 would also require a detailed

geotechnical investigation prior to construction, and would reduce this potential impact to a level that is less than significant.

Slope Stability

Based on experience with earth materials encountered within the Project sites and adjacent properties and considering the maximum slope ratio and height of proposed slopes, proposed cut and fill slopes are generally anticipated to be grossly and surficially stable under static and seismic conditions. All grading and construction must conform to the requirements of the Uniform Building Code, with any locally adopted amendments. In addition, Mitigation Measure GEO-1 would also require a detailed geotechnical investigation prior to construction, and would reduce this potential impact to a level that is less than significant.

Settlement

Based on a review of previous site investigations within and near the sites, as well as experience with similar projects, the artificial fill, topsoil, colluvium, recent alluvium, and the upper portion of older alluvium within the sites would undergo significant settlement due to the weight of new fills and introduction of water. Settlement from these materials would likely exceed 1 inch, of which significant portions of settlement could occur after construction of proposed structures. These materials are not suitable to be left in-place within the influence of proposed fills and improvements. This condition can be readily mitigated by removal of these materials and replacing them as engineered fill. Long-term settlement of proposed fills and underlying competent earth materials is anticipated to be within tolerable limits. All grading and construction must conform to the requirements of the Uniform Building Code, with any locally adopted amendments. Mitigation Measure GEO-1 would also require a detailed geotechnical investigation prior to construction, and would reduce this potential impact to a level that is less than significant.

Groundwater

Groundwater and surface water conditions in the future may vary substantially from those observed within the sites as a result of seasonal variations of rainfall and future development and irrigation. The relatively low permeability characteristic of portions of the soil beneath the sites may increase the potential for localized groundwater ponding subsequent to development. Provided appropriate remedial grading measures and subsurface drainage devices are incorporated into the construction of the Project, adverse effects from future groundwater conditions are not anticipated. All grading and construction must conform to the requirements of the Uniform Building Code, with any locally adopted amendments. Mitigation Measure GEO-1 would also require a detailed geotechnical investigation prior to construction, and would reduce this potential impact to a level that is less than significant.

Level of Significance: Potentially significant.

Mitigation Measures: Mitigation Measure GEO-1 would reduce all potential impacts to a level that is less than significant.

Level of Significance after Mitigation: Less than significant.

La Floresta Village Site

Liquefaction

The State of California Seismic Hazards Zone Map for the Yorba Linda Quadrangle has incorporated the eastern portion of the La Floresta Village site within a zone considered potentially liquefiable. As such, a site-specific liquefaction analysis is required prior to construction of the site.

Engineering research of soil liquefaction potential (Youd, et al., 2001) indicates that generally three basic factors must exist concurrently in order for liquefaction to occur. These factors include:

- A source of ground shaking, such as an earthquake, capable of generating soil mass distortions.
- A relatively loose silty and/or sandy soil.
- A relative shallow groundwater table (within approximately 50 feet below ground surface) or completely saturated soil conditions that will allow positive pore pressure generation.

The liquefaction susceptibility of the onsite subsurface soils was evaluated by analyzing the potential concurrent occurrence of the above-mentioned three basic factors. The liquefaction evaluation for this site was completed under the guidance of Special Publication 117: Guidelines for Evaluating and Mitigating Seismic Hazards in California (CDMG, 1997).

Subsurface soils beneath the site consist of dense to very dense alluvial deposits that are not considered prone to seismic-induced liquefaction. In addition, groundwater was not encountered within the upper 51.5 feet of the ground surface at the time of our exploration and is not anticipated to rise above this level for extended periods of time in the future. As such, the potential for liquefaction at the site is considered low, and therefore potential impacts would be less than significant.

Soil Expansion and Foundations

Based on laboratory test results and the USGS visual manual classification, the near-surface soils within the La Floresta Village site are generally anticipated to possess a Very Low to High expansion potential (UBC Table 18-1-B). Additional testing for soil expansion will be required subsequent to rough grading and prior to construction of foundations and other concrete work to confirm these conditions.

Adverse effects from expansive soils can be readily mitigated through the use of well-reinforced foundations, post-tension slabs, and pre-moistening of supporting surface soils

prior to construction. All grading and construction must conform to the requirements of the Uniform Building Code, with any locally adopted amendments. Mitigation Measure GEO-1 would also require a detailed geotechnical investigation prior to construction, and would reduce this potential impact to a level that is less than significant.

Level of Significance: Potentially significant.

Mitigation Measures: Mitigation Measure GEO-1 would reduce all potential impacts to a level that is less than significant.

Level of Significance after Mitigation: Less than significant.

Birch Hills Site

Liquefaction

Engineering research of soil liquefaction potential (Youd, et al., 2001) indicates that generally three basic factors must exist concurrently in order for liquefaction to occur. These factors include:

- A source of ground shaking, such as an earthquake, capable of generating soil mass distortions.
- A relatively loose silty and/or sandy soil.
- A relative shallow groundwater table (within approximately 50 feet below ground surface) or completely saturated soil conditions that will allow positive pore pressure generation.

The liquefaction susceptibility of the onsite subsurface soils was evaluated by analyzing the potential concurrent occurrence of the above-mentioned three basic factors. The liquefaction evaluation for the Birch Hills site was completed under the guidance of Special Publication 117: Guidelines for Evaluating and Mitigating Seismic Hazards in California (CDMG, 1997).

Subsurface soils beneath a depth of approximately 20 feet below the ground surface consist of dense to very dense Pleistocene-age earth material that are not considered prone to seismic-induced liquefaction. In addition, groundwater is not anticipated within the upper 30 feet of the ground surface. Furthermore, the site is not located within a mapped California Geologic Survey liquefaction hazard zone. As such, the potential for liquefaction at the site is considered low, and therefore potential impacts would be less than significant.

Soil Expansion and Foundations

Based on laboratory test results and the USGS visual manual classification, the near-surface soils within the Birch Hills site are generally anticipated to possess a Low to Medium expansion potential (UBC Table 18-1-B). Additional testing for soil expansion will be required subsequent to rough grading and prior to construction of foundations and other concrete work to confirm these conditions.

Adverse effects from expansive soils can be readily mitigated trough the use of well-reinforced foundations, post-tension slabs, and pre-moistening of supporting surface soils prior to construction. All grading and construction must conform to the requirements of the Uniform Building Code, with any locally adopted amendments. Mitigation Measure GEO-1 would also require a detailed geotechnical investigation prior to construction, and would reduce this potential impact to a level that is less than significant.

Level of Significance: Potentially significant.

Mitigation Measures: Mitigation Measure GEO-1 would reduce all potential impacts to a level that is less than significant.

Level of Significance after Mitigation: Less than significant.

5.5.5 Cumulative Impacts

Both Sites

Geotechnical constraints are site specific concerns, and other developments would not affect geological or soils conditions at these Project sites nor would the proposed Project contribute to cumulative impacts elsewhere. The Project sites have been investigated and the recommended mitigation measures would reduce any potentially significant impacts to less than significant levels. While the proposed development would expose future residents to certain hazards, all of Southern California is exposed to seismic safety hazards. Standard building practices in compliance with existing codes would mitigate such impacts to acceptable levels. In consideration of these factors, the project's contribution to cumulative impacts to, and from, geology and soils would be rendered less than considerable and, therefore, less than cumulatively significant.

Level of Significance: Less than significant.

Mitigation Measures: None are required.

Level of Significance after Mitigation: Not applicable.

5.5.6 Significant Unavoidable Impacts

Both Sites

With the implementation of existing code requirements and the recommended mitigation measure, all potential impacts would be reduced to a level that is less than significant.