21. Geological Hazards

21.1 BACKGROUND AND CONTEXT

21.1.1 Fault Rupture

A fault is a shear or zone of closely associated shears across which earth materials on one side have been displaced with respect to those on the other side because of tectonic forces. A fault is distinguished from those fractures or shears caused by landsliding or other gravity-driven surficial failures. Fault rupture hazards primarily exist along pre-existing faults. These faults are considered to pose a hazard if they have moved within a specific recent period of time. This period depends upon the type of project. For almost all projects, the period of interest is the past 11,000 to 12,000 years. For the siting of critically hazardous facilities, such as atomic power plants, fault activity over longer periods of time needs to be considered. Section 11.1 of the Ventura County General Plan Background Report ("Background Report") provides additional information on major faults located in Ventura County, which are also mapped in Figure 11-1 in Section 11.1 of the Background Report and *County View* and the Ventura County *Resource Management Agency Geographic Information System (RMA GIS) Viewer*.

21.1.2 Ground Shaking

Ground shaking hazards are ubiquitous throughout Ventura County and are addressed in the Ventura County Building Code. Ground shaking hazard areas are areas expected to experience intense ground shaking during a maximum probable earthquake.

The potential for the highest amplification of ground shaking occurs in the Oxnard Plain and the Santa Clara River Valley in the south half of the County, and in the Lockwood, Cuyama, and Cuddy Valleys in the north half. Additional information on ground shaking hazards specific to Ventura County is provided in Section 11.1 of the Background Report.

21.1.3 Liquefaction

Liquefaction can result in settling of roadways, rupture of underground pipelines and cables, and shifting of building foundations. As foundations lose support, buildings and other objects on the ground surface can settle, tilt, and collapse. Lightweight buried structures can float to the surface. Four types of failure commonly result from liquefaction:

- **Lateral spreading:** Lateral movement in a fractured mass of rock or soil, which result from liquefaction or flow of subjacent materials. Commonly developed *adjacent* to channels and riverbanks on slopes between 0.3 and 3 degrees. Movements are commonly several feet, although displacements up to several tens of feet are possible.
- **Flow failure:** Occurs where liquefied soil is present on an original slope usually greater than 3 degrees. Liquefied soil and blocks of solid ground are often displaced many tens of feet at speeds up to several tens of miles per hour and can produce catastrophic effects. Almost all human-made structures are susceptible to damage by flow slides.

- **Ground oscillation:** Occurs when the liquefied layer is present at depth and the slope is too gentle for flow failure or lateral spreading. Ground cracks may open and close, settlement can occur, and sand boils may be present. Overlying structures and particularly sub-grade facilities are commonly damaged through this mode of ground failure.
- **Loss of bearing:** Liquefied soil with little internal shear resistance and ability to support load without deformation. Bearing failures can result in general settlements, tipping or toppling of buildings and the buoyant rise of empty buried tanks.

The liquefaction hazard generally exists throughout the Oxnard Plain and Pleasant Valley. The hazard areas extend up the Ventura and Santa Clara Rivers, mainly in the areas underlain by extensive alluvial deposits. Some of the valleys in the Thousand Oaks area are also affected, as is the Arroyo Santa Rosa downstream of the City of Thousand Oaks-Hill Canyon Wastewater Treatment Plant. Simi Valley is affected at both the east and west ends. Both the upper and lower Ojai Valleys are in the hazard areas as well as San Antonio Creek from Ojai to the Ventura River. The low-lying areas north of Lake Casitas are also subject to liquefaction.

Additional information on liquefaction hazards in Ventura County is provided in Section 11.1 (Figure 11-1 and 11-2) of the Background Report.

21.1.4 Landslide/Debris Flow Hazard

Landslide and debris flow are terms to designate certain forms of natural or human-induced slope failures. The term "landslide" means the dislodging and fall of a mass of soil or rocks along a sloped surface, or the dislodged mass itself. A debris flow is a flow of very wet rock and soil. Included within the definition of this hazard, for the purposes of conducting environmental assessments, are all gravity-induced downslope movements, including the separate phenomena of rockfall, soil creep, soil failures, dry raveling, rotational and transitional slides, flows, slumps and complex combinations of the above phenomena. The hazard applies to both natural and constructed slopes. Contributing factors include erosion, earthquake ground shaking, brush fires, and groundwater.

There are presently two landslide hazards that are distinguished and are required to be assessed for the preparation of the Initial Study Checklist. The first landslide hazard is from mapped or known landslides. The sources of mapped landslides include but are not limited to the Public Works Agency (PWA) files, Dibblee Quadrangle Maps, and the California Geologic Survey (California Division of Mines and Geology) Landslide Evaluation maps. The second landslide hazard is from potential earthquake induced landslide areas as shown on the State of California Seismic Hazard Maps.

Landslide/debris flow hazards potentially exist on all hillside and *adjacent* downslope areas in Ventura County. Additional information on landslide hazards in Ventura County is provided in Section 11.1 of the Background Report.

21.1.5 Subsidence

Subsidence is any settling or sinking of the ground surface over a regional area arising from surface or subsurface causes, such as earthquakes or groundwater and/or oil/gas extraction. Subsidence occurs as a gradual change over a considerable distance (miles), or less commonly, it can occur in discrete zones. Subsidence is in contrast to settlement, a term used to describe site-specific consolidation of strata from an imposed load such as a landfill or from some other man-caused increase in the effective stress conditions of subsurface earth materials.

Subsidence that results from groundwater withdrawal can be responsible for numerous structural effects. Drainage courses, roads, rail lines, wells, oil/gas pipelines, and utility (water, gas, power, and sewer) lines are potentially the most vulnerable to damage. The process by which this most important type of subsidence occurs involves the extraction of a large quantity of water from an unconsolidated aquifer.

Subsidence is any settling or sinking of the ground surface over a regional area arising from surface or subsurface causes, such as earthquakes or groundwater, or oil and gas extraction. Subsidence caused by groundwater withdrawal generally occurs in valley areas underlain by alluvium. Groundwater extraction has contributed to subsidence in the Oxnard Plain, the Las Posas Valley, and the Santa Clara River Valley.

21.1.6 Expansive Soils

Expansive soils are primarily clay-rich soils subject to changes in volume with changes in moisture content. The resultant shrinking and swelling of soils can influence all fixed structures, utilities and roadways. Included within the definition of expansive soils are certain bedrock formations with expansive rock layers or zones and weathered horizons. In addition, as expansive soil on sloping ground expands and contracts, it tends to move down slope in response to gravity.

Expansive soils are present throughout most areas of Ventura County, including both low-lying and hillside terrain. They are present in some areas in thick accumulations and in others as a thin cover. Beaches, sea cliffs, bare rock and active stream channels are usually free of expansive soil accumulations. Additional information on expansive soils in Ventura County is provided in Section 11.1 of the Background Report.

21.1.7 Seiche and Tsunami Hazards

A seiche is a standing wave oscillating in a body of water. Seiches typically occur in lakes and bays, and are normally caused by unusual tides, winds or currents, but can also be produced by earthquake ground motion. The primary hazards resulting from a seiche are to structures and boats in or very near a lake, harbor or bay. Only in the case of a severe seiche or unusual circumstances would loss of life be likely from the seiche itself. Large seiches can overtop the dams of man-made lakes or reservoirs, causing flood in the areas downstream. This overtopping can also wash out unprotected earth-fill dams, causing their complete collapse.

Areas subject to seiche hazards are typically those located within 20 feet of vertical elevation from a smaller enclosed body of water such as a bay, lake or reservoir. The height of hazard above the water level is dependent on the ground motion intensity, duration of shaking, and subsurface topography of the bay, lake or reservoir.

There is no record of a seiche that resulted in damage in Ventura County. As such, the actual threat that is posed by seiches in Ventura County is small, in that it is probably the most remote of the hazards studied, although it may not be the least severe.

Tsunamis are giant waves caused by earthquakes or volcanic eruptions under the sea. They can cause loss of life from drowning and extensive damage to structures on or near beaches and river mouths. There can also be an increased occurrence of fire from broken oil or gas tanks or lines, as well as flooding from blocked rivers. The tsunami hazard is mainly confined to the immediate beach areas and river mouths.

As shown in Table 11-3 in Section 11.2 of the Background Report, there have been eight notable tsunami event run-ups recorded in Ventura County.

21.2 THRESHOLDS OF SIGNIFICANCE

The determination of significance shall be made on a case-by-case basis and evaluated using the following thresholds of significance as specified below. State CEQA Guidelines Section 15126.2(a) provides guidance for when and how the effects of locating projects in hazardous or vulnerable locations should be analyzed under CEQA. A *Lead Agency* is not required to perform "reverse CEQA analysis" by analyzing the impacts of the existing environment on the project and its future users unless the project has a reasonably foreseeable risk of causing or exacerbating existing environmental hazards by bringing development or people into the area affected. Within this analytical framework, State CEQA Guidelines Section 15126.2(a) states that "the EIR should evaluate any potentially significant direct, indirect, or cumulative environmental impacts of locating development in areas susceptible to hazardous conditions . . . including both short-term and long-term conditions, as identified in authoritative hazard maps, risk assessments or in land use plans addressing such hazards areas." The thresholds of significance in this section should be interpreted and applied in accordance with this guidance.

GEO-1 A project may have a significant impact if it would directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map, strong seismic ground shaking, or seismic-related ground failure.

GEO-2 A project may have a significant impact if it would be located on a geologic unit or soil that is unstable or cause the geologic unit or soil to become unstable as a result of the project, and directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving on- or off-site liquefaction, *lateral spreading*, landslide/debris flow, subsidence, or collapse.

GEO-3 The project may have a significant impact if it would cause potential substantial adverse effects, including the risk of loss, injury, or death involving soil expansion if the project is located within a soils expansive hazard zone or where soils with an expansion index greater than 130 are present.

GEO-4 The project may have a significant impact if it would expose people or structures, either directly or indirectly, to a significant risk of loss, injury, or death involving seiche hazard if the project is located within 20 feet of vertical elevation from an enclosed body of water, such as a lake or reservoir or within a tsunami inundation hazard zone.

21.3 IMPACT ANALYSIS

Projects that involve new construction or grading within a hillside or area containing a geologic hazard as described in Section 11.1 of the Background Report shall retain a geotechnical engineer and/or qualified engineering geologist to prepare a geotechnical and/or geologic report. The project's qualified geotechnical engineer and/or qualified engineering geologist must apply all applicable regulatory requirements to the seismic design of the project. For projects that are not regulated by the Ventura County Building Code, the project should incorporate customary

industry practices and materials, or the geotechnical and/or geologic report must address and provide design recommendations to reduce seismic hazards.

Proposed structures, including nonstructural components that are permanently attached to structures and their supports and attachments, must be reviewed and evaluated in light of the requirements of the Ventura County Building Code and the geotechnical and/or geologic report regarding seismic effects like earthquake ground shaking. The evaluation must use minimum design criteria for structures appropriate to their primary function and use, taking into consideration the need to protect the health, safety, and welfare of the general public by minimizing seismic-related risk to life, and to improve the capability of essential (or critical) facilities to function during and after seismic events.

The report by the qualified geotechnical engineer and/or engineering geologist must be submitted to the PWA for review and use in completing the Initial Study Checklist.

Guidance on addressing the questions from the Initial Study Checklist is provided below. In order to determine whether project impacts exceed or meet the criteria of the thresholds of significance in Section 21.2, the level of impact shall be evaluated based on the appropriate assessment methodologies as outlined below.

(a) Would the project directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map, strong seismic ground shaking, seismic-related ground failure?

Earthquake Fault Zones

Earthquake Fault Zones, which are also known as Alquist-Priolo Earthquake Fault Zones, are regulatory zones that encompass traces of Holocene-active faults[10] to address hazards associated with surface fault rupture. Earthquake Fault Zones are delineated by the State Geologist and implemented by public agencies through permitting, inspection, and land use planning activities.

The project applicant, working with consultants retained by the applicant, shall determine whether the project is within or near an Earthquake Fault Zone. For projects that are not within or near a designated Earthquake Fault Zone, a determination of **No Impact (N)** shall be made.

If the project lies within or near a designated Earthquake Fault Zone, the project applicant shall obtain a geologic fault investigation report addressing the Holocene-active fault rupture hazard and potential surface deformation. If the fault investigation report is required by appropriate law or ordinance, or in accordance with standard practices, such report must address the potential fault rupture hazard. Significance determinations shall be based on the following conclusions of such reports.

- If the proposed habitable structures are free of potential hazards from surface fault rupture and surface deformation, a determination of **Less than Significant Impact (LS)** shall be used to complete this item in the Initial Study Checklist.

[10] "Holocene" is an epoch of the Quaternary period, from the end of the Pleistocene, approximately 11,700 years ago, to the present time. A Holocene-active fault is a fault that has had surface displacement within Holocene time (i.e., the last 11,700 years).

- If the proposed habitable structures at the project site are subject to hazard from surface fault rupture and/or surface deformation, but that the amount of rupture or surface distortion may be mitigated by various methods including structural design or relocation within the project site, a determination of **Less Than Significant with Mitigation Incorporated (LS-M)** shall be used to complete this item in the Initial Study Checklist.
- If there is *substantial evidence* that the proposed habitable structures at the project site are subject to hazards from surface fault rupture and surface deformation, a determination of **Potentially Significant Impact (PS)** shall be made, and further analysis shall be addressed in an EIR.

The project applicant shall submit the geologic fault investigation report to the PWA which shall review for adequacy and use it for the completion of the appropriate sections of the Initial Study Checklist. The fault investigation report must be prepared by a Professional Geologist following the outline of the appropriate California Geological Survey (formerly California Division of Mines and Geology) Special Publication 42 or as agreed by the PWA.

Cumulative Impacts

There is no cumulative impact from fault rupture hazards that would occur as a result of past, present, and reasonably foreseeable probable future projects.

(b) Would the project be located on a geologic unit or soil that is unstable or cause the geologic unit or soil to become unstable as a result of the project, and directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving on- or off-site liquefaction, lateral spreading, landslide/debris flow, subsidence, or collapse?

Liquefaction

The State of California has produced the Seismic Hazard Zone Maps, including potential for liquefaction, based on the Quaternary Geology of Ventura County, water well records for material type and density, and highest groundwater elevations. Figures 11-1 and 11-2 in Section 11.1 of the Background Report and *County View* and the Ventura County *Resource Management Agency Geographic Information System (RMA GIS) Viewer* show fault and liquefaction zones in Ventura County based on the maps from the State of California.

A determination of whether the project is in a zone of required investigation for liquefaction shall be performed by the project applicant's technical consultants.

Projects located in mapped zones of required investigation for liquefaction must be evaluated for liquefaction potential defined in Public Resources Code Section 2693(c). The liquefaction evaluation shall be completed and summarized in a report subject to review and acceptance by the PWA.

The liquefaction evaluation must be conducted in accordance with the requirements of the Guidelines for Evaluating and Mitigating Seismic Hazards in California, Special Publication 117A, latest edition, prepared by the California Geological Survey. Liquefaction evaluations should also discuss the type(s) of liquefaction failure and the most likely to occur, such as *lateral spreading*.

Landslide

Evaluation and mitigation of landslide/debris flow hazard is subject to the provisions of the Ventura County Building Code administered by PWA and Resource Management Agency, Building and Safety Division. Site-specific, detailed geologic investigations are required as a part of all development

projects in the hillside areas of Ventura County for the purpose of determining development feasibility with respect to geologic hazards. If a site-specific geology report prepared by the applicant has analyzed this concern, the report shall be reviewed to determine the significance of any potential landslide/debris flow impacts resulting from the project. Additional means of evaluating this hazard include site reconnaissance, review of aerial photographs and review of published geologic literature and unpublished consultant studies.

The PWA, based on review of the various available maps, publications and/or field information, shall determine the general potential for landslides/debris flow.

Subsidence

The project applicant shall determine if the project is within a subsidence hazard zone. The project applicant, in consultation with the *Lead Agency*, shall complete a preliminary subsidence assessment to determine whether a full subsidence evaluation is required. Projects that are within the limits of a probable subsidence zone and involve extraction of groundwater, oil, or gas, or are sensitive to slight changes in surface gradients, will be required to have a geologic/geotechnical report evaluate the potential subsidence hazards resulting from the project. Subsidence evaluation reports shall be reviewed by PWA based on the latest available maps, publications and field data.

Preparation of the Initial Study Checklist

A determination of **No Impact (N)** shall be made if the project:

- Is not within a zone of required investigation for liquefaction.
- Is not within a hillside area and not affected by potential landslide or debris flow.
- Is not within a known subsidence hazard zone or do not relate to oil, gas, or groundwater withdrawal.

A determination of **Less Than Significant Impact (LS)** shall be made if the project:

- Indicates liquefaction hazards do not exist, or the effects of liquefaction do not require any mitigation.
- Indicates sufficient project slope stability factors of safety have been obtained.
- Indicates that it is not sensitive to slight changes in gradient or slope resulting from subsidence and the project does not extract oil, gas or water from the earth.

A determination of **Less Than Significant with Mitigation Incorporated (LS-M)** shall be made if:

- Liquefaction hazards are present and recommendations acceptable to the PWA are provided to mitigate the potential liquefaction hazards.
- The project is within a mapped landslide or earthquake induced landslide zone or immediate to these areas and recommendations are provided to mitigate the potential hazards.
- The project is within the limits of the probable subsidence zone that are sensitive to slight changes in gradient or slope and/or will extract oil, gas or water from the earth, and recommendations are provided to mitigate the potential hazards to less than significant levels.

A determination of **Potentially Significant Impact (PS)** shall be made, and further analysis shall be addressed in an EIR if there is *substantial evidence* that the project would directly or indirectly cause

potential substantial adverse effects, including the risk of loss, injury, or death involving on- or off-site liquefaction, *lateral spreading*, landslide/debris flow, subsidence, or collapse.

(c) Would the project cause potential substantial adverse effects, including the risk of loss, injury, or death involving soil expansion if the project is located within a soils expansive hazard zone or where soils with an expansion index greater than 130 are present?

For geotechnical reports that evaluate the soil expansion of the project area, the expansion index shall be determined by the latest edition of American Society for Testing and Materials (ASTM) D4829 and in the event that soil expansion varies with depth, the weighted index shall be determined in accordance with the method prescribed in the Ventura County Building Code.

For projects that contain near surface soils with an expansion index less than 20, a determination of **No Impact (N)** shall be used to complete this item in the Initial Study Checklist.

If the project lies in an area of expansive soils that have an expansion index that is:

- Between 20 and 130, and a geotechnical report provides design recommendations for expansive soils, a determination of **Less than Significant Impact (LS)** shall be used to complete this item in the Checklist.
- Greater than 130 and a geotechnical report has been prepared that provides mitigation recommendations for the expansive soils, a determination of **Less Than Significant with Mitigation Incorporated (LS-M)** shall be used to complete this item in the Checklist.
- Greater than 130 and there is *substantial evidence* that the project could result in potentially substantial adverse effects, including the risk of loss, injury, or death involving soil expansion, a determination of **Potentially Significant Impact (PS)** shall be made, and further analysis shall be addressed in an EIR.

(d) Would the project expose people or structures, either directly or indirectly, to a significant risk of loss, injury, or death involving seiche hazard if the project is located within 20 feet of vertical elevation from an enclosed body of water, such as a lake or reservoir or within a tsunami inundation hazard zone?

A preliminary assessment should be completed by the project applicant's technical consultant to determine whether the project is located within 20 feet of elevation from an enclosed body of water or within a tsunami inundation hazard zone.

For projects located near known tsunamis or seiche hazard areas, the geologist and geotechnical engineer should evaluate potential seiche and/or tsunami effects during the preliminary design of structures. The evaluation should consider the inundation effects and hazards of seiche and tsunamis, such as, but not limited to, whether the project would exacerbate risks of exposure to leaks or spills of hazardous materials, hazardous waste, or other pollutants into the environment. The evaluation report shall be reviewed by the PWA for adequacy and in determining the significance of the hazard.

If the project is not located within an area subject to seiche or tsunami hazards, a determination of **No Impact (N)** shall be used to complete this item in the Initial Study Checklist.

A determination of **Less Than Significant Impact (LS)** shall be made if the project is located within an area subject to tsunami or seiche hazards, and the project design complies with regulatory standards and requirements which would avoid or minimize adverse environmental effects.

A determination of **Less Than Significant with Mitigation Incorporated (LS-M)** shall be made if the project is located within 20 feet of elevation from an enclosed body of water or an area subject to tsunami or seiche hazards, and would expose people or structures, either directly or indirectly, to a significant risk of loss, injury, or death. However, mitigation measures have been identified and will be implemented as part of the project to reduce adverse effects to a less-than-significant level.

A determination of **Potentially Significant Impact (PS)** shall be made and further analysis shall be addressed in an EIR if there is *substantial evidence* that the project is located within 20 feet of elevation from an enclosed body of water or an area subject to tsunami or seiche hazards, and there is *substantial evidence* that the project could result in potentially substantial adverse effects, including the risk of loss, injury, or death involving a tsunami or seiche.

21.4 RESOURCES & REFERENCES

Source	Managing Agency/Organization	Online Access
Resources		
Ventura County CEQA Implementation Manual	Ventura County Resource Management Agency (RMA) Planning Division	PDF | Website
Ventura County Initial Study Assessment Guidelines, Introduction	Ventura County RMA Planning Division	PDF | Website
Ventura County Initial Study Checklist Template	Ventura County RMA Planning Division	PDF | Website
References		
California Earthquake Hazards Zone Online Map Application	California Department of Conservation, California Geological Survey	Website
California Environmental Quality Act	California Governor's Office of Land Use and Climate Innovation, formerly Office of Planning and Research	Website
California Geological Survey Information Warehouse (contains hazard maps)	California Department of Conservation, California Geological Survey	Website
California Regional Geologic Maps	California Department of Conservation, California Geological Survey	Website
California Seismic Hazard Zones	California Department of Conservation, California Geological Survey	Website
County View	Ventura County Geographic Information Systems	Website
Guidelines for Evaluating and Mitigating Seismic Hazards in California, Special Publication 117A	California Department of Conservation, California Geological Survey	Website
Standard Test Method for Expansion Index of Soils D4829	American Society for Testing and Materials (ASTM)	Website
Ventura County Building Code	Ventura County RMA Building and Safety Division	Website

Source	Managing Agency/Organization	Online Access
Ventura County General Plan Background Report, Chapter 11	Ventura County RMA Planning Division	PDF | Website
Ventura County RMA Geographic Information Systems Viewer	Ventura County Information Technology Services	Website
Ventura County Tsunami Hazard Areas	California Department of Conservation, California Geological Survey	Website