

4.5 GEOLOGY AND SOILS

This chapter summarizes information on geology, soils and seismic hazards, and mineral resources in the project area, as well as potential area-wide geologic hazards and regional seismic characteristics that are relevant to development within the Specific Plan Area. An evaluation of the impacts of adoption and implementation of the Specific Plan with regard to these potential hazards and resources follows.

Included is a discussion of potential impacts and mitigations for development. Certain conditions, such as weak or erosive soils, may be practically mitigated through suitable grading, foundation engineering, and drainage controls, while other impacts such as the impact from seismic shaking can only be mitigated to an acceptable standard or level of risk. Most geologic impacts result from the active tectonic setting of the region with its location on the margin between the Pacific and North American Tectonic Plates. Soils are especially influenced by climate and both historical and recent changes in land use and vegetation patterns.

A. Regulatory Framework

This section summarizes existing State and City of Santa Rosa policies and regulations that apply to the geology, soils and mineral resources of the Specific Plan Area.

1. State Laws and Regulations

a. Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act was passed by the California Legislature in 1972¹ to mitigate the hazard of surface faulting to structures. The act's main purpose is to prevent the construction of buildings used for human occupancy on the surface trace of active faults. The act addresses only the hazard of surface fault rupture and is not directed toward other earthquake hazards. Local agencies must regulate most development in fault zones

established by the State Geologist. Before a project can be permitted in a designated Alquist-Priolo Earthquake Fault Zone, the city or county with jurisdiction must require a geologic investigation to demonstrate that proposed buildings would not be constructed across active faults.

b. California Seismic Hazards Mapping Act

The California Seismic Hazards Mapping Act of 1990² (California Public Resources Code Sections 2690-2699.6) addresses seismic hazards other than surface fault rupture, such as liquefaction and seismically induced landslides. The Seismic Hazards Mapping Act specifies that the lead agency for a project may withhold development permits until geologic or soils investigations are conducted for specific sites and mitigation measures are incorporated into project plans to reduce hazards associated with seismicity and unstable soils.

c. California Building Code

The California Building Code (CBC) of 2001 has been adopted by most jurisdictions in California to oversee construction. The CBC defines four Seismic Zones in California, which are ranked according to their seismic hazard potential. Zone 1 has the least seismic potential and Zone 4 has the highest seismic potential. The Bay Area is located in Seismic Zone 4 and thus development is required to comply with all design standards applicable to Seismic Zone 4.

The earthquake protection law (California Health and Safety Code section 19100 et seq.) requires that structures be designed to resist stresses produced by lateral forces caused by wind and earthquakes. Specific minimum standards for seismic safety and structural design to meet earthquake protection requirements are set forth in Chapter 16 of the CBC.

¹ California Department of Conservation's website. <http://www.consrv.ca.gov/CGS/rghm/ap/index.htm>, accessed on November 4, 2006.

² California Department of Conservation's website. <http://www.consrv.ca.gov/CGS/shzp/article10.htm>, accessed on November 4, 2006.

d. Surface Mining and Reclamation Act

The California Surface Mining and Reclamation Act of 1975 (SMARA) was enacted in response to land use conflicts between urban growth and essential mineral production. SMARA requires the State Geologist to classify land according to the presence or absence of significant mineral deposits. Local governments must consider this information before land with important mineral deposits is committed to land uses incompatible with mining.

SMARA provides for the evaluation of an area's mineral resources using a system of Mineral Resource Zone (MRZ) classifications that reflect the known or inferred presence and significance of a given mineral resource.

- ◆ MRZ-1. Areas where adequate information indicates that no significant mineral deposits are present, or where it is judged that little likelihood exists for their presence.
- ◆ MRZ-2. Areas where adequate information indicates that significant mineral deposits are present, or where it is judged that a high likelihood for their presence exists.
- ◆ MRZ-3. Areas containing mineral deposits, the significance of which cannot be evaluated from available data.
- ◆ MRZ-4. Areas where available information is inadequate for assignment into any other MRZ.

2. Local Regulations and Policies

a. City of Santa Rosa General Plan Health and Safety Element

The intent of the Health and Safety Element is to identify and evaluate natural and human-made hazards that are present or potentially present in the community, and to establish goals, policies and actions necessary to reduce those hazards to acceptable levels. Hazards discussed in the element include seismic hazards, such as earthquakes, soil erosion and landslide hazards. The following lists applicable General Plan goals and policies most pertinent to the Specific Plan.

Goal NS-C: Prohibit development in high-risk geologic and seismic hazard areas to avoid exposure to seismic and geologic hazards.

- ◆ **Policy NS-C-1:** Prior to development approval, require appropriate geologic studies to identify fault trace locations within active fault zones as designated by the provisions of the Alquist-Priolo Earthquake Fault Zoning Act. California registered geologists or engineers must conduct these studies and investigation methodologies must comply with guidelines set forth by the Alquist-Priolo Earthquake Fault Zoning Act.
- ◆ **Policy NS-C-2:** Require comprehensive geotechnical investigations prior to development approval, where applicable. Investigations shall include evaluation of landslide risk, liquefaction potential, settlement, seismically-induced landsliding, or weak and expansive soils. Evaluation and mitigation of seismic hazards, including ground shaking, liquefaction, and seismically-induced landslides, shall comply with guidelines set forth in the most recent version of the California Division of Mines and Geology (CDMG) Special Publication 117.
- ◆ **Policy NS-C-3:** Restrict development from areas where people might be adversely affected by known natural or manmade geologic hazards. Hazards might include unstable slopes, liquefiable soils, expansive soils or weak poorly engineered fills, as determined by a California registered geologist or engineer.
- ◆ **Policy NS-C-4:** Restrict development of critical facilities—such as hospitals, fire stations, emergency management headquarters, and utility lifelines, including broadcast services, sewage treatment plants, and other places of large congregations—in areas determined as high risk geologic hazard zones (e.g. Rodgers Creek Fault zone, liquefiable soils, areas of slope instability).
- ◆ **Policy NS-C-5:** Require identification and evaluation of existing structural hazards related to unreinforced masonry, poor or outdated construction techniques, and lack of seismic retrofit. Abate or remove any structural hazard that creates an unacceptable level of risk, including re-

quiring post-earthquake building inspections and restricting entry into compromised structures.

- ◆ **Policy NS-C-6:** Require appropriate and feasible seismic retrofit, as determined by a registered structural engineer, of commercial, industrial and public buildings that are not currently retrofitted and are located within areas determined to experience strong ground shaking during an earthquake.
- ◆ **Policy NS-C-7:** Require inspection for structural integrity of water storage facilities, water conveyance facilities, electricity transmission lines, roadways, water detention facilities, levees and other utilities after a major seismic event, especially on the San Andreas or Rodgers Creek faults.
- ◆ **Policy NS-C-8:** Adopt mandatory, minimum erosion control measures for current properties and those under construction that exhibit high erosion potential, are in areas of steep slopes, or have experienced past erosion problems. Control measures shall reduce soil erosion from primary erosional agents, including wind, construction operations, and storm water runoff.

b. Association of Bay Area Governments (ABAG) Multi-Jurisdictional Local Hazard Mitigation Plan for the Bay Area, City of Santa Rosa

The Disaster Mitigation Act of 2000 (DMA 2000) was signed into law by the President of the United States on October 30, 2000.³ It places new emphasis on local mitigation planning to promote a proactive disaster preparedness approach and reduce the growing cost of disaster relief efforts by the Federal Emergency Management Agency (FEMA). It requires State and local jurisdictions to develop Hazard Mitigation Plans to qualify for specific post disaster grants. The Plans must identify measures that will be undertaken before natural disasters occur to reduce the level, frequency and cost of damage and harm occurring from such events.

³ North Carolina Division of Emergency Management's website. http://www.dem.dcc.state.nc.us/PA/dma_2000_detail.htm, accessed on November 4, 2006.

ABAG has developed a Multi-Jurisdictional Local Hazard Mitigation Plan for the Bay Area that was adopted on March 17, 2005. The Santa Rosa City Council has adopted (Resolution No. 26562 on May 16, 2006) the ABAG document *Taming Natural Disasters* as the City's Hazard Mitigation Plan.⁴

c. Building Code

Chapter Title 18 of the Santa Rosa Municipal Code addresses general building and construction practices and lists requirements. Building and construction is required to be in accordance with the California Building Code Volumes 1 & 2, 2001 Edition, published by the International Conference of Building Officials and the California Building Standards Commission. Review and abatement of existing buildings considered seismic hazards is included under Chapter 18-48.

d. Grading and Soils Ordinances

Chapter Title 19 of the City of Santa Rosa Municipal Code discusses grading and soils requirements for structural foundations. Provisions include completion of a preliminary soils report prepared by a licensed civil engineer based upon adequate test borings or excavations of the subdivision. This may be waived if the Chief Building Official determines that critically expansive soil or other soils problems that could lead to structural defects do not exist. If the soils report indicates the presence of critically expansive soil or other soil problems which, if not corrected, would lead to structural damage, the City requires a complete soils investigation for each lot in the subdivision prepared by a licensed civil engineer. This report is required to include recommended corrective actions to prevent structural damage to proposed structures. The report and investigation are conditions of approval for subsequent plan level and building permits.

⁴ Association of Bay Area Governments' website. <http://quake.abag.ca.gov/mitigation/plan.html>, accessed on November 4, 2006.

e. Santa Rosa Storm Water Mitigation Plan

In 1997, Santa Rosa was issued a joint National Pollutant Discharge Elimination System (NPDES) permit with the County of Sonoma and Sonoma County Water Agency (SCWA) by the regional water quality control board (RWQCB). The NPDES permit identifies the Storm Water Management Plan (SWMP) implemented by the City to control and eliminate storm water pollution discharge. The City must comply with the provisions of the permit by ensuring that new development and redevelopment mitigate water quality impacts to storm water runoff both during construction and operation periods of projects.

Under direction from the SWRCB, the City prepared a Standard Urban Storm Water Mitigation Plan (SUSMP). The SUSMP was developed in 2003 as a part of the NPDES permit for the City of Santa Rosa, the County of Sonoma and the SCWA. The purpose of the SUSMP is to manage the quality and quantity of storm water runoff in the Santa Rosa area and to aid in the conservation of natural areas in the region. The SUSMP describes and evaluates various “Best Management Practices” (BMPs) for storm water management and outlines procedures for BMP maintenance and inspection. Both private-sponsored and public capital improvement projects in the Santa Rosa area are governed by SUSMP requirements.

Additionally, a Notice of Intent (NOI) with the RWQCB is required to be covered under the State NPDES General Construction Permit for discharges of storm water associated with construction activity. A developer must propose control measures that are consistent with the State General Permit. A Storm Water Pollution Prevention Plan (SWPPP) must be developed and implemented for each site covered by the general permit. A SWPPP should include SUSMP BMPs designed to reduce potential impacts to surface water quality during construction of the project.⁵

⁵ Public Works Department. *Storm Water Management Plan*. City of Santa Rosa. (<http://ci.santa-rosa.ca.us/default.aspx?PageID=1171>), accessed on November 6, 2006.

B. Existing Conditions

This section discusses the existing geological and soil conditions of the Specific Plan Area and its immediate surroundings.

1. Regional Seismicity

The Specific Plan Area lies in the tectonically active Coast Ranges Geomorphic Province of Northern California, on the plain of Santa Rosa Creek. Northwest to southeast trending ridges and valleys are common in the area. This alignment is strongly influenced by active tectonics along the boundary between the North American and Pacific Tectonic Plates delineated by the San Andreas Fault System. Active deformation is expressed along this boundary margin through discrete movement along various faults, movement that generates earthquakes.

Sonoma County faults are characterized by both strike-slip or horizontal displacement and dip-slip or vertical displacement. Some faults strike northwest-southeast and include several fault strands in a broad zone, while others are represented by a single actively creeping fault trace. Displacement along a fault trace or series of fault traces generates an earthquake. Over long periods of time the fault traces accommodating movement and active deformation within a fault zone change. Some traces become inactive as movement is accommodated along other traces. The frequency of recent fault rupture can be determined from fault trenching, geomorphic mapping, seismic refraction studies and other techniques and is a good indicator of future earthquakes, especially where there is good exposure. However, since earthquakes sometimes result from rupture along historically inactive or even buried faults their exact location can be difficult to predict.

Major active faults located within 30 miles of the Specific Plan Area are the Rodgers Creek, San Andreas, Maacama and Hayward Faults.⁶ Each of these faults is capable of producing a large earthquake that could result in strong

seismic shaking of the site. The nearest mapped active fault trace to the Specific Plan Area is the Rodgers Creek fault, which passes approximately 3,000 feet east of the Specific Plan Area. Other nearby active faults includes the Maacama fault (10 miles north), San Andreas Fault (19 miles southwest) West Napa fault (26 miles southeast), Green Valley fault (29 miles east) and Hayward fault (35 miles southeast). These faults are identified in Figure 4.5-1.

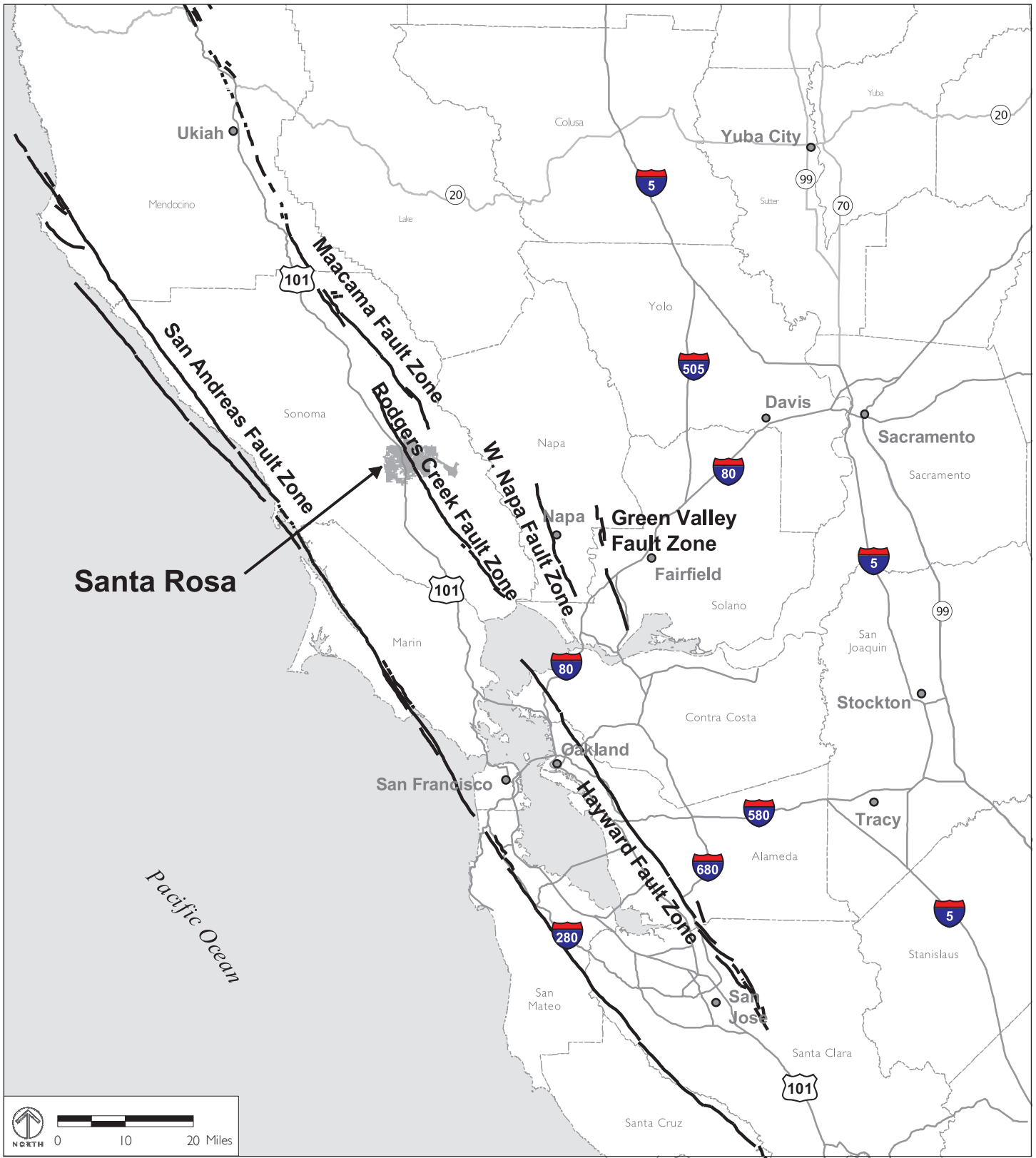
Major seismic events in the region that have resulted in moderate to strong ground shaking of the site include the 1868 Hayward earthquake of estimated magnitude 7.0, the great 1906 San Francisco earthquake of approximate magnitude 7.9, the 1969 5.6 and 5.7 earthquakes in Santa Rosa, and the 1989 Loma Prieta Earthquake of magnitude 6.9. A recent earthquake of magnitude 5.2 on the nearby West Napa fault on September 3, 2000, near the town of Yountville, reportedly caused between 15 and 70 million dollars in losses, mostly in Napa, while little or no damage was reported in Santa Rosa.

2. Regional Geology

The Geologic Map of the Santa Rosa Quadrangle shows the site is located on the alluvial plain of Santa Rosa Creek.⁷ The area is underlain by recent Holocene age alluvium (deposited in the last 11,000 years) while also being bordered by older Pleistocene age alluvial fan and terrace deposits of the Huichica Formation and Glenn Ellen Formation that are dated to between 11,000 years and 2 million years before present. Most sediment has been eroded and washed from neighboring Pliocene age rocks of the Sonoma Volcanic formation that is thought to underlie alluvium at depth. These volcanic deposits of basalt, andesite, rhyolite and volcanic tuff are common in the Sonoma Mountains east of the site. The volcanics are thought to have intruded

⁶ Association of Bay Area Governments' website. <http://quake.abag.ca.gov/faults/>, accessed on November 4, 2006.

⁷ California Division of Mines and Geology, 1980, *Geology for Planning in Sonoma County*.



Source: USGS web site <http://quake.usgs.gov/>, accessed November 16, 2006. USGS Disclaimer: Because of the large number of faults in California and Nevada, the faults shown on these maps do not constitute an exhaustive collection. They were chosen typically because they are larger and/or exhibit more recent offset than others. However, our understanding of faults is constantly expanding, and new faults and better data may be added to these maps as our knowledge about these structures advances. These maps should not be considered as zoning guides, nor be used for risk assessment.

FIGURE 4.5-1

REGIONAL FAULTS

through the older Cretaceous to Jurassic age rocks of the Franciscan Formation between 5 and 2 million years ago. The older Franciscan Complex rocks of estimated age between 64 million and 180 million years are commonly found west of the Santa Rosa Plain in the coastal mountains and along the ridgeline of the Sonoma Mountains. Intermediate Pliocene age sedimentary deposits of both the non-marine Petaluma Formation and marine Wilson Grove Formation show that the area was subject to rising and falling sea level that throughout the late Cenozoic era and into the Pleistocene.

The Franciscan complex is composed of weakly to strongly metamorphosed greywacke (sandstone), argillite, limestone, basalt, serpentinite, chert and other rocks.⁸ This rock was accreted onto the edge of the North American continent during the long period of active subduction of the Pacific Plate beneath the North American Plate. The formation is derived from Jurassic oceanic crust and pelagic deposits that are overlain by Late Jurassic to Late Cretaceous sedimentary deposits. Metamorphic grade in this rock is highly variable which reflects the complicated history of the Franciscan.

Since the late Cenozoic era, subduction has been replaced by transform faulting along faults of the San Andreas System. There has also been major climate change and dramatic rising and lowering of sea level. Due to the complex geologic history of the area there is a wide variety of volcanic rocks and sedimentary rocks of varying metamorphic grade to be found in the region. These units are often juxtaposed along ancient fault contacts and the structure is complicated by not only ancient deformation, but by active fault deformation. Imprinted on this geology is the drainage pattern of the Santa Rosa Creek Watershed.

⁸ U.S. Geological Survey's website. <http://pubs.usgs.gov/mf/2000/2337/mf2337g.pdf>, accessed on November 4, 2006.

3. Site Geology

An area geologic map shows two units mapped within the Specific Plan area.⁹ Young alluvial fan deposits (Qyf) of Quaternary age are mapped north of Santa Rosa Creek and south of the creek west of Roberts Avenue, while the remainder of the plan area south of the creek is mapped as old alluvial fan deposits (Qof) of Quaternary Age (greater than 10,000 years old and less than 2 million years old). The younger fan deposits are described as consisting of moderately sorted fine sand and silt with gravel. Older deposits are described as deeply weathered and poorly sorted coarse sand and gravel.

The older deposits are coarser since they are nearer the sediment source, while the more distal and younger deposits are likely comprised of the finer fraction of sediment washed from the older deposits. Since the area has been developed these deposits are likely to have been significantly graded and there is also a significant volume of imported fill in developed areas that may have a totally different composition.

More detailed geotechnical information will need to be obtained during completion of site design level geotechnical reports completed for developments within the Specific Plan Area. During the site visit on January 17, 2006, soils in the vicinity of the railroad track were generally observed to be silty and able to pond water.

4. Site Soils

According to the Sonoma County Soils Survey¹⁰, the Specific Plan Area north of Santa Rosa Creek is underlain by Yolo Silty Loam (YsA), while the area south of the creek is underlain by the Zamora Silty Clay Loam. Deposits within the channel were mapped as river wash.

⁹ United State Geologic Survey, 1973, *Preliminary Geologic Map of Eastern Sonoma County and Western Napa County (USGS MF-483, 1973)*.

¹⁰ United States Department of Agriculture (USDA) Soil Conservation Service (SCS), 1972, *Soil Survey for Sonoma County*.

Yolo soils are well drained loams underlain by recent alluvium derived from sandstone and shale. Zamora soils are described as well-drained clay loams underlain by alluvium from mixed sedimentary sources. Prior to urbanization these soils would have been considered good for orchards, vineyards, row crops and truck crops. A significant difference is that soils of the Zamora series have high shrink swell potential, compared to low to moderate potential for soils of the Yolo series. With higher clay content soils of the Zamora Series may not drain as well and could promote ponding and more runoff. River wash is composed of recent deposits of gravel, sand and silt. These soils are depicted in Figure 4.5-2.

5. Mineral Resources

According to the Santa Rosa General Plan, no significant mineral resources are identified with the Specific Plan Area.

C. Standards of Significance

The Specific Plan would have a significant impact with regard to geological and soil conditions if it would:

- a. Expose people or structures to 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 issued by the State Geologist for the area or based on other substantial evidence of a known fault;
 - ◆ Strong seismic ground shaking;
 - ◆ Seismic-related ground failure, including liquefaction; or
 - ◆ Landslides.
- b. Result in substantial soil erosion or the loss of top soil.

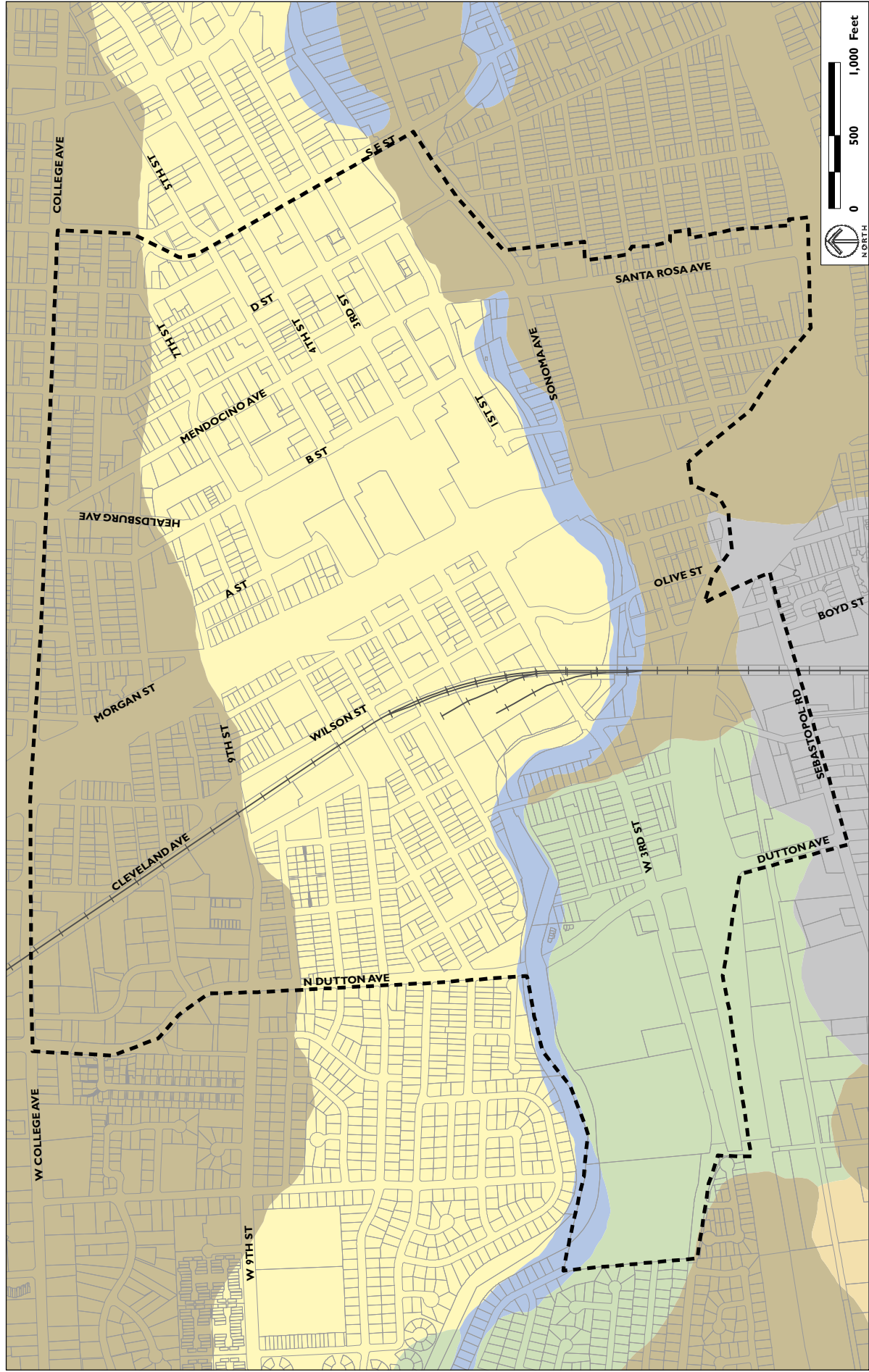


FIGURE 4.5-2

SOILS

- Specific Plan Area
- Railroad
- Riverwash (RnA)
- Yolo Loam (YoB)
- Yolo Gravelly Loam (YrB)
- Yolo Silty Loam (YsA)
- Yolo Clay Loam (YrC)
- Zamora Silty Clay Loam (ZaA)

- 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 Uniform Building Code (1997), creating substantial risks to life or property.
- e. Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater.
- f. Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state.
- g. Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan.

D. Impact Discussion

This section analyzes potential geological impacts for the Specific Plan Area. This discussion is organized by and responds to each of the potential impacts identified in the Standards of Significance.

1. Project Impacts

- a. Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving: fault rupture, strong seismic ground shaking and seismic-related ground failure, such as liquefaction or landslides.

i. Ground Rupture

The potential impact from fault rupture is that ground movement along a fault cause tearing apart, cracking, or other damage that will destroy or severely undermine structures built on or in close proximity to a fault. Such

damage would result in major property damage and could endanger the life and health of any occupants.

The Alquist-Priolo Earthquake Fault Zoning Act of 1972 initiated a program of mapping active and potentially active faults. Active and potentially active faults in Sonoma County have undergone extensive investigation in the past. ABAG has summarized results from many of these studies to quantify the potential impact to certain areas, while the California Geological Survey has established Earthquake Fault Zone (EFZ) boundaries.

The latest available maps show the nearest EFZ to the Specific Plan Area is for the Rodgers Creek Fault. The western edge of this approximately 1,000 to 1,500 foot wide zone is mapped 2,500 feet east of the eastern edge of the Plan Area, while the actual fault trace upon which the zone is centered lies about 3,000 feet to the east. No other faults considered active or potentially active are mapped across the Specific Plan Area. Aside from mapped faults there could also be a rupture on an undiscovered or blind thrust fault. Such an earthquake caused major damage in the Northridge area of the San Fernando Valley in Southern California in 1991. This risk is difficult to assess, but is considered most likely parallel to a mapped thrust fault zone, particularly where there has been evidence of recent uplift or mountain building. However, this is not the case in the Specific Plan Area so the risk from fault rupture is considered a *less-than-significant* impact.

ii. Ground Shaking

The impact from ground shaking is that strong to violent ground shaking cause foundation or other major structural damage leading to damage or collapse, falling objects endangering people and structures, and creation of general ground instability undermining or weakening structures leading to eventual collapse or requiring major repairs. The San Francisco Bay Area is a seismically active region and experts consider it likely that the Specific Plan Area would be subjected to at least strong seismically induced ground shaking within the design life of the development. According to a recent study completed by the Working Group on California Earthquake Probabilities

(WGCEP) assessing the probability of earthquakes in the San Francisco Bay Area,¹¹ there is a 62 percent probability that a major earthquake of Richter Magnitude 6.7 or greater will strike the region during the next 30 years.

The intensity of ground shaking will vary with the distance and magnitude of the earthquake causing the ground shaking. There is likely to be at least strong shaking equivalent to a Modified Mercalli intensity (MMI) of VII due to a major earthquake along the San Andreas, Maacama, Hayward, or other faults. A major earthquake along the nearby Rodgers Creek Faults is predicted to generate violent ground shaking equivalent to a MMI level of IX.¹²

According to ABAG, such shaking could completely destroy or badly damage unreinforced masonry or poorly built structures not meeting the current seismic code. Structures built to meet the current seismic code for resistance to lateral movement including shear keys, bolted foundations, shear walls and other precautionary engineering methods are not predicted to be destroyed, but are likely to suffer at least minor damage, especially from items falling off shelves, cracked facades, damaged utility pipes, etc. Frame structures are predicted to shift off foundations if not bolted. Peak ground accelerations for the site with a 10-percent probability of being exceeded in a 50-year period are estimated to be between 60 and 70 percent of the acceleration due to gravity (g) for the Specific Plan Area north of Santa Rosa Creek and between 50 and 60 percent of gravity for the area south of Santa Rosa Creek.

Actual ground motions resulting from ground acceleration may be amplified or dampened depending on the underlying geologic materials. Deep and soft soils tend to amplify waves, whereas shallow soils overlying hard bedrock tend to dampen shaking intensity. In the Specific Plan Area, a relatively thick layer of alluvium from Santa Rosa Creek could amplify shaking where sedimentary layers are unconsolidated, or where there are weak soils. Factors

¹¹ U.S. Geological Survey's website. <http://quake.usgs.gov/research/seismology/wg02/>, accessed on November 4, 2006.

¹² Association of Bay Area Governments' website. <http://www.abag.ca.gov/bayarea/eqmaps/mapsba.html>, accessed on November 4, 2006.

reducing amplification of ground waves include use of engineered fill, shallow rock and subsurface drains designed to reduce ground saturation underneath foundations.

However, all structures in the Specific Plan Area shall be designed in accordance with currently adopted building codes and ordinances of the City of Santa Rosa, including the 2001 California Building Code. Furthermore, General Plan Policy NS-C-2 requires a comprehensive geotechnical investigation prior to development approval, where applicable. Such investigation shall include evaluation of all seismic hazards, including seismic ground shaking. Additionally, Policy NS-C-4 under the General Plan restricts development of critical facilities in high-risk geologic hazard zones. Policy measures NS-C-5 and NS-C-6 under the General Plan further require identification, evaluation and retrofitting of historical buildings, including any proposed to remain in the historical districts proposed in the Specific Plan Area. Moreover, Policy NS-C-7 under the General Plan requires inspection of major utilities following earthquakes. In addition, Title 19 of the Santa Rosa Municipal Ordinance requires proper foundation engineering and construction in accordance with recommendations of a licensed civil engineer.

Incorporation of seismic construction standards will reduce the potential for significant catastrophic effects of ground shaking such as complete structural failure, but may not eliminate completely the hazard of seismically induced ground shaking. Therefore, seismic shaking is considered a *significant* impact to development proposed in the Specific Plan.

iii. Liquefaction

Liquefaction is the temporary transformation of saturated, cohesionless soil into a viscous liquid as a result of ground shaking. According to the USGS (2000) map of liquefaction risk summarized on the Sonoma County website, soils within the Specific Plan Area are considered to have moderate susceptibility to liquefaction. This assessment is likely due to the occurrence of deep alluvial soils in close proximity to active faults.

The Specific Plan Area is not shown to be an area with a high liquefaction risk such as the area along the Russian River. While the site is shown to have moderate susceptibility it does not have shallow groundwater and well sorted or poorly graded sandy soils like those found along the Russian River that are considered most susceptible, nor does it have deep unconsolidated fill deposits such as those that failed in the Marina District of San Francisco during the 1989 Loma Prieta earthquake of estimated magnitude 6.9.

In order to assess the liquefaction potential in more detail requires site-specific analysis of soils that would be completed for a geotechnical investigation or geologic assessment. While this may have been done for newer structures or renovations within the Specific Plan Area, it has not been comparatively assessed for all sites within the Specific Plan Area. However, general soils characteristics used to determine liquefaction potential may be determined from the soil survey. In addition to shallow groundwater causing saturated soils, the most important measure determining if a soil is prone to liquefaction is cohesion. Cohesion reduces liquefaction potential, with those soils at greatest risk having little or no cohesion, such as sandy or silty soils. While the soils survey did not directly measure cohesion, it is well known that clayey or highly plastic soils have the highest cohesion. Based on these criteria, the area underlain by Yolo Silty Clay Loam soils with plasticity index between 5 and 15, would have slightly less cohesion than the area underlain by the Zamora Clay Loam, with plasticity index between 5 and 20. Therefore, the area north of Santa Rosa Creek may have a slightly greater risk for liquefaction.

General Plan Policy Measure NS-C-2 requires an investigation for all development for the potential of soil liquefaction during seismic ground shaking to result in damage to structures, pavements and utilities. However, even with this policy, liquefaction represents a *significant impact* to development proposed in the Specific Plan area.

Closely related to liquefaction, but not requiring saturated soils, is dynamic densification. Dynamic densification or ground subsidence can occur when dry cohesionless soils collapse as a result of seismic shaking. This may be par-

ticularly true of unconsolidated sandy fill, or ground overlying hollow areas due to caves, mines, or areas with excessive groundwater removal. Since soils described within the Specific Plan Area are considered to have significant quantity of fine and at least low to moderate plasticity soils they may have enough cohesion to produce only a slight risk of seismically induced densification. However, proper implementation of City and State regulations regarding site specific geotechnical investigations should establish the severity of this hazard. This impact is considered *less than significant*.

iv. Landslides

Seismically induced slope failure is another secondary seismic hazard. During earthquake-induced ground shaking, unstable slopes can fail, causing landslides and debris flows. The Specific Plan Area is not known to be located within an earthquake induced landslide zone. However, very steep slopes greater than 50 percent adjacent to the creek may be subject to some type of slope failure as a result of violent ground shaking.

Another feature characteristic of slope instability that could result from an earthquake is lurch cracking. Lurch cracking is the development of fissures or cracks on slopes overlain by weak soils that can result from swaying, rolling, or spreading of the ground during a strong earthquake. This hazard is considered minimal due to lack of slopes, except at the top of bank next to Santa Rosa Creek where development that encroaches upon the bank top may be susceptible to some sort of slope failure. Although General Plan Policy NS-C-3 requires development restrictions in unstable areas, including any unstable slopes, the policy does not identify the banks of Santa Rosa Creek as particularly unstable. The greatest chance of such failure would occur in response to strong seismic shaking, and, therefore, seismically induced slope failure and instability adjacent to Santa Rosa Creek. This is considered a *significant* impact to development under the Specific Plan.

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

Redevelopment of sites within the Specific Plan Area will involve the removal of existing structures and pavement that currently help to stabilize site soils.

The exposure of the soils during land clearing and grading activities may lead to increased surface runoff and erosion, with possible impacts to Santa Rosa Creek. However, because the Plan Area is nearly level, the potential for soil erosion is slight and soil loss can be easily controlled. To reduce erosion the City of Santa Rosa Grading and Erosion Control Ordinance requires the preparation and implementation of an erosion control plan. Moreover, Policy NS-C-8 under the General Plan requires erosion control measures be implemented to reduce soil erosion from runoff, construction operations, wind and other causes. These requirements overlap those of the Storm Water Management Plan, which requires the preparation and implementation of a SWPPP for individual development or redevelopment projects proposed under the Specific Plan. Therefore, erosion and loss of topsoil is considered a *less-than-significant* impact to development under the Specific Plan.

- 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.

Settlement of soils is a primary consideration for the stability of any foundation or structure. Settlement may be due to removal of groundwater trapped in pore spaces within soils. This type of settlement generally occurs in sand and silty sand soils. The reduction in pore pressure would cause the load to compress the pore space causing settlement. Settlement may also occur due to compressibility of dry soils. Fine-grained soils such as silts and clays may also settle. Settlement of fine-grained soils is generally related to density and moisture content of the soils. Low density, high moisture content soils commonly settle during loading. Deep, fine-grained soils are present within the Specific Plan Area and may be subject to compression and settlement during loading with fill soils or structural foundations.

According to the “geotracker” database¹³ maintained by the State of California that contains monitoring well data, the depth to groundwater in the area

¹³ California State Water Resources Control Board’s website. <http://geotracker.swrcb.ca.gov>, accessed on November 4, 2006.

has been recorded between 7 and 25 feet below the ground surface, while general soils information indicates no difference in compressibility between different soils mapped across the Specific Plan Area.

In general, soils conditions are suitable for development and may be engineered in accordance with the California Building Code and other geotechnical requirements to provide sufficient foundation for structures. Requirements include removal of any non-suitable soils consisting of native subgrade or fill soils and replacement with compacted and moisture conditioned engineered fill in accordance with accepted geotechnical standards. Testing, required under General Plan Policy NS-C-2, will be required prior to development approval, where applicable. Investigations shall include evaluation of landslide risk, liquefaction potential, settlement, seismically-induced landsliding, or weak and expansive soils. Proper implementation of these regulations and policies would reduce the impact from geologic units and soils on development to a *less-than-significant* impact.

Slope steepness is generally the dominant factor governing slope stability, along with drainage and soil and bedrock conditions. Steep slopes that exceed 50 percent are especially prone to landslides in areas of weak soil and/or bedrock. Debris flows and shallow slope failures are known to occur on very steep slopes with shallow soils.

Slope failures occur when the shear stress of a soil or rock mass exceeds its shear strength. Shear stress can be increased by adding to the weight of the soil or rock mass through saturation or loading. Shear strength can be reduced by erosion or grading at the toe of a slide mass. Failure can occur due to either an increase in shear stress or a decrease in shear strength. Zones of low shear strength are often associated with the presence of expansive clay soils and weak bedrock units or structural features susceptible to failure. Sandy soils on steep slopes can experience failure during periods of intense rainfall when loading of the soil with water exceeds the rate at which the soil can drain. These types of failures are generally termed debris flows or mudflows when finer material is involved. Landslides involve the discrete or co-

herent motion of a block of material and frequently occur along fault traces or structural discontinuities.

The Specific Plan Area slope is easterly at approximately 0.5 percent and geologic maps show no landslides that threaten the project area since the area is nearly flat, so the risk of slope failure on the majority of the Specific Plan Area is considered low. However, maps are not detailed enough to show small slope failures such as could occur along the banks of Santa Rosa Creek and on embankments. The occurrence of these slope failures is reduced due to revetments along the creek and banks that are typically less steep than two horizontal to one vertical (50 percent). No obvious signs of slope failure were observed during the site reconnaissance in the vicinity of the railroad bridge and retaining walls were in good condition.

While existing conditions do not indicate particularly unstable soil conditions, improper compaction of engineered fill, creation of unstable slopes or cuts during mass grading or unforeseen conditions could be an issue. Due to the lack of subsurface data and uncertainty regarding specific development plans adjacent to Santa Rosa Creek could be considered a *significant* impact.

d. Be located on expansive soil creating substantial risks to life or property. Soils with moderate to high expansion potential are susceptible to shrinking and swelling due to fluctuations in moisture content and are a common cause of foundation deterioration, especially cracking of concrete slabs. Expansive soils are defined in Table 18-1-B of the Uniform Building Code (1994), later adapted in the 2001 California Building Code adopted by the City of Santa Rosa. According to these criteria, highly expansive soils have an expansion index exceeding 90. Such soils are highly plastic, as they will deform constantly under a constant stress, not the case for brittle or visco-elastic solids and liquids. Highly plastic soils have a large plasticity index and behave plastically over a wide range of moisture conditions.

Within the Specific Plan Area, soils are considered moderately plastic and are therefore considered to have at least moderate expansion potential. Soil properties are summarized in Table 4.5-1.

The primary difference between the soils is that those mapped south of the creek are slightly more plastic and predicted to have a higher shrink swell potential. In general, Table 4.5-1 shows a general occurrence of fine-grained alluvial soils, some of which may be expansive enough to cause foundation damage across the Specific Plan Area. This represents a *significant* impact.

- e. Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater.

The area wastewater will be serviced by the City of Santa Rosa's sewer system. Therefore, this is considered to have *no impact*.

- f. Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state.

No mineral resources are identified within the Specific Plan Area by the Santa Rosa 2020: General Plan. Therefore, *no impact* would occur.

- g. Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan.

As indicated before, the Specific Plan is considered to have *no impact* on mineral resources as no mineral resources are identified within the Specific Plan Area.

2. Cumulative Impacts

Development within the Santa Rosa Urban Growth Boundary has the potential to result in a cumulative impact related to geology and seismicity. However, the 2002 General Plan EIR identified that with the policies included in the General Plan, that the potential for development under the General Plan to result in a geologic or seismic cumulatively impact would be reduced to a

TABLE 4.5-1 **SOILS SURVEY CHARACTERISTICS**

Soil Type	Area	Shrink Swell Potential	PI ^a	Strength	Com-pressibility	Runoff Rates	Erosion
Yolo Silty Loam	Nth. of Creek	Low to Moderate	5-15	Fair to Poor	Medium	Slow	Slight
Zamor a Silty Clay Loam	St. of Creek	Moderate	5-20	Fair to Poor	Medium	Slow	Slight

^a PI: Plasticity Index

Source: USDA Soils Conservation Service, 1972, *Sonoma County Soils Survey*.

less-than-significant level. Given that the Specific Plan Area is relatively flat, there is low potential for the Specific Plan to cumulatively contribute to erosion or landslides. Soils in the Specific Plan Area are not designated for protection and therefore it does not matter if they are graded in compliance with existing policies and regulations. There is a potential impact from increased population in a seismic zone. However, this impact is discussed under the risk from seismic shaking and would be adequately addressed through compliance with City’s General Plan policies, ordinances and the mitigated measures adopted as part of the Specific Plan. In addition, the Specific Plan would result in no impact to mineral resources. Overall development is unlikely to change the geology of the region, therefore, the Specific Plan would not contribute to a cumulative impact regarding geological and soil concerns.

E. Impacts and Mitigation Measures

Impact GEO-1: Development allowed under the Specific Plan would be subject to seismic ground shaking. This is considered a *significant* impact.

Mitigation Measure GEO-1a: All structures in the Specific Plan Area shall be designed in accordance with currently adopted building codes

and ordinances of the City of Santa Rosa, including the 2001 California Building Code. A Final Design Review shall be performed by a licensed civil/structural engineer for adherence to the seismic design criteria within the Specific Plan Area.

Mitigation Measure GEO-1b: A subsurface geotechnical investigation shall be performed to evaluate soils in the subsurface at each proposed development or redevelopment site. The investigation shall include the following elements.

- (1) The investigation shall be performed under the direction of a state licensed Geotechnical Engineer and/or a Certified Engineering Geologist.
- (2) The subsurface investigation shall include drilling, logging and sampling of boreholes to a minimum depth of 25 feet below the ground surface to evaluate soils for their susceptibility to seismically induced ground failure.
- (3) If a seismically unstable subsurface material is encountered, the engineer shall identify specific measures to mitigate the impact of seismic ground shaking. Mitigation measures may include soil stabilization techniques such as pressure grouting, specific foundation design measures such as pile foundations, or other methods identified by the engineer.
- (4) A written report shall be prepared summarizing the methods used, results of the investigation and specific design measures recommended.
- (5) Results of the investigation shall be reviewed by the City, or by a qualified independent consultant retained by the City.

The City shall require developers to incorporate the mitigation measures into new development.

Significance After Mitigation: Less than significant.

Impact GEO-2: Liquefaction leading to structural damage or collapse of structures could occur within the Specific Plan Area. This is considered a *significant* impact.

Mitigation Measure GEO-2: Development of sites within the Specific Plan Area shall require investigation of the potential for soil liquefaction during seismic ground shaking that could result in damage to structures, pavements and utilities. A subsurface geotechnical investigation shall be performed to evaluate soils in the subsurface at each proposed development or redevelopment site. The investigation shall include those elements outlined under Mitigation Measure GEO-1B.

The City shall require developers to incorporate the mitigation measures into new development.

Significance After Mitigation: Less than significant.

Impact GEO-3: Seismically-induced slope failure and instability adjacent to Santa Rosa Creek may be present in the Specific Plan Area for sites located adjacent to Santa Rosa Creek. This is considered a *significant* impact.

Mitigation Measure GEO-3: Any new structures planned within 50 feet from the top of the bank of Santa Rosa Creek shall complete a stream-bank stability analysis to examine the effect of a new structure on bank stability. Structures to be evaluated shall include paved parking areas, retaining walls, buildings and other site improvements. A licensed Civil Engineer or Certified Engineering Geologist shall complete the slope stability analysis.

Analysis shall include the effect of increased or concentrated runoff on bank erosion, likelihood of foundation pressure causing bank failure and the impact of grading next to the creek bank in terms of future settlement and erosion.

Recommendations from the analysis to be incorporated into development plans shall include use of energy dissipaters or other techniques to reduce outflow velocities of storm drains discharging into Santa Rosa Creek, building setback from the creek and stable grading setback from the creek.

Significance After Mitigation: Less than significant.

Impact GEO-4: Expansive soils may be present in the Specific Plan Area. Expansive soils may cause damage to pavements, concrete slabs and foundations. This is considered a *significant* impact.

Mitigation Measure GEO-4: A subsurface geotechnical investigation shall be performed to evaluate soils in the subsurface at each proposed development or redevelopment site. The investigation shall include those elements outlined under Mitigation Measure GEO-1B.

The City shall require developers to incorporate the mitigation measures into new development.

Significance After Mitigation: Less than significant.