IV. ENVIRONMENTAL IMPACT ANALYSIS
G. GEOLOGY/SOILS

INTRODUCTION

This section of the Revised Draft EIR provides a description of geology and soils within the City of Healdsburg, information on regulations and agencies with jurisdiction over the Project area, proposed General Plan policies relevant to geology and soils, and an analysis of potential impacts on related to geology and soils resulting from implementation of the proposed General Plan. Information used to prepare this section was taken from the *Healdsburg 2030 General Plan Background Report* (January 2009 Draft).

ENVIRONMENTAL SETTING

Physical Setting

Regional Geologic Setting

The city is located in northern Sonoma County, in the central portion of the Russian River watershed. The region is within the central portion of the Coast Ranges geomorphic province of California, a region characterized by northwest-trending valleys and mountain ranges. This alignment of valleys and ridges has developed in response to uplift, folding and faulting along the San Andreas system of active faults.

Topography

The city is located along the Russian River, at the north end of the Santa Rosa Valley. Elevations within the city range from about 90 feet along the Russian River along the south side of the city, to more than 500 feet on the west side of Fitch Mountain. This area drains to the west and south via intermittent creeks and drainage channels, discharging into the Russian River. The western and central portions of the city are characterized by low-lying, gently sloping topography. Hilly upland areas characterize the northern and eastern portions of the city.

Geologic Units

Two principal rock units, referred to as the Great Valley Sequence and the Franciscan Assemblage, underlie the Healdsburg area. Geologic units are shown in Figure IV.G-1. Rocks of the Great Valley Sequence underlie the majority of the upland areas. These rocks are of Cretaceous age (the period from about 130 to 65 million years ago) and consist mainly of claystone, siltstone, and sandstone.

The Great Valley Sequence is a widespread series of marine sedimentary rocks of Cretaceous age (the period from about 135 million to 65 million years ago) that underlies much of west-central California. In the Healdsburg area, the Great Valley Sequence rocks typically consist of claystone with some interbedded siltstone and sandstone. These rocks are generally thin-bedded, are weak to moderately

This page intentionally left blank.

Figure IV.G-1 Geologic Units and Local Earthquake Faults

This page intentionally left blank.

strong, and moderately to deeply weathered near the ground surface. The Great Valley Sequence rocks are complexly folded and locally sheared.

Rocks of the Franciscan Assemblage underlie a small area in the northern portion of the city. This unit consists of a diverse and structurally complex group of igneous, metamorphic and sedimentary rocks of Upper Jurassic to Cretaceous age (140 to 65 million years old). Within the Healdsburg area, the Franciscan rocks consist mainly of sheared sandstone and shale and are generally similar to the Great Valley Sequence rocks.

The following types of geologic units are present within the city:

<u>Serpentinite</u>

Areas of serpentinite (a rock composed of serpentine and other minerals) are intermixed with both the Great Valley Sequence and Franciscan rocks. The serpentinite is typically gray to green in color, and ranges from friable to moderately strong and moderately to deeply weathered. Several areas of serpentinite crop out in the eastern and northern portions of the city. Exposures of serpentinite locally contain some veins of chrysotile, a variety of asbestos.

<u>Sedimentary and Volcanic Deposits</u>

Locally, the Franciscan and Great Valley rocks are overlain by younger sedimentary and volcanic deposits of Tertiary age (the period from about 65 to 2 million years ago). These units include the Sonoma Volcanics and Glen Ellen Formation.

Volcanic rocks, referred to as the Sonoma Volcanics, occur in two broad areas in eastern and northern Healdsburg. The Sonoma Volcanic rocks include tuff (a rock composed of volcanic ash), agglomerate, basalt and andesite. These rocks range from friable to strong and are typically deeply weathered.

Portions of the low hills in central and northern Healdsburg are underlain by sediments of the Glen Ellen Formation of late Tertiary to Quaternary age. These consolidated sediments consist of clay, silt, sand, and gravel and locally contain large numbers of well-rounded pebbles and cobbles.

<u>Surficial Deposits</u>

Several types of surficial deposits are present in Healdsburg. These include surficial soils, colluvium, alluvium, and landslide deposits. In addition, man-made fills have been placed in many areas. These units are described below.

Surficial soils in the Healdsburg area can be divided into two basic groups that are associated with the underlying geologic units. The near-level valley bottom areas are blanketed by surficial soils of the Pleasanton, Yolo, and Haire soil series. These soils are typically loams and sandy loams with relatively low shrink-swell potential and moderate permeability. Erosion potential is typically moderate to high.

The upland portions of the city are typically blanketed by soils of the Las Gatos, Speckles, Dibble, and Boomer soils series. The majority of these soils are clays and clay loams. Shrink-swell potential is moderate to high and permeability is low to moderate. Erosion potential is typically moderate to high.

Colluvium is a thick soil deposit that accumulates in hillside swales and along the toes of slopes. The composition of these soils varies from sandy silt to clay. Colluvium deposits are generally prone to various types of slope instability including landslides and debris flows.

Alluvium underlies the near-level valley bottoms including much of the downtown area. These sediments were deposited by ancestral streams and consist of clay, silt, sand, and gravel. Older alluvium of similar composition is also present in the Healdsburg area. These deposits form elevated terraces in central Healdsburg and along the Russian River.

Seismic Setting

Seismicity in Healdsburg is directly related to activity on the San Andreas fault system, including major active faults in the region and within the city (see Figures IV.G-1 and IV.G-2). The active Healdsburg-Rodgers Creek fault passes through the eastern and northern areas of the city. The Healdsburg-Rodgers Creek fault is a right-lateral strike-slip fault (i.e., the land west of the fault generally moves north with respect to the land east of the fault during large earthquakes), and has historically been the source of significant earthquakes.

Other major active faults in the region include the San Andreas, 19 miles to the west, and the Maacama, four miles to the east. Other, more distant, active faults in the region include the West Napa, Green Valley, Hayward, San Gregorio, Calaveras, Concord, and Greenville faults. Table IV.G-1 shows the distance to these faults from the city and the maximum earthquake each fault is capable of producing.

The city is not currently within one of the Alquist-Priolo Earthquake Fault Zones (APEFZ) established by the California Division of Mines and Geology (CDMG) around known active faults. The CDMG defines an active fault as one with surface displacement in the last 11,000 years, or one that has experienced historic earthquakes. Several active fault traces have been mapped in the northern and eastern portions of the city (see Figure IV.G-1).

During the 1970s, portions of the city were included within an APEFZ encompassing the Healdsburg-Rodgers Creek fault, and active fault traces were considered to be present within the city. In 1983, the State of California removed the APEFZ from the area, apparently based on the opinion of the California Division of Mines and Geology that traces of the Healdsburg-Rodgers Creek fault in the city were no longer active. Subsequent work by consultants has demonstrated the presence of active faults within the northern and eastern portions of the city. It is therefore likely that the APEFZ will be re-established by the State of California in the Healdsburg area sometime in the future.

Figure IV. G-2 Fault Locations

This page intentionally left blank.

Table IV.G-1
Fault Parameters

Fault[1]	Distance and Direction from Healdsburg[2]	Maximum Moment Magnitude[3]
Healdsburg-Rodgers Creek	Crosses portions of city	7. 0
Maacama	4. 5 miles north	6. 9
San Andreas	19 miles west	7. 9
Hunting Creek	29 miles northeast	6. 9
West Napa	28 miles southeast	6. 5
Concord-Green Valley	40 miles east	6. 9
Cordelia	43 miles southeast	6. 7[4]
Hayward	46 miles southeast	7. 1
San Gregorio	52 miles south	7. 3

[1] Fault designations, including segment designations, are from CDMG (1996).
[2] Distances measured from Wagner and Bortugno (1982) and Jennings (1994).
[3] Except where noted, Maximum Moment Magnitudes are from CDMG (1996).
[4] Murphy and Wesnousky (1994).

Source: Healdsburg 2030 General Plan Background Report, Final Draft - January 2008.

The San Francisco Bay Region has been affected by several large earthquakes during historical times. Table IV.G-2 shows the Modified Mercalli Intensity Scale, which measures the felt effects of ground shaking, is presented in. A summary of the more significant historical earthquakes felt in the Healdsburg area is presented in Table IV.G-3, along with estimated earthquake magnitudes and shaking intensities in the city.

Historically, the only earthquake to cause liquefaction in the Healdsburg area was the San Francisco earthquake of 1906. As a result of that earthquake, several areas of lateral spreading and one area of sand boils were reported. These areas were all within or adjacent to the flood plain of the Russian River. Overall, damage due to liquefaction in the 1906 earthquake was relatively slight and consisted of cracking and lateral spreading along the riverbanks. Other more recent earthquakes, such as the Santa Rosa earthquakes of 1969 and the Loma Prieta earthquake, have not caused liquefaction in the Healdsburg area.

Geologic Hazards

Within the city, the most significant geologic hazards are those associated with earthquakes, including landslides, debris flows, and liquefaction. Other geologic hazards include expansive soils, erosion, and the general impact of grading. These and other possible hazards are discussed below.

Table IV.G-2
Modified Mercalli Intensity Scale

MMI Value	Damage	Detailed Perception and Damage
I	None	Not felt, except rarely under especially favorable circumstances. Marginal and long period effects of large earthquakes.
II	None	Felt by persons at rest, on upper floors, or favorably placed.
III	None	Felt indoors. Hanging objects swing slightly. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.
IV	None	Felt indoors by many, outdoors by few. Awakens few. Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing automobiles rock. Windows, dishes, doors rattle; glasses clink; crockery clashes. Wooden walls and frames may creak.
V	None	Felt outdoors; direction estimated. Awakens most. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rates.
VI	Minor damage	Felt by all. Awakens all. Many frightened and run outdoors. Persons move unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells (church, school) ring.
VII	Non-structural damage	Difficult to stand. Frightens all. Noticed by drivers. Hanging objects quiver. Furniture broken. Masonry D cracked, damaged; some cracks in masonry C. Weak chimneys broken at roofline. Fall of plaster, loose bricks, stones, tiles, cornices, unbraced parapets, and architectural ornaments. Waves on ponds; water turbid with mud. Small slides and caving along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.
VIII	Moderate damage	Alarm approaches panic. Steering of automobiles affected. Masonry C damaged; partial collapse. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.
IX	Heavy damage	General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. General damage to foundations. Frame structures, if not bolted, shifted off foundations. Frames racked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. Liquefaction.
X	Extreme damage	Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.
XI	Extreme damage	Few if any masonry structures remained standing. Rails bent greatly. Underground pipelines completely out of service.
XII	Extreme damage	Damage nearly total. Large rock masses displaced. Objects thrown into air.

Masonry A: Good workmanship, mortar, and design; reinforced, especially laterally, and bound together by using steel, concrete, etc. ; designed to resist lateral forces.
Masonry B: Good workmanship and mortar; reinforced, but not designed in detail to resist lateral forces.
Masonry C: Ordinary workmanship and mortar; no extreme weaknesses like failing to tie in at corners, but neither reinforced nor designed against horizontal forces.
Masonry D: Weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally.
Source: Healdsburg 2030 General Plan Background Report, Final Draft – January 2008. Original Source: Modified from Perkins and Boatwright (1995).

Table IV.G-3
Earthquakes Felt in Healdsburg

Name	Year	Fault	Location	Damage in Healdsburg	Richter Scale	MMI Scale
Hayward Earthquake	1868	Southern Hayward	East Bay	Moderate	6. 8	MMI V - VI
Winters Earthquake	1892	Unknown	Central Valley region	Minor to moderate	6. 4-7. 0, 6. 2-7. 0, and 5. 5	MMI V
(Santa Rosa)	1893	Unknown	8 miles east of Santa Rosa	Chimneys shaken down, plaster fell	5. 1	MMI V
Mare Island Earthquake	1898	Rodgers Creek			6. 7	MMI V - VI
Great San Francisco Earthquake	1906	San Andreas	Near San Francisco	Extensive; several buildings collapsed or severely damaged (primarily brick)	8. 3	MMI VII - IX
Santa Rosa Earthquakes	1969	Rodgers Creek	Northern Santa Rosa		5. 6, 5. 7	MMI VI
Loma Prieta Earthquake	1989	Near San Andreas	Near Santa Cruz	Slight	7. 1	MMI VI

Source: Healdsburg 2030 General Plan Background Report, Final Draft – January 2008.

Seismic Hazards

The Working Group on California Earthquake Probabilities has estimated that there is 27 percent or higher chance of a large earthquake (magnitude 6.7 or greater) occurring on the Healdsburg-Rodgers Creek fault or the Hayward fault in the next 30 years. It estimates a 62 percent or higher chance of a large earthquake occurring in the greater San Francisco Bay region by the year 2032. Such earthquakes are considered most likely to occur on the San Andreas, Healdsburg-Rodgers Creek, or Hayward faults. Assuming that the earthquake epicenter is located on a nearby segment of one of the principal active faults, ground shaking intensities of approximately IX to X, corresponding to violent ground shaking, could be expected in the city.

Fault Rupture

The Healdsburg-Rodgers Creek fault is the only fault known to be active within the city. During large earthquakes, fault rupture tends to occur along lines of previous faulting. Ground rupture has occurred in the past and is likely to occur in the future along the Healdsburg-Rodgers Creek fault as a result of a large earthquake. The risk of fault rupture in other portions of the city is very low.

Several possible active faults traces have been mapped within the city (see Figure IV.G-1). Several of these fault traces have been studied in detail and are considered active. Other possible fault traces have been tentatively identified. However, their specific location and degree of seismic risk has not been evaluated in detail.

Active fault traces can undergo ground rupture during earthquakes. Movement up to several feet may be possible along active fault traces during a major local earthquake. Such movements could severely damage structures built across the fault. Currently, state law restricts placement of residential structures on active fault traces, and occupied structures are typically required to be set back a minimum of 50 feet from fault traces.

Ground Shaking

The City of Healdsburg lies within a seismically active region that includes much of western California. The principal faults in the area are capable of generating large earthquakes that could produce strong to violent ground shaking in the city. The recent increase in earthquake activity in the San Francisco Bay Region suggests that the region is entering a period of increased seismic activity that could include one or more large and destructive earthquakes.

In the event of an earthquake, seismic risk to a structure will depend on the characteristics of the earthquake, the distance to the earthquake epicenter, the subsurface conditions underlying the structure and its immediate vicinity, and the characteristics of the structure. At present, it is not possible to predict precisely when, where, or exactly what kind and amount of movement will occur on these faults. However, geologic conditions and construction standards are a major factor in seismic response and can be evaluated.

The intensity of ground shaking can be amplified by local geologic conditions. Areas most susceptible to a significant amplification of ground shaking are those areas underlain by thick layers of soft sediments, which are not common in the city. The alluvium deposits that underlie most of downtown Healdsburg may be somewhat susceptible to ground shaking amplification. Those areas could experience somewhat stronger ground shaking than nearby areas underlain by bedrock.

The Association of Bay Area Governments has released maps that show the estimated ground shaking from various postulated earthquake scenarios around the Bay Area. For the city, the scenario that generates the strongest ground shaking is an earthquake of magnitude 7.0 occurring on the Healdsburg-Rodgers Creek fault. They estimate that ground shaking of MMI VIII to IX will occur in the city during an earthquake of that size located near the city.

Experience gained during previous earthquakes has shown that the structures most susceptible to earthquake damage are older structures (those constructed before about 1950) and unreinforced masonry buildings (URMs), i.e., brick, cinder block, or stone buildings without steel reinforcement. For older wood-frame structures, structural damage occurs most frequently as a result of poorly designed foundations or a lack of structural bonding between the foundation and the building. During the recent Loma Prieta earthquake, many such structures in Los Gatos and Santa Cruz were thrown from their foundations and received moderate to severe structural damage as a result. The risk of structural damage can be often be significantly reduced by securely attaching the structure to the foundation. Shear walls or other structural reinforcements within the building are also useful in improving resistance to earthquakes.

URMs were common in California in the early part of the last century. Structures of this type are prone to collapse during severe earthquakes and should be considered a significant risk to public safety in the city. Several unreinforced brick structures in downtown Santa Cruz and Los Gatos collapsed during the Loma Prieta earthquake, resulting in several fatalities.

URMs can often be brought up to acceptable earthquake design standards by adding structural reinforcement, which will adequately mitigate the risk of structural collapse. All but one of the URMs in the city has been brought up to current standards and it is in the design process for structural retrofit.

<u>Liquefaction</u>

Liquefaction occurs in granular materials as a result of ground shaking, and is often followed by sudden local ground settlement or slope failure. Liquefaction is likely to occur in the Healdsburg area only during large earthquakes occurring in the North Bay region (Marin, Sonoma, and Napa Counties). Major events occurring on the San Andreas, Maacama, Healdsburg-Rodgers Creek, or Hayward faults are the most likely sources for liquefaction in the Healdsburg area.

The potential for liquefaction is considered to be highest in areas underlain by saturated, unconsolidated, granular sediments (see Figure IV.G-3). Within the city, the areas most at risk from liquefaction are alluvial areas along the banks of the Russian River and its major tributaries.

The majority of the developed portion of the city in the downtown area is underlain by alluvial deposits. Potentially liquefiable deposits are likely to occur locally within this area. It is likely, however, that liquefiable materials are not continuous or wide spread throughout the area.

Although liquefaction often causes severe damage to structures, structural collapse is uncommon. The risk to public safety from liquefaction, therefore, is relatively low. Structures can be protected from liquefaction through the use of special foundations. Liquefaction hazard is typically evaluated as a part of a development project’s geotechnical investigation.

<u>Earthquake-Related Ground Failure</u>

Various forms of ground failure often occur during or immediately following an earthquake, as a result of ground shaking. The nature and severity of these effects are determined by the magnitude and duration of shaking and the local geologic and groundwater conditions. Earthquake-related ground failures can be divided into several types, including lateral spreading, lurch cracking, and landsliding.

This page intentionally left blank.

Figure IV.G-3 Liquefaction Hazard Locations

This page intentionally left blank.

Liquefaction could cause localized lateral spreading or landsliding of developed areas located immediately adjacent to the riverbanks. In addition, sand boils, seismically induced settlement, or ground cracking could occur in other areas away from the river.

Lateral spreading is the movement of soft or loose surficial materials over gentle slopes during an earthquake. This phenomenon occurs most often in areas underlain by soft thick soils or unconsolidated sediments adjacent to a slope such as a creek channel. Often, lateral spreading occurs as a result of liquefaction of subsurface materials. Movements of up to several feet are possible. Areas most at risk of lateral spreading are on the banks of the Russian River.

Lurch cracking is the formation of various types of fissures or cracks in the ground surface resulting from the oscillatory motion of the ground during an earthquake. This usually occurs in relatively flat areas underlain by loose, unconsolidated materials, and is exacerbated by the presence of shallow groundwater. The hazard of lurch cracking is relatively minor in the city, but could occur locally in areas of alluvium.

Slope failure or landsliding most frequently occurs under non-seismic conditions, but can be triggered or accelerated by ground shaking. In the Healdsburg area, the potential for seismically induced landsliding to occur depends upon a number of factors, including the type of bedrock, type and depth of soils, angle and direction of the slope, and moisture content. The most common type of earthquake-induced ground failures are small sloughs or rock slides in steep slopes. Movement can also occur in pre-existing landslides.

The risk of lateral spreading, lurch cracking, or liquefaction is moderate to low within the low-lying portions of the city and very low in upland areas. Small rock slides are likely to occur in steep cut slopes such as along roadways during earthquakes and some movement of the larger landslides may occur.

<u>Tsunamis</u>

Tsunamis are large, long period sea waves generated by earthquakes. Several small- to moderate-size tsunamis have historically impacted the coast of California. Because the city is located well inland, tsunamis are not considered a risk.

Slope Stability Hazards

<u>Relative Slope Stability</u>

Virtually all of the hillside areas in the city were mapped as Zone C, the least stable category. The broad, gently sloping ridge crests in the northern portion of the city were mapped as Zone Bf, which consists of near-level areas that are adjacent to potentially unstable slopes. The near-level valley bottoms were mapped as Zone A, the most stable zone. Figure IV.G-4 depicts the overall levels of slope stability hazards within the city.

This page intentionally left blank.

Figure IV.G-4 Slope Hazard Zones

This page intentionally left blank.

Landslides

Landslides can cause extensive damage to buildings, roadways or other facilities located on or below the landslide and can result in property damage. Because these types of landslides are slow-moving, people are rarely injured or killed by landslide movement. Several types of landslides are common in the city, and the area has been impacted many times by slope failures in recent years. Numerous landslides have been mapped within the city by the CDMG and consultants. The larger landslides are shown on Figure IV.G-5.

The mapped landslides are mainly slow-moving slump or earthflow landslides that are confined to the soil mantle and shallow, weathered bedrock. Movement on these landslides typically occurs during the winter or spring as a result of heavy rainfall. Movement can also occur during large earthquakes or as a result of improper grading or drainage practices.

Landsliding can also result where excavations (cut slopes) are made into hillsides. The Glen Ellen Formation sediments and both the Great Valley Sequence and serpentinite rock are highly prone to landslides in overly steep cut slopes.

Experience in Sonoma County within similar geologic settings has shown that cut slopes can be unstable if constructed at steep inclinations. Generally slopes inclined at 3:1 (horizontal to vertical) or flatter will perform adequately although failures can occur even in these slopes if unstable geologic conditions are present. If unstable geologic conditions exist, slopes can be effectively stabilized by constructing a compacted fill buttress or retaining wall. Slope repairs of this type require careful geotechnical engineering and geologic investigation to formulate an appropriate design.

Landslides can be stabilized by removing all or part of the landslide and rebuilding the area as a compacted, engineered fill with subdrainage. This type of mitigation has been used widely throughout California. Smaller landslides can also be stabilized by constructing retaining walls.

Within the city, many of the swales or ravines that occupy the steep hill slopes may be capable of generating debris flows. Debris flows are most likely to originate on slopes underlain by sandstone or Glen Ellen sediments. Areas underlain by mudstone of the Great Valley Sequence are generally characterized by earthflows or slumps and are considered less likely to generate debris flows.

The risk of loss of property or life as a result of debris flows can be reduced in several ways. The most effective strategy is to avoid placing structures or facilities in debris flow paths. Where structures exist within areas at risk of debris flows, several measures can be taken to protect structures. These strategies generally involve stabilizing the debris flow source areas through regrading, subdrainage, or retaining walls, constructing basins to retain debris, or diverting debris away from structures. Detailed geologic mapping and subsurface exploration are required to evaluate debris flow risk and provide recommendations for mitigation measures.

This page intentionally left blank.

Figure IV.G-5 Landslide Locations

This page intentionally left blank.

Within developed areas, debris flows are sometimes triggered by concentrated runoff being discharged onto natural slopes, manmade slopes, or into swales filled with unstable deposits. This risk can be minimized through construction of appropriate storm drainage facilities in these areas.

Other Geologic Hazards

Expansive Soils

Portions of the city are underlain by expansive soils. Soils of this type undergo a significant volume change as a result of wetting or drying that can cause damage to improperly designed structures. Although the extent of expansive soils is not well known, such soils occur most frequently in areas underlain by rocks of the Great Valley Sequence or Sonoma Volcanics. Expansive soils can be mitigated through special foundation or pavement design.

Expansive Bedrock

Moderately- to highly-expansive materials can occur within the bedrock formations present in the city. These materials are most commonly layers of mudstone or volcanic tuff. Mudstone within the Great Valley Sequence and Glen Ellen sediments may locally be moderately expansive. Tuff beds occur commonly in the Sonoma Volcanics and can be highly expansive. Areas of expansive rock can be evaluated during grading by geologic mapping and laboratory testing.

Erosion

The potential for erosion can be a significant consideration for development along river banks. Generally, the banks of the Russian River within the city have erosion protection or buildings are set back a reasonable distance. The potential for large amounts of bank erosion is moderate to small. It is likely that bank erosion can be controlled in the future by maintaining adequate erosion protection measures such as those already in place.

To reduce erosion in developed areas, surface v-ditches, and storm drains must be regularly maintained to continue functioning as designed. Failure to do so could result in degradation of the stability of cut and fill slopes. In addition, proper drainage and erosion control during grading is necessary to control erosion and avoid downstream sedimentation. Typically, erosion impacts are greatest in the first two years after construction, the time generally required to reestablish a good vegetation cover on man-made slopes.

Septic Systems

Currently, the Old Redwood Highway Study Area, which is bound by the South Healdsburg Avenue freeway interchange on the south, Memorial Bridge and the Syar Industries property on the north, the city limits on the east and Russian River on the west, is unsewered and sewage treatment in this area is presently limited to individual septic systems. This area was annexed by the City of Healdsburg in 1979 primarily for the purpose of extending City services and utilities; however, this extension has not occurred. A major constraint to providing sewer service in this area is the need to span the Russian River with a major sewer trunk line as well as the need to construct an additional sewer lift station to serve the area.

Regulatory Setting

Federal

Earthquake Hazards Reduction Act

In October 1977, the U.S. Congress passed the Earthquake Hazards Reduction Act to reduce the risks to life and property from future earthquakes in the United States through the establishment and maintenance of an effective earthquake hazards and reduction program. To accomplish this, the act established the National Earthquake Hazards Reduction Program (NEHRP). This program was significantly amended in November 1990 by the National Earthquake Hazards Reduction Program Act (NEHRPA) by refining the description of agency responsibilities, program goals, and objectives.

The mission of NEHRP includes improved understanding, characterization, and prediction of hazards and vulnerabilities; improved building codes and land use practices; risk reduction through post earthquake investigations and education; development and improvement of design and construction techniques; improved mitigation capacity; and accelerated application of research results. The NEHRPA designates the Federal Emergency Management Agency as the lead agency of the program and assigns several planning, coordinating, and reporting responsibilities. Other NEHRPA agencies include the National Institute of Standards and Technology, National Science Foundation, and the U. S. Geological Survey.

State

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act (Public Resources Code Sections 2621–2630) was passed in 1972 to mitigate the hazard of surface faulting to structures designed for human occupancy. The main purpose of the law is to prevent the construction of buildings used for human occupancy on the surface trace of active faults.

The law addresses only the hazard of surface fault rupture and is not directed toward other earthquake hazards. The act requires the State Geologist to establish regulatory zones known as “earthquake fault zones” around the surface traces of active faults and to issue appropriate maps. The maps are distributed to all affected cities, counties, and state agencies for their use in planning efforts. Before a project can be permitted in a designated Alquist-Priolo Earthquake Fault Zone, cities and/or counties must require a geologic investigation to demonstrate that proposed buildings will not be constructed across active faults.

Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act of 1990 (Public Resources Code Sections 2690–2699. 6) addresses earthquake hazards, including liquefaction and seismically induced landslides. The act established a mapping program for areas that have the potential for liquefaction or earthquake-induced landslides. The act also specifies that the lead agency for a project may withhold development permits until site-specific geologic or soils investigations are conducted and mitigation measures are incorporated into plans to reduce hazards to acceptable levels. At present, the Seismic Hazards Mapping program has not extended into Sonoma County. Therefore, maps showing where studies of potential liquefaction and seismically induced landslides will be required are not yet available.

National Pollutant Discharge Elimination System Permit

In California, the State Water Resources Control Board (SWRCB) administers regulations promulgated by the U. S. Environmental Protection Agency requiring the permitting of stormwater-generated pollution under the National Pollutant Discharge Elimination System (NPDES). In turn, SWRCB's jurisdiction is administered through nine regional water quality control boards. Under these federal regulations, a developer must obtain a general permit through the NPDES Stormwater Program for all construction activities with ground disturbance of one acre or more. The general permit requires the implementation of best management practices (BMPs) to reduce sedimentation into surface waters and to control erosion. One element of compliance with the NPDES permit is preparation of a storm water pollution prevention plan (SWPPP) that addresses control of water pollution, including sediment, in runoff during construction.

California Building Standards Code

The State of California provides minimum standards for building design through the California Building Standards Code (CBC). Where no other building codes apply, CBC Chapter 29 regulates excavation, foundations, and retaining walls. The CBC applies to building design and construction in the state and is based on the federal Uniform Building Code (UBC) used widely throughout the country. The CBC has been modified for California conditions with numerous more detailed and/or more stringent regulations.

The state earthquake protection law requires that structures be designed to resist stresses produced by lateral forces caused by wind and earthquakes. Specific minimum seismic safety and structural design requirements are set forth in CBC Chapter 16. The Code identifies seismic factors that must be considered in structural design.

Chapter 18 of the CBC regulates the excavation of foundations and retaining walls, and Appendix Chapter A33 regulates grading activities, including drainage and erosion control, and construction on unstable soils, such as expansive soils and areas subject to liquefaction.

Regional

City of Healdsburg Resolution No. 147-186

In 1986, the City commissioned a study to examine geologic hazards within and adjacent to the city. The resulting Fitch Mountain Geologic Study and Resolution No. 147-186 adopted the findings of the report and implemented procedures for construction in areas of geologic hazards. As mandated by the resolution, a geologic report and/or investigation, a soil foundation engineering investigation, a grading erosion and sediment control plan, a plan review letter, and an as-built construction report is required for new construction located on potentially hazardous geologic formations.

Septic System Permits

The Sonoma County Permit and Resource Management Department (SCPRMD) requires permits for operation of sewage disposal systems. Septic systems must be designed by a qualified environmental professional and all SCPRMD requirements for soils analysis, percolation testing, groundwater testing, and design elements must be satisfied to obtain the permit.

Adopted Specific and Area Plans

The City of Healdsburg has adopted a number of plans to guide the development of specific areas of its Planning Area, including the Specific Plan for Area A, the Ridgeline North Area Plan, the Saggio Hills Area Plan and the Grove Street Neighborhood Plan. All of these plans include objectives and policies intended to protect residents and property from geologic hazards.

PROPOSED GENERAL PLAN POLICIES AND IMPLEMENTATION MEASURES

Proposed General Plan policies and implementation measures that affect or pertain to geology and soils are listed below.

Policies

- ***LU-A-6:*** The city will not consider the annexation of any properties in the unincorporated fitch mountain area except under the following circumstances:

  (a) A comprehensive study is completed examining the feasibility of annexation of the area examining Fitch Mountain resident views, geotechnical and public service constraints and fiscal impacts.

  (e) An assessment district is formed to design and construct necessary street, drainage and other improvements to city standards.

  (f) One or more geologic hazard abatement districts are formed and a plan to control and mitigate geologic and soil erosion hazards is implemented.

- *LU-C-1:* Only low-intensity urban development and open space land uses shall be allowed in areas characterized by steep slopes, environmental hazards, scenic ridgelines and hillsides. Clustering of development in these areas shall be encouraged to preserve open space, meet the policies of the General Plan concerning natural hazards and scenic resources and minimize the costs of infrastructure improvements.
- *LU-C-2:* Intensive urban development shall be allowed only in areas that are relatively free of topographic, geologic and environmental limitations.
- *T-A-8*: The development of private streets in new residential projects is discouraged, except in extraordinary circumstances, such as environmental constraints and the desire to limit grading and impacts to native trees, or a determination by the City Engineer that the street is not a component of the main circulation system of the City (e. g., providing through access to other areas).
- *T-A-12:* The City will strive to complete links in the existing street system to improve continuity and provide emergency vehicle access, subject to fiscal and geological limitations.
- *S-A-1:* Lands with significant, identified geological hazards shall be designated for open space or low-intensity uses.
- *S-A-2:* The City will ensure that public and private development in areas with significant geologic hazards are sited to minimize the exposure of structures and improvements to damage and to minimize the aggravation of off-site geologic hazards. Development may be clustered on lots smaller than required by the Zoning Ordinance to avoid areas with identified hazards.
- *S-A-3:* The City will continue to collect and maintain current geologic data for use in identifying hazardous areas.
- *S-B-1:* The City will continue to enforce requirements for the seismic retrofitting of all hazardous unreinforced masonry buildings within the city.
- *S-B-2:* The City will ensure that all public facilities, such as buildings, water tanks, and reservoirs, are structurally sound and able to withstand seismic shaking and the effects of seismically-induced ground failure.

Policy Implementation Measures

- *S-1:* Maintain and regularly update the City's Index to Geological Reports prepared for public and private projects to facilitate their use by others.
- *S-2:* Retain as necessary a qualified consulting geologist to assist the City in updating its geological data and to review geological reports prepared in connection with new development projects.
- *S-3:* Continue to require geotechnical reports and plans to be submitted for all projects within slope hazard zones, seismic hazard areas and in high liquefaction potential areas.

ENVIRONMENTAL IMPACTS

Methodology

Impacts associated with geology and soils were evaluated based on the information found within the *Healdsburg 2030 General Plan Background Report*.

Thresholds of Significance

In accordance with Appendix G to the CEQA Guidelines, the proposed Project would have a significant impact related to geology and soils if it would:

(a) Result in substantial erosion or unstable soil conditions from excavation grading or fill;

(b) Expose people or property to seismic hazards including fault rupture on active faults, strong seismic ground shaking, or seismically induced ground failure, including liquefaction;

(c) Expose persons or property to geologic hazards such as landslides, land subsidence, or unstable or expansive soils; or

(d) 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.

Project Impacts

Impact IV.G-1: The proposed Project would not result in substantial erosion or unstable soil conditions from excavation grading or fill.

Construction under buildout allowed by the proposed General Plan could necessitate extensive grading, including both cuts and fills.

As stated previously in this section, two basic groups of surficial soils exist in the city. In the near-level valley bottom areas Pleasanton, Yolo, and Haire soil series are present which have a moderate to high potential of erosion. In the upland portions of Healdsburg, soils of the Las Gatos, Speckles, Dibble, and Boomer soils series are present, which also have a moderate to high potential for erosion. Colluvium and Alluvium deposits are also present within the city. Colluvium deposits are prone to slope instability. The potential for erosion can be a concern along the city's riverbanks; however, design and protection measures have been taken along the Russian River, thereby reducing the risk of erosion. According to the *Healdsburg 2030 General Plan Background Report*, the potential for large amounts of bank erosion is moderate to small.

The city has been divided into three slope stability categories (see Figure IV.G-4). The majority of the city is located within Zone A, the most stable zone, while portions of the city lie within Zone B, the marginally stable zone, and Zone C, the least stable zone. As can be seen when comparing Figures IV.G-4 and IV.G-5, the majority of landslides within the city have occurred in Zones B and C. Landslides can occur from improper grading and drainage practices as well as heavy rainfall. When comparing Figures IV.G-4 and Figure III.7 (Development Sub-Areas) there is apparent overlap between slope hazard zones and areas identified for potential development in the *Healdsburg 2030 General Plan Background Report*. Areas of potential development occur within Slope Hazard Zone B (slight to moderate risk of landslides) in Planning Sub-Areas A, B, C, D, E, and H. Areas of potential development occur within Slope Hazard Zone C (moderate to high risk of landslides) in Planning Sub-Areas A, B, C, and H. The majority of land use designations within Slope Hazard Zones B and C are low density/low intensity uses such as Open Space (OS), Public/Quasi Public (PQP), Very Low Density Residential (VLR), and Low Density Residential (LR), although designations such as High Density Residential (HR), Medium High Density Residential (MHR), Medium Density Residential (MR), and Industrial (I) do exist within those slope hazard zones. Therefore, development within Slope Hazard Zones B and C could result in substantial erosion or unstable soil conditions from excavation grading or fill.

As discussed above, the risk of erosion ranges from small to high and the risk associated with unstable soil conditions ranges from slight to high. However, compliance with the CBC as well as the proposed General Plan policies listed previously in this section will ensure that impacts associated with implementation and buildout of the proposed General Plan remain less than significant. The CBC regulates grading activities, including drainage and erosion control, and construction on unstable soils and future developments will be required to comply with these guidelines. Policy LU-A-6 will ensure that any proposed annexation areas on Fitch Mountain will be studied to determine geotechnical constraints. Implementation of Policy LU-C-2 will only allow intensive development in areas not subject to geologic and environmental limitations. Policy T-A-8 discourages the development of private streets in new residential development areas unless it will serve to limit grading, which will reduce the potential for erosion. Policy S-A-1 will ensure that areas within known geological hazards will be reserved for open space or low intensity uses. In addition, any future development will be required to apply for a grading permit with the city as well as submit a SWPPP that will further address any potential risk of erosion. Therefore, impacts related to erosion or unstable soil conditions would be considered to be ***less than significant***.

Impact IV.G-2: The proposed Project would not expose people or property to seismic hazards including fault rupture on active faults, strong seismic ground shaking, or seismically induced ground failure, including liquefaction.

As stated earlier in this section, the city is located on the Healdsburg-Rogers Creek fault and is in proximity to other major regional faults. As such, the city is at risk of experiencing shaking intensities of approximately IX to X, corresponding to violent ground shaking. The city is not however, located within an Alquist-Priolo Fault Zone. The closest Alquist Priolo Fault Zone is over three miles from the city.[1]

[1] *California Department of Conservation, California Geologic Survey, GIS Files of Official Alquist-Priolo Earthquake Zones, 2002.*

Fault rupture within the city along the Healdsburg-Rogers Creek fault is likely as a result of a large earthquake on the fault. The risk of fault rupture in other parts of the city is very low. However, as shown in Figure IV.G-1, there are several other active and potentially active faults within the city. Movement along these faults as a result of an earthquake could also lead to fault rupture. Structures built across such faults could be severely damaged. When comparing Figure IV.G-1 and Figure III-8, it is apparent that the majority of land use designations overlapping active faults are low density/low intensity land use designations such as Open Space (OS), Public/Quasi Public (PQP), Very Low Density Residential (VLR), and Low Density Residential (LR), although designations such as High Density Residential (HR), Medium High Density Residential (MHR), Medium Density Residential (MR), and Industrial (I) do overlap active faults. Most of the city's designated land uses have been developed, however there is still a potential for new development and infill development within the city. When comparing Figures IV.G-1 and Figure III.7 (Development Sub-Areas) there is apparent overlap between active faults and Sub-Areas A, B, C, E, and H which have been identified for potential development in the *Healdsburg 2030 General Plan Background Report*. As such, new developments would be located on or near and active earthquake faults.

The principal faults in the area could generate earthquakes capable of producing strong to violent ground shaking in the city. The intensity of ground shaking can be amplified by local geologic conditions. The alluvium deposits that underlie most of the downtown area may be somewhat susceptible to groundshaking amplification. URMs would be most susceptible to earthquake damage. However, most of the city's URMs have been retrofitted. There is only one remaining URM that has not been retrofitted and it is currently undergoing the process to meet acceptable earthquake design standards.

The risk of lateral spreading, lurch cracking, or liquefaction is moderate to low within the low-lying portions of the city and very low in upland areas. Within the downtown area, potentially-liquefiable deposits are likely to occur locally.

The seismic hazards discussed above coupled with an increase of residents within the SOI will result in greater numbers of people exposed to seismic hazards due to buildout under the proposed General Plan. The additional residential, commercial, and industrial structures resulting from proposed General Plan buildout will also be exposed to seismic hazards.

Federal and state regulations as well as the proposed General Plan policies listed earlier in this section will reduce the risks associated with exposure of people and property to seismic hazards. For example, the State's Seismic Hazards Mapping Act establishes a mapping program for earthquake-related hazards and allows lead agencies to withhold building permits until geologic or soils investigations are conducted for specific sites and mitigation measures are incorporated into plans to reduce hazards associated with seismicity and unstable soils. Additionally, the CBC requires that structures be designed to resist stresses produced by lateral forces caused by wind and earthquakes. The City's Resolution 147-186 also requires geologic and soils investigations, grading erosion and sediment control plans, plan review letters, and "as-built" construction reports in order to ensure safe construction on potentially hazardous geologic locations. In addition to Policies LU-A-G, LU-C-2, and S-A-1 described in Impact IV.G-1, Policies LU-

C-1, T-A-2, S-A-3, S-B-1, and S-B-2 will constrain future development to areas of low geological constraints, designate geologically hazardous lands as open space or low intensity uses, require continued collecting of geological data, and ensure structurally sound buildings and infrastructure. These measures will reduce the impacts resulting from seismic hazards by ensuring that new development will be capable of withstanding seismic events. Therefore, impacts related to exposure of people or property to seismic hazards would be ***less than significant***.

Impact IV.G-3: The proposed Project would not expose persons or property to geologic hazards such as landslides, land subsidence, or unstable or expansive soils.

As discussed in Impact IV.G-1, the risk of landslide ranges from slight to high within Planning Sub-Areas A, B, C, D E, K, and H. The risk of liquefaction is moderate to low within the low-lying portions of the city and very low in upland areas. Within the downtown area, potentially-liquefiable deposits are likely to occur locally. According to the *Healdsburg 2030 General Plan Background Report*, moderately- to highly-expansive materials can occur within the bedrock formations present in the city.

An increase from 12,200 residents in 2005 in the Healdsburg SOI to 14,468 residents under proposed General Plan buildout could result from development under the proposed General Plan. As such, greater numbers of people will be exposed to geologic hazards. The additional residential, commercial, and industrial structures will also be exposed to geologic hazards.

However, federal and state regulations as well as proposed General Plan policies listed earlier in this section have been drafted to reduce the risks associated with exposure of people and property to geologic hazards. As discussed in Impact IV.G-2, adherence with the Earthquake Hazards Reduction Act, the Alquist-Priolo Earthquake Fault Zoning Act, the State's Seismic Hazards Mapping Act, the CBC, and the City's Resolution No. 147-186 will result in reduced impacts from geologic hazards. In addition the proposed Project will be subject to Policies LU-A-6, LU-C-1, LU-C-2, T-A-8, T-A-12, S-A-1, S-A-2, S-A-3, S-B-1, and S-B-2 which will further ensure that future developments will be sited in accordance with geological limitations and will be required to employ structurally sound building practices. Therefore, impacts relating to exposure of people and property to geologic hazards such as landslides, land subsidence, or unstable or expansive soils would be considered ***less than significant***.

Impact IV.G-4: The proposed Project would not 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.

Future buildout covered in the proposed General Plan will be integrated into the city's wastewater treatment system and sewer infrastructure with the exception of the Old Redwood Highway Study Area described above. Sewer infrastructure is not currently available in the area and plans to provide sewer services have yet to be finalized. Land uses in the area currently rely on septic systems for the disposal of waste water and sewage. The proposed General Plan will only minimally change land use designations in the area from Heavy Industrial (HI) to Industrial (I), and from Highway Commercial (HC) to Mixed Use

(MU); therefore, any new development will be similar to that allowed under existing designations. Until sewer services are extended to the area, new development will continue to be served by septic systems. Existing geotechnical information indicates that the soils in this area are able to support the use of septic tanks. In addition, specific projects within Sub-Area J will be required to adhere to the guidelines of the SCPRMD septic system permitting process. Therefore, impacts related to soils and the use of septic tanks would be ***less than significant***.

CUMULATIVE IMPACTS

The geographic context for the analysis of impacts resulting from geologic and seismic hazards is generally site specific, rather than cumulative in nature, because each development site has unique geologic considerations that will be subject to uniform site development and construction standards. Geotechnical impacts related to future development in the city involve hazards associated with site-specific soil conditions, erosion, and ground-shaking during earthquakes. The impacts from buildout proposed in the proposed General Plan will be specific to each site and its users and will not be common or contribute to (or shared with, in an additive sense) the impacts on other sites. In addition, development on each site will be subject to uniform site development and construction standards that are designed to protect public safety. These measures will reduce impacts that will result from the buildout of the proposed General Plan. Therefore, cumulative impacts related to geology and soils would be ***less than significant***.

MITIGATION MEASURES

With implementation of the applicable regulations and the proposed General Plan policies and implementation measures listed above, no mitigation measures would be required for Impacts IV.G-1 through IV.G-4. Additionally, no mitigation measures would be required for cumulative impacts.