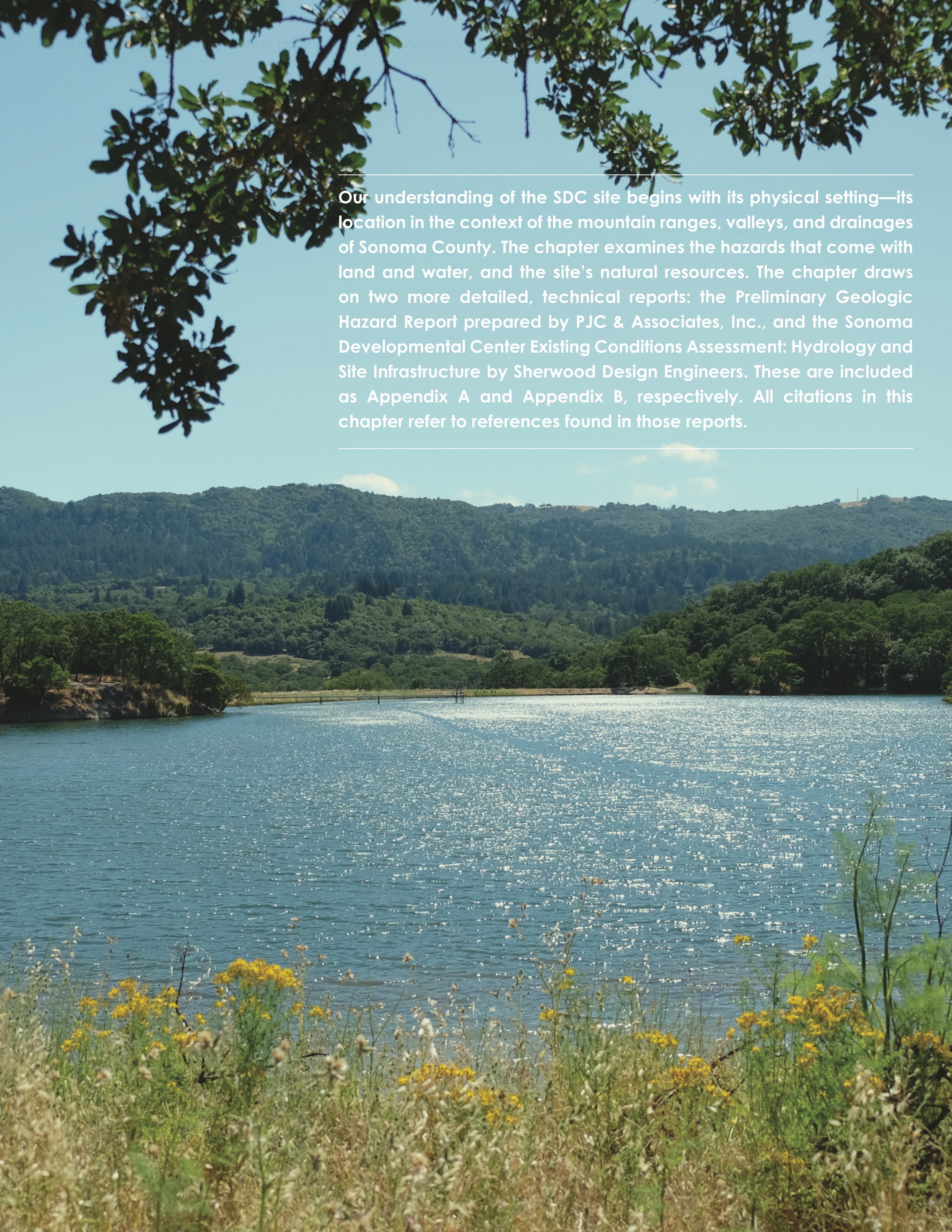
4. LAND + WATER



Our understanding of the SDC site begins with its physical setting—its location in the context of the mountain ranges, valleys, and drainages of Sonoma County. The chapter examines the hazards that come with land and water, and the site's natural resources. The chapter draws on two more detailed, technical reports: the Preliminary Geologic Hazard Report prepared by PJC & Associates, Inc., and the Sonoma Developmental Center Existing Conditions Assessment: Hydrology and Site Infrastructure by Sherwood Design Engineers. These are included as Appendix A and Appendix B, respectively. All citations in this chapter refer to references found in those reports.

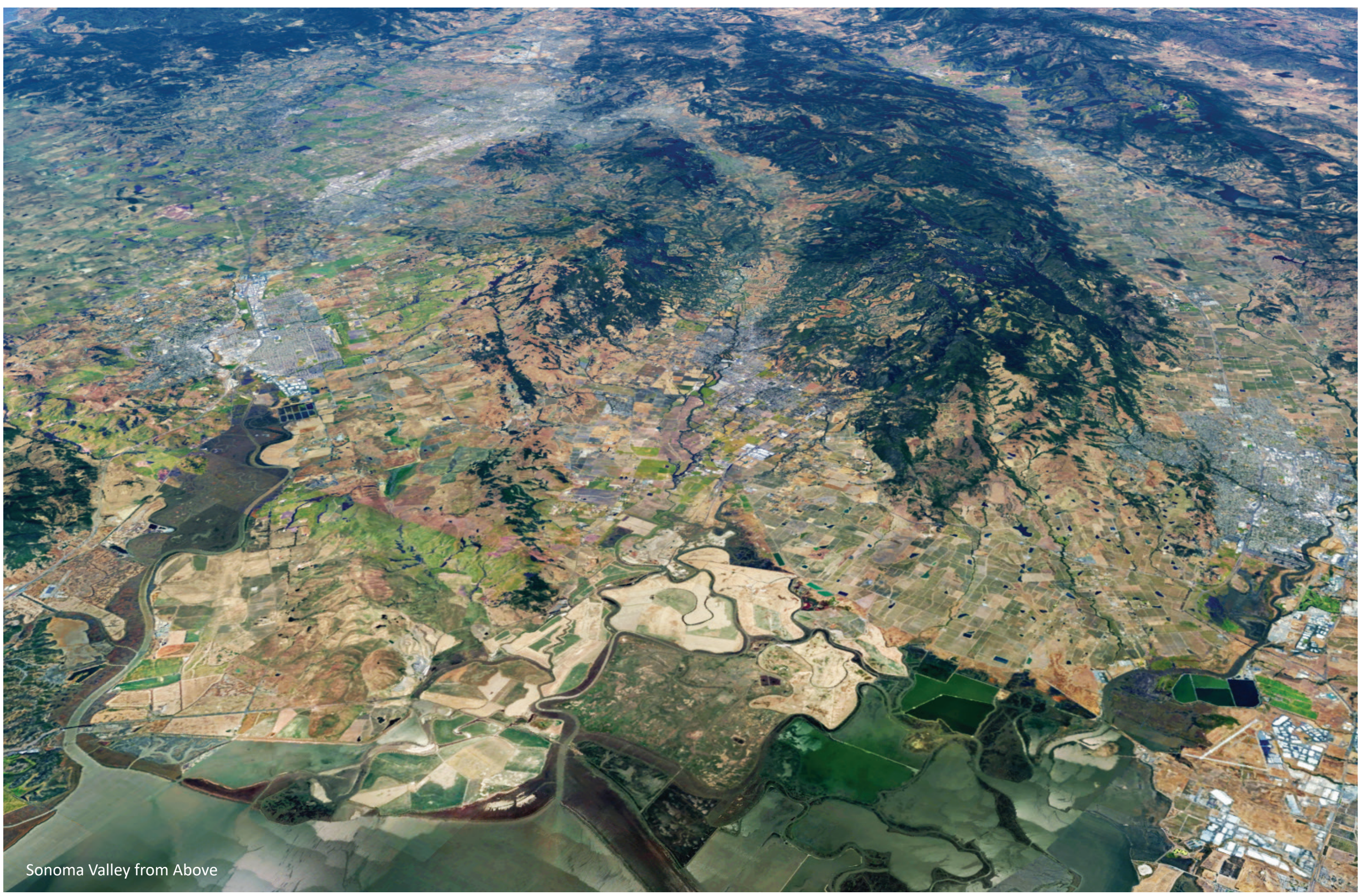
4.1 Regional Setting

REGIONAL GEOLOGICAL SETTING

The SDC site is located in the Coast Ranges Geomorphic Province of California. This province is characterized by northwest trending topographic and geologic features, and includes many separate ranges, coalescing mountain masses and several major structural valleys. The province is bounded on the east by the Great Valley and on the west by the Pacific Ocean. It extends north into Oregon and south to the Transverse Ranges in Ventura County.

The structure of the northern Coast Ranges region is extremely complex due to continuous tectonic deformation imposed over a long period of time. The initial tectonic episode in the northern Coast Ranges was a result of plate convergence which is believed to have begun during late Jurassic time. This process involved eastward thrusting of oceanic crust beneath the continental crust (Klamath Mountains and Sierra Nevada) and the scraping off of materials that were accreted to the continent (northern Coast Ranges). East-dipping thrust and reverse faults were believed to be the dominant controlling structures.

Right lateral, strike slip deformation was superimposed on the earlier structures beginning in mid-Cenozoic time, and has progressed northward to the vicinity of Cape Mendocino in Southern Humboldt County. Thus, the principal structures south of Cape Mendocino are northwest-trending, nearly vertical faults of the San Andreas system.


Sonoma Valley from Above

HYDROLOGY OF THE SONOMA VALLEY

The Sonoma Valley is tucked between Sonoma Mountain to the west and the Mayacamas Range to the east. The mountain slopes are mostly undeveloped and wooded with numerous small seepages, springs and creeks. The slopes are moderate, primarily at less than 20 percent grade. The entire valley drains to Sonoma Creek, which discharges to the San Francisco Bay via Skaggs Island and the San Pablo Bay National Wildlife Refuge. The entire Sonoma Valley, ridge to ridge and from Mount Hood to the bay, are all within the Sonoma Creek watershed.

Accounts of Sonoma Valley from the early and mid-1800s describe a very different landscape than what is present today. Sonoma Creek appears to have had "no set watercourse upon leaving Adobe Canyon" (just north of Kenwood) (Barber et al. 2012). Instead, the valley was covered with interconnected marshes, ponds, vernal pools, and networks of small channels (Barber et al., 2012; San Francisco Estuary Institute, 2008, Dawson et al. 2016). It is estimated that perennial wetlands covered about 1% of the valley floor and seasonal wetlands covered 20 percent or more. Many tributary channels were disconnected from Sonoma Creek; they flowed directly into the wetlands on the valley floor, while others flowed across alluvial fans and shifted their course frequently.

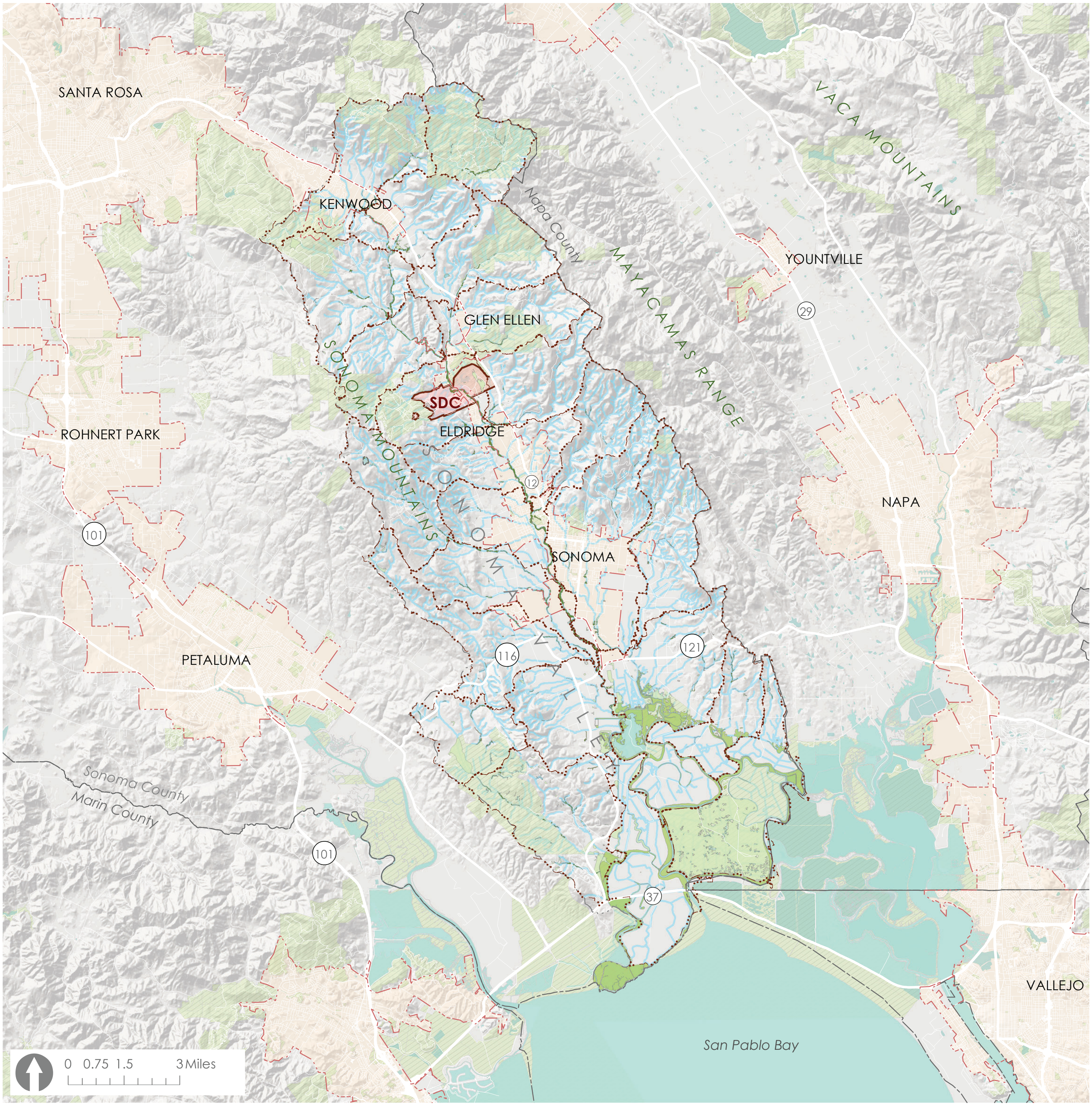
The Sonoma Valley experiences significant variation in rainfall, with the higher elevations and northern reach of the valley receiving significantly greater precipitation. The National Weather Service Cooperative station data dating back to 1898 record annual rainfall between 11.34 and 63.45 inches with an average recorded annual rainfall of 29.4 inches in the town of Sonoma. Since 1953, the Sonoma Developmental Center has maintained a gage at Fern Lake on the northeastern slope of Sonoma Mountain. This location has experienced between 15.05 and 116.64 inches of rain during the (September 1 to August 31) year, with an average annual rainfall of 47.03 inches. Typically, the upper reaches of the watershed receive roughly 40-50% more rainfall than the valley floor. This precipitation drains to creeks, seeps into the soils, feeds the vegetation, recharges the groundwater, dissipates into the atmosphere through evaporation and transpiration and, under saturated conditions, seeps out of the ground to flow into streams and Sonoma Creek. These streams are the collectors in sub-watersheds that are determined by the topography over which the water flows. Figure 4-1 depicts the region highlighting the Sonoma Creek Watershed. Figure 4-2 presents an isohyetal map of the region indicating the variation of rainfall between the valley floor and higher altitudes.

Regionally, the Sonoma Valley depends heavily on groundwater for domestic and agricultural uses. Studies by the USGS and others have identified that groundwater pumping has increased significantly in recent years and that the Sonoma Valley is now experiencing declining groundwater levels and related concerns over groundwater quality as a result of potential seawater intrusion and geothermal upwelling. In response to these concerns, and well ahead of state mandated reporting by the Sustainable Groundwater Management Act, the Sonoma Valley Water Agency, local water districts and other local stakeholders developed a Groundwater Management Plan for the Sonoma Valley groundwater basin in 2007. This plan developed a set of Basin Management Objectives (BMO) to preserve, protect and manage groundwater resources in the region. Among these BMOs is one to identify, protect and enhance the recharge of groundwater where appropriate.

Regional water supply is discussed further in Section 4.4.

Figure 4-1

CREEKS AND WATERSHEDS OF THE SONOMA VALLEY

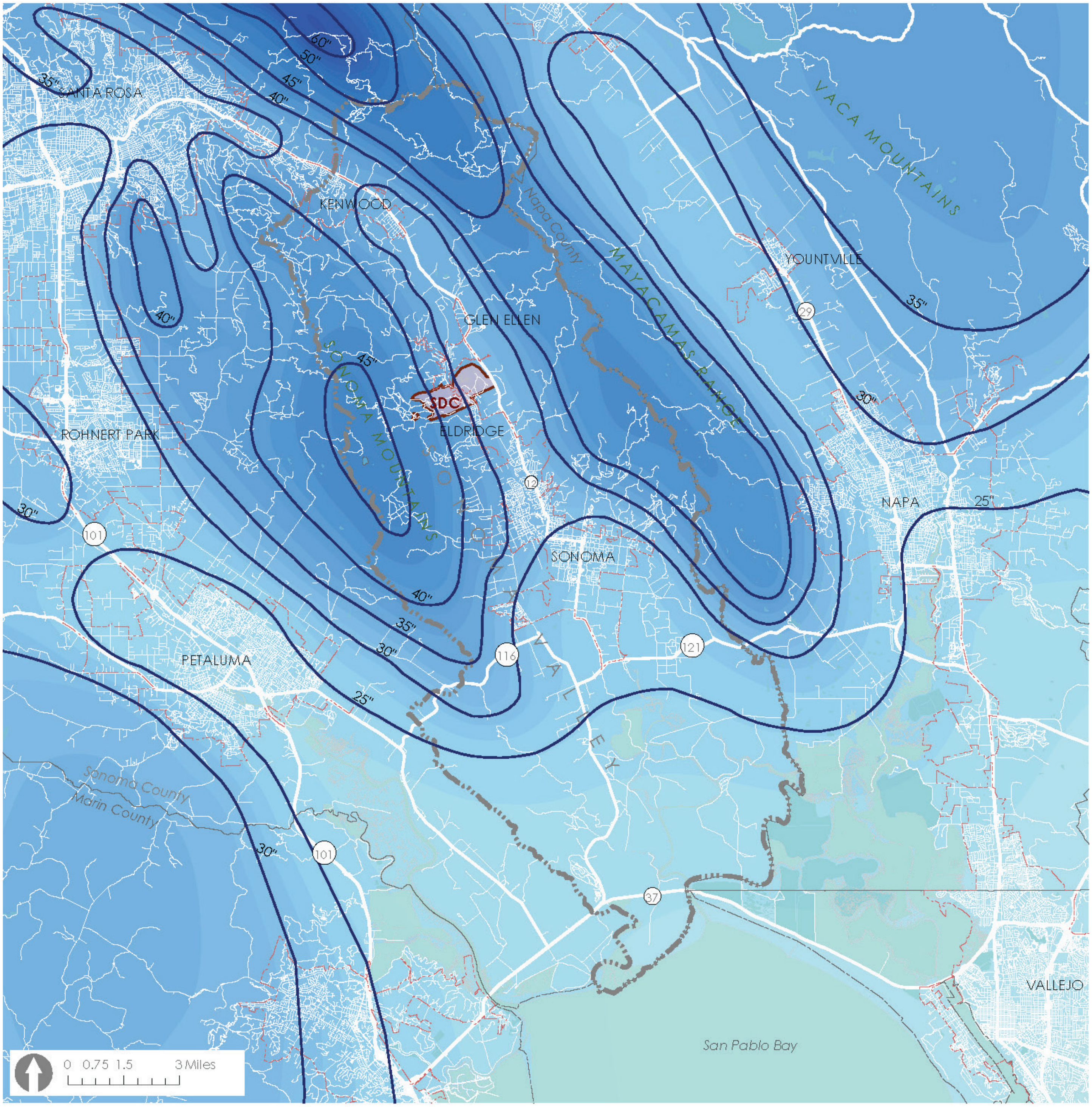


Sonoma Creek Micro-Watersheds
Sonoma Creek Watershed
County Boundary
SDC Property
Water
Public and Protected Lands
Freshwater Herbaceous Wetland
Tidal Salt Marsh
Woody Riparian
Streams
Urbanized Areas

Sources:
USGS, US Census Bureau, California Geoportal, GreenInfo Network, Sonoma Ecology Center, Sonoma County Water Agency, Sonoma County Agricultural Preservation and Open Space District, Sonoma County Vegetation Mapping and LiDAR Program, San Francisco Estuary Institute

Figure 4-2

RAINFALL



SDC Property
County Boundary
Sonoma Creek Watershed
Water & Wetlands
Isohyetal Line (5")

Isohyetal (Inches)
20"
30"
40"
50"
60"
70"
80"

Sources:
USGS, US Census Bureau, California Geoportal, GreenInfo Network, Sonoma Ecology Center, Sonoma County, Sonoma County Water Agency

4.2 Geology of the SDC Site

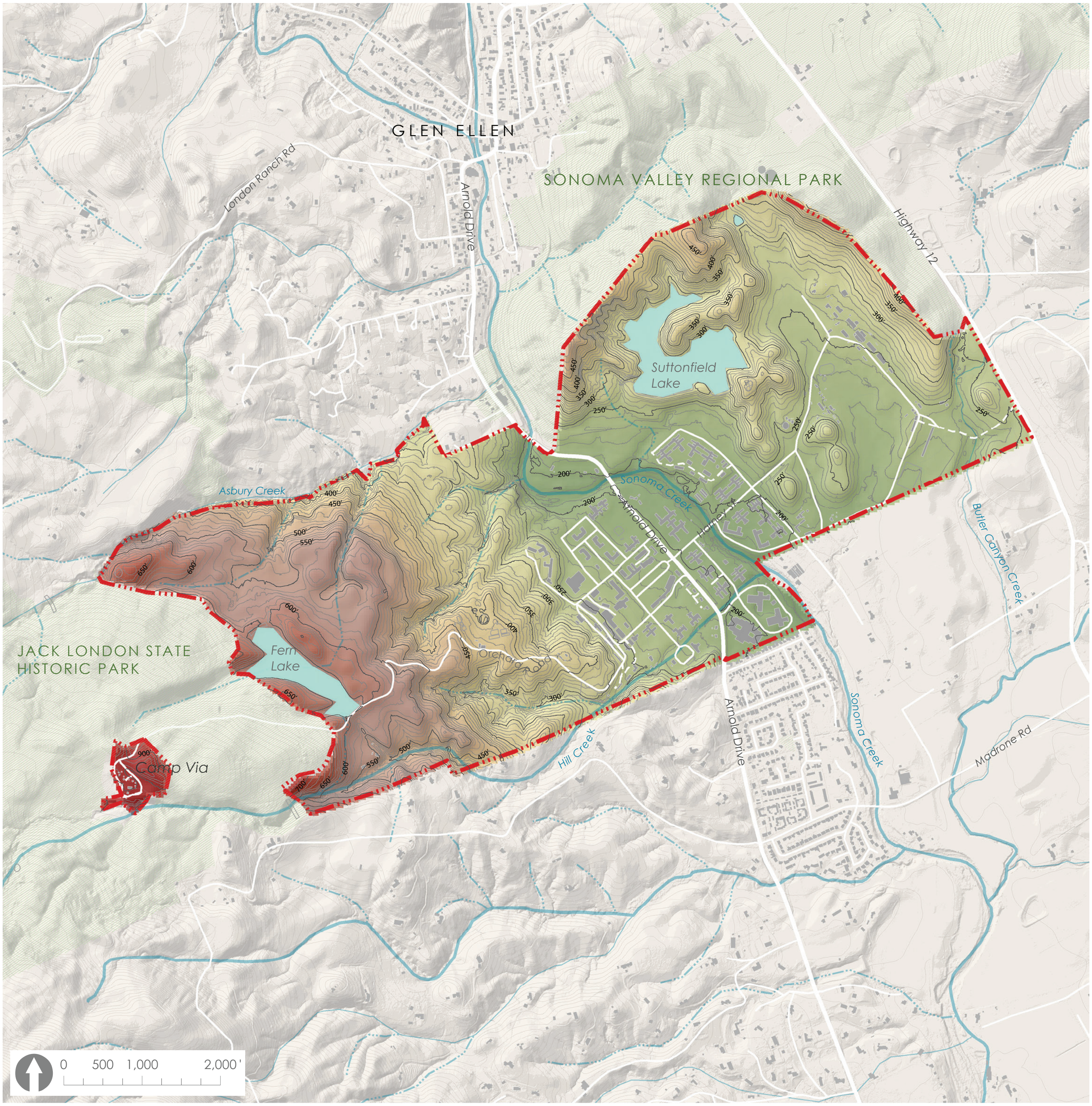
TOPOGRAPHY

The SDC property forms a swath across the Sonoma Valley, extending from Highway 12 on the east and up the slope of Sonoma Mountain on the west. This eastern part of the site is undulating small hills with a valley that begins in the northeastern corner of the property and broadens as it slopes downward toward the south. Suttonfield Lake is a reservoir formed among the hills in the northeast corner of the site. These hills form a small ridge between the "Farm" area of the site to the east (at approximately 230 feet) and the east side of the core campus. The east side of the core campus (approximate elevation 200 feet) is a flat area between this low ridge and Sonoma Creek.

Sonoma Creek cuts across the midsection of the property with an average water surface elevation of roughly 170 feet.

West of the creek, the campus is flat for a few blocks of broad manicured lawns, including sports fields and a broad parade ground up to Sonoma Road. West of Sonoma Road, the grade increases as you continue across the rest of the main campus. By the time you reach Manzanita Street at elevation 250, the grade increases noticeably. Refer to Figure 4-3 Elevation Analysis for a map of the topography of the property. Roughly a third of the property is west of the main campus with slopes from 10 percent to well above 20 percent. Refer to Figure 4-4, which uses existing grades to identify different slope gradients on the site. The property reaches an elevation of approximately 900 feet and the surface elevation of Fern Lake is roughly 590 feet.

Figure 4-3
ELEVATION ANALYSIS



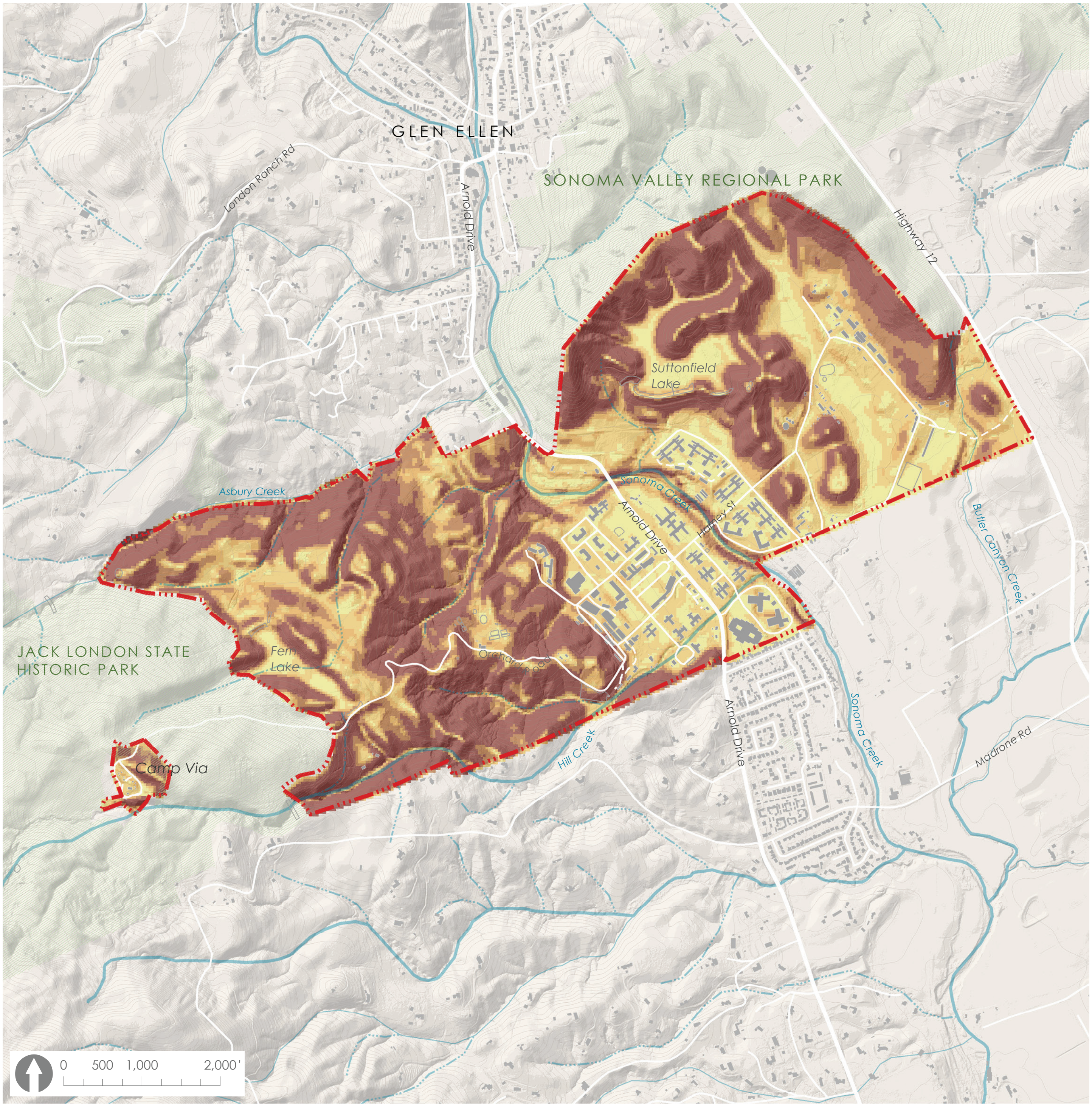
SDC Property line
Lakes
Protected and Public Lands
Ephemeral Streams
Perennial Streams
Intermittent Streams
On-Site Contours (10')
On-Site Contours (50')

Elevation (feet)
150' 350' 550' 750' 950'

Source
USGS, GreenInfo Network,
Sonoma Ecology Center

Figure 4-4

SLOPE



SDC Property line

Protected and Public Lands

Ephemeral Streams

Perennial Streams

Intermittent Streams

Slopes (%)

- 0 - 2.9%
- 3 - 5.9%
- 6 - 7.9%
- 8 - 10%
- > 10%

Source
USGS, GreenInfo Network, Sonoma Ecology Center

SITE GEOLOGY

The Sonoma Developmental Center's local geology varies from historic and relatively young alluvial soils deposited in the channel and terraces along Sonoma Creek and in the Valley of the Moon, to the clastic terrestrial sediments of the Glen Ellen Formation and extrusive volcanic lava flows and ash tuff of the Sonoma Volcanics Group. A large-scale Pleistocene landslide has been mapped at the upper western margin of the project site. A regional geologic map prepared by the California Geologic Survey (CGS) is presented on Figure 4-5. A geologic cross-section of the project site is presented on Figure 4-6. The following subsections provide additional explanations of the mapped geologic units.

Artificial Fill (af)

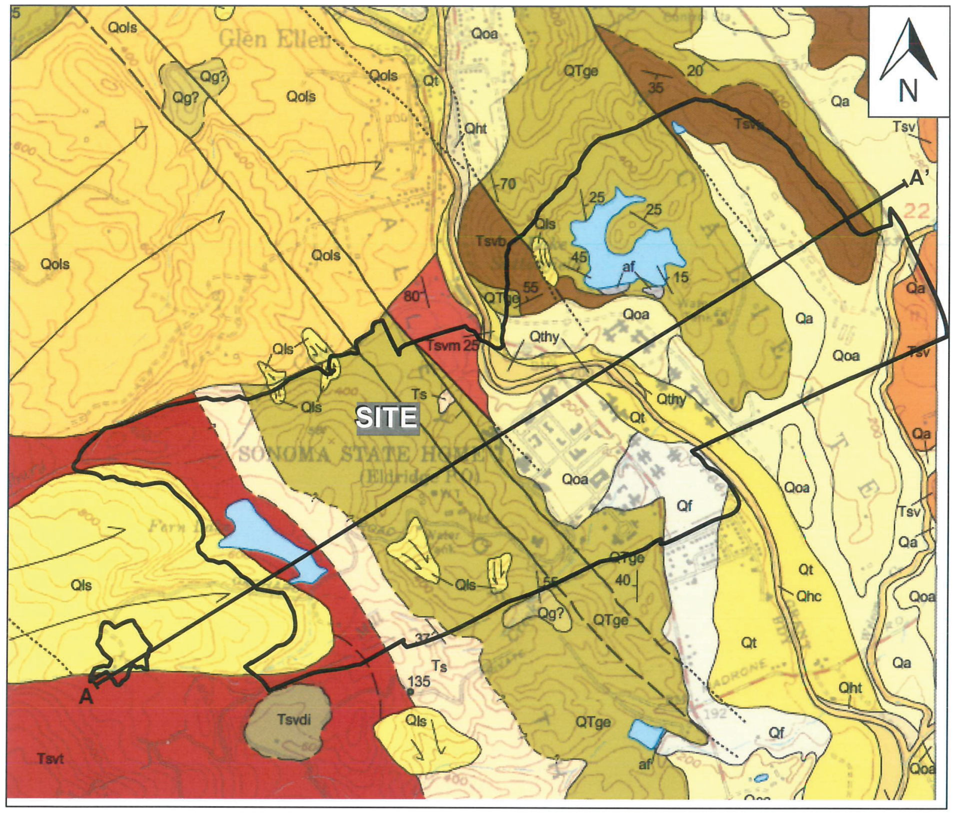
Two man-made embankments exist at the southern perimeter of Lake Suttonfield. In addition, two man-made embankments exist at the northern and southern perimeters of Fern Lake. The embankments consist of compacted artificial fill and were constructed during development of Suttonfield Lake and Fern Lake. We also observed artificial fill along some the roadways, driveways, parking areas, and building pads at the project site.

Recent Stream Deposits along Sonoma Creek (Qhc)

Late Holocene to modern (less than 150 years old) stream channel sediments exist within the Sonoma Creek channel. These deposits consist of loose alluvial

Figure 4-5

GEOLOGIC MAP OF THE GLEN ELLEN 7.5 MINUTE QUADRANGLE



SCALE 1:24,000

REFERENCE: GEOLOGIC MAP OF THE GLEN ELLEN 7.5 MINUTE QUADRANGLE, CALIFORNIA GEOLOGIC SURVEY DATED 2003.

A—A' GEOLOGIC CROSS SECTION LINE, *SEE PLATE 3

*SEE PLATE 2B FOR EXPLANATION OF GEOLOGIC UNITS

af Artificial fill.

Qhc Late Holocene to modern (<150 years) stream channel deposits in active, natural stream channels. Consists of loose alluvial sand, gravel, and silt.

Qhty Latest Holocene stream terrace deposits. Stream terraces are deposited as point bar and overbank deposits by Sonoma Creek.

Qls Landslides. Includes debris flow and block slump landslides. Arrows show the direction of movement.

Qa Latest Pleistocene to Holocene alluvium in small valleys. Sand, gravel, silt and clay.

Qt Latest Pleistocene to Holocene stream terrace deposits. Sand, gravel, silt and minor clay. Relatively flat, undissected stream terraces where absolute age is uncertain.

Qf Latest Pleistocene (<30,000 years) to Holocene alluvial fan deposits. Sand, gravel, silt, and clay mapped on gently sloping, fan-shaped, relatively undissected alluvial surfaces. Qfc - Fan of Carriger Creek consisting of cobble gravel rich in well-rounded volcanic clasts.

Qoa Early to late Pleistocene alluvial deposits, undivided. Alluvial fan, stream terrace, basin, and channel deposits. Topography is gently rolling with little or no original alluvial surfaces preserved; moderately to deeply dissected.

QTge Glen Ellen Formation. Gravel, sand, reworked tuff and clay of unknown age. Sediments derived mostly from the Sonoma Volcanics. Obsidian pebbles are characteristic of this unit.

Ts (Tsdi) Sand and gravel, tuff and diatomite. Rich in both Franciscan and Sonoma Volcanic detritus. Contains tuff dated at 4.8 +/- 0.03 Ma (J. Allen, Written communication).

Tsv (Tsvb, Tsvm, Tsvt, Tsvr)

Sonoma Volcanics- Mafic lava flows, breccias, agglomerate tuff, tuff breccia with interbedded tuffaceous sediments; also includes dacitic to rhyolitic lava flows, debris flows, tuff, and tuffaceous sediment. The age range for the Sonoma Volcanics on this quadrangle is 8.65 to 3.80 Ma (Fox and others, 1985). There is a diatomite-rich sequence within the Sonoma Volcanics (Tsvdi). The Sonoma Volcanics are divided into the following subunits:

Tsvb- Basalt flows. The basalt flows near Carriger Creek yielded an Ar/Ar date of 4.1 Ma (Robert Fleck, Personal communication, 2004).

Tsvm- Mafic flows and breccias. Andesite and basaltic andesite.

Tsvt- Silicic tuff and interbedded tuffaceous sediments. Interbedded sand and gravel is similar to the Petaluma Formation.

Tsvr- Rhyolitic to dacitic flows, breccias, and sediments. Pink, white, gray, brown flow banded rhyolite in flows, debris flows and breccia. Interbeds of sand, gravel, and tuff. Dacite near Carriger Creek is dated at 5.79 +/- 0.3 Ma; Robert Fleck (Personal communication, 2004).

Contact between map units - Solid where accurately located, dashed where approximately located; short dash where inferred; dotted where concealed; queried where uncertain.

Fault - Solid where accurately located, dashed where approximately located; short dash where inferred; dotted where concealed; queried where uncertain. U = upthrown block, D = downthrown block. Arrow and number indicate direction and angle

Strike and dip of sedimentary beds:

Landslide - Arrows indicate principal direction of movement. Queried where questionable. A megalandslide occurs in the west part of the quadrangle. It displays a well-developed headwall scarp but its full extent is difficult to ascertain. Because it is a large block landslide, geologic units can be mapped within it. This slide is shown by a stipple pattern. Its full extent may be considerably greater than shown on this map.

sand, gravel, and silt. During our site reconnaissance we observed recent stream deposits within the active channel of Sonoma Creek. These deposits are actively reshaped annually during and following the wet season.

Latest Holocene Point Bar and Overbank Steam Deposits (Qhty)

Stream terraces are deposited as point bar and overbank deposits within and along Sonoma Creek. These deposits consist of loose alluvial sand, gravel, and silt and are actively reshaped during and following significant Sonoma Creek flood stages.

Landslides (Qls)

The CGS geologic map indicates a total of six landslides partially or entirely within the boundaries of the project site. The mapped landslide includes both debris flow and block slump type landslides. Furthermore, we observed a few unmapped landslides which are not indicated on the CGS regional geologic map, including a landslide along Orchard Road and a failure along the Sonoma Creek bank. A notable landslide on the CGS geologic map is a massive landslide complex west and above Fern Lake. The majority of the massive landslide complex is within Jack London State Park; however the toe of the landslide extends to the shoreline of Fern Lake. Arrows on the geologic map indicate the direction of the landslide movement.

Latest Alluvium (Qa)

Latest Pleistocene to Holocene alluvium deposited within Valley of the Moon. These deposits consist of heterogeneous and discontinuous layers of sand, gravel, silt, and clay.

Stream Terrace Deposits (Qt)

Latest Pleistocene to Holocene stream terrace deposits consisting of sand, gravel, silt, and minor clay. The relatively flat, undissected stream terraces are located in the nearly level terrain above Sonoma Creek.

Older Alluvium (Qoa)

Early to late Pleistocene alluvial deposits. The older alluvium consists of sand, gravel, silt, and minor clay which was deposited in alluvial fans, stream terraces, basins, and channels. Topography is gently rolling with little or no original alluvial surfaces preserved. These deposits are generally moderately to deeply dissected.

Glen Ellen Formation (QTge)

The Glen Ellen Formation consists of gravel, sand, reworked tuff and clay which was deposited during the Pliocene and Pleistocene epochs in a fluvial type environment. In general, sediments within the Glen Ellen Formation are derived from the older Sonoma Volcanic Group, Great Valley Sequence and Franciscan Complex bedrock formations. In the project area, sediments are primarily or possibly entirely derived from the Sonoma Volcanics Group. The Glen Ellen Formation mainly consists of sand, gravel, cobbles, mudstone and reworked tuff units. Obsidian pebbles are often found in the Glen Ellen Formation. The Glen Ellen Formation tuff units are often reworked ash material from older tuff bedrock.

Tertiary Sand, Gravel, tuff, and Diatomite (Ts)

Tertiary sand, gravel, tuff, and diatomite are generally rich in both Franciscan Complex and Sonoma Volcanic Group detritus. In the project area, sediments are primarily or possibly entirely derived from the Sonoma Volcanics Group. The CGS map indicates age dates of tuff in this unit around 4.8 million years old.

Sonoma Volcanic Group (Tsv, Tsvt, Tsvm, & Tsvb)

According to the CGS map, several members of the Sonoma Volcanics Group exist at SDC. The Sonoma Volcanics Group is generally characterized to consist of extrusive volcanic lava flows and layers of ash tuff. The volcanic bedrock was emplaced during the Pliocene and Miocene epochs, approximately three to eight and one-half million years ago. Resistant basalt and andesite boulders are scattered throughout the surface of the slopes at the western and eastern margins of the project site. Shortly after deposition, compressive forces uplifted and folded the bedrock units. The volcanic bedrock can be highly fractured and weathered to depths of 40 to 60 feet below the ground surface.

Figure 4-6

GEOLOGIC CROSS-SECTION A-A', SONOMA DEVELOPMENTAL CENTER

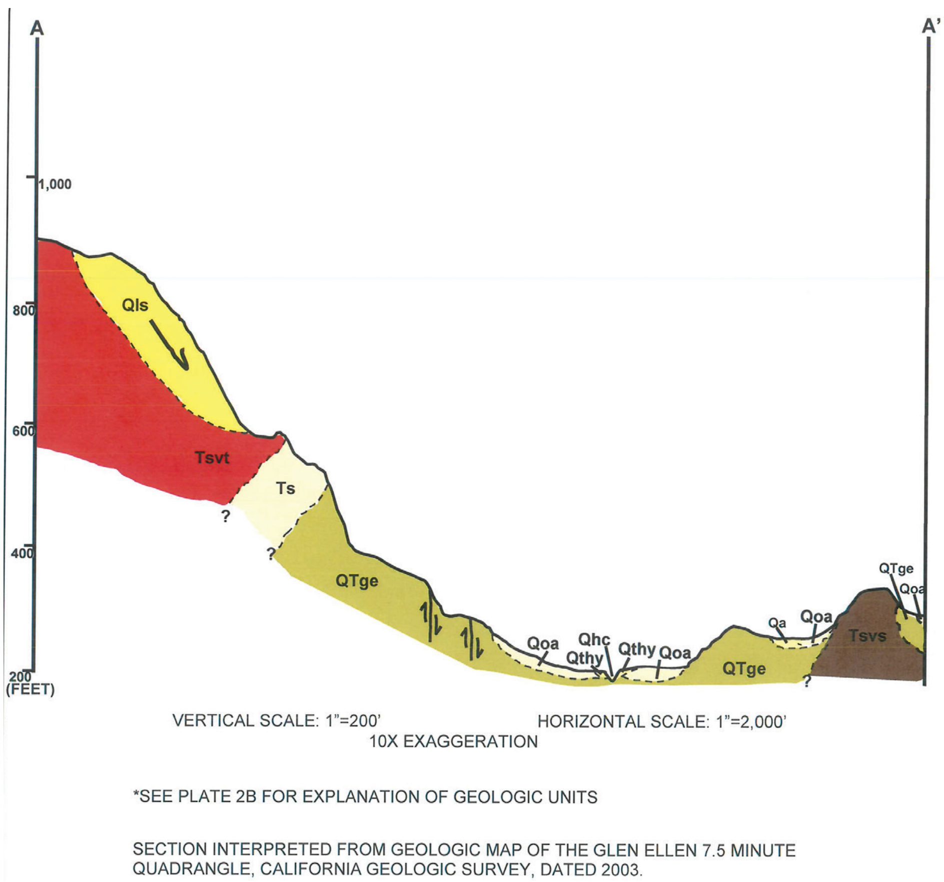
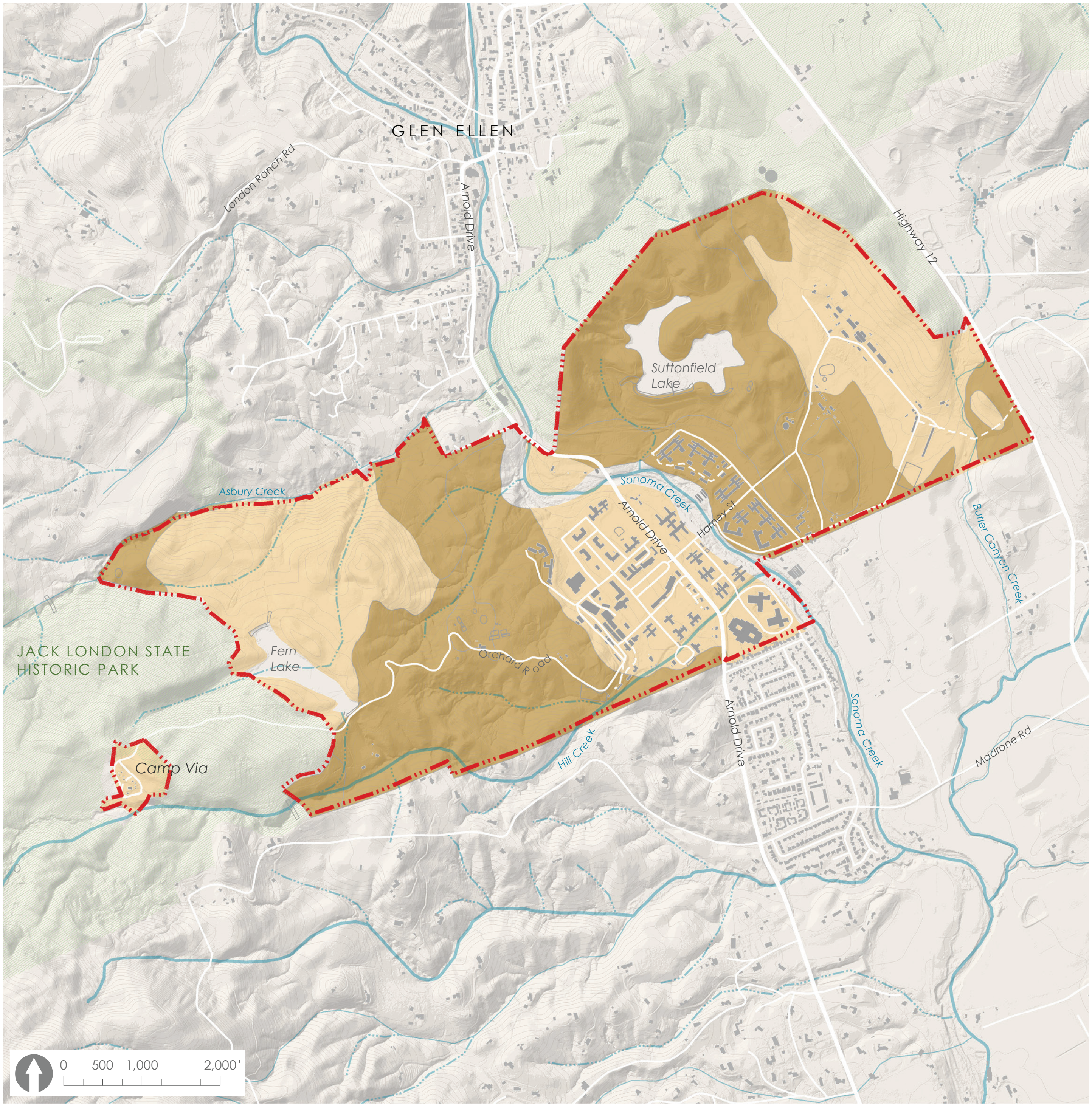


Figure 4-7
HYDROLOGIC SOIL GROUPS



SDC Property line

Protected and Public Lands

Ephemeral Streams

Perennial Streams

Intermittent Streams

Soils (HSG)

HSG

C

D

HSG DEFINITION

• Group C
Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

• Group D
Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Source
USGS, GreenInfo Network, Sonoma Ecology Center

SOILS

Nine soil types are mapped within SDC (NRCS 2017). In general, soils in the hilly portions of the site are derived from Sonoma Volcanics materials, while soils in gentler terrain are derived from alluvium. Most of these soils are moderately or well-drained, with the exception of Huichica loam (in the central campus), which can be somewhat poorly drained. Permeability is generally slow to moderate, and erosion hazard ranges from slight to high, depending on slope. The table below lists soil types mapped on the site, with ecological traits relevant to planning future land use and stewardship. Key processes that influence the site's soils include the flows of water and associated erosion or deposition, plant growth and decay, agriculture/livestock uses, trail and road uses, and other grading or site development.

SOILS AND INFILTRATION

Soil type, along with vegetation, slope, rainfall, and impervious surfaces such as buildings and pavement are a key consideration in understanding site hydrology. In general, the soils found on the property are not very infiltrative, meaning that while water will percolate into the soils, it will do so quite slowly.

Figure 4-7 depicts near surface soils found on the site, classified by Hydrologic Soil Group, a classification system developed by the Natural Resource Conservation Service to assess the runoff potential of soils. The dominant soil types found on the site are Group C and D, which have the highest runoff potential and low to very low infiltration rates because of the presence of clay or other properties that impede the movement of water within the soil. On steeper slopes, precipitation is likely to form surface runoff. In flat areas, surface water will tend to puddle. The primary way to improve infiltration in these soils is through vegetation and ponding. Vegetation acts to hold fine soils in place and reduce the energy of runoff. Ponding allows water to slowly infiltrate and provides a water source for the small components of the biosystem. Class C and D soils that are on steep slopes with poor vegetative cover are prone to soil erosion from the slopes and sedimentation of the water courses to which they discharge, creating an ecologically unstable condition. The natural vegetative cover and slowing the overland flow of runoff by encouraging upland ponding, help to maintain the ecological stability of the property.

Chapter 9: Considerations for Reuse and Conservation identifies how the site's capacity for infiltration can inform future land use.

Table 4-1

SOIL TYPES MAPPED AT THE SDC SITE

SOIL TYPE & TYPICAL SLOPES	GENERAL LOCATION AT SDC	UNDERLYING MATERIAL	TYPICAL VEGETATION/ VEGETATION AT SDC	DRAINAGE/ PERMEABILITY	RUNOFF/EROSION
Clough gravelly loam, 2-9%	Developed area east of creek (old bench terrace of creek)	Alluvium; very gravelly clay subsoil, and indurated hardpan at 12-34".	Oaks, manzanita, poison oak, grasses/ Developed, oak woodland, wetland	Moderately well-drained/ Very slow	Slow to medium/ Slight to moderate
Goulding clay loam, 5-30%	Upper slopes	Sonoma Volcanics bedrock at 12-24"	Scattered oaks, shrubs, and grasses/ Forest, woodland	Somewhat excessively drained/ Moderate	Medium to rapid/ Moderate to high
Huichica loam, 2-9%	Developed area west of creek – central campus	Strongly cemented valley alluvium at 25-40"	Grassland, scattered oaks/ Developed, remnant oaks	Somewhat poorly- to moderately well-drained/ Very slow	Slow to medium/ Slight to moderate
Laniger loam, 30-50%	Small knoll on eastern edge of property	Weathered rhyolite and tuff at 18-45"	Blue oaks, live oaks, manzanita, ceanothus, poison oak, brush and grasses/Oak woodland	Well- to somewhat excessively-drained/ Moderate	Rapid/High
Los Robles gravelly clay loam, 0-5%	Along Butler Canyon Creek and bend of Sonoma Creek north of central campus	Gravelly sandy clay loam subsoil, underlain by mixed alluvium at 36-48"	Grassland, scattered valley or live oaks/Oak woodland	Moderately well-drained/ Moderately slow	Slow/Slight
Red Hill clay loam, 2-30%	Northeastern agricultural area, western edge of Fern Lake, Camp Via	Sonoma Volcanics, basalt at 30-60"	Douglas fir, madrone, oaks, and shrubs/Dairy, grassland, woodland	Moderately well-drained/ Moderately slow	Medium to rapid/Moderate to high
Riverwash	Along Sonoma Creek	Recent depositions of gravel, sand and silt	Riparian herbaceous species, shrubs and trees/ Riparian forest	(Well-drained)/ (Rapid)	n/a/(High)
Spreckles loam, 2-30%	Mid-slopes	Clay subsoil underlain by volcanic ash at 22-60"	Oaks, madrones, manzanitas, poison oak, perennial grasses/ Oak woodland	Well-drained/ Slow	Medium to rapid/Slight to high
Tuscan cobbly clay loam, 0-9%	Eastern edge of property	Indurated hardpan of igneous materials at 10-25", on bench terraces	Grasses, shrubs/Oak woodland	Moderately well-drained/ Slow	Slow to medium/ Slight to moderate

GEOLOGIC AND SEISMIC HAZARDS

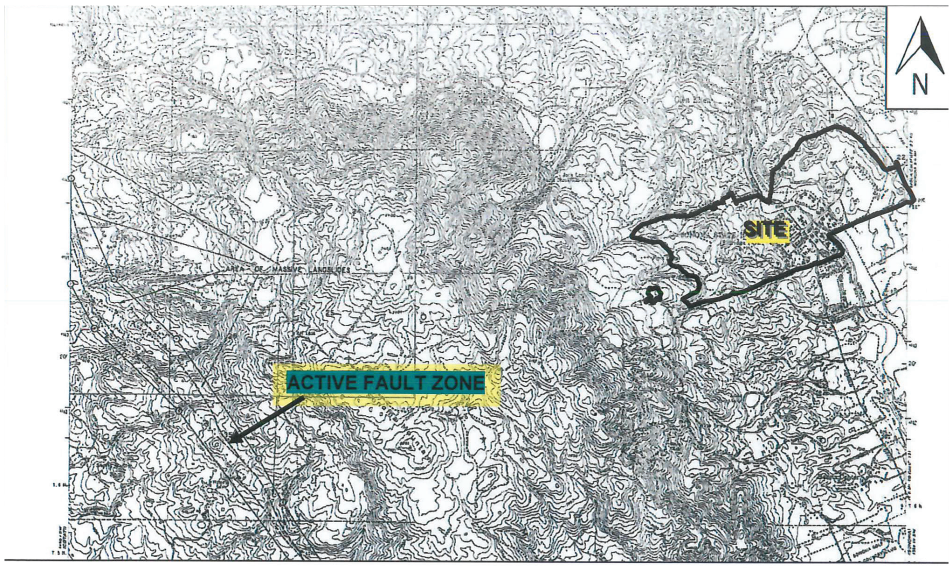
FAULTING

Geologic structures in the region are primarily controlled by northwest trending faults. The property is not located within the State of California Earthquake Fault Studies Zone. The location of the nearest active fault zone in relation to the project site is presented on Figure 4-8. According to the State of California, no known active faults extend through the project site. However, according to the CGS fault activity map (Figure 4-9), two well-located Quaternary faults bisect the SDC site. A Quaternary fault exhibits surface rupture features during the Quaternary geologic period (the past approximately 2.6 million years). Furthermore, the CGS map indicates three concealed fault liniments at the eastern margin project site.

According to the computer fault modeling software program EQFAULT, the three closest known active faults to the site are the Rodgers Creek, the West Napa, and the Maacama (South) faults. The Rodgers Creek fault is located approximately 4.5 miles to the southwest, the West Napa fault is located approximately 9.1 miles to the east-northeast, and the Maacama (South) fault is located approximately 18.4 miles north of the project site. The San Andreas fault, a notable fault, is located 24.1 miles southwest of the site. Figure 4-9 outlines the nearest known active faults, their associated maximum magnitudes and the estimated peak ground accelerations due to earthquakes which are expected to occur on those faults.

Figure 4-8

ALQUIST-PRIOLO LOCATION



SCALE 1" = 6000 FT

MAP EXPLANATION

POTENTIALLY ACTIVE FAULTS:
Faults considered to have been active during Holocene time and to have a relatively high potential for surface rupture, solid line where accurately located, long dash where approximately located, short dash where inferred, dotted where concealed, query (?) indicates additional uncertainty. Evidence of historic offset indicated b year of earthquake-associated event or C for displacement caused by creep or possible creep.

SPECIAL STUDIES ZONE BOUNDARIES:

These are delineated as straight line segments that connect encircled turning points so as to define special studies zone segments.

Reference: California Department of Conservation "State of California Special Study Zone, Glen Ellen Quadrangle," dated July 1, 1983

GEOLOGIC AND SEISMIC CONSIDERATIONS

The following discussion reflects the possible earthquake effects and various geologic hazards which could result in damage to the project site. [1]

1 The data, information, interpretations and recommendations contained in this report were presented for the Sonoma Developmental Center Site Assessment Study. The conclusions and professional opinions presented herein were developed by PJC in accordance with generally accepted geological principles and practices. No warranty, either expressed or implied, is intended.

This report has been prepared for use by parties studying the general reuse potential of the SDC site that may be part of an ongoing conceptual land use and building reuse study. It may not contain sufficient information for the purposes of other parties or other uses. If any changes are made in the project as described in this report, the conclusions and recommendations contained herein should not be considered valid, unless the changes are reviewed by PJC and the conclusions and recommendations are modified or approved in writing.

FAULT RUPTURE

Rupture of the ground surface is expected to occur along known active fault traces. No evidence of existing active faults or previous ground displacement on the site due to fault movement is indicated in the geologic literature or field exploration. Therefore, the likelihood of ground rupture at the site due to faulting is considered to be low. However, two well located Quaternary faults and three concealed faults have been mapped at the project site. Whether or not the Quaternary faults and concealed fault lineaments are active or pose a hazard to man is generally unknown. The State of California has not classified these fault features as active fault sources during the Holocene geologic epoch (the past approximately 11,000 years).

Table 4-2

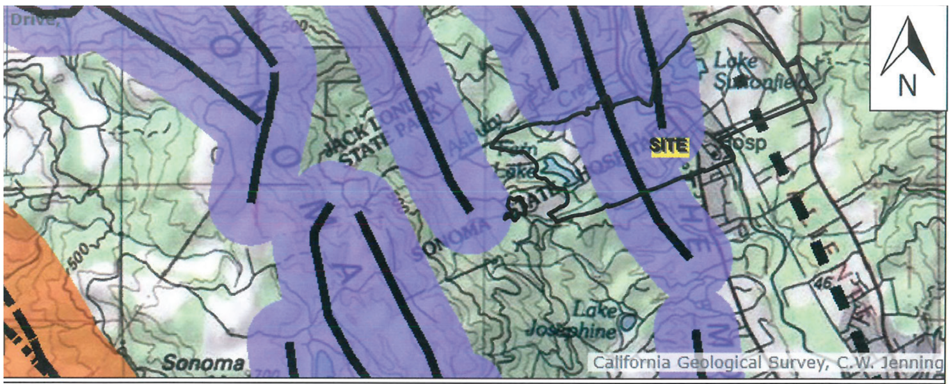
CLOSEST KNOWN ACTIVE FAULTS AND SITE DETERMINISTIC PARAMETERS

FAULT NAME	DISTANCE FROM SITE (MILES)	MAXIMUM EARTHQUAKES (MOMENT MAGNITUDE)	ESTIMATED PEAK GROUND ACCELERATIONS (G'S)
RODGERS CREEK	4.5	7.0	0.418
WEST NAPA	9.1	6.5	0.211
MAACAMA (SOUTH)	18.4	6.9	0.157

Reference: Blake, T.F, "EQFAULT" Ver 3.00, software program.

Figure 4-9

FAULT ACTIVITY



SCALE 1" = .9 MILES

EXPLANATION

Holocene fault displacement (during past 11,700 years) without historic record.

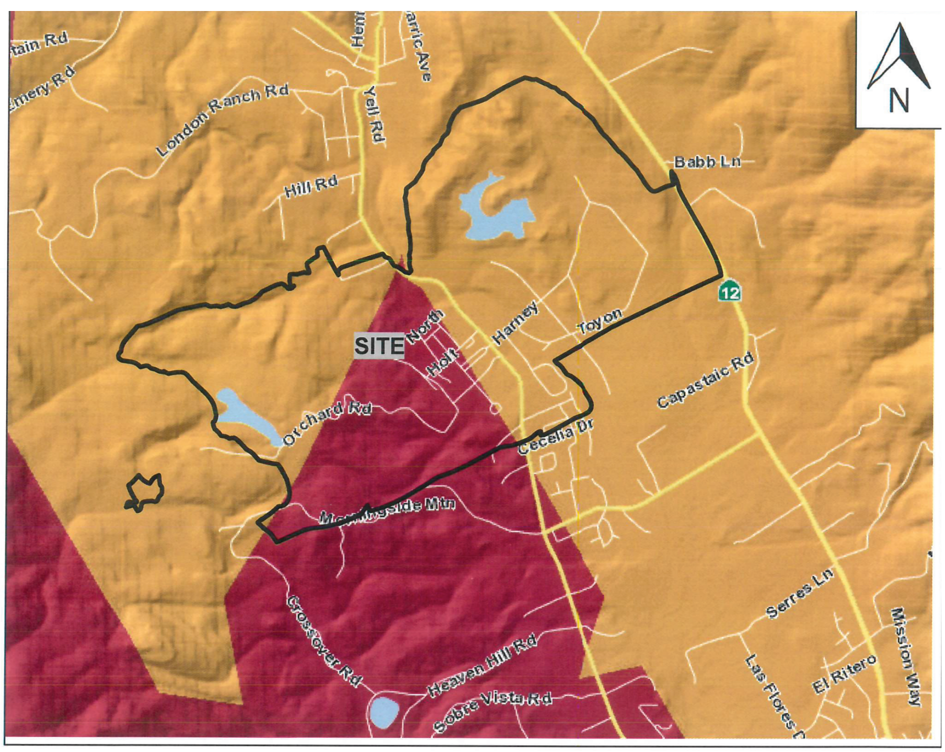
Quaternary fault (age undifferentiated).

Pre-Quaternary fault (older that 1.6 million years) or fault without recognized Quaternary displacement.

Reference: California Geological Survey, dated 2013

Figure 4-10

SHAKE SEVERITY – RODGERS CREEK FAULT



SHAKE SEVERITY MAP- **RODGERS CREEK FAULT** SCALE 1" = .5 MILES

EXPLANATION

Shaking Severity

- Light - MMI 5
- Moderate - MMI 6
- Strong - MMI 7
- Very Strong - MMI 8
- Violent - MMI 9
- Very Violent - MMI 10

Reference: Association of Bay Area Governments, Shake Susceptibility Map, dated June, 2009

GROUND SHAKING

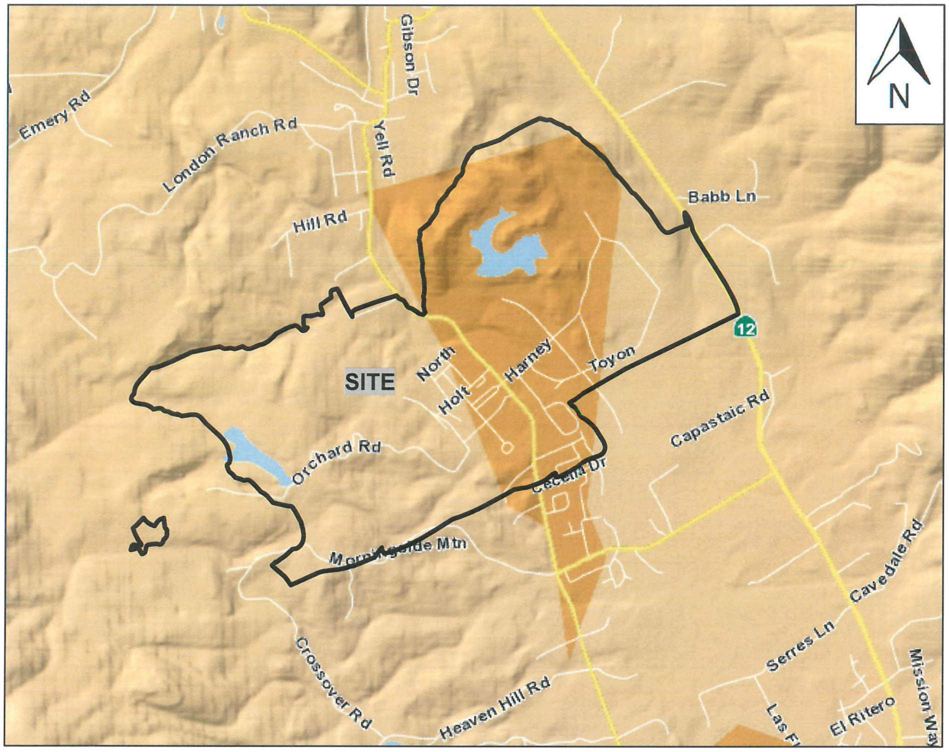
The site has been subjected in the past to ground shaking by earthquakes on the active fault systems that traverse the region. It is believed that earthquakes with significant ground shaking will occur in the region within the next several decades. Therefore, it must be assumed that the site will be subjected to strong ground shaking during the design life of the project. Shaking severity is indicated to be strong to very strong (MMI 7-8) due to potential activity from the Rodgers Creek fault, Maacama (South) fault, and to a lesser degree, the West Napa and San Andreas faults. Maps displaying projected shaking severity from nearby faults are presented on Figures 4-10, 4-11, and 4-12. An associated soil type and shaking hazard map is presented on Figure 4-13. An evaluation of the structural condition of buildings and infrastructure at the SDC site is provided in Chapter 7.

LIQUEFACTION

Liquefaction is a phenomenon in which loose and saturated, fine to medium grained sandy soils experience temporary shear strength loss during and immediately following seismic ground shaking. The shear strength loss could cause ground settlement and/or ground failure. The degree of potential liquefaction at the site depends on several factors including the intensity and duration of ground shaking, soil density and grain size, depth of the groundwater table and thickness of underlying unconsolidated sediments.

Figure 4-11

SHAKE SEVERITY – WEST NAPA FAULT



SHAKE SEVERITY MAP- **WEST NAPA FAULT** SCALE 1" = .5 MILES

EXPLANATION

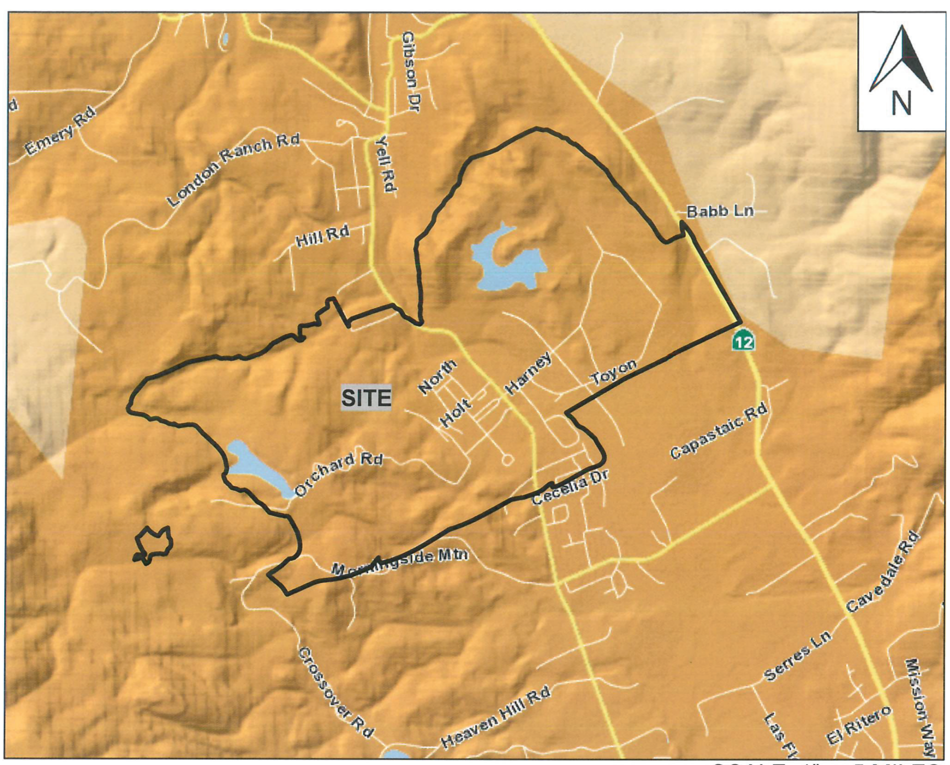
Shaking Severity

- Light - MMI 5
- Moderate - MMI 6
- Strong - MMI 7
- Very Strong - MMI 8
- Violent - MMI 9
- Very Violent - MMI 10

Reference: Association of Bay Area Governments, Shake Susceptibility Map, dated June, 2009

Figure 4-12

SHAKE SEVERITY – SAN ANDREAS FAULT



SHAKE SEVERITY MAP- **SAN ANDREAS FAULT** SCALE 1" = .5 MILES

EXPLANATION

Shaking Severity

- Light - MMI 5
- Moderate - MMI 6
- Strong - MMI 7
- Very Strong - MMI 8
- Violent - MMI 9
- Very Violent - MMI 10

Reference: Association of Bay Area Governments, Shake Susceptibility Map, dated June, 2009

A liquefaction susceptibility map is presented on Figure 4-14. The terraces along Sonoma Creek are considered to have high liquefaction potential, and the flanking Valley of the Moon is considered to have moderate liquefaction potential. Existing buildings at the project site generally span across moderate to high liquefaction zones and could be affected by liquefaction during or following a severe seismic event. Liquefaction potential should be evaluated with a detailed subsurface exploration, soil laboratory testing, and analysis.

DIFFERENTIAL COMPACTION AND DENSIFICATION

Soil densification is a phenomenon where earthquake induced ground shaking causes soil particles to compress, thus causing ground settlement. Non-cemented, cohesionless soils, such as loose sands or gravels above the groundwater level, are susceptible to this type of settlement. Densification potential should be evaluated during a detailed subsurface exploration, soil laboratory testing, and analysis.

LATERAL SPREADING AND LURCHING

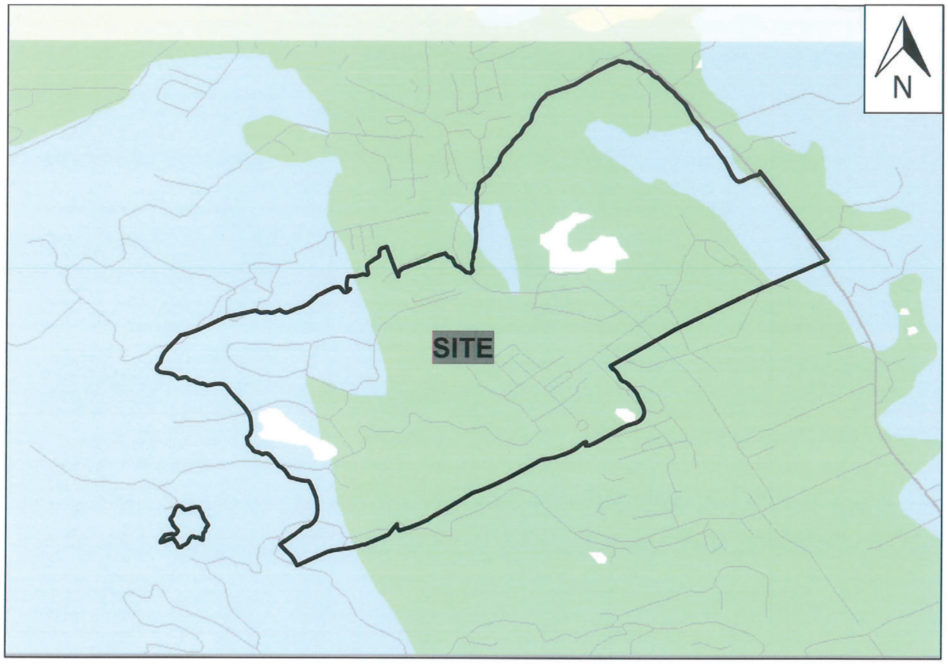
Lateral spreading is normally induced by vibration of near-horizontal alluvial soil layers adjacent to an exposed face. Lurching is an action, which produces cracks or fissures parallel to streams or banks when the earthquake motion is at right angles to them. The banks along Sonoma Creek could be prone to lateral spreading and lurching. Furthermore, cuts abutting failing retaining walls or basement walls could be prone to lateral spreading and lurching. Further detailed studies should be performed to define lateral spreading and lurching concerns at the project site.

SEICHE WAVES

A seiche wave is a standing wave that can oscillate in an enclosed body of water such as a lake, bay or gulf. Although a remote possibility, it should be considered as a potential geologic hazard in Lake Suttonfield and Fern Lake.

Figure 4-13

SOIL TYPE AND SHAKING HAZARDS



NO SCALE

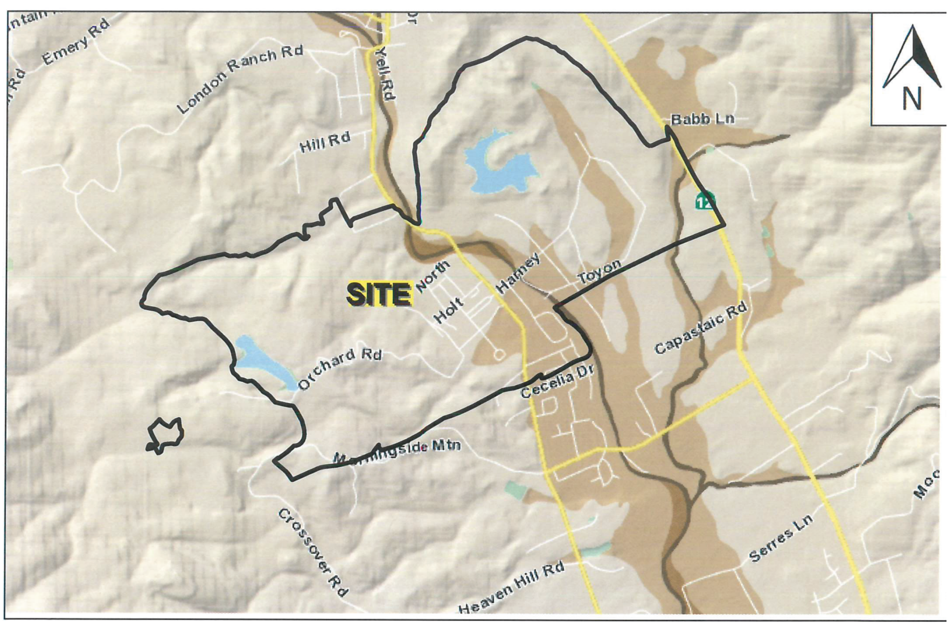
Reference: USGS-Soil Type and Shaking Hazard in the San Francisco Bay Area, no data indicated (online version).

Explanation

		Explanation
Soil type A	Vs > 1500 m/sec	Includes unweathered intrusive igneous rock. Occurs infrequently in the bay area. We consider it with type B (both A and B are represented by the color blue on the map). Soil types A and B do not contribute greatly to shaking amplification.
Soil type B	1500 m/sec > Vs > 750 m/sec	Includes volcanics, most Mesozoic bedrock, and some Franciscan bedrock. (Mesozoic rocks are between 245 and 64 million years old. The Franciscan Complex is a Mesozoic unit that is common in the Bay Area.)
Soil Type C	750 m/sec > Vs > 350 m/sec	Includes some Quaternary (less than 1.8 million years old) sands, sandstones and mudstones, some Upper Tertiary (1.8 to 24 million years old) sandstones, mud stones and limestone, some lower Tertiary {24 to 64 million years old) mudstones and sandstones, and Franciscan melange and serpentinite.
Soil Type D	350 m/sec > Vs > 200 m/sec	Includes some Quaternary muds, sands, gravels, silts and mud. Significant amplification of shaking by these soils is generally expected.
Soil Type E	200 m/sec > Vs	Includes water-saturated mud and artificial fill. The strongest amplification of shaking due is expected for this soil type.

Figure 4-14

LIQUEFACTION SUSCEPTIBILITY



EXPLANATION

- VERY HIGH LIQUEFACTION SUSCEPTIBILITY
- HIGH LIQUEFACTION SUSCEPTIBILITY
- MODERATE LIQUEFACTION SUSCEPTIBILITY
- LOW LIQUEFACTION SUSCEPTIBILITY

Reference: Association of Bay Area Governments, Shake Susceptibility Map, dated June, 2009

SCALE 1" = .5 MILES

SUBSIDENCE

The withdrawal of large amounts of groundwater would cause subsidence to be a serious geologic concern, but this is not currently the case. Hillsides at the project site are generally underlain by the Glen Ellen Formation and Sonoma Volcanic Group bedrock which typically do not contain large amounts of organic matter (peat or soft coal) that could cause subsidence through oxidation. Although a remote possibility, it is possible the young alluvial soils in the Valley of the Moon and along Sonoma Creek could be prone to subsidence if large amounts of groundwater are withdrawn from the underlying aquifer.

CORROSIVE SOILS

It is unknown if corrosive soils are present at the project site. This should be verified by subsurface investigation and laboratory testing.

ASBESTOS

Based on our investigation and review of published geologic literature, the project site is not underlain by soils or bedrock which could contain naturally occurring asbestos such as serpentinite bedrock. However, asbestos fibers are likely present in building materials within the existing structures. A site-level survey of hazardous materials is described in Chapter 7 of this report. Building materials should be evaluated by an asbestos abatement company associated with any demolition or construction.

EXPANSIVE SOILS AND BEDROCK

Potentially expansive soils and bedrock exist in the nearby hillsides and valleys, and it is possible potentially expansive soils and bedrock exist at the project site. However, this should be confirmed by a subsurface exploration and laboratory testing. If expansive soils are present, they can be mitigated with geotechnical engineering strategies.

UNCOMPACTED FILL AND UNSUPPORTED CUTS

Overly steep and tall fill slopes and unsupported near-vertical to vertical cut slopes are present at the project site. Cut and fill slopes should not exceed inclinations of two horizontal to one vertical (2H:1V). Steeper slopes should be retained with walls. A geotechnical engineer and civil engineer should further evaluate cut and fill slopes at the project site as part of any detailed design exploration.

EROSION

Erosion is possible along the banks of Sonoma, Mill, and Asbury creeks. Furthermore, slopes at the project site could be potentially unstable and erodable in manufactured (cut and fill) slopes unless proper grading procedures are implemented. Care should be exercised in protecting finished slope surfaces from the effects of erosion by appropriate drainage control and landscaping. Effective slope face protection from erosion damage can be achieved by placing a jute mat or equivalent erosion control parameters on the slope face and landscaping slope faces in accordance with the recommendations of a landscape architect.

LANDSLIDES AND SLOPE STABILITY

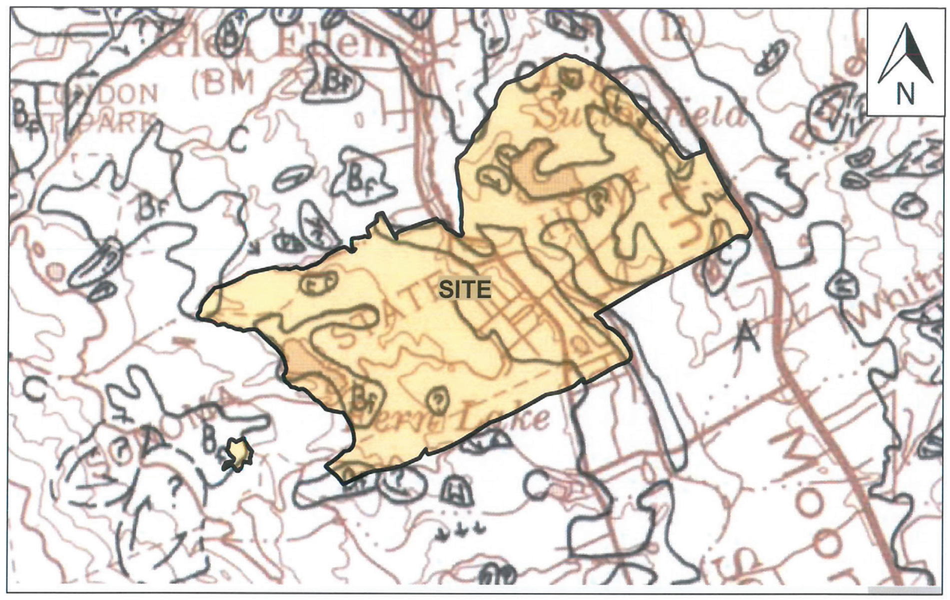
Landslides consist of deposits varying from intact slabs of bedrock to unconsolidated rock, soil, and colluvium that are displaced down-slope by gravitational processes. Topography at the SDC site varies from level terrain along Valley of the Moon to steep hillsides, and near vertical creek banks. The vast majority of hillsides at the project site are considered to be relatively unstable soil and rock units, on slopes greater than 15 percent (Category C). Areas mapped in this slope stability category generally contain numerous landslides. A slope stability map is presented on Figure 4-15. The Valley of the Moon is considered relatively stable due to low slope inclinations. However, although a remote possibility, it is of concern that debris flows triggered from landslides in the slopes above could potentially extend down and into the valley. A landslide distribution and earth flow map is presented in Figure 4-16. The creek banks at the project site are also prone to block slides and bank failures. Slopes exceeding 15 percent could also be prone to soil creep.

The CGS geologic map indicates a total of six landslides partially or entirely within the boundaries of the SDC site. We observed several landslides at the project site which are not indicated on the CGS regional geologic map, including a landslide along Orchard Road and a 2001 bank failure along Sonoma Creek. It was reported that a landslide in 2001 damaged a water supply line from the spring at the upper western edge of the SDC site. We observed a small landslide above the concrete spillway at Suttonfield Lake, as well as hummocky terrain features in the sloping grasslands below Fern Lake. The hummocky terrain is indicative of the prevalence of landslides. Existing landslides and unstable slopes should be mapped in detail. Following mapping, the landslides should be evaluated by a subsurface exploration, laboratory testing, and analysis.

A notable mapped landslide is a massive complex west and above Fern Lake. The majority of the massive landslide complex is within Jack London State Park, although the toe of the landslide extends down to the western shoreline of Fern Lake. Another massive older landslide complex has been mapped beyond the northern border of the SDC site. The mapped large-scale landslide within the site boundaries appears to be a relatively old feature which was likely triggered during a climatic wet period of the Pleistocene epoch which coincided with a significant seismic event. Based on site reconnaissance there are no obvious indications that the global mapped landslide is actively moving. However, a detailed study of the mapped global

Figure 4-15

LANDSLIDE AND SLOPE STABILITY



SCALE: 2.5" = 1 MILE

EXPLANATION

Landslides; arrows show general direction of movement (areas of lowest relative slope stability), question marks indicate possible landslides.

Relative Slope Stability Categories:

C Areas of relatively unstable rock and soil units on slopes greater than 15%, containing abundant landslides.

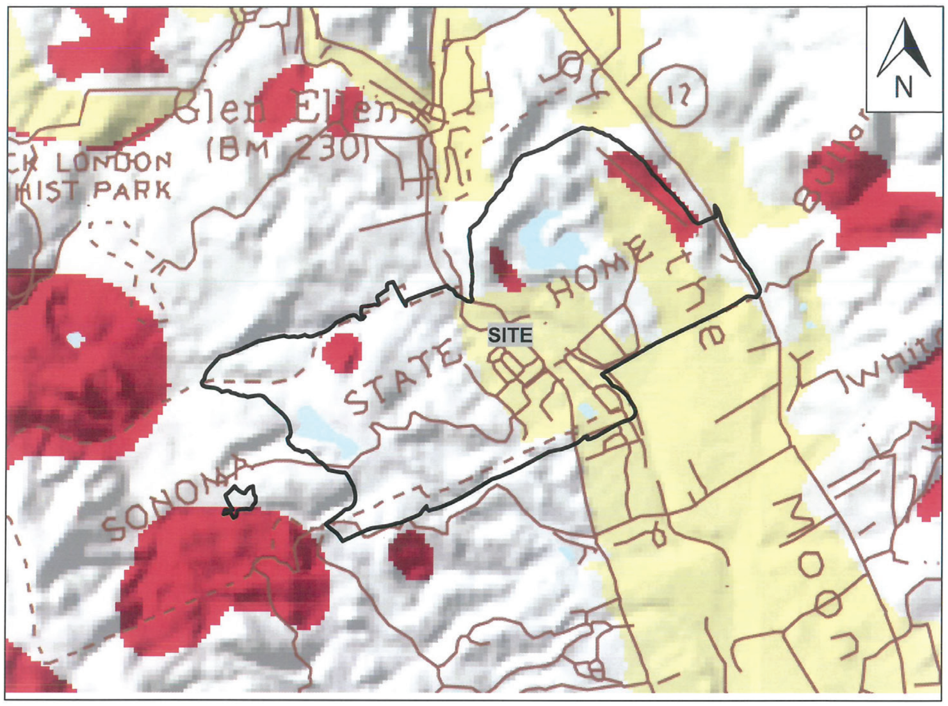
B Areas of relatively stable rock and soil units, on slopes greater than 15%, containing few landslides.

A Areas of greatest relative stability due to low slope inclinations, dominantly less than 15%.

Reference: Landscape and Relative Slope Stability, Sonoma County, prepared by the California Division of Mines and Geology, Compiled by Charles F. Armstrong, dated 1980

Figure 4-16

DISTRIBUTION OF SLIDES AND EARTH FLOWS



APPOXIMATE SCALE 2” = 1 MILE

Explanation

Mostly Landslide - consists of mapped landslides, intervening areas typically narrower than 1500 feet, and narrow borders around landslides; defined by drawing envelopes around groups of mapped landslides.

Many Landslides - consists of mapped landslides and more extensive intervening areas than in 'Mostly Landslide'; defined by excluding areas free of mapped landslides; outer boundaries are quadrangle and County limits to the areas in which this unit was defined.

Few Landslides - contains few, if any, large mapped landslides, but locally contains scattered small landslides and questionably identified larger landslides; defined in most of the region by excluding groups of mapped landslides but defined directly in areas containing the 'Many Landslides' unit by drawing envelopes around areas free of mapped landslides.

Flat Land - areas of gentle slope at low elevation that have little or no potential for the formation of slumps, translational slides, or earth flows except along stream banks and terrace margins; defined by the distribution of surficial deposits (Wentworth, 1997).

Reference: USGS-Summary Distribution of Slides and Earth Flows in Sonoma County California, dated 1997

massive landslide complex is beyond the scope of this project. Large-scale global landslides can be triggered during severe seismic events which coincide with extreme wet periods. The SDC site is located in an area which is considered to have a higher than normal risk for displacement and deformation resulting from earthquake-induced landslides. Detailed geologic mapping and geotechnical evaluations should be performed to determine the locations and activity of landslides at the project site.

4.3 Site Hydrology

CREEKS AND WATERSHEDS

SONOMA CREEK

Sonoma Creek, the primary watercourse through the Sonoma Valley and the drain for the Sonoma Creek watershed, bisects the SDC property. Most of the on-site storm drainage flows to Sonoma Creek.

Sonoma Creek bisects SDC after it flows out of Warm Springs Canyon and heads south towards San Pablo Bay. The 0.8 mile-long section of the creek through the SDC property is characteristic of the creek's central reach that runs from Glen Ellen to Schellville. Within the central reach, channel depths range from 20-35 feet and channel slopes range from 0.001 to 0.02 (SEC 2006). Within SDC, channel widths range from 500 feet at its widest to 25 feet at its narrowest (measured from valley-bottom terrace edge to terrace edge, which delineates the active riparian zone). The substrate in the active channel is primarily gravel and cobble, with pockets of sand and silt found in low-velocity zones within the channel and on gravel bars and the inset floodplain benches. Large, coarse-grained, often well-sorted gravel bars occur along the length of Sonoma Creek's SDC reach. The wide, low gravel bars support willow and alder establishment along their edges (see photo below). In many sections, high flows are split between multiple channels that form through and around the gravel bars. This creates beneficial, complex habitat for fish and other aquatic organisms. Sedge clumps are common on the gravel bars and along the channel banks, providing shade and habitat at the water's edge.

Sonoma Creek during summer low flow (looking downstream). Note low gravel bar on right and associated willow and alder establishment, woody debris, and sedge.

Concrete bag retaining wall downstream of the Harney Drive crossing.

The stream banks within SDC are subject to erosion and widening. This is a natural process, especially for deeply incised systems like Sonoma Creek. In the upstream section of Sonoma Creek in SDC, between the first and second Arnold Drive crossings, bank erosion does not threaten structures so it appears to have been left to take its course. It is supplying coarse sediment to the creek, and large cobble bars have formed downstream of the active erosion sites. Bank stabilization is more prevalent downstream of the second Arnold Drive crossing, as this section bisects the main campus and bank erosion in this reach quickly threatens structures. There are multiple sites where past bank erosion has been arrested using rip rap, shotcrete, and concrete bag retaining walls (see photo below). These hardened banks provide little to no habitat value. There are several steep, vertical banks along the lower reach of Sonoma Creek that currently are experiencing significant, active bank erosion. The erosion at one of these sites may compromise nearby buildings and facilities.

Sonoma Creek has a flashy and seasonally variable hydrology typical of the region's incised streams and Mediterranean climate patterns. For example, the average mean discharge during February in the wet winter period is 224 cubic feet per second (cfs) while in September at the end of the dry period it is only 0.75 cfs (USGS 2015b). Peak flows range from 100 cfs (1977) to over 20,000 cfs (2006) as recorded at the USGS streamflow gauge.

Studies indicate that Sonoma Creek is a gaining reach through SDC, in that groundwater is discharging into the creek. During extreme drought conditions, such as in October 2014, the groundwater table is below the stream thalweg and it can become a losing reach (SCWA 2015).

SDC has an appropriative water right to direct divert and divert water to storage from Sonoma Creek. The period of diversion is December 1 to May 1 with a maximum rate of 0.55 cfs (SCWA 2015). The water can be pumped to the water treatment plant, Suttonfield Lake, or Fern Lake. A concrete diversion structure associated with the sump and pumps is located on Sonoma Creek between Arnold Drive and Railroad Avenue.

TRIBUTARIES

WEST SIDE

The two perennial tributaries within SDC are Asbury and Hill Creeks, which drain east from the flanks of the Sonoma Mountains. These watersheds are steep and prone to landsliding and bank instability, especially Asbury along its north side and Hill Creek near Camp Via. The channel beds are composed primarily of boulders, cobbles, and gravel. The fairly steep, cascade-type channels are cut deeply into the hillsides. Landslide activity is highest during wet winters, such as 2017, and creates episodically high sediment delivery rates. Sediment delivered to the creeks moves down the tributaries and to Sonoma Creek in pulses. Trees and branches that fall into the creeks are transported downstream as woody debris, which can form log jams that temporarily store sediment.

Asbury Creek drains approximately 1.1 square miles, and extends approximately 2.2 miles as a blue line (perennial) stream. The middle portion of Asbury Creek is within SDC and the creek forms the northern boundary of the property; the lower 1,200 feet is outside of SDC. Asbury Creek is the primary water supply for SDC, providing an estimated 60 percent of the demand (SCWA 2015). The role of surface water in SDC's water supply system is covered in more detail in Section 3.5.

Hill Creek drains approximately 1 square mile, and extends approximately 2.7 miles as a blue line stream. The creek runs through or near the southern portion of the property on the west side, from Camp Via to Sonoma Creek. The upper reach of the creek near Camp Via is sinuous, with streambanks in various stages of erosion and recovery (Barber et al. 2012). Metal debris is found throughout the watershed from past water collection endeavors. The debris can be found throughout the Hill Creek subwatershed with a heavy concentration in the Camp Via area. Hill Creek provides approximately 30 percent of SDC's water supply (SCWA 2015).

Downstream of the diversion, Hill Creek is perennial with many springs and seeps along its course. As Hill Creek transitions from the steep hillsides to the valley floor it becomes channelized and encroached upon by development. Bank stabilization, including concrete retaining walls and rock rip rap, is prevalent. The lower channel reaches appear to have experienced recent incision, as there are several perched culverts along the valley floor through the SDC main campus.

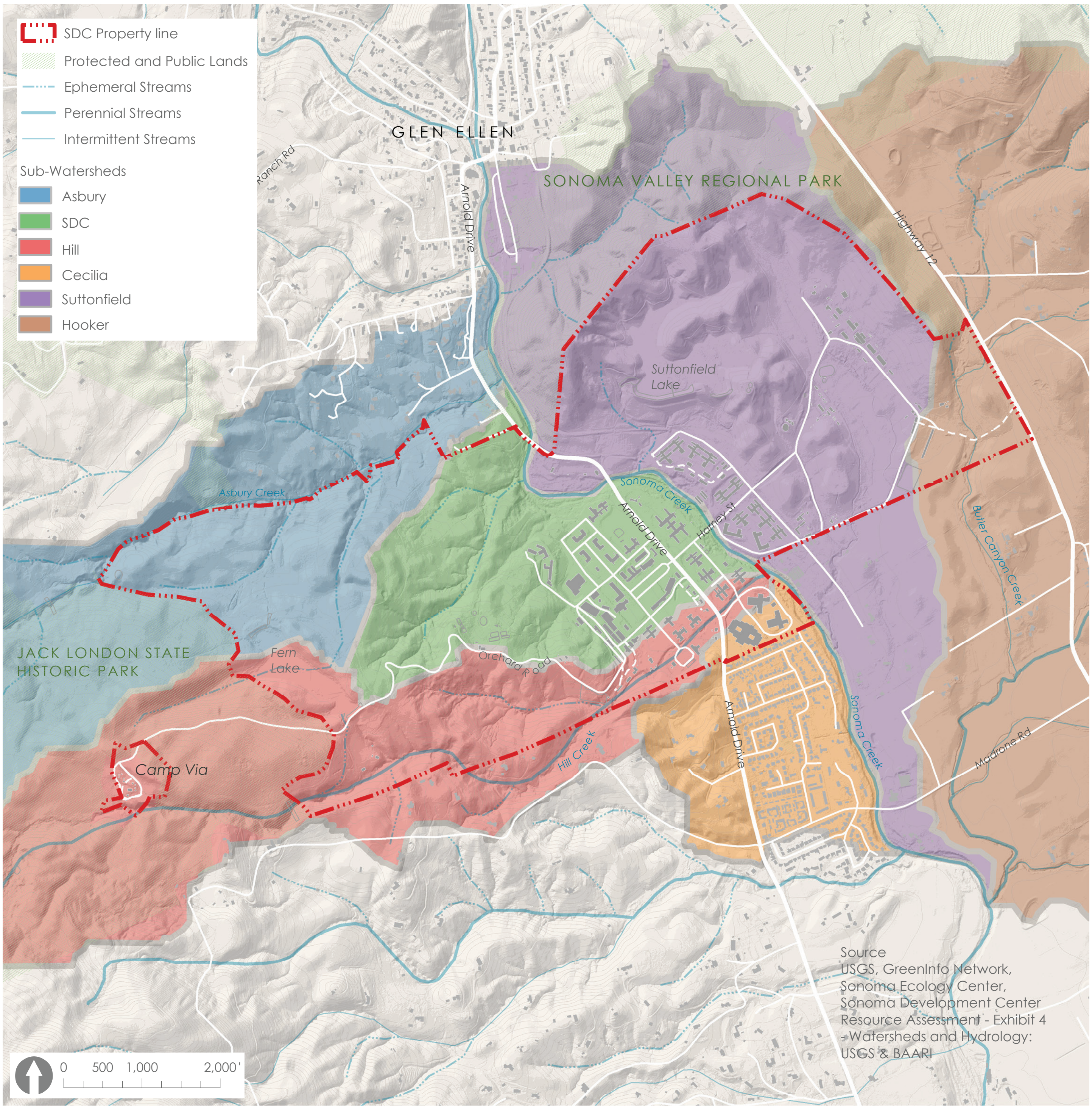
EAST SIDE

The intermittent streams found on the eastern portion of SDC flow from and across the oak woodlands and grasslands (see photos below). Several of these intermittent streams are man-made ditches created to drain the seasonal wetlands and reduce flooding on the property. Butler Canyon Creek collects water and sediment draining from the eastern side of Sonoma Valley. Its narrow riparian corridor provides refuge for wildlife traversing the valley. The other significant intermittent drainage on the eastern side of SDC feeds and contains Suttonfield Lake.

Hill Creek downstream of the water diversion structure and the Ropes Course.

Examples of the intermittent drainages on the eastern side of SDC; left, at John Mesa Road. Right, within the wet meadow north of Sunrise Road.

Figure 4-17
SUB-WATERSHEDS ON THE SDC SITE



SPRINGS

Multiple springs and seeps are found along the western border of the property, especially within the area west and north of Fern Lake. Purportedly several of them feed into the lake. Several seeps were observed along the banks of upper Hill Creek in the vicinity of the Ropes Course. It has been noted that these springs are found in conjunction with interbedded landslide deposits and the near-surface exposure of the Sonoma Volcanics formation (SCWA 2015). A complex of multiple small, perennial spring-fed watercourses, known as Roulette Springs, forms a primary tributary to Asbury Creek. The springs are located between Asbury Creek and Fern Lake near the western edge of the property. SDC has a water right for Roulette Springs with no restrictions on timing or amount of flow diverted.

Spring box and wetlands surrounding the diversion at Roulette Springs.

Some of the water supply for the facility is sourced directly from Roulette Springs, at the upper western margin of the property. It is possible the spring discharge rate, quality, and quantity could change over time due to factors such as seismic events, aquifer drawdown, and landslides. Springs are discussed in more detail below as they relate to the site's water supply.

RESERVOIRS

Two reservoirs are located on the property. Both are currently used for raw water storage for use at SDC, and are described further in section 4.5: Water Supply System.

Fern Lake, on western portion of SDC (top). Suttonfield Lake, on eastern portion of SDC (bottom).

FLOOD HAZARDS

In the reach within the SDC property, Sonoma Creek runs through a natural channel that is wide and deep enough to contain the 100-year storm. While there are numerous bridges and utilities crossing the creek that could become blocked due to trees or other flood debris being caught in an undercrossing, (barring a blocked undercrossing), even in a 500-year storm, only the banks near the creek where no buildings currently exist, would be expected to be inundated. It is likely that in the foreseeable future, what we currently consider as a 100-year storm will be downgraded, as we develop tools to assess the impacts of climate change and incorporate new climate assessments into flood forecasting. However, given the topography, the risk of flooding on the SDC campus from Sonoma Creek is remote. The greater concern is existing finished floor elevations and site drainage from surface runoff. This is discussed in greater detail in the discussion of the storm drainage system in Chapter 7.

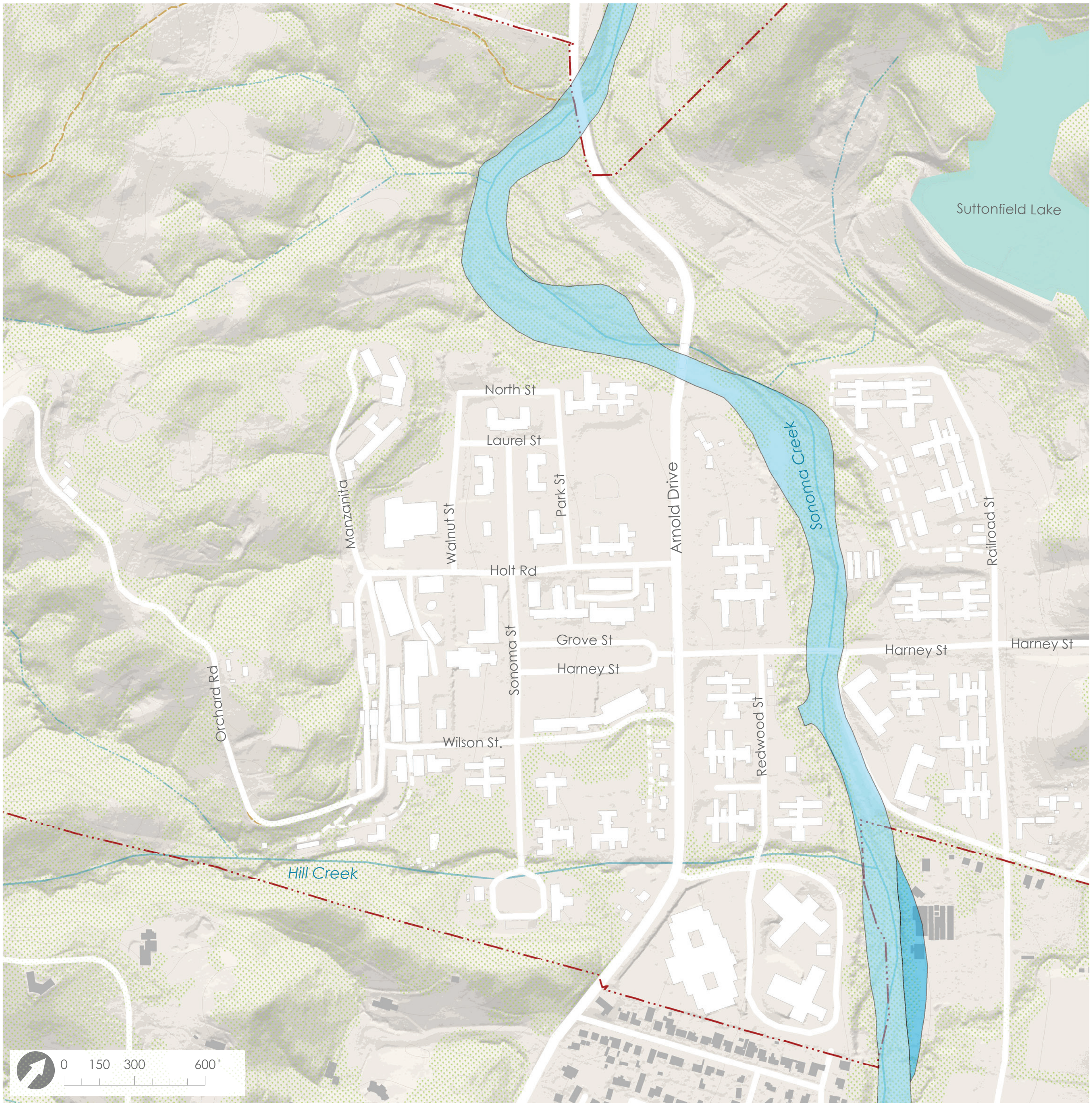
DAM FAILURE

Two moderate size reservoirs impounded with man-made embankments exist at the project site. The embankments should be inspected and routinely monitored. The concrete spillways should also be routinely inspected and repaired as needed.

The Consultant team could not locate any records of dam design and construction, making it impossible to accurately assess risk associated with those dams. The risk level for dam failure would require additional studies to evaluate and quantify the stability of the embankments under static and seismic conditions. Additional studies would consist of subsurface exploration, laboratory testing, and geotechnical engineering analysis including seismic and static quantitative stability analysis. Identification of hazard zones associated with potential dam failure would require a civil engineer to determine maximum capacities of the reservoirs to accurately assign and map the impact zones based on accurate land surveys. Pursuant to SB 92 the State is currently in the process of preparing dam inundation maps and emergency action plans for the dams onsite.

Figure 4-18

100- AND 500-YEAR FLOOD ZONES



SDC Property

Lakes

Protected and Public Lands

Trails

Ephemeral Streams

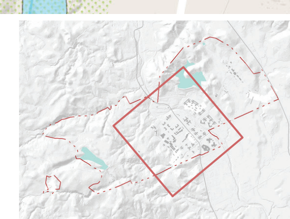
Perennial Streams

Intermittent Streams

100 - Year Flood

500 - Year Flood

Source
USGS, GreenInfo Network,
Sonoma Ecology Center,
FEMA



GROUNDWATER

Groundwater is found in numerous geologic formations throughout the Sonoma Valley at varying depths, and SDC is within the Sonoma Valley Groundwater Management Program area.

The SCWA report (2015) recommends that land use practices within the upper, western portions of the SDC property "should be carefully managed to avoid water quality impacts to the shallow groundwater system within the Sonoma Volcanics, which discharge as the springs and seeps that contribute to the existing water supply system" and also that "care should be taken to limit the potential for any additional groundwater development to impact spring and stream flows at the SDC property."

Groundwater recharge in the region is through streambeds and precipitation infiltration. On SDC, the principal method is through direct infiltration of precipitation, as the creeks appear to primarily gain water from the discharge of shallow groundwater. The amount of water that can be intercepted and infiltrated into the soil to recharge the groundwater is dependent upon soil type, slope, vegetation, and geology. Mapping of these characteristics across SDC indicates that groundwater recharge potential varies from very good to poor, with the areas of highest potential in the eastern portion of the property, the flat alluvial areas adjacent to Sonoma Creek, and in a narrow band around Fern Lake on the western property boundary (SEC and SCWA 2014). Average annual recharge volume is estimated to be 640 acre feet per year, with a range of 45 to 1,430 acre feet. However, much of this recharge volume likely re-emerges on or near the property at springs, seeps, and stream base flows.

With half of Sonoma Valley's water supply dependent on local groundwater, preserving the rainwater capture and infiltration capacity of the undeveloped SDC landscape is a highly cost-effective way to support recharge and sustain flows for steelhead, California freshwater shrimp, and other aquatic species in Sonoma Creek. The Basin Advisory Panel (Panel), a group of twenty stakeholders representing varied water interests, has been working together since 2006 to manage Sonoma Valley groundwater resources in a sustainable way that meets both ecological and water supply needs. The Panel created the non-regulatory Sonoma Valley Groundwater Management Plan, which was subsequently adopted by the Sonoma County Water Agency, City of Sonoma, Valley of the Moon Water District, and the Sonoma Valley County Sanitation District. The report presents a range of voluntary water management options, including enhanced groundwater recharge, conjunctive use of surface water and groundwater, increased conservation, and greater use of recycled water. Studies by the Sonoma Ecology Center and Sonoma County Water Agency (2011) and GEI Consultants (2013) identified the SDC property as a potential location for a groundwater recharge project.

WELLS

Although groundwater is found in all soil types on the SDC property, groundwater resources are predominantly found within Sonoma Volcanics geologic formations and are most evident in the form of seeps and springs west of Fern Lake. There are four wells on the property, described in section 4.4: Water Supply System and shown on Figure 7-7.

GEOTHERMAL RESOURCES

The California Division of Mines and Geology has investigated the geothermal potential on the property and concluded that there may be higher temperature groundwater northwest of the Eastside Fault zone in the easternmost area of the property. This conclusion seems to be borne out by the somewhat elevated temperatures found in the Suttonfield well. In 1982, a private contractor performed a geothermal investigation, including drilling a 1,400-foot-deep exploratory well. The results at this exploratory well were apparently inadequate to warrant further investment because the well was never used. It was abandoned and plugged in 1987. However, it should be noted that this well was drilled quite some distance from the area the CDMG identified as most promising for geothermal exploitation. The potential for geothermal resources may be a subject for additional analysis, and could be a potential opportunity for the SDC site.

IMPACT OF CLIMATE VARIATION

As local climate conditions change in the future, we can expect the extremes in the weather to become more frequent. More intense rain events and droughts are likely to become more common. The notion of a 10-year storm or a 100-year storm should be reconsidered because we are likely to see peak flood stages for what is now considered a 10-year event happen with statistically greater frequency than every 10 years. What this will mean for the project site is that short-burst intense rainfall will result in higher than normal runoff, less groundwater replenishment, more soil erosion, and increased sediment transport into the creeks. Supporting the creation of a robust environment that will be able to withstand or rebound from frequent extreme weather events will include tactics that preserve vegetation and retain water on steeper parts of the site. Slowing runoff encourages infiltration, which will support vegetation growth, which, in turn will help retain soils.

4.4 Water Supply System

SDC has an extensive and elaborate raw water collection system that includes wet weather in-stream diversions with storage in man-made reservoirs; collection of spring water; raw water transfer and transmission lines that are primarily managed by gravity flow; and bidirectional flow in transmission lines by use of valves, a primary pump station capable of pumping in either direction, storage tanks located at appropriate hydraulic grades, and a booster pump. Almost all the water for domestic and irrigation use is obtained on site through three surface water diversions on the eastern slope of Sonoma Mountain. Approximately 60 percent of the SDC water supply is drawn from Asbury Creek, approximately 30 percent is drawn from a diversion on Hill Creek, and 10 percent is drawn from a collection of springs and seeps known as Roulette Springs. Other less significant water sources include a diversion from Sonoma Creek and a number of wells in the remote parts of the property.

Raw water is diverted from Hill and Asbury creeks by gravity to Fern Lake and is pumped from Sonoma Creek to Suttonfield Lake. A small tributary referred to as "Unnamed Creek" flows directly into Suttonfield Lake. A 10-inch raw water transfer line is designed to be operated in either direction. It enables operators to transfer water from Fern Lake to Suttonfield Lake by gravity or in the reverse direction by pumping. The same pumps are used for the majority of the raw water transfers on the property, including from Sonoma Creek to Suttonfield Lake, and from Suttonfield Lake and Sonoma Creek to the Water Treatment Plant. A separate pump station transfers water from the 25,000-gallon break tank below the Water Treatment Plant to Fern Lake.

This section describes the water supply sources and storage reservoirs in more detail. Raw water distribution, water treatment, and treated water distribution are covered in Chapter 7. A representational layout of the collection system is shown on Figure 7-7.

SURFACE WATER DIVERSIONS

ASBURY DIVERSION

The Asbury Creek diversion is the oldest developed water on the property, having been in use since at least the1880's. The diversion structure consists of a weir built across the creek with an orifice at its base sized to guarantee that the mandated 0.9 cfs will be released through the orifice before water can be diverted. Boards must be placed manually to detain creek flow to a depth that it can be diverted. Metering and flow recording equipment is installed at the diversion.

In 2002, a large parcel of land was deeded to the adjacent Jack London State Park. The Asbury Diversion is located at the northwestern most edge of the property on a small spur of the property that retains the diversion structure at about 660 feet elevation. SDC maintains the diversion structure and the associated rights and reports operational data to state regulators. To maintain sustainable riparian habitat, SDC is limited to only withdraw up to 1 cfs of water from the Asbury diversion provided a minimum of 0.9 cfs flows downstream. The SDC water manager maintains logs of the flow conditions and reports back to the National Marine Fisheries Service (NMFS).

The old diversion structure was damaged in heavy storms in 2006 and was redesigned and constructed in 2011. It includes a low-head dam, adjustable weir, and a bypass flow structure to ensure that water is only diverted once at least the required 0.9 cfs streamflow passes the structure. It is also equipped with gage and metering equipment. Diverted water is transmitted to Fern Lake via a 24-inch pipeline that transitions to an open channel for the final +/-500 feet. The diversion is generally only possible between November and May, or significantly less in years of very high (because the lakes are full) or very low (because there is not sufficient streamflow) rainfall. Although water is reported to flow in the creek year-round, summer flows typically drop to 0.5 cfs or less.

Photo of Asbury Creek diversion (left) and flow monitoring equipment (right: Asbury data recorders). Note the small pipe opening in the weir wall designed to allow 0.9 cfs stream flow to bypass diversion.

HILL DIVERSION

The Hill Creek Diversion is at approximately 600 feet elevation on Hill Creek southwest of Fern Lake. Originally built in 1904, this diversion structure was also severely damaged in the 2006 storms and was reconstructed in 2007. The constructed diversion includes gabion revetment, cemented riprap, and an 18-inch steel pipeline on concrete piers across a deep ravine carrying the diverted flow. The pipeline transitions to an open channel for the last +/-50 feet of the run. The permit for the Hill Creek diversion does not require maintenance of a prescribed


Photos of the Hill Creek diversion weir (left) and the diverted water pipeline over the culvert that carries the streamflow (right).

minimum stream flow — the SDC is allowed to take as much water from this location as they want. The constraint at this location is that although the creek does flow year-round, at low flows, infiltration exceeds streamflow in the area just above the diversion weir leaving no surface water at the diversion itself. Therefore, it is only possible to divert water when flows are above this naturally limiting low flow condition. Although there are no reporting requirements at this location, the flow is metered and SDC maintains records of creek and diversion flows.

ROULETTE SPRINGS

The Roulette Springs collection box was developed in 1897 and provides water year-round. Rather than a discrete spring, it consists of several seeps and springs in a boggy forest area where a simple leaky collection box has been set in a depression and a collection pipe laid into it. The fact that it leaks ensures that some (although unmeasured) volume of streamflow bypasses the collection pipe to maintain a riparian condition. According to SDC personnel, diversions from Roulette Springs typically flow at about 80 gpm during the summer and at 120 gpm in the winter, providing a potential of about 1,200 acre-feet per year. Water from the diversion is transferred to the water treatment plant by a 3-inch steel pipe.

SONOMA CREEK DIVERSION

SDC maintains their rights to draw water from Sonoma Creek primarily to ensure that they maintain their storage of raw water through the dry season, ensuring adequate water supplies during drought and times of high fire threat. In years of average rainfall and normal lake levels, they run the pumps for a month each winter, sending 1 million gallons per day (mgd) of water to Suttonfield Lake, to ensure that they keep the Lakes full for fire protection through the summer. The diversion sump, 6 feet x 6 feet x 14 feet deep, is located at the west edge of the creek just below the pump house.

Licensed withdrawal from Sonoma Creek is limited by stream flow, time of year and storage limitations. The withdrawal rate is limited to 1,657 gallons per minute (2.39 mgd) with a storage limitation of 525 acre-feet. Thirty days at 1 mgd with no discharge from the lake would provide 92 acre-feet of stored water. So their typical withdrawal is well within licensed limits, and they have the flexibility to increase withdrawals if conditions warrant doing so.

GROUNDWATER SOURCES

Dairy well

There are two active and two abandoned water supply wells on the property. None are connected to the domestic water system that serves the main campus.

- The Camp Via well, roughly half a mile west and uphill from Fern Lake;
- The Suttonfield well at the southwest edge of Suttonfield Lake;
- The Dairy well near the intersection of Sunset and Dairy Roads; and
- The Soccer Field well opposite residence #150 at the end of John Mesa Rd.

These four wells are located on Figure 7-7.

CAMP VIA WELL

The Camp Via well has been used to supply water to the Camp, a 5-acre outdoor recreational facility for the residents of SDC. This well is developed to 195 feet below ground surface (bgs) and draws from groundwater between 75 and 195 feet deep. At the time of its development, the yield of this well was 20 gallons per minute (gpm) with a drawdown of 35 feet.

This well provides water to Camp Via at sufficient yield for its intended use. It appears to be fully operational and regularly maintained. This well is used locally, and not connected to the main campus water system; there is a small distribution system with nine delivery points. The water at Camp Via is not treated, but is disinfected by sodium hypochlorite as water enters the distribution system.

SUTTONFIELD WELL

The Suttonfield Well is developed to 890 feet bgs and draws from between 570 and 870 feet. At the time of its development, its yield was recorded as 300 gpm. No record of current yield is available; however, as yield tends to decline over time, it is likely the current yield is lower than 300 gpm.

The proximity of the Eastside Fault appears to impact the water temperature and quality, because upwelling of highly mineralized water would explain the elevated arsenic and boron levels in the well water. Because of these quality issues, the well has been capped and is no longer in use.

DAIRY WELL

The Dairy well, in front of the old dairy has been closed with a brick dome. No information has been identified with regard to the quantity and quality of the water from this well, nor is it known why it was closed. This well has a brick dome-like cap with a steel lid and appears to have been a dug well from which water was drawn with buckets. It is likely that this well has not been capped or plugged.

SOCCER FIELD WELL

Records indicate that the Soccer Field well was used for irrigation of the playing fields in the southeast corner of the property until recent years and offer no mention that the well has been capped, plugged or abandoned. However, when staff went out to locate the well for this report, it could not be positively identified. Near where it was believed to be was a small pile of rock and concrete rubble, which may be all that remains of it. At the intersection of Dairy and John Mesa Roads, there are still two concrete pads where storage tanks used to be.

RAW WATER STORAGE

FERN LAKE

Fern Lake is located on the western edge of the property. It was originally created with the construction of the south dam in 1910. That dam was later raised and a north dam constructed to increase its capacity to its present day volume of 240 acre-feet. The lake is fed by direct runoff and by diversions from Asbury and Hill Creeks. The spillway is located on the north dam at an elevation of 590 feet and feeds into a tributary to Asbury Creek. The lake is approximately 28 feet deep when full.

The dam has had a slow leak for many years (at about 5 gpm). The leak is monitored and has not been observed to change over time. The dams are inspected annually by the California Department of Water Resources Division of Dam Safety (DODS) and maintained regularly by the SDC staff. The dam is 40 feet high and 300 feet long. The outlet structure for Fern Lake is a 10-inch vertical pipe with three service intakes at different levels.

Intake at Fern Lake

SUTTONFIELD LAKE

Suttonfield Lake is located on the northeastern part of the property. Several popular maps depict Suttonfield Lake as part of the adjacent Sonoma Valley Regional Park, and it is considered by some to be a "hidden gem" for recreational purposes. However, most recreational uses, such as swimming, are prohibited for water quality, safety, and liability reasons.

This reservoir was initially constructed in 1938 and was increased to its present volume of 600 acre-feet in the 1950's. The earthen dam, constructed in two segments, is 76 feet high and 965 feet long, and lies along the south side of the lake. The spillway is at the western edge of the lake at an elevation of 291 feet, and directs flow down an intermittent creek to Sonoma Creek. The lake is 62.5 feet deep when full. Like Fern Lake, it is inspected annually by Division of Safety of Dams (DSOD). Suttonfield Lake is supplied by gravity from Fern Lake via a 10-inch transmission line. It also receives direct flow from the "unnamed creek", but no flow data is available for this small tributary. Water pumped from Sonoma Creek is also stored in Suttonfield Lake. Suttonfield Lake is used as storage for the SDC's domestic water use, irrigation and fire protection. The outlet structure is an octagonal concrete tower with two service inlets at different elevations.

PONDS

In addition to the two large reservoirs, there are two small perennial ponds that appear man-made. One is located on the far eastern side of the property between two hillsides. It is approximately 0.3 acre in size and is at the upstream end of a large wet meadow. The other is adjacent to the water storage tanks along Orchard Road, and is less than 0.1 acre.

4.5 Considerations for Reuse and Conservation

GEOLOGICAL HAZARDS

Several geologic hazards exist at the SDC site. As the project proceeds, detailed geologic assessments and geotechnical investigations will need to be performed to develop recommendations and design criteria. The additional geologic and geotechnical studies should include detailed mapping and reconnaissance, subsurface exploration, laboratory testing, and engineering analysis. Qualitative and quantitative slope stability analyses should also be performed to evaluate slope stability and landsliding at the project site. This information should be analyzed to provide specific geologic and geotechnical conclusions and recommendations regarding grading and earthwork, roadway and driveway recommendations, retaining wall design criteria, foundation design criteria, slab-on-grade floor recommendations, geotechnical engineering drainage recommendations and cut and fill grading guidelines, seismic design criteria, etc. A civil engineer should assess the roadways, driveways, alignment grades, embankments, and site drainage conditions. We also recommend floor level surveys be performed inside existing buildings to determine if settlement, heave, or distress has occurred. A structural engineer should provide seismic retrofit recommendations and design criteria for the existing buildings. We recommend a hydrogeologist evaluate the spring water supply. The dams and spillways should also be inspected and monitored.

WATER RIGHTS

The SDC holds riparian and appropriative water rights, and rights that were held before 1914 when State water rights legislation was enacted. These rights govern how much water can be diverted from water courses and how that water can be used. While the pre-1914 riparian rights do not permit storage of water, SDC has secured additional appropriative rights to store water for beneficial use. In this manner, the facility can secure adequate stores of water to provide reliable year-round domestic water for all uses at the property, to compensate for drought, and to provide substantial storage for fire suppression. SDC has an agreement with the Valley of the Moon Water District (VOMWD) to provide emergency water for fire protection or other emergency conditions. The water system also has a direct connection to the Sonoma County Water Agency, allowing SDC to supplement the Water Agency supply if, for example, the Water Agency needs to perform maintenance on the water treatment plant. It is expected that SDC has ample rights to continue to divert and store water for beneficial use for future moderate density development of the property, including domestic, irrigation and fire suppression requirements.

MINIMUM STREAM FLOWS

The SDC property boasts a critical wildlife corridor between the Sonoma Mountains and the Mayacamas Range (see Chapter 5). A host of animals is dependent upon riparian corridors fed by local streams on and adjacent to the SDC property. Maintaining stream flows will help support sustainable ecological balance and biodiversity.

LOW IMPACT DEVELOPMENT (LID) MEASURES TO MANAGE STORMWATER

New development at SDC will need to meet current stormwater regulations that focus on water quality and hydromodification (stormwater runoff rates). Stormwater management should be considered at two complementary scales: the building cluster scale (the scale at which future phased development efforts would most likely be focused) and the campus scale. By using a two-pronged approach, stormwater can be managed as the campus exists today, and as it is developed over time.

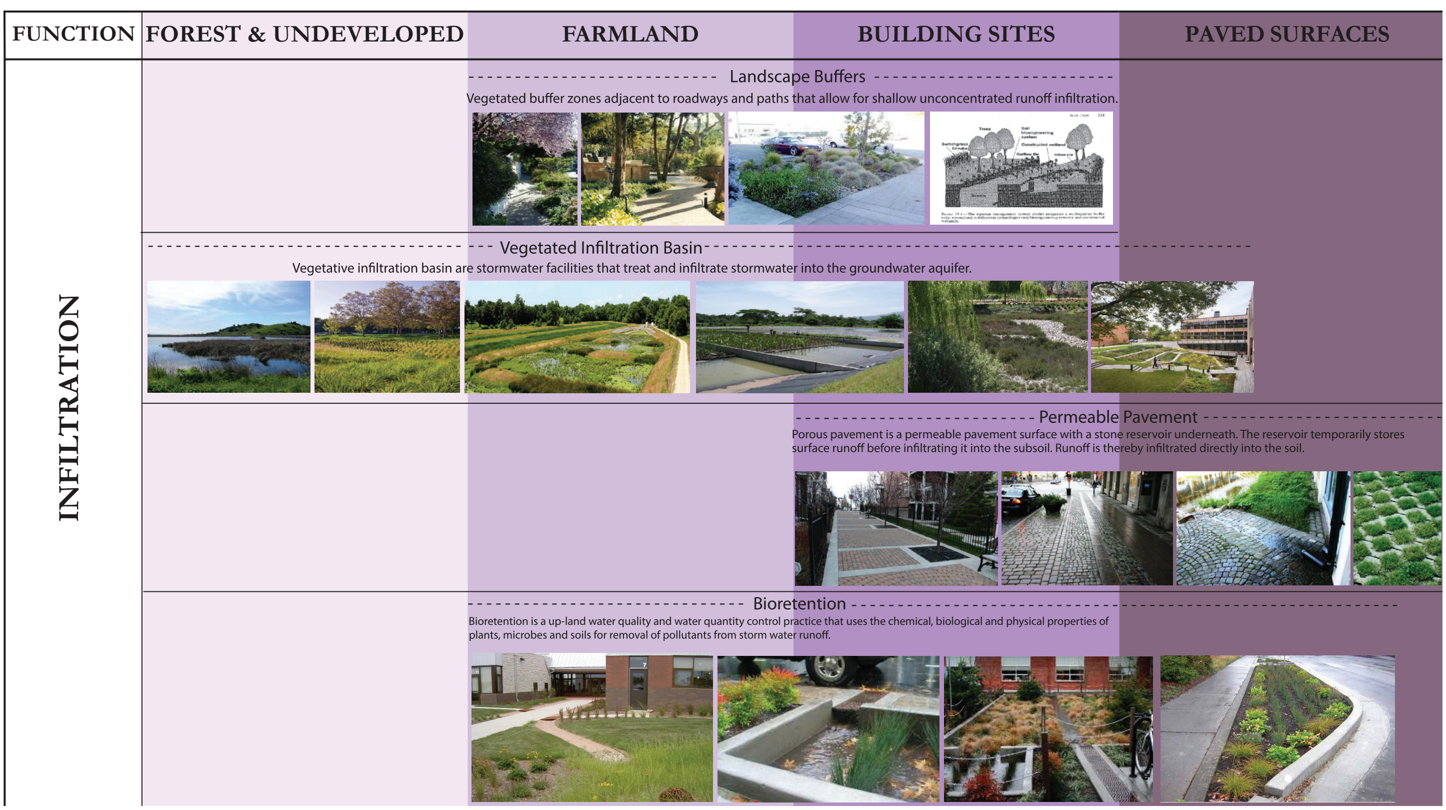
The term low-impact development (LID) refers to systems and practices that result in the infiltration, evapotranspiration or use of stormwater to protect water quality and associated aquatic habitat. Traditional methods of closed drainage collection and centralized detention areas act to remove stormwater runoff from the site in the quickest and most efficient manner possible. LID, in contrast, treats stormwater as an asset to be retained in an effort to mimic the natural hydrologic cycle.

Implementation of LID techniques can improve the quality of stormwater runoff, restore the infiltration of water to the aquifer, eliminate costs associated with conventional drainage systems, and reduce erosion and flooding. The following LID best practices should be followed for future development:

- Assess the site's topography, soils, vegetation and natural drainage for integration of LID techniques to minimize the future development footprint.
- Assess native vegetation and soils for placement of LID facilities.
- Minimize and manage stormwater at the source to promote treatment and infiltration
- Minimize areas of impervious surfaces such as parking lots, driveways, courtyards and roof tops, using permeable pavements and green roofs to maximize evapotranspiration and allow infiltration of precipitation into the soils.
- Manage runoff by disconnecting the impervious surfaces from one another, and directing runoff to LID features such as vegetated swales, planters, rain gardens and pervious pavement.

Figure 4-19

INFILTRATION BEST MANAGEMENT PRACTICES



- Preserve existing trees and plant new trees in coordination with development.
- Avoid compaction of soils in areas of the site that will not have structure.
- Minimize surface parking areas through the use of structured parking.
- Provide micro-detention in landscape areas (self-retaining areas).

Stormwater runoff should be collected throughout the site and transported, mostly through surface conveyance, to LID water-quality treatment areas. These areas will act to evapotranspire, infiltrate and remove contaminants from the water. Overflow volumes will be released to the campus scale storm drain network that leads to the local creeks.

Stormwater best management practices (BMPs) should be tailored to specific settings and functional priorities: infiltration, water quality, water quantity, and conveyance. The Stormwater BMP Matrix shown in Figure 4-19 helps convey the goals of various BMP technologies and how their form and function may change depending on the site.

OPPORTUNITIES FOR LOCAL INFILTRATION

The Sonoma Valley has seen dropping groundwater levels over the last few decades as demand, particularly in the southern part of the valley, has increased and groundwater supplies have been drawn beyond their capacity for natural recharge. The Sonoma Valley Groundwater Management Plan has identified ten Basin Management Objectives (BMO's) aimed at managing the valley's groundwater to achieve a sustainable condition. These BMOs include the intent to "identify and protect groundwater recharge areas and enhance the recharge of groundwater where appropriate." The SDC property presents an opportunity to recharge groundwater upgradient in the basin for improved regional groundwater sustainability. Groundwater recharge could include:

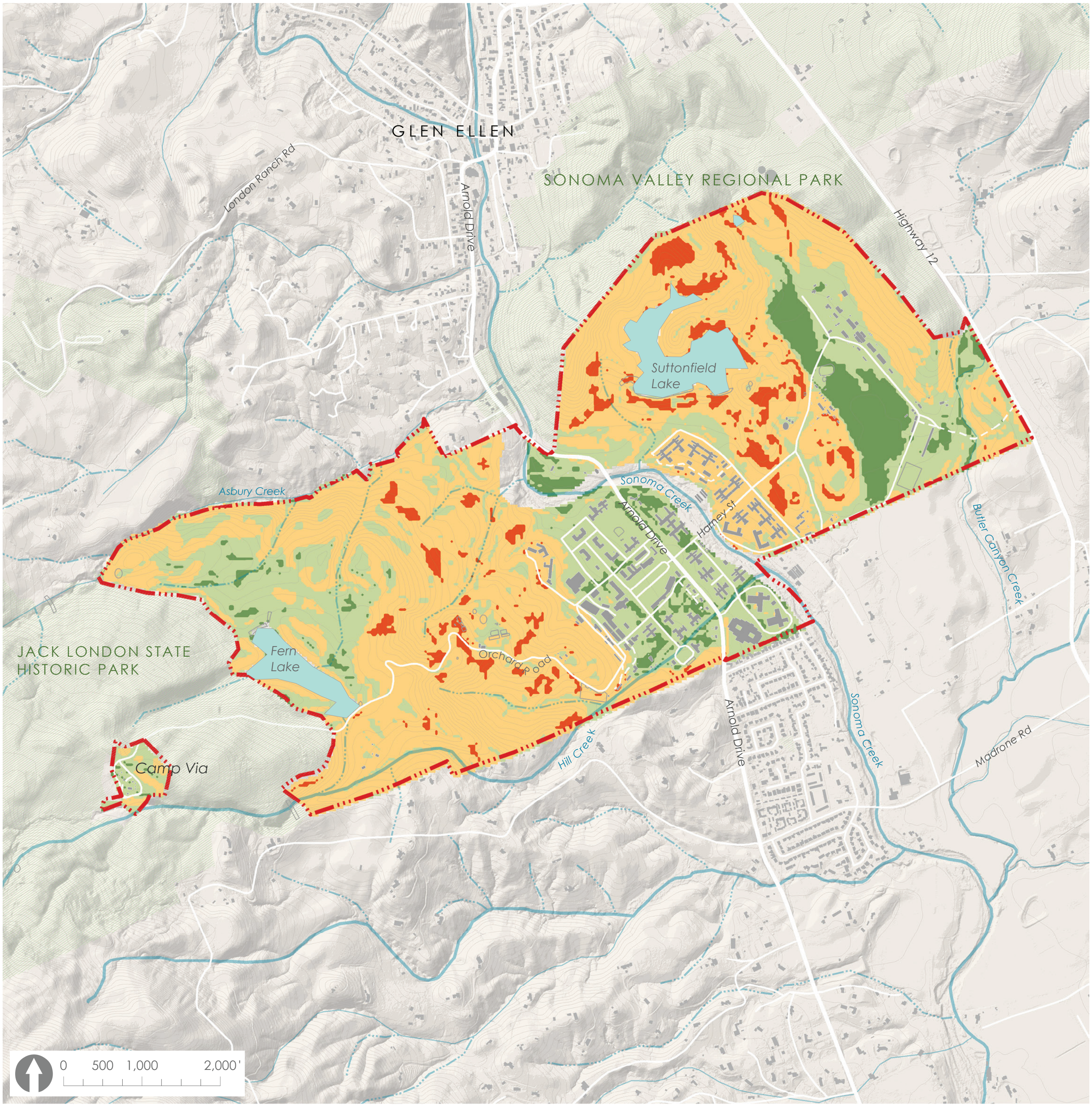
- Surplus water from the current water supplies on the property;
- Construction of an on-site wastewater treatment plant that, in addition to improving the local collection and transmission system, provide a source of reclaimed water.

Infiltration potential at the SDC site was analyzed for this study. The analysis takes into account three major factors that influence a site's relative infiltration and runoff related to rainfall events: slope steepness, soil type; and vegetation. The first two factors are shown in Figures 4-4and 4-7. Vegetation is described in Chapter 5 and shown in Figure 5-3.

These three sets of physical data were weighted by relative importance and layered to form a single Infiltration Potential map (Figure 4-20). Areas in lowlands adjacent to wetlands and significant vegetation present an important opportunity for infiltrating surface water and using BMP installations. Areas with significant slopes and chaparral vegetation are viewed as less appropriate for water infiltration and would be better served by using permaculture techniques like contour swales.

Figure 4-20

INFILTRATION POTENTIAL



SDC Property line
Protected and Public Lands
Ephemeral Streams
Perennial Streams
Intermittent Streams

Infiltration Analysis

- Not Suitable for Infiltration
- Preferred Area for Native Woodland, Slow Infiltration & Soil Retention
- Best Suited for Small, Decentralized Stormwater Management Practices
- Best Suited for Centralized Infiltration Practices & Wetland Restoration

Source
USGS, GreenInfo Network, Sonoma Ecology Center, Sonoma County Vegetation Mapping & LIDAR Program