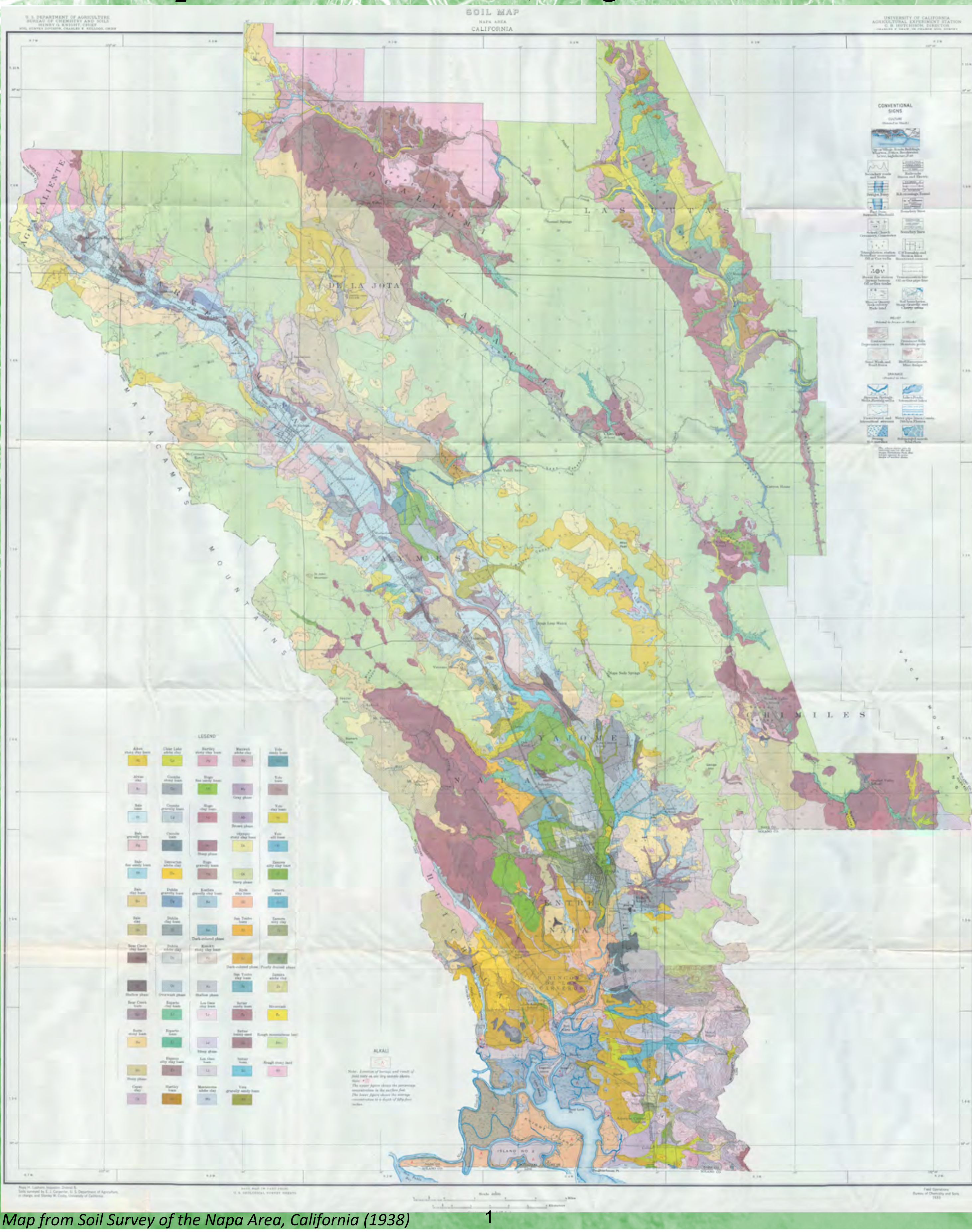
Professional Soil Scientists Association of California Annual Meeting & Field Tour Guide Book

Napa River Watershed, May 30-31, 2019



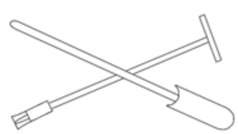
Map from Soil Survey of the Napa Area, California (1938)

Welcome to the
Professional Soil Scientists Association of California
Annual Meeting & Field Tour
May 30-31, 2019

Guide Book

Napa River Watershed

Joel Butterworth, Editor
ICF Jones & Stokes



Thank you to the following individuals who helped organize this meeting and field tour:

Bryan Rahn, Coastal Viticultural Consultants
David B. Kelley, Kelley & Associates Environmental Sciences, Inc.
Bill Reed, NRCS (Retired)
Mary Reed, PSSAC
C. Scott Frazier, SWRCB

Professional Soil Scientists Association of California
Annual Meeting & Field Tour Guide Book
May 30-31, 2019

Napa River Watershed

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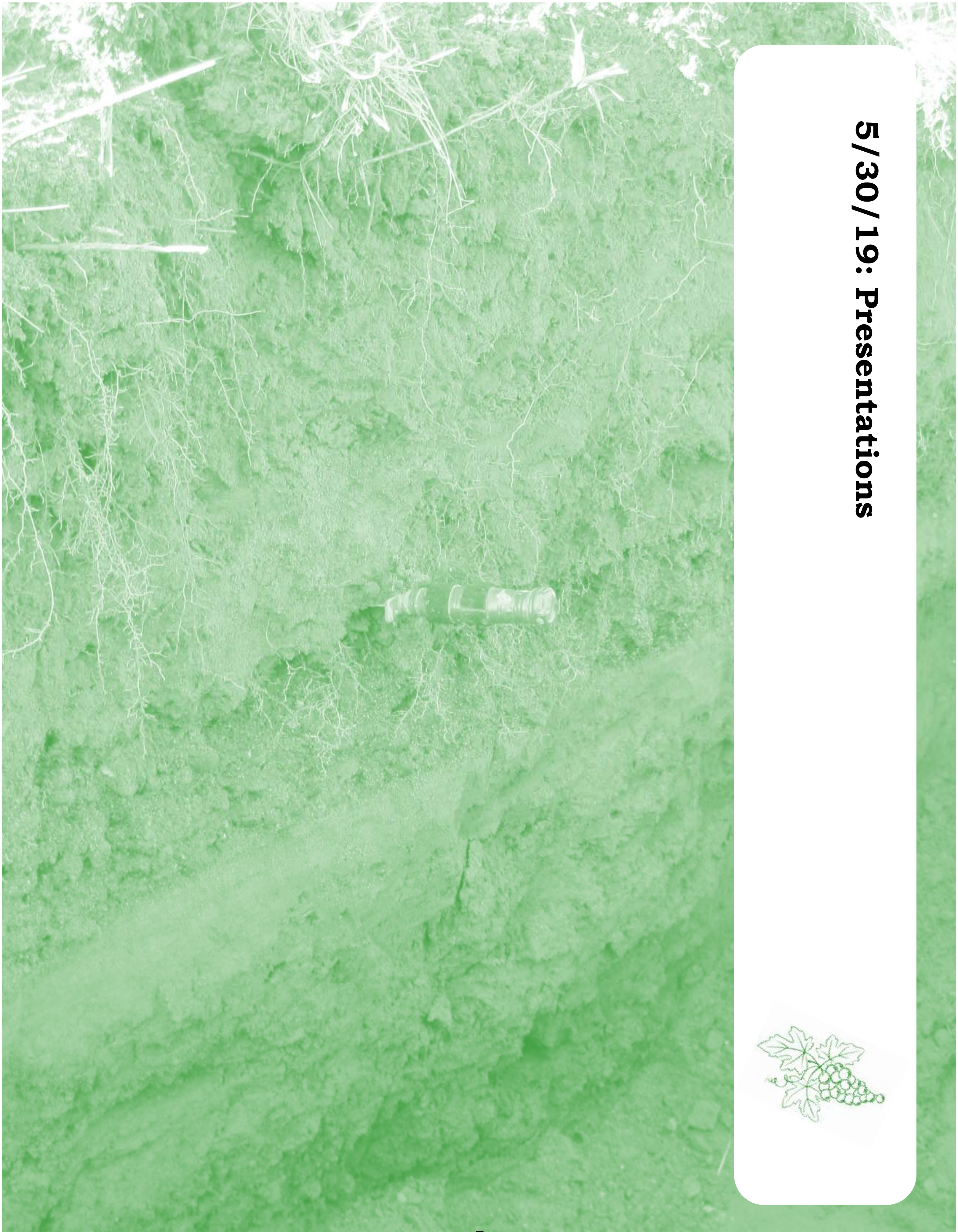
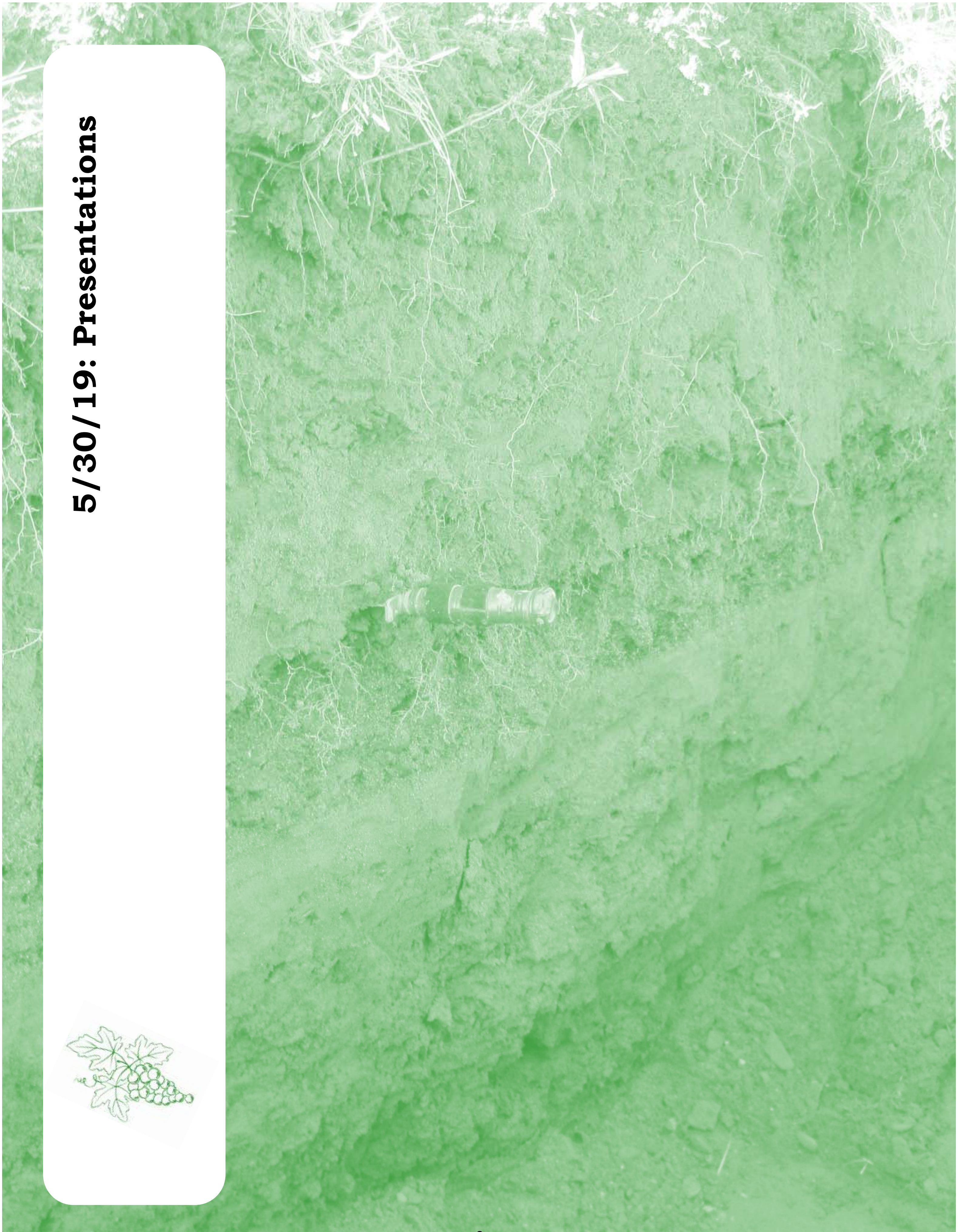


5/30/19: Presentations

5/30/19: Presentations



PSSAC

Professional Soil Scientists Association of California
May 30-31, 2019
Annual Meeting and Field Tour

"Napa River Watershed"

Agenda for Thursday, May 30

10:30 - 11:45 am	PSSAC Board of Directors Meeting (all are welcome)
12:30 – 1:00 pm	Registration Table Open
1:00 – 1:10 pm	"Welcome & Introduction" *Joel Butterworth, ICF Jones & Stokes, President, PSSAC*
1:10 – 2:00 pm	"An Overview of Native American Prehistory and Economy in the Napa Valley Region" *Darren Andolina, Archaeologist, ICF Jones & Stokes*
2:00 – 3:10 pm	"Mare Island Naval Shipyard: History of Operations, and Soil Remediation after Base Closure in 1996" *Bill Reed, USDA-NRCS (retired)*
3:10 – 3:25 pm	Break
3:25 – 3:45 pm	"Healthy Lands, Healthy Waters" *Lucas Patzek, Executive Director, Napa County RCD*
3:45 – 4:15 pm	"SFPUC Bioregional Habitat Restoration at Sheep Camp Creek: Stream Channel Stability Assessment" *Jeff Peters, Geomorphologist/Restoration Specialist, ICF Jones & Stokes*
4:15 – 5:00 pm	"Napa County RCD's Technical Assistance with Soil Health, Erosion Control, and Irrigation Management" *Miguel Garcia, Sustainable Agriculture Program Manager, Napa County RCD*
6:00 – 8:00 pm	Annual Banquet and Brief Business Meeting

2019 PSSAC Annual Meeting Speaker Bios and Presentation Abstracts

Darren Andolina holds an MA and BA in Anthropology from the University of California, Davis and has 22 years of professional experience in archaeology, working primarily in California and the Great Basin. His career has focused on the identification and preservation of archaeological sites through cultural resource management while working for private industry. He has completed projects and authored reports for a variety of national, state, and local agencies as well as private enterprises. His research interests focus on hunter-gatherer foraging and adaptation through a human behavioral ecology theoretical framework. His expertise lies in the analysis of flaked stone, ground stone, and shellfish assemblages from prehistoric archaeological sites.

ABSTRACT: "An Overview of Native American Prehistory and Economy in the Napa Valley Region"

This presentation will provide an overview of the prehistory of the Napa Valley and a history of archaeological research in the region. The presenter will include a summary of the Native American ethnographic groups that lived in and around the Napa Valley and describe their economy as understood from ethnographic and archaeological research. Special attention will be given to the importance of obsidian in the Native economy. Obsidian, as well as serving as a valuable base material for fashioning stone tools, has also been used by archaeologists to date prehistoric sites. A review of the benefits and limitations of the obsidian hydration dating technique will be presented.

+ + +

William Reed earned a B.A. in Geography from Fresno State University and was hired shortly afterward by the USDA Soil Conservation Service. A few years later he completed his Masters in Plant Science, also from Fresno State University. Bill helped map Sacramento and Yuba counties, and served as party leader for the soil mapping efforts in Colusa County, Northern Humboldt County, and Western Santa Clara County. He then served five years as the California Natural Resources Inventory (NRI) Coordinator at the NRCS State Office.

After retirement from the NRCS in 2015, Bill continues to assist with several ongoing NRCS projects, including the annual NRI Crop Data Collection, but has more free time to learn more about his favorite subject (history) and help his wife with her animals and the various and sundry never-ending projects on their small Vacaville farm. In 2017 he became a Master Gardener with the UC Master Gardener program.

ABSTRACT: "Mare Island Naval Shipyard: History of Operations, and Soil Remediation after Base Closure in 1996"

Mare Island Naval Shipyard was established in 1853, and was the first shipyard on the West Coast. It became a major shipbuilding facility, with over 500 ships and submarines constructed, and thousands of

major repairs completed. Expansion of the island was implemented with a variety of imported fill or dredge materials, to about four times its original size. Mare Island was the site of massive naval wartime operations during WWII, and was the command center for naval operations in annex locations in multiple states. After base closure, the Mare Island EIR/EIS indicated a superfund site was warranted with at least 24 individual sites requiring remediation of soils, groundwater and buildings. At least seven of those sites have required extensive work: clearing toxic metals, chemicals, and radiological debris. After the expenditure of $290 million, the Navy still controls about a quarter of the island and redevelopment continues more slowly than originally anticipated.

+ + +

Lucas Patzek became the Napa RCD's Executive Director in 2018. He believes deeply in the District's collaborative and non-regulatory approach to inspiring behavior change, and has experience working with similar Districts across California and Washington. For the past 11 years he has worked with diverse stakeholders to improve agricultural and natural resource systems by finding common ground and working together on long-term solutions. His experience includes serving as a County Director and Agriculture & Natural Resource Faculty with the Cooperative Extension Service in Washington, and as the Associate Executive Director of the Sonoma County-based non-profit Ag Innovations. He received a Ph.D. in Crop Science from Washington State University and a B.S. in Biology from University of California at Santa Cruz.

ABSTRACT: "Healthy Lands, Healthy Waters: The Work of the Napa RCD"

Resource Conservation Districts (RCDs) are one of California's earliest grassroots conservation organizations. They identify conservation needs and support land managers in implementing solutions on a voluntary basis. The Napa County RCD was formed in 1945, and currently has a range of programs which help the local community conserve, protect, and restore natural resources in a landscape that supports agriculture, urban areas, and wild spaces. This presentation will explore the strategies used by the RCD to achieve success, including monitoring indicator species, advising on erosion control measures, enhancing oak woodlands, providing youth education, and conducting cleanups.

+ + +

Jeff Peters is a geologist and restoration specialist with ICF Jones & Stokes. He conducts restoration feasibility studies, which he prepares in support of watershed and stream corridor management plans. He also conducts stream bank and channel stability assessments and monitoring; stream classification methodologies in support of watershed analyses; channel and floodplain restoration and geomorphic assessments in support of channel and floodplain restoration; hydraulic modeling; water availability analyses; topographic surveys; upstream limit of anadromy surveys; streamflow surveys; rain gage operation; and fish habitat suitability and fish passage analyses. Jeff has a significant amount of experience working on water rights projects throughout northern California, working both on the CEQA documentation and the associated technical studies. Jeff also conducts bioassessments that involve benthic macroinvertebrate collection, physical habitat surveys, and water quality assessments. Jeff has worked on many other river systems, including Big Tujunga Canyon (southern CA) where he conducted a geomorphic analysis for a road repair bordering the creek; the Middle Fork American River (northern CA) where he has been monitoring the effects of gravel augmentation since 2001; the Napa River (northern CA), where he helped identify areas of severe bank erosion; and the Tongue River (MT), where he assessed geomorphic conditions relative to fish habitat. Jeff received a BA in Geology (with an Environmental Science option) from Colby College in 1996 and a MA in Geography (with a focus on geomorphology) from the University of Oregon in 2001.

ABSTRACT: "SFPUC Bioregional Habitat Restoration at Sheep Camp Creek"

Avila & Associates and ICF support the San Francisco Public Utilities Commission on restoration of Sheep Camp Creek Mitigation Area, a Bioregional Habitat Restoration site in the Alameda watershed. In 2014, Avila developed and implemented a strategy to install and irrigate 21,000 plantings of 40 native species across the 430-acre site via direct seeding and rhizome-division propagation. Vegetation surveys and habitat assessments began in 2015, collecting a broad suite of data to monitor germination, survivorship and recruitment rates, as well as absolute coverage of native and non-native species. Despite severe drought conditions in 2014 and 2015, the Site is now transforming from heavily degraded non-native grassland into a matrix comprising oak, sycamore and willow riparian and seasonal wetland habitats. High rainfall in 2016 and 2017 continue to bolster the preliminary success of these re-vegetation efforts.

In 2014, ICF conducted a baseline erosion inventory of all erosion features within the Site. The baseline hydrogeomorphic surveys identified such features as eroding banks, headcuts, canyon wall slumps, and other "legacy erosional features" from years of sheep and cattle grazing. To protect and support extensive habitat restoration efforts, remedial actions have been taken to address bank erosion, headcuts, and other erosional features on site. Recent monitoring by ICF has shown significant increase in vegetation establishment and reduced bank erosion. This exciting project will continue until Year 10, and Avila & Associates and ICF will to continue identify areas of erosion severity for future restoration potential.

+ + +

Miguel Garcia currently serves as the Sustainable Agriculture Program Manager for the Napa County Resource Conservation District, where he provides on-farm technical assistance and planning related to soil health, erosion control, and irrigation management. He also designs educational programs aiming at providing local growers with valuable information on various topics related to sustainable agriculture. Before joining the Napa County RCD, Miguel worked for the Coachella Valley and the Inland Empire RCDs developing and implementing diverse sustainable agriculture programs. He has a PhD in Environmental Sciences and a B.S. in Chemistry from UC Riverside. Miguel believes the future wellbeing of our local water resources and the world's food security lies heavily on the implementation of adequate sustainable agriculture practices today. By working one-on-one with growers, he believes true change can be attained.

ABSTRACT: "Napa County RCD's Technical Assistance with Soil Health, Erosion Control, and Irrigation Management"

I will be discussing the role that Napa RCD has played in developing the North Coast Soil Health Hub, a collaborative effort between Napa RCD, Mendocino RCD, Sonoma RCD, and Gold Ridge RCD focused in address regional specific needs, successes and challenges. I will also talk about the different farm assistance programs that the Napa RCD offers: Education and training, soil health assessments, erosion control and mitigation, carbon farming, and irrigation efficiency assessments.

\+ + +

icf.com

we are ICF

An Overview of Native American Prehistory and Economy in the Napa Valley Region

Darren Andolina
Senior Archaeologist

30 May 2019

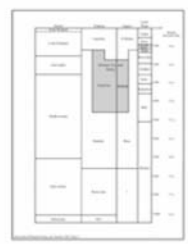
Napa Valley Ethnography

- Wappo
- Pomo
- Patwin
- Lake Miwok

Napa Valley Archaeological Research

Napa Valley Archaeological Research

- Local Cultural Sequence
  - Paleoindian - >10,000 BP
  - Early Archaic – 10,000 – 7,000 BP
  - Middle Archaic – 7,000 – 2,500 BP
  - Late Archaic – 2,500 – 1,500 BP
  - Lower Emergent – 1,500 BP - Contact



Napa Valley Prehistoric Economy: Obsidian

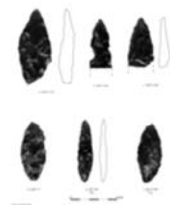
- Major Obsidian Sources in Napa Region
  - Napa Glass Mountain
    - Napa Main Source
    - Meg's Crown
    - Crystal Summit
  - Annadel
  - Franz Valley
  - Blossom Creek
  - Mt. Konocti
  - Borax Lake

Napa Valley Prehistoric Economy: Obsidian

- Valuable Flaked Stone Material
  - Projectile Points
  - Bifacial Knives
  - Casual Flake Tools

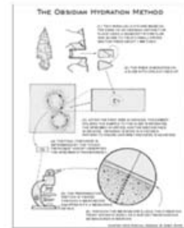
Napa Valley Prehistoric Economy: Obsidian

- Early Economy
  - Biface Production for Consumption and Export
  - Specialized Producers
- Late Archaic/Emergent
  - Biface Production for Export Still Occurs
  - Unmodified Cobbles Also Exported



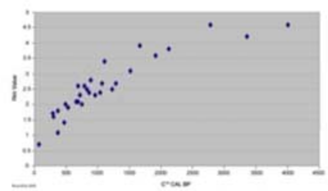
Obsidian Hydration Dating

- Obsidian Hydration
  - Relative Dating Technique
  - Absolute Dating
  - Freshly-knapped Surfaces Absorb Water
  - Cut Fragment from Artifact Margin
  - Analyze Microscopic Hydration Band



Obsidian Hydration Dating

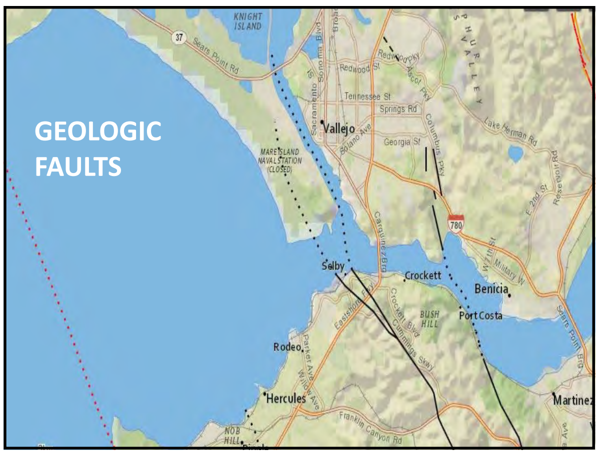
- Obsidian Hydration
  - Determine Hydration Rate by Comparing Hydration Readings with 14C Dates.
  - Napa Obsidian Rate - $y=148.99x^2$

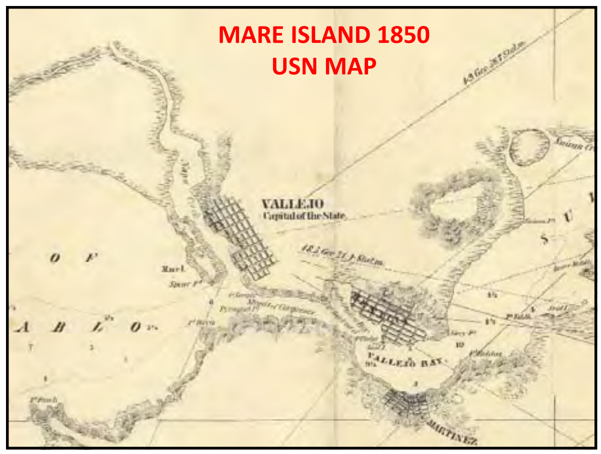


Concluding Remarks

Mare Island Overview

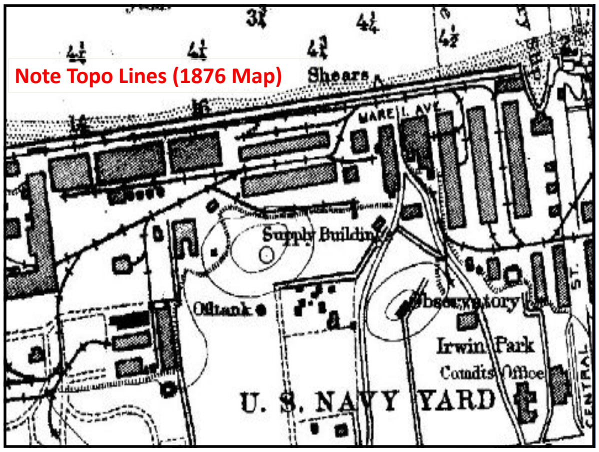
- Old Maps of Mare Island and Geology
- Navy historical use of Island
- Fill materials, dredging, tides
- Navy cleanups pre-1996
- Remediation activity post 1996
- Current uses and future plans





MARE ISLAND MAP, 1851 USN, LANDFORMS

Note Topo Lines (1876 Map)

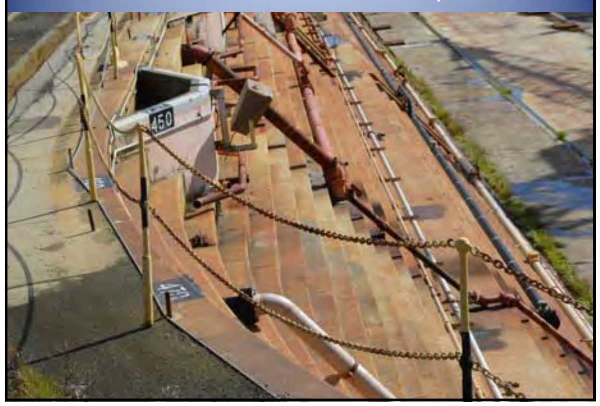


1876 Rapidly Developing Naval Shipyard, Not Much Landfill Yet

Dry Dock 1, Built After The Civil War

THE OLD LOOK AND THE NEW
The new dry dock takes the old *Independence* to tighten her seams for use as a Receiving Ship in 1886.

Granite Blocks From Rocklin in Dry Dock 1



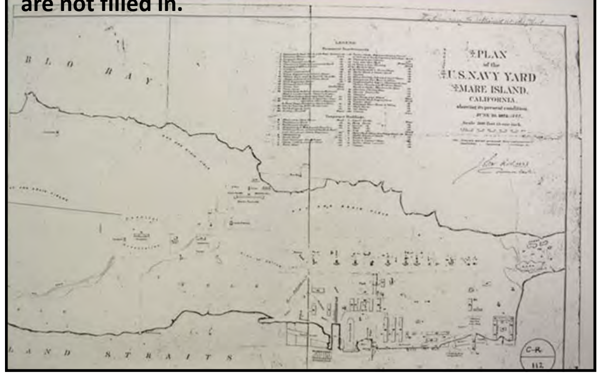
Dry Dock Number 2 built late 1800's was over 750 feet long, built in wetlands

WHOLESALE DOCKING
Dry Dock Number 2 was so big it could dock six destroyers at a time. Here the whole 36th Destroyer Division is getting the treatment in a bunch.

Mare Island Museum, Bldg. 46, Built in 1855, Oldest Building on Mare Island

Stone Foundation of Bldg. 46, Stone was Quarried from Angel Island Sandstone

Development on Mare Island as of 1883, Dry Dock 1 under construction. Wetlands south of developed area are not filled in.

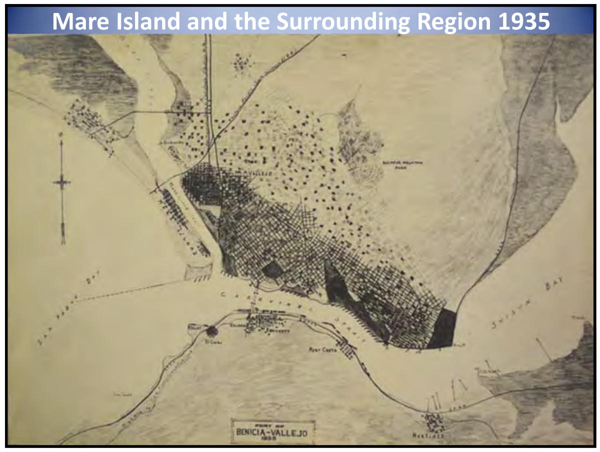


1898 Earthquake Damage at Mare Island

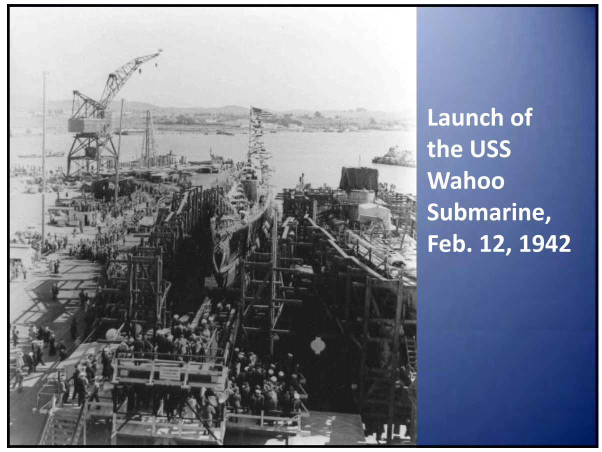
USS California, launched in 1919. First and only battleship from Mare Island. 624 feet long, it had 12-14 inch guns. Severely damaged in the Pearl Harbor attack, limped back to Bremerton, sent out again in 1944, served at the battles of Okinawa & Layete Gulf.

1917 Start of WW1. Sabotage at Mare Island Munitions Factory Dock, two millions pounds of Black Powder exploded by German sabotage.

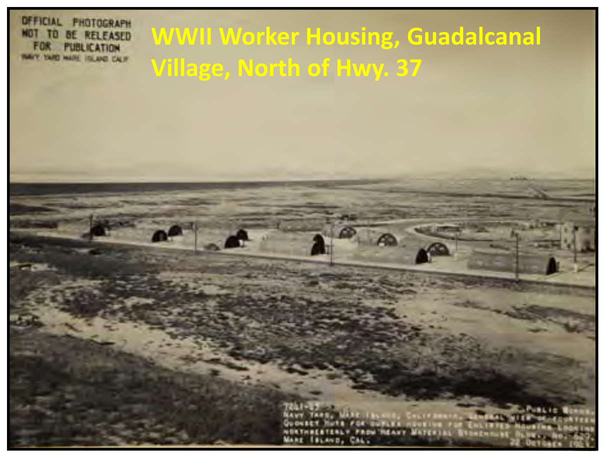
Mare Island and the Surrounding Region 1935




OFFICIAL PHOTOGRAPH NOT TO BE RELEASED FOR PUBLICATION
NAVY YARD MARE ISLAND, CALIF
RESTRICTED
Mare Island WWII Dock Activity


Launch of the USS Wahoo Submarine, Feb. 12, 1942


On Mare Island: Women Making Gas Masks for WWII


OFFICIAL PHOTOGRAPH NOT TO BE RELEASED FOR PUBLICATION
WWII Worker Housing, Guadalcanal Village, North of Hwy. 37


Post War Mothball Fleet Stationed at Mare Island


Launch of the USS Vallejo 1963

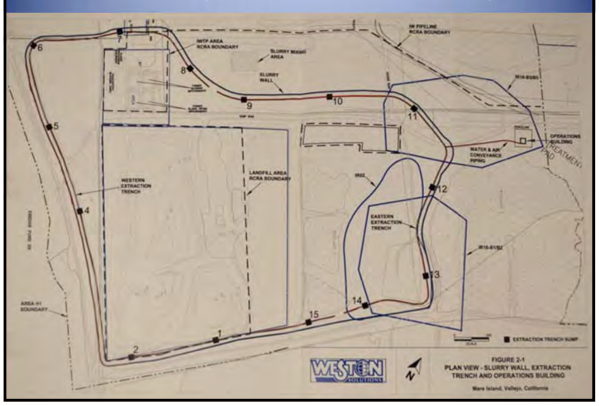
Mare Island Naval Shipyard (MINS) Closed April 1, 1996

- MINS Closed as part of 1993 Base Realignment and Closure.
- MINS in operation for 142 years, over 500 ships launched, thousands repaired or refurbished, some from other nations.
- Navy inspections, investigations and studies 1976 to 1996.
- 1998 Full EIS/EIR completed for MINS.
- MINS designated as EPA Superfund site CA7170024775, with 24 sites identified as contaminated.

Major Remediation Sites on Mare Island

- Base Dump
- Crane Test Area
- Scrap yard/Oil Disposal area
- Rail Road Corridor
- Munitions Plant, Disposal Area
- Paint Factory
- Sand Blasting Material, New and Used Storage
- Marine Artillery Range

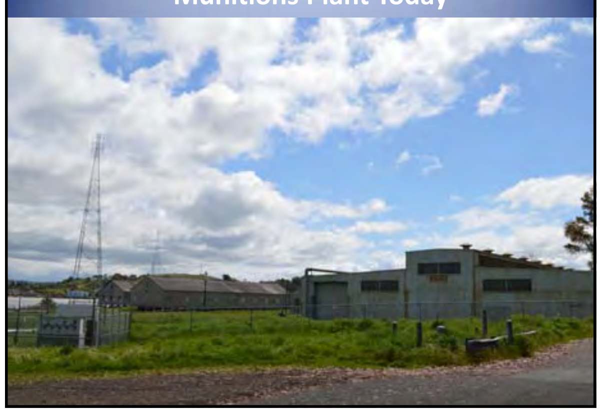
Base Dump General Construction Layout



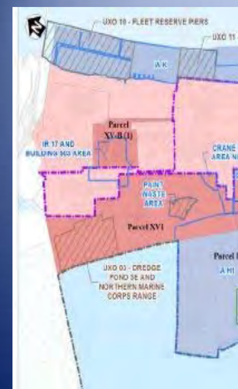
Crane Test Area Map on Dump Road

Munitions Plant South East and South End of MINS

Munitions Plant Today



West Side of Island Used for Munitions Storage, Inert Munitions Storage, and Disposal by Burning and Detonation of Outdated Munitions



Paint Factory at Parcel XV-8(1) and the Paint Waste area south-west of the Paint Factory, was a major source of toxic chemicals.

Sand Blasting, storage and Paint Area North of Munitions Factory

Marine Rifle Range Remediation

Future of Mare Island

- Complete transfer of the parts of the island to the City of Vallejo that can be safely remediated
- Complete Residential Area
- Develop increased commercial businesses on the Island
- Navy to retain indefinitely those areas not safe for public use

-QUESTIONS?

Sources

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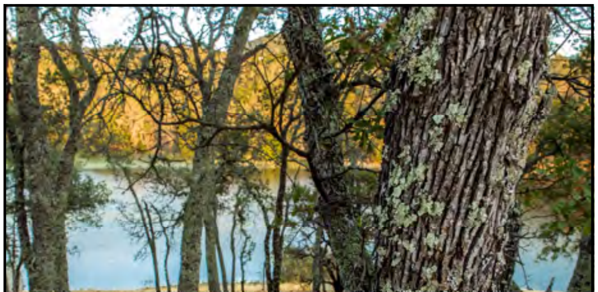
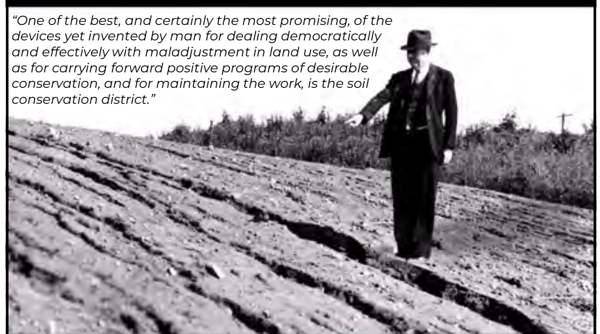


Healthy Lands
Healthy Waters

Lucas Patzek, Executive Director
Lucas@NapaRCD.org, 707-690-3119

"One of the best, and certainly the most promising, of the devices yet invented by man for dealing democratically and effectively with maladjustment in land use, as well as for carrying forward positive programs of desirable conservation, and for maintaining the work, is the soil conservation district."



Dr. Hugh Hammond Bennett

Leaders from California's conservation community at an annual CARCD Conference.

From left: Carlos Suarez, NRCS State Conservationist; Glenn Franklin, former CARCD Board President; Dr. David Bunn, Director of the Department of Conservation; and Karen Buhr, Executive Director of CARCD

- Public agency – Special District
- Formed in 1945
- 7-member volunteer Board
- Nine staff
- $1.8M annual budget
- 85% of revenue from grants and contracts
- Partnership with USDA

Investigate: Understand our Watersheds
Monitor Indicator Species | Monitor Streamflow & Groundwater | Track & Communicate Changes

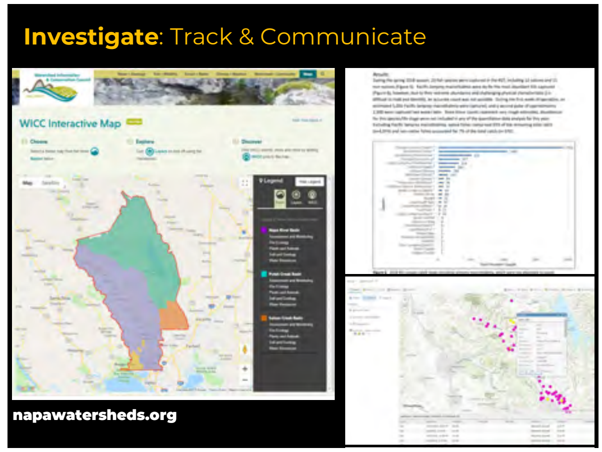
Act: Improve Ecosystems
Reduce Erosion | Conserve Water | Enhance Habitats

Inspire: Engage Community
Involve Youth | Provide Community Opportunity | Communicate Regularly

Manage Responsibly: Practice Excellence
Build Partnerships | Operate Responsibly

Investigate: Fisheries Monitoring


Investigate: Streamgaging, Sediment Monitoring & Project Effectiveness Monitoring


Investigate: Track & Communicate
WICC Interactive Map
napawatersheds.org


Act: Erosion Control

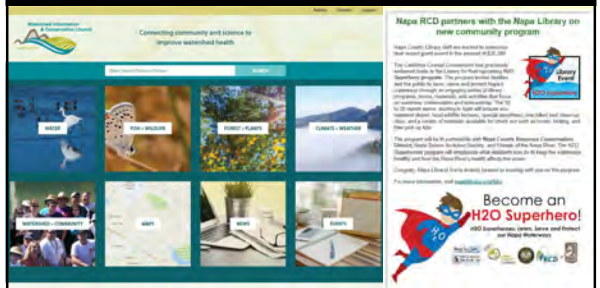

Act: Sustainable Farming Practices
Water Management
Worker Health & Well-being
Pest Management
Habitat Restoration
Soil Health
Diversification


Inspire: Youth Environmental Education


Inspire: Clean-Up Events, Speaker Forums, Garden Tours, Citizen Science Experiences
BAY-FRIENDLY GARDEN TOUR

Inspire: Agricultural Workshops & Field Days

Inspire: Communicate Regularly



Manage Responsibly: Partnerships
(*only a few examples*)

Thank you!

Lucas Patzek, Executive Director – lucas@naparcd.org, 707-690-3119

Sheep Camp Creek Soils

Introduction

The SFPUC developed the Bioregional Habitat Restoration (BHR) program to compensate for impacts to habitat and species primarily associated with the Water System Improvement Program (WSIP) projects.

Sheep Camp Creek Soils

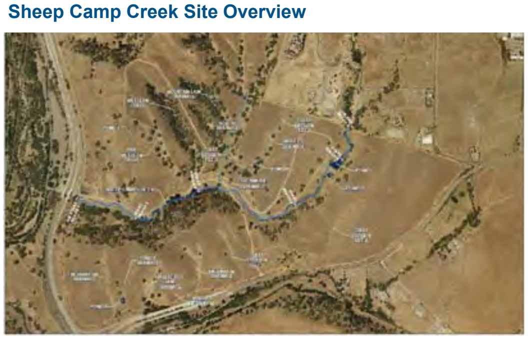
Soil Map Units:

- Positas gravelly loam, 2 to 20 percent slopes, eroded (PoC2)
- Positas gravelly loam, 20 to 40 percent slopes, eroded (PoE2)
- Perkins loam, 45 to 75 percent slopes, eroded (PcF2)

Soil Characteristics:

- Deep (80 inches) gravelly loam
- Compacted due to historic sheep grazing and present-day cattle grazing
- *Very high runoff rates*
- Numerous mammal burrows

Sheep Camp Creek Site Overview



Bioregional Habitat Restoration Activities at Sheep Camp Creek

1

Revegetation Efforts: 2014-2017

Established, Re-established and Rehabilitated Habitats:

21,000 plants of 44 species were planted and irrigated throughout 14 acres of mitigation habitats.

Current Conditions: Vegetation

Despite some obstacles, the team's tenacity was rewarded with recent wet winters, resulting in an abundance of plant growth.

Benefits of Thriving Vegetation

The success in revegetation efforts aids in ground stabilization and reduces erosion along the tributaries, stream banks, and other planted areas.

Erosion and Geomorphic Monitoring

- **Erosion Features Inventory**
- **Channel Stability Monitoring**
- **Photo Monitoring**
- **Repeat Topographic Surveys**

- **Analysis**
  - Year to year variability
  - Cross section overlay
  - Remedial Recommendations

Erosion and Geomorphic Monitoring

- **Erosion Features Inventory**

Types:
- Arroyo
- Burrow
- Cattle path
- Constructed cattle crossing
- Cutbank
- Eroding bank
- Eroding gully
- Headcut
- Pothole
- Ravine
- Roadcut
- Road stabilization
- Rill
- Slump
- Swale
- Trench pool

Erosion and Geomorphic Monitoring

- **Erosion Features Inventory**

Erosion and Geomorphic Monitoring

- Channel Stability Monitoring (erosion pins)

Erosion and Geomorphic Monitoring

- Channel Stability Monitoring (Modified Pfankuch Procedure)

Erosion and Geomorphic Monitoring

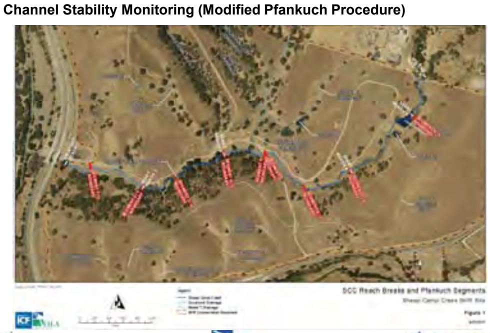
- Channel Stability Monitoring (erosion pins)

Erosion and Geomorphic Monitoring

- Channel Stability Monitoring (Modified Pfankuch Procedure)

Erosion and Geomorphic Monitoring

- Channel Stability Monitoring (Modified Pfankuch Procedure)



Erosion and Geomorphic Monitoring

- Channel Stability Monitoring (Modified Pfankuch Procedure)

F6: deeply entrenched; moderate sinuosity; moderate to high W/D; working to create new floodplain at lower elevation; very high levels of bank erosion, bar development, and sediment transport

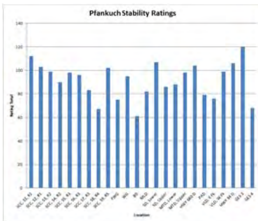
G6: "gully" types, similar to the "F" types, but with lower W/D (less than 12); high rates of bank erosion as they try to widen into an "F."

E5: slightly entrenched; very low channel W/D; very high channel sinuosities; occur on alluvial valleys that exhibit low elevational relief

3

Erosion and Geomorphic Monitoring

- Channel Stability Monitoring (Modified Pfankuch Procedure)



Location	Rating Total	Existing Stream Type	Potential Stream Type	Rating
SCC, S1, R1	112	F6	F6	POOR
SCC, S2, R1	103	F6	F6	FAIR
SCC, S3, R2	99	F6	F6	FAIR
SCC, S4, R2	90	F6	F6	GOOD
SCC, S5, R3	98	F6	F6	FAIR
SCC, S6, R3	96	F6	F6	FAIR
SCC, S7, R3	83	F6	F6	GOOD
SCC, S8, R4	67	E5	E5	GOOD
SCC, S9, R5	102	F6	F6	FAIR
FWG	75	F6	F6	GOOD
WG	95	F6	F6	GOOD
BD	61	G6	G6	GOOD
MLD	82	G6	G6	GOOD
SD, Lower	107	F6	F6	FAIR
SD, Upper	86	F6	F6	GOOD
MTD, Lower	88	F6	F6	GOOD
MTD, Upper	98	F6	F6	FAIR
HWY 680 D	104	F6	F6	FAIR
PAD	79	F6	F6	GOOD
VLD, E Fk	76	F6	F6	GOOD
VLD, W Fk	99	F6	F6	FAIR
HWY 84 D	106	F6	F6	FAIR
GES 3	120	F6	F6	POOR
GES 4	68	F6	F6	GOOD

Erosion and Geomorphic Monitoring

THE GOOD (BANKS ON SCC)

SPRING 2018

SPRING 2019

Erosion and Geomorphic Monitoring

THE GOOD, THE BAD, AND THE (TEMPORARILY) UGLY

Erosion and Geomorphic Monitoring

THE GOOD (Gully Erosion Site 4)

Erosion and Geomorphic Monitoring

THE GOOD (BANKS ON SCC)

FALL 2014

SPRING 2015

SPRING 2016

SPRING 2017

Erosion and Geomorphic Monitoring

THE GOOD (Gully Erosion Site 4)

Fall 2014

Spring 2015

Spring 2016

Spring 2017

Erosion and Geomorphic Monitoring

THE GOOD (Gully Erosion Site 4)

Spring 2018

Spring 2019

Erosion and Geomorphic Monitoring

- THE BAD (UPPER SYCAMORE DRAINAGE HEADCUT)

Erosion and Geomorphic Monitoring

THE BAD (LOWER SCC HEADCUT)

Fall 2014

Spring 2015

JAN 2017

FEB 2017

Erosion and Geomorphic Monitoring

THE UGLY (2016/2017 winter was INTENSE!!)

before

after

Erosion and Geomorphic Monitoring

THE BAD (LOWER SCC HEADCUT)

Spring 2018

Spring 2019

Erosion and Geomorphic Monitoring

THE UGLY (2016/2017 winter was INTENSE!!)

before

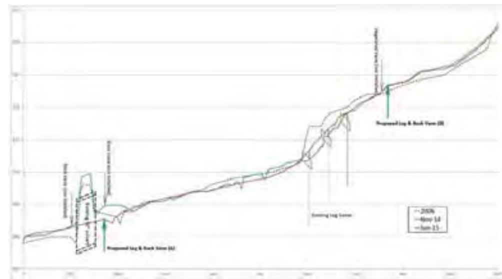
2019

Erosion and Geomorphic Monitoring

THE UGLY (Headcut formation at bottom of Reach 1, SCC in 2017)

Erosion and Geomorphic Monitoring

Lower Sycamore Drainage / GES 2 Restoration



Erosion and Geomorphic Monitoring

THE UGLY (Headcut formation at bottom of Reach 1, SCC in 2017)

2018

2019

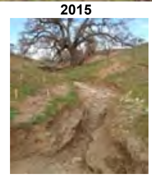
Erosion and Geomorphic Monitoring

Lower Sycamore Drainage / GES 2 Restoration

2014

2015

2017



Erosion and Geomorphic Monitoring

Lower Sycamore Drainage / GES 2 Restoration

Erosion and Geomorphic Monitoring

Lower Sycamore Drainage / GES 2 Restoration

2018

2019

6

Erosion and Geomorphic Monitoring

Lower Sycamore Drainage / GES 2 Restoration



2014 **2015** **2017**



Revegetation Effort Summary


In summary the planting effort at Sheep Camp Creek has had several setbacks, but we have made progress toward obtaining native plant cover throughout the planted habitats.

Erosion and Geomorphic Monitoring

Lower Sycamore Drainage / GES 2 Restoration


2018 **2019**


Erosion and Geomorphic Monitoring Summary

- **Overall, channel conditions/stability have significantly improved since baseline monitoring**
- **Channel banks improving (riparian cattle fencing)**
- **Headcuts are result of "legacy erosion" (rapid runoff/erodible soils)**
- **Precipitation duration and intensity**

Erosion and Geomorphic Monitoring

Lower Sycamore Drainage / GES 2 Restoration

Napa County RCD's Technical Assistance with Soil Health, Erosion Control, and Irrigation Management

Miguel A. Garcia, PhD
Napa Resource Conservation District

How farming practices affect soils




The role of the Napa County RCD in the North Coast Soil Health Hub

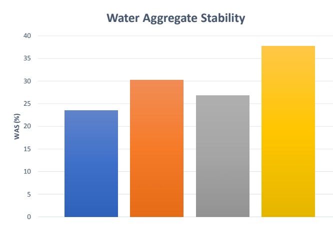
What is the North Coast Soil Health Hub?

Mendocino, Napa and Sonoma County farmers and partners are working together as the North Coast Soil Health Hub, and are part of the larger California Farmer-to Farmer Soil Health Network. Soil Health Hubs are agriculturally focused networks that address region specific needs, successes and challenges. Regional hubs are focused on specific needs for specific crops, soils, climate, land management practices, and marketing.

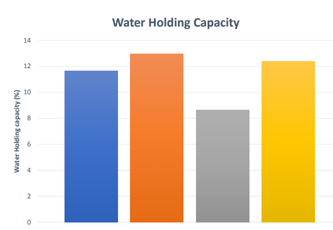
Participate,

Soilhub.org is the on-line home for the new hub. Visit the website for events, news, research, and anecdotes related to soil health, farming practices, and soil carbon sequestration in Northern California.

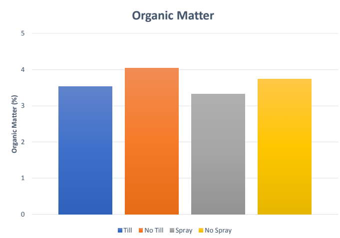
How farming practices affect soils



How farming practices affect soils



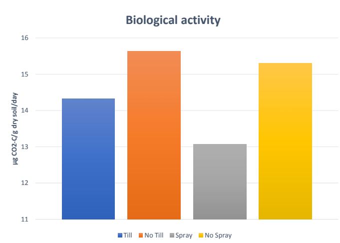
How farming practices affect soils



Work Done by Napa RCD

- Farm education and training
- Soil health assessments
- Erosion control and mitigation
- Carbon farm planning
- Irrigation efficiency assessments

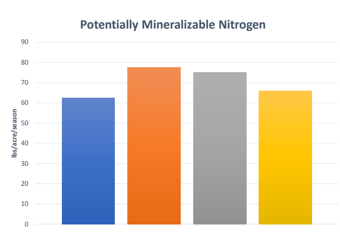
How farming practices affect soils



Farm education and Training

- We work closely with farmers to help address their concerns.
- Throughout the year, the Napa RCD organizes various educational workshops where professionals present on important topics.
- Topics: Soil health indicators, impact of tillage, alternative weed management alternatives, integrated pest management, etc.
- **Goal:** That every farmer in the Napa Valley has all the tools and knowledge to make inform decisions when managing their soils.

How farming practices affect soils



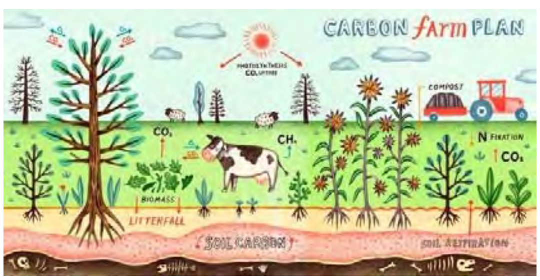
Soil Health Assessments

Soil Health Assessment Properties to be monitored as part of the Climate-Beneficial Vineyard Management Practices for the North Coast Area Project Soil Property
Texture- % of sand, silt, clay, gravel content
Aggregate stability-% of aggregates stable to simulated rain
pH- measure of soil reaction (acid, neutral, basic)
Micro and macronutrients
Cation exchange capacity (CEC)
Total organic carbon (TOC)- the carbon contained in soil organic matter (SOM)
Active organic carbon- measured by permanganate oxidation.
Total nitrogen
Potentially mineralizable nitrogen- the amount of organic N converted to plant available mineral forms
Bulk density- the weight of dry soil per volume
Water infiltration- rate of water entry into soil at field capacity water content
Compaction- loss of soil porosity or "densification", measured as resistance using penetrometer with conical tip

Erosion Control and Mitigation

- We have been providing assistance to farmers in determining erosion risks, address erosion concerns, and develop erosion management plans.
- This helps farmers address incoming discharge regulations.

Carbon Farm Planning



Irrigation efficiency Assessments

- Napa RCD provides irrigation efficiency assessments at no cost to farmers.
- Water conservation is important to protect local water resources.
- Appropriate irrigation management helps establish strong plants that require less pesticides and less invasive soil management practices.

Miguel Garcia, PhD
Napa County Resource Conservation District
Sustainable Agriculture Program Manager
mgarcia@naparcd.org
707-690-3122

Notes:

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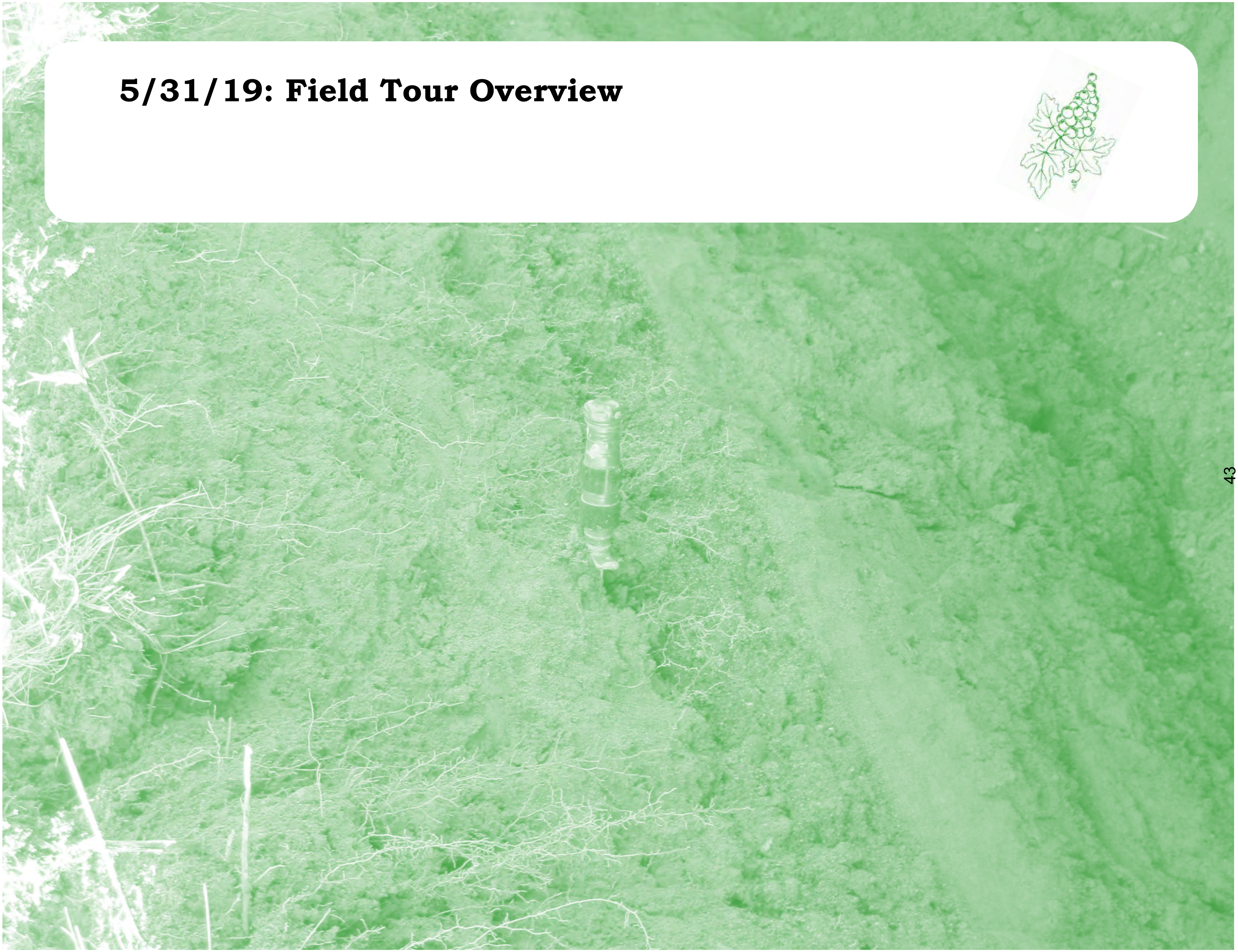
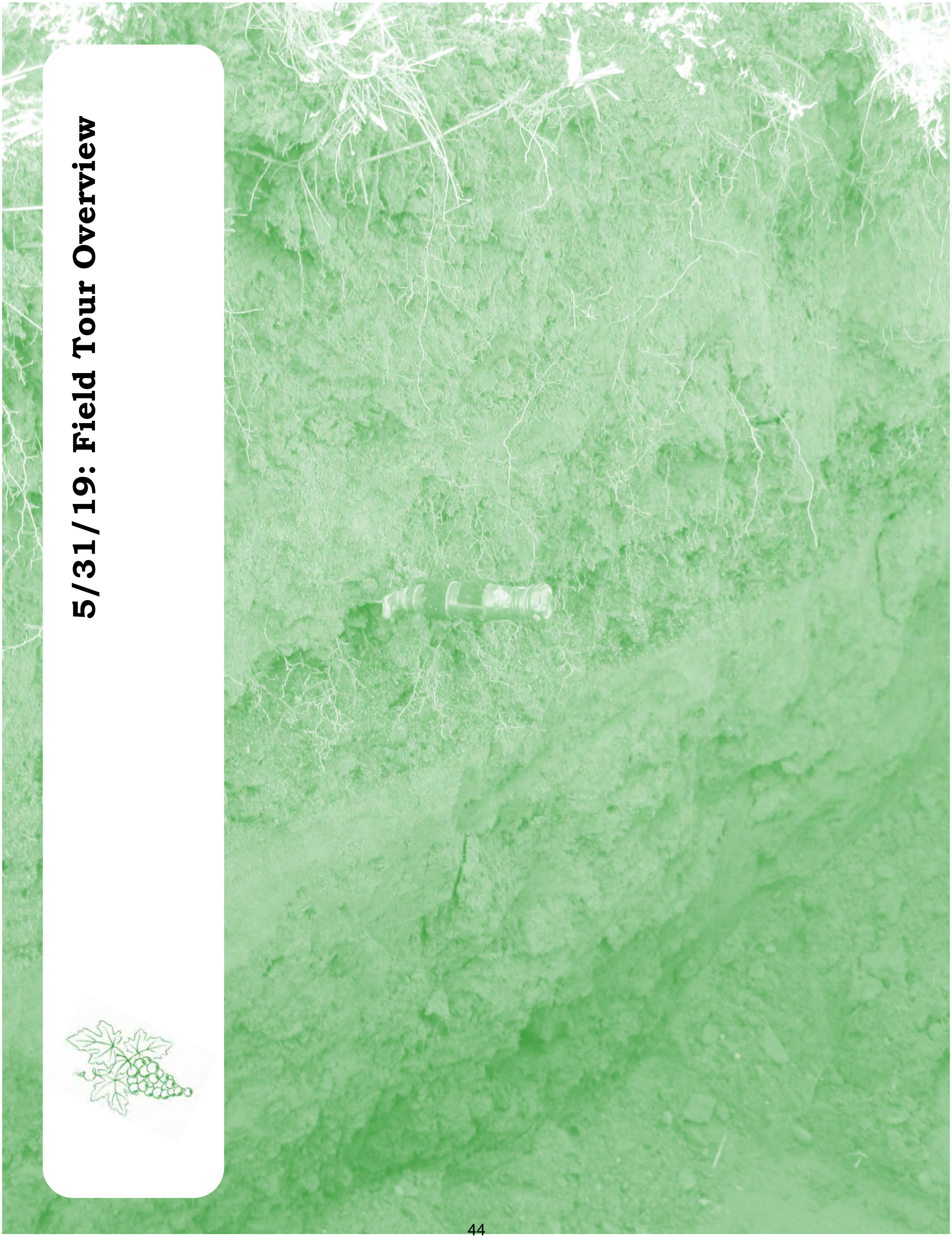
5/31/19: Field Tour Overview



5/31/19: Field Tour Overview



2019 PSSAC Field Tour Itinerary

7:30-7:45 am: Bus arrives at DoubleTree, 3600 Broadway, American Canyon.

8:00 am: Leave DoubleTree hotel.

8:30 am: Arrive at Mare Island (**Stop 1**). G Street and Walnut Ave., Vallejo (on Mare Island). Continue to Dump Road. [8:30-8:50]

9:15 am: Arrive at American Canyon wetlands park (near intersection of Eucalyptus Drive and Wetlands Edge Road, American Canyon) (**Stop 2**). [9:15 to 10:15]

10:15 am: Travel to Domaine Chandon (1 California Drive, Yountville) (**Stop 3**). [10:45 to 12:00]

12:00 pm: Travel to Veterans Memorial Park site #5 (Washington Street & Champagne Drive) for lunch.

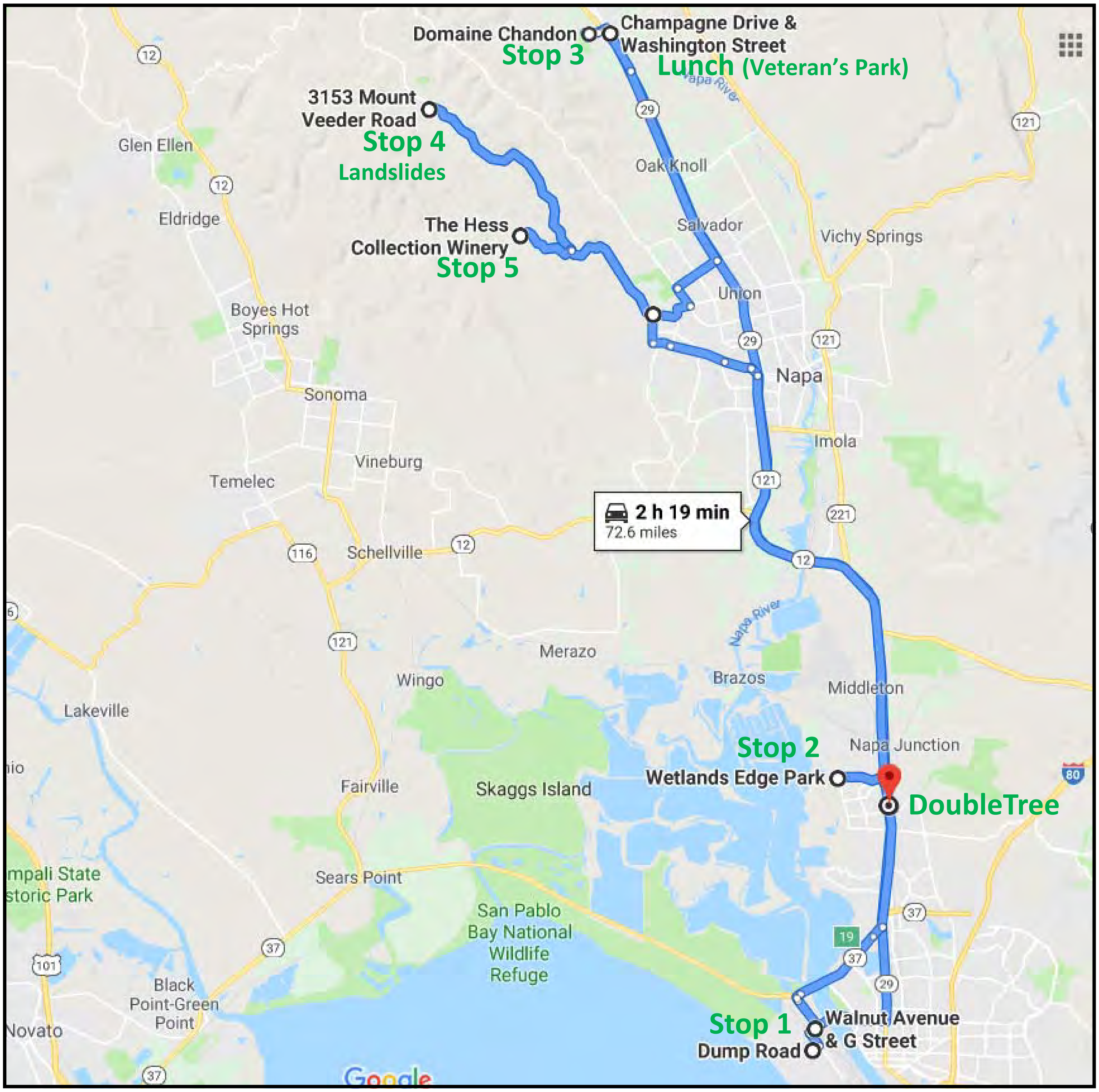
1:00 pm: Leave Veterans Memorial Park and travel to Landslide Area, near 3153 Mt. Veeder Road, Napa.

1:30 pm: Arrive at Landslide area (near 3153 Mt. Veeder Road, Napa) (**Stop 4**). [1:30 to 2:15]

2:15 pm: Leave Stop 4 and travel to Hess Collection Winery, 411 Redwood Road, Napa) (**Stop 5**). [2:30 to 4:30]

4:30 pm: Leave Stop 5 and return to DoubleTree hotel.

5:00 pm: Arrive DoubleTree, unload passengers and gear from bus.



maps.google.com

Driving Directions to Tour Stops

Need directions/help? Call Joel Butterworth, mobile 707-299-8809.

From DoubleTree Hotel & Spa (3600 Broadway, American Canyon) to Stop #1 (Mare Island)

(Leave hotel at 8:00 am.)

Turn right (north) out of parking lot onto Hwy. 29 (aka Sonoma Blvd., aka Broadway) and make a U-turn at Poco Wy. Proceed south on Hwy. 29 into Vallejo. Turn right onto Tennessee St. and continue on Tennessee St. to cross causeway to Mare Island. (Tennessee St. turns into G St.) Park in front of large white building (Building 571) at northeast corner of the intersection of Walnut Ave. and G St. **(Address: 571 G St., Vallejo)** (Bus will then proceed west on G St., then turn left on Azar Dr., then turn right on Dump Rd./A St. (look for blue sign: San Pablo Bay Trail), then continue on gravel road to the parking area.)

From Stop #1 (Mare Island) to Stop #2 (American Canyon Wetlands)

From corner of Walnut Ave. and G St., follow bus to take in the dry docks, etc. on east side of the island along Nimitz Ave.) (route to Nimitz Ave. TBD). From Nimitz Ave., the bus will then turn left on G St., then turn right on Railroad Ave. (Railroad Ave. turns into Main Gate.) Then take onramp for Hwy. 37/Sears Point Rd. eastbound. Turn left (north) on Hwy. 29 and proceed to American Canyon. Turn left (west) onto Rio Del Mar then take immediate right turn onto Eucalyptus Dr. Continue to end of Eucaplyptus Dr. and park in (or in vicinity of) the parking lot (see “Napa River and Bay Trail” sign) on the left, located just past Wetlands Edge Rd. **(Address: “Wetlands Edge Park” near 572 Wetlands Edge Rd., American Canyon)**

From Stop #2 (American Canyon Wetlands) to Stop #3 (Domaine Chandon Winery, Yountville)

Proceed east on Eucalpytus Dr. to Rio Del Mar. Turn left on Rio Del Mar and turn left (north) onto Hwy. 29. Proceed on Hwy. 29 to Yountville. Once in Yountville, take the California Dr. exit. Turn left (west) onto California Dr. Go under Hwy. 29 and take first right after the railroad tracks into winery entrance. Look for and meet at “Domaine Chandon” arch.) **(Address: 1 California Dr., Yountville)**

From Stop #3 (Domaine Chandon Winery, Yountville) to Lunch Stop (Veterans Memorial Park, Yountville)

Leave the Winery grounds and turn left onto California Dr. Go under Hwy. 29 and turn right (south) on Washington St. Proceed to near intersection of Washington St. and Champagne Dr. Park along street or in gravel area on west side of Washington St., just beyond south end of Veterans Memorial Park. **(Address: Intersection of Washington St. and Champagne Dr., Yountville)**

From Lunch Stop (Yountville Community Park) to Stop #4 (Landslide Area)

Proceed north on Washington St. Turn left on California Dr. and go under Hwy. 29. Take onramp for Hwy. 29 – south. Proceed on Hwy. 29 into Napa and take the Redwood Rd. exit. Turn right (west) on Redwood Rd. and continue roughly 9 miles to driveway "split" in the road near 3153 Mt. Veeder Rd. (Look for mailbox number.) **(Address: near 3153 Mt. Veeder Road, Napa)**

From Stop #4 (Landslide Area) to Stop #5 (Hess Collection Winery)

Proceed east on Mt. Veeder Rd. toward Napa for roughly 5 miles, then turn hard right on Redwood Rd. Continue roughly 1.3 miles to entrance to Hess Collection winery, on left. Park in lower parking lot. **(Address: 4411 Redwood Road, Napa)**

From Stop #5 (Hess Collection Winery) to return to DoubleTree Hotel and Spa

Turn right (east) out of the parking lot onto Redwood Rd. toward Napa. Turn right (south) at "T" intersection with Mt. Veeder Rd. to continue on Redwood Rd. toward Napa. Continue on Redwood Rd. to Hwy. 29. Turn right (south) on Hwy. 29 and continue to American Canyon. At Donaldson Way, make a U-turn to get on the northbound lane of Hwy. 29. Proceed 500 feet to turn right into hotel. **(Address: 3600 Broadway, American Canyon)**

CHAPTER 1
GEOLOGICAL RESOURCES

UPDATE CHRONOLOGY

NOVEMBER 30, 2005—VERSION 1

LANDSLIDING AND HUMMOCKY TERRAIN IN A NAPA VALLEY GRASSLAND

PURPOSE

The purpose of this chapter is to provide a current summary of baseline geologic features and related hazards in Napa County and to provide a current map inventory of these features. This document and the data assembled provide broad tools for site and regional planning as well as the basis for future planning documents relating to the protection and management of geological resources.

TABLE OF CONTENTS

TABLES

MAPS

LIST OF ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
Bay Area	San Francisco Bay Area
BDR	Baseline Data Report
BMPs	Best management practices
Caltrans	California Department of Transportation
CBC	California Building Code
CDF	California Department of Forestry
County	Napa County
CWA	Federal Clean Water Act
DSA	California Division of State Architect
DSOD	California Division of Safety of Dams
EFZs	Earthquake Fault Zones
EIR	Environmental impact report
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FERs	Fault Evaluation Reports
g	The force an earthquake applies to a structure is expressed in terms of a percentage of gravity
General Permit	General Permit for Storm Water Discharges Associated with Construction Activity
GIS	Geographic information systems
Ka	Thousand years ago
m	Meters
Ma	Million years ago
NPDES	National Pollutant Discharge Elimination System
NRCA	National Resources Conservation Agency
NRCS	Natural Resources Conservation Service
NTMPs	Non-Industrial Timberland Management Plans
PGADBE	Design-Basis Earthquake Ground-Motion
PGAs	Peak ground accelerations
PGAUBE	Upper-Bound Earthquake Ground Motion
Program	Seismic Hazard Mapping Program
SMARA	Surface Mining and Reclamation Act
SSURGO	Soil Survey Geographic
SWPPP	Stormwater pollution prevention plan
THP	Timber Harvesting Plan
UBC	Uniform Building Code
USGS	U.S. Geological Survey
Valley	Napa Valley

Napa County subregions for geologic analysis

INTRODUCTION

This chapter provides a discussion of the geologic features and hazards known in the three subregions into which Napa County (County) has been divided for geologic evaluation (Map 1-1; all maps appear at the end of the chapter). The chapter provides a baseline discussion of federal, state, and local policies and regulations that involve geologic hazards and Earth resources in the County. This chapter includes a description of the methodology used to identify and quantify the geologic hazards and Earth resources present in the evaluation areas. This chapter provides a countywide overview of several geologic topics, including regional geologic history, physiography, principal bedrock units, unconsolidated deposits, soils, and geologic structure. In addition, the chapter provides a discussion of geologic processes that influence the existing geology, geologic hazards and physiography of the County.

PURPOSE

The purpose of this chapter is to provide a comprehensive and current review of baseline geologic features and related hazards within the County and to provide a current map inventory of these features. In addition to the geographic information systems (GIS) maps included within this chapter, other geologic information, including non-digital maps, are listed in the references.

This information has been assembled to assist the land use planning, permitting, and environmental compliance process. Much of the information included or referenced in this geologic section should be suitable for General Plan update and for preparation of a Programmatic environmental impact report (EIR). For technically correct inclusion of this information in either of these documents, the assistance of a qualified geologist and/or engineering geologist is necessary.

LIMITATIONS AND USE

The *Napa County Baseline Data Report* (BDR) can be used to indicate the level of detail required for on-site geologic evaluations. The referenced GIS-based and hard copy maps are suitable for use in planning, preliminary environmental assessments, and assessing the need for more detailed investigation. Additional application of this information includes using the maps early in the planning process to (1) learn of the bedrock/surficial geologic conditions and (2) develop an initial indication of the degree of hazard and impact of a particular project. Maps are useful indicators; however, they are not a substitute for detailed site-specific investigations that are required for earthquake fault identification, landslide investigations, and the development of design-level geotechnical recommendations.

Although not generally anticipated, these maps may also in some instances incorrectly predict hazards. For instance, a particular landform interpreted to be a hazard (such as a landslide) and indicated as such on a landslide map may, in fact, not be of landslide origin. This possibility exists because many of the maps, especially the landslide maps, are partially or largely prepared using aerial photographs. While aerial photo geology is powerful, effective and time efficient, it is also interpretive, and its accuracy largely depends on the experience and skill of the geologist. This fact underscores the need to perform site-specific geologic work to confirm the existence of features shown in the maps and to better characterize them once their presence has been confirmed.

Some maps were prepared at a scale of 1:24,000 and others at 1:62,500 or smaller. Electronically enlarging a map beyond its original scale of preparation does not provide additional detail or better information and can be misleading. Each geologic hazard section contains a table that indicates the sources that were used in preparation of this chapter—each geologic hazard discussion is dependent on the scale of detail referenced in its preparation.

POLICY CONSIDERATIONS

This section provides a general discussion of the federal, state, and local policies that apply to geologic hazards and Earth resources in the County and are known to require significant geological and geotechnical input.

FEDERAL POLICIES

SECTION 402 OF THE CLEAN WATER ACT/NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

The federal Clean Water Act (CWA) is discussed in detail in Chapters 15, 16, and 17. Because CWA Section 402 is directly relevant to earthwork, additional information is provided here.

Amendments to the CWA in 1987 added Section 402[p], which establishes a framework for regulating municipal and industrial storm water discharges under the National Pollutant Discharge Elimination System (NPDES) program. The U.S. Environmental Protection Agency (EPA) has delegated to the State Water Resources Control Board the authority for the NPDES program in California, where it is implemented by the state's nine Regional Water Quality Control Boards. Under the NPDES Phase II Rule, any construction activity disturbing 1 acre or more must obtain coverage under the state's General Permit for Storm Water Discharges Associated with Construction Activity (General Permit). General Permit applicants are required to prepare a Notice of Intent stating that stormwater will be discharged from a construction site, and a stormwater pollution prevention plan (SWPPP) that describes the best management practices (BMPs) that will be implemented to avoid adverse effects on receiving water quality as a result of construction activities, including earthwork.

STATE POLICIES

ALQUIST-PRIOLO EARTHQUAKE FAULT ZONING ACT

The Alquist-Priolo Earthquake Fault Zoning Act was signed into law on December 22, 1972, and went into effect March 7, 1973. The act, codified in the Public Resources Code as Division 2, Chapter 7.5, has been amended eleven times. The law was initially designated the Alquist-Priolo Geologic Hazard Zones Act. The act was renamed the Alquist-Priolo Special Studies Zones Act effective May 4, 1975, and the Alquist-Priolo Earthquake Fault Zoning Act effective January 1, 1994. The original designation *Special Studies Zones* was changed to *Earthquake Fault Zones* when the act was last renamed. The purpose of the act is to prohibit the location of most structures for human occupancy across the traces of active faults and thereby to mitigate the hazard of fault rupture (Section 2621.5).

Under the act, the State Geologist (Chief of the Division of Mines and Geology, now the California Geological Survey) is required to delineate Earthquake Fault Zones (EFZs) along known active faults in California. Cities and counties affected by the zones must regulate certain development projects within the zones. They must withhold development permits for sites within the zones until geologic investigations demonstrate that the sites are not threatened by surface displacement from future faulting. The State Mining and Geology Board provides additional regulations (their "Policies and Criteria") to guide cities and counties in their implementation of the law (California Code of Regulations, Title 14, Div. 2).

Requirements of the act, including procedures for zoning and updating geologic and seismic data for the Fault Evaluation Reports (FERs), are described in Special Publication 42, *Fault-Rupture Hazard Zones in California, Alquist-Priolo Earthquake Fault Zoning Act with index to Earthquake Fault Zones Maps* (Hart and Bryant 1997). FERs and Alquist-Priolo Maps are produced by the California Department of Conservation, California Geological Survey. Digital images of the maps and FERs are available on CD-ROM (CD 2000-004, 2000 for map images; CD 2002-01, 2002 for FERs) (California Department of Conservation, California Geological Survey 2000, 2002). The Alquist-Priolo Earthquake Fault Zoning Act establishes regulatory zones that average 0.25 mile on either side of the active fault; the Alquist-Priolo Maps for earthquake fault zones are updated as zones are revised based on earthquake-trenching investigations that reveal new evidence of earthquakes.

The law's intent is to protect the public from the hazard of surface fault rupture. The application approval process for building permits requires that Alquist-Priolo Maps be consulted and responded to as necessary before permits are issued. However, the act has several exceptions; building within an Alquist-Priolo zone is allowable for certain types of structures/dwellings, and setbacks (distances from an active, Alquist-Priolo zoned earthquake trace) may be used in order to allow building within an established Alquist-Priolo zone.

1997 UNIFORM BUILDING CODE AND 2001 CALIFORNIA BUILDING CODE

The Uniform Building Code (UBC) was first enacted in 1927 and has been revised approximately every three years since then. The function of the UBC is to promote and ensure the development of improved building construction and greater safety to the public by uniformity in building laws.

The UBC is founded on broad-based principles that make possible the use of new materials and new construction systems. It is designed to be compatible with related publications to provide a complete set of documents for regulatory use.

The UBC recognizes that nearly all of western California is seismically active, and that within this broad region there are areas underlain by deeper unconsolidated deposits that are subject to higher amplitude, longer duration shaking motions. Thus, while these shaking impacts are potentially more damaging, implementation of UBC criteria tend to reduce their effects.

From the standpoint of earthworks construction and seismic criteria, the UBC and the California Building Code (CBC) are nearly identical.

SEISMIC HAZARDS MAPPING ACT

The Seismic Hazards Mapping Act of 1990 (Public Resources Code, Chapter 7.8, Section 2690-2699.6) directs the Department of Conservation, California Geological Survey to identify and map areas prone to earthquake hazards of liquefaction, earthquake-induced landslides, and amplified ground shaking. The purpose of the act is to reduce the threat to public safety and to minimize the loss of life and property by identifying and mitigating these seismic hazards. The act was passed by the state Legislature following the 1989 Loma Prieta earthquake. This pertains to seismic hazards other than the fault surface rupture hazard regulated by the Alquist-Priolo Earthquake Fault Zoning Act of 1972.

The maps produced per the Seismic Hazards Mapping Act are the *Seismic Hazard Zone Maps*, prepared by California Geological Survey geologists in the Seismic Hazard Mapping Program (Program). The program will ultimately map all of California's principal urban and major growth areas. Each map covers an area of approximately 60 square miles and uses a scale of 1 inch = 2,000 feet (1:24,000 scale).

The Seismic Hazard Zone maps include designated "Zones of Required Investigation" for areas prone to liquefaction and earthquake-induced landslides. Once a map becomes available for a certain area, cities and counties within that area are required to withhold development permits for projects proposed within a Zone of Required Investigation until geologic and soil conditions are investigated and appropriate mitigations, if any, are incorporated into development plans.

A Certified Engineering Geologist, Geotechnical Engineer, or Registered Civil Engineer with competence in the field of seismic hazard evaluation is required to prepare, review, and approve the

> The State of California has enacted measures to protect the public from earthquake-related hazards. The Alquist-Priolo Act prohibits the location of most structures for human occupancy across the traces of active faults. The Seismic Hazards Mapping Act identifies seismic hazards to improve public safety and minimize the potential loss of life and property.

The unique combination of topography, soils, and climate in Napa County create the physical setting to produce the premium wine grapes for which the County is famous.

geotechnical report. A copy of each approved geotechnical report, including the mitigation measures, is required to be submitted to the Program within 30 days of approval of the report. The act requires peer review; the reviewer may be either local agency staff or a retained consultant. The Department of Conservation does not have authority to approve or disapprove these geotechnical reports; rather, the data is used to monitor the effectiveness of the Program and is used for future updates. Further, cities and counties must incorporate the Seismic Hazard Zone Maps into their Safety Elements. Both the act and the Natural Hazard Disclosure Statement also require sellers of real property to disclose to buyers if property is in a Seismic Hazard Zone of Required Investigation.

Maps under development are distributed as *Preliminary* and *Official* versions. The Preliminary version is released for a 90-day public comment period for technical review and comment. Once the public review period has ended, the Department of Conservation has 90 days to revise the maps and to issue the Official versions to affected cities, counties and state agencies.

As of early 2005, Seismic Hazard Zone Maps have been prepared for portions of Southern California and the San Francisco Bay Area (Bay Area). The intent is to first prepare the maps for areas that are undergoing the most rapid urbanization and which have recognized hazards. However, the maps have yet to be prepared for any part of the County. When the maps are prepared and acquired by the County and other lead agencies, e.g., cities, it will then be necessary for those agencies to respond to the provisions of the act. Further information on the act can be obtained from Special Publication 117, *Guidelines for Evaluating and Mitigating Seismic Hazards in California* (California Geological Survey 1997).

California Water Code-Division 3, Dams and Reservoirs

Since 1929, the State of California has supervised dams to prevent failure in order to safeguard life and protect property. The legislation resulted from the failure of St Francis Dam in March of 1928. Legislation enacted in 1965, as a result of the failure of Baldwin Reservoir in 1963, revised the statutes to include off stream storage. This legislation is regulated by the California Department of Water Resources, Division of Safety of Dams. Two classifications of dam types are covered: (1) dam structures that are or will be in the future 25 feet or more in height from the natural bed of the stream or water course at the downstream toe of the barrier and (2) dams that have an impounding capacity of 50 acre feet or more (California Department of Water Resources 2004).

Implementing the legislation involves use of geology and geotechnical engineering over the entirety of the dam's useful life for site selection, dam design and construction, and on-going inspection of the impounding structures.

Surface Mining and Reclamation Act

The Surface Mining and Reclamation Act (SMARA) was signed into law in 1975, went into effect in 1976, and has been amended 24 times since its effective date. The intent of the act is to (1) assure reclamation of mined lands, (2) encourage production and conservation of minerals, and (3) create and maintain surface mining and reclamation policy (regulations).

SMARA applies to anyone, including government agencies. There are a number of exceptions to the act, among them those related to agriculture, flood control, small mines (less than 1000 cubic yards or no more than 1 acre), and emergency work. SMARA is administered by lead agencies (most often counties or cities) and the California Department of Conservation.

Timber Harvesting Plan Projects

The Timber Harvesting Plan (THP) Projects provide engineering geologic review of proposed THPs, Non-Industrial Timberland Management Plans (NTMPs), and other regional-scale land management projects, submitted to the California Department of Forestry (CDF) under the 1973 Z'Berg-Nejedley Forest Practice Act and Rules. It is the intent of the state legislature to create and maintain an effective and comprehensive system of regulation and use of all timberlands in order to assure that (1) where feasible, the productivity of timberlands is restored, enhanced, and maintained; and (2) the goal of maximum sustained production of high-quality timber products is achieved while at the same time values relating to recreation, watershed, wildlife, range and forage, fisheries, regional economic vitality, employment, and aesthetic enjoyment are upheld. Since 1975, the California Geological Survey has provided advisory comments to CDF and the Board of Forestry regarding geologic and slope stability concerns as they pertain to THPs.

The California Geological Survey also provides review and comment to applicants who have had the THPs prepared. This is done because of the potential for accelerated soil erosion and landsliding associated with timber harvesting.

Local Policies

General Plan Policies

Seismic hazards and safety concerns within the County are addressed within the Seismic Safety and Safety Elements of the County's existing General Plan (Napa County 1992). This information directly relates to the geology and seismic section of the BDR because it discusses the existing conditions of seismic hazards in the County, including background information about the following issues.

- Structural geology of the County.
- Fault displacement in the County.
- Ground shaking.
- Ground failure.

- Flood zones from dam failures.
- Tsunamis.

The Seismic Safety Element includes three primary goals (Goal A, Goal B, and Goal C below) and associated policies related to seismic safety.

Goal A: Use existing authority of local governments to reduce hazards to life and property. This goal is supported by 11 policies.

- Evaluation of geologic/seismic hazards for environmental impact reports.
- Requirements for geologic/seismic reports.
- Discouragement of development within 0.125 mile of an active fault, unless a geologic or seismic reports indicate the development is consistent with public safety guidelines.
- Installation of strong-motion accelerographs, where appropriate.
- An inventory of existing structures to improve public safety.
- Restriction of development in areas adjacent to active faults.
- Geologic/seismic report requirements for issuance of building permits.
- Development of a program for on-site inspection of grading work.
- Encouragement of planting of native vegetation on unstable slopes.
- Review of safety standards for risk of earthquake induced dam failure and resulting downstream inundation.
- Rezoning of open space lands subject to extreme geologic hazards and geologically sensitive areas.

Goal B: Promote intergovernmental cooperation directed towards lessening known hazards and defining uncertain hazards. This goal is supported by 13 policies.

- Support for mandatory requirement of earthquake insurance as a condition to loan granting for residential structures.
- Encouragement for the purchase of National Flood Insurance.
- Promotion of inter-government collaboration for technical assistance regarding seismic hazards.
- Assessment of potential hazards from failure of above-ground tanks containing water, wine, or petroleum products.
- Discouragement of development in wetlands and drained wetlands in southern Napa County.
- Application of the 1974 California Urban Geology Master Plan program to the County.
- Development of a geologic mapping program with federal and state agencies.
- Support for development of dam safety programs.
- Encouragement for development of emergency preparedness programs by local governments.
- Implementation of recommendations of the Joint California Legislative Committee on Seismic Safety, 1972.
- Revision of the County Zoning Ordinance to identify a combined geologic hazard zone.
- Potential requirement for dynamic analysis of designs for proposed buildings.
- Support for research and development of seismic protection standards for inclusion in the County Building Code.

Goal C: Participate in public education programs. This goal is supported by two policies.

- Preparation of materials to inform the public of potential seismic hazards in the county.
- Support for first-aid training for emergency/hazard situations in schools.

In addition to the policies stated above, the Safety Element includes the following seven policies to address geologic hazards.

- Consider safety hazards prior to county land use decisions, such as General Plan amendments, rezoning, or project approvals.
- Restrict extensive grading on slopes over 15% where landslides or other geologic hazards are present.
- Assure that future residential lots on hillsides are large enough to provide a stable buildable site and driveway.
- Restrict construction of roads on or adjacent to landslides, hills, or areas subject to liquefaction, subsidence, or settlement.

Napa County's relative location within the Coast Ranges north of San Francisco Bay.

Physiography of the Napa Valley subregion.

- Encourage the Building Inspection Division to analyze slope failure records and improve the county grading ordinance.
- Discourage urban development in reclaimed wetlands.
- Where necessary, rezone lands subject to extreme geologic hazards and geologically sensitive areas into a combined geologic hazard zone.

It is anticipated that the County will update and revise the Seismic Safety and Safety Elements of the General Plan in 2005. The baseline information contained in this BDR should be useful for the following purposes.

- Bringing geologic/seismic data up to date with current data.
- Providing a comprehensive geologic overview of the County.
- Providing more detail on the existing baseline information relating to seismic hazards.

In addition to General Plan policies, the County has incorporated a number of ordinances into the Napa County Municipal Code that relate to geologic resources and seismic safety. It is not anticipated that the BDR would directly affect the existing code or ordinances within the code. However, revisions to the General Plan may in turn require revisions to the Napa County Municipal Code. The following specific sections of the code relate to geologic resources and seismic safety: 13.16.390, 13.28, 15.08.050, 16.12, 17.08, 17.14, 17.42, 18.04, 18.88, 18.180.027(F), 18.108.060, 18.108.080, 18.108.140, 18.117.040.

METHODOLOGY

DEFINITION OF STUDY AREA

The study area is all of Napa County. For the purposes of this chapter on geological resources, the study area was divided into three subregions: the Napa Valley (including the Napa River Watershed), the interior valleys, and the Berryessa/Knoxville area. Following each countywide overview, details unique to each of the three subregions are described.

TECHNICAL APPROACH

The preparation of this chapter included the review of numerous GIS-based and hard-copy geologic maps and documents collected from numerous sources (see *References* section below). The purpose of this data collection was to identify the most current, comprehensive geologic information for inclusion in the BDR.

PHYSIOGRAPHY

PHYSIOGRAPHY OF NAPA COUNTY

Eleven distinct and diverse geomorphic provinces are recognized in California. Each of these provinces displays unique, defining features based on geology, faults, topographic relief, and climate. The County is located in the Coast Ranges Geomorphic Province. This province is bounded on the west by the Pacific Ocean and on the east by the Great Valley geomorphic province. The Coast Ranges Province extends several hundred miles northward from southern California to near the Oregon border.

A conspicuous characteristic of this province, including Napa County, is the general northwest-southeast orientation of physiographic features such as valleys and ridgelines. In the County, located in the eastern, central section of the province, this trend consists of a series of long, linear, major and lesser valleys, separated by steep, rugged ridge and hill systems of moderate relief that have been deeply incised by their drainage systems (Map 1-2).

The County's highest topographic feature is Mount St. Helena, which is located in the northwest corner of the County and whose peak elevation is 4,343 feet. Principal ridgelines have maximum elevations that roughly vary between 1,800 and 2,500 feet. These elevations decrease in the southern part of the County. This physiography has influenced the local climate (creating several microclimates), the development of soils, and the existence and location of geologic hazards such as landsliding. The combination of physiography, soils, and climate has helped give rise to the production of premium wine grapes and other agricultural products for which the County is famous.

The physiography of the County is strongly influenced by its bedrock geology, geologic structure, and the mountain building and erosion processes operative during the Quaternary (the last two million years). These topics are described in subsequent sections. Maps for Napa County's physiography and slope conditions are shown in Maps 1-2 and 1-3.

Napa Valley is the main valley in the County. It extends southeast along the west side of the County to near the edge of San Pablo Bay. Valley floor elevations are up to approximately 400 feet near the north end of the valley and approach sea level on the south. Along the east central part of the County is a similar but smaller valley occupied by Lake Berryessa Reservoir (formerly Berryessa Valley). Between these two principal valleys are a series of lesser valleys including Pope Valley in the north, a somewhat smaller Chiles Valley slightly further south, and much smaller valleys, such as Capell and Wooden Valleys in the southern parts of the County. Elevations of these interior valleys vary between approximately 700 and 900 feet. In the west and east, the County line coincides with the crest of major northwest-trending ridge systems that border on Sonoma and Yolo Counties, respectively. The County is also bounded by Lake County to the north and Solano County to the south.

PHYSIOGRAPHY OF COUNTY SUBREGIONS

NAPA VALLEY SUBREGION

The Napa Valley subregion comprises the Napa Valley and flanking continuous ridge systems. The Napa Valley (Valley) is the principal valley in the County. The Valley is relatively narrow and northwest-southeast trending. The northwest-southeast trend is typical of most of the intermontane valleys and ridge systems of the Coast Range Geomorphic Province.

The Valley is about 31 miles long, commencing about 2.5 miles north of Calistoga and extending southeastward to its mouth about 3 miles south of the City of Napa, where it meets the extensive marshlands that surround the north half of San Pablo Bay. The Valley is up to 3.5 miles wide in its southern half, and narrows to between 0.8 and 1.2 miles along the north half. The valley floor elevations are up to approximately 400 feet near the north end of the valley and approach sea level on the south.

The Napa Valley contains the Napa River, which is the principal drainage course in the County. It has numerous tributary streams that drain its flanking ridge systems. Some of these contain reservoirs, such as Rector Reservoir and Lake Hennessey. The Napa River empties into San Pablo beyond a few miles south of this subregion.

The flanking ridge systems comprise the rest of this subregion. They have higher elevations on the northwest, which decrease to the southeast toward the mouth of the Valley and adjacent marshlands. The physiography of the ridge systems has been influenced by the geology of recent (Miocene-Pliocene) tectonism and volcanism (with associated ash and flow rocks from the Sonoma Volcanics). Along the west ridge system, the principal peaks are Mt. Veeder (2,677 feet) and Mt. St. John (2,375 feet); and along the east, the principal peaks are Table Rock (2,462 feet), the Palisades (up to 2,574 feet), and Atlas Peak (2,663 feet).

The Napa Valley is one of several fault-formed basins of the northern California Coast Ranges. The bordering ridge systems are the result of recent, ongoing tectonism (mountain building) as described elsewhere in this chapter. The combination of mountain building and regionally high erosion rates has resulted in ongoing shedding from the ridge side slopes of sediment that has accumulated in the Napa Valley, forming thick deposits of sand gravel and volcanic debris. In the vicinity of the City of Napa, these deposits may be several thousand feet thick (U.S. Geological Survey 2003). Although previously it was thought that these unconsolidated valley deposits generally thinned toward the north in the valley, it is now believed that there are local pockets of very deep deposits. For example, in the Calistoga area (based on geothermal exploratory drilling) valley-filling deposits are at least 1800 feet deep near downtown Calistoga (Taylor 1981, Enderlin 1993). This deep asymmetric accumulation of valley-filling material is attributed to subsidence along an inferred growth fault system, which bounds the western margin of the upper Napa Valley. Similar downwarping along growth fault(s)is observed in the Clear Lake structural basin. Such local deeper areas of unconsolidated deposits may have important consequences in terms of seismic design criteria in the upper valley.

There are also a few, much smaller valleys within this subregion. These include the northwest-trending Carneros Valley (elevation about 150 feet) on the west and on the east, the upland valley that contains Angwin (elevation about 200 feet), and Foss Valley (elevation about 1,400 feet).

To the south, beyond the mouth of the Napa Valley and the north edge of San Pablo Bay, is the large, flat area of marsh and inter-tidal deposits through which the Napa River meanders to its mouth at San Pablo Bay.

INTERIOR VALLEYS SUBREGION

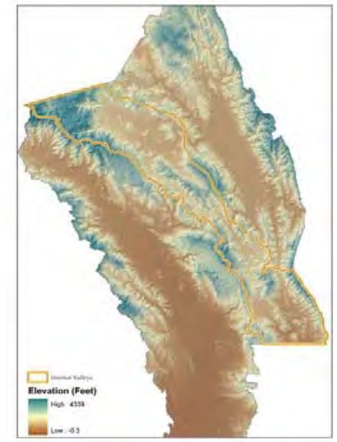
The physiography of the interior valleys subregion is distinctly different from that of the Napa Valley subregion. Unlike the Napa Valley subregion, which has a single, long, well-developed valley with extensive marshlands at its mouth, the interior valleys subregion consists of a series of much shorter valleys that vary considerably in their general outline. From north to south, the principal named valleys of the interior are Pope, Chiles, Capell, Foss, Gordon, and Wooden Valleys.

The largest and most irregular in outline is the northwest-trending Pope Valley, which is approximately 10 miles long and up to about 2.5 miles wide. It is roughly bisected by a linear, discontinuous series of hills with a maximum elevation of 1,200 feet. With the exception of occasional peaks, peripheral ridgelines to the east and west are up to 1,600 and 1,900 feet in elevation, respectively. The valley floor elevation is about 700 feet. The principal stream of the valley is Pope Creek, which drains southeast through a narrow canyon into Lake Berryessa.

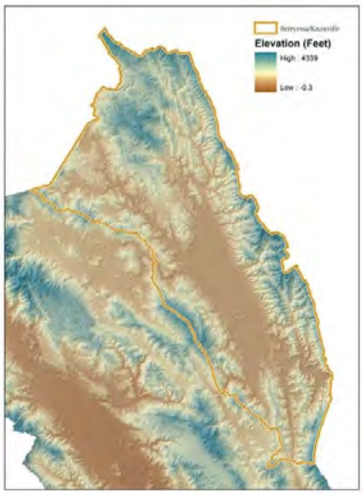
The next valley to the south is Chiles Valley. The form of this valley is distinctly different from Pope Valley. It is long and narrow, with a consistent northwest trend. The valley length is about 8 miles and has a width between 1,000 and 3,000 feet. Peripheral ridgelines have elevations between 1,600 and 2,000 feet and 1,500 and 1,700 feet, respectively. The valley floor elevation is about 800 feet.

The remaining above-named valleys are to the south of Pope and Chiles Valleys. They are much smaller, generally northwest trending, about 2 to 3 miles long, and between about 0.5 and 1 mile in width. Valley floor elevations are between 400 and 600 feet. Peripheral ridge elevations to either side of these smaller valleys range from as high as 2,500 feet opposite Foss Valley to as low as 800 feet (Wooden Valley). Generally, ridge top and valley floor elevations decrease toward the southern part of the County.

Details on the geomorphic evolution of this subregion are not known. However, the strong northwest trend of the ridges and major valleys of this subregion has developed in response to geologically recent transpressive tectonic forces generated by the San Andreas fault system. These forces are responsible for the development of folds and numerous faults of the same orientation, as well as the regional, tectonic uplift (mountain building) that is occurring. The direction of major streams of this subregion has preferentially controlled this structural grain, which is common to the all of the California Coast Ranges. As a result, the principal streams and valleys have this same general northwest trend. The tectonic uplift and rainfall have combined to produce deeply incised side drainages, and high erosion rates, which generate the sediment that has partially filled the valleys of this subregion.



Physiography of the interior valley subregion.



Physiography of the Berryessa/Knoxville subregion.

BERRYESSA/KNOXVILLE AREA SUBREGION

The principal physiographic feature of the Berryessa/Knoxville area subregion is the former Berryessa Valley now occupied by Lake Berryessa. This valley is about 12 miles long and about 3 miles wide. The principal drainage is Putah Creek, which enters the reservoir from the northwest. The elevation of the valley floor is not known, but the spillway elevation of the reservoir is about 440 feet. No other valleys of any significance are known within this subregion.

The northwest and southeast areas of this subregion are occupied by generally northwest-trending ridge systems with intervening, deeply incised stream canyons. Maximum ridgeline elevations are mostly less than 2,000 feet. Along the upper reaches of Putah Creek, an area, covering approximately 3 miles in width by 5 miles in length, projects southeast into this subregion from Lake County. This area has lower elevations (maximum ridge tops of about 1,100 feet), less deeply incised streams, and broader appearing ridge tops. This area is part of a more extensive area of this type that extends well into Lake County. The presence of pervasively sheared, erodible serpentinite bedrock capped by younger volcanic flows and possibly faulting appears to have controlled the development of this noticeably more subdued terrain.

The easternmost part of this subregion is occupied by the Vaca Mountains, whose ridgeline is the County line. The ridgeline of these mountains is uniformly higher in elevation than ridges west of the reservoir and the range has a pronounced and uniform northwest trend. This is due to the presence of structurally less deformed and uniformly eastward dipping sedimentary rock of the Great Valley Sequence. Maximum ridgeline elevations are typically about 2,500 feet to 3,000 feet.

The geomorphic evolution of this subregion includes the effects of San Andreas transpression and climate as described above for the interior Valleys. It is also is due to the presence of bedrock types and geologic structures. Large masses of fracture/sheared, erodible serpentinite are present in the north part of this subregion and structurally more uniform, often less erodible sedimentary rocks of the Great Valley Sequence occupy much of the region including the topographically prominent Vaca Mountains.

BEDROCK FORMATIONS AND GEOLOGIC STRUCTURE

Much of the information in the following sections on bedrock geology and structure is technical and has been excerpted with some modification from the recent geologic work in the County by Graymer et al. 2002 and 2005 (in press). Additional published sources on County geology are referenced.

EVOLUTION OF THE NORTHERN CALIFORNIA COAST RANGES

As discussed above in the *Physiography* section, the County is located in the northern part of the Coast Range Geomorphic Province. A conspicuous characteristic of this province is the northwest orientation of the landscape, which consists of a series of long, northwest-trending ranges separated by river valleys of the same trend. Like many of California's landscape features, the orientation of these ranges and river valleys is controlled by regional tectonics—the deformation and motion of the Earth's crust, e.g., faulting, mountain building. Landscape controlled by such processes is often referred to as *structurally controlled topography* (Hardin 2004). Even a brief glance at the regional terrain of the County reveals the pronounced northwest orientation of the main valleys and intervening ranges.

The forces resulting in the eventual evolution and orientation of this present physiography started about 140 million years ago (Mesozoic Era). They involve the geometry and long-term relative motions between the regionally very large Farallon, Pacific, and North American Plates. At this early time, the eastward migrating Farallon Plate and the opposing North American Plate were colliding. The result was the accretion and subduction of oceanic crust along the north-south boundary of these plates.

At about 28 million years ago (mid-late Cenozoic Era) the Pacific Plate, which was trailing the Farallon Plate in its eastward path, made contact with the North American Plate. When this occurred, the earliest stage of a major transform fault resulted at the contact between the plates, which grew in length as the contact migrated both north and south along what is now the California coastline. As this migration continued, subduction and accretion associated with the Farallon Plate progressively ended. This major transform fault is the San Andreas. Over the last 28 million years, subsequent motions (the west side of the fault moving northward relative to the southward-moving east side of the fault) along the San Andreas and related faults to the east have left their regional physiographic imprint on the terrain in the form of the northwest-trending ranges and valleys mentioned above.

FAULTS AND GEOLOGIC STRUCTURES OF NAPA COUNTY

Structural geology refers to the study of the architecture of the Earth's crustal rocks. As such, it pertains to the general disposition, attitude, arrangement or relative positions of bedrock folds, faults and igneous intrusions, and their analysis, including the forces that created them. In the greater San Francisco Bay Area, including Napa County, mapped structures fall into two general age categories: younger and older. The younger structures are north-northwest-trending faults and associated folds generated by the transpressional forces (a combination of compressional and shearing forces) acting along Pacific-North American plate margin. The faults have a predominantly right-lateral strike-slip offset, but also accommodate a component of compression at a ninety-degree angle to the faults, as shown by the uplift of fault-parallel ridges and formation of fault-parallel folds (Jones et al. 1994). These younger structures probably initiated with the establishment of the transpressional plate margin in the region in the wake of the northward migration of the Mendocino Triple Junction, which passed through the San Francisco Bay region between about 12 and 4 million years ago (Ma). These younger structures therefore cut and deform late Miocene and somewhat younger rocks.

Important among these younger structures in the North Bay Area are the Quaternary-active, including Holocene-active (within the last 11,000 years), faults of the San Andreas fault system, including the Maacama, Healdsburg, and Rodgers Creek faults. In the County, the Holocene-active faults include the West Napa fault, the northernmost few miles of the Green Valley (historically active) and Cordelia faults and the Hunting Creek fault. On the Graymer map faults are shown in magenta (Holocene-active, as defined by Hart and Bryant 1999) and orange (Quaternary-active). A Holocene-active fault (fault movement has occurred in the last 11,000 years) must be investigated if structures for human habitation are to be built in its close proximity. A Quaternary-active fault has not experienced such geologically recent movement and for this reason does not require investigation but should be considered during development. The details regarding Holocene-active investigation are discussed in the *Policy and Regulatory Considerations* section of this chapter.

The mountainous topography west of Napa Valley has resulted from the latest Pliocene and Quaternary uplift associated with the geologic younger structures. This topography was absent in earlier Pliocene, but since latest Pliocene at least 650 meters (m) of uplift has apparently occurred. This rate of uplift exemplifies that tectonics and associated mountain building are active in the County.

The structures in the mountains east of Napa Valley are more complex. Mesozoic rocks in this area have undergone much compressional deformation, resulting in imbricate faulting and overturned folds. Some of these structures have evidence of Pliocene or younger activity, whereas others are mapped as overlapped by young (<4 Ma) parts of the Sonoma and Clear Lake Volcanics. Swinchett and Howell (2004) have hypothesized that uplift of the mountains east of Napa Valley was caused by Neogene thrusting on these structures that has continued into the Quaternary, and has generated massive landslides. This hypothesis, however, is not universally accepted and is under scientific debate. However, normal faults also cut the Sonoma Volcanics and Clear Lake in the area, and the regional gravity expression (Langenhein et al. 2003) suggests that there may be volcanic rock filled basins that could be *grabens* (an elongated bedrock block that has downdropped between two parallel faults relative to rock of the surrounding area).

In the area northeast of Napa Valley, Great Valley Sequence, Coast Range Range ophiolite,and Franciscan Complex rocks are *imbricated* (a series of closely spaced thrust fault sheets dipping in the same direction) along northwest to west-northwest-trending reverse faults. These faults, and associated folds, also involve Franciscan Complex rocks (Phipps 1984). The map area also includes a broad, regional deformation that is manifested as a somewhat disrupted east-dipping homocline (a series of beds of rock that all have a similar orientation, i.e., similar strike and dip) northeast of Lake Berryessa and reverse fault repetition of Great Valley Sequence strata in the eastern part of the map area. These older structures are largely pre-Miocene, as shown by the large angular unconformity at the base of the Putnam Peak Basalt east of the map area (Graymer et al. 2002). However, the more modest deformation of the Pliocene Tehama Formation, also east of the map area (Graymer et al. 2002), as well as the uplift of early to late Pleistocene alluvial deposits in the map area (QTc, Qoa), suggests that deformation on the older structures may have continued into the Quaternary. The young deformation is probably the result of the same compression that is postulated above for the mountains east of Napa Valley. This compression has resulted in ongoing eastward-directed wedging of Franciscan Complex rocks beneath the upturned western margin of the Great Valley.

The structural geology of the County, like all of the Coast Ranges, is complex and continues to evolve due to broadly regional forces acting along the above-described plate boundary. However, the overall picture (generally shown in Map 1-4) is consistent with Pliocene and Quaternary compressional deformation superimposed on earlier extensional deformation. Resolution of further details of the structural history of this region is beyond the scope of this study.

MAJOR BEDROCK GROUPS IN NAPA COUNTY

The rock units associated with the above-described tectonics in the San Francisco Bay region, including those of the County, are made up of two principal components: (1) an older set of rocks composed of amalgamated, highly deformed tectonostratigraphic terrenes that have been displaced (at least in part) via plate tectonics, from hundreds to thousands of kilometers from their position of origin; and (b) a younger, less deformed set of rocks that overlie the accreted terrenes and which are roughly in their original position (except for San Andreas fault system offsets and smaller dislocations described below). Throughout Graymer's maps, the older set of rocks are Mesozoic in age and the younger are Cenozoic (see Geologic Time Scale).

MESOZOIC UNITS

The Mesozoic-aged rocks can be grouped into three related tectono-stratigraphic units, two of which crop out in the mapped area. The three Mesozoic that are generally recognized in the geologic literature are: (1) Franciscan Complex, (2) Coast Range ophiolite, and (3) the Great Valley Sequence (or Group) (see Map 1-4).

The Jurassic-aged Coast Range ophiolite in the map area consists mostly of serpentinite, serpentinite-matrix mélange, gabbro, diabase, basalt, and metasediments. The serpentinite and serpentinite-matrix mélange are generally known for their poor engineering properties and relatively high incidence of landsliding.

The Great Valley Sequence is composed of sandstone, conglomerate, and shale of Jurassic and Cretaceous age. Although the sedimentary rocks and ophiolite have been tectonically separated almost everywhere in the map area, the Great Valley Sequence was originally deposited on top of the ophiolite. This depositional relationship is preserved locally in the Chiles Valley and St. Helena quadrangles. This complex represents the accreted and deformed remnants of arc-related Jurassic oceanic crust with a thick sequence of overlying turbidites, at least in part related to the North American forearc. See the Graymer report and geologic map with accompanying legend for more information on the details and locations of these various units within the County.

Phanerozoic Eon (343 mya to present)	Cenozoic Era (65 mya to today)	Quaternary (1.8 mya to today) Holocene (10,000 years to today) Pleistocene (1.8 mya to 10,000 yrs) Tertiary (65 to 1.8 mya) Pliocene (5.3 to 1.8 mya) Miocene (23.8 to 5.3 mya) Oligocene (33.7 to 23.8 mya) Eocene (54.8 to 33.7 mya) Paleocene (65 to 54.8 mya)
	Mesozoic Era (248 to 65 mya)	Cretaceous (144 to 65 mya) Jurassic (206 to 144 mya) Triassic (248 to 206 mya)
	Paleozoic Era (543 to 248 mya)	Permian (290 to 248 mya) Carboniferous (354 to 290 mya) Pennsylvanian (323 to 290 mya) Mississipian (354 to 323 mya) Devonian (417 to 354 mya) Silurian (443 to 417 mya) Ordovician (490 to 443 mya) Cambrian (543 to 490 mya) Tommotian (530 to 527 mya)
Precambrian Time (4,500 to 543 mya)	Proterozoic Era (2,500 to 543 mya)	Neoproterozoic (900 to 543 mya) Vendian (650 to 543 mya) Mesoproterozoic (1,600 to 900 mya) Paleoproterozoic (2,500 to 1,600 mya)
	Archaean (3,800 to 2,500 mya)	
	Hadean (4,500 to 3,800 mya)	

Geologic Time Scale

The dominant exposures within this subregion are the rocks of the Sonoma Volcanics.

The second set of accreted terrenes makes up the Franciscan Complex, which is composed of weakly to strongly metamorphosed greywacke, argillite, basalt, serpentinite, chert, limestone, and other rocks. The rocks of the Franciscan Complex in the map area are mostly derived from Jurassic to Cretaceous oceanic crust and pelagic (open ocean organic oozes and clays) deposits overlain by Late Jurassic to Late Cretaceous turbidites (a sediment deposited in water by turbidity currents). Although most Franciscan Complex rocks are little metamorphosed, high-pressure, low-temperature metamorphic minerals are common in rocks that crop out as mélange blocks (Bailey et al. 1964) and in several fault-bounded lenses within the map area. High-grade metamorphic blocks, enclosed in relatively unmetamorphosed argillite, (a sedimentary rock formed from shale or mudstone by pressure and cementation) (Blake and Jones 1974) reflects the complicated history of the Franciscan Complex.

The parts of the Franciscan Complex that crop out in the map area were subducted beneath the Coast Range ophiolite, a process that continued through Late Cretaceous time, after the deposition of the Franciscan Complex sandstone containing Campanian (Late Cretaceous) fossils that crops out just south of the map area (Blake et al. 2000). The youngest parts of the Franciscan Complex do not crop out in the map area, but are well exposed to the northwest in Sonoma and Mendocino Counties. These include Eocene and younger sedimentary rocks of the Coastal Belt that must have accreted deposition. However, their original relationship to the older Franciscan Complex rocks and Great Valley Sequence rocks seen in the map area is not well understood. Because much of the Franciscan Complex was accreted under the Great Valley Sequence and structurally linked Coast Range ophiolite, the contact between the two structural blocks is everywhere faulted (Bailey et al. 1964), and the Franciscan Complex presumably underlies the entire San Francisco Bay area east of the San Andreas fault. Rocks of the Franciscan Complex are highly variable in their engineering properties. The more highly sheared varieties, especially mélanges, can have very poor engineering properties and are often subject to landsliding.

A third rock complex is exposed west of the San Andreas fault zone and well west of the map area. This complex consists of the granitic rocks of the Salinian Block.

Both the Franciscan Complex and Coast Range ophiolite have been further divided into a number of fault-bounded tectonostratigraphic terranes (Blake et al. 1982, 1984). Terrane distribution in the map area is shown in the index map of terranes on the map sheet. Faults and shears associated with these fault-bounded terranes are likely subject to landsliding and also probably have poor engineering properties. The various Mesozoic terrains are described in detail elsewhere. See Blake et al. (2002) for a recent discussion of the origin of the Coast Range ophiolite and the Franciscan mélange, as well as a description of the terrains listed above.

TERTIARY (CENOZOIC) UNITS

In the San Francisco Bay area, Franciscan Complex *detritus* (erosional debris) in the Paleocene strata overlying Great Valley Sequence rocks in Rice Valley and the eastern Diablo Range (Bartow 1985), as well as unmetamorphosed early Eocene quartzofeldspathic strata overlying Franciscan Complex metamorphic rocks (Pampeyan 1993), indicate that much of the tectonic activity that brought the two Mesozoic complexes together was complete by early Tertiary time.

In the map area, most Paleogene strata was probably eroded prior to the eruption of the Sonoma Volcanic field in Miocene and Pliocene time, as indicated by the little early Tertiary strata that is exposed at the base of the volcanic deposits.

The Sonoma Volcanics are continuously exposed along the rugged range of hills that borders the east side of the Napa Valley (Map 1-4). To the northwest these hills become the Palisades, a particularly prominent volcanic mountain range that terminates at Mt. St. Helena, the highest peak in the County. North of the City of St Helena the Sonoma Volcanics also occupy the hills to the west of the valley. The Sonoma Volcanics are Late Pliocene to Late Miocene in age. They consist predominantly of basalt, andesite, and silicic flows, breccias and tuffs. The fine grained, dark gray andesites and basalts are quite hard, and when their flows are sufficiently thick and free of other less desirable rock types, they have the potential to produce high grade quarry rock. In the recent past, these rock types were extensively mined in the hills just south and east of Napa. Most mining has since ceased and the mined areas have been reclaimed. The tuff (ash) of the volcanics is variable in its engineering properties. Where deeply weathered, tuff is often subject to landsliding.

A large fault-bounded block of Eocene and Paleocene strata (Td) is preserved in the area of the west Napa Valley in the Napa Quadrangle, which is in the same structural block as a thick section of Eocene strata that unconformably overlie Late Cretaceous strata in the Cordelia quadrangle (Graymer et al. 2002). A very small outcrop of Paleogene strata (Ts) is present at the border of Chiles Valley and Walter Springs quadrangles in angular unconformity on lower Great Valley Sequence strata (KJgvl), which has been tentatively correlated (Wagner 1975) with Paleogene strata that conformably overlie the Late Cretaceous rocks northwest of Vacaville, east of the map area. Small outcrops of Paleogene strata are also found in the vicinity of Knoxville (Dean Enderlin, personal communication) and north of the map area near Lower Lake (Brice 1953). In the western part of the map area, the Franciscan Complex, Coast Range ophiolite, and Great Valley Sequence rocks are unconformably overlain by Miocene sedimentary and volcanic rocks.

The Tertiary stratigraphic relationships in the area also reveal significant late Tertiary and Quaternary fault offset. For example, in the southwest part of the Napa Quadrangle Sonoma Volcanic are underlain by Oligocene to late Miocene marine strata (Tkt, Tms, Tci, Tn) more than 850 m (2,800 feet) thick that are completely missing just to the east where Sonoma Volcanics overlie Eocene strata (Td). This juxtaposition suggests that many kilometers of offset on the intervening Carneros fault have brought deposits from different depositional basins or widely separated parts of the same basin.

GEOLOGY OF COUNTY SUBREGIONS

NAPA VALLEY

BEDROCK FORMATIONS AND THEIR CHARACTERISTICS

The principal bedrock formations within the Napa Valley subregion are the Sonoma Volcanics of Miocene-Pliocene age and the underlying, geologically much older rocks of the Franciscan Complex of Jurassic to Cretaceous age, and the Great Valley Sequence (Late Jurassic to Late Cretaceous). These various bedrock formations are exposed along the prominent, northwest-trending ridges that flank the east and west sides of the Napa Valley (and seen in the low hills in the valley near Yountville). For the distribution of these various bedrock formations see Graymer et al. 2004.

The dominant exposures within this subregion are the various rock types of the Sonoma Volcanics. In this subregion they consist primarily of andesite-basalt flows (Tsa) and rhyolitic flows (Tsr), with subordinate amounts of other rock types including tuff (Tsft), tuff breccia (Tslt), pumicitic ash-flow tuff (Tst), welded tuff (Tswt), agglomerate (Tsag), and volcanic sand and gravel (Tss). The exposures of tuff and sand and gravel are probably the most susceptible to erosion and landsliding. The andesite-basalt flows are probably relatively more susceptible to rock falls and topples. Their outcrops occupy nearly the entire length of the ridge system that flanks the east side of the Napa Valley (a distance of nearly 40 miles). Franciscan Complex and Great Valley Sequence rocks (KJfm, KJgv) are exposed across the mid to upper part of this ridge system for a total of about 7 miles to either side of Lake Hennessey Reservoir. These rocks consist of metagraywacke sandstone with greenstone, chert and associated serpentinite. Of these Franciscan rock types, the associated serpentinite is likely the most susceptible to landsliding and erosion. Soils derived from highly sheared and weathered serpentinite are also expected to have expansive properties.

On the west flanking ridge system, Sonoma Volcanics dominate on the north. The predominant rock type shown is pumiceous ash-flow tuff (Tst), with minor included exposures of andesite to basalt flows (Tsa). In the vicinity of St Helena these rocks are replaced along a depositional contact by underlying exposures of Franciscan rocks of early Cretaceous and late Cretaceous age that are predominantly mélange (KJfs), and associated serpentinite. These rocks continue southward along the ridge for about 7 miles, where, approximately opposite Oakville, they terminate against the St. Johns Mountain fault. Mélange and serpentinite are known to be susceptible to landsliding and erosion.

From this fault contact southward, the dominant rocks of the ridge are early Cretaceous and late Jurassic sandstone and shale of the Great Valley Sequence (KJgvl). These rocks are dominant until the ridge terminates at the mouth of the Napa Valley (Map 1-4). These rocks are subject to landsliding and, when well weathered, are susceptible to erosion. The weathered shales may have expansive properties. Commencing just north of Oakville and continuing southward for about 6 miles, the mid-lower flanks of the west-flanking ridge contain exposures of Sonoma Volcanics that are predominantly andesite-basalt flows with minor rhyolitic flows. These Sonoma Volcanic rocks that bound the west valley are separated from the core rocks comprising the ridge (Great Valley Sequence) by the West Napa Fault. Discontinuous slivers of the same volcanic rock are exposed further south commencing opposite the City of Napa and continuing to the end of the ridgeline at the mouth of the Napa River. The Yountville Hills are also composed of andesite-basalt flows and rhyolitic intrusives of the Sonoma Volcanics.

GEOLOGIC STRUCTURE

The younger, mapped (Graymer et al. 2004) geologic structures within the Napa Valley subregion are north-northwest-trending faults and associated folds generated by the transpressional Pacific-North American plate margin (San Andreas fault system). The faults have a predominant right-lateral strike-slip offset, but also have a component of fault-normal compression (at a ninety-degree angle to the fault). This component is shown in the uplift of fault-parallel ridges and the development of fault-parallel folds.

The only known active fault in this subregion is the West Napa fault, which flanks the west side of the Napa Valley. This fault is known to be active south of the City of Napa (Hart and Bryant 1997 [revised]) and is suspected to be active as far north as St Helena (Graymer pers. comm.).

INTERIOR VALLEYS

BEDROCK FORMATIONS AND THEIR CHARACTERISTICS

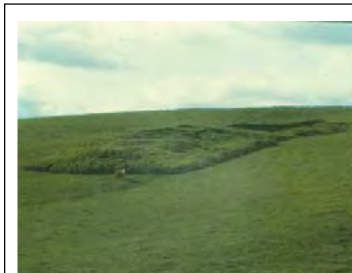
The number of geologic units and their outcrop pattern are more numerous and complex in the interior valleys subregion. These relationships can be seen in Graymer et al. 2004 and in Graymer et al. 2005 (in press).

The most widespread bedrock types within the interior valleys subregion are the early Cretaceous and Late Jurassic sandstones and shales of the Great Valley Sequence (KJgvl) and late Cretaceous to late Jurassic sandstone, shale and conglomerate (KJgv), also part of the Great Valley Sequence (Graymer et al. 2004). These rocks occupy most of the area from just north of Pope Valley to the south terminus of this subregion at the south border of the County. The early Cretaceous-late Jurassic rocks are mostly rhythmically thin bedded, fine-grained quartz-lithic wacke (sandstone that contains lithic fragments of primarily quartz but may also contain other rock fragments) and greenish gray to black mudstone and shale. Locally this unit contains beds of massively bedded sandstone or conglomerate that can be mapped for several miles before pinching out. The late Cretaceous-Late Jurassic rocks, not described here in detail, are expected to be similar to those of the KJgvl unit. Weathered mudstones and shales of these units may have expansive properties, and weathered sandstones and conglomerates may be susceptible to erosion. Zones of massive, deep landsliding have occurred in this unit, as described in the *Soil Deposits of County Subregions* section of this chapter.

Bordering the above unit on the west and east for over one-half of its length, and in fault contact with it, are continuous northwest-trending zones of serpentinite. These rocks are generally pervasively sheared. They are subject to landsliding and to the development of large zones of massive sliding and are erodible. The more sheared and correspondingly weathered varieties probably have expansive properties.

Franciscan Complex rocks are also exposed in this subregion, but not extensively. The Franciscan unit (KJfm) is exposed east of Lake Hennessey Reservoir and extends both north and south along the ridge at this location. These rocks consist of metagreywacke (poorly sorted lithic sandstone) with greenstone and chert. In general these rocks are subject to a nominal amount of landsliding and probably localized erosion hazards. The cherts located in the east central part of this unit are suspected to be quite hard.

Other subordinate rock units present in this subregion are a variety of units assigned to the Sonoma Volcanics. These are located along the west edge of this subregion in both the north and south. The outcrop pattern (Graymer et al. 2004) is complex. The rock types shown to be present are undifferentiated Sonoma Volcanics (Tsv), welded ash- flow tuff (Tswt), agglomerate (Tsag), tuff (Tsft),



Slump and earthflow type landslides are observed in several locations throughout the County.

Except for very minor exposure within the Interior Valley subregion, olivine basalts are unique to the Knoxville/Knoxville subregion.

Exposed basalt

pumicitic ash-flow tuff (Tst), rhyolite flows (Tsr) and andesite to basalt flows (Tsa). These rocks exhibit a wide range of physical characteristics. In general, the tuff and pumiceous ash-flow tuff are suspected to be subject to landsliding and erosion, and possibly have expansive properties. The welded ash-flow tuff, agglomerate, and andesite-basalt flows are expected to be generally more competent and less subject to landsliding, erosion and expansive properties.

GEOLOGIC STRUCTURE

The geologic structures in the mountains of the interior valleys subregion are relatively more complex than those to the west. Mesozoic rocks (pre-Sonoma Volcanics) in this area have undergone much compressional deformation, resulting in imbricate faulting and overturned folds. Some of these structures have evidence of Pliocene or younger activity, whereas others are overlapped by young (less than 4 Ma) parts of the Sonoma Volcanics (Graymer et al. 2004). It has been hypothesized (Swinchett and Howell 2004) that Neogene thrusting on these structures—that has continued into the Quaternary and has generated some of the massive landslide zones described earlier in this geology chapter—caused uplift of the mountains east of the Napa Valley. However, normal faults also cut the Sonoma Volcanics in the area, and the regional gravity expression (Langenheim et al. 2003) suggests that volcanic filled basins could be grabens. However, the overall structural picture of the area is consistent with Pliocene and Quaternary compressional deformation superimposed on earlier extensional deformation.

As the above description indicates, there are many faults cutting this subregion. The principal faults are northwest trending. There is only one known active fault in this subregion, the Green Valley fault, which extends northwestward into this subregion from Solano County. This fault has undergone movement in historic times. The nearby, possibly Holocene-active Cordelia fault extends a few miles into the County from Solano County as a series of short disconnected segments until it dies out near Lake Curry.

BERRYESSA/KNOXVILLE AREA

BEDROCK FORMATIONS AND THEIR CHARACTERISTICS

The number and type rock of bedrock units present in Berryessa/Knoxville area subregion is similar to those of the interior valleys subregion. The bedrock relationships can be seen in Graymer et al. 2004 and Graymer et al. 2005 (in press).[1]

The predominant bedrock units present are those of the Great Valley Sequence (either KJgv or KJgvl). Both of these units have been described immediately above in the subsection on the interior valleys subregion. The north part of the unit contains extensive exposures of serpentinite. The serpentinite is associated with the Coast Range fault, a regional northwest-trending fault of probable late Mesozoic to Pleistocene age. The general characteristics of serpentinite have also been described above.

A discontinuous band of volcanic rocks projects into the northwestern part of this subregion from Lake County. The band narrows and terminates along the northwest shore of Lake Berryessa. Except for very minor exposure at the County line within the interior valleys subregion, these rocks are unique to the Berryessa/Knoxville subregion. They are predominantly olivine augite basaltic andesite and basalt of Pleistocene and Pliocene age. They are dark gray and black olivine-porphyry and basalt, and grayish to brownish gray basaltic andesite and andesite. The unit also includes some interlayered rhyolite, rhyolite tuff, and conglomerate. [Note that most historically described rhyolites in this district are actually hydrothermally altered basaltic andesitepyroclastics. Rarerhyolitic airfall tuff deposits (possibly correlating with the Putah tuff) are known in the vicinity of Knoxville. These predate the basaltic andesite eruptions in the vicinity]. These rocks generally correlate with and are the southernmost extent of the Clear Lake Volcanics. The basalts are expected to be generally competent, but may be occasionally subject to rock toppling due to their often rim rock form with associated abrupt, steep breaks in slope.

GEOLOGIC STRUCTURE

The geologic structure of this subregion is similar to that of the eastern part of the interior valleys subregion and is not further discussed.

The Hunting Creek-Knoxville fault is present in the north part of this subregion. This fault is active (Holocene) and is associated with the regional San Andreas fault system. The Hunting Creek-Knoxville fault is up to a few miles wide and extends from the vicinity of Wilson Valley southward to Cedars Rough west of Lake Knoxville. The fault is divided from north to south into the Wilson, Hunting Creek, and Lake Knoxville sections. The section boundaries of this fault are based on changes in their geomorphic expression.

SOIL DEPOSITS

GEOLOGIC SURFICIAL DEPOSITS IN NAPA COUNTY

Unconsolidated surficial deposits generally consist of unstratified, geologically very young materials (clay, silt, sand, rock fragments and gravel, and organic material) lying on bedrock (or older deposits or other sedimentary materials) at or near the Earth's surface. They are of Quaternary age (the last 2 million years). Relative to the underlying rock, they are most often weak, soft, loose, and generally susceptible to erosion. They are the product of weathering, erosion, and deposition. These deposits are of variable thickness and comprise valley alluvium, alluvial fans, levee deposits, estuarine deposits, colluvium, stream channel and terrace deposits, and various types of landslide deposits, and the soil horizons that have developed upon them. Within the County the larger and thicker of these deposits are principally found within the major valleys—Napa, Chiles and Pope. Symbols on the geologic maps that start with an "a" or a "Q" should generally be considered unconsolidated surficial deposits. Soils and landslides, which are surficial deposits, are described in more detail in following subsections. Unconsolidated surficial deposits are shown in Map 1-5.

1 There are discrepancies in map symbols between these published and in-press maps. The principal ones are between sedimentary rock units of the Great Valley sequence. For example, the 2004 publication contains KJgvl, while the in press map shows KJgv for the same unit. The lithologies are similar. The principal difference seems to be in the age difference between the units. Once the U. S. Geological Survey completes technical review, these differences will be rectified.

MAJOR SOIL GROUPS IN NAPA COUNTY

A discussion of soil must indicate how the term *soil* is being used. The term has many definitions, depending on who is using it (Birkeland 1999).[2] To soil scientists, *soil* is mainly the medium for plant growth (agricultural soils) and as such is a resource that should be conserved. From this perspective, its study at a given location relies heavily on the nature and depth of soil horizons. This section primarily deals with soils from the soil science/agricultural perspective. This also includes information on the general engineering properties that can be deduced from characterization of the soils. Soil texture and engineering properties for Napa County are shown in Maps 1-6 and 1-7 respectively.

A soil is generally defined as a natural body consisting of *horizons* (layers) of mineral and/or organic constituents of variable thickness, which differ from the parent materials in their morphological, physical, chemical, and mineralogical properties and their biological characteristics (Birkeland 1999). In an agricultural context, *soil* refers to the unconsolidated and/or organic material at the ground surface that serves as the natural medium for growth of plants.

The interaction of five forming factors is usually used to define the state of a soil system. These are climate, organisms, topography, parent material, and time. More information on the importance of these factors and on soils in general can be found in the Soil Survey of Napa County, described below.

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The Soil Survey of Napa County (Lambert and Kashiwagi 1978), prepared by the U.S. Soil Conservation Service (now known as the Natural Resources Conservation Service [NRCS]), contains photo-based maps (1:24,000 scale) delineating the approximate boundaries of identified soils units and provides detailed written descriptions that characterize these soils. This information can be used for a variety of purposes, including assistance in the management of agricultural properties and woodlands, and initial evaluations that are useful in selecting potential sites for roads, ponds, and structures. The survey information is also useful for assisting in land appraisals and for general land use planning purposes. Engineering tables present information on the engineering properties of the soil units and name soil features that affect engineering practices and structures.

Other uses of the information in the soil survey include environmental impact identification and the relation between soil types and landforms, which have both applied and research value. The more detailed characterization of the physical and chemical properties of a soil at a particular location through further site-specific study can also be used to estimate the age of the soil. For example, this information can be particularly important to investigative geologists in determining if a fault through a site is active or inactive.

[2] For example, to many engineers, soil is unconsolidated surficial material. Whether it has or has not undergone weathering and the consequent development of soil horizons may or may not be of significance to the engineer; rather, it is the physical properties that are of interest. To the geologist, soils and other weathering products are the loose, unconsolidated products of weathering and erosion that can present clues that greatly assist in the unraveling of their relative ages and add detail to the geologic history of the area within which such materials have been deposited.

As useful as the soils maps and the soils descriptions are, it is important to appreciate that the information is general rather than specific, due to the scale (1:24,000) of the mapping, and cannot be used with great reliability for site-specific characterizations. Site-specific investigation is necessary to develop this information.

The Soil Survey of Napa County is available in both electronic and hard copy forms as described below. The Soil Survey Geographic (SSURGO) Database contains a series of reports (e.g., soil properties) and describes soil groups according to properties such as engineering classification and chemical properties.

Presently, the SSURGO website of the NRCS is the primary source of the online soil data, including Napa County. In an effort to improve the distribution of this regional soil mapping data, the NRCS has recently developed the Soil Data Mart. Soon, the Data Mart will supersede the National SSURGO website as the repository for this information. During this period of transition, data for a particular a survey, such as that for the County, may reside at either site, but never at both sites simultaneously.

As of the preparation of Napa County BDR, the SSURGO database is still being used to compile soil maps for the County. The Napa County soil units have been defined on the GIS Metadata Sheets (layers of a data set) and the units are outlined on these individual soil sheets.

The SSURGO user is allowed to make queries and download data through using the Internet. The website contains all of the details for this database (data at http://datagateway.nrcs.usda.gov). In addition, the State Soil Scientist can be reached for questions and directions on how the database was made and its many applications.

The following chapters accompany the SSURGO database:

- 618.20: AASHTO Engineering Characteristics and classification.
- 618.21: Erosion-Accelerated, and Kind.
- 618.22: Erosion Class.
- 618.23: Excavation Difficulty Classes.

The soils that have a high shrink-swell potential, rapid run-off, and excavation difficulties are described in the SSURGO database, listed in the above database chapters. In addition, this database contains information on the American Association of State Highway and Transportation Officials (AASHTO) Engineering Characteristics and classifications. The database is available in GIS.

The following are additional sources of soil information.

- National Soil Handbook (http://soils.usda.gov/technical/handbook/detailedtoc.html).

Soil Profile in Napa County

Soils information can be used for a variety of purposes, including management of agricultural properties and woodlands; initial site evaluations for roads, ponds, and structures; land appraisals; general land use planning purposes; and identification of potential environmental impacts.

Map of Napa County showing surficial deposits and significant water bodies.

- USDA Geospatial Gateway (http://datagateqay.nrcs.usda.gov/).
- Other available GIS layers for California (http://www.pacificsites.com/~cbrooks/gisl.shtml).

SURFICIAL GEOLOGIC DEPOSITS AND SOIL TYPES OF COUNTY SUBREGIONS

Characteristics and properties of geologic surficial deposits and soil types in the County are described below by subregion. Additional information that may be needed on the characteristics and properties of geologic surficial deposits in the County can be found in the various referenced geologic maps and reports in this chapter. The level of detail of this information is uniform throughout the County.

Needed information on soil behavior properties for the County can presently be found electronically on the SSURGO website of the Natural Resources Conservation Service. This information includes engineering classification, erosion potential, erosion class, and excavation difficulty. The Data Mart will supersede the National SSURGO website in the near future as the repository for soil information. During this period of transition, data for a particular soil survey, such as that for the County, may be found at either site, but never at both sites simultaneously.

NAPA VALLEY

GEOLOGIC SURFICIAL DEPOSITS

The surficial geologic deposits of the Napa Valley subregion consist of widespread, locally deep alluvium in the Napa Valley and generally discontinuous deposits on the flanking ridge systems of colluvium, soil creep, and landslides (Maps 1-5 and 1-8). Between the mouth of the Napa Valley and the edge of San Pablo Bay is the large area of soft, largely saturated marsh and inter-tidal deposits that are mapped as predominantly Bay Mud deposits. Thin, discontinuous deposits of predominantly sand and gravel are present along the lesser stream channels that drain into the Valley.

The valley alluvium consists predominantly of alluvial fan, stream channel, flood plain, and terrace deposits that range in age from Earliest Pleistocene (slightly less than 2 Ma) to Holocene (10 thousand years ago [Ka] or less). Typically they are stratified to discontinuously or poorly stratified sands, gravels, silts and clays in various combinations. Generally, the Holocene deposits are relatively thin, found at or near the surface, and are loose, unconsolidated, and highly permeable. In contrast, Pleistocene deposits are generally thicker and more deeply buried (though some may be found at the surface locally), remain permeable, and are more prone to be semi-consolidated, but not yet rock in their mechanical properties. The alluvium of Napa Valley is the largest, continuous source of groundwater in the County.

The colluvial and landslide deposits are typically more heterogeneous in composition and consist of various combinations of mostly unconsolidated soil and rock fragments. They are mostly Holocene in age, but larger landslides and thicker, more continuous colluvial deposits are likely Late Pleistocene or slightly older in age.

The density of known landslide occurrence in the ridge systems of the Napa Valley subregion is variable and ranges form mostly low or moderate to locally high. Most commonly they are combined slump-earthflows and less commonly very rapid failures such as debris flows, mudflows, rock falls, and toppling.

One of the areas of higher landslide density is on the ridge slopes separating Carneros Valley from the Napa Valley. In this area, several large and many smaller landslides have been mapped (Wills and Majmundar 1999; Dwyer et al. 1976).

In some locations, extremely large, deep, presumably dormant slides have been mapped (Dwyer et al. 1978). These large features can be up to 3 or 4 miles wide and over a mile in length. For example, the south canyon of Sage Creek, immediately east of Lake Hennessy Reservoir, is the location of such a mapped slide. A group of these slides have also been mapped about 3 miles west of the Yountville Hills along the Napa-Sonoma County boundary.

While obvious to an experienced aerial photo geologist, such features are so large, as well as partially subdued by erosion, that they can easily go unnoticed by the layperson at the ground surface. Because they provide relatively large, flat areas on otherwise steeper hillside terrain, they are attractive for residences, vineyards, and other improvements. For this reason, flatter areas on steeper hillsides should be carefully evaluated prior to approving significant development on their surfaces. This comment applies to such slide features regardless of the subregion in which they are found.

Other geologic hazards locally associated with surficial deposits of this subregion include accelerated erosion, weak/expansive properties, and the potential for earthquake shaking effects, particularly in deeper valley alluvium and marsh and inter-tidal deposits. The potential for subsidence is significant within the weak, saturated Bay Mud deposits associated with the marsh and tidal deposits.

SOILS AND THEIR CHARACTERISTICS

Soil types (agricultural) and their characteristics in the Napa Valley subregion are controlled in part by location, i.e., valley or hillside. The principal soil series in the Napa Valley is Bale-Cole-Yolo. Soils of this series have formed on the nearly level to gently sloping, deep alluvium of the Valley. The soils are well drained to somewhat poorly drained loams, silt loams, and clay loams on flood plains, alluvial fans and terraces (Map 1-6). These soils are among the most agriculturally productive in the County.

The principal soil series on the ridge system to the west of the Valley are Maymen-Lodo-Felton, Forward-Boomer-Felton, Bressa-Dibble- Sobrante, and Forward-Aken. On the ridge system to the east, the principal soil series are Rock Outcrop-Kidd-Hambright, and Bressa-Dibble-Sobrante, and Forward-Aiken.

Soils present on the ridge systems to either side of the Valley have formed from a wide range of parent materials under varying conditions of slope steepness and stability, slope aspect, time, and annual rainfall. Therefore, it is not surprising that the properties of these soils, including their hazards, are more variable than those formed on the more uniformly flat Valley floor (stable geomorphic surface), with its more homogeneous parent materials (alluvium).

Geologic hazards are essentially the same as those discussed above for surficial geologic deposits.

INTERIOR VALLEYS

GEOLOGIC SURFICIAL DEPOSITS

The surficial geologic deposits of the interior valleys subregion consist of alluvium and associated fan, terrace, and flood plain deposits that occupy the several valleys of this subregion (Map 1-5). Since these valleys are small, their deposits are not as thick or continuously distributed as those of the Napa Valley subregion. Thin, discontinuous channel and peripheral terrace deposits of predominantly sand and gravel are present along the stream channels that drain into the valleys of this subregion. The geologic age of these various deposits is latest Pleistocene to latest Holocene. The surficial deposits of the hill and ridge systems consist of colluvium, soil creep and landslides. The deposits are mostly Holocene. Some of the very large landslide deposits are quite possibly of late Pleistocene age.

The density of mapped landslide occurrence in the hills and ridge systems of the interior valleys subregion (Map 1-8) is variable and ranges form mostly low or moderate to locally high and very high (Dwyer et al. 1976). Most commonly the slides are interpreted to be combined slump-earthflows and less commonly very rapid failures such as debris flows, mud flows, rock falls, and toppling. Mapped slides typically range in length from less than 100 feet to several hundred feet. Activity levels are from recently active to dormant.

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Within this subregion are several areas where extremely large and deep slides and slide zones have been mapped (Dwyer et al. 1978; Sims and Frizzell 1976). Most of these slides are classified as dormant through aerial photo interpretation, but in most cases without onsite investigations to confirm geologic mapping and related issues. In the northernmost part of the subregion, these features are up to 2 miles wide and 1.5 miles long. Slightly further south, there is a nearly continuous, northwest-trending zone of such sliding 7 to 8 miles long. This linear zone has developed on the west facing slopes above Hardin and Soda Creeks, just below the ridge crest of the Cedars Rough.

A similar or even larger zone of sliding is present in the south part of the subregion. This area is south and west of Wooden Valley and extends discontinuously northwestward for several miles along high, east-facing slopes. Similar but somewhat smaller zones large landsliding is also present on east facing slopes of Soda Creek, west of Gordon Valley. It is roughly estimated that 30% of this southernmost part of the subregion is composed of landslide deposits of various dimensions.

While obvious to an experienced aerial photo geologist, such features are so large as well as partially subdued by erosion, that they can easily go unnoticed by the layperson at the ground surface. Because they provide relatively large, flat areas on otherwise steeper hillside terrain, they are attractive for residences, vineyards and other improvements. For this reason, flatter areas on steeper hillsides should be carefully evaluated prior to approving significant development on their surfaces.

Other geologic hazards locally to extensively associated with surficial deposits of this subregion include accelerated erosion, extensive areas of weak/expansive soils associated with serpentinite bedrock, and the potential for amplified earthquake shaking and related effects in the deeper alluvium of valleys. The potential for earthquake shaking to reactivate portions of large landslide zones is potentially high.

SOILS AND THEIR CHARACTERISTICS

Soil types (agricultural) and their characteristics in the interior valleys subregion are controlled in part by valley versus hillside location. The principal soil series in the named valley areas are Bressa-Dibble-Sobrante (Pope Valley), Tehama (Chiles Valley), Bale-Cole-Yolo (Wooden, Gordon and Foss Valleys), and Henneke-Montara (Capell Valley).

The principal soil series on the hills and ridge system on the west side of the subregion are Forward-Aiken, Rock Outcrop-Kidd-Hambright, and Bressa-Dibble-Sobrante. On the east side the soil series are Henneke-Montara, Bressa-Dibble-Sobrante, Forward-Aiken, and Tehama.

The above-listed soil series are numerous and variable in their agricultural resources, physical properties, and hazard potential. This is due to the variation throughout the subregion in soil forming properties, including slope steepness and parent material, both of which are highly variable.

As discussed at the beginning of this subsection, details on the properties of these various soils can be obtained electronically from the National Resources Conservation Agency (NRCA).

Interior Valleys have significant areas of alluvium and associated fan, terrace, and flood plain deposits, and landslides.

BERRYESSA/KNOXVILLE AREA

GEOLOGIC SURFICIAL DEPOSITS

Surficial geologic deposits of the Berryessa/Knoxville subregion consist primarily landslide, colluvial and soil creep deposits on sloping terrain, and minor, widely spaced gravel/sand/silt deposits associated with very narrow stream valleys and the confluences of streams. The principal valley of the subregion is occupied by Lake Berryessa Reservoir. There are no other sizable valleys in the subregion. Snell Valley is a minor alluviated valley on the northwest border of the County.

The narrow stream valley and confluence deposits consist of alluvium, alluvial fans, terraces, and overbank deposits. These deposits range in age from latest Holocene to late Pleistocene. They are primarily found along the upper reaches of Putah and Eticuera Creeks and Long Canyon in the north part of the subregion, and in the south, the very narrow Cherry Valley (Wragg Canyon) and Steel Canyon immediately south and tributary to Lake Berryessa.

Landslides occur throughout the subregion. The intensity of mapped landslide development varies from mostly low to moderate to occasionally high (Dwyer et al. 1976; Sims and Frizzell 1976). Most commonly the slides are interpreted to be combined slump-earthflows and less commonly very rapid failures such as debris flows, mud flows, rock falls, and toppling. Mapped slides typically range in length from less than 100 feet to several hundred feet. Activity levels are from recently active to dormant. The geologic age of the landslide and colluvial deposits is predominantly Holocene, with some of the massive landslide zones probably latest Pleistocene.

> The chance for a magnitude 6.7 or larger earthquake to occur in the Bay Area by the year 2032 is 62%.

There are occasional large zones of landsliding, but the level is substantially lower than in the interior valleys subregion. In the north, zones of such landsliding are located between Turner Mountain on the west and Eticuera Creek on the east. The west facing slopes above Lake Berryessa on the east contain a moderate numbers of landslides with maximum lengths up to several hundred feet. However, massive landslide zones have not been mapped on these slopes. This absence appears due to uniformly eastward dipping, less structurally disturbed and broken sedimentary rocks of the Great Valley Sequence.

Landslide conditions in the south part of the subregion are similar to those on the north. Just below the ridge crest of the Vaca Mountains (County line) and slightly north of Vaca Mountain, there is one area of large massive landsliding on west-facing slopes.

SOILS AND THEIR CHARACTERISTICS

The principal soil series of the Berryessa/Knoxville subregion are few in number; in the north-northwest part of the subregion they consist of the Henneke-Montara Series, and in the north-northeast of the Bressa-Dibble-Sobrante Series. The Maymen-Lodo-Felton Series is found long the top of Blue Ridge (County Line). The Tehama series occupies part of the eastern shore of Lake Berryessa. In the south part of the subregion, the predominating soil series are Bressa-Dibble-Sobrante and Maymen-Lodo-Felton.

As discussed at the beginning if this subsection, details on the properties of these various soils can be obtained electronically from the NRCA.

SEISMICITY

> When an earthquake occurs, energy waves are radiated outward from the fault. The amplitude and frequency of earthquake ground motions partially depends on the material through which it is moving and distance from the source.

The County is located within a seismically active area and will therefore experience the effects of future earthquakes. Earthquakes are the product of the buildup and sudden release of stress along a *fault zone*, or zone of weakness in the Earth's crust. Stored energy may be released as soon as it is generated or it may be accumulated and stored for long periods of time. Individual releases may be so small that only sensitive instruments detect them, or they may be violent enough to cause destruction over vast areas.

When an earthquake occurs, energy waves are radiated outward from the fault. The amplitude and frequency of earthquake ground motions partially depends on the material through which it is moving and distance from the source. The earthquake force is transmitted through hard rock in short, rapid vibrations, while this energy movement becomes a long, high-amplitude motion when moving through soft ground materials, such as valley alluvium or bay mud. The force an earthquake applies to a structure is expressed in terms of a percentage of gravity (g). For example, an earthquake that produces 0.30g horizontal ground acceleration will impose a lateral force on a structure equal to 30% of its total vertical weight.

The intensity of an earthquake is expressed in terms of its effects, as measured by the Modified Mercalli Intensity Scale, and in terms of the quantity of energy released, or magnitude, as measured by the Richter, or Moment Magnitude, Scale.

The Modified Mercalli Intensity Scale (Table 1-1) describes the physical effects of an earthquake with the lowest ratings based on human reactions, such as "felt indoors by few" and the highest intensities measured by geologic effects such as "broad fissures in wet ground, numerous and extensive landslides, and major surface faulting." Moderate intensities are determined by the degree of observed structural damage to buildings. Therefore, a single earthquake can have different intensity ratings based on geologic conditions, structural design, or distance from the earthquake's epicenter.

The Richter Scale provides a method to deduce the magnitude of an earthquake from seismologic instruments. The measurement of magnitude provides a rating that is independent of the place of observation and thus allows a comparison of seismic events. Magnitude is measured on a logarithmic scale; every one-unit increase indicates an increment of roughly 30 times the energy. For example, an 8.0 magnitude earthquake would have an energy level 30 times that of a 7.0 magnitude and 900 times that of a 6.0 magnitude earthquake. Earthquakes are ranked as "Large" between magnitudes 6.0 and 6.9, "Major" between magnitudes 7.0 and 7.9, and "Great" when over 8.0. On a worldwide basis there is usually only one Great earthquake per year. However, many small earthquakes occur in the same time frame. For example about 100,000 small (less than magnitude 3.5) earthquakes occur each day on a worldwide basis (Keller et al. 2006 in press)

Table 1-1. Modified Mercalli Intensity Scale

Average peak velocity (cm/s)	Intensity value and description	Average peak acceleration (g = 9.80 m/s)
Less than 1	I. Not felt except by a very few under especially favorable circumstances.	Less than 0.015g
	II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.	
	III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing automobiles may rock slightly. Vibration like passing of truck. Duration estimated.	
1–2	IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing automobiles rocked noticeably.	0.015g–0.02g
2–5	V. Felt by nearly everyone, many awakened. Some dishes, windows, and so on broken; cracked plaster in a few places; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.	0.03g–0.04g
5–8	VI. Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster and damaged chimneys. Damage slight.	0.06g–0.07g
8–12	VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving cars.	0.10g–0.15g
20–30	VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stack, columns, monuments, and walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving cars disturbed.	0.25g–0.30g
45–55	IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.	0.50g–0.55g
More than 60	X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from riverbanks and steep slopes. Shifted sand and mud. Water splashed, slopped over banks.	More than 0.60g
	XI. Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.	
	XII. Damage total. Waves seen on ground surface. Lines of sight and level distorted. Objects thrown into the air.	

Notes:
cm/s = centimeters per second.
g = the force an earthquake applies to a structure is expressed in terms of a percentage of gravity.
m/s = meters per second.
Source: Bolt 1993.

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HISTORIC FAULT ACTIVITY

Numerous earthquakes have occurred in the Napa County region within historic times. The computer database search (NCEDC Northern California Earthquake Catalog Search, joint effort by UCB and USGS) indicated that 97 earthquakes of magnitude 5.0 or larger have occurred within 200 kilometers of the center of the County between 1735 and 2005. The significant historic earthquakes that have affected the County are summarized in Table 1-2.

Table 1-2. Significant Historic Earthquake Activity—Napa County

Epicenter latitude – longitude	Magnitude	Year	Distance from County Center (km)	Median Peak Bedrock Acceleration
37.70–122.50	8.3	1906	89	0.10g
37.80–122.20	6.8	1836	76	0.05g
37.60–122.40	7.0	1838	98	0.04g
38.40–122.00	6.4	1892	27	0.10g
37.70–122.10	6.8	1868	88	0.04g
38.20–122.40	6.2	1898	33	0.07g
38.38–122.41	5.2	2000	15	0.08g

Notes:
g = The force an earthquake applies to a structure is expressed in terms of a percentage of gravity.
km = Kilometers.
Sources: U.S. Geological Survey 2001; Idriss 1995.

The calculated bedrock accelerations are reasonable estimates at the center of the County. Many factors (soil conditions, distance, orientation to the fault, etc.) can influence the actual ground surface accelerations. Significant deviation from the values presented is possible due to geologic variations from the typical conditions used in the empirical correlations.

The County is located within a seismically active area. Earthquakes are the product of the buildup and sudden release of stress along a *fault zone*, or zone of weakness in the Earth's crust. Stored energy may be released as soon as it is generated or it may be accumulated and stored for long periods of time. Individual releases may be so small that only sensitive instruments detect them, or they may be violent enough to cause destruction over vast areas.

PROBABILITY OF FUTURE EARTHQUAKES

The historical records do not directly indicate either the maximum credible earthquake or the probability of such a future event. To evaluate earthquake probability in this region, the U.S. Geological Survey (USGS) has convened a group of researchers into the Working Group on California Earthquake Probabilities to estimate the probabilities of earthquakes on active faults. Potential sources were analyzed considering fault geometry, geologic slip rates, geodetic strain rates, historic activity, and micro-seismicity, to arrive at estimates of probabilities of earthquakes.

The probability studies focus on seven fault systems within the Bay Area. Fault systems are composed of different, interacting fault segments capable of producing earthquakes within the individual segment or in combination with other segments of the same fault system. The probabilities for the individual fault segments in the San Francisco Bay Area are shown in Table 1-3.

In addition to the seven fault systems, the studies included probabilities of *background earthquakes*. These earthquakes are not associated with the identified fault systems and may occur on lesser faults (i.e., West Napa) or previously unknown faults (i.e., the 1989 Loma Prieta and 1994 Northridge earthquakes). Based on a combined probability of all seven fault systems and background earthquakes, there is a 62% chance for a magnitude 6.7 or larger earthquake to occur in the Bay Area by the year 2032. Smaller earthquakes (between magnitudes 6.0 and 6.7), capable of considerable damage depending on proximity to urban areas, have about an 80% chance of occurring in the Bay Area by 2030 (U.S. Geological Survey 2003).

Additional studies by the USGS regarding the probability of large earthquakes in the Bay Area are ongoing. These current evaluations include data from additional active faults and updated geological data.

GENERAL PROBABILISTIC SEISMIC DESIGN

Faults are seldom single breaks or fissures in the Earth's crust, but typically are braids of breaks that comprise shatter zones which link to form networks of major and minor faults. Within the Bay Area, active faults are components of the San Andreas fault zone, a broad north-northwest trending system that extends across the Bay Area and includes many active faults, including the main trace of the San Andreas fault.

For detailed planning studies of important or critical structures (schools, hospitals, police, fire, etc.), the California Division of State Architect (DSA) requires two probabilistic seismic hazard ground motions to be utilized for project design. The first ground motion is the Upper-Bound Earthquake Ground Motion (PGAUBE) and is caused by an earthquake with a 10% chance of exceedance in 100 years. The second ground motion defined by DSA is the Design-Basis Earthquake Ground-Motion (PGADBE) and is caused by an earthquake with a 10% chance of exceedance in 50 years. Because the PGAUBE has a longer return period, larger earthquakes and subsequently larger ground motions are associated with it. DSA requires the more conservative PGAUBE to be utilized when determining the sites susceptibility to liquefaction and the PGADBE to be utilized for structure design.

A common approach for site-specific analysis is to use the PGAUBE and PGADBE listed below in Table 1-3 from the USGS Earthquake Hazards Program (Seed et al. 1997). Note, however, that these numbers are generalized for large physiographic regions across the County; for planning purposes, individual latitudes and longitudes must be used to obtain correct peak ground accelerations (PGAs).

The interpolated probabilistic ground-motion values, in percent g, at the three sub regions are listed below in Table 1-3.

Table 1-3. Probabilistic Seismic Hazard Analysis—Three Physiographic Regions of Napa County, California

Physiographic Regions	Peak Ground Accelerations	Statistical Return Period	Statistical Return Period	Statistical Return Period
City of Napa		10% PE in 50 year PGA=0.422g	2% PE in 50 year PGA=0.751	10% in 100 yr = 0.501g
	0.2 sec SA	1.016g	1.795g	
	1.0 sec SA	0.371g	0.640g	
Interior Valleys: Pope Valley		10% PE in 50 year PGA=0.354g	2% PE in 50 year PGA=0.621g	10% in 100 yr = 0.417g
	0.2 sec SA	0.840g	1.506g	
	1.0 sec SA	0.324g	0.563g	
Berryessa/ Knoxville Area		10% PE in 50 year PGA=0.455g	2% PE in 50 year PGA=0.901g	10% in 100 yr = 0.561g
	0.2 sec SA	1.056g	2.174g	
	1.0 sec SA	0.390g	0.827g	

Source: U.S. Geological Survey 2004.

MAJOR EARTHQUAKE FAULTS IN NAPA COUNTY

Faults are seldom single breaks or fissures in the Earth's crust, but typically are braids of breaks that comprise shatter zones which link to form networks of major and minor faults. Within the Bay Area, active faults are components of the San Andreas fault zone, a broad north-northwest trending system that extends across the Bay Area and includes many active faults, including the main trace of the San Andreas fault.

The movement between rock formations along either side of a fault may be horizontal, vertical, or a combination. An *active* fault is one that shows displacement within the last 11,000 years and is therefore considered more likely to generate a future earthquake than a fault that shows no sign of recent rupture. The active faults are classified into two types. *Type A* faults are capable of large magnitude earthquakes and have a high rate of seismic activity. *Type* B faults are capable of large magnitude earthquakes with a low rate of seismic activity or are smaller faults with a high rate of seismic activity.

A large number of faults have been mapped within the County (Graymer et al. 2000; Graymer et al. 2005 in press). Only a very small number of these faults have been designated as active by the California Geological Survey (formerly the California Division of Mines and Geology). To be so designated a fault must be judged as "sufficiently active and well defined." That is, it must have undergone movement during the Holocene (the last 11,000 years), and the trace of the fault must be clearly detectable by a trained geologist as a physical feature at or just below the ground surface. When a fault meets this criterion it is zoned as active according to the mandates of the Alquist-Priolo Earthquake Fault Zoning Act of 1972. Such zones are known as *earthquake fault zones*. These zones are graphically shown for the entire state on a series of quadrangle maps available to the public. Within the County, three faults are designated as active based on the above-described criteria. These are the West Napa fault, the Green Valley fault, and the Hunting Creek fault (Map 1-4). (The Cordelia fault is a potential fourth active fault in the County.) Their characteristics are summarized in Table 1-4.

The locations of the major faults are indicated on the Geologic Maps of Graymer (2002 and 2004) and shown in Map 1-4. Additional geologic maps that were used for this study include recent maps by the California Geological Survey, the Unified Building Code Map of known active faults, and the California Department of Transportation's (Caltrans') 1996 map of maximum credible earthquake events.

Five 7.5-minute quadrangles contain faults that are Alquist-Priolo zones: Cordelia, Cuttings Wharf, Jericho Valley, Knoxville, and Mt. George maps. A map indicating the County's 7.5-minute quadrangles can be found at http://www.conservation.gov/CGS/rghm/ap/Map_index/county.htm.

Additional investigations are underway on the West Napa fault, particularly the northern part. Portions are believed to be active, and additional earthquake trenching studies may be required to definitively zone segments as "Sufficiently Active." Bill Bryant of the California Geological Survey in Sacramento is the head of the Special Studies Zones mapping program for the State of California (Alquist-Priolo Zone mapping). For development in any areas of suspected faulting, cities and counties should be contacted and previous geological and geotechnical reports should be reviewed.

Table 1-4. Known Active Faults in Napa County

Fault Name	General Information	Activity; AP Zoned	Mapped/Investigated by
Hunting Creek-Berryessa, Hunting Creek section (medial Section)	This fault has 3 segments in Napa County. Section boundaries are based on a change in geomorphic expression of the fault.	Active: AP Zoned	Bryant (1982) Investigation by Steffen, Robertson, and Kirsten and Woodward-Clyde Consultants (1983) demonstrated latest Pleistocene and probable Holocene displacement along some traces.
Hunting Creek-Berryessa, Lake Berryessa section	Extends from the vicinity of Wilson Valley south-southeast to the Cedar Roughs area west of Lake Berryessa.	Active	Compiled by William A. Bryant, California Geological Survey, 2000.
Hunting Creek-Berryessa, Wilson section (northern section)	Probably transfers dextral slip to the Bartlett Springs fault system. The whole system is expressed as a zone of discontinuous fault traces as much as 3.5km wide.	Active	Compiled by William A. Bryant, California Geological Survey, 2000Working Group on Northern California Earthquake Potential (1996).
West Napa fault Napa County Airport section (southern section)	Delineated by northwester-striking dextral slip faults that exhibit geomorphic evidence of Holocene displacement.	Yes: Exhibits geomorphic evidence of Holocene displacement	Helley and Herd (1977), and Bryant (1982).
West Napa fault, Browns Valley section (northern section)	Delineated by a zone of north-northwestern-striking late Pleistocene faults that generally lack geomorphic evidence of Holocene displacement.	No	Mapped by Weaver (1949), Fox et al. (1973), Helley and Herd (1977) Pampeyan (1979) and Bryant (1982).
Green Valley fault: This dextral fault borders the eastern side of the Sulphur Springs Mountains	Holocene Active. Slip rate category: between 1.0 and 5.0 mm/yr.	Portions are AP Zoned.	Borchardt trenched at Hwy 12 and 80, not found evidence of active. Evidence of Holocene movement may be found in stream.
Possibly a section of the Cordelia fault	A road on the north end, but the fault only goes a short distance into Napa County. Not listed as part of Napa County, but should be evaluated on a case-by-case basis.	Possibly Active	Working Group on Northern California Earthquake Potential, 1996, Database of potential sources for earthquake larger than magnitude 6 in northern California: U.S. Geological Survey Open-File Report 96-705, 40p.

mm/yr = millimeters per year.

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Active Faults in Napa County

MAJOR ACTIVE FAULTS IN NAPA COUNTY

Three faults are designated as active in the County: the West Napa fault, Green Valley fault and Hunting Creek fault, discussed below. The Cordelia fault can possibly also be considered active within Napa County.

WEST NAPA FAULT

The West Napa fault has been mapped as Holocene-active (California Division of Mines and Geology 2000) in the southern part of the map area (south from the Napa Airport to very near the Napa-Solano County boundary). It is not presently designated as active along its northern segment that is shown to terminate in the vicinity of Yountville (Helley and Herd 1977). However, recent work (Langenhein et al. 2003) has shown that the damaging M5.2 2000 Yountville earthquake may have occurred on the northern segment West Napa fault. In this northern area (Rutherford Quadrangle), right-deflected streams along the western margin of Napa Valley could have resulted from right-lateral offset associated with Holocene activity on the West Napa fault. However, the detailed paleoseismic work (detailed trenching and logging of the fault) required to prove Holocene activity on the West Napa fault in this northern segment has not yet been done. Therefore, while the mapping of Graymer is suggestive regarding activity, it is not conclusive.

The West Napa fault is a dextral (right lateral) strike-slip fault that forms a part of the larger San Andreas fault system. This fault is generally located along the western side of Napa Valley and extends from Yountville southeast to the vicinity of Napa Junction. Fox (1983) suggested that the West Napa fault may continue further to the northwest in the bedrock hills to near St. Helena, rather than striking more northerly into the alluvium of Napa Valley. However, fault recency has not been documented along this northwestern part of the trace other than the fact that it offsets Pliocene Sonoma Volcanics against rocks of the Cretaceous Great Valley Sequence (Fox 1983). Cumulative lateral displacement on the fault is unknown. Helley and Herd (1977) reported that at least 24 m (about 75 feet) of down-to-east vertical (normal dip slip) has occurred along a strand just north of Browns Valley. Fox (1983) reported that this down-to-the east vertical component might be greater than 79 m (about 240 feet), based on the thickness of alluvium logged in a water well just east of the fault in western Napa Valley.

According to other research geologists, such as Langenheim (2003), the north-northwest striking West Napa fault is mapped along the western margin of Napa Valley, California. The epicenter of the M5.2 earthquake in 2000 was located west of Yountville and may have occurred on a strand of the West Napa fault. A linear aeromagnetic anomaly along strike with the Holocene West Napa fault extends northwest 30 km (about 21 miles) from just north of the Napa County Airport to the latitude of the town of Rutherford. North of Rutherford, another linear aeromagnetic anomaly can be traced 20 km north to Calistoga. The source of the anomalies resides within the pre-Cenozoic basement rocks, most likely unexposed ophiolitic basement rocks of the Great Valley Sequence. Both of the aeromagnetic anomalies occur near the base of a linear east-facing gravity gradient. The gravity gradient is caused by the juxtaposition of Great Valley and Franciscan rocks to the southwest with less dense Cenozoic Sonoma Volcanics all along the west side of the valley.

The correlation of the potential-field anomalies suggests that a steeply west-dipping reverse fault bounds the western margin of the Napa Valley basin. The alignment of the reverse fault with the Holocene mapped West Napa fault suggests that they are related. The focal mechanism of the Yountville Earthquake, which occurred at a depth of about 10 km, indicates slip occurred on a steeply southwest-dipping, northwest-striking fault plane. Projection of this fault plane to the surface coincides closely with the location of the geophysically defined fault bounding the western margin of the Napa Valley basin and the surface trace of the West Napa fault as mapped by Fox (1983) and Graymer et al. 2005 (in press). Although the focal mechanism indicates nearly pure right-lateral slip, aftershocks of the event include both right-lateral and reverse mechanisms. Despite the relatively small magnitude of the Yountville earthquake, it probably occurred on a fault capable of much larger earthquakes. Given the length of the geophysically defined West Napa fault, it may be capable of producing an M6.8-7.1 earthquake (large to major earthquake). An unusual characteristic of the Yountville earthquake was more extensive damage in the city of Napa than in communities more proximal to the epicenter. A preliminary inversion of the gravity data indicates that the Cenozoic basin fill is as much as 2 km thick beneath the town of Napa and substantially thinner beneath Yountville. The variation in thickness of the basin fill, combined with variable groundwater saturation, may be a factor that contributed to the unusually strong ground accelerations recorded in parts of Napa and the lack of damage to older buildings at Yountville during the 2000 earthquake.

GREEN VALLEY FAULT

The Green Valley fault extends northward 4 to 5 miles into the southeast part of the County and terminates along the west edge of Wooden Valley. It is a Holocene active, right lateral strike-slip fault, which is the easternmost significant strike-slip fault of the larger San Andreas system within the San Francisco Bay area. It is characterized by seismic creep (slow, gradual movement on a fault not associated with felt earthquakes), and has been monitored by Galehouse (1992) since 1984. In addition to Graymer (2002), other geologic publications providing information on this fault and other faults in the region include Weaver 1949, Sims et al. 1973, Dooley 1973, Frizzell and Brown 1976, Bryant 1982 and 1992, Sowers et al. 1995, and Bezore et al. 2004.

Several site-specific studies have been completed in compliance with Alquist-Priolo Earthquake Fault Zoning Act (Hart and Bryant 1997), which have documented the location and approximate time of the most recent faulting. Information from the Lopes Ranch paleoseismic site indicates that the Green Valley fault has produced multiple surface-rupturing events in the past 2.7-thousand (ka) and has minimum late Holocene dextral slip rate of 3.8 mm/yr to 4.8 mm/yr (Baldwin and Lienkemper 1999)

HUNTING CREEK FAULT

The Hunting Creek-Berryessa fault is an active (Holocene) dextral strike-slip fault system associated with the larger San Andreas fault system. The Hunting Creek-Berryessa fault system extends from the vicinity of Wilson Valley south-southeast to the Cedar Roughs area west of Lake Berryessa. In the USGS Fault and Fold Database, the fault zone is divided from north to south into the Wilson, Hunting Creek, and Lake Berryessa sections. The section boundaries are based on changes in geomorphic expression of the faults. The Wilson section probably transfers dextral slip to the Bartlett Springs fault system, north of the County.

The Hunting Creek-Berryessa fault system is expressed as a zone of discontinuous fault traces as much as 3.5 km wide. This fault system is locally delineated by geomorphic evidence of Holocene dextral strike-slip displacement, predominantly along the Hunting Creek section (Bryant 1982). An investigation by Steffen, Robertson, and Kirsten and Woodward-Clyde Consultants (1983) demonstrated latest Pleistocene and probable Holocene displacement along traces of the Hunting Creek-Berryessa fault system. The investigation by Steffen et al. (1983) inferred a late Pleistocene dextral slip rate of 0.09 mm/yr to 0.4 mm/yr, based on apparent vertical separation of a late Pleistocene to Holocene colluvium. Bryant (1983) argued that the geomorphic expression of the Hunting Creek fault indicated a dextral slip rate of at least 1 mm/yr. It is generally necessary to establish a slip rate of at least 1 mm/yr on a given fault before it is designated as sufficiently active by the California Geological Survey and therefore zoned according to the provisions of the Alquist-Priolo Fault Zoning Act. The Hunting Creek fault has been zoned as active.

CORDELIA FAULT

The Cordelia fault is roughly parallel to and located a few miles east of the Green Valley fault. According to Helley and Herd 1977 and Wagner and Bortugno 1982, the fault extends into the County from Solano County and terminates a few miles north of the County boundary near Lake Curry. The Cordelia fault is Holocene-active based on a slip rate of 1mm/yr as determined from fault trenching investigations conducted near the north end of the fault (Borchardt, verbal communication, 2005).

The USGS Earthquake Hazards Program's Fault and Fold Database provides detailed information on faults and on the consultants who have investigated the faults. This information can be accessed at http://eqint.cr.usgs/neic/eq-bin/epic, or at the USGS Earthquake Hazards Program, which provides a broad link of earthquake data, both recent and historical.

SEISMICITY OF COUNTY SUBREGIONS

The data presented below comes form the USGS Earthquake Hazards Program, USGS National Earthquake Information Center. The data is collected using a "Circular Search" (i.e., a 100-km radius from a given latitude and longitude). Two sets of data were accessed for this presentation: (1) *USGS/NEIC (PDE) 1973–Present* and (2) *California, 1735–1974*. This information is generalized; for planning purposes, detailed fault investigations are recommended.

NAPA VALLEY

Historical and preliminary data indicate that there have been eight earthquakes within a 100-km radius of the City of Napa between 1950 and 2005. Magnitudes have ranged from 5.0M to 5.9M.

Between 1900 and 1950, there were three recorded earthquakes ranging from 5.5M to 8.25M (the 1906 earthquake). Between 1836 and 1900, there were nineteen recorded earthquakes, with estimated magnitudes (pre Richter scale development) ranging from 5.1M to 7.0M.

INTERIOR VALLEYS

Historical and preliminary data indicate that there have been seven earthquakes within a 100-km radius of the interior Pope Valley between 1950 and 2005. Magnitudes have ranged from 5.0M to 5.9M.

Between 1900 and 1950, there was one recorded earthquake event of magnitude 5.5M. Between 1836 and 1900, there were twelve recorded earthquake events with estimated magnitude ranging from 5.10M to 6.8M.

BERRYESSA/KNOXVILLE AREA

Historical and preliminary data indicate that there have been three recorded earthquakes within a 100-km radius of the Berryessa/Knoxville area between 1950 and 2005. Magnitudes have ranged from 5.0M to 5.9M.

Between 1900 and 1950, there was one recorded earthquake event and that was a 5.5M in the year 1902. Between 1836 and 1900, there were twelve earthquakes recorded, with estimated magnitude ranging from 5.1M to 6.8M.

Further information on faults and earthquakes can be found on the USGS Earthquake Hazards Program website at: http://eqint.cr.usgs/neic/eq-bin/epic.

GEOLOGIC AND SEISMIC HAZARDS

Napa County is subject to several seismic and geologic hazards. In accordance with the State Government Code §65302 (g), the geologic hazards to be evaluated include slope instability leading to mudslides and landslides, expansive soils, seismically induced surface rupture, ground shaking, ground failure, dam failure, seiches and tsunamis, and subsidence. Bedrock geology has recently been completed (1:24,000 scale) of the southern parts of the County by the California Geological Survey. These maps also show geologic hazards such as landslides and fault traces. A map of Napa County's landslides is shown in Map 1-8.

Landsliding is generally considered the most potentially damaging cumulative geologic hazard in the County because of the widespread and frequent occurrence of damaging events.

HAZARD SUMMARY

Landsliding is generally considered the most potentially damaging cumulative geologic hazard in the County because of the widespread and frequent occurrence of damaging events. [Note that it is important to distinguish between a single event and the cumulative effect when comparing hazards. The most damaging single event would likely be a large (M~7) earthquake on the West Napa fault. However, the probability of such an event is much less than that of damaging slides, so the cumulative potential damage from slides as a class of hazard is greater.] All the major ridge and hills systems within the County have experienced landsliding to varying degrees. Because of similar geology, terrain and climate, this condition is common to the entire Bay Area. Numerous GIS-based and hard copy landslide maps of the County have been developed. Most landslides present the risk of property damage. However, rapid slides such as debris flows and debris avalanches also present the risk of

Earthquake damage in Napa County winery

injury and death. These latter slides are often referred to in the media as mud slides. They are much less prevalent in the County than slower moving types of sliding.

Expansive soils are present within numerous areas throughout the County. While landslides are restricted to hilly areas, the base of hill slopes, and steep banks, expansive soils, along with accelerated erosion (minor rutting and rilling to extensive gullying) can occur on both hills and gently sloping valley areas. While not perceived to present as high a risk as landsliding, these latter two hazards can be damaging to various kinds of improvements. The locations of expansive soils and soils with high erosion potential are shown in the GIS-based soil maps of the County.

Seismic hazard effects are classified as those of seismic shaking and those caused by surface fault rupture. Structural damage from seismic shaking should be anticipated in the County sometime within the next few decades. This risk is high because shaking damage can be caused by one of several of the Bay Areas major faults, which are located outside of the County. In addition, shaking damage can be caused by one of the lesser, active faults within the County. When an earthquake will occur within this decades-long time frame is uncertain.

Depending on the severity of the shaking and the nature of the deposits at the location being shaken, structural damage of various types could occur, including that caused by liquefaction and other ground failures. Older, unreinforced masonry buildings and other city buildings constructed before 1930 that have not been seismically retrofitted are most subject to shaking-induced structural failure/collapse.

The largest area where greater shaking damage is anticipated is within the various valleys of the County. Deeper, unconsolidated alluvial deposits occupy these areas, especially the lower part of the Napa Valley, which is underlain by saturated, estuarine deposits, including the very weak compressible bay muds. Deep, unconsolidated deposits associated with valleys are subject to higher amplitude, longer duration shaking motions (ground shaking amplification), which can cause more damage to improvements than those sited on firmer, shallower deposits. Other areas where ground failure potential exists have been mapped within the County. The locations of areas are shown in the regional, generalized GIS-based maps that are part of the County's database. Generalized maps by Caltrans (1996) showing estimated ground accelerations from a maximum credible earthquake in the Bay Area are also part of the database.

While deep unconsolidated deposits have greater potential for stronger earthquake shaking, this greater potential is recognized in the 1997 UCB or the 2001 CBC. These codes provide for more stringent earthquake resistant design parameters for such areas. Thus, while these shaking impacts are potentially more damaging, they also will tend to be reduced in their structural effects due to UBC or CBC criteria that recognize this potential.

The highest potential for surface fault rupture is along the three known, active faults within the County—the West Napa, Green Valley and Hunting Creek faults. These faults are zoned (at least in part) for special investigation according to the provisions of the Alquist-Priolo Earthquake Fault Zoning Act of 1972. Unlike ground shaking, which has the potential to damage broad areas, surface fault rupture is confined to the relatively narrow zone that brackets the trace of the breaking fault. Extensive damage from fault rupture within the County is judged to have a lower probability of occurring than shaking damage. Fault creep, which is a very slow form of surface faulting, is documented to be occurring along the Green Valley fault, but it is not known if it occurs along the northernmost part of this fault that extends into the County. The potential for seismically induced failures of dams, levees, and large tanks is presumably low, but requires site-by-site evaluation. The more likely candidates for failure damage of this type are older, smaller dams not under the jurisdiction of the Division of Dam Safety of the California Department of Water Resources.

The potential for damage caused by seiches and tsunamis is judged to be low due to lack of bay front exposure within the County. There may be some potential for seiche within large bodies of water within the County, such as reservoirs. While presumably low, the risk has not been evaluated and is beyond the scope of this chapter. To evaluate seiche risk to large tanks requires a site-specific investigation. The Federal Emergency Management Agency (FEMA)-mapped flood zones for Napa County are shown in Map 1-9.

The potential for geologic and seismic hazards to occur at a given location or within a broad area can first be indicated by review of the numerous maps that are listed in this chapter. The actual potential and the characterization of the hazard severity, as well as development of adequate mitigation measures is then determined by geologic and geotechnical investigation done in sufficient detail.

It is beyond the scope of this chapter to predict on a detailed, countywide basis the risk of damage and injuries from future geologic and seismic events. Over the years, a number of reports have been prepared that assess the possibilities of such damaging events on a regional basis throughout California (Hart et al. editors 1982, Ziony editor 1985, Borchardt editor, 19.X, Rowshandel et al. 2005). The only County-specific information acquired that shows specific damage locations was for reported landslide damage as a result of the 1997–1998 El Niño rainstorms (Godt et al. 1999). As a result of these storms, 16 damaging slides were reported. This is a nominal amount of sliding and the County was relatively unaffected. No homes were condemned or in need of significant repair. The Napa County Road Department estimated a total of $1.1 million was required for repair of road surfaces and for debris removal (Godt et al. 1999). Had a large earthquake occurred during these wet winter months, the landslide incidence and damage could have been many times greater.

Rowshandel et al. (2005) have developed estimates of future earthquake shaking damage in the ten Bay Area Counties. This has been done for a number of earthquake scenarios throughout the region. Depending on the scenario, the estimated building damage for the County ranged from a few tens of millions of dollars to 200 to 300 million dollars. Most of this damage would be in the southern, more populated part of the County. Smaller earthquakes, even when on more local faults would result in much less damage. A good example is the Napa Earthquake of 2000, which caused a nominal amount of property damage in the City of Napa, but little damage elsewhere.

The following discusses in more detail the hazards that have been summarized above.

SURFACE FAULT RUPTURE

Surface fault rupture occurs when a fault breaks through to the ground surface as a result of an earthquake. The movement is essentially instantaneous (several kilometers per second) and one side of the fault is displaced relative to the other. The sense of movement can be horizontal, vertical, or a combination of these. The amount of the displacement can vary from a few inches or less to several feet, depending on the characteristics of the fault and the specific event. The length of the rupture varies widely, again depending on fault characteristics. For example, the Great San Francisco Earthquake of 1906 had a magnitude of about 8.0 and broke for a length along the fault of about 430 kilometers (287 miles). Typically, shorter faults correspondingly experience lower maximum magnitude earthquakes and undergo less rupture length. The width of the ground breakage associated with fault rupture depends on a number of factors, including the movement and type and thickness of material the fault breaks through as it nears the ground surface. The surface pattern of mapped faults in the Coast Ranges is typified by those encountered in the County and consists of a series of parallel to sub-parallel traces of varying length comprising a zone that may be up to several hundred or, in some cases, thousands of feet wide. The traces partially overlap their neighboring trace or traces and this pattern is referred to as *en echelon*.

Structures built astride a fault that experience the effects surface fault rupture can be severely damaged or undergo collapse from the nearly instantaneous stress imposed by the fault displacement. Such damage presents high risk for injury and death. Although there is a body of developing research and application for minimizing the surface rupture effects on structures built across active faults, it is still evolving, is relatively expensive compared to standard foundation design, and does not necessarily mitigate all risk of damage (Bray 2001). In the majority of cases at this time, the simplest, least expensive, and safest approach is to avoid the active fault trace. This is done by exposing the fault trace(s) at the project location through trenching and detailed logging. As necessary, this is followed by the development of setback recommendations of human-habitation structures to avoid the trace(s).

The California Geological Survey has designated three faults within the County as active and capable of undergoing surface fault rupture. They are the West Napa, Green Valley and Hunting Creek faults. The characteristics of these faults have been described in detail in the *Seismicity* section of this chapter, above. Since designated as active, these faults are zoned according the provisions of the State mandated Alquist-Priolo Earthquake Zoning Act. With very few exceptions, this act requires detailed investigation of projects intended for human habitation. The intent of the act is to mitigate the risk of damaging surface rupture by avoidance. This includes identifying the fault traces(s) at the project site through detailed subsurface investigation and "setting back" the proposed structure(s) from the trace(s) a specified distance. Provisions for identifying and mitigating the hazard of surface fault rupture for dams above certain dimensions and storage capacities is supervised by the California Department of Water Resources, Division of Safety of Dams (California Department of Water Resources 2004). The California Division of State Architects (DSA) requires the California Geological Survey to review for accuracy and completeness geologic/geotechnical reports prepared for proposed schools and hospitals.

In addition to sudden fault rupture, as described above, a much slower form of rupture exists, known as fault creep. In addition to its slow rate of movement (as slow as a few millimeters per year), creep movements are not associated with the sudden generation of ground shaking that results from rapid rupture events. Although lacking great rupture speed and associated ground shaking, creep movements can nonetheless cause substantial damage to improvements over time. Several faults in the Bay Area are known to be associated with creep movements of various types (Yeats et al.1997). The Green Valley fault that extends into the southeast part of the County is known to have undergone creep movements (Galehouse 1992). It is zoned according to the provisions of the Alquist-Priolo Earthquake Zoning Act.

SEISMICALLY INDUCED GROUND SHAKING

Damage to structures and infrastructure from *seismic ground shaking* caused by the Bay Region's active faults is likely in the County sometime within the next few decades. Based on a combined probability of all seven fault systems and background earthquakes, there is a 62% chance for a magnitude 6.7 or larger earthquake to occur in the Bay Area by the year 2032. Smaller magnitude earthquakes (between magnitudes 6.0 and 6.7), capable of considerable damage depending on proximity to urban areas, have about an 80% chance of occurring in the Bay Area by 2032 (U.S. Geological Survey 2002). A map of Napa County's liquefaction susceptibility conditions is shown in Map 1-10.

> *Landsliding* is one of the most common types of failure resulting from earthquake shaking, which can reactivate dormant landslides, cause new landslides, and accelerate or aggravate movement on active slides.

The severity of the shaking damage at a particular location within the County depends not only on the magnitude of the earthquake and the distance to its epicenter, but also on other factors including the nature and thickness of the deposits at the location. For example, the Napa Earthquake of 2000 resulted in unusually strong ground accelerations (relative to its magnitude) in the City of Napa with attendant damage to structures, while nearer the epicenter at Yountville damage was minimal, even to older buildings. These stronger accelerations and related damage appear to have been contributed to by the apparently much deeper alluvial fill beneath the valley at Napa than at Yountville, which intensified or amplified shaking damage.

> The severity of ground shaking damage at a particular location depends not only on the magnitude of the earthquake and the distance, but also on other factors including the nature and thickness of the deposits at the location.

Caltrans' (1996) map of Maximum Credible Earthquake shaking indicates (with contour lines), the maximum credible earthquake event (deterministic approach) for the entire state of California. A summary table of faults and their Maximum Credible Earthquake can be accessed online at http://www.dot.ca.gov/hq/esc/earthquake_engineering/Seismology/MapReport.PDF.

DSA requires two probabilistic seismic hazard ground motions to be utilized for design of projects. The first ground motion is the PGAUBE and is caused by an earthquake with a 10% chance of exceedance in 100 years. The second ground motion defined by DSA is the PGADBE and is caused by an earthquake with a 10% chance of exceedance in 50 years. Because the PGAUBE has a longer return period, larger earthquakes and subsequently larger ground motions are associated with it. DSA requires that the more conservative PGAUBE be used to determine a site's susceptibility to liquefaction and the PGADBE be used for structure design.

Liquefaction is the sudden loss of soil shear strength during strong ground shaking, due to increased pore water pressure and decreased *effective stress*, that portion of the total stress on the soil that is borne by the soil grains. As a result, sufficiently liquefied soils can no longer support structures built on them or maintain buoyant structures placed beneath them.

Lateral spreading is a ground failure in which a subsurface layer of soil liquefies, resulting in the overlying soil mass deforming laterally toward a free face.

Using the USGS Earthquake Hazards Program and a specific location of the following areas (Seed et al. 1997), the following PGAUBE and PGADBE are recommended.

- Discuss probabilistic versus deterministic approach. For planning, use probabilistic for hospitals and schools; use deterministic for all else.

- The probability studies focus on seven fault systems within the Bay area. Fault systems are composed of different, interacting fault segments capable of producing earthquakes within the individual segment or in combination with other segments of the same fault system.

SEISMICALLY INDUCED GROUND FAILURES

Ground failures due to seismically induced ground shaking are also referred to as *secondary effects*. This is to distinguish them from the primary movement or displacement (surface fault rupture) that occurs along the fault plane, which in turn generates the earthquake shaking. In contrast to primary fault rupture, whose effects are localized along the fault, secondary-shaking effects can extend many miles from the earthquake fault that generated the shaking. That is why a sizable earthquake on a fault outside of the County can inflict damage within the County. Ground failures can result directly from earthquake shaking, or from liquefaction induced by the shaking. In either case, they are referred to as seismically induced ground failures.

The following represent principal ground failures due to shaking.

- Various types of landsliding.

- Liquefaction, including liquefaction-triggered landslides.

- Ground settlements, including differential settlement.

- Lateral spreads, lurching and ground cracking.

Depending on their severity and location, ground failures can be quite damaging.

EARTHQUAKE GENERATED LANDSLIDING

Landsliding is one the most common types of failure resulting from earthquake shaking. Landsliding triggered by ground shaking occurs in the same types of hilly or mountainous terrain that is also the source area for non-seismically induced sliding. Ground shaking can reactivate dormant landslides, cause new landslides, and accelerated or aggravate movement on active slides.

A number of landslide types can occur as the result of shaking. These include all of the slide types shown in the landslide maps of the County. Rock falls and rock topples probably have a higher incidence during earthquakes than under non-earthquake conditions. A large earthquake occurring when the ground is saturated from winter rains has the potential to trigger a large number of landslides of various dimensions and types of movement, i.e., falls, flows, rotations, translations. Non-earthquake generated landslides are discussed in the *Landslides and Soil Creep* section below. In sum, susceptibility to earthquake-generated landslides can be estimated using probabilistic maps of ground shaking and statistical or deterministic evaluation of landslide susceptibility.

LIQUEFACTION

Liquefaction is the sudden loss of soil shear strength during strong ground shaking, due to increased pore water pressure and decreased *effective stress*, that portion of the total stress on the soil that is borne by the soil grains. As a result, sufficiently liquefied soils can no longer support structures built on them or maintain buoyant structures placed beneath them. Liquefied soils on sloping ground may flow in a semi-fluid or plastic state (a lateral spreading), disrupting the original ground surface and damaging improvements in their path. Liquefaction susceptibility in Napa County is shown in Map 1-10.

Experience gained from large earthquakes throughout the world has revealed that liquefaction effects are not random. They occur in areas underlain by loose, saturated, cohesionless (non-clayey) sand, silt, and gravel. Liquefaction prone deposits of this type are geologically young, relatively unconsolidated materials that are most commonly associated with alluviated valleys with high groundwater levels. The GIS-based maps accompanying this chapter indicate that even within these areas, the liquefaction potential varies from high to low due to various factors, including soil type, soil thickness and groundwater levels. Estuarine areas, and areas comprising unengineered, saturated, cohesionless fill are often considered to have relatively high liquefaction potential.

Relative to the total area of the County, alluviated valleys represent a relatively small percentage; roughly about 20% or somewhat less. Therefore, on a countywide basis, the potential for liquefaction-induced ground failures is relatively low. However, most of the County's improved areas are within parts these valleys. As a result, liquefaction that may occur presents a commensurately higher risk of causing damage. Estuarine (marshlands) areas generally present a uniformly higher potential for liquefaction. The largest contiguous area within the County where liquefaction failures could occur is within the loose saturated estuarine deposits along the Napa River, south of the City of Napa. Other smaller areas with ground failure potential are scattered within valley areas throughout the County. More information on liquefaction and it effects can be found on the USGS Earthquake hazards website, *Shake Maps*. USGS Open File Report (OFR 00-444) shows regional liquefaction susceptibility.

OTHER EARTHQUAKE GROUND FAILURES

LATERAL SPREADING

Lateral spreading is a ground failure in which a subsurface layer of soil liquefies (the liquefaction process has been described above), resulting in the overlying soil mass deforming laterally toward a free face. This is a type of landsliding triggered by shaking. Most of the County is not susceptible to lateral spreading. Limited lateral spreading could occur in alluvial areas adjacent to open stream channels where a bank or terrace face exists.

LURCHING

Ground lurching is a short-term ground failure caused by seismic forces exerted on the soil. Ground lurching can occur in areas underlain with soft, weaker surficial deposits and soils and often results in ground cracking and permanent displacements. The largest known area within the County underlain by soft, weak soils is the lower Napa Valley immediately south of the City of Napa. Weaker surficial deposits in the Napa area typically include the Bay Mud, indicated by the map symbol Qhbm on the Graymer map.

SEISMIC DIFFERENTIAL SETTLEMENT

Differential settlement is the non-uniform densification of loose soils that occurs during strong ground shaking and causes uneven settlement of the ground surface. Soils of this type are likely to occur in numerous locations in the County. The largest of these areas are in valley areas. Differential settlement can also occur under non-seismic conditions. Differential settlement can be quite damaging to structures and other above and below ground facilities.

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FAILURE OF LEVEES AND DAMS

The seismically induced failure of levees, earth-fill dams, and other embankments can occur due to the direct failure of the embankment itself or due to seismic failure of the natural foundation materials beneath the embankment, leading to failure of the overlying embankment structure. Due to generally weak foundation materials believed to be present in the southernmost part of the Napa Valley, the risk of levee failure resulting from seismic shaking could be moderate or higher. This is particularly the case for older levees that may not have been constructed to modern standards, including older levees in the Cuttings Wharf area just west of the Napa River.

As of October 15, 2004, 51 dams of various sizes and ages were in the County (California Department of Water Resources 2004). Most of these are believed to be earth-fill structures. Some of these dams are within the jurisdiction of the Division of Safety of Dams of the California Department of Water Resources. Dams that fall within this jurisdiction include (1) dams with structures that are, or will be in the future, 25 feet or more in height from the natural bed of the stream or water course at the down stream at the toe of the barrier or (2) dams that have an impounding capacity of 50 acre feet or more (California Department of Water Resources 2004). These dams are highly regulated during their design and construction phases and routinely inspected during their impoundment life. As such, these jurisdictional dams are monitored and maintained to assure ongoing compliance with seismic stability standards. The remaining dams are either lower or have less impounding capacity. The largest, oldest, and least maintained of these latter dams very likely present the highest risk for seismic failure.

The Division of Safety of Dams report by the California Department of Water Resources (1990) contains a chart showing jurisdictional dam sizes, which correlates dam height in feet to storage capacity. This chart identifies the dam size (jurisdictional versus non-jurisdictional). A first indication of the potential of the underlying geologic materials to fail or cause settlement problems for a dam can be obtained by the various maps that accompany this chapter.

The potential for seismically induced structural failure of large storage tanks must be determined on the basis of site-specific geotechnical design investigation and other engineering investigations.

GROUND SUBSIDENCE/SETTLEMENT

Subsidence and *settlement* result from the same physical processes. Settlement is usually considered to occur within a relatively short time frame and within a small area, for instance on the project scale. Subsidence takes place over a longer time frame and a broader regional area. Subsidence/settlement can occur differentially; that is, one area or location subsides or settles more than another. The results of subsidence/settlement, especially when it occurs differentially, can be quite damaging.

Ground subsidence/settlement has two basic mechanisms: elastic settlement and consolidation. Elastic settlement occurs from structures and other loads that cause deformation of the subsurface soils. Elastic settlement from structures is usually minor and usually occurs during construction or within the first few weeks after construction.

Longer-term ground subsidence requiring months to decades also occurs as a result of the consolidation of natural surficial materials that are compressible. A surficial geologic unit that is known to be quite prone to subsidence is the bay mud that underlies parts of the marsh area in the lower parts of the Napa Valley south of the City of Napa. When fill or structure loads are placed on these muds for development, flood control, or other purposes, significant settlement can result. It is expected that fills previously placed on these deposits are likely undergoing consolidation and settlement of the ground surface. Any new fill or structure loads will induce new settlement in addition to any on-going settlement. Detailed geotechnical investigation is required in order to reduce the amount of settlement to acceptable levels. The time required to complete consolidation of the bay mud depends on the thickness of the bay mud and distance to a drainage layer (underlying sand lenses). The time required to complete settlement can range from a few months to many decades.

Subsidence may result in flooding as ground levels are lowered, including the freeboard of flood control levees. Subsidence can also cause damage to structures, utilities, and roadways from differential settlement. Foundation and walls can crack and the structure tilt out of level. Gravity-based utilities and storm drains can become inoperable due to differential settlement that causes sag in the lines or slope reversal. This potential highlights the need for recognition of the presence of bay mud and similar deposits, and their careful investigation.

Differential settlement is the non-uniform densification of loose soils that occurs during strong ground shaking and causes uneven settlement of the ground surface.

Gully Erosion

Settlement is usually considered to occur within a relatively short time frame and within a small area, for instance on the project scale. Subsidence takes place over a longer time frame and a broader regional area.

Ground lurching is a short-term ground failure caused by seismic forces and can occur in areas underlain with soft, weak soils and often results in ground cracking and permanent displacements.

LANDSLIDES AND SOIL CREEP

The purpose of this section is to provide introductory-level discussion and description of landsliding and related types of slope failures in the County. This, along with appropriate review of the accompanying GIS-based landslide maps and hard copies of referenced, non-GIS landslide maps, is the first step in identifying potential landslide hazards at given a locality and in developing appropriate measures for hazard mitigation.

MAP TYPES, USES, AND LIMITATIONS

The GIS-based landslide maps and list of referenced, non-GIS landslide maps that accompany this chapter are a countywide compilation selected from sources published over several decades (1976–1999). Various geologic professionals, using similar but not identical mapping and classification techniques, prepared the maps. The principal mapping method used in their preparation was aerial photograph interpretation, supplemented in some cases by varying amounts of field mapping. Each of the selected landslide publications covers only part of the County, and not all of the maps were prepared at the same scale; some at one inch equals 2,000 feet (1:24,000 scale) and others at 1 inch = 1 mile (1:64,500 scale).

As a result published maps vary in several respects, including the landslide classifications selected to depict the slides shown in the maps, the level of graphical detail employed to show the various landslide features, the degree of indicated landslide activity, and the type of indicated movement. Some landslide maps are accompanied by geologic maps of the same scale and area, showing bedrock and surficial deposits; others are not so accompanied. These former maps can be quite useful because they provide an indication of which bedrock and surficial units are most susceptible to landsliding. Using GIS, landslide maps can be compared and even statistically correlated.

Essentially, landslide maps are useful for planning, preliminary environmental assessments, identifying the need for more detailed investigation, and providing an initial indication of the level of detail required in performing on-site geologic evaluations. Proper application includes using the maps early in the planning process to develop an initial indication of the possible degree of landslide hazards and their impact on a project and its surrounding environment.

In some cases, relative landslide susceptibility maps accompany landslide maps. These are derivative maps; their intent is to show the relative potential for future landsliding throughout the entire area covered by landslide maps and at the same scale. They are interpretive in nature and are based on a number of factors, including variations in bedrock type, degree of slope, slope aspect, and so forth. Typically, a four-value scale, ranging from least to most susceptible, is used.

Although interpretive, and varying in scale and detail, landslide susceptibility maps provide a good planning-level depiction of existing and potential landslide hazards and their variability throughout those parts of the County for which they have been prepared.

Essentially, landslide maps are useful for planning, preliminary environmental assessments, identifying the need for more detailed investigation, and providing an initial indication of the level of detail required in performing on-site geologic evaluations. Proper application includes using the maps early in the planning process to develop an initial indication of the possible degree of landslide hazards and their impact on a project and its surrounding environment. It is important to recognize that the maps are not a substitute for detailed site-specific landslide investigations. They are useful, however, to indicate when such investigation is required or desirable for a particular project; along with the type of proposed project, landslide maps can be used to suggest the extent and detail of the investigation. Although not generally anticipated, these maps may also in some instances incorrectly predict hazards. For instance, a particular landform interpreted to be a hazard (such as a landslide) and indicated as such on a landslide map may, in fact, not be of landslide origin. This can only be revealed by site-specific investigation.

Some of the maps were prepared at a scale of 1:24,000 and others at 1:62,500. Electronically enlarging a map beyond its original scale of preparation will not provide additional detail or better information, and may be misleading.

The first two GIS landslide maps in the series are large-area overview maps. By initially referring to these maps or the described landslide susceptibility maps, the user will benefit by gaining a sub regional sense of landslide occurrence and landslide potential in the area surrounding a particular site. Reference should then be made to the relatively more detailed maps (quadrangle sheet) which, focus on delineating specific landslides and their locations relative to a given project, or area of interest.

IMPORTANCE OF LANDSLIDE TYPE

Like other parts of the Coast Ranges, Napa County exhibits a wide variation in landslide types. This variation includes type of movement, size and depth, geometry, degree of activity, rate of movement, and density of landslide development. Based on these variations (generally by type of material and type of movement) landslides are classified and referred to by such terms as *slump*, *earth flow*, *translational*, *fall*, *flow*, and so forth. Not all landslides present the same level of risk to a given project, and different projects may have different levels of risk from the same landslide. Some bedrock formations and surficial deposits are more prone to landslide failure than others, and some slope types can be more prone to sliding or particular types of sliding than others. Information on landslide variation within the County can be obtained by review of referenced landslide maps and their accompanying explanatory text. Additional information is available online and in hard copy from state and federal agencies such as the California Geological Survey and the USGS.

Most landslide types usually present a greater risk of property damage than risk of physical injury or death, because most landslides proceed at a slow rate of movement. However, some types have a higher probability of causing physical injury or death. These latter slides are characterized by their rapid movement (up to several tens of feet per second) and long travel distance (runout) from point of origin. They are most commonly classified as *debris flows* and *debris avalanches* on the landslide maps. When their movement is reported to the public by the media, such failures are often referred to as *mud slides* or *mud flows*. Several but not all of the County landslide maps show the potential for slope failures of this type. Because of the type of risk they present, such slides and the areas within which they are shown to occur should be carefully investigated and, as found necessary, appropriately mitigated. This is especially the case for proposed improvements designated for human habitation, including critical facilities (hospitals, police/fire stations, schools, prisons, main access routes, etc.).

EROSION

Erosion is the general process or group of processes in which materials of the Earth's crust are loosened, dissolved, or worn away and simultaneously moved from one place to another by natural agencies. These agencies include weathering, solution, corrosion, and transportation, but usually exclude mass wasting processes such as landsliding and soil creep. More specifically, erosion is the mechanical breakdown of rock material and the removal of the resultant materials, such as soil and rock particles, by running water, wind, etc. Erosion can be natural or it can be caused or exacerbated by the activities of humankind. Exacerbated erosion is referred to as *accelerated erosion*. Erosion K factor is shown in the map of Map 1-11.

Sandy soils on moderate slopes or clayey soils on steep slopes are susceptible to erosion, especially when subjected to concentrated surface water flow. Weathered rock can also be eroded if the concentrated flows are sufficiently high. The potential for erosion is accelerated when established vegetation is disturbed or removed, particularly on hillside areas. On hillside areas the result can be rilling, rutting, and, without correction, the eventual development of damaging gully systems. The eroded material may be transported to stream courses and cause water quality and other environmental problems.

Along many natural drainage courses on both hillsides and within the valley areas, stream and river flow erodes banks. This results in water siltation and also causes the location of the stream or river to meander (lateral migration of the channel). If the migration is sufficient, it can undermine structures or roadways and cause damage or collapse. These natural processes can be accelerated or initiated by inappropriate or poorly designed/constructed improvements.

The potential for natural and accelerated erosion damage exists at many locations throughout the County. This potential is also common to most of the Bay Area. This potential is due to the large total area occupied by hill and ridge systems in the County relative to gently sloping valley areas. The potential for increasing amounts of accelerated erosion exists due to such activities as continued hillside development, including vineyards and other types of land modification.

If the potential for accelerated erosion is recognized in the project planning process, it can be greatly reduced by the design and installation of adequate erosion control facilities. Alternatively, areas identified as environmentally sensitive or excessively prone to erosion can be precluded from development or greatly scaled back in terms of the amount or type of development. Where erosive soils should be anticipated can be found by referring to the earlier described SSURGO database or the equivalent hard copy U.S. Soil Conservation report by Lamber and Kashiwagi (1978). The soil database contains a list of the soil units that have the potential for accelerated erosion. Referral to GIS-based and hard copy maps of landslides and surficial deposits can also assist in identifying erosion prone areas. The actual potential for such erosion should be confirmed by site-specific, follow-up investigation.

EXPANSIVE SOILS

Certain clay-rich soils can cause considerable damage to structures, streets, and roads as they shrink and swell in response to seasonal changes in their moisture content. Such soils are referred to as *expansive*. In late summer, expansive soil shrinks and cracks (up to 1 to 4 inches wide) as the soil dries and hardens. In the wet season, swelling of the clay closes the cracks, and the soil then is plastic and weak. The forces exerted during expansion and contraction are sufficient to heave and distort buildings and to crack shallow foundations and pavements.

Expansive soils exist at a number of locations in the County. Such conditions are typical of much of the Bay Area. The SSURGO database or the equivalent hard copy report by the U.S. Soil Conservation Lamber and Kashiwagi (1978) are good sources that indicate where such soils should be anticipated.

If expansive soils are initially anticipated through map review, their actual presence or absence should be determined prior to construction by site-specific geotechnical investigation. When this is done, special engineering methods can be used to reduce the stresses on buildings and utility lines. When expansive soils occur on a hill slope, they undergo the slow seasonal down slope movement known as *soil creep*. This down slope process adds to the potential for these soils to damage improvements.

Erosion is the general process by which materials are loosened, dissolved, or worn away. There are many natural and human-related causes of erosion. The process of in-stream channel erosion, as shown in this image, includes bank slumping and shearing, channel bed incision, and channel widening.

In the event of a large earthquake, the planning area could locally experience some or all of the above-listed ground failures. Such failures can cause damage to structures, breaking of underground utilities, embankment failures, differential settlement of structures, cracking in paved areas, and rising of buoyant buried facilities relative to ground level, such as empty or partially empty storage tanks. The potential for highly damaging failures of this type within the planning area ranges from moderate to low in the unconsolidated deposits of colluvium, alluvium, and marsh/bay mud (hill-front, valley, and near-bay front areas, respectively) to remote in areas underlain by bedrock (primarily hill-slopes). Failure potential is moderate in undocumented fill areas that are or might be subject to development at some future time. Such fills are believed to be primarily present over bay mud and in existing landfill areas (the same areas as those identified in the Modified Mercalli Scale.

GEOLOGIC HAZARDS OF COUNTY SUBREGIONS

Geologic hazards of the BDR study area have been discussed in earlier parts of this chapter. The following provides a summary of the types of hazards particular to the subregions and indicates the order of their importance. Seismic ground shaking will affect all the subregions, but not uniformly.

NAPA VALLEY

Landsliding, amplified seismic ground shaking and related effects, and subsidence are identified as the principal geologic hazards of the Napa Valley subregion. Erosion and expansive soils are significant on a more localized basis. Landslides are non-uniformly present on slopes to either side of the Napa Valley, including large zones of sliding. Most amplified ground shaking is expected in the Napa Valley from the City of Napa southward. Subsidence hazards are primarily located in the larger areas of marshlands located in the southern part of the subregion associated with fault rupture on the West Napa fault.

INTERIOR VALLEYS

Landsliding is the greatest hazard due to the many very large, continuous zones of massive landslides present throughout the length of the interior valleys subregion. Large areas of expansive soils/rock are suspected due to the presence continuous serpentinite bodies and shales associated with the Great Valley sequence rocks. Erosion hazard are expected to be locally high. Some amplified ground shaking and related effects may occur in the relatively small valleys of the subregion. Earthquake shaking could reactivate some of the large landslide zones. In the interior valley areas most of these hazards are associated with rupture along the Green Valley fault.

BERRYESSA/KNOXVILLE AREA

The type and degree of geologic hazards of the Berryessa/Knoxville subregion are expected to be similar to that of the interior valleys subregion. There are however, fewer large zones of landsliding present, and the risk of massive failures of this sort is lower. Because the areal extent of serpentinite is greater, there is probably increased potential for expansive soils/bedrock. The potential for seiche occurrence in Lake Berryessa has apparently not been evaluated and is beyond the scope of the Baseline Report. In the Berryessa/Knoxville area most of these hazards are associated with rupture along the Hunting Creek fault.

CONCLUSIONS AND REPORT UPDATE RECOMMENDATIONS

Certain clay-rich soils can cause considerable damage to structures, streets, and roads as they shrink and swell in response to seasonal changes in their moisture content. Such soils are referred to as *expansive*.

COUNTYWIDE

There are several regulations, acts, codes, and ordinances, from the federal to the county level, that require geologic or geotechnical study or investigation, and for which the County is required to provide some form of response, regulation or review. These various laws are for the purposes of protecting public safety and welfare, and environmental protection.

The physiography of Napa County is predominantly rugged and consists of a small number of long, linear, northwest-trending, major and lesser valleys, separated by broad, steep, rugged ridge and hill systems of moderate relief that have been deeply incised by their drainage systems. The present geomorphic setting is a result of complex interactions of tectonics that took place over millions of years. The result is a region of unique and varied beauty.

The physiography influences the local climate, the development of soils, and the existence and location of geologic hazards such as landsliding. The combination of physiography, bedrock types, soils, and climate (and micro-climates) has resulted in a County rich in resources and the benefits they offer, including the production of premium wine grapes and other agricultural products for which the County is famous.

The bedrock types of the County are varied and are made up of two principal components: (1) an older set of rocks composed of amalgamated, highly deformed terrenes that have been displaced (at least in part) via plate tectonics, from hundreds to thousands of kilometers from their position of origin and (2) a younger, less deformed set of rocks that overlie the amalgamated terrains and which are roughly in their original position.

The structural geology of Napa County, like all of the Coast Ranges, is complex and continues to evolve due to broadly regional forces acting along the North American and East Pacific plate boundary. However, the overall picture is consistent with the younger Pliocene-Quaternary (about the last 5 million years) compressional deformation superimposed on earlier extensional deformation.

The continued structural evolution of the County occurs as a number of ongoing but deceptively slow, subtle geologic processes. The results of these processes are best identified over long time periods known as *geologic time*. An episodic and more abrupt geologic process that is more obvious to the layperson is the presence of active faulting, which occasionally results in felt and sometimes damaging earthquakes. The most recent damaging earthquake was the Napa Earthquake of 2000.

Important among these younger structures in Napa County, are three active faults: the West Napa fault, the northernmost few miles of the Green Valley fault, and the Hunting Creek fault. While not zoned by the State of California, this chapter also considers the Cordelia fault to be active.

A number of geologic and seismic hazards exist in Napa County.

- Landsliding.
- Structural damage directly caused by earthquake shaking or from ground failures resulting from the shaking.
- Surface fault rupture caused by movement along a fault trace as a result of an earthquake.
- Seismic and non-seismic subsidence and settlement.
- Expansive soils.
- Accelerated erosion.
- Water wave damage by seiche and tsunami.

The losses from these various hazards can be greatly reduced by diligent adherence to the laws, regulations and codes described in this chapter. On a year-in and year-out basis, landsliding is potentially the most damaging hazard. On a longer time frame (decades), greater damage is projected to result from earthquake ground shaking.

It is currently estimated that there is a there is a 67% chance for a magnitude 6.7 or larger earthquake to occur in the Bay Area by the year 2032. Depending on the proximity to the County and actual magnitude of the earthquake, shaking damage in the County could range from nominal to high. Older, unreinforced masonry buildings and other buildings constructed before 1930 that have not been seismically retrofitted are most subject to structural failure/collapse. Worst-case earthquake scenarios indicate that intense ground shaking generated by a very large earthquake (greater than 6.7) on one of the Bay Areas major faults in relatively close proximity to the County could cause loss (structural damage, injury and social/economic dislocation) within the County totaling more than $300 million. As the County becomes more populated and developed, this figure will increase. Smaller or more distant earthquakes could cause loss in the millions to tens of millions of dollars.

The three known active faults listed above have the potential to cause surface fault rupture within the County. Damage from surface fault rupture is relatively low compared to the much wider effects of earthquake ground shaking.

The potential for damage caused by seiches and tsunamis is judged to be low, but further study is necessary for confirmation.

CONCLUSIONS SPECIFIC TO COUNTY SUBREGIONS

NAPA VALLEY

The physiography of the Napa Valley subregion has dominant northwest-southeast trend. Major streams are generally well incised with deep canyons. The Napa Valley is the largest and most significant valley of the subregions. Napa Valley is a major groundwater resource.

Near the south end of Napa Valley the alluvium may be relatively quite thick, possibly as much as about 1.2 miles (2 km). The mouth of Napa Valley and southward to the County line in the subregion contains major marshlands.

Soils of the Napa Valley and those of localized side slopes to either side are a major resource for agriculture.

Landsliding, amplified seismic ground shaking and related effects, and subsidence are identified as the principal geologic hazards of the subregion. Landsliding hazards are distributed non-uniformly throughout the hillside areas of the subregion. There is potential for surface ground rupture along the West Napa fault, with attendant ground shaking. The potential for amplified ground shaking damage appears greatest in the vicinity of the City of Napa and southward. The potential for subsidence is greatest in the marshlands from just south of the City of Napa to the southern boundary of the subregion. On a more localized basis, erosion and expansive soils are significant hazards within the subregion.

INTERIOR VALLEYS

The interior valleys subregion is predominantly hilly with major ridge systems that have a dominant northwest-southeast trend. Major streams are generally well incised with deep canyons. There are several small valleys located from north to south within the subregion.

There are numerous, very large zones of landsliding present within the subregion. Landsliding is the principal geologic hazard within the subregion. Due to their relatively large numbers, earthquake shaking could reactivate some of the large zones of landsliding. Large areas of expansive soils/bedrock are expected to be in existence due to the presence of continuous bodies of serpentinite and shale/mudstone. Erosion hazards are expected to be locally high.

Some amplified ground shaking and related effects may occur in the valley areas. The active Green Valley fault is a localized, potential source for surface ground rupture in the southernmost part of the subregion. The Green Valley fault may be undergoing fault creep. The nearby, active Cordelia fault presents less potential for surface ground rupture than the Green Valley fault.

BERRYESSA/KNOXVILLE AREA

The physiography of this Berryessa/Knoxville subregion is similar to that of the interior valleys subregion. The principal physiographic feature is the former Berryessa Valley that now contains the reservoir of Lake Berryessa. The high, steep, northwest-southeast Blue Ridge that borders the County on the east is a prominent physiographic feature.

Landslide development is locally high, but not as high as in the interior valleys subregion. The type of geologic hazards is similar to that of the interior valleys subregion. The active Hunting Creek fault presents potential for ground surface rupture. The potential for seiche occurrence in Lake Berryessa is not known and its evaluation is beyond the scope of this chapter.

UPDATE RECOMMENDATIONS COUNTYWIDE

The County should continue to provide regulation, review, and other oversight duties of the various acts, codes and ordinances that contain geologic and geotechnical provisions. Some of the more pertinent of these have been described in this chapter.

A formalized geologic peer review process should be developed by the County and implemented for large, complex projects. In particular, peer review should be done for those projects with significant, recognized or potential geologic or seismic hazards.

Generally, landsliding is the principal geologic hazard in the County. This dictates the need for careful review and investigation of landslide hazards as they relate to public and private improvements.

In the longer term (years to decades), the greatest damage potential will be from earthquake ground shaking.

Part of the peer review development process should include identifying a small number highly qualified geologic and geotechnical consultants experienced in the review process, and developing criteria for avoiding conflict of interest.

If the County decides peer review is required, the reviewer should be selected and should commence to communicate and work with the applicant's consultants. The intent is to provide proactive rather than reactive peer review, resulting in a fair, complete, and expeditious review product.

The various GIS-based and hard copy maps that have been compiled and reviewed for use in the geologic data base should be routinely updated by the County or their consultants. The update search should be formalized and done yearly.

The USGS maps of Graymer et al. 2002 and 2005 (in press) should be referred to as the most recent geologic maps that provide countywide coverage. However, there are also recent (2004) geologic maps that provide partial coverage of the County that is of at least equal detail. These are of 1:24,000 scale maps of the California Geological Survey and are presently only available for the southernmost part of the County. These maps should also be referred to for these southern areas.

Subsidence in all areas of mud levees needs to be evaluated.

A workshop should be conducted by geologists for County personnel responsible for using the many maps and related documents comprising the BDR. The purpose would be to clarify the proper use of BDR by developing use methodology.

When the forthcoming maps for the Seismic Hazards Mapping Program (Seismic Hazards Mapping Act of 1990) become available, the County will be required to comply with the provisions of the Act. The basic responsibilities the County will have can be found in publications (electronic and hard copy) by the California Geological Survey.

Generally, landsliding is the principal geologic hazard in the County. This dictates the need for careful review and investigation of landslide hazards as they relate to public and private improvements.

In the longer term (years to decades), the greatest damage potential will be from earthquake ground shaking.

The County should require or continue to require the seismic retrofitting of older, unreinforced masonry buildings used or proposed for use in any form of human occupancy. This should include other older structures built before 1930.

The County should consider further study or investigation for tsunami and seiche potential.

UPDATE RECOMMENDATIONS SUBREGION

NAPA VALLEY

The soils of the Napa Valley subregion are an important resource, particularly the agricultural soils, and they should be protected from erosion. This includes continued implementation of existing erosion control ordinances and regulations for agriculture and facilities development.

Continued research and related field investigation should be done on the surface ground rupture and seismic shaking potential of the West Napa fault.

The potential for amplified ground shaking should be recognized in the southern part of this subregion and be responded to in the investigation and design for new facilities, especially critical facilities and larger multi-story facilities.

Given the greater relative number and long history of communities in the subregion, requirements for seismic retrofitting of older, unreinforced masonry buildings for human occupation should be adopted, or if this requirement already exists, its enforcement should continue. This recommendation should also apply to older structures built before 1930.

Detailed geologic and geotechnical investigation should be required for areas with recognized geologic hazards. These hazards have been discussed in the subsection on subregion hazards. Particular care should be exercised in areas of recognized large landsliding, areas susceptible to subsidence and surface fault rupture. It may be found advisable to limit development in the zones of massive landsliding due to their size and great economic and technical challenges associated with their mitigation.

INTERIOR VALLEYS

The soils of the interior valleys subregion are an important resource, including more localized areas of agricultural soils, and they should be protected from erosion. This includes continued implementation of existing erosion control ordinances and regulations for agriculture and facilities development.

With respect to future development, especially for large or critical facilities, the large number of zones of massive landsliding prevalent within the subregion should be very carefully evaluated for the risk of future movement. It may be found advisable to limit development in these landslide areas due to their size and great economic and technical challenges associated with their mitigation.

Continued research and related field investigation should be done on the surface ground rupture and seismic shaking potential of the Green Valley and Cordelia faults.

While not zoned as active by the State of California, it is recommended that investigation similar to that required by the Alquist-Priolo Earthquake Act be required for the Cordelia fault.

BERRYESSA/KNOXVILLE AREA

The recommendations for this Berryessa/Knoxville subregion are similar to those of the interior valleys.

Continued research and related field investigation should be done on the surface ground rupture and seismic shaking potential of the Hunting Creek fault.

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SUMMER 2008

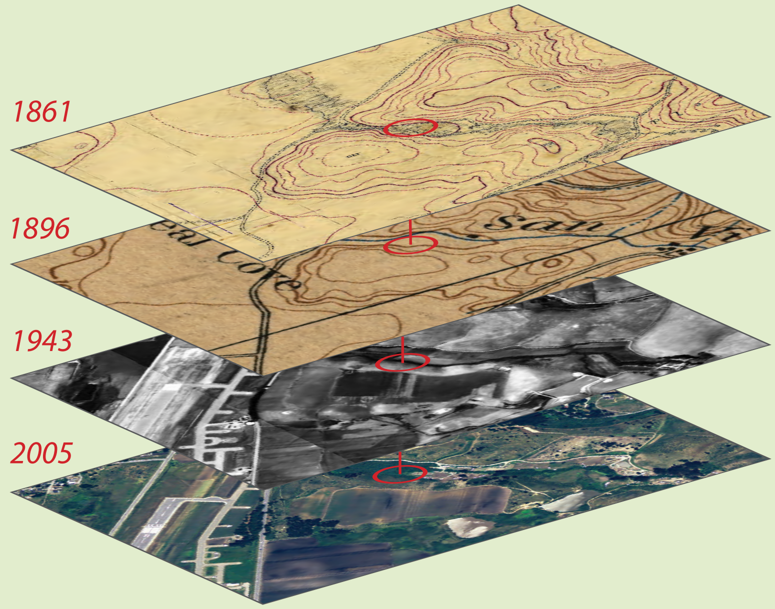
THE HISTORICAL ECOLOGY OF NAPA VALLEY: *An Introduction*

Old Adobe House, Soscol Ave., Napa.

Over the past several years, a team of researchers has assembled thousands of pieces of evidence about how the Napa Valley functioned under more natural conditions. Previewed for the first time here, this information can help us understand how the local landscape has changed through time and help us develop strategies to improve its health in the future.

Photograph courtesy of The Bancroft Library, UC Berkeley.

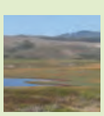
DATA COLLECTION • Research begins with the acquisition of historical materials from a broad range of institutions, including local museums and historical societies, city and county archives, and regional libraries. Journals, diaries, and newspaper articles about the landscape and notable environmental features document historical conditions. Early maps, surveys, and aerial photography provide the locations of historical features, such as streams, wetlands, and plant communities, as well as remaining property boundaries and roads that are valuable links to the contemporary landscape. Other important sources include landscape photography, sketches, and paintings.



DATA COMPILATION • Sources are drawn together for synthesis and analysis along the themes of historical vegetation types, channel geometry, seasonality, and land use. We georeference early maps and aerial photography in a geographic information system (GIS), which allows historical evidence to be compared to modern conditions. We also extract and organize pertinent quotes from early land surveys and narrative sources and, where possible, place them on maps of the past and present. This process of comparing multiple, independent sources of historical and modern information facilitates a detailed and accurate depiction of environmental change.

SYNTHESIS AND ANALYSIS • We rely heavily on GIS to synthesize the data into layers that represent historical landscape characteristics. Mapped features may include channels, perennial and seasonal wetlands, coastal features, woodlands and savanna, and other habitats — each coded independently with their supporting sources and relative certainty level. A variety of methods are used to compare past and present landscapes, describing changes in habitat form and distribution. These depictions of habitat change are used by ecologists and other environmental scientists to describe changes in ecological functions, such as wildlife support. As a reliable map of the pre-modification landscape is developed, it begins to reveal the relationships between native habitats and physical gradients such as topography, salinity, and hydrology, providing a basis for identifying adaptive restoration and management strategies for the contemporary landscape.

REPORTS, GRAPHICS, AND PRESENTATIONS • The analysis is brought together into broadly accessible tools, including illustrated reports, websites (such as wetlandtracker.org), and maps. These present trends in habitat types and extent, discuss conceptual models and areas of interest for future environmental improvements, and provide direct access to many of the most significant historical data sources.



APPLICATIONS • Understanding the historical landscape and how it has changed over time can help address many of the challenges associated with managing and planning for the future of local watersheds. Historical ecology can help set priorities for restoring natural functions to local creeks, identify natural ways to reduce flood hazards, and reveal previously unrecognized conservation opportunities. The historical analysis often reveals ways to restore native habitats within our developed landscape for recreational benefits as well as wildlife conservation. Historical ecology can also reveal management constraints resulting from historical landscape changes, providing a more realistic basis for planning the future.

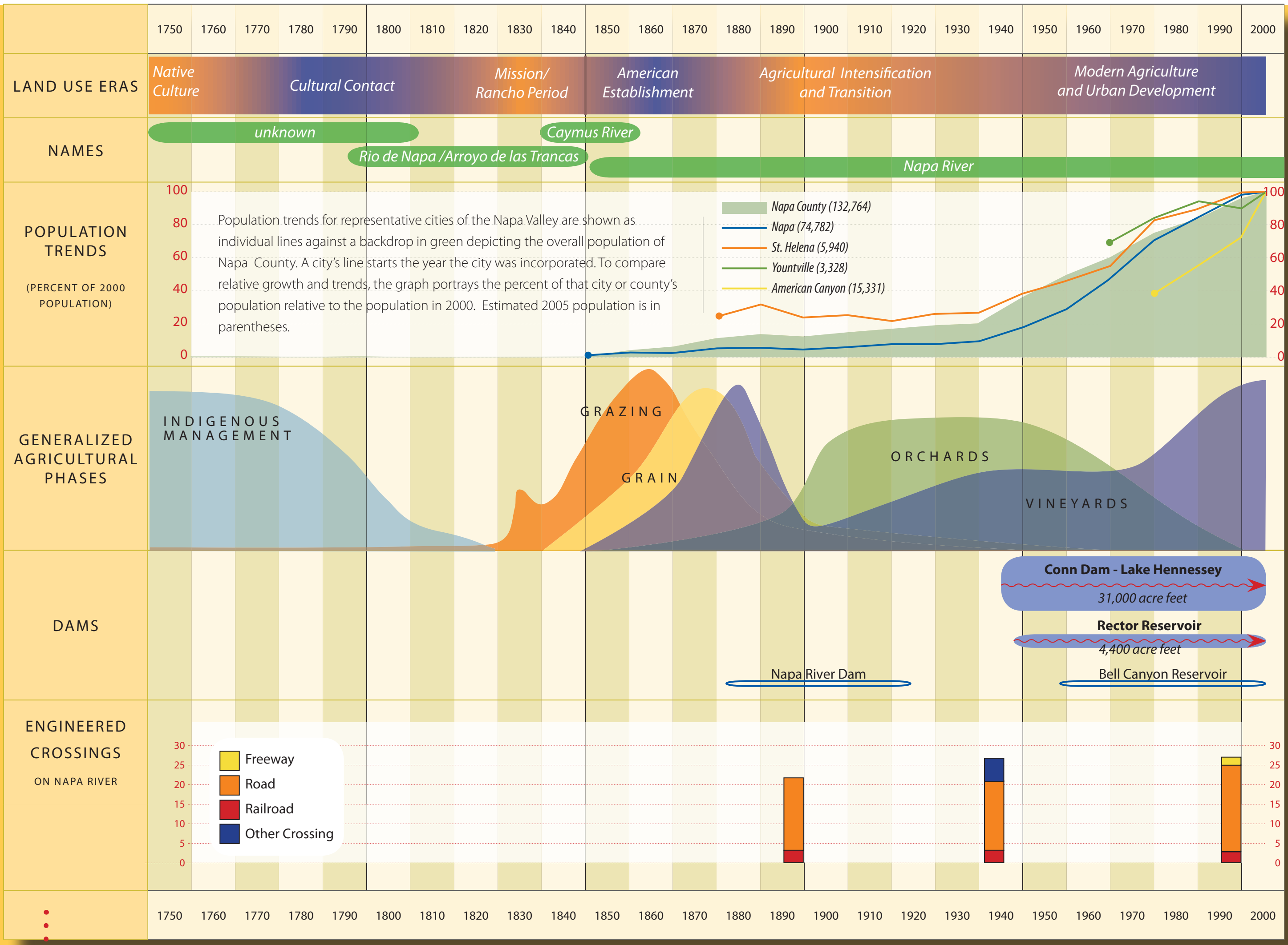
Napa Valley in the RECENT PAST

HISTORICAL RECORDS paint a picture of a moist Napa Valley that naturally stored water for the long summer drought. In the lowlands, there were thousands of acres of seasonally wet meadows surrounding pockets of tall tule marsh. The river bed was not much lower than the valley floor, and flood water spread into sloughs and wetlands. The river divided and reunited, creating natural islands hundreds of acres in size. Many of the tributaries did not connect directly to the Napa River, but dissipated into valley wetlands, recharging groundwater. As the rest of the valley dried in the summer months, the wetlands released water to the river, which helped maintain its flow.

April Showers, Napa Valley by Jules Tavernier, ca. 1880. Courtesy of California Historical Society.

On the well-drained tributary fans, sloping gently between the valley bottom and the adjacent hills, grand valley oaks flourished. Able to reach the seasonally receding groundwater table, these majestic trees dominated the drier parts of the valley. Further downstream where the river met the Bay, it spread into a vast area of tidal marshland.

During the last two centuries, the river and its valley have been extensively modified. Memories of the native landscape and the history of modification have faded. Yet many of the most basic physical and ecological characteristics persist. The historical landscape provides a template for strategically recovering selected ecological functions. Historical ecology can help us decide the next steps toward better ecological health.



Above, this series of timelines encapsulates the history of Napa Valley land use, from indigenous land management to Mission/Rancho-era ranching to American farming, viticulture, and residential expansion.

3

NAPA VALLEY circa 1830

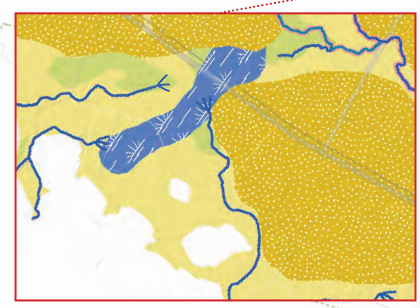
THIS MAP SHOWS THE HABITATS AND DRAINAGE PATTERNS of the Napa Valley before significant modification by Spanish and American settlers. It is based upon hundreds of historical records – including early surveys, photographs, and written accounts – which have been integrated into an annotated, composite map.

Photo courtesy of Sharon Cisco Graham

IN EARLIER TIMES there were various river reaches (see figure below) with differing functions for fish and wildlife habitat, sediment transport or storage, and flood conveyance. The river spread into floodplain wetlands where the valley was wide, narrowed and steepened at confining topographic and geologic barriers, and picked up sediment and water at major tributary confluences. In contrast, today's Napa River is relatively homogenous, generally occupying a single thread channel with a narrow adjacent riparian corridor.

The topography that controlled the river has not much changed, suggesting that a variety of river reaches and functions can be restored.

The broad gravel bars formerly common along Napa River are now relatively rare. As the channel has cut down, these areas have received less frequent scour and are now often invaded by dense riparian vegetation.



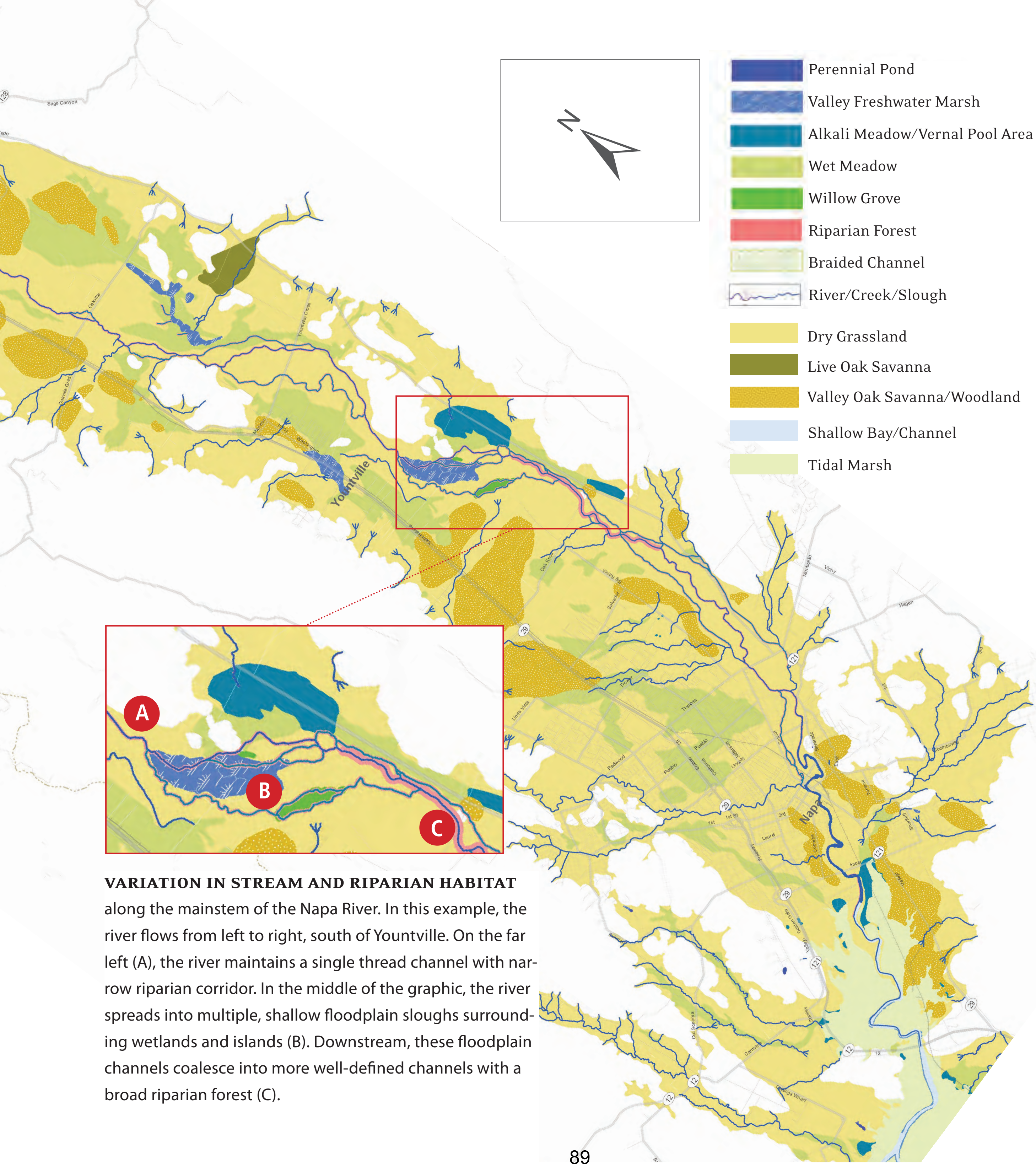
MANY OF NAPA VALLEY'S CREEKS dissipated on the valley bottom or lower alluvial fans. High flows temporarily linked valley floor wetlands, intermittent streams, and the Napa River. In the dry season, these features were mostly disconnected from each other.

Distinct Napa River reaches, based on historical evidence.

4

NATURAL VARIATIONS IN FORM AND FUNCTION

The Napa Valley of the 19th-century supported varied habitats within a relatively small area. Dryland habitats such as oak savanna and grasslands were found not far from perennially wet marshes. Seasonally flooded wet meadows covered large areas of the valley floor, especially in the flatter, broader southern half of the valley. There were alkali meadows at the Calistoga hot springs, near the head of the valley, and adjacent to tidal marshland at the edge of the Bay.



VARIATION IN STREAM AND RIPARIAN HABITAT along the mainstem of the Napa River. In this example, the river flows from left to right, south of Yountville. On the far left (A), the river maintains a single thread channel with narrow riparian corridor. In the middle of the graphic, the river spreads into multiple, shallow floodplain sloughs surrounding wetlands and islands (B). Downstream, these floodplain channels coalesce into more well-defined channels with a broad riparian forest (C).

WETLAND MOSAICS: *Wildlife Habitat, Surface Water Storage, and Groundwater Recharge*

CALISTOGA HOT SPRINGS circa 1880

FRESHWATER WETLANDS IN NAPA VALLEY OCCURRED IN SEVERAL DISTINCT PATTERNS. Large wet meadows were common at the base of alluvial fans and behind the natural levees of the Napa River. Perennial freshwater "tule marshes" were associated with distinct topographic basins on the valley floor. There were also vernal pool areas, alkali meadows, and willow groves. These habitats generally occurred in association with each other, forming larger mosaics of wetlands along gradients in topography and hydrology.

Some of the areas of historical wetlands remain flood-prone and difficult to farm. These areas may provide some of the best opportunities for restoring wildlife habitats and, at the same time, reducing downstream flood hazards.

Turrill and Miller, n.d [circa 1880]. Courtesy of California Historical Society.

THE MARSHY LAND can be made tillable land by drainage – with present condition it cannot be cultivated.
–Vines 1861

Courtesy of Napa County.

Steam spouts show the wetlands associated with Calistoga Hot Springs (note standing water to the right of the row of white houses). The thermal springs and surrounding area were described by Bartlett in the mid-1850s: "[the springs] are in a plane near the base of a small hill of conglomerate rock; but owing to the wet and boggy condition of the valley, we were unable to approach within thirty feet of them. Columns of steam were rising from them on all sides" (Bartlett 1854).

This County survey shows "Marsh Land" and "Sloughs" north of Yount's Mill in the 1870s. Wetlands like these occupied natural flood basins receiving overflow from the Napa River and tributaries, providing foraging habitat and high flow refuge for native fish, including salmon.

6

The Future
of the VALLEY'S GREAT OAKS

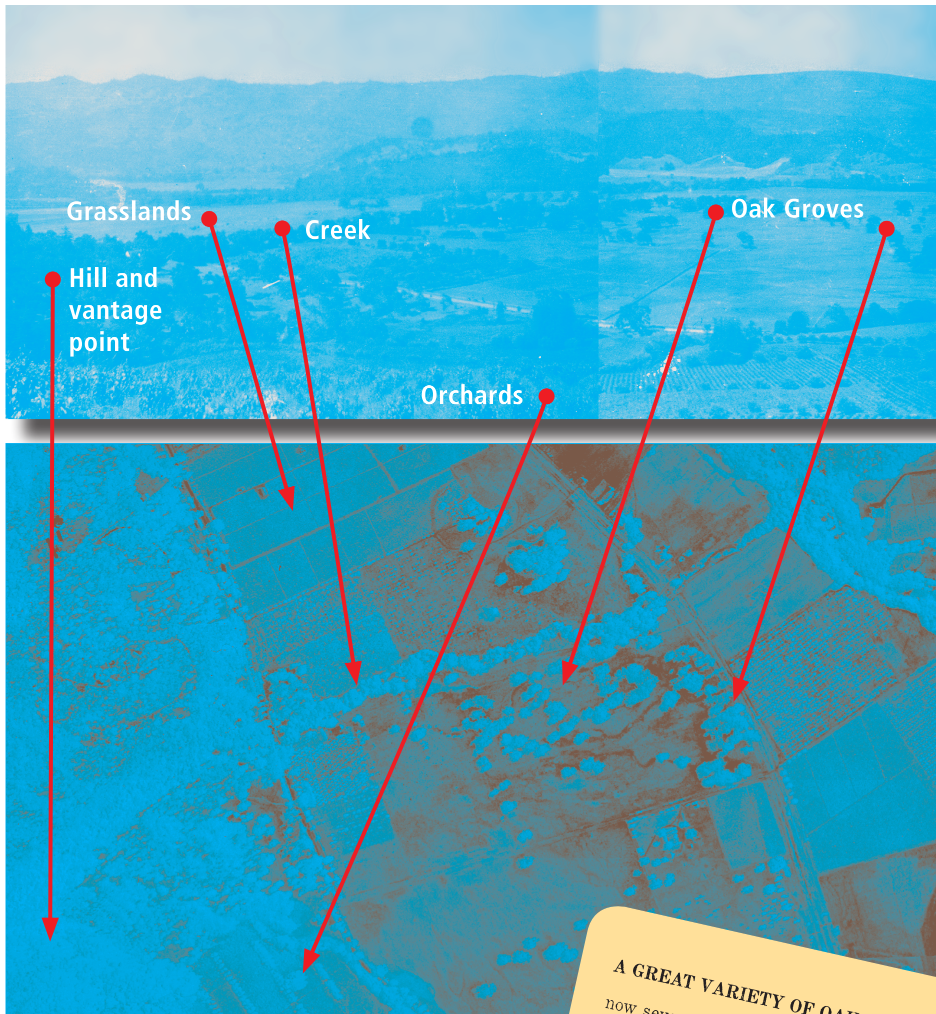
Stately valley oak trees are emblematic of the Napa Valley, perhaps its most celebrated attribute in early accounts.

"The magnificent oaks are one great secret of Napa's beauty. Their rustling leaves and finely formed tops are the glory of the landscape scenery…"

– Smith and Elliott 1878

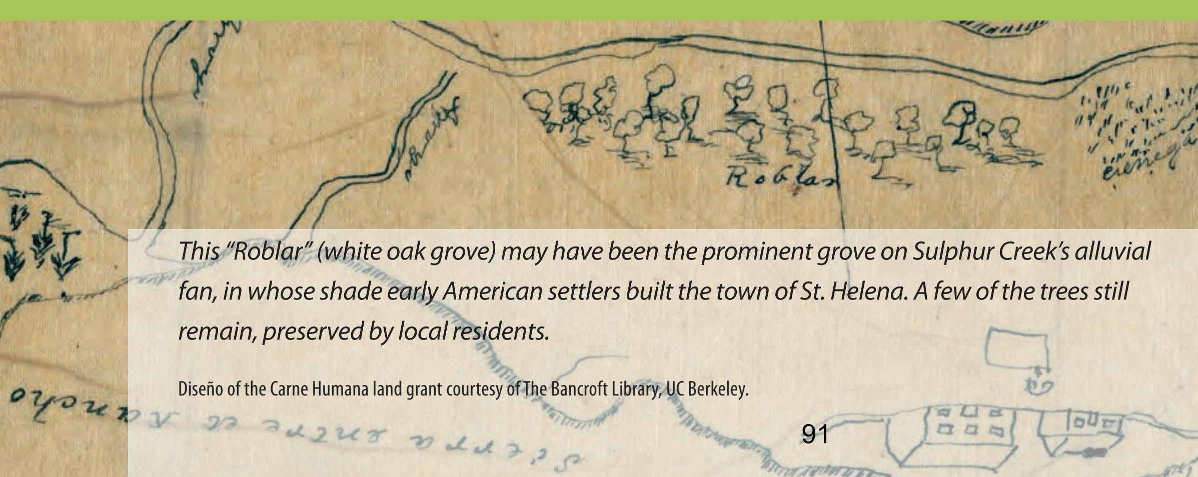
The photographs on the right provide complementary views of a typical historic oak savanna — this one occupying the Mill Creek alluvial fan between Calistoga and St. Helena. The trees formed a relatively dispersed, open pattern of light and shade that dominated large areas of the valley landscape. Traveler John Bartlett noted that the valley was "studded with gigantic oaks...though not so close together as to render it necessary to cut away to prepare the land for cultivation" (Bartlett 1854).

While the old oak savannas are nearly gone, naturalistic patterns of valley oaks could be created, even in urban areas. Trees could be strategically reintroduced along roads, fence lines, and public spaces. These efforts would build on a surprising number of surviving trees that have been maintained as landscape elements in vineyards and private residences, and reverse the long-term decline in valley oaks.



Top: Lyman Ranch/Mill Creek, ca. 1905. Courtesy of the Lyman family.
Bottom: 1942 aerial photograph of the same area. Courtesy of the Napa RCD.

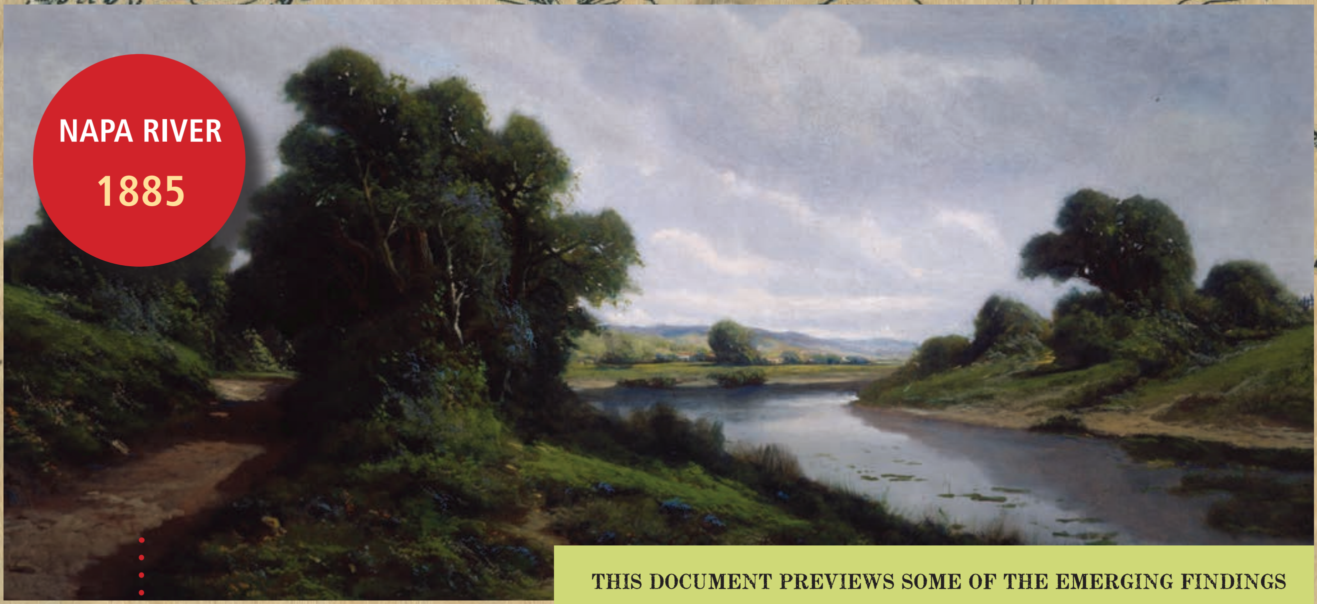
A GREAT VARIETY OF OAKS STOOD, now severally, now in a becoming grove, among the fields and vineyards.
–STEVENSON 1883



This "Roblar" (white oak grove) may have been the prominent grove on Sulphur Creek's alluvial fan, in whose shade early American settlers built the town of St. Helena. A few of the trees still remain, preserved by local residents.

Diseño of the Carne Humana land grant courtesy of The Bancroft Library, UC Berkeley.

7



Napa River and Valley, 1885, by Manuel Valencia.
Collection of the Hearst Art Gallery,
St. Mary's College of California,
Gift of James J. Coyle and William T. Martinelli

THIS DOCUMENT PREVIEWS SOME OF THE EMERGING FINDINGS of the historical ecology component of the Napa Agricultural Water Quality Project. The full Napa Valley Historical Ecology Atlas is anticipated for release later in 2008. For more information about these projects, please see www.sfei.org.

The Napa River Watershed Historical Ecology Project has been developed by the San Francisco Estuary Institute, Friends of the Napa River, and the Napa County Resource Conservation District.

AUTHORS: Robin Grossinger, Erin Beller, Josh Collins, and Shari Gardner

DESIGN AND LAYOUT: Linda Wanczyk and Ruth Askevold

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FOR MORE INFORMATION: Please contact Friends of the Napa River at info@friendsofthenapariver.org

To learn more about historical ecology methods and resources, contact the San Francisco Estuary Institute at www.sfei.org/HEP

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Napa Valley American Viticultural Area and Nested AVAs

napa valley vintners
napavintners.com

The Diversity of the Napa Valley AVA

Napa Valley stands for wines of the highest quality, cultivated with excellence in one of the world's most extraordinary places. The Napa Valley was California's first AVA, or American Viticultural Area, recognized by the U.S. government in 1981. An AVA is a legally designated grape growing area possessing distinguishable characteristics such as climate, terrain, soils and cultural and historic significance. In order for a wine to be labeled with a specific AVA, at least 85% of the grapes must be sourced from that AVA.

The Napa Valley produces just 4% of California's and .04% of the world's winegrape harvest. It has a dry Mediterranean climate shared with only 2% of the world's surface, which is ideal for producing consistent wines from vintage to vintage. Napa Valley has 16 nested AVAs, each possessing distinct attributes. The sheer number of AVAs within Napa Valley speaks to the region's diversity, allowing winemakers to produce a wide range of wines in an array of styles.

LOS CARNEROS

Climate: Cool, with marine winds from the San Pablo Bay as well as the Petaluma Gap to the west; high temperatures rarely exceed 80° (27°C).
Elevation: Sea level–700 feet (213 m)
Principal varieties: Chardonnay, Pinot Noir and Merlot

COOMBSVILLE

Climate: Weather is moderated by its proximity to the San Pablo Bay. Daily average high temperatures can be as much as 10 degrees cooler during the hot months than most other AVAs, and heat spikes tend to be less severe.
Elevation: 100–1000 feet (30-305 m)
Principal varieties: Cabernet Sauvignon, Merlot, Chardonnay, Syrah and Pinot Noir

WILD HORSE VALLEY

Climate: Due to elevation and proximity to San Pablo Bay, it is the coolest of all the Napa AVAs. The air mass that passes over Carneros cools another 10 degrees by the time it rises to the AVA.
Elevation: 850–2130 feet (259-650 m)
Principal varieties: Pinot Noir and Chardonnay

MOUNT VEEDER

Climate: Cool to moderate, with most vineyards above the fog line, meaning warmer nights and cooler days than on the valley floor; typical summer highs are 85° (29°C).
Elevation: 500–2600 feet (152–792 m)
Principal varieties: Cabernet Sauvignon, Merlot, Zinfandel and Chardonnay

OAK KNOLL DISTRICT OF NAPA VALLEY

Climate: Moderate to cool, with marine air and fog often remaining until late morning; afternoon breezes maintain slightly cooler temperatures than in the upper valley; summer temperatures may reach low 90s° (33°C) and drop to around 50° (10°C) at night.
Elevation: Sea level–800 feet (244 m)
Principal varieties: Cabernet Sauvignon, Chardonnay, Merlot, Sauvignon Blanc and Riesling

YOUNTVILLE

Climate: Moderate, with marine influence and fog contributing to cool summer mornings; the marine breeze keeps afternoons more comfortable than farther up valley; summer temperatures may reach the low 90s° (33°C), with nighttime temperatures dropping into the mid-50s° (13°C).
Elevation: 20–200 feet (6–61 m)
Principal varieties: Cabernet Sauvignon and Merlot

STAGS LEAP DISTRICT

Climate: Moderately warm with afternoon marine winds cooling the warmer air radiating off the bare rocks of the surrounding hillsides; summer temperatures can reach 100°, but more regularly are in mid-90s° (34–36°C).
Elevation: Sea level–400 feet (122 m)
Principal varieties: Cabernet Sauvignon and Merlot

ATLAS PEAK

Climate: Cool, mountain influenced with temperatures about 10–15° cooler than the valley floor in summer; above the fog line, there is low day-to-night temperature range, with summer temperatures rarely rising above 90° (32°C).
Elevation: 760–2600 feet (232–792 m)
Principal varieties: Cabernet Sauvignon and Chardonnay

OAKVILLE

Climate: Moderately warm, with temperatures commonly in the mid-90s° (35°C) in summer, but affected by night and early morning fog creating a day-to-night temperature fluctuation. The east side hills receive warm afternoon sun while the west side cools as the sun sets behind the Mayacamas range.
Elevation: 130–1000 feet (40-305 m)
Principal varieties: Cabernet Sauvignon, Merlot, Cabernet Franc and Sauvignon Blanc

RUTHERFORD

Climate: Moderately warm, marginally influenced by early morning fog; usual summer peak temperatures are in the mid-90° range (34 - 36°C), averaging a bit warmer and higher base elevation than Oakville and Stags Leap District.
Elevation: 155–500 feet (47–152 m)
Principal varieties: Cabernet Sauvignon, Sauvignon Blanc, Merlot and Cabernet Franc

ST. HELENA

Climate: Warm, due to greater protection from western hills, with less fog and wind; the narrowing of the valley floor provides more heat reflection off the hillsides; summer temperatures often peak in the mid-to-high 90s° range (34–37°C).
Elevation: 200–475 feet (61-145 m)
Principal varieties: Cabernet Sauvignon, Cabernet Franc, Merlot, Sauvignon Blanc, Syrah, Zinfandel and Viognier

SPRING MOUNTAIN DISTRICT

Climate: Cool to moderate depending on elevation and aspect. Most vineyards sit above the fog-line, providing warmer nights and cooler days than the valley floor. Typical mid-summer high temperatures reach 85° (29°C).
Elevation: 600–2600 feet (183–792 m)
Principal varieties: Cabernet Sauvignon, Merlot, Cabernet Franc, Chardonnay and Zinfandel

CHILES VALLEY DISTRICT

Climate: Summer temperatures peak in the mid-80s° (29°C), but due to higher elevation and evening fog, drop to below 50° (10°C).
Elevation: 600–1200 feet (182–366 m)
Principal varieties: Cabernet Sauvignon, Merlot, Cabernet Franc and Zinfandel

HOWELL MOUNTAIN

Climate: Located above the fog line on the eastern side of the valley, the AVA is warmer and drier than other AVAs with more hours of sunshine and little-to-no marine influence.
Elevation: 1400–2600 feet (427–792 m)
Principal varieties: Cabernet Sauvignon, Merlot, Zinfandel and Viognier

DIAMOND MOUNTAIN DISTRICT

Climate: Moderately warm temperatures with less fluctuation than the north Napa Valley floor; temperatures in the summer range from 50–90° (10–32°C).
Elevation: 400–2200 feet (122–671 m)
Principal varieties: Cabernet Sauvignon and Cabernet Franc

CALISTOGA

Climate: Daytime summer temperatures may peak above 100° (38°C) and fall to low 40s° (6°C) at night, due to cool afternoon and evening breezes drawn in through the Chalk Hill Gap from the Pacific.
Elevation: 300–1200 feet (91–366 m)
Principal varieties: Cabernet Sauvignon, Zinfandel, Syrah and Petite Sirah

CHAPTER 14
CULTURAL RESOURCES
(INCLUDES HISTORICAL AND ARCHAEOLOGICAL RESOURCES)

CHRONOLOGY OF UPDATES

NOVEMBER 30, 2005—VERSION 1

HISTORIC WINE CAVE, CONSTRUCTED IN 1882

PURPOSE

The purpose of this chapter is to provide a summary of known cultural resources in Napa County. This chapter is based on the review of numerous existing background reports and publications that contain information on prehistoric, historic, scientific, and cultural resources in Napa County. This document and the data assembled provide broad tools for site and regional planning as well as the basis for future planning documents relating to the protection and management of the County's rich cultural resources.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACHP	Advisory Council on Historic Preservation
BLM	U.S. Bureau of Land Management
B.P.	Before Present
CEQA	California Environmental Quality Act
CRHR	California Register of Historical Resources
GIS	Geographic information system
MOA	Memorandum of agreement
NAHC	Native American Heritage Commission
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NRHP	National Register of Historic Places
NWIC	Northwest Information Center
PRC	Public Resources Code
SB18	Senate Bill 18
SHPO	State Historic Preservation Officer
UC	University of California
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geological Survey

INTRODUCTION

This chapter provides a detailed discussion of the cultural resources that have been identified to date throughout Napa County (County). For the purposes of this discussion, the County is discussed as a whole as opposed to according to specific evaluation areas. This chapter details the federal, state, and local policies that govern cultural resource protection and preservation in the County; the ethnographic, prehistoric, and historic settings for the County; the methods used to identify and create maps of known archaeological, historic, architectural, recreational, and scientific resources; the likelihood and type of future finds expected; and conclusions regarding cultural resource importance in the County.

The term *cultural resource* describes different types of properties and sites—including prehistoric, historic, and architectural sites—that have been created, manufactured, or used by people of the prehistoric or historic past and that that are of cultural or scientific importance.

PURPOSE

The purpose of this chapter is to provide a comprehensive inventory of the known prehistoric, historic, and current cultural resources present in Napa County, a projection of the overall extent (number) of the resources present, a discussion of their context; and recommendations for protection and preservation as appropriate.

This chapter also aims to provide clear guidance regarding the County's policy and procedures for the identification and treatment of previously undiscovered cultural resources that have not yet been inventoried by professional archaeologists and architectural historians.

SPECIALIZED TERMS USED

The following are common specialized terms used to discuss regulatory requirements and the treatment of cultural resources.

- *Cultural resource* is the term used to describe several different types of properties, such as those listed below, that have been created, manufactured, or used by people of the prehistoric or historic past.
  - Prehistoric archaeological sites significant to the prehistory of the region and to the Native American community.
  - Historical archaeological sites that can consist of subsurface foundations, activities such as mining or blacksmithing, ranching etc important to the contact period of Euro-American settlement in the region.
  - Architectural properties such as buildings, bridges, and infrastructure; and resources of importance to Native Americans.

  In this chapter, this term has been expanded to include sites of cultural or scientific importance, such as historic swimming holes and meeting grounds and mineral and formation-type locations.

- *Historic property* is a term defined by the National Historic Preservation Act (NHPA) as any prehistoric or historic district, site, building, structure, or object included or eligible for inclusion in the National Register of Historic Places (NRHP), including artifacts, records, and material remains related to such a property.

- *Historical resource* is a CEQA term that includes buildings, sites, structures, objects, or districts that may have historical, prehistoric, architectural, archaeological, cultural, or scientific importance and is listed or eligible for listing in the California Register of Historical Resources (CRHR).

POLICY CONSIDERATIONS

This section discusses the federal, state, and local policies that are relevant to the analysis of cultural resources in Napa County.

FEDERAL POLICIES

NATIONAL ENVIRONMENTAL POLICY ACT

The use of federally owned land controlled by U.S. Bureau of Reclamation (USBR) and the U.S. Bureau of Land Management (BLM) or any project involving the use of federal funds triggers review under the National Environmental Policy Act (NEPA). NEPA addresses potential adverse effects on districts, sites, highways, structures, or objects listed or eligible for listing in the NRHP, and requires mitigation for loss or destruction of significant scientific, cultural, or historical resources.

NATIONAL HISTORIC PRESERVATION ACT

Section 106 of the NHPA requires that, before beginning any undertaking, a federal agency take into account the undertaking's effects on historic properties and afford the Advisory Council on Historic Preservation (ACHP) an opportunity to comment on these actions. The Section 106 process entails the following six basic steps.

1. Initiate consultation and public involvement
2. Identify and evaluate historic properties
3. Assess effects of the project on historic properties
4. Consult with the State Historic Preservation Officer (SHPO) regarding adverse effects on historic properties, resulting in a memorandum of agreement (MOA)
5. Submit the MOA to the ACHP for approval
6. Proceed in accordance with the MOA.

NATIONAL REGISTER OF HISTORIC PLACES

For federal projects, cultural resource significance is evaluated in terms of eligibility for listing in the NRHP. NRHP criteria for eligibility are defined below.

The quality of significance in American history, architecture, archaeology, and culture is present in districts, sites, buildings, structures, and objects of state and local importance that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and that:

- are associated with events that have made a contribution to the broad pattern of our history;
- are associated with the lives of people significant in our past;
- embody the distinct characteristics of a type, period, or method of construction; represent the work of a master; possess high artistic values; or represent a significant and distinguishable entity whose components may lack individual distinction; or
- have yielded or are likely to yield information important in prehistory or history (36 Code of Federal Regulations 60.4).

STATE POLICIES

CALIFORNIA ENVIRONMENTAL QUALITY ACT

CEQA requires that public agencies that finance or approve public or private projects assess the effects of the respective project on historical resources. CEQA requires that if a project would result in an effect that may cause a substantial adverse change in the significance of a historical resource, alternative plans or mitigation measures must be considered; however, only significant cultural resources need to be addressed. Criteria for the assessment of cultural significance appear later in this discussion.

The following steps are typically performed in a cultural resource investigation for CEQA compliance.

- Identify potential cultural resources
- Determine the significance and thus eligibility for protection of the cultural resources identified
- Evaluate the effects of the project on all eligible resources

The State CEQA Guidelines define the following three ways that a property can qualify as a significant historical resource for the purposes of CEQA review

- The resource is listed in or determined eligible for listing in the CRHR.
- The resource is included in a local register of historical resources, as defined in Public Resources Code (PRC) Section 5020.1(k), or identified as significant in a historical resource survey meeting the requirements of PRC Section 5024.1(g), unless the preponderance of evidence demonstrates that it is not historically or culturally significant
- The lead agency determines the resource to be significant as supported by substantial evidence in light of the whole record (14 California Code of Regulations 15064.5).

CALIFORNIA REGISTER OF HISTORICAL RESOURCES

A historical resource is eligible for listing in the CRHR if it

- is associated with events that have made a significant contribution to the broad patterns of California's history and cultural heritage;
- is associated with the lives of persons important in our past;
- embodies the distinctive characteristics of a type, period, region, or method of construction;
- represents the work of an important creative individual;
- possesses high artistic values; or
- has or may be likely to yield information important in prehistory or history.

Historic properties listed or formally determined eligible for listing in the NRHP are automatically listed in the CRHR (PRC Section 5024.1).

> The National Register of Historic Places is the nation's official list of cultural resources worthy of preservation. The California Register of Historical Resources is the state's authoritative guide to California's significant historical and archeological resources.

The intent of SB18 is to provide California Native American tribes an opportunity to participate in local land use decisions at an early stage of planning, for the purpose of protecting, or mitigating impacts to cultural places.

SENATE BILL 18

Governor Schwarzenegger signed Senate Bill 18 (SB 18) on September 29, 2004. Guidelines for this law were published March 2005. SB 18 requires that local governments (city and county) consult with Native American tribes to aid in the protection of traditional tribal cultural places through local land use planning. The intent of SB18 is to provide California Native American tribes an opportunity to participate in local land use decisions at an early stage of planning, for the purpose of protecting, or mitigating impacts to cultural places. The purpose of involving tribes at these early planning stages is to allow consideration of cultural places in the context of broad local land use policy, before individual site-specific, project-level land use designations are made by a local government. SB 18 requires local governments to consult with tribes prior to making certain planning decisions and to provide notice to tribes at certain key points in the planning process. These consultation and notice requirements apply to the adoption and amendment of both general plans and specific plans (OPR 2005).

Basic SB 18 procedural steps include several components. Meetings between the local governments and the appropriate Native American tribes should be held to establish working relationships, discuss project goals, planning priorities, and processes, and how cultural places play a role in tribal culture, and inquire into tribal consultation protocols, among other issues. Additional consultation meetings are also recommended depending on the willingness of the various tribes to engage in joint consultation. To ensure implementation of the new guidelines, consultation meetings will be held to initiate discussion with designated members of the Native American descendents. Discussion and consultation with the various Native Americans will focus on the following activities.

- Establish meaningful dialogue between local and tribal governments in order to identify cultural places and consider cultural places in land use planning.
- Develop a program to systematically avoid conflicts over the preservation of Native American cultural places by ensuring local and tribal governments are provided with information early in the land use process.
- Discuss the possibilities of preserving and protecting various Native American cultural places by placing them in open space where possible.
- Develop proper management and treatment plans to preserve cultural places.
- Develop a program to enable tribes to manage and caretake their cultural places.
- Consultation regarding all lands to be designated as open space will require contacting the NAHC and the contacts for Napa County and NWIC in order to identify cultural places within those proposed open space lands.

PUBLIC RESOURCES CODE SECTION 5097 (HUMAN REMAINS)

According to the California Health and Safety Code, six or more human burials at one location constitute a cemetery (Section 8100) and disturbance of Native American cemeteries is a felony (Section 7052). Section 7050.5 requires that construction or excavation be stopped in the vicinity of discovered human remains until the coroner can determine whether the remains are those of a Native American. If the remains are determined to be Native American, the coroner must contact the Native American Heritage Commission (NAHC). The NAHC must then attempt to notify any descendants, and arrangements for appropriate treatment of the remains must be made in consultation with the descendants.

If buried cultural resources such as chipped or ground stone, quantities of bone or shell material, or historic debris or building foundations are inadvertently discovered during ground-disturbing activities, work will be stopped within a 100-foot radius of the find until a qualified archaeologist can assess the significance of the find. If, after evaluation by a qualified archaeologist, an archaeological site or other find is identified as meeting the criteria for inclusion in the NRHP or CRHR, the project proponent or Napa County will retain a qualified archaeologist to develop and implement an adequate program for investigation, avoidance if feasible, and data recovery for the site, with Native American consultation, if appropriate.

LOCAL POLICIES

NAPA COUNTY GENERAL PLAN

The 1983 Napa County General Plan has only two policies that address cultural resources; both are contained in the Conservation and Open Space Element.

- Goal III B (Areas of Outstanding Historical and Archaeological Value): *Encourage preservation and scientific study of areas of unique historical and archaeological value.* To accomplish this the General Plan suggests the following actions, which have not to date been implemented.
  - Prepare a priority list identifying critical areas and features threatened with destruction and encourage their inclusion in a natural resources conservation or open space easement with features similar to those recommended for protecting ecologically important areas (see Conservation Policy I B [Areas Required for Ecological and Other Scientific Study Purposes]). See SB 18 regarding tribal consultation and conservation easements and identification of sacred sites.
  - Prepare specific plans (within the meaning of Sections 65451–2 of the Government Code), and establish plan lines or other appropriate devices to protect sites and provide a protective buffer zone.
  - Protect existing or potential sites for scientific purposes.

- Goal III C (Areas of Scenic Value): *Encourage preservation of and provide visual access to the natural beauty of Napa County, thereby enriching the lives of its citizens and enhancing and maintaining one of the County's primary industries, the tourist industry*. The General Plan suggests the following action to accomplish this, which has to date only been partially implemented.
  - Identify and preserve the area's architectural and historical landmarks.

METHODOLOGY

DEFINITION OF STUDY AREA

For the purposes of this discussion, the most useful way to present information regarding Napa County is to discuss the County as a whole. While there were only a handful of independent Native American groups that inhabited the County, the Native American patterns of settlement and intertribal interactions among the thousands of indigenous inhabitants in the region were extensive, creating a scenario of great cultural overlap. Therefore, it is useful to describe the prehistoric resources and ethnographic background of the indigenous people of the region on a countywide scale.

At this time, no reference to separate resources has been identified that fall under the category of recreational, geologic, or scientific resources. All identified historical resources, such as trails, locations of important events, and discoveries are included within the overall subject of cultural resources. The analysis of recreation and geology completed for the Napa County BDR may add information in those subject areas. Please see Chapter 1, *Geological Resources*, and Chapter 13, *Public Facilities and Services*, of the BDR for additional information regarding recreational, geologic, and scientific resources.

TECHNICAL PROCESS

PREHISTORIC ARCHAEOLOGICAL RESOURCES: MAP 14-1

The Napa County Conservation Division provided a GIS dataset of archeological sites in Napa County. In February 2004, a Jones & Stokes archaeologist conducted a search for additional records at the NWIC of the California Historical Resources Information System at Sonoma State University, the central repository for archaeological information on the 11 counties around the San Francisco Bay Area. The 290 additional sites found during that search were mapped onto 1:24,000-scale U.S. Geological Survey (USGS) topographic hardcopy maps and labeled with the primary or trinomial number associated with the site. In addition, corrections were made to incorrect labels in the existing County dataset.

The new sites were screen-digitized on scanned USGS topographic maps. The sites were then buffered and the resulting buffered areas assigned a primary number and a trinomial number. Once the dataset was attributed, it was combined with the County's existing dataset. Five additional fields were added to the existing GIS attribute table. The new fields were for the primary number prefix (P-28-), primary number, trinomial prefix (CA-NAP-), trinomial number, and general site type. Historical resources located within the 16-County service area covered by the NWIC are assigned primary and trinomial numbers to act as unique identifiers for individual sites throughout the state.

It is important to note that as the NWIC assigns trinomial numbers to sites, the sites that only have a primary number and are labeled with the data type "prehistoric or historic" and are herein identified and assigned a single or multiple site type, as appropriate. Therefore, the "unknown" category below includes all sites that could not be determined either historic or prehistoric. In Table 14-1, below, the site type field indicates whether the site is recorded as "prehistoric or "prehistoric and historic." However, due to the process followed for the synthesis of information for this document, specific site records for each site mapped were not obtained. Therefore, it is not possible to make a distinction of site type as either historic or prehistoric in most instances; therefore, the unknown category holds the highest number of resources.

Based on this effort, a new, updated roster of archaeological resources located in the unincorporated portions of Napa County was created. This roster contains 1021 sites (Table 14-1).

Table 14-1. Previously Recorded Archaeological Resource Sites In Napa County

		Type			
Evaluation Area	Number of Occurrences	Prehistoric Archaeological Site	Historical Archaeological Site	Historic and Prehistoric	Unknown
Lower Napa Valley					
Napa Valley Floor		18		3	349
Western Mountains		2			70
Angwin/Livermore Ranch Area		3			14
Eastern Mountains		5			117
Pope Valley		11			121
Central Interior Valleys		2			35
Southern Interior Valleys		15			24
Berryessa Area		6			99
Knoxville Area		1		1	70
Carneros		2			24
Jamieson/American Canyon		5			22
Napa River Marshes					2
Total		70		4	947

Native American patterns of settlement and intertribal interactions among the thousands of indigenous inhabitants in the region were extensive, creating a scenario of great cultural overlap.


Architectural resources can include historic infrastructure, irrigation and sewer systems, and farm complexes, rock walls, foundations, bridges and anything resulting from human manufacture.

HISTORIC ARCHITECTURAL RESOURCES: MAP 14-2

The Napa County Conservation Division provided Jones & Stokes a GIS dataset of historical resources in Napa County and USGS topographic quadrangles with recorded sites that were not in the database. These sites were added to the database, and this revised dataset was updated using the records of additional historical sites found at the NWIC. Historic architectural sites that have not been evaluated (including significance for listing in the NRHP or CRHR) are listed as unknown.

The additional sites found during this process were mapped onto 1:24,000-scale USGS hardcopy topographic maps and labeled with the primary or trinomial number associated with the site. In addition, corrections were made to site locations and incorrect labels in the existing County dataset.

The new resources were then transferred into a GIS dataset using on-screen digitizing on scanned 1:24000-scale USGS topographic maps. The existing dataset and additional sites were combined into a single dataset. Four additional fields were added to the existing GIS attribute table: the primary number prefix (P-28-), primary number, trinomial prefix (CA-NAP-) and trinomial number. The primary and trinomial numbers are identification numbers used by the NWIC to identify individual sites. At this time, it has not been possible to make determinations among sites that have been listed in the NRHP or CRHR, those that are eligible for listing on the NRHP or CRHR, and those that have simply been evaluated for inclusion in the NRHP or CRHR and determined not significant. Additional research into each individual site record would be required to separate the resources into these categories. Based on this effort, a roster of historic properties that are located in Napa County and are listed in the NRHP, CRHR, or local or regional historic registers was created. This roster contains 1,635 previously recorded historic architectural features and structures (Table 14-2).

Table 14-2. Historic Architectural Features in Historic Resource Dataset

Evaluation Area	Number of Occurrences
Napa Valley Floor	1,471
Western Mountains	38
Angwin/Livermore Ranch Area	5
Eastern Mountains	34
Pope Valley	52
Central Interior Valleys	8
Southern Interior Valleys	1
Berryessa Area	1
Knoxville Area	5
Carneros Area	14
Napa River Marshes	3
Jamieson/American Canyon	3
Total	**1,635**

CULTURAL SENSITIVITY: MAP 14-3

To determine areas of sensitivity for architectural structures and associated resources, there are many resources that are obvious to the naked eye and others that may be obscured by overgrown vegetation, landscaping, and new development. Architectural resources can include historic infrastructure, irrigation and sewer systems, and farm complexes, rock walls, foundations, bridges and anything resulting from human manufacture. Where human-made structures of any kind exist, an examination is required to determine whether it is possible that the structures have the potential to be more than 45 years old, and if so whether they might be eligible for inclusion in the NRHP or CRHR. To determine sensitivity for prehistoric resources, Map 14-3 was developed using the existing database of previously recorded archaeological sites as currently mapped.

While Map 14-3 depicts the overall sensitivity for cultural resources within the County, this information is based on previously identified and inventoried resources. While it can be a useful tool in the broad sense, it is important to remember that there are many areas that have not been subject to survey, and previously inventoried sites should be revisited on a specific project level basis. Field surveys should be conducted early in the planning phase of all specific projects per state and federal regulations.

Maps 14-1, 14-2, and 14-3 all appear at the end of this chapter.

METHODS AND APPROACH

For sensitivity analysis of archaeological resources within the County, the GIS-based cultural sensitivity dataset was created using a raster-based GIS analysis that used the distribution of known cultural sites in Napa County and their relationship with soils, slope, elevation, and distance to current water bodies. There were three steps to the analysis, as described below.

The first step was to identify the slope, elevation, and distance to streams in regards to the location of each cultural resources. This was accomplished by overlaying the cultural site map with the datasets for slope, elevation, and distance to streams. The results were used as a guide to divide the datasets for slope, elevation, and distance to stream into categories that could be ranked from 1 to 5, with 1 being areas where sites do not often occur and 5 being areas where sites are found frequently.

The second step in the analysis was to evaluate the soils. Because soils are a categorical data type, not a continuous data type, the frequency of cultural site occurrences were used. The center of each site was used to select the soil polygon for each cultural site. The frequency of cultural sites by soil type was calculated, and the resulting frequency was assigned to each soil type. The frequency of occurrences were ranked from 1 to 5 (same meaning as described in previous paragraph), and the ranking was assigned to the final dataset.

The third step was to add all of the datasets together using Environmental System Research Institute's Spatial Analyst at a 25-foot cell size. Each dataset was assigned the ranked values of 1 to 5 and added together; the highest score possible was a 20. Areas in the County with high values are areas most similar to the cultural sites that have been mapped.

Table 14-3 lists the frequency of the archaeological sites across the landscape and the associated sensitivity ranks for potential presence of cultural resources.

Table 14-3. Sensitivity Ranking for Archaeological Sites across the Landscape

Distance to Streams (feet)	Rank	Elevation (feet)	Rank	Slope (%)	Rank	Frequency of Cultural Sites Occurring in a Soil Type	Rank
0–1,320	5	0–500	5	0–15	5	>= 20	5
1,320–2,640	4	500–1,000	4	15–20	4	>=15 < 20	4
2,640–3,960	3	1,000–1,500	3	20–30	3	>= 10 < 15	3
3,960–5280	2	1,500–2,000	2	30–40	2	>= 5 < 10	2
5,280–6,746	1	2,000–2,741	1	40–575	1	< 5	1

RESULTS

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PREHISTORIC RESOURCES

Many regions of Napa County are highly sensitive for the presence of archaeological resources, due to the rich resources base and varied terrain available. Indigenous populations had access to the abundant floral and faunal resources in the river valleys, riparian areas and mineral resources, such as obsidian, from Napa Glass Mountain, which was a highly coveted trade item. Access to the coast was fairly easy and provided the prehistoric people of Napa a way to acquire coastal resources, such as shell for beads and marine food sources.

While the database created for this report remains broad, it is clear where the archaeological sites are most frequently situated, near a year round water source, at fairly low elevation and away from steep slopes and mountainous terrain. However, one must bear in mind that the locations where archaeological sites have been discovered are also the most desirable habitation places for modern day populations as well. Due to this fact, there has been a high occurrence of archaeological discovery where modern and historic peoples have had the highest impact. It is likely that numerous archaeological resources, such as special purpose hunting camps or resource procurement sites await future discovery in the less inhabited and explored corners of the County.

HISTORIC ARCHITECTURAL RESOURCES

European, American, and Mexican settlers have used the Napa County landscape since the early days of exploration. The level of sensitivity for the presence of historic architectural features and structures are directly related to the history of human use for homes, ranches, farms, infrastructure such as trails, roads, railroads, commerce, etc. Napa County is abundant with historic resources, many of which have retained their integrity and therefore are potentially significant resources that should be considered for their importance to Napa County and throughout the planning process for new development and projects.

The map depicting the known historic resources within Napa County provides an excellent broad view of areas that are likely to contain historic structures and features, such as currently well developed areas, city and town centers, areas that encompass long-term ranching, and farming communities. As with the archaeological sensitivity map however, the map of historic resources reveals the general locations of resources that have previously been recorded due to development or interest in the area where they are recorded. In areas that have not been surveyed or subject to extensive human use to date, there likely exist numerous historic resources, yet to be discovered and studied.

PREHISTORIC CONTEXT

EARLY ARCHAEOLOGICAL INVESTIGATIONS IN NAPA COUNTY

Nelson conducted the first recorded archaeological work in Napa County as well as in many other Bay Area communities in 1909. Nelson conducted extensive surveys and recorded many of the large shellmounds around San Francisco Bay. Nelson noted that the shellmounds in Napa County exhibited large concentrations of ash and earth, which suggest a broad subsistence base, unlike the shellmounds in the East Bay and on the coast, which contained primarily shellfish remains (Stewart 1982). There was minimal archaeological work in the years that followed, until the Napa region became the focus of research for professors and students of the University of California (UC), Berkeley, in the 1940s.

Early archaeological investigations in Napa County in the 1940s concentrated on excavation of large habitation sites. At this time, UC archaeologists conducted extensive survey and large-scale excavations. Heizer's 1953 *Archaeology of the Napa Region* presents a comprehensive summary of this work and remains the definitive document for early work in Napa County.

Some of the earliest and most prominent sites excavated in the Napa County are CA-NAP-1 (the Goddard site), CA-NAP-16 (the Suscol Creek site), CA-NAP-14 (the Las Trancas site), CA-NAP-39 (the Tulukai site), CA-NAP-131 (the Hultman site), and CA-NAP-129 (the Merriam site).

CA-NAP-1 was the subject of many decades of avocational archaeological investigations and was excavated by UC students in the late 1930s. In the upper portions of the site, there were concentrations of soft ashy midden and several cremations with associated grave goods. Deeper in the site, there were painted stone slabs, several burials, and many obsidian artifacts. Artifact analysis by Cook and Heizer (1965) and Bennyhoff (1950) suggest that this site was occupied for many thousands of years, spanning from the Middle Period (2500 Before Present [B.P.]–A.D 700) until the Late Period (A.D. 700–Contact) (Stewart 1982).

Zinfandel Bridge, Napa County.
Napa County is abundant with historic resources, many of which have retained their integrity and therefore are potentially significant resources that should be considered for their importance to Napa County and throughout the planning process for new development and projects.

<u>Archaeological Periods</u>

Early Archaic – 6000 B.C. to 3000 B.C.
Middle Archaic – 3000 B.C. to 500 B.C.
Upper Archaic – 500 B.C. to A.D. 500
Lower Emergent – A.D. 500 to A.D. 1500
Upper Emergent – A.D. 1500 to Contact

Heizer excavated CA-NAP-16 in 1945. The site contained human remains throughout, an abundance of shellfish remains, obsidian points, *Olivella* beads, charmstones, numerous bone tools and stone mortars, and both cremations and burials, all of which date the occupation of the site to the Late Period (Stewart 1982).

UC students conducted excavations at CA-NAP-14 in 1947 under the supervision of Heizer. The site was composed of dark ashy midden with numerous obsidian flakes and mammal bone, but the artifact concentration was low. There was also a fixed bowl mortar (the first of its kind in the archaeological record), two burials, one cremation, and associated grave goods. Fredrickson (1973) later noted that the methods the students employed may have resulted in the loss of significant data from different temporal periods (Stewart 1982).

From the late 1940s to the mid- and late 1960s, American archaeologists were moving away from the presentation of simple culture histories based on sequences of diagnostic artifacts. The change to a cultural/theoretical approach came to be known as "New Archaeology." The "new" archaeologists now wanted to know more than "when people were doing what" in prehistoric times. Researchers also wanted to know how and why people chose to organize, develop, modify, or discard certain modes of adaptation. Research themes shifted to focus on areas including food procurement (e.g., hunting vs. collecting); exchange/trade of ideas, stylistic items, raw materials, and other items (e.g., production specialization, shell beads, obsidian); interaction across cultural boundaries (e.g., alliances for economic/defensive purposes); and environmental knowledge (e.g., utility of particular gathering locations) (Hayes 2004).

In response to the desire to address confusing and sometimes conflicting classificatory terms and the burgeoning new directions for research, Fredrickson took on the obvious need to revise the Central California classification system and to synthesize the state of current knowledge in central California archaeology. He produced a dissertation proposing two sets of related terms and drew north Coast Ranges archaeology into a clear relationship with central California and San Francisco Bay (Hayes 2004).

Artifacts recovered from sites and eventually larger spatial units (e.g., localities and districts) are used to define prehistoric peoples adaptive mode or "pattern." As more data become available, we should be able to define subsets (i.e., phases and aspects) of the pattern, thereby enhancing our understanding of the variety of a given pattern across space. In Fredrickson's scheme, time is deliberately pushed to the background, although control of the temporal factor remains as crucial as ever in order to define components and assemblages or determine which precedes or follows the other. By making adaptation in all its various forms the prime objective, with considerations of the temporal framework kept in perspective, we work toward a clearer picture of human behavior.

During the Early Archaic Period (6000 to 3000 B.C.), subsistence strategies were thought to be focused on both hunting and the processing of hard seeds, as suggested by large numbers of projectile points and the presence of milling slabs in occupation sites. Fredrickson (1974:49), in his early work, suggested that the period be characterized by a semi-sedentary lifestyle. Other researchers think these people pursued their subsistence activities as "mobile" groups (Wickstrom 1986:25). Not only did True, Baumhoff, and Hellen (1979) feel that this period was characterized statewide by high mobility, but also by a reliance on casual artifacts (Hayes 2004).

The ensuing Middle Archaic Period (3000 to 500 B.C.) is extremely problematic in regard to the adaptive mode. Although a stylistic change of artifacts (e.g., from wide-stem to concave-base projectile points) is evident, no concurrent settlement shift has been documented. The appearance of the mortar and pestle suggests, however, that new lifeways were being pursued. Fredrickson originally proposed a shift to sedentism during the Middle Archaic Period that corresponded with adoption of the mortar and pestle and the arrival of Penutian speakers into central California. The Berkeley Pattern was thought to represent this new adaptation, with the Borax Lake Pattern being a manifestation of the older, more mobile lifeway. Both patterns may have co-existed in the southern north Coast Ranges in the Middle Archaic Period (Hayes 2004).

Between 500 B.C. and A.D. 500, major changes in artifact inventories and settlement locations are apparent. According to Wickstrom (1986:20), these changes signify the onset of a sedentary adaptive mode in which both hunting and acorn collecting played essential roles. This is the same shift that Fredrickson originally associated with the appearance of the Berkeley Pattern during the Middle Archaic Period, but the hydration data organized by Wickstrom has produced a refinement in the temporal placement of these traits. In his most recent chronological scheme, Fredrickson (1984:485) shows the Berkeley/Borax Lake Pattern co- existence during the Upper rather than Middle Archaic Period (Hayes 2004).

The Lower Emergent Period (A.D. 500 to A.D. 1500) appears to represent a continued population expansion (suggested by a slight increase in the number of sites occupied) concurrent with development of the bow and arrow. Fredrickson (1974) felt this sub-period also included regularized exchange and the beginnings of stratified social organization.

Regulation of exchange by a managerial elite and craft specialization during the Upper Emergent Period (A.D. 1500 to contact) evinces a high degree of economic sophistication. This period also marked a noticeable decline in both the number of sites inhabited and the amount of obsidian present at sites. Amaroli (1982a) proposed three alternative explanations for this apparent decline. First, craft specialization decreased flaked stone debris by restricting the number of people working with obsidian. Second, a managerial elite controlled subsistence activities, resulting in consolidation of scattered hamlets into a few major villages. Third, population decline occurred because of exposure to European diseases reaching California before the Europeans themselves, resulting in decreased obsidian use and fewer sites (Hayes 2004).

RECENT RESEARCH IN NAPA COUNTY

Research after Fredrickson's focused on development of refined local sequences using of the obsidian hydration method. Origer (1982) presented a temporal ordering of projectile points from Sonoma, Marin, and Napa Counties along with the micron ranges for the time periods and cultural patterns proposed by Fredrickson in 1973. In his 1984 chronologies for the Sonoma and Napa districts, Fredrickson used hydration and cross dating to rank materials into periods defined in years (Hayes 2004).

Recent archaeological investigations in Napa County for compliance with CEQA and NEPA have been conducted in response to the increasing level of development in the area. As a result of the nature of archaeological investigations in the Napa region, little comprehensive archaeological research has been conducted in Napa that has contributed to the overall prehistory of the area. Archaeological investigations have been limited in focusing on management goals and site-specific mitigation (Jaffke and Meyer 1998). The following compilation of sites is taken from Origer 1995: CA-NAP-261 (Jackson 1978), CA-NAP-14 (Beard 1991), CA-NAP-666 (Hayes 1984), CA-NAP-710/H (Dowdall 1991), CA-NAP-543 and CA-NAP-544 (Flynn 1979), CA-NAP-159 (Beard and Origer 1995), CA-NAP-36 (Deitz and Holson 1983), Bale Grist Mill State Historic Park (Felton 1978; Alvarez, Hayes, Praetzellis and Praetzellis 1988), and CA-NAP-401 and CA-NAP-424.

Other recent and prominent archaeological investigations have been conducted at the following sites in Napa County: CA-NAP-916 (Jaffke and Meyer 1998), CA-NAP-911, CA-NAP-328, and CA-NAP-39 (Darcangelo et al 2000).

Test excavations at CA-NAP-916 revealed that this buried archaeological deposit was likely a special use or temporary encampment. Artifacts at the site consisted primarily of obsidian flaking debris and fire-affected rock (resulting from exposure to high heat). Other artifacts found here include charcoal, baked clay, imported cobbles, and the remains of carbonized seeds.

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As stated, the recent prehistoric archaeological investigations in Napa County have all occurred in response to the continued development and growth of the region. Research questions continue to focus on questions of chronology of different occupations and adaptations of the prehistoric populations in the various areas of Napa County. Archaeologists are currently primarily concerned with the following research questions.

- In what activities was the prehistoric population engaging at a particular site, and what was the function or main purpose of the site?
- Was the site occupied for more than one time period?
- What evidence is available to indicate travel and trade networks?
- Is there evidence for social or technological change?
- How does a site relate to the surrounding sites in terms of settlement patterns and seasonal lifeways?
- Does the site have a necessary degree of integrity to make it eligible for listing in the NRHP under criterion D (the potential to yield important information)?

Aspects of the archaeological record and methods of analysis that can help answer these questions include the presence of temporally diagnostic artifacts and milling equipment, conducting obsidian hydration dating and sourcing methods, examination of artifact manufacturing techniques, carbon dating from hearth and fire features, and examination of burials and associated artifacts.

Many of the recent archaeological investigations have aided in the understanding of the prehistoric people who inhabited the Napa region and have begun to answer many of the current research themes. Recent archaeological investigations throughout the region have advanced our knowledge of the climate natural environment, as well as the adaptive strategies used by the prehistoric cultures. Archaeological method and theory have made understanding the adaptive processes of the prehistoric cultures more accessible through such techniques as the study of obsidian hydration dating techniques, trace element analysis, and radiocarbon dating (Moratto 2004). Archaeologists are also examining innovative techniques in tool manufacture and subsistence strategies through the study of material remains recovered from archaeological sites throughout the Napa region. However, as discussed above, current archaeological investigations have been limited to site-specific mitigation goals, not to the contribution of knowledge to the overall prehistory of the region.

ETHNOGRAPHIC CONTEXT

The ethnographic information presented in this document is based on the work of several ethnographers who specialized in ethnographic information for California and the Bay Area. Sources include Kroeber's early ethnographic work in 1925 (Kroeber 1925), Heizer's *Archaeology of the Napa Region* (Heizer 1953), overviews of the Wappo and Patwin groups by Sawyer and Johnson (Sawyer 1978; Johnson 1978), and Milliken's comprehensive research regarding the ethnography of the Native Americans of the Bay Area based upon mission records (Milliken 1995). In this context, the term *ethnography* refers to the study of the Native American people and their culture based on primary sources of historical records and documents and interviews with descendents of the Native American people who were indigenous to the region.

FIRST INHABITANTS

The earliest evidence for human occupation is derived from obsidian hydration reading from the Napa Valley. Artifacts indicate that the earliest dates for Napa Valley are approximately 5,000 years ago (Bennyhoff 1994). Although unsubstantiated information indicates that habitation dates may reach several thousand years earlier, review of present literature for the Napa region provides scant evidence for these early occupations.

Exhibition of obsidian arrowheads.

TRIBAL GROUPS

Archaeological record shows that the Napa region was inhabited in prehistoric times primarily by the Wappo, Lake Miwok, and Patwin tribal groups. The major differences between the Native American groups who inhabited the region were the origins of their specific tribal languages and territorial boundaries. However, the lifeways, technologies, subsistence strategies, and settlement patterns of the groups were very similar in nature and therefore are discussed together.

The Napa region was inhabited in prehistoric times primarily by the Wappo, Lake Miwok, and Patwin tribal groups. These groups shared similar lifeways, technologies, subsistence strategies, and settlement patterns.

WAPPO

Wappo is a dialect of the Yukian language, which also includes Yuki, Coast Yuki, and Huchnom. Wappo is also the name given to the Wappo-speaking people by the Spanish. The word *Wappo* is derived from the Spanish word *guapo*, which means brave. This name apparently originated from the Wappo resistance to the infusion of Europeans in the eighteenth and nineteenth centuries into their territory in the Napa Valley (Heizer 1953). The Wappo dialect appears to have diverged considerably from the other dialects, suggesting that the Wappo-speaking people operated more freely from the other groups and also may have been separated temporally by 500 years (Heizer 1953). The Wappo language was influenced by languages of surrounding groups, including the Lake and Coast Miwok, Southern Pomo, and certain Wintun groups (Sawyer 1978).

The Wappo dialects were spoken in a territory that consisted of two divisions. The small division existed in just a 5-square-mile radius, south of Clear Lake. The larger division extended from just north of Napa and Sonoma in the south to Cloverdale and Middletown in the north (Figure 14-1). Wappo territory extended farther in summer, as there is evidence that the Wappo made annual summer trips to Clear Lake and the Pacific Ocean. The permanent habitation site south of Clear Lake in the smaller division may have been a result of such annual summer trips (Sawyer 1978).

Both ethnographic information from Elmendorf (1963) and archaeological evidence from Heizer's extensive research in Napa suggest that the Wappo may have been among the first settlers and groups to use the Napa Glass Mountain area around 2000 B.C. (Heizer 1953). However, the Wappo appear to diverge from neighboring groups such as the Pomo and other Yukian-speaking peoples physically and linguistically. Later in Wappo history, the Wappo were clearly influenced by the surrounding cultures and languages. Evidence points to the possibility that differences among the surrounding groups were a result of Wappo migration into the area. The Wappo were generally a minority in their region, but they appeared to have maintained generally good relationships with neighboring groups with some exceptions (Sawyer 1978).

The sociopolitical unit of the Wappo was the village, which was generally located along a creek or another water source and included either one or two sweathouses, depending on the size of the village. Although Kroeber claims that the population of the Wappo never exceeded 1,000 people (Kroeber 1925), later evidence suggests that the Wappo had a minimum of seven villages in the Geyserville area; the population of Wappo in this region alone may have exceeded 1,500 people (Sawyer 1978).

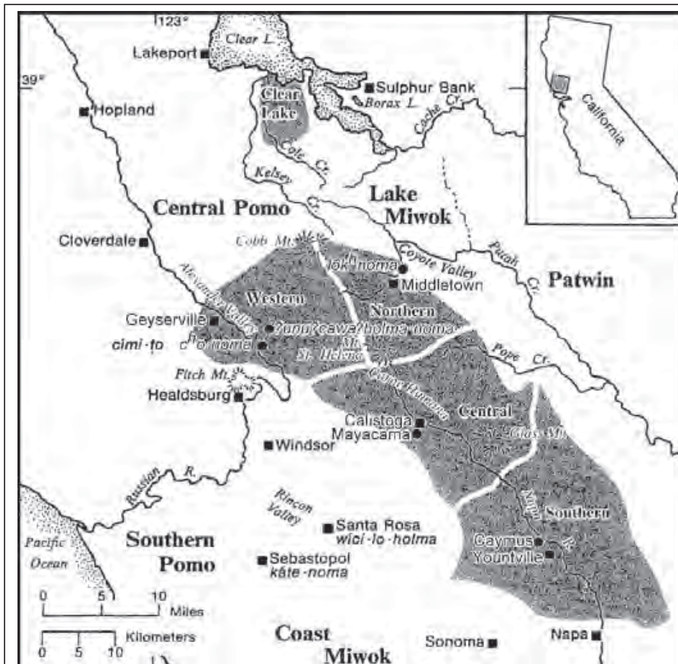


Figure 14-1. Ethnographic Territories of the Wappo, Patwin, and Surrounding Tribes
Source: Sawyer 1978.

The Wappo's unsuccessful battle against the Spanish is evident in the mission records of the period. Most Wappo from all territories were brought to the Mission at Sonoma between 1823 and 1834, and many of the remaining Wappo were used as labor (Sawyer 1978). Wappo villages that were represented at the mission include Canijolmano, Caymus, Chemoco (Mixed Wappo and Patwin), Huiluc, Locnoma, Mayacama, and Napa (Milliken 1995).

In 1854, the Wappo of the Russian River Valley, whose population likely included Wappo from territories within Napa County, were moved to a reservation in Mendocino. Within 2 years, nearly half of the population had died; the reservation was closed in 1867 (Sawyer 1978). In 1855, according to Yount, approximately 500 Wappo remained in the Napa Valley (Sawyer 1978).

LAKE MIWOK

The Lake Miwok spoke the Penutian language, and their native territory was geographically isolated from other Miwok groups located to the south. They were, however, in regular contact with their neighbors of different linguistic origins, such as the Wappo, Patwin, and Eastern and Southeastern Pomo. The Lake Miwok language is related to that of the Coast Miwok of Marin County and coastal Sonoma County and the Eastern Miwok of the Sierra Nevada. The Miwok groups are also related to the Costanoan (Ohlone) group that occupied the area from San Francisco to Monterey County. The Lake Miwok inhabited an area that extended south from Clear Lake to Pope Valley, west to Cobb Mountain in Lake County (where they shared borders with the Pomo and Wappo) and east to Patwin territory (including Jerusalem Valley, Soda Creek, Putah Creek). The primary ruling village for the northern part of Lake Miwok territory was situated just south of Lower Lake, and the central village in the southern part of Lake Miwok territory was located in the Coyote Valley along Putah Creek (Levy 1978).

During European and American settlement in the early nineteenth century, many Lake Miwok were taken from their settlements and homes to work as laborers on ranches in the area; others were massacred. Kroeber estimates that the population of the Lake Miwok was no more than 500 individuals prior to European and American settlement. In 1841 the U.S. Census revealed the presence of only 41 people of Lake Miwok descent. The 1910 U.S. Census indicated that there were seven individuals remaining (Levy 1978).

PATWIN

Portions of Napa County were once inhabited by the Patwin, who held an extensive region within north-central California. Patwin territory included the lower portion of the western Sacramento Valley, west of the Sacramento River from about Princeton in the north to Benicia in the south (Kroeber 1925). The Patwin were bordered to the north, northeast, and east by other Penutian-speaking peoples (the Nomlaki, Wintu, and Maidu, respectively) and to the west by the Pomo and other coastal groups. Within this large territory, the Patwin have traditionally been divided geographically into River, Hill, and Southern Patwin groups, although a more complex set of linguistic and cultural differences actually existed than is indicated by these divisions. Near the project area, the Patwin are believed to have reached the Carquinez/Suisun area by about 1,500 B.P. (McCarthy 1985).

The onslaught of Euro-American culture brought the end of Patwin culture. By 1871–1872, when Powers surveyed the state gathering ethnographic information, the Patwin culture appeared virtually extinct.

WAPPO AND PATWIN CULTURE

Hayes and Siskin compiled the following information regarding the general settlement patterns, subsistence, and technology of the Wappo and Patwin for the Knight's Valley Section 106 report (Hayes 2004).

GROUP ORGANIZATION

As with most of the hunting-gathering groups of California, the 50- to 150-person "tribelet" represented the basic social and political unit of both the Wappo and Patwin. Typically, a tribelet chief would reside in a major village in which ceremonial events were usually held. The status of such individuals was inherited patrilineally among the Patwin, although village elders had considerable power in determining who actually succeeded to particular positions. Apparently, a Patwin chief had more authority than his counterparts in many of the other central California groups (McKern 1922; Kroeber 1925). The Wappo village chief was either elected or appointed, and generally rejected the tendency to impose authority over other members of the group. Whether the chief was man or woman, the chief's main functions in both groups included maintaining relationships with other villages and neighboring groups; overseeing internal operations of the village; directing ceremonies, medicine, and dances; and disseminating and receiving information (Sawyer 1978). Such individuals often decided when and where various fishing, hunting, or gathering expeditions would occur and similarly made critical decisions concerning more elaborate ceremonial activities. The chief also played a central role in resolving conflicts within the community or during wars, which occasionally broke out with neighboring groups.

One explanation of the origin of the name *Napa* is that it was derived from the Patwin word *napo*, meaning house.

SUBSISTENCE

The acorn was the primary plant food, along with a variety of roots, bulbs, grasses, and other edible greens. Deer, elk, and antelope were the primary big game. Smaller game, such as rabbits, squirrels, and birds, was also important. Fish were caught but may not have been as important as terrestrial animals, which were abundant in the grassy valleys (Bean and Theodoratus 1978).

A variety of raw materials were available for the manufacture of hunting, gathering, and processing implements. Stone may have been the most important. The Wappo and Patwin, similar to every other Indian group in California, used stone in almost every aspect of their lives. Napa Glass Mountain, a regionally important obsidian site and quarry, and other local obsidian sources are situated within Wappo territory proper. Other major obsidian sources lay near the eastern and southern edges of the Russian River Subregion in the Clear Lake District (i.e., Borax Lake and Mount Konocti sources) and the Santa Rosa Locality (i.e., Annadel source).

A variety of raw materials were available for the manufacture of hunting, gathering, and processing implements. Stone may have been the most important.

TECHNOLOGY

Obsidian was used for projectile points, knives, scrapers, drills, and many other tool types. Chert, found naturally throughout the north Coast Ranges, was also used for a wide range of tools, including projectile points, knives, scrapers, cobble tools, and other tools. This sedimentary stone was sometimes found in concentrations or outcrops that became quarry locations. More commonly, though, it was found in drainages and alluvial fans throughout the region as useable cobbles. Basalt was also


Napa County, as mapped in 1908.


The Bale Grist Mill, a Napa County Historic resource

used for tool manufacture, quite often as heavy items that did not require detailed flaking, but it was not the preferred material. Men generally created the tools that were used in hunting large and small mammals. Women were generally thought to have a lesser role in stone tool manufacturing. Bone tools were generally made from bird and deer bone and antler. The Wappo used bone awls, needles, whistles (bird bone), perforators, and many other bone tools.

TRADE AND TRAVEL

Trade or visits with people outside a given linguistic group's territory was also common during ethnohistorical times. The Pacific coast or San Francisco Bay would have been important for marine resources (e.g., surf fish, shell, salt). Inland locations or locations outside a group's territory also would have been important for food resources (e.g., acorns, grass seeds, waterfowl) or other raw materials (e.g., obsidian). Because Napa Glass Mountain obsidian was known for its high quality, it was a valuable trade commodity and spread to areas across the western states. This gave the Wappo strong trading power.

COAST MIWOK

The Coast Miwok were also involved in frequent trade with the inhabitants of Napa County. The Coast Miwok language, a member of the Miwokan subfamily of the Utian family, is divided into two dialect groups: Western (Bodega) and Southern (Kelly 1978:414; Shipley 1978:84). The Coast Miwok territory extended from Duncan's Point on the Sonoma County coast to the end of the Marin County peninsula (Kroeber 1925). To the east, Coast Miwok territory extended as far as midway between the Sonoma and Napa Rivers (Kelly 1978).

Some of the main tribelets in Coast Miwok territory included the Omiomi, Alaguali, Olompali, Petaluma, Tamal, and several others. The Alaguali tribelet was located on the marshland borders of the northern shores of San Pablo Bay, northeast of the Omiomi tribelet in Novato (Milliken 1995:250). The Olompali tribelet was located northwest of the Omiomi tribelet in an inland valley. The distinction between tribelet territories is sometimes difficult to ascertain.

Coast Miwok sociopolitical organization did not extend beyond the village. Larger villages had a chief, whose position was nonhereditary. Other important leaders included the woman chief and the *máien*. The woman chief appears to have been primarily a ceremonial leader who was involved in the Bird Cult and coordinated the Acorn Dance and Sünwele Dance. The *máien* was the head of the female ceremonial house and directed the construction of new dance houses, had wood hauled for festivals, supervised the preparation of foods for special events, sent invitations to dances, and sometimes selected dance performers (Kelly 1978:19).

Coast Miwok villages were usually located near major inland watercourses and sometimes along the coast. The villages were composed of several types of structures, including dwelling houses, sweathouses (in larger villages), and dance houses (in larger villages).

The Coast Miwok subsistence strategy focused on the coast and adjacent inland areas (e.g., throughout Napa County) for much of the year, where salmon and other fish, deer, crab, kelp, seeds, mudhens, geese, mussels, and clams were available. During summer, the focus of hunting and plant-gathering activities shifted to the hills, where rabbit, bear, elk, deer, squirrels, gophers, seeds, greens, and acorns were plentiful. Acorns were pounded into meal, leached, and boiled with hot stones to make mush; tanbark acorns were preferred. Adult men smoked tobacco, which was gathered along Healdsburg and Santa Rosa Creeks (Kelly 1978:415–417; Heizer and Elsasser 1980).

Coast Miwok technology consisted of items fashioned from wood, stone, shell, and animal materials. The Coast Miwok polished and sometimes perforated stone for use as hunting and fishing charms. Hunters used long obsidian blades as charms when hunting bear. Obsidian was obtained from the Wappo for manufacturing butchering knives and arrow points. Coast Miwok traded clamshell disk beads to the Wappo in exchange for unworked obsidian. General utility knives were made from green chalcedony. Women made basketry, and men made willow containers for hunting implements, as well as burden baskets and mortar hoppers. (Kelly 1978:417–418.)

Many of the Coast Miwok were taken to San Francisco Mission Dolores, established in 1776; Mission San Jose de Guadalupe, established in 1797; and Mission San Rafael Arcangel, established in 1817, to be converted. Large groups were taken, ranging in size from approximately 40 to 150 tribal members at a time (Milliken 1995). After which time, their numbers decreased rapidly, as did all Native American populations throughout the Bay Area and California.

HISTORICAL CONTEXT

The following historical context has been adapted from previous Napa County contexts prepared John F. Hayes in 2004 and Jennifer Ferneau et al. in 2000 (Hayes 2004; Ferneau et al. 2000) as well as information from Hoover 1990.

EARLY HISTORY

Napa County was one of the original 27 counties created when California became a state in 1850. The name is derived from a tribe of Native Americans that once inhabited the area. The City of Napa serves as the County seat. In 1823, the first recorded European explorers in the upper Napa Valley, Don Francisco Castro and Franciscan Friar Jose Altimira, traveled through the area in search of a site for a new mission. They explored present-day Petaluma, Sonoma, and Napa before eventually settling on Sonoma as the new mission site (Hoover 1990).

RANCHO PERIOD

RANCHO CAYMUS

George C. Yount was the first pioneer to settle in Napa County. Born in North Carolina in 1794, Yount arrived at Fort Yuma with a group of trappers known as the Wolfskill party in 1827. They departed Missouri and came to California in 1831 to hunt and trap sea otters. Yount eventually settled in San Rafael, where he worked at odd jobs in the region, including the Sonoma Mission and at General Vallejo's residence in Sonoma. In 1836, Yount was baptized as Jorge Concepcion Yount and became a Mexican citizen. He received the Rancho Caymus land grant in the Napa Valley, which included more than 11,000 acres, from the Mexican government. Yount built an adobe house and later a Kentucky-style blockhouse and gristmill on his property (Hayes 2004).

From 1836 to 1846, most of the rancho was used for open grazing for horses, cattle, and sheep. A lesser portion was used for cultivation, including wheat, which was the most popular crop at the time. Historic records indicate that by the late 1870s, some of the landowners who lived in the general area conducted multi-crop farming, consisting mainly of wheat, fruit orchards, and vineyards. Prune orchards were also historically cultivated throughout the valley (Hayes 2004).

In 1855, Yount laid out a town grid on his property, which he called Sebastopol. After Yount's death in 1865, a large remaining portion of his rancho (after allotments were made to relatives and assigned acreage cultivated by tenants) was subdivided into several blocks containing various-sized lots, which were then sold. The town was renamed Yountville sometime after his death (Hayes 2004).

RANCHO CARNE HUMANA

Dr. Edward Turner Bale was another early settler in Napa County. He served as surgeon-in-chief of the Mexican army in Alta California. After marrying General Vallejo's niece Maria Ignacia Sobrantes in 1839, Bale was granted almost 18,000 acres, just north of Yount's property, called Rancho Carne Humana. Bale commissioned the building of a gristmill just north of Mill Creek. The gristmill, with a granary nearby, was used to grind the corn and wheat for northern valley farmers. Wheat continued to be an important crop through the 1860s, when much of the exported hay harvested in Napa County was shipped to England (Hayes 2004).

Other settlers during this period included Ralph L. Kilburn, Thomas Kittleman, Florentine Kellogg, and Sarah Graves Fosdick. In July 1847, Fosdick opened the first school in Napa Valley and the second American school in California (Hayes 2004).

RANCHO CATACULA

Joseph Ballinger Chiles was amongst the first Americans to settle in California in the early 1840s. In the 1840s and 1850s, he made several journeys between California and Missouri. Chiles and his party blazed several trails across the Sierra Nevada on early expeditions. In 1844, Chiles obtained title to Rancho Catacula, which was located in the valley that later bore his name. For decades, the valley was used to graze both cattle and horses (Hayes 2004).

Chiles built an adobe house on Rancho Catacula in 1846 and settled down to farm the land and raise Missouri mules and Durham cattle, for which he became well known. Chiles also built a gristmill on the rancho in 1846, which was among the first built in northern California. The mill was in operation until the 1880s, producing nine barrels of flour daily as the demand for commodities skyrocketed during the Gold Rush in 1849. Chiles also manufactured whiskey until the late 1870s under the Catacula label, touted as a sign of excellence (Hayes 2004).

MALLACOMES RANCHO

The history of Mallacomes Rancho, a portion of which extends into Napa County, began with the settlement of Jose de los Santos Berryessa, former Alcalde of Sonoma under General Vallejo in Knights Valley. Micheltorena approved the formal grant of the Mallacomes Rancho, or Muristal y Plan de Agua Caliente (about 17,754 acres), to Berryessa in 1843 as a reward for serving the Mexican governor (Hayes 2004).

In 1850, after California became part of the United States, the majority of Spanish settlers (including Berryessa) living in the new state returned to Mexico. In 1853, Thomas B. Knight purchased a large portion of Berryessa's rancho and named it Rancho Muristood. Knight had participated in the Bear Flag Revolt led by Colonel Fremont and included a number of other Napa Valley settlers. Knight's rancho eventually became known as Knights Valley (Hayes 2004).

EARLY AMERICAN SETTLEMENT

The following section is based on information from a website dedicated to the history of the Napa Region (www.cagenweb.com/napa/2napa_hist.htm).

Napa County was created in 1850. It was named after Napa Valley. The word napa is of Indian derivation and has been variously translated as "grizzly bear," "house," "motherland," or "fish." Of the many explanations of the name's origin, the most plausible seems to be that it is derived from the Patwin word napo, meaning house.

On January 4, 1850, a committee of California's first constitutional convention, chaired by General Vallejo, recommended the creation of 18 counties: Benicia, Butte, Fremont, Los Angeles, Mariposa, Monterey, Mount Diablo, Oro, Redding, Sacramento, San Diego, San Francisco, San Joaquin, San Jose, San Luis Obispo, Santa Barbara, Sonoma, and Sutter.

In the 1830s, the Napa Valley became one of the first in California to be settled by American farmers. When California was granted statehood in 1850, the Napa Valley was in the territory of California, district of Sonoma. In 1850, when counties were first being organized, Napa became one of the original 27 counties of California with Napa City (later shortened to Napa) as the County seat.

The Gold Rush of the early 1850s caused Napa City to grow. After the first severe winter in the gold fields, miners sought warmer refuge in the young city. There was plenty of work on the cattle ranches and in the lumber industry.

Historic Christian Brothers Winery

By 1870, Euro-Americans had inhabited the Napa Valley and the Native Americans who once roamed freely were wiped out by smallpox and other introduced diseases. In 1848, Nathan Coombs laid out Napa City on property he acquired from Nicholas Higuera's Rancho Entre-Napa, an 1836 Mexican land grant.

The Gold Rush of the early 1850s caused Napa City to grow. After the first severe winter in the gold fields, miners sought warmer refuge in the young city. There was plenty of work on the cattle ranches and in the lumber industry. Sawmills in the valley were cutting timber that was hauled by horse team to Napa City, where it was then shipped out via the Napa River to Benicia and San Francisco.

The Napa Valley is now known mostly for its premier wines. At the start of the industry, Euro-American settlers planted vineyards with cuttings supplied by Catholic priests from Sonoma and San Rafael. In 1861, Riesling cuttings were introduced to the valley. From these small beginnings, the Napa Valley has become noted as one of the premier winemaking regions of the world.

VITICULTURE INDUSTRY

The Napa Valley is known mostly for its premier wines. The viticulture industry was started with cuttings supplied by Catholic priests from Sonoma and San Rafael.

In California, the Spanish and then Mexican missions are credited with planting the first grapevines and making the first wines, initially for sacramental and then general use. Although these vines produced abundant fruit, the resulting wine was described as bland and heavy, with a high sugar and alcohol content. The first grape vines grown in the Napa Valley are credited to George Yount, who in 1838 planted table grapes. Production increased between 1845 and 1847, when William Nash and F. E. Kellogg planted orchards and vines near Bale Mill and sold their products in San Francisco. Little effort was made to improve the variety of mission grapes, growing techniques, or winemaking process until the mid-1850s, when Agoston Haraszthy concentrated his efforts on these goals. He is credited with introducing zinfandel into California in 1852. He also planted additional European varietals in the Napa Valley in the 1860s. During this time, the United States market for California wines was generally based on inexpensive price, rather than a sophisticated palate (Ferneau et al. 2000).

In 1865, France and Spain experienced an outbreak of phylloxera, with wine production reduced by half. Vineyards in the United States were initially unaffected and for a brief time profited from Europe's misfortune. The California legislature removed the tax from wines in 1866 to encourage the industry and provide opportunities for those abandoning unprofitable gold mining ventures. In addition, the construction of the Napa Valley Railroad in 1868 increased the marketing potential for grain and grape growers, allowing easy shipment of their crops to Napa and then via steamer to San Francisco and beyond. These changes created a large impact on the burgeoning Napa Valley wine industry and settlement in the region (Ferneau et al. 2000).

The 1870s marked a period of tremendous growth in the Napa Valley wine industry, with the number of wineries between Calistoga and Oakville doubling from 15 to 30. Wine production employed more workers than any other form of California agriculture, leading to an increase in the use of Chinese laborers. Dozens of Chinese laborers arrived in the valley to build the Napa Valley Railroad and remained to work in viticulture (Ferneau et al. 2000).

Napa Valley growers started focusing on improving the taste of their product, which was enhanced by the use of underground wine cellars that provided constant temperature. An economic depression in the mid-1870s and a phylloxera outbreak in the Napa Valley affected the direction of winemaking by eliminating many struggling wine businesses. By the mid-1870s, grapes had become a major crop as wheat declined and agricultural diversity was on the increase. St. Helena became the focal point of wine growing in the Napa Valley (Ferneau et al. 2000).

By the late 1870s and early 1880s, overproduction of wine, the poor quality of the product, and a tax on brandy posed serious challenges for winemakers in the Napa Valley. To face these challenges, wine growers gradually replace old or diseased vines with a variety of the best European varietals. With experience, growers extended their vineyards into hillier terrain, where vines were less affected by hard valley frost, and planted other varieties, such as cabernet sauvignon, cabernet franc, and merlot. While total output varied over the years, California saw a relatively steady increase in wine production. With 4 million gallons of new wine in 1877 increasing to 17 million in 1888, Napa County was producing as much wine as the United States was importing from other countries (Ferneau et al. 2000).

In the early 1890s, a phylloxera infestation seriously affected half of the vineyards in Napa County. Wine production fell from roughly 5 million gallons in 1890 to 2 million gallons in 1892. A native eastern United States grapevine resistant to phylloxera was used as rootstock for grafting the European varietal vines; by the mid-1890s, the wine industry was beginning to re-establish itself as an important agricultural industry (Ferneau et al. 2000).

While viticulture remained the dominant agricultural activity in the valley in the late 1800s, agricultural diversity began to increase in response to the problems that faced the wine and wheat industries. Fruit growing (mostly apples and peaches) was a major enterprise in the late nineteenth century. By the 1880s, olives and prunes also became important tree crops; by the turn of the century, prunes had become the main fruit crop in Napa Valley. The wine industry had another setback with the San Francisco earthquake of 1906 because San Francisco was California's center for shipping, trading, and cellaring of wine. The California Wine Association alone lost more than 9 million gallons of wine in the earthquake (Ferneau et al. 2000).

The industry rebounded once again, only to be dealt another more serious blow—Prohibition, established by the 18th Amendment to the Constitution in January 1920. A few viticulturists survived by producing limited amounts of wine for medicinal, sacramental, or cooking purposes. Creative ways to acquire wine were enlisted, with local doctors prescribing wine to cure ills and families taking up at-home winemaking, which was still legal if a family produced 200 gallons or fewer annually. Among those that survived was the Christian Brothers, a religious teaching order of the Roman Catholic Church that moved its winemaking operation from Martinez to Mont La Salle in the Napa Valley in 1932 and purchased the Greystone Cellars in 1950. The wine industry did not recover until the 1950s, after the Great Depression and World War II (Ferneau et al. 2000).

CONCLUSIONS AND REPORT UPDATE RECOMMENDATIONS

This section is presented to provide direction to Napa County regarding future work to refine the information included in this document to maximize its utility and effectiveness. The scope of this document allowed Jones & Stokes to create a baseline database and limited contextual background regarding existing archaeological, historical, and architectural resources that are presently recorded within Napa County.

CULTURAL RESOURCES

The goal of this document is to provide a summary of prehistoric and ethnographic background information for Napa County. This information is appropriate for use in cultural resource setting sections for all types of projects that will be conducted in Napa County and should be useful for use in environmental impact reports, initial studies, and the general plan update.

There are many unique archaeological resources in Napa County, and the ethnographic record of the Patwin, Wappo, Coast Miwok and all those with whom they interacted just begins to show the cultural complexity that was in place at the time of European- American contact. Napa County also played a historically significant role in the development of California and the West. Many important figures of history and events that took place here have had far reaching implications for modern-day Californians. The record of significant historic properties within the County is extensive and will surely grow as more properties are identified and evaluated.

In addition, the regulatory requirements for conducting cultural resources investigations within Napa County, including the new SB 18, are presented so as to provide guidance and direction for applicants and the local Napa County and Cities for complying with CEQA for future development.

It is clear from the synthesis of information shown on the maps and in the datasets, that Napa County was a rich resource base and home to many thousands of Native Americans stretching back for thousands of years. The archaeological and broad historical record of the County are important resources significant not simply to California, but to North America. The regulatory requirements presented in this chapter should guide the conservation and treatment of these resources.

ARCHAEOLOGICAL RESOURCES

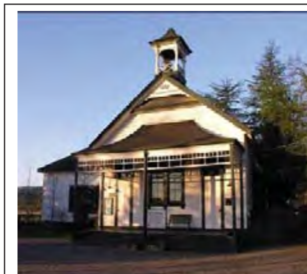
The sensitivity analysis of prehistoric resources is designed to present information about where archaeological sites will likely be located across the landscape. This information can be useful as a broad planning tool for projects such as the general plan update and can communicate to developers and other project applicants whether a project location has a low or high level of sensitivity for the presence of archaeological resources. The sensitivity analysis is not, however, included to provide either a comprehensive or long-term gauge regarding where there is the need for specific project level investigations.

The following list includes recommendations for the continuing utility of the archaeological database.

- Develop in-depth ethnographic contexts for small localities within Napa County that discuss intergroup relationships and relations with European, Mexican, and American settlers from the time of contact through the twentieth century.
- Develop additional prehistoric studies that provide detail regarding Native American settlement patterns across the landscape.
- Develop a cultural landscape component within the discussion of archaeological, historical, and architectural resources.
- Maintain the cultural resources database by conducting record searches at the NWIC every 18 months to determine whether new sites have been located.
- Ensure that any archaeological investigations conducted within Napa County are reported and that the information is provided to the NWIC on an individual project basis.
- Ensure that field surveys are conducted by a professional archaeologist on an individual project basis, based on the list provided by the NWIC, if survey is required.
- Conduct consultation efforts with the NAHC and interested Native American individuals on an individual project basis, as required.
- Adhere to the guidelines set forth by SB18 regarding Native American involvement and consultation in the General Plan Update EIR- see detail in regulatory section at the beginning of this document.

ARCHITECTURAL AND HISTORICAL RESOURCES

To serve the comprehensive and broad thematic needs of any future cultural resource investigations conducted within Napa County, the subject matter and detail of the context should be expanded to streamline report preparation efforts. Whereas the initial effort conducted by Jones & Stokes was scoped to be limited to information provided by Napa County, a more intensive study utilizing primary and secondary source information may expand the utility of the historic context. Themes researched and documented should be tailored to address those events of Napa County's history against which cultural resource evaluations can be reasonably measured for historic significance on a more localized level. Below is a list of proposed themes of more in-depth studies that would help to improve the context's utility.



Nineteenth-century Napa schoolhouse

- Contact period/exploration
- Mexican period, including various ranchos contained within Napa County
- Ethnic diversity regarding Chinese communities, Italian community
- California Gold Rush period, focused on local settlement, impacts, etc.
- Local silver mining (Mount St. Helena, etc.), cinnabar (mercury), and magnesite
- Annexation period, including any appropriate Bear Flag Revolt data because it took place largely in Sonoma
- City/town/county settlement and boundary development
- Early industrial development (Bale Grist Mill, etc.)
- Various agricultural practices in addition to viticulture, such as hops, prunes, orchard crops, and livestock.
- Commerce/labor distribution
- Transportation networks (railroads, river travel, and roadway development)
- Military and wartime/postwar County changes.
- Water use (mineral water, irrigation, water storage, and flooding)
- Infrastructure development (sewage, water, electricity, police, fire, hospitals, schools, etc.)
- Ethnic settlements/demographics
- Economic changes (depressions, boom periods)
- Tourism

The extrapolation of information regarding these themes with regard to Napa County will provide a background for the historic significance of existing resources, as well as expedite one of the most time-intensive components of any cultural resources study conducted within the County boundaries. The early identification and documentation of important historic themes within Napa County will facilitate quick, accurate determinations of eligibility and assist in the management of any future significant historic resources.

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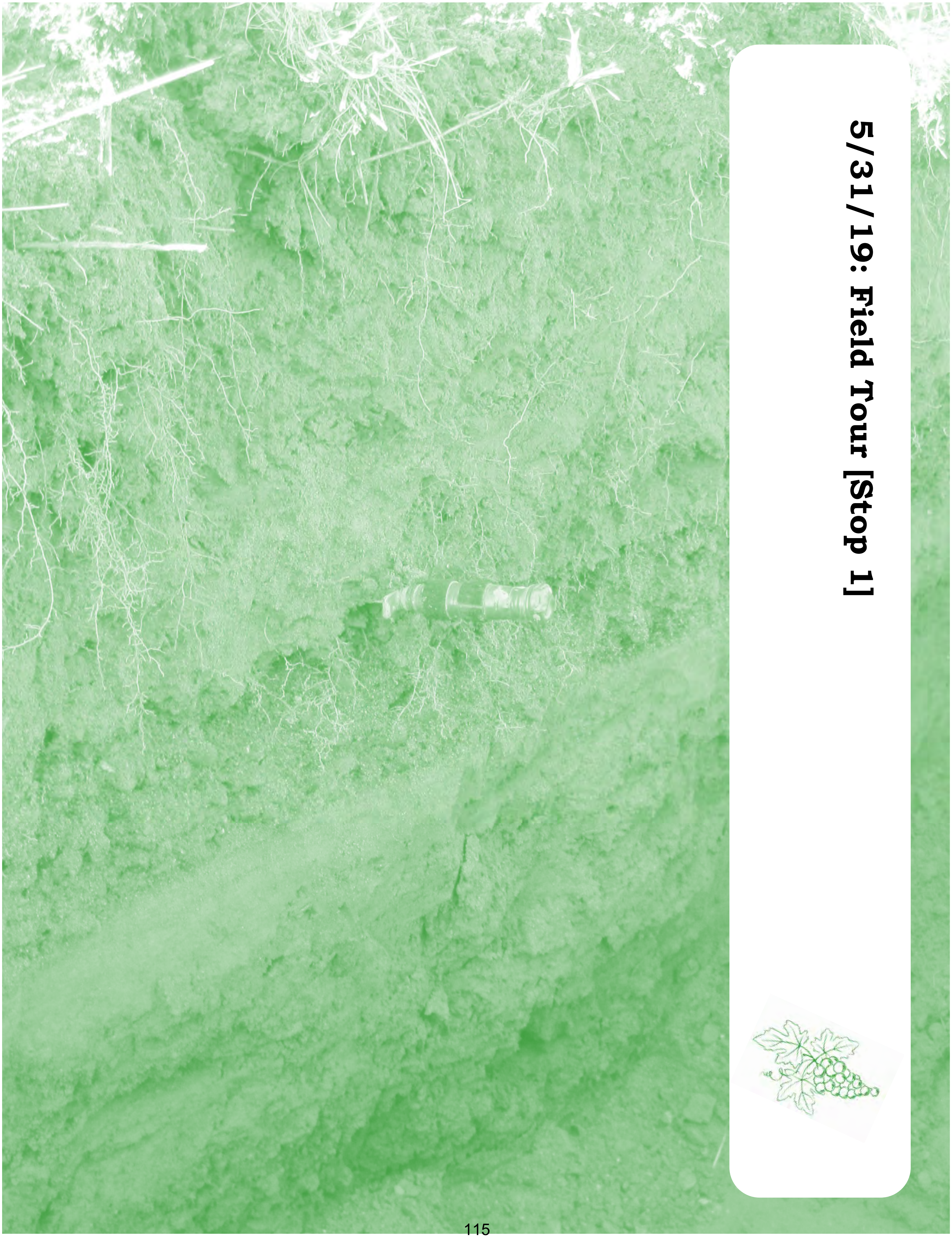
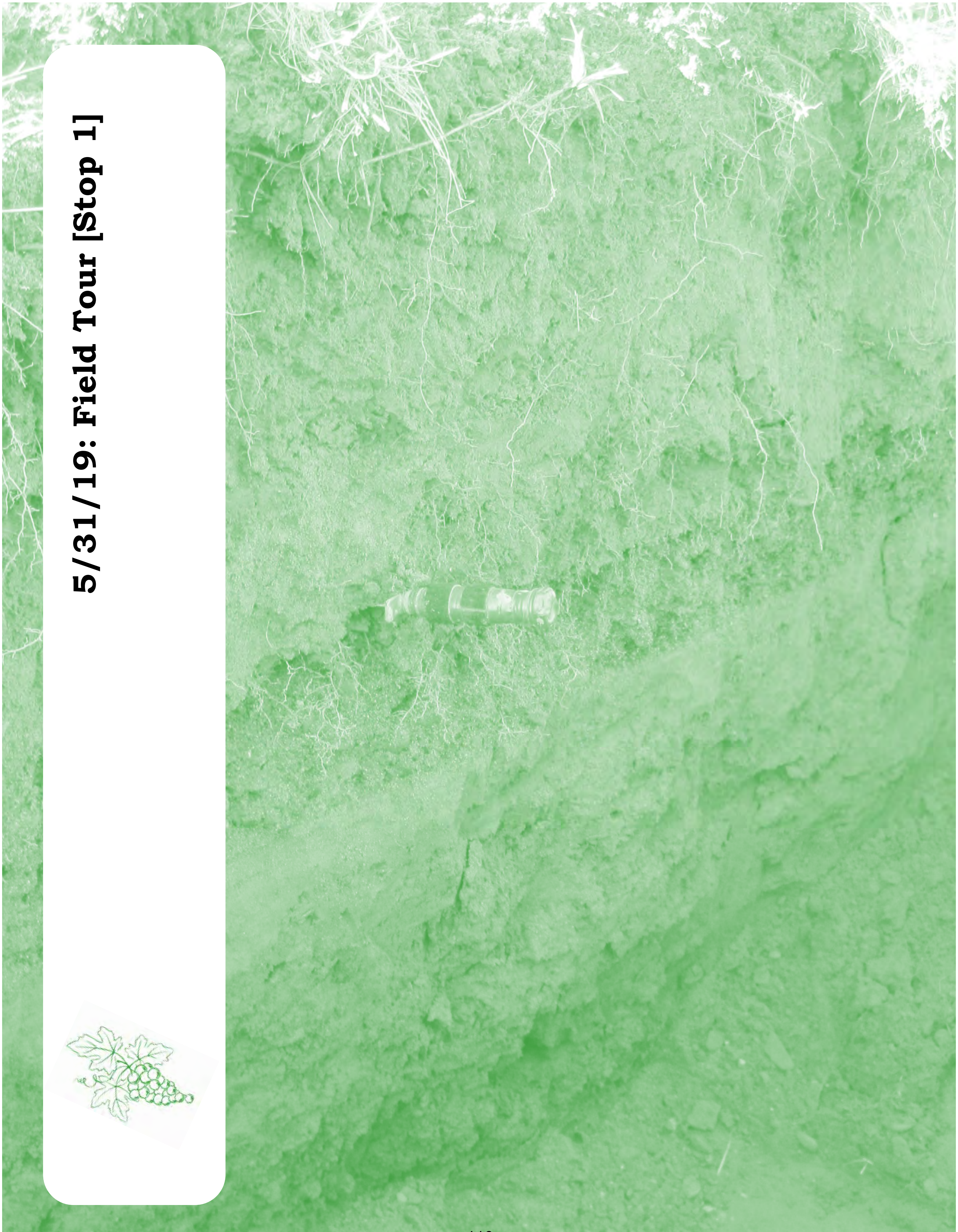


5/31/19: Field Tour [Stop 1]

5/31/19: Field Tour [Stop 1]




MARE ISLAND
Solano County Soil
Survey 1977
Source:
UC SoilWeb
SP
Td
Td
Td
Rd
Vd
Re
W
W
Ja
BP
DlC
Ma
Td
DlE
CeA
Ma
RoA
Re
DlC
DaC
Ma
Vd
W
BP
DlE
DbE
MmE
W
AcE
DlF2
MmG2
DlF2
W

LOCATION VALDEZ CA

Established Series
Rev. CBG-GMK-WBS-MAV-ET
03/2003

VALDEZ SERIES

The Valdez series consists of very deep, poorly drained soils that formed in recent alluvial material from mixed rock sources. Valdez soils are near rivers, sloughs and old stream channels in river deltas and flood plains and have slopes of 0 to 2 percent. The mean annual precipitation is about 17 inches, and the mean annual air temperature is about 60 degrees F.

TAXONOMIC CLASS: Fine-silty, mixed, superactive, nonacid, thermic Aeric Fluvaquents

TYPICAL PEDON: Valdez silt loam - on a less than 1 percent west facing slope at 1 foot elevation in irrigated cropland. (Colors are for dry soil unless otherwise noted.)

Ap--0 to 14 inches; pale brown (10YR 6/3) silt loam, brown (10YR 4/3) moist; few fine brownish yellow (10YR 6/8) mottles, brown (7.5YR 4/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; common very fine and few medium and coarse roots; few very fine tubular and common fine interstitial pores; slightly calcareous, lime segregated in rounded fine soft masses (beet lime was applied); moderately alkaline (pH 8.0); abrupt smooth boundary. (5 to 18 inches thick)

C1--14 to 21 inches; light gray (10YR 7/2) very fine sandy loam, grayish brown (10YR 5/2) moist; many medium brown (7.5YR 4/4) and strong brown (7.5YR 5/6) mottles, dark reddish brown (5YR 3/2) and reddish brown (5YR 4/4) moist; massive (weak tillage pan); slightly hard, very friable, nonsticky and nonplastic; common very fine roots; few very fine and fine tubular pores; common mica flakes; neutral (pH 7.0); abrupt smooth boundary. (6 to 30 inches thick)

C2--21 to 49 inches; pale brown (10YR 6/3) silt loam, brown (10YR 4/3) moist; common fine strong brown (7.5YR 5/6) mottles with pale olive (5Y 6/3) mottling and yellowish red (5YR 4/6) with olive (5Y 4/3) moist mottles in bands, pores, root channels and cleavage planes; strong very thin and medium platy structure with mica visible on cleavage planes; slightly hard, friable, slightly sticky and slightly plastic; common very fine roots; many very fine tubular pores; slightly alkaline (pH 7.5); clear wavy boundary. (20 to 30 inches thick)

C3--49 to 65 inches; light yellowish brown (10YR 6/4) silt loam, dark yellowish brown (10YR 4/4) moist; common medium strong brown (7.5YR 5/8) mottles, yellowish red (5YR 4/8) moist; strong very thin and medium platy structure with mica visible on cleavage planes; hard, firm, slightly sticky and nonplastic; common very fine roots; common very fine tubular pores; neutral (pH 7.0).

TYPE LOCATION: Yolo County, California; about 1/2 mile SE of railroad siding of Valdez; 4 1/2 miles west and 6 3/4 miles south of Clarksburg; 0.4 mile south of Sutter Road, 0.25 mile east of Sacramento Northern Railroad, 50 feet south of irrigation ditch, T.6 N., R.3 E in an unsectionized area Courtland Quad.

RANGE IN CHARACTERISTICS: Unless drained and not irrigated, the upper 20 inches of the soil usually does not become dry. The mean soil temperature is about 60 degrees to 64 degrees F. The soils have coarse stratification and the organic matter decreases irregularly with increasing depth. The 10 to 40 inch section is dominantly silt loam, silty clay loam, or very fine sandy loam. There is about 18 to 35 percent clay and less than 15 percent material coarser than very fine sand. Except where soil amendments have been used, the soils are noncalcareous or are calcareous only in some pedons below depth of 30 inches. It has distinct or prominent mottles thoughout.

The A horizon is 10YR 6/2, 6/3, 6/4, 7/1, 7/2, 2.5Y 7/2 or 6/2. Moist colors are 10YR 4/4, 4/3, 4/2, 4/1, 3/2, 5/2, 5/3; 2.5Y 4/2 or 3/2. It is strongly acid to moderately alkaline where soil amendments have been applied.

The upper C horizon is 10YR 7/1, 7/2. 6/2; or 5Y 6/2. Moist colors are 10YR 5/1, 5/2, 4/2; 2.5Y 3/2 or 4/2. It ranges from fine sandy loam to silty clay loam. This horizon is slightly alkaline to moderately acid.

The lower C horizon is 10YR 7/1, 7/2, 7/3, 6/2, 6/3, 6/4, 4/1, 3/1; 2.5Y 6/2; 5Y 6/3, 6/4. Moist colors are 10YR, 5/1, 5/2, 5/3, 4/2, 4/3, 4/4, 3/1, 3/2; 5Y 4/3, 4/4 and contains distinct or prominent mottles in some part. It is sandy loam to silty clay loam and is moderately acid to moderately alkaline. Pedons with 2C or 3C horizons are 10YR 3/1 or 4/1. Moist color is 10YR 2/1 or 3/1. Reaction is moderately acid to neutral. They are stratified below a depth of 40 inches with mucky silt loam, mucky silty clay loam, muck and mucky peat.

COMPETING SERIES: These are the Belden and Commerce soils. Belden soils have moderate permeability in the series control section. Commerce soils have a mean annual temperature of about 66 degrees F.

GEOGRAPHIC SETTING: Valdez soils are in river deltas and flood plains near rivers, sloughs and old stream channels at elevations of 15 feet below sea level to 20 feet above. Slopes are 0 to 2 percent. The climate is dry subhumid, with hot dry summers and cool moist winters. Mean annual precipitation is 14 to 19 inches. Average January temperature is 45 degrees F.; average July temperature is 75 degrees F.; mean annual temperature is 60 to 61 degrees F. The average frost-free period is over 260 to 300 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Columbia, Lang, Merritt, Sacramento, Sycamore and Tyndall soils. Columbia soils have less than 18 percent clay in the 10 to 40 inch control section. Lang soils are sand or loamy sand in the 10 to 40 inch control section. Merritt soils have mollic epipedons. Sacramento soils have dark A horizons and more than 60 percent clay. Sycamore soils have a dry value of 4 or less in the A horizon. Tyndall soils average less than 18 percent clay in the 10 to 40 inch control section.

DRAINAGE AND PERMEABILITY: Poorly drained under natural conditions; slow to very slow runoff; moderately slow permeability (organic substratum phase has rapid permeability below a depth of 40 inches). The water table fluctuates from 3 feet to below 5 feet in many drained areas.

USE AND VEGETATION: Irrigated areas are used for intensive row and field crops. Alfalfa and orchards are grown where the water table has been lowered. Nonirrigated areas are used for grain and wildlife.

DISTRIBUTION AND EXTENT: The soil occurs along the lower Sacramento River near Suisun Bay and the Sacramento-San Joaquin Delta. The series is of moderate extent in MLRA-16, 17.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Davis, California

SERIES ESTABLISHED: Yolo County, California, 1971.

REMARKS: The activity class was added to the classification in March of 2003. Competing series were not checked at that time. - ET

Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - the zone from the surface to a depth of 14 inches (Ap)

Aeric subgroup - the zone from 10 to 30 inches has 10YR or 2.5Y hues with chromas of 2 or less in the matrix and distinct or prominent mottles in 5YR or 7.5YR hues.

National Cooperative Soil Survey
U.S.A.

LOCATION REYES CA

Established Series
Rev. GML/SBJ/TDC/ET
03/2003

REYES SERIES

The Reyes series consists of deep, somewhat poorly drained soils that formed in alluvium from mixed sources. Reyes soils are in reclaimed and protected marsh areas and have slopes of 0 to 2 percent. The mean annual precipitation is about 25 inches. The mean annual temperature is about 59 degrees F.

TAXONOMIC CLASS: Fine, mixed, active, acid, thermic Sulfic Fluvaquents

TYPICAL PEDON: Reyes silty clay, on a gently undulating slope of 1 percent in a cultivated oat hay field at 1 foot elevation. (Colors are for dry soil unless otherwise stated. When described (6/28/61) the soil was dry to 14 inches, moist to 31 inches, and wet below 31 inches. A water table at about 5 feet.)

Ap1--0 to 7 inches; light brownish gray (10YR 6/2) silty clay, dark brown (10YR 3/3) moist; strong fine granular structure; slightly hard, friable, sticky and plastic; many very fine and fine roots; many very fine and fine interstitial pores; extremely acid (pH 4.2); gradual smooth boundary. (5 to 8 inches thick)

Ap2--7 to 14 inches; grayish brown (10YR 5/2) silty clay, very dark grayish brown (10YR 3/2) moist; strong fine granular structure; hard, friable, sticky and plastic; many very fine and fine roots; many very fine and fine interstitial pores; extremely acid (pH 4.1); abrupt wavy boundary. (5 to 10 inches thick)

B21--14 to 22 inches; light brownish gray (10YR 6/2) silty clay, dark gray (10YR 4/1) moist; common fine distinct brownish yellow (10YR 6/6) mottles, strong brown (7.5YR 5/6) moist; root stains are very dark brown (10YR 2/2) and strong brown (7.5YR 5/6); weak coarse subangular blocky structure; extremely hard, firm, sticky and plastic; many very fine and fine roots; many very fine and fine tubular pores; stains along root channels are light gray (2.5Y 7/2) dry; extremely acid (pH 3.7); gradual smooth boundary. (6 to 20 inches thick)

B22--22 to 31 inches; light gray (5Y 6/1) silty clay, dark gray (5Y 4/1) moist; common fine prominent yellowish red (5Y 5/6) mottles dry; few streaks of very dark grayish brown, black moist; weak coarse prismatic structure; extremely hard, firm, sticky and very plastic; many very fine and fine roots; common very fine and fine tubular pores; root stains are strong brown (7.5YR 5/6) and very dark brown (10YR 2/2); stains along root channels are light gray (2.5Y 7/2) dry; extremely acid (pH 3.7); gradual smooth boundary. (8 to 18 inches thick)

C1g--31 to 51 inches; gray (N 6/) silty clay, dark gray (5Y 4/1) moist; common fine prominent yellow (2.5Y 7/6) jarosite mottles; brown stains on parting planes; moderate very coarse prismatic structure; extremely hard, firm, sticky and plastic; many very fine and fine exped roots; many very fine and fine tubular pores; extremely acid (pH 3.6); gradual smooth boundary. (10 to 24 inches thick)

IIC2g--51 to 63 inches; gray (N 5/) and black (N 2/) silty clay, dark gray (5Y 4/1) and gray (N 5/) moist; few fine distinct yellowish brown (10YR 5/6) mottles, dark greenish gray (5GY 4/1) and black blotches moist; massive; extremely hard, firm, sticky and plastic; common very fine and fine tubular pores, some of which are filled with organic matter; hydrogen sulfide odor; extremely acid (pH 3.6) to moderately acid (pH 6.0) over the space of a few inches.

TYPE LOCATION: Sonoma County, California; 100 feet east of Leveroni Road, 57 degrees and 3,800 feet from Railroad Bridge at Wingo. The projected section is SW1/4, SW1/4 sec. 4, T.4N., R.5W., MDB&M.

RANGE IN CHARACTERISTICS: Solum thickness is 31 to 50 inches to the bottom of the B horizon. The mean annual soil temperature is 59 degrees to 61 degrees F. The soils have mottles within depths of 10 to 18 inches. The profile contains major strata of mineral soil low in organic matter and thin strata of soil with 5 to 30 percent organic matter. Organic matter averaged less than 15 percent in the control section. The soil is silty clay loam, silty clay, or clay. The weighted average of the 10- to 40-inch control section commonly is 35 to 60 percent clay. The n value is 0.3 to 0.7. These soils are drained and protected by levees and large drainage ditches. With cultivation the soil becomes oxidized and is slightly to extremely acid. The lower horizons (C horizons) are commonly extremely acid but range from moderately acid to extremely acid within a space of a few inches. Usually the more the soil is drained and oxidized, the more acid it becomes. The soils are slightly to strongly saline. Sulfidic materials occur at depths of 20 to 40 inches.

The A horizon has dry color of 10YR 5/1, 5/2, 5/3, 6/1, 6/2, 6/3, 6/4, 6/6, 7/1, 7/2; 2.5Y 5/2, 6/2, 6/4 or 7/2 and moist color of 10YR 3/2, 3/3, 4/1, 4/2, 5/1, 5/2; 2.5Y 3/2, 4/2 or 5/2. Some or all of the upper 10 inches has dry value of 6 or has moist value of 4 or 5. There are few to common, fine to medium, faint to prominent 10YR 4/6; 7.5YR 3/4, 4/4, 4/6, 5/6; 5YR 3/4, 4/3, 4/4 or 4/6 mottles.

The B horizon has dry color of 10YR or 5Y 5/1, 5/2, 6/1, 6/2; N 5/0, or N 6/0 and moist color of 10YR or 5Y 4/1, 5/1; N 4/0, or N 5/0. Distinct or prominent mottles are present in hue of 5Y, 2.5Y, 10YR, 7.5YR, or 5YR. The moist value is 4, or if 5 the hue is 5Y or 2.5Y. In the lower part of the B horizon, jarosite mottles are many or common and are 2.5Y 7/6, 8/6, 8/8; 5Y 7/6, 7/8, 8/6, 8/8.

The C horizon commonly has moist hue of 5Y or is neutral. It has mottles with hue of 10YR to 5GY, 5G, 5BG, or 5B. Jarosite mottles are many or common and are 2.5Y 7/6, 7/8, 8/6, 8/8; 5Y 7/6, 7/8, 8/6, or 8/8.

COMPETING SERIES: These are the Alviso, Novato, and Ryde series in other families. Alviso soils are neutral to moderately alkaline and do not become extremely acid following drainage. Novato soils have n values of 1.0 to 1.5 and have nonacid reaction control sections. Ryde soils have a mollic epipedon and a fine-loamy particle-size control section.

GEOGRAPHIC SETTING: The Reyes soils are in salt water marches which ar adjacent to bodies of sea water and are now drained by large ditches and protected by levees and dikes. Slopes are 0 to 2 percent. Elevations are between 2 feet below sea level to about 10 feet above. The soils formed in mixed bay and stream alluvium under march type plants such as pickleweed, bulrush, and saltgrass. The climate is Mediterranean with hot, dry summers and cool moist winters. Mean annual precipitation is 12 to 35 inches. The mean annual temperature is 57 degrees to 61 degrees F.; average January temperature is about 46 degrees F.; average July temperature is about 72 degrees F. Frost-free season is 250 to 330 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Clear Lake, Joice, and Suisun soils and the competing Alviso and Novato soils. Clear Lake soils are not affected by sea water and lack high levels of polysulfides. Joice and Suisun soils have more than 30 percent organic matter in the series control section.

DRAINAGE AND PERMEABILITY: Somewhat poorly drained; very slow runoff or ponded; slow permeability. Water table fluctuates from 3 to 5 feet. The soils are protected by levees and are flooded only during periods of severe storms and very high tides.

USE AND VEGETATION: Where they have been reclaimed, the Reyes soils are used for production of oat hay, grain, and livestock pasture. Other areas are used as game refuges or by duck clubs. Vegetation in uncultivated areas is annual grasses, saltgrasses, coyotebush, and lambsquarter.

DISTRIBUTION AND EXTENT: Mainly around the edges of Suisun and San Pablo Bays and scattered in the Sacramento Delta in California. The series is of moderate extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Davis, California

SERIES ESTABLISHED: Sonoma County, California, 1971.

REMARKS: The Reyes soils formerly were a part of the Alviso and Ryde series. The part of the Reyes soils mapped in other survey areas that are not protected by levees and are flooded daily by tides would now be recognized as the Novato series.

ADDITIONAL DATA: Sampled by the Riverside Laboratory 6/28/61. Sample No. S61 Calif-49-13, SSIR No. 24, June, 1973.

National Cooperative Soil Survey
U.S.A.

The environmental restoration team for the former Mare Island Naval Shipyard (MINS) achieved remedy-in-place (RIP) for a complex, 230-acre disposal area (landfill) known as Investigation Area H1 (IA-H1). Achieving RIP was complicated by IA-H1's geology as well as its location in an environmentally sensitive and politically active community. The IA-H1 Restoration Team employed transformational thinking to execute the landfill cap placement with ongoing time-critical removal actions occurring at five other installation restoration (IR) sites at MINS which ultimately resulted in substantial cost savings and avoidance of green house gas emissions. The transformation of a landfill into a recreation area, wildlife refuge and wildlife viewing platform was ultimately the pride of not only the IA-H1 Restoration team, but the contributing community members, regulators and contractors. Specific accomplishments include:

- Successful resolution of numerous remedy and geotechnical challenges encountered during remedy design
- Cost savings of $42M and avoidance of green house gas (GHG) emissions (>9,000 tons of CO_2) by consolidation of contaminated soil and debris from onsite and adjacent restoration sites to create the cap.
- Incorporation of green remediation techniques in the design and implementation of the landfill cap (such as wetlands surface water replenishment from landfill cap runoff and onsite fuel storage, carpooling and use of local vendors)
- Successful partnering for the protection of the salt marsh harvest mouse, a State and Federally-listed Endangered Species, along with the improvement of 120 acres of existing wetlands and the successful creation of 8.7 acres additional wetlands
- Resolution of stakeholder issues and concerns for eco-receptors including creation of 4 miles of public access trails for wildlife and bay viewing with interpretative panels for public education of the environmental restoration process, local wildlife, and MINS history
- Successful outreach to nearby residences during development and implementation of cap
- Economic generation in the amount of $20M for small and disadvantaged businesses in a local community which was severely impacted by base closure

Installation

Former MINS, Vallejo, CA
Est.: 1854, *Closed*: 1996

Nominee

BRAC PMO, Naval Facilities Engineering Command Headquarters

Site Description

IA H1; 230-acre Waste Disposal Area (Landfill)

Technology/Method

Containment Area, Soil/Bentonite Slurry Wall, Groundwater Extraction, Geosynthetics-Soil Cover System, Wetland Mitigation

Contaminants

Metals, PCBs, VOCs, PAHs, TPH, asbestos, discarded military munitions

Action Levels

Human Health: (< 1E-5)
Eco Risk: HQ = 3 (uplands)
HQ = 1 (wetlands)

Planned Community Reuse

Open space/Recreation

Restoration Team

Navy BRAC PMO Team
Ms. Janet Lear
Ms. Heather Wochnick
Ms. Brooks Pauly
Ms. Patricia McFadden
Mr. Izzat Amadea

Regulatory Lead
Ms. Janet Naito,
Department of Toxic Substances Control,
Berkeley, CA

Regulatory Partner
Ms. Elizabeth Wells,
San Francisco Regional Water Quality Control Board,
Oakland, CA

RAB Co-Chair
Ms. Myrna Hayes

https://www.denix.osd.mil/awards/previous-years/fy11secdef/erit/former-mare-island-naval-shipyard-investigation-area-h1-restoration-team/

BRAC PMO NAVFAC and the Former Mare Island Naval Shipyard

The mission of the Department of the Navy (DON) Naval Facilities Engineering Command Base Realignment and Closure Program Management Office (BRAC PMO) is to expeditiously and cost effectively provide the services necessary to realign, close and dispose of DON BRAC properties. Such closures provide cost savings which can be reapplied to support DON and Department of Defense programs. The BRAC PMO prides itself on providing comprehensive environmental restoration and expedited property transfer actions to stimulate economic redevelopment at those installations where for many decades the community hosted the military mission.

Aerial view of the Mare Island Naval Shipyard

Mare Island Naval Shipyard (MINS) is located in Vallejo, California within Solano County in the northeastern portion of the San Francisco Bay area. It is bordered by San Pablo Bay to the west, the Carquinez Strait to the south, and Mare Island Strait (Napa River) to the east. Although originally a natural island, years of land reclamation by the DON through deposition of sediments from maintenance dredging of the Napa River created a peninsula and expanded the size of MINS from approximately 700 acres to over 5,000 acres, of which approximately 1,400 acres are developed.

The population of Vallejo is approximately 116,000 with a median household income of $61,000. MINS played a major role in the economic development of Vallejo and surrounding communities, and was the largest employer in Vallejo and Solano County. At the height of its operations in 1989, MINS employed 15,000 persons on base, with an additional 12,000 ancillary jobs indirectly supporting the shipyard. 1993 data shows that approximately 83% of MINS employees lived within Solano or Napa counties. In 2008, the City of Vallejo was the first municipality in California history to declare bankruptcy.

IA-H1 Location and Land Subject to State Reversion

MINS was the first United States Naval installation on the West Coast, operating for 142 years from 1854 until its closure in 1996. Its primary mission was to build, maintain, and repair Navy ships and submarines. Over 500 ships were built at MINS, with an additional 1,200 repaired or overhauled. MINS was also home to an ordnance facility located at the southern end of the island that produced and stored munitions from 1857 to 1972. A large portion of MINS is subject to reversionary land interest that must revert to the State of California once the military mission has ceased.

Investigation Area H1 Background

Investigation Area H1 (IA-H1), identified in 1983 during the Initial Assessment Study, comprises 230-acres. The Navy managed solid wastes at IA-H1 generated from the base during the early 1940s until 1989. Waste oil was discharged into unlined oil sumps constructed within IA-H1 from the early 1940s until the late 1960s. IA-H1 also contained an industrial wastewater treatment plant, sanitary sewage treatment plant, demolition debris disposal areas, lead battery disposal areas, and other miscellaneous disposal areas. Approximately 120 acres of the site contains non-tidal wetlands adjacent to or within disposal areas, which includes critical habitat for the Federal- and State-listed endangered salt marsh harvest mouse (SMHM).

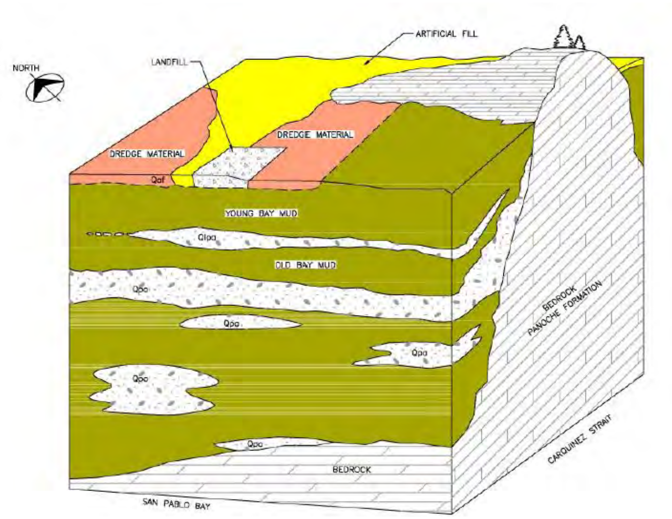
IA-H1 and Surrounding Wetlands

The Remedial Action Plan/Record of Decision/RCRA Closure Plan for IA-H1 was signed in 2006 and remedy-in-place was achieved in late 2010. A subarea of the site, which was most impacted by historic waste disposal, is called the Containment Area. It is approximately 73 acres and located in the southwest corner of the site. The remedy included hot spot removals, construction of a Resource Conservation and Recovery Act (RCRA) and a non-RCRA multi-layer cap (requiring two different cap designs) over the Containment Area, a slurry wall and groundwater extraction trench around the Containment Area, wetland mitigation and 2-ft soil cover on surrounding areas, long-term monitoring and land use controls. The remedy reduces the risks to humans and the environment from the contaminants of concern (COCs) at the site. Remaining site closure documentation is nearly complete.

Resolution of IA-H1 Design Challenges

The Team encountered and overcame numerous challenges during investigation and implementation of the IA-H1 environmental restoration. The IA-H1 landfill area is located on former mudflats of San Pablo Bay and required careful evaluation of geotechnical design parameters. The landfill waste materials are underlain by Young Bay Mud, Merritt Sand, and Old Bay Mud. The Young Bay Mud is soft and poses potential issues with settlement and stability of the cover system. Shear strength parameters for the site subsurface soils and import fill materials to be used for the cover system were determined via a combination of in-situ measurements (cone penetrometer testing) and laboratory testing (unconfined and tri-axial shear strength tests). To determine requirements for the landfill cover slope inclinations, drainage channel slopes, and material interfaces, the following evaluations were completed as part of the final design:

- Static global slope stability (circular and block failure surfaces)
- Assessment of seismic parameters
- Seismic slope stability
- Dynamic deformation
- Veneer slope stability
- Settlement (primary and secondary consolidation)
- Bearing capacity analysis
- Surface water infiltration Surface water control system using 24-hr storm event software
- Erosion loss using Universal Soil Loss Equation (USLE)



Geologic Cross-Section IA-H1 Landfill Before Cap

Rather than follow the typical CERCLA process, where remedial design occurs after the Record of Decision, the IA-H1 Restoration Team engaged the regulators early in the design process to establish the key geotechnical design parameters prior to preparing the remedial design document. This effort streamlined the preparation and approval of the final design.

Environmental Sustainability and Cost Savings to the Taxpayer

Construction of the Containment Area (within the original landfill footprint) allowed similar contaminated materials to be consolidated from H1 (during hot spot removals) and five other Mare Island removal actions under the IA-H1 engineered cap. By using a localized containment area, the DON avoided an estimated 9,000 tons of carbon dioxide (CO_2) emissions by eliminating trucking contaminated materials to off-site landfills. This practice also saved off-site landfill capacity and reduced risk by limiting the truck miles driven on public roads. In total, over 150,000 cubic yards of contaminated materials within IA-H1 and an additional 265,000 cubic yards from other MINS sites were consolidated within the Containment Area resulting in savings of over $40M compared with offsite land disposal alternatives. The additional material consolidated from the removal actions outside IA-H1 required a revision to the cap design. All previous calculations for slope stability, settlement and materials analysis were modified and verified by the team and approved by the California Environmental Protection Agency Department of Toxic Substance Control (DTSC). The re-design and approval process was conducted with cooperation from DTSC as a parallel process with cap construction to accelerate the implementation schedule and save taxpayer dollars by not having to re-mobilize the contractor. Additional CO_2 emission savings of approximately 245 tons were realized by testing and using on-island dredge pond soil for the required clean, top two-foot cover instead of importing 250,000 tons of clean fill from off-site locations. The results of the chemical and geophysical testing were reviewed and approved by the DTSC prior to using the dredge pond soil as the engineered cap. This resulted in an additional savings of approximately $2M.

The IA-H1 Containment Area includes a 7,300 linear foot soil-bentonite slurry wall surrounding it and a groundwater/leachate collection system to eliminate any lateral migration of contamination into the shallow groundwater zone. The cap design provided for gentle slopes of less than 10% to minimize the potential for soil erosion and future maintenance. Native grasses were utilized for re-vegetation of cover soil to eliminate the need for irrigation and to enhance habitat value.

The groundwater collection system was designed to utilize electrical line power rather than a fossil fuel-powered generator. The groundwater collection pumps are operated with compressed air and designed to automatically shut off at 120 psig and restart when the line pressure drops to 60 psig. This significantly reduces electricity usage, cost and CO_2 emissions to operate the compressor. An auto-dialer is used to notify personnel if a shutdown of the groundwater collection system occurs. Due to the limits of degraded waste within the landfill, it was determined not to be economically feasible to capture landfill gas and reuse it to power site operations or for commercial resale value. Instead wind turbines were utilized onsite as a safe and effective means to passively vent landfill gas.

Concrete Rip-Rap Surface Water Drainage to Wetlands

Other green remediation techniques implemented during field activities include crushing and re-using 100 tons of concrete as rip-rap to create surface water drainage features and enhance erosion control, in addition to, recycling of construction materials and debris including paper, plastics, and aluminum. On-site fuel storage was utilized to minimize vehicle fueling trips and workers carpooled to the site when practical. A "no- idling" policy was instituted for vehicles and heavy equipment, and local vendors were utilized to the maximum extent feasible to minimize delivery mileage.

Endangered Species Protection and Partnering with the Regulators

Salt Marsh Harvest Mouse in Pickleweed

Since the landfill closure in 1989, low-lying areas within the planned footprint of the IA-H1 Containment Area had developed into approximately 7-acres of low-grade wetlands containing pickleweed, which is the preferred habitat of the endangered SMHM (*Reithrodontomys raviventris*). These wetlands jeopardized acceptance of the preferred remedy of containment and capping, which required that the isolated wetlands be backfilled. The IA H1 Restoration Team successfully negotiated with the resource agencies to trap and relocate any recovered SMHM within the isolated wetlands prior to their removal. In addition, the Team negotiated an overall wetland compensatory mitigation ratio of only 1.15:1 (as opposed to 1.5:1) to replace the backfilled wetland area. After four years the 8.7 acres of created wetlands are exceeding the incremental goals for vegetation type and density.

The existing 120 acres of wetlands outside the cap were also preserved during the remedy implementation using stormwater best management practices and designated routes for heavy equipment to avoid the wetlands. The habitat value of the existing wetlands has been improved through a combination of contaminant removal, re-grading and the redirection of clean surface water runoff from the landfill soil cap to the existing and created non-tidal wetland areas. The runoff helps provide adequate hydrology to maintain the target plant species with minimal or no maintenance. In addition to supporting the SMHM, these wetlands are important because they lie along the Pacific Flyway, a major migratory bird pathway, which runs from Alaska to Patagonia.

Improved Wetlands

Partnering with Stakeholders in a Redeveloping Community

After base closure the DON created two groups to facilitate the base transfer process: the BRAC Clean-up Team (BCT) and the Restoration Advisory Board (RAB). The BCT consists of members of the DON and regulatory agencies such as the DTSC, the Regional Water Quality Control Board (Water Board) and the United States Environmental Protection Agency (EPA). The purpose of the BCT is to streamline communications of technical issues during site remediation and closure. The BCT members are supported by other agencies such as the California Department of Fish and Game (Cal DFG), the United States Fish and Wildlife Service (USFWS) and the California Department of Public Health. The RAB consists of the BCT, the City of Vallejo, and members of the local community with the purpose of facilitating communication on the DON's remediation progress and to be a forum for community concerns and suggestions. The IA-H1 Restoration Team leads both of these forums and routinely presented IA-H1 status updates to the RAB and BCT. A key aspect of the IA-H1 Restoration Team success included engagement with regulatory and community stakeholders to facilitate early and frequent communication and gain acceptance of the DON's preferred remedial alternative to achieve protection of human health and the environment in a cost-effective and timely manner.

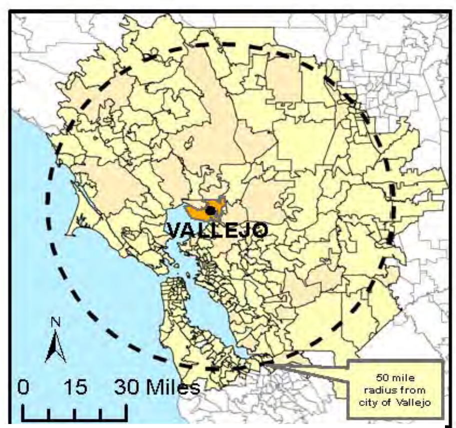
The concept of leaving waste in place is a controversial one. While the City and the BCT agreed with the remedy approach, the community was concerned and vocalized their issues through the RAB. After base closure, MINS was made accessible to the general public and ultimately became a popular destination for bird-watchers and others who enjoy the views of San Pablo Bay. Community members were concerned not only that the remedy construction might disturb the natural resources, but also that the final cap configuration would be unsightly and restrict the views of the Bay. The IA H1 Restoration Team used its risk communication strategy, and education of the RAB to turn the community from an adversary of the project into an ally. The San Pablo Bay hiking trail was installed as a requirement of the Final Remedial Action Plan.

IA-H1 now provides the trail head for the hiking trail. The 4-mile public access trail provides views of San Pablo Bay and the wildlife located in the non-tidal wetlands on the western side of MINS. The walking trail allows public viewing access from a protected and maintained area while reducing the public desire to go off trail. This has the dual benefit of increasing safety for human health and reducing risk of disturbance to the natural resources located with the non-tidal wetlands and former dredge ponds. The IA-H1 Restoration Team collaborated on interpretive panels that have been placed along the trail to educate the public on sensitive natural resources, potential munitions explosive hazards and MINS military history. Hikes on the trail are now a feature of annual MINS events like the Flyway Festival and the Mare Faire. The trail has been highlighted at these events as a new community jewel.

Additionally, the clean-up action was performed within half a mile of nearby residential redevelopment. This close proximity required careful execution of construction activities to minimize noise, dust emissions, or off-site migration of contaminants. Through consistent outreach to local residents using the RAB and close monitoring of field execution, no complaints were registered by the local residents.

Small and local businesses benefitted from the remedy implementation

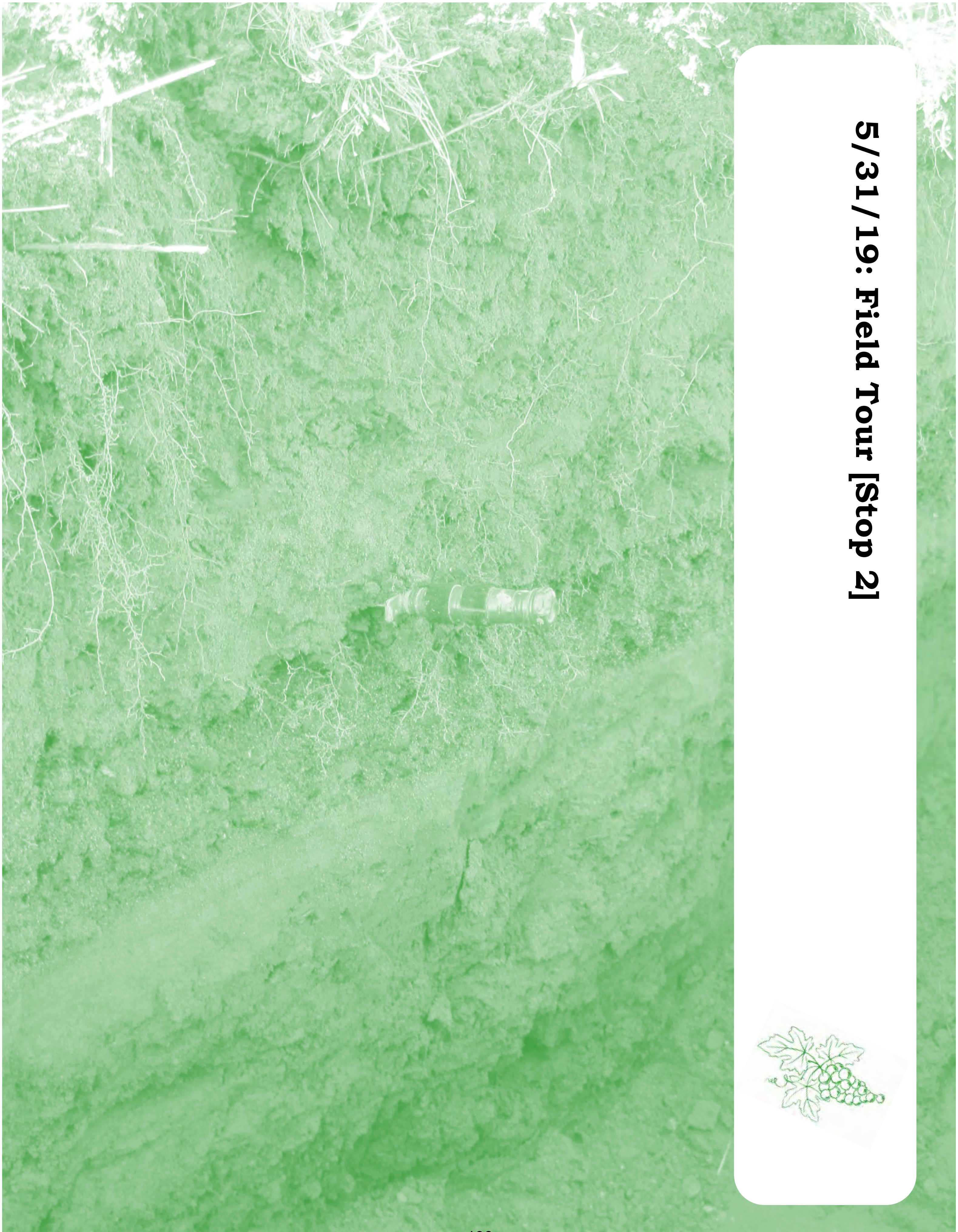
To maximize small business (SB) and small disadvantaged business (SDB) subcontracting opportunities several sources were used over the course of executing the remedial program at IA-H1. The DON acquired small business services through the DoD's Central Contractor Registration (CCR) website, Dynamic Small Business Search, Vallejo Chamber of Commerce, and the prime contractor's internal database of prequalified SB and SDBs. SBs and SDBs performed analytical services; surveying; drilling/soil boring; equipment rentals, material suppliers; electrical and mechanical services; import fill hauling; transportation and disposal services over the course of the project. Approximately two-thirds of subcontracted dollars were spent within a 50-mile radius of the site (a total of almost $20 million), with the largest share of procured goods and services spent within Vallejo and the immediate vicinity.



$20M Spent in Vallejo Community

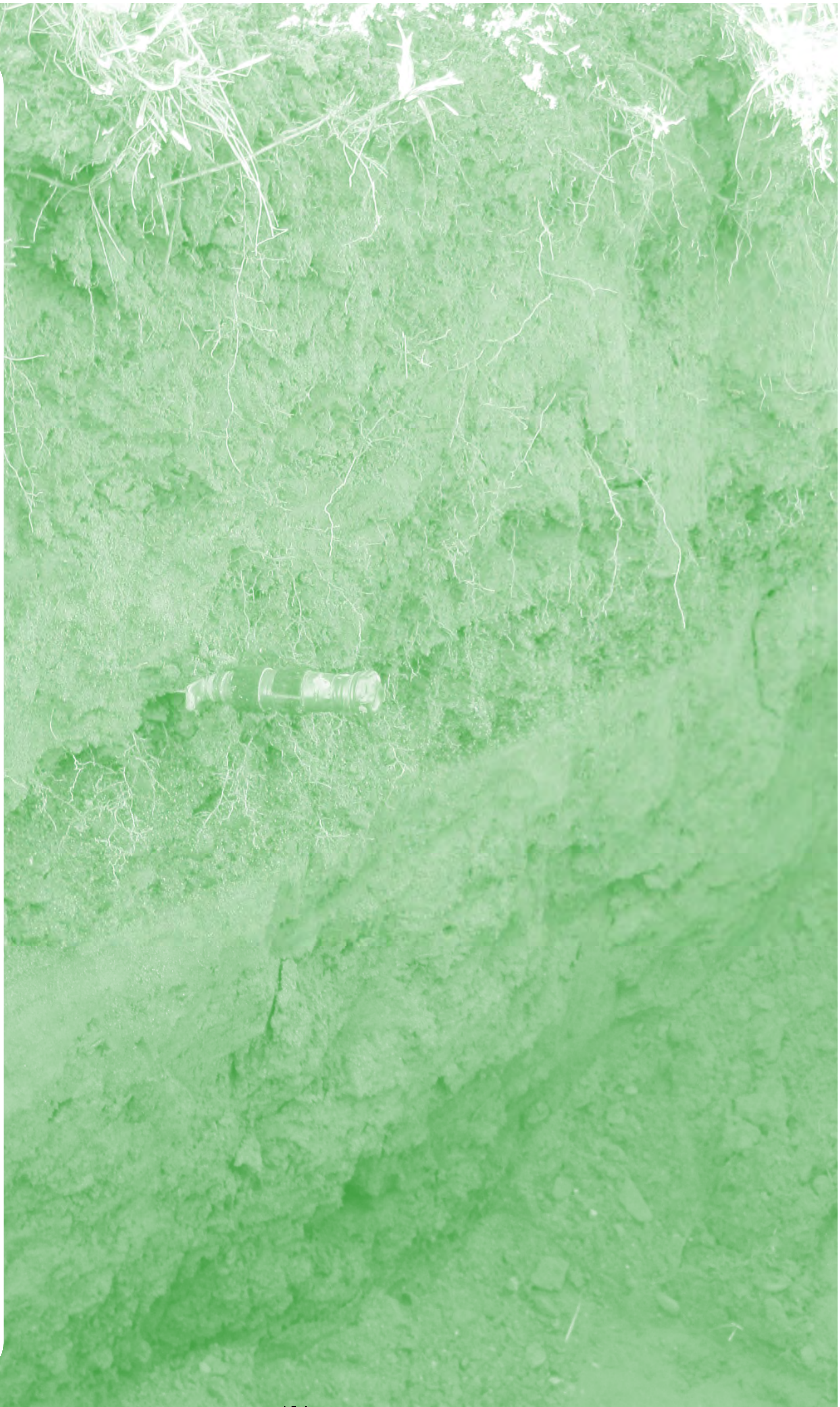
Additional IA-H1 Restoration Team Accomplishments

- Team Lead Remedial Project Manager received the BRAC/NAVFAC SW DRUM-E award for 2010 for work conducted on Mare Island
- Contractor has worked more than 280,000 hours on MINS with no recordable safety incidents. Contractor has received multiple safety STAR awards for their fieldwork

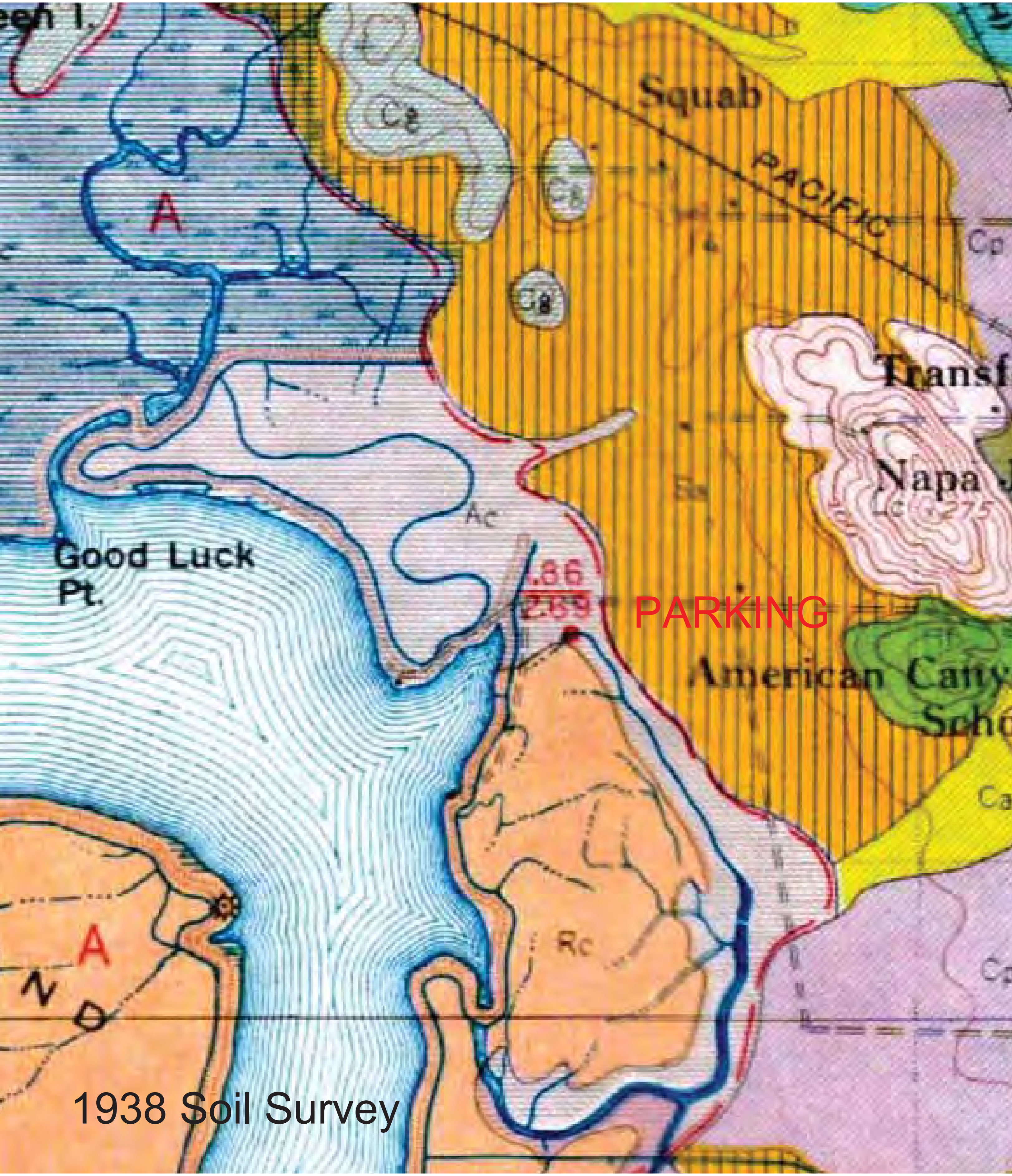


5/31/19: Field Tour [Stop 2]

5/31/19: Field Tour [Stop 2]

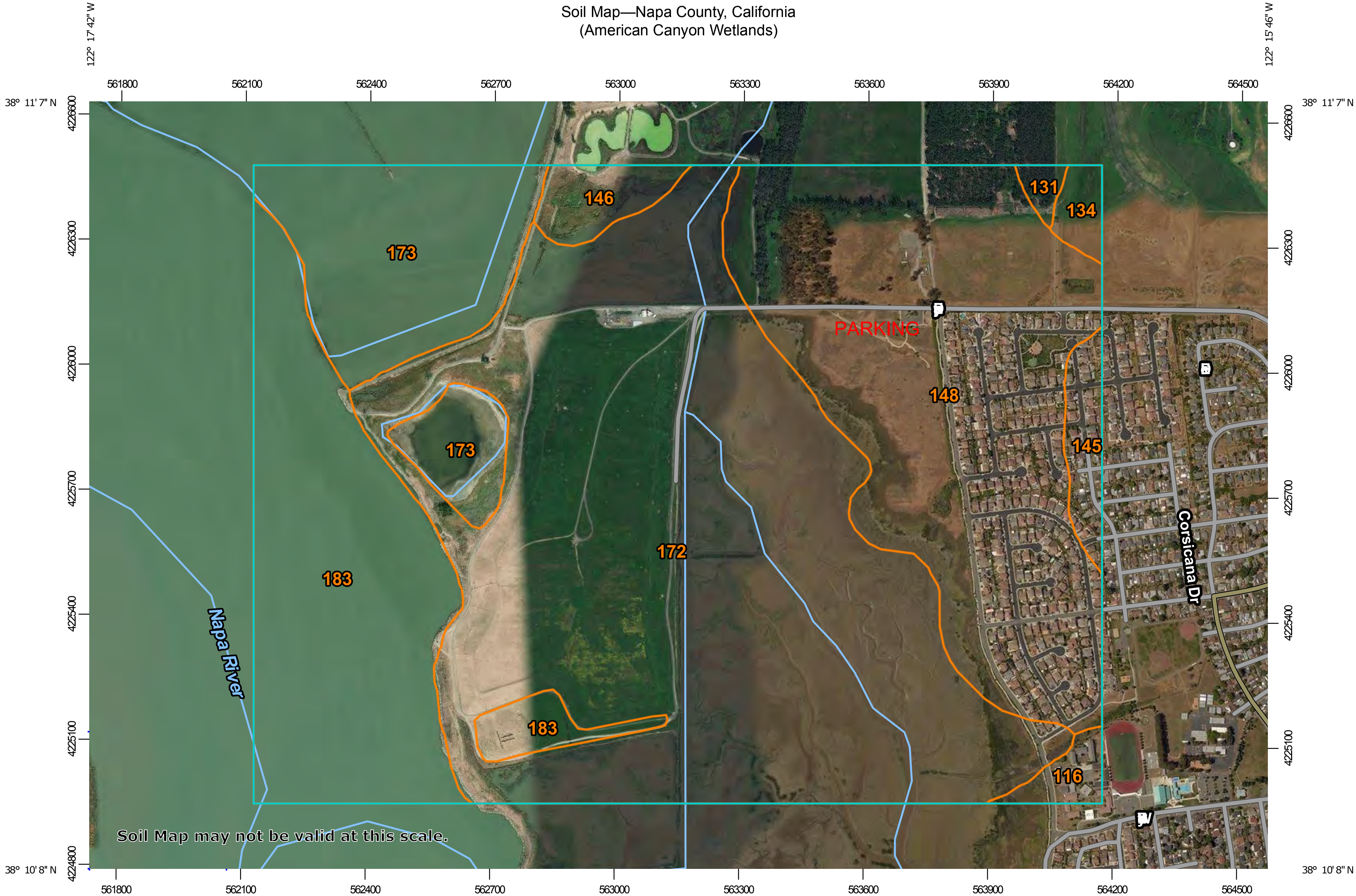


From U.S. Coast Survey Plane Table "T" Sheet, "Napa Creek and Napa City", 1858



1938 Soil Survey

Soil Map—Napa County, California
(American Canyon Wetlands)



Map Scale: 1:13,000 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 150 300 600 900

Feet: 0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Napa County, California
Survey Area Data: Version 11, Sep 12, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Nov 2, 2010—Oct 31, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
116	Clear Lake clay, drained, 0 to 2 percent slopes, MLRA 14	6.2	0.8%
131	Fagan clay loam, 5 to 15 percent slopes	2.7	0.3%
134	Fagan clay loam, 30 to 50 percent slopes, slipped	5.5	0.7%
145	Haire loam, 0 to 2 percent slopes	10.5	1.4%
146	Haire loam, 2 to 9 percent slopes	11.7	1.5%
148	Haire clay loam, 2 to 9 percent slopes	191.0	24.6%
172	Reyes silty clay loam	345.0	44.4%
173	Reyes silty clay loam, salt ponds	78.1	10.1%
183	Water	126.2	16.2%
Totals for Area of Interest		**776.9**	**100.0%**


Untitled Map
Write a description for your map.
Legend
Former Salt Pond
Napa River
Landfill
Diked Historic Bayland
(levee breached ca.1990s)
PARKING
Commerce Blvd
Eucalyptus D
Gadwall St
Goldeneye Ct
Elke Dr
Ring Neck St
Bufflehead St
Bluebell St
Spikerush Cir
Rio Grande
Red Clover Way
San Francisco Bay Trail
Peacock
Landfill Loop Trail
3000 ft
N
Google Earth
© 2018 Google

LiDAR Map. Source: Data acquired by the National Center for Airborne Laser Mapping (NCALM) (2003).


7/24/2002 GE Image
Write a description for your map
Legend
Coon Island
PARKING
Google Earth
1 mi

LOCATION HAIRE CA

Established Series
Rev. SBJ/GMX/ET
02/2003

HAIRE SERIES

The Haire series is a member of the clayey, mixed, thermic family of Typic Haploxerults. Typically, Haire soils have gray and grayish brown, neutral or slightly acid, light clay loam A horizons, pale brown, strongly acid, clay B2t horizons, and pale yellow, strongly acid, gravelly clay loam C horizons.

TAXONOMIC CLASS: Fine, mixed, superactive, thermic Typic Haploxerults

TYPICAL PEDON: Haire clay loam - pasture (Colors are for dry soil unless otherwise noted.)

Ap--0 to 7 inches; gray (10YR 5/1) light clay loam, very dark grayish brown (10YR 3/2) moist; distinct brown mottles; hard, friable, nonsticky, plastic; many very fine roots; many very fine tubular pores; neutral; clear smooth boundary. (4 to 8 inches thick)

A12--7 to 12 inches; grayish brown (10YR 5/2) light clay loam, very dark grayish brown (10YR 3/2) moist; massive; hard, friable, slightly sticky, plastic; common fine roots; many very fine and common fine tubular pores; few thin clay films lining pores; slightly acid; clear smooth boundary. (3 to 7 inches thick)

A3--12 to 24 inches; grayish brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) moist; common fine distinct dark reddish brown mottles; massive; hard, friable, sticky, plastic; few very fine roots; many very fine and fine, few medium tubular pores; few thin clay films lining pores; common worm casts; slightly acid; abrupt wavy boundary. (9 to 14 inches thick)

B2t--24 to 36 inches; pale brown (10YR 6/3) clay, dark grayish brown (2.5Y 4/2) moist; upper part weak medium columnar structure with thin discontinuous bleached capping on columns, lower part is massive; extremely hard, very firm, sticky, very plastic; few very fine roots; common very fine tubular pores; continuous thick clay films; upper two to three inches of peds have black colloidal stains on faces; strongly acid; gradual wavy boundary. (8 to 15 inches thick)

IIC--36 to 60 inches; pale yellow (5Y 7/3) and pale brown (10YR 6/3) very gravelly clay loam, variegated dark brown (10YR 3/3) and olive brown (2.5Y 4/4) moist; massive; sticky, plastic; few fine roots; strongly acid (pH 5.2).

TYPE LOCATION: Sonoma County, California; in the NW1/4 NE1/4 sec. 2, T.4N., R.SW.

RANGE IN CHARACTERISTICS: The mean annual soil temperature is 59 degrees to 63 degrees F. Soil between depths of about 4 and 12 inches usually is dry from May until November and usually is moist the rest of the year.

The A horizon is gray to dark grayish brown (10YR 5/1, 5/2, 4/1, 4/2). It is loam or light clay loam and in some pedons it is gravelly. It is neutral to moderately acid. Fine mottles are present in some pedons.

The B2t horizon is pale brown to dark grayish brown (10YR 6/3, 5/3, 7/3, 7/4, 6/4, 6/2, 5/3, 5/2, 4/2; 2.5Y 6/2) or olive gray (5Y 5/2). It is light clay, sandy clay or clay. This horizon has blocky, prismatic or columnar structure. It is moderately to strongly acid and has 20 to 35 percent base saturation.

The C horizon has dry value of 6 or 7 and is loam or clay loam with 2 to 75 percent rock fragments of various sizes. It is strongly or very strongly acid.

COMPETING SERIES: These are the Cotati, Huichica, Rilarc, Santa Ynez, San Ysidro, Sebastopol, Tierra, and Wright series. Cotati soils have an albic horizon and a mean soil temperature of 57 degrees to 58 degrees F. Huichica soils have a duripan. Rilarc and Sebastopol soils have a mean soil temperature of less than 59 degrees F. Santa Ynez soils have an argillic horizon that has more than 35 percent base saturation and more than 35 percent rock fragments. San Ysidro and Tierra soils have base saturation of more than 35 percent in the argillic horizon. Wright soils are wet, have mottles, and have more than 35 percent base saturation in the argillic horizon.

GEOGRAPHIC SETTING: Haire soils are on nearly level to moderately steep hills at elevations of 20 to 2,400 feet. They formed in terrace deposits and in part in residuum weathered from arkosic sandstone and granodiorite. The climate is subhumid mesothermal with warm dry summers and cool moist winters. The mean annual precipitation is 20 to 45 inches. Average July temperature is about 70 degrees F., average January temperature is about 46 degrees F., and the mean annual temperature is about 54 degrees to 60 degrees F. The freeze-free season is 200 to 300 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Competing Cotati soils and the Arbuckle, Clear Lake, Santa Lucia, and Sheridan soils. Arbuckle soils have less than 35 percent clay and more than 75 percent base saturation in the argillic horizon. Clear Lake soils have clay texture to the surface; the soil cracks and has slickensides. Santa Lucia and Sheridan soils have mollic epipedons more than 20 inches thick and lack an argillic horizon.

DRAINAGE AND PERMEABILITY: Moderately well drained; slow to rapid runoff; very slow permeability.

USE AND VEGETATION: Principal use is pasture, dry and irrigated. Uncultivated vegetation is mostly annual grasses and forbs.

DISTRIBUTION AND EXTENT: Sonoma and Monterey Counties, California The soils are of moderate extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Davis, California

SERIES ESTABLISHED: Monterey County, California, 1972.

REMARKS: The Haire soils formerly were classified Noncalcic Brown soils

The activity class was added to the classification in February of 2003. Competing series were not checked at that time. - ET

OSED scanned by SSQA. Last revised by state 10/74.

National Cooperative Soil Survey
U.S.A.

LOCATION REYES CA

Established Series
Rev. GML/SBJ/TDC/ET
03/2003

REYES SERIES

The Reyes series consists of deep, somewhat poorly drained soils that formed in alluvium from mixed sources. Reyes soils are in reclaimed and protected marsh areas and have slopes of 0 to 2 percent. The mean annual precipitation is about 25 inches. The mean annual temperature is about 59 degrees F.

TAXONOMIC CLASS: Fine, mixed, active, acid, thermic Sulfic Fluvaquents

TYPICAL PEDON: Reyes silty clay, on a gently undulating slope of 1 percent in a cultivated oat hay field at 1 foot elevation. (Colors are for dry soil unless otherwise stated. When described (6/28/61) the soil was dry to 14 inches, moist to 31 inches, and wet below 31 inches. A water table at about 5 feet.)

Ap1--0 to 7 inches; light brownish gray (10YR 6/2) silty clay, dark brown (10YR 3/3) moist; strong fine granular structure; slightly hard, friable, sticky and plastic; many very fine and fine roots; many very fine and fine interstitial pores; extremely acid (pH 4.2); gradual smooth boundary. (5 to 8 inches thick)

Ap2--7 to 14 inches; grayish brown (10YR 5/2) silty clay, very dark grayish brown (10YR 3/2) moist; strong fine granular structure; hard, friable, sticky and plastic; many very fine and fine roots; many very fine and fine interstitial pores; extremely acid (pH 4.1); abrupt wavy boundary. (5 to 10 inches thick)

B21--14 to 22 inches; light brownish gray (10YR 6/2) silty clay, dark gray (10YR 4/1) moist; common fine distinct brownish yellow (10YR 6/6) mottles, strong brown (7.5YR 5/6) moist; root stains are very dark brown (10YR 2/2) and strong brown (7.5YR 5/6); weak coarse subangular blocky structure; extremely hard, firm, sticky and plastic; many very fine and fine roots; many very fine and fine tubular pores; stains along root channels are light gray (2.5Y 7/2) dry; extremely acid (pH 3.7); gradual smooth boundary. (6 to 20 inches thick)

B22--22 to 31 inches; light gray (5Y 6/1) silty clay, dark gray (5Y 4/1) moist; common fine prominent yellowish red (5Y 5/6) mottles dry; few streaks of very dark grayish brown, black moist; weak coarse prismatic structure; extremely hard, firm, sticky and very plastic; many very fine and fine roots; common very fine and fine tubular pores; root stains are strong brown (7.5YR 5/6) and very dark brown (10YR 2/2); stains along root channels are light gray (2.5Y 7/2) dry; extremely acid (pH 3.7); gradual smooth boundary. (8 to 18 inches thick)

C1g--31 to 51 inches; gray (N 6/) silty clay, dark gray (5Y 4/1) moist; common fine prominent yellow (2.5Y 7/6) jarosite mottles; brown stains on parting planes; moderate very coarse prismatic structure; extremely hard, firm, sticky and plastic; many very fine and fine exped roots; many very fine and fine tubular pores; extremely acid (pH 3.6); gradual smooth boundary. (10 to 24 inches thick)

IIC2g--51 to 63 inches; gray (N 5/) and black (N 2/) silty clay, dark gray (5Y 4/1) and gray (N 5/) moist; few fine distinct yellowish brown (10YR 5/6) mottles, dark greenish gray (5GY 4/1) and black blotches moist; massive; extremely hard, firm, sticky and plastic; common very fine and fine tubular pores, some of which are filled with organic matter; hydrogen sulfide odor; extremely acid (pH 3.6) to moderately acid (pH 6.0) over the space of a few inches.

TYPE LOCATION: Sonoma County, California; 100 feet east of Leveroni Road, 57 degrees and 3,800 feet from Railroad Bridge at Wingo. The projected section is SW1/4, SW1/4 sec. 4, T.4N., R.5W., MDB&M.

RANGE IN CHARACTERISTICS: Solum thickness is 31 to 50 inches to the bottom of the B horizon. The mean annual soil temperature is 59 degrees to 61 degrees F. The soils have mottles within depths of 10 to 18 inches. The profile contains major strata of mineral soil low in organic matter and thin strata of soil with 5 to 30 percent organic matter. Organic matter averaged less than 15 percent in the control section. The soil is silty clay loam, silty clay, or clay. The weighted average of the 10- to 40-inch control section commonly is 35 to 60 percent clay. The n value is 0.3 to 0.7. These soils are drained and protected by levees and large drainage ditches. With cultivation the soil becomes oxidized and is slightly to extremely acid. The lower horizons (C horizons) are commonly extremely acid but range from moderately acid to extremely acid within a space of a few inches. Usually the more the soil is drained and oxidized, the more acid it becomes. The soils are slightly to strongly saline. Sulfidic materials occur at depths of 20 to 40 inches.

The A horizon has dry color of 10YR 5/1, 5/2, 5/3, 6/1, 6/2, 6/3, 6/4, 6/6, 7/1, 7/2; 2.5Y 5/2, 6/2, 6/4 or 7/2 and moist color of 10YR 3/2, 3/3, 4/1, 4/2, 5/1, 5/2; 2.5Y 3/2, 4/2 or 5/2. Some or all of the upper 10 inches has dry value of 6 or has moist value of 4 or 5. There are few to common, fine to medium, faint to prominent 10YR 4/6; 7.5YR 3/4, 4/4, 4/6, 5/6; 5YR 3/4, 4/3, 4/4 or 4/6 mottles.

The B horizon has dry color of 10YR or 5Y 5/1, 5/2, 6/1, 6/2; N 5/0, or N 6/0 and moist color of 10YR or 5Y 4/1, 5/1; N 4/0, or N 5/0. Distinct or prominent mottles are present in hue of 5Y, 2.5Y, 10YR, 7.5YR, or 5YR. The moist value is 4, or if 5 the hue is 5Y or 2.5Y. In the lower part of the B horizon, jarosite mottles are many or common and are 2.5Y 7/6, 8/6, 8/8; 5Y 7/6, 7/8, 8/6, 8/8.

The C horizon commonly has moist hue of 5Y or is neutral. It has mottles with hue of 10YR to 5GY, 5G, 5BG, or 5B. Jarosite mottles are many or common and are 2.5Y 7/6, 7/8, 8/6, 8/8; 5Y 7/6, 7/8, 8/6, or 8/8.

COMPETING SERIES: These are the Alviso, Novato, and Ryde series in other families. Alviso soils are neutral to moderately alkaline and do not become extremely acid following drainage. Novato soils have n values of 1.0 to 1.5 and have nonacid reaction control sections. Ryde soils have a mollic epipedon and a fine-loamy particle-size control section.

GEOGRAPHIC SETTING: The Reyes soils are in salt water marches which ar adjacent to bodies of sea water and are now drained by large ditches and protected by levees and dikes. Slopes are 0 to 2 percent. Elevations are between 2 feet below sea level to about 10 feet above. The soils formed in mixed bay and stream alluvium under march type plants such as pickleweed, bulrush, and saltgrass. The climate is Mediterranean with hot, dry summers and cool moist winters. Mean annual precipitation is 12 to 35 inches. The mean annual temperature is 57 degrees to 61 degrees F.; average January temperature is about 46 degrees F.; average July temperature is about 72 degrees F. Frost-free season is 250 to 330 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Clear Lake, Joice, and Suisun soils and the competing Alviso and Novato soils. Clear Lake soils are not affected by sea water and lack high levels of polysulfides. Joice and Suisun soils have more than 30 percent organic matter in the series control section.

DRAINAGE AND PERMEABILITY: Somewhat poorly drained; very slow runoff or ponded; slow permeability. Water table fluctuates from 3 to 5 feet. The soils are protected by levees and are flooded only during periods of severe storms and very high tides.

USE AND VEGETATION: Where they have been reclaimed, the Reyes soils are used for production of oat hay, grain, and livestock pasture. Other areas are used as game refuges or by duck clubs. Vegetation in uncultivated areas is annual grasses, saltgrasses, coyotebush, and lambsquarter.

DISTRIBUTION AND EXTENT: Mainly around the edges of Suisun and San Pablo Bays and scattered in the Sacramento Delta in California. The series is of moderate extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Davis, California

SERIES ESTABLISHED: Sonoma County, California, 1971.

REMARKS: The Reyes soils formerly were a part of the Alviso and Ryde series. The part of the Reyes soils mapped in other survey areas that are not protected by levees and are flooded daily by tides would now be recognized as the Novato series.

ADDITIONAL DATA: Sampled by the Riverside Laboratory 6/28/61. Sample No. S61 Calif-49-13, SSIR No. 24, June, 1973.

National Cooperative Soil Survey
U.S.A.

LOCATION NOVATO CA

Established Series
Rev. ET
04/2009

NOVATO SERIES

The Novato series consists of deep, very poorly drained soils that formed in alluvium deposited along the margin of bays. Novato soils are in tidal marshes and have slopes of 0 to 2 percent. The mean annual precipitation is about 25 inches and the mean annual temperature is about 59 degrees F.

TAXONOMIC CLASS: Fine, mixed, superactive, nonacid, mesic Typic Sulfaquents

TYPICAL PEDON: Novato clay, on a nearly level slope with a cover of cordgrass, pickleweed, and saltgrass at 2 feet elevation. (colors and pH are for dry soil unless otherwise stated. When described (9/3/78) the soil was wet throughout. A water table was at 18 inches. The soil was described during low tide.)

A11g--0 to 2 inches; light gray (5Y 7/1) clay, very dark gray (2.5Y 3/2) moist; common medium distinct dark brown (7.5YR 4/4) mottles moist; massive; extremely hard, firm, sticky and plastic; many very fine and coarse rots; many fine tubular pores; moderately alkaline (pH 8.0); abrupt smooth boundary. (1 to 4 inches thick)

A12g--2 to 6 inches; light gray (5Y 7/1) clay, dark olive gray (5Y 3/2) moist; common medium distinct dark reddish brown (5YR 3/4) mottles moist; massive; extremely hard, firm, sticky and plastic, common very fine and fine roots; common fine tubular pores; moderately alkaline (pH 8.0); clear smooth boundary. (3 to 6 inches thick)

A13g--6 to 15 inches; gray (5Y 6/1) clay, dark gray (5Y 4/1) moist; common medium distinct reddish brown (5YR 4/4) mottles moist; massive; extremely hard, firm, sticky and plastic; common very fine and fine roots; few fine and medium tubular pores; moderately alkaline (pH 8.0); gradual smooth boundary. (6 to 9 inches thick)

C1g--15 to 27 inches; gray (5Y 6/1) clay, dark gray (5Y 4/1) moist; common medium distinct reddish brown (5YR 4/4) mottles and common medium distinct pale brown (2.5Y 7/4) jarosite mottles moist in the lower part; massive; extremely hard, firm, sticky and plastic; few very fine roots; few fine tubular pores; moderately alkaline (pH 8.0); gradual smooth boundary. (10 to 15 inches thick)

C2g--27 to 40 inches; gray and light gray (5Y 6/1, 7/1) clay, dark gray (5Y 4/1) moist; common medium distinct pale yellow (2.5Y 8/4) jarosite mottles moist; massive, extremely hard, firm, sticky and plastic; few very fine roots; few very fine and common coarse tubular pores; moderately alkaline (pH 8.0); gradual smooth boundary. (10 to 14 inches thick)

C3g--40 to 60 inches; light gray (N 6/) clay, very dark gray (N 3/) moist; massive; extremely hard, firm, sticky and plastic; few very fine roots; few very fine and common coarse tubular pores; moderately alkaline (pH 8.0).

TYPE LOCATION: Marin County, California; about 1 mile east from southern edge of Marin County Airport (Gnoss Field) runway, 1,250 feet west of DCBS radio station, thence 1,000 feet north of corral, 50 feet north of levee.

RANGE IN CHARACTERISTICS: Organic matter decreases irregularly with increasing depth. The soils are saturated with water at all times of the year and have at some depth within 50 cm of the surface dominant chromas on the matrix of 2 or less. The n value is 1.0 to 1.5. The average clay content in the control section is 35 to 60 percent. Textures are silty clay loam, silty clay, or clay. Mean annual soil temperature is 55 degrees to 59 degrees F. The difference between mean summer and mean winter soil temperatures is 5 degrees to 9 degrees F. Sulfidic material occurs at a depth of 20 to 40 inches. The soil is mildly alkaline through strongly alkaline throughout and is noncalcareous.

The A horizon has dry color of 2.5Y 5/2, 6/2, 7/2; 10YR or 5Y 4/2, 5/2, 5/3, 6/2, 6/3, 7/1 or 7/2 and moist color of 2.5Y 3/2, 4/2; 10YR or 5Y 3/2, 3/3, 4/1, 4/2, or 4/3. There are few to common, fine to medium, distinct 10YR 4/6; 7.5YR 3/4, 4/4, 4/6, 5/6; 5YR 3/4, 4/3, 4/4, or 4/6 moist mottles.

The C horizon has dry color of N 5/, 6/; 5Y 6/1, 6/2; 2.5Y 6/2, 7.1; 10YR 6/1, or 6/2 and moist color of N 2/0, N 3/0, N 4/0; 5Y 4/1, 4/2; 2.5Y 4/1, 4/2; 10YR 4/1, or 4/2. There are few to common, fine to medium, distinct or prominent 10YR 4/4, 4/6; 7.5YR 3/4, 4/4, 4/6, or 5YR 3/4, 4/4 moist mottles. Some mottles have moist hue of 5Y, 5GY, 5G, 5BG or 5B, or are neutral.

COMPETING SERIES: These are the Alviso, Joice, Reyes, Rindge, and Ryde series in other families. Alviso soils lack sulfidic materials within 40 inches of the surface. Joice soils have histic epipedons and consist of sapric materials. Reyes soils have n values of less than 0.7. Rindge soils have sapric material to a depth of 60 inches. Ryde soils have a fine-loamy particle-size control section and has a mollic epipedon.

GEOGRAPHIC SETTING: Novato soils are in tidal marshes. They are nearly level, and were deposited as bay mud. Elevation is 2 to 10 feet. The climate is subhumid with warm and partially foggy summer and cool moist winters. Mean annual precipitation is 12 to 35 inches. Mean annual temperature is 59 degrees to 61 degrees F. The mean January temperature is about 46 degrees F.; and the mean July temperature is about 68 degrees F. The frost-free season is about 270 to 320 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Reyes soils and the Blucher and Cole soils. Blucher soils are fine-loamy and have a mollic epipedon. Cole soils have an argillic horizon and a mollic epipedon.

DRAINAGE AND PERMEABILITY: Very poorly drained; very slow runoff; slow permeability. Water table fluctuates with the tides from 2 feet above the surface during very high tides to a depth of 2 feet during low tides.

USE AND VEGETATION: It is used for wildlife habitat. The principal native plants are pickleweed, saltgrass, and cordgrass.

DISTRIBUTION AND EXTENT: Along the margins of San Francisco, San Pablo, and Tomales Bays in California. The soils are of small extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Davis, California

SERIES ESTABLISHED: Marin County, California, 1979.

REMARKS: A proposal has been prepared defining the Typic and other subgroups of Hydraquents. Novato soils would be Sulfic Hydraquents. The part of the Reyes soils mapped in other survey areas not protected by levees and flooded daily by tides would now be recognized as the Novato series. Reyes soils have now been redefined to include only those soils that have been reclaimed and are protected by levees.

The activity class was added to the classification in February of 2003. Competing series were not checked at that time. - ET

National Cooperative Soil Survey
U.S.A.

TOUR STOP #2 – AMERICAN CANYON WETLANDS AREA

Sequence of Baylands Marsh Formation, Reclamation, Salt Pond Use, and Habitat Restoration

The baylands consist of the shallow water habitats around the San Francisco Bay between the maximum and minimum elevations of the tides. They are the lands that are touched by the tides, plus the lands that would be tidal in the absence of any levees, sea walls, or other man-made structures that block the tides.

Beginning 15,000 to 18,000 years ago, sea levels began their most recent rise, at the end of the last glacial period.

About 10,000 years ago, ocean waters began to flood the valleys now occupied by the San Francisco Bay Estuary.

Beginning about 6,000 years ago, the rate of sea level rise slowed.

Between about 2,000 and 3,000 years ago, mudflats and tidal marshes began to form around the edges of western Suisun Bay, North Bay, Central Bay, and South Bay.

Beginning in the mid-1800s, large areas of the Estuary's tidal marshes and mudflats were filled, diked, or drained. The early levees were built by immigrant Chinese laborers using shovels and wheelbarrows. Much of the initial impetus for this activity stemmed from the federal Arkansas Act of 1850, which gave to the states all of the unsold federal land within their borders that was "swamp and overflowed". Subsequent state legislation, particularly the Green Act of 1868, also spurred the conversion of wetlands into agricultural uses. By the 1870s, commercial dipper dredges and then larger clamshell dredges enabled the construction of taller and wider levees.

As a result of Gold Rush hydraulic mining (1853-1884), the increased supply of sediment into the Bay helped to fill remnant tidal channels that remained between the diked baylands, and caused shallow bays to aggrade into mudflats, while deep bays became shallower. Some of the mudflats formed by hydraulic mining debris evolved into tidal marshes, and some of this new marshland was again reclaimed for agriculture and urban development by a second generation of levees. A large proportion of the present extent of baylands originated since 1850 as a result of hydraulic mining debris deposition.

About 1870, initial diking of tidal marshes in the North Bay was undertaken to establish grazing lands for livestock. Some of the early reclamation efforts converted large tracts of tidal marsh to diked baylands. For example, during the summer of 1870, 12,000 acres west of the Napa River were being leveed.

By the 1930s, diking for farming purposes was essentially complete. Livestock grazing was the sole agricultural practice in North Bay diked baylands for many decades, as the high water table and soil salinities discouraged the production of truck crops. However, in the past several decades, the remaining farmed areas have been managed for the production of dairy cattle silage and oat hay. In total, there are about 28,000 acres of diked baylands in North Bay that are now, or recently were, in some form of agriculture.

On a 1916 USGS topographic map, levees are mapped along the Napa River.

On a 1938 Bureau of Chemistry and Soils soil survey map, levees are mapped along the river and encircling many of the islands along the river.

From 1942 until the 1990s, a 300-acre site west of American Canyon was operated as a municipal landfill, receiving trash from Napa and Solano counties. Trash was placed first in pits dug on the drained marshland and covered, then later buried in layers interspersed with soil.

In the 1950s, commercial salt ponds were established by Leslie Salt Company (later purchased by Cargill Inc.) along the Napa River north to Green Island Road.

In the early 1990s, an intentional levee breach south of landfill re-introduced tidal action to the American Canyon wetlands. Based on aerial photos, this now-subsided area appears to have never been a salt pond.

Beginning in the mid-1990s, thousands of acres of subsided, diked baylands (including the former Cargill salt ponds), part of the Napa-Sonoma Marshes Wildlife Area (located northwest of the American Canyon Wetlands) began to be restored to tidal marsh habitat.

Marsh Plain Elevation and Subsidence

Prior to diking and draining beginning in about 1850 to 1870 (depending on location in the Bay Area), the tidal marsh plains (dominated by pickleweed [*Salicornia pacifica*] in many areas but including other halophytes depending salinity levels, elevation, etc.) occurred at approximately mean higher high water (MHHW). Due to the oxidation of soil organic matter and consolidation of the formerly saturated sediments, between 4 and 6 feet of land surface subsidence has occurred at many diked bayland sites. For reference, MHHW at the nearby former Cargill Napa Plant site is 6.21 feet NGVD 88. Average elevations in the Napa Plant site before restoration efforts were implemented ranged from 2.3 to 3.6 feet NGVD, indicating that those salt ponds had subsided approximately 2.61 to 3.91 feet.

The remaining marshlands of the North Bay have unique characteristics that distinguish them from older marsh fragments in other subregions of the Bay, in that they are higher in elevation, they have a lesser degree of subsidence relative to mean tide level, they receive a higher inflow of fresh water, and are larger than the marshes of the southern reaches of San Francisco Bay.

For the diked historic baylands, the age of the marsh when it was diked is a major factor in the determination of its eventual (i.e., subsided) elevation. Additionally, there is evidence to suggest that the northern shoreline of San Pablo Bay continues to subside, probably as a result of a combination of compaction of sediments with a high organic matter content and ongoing tectonic subsidence.

Common Soil Series Associated with North Bay Tidal Marshes

The Reyes and Novato series are extensive in the undrained and drained “high marsh” areas in the North Bay.

Table 1. Summary of Reyes and Novato Series Descriptions

Attribute	Reyes	Novato
Summary	Deep, somewhat poorly drained soils that formed in alluvial settings from mixed sources.	Deep, poorly drained soils that formed in alluvium deposited along bay margins.
Location	Reclaimed and protected marsh areas.	Tidal marsh areas.
Slopes	0 to 2 percent.	0 to 2 percent.
Taxonomic class	Fine, mixed, acid, thermic Sulfic Fluvaquents*.	Fine, mixed, nonacid, isomesic Typic Hydraquents.**
Distribution	Around edges of Suisun and San Pablo Bays and scattered throughout the Sacramento Delta.	Along the margins of San Francisco, San Pablo, and Tomales Bays.
Drainage and permeability	Somewhat poorly drained; very low runoff; slow permeability	Very poorly drained; very slow runoff; slow permeability.
Geographic setting	In current and former tidal marshes. Former marsh areas are drained by ditches and protected by levees and dikes.	In current and former tidal marshes. They are nearly level and were deposited as bay mud. Former marsh areas are drained by ditches and protected by levees and dikes.
Characteristics	Major strata of mineral soil low in organic content and thin strata of soil with 5 to 30% organic content and 35 to 60% day. When cultivated, soils become increasingly acidic as they are drained.	Organic matter decreases irregularly with increasing depth. Soils are saturated with water at all times. Average clay content is 35 to 60 percent. Textures are silty clay, silty loam, or clay. The soil is mildly to strongly alkaline and noncalcereous.

Source: Siegel and Bachand (2002).

*Now classified as fine, mixed, superactive, acid, thermic Typic Sulfaquents (SSURGO).
**Now classified as fine, mixed, superactive, nonacid, mesic Typic Sulfaquents (SSURGO).

Table 2. Comparison of Selected Properties of Reyes and Novato Series

Reyes Series

Depth Range (cm)	Horizon Designation	Percent Organic Matter	EC (dS/m)	pH by Water Extraction
0 - 3	Oi	75.0	0	5.5
3 - 38	Ag	6.0	3	4.5
38 - 140	2Bjg	1.35	3	4.5
140 - 200	3Cg	0.71	6	5.0

Novato Series

Depth Range (cm)	Horizon Designation	Percent Organic Matter	EC (dS/m)	pH by Water Extraction
0 - 28	Azg	9.0	24	8.0
28 - 200	Czg	7.0	42	8.0

Source: California Soil Resource Laboratory (2019).

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Compiled by Joel Butterworth, ICF. April 28, 2019

National Cooperative Soil Survey Newsletter

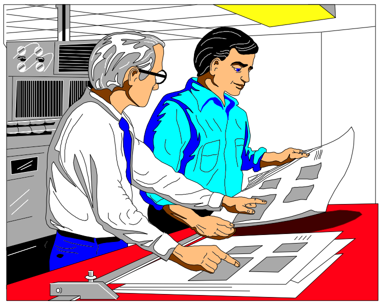
November 1998
Issue 5

In This Issue—

Editor's Note

Issues of this newsletter are available on the World Wide Web (www.statlab.iastate.edu/soils/soildiv). Click on NCSS and then on the desired issue number of the NCSS Newsletter.

You are invited to submit stories for future issues of this newsletter to Stanley Anderson, National Soil Survey Center, Lincoln, Nebraska. Phone—402-437-5357; FAX—402-437-5336; email—sanderson@nssc.nrcs.usda.gov.



Soil Survey Field Methods in the Late 1890's and Early 1900's

By David W. Smith, Soil Scientist, USDA, Natural Resources Conservation Service, West Regional Office, Sacramento, California.

Macy H. Lapham, a soil surveyor who worked in the soil survey program in the United States from 1899 to 1945, mapping soils in many of the Western States and then serving as Inspector for the Western Division of the Bureau of Soils, published a book entitled *Crisscross Trails: Narrative of a Soil Surveyor* in 1949. In his words: "[I offer this book] as an unpretentious historical record of the organization and development of the soil survey in which the recital of associated personal observations and incidents has been included."

I recommend the book to anyone who is interested in the story of the early soil survey and who can get hold of a copy. The book is out of print and hard to obtain.

Early Field Methods

Lapham's first season of fieldwork began in the spring of 1900, in the Sevier Valley of southern Utah. After a cross-country train ride to Richfield, Utah, he met up with Frank D. Gardner (who had mapped in the Utah Valley the first season of 1899) and was "ushered into the technique of soil survey." About his first field day, he wrote:

> After a hearty breakfast, attired in old clothes, stout shoes, and canvas leggings, I was ready for the field. With two frisky western horses and a light ambulance-like canvas covered wagon, we stopped in a vividly green alfalfa field on a red alluvial soil. Here I was shown how to handle a six-foot auger and to note the character of the fine sandy loam soil, the boundaries of which were sketched on the pages of a notebook.

Lapham summarizes the field methods used in 1900 as follows:

> The usual western field equipment consisted mainly of a cumbersome electrolytic bridge and field kit for determining the character and amount of soluble salts, popularly but inaccurately known as "alkali." Included were a six-foot soil auger with extensions; a compass; protractor and scale; a shovel or spade; and a copy of the usually inadequate county or other available base map. Technique of determining and mapping soil boundaries was acquired by experience. At that time there were no soil surveyors with previous training and no place in this country or elsewhere at which training in soil classification and mapping might be learned. Soil boundaries, determined by noting differences in texture, color, structure, and in mineral character—by means of frequent borings—were, in the absence of a suitable base map, sketched into the pages of a blank township plat book ruled off into sections. These were also

Field Methods continued on page 5

feet through this "hard pan" material, which behaves like concrete. Much credit goes to Pete Whitcomb, Kathy Swain, Marie Danforth, and Laura Morton and to Marc Southerland, the human backhoe,

As the volumes of data start coming in, they will need to be compiled and interpreted. Additional studies are planned at this site to help complete the picture of what is going on in terms of soil-water behavior. All of this information will enable the soil science community to better predict the behavior of these kinds of soil under specific kinds of land use.

Preliminary observations completed during the week of data collection indicate that surface water may not necessarily perch on top of the "hard pan" in certain locations. Some preliminary evidence indicates that the "hard pan" is made up of many discontinuous bands that act as hydrologic barriers. Instead of perching on the "hard pan," however, water may cascade through discontinuous "hard pan" layers, flowing laterally through sandy layers and spilling over one barrier to the next—like a giant, elaborate underground fountain.

This kind of information and documentation is critically important in our attempt to provide knowledgeable and meaningful interpretations to developers, consultants, farmers, home buyers, and other property owners. It is very valuable information for the proper siting and installation of septic systems. Having scientifically based documentation of this nature provides credibility to the National Cooperative Soil Survey and adds to our reservoir of knowledge about soil behavior. The information that comes out of projects of this nature ensures that NRCS soils information and interpretations and the data extracted out of the NASIS data base are technically sound and legally defensible. ■

Field Methods continued from page 1

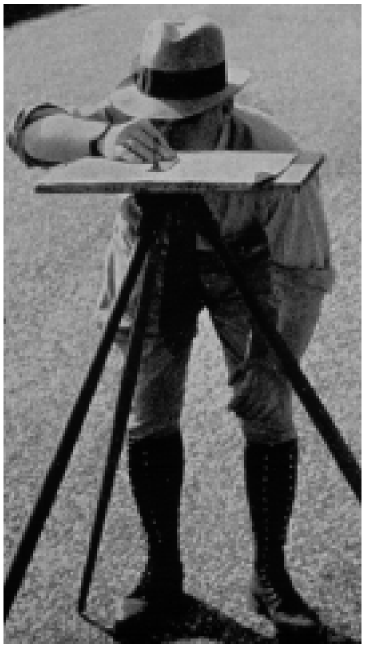
usually without provision for correcting errors in the original U. S. Land Office Surveys. Bearings were determined by compass, and courses were plotted by protractor and scale. Topographic quadrangles of the U.S. Geological Survey, where available, were made use of as base maps; but these were frequently on small scale or of earlier publication, and required a great deal of revision in bringing roads and other cultural features up to date.

Transportation in the field was usually afforded by hired horse and buggy; at times this was supplemented by a saddle horse. Distances were measured by an odometer attached by a metal clip to the front axle of the buggy. This consisted of a dial traversed by yellow, red, and blue hands actuated by a spur or sprocket wheel turned by a metal pin driven into the wooden hub of the vehicle. This projecting pin engaged the spur wheel with each revolution of the buggy wheel. The dial was calibrated in units of number of revolutions of the wheel. With a standard-size wheel of 42 inches diameter, 100 revolutions were equivalent to a mile; the number of revolutions in multiples of 100 up to 40,000 were recorded. Careful determination of the wheel diameter was necessary. It was usually necessary to dismount from the vehicle and read the instrument from the ground for accuracy, though much of the time this could be checked from the seat for approximate distance traveled. A bell mounted on the back of the instrument was struck by a small hammer on completion of each 100 revolutions of the wheel. It often became necessary, even in those horse and buggy days to "get out and get under" (to fix the equipment). In extremity we could resort to the simple expedient of tying a bit of cloth to one of the buggy spokes and recording the revolutions with a tally register.

Field parties were expected to obtain accommodations with farmers or in local towns and villages near enough the scene of operations to avoid undue expense and interruption in fieldwork necessitated by long drives. In the thickly settled Mormon communities of Utah this was usually not difficult; but the problem presented grave difficulties in other areas.

Lapham talks about using a plane table and alidade while mapping in the Salinas Valley during 1901:

At the time of this early soil

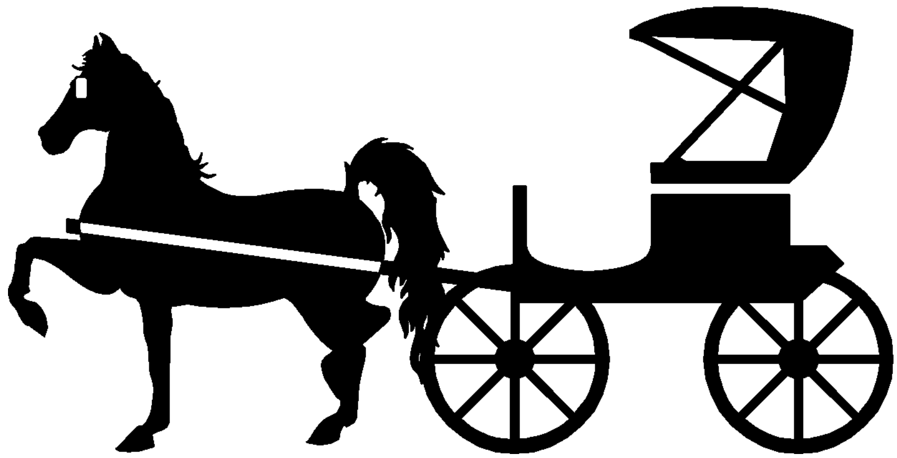


survey, some simple equipment had been acquired by the Bureau with which we undertook our first experience in plane-table surveying in the construction of a base map upon which soils were delineated. This consisted of a tripod upon which was mounted a detachable board, in one side of which was fixed a small brass box containing a compass needle. With a piece of heavy drawing paper attached to the board, and when set up in the field and oriented with the compass needle, sights were taken by means of a simple alidade; this permitted the sketching of roads . . . windmills, courses of streams, [etc.]. At the end of the day these were inked in, and soil types indicated by colored pencils. With latitude in recognition and mapping of soil types at the time, a half dozen colored pencils in the vest pocket might take the place of a hundred or more mapping units in the complicated soil map legend of today.

These early plane-table surveys were crude; but with experience in technique, they have served well for many years, and are still serving a useful purpose in the absence of suitable topographic or aerial base maps.

Lapham chronicles the first attempt to use an automobile in mapping:

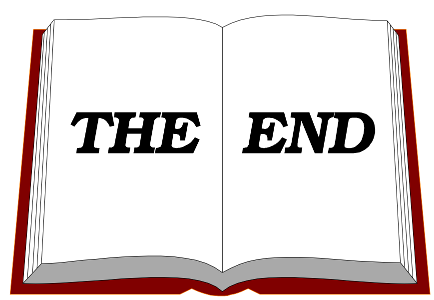
[Sacramento Valley, California, 1904] . . . the auto was making its bid as a practical means of transport. I foolishly became infected with ambition to substitute one for the old slow moving horse drawn vehicle [and] engaged in an abortive attempt to introduce auto to soil survey. . . . This consisted of a narrow-gauge vehicle powered by a single

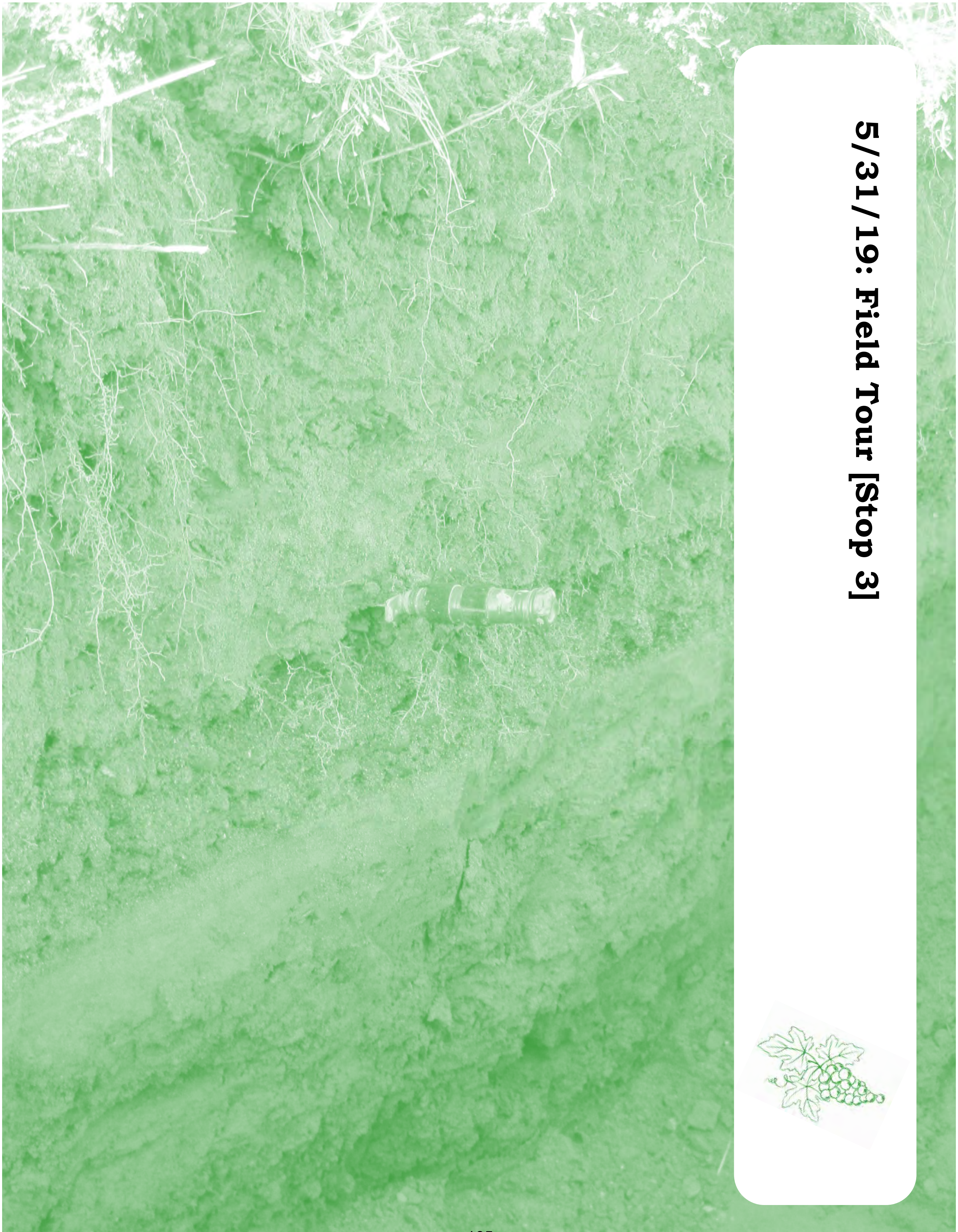


cylinder air-cooled motor mounted on rear. Chain and sprocket connected it to the rear axle. When started with crank . . . usually at expense of blisters, it made a terrible clatter, and would maintain speed of 15-20 mph on smooth oiled road [of which there were few]. It was without speedometer, but with ingenuity . . . I installed odometer . . . and finally succeeded in mapping a few miles of highway with its bordering soils. I believe this to be the first instance in which any form of auto transportation was used in the soil survey. Invention is, however, at times the mother of necessity and we soon returned to the slower and more dependable horse and buggy.

The history of soil survey during its infancy is truly rich, and as we approach the centennial celebration of the soil survey, it is good to reflect. I hope that this abbreviated look back has captured your interest and has provided knowledge that can be used as we carry the work forward. Certainly, the excerpts from Macy Lapham's *Crisscross Trails: Narrative of a Soil Surveyor* have enhanced the storytelling. It is only fitting to close with this end quote from Macy's book:

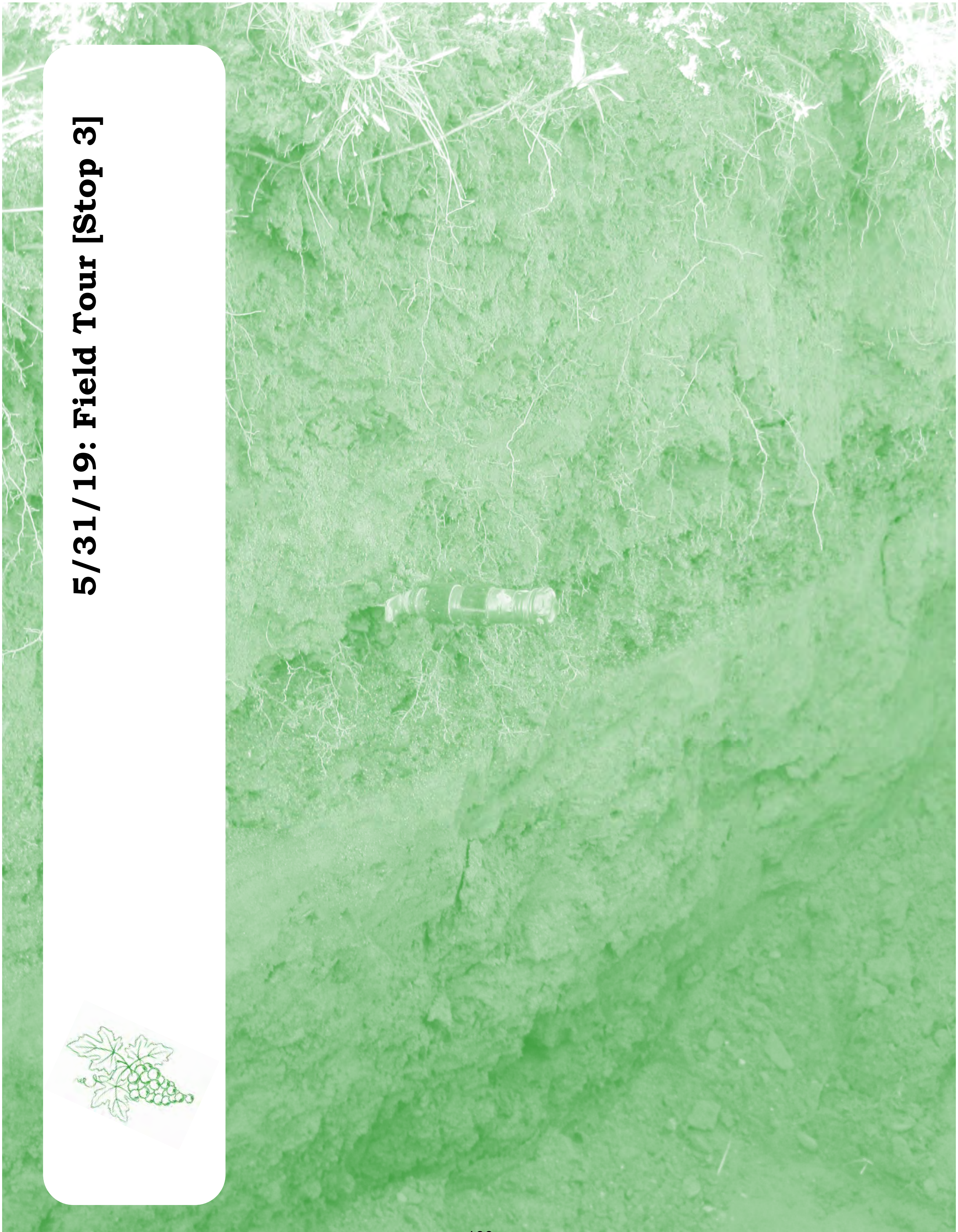
When the old horse and buggy stepped out of the picture and was replaced by the automobile, and when Dr. Marbut brought to us the principles of modern soil science, a new era was ushered into the Soil Survey. Modern field equipment and modern methods of observation and record have relegated the soil surveys of yesterday to a background of historical interest and of outmoded pedological and agricultural significance. Nevertheless, to one who has served through a pioneering period of slower tempo, recollection of the old horse and buggy jogging along a dusty country road with plane-table by side of the driver and a feed of oats and hay in the rear, brings nostalgic memories of many peaceful, pleasant country scenes. ■

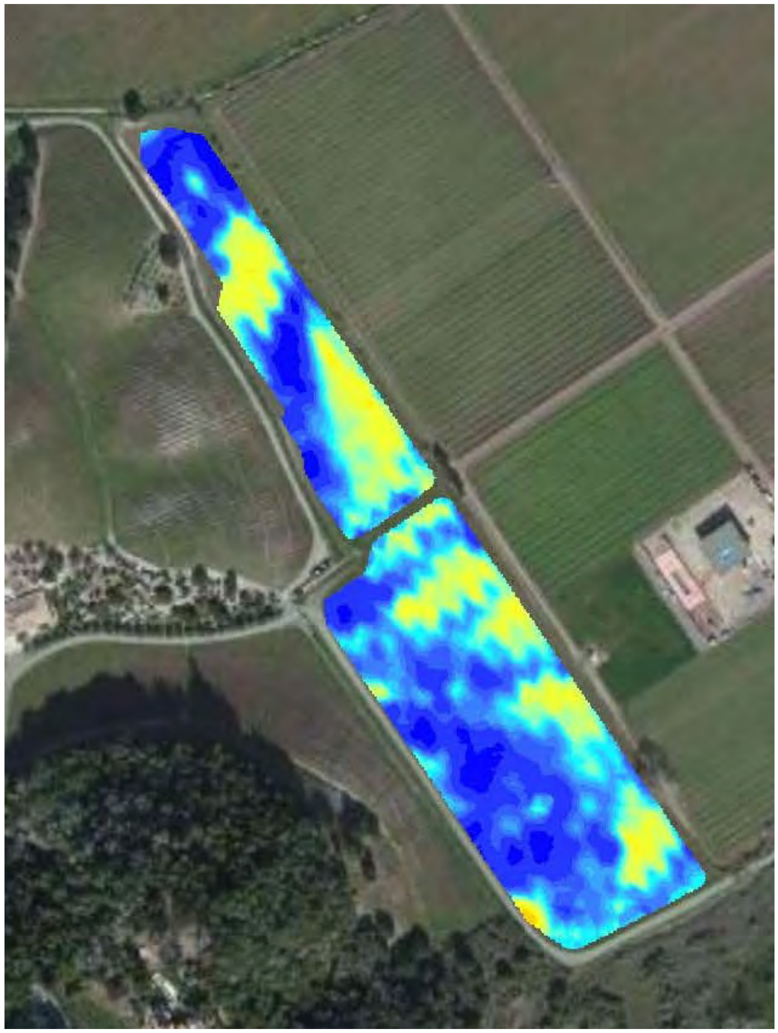




5/31/19: Field Tour [Stop 3]

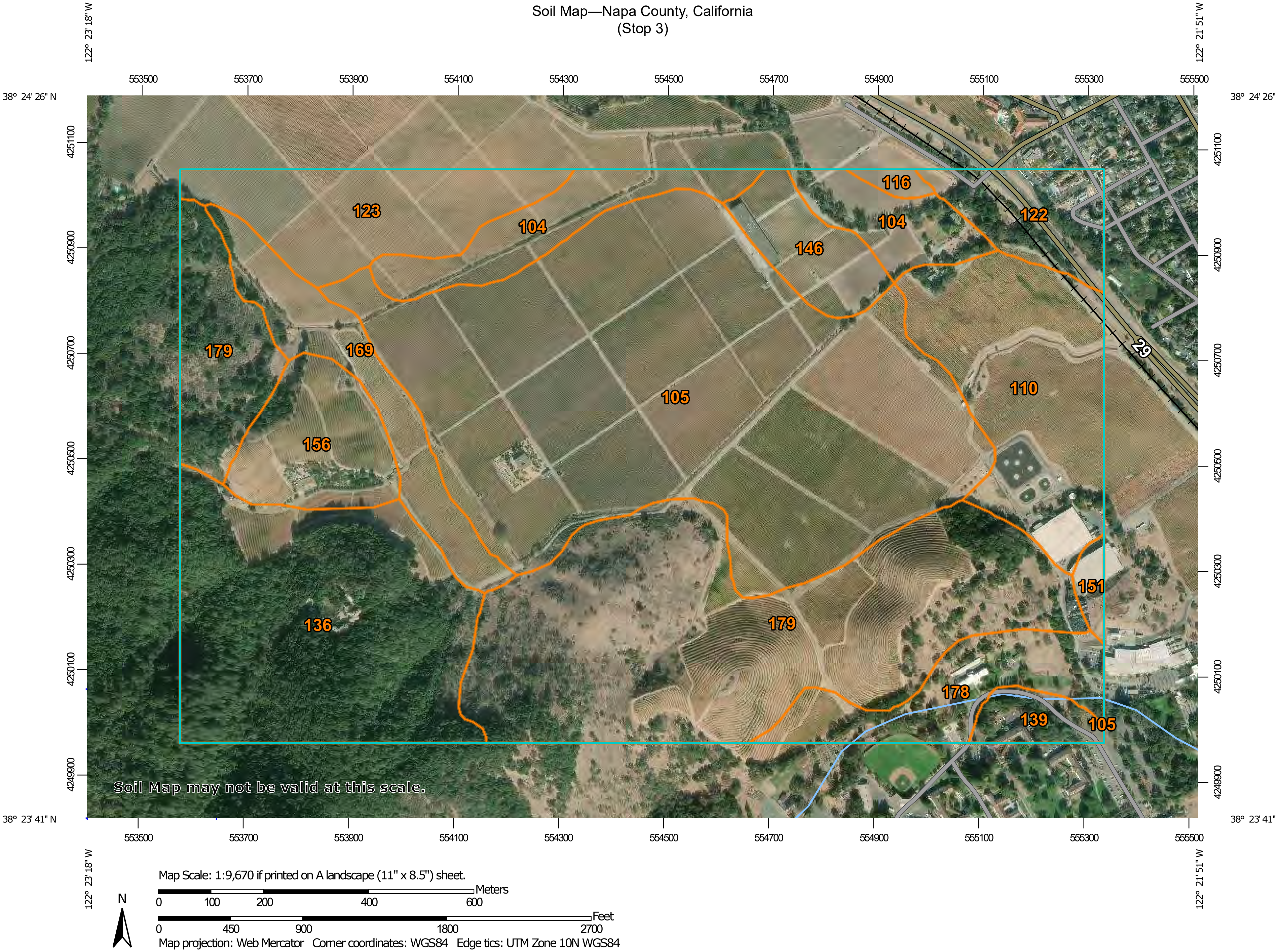
5/31/19: Field Tour [Stop 3]





Resistivity Image

Soil Map—Napa County, California
(Stop 3)



Map Scale: 1:9,670 if printed on A landscape (11" x 8.5") sheet.

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
104	Bale clay loam, 0 to 2 percent slopes	23.9	5.0%
105	Bale clay loam, 2 to 5 percent slopes	138.1	29.1%
110	Boomer-Forward-Felta complex, 30 to 50 percent slopes	37.4	7.9%
116	Clear Lake clay, drained, 0 to 2 percent slopes, MLRA 14	1.4	0.3%
122	Coombs gravelly loam, 0 to 2 percent slopes	12.7	2.7%
123	Coombs gravelly loam, 2 to 5 percent slopes	24.3	5.1%
136	Felton gravelly loam, 30 to 50 percent slopes	60.8	12.8%
139	Forward silt loam, 5 to 39 percent slopes, MLRA 15	5.2	1.1%
146	Haire loam, 2 to 9 percent slopes	10.9	2.3%
151	Hambright-Rock outcrop complex, 2 to 30 percent slopes	2.1	0.4%
156	Kidd loam, 30 to 75 percent slopes	17.1	3.6%
169	Perkins gravelly loam, 5 to 9 percent slopes	18.4	3.9%
178	Sobrante loam, 5 to 30 percent slopes	17.4	3.7%
179	Sobrante loam, 30 to 50 percent slopes	105.0	22.1%
Totals for Area of Interest		**474.8**	**100.0%**

LOCATION PERKINS CA

Established Series
Rev. WRR/DJL/WBS/DJE/SBS/DWB/AEC
03/2018

PERKINS SERIES

The Perkins series consists of very deep, well drained soils that formed in alluvium derived from mixed rock sources. Perkins soils are on terraces and have slopes of 0 to 30 percent. The mean annual precipitation is about 24 inches and the mean annual air temperature is about 62 degrees F.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, thermic Mollic Haploxeralfs

TYPICAL PEDON: Perkins loam - on a west facing slope of 1 percent under annual grasses at an elevation of 142 feet. (Colors are for dry soil unless otherwise stated. When described on June 14, l984, the soil was slightly moist below 20 inches.)

A--0 to 5 inches (0 to 13 cm); brown (7.5YR 5/4) loam, dark brown (7.5YR 3/4) moist; massive; very hard, friable, slightly sticky and slightly plastic; common very fine roots; common very fine interstitial and tubular pores; 2 percent pebbles; neutral (pH 7.0); clear smooth boundary. (4 to 15 inches thick)

Bt1--5 to 13 inches (13 to 33 cm); strong brown (7.5YR 5/6) clay loam, dark brown (7.5YR 3/4) moist; weak coarse subangular blocky structure; very hard, friable, slightly sticky and slightly plastic; common very fine roots; common very fine, fine and medium tubular pores; common thin clay films lining pores; 5 percent pebbles; neutral (pH 7.0); clear smooth boundary. (4 to 21 inches thick)

Bt2--13 to 23 inches (33 to 58 cm); yellowish red (5YR 5/6) clay loam, dark reddish brown (5YR 3/4) moist; moderate coarse subangular blocky structure; very hard, friable, slightly sticky and slightly plastic; common very fine roots; common very fine and fine and many medium tubular pores; common thin clay films on ped faces and lining pores; 5 percent pebbles; neutral (pH 7.0); gradual smooth boundary. (6 to 17 inches thick)

Bt3--23 to 35 inches (58 to 89 cm); yellowish red (5YR 5/6) loam, reddish brown (5YR 4/4) moist; weak coarse subangular blocky structure; very hard, friable, slightly sticky and slightly plastic; few very fine roots; common very fine, fine and medium and few coarse tubular pores; common thin clay films on ped faces and lining pores; 5 percent pebbles; neutral (pH 6.8); gradual smooth boundary. (12 to 18 inches thick)

Bt4--35 to 47 inches (89 to 119 cm); yellowish red (5YR 5/6) loam, reddish brown (5YR 4/4) moist; weak coarse subangular blocky structure; very hard, friable, sticky and plastic; few very fine roots; common very fine and fine and few medium tubular pores; common thin clay films on ped faces; 5 percent pebbles; neutral (pH 7.0); gradual smooth boundary. (12 to 25 inches thick)

Bt5--47 to 58 inches (119 to 147 cm); yellowish red (5YR 5/6) loam; yellowish red (5YR 4/6) moist; massive; hard, friable, slightly sticky and slightly plastic; few very fine roots; common very fine and fine and few medium tubular pores; common thin clay films lining pores; 5 percent pebbles; neutral (pH 7.0); clear smooth boundary. (0 to 11 inches thick)

BC--58 to 66 inches (147 to 168 cm); yellowish red (5YR 5/6) sandy loam, yellowish red (5YR 4/6) moist; massive; slightly hard, very friable, slightly sticky and nonplastic; few very fine roots; common very fine and fine pores; 5 percent pebbles; neutral (pH 7.0); clear smooth boundary. (0 to 25 inches thick)

C--66 to 72 inches (168 to 183 cm); yellowish red (5YR 4/6) very cobbly sandy loam, dark reddish brown (5YR 3/4) moist; massive; slightly hard, very friable, nonsticky and nonplastic; few very fine pores; 35 percent cobbles; 20 percent pebbles; neutral (pH 7.2).

TYPE LOCATION: Yuba County, California; Beale AFB, about 0.5 miles southwest of Capehart Housing, about 3,400 feet south and 1,150 feet east of the northwest corner of section 6, T.14 N., R.6 E., Camp Far West Quad. 39 degrees 5 minutes 32 seconds north latitude, 121 degrees 21 minutes 15 seconds west longitude, NAD83.

RANGE IN CHARACTERISTICS: The mean annual soil temperature is 61 degrees F to 68 degrees F and the soil temperature remains above 47 degrees F at all times. The 6 to 17 inch soil moisture control section is dry in all parts from May 15 to October 31 and moist in all parts from November 15 to May l.

The A horizon has dry color of 10YR 5/6, 5/4, 5/3, 5/2, 4/3; 7.5YR 3/4, 4/6, 5/4, 5/2, 4/4, 4/2; or 5YR 5/6 and moist color of 10YR 3/4, 3/3, 3/2; 7.5YR 3/4, 3/3, 3/2; 5YR 3/3, 3/4, or 3/6. Texture is fine sandy loam, very fine sandy loam or loam and gravel ranges from 1 percent to as much as 35 percent. In untilled areas the organic matter is 1.5 to 7 percent in the upper 4 inches, but decreases to less than 1 percent 7 to 10 inches below the surface. The A horizon is hard or very hard and is massive in some or all parts. It is medium acid to neutral. Some pedons have a gradual or diffuse boundary between the A horizon and the Bt horizon.

The Bt horizon has dry color of 7.5YR 4/4, 5/6; 5YR 6/4, 5/6, 5/4, 4/6, 4/8; 2.5YR 5/6, 5/4, 4/6 or 4/4 and moist color of 5YR 5/4, 4/6, 4/4, 3/6, 3/4; 2.5YR 4/4, 4/6, 3/6 or 3/4. The upper part of the horizon has dry color of 7.5YR 5/6, 5/4 or 3/4 and moist color of 4/6, 4/4 or 3/4. Texture is loam, clay loam, sandy clay loam, gravelly loam, gravelly clay loam, gravelly sandy clay loam, or very gravelly sandy clay loam and averages 25 to 35 percent clay and 5 to 35 percent gravel. The horizon has weak prismatic, moderate or strong angular or subangular blocky structure. It is neutral to medium acid and base saturation is 75 to 100 percent. Some pedons have 35 to 50 percent gravel and 5 to 15 percent cobbles below a depth of 40 inches.

The BC or C horizon has dry color of 7.5YR 4/6; 5YR 5/6 or 4/6 and moist color of 7.5YR 4/6, 3/4; 5YR 4/6, 3/4; or 2.5YR 3/6. This horizon is stratified with textures of clay loam, loam, sandy clay loam or sandy loam or their gravelly, cobbly very gravelly or very cobbly equivalents with 10 to 30 percent clay and 5 to 65 percent coarse fragments. Some thin individual strata are relatively gravel free. Reaction is slightly acid to neutral.

Some pedons lack BC or C horizons.

COMPETING SERIES: These are the Bellyspring, Coarsegold, Hicksville, Olashes, Pleasanton, Redsluff and Rescue series. Bellyspring soils are 20 to 40 inches deep to paralithic sandstone bedrock. Coarsegold soils have a lithic or paralithic contact at depths of 20 to 40 inches. Hicksville soils lack 5YR and 2.5YR hues. Pleasanton soils have less than 25 percent clay in the upper 20 inches of the argillic horizon. Redsluff soils have less than 10 percent clay and greater than 60 percent rock fragments in the C horizon. Rescue and Olashes soils lack rock fragments in the Bt horizon.

GEOGRAPHIC SETTING: Perkins soils are on terraces. Slope is 0 to 30 percent but usually have slopes of less than 9 percent. Elevation is 50 to 1,700 feet. They formed in alluvium from a variety of rock sources, including sedimentary, granitic, and metamorphosed acid- igneous rock. The climate has hot, dry summers and cool, moist winters. Mean annual precipitation is 14 to 43 inches. Average January temperature is 45 to 52 degrees F., average July temperature is 71 to 80 degrees F., and the mean annual temperature is 58 to 65 degrees F. The freeze-free season is 230 to 310 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Auburn, Cometa, Corning, Cortina, Churn, San Joaquin, and Sorrento soils. Auburn soils lack an argillic horizon and have in some part a lithic contact at a depth of less than 20 inches. Cometa and Corning soils have more than 35 percent clay and have an abrupt A-Bt horizon boundary. Cortina soils lack an argillic horizon and have more than 35 percent rock fragments. Churn soils have 50 to 75 percent base saturation in the argillic horizon. San Joaquin soils have a duripan. Sorrento soils have a mollic epipedon.

DRAINAGE AND PERMEABILITY: Well drained; slow to rapid runoff; moderately slow permeability. Some areas are subject to rare or occasional flooding.

USE AND VEGETATION: Used for growing field crops, citrus, olives, pasture, small grain, hay and range and home site development. Dominantly, plants are naturalized grasses and forbs. The principal native plants are live oak, California sagebrush, blue oak, valley oak, and shrubs.

DISTRIBUTION AND EXTENT: Sacramento Valley and intermountain valleys of southern California. The series is extensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Davis, California

SERIES ESTABLISHED: Sacramento County (Sacramento Area), California, 1946.

REMARKS: This revision represents a change in the type location from Sacramento Co. which no longer has any Perkins soil. The Ojai Series as mapped in the Ventura SSA has been inactivated and correlated to Perkins. Edits to description and competing series section updated for use in Butte Co.
2017 edits are from SDJR projects-AEC

National Cooperative Soil Survey
U.S.A.

LOCATION BALE CA

Established Series
Rev. GL-TDC-GMK
3/97

BALE SERIES

The Bale series consists of very deep, somewhat poorly drained soils formed in stratified, gravelly and sandy alluvium from mixed sources. Bale soils are on nearly level to gently sloping alluvial fans and terraces and have slopes range from 0 to 3 percent. The mean annual precipitation is about 32 to 40inches and the mean annual temperature is 59 to 60 degrees F.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, thermic Cumulic Ultic Haploxerolls

TYPICAL PEDON: Bale loam - cultivated. (Colors are for dry soil unless otherwise noted).

Ap--0 to 6 inches; dark gray (10YR 4/1) loam, black (10YR 2/1) moist; weak fine crumb structure; hard, very friable, slightly sticky, slightly plastic; common very fine roots; many very fine interstitial and tubular pores; slightly acid (pH 6.3); clear smooth boundary. (6 to 8 inches thick)

B21--6 to 17 inches; grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; weak fine subangular blocky structure; hard, friable, slightly sticky, slightly plastic; few coarse and common fine roots; common medium and fine tubular and interstitial pores; common thin clay films on peds; slightly acid (pH 6.3); clear smooth boundary. (6 to 12 inches thick)

B22--17 to 24 inches; brown (10YR 5/3) loam, very dark grayish brown (10YR 3/2) moist; weak fine subangular blocky structure very hard, friable, slightly sticky, slightly plastic; few very fine roots; common very fine tubular and interstitial pores; slightly acid (pH 6.3); gradual smooth boundary. (8 to 12 inches thick)

A11b--24 to 33 inches; gray (10YR 5/1) loam, black (10YR 2/1) moist; medium fine subangular blocky structure; extremely hard, friable, slightly sticky, slightly plastic; few fine and coarse roots; few fine and very fine tubular and interstitial pores; common thin clay films on peds and in pores; slightly acid (pH 6.3); gradual smooth boundary. (8 to 10 inches thick)

A12b--33 to 44 inches; gray (10YR 5/1) loam, very dark grayish brown (10YR 3/2) moist, weak fine subangular blocky structure; extremely hard, friable, slightly sticky, slightly plastic; few fine roots; common very fine tubular and interstitial pores; slightly acid (pH 6.3); gradual smooth boundary. (6 to 15 inches thick)

IIC1--44 to 50 inches; pale brown (10YR 6/3) gravelly sandy loam, dark brown (10YR 3/3) moist; moderate medium granular structure; hard, friable, nonsticky, nonplastic; many fine interstitial pores; about 20 percent fine gravel; slightly acid (pH 6.30; clear smooth boundary. (5 to 10 inches thick)

IIIC2--50 to 58 inches; pale brown 910YR6/3) sandy loam, dark brown (10YR 3/3) moist; moderate medium granular structure; hard, friable, nonsticky, nonplastic; many fine interstitial pores; slightly acid (pH 6.3).

TYPE LOCATION: Napa County, California; about 1 mile southeast of Calistoga; 950 feet, southwest from Silverado Trail Road on Pickett Road and 100 feet northwest along a lane between vineyards; NE 1/4 section 6 (projected), T. 8 N., R. 6 W.

RANGE IN CHARACTERISTICS: The mean annual soil temperature is about 60 to 63 degrees F and the soil temperature usually is not below 47 degrees F at any time. The soil between depths of 5 to 25 inches is usually dry from June until November 15 and is moist in some or all parts the rest of the year.

Rock fragments make up about 10 to 25 percent of the 10 to 40 inch control section. The fragments consist of rounded pebbles ranging in diameter from 2 mm to 1 inch and very few up to 3 inches. Thin very gravelly horizons occur at depths of 26 to 40 inches. The 10 to 40 inch control section averages 18 to 28 percent clay. Some pedons have a few mottles below a depth of 2 feet. Reaction is slightly acid or medium acid with some pedons strongly acid.

The Ap horizon is dark gray to very dark grayish brown in 10YR or 7.5YR hue and has value of 3, 5 or 5 dry and 2 or 3 moist and chroma of 1 or 2 dry or moist. Texture is loam, or clay loam. Structure is weak or moderate crumb, subangular blocky or is massive. This horizon is slightly hard or hard but is not massive and hard when dry.

The B2 horizon is dark gray and dark grayish brown to brown in 10YR or 7.5YR hue with value of 3, 4 or 5 dry and chroma of 1, 2 or 3 dry or moist. It is loam, heavy loam, sandy clay loam or clay loam. There is a slight clay increase with some thin clay films but not enough to qualify for an argillic horizon. This horizon has weak or moderate subangular blocky structure.

The horizons below the B2 horizon are buried A horizons or highly stratified C horizons. They are light gray to dark grayish brown in 10YR hue with value of 4 to 7 and chroma of 1 to 3. Texture is sand, loamy sand, sandy loam, loam, sandy clay loam or clay loam. Rock fragments, as described above, make up less than 50 percent of the C horizon.

COMPETING SERIES: These are the Cole, Pacheco, Pajaro, and Soquel series. Cole soils have a fine particle-size class, an argillic horizon, and have more than 75 percent base saturation. Pacheco soils have a mollic epipedon less than 20 inches thick and have mottles with chroma of 2 or less within depth of 30 inches. Pajaro soils have an aquic moisture regime, have mesic temperature, and have a coarse-loamy control section. Soquel soils have a regular decrease in organic matter, more than 75 percent base saturation throughout and have mesic temperature.

GEOGRAPHIC SETTING: Bale soils are on nearly level to gently sloping alluvial fans and terraces at elevations of 100 to 300 feet. They formed in stratified, gravelly and sandy alluvium from mixed sources. The climate is subhumid mesothermal with hot dry summers and cool moist winters. Mean annual precipitation is 32 to 40 inches. Average January temperature is 46 degrees F; average July temperature is 70 degrees F; mean annual temperature is 59 to 60 degrees F. The frost-free season is 220 to 270 days.

GRAPHICALLY ASSOCIATED SOILS: These are the competing Cole soils and the Cortina and Yolo soils. Cortina soils have an ochric epipedon and a loamy-skeletal control section. Yolo soils have an ochric epipedon, lack stratification, and have a fine-silty control section.

DRAINAGE AND PERMEABILITY: Somewhat poorly drained; slow runoff; moderate permeability. Some areas have a water table within 4 feet of the surface, and are ponded for short periods in the winter. Most areas are artificially drained.

USE AND VEGETATION: Used mostly for wine grape production with small acreages of orchards and irrigated pasture. Native vegetation was oak-grass and willows, blackberry and poison oak.

DISTRIBUTION AND EXTENT: Napa County, California. The soils are moderately extensive. MLRA 14.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Davis, California

SERIES ESTABLISHED: Napa Area, California, 1933.

REMARKS: Bale soils formerly were classified as Brunizems. The classification is changed from Typic Umbraqualfs to Cumulic Ultic Haploxerolls. No other soils are presently placed in the fine-loamy, mixed, thermic family.

ADDITIONAL DATA: NSSL pedon S72CA-055-007 (type location; not in Ultic subgroup) and pedon S91CA-055-001 (which would be a better type location)

Last revised by the state on 10/74.

National Cooperative Soil Survey
U.S.A.

LOCATION FELTA CA

Established Series
Rev. SBJ/TDC/GMK/ET
02/2003

FELTA SERIES

The Felta series is a member of the loamy-skeletal, mixed, thermic family of Pachic Argixerolls. Typically, Felta soils have grayish brown, slightly acid, very gravelly heavy loam A horizons and grayish brown, slightly acid, very gravelly clay loam B2t horizons underlain by gravelly old alluvium at a depth of about 24 inches.

TAXONOMIC CLASS: Loamy-skeletal, mixed, superactive, thermic Pachic Argixerolls

TYPICAL PEDON: Felta very gravelly loam - rangeland (Colors are for dry soil unless otherwise noted.)

Al--O to 5 inches; grayish brown (10YR 5/2) very gravelly heavy loam, very dark brown (10YR 2/2) moist; moderate very fine subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; many very fine roots; many very fine and fine interstitial, and common fine tubular pores; slightly acid (pH 6.5); clear wavy boundary. (4 to 19 inches thick)

B21t--5 to 14 inches; grayish brown (10YR 5/2) very gravelly clay loam, very dark grayish brown (l0YR 3/2) moist; moderate medium subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; very fine and fine grass and tree roots; many fine interstitial pores; many thin clay films in pores; slightly acid (pH 6.3); clear wavy boundary. (6 to 12 inches thick)

B22t--14 to 24 inches; grayish brown (l0YR 5/2) very gravelly heavy clay loam, very dark grayish brown (10YR 3/2) moist; moderate medium subangular blocky structure; slightly hard, friable, sticky, slightly plastic; common medium and many very fine and fine roots; many very fine and fine interstitial and common fine tubular pores; many thin clay films in pores and as bridges; slightly acid (pH 6.3); abrupt irregular boundary (6 to 14 inches thick)ll

C--24 to 60 inches; grayish brown (10YR 5/2) and brown (10YR 5/3) very gravelly sandy clay loam, dark yellowish brown (10YR 4/4) moist; massive; hard, firm, slightly sticky, slighty plastic; few fine and medium roots; few fine tubular and common medium interstitial pores; many moderately thick clay films in pores and as bridges; about 80 percent mixed gravel of volcanic, basic, and rhyolitic rocks; strongly acid (pH 5.5)

TYPE LOCATION: Sonoma County, California one mile east of the junction of Chalk Hill Road and Pleasant Avenue; in the SE1/4 of the NW1/4 sec. 16, T.8N., R.8W.

RANGE IN CHARACTERISTICS: The mean annual soil temperature is about 59 degrees to 65 degrees F. and the soil temperature usually is not below 47degrees F. at any time. The soil between depths of 8 to 20 inches is usually dry from June 15 until October 15 and is moist in some or all parts the rest of the year. Rock fragments of rounded pebbles and cobbles make up about 50 to 90 percent of the volume of the soil.

The A horizon is grayish brown or brown in 10YR or 7.5YR hue and has value of 5 dry, 2 or 3 moist and chroma is 2 or 3 both dry and moist. It is loam or heavy loam, and has moderate or weak subangular blocky structure. This horizon is neutral or slightly acid.

The Bt horizon has colors similar to the A horizon. It has weak or moderate subangular blocky structure. This horizon is slightly hard or hard and is slightly acid or moderately acid. The C horizon is pale brown to light brownish gray in 10YR hue and has value of 5 or 6 and chroma of 2 or 3. It is moderately acid or strongly acid.

COMPETING SERIES: These are the Botella, Elkhorn, Lockwood, and McCoy series. All these soils have less than 35 percent rock fragments.

GEOGRAPHIC SETTING: Felta soils are on dissected terraces at elevations of 100 to 2,000 feet. Slopes are 5 to 75 percent. The soils formed in mixed gravelly alluvium from mixed igneous rocks. The climate is subhumid mesothermal with hot dry summers and cool moist winters. Mean annual precipitation is 25 to 40 inches. Average January temperature is 47 degrees F.; average July temperature is 67 degrees F.; mean annual temperature is 59 degrees to 62 degrees F. The freeze-free season is 220 to 280 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Boomer, Forward, Guenoc, Hambright, Kidd, and Laniger soils. Boomer soils have ochric epipedons, have less than 75 percent base saturation and have less than 35 percent coarse fragments. Forward soils have ochric epipedons and have medial control sections. Guenoc soils have ochric epipedons and have fine kaolinitic control sections with hue of 2.5YR or redder. Hambright and Kidd soils have a lithic contact at depths of less than 20 inches. Laniger soils have ochric epipedons and have medial control sections.

DRAINAGE AND PERMEABILITY: Well-drained; medium to rapid runoff; moderate permeability.

USE AND VEGETATION: The soils are used for grazing. Native vegetation is white oak, manzanita, annual grasses and shrubs. Some areas have a few black oak trees.

DISTRIBUTION AND EXTENT: Sonoma and Napa Counties, California. The soils ate moderately extensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Davis, California

SERIES ESTABLISHED: NAPA County, California, 1974

REMARKS: The activity class was added to the classification in February of 2003. Competing series were not checked at that time. - ET

OSED scanned by SSQA. Last revised by state on 10/74

National Cooperative Soil Survey
U.S.A.

LOCATION KIDD CA

Established Series
Rev. SBJ/DJE/JJJ/AEC
05/2018

KIDD SERIES

The Kidd series consists of shallow, somewhat excessively drained soils formed in material weathered from rhyolitic tuff and rhyolite. Kidd soils are on hills and have slopes of 2 to 75 percent. The mean annual precipitation is about 45 inches and the mean annual temperature is about 56 degrees F.

TAXONOMIC CLASS: Loamy, mixed, superactive, mesic Lithic Haploxerepts

TYPICAL PEDON: Kidd gravelly loam--on a northwest facing convex slope of 35 percent under brush and scattered conifers at 1,400 feet elevation. (Colors are for dry soil unless otherwise stated. When described on November 14, 1972, the soil was moist throughout).

A--0 to 4 inches (0 to 10 cm); grayish brown (10YR 5/2) and very pale brown (10YR 7/3) gravelly loam, dark brown (7.5YR 3/2) and brown (7.5YR 4/4) moist; moderate medium crumb structure; slightly hard, friable, slightly sticky, and slightly plastic; many fine and medium roots; many very fine and fine interstitial and tubular pores; moderately acid (pH 5.8); clear smooth boundary. (3 to 8 inches thick)

Bw1--4 to 10 inches (10 to 25 cm); very pale brown (10YR 7/3) loam, brown (7.5YR 4/4) and brown (7.5YR 5/4) moist; weak medium subangular blocky and weak medium crumb structure; slightly hard, friable, slightly sticky, slightly plastic; common fine and coarse, few very fine roots; many very fine and fine, common medium interstitial and tubular pores; continuous thin clay films on peds, in pores and as bridges between mineral grains; moderately acid (pH 6.0); clear wavy boundary. (4 to 10 inches thick)

Bw2--10 to 14 inches (25 to 36 cm); very pale brown (10YR 8/3) loam, light yellowish brown (10YR 6/4) moist; massive; hard, friable, slightly sticky, slightly plastic; few fine roots; many fine tubular pores; very thin clay films in pores; moderately acid (pH 6.0); abrupt irregular boundary. (3 to 6 inches thick)

R--14 to 18 inches (36 to 46 cm); white (10YR 8/1) shattered rhyolitic tuff

TYPE LOCATION: Napa County, California; about 2 miles southwest of Angwin; about 500 feet west from intersection of Deer Park Road and Crestmont Drive and 100 feet south of Deer Park Road; in the SW 1/4 SW 1/4 section 7, T.8 N., R.5 W. 38 degrees 33 minutes 21.2 seconds North, 122 degrees 27 minutes 56.7 seconds West, NAD83.

RANGE IN CHARACTERISTICS: Depth to bedrock is 10 to 20 inches (25 to 51 cm). The mean annual soil temperature is 55 degrees to 59 degrees F, and the soil temperature usually is not below 47 degrees F at any time. The soil to bedrock is dry in all parts from about June 5 until October 15 and is moist in all parts from December through April 30. Rock fragments, mostly 1/2 to 3 inches in size, makeup about 10 to 35 percent of the soil. Rock fragments commonly increase as depth increases and exceed 35 percent in the lower part of the Bw horizon in some pedons. They average less than 35 percent in the control section.

The A horizon is 10YR with value of 4 through 8 dry, 3, 4, or 5 moist, and chroma of 1 through 4 dry, and 1, 2, or 3 moist. Some pedons are 7.5YR 4/4 or 5/4 moist. It is gravelly loam, sandy loam or fine sandy loam and has weak or moderate granular or crumb structure. It is slightly or medium acid.

The Bw horizon is 10YR or 7.5YR hue with value of 4 through 8 dry and 4 through 6 moist and chromas of 1, 2, 3 or 4 dry and 3 or 4 moist. It is sandy loam, clay loam, gravelly loam or loam and has granular or crumb structure or is massive. It is slightly through strongly acid.

COMPETING SERIES: These are the Crater Lake, Forward, and Synarep series in other families. Crater Lake and Synarep soils are more than 60 inches deep. Forward soils are 20 to 40 inches deep to a lithic or paralithic contact.

GEOGRAPHIC SETTING: Kidd soils are on hills. Slopes are 2 to 75 percent. The soils formed in material weathered from rhyolitic tuff and rhyolite. Elevations are 500 to 4,300 feet. The climate is subhumid with warm to hot dry summers and cool moist winters. Mean annual precipitation is 30 to 60 inches. Mean January temperature is 40 degrees F; mean July temperature is 72 degrees F; and mean annual temperature varies from 50 degrees to 56 degrees F. Frost-free season is 145 to 260 days.

GEOGRAPHICALLY ASSOCIATED SOILS: This is the competing Forward soil and the Boomer, Cohasset, Goulding, Hambright, Henneke, Los Gatos, and Neuns soils. Boomer, Cohasset, Henneke, and Los Gatos soils have argillic horizons and lack medial control sections. Goulding soils lack medial control sections and have frigid temperature regimes. Hambright soils have mollic epipedons, loamy-skeletal control sections, and thermic temperature regimes. Neuns soils have bulk density of 1 or more and have loamy-skeletal control sections.

DRAINAGE AND PERMEABILITY: Well-drained to excessively drained; medium to very rapid runoff; moderately rapid or rapid permeability.

USE AND VEGETATION: Used for watershed and recreation with some very limited grazing. Natural vegetation is hoary manzanita, chamise, ceanothus, scrub oak, knobcone pine, grasses, forbs and scattered ponderosa pine.

DISTRIBUTION AND EXTENT: Northern Coast Range Mountains and Cascade Range of California. The soils are moderately extensive in MLRAs 15 and 18.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Davis, California

SERIES ESTABLISHED: Napa County, California, 1974.

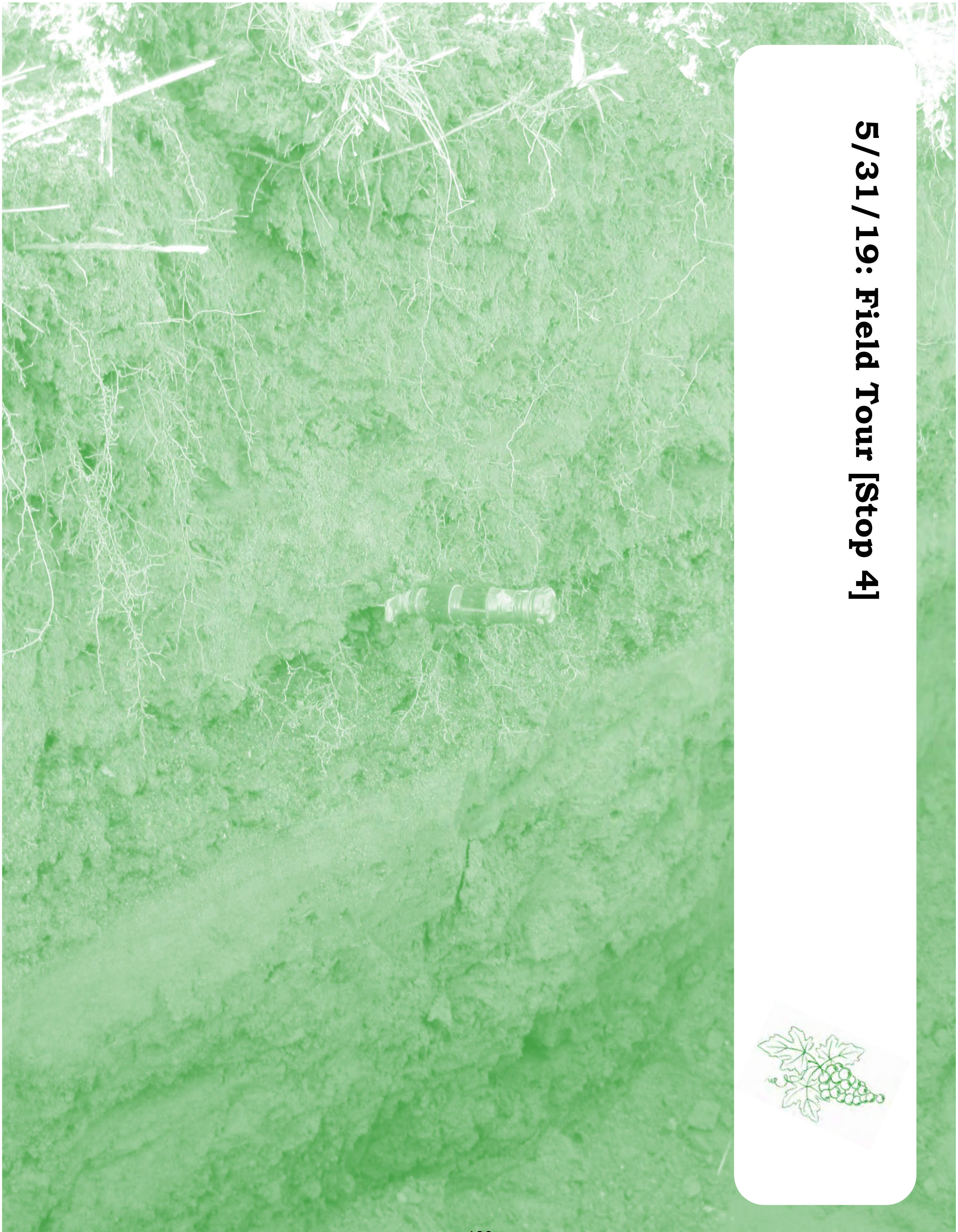
REMARKS: The Kidd soils mapped with depths that range from 5 to 20 inches was changed to eliminate those soils with depths of 5 to 10 inches. Soils with depths less than 10 inches would exclude cambic horizons.

Series reclassified 5/95. Mineralogy family added 3/97. Competing series not updated at that time.

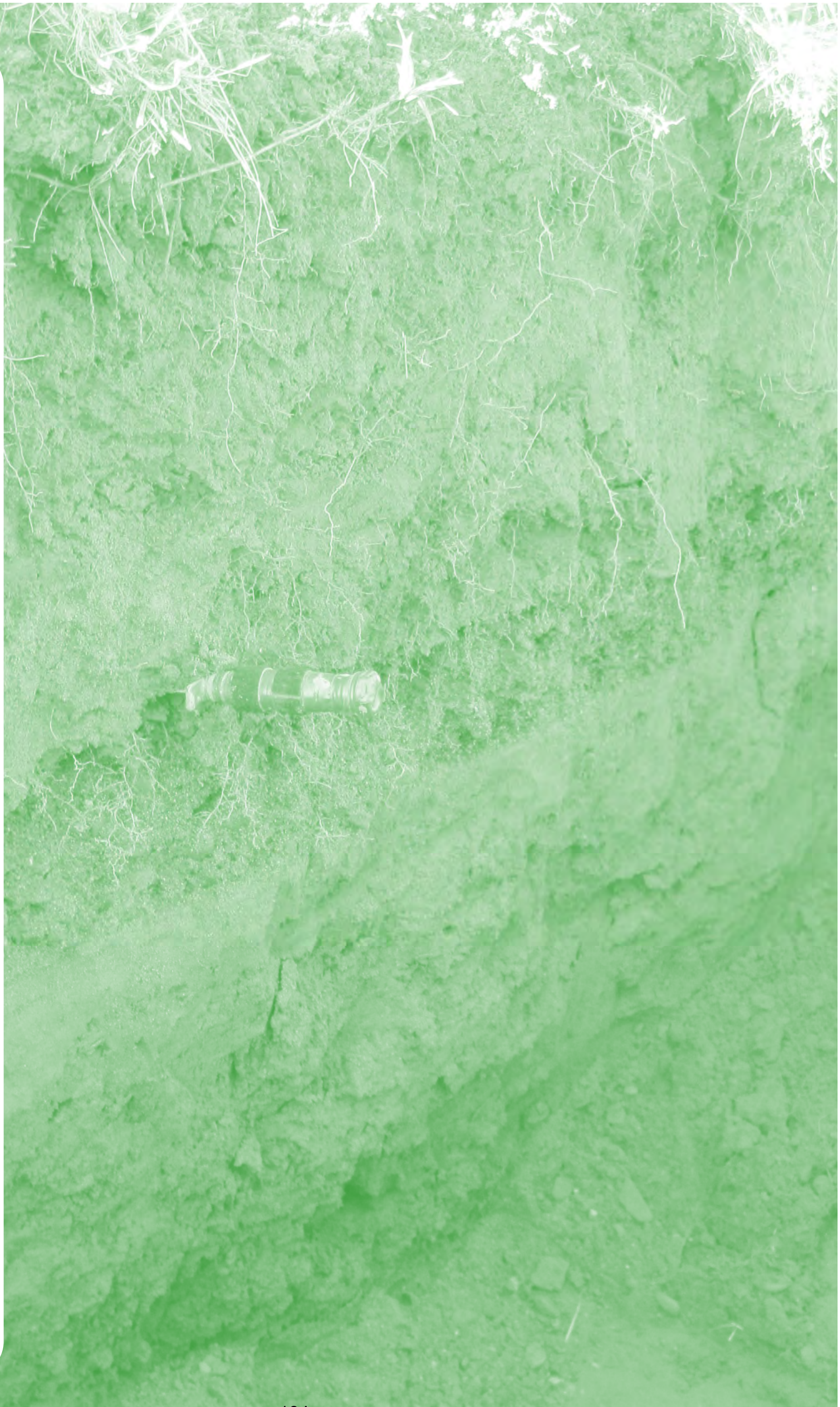
Series reclassified on 5/2018 with insufficient lab data and the assumption that soils in the Sonoma volcanics lack ASP. - AEC

ADDITIONAL DATA: NSSL pedon S72CA-055-001 (type location). Andic soil porperties were not run on the type location samples.

National Cooperative Soil Survey
U.S.A.



5/31/19: Field Tour [Stop 4]



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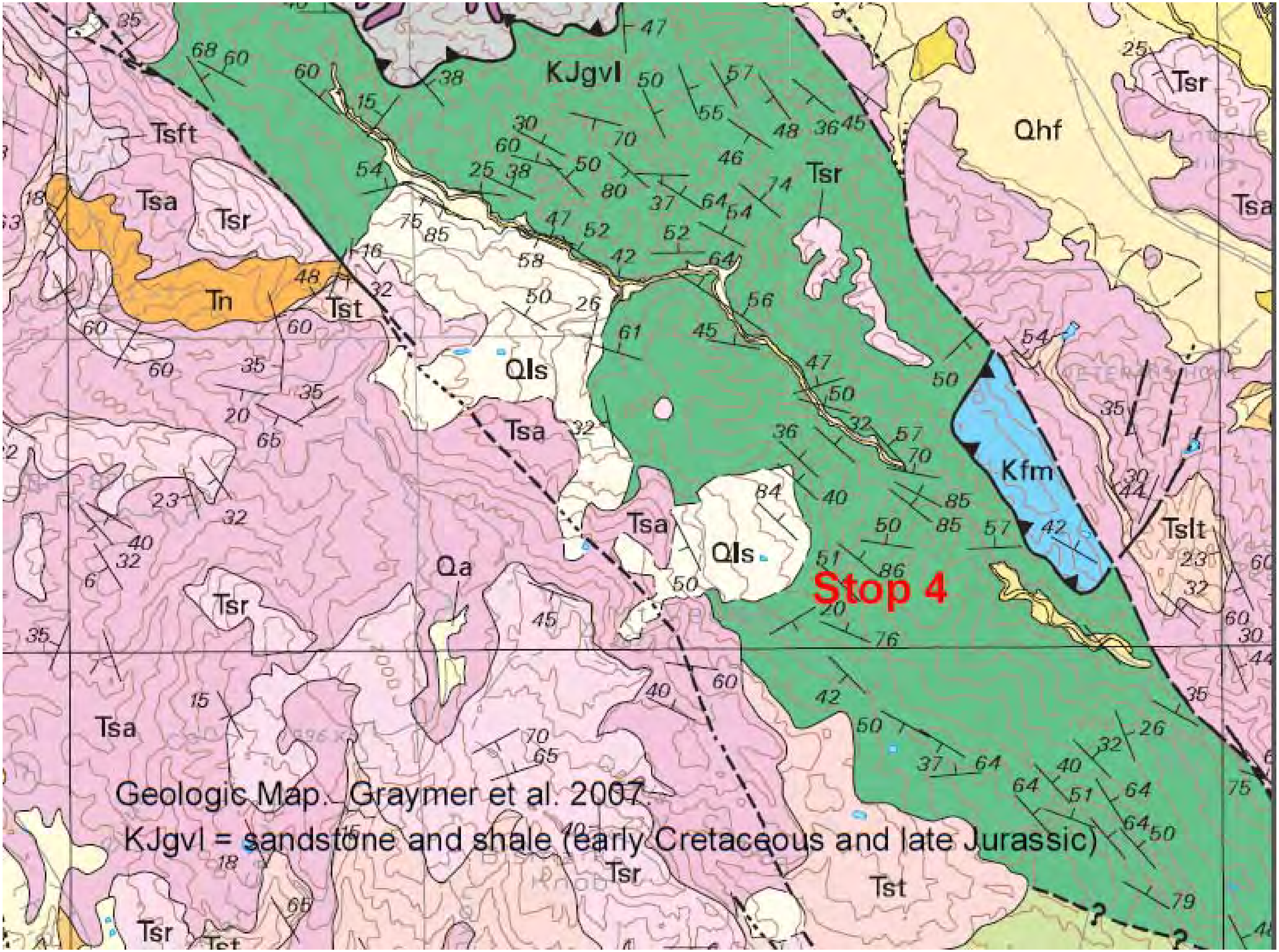
KJgvl
Tsr
Qhf
Tsa
Tsft
Tn
Tst
Qls
Kfm
Tslt
Qa
Stop 4
Geologic Map. Graymer et al. 2007.
KJgvl = sandstone and shale (early Cretaceous and late Jurassic)

SUMMARY DISTRIBUTION OF SLIDES AND EARTH FLOWS IN NAPA COUNTY, CALIFORNIA

By
Carl M. Wentworth, Scott E. Graham, Richard J. Pike, Gregg S. Beukelman, David W. Ramsey, and Andrew D. Barron

1997

INTRODUCTION

Slides and earth flows are landslides that can pose serious hazard to property in the hillside terrain of the San Francisco Bay region. They tend to move slowly and thus rarely threaten life directly. When they move—in response to such changes as increased water content, earthquake shaking, addition of load, or removal of downslope support—they deform and tilt the ground surface. The result can be destruction of foundations, offset of roads, and breaking of underground pipes within and along the margins of the landslide, as well as overriding of property and structures downslope.

DESCRIPTION

The best available predictor of where movement of slides and earth flows might occur is the distribution of past movements (Nilsen and Turner, 1975). These landslides can be recognized from their distinctive topographic shapes, which can persist in the landscape for thousands of years. Most of the landslides recognizable in this fashion range in size from a few acres to several square miles. Most show no evidence of recent movement and are not currently active. Some small proportion of them may become active in any one year, with movements concentrated within all or part of the landslide masses or around their edges.

This map provides a summary of the distribution of landslides evident in the landscape of the San Francisco Bay region. Original identification and map delineation of these landslides required detailed analysis of the topography by skilled geologists, a task generally accomplished through the study of aerial photographs. Such detailed landslide maps are now available for most of the region at scales of 1:24,000–1:62,500 (Pike, 1997). The summary map presented here makes selected use of these original maps and the 9-county compilation by Nilsen, Wright, and others (1979) to provide a basis for initial evaluation of areas vulnerable to slumps, translational slides, and earth flows in the region.

The summary map modifies and improves the compilation by Nilsen and Wright, which was prepared from sources available in the mid-1970's. The generalized landslide distribution shown on that map has here been improved in areas where the 1970's sources were notably deficient (Figure 1), has been extended to include Santa Cruz County, and includes the distribution of surficial deposits that define landscape not generally susceptible to these kinds of landsliding. The method of compilation and resolution of 1:125,000 (1 inch = 2 miles) limits use of the map to regional considerations. For more detailed information, see the maps listed by Pike (1997) or consult local officials or private consultants.

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Cooper-Clark and Associates, 1975, Preliminary map of landslide deposits in Santa Cruz County, in Seismic Safety Element of the County General Plan: Santa Cruz County, California, Planning Department, 1 sheet, map scale 1:62,500.
Dwyer, M.J., Noguchi, N., and O'Rourke, J., 1976, Reconnaissance photointerpretation map of landslides in 24 selected 7.5-minute quadrangles in Lake, Napa, Solano, and Sonoma Counties, California: U.S. Geological Survey Open-File Map 76-74, map scale 1:24,000.
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Nilsen, T.H., and Turner, B.L., 1975, Influence of Rainfall and ancient landslide deposits on recent landslides (1950-71) in urban areas of Contra Costa County, California: U.S. Geological Survey Bulletin 1388.
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Pike, R. J., 1997, Index to detailed maps of landslides in the San Francisco Bay region, California: U.S. Geological Survey Open-File Report 97-745 D.
Wentworth, C.M., 1997, General distribution of geologic materials in the San Francisco Bay region, California: a digital map database: U.S. Geological Survey Open-File Report 97-744, database resolution 1:125,000.

MAP UNITS

Mostly Landslides - 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 Landslides"; defined by excluding areas free of mapped landslides; outer boundaries are quadrangle and County limits to the area 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).

INTRODUCTION

This map identifies the principal areas in the San Francisco Bay region that are likely to produce debris flows, which are also called "mudslides." Debris flows that occur in the bay region are fast-moving downslope flows of mud that may include rocks, vegetation, and other debris. These flows begin during intense rainfall as shallow landslides on steep slopes. The rapid movement and sudden arrival of debris flows pose a hazard to life and property during and immediately following the triggering rainfall.

Debris flows in a given storm originate from a number of sources scattered throughout steep parts of the landscape (figure 1). During subsequent storms, new debris flows originate from different sources. These various sources, however, are similar in topographic form because debris-flow initiation requires steep slopes and prefers concave parts of hillsides. These topographic characteristics are used to predict the likely future source areas shown on this map.

MAP UNITS

The red zones of the map portray the principal areas from which debris flows can be expected during future storms. The black dots represent the debris-flow sources mapped after the catastrophic storm of January 1982. The dots provide an example of the abundance of debris flows that might be expected during a major rainstorm, and they illustrate the approximate nature of this predictive map.

HAZARD

Because debris flows travel downslope and downstream from source areas, hazards commonly extend beyond the red zones of the map. In the vicinity of the red zones, common areas of hazard are 1) near the base of steep hillsides, 2) near the mouths of steep sidehill drainages, and 3) in and near the mouths of canyons that drain steep terrain. Examples of these hazardous settings are shown in figure 1.

USE OF THE MAP

The map shows the principal source areas of debris flows from natural hillslopes in the region. Debris flows and other fast-moving landslides may also occur from man-made slopes, such as the cut slopes along highways in hilly terrain, but such sources generally are not shown on the map. Debris flows also are possible from unmodified steep areas outside of the red zones, but we expect that most debris flows will originate in or near the red zones of the map.

Because the map depicts source areas and not flow paths, and because of its broad areal coverage and small scale, the map is intended to be used as a guide to general areas of debris-flow hazard rather than as a prediction of hazard at specific sites. Appropriate uses include storm-preparedness planning for emergency access and response.

PREPARATION OF MAP

The map was produced using a Geographic Information System (GIS) from a 30-meter-square grid of topographic elevations in the region. The grid of elevations, called a digital elevation model (DEM), permits calculation of hillslope steepness and curvature for each 30-m cell. The potential debris-flow sources shown on the map were determined using the values of steepness and curvature defined in table 1. Mapped sources of historical debris flows in calibration areas were used to determine the parameters in table 1; the calibration areas we used are near Montara Mountain in San Mateo County (Wentworth, 1986) and in part of Marin County (plate 6 of Ellen and others, 1988). In these individually mapped calibration areas, the red zones include 82 percent of the mapped debris-flow sources. In the bay region as a whole, only 53 percent of the black dots of the map lie within the red zones. This low percentage probably results at least in part from inaccurate location of the black region-wide mapping.

EXPLANATION

Principal predicted debris-flow source areas

Approximate sources of debris flows triggered during the storm of January 1982

Approximate extent of mapping of 1982 debris flows

Figure 1. Perspective view showing typical debris flows (yellow) resulting from a major storm, in relation to potential source areas (red zones) like those shown on the map. In any one storm only a small fraction of the potential source areas may be activated. Most debris flows in the San Francisco Bay region travel only several tens of yards or less, but some may travel hundreds of yards downslope from their sources and others have traveled as much as a mile or more down stream channels. Numbers refer to typical hazardous locations discussed above.

Table 1. Hillslope steepness and curvature used to map potential debris-flow source areas (Values as measured on 30-m elevation grids. Plan curvature is curvature of the ground surface in a horizontal plane; it is measured as 1/r, where r is radius of curvature in meters and negative values indicate concave areas such as swales)

Hillslope steepness	Plan curvature
20 degrees and greater	+ 0.01 and less (including all negative values)

References Cited

Ellen, S.D., Cannon, S.H., and Reneau, S.L., 1988, Distribution of debris flows in Marin County, plate 6, in Ellen, S.D., and Wieczorek, G.F., eds., Landslides, floods, and marine effects of the storm of January 3-5, 1982, in the San Francisco Bay region, California: U.S. Geological Survey Professional Paper 1434, 310 p., plate 6 at 1:24,000 scale.

Wentworth, C.M., 1986, Maps of debris flow features evident after the storms of December 1955 and January 1982, Montara Mountain area, California: U.S. Geological Survey Open-File Map 86-353, 2 sheets at 1:24,000 scale.

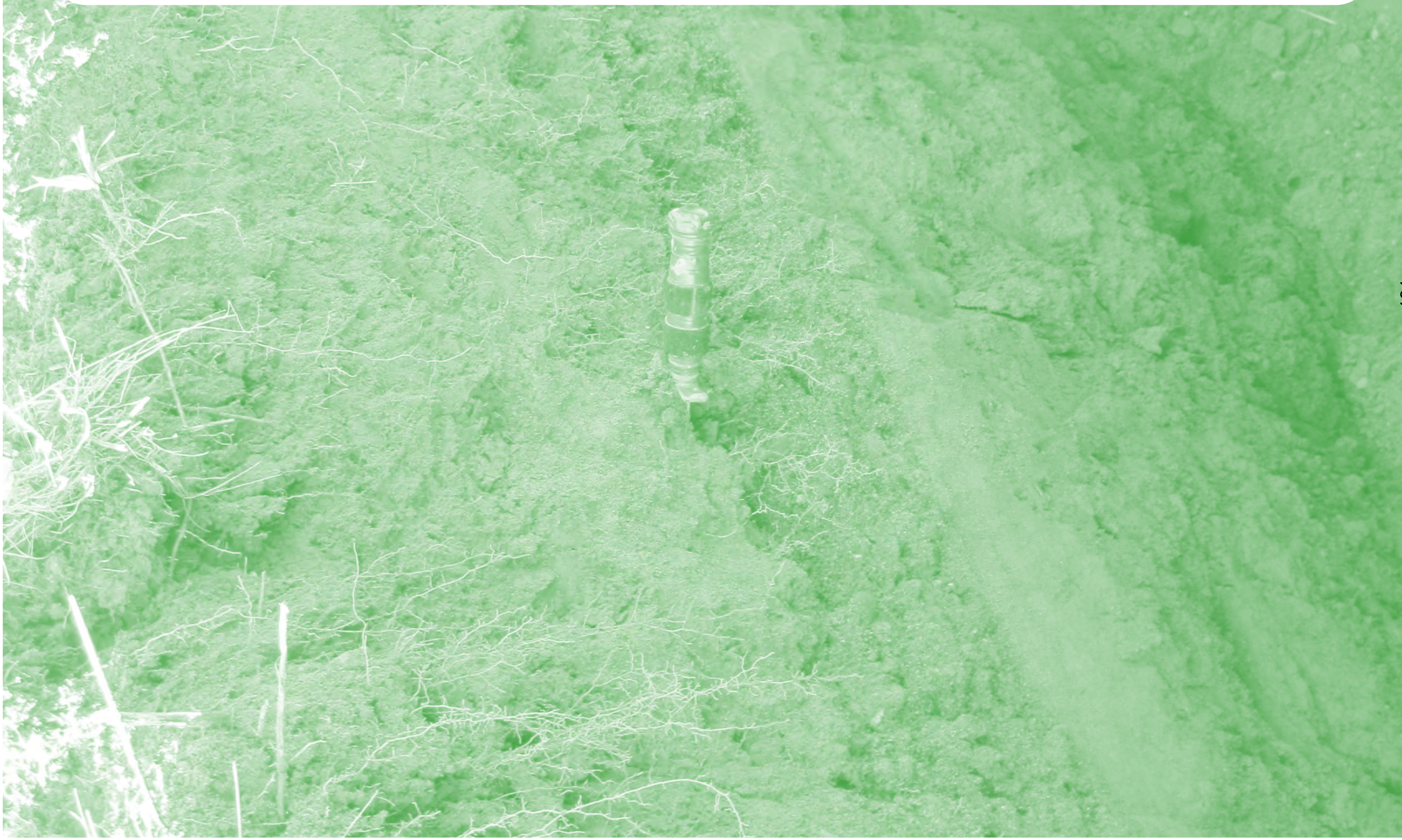
MAP SHOWING PRINCIPAL DEBRIS-FLOW SOURCE AREAS IN NAPA COUNTY, CALIFORNIA

By

Stephen D. Ellen, Robert K. Mark, Gerald F. Wieczorek,
Carl M. Wentworth, David W. Ramsey, and Thomas E. May
with digital cartographic assistance by Scott E. Graham,
Gregg S. Beukelman, and Andrew D. Barron

1997

5/31/19: Field Tour [Stop 5]



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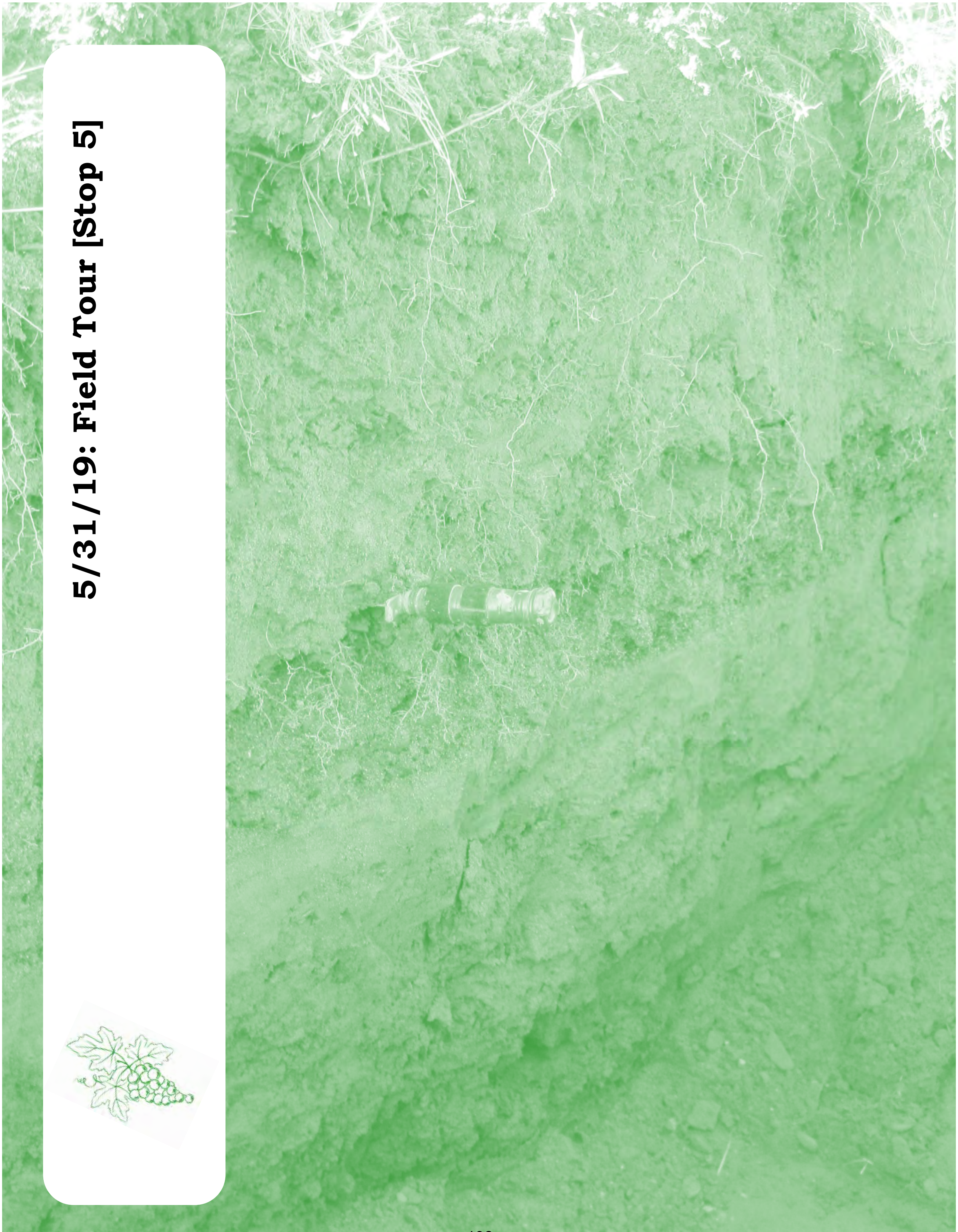
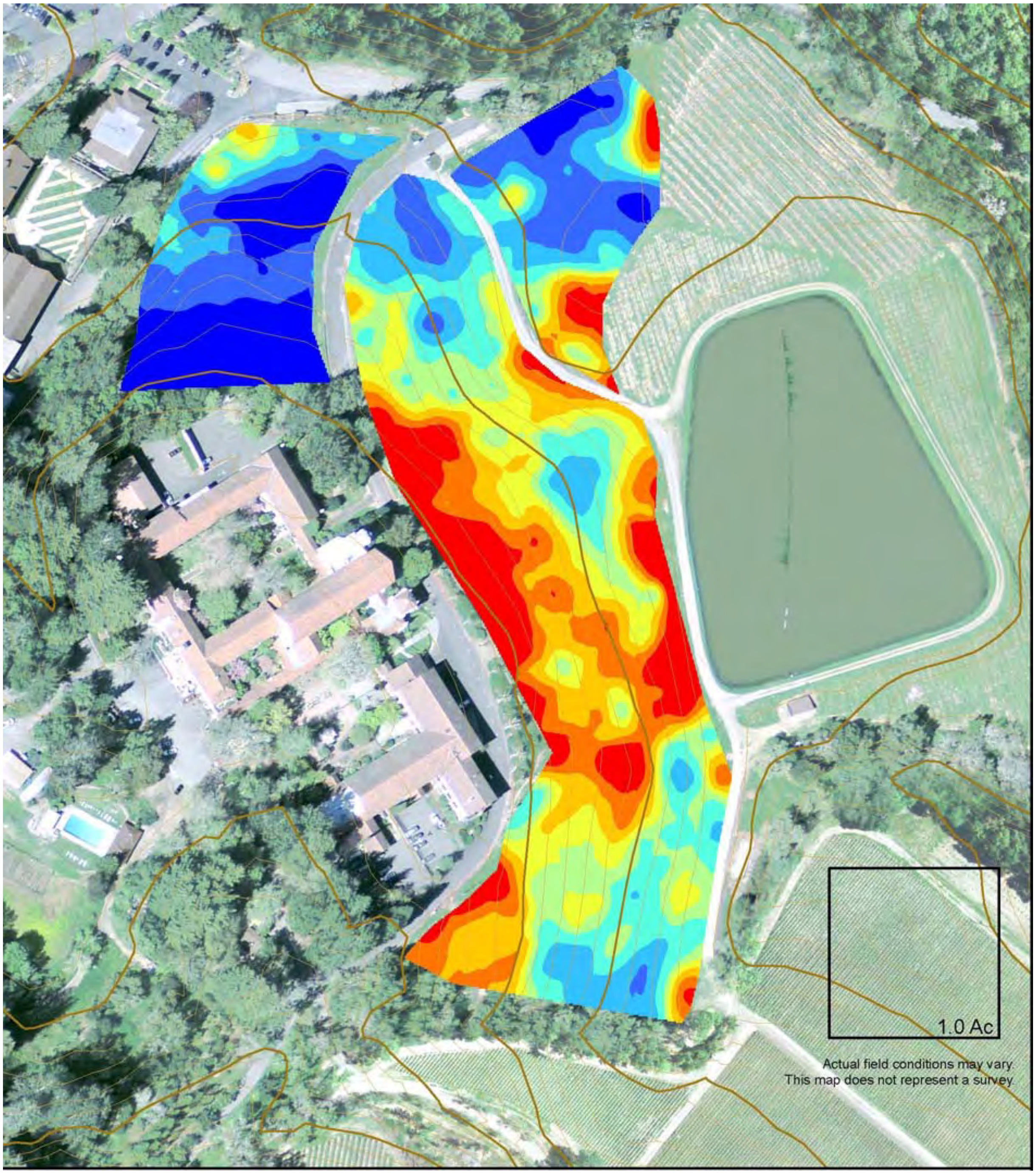
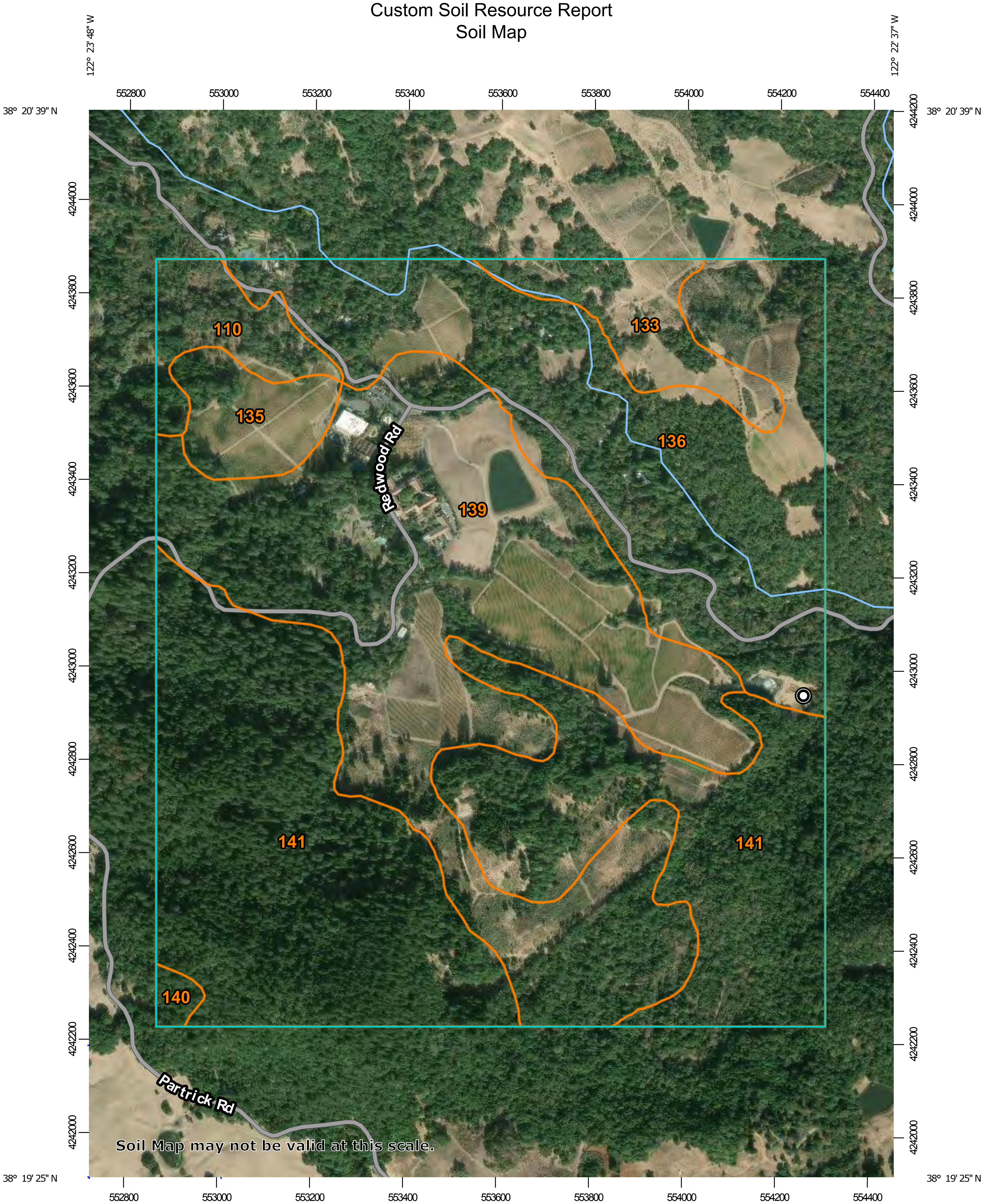




Resistivity Image

Custom Soil Resource Report
Soil Map



Map Scale: 1:11,200 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 150, 300, 600, 900

Feet: 0, 500, 1000, 2000, 3000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
110	Boomer-Forward-Felta complex, 30 to 50 percent slopes	17.2	2.9%
133	Fagan clay loam, 30 to 50 percent slopes	21.8	3.7%
135	Felton gravelly loam, 15 to 30 percent slopes	17.7	3.0%
136	Felton gravelly loam, 30 to 50 percent slopes	132.1	22.5%
139	Forward silt loam, 5 to 39 percent slopes, MLRA 15	189.7	32.3%
140	Forward silt loam, 12 to 57 percent slopes, MLRA 15	2.5	0.4%
141	Forward-Kidd complex, 11 to 60 percent slopes, MLRA 15	206.5	35.2%
Totals for Area of Interest		**587.4**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit

LOCATION FORWARD CA

Established Series
Rev. SBJ/GMK/DJE/AEC
03/2018

FORWARD SERIES

The Forward series consists of moderately deep, well drained soils formed in material weathered from rhyolithic tuff. Forward soils are on hills and mountains and have slopes of 2 to 75 percent slopes. The mean annual precipitation is 45 inches and the mean annual temperature is 42 degrees F.

TAXONOMIC CLASS: Ashy, mixed, mesic Typic Vitrixerands

TYPICAL PEDON: Forward sandy loam--on an east facing slope of 24 percent in an area logged but under a dense stand of conifers and shrubs at an elevation of 3,800 feet. (Colors are for dry soil unless otherwise stated.)

0i--0 to 2 inches (0 to 5 cm); fresh pine and oak litter, partially decomposed in lower portion.

A1--2 to 3 inches (5 to 8 cm); grayish brown (10YR 5/2) sandy loam, very dark brown (10YR 2/2) moist; moderate medium granular structure; soft, very friable; few very fine roots; many very fine pores; slightly acid; abrupt wavy boundary.

A2--3 to 9 inches (8 to 23 cm); light brownish gray (10YR 6/2) sandy loam, dark grayish brown (10YR 4/2) moist; weak medium subangular blocky structure; soft, very friable; common very fine, fine and medium roots; many very fine pores; medium acid; abrupt wavy boundary. (Combined thickness of the A horizon is 3 to 15 inches.)

Bw1--9 to 17 inches (23 to 43 cm); very pale brown (10YR 7/3) coarse sandy loam, pale brown (10YR 6/3) moist; weak medium subangular blocky structure; slightly hard, very friable; common very fine and fine roots; many very fine pores; medium acid; clear irregular boundary. (6 to 14 inches thick)

Bw2--17 to 26 inches (43 to 66 cm); pale yellow (2.5Y 8/4) coarse sandy loam, light yellowish brown (2.5Y 6/4) moist; weak medium subangular blocky structure; slightly hard, very friable; few medium and large roots throughout with a dense layer of very fine, fine, medium and coarse roots resting abruptly on tuff below; strongly acid; abrupt wavy boundary. (6 to 24 inches thick)

Cr--26 to 32 inches (66 to 81 cm); pale yellow (2.5Y 8/4) massive rhyolitic tuff, ranging in color from nearly white to pale yellow. The tuff contains fine angular particles of volcanic ash and angular fragments of pumice. Roots penetrate the tuff only along fracture planes.

TYPE LOCATION: Tehama County, California; about 1-1/2 miles southwest of Forward Mill near the center of the SW1/4 of SW1/4 of sec. 27, T. 30 N., R. 2 E. 40 degrees 25 minutes 29 seconds N 121 degrees 45 minutes 39.9 seconds W, NAD83

RANGE IN CHARACTERISTICS: Rhyolitic tuff occurs at depths of 20 to 40 inches. The solum contains 60 to 80 percent vitric material in the silt, sand and gravel fractions. Gravel fraction of the whole soil ranges from 5 to 35 percent. The mean annual soil temperature is about 52 degrees to 57 degrees F. The soils are usually moist but are dry in late May or June and remain dry until October.

The A horizon is 10YR 4/2, 5/2, 6/1, 6/2, or 6/3, 7/1 or 7/2. Moist color is 10YR 2/2, 3/2, 3/3, 4/2, 4/4, 5/2, 5/3 or 5/4. Dry colors of 4/2 or 5/2 and moist colors of 2/2 or 3/2 only occur in the upper 1 to 3 inches. It is loamy sand, sandy loam or light loam and may be gravelly. It is slightly to strongly acid.

The Bw horizon is 10YR 5/3, 6/2, 6/3, 7/1, 7/2, 7/3, 7/4; 2.5Y 7/4, 8/2, or 8/4. Moist color is 10YR 4/3, 4/4, 5/2, 5/3, 5/4, 6/3; 2.5Y 5/2, 6/2, 6/4, 7/4, or 8/4. It is coarse sandy loam, sandy loam or loam and may be gravelly. It is slightly to very strongly acid. Some pedons have an A or BA horizon transitional to the Bw horizon, or the BC horizon may be absent.

The C horizon, where present, is 10YR 7/1, 7/2, 7/3, 8/3; 2.5Y 6/2, 7/2, 8/3, or 8/4. Moist color is 10YR 5/3, 6/2, or 6/3 and has a lower chroma or yellower hue than the overlying Bw horizon. It is slightly acid to very strongly acid.

COMPETING SERIES: These are the Crater Lake, Synarep, and Toutle series. Crater Lake soils lack a paralithic contact at depths of 20 to 40 inches. Synarep and Toutle soils are over 60 inches deep.

GEOGRAPHIC SETTING: Forward soils are on hills and mountains. Slopes are 2 to 75 percent. The soils formed in material overlying rhyolitic tuff. Elevations are 400 to 4,500 feet. The climate is subhumid with warm to hot dry summers and cool moist winters. Mean annual precipitation is 30 to 60 inches. Some areas may have up to 25 inches of annual snowfall. Mean January temperature is 34 degrees F, mean July temperature is 67 degrees F, and mean annual temperature varies from 48 degrees to 55 degrees F. Frost-free season is 150 to 250 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Aiken, Cohasset, and Nanny soils. Aiken and Cohasset soils have argillic horizons. Nanny soils have more than 35 percent coarse fragments.

DRAINAGE AND PERMEABILITY: Well drained; medium runoff; moderately rapid permeability above the tuff.

USE AND VEGETATION: Used mainly for timber production. Natural vegetation is ponderosa pine, Douglas-fir, incense cedar, black oak, squaw carpet, manzanita and a few herbaceous plants.

DISTRIBUTION AND EXTENT: Occurs at moderate elevations in the Cascade and Coast Ranges of northern California. The soils are moderately extensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Davis, California

SERIES ESTABLISHED: Tehama County, California, 1962.

REMARKS: The soils mapped as Forward in Napa County were formerly named the Butte series.

Edits made after sdjr projects. Substitute particle-size class changed to ashy based on air-dry 15 bar water data from lab data for OSD profile (S1954-CA-52-011) of less than 12 percent. There is insufficient lab data to determine Andic soil properties. - AEC

National Cooperative Soil Survey
U.S.A.

LOCATION FELTON CA

Established Series
Rev. WCL/GMK/RWK/ET/WRR
11/2009

FELTON SERIES

The Felton series consist of deep, well drained soils that formed in material weathered from shale, sandstone or mica schist. Felton soils are on uplands and have slopes of 5 to 75 percent, The mean annual precipitation is about 40 inches and the mean annual air temperature is about 55 degrees F.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, mesic Ultic Argixerolls

TYPICAL PEDON: Felton silt loam, forested. (Colors are for dry soil unless otherwise noted.)

0i--1 inch to 0; leaves, needles, and twigs, some partially decomposed; abrupt smooth boundary.

A1--0 to 2 inches; brown (7.5YR 5/2) silt loam, dark brown (7.5YR 3/2) moist; moderate medium subangular blocky structure parting to fine granular; slightly hard, friable, nonsticky and nonplastic; common very fine roots; many very fine interstitial and tubular pores; moderately acid (pH 6.0); clear smooth boundary. (2 to 10 inches thick)

A2--2 to 10 inches; brown (7.5YR 5/2) light clay loam, dark brown (7.5YR 3/2) moist; moderate medium subangular blocky structure; hard, friable, sticky and plastic; common fine and few medium roots; many very fine interstitial and tubular pores; few thin clay films on peds and lining pores; moderately acid (pH 6.0); clear wavy boundary. (8 to 10 inches thick)

Bt1--10 to 23 inches; light brown (7.5YR 6/4) clay loam, brown (7.5YR 5/4) moist; moderate medium subangular blocky structure; hard, firm, sticky and plastic; few fine and many medium and coarse roots; many very fine interstitial and tubular pores, few fine, medium and coarse tubular pores; many thin clay films on faces of peds and lining pores; moderately acid (pH 6.0); clear wavy boundary. (12 to 16 inches thick)

Bt2--23 to 39 inches; light yellowish brown (10YR 6/4) clay loam, yellowish brown (10YR 5/6) moist; moderate medium subangular blocky structure; hard, firm, sticky and plastic; few medium and coarse roots; many very fine interstitial and tubular pores, few medium and coarse tubular pores; common thin clay films lining pores and on faces of peds; strongly acid (pH 5.5); gradual wavy boundary. (8 to 18 inches thick)

C1--39 to 48 inches; light yellowish brown (10YR 6/4) shaly clay loam, yellowish brown (10YR 5/6) moist; weak medium subangular blocky structure; hard, firm, sticky and plastic; few medium and coarse roots; many very fine and fine tubular pores, few medium and coarse tubular pores; few thin clay films lining pores and on faces of peds; about 25 percent shale fragments 1 to 1/2 inch in diameter; strongly acid (pH 5.5); gradual wavy boundary. (0 to 12 inches thick)

C2--48 to 60 inches; yellowish brown (10YR 5/6) very shaly clay loam, dark yellowish brown (10YR 4/4) moist; massive; hard, firm, sticky and plastic; about 50 percent shale fragments 1 to 2 inches in diameter; strongly acid (pH 5.5); gradual irregular boundary.

Cr--60 to 65 inches; shale.

TYPE LOCATION: Santa Clara County, California; 1.9 miles above Spring Lake on Watsonville Road; 200 yards uphill on old skid trail; SW1/4 NW1/4 section 6, T.11S., R.3E.

RANGE IN CHARACTERISTICS: Depth to paralithic contact is 40 to 80 inches. The mean annual soil temperature is about 56 degrees F.; the mean winter soil temperature is about 47 degrees F.; and the mean summer soil temperature is about 60 degrees F. Soil between depths of about 5 and 15 inches usually is dry in all parts all the time from mid-May to mid-June until about late October or early November and usually is moist the rest of the year.

Organic matter is 3 to 8 percent in the uppermost 10 inches of the profile and decreases gradually to 1.5 to 0.5 percent 20 inches below the surface and in most pedons is less than 1 percent within 16 to 25 inches of the surface. Base saturation is 60 to 75 percent in some part of the upper 30 inches of the profile and in most pedons is less than 75 percent in all parts. Base saturation in the lower part of the profile, below a depth of 30 inches, is 40 to 80 percent but in many pedons it is similar to that in the upper 30 inches of the profile. The soil is slightly or strongly acid in the A and B horizons and slightly to very strongly acid in the C horizon.

Shale fragments or other rock fragments usually are less than 15 percent in the A and B horizons and average less than 35 percent in all pedons. In pedons with C horizons, rock fragments make up 15 to 65 percent.

The A horizon is brown or dark brown in 7.5YR hue, dark reddish gray and dark reddish brown in 5YR hue and dark grayish brown or brown in 10YR hue, and has moist chroma of 2 or 3. Texture is sandy loam, loam, silt loam or light clay loam and has moderate or strong granular, subangular blocky or angular blocky structure. The upper boundary of the Bt horizon is gradual or diffuse or there is a transitional AB or B horizon.

The Bt horizon is brown or light brown in 7.5YR hue, light yellowish brown, light brown, brown, pale brown or yellowish brown in 10YR hue and reddish brown, light reddish brown or yellowish red in 5YR hue and has moist chroma of 4 or 6. Texture is clay loam, silty clay loam, or sandy clay loam and has 6 to 15 percent more clay (absolute) than the A horizon. This horizon has moderate or strong subangular blocky or angular blocky structure. In some pedons a loam, sandy loam or clay loam C horizon modified by shale fragments is between the B horizon and the shale.

COMPETING SERIES: These are the Annum, Brownlee, Chirpchatter, Ebadlow, Fisherhill, Goldendale, Hellake, Lompico, Lorena, Meland, Mendian, Meystre, Quiden, Rehfield, Robbscreek, Schumacher, Stacker, Stardust, Updegraff and Van Horn series.Annum, Brownlee,Chirpchatter, Ebadlow, Fisherhill, Goldendale, Hellake, Mendian, Meystre, Quiden, Rehfield, Robbscreek, Stardust and Van Horn soils all have MAAT of less than 52 degrees F. Loeren, Meland and Stacker soils have lithic contacts at 20 to 40 inches. Schumacher soils have MAAT of less than 52 degrees F. and have a lithic contact at 40 to 60 inches. Updegraff soils have lithic contacts at 40 to 60 inches. Lompico soils are 20 to 40 inches deep to a lithic contact. Schumacher soil have a lithic contact at 40 to 60 inches and MAAT of less than 52 degrees F.

GEOGRAPHIC SETTING: Felton soils formed in material weathered from shale and sandstone or mica schist. They are on uplands and have gradients of 5 to 75 percent. Elevations are 400 to 3,000 feet . The climate is humid mesothermal with warm to cool dry summers and cool, moist winters. The mean annual precipitation is 25 to 70 inches. Snow is rare and remains for only a few hours. The average January temperature is about 47 degrees F.; the average July temperature is about 61 degrees F.; and the mean annual temperature is 54 to 57 degrees F. The frost free season is about 220 to 330 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Ben Lomond, Gilroy, Hugo, Lompico, Los Osos, Madonna and Maymen soils. Ben Lomond soils lack an argillic horizon and have coarse loamy textural control sections. Gilroy and Los Osos soils have a mean soil temperature above 59 degrees F. and a lithic and paralithic contact respectively at a depth of 20 to 40 inches. Hugo, Madonna and Maymen soils lack argillic horizons and lack mollic epipedons.

DRAINAGE AND PERMEABILITY: Well drained; rapid to very rapid runoff; moderately slow permeability.

USE AND VEGETATION: Used for timber production, recreation, watershed, growing Christmas trees and homesites. Most areas have been cut over. Vegetation is redwood, Douglas fir, madrone, and oak.

DISTRIBUTION AND EXTENT: Mountainous areas near the coast in central California. The soil is moderately extensive. MLRA 4.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Davis, California

SERIES ESTABLISHED: Santa Cruz County, California, 1936.

REMARKS: The activity class was added to the classification in February of 2003. Competing series checked 11/2009.

ADDITIONAL DATA: NSSL Lab Data 40A3038

National Cooperative Soil Survey
U.S.A.

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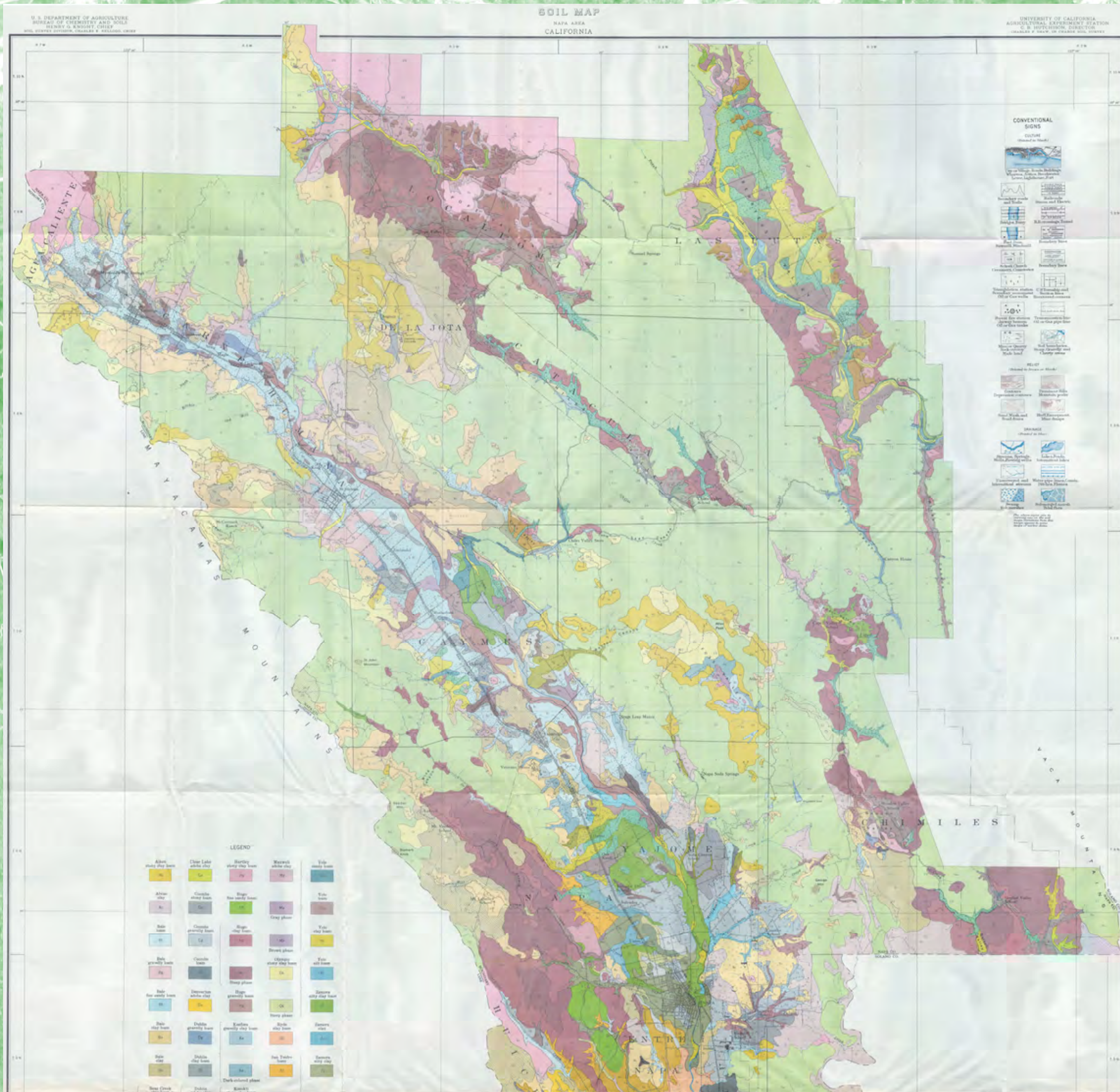

Map from Soil Survey of the Napa Area, California (1938)