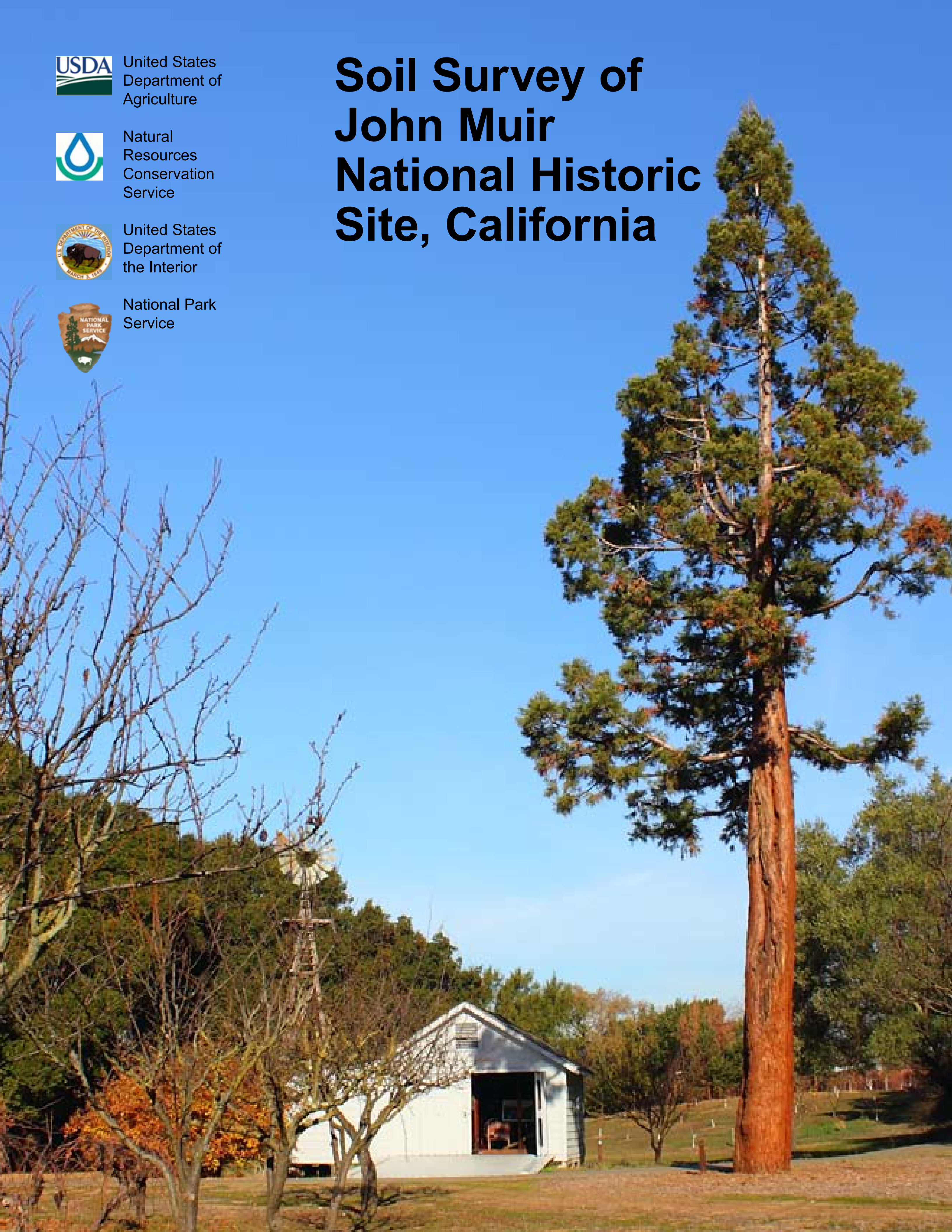
United States Department of Agriculture

Natural Resources Conservation Service

United States Department of the Interior

National Park Service

Soil Survey of John Muir National Historic Site, California



How To Use This Soil Survey

This publication consists of text, tables, and a map. The text includes descriptions of detailed soil map units and provides an explanation of the information presented in the tables. It also includes a glossary of terms used in the text and tables and a list of references.

The detailed soil map can be useful in planning the use and management of small areas. To find information about your area of interest, locate that area on the map sheet. Note the map unit symbols that are in that area. Go to the Contents, which lists the map units by symbol and name and shows where each map unit is described.

The Contents shows which table has data on a specific land use for each detailed soil map unit. Also see the Contents for sections of this publication that may address your specific needs.

National Cooperative Soil Survey

This soil survey is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey.

The soil map in this survey may be copied without permission. Enlargement of this map, however, could cause misunderstanding of the detail of mapping. If enlarged, the map does not show the small areas of contrasting soils that could have been shown at a larger scale.

Literature Citation

The correct citation for this survey is as follows:

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Cover Caption

A giant sequoia (*Sequoiadendron giganteum*) planted by John Muir during the 1890s, in map unit 455796 (Garretson loam, 0 to 2 percent slopes). Although far from its native habitat of the Sierra Nevada Mountains, this tree has thrived in the very deep Garretson soils. These alluvial soils formed in material deposited by Franklin Creek. If irrigated, areas of map unit 455796 are considered prime farmland.

Additional information about the Nation's natural resources is available online from the Natural Resources Conservation Service at http://www.nrcs.usda.gov/.

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Contents

Issued 2013

Preface

This soil survey was developed in conjunction with the National Park Service's Soil Inventory and Monitoring Program and is intended to serve as the official source document for soils occurring within John Muir National Historic Site.

This soil survey contains information that affects current and future land use planning in the park. It contains predictions of soil behavior for selected land uses. The survey highlights soil limitations, actions needed to overcome the limitations, and the impact of selected land uses on the environment. It is designed to meet the needs of the National Park Service and its partners to better understand the properties of the soils in the park and the effects of these soil properties on various natural ecological characteristics. This knowledge can help the National Park Service and its partners to understand, protect, and enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. The information in this report is intended to identify soil properties that are used in making various land use or land treatment decisions. Statements made in this report are intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are shallow to bedrock. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

These and many other soil properties that affect land use are described in this soil survey. The location of each map unit is shown on the detailed soil map. Each soil in the survey area is described, and information on specific uses is given. Help in using this publication and additional information are available at the local office of the Natural Resources Conservation Service or the park office for John Muir National Historic Site.

Soil Survey of
John Muir National Historic Site, California

United States Department of Agriculture, Natural Resources Conservation Service, and United States Department of the Interior, National Park Service

How This Survey Was Made

This survey was made by the Natural Resources Conservation Service (NRCS) in conjunction with the National Park Service's Soil Inventory and Monitoring Program to provide information about the soils and miscellaneous areas within John Muir National Historic Site.

The original county-based soil survey of Contra Costa County, California, was initiated in 1962 by the Soil Conservation Service (now NRCS). Correlation of the survey was completed in March 1973. Mapping was at a scale of 1:24,000. This work involved establishing new series for broadly defined components. The soil survey data was recertified by NRCS in March 2010. At the time this document was compiled, there were 6 map units used in the park with 29 different components. The soil survey of Contra Costa County has been designated by NRCS as needing update work.

The information in this report includes a description of the soils and miscellaneous areas and their location and a discussion of their suitability, limitations, and management for specified uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of native plants; and the kinds of bedrock. They dug many holes to study the soil profile, which is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

The soils and miscellaneous areas in the survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units).

Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they delineated the boundaries of these bodies on digital imagery and identified each as a specific map unit.

Detailed Soil Map Units

The map units delineated on the detailed soil map in this survey represent the soils or miscellaneous areas in the park. The map unit descriptions in this section, along with the map, can be used to determine the suitability and potential of a unit for specific uses. They also can be used to plan the management needed for those uses.

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. The contrasting components are mentioned in the map unit descriptions. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives the principal hazards and limitations to be considered in planning for specific uses.

Soils that have profiles that are almost alike make up a *soil series*. All the soils of a series have major horizons that are similar in composition, thickness, and arrangement. The soils of a given series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Botella clay loam, 0 to 2 percent slopes, is a phase of the Botella series.

Table 1 lists each map unit in the park, its major and minor components, and the percentage of each component in the unit. Other tables give properties of the soils and the limitations, capabilities, and potentials for many uses. The Glossary defines many of the terms used in describing the soils or miscellaneous areas.

455765—Botella clay loam, 0 to 2 percent slopes (fig. 1)

Map Unit Setting

Major land resource area (MLRA): 17—Sacramento and San Joaquin Valleys
Elevation: 295 to 695 feet
Mean annual precipitation: 15 to 25 inches
Mean annual air temperature: 59 degrees F
Frost-free period: 260 to 290 days

Map Unit Composition

Botella and similar soils: 85 percent
Dissimilar minor components: 15 percent

Description of Botella Soil

Taxonomic Classification
Fine-loamy, mixed, superactive, thermic Pachic Argixerolls

Setting
Landform: Flood plains and alluvial fans
Landform position (three-dimensional): Tread
Slope range: 0 to 2 percent
Down-slope shape: Linear
Across-slope shape: Linear
Representative aspect: Northeast
Aspect range: Southwest to east (clockwise)
Soil temperature class: Thermic
Soil temperature regime: Thermic
Soil moisture class: Xeric

Properties and Qualities
Runoff: Low
Parent material: Alluvium derived from sedimentary rock
Restrictive feature(s): None within a depth of 60 inches
Frequency of flooding: None
Frequency of ponding: None
Depth to water table: More than 72 inches
Drainage class: Moderately well drained
Shrink-swell potential: Moderate (about 4.5 LEP)
Salinity maximum: Not saline
Sodicity maximum: Not sodic
Calcium carbonate equivalent (maximum weight percentage): 0
Available water capacity: Very high (about 12.9 inches)

Interpretive Groups
Land capability subclass: Nonirrigated areas—4c; irrigated areas—1
Meets hydric soil criteria: No
Hydrologic soil group: B

Figure 1.—The Martinez Adobe, in John Muir National Historic Site, in an area of Botella clay loam, 0 to 2 percent slopes (map unit 455765). If irrigated, areas of this map unit are considered prime farmland. Most of the 2,600 acres farmed by John Muir in the Alhambra Valley were in areas similar to this map unit.

Typical Profile

0 to 3 inches; clay loam
3 to 68 inches; silty clay loam

Minor Components

Clear Lake soils

Percent of map unit: 3 percent
Landform: Depressions
Slope range: 0 to 2 percent
Meets hydric soil criteria: Yes

Conejo soils

Percent of map unit: 3 percent
Slope range: 0 to 2 percent
Meets hydric soil criteria: No

Garretson soils

Percent of map unit: 3 percent
Slope range: 0 to 2 percent
Meets hydric soil criteria: No

Unnamed soils

Percent of map unit: 3 percent
Slope range: 0 to 2 percent
Meets hydric soil criteria: No

Unnamed hydric soils
Percent of map unit: 3 percent
Landform: Depressions
Meets hydric soil criteria: Yes

455796—Garretson loam, 0 to 2 percent slopes

Map Unit Setting

Major land resource area (MLRA): 14—Central California Coastal Valleys
Elevation: 95 to 495 feet
Mean annual precipitation: 14 to 20 inches
Mean annual air temperature: 59 degrees F
Frost-free period: 250 to 300 days

Map Unit Composition

Garretson and similar soils: 85 percent
Dissimilar minor components: 15 percent

Description of Garretson Soil

Taxonomic Classification
Fine-loamy, mixed, nonacid, thermic Typic Xerorthents

Setting
Landform: Flood plains
Slope range: 0 to 2 percent
Down-slope shape: Linear
Across-slope shape: Linear
Representative aspect: Northeast
Aspect range: West to east (clockwise)
Soil temperature class: Thermic
Soil temperature regime: Thermic
Soil moisture class: Xeric

Properties and Qualities
Runoff: Low
Parent material: Alluvium derived from sedimentary rock
Restrictive feature(s): None within a depth of 60 inches
Frequency of flooding: None
Frequency of ponding: None
Depth to water table: More than 72 inches
Drainage class: Well drained
Shrink-swell potential: Low (about 1.5 LEP)
Salinity maximum: Not saline
Sodicity maximum: Not sodic
Calcium carbonate equivalent (maximum weight percentage): 0
Available water capacity: High (about 9.6 inches)

Interpretive Groups
Land capability subclass: Nonirrigated areas—4c; irrigated areas—1
Meets hydric soil criteria: No
Hydrologic soil group: B

Typical Profile
0 to 25 inches; loam
25 to 60 inches; loam

Minor Components

Conejo soils
Percent of map unit: 10 percent
Meets hydric soil criteria: No

Botella soils
Percent of map unit: 5 percent
Meets hydric soil criteria: No

455815—Los Gatos loam, 15 to 30 percent slopes

Map Unit Setting

Major land resource area (MLRA): 15—Central California Coast Range
Elevation: 495 to 2,000 feet
Mean annual precipitation: 18 to 25 inches
Mean annual air temperature: 55 degrees F
Frost-free period: 260 to 300 days

Map Unit Composition

Los Gatos and similar soils: 85 percent
Dissimilar minor components: 15 percent

Description of Los Gatos Soil

Taxonomic Classification
Fine-loamy, mixed, mesic Typic Argixerolls

Setting
Landform: North-facing upland slopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Slope range: 15 to 30 percent
Down-slope shape: Convex
Across-slope shape: Convex
Representative aspect: North
Aspect range: All aspects
Soil temperature class: Mesic
Soil temperature regime: Mesic
Soil moisture class: Xeric

Properties and Qualities
Runoff: High
Parent material: Residuum weathered from sedimentary rock
Restrictive feature(s): Lithic bedrock at a depth of 20 to 40 inches
Frequency of flooding: None
Frequency of ponding: None
Depth to water table: More than 72 inches
Drainage class: Well drained
Shrink-swell potential: Moderate (about 4.5 LEP)
Salinity maximum: Not saline
Sodicity maximum: Not sodic
Calcium carbonate equivalent (maximum weight percentage): 0
Available water capacity: Low (about 4.5 inches)

Interpretive Groups
Land capability subclass (nonirrigated and irrigated): 4e-1
Meets hydric soil criteria: No
Hydrologic soil group: C

Vegetation
Existing plants: California buckeye, sedge, California live oak, pea, soft chess, blue wildrye, wild oat, and American vetch

Typical Profile
0 to 8 inches; loam
8 to 27 inches; clay loam
27 to 30 inches; unweathered bedrock

Minor Components

Dibble soils
Percent of map unit: 5 percent
Meets hydric soil criteria: No

Los Osos soils
Percent of map unit: 5 percent
Meets hydric soil criteria: No

Millsholm soils
Percent of map unit: 5 percent
Meets hydric soil criteria: No

455816—Los Gatos loam, 30 to 50 percent slopes

Map Unit Setting

Major land resource area (MLRA): 15—Central California Coast Range
Elevation: 495 to 2,000 feet
Mean annual precipitation: 18 to 25 inches
Mean annual air temperature: 55 degrees F
Frost-free period: 260 to 300 days

Map Unit Composition

Los Gatos and similar soils: 85 percent
Dissimilar minor components: 14 percent

Description of Los Gatos Soil

Taxonomic Classification
Fine-loamy, mixed, mesic Typic Argixerolls

Setting
Landform: North-facing upland slopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Slope range: 30 to 50 percent
Down-slope shape: Convex
Across-slope shape: Convex
Representative aspect: North
Aspect range: All aspects
Soil temperature class: Mesic

Soil temperature regime: Mesic
Soil moisture class: Xeric

Properties and Qualities
Runoff: High
Parent material: Residuum weathered from sedimentary rock
Restrictive feature(s): Lithic bedrock at a depth of 20 to 40 inches
Frequency of flooding: None
Frequency of ponding: None
Depth to water table: More than 72 inches
Drainage class: Well drained
Shrink-swell potential: Moderate (about 4.5 LEP)
Salinity maximum: Not saline
Sodicity maximum: Not sodic
Calcium carbonate equivalent (maximum weight percentage): 0
Available water capacity: Low (about 4.5 inches)

Interpretive Groups
Land capability subclass (nonirrigated and irrigated): 6e
Meets hydric soil criteria: No
Hydrologic soil group: C

Vegetation
Existing plants: Blue wildrye, wild oat, California live oak, sedge, California buckeye, pea, soft chess, and American vetch

Typical Profile
0 to 8 inches; loam
8 to 27 inches; clay loam
27 to 30 inches; unweathered bedrock

Minor Components

Dibble soils
Percent of map unit: 4 percent
Meets hydric soil criteria: No

Los Osos soils
Percent of map unit: 4 percent
Meets hydric soil criteria: No

Millsholm soils
Percent of map unit: 4 percent
Meets hydric soil criteria: No

Vallecitos soils
Percent of map unit: 2 percent
Meets hydric soil criteria: No

455818—Los Osos clay loam, 15 to 30 percent slopes

Map Unit Setting

Major land resource area (MLRA): 15—Central California Coast Range
Elevation: 95 to 2,495 feet
Mean annual precipitation: 14 to 25 inches
Mean annual air temperature: 59 degrees F
Frost-free period: 260 to 300 days

Map Unit Composition

Los Osos and similar soils: 85 percent
Dissimilar minor components: 13 percent

Description of Los Osos Soil

Taxonomic Classification
Fine, smectitic, thermic Typic Argixerolls

Setting
Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Slope range: 15 to 30 percent
Down-slope shape: Convex
Across-slope shape: Convex
Representative aspect: North
Aspect range: All aspects
Soil temperature class: Thermic
Soil temperature regime: Thermic
Soil moisture class: Xeric

Properties and Qualities
Runoff: Very high
Parent material: Residuum weathered from sandstone and shale
Restrictive feature(s): Paralithic bedrock at a depth of 24 to 40 inches
Frequency of flooding: None
Frequency of ponding: None
Depth to water table: More than 72 inches
Drainage class: Well drained
Shrink-swell potential: High (about 7.5 LEP)
Salinity maximum: Not saline
Sodicity maximum: Not sodic
Calcium carbonate equivalent (maximum weight percentage): 0
Available water capacity: Low (about 5.1 inches)

Interpretive Groups
Land capability subclass (nonirrigated and irrigated): 4e-3
Meets hydric soil criteria: No
Hydrologic soil group: C

Vegetation
Existing plants: Purple tussockgrass, burclover, ripgut brome, miniature lupine, oak, clover, soft chess, stork's bill, wild oat, and blue oak

Typical Profile
0 to 10 inches; clay loam
10 to 32 inches; clay
32 to 36 inches; weathered bedrock

Minor Components

Alo soils
Percent of map unit: 5 percent
Meets hydric soil criteria: No

Lodo soils
Percent of map unit: 3 percent
Meets hydric soil criteria: No

Millsholm soils
Percent of map unit: 3 percent
Meets hydric soil criteria: No

Diablo soils
Percent of map unit: 1 percent
Meets hydric soil criteria: No

Tierra soils
Percent of map unit: 1 percent
Meets hydric soil criteria: No

455819—Los Osos clay loam, 30 to 50 percent slopes

Map Unit Setting

Major land resource area (MLRA): 15—Central California Coast Range
Elevation: 95 to 2,495 feet
Mean annual precipitation: 14 to 25 inches
Mean annual air temperature: 59 degrees F
Frost-free period: 260 to 300 days

Map Unit Composition

Los Osos and similar soils: 85 percent
Dissimilar minor components: 15 percent

Description of Los Osos Soil

Taxonomic Classification
Fine, smectitic, thermic Typic Argixerolls

Setting
Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Slope range: 30 to 50 percent
Down-slope shape: Convex
Across-slope shape: Convex
Representative aspect: North
Aspect range: All aspects
Soil temperature class: Thermic
Soil temperature regime: Thermic
Soil moisture class: Xeric

Properties and Qualities
Runoff: Very high
Parent material: Residuum weathered from sandstone and shale
Restrictive feature(s): Paralithic bedrock at a depth of 24 to 40 inches
Frequency of flooding: None
Frequency of ponding: None
Depth to water table: More than 72 inches
Drainage class: Well drained
Shrink-swell potential: High (about 7.5 LEP)
Salinity maximum: Not saline
Sodicity maximum: Not sodic
Calcium carbonate equivalent (maximum weight percentage): 0
Available water capacity: Low (about 5.1 inches)

Interpretive Groups
Land capability subclass (nonirrigated and irrigated): 6e
Meets hydric soil criteria: No
Hydrologic soil group: C

Vegetation
Existing plants: Clover, blue oak, stork's bill, wild oat, ripgut brome, purple tussockgrass, burclover, soft chess, miniature lupine, and oak

Typical Profile
0 to 10 inches; clay loam
10 to 32 inches; clay
32 to 36 inches; weathered bedrock

Minor Components

Alo soils
Percent of map unit: 5 percent
Meets hydric soil criteria: No

Unnamed soil slips
Percent of map unit: 5 percent
Meets hydric soil criteria: No

Lodo soils
Percent of map unit: 3 percent
Meets hydric soil criteria: No

Millsholm soils
Percent of map unit: 2 percent
Meets hydric soil criteria: No

Use and Management of the Soils

This soil survey is an inventory and evaluation of the soils in John Muir National Historic Site. It can be used to adjust land uses to the limitations and potentials of natural resources and the environment. Also, it can help to prevent soil-related failures in land uses.

In preparing a soil survey, soil scientists, conservationists, engineers, and others collect extensive field data about the nature and behavioral characteristics of the soils. They collect data on erosion, droughtiness, flooding, and other factors that affect various soil uses and management. Field experience and collected data on soil properties and performance are used as a basis in predicting soil behavior.

Information in this section can be used to plan the use and management of soils as rangeland and as sites for buildings, sanitary facilities, highways and other transportation systems, and recreational facilities. It can be used to identify the potentials and limitations of each soil for specific land uses and to help prevent construction failures caused by unfavorable soil properties.

Planners and others using soil survey information can evaluate the effect of specific land uses on productivity and on the environment in all or part of the park. The survey can help planners to maintain or create a land use pattern in harmony with the natural soil.

Contractors can use this survey to locate sources of sand and gravel, roadfill, and topsoil. They can use it to identify areas where bedrock, wetness, or very firm soil layers can cause difficulty in excavation.

Health officials, highway officials, engineers, and others may also find this survey useful. The survey can help them plan the safe disposal of wastes and locate sites for pavements, sidewalks, campgrounds, playgrounds, and trees and shrubs.

Interpretive Ratings

The interpretive tables in this survey rate the soils in the park for various uses. Many of the tables identify the limitations that affect specified uses and indicate the severity of those limitations. The ratings in these tables are both verbal and numerical.

Rating Class Terms

Rating classes are expressed in the tables in terms that indicate the extent to which the soils are limited by all of the soil features that affect a specified use or in terms that indicate the suitability of the soils for the use. Thus, the tables may show limitation classes or suitability classes. Terms for the limitation classes are *not limited, slightly limited, somewhat limited,* and *very limited*. The suitability ratings are expressed as *well suited, moderately well suited, poorly suited,* and *unsuited* or as *good, fair,* and *poor*.

Numerical Ratings

Numerical ratings in the tables indicate the relative severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.00 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use and the point at which the soil feature is not a limitation. The limitations appear in order from the most limiting to the least limiting. Thus, if more than one limitation is identified, the most severe limitation is listed first and the least severe one is listed last.

Land Capability Classification

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The criteria used in grouping the soils do not include major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor do they include possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, for forestland, or for engineering purposes.

In the capability system, soils are generally grouped at three levels—capability class, subclass, and unit (USDA-SCS, 1961).

Capability classes, the broadest groups, are designated by the numbers 1 through 8. The numbers indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class 1 soils have slight limitations that restrict their use.

Class 2 soils have moderate limitations that restrict the choice of plants or that require moderate conservation practices.

Class 3 soils have severe limitations that restrict the choice of plants or that require special conservation practices, or both.

Class 4 soils have very severe limitations that restrict the choice of plants or that require very careful management, or both.

Class 5 soils are subject to little or no erosion but have other limitations, impractical to remove, that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.

Class 6 soils have severe limitations that make them generally unsuitable for cultivation and that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.

Class 7 soils have very severe limitations that make them unsuitable for cultivation and that restrict their use mainly to grazing, forestland, or wildlife habitat.

Class 8 soils and miscellaneous areas have limitations that preclude commercial plant production and that restrict their use to recreational purposes, wildlife habitat, watershed, or esthetic purposes.

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e, w, s,* or *c,* to the class numeral, for example, 2e. The letter *e* shows that the main hazard is the risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c,* used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry.

In class 1 there are no subclasses because the soils of this class have few limitations. Class 5 contains only the subclasses indicated by *w, s,* or *c* because the soils in class 5 are subject to little or no erosion. They have other limitations that restrict their use to pasture, rangeland, forestland, wildlife habitat, or recreation.

Capability units are soil groups within a subclass. The soils in a capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, 2e-4. These units are not given in all soil surveys.

The capability classification of map units in this park is given in the section “Detailed Soil Map Units” and in table 2.

Prime and Other Important Farmland

Table 3 lists the map units in the park that are considered important farmlands. Important farmlands consist of prime farmland, unique farmland, and farmland of statewide or local importance. This list does not constitute a recommendation for a particular land use.

In an effort to identify the extent and location of important farmlands, the Natural Resources Conservation Service, in cooperation with other interested Federal, State, and local government organizations, has inventoried land that can be used for the production of the Nation’s food supply.

Prime farmland is of major importance in meeting the Nation’s short- and long-range needs for food and fiber. Because the supply of high-quality farmland is limited, the U.S. Department of Agriculture recognizes that responsible levels of government, as well as individuals, should encourage and facilitate the wise use of our Nation’s prime farmland.

Prime farmland, as defined by the U.S. Department of Agriculture, is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is available for these uses. It could be cultivated land, pastureland, forestland, or other land, but it is not urban or built-up land or water areas. The soil quality, growing season, and moisture supply are those needed for the soil to economically produce sustained high yields of crops when proper management, including water management, and acceptable farming methods are applied. In general, prime farmland has an adequate and dependable supply of moisture from precipitation or irrigation, a favorable temperature and growing season, acceptable acidity or alkalinity, an acceptable salt and sodium content, and few or no rocks. The water supply is dependable and of adequate quality. Prime farmland is permeable to water and air. It is not excessively erodible or saturated with water for long periods, and it either is not frequently flooded during the growing season or is protected from flooding. Slope ranges mainly from 0 to 6 percent. More detailed information about the criteria for prime farmland is available at the local office of the Natural Resources Conservation Service.

For some of the soils identified in the table as prime farmland, measures that overcome a hazard or limitation, such as flooding, wetness, and droughtiness, are needed. Onsite evaluation is needed to determine whether or not the hazard or limitation has been overcome by corrective measures.

A recent trend in land use in some areas has been the loss of some prime farmland to industrial and urban uses. The loss of prime farmland to other uses puts pressure on marginal lands, which generally are more erodible, droughty, and less productive and cannot be easily cultivated.

Unique farmland is land other than prime farmland that is used for the production of specific high-value food and fiber crops, such as citrus, tree nuts, olives, cranberries, and other fruits and vegetables. It has the special combination of soil quality, growing season, moisture supply, temperature, humidity, air drainage, elevation, and aspect needed for the soil to economically produce sustainable high yields of these crops when properly managed. The water supply is dependable and of adequate quality. Nearness to markets is an additional consideration. Unique farmland is not based on national criteria. It commonly is in areas where there is a special microclimate, such as the wine country in California.

In some areas, land that does not meet the criteria for prime or unique farmland is considered to be *farmland of statewide importance* for the production of food, feed, fiber, forage, and oilseed crops. The criteria for defining and delineating farmland of statewide importance are determined by the appropriate State agencies. Generally, this land includes areas of soils that nearly meet the requirements for prime farmland and that economically produce high yields of crops when treated and managed according to acceptable farming methods. Some areas may produce as high a yield as prime farmland if conditions are favorable. Farmland of statewide importance may include tracts of land that have been designated for agriculture by State law.

In some areas that are not identified as having national or statewide importance, land is considered to be *farmland of local importance* for the production of food, feed, fiber, forage, and oilseed crops. This farmland is identified by the appropriate local agencies. Farmland of local importance may include tracts of land that have been designated for agriculture by local ordinance.

Hydric Soils

Table 4 lists the map unit components that are rated as hydric soils in the park. This list can help in planning land uses; however, onsite investigation is recommended to determine the hydric soils on a specific site (National Research Council, 1995; USDA-NRCS, 2010).

The three essential characteristics of wetlands are hydrophytic vegetation, hydric soils, and wetland hydrology (Cowardin and others, 1979; U.S. Army Corps of Engineers, 1987; National Research Council, 1995; Tiner, 1985). Criteria for all of the characteristics must be met for areas to be identified as wetlands. Undrained hydric soils that have natural vegetation should support a dominant population of ecological wetland plant species. Hydric soils that have been converted to other uses should be capable of being restored to wetlands.

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, 1994). These soils, under natural conditions, are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation.

The NTCHS definition identifies general soil properties that are associated with wetness. In order to determine whether a specific soil is a hydric soil or nonhydric soil, however, more specific information, such as information about the depth and duration of the water table, is needed. Thus, criteria that identify those estimated soil properties unique to hydric soils have been established (Federal Register, 2002). These criteria are used to identify map unit components that normally are associated with wetlands. The criteria used are selected estimated soil properties that are described in “Soil Taxonomy” (Soil Survey Staff, 1999) and “Keys to Soil Taxonomy” (Soil Survey Staff, 2010) and in the “Soil Survey Manual” (Soil Survey Division Staff, 1993).

If soils are wet enough for a long enough period of time to be considered hydric, they should exhibit certain properties that can be easily observed in the field. These visible properties are indicators of hydric soils. The indicators used to make onsite determinations of hydric soils are specified in “Field Indicators of Hydric Soils in the United States” (USDA-NRCS, 2010).

Hydric soils are identified by examining and describing the soil to a depth of about 20 inches. This depth may be greater if determination of an appropriate indicator so requires. It is always recommended that soils be excavated and described to the depth necessary for an understanding of the redoximorphic processes. Then, using the completed soil descriptions, soil scientists can compare the soil features required by each indicator and specify which indicators have been matched with the conditions observed in the soil. The soil can be identified as a hydric soil if at least one of the approved indicators is present.

Map units that are dominantly made up of hydric soils may have small areas, or inclusions, of nonhydric soils in the higher positions on the landform, and map units dominantly made up of nonhydric soils may have inclusions of hydric soils in the lower positions on the landform.

The criteria for hydric soils are represented by codes in the table (for example, 2B3). Definitions for the codes are as follows:

1. All Histels except for Folistels and Histosols except for Folists.
2. Soils in Aquic suborders, great groups, or subgroups, Albolls suborder, Historthels great group, Histoturbels great group, Pachic subgroups, or Cumulic subgroups that:
    - A. are somewhat poorly drained and have a water table at the surface (0.0 feet) during the growing season, or
    - B. are poorly drained or very poorly drained and have either:
        - 1) a water table at the surface (0.0 feet) during the growing season if textures are coarse sand, sand, or fine sand in all layers within a depth of 20 inches, or
        - 2) a water table at a depth of 0.5 foot or less during the growing season if saturated hydraulic conductivity (K_{sat}) is equal to or greater than 6.0 in/hr in all layers within a depth of 20 inches, or
        - 3) a water table at a depth of 1.0 foot or less during the growing season if saturated hydraulic conductivity (K_{sat}) is less than 6.0 in/hr in any layer within a depth of 20 inches.
3. Soils that are frequently ponded for periods of long or very long duration during the growing season.
4. Soils that are frequently flooded for periods of long or very long duration during the growing season.

Land Management

In table 5, parts I through IV, interpretive ratings are given for various aspects of land management. The ratings are both verbal and numerical.

Some rating class terms indicate the degree to which the soils are suited to a specified land management practice. *Well suited* indicates that the soil has features that are favorable for the specified practice and has no limitations. Good performance can be expected, and little or no maintenance is needed. *Moderately suited* indicates that the soil has features that are moderately favorable for the specified practice. One or more soil properties are less than desirable, and fair performance can be expected. Some maintenance is needed. *Poorly suited* indicates that the soil has one or more properties that are unfavorable for the specified practice. Overcoming the unfavorable properties requires special design, extra maintenance, and costly alteration. *Unsuited* indicates that the expected performance of the soil is unacceptable for the specified practice or that extreme measures are needed to overcome the undesirable soil properties.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the specified land management practice (1.00) and the point at which the soil feature is not a limitation (0.00).

Rating class terms for *fire damage* and *seedling mortality* are expressed as low, moderate, and high. Where these terms are used, the numerical ratings indicate gradations between the point at which the potential for fire damage or seedling mortality is highest (1.00) and the point at which the potential is lowest (0.00).

Rating class terms for *hazard of erosion* are expressed as slight, moderate, severe, and very severe. Where these terms are used, the numerical ratings indicate gradations between the point at which the potential for erosion is highest (1.00) and the point at which the potential is lowest (0.00).

The paragraphs that follow indicate the soil properties considered in rating the soils for land management practices.

Ratings in the columns *suitability for hand planting* and *suitability for mechanical planting* are based on slope, depth to a restrictive layer, content of sand, plasticity index, rock fragments on or below the surface, depth to a water table, and ponding. The soils are described as well suited, moderately suited, poorly suited, or unsuited to these methods of planting. It is assumed that necessary site preparation is completed before seedlings are planted.

Ratings in the column *soil rutting hazard* are based on depth to a water table, rock fragments on or below the surface, the Unified classification, depth to a restrictive layer, and slope. Ruts form as a result of the operation of planting equipment. The hazard is described as slight, moderate, or severe. A rating of *slight* indicates that the soil is subject to little or no rutting, *moderate* indicates that rutting is likely, and *severe* indicates that ruts form readily.

Ratings in the column *hazard of erosion* are based on slope and on soil erodibility factor K. The soil loss is caused by sheet or rill erosion in areas where 50 to 75 percent of the surface has been exposed by different kinds of disturbance. The hazard is described as slight, moderate, severe, or very severe. A rating of *slight* indicates that erosion is unlikely under ordinary climatic conditions; *moderate* indicates that some erosion is likely and that erosion-control measures may be needed; *severe* indicates that erosion is very likely and that erosion-control measures, including revegetation of bare areas, are advised; and *very severe* indicates that significant erosion is expected, loss of soil productivity and off-site damage are likely, and erosion-control measures are costly and generally impractical.

Ratings in the column *hazard of erosion on roads and trails* are based on the soil erodibility factor K, slope, and content of rock fragments. The ratings apply to unsurfaced roads and trails. The hazard is described as slight, moderate, or severe. A rating of *slight* indicates that little or no erosion is likely; *moderate* indicates that some erosion is likely, that the roads or trails may require occasional maintenance, and that simple erosion-control measures are needed; and *severe* indicates that significant erosion is expected, that the roads or trails require frequent maintenance, and that costly erosion-control measures are needed.

Ratings in the column *suitability for roads (natural surface)* are based on slope, rock fragments on the surface, plasticity index, content of sand, the Unified classification, depth to a water table, ponding, flooding, and the hazard of soil slippage. The ratings indicate the suitability for using the natural surface of the soil for roads. The soils are described as well suited, moderately suited, or poorly suited to this use.

Ratings in the column *suitability for mechanical site preparation (deep)* are based on slope, depth to a restrictive layer, rock fragments on or below the surface, depth to a water table, and ponding. The soils are described as well suited, poorly suited, or unsuited to this management activity. The part of the soil from the surface to a depth of about 3 feet is considered in the ratings.

Ratings in the column *suitability for mechanical site preparation (surface)* are based on slope, depth to a restrictive layer, plasticity index, rock fragments on or below the surface, depth to a water table, and ponding. The soils are described as well suited, poorly suited, or unsuited to this management activity. The part of the soil from the surface to a depth of about 1 foot is considered in the ratings.

Ratings in the column *potential for damage to soil by fire* are based on texture of the surface layer, content of rock fragments and organic matter in the surface layer, thickness of the surface layer, and slope. The soils are described as having a low, moderate, or high potential for this kind of damage. The ratings indicate an evaluation of the potential impact of prescribed fires or wildfires that are intense enough to remove the duff layer and consume organic matter in the surface layer.

Ratings in the column *potential for seedling mortality* are based on flooding, ponding, depth to a water table, content of lime, reaction, salinity, available water capacity, soil moisture regime, soil temperature regime, aspect, and slope. The soils are described as having a low, moderate, or high potential for seedling mortality.

Recreation

The soils of the park are rated in table 6, parts I and II, according to limitations that affect their suitability for recreation. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the recreational uses. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The ratings in the table are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites, and access to public sewer lines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation also are important. Soils that are subject to flooding are limited for recreational uses by the duration and intensity of flooding and the season when flooding occurs. In planning recreational facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential.

The information in table 6 can be supplemented by other information in this survey, for example, interpretations for building site development, construction materials, and water management.

Camp areas require site preparation, such as shaping and leveling the tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The ratings are based on the soil properties that affect the ease of developing camp areas and the performance of the areas after development. Slope, stoniness, and depth to bedrock or a cemented pan are the main concerns affecting the development of camp areas. The soil properties that affect the performance of the areas after development are those that influence trafficability and promote the growth of vegetation, especially in heavily used areas. For good trafficability, the surface of camp areas should absorb rainfall readily, remain firm under heavy foot traffic, and not be dusty when dry. The soil properties that influence trafficability are texture of the surface layer, depth to a water table, ponding, flooding, permeability, and large stones. The soil properties that affect the growth of plants are depth to bedrock or a cemented pan, permeability, and toxic substances in the soil.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The ratings are based on the soil properties that affect the ease of developing picnic areas and that influence trafficability and the growth of vegetation after development. Slope and stoniness are the main concerns affecting the development of picnic areas. For good trafficability, the surface of picnic areas should absorb rainfall readily, remain firm under heavy foot traffic, and not be dusty when dry. The soil properties that influence trafficability are texture of the surface layer, depth to a water table, ponding, flooding, permeability, and large stones. The soil properties that affect the growth of plants are depth to bedrock or a cemented pan, permeability, and toxic substances in the soil.

Foot traffic and equestrian trails for hiking and horseback riding should require little or no slope modification through cutting and filling. The ratings are based on the soil properties that affect trafficability and erodibility. These properties are stoniness, depth to a water table, ponding, flooding, slope, and texture of the surface layer.

Mountain bike and off-road vehicle trails require little or no site preparation. They are not covered with surfacing material or vegetation. Considerable compaction of the soil material is likely. The ratings are based on the soil properties that influence erodibility, trafficability, dustiness, and the ease of revegetation. These properties are stoniness, depth to a water table, ponding, slope, flooding, and texture of the surface layer.

Engineering

This section provides information for planning land uses related to urban development and to water management. Soils are rated for various uses, and the most limiting features are identified. Ratings are given for building site development, landscaping, sanitary facilities, construction materials, and water management. The ratings are based on observed performance of the soils and on the estimated data and test data in the “Soil Properties” section.

Information in this section is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil between the surface and a depth of 5 to 7 feet. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this section. Local ordinances and regulations should be considered in planning, in site selection, and in design.

Soil properties, site features, and observed performance were considered in determining the ratings in this section. During the fieldwork for this soil survey, determinations were made about particle-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock within 5 to 7 feet of the surface, soil wetness, depth to a water table, ponding, slope, likelihood of flooding, natural soil structure aggregation, and soil density. Data were collected about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kinds of adsorbed cations. Estimates were made for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, and other behavioral characteristics affecting engineering uses.

This information can be used to evaluate the potential of areas for residential, commercial, and recreational uses; make preliminary estimates of construction conditions; evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; evaluate alternative sites for septic tank absorption fields and sewage lagoons; plan detailed onsite investigations of soils and geology; locate potential sources of gravel, sand, earthfill, and topsoil; plan drainage systems, ponds, and other structures for soil and water conservation; and predict performance of proposed small structures and pavements by comparing the performance of existing similar structures on the same or similar soils.

The information in the tables, along with the soil map, the soil descriptions, and other data provided in this survey, can be used to make additional interpretations.

Some of the terms used in this soil survey have a special meaning in soil science and are defined in the Glossary.

Dwellings and Small Commercial Buildings

Soil properties influence the development of building sites, including the selection of the site, the design of the structure, construction, performance after construction, and maintenance. Table 7 shows the degree and kind of soil limitations that affect dwellings and small commercial buildings.

The ratings in the table are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect building site development. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Dwellings are single-family houses of three stories or less. For dwellings without basements, the foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of 2 feet or at the depth of maximum frost penetration, whichever is deeper. For dwellings with basements, the foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of about 7 feet. The ratings for dwellings are based on the soil properties that affect the capacity of the soil to support a load without movement and on the properties that affect excavation and construction costs. The properties that affect the load-supporting capacity include depth to a water table, ponding, flooding, subsidence, linear extensibility (shrink-swell potential), and compressibility. Compressibility is inferred from the Unified classification. The properties that affect the ease and amount of excavation include depth to a water table, ponding, flooding, slope, depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, and the amount and size of rock fragments.

Small commercial buildings are structures that are less than three stories high and do not have basements. The foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of 2 feet or at the depth of maximum frost penetration, whichever is deeper. The ratings are based on the soil properties that affect the capacity of the soil to support a load without movement and on the properties that affect excavation and construction costs. The properties that affect the load-supporting capacity include depth to a water table, ponding, flooding, subsidence, linear extensibility (shrink-swell potential), and compressibility (which is inferred from the Unified classification). The properties that affect the ease and amount of excavation include flooding, depth to a water table, ponding, slope, depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, and the amount and size of rock fragments.

Roads and Streets, Shallow Excavations, and Landscaping

Soil properties influence the development of building sites, including the selection of the site, the design of the structure, construction, performance after construction, and maintenance. Table 8 shows the degree and kind of soil limitations that affect local roads and streets, shallow excavations, and landscaping.

The ratings in the table are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect building site development. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material; a base of gravel, crushed rock, or soil material stabilized by lime or cement; and a surface of flexible material (asphalt), rigid material (concrete), or gravel with a binder. The ratings are based on the soil properties that affect the ease of excavation and grading and the traffic-supporting capacity. The properties that affect the ease of excavation and grading are depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, depth to a water table, ponding, flooding, the amount of large stones, and slope. The properties that affect the traffic-supporting capacity are soil strength (as inferred from the AASHTO group index number), subsidence, linear extensibility (shrink-swell potential), the potential for frost action, depth to a water table, and ponding.

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for graves, utility lines, open ditches, or other purposes. The ratings are based on the soil properties that influence the ease of digging and the resistance to sloughing. Depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, the amount of large stones, and dense layers influence the ease of digging, filling, and compacting. Depth to the seasonal high water table, flooding, and ponding may restrict the period when excavations can be made. Slope influences the ease of using machinery. Soil texture, depth to the water table, and linear extensibility (shrink-swell potential) influence the resistance to sloughing.

Landscaping requires soils on which turf, trees, and shrubs can be established and maintained. Irrigation is not considered in the ratings. The ratings are based on the soil properties that affect plant growth and trafficability after vegetation is established. The properties that affect plant growth are reaction; depth to a water table; ponding; depth to bedrock or a cemented pan; the available water capacity in the upper 40 inches; the content of salts, sodium, or calcium carbonate; and sulfidic materials. The properties that affect trafficability are flooding, depth to a water table, ponding, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer.

Sewage Disposal

Table 9 shows the degree and kind of soil limitations that affect septic tank absorption fields and sewage lagoons. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect these uses. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 24 and 72 inches or between a depth of 24 inches and a restrictive layer is evaluated. The ratings are based on the soil properties that affect absorption of the effluent, construction and maintenance of the system, and public health. Saturated hydraulic conductivity (K_{sat}), depth to a water table, ponding, depth to bedrock or a cemented pan, and flooding affect absorption of the effluent. Stones and boulders, ice, and bedrock or a cemented pan interfere with installation. Subsidence interferes with installation and maintenance. Excessive slope may cause lateral seepage and surfacing of the effluent in downslope areas.

Some soils are underlain by loose sand and gravel or fractured bedrock at a depth of less than 4 feet below the distribution lines. In these soils the absorption field may not adequately filter the effluent, particularly when the system is new. As a result, the ground water may become contaminated.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons should have a nearly level floor surrounded by cut slopes or embankments of compacted soil. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water. Considered in the ratings are slope, saturated hydraulic conductivity (K_{sat}), depth to a water table, ponding, depth to bedrock or a cemented pan, flooding, large stones, and content of organic matter.

Saturated hydraulic conductivity (K_{sat}) is a critical property affecting the suitability for sewage lagoons. Most porous soils eventually become sealed when they are used as sites for sewage lagoons. Until sealing occurs, however, the hazard of pollution is severe. Soils that have a K_{sat} rate of more than 14 micrometers per second are too porous for the proper functioning of sewage lagoons. In these soils, seepage of the effluent can result in contamination of the ground water. Ground-water contamination is also a hazard if fractured bedrock is within a depth of 40 inches, if the water table is high enough to raise the level of sewage in the lagoon, or if floodwater overtops the lagoon.

A high content of organic matter is detrimental to proper functioning of the lagoon because it inhibits aerobic activity. Slope, bedrock, and cemented pans can cause construction problems, and large stones can hinder compaction of the lagoon floor. If the lagoon is to be uniformly deep throughout, the slope must be gentle enough and the soil material must be thick enough over bedrock or a cemented pan to make land smoothing practical.

Source of Gravel and Sand

Table 10 gives information about the soils as potential sources of gravel and sand. Normal compaction, minor processing, and other standard construction practices are assumed.

Gravel and sand are natural aggregates suitable for commercial use with a minimum of processing. They are used in many kinds of construction. Specifications for each use vary widely. Only the likelihood of finding material in suitable quantity is evaluated. The suitability of the material for specific purposes is not evaluated, nor are factors that affect excavation of the material. The properties used to evaluate the soil as a source of sand or gravel are gradation of grain sizes (as indicated by the Unified classification of the soil), the thickness of suitable material, and the content of rock fragments. If the bottom layer of the soil contains sand or gravel, the soil is considered a likely source regardless of thickness. The assumption is that the sand or gravel layer below the depth of observation exceeds the minimum thickness. The ratings are for the whole soil, from the surface to a depth of about 6 feet.

The soils are rated *good, fair,* or *poor* as potential sources of sand and gravel. A rating of *good* or *fair* means that the source material is likely to be in or below the soil. The bottom layer and the thickest layer of the soils are assigned numerical ratings. These ratings indicate the likelihood that the layer is a source of sand or gravel. The number 0.00 indicates that the layer is a poor source. The number 1.00 indicates that the layer is a good source. A number between 0.00 and 1.00 indicates the degree to which the layer is a likely source.

Source of Reclamation Material, Roadfill, and Topsoil

Table 11 gives information about the soils as potential sources of reclamation material, roadfill, and topsoil. Normal compaction, minor processing, and other standard construction practices are assumed.

The soils are rated *good, fair,* or *poor* as potential sources of reclamation material, roadfill, and topsoil. The features that limit the soils as sources of these materials are specified in the table. Numerical ratings between 0.00 and 0.99 are given after the specified features. These numbers indicate the degree to which the features limit the soils as sources of topsoil, reclamation material, or roadfill. The lower the number, the greater the limitation.

Reclamation material is used in areas that have been drastically disturbed by surface mining or similar activities. When these areas are reclaimed, layers of soil material or unconsolidated geological material, or both, are replaced in a vertical sequence. The reconstructed soil favors plant growth. The ratings in the table do not apply to quarries and other mined areas that require an offsite source of reconstruction material. The ratings are based on the soil properties that affect erosion and stability of the surface and the productive potential of the reconstructed soil. These properties include the content of sodium, salts, and calcium carbonate; reaction; available water capacity; erodibility; texture; content of rock fragments; and content of organic matter and other features that affect fertility.

Roadfill is soil material that is excavated in one place and used in road embankments in another place. In this table, the soils are rated as a source of roadfill for low embankments, generally less than 6 feet high and less exacting in design than higher embankments. The ratings are for the whole soil, from the surface to a depth of about 5 feet. It is assumed that soil layers will be mixed when the soil material is excavated and spread.

The ratings are based on the amount of suitable material and on soil properties that affect the ease of excavation and the performance of the material after it is in place. The thickness of the suitable material is a major consideration. The ease of excavation is affected by large stones, depth to a water table, and slope. How well the soil performs in place after it has been compacted and drained is determined by its strength (as inferred from the AASHTO classification of the soil) and linear extensibility (shrink-swell potential).

Topsoil is used to cover an area so that vegetation can be established and maintained. The upper 40 inches of a soil is evaluated for use as topsoil. Also evaluated is the reclamation potential of the borrow area. The ratings are based on the soil properties that affect plant growth; the ease of excavating, loading, and spreading the material; and reclamation of the borrow area. Toxic substances, soil reaction, and the properties that are inferred from soil texture, such as available water capacity and fertility, affect plant growth. The ease of excavating, loading, and spreading is affected by rock fragments, slope, depth to a water table, soil texture, and thickness of suitable material. Reclamation of the borrow area is affected by slope, depth to a water table, rock fragments, depth to bedrock or a cemented pan, and toxic material.

The surface layer of most soils is generally preferred for topsoil because of its organic matter content. Organic matter greatly increases the absorption and retention of moisture and nutrients for plant growth.

Ponds and Embankments

Table 12 gives information on the soil properties and site features that affect water management. The degree and kind of soil limitations are given for pond reservoir areas; embankments, dikes, and levees; and aquifer-fed excavated ponds. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect these uses. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 60 inches. The seepage potential is determined by the saturated hydraulic conductivity (K_{sat}) of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

Embankments, dikes, and levees are raised structures of soil material, generally less than 20 feet high, constructed to impound water or to protect land against overflow. Embankments that have zoned construction (core and shell) are not considered. In this table, the soils are rated as a source of material for embankment fill. The ratings apply to the soil material below the surface layer to a depth of 5 or 6 feet. It is assumed that soil layers will be uniformly mixed and compacted during construction.

The ratings do not indicate the ability of the natural soil to support an embankment. Soil properties to a depth even greater than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties.

Soil material in embankments must be resistant to seepage, piping, and erosion and have favorable compaction characteristics. Unfavorable features include less than 5 feet of suitable material and a high content of stones or boulders, organic matter, or salts or sodium. A high water table affects the amount of usable material. It also affects trafficability.

Aquifer-fed excavated ponds are pits or dugouts that extend to a ground-water aquifer or to a depth below a permanent water table. Excluded are ponds that are fed only by surface runoff and embankment ponds that impound water 3 feet or more above the original surface. Excavated ponds are affected by depth to a permanent water table, K_{sat} of the aquifer, and quality of the water as inferred from the salinity of the soil. Depth to bedrock and the content of large stones affect the ease of excavation.

Soil Properties

Data relating to soil properties are collected during the course of the soil survey.

Soil properties are ascertained by field examination of the soils and by laboratory index testing of some benchmark soils. Established standard procedures are followed. During the survey, many shallow borings are made and examined to identify and classify the soils and to delineate them on the soil maps. Samples are taken from some typical profiles and tested in the laboratory to determine particle-size distribution, plasticity, and compaction characteristics.

Estimates of soil properties are based on field examinations, on laboratory tests of samples from the survey area, and on laboratory tests of samples of similar soils in nearby areas. Tests verify field observations, verify properties that cannot be estimated accurately by field observation, and help to characterize key soils.

The estimates of soil properties are shown in tables. They include engineering properties, physical and chemical properties, and pertinent soil and water features.

Engineering Properties

Table 13 gives the engineering classifications and the range of engineering properties for the layers of each soil in the park.

Depth to the upper and lower boundaries of each layer is indicated.

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, "gravelly."

Classification of the soils is determined according to the Unified soil classification system (ASTM, 2005) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 2004).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to particle-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Rock fragments larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

Physical Soil Properties

Table 14 shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the park. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (K_{sat}), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at $^{1}/_{3}$- or $^{1}/_{10}$-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In table 14, the estimated moist bulk density of each soil horizon is expressed in grams per cubic centimeter of soil material that is less than

2 millimeters in diameter. Bulk density data are used to compute linear extensibility, shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. Depending on soil texture, a bulk density of more than 1.4 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Permeability (K_{sat}) refers to the ability of a soil to transmit water or air. The term "permeability," as used in soil surveys, indicates saturated hydraulic conductivity (K_{sat}). The estimates in the table indicate the rate of water movement, in inches per hour, when the soil is saturated. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Permeability is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Shrink-swell potential is the potential for volume change in a soil with a loss or gain in moisture. Volume change occurs mainly because of the interaction of clay minerals with water and varies with the amount and type of clay minerals in the soil. The size of the load on the soil and the magnitude of the change in soil moisture content influence the amount of swelling of soils in place. Laboratory measurements of swelling of undisturbed clods were made for many soils. For others, swelling was estimated on the basis of the kind and amount of clay minerals in the soil and on the basis of measurements of similar soils.

If the shrink-swell potential is rated moderate to very high, shrinking and swelling can cause damage to buildings, roads, and other structures. Special design is often needed.

Shrink-swell potential classes are based on the change in length of an unconfined clod as moisture content is increased from air-dry to field capacity. The classes are *low,* a change of less than 3 percent; *moderate,* 3 to 6 percent; *high,* 6 to 9 percent; and *very high,* greater than 9 percent.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In table 14, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of organic matter in a soil can be maintained by returning crop residue to the soil. Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms.

Erosion Properties

Table 15 shows estimates of some erosion factors that affect a soil's potential for different uses. These estimates are given for each layer of every soil for K factors and are given as one rating for the entire soil for the T factor, the wind erodibility group, and the wind erodibility index. Values are reported for each soil in the park. Estimates are based on field observations and on test data for these and similar soils.

Erosion factors are shown in the table as the K factor (Kw and Kf) and the T factor. Soil erosion factors Kw and Kf quantify soil detachment by runoff and raindrop impact. These erosion factors are indexes used to predict the long-term average soil loss from sheet and rill erosion under crop systems and conservation techniques. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and K_{sat}. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

The procedure for determining the Kf factor is outlined in Agriculture Handbook 703, “Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE),” USDA, Agricultural Research Service, 1997.

Depth to the upper and lower boundaries of each layer is indicated.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments. In horizons where total rock fragments are 15 percent or more, by volume, the Kw factor is always less than the Kf factor.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size. Soil horizons that do not have rock fragments are assigned equal Kw and Kf factors.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are described in the “National Soil Survey Handbook.”

Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Total Soil Carbon

Table 16 gives estimates of total soil carbon. Soil carbon occurs as organic and inorganic carbon.

Soil organic carbon (SOC) is carbon (C) in soil that originated from a biological source, such as plants, animals, or micro-organisms. SOC is found in both organic and mineral soil layers. The term “soil organic carbon” refers only to the carbon occurring in soil organic matter (SOM). Soil organic carbon makes up about one-half the weight of soil organic matter. The rest of SOM is mostly oxygen, nitrogen, and hydrogen.

Soil inorganic carbon (SIC) is carbon found in soil carbonates, typically as calcium carbonate layers in the soil or as clay-sized fractions throughout the soil. Carbonates in soils are most common in areas where evaporation rates exceed precipitation, as is the case in most desert environments. Typically, the carbonates accumulated from carbonatic dust or from solution during periods of wetter climates. Soil inorganic carbon also occurs in soils that formed in marl in all regions of the country.

The SOC and SIC contents are reported in kilograms per square meter to a depth of 2 meters or to a representative depth of either hard bedrock or a cemented horizon. The SOC and SIC values are on a whole soil basis, corrected for rock fragments.

SOC can be an indicator of overall soil fertility and soil quality that affects ecosystem function. SOM is the main reservoir for most plant nutrients, such as phosphorus and nitrogen. Managing for SOC by managing for SOM increases the content of these elements and improves soil resiliency.

Soil organic matter binds soil particles together and thus increases soil porosity and water infiltration and allows better root penetration and waterflow into the soil. Greater inflow of water reduces the hazard of erosion and the rate of surface water runoff.

Greater SOC levels improve not only soil quality but also the quality of air and water. Soil acts as a filter and improves water quality. Fertile soils that support plant life remove CO_2 from the atmosphere and increase oxygen levels through photosynthesis. Maintaining the level of soil organic carbon reduces C release into the atmosphere and thus can lessen the effects of global warming.

SIC influences the types of plants that will grow. High SIC levels are commonly associated with a higher soil pH, which limits the types of plants that will thrive.

Like SOM, soil carbonates, the source of SIC, also bind soil particles together. They fill voids in the soil and thus can reduce soil porosity. Compacted soil carbonates may restrict root penetration and waterflow into the soil.

Chemical Soil Properties

Table 17 shows estimates of some chemical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the park. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Cation-exchange capacity is the total amount of extractable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. Soils having a low cation-exchange capacity hold fewer cations and may require more frequent applications of fertilizer than soils having a high cation-exchange capacity. The ability to retain cations reduces the hazard of ground-water pollution.

Effective cation-exchange capacity refers to the sum of exchangeable cations plus aluminum expressed in terms of milliequivalents per 100 grams of soil. It is determined for soils that have pH of less than 5.5.

Soil reaction is a measure of acidity or alkalinity. The pH of each soil horizon is based on many field tests. For many soils, values have been verified by laboratory analyses. Soil reaction is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Salinity is a measure of soluble salts in the soil at saturation. It is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25 degrees C. Estimates are based on field and laboratory measurements at representative sites of nonirrigated soils. The salinity of irrigated soils is affected by the quality of the irrigation water and by the frequency of water application. Hence, the salinity of soils in individual fields can differ greatly from the value given in the table. Salinity affects the suitability of a soil for crop production, the stability of soil if used as construction material, and the potential of the soil to corrode metal and concrete.

Water Features

Table 18 gives estimates of various soil water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

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

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

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas.

The *months* in the table indicate the portion of the year in which a water table, ponding, and/or flooding is most likely to be a concern.

Water table refers to a saturated zone in the soil. Table 18 indicates, by month, depth to the top (*upper limit*) and base (*lower limit*) of the saturated zone in most years. Estimates of the upper and lower limits are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors or mottles (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

Ponding is standing water in a closed depression. Unless a drainage system is installed, the water is removed only by percolation, transpiration, or evaporation. The table indicates *surface water depth* and the *duration* and *frequency* of ponding. Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, rare, occasional, and frequent. *None* means that ponding is not probable; *rare* that it is unlikely but possible under unusual weather conditions (the chance of ponding is nearly 0 percent to 5 percent in any year); *occasional* that it occurs, on the average, once or less in 2 years (the chance of ponding is 5 to 50 percent in any year); and *frequent* that it occurs, on the average, more than once in 2 years (the chance of ponding is more than 50 percent in any year).

Flooding is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding.

Duration and *frequency* are estimated. Duration is expressed as *extremely brief* if 0.1 hour to 4 hours, *very brief* if 4 hours to 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent. *None* means that flooding is not probable; *very rare* that it is very unlikely but possible under extremely unusual weather conditions (the chance of flooding is less than 1 percent in any year); *rare* that it is unlikely but possible under unusual weather conditions (the chance of flooding is 1 to 5 percent in any year); *occasional* that it occurs infrequently under normal weather conditions (the chance of flooding is 5 to 50 percent in any year); *frequent* that it is likely to occur often under normal weather conditions (the chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year); and *very frequent* that it is likely to occur very often under normal weather conditions (the chance of flooding is more than 50 percent in all months of any year).

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and little or no horizon development.

Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

Soil Features

Table 19 gives estimates of various soil features. The estimates are used in land use planning that involves engineering considerations.

A *restrictive layer* is a nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restrict roots or otherwise provide an unfavorable root environment. Examples are bedrock, cemented layers, dense layers, and frozen layers. The table indicates the hardness of the restrictive layer, which significantly affects the ease of excavation. *Depth to top* is the vertical distance from the soil surface to the upper boundary of the restrictive layer.

Potential for frost action is the likelihood of upward or lateral expansion of the soil caused by the formation of segregated ice lenses (frost heave) and the subsequent collapse of the soil and loss of strength on thawing. Frost action occurs when moisture moves into the freezing zone of the soil. Temperature, texture, density, saturated hydraulic conductivity (K_{sat}), content of organic matter, and depth to the water table are the most important factors considered in evaluating the potential for frost action. It is assumed that the soil is not insulated by vegetation or snow and is not artificially drained. Silty and highly structured, clayey soils that have a high water table in winter are the most susceptible to frost action. Well drained, very gravelly, or very sandy soils are the least susceptible. Frost heave and low soil strength during thawing cause damage to pavements and other rigid structures.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The steel or concrete in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the steel or concrete in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low, moderate,* or *high,* is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion also is expressed as *low, moderate,* or *high.* It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

Formation and Classification of the Soils

This section relates the soils in John Muir National Historic Site to the major factors of soil formation and describes the system of soil classification.

Factors of Soil Formation

By Susan Burlew Southard, Natural Resources Conservation Service.

Soil covers the surface of the earth as a three-dimensional body of varying thickness and is made up of different proportions of organic and mineral material and pore space filled with gases and water. Soils differ in their appearance, productivity, and management requirements due to their chemical and physical properties. The characteristics and properties of soils are determined by physical and chemical processes that result from the interaction of five soil-forming factors. These factors of soil formation are interdependent, and few generalizations can be made regarding any one factor unless the effects of the other factors are known. The term “pedogenesis” is often used to connote the processes of soil formation.

The interacting soil-forming factors are parent material, climate, organisms, time, and topography or relief (Jenny, 1941). Parent material is the source material in which soils formed. Soils are influenced by the texture and structure of the parent material and its mineralogical and chemical composition. Climate is predominantly the temperature and kind and amount of precipitation. Climate is also seasonal distribution of temperature and precipitation. Organisms are the plants and other organisms living in and on the soil, including humans. Time refers to how long the soil-forming factors have been operating on a particular landscape. Topography or relief is the shape and elevation of the landscape and affects internal and external soil properties, such as soil drainage, aeration, susceptibility to erosion, and the soil’s exposure to the sun and wind.

The processes of soil formation are sequences of events, involving biogeochemical reactions that are energized by climate and spatially related to relief or topography (Buol and others, 2011). The physical and chemical properties of a soil are altered by these reactions over time. The influence of any one of these factors varies among all parks and within localities of a particular park. Soils may differ significantly from place to place in a park and within very short distances as a result of complex interaction among the five factors. On the other hand, in some instances, parks may have vast stretches of the same type of soil because of uniform soil-forming factors.

Parent Material

The unconsolidated mass in which soils form is called parent material. Mineral soil parent material is a product of weathering of underlying bedrock in place or weathering of material that has been transported. Organic soils form in place from the accumulation and decomposition of plant material, such as wood, leaves, and aquatic plants. Weathering refers to the chemical and physical disintegration and decomposition of parent material. Few soils weather directly from the underlying rocks. More commonly, soils form in materials that have been moved in from elsewhere. Soils generally have a dominant kind of parent material but are influenced by other types of parent material. Material may have been moved only a few feet by gravity (colluvial parent material) or transported long distances by wind (eolian parent material) or water (alluvial parent material). Soils are said to have residual parent material if they formed directly from underlying rocks or from an *in situ* plant source. Soils that formed in residuum may have the same general chemistry as the original rocks depending on the degree of weathering that has occurred. There are three types of parent material in John Muir National Historic Site (NHS)—alluvium, residuum, and colluvium.

The hills around the historic home of John Muir are part of the California Coast Range. The Coast Range is hilly with a series of folds and faults that form a series of nearly parallel, northwest-trending ridges composed of sedimentary rocks. Between the ridges are valleys filled with alluvium on small fans and flood plains.

At the base of Mount Wanda in John Muir NHS, soils form in residuum and colluvium from the Martinez Formation. The Martinez Formation formed as sand sediments were deposited on the ocean floor during a period of very slow sedimentation. The rock contains fossils of shell-bearing creatures and glauconite, a mica that indicates slow rates of deposition. It formed on the ocean floor around 60 million years ago, in the Paleocene Epoch (Watson, 1942).

Higher on Mount Wanda, the rocks are part of a group known as the Great Valley Sequence of Cretaceous age. The Great Valley Sequence consists of interbedded layers of sandstones, siltstones, and shales that were deposited from erosion of the Sierra Nevada to the east. These rocks are older than the Martinez Formation at the bottom of the hill. The forces along the tectonic plate boundaries caused many of the rocks in this area to be complexly folded and, in some cases, overturned, as they are in John Muir NHS. As a result, the oldest rocks are on top of Mount Wanda (CCRCD, 2011).

Some parent materials are soft and break down into smaller rocks easily. Others, such as those of Los Gatos and Los Osos soils, are much harder and resist weathering processes. Los Osos soils are dominant in the higher landscape positions in John Muir NHS, and Los Gatos soils are on eroded hillslopes (figs. 2 and 3). Both soils formed from a combination of colluvium and residuum.

Los Osos soils are clayey and overlie weathered shale of the Great Valley Sequence. They have a clay type (smectite) that has high shrink-swell capacity, especially below a depth of 10 inches (see table 14). Shrinking and swelling is the seasonal cracking and expansion of soil due to wetting and drying. Surface cracking can be seen when hiking on the Mount Wanda trails during the dry seasons (fig. 4). Los Osos soils have a higher permeability than other smectitic soils (USDA-SCS, 1977). As a result, they become supersaturated during heavy rains and prone to slope instability.

Los Gatos soils are on eroded, steeper slopes at the lower elevations in the park and may correlate with the underlying Martinez Sandstone, which is more resistant to weathering. They overlie a hard sandstone contact in most places (see table 19).

Alluvium, which is parent material deposited by running water, can have different textures depending on whether the water moves quickly or slowly. The type of rocks occurring in the source region of the streams and rivers also determine the characteristics of the parent material. Fast-moving water deposits gravel, rocks, and sand. Slow-moving water leaves fine textured deposits (clay and silt) when sediments in the water settle out. Soils that formed in alluvium are typically on fairly level slopes and are also typically very deep. In John Muir NHS, Bella and Garretson soils formed predominantly from alluvium. Both soils lie along the flood plain of Franklin Creek. Botella soils occur in the slightly higher landscape positions. Garretson soils lie closer to the active creek channel and have coarser textures than Botella soils (fig. 5).

Figure 2.—An area of Los Osos clay loam, 15 to 30 percent slopes (map unit 455818), on the summit of Mount Wanda. The clayey, high shrink-swell Los Osos soils formed in residuum from interbedded sandstones and shales of the Great Valley Sequence.

Figure 3.—An area of Los Gatos loam, 30 to 50 percent slopes (map unit 455816), along the Mount Wanda Trail. The vegetation consists of grasses or deciduous oak on south slopes and laurel and live oak on north slopes.

Figure 4.—Cracking in an area of Los Osos soils. The clay in these soils has a high shrink-swell potential due to the clay type. The clay content in Los Osos soils ranges as high as 50 percent, by weight (see table 14).

Figure 5.—Pear and apricot trees to the east of the Martinez Adobe in an area of Garretson loam, 0 to 2 percent sloes (map unit 455796). If irrigated, areas of this map unit are considered prime farmland. Garretson soils formed from alluvium deposited by Franklin Creek.

Soils that formed in alluvium influenced land use in the park. Past and present agricultural production in the Alhambra Valley was on alluvial soils that are very deep, rock free, and commonly well drained.

Soil properties, dictated by parent material, probably influenced which soils were used to build the Martinez Adobe located in the park. In creating the adobe bricks, a soil with a low shrink-swell potential would have been preferred. Potential cracking of adobe bricks would have deterred builders from using Los Osos and Los Gatos soils. The builders most likely used Botella or Garretson soils, which formed in alluvium, to mix the adobe bricks.

Climate

John Muir NHS has a Mediterranean climate with cool, wet winters and warm, dry summers. Mean annual precipitation is about 25 inches, and mean annual air temperature is about 60 degrees F. The soils are moist from late fall to early spring and are dry the rest of the year. The soils are rarely frozen, so the surface is not broken up by frost action. The alternating dry and wet cycles result in cracks on the surface of soils that have a high content of smectitic clays, such as Los Osos soils.

Differences in climate can result in differences in soils. Temperature and moisture influence soil formation and are the two most commonly measured features of climate. Weathering is most active when soils are moist and warm because these soil conditions are conducive to rapid chemical reactions and increased biological activity in the soil. Cooler temperatures result in slower chemical reactions. While average temperatures and precipitation are important in determining soil properties, the extremes of climate in any given locale also play a major role in soil formation.

During periods of rainfall, water carrying dissolved or suspended solids moves through the soil in a process called leaching. The leaching process becomes active with the onset of rainfall or snowmelt. Different temperatures and moisture amounts cause different patterns of weathering and leaching in the soil. Seasonal and daily changes in temperature affect moisture effectiveness, biological activity, rates of chemical reactions, and kinds of vegetation.

Organisms

Plants, animals, micro-organisms, and humans affect the formation and shape of soils. Plants capture solar energy, which is a fundamental driver of many soil processes, via photosynthesis and transfer that energy to the soil as organic matter. Fungi and bacteria are the primary organisms that decompose organic matter and add nutrients to the soil. Micro-organisms affect chemical exchanges between roots and soil. Animals and micro-organisms mix soils and form burrows and pores. Abandoned tunnels commonly are filled with loose material from the overlying horizons and transmit water more readily than the surrounding undisturbed soil material. Humans also can mix the soil extensively, such as by plowing or excavation for building structures.

Plant roots open channels in the soils. Different types of roots have different effects on soils. Grass roots are fibrous and decompose easily, adding organic matter to the soil. Fine grass roots can extend below the surface for many feet. Plant roots also help to develop soil structure and aggregate stability. Vegetation increases soil stability by protecting the surface against wind and water erosion. Taproots open pathways through dense layers.

The native vegetation depends on climate, topography, and biological factors plus many soil factors, such as soil density, depth, chemistry, temperature, and moisture. John Muir NHS has forest, grassland, and wetland vegetation. Each of these vegetation types affects soil formation and soil types in different ways.

Figure 6.—An area of Los Gatos loam, 30 to 50 percent slopes (map unit 455816). This map unit occurs on all slopes. On south-facing slopes, the soil is drier, favoring grasses and black oak. On north-facing slopes, it is wetter and cooler, favoring more live oaks and laurel.

The influence of parent material on organisms is commonly a major factor in the development of ecological niches in a park. The influence of parent material on soil depth and soil chemistry plays a major role in determining the types of vegetation in specific areas. The valley soils that formed in alluvium have large valley oak and live oak ecosystems, whereas the steeper, shallow soils that formed in colluvium and residuum on the drier hillslopes favor black oak, blue oak, and grassland ecosystems (fig. 6). Leaves from plants fall to the surface, organisms decompose these leaves and mix them with the upper part of the soil, and the result is the cycling of nutrients and energy back to the soil and the vegetation.

John Muir NHS has mixed oak woodland habitat. These forested areas have woody roots that help break up rocks, resulting in channels that increase water penetration and soil depth (fig. 7). Besides the mechanical breaking of rocks by large tree roots, the trees capture energy and produce organic matter through photosynthesis. Organic-mineral complexes that formed in the soil are recycled many times within the ecosystem (Buol and others, 2011).

Live oaks occur in small stands mixed with grasslands throughout the park (fig. 8). The understory, which is in mostly sunny areas, consists of a few shrubs and a wide variety of herbaceous plants. The open oak canopy results in warm soils that dry out during dry seasons. Understory shrubs include buckbrush, coffeeberry, toyon, and California bay, which can leave a thick leaf litter on the soil. The leaf litter helps prevent nutrient loss, conserves soil moisture, and reduces raindrop impact. These areas of live oak are mapped as Los Osos and Los Gatos soils.

Some areas of John Muir NHS were once covered with grasslands dominated by perennial bunchgrasses. Distinct soils formed under these grasslands. Bunchgrasses, such as purple needlegrass, tufted hairgrass, blue wildrye, and California oatgrass, form clumps. These clumps help stabilize soils such as Los Osos. Los Osos soils have an accumulation of organic matter due to grassland vegetation.

The main riparian ecosystem in John Muir NHS is along Franklin Creek. Soils in this area have a shallow water table, which helps support wetland vegetation, including water-loving trees like Pacific willow. Garretson soils are typical soils that formed on these stream terraces. The survival of the John Muir giant sequoia is probably tied to natural subsurface irrigation water supplied by Franklin Creek.

The park is susceptible to wildfires. Wildfires can alter physical and chemical properties of the soil. Erosion may be accelerated by the loss of vegetation and surface ground cover. Slopes may be destabilized by increased runoff. There have been periods of wildfire in John Muir NHS that have affected present vegetation and soil erosion potential.

Time

Time for parent material, climate, organisms, and relief to interact with the soil also is a soil-forming factor. Over time, soils exhibit features that reflect the interaction of other soil-forming factors. Recently deposited material, such as material deposited by a flood, exhibits no features from soil development activities and its properties are mostly inherited from the new material. For soils in these areas, the previous soil surface and underlying horizons become buried. The time clock resets for these soils. The different horizons in a soil profile and the degree of development can be directly related to time.

Such soils as Botella and Garretson on alluvial fans and stream terraces have few distinctive characteristics and no diagnostic subsurface horizons. Such soils as Los Osos and Los Gatos have argillic diagnostic subsurface horizons (or an accumulation

Figure 7.—Tree roots along the Mount Wanda Trail. Tree roots help to hold soil in place and prevent down-slope erosion, thereby increasing water penetration into the soil and reducing surface runoff.

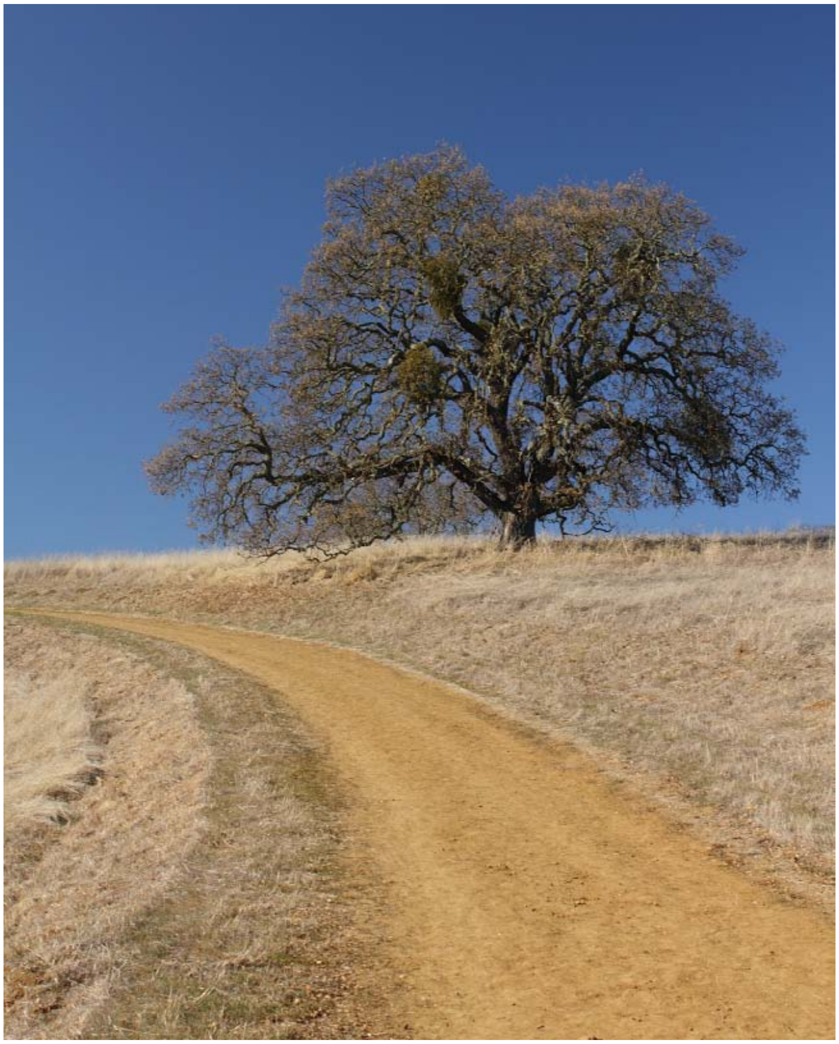

Figure 8.—Grassland near the summit of Mount Wanda.

of clay). These soils experienced periods of landscape stability, which has allowed distinctive profile characteristics to form.

Topography and Relief

Topography refers to the shape of the landscape, and relief refers to differences in elevation. The overall landscape in a park, whether it consists of stream terraces, rolling hills, or steep mountains, is the result of erosion and depositional processes. These processes may have occurred in response to changes in climate, fluctuating sea levels, and/or tectonic activities. Cyclic periods of landscape stability and instability influence the types of soils that form on the landscape. Slope and aspect of the overall landscape can affect the moisture and temperature of the soil. Steep slopes facing the sun are warmer than more gentle slopes that face away from the sun.

Steep soils may be eroded and lose their surface horizons as quickly as they form. Water moving down hill in the folds of Mount Wanda is a process of down cutting. This process is part of natural stream dynamics. In steep streams, waterfalls and plunge pools reduce the energy of the flowing water. The down-cutting process typically continues until resistant material, such as bedrock under the soil, is encountered.

The soil is washed down slope and out of the mouth of side canyons. This is how the relatively flat alluvial fans at the mouths of the side canyons of Mount Wanda formed. As the small tributaries flow out of the side canyons, they traverse the open, gentle side slopes of the valley floors. The intermittent streams spread out, forming gently sloping alluvial fans where velocities decrease and sediment loads can be deposited and build up alluvial fan soils.

Some water infiltrates the soil rather than flowing through distinct channels. When the soil can no longer soak up the water, the water flows overland, sometimes cutting seasonal channels. Vegetation in areas of steep topography limits seasonal down cutting and overland flow.

The rolling ridgetops define the limits of the watershed encompassing John Muir NHS. The hilltops are mostly open grassland with some oak woodland. The steep slopes below these ridges are generally more wooded, especially north- and east-facing slopes and slopes in folds in the hills. Laurel and live oaks thrive on the northern slopes where the soils are cooler and moist (fig. 9).

Deeper, darker soils, such as Botella, occur on the alluvial land below the steep hillslopes. Botella soils have accumulated organic material due to their productive and stable valley position. These soils have the highest soil carbon content of the four soils mapped in John Muir NHS; Garretson soils have the second highest (see table 16).

The youngest geomorphic surfaces generally are alluvial fans, flood plains, and basin floors associated with the major rivers and streams where alluvium has been

Figure 9.—Vegetation on north-facing slopes is predominantly live oaks and laurel. Los Gatos soils are cool and moist on north-facing slopes where leaf litter accumulates.

Figure 10.—A peach orchard in an area of Los Gatos loam, 15 to 30 percent slopes (map unit 455815). Los Gatos soils in this hillslope landscape are transitioning to the alluvial setting along Franklin Creek.

deposited. Soils in toeslope and alluvial fan positions adjacent to the valley (fig. 10) generally are deeper than soils in other hillslope positions.

Soil-forming factors affect soils even in the less steep, stable landscape positions. New soil-forming materials may be quickly deposited on the surface or washed away during major flood events.

Classification of the Soils

Soils are named and classified on the basis of physical and chemical properties in their horizons (layers). Color, texture, structure, and other properties of the soil to a depth of 2 meters are used to key the soil into a classification system. This system helps people to use soil information and also provides a common language for scientists.

Soils and their horizons differ from one another, depending on how and when they formed. Soil scientists use the five soil-forming factors to help predict where different soils may occur. The degree and expression of the soil horizons reflect the extent of interaction of the soil-forming factors with one or more of the soil-forming processes (Simonson, 1959).

When mapping soils, a soil scientist looks for areas with similar soil-forming factors to find similar soils. The properties of the soils are described. Soils with the same kind of properties are given taxonomic names. Soils are classified, mapped, and interpreted on the basis of various kinds of soil horizons and their arrangement. The distribution of soil orders corresponds with the general patterns of the soil-forming factors within the park.

The system of soil classification used by the National Cooperative Soil Survey has six categories (Soil Survey Staff, 1999 and 2010). Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. The categories are defined in the following paragraphs.

ORDER. Soil taxonomy at the highest hierarchical level identifies 12 soil orders. The names for the orders and taxonomic soil properties relate to Greek, Latin, or other root words that reveal something about the soil. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in *sol*. An example is Mollisols.

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that reflect the most important variables within the orders. Sixty-four suborders are recognized at the next level of classification. The last syllable in the name of a suborder indicates the order. An example is Xeroll (*Xer,* meaning dry, plus *oll,* from Mollisols).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; type of saturation; and base status. There are about 300 great groups. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Argixerolls (*Argi* meaning presence of an argillic horizon, plus *xerolls,* the suborder of the Mollisols that has a xeric moisture regime).

SUBGROUP. There are more than 2,400 subgroups. Each great group has a typic subgroup. The typic subgroup is the central concept of the great group; it is not necessarily the most extensive. Other subgroups are intergrades or extragrades. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group but do not indicate transitions to any other taxonomic class. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Pachic* (from *pachys*) identifies the subgroup extragrade that has a thick surface layer. An example is Pachic Argixerolls.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Generally, the properties for family placement are those of horizons below a traditional agronomic plow depth. Among the properties and characteristics considered are particle-size class, mineralogy class, cation-exchange activity class, soil temperature regime, soil depth, and reaction class. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is fine-loamy, mixed, superactive, thermic Pachic Argixerolls.

SERIES. The soil series is the lowest category in the soil classification system. The series consists of soils within a family that have horizons similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile.

Most parks are mapped to the series level. The names of soil series are selected by the soil scientists during the course of mapping. The series names are commonly geographic place names or are coined. An example is the Botella series, which classifies as fine-loamy, mixed, superactive, thermic Pachic Argixerolls. Because of access limitations and soil variability, soils in some remote areas are classified at the great group or subgroup level.

Table 20 indicates the order, suborder, great group, subgroup, and family of the soil series in the park. Table 21 displays classification as a key sorted by soil order.

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Glossary

Aeration, soil. The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkali (sodic) soil. A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Alluvial fan. The fanlike deposit of a stream where it issues from a gorge upon a plain or of a tributary stream near or at its junction with its main stream.

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Alpha,alpha-dipyridyl. A dye that when dissolved in 1N ammonium acetate is used to detect the presence of reduced iron (Fe II) in the soil. A positive reaction indicates a type of redoximorphic feature.

Aquic conditions. Current soil wetness characterized by saturation, reduction, and redoximorphic features.

Argillic horizon. A subsoil horizon characterized by an accumulation of illuvial clay.

Aspect. The direction in which a slope faces.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as:

Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	9 to 12
Very high	more than 12

Base saturation. The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, and K), expressed as a percentage of the total cation-exchange capacity.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Canopy. The leafy crown of trees or shrubs. (See Crown.)

Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Claypan. A slowly permeable soil horizon that contains much more clay than the horizons above it. A claypan is commonly hard when dry and plastic or stiff when wet.

Climax plant community. The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

Coarse textured soil. Sand or loamy sand.

Colluvium. Soil material or rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

Complex, soil. A map unit of two or more kinds of soil or miscellaneous areas in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas.

Control section. The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

Corrosion. Soil-induced electrochemical or chemical action that dissolves or weakens concrete or uncoated steel.

Crown. The upper part of a tree or shrub, including the living branches and their foliage.

Culmination of the mean annual increment (CMAI). The average annual increase per acre in the volume of a stand. Computed by dividing the total volume of the stand by its age. As the stand increases in age, the mean annual increment continues to increase until mortality begins to reduce the rate of increase. The point where the stand reaches its maximum annual rate of growth is called the culmination of the mean annual increment.

Depth, soil. Generally, the thickness of the soil over bedrock. Very deep soils are more than 60 inches deep over bedrock; deep soils, 40 to 60 inches; moderately deep, 20 to 40 inches; shallow, 10 to 20 inches; and very shallow, less than 10 inches.

Drainage class (natural). Refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized—*excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained,* and *very poorly drained*. These classes are defined in the “Soil Survey Manual.”

Drainage, surface. Runoff, or surface flow of water, from an area.

Ecological site. An area where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. An ecological site is the product of all the environmental factors responsible for its development. It is typified by an association of species that differ from those on other ecological sites in kind and/or proportion of species or in total production.

Eluviation. The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Eolian soil material. Earthy parent material accumulated through wind action; commonly refers to sandy material in dunes or to loess in blankets on the surface.

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of human or animal activities or of a catastrophe in nature, such as a fire, that exposes the surface.

Escarpment. A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and resulting from erosion or faulting. Synonym: scarp.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fill slope. A sloping surface consisting of excavated soil material from a road cut. It commonly is on the downhill side of the road.

Fine textured soil. Sandy clay, silty clay, or clay.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Fluvial. Of or pertaining to rivers; produced by river action, as a fluvial plain.

Forb. Any herbaceous plant not a grass or a sedge.

Forest cover. All trees and other woody plants (underbrush) covering the ground in a forest.

Forest type. A stand of trees similar in composition and development because of given physical and biological factors by which it may be differentiated from other stands.

Gravel. Rounded or angular fragments of rock as much as 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravelly soil material. Material that has 15 to 35 percent, by volume, rounded or angular rock fragments, not prominently flattened, as much as 3 inches (7.6 centimeters) in diameter.

Ground water. Water filling all the unblocked pores of the material below the water table.

Hard bedrock. Bedrock that cannot be excavated except by blasting or by the use of special equipment that is not commonly used in construction.

Hill. A natural elevation of the land surface, rising as much as 1,000 feet above surrounding lowlands, commonly of limited summit area and having a well defined outline; hillsides generally have slopes of more than 15 percent. The distinction between a hill and a mountain is arbitrary and is dependent on local usage.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the “Soil Survey Manual.” The major horizons of mineral soil are as follows:

O horizon.—An organic layer of fresh and decaying plant residue.

A horizon.—The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

E horizon.—The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying soil material. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon.—Soft, consolidated bedrock beneath the soil.

R layer.—Consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon, but it can be directly below an A or a B horizon.

Hydrologic soil groups. Refers to soils grouped according to their runoff potential. The soil properties that influence this potential are those that affect the minimum rate of water infiltration on a bare soil during periods after prolonged wetting when the soil is not frozen. These properties are depth to a seasonal high water table, the infiltration rate and permeability after prolonged wetting, and depth to a very slowly permeable layer. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff.

Illuviation. The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration capacity. The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Intake rate. The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake, in inches per hour, is expressed as follows:

Less than 0.2	very low
0.2 to 0.4	low
0.4 to 0.75	moderately low
0.75 to 1.25	moderate
1.25 to 1.75	moderately high
1.75 to 2.5	high
More than 2.5	very high

K_{sat}. Saturated hydraulic conductivity. (See Permeability.)

Leaching. The removal of soluble material from soil or other material by percolating water.

LEP. See Linear extensibility percent.

Linear extensibility (LE). Refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. Linear extensibility is used to determine the shrink-swell potential of soils. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. Volume change is influenced by the amount and type of clay minerals in the soil. The volume change is the percent change for the whole soil. If it is expressed as a fraction, the resulting value is COLE, coefficient of linear extensibility.

Linear extensibility percent. Refers to the percent change in linear extensibility.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess. Fine grained material, dominantly of silt-sized particles, deposited by wind.

Low strength. The soil is not strong enough to support loads.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Miscellaneous area. An area that has little or no natural soil and supports little or no vegetation.

Moderately coarse textured soil. Coarse sandy loam, sandy loam, or fine sandy loam.

Moderately fine textured soil. Clay loam, sandy clay loam, or silty clay loam.

Neutral soil. A soil having a pH value of 6.6 to 7.3. (See Reaction, soil.)

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter. Plant and animal residue in the soil in various stages of decomposition. The content of organic matter in the surface layer is described as follows:

Very low	less than 0.5 percent
Low	0.5 to 1.0 percent
Moderately low	1.0 to 2.0 percent
Moderate	2.0 to 4.0 percent
High	4.0 to 8.0 percent
Very high	more than 8.0 percent

Pan. A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan, fragipan, claypan, plowpan,* and *traffic pan*.

Parent material. The unconsolidated organic and mineral material in which soil forms.

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedon. The smallest volume that can be called “a soil.” A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The movement of water through the soil.

Permeability. The quality of the soil that enables water or air to move downward through the profile. The rate at which a saturated soil transmits water is accepted as a measure of this quality. In soil physics, the rate is referred to as “saturated hydraulic conductivity,” which is defined in the “Soil Survey Manual.” In line with conventional usage in the engineering profession and with traditional usage in published soil surveys, this rate of flow continues to be expressed as “permeability.” Terms describing permeability, measured in inches per hour, are as follows:

Extremely slow	0.0 to 0.01 inch
Very slow	0.01 to 0.06 inch
Slow	0.06 to 0.2 inch
Moderately slow	0.2 to 0.6 inch
Moderate	0.6 inch to 2.0 inches
Moderately rapid	2.0 to 6.0 inches
Rapid	6.0 to 20 inches
Very rapid	more than 20 inches

Phase, soil. A subdivision of a soil series based on features that affect its use and management, such as slope, stoniness, and flooding.

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from semisolid to plastic.

Plowpan. A compacted layer formed in the soil directly below the plowed layer.

Ponding. Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

Poorly graded. Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Potential native plant community. See Climax plant community.

Potential rooting depth (effective rooting depth). Depth to which roots could penetrate if the content of moisture in the soil were adequate. The soil has no properties restricting the penetration of roots to this depth.

Productivity, soil. The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Rangeland. Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Reaction, soil. A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degrees of acidity or alkalinity, expressed as pH values, are:

Ultra acid	less than 3.5
Extremely acid	3.5 to 4.4
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Moderately acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Slightly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Redoximorphic concentrations. Nodules, concretions, soft masses, pore linings, and other features resulting from the accumulation of iron or manganese oxide. An indication of chemical reduction and oxidation resulting from saturation.

Redoximorphic depletions. Low-chroma zones from which iron and manganese oxide or a combination of iron and manganese oxide and clay has been removed. These zones are indications of the chemical reduction of iron resulting from saturation.

Redoximorphic features. Redoximorphic concentrations, redoximorphic depletions, reduced matrices, a positive reaction to alpha,alpha-dipyridyl, and other features indicating the chemical reduction and oxidation of iron and manganese compounds resulting from saturation.

Relief. The elevations or inequalities of a land surface, considered collectively.

Residuum (residual soil material). Unconsolidated, weathered or partly weathered mineral material that accumulated as consolidated rock disintegrated in place.

Rock fragments. Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Root zone. The part of the soil that can be penetrated by plant roots.

Runoff. The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Saline soil. A soil containing soluble salts in an amount that impairs growth of plants. A saline soil does not contain excess exchangeable sodium.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sandstone. Sedimentary rock containing dominantly sand-sized particles.

Saprolite. Unconsolidated residual material underlying the soil and grading to hard bedrock below.

Saturation. Wetness characterized by zero or positive pressure of the soil water. Under conditions of saturation, the water will flow from the soil matrix into an unlined auger hole.

Sedimentary rock. Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Series, soil. A group of soils that have profiles that are almost alike. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Shale. Sedimentary rock formed by the hardening of a clay deposit.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Siltstone. Sedimentary rock made up of dominantly silt-sized particles.

Similar soils. Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

Site index. A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Sodic (alkali) soil. A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Sodicity. The degree to which a soil is affected by exchangeable sodium. Sodicity is expressed as a sodium adsorption ratio (SAR) of a saturation extract, or the ratio of Na^+ to Ca^{++} + Mg^{++}. The degrees of sodicity and their respective ratios are:

Slight	less than 13:1
Moderate	13-30:1
Strong	more than 30:1

Sodium adsorption ratio (SAR). A measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration.

Soft bedrock. Bedrock that can be excavated with trenching machines, backhoes, small rippers, and other equipment commonly used in construction.

Soil. A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	less than 0.002

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the material below the solum. The living roots and plant and animal activities are largely confined to the solum.

Stone line. A concentration of coarse fragments in a soil. Generally, it is indicative of an old weathered surface. In a cross section, the line may be one fragment or more thick. It generally overlies material that weathered in place and is overlain by recent sediment of variable thickness.

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded or 15 to 24 inches (38 to 60 centimeters) in length if flat.

Stony. Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles adhering without any regular cleavage, as in many hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. The part of the soil below the solum.

Subsurface layer. Any surface soil horizon (A, E, AB, or EB) below the surface layer.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the “plow layer,” or the “Ap horizon.”

Surface soil. The A, E, AB, and EB horizons, considered collectively. It includes all subdivisions of these horizons.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet. A terrace in a field generally is built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying “coarse,” “fine,” or “very fine.”

Tilth, soil. The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Upland. Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Weathering. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

Well graded. Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Tables

Table 1.—Soil Legend

Map unit symbol and map unit name	Components in map unit	Percent of map unit
455765:		
Botella clay loam, 0 to 2 percent slopes	Botella	85
	Clear Lake	3
	Conejo	3
	Garretson	3
	Unnamed soils	3
	Unnamed hydric soils	3
455796:		
Garretson loam, 0 to 2 percent slopes	Garretson	85
	Conejo	10
	Botella	5
455815:		
Los Gatos loam, 15 to 30 percent slopes	Los Gatos	85
	Dibble	5
	Los Osos	5
	Millsholm	5
455816:		
Los Gatos loam, 30 to 50 percent slopes	Los Gatos	85
	Dibble	4
	Los Osos	4
	Millsholm	4
	Vallecitos	2
455818:		
Los Osos clay loam, 15 to 30 percent slopes	Los Osos	85
	Alo	5
	Lodo	3
	Millsholm	3
	Diablo	1
	Tierra	1
455819:		
Los Osos clay loam, 30 to 50 percent slopes	Los Osos	85
	Alo	5
	Unnamed soil slips	5
	Lodo	3
	Millsholm	2

Table 2.—Land Capability Classification

(Land capability classification is a system of grouping soils primarily on the basis of their capability to produce common cultivated crops and pasture plants without deteriorating over a long period of time)

Map unit symbol and component name	Land capability N	Land capability I
455765:		
Botella	4c	1
455796:		
Garretson	4c	1
455815:		
Los Gatos	4e-1	4e-1
455816:		
Los Gatos	6e	6e
455818:		
Los Osos	4e-3	4e-3
455819:		
Los Osos	6e	6e

Table 3.—Prime and Other Important Farmland

(Only the soils considered prime or important farmland are listed. Urban or built-up areas of the soils listed are not considered prime or important farmland. If a soil is prime or important farmland only under certain conditions, the conditions are indicated in the column "Farmland classification")

Map unit symbol	Map unit name	Farmland classification
455765	Botella clay loam, 0 to 2 percent slopes	Prime farmland if irrigated
455796	Garretson loam, 0 to 2 percent slopes	Prime farmland if irrigated

Table 4.—Hydric Soils

(This report lists only those map unit components that are rated as hydric. Definitions of hydric criteria codes are included at the end of the report)

Map unit symbol and map unit name	Component	Percent of map unit	Landform	Hydric soils criteria: Hydric criteria code	Meets saturation criteria	Meets flooding criteria	Meets ponding criteria
455765:							
Botella clay loam, 0 to 2 percent slopes	Clear Lake	3	depressions	2B3	Yes	No	No
	Unnamed soils	3	depressions	2B3	Yes	No	No

Explanation of hydric criteria codes:

1. All Histels (except for Folistels), and Histosols (except for Folists), which are, by definition, saturated.
2. Soils in Aquic suborders, great groups, or subgroups, Albolls suborder, Historthels great group, Histoturbels great group, Pachic subgroups, or Cumulic subgroups that:
   A. are somewhat poorly drained and have a water table at the surface (0.0 feet) during the growing season, or
   B. are poorly drained or very poorly drained and have either:
      1.) a water table at the surface (0.0 feet) during the growing season if textures are coarse sand, sand, or fine sand in all layers within a depth of 20 inches, or
      2.) a water table at a depth of 0.5 foot or less during the growing season if permeability is equal to or greater than 6.0 in/hr in all layers within a depth of 20 inches, or
      3.) a water table at a depth of 1.0 foot or less during the growing season if permeability is less than 6.0 in/hr in any layer within a depth of 20 inches.
3. Soils that are frequently ponded for periods of long or very long duration during the growing season.
4. Soils that are frequently flooded for periods of long or very long duration during the growing season.

Table 5.—Land Management, Part I (Planting)

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and soil name	Pct. of map unit	Suitability for hand planting: Rating class and limiting features	Value	Suitability for mechanical planting: Rating class and limiting features	Value	Soil rutting hazard: Rating class and limiting features	Value
455765:							
Botella	85	Well suited		Well suited		Severe	
						Low strength	1.00
455796:							
Garretson	85	Well suited		Well suited		Severe	
						Low strength	1.00
455815:							
Los Gatos	85	Well suited		Poorly suited		Severe	
				Slope	0.75	Low strength	1.00
455816:							
Los Gatos	85	Moderately suited		Unsuited		Severe	
		Slope	0.50	Slope	1.00	Low strength	1.00
455818:							
Los Osos	85	Moderately suited		Poorly suited		Severe	
		Stickiness; high plasticity index	0.50	Slope	0.75	Low strength	1.00
				Stickiness; high plasticity index	0.50		
455819:							
Los Osos	85	Moderately suited		Unsuited		Severe	
		Stickiness; high plasticity index	0.50	Slope	1.00	Low strength	1.00
		Slope	0.50	Stickiness; high plasticity index	0.50		

Table 5.—Land Management, Part II (Hazard of Erosion and Suitability for Roads)

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and soil name	Pct. of map unit	Hazard of erosion: Rating class and limiting features	Value	Hazard of erosion on roads and trails: Rating class and limiting features	Value	Suitability for roads (natural surface): Rating class and limiting features	Value
455765:							
Botella	85	Slight		Slight		Moderately suited	
						Low strength	0.50
455796:							
Garretson	85	Slight		Slight		Moderately suited	
						Low strength	0.50
455815:							
Los Gatos	85	Moderate		Severe		Poorly suited	
		Slope/erodibility	0.50	Slope/erodibility	0.95	Slope	1.00
						Low strength	0.50
455816:							
Los Gatos	85	Severe		Severe		Poorly suited	
		Slope/erodibility	0.75	Slope/erodibility	0.95	Slope	1.00
						Low strength	0.50
455818:							
Los Osos	85	Moderate		Severe		Poorly suited	
		Slope/erodibility	0.50	Slope/erodibility	0.95	Slope	1.00
						Low strength	0.50
455819:							
Los Osos	85	Severe		Severe		Poorly suited	
		Slope/erodibility	0.75	Slope/erodibility	0.95	Slope	1.00
						Low strength	0.50

Table 5.—Land Management, Part III (Site Preparation)

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and soil name	Pct. of map unit	Suitability for mechanical site preparation (deep): Rating class and limiting features	Value	Suitability for mechanical site preparation (surface): Rating class and limiting features	Value
455765:					
Botella	85	Well suited		Well suited	
455796:					
Garretson	85	Well suited		Well suited	
455815:					
Los Gatos	85	Poorly suited		Poorly suited	
		Slope	0.50	Slope	0.50
		Restrictive layer	0.50		
455816:					
Los Gatos	85	Unsuited		Unsuited	
		Slope	1.00	Slope	1.00
		Restrictive layer	0.50		
455818:					
Los Osos	85	Poorly suited		Poorly suited	
		Slope	0.50	Slope	0.50
455819:					
Los Osos	85	Unsuited		Unsuited	
		Slope	1.00	Slope	1.00

Table 5.—Land Management, Part IV (Site Restoration)

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and soil name	Pct. of map unit	Potential for damage to soil by fire: Rating class and limiting features	Value	Potential for seedling mortality: Rating class and limiting features	Value
455765:					
Botella	85	Low		Moderate	
				Available water	0.50
455796:					
Garretson	85	Moderate		Moderate	
		Texture/rock fragments	0.50	Available water	0.50
455815:					
Los Gatos	85	Low		Low	
		Texture/rock fragments	0.10		
455816:					
Los Gatos	85	Low		Low	
		Texture/slope/ rock fragments	0.10		
455818:					
Los Osos	85	Low		Low	
455819:					
Los Osos	85	Low		Low	

Table 6.—Recreation, Part I (Camp and Picnic Areas)

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and soil name	Pct. of map unit	Camp areas: Rating class and limiting features	Camp areas: Value	Picnic areas: Rating class and limiting features	Picnic areas: Value
455765:					
Botella	85	Not limited		Not limited	
455796:					
Garretson	85	Somewhat limited		Somewhat limited	
		Dusty	0.50	Dusty	0.50
455815:					
Los Gatos	85	Very limited		Very limited	
		Slope	1.00	Slope	1.00
455816:					
Los Gatos	85	Very limited		Very limited	
		Slope	1.00	Slope	1.00
455818:					
Los Osos	85	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Slow water movement	0.41	Slow water movement	0.41
455819:					
Los Osos	85	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Slow water movement	0.41	Slow water movement	0.41

Table 6.—Recreation, Part II (Trail Management)

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and soil name	Pct. of map unit	Foot traffic and equestrian trails		Mountain bike and off-road vehicle trails	
		Rating class and limiting features	Value	Rating class and limiting features	Value
455765:					
Botella	85	Not limited		Not limited	
455796:					
Garretson	85	Somewhat limited		Somewhat limited	
		Dusty	0.50	Dusty	0.50
455815:					
Los Gatos	85	Somewhat limited		Not limited	
		Slope	0.92		
455816:					
Los Gatos	85	Very limited		Very limited	
		Slope	1.00	Slope	1.00
455818:					
Los Osos	85	Somewhat limited		Not limited	
		Slope	0.92		
455819:					
Los Osos	85	Very limited		Very limited	
		Slope	1.00	Slope	1.00

Table 7.—Dwellings and Small Commercial Buildings

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and soil name	Pct. of map unit	Dwellings without basements		Dwellings with basements		Small commercial buildings	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
455765:							
Botella	85	Somewhat limited		Somewhat limited		Somewhat limited	
		Shrink-swell	0.50	Shrink-swell	0.50	Shrink-swell	0.50
455796:							
Garretson	85	Not limited		Not limited		Not limited	
455815:							
Los Gatos	85	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to hard bedrock	0.71	Depth to hard bedrock	1.00	Depth to hard bedrock	0.71
		Shrink-swell	0.50	Shrink-swell	0.50	Shrink-swell	0.50
455816:							
Los Gatos	85	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to hard bedrock	0.71	Depth to hard bedrock	1.00	Depth to hard bedrock	0.71
		Shrink-swell	0.50	Shrink-swell	0.50	Shrink-swell	0.50
455818:							
Los Osos	85	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Shrink-swell	1.00	Shrink-swell	1.00	Shrink-swell	1.00
				Depth to soft bedrock	0.29		
455819:							
Los Osos	85	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Shrink-swell	1.00	Shrink-swell	1.00	Shrink-swell	1.00
				Depth to soft bedrock	0.29		

Table 8.—Roads and Streets, Shallow Excavations, and Landscaping

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and soil name	Pct. of map unit	Local roads and streets: Rating class and limiting features	Value	Shallow excavations: Rating class and limiting features	Value	Landscaping: Rating class and limiting features	Value
455765:							
Botella	85	Very limited		Somewhat limited		Not limited	
		Low strength	1.00	Unstable excavation walls	0.10		
		Shrink-swell	0.50				
455796:							
Garretson	85	Not limited		Somewhat limited		Not limited	
				Unstable excavation walls	0.10		
455815:							
Los Gatos	85	Very limited		Very limited		Very limited	
		Slope	1.00	Depth to hard bedrock	1.00	Slope	1.00
		Low strength	0.78	Slope	1.00	Depth to bedrock	0.71
		Depth to hard bedrock	0.71	Unstable excavation walls	0.10		
		Shrink-swell	0.50				
455816:							
Los Gatos	85	Very limited		Very limited		Very limited	
		Slope	1.00	Depth to hard bedrock	1.00	Slope	1.00
		Low strength	0.78	Slope	1.00	Depth to bedrock	0.71
		Depth to hard bedrock	0.71	Unstable excavation walls	0.10		
		Shrink-swell	0.50				
455818:							
Los Osos	85	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Shrink-swell	1.00	Depth to soft bedrock	0.29	Depth to bedrock	0.29
		Low strength	1.00	Unstable excavation walls	0.10		
				Too clayey	0.03		
455819:							
Los Osos	85	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Shrink-swell	1.00	Depth to soft bedrock	0.29	Depth to bedrock	0.29
		Low strength	1.00	Unstable excavation walls	0.10		
				Too clayey	0.03		

Table 9.—Sewage Disposal

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and soil name	Pct. of map unit	Septic tank absorption fields: Rating class and limiting features	Septic tank absorption fields: Value	Sewage lagoons: Rating class and limiting features	Sewage lagoons: Value
455765:					
Botella	85	Very limited		Not limited	
		Slow water movement	1.00		
455796:					
Garretson	85	Somewhat limited		Somewhat limited	
		Slow water movement	0.50	Seepage	0.50
455815:					
Los Gatos	85	Very limited		Very limited	
		Depth to bedrock	1.00	Depth to hard bedrock	1.00
		Slow water movement	1.00	Slope	1.00
		Slope	1.00	Seepage	0.27
455816:					
Los Gatos	85	Very limited		Very limited	
		Depth to bedrock	1.00	Depth to hard bedrock	1.00
		Slow water movement	1.00	Slope	1.00
		Slope	1.00	Seepage	0.27
455818:					
Los Osos	85	Very limited		Very limited	
		Depth to bedrock	1.00	Depth to soft bedrock	1.00
		Slow water movement	1.00	Slope	1.00
		Slope	1.00		
455819:					
Los Osos	85	Very limited		Very limited	
		Depth to bedrock	1.00	Depth to soft bedrock	1.00
		Slow water movement	1.00	Slope	1.00
		Slope	1.00		

Table 10.—Source of Gravel and Sand

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The ratings given for the thickest layer are for the thickest layer above and excluding the bottom layer. The numbers in the value columns range from 0.00 to 0.99. The greater the value, the greater the likelihood that the bottom layer or thickest layer of the soil is a source of sand or gravel. See text for further explanation of ratings in this table)

Map unit symbol and soil name	Pct. of map unit	Gravel source: Rating class and limiting features	Gravel source: Value	Sand source: Rating class and limiting features	Sand source: Value
455765:					
Botella	85	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
455796:					
Garretson	85	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
455815:					
Los Gatos	85	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
455816:					
Los Gatos	85	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
455818:					
Los Osos	85	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
455819:					
Los Osos	85	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00

Table 11.—Source of Reclamation Material, Roadfill, and Topsoil

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.00 to 0.99. The smaller the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and soil name	Pct. of map unit	Source of reclamation material: Rating class and limiting features	Value	Roadfill source: Rating class and limiting features	Value	Topsoil source: Rating class and limiting features	Value
455765:							
Botella	85	Fair		Poor		Fair	
		Too clayey	0.88	Low strength	0.00	Too clayey	0.73
		Too acid	0.95	Shrink-swell	0.87		
		Water erosion	0.99				
455796:							
Garretson	85	Fair		Good		Good	
		Low content of organic matter	0.12				
455815:							
Los Gatos	85	Fair		Poor		Poor	
		Low content of organic matter	0.12	Depth to bedrock	0.00	Slope	0.00
				Slope	0.08	Depth to bedrock	0.29
		Depth to bedrock	0.29	Low strength	0.22		
		Droughty	0.57				
455816:							
Los Gatos	85	Fair		Poor		Poor	
		Low content of organic matter	0.12	Depth to bedrock	0.00	Slope	0.00
				Slope	0.00	Depth to bedrock	0.29
		Depth to bedrock	0.29	Low strength	0.22		
		Droughty	0.57				
455818:							
Los Osos	85	Poor		Poor		Poor	
		Too clayey	0.00	Depth to bedrock	0.00	Slope	0.00
		Low content of organic matter	0.12	Low strength	0.00	Too clayey	0.00
				Shrink-swell	0.12	Depth to bedrock	0.71
		Droughty	0.84				
455819:							
Los Osos	85	Poor		Poor		Poor	
		Too clayey	0.00	Depth to bedrock	0.00	Slope	0.00
		Low content of organic matter	0.12	Slope	0.00	Too clayey	0.00
				Low strength	0.00	Depth to bedrock	0.71
		Droughty	0.84				

Table 12.—Ponds and Embankments

(Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table)

Map unit symbol and soil name	Pct. of map unit	Pond reservoir areas		Embankments, dikes, and levees		Aquifer-fed excavated ponds	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
455765:							
Botella	85	Somewhat limited		Somewhat limited		Very limited	
		Seepage	0.03	Piping	0.12	Depth to water	1.00
455796:							
Garretson	85	Somewhat limited		Very limited		Very limited	
		Seepage	0.70	Piping	1.00	Depth to water	1.00
455815:							
Los Gatos	85	Very limited		Somewhat limited		Very limited	
		Slope	1.00	Piping	0.98	Depth to water	1.00
		Depth to bedrock	0.93	Thin layer	0.93		
		Seepage	0.53				
455816:							
Los Gatos	85	Very limited		Somewhat limited		Very limited	
		Slope	1.00	Piping	0.98	Depth to water	1.00
		Depth to bedrock	0.93	Thin layer	0.93		
		Seepage	0.53				
455818:							
Los Osos	85	Very limited		Somewhat limited		Very limited	
		Slope	1.00	Thin layer	0.81	Depth to water	1.00
		Depth to bedrock	0.08				
455819:							
Los Osos	85	Very limited		Somewhat limited		Very limited	
		Slope	1.00	Thin layer	0.81	Depth to water	1.00
		Depth to bedrock	0.08				

Table 13.—Engineering Properties

(Absence of an entry indicates that data were not estimated)

Map unit symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 in	Fragments: 3-10 in	Percentage passing sieve number--: 4	Percentage passing sieve number--: 10	Percentage passing sieve number--: 40	Percentage passing sieve number--: 200	Liquid limit	Plasticity index
	In				Pct	Pct					Pct	
455765:												
Botella---------	0-3	Clay loam	CL	A-6	0	0	100	100	85-95	70-80	30-40	15-20
	3-68	Silty clay loam	CL	A-6	0	0	100	100	85-95	70-80	30-40	15-20
455796:												
Garretson-------	0-25	Loam	ML, CL-ML	A-4	0	0	100	100	85-95	70-75	25-35	5-10
	25-60	Loam	CL-ML, CL	A-4	0	0	100	100	85-95	70-75	25-35	5-10
455815:												
Los Gatos-------	0-8	Loam	CL, CL-ML	A-4	0	0	100	100	85-95	60-75	15-25	5-10
	8-27	Clay loam, loam	CL	A-6	0	0	100	100	85-95	60-80	30-35	10-15
	27-30	Unweathered bedrock			0	0	0	0	0	0	0-0	NP
455816:												
Los Gatos-------	0-8	Loam	CL, CL-ML	A-4	0	0	100	100	85-95	60-75	15-25	5-10
	8-27	Clay loam, loam	CL	A-6	0	0	100	100	85-95	60-80	30-35	10-15
	27-30	Unweathered bedrock			0	0	0	0	0	0	0-0	NP
455818:												
Los Osos--------	0-10	Clay loam	CL	A-6	0	0	100	95-100	85-100	75-95	30-40	10-15
	10-32	Clay loam, clay	CL	A-7	0	0	100	95-100	85-100	75-95	40-50	20-30
	32-36	Weathered bedrock			0	0	0	0	0	0	0-0	NP
455819:												
Los Osos--------	0-10	Clay loam	CL	A-6	0	0	100	95-100	85-100	75-95	30-40	10-15
	10-32	Clay loam, clay	CL	A-7	0	0	100	95-100	85-100	75-95	40-50	20-30
	32-36	Weathered bedrock			0	0	0	0	0	0	0-0	NP

Table 14.—Physical Soil Properties

(Sand, silt, and clay values are shown either as a range or as a representative value. Absence of an entry indicates that data were not estimated)

Map unit symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Permeability (Ksat)	Available water capacity	Shrink-swell potential	Organic matter
	In	Pct	Pct	Pct	g/cc	In/hr	In/in	Pct	Pct
455765:									
Botella---------	0-3	35	34	27-35	1.35-1.45	0.2-0.6	0.18-0.20	3.0-5.9	2.0-6.0
	3-68	18	50	30-35	1.30-1.40	0.2-0.6	0.18-0.20	3.0-5.9	0.5-2.0
455796:									
Garretson-------	0-25	42	38	15-25	1.45-1.55	0.6-2.0	0.15-0.17	0.0-2.9	0.5-2.0
	25-60	40	38	18-27	1.45-1.55	0.6-2.0	0.15-0.17	0.0-2.9	0.0-0.5
455815:									
Los Gatos-------	0-8	40	38	20-25	1.45-1.55	0.6-2.0	0.14-0.18	0.0-2.9	1.0-4.0
	8-27	34	36	25-35	1.40-1.50	0.2-0.6	0.16-0.17	3.0-5.9	0.0-0.5
	27-30	0-0	0	0-0	---	0.2-2.0	---	0.0-0.0	0.0-0.0
455816:									
Los Gatos-------	0-8	40	38	20-25	1.45-1.55	0.6-2.0	0.14-0.18	0.0-2.9	1.0-4.0
	8-27	34	36	25-35	1.40-1.50	0.2-0.6	0.16-0.17	3.0-5.9	0.0-0.5
	27-30	0-0	0	0-0	---	0.2-2.0	---	0.0-0.0	0.0-0.0
455818:									
Los Osos--------	0-10	35	34	27-35	1.40-1.50	0.2-0.6	0.17-0.19	3.0-5.9	2.0-4.0
	10-32	28	30	35-50	1.35-1.45	0.1-0.2	0.14-0.16	6.0-8.9	0.0-0.5
	32-36	0-0	0	0-0	---	0.0-0.2	---	0.0-0.0	0.0-0.0
455819:									
Los Osos--------	0-10	35	34	27-35	1.40-1.50	0.2-0.6	0.17-0.19	3.0-5.9	2.0-4.0
	10-32	28	30	35-50	1.35-1.45	0.1-0.2	0.14-0.16	6.0-8.9	0.0-0.5
	32-36	0-0	0	0-0	---	0.0-0.2	---	0.0-0.0	0.0-0.0

Table 15.—Erosion Properties

(Entries under "Erosion factors" apply to the entire profile. Entries under "Wind erodibility group" and "Wind erodibility index" apply only to the surface layer)

Map unit symbol and soil name	Depth (inches)	Erosion factors			Wind erodibility group	Wind erodibility index
		Kw	Kf	T		
455765:						
Botella	0-3	.24	.24	5	6	48
	3-68	.37	.37			
455796:						
Garretson	0-25	.32	.32	5	6	48
	25-60	.32	.32			
455815:						
Los Gatos	0-8	.28	.28	2	6	48
	8-27	.28	.28			
	27-30	---	---			
455816:						
Los Gatos	0-8	.32	.32	2	6	48
	8-27	.24	.24			
	27-30	---	---			
455818:						
Los Osos	0-10	.28	.28	3	6	48
	10-32	.32	.32			
	32-36	---	---			
455819:						
Los Osos	0-10	.28	.28	3	6	48
	10-32	.32	.32			
	32-36	---	---			

Table 16.—Total Soil Carbon

(This table displays soil organic carbon (SOC) and soil inorganic carbon (SIC) in kilograms per square meter to a depth of 2 meters or to the representative top depth of any kind of bedrock or any cemented soil horizon. SOC and SIC are reported on a volumetric whole soil basis, corrected for representative rock fragments indicated in the database. SOC is converted from horizon soil organic matter of the fraction of the soil less than 2 mm in diameter. If soil organic matter indicated in the database is NULL, SOC is assumed to be zero. SIC is converted from horizon calcium carbonate content fraction of the soil less than 2 mm in diameter. If horizon calcium carbonate indicated in the database is NULL, SIC is assumed to be zero. A weighted average of all horizons is used in the calculations. Only major components of a map unit are displayed in this table)

Map unit symbol, component name, and component percent	SOC	SIC
	kg/m^2	kg/m^2
455765:		
Botella (85%)	19	0
455796:		
Garretson (85%)	9	0
455815:		
Los Gatos (85%)	5	0
455816:		
Los Gatos (85%)	5	0
455818:		
Los Osos (85%)	7	0
455819:		
Los Osos (85%)	7	0

Table 17.—Chemical Soil Properties

(Absence of an entry indicates that data were not estimated)

Map unit symbol and soil name	Depth	Cation-exchange capacity	Effective cation-exchange capacity	Soil reaction	Salinity
	In	meq/100 g	meq/100 g	pH	mmhos/cm
455765:					
Botella--------------	0-3	15.0-33.0	---	5.6-6.5	0.0-2.0
	3-68	13.0-25.0	---	6.1-7.3	0.0-2.0
455796:					
Garretson------------	0-25	7.0-19.0	---	6.1-7.3	---
	25-60	7.0-17.0	---	6.1-7.8	---
455815:					
Los Gatos------------	0-8	10.0-23.0	---	5.6-6.5	---
	8-27	10.0-22.0	---	5.6-6.5	---
	27-30	0.0-0.0	0.0-1.0	---	0
455816:					
Los Gatos------------	0-8	10.0-23.0	---	5.6-6.5	---
	8-27	10.0-22.0	---	5.6-6.5	---
	27-30	0.0-0.0	---	---	0
455818:					
Los Osos-------------	0-10	20.0-36.0	---	5.6-7.3	---
	10-32	21.0-41.0	---	5.6-7.3	---
	32-36	0.0-0.0	---	---	0
455819:					
Los Osos-------------	0-10	20.0-36.0	---	5.6-7.3	---
	10-32	21.0-41.0	---	5.6-7.3	---
	32-36	0.0-0.0	---	---	0

Table 18.—Water Features

(See text for definitions of terms used in this table. Estimates of the frequency of ponding and flooding apply to the whole year rather than to individual months. Absence of an entry indicates that the feature is not a concern or that data were not estimated)

Map unit symbol and soil name	Hydro-logic group	Months	Water table: Upper limit	Water table: Lower limit	Ponding: Surface water depth	Ponding: Duration	Ponding: Frequency	Flooding: Duration	Flooding: Frequency
			Ft	Ft	Ft				
455765:									
Botella	B								
		Jan-Dec	---	---	---	---	None	---	None
455796:									
Garretson	B								
		Jan-Dec	---	---	---	---	None	---	None
455815:									
Los Gatos	C								
		Jan-Dec	---	---	---	---	None	---	None
455816:									
Los Gatos	C								
		Jan-Dec	---	---	---	---	None	---	None
455818:									
Los Osos	C								
		Jan-Dec	---	---	---	---	None	---	None
455819:									
Los Osos	C								
		Jan-Dec	---	---	---	---	None	---	None

Table 19.—Soil Features

(See text for definitions of terms used in this table. Absence of an entry indicates that data were not estimated)

Map unit symbol and soil name	Restrictive layer			Potential for frost action	Risk of corrosion	
	Kind	Depth to top	Hardness		Uncoated steel	Concrete
		In				
455765:						
Botella	---	---	---	None	Moderate	Moderate
455796:						
Garretson	---	---	---	None	Low	Low
455815:						
Los Gatos	Lithic bedrock	20-40	Indurated	None	Moderate	Moderate
455816:						
Los Gatos	Lithic bedrock	20-40	Indurated	None	Moderate	Moderate
455818:						
Los Osos	Paralithic bedrock	24-40	Extremely weakly cemented	None	High	Moderate
455819:						
Los Osos	Paralithic bedrock	24-40	Extremely weakly cemented	None	High	Moderate

Table 20.—Taxonomic Classification of the Soils

Soil name	Family or higher taxonomic class
Botella	Fine-loamy, mixed, superactive, thermic Pachic Argixerolls
Garretson	Fine-loamy, mixed, nonacid, thermic Typic Xerorthents
Los Gatos	Fine-loamy, mixed, mesic Typic Argixerolls
Los Osos	Fine, smectitic, thermic Typic Argixerolls

Table 21.—Soil Classification Key

ORDER Suborder Great Group Subgroup Series or Higher Category	
ENTISOLS	
Orthents	
Xerorthents	
Typic Xerorthents	
Garretson	Fine-loamy, mixed, nonacid, thermic Typic Xerorthents
MOLLISOLS	
Xerolls	
Argixerolls	
Typic Argixerolls	
Los Osos	Fine, smectitic, thermic Typic Argixerolls
Los Gatos	Fine-loamy, mixed, mesic Typic Argixerolls
Pachic Argixerolls	
Botella	Fine-loamy, mixed, superactive, thermic Pachic Argixerolls

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