SECTION II
A. SOILS INFORMATION

4. SOIL INTERPRETATIONS
j. Engineering

INTRODUCTION

Some soil properties may be of special interest to engineers because of their effect on the construction and maintenance of roads, pipelines, foundations, and structures of many types. Properties such as permeability, compaction characteristics, plasticity, depth to water table and bedrock, soil drainage, and shrink-swell potential are important in making land-use decisions, planning farm practices, selecting project locations, and determining the suitability of soils for certain activities. Much of this information can be found in the Official Soil Survey Information for a soil survey area in the Soil Data Mart or Web Soil Survey.

Soil properties relating to engineering interpretations are determined by field examination of the soils and by laboratory index testing of some benchmark soils. During the survey, many shallow borings are made and examined to identify and classify the soils and to delineate them on soil maps. Samples are taken from some typical profiles and tested in the laboratory to determine grain-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 characterize key soils. Pertinent soil and water features are also provided in this subsection.

This subsection includes the following discussions and tables:

Engineering Index Properties
Physical and Chemical Properties
Water Features
Soil Features
Water Management Interpretations
Irrigation Interpretations

ENGINEERING PROPERTIES TABLE

General

This table gives estimates of the engineering classification and the range of index properties for the major layers of each soil in the survey areas. Most soils have layers of contrasting properties within the upper 5 to 6 feet. Information in this table includes depth, USDA texture, Unified and AASHTO Classifications, rock fragments larger than 3 inches in diameter, percentage passing designated sieves, liquid limit, and plasticity index.

Properties

DEPTH – The upper and lower boundaries of each layer is indicated.

USDA TEXTURE – Standard texture classes used by the USDA. The classes are defined according to the percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. Texture terms are defined in Chapter 4 of the USDA-NRCS Soil Survey Manual. If the content of particles coarser than 2 mm is 15 percent or more, an appropriate texture modifier such as “gravelly” is used (e.g. gravelly sandy loam).

UNIFIED CLASSIFICATION – Classifies soils according to properties that affect their use as construction material. Soils are classified according to grain-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content.

AASHTO CLASSIFICATION – Classification system adopted by the American Association of State Highway and Transportation Officials. It classifies soils according to those properties that affect road construction.

ROCK FRAGMENTS – 3 to 10 inches (cobbles) and greater than 10 inches (stones) in diameter, as indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentages in the field to a weight percentage.

PERCENT PASSING SIEVE NUMBER – The percentage of the soil fraction less than 3 inches in diameter based on an oven-dry weight. The sieves, numbers 4, 1o, 40, and 200 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 – (Atterburg Limits) Indicates the plasticity characteristics of a soil. The estimates are based on test data from the survey areas, or from nearby areas, and on field examination.

The Engineering Properties table is available for each California soil survey area in the USDA-NRCS Soil Data Mart. Within the Web Soil Survey the table is found under the "Soil Reports" tab, under the section "Soil Physical Properties".

PHYSICAL SOIL PROPERTIES TABLE

General

This table shows estimates of some characteristics and features that affect soil behavior. These estimates are given for the major layers of each soil in the soil survey area. The estimates are based on field observations and on test data for these and similar soils. Information in this table includes depth, percent sand, silt, and clay, moist bulk density, saturated hydraulic conductivity, available water capacity, linear extensibility (shrink-swell potential), organic matter content, K and T erosion factors, wind erodibility group, and wind erodibility index.

Properties

DEPTH – The upper and lower boundaries of each layer is indicated.

SAND – As a soil separate consists of mineral soil particles that are 0.05 millimeters 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 .002 millimeters to 0.05 millimeters 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 .002 millimeters 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.

MOIST BULK DENSITY – The weight of a soil (oven-dry) per unit volume. In this table, 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.

SATURATED HYDRAULIC CONDUCTIVITY (Ksat) – The ease with which soil pores in a saturated soil transmit water. The estimates in the table are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity (Ksat) is considered in the design of soil drainage systems and septic tank adsorption fields.

AVAILABLE WATER CAPACITY – Is 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 water retention. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important in the choice of plants or crops to be grown and in the design and management of irrigation systems.

LINEAR EXTENSIBILITY – Refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3 or 1/10 bar tension and oven dryness. The volume change is reported in the table as a percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design is commonly needed.

ORGANIC MATTER – The plant and animal residue in the soil at various stages of decomposition. In this table, 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.

EROSION FACTORS – Are shown in the table as the K factor (Kw and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is 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 Ksat. 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.

Kw – Indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Kf – Indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

T – 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 GROUP – Groups of soils that have similar properties affecting 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. Wind Erodibility Groups are described in the USDA-NRCS National Soil Survey Handbook.

WIND ERODIBILITY INDEX – 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.

The Physical Properties table is available for each California soil survey area in the USDA-NRCS Soil Data Mart. Within the Web Soil Survey the table is found under the "Soil Reports" tab, under the section "Soil Physical Properties".

CHEMICAL SOIL PROPERTIES TABLE

General

This table shows estimates of some characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils. Information in this table includes depth, cation exchange capacity, effective cation exchange capacity, soil reaction, calcium carbonate, gypsum, salinity, and sodium adsorption ratio.

DEPTH – The upper and lower boundaries of each layer is indicated.

CATION EXCHANGE CAPACITY - The total amount of extractable bases 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.

EFFECTIVE CATION EXCHANGE CAPACITY – The sum of extractable bases 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 – A measure of a soil's acidity or alkalinity. It is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

CALCIUM CARBONATE EQUIVALENT – The percent of carbonates, by weight, in the fraction of the soil less than 2 millimeters in size. The availability of plant nutrients is influenced by the amount of carbonates in the soil.

GYPSUM – The percent of hydrated calcium sulfates, by weight, in the fraction of the soil less than 2 millimeters in size. Gypsum is partially soluble in water. Soils that have a high content of gypsum may collapse if the gypsum is removed by percolating water.

SALINITY – A measure of soluble salts in the soil at saturation, it is 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 non-irrigated soils. The salinity of irrigated soils is affected by the quality of the irrigation water and 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 if used as construction material, and the potential of the soil to corrode metal and concrete.

SODIUM ADSORPTION RATIO (SAR) - The measure of the amount of sodium (Na) relative to calcium 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. Soils that have SAR values of 13 or more may be characterized by an increased dispersion of organic matter and clay particles, reduced saturated hydraulic conductivity and aeration, and a general degradation of soil structure.

The Chemical Properties table is available for each California soil survey area in the USDA-NRCS Soil Data Mart. Within the Web Soil Survey the table is found under the "Soil Reports" tab, under the section "Soil Chemical Properties".

SOIL FEATURES TABLE

General

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

RESTRICTIVE LAYER – 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 restricts roots or otherwise provides an unfavorable root environment. Examples are bedrock, cemented layers, dense layers, and frozen layers. The table indicates the hardness and thickness of the restrictive layer, both of which significantly affect the ease of excavation. "Depth to top" is the vertical distance from the soil surface to the upper boundary of the restrictive layer.

SUBSIDENCE – The settlement of organic soils or of saturated mineral soils of very low density. Subsidence generally results from either desiccation and shrinkage, or oxidation of organic material, or both, following drainage. Subsidence takes place gradually, usually over a period of several years. The table shows the expected initial subsidence, which usually is a result of drainage, and total subsidence, which results from a combination of factors.

POTENTIAL FOR FROST ACTION – 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 (Ksat), organic matter content, 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 – The 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 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.

The Soil Features table is available for each California soil survey area in the USDA-NRCS Soil Data Mart. Within the Web Soil Survey the table is found under the "Soil Reports" tab, under the section "Soil Qualities and Features".

WATER FEATURES TABLE

General

This table gives estimates of various soil water features. The estimates are used in land use planning and involve engineering considerations.

HYDROLOGIC SOIL GROUP – Soil groups 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 soils consist of mainly deep, well 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 soils consist of moderately deep or deep, moderately well or well drained soils that have a

moderately fine 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 that have a layer that impedes the downward movement of water or soils of moderately fine or fine texture. These soils shave 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 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.

SURFACE RUNOFF – The loss of water from an area by flow over the land surface. Surface runoff classes are based on slope, climate, and vegetative cover. The concept indicates relative runoff for very specific conditions. It is assumed that the surface of the soil is bare and that the retention of surface water resulting from irregularities in the ground surface is minimal. The classes are: negligible, very low, low, medium, high, and very high.

MONTH – Indicates the portion of the year in which a water table, ponding, and/or flooding is most likely to occur

WATER TABLE – A saturated zone within the soil. The water features table 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 redoximorphic features in the soil. A saturated zone that lasts for less than a month is not considered a water table.

PONDING – 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 from 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; "occasional" that it occurs, on the average, once or less in 2 years; and "frequent" that it occurs, on the average, more than once in 2 years.

FLOODING – The temporary inundation of an area caused by overflowing streams, 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 to 4 hours; "very brief" if from 4 hours to 2 days; "brief" if from 2 to 7 days; "long" if from 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 (chance of less than 1 percent in any year); "rare" that it is unlikely but possible under unusual weather conditions (chance of flooding 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 (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 Water Features table is available for each California soil survey area in the USDA-NRCS Soil Data Mart. Within the Web Soil Survey the table is found under the "Soil Reports" tab, under the section "Water Features".

WATER MANAGEMENT INTERPRETATIONS

Interpretations of soils for water management available through the Soil Data Mart or Web Soil Survey are: "Embankments, dikes, and levees", "Pond reservoir area", and "Excavated ponds (aquifer-fed)". Rating class terms indicate the extent to which soils are limited by all the soil features that affect these uses. "No Limitations" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Limitations" indicates that the soil has features that are favorable to unfavorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair to poor performance and moderate 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 use (1.00) and the point at which the soil feature is not a limitation (0.00).

Pond Reservoir Area (CA)

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 (Ksat) 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 (CA)

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 about 5 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 on-site 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.

Excavated Ponds (aquifer-fed)

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, Ksat 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.

IRRIGATION INTERPRETATIONS

These interpretations show the degree and kind of soil limitations that affect the irrigation of soils in California. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all the soil features that affect these uses. “No Limitations” indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance are expected. “Limitations” indicates that the soil has features that are favorable to unfavorable for the specified use. Each interpretation only shows the top limitations for any given soil. The limitations can be overcome or minimized by special planning, design, or installation. Fair to poor performance and moderate to high maintenance can be expected, depending on the number of limitations and the severity of each limitation.

Numerical ratings in the tables 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 limitation (0.0).

The following irrigation interpretations are available through the Soil Data Mart or Web Soil Survey for California soil survey areas:

Basin or paddy irrigation (CA)

Graded border irrigation (CA)

Furrow irrigation (CA)

Sprinkler irrigation (CA)

Drip or trickle irrigation (CA)

These interpretations were developed by the Davis, California interpretation staff. The interpretation was developed using input from the Davis, California NRCS – Resource Technology staff. The interpretations received further technical review from an irrigation specialist on staff at UC-Davis.

IMPORTANT: These interpretations are not designed nor intended to be used in a regulatory manner.

The soil properties and qualities important in design and management are the sodium adsorption ratio, depth to a seasonal high water table, the available water capacity, saturated hydraulic conductivity, wind erodibility, erosion factor, slope, and flooding. The soil properties and qualities that influence construction are stones, depth to bedrock or to a cemented pan, and depth to a seasonal high water table. The properties and qualities that affect performance of the irrigation system are depth to bedrock or cemented pan, bulk density, the sodium adsorption ratio, salinity, and soil reaction. Permanently frozen soils are not suited to irrigation.