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DRAFT Chapter 4
180/400-Foot Aquifer Subbasin
Groundwater Sustainability Plan

Prepared for:

Salinas Valley Basin
Groundwater Sustainability Agency

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CHAPTER 4 HYDROGEOLOGIC CONCEPTUAL MODEL

4.1 SUBBASIN SETTING

The 180/400-Foot Aquifer Subbasin is at the northern, down-gradient end of the Salinas Valley Groundwater Basin – an approximately 90-mile long alluvial basin underlying the elongated, intermountain valley of the Salinas River. The Subbasin is oriented southeast to northwest, with the Salinas River draining towards the northwest into the Pacific Ocean at Monterey Bay (Figure 4-1).

The Subbasin slopes at an average grade of approximately 5 feet/mile to the northwest. Elevations in the Subbasin range from approximately 500 feet above mean sea level (msl) along the Sierra de Salinas to sea level at Monterey Bay. The colored bands on Figure 4-1 shows the topography of the Subbasin, derived from the United States Geological Survey (USGS) Digital Elevation Model (DEM).

4.2 SUBBASIN GEOLOGY

The Subbasin was formed through periods of structural deformation and periods of marine and terrestrial sedimentation in a tectonically active area on the eastern edge of the Pacific Plate. Figure 4-2 presents a geologic map of the basin and vicinity, illustrating both the locations of faults and the geologic formations present at ground surface. The legend in Figure 4-2 presents the age sequence of the geologic materials from the youngest unconsolidated Quaternary sediments to the oldest pre-Cambrian basement rock.

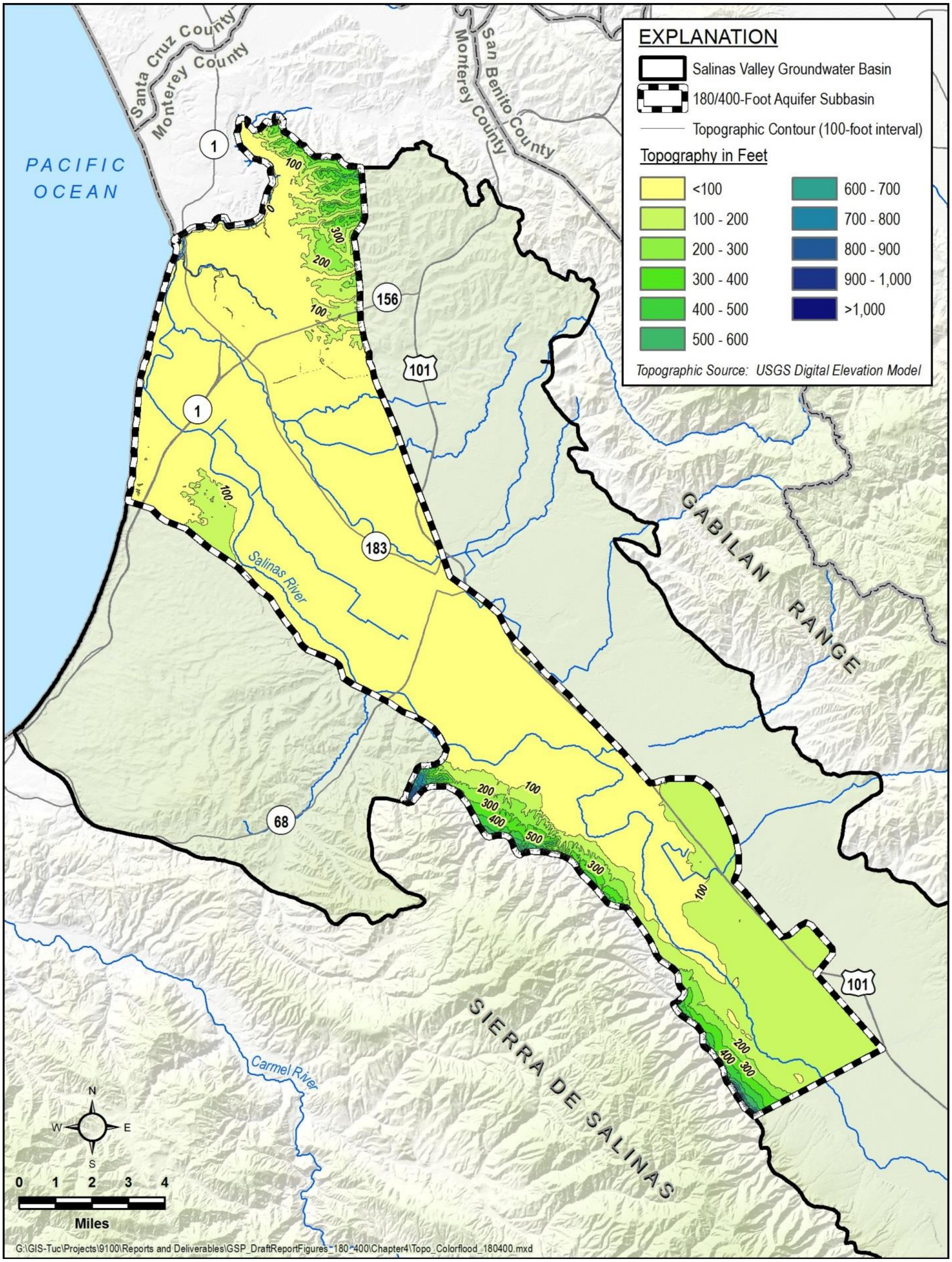

Figure 4-1: Salinas Valley Topography

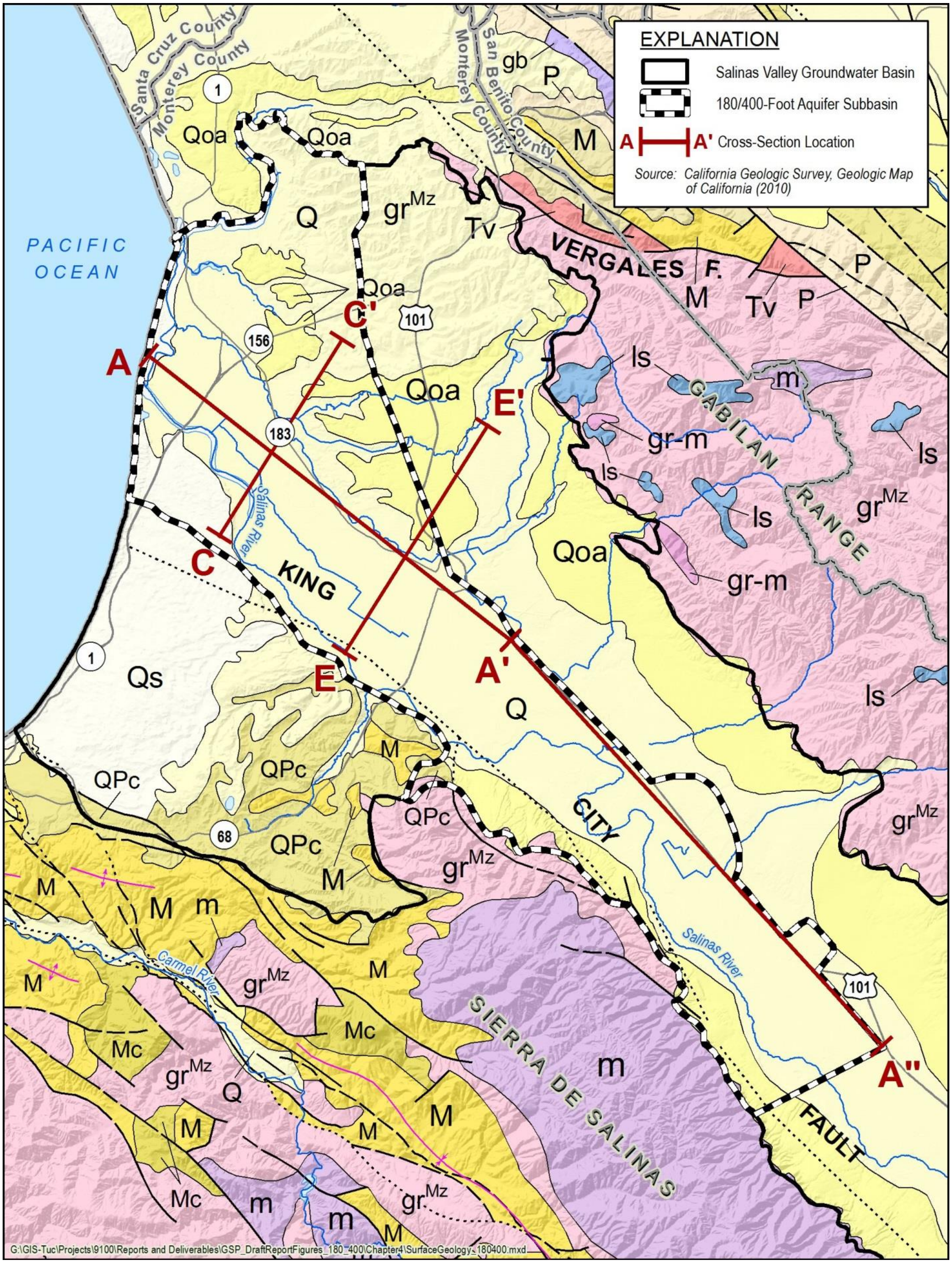

Figure 4-2: Subbasin Geology

FIGURE 4-2. EXPLANATION

QUATERNARY DEPOSITS

Qs	Extensive marine and nonmarine sand deposits, generally near the coast or desert playas
Q	Alluvium, lake, playa, and terrace deposits; unconsolidated and semi-consolidated
Qoa	Older alluvium, lake, playa, and terrace deposits
QPc	Pleistocene and/or Pliocene sandstone, shale, and gravel deposits, mostly loosely consolidated

TERTIARY SEDIMENTARY ROCKS

P	Pliocene marine sandstone, siltstone, shlae, and conglomerate, mostly moderately consolidated
M	Miocene marine sandstone, shale, siltstone, conglomerate, and breccia, moderately to well consolidated
Mc	Miocene nonmarine sandstone, shale, conglomerate, and fanglomerate, moderately to well consolidated
O	Oligocene marine sandstone, shale, and conglomerate, mostly well consolidated

TERTIARY VOLCANIC ROCKS

Tv	Tertiary volcanic flow rocks, minor pyroclastic deposits

MESOZOIC SEDIMENTARY AND METASEDIMENTARY ROCKS

ls	Limestone, dolomite, and marble whose age is uncertain but probably Paleozoic or Mesozoic

MESOZOIC MIXED ROCKS

gr-m	Mesozoic to Precambrian granitic and metamorphic rocks, mostly gneiss and other metamorphic rocks injected by granitic rocks

MESOZOIC PLUTONIC ROCKS

grMz	Mesozoic granite, quartz monzonite, granodiorite, and quartz diorite
gb	Gabbro and dark dioritic rocks, chiefly Mesozoic

PALEOZOIC MIXED ROCKS

m	Undivided pre-Cenozoic metasedimentary and metavolcanic rocks of great variety. Mostly slate, quartzite, hornfels, chert, phyllite, mylonite, schist gneiss, and minor marble

GEOLOGIC SYMBOLS

- fault, certain
- fault, approx. located
- fault, concealed
- normal fault, approx. located
- dextral fault, certain
- Plunging anticline, certain
- Syncline, certain

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4.2.1 GEOLOGIC FORMATIONS

Major geologic units present in the 180/400-Foot Subbasin are described below starting at the surface and moving through the strata from youngest to oldest. The corresponding designation on Figure 4-2 is provided in parenthesis.

- *Alluvium (Qa)* – This Holocene unit predominately consists of unconsolidated layers of mixed sand, gravel, silt, and clay that were deposited in a fluvial environment by the Salinas River and its tributaries. In this subbasin, this unit also includes extensive laterally-continuous clay layers that were deposited in a shallow marine to brackish-water estuarine environment during periods when sea level rise caused submergence of the northern portion of the basin (Durham, 1974). The estuarine deposits extend throughout most of the subbasin and are the primary characteristic defining this subbasin (Chapter 4.3). This unit covers nearly the entire valley floor and was deposited by precursors to current geomorphic features and therefore its distribution is approximately coincident with current geography. The thickness is not well established because the alluvium is difficult to distinguish from underlying units, but it is likely 100 to 300 feet thick along the axis of the valley (Durham, 1974).

In some reports, (e.g., Harding ESE 2001, and Kennedy-Jenks, 2004), the Qa is limited to the shallowest deposits overlying the first estuarine clay layer, and the remaining thickness of Qa described herein is combined with the underlying Older Alluvium (Qoa) to form a unit called Valley Fill Deposits (Qvf). These alternate geologic descriptions have not been adopted in this ISP, and do not have a bearing on the hydrostratigraphic nomenclature (Chapter 4.4.2) that forms the basis for the ISP and GSPs.

- *Older Alluvium (Qoa)* – This Pleistocene unit is composed of alternating, interconnected beds of fine-grained and coarse-grained deposits predominately associated with alluvial fan depositional environments. The Older Alluvium underlies the Alluvium (Qa) throughout the subbasin but is not exposed at the ground surface. The alluvial fan deposits have an estimated maximum saturated thickness of 500 feet (Durham, 1974).

- *Aromas Sand (QPc)* – This Pleistocene unit is composed of cross-bedded sand containing some clayey layers (Harding ESE, 2001). This unit was deposited in a combination of eolian, high-energy alluvial, alluvial fan, and shoreline (Harding ESE, 2001; Greene, 1970; and Dupre, 1990). The Aromas Sand may be up to 300 feet thick (Harding ESE, 2001) in the adjacent Monterey Subbasin (Harding ESE, 2001) and likely extends into the northern portion of the 180-400 Foot Aquifer Subbasin (MCWRA, 2017a), but is not found in other portions of the basin.

- *Paso Robles Formation (Tc)* – This Pliocene to lower Pleistocene unit is composed of lenticular beds of sand, gravel, silt, and clay from terrestrial deposition (Thorup, 1976, Durbin, 1978). The depositional environment is largely fluvial (Durbin, 1973) but also includes alluvial fan, lake and floodplain deposition (Harding ESE, 2001; Thorup, 1976; Greene, 1970). The alternating beds of fine and coarse materials typically have bed thicknesses of 20 to 60 feet (Durbin, 1978). The Paso Robles Formation overlies the Purisima Formation and underlies all of the subbasin but is rarely exposed at the surface. Durham (1974) reports that the thickness is variable due to erosion of the upper part of the unit and that the Formation is approximately 1,500 feet thick near Spreckels and 1,000 feet thick near Salinas. Through most of the subbasin, this is the deepest unit and the underlying marine deposits typically do not yield high rates of fresh water.

- *Purisima Formation (P)* – This Pliocene unit consists of intercalated siltstone, sandstone, conglomerate (Greene, 1977), clay and shale (Harding ESE, 2001) deposited in a shallow marine environment. The Purisima Formation is found in the subsurface in the subbasin and ranges from 500 to 1,000 feet in thickness (WRIME, 2003). It is the youngest consolidated sedimentary units encountered in the subbasin vicinity and for the most part underlies the basin.

- *Santa Margarita Sandstone and Monterey Formation (M)* – These Miocene units consists of friable arkosic sandstone (Santa Margarita) and shale/mudstone (Monterey) deposited in a shallow marine environment (Harding ESE, 2001; Greene, 1977). In some areas Santa Margarita Sandstone directly underlies the Paso Robles Formation where the Purisima Formation is absent (Greene, 1977). These units typically underlie the basin.

4.2.2 Structural Restrictions to Flow

There are no known structural features that restrict groundwater flow inside the 180/400-Foot Aquifer Subbasin.

4.2.3 SOILS

The soils of the Subbasin are derived from the underlying geologic formations and influenced by the historical and current patterns of climate and hydrology. Productive agriculture in the Subbasin is supported by deep, dark, fertile soils. The arable soils of Subbasin historically were classified into four groups (Carpenter and Cosby 1925): residual soils, old valley-filling soils, young valley-filling soils, and recent-alluvial soils. In addition, five classes of miscellaneous soils were mapped that included tidal marsh, peat, coastal beach and dune sands.

More recent surveys classify the soils into categories based on detailed soil taxonomy (U.S. Department of Agriculture, 2018). Figure 4-3 is a composite soil map of soils in the Subbasin from the USDA Natural Resources Conservation Service (NRCS) and the Gridded Soil Survey Geographic (gSSURGO) Database that is produced by the National Cooperative Soil Survey (NCSS).

The Subbasin is dominated by four soil orders: mollisols, entisols, vertisols, and alfisols.

- Mollisols are the most widespread soil order in the Salinas Valley. Mollisols are characterized by a dark surface horizon, indicative of high organic content. The organic content often originates from roots of surficial grasses or similar vegetation. They are highly fertile and often alkaline rich (calcium and magnesium). Mollisols can have any moisture regime, but enough available moisture to support perennial grasses is typical.

- Entisols are the predominant soil order along the river corridor. Entisols are mineral soils without distinct soil horizons because they have not been in place long enough for distinct horizons to develop. These soils are often found in areas of recent deposition such as active flood plains, river basins, and areas prone to landslides. Nearly all the soils along active river corridor are entisols.

- Vertisols are present over large areas on the valley lowlands in the central and northern Salinas Valley. Vertisols are predominantly clayey soils with high shrink-swell potential. Vertisols are present in climates that have distinct wet and dry seasons. During the dry season these soils commonly have deep, wide cracks. During the wet season these soils trend to have water pooling on the surface due to the high clay content.

- Alfisols are present along portions of the margin of the management area. Alfisols are known to have natural fertility both from clay acumination in the subsurface horizons and from leaf litter when under forested conditions. This order of soils is commonly associated with high base minerals such as calcium, magnesium, sodium, and potassium.

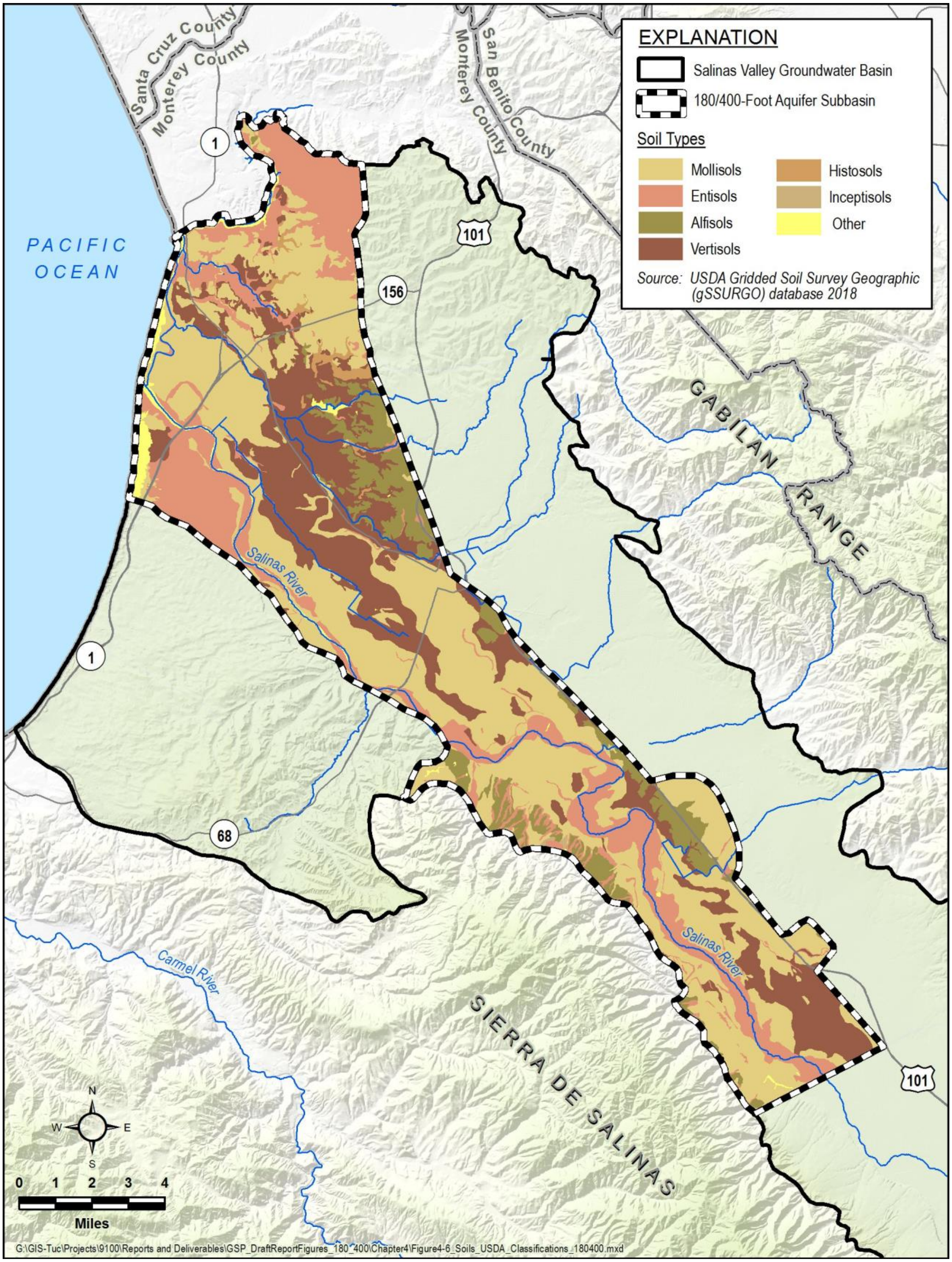

Figure 4-3: Composite Soils Map

4.3 SUBBASIN EXTENT

The 180/400-Foot Aquifer Subbasin is one of eight subbasins of the Salinas Groundwater Basin, of which six subbasins are being managed in part or in whole by SVBGSA. The Subbasin extents are defined by the California Department of Water Resources (DWR) and are documented in Bulletin 118, (DWR, 2003; DWR, 2016). Figure 1-1 illustrates the extent of the Subbasin.

4.3.1 LATERAL SUBBASIN BOUNDARIES

The subbasin is bounded by the following combination of subbasin boundaries and boundaries of the Salinas Valley Basin:

- Subbasin boundaries surrounding the 180/400-Foot Aquifer Subbasin include boundaries with:
    - The Forebay Subbasin
    - The Eastside Subbasin
    - The Langley Subbasin
    - The Monterey Subbasin
- Basin boundaries surrounding the 180/400-Foot Aquifer Subbasin include:
    - The Monterey Bay shoreline
    - Elkhorn Slough
    - The Sierra de Salinas

The southeastern boundary with the adjacent Forebay Subbasin is approximately located near the southern limit of the regional clay layers that are characteristic of the 180/400-Foot Aquifer Subbasin.

The northeastern boundary with the adjacent Eastside Subbasin generally follows both the trace of Highway 101 and coincides with the northeastern limit of confining conditions in the 180/400-Foot Aquifer Subbasin. Previous studies of groundwater flow across this boundary indicate that the geologic conditions changes result in restricted hydraulic connectivity between the subbasins. An analysis of stratigraphic correlations concluded that there is a change in the depositional facies near this boundary, with tributary alluvial fan deposits on the east side of the boundary and Salinas River fluvial deposits on the west side of the boundary (Kennedy-Jenks, 2004).

The boundary with the Langley Subbasin is based on a topographic change from the valley floor to an elevated foothill area. This boundary generally coincides with the northeastern limit of confining conditions in the 180/400-Foot Aquifer Subbasin.

Although the Langley Subbasin is not on the valley floor, there are no reported hydraulic barriers separating these subbasins and therefore the GSP needs to consider potential for groundwater flow between these adjacent subbasins.

The northern boundary separates the 180/400-Foot Aquifer Subbasin from the Pajaro Valley Groundwater Basin. The boundary follows the current course of Elkhorn Slough; corresponding to a paleo-drainage of the Salinas River (DWR, 2003). The paleo-drainage is a 400-foot deep, buried, clay-filled layer that limits groundwater flow between these basins (Durbin, *et al.*, 1978).

The northern Subbasin boundary is defined by the Monterey Bay shoreline. The Subbasin aquifers extend across this boundary into the subsurface underlying Monterey Bay and there no hydrogeologic barriers limiting groundwater flow across this coastal boundary.

The Subbasin boundary with the Monterey Subbasin is based on topographic rise that coincides with a buried trace of the King City fault. This fault may act a groundwater flow barrier between subbasins beneath a cover of Holocene sand dunes (Durbin *et al.* 1978). Although a groundwater divide is commonly found near the subbasin boundary, the GSP needs to consider potential for groundwater flow between adjacent subbasins.

Further southwest, the King City fault boundary corresponds to the contact between the Quaternary deposits and the low-permeability granitic and metamorphic basement rock of the Sierra de Salinas. This geologic contact creates a groundwater flow barrier and the southwestern hydrogeologic boundary of the Subbasin.

4.3.2 VERTICAL SUBBASIN BOUNDARIES

The base of the Subbasin is not a sharp interface between permeable sediments and lower-permeability basement rock. The sedimentary sequence in the Salinas Valley structural trough is 10,000 to 15,000 feet thick. However, the productive fresh water aquifers are only at shallower depths, with the effective thickness of the groundwater Subbasin being approximately 1500 feet. With increasing depth, two factors limit the viability of the sediments as productive aquifers:

1. Increased consolidation and cementation of the sediments decreases the well yield, and
2. Deeper strata contain poor-quality brackish water unsuitable for most uses.

Because these factors gradually change with depth, there is not a sharp well-defined base to the basin. This GSP has adopted the base of the aquifer that was defined by the USGS (Durbin et al., 1978) and extrapolated that surface to other portions of the basin. **Error! Reference source not found.** Figure 4-4 shows a map of elevation contours of the base of the basin. Figure 4-5 shows a contour map of depth to base of the basin based on the base elevation and ground surface elevation.

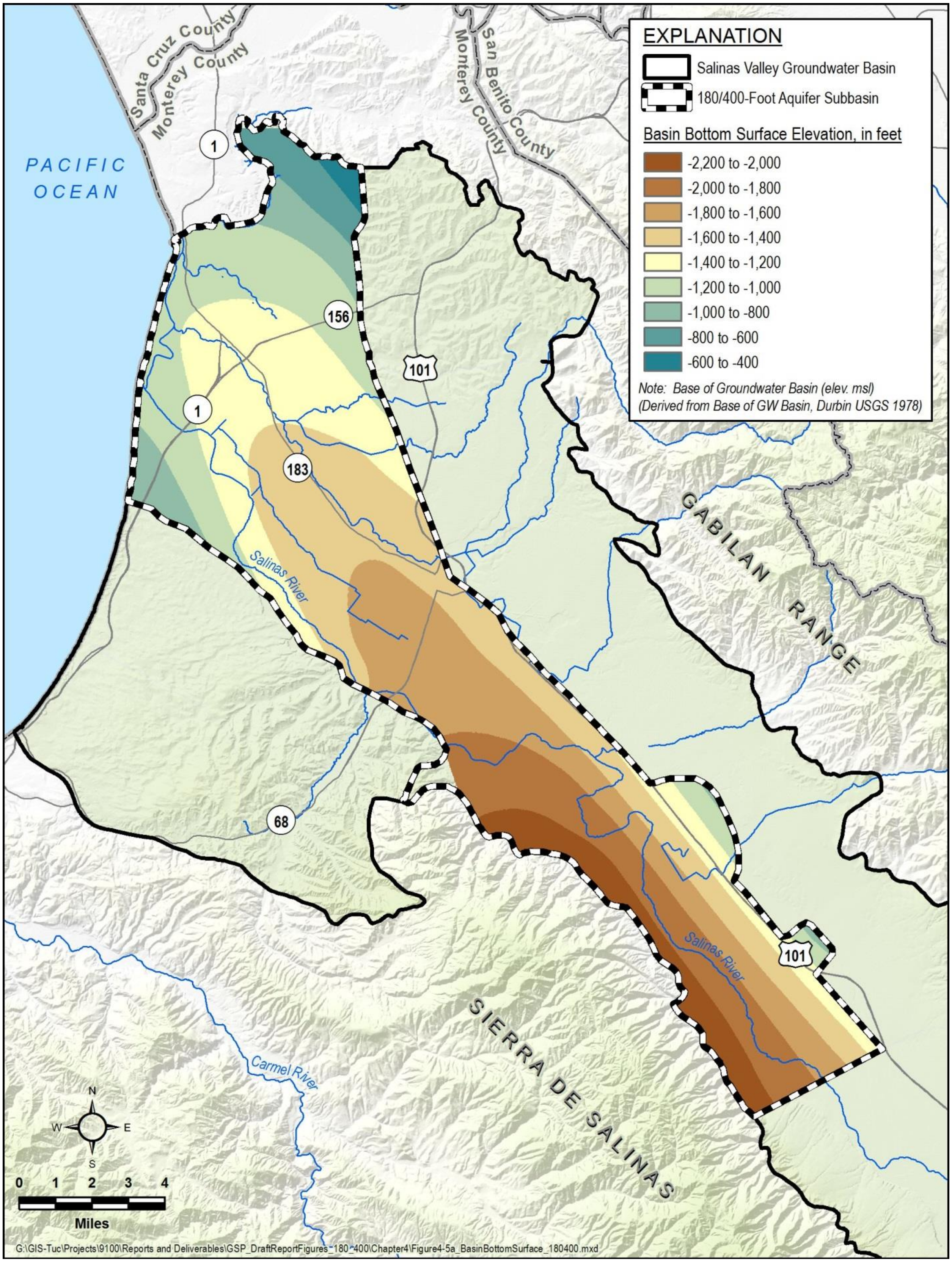

Figure 4-4: Elevation of the Base of the 180/400-Foot Aquifer Subbasin

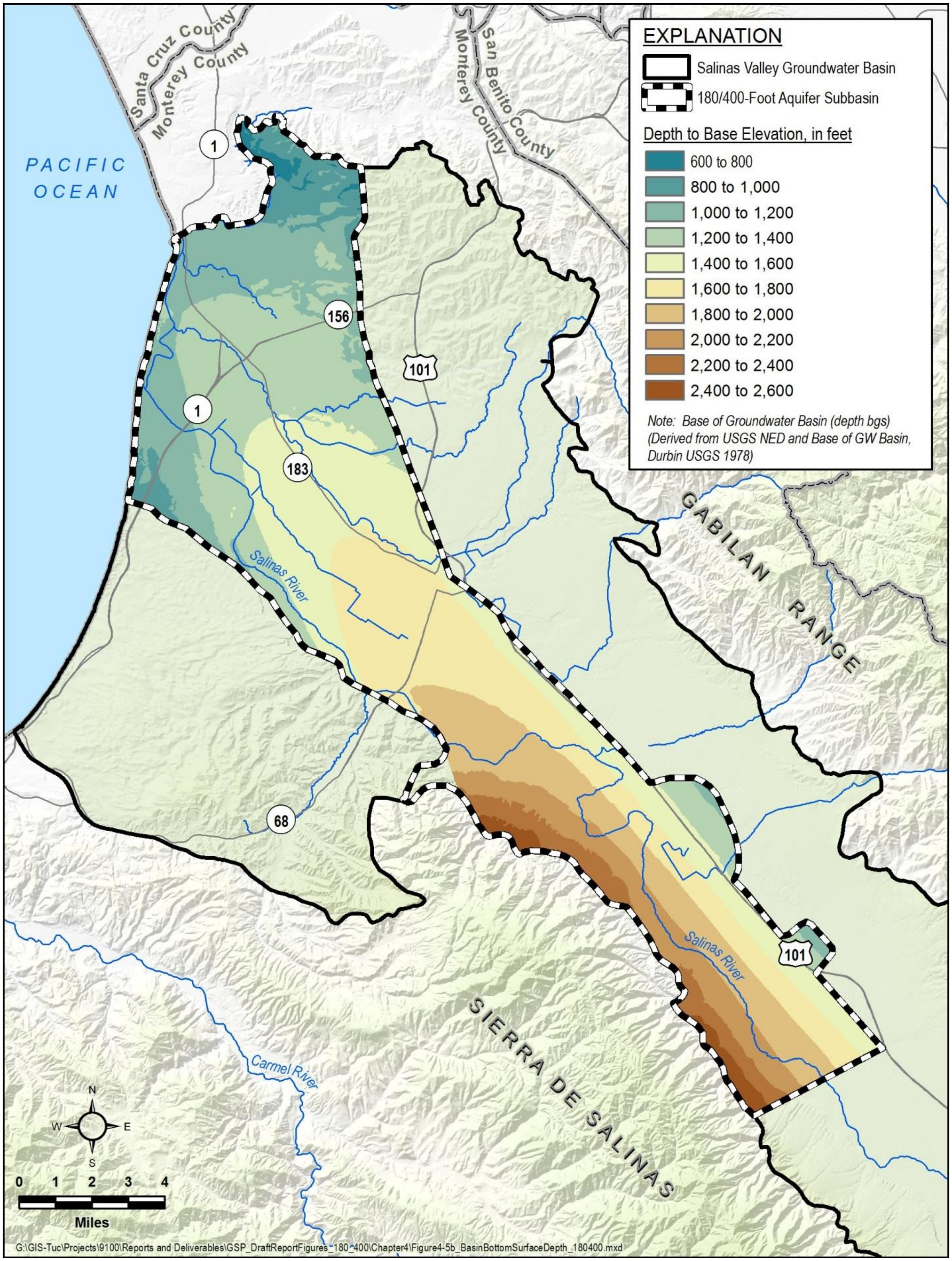

Figure 4-5: Depth to Base of the 180/400-Foot Aquifer Subbasin

4.4 GROUNDWATER HYDROLOGY

4.4.1 PRINCIPAL AQUIFERS AND AQUITARDS

Groundwater in the 180/400-Foot Aquifer Subbasin is primarily produced from alluvial deposits belonging to three geologic units: the Holocene Alluvium (Qa), the Quaternary Older Alluvium (Qoa), and Pliocene Paso Robles Formation. Although these three geologic formations differ in age, they have similar distributions of sediment type and layering and in practice are very difficult to distinguish during drilling. For purposes of groundwater development in the Basin, these geologic units are collectively referred to as alluvium. Other terminology, such as "Valley Fill" (Harding ESE, 2001; Kennedy-Jenks, 2004) have also been assigned to the combined geologic units. The aquifers and aquitards within the alluvium have been identified and recognized based not on geologic characteristics but rather on their depth, influence on groundwater production, water levels, and water quality.

The most recent, detailed hydrostratigraphic analysis of the 180-400 Foot Aquifer Subbasin was published in 2004 with an update in 2015 (Kennedy-Jenks, 2004; Brown and Caldwell, 2015). Three cross-sections along and across the subbasin are shown in Figure 4-6**,** Figure 4-7**,** and Figure 4-8 (Kennedy-Jenks, 2004). The location of these cross-sections is depicted in Figure 4-2. The hydrogeologic cross-sections are based on geologic logs provided in California Department of Water Resources Water Well Drillers Reports (DWR-188 forms) filed by the well drillers. Geologic log descriptions were grouped into hydrologic units as follows:

- Fine-grained sediments (e.g. clay, silt, sandy clay, and gravelly clay) are shown as aquitards;
- Coarse-grained sediments (e.g. sand, gravel, and sand-gravel mixtures) are shown as aquifers; and
- Sediments logged as gravel/clay, sand/clay, and sand/gravel/clay are interpreted to consist of interbedded coarse-grained and fine-grained deposits and are included with aquifer materials.

In some cases, the logs may be old, the depth resolution poor, or the lithologic distinction suspect, and therefore the lithology shown on the well logs should not be viewed as precise (Kennedy-Jenks, 2004).

Within the 180/400-Foot Aquifer Subbasin the following series of laterally continuous aquitards and aquifers have long been recognized and are the distinguishing feature of this subbasin.

- Shallow Aquifer
- Salinas Valley Aquitard
- 180-Foot Aquifer
- 180/400-Foot Aquitard
- 400-Foot Aquifer
- 400-Foot/Deep Aquitard
- Deep Aquifers

Starting from ground surface, the shallowest water-bearing zone is the Shallow Aquifer. The sandy water-bearing layers of this aquifer are thin and laterally discontinuous. The aquifer is less than 100 feet thick and is part of the Holocene Alluvium (Qa) unit. Although this water-bearing zone is a minor source of water due to its poor quality and low yield (Kennedy-Jenks, 2004; DWR, 2003; Showalter, 1984), there are low-yield domestic wells that draw from this zone. Groundwater in this zone is hydraulically connected to the Salinas River but very poorly connected to the underlying productive aquifers. Groundwater in the Shallow Aquifer may be locally perched.

The base of the Shallow Aquifer is the Salinas Valley Aquitard, an aquitard composed of blue or yellow sandy clay layers with minor sand layers (DWR, 2003). The Salinas Valley Aquitard correlates to the Pleistocene Older Alluvium (Qoa) stratigraphic unit and was deposited in a shallow sea during a period of relatively high sea level.

The Salinas Valley Aquitard overlies and confines the 180-Foot Aquifer. Laterally, the Salinas Valley Aquitard extends from Monterey Bay to Chualar in the south and to an irregular contact in the east, roughly represented by the DWR-designated boundary with the Eastside Subbasin (DWR, 2003). The Salinas Valley Aquitard is generally encountered at depths of less than 150 feet. Close to Monterey Bay, the Salinas Valley Aquitard is over 100 feet thick but thins to 25 feet near Salinas, eventually pinching out near Chualar and east of Salinas (DWR, 1975). While this clay layer is relatively continuous in the northern portion of the Valley, it is not monolithic. The clay layer is missing in some areas and pinches out in certain areas.

The 180-Foot Aquifer is the shallowest laterally extensive aquifer in the 180-400 Foot Aquifer Subbasin. This aquifer consists of interconnected sand and gravel beds that are from 50 to 150 feet thick. The sand and gravel layers are interlayered with clay lenses. This aquifer is correlated to the Older Alluvium (Qa) or upper Aromas Sand (QPc) formations (Harding ESE 2001; Kennedy-Jenks, 2004). The 180-Foot Aquifer is exposed on the floor of the Monterey Bay (Todd, 1989).

The base of the 180-Foot Aquifer is an aquitard consisting of interlayered clay and sand layers, including a marine blue clay layer similar to the Salinas Valley Aquitard (DWR, 2003). The 180/400-Foot Aquitard is widespread in the Subbasin but varies in thickness and quality. Areas of connection between the 400-Foot and 180-Foot Aquifers exist (Kennedy-Jenks, 2004).

The 180/400-Foot Aquitard overlies and confines the 400-Foot Aquifer. The 400-Foot Aquifer is a hydrostratigraphic layer of sand and gravel with varying degrees of interbedded clay layers, usually encountered between 270 and 470 feet below ground surface. This hydrogeologic unit correlates to the Aromas Red Sands (QPc) and the upper part of the Paso Robles Formation (Tc). Near Salinas, the 400-Foot Aquifer is a single permeable bed approximately 200 feet thick, but in other areas the aquifer is split into multiple permeable zones by clay layers (DWR, 1973). The upper portion of the 400-Foot Aquifer merges and interfingers with the 180-Foot Aquifer in some areas (DWR, 1973).

The base of the 400-Foot Aquifer is the 400-Foot/Deep Aquitard. The 400-Foot/Deep Aquitard is a blue marine clay layer. This aquitard can be several hundred feet thick (Kennedy-Jenks, 2004)

The 400-Foot Aquitard overlies and confines the Deep Aquifers. The Deep Aquifers, also referred to as the 900-Foot and 1500-Foot Aquifers, are up to 900 feet thick and have alternating layers of sand-gravel layers and clays which do not differentiate into distinct aquifer and aquitard units (DWR, 2003). The deep aquifers correlate to the lower Paso Robles (Tc), Purisima (P) and Santa Margarita (M) formations. The deep aquifers overlie the low permeability Monterey Formation, which forms the bottom of the 180-400 Foot Aquifer Subbasin. While the deep aquifers are relatively poorly studied, some well owners have indicated that there are different portions of the deep aquifers with different water qualities. No public data exists to substantiate these statements.

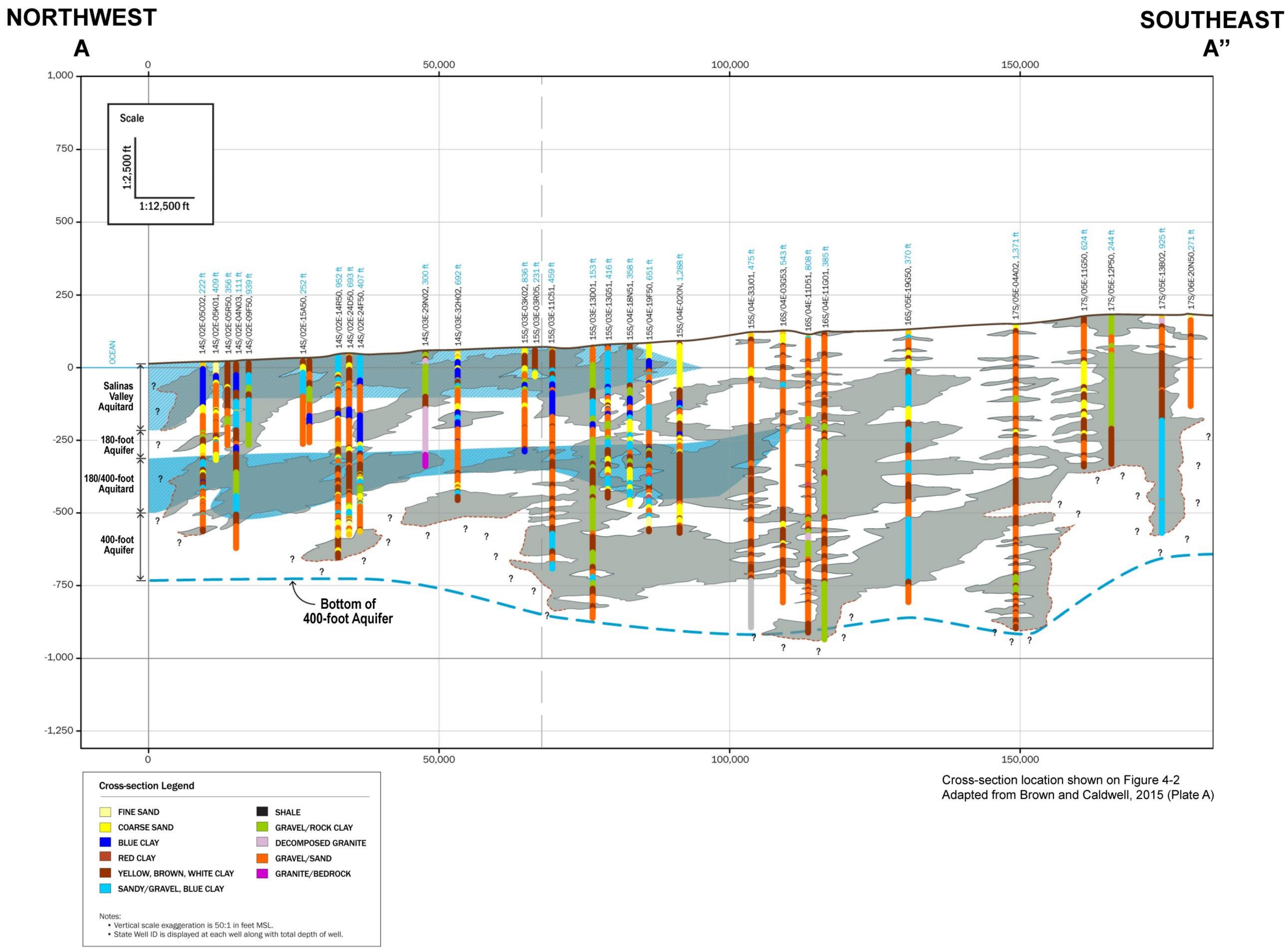

Figure 4-6: Cross-Section A-A′

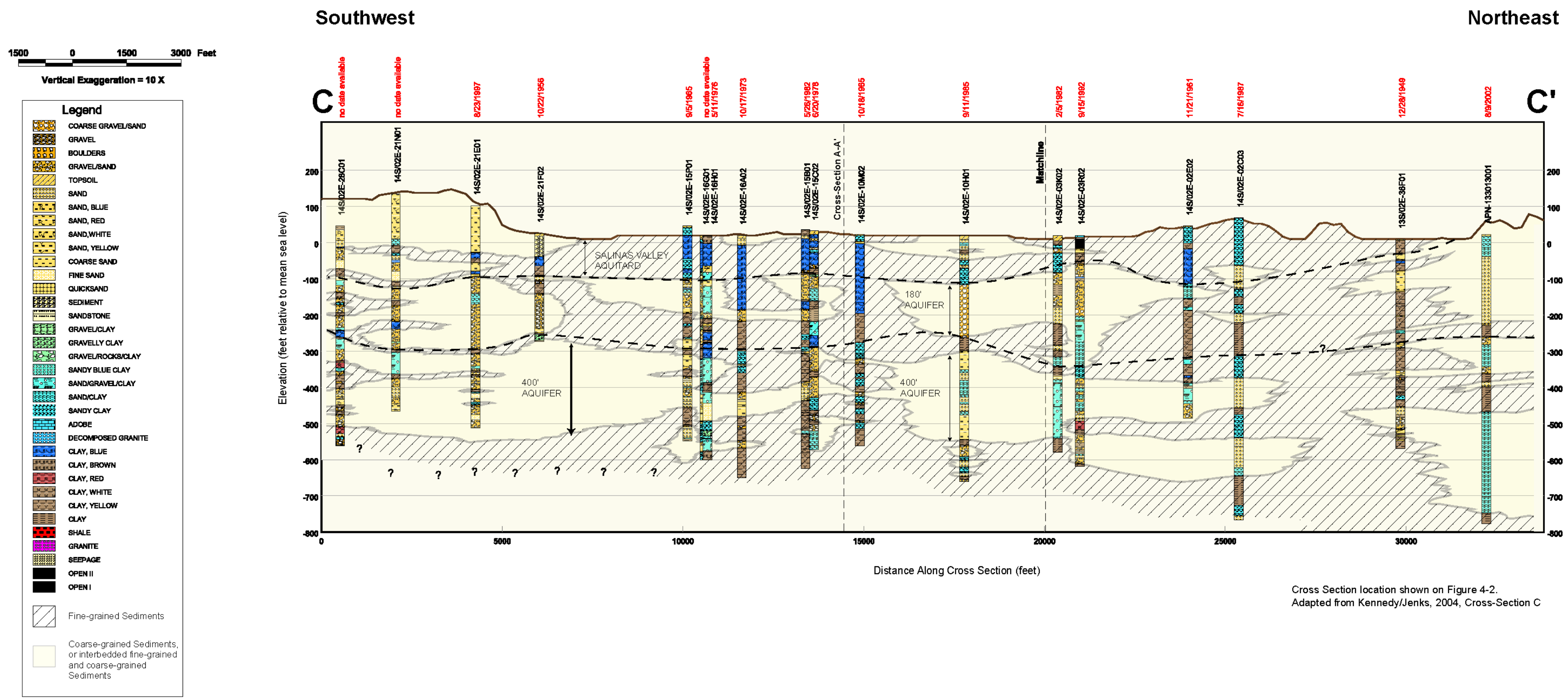

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Figure 4-7: Cross-Section C-C′

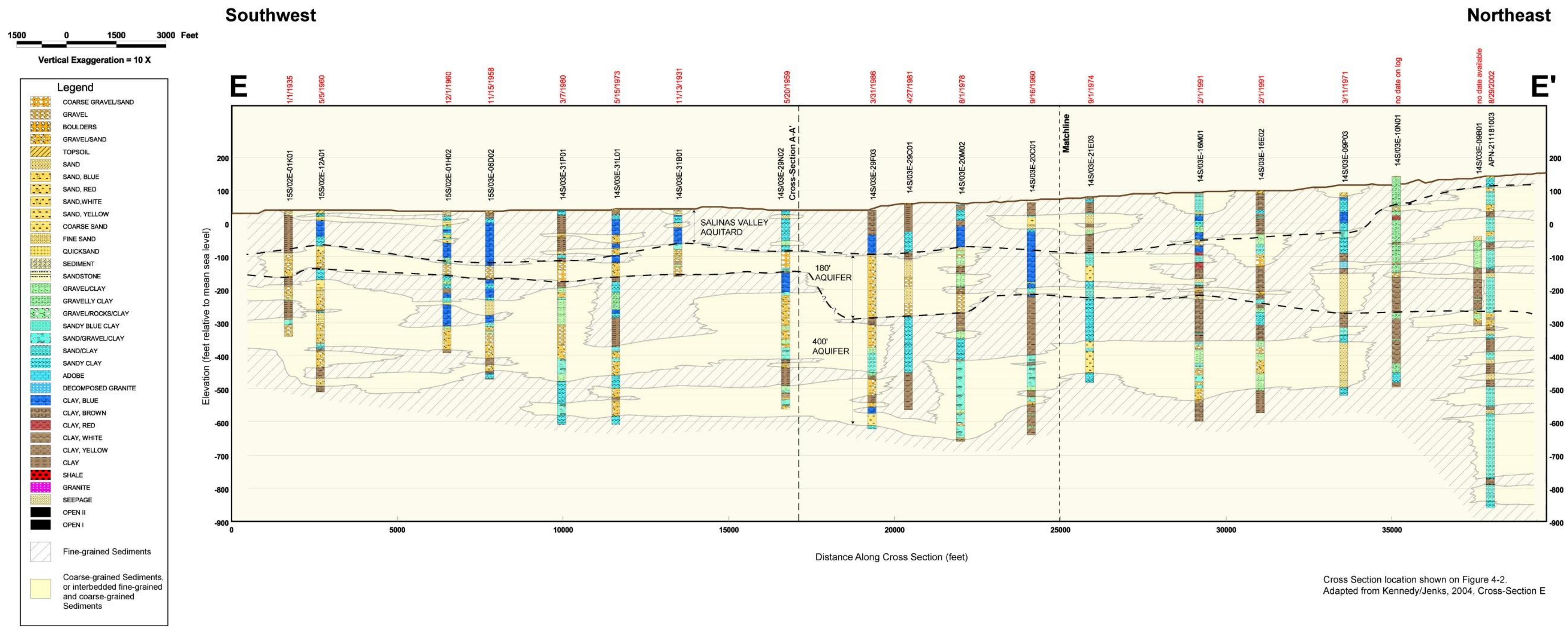

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Figure 4-8: Cross-Section E-E′

4.4.2 AQUIFER PROPERTIES

The values and distribution of aquifer properties in the Subbasin have not been well characterized and documented. The relatively sparse amount of measured aquifer properties throughout the Subbasin is considered a data gap that can be addressed during implementation of the GSPs.

Although hydrogeologic properties have not been measured at many specific locations in the basin, the aquifer properties have been estimated through the process of model calibration. Aquifer property calibration has completed for numerous published modeling studies including studies by Durbin (1974); Yates (1987); WRIME (2003); and the unpublished Salinas Valley Integrated Hydrologic Model (SVIHM) developed by USGS that is being used in this ISP.

There are two general types of aquifer properties relevant to groundwater management:

- Aquifer storage properties: these properties control the relationship between the volume of groundwater stored in the aquifer and the water level measured in the aquifer, and
- Groundwater transmission properties: these properties control the relationship between hydraulic gradients and the rate of groundwater.

4.4.2.1 AQUIFER STORAGE PROPERTIES

The aquifer properties that characterize the relation between water level and aquifer storage volume are specific yield for unconfined aquifers and specific storage for confined aquifers.

- Specific Yield is the amount of water that drains from pores when an unconfined aquifer is dewatered. Often specific yield values range from 8% to 20%
- Specific storage is the amount of water derived from a cubic foot of confined aquifer due to the pressuring of the aquifer. Often specific storage values are on the order of $1x10^{-5}$.
- Storativity is the specific storage of a confined aquifer times the thickness of the aquifer. Because storativity depends on the thickness of the aquifer, a common range of values is not available.

Estimates of specific yield, compiled by DWR for Bulletin 118 are summarized in the middle column of Table 4-1. Estimates specific storage are listed in the right-hand column of Table 4-1. The specific yield values were compiled by DWR. The specific storage values were compiled by the USGS.

Table 4-1: Aquifer Storage Properties

Subbasin	Specific Yield (ft^3/ft^3)	Storativity (ft^3/ft^3) or Specific Storage (1/ft)
180/400-Foot Aquifer	0.06 – 0.16	0.00012 - 0.00029

4.4.2.2 Groundwater Transmission Properties

Hydraulic conductivity measures the ability of an aquifer to transmit water. Hydraulic conductivity is measured in units of feet per day. Units with higher hydraulic conductivities, such as sands and gravels, transmit groundwater more easily than units with lower hydraulic conductivities. Another common measurement of the ability of an aquifer to transmit water is transmissivity. Transmissivity is equivalent to the hydraulic conductivity of an aquifer times the thickness of an aquifer. Unfortunately, very few estimates of hydraulic conductivity or transmissivity exist for the Basin.

Potential well yields are sometimes used as a surrogate for aquifer transmissivity. The potential well yields are characterized by the specific capacity of a well. The specific capacity of a well is the ratio between the well production rate in gallons per minute (gpm) and the water level drawdown in the well during pumping, measured in feet (ft).

Specific capacity is relatively well correlated, and approximately proportional to, aquifer transmissivity. Durbin (1978) reported the following well yields and specific capacity estimates:

- Fluvial deposits that constitute the shallowest productive zones in most of the Subbasin, including the 180-foot aquifer, have well yields of 500 to 4,000 gpm and an average specific capacity of approximately 70 gpm/ft.
- In the 400-foot aquifer, well yields range from 300 to 4,000 gpm and average 1,200 gpm, with specific capacity averaging about 30 gpm/ft.

4.4.3 Natural Recharge Areas

Areas of significant, natural, areal recharge and discharge within the Subbasin are discussed below. Quantitative information about all natural and anthropogenic recharge and discharge is provided in Chapter 6: Water Budgets. Natural groundwater recharge occurs through the following processes:

- Infiltration of surface water from the Salinas River and tributary channels
- Deep percolation of excess applied irrigation water
- Deep percolation of infiltrating precipitation

The capacity for groundwater recharge is a dependent on a combination of factors, including steepness of grade, soil surface condition such as paving or compaction, and ability of soil to transmit water past the root zone. To assist agricultural communities in California with assessing groundwater recharge potential, a consortium of researchers at UC Davis developed a Soil Agricultural Groundwater Banking Index (SAGBI) and generated maps of recharge potential in agricultural areas of California (O'Geen et al., 2015). Figure 4-9 presents the SAGBI index map for the Subbasin. This map ranks soil suitability to accommodate groundwater recharge based on five major factors that affect recharge potential including: deep percolation, root zone residence time, topography, chemical limitations, and soil surface condition. Areas with excellent recharge properties are shown in green. Areas with poor recharge properties are shown in red. Not all land is classified, but this map provides good guidance on where natural recharge likely occurs.

Although Figure 4-9 shows some areas of good potential recharge in the 180/400-Foot Aquifer Subbasin, recharge to the productive zones of the Subbasin is very limited because of the low permeability Salinas Valley Aquitard. It is unlikely that any significant surficial recharge in the 180/400-Foot Aquifer Subbasin reaches the productive 180-Foot Aquifer or the 400-Foot Aquifer. This demonstrates the limited utility of potential recharge maps that are based on soil properties. This map should not be used to identify recharge areas that will directly benefit the extensive aquifers in the 180/400-Foot Aquifer Subbasin.

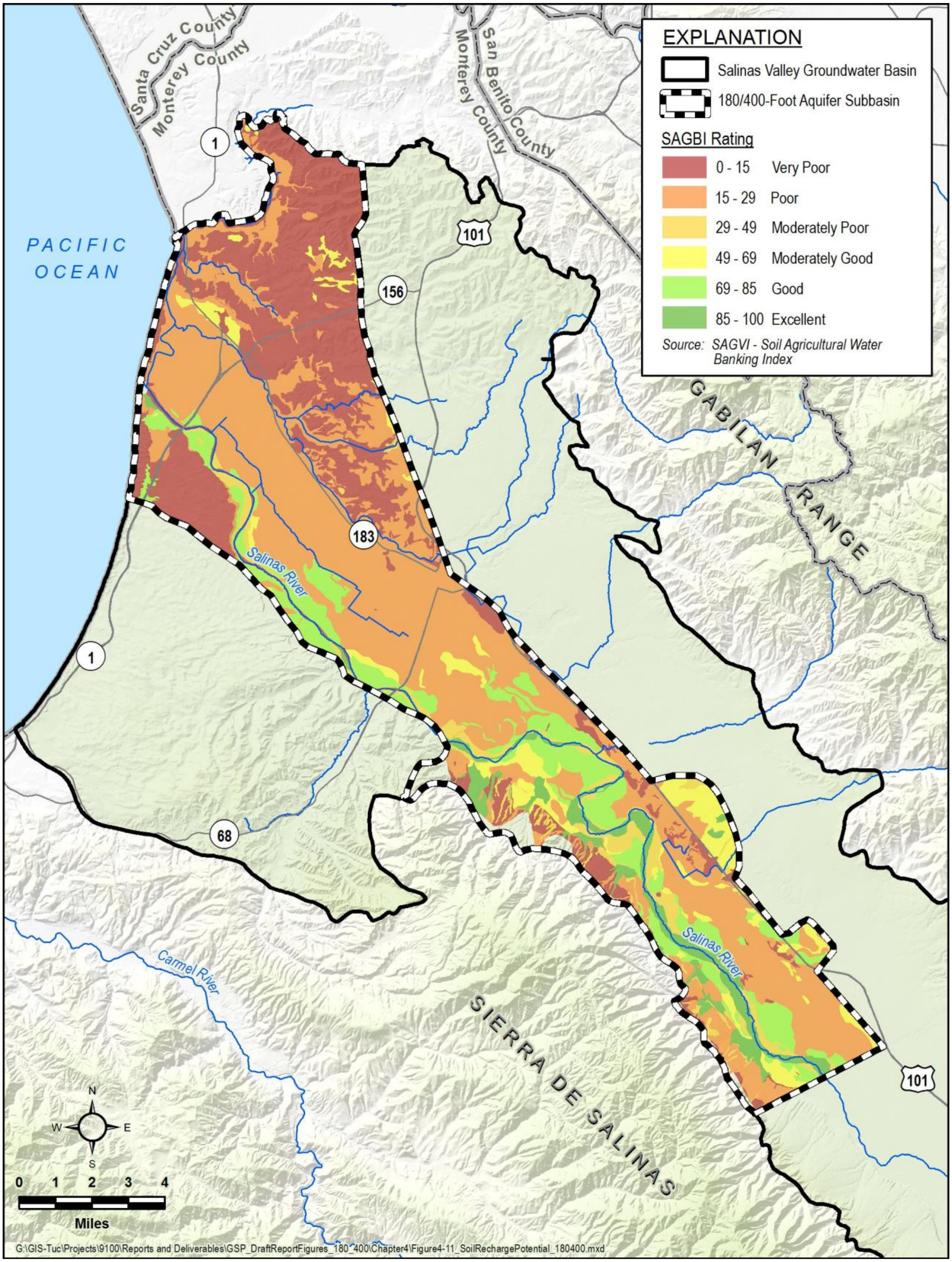


Figure 4-9: SAGBI Soils Map for the 180/400-Foot Aquifer Subbasin

4.4.4 Natural Discharge Areas

Natural groundwater discharge areas within the Subbasin include springs and seeps, groundwater discharge to surface water bodies, and evapotranspiration (ET) by phreatophytes. There are no springs and seeps in the Subbasin as identified in the National Hydrology Dataset (NHD). Natural groundwater discharge to streams – primarily, the Salinas River and its tributaries – has not been mapped to date. Instead, areas of potential groundwater discharge to streams are identified using the groundwater flow model. *TO BE COMPLETED WHEN THE GROUNDWATER MODEL BECOMES AVAILABLE.*

Figure 4-10 shows the distribution of potential groundwater-dependent ecosystems (GDEs) and Natural Communities Commonly Associated with Groundwater (NCCAG) within the Subbasin area. In areas where the water table is sufficiently high, groundwater discharge may occur as ET from phreatophyte vegetation within these GDEs. Appendix 4A describes methods used to determine the extent and type of potential GDEs. Figure 4-10 shows only potential GDEs. There has been no verification that the locations shown on this map constitute groundwater dependent ecosystems. Additional field reconnaissance is necessary to verify the existence of these potential GDEs.

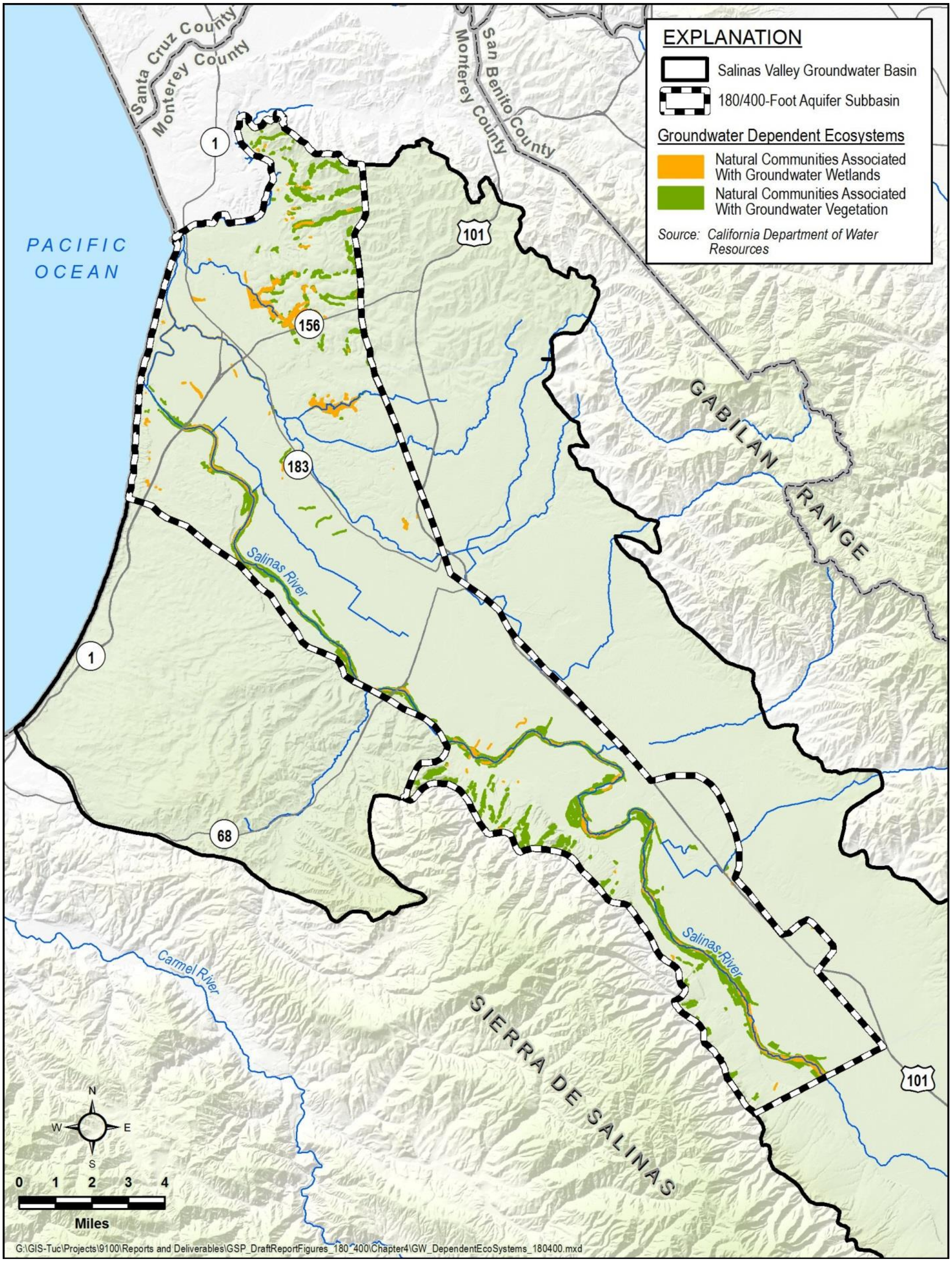


Figure 4-10 Groundwater Dependent Ecosystems

4.5 SURFACE WATER BODIES

The primary surface water body in the Subbasin is the Salinas River. This river runs through the entire length of the Subbasin and is fed by local tributaries (Figure 4-11).

The following surface water bodies are located outside of the subbasin but are important controls on the rate and timing of Salinas River flows in the subbasin:

- Two reservoirs constructed to control flooding and to increase recharge from Salinas River to groundwater.
    - Lake Nacimiento, in San Luis Obispo County, was constructed in 1957 and has a storage capacity of 335,00 acre-feet (MCWRA, 2018).
    - Lake San Antonio, in Monterey County, was constructed in 1967 and has a storage capacity of 377,900 acre-feet.
- Arroyo Seco, a tributary with a 275 square mile drainage area that has no dams in its drainage basin and is characterized by both very high flood flows and extended dry periods.

Within the subbasin, two constructed canals convey surface water across the valley floor. The Rec Ditch was originally constructed in 1917 and is operated in part by MCWRA for flood management. The ditch flows southeast to northwest and drains the stormwater detention from Smith Lake and Carr Lake before flowing northwest towards Castroville and discharging first into Tembladero Slough and then into the Old Salinas River Channel and ultimately into Moss Landing Harbor (MCWRA Website). Blanco Drain, also known as Storm Maintenance District No. 2, is a drainage system that covers approximately 6.400 acres of farmland, predominately receiving agricultural return flow from tile drains in the dry season and stormwater runoff in the wet season. Blanco drain discharges into the Salinas River (Figure 4-11).

The mouth of the Salinas River forms a lagoon; and its outflow to Monterey Bay is blocked by sand dunes except during winter high-water flows. MCWRA operates a slide-gate to transfer water through a culvert from the lagoon into Old Salinas River during the wet season for flood control (MCWRA, 1994). The Old Salinas River discharges through tide gates at Potrero Road into Moss Landing Harbor and ultimately the Monterey Bay.

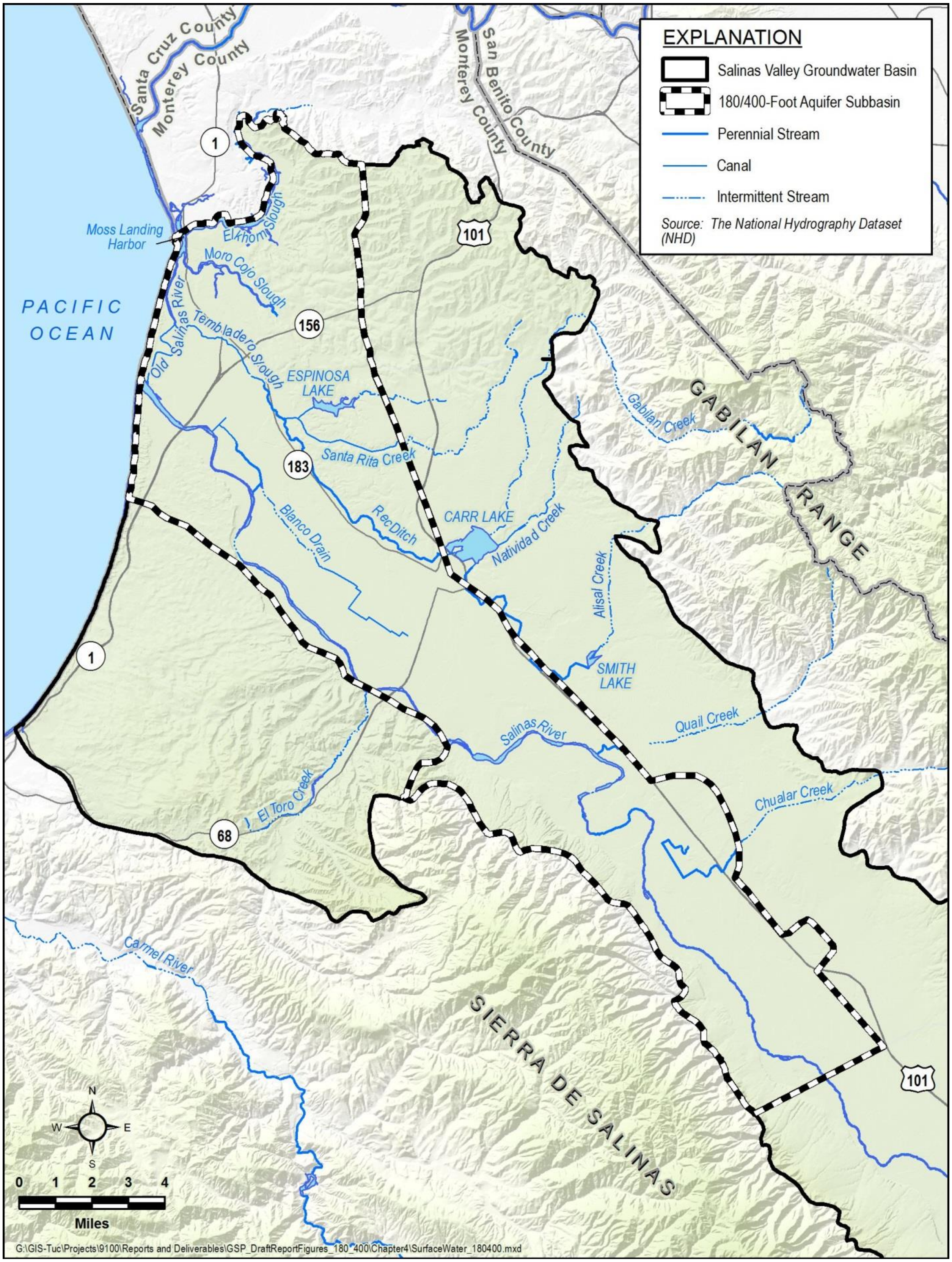


Figure 4-11: Surface Water Bodies in the 180/400-Foot Aquifer Subbasin

4.5.1 Imported Water Supplies

There is no water imported into the 180/400-Foot Aquifer Subbasin.

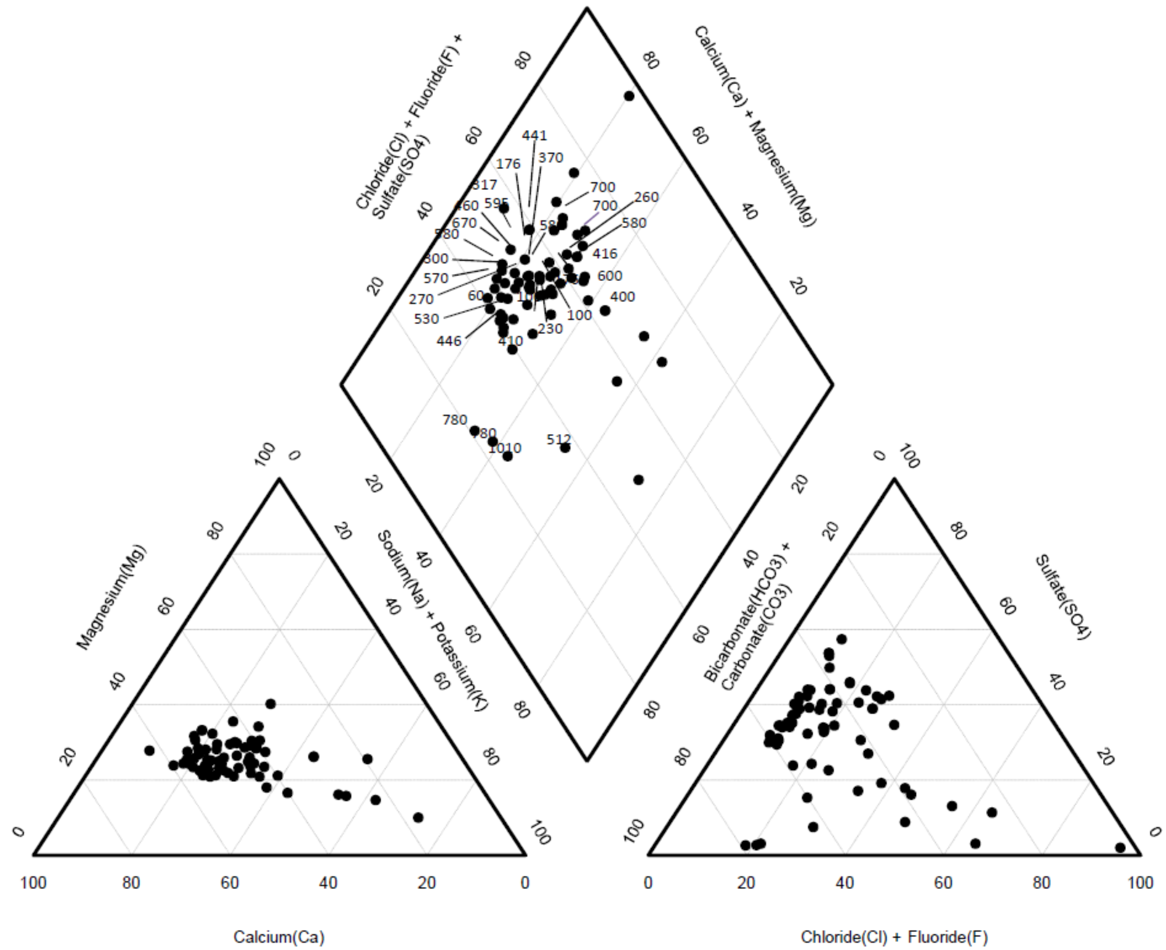
4.6 Water Quality

This chapter presents a general discussion of the natural groundwater quality in the Subbasin, focusing on general minerals based on previous reports. Discussion of the distribution and concentrations of specific constituents is presented in Chapter 5: Current Conditions.

4.6.1 General Mineral Chemistry

The major ion chemistry of Salinas Basin groundwater was characterized in a report prepared for the Central Coast Groundwater Coalition (CCGC) titled *Distribution of Groundwater Nitrate Concentrations, Salinas Valley, California* (LSCE, 2015). The purpose of the report was to respond to the Regional Board requirement for monitoring elevated nitrate concentrations near drinking water supply wells. The report included the results of extensive groundwater quality sampling and thus provided a good characterization of the general mineral water quality.

Figure 4-12presents a Piper diagram from the CCGC report that plots major ion data from within and near the Subbasin. The diagram provides a means of representing the proportions of major anions and cations in water samples and thereby can be used to illustrate the character of the water quality.



Note: Well depths indicated when available.

Figure 18. Piper Plot of Pressure Subbasin Wells Sampled by the CCGC

Figure 4-12: Piper Diagrams

4.6.2 SEAWATER INTRUSION

Groundwater pumping has reduced groundwater levels below sea level and caused seawater to flow into the Subbasin from the Monterey Bay. Increased salt concentrations. measured as TDS or chloride concentration are considered a nuisance rather than a health or toxicity concern. Increased salt concentrations impact the ability to use water for applications such as irrigation.

The impact of seawater intrusion on the practical use of groundwater occurs at concentrations much lower than that of seawater. TDS concentration in seawater is approximately 35,000 mg/L. The State of California has adopted a recommended Secondary Maximum Contaminant Level (SMCL) for TDS of 500 mg/L, and a short term maximum SMCL of 1,500 mg/L. These recommendations are based on taste rather than health impacts. The TDS limit for agricultural use is crop dependent: a 10% loss of yield in lettuce crops has been observed at a TDS of 750 mg/L; a 10% loss of yield in tomatoes has been observed at a TDS of 1,150 mg/L (FAO Irrigation and Drainage Paper 29, 1985).

The current seawater intrusion conditions are described more fully in Chapter 5.

4.7 DATA GAPS

Due to decades of extensive study and groundwater development, the structure and boundaries of the hydrogeologic conceptual model is relatively well-developed. However, there are a few notable data gaps including:

- There are very few measured aquifer parameters in the Basin.
- The hydrostratigraphy, vertical and horizontal extents, and potential recharge areas of the deep aquifers are poorly known.

Therefore, the GSPs should include actions to reduce this data gap and thereby improve the quantification associated with this hydrogeologic conceptual model.

As described in Chapter 8, the GSP will include ongoing data collection and monitoring that will allow continued refinement and quantification of the groundwater system. However, the proposed data collection is not expected to alter the conceptual model as described above.

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