APPENDIX B

Hydrogeologic Conceptual Model: Geologic Framework and Principal Aquifers, Prepared by Richard C. Slade & Associates LLC

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Technical Memorandum

Hydrogeologic Conceptual Model: Geologic Framework and Principal Aquifers

Santa Clara River Valley Groundwater Basin
East Subbasin
Groundwater Sustainability Plan
Santa Clarita Valley Groundwater Sustainability Agency

Prepared for
GSI Water Solutions, Inc.

Prepared by
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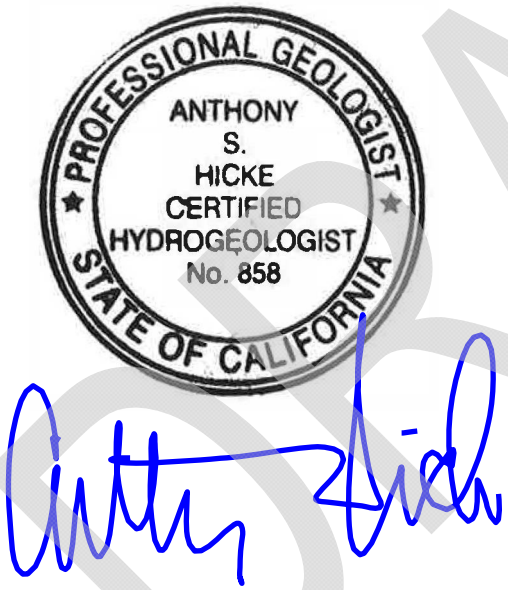

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SECTION 1: 1.0 Hydrogeologic Conceptual Model

Provided in this Technical Memorandum (TM) is a description of the hydrogeologic conceptual model of the Santa Clara River Valley Groundwater Basin, East Subbasin (Basin). The purpose of this TM is to describe the physical characteristics of the Basin as they relate to groundwater occurrence in the aquifers. This TM has been prepared as part of the ongoing efforts by the Santa Clarita Valley Water Agency (SCV Water) on behalf of the Santa Clarita Valley Groundwater Sustainability Agency to prepare a Groundwater Sustainability Plan (GSP) for the Basin. Data and interpretations compiled herein are based on the long term experience of Richard C. Slade & Associates LLC (RCS) performing hydrogeologic services for various water agencies and private parties in the Basin, coupled with information from a number of publicly available resources.

Note that as part of ongoing GSP development, an updated groundwater flow model will be utilized to further quantify ranges of key terms listed below.

1.1 Basin Setting

1.1.1 Topography and Boundaries

Figure 1-1, "Location Map", shows the boundary of the local groundwater basin superimposed on a topographic map of the area, and the locations of select wells that are known to exist or to have existed in the region. Topographically, the area surrounding the groundwater basin is defined by higher elevations on the north, south, and east, and lower elevations on the west. This topography defines the watershed of the Santa Clara River, which has its headwaters in Soledad Canyon, and this watershed has a drainage area of several hundred square miles. The Santa Clara River provides regional drainage in an east to west direction across the groundwater basin and it continues westerly across Ventura County and into the Pacific Ocean. In general, the local groundwater basin is oriented along the Santa Clara River.

Principal tributaries draining the northern side of the groundwater basin include, from east to west, Mint Canyon, Bouquet Canyon, San Francisquito Canyon, and Castaic Creek Canyon. Principal tributaries draining the southern side of the basin include, from east to west, Oak Spring Canyon, Sand Canyon, and Potrero Canyon. The South Fork of the Santa Clara River, which drains in a

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northerly direction toward its confluence with the main reach of the Santa Clara River (located just west of Bouquet Junction), has Placerita Creek Canyon, Newhall Creek Canyon, and Pico Canyon as its main tributaries.

DWR-defined boundaries of the groundwater basin are based on ground surface exposures of the two main aquifers that comprise the local groundwater basin: the alluvial aquifer, and the Saugus Formation aquifer (Slade, 1988, 2001). Depending on the location of the boundary, the boundary of the Basin is either defined as the geologic contact of the Saugus Formation with other geologically older, nonwater-bearing formations, or the contact of the alluvium of the Santa Clara River and its tributaries with geologically older, nonwater-bearing formations. The same is true for the "bottom" of the Basin in the subsurface: in some instances, the alluvial aquifer is in contact with non-water bearing sediments where no Saugus Formation is present (as in the western portion of the groundwater basin), and in areas where the Saugus Formation is relatively thick, the Basin is defined as its contact with the underlying Pico Formation, or even other older, nonwater-bearing formations. Additional discussions of the nature of these geologic contacts are discussed below.

1.1.2 ~~Soils~~Soil Infiltration Potential

Soil infiltration is defined as the ability of a soil to allow water movement through the soil profile. The infiltration rate of a soil is the velocity or speed at which water enters and flows into the soil under gravimetric forces. Publicly available databases of soil types and estimated infiltration rates of these soils were reviewed, and are summarized below.

1.1.2.1 Soil Types in the Basin

Soils in the region have been mapped and described by the Natural Resources Conservation Service (NRCS, 1999), a division of the United States Department of Agriculture (USDA). Figure 1-2, "NRCS Soil Map," shows the locations of soil groups within the boundaries of the Basin and the surrounding region. Four groups of soil types are shown to exist within the boundaries of the Basin on Figure 1. Below is a description of these four soil groups as adapted from the NRCS (1999), shown in order of relative abundance within the Basin:

- Entisols are the most prevalent soil group within the Basin, and are exposed throughout the Basin. Entisols are comprised of mineral soils that have not yet developed distinct soil horizons. Because entisols have no diagnostic horizons, these soils appear unaltered

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from their parent material, which can be unconsolidated sediment or rock. Entisols are the most abundant soil order on earth, occupying about 16% of the global ice-free land area.

- Inceptisols are the second most prevalent soil group and are exposed primarily in the western portion of the Basin. These soils are comprised of freely draining soils in which the formation of distinct horizons is not far advanced. By definition, Inceptisols are more developed than Entisols, but have no accumulation of clays or organic matter. Inceptisols develop more rapidly from parent material than do Entisols,
- Alfisols are similar in abundance to inceptisols, but occur primarily in the eastern portion of the Basin. Alfisols consist of a group of leached basic or slightly acidic soils, exhibiting clay-enriched subsoils with a relatively high native fertility. These subsoils are considered mineral soils and contain higher concentrations of aluminum (Al) and iron (Fe) than other soils. Alfisols typically are found to have formed on late-Pleistocene aged geologic deposits.
- Mollisols are the least abundant soil type within the Basin, generally found along the Santa Clara River. These soils are commonly very dark colored, base-rich, mineral soils and contain high concentrations of calcium and magnesium. These soils typically develop under grassland cover.

1.1.2.2 Soil Infiltration Rates

To help provide a general understanding of estimated infiltration capacity of the soils within the boundaries of the Basin, infiltration rates for these soils were compiled from the Los Angeles County Department of Public Works (LACDPW) Hydrology Manual (LACDPW, 2006). Infiltration rates throughout Los Angeles County were obtained by LACDWP by performing double ring infiltrometer tests of various soil types (LADPW, 2006). Results of these infiltration tests were reportedly used by LACDPW to produce runoff coefficient curves of the tested soil type, from which infiltration rates were interpreted. Compiled results from the LADPW infiltration tests are presented in Figure 1-3, “Infiltration Rates, LA County.” Reported infiltration rates ranged from 0.1 to 1.0 inch(es) per hour (in/hr). Lower infiltration rates of 0.1 in/hr were observed in individual areas located in the southern portion of the Basin. Spatially, an infiltration of 0.3 in/hr was more prevalent than others.

1.1.3 Regional Geology

The regional geologic conditions in and around the Basin consist predominantly of continental to marine deposits of clay, silt, sand and gravel divided amongst several formations ranging in geologic age from late-Tertiary (approximately 25 million years old) through the present. The oldest of these Formations lies unconformably (a separation of two or more units by a geologic time gap) upon basement complex rock, which consist of undifferentiated crystalline granitic rocks and metamorphic-type rocks of late Mesozoic age (greater than 66 million years old). Figure 1-4, "Geologic Map Showing Cross Sections," shows the locations and lateral extents of these various earth materials as mapped at ground surface by others. This map, which provides the basis for the following discussion of the geologic conditions of the region, has been adapted from geologic maps published by Slade (Slade, 1986, 1988). Those maps by Slade were created by updating interpretation on various geologic mapping efforts by others combined with subsurface interpretation of geologic materials derived over time during the drilling of deep boreholes. Among the geologic references used by Slade (1986, 1988) were those by Oakeshott (1958), Dibblee (1991), and others. For Figure 1-4, various crystalline rocks have been simplified and grouped into a single unit named "basement complex," and no distinction is provided between the various rock types of which those crystalline rocks are comprised. Also, alluvial deposits are shown as one unit, although Quaternary mapping efforts by others in the past have separated those into more discrete units based on slight differences in age or location. The legend to the map provides information on the names and basic earth materials of each formation shown on that map. The locations of several geologic faults are also shown on the Figure 1-4 map; these faults are discussed later in this text. It should be noted that the locations of the faults have been somewhat simplified for this study. In some cases, faults actually exist as en echelon faults within a fault zone, with a number of approximately parallel, similarly trending smaller faults. For this study, however faults are represented by a single line-trace on Figure 1-4. For the geologic cross sections (discussed in Section 1.1.5), where data support the interpretation, multiple fault line traces may be shown for a single-named fault. Also shown on Figure 1-4 are the alignments of several geologic cross sections which are discussed later in this text.

1.1.3.1 Geologic Formations within the Basin

There are three relatively young geologic formations that comprise the local Basin, namely: Alluvium, Terrace Deposits and the Saugus Formation. These formations, except for the Terrace

Deposits, are generally utilized by high-capacity water production wells for municipal-supply purposes by SCV Water and the County Waterworks District and, thus, provide a major portion of the water-supply to valley residents. Privately owned wells that utilize these formations (primarily the Alluvial aquifer) are owned by FivePoint (formerly Newhall Land and Farming Company), the Disney Company, multiple golf courses, and others for agricultural irrigation, turf irrigation or local domestic purposes. The spatial distribution of the extraction, and general rates of those extractions are described in later Technical Memoranda.

1.1.3.1.1 Alluvium

The Quaternary Alluvium (Qa) is of Holocene (Recent) geologic age, ranging from 10,000 years in age to the present. These recent alluvial deposits consist primarily of stream channel and floodplain materials along the course of the Santa Clara River and its tributaries. The alluvial sediments are composed of complexly interlayered and interfingered beds of unconsolidated gravel, sand, silt, and clay containing variable concentrations of cobbles and boulders. The source material for this alluvium is from weathering and erosion of the surrounding hills and mountains bordering the Santa Clarita Valley. In general, alluvium along the main reach of the Santa Clara River ranges from medium-grained sand in the west, to cobbly- or gravelly-sand in the east. The maximum thickness of the alluvium varies along the course of the Santa Clara River, but can attain a maximum thickness of ± 200 feet. Typically, the alluvium tends to be thickest near the central portion of the river channel and thins or pinches out as the base of the adjoining hills is approached.

The alluvium in the tributary canyons is generally thinner than that along the main river valley. Larger watershed areas such as Castaic Creek and Bouquet Canyon are typically underlain by more extensive and thicker accumulations of alluvium than what exists within the smaller tributaries, such as the Oak Spring or Pico canyons. In these latter canyons, the maximum alluvial thickness occurs near the confluence with the main river valley, where it may be from 75 to 125 feet in thickness.

1.1.3.1.2 Terrace Deposits

Terrace deposits (Qt) are isolated remnants of what was, during the late Pleistocene (129,000 years or less in age), a continuous blanket of alluvial material covering the entire floor of the Santa Clara River Valley (Winterer and Durham, 1962). Tectonic uplift of the valley floor led to

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downcutting and incision of this somewhat geologically older alluvial material by the Santa Clara River, leaving the terrace deposits restricted to platforms or benches that are topographically higher than the Santa Clara River, and hence above the regional water table. Sediments comprising the terrace deposits include crudely stratified, poorly consolidated reddish-brown gravel, sand and silt (Winterer and Durham, 1962). Terrace deposits are sometimes weakly cemented by iron oxides, clay minerals, or calcium carbonate.

Terrace deposits may be up to 200 feet thick in some areas, but because of the limited areal extent of these deposits and because they are generally above the regional water table, they are not a viable source for the development of groundwater resources. However, limited zones of perched groundwater may be locally present in some areas on a seasonal basis within these terrace deposits.

1.1.3.1.3 Saugus Formation

The Saugus Formation (QTs), of late-Pliocene to early-Pleistocene geologic age (ranging from approximately 3.6 to 1.8 million years in age), has traditionally been divided into two stratigraphic units: a lower, geologically older Sunshine Ranch Member (QTsr) of mixed marine to terrestrial origin; and an overlying, upper portion of the formation (QTsu) which is entirely terrestrial (non-marine) in origin (Winterer & Durham, 1962). Figure 1-5. “Generalized Saugus Formation Stratigraphy”, graphically illustrates these two stratigraphic units and the overall characteristics of each. Ground surface exposures of the Saugus Formation shown on Figure 1-4 are labeled as undifferentiated Saugus Formation (QTs) because data necessary to distinguish the upper portion (QTsu) from the Sunshine Ranch Member (QTsr) are not available for all areas of the basin. For the Cross Sections (discussed in Section 1.1.5), the upper portion of the Saugus Formation (QTsu) and the Sunshine Ranch Member (QTsr) are labeled discretely where data allow for interpretation of the contact between the members; otherwise, the same undifferentiated Saugus Formation (QTs) label is used.

The Upper stratigraphic unit of the Saugus Formation consists of terrestrial fluvial and floodplain deposits that are composed of slightly cemented, interfingered and interbedded conglomerate, sandstone and clay/mudstone layers. These deposits generally extend to a maximum depth of 5,300 feet in the local groundwater basin, based on an electric log (E-log) for a deep oil well1

[1] Badger Oil Co. Magic Mountain No. 1 - 04N/16W-17Ka

located in the approximate center of the basin; these depths vary in other parts of the basin. This deep wildcat (exploratory) oil well was drilled near the east end of a prominent topographic high (called Round Mountain), which is an isolated outcrop of the Saugus Formation, just southeast of Rye Canyon Rd and Avenue Stanford, within the course of the Santa Clara River.

Strata within the Saugus Formation tend to become coarser-grained and generally more permeable in an upward direction, which is from the older and less permeable beds within the Sunshine Ranch Member to the coarser and somewhat younger beds within the main part of the formation. The formation consists mainly of lenticular beds of light-gray and brown sandstone and conglomerate intercalated with lesser amounts of reddish-brown sandy mudstone. These terrestrial sediments were deposited in stream channels, floodplains and alluvial fans of an ancestral drainage system in the Santa Clarita Valley. The coarser-grained sand and gravel beds of the Saugus Formation were deposited in the main channels of the ancient drainage system, and these more permeable beds constitute the principal, potential water-bearing materials within the present-day Saugus Formation. As the locations of the ancestral drainage channels changed during the approximately 3 million-year period of deposition of the Saugus Formation strata, the distribution of the coarse-grained channel deposits also changed, both laterally and vertically (in space and time).

In contrast, the underlying and older Sunshine Ranch Member of the formation is comprised of interfingered, fine-grained, shallow marine, brackish-water to non-marine deposits of generally thinly interbedded gray to greenish-gray sandstone and siltstone. The base of this member occurs at a depth of approximately 7,700 feet below ground surface (bgs) and attains a maximum thickness of approximately 2,400 feet in the central part of the local groundwater basin.

Because of the marine origin and the fine-grained nature and relatively low-permeability of the Sunshine Ranch Member, it is not considered to be a target for groundwater exploration or production. Wells drilled near the periphery of the Saugus Formation surface exposures in the Santa Clarita River Valley (i.e., in those areas where the Sunshine Ranch Member is at or very near to ground surface) have typically produced groundwater at rates too low for municipal-supply purposes, but may provide sufficient water for small capacity domestic supply wells, depending on water quality. Evidence from oilfield E-logs suggests that the groundwater in much of the Sunshine Ranch Member may be brackish and hence not useful for municipal supply purposes.

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1.1.3.2 *Geologic Formations Surrounding the Basin*

There are a number of geologically older formations that underlie the Alluvium and the Saugus Formation and that occur outside of the Basin; refer to Figure 1-4 for DWR-derived boundaries of this local groundwater basin. Each of these older formations are considered to be non-water bearing for large scale water-supply purposes (i.e., high-volume production wells), though groundwater in these formations could possibly be utilized for small-scale residential or landscape purposes (depending on water quality). Because they are not a significant source of groundwater for municipal water-supply purposes, these essentially non-water bearing formations will only be discussed briefly in this section. As noted above, none of these older geological formations lie within the local groundwater basin as defined by DWR Bulletin 118, update 2016 (DWR, 2016).

The formations that are present differ slightly on the north and south sides of the San Gabriel Fault as defined in Figures 2 and 3 of the report by Oakeshott (1958). Many of the named formations in those figures are not exposed at ground surface in the Basin and some of their names have been reassigned to other formations or have been renamed by others over time. Thus, the formations discussed below are in accordance with, and confined to, only those depicted on the surface geology shown on Figure 1-4 within the Basin.

1.1.3.2.1 South of the San Gabriel Fault

South of the San Gabriel Fault, the Saugus Formation lies conformably and gradationally upon the Pico Formation of late-Pliocene to Pleistocene geologic age (ranging approximately from 3 to 1.8 million years old). The Pico Formation is of marine origin and consists of gray clay, siltstone, fine-grained sandstone and light-colored sandstone and conglomerate. The Pico Formation is present at or near ground surface on the west end of the Basin where the Saugus Formation ceases to exist (or "pinches out"). Local residents sometimes refer to an area called "blue cut", which is a location where the Santa Clara River has incised into the Pico Formation; sediments in the Pico Formation often exhibit a blue-colored hue.

Conformably underlying the Pico Formation (Tp) is the Towsley Formation (Tt) of late-Miocene to early-Pliocene geologic age, approximately 6 to 3(?) million years in age. This unit is composed of terrestrial fluvial deposits consisting of well consolidated to cemented and interbedded shales, siltstones, sandstones and conglomerates. The Towsley Formation is, in turn, unconformably underlain by sedimentary rocks of the Modelo Formation (Tms) of middle- to late-Miocene age,

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ranging from approximately 16 to 7 million years ago, and consisting chiefly of cemented sandstone and siliceous, diatomaceous shales.

The above-described bedrock units unconformably overlie pre-Tertiary basement complex rocks (bc) of the San Gabriel Mountains. These geologically old materials consist of the crystalline rocks of quartz diorite, hornblende diorite gabbro and gneiss; they were likely emplaced during the Cretaceous period; i.e. approximately 145 to 90 million years before the present.

1.1.3.2.2 North of the San Gabriel Fault

North of the San Gabriel Fault, the formations below the Saugus Formation are not the same as those on the south side of the fault. Movement along the fault during and following formation of the Basin-area sediments caused the Saugus Formation to be deposited on top of different, but geologically-older formations. On the north side of the fault, the Saugus Formation unconformably overlies Miocene-aged (ranging from 23 to 5.2 million years ago) terrestrial sediments of the Castaic (Tc), Tick Canyon (Tt), Mint Canyon (Tm), Vasquez (Tv) formations and the Violin Breccia (Tvb, located northwest of Castaic Lake); refer to Figure 1-4. These older formations that underlie the water-bearing alluvium and Saugus Formation (within the local groundwater basin) tend to be well-consolidated and cemented and have relatively low porosity and permeability. The Violin Breccia, in particular, of late Miocene age, is considered to be a facies of the Ridge Basin Group and is an assemblage of hard sand, gravel and breccia derived from basement rocks southwest of the San Gabriel Fault (Dibblee, 1997a). These rocks were deposited as debris flows, talus and alluvial fans accumulating along the San Gabriel Fault scarp (Link & Osborne, 1978, Link, 2003), during development of the San Gabriel Fault at that time.

These older rocks essentially form the local bedrock and are not considered water-bearing in terms of their ability to supply groundwater in useable quantities and of acceptable quality for municipal or agricultural supply purposes. Wells and test holes drilled into these bedrock materials have typically encountered low groundwater production rates and sometimes less than favorable water quality.

The assemblage of bedrock units, discussed above, also unconformably overlie all pre-Tertiary basement complex rocks of the San Gabriel Mountains. The rocks in this area of the mountains consist of crystalline, intrusive igneous rock granite and metamorphic rocks of the Pelona Schist,

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both of late Mesozoic age (approximately 80 to 66 million years in geologic age) and augen gneiss, of Pre-Cambrian geologic age (approximately 1.65 billion years old).

1.1.3.3 Regional Geologic Structures

The Quaternary alluvium along the Santa Clara River and its tributaries generally overlies the older terrace deposits and the Saugus Formation in the area. As such, a significant unconformity (a separation of two or more units by a geologic time gap) occurs between those two older formations and the alluvium. The alluvium appears to be undeformed by any recent tectonic activity (occurring since the beginning of the Holocene period), such as folding or faulting. To some extent this is also the case for the terrace deposits, although they have been tectonically uplifted in some areas and are slightly folded. One such fold has been mapped in an area where the terrace deposits crop out in the hills east of San Fernando Road and the South Fork of the Santa Clara River

However, the alluvium generally exhibits sedimentary structures associated with deposition by the typical mode of meandering rivers and streams. Examples of such sedimentary structures are cross-bedding (where one set of sediments have been laid at an angle to previously deposited sediments) and cut and fill structures (where one stream bed has cut into underlying previously deposited sediments and then subsequently filled in by more recent material).

The general overall structure of the slightly geologically older Saugus Formation is one of an isolated “bowl” that has been cut (at least in part) by two major faults, namely the San Gabriel Fault and the Holser Fault, and also folded along a number of generally east-west trending folds. The sedimentary layering in the Saugus Formation and in the underlying bedrock dips (i.e., the beds are inclined) generally toward the center of the “bowl” from all locations along the outer (perimeter) contact of the Saugus Formation. However, there is some degree of localized folding of the layers along the San Gabriel Fault, resulting in small and large anticlinal and synclinal structures with axes trending from the northwest to the southeast (Dibblee, 1996a).

The San Gabriel Fault system and the Holser Fault generally cut across the Saugus Formation and all older formations in the region. The San Gabriel Fault system has a relative right-lateral movement (where land on one side or the other moves to the right, relative to the other side); whereas the Holser Fault is considered to have left lateral movement However, these two faults also show some vertical component of movement. The San Gabriel fault is theorized to have a

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horizontal displacement on the order of 20 miles, and vertical displacement of 1,400 feet (Crowell, 1954) . Displacement on the Holser Fault has been estimated to be roughly four miles horizontally, and perhaps 3,000 to 5,000 feet vertically (Slade, 1988). Further, these two faults divide the Saugus Formation into three distinct fault-bounded blocks, sometimes referred to as the South, Central and Northern blocks.

1.1.4 Principal Aquifer Systems

1.1.4.1 Alluvial Aquifer System

The alluvial aquifer system overlies the Saugus Formation and serves as one major source of groundwater to groundwater users in the region. Data from the numerous shallow wells in the valley show that the maximum thickness of alluvium varies along the Santa Clara River and it appears to reach a maximum depth to 200 feet bgs in several wells in the approximate center of the valley. The alluvial sediments generally thin and pinch out traversing from the valley center and progressing outward towards the surrounding hills. The alluvial aquifer is replenished/recharged chiefly by rainfall and infiltration of surface water runoff in the Santa Clara River and its tributaries, as evidenced by static water level changes shown on hydrographs from the numerous wells in the valley that obtain groundwater solely from this aquifer. Those hydrographs (presented here in the Groundwater Conditions Technical Memorandum, by others) show that static water levels exhibit rapid responses and large fluctuations during rainfall events and intervening drought periods. The alluvial aquifer along the main-stem of the river is also replenished from discharge of treated wastewater from the Saugus and Valencia Water Reclamation Plants (WRPs).

1.1.4.1.1 *Exclusion of Portrero Canyon from GSP Management*

Potrero Canyon lies in an unincorporated portion of Los Angeles County west, of Interstate 5 and south of the Santa Clara, and just west of the Los Angeles/Ventura county line (see Figure 1-1). The canyon is nearly four miles long, extends westward from its headwaters near Stevenson Ranch to its outlet just south of the Santa Clara River, about one mile upstream of the County line and the western terminus of the groundwater basin. Because the floor of the canyon is shallowly underlain by Alluvium, it is included as part of the DWR-defined groundwater basin shown on Figure 1-1. However, for the reasons described below, Potrero Canyon will not be included as an area that is subject to management under this GSP.

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Available geologic and water quality data indicate that groundwater in the alluvium of Potrero Canyon and the underlying Pico Formation bedrock is saline. Furthermore, those earth materials do not readily transmit groundwater to wells. As shown on Figure 1-4, the principal geologic units in the canyon are shallow Alluvium (Qa) and the underlying Pico Formation (Tp). As noted in Section 1.1.3.2, the Pico Formation is considered to be non-water bearing for large-scale water supply purposes. Within Portrero Canyon, the alluvium is also fine grained and contains saline groundwater (Slade, 2002). No water supply wells are currently present in the Potrero Canyon area. Available water quality data in Potrero Canyon indicate that alluvial groundwater and surface water are saline, likely because the alluvium is derived from the weathering, transport, and redeposition in the Potrero Canyon watershed of Pico Formation strata, which are of marine origin (Slade, 2002).

Potrero Canyon is largely undeveloped and is owned by FivePoint. A cattle ranching operation was formerly present in the canyon, but is not currently in operation. No agricultural or other irrigation-dependent activities are present or are known to have existed in the past, except for domestic outdoor use at the existing ranch (now owned by FivePoint). The limited water use in the canyon has been mainly for domestic purposes and has been supplied by a pipeline that imports water from a water well located outside of Potrero Canyon.

Three sensitive plant communities have been identified by others in Potrero Canyon: the riparian strip along the main stream channel in the canyon, the Salt Grass community, and the Mesic Meadow. Shallow saline groundwater is supporting each of the sensitive plant communities in the canyon. Because the local groundwater has high concentrations of total dissolved solids, the predominant plant species living in the Salt Grass and Mesic Meadow areas (e.g., those that are characteristic of a cismontane alkali marsh) are salt tolerant. Evapotranspiration processes occurring in and around these plant communities also tend to concentrate salts in the upper soil profile, and as a result salt is visible at the ground surface in some locations.

1.1.4.2 Saugus Formation Aquifer System

Depending on location within the local basin groundwater basin, the Saugus Formation may exist under confined, semi-confined or even unconfined conditions. This formation serves as the other major source of groundwater in the region. In the center of the valley, the sedimentary layering of the formation is nearly horizontal and some confining layers of low permeability (fine-grained

silts and clays) may limit groundwater movement in an upward or downward direction. Consequently, groundwater occurs under pressure within the intervening sand and gravel units, and water levels in Saugus Formation water wells tend to be above the top of the perforated casing intervals that intersect these coarse-grained aquifer units, thereby providing evidence that groundwater is under confined or semi-confined conditions.

In contrast, near the outer perimeter of the Saugus Formation, near the boundaries of the groundwater basin, the sedimentary layering is tilted downward toward the center of the "bowl" and the permeable sand and gravel beds of the formation are in direct contact with either the ground surface or with highly permeable alluvial or terrace deposit materials. In these areas, the Saugus Formation aquifer may be essentially under unconfined, water table conditions.

Virtually all known existing and historic Saugus Formation water wells have been drilled south of the San Gabriel Fault. Only one known attempt has been made to drill and construct a Saugus Formation water well into the lower and geologically older Sunshine Ranch Member of the Saugus Formation, which predominates in the area north of the San Gabriel Fault. That well did not produce groundwater in sufficient quantities or acceptable quality for municipal-supply purposes, and it was subsequently destroyed.

As discussed above, the San Gabriel and Holser faults divide the Saugus Formation into three distinct blocks: the South, Central and North blocks. These fault blocks control the geographic distribution of potential sand and gravel aquifers within the Saugus formation; wherein the Central block contains the thickest accumulation of potentially water-bearing sediments, the South block has the second greatest accumulation of such sediments, and the North block has the thinnest accumulation of sediments. Details regarding the sediment thickness of the Saugus Formation within each block are described below under "Depth to Base of Fresh Water."

Slade (2002) identified an important stratigraphic zone of coarse-grained sediments near the base of the Upper Saugus Formation through the correlation of E-Logs of several existing oil wells and water wells. This correlated stratigraphic zone was informally termed the Santa Clarita Aquifer Zone by Slade (2002). This zone in the subsurface can be identified on E-Logs of wells over a wide area of the Basin and generally occurs at depths ranging from 800 to 1,500 feet bgs. Existing Saugus Formation water wells with the highest pumping rates generally tend to produce groundwater from within and stratigraphically above this Santa Clarita Aquifer Zone.

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1.1.4.3 Aquifer Properties

1.1.4.3.1 Alluvial Aquifer

The alluvial aquifer generally consists of unconsolidated and intercalated (i.e., interfingering lenticular beds) deposits of clay, silt, sand and gravel. Groundwater within the alluvial aquifer in the study area occurs under unconfined (i.e., water table conditions) and groundwater within this aquifer is generally contained within the interstitial pore spaces (known as porosity). Moreover, the degree of interconnectedness of these pore spaces is a measure of its permeability, which is the ability of the material to transmit water. Permeability values are generally used in groundwater flow and transport modeling studies.

Groundwater in the alluvial aquifer system, because it is under the direct influence of atmospheric conditions of pressure (water table conditions), moves (flows) from higher to lower elevations via the force of gravity. Thus, the slope of the water table surface is known as the hydraulic gradient and is governed by both elevation and the amount of groundwater moving through the alluvium. In addition, because of the unconsolidated nature of the aquifer materials, the permeability (hydraulic conductivity) of the alluvial aquifer is relatively higher than that of the underlying Saugus Formation. As such, wells perforated in the alluvial aquifer system tend to be relatively efficient, compared to that in the less permeable aquifer systems in the underlying Saugus Aquifer system.

1.1.4.3.1.1 Porosity & Specific Yield

The porosity of the alluvial aquifer system may range from 10% to 30%, or slightly greater, depending on the grain size distribution in the type of earth materials present; an average value of 20% is often assumed for the purposes of evaluating aquifer characteristics. The porosity of the alluvial sediments is governed by the type of earth materials present in the aquifer system. Generally, clays tend to have the highest porosities whereas sands and gravels tend to have lower porosity values. However, porosity values for the alluvial sediments of the Santa Clarita Valley were estimated based on a review of over 300 driller's logs for historic alluvial water-supply wells throughout the basin. These porosities were estimated by Slade (1986) to range from 9% to 16%.

Specific yield is a measure of the amount of groundwater that can flow to a well under gravity drainage only. For unconsolidated alluvial sediments, the porosity is approximately equal to the

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specific yield. Thus, the specific yield for the alluvium is estimated to be in that aforementioned range of 9% to 16%.

1.1.4.3.1.2 Hydraulic Conductivity, Transmissivity, & Storativity Values

As noted above, hydraulic conductivity is a measure of the ability of geologic media to transport water through the pore spaces in the sediments of an aquifer system. Generally, clays have the lowest hydraulic conductivities whereas gravels tend to display the highest values. This character is usually determined through aquifer testing of wells, although values can be estimated using empirical relationships. Based on the results of aquifer testing, calculation of the aquifer coefficients of transmissivity (T) and storativity (S) can be made. The parameter T is a measure of the transmitting property of an aquifer and can expressed in units of square feet per day (ft^2/day). The parameter S is a measure of the volume of water that can be released from an aquifer per unit area of the aquifer and per unit reduction in hydraulic head (water level change). This value is usually expressed in cubic feet per square foot per foot, ft^3/ft^3 and thus is a dimensionless quantity. In alluvial aquifer systems, S can be considered to be equal to the specific yield. Hydraulic conductivity, which is a measure of the velocity at which groundwater moves through a formation, is expressed as k, in units of feet per day, ft/day). This parameter can be calculated directly from T values, by dividing T by the saturated thickness of the aquifer section perforated in a well. As such, calculated k values reflect the intrinsic property of the aquifer and do not change, whereas T values could change, based on the differences in the saturated thickness of the aquifer system.

For the alluvial aquifer system, Slade (1986, Plate 7 and updated with results of constant rate pumping test data from numerous alluvial wells constructed between 1986 and 2009) provided values for T and k values. These values tend to vary spatially in the alluvial aquifer system. The following table summarizes the ranges of those T and k values for the alluvial aquifer system along the Santa Clara River and its tributary watersheds, from the west (near the Ventura County Line) to the east (near Lang):

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RIVER SECTION	k VALUES (ft/day)	T VALUES (ft^2/day)
Dell Valle to Castaic Junction	40 to 735	2,850 to 67,300
Castaic Valley Tributary	25 to 710	1,778 to 60,600
San Francisquito Canyon Tributary	11 to 285	1,000 to 22,000
Castaic Junction to Bouquet Junction	3 to 460	3,000 to 29,400
Bouquet Canyon Tributary	10 to 440	700 to 55,200
Bouquet Junction to Newhall (South Fork of Santa Clara River)	2 to 47	1,400 to 19,300
Saugus to Solemint	<7 to 935	<670 to 84,600
Solemint to Lang	<7 to 930	<670 to 67,600

The above table shows that both T and k values in the alluvium tend to show a great degree of variability. Such variability is likely due to local lithologic differences in the alluvial sediments between different well locations, methods of well construction, depth interval of the perforated section(s) of the well, degree of plugging of the casing perforations, and/or differences between the efficiency of the well, or a combination of some or all of these factors.

1.1.4.3.1.3 Historic Groundwater in Storage Calculations

The amount (i.e., the total volume) of groundwater contained within pore spaces within the alluvial sediments that is present at any one particular time is known as the groundwater in storage. The amount of groundwater in storage in the alluvial aquifer system depends on the following:

- the total volume of the alluvial sediments in the defined alluvial aquifer system of the local groundwater basin;
- the specific yield of those sediments;
- the proportion of those sediments that is saturated with groundwater at a specific water level monitoring date.

Because the volume of sediments and specific yield of an aquifer do not generally change over time, the amount of groundwater in storage in the alluvial aquifer is directly related to its saturated

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thickness (i.e., to a specific water level monitoring date for wells in the alluvium). This is indicated by measured groundwater levels at a specific date in water wells within the alluvial sediments. A rising water table increases the thickness of the saturated water-bearing section, thereby increasing the volume of groundwater in storage; the converse is true for a declining water table.

Groundwater levels in the alluvial aquifer are highly influenced by local rainfall and recharge (a highly variable factor in southern California). The amount of groundwater in storage in the alluvial aquifer has varied considerably over the past 50 to 60 years as the local climate has experienced periods of both higher than average rainfall (wet years) and lower than average rainfall (dry years). Slade (1986 & 2002) estimated the volume of groundwater in storage (in units of acre feet, AF) for years 1945, 1965, 1985, and 2000; those volumes ranged from 100,000 AF to 200,000 AF. As part of the GSP development, current groundwater storage estimates will be calculated using a groundwater flow model, and reported in forthcoming Technical Memoranda.

1.1.4.3.2 Saugus Aquifer System

Groundwater moves slowly through the Saugus Formation because it is slightly more consolidated, in comparison to that in the overlying alluvial sediments, and groundwater must travel through more restricted pore spaces within the individual sand and gravel aquifer units in the Saugus Formation. The groundwater velocity at any location within this formation depends on the hydraulic conductivity (permeability) of the aquifer materials, which differs from one individual sand and gravel unit to the next, and on the hydraulic gradient that drives the groundwater movement. The hydraulic gradient is defined as the slope of the water level surface (or more correctly, the slope of the piezometric surface where the formation is under confined conditions), and this slope will vary on both seasonal and longer-term cycles over time.

1.1.4.3.2.1 Hydraulic Conductivity, Transmissivity, & Storativity Values

T and k values of the Saugus Formation sediments also show some degree of variation across the local groundwater basin. T values determined from aquifer (pumping) tests in several Saugus Formation wells located in different parts of the local groundwater basin have generally ranged from 400 ft^2/day to as high as 24,300 ft^2/day (Slade, 1988, 1989, 2001). Calculated k values for wells exhibiting these T values ranged from 1 ft/day to 34 ft/day. Only a few additional Saugus Formation wells have been constructed since 1988. Testing of these more recently-constructed deep wells have yielded T values of 3,300 ft^2/day and 8,300 ft^2/day (VWD-207 and VWD-206,

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respectively). Values of k for these two wells were 1 ft/day to 34 ft/day, respectively. The distribution of the T and k values in the wells indicates a general trend from lower transmissivity values near the southeastern edge of where the Saugus Formation is exposed at ground surface to higher transmissivity values near the center of the local groundwater basin.

Storativity, which is a term typically used for confined aquifer systems, is a dimensionless measure of the volume of water that will be discharged from an aquifer per unit area of the aquifer and per unit reduction in hydraulic head. These values for wells in the Saugus Formation are on the order of 1.0×10^{-4}.

1.1.4.3.2.2 Depth to the Base of Freshwater and Santa Clarita Zone

Groundwater in the Saugus Formation is classified into two basic divisions, depending upon water quality conditions. These conditions exist where the groundwater grades from freshwater, considered to be 3,000 parts per million (ppm) or less in salinity, to brackish and saline groundwater which may display salinity values above 3,000 ppm. Estimation of the maximum depth to which fresh groundwater occurs within the Saugus Formation, defined as the base of fresh water, had been performed with some degree of accuracy through an evaluation of both water well and oil well E-Logs. More than 250 of these E-Logs, located throughout the river valley, were utilized in previous studies (Slade 1988, 2002), as a part of the effort to define the base of fresh water within the local groundwater basin. On some E-Logs, the vertical transition from the overlying fresh water to the underlying saline water is very abrupt and unambiguous, and thus can be identified at a specific depth. On other E-logs, the transition from fresh water to saline water is gradual and may occur over a vertical distance of hundreds of feet. In such cases, and in order to be conservative, the base of fresh water was chosen, insofar as possible, at the top of the zone of transition from fresh water to saline water (Slade, 1988, 2002).

The depth and thickness of the water bearing deposits in each of the fault blocks in the valley are as follows:

- North Block. Northeast of the San Gabriel fault, the maximum depth to the base of fresh water within the Saugus Formation is approximately 1,500 ft. By comparison, the maximum total thickness of the Saugus Formation, based on E-Logs, is on the order of 2,000 ft in this area. In this fault block, the Santa Clarita Aquifer Zone does not exist and, instead, only deposits of the underlying Sunshine Ranch Member are considered to occur.

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- Central Block. In the wedge-shaped central fault block between the San Gabriel fault and the Holser fault, the maximum depth to the base of fresh water within the Saugus Formation is approximately 5,500 ft. In this area, the maximum total thickness of the Saugus Formation is approximately 8,500 ft. The top of the Santa Clarita Aquifer Zone in this fault block was determined to occur at a depth ranging from 100 ft in the north-northwestern portion of the block, to 1,500 ft in the southeastern corner of the block adjacent to the San Gabriel fault, and to as great as 2,900 ft bgs in the central (deepest) portion of this block.
- South Block. Southwest of the Holser fault, the maximum depth to the base of fresh water within the Saugus Formation is approximately 5,000 ft. The Saugus Formation obtains a maximum total thickness on the order of 7,500 ft in this block. The depth to the top of the Santa Clarita Zone is estimated to be roughly 2, 200 ft bgs.

1.1.4.3.2.3 Confining Beds

The Saugus Formation generally contains disconnected and interbedded layers of clay, silt, sand and gravel. The interbedded clay layers may act as local aquitards (confining beds), thereby providing at least a partial barrier to the vertical migration of groundwater. Interbedded clay layers range in thickness from 10 ft to as much as 50 ft. However, the depths and thicknesses of these clay layers have not been defined to date in any studies of the groundwater basin, but, depending on the locations of a well in the basin, there is likely to be several such clay layers dispersed throughout a vertical section of the formation.

1.1.5 Cross Sections

As part of the geologic and hydrostratigraphic characterization of the basin, five geologic cross-sections have been prepared by RCS to further describe and illustrate the vertical and lateral extent of the aforementioned geologic formations and units. Figure 1-4, “Geologic Map showing Cross Sections,” illustrates the ground surface traces and alignments of these cross sections plotted on a geologic map of the Basin. These five, RCS-prepared Cross sections (AA-AA’ through EE-EE’) are presented in Figures 1-6 through 1-10, respectively and illustrate the subsurface interpretation based on a comparative review of available geologic data and electric log data.

1.1.5.1 Cross Section Preparation

Preparation of the five RCS cross sections utilized a step-wise multifaceted approach combining previous studies with additional more recent geologic data. Cross section data were obtained from previous basin wide studies completed by RCS (1986, 1988, 2001, & 2002), as well as from

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review of published geologic maps and geophysical well logs (E-logs) from the Geologic Energy Management Division (CalGEM) well database. Some data were reinterpreted, and prior interpretations were updated based on the availability of newer subsurface data that were available in some areas of the local groundwater basin.

1.1.5.2 *Cross Section Traces*

Cross section traces were selected to illustrate the stratigraphy and general geologic structure of the groundwater basin. Section line traces AA-AA', DD-DD', EE-EE' (see Figure 1-4) extend past opposite basin boundaries in a semi-orthogonal orientation to provide representative subsurface illustrations of the long and short axes of the Basin. Obliquely oriented cross sections BB-BB' and CC-CC' illustrate subsurface conditions along the Santa Clara River and the southeastern zone of the basin, respectively. Each of these sections is presented at the same vertical scale, but due to the small horizontal scales of the sections, the sections are vertically exaggerated, as shown on the Figures. Cross Section FF-FF', Figure 1-11 (the section trace is shown on Figure 1-4 for reference), was created by ~~Geomatrix~~Geosyntec Consultants, Inc (~~Geomatrix~~Geosyntec) using different methodology than that used by RCS and for a separate purpose (to be covered in a separate Technical Memorandum to be prepared by others), and does not possess the same horizontal or vertical scale as the five other cross sections discussed herein. Specific discussion of Section FF-FF' is provided in Section 1.1.5.5.

1.1.5.3 *Geologic Structures*

Construction of the five cross-sections required derivation and correlation of geologic formations in the subsurface using various data and methods. First, shallow formation contacts were interpreted and derived from mapped surface contacts and structural geology features. Surface mapped contacts and bedding orientations were plotted and projected from surface to depth, allowing for an initial starting point to correlate geologic formations.

Additional review of regional geologic structures was conducted with respect to previous studies. Fault traces and contact planes were compared to available geographic information system (GIS) data sets. Similarly, local fold structures, escarpments, and topography GIS data sets were reviewed to provide a summary representation of local fault structures and geologic contacts. As discussed in Section 1.1.3, a majority of the fault traces depicted in the figures created for this

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document have been simplified to be represented by single-line traces, and not by a series of en echelon faults within various fault zones.

1.1.5.4 Well Log Analysis & Interpretation

After plotting surficial contacts and regional structural features, formation depth intervals were derived from analysis of available groundwater and oil/ gas well E-logs. Formation identification

and interpretation based on E-logs is a common method and is a practice that is routinely used in the energy and resource sectors. The process involves comparing different geophysical logs such as gamma-ray, spontaneous potential, resistivity, and density-neutron in combination with other geologic data gathered during drilling (core, cuttings, drilling progression, etc.) to help identify formations and changes in subsurface materials. For further detail on well logging see, for example, Asquith and Krygowski (2004).

Due to the nature and availability of E-logs from the CalGEM database, short and long normal resistivity logs were primarily used to identify and correlate the respective formations within the Basin. To demonstrate how the well log and E-log information was correlated, Figure 1-12, "Detailed Stratigraphic Interpretation," plots three sequential (west to east) resistivity logs that were used to correlate formation contacts in cross-section AA-AA'. Higher resistivity values (ohm meters per meter) plotted in Figure 1-12 infer higher porosity within the local subsurface material, which can be inferred to be "coarser grained" strata. Thus, the vertical resistivity profile can show a stratigraphic package(s) of geologic units (and may even suggest depositional environments) when coupled with drill hole cuttings and core logs. These geologic or stratigraphic packages or units were correlated with similar geologic units in selected E-logs to infer the subsurface extent and continuity of each respective formation as shown on the cross sections.

Additionally, lithologic interpretation of the resistivity logs shown in Figure 1-12 was also conducted to show sedimentary variance within the Saugus Formation. Interpretation of lithology based on resistivity is provided in a color sequence in Figure 1-12. Lithologic comparison between resistivity logs of wells VWD-160 and VWD-203 show correlative units of coarser grained sediments but with varying intensity of resistivity. The lithology logs show finer grained (lower resistivity) units are interbedded with coarser-grained units within both well logs as documented in previous studies (Winterer & Durham, 1962). Moreover, resistivity signatures in the well log for the wildcat oil well Magic Mountain 1 indicate coarser grained sediments at the same elevation

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where finer grained sediments are correlated in well VWD-160, further indicating lateral formation variation within the Saugus Formation.

1.1.5.5 Cross Section FF-FF'

As discussed above, Cross Section FF-FF' (Figure 1-11) was created by ~~Geomatrix~~Geosyntec using different methodology than that used by RCS to create the other five cross sections shown on Figure 1-4 and therefore does not possess the same horizontal or vertical scale as the other five cross sections presented on Figures 1-6 through 1-10. Further, Section FF-FF' was created by ~~Geomatrix~~Geosyntec to help evaluate the interaction of groundwater between the shallow alluvium of the Santa Clara River, the Saugus Formation, and the Pico Formation.

Cross Section FF-FF' is aligned along the approximate center of the Santa Clara River channel, traversing approximately east to west, beginning in the vicinity of an outcrop of the Saugus Formation known as "Round Mountain". From there, this cross section continues westerly to a point outside of the western boundary of the groundwater basin (See Figure 1-4) that coincides with the edge of the existing MODFLOW model boundary; the MODFLOW model is discussed in other technical memoranda prepared by others.

To create Cross Section FF-FF', ~~Geomatrix~~Geosyntec incorporated the five RCS-prepared cross sections (AA-AA' through EE-EE') into the Leapfrog Geological Modeling software package. Geologic contacts on those sections were digitized and interpolated across the model domain by ~~Geomatrix~~Geosyntec. Sections AA-AA', DD-DD', and EE-EE' (Figures 1-6, 1-9, and 1-10, respectively) reportedly provided the most influence on lithologic interpretations by ~~Geomatrix~~Geosyntec along the central and eastern portions of Section FF-FF'. Depth of alluvium on those three Cross Sections serve as the primary drivers for depth of alluvium in the central and eastern potions of Section FF-FF'. Section A-A' from the Slade (1988) report was also used to support the interpreted depth of alluvium in the eastern portion of FF-FF' by ~~Geomatrix~~Geosyntec.

Because the ground-surface profile of Cross Section FF-FF' is relatively shallow compared to the that on each of the other five Cross Sections, ~~Geomatrix~~Geosyntec used a high-resolution Lidar survey to supplement the existing 1/3-arcsecond digital elevation model (DEM) from USGS that was used to create the ground surface profiles for Sections AA-AA' through EE-EE'. The high-resolution Lidar survey was conducted by others along the Santa Clara River in the vicinity of FF-FF', and provided for a more accurate ground surface profile of Section FF-FF'. Lidar

Survey data were

down-sampled to 0.5-meter resolution in order to maintain a manageable file size and were converted from their native coordinate system (NAD83 2011 UTM Zone 11 North) into the Leapfrog model projection (NAD83 CA State Plane V).

Alluvium depths shown on Section FF-FF' that were interpreted using the RCS Cross Sections and the Leapfrog Modeling software were calibrated using a series of surface geophysical

transects that were performed by ~~Geomatrix~~Geosyntec in February and March 2007. Data from four seismic refraction lines were collected in the vicinity of "blue cut" perpendicular to Henry Mayo Drive (near the west end of the groundwater basin). Data collected were used to digitize the survey profiles into the Leapfrog model and were calibrated using the existing 0.5-meter resolution DEM (created using the Lidar data). The depth of alluvium interpreted from each of the four seismic refraction surveys was used to establish control points along each profile and interpolated between adjacent transects. Those data were then used to adjust the alluvial depths shown on Section FF-FF'.

1.2 Groundwater Recharge and Discharge Areas within the Basin

1.2.1 Groundwater Recharge

1.2.1.1 Alluvial Aquifer System

Groundwater in the alluvial aquifer is recharged by both natural and artificial (man-made) sources. The relative volume of each of the recharge sources discussed below is variable depending on a number of factors, including annual variations in precipitation and temperature.

Sources of natural recharge to the sediments of this aquifer include:

- Streamflow infiltration from runoff along the Santa Clara River and its tributaries.
- Deep percolation of direct rainfall.
- Subsurface groundwater inflow from upstream areas along the Santa Clara River or its tributaries.
- Upward groundwater flow from certain portions of the Saugus Formation where it is overlain by alluvium. This interaction between the alluvium and the underlying Saugus Formation is discussed in the 2003 Groundwater Management Plan for the Basin (LSCE 2003). In general, groundwater moves from the Saugus Formation aquifers to the alluvial aquifer in areas west of Bouquet Canyon (LSCE, 2003).

Sources of anthropogenic (man-made) recharge to the sediments of this aquifer include:

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- Recharge to the alluvium also occurs from deep percolation of irrigation water and is obtained from urban irrigation (landscape irrigation) in the developed areas of the groundwater basin and from areas that are farmed. Agricultural irrigation was historically widespread in the valley; current irrigated acreage is on the order of 1250 acres.

- Recharge also occurs indirectly as a result of the infiltration of reclaimed water that is actively treated by and discharged from two water reclamation plants (WRPs) in the area, namely: the Saugus WRP, placed into operation in 1962, and located east of the intersection of Cinema Drive and Bouquet Canyon Road; and the Valencia WRP, in operation since 1967, and located west of the intersection of Rye Canyon Road and the Old Road. Both plants are operated by the Los Angeles County Sanitation Districts, and together discharge approximately 18 million gallons of treated water per day to the Santa Clara River, with an average annual discharge of approximately 20,000 AF/Y. The treated water from the Saugus WRP is either discharged to the Santa Clara River north west of the intersection of Bouquet Canyon Road and Valencia Boulevard, or conveyed to the Valencia WRP for additional treatment and then released to the Santa Clara River west of Interstate 5.
- Artificial recharge of the alluvial aquifer system, via spreading basins or injection wells, has not been conducted within the Santa Clarita Valley; however, SCV Water is presently conducting studies to evaluate the feasibility of managed aquifer recharge.

1.2.1.2 Saugus Aquifer System

Direct natural recharge to the Saugus Formation occurs via deep percolation of rainfall within and around the perimeter of the outcrop area where the permeable sand and gravel beds are either exposed at ground surface or lie directly beneath the relatively thin, permeable alluvial and terrace deposits. Natural recharge to the Saugus Formation also takes place in the eastern end of the outcrop area due to leakage from overlying portions of the saturated alluvium, as originally discussed by Slade (1988). Groundwater recharge from the alluvium to the Saugus Formation generally occurs in areas east of Bouquet Junction where the alluvium overlies the Saugus (LSCE, 2003).

Anthropogenic sources of recharge to the Saugus Formation chiefly include deep percolation of landscape irrigation water in existing areas, and areas subject to future development, where the

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Saugus Formation crops out at the surface. Agricultural returns are not likely to contribute significant amounts of recharge, as agricultural operations have generally been situated over alluvial areas.

To date, artificial recharge of the Saugus Formation via injection wells or highland spreading basins has not been undertaken in the region (RCS, 2001). However, an injection and recovery study carried out in 2000 at Saugus Formation well VWD-205 located in the vicinity of McBean Parkway and Valencia Blvd (Slade 2001) demonstrated that it is feasible to conduct and operate an aquifer storage and recovery (ASR) program in the Saugus Formation.

1.2.2 Groundwater Discharge

1.2.2.1 Alluvial Aquifer System

Discharges from the alluvial aquifer system occurs primarily through pumping extraction for municipal-supply use by the water purveyors and for agricultural-supply use by others. As previously noted, FivePoint farms utilizes irrigation-supply water wells in the western end of the basin. In the eastern end of the Basin, other agricultural operations and golf courses extract water. There are also an unknown number of other privately-owned wells that utilize groundwater from the alluvial aquifer system for private irrigation and/or domestic use.

Evapotranspiration by phreatophyte vegetation is also a significant component of discharge of groundwater from the alluvium. Phreatophytes are plants such as willows and cottonwoods, as well as invasive species such as Arundo and Tamarisk, that root directly into the water table in areas of shallow groundwater.

The westernmost part of the basin is also an area of groundwater discharge from the alluvium to the Santa Clara River. The amount of flow into the river will depend largely on water levels within the alluvium. Groundwater also flows out of the basin into Ventura County, but this occurs solely as underflow from groundwater present within relatively thin alluvium at the Los Angeles-Ventura County Line. The only other water to flow from the valley into Ventura County is via surface water flow along the Santa Clara River, including releases from Castaic Reservoir into Castaic Creek that flows into the Santa Clara River and WRP discharges to the River, and from direct discharge via an agricultural supply line operated by FivePoint, which is supplied via their alluvial wells located at the western end of the valley.

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1.2.2.2 *Saugus Aquifer System*

Discharge from the Saugus Aquifer System has historically occurred primarily through ~~the~~ pumping of the several municipal-supply water wells in the Saugus Formation that are situated throughout the central portion of the valley. At the time of this study, there are ~~no known water~~

only a limited number of wells that extract groundwater from the Saugus Formation for agricultural-supply or landscape irrigation purposes. Saugus Formation wells currently in operation for irrigation purposes are located at Vista Valencia Golf Course and Valencia Country Club. ~~Irrigation~~Agricultural irrigation using groundwater pumped from the Saugus Formation also occurs at the Disney Company property in the southeastern portion of the groundwater basin, east of the Whitney Canyon fault. An additional natural discharge source occurs at the west end of the valley where Saugus Formation groundwater is considered to flow upward into the overlying alluvium in the western portion of the Saugus Formation (LSCE, 2003).

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APPENDIX C

Hydrogeologic Conceptual Model: Groundwater Conditions in the Santa Clara River Valley Groundwater Basin, East Subbasin; and Subsidence Vulnerability Technical Memorandum, Prepared by Luhdorff & Scalmanini, Consulting Engineers

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Luhdorff & Scalmanini
Consulting Engineers

TECHNICAL MEMORANDUM

DATE: ~~June 7~~December 15, 2021 Project No.: 18-1-132

TO: Mr. Jeff M. Barry, GSI Water Solutions, Inc.

FROM: Mr. Will Halligan, PG

SUBJECT: **Draft Hydrogeologic Conceptual Model: Groundwater Conditions in the Santa Clara River Valley Groundwater Basin, East Subbasin**

INTRODUCTION

This technical memorandum (TM) presents a description of groundwater conditions present in the Santa Clara River Valley Groundwater Basin, East Subbasin (Basin). This TM describes the hydrogeologic framework of the Basin. It is intended to provide a general understanding of the physical controls that influence the flow of groundwater and groundwater quality conditions in the Basin. This TM focuses on the groundwater conditions portion of the hydrogeologic conceptual model. Following are the elements discussed in this TM:

- Groundwater occurrence, flow direction, and vertical gradients in each principal aquifer
- Primary use or uses of each aquifer
- Ground Surface Subsidence
- General water quality of principal aquifers

GROUNDWATER OCCURRENCE, FLOW DIRECTION, HORIZONTAL AND VERTICAL GRADIENT

The occurrence and movement of groundwater in the Basin are described in this section. Water level contours for seasonal high and seasonal low conditions for water year (WY) 2018 are presented as it is a year that had the most complete dataset at the time this document was first drafted in early 2020. WY is an abbreviation for water year that refers to the 12-month period from October 1 through September 30 for any given year for which precipitation and surface water supply totals are measured (**Figure 5-1**). Under the Sustainable Groundwater Management Act (SGMA), the California Department of Water Resources requires that groundwater related data be represented as a WY rather than a calendar year or other year type.

Historically, seasonal high groundwater conditions occur in the winter and early spring between January and April. This time frame is generally associated with the least amount of groundwater pumping and the greatest amount of recharge from rainfall and streamflow. The greatest amount of precipitation in WY

2018 (October 2017 through September 2018) occurred in January (3.18 inches) and March (7.5 inches). Seasonal low conditions occur at the end of the water year following the summer and early fall which are associated with the least amount of recharge from precipitation and the greatest amount of groundwater pumping. Historic groundwater elevation data are presented in hydrographs for wells that are representative of conditions in each principal aquifer **(Appendix A)**. There are two principal aquifers in the Basin: the Alluvial Aquifer and the Saugus Formation. The areal extent of each of these aquifers are presented in **Figure 5-2** and described in the following sections. The areal extent of these aquifers has been generalized to conform to the California Department of Water Resources Bulletin 118 Basin boundary.

Alluvial Aquifer

Groundwater Occurrence

The Alluvial aquifer is the uppermost principal aquifer in the Basin. Primary sources of recharge include precipitation, recharge from the Santa Clara River, recharge from the Saugus Formation, and mountain front recharge (**CLWA, 2003**). Sources of manmade recharge include infiltration of irrigation water, infiltration of stormwater runoff from urban areas, infiltration of surface flow and underflow from Castaic Dam, infiltration releases by LADPW from its reservoir facilities in the San Francisquito and Bouquet Canyon area, and infiltration associated with discharges from the water reclamation plants.

Discharge from the Alluvial aquifer occurs through pumping of irrigation and municipal supply wells, discharge to the Santa Clara River in the western portion of the Basin, subsurface discharge to the neighboring Piru Basin to the west, and evapotranspiration (ET) by riparian vegetation. Discharge also occurs in the form of seepage to the underlying Saugus Formation.

Flow Direction - Water Level Contours

Figures 5-3 and 5-4 present water level contours for seasonal high and seasonal low conditions for 2018. Contours of equal groundwater elevations provide information on the elevation of groundwater in various parts of the Basin where the aquifer exists, and data is collected. Contour maps also provide information on the direction of groundwater flow. Groundwater flow is in the direction from high elevation to lower elevations and are perpendicular to the contour lines. The general pattern and orientation of the contours shown in **Figures 5-3 and 5-4** are generally representative of historical conditions in the Basin, although the elevation values on the contour lines may change from year to year.

Under seasonal high conditions, groundwater depths range between 10 feet and 150 feet below ground surface (bgs) with groundwater elevations between 878 and 1,888 ft above mean sea level (msl) using the North American Vertical Datum 1988 (NAVD88). Groundwater flow is toward the Santa Clara River on the flanks of the Basin and to the west in the lower portions of the Valley along the Santa Clara River (refer to the groundwater contour map, **Figure 5-3**). Under seasonal low conditions, groundwater depths range between 12 feet and 150 feet bgs with groundwater elevations between 877 and 1,887 ft msl. Contours are not shown where there is a lack of water level data. The groundwater flow directions in the seasonal low conditions are similar to seasonal high directions. (**Figure 5-4**). During both seasonal high and seasonal low conditions, the highest groundwater elevations occurred in the northeastern part of the Basin and

the lowest occurred in the southwest part of the Basin. For WY 2018, there was minimal variation between seasonal high and seasonal low groundwater conditions. Groundwater flow conditions based on 2018 data are consistent with the observation of **RCS 1986** and with water level contours presented in the Salt and Nutrient Management Plan for 2016 (**CLWA, 2016**).

Water Level Hydrographs

Historic water level trends for wells in the subareas of the Basin that represent groundwater levels in those subareas are presented in **Figures 5-5 & 5-6**. The wells presented in these hydrographs are located in different areas of the Basin and represent groundwater levels in the Alluvial aquifer in those areas (**Figure 5-7**). **Figure 5-5** includes wells in the eastern part of the Basin (Mint Canyon, Santa Clara River area above Saugus Water Reclamation Plant (WRP), and Bouquet Canyon) where water levels are heavily influenced by climatic conditions and seasonal pumping. Wells in the Mint Canyon area and Santa Clara River area above the Saugus WRP all exhibit a similar pattern of gradual declines over five to 10-year periods when there are below normal periods of rainfall, followed by rapid recoveries during wet periods. Generally, one to two consecutive wet years can provide enough recharge to replenish the Alluvial aquifer in the eastern areas of the Basin. Wells in the eastern portion of the Basin have shown substantially lower water levels during extended drought periods (e.g., 2006 – 2019), causing a reduction in well production in this area. Since 2006, the Basin has experienced a long-term dry period interrupted by a wet year in 2011. Over the past 10 years, the average seasonal variation between high and low conditions in the Mint Canyon and above Saugus WRP area was approximately 16 feet. This small amount of variation is due primarily to a lack of recharge and the effect depressed groundwater levels in this area have had on minimizing groundwater production. Over multi-year drought periods, water levels can decline by as much as 70 feet, which occurred in SCWD-North Oaks Central from 2011 through 2016. Wells in the Bouquet Canyon area show a less rapid decline and recovery. Declines in groundwater levels during extended dry periods is not an indication of overdraft, which is why it is important to look at a long-term period of time that represents average annual climatic conditions. With this in mind, over the past 30 years, these wells have exhibited stable water levels with periods of rising levels during wet periods and declining water levels during droughts. Over the past 10 years, the average seasonal variation in water levels was approximately 10 feet.

Figure 5-6 represents the historical groundwater levels measured in wells located in the western part of the Basin (San Francisquito Canyon, Santa Clara River below Saugus WRP, Castaic Valley, and below Valencia WRP). Groundwater levels in the western part of the Basin exhibit similar trends to those in the eastern portion of the Basin (San Francisquito and below Saugus WRP) VWD-W11, VWD-9, VWD-Q2, and NLF-W5. However, the magnitude of water level declines during periods of reduced rainfall are less due to the recharge from the two WRPs and the upward vertical gradient from the Saugus Formation into the Alluvial aquifer. This influence is indicated in the hydrograph for well VWD-I. Since 2010, the average variation between seasonal high and seasonal low water levels was approximately 10 feet. Over drought periods, depth to water has ranged between 20 and 50 feet as exhibited in VWD-I and VWD-W11 from 2011 through 2016, respectively. All the Alluvial aquifer wells completed in the Castaic Creek drainage and the western portion of the Basin below the Valencia WRP along the Santa Clara River remained stable over various hydrologic wet and dry periods. Since 2010, the average variation between seasonal high and low water levels on average is approximately 9 feet, similar to other areas of the Basin in the Alluvial

aquifer. Over drought periods, water levels have declined by as much as 40 feet as exhibited in VWD-D from 2011 through 2016. Other wells such as NLF-B10 and NLF-B4 have shown almost no change in water levels over dry periods. Historic groundwater elevations for All alluvial aquifer wells having long-term monitoring data are presented in hydrographs in **Appendix A.**

Saugus Formation Aquifer

Groundwater Occurrence

The Saugus Formation Aquifer underlies the Alluvial aquifer and is present throughout the entire Basin, unlike the Alluvial aquifer. The Saugus Formation can be further subdivided into two units. The upper portion, which is up to 5,000 ft thick and consists of coarse-grained sand and gravel beds, contains the majority of the accessible groundwater. The lower portion, known as the Sunshine Ranch Member, is up to 3,500 ft thick and is composed of fine-grained sediments with low permeability. The Sunshine Ranch Member does not provide groundwater in sufficient quantity or adequate quality for municipal use (**Slade, 2002**). Generally, the upper 1,000 to 2,000 ft of the upper portion of the Saugus Formation is utilized for municipal groundwater production. The underlying 3,000 ft is not utilized for municipal supply.

The primary sources of recharge to the Saugus Formation include percolation from the Alluvial aquifer (particularly on the east end of the Basin), direct recharge from precipitation, and inflow from outside the Basin (**CLWA, 2003**). Discharge from the Saugus Formation is primarily from groundwater extraction and flow to the Alluvial aquifer in the western portion of the Basin (**CH2MHill, 2004**).

Flow Direction - Water Level Contours

Under seasonal high conditions, groundwater depths range between 50 and 185 feet bgs with groundwater elevations ranging between 964 and 1,190 ft msl (**Figure 5-8**). Water level measurements across the Saugus Formation are limited due to the lack of wells in many areas of the Basin where the Saugus Formation is present. However, utilizing available data, the general groundwater flow direction is ~~predominantly east~~thought, based upon groundwater modeling results, to ~~west~~be generally westerly toward ~~Interstate 5. West of Interstate 5, data is limited, however,~~where the ~~direction~~Saugus Formation naturally discharges to the alluvium. As shown on Figure 5-8, there also appears to be a component of flow ~~is~~ from the northwest to southeast, perhaps toward major production wells in the central part of the Basin. During seasonal low conditions, groundwater depths range between 50 and 217 feet bgs and groundwater elevations range between 956 and 1,192 ft msl (**Figure 5-9**). The direction of flow during seasonal low conditions is similar to seasonal high directions. Groundwater flow conditions based on 2018 water level measurements are similar to the contours presented for the Fall 2000 in **CH2MHill, 2004**.

Water Level Hydrographs

Historic water level trends for selected Saugus Formation wells are presented in **Figure 5-10** and well locations are illustrated in **Figure 5-11**. The spatial extent and availability of groundwater level data for the Saugus Formation is limited to two areas (South and Central/West). Groundwater elevation data extends to the mid-1960s in only one well. VWD-160, shows a trend of gradual rising and falling groundwater elevations in response to wet and dry periods with historic highs occurring in the mid-1980s.

Two dry periods that occurred in the early 1990s and from the mid-2000s to 2019, resulted in groundwater levels declines of approximately 100 ft. Following the first dry period, groundwater levels recovered, however full recovery from the most recent dry period has not occurred by 2019 as the Basin has been in an extended dry period since 2006, with the exception of 2011. All of the Saugus Formation wells show this general trend. The downward trend in the most recent dry period was a result of lower amounts of recharge rather than from an increase in groundwater extractions from the Saugus Formation. In recent years in the South Area groundwater levels have shown an upward trend (NWD-12 and VWD-159) due to increased rainfall since 2016 as compared to prior years. Since 2010, the average variation between seasonal high and seasonal low water levels in the south area was approximately 18 feet, and the average variation in the central/west area was approximately 16 feet. All available historic water level data for Saugus Formation wells are included in **Appendix A**.

Horizontal Gradient

Alluvial Aquifer

The horizontal hydraulic gradient is as high as 0.018 ft/ft (95 ft/mile) in eastern portions of the Basin in the Mint Canyon area and as low as 0.005 ft/ft (29 ft/mile) in the west along the Santa Clara River (**Figure 5-3**). Under seasonal low conditions, the gradient in the east is the same as seasonal high conditions at approximately 0.018 ft/ft (95 ft/mile), but with a slightly steeper gradient in the west at 0.006 ft/ft (31 ft/mile) (**Figure 5-4**).

Saugus Formation

Under seasonal high conditions, the horizontal hydraulic gradient is approximately 0.008 ft/ft (42 ft/mile) (**Figure 5-8**). Under seasonal low conditions, the hydraulic gradient is approximately 0.007 ft/ft (35 ft/mile) (**Figure 5-9**). Gradient values are based on groundwater flow from east to west. In the western portion of the Basin where the groundwater flow directions are northwest to southeast in the area east of Interstate 5, there was insufficient data to calculate a horizontal flow gradient.

Vertical Gradient Between Principal Aquifers

The vertical gradient between the Alluvial aquifer and Saugus Formation is the mechanism to assess flow between the two aquifers. Vertical gradients or flow can be either in an upward or downward direction. For example, if the water level in the Alluvial aquifer is higher than the water level in the Saugus Formation at a particular location, there is the potential for groundwater to move vertically from the Alluvial aquifer to the Saugus Formation. The reverse can also occur in areas where groundwater elevations in the Saugus Formation are higher than those in the Alluvial aquifer. The magnitude and direction of vertical gradients were determined based on the average seasonal high-water level since 2010 at two locations in the Basin where groundwater level data from Saugus Formation wells is generally available along with nearby wells screened in the Alluvial aquifer. The average vertical gradient was determined in the vicinity of Saugus well VWD-201 located in the South area, and at the Saugus well VWD-207 area located in the western portion of the Basin. Results are presented in **Table 5-1**. The negative value in the South area indicates a downward gradient (i.e., groundwater elevations in the Alluvial aquifer at this location are higher than groundwater elevations measured in the Saugus Formation). The positive values indicate an upward

gradient from the Saugus Formation to the Alluvial aquifer. These estimates are based on available groundwater level measurements in both aquifers.

Table 5-1. Approximate Aquifer Vertical Gradient

Basin Area	Aquifer – Seasonal Condition	Average GWE	Gradient (ft/ft)
South Area	Alluvial – All VWD Monitor Wells	1079	-0.04
	Saugus – VWD 201	1024	
Western Area	Alluvial – VWD-E14	983	0.003
	Saugus – VWD-207	984	

Change in Groundwater Storage

Change in groundwater storage can be estimated using groundwater elevation data from successive seasonal high periods; or using water budget results from a groundwater flow model. The change in storage of water using the change in water level approach is a function of aquifer storage coefficients, amount of water level change, and areal extent of water level changes. A change in storage calculation using the water budget approach calculates the difference between recharge and discharge terms. The water budget approach using the Basin groundwater model will be utilized in the GSP for each of the principal aquifers when it is available. The groundwater flow model will calculate the change in groundwater storage for the historical, current, and projected water budget periods.

Subsidence

According to the U.S. Geological Survey (USGS), land subsidence is a phenomenon found across the United States, affecting the land surface of over 17,000 square miles in 45 states (**Galloway et al., 1999**). Land subsidence in California is commonly a result of fluid withdrawal (oil or groundwater). The principal causes of land subsidence are ~~aquifer system~~the compaction of fine-grained materials (caused by reduction in hydraulic head affecting the physical structure and orientation of clay minerals and drainage of organic soils. Subsidence can occur in two forms, elastic and inelastic (or permanent). For SGMA, only inelastic subsidence is to be evaluated in the GSP. ~~Elastic subsidence is similar to a rubber band being stretched and then released; the rubber band, like the land surface, returns to its original form. Elastic~~Generally, elastic subsidence occurs on a seasonal basis. When groundwater pumping occurs and groundwater levels decline ~~seasonally, elastic subsidence occurs. When groundwater pumping decreases and groundwater levels rise, elastic subsidence generally disappears.~~, the land surface can temporarily subside. When groundwater levels recover following wetter conditions and reduced groundwater pumping, the land surface can recover, similar to compressing and releasing a spring. The amount that the ground surface subsides and subsequently "springs back" is considered elastic subsidence. Conversely, the amount of decline in the ground surface elevation that remains regardless of groundwater level recovery is considered to be inelastic subsidence. This cycle occurs every year and is common everywhere there are seasonal variations in groundwater levels. For inelastic subsidence to occur in an area, that area generally requires two primary conditions. One is to have wells screened in ~~confined~~ aquifers which contain

substantial amounts of clay within the depth interval that the well is screened. The second condition is that there needs to be a multi-year period where groundwater levels in the ~~confined~~ aquifer are at elevations below historical low levels in that area of the Basin. If both conditions do not occur, then inelastic subsidence is unlikely to occur in appreciable quantities to impact critical infrastructure. Short term declines in groundwater levels over one or two years likely will not result in significant amounts of inelastic subsidence and impacts to infrastructure. This is based on data collected areas in the San Joaquin Valley that have experienced significant amounts of subsidence and where there have been significant investments in subsidence monitoring networks.

As discussed above, when discussing the potential for inelastic land subsidence in any area, it is important to consider the type of subsurface materials that could contribute to subsidence combined with well construction data, pumping records and groundwater level measurements through a multi-year period of record. As described above, the upper portion of the Saugus Formation generally consists of sands and gravels, while the Sunshine Ranch member is composed primarily of fine-grained materials. However, the upper portion of the Saugus Formation, in some but not all areas where there are current wells, contains lenses of silt and clay, which are located within the depth interval that some Saugus Formation wells are perforated and extract groundwater. However, based on an evaluation of existing geologic data for Saugus Formation wells, these materials are not laterally continuous. In addition, the Saugus Formation has not been pumped significantly to cause extended periods of groundwater level declines that have resulted in subsidence to a degree that impacts critical infrastructure to a significant and unreasonable degree. Through the last nineteen years of reviewing and reporting on the geology and water resources in the Basin, there has not been evidence of chronic groundwater level declines in areas with Saugus Formation geology with silts and clays within the screened intervals of municipal supply wells that would contribute to subsidence (**LSCE, 2017**).

A comprehensive description of land subsidence and available historical data is described by LSCE in a separate TM (**see Appendix C, LSCE, 2021**). There are three sources of information on subsidence in the region. These sources include benchmark survey data from Los Angeles County Department of Public Works (LADPW) from a comprehensive network of benchmarks located throughout Los Angeles County. Unfortunately, LADPW ~~does not have the~~provides general benchmark locations on maps, but exact coordinate information is not available ~~in a form which is able to be shown on a map of the Basin due to location confidentiality.~~at this time. The second source of data is Interferometic Synthetic Aperture Radar (InSAR) data from the Department of Water Resources SGMA Data viewer. The TRE Altamira InSAR Dataset contains vertical displacement data from 2015 through September 2019. These data were collected by the European Space Agency Sentinel-1A satellite and processed by TRE Altamira. The dataset covers more than 200 groundwater basins across the state at a resolution of approximately 100 square meters. The third source of data involves land surface elevation monitored at two continuous global positioning system (CGPS) sites, one located in the Basin north of the Santa Clara River (station SKYB) and the other outside the Basin to the north just east of Interstate 5 (station CTDM) as shown in **Figure 5-12**. The data from these two stations are reported by UNAVCO from its Data Archive Interface (~~http://www.unavco.org/data/data.html).~~http://www.unavco.org/ data/data.html). Data collection has been ongoing since the early 2000s with daily measurements.

The LACDPW has a network of over one hundred benchmarks in the Basin as part of a larger survey network in Los Angeles County (http://dpw.lacounty.gov/sur/BenchMark/). LACDPW reportedly surveys these benchmarks approximately every six years. The last survey in the Basin was conducted in 2018 and the surveys began in ~~the 1950s and 1960s~~1978, however, prior to the 1995 survey, the vertical datum was ~~NGVD27~~NGVD29 and not NAVD88. The ~~NGVD27~~NGVD29 and NAVD88 referenced data cannot be compared without conducting a complex conversion. These benchmarks could be utilized as part of a subsidence monitoring network, pending LACDPW approval. These benchmarks are located in the "Newhall Quad." The Index of benchmarks contained in this quad is depicted in **Figure 5-12**. Land surface elevation data from these benchmarks that were measured using the NAVD88 vertical datum required by DWR, date back to 1995. Benchmark measurements reflect a basic accuracy of ± 0.017 ft. Between 1995 and 2018, the total change in elevation ~~change~~ of benchmarks located in the south/central area of the Basin in the vicinity of wells Saugus 1, Saugus 2, V201, and V205 ranged ~~between~~ from -0.~~01~~099 to 0.~~17~~011 feet~~. West of these wells near~~ . Near wells V206 and V207 and south near well NCWD Saugus Formation wells, the total elevation changes over 1995 and 2018 ranged ~~between~~ from -0.~~08~~149 to -0.~~15~~082 ft. These represent slight declines that average about -0.~~004~~0045 ft/year over this 24-year period. Groundwater elevations in the Saugus Formation historically have been most depressed in the early 1990s which corresponded to the highest amount of pumping form the Saugus Formation. The 1995 dataset was collected by LACDPW about one or two years after the peak decline in groundwater levels. Due to experience in evaluation of subsidence occurrence in the San Joaquin Valley during short term dry periods with high amounts of groundwater pumping (one to two years in length), the amount of inelastic subsidence is dependent on local conditions and often ~~include~~includes large proportions of elastic subsidence. ~~Following~~Pumping from the ~~early 1990s when~~ Saugus Formation ~~pumping~~ reached a peak in the early 1990s, and the intervening years have seen lower levels~~, groundwater~~ of pumping ~~has not reached those levels~~than this historic peak. Between ~~1995~~2009 and 2018, the 0.~~02 to 0.1~~13 feet of subsidence that occurred in the vicinity of well V201 ~~area~~ is likely a result of ~~groundwater pumping effects on groundwater levels and clay sediments.~~multiple factors, including time of year that data was collected and the influence of elastic subsidence on the dataset, tectonic activity, and variations in groundwater levels and pumping. The rate of subsidence that occurred between 2009~~1995~~ and 2018 was 0.~~004~~014 feet per year~~ assuming a maximum amount of subsidence of 0.1 feet~~. That rate is within the accuracy of the benchmark surveying equipment and is negligible.

Table 5-2 – Benchmark Elevation Data

Basin Area	~~Nearby~~ Well	Benchmark	Year	Elevation (ft ~~,~~ NAVD88)	Total Elevation Change 1995-2018 (ft)	
Southern Saugus	VWD-206	1947	1995	1,059.463	~~9 Year~~ 0.082	~~23 Year~~
			2009	1,059.359	~~0.022~~	~~-0.082~~
			2018	1,059.381		
		1948	1995	1,034.371	~~9 Year~~ 0.092	~~23 Year~~
			2009	1,034.287	~~-0.008~~	~~-0.092~~
			2018	1,034.279		
		5210	1995	1,061.530	~~9 Year~~ 0.097	~~23 Year~~
			2009	1,061.448	~~-0.015~~	~~-0.097~~
			2018	1,061.433		
		5402	1995	~~1031~~1,031.950	~~9 Year~~ 0.126	~~23 Year~~
			2009	~~1031~~1,031.831	~~-0.007~~	~~-0.126~~
			2018	~~1031~~1,031.824		
		7104	1995	No Data	No Data	
			2009	1,047.77		
			2018	1,047.76		
		7106	1995	No Data	No Data	
			2009	1,043.68		
			2018	1,043.67		
		7103	1995	No Data	No Data	
			2009	1,023.59		
			2018	1,023.58		
	VWD-207	4511	1995	1,012.295	~~9 Year~~ 0.149	~~23 Year~~
			2009	1,012.182	~~-0.036~~	~~-0.149~~
			2018	1,012.146		
		7204	1995	No Data	No Data	
			2009	1,018.51		
			2018	1,018.51		
		6082	1995	No Data	No Data	
			2009	1,019.99		
			2018	1,019.97		
	VWD-201	6077	1995	~~N/A~~No Data	~~9 Year~~No Data	~~23 Year~~
			2009	1,146.896	~~-0.130~~	~~N/A~~
			2018	1,146.766		

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Basin Area	Nearby Well	Benchmark	Year	Elevation (ft, NAVD88)	Total Elevation Change 1995-2018 (ft)		
Southern Saugus	VWD-205/205M	6078	1995	~~N/A~~No Data	~~9 Year~~No Data		~~23 Year~~
			2009	1,182.083	~~-0.064~~		~~N/A~~
			2018	1,182.019			
		5267	1995	1,151.717	~~9 Year~~ 0.099		~~23 Year~~
			2009	1,151.683	~~-0.065~~		~~-0.099~~
			2018	1,151.618			
		6076	1995	~~N/A~~No Data	~~9 Year~~No Data		~~23 Year~~
			2009	1,151.860	~~-0.075~~		~~N/A~~
			2018	1,151.785			
	Saugus-1	611	1995	1,157.803	~~9 Year~~ 0.068		~~23 Year~~
			2009	1,157.800	~~-0.065~~		~~-0.068~~
			2018	1,157.735			
		6068	1995	No Data	No Data		
			2009	1,166.50			
			2018	1,166.43			
		5311	1995	1,159.535	0.011		
			2009	1,159.575			
			2018	1,159.546			
	Saugus-2	5260	1995	1,170.900	-0.056~~9 Year~~		~~23 Year~~
			2009	1,170.923	~~-0.079~~		~~-0.056~~
			2018	1,170.844			
		5312	1995	1,168.039	~~9 Year~~ 0.041		~~23 Year~~
			2009	1,168.086	~~-0.088~~		~~-0.041~~
			2018	1,167.998			
		5259	1995	1,177.996	~~9 Year~~ 0.089		~~23 Year~~
			2009	1,178.015	~~-0.108~~		~~-0.089~~
			2018	1,177.907			
~~Southern Saugus~~		5375	1995	1,276.700	~~9 Year~~ 0.042		~~23 Year~~
			2009	1,276.714	~~-0.056~~	~~-0.042~~	
			2018	1,276.658			
	VWD-159	7054	1995	N/A	~~9 Year~~No data		~~23 Year~~
			2009	1,329.124	~~-0.051~~	~~N/A~~	
			2018	1,329.073			
		7055	1995	N/A	~~9 Year~~No Data		~~23 Year~~
			2009	1,348.352	~~-0.028~~	~~N/A~~	
			2018	1,348.324			

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Basin Area	Nearby Well	Benchmark	Year	Elevation (ft, NAVD88)	Total Elevation Change 1995-2018 (ft)		
		5085	1995	1,317.921	~~9 Year~~0.005		~~23 Year~~
			2009	1,317.966	~~-0.040~~	~~0.005~~	
			2018	1,317.926			
	NWD-12	5256	1995	1,217.960	~~9 Year~~ 0.074		~~23 Year~~
			2009	1,217.936	~~-0.050~~	~~0.074~~	
			2018	1,217.886			
		6066	1995	~~N/A~~No Data	~~9 Year~~No Data		~~23 Year~~
			2009	1,201.063	~~-0.038~~		~~N/A~~
			2018	1,201.025			
	NWD-13	5337	1995	1,192.215	~~9 Year~~ 0.059		~~23 Year~~
			2009	1,192.211	~~-0.055~~		~~-0.059~~
			2018	1,192.156			
		6067	1995	~~N/A~~No Data	~~9 Year~~No Data		~~23 Year~~
			2009	1,193.131	~~-0.077~~		~~N/A~~
			2018	1,193.054			

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The TRE Altamira InSAR Dataset contains vertical displacement data from June 2015 through September 2019. These data were collected by the European Space Agency Sentinel-1A satellite and processed by TRE Altamira. As discussed above, the evaluation of subsidence occurrence requires the ability to quantify the occurrence of inelastic subsidence and not elastic subsidence. Elastic subsidence is greatest during seasonal periods (normally summer and fall) when seasonal groundwater levels are lowest. Inelastic subsidence generally is best quantified by evaluating changes in ground surface elevations during the winter/early spring periods when groundwater levels are generally at higher elevations, groundwater pumping is low, and over a multi-year period. For the InSAR data, vertical displacement for the winter-to-winter period from 2015/2016 through 2018/2019 period over the entire Subbasin from the TRE Altamira InSAR dataset is presented in **Figure 5-13.** ~~This~~Notwithstanding the potential influence of tectonic activity influences on the dataset, this winter-to-winter period of time represents the least amount of elastic subsidence which results in the change in elevation data being primarily related to inelastic subsidence. Vertical displacement values in the Basin ranged between -0.25 and +0.25 ft ~~between~~for that three-year period. In the south-central area of the Subbasin in the vicinity of wells V201, V205, Saugus 1, and Saugus 2 the range was 0.025 to 0.032 ft during that three-year period.

The locations of the UNAVCO CGPS sites along with historic vertical displacement data are presented in **Figure 5-14.** The relatively stable trend of these plots, along with the positive values of displacement, indicate that no long-term subsidence is occurring in these monitored areas and the variations observed appear to be related to tectonic factors rather than from activities associated with groundwater pumping. Since the beginning of data collection in the early 2000s at both locations, the net vertical displacement is positive (0.05 ft) at the CTDM site and zero at the SKYB site. This means that the land surface has actually

risen (positive displacement) or stayed the same in these areas since 2000. In any given year, the vertical displacement is generally less than 0.05 feet, with the exception of 2006 to 2007 at the SKYB site. Within the context of complex southern California geology, the elevation change (less than 0.2 feet vertical change over the last 20 years) seen at the two UNAVCO stations ~~is~~are likely due to tectonic activity as mentioned above.

The three datasets pertaining to subsidence all indicate minimal or no subsidence occurring in the Subbasin. Los Angeles County Public Works Benchmarks indicate an average ground surface elevation decline of 0.004 feet per year, the TRE Altamira InSAR dataset indicates a ground surface elevation increase in the area of Saugus Formation wells, and the UNAVCO CGPS dataset also indicates a ground surface elevation increase at various points in the Subbasin.

Primary Uses of Each Aquifer

Groundwater production rates presented in this section for municipal/industrial, agricultural, domestic water users were obtained from the 2018 Santa Clarita Valley Water Report (**LSCE, 2019**). Each is summarized in the following section.

Municipal/Industrial

Municipal/Industrial groundwater production for both the alluvial aquifer and the Saugus Formation from 1980 to 2018 are presented in **Figure 5-15**. Groundwater production in the alluvial aquifer has ranged from 8,684 to 27,919 acre-feet/year (AFY) with an average of 19,400 AFY. Production increased until the late 1990's, after which production remained at this level until 2015 when it began to decline rapidly. Saugus Formation production has ranged from 2,728 to 14,417 AFY with a long-term average of 6,750 AFY. Saugus Formation production peaked in the early 1990's for a short period before reaching its lowest point in 1999. Production gradually returned to normal levels and was relatively stable thereafter.

Agricultural

Agricultural production for both the alluvial and Saugus Formation aquifers from 1980 to 2018 are presented in **Figure 5-16**. Alluvial production ranged from 5,951 to 13,824 AFY with an average of 10,194 AFY. Alluvial production has been relatively steady over the four decades presented in **Figure 5-16** with year-to-year variation typically within 2,000 AF. Agricultural production from the Saugus Formation has been minor. Presently, there is no agricultural production from the Saugus Formation.

Private Domestic Uses

Private domestic uses of groundwater constitute a minor percentage of the total groundwater extraction in the Basin. Private domestic also includes groundwater production used for golf courses. Total domestic groundwater extractions by aquifer are presented in **Figure 5-17**. Alluvial aquifer domestic well production values are estimated to range from 500 to 1,369 AFY with an average of 741 AFY.

Groundwater Quality

This section summarizes the constituents of general groundwater quality (from both natural and anthropogenic sources) for both principal aquifers based on previous technical studies and monitoring

performed by SCV Water. Natural constituents discussed in this TM include total dissolved solids (TDS), chloride, nitrate, and sulfate. These constituents are naturally occurring in groundwater, but some constituents can also result from human activities.

Also discussed are anthropogenic groundwater constituents of concern (COC) that have been observed in the Basin. The Santa Clarita Valley Water Report identifies perchlorate and volatile organic compounds (VOCs) as the primary human caused COC. The most frequently detected VOCs in the Basin are Trichloroethylene (TCE) and Tetrachloroethylene (PCE). Less frequently detected compounds include Chloroform, and 1,1-dichloroethene which have been detected in trace amounts below the state drinking water standards maximum contaminant levels (MCL) in the Basin (**LSCE, 2019**). The Salt and Nutrient Management Plan (SNMP) prepared by SCV Water in 2016 identified dichlorodiphenyltrichloroethane (DDT) and polychlorinated biphenlys (PCBs) as other COC. A contaminant of emerging concern in the Basin are perfluoroalkyl substances or PFAS.

Groundwater quality concentration data are expressed in terms of milligrams per liter (mg/L) or parts per million (ppm) and also micrograms per liter (ug/L) or parts per billion (ppb). Historic and recent concentrations are compared to primary and secondary maximum contamination levels (MCL, SMCL) that are based on State Water Resource Control Board Division of Drinking Water (SWRCB DDW) and Environmental Protection Agency (EPA) standards. These are generalized standards for drinking water, which are set to protect public health. Groundwater quality concentrations are also compared to water quality objectives (WQO) as set by the Los Angeles Regional Water Quality Control Board (LARWQB) that are site specific based on location conditions. WQOs have been set by the LARWQB for the alluvial aquifer but not for the Saugus Formation. The SNMP identifies WQOs for TDS, chloride, and nitrate, but state that further analysis is necessary in order to establish meaningful WQOs (CLWA, 2016).

Water quality concentration graphs for TDS, chloride, nitrate, and sulfate are presented in **Appendix B**. Data through 2018 are included in the individual concentration graphs. A summary of groundwater quality data for each principal aquifer is presented below.

Groundwater Quality – Alluvial Aquifer

Total Dissolved Solids

The amount of dissolved solids or salts in water is represented by TDS. Water quality in terms of TDS has been described in the Water Report prepared for SCV Water for about 20 years. Groundwater quality conditions in the alluvial aquifer are described for the different zones shown in **Figure 5-7**. The SWRCB DDW recommends an SMCL for TDS of 500 mg/L, with an upper limit of 1000 mg/L and a short-term limit of 1,500 mg/L. In addition to the SMCL, the WQO values range between 700 and 1,000 mg/L.

In the Mint Canyon and Above Saugus WRP areas (**Figure 5-18**), TDS concentrations show a long-term stable trend over the past 30 years with the exception of well VWD-U4 that has shown an increasing trend overall with concentrations above the WQO. Concentrations in this well have decreased over the past three years.

In Bouquet Canyon, TDS concentrations show long-term stable trends over the past 30 years with minimal variation and may be correlated with periods of flow in Bouquet Canyon Creek (**Figure 5-18**). TDS concentrations in Bouquet Canyon have ranged from approximately 400 to almost 900 mg/L historically. In 2018, TDS concentrations exceeded the historical range with a value of 910 mg/L in one of the wells in this area while another well was within the range. The WQO for Bouquet Canyon is 700 mg/L. The SNMP found that the average TDS concentration for this area was 710 mg/L, slightly above the WQO.

TDS concentrations in the western areas of the Basin exhibited similar patterns and responses to wet and dry periods as those observed in the eastern portions of the Valley (**Figure 5-19**). TDS concentrations in San Francisquito Canyon and Below Saugus WRP areas historically have ranged from approximately 300 to 1,100 mg/L. In 2018, TDS concentrations were within historical ranges and ranged from approximately 580 to 960 mg/L. The WQO for San Francisquito Canyon and Below Saugus WRP is 700 mg/L.

In the Castaic Valley and Below Valencia WRP areas, TDS concentrations have historically ranged between 300 to 1,100 mg/L (**Figure 5-19**). At times, variations in TDS concentrations appear to be related to wet and dry periods along with discharge from Castaic Lake. In 2018, there was only one analysis for TDS with a concentration of 460 mg/L, which is within the historic range. The WQO for the Castaic Valley and Below Valencia WRP areas is 1000 mg/L. The SNMP found that the average TDS in this area was 727 mg/L.

Box and Whisker plots illustrating summary statistics for TDS measured in wells located in each area are shown in **Figure 5-20.** This figure is based on data collected from 1990 through 2018. The largest range of values and highest concentration occurred in the Above Saugus WRP area. The Below Valencia WRP area displayed the smallest range but also the highest median value. Castaic Valley has the lowest median TDS concentrations. Below Saugus WRP, Bouquet Canyon, and Mint Canyon all exhibited similar distributions of TDS concentrations.

Long-term groundwater quality monitoring data for TDS shows a consistent pattern of meeting drinking water standards, although it appears to be intermittently affected by wet and dry cycles. This supports the conclusion that the Alluvium remains a viable ongoing water supply source in terms of groundwater quality even with short-term exceedances of water quality standards in a few of the wells.

Chloride

Chloride is a naturally occurring inorganic salt, but higher concentrations in groundwater can be associated with anthropogenic activities such as urban runoff or discharge of recycled water (**CLWA, 2016**). High concentrations result in a salty taste when used for drinking water. The SCML for chloride recommended by SWRCB DDW is 250 mg/L, with and upper limit of 500 mg/L and a short-term limit of 600 mg/L. The WQOs for chloride range from 100 to 150 mg/L.

Chloride concentrations in the Mint Canyon and Above Saugus WRP areas have historically ranged from 17 to 160 mg/L. Values in 2018 were between 46 and 120 mg/L (**Figure 5-21**). Concentrations have increased and decreased over time likely due to wet and dry conditions. WQO for this area is 150 mg/L and all representative wells are currently below this level. The SNMP found that the average concentration for the Mint Canyon and Above Saugus WRP area was 89 mg/L and 72 mg/L, respectively.

Chloride concentrations in the Bouquet Canyon have ranged between 40 and 120 mg/L (**Figure 5-21**). Values in 2018 were between 94 and 120 mg/L. Historical data is available since the mid 1970's where chloride concentrations are generally stable and below the WQO of 100 mg/L. The SNMP found that the average concentration for this area is 77 mg/L.

Chloride concentrations in the San Francisquito Canyon and Below Saugus WRP areas range from 36 to 130 mg/L, with 2018 values between 62 and 130 mg/L (**Figure 5-22**). Similar to other alluvial areas, chloride concentrations are stable but with a small increase in recent years. WQO for this area is 100 mg/L. The SNMP found that the average concentration for this area is 77 mg/L.

In the Castaic Valley and Below Valencia WRP Areas, chloride concentrations have ranged between 55 and 180 mg/L with a single 2018 measurement at 97 mg/L (**Figure 5-22**). There has been a slight upward trend in chloride concentrations since the mid-1990s.

Chloride concentrations across the alluvial aquifer are presented statistically as Whisker plots in **Figure 5-23**. Chloride concentrations in the Above Saugus, Below Valencia, and Castaic Valley all have similar distributions. The highest median value occurred in the Below Valencia area and the lowest in the San Francisquito Canyon. The SNMP found that the average concentration for this area was 77 mg/L.

Nitrate

Nitrate is a compound that is associated with agricultural activities, septic systems, confined animal facilities, landscape fertilization, and water treatment facilities. Consumption of water with high concentrations of nitrate can have adverse health effects, specifically for infants under the age of six months who can develop methemoglobinemia or blue baby syndrome (**SWRCB, 2017**). The MCL and the WQO objectives for each of the management areas for nitrate concentration is 45 mg/L (**CLWA, 2016**).

In the Mint Canyon and Above Saugus WRP areas, nitrate concentrations have ranged between non-detect (ND) and 38 mg/L. There is no apparent trend of increasing nitrate concentration in the Mint Canyon and Above Saugus WRP areas (**Figure 5-24**). The average concentration identified in the SNMP for the Mint Canyon and Above Saugus WRP area were 20 and 21 mg/L, respectively.

Nitrate concentrations in the Bouquet Canyon Area have ranged from 3 to 34 mg/L. Values have not shown any increasing trend over time (**Figure 5-24**). Average concentration identified in the SNMP for this area was 16 mg/L.

Nitrate concentrations in the San Francisquito Canyon and the Below Saugus WRP area have ranged from ND to 50 mg/L. This area has exhibited a wide range of values dating back to the mid 1950's but has not shown any increasing trend over time (**Figure 5-25)**. Average concentration identified in the SNMP for this area was 16 mg/L.

In the Castaic Valley and Below Valencia WRP areas, nitrate concentrations have ranged from ND to 36 mg/L with the highest concentration occurring in the 1950's. There has not been an increasing trend in nitrate concentrations (**Figure 5-25**). Average concentration identified in the SNMP for this area was 8 mg/L.

Figure 5-26 includes Box and Whisker plots representing the statistical distribution of nitrate concentrations across the alluvial aquifer that includes data from 1990 to present. Median concentrations are all well below the MCL and WQO of 45 mg/L. The lowest median value is in Castaic area while the highest is the Below Saugus WRP area.

Sulfate

Sulfate is naturally occurring in groundwater and can occur as a result as runoff from natural geological deposits and from industrial waste. Consumption of sulfate in high concentrations can have a laxative effect (**WHO, 2004**). The SMCL is 250 mg/L with an upper limit of 500 mg/L and a short-term limit of 600 mg/L. The WQOs for the alluvial aquifer range from 150 to 350 mg/L (**CLWA, 2016**).

In the Mint Canyon and Above Saugus WRP areas, sulfate concentrations have historically ranged between 34 and 538 mg/L (**Figure 5-27**). In the set of wells shown on **Figure 5-27**, all wells except VWD-U4 exhibit a similar steady trend with values less than the WQO of 150 mg/L and no long-term increasing trend. VWD-U4 has shown a very wide range of sulfate concentrations with values exceeding the WQO and SMCL. The last available measurement for this well was in 2014 with a concentration of 440 mg/L. 2018 values were between 78 and 140 mg/L, which were measured at VWD-T7 and SCWD-N. Oaks Central, respectively (**Figure 5-27**). VWD-U4 has had sulfate concentrations as high as 500 mg/L. The last measurement for this well was in 2014 with a concentration of 440 mg/L. The average concentration identified in the SNMP for the Mint Canyon and Above Saugus WRP area was 138 and 269 mg/L, respectively.

In the Bouquet Canyon area, sulfate concentrations have historically ranged from 89 and 260 mg/L. Values have shown little variation over time with a gradual increasing trend. 2018 values were 210 and 260 mg/L measured at SCWD-Clark and SCWD-Guida (**Figure 5-27**). The WQO for this area is 250 mg/L. The average concentration identified in the SNMP for this area was 189 mg/L.

In the San Francisquito Canyon and Below Saugus WRP areas, sulfate concentrations have historically ranged between 46 and 506 mg/L. The highest value occurred in the early 1960s. Since the early 1990's values have been consistent in this area, showing a gradual increasing trend. In 2018, sulfate concentrations were between 160 and 300 mg/L (**Figure 5-28**). The WQO for this area is 250 mg/L. The average concentration identified in the SNMP for this area was 189 mg/L.

In the Castaic Valley and Below Valencia WRP areas, sulfate concentrations have historically ranged between 89 and 606 mg/L (**Figure 5-28**). The historic high value occurred in the late 1960's with the historic low occurring in 2018. Wells in the area have exhibited a decreasing trend of sulfate concentration. The WQO for this area is 350 mg/L. The average concentration identified in the SNMP for this area was 246 mg/L.

Figure 5-29 is a Box and Whisker plot that presents the distribution of sulfate concentrations across the alluvial aquifer with data from 1990 to present. The greatest variation occurs in the Above Saugus WRP area with the highest median value in the Below Valencia WRP area.

Groundwater Quality – Saugus Formation

TDS

TDS concentrations for wells in the Saugus Formation are illustrated in **Figure 5-30**. Beginning in 2000, several wells within the Saugus Formation have exhibited an increase in TDS concentrations, similar to short-term changes in the Alluvium, possibly as a result of decreased recharge to the Saugus Formation from the Alluvium. From 2006 through about 2010, TDS concentrations had been steadily declining, followed by an increase through 2016 and a slight decrease in 2017/2018. TDS concentrations in the Saugus Formation remain within the range of historic concentrations and below the SMCL upper level. The WQO for the Saugus Formation is 700 mg/L. (**CLWA, 2016**). The average concentration identified in the SNMP was 636 mg/L. Groundwater quality within the Saugus Formation will continue to be monitored to ensure that the long-term viability of the Saugus Formation as a component of overall water supply is preserved.

Chloride

Chloride concentrations for representative wells are presented in **Figure 5-31.** Historic chloride concentrations have ranged between 17 and 420 mg/L. Chloride concentration in the Saugus Formation have been stable for the past 50 years. The WQO for chloride in the Saugus Formation is 100 mg/L. The average concentration identified in the SNMP was 28 mg/L.

Nitrate

Nitrate concentrations for representative wells are presented in **Figure 5-32.** Nitrate concentrations in the Saugus Formation have ranged from ND to 28 mg/L. Values have historically been stable but have shown higher concentrations in recent years, but are still well below the WQO of 45 mg/L. The average concentration identified in the SNMP was 14 mg/L.

Sulfate

Sulfate concentrations for representative wells are presented in **Figure 5-33**. Historic sulfate concentrations have ranged from 80 to 730 mg/L. The highest concentrations have been observed in VWD-159, which has not been sampled since 1998. Overall, sulfate concentrations have exhibited an increasing trend in recent years. The high sulfate in the Saugus Formation is mostly likely due to naturally occurring minerals present in the rock. The average concentration identified in the SNMP was 235 mg/L. A WQO for sulfate in the Saugus Formation is not identified in the SNMP.

Groundwater Constituents of Concern (Anthropogenic) in the Alluvium and Saugus Formation

Groundwater COC that have been measured in the Alluvium and Saugus Formation include perchlorate, per- and polyfluoroalkyl substances (PFAS), and volatile organic compounds (VOCs) such as trichloroethylene (TCE), and tetrachloroethylene (PCE). These contaminates have been identified in previous studies and are currently monitored under other state and federal regulatory programs (**LSCE, 2019; CLWA, 2016; CLWA, 2016a**).

Perchlorate and VOCs

Perchlorate is a regulated substance that is commonly used in propellants for rockets, missiles, and fireworks. Consumption of groundwater with high concentrations perchlorate can result in issues with the thyroid gland (**EPA, 2014**). There have been a number of detections in the Basin, both in the alluvial aquifer and in the Saugus Formation. Perchlorate was first detected in the Basin in 1997 and since has been detected in a total of eight wells. Wellhead treatment systems have been built for four Saugus Formation production wells operated by SCV water, with oversight from the California Department of Toxic Substances Control (**LSCE, 2019**).

PCE is a VOC that is commonly associated with dry cleaning and metal degreasing processes. Long-term exposure at levels near the MCL can result in cancer. Other adverse effects include damage to the liver, kidneys, and central nervous system (**SWRCB, 2017a**). Detections of PCE have primarily occurred in the alluvial aquifer, however, the concentrations have been below the MCL.

TCE is a VOC that is primarily associated as a solvent to remove grease from metal parts. Long-term exposure could result in cancer. Exposure can also affect the central nervous system with symptoms such as light-headedness, drowsiness, and headache (**SWRCB, 2017b**). Detections of TCE have primarily occurred in the Alluvial Aquifer, however, the concentrations have been below the MCL. **Table 5-3** presents the number of wells with detections above the reporting limit (RL) and MCL for each Perchlorate and VOCs of interest across the Basin.

Table 5-3. Wells with Perchlorate and VOC Detections

COC	Alluvial Wells with Detections > RL	Saugus Wells Detections > RL	RL	Max Concentration	MCL	Wells with Detections Above MCL	Units
PERCHLORATE	2	6	4	47	6	7	ug/L
PCE	14	1	0.5	2.6	5	0	ug/L
TCE	4	6	0.5	4.4	5	0	ug/L

PFAS

PFAS refers to the larger group of COC of per- and polyfluoroalkyl substances. Largely used in firefighting foams, non-stick coatings, cookware, carpets, and furniture, these substances tend to accumulate in groundwater and long-term exposure could potentially affect the immune system, thyroid, liver, and can cause cancer. The most common types of PFAS are perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS). They are a contaminant of emerging concern that are not currently regulated. The SWRCB DDW have identified notification levels for PFAS concentrations that is a precautionary health-based measure for concentrations of chemicals in drinking water that warrant further monitoring and assessment (**SWRCB, 2019**).

The DTSC and LA Regional Water Quality Control Board are overseeing the monitoring of and response to detections of constituents of concern exceeding the MCLs. SCV Water is actively addressing the issue with the regulatory agencies and has taken wells out of service that have detections above reporting limits until wellhead treatment systems are deployed.

The following is a SCVWA News Release from March 13, 2020.

> *SANTA CLARITA –SCV Water has taken proactive steps to protect public health by voluntarily removing 13 of its groundwater wells from service. This move follows the State Water Resources Control Board – Division of Drinking Water (DDW) Feb. 6, 2020, decision to lower its response level guidelines for two chemicals found in low concentrations in drinking water across the state.*
>
> *Voluntary quarterly sampling of all active wells was done in February, and this action is based on those results for perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS). The Agency did not find more or higher levels of the chemicals, but instead is taking action based on the lowered response levels set by the DDW.*
>
> *The action this week is not related to the COVID-19 virus. The virus is not found in drinking water.*
>
> *Under the new levels, 14 of the 44 agency wells are impacted. This accounts for approximately 34 percent of the Agency's groundwater supply. In 2019, groundwater accounted for just 28% of the total water used in the SCV Water service area. SCV Water will continue to rely on its diverse water supply portfolio, including imported and banked water, to minimize supply impacts to customers.*
>
> *"SCV Water has a diverse and resilient water supply, so this action will not impact the availability of water to our customers," stated Matt Stone, general manager. "However, with some groundwater wells temporarily offline, it remains important that customers continue to use water efficiently in their homes and on their landscapes.*

Last month, the DDW lowered its response levels to 10 parts per trillion (ppt) for PFOA and 40 parts per trillion (ppt) for PFOS. The state's previous response level set a combined 70 ppt for PFOA and PFOS. These response levels are some of the most stringent guidelines in the nation, and lower than the Environmental Protection Agency's Lifetime Health Advisory level of 70 ppt. For perspective, one part per trillion would be equal to four grains of sugar in an Olympic-size swimming pool.

The updated guidelines are part of DDW's statewide effort to assess the scope of water supply contamination by PFOS and PFOA.

"We have three quarters of sampling data we can factor in now, giving us a head start in addressing the new guideline," stated Matt Stone, general manager of SCV Water. "Our top priority is providing clean and reliable water to our customers. We immediately removed one well from service last year when it exceeded the original response level, and we have taken the same actions for the 13 additional wells that exceeded the revised response level."

SCV Water is also quickly moving forward with the construction of several water treatment plants to return affected wells back to service. The first PFAS treatment facility has started construction and is expected to be in operation by June of this year, restoring three key wells to service, which provides enough groundwater for 5,000 families. The fast-tracked project is estimated to cost $6 million to build and $600,000 annually to operate. Additional groundwater treatment facilities are in the planning and design phase.

"We are committed to clear and timely communication with our customers about all water quality changes and how we plan to address them," said Stone. "Our customers are our top priority, and we are committed to rigorously testing our water thousands of times per year to ensure it meets or surpasses all water-quality standards and is safe for our customers to drink."

Per- and polyfluoroalkyl substances (PFAS) are a group of manmade chemicals that are prevalent in the environment and were commonly used in industrial and consumer products to repel grease, moisture, oil, water and stains. Water agencies do not put these chemicals into the water, but over time very small amounts enter the water supplies through manufacturing, wastewater discharge and product use. Exposure to these chemicals may cause adverse health effects.

For more information and resources on PFAS, visit yourSCVwater.com/pfas.

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Figures

Appendices

Luhdorff & Scalmanini
Consulting Engineers

Appendix C

TECHNICAL MEMORANDUM

DATE: ~~July~~December 15, 2021 Project No.: 18-1-132

TO: Jeff Barry, GSI Water Solutions, Inc.

FROM: William L. Halligan, PG

SUBJECT: **Revised Subsidence Vulnerability, Santa Clarita Valley Water Agency, Santa Clara River Valley Basin, East Subbasin**

INTRODUCTION

According to the U.S. Geological Survey (USGS), land subsidence is a phenomenon found across the United States, affecting the land surface of over 17,000 square miles in 45 states (Galloway ~~etal~~et al., 1999). Land subsidence in California is commonly a result of fluid withdrawal (oil or groundwater). The principal causes of land subsidence are compaction of fine-grained subsurface materials (caused by reduction in hydraulic head affecting the physical structure and orientation of clay minerals and drainage of organic soils. Subsidence can occur in two forms, elastic (temporary) and inelastic (permanent). Impacts from subsidence are primarily related to infrastructure, such as roadways, pipelines, railroad tracks, etc.

GEOLOGIC AND GROUNDWATER CONDITIONS

When discussing the potential for land subsidence, it is important to consider the type of geologic materials that exist and if they may be susceptible to subsidence, along with factors that can create the conditions for subsidence such as groundwater extraction or oil extraction.

Out of the two primary water production aquifers in the Santa Clara River Valley Basin, East Subbasin (Subbasin), the Saugus Formation contains some silt and clay beds occurring predominantly in the central portion of the Subbasin in the vicinity of the Whittaker-Bermite site. The lateral extent of these clay beds has not been fully documented, however, review of available well logs, geophysical logs and other information indicates these beds may be confined to the Whittaker-Bermite site area and west of the site in the vicinity of Saugus Formation wells Saugus 1 and 2, V201, V205, V206, and V207. A schematic depiction of these units is illustrated in **Figure 1**.

The hydrostratigraphic units in the central portion of the Subbasin in the Saugus Formation correspond to alternating coarse and fine-grained beds with the coarse-grained units being relatively thick compared to the fine-grained units and identified as the SI, SIII, SV, SVII, and SVIII units while the fine-grained beds are relatively thin in comparison and designated as the SII, SIV, and SVI units. The coarse-grained units are generally about 200 to 600 feet thick and are generally not susceptible to compaction. This is because the structure of the

coarse-grained materials (sand and gravel) do not compact with declines in groundwater elevations like silts and clays.

The silt and clay beds are not laterally continuous throughout the Saugus Formation. In the western portion of the Subbasin in the vicinity of wells V206 and V207, analysis of lithology indicates that clay beds are minimal at the V206 site. Identification of clay beds at depths greater than 1,200 feet exist at the V207 site, however, that well is not constructed at those depths and projections of groundwater levels in the V206 and V207 area are expected to be similar to historical levels during normal years, however, will decline up to a maximum of approximately 150 feet below historical levels during short term droughts of one to five years (**Appendix A**). There are plans to construct and operate four new wells in the vicinity of V206 and V207 in the future. The simulated future low water levels described above include pumping from these not-yet constructed wells. The geology at the locations of these future wells are not known and will be evaluated once those wells are constructed to assess the potential for subsidence near the future wells.

As discussed further below, periods of historical low groundwater elevations were followed by periods of groundwater elevation recovery. Further, some evidence of subsidence exists, but the cause or causes are not clear. Also, impacts to infrastructure from subsidence have not been observed. Through the last nineteen years of reviewing and reporting on the geology and water resources in the Basin (Luhdorff and Scalmanini, 2019), there has not been evidence of chronic groundwater level declines that would contribute to subsidence (Luhdorff and Scalmanini, 2019).

Logs of production and monitoring wells were evaluated to identify areas where the Saugus Formation contains clay beds that could potentially undergo compaction should a pronounced and extended decline in groundwater elevations occur. Analysis of historical geologic cross sections was also conducted (CH2M HILL, 2004) that resulted in the identification of an area of the Subbasin where the Saugus Formation was subdivided into distinct hydrostratigraphic units, separated by three primary fine-grained confining units (CH2M Hill, 2004). As discussed above, this geographic location is in the central portion of the Basin where the Whittaker-Bermite site and production wells Saugus 1, Saugus 2, V201, and V205 are located. The three confining units, SII, SIV, and SVI (CH2M Hill, 2004; Luhdorff and Scalmanini, 2013) are each approximately 50 to 100 feet thick and composed of silts and clays with some coarse-grained materials as estimated from a review of geologic cross sections, well completion reports, and geophysical logs.

Should groundwater levels in the confined Saugus Formation substantially decline over an extended period where compressible layers are present along with decreases in the potentiometric head and associated decrease in pore pressure, some degree of compaction of these clay materials could occur resulting in subsidence. However, these three fine-grained units are at depths that are several hundreds of feet below the potentiometric head in the Saugus Formation when observing both historical Saugus Formation groundwater levels and projected elevations based on model simulations (**Appendix A)**. These clay units are not as extensive in the western portion of the Saugus Formation in the vicinity of V206 and V207 and pinch out (become very thin) toward the South Fork area of the Subbasin where wells NC12 and NC13 are present. As mentioned, data on the occurrence of clay beds in the vicinity of the four new Saugus Formation wells near the Magic Mountain area is not known as the exact location of these wells has not been finalized nor the borings drilled.

Land Surface and Groundwater Elevation Monitoring Data

Land surface elevation monitoring data is available from three separate sources. UNAVCO operates a network of continuous global positioning system (CGPS) sites throughout California and has two sites in the Subbasin outside the margin of the Alluvial valley floor. The second source of data is from the European Space Agency in the form of INSAR data that is available through DWR. The third source of data is from Los Angeles County Department of Public Works (LACDPW) through its network of survey benchmarks throughout the Subbasin. There is also groundwater elevation monitoring conducted by SCV Water from selected wells in the Subbasin including Wells V201, V205, V205M, Saugus 1, and Saugus 2. The locations of these wells are depicted in **Figure 2**.

UNAVCO CGPS

As of February 2020, land surface elevation is being monitored at two continuous global positioning system (CGPS) sites in the Basin as reported by UNAVCO (http://www.unavco.org/data/data.html). Data collection has been ongoing since the early 2000's with daily measurements.

The locations of the UNAVCO CGPS sites along with historic vertical displacement data are presented in **Figure 3**. The relatively stable trend of these plots indicate that long-term subsidence is not occurring. Since the beginning of data collection in the early 2000's at both UNAVCO locations, the net vertical displacement is positive (0.05 ft) at the CTDM site and zero at the SKYB site. This means that the land surface has risen (positive displacement) or stayed the same. In any given year, the vertical displacement is generally less than 0.05 feet, with the exception of 2006 to 2007 at the SKYB site. Within the context of complex southern California geology, the elevation change (less than 0.2 feet vertical change over the last 20 years) seen at the two UNAVCO stations is likely due to tectonic activity since these stations are located north of the San Gabriel fault in locations where minimal groundwater extraction occurs.

DWR ESA INSAR

Land surface elevation data was also obtained from the Department of Water Resources SGMA Data viewer. The TRE Altamira InSAR Dataset contains vertical displacement data from June 2015 through September 2019. These data were collected by the European Space Agency Sentinel-1A satellite and processed by TRE Altamira. The dataset covers more than 200 groundwater basins across the state at a resolution of approximately 100 square meters (almost 1,100 square feet). Vertical displacement for the winter-to-winter period from 2015/2016 through 2018/2019 period over the entire Subbasin from the TRE Altamira InSAR dataset is presented in **Figure 4**. Vertical displacement values in the Subbasin ranged between -0.25 and +0.25 feet. In the central area of the Subbasin in the vicinity of wells V201, V205, Saugus 1, and Saugus 2 the range of displacement was smaller (0.025 to 0.032 feet). To avoid accounting for elastic (temporary) compaction without recognizing corresponding elastic rebound, it is best to evaluate subsidence from a comparison of data collected in the winter or early spring to avoid incorporating elastic or temporary subsidence that can vary season to season and from year to year. Because the satellite data was developed from a summer to early fall time frame, it likely is not a reliable starting and ending date to evaluate inelastic or permanent subsidence. In addition, the resolution of satellite data for subsidence monitoring is not as accurate as ground-based data collection. GPS

benchmark monitoring locations such as those maintained by UNAVCO generally have an accuracy of approximately 0.05 feet, while satellite data from the DWR website via the European Space Agency has an error that is approximately 0.02 feet greater than global positioning system measurements.

Los Angeles County Department of Public Works Benchmark Surveys

The Los Angeles County Department of Public Works (LACDPW) has a network of over one hundred benchmarks in the Subbasin as part of a larger survey network in Los Angeles County (http://dpw.lacounty.gov/sur/BenchMark/). LACDPW reportedly surveys these benchmarks approximately every six years. The surveys began in 1978 and the most recent survey in the Subbasin was conducted in 2018. These benchmarks are located in the "Newhall Quad." The Index of benchmarks contained in this quad are depicted in **Figure 5** and the specific benchmarks in the vicinity of existing Saugus Formation wells are presented in **Table 1**.

Ideally land surface data from 1978 to the present could be precisely compared to each successive survey event, but this is not practical because vertical datums changed between 1993 and 1995. Land surface elevation data from 1995, 2009, and 2018 for these benchmarks were evaluated to determine the magnitude of subsidence that occurred over this time period because the elevations were measured using the same NAVD88 vertical datum required by DWR. The benchmark surveys measured prior to 1995 in 1978, 1983, and 1993 were measured using the older and different NGVD29 vertical datum.

Benchmark measurements are recorded to the nearest thousandths of a foot reflect a basic accuracy of ± 0.017 feet per mile (LADPW, 2018). Between 1995 and 2018, benchmarks located near the Saugus Formation production wells in the western and central area of the Subbasin had recorded changes in land surface elevations that ranged from -0.179 to +0.011 feet over the 23-year period between 1995 and 2018 (**Table 1**).

Groundwater elevations in the Saugus Formation historically were most depressed in the early 1990s during the highest amount of pumping from the Saugus Formation. The 1995 dataset was collected by LADPW about one or two years after the peak decline in Saugus Formation groundwater levels. The 1993 benchmark survey was collected using a different vertical datum than the 1995 making it difficult to compare the 1993 to 1995 surveys in order to see if the peak Saugus pumping could be correlated with land surface elevation changes. Generally, the examination of LADPW benchmark data indicates that many factors are contributing to the very small amount of land elevation shifts that have occurred over time. These factors include tectonic influences from this seismically active area of California, the time of year each benchmark survey was collected (meaning it is difficult to determine if land surface changes are elastic or inelastic), and groundwater pumping. LADPW data was also reviewed outside of the areas where these Saugus Wells are located. Positive and negative ground surface elevation changes can be seen in areas away from Saugus Wells, including north of the San Gabriel Fault. In the future, with the implementation of a basin-wide subsidence monitoring program, correlations of groundwater pumping to changes in land surface elevations will be better understood. The ~~average~~yearly rate of subsidence that occurred between 1995 and 2018 was 0.008 feet per year ~~assuming a~~given the maximum ~~amount of~~ subsidence of -0.179 feet noted above. That annual average rate is less than the accuracy of the benchmark surveying equipment and is negligible.

Summary of Land Surface Elevation Data Sets

The data that has been available for review has provided the following understanding of the occurrence of changes in land surface elevations over time as summarized in **Table 2**. From the period spanning 1995 to 2018, LADPW benchmark survey data in the vicinity of the Saugus Formation wells show changes in land surface elevations that have ranged from -0.179 to +0.011 feet over 23 years from 1995 to 2018 with an average annual rate of -0.008 feet per year to less than 0.001 feet per year. The InSAR ground surface elevation data for the three-year period from 2015/16 to 2018/19 in the central portion of the Subbasin where clay beds are most prevalent, the magnitude of subsidence was -0.025 to -0.032 feet or approximately -0.008 to -0.010 feet per year over that very short time frame. The UNAVCO benchmark data showed either no change in land surface elevation over the past 20 years or a rise of 0.05 feet, equating to an annual rise of 0.002 feet per year. The locations of the UNAVCO stations are north of the San Gabriel fault where no large-scale municipal pumping occurs from the Saugus Formation, thereby the changes in land surface elevations are likely the result of the regions seismic activity.

Dataset	Time Period	Range of Elevation Change (ft)	Annual Rate of Elevation Change (ft/yr)
UNAVCO CGPS	**CTDM: 2001-Present**	**+0.05**	**+0.003**
	SKYB: 2006-Present	**+0.00**	**+0.00**
DWR ESA INSAR	**2015-2020**	**-0.025 to +0.028**	**-0.0017 to +0.0056**
LA County DPW Benchmark Surveys	**1995-2018**	**-0.179 to +0.011**	**-0.0078 to +0.00048**

Table 2: Subsidence Datasets

Dataset	Time Period	Range of Elevation Change (ft)	Annual Rate of Elevation Change (ft/yr)
UNAVCO CGPS	**CTDM: 2001-Present**	**+0.05**	**+0.003**
	SKYB: 2006-Present	**+0.00**	**+0.00**
DWR ESA INSAR	**2015-2020**	**-0.025 to +0.028**	**-0.0017 to +0.0056**
LA County DPW Benchmark Surveys	**1995-2018**	**-0.179 to +0.011**	**-0.0078 to +0.00048**

Historical Saugus Formation Groundwater Elevations

Evaluation of groundwater elevation data from the area of the Subbasin where projected groundwater levels during normal years are expected to have the greatest declines as compared to historical elevations (Appendix A) were evaluated. This area is located in the central area of the Subbasin in the vicinity of five wells (Saugus 1, Saugus 2, V201, V205, and V205M). This also corresponds to the area that has the most pronounced evidence of fine-grained clay beds (see discussion of geology above).

Analysis of historical groundwater level data indicated that data was collected beginning in the early 1990s and into 2020, however, only one of the five wells (V201) had a complete dataset for this period while the other four wells had partial datasets (**Appendix A**). Data from Saugus 1 and Saugus 2 are not available after 2011 due to the well repair that impacted the sounding tubes. However, the data from these two wells is valuable because the data (coupled with data from well V201) capture the period (1993) when groundwater levels in the Saugus Formation declined to historic lows. The historic low was brief and was not maintained.

Projected Saugus Formation Pumping

The hydrographs in Appendix A were prepared using results from the Subbasin numerical model and show historical groundwater level data along with projected (future) groundwater elevations. The comparison of the projected and historical data at each well allows one to see simulated future groundwater levels, including during normal periods and drought periods. The future water levels are representative of "full build-out land use conditions" that include the sustained operation of wells V201 and V205 (in part for perchlorate removal), along with additional source capacity for extraction of groundwater from the Saugus Formation in the V206 and V207 area of the Subbasin that would allow SCV Water to extract approximately 35,000 acre feet per year during multiple dry years.

Central Area

Projections of Saugus Formation groundwater pumping volumes in the central area (Saugus 1 and 2, V201, V205) are expected to be higher than historical amounts during normal *and* dry years. Groundwater model simulations of future normal year conditions (Saugus 1 and 2, V201) indicate groundwater levels will be maintained approximately 100 to 150 feet lower in normal years than in the past, with some shorter-term decreases in water level beyond these during drought.

Western Area

Projections of Saugus Formation groundwater pumping in the western area (V206, V207 and four to-be-constructed Saugus wells) are expected to be higher than historical amounts during dry years. Groundwater model simulations of future conditions (V 206 and 207) indicate groundwater levels will be similar to historical normal year levels, but in drought years are projected to be approximately 100 to 150 feet lower than in the past.

Conclusions

The potential for subsidence to occur is driven by many factors as described above, however, the presence of significant clay beds coupled with a significant length of time (years) of sustained groundwater

elevations at or below historic lows is one component necessary for inelastic land subsidence (permanent land subsidence) to occur.

Evidence of Past Land Subsidence Caused by Groundwater Extraction

A review of past groundwater elevations show that chronic decline in water levels has not taken place. A review of three different land surface elevation data sets provide good information about elevations over time, but do not suggest clear evidence of groundwater pumping caused subsidence. Land surface elevations have varied across the Subbasin, resulting in some areas showing increases in land surface elevations and other areas exhibiting decreases, dependent on the time frame and location that the datasets cover. The data indicates that many factors appear to contribute to changes in land surface elevations. These factors include:

- The Subbasin being located in a tectonically active area,
- Time of year data is collected and whether it includes the effects of elastic subsidence on the land surface elevation data,
- Frequency of data collection, and;
- Analysis and characterization of the occurrence of significant clay beds and potential for compaction.

Potential Future Land Subsidence

The potential for subsidence in the various areas of the Subbasin to occur in the future is difficult to predict or quantify based on the datasets evaluated and documented above. Groundwater elevations in the future, in particular at full build out, will be lower than in the past. In some areas, groundwater elevations will be lower than past drought water elevations (western area), and in other cases groundwater elevations will be lower both in normal and drought conditions (central area). The central area appears to contain more compressible fine grained layers than the west and because of these factors, there may be a potential for future subsidence, but it is difficult to predict, and should be monitored.

Further, these fine-grained materials are at depths that are several hundreds of feet below the potentiometric head in the Saugus Formation when observing both historical Saugus Formation groundwater levels and projected elevations based on model simulations (**Appendix A)**. This fine-grained unit placement is considered a more favorable condition than physically dewatering clays as the groundwater potentiometric surface becomes lower. These clay units are not as extensive in the western portion of the Saugus Formation in the vicinity of V206 and V207 and pinch out (become very thin) toward the South Fork area of the Subbasin where wells NC12 and NC13 are present. As mentioned above, data on the occurrence of clay beds in the vicinity of the four new Saugus Formation wells near the Magic Mountain area is not known as the exact location of these wells has not been finalized nor the borings drilled.

Approach to Establish a Preliminary Subsidence Minimum Threshold

In order to develop the minimum threshold for subsidence in the GSP, a methodology was developed to approximately estimate the magnitude of subsidence that may occur in the planning and implementation period of the GSP. There was a short period of time between the winter of 2015/2016

to winter 2018/2019 where a comparison of observed land surface elevation from DWR's InSAR dataset could be compared to groundwater level declines in the area of the Basin where clay beds exist in the Saugus Formation and where the potential for future subsidence is the most probable as a result of increased pumping. As described above, the central portion of the Basin in the vicinity of well V-201 is where groundwater levels are predicted by the groundwater model to be lowest in future. In this area, a groundwater level decline of 15 feet was measured between winter of 2015/2016 and winter of 2018/2019. The inSAR data showed a corresponding reduction in ground surface elevation of approximately 0.032 feet. If the change in ground surface elevation shown in the inSAR data is actually related to groundwater extraction, this equates to approximately 0.01 feet of subsidence per 5 feet of groundwater elevation decline. As stated previously, it is not known if the observed reduction in ground surface elevation is related to pumping or to tectonics.

It is anticipated that groundwater elevations could be lower in the future as the Basin Operating Plan is implemented at full build out of the Basin to meet future demands during extended drought periods. The groundwater flow model was used to estimate future groundwater levels in the Basin. The approximate difference between long term average historic groundwater levels observed in well V-201 and future projected groundwater levels is estimated to be on the order of 150 feet. When considering historical low groundwater levels (e.g., 1993) measured at well V-201, the difference between measured groundwater levels and the predicted lowest dry year/drought groundwater levels in the future is approximately 70 feet. Depending on which of the two water level differences that are used, the approximate amount of subsidence that could occur in the future ranges between 0.3 feet of subsidence for the 150 feet of groundwater level decline to approximately 0.14 feet for the 70 feet of decline. This estimate assumes that the inSAR measured reduction in land surface elevation used in the calculations is a direct result of groundwater extraction, which may not be the case. It is also not known over what timeframe this estimated subsidence might occur since it is understood that subsidence effects can be delayed and because the rate of subsidence can be affected by the duration that groundwater levels are below the historical low.

Based on this evaluation, the minimum threshold for subsidence has been preliminarily set at a rate of 0.1 feet in any single year with a maximum subsidence of 0.5 feet over any 5-year period. Due to the considerable uncertainty associated with estimating subsidence rates in the Basin and the lack of a complete data set from which to estimate subsidence, the GSA plans to conduct robust subsidence monitoring and consider adjusting thresholds should monitoring data indicate that this is advisable and warranted.

Data Gaps and Next Steps

Some areas in California that have a history of subsidence (California's Central Valley) and impacts on infrastructure have existing subsidence monitoring networks that can be used to correlate subsidence to groundwater pumping and changes in groundwater elevations.

The East Subbasin has not had a history of impacts on infrastructure related to subsidence in general, regardless of the cause, and therefore, an organized subsidence monitoring program has not been developed. This lack of sufficient historical subsidence data collection has resulted in a large degree of uncertainty in identifying past causes of land surface elevation changes.

With the current uncertainty about the potential for future groundwater extraction to cause land subsidence, a robust monitoring program has been developed and described in the GSP to monitor land surface elevations utilizing the existing subsidence monitoring programs above, but with additional data collection by the SCV GSA. These data will allow for the GSA to determine if land surface elevation changes can be correlated with groundwater extraction and if the changes are elastic or inelastic. Data will be evaluated to help manage groundwater pumping in the Saugus Formation to minimize the impacts of subsidence should it occur.

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Figures

Figure 1. Saugus Hydrostratigraphic Units Schematic

Figure 2. Saugus Formation Well Locations

Figure 3. UNAVCO Continuous GPS Station Locations

Figure 4. TRE Alatamira InSAR Dataset (October 2018 – October 2019)

Figure 5. Newhall Quad Benchmark Index

APPENDIX A

Groundwater Elevation Hydrographs, Historical and Projected GSI Water Solutions

LSCE

APPENDIX E

Considerations for Evaluating Effects to Groundwater Dependent Ecosystems in the Upper Santa Clara River Basin, Prepared by Environmental Science Associates (ESA)

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Segment Description	Dry Year Gaining/Losing	GDE Resource
SCR from approximately two miles below Castaic Creek to Ventura County border	Losing/Gaining	This reach stretches for another mile to the end of the Upper Santa Clara Basin near the Ventura County border. The channel narrows and the riparian forest is dense in this segment although groundwater levels may drop below 25 feet during the driest months of dry years. Surface water flows are perennial.

Aquatic Habitat

The Valencia WRP discharges of approximately 15 mgd create perennial surface flows. The aquatic habitat also is supported by groundwater upwelling. The cooler groundwater may cool the WRP discharges presenting preferable water quality conditions for extant special status species such as UTS. As a result, groundwater upwelling in areas that historically have been gaining reaches improves aquatic habitat quality.

Historic Groundwater Levels

Groundwater levels tend to decline in the late summer and recover in the winter responding to natural recharge and reduced pumping in the winter months, and groundwater levels also reflect multi year drought with progressively lower levels each year, followed by recovery in wetter periods. The existing GDEs have been sustained through a recent drought (2012-2016) that resulted in historically low groundwater levels. **Table 2** summarizes the historic lows recorded in several representative locations along the river corridor. **Figure 3** identifies these locations. When groundwater levels are above these recorded temporary historic lows, it can be inferred that GDEs are not significantly and unreasonably affected. As a result, these existing wells may be used to monitor future groundwater elevations to ensure that GDEs are sufficiently maintained throughout the upper SCR. The locations have been chosen as potential future monitoring locations, but may not all be located within GDE areas.

TABLE 2: GDE MONITORING LOCATIONS AND HISTORICAL LOW GROUNDWATER LEVELS

Location Description	Well Name	Historical Low Depth to Groundwater below River Thalweg (feet bgs)[a]	Historical Low Groundwater Elevation (feet NAVD88)[b]
San Francisquito Canyon	NLF-W5[c]	42	1,108
Santa Clara River Below Mouth of Bouquet Canyon	GDE-A[c]	42	1,~~087~~ 089
Santa Clara River at I-5 Bridge	GDE-B	-5	1,~~060~~ 062
Santa Clara River Near Valencia WRP	GDE-C	8	1,027
Santa Clara River 1 Mile Downstream of Valencia WRP	NLF-G3	5	975
~~Castaic Creek in Lower Castaic Valley~~	~~NLF-E~~	~~40~~	~~981~~
Santa Clara River Below Mouth of Castaic Creek	GDE-D	3	932
Santa Clara River at Mouth of Potrero Canyon	GDE-E	0	860
Castaic Creek in Lower Castaic Valley	NLF-E[c]	40	981

[a] Subject to change in monitoring plan
[b] Historical groundwater elevations are from simulations conducted using the calibrated groundwater flow model.
[c] Might not be within an actual GDE area.

bgs = below ground surface; GDE = groundwater-dependent ecosystem; NAVD88 = North American Vertical Datum of 1988; WRP = water reclamation plant

APPENDIX N

Stakeholder Communication and Engagement Plan,
Prepared by CV Strategies

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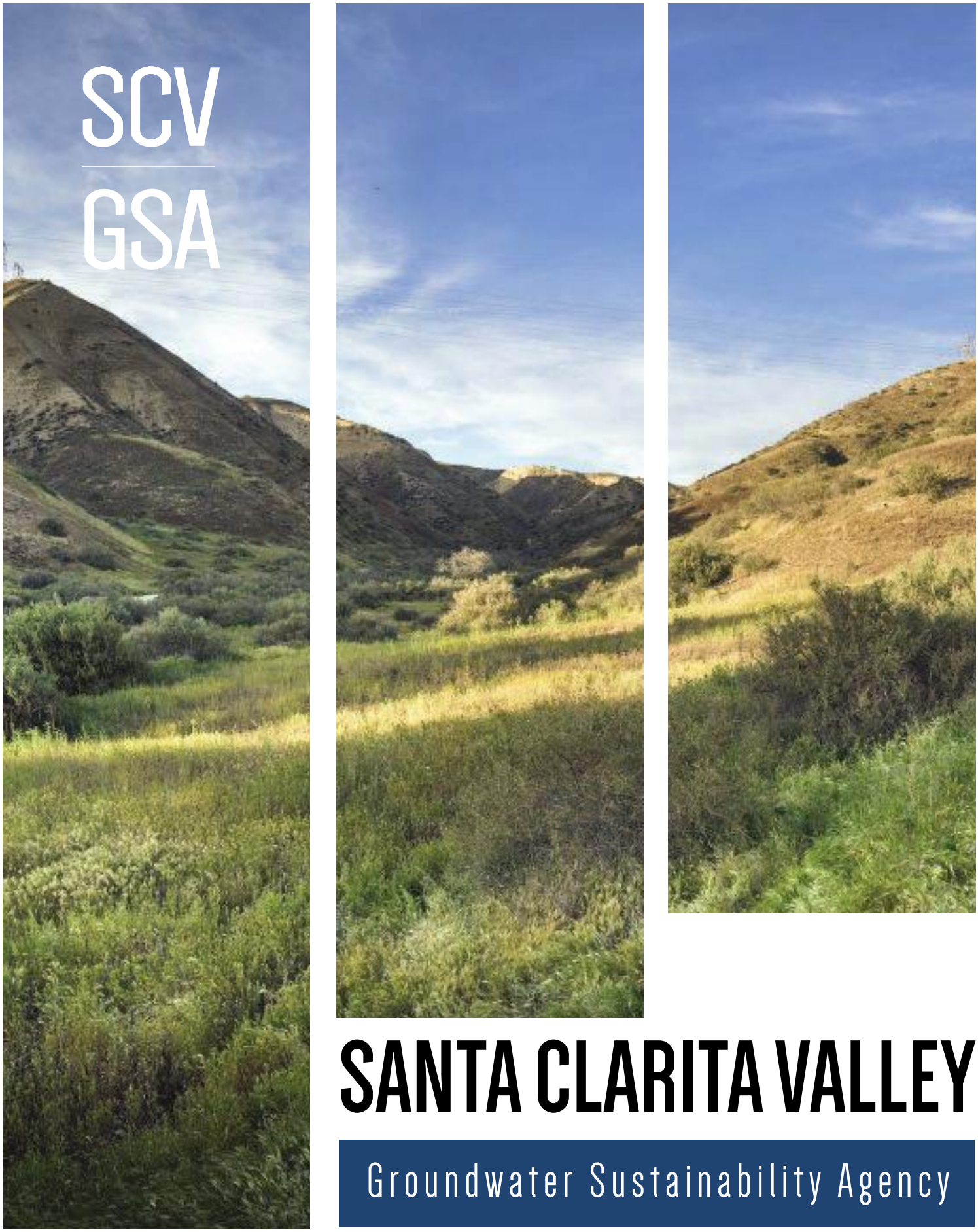

SANTA CLARITA VALLEY

Groundwater Sustainability Agency

Stakeholder Communication and Engagement Plan

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Glossary of Terms/Abbreviations

Abbreviations

Acronym/Term	Definition
DACs	Disadvantaged Communities
DWR	California Department of Water Resources
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
JPA	Joint Powers Agreement
SCV-GSA	Santa Clarita Valley Groundwater Sustainability Agency
SGMA	Sustainable Groundwater Management Act of 2014

Glossary

Aquifer - Underground layers of porous rock filled with water that can be brought to the surface through natural springs or by pumping.

Groundwater - The water beneath the earth's surface that completely fills gaps in rocks or sediment.

Groundwater basin - An aquifer or aquifer system bounded by one or more of the following features that limit groundwater flow: rocks, sediment, faults, streams or lakes.

Groundwater Sustainability Agency (GSA) – A Groundwater Sustainability Agency is charged with developing a plan to manage and protect local groundwater resources under the Sustainable Groundwater Management Act.

Groundwater Sustainability Plan (GSP) – A Groundwater Sustainability Plan is a blueprint for how a groundwater basin will reach long-term sustainability.

Joint Powers Agreement (JPA) – A JPA is a legal agreement between two or more public agencies that share a common power and want to jointly implement programs, build facilities, or deliver services. The Santa Clarita Valley Groundwater Sustainability Agency is a JPA.

Overdraft – Overdraft occurs when, over a period of years, more water is pumped from a groundwater basin than is replaced from rainfall, runoff and other sources.

Overpumping – Sustained groundwater pumping that produces declines in basin water levels and storage capacity and can cause the land above to sink, or subside.

Recharge – When surface water percolates into the aquifer below. Natural recharge involves rain and snow melt; artificial recharge involves spreading water on the surface and letting it seep into the ground or using wells to put it back into the aquifer.

Sustainable Groundwater Management Act of 2014 (SGMA) – The Sustainable Groundwater Management Act of 2014 requires local water agencies and governments to halt overdraft and bring groundwater basins into balanced levels of pumping and recharge.

Subbasin – A subbasin is a smaller unit within a groundwater basin that is created by geologic and hydrologic barriers; often used to manage water resources and adjudicated basins.

Introduction

This Stakeholder Communication and Engagement Plan details the methods and tactics for involving individuals and organizations who have a direct interest in management of the Santa Clara River Valley East Subbasin in the development of a Groundwater Sustainability Plan (GSP).

The GSP will be developed in accordance with the Sustainable Groundwater Management Act (SGMA) of 2014, which provides local water agencies with a framework for balancing levels of groundwater pumping and recharge while empowering them to adopt groundwater management plans that are tailored to the resources and needs of their communities.

The Santa Clarita Valley Groundwater Sustainability Agency (SCV-GSA) is responsible for development of the GSP. The SCV-GSA was formed in 2017 and is comprised of four agencies: Santa Clarita Valley Water Agency, City of Santa Clarita, County of Los Angeles Planning, and Los Angeles County Waterworks District No. 36.

Under SGMA, a critical part of the GPS development is communication with and involvement of the public and stakeholders, including private citizens, well owners, community organizations, environmental groups, tribal communities and anyone with an interest in the prudent management of groundwater resources. Participation from a variety of stakeholders will help SCV-GSA make decisions that consider varying needs and interests in the Santa Clara River Valley East Subbasin.

This document highlights opportunities for engagement, including formation of a Stakeholder Advisory Committee, and specifies the decision-making process, key messages and schedule for accomplishing communication outreach tasks.

Background on Santa Clarita Valley GSA

The Santa Clarita Valley Groundwater Sustainability Agency (SCV-GSA) is responsible for sustainably managing groundwater in the Santa Clara River Valley East Subbasin. The subbasin is primarily located in the Santa Clarita Valley. Its western limit is near the Los Angeles-Ventura County Line and its eastern limit is generally along Highway 14. It includes the neighborhoods of Castaic, Stevenson Ranch, Valencia, Newhall, Saugus and Canyon Country.

In the Santa Clarita Valley, about half of the water supply is produced by local groundwater. Sustainable groundwater management is essential to a reliable and resilient water system. Effective groundwater management will provide a buffer against drought and climate change and contribute to reliable water supplies regardless of weather patterns.

The GSA was initially governed through a Memorandum of Understanding (MOU) signed by its four member agencies in 2017. A more comprehensive Joint Powers Agreement was approved in September 2018. The Joint Powers Agreement will provide streamlined governance for the SCV-GSA by clarifying member financial contributions and administration.

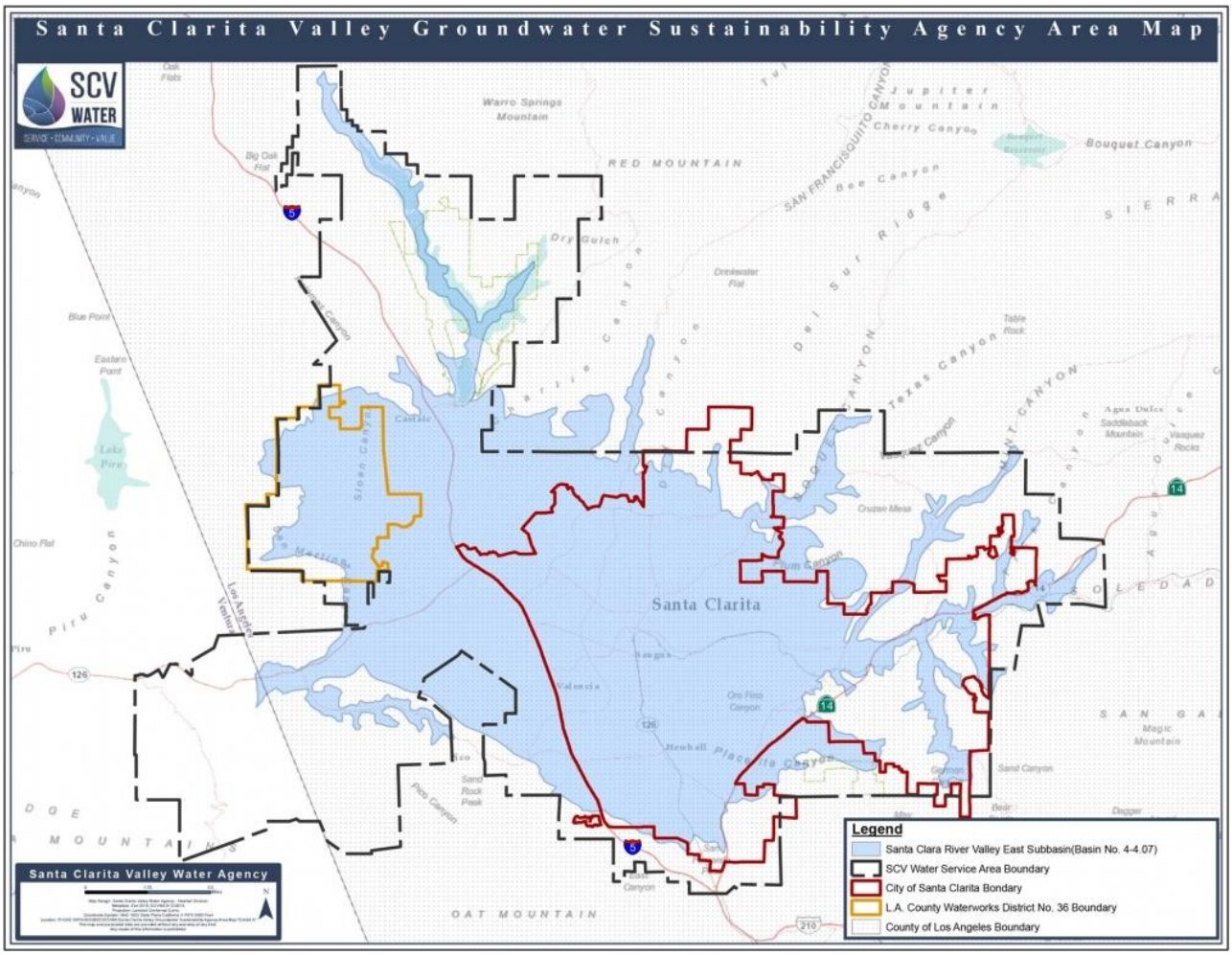
The SCV-GSA is responsible for developing a Groundwater Sustainability Plan (GSP). To do so, they may adopt rules, regulations and ordinances, conduct groundwater investigations, require registration, metering and extraction reports from individual wells, and assess fees to support creation and implementation of the GSP.

SCV-GSA Decision Making Process

The SCV-GSA is comprised of Santa Clarita Valley Water Agency, City of Santa Clarita, County of Los Angeles Planning, and Los Angeles County Waterworks District No. 36. Overall direction, funding, and approval for the groundwater sustainability planning process and work products is provided by the governing board of the SCV-GSA. The final Groundwater Sustainability Plan will be adopted by the elected governing body. Meetings of the Board of Directors will be noticed and open to the public.

Levels of Engagement & Decision Making

Figure 1: SCV-GSA Jurisdiction and Basin Boundaries



Background on Groundwater Sustainability Plans

The Sustainable Groundwater Management Act (SGMA) of 2014 is a comprehensive package of three bills (AB 1739, SB1168 and SB 1319) passed in the state of California. The SGMA provides local water agencies with a framework for sustainable management of groundwater resources, while empowering them to adopt groundwater management plans that are tailored to the resources and needs of their communities.

The SGMA requires agencies to bring groundwater basins into balanced levels of pumping and recharge through development of the GSP. The GSP will be developed by January 2022. The goal is to achieve sustainability within 20 years.

A review of long-term hydrograph data indicates the Santa Clara River Valley East Subbasin is not in overdraft. The GSP will consider various plans and management actions to ensure sustainability is maintained over the long term. The GSP will consider various groundwater supply scenarios and recharge sources that can help the GSA best manage the basin for sustainability.

Purpose of the Document

Importance of Public or Stakeholder Engagement

Public and stakeholder communication is a vital part of the GSP development process. The SCV-GSA will communicate with interested individuals and organizations (stakeholders) in order to share information and obtain input on GSP development. This will include, but is not limited to private citizens, well owners, community organizations, environmental groups, tribal communities and anyone with an interest in the prudent management of groundwater
resources.

Participation from a variety of stakeholders will help SCV-GSA make decisions that consider varying needs and interests in the Santa Clara River Valley East Subbasin.

SGMA Requirements
The SGMA requires that the GSA encourage the active involvement of diverse social, cultural, and economic elements of the population within the groundwater basin. To do so, the SGMA sets out numerous public notice requirements for both local GSAs and the state. These requirements include:

- Public notice and hearing before establishing a GSA, adopting or amending a Groundwater Sustainability Plan (GSP), or imposing or increasing a fee.
- Creation and use of an interested persons list for the subbasin or GSA.
- Participation of federally recognized Indian Tribes sharing the interest of the sustainability of the groundwater agency (if tribes choose to participate).
- Development of a written statement describing the manner in which interested parties may participate in the development and implementation of the GSP.

The SGMA requires that GSAs consider the interests of all beneficial uses and users of groundwater throughout the GSA and GSP development process. In addition, GSP Regulations (Section 354.10) require a communications section to include the following:

- An explanation of the Agency's (GSA's) decision-making process.
- Identification of opportunities for public engagement and a discussion of how public input and response will be used.
- A description of how the Agency (GSA) encourages the active involvement of diverse social, cultural, and economic elements of the population within the basin.

- The method the Agency (GSA) shall follow to inform the public about progress implementing the Plan, including the status of projects and actions.

Key Messages

1. *Our mission is to sustainably manage and protect the Santa Clara River Valley East Subbasin.*
    - The Sustainable Groundwater Management Act (SGMA) of 2014 established new requirements for groundwater management across California.
    - The Santa Clarita Valley Groundwater Sustainability Agency was formed with the City of Santa Clarita, Los Angeles County, Water Works District 36 (Val Verde) and SCV Water.
    - We are working pro-actively to form a plan that will meet anticipated state requirements.
    - The SCV-GSA will develop a Groundwater Sustainability Plan (GSP) by January 2022.
    - The goal of the GSP is to achieve sustainable groundwater management within 20 years.
    - About half of the water supply in the Santa Clarita Valley comes from local groundwater.
    - Member agencies of the SCV-GSA have carefully planned and invested to ensure adequate water supplies exist to meet water demand in the Santa Clarita Valley.

2. *SCV-GSA is committed to working with stakeholders using an open and transparent communication and engagement process.*
    - The SCV-GSA will create opportunities for stakeholders to become involved in problem-solving and decision-making.
    - We will weigh a variety of perspectives, listen to each other's views and manage differences.
    - Proactive outreach and engagement with all interested parties is essential to achieving a sustainable groundwater management plan.
    - We will consider effects of the plan on all stakeholder groups, including those with water rights, public water systems, local land use planning agencies, environmental users, surface water users, federal government, tribes and disadvantaged communities.
    - A Stakeholder Advisory Committee comprised of water users and business and environmental interests will be formed to provide the GSA with insight, support and expertise on various social, cultural and economic issues.

3. *Balance – of the water flowing into and out of the system and of public input and interests – is essential for developing an effective groundwater sustainability plan.*
    - As part of our work, we will establish how much water can safely be extracted from the subbasin on an annual basis.
    - The local groundwater basin is a drought-proof water supply.
    - It is critical that over time, basin users avoid pumping out more water than can be replaced from rainfall, runoff and other sources. This condition, known as overdraft, depletes the supply and can exacerbate pollution, causing water quality issues.
    - Pumping out too much water from a basin can cause the land above to sink and wells to dry up, damage infrastructure, harm ecosystems, and lead to economic losses from an unreliable water supply.
    - Groundwater rights will be considered when allocating groundwater extraction limits under the GSP.
    - We will determine how much overdraft can be tolerated in the transition to a level of sustainable extraction while avoiding undesirable results.
    - The plan we develop will be tailored to the resources and needs of our communities.
    - We will strive to ensure the costs of groundwater pumping remain as low as possible while preserving and protecting the environment.

4. *Maintaining healthy groundwater levels is key to ensuring a sustainable future for the region.*
    - The GSA will identify any necessary programs to enhance water supply.
    - We will track compliance with the GSP and establish enforcement policies. Consequences for non-compliance may include fees, orders to stop pumping and civil penalties.
    - The plan will detail current and historical groundwater conditions in the basin, including any water quality issues that may affect the supply and beneficial uses of groundwater.
    - The GSP will consider various plans and management actions to ensure sustainability is maintained over the long term, including removal of invasive species.
    - Local groundwater costs less than imported water supplies and having it available ensures our community can grow and thrive.

Opportunities for Public Involvement and Engagement

SCV-GSA is committed to frequent, transparent communication with stakeholders and interested parties. The following opportunities outline the numerous ways SCV-GSA will work to engage the public and provide updates in a timely manner.

Meeting Opportunities

Opportunities for public comment are provided at all SCV-GSA Board meetings, advisory group meetings, Board-appointed committee meetings and workshops. Meetings are also an opportunity for stakeholders to stay informed on what is happening with the GSA and the GSP process.

Public Notices
Public notices will be sent out in compliance with SGMA requirements.

Board Meetings and Hearings
The SCV-GSA Board of Directors meets on the first Monday of January, April, July and October at 2:30 p.m. All meetings are open to the public. Meetings take place in the SCV Water Board Room located at 27234 Bouquet Canyon Road, Santa Clarita, CA 91350.

All agendas and meeting minutes from past meetings are available on the SCV-GSA website.

Public Workshops
Public meeting and workshop dates, times, locations and key information will be communicated in advance of each meeting.

Collaborative Opportunities

Stakeholder Groups

- Large Water Pumpers
- Medium Water Pumpers
- Small Water Pumpers
- Environmental Groups
- Businesses
- Residences
- Media
- SCV Water

- Los Angeles County
- L.A. County Waterworks District Number 36
- Local Cities

Stakeholder Advisory Committee
The SCV-GSA will create a Stakeholder Advisory Committee (SAC) made up of stakeholders and basin water users. Members of this group will provide meaningful insight, support and expertise from a variety of viewpoints for the SCV-GSA Board to consider.

The committee is strictly advisory and will not vote on Board items, but representatives will represent a number of social, cultural and economic backgrounds to gain the widest possible perspective.

Committee makeup
The SAC will be made up of the following groups:
2 representatives of small pumpers (2 acre-feet or less per year)
2 representatives of medium pumpers (Over 2 and up to 25 acre-feet per year)
2 representatives of large pumpers (More than 25 acre-feet per year)
2 representatives of the business community
2 representatives of environmental interests
2 members-at-large

The outreach consultant, CV Strategies, will work with SCV Water staff to identify potential committee members through local media, social media and email to the stakeholder list. It is expected that some stakeholder groups will have numerous applicants; the selected representative must reflect the greatest diversity of his or her group and be able to effectively communicate the group's opinions and feedback. The applicants within each stakeholder group will be responsible for selecting their representative to the committee.

CV Strategies will oversee facilitation of the SAC. Work includes selection of a chair person by committee members, review of topics, reporting input to the Board.

Accommodations will be made to ensure the SAC complies with the Brown Act, which may include staff assistance with agenda preparation, meeting minutes and reserving meeting space.

Communication with SCV-GSA

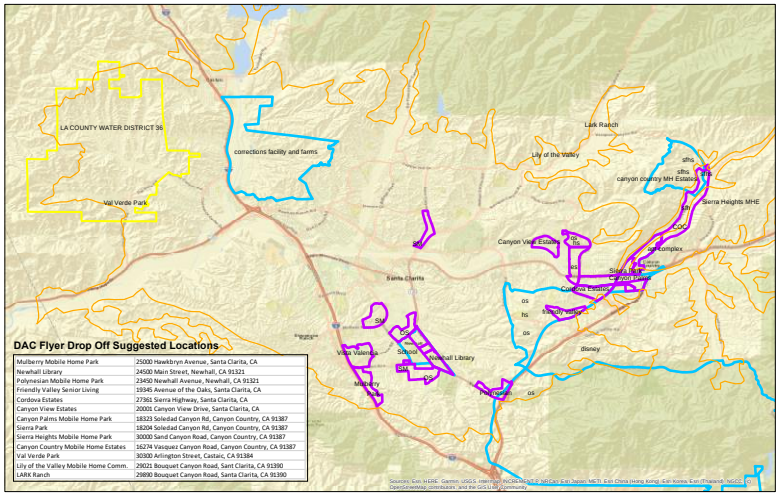
Opportunities for Tribal Communities
SCV-GSA will invite participation of federally recognized Indian Tribes sharing the interest of sustainability of the groundwater agency, as required by the SGMA, including the Fernandeño Tataviam Band of Mission Indians.

Opportunities for DAC Communities
As there are no specific Disadvantaged Communities (DACs) within the Santa Clara River Valley East Subbasin, SCV-GSA will continue its efforts to reach all stakeholders regardless of economic status, but will not be targeting a specific organization or group.

In addition to this broader outreach, a map of DACs was developed to identify areas of interest. Leveraging the map, CV Strategies crafted handouts announcing the draft plan and upcoming meetings. Handouts were left at the list of addresses below, located in or around the identified DAC areas.

DAC Handout Locations

1. Von's, 24160 Lyons Avenue
2. Newhall Library
3. Polynesian Mobile Home Park
4. Stater Bros, 26900 Sierra Hwy
5. Cordova Estates
6. Canyon View Estates
7. Canyon Palms Mobile Home Park
8. Sierra Heights Mobile Home Park
9. Canyon Country Mobile Home Estates
10. Val Verde Park
11. Lily of the Valley Mobile Home Comm.
12. LARK Ranch
13. Canyon Country Jo Anne Darcy Library
14. Bodhi Leaf, 26910 Sierra Hwy
15. Canyon Country Community Center, 18410 Sierra Hwy



Mulberry Mobile Home Park	25000 Hawkbryn Avenue, Santa Clarita, CA
Newhall Library	24500 Main Street, Newhall, CA 91321
Polynesian Mobile Home Park	23450 Newhall Avenue, Newhall, CA 91321
Friendly Valley Senior Living	19345 Avenue of the Oaks, Santa Clarita, CA
Cordova Estates	27361 Sierra Highway, Santa Clarita, CA
Canyon View Estates	20001 Canyon View Drive, Santa Clarita, CA
Canyon Palms Mobile Home Park	18323 Soledad Canyon Rd, Canyon Country, CA 91387
Sierra Park	18204 Soledad Canyon Rd, Canyon Country, CA 91387
Sierra Heights Mobile Home Park	30000 Sand Canyon Road, Canyon Country, CA 91387
Canyon Country Mobile Home Estates	16274 Vasquez Canyon Road, Canyon Country, CA 91387
Val Verde Park	30300 Arlington Street, Castaic, CA 91384
Lily of the Valley Mobile Home Comm.	29021 Bouquet Canyon Road, Sant Clarita, CA 91390
LARK Ranch	29890 Bouquet Canyon Road, Santa Clarita, CA 91390

Communication on Plan Implementation

The GSA intends to inform the public, including key stakeholder groups, about progress toward implementing the GSP, including monitoring results and the status of projects and actions. This information will be disseminated through several means, including the following:

- The GSA website.
- GSA Board meetings, where information will be presented, and the public will be invited to comment.
- Annual reports describing monitoring results and progress toward implementing the plan and meeting sustainability goals.
- GSP updates submitted to the California Department of Water Resources every 5 years. Basin stakeholders will be asked to review and comment on the update report.

In addition, the SCV-GSA will conduct public outreach and engagement throughout the implementation period to provide timely information to stakeholders about GSP implementation progress as well as monitored and modeled subbasin conditions.

To meet the requirements of SGMA, the GSA will communicate any potential changes in administration and management in a public process with stakeholders. The SCV-GSA website will be maintained as a communication tool for posting data, including reports, meeting information, technical updates, and data analyses. Other outreach will include: regular meetings; government-to-government communication; focused stakeholder briefings; paid and earned media coverage; press releases; periodic newsletters; and email blasts.

Additional Outreach Efforts

Media Outreach

- Press Releases
- Opinion/Editorials

Stakeholder Email List

Subscribers will continue receive news and updates about the GSA process and details about stakeholder forums. SCV-GSA will explore additional opportunities to grow the email subscription list and the type of information distributed.

Online Resources

- SCV-GSA website
- Basin border map

- Board meeting agendas and minutes

Collateral

- Fact sheets
- Infographics
- FAQS
- Videos

Conclusion

Public input is an important tool to support the work of the Santa Clarita Valley Groundwater Sustainability Agency and formation of a Groundwater Sustainability Plan for the Santa Clara River Valley East Subbasin.

This Plan will identify strategies for groundwater management that reflect local needs and conditions and prioritizes and preserves local control over water resources. The Plan will meet SGMA regulatory requirements by the January 31, 2020, deadline and provide direction for sustainable groundwater management within 20 years.

Stakeholder involvement and public outreach are critical to the successful development and implementation of the Plan. Including numerous voices and perspectives in the process will foster trust and support and ultimately result in reduced conflict and a better outcome.

By employing the strategies identified in this document, the SCV-GSA will include the public and stakeholders in formulating a plan that will ensure the long-term sustainability of locally managed groundwater resources in the Subbasin now and into the future.

For more information regarding the SCV-GSA and the GSP, please contact Kathie Martin at (661) 513-1265 or email ~~kmartin@scvwa.org.~~kmartin@scvwa.org.