PLATE 2

COMPARISON OF VEGETATION PATTERNS WITH SURFICIAL GEOLOGIC MAPPING

SOUTHWESTERN PORTION OF JOHNSON VALLEY

A Project for the California Department of Fish and Wildlife
By the California Geological Survey

By: Jeremy T. Lancaster CEG

Project Background

Solar, wind, and geothermal renewable energy projects in California have increased with the passing of federal and state initiatives. In response to potential increased land use from these activities, the California Department of Fish and Wildlife (CDFW) and the State and Federal Renewable Energy Action Team agencies are identifying areas of higher biological value for inclusion into a Habitat Conservation Plan / Natural Community Conservation Plan. This plan is designated as the Desert Renewable Energy Conservation Plan (DRECP). As part of the DRECP process, Johnson Valley, located in San Bernardino County, 32 miles east of Victorville, California, has been designated as a development focus area (DFA) for renewable energy.

Prior to changes in land use, it is important to understand the relationship between surficial processes and ecosystem patterns. A collaborative study between CDFW ecologists and California Geological Survey (CGS) geologists was conducted to provide insight into the spatial and temporal history of landform development, soil substrate, and the distribution of ecological values. This project was designed to highlight the relationships between Quaternary geomorphic landforms and processes with the areal distribution of vegetation alliances in the study area. The general approach uses a regional geomorphic hierarchy that relates common landform terminology with surficial geologic nomenclature, defines soil properties (pedogenic development and texture) within each surficial unit to provide a better understanding of the relationship between surficial processes and ecological function. This surficial geologic map provides the basic geologic data for the collaborative project. The project report emphasizes complex interactions between vegetation and geomorphic processes by providing observational and analytical results based on geographic comparison of this surficial geologic map and the CDFW vegetation map (See project report, Lancaster et al., 2014). Surficial geologic mapping was conducted for a 69 km^2 (17,158 acres) area located in southwestern part of Johnson Valley within portions of the Old Woman Springs, Melville Lake, Rattlesnake Canyon, and Bighorn Mountains 7.5 minute quadrangles. This mapping area coincides with the southwest portion of the Johnson Valley DFA and is bounded by the San Bernardino Mountains to the south and a broad basin to the north. The study area includes streams that issue from Rattlesnake Canyon, the largest tributary upland watershed to this internally draining basin.

Surficial Processes and Vegetation Comparison

CDFW plant ecologists and CGS geologists conducted independent mapping of vegetation alliances and surficial geology in order to highlight the relationships between Quaternary landforms, processes and substrate with vegetation patterns in the study area. The analytical results are consistent with similar studies in the Mojave Desert (Hamerlynck et al., 2002; Bedford at al., 2009; Miller et al., 2009; and Schwinning et al., 2009) that describe the influence of surficial geology - the lithology, texture, age, and depositional environment of surficial deposits – on hydrology, vegetation morphology, and community characteristics. Concurrent classification and mapping of vegetation patterns conducted by CDFW plant ecologists were then compared to surficial geology in order to highlight the relationships between Quaternary landforms, processes, and substrate with the areal distribution of vegetation alliances. The results of this collaborative effort provide insight into corroborative nature of certain vegetation types and surficial processes.

Within the distal piedmont and basin region, thick eolian deposits have excessively drained soils that receive little to no runoff from streams. In this setting, where soil moisture is a function of direct precipitation and infiltration, the relative cover of *Atriplex polycarpa* increases. In the areas where active alluvial fan and alluvial wash systems enter a zone of active eolian transport, eolian processes affect stream processes by filling alluvial swales and covering gravel bars. Over time this process enhances channel instability and results in changes in location of ephemeral streams. Vegetation patterns in this setting indicate a strong response to deep unconsolidated sandy soils. Relative cover of *Ambrosia dumosa*, a drought dormant shrub with relatively shallow root systems, is lower in this setting. *Larrea tridentata*, having both shallow and deep root systems, tends to thrive in these well-drained soils that receive runoff from streams. In this setting the formation of robust clonal stands of *Larrea tridentata* correspond to active eolian sand deposition and the formation coppice dunes. Findings from the CGS analysis indicate that:

- The presence of the *Larrea tridentata* alliance and relative lower cover of *Ambrosia dumosa* corresponds to geologically young, well-drained sandy soils, associated with distal piedmont alluvial fan and eolian deposits.
- Clonal stands of *Larrea tridentata* also generally match the orientation and distribution of active eolian transport across the mid- and distal- piedmont. This suggests that eolian sand accumulation enhances the growth of *Larrea tridentata*.
- The relative cover of *Ambrosia dumosa* increases on interbedded alluvial fan and eolian deposits that have incipient to well-developed pedogenic horizons. This is consistent with fact that *Ambrosia* has a shallow root structure that requires soil characteristics that retain moisture.

This geologic map of surficial deposits is identical to the map included as Plate 1 in the project report (Lancaster et al., 2014), but includes an overlay of the mapped extent of clonal *Larrea tridentata,* and the mapped changes in relative cover of *Ambrosia dumosa*.

Special Map Features

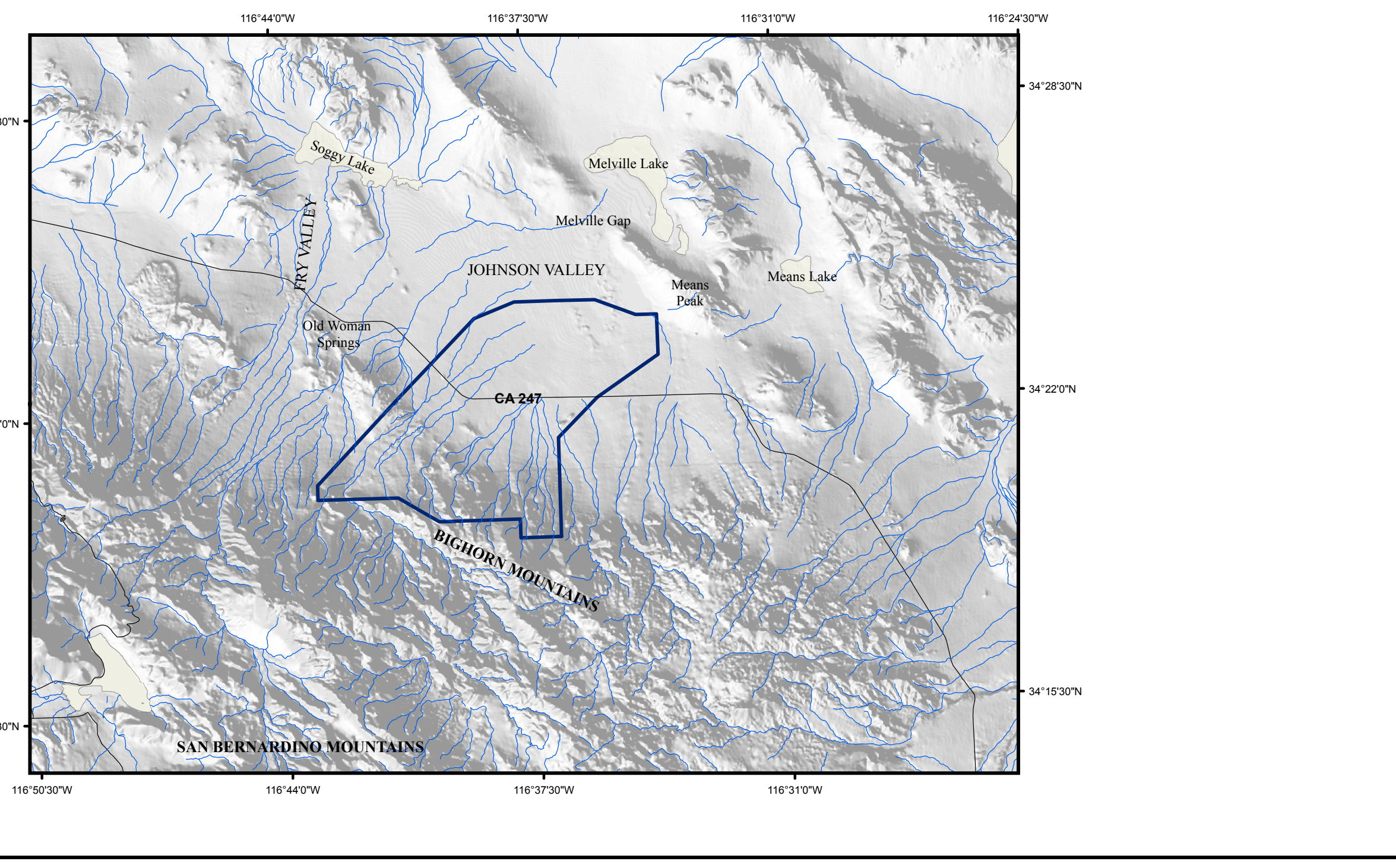
▨ *Larrea tridentata – Ambrosia dumosa* Alliance, where vegetation mapping indicates presence of clonal *Larrea*.

▩ *Larrea tridentata* Alliance, where vegetation mapping indicates presence of clonal *Larrea.*

CONTOUR INTERVAL 10 METERS

Projection: Universal Transverse Mercator, Zone 11 North, North American Datum of 1983

Topographic contours derived from USGS 1/3 arc-second National Elevation Dataset (Gesch et al., 2002); Shaded topographic relief derived from USGS 1/3 arc-second National Elevation Dataset.



Interpretation and Description of Map Units

Map units were attributed by remote sensing; i.e., observing features on aerial photographic images of different dates to identify depositional environment (i.e. alluvial fan, alluvial wash), geomorphic position, surface morphology and tonal contrasts. Aerial photography was used to identify changes in areal distribution of eolian sand deposition. Topographic maps and digital elevation models were used to identify topographic boundaries, relative dissection and geomorphic position. Interpretations were confirmed or revised by field classification of surficial deposits conducted by CGS in November and December of 2013, and in February and April of 2014. This included observation of soil texture, depositional environment, and degree of soil development. To assist in developing the chronology of Quaternary surficial deposits, observable soil factors were used to compare soil development (pedogenesis) among geomorphic surfaces (Harden 1982; Birkeland, 1999; Machette, 1985; Bull 1991; and Melton, 1965). These included desert pavement and desert varnish, cobble weathering stage, pedogenic horizon development, soil rubification, and carbonate morphology. CGS used these relative age indicators in our assessment of surficial geology. In addition, CGS reviewed surficial mapping developed for the Cougar Buttes 7.5 minute quadrangle to the west of the project area (Powell and Matti, 2000), and Soil Survey data (CA698) for the Mojave Desert Area – Western Central Part (Soil Survey Staff, in progress). The following description of map units comes from a synthesis of these data and interpretations.

Late Holocene Surficial Deposits

af **Artificial Fill** – Deposits of fill resulting from human construction primarily along improved and unimproved roads.

Qa **Very Young Alluvial Valley Deposits (latest Holocene)** - Alluvial valley deposits forming low lying terraces that border active alluvial washes. Consisting of unconsolidated fine- to coarse-grained sand and sandy gravel with subordinate fine sand and silt.

Qw **Very Young Alluvial Wash Deposits (latest Holocene)** - Active alluvial wash deposits consisting of unconsolidated fine - to coarse-grained sand and sandy gravel with subordinate fine sand and silt, dry soil color is brownish yellow, 10YR 6/6; bar and swale morphology (where unobscured by eolian processes). Unit lacks soil profile development.

Qe **Very Young Eolian Deposits (latest Holocene)** - Windblown deposits consisting of laminated and cross bedded fine- to medium- sand, soil color is pale yellow brown 10YR 8/2 to 7/3. These deposits comprise a wide range of geomorphic forms, including simple and complex barchan and parabolic dunes, as well as coppice dunes and sand sheets. These are considered to be actively forming and/or migrating along principal drift directions. Sand sheets are also interbedded with alluvial deposits, or form a veneer, depositing in abandoned alluvial channels that traverse alluvial fans, on older alluvial surfaces, and on bedrock surfaces that lie in the path of eolian transport. Locally, stands of clonal *Larrea tridentata* are associated with this map unit.

Qf **Very Young Alluvial Fan Deposits (latest Holocene)** - Active alluvial fans and fan skirts consisting of unconsolidated fine- to coarse-grained sand and sandy gravel with subordinate fine sand and silt, dry soil color is brownish yellow, 10YR 6/6; bar and swale morphology (where unobscured by eolian processes). Unit lacks soil profile development. These deposits are observed along the distal piedmont/basin interface, are formed by actively migrating distributary alluvial washes and sheet flow processes, and are locally overlain by active sand sheets derived from local alluvial deposits.

Qdf **Very Young Debris Fan Deposits (latest Holocene)** - Debris flow fans consisting of unconsolidated sand and gravels to boulder size. As mapped, these deposits are relatively small in areal distribution and confined to locations along the proximal piedmont/upland interface. Surface morphology expressed as steeply sloping boulder fields, boulder splays, and terminal snouts.

Qc **Very Young Colluvial Deposits (latest Holocene)** - Colluvial aprons composed of gravity and slope wash deposits consisting of poorly sorted sands and gravels that mantel mountainous slopes and fault scarps. Unit lacks soil profile development.

Holocene to Late Pleistocene Surficial Deposits

Young Eolian Deposits (Holocene and late Pleistocene) - Windblown deposits consisting of thin, laterally discontinuous sand sheets and eroded dune and coppice dune deposits. As observed, these deposits formed on abandoned alluvial fan and wash deposits adjacent to formerly active alluvial channels and washes. These deposits have pedogenic soil development consisting of carbonate filaments and coatings on pebble clasts with carbonate morphology up to Stage II. The fine grained texture, as well as pedogenic development, appears to enhance moisture holding capacity of these deposits. Locally, stands of clonal *Larrea tridentata* are associated with these map units.

Holocene and Late Pleistocene Eolian Subunits

Qye_3 **(Subunit 3)** – Eolian sand sheets of late Holocene age composed of fine to coarse sand with some silt. Dry soil color, yellowish brown, 10YR 5/4. Stabilized and locally active sand sheets forming over alluvial fans and alluvial washes. This unit may have incipient pedogenic carbonate development.

Qye_2 **(Subunit 2)** - Eolian sand sheets of middle Holocene age composed of fine- to coarse- sand with some silt, dry soil color, yellowish brown, 10YR 5/6. Pedogenic carbonate forming discontinuous filaments and thin coatings on gravel clasts; locally may be weakly cemented and strongly effervescent, carbonate development Stage I to I+. Interpreted as stabilized sand sheets forming over alluvial fans and alluvial washes.

Qye_1 **(Subunit 1)** - Eolian sand sheets of middle Holocene and Late Pleistocene age composed of fine- to coarse- sand with some silt. Soil color, very pale brown, 10YR 8/2 on the upper Rattlesnake Canyon piedmont, and reddish yellow, 7YR 7/6 where found in the distal piedmont and basin region of the map area. Pedogenic carbonate forms filaments and within sediment matrix as bridges and coatings on gravel clasts; locally may be moderately cemented and strongly effervescent, carbonate development to Stage I+ to II. These deposits form a veneer over a relict alluvial wash deposit (Qye_1/Qow) that formed on the uplifted and dissected fan deposits of Pleistocene age, south of the Old Woman Springs Fault.

Qya **Young Alluvial Valley Deposits (Holocene and late Pleistocene)** - Alluvial valley deposits consisting of unconsolidated fine- to coarse-grained sand and sandy gravel with subordinate fine sand and silt. This unit is locally differentiated into subunit 1 and subunit 2, interpreted from inset topographic positions in the upper Rattlesnake Canyon piedmont.

Holocene and Late Pleistocene Alluvial Valley Subunits

Qya_2 **(Subunit 2)** - Alluvial valley deposits consisting of unconsolidated fine- to coarse-grained sand and sandy gravel with subordinate fine sand and silt. This unit occupies a lower topographic position than Qya_1 along the margins of Rattlesnake Canyon Wash.

Qya_1 **(Subunit 1)** - Alluvial valley deposits consisting of unconsolidated fine- to coarse-grained sand and sandy gravel with subordinate fine sand and silt. Locally overlain by a veneer of eolian sand with incipient pedogenic development. This unit occupies a higher topographic position than Qya_2 along the margins of Rattlesnake Canyon Wash.

Qya_{sw} **Young Alluvial and Slope Wash Deposits (Holocene and late Pleistocene)** - Alluvial and slope wash aprons on flanks of dissected pediment veneers. Unit includes sand and pebbly sand deposited by channelized flow on small alluvial fans and in small washes, and by unconfined overland flow across older surfaces.

Qyw **Young Alluvial Wash Deposits (Holocene and late Pleistocene)** - Alluvial wash deposits consisting of unconsolidated fine - to coarse-grained sand and sandy gravel with subordinate fine sand and silt. As mapped these deposits are abandoned geomorphic features that retain their former topography where unobscured by eolian processes.

Qyf **Young Alluvial Fan Deposits (Holocene and late Pleistocene)** - Unconsolidated to slightly consolidated sand and gravel, poorly to moderately sorted. Sand is medium- to coarse-grained; gravel includes pebbles, cobbles, and boulders. Locally subdivided into:

Holocene to Latest Pleistocene Alluvial Fan Subunits

Qyf_2 **(Subunit 2)** - Unconsolidated to slightly consolidated sand and gravel, poor- to moderately- sorted. Sand is fine - to coarse-grained; gravel includes pebbles, cobbles, and boulders. Surfaces exhibit prominent bar and swale morphology, locally obscured by eolian deposition and are traversed by incised active alluvial washes (Qw). Soil color is pale brown, 10YR 6/3.

Qyf_1 **(Subunit 1)** - Unconsolidated to slightly consolidated sand and gravel, poorly to moderately sorted. Sand is fine- to coarse-grained; gravel includes pebbles, cobbles, and boulders. Surface mantled by gravel lag to 60 mm, and is slightly dissected. On the distal piedmont of Rattlesnake Canyon wash and the Bighorn Mountains this unit is interbedded or overlain by eolian sand of variable age and thickness. Soil color is pale brown, 10YR 6/3 and has a faint 10-20 mm thick vesicular horizon.

Qydf **Young Debris Fan Deposits (Holocene and late Pleistocene)** - Debris flow fans consisting of unconsolidated sand and gravels to boulder size, soil color, light yellowish brown, 10YR 6/4. As mapped, these deposits are observed along the proximal Bighorn Mountains and Rattlesnake Canyon piedmont, are inset or superimposed on debris flow and alluvial deposits of Pleistocene age (Qof). Surface morphology expressed as steeply sloping boulder fields, boulder splays and terminal snouts. Locally, moderate to strong varnish is preserved on surface clasts. Cobble and boulder fields cover up to 80 % of surface. On the Bighorn Mountains piedmont, pedogenic clay films coating the underside of gneissic clasts have a reddish yellow color, 7.5YR 7/8.

Late to Middle Pleistocene Surficial Deposits

Qoa **Old Alluvial Valley Deposits (Pleistocene)** – Undifferentiated alluvial deposits composed of fine to coarse sand and gravel exposed in upland canyons and valleys. In exposures within the Bighorn Mountains, the surface of this unit is mantled by a gravel lag and vesicular horizon to 40 mm. Gravel clasts are up to 70 mm, composed of granite, diorite, and amphibolite. Amphibolite is strongly varnished with pedogenic clay accumulation on the undersides of clasts having 5YR 6/6 color. Where exposed in stream cuts, this surface is underlain by a thick pedogenic carbonate horizon.

Qof **Old Alluvial Fan Deposits (Pleistocene)** – Alluvial and debris flow deposits comprised of sand and pebble to boulder gravel, locally subdivided into subunit 1 and 2:

Late Pleistocene Alluvial Fan Subunits

Qof_2 **(Subunit 2)** - Unconsolidated to slightly consolidated sand and gravel, poorly to moderately sorted. Sand is medium- to coarse-grained; gravel includes pebbles, cobbles, and boulders. Gravel lag covers 40 to 60 % of the surface. As mapped these deposits are found on the upper Rattlesnake Canyon piedmont and are differentiated based on inset relationships with older alluvial fans (Qof1 and Qvof).

Qof_1 **(Subunit 1)** - Unconsolidated to slightly consolidated sand and gravel, poorly to moderately sorted. Sand is medium- to coarse-grained; gravel includes pebbles, cobbles, and boulders. Surface lacks original depositional topography. Cobbles and boulders cover less than 50% of surface; exhibits moderate pavement that is locally eroded or disrupted by vegetation. On the Bighorn Mountains upper piedmont, these deposits are of primarily of debris flow origin, with a gravel lag composed of granite and amphibolite with a subordinate amount of gneiss. Amphibolite clasts have strong varnish 7.5YR 2.5/1 with pedogenic clay on clast undersides 5 YR 5/8 to 4-5/6. Granitic clasts are strongly pitted.

Qodf **Old Debris Fan Deposits (late Pleistocene)** – Moderately consolidated sand and gravel, poorly sorted. Sand is medium- to coarse-grained; gravel includes pebbles, cobbles, and boulders. As mapped along the Bighorn Mountains upper piedmont, surface gravels are composed of granite and gneiss with subordinate amphibolite. Boulder and cobble clasts make up about 40 to 60 % of surface, with sandy grus up to 60 mm in diameter making up swales. Bottom of gneissic clasts have pedogenic clay films from 7.5YR 5/4 to 5YR 4/6. Locally, this surface lacks reddened soil and has a silty vesicular horizon to 20 mm (10YR 7/4). Surfaces are moderately smooth with remnant boulder fields preserved locally. These deposits are inset or superimposed on older alluvial and debris flow deposits of Pleistocene age (Qof_1).

Qoc **Old Colluvial Deposits (Pleistocene)** - Colluvial aprons composed of gravity and slope wash deposits consisting of poorly sorted sands and gravels, preserved on the flanks of steep mountain slopes and fault scarps. Locally, these deposits are cemented by carbonate soil development.

Qopv **Old Pediment Veneer Deposits (Pleistocene)** – Pervasively chalky-cemented sand and pebbly sandstone; firm to hard; poorly sorted; cemented to well cemented. Calcification is consistent with a Stage IV to VI petrocalcic soils. Based on field relations in the map area, this unit is interpreted to form a veneer over a former (Pleistocene?) bedrock erosional surface.

Middle to Early Pleistocene Deposits

Qvof **Very Old Debris Fan Deposits (Pleistocene)** – Moderate- to well- cemented fanglomerate; interbedded fluvial and debris flow deposits. Fluvial deposits are thin- to thick-bedded, poorly sorted pebble to cobble conglomerate that exhibit channels and cross-bedding. Debris flow deposits are massive and unsorted with angular pebble- to cobble-sized angular to subangular clasts. As mapped these deposits are exposed as fault-bound ridges associated with the Lenwood and Old Woman Springs faults. Over 30 m of this unit is exposed on the western margin of Rattlesnake Canyon Wash. Locally these deposits contain several well developed pedogenic Bt and calcic (k) horizons.

QTs **Very Old Alluvial and Lacustrine Deposits (Pleistocene and Tertiary)** – Poor- to moderately- consolidated clay, silt, and sand, moderately sorted. Sand is medium- to coarse-grained. As mapped this unit is exposed along the fault-bound topographic break at the northern margin of the Bighorn Mountains.

Mesozoic and Older Bedrock

Br **Bedrock Undifferentiated (Pliocene to Proterozoic)** – Undifferentiated crystalline bedrock composed of Precambrian gneiss, schist; Paleozoic quartzite, gneissic quartzite and limestone; Mesozoic granodiorite and quartz monzonite.

Symbol Explanation

——— — — — **Geologic Contact** – Solid where location in accurate, long-dashed where location is approximate

——— —…… **Fault** - Solid where location in accurate, long-dashed where location is approximate, dotted where location is concealed. Compiled by Bryant (2005)

………… **Lineament** – Vegetation, tonal, and topographic. Mapped by author as a part of this assessment.

REFERENCES

Bedrossian, T. L., Roffers, P., Hayhurst, C. A., Lancaster, J. T., and Short, W. R., 2012, Geologic Compilation of Quaternary Surficial Deposits in Southern California: California Geological Survey, Special Report 217, 20 p, 25 plates, scale 1:100,000.

Bedford, D.R., Miller, D.M. and Phelps, G.A., 2010, Surficial Geologic Map of the Amboy 30' x 60' quadrangle, San Bernardino County, California: U.S. Geological Survey Scientific Investigations Map 3109, scale 1:100,000.

Bedford D. R., Miller D. M., Schmidt K. M., and Phelps G. A., 2009, Landscape-Scale Relationships Between Surficial Geology, Soil Texture, Topography, and Creosote Bush Size and Density in the Eastern Mojave Desert of California. in: Webb, R. H., Fensternmaker L. F., Heaton J. S., Hughson D. L., McDonald E. V., and Miller D. M., (Eds.) The Mojave Desert, Ecosystem Process and Sustainability, University of Nevada Press, pp. 252-278.

Birkeland, P. W., 1999, Soils and Geomorphology: Oxford University Press, 430p.

Blair, T.C., and McPherson, J.G., 1994, Alluvial Fan Processes and Forms: In Geomorphology of Desert Environments: Springer Netherlands. p. 354-402.

Bryant, W.A., (compiler), 2005, Digital Database of Quaternary and Younger Faults from the Fault Activity Map of California: California Geological Survey, version 2.0.

Bull, W. B., 1991, Geomorphologic Response to Climate Change: New York, Oxford University Press, 326 p.

Cooke, R. U., Warren, A., and Goudie, A. S, 1993, Desert Geomorphology: University College of London Press, 526p.

Dibblee, T.W. and Minch, J.A., 2008, Geologic Map of the Old Woman Springs & Emerson Lake 15 Minute Quadrangles, San Bernardino County, California: Dibblee Geological Foundation, Dibblee Foundation Map DF-380, scale 1:62,500.

Gesch, D., Oimoen, M., Greenlee, S., Nelson, C., Steuck, M., and Tyler, D., 2002, The National Elevation Dataset: Photogrammetric Engineering and Remote Sensing, v. 68, no. 1, p. 5-11.

Hamerlynck, A. P., McAuliffe, J. R., McDonald E. V., and Smith S. D., 2002, Ecological Responses of Two Mojave Desert Shrubs to Soil Horizon Development and Soil Water Dynamics: Ecology, Vol. 83(3), pp. 768-779.

Harden J. W., 1982, A Quantitative Index of Soil Development From Field Descriptions: Examples From a Chronosequence in Central California: Geoderma, vol. 28, p.1-28.

Lancaster, J. T., Boul, R., Keeler-Wolf, T., 2014, Memorandum Report to Mr. Serge Glushkoff, CDFW, Dated August 2014, Titled, The Influence of Surficial Processes on Vegetation Patterns in Southern Johnson Valley: California Geological Survey, 39p., 2 plates, scale 1:12,000.

Machette, M. N., 1985, Calcic Soils of the United States: in Weide, D. L., Soils and Geology of the Southwestern United States, Geological Society of America Special Paper 203, p.1-21.

Melton, M.A., 1965, The Geomorphic and Paleoclimatic Significance of Alluvial Deposits in Southern Arizona: Journal of Geology, vol. 73, p. 1–38.

Miller D. M., Bedford D. R., Hughson D. L., McDonald E. V., Robinson S. E., and Schmidt K. M., 2009, Mapping Mojave Desert Ecosystem Properties with Surficial Geology. in: Webb, R. H., Fensternmaker L. F., Heaton J. S., Hughson D. L., McDonald E. V., and Miller D. M., (Eds.) The Mojave Desert, Ecosystem Process and Sustainability, University of Nevada Press, pp. 225-251.

Norris, R. M., and Webb, R. W., 1990, Geology of California: Wiley.

Powell, R.E. and Matti, J.C., 2000, Geologic Map and Digital Database of the Cougar Buttes 7.5' Quadrangle, San Bernardino County, California: U.S. Geological Survey, Open-File Report OF-2000-175, scale 1:24,000.

Schwinning, S. K., and Hooten M. M., 2009, Mojave Desert Root Systems. in: Webb, R. H., Fensternmaker L. F., Heaton J. S., Hughson D. L., McDonald E. V., and Miller D. M., (Eds.) The Mojave Desert, Ecosystem Process and Sustainability, University of Nevada Press, pp. 279-311.

Soil Survey Staff, in progress, Soil Survey of the Mojave Desert Area – Western Central Part (CA 698).

Imagery Used

County of San Bernardino, 2009, accessed via Google Earth (v. 7.1.2.2041) on January 5, 2014

Google Earth, 2005, Digital Globe Imagery, accessed via Google Earth (v. 7.1.2.2041) on January 5, 2014

Google Earth, 2010, Digital Globe Imagery, accessed via Google Earth (v. 7.1.2.2041) on January 5, 2014

Google Earth, 2013, Digital Globe Imagery, accessed via Google Earth (v. 7.1.2.2041) on January 5, 2014

U.S. Department of Agriculture, 1952 and 1953, Aerial Photographs AXL-14K-79 to 89 and 138 to 141; 16K-33 to 39; 17K-32 to 40; 48K-66 to 70, black and white, vertical, approximate scale 1:20,000.

U.S. Department of Agriculture, Farm Service Agency-Aerial Photography Field Office, National Agriculture Imagery Program (NAIP), 2005, 1-meter resolution.

U.S. Department of Agriculture, Farm Service Agency-Aerial Photography Field Office, National Agriculture Imagery Program (NAIP), 2009, 1-meter resolution.

U.S. Department of Agriculture, 2009, accessed via Google Earth (v. 7.1.2.2041) on January 5, 2014U.S. Geological Survey, 1989, accessed via Google Earth (v. 7.1.2.2041) on January 15, 2014