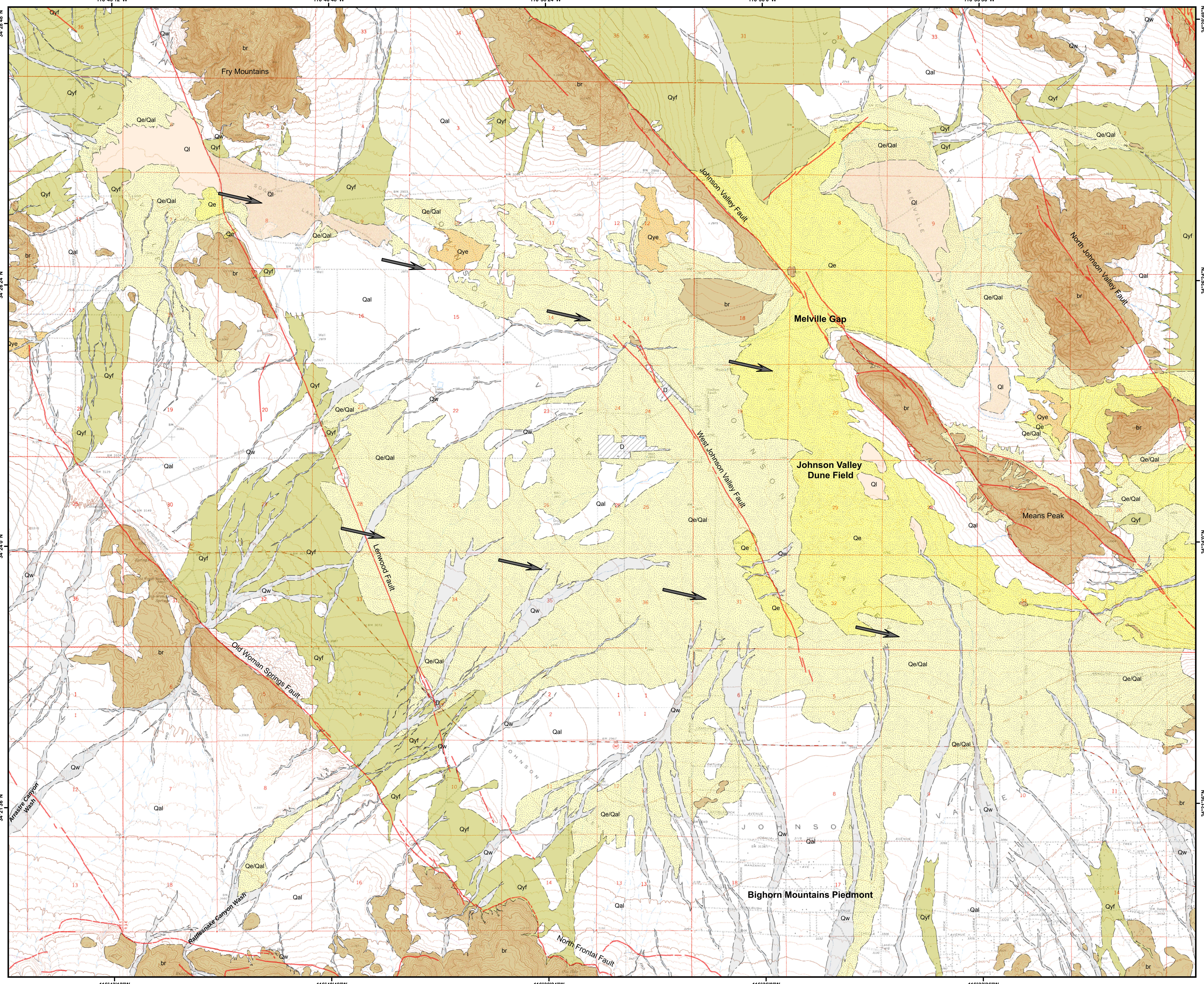


Projection: Universal Transverse Mercator, Zone 11 North, North American Datum of 1983

Topographic base from U. S. Geological Survey Big Horn Canyon 7.5-Minute Quadrangle, 1972, Minor Revision 1994; Contour Interval 40ft. U. S. Geological Survey Melville Lake 7.5-Minute Quadrangle, 1972, Minor Revision 1994; Contour Interval 20ft (Supplemental 10 ft). U. S. Geological Old Woman Springs 7.5-Minute Quadrangle, 1972, Minor Revision 1994; Contour Interval 20ft (Supplemental 10 ft). U. S. Geological Survey Rattlesnake Canyon 7.5-Minute Quadrangle, 1972, Photo Revision 1988, Minor Revision 1994; Contour Interval 40ft.

N

Map Scale: 1:36,000

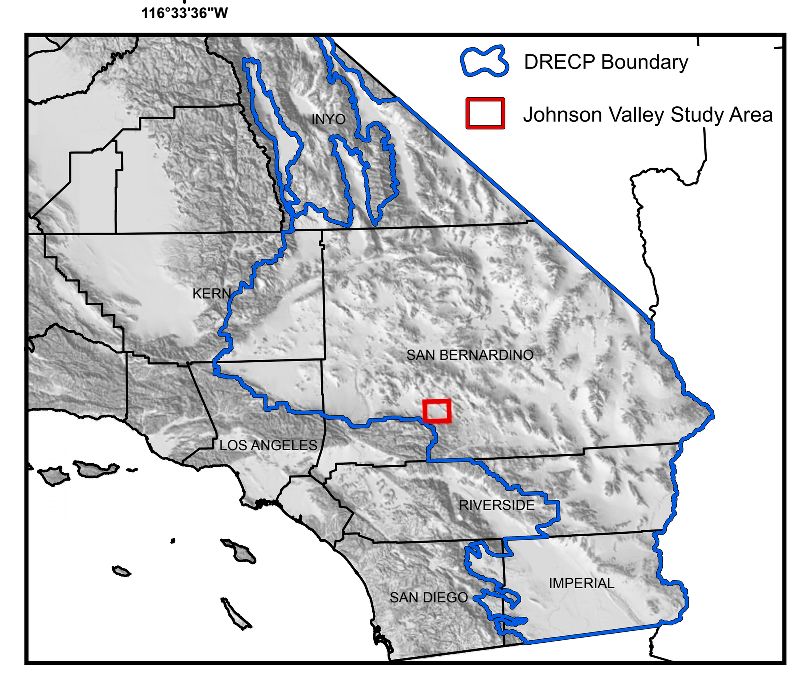
2 1 0 2 Miles

4.5 2.25 0 4.5 Kilometers

EOLIAN SYSTEM MAP OF THE JOHNSON VALLEY AREA

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

By: Jeremy T. Lancaster CEG



PROJECT OVERVIEW

PLATE 1

Eolian deposits are recognized as areas of higher biological value because they support specific natural communities and wildlife habitats. In response to potential increased land use from renewable energy projects in California where eolian deposits and processes are present, the California Department of Fish and Wildlife (CDFW) and the State and Federal Renewable Energy Action Team have designated sand dunes and their associated processes as areas of higher biological value for inclusion into a Habitat Conservation Plan / Natural Community Conservation Plan. This plan is known as the Desert Renewable Energy Conservation Plan (DRECP, http://www.drecp.org/). The Department of Conservation's California Geological Survey (CGS) provided CDFW with technical assistance on Eolian System Mapping under the Cooperative Endangered Species Conservation Fund (Section 6) Grant Program (Agreement Number P1382002). This project addresses the need for map-based information that identifies the presence of active eolian deposits and their source areas. The Johnson Valley area is one of several priority areas that are part of the DRECP, identified as Development Focus Areas.

This map of Johnson Valley was developed by CGS to assist in identifying components of the eolian system, including active areas of deposition, source areas, and zones of sand transport. This 36,000 scale map is based on new mapping by CGS of Quaternary age surficial deposits that form the interpretive source in the identification of eolian deposits, sources, and zones of transport for the Johnson Valley study area. Depending on the geomorphic setting, eolian processes range from primary to secondary (Blair and McPherson, 1994). Within the regional zone of transport, eolian sand accumulates as dunes, sand sheets, and sand ramps. Eolian processes are primary where thick deposits accumulate, develop dune forms, and influence the geomorphology of the landscape. Where these eolian sand accumulations attain sufficient thickness (> 1.5 m) they are typically portrayed as eolian deposits on geologic maps. However, complex interactions occur locally on the landscape between source and deposition areas. Eolian sand is transported across playa lakes, playa fringe, alluvial fans, alluvial washes, and along bedrock divides. In these geomorphic settings, the primary processes acting on the landscape are gravity-driven flow of water and gravity-induced slope movements (e.g. translational failures and rockfalls). Along playa margins and piedmont landforms, transported eolian sediment interacts with vegetation and topographic irregularities that act as baffles, causing eolian sediment to deposit as thin sand sheets superimposed on these geomorphic surfaces. In the presence of vegetation, sand sheets are typically thin, relatively planar, and lack dune form (Cooke et al., 1993).

To address this complexity, CGS used a hybridized mapping nomenclature that identifies both the primary geomorphic process and the secondary processes superimposed on those features that are specific to eolian systems. Using an original surficial geologic nomenclature of Bedrossian et al. (2012), CGS developed a hybrid geologic nomenclature to identify the presence of eolian veneers. For example, a Holocene to late Pleistocene age alluvial fan (Qyf) within an active eolian transport corridor, may be overlain by a veneer of eolian sand. In order to represent the superimposition of this secondary process on the landscape, the map unit is termed Qe/Qal. Conversely, the designation Qe is used singularly when the map unit attained an estimated thickness of > 1.5 m.

In addition to the hybridized mapping nomenclature, CGS used aerial photographic interpretation and field observations of deposit thickness, texture, and soil development in order to attribute map units with their relative state of activity. The relative state of activity is identified by observing the relative degree of soil development, including consolidation and pedogenic horizon development. Where eolian deposits have formed during past episodes of activity (late Quaternary), but have been stabilized by soil development, the land surface may have relatively lower reflectance, or albedo. Active eolian surfaces typically present features that suggest fresh scour of existing soil and vegetation, or deposition of eolian sand over pre-existing land cover. These surfaces have a relatively high albedo. Where observations suggested a period of stability, eolian deposits are designated as Qye (Inactive). Where observations suggest relatively recent activity, eolian deposits are designated as Qe.

This map, along with others developed as part of this study to address eolian system processes, is regional in nature and should not be used as a substitute for detailed studies in any specific area. It is intended for regional planning efforts and may be used as the framework to identify regional eolian processes and to guide future studies. For additional discussion regarding Johnson Valley and other mapped areas, please refer to the project report (Lancaster and Bedrossian, 2014).

Johnson Valley

Johnson Valley is located entirely within the Mojave Desert geomorphic province, north of the San Bernardino Mountains in San Bernardino County. The Mojave Desert is a broad interior region of isolated mountain ranges separated by expanses of desert plains that form sharp angles between the Garlock Fault to the northwest and the San Andreas Fault to the southwest (Norris and Webb, 1990). The area is characterized by isolated mountain ranges separated by desert plains averaging 750 m in elevation, with extreme variations in relief from 180 to 2,440 m (Bedrossian et al., 2012). The climate is arid, hot, and dry with average annual temperatures reported for the adjacent Lucerne Valley ranging between 6.2° and 25.7°C (43.2° and 78.2° F) (DRI, 2014). According to the Desert Research Institute (DRI), January mean temperatures range from 11° to 13°C (27.3° to 58.9°F) and July mean temperatures range between 17.4 and 37.5°C (63.4° and 99.6°F). The average annual rainfall is 103 mm/yr and the average annual snowfall is 58 mm/yr (DRI, 2014).

Johnson Valley is part of a broad depression that extends southeast from Fry Valley and Soggy Lake to the unnamed mountains that contain Means Peak in the east. This internally draining basin opens at Melville Gap into the Upper Johnson Valley that hosts Melville Lake. Faults of the eastern California shear zone trend northwest to southeast through Johnson Valley; the Lenwood Fault bounds the west side of the valley, and the Johnson Valley Fault bounds the east side of the valley (Bryant, 2005). Along the northern margin of the Big Horn and San Bernardino Mountains, the west to east trending North Frontal Fault bounds the south side of Johnson Valley (Bryant, 2005). The margin of the San Bernardino Mountains follows this trend. In contrast, the mountains along the west and east margins of Johnson Valley have northwest to southeast orientation. They range in elevation from 1,232 m in the Fry Mountains to the west to 1,098 m at Means Peak in the east.

During Quaternary time Johnson Valley has functioned as an alluvial basin, receiving water-borne sediment from the San Bernardino Mountains to the south and the Fry Mountains to the north. Alluvial deposits of Pleistocene age are found bordering these mountain ranges and are typically tilted, folded, and dissected due to deformation resulting from active faulting throughout the Quaternary Period. Holocene age alluvial fans and alluvial washes mimic the Pleistocene flow regime and locally cover, or are inset into Pleistocene deposits. Holocene alluvial fan and alluvial wash deposits are comprised of poorly consolidated sand and gravel with subordinate amounts of silt and clay. These deposits merge onto the valley floor from north and south, locally aggrading on the distal piedmont plain and the basin floor. Alluvial washes are incised into deposits within the central basin and drain east through Melville Gap into Upper Johnson Valley, terminating at Melville Lake. The principal watersheds that contribute water and sediment to Johnson Valley are Arrastre and Rattlesnake canyons. Both drain the north flank of the San Bernardino Mountains. Arrastre Canyon is roughly 79.5 km^2 in area, with a maximum elevation of 2,883 m and a mean annual rainfall of 510.5 mm (USGS, 2012). Rattlesnake Canyon is roughly 94.8 km^2 in area, with a maximum elevation of 2,647 m and a mean annual rainfall of 373.4 mm (USGS, 2012). Numerous smaller drainages issue from the San Bernardino Mountains as well as isolated mountains that bound the valley.

Interpretation and Description of Map Units

CGS focused preliminary mapping efforts on the identification of late Pleistocene to Holocene age eolian deposits. Mapping included the identification of features related to primary geomorphic processes (e.g. alluvial fan), followed by interpretation of those deposits related to secondary processes (e.g. eolian sand sheets superimposed on alluvium). CGS made field observations and collected data in November and December 2013, as well as February 2014. These observations included identification of soil texture and pedogenic development, as well as descriptions of surface cover, including the presence of gravel lag, desert pavement, or the accumulation of freshly deposited eolian sands. Based on field observations, Quaternary alluvial deposits exhibiting soil development and/or having a gravel lag, were not retained as map units. These are Pleistocene to mid Holocene age deposits that have been isolated from deposition for thousands of years. Eolian transport may occur across these surfaces, but thick, laterally continuous deposition of eolian sand is of low potential.

The collection of site-specific wind data was not a part of the project scope, however, CGS used several lines of evidence to identify eolian transport directions in Johnson Valley. To provide a regional perspective, CGS reviewed hourly wind data from a weather station to the west in Adelanto, and to the east in Twentynine Palms. Using a minimum of 20 years of hourly data, the principal drift directions at these two locations are 50° and 83° aziumuth, respectively. Additionally, CGS evaluated the distance and direction of dune crests between 1989 and 2013 for several parabolic dunes in Johnson Valley. These data suggest an average drift direction of 104° azimuth and an average drift distance over the period of 189 m, or 7.9 m/yr in the central dune field of Johnson Valley. The dune crest migration data also closely match the direction of surface lineations (ventifacts) developed in volcanic rock outcrops near Soggy Lake, having an average azimuth of 103°. CGS considers these local data to be a better indicator of transport direction than the regional data because they are likely due to effects of local topographic conditions on wind patterns. Along this drift direction, active sand sheets extend, but are discontinuous, from the south margin of Soggy Lake, over the bedrock ridge south of Soggy Lake, to the primary dune field of Johnson Valley. In the active zone of sand transport, strong interactions occur between alluvial fan and alluvial wash systems with active sand sheet distribution. Areas of active distributary flow (and sheet flow) appear to form the most prominent sources of eolian sand. As observed in sequence aerial photography, strong geomorphic connections are expressed between the principal local eolian sediment sources (Arrastre and Rattlesnake Canyons) and active sand sheet distribution, as sand sheets appear downwind (east) of the active alluvial washes (Qw) and alluvial fans (Qyf) on the medial and distal piedmont. The following description of map units summarize CGS observations.

Active Eolian Deposits

Qe/Qal Active windblown deposits consisting primarily of sand sheets superimposed on alluvial deposits typically < 1.5 m in thickness. Sand is predominantly fine- to medium- grained and having mean grain size ranging from 0.18 to 1.12 mm. Dry color is typically very pale brown 10YR 8/2 to 10YR 7/3. As mapped, these deposits have no appreciable dune form, but may locally accumulate as coppice dunes around *Larrea Tridentata* (Creasote Bush).

Qe Active windblown deposits consisting of dunes and sand sheets typically greater than > 1.5 m in thickness. Sand is predominantly fine- to medium- grained. Particle size distribution testing indicates dunes in the central Johnson Valley dune field have a mean grain size ranging from 0.17 to 0.46 mm. Dunes include parabolic and barchanoid forms of the central dune field, as well as coppice dune and amorphous sand hummocks. Dry soil color is typically very pale brown 10YR 8/2 to 10YR 7/3.

Active Eolian Sources

Qw 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 unobscurred by eolian processes). No soil profile development. Based on particle size distribution testing, the median grain size of this map unit ranges from 0.5 to 1.6 mm.

Qyf Young alluvial fan deposits. Unconsolidated to slightly consolidated sand and gravel, poorly to moderately sorted, fine - to coarse-grained; gravel includes pebbles, cobbles, and boulders. Surfaces exhibits bar and swale morphology, locally obscured by eolian deposition and are traversed by active alluvial washes (Qw). Dry soil color is 10YR 5/4.

Qye Windblown deposits consisting primarily of sand sheets and eroded dunes. Sand is predominantly fine- to medium- grained. Dry soil color is very pale brown 10YR 7/3. As observed, these deposits have pedogenic soil development consisting of carbonate filaments and coatings on pebble clasts, carbonate morphology is Stage I to I+. These deposits are widespread throughout the Johnson Valley area, however, they are retained on this map only where observations suggest active wind erosion and entrainment.

Ql Lacustrine deposits of Holocene and Pleistocene age. Moderately consolidated silt, very fine sand and clay. Dry soil color is pale brown 10YR 6/3. In the map area, these deposits are present at Soggy Lake, Melville Lake, and as inter-dune lacustrine deposits within the Johnson Valley Dune Field.

Other Map Units

Qal Alluvial deposits of Holocene and Pleistocene age (undifferentiated). This map unit is comprised of alluvial fan, alluvial valley, and alluvial terrace, pediment veneers, relict eolian and sediment-gravity deposits.

br Bedrock (undifferentiated). This map unit is comprised of a variety of Paleozoic sedimentary, Mesozoic granitic, and Tertiary volcanic and sedimentary rocks.

D Areas within active sand transport/deposition resulting from anthropogenic modification of the land surface. In the map area, these include farms and residences larger than 10 acres.

Contact between map units, approximately located. May be gradational where local variations in map unit thickness exist.

Quaternary faults compiled by Bryant (2005)

Predominant transport direction. Inferred from geomorphic interpretation of dune crest migration, sand sheets and streaks, and ventifacts. Active sand transport occurs between mapped source and active eolian deposits.

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