| DOCKETED | |
|---|---|
| **Docket Number:** | 26-OPT-01 |
| **Project Title:** | Vaca Dixon Power Center Project |
| **TN #:** | 270273 |
| **Document Title:** | Appendix DR PALEO References |
| **Description:** | Appendix to Data Request Response Set #1 |
| **Filer:** | Adam Morrison |
| **Organization:** | Rincon Consultants, Inc. |
| **Submitter Role:** | Applicant Consultant |
| **Submission Date:** | 5/27/2026 9:13:16 AM |
| **Docketed Date:** | 5/27/2026 |

# Appendix DR PALEO

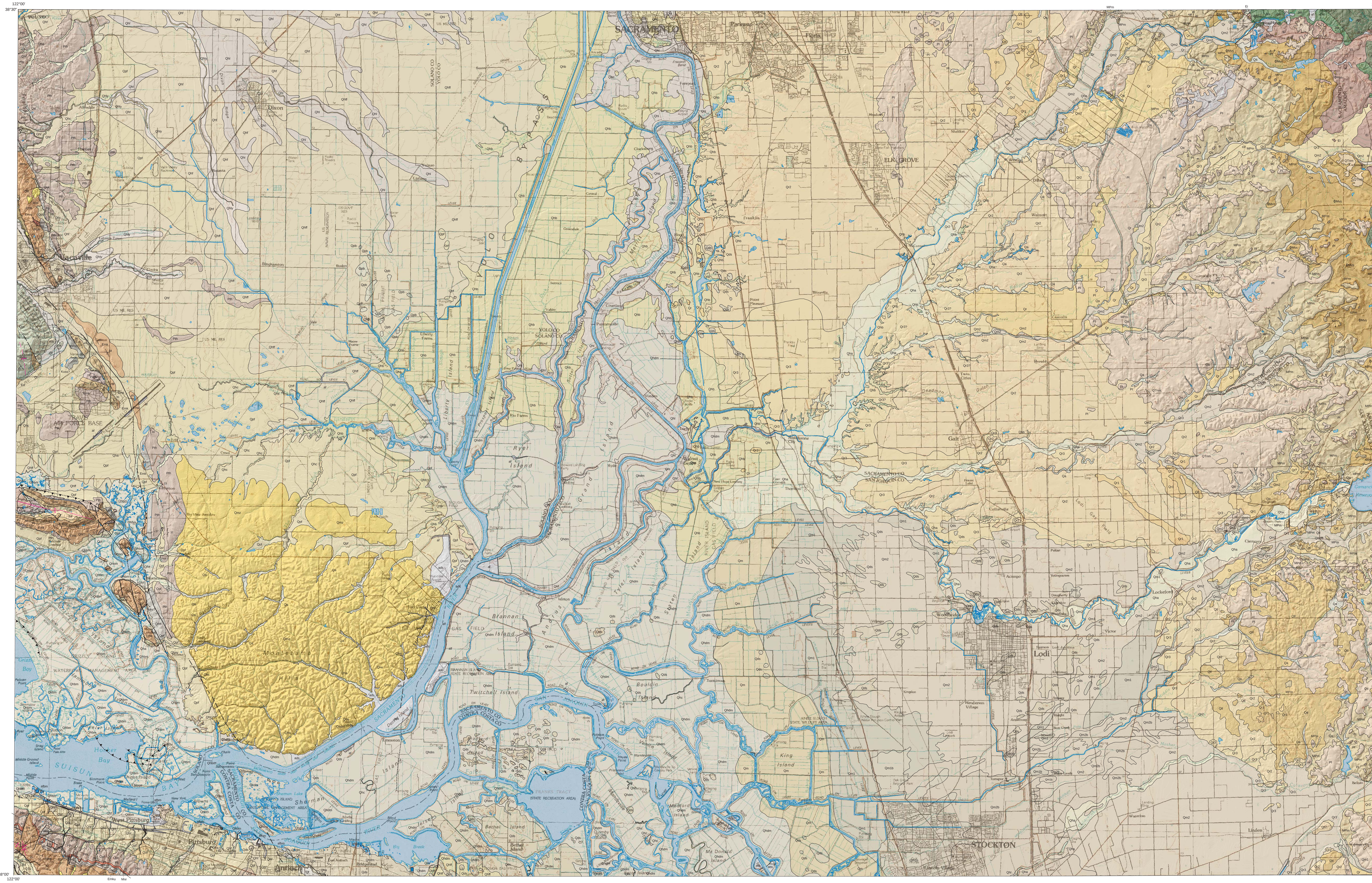
References

Preliminary Geologic Map available from:
http://www.conservation.ca.gov/cgs/rghm/rgm/preliminary_geologic_maps.htm

CALIFORNIA GEOLOGICAL SURVEY
JOHN G. PARRISH, Ph.D., STATE GEOLOGIST

STATE OF CALIFORNIA - ARNOLD SCHWARZENEGGER, GOVERNOR
THE NATURAL RESOURCES AGENCY - MIKE CHRISMAN, SECRETARY FOR NATURAL RESOURCES
DEPARTMENT OF CONSERVATION - BRIDGETT LUTHER, DIRECTOR

LODI 30' X 60' QUADRANGLE




Base Map
Topographic base from U.S.G.S. Lodi 30' x 60' quadrangle. Shaded relief base from U.S.G.S. digital elevation model. Projection is UTM, zone 10, North American Datum 1927

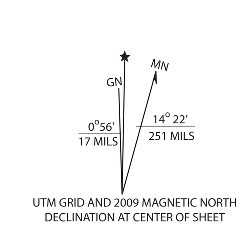
This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program, Statemap Award no. 08HQAG0102

# PRELIMINARY GEOLOGIC MAP OF THE LODI 30' x 60' QUADRANGLE, CALIFORNIA

Compiled by

Timothy E. Dawson

2009




SCALE 1:100,000

2 0 2 4 6 Miles

2 0 2 4 6 Kilometers

Contour Interval: 20 meters

## ABBREVIATED EXPLANATION

Approximate stratigraphic relationships only

### Holocene

- af — Artificial fill
- afbm — Artificial fill placed over bay mud
- alf — Artificial levee fill
- ads — Dredge spoils
- ac — Artificial stream channel
- gq — Gravel quarry
- Qhc — Latest Holocene stream channel deposits
- Qhay — Latest Holocene alluvial deposits, undivided
- Qhly — Latest Holocene fan levee deposits
- Qhty — Latest Holocene stream terrace deposits
- Qhl — Holocene fan levee deposits
- Qhbm — Holocene estuarine deposits, (bay mud)
- Qhdm — Holocene Delta mud
- Qht — Holocene stream terrace deposits
- Qhb — Holocene basin deposits
- Qha — Holocene alluvium, undivided
- Qhf — Holocene alluvial fan deposits
- Qhff — Holocene alluvial fan deposits, fine-grained
- Qa — Alluvium, undivided
- Qds — Dune sand
- Qf — Alluvial fan deposits
- Qt — Stream terrace deposits
- Qls — Landslide deposits

### Pleistocene

Modesto Formation

Qm | Qm2 | Qm2b | Qm1 | Qm1b

- Qm - Undivided
- $Qm_2$ - Upper member, undivided alluvium
- $Qm_{2b}$ - Upper member, fine-grained
- $Qm_1$ - Lower member, undivided alluvium
- $Qm_{1b}$ - Lower member, fine-grained

- Qoa — Alluvium, undivided (older)
- Qpb — Latest Pleistocene basin deposits
- Qpf — Alluvial fan deposits
- Qop — Pediment deposits

Riverbank Formation

Qr | Qr3 | Qr2 | Qr1

- Qr - Undivided
- $Qr_3$ - Upper unit
- $Qr_2$ - Middle unit
- $Qr_1$ - Lower unit

- Qof — Early to Middle Pleistocene alluvial fan deposits
- Qmz — Montezuma Formation
- Qtl — Turlock Lake Formation
- QTu — Pittsburgh Assemblage
- QTnm — North Merced Gravels

### Pliocene

- Pl — Laguna Formation
- Pth — Tehama Formation
- Plt — Lawlor Tuff
- MPm — Mehrten Formation

### Miocene

- Mnr — Neroly Sandstone
- Mc — Cierbo Sandstone
- Mpb — Putnam Peak Basalt

### Oligocene

- ΦMvs — Valley Springs Formation

### Eocene

- Ei — Ione Formation

Markley Formation

Emk | Emku | Emkl

- Emk - Undivided
- Emku - Upper member
- Emkl - Lower member

Nortonville Formation

Env | Envu

- Env - Undivided
- Envu - Upper member

- Ed — Domengine Formation
- Esh — Unnamed shale

### Paleocene

- Ꝑpu — Shale and sandstone
- Ꝑmz — Martinez Formation

### Cretaceous

Great Valley Sequence

- Ksh — Great Valley Sequence, siliceous shale
- Kfo — Forbes Formation
- Kg — Guinda Formation
- Kuhs — Great Valley Sequence, unnamed sandstone and shale
- Kuss — Great Valley Sequence, sandstone

### Jurassic

- Jss — Salt Springs Slate
- Jgo — Gopher Ridge Volcanics

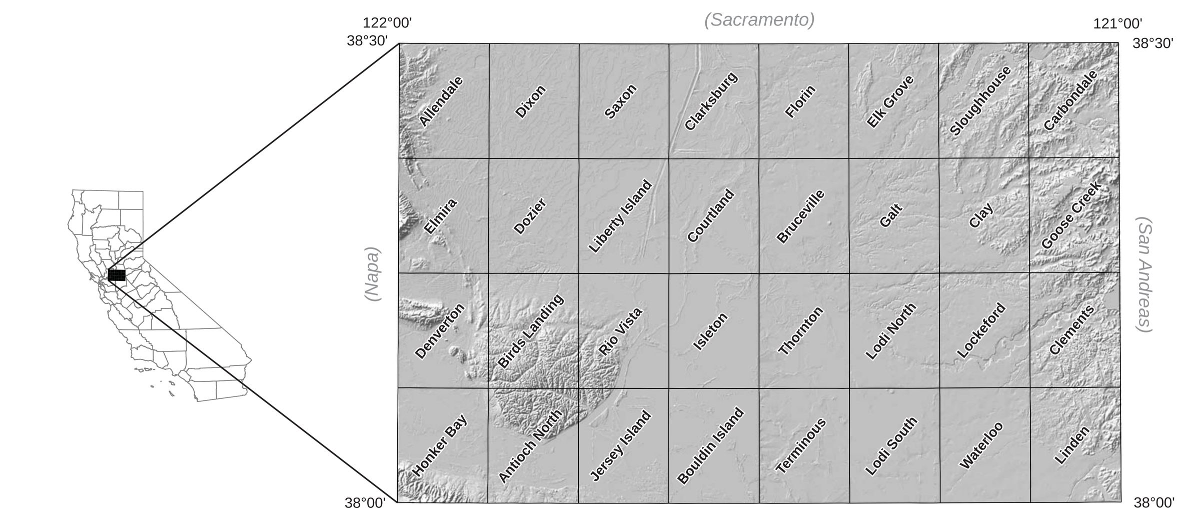
## MAP SYMBOLS

- Contact - Contact between map units; dotted where where concealed; queried where uncertain.
- Fault - Solid where accurately located; dashed where approximately located; short dash where inferred; dotted where concealed; queried where uncertain.
- Thrust Fault - Solid where accurately located; dashed where approximately located; short dash where inferred; dotted where concealed; queried where uncertain. Barb located on upthrown block.
- Synclinal axis - Solid where accurately located; dashed where approximately located; dotted where concealed.
- Anticlinal axis - Solid where accurately located, dashed where approximately located; dotted where concealed.

Strike and dip of sedimentary beds:

- 25 Inclined bedding
- 25 Overturned bedding

Note: Due to the scale of the map, many small artificial fills and levees are not shown. These are included in the digital database as a separate feature class.




## ABBREVIATED INDEX TO GEOLOGIC SOURCE DATA

***(Primary compilaton sources shown in bold type)***

**Allendale Quadrangle**
**Graymer and others, 2002**; Helley and Harwood, 1985; **Knudsen and others, 2000**.

**Antioch North Quadrangle**
**Atwater, 1982**; Bryant, 2005; Graymer and others, 2002; **Knudsen and others, 2000**.

**Birds Landing Quadrangle**
Graymer and others, 2002; **Knudsen and others, 2000**.

**Bouldin Island Quadrangle**
**Atwater, 1982**; Graymer and others, 2002; **Knudsen and others, 2000**.

**Bruceville Quadrangle**
**Atwater, 1982**; Helley and Harwood, 1985.

**Carbondale Quadrangle**
Clarke, 1964; **Bartow and Marchand, 1979**.

**Clarksburg Quadrangle**
**Atwater, 1982**; Helley and Harwood, 1985.

**Clay Quadrangle**
**Bartow and Marchand, 1979**.

**Clements Quadrangle**
**Marchand and Bartow, 1979**.

**Courtland Quadrangle**
**Atwater, 1982**; Helley and Harwood, 1985; Knudsen and others, 2000.

**Denverton Quadrangle**
Bryant, 2005; **Graymer and others, 2002**; Knudsen and others, 2000; **Witter and others, 2006.**

**Dixon Quadrangle**
Helley and Harwood, 1985; **Knudsen and others, 2000.**

**Dozier Quadrangle**
Helley and Harwood, 1985; **Knudsen and others, 2000.**

**Elk Grove Quadrangle**
**Atwater and Marchand, 1980**.

**Elmira Quadrangle**
Bryant, 2005; **Graymer and others, 2002**; Knudsen and others, 2000; **Witter and others, 2006.**

**Florin Quadrangle**
**Atwater, 1982**.

**Galt Quadrangle**
**Atwater and Marchand, 1980**.

**Goose Creek Quadrangle**
Bartow and Marchand, 1979.

**Honker Bay Quadrangle**
**Graymer and others, 2002**; Knudsen and others, 2000; **Witter and others, 2006**.

**Isleton Quadrangle**
**Atwater, 1982**; **Graymer and others, 2002**; Knudsen and others, 2000.

**Jersey Island Quadrangle**
**Atwater, 1982**; Bryant, 2005; **Graymer and others, 2002**; Knudsen and others, 2000.

**Liberty Island Quadrangle**
**Atwater, 1982**; Helley and Harwood, 1985; **Knudsen and others, 2000**.

**Linden Quadrangle**
**Marchand and Bartow, 1979**; Cosby and Carpenter, 1937.

**Lockeford Quadrangle**
**Marchand and Bartow, 1979**.

**Lodi North Quadrangle**
**Marchand and Atwater, 1979**.

**Lodi South Quadrangle**
Atwater, 1982; **Marchand and Atwater, 1979**; Cosby and Carpenter, 1937.

**Rio Vista Quadrangle**
**Atwater, 1982**; Bryant, 2005; Graymer and others, 2002; **Knudsen and others, 2000**.

**Saxon Quadrangle**
Helley and Harwood, 1985; **Knudsen and others, 2000**.

**Sloughhouse Quadrangle**
**Bartow and Marchand, 1980**.

**Terminous Quadrangle**
**Atwater, 1982**; **Marchand and Atwater, 1979**.

**Thornton Quadrangle**
**Atwater, 1982**; **Marchand and Atwater, 1979**.

**Waterloo Quadrangle**
**Marchand and Bartow, 1979**.



Revised: 9/28/2009

# Preliminary Geologic Map of the Lodi 30'x 60' Quadrangle, California

Compiled by
Timothy Dawson

2009

**CALIFORNIA GEOLOGICAL SURVEY**
**JOHN G. PARRISH, Ph.D.**
**STATE GEOLOGIST**

## INTRODUCTION

The *Preliminary Geologic Map of the Lodi 30'x60' Quadrangle, California* was compiled from existing geologic mapping covering the area between 38° and 38°30' N. latitude and 121° and 122° W. longitude. This map was prepared by the Department of Conservation, California Geological Survey (CGS) and was supported in part by the U.S. Geological Survey (USGS) STATEMAP award No. 08HQAG0102. The map is a compilation of existing geologic mapping from a number of sources (see index map on map sheet and references). Where available, existing digital data was used in this compilation, as shown on Figure 1. For areas where digital data was not available, contacts and geologic features were digitized in ArcGIS 9.3 by CGS from scanned geologic maps obtained from the USGS Publications Warehouse (http://pubs.er.usgs.gov).

Because much of the available digital data were compiled at a larger scale (1:24,000), numerous small artificial fills and artificial levees are too small to be shown on the map. However, these have been preserved in the digital database as a separate feature class. Along the eastern half of the map, artificial levees were not mapped on the original source map. For consistency across the map, these artificial levees and larger fills have been digitized by CGS as shown on 1:24,000-scale USGS topographic base maps and are included in the digital database.

## BASE MATERIAL

The base materials used for the geologic map of the Lodi 30'x 60' quadrangle consists of a shaded-relief and a topographic map image. The topographic base map is taken from the USGS digital raster graphic (DRG) of the Lodi 1:100,000-scale quadrangle available from the California Spatial Information Library (CaSIL) (http://www.atlas.ca.gov/). The shaded-relief image originates from a hillshade image based on the National Elevation Dataset (NED) at 30 meter resolution. Hydrography shown on the map is taken from the digital source data and supplemented with USGS National Hydrography Data (NHD) for areas that were digitized for this compilation.

## DESCRIPTION OF MAP UNITS

af **Artificial fill (Historic)** - May be engineered and/or non-engineered. Locally includes artificial dam fill and tailings associated with dredge mining.

afbm **Artificial fill placed over bay mud (Historic)** - May be engineered and/or non-engineered.

alf **Artificial levee fill (Historic)** - May be engineered and/or non-engineered.

ads **Artificial dredge fill (Historic)** - Fill located adjacent to channels dredged for navigation.

ac **Artificial stream channel (Historic) –** Modified stream channels including straighten channels, flood control channels, and concrete canals.

gq **Gravel quarry (Historic) –** Excavations, spoil piles, and disturbed ground in areas being used for the extraction of sand and gravel.

Qhc **Stream channel deposits (late Holocene to modern <150 years) -** Deposits in active, natural stream channels. Consists of loose alluvial sand, gravel, and silt.

Qhay **Alluvial deposits, undivided (latest Holocene, <1,000 years)** - Fluvial sediment deposited on the modern flood plain.

Qhly **Alluvial fan levee deposits (latest Holocene, <~1,000 years)** - Natural levee deposits of latest Holocene alluvial fans.

Qhty **Stream terrace deposits (latest Holocene, <1,000 years)** - Stream terraces are deposited as point bar and overbank deposits. Composed of moderately sorted clayey sand and sandy clay with gravel.

Qhl **Fan levee deposits (Holocene) –** Natural levees deposited as long, low ridges oriented down fan. The deposits contain coarser material than the adjoining interlevee areas.

Qhbm **Bay mud (Holocene)** - Estuarine silt, clay, peat, and fine sand deposited at or near sea level in the San Francisco Bay estuary.

Qhdm **Delta Mud (Holocene)** – Sediment deposited at, or near sea level in tidal marshes of the Sacramento – San Joaquin delta

Qht **Stream terrace deposits (Holocene) -** Sediment deposited in point-bar and overbank settings. Includes sand, gravel, silt, and minor clay. Moderately to well sorted and bedded.

Qhb **Basin deposits (Holocene) –** Fine grained sediments of late Holocene age with horizontal stratification deposited in topographic lows.

Qha **Alluvium, undivided (Holocene)** - Alluvium deposited on fans, terraces, or in basins. Sand, gravel, and silt that are poorly to moderately sorted. Mapped where separate types of alluvial deposits are not delineated.

Qhf **Alluvial fan deposits (Holocene)** - Alluvial fan sediment deposited by streams emanating from the mountains as debris flows, hyper-concentrated mudflows, or braided stream flows. Sediments include sand, gravel, silt and clay, that are moderately to poorly sorted, and moderately to poorly bedded; Qhff - fine-grained facies.

Qa **Alluvium, undivided (latest Pleistocene to Holocene)** - Undivided alluvium consisting of flat, relatively undissected fan, terrace, basin deposits, and small active streams.

Qds **Dune sand (latest Pleistocene to Holocene)** - Very well-sorted fine- to medium-grained eolian sand.

Qf **Alluvial fan deposits (latest Pleistocene to Holocene)** - Sand, gravel, silt, and clay mapped on gently sloping, fan-shaped, relatively undissected alluvial surfaces. Moderately to poorly sorted, and poorly to moderately bedded.

Qt **Stream terrace deposits (latest Pleistocene to Holocene) –** Sand, gravel, silt, minor clay on relatively flat surfaces. Moderately to well sorted, and moderately to well bedded.

Qls **Landslides (Pleistocene to Holocene)** - Large, complex slides consisting of chaotic deposits of sand, silt, clay, boulders, and blocks of bedrock. Only the largest landslides included by Graymer and others (2002) are shown.

Qpb **Basin deposits (Late Pleistocene) -** Older alluvium exposed at the toe of the Putah Creek fan. Commonly in basins between deposits of younger alluvium.

Qpf **Alluvial fan deposits (latest Pleistocene) –** Sand, gravel, silt, and clay that is moderately to poorly sorted and bedded. Similar to Holocene fans (Qhf), but they are more dissected.

Qm **Modesto Formation (Late Pleistocene)** – Arkosic alluvium, sand with minor gravel and silt, forming low terraces, high floodplains, and alluvial fans along the Consumnes and Mokelumne Rivers. Qm2 – Upper member, undivided alluvium; Qm2b – Upper member, fine-grained, alluvium of flood basins, lower fans, and interdistributary fan areas; Qm1 – Lower member, undivided alluvium; Qm1b – Lower member, fine-grained, alluvium of flood basins, lower fans, and interdistributary fan areas

Qr **Riverbank Formation (Middle to Late Pleistocene) -** Arkosic alluvium, sand with and silt, forming terraces, and alluvial fans along the Consumnes and Mokelumne Rivers. Qr3 – Upper unit; Qr2 – Middle unit; Qr1 – Lower unit.

Qoa **Alluvial deposits, undivided (early to late Pleistocene)** - Alluvial fan, stream terrace, basin, and channel deposits. Topography is gently rolling with little or no original alluvial surfaces preserved; moderately to deeply dissected.

Qof **Alluvial fan deposits (early to late Pleistocene)** - Sand, gravel, silt, and clay, deeply dissected. Topography is moderately rolling with little or no original alluvial surfaces preserved.

Qmz **Montezuma Formation (early Pleistocene) -** Orange-weathering, soft, brown, poorly sorted quartz-lithic sand, silt, and pebble gravel. Pebbles include red chert and volcanics

Qtl **Turlock Lake Formation (Pleistocene) –** Arkosic alluvium, sand with some silt and minor gravel.

QTu **Sandstone, siltstone, and gravel (late Pliocene and early Pleistocene) –** Semi-consolidated to unconsolidated poorly sorted gravel, sand, silt and clay.

QTnm **North Merced gravels (Pliocene and early Pleistocene) –** Thin, locally-derived pediment gravel, caps older Tertiary deposits.

Pl **Laguna Formation (Pliocene) –** Cobble gravel, sand, and minor silt of mixed metamorphic, granitic, and volcanic source.

Pth **Tehama Formation (Pliocene) –** Poorly consolidated, nonmarine, gray to maroon siltstone, quartz arenite sandstone, tuff, and pebble to cobble conglomerate.

Plt **Lawlor Tuff (Pliocene)** - Nonmarine, pumiceous, andesitic ash-flow tuff. Ar/Ar age of 4.83 ± 0.04 Ma.

MPm **Mehrten Formation (Miocene and early Pliocene) –** Mudstone, claystone, siltstone, and minor sandstone and conglomerate derived from andesitic volcanic source areas near the crest of the Sierra Nevada.

Mnr **Neroly Sandstone (late Miocene) –** Blue-gray, fine to coarse-grained lithic sandstone.

Mc **Cierbo Sandstone (late Miocene) –** Light-gray, light-blue, and black, massive to bedded quartz-mica-lithic arenite, conglomerate, siltstone, and tuff.

Mpb **Putnam Peak Basalt (Miocene) -** Olivene basalt flow. Correlated to the Lovejoy Basalt of the Sierra Nevada foothills.

OMvs **Valley Springs Formation (Oligocene to Miocene) –** Rhyolitic sandstone and interbedded tuffs.

Ei **Ione Formation (Eocene) –** Light-colored conglomerate, sandstone, and claystone.

Emk **Markley Sandstone (Eocene) –** Yellow- and tan-weathering, white to light-gray quartz-muscovite and quartz lithic sandstone and siltstone. Emku – Upper member, brownish, gray shale with thin sandstone beds. Emkl – Lower member, brownish gray silty shale.

Env **Nortonville Shale (Eocene)** - Gray-weathering, brown shale. Also contains thin beds of fine-grained, quartz-lithic, glauconitic sandstone. Envu – Upper member, Brownish-gray shale with thin sandstone beds.

Ed **Domengine Sandstone (Eocene) -** Light colored, fine- to coarse-grained quartzose sandstone. Locally includes conglomerate with pebbles of quartz, chert, and andesite, as well as thin beds of shale.

Esh **Shale (Eocene) –** Brown, thin-bedded and laminated, foraminiferal shale and mudstone.

Ꝑpu **Sandstone and shale (Paleocene) –** Brown, glauconitic, mica-lithic wacke and gritstone; gray, fine-grained quartz-biotite-lithic wacke; gray foraminferal shale and mudstone.

Ꝑmz **Martinez Formation (Paleocene) -** Light-brown and light-gray fine-grained micaceous sandstone and mudstone.

Ksh **Great Valley Complex (Late Cretaceous) –** Siliceous shale containing radiolarians and foraminifers of Late Cretaceous age.

Kfo **Forbes Formation (Late Cretaceous) –** Thick beds of massive, fine- to coarse-grained biotite-feldspar-lithic wacke grading up into interbedded siltstone and shale.

Kg **Guinda Formation (Late Cretaceous) –** Thick-bedded to massive, coarse to fine-grained, biotite-quartz-feldspar-lithic wacke.

Kuhs **Great Valley Complex (Late Cretaceous) –** Sandstone and shale. Kuss – Sandstone.

Jss **Salt Springs Slate –** Dark gray slate with some mica schist.

Jgo **Gopher Hill Volcanics –** Metamorphosed mafic to felsic pyroclastic rocks.

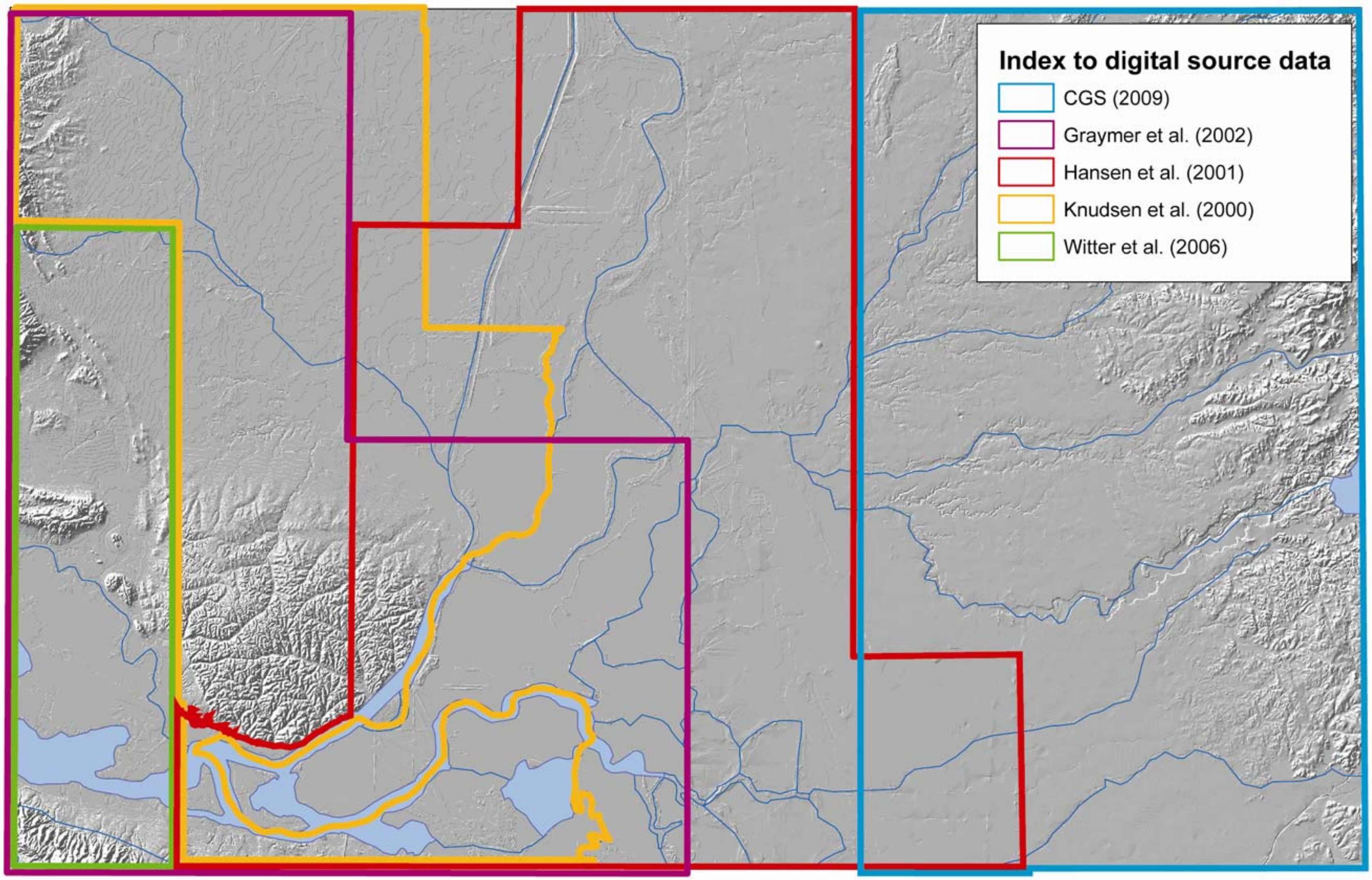



Figure 1. Sources of digital data used in this compilation.

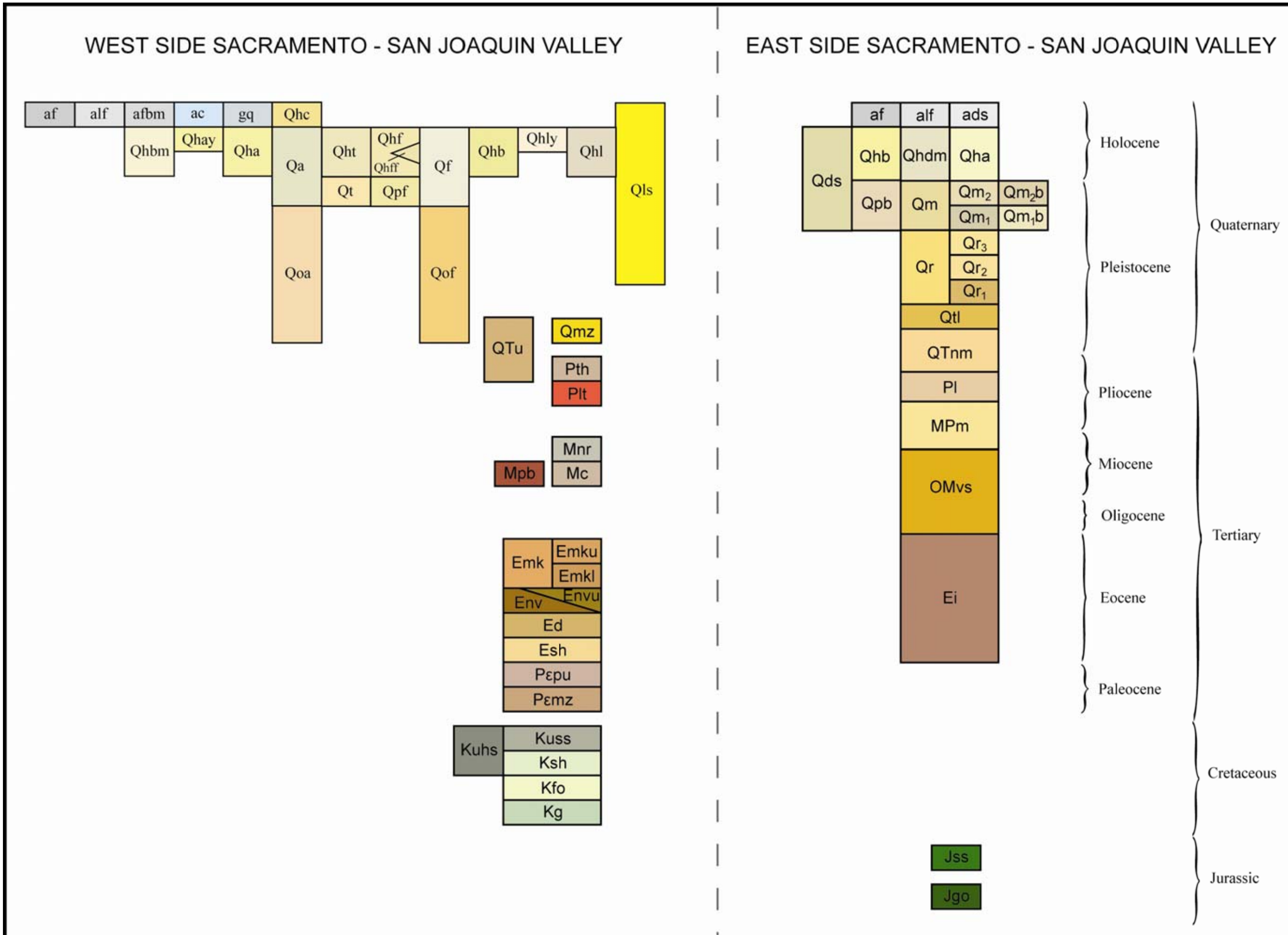



Figure 2. Correlation of map units for the Lodi 30' x 60' quadrangle.

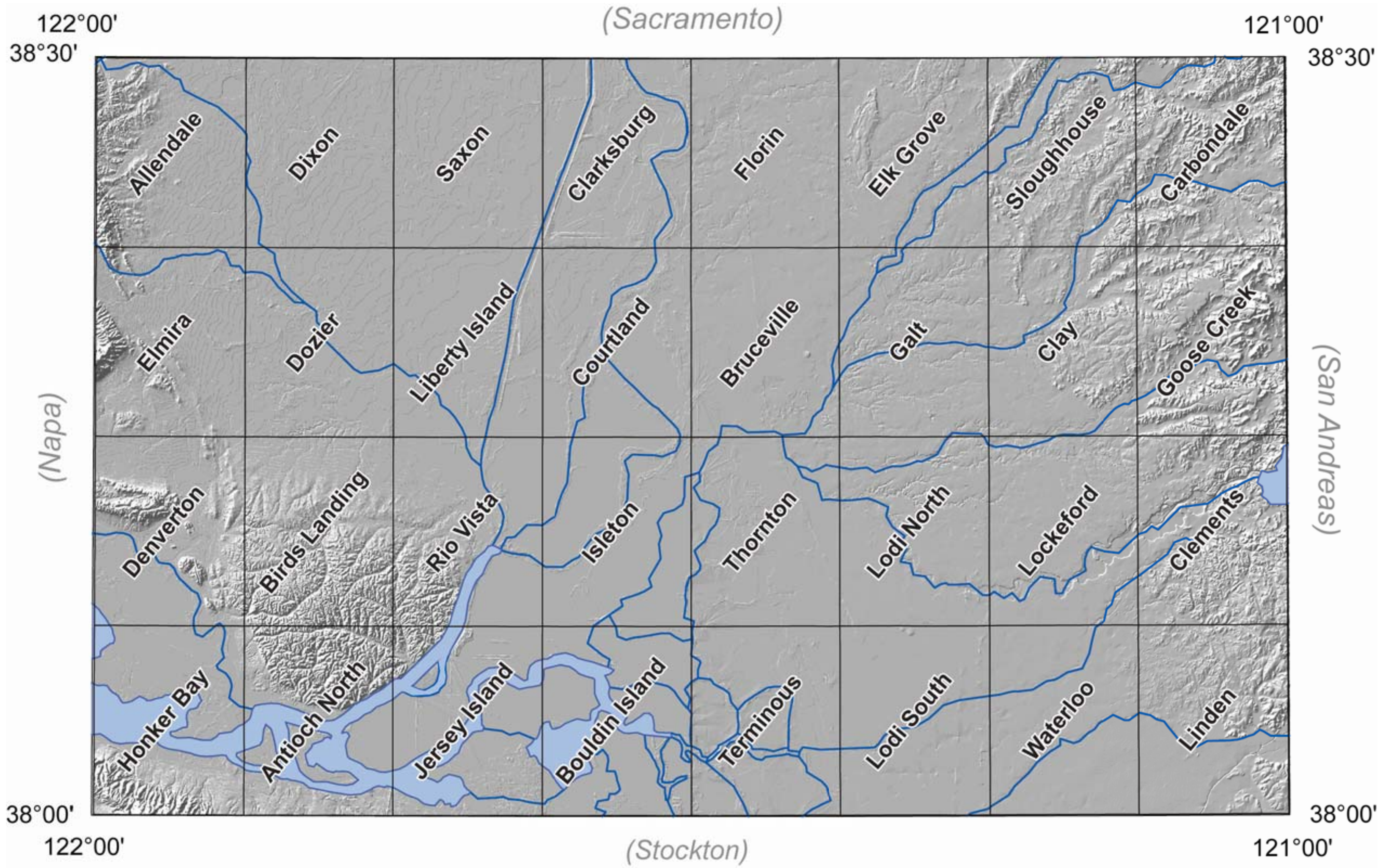



Figure 3. Index to 7.5-minute quadrangles in the Lodi 30' x 60' quadrangle.

Sources of mapping of the Lodi 30' x 60' quadrangle. For complete citation see the reference section following this list.

**Allendale**
Graymer, R.W., Jones, D.L. and Brabb, E.E., 2002; Helley, E.J. and Harwood, D.S., 1985; Knudsen, K.L., Sowers, J.M., Witter, R.C., Wentworth, C.M. and Helley, E.J., 2000.

**Antioch North**
Atwater, B.F., 1982; Bryant, W.A. (compiler), 2005; Graymer, R.W., Jones, D.L. and Brabb, E.E., 2002; Knudsen, K.L., Sowers, J.M., Witter, R.C., Wentworth, C.M. and Helley, E.J., 2000.

**Birds Landing**
Graymer, R.W., Jones, D.L. and Brabb, E.E., 2002; Helley, E.J. and Harwood, D.S., 1985; Knudsen, K.L., Sowers, J.M., Witter, R.C., Wentworth, C.M. and Helley, E.J., 2000.

**Bouldin Island**
Atwater, B.F., 1982; Graymer, R.W., Jones, D.L. and Brabb, E.E., 2002; Helley, E.J. and Harwood, D.S., 1985; Knudsen, K.L., Sowers, J.M., Witter, R.C., Wentworth, C.M. and Helley, E.J., 2000.

**Bruceville**
Atwater, B.F., 1982; Helley, E.J. and Harwood, D.S., 1985.

**Carbondale**
Clark, L.D., 1964; Bartow, J.A. and Marchand, D.E., 1979.

**Clarksburg**
Atwater, B.F., 1982; Helley, E.J. and Harwood, D.S., 1985.

**Clay**
Bartow, J.A. and Marchand, D.E., 1979.

**Clements**
Marchand, D.E. and Bartow, J. A., 1979.

**Courtland**
Atwater, B.F., 1982; Helley, E.J. and Harwood, D.S., 1985; Knudsen, K.L., Sowers, J.M., Witter, R.C., Wentworth, C.M. and Helley, E.J., 2000.

**Denverton**
Bryant, W.A. (compiler), 2005; Graymer, R.W., Jones, D.L. and Brabb, E.E., 2002; Knudsen, K.L., Sowers, J.M., Witter, R.C., Wentworth, C.M. and Helley, E.J., 2000; Witter, R.C., Knudsen, K.L., Sowers, J.M., Wentworth, C.M., Koehler, R.D. and Randolph, C.E., 2006.

**Dixon**
Helley, E.J. and Harwood, D.S., 1985; Knudsen, K.L., Sowers, J.M., Witter, R.C., Wentworth, C.M. and Helley, E.J., 2000.

**Dozier**
Helley, E.J. and Harwood, D.S., 1985; Knudsen, K.L., Sowers, J.M., Witter, R.C., Wentworth, C.M. and Helley, E.J., 2000.

**Elk Grove**
Atwater, B.F. and Marchand, D.E., 1980.

**Elmira**
Bryant, W.A. (compiler), 2005; Graymer, R.W., Jones, D.L. and Brabb, E.E., 2002; Knudsen, K.L., Sowers, J.M., Witter, R.C., Wentworth, C.M. and Helley, E.J., 2000; Witter, R.C., Knudsen, K.L., Sowers, J.M., Wentworth, C.M., Koehler, R.D. and Randolph, C.E., 2006.

**Florin**
Atwater, B.F., 1982.

**Galt**
Atwater, B.F. and Marchand, D.E., 1980.

**Goose Creek**
Bartow, J.A. and Marchand, D.E., 1979.

**Honker Bay**
Graymer, R.W., Jones, D.L. and Brabb, E.E., 2002; Knudsen, K.L., Sowers, J.M., Witter, R.C., Wentworth, C.M. and Helley, E.J., 2000; Witter, R.C., Knudsen, K.L., Sowers, J.M., Wentworth, C.M., Koehler, R.D. and Randolph, C.E., 2006.

**Isleton**
Atwater, B.F., 1982; Graymer, R.W., Jones, D.L. and Brabb, E.E., 2002; Knudsen, K.L., Sowers, J.M., Witter, R.C., Wentworth, C.M. and Helley, E.J., 2000.

**Jersey Island**
Atwater, B.F., 1982; Bryant, W.A. (compiler), 2005; Graymer, R.W., Jones, D.L. and Brabb, E.E., 2002; Knudsen, K.L., Sowers, J.M., Witter, R.C., Wentworth, C.M. and Helley, E.J., 2000.

**Liberty Island**
Atwater, B.F., 1982; Helley, E.J. and Harwood, D.S., 1985; Knudsen, K.L., Sowers, J.M., Witter, R.C., Wentworth, C.M. and Helley, E.J., 2000.

**Linden**
Marchand, D.E. and Bartow, J. A., 1979; Cosby and Carpenter, 1937.

**Lockeford**
Marchand, D.E. and Bartow, J. A., 1979.

**Lodi North**
Marchand, D.E. and Atwater, B.F., 1979.

**Lodi South**
Atwater, B.F., 1982; Marchand, D.E. and Atwater, B.F., 1979; Cosby and Carpenter, 1937.

**Rio Vista**
Atwater, B.F., 1982; Bryant, W.A. (compiler), 2005; Graymer, R.W., Jones, D.L. and Brabb, E.E., 2002; Knudsen, K.L., Sowers, J.M., Witter, R.C., Wentworth, C.M. and Helley, E.J., 2000.

**Saxon**
Helley, E.J. and Harwood, D.S., 1985; Knudsen, K.L., Sowers, J.M., Witter, R.C., Wentworth, C.M. and Helley, E.J., 2000.

**Sloughhouse**
Bartow, J.A. and Marchand, D.E., 1979.

**Terminous**
Atwater, B.F., 1982; Marchand, D.E. and Atwater, B.F., 1979.

**Thornton**
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# Standard Procedures for the Assessment and Mitigation of Adverse Impacts to Paleontological Resources

Society of Vertebrate Paleontology
Impact Mitigation Guidelines Revision Committee

**Abstract**
Fossils are nonrenewable paleontological resources that are subject to impacts from land development. Procedures are presented for evaluating the potential for impacts of a proposed action on paleontological resources and for mitigating those impacts. Impact mitigation includes pre-project survey and salvage, monitoring and screen washing during excavation to salvage fossils, conservation and inventory, and final reports and specimen curation. The objective of these procedures is to offer standard methods for assessing potential impacts to fossils and mitigating these impacts.

**Introduction**
Fossils are nonrenewable paleontological resources that are afforded protection by federal, state, and local environmental laws and regulations. The Paleontological Resources Preservation Act (PRPA) of 2009 calls for uniform policies and standards that apply to fossils on all federal public lands. All federal land management agencies are required to develop regulations that satisfy the stipulations of the PRPA. Section 6302 of the PRPA mandates that federal agencies "*shall manage and protect paleontological resources on Federal land using scientific principles and expertise.*" Thus, federal agencies need the help of the professional paleontological community in the formulation and implementation of these PRPA-mandated policies and regulations. The potential for destruction or degradation of paleontological resources on both public and private lands selected for development under the jurisdiction of various governmental planning agencies is recognized. The standard procedures below are intended to be applicable to both private and public lands under the jurisdiction of local, city, county, regional, state, and federal agencies. Protection of paleontological resources includes: (a) assessment of the potential for land to contain significant paleontological resources which could be directly or indirectly impacted, damaged, or destroyed by proposed development and (b) formulation and implementation of measures to mitigate these adverse impacts, including permanent preservation of the site and/or permanent preservation of salvaged fossils along with all contextual data in established institutions.

**Assessment of the Paleontological Potential of Rock Units**
Rock units are described as having (a) high, (b) undetermined, (c) low, or (d) no potential for containing significant paleontological resources.

**High Potential**
Rock units from which vertebrate or significant invertebrate, plant, or trace fossils have been recovered are considered to have a high potential for containing additional significant paleontological resources. Rocks units classified as having high potential for producing paleontological resources include, but are not limited to, sedimentary formations and some volcaniclastic formations (e. g., ashes or tephras), and some low-grade metamorphic rocks which contain significant paleontological resources anywhere within their geographical extent, and sedimentary rock units temporally or lithologically suitable for the preservation of fossils (e. g., middle Holocene and older, fine-grained fluvial sandstones, argillaceous

and carbonate-rich paleosols, cross-bedded point bar sandstones, fine-grained marine sandstones, etc.). Paleontological potential consists of both (a) the potential for yielding abundant or significant vertebrate fossils or for yielding a few significant fossils, large or small, vertebrate, invertebrate, plant, or trace fossils and (b) the importance of recovered evidence for new and significant taxonomic, phylogenetic, paleoecologic, taphonomic, biochronologic, or stratigraphic data. Rock units which contain potentially datable organic remains older than late Holocene, including deposits associated with animal nests or middens, and rock units which may contain new vertebrate deposits, traces, or trackways are also classified as having high potential.

**Undetermined Potential**
Rock units for which little information is available concerning their paleontological content, geologic age, and depositional environment are considered to have undetermined potential. Further study is necessary to determine if these rock units have high or low potential to contain significant paleontological resources. A field survey by a qualified professional paleontologist (see "definitions" section in this document) to specifically determine the paleontological resource potential of these rock units is required before a paleontological resource impact mitigation program can be developed. In cases where no subsurface data are available, paleontological potential can sometimes be determined by strategically located excavations into subsurface stratigraphy.

**Low Potential**
Reports in the paleontological literature or field surveys by a qualified professional paleontologist may allow determination that some rock units have low potential for yielding significant fossils. Such rock units will be poorly represented by fossil specimens in institutional collections, or based on general scientific consensus only preserve fossils in rare circumstances and the presence of fossils is the exception not the rule, e. g. basalt flows or Recent colluvium. Rock units with low potential typically will not require impact mitigation measures to protect fossils.

**No Potential**
Some rock units have no potential to contain significant paleontological resources, for instance high-grade metamorphic rocks (such as gneisses and schists) and plutonic igneous rocks (such as granites and diorites). Rock units with no potential require no protection nor impact mitigation measures relative to paleontological resources.

**Discussion**
It is extremely important to distinguish between archaeological and paleontological resources (see "definitions" section in this document) when discussing the paleontological potential of rock units. The boundaries of an archaeological resource site define the areal/geographic extent of an archaeological resource, which is generally independent from the rock unit on which it sits. However, paleontological sites indicate that the containing rock unit or formation is fossiliferous. Therefore, the limits of the entire rock unit, both areal and stratigraphic, define the extent of paleontological potential.

It is also important to ascertain if the paleontological resources are uniformly distributed throughout a rock unit or if they are confined as localized concentrations to specific members or facies. Using this information, paleontologists can develop maps which suggest areas that are likely to contain paleontological resources. These maps (Paleontological Resource Potential Maps) form the basis for preliminary planning decisions on which areas require a detailed paleontological resource impact assessment by a qualified professional paleontologist and which areas do not. Lead agency evaluation of a proposed project relative to such paleontological resource potential maps should trigger a "request for opinion" from a qualified professional paleontologist, state paleontological clearing house, or an accredited institution with an established paleontological repository housing paleontological resources from the region of interest.

The determination of the paleontological resource potential of an area proposed for development is first founded on a review of pertinent geological and paleontological literature, geological maps, and on records in fossil locality databases of paleontological specimens deposited in institutions (e. g., museums and universities). This preliminary review may clearly indicate that particular rock units have known high potential. If the paleontological resource potential of a rock unit cannot be delimited from the literature search and specimen records, a field survey by a qualified professional paleontologist will be necessary to determine the fossiliferous potential and the distribution or concentrations of fossils within the extent of the rock units present in a specific project area. The field survey may need to extend outside the defined project limits to areas where the relevant rock units are better exposed. If the rock units in an area are determined to have a high potential for containing paleontological resources, a program to mitigate impacts to fossil resources must be developed. In areas containing rock units with high potential, a preconstruction survey (intensive reconnaissance) may be necessary to locate surface concentrations of fossils which might require salvage in advance of excavations to avoid delays to construction schedules.

**Measures to Mitigate Adverse Impacts from Development**

Measures for adequate protection or salvage of significant paleontological resources are applied to areas determined to contain rock units that have either a high or undetermined potential for containing significant fossils. The Paleontological Resource Preservation Act of 2009 establishes a uniform code for decision-making on all federal lands. Specific mitigation measures generally need not be developed for areas of low paleontological potential. Developers (public and private) and contractors should be made aware, however, that if there is not an on-site monitor it will be necessary to contact a qualified professional paleontologist if fossils are unearthed in the course of excavation. This contingency should be planned for in advance. In order to save time and project delays, in the advance planning phases of a project the developer should contact a qualified professional paleontologist and arrange for the salvage of any unanticipated fossils. The paleontologist will then salvage the fossils and assess the necessity for further mitigation measures, if applicable. Decisions regarding the intensity of the paleontological resource impact mitigation program will be made by the project paleontologist on the basis of the significance of the paleontological resources, and their biostratigraphic, biochronologic, paleoecologic, taphonomic, and taxonomic attributes, not on the ability of a project proponent to fund the paleontological resource impact mitigation program.

In areas determined to have high or undetermined potential for significant paleontological resources, an adequate program for mitigating the impact of development must include:

1. an intensive field survey and surface salvage prior to earth moving, if applicable;
2. monitoring by a qualified paleontological resource monitor (see "definitions" section in this document) of excavations in previously undisturbed rock units;
3. salvage of unearthed fossil remains and/or traces (e. g., tracks, trails, burrows, etc.);
4. screen washing to recover small specimens, if applicable;

5. preparation of salvaged fossils to a point of being ready for curation (i. e., removal of enclosing matrix, stabilization and repair of specimens, and construction of reinforced support cradles where appropriate);

6. identification, cataloging, curation, and provision for repository storage of prepared fossil specimens; and

7. a final report of the finds and their significance.

All phases of mitigation must be supervised by a qualified professional paleontologist who maintains the necessary paleontological collecting permits and repository agreements. All field teams will be supervised by a paleontologist qualified to deal with the significant resources that might be encountered. The lead agency must assure compliance with the measures developed to mitigate impacts of excavation. To assure compliance at the start of the project, a statement that confirms the site's paleontological potential, confirms the repository agreement with an established public institution, and describes the program for impact mitigation, must be deposited with the lead agency and contractor(s) before any ground disturbance begins. In many cases, it will be necessary to conduct a salvage program prior to grading to prevent damage to known paleontological resources and to avoid delays to construction schedules. The impact mitigation program must include preparation, identification, cataloging, and curation of any salvaged specimens. All field notes, photographs, stratigraphic sections, and other data associated with the recovery of the specimens must be deposited with the institution receiving the specimens. Since it is not professionally acceptable to salvage specimens without preparation and curation of specimens and associated data, costs for this phase of the program must be included in the project budget. The mitigation program must be reviewed and accepted by the lead agency. If a mitigation program is initiated early during the course of project planning, construction delays due to paleontological salvage activities can be minimized or even completely avoided.

**Standard Procedures**

These standard procedures for paleontological resource impact assessment and mitigation are designed to apply to areas containing rock units with high, low, and undetermined paleontological resource potential.

**Assessment before Construction Starts**

An adequate preconstruction paleontological resource impact assessment is the key to developing an adequate paleontological resource impact mitigation program. Only a professional paleontologist is qualified to prepare a paleontological resource impact assessment. An adequate assessment of potential impacts typically includes all the following elements:

1. Literature Search—A review of the pertinent paleontological, geological, geotechnical, and environmental literature provides an information baseline for evaluating the extent of previous paleontological work in an area. Such a review also provides a fundamental basis for formulating mitigation plans and for understanding the significance of paleontological resources. The preconstruction assessment should also include examination of geotechnical reports, borehole logs, and geologic cross sections to address whether project excavations will impact rock units with high potential.

2. Records Search—A review of institutional localities and specimen records provides a means for determining the extent of previous fieldwork and fossil recovery in, and adjacent to, an area of interest. This task can be accomplished either by sending a written request for information to the relevant institution(s) or visiting the institution to review the records directly. A simple, on-line search of an institution's records is often incomplete and inadequate for determining the number and extent of known fossil localities in an area.

3. Consultation with Others—The preconstruction assessment should include consultation with geologists and paleontologists knowledgeable about the paleontological resource potential of rock units present in the vicinity of the proposed project.

4. Field Survey—The assessment should include a field survey by a qualified professional paleontologist and approved staff, as needed, to determine the paleontological potential of each rock unit, to re-examine any known fossil localities on or near the project, to search for unknown fossil localities, and to delimit the specific boundaries of rock units within the project area.

5. Reports—A paleontological resource impact assessment report and a project-specific paleontological resource impact mitigation program should be prepared based upon data gathered during the assessment.

6. Agency Confirmation—Prior to ground disturbance, the lead agency should review the paleontological resource impact assessment and proposed mitigation program to determine the adequacy of the proposed program.

7. Repository Agreement—The project paleontologist should have a repository agreement arranged prior to the start of earth-moving for the project.

8. Pre-excavation meetings—The project paleontologist should hold pre-excavation meetings with representatives of the lead agency, the developer or project proponent, and contractors to

explain the importance of fossils, the laws protecting fossils, the need for mitigation, the types of fossils that might be discovered during excavation work, and the procedures that should be followed if fossils are discovered. Defining the process of salvaging fossils will reduce project delays.

**Paleontological Resource Mitigation Plan**
Prior to any ground disturbance at the project site, a paleontological resource mitigation plan should be prepared by a qualified professional paleontologist, who then will implement the plan as the project paleontologist, program supervisor, and principal investigator. The paleontological resource mitigation plan establishes the ground rules for the entire paleontological resource mitigation program. Excavations at the project site may reveal conditions unanticipated when the paleontological resource mitigation plan was prepared. These conditions may require additional tasks not described in the previously prepared project impact mitigation plan. The project paleontologist should be the person who makes these project-specific modifications to the paleontological resource mitigation program in consultation with representatives of the lead agency and project proponent.

**Adequate Monitoring**
For excavations in rock units of known high potential, the project paleontologist or paleontological monitor will need to be present initially during 100% of the earth-moving activities. After 50% of excavations are complete in either an area or rock unit and no fossils of any kind have been discovered, the level of monitoring can be reduced or suspended entirely at the project paleontologist's discretion. For excavations in rock units with high or undetermined potential, it is never acceptable to have excavation monitoring done by construction workers, engineers, or persons who are not qualified paleontological resource monitors (see "definitions" section below). For excavations in rock units determined by a qualified professional paleontologist to have low potential, non-paleontologists may monitor for fossils. If potential paleontological resources are discovered during excavations in a rock unit with low potential, all ground disturbance in the vicinity of the find should stop immediately until a qualified professional paleontologist can assess the nature and importance of the find and recommend appropriate salvage, treatment, and future monitoring and mitigation.

Paleontologists who monitor excavations must be experienced in locating and salvaging fossils, and collecting necessary associated critical data. The paleontological resource monitor must be able to document the stratigraphic context of fossil discovery sites. Paleontological resource monitors must be properly equipped with tools and supplies to allow rapid removal of specimens. The monitor must be empowered to temporarily halt or redirect the excavation equipment away from fossils to be salvaged. Some lead agencies require that paleontological monitors be approved prior to performing any field work.

To reduce potential delays to excavation schedules, provision must be made in the mitigation program for additional assistants to monitor or help in removing large or abundant fossils. If many pieces of heavy equipment are in use simultaneously but at diverse locations, each location will need to be individually monitored.

**Macrofossil Salvage**
Many specimens recovered from excavations are readily visible to the eye and large enough to be easily recognized and removed. Upon discovery of such macrofossils, the monitor will flag the fossiliferous area for avoidance until the project paleontologist can evaluate the resource and develop plans for removal/salvage of these specimens. Some fossil specimens may be fragile and require consolidation

with archival quality media (e. g., Acryloid, Butvar, or Vinac) before moving. Others may require protection by encasing them within a plaster jacket before removal to a laboratory for later preparation and conservation. Occasionally specimens encompass all or much of a skeleton and will require moving either as a whole or in multiple blocks for later preparation. Such specimens require time to excavate and strengthen with a hardening solution before removal and the patience and understanding of the contractor to recover the specimens properly. It is thus important that contractors and developers are fully aware of the importance and fragility of fossils for their recovery to be undertaken with the optimum chances of successful extraction.

**Avoidance and Site Protection**
In exceptional instances the process of preconstruction assessment or construction monitoring itself may reveal a fossil occurrence of such importance that salvage or removal is unacceptable to all concerned parties. In such cases, the project design may need to be modified to avoid, protect and/or exhibit the fossil occurrence, e. g., in the floor or wall of a museum or as a basement exhibit in a mall. Under such circumstances, the site may be declared and dedicated as a protected resource of public value. Associated fossil fragments salvaged from such a site should be placed in an approved institutional repository. Federal land managers have the ability to set aside such exceptional areas providing documentation supports special management considerations.

**Microfossil Salvage**
Many significant vertebrate fossils (e. g., small mammal, bird, reptile, amphibian, or fish remains) are too small to be readily visible within the sedimentary matrix and are referred to as "microvertebrates". Small fossils also include non-vertebrate paleoenvironmental indicators (e. g., foraminifers, small gastropods, and plant seeds). Fine-grained sedimentary horizons (e. g., mudstones and paleosols) most often contain such fossils, which are typically recovered through a process of bulk matrix sampling followed by screen washing through 20 and/or 30 mesh screens. If indicators of potential microvertebrate fossils are found (e. g., plant debris, abundant mollusks, clay clasts, carbonate-rich paleosols, or mudstones) screening of a "test sample" (0.4 cubic yard/meter, ~600 lbs) may produce significant returns and indicate whether or not a larger sample needs to be screen washed. An adequate sample (standard sample) consists of approximately 4.0 cubic yards/meters (6,000 lbs or 2,500 kg) of matrix from each site, horizon, or paleosol. However, the uniqueness of the microvertebrate fossils recovered may justify screen washing even larger amounts. With this possibility in mind, two standard samples (~8.0 cubic yards/meters) or more as determined by the project paleontologist should be collected when the discovery is first made and set aside in case processing of a larger sample is later determined to be necessary. The developer must recognize that funding must be available to process these bulk matrix samples, thereby reducing volume to facilitate cost-effective storage of fossil specimens.

To avoid construction delays, samples of matrix may need to be removed from the project site and processed elsewhere. Chemicals (e. g., detergents, weak acids, orange oil, etc.) may be necessary to facilitate the breakdown of matrix. In some cases the concentrate will need to be further processed using heavy liquids (e. g., zinc bromide, polytungstate, or tetrabromide) to remove mineral grains and create a concentrate enriched with microvertebrate bones and teeth. The concentrate should be directly examined under a microscope to locate and remove individual microfossils.

**Samples**
To place fossils within a temporal context, dating of rock units may be necessary. If available, samples of volcanic ash and organic carbon should be collected for radiometric and/or thermoluminescence dating.

When appropriate, oriented samples should also be collected for paleomagnetic analysis. In addition, samples of fine-grained matrices should be collected from measured stratigraphic sections for microfossil (e. g., pollen, spores, dinoflagellates, ostracodes, diatoms, foraminifers, etc.) analyses. Other matrix samples may need to be collected and retained with the samples submitted to the repository institution for future analysis, for clast source analysis, or as witness to the source rock unit and possibly for procedures not yet envisioned. The project paleontologist should determine which of these samples should be immediately processed and which samples can be stored for later processing. Many museums will not accept such rock or sediment samples for curation and storage.

**Preparation**

Salvaged specimens must be prepared for identification and curation (not exhibition). This means removal of all or most of the enclosing sediment to reduce the specimen volume, increase surface area for the application of consolidants/preservatives, provide repairs and stabilization of fragile/damaged areas on a specimen, and allow identification of the fossils. Large specimens may require construction of reinforced plaster or fiberglass cradles. Removal of excess matrix from macrofossils during the preparation process will facilitate identification, reduce storage space, and reduce the cost of storage. Project paleontologists need to be aware that many museums will not accept specimens that are not fully prepared for permanent curation.

**Identification and Cataloging**

Specimens must be identified by competent qualified paleontological specialists to the lowest taxonomic level possible. Ideally, identification of individual specimens will be to genus and species and to skeletal element. Specimens must be cataloged and a complete list of specimens to be accessioned into the collections must be prepared for the curator of the repository institution. Batch identification and batch numbering (e. g., “mammals, 75 specimens”) is unacceptable.

**Analysis**

Although academic research questions should dictate the field methods and types of data recorded, the overall goal of a paleontological resource mitigation program is not to conduct research but rather to discover and salvage significant fossil remains, record relevant stratigraphic and taphonomic data, and curate and permanently house the salvaged fossil remains for future study. However, before salvaged specimens are curated, either the project paleontologist or a competent qualified paleontological specialist should determine the significance and importance of the salvaged specimens and this information should be included in the final report.

**Storage**

Adequate curation and storage of salvaged specimens in an approved repository institution is an essential goal of the paleontological mitigation program. Adequate storage must include curation of individual specimens into the collections of a recognized, not-for-profit repository with a permanent curator, such as a museum or a university (institution). A complete set of GPS data, field notes, photographs, locality forms, and stratigraphic sections must accompany the fossil collections. Specimens must be stored in a fashion that allows retrieval of specific, individual specimens by future researchers.

Specific requirements of the designated repository must be established prior to the start of the project, field salvage work, and laboratory analysis. Adequate advance notice of funds required by the repository for curation is needed for the benefit of project funding. Costs of the project should cover the necessary curatorial supplies such as, but not limited to, trays, vials, foam, and storage cabinets or shelves to provide for the appropriate curation of the specimens.

**Reporting**

**1) Interim report**
At the close of the excavation phase of a project, an interim report should be prepared. This interim report should summarize exceptional fossil discoveries, note areas where monitoring occurred and fossils were collected, and list tasks remaining for preparation, identification, and curation of the salvaged specimens. In the interim report, the preconstruction repository agreement should be appended and any additional repository considerations and costs should be described.

**2) Final report**
After preparation, identification, analysis of significance, and curatorial inventory of the salvaged specimens is complete, a final report must be prepared by the project paleontologist including a summary of the field and laboratory methods, site geology and stratigraphy, faunal/floral list(s), and a brief statement of the significance and relationship of the fossils discovered to similar fossils found elsewhere The final report should emphasize the discovery of any new or rare taxa, or paleoecological or taphonomic significance. A complete set of field notes, geologic maps, stratigraphic sections, and a list of identified specimens must be included in or accompany the final report. This report should be finalized only after all aspects of the mitigation program are completed, including preparation, identification, cataloging, and curatorial inventory.

The final report (with any accompanying documents) and repository curation of specimens and samples constitute the goals of a successful paleontological resource mitigation program. Full copies of the final report should be deposited with both the lead agency and the repository institution with the request that all locality data remain confidential and not made available to the general public.

**Compliance**
From the beginning of the project, the lead agency should assure compliance with measures to protect fossil resources by:

1. requesting during initial planning phases an assessment and program for impact mitigation that is consistent with these SVP Standard Procedures;
2. ensuring the adequacy of the proposed mitigation measures;
3. acknowledging arrangements for salvaged specimens to be permanently housed in an institutional paleontological repository;
4. ensuring that the paleontological resource mitigation program is supervised by a qualified professional paleontologist;
5. ensuring that all monitoring for paleontological resources is performed by qualified paleontological resource monitors;
6. inspecting the monitoring program in the field periodically during project construction;
7. ensuring that specimens are prepared, identified, cataloged, and properly curated;
8. requiring an interim and final report before issuing final occupancy permits or equivalent documents; and

9. ensuring that the final report is complete and adequately describes the methods and results of the mitigation program.

The project paleontologist should be responsible for:

1. assessing potential impacts to paleontological resources and developing a program for impact mitigation during initial planning phases;

2. obtaining a repository agreement, and ensuring repository acceptance of specimens;

3. ensuring implementation of the mitigation measures; and

4. preparing the interim and final reports.

Acceptance of the final report by the lead agency signifies completion of the program of mitigation for the project. Review and approval of the final report by a qualified professional paleontologist designated by the lead agency will determine the effectiveness of the program and adequacy of the report. Inadequate performances in either area comprise noncompliance, and may result in the lead agency removing the project paleontologist from its list of qualified professional paleontological consultants.

**Definitions**

**A QUALIFIED PROFESSIONAL PALEONTOLOGIST (Principal Investigator, Project Paleontologist)** is a practicing scientist who is recognized in the paleontological community as a professional and can demonstrate familiarity and proficiency with paleontology in a stratigraphic context. A paleontological Principal Investigator shall have the equivalent of the following qualifications:

1. A graduate degree in paleontology or geology, and/or a publication record in peer reviewed journals; and demonstrated competence in field techniques, preparation, identification, curation, and reporting in the state or geologic province in which the project occurs. An advanced degree is less important than demonstrated competence and regional experience.
2. At least two full years professional experience as assistant to a Project Paleontologist with administration and project management experience; supported by a list of projects and referral contacts.
3. Proficiency in recognizing fossils in the field and determining their significance.
4. Expertise in local geology, stratigraphy, and biostratigraphy.
5. Experience collecting vertebrate fossils in the field.

**PALEONTOLOGICAL RESOURCE MONITORS** shall have the equivalent of the following qualifications:

1. BS or BA degree in geology or paleontology and one year experience monitoring in the state or geologic province of the specific project. An associate degree and/or demonstrated experience showing ability to recognize fossils in a biostratigraphic context and recover vertebrate fossils in the field may be substituted for a degree. An undergraduate degree in geology or paleontology is preferable, but is less important than documented experience performing paleontological monitoring, or
2. AS or AA in geology, paleontology, or biology and demonstrated two years experience collecting and salvaging fossil materials in the state or geologic province of the specific project, or
3. Enrollment in upper division classes pursuing a degree in the fields of geology or paleontology and two years of monitoring experience in the state or geologic province of the specific project.

4. Monitors must demonstrate proficiency in recognizing various types of fossils, in collection methods, and in other paleontological field techniques.

**ASSOCIATED CRITICAL DATA** includes adequate field notes, sketches of stratigraphic sections, geologic maps, and site and specimen photos. Associated critical data may also include samples of organic carbon and volcanic ash for radiometric dating, oriented samples for paleomagnetic analysis, samples for microfossil analysis, and samples for determining the sediment source.

A **PALEONTOLOGICAL REPOSITORY** is a not-for-profit museum or university approved by the lead agency and employing a permanent curator responsible for paleontological records and specimens. Such an institution assigns accession, locality, and/or catalog numbers to individual specimens that are stored and conserved to ensure their preservation under adequate security against theft, loss, damage, fire, pests, and adverse climate conditions. Specimens will be stored in a stable environment away from flammable liquids, corrosive chemicals, organic materials subject to mildew, and sources of potential water damage. Specimens must have all modifications, preparation techniques, etc. documented and linked with the specimen. The repository will also archive lists of collected specimens, and any associated field notes, maps, photographs, diagrams, or other data. The repository must have procedures for tracking specimens removed from storage for study, preparation, exhibit, or loan. The repository must make its collections of cataloged specimens available for study by qualified researchers.

**ARCHAEOLOGICAL RESOURCES** are human remains and items or artifacts associated with human cultures. If paleontological resources are determined to be in close stratigraphic association with human remains or human manufactured items, or if fossils can be demonstrated to be intentionally modified by humans, they are also considered archaeological resources.

**SIGNIFICANT PALEONTOLOGICAL RESOURCES** are fossils and fossiliferous deposits, here defined as consisting of identifiable vertebrate fossils, large or small, uncommon invertebrate, plant, and trace fossils, and other data that provide taphonomic, taxonomic, phylogenetic, paleoecologic, stratigraphic, and/or biochronologic information. Paleontological resources are considered to be older than recorded human history and/or older than middle Holocene (i. e., older than about 5,000 radiocarbon years).

A **LEAD AGENCY** is the agency responsible for addressing impacts to resources that a specific project might cause, and for ensuring compliance with approved mitigation measures.

**PALEONTOLOGICAL POTENTIAL** is the potential for the presence of significant paleontological resources. All sedimentary rocks, some volcanic rocks, and some low-grade metamorphic rocks have potential to yield significant paleontological resources. Paleontological potential is determined only after a field survey of a rock unit in conjunction with a review of available literature and relevant paleontological locality records.

| loc_ID_num | loc_name | county_std | state_prov_st | country_std |
|---|---|---|---|---|
| B930 | | Colusa County | California | United States |
| P347 | San Pablo | Contra Costa Coun | California | United States |
| V2906 | Cache Creek | Yolo County | California | United States |
| V3022 | Black Ranch District 1 | Tehama County | California | United States |
| V3023 | Black Ranch District 2 | Tehama County | California | United States |
| V3216 | Tehama Fm 1 | Tehama County | California | United States |
| V3403 | Salt Creek | Colusa County | California | United States |
| V3509 | Colusa 1 | Colusa County | California | United States |
| V3526 | Government Gulch | Tehama County | California | United States |
| V3627 | Cottonwood | Tehama County | California | United States |
| V3715 | Diehl Ranch | Tehama County | California | United States |
| V3822 | Heavy Estate Ranch | Tehama County | California | United States |
| V3932 | Scott Ranch | Napa County | California | United States |
| V4403 | Gridley | Butte County | California | United States |
| V4501 | Reed's Creek | Tehama County | California | United States |
| V4546 | Vacaville | Solano County | California | United States |
| V5012 | Mill Creek | Tehama County | California | United States |
| V5129 | Dunnigan 1 | Yolo County | California | United States |
| V5249 | Cortina Creek | Colusa County | California | United States |
| V5315 | Rumsey Hills 1 | Yolo County | California | United States |
| V5363 | Flournoy E | Tehama County | California | United States |
| V5563 | Black Butte | Tehama County | California | United States |
| V6342 | Gallup Ranch | Yolo County | California | United States |
| V6876 | Spring Creek | Tehama County | California | United States |
| V72187 | Smith Creek | Yolo County | California | United States |
| V72240 | Chamisal Creek | Colusa County | California | United States |
| V75105 | Colusa 2 | Colusa County | California | United States |
| V81037 | Tehama Colusa Canal | Yolo County | California | United States |
| V81038 | Tehama County NW | Tehama County | California | United States |
| V81039 | Sand Creek N | Colusa County | California | United States |
| V81040 | Dunnigan Creek 1 | Yolo County | California | United States |
| V81041 | Tehama Fm General | Tehama County | California | United States |
| V81042 | Cache Creek Aggregates | Yolo County | California | United States |
| V81123 | Dunnigan Hills | Yolo County | California | United States |
| V81124 | Black Butte Reservoir | Glenn County | California | United States |
| V81125 | Bend Bridge N | Tehama County | California | United States |
| V81126 | Spring Creek E | Tehama County | California | United States |
| V84125 | North Fork | Tehama County | California | United States |
| V84217 | Knoch Ranch | Tehama County | California | United States |
| V91176 | Lawler 1 | Tehama County | California | United States |
| V91177 | Lawler 2 | Tehama County | California | United States |
| V91178 | Lawler 3 | Tehama County | California | United States |

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|---|---|---|---|---|
| V91179 | Lawler 43 | Tehama County | California | United States |
| V92032 | Dunnigan Hills North | Yolo County | California | United States |
| V96016 | Corcoran Ranch 1 | Yolo County | California | United States |

| cont_ocean | period | epoch | formation | formation_mari | member | storage_ag | flora_fauna | ucmp_coll |
|---|---|---|---|---|---|---|---|---|
| North America | Neogene | Pliocene | Tehama | Marine | | | | I |
| North America | Tertiary | Miocene | Tehama | Marine | | Miocene | | P |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Neogene | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Neogene | Pliocene | Tehama | Non-Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | | V |

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|---|---|---|---|---|---|---|---|
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | V |
| North America | Tertiary | Pliocene | Tehama | Marine | | Blancan | V |