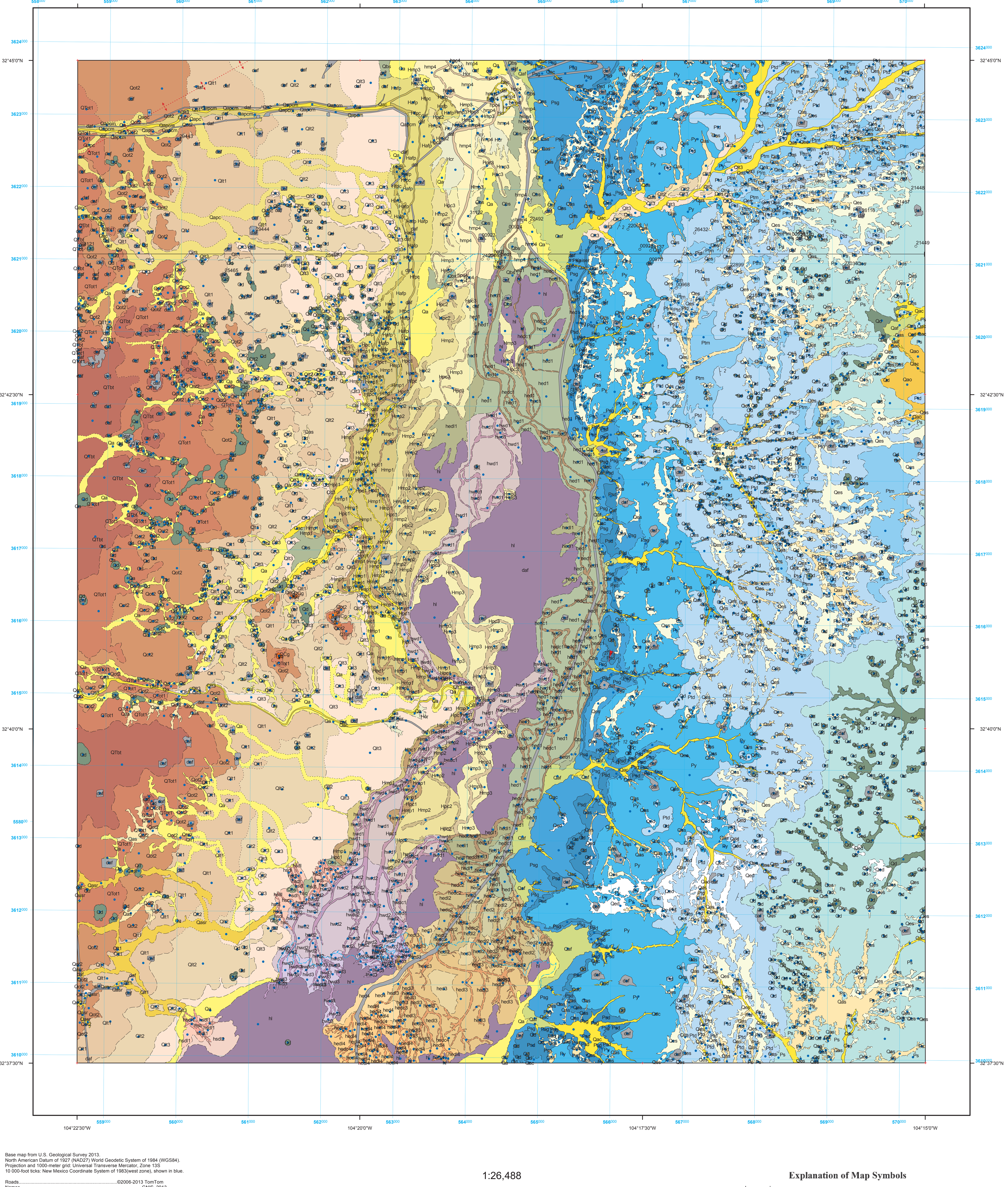
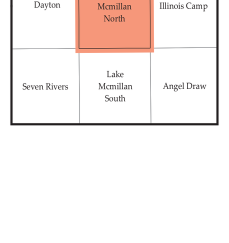
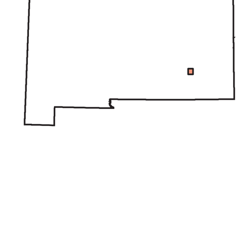


Base map from U.S. Geological Survey 2013.
North American Datum of 1927 (NAD27) World Geodetic System of 1984 (WGS84).
Projection and 1000-meter grid: Universal Transverse Mercator, Zone 13S
10 000-foot ticks: New Mexico Coordinate System of 1983(west zone), shown in blue.

Roads....©2006-2013 TomTom
Names....GNIS, 2013
Hydrography....National Hydrography Dataset, 2011
Contours....National Elevation Dataset, 2002





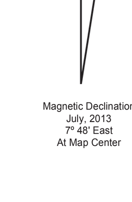
Quadrangle Location

New Mexico Bureau of Geology and Mineral Resources
New Mexico Tech
801 Leroy Place
Socorro, New Mexico
87801-4796

[575] 835-5490

This and other STATEMAP quadrangles are available for free download in both PDF and ArcGIS formats at:

http://geoinfo.nmt.edu



Magnetic Declination
July, 2013
7° 48' East
At Map Center

1:26,488

1 0.5 0 1 Mile
1000 0 1000 2000 3000 4000 5000 6000 7000 Feet
1 0.5 0 1 Kilometer

Contour Interval 10 Feet
North AmericanVertical Datum of 1988

New Mexico Bureau of Geology and Mineral Resources
Open-File Geologic Map 167

Mapping of this quadrangle was funded by a matching-funds grant from the STATEMAP program of the National Cooperative Geologic Mapping Act, administered by the U. S. Geological Survey, and by the New Mexico Bureau of Geology and Mineral Resources, (L. Greer Price, *Director and State Geologist*, Dr. J. Michael Timmons, *Assoc. Director for Mapping Programs*).

Geologic Map of the Lake McMillan North 7.5-Minute Quadrangle, Eddy County, New Mexico

May, 2008

by
David J. McCraw and Lewis A. Land

New Mexico Bureau of Geology and Mineral Resources, 801 Leroy Place, Socorro, NM 87801

Explanation of Map Symbols

- A——A′ Location of geologic cross section.
- Geologic contact. Solid where exposed or known; long dash where approximately known; short dash where agricultural land use has obfuscated location, approximated from aerial photographic interpretation; dotted at channel ends where surficial processes have obliterated channel exposure.
- Collapse structure or sinkhole, hachures indicate side of failure. Usually coincides with the geologic contact surrounding Quaternary depression fill, *Qd*.
- Plunging synclinal fold due to solution/subsidence of underlying gypsiferous deposits.
- Concealed, subsurface antiform of the Artesia-Vacuum arch.
- Northernmost shoreline documenting the maximum extent of Lake McMillan, shortly after impoundment (Cox and Havens, 1974).
- Northern shoreline of Lake McMillan in March, 1940, digitized from U.S. Soil Conservation Service aerial photograph.
- 13 Strike and dip of inclined bedding. Most dips >2° are associated with solution collapse structures.
- Paleocurrent vector measured from clast imbrication; tail of arrow is located at measurement.
- C Cave entrance. Symbol points in the direction of the entrance.
- QCg Sample locations of quartzose conglomerate (*QCg*) or limestone conglomerate (*LCg*).
- St.Vs Gravel pit wall exhibiting soil with Stage V pedogenic carbonate horizon.
- 29444 Oil and gas exploration/production drill hole used in the construction of the geologic cross section. Drill hole is identified by the last five digits of the API number.
- △ USGS Kaiser Channel gauging station, mentioned in report.

Description of Map Units

Note: Partial unit descriptions listed below, see accompanying report for the complete description of map units. Historic map unit labels are given a lower case "h-" to differentiate them from Holocene "H-" map units.

Quaternary

Pecos River alluvial valley floor deposits

Pecos River meanderbelt fluvial deposits (Historic to lower Holocene) — The Pecos River has built four distinguishable Holocene meanderbelts on top of the basal, upper Pleistocene Pecos River braided alluvial valley-fill mapped to the north (McCraw et al., 2007; 2011). Consisting of channel, channel bar, point bar, and natural levee deposits, undivided, these meanderbelts are differentiated based upon cross-cutting relationships observed in the field, as well as photogrammetric interpretation into an historic unit (**hmp4**) and three older Holocene units (**Hmp1-3**). Channels within meanderbelts are mapped where recognized (**hpc4**; **Hpc3-1**).

hpc4 / hmp4 **Historic Pecos River channels (hpc4) set in historic meanderbelt deposits (hmp4) (upper Holocene to Historic)** — Scattered gravels of carbonate, sandstone, chert, and quartzite in a very pale-brown (10YR7/4) to reddish-brown (2.5YR4/6), unconsolidated, moderately- to well-sorted, coarse- to fine-grained sand in the former modern channel and adjacent bar crests, grading to silty sand and sandy clay with distance from channels. The meanderbelt was abandoned following the channelization of the Pecos River into the low-flow conveyance Kaiser Channel in 1945. Meanderbelt thicknesses commonly range from 1-5 m.

Hpc3 / Hmp3 **Young Pecos River channels (Hpc3) set in young meanderbelt deposits (Hmp3) meanderbelt deposits (upper Holocene)** — Very pale-brown (10YR7/4) to reddish-brown (2.5YR4/6), unconsolidated, moderately-sorted, coarse- to fine-grained sand, silty sand, and sandy clay with a few scattered gravels comprised of carbonate, sandstone, chert, and quartzite. Unit lies immediately west of **hmp4** in the center of the floodplain. Thickness 2-5 m.

Hpc2 / Hmp2 **Older Holocene Pecos River channels (Hpc2) set in older Holocene meanderbelt deposits (Hmp2) meander belt deposits (middle to upper Holocene)** — Very pale-brown (10YR7/4) to reddish-brown (2.5YR4/6), unconsolidated, moderately-sorted, coarse- to fine-grained sand, silty sand, and sandy clay with a few scattered gravels comprised of carbonate, sandstone, chert, and quartzite. Unit lies immediately west of **Hmp3**. Thickness 3-5 m.

Hpc1 / Hmp1 **Old Holocene Pecos River channels (Hpc1) set in old Holocene meanderbelt deposits (Hmp1) meander belt deposits (lower to middle Holocene)** — Very pale-brown (10YR7/4) to reddish-brown (2.5YR4/6), unconsolidated, moderately-sorted, coarse- to fine-grained sand, silty sand, and sandy clay with a few scattered gravels comprised of carbonate, sandstone, chert, and quartzite. Unit has the largest channel geometry (channel width up to 180 m and meander amplitude up to 1km) of all the meanderbelts and lies immediately west of **Hmp2** against the western valley floor margin. Thickness 3-6 m.

Hfpc / Hafp **Holocene Rio Peñasco floodplain channels (Hfpc) set in Holocene fan and backswamp deposits (Hafp) (middle to upper Holocene)** — Rare scattered carbonate, chert, and quartzite pebble stringers in brown (7.5YR4/2) to reddish-brown (2.5YR4/6), unconsolidated, moderately sorted sand, silty sand, and sandy clay in the former anastomosing **Hfpc** channels and adjacent bar crests, grading to silty sand, silt, and sandy clay **Hafp** fan and backswamp deposits near the mouth of the Rio Peñasco and nearest to channels, which in turn grade downvalley to sheetflood and overbank silt and clay with distance from the mouth. Thickness 1-13 m.

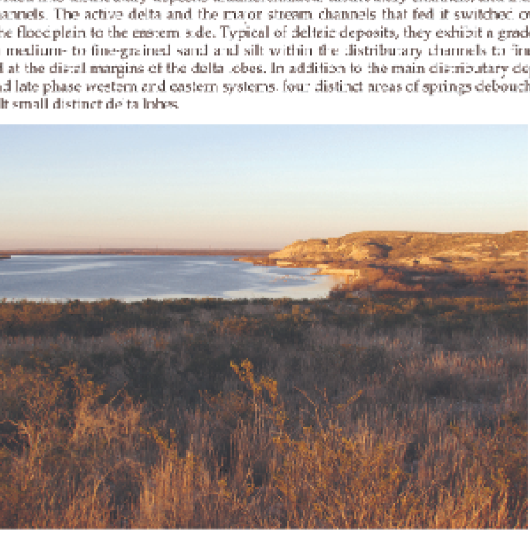
Hcr **Holocene crevasse splay deposits (middle to upper Holocene)** — Very pale-brown (10YR7/4) to reddish-brown (2.5YR4/6), unconsolidated, graded sand and silty sand closest to the channel bank breached by the crevasse to sandy clay at the distal margins. Thickness ≤ 2 m.

Qbs **Floodplain alluvial backswamp deposits (upper Pleistocene to Historic)** — Light reddish brown (5YR6/4) to very dark gray (7.5YR3/1), unconsolidated, well-sorted, silty sand, sandy clay, silt, and clay in low-lying, poorly drained areas. These areas commonly received only fine-grained, slack-water flood deposition, prior to channelization. Thicknesses range from 3-15 (?) m.

Historic Lake McMillan

Lake McMillan was impounded in 1893 and due to its location up against the eastern bluffs, comprised of highly fractured Seven Rivers Formation gypsum (**Psg**), significantly leaked from the onset. Water flowed through karstic conduits and discharged ~5.6 km downstream into the Pecos River at Major Johnson Springs, the location of a facies change in the Seven Rivers Formation to dolomite (**Psd**) (Cox, 1967). The seepage control and containment levee constructed in 1908-09 and extended in 1953-54 was ineffective. By the early 1940s, less than half of the storage capacity of the reservoir remained. A detailed chronology of the reservoir's lifespan is described in the accompanying report.

As the reservoir's surface area shrank, an extensive deltaplain was built along the southward prograding northern shoreline. These deltaic deposits are subdivided into distributary deposits undifferentiated, distributary channels, and individual delta lobes built by distinct distributary channels. The active delta and the major stream channels that fed it switched over time back and forth from the western side of the floodplain to the eastern side. Typical of deltaic deposits, they exhibit a graded sorting ranging from a few scattered pebbles in medium- to fine-grained sand and silt within the distributary channels to fines (silts and clay) in the interdistributary areas and at the distal margins of the delta lobes. In addition to the main distributary deposits which are further differentiated into early and late phase western and eastern systems, four distinct areas of springs debouching from the base of the Lakewood terrace also built small distinct delta lobes.



A view of the McMillan Escarpment overlooking the old Lake McMillan reservoir taken from the dam. The photograph was taken in November 2014, after an usually wet fall season in which a tropical cyclone dropped over 6 inches of rainfall locally. Even though the dam was breached by dynamite in 1991 following the completion of the Lake Brantley reservoir dam ~9.5 km downstream in 1988, Lake McMillan is partially re-inundated from water backed up from Lake Brantley. The levee seen along the base of the bluffs from center to center-right was constructed in 1908-09 for seepage control and containment.

hl **Lake McMillan lakebed lacustrine deposits** — Reddish-brown (2.5YR4/6) to light-reddish-brown (5YR6/4), well-sorted silt and clay with uncommon stringers of fine-grained sand overlying Holocene valley fill deposits. Thickness ≤ 2 m.

Western delta system

hwd3 **Late phase western delta lobe and interdistributary deposits, undifferentiated** — Very pale-brown (10YR7/4) to reddish-brown (2.5YR4/6), well sorted silt and clay overlying Holocene valley fill deposits, built south of Fourmile Draw between 1940 and the 1980s. Thickness ≤ 2 m.

hwdc4 **Late phase western distributary channel deposits** — Very pale-brown (10YR7/4) to reddish-brown (2.5YR4/6), coarse- to fine-grained sand and silt overlying Holocene valley-fill deposits. Thickness ≤ 1.2 m.

hwd2 **Early phase western delta lobe and interdistributary deposits, undifferentiated** — Very pale-brown (10YR7/4) to reddish-brown (2.5YR4/6), well-sorted silt and clay overlying Holocene valley-fill deposits, built south of Fourmile Draw prior to 1940. Thickness ≤ 1.5 m.

hwdc2 **Early phase western distributary channel deposits** — Very pale-brown (10YR7/4) to reddish-brown (2.5YR4/6), coarse- to fine-grained sand and silt overlying Holocene valley-fill deposits. These channels often occupied older meanderbelt **Hpc3-2** channels. Thickness ≤ 1.5 m.

hwd1 **Earliest phase western delta lobe and interdistributary deposits, undifferentiated** — Very pale-brown (10YR7/4) to reddish-brown (2.5YR4/6), well-sorted silt and clay overlying Holocene valley-fill deposits, built progressively southward from south of Chalk Bluff Draw to south of Fourmile Draw prior to 1940. Thickness ≤ 1.8 m.

hwdc1 **Earliest phase western distributary channel deposits** — Very pale-brown (10YR7/4) to reddish-brown (2.5YR4/6), coarse- to fine-grained sand and silt overlying Holocene valley-fill deposits. These channels often occupied older meanderbelt **Hpc3** channels and distributary channel bifurcation rarely occurred until reaching active delta lobes. Thickness ≤ 1.5 m.

Eastern delta system

hed4 **Latest phase eastern interdistributary deposits** — Reddish-brown (2.5YR4/6) to light reddish-brown (5YR6/4), well sorted silt and clay overlying Holocene valley fill deposits, built south of Fourmile Draw from both the Pecos River and eastern tributaries between the 1970s and 1991. Thickness ≤ 1 m.

hedl4 **Latest phase eastern delta lobe deposits** — Reddish-brown (2.5YR4/6) to light-reddish-brown (5YR6/4), well-sorted, fine-grained sand, silt, and clay overlying Holocene valley-fill deposits, built south of Fourmile Draw from both the Pecos River and eastern tributaries between the 1970s and 1991. Thickness ≤ 1.2 m.

hedc4 **Latest phase eastern distributary channel deposits** — Rare scattered carbonate pebbles eroded from the adjacent eastern Permian uplands in a reddish-brown (2.5YR4/6) to light-reddish-brown (5YR6/4), medium- to fine-grained sand, silt and clay overlying Holocene valley fill deposits, built south of Fourmile Draw from both the Pecos River and eastern tributaries between the 1970s and 1991. Thickness ≤ 1 m.

hed2 **Late phase eastern interdistributary deposits** — Reddish-brown (2.5YR4/6) to light-reddish-brown (5YR6/4), well-sorted silt and clay overlying Holocene valley-fill deposits, built south of Fourmile Draw between 1940 and the 1970s. Thickness <1-1.2 m.

hedl3 **Late phase eastern delta lobe deposits** — Reddish-brown (2.5YR4/6) to light-reddish-brown (5YR6/4), well-sorted, fine-grained sand, silt, and clay overlying Holocene valley-fill deposits, built south of Fourmile Draw from both the Pecos River and eastern tributaries between 1940 and the 1970s. Rapid growth occurred after the 1949 construction of the Kaiser Channel. Thickness ≤ 2 m.

hedc3 **Late phase eastern distributary channel deposits** — Rare scattered carbonate pebbles eroded from the adjacent eastern Permian uplands in a reddish-brown (2.5YR4/6) to light-reddish-brown (5YR6/4), medium- to fine-grained sand, silt and clay overlying Holocene valley-fill deposits, built south of Fourmile Draw from both the Pecos River and eastern tributaries between 1940 and the 1970s. Thickness <1-1.5 m.

hed2 **Early phase eastern interdistributary deposits** — Reddish-brown (2.5YR4/6) to light-reddish-brown (5YR6/4), well-sorted silt and clay overlying Holocene valley-fill deposits, built south of Fourmile Draw from both the Pecos River and eastern tributaries prior to 1940. Thickness ≤ 1.2 m.

hedl2 **Early phase eastern delta lobe deposits** — Reddish-brown (2.5YR4/6) to light-reddish-brown (5YR6/4), well-sorted silt and clay overlying Holocene valley-fill deposits, built south of Fourmile Draw from both the Pecos River and eastern tributaries prior to 1940. Thickness ≤ 1.5 m.

hedc2 **Early phase eastern distributary channel deposits** — Rare scattered carbonate pebbles eroded from the adjacent eastern Permian uplands in a reddish-brown (2.5YR4/6) to light-reddish-brown (5YR6/4), medium- to fine-grained sand, silt and clay overlying Holocene valley-fill deposits, built south of Fourmile Draw from both the Pecos River and eastern tributaries prior to 1940. Thickness ≤ 1.5 m.

hed1 **Earliest phase eastern interdistributary and delta lobe deposits, undifferentiated** — Reddish-brown (2.5YR4/6) to light-reddish-brown (5YR6/4), well sorted, fine grained sand, silt, and clay overlying Holocene valley fill deposits, built progressively southward from south of Chalk Bluff Draw to south of Fourmile Draw from both the Pecos River and eastern tributaries prior to 1940. The main delta growth occurred here in the earliest 20th Century. Thickness ≤ 1.5 m.

hedl1 **Earliest phase eastern delta lobe deposits** — Reddish-brown (2.5YR4/6) to light-reddish-brown (5YR6/4), well-sorted silt and clay overlying Holocene valley-fill deposits, built south of Fourmile Draw from both the Pecos River and eastern tributaries prior to 1940. Thickness ≤ 1.5 m.

hedc1 **Earliest phase eastern distributary channel deposits** — Rare scattered carbonate pebbles eroded from the adjacent eastern Permian uplands in a reddish-brown (2.5YR4/6) to light-reddish-brown (5YR6/4), medium- to fine-grained sand, silt, and clay overlying Holocene valley-fill deposits, built progressively southward from south of Chalk Bluff Draw to south of Fourmile Draw from both the Pecos River and eastern tributaries prior to 1940. Thickness ≤ 2 m.

Lakewood Terrace spring delta system

hsd2 **Youngest of the southernmost Lakewood Terrace spring delta lobe** — Very pale-brown (10YR7/4), well-sorted, fine-grained sand, silt, and clay deposited by discharge from at least 5 unnamed springs discharging from the base of the Lakewood terrace along the western margin of the floodplain adjacent to the southernmost of the Qasr channels on the quadrangle. Following a relatively stable lake level period when the hsd1 lobe built directly into the lake, the lake level dropped, and a new lobe (**hsd2**) built out from the margin of **hsd1**. Overlies lacustrine **hl** and Holocene valley margin deposits. Thickness ≤ 1.2 m.

hsd / hsd1 **Lakewood Terrace spring delta lobes** — Very pale-brown (10YR7/4), well-sorted, fine-grained sand, silt, and clay deposited from discharge by numerous unnamed springs discharging from the base of the Lakewood terrace. The northern three spring delta lobes were built from prior to 1940 to sometime in the late 20th Century when the water table dropped with the receding lake as their distal margins both interfinger with and overlap hwd2 deposits. Southernmost spring delta lobe (**hsd1**) built directly into the lake, overlying lacustrine **hl** and Holocene valley margin deposits. Thickness ≤ 2.5 m.

hsc **Lakewood Terrace spring conduit channels** — Very pale-brown (10YR7/4), well-sorted, fine-grained sand, silt, and clay deposited by discharge from numerous unnamed springs discharging from the base of the Lakewood terrace along the western margin of the floodplain. Thickness ≤ 1.2 m.

Other alluvium, eolian, and anthropogenic deposits

daf **Disturbed land and/or artificial fill** — Dumped fill and areas affected by human disturbances, mapped where deposits or extractions are aerially extensive. Especially notable are the numerous constructed oil and gas well pads. Also includes gravel pits, artificial channels, and levees.

Qa **Tributary alluvium and valley-fill alluvium, undifferentiated (uppermost Pleistocene to Historic)** — Brown (7.5YR4/2) to pinkish-gray (7.5YR6/2) (**tributaries**) to light-reddish-brown (5YR 6/4) to reddish-brown (2.5YR4/6) (**Pecos floodplain valley-fill**), unconsolidated, moderately sorted, pebbly sand, silt, and clay. Varies considerably in thickness from <1 to 3 m in tributaries and up to ~10 - ~75 m in the floodplain.

Qac **Active channel alluvium, undifferentiated (Holocene to Modern)** — Predominantly carbonate-clast gravels in a brown (7.5YR4/2) to pinkish-gray (7.5YR6/2) to light-reddish-brown (5YR 6/4) to reddish-brown (2.5YR4/6), unconsolidated, moderately sorted, sand to silty sand. Varies considerably in thickness from <1 to ~8 m.

Qaf **Alluvial fan deposits (uppermost Pleistocene to Historic)** — Predominantly carbonate-clast gravels, often in stringers, in a brown (7.5YR4/2) to pinkish-gray (7.5YR6/2), unconsolidated, poorly-sorted, and coarse- to fine-grained sand to silty sand. These fans were built by tributaries along the base of both the eastern bluffs and the western floodplain margin, and interfinger with and/or spread out onto Pecos floodplain deposits. Thicknesses vary considerably from <1 m for small fans (as well as larger fans at their distal margins) up to ~8 m at the apices of fans built by large tributaries (e.g., Chalk Bluff Draw).

Qas **Alluvial slopewash deposits (uppermost Pleistocene to Historic)** — Thin (<1-1.5 m, usually <60 cm) alluvial deposits of pinkish-gray (7.5YR6/2) to light reddish-brown (5YR 6/4), unconsolidated, well-sorted, pebbly sand, silt, and clay occupying swales, ravines and gullies. Gravels predominantly consist of subrounded to subangular clasts of gypsum and dolomite on the eastern Permian uplands, and a variety of rounded to subrounded carbonate, chert, and occasional volcanic clasts elsewhere.

Qes **Eolian and/or alluvial sheetwash deposits (uppermost Pleistocene to Historic)** — Pinkish-gray (7.5YR6/2) to light-reddish-brown (5YR 6/4), unconsolidated, well-sorted, fine- to very fine-grained sand, silt and clay occupying broad, flat surfaces. Predominantly thin (≤ 1.5 m) eolian deposits often reworked by sheetwash.

Qao **Older alluvium (lower to upper Pleistocene)** — Scattered gravels and pebbles in a light-reddish-brown (5YR 6/4) to red (2.5YR5/3) unconsolidated, moderately-sorted, coarse- to medium-grained sand to silty sand. Gravel clasts are comprised of brown to reddish-brown to purplish chert, quartzite, Permian carbonates, and uncommon volcanic clasts, likely derived from the Sacramento Mountains. The unit covers a large area predominantly to the east of the quadrangle and is thought to be reworked Gatuña and/or Ogallala Formation, both outcropping further to the east. Up to 8-9 m thick.

Pecos Valley western tributaries and terrace complexes

Hacp **Modern channel alluvium of the Rio Peñasco (upper Holocene to Historic)** — Gravel clasts comprised of carbonate, sandstone, chert, quartzite, and minor volcanics are scattered in dark-yellowish-brown (10YR3/4) to very pale-brown (10YR7/4), unconsolidated, moderately- to well-sorted, medium- to fine-grained sand, silty sand, and sandy clay. Thickness ≤ 2 m.

Qap **Modern floodplain alluvium of the Rio Peñasco (middle Holocene to Historic)** — Gravel clasts comprised of carbonate, sandstone, chert, quartzite, and minor volcanics are scattered in dark-yellowish-brown (10YR3/4) to very pale-brown (10YR7/4), unconsolidated, moderately-sorted, medium- to fine-grained sand, silty sand, silt, and sandy clay. Thickness ≤ 3 m.

Qacp **Quaternary channel alluvium of the Rio Peñasco (upper Pleistocene to late Holocene)** — Gravel clasts comprised of carbonate, sandstone, chert, quartzite, and minor volcanics are scattered in dark-yellowish-brown (10YR3/4) to very pale-brown (10YR7/4), unconsolidated, moderately-sorted, medium- to fine-grained sand, silty sand, and sandy clay. During the uppermost Pleistocene, the Rio Peñasco built a braided fluviodeltaic fan at its mouth. While actual fan deposits are just scattered veneers atop the Lakewood terrace, too thin to be mappable units, these distributary fan channels do form distinct deposits. Thickness ≤ 3 m.

Qacf **Quaternary channel alluvium of Fourmile Draw (upper Pleistocene to Holocene)** — Gravel clasts comprised of carbonate, sandstone, chert, quartzite, and minor volcanics are scattered in dark-yellowish-brown (10YR3/4) to very pale-brown (10YR7/4), unconsolidated, poorly-sorted, medium- to fine-grained sand, silty sand, and sandy clay. Thickness ≤ 3 m.

Hcrf **Holocene crevasse splay deposits of Fourmile Draw (upper Holocene)** — Dark-yellowish-brown (10YR3/4) to very pale-brown (10YR7/4), unconsolidated, graded sand and silty sand closest to the channel bank breached by the crevasse to sandy clay at the distal margins. Thickness ≤ 2 m.

Qasr **Quaternary channel alluvium of North Seven Rivers (upper Pleistocene to middle Holocene)** — Gravel clasts comprised of carbonate, sandstone, chert, quartzite, and minor volcanics are scattered in dark-yellowish-brown (10YR3/4) to very pale-brown (10YR7/4), unconsolidated, moderately sorted, medium- to fine grained sand, silty sand, and sandy clay. Draining the northern Guadalupe Mountains and Seven Rivers Hills, North Seven Rivers has occupied numerous fan channels in proximity to its mouth over time. During the upper Pleistocene to late Holocene, several channels flowed across the Lakewood terraces east of Lakewood into the Pecos River. Thickness ≤ 3 m.

Lakewood terrace alluvial deposits (upper Pleistocene) — Fiedler and Nye's (1933) original Lakewood terrace is located 6 to 9 m above and just west of the floodplain, and extends up many of its tributaries. It is the youngest terrace of the lower Pecos Valley, and its clast composition, reddish brown, fine grained sediments, and reddish brown soils are indicative of being deposited from a southern Rocky Mountains-headed, south-flowing Pecos River. McCraw et al. (2007) further differentiated the Lakewood terrace based upon subtle yet distinct, low-lying surface treads and an increase in soil development into three distinct, low-lying Lakewood terraces (**Qlt3-1**). Surface tread elevations for these three are ≤ 1.2 m, 1.2-6 m, and 6-9 m above the floodplain, respectively. Gravels are comprised of carbonates, sandstone, chert, quartzite, granitics, and minor volcanics in a reddish-brown (5YR4/4) to dark yellowish-brown (10YR3/4), unconsolidated, moderately sorted, coarse- to fine-grained sand, silty sand, silt, and sandy clay. Pedogenic carbonate increases from stage I to stage II-II+ from **Qlt3** to **Qlt1**. Mostly non-gypsiferous.

Qlt3 **Youngest Lakewood terrace alluvial deposits (upper Pleistocene)** — Thickness <1-5 m.

Qlt2 **Young Lakewood terrace alluvial deposits (upper Pleistocene)** — Thickness 1.5-7 m.

Qlt1 **Older Lakewood terrace alluvial deposits (upper Pleistocene)** — Thickness ~2-12 m.

South bank of the Rio Peñasco, showing 2.8 m of modern Rio Peñasco floodplain alluvium (**Qap**) atop of youngest Lakewood terrace (**Qlt3**) sediments. This latter deposit is a coarse- to medium-grained sand with occasional carbonate, chert, and sandstone clasts. Hoe-pick is 65 cm long.

Orchard Park terrace alluvial and eolian deposits (lower to upper Pleistocene) — The Orchard Park terrace rises 1.5-3 m above the Lakewood terrace and 6-10.7 m above the Pecos floodplain. Fiedler and Nye (1933) considered it to largely consist of erosional Blackdom terrace detritus, its clast composition dominated by carbonates and subordinate volcanics largely derived from the Sacramento Mountains, but with a smaller (small cobbles to pebbles) clast size than the Blackdom. This Blackdom – Sacramento Mountains provenance for the Orchard Park terrace is evident on Lake McMillan North, but further north large eastern, lower areas of the terrace resemble the Lakewood terrace with its southern Rocky Mountain – Pecos River source. This suggests that upstream Pecos River integration occurred during Orchard Park deposition, likely during the middle Pleistocene, based upon degree of soil development.

Two levels of this alluvial eolian complex are recognized here (**Qot2-1**). Consistent with the Orchard Park terrace to the north, many solution subsidence-related depressions and sinkholes (**Qd**) pit its surface. Carbonates dominate clast composition; sandstone, chert, quartzite, and volcanics also occur. Finer-grained sediments consist of very pale-brown (10YR7/4) to yellowish-brown (10YR5/4), unconsolidated, moderately-sorted, coarse- to fine-grained sand, silty sand, silt, and sandy clay. Pedogenic carbonate increases from stage III in **Qot2** to stage III+ - IV in **Qot1**.

Qot2 **Younger Orchard Park terrace alluvial-eolian complex deposits (middle to upper Pleistocene)** — Thickness 5-45 m.

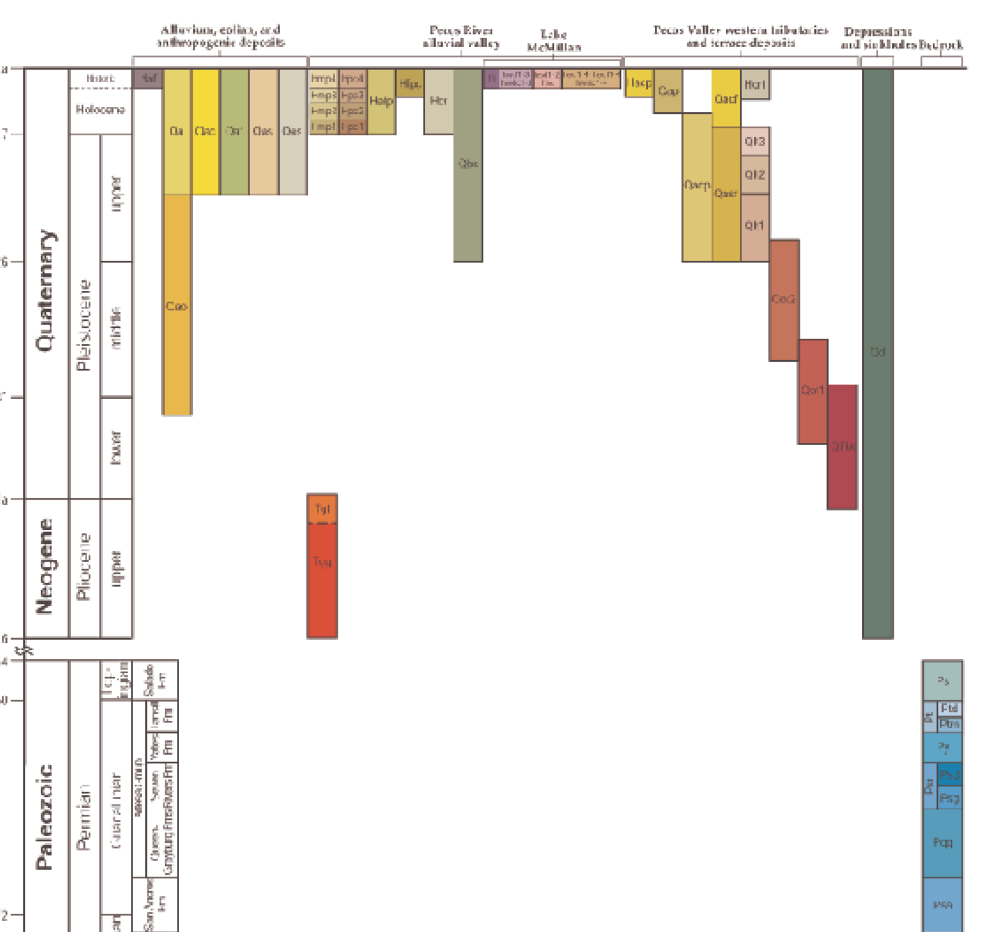
Qot1 **Older Orchard Park terrace alluvial-eolian complex deposits (lower Pleistocene)** — Thickness 5-45 m.

QTbt **Blackdom terrace alluvial deposits (upper Pliocene to lower Pleistocene)** — Fiedler and Nye (1933) described the Blackdom terrace as isolated erosional terrace remnants of a large clastic carbonate apron, shed off of the Sacramento Mountains and the Diamond "A" plain. They rise 9-15.5 m above the Orchard Park terrace, and are uppermost Pliocene to early Pleistocene in age. They are comprised of carbonate-dominant – volcanic-subordinate boulders, cobbles, and gravels; clasts of sandstone, chert, and quartzite, if present, are rare. Finer-grained sediments consist of very pale-brown (10YR7/4) to yellowish-brown (10YR5/4), unconsolidated, moderately-sorted, coarse- to fine grained, sand and silty sand. Pedogenic carbonate varies from stage III to IV. Numerous gravel pit operations near U.S. Highway 285 are sited in this unit on this quadrangle. Thickness 15-30(?) m.

Quaternary depression fill and sinkhole deposits

Qd **Quaternary depression fill within solution-subsidence collapse structures and sinkholes, undifferentiated (middle (?) Pleistocene to Holocene)** — Unconsolidated, well-sorted, fine-grained sand, silt, and clay complexes of alluvial, colluvial, eolian, deposits within closed depressions. While colors are variable, **Qd** deposits in gypsiferous terrain of the eastern Permian uplands typically range from a dark-reddish-brown (2.5YR3/4) to a reddish-brown (2.5YR4/6). Soils typically have overthickened A horizons, up to 10-15 cm, due to the concentration of eolian fines and organic matter derived from a concentration of trapped vegetal remains. **Qd** deposits are usually 1-5 m thick but can reach thicknesses in excess of 30 m.

Correlation Of Map Units

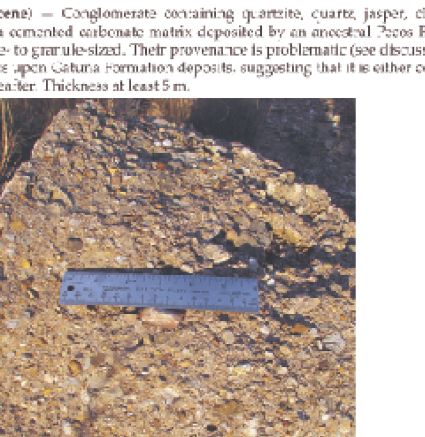


Neogene

Basal Pecos Valley alluvial deposits

Tgl **Limestone conglomerate (upper Pliocene to lower Pleistocene (?))** — Cobbles and gravels of limestone-dominated carbonates with minor chert, and sandstone in a cemented carbonate matrix. Tgl has the same Sacramento-Guadalupe Mountains provenance as the Blackdom terrace, but underlies it and is older. It is considered to be post-Ogallala, and possibly contemporaneous with the gravels of the Diamond "A" plain west of the alluvial valley. Thickness unknown, but at least 5 m.

Tgq **Quartzose conglomerate (upper Pliocene)** — Conglomerate containing quartzite, quartz, jasper, chert, granitic, sandstone, carbonate, and rare volcanic clasts in a cemented carbonate matrix deposited by an ancestral Pecos River in the basal alluvial valley. Clasts are predominantly pebble- to granule-sized. Their provenance is problematic (see discussion in the accompanying report). Kelley (1980) reports that it rests upon Gatuña Formation deposits, suggesting that it is either contemporaneous with the Ogallala or deposited very shortly thereafter. Thickness at least 5 m.



Detail of the quartzose conglomerate (**Tgq**) reveals clasts are well-rounded, mostly pebble-sized, and composed of quartzite, jasper and other cherts, sandstones, carbonates, and occasional volcanic clasts in a carbonate matrix.

Paleozoic

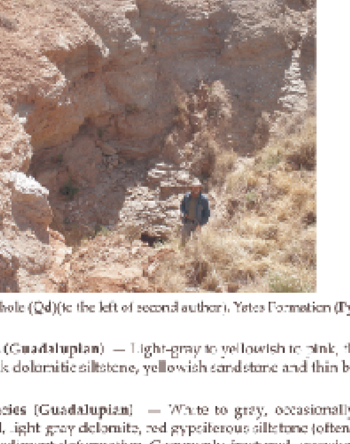
Ps **Salado Formation, mixed silty gypsiferous facies (Ochoan / Lopingian)** — Massive, orange-red gypsum, reddish-brown siltstone, and greenish and reddish clay at the surface grading into argillaceous halite, with lesser amounts of anhydrite and polyhalite at depth. Often covered by a thin veneer of chert, sandstone, and carbonate gravels most likely derived from the Ogallala and/or Gatuña Formations, as well as windblown sands and fines. Thickness ~30 m.

Permian Artesia Group

Ptd **Tansill Formation, dolomitic facies (Guadalupian)** — Light-gray to tan to light-brown, thick dolomite occupying both the base and top of the Formation, with scattered, thin interbeds between. Distinct hackley appearance. From its type section ~16 km south of the quadrangle to just beyond 32° 40′ N, this facies comprises the entire formation. Beyond this latitude, the dolomite interfingers with, and gives way to an evaporitic lithofacies (**Ptm**). It forms prominent buttes and cuestas east of the McMillan Escarpment. Thickness 2-12 m.

Ptm **Tansill Formation, mixed silty gypsiferous facies (Guadalupian)** — Interbedded mixed-gray, silty gypsum, siltstone, and light-gray dolomite, with subordinate yellowish, sublithiarenite sandstone, and orange-red chert grains. Thickness 2-50 m.

Py **Yates Formation, mixed gypsiferous facies (Guadalupian)** — Very light-gray, massive to vesicular gypsum interbedded with pink dolomite, green to white and orange to red siltstone and minor sandstone. Folded on a meter to several decimeter scale. Forms caverns like Turtle Cave. Outcrop exposures poor. Forms low-relief strike valley east of the Seven Rivers Formation bluffs. Thickness increases westward to ~30 m.



Turtle Cave opening in the base of a sinkhole (**Qd**)(to the left of second author). Yates Formation (**Py**) gypsum is seen at the surface.

Psd **Seven Rivers Formation, dolomitic facies (Guadalupian)** — Light-gray to yellowish to pink, thinly- to thickly-bedded, vesicular to massive dolomite interbedded with pink dolomitic siltstone, yellowish sandstone and thin beds of milky gypsum. Thickness 1-20 m.

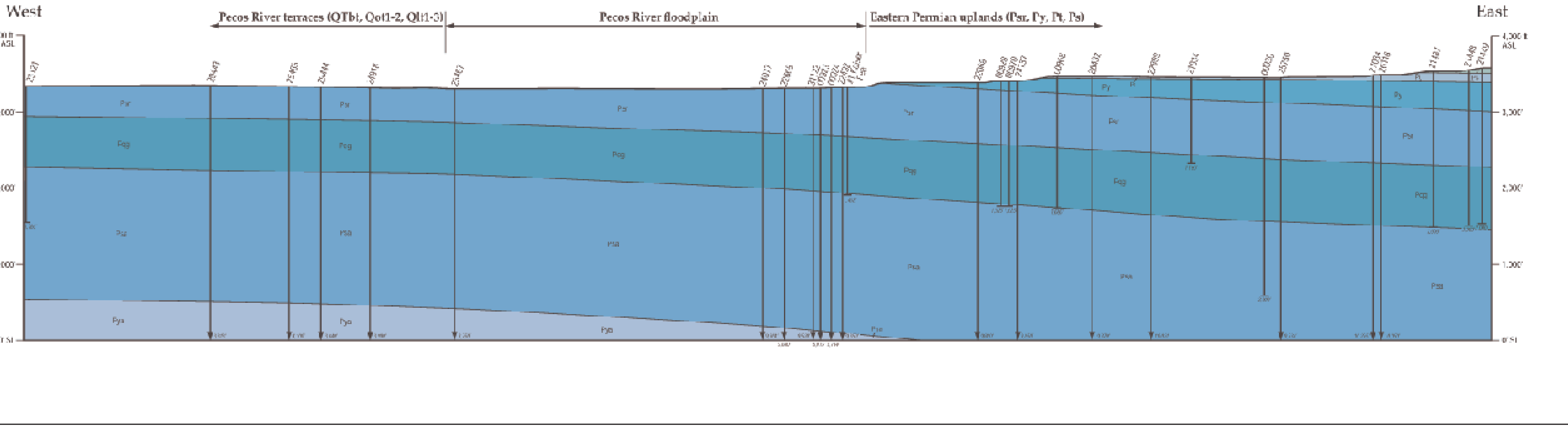
Psg **Seven Rivers Formation, gypsiferous facies (Guadalupian)** — White to gray, occasionally yellow to red massive gypsum interbedded with thin- to medium-bedded, light gray dolomite, red gypsiferous siltstone (often containing gypsum nodules), and yellowish sandstone. Often exhibits soft sediment deformation. Commonly fractured, occasionally forming caverns, with many low amplitude folds varying in scale from meters to kilometers. Thickness up to ~250 m.

Pqg **Queen and Grayburg Formations (Guadalupian)** — Cross section only.

Psa **San Andres Formation (Cisuralian/Guadalupian)** — Cross section only.

Pya **Yeso and Abo Formations, undifferentiated (Cisuralian)** — Cross section only.

GEOLOGIC CROSS SECTION



COMMENTS TO MAP USERS

A geologic map displays information on the distribution, nature, orientation, and age relationships of rocks and deposits and the occurrence of structural features. Geologic and fault contacts are irregular surfaces that form boundaries between different types or ages of units. Data depicted on this geologic quadrangle map may be based on any of the following: reconnaissance field geologic mapping, compilation of published and unpublished work, and photogeologic interpretation. Locations of contacts are not surveyed, but are plotted by interpretation of the position of a given contact onto a topographic base map; therefore, the accuracy of contact locations depends on the scale of mapping and the interpretation of the geologist(s). Any enlargement of this map could cause misunderstanding in the detail of mapping and may result in erroneous interpretations. Site-specific conditions should be verified by detailed surface mapping or subsurface exploration. Topographic and cultural changes may not be shown due to recent development.

Cross sections are constructed based upon the interpretations of the author made from geologic mapping, and available geophysical, and subsurface (drillhole) data. Cross sections should be used as an aid to understanding the general geologic framework of the map area, and not be the sole source of information for use in locating or designing wells, buildings, roads, or other man-made structures.

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