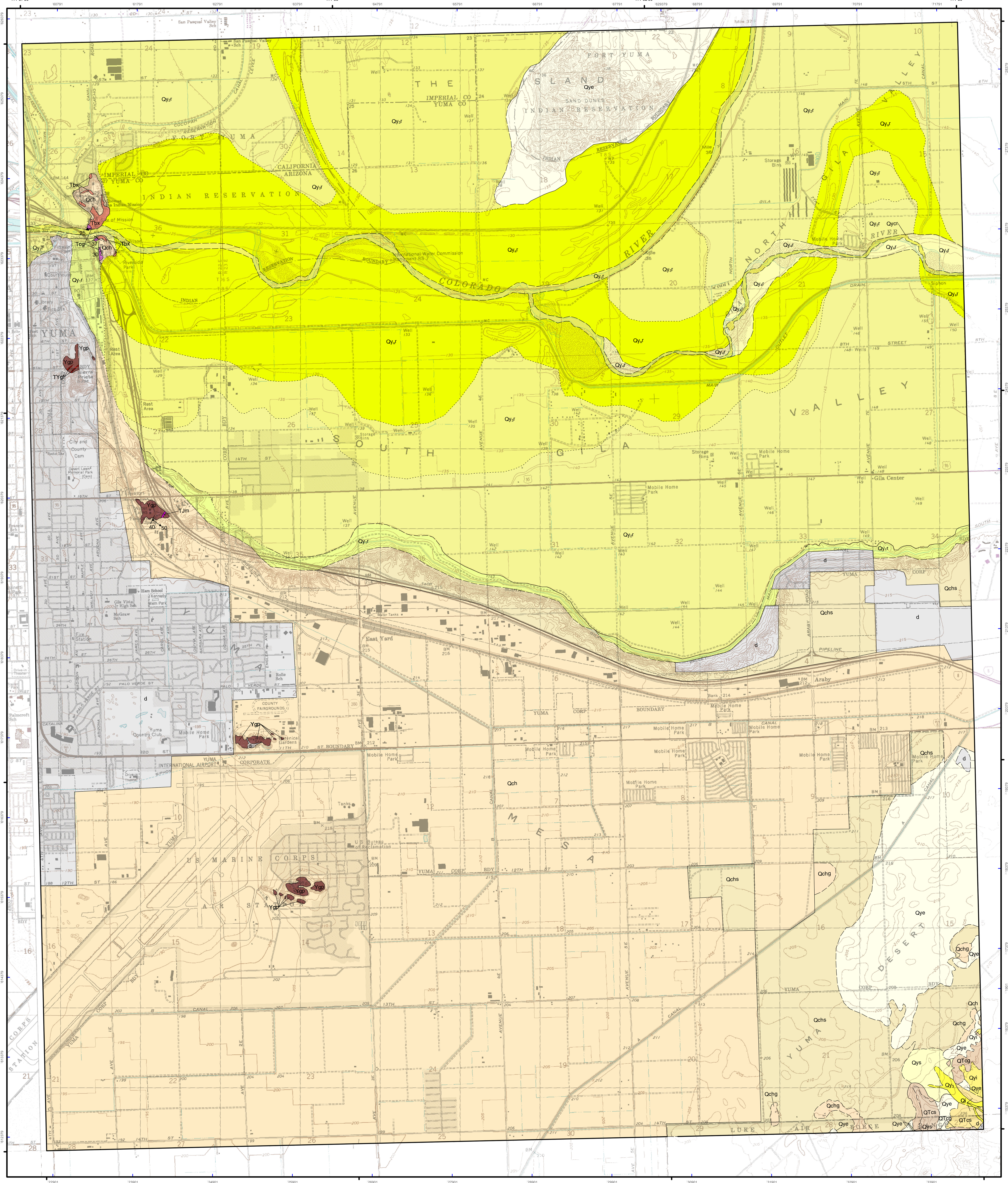
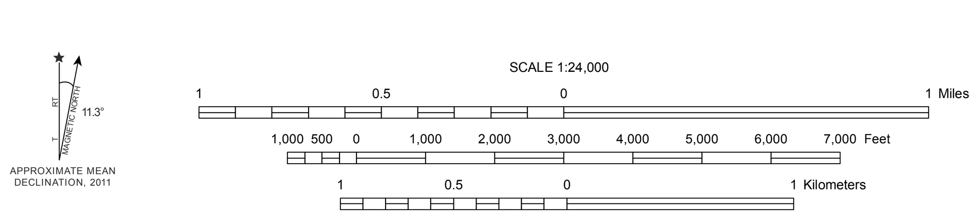
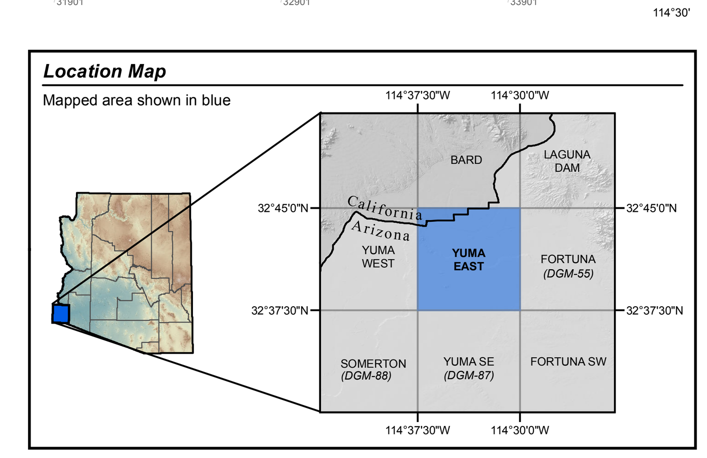


Topographic base from USGS 1:24,000 Quadrangle Series.
Seamless basemap generated using iGage All Topo Pro software.

Projection Information:
North American Datum of 1983.
1000-meter Universal Transverse Mercator
grid tics, zone 11, shown in blue.





Map Unit Descriptions

Other Deposits

d — **disturbed ground** - Land that has been substantially modified or obscured by human activity. Includes heavily urbanized areas and aggregate pits, but does not include areas disturbed by agricultural activity.

Qye — **Sandy eolian deposits** - Windblown sand and silt deposits in broad valleys and mantling the lower portions of hillslopes in upland areas. Deposits are reworked Colorado River quartz-rich medium to fine sand, and eolian silt. Local topography is undulating, with ubiquitous small-scale coppice dunes and mounds around vegetation. Soil development is minimal.

Piedmont Deposits

Qy_3 — **Small active channels, bars, and low terraces associated with large washes** - Deposits associated with active channels, bars and low terraces along relatively large piedmont washes. Deposits mainly consist of moderately sorted silt, sand, and fine gravel, including some pebbles and cobbles in channels. Channels are typically incised less than 1 m below adjacent terraces. Channel morphologies generally consist of multi-threaded, shallow, low-flow channels with adjacent bars and finer terrace deposits. Terraces commonly have planar to gently undulating surfaces and are covered primarily with fine-grained deposits with minor gravel concentrations. Soil development is minimal.

Qys — **Sandy fluvial deposits** - Quartz-rich medium to fine sand deposits with minor gravel associated with wash systems draining upland areas. Qys deposits are reworked from older Colorado River deposits and are compositionally very similar to them, but generally contain only minor gravel, pebbles and cobbles. Channels are small, discontinuous, and multi-threaded, with low sand bars and small terraces between channels. Soil development is minimal.

Qyi — **Fluvial(?) deposits** - Sand, silt, and fine gravel deposits with minor eolian overprint. Deposits are mostly reworked older Colorado River sand and gravel, so sand is quartz-rich and medium to fine-grained, and gravel is commonly rounded to well-rounded. Surfaces are relatively planar with small mounds around bushes and burrows. Surfaces typically have lightly varnished pebble lags, although open gravel pavements with more darkly varnished clasts are found in some areas. Qyi surfaces are darker and topographically higher than adjacent Qys surfaces, but lower than adjacent Qye surfaces.

Qi — **Gravel and sand deposits** - Intermediate age gravel and sand deposits reworked from older Colorado River deposits. Pebbles and cobbles are well-rounded to subangular, mixed lithologies. Medium to fine sand is quartz-rich. Surfaces are typically planar to broadly rounded; surface margins are rounded by local erosion. Surface character varies from weak to moderate gravel pavements with moderate rock varnish, making these surfaces substantially darker than those on younger and finer deposits.

River Deposits

Qy_cr — **Active river channel deposits** - Deposits associated with the active channels of the Colorado and Gila Rivers. Deposits are inundated most or all of the year, especially on the Colorado River. Where exposed, deposits are dominantly unconsolidated, very poorly sorted sandy to cobbly bars and narrow, low terraces mantled with fine-grained deposits along channel margins. Gravel clasts are typically well-rounded but may be angular to sub-angular, and sand is medium to fine-grained and quartz rich. Qy_cr deposits are unvegetated to lightly vegetated. Qy_cr deposits are entrenched from 2-5 meters or more below adjacent low terraces and abandoned historical flood channels. Extent of Qy_cr deposits varies and shifts with significant flooding.

Qy_4r — **Active flood channel and floodplain deposits** - Unit Qy_4r is composed of bars and overflow channels of the Gila River that were created or reworked in the 1993 flood. Qy_4r is composed of sand, silt and clay, with some gravel bars and no soil development. The surface is hummocky due to the bars and swales and has channelized flow. These surfaces are inundated during moderate flooding. Qy_4r is sparsely vegetated with some grasses.

Qy_ar — **Recently abandoned river channels** - Recently abandoned, pre-dam river channels and adjacent floodplains. These areas are currently covered by impenetrable tamarisk growth or agricultural fields. Surface deposits consist of sand, silt and clay, but river sand and gravel deposits likely underlie much of the unit. Qy_ar may be inundated during large flooding events; many areas of this unit were inundated during the 1993 Gila River floods. Qy_ar was identified and mapped using historical aerial photos, soil surveys, and topographic maps.

Qy_3r — **Recently active river terrace and floodplain deposits** - Deposits associated with the historical river floodplain that are up to 3-5m above active river channels and 2-3m above Qy_4r surfaces. Qy_3r surfaces are planar and have been almost completely altered by agricultural activity. Sediments composing these deposits are poorly sorted silt, sand, pebbles and cobbles. Pebbles and cobbles are well-rounded to sub-angular. These deposits are prone to flooding during extreme flow events. Qy_3r was mapped using historical air photos, soil surveys, and topographic maps.

Qy_2r — **Young river terrace and floodplain deposits** - Deposits associated with the late Holocene to historical river floodplain that are up to 6m above active river channels and ~2m above adjacent Qy_3r surfaces. Qy_2r surfaces are planar and have been almost completely altered by agricultural activity or urban development. Sediments composing these deposits are poorly sorted silt, sand, pebbles and cobbles. Pebbles and cobbles are well-rounded to sub-angular. These deposits are probably not prone to flooding in the modern, post-dam environment.

Qy_1r — **Older river terrace and floodplain deposits** - Deposits on the fringe of the Holocene river floodplain that are up to 8m above active river channels and ~2m above adjacent Qy_2r surfaces. Qy_1r surfaces are planar and slope gently toward the river. These deposits are composed of poorly sorted silt, sand, pebbles and cobbles, some of which is likely eroded from adjacent Qch deposits. Pebbles and cobbles are well-rounded to sub-angular.

Qch — **Chemehuevi Formation, undivided** - Undifferentiated Colorado River deposits associated with a late Pleistocene aggradation period. Deposits in this area consist of two facies; an upper sand facies composed of upper loose sands and gravels that unconformably overlies a lower mud facies composed of fine sand, clay and silt, generally in thin to medium, nearly horizontal beds, with minor lenses of pebbles and cobbles (Malmon and others, 2011). In this area, exposures of the mud facies were observed, but not at a mappable scale. Sediments from the Gila River, a major tributary to the Colorado River, are likely included in these deposits, but no exposures were observed during mapping. Deposits are at least 20m thick; the base of the unit is not exposed. Luminescence dating of similar deposits in Yuma and farther upstream along the Colorado River suggests that they are ~ 70 - 40 ka (Lundstrom and others, 2008) while tephrachronology of four tephras suggest an age of 74 - 59 ka (Sarna-Wojcicki and others, 2011). The surface of this unit is modified by agricultural activity or urban development.

Qchg — **Chemehuevi Formation, gravel unit, sand facies** - Colorado River deposits composed of loose pebbles, cobbles, and quartz-rich sand, with minor silt and clay. The surfaces of these areas are covered with open to tight pebble to fine cobble lag. Surface clasts range from well-rounded with very diverse lithologies, reflecting Colorado River and Gila River origins, to less diverse, subangular clasts that are mostly locally derived. This unit forms gentle slopes and rounded ridges at the edge of Yuma Mesa.

Qchs — **Chemehuevi Formation, sand unit, sand facies** - Colorado River deposits, and to a lesser extent Gila River deposits, associated with a major aggradation period. Deposits consist primarily of beds of loose quartz-rich sand with lenses of pebbles and cobbles and minor beds of silt and clay. Surface deposits are commonly reworked into small-scale eolian features. This unit forms gentle slopes and rounded ridges at the edge of Yuma Mesa.

QTcg — **Colorado River gravel deposits** - Older Colorado River gravel and sand deposits underlying dissected upland areas. Surfaces are partially or completely covered by well-rounded to subangular pebbles and cobbles of diverse lithology. Exposures are limited, but gravel bedding varies from subhorizontal to large-scale crossbedding. Because gravel clasts are difficult to transport by local fluvial processes, gravel likely mantles ridge crests and side slopes as underlying sandier deposits are translocated by erosion.

QTcs — **Sand deposits** - Older Colorado River coarse to fine-grained sand deposits with minor gravel. Sand is quartz-rich and mature. Gravel consists of rounded to well-rounded pebbles of diverse lithology. Surface sand deposits have been reworked by eolian activity to varying degrees, and locally QTcs deposits are mantled by small-scale dunes and mounds.

Bedrock Map Units

Tcg — **Conglomerate of Yuma Prison** - Poorly sorted and crudely bedded conglomerate with subangular to subrounded, 2-20 cm clasts, locally to 1 m. Clasts consist of porphyritic biotite granite like that of bedrock hills to south, plus other granitoids and gneiss. Unit includes very sparse thin beds of sandstone. This unit and underlying breccia are tilted 30-40 degrees to the southwest. This conglomerate hosts the prison cells at the Yuma Territorial Prison.

Tbx — **Rock-avalanche breccia** - Massive breccia with clasts generally 1-100 cm in an unsorted matrix. Some clasts are larger (up to 5 m), and consist of porphyritic biotite granite as is exposed in hills to the south, with about 1-2% of clasts consisting of very fine grain biotite granitoid. This deposit is inferred to represent a large rock avalanch breccia, as are common in the Laguna Hills to the northeast.

TJm — **Fine-grain mafic dike** - Fine grain, medium to dark gray mafic dike at hill at16th street and I-8. Mafic content is highly variable (15-70%). Rock is holocrystalline but all phenocrysts are <0.2 mm. Post-Proterozoic age is based on inference that this hypabyssal rock unit was emplaced at shallow depth in the crust following post 1.4 Ga erosional exhumation of the host granite and possibly Phanerozoic exhumation as well.

TYgf — **Fine-grained biotite granitoid** - ~1-10 m thick dikes intruding Proterozoic granite (map unit Ygp) at Sierra Prieta hill. Dikes consist of 6-10%, <1mm mafic minerals, and fine gray quartz and pale gray to whitish gray feldspar.

Ygp — **Porphyritic biotite granite** - Coarse-grained granite with pale gray K-feldspar phenocrysts up to 5 cm across. Mafic content is ~15 to 20%. Mafic minerals consist of felted, very fine aggregates of biotite, magnetite(?), and hornblende(?). In some samples, recrystallization has affect all minerals, which have been transformed to very fine aggregates of grains (as with the mafic minerals). Pegmatites are rare to sparse. Similar granite in the Fortuna 7.5' Quadrangle is dated at 1.4 Ga.

Structure Symbol Descriptions

- 30 strike and dip of bedding
- 30 foliation defined by preferred mineral orientation
- 30 trend and plunge of lineation in foliation plane
- 30 dip of contact

Line Symbol Descriptions

- contact, accurately located
- contact, approximately located
- contact, concealed

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GEOLOGIC MAP OF THE YUMA EAST 7 ½' QUADRANGLE, YUMA COUNTY, ARIZONA

Arizona Geological Survey Digital Geologic Map

DGM-86, version 1.0

Scale 1:24,000

By

Ann Youberg, Jon E. Spencer, and Philip A. Pearthree

October 2011

Citation for this map:
Youberg, Ann, Spencer, J.E., and Pearthree, P.A., 2011, Geologic map of the Yuma East 7 ½' Quadrangle, Yuma County, Arizona: Arizona Geological Survey Digital Geologic Map DGM-86, version 1.0, scale 1:24,000.

Research supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program, under USGS award number G09AC00199. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

Arizona Geological Survey

416 W. Congress Street, Suite 100
Tucson, AZ 85701
(520) 770-3500
www.azgs.az.gov

Introduction

The Yuma East 7½' Quadrangle is located in southwestern Arizona along the lower Colorado River on the northeastern margin of the Salton Trough. Production of this new geologic map continues the Arizona Geological Survey mapping program in Yuma County. This mapping was done under the joint State-Federal STATEMAP program, as specified in the National Geologic Mapping Act of 1992, and was jointly funded by the Arizona Geological Survey and the U.S. Geological Survey under STATEMAP assistance award G09AC00199. Mapping was compiled digitally using ESRI ArcGIS software.

This map area is almost entirely comprised of late Cenozoic sediments. In general, depth to bedrock ranges from ~1,460 m (4,800 ft) in the extreme southeastern corner of the quadrangle to ~120 m (400 ft) in the southwestern corner (Richard and others, 2007), with several small bedrock hills rising above the Cenozoic sediments in the western half of the quadrangle. The map area can be divided into two geomorphic settings. The northern half of the quadrangle includes portions of Bard, North Gila and South Gila Valleys (Olmsted and others, 1973) and consists of Holocene Gila and Colorado River deposits. Approximately 12 m (40 ft) above the river valley is Yuma Mesa which occupies the southern half of the quadrangle (Olmsted and others, 1973) and is composed of older Colorado River deposits. Elevations range from 35 m (115 ft) in the river valley to 95 m (310 ft) on Yuma Mesa, however the surfaces in both geomorphic settings are relatively subdued and flat lying. Most of the mapping area has been extensively modified by agricultural activities and urban development.

Surficial geologic units are typically mapped using field observations in conjunction with examinations of aerial photographs and digital elevation models (DEMs). Relative ages of alluvial deposits can be estimated using characteristics of clast weathering, soil development, carbonate accumulation, and position in the landscape (Gile and others, 1981; Machette, 1985; Bull, 1991; Birkland, 1999). Because this map area has been so heavily modified by human activity, however, it was difficult to find original, undisturbed alluvial surfaces with which to assess relative ages. The goal of this mapping effort in the northern half of the quadrangle was to reconstruct and represent, as best as possible, the likely extents of young Holocene Colorado and Gila River deposits that have been obscured by agricultural activities and urban development. In addition to field observations, mapping was based on information gleaned from historical topographic maps, soil surveys, historic aerial photographs, digital ortho-photographs, and 10 m DEMs. Historical topographic maps show a snapshot of the locations of the main river channels, side channels, and, in some cases the extent of the active floodplain. Topographic maps used in this project include 1903 Fortuna and Yuma 15' quadrangles, the 1919 Yuma 15' quadrangle, and the 1964 Yuma East 7.5' quadrangle. Historic soil surveys also provide information about the ages of the deposits and the location and extent of floodplains, in addition to channel locations (Youngs, 1929; Chamberlin and Richardson, 1974; Barmore, 1980). Conditions of the Colorado and Gila River floodplains were assessed using 1926, 1927, 1930, 1938, 1953, 1997, and 2001 aerial photographs, 1994 and 1996 NAPP digital ortho-photographs, 2007 and 2010 NAIP images (1 m resolution), and 2008 DHS border imagery (30-cm resolution). The Bureau of Reclamation provided GIS shapefiles of channel locations from 1874, 1990, and 1994, and the extent of flooding along the Gila River in 1993.

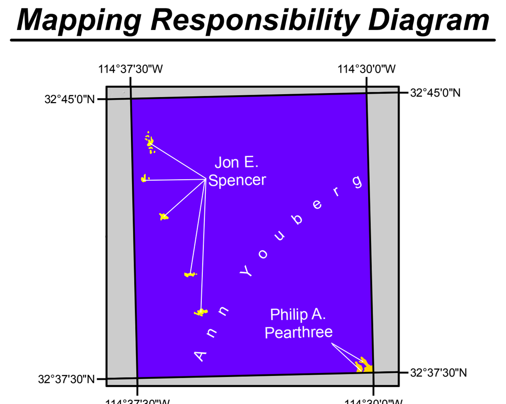
This map has six Holocene river map units. Unit boundaries represent the largest likely extent of each unit. The modern active channels (Qy_cr) and active flood channels and floodplains (Qy_4r) of the Colorado and Gila Rivers are based on the most recent information. Recently abandoned channels (Qy_ar) and recently active river terrace and floodplain deposits (Qy_3r) are based on a compilation of historical information. Young river terrace and floodplain deposits (Qy_2r) are areas that appear to be relatively stable (no active channels or flooding) since being converted to agricultural fields. This unit likely has inclusions of older alluvial deposits but that evidence has been obscured. The oldest, and smallest, Holocene river unit is a remnant floodplain and terrace deposit (Qy_1r) on the fringe of the Holocene river floodplain along the base of Yuma Mesa.

Yuma Mesa occupies the southern half of the quadrangle. The surfaces in this area have also been heavily modified by human activity, thus very few original, undisturbed alluvial surfaces can be assessed. Yuma Mesa is composed mainly of Colorado River sediments deposited during a late Pleistocene aggradation period. Malmon and others (2011) formally proposed the name Chemehuevi Formation for this lithostratigraphic unit. In the Yuma East 7½' quadrangle, there are two Chemehuevi map units, both part of the sand facies. The gravel-dominated sand facies (unit Qchg) consists of surfaces covered with open to tight pebble to fine cobble lag reflecting coarser deposits within the sand-dominated sand facies (unit Qchs). Where surfaces are disturbed these deposits are mapped as Chemehuevi Formation, undivided (Qch). There are exposures of the lower mud facies of the Chemehuevi Formation in the Yuma East 7½' quadrangle, but not at a mappable scale. The Chemehuevi Formation in this map area likely includes sediments from the Gila River (Malmon and others, 2011), although no exposures were observed. Longitudinal profile data of the Chemehuevi Formation from the mouth of the Grand Canyon to the Gulf of California indicate a valley gradient 50% steeper than the modern channel. Malmon and others (2011) suggests this indicates a single aggradational episode due to an increase in upstream sediment supply. Thermal luminescence (TL) and optically stimulated luminescence (OSL) dating of these sediments at Yuma and farther upstream indicate these sediments were deposited from approximately 70 – 40 ka (Lundstrom and others, 2008), while trephrochology of four tephras in the Cottonwood Valley area suggest an age of 74 - 59 ka (Sarna-Wojcicki and others, 2011). In the far southeastern corner of the quadrangle, there are limited remnants of older Colorado River deposits (QTcg and QTcs) estimated to be Pliocene to Quaternary in age, with limited younger fluvial (Qyi) and eolian deposits (Qye).

Acknowledgements

Several people and organizations provided access to and copies of historical aerial photographs, including Ron Simms, Julie Martinez and the Yuma Bureau of Reclamation Field Office, Laura Norman (USGS), Mike Kellog (JE Fuller Hydrology and Geomorphology), Michael Hoy and the NRCS Yuma Field Office, and the Yuma Arizona Historical Society. Gabby Black and Jennifer Wilber arranged access to the Marine Corps Air Station. Ryan Clark created GIS tools that made the job of turning field data into digital geologic maps easy. The final map and digital information products were produced by the talented hands of Janel Day.

Mapping Responsibility Diagram



Unit Correlation Diagram