Mapping of Holocene River Alluvium along the Verde River, Central Arizona

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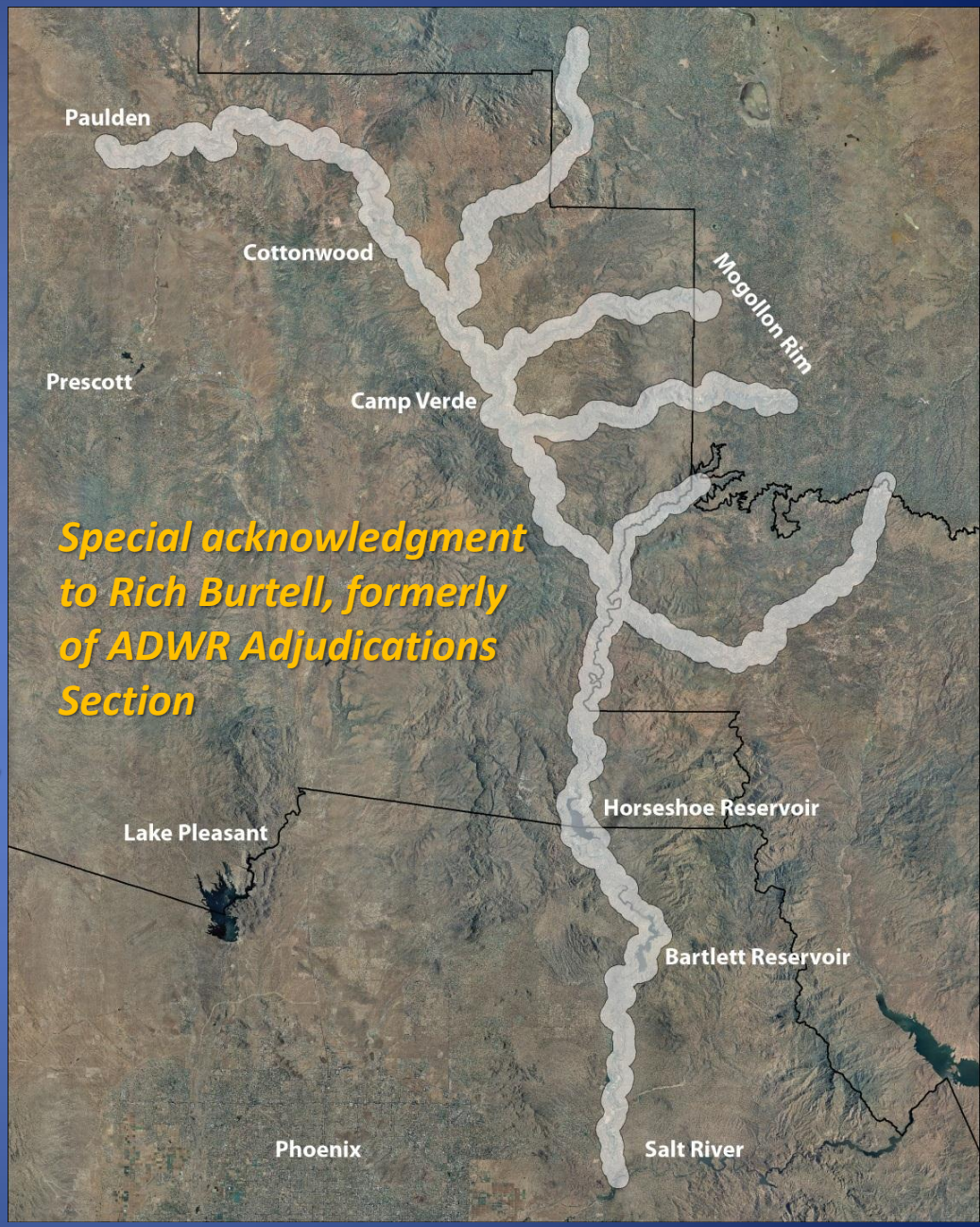
Arizona Geological Survey

in cooperation with the

Arizona Department of Water Resources



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Overview / Objectives

- **Impetus behind the mapping effort**
- **Mapping strategy and methods**
- **Characteristics and extent of Holocene river alluvium**
- ***Geologic mapping is one component used in determination of the lateral extent of the subflow zone***

Motivation for mapping efforts

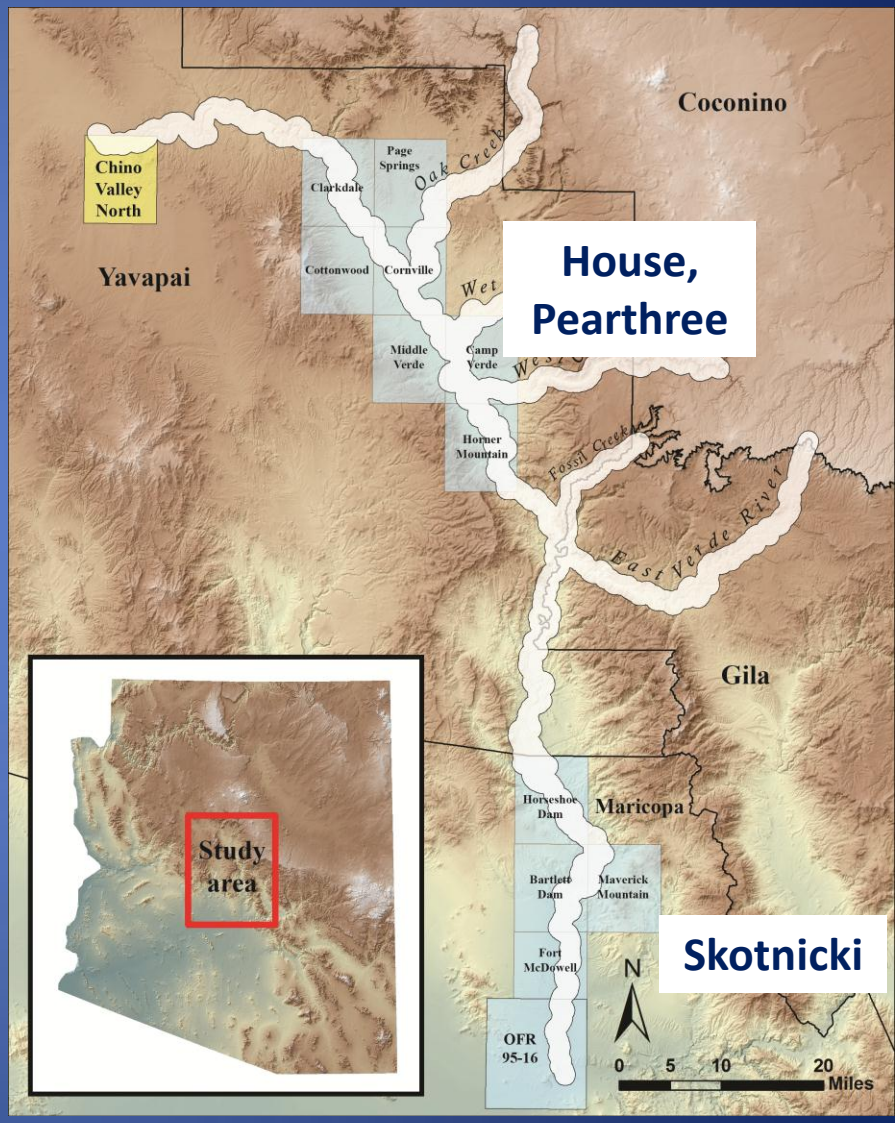
- Subflow associated with rivers treated as *appropriable water* under Arizona law
- Need for some procedure to evaluate whether groundwater pumping is affecting or may affect stream flow
- Necessary to somehow define lateral extent of subflow zone
- Surface extent of Holocene river alluvium proposed as ***rough proxy*** for saturated subsurface alluvium
- Adopted by AZ courts, with input from hydrologists and geologists
- **San Pedro River is the test case**

How to determine lateral extent of Holocene river alluvium?

- Need geologic mapping – was existing mapping accurate, uniform, adequate for the task?
- Mapping must differentiate river deposits from all other geologic units
- And differentiate Holocene river deposits from older river deposits
- In desperation, ADWR turned to AZGS to develop consistent geologic maps of the San Pedro and Verde river corridors

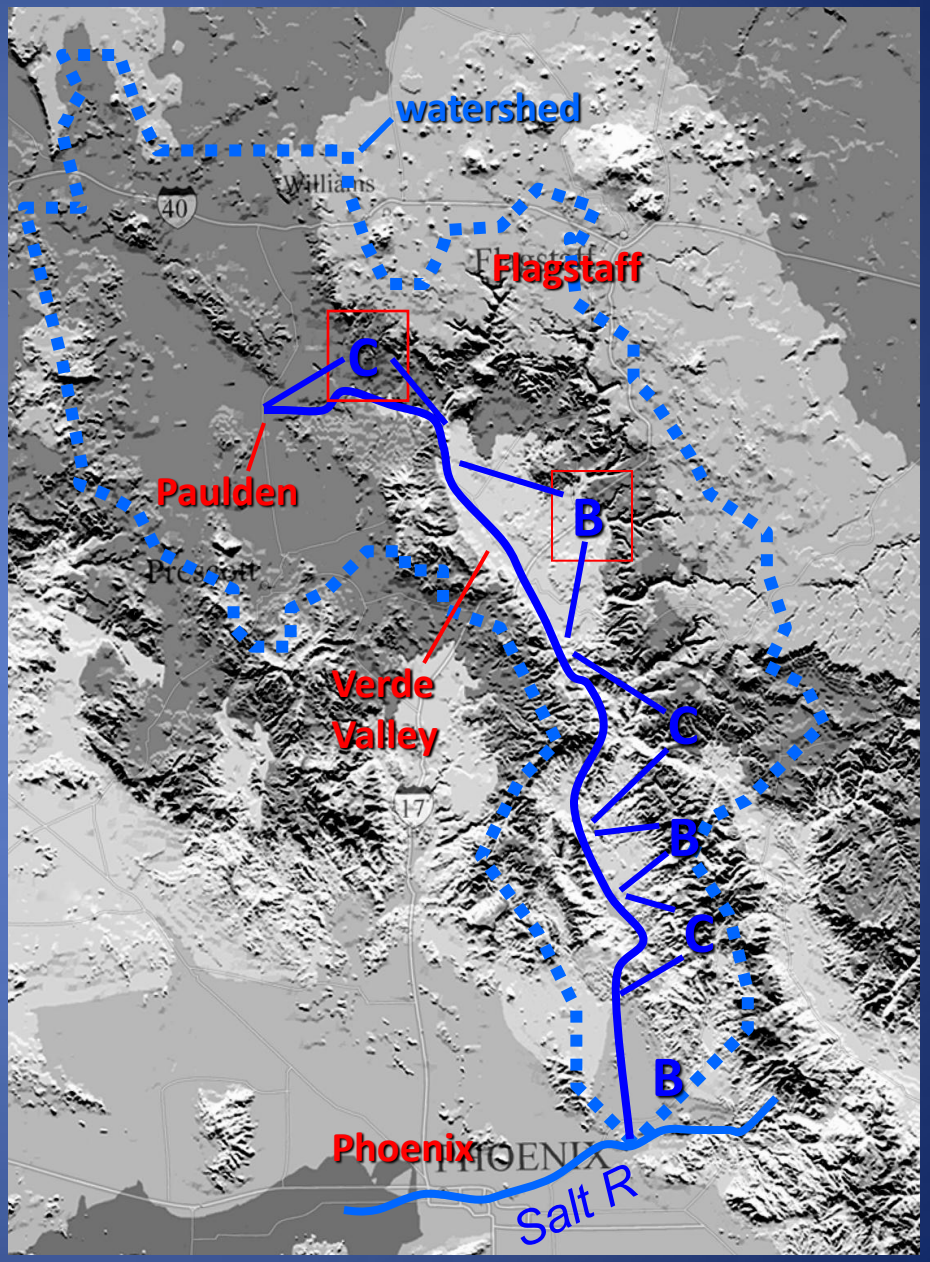
Mapping strategy

- Review and compile existing geologic mapping
- Standard mapping procedures to differentiate Holocene river deposits from other geologic units
- Mapping supported by field observations on both banks every mile along the river
- 2-mile-wide strip map at 1:24,000 scale, ArcGIS, 2007 NAIP orthophoto base, variety of topographic data



Verde River physiography

- Large, topographically rugged watershed
- Alternating bedrock canyons and alluvial basins
- Potential for large floods



River vs. Tributary deposits

Factor	River	Tributary
Gravel character	Many lithologies, some well-rounded	Limited lithologic mix, subangular to angular
Overbank (terrace) deposits	Thick, generally fine sand silt and clay with minor fine gravel layers; weakly developed buried soils	Generally thinner, poorly sorted fine gravel to silt
Landform slope	Low gradient, subparallel to river channel	Higher gradient, slope toward river

Holocene vs. older deposits

Factor	Holocene	Pleistocene
Surface character	Brown to gray, minimal or no rock varnish	Brown to reddish brown, reddish or brown rock varnish
Soil development	Weak to moderate cambic horizons, slight calcium carbonate	Moderate to strong, clay argillic horizons, obvious calcic carbonate
Vegetation	Hydro- or meso-riparian	Desert scrub
Height above river channel	0 to 30 ft	50 to 700 ft

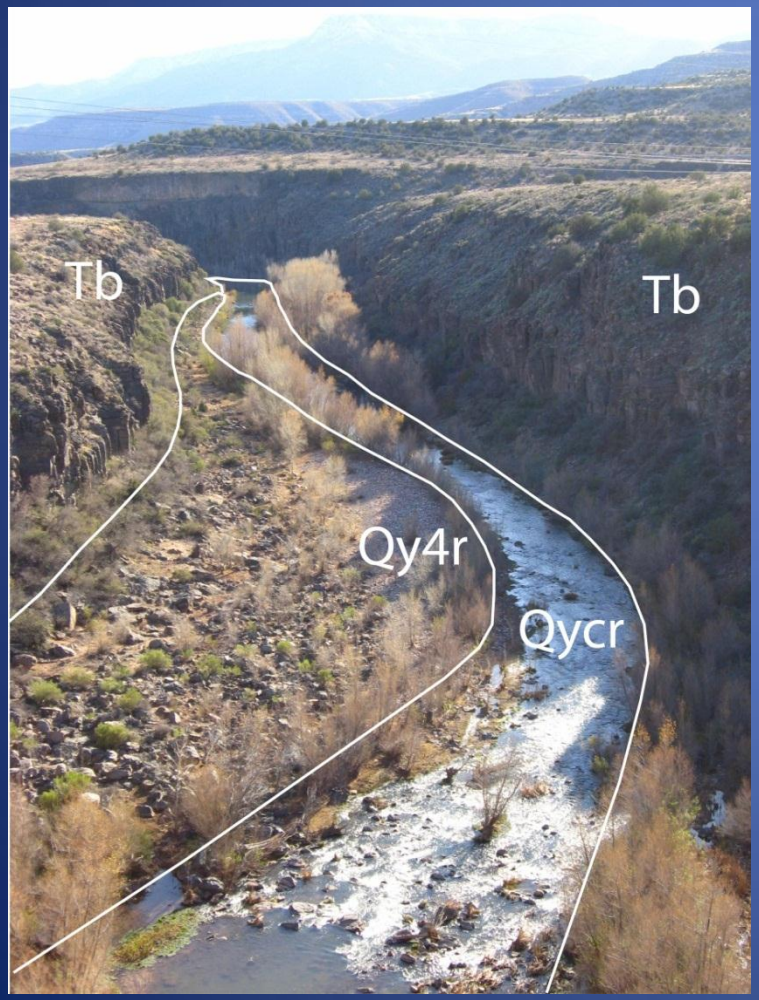
Age control on Holocene river deposits

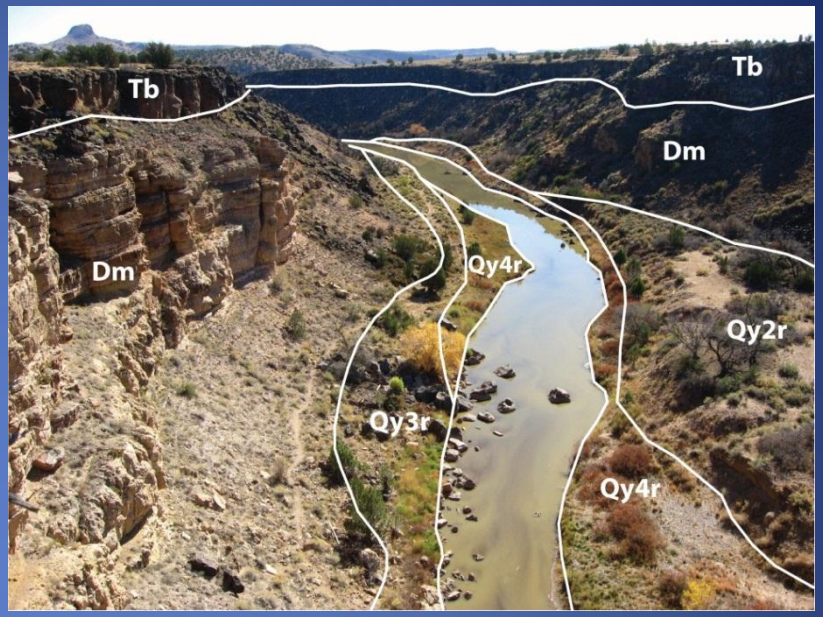
- All recorded archaeological sites possibly on Holocene river deposits were evaluated – prehistoric features on or in Qy2r terrace deposits
- Numerous (44) radiocarbon dates from flood studies that date to past 4,000 years
- A few late Pleistocene dates

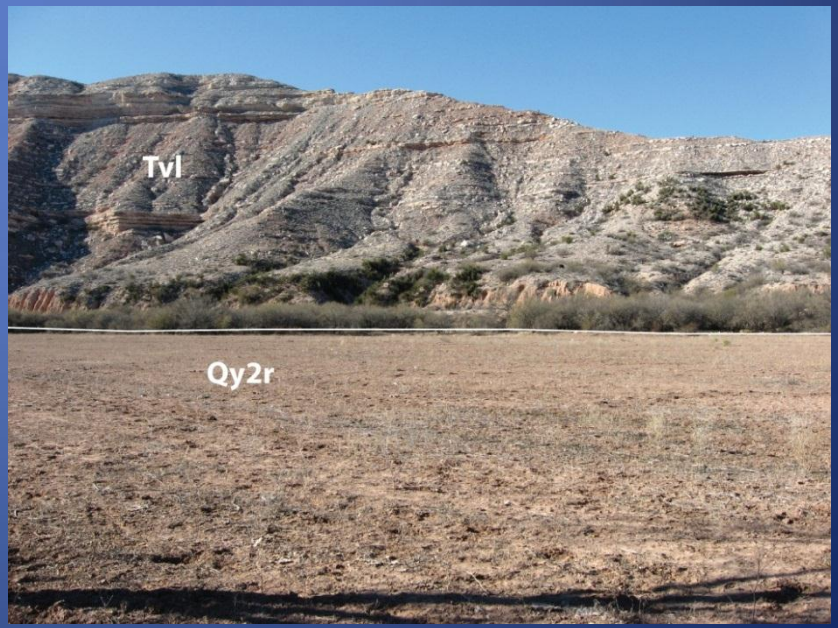
Map unit boundary uncertainty

Solid lines

- Accurately located contacts
- Abrupt, distinct boundaries clearly recognizable in the field and on aerial photos

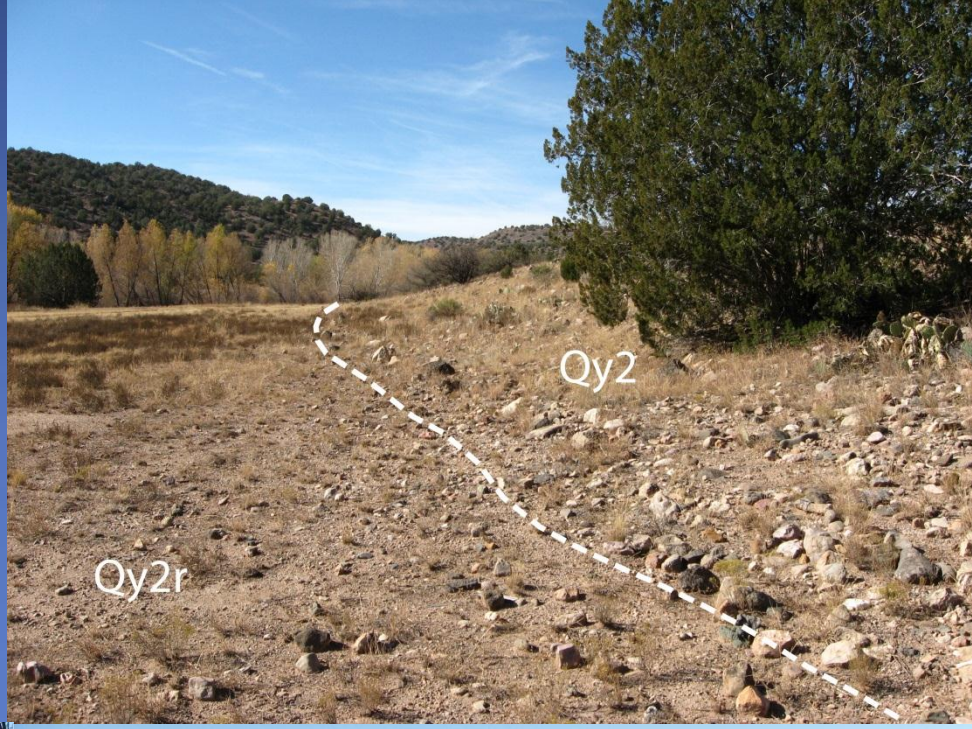


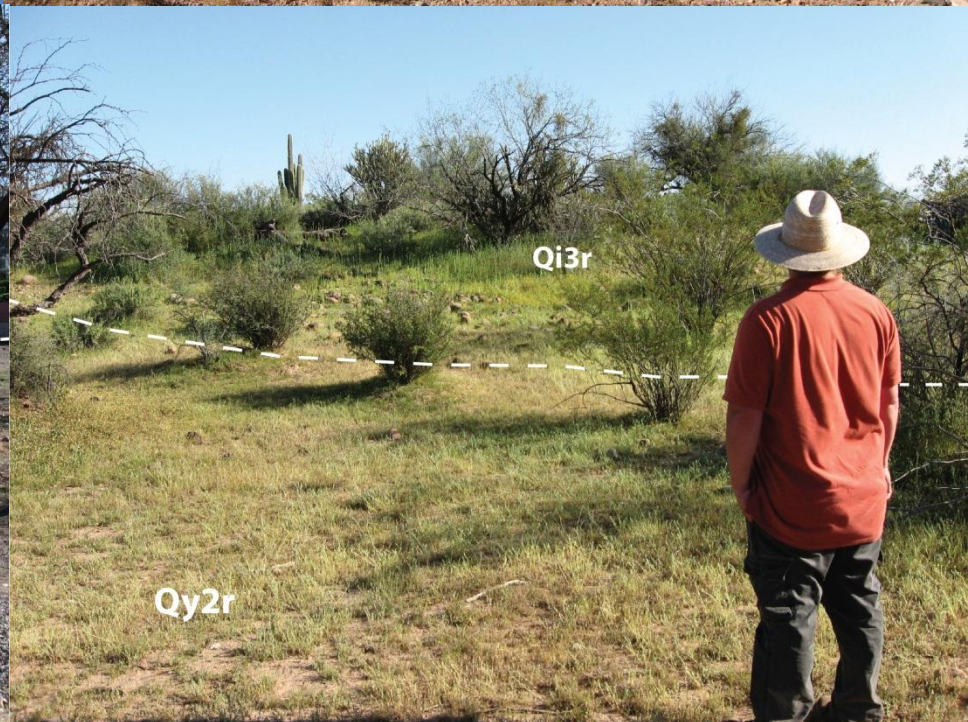




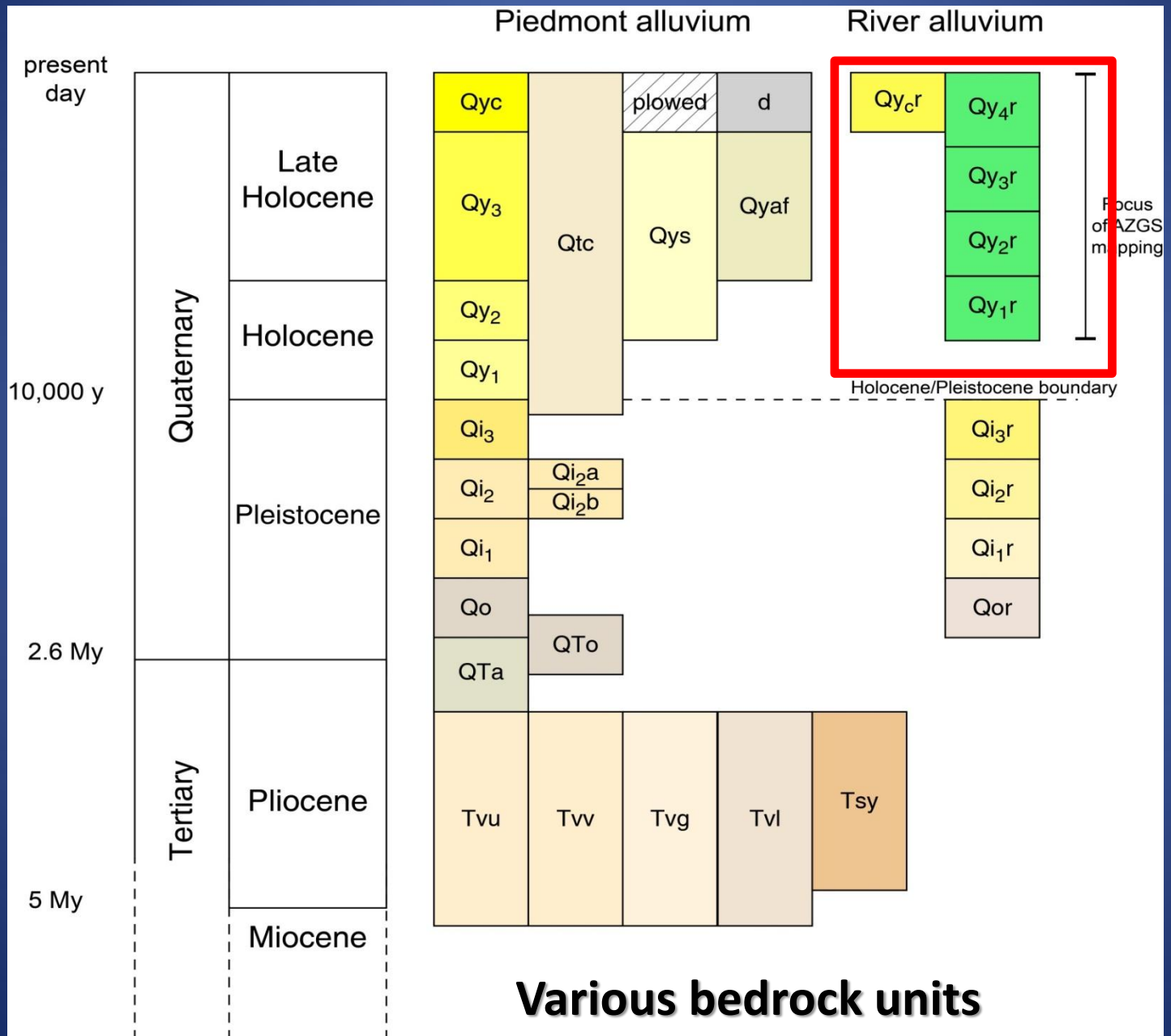
Dashed lines

- Subtle or gradational contacts
- Used along low relief fan boundaries
- Contacts obscured by human activities
- Change in slope or gravel character marks boundary





Stratigraphic Framework



Various bedrock units

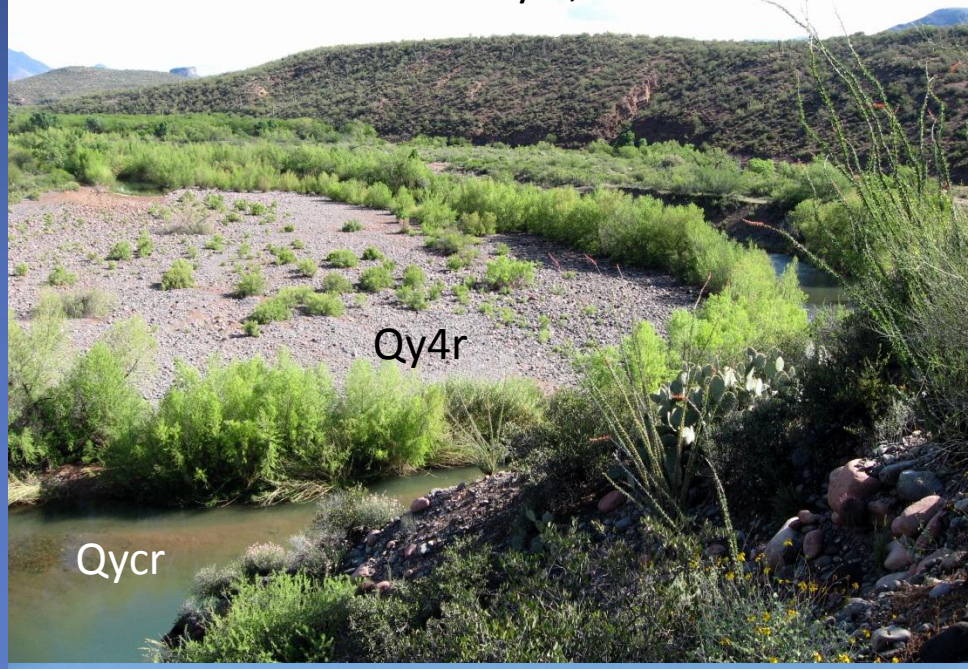
Active Channels - Qycr

- Unconsolidated gravel and sand
- Pool and riffle sequences
- Lined with riparian trees
- Commonly submerged

Flood channels - Qy4r

- Adjacent to Qycr deposits
- Inundated under higher flow
- No soil development
- Unvegetated or lightly vegetated
- Often show signs of recent flooding

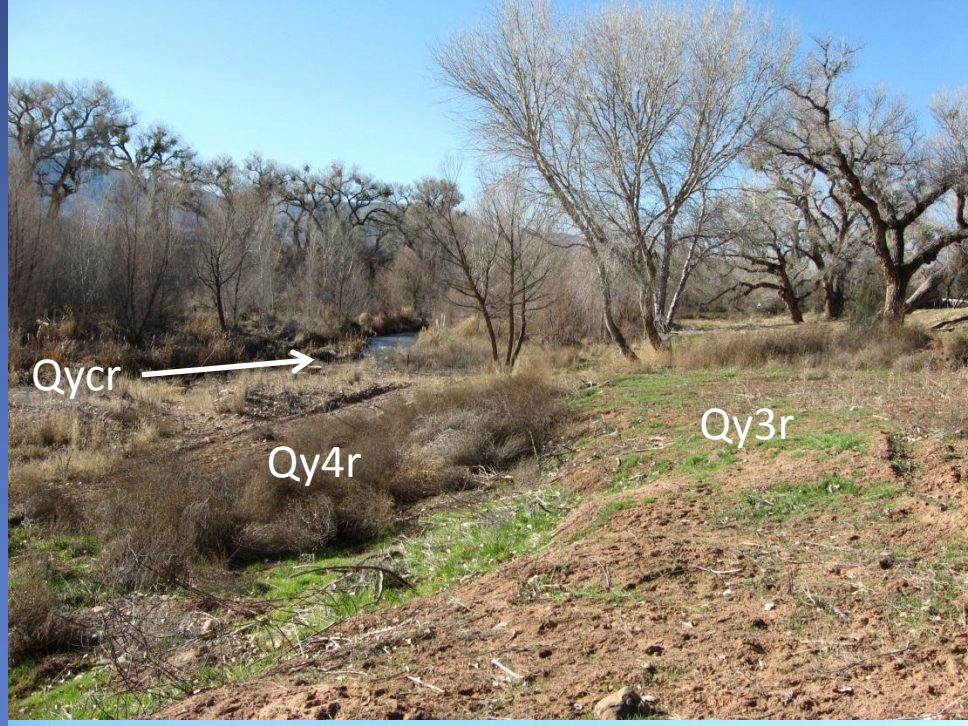
Wide cobble dominated Qy4r, Wild & Scenic Verde

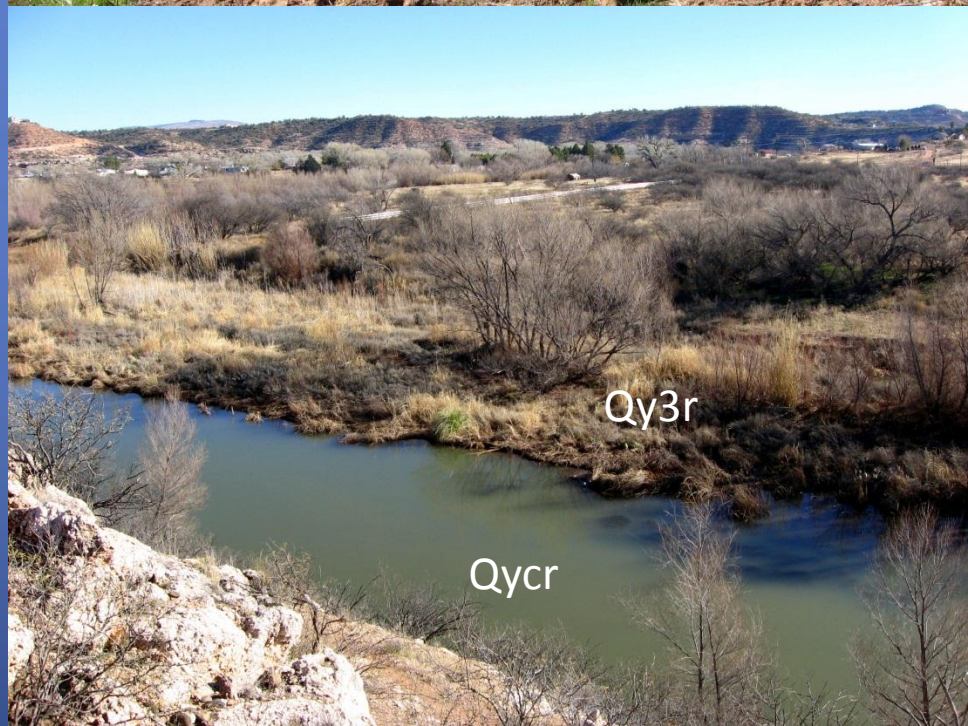


Wide sandy Qy4r, Fort McDowell Reservation

Floodplain / low terraces - Qy3r

- Higher than Qy4r surfaces
- Only inundated during more extreme flow
- Riparian trees, grasses
- Former floodplain and river meanders

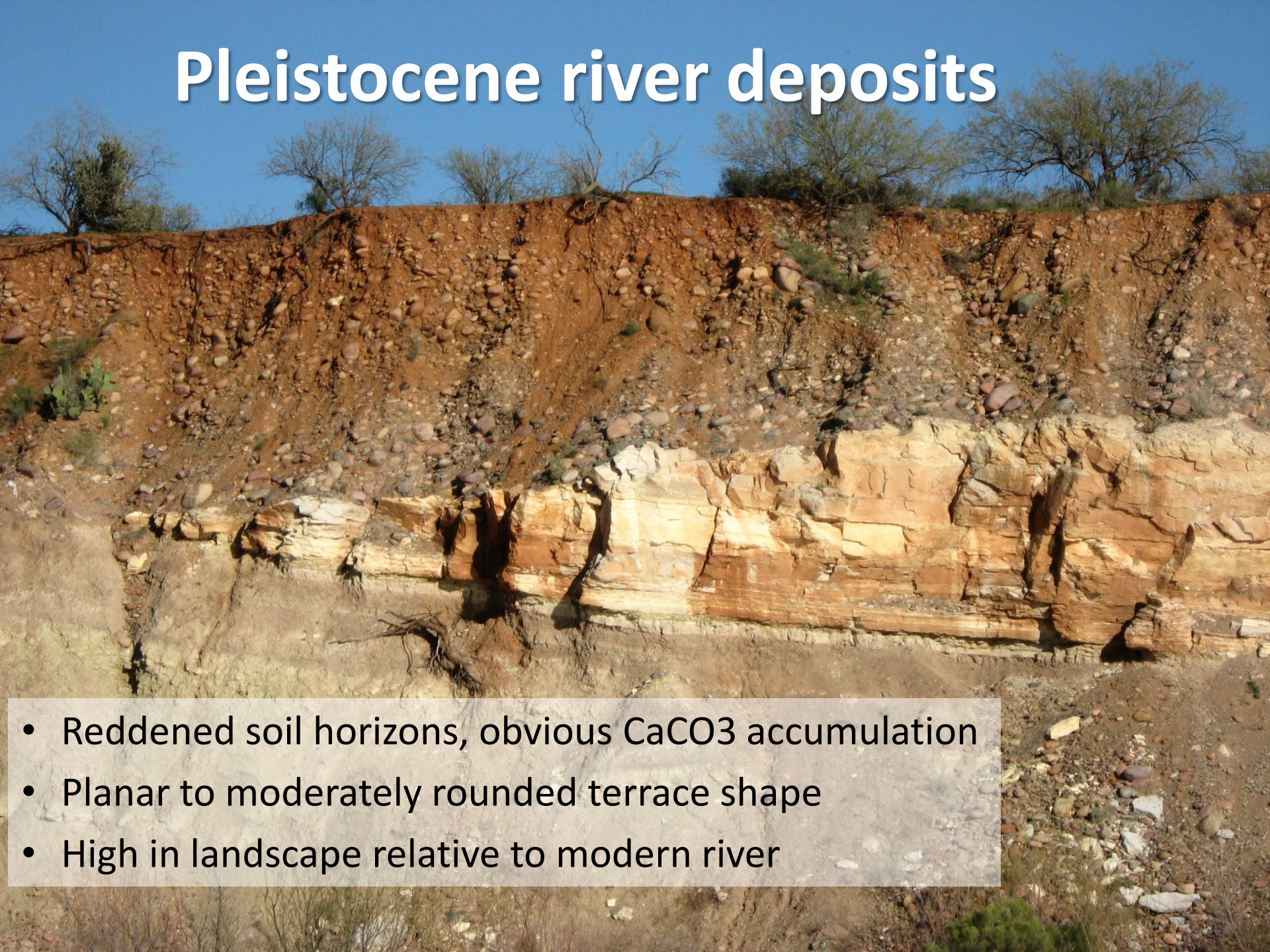




Young river terraces – Qy2r

- Higher in landscape than Qy3r terraces
- Generally fine-grained with gravel
- Some soil development, minor soil carbonate accumulation
- Typically are / were plowed & irrigated; developed near urban areas
- Usually most extensive terrace

Pleistocene river deposits



- Reddened soil horizons, obvious $CaCO_3$ accumulation
- Planar to moderately rounded terrace shape
- High in landscape relative to modern river

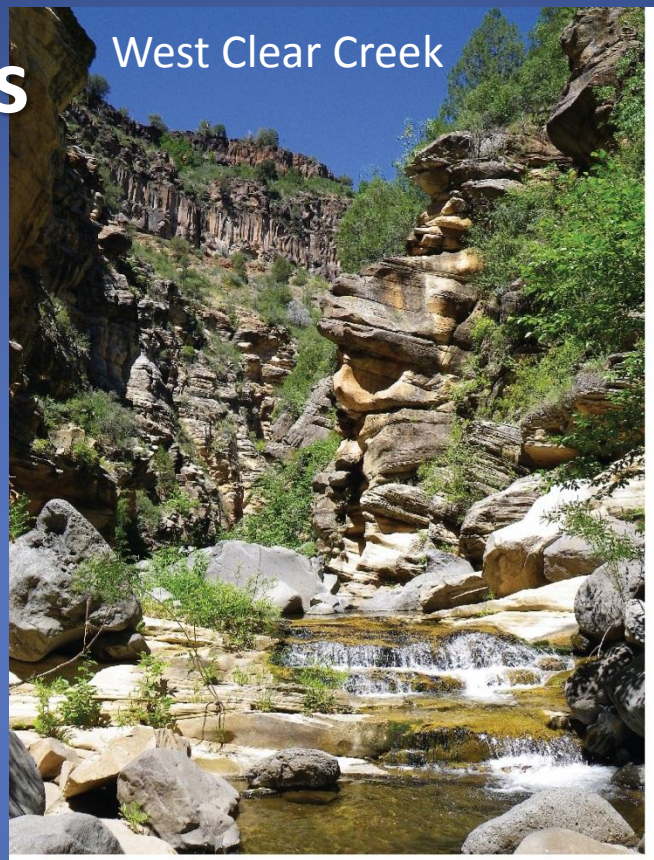
Pleistocene terraces stand high above the modern channel

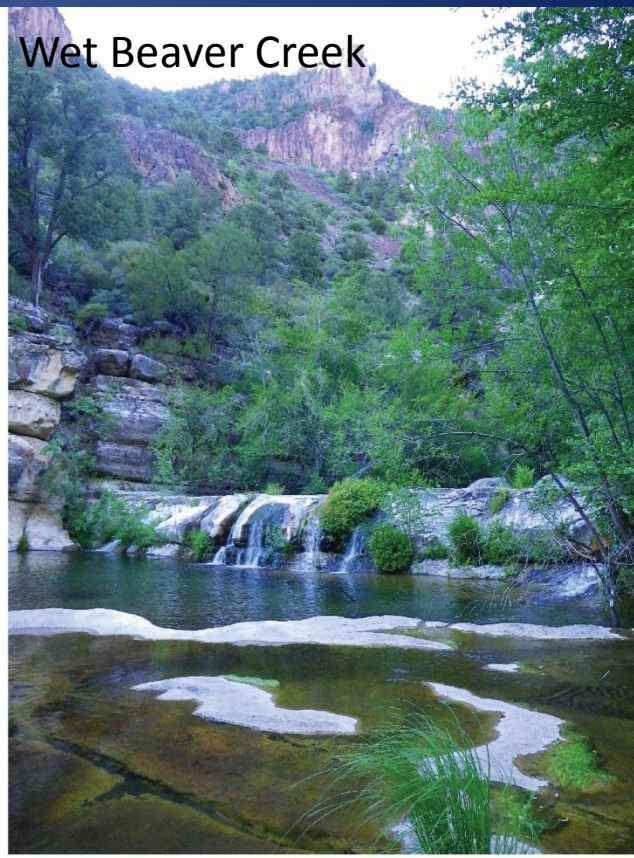
160 ft above modern channel near Beasley Flat

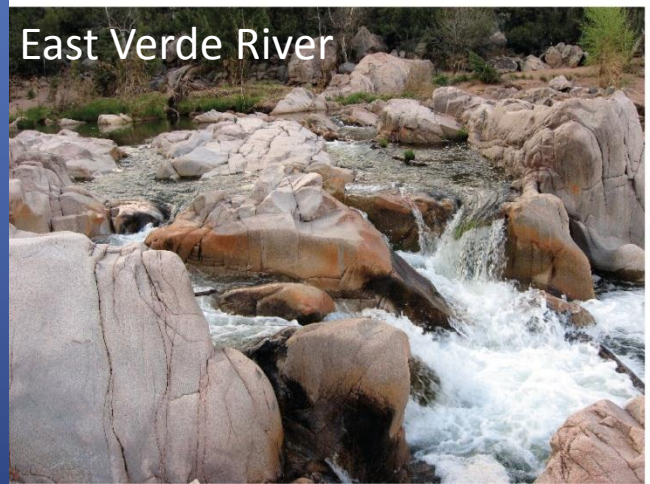
165 ft above modern channel at Verde – Salt confluence

Bedrock lined channel reaches

- Tributaries to Verde often very narrow bedrock lined channels
- Transient sediment present but extent depends on recent flow

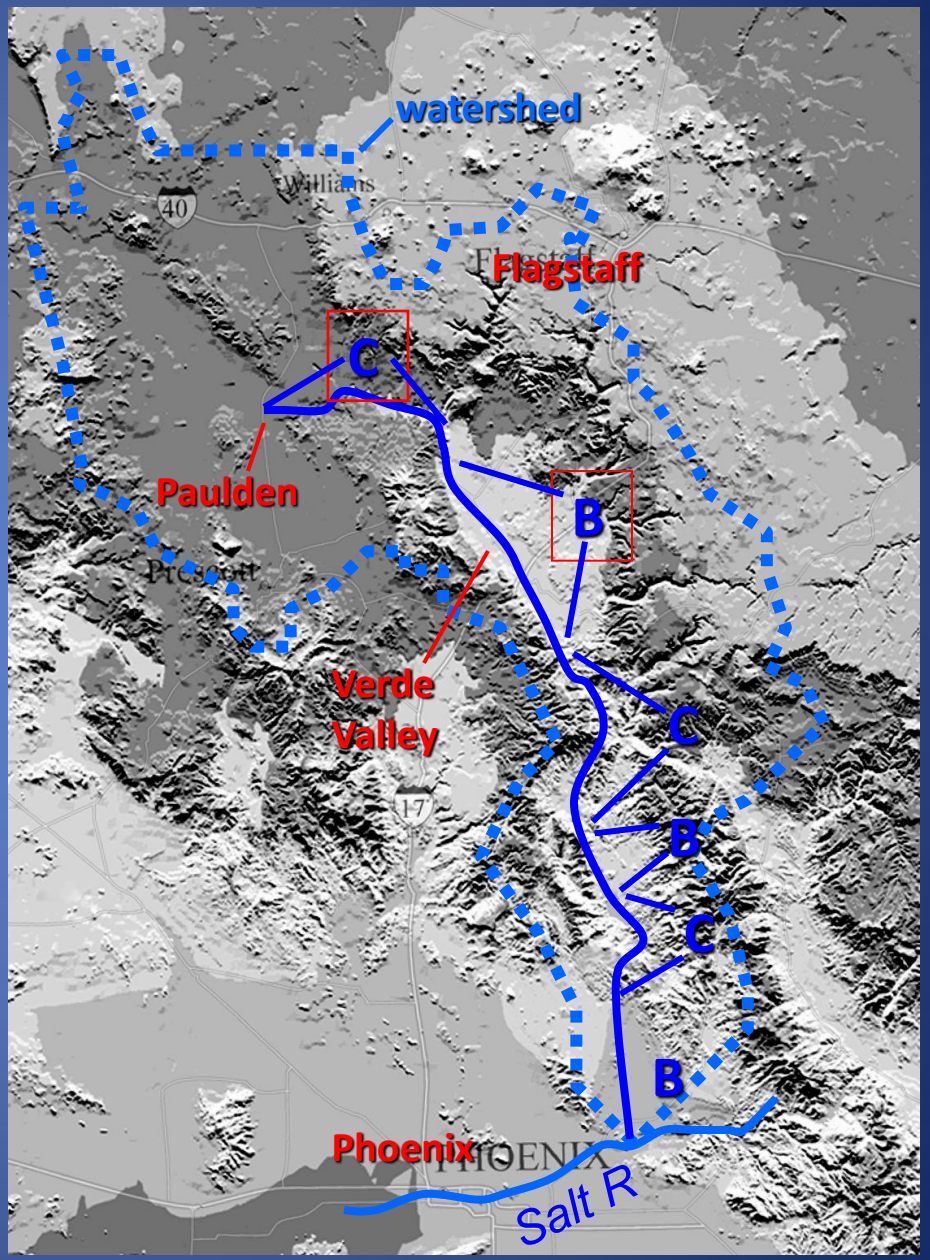






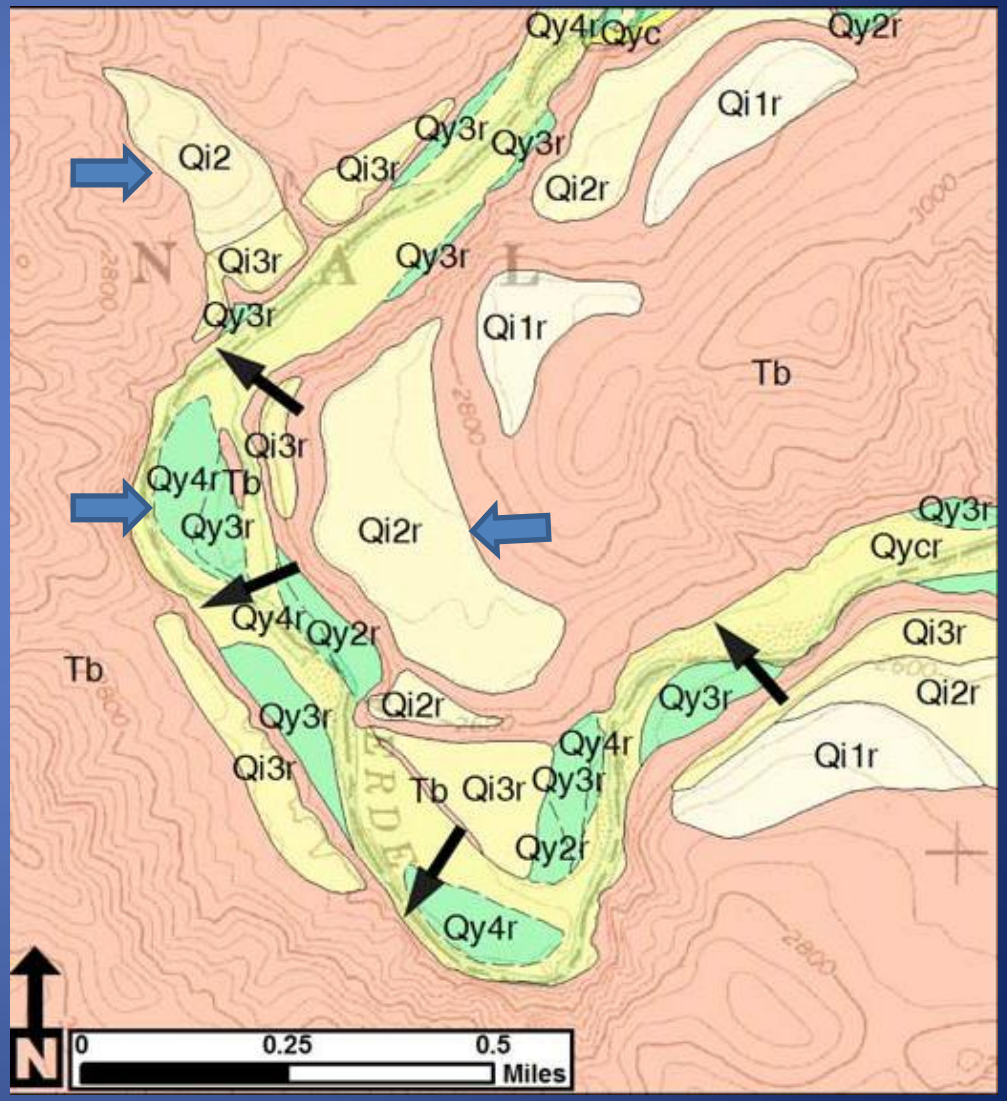
Verde River physiography

- Alternating bedrock canyons and alluvial basins
- Verde River entrenched everywhere and somewhat confined even in basins



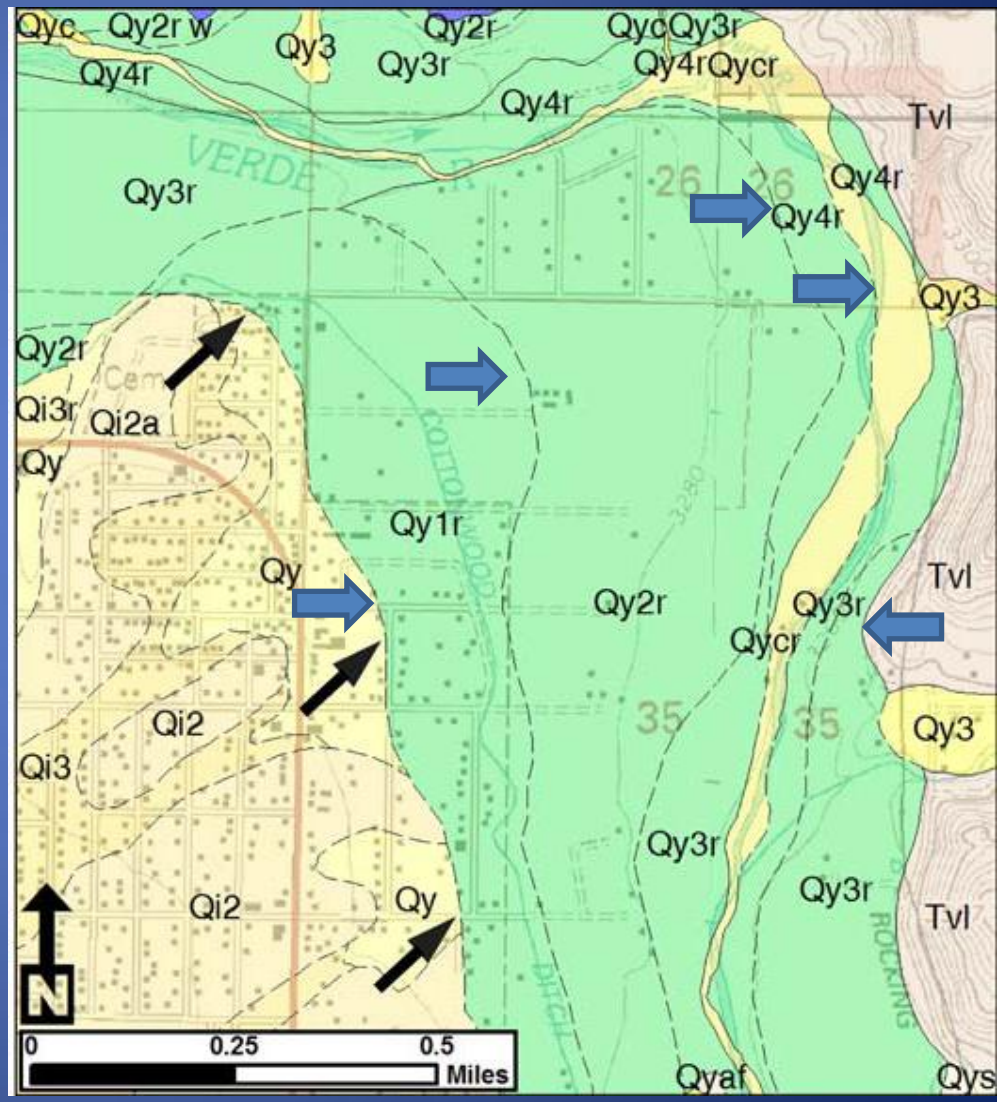
Canyon reaches

- Channels make up much of canyon bottomland; flood flows quite deep
- Low terrace deposits
- Tributary deposits limited in extent
- Remnant Pleistocene river terraces

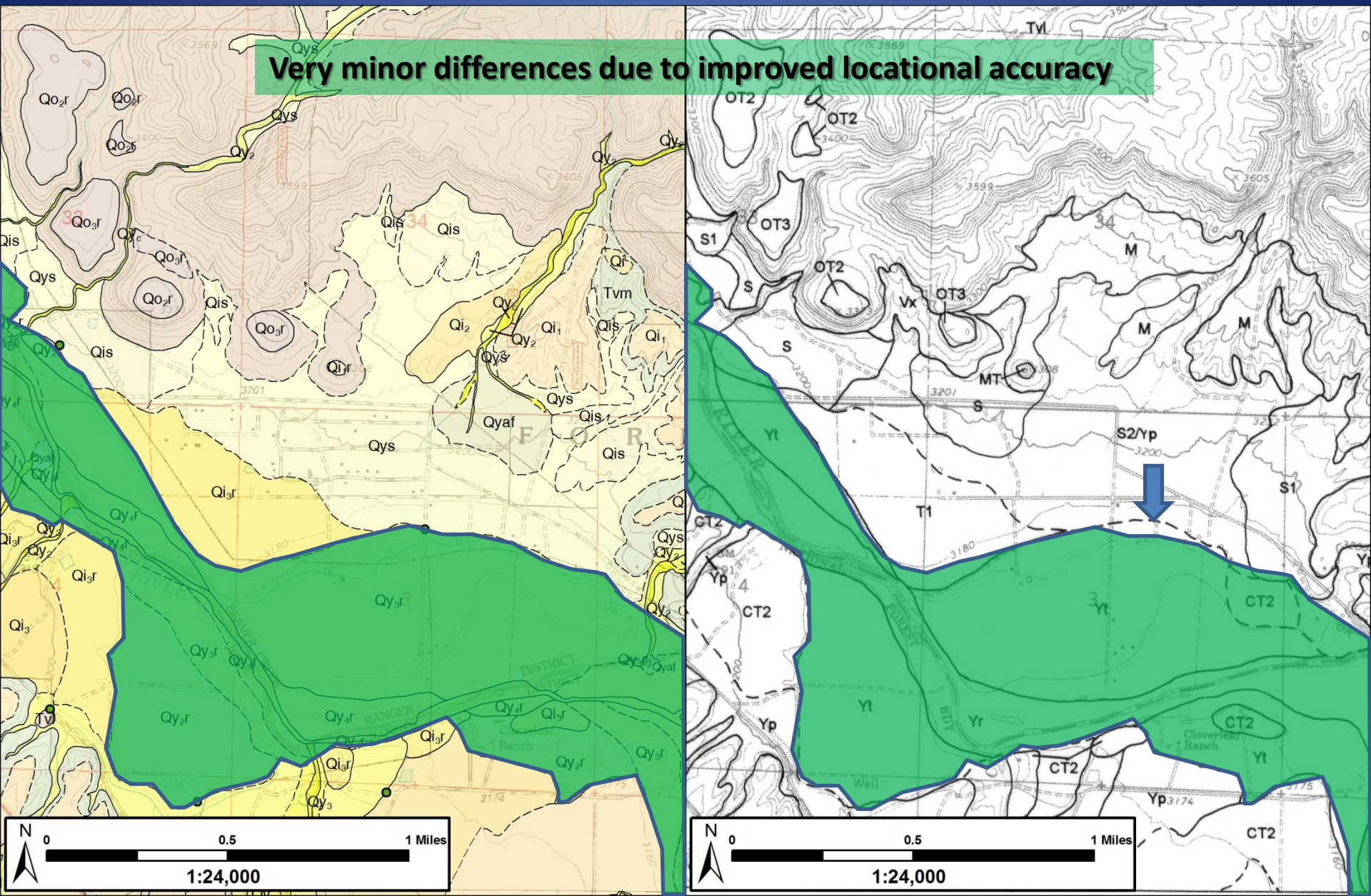


Basin reaches

- active channel a small part of river system
- flood channels much wider
- extensive young terraces
- tributary deposits grade to them
- lateral topographic constraints older river deposits or eroded basin deposits

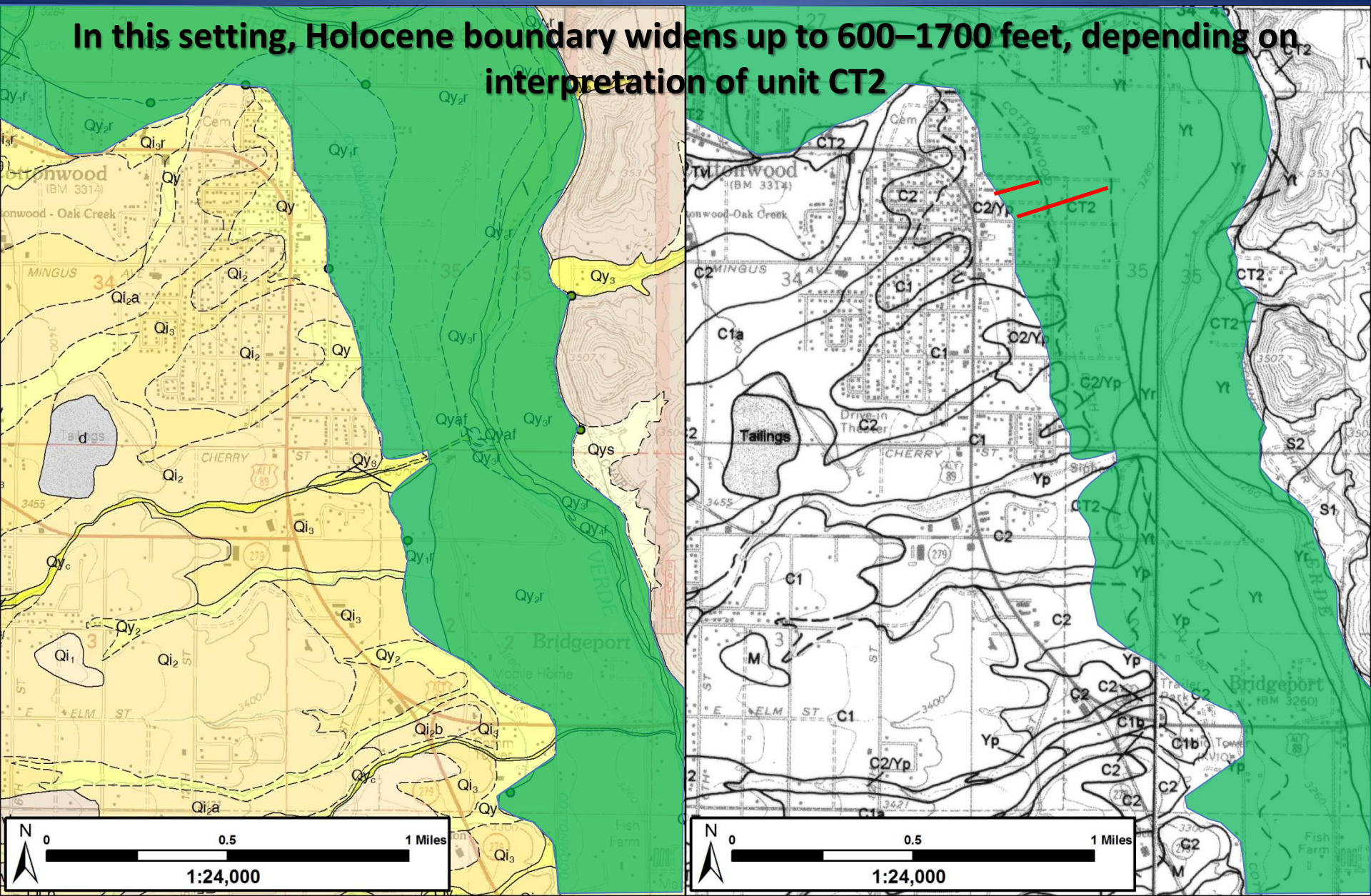


Changes between older and new mapping

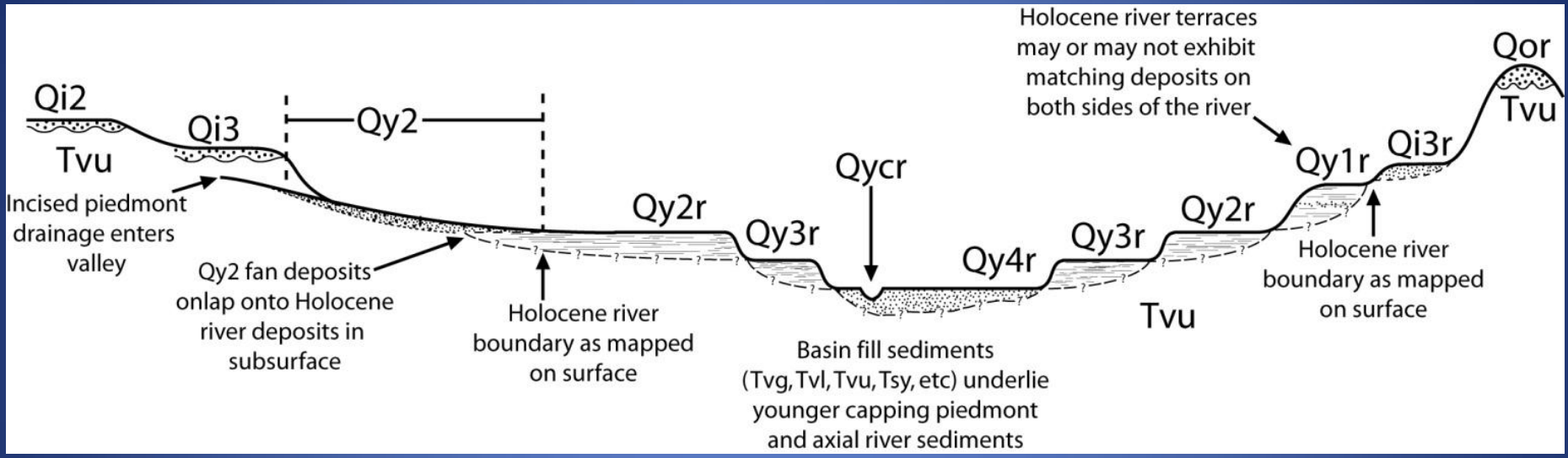


There are some borderline geologic units

In this setting, Holocene boundary widens up to 600–1700 feet, depending on interpretation of unit CT2

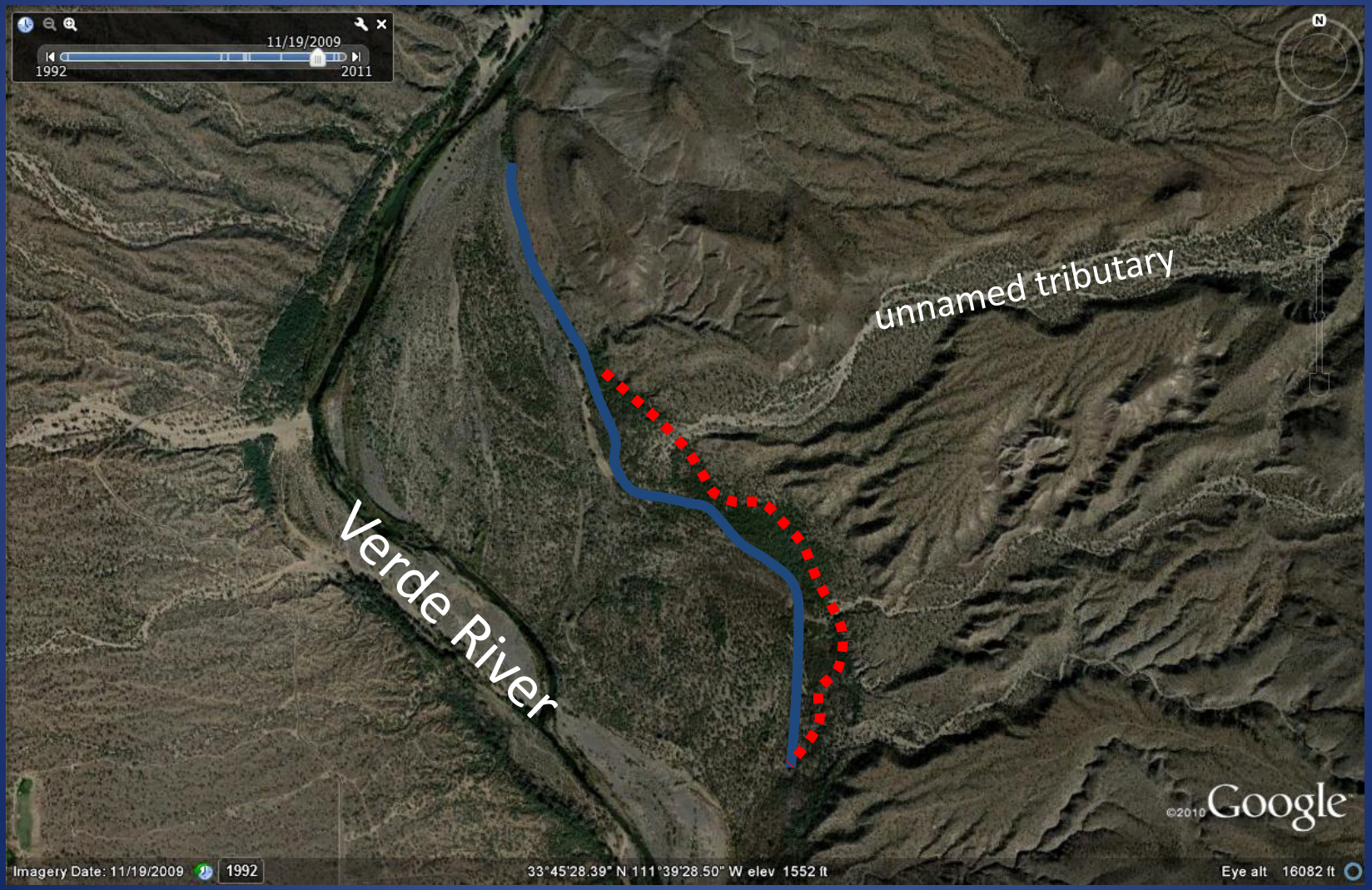


What about the subsurface?



- Lots of dashed lines and question marks
- Variation from place to place
- Generally, we think that Holocene river deposits are thin

River – tributary 3D complexities



Summary

- Holocene river alluvium has been mapped consistently
- Depiction of boundary uncertainty
- Width of Holocene river alluvium varies with geologic / geomorphic setting
- Does not address potential 3-D complexities
- Important component of subflow delineation, but is not the subflow delineation
- Fairly detailed description of physical framework of riparian corridors

For more information

- ADWR
  - Adjudications - http://www.azwater.gov/AzDWR/SurfaceWater/Adjudications/
  - Original San Pedro Subflow Report, Objections, ADWR response
- AZGS publications
  - http://www.azgs.state.az.us/
  - DM-RM-2, Mapping of Holocene River Alluvium along the Verde River, Central Arizona by J.P. Cook, P.A. Pearthree, P.A. Onken, A. Youberg and E.R. Bigio, 2010
  - DM-RM-3, Mapping of Holocene River Alluvium Along Oak Creek, Wet Beaver Creek, West Clear Creek Fossil Creek, and the East Verde River, Central Arizona by J.P. Cook, P.A. Pearthree, J.A. Onken, E.R. Bigio, 2010