Geologic Map of the Cañon Largo Watershed on the Jicarilla Apache Nation, Rio Arriba and Sandoval Counties, New Mexico

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by
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Comments to Map Users

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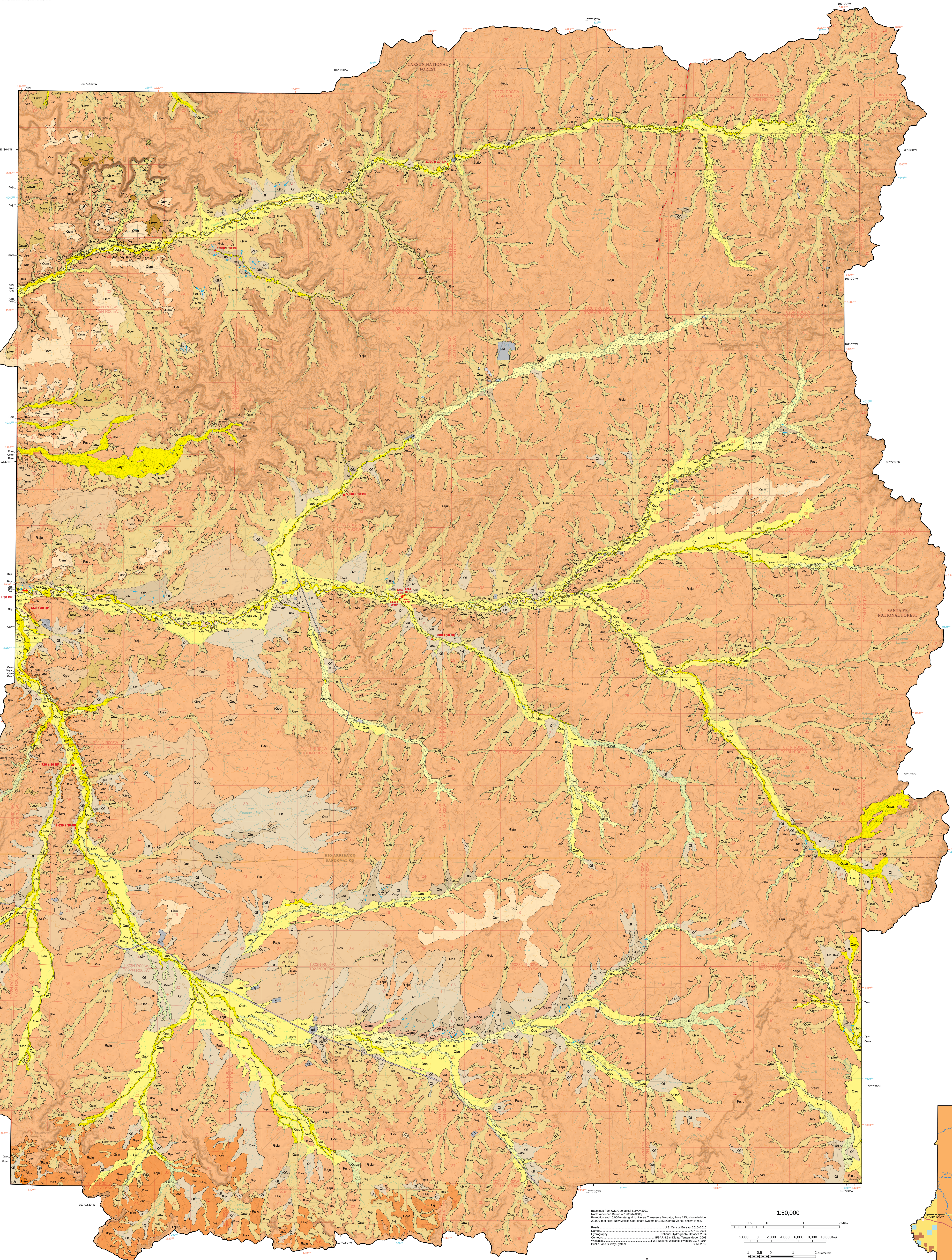
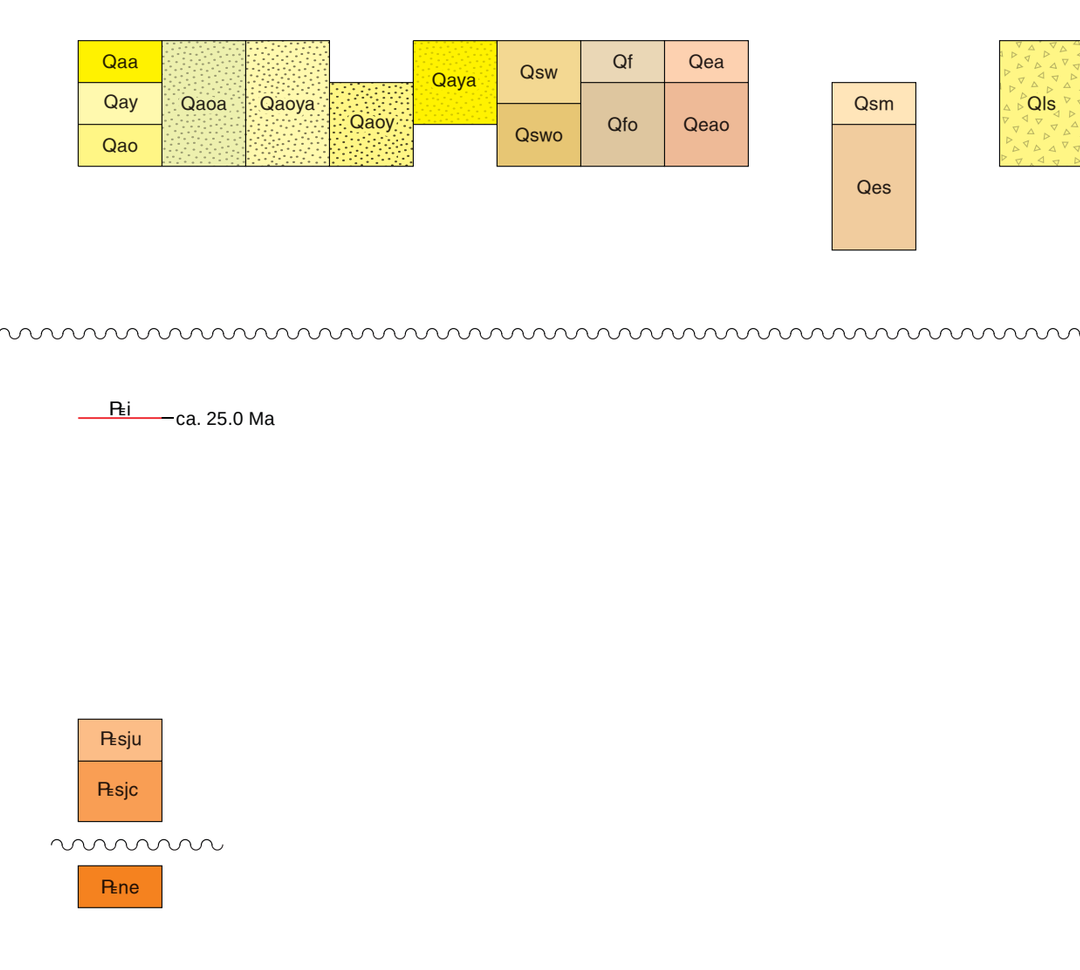


1:50,000

Correlation of Map Units



Description of Map Units

QUATERNARY

Anthropogenic Units

af — **artificial fill (present to ca. 0.1 ka)**—Accumulations of clay, silt, and sand for the construction of dams, berms, roads, and well pads. Deposits of clay, silt, sand, and pebbles on the upstream sides of dams. The thickness is 1–5 m (3.3–16.4 ft).

ad — **disturbed ground (present to ca. 0.1 ka)**—Disturbed ground and soil dump areas mapped where the original topography or geomorphic expression is obscured or significantly altered. Includes a 50 ha (123 acre) soil reclamation facility on Highway 537 on the north side of Cañon de los Ojitos. Where used for infrastructure, like electric power transformer stations or well pads, this map unit is sometimes capped with trucked-in gravel of different lithologic composition than other gravels found in situ within the map area. The thickness is <1 m (<3.3 ft).

Valley-Floor Units

Qaa — **active alluvium (present to historic)**—Stream-deposited clay, silt, sand, and gravel within channels of active ephemeral and intermittent streams. This deposit occupies the lowest geomorphic position in any alluvially active valley. Mineral composition and grain rounding are influenced by, and largely inherited from, the bedrock composition of the drainage basin in which the deposit is found; deposits typically have the composition of feldspathic arenite or feldspathic wacke. A typical deposit consists of light-yellowish-brown, light-brown, or light-gray unconsolidated sand and silty sand with subordinate pebbly silty sand, sandy silt, and silty clay. The average sand grain size is slightly larger than that of the older alluvial units (map units **Qay** and/or **Qao**) in the same reach of the valley. The deposit contains trace pebble- through boulder-sized, rounded to spherical mud clasts. In Tapicito Creek, the deposit contains pebbles through cobbles of subangular to subrounded trachybasalt derived from dikes at Tapicito Ridge. In addition, the deposit sometimes contains rounded cobbles through boulders of quartzite, granite, gneiss, schist, and/or metapelite assumed to have been transported downstream from road crossings, where it was placed as non-locally sourced aggregate. The deposit contains anthropogenic detritus at the surface and in cross-sectional outcrop at a depth of up to 2 m (6.6 ft), including common litter, asphalt macadam, wire fencing, fenceposts, rubber tires, and household appliances. Bedforms include trough cross-bedding, ripple cross-bedding, ripple laminations, graded bedding, scour-and-fill structures, and plane bedding. In cross section, horizontal-plane bedding is the predominant bedform. Waning-stage mud films often overlie this unit but are rarely, if ever, preserved; muds at the surface are presumably removed during the early stages of subsequent streamflow events. This unit includes minor eolian dunes that are too small to map at the 1:50,000 scale; these dunes are up to 2 m (6.6 ft) high and are rare but present in cross-sectional outcrops. This unit does not effervesce in 10% HCl. The unit is predominantly unvegetated; primary successional grasses and forbs are present but rare. Perpendicular to the down-valley direction, the topographic profile atop this unit is horizontal. The observed thickness is 3 m (9.8 ft); the total thickness is unknown.

Qay — **young alluvium (historic to ca. 1.4 ka)**—Stream-deposited clay, silt, sand, and gravel in valley floors that compose the first alluvial terrace above the active stream bed. Where present, this unit occupies the second-lowest geomorphic position in the valley. Mineral composition and grain rounding are influenced by, and largely inherited from, the bedrock composition of the drainage basin in which the deposit is found; deposits typically have the composition of feldspathic arenite or feldspathic wacke. A typical deposit consists of light-yellowish-brown, light-brown, or light-gray; poorly consolidated to unconsolidated sand and silty sand with subordinate pebbly silty sand, sandy silt, and silty clay. The average sand grain size is typically slightly finer than **Qaa** but slightly coarser than **Qao** in the same reach of the valley. In Tapicito Creek, the deposit contains pebbles through cobbles of subangular to subrounded trachybasalt derived from dikes at Tapicito Ridge. In Tapicito Creek and Cañon de los Ojitos, this unit contains trace anthropogenic detritus up to 1 m (3.3 ft) below the surface, including glass bottles and rubber tires. Bedforms include cross-bedding, ripple cross-bedding, ripple laminations, graded bedding, scour-and-fill structures, and plane bedding. In cross section, horizontal-plane beds comprise approximately 90% of observed bedforms. Bed thickness varies from laminated (<1 cm [<0.4 in]) to thick (>30 cm [>11.8 in]). Thin beds are the most dominant. Reddish-brown to light-reddish-brown paleosols up to 80 cm (31.5 in) thick with columnar peds, weak horizonation, and root traces are present but rare. Loosely to moderately consolidated; forms vertical faces up to 2.5 m (8.2 ft) tall. There is a distinct contact with underlying units. There is a gradational contact with surrounding fans and colluvial deposits. Where present in the same valley as older alluvium (unit **Qao**), this unit is inset by 1.5–7 m (4.9–23 ft) in a lower geomorphic position. Radiocarbon dates from charcoal collected within this unit on the Jicarilla Apache Nation range from 0.5–1.38 ka. The unit displays weak effervescence in 10% HCl at depths of 10–20 cm (3.9–7.9 in) below the surface. Surfaces of this unit typically contain grama grass (*Bouteloua sp.*), galleta grass (*Hilaria jamesii*), saltbrush (*Artiplex canescens*), big sagebrush (*Artemisia tridentata*), and chamisa (*Ericameria nauseosa*), with subordinate saltcedar (*Tamarix ramosissima*) and cottonwood (*Populus sp.*). Bar-and-swale topography up to 30 cm (11.8 in) tall is plainly evident on some surfaces. The unit includes minor amounts of debris fans, canyon-mouth fans, colluvium, eolian dunes, and sheetwash deposits. Perpendicular to the down-valley direction, the topographic profile atop this unit is horizontal. The observed thickness is 1.5–2.5 m (4.9–8.2 ft); the total thickness is unknown.

Qao — **older alluvium (Holocene)**—Clay, silt, sand, and gravel that underlie terraces 3.5–9 m (11.4–29.5 ft) above the active stream bed. Sediment is in laminated to thick tabular to lenticular beds with cross-beds, ripple cross-beds, graded bedding, scour-and-fill structures, and horizontal-plane beds. In cross section, horizontal plane beds comprise approximately 80% of observed bedforms and trough cross-beds comprise approximately 15% of observed bedforms. Mineral composition and grain rounding are influenced by, and largely inherited from, the bedrock composition of the drainage basin in which the deposit is found; deposits typically have the composition of feldspathic wacke with subordinate feldspathic arenite. The average sand grain size is finer than that of the younger alluvial units (map units **Qay** and/or **Qaa**) in the same reach of the valley. A typical deposit consists of brown, light-brown, or yellowish-brown, loosely to moderately consolidated silty sand with subordinate silty clay, pebbly silty sand, sandy silt, and trace sandy gravel. Reddish-brown to light-reddish-brown paleosols with columnar peds and root traces are common; Stage II calcic horizons are present in some of these paleosols. This unit forms vertical faces up to 10 m (32.8 ft) tall. Where observed, this unit has a distinct contact with underlying units (typically Paleogene sandstones). There is a gradational contact with surrounding fans and colluvial deposits. This unit occupies the highest landscape position out of all alluvial units in the map area. Radiocarbon dates from charcoal collected within this unit on the Jicarilla Apache Nation range from 1.48–8.0 ka. This unit displays moderate effervescence in 10% HCl at depths of 10–30 cm (3.9–11.8 in). The surface of this unit typically contains plant communities dominated by big sagebrush (*Artemisia tridentata*), chamisa (*Ericameria nauseosa*), and saltbrush (*Artiplex canescens*), with rare cottonwood (*Populus sp.*), juniper (*Juniperus sp.*), piñon (*Pinus edulis*), cane cholla (*Cylindropuntia imbricata*), and prickly pear (*Opuntia sp.*). The unit includes debris fans, canyon-mouth fans, colluvium, and minor sheetwash alluvium. The surface topography is muted. This unit is differentiated from map unit **Qay** (young alluvium) by higher geomorphic position, slightly finer-grained texture, slightly darker color in outcrop, and a different plant community. Since the 19th century, this unit has been incised by up to 10 m (32.8 ft). Perpendicular to the down-valley direction, the topographic profile atop this unit is horizontal. The observed thickness is 7–10 m (23–32.8 ft); the total thickness is unknown.

Qaoa — **combination of Qao and Qaa (present to Holocene)**—Combined map units where **Qaa** and **Qao** share a contact but are too small to map separately at the 1:50,000 scale. Does not include map unit **Qay**.

Qaoya — **combination of Qao, Qay, and Qaa (present to Holocene)**—Combined map units where **Qao**, **Qay**, and **Qaa** share contacts but are too small to map separately at the 1:50,000 scale.

Qaoy — **combination of Qao and Qay (historic to Holocene)**—Combined map units where **Qao** and **Qay** share a contact but are too small to map separately at the 1:50,000 scale. Does not include map unit **Qaa**.

Qaya — **combination of Qay and Qaa (present to ca. 1.4 ka)**—Combined map units where **Qay** and **Qay** share a contact but are too small to map separately at the 1:50,000 scale. Does not include map unit **Qao**.

Other Alluvial Units

Qsw — **sheetwash deposits (present to Holocene)**—Unconsolidated to weakly consolidated clay, silt, sand, and gravel. This unit includes minor colluvium on the toes of slopes. This unit may include mudflows, poorly sorted debris flow deposits, and associated debris flow levees at the foot of slopes. At the base of slopes, this unit includes locally-derived clay, silt, sand, and mud, whose composition and texture are controlled by the composition of upslope bedrock outcrops. In these settings, the unit often includes coalesced alluvial sediment aprons that grade upslope into colluvial aprons. Where this unit is found on broad upland flats, it consists of alluvially reworked eolian sands. In these settings, it comprises weakly consolidated, light-brown to light-yellowish-brown, poorly to moderately sorted clay, silt, and sand in poorly expressed very thin to medium horizontal-plane beds. In cross section, this unit exhibits poorly expressed plane bedding or no visible bedding. Cut-and-fill structures are not observed. Root traces and buried in situ vegetation are more common in this unit than in valley-floor units. This unit grades laterally into adjacent map units. In steep, narrow drainages, this unit consists of brown, light-brown, or yellowish-brown; cobbly, pebbly, and bouldery; medium- to very coarse-grained sand with minor sandy silt and trace sandy gravel. Reddish-brown paleosols are present in most outcrops. The surface of this unit usually contains a soil marked by a 30–50-cm-thick (11.8–19.7 in) Btw horizon. Weak effervescence in 10% HCl indicates the presence of calcium carbonate. Flow paths on the surface are non-parallel. Areas of recent deposition host grasses at the surface, while less recently active areas host roughly equal proportions of saltbrush (*Artiplex canescens*) and big sagebrush (*Artemisia tridentata*), with subordinate grasses, Mormon tea (*Ephedra sp.*), broom snakeweed (*Gutierrezia sarothrae*), prickly pear (*Opuntia sp.*), and cane cholla (*Cylindropuntia imbricata*). In upland areas, the contact with the underlying unit often is gradational and may be obscured by pedogenic or paleo-pedogenic alteration. Where found at the base of slopes, the lower contact is often distinct and marked by a scour surface. The contacts with adjacent units are gradational and this unit interfingers with alluvium. One radiocarbon date from charcoal found within this unit yields an age of 5.8 ka. This unit is rarely sharply incised and subdued topography is prevalent. The cross-sectional profile of the surface is not horizontal; where confined to a valley, the profile is concave-up. This unit has been incised up to 12 m (39.4 ft). The observed thickness is 1–12 m (3.3–39.4 ft); the total thickness is unknown.

Qswo — **older sheetwash alluvium (Holocene to Pleistocene)**—Weakly consolidated clay, silt, sand, and gravel in a higher landscape position than map unit **Qsw**; otherwise similar lithologic description as **Qsw**. This unit appears darker and redder on orthophotographs and in outcrop and lacks any indication of recent or active deposition at the surface. The surface of the unit is smooth and hosts plant communities which include grasses, big sagebrush (*Artemisia tridentata*), and chamisa (*Ericameria nauseosa*) with rare pines and junipers. When measured, it has a concave-up topographic profile that is perpendicular to flow direction. The observed thickness is 2–8 m (6.6–26.2 ft); the total thickness is unknown.

Fan Deposits

Qf — **fan deposits (present to Holocene)**—Unconsolidated to weakly consolidated silty sand, sand, and pebbly sand with trace cobbles. The lithologic composition is inherited from the bedrock composition of drainages upstream of the deposit. Internal structures include massive horizontal-plane beds, lenticular beds, cut-and-fill structures, and pebble imbrication. The sand is typically light-brown or yellowish-brown. The weakly developed topsoil includes a Btw horizon and is up to 50 cm (19.7 in) thick. There are up to 120 cm (47.2 in) of channel and swale topography on the surface of this deposit. In aerial photographs, active avulsions and deposition can be observed within this unit between 1997 and 2017. The plant community at the surface includes grama grass (*Bouteloua sp.*), galleta grass (*Hilaria jamesii*), saltbrush (*Artiplex canescens*), big sagebrush (*Artemisia tridentata*), and chamisa (*Ericameria nauseosa*). Flow paths show radial flow directions from the apex of the fan. This unit interfingers with adjacent alluvial deposits of the same age. This unit has been incised by up to 2 m (6.6 ft). The thickness is <10 m (<32.8 ft).

Qfo — **older fan deposit (Holocene)**—Loosely to weakly consolidated silty sand, sand, and pebbly sand with trace cobbles. The lithologic composition is inherited from the bedrock composition of drainages upstream of the deposit. Limited outcrop exposures preclude describing the internal structure and total thickness. This unit occupies a higher landscape position than the adjacent younger fan deposits of map unit **Qf**. The surface of this unit is also smoother than that of map unit **Qf**. Very weak to weak effervescence in 10% HCl at depths of 10–30 cm (3.9–11.8 in). No active avulsion or deposition is observed in aerial photographs. The plant community at the surface is dominated by saltbrush (*Artiplex canescens*), big sagebrush (*Artemisia tridentata*), and chamisa (*Ericameria nauseosa*). This unit interfingers with adjacent alluvial deposits of the same age. Where this unit borders younger fan deposits of map unit **Qf**, it is 1–2 m (3.3–6.6 ft) higher. The thickness is likely <12 m (<39.4 ft).

Mixed Eolian-Alluvial Units

Qea — **active to historic eolian deposits derived from sand-bed arroyos and within valley floors (present to 0.2 ka)**—Well-sorted coarse-grained silt to medium-grained sand that is light-yellowish-brown to white and unconsolidated. Bedforms include laminated to thin cross-beds with subordinate horizontal-plane beds. Ripples and sand avalanches are seen on active deposits. The grains are subrounded to subangular and are composed of quartz, feldspars, and lithic fragments. Little to no frosting is observed. The deposits have the composition of feldspathic arenite. This unit includes coppice dunes up to 3 m (9.8 ft) tall. The deposit is frequently reworked by lateral migration of active stream channels in west-flowing drainages such as Tapicito Creek and Cañada Larga. The unit also includes minor amounts of alluvium and sheetwash around active and stabilized dunes. Where dunes block surface drainages, and in deflation blowouts, the unit includes subordinate palustrine deposits consisting of horizontal-plane laminated clay and silt. Active dunes are 1.5–7 m (4.9–23 ft) tall. Stabilized dunes typically contain sacaton grass (*Sporobolus sp.*), grama grass (*Bouteloua sp.*), cocklebur (*Xanthium sp.*), and saltbrush (*Artiplex canescens*). This unit does not react with 10% HCl. The dunes sometimes bury riparian trees and shrubs. This unit can be differentiated from map unit **Qes** (eolian sheet sands) by its lower geomorphic position, active dunes, less mature lithologic composition, lighter color, and less-developed soil. The thickness is 1–8 m (3.3–26.2 ft).

Qeao — **inactive stabilized eolian deposits derived from sand-bed arroyos and within valley floors (Holocene)**—Well-sorted, coarse-grained silt to medium-grained sand that is light-yellowish-brown and unconsolidated. No known cross-sectional exposures exist in the map area. The grains are subrounded to subangular and are composed of quartz, feldspars, and lithic fragments. No grain frosting is observed. The deposits have the composition of feldspathic arenite. The unit is mostly found as isolated vegetated and stabilized dunes northeast of Cañon Largo in the southern map area. Stabilized dunes are 1.5–4 m (4.9–13.1 ft) tall and typically contain grasses and saltbrush (*Artiplex canescens*) with few isolated pines and junipers. The surface of the unit contains a weakly developed soil with a 10-cm-thick (3.9 in) Ah horizon and weak effervescence in 10% HCl, indicating the presence of calcium carbonate. This unit can be differentiated from map unit **Qea** by its more-developed topsoil, lack of evidence for active eolian processes, and distinct plant community. The thickness is <8 m (<26.2 ft).

Surficial Units Not Confined to Valley Floors

Qsm — **mesa-top sands (Holocene)**—Weakly consolidated sand and silt in broad sheets atop small topographically-isolated mesas. The unit is composed of moderately sorted laminated to thin-bedded silt and sand with trace granules and pebbles. The sand is composed of 70–80% quartz, 30–20% feldspar, and trace lithic fragments. Pebbles include petrified wood, quartzite, and sandstone. This unit likely represents remnants of eolian sheet sands (map unit **Qes**) that have been alluvially reworked and pedogenically altered, though not transported significant distances. Very poorly exposed in outcrop. Effervesces in 10% HCl at depths of 10–30 cm (3.9–11.8 in). This unit can be identified in orthophotographs based on landscape position, lack of recognizable dune forms, smooth surface, and redder color than **Qes**. The unit supports plant communities dominated by grasses, big sagebrush (*Artemisia tridentata*), and chamisa (*Ericameria nauseosa*); few woody trees are present except in the easternmost high-elevation outcrops in the central map area where pines and junipers are present in addition to the aforementioned plant species. The thickness is unknown but presumed to be <12 m (<39 ft) thick based on outcrop character and inferred origin.

Qes — **eolian sheet sands (early Holocene to Pleistocene)**—Unconsolidated to weakly consolidated sand in broad sheets and stabilized dunes. Younger deposits consist of linear or parabolic dunes composed of very fine- to fine-grained sand that is white to pink, well-sorted, cross-bedded, and quartz arenitic to feldspathic arenitic (80–95% quartz in the sand size class). Older deposits are more common and consist of stabilized longitudinal dunes and sand sheets on upland areas composed of coarse-grained silt to medium-grained sand that is light-brown, pale-brown, and very pale-brown; loosely consolidated; moderately sorted to well-sorted; and subrounded. The bedding is disturbed to the point of obscurity in lower portions of the unit. The upper 30 cm (11.8 in) of this unit is noneffervescent in HCl; lower paleosols within the unit are effervescent, indicating the presence of calcium carbonate. At least six stratigraphically distinct paleosols are present in older deposits; these comprise pale-brown to strong-brown, poorly sorted to moderately sorted clay to medium-grained sand, silty sand, sandy silt, and clayey silt; massive horizons with block ped structures; and up to Stage II pedogenic carbonate horizons with few carbonate nodules and filamental coatings. In general, lower paleosols are darker (lower Munsell color value), finer-grained, and more likely to contain blocky peds, pedogenic carbonate, and thin clay cutans on ped faces. The unit has a distinct contact with underlying units, though this contact is sometimes overprinted by a paleosol. In approximately 50% of outcrop locations, this unit overlies a 2–7-m-thick deposit of subangular to rounded (predominately subrounded) sandy gravel with trace pebbles and cobbles. The gravel comprises, in decreasing abundance, quartzite, chert, quartz, crystalline metamorphic rocks, petrified wood, and intermediate to felsic volcanic rocks, including ignimbrites. Gravel outcrops are rare, but gravels are often seen as float or lag on slopes below outcrops of this map unit. Gravels are included within map unit **Qes** because of their association with that unit and because their outcrop areas are too small to map separately at the 1:50,000 scale. Stabilized dunes are typified by big sagebrush (*Artemisia tridentata*)-dominated plant communities, with subordinate ricegrass (*Achnatherum hymenoides*), grama grass (*Bouteloua sp.*), saltbrush (*Artiplex canescens*), chamisa (*Ericameria nauseosa*), broom snakeweed (*Gutierrezia sarothrae*), and Mormon tea (*Ephedra sp.*). Pine (*Pinus sp.*) and juniper (*Juniperus sp.*) are nearly entirely absent on this deposit. The unit is generally poorly exposed and only well-exposed in active headcuts and construction trenches for pipelines and roads. The average sediment eolian transport azimuth is 069° as determined by dune morphologies in aerial imagery. Stabilized longitudinal dunes are up to 10 m (32.8 ft) tall. The thickness is 4–15 m (13.1–49.2 ft).

Mass-Wasting Deposits

Qls — **landslide deposits (Holocene)**—The composition is inherited from the bedrock composition at the head of landslides, which primarily comprises sandstones and mudstones of the Paleogene San Jose Formation and includes back-rotated Toreva blocks. This unit mostly occurs in steep-walled canyons in the San Jose Formation. In a large rotational landslide on the north side of Tapicito Creek, this unit includes sands and silts accumulated in a sag at the base of the headscarp. The thickness is not measured but is likely 5–20 m (16–66 ft).

PALEOGENE

Igneous Rocks

₱i — **intrusive dikes of the Dulce dike swarm of Lipman & Zimmerer (2019) (ca. 25.0 Ma)**—Light-gray to gray trachybasalt and basaltic trachyandesite dikes that intrude Eocene-aged San Jose Formation mudstones and sandstones on Tapicito Ridge in the northern map area. Dike orientation is subvertical. Dikes in the map area are up to 5.5 km (3.1 mi) long and 1–8 m (3.3–26.2 ft) thick. They contain phenocrysts of olivine and clinopyroxene with mica and amphibole present in the groundmass. The dikes often form resistant ridges with >30 m (>98 ft) of topographic relief above the surrounding landscapes.

Siliciclastic Rocks

₱sju — **Regina, Llaves, and Tapicitos Members of the San Jose Formation, undivided (Eocene)**—This unit contains interfingering rocks fitting the lithologic descriptions of the Regina, Llaves, and Tapicito Members of the San Jose Formation as described by Baltz (1967) and Smith (1992a). Because of complex lateral gradational changes observed in the map area, these units are difficult to map in a sensible way. Below, we provide lithologic descriptions for the mudstone-dominated and the sandstone-dominated portions of this map unit. The total thickness in the map area is up to 450 m (1,476 ft).

Mudstone-dominated portions—Reddish-brown, light-reddish-brown, light-reddish-gray, and light-brown mudstone with subordinate reddish-yellow, yellow, yellowish-brown, and light-red sandstone and conglomerate. Both mudstones and sandstones are slope-formers. Mudstones are moderately to well-consolidated, non-fissile silty claystones, sandy silty claystones, and siltstones. The bedding is generally obscured by weathering and by the crumbly nature of the units. The sandstones are poorly consolidated, medium- to coarse-grained, subangular to angular, thin- to medium-bedded, cross-bedded feldspathic arenites and feldspathic wackes with trace conglomerate lenses. The conglomerates contain subangular to subrounded pebbles of crystalline igneous and metamorphic rocks with subordinate chert, quartzite, and limestone. The sand bodies within this unit are 1–10 m (3.3–32.8 ft) thick. The mudstones and sandstones grade laterally and vertically with each other and with the subjacent and adjacent sandstone-dominated portions of the Regina, Llaves, and Tapicitos Members of the San Jose Formation. Overlies the Cuba Mesa Member of the San Jose Formation.

Sandstone-dominated portions—Reddish-yellow, light-red, very pale-brown, yellow, and brownish-yellow; cross-bedded; medium- to very coarse-grained; moderately sorted; subangular sandstone and conglomerate with lesser reddish-brown, yellowish-brown, pale-olive, and gray mudstone. Primarily forms cliffs. The sandstones are poorly to well-consolidated, medium- to coarse-grained, subangular to angular, thin- to thick-bedded, cross-bedded and plane-bedded feldspathic arenites and feldspathic wackes with trace conglomerate lenses. The conglomerates contain subangular to subrounded pebbles of crystalline igneous and metamorphic rocks with subordinate chert, quartzite, and limestone. Individual sand bodies are 2–30 m (6.6–98.4 ft)thick but are amalgamated into thicker sand bodies. The mudstones and sandstones grade laterally and vertically with each other and with the subjacent and adjacent map unit (mudstone-dominated portions of the Regina, Llaves, and Tapicitos Members of the San Jose Formation). Defined here as a lithostratigraphic unit with varying ages. Overlies the Cuba Mesa Member of the San Jose Formation.

₱sjc — **Cuba Mesa Member of the San Jose Formation (Eocene)**—White to yellow, rusty-weathering sandstone, pebbly sandstone, and trace conglomerate with lenses of light-gray to reddish-gray mudstone and silty mudstone. Sandstones are medium- to very coarse-grained, moderately sorted, angular to very angular feldspathic arenites. The sand composition is 40–55% quartz, 45–55% feldspar, and 5–15% lithics. Pebbles include phaneritic igneous rocks, quartzite, gneissic rocks, chert, and trace limestone. Sandstone bedforms include tabular cross-beds, horizontal-plane beds, scour-and-fill structures, contorted beds, and massive beds. Molds of trees are common throughout, especially in the bases of sandstone beds that overlie mudstones. The sandstones form prominent and continuous cliffs. The mudstones are lens-shaped, slope-forming, discontinuous over kilometers, and may grade into sandstones over meters. The unit contains vertebrate fossils from the Wasatchian North American Stage (50.3–55.4 Ma). The contact with the underlying Nacimiento Formation is disconformable to slightly angular unconformable. There is a conformable and/or intertounguing contact with the overlying member of the San Jose Formation. The total thickness is 210 m (689 ft) in the southwestern corner of the map area; only the upper 60 m (196 ft) are exposed in limited outcrops in Tapicito Creek and Cañada Larga at the western boundary of the map.

₱ne — **Escavada Member of the Nacimiento Formation (Paleocene)**—White to gray sandstone and mudstone. Sandstones are very fine- to medium-grained, poorly to moderately sorted, angular to subrounded (primarily subangular), feldspathic arenites and feldspathic wackes. Sandstone beds are rarely visible; those observed are thin to medium horizontal-plane beds and tabular cross-beds. Mudstones include silty claystone, clayey siltstone, and clayey sandy siltstone. Bedding is difficult to observe in Escavada Member mudstones. The contact with the overlying San Jose Formation is disconformable; a slight (2–5°) angular unconformity exists atop the Escavada Member just south of the map area. The lower contact does not exist within the map area. The total thickness is up to 90 m (295 ft), but only the upper 20 m (66 ft) are exposed in the far southwestern corner of the map area.

Explanation of Map Symbols

Contact—The identity and existence are certain. The location is accurate where solid, approximate where dashed, or concealed where dotted.

Gradational contact—The identity and existence are certain. The location is accurate where solid or approximate where dashed.

Normal fault—The identity and existence are certain. The location is accurate where solid, approximate where dashed, or concealed where dotted. Ball and bar on downthrown block.

Direction of downslope movement of landslide.

Head or main scarp of landslide—Active, sharp, distinct, and the location is accurate where solid or inactive subdued, indistice and (or) the location is approximate where dashed. Hachures point down scarp.

Unconformity as shown in the Correlation of Map Units—The identity and existence are certain.

₱i — Dike—The identity and existence are certain. The location is accurate. See description of map unit ₱i in the Description of Map Units.

Inclined bedding—Showing strike and dip.

Fluvial transport direction.

Sediment transport direction determined from dune forms.

1,128 ± 30 BP — Radiometric sample locality—Showing age.

Figure 1—Three alluvial units in Cañada Larga at approximately 36.321°N, 107.224°W NAD83. The oldest unit, **Qao**, forms the highest bluff on the left. Inset into **Qao** is **Qay**, forming the medium cliff in the center and right. The youngest and lowest alluvial unit, **Qaa**, forms the mostly unvegetated area in the foreground. Photograph taken August 24, 2021 (Figure 6 in report). May not be used without permission of the Jicarilla Apache Nation.

Map Location

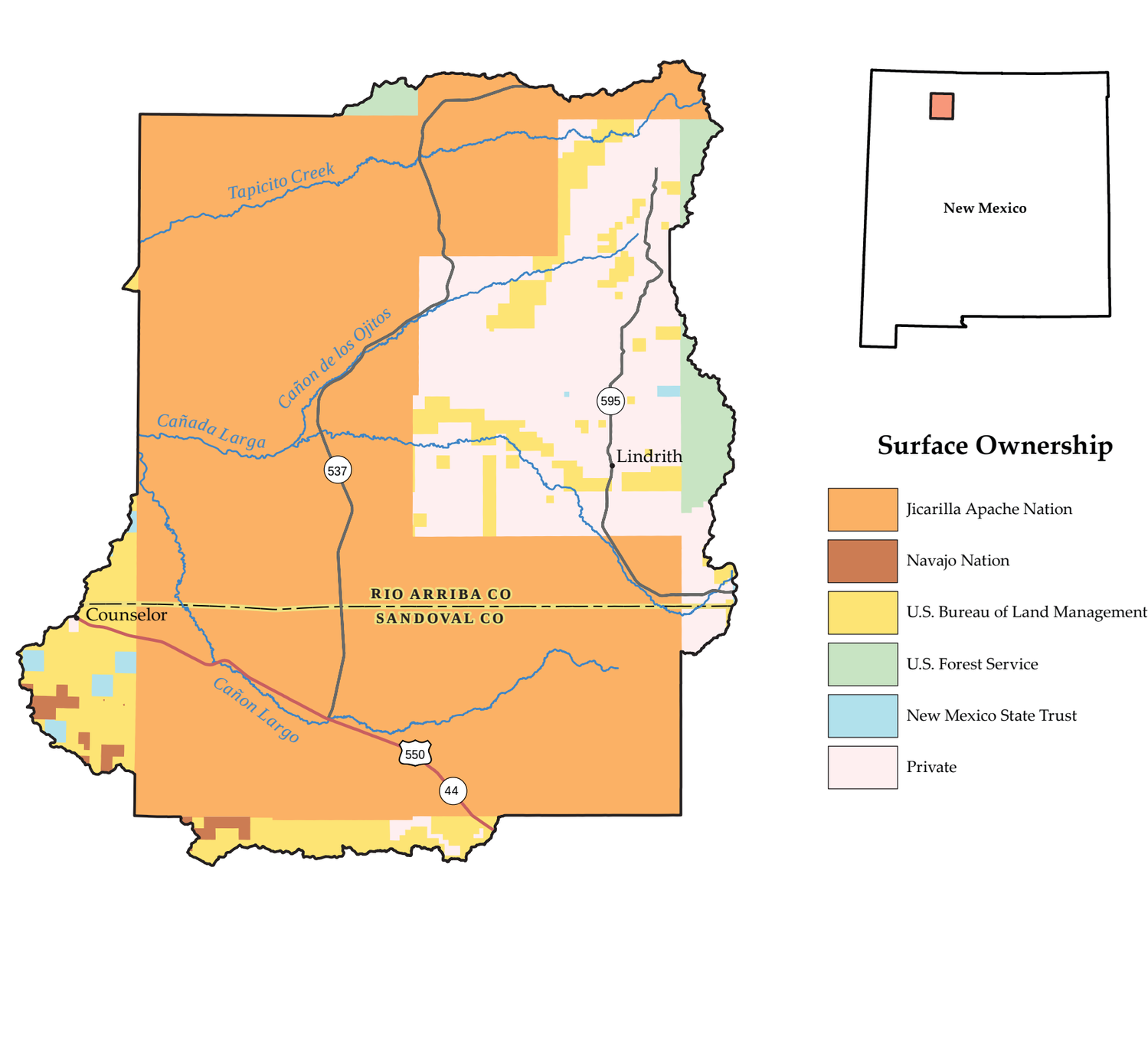


Table 1—Summary [14]C Ages From Charcoal Within Surficial Sediments in Map Area					
Sample Name	Age (BP)	Latitude (°N)	Longitude (°W)	Depth below surface	Map unit
JAN21-01	3,700	36.494481	-107.197067	410 cm (161 in)	Qao
JAN21-07	1,480	36.459912	-107.312239	300 cm (118 in)	Qao
JANC-02	2,030	36.22864	-107.380353	400 cm (158 in)	Qao
JANC-03	4,720	36.253817	-107.382444	200 cm (161 in)	Qao
JANC-11	1,560	36.320341	-107.220894	400 cm (79 in)	Qao
JANC-01	8,000	36.304107	-107.204801	400 cm (158 in)	Qao
JAN21-02	820	36.321576	-107.219529	360 cm (142 in)	Qay
JAN21-03	950	36.321576	-107.219529	195 cm (77 in)	Qay
JAN21-04	1,380	36.321685	-107.218415	60 cm (24 in)	Qay
JANC-08	500	36.323808	-107.406811	70 cm (28 in)	Qay
JANC-09	560	36.323534	-107.405494	190 cm (75 in)	Qay/Qf?
JAN21-05	5,810	36.362208	-107.248347	400 cm (158 in)	Qsw

Note: Margins of error can be found in the report provided in Appendix A. Geographic coordinates recorded with handheld GPS in NAD83 datum; typical error is ±4 m (±13.1 ft). All analyses performed at Beta Analytics, Inc.