ECOLOGICAL OVERVIEW

6L RANCH PARCEL
YAVAPAI COUNTY, ARIZONA

Prepared for:

Resolution Copper Company

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EXECUTIVE SUMMARY

WestLand Resources, Inc. (WestLand) was retained by Resolution Copper Company to prepare an Ecological Overview for approximately 60.4 hectares (149.3 acres) in Maricopa County, Arizona (6L Ranch, or "the Property"). The 6L Ranch is a private in-holding within the Tonto National Forest, located along Cave Creek about 10 kilometers (km; 6 miles) north of the town of Cave Creek. The Property is located in the central portion of the narrow Cave Creek canyon, and includes an approximately 1.6-km (1-mile) reach of Cave Creek as well as adjacent floodplains and upland areas. Cave Creek is an ephemeral to intermittent (with some brief perennial reaches) tributary to the Salt River, although Cave Creek's flow is interrupted by the Arizona Canal downstream of the Property. The nearest large metropolitan community is Phoenix, Arizona, located approximately 40 km (25 miles) south of the Property.

This ecological evaluation was conducted to identify the type and relative condition of the biological resources found and evaluate ecological characteristics of the Property to identify remarkable resource attributes, and to briefly assess their conservation values in reference to local and regional contexts. In this report, cultural resources were also evaluated.

The 6L Ranch was reportedly settled in the 1880s and certified as a homestead in 1920. The Property was used for cattle grazing until 2001 when the US Forest Service restricted grazing on the public lands (the Tonto National Forest) in which the Property is located. Early history of the 6L Ranch included residential use until the 1920s. Prehistorically, the Property was apparently extensively used and occupied by prehistoric cultures, as indicated by petroglyphs, stone structures, and grinding areas at several locations along Cave Creek and on ridge tops overlooking the stream.

Value #1: Petroglyph Site

The petroglyphs on the 6L Ranch are significant because the majority appear to be highly varnished, probably late Pleistocene or early Holocene in age, and generally in a good state of preservation. As discussed, two of the petroglyphs appear to represent mammoths; if this interpretation is correct, they belong to only a handful of petroglyphs in North America that depict extinct Pleistocene mammals.

Value #2: Habitat for rare or Diminishing Populations of Native Fish and Amphibians

The perennial pools and reaches of Cave Creek support both native and non-native fish as well as native amphibians. Two native fish have recently been reported in Cave Creek's watercourse, near the 6L Ranch: long-finned dace (*Agosia chrysogaster*) and Gila topminnow (*Poeciliopsis occidentalis occidentalis*). The Lowland leopard frog (*Rana yavapaiensis*) is also likely to occur on the Property. Obviously, these rare, aquatic species need perennial water for their continued existence.

Value #3: Only One Invasive Tree Species on the 6L Ranch

We saw only one species of invasive, non-native woody plant, salt cedar (*Tamarix ramosissima*), along the channel of Cave Creek. Furthermore, a number of other invasive tree species that occur problematically in similar watersheds throughout Arizona are not present on the 6L Ranch (or other nearby reaches of Cave Creek). Thus, this relatively unaltered aspect of the 6L Ranch represents a unique value of the property.

Opportunity #1: Conservation of the Petroglyph Site

Conservation of petroglyph sites on public lands presents a series of challenges. There are several approaches that have been developed for managing archaeological and culturally sensitive sites on public lands.

Several opportunities present themselves in the conservation of this archaeological site:

- Photographic documentation of all panels on the site with photographs deposited in the Arizona State Museum (Office of Records) and with the Tonto National Forest.
- Non-obtrusive signage briefly describing the site, reminding visitors of the laws protecting archaeological sites, informing visitors that all panels have been photographically documented and archived, and suggesting appropriate behavior around the petroglyphs.
- Sign-in ledger at Spur Cross Ranch, a Maricopa County access point to Cave Creek downstream from the 6L Ranch.
- Encouragement of local volunteer groups to help with the conservation of this and other sites along Cave Creek.

Opportunity #2: Non-native Fish Eradication

Control of sunfish would benefit the native Gila topminnow and long-finned dace. These native fish could be held in tanks while a piscicide (e.g., Rotenone) could be applied to the pools and reaches to kill the remaining (largely non-native) populations of fish.

A better hydrological understanding of Cave Creek is likely to enhance or better inform conservation efforts for these species. To that end, we suggest a simple hydrologic study of Cave Creek in the vicinity of the 6L Ranch. It would be helpful to know the source of water in the perennial pools on the 6L Ranch, and the flood behavior (duration and discharge over time).

Opportunity #3: Eradication of Invasive Trees in Cave Creek

Under management by Tonto National Forest, there is an opportunity to systematically eradicate (using the appropriate herbicides) the incipient colonies of salt cedar along Cave Creek. The drainage is large enough that once the eradication is complete, the rate of seed reentry into the watershed will be likely low enough that small-scale control efforts in the future will suffice.

1. INTRODUCTION AND METHODS

1.1. Purpose and Organization of Report

WestLand Resources, Inc. (WestLand) was retained by Resolution Copper Company (Resolution) to prepare an Ecological Overview for approximately 60.4 hectares (149.3 acres) in Maricopa County, Arizona. In this report, the site is referred to as 6L Ranch, or "the Property."

The 6L Ranch is a private in-holding within the Tonto National Forest (Figure 1), located along Cave Creek about 10 kilometers (km; 6 miles) north of the town of Cave Creek. The Property is located in the central portion of the narrow Cave Creek canyon (Figure 2), and includes an approximately 1.6 kilometers (km; 1 mile) reach of Cave Creek as well as adjacent floodplains and upland areas. Cave Creek is an ephemeral to intermittent (with some brief perennial reaches) tributary to the Salt River, although Cave Creek's flow is interrupted by the Arizona Canal downstream of the Property. The nearest large metropolitan community is Phoenix, Arizona, located approximately 40 km (25 miles) south of the Property. Access to the Property is via Forest Trail (TR) 4 from the south.

This ecological overview was conducted to identify the types and condition of the biological resources on the Property and evaluate ecological characteristics of the Property to identify remarkable resource attributes, and to briefly assess their current and potential conservation values in reference to local and regional contexts.

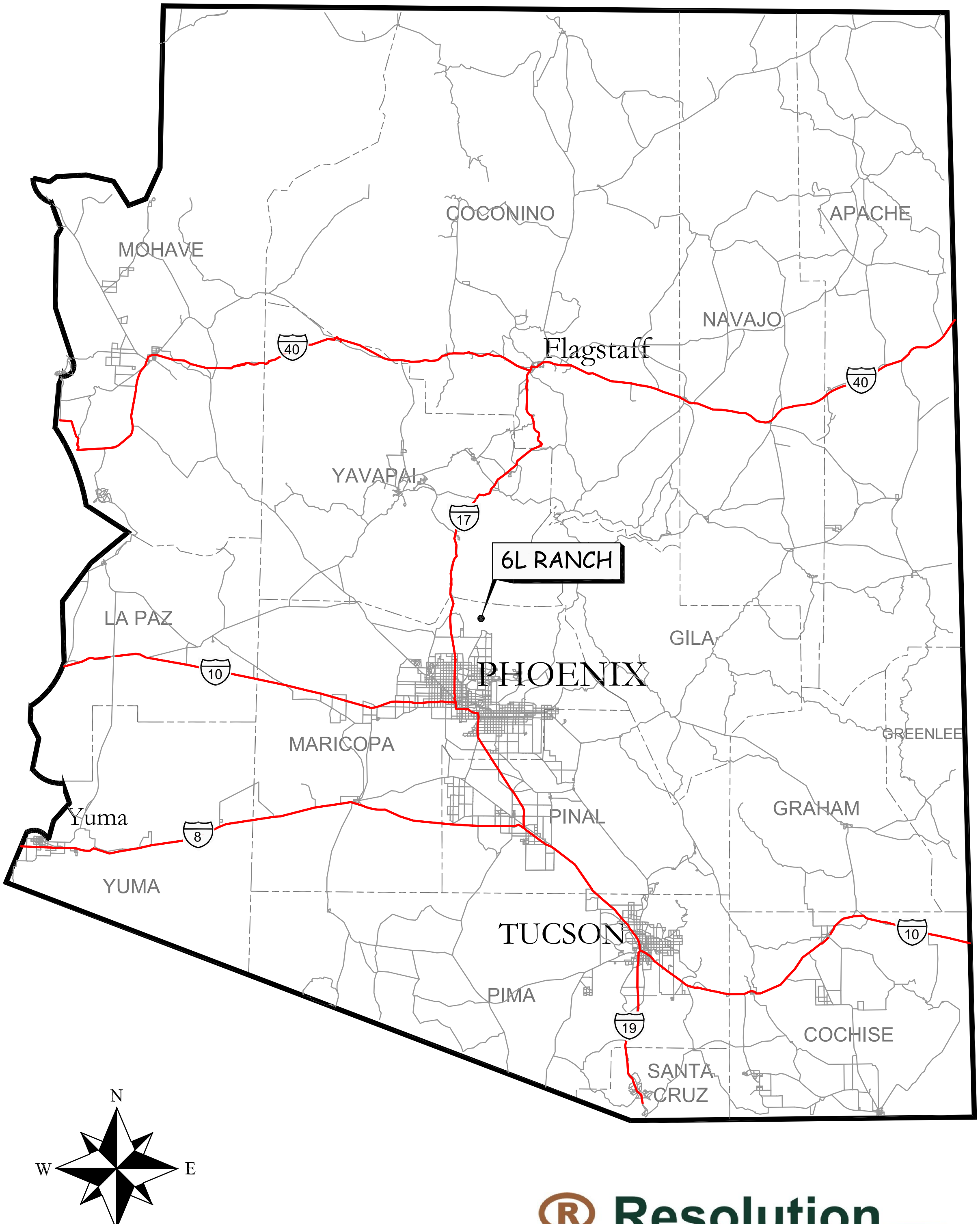
This report is presented in seven sections:

- Section 1 – Introduction and Methods (this section)
- Section 2 – Regional Setting
- Section 3 – Existing and Adjacent Land Uses
- Section 4 – Physical Resources
- Section 5 – Biological Resources
- Section 6 – Conservation Value and Opportunities
- Section 7 – References

1.2. Methods and Approach

WestLand completed this evaluation by conducting background research of available natural history information and aerial photography of the Property and surrounding region, and through field reconnaissance to identify, map, and photograph vegetation and habitat. WestLand also interviewed a representative (Mr. Ed Childers) of the current Property owner to determine the human development history of the 6L Ranch.

ARIZONA



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6L RANCH

VICINITY MAP
Figure 1

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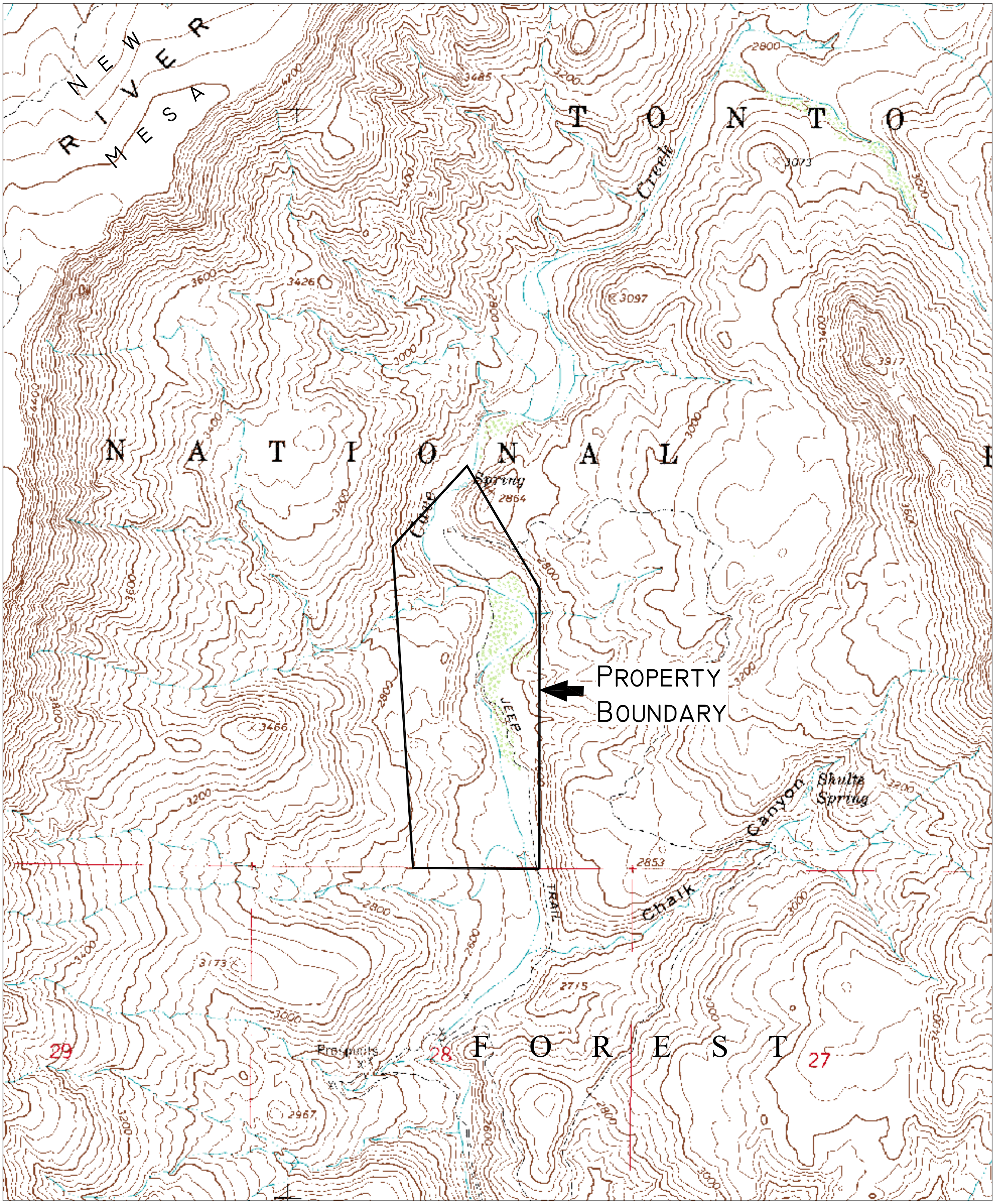

T.7N.,R.4E., Portion of Section 21,
Maricopa County, Arizona
New River Mesa USGS Quadrangle

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N
W E
S

0' 1000' 2000'
SCALE: 1" = 2000'

Resolution Copper Company

6L RANCH

6L RANCH STUDY AREA
Figure 2

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WestLand obtained and reviewed available literature pertaining to biotic communities of the southwest, riparian ecosystems, and the Cave Creek area. Primary sources of information that were reviewed include *Biotic Communities of the Southwestern United States and Northwestern Mexico* (Brown, 1994; a comprehensive reference of the desert southwest), wildlife abstracts from the U.S. Fish & Wildlife Service (USFWS), and various websites maintained by the US Forest Service (USFS), Tonto National Forest, Arizona Department of Water Resources (ADWR), and other agencies and conservation organizations. These references and aerial photographs were reviewed to identify potential and confirm observed vegetation communities on the Property.

To identify special-status species that might occur on the Property, we obtained the current list of federally listed species for Maricopa County from the USFWS database (USFWS, 2003). The life history of each of these species was then studied to determine habitat requirements such as vegetation communities, elevation ranges, presence of surface water, and other landscape features. This information was utilized in a screening analysis to identify species potentially occurring on or near the Property for further evaluation, as well as eliminate those that were unlikely to occur. Additional literature research was conducted and summarized for those species that have known ranges and habitat requirements close to or which have a high likelihood of occurring on the Property.

WestLand biologists conducted field reconnaissance of the Property on March 22, 2004 to observe current site conditions, biological resources, and abiotic factors affecting biota distribution and relative habitat value within the Property. The reconnaissance consisted of a vehicular tour of the access road and a pedestrian reconnaissance that focused on areas of interest identified during the background research phase of the evaluation. Inaccessible areas were scanned using binoculars to observe distant vegetation communities. Field observations were recorded and photographs taken during the reconnaissance to document the various physical and biological resources present on the Property. In particular, vegetation patterns were noted and observed species recorded. The general vegetation patterns were delineated on an aerial photograph and transcribed onto a vegetation map of the Property. Direct and indirect (tracks, scat, burrows, etc.) observation of wildlife was noted.

Specific attention was paid to the Property's potential to provide habitat for special-status species, as mentioned above. Using the list of special-status species and data collected during field reconnaissance, we conducted a screening analysis to identify those special-status species that had the potential to occur on or near the Property. Information such as the Property's elevation range, habitat type, availability of water resources, climate data, and other related information was compiled and compared to the background research information to predict the potential for occurrence of listed species in the Property area. The screening analysis resulted in a list of target species that have potential to occur on the Property.

2. REGIONAL SETTING

The Property is located near the center of the narrow Cave Creek canyon (Photograph 1), within the New River Mountain range. Cave Creek is the dominant stream in the immediate area; numerous named and unnamed tributaries feed Cave Creek. As detailed in Sections 4.1 and 4.2, Cave Creek roughly parallels a Tertiary fault, and the canyon was likely formed by erosion of the weakened rock along the fault line.

Photograph 1. Cave Creek.

Cave Creek, as previously mentioned, bisects the 6L Ranch from north to south and originally flowed to the Salt River. Currently, Cave Creek's flow is interrupted by the Arizona Canal downstream of the Property. The Cave Creek streambed slopes moderately. Nearly flat floodplains and terraces (Photograph 2) adjacent to the stream are up to approximately 2 meters (m; 6 feet [ft]) above the active channels. Upland areas display moderate to steep slopes (Photograph 3), with some vertical sections where erosion has removed sedimentary (alluvial [stream bed] or lacustrine [lake bed]) deposits. Surrounding mountains are rugged and rise steeply to elevations near 1,500 m (5,000 ft) above mean sea level (amsl).

Photograph 2. Terrace above active Cave Creek channel.

Photograph 3. View across Cave Creek floodplains and terraces to upland areas.

The closest large metropolitan community is Phoenix, Arizona, located approximately 40 km (25 miles) to the south. Maricopa County, in which the Phoenix metropolitan area lies, has some 3.2 million residents. Cave Creek (2000 census population = 3,720; US Census Bureau, 2001), a rural suburb of Phoenix, is located about 13 km (8 miles) south. Regardless of the presence of the Phoenix metropolitan area, no significantly populous communities are within 16 km (10 miles) of the Property.

3. PROPERTY AND ADJACENT LAND USES

Reportedly settled in the 1880s and certified as a homestead in 1920, the 6L Ranch was used for cattle grazing until 2001 when the USFS restricted grazing on the public lands (the Cartwright allotment of the Tonto National Forest) in which the Property is located. US Department of Interior, Bureau of Land Management (BLM) homestead records maintained by the General Land Office include a Record of Patent for the Property identifying John W. Lewis as establishing a claim to the land pursuant to the Homestead Act. The Record of Patent is dated April 28, 1920. The site representative, Mr. Ed Childers, also identified Mr. Lewis as the original landowner. According to Mr. Childers, the land was acquired by the Cartwrights, another cattle rancher in the area, in the 1930s or 1940s. The current owner, Johnson Cattle Company, acquired the Property from the Cartwright organization in 1980.

A small portion of the Property was reportedly cleared in the late 1800s and used for cattle roundup (branding, feeding, and transportation) until the late 1900s (Photograph 4). Wood, wire, and stone fences define the outlines of livestock enclosures. A small house was reportedly constructed nearby during the homestead era, but no evidence of the building remains. The residence was apparently used until the 1920s. A concrete and steel structure with water piping is present near the former house location; this structure has the appearance of a still. A hand-dug well, apparently some 9 m (30 ft) deep and 1.5 m (5 ft) in diameter (according to Mr. Childers) was also formerly present at the house site; this feature was not found during the field reconnaissance and may have been filled in or overgrown. One primitive (dirt) road, Forest Trail 4 (TR 4), accesses the Property from the south, along Cave Creek. A steel gate controls access to the 6L Ranch at the southern Property boundary.

Photograph 4. Livestock Management facilities at 6L Ranch.

The Property has been largely inactive since the late 1990s. Evidence was observed of unauthorized dispersed recreational activities (hunting and hiking) encroaching on the Property from adjacent public lands. Land uses evident on adjoining properties include the aforementioned dispersed recreational activities (hunting) and, formerly, cattle grazing. Designated pack and jeep trails are located on nearby public lands. Roads accessing the site and surrounding properties are dirt, and are frequently enjoyed by off-road vehicle enthusiasts.

4. PHYSICAL RESOURCES

4.1. LANDFORM AND TOPOGRAPHY

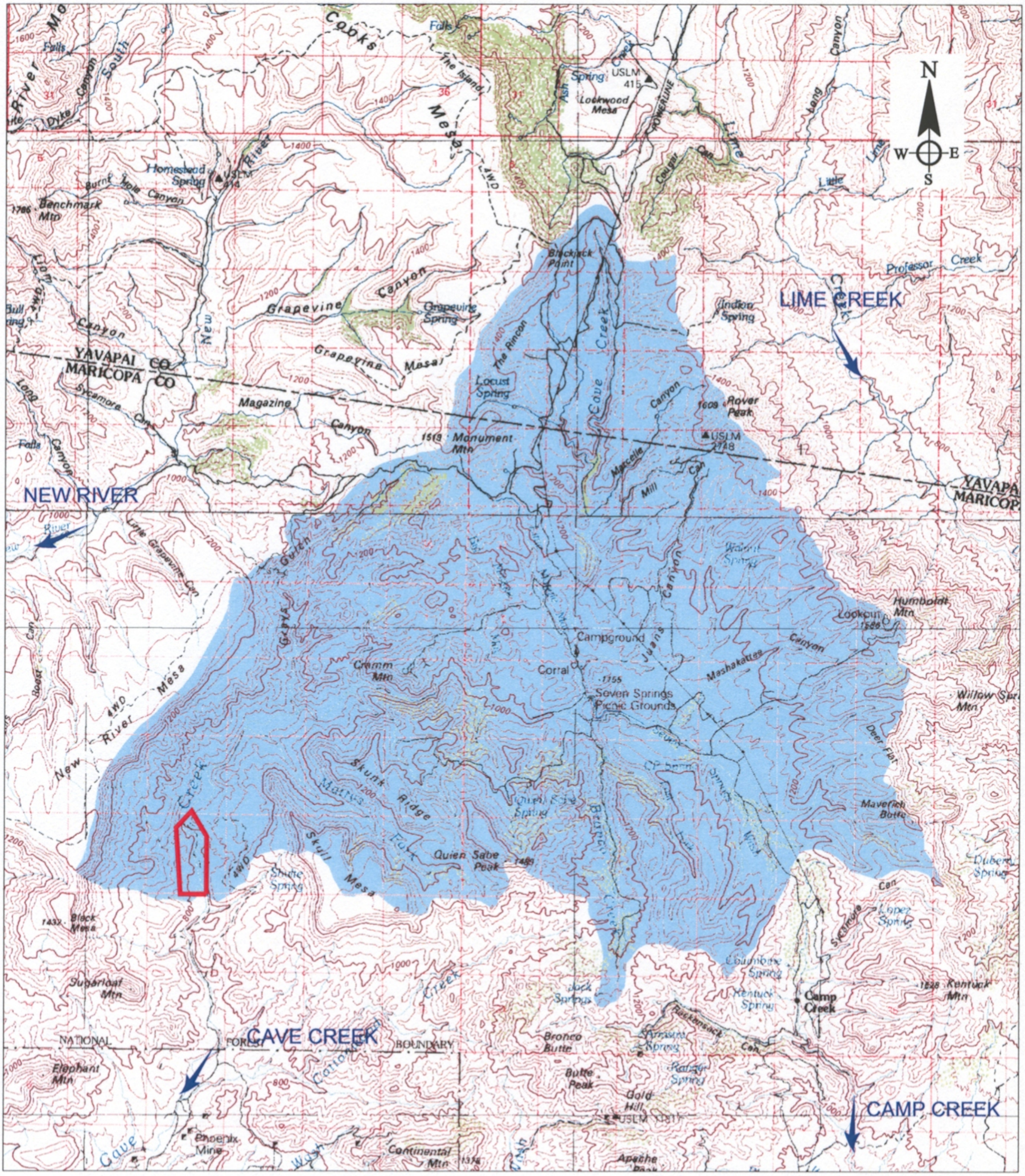
Photograph 5. Igneous boulders.

The 6L Ranch is situated within the canyon of Cave Creek southeast of the New River Mountains in central Arizona. In the 6L Ranch area, Cave Creek has carved a canyon approximately 400 m (1,300 ft) deep through large mesa-forming Tertiary lava flows. On the upper slopes of the canyon, the walls are generally steep, even cliff-forming; the lower slopes are less steep in most places. A notable feature of the lower slopes is the high number of large igneous boulders that have slid, tumbled, or slumped from the mesas above (Photograph 5). The Property lies between Skull Mesa to the east, and New River Mesa and Black Mesa to the west. The tops of these three mesas are about 1,340 to 1,400 m (4,400 to 4,600 ft) in elevation.

The Cave Creek watershed at and above the 6L Ranch is very large, and includes at least 145 km^2 (56 square miles) (Figure 3). The highest elevations within the upper reaches of this watershed are Rover Peak (1,609 m; 5,278 ft) and Humboldt Mountain (1,586 m; 5,203 ft), both northeast of the Property. Numerous named and unnamed tributaries to Cave Creek, as well as several springs, are included within this watershed. The main tributaries are Bronco Creek, Springs Wash, Little Maggie May, Big Maggie May, Grays Gulch, and Mattys Fork. Significant springs in the Cave Creek watershed include Quien Sabe Spring, CP Spring, Walnut Spring, and Maggie May Spring.

Flowing generally to the south through 6L Ranch, below the Property Cave Creek continues to the south-southwest for about 19 km (12 miles) before reaching an impoundment at Cave Creek Dam. This dam is adjacent to Union Hills, about 13 km (8 miles) due south of the town of Cave Creek. It appears that in the event Cave Creek flowed beyond Cave Creek Dam, the Arizona Canal would intercept it. Cave Creek originally flowed south and emptied into the Salt River. The Salt River joins the Gila River south of Phoenix. The ephemeral (formerly perennial) Gila River flows west and southwest to Yuma, where it joins the Colorado River, ultimately discharging into the Gulf of California (Sea of Cortez).

The elevation of Cave Creek channel as it enters the northern, upstream portion of the 6L Ranch is about 799 m (2,620 feet). As it leaves the southern, lowest portion of the Property, the elevation is 768 m (2,520 feet). The channel bed of Cave Creek within the Property is relatively level (0.017 slope), dropping only about 30.5 m (100 feet) in 1.7 km (1.05 miles).



6 L RANCH PROPERTY BOUNDARY

WATERSHED REPORTING TO 6L RANCH

DIRECTION OF SURFACE WATER FLOW

Located on the Theodore Roosevelt Lake & Mesa
1:100,000 USGS Quadrangles

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Copper Company

6L RANCH

THE WATERSHED OF CAVE CREEK
AT AND ABOVE 6L RANCH

Figure 3

0' 5000' 10000'

SCALE: 1" = 10000'

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4.2. Geology and Geomorphology

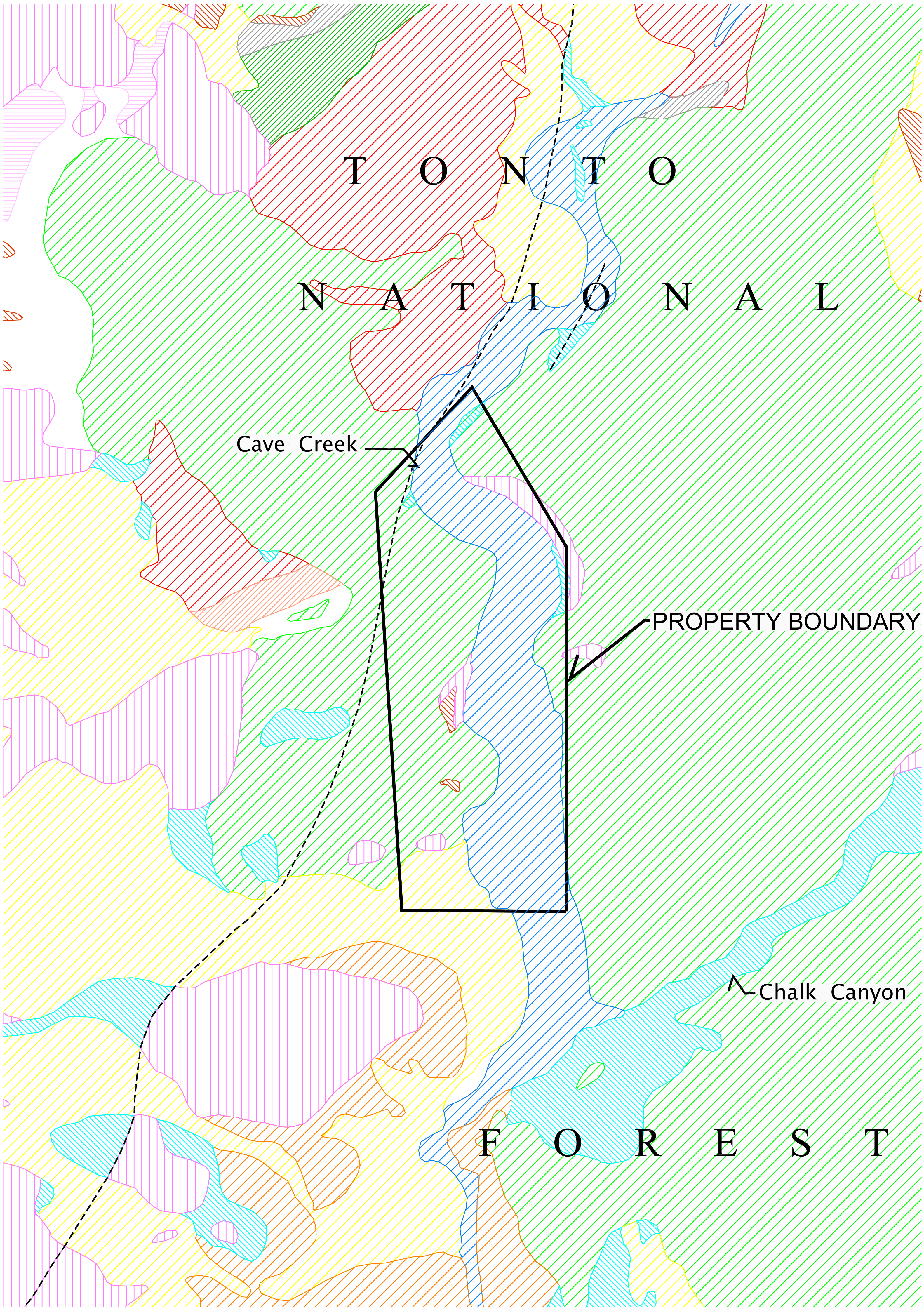
The geology of Cave Creek within the New River Mesa 7.5-minute quadrangle, and including the 6L Ranch, has been recently mapped in detail (1:24,000) by Ferguson et al. (1998). Gilbert et al. (1998) mapped the Humboldt Mountain 7.5-minute quadrangle on the east side of the New River Mesa quadrangle concurrently with Ferguson's mapping project. Ricketts (1887) was the first to describe the New River Mesa area geologically, primarily in terms of its mining potential. The New River Mesa quadrangle is mountainous. Bedrock dominates most of the land surface within this rugged quadrangle, with colluvium and alluvium accumulations on valley and canyon floors. Because of the steep slopes within the New River Mesa Quadrangle, recent colluvium or landslides cover bedrock at the toes of the mesa cliffs and slopes. Alluvium is present only in and along narrow stream channels. Two rock groups, Proterozoic and mid-Tertiary age, constitute most of the exposed bedrock on the New River Mesa quadrangle.

Lewis (1920) provided one of the first detailed analyses of the geology and mining potential of the New River Mesa area. Anderson (1989) has summarized the Proterozoic stratigraphy of the area. Other geologists who have described the Proterozoic geology of the New River Mesa and surrounding areas include Maynard (1986, 1989), Reynolds and DeWitt (1991), and Bryant (1994). Geological descriptions of the area from the standpoint of Tertiary rocks and structures include Gomez (1978), Gomez and Elston (1978), Leighty et al. (1997), and Leighty (1997). The uranium potential of the Tertiary sediments have been described by Scarborough and Wilt (1979); some of these sediments are regarded as a potential radon hazard (Duncan and Spencer 1993; Harris 1997).

The following accounts of surficial deposits and bedrock outcrops pertain only to the geology of the 6L Ranch itself (i.e., do not encompass the range of geologic materials present in the New River Mesa quadrangle). Ferguson et al. (1998) is the primary source for the descriptive information. A portion of the geologic map of the New River Mesa quadrangle drawn by Ferguson et al. (1998) that covers the 6L Ranch is provided in Figure 4.

4.2.1. Surficial Deposits

Younger and older alluvium along Cave Creek (Qay and Qao) - The alluvium consists of unconsolidated sediments along the active stream channel. The active channel and both the younger and older alluvium cover about one-half of the 6L Ranch (Figure 4). Along Cave Creek within the 6L Ranch there are terraces of old (possibly Pleistocene age) floodplains that have been abandoned by stream flow, evidently even during modern high-water events. These terraces are about 2 to 3 m (6 to 9 ft) above the streambed. Where the stream channel has cut into the terraces, it has exposed a generally clast-supported matrix of cobblestones and boulders with sand and gravel in the interstices. The surface of the terraces is sandy silt. Basaltic boulders that descended the nearby slopes as landslide material are included in (or on) these older terraces (Photograph 6).



T.7N.,R.4E., Portion of Section 21,
Maricopa County, Arizona

Located on the New River Mesa USGS Quadrangle

Property Boundary

Based on Furguson et al. (1998).

Quaternary

Qay: Younger alluvium
Qc: Talus and colluvial slope deposits
Qls: Landslides and mass movement deposits

Tertiary

Tb: Basaltic lava
Tbs: Basaltic scoria (cindery crust on the surface of lava flows)
Tvs Volcaniclastic sandstone, conglomerate, mudstone, marl, and nonwelded tuff
Tc: Nonvolcaniclastic conglomerate and sandstone

Early Proterozoic

Xa: Andesite tuff and tuff breccia (mostly subaqueous)
Xma: Mafic subaqueous lava complex
Xm: Mafic subaqueous lava complex
Xs: Felsix volcaniclastic and pyroclastic rocks
Xfv: Felsic lava and lava breccia

Approximate position of the most prominent Tertiary normal fault in the region, north-striking, east-side-down, structure that parallels the south-flowing segment of Cave Creek with up to 550 m displacement within the 6L Ranch area, as inferred by the position of Tvs on either side of fault.

N
W E
S

0' 600' 1200'

SCALE: 1" = 1200'

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6L RANCH

1992 Aerial

Figure 4

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Photograph 6. 6L Ranch in Cave Creek Canyon from near the southern border, facing north. Foreground includes stream terraces along Cave Creek and large basalt boulders that have rolled down from the upper slopes to the east (right). Basaltic lava cliffs on the east slopes of New River Mesa in background (left).

Although Ferguson et al. (1998) did not recognize older alluvial surfaces in the 6L Ranch portion of Cave Creek, it is likely that the alluvium along the south Property boundary west of the stream channel may be these materials, or at least some of the oldest alluvium in this portion of Cave Creek. We have not carefully examined this alluvium, but its relative height above the active channel suggests a Qao (rather than Qay) determination.

Photograph 7. Cleared fields partially reclaimed by mesquite.

On the north portion of the 6L Ranch, the terraces have evidently been cleared of boulders during the late 1800s or early 1900s in order to create fields or agricultural plots (Photograph 7). Excess boulders were probably used in creating (near the home site) the rock walls between the terrace fields and the stream channel (Photograph 8).

Photograph 8. Edward Childers standing in front of a rock wall near the home site on 6L Ranch. Skull Mesa, a Tertiary basaltic lava flow east of the Property, is visible on the horizon.

Landslides and mass movement deposits (Qls) – There are large areas of lower Cave Creek, including about one-half of the 6L Ranch, that are covered with landslide material (Figure 4). Ferguson et al. (1998) has interpreted this material as a mixture of landslides and slumps derived from the slopes of both New River Mesa to the west and Skull Mesa to the east. The most conspicuous elements of this landslide and slump material are the large basalt boulders on the slopes and remnant boulders on the channel terraces (Photographs 5 and 6, above).

Talus and colluvial slope deposits (Qc) – These unconsolidated materials represent a small portion of the surficial deposits on the 6L Ranch, and are present at the southwestern corner (Figure 4). Ferguson et al. (1998) has interpreted this material as a mixture of unvegetated talus and soil-covered slope deposits found chiefly along the steeper slopes of both New River Mesa to the west and Skull Mesa to the east. The Qc within the Property boundary is the northwestern extent of a larger deposit extending west and south, and originating from the New River Mesa.

We interpret the differentiation of Qls and Qc units to be based on the events generating these deposits. It is likely that the Qls materials were generated in fewer, catastrophic events whereas the Qc materials were generated by ongoing, small-scale erosion. Although the source rocks are likely the same, the coarseness of the generated material varies considerably between the two units: Ferguson et al. (1998) cites boulders up to 50 m comprising the Qls unit, whereas talus and soil are generally understood to be sand, gravel, and rocks up to 0.3 m (1 foot) in diameter.

4.2.2. Bedrock

There are three types of bedrock exposed on the 6L Ranch, all of which are Tertiary-age. These include Tertiary basalt (Tb), Tertiary Chalk Canyon Formation (Tvs), and Tertiary conglomerate (Tc). The coverage of each bedrock type on the 6L Ranch is relatively small.

Tertiary basaltic lava (Tb) – There are three relatively small outcrops of basaltic lava on the 6L Ranch. The largest of these outcrops is exposed in a bank cut on the east side of the stream channel on the north end of the Property. The other two outcrops are near the center and southeast corner of the Property. Although a minor presence on the 6L Ranch, this is the same basaltic lava that formed the large mesas throughout the Cave Creek watershed (Photograph 8, above, of Qls; Skull Mesa in background). Ferguson et al. (1998) and others consider these basaltic lavas to be part of a more widespread basaltic volcanism across the Basin and Range physiographic province and Transition Zone. Within the New River Mesa quadrangle, samples of basalt from the cliffs of Skull and New River mesas yield dates of 14.8 and 14.7 Ma (Middle Miocene). At the time of their deposition, these basaltic flows probably extended across most of the area. The flows had a very slight regional dip to the south. Ferguson, who has a particular interest in volcanic stratigraphies, has carefully mapped the basaltic lava deposits in the New River Mesa region and finds as many as 8 to 10 flow units in the thickest sequences (60 to 150 m [200 to 500 ft] thick). Thin sediment and soil horizons separate the individual flow units (as well as the lowest lava flow from the underlying Chalk Canyon Formation). The presence of these sediments interbedded between flows suggests that some (geologic scale) time elapsed between the eruptions responsible for each lava deposit. The basaltic lava flows in this area have been named by Gomez (1978) as New River Mesa Basalt but are considered by Ferguson et al. (1998) and Leighty (1997) to be part of the southern Transition Zone equivalent to the Hickey Formation, a similarly described basaltic flow unit named for Hickey Mountain (some 95 km [60 miles] north of the Property).

Tertiary Chalk Canyon Formation (Tvs) – Ferguson et al. (1998) mapped several significant outcrops of lacustrine-like or lacustrine-included Tertiary sediments in the general region of the 6L Ranch. It is necessary to qualify these sediments as lacustrine-like or lacustrine–included because geologists have lumped a number of sediments (including volaniclastic sandstone, conglomerate, mudstone, marl, and non-welded tuff) in their mapping efforts in the Cave Creek area. These sediments are temporally constrained. Gomez (1978) informally named this assemblage of sediments the Chalk Canyon Formation. This assemblage of sediments overlies (post-dates) the pre-volcanic mid-Tertiary conglomerates (Tc), several outcrops of which occur along the Cave Creek stream channel on the 6L Ranch (Figure 4). Near the base of the Chalk Canyon Formation, basalts have yielded K-Ar dates of 21.3 ± 0.5 Ma (Scarborough and Wilt, 1979) and 23.3 ± 2.7 Ma (Shafiqullah et al., 1980). The top of the Chalk Canyon Formation has been dated as young as 15.4 Ma (Doorn and Péwé, 1991).

Within the general vicinity of the 6L Ranch, there are several outcrops of the Chalk Canyon Formation. The most conspicuous outcrops are near the top of the east-facing cliffs of New River Mesa (off-property); these outcrops are at least 300 m (1,000 ft) above the Property. The outcrops along the east-facing cliffs of the New River Mesa immediately above the 6L Ranch are generally only 6 to 36 m (20 to 120 feet) thick. Much of this formation along the cliffs is obscured by Quaternary-age colluvium but, where exposed, the sections are easily seen from a considerable distance because they are very white and stand out from the over- and underlying darker basalt. About 2.4 km (1.5 miles) southwest of the southwest corner of the Property, a nearly 180-m (600-foot) tall section of the Chalk Canyon Formation is exposed on the southeast side of Black Mesa. Additionally, there are several small outcrops of this unit within the 6L Ranch itself. The three outcrops of this Formation on the Property are small and close together. Photograph 9 depicts one outcrop of the Chalk Canyon Formation. Note the white lacustrine sediments that are exposed in the bank cut made by Cave Creek.

Photograph 9. Chalk Canyon Formation exposure along Cave Creek.

Tertiary conglomerate (Tc) – There are also three relatively small outcrops of pre-volcaniclastic conglomerate on the 6L Ranch. These are essentially downcut or sidecut exposures along the stream channel, on either side of Cave Creek within the north half of the Property. The conglomerate's interstitial clay is a brick red and is easily seen from a distance. The clasts within the conglomerate are uniformly Proterozoic rocks. Tertiary volcanics are entirely absent from the clast material, clear evidence for its prevolcanic deposition. Photograph 10 shows the outcrop of conglomerate beside Cave Creek on the north side of the property.

Photograph 10. Outcrop of non-volcaniclastic conglomerate on the north end of the 6L Ranch, beside Cave Creek.

4.2.3. Structural Features

There is a prominent north-striking Tertiary normal fault that runs through the northwest corner of the 6L Ranch (Figure 4). Ferguson et al. (1998) states that his fault has an east-side-down displacement of usually between 60 and 300 m (200 to 985 ft). However, we found a 550 m (1,800 ft) displacement of lacustrine sediments (Tvs) in the vicinity of the 6L Ranch that is likely accounted for by this fault. The lacustrine sediments are high up on New River Mesa, on the west side of the fault (east–facing slopes) at about 1,280 m (4,200 ft) elevation; the same lacustrine sediments occur on the east side of this fault (on the 6L Ranch) at about 731 m (2,400 ft) elevation. Ferguson et al. (1998) regard this north-striking fault as part of an array of north-striking faults that probably correlate with the Late Miocene east-west extension of the Basin and Range disturbance, an extensional faulting event discussed in detail by Leighty and Reynolds (1996).

On December 19 and 23, 1974, two earthquakes occurred near Cave Creek. Sauck (1976) compiled descriptions of these two earthquakes and made several seismological inferences. His analysis indicated that these earthquakes had Richter magnitudes of 2.5 and 3, respectively. Without enough seismic recording stations in the area, he was not able to identify the exact epicenter. However, he suggested that the deep faults were in the New River Mesa area, very close to the 6L Ranch, in Precambrian rocks, with the most obvious structural elements striking N60ºW. These earthquakes are mentioned only to indicate that there are still at least some locally active deep faults in the region of 6L Ranch.

4.3. CLIMATE

The weather station nearest to the 6L Ranch is the Ashdale Ranger Station, only 7.45 km (4.6 miles) northeast of the midpoint of the Property. The Ashdale Ranger Station is at 1,012 m (3,320 ft) elevation on Cave Creek near the confluence of Big Maggie May Creek (Figure 3). Less than 8 km (5 miles) away and only 213 m (700 ft) higher than the 6L Ranch, Ashdale Ranger Station's climate probably resembles that of the 6L Ranch more closely than any of the long-term weather stations within a 32-km (20-mile) radius around 6L Ranch. Both the Property and the Ashdale Ranger Station are along the stream channel of the Cave Creek watershed and are likely to experience similar thermal regimes throughout the year. For example, both sites may experience similar kinds of cold air drainage during winter nights and both may have higher daytime summer temperatures than expected given their elevations alone – if the canyon behaves as a heat trap.

Temperature and precipitation records were collected from the Ashdale Ranger Station's weather station only in the 1930s and 1940s. Mean daily maximum temperatures for Ashdale Ranger Station ranged from a high of 36º Centigrade (C; 97º Fahrenheit [F]) in July to a low of 15.5º C (59º F) in January. Mean daily minimum temperatures ranged from a high of 18º C (64º F) in August to a low of –1.7º C (29º F) in December (Sellers and Hill, 1974). Mean annual precipitation for Ashdale (from a very limited period of record of 1941 to 1948) was 39 cm (15.3 in). As is true for much of central and southern Arizona, precipitation at the Ashdale site was almost evenly divided between the monsoon season (July to October) and winter (December to March).

4.4. WATER RESOURCES

4.4.1. General Considerations of Water Resources

Several features of this area along Cave Creek are likely to contribute to a complex and interesting hydrological system. Some of these features include:

- A complex assemblage of bedrock types, some water permeable, others impermeable;
- Faults and fractures, some conducive to water flow with others acting as barriers;
- A perennial reach of stream only a few miles upstream, and probably uninterrupted near-surface flow within the Property;
- A deep canyon incision that may provide situations where deep bedrock basal flow may surface, with springs in the bottom of the channel bed;
- A large watershed upstream, a large amount of exposed bedrock, and topography that can intercept winter storm fronts – all conducive to enhancing flood events in this relatively narrow portion of Cave Creek; and
- Channel terrace alluvium and slope colluvium – unconsolidated material that can function as "sponges", absorbing water and providing a longer period of release downstream.

These features each may play a role in structuring the riparian vegetation along this portion of Cave Creek. The following subsections describe the known unique characteristics of Cave Creek surface water and groundwater resources in the vicinity of the Property, forming the conceptual foundation upon which the riparian vegetation account, provided in Section 5.1.3, is based.

4.4.2. Surface Water Resources

As observed during WestLand's March 22, 2004, field reconnaissance, Cave Creek was flowing throughout the length of 6L Ranch. We did not measure the rate of flow at this time but a reasonable estimate might be about 0.6 liters per second (L/sec; 10 gallons per minute [gpm]). We observed green sunfish (*Chaenobryttus cyanellus*) in several of the deeper pools on the Property, a good indication that these pools are perennial. Edward Childers, who accompanied us on this reconnaissance and is a rancher with about 20 years experience in upper Cave Creek, said that some of the pools along Cave Creek on the 6L Ranch are perennial, even though stream flow itself is ephemeral. Brown et al. (1978) indicate on their map of perennial streams in Arizona that there is an approximately 6.4-km (4-mile) long stretch of Cave Creek upstream from the 6L Ranch that flows perennially. The lower reach of this perennial portion is at least 2.0 km (1.5 miles) above the north boundary of the 6L Ranch.

The channel of Cave Creek within the 6L Ranch has very little exposed bedrock. Most of the stream reach within the Property is lined with coarse soil (sand and gravel), cobbles, and boulders (Photograph 11): the alluvial materials described above.

Photograph 11. Perennial pool of Cave Creek on the 6L Ranch.

Current stream flow status may, of course, not reflect historical or even prehistorical conditions. WestLand reviewed available literature to identify regional and local variations in surface water resources to determine if this factor had or has an effect on the unique characteristics of the vegetation observed on-site (Section 5.10). The following paragraphs describe flood flow characteristics of the Verde River (regional perspective) and Cave Creek (local perspective), based on published studies.

On a broad (regional) scale, Smith and Stockton (1981) used tree-ring data from the Verde River watershed (for trees growing on shallow soil slopes away from valley alluvium) to identify periods of above- and below-average precipitation and then correlated the tree-ring data to the actual discharge data on the Verde River (for a gage below Bartlett Dam [some 32 km {20 miles} east-southeast] from 1895 to 1945, and for a gage on the Verde River below Tangle Creek [some 26 km {16 miles} east-northeast] from 1945 to 1979). The correlation between tree-ring data and Verde River discharge data was sufficient to reconstruct a discharge record for the Verde River, based on older tree-ring records, that extends back to 1580 (Figure 5). The reconstructed stream flow of the Verde River was above average from about 1830 to 1850, and again between about 1865 and 1870.

The reconstructed stream flow of the Verde River suggests that the last period of sustained above-average discharge in the Verde River was from about 1905 to 1920. Stream flow during the rest of the 1900s was generally below average. What is interesting, in addition to the phases of significant maximum and minimum discharge events over the last nearly 400 years, is the 22.2 return period of extended low flow periods. This finding suggests that regionally, including Cave Creek watershed in which the 6L Ranch is located, low or deficient stream flow is expected to occur on average every 22 years. Mitchell et al.

(1979) also found a pervasive 22-year periodicity to extended, large-area drought occurrence in western United States and related it to the 22-year Hale Solar Cycle. Current precipitation data suggest that Arizona is in the early stages of an extended drought cycle. Given the proximity of Cave Creek's watershed to the Verde River's, the timing of high and low flow years in Cave Creek probably resemble that of the Verde River. If this assumption is correct, there are two key features to Cave Creek's discharge over the last century: the 1905 to 1920 period of high flow, and the general low flow during the remainder of the century. It is notable that the high flow period in the early 1900s coincides with the early ranching phase of the 6L Ranch.

Of course, significant, short-term flood events (because of their channel-altering effects) are as important as periods of sustained high flow and prolonged droughts (low flow) for understanding aquatic systems and riparian vegetation dynamics along Cave Creek. With regard to flood events, several studies of Cave Creek are worth mentioning:

- Werho's (1967) description of the gaging stations on Cave Creek,
- House and Hirschboeck's (1995) study of the extreme winter flood events of 1993, and
- Enzel et al.'s (1993) estimate of the maximum possible discharge of water into a watershed the size of Cave Creek at 6L Ranch based on their regional assessment of maximum flood events for tributaries of the Colorado River Basin.

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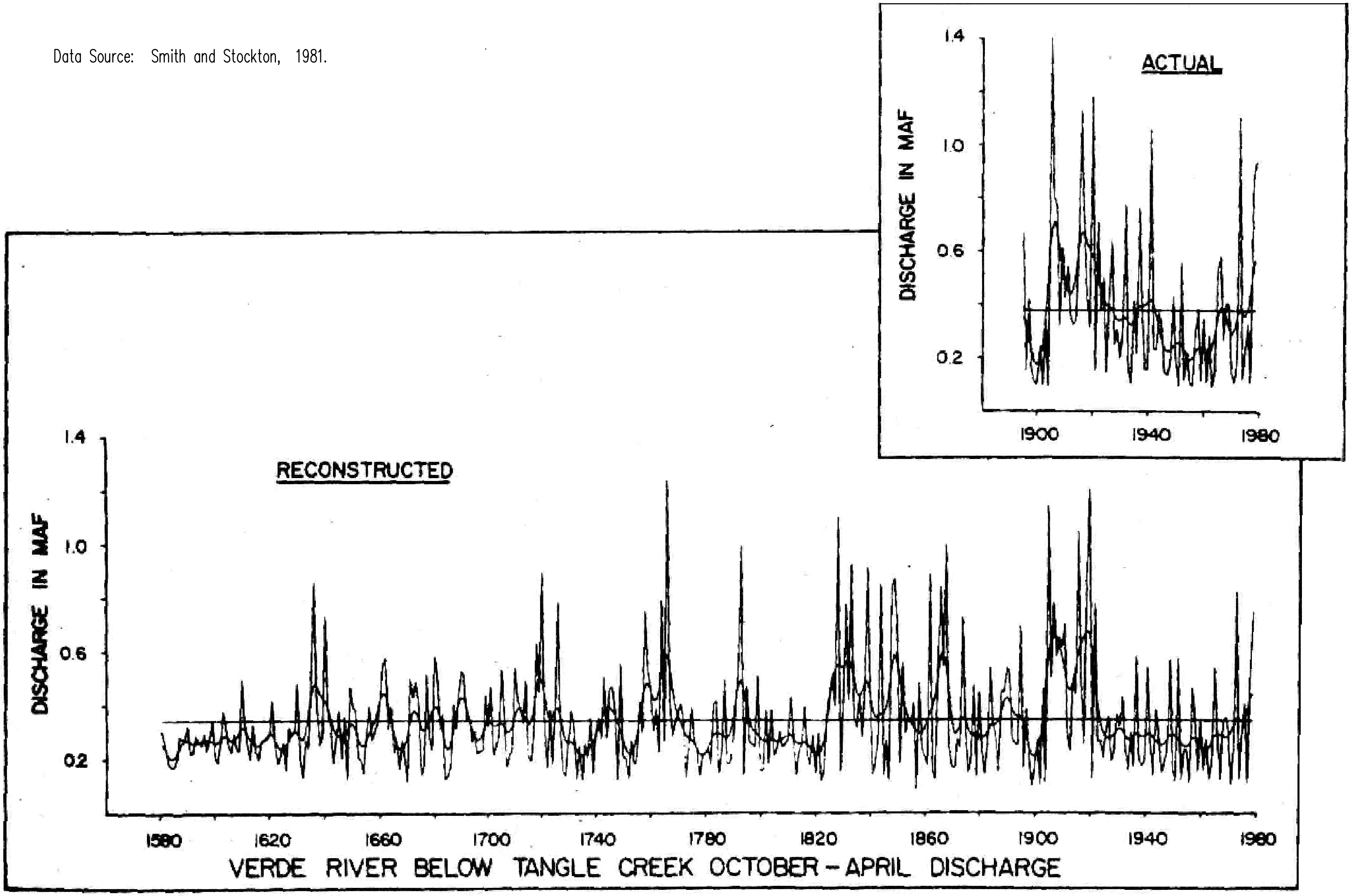
Reconstructed Stream Flow for the Verde River From Tree-Ring Data

Data Source: Smith and Stockton, 1981.



Actual and Reconstructed Stream Flow of the Verde River Below Tangle Creek (calibration period is from 1895-1979).

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Note: Not to Scale

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RECONSTRUCTED STREAM FLOW

Figure 5

These studies of Cave Creek are summarized below.

Gaging Stations on Cave Creek

There are no gaging stations at or above the 6L Ranch on Cave Creek. However, there are two stations downstream on Cave Creek (Werho, 1967), identified as numbers 18 and 19. Station 18 is 7.6 km (4.75 miles) southwest of the Town of Cave Creek at a site with 313 square kilometers (km^2; 121 square miles) of watershed. This station is a continuous-recording station installed as part of non-USGS flood monitoring. From 1958 through 1965, the base discharge was determined to be 500 cubic feet per second (cfs); the base discharge is defined as that which will be exceeded on an average of about three times a year. Peak discharge was 8,570 cfs (on October 29, 1959) during this period. The second gaging station is in Phoenix; it is less informative than the first because it lies downstream from the Cave Creek Dam. This second gaging station is also a continuous-recording station and was installed by the USGS. The potential watershed area is 653 km^2 (252 square miles); however, peak discharge during the 1958 to 1965 interval (presumably because of the impoundment upstream) was only 573 cfs.

The Extreme Winter Flood Events of 1993

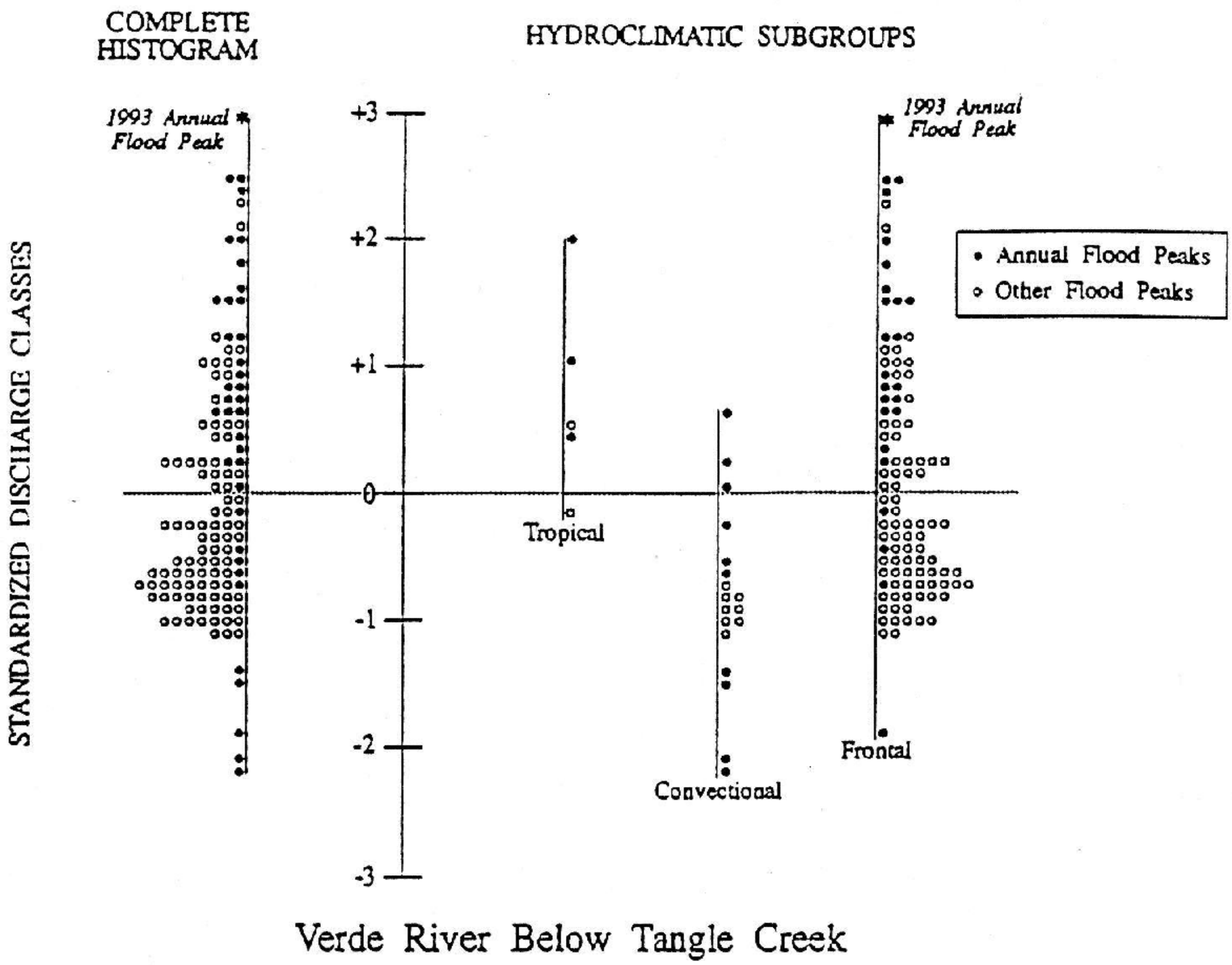
House and Hirschboeck (1995) reviewed the extreme flooding events in Arizona during the winter of 1993. Their review included one data point in Cave Creek. The gaging station on Cave Creek near the Town of Cave Creek had a maximum discharge of 922 cfs on January 8, 1993. The maximum discharge at this gaging station during the previous 15 years was 388 cfs, less than half of the 1993 maximum. The watershed above the Cave Creek gaging station is 214 km^2 (82 square miles); the watershed reporting to 6L Ranch is 129 km^2 (50 square miles). Assuming a simple proportional contribution, we would estimate the maximum flood discharge at the 6L Ranch in 1993 to be about 558 cfs. The commonly used Manning equation (Chow, 1959) for uniform, open-channel flows can be applied in this case to (under) estimate the flood height in the channel. We estimate the 1993 flood's maximum height to have been at least 5.5 m (18 ft) along portions of the channel that are 15.2 m (50 feet) wide, and 3.0 m (10 feet) in a 30.5 m (100 feet) wide channel. Although these values are only approximations, it does suggest the maximum 1993 winter flood height may have ranged somewhere between 3 to 5.5 m (10 and 18 ft) above the active channel. This depth would be expected to have had a significant effect on the riparian vegetation along the Cave Creek channel.

House and Hirschboeck (1995) also examined the nearby Verde River historical discharge records from 1950 to 1985 and found that, for the three hydroclimatic causes of floods (convectional, tropical, and frontal storms), summer flooding due to convectional storms was responsible for only about 14 percent (N=18) of the flood events, tropical cyclones produced 4 percent (N=5) of the events; and frontal storms produced the remaining 82 percent (N=102) events (Figure 6). Although tropical cyclones were responsible for only a few floods, four of the five tropical cyclone floods in the period of record were in the top 30 percent of floods (by peak discharge). The winter floods of 1993 were due to an unusually high frequency of winter frontal passages across Arizona. The conditions that favored these extreme flood events were: 1) a persistent winter circulation anomaly in the North Pacific ocean that repeatedly steered alternately warm and cold storms into the region along a southerly displaced storm track, and 2) an active subtropical jetstream, common during El Niño-Southern Oscillation events.

The Maximum Potential Flood Discharge Through 6L Ranch

Enzel et al. (1993) reviewed both historic flood and paleoflood events in a large number of watersheds within the Colorado Basin. They provided a graph of the maximum flood discharges known for watersheds of a given area and described a regional envelope of discharge as a function of drainage area (Figure 7). For the 129-km² (50-square-mile) watershed at 6L Ranch on Cave Creek, the maximum discharge would be about 3,530 cfs.

Hjalmarson (1978) delineated a flood map of the Cave Creek quadrangle several miles south of the 6L Ranch. By inference from the upper tributaries of his mapped channels (including Cave Creek), we would suggest that the 15 to 30 m (50 to 100 ft) width of the Cave Creek channel along the 6L Ranch would be rated as Zone 1, an area that would be inundated during high flood events. Floodwaters discharge through Zone 1 at high velocity. According to Hjalmarson (1978) "[t]he alluvium of the channels is composed of sand, gravel, and boulders that are easily moved by floodwater. The erosion, deposition, and movement of the alluvium causes varying amounts of obstructions, such as uprooted trees, on flood depths and velocities are unpredictable. The obstructions occur during major floods, and large changes in flow pattern in the flood plains can result." Further, and again based on the inference of Hjalmarson's work, we suggest that the rest of the 6L Ranch, above the flood terraces, would be rated as Zone 6. "Zone 6 consists of well-drained areas of steeply sloping hills and mountains, and most of the zone has a low flood-hazard potential. … Sheetflow may occur along some steep slopes possibly accompanied by landslides and rolling boulders" (Hjalmarson, 1978).



Decomposition of the Verde River flood histogram according
to hydroclimatic cause of flood.

Data Source: House & Hirschboeck (1995)

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VERDE RIVER FLOOD HISTOGRAM

Figure 6

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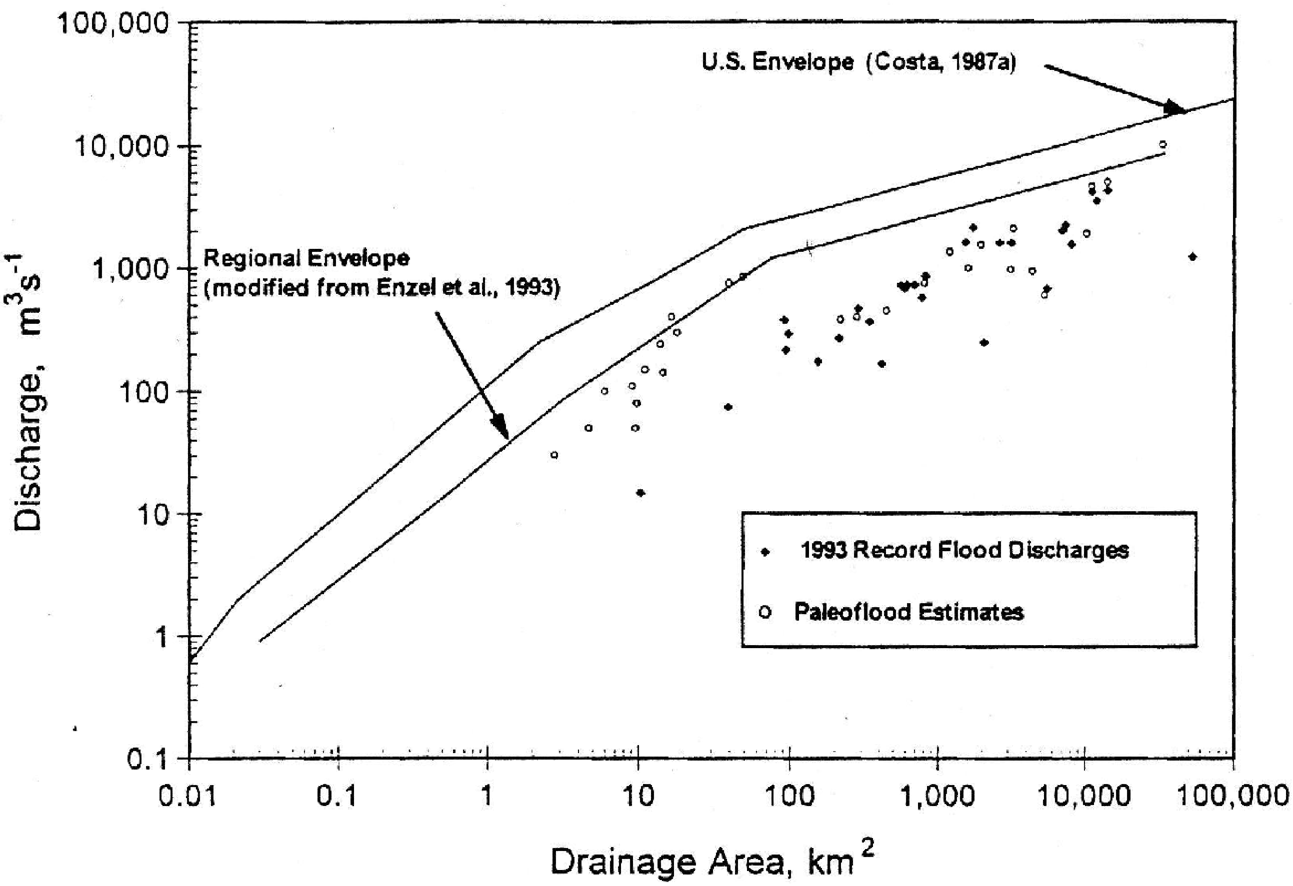

Comparison of the 1993 record flood peaks from unregulated basins to paleofloods and the envelope curve of the maximum gaged and historical floods in Arizona. Envelope curve slightly modified from Enzel et al. (1993).

Data Source: House & Hirschboeck (1995); modified figure from Enzel et al. (1993).

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RECORD FLOOD PEAKS

Figure 7

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4.4.3. Groundwater Resources

As described above, there are confirmed perennial pools along the 6L Ranch portion of Cave Creek. Because of the presence of these perennial pools, depth to groundwater along the channel is likely to be very shallow and on the terraces is likely to be less than 15 m (45 ft) in most places (our estimate). On the upland sites in the region of New River Mesa and Skull Mesa (including 6L Ranch), water may occur in several types of bedrock (Littin, 1979). The conglomerate (at least north of the town of New River, west of the Property), overlain by basalt flows, may yield as much as 0.6 L/sec (10 gpm) of water to wells. The yield in this same bedrock is greater in the Cave Creek-Carefree area and depends on degree of saturation and the extent of fracturing. Littin (1979) notes that the basalt flows that cap the New River and Skull Mesas "may collect and transmit water where sufficiently fractured, and if the underlying unit is impermeable, contact springs may be present at or near the base of the basalt. The unit may yield as much as 0.6 L/sec [10 gpm] of water to wells through fractures." Schist, gneiss, and granite (which are at greater depths in the 6L Ranch area) "generally yield less than 0.6 L/sec [10 gpm] to wells and springs through fractures" (Littin, 1979). Both Littin (1979) and Osterkamp (1973) note that depth to groundwater, water yield, and water chemistry in the bedrock of these mountainous areas varies erratically from place to place. Osterkamp's (1973) map does not extend north far enough to include the 6L Ranch, but his well depths to water in bedrock north of the town of Cave Creek clearly indicate the amount of variation in water depth.

As previously mentioned, a hand-dug well was reportedly on-site historically. However, no evidence of wells was observed on the 6L Ranch during our site visit on March 22, 2004. In addition, the ADWR was contacted in reference to their Well Registry database, which also includes well information obtained from the USGS and local public water systems. On the 6L Ranch, no USGS-registered or public water system wells were found, and ADWR-registered wells were found only in the adjacent section to the south (i.e., no registered wells are on-site).

5. BIOLOGICAL RESOURCES

5.1. VEGETATION AND HABITAT DESCRIPTION

The on-site vegetation is described in terms of several of Brown's (1994) biotic communities of the southwestern United States and northwestern Mexico. Within 20 km (12.5 miles) of the 6L Ranch, Brown and Lowe (1994) mapped only two biotic communities:

- Interior Chaparral, and
- Arizona Upland Subdivision of Sonoran Desertscrub.

The 6L Ranch lies completely within the Arizona Upland Subdivision of Sonoran Desertscrub as mapped at a 1:1,000,000 scale by Brown and Lowe (1994). At a higher resolution (1:250,000), a vegetation map by Turner (1974) indicates that the Interior Chaparral is actually much closer to the 6L Ranch (on top of the adjacent Skull and New River mesas) than indicated by Brown and Lowe. In addition, Turner (1974) recognizes one more vegetation type as occurring near the Property:

- Deciduous Riparian Forest.

It should be noted that Turner's map does not extend north far enough to include the 6L Ranch but stops within several miles of the ranch. Based on this close proximity and our observations of the similarity between the mapped Deciduous Riparian Forest downstream and the unmapped on-site vegetation, we believe that this biotic community is also represented on the Property. In this section, we provide a brief description of these three vegetation types on or near the 6L Ranch. Our descriptions are synoptic, based on our field observations on March 22, 2004, and on the general outlines provided by Turner (1974) and Brown (1994).

5.1.1. Interior Chaparral

This vegetation type is characterized by dense stands of woody, sclerophyllous shrubs. The two most common (diagnostic) species of Interior Chaparral in central Arizona are manzanita (*Arctostaphylos pungens*) and scrub oak (*Quercus turbinella*). We did not observe either of these plants on the 6L Ranch. Instead, we saw several other species that are common constituents of Interior Chaparral, most notably barberry (*Berberis haematocarpa*) (Photograph 12) and buckbrush (*Ceanothus greggii*) (Photograph 13). Both species were found on the stream terraces several meters above the active channel of Cave Creek; both species were in full flower during our March visit. Another species common to chaparral landscapes, one-seed juniper (*Juniperus monosperma*), was not observed on-site but occurred on nearby slopes. We did not climb to the top of New River and Skull mesas, but Turner's (1974) map indicates that chaparral is likely to occur in at least small stands on portions of these mesas.

Photograph 12. *Berberis haematocarpa* in full flower on March 22, 2004.

Photograph 13. *Ceanothus greggii* in full flower on March 22, 2004.

5.1.2. Arizona Upland Subdivision of the Sonoran Desertscrub

Photograph 14. *Prosopis velutina* on the 6L Ranch.

This vegetation type is best represented or developed on the warmer slopes of the Cave Creek canyon. Several species of trees are important components of the Arizona Upland Subdivision of the Sonoran Desertscrub biotic community. These species include saguaro (*Carnegia gigantea*), foothill palo verde (*Cercidium microphyllum*), and ironwood (*Olneya tesota*). Each of these species was found on the 6L Ranch (or in the case of ironwood, very near the property). Saguaros appeared to be generally restricted to south- and east-facing exposures, where warmer microclimates critical to their winter survival occur. In addition, velvet mesquite (*Prosopis velutina*) was common on the terraces and within the active channel of Cave Creek (Photograph 14). On the exposures of Tertiary lacustrine sediments, both ironwood and crown of thorns (*Canotia holocantha*) occurred. Additional species common to this biotic community observed on both the slopes and terraces included desert hackberry (*Celtis palida*), prickly pear (*Opuntia phaeacantha*), and jojoba (*Simmondsia chinensis*).

5.1.3. Deciduous Riparian Forest

Riparian vegetation, by definition, occurs along stream channels. In Arizona, there are marked differences in vegetation composition usually associated with several key features of the hydrology, geomorphology, and elevation of the stream. As described in Section 4.4, the presence of perennial pools and the low gradient channel of Cave Creek within the 6L Ranch suggests that shallow subsurface water is present along the length of the channel. This abiotic factor affects the character of riparian vegetation on the 6L Ranch. Riparian trees seen on the 6L Ranch included sycamore (*Platanus wrightii*), velvet ash (*Fraxinus velutina*), and Goodding's willow (*Salix gooddingii*). Of these three, willow is most dependent on a continuous supply of surface or near-surface water. Once established, sycamore and ash can survive on deeper ground sources of water. Significantly, one of the larger stands of willow we saw on the 6L Ranch was beside a pool of water; but this stand showed evidence of die-back likely due to water stress in the past few years during the current drought (Photograph 15). In fact, a majority of the sycamores, ash, and willows in this part of Cave Creek had a noticeable amount of dead upper branches.

Photograph 15. *Salix gooddingii* showing dieback.

Photograph 16. *Mimulus guttatus* on the 6L Ranch.

Riparian (or at least terrace) vegetation also included wolfberry (*Lycium* sp.), desert hackberry, barberry (a late spring climbing cucurbit, *Marah gilensis*), in some of the wetter areas cattail (*Typha* cf *domingensis*), and monkey flower (*Mimulus guttatus*) (Photograph 16), and in areas of the channel that receive the brunt of flood waters, seep willow (*Baccharis glutinosa*).

5.2. Potential Role of Floods along Cave Creek in Structuring the Riparian Vegetation

As detailed in Section 4.4.2, Cave Creek and its watershed above the 6L Ranch include conditions favorable for frequent high-water flood events. There are several aspects to the vegetation that appear to be a consequence of strong flood events, most notably the general scarcity of mature ash and sycamores along the channel and a local abundance of smaller shrubs. There are very few of these trees in spite of the presence of perennial pools which would normally support these species. Stromberg (2002) has found in a demographic study of sycamores in nine study sites in Arizona that recruitment of sycamores is historically infrequent and that seedling establishment is positively correlated with winter flood size and annual flow rates and weakly negatively associated with summer flood size. She found that sycamores had established at many of her study sites after the significant winter floods of 1993 and 1995, particularly along channels scoured and widened by flood waters.

Comparing 1962 and 1992 aerial photographs (Appendix A), it is readily apparent that many large trees were present along the active channel in 1962 but few were present in 1992. As shown in Figure 5, data from the nearby Verde River indicate above average stream flow in the late 1970s; it is likely that similar flood events occurred in Cave Creek at this time. Thus, it is likely that the mature trees present in 1962 were washed out in flood events such as those that occurred in the late 1970s.

We did not age-date the on-site trees during our study; based on casual observation, it is likely that the most mature sycamores, ash, and willows on the 6L Ranch are not more than 30 years old. This age would correlate well with the late 1970s flood events and Stromberg's study results.

Our observations suggest that more recent recruitment of young sycamores, willows, and ash to the population on the 6L Ranch has been infrequent or zero, in spite of evidence for large winter floods in Cave Creek in 1993. The difference between Stromberg's observations at her study sites and ours on Cave Creek may be due to presence of sediment loading and redeposition after flood events at her sites and an absence at ours. In particular, the 1993 flood events may have removed an exceptional volume of sediment from the active channel. Cave Creek's channel appears to be highly scoured with little evidence for sediment redeposition along the channel (in back waters or as point bars). That much of the channel bottom is cobblestone or boulders may make it difficult for seedlings to establish. Another feature of Cave Creek's channel on the 6L Ranch is the absence of large bedrock outcrops that, elsewhere, appear to provide downstream refugia for these riparian trees during flood events. Furthermore, the large watershed upstream of the Property and the canyon shape at 6L Ranch appear to concentrate flood flows in a relatively narrow section as the stream enters the north end of the site, likely increasing flow velocity. The geomorphology of the channel suggests adult sycamores, willows, and ash are hardly protected from the force of floodwaters, so adult mortality is not offset by seedling recruitment, and large riparian trees remain rather infrequent in this otherwise well-watered drainage.

5.3. Human Altered Aspects of Vegetation on 6L Ranch

Although we did not systematically look for evidence of human impacts to vegetation, there appeared to be a minimum amount of disturbance. There were three general impacts:

- Cleared fields in the north portion of the property,
- A dirt road that traverses the property from south to north, and
- Introduced Eurasian plants.

The fields had been cleared of boulders and vegetation by homesteaders by the early 1900s; small mesquite trees have since become reestablished in these fields. Edward Childers stated that the mesquite in the fields had been cut to the ground and the fields generally cleared as recently as within the last 20 years. As noted below, velvet mesquite is an "increaser." The current population of these trees may be higher than historically due to this disturbance.

The dirt road represents a long-lasting gap in the vegetation structure and canopy along the east side of the channel. It does not, however, appear to have been conducive to the spread or establishment of woody exotic species that would otherwise not be present. Velvet mesquite is now a very common element along the channel and on some of the slopes above Cave Creek. Generally, mesquite is understood to have increased and spread out of the larger rivers beginning in the late 1800s (Hastings and Turner, 1965; Bahre, 1991). If velvet mesquite has indeed invaded upper Cave Creek within the last 150 years, we have no information on its time of arrival, nor information on its population behavior in this particular watershed.

Introduced Eurasian plants observed on-site or potentially present are the same ones now ubiquitous in central and southern Arizona: filaree (*Erodium cicutarium*), London rocket (*Sisymbrium irio*), cheeseweed (*Malva parviflora*), wild barley (*Hordeum stebbinsii*), red brome (*Bromus rubens*), and Mediterranean grass (*Schismus barbatus*). These invasive species are known to compete with natives for nutrients and water, and can replace indigenous vegetation. Furthermore, red brome can alter natural fire regimes, providing fuel that would otherwise not be present. Fires in Sonoran Desertscrub without exotic grasses often burn out due to lack of fuel prior to excessive harm (or mortality) to plants. Sonoran Desertscrub with a ground cover of exotic grasses can burn hotter, more extensively, and more frequently. Such fires, fueled by exotic grasses, can have a significant effect on species composition and vegetation structure, as native species with little or no fire tolerance are killed out (McLaughlin and Bowers, 1982). The fire history of Cave Creek canyon in general and the 6L Ranch in particular is not known to us; however, we did not see evidence of past burns (burned stumps, scars of trees, etc.) in the 6L Ranch area.

5.4. WILDLIFE

As described above, the biotic communities (as identified by Brown, 1994) on, and immediately adjacent to, the 6L Ranch are:

- Arizona Upland Subdivision of Sonoran Desertscrub
- Interior Chaparral
- Deciduous Riparian Forest.

Common reptile and amphibian species that can be expected to occur in these biotic communities on or adjacent to the Property include the western diamondback rattlesnake (*Crotalus atrox*), gopher snake (*Pituophis melanoleucus*), Gila monster (*Heloderma suspectum*), Couch's spadefoot toad (*Scaphiopus couchii*), red-spotted toad (*Bubo punctatus*), whiptail lizards (*Cnemidophorus* spp.), Clark's spiny lizard (*Sceloporus clarkii)*, canyon tree frog (*Hyla arenicolor*), Sonoran desert tortoise *(Gopherus agassizii)*, and Sonoran mud turtle (*Kinosternon sonoriense*) (Stebbins, 2003). Common bird species expected to occur on or adjacent to the Property include red-tailed hawk (*Buteo jamaicensis*), great-horned owl (*Bubo virginianus*), mourning dove (*Zenaida macroura*), white-winged dove (*Zenaida asiatica*), northern mockingbird (*Mimus polyglottos*), Gambel's quail (*Callipepla gambelii*), ash-throated flycatcher (*Myiarchus cinerascens*), cactus wren (*Campylorhynchus brunneicapillus*), black-throated sparrow

(*Amphispiza bilineata*), Gila woodpecker (*Melanerpes uropygialis*), verdin (*Auriparus flaviceps*), great blue heron (*Ardea herodias*), green winged teal (Anas crecca), common raven (*Corvus corax*), American robin (*Turdus migratorius*), and phainopepla (*Phainopepla nitens*) (National Geographic, 1987). Common mammals expected to occur on the Property include white-footed mice (*Peromyscus* spp.), pack rats (*Neotoma* spp.), pocket gophers (*Thomomys* ssp.), rock squirrel (*Citellus variegatus*), cottontail rabbit (*Sylvilagus* spp.), mule deer (*Odocoileus hemionus*), javelina (*Tayassu tajacu*), bobcat (*Felis rufus*), mountain lion (*Felis concolor*), raccoon (*Procyon lotor*), skunks (*Mephitus* ssp.), ringtail rat (*Bassariscus astutus*), grey fox (*Urocyon cinereoargenteus*), and coyote (*Canis latrans*) (Hoffmeister, 1986).

As described above, the portion of Cave Creek that passes through the 6L Ranch flows ephemerally and contains perennial pools. However, the flows for a 6.5-km (4-mile) reach above 6L Ranch are perennial. The lower reach of this perennial portion is at least 2.0 km (1.5 miles) above the north boundary of the 6L Ranch. Cave Creek was flowing throughout the length of 6L Ranch at the time of WestLand's visit on March 22, 2004. Two species of native fish have been recently recorded from Cave Creek.[1] These species are long-finned dace (*Agosia chrysogaster*) and Gila topminnow (*Poeciliopsis occidentalis occidentalis*). Non-native green sunfish (*Lepomis cyanellus)* also occurs in Cave Creek, and specimens of this species were observed by Westland on the property. Green sunfish have been implicated in the recent decline in native fish species elsewhere in Arizona (USFWS, 2001a). During periods of sustained intermittent flows, we would expect all three of these species to be found on the reach of Cave Creek that passes through the Property. This reach may also serve as an important avenue for fish dispersal between perennial reaches upstream and downstream of the Property.

Wildlife species observed[2] by WestLand on the Property include mule deer, coyote, grey fox, skunk, raccoon, rock squirrel, pack rat, Gambel's quail, great blue heron, cactus wren *(Campylorrhynchus brunneicapillus),* curve-billed thrasher *(Toxostoma curvirostre),* Gila woodpecker *(Melanerpes uropygialis),* turkey vulture *(Cathartes aura)*, phainopepla, gilded flicker *(Coloptes auratus)*, mourning dove, raven, green sunfish, and Sonoran mud turtle.

[1] HDMS
[2] Wildlife observations included direct visual observation and the observation of tracks and scat.

Photograph 17. Javelina wallow on 6L Ranch.

During WestLand's field reconnaissance, we observed an especially large amount of javelina sign along Cave Creek, with well-worn trails leading from the uplands into the riparian forest. Within this area was a well-defined wallow that showed evidence of continuous and recent use (Photograph 17). In fact, the characteristic musky odor[3] of javelina was noted in the vicinity of the wallow, indicating the very recent presence of these animals. Another interesting wildlife encounter was the observation of two possible lowland leopard frogs (*Rana javapaiensis*) in a perennial pool on the northern portion of the Property. The lowland leopard frog has no federal listing status but is classified as a species of special concern by the Arizona Game & Fish Department (AGFD). Ranid frogs and their extirpation from any Arizona streams is of concern to wildlife managers in general. While the observer was approaching the pool, two frogs jumped from the bank into the water, but were not seen again. Although the brevity of the encounter precluded positive identification, WestLand believes that these frogs may have been lowland leopard frogs for the following reasons:

- The lowland leopard frog is known to occur in Cave Creek;
- The site is below the elevational range of the closely related and similar-appearing Chiricahua leopard frog;
- The introduced bullfrog (*Rana catesbeiana*), a known predator of native frogs, is not known to occur in Cave Creek (John Gunn, Spur Cross Ranch, personal communication to M. Cross); and
- Bullfrogs, especially young adults, characteristically vocalize as they jump when disturbed.

5.5. SPECIAL-STATUS SPECIES

The following special-status species list (Table 1) was provided by the USFWS (2004) and contains all federally listed threatened, endangered, proposed, and candidate species for Maricopa County, Arizona. The table includes the species' common and scientific name, federal listing status, and WestLand's evaluation of the likelihood of occurrence on or near the Property.

[3] Javelinas have a conspicuous scent gland on their lower back which emits a musky odor used in social interactions

Table 1. Special-Status Species: Known or Suspected to Occur in Maricopa County, Arizona.

Species	Status	Potential Occurrence at Project Site and Basis for Potential Occurrence Determination
Arizona agave (*Agave arizonica*)	Endangered	None: there are known locations of this plant in the vicinity; however, the site is below the lower limit of this plants elevation range (915 to 1,830 m [3,000 to 6,000 ft]) and lacks steep, rocky slopes that are preferred by this species. No specimens were observed on the site during field reconnaissance. It should be noted that this species is known to occur on the nearby New River Mesa.
Arizona cliffrose (*Purshia subintegra*)	Endangered	Unlikely: the white soils of tertiary limestone lakebed deposits required by this species only occur in three small patches on the Property. These areas are very small (< 1 ha) and support a much denser vegetation than those commonly occupied by the Arizona cliffrose. The nearest known location of this species is approximately 25 km (15.6 miles) east of the site near Horseshoe Reservoir. No specimens were observed on the site during field reconnaissance.
Bald eagle *(Haliaeetus leucocephalus)*	Threatened	**Possible**: there are documented bald eagle breeding territories along the Verde River approximately 30 km (19 miles) east of the site. There is some potential for the site to be infrequently utilized for foraging by resident or wintering bald eagles.
Desert Pupfish (*Cyprinodon macularius*)	Endangered	None: this species has been extirpated from this drainage.
Gila Topminnow (*Poeciliopsis occidentalis occidentalis*	Endangered	**Possible:** there are recent records of this species from Cave Creek
Lesser long-nosed bat *(Leptonycteris curasoae yerbabuenae)*	Endangered	None: the Property is located outside of the published range of this species.
Cactus ferruginous pygmy-owl *(Glaucidium brasilianum cactorum)*	Endangered	**Possible:** there are historical (1895) records of this species in the vicinity. Unconfirmed reports of this species continue to this day.
California Brown Pelican (*Pelecanus occidentalis californicus)*	Endangered	None: occurrence of this species is Arizona is limited to larger lakes and rivers.
Mexican Spotted Owl (*Strix occidentalis lucida*)	Threatened	None: the Property lacks narrow canyons and dense forest habitats preferred by this species. Additionally, this species occurs at an elevation range from 1,250 to 2,750 m (4,100 to 9,000 ft), above the elevation of the Property.
Razorback Sucker (*Xyrauchen texanus*)`	Endangered	None: naturally occurring populations of this species have been eliminated in the Gila River basin. Recent reintroduction efforts have occurred outside of the Cave Creek drainage.
Sonoran pronghorn (*Antilocapra American sonoriensis)*	Endangered	None: the Property is located outside of the geographical range occupied by this species.
Southwestern willow flycatcher *(Empidonax traillii extimus)*	Endangered	Unlikely: the Property lacks sufficient stands of riparian vegetation to support this species.
Yuma clapper rail (*Rallus longirostris yumanensis)*	Endangered	None: the Property lacks large stands of dense riparian and marshland vegetation required by this species.
Gila chub *(Gila intermedia)*	Proposed Endangered	Unlikely: there are no recent records of this species within the vicinity.
Yellow-billed cuckoo *(Coccyzus americanus)*	Candidate	Unlikely: the Property lacks sufficient stands of riparian vegetation to support this species.

The screening analysis conducted by WestLand indicates that at least three federally listed threatened, endangered, proposed, or candidate species for Maricopa County, Arizona have the potential to occur on the Property. These species are the bald eagle, Gila topminnow, and cactus ferruginous pygmy-owl. These species are discussed in the following sections.

5.5.1. Bald Eagle

Life History

The bald eagle (*Haliaeetus leucocephalus*) is a large bird of prey up to 1 m (3 ft) long and with a wingspan of about 2 m (6 to 7 ft) (AGFD, 2002). Adults have a characteristic white head and tail with a brown body. Immature bald eagles are mostly dark and lack the white head and tail found in adult birds. Nesting populations are increasing throughout the United States. Arizona supports a small, widely dispersed resident population of approximately 40 pairs that breed along the Salt, Verde, Gila, Bill Williams, Agua Fria, and San Francisco rivers and associated reservoirs, and also Tonto and Canyon creeks. Arizona also hosts a number of wintering eagles, with at least 200 to 300 wintering birds documented each year. Bald eagles in Arizona prey upon fish, waterfowl, small mammals, and carrion (USFWS, 2002).

Terrestrial habitats are also utilized during certain periods of the year, especially by non-breeding and wintering birds. Cattle (as carrion) may become important as a food item both episodically (during prolonged droughts) and periodically during the calving season (such as early spring) when placentas, stillborn calves, and cows that die while calving become available to scavengers. Terrestrial habitats also supply deer carrion, rabbits, and other mammals of appropriate size, upland birds, and reptiles (Hunt et. al., 1992).

The bald eagle was down-listed from endangered to threatened status in 1995 (USFWS, 1995).

Potential for Occurrence on the Property

There is little potential for bald eagle to utilize the property for nesting due to the small size of Cave Creek and the lack of abundant fish resources such as large carp and suckers. However, there are documented bald eagle breeding territories along the Verde River approximately 30 km (19 miles) east of the site. Bald eagles in Arizona are known to forage miles away from their nest locations, and the bald eagles on the Verde may infrequently visit the site (Hunt et. al., 1992). Wintering bald eagles are also known to range widely throughout central Arizona, including areas within the Property's vicinity. Therefore, there is some potential for the site to be utilized for foraging by resident or wintering bald eagles.

5.5.2. Gila Topminnow

Life History

The Gila topminnow (*Poeciliopsis occidentalis occidentalis*) is a small (2.5 to 5 cm [1 to 2 inches] long) guppy-like live-bearing fish (AGFD, 2001). It occurs in small streams, springs, and cienegas below 1,350 m (4,500 ft) elevation, primarily in shallow waters with aquatic vegetation and debris for cover. Historically, this fish was one of the most common and widespread species in the Gila River drainage in Arizona, New Mexico, and Mexico. This species has declined due to habitat destruction and the impacts of the introduction and spread of non-indigenous predatory and competitive fishes. The species persists in suitable habitats in Mexico and Arizona. Over 100 artificial populations are being maintained in order to provide stock for the re-establishment of Gila topminnows into numerous sites in Arizona. To date, Gila topminnows have been introduced to over 20 sites (USFWS, 2001b).

The Gila topminnow was listed as an endangered species without critical habitat in 1967 (32 FR 4001, March 11, 1967).

Potential for Occurrence on the Property

As stated above, this fish was historically one of the most common and widespread species in the Gila River drainage in Arizona, New Mexico, and Mexico. One primary reason for this species' recent decline is the introduction and spread of non-indigenous predatory and competitive fishes. There are two recent records of Gila topminnows along Cave Creek within 16 km (10 miles) of the Property. One record is from a site where native Gila topminnows were last observed in 1993. The second record is from a reintroduction site. This success of this reintroduction effort is in question. However, the possible continued presence of this species in Cave Creek cannot be discounted. We are unaware of any recent large-scale systematic fish surveys that have been conducted in Cave Creek and relict populations of Gila topminnows have been known to persist undetected for long periods of time. These factors, when considered in light of the recent documented occurrences of the species in Cave Creek, indicate that the endangered Gila topminnow may be extinct on the Property.

5.5.3. Cactus Ferruginous Pygmy-Owl

Life History

The cactus ferruginous pygmy-owl (CFPO) is a small non-migratory neo-tropical owl found from Argentina to southern Arizona and Texas in the United States. The northernmost subspecies though described as common in Arizona early in this century, has declined since 1900 (Millsap and Johnson, 1988). The best information available suggests that the Arizona population began to decline in the 1920s, and by the 1950s was rare (Johnson et al., 1999). The AGFD classifies the CFPO as a species of special concern. The USFWS listed the owl as an endangered species in Arizona in 1997.

Little is known about the habitat needs of CFPO in Arizona (Wilcox et al., 1999). The owls have been known to occur in river bottom woodlands, woody thickets, Sonoran desertscrub, and semi-desert grasslands. The common element among the different habitats occupied by the pygmy-owls is dense vegetation and structural diversity with nearby trees and/or saguaros of sufficient size to contain nest cavities (USFWS, 1999). CFPO nest sites in Arizona may be loosely associated with water, but the relationship is not definitive as some nests have been located in areas devoid of water (Ingraldi, 2000). It may be that CFPO take advantage of water and the associated benefits it provides when available, but its presence may not be necessary for successful nesting. It is possible that this preference is directly related to increased vegetation densities and prey availability associated with water sources such as washes and irrigation.

Potential for Occurrence on the Property

There are historical (1895) records of this species in the vicinity of the 6L Ranch. The riparian deciduous forest and adjacent uplands on the Property contains what may be considered ideal CFPO habitat. Early records of this species, especially in the Phoenix area, are almost exclusively from wet riparian habitats. The lack of recent records in the Property vicinity does not necessarily indicate absence. This small owl is inconspicuous and difficult to survey. Previously unknown populations of CFPO continue to be found in Arizona. We are unaware of any recent significant survey efforts along Cave Creek. Nevertheless, credible unconfirmed reports of this species in the Property vicinity continue to this day.

6. ARCHAEOLOGICAL RESOURCES

6.1. INTRODUCTION

A petroglyph site is present on the 6L Ranch near its southeastern corner. The petroglyphs are carved in the large basaltic boulders which have rolled from the top of Skull Mesa, as described in Section 4.2.2. At least 10 panels (rock faces) were found. Most of the petroglyphs at the site are motifs more commonly used during pre-Ceramic cultural phases of indigenous cultures of southwestern North America. Most of the petroglyphs at this site also are well varnished[4]; some are as darkened by desert varnish as the surrounding rock surfaces. The motifs, the amount of varnishing, and the weathered (naturally pitted) appearance of the petroglyphs suggest these petroglyphs were made during the Archaic Period (circa 8,000 years before present [ca 8,000 ypb] to the beginning of the Ceramic Period, ca 1,800 ybp) or even earlier, by earlier Paleoindians (late Pleistocene, 11,500 to ca 8,000 ybp). All indications are that this is a significant assemblage of archaic petroglyphs.

WestLand personnel inspected the petroglyphs and made a photographic record of characteristic and/or unique features, researched petroglyph literature about sites in the southwestern United States and the archaeological context in which the site may fit, and interviewed experts in the field. Our findings are described in this section.

6.2. PETROGLYPH DESCRIPTION

The petroglyph site is located on the east side of Cave Creek on the 6L Ranch, near the southeastern corner as noted above. On one of the older stream terraces are a number of large basalt boulders that originated from the top of Skull Mesa (Photograph 18). At least 10 of the boulders on or near the stream terraces have petroglyphs. Some boulders have only one or two petroglyphs; others have a score or more. At least two boulders have complex panels (overlapping arrays) of petroglyphs that cover nearly the entire upper surface (Photograph 5, provided in Section 4.1 on page 8).

[4] Desert varnish is the bacterial-mediated deposition of manganese oxyhydroxides on the surface of rocks. Over enough time, a varnished rock can eventually become dark black. The rate of accumulation of desert varnish is slow. For example, Bull (1991) suggests that 10,000 to 20,000 years would be required for varnish to significantly darken a rock. Bull, at one point in his research, looked at the amount of varnishing that had occurred since the well-dated siege of the fortress of Masada (50 AD) by Roman soldiers in the desert of what today is southeastern Israel. Roman soldiers had inadvertently broken rocks when building a siege ramp up to the walls of Masada. Although undisturbed rocks in the area of Masada are black with varnish, the freshly exposed surfaces of rocks broken during the siege were scarcely varnished 2,000 years later.

Photograph 18. Basalt Boulders on stream terrace at petroglyph site.

A remarkable number of the petroglyphs at this site were apparently deeply incised (by pecking) to a depth of 3 to 6 millimeters (mm) when made, have weathered significantly, and have become darkened by desert varnish to the same degree as the surrounding boulder surface. Accordingly, we believe that these varnished petroglyphs are very old. These petroglyphs include tree-like (herringbone) motifs (Photograph 19) and geometric designs (Photographs 20 and 21). In contrast, there is at least one panel of petroglyphs that appears to be relatively recent; these petroglyphs are scratched in the rock surface rather than deeply incised (Photograph 22), removing the varnish and a very shallow (1 to 2 mm) layer of the rock surface. The petroglyphs on this panel are only slightly varnished (or not varnished at all) and stand in sharp contrast to the dark, varnished surrounding boulder surface. The exposed rock surface here appears to be the natural rock color, as opposed to the dark varnish color of adjacent surfaces. These scratched petroglyphs include anthropomorphs and other figures that are characteristic of the later Ceramic periods; the lack of varnish on these petroglyphs also indicates a relatively recent origin.

Photograph 19. Archaic tree motif at 6L Ranch site.

Photograph 20. Archaic geometric petroglyph. Note that the design is pecked rather than scratched, and the worked surface is highly varnished.

Photograph 21. Archaic geometric petrogyph. Note that the design is relatively deeply incised by pecking, and the pecked surface is highly varnished (comparable to the adjacent rock surface).

Photograph 22. Scratched petroglyphs, probably Ceramic period (after 200 A.D.)

There are two highly varnished, very weathered (pitted) petroglyphs side by side on one of the boulders that look very much like elephants (Photograph 23), but probably actually represent Columbian mammoths (*Mammuthus columbi*). Mammoths were present in North America until at least the latest Pleistocene (11,000 ybp) before going extinct. If these petroglyphs actually represent mammoths, they are two of only a handful of known petroglyphs in North America that are considered to depict extinct late Pleistocene megafauna.

Photograph 23. Two petroglyphs that we interpret to represent two Columbian mammoths (*Mammuthus columbi*).

Several features of the petroglyphs are mammoth- or elephant-like:

- There are four pillar-like downward extensions on each petroglyph. These we interpret as elephant legs. The left petroglyph (Panel A-1) has two pairs of "legs" that are more closely spaced than the space between these two pairs; we interpret these pairs as forelegs and hind legs. The right petroglyph's "legs" also suggest a natural stance of an elephant rather than equally spaced lines. Henry Wallace (2004), who has reviewed our photograph of these petroglyphs, pointed out that the general element form (what we interpret as a torso with four legs) is "very similar to one of the more common Archaic designs (rakes)." However, petroglyphs with the rake design that we have seen in Wallace's reports (1986, 1989) generally have more "tines" than four; the number of tines is variable within and between sites and the horizontal line connecting the tines is the same width as the tines themselves. For example, an Archaic rake at this petroglyph site is prominent in Photograph 5 (page 8); this particular rake has at least 19 tines. The "legs" of the possible mammoth petroglyph are wider at their distal ends, not uniform in width as is generally the case of the "tines" of rake motifs. We interpret the wide distal ends of this petroglyph as feet. In living elephants, the feet are almost twice the width of the legs.
- On the right side of the left petroglyph is a half-inturned extension, roughly two-thirds the length of the legs. We interpret this as a trunk. Elephants, when either walking or standing and not engaged in feeding or other behaviors requiring the trunk, typically hold their trunk somewhat turned in. The right petroglyph does not have a pecked trunk; instead, a crack in the boulder is interpreted as the front outline of the trunk and the forehead of the elephant. Another crack represents the domed or convex outline of the back of the mammoth.

- The left petroglyph has what we interpret as a raised tail. The raised tail is a feature of many zoomorphic petroglyphs in the southwest (including the more commonly depicted deer and bighorn sheep) (Steward ,1929; Whitley et al., 1999).
- On the upper right of the left petroglyph, the outline suggests to us a domed forehead, a profile that is characteristic of both mammoths (*Mammuthus* spp.) and modern Asian elephants (*Elephas maximus*), but not African elephants (*Loxodonta africana*). There is a circular pecked image behind the "forehead" that appears to be an ear. As already mentioned, the right petroglyph has a rock crack that suggests the outline of the domed forehead of a mammoth. It also has a pecked feature of the lower edge of an ear, which has the shape characteristic of Asian elephants.

Figure 8 is our schematic drawing of the elements of the petroglyphs, color-enhanced for both pecked (orange) and natural (black) features of the boulder's surface. The blue line represents our interpretation of the outlines of the mammoths.

We interpret these two petroglyphs to be Columbian mammoths. The left petroglyph's design is almost entirely achieved by having pecked the surface of the rock. However the underside of the jaw, a portion of the trunk, and the eye are not pecked but are the natural surface of the rock. The right petroglyph has the forehead, outer edge of trunk, and back delineated by natural cracks in the boulder. That natural features contribute to the composition of the petroglyph may seem, on a first consideration, to detract from the case we make that these are depictions of a now extinct animal. However, Whitley (1996), in summarizing religious features of rock art and rock art sites, has described cracks in boulders at petroglyph sites in terms of valued portals during shamanistic experiences. Whitley (1996) has also emphasized the variety of shamanistic visions represented in petroglyphs (entoptic/geometric, representational + entoptic, and figurative). We would suggest someone seated or standing in front of this boulder may have first used the natural combination of cracks and surface features to "see" the right mammoth, pecked the remaining features of the right mammoth, then "saw" the left mammoth and pecked the missing portions of the vision. Given the smaller size of the left petroglyph and its proportions in the ear and head, it is tempting to suggest the left depicts a juvenile mammoth; the right, an adult mammoth.

Resolution Copper Company

6L Ranch

ENHANCED "MAMMOTH" PETROGLYPH
Figure 8

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Jobs/807.06/6L Ranch/petroglyph figure8 |Drawn by: JJC |Reviewed by: BS |Date: 06-14-04

If these are petroglyphs of mammoths, it is interesting that tusks are not depicted. Columbian mammoths did have tusks, although not as well developed as the wooly mammoth (Sukumar, 2003). We are unaware of research on the proportion of tusked crania, by region, of Columbian mammoths in North America. Osborn (1942) in his monograph on Proboscidea may have described regional variation for tusks in Columbian mammoths (but a copy of this paper is unavailable to us). The fossil evidence for mammoth at most sites in North America includes only one specimen (ex. Anderson and Williams, 1974; Davis et al., 1972; Harington et al., 1974; Holman, 1971), so measures of the tuskless proportion of a population are unavailable. This situation, only one or a few specimens at any given locality, is true for Arizona as well (Lindsay and Tessman, 1974; Saunders, 1970). However, for many described specimens, the anterior portion of the cranium is absent so the character state, tusked or tuskless, cannot be determined. Fossil sites with more than one mammoth specimen are known (ex. Walker and Frison, 1980); yet sites with many complete and well-preserved skeletons of mammoths are rare. Several site with large numbers of mammoths include Hot Springs, South Dakota (N = 49) (studied by L. D. Agenbroad, no ref.) and two sites in Texas, Waco (N = 23) and Friensenhahn Cave (N $\geq$ 100) (Hoppe 2004). At present, we do not know if all adult Columbian mammoths were tusked in Arizona, or if females were tuskless. Variation in tusk traits among populations of Asian and African elephants have been observed, and therefore, tuskless Columbian mammoths should be regarded as a possibility, pending review of a large set of fossils for the region.

6.3. MAMMOTHS IN NORTH AMERICA

6.3.1. Mammoth Evolution and Immigration into North America

There are only two living species of proboscidians, the Asian elephant (*Elephas maximus*) and the African elephant (*Loxodonta africana*). These are relatively closely related; both are in the family Elephantidae. Proboscidians first evolved in the late Paleocene along the coast of the Tethys Sea (northern Africa, southern Asia) (Lambert and Shoshani, 1998). By way of Beringia out of Asia, proboscidians first entered North America in late early Miocene. They were the largest late Cenozoic land animals in North America and part of the fauna of North America for about 17 million years, from the Miocene to the end of the Pleistocene (Lambert and Shoshani, 1998). During the peak of their diversity in North America (about 10 to 7 million years ago), there were eight genera (*Mammut, Gomphotherium, Megabelodon, Rhynchotherium, Amebelodon, Serbelodon, Torynobelodon*, and *Platybelodon*). By the end of the Pliocene, the number of proboscidian genera was reduced to about six. Most of the diversity of proboscideans in North America was due to immigration across Beringia from Asia, not from local evolutionary diversification. Mammoths, relative late-comers to North America after the peak noted above, are no exception.

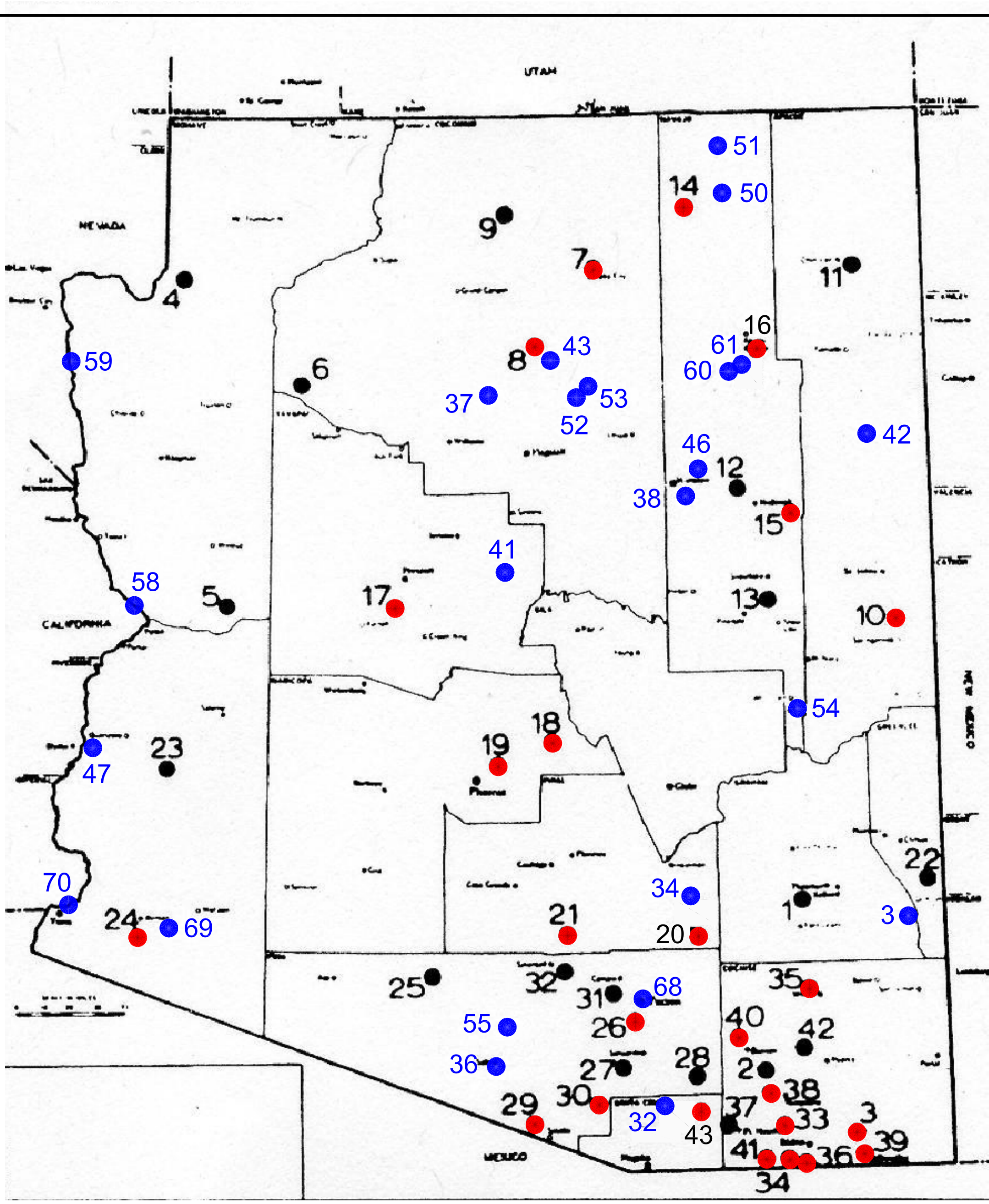
The first mammoth in North America was *Mammuthus meridionalis*, appearing in the Aftonian interglacial in Canada about 1.7 million years ago (reviewed by Harington and Shackleton, 1978). Harington and Shackleton (1978) reviewed all mammoth fossil localities for southwestern Canada.

Lambert et al. (1995) provide evidence to suggest that mammoths had arrived in North America by the Late Blancan. Lambert and Shoshani (1998) indicate an arrival of *Mammuthus* in late Pliocene (no earlier than about 2.4 million years ago). Columbian mammoths (*M. columbi*) arrived in southern Canada by the Sangamon interglacial of the Pleistocene. Recently, Arroyo-Cabrales et al. (2003a) and Arroyo-Cabrales et al. (2003b) have reviewed the localities and fossil collections for Mexico. We are unaware of any recent synthetic, published reviews of mammoth localities for the entire United States since Agenbroad's (1984) isocline maps of the distribution of each *Mammuthus* species, including *M. columbi*. It is interesting to note that the map for the distribution of *M. columbi* in North America shows four regions well-represented by fossils: central Great Plains, central Texas, Florida, and Arizona. A recent web site for the Hot Springs mammoth site in South Dakota, developed by Agenbroad (www.mammothsite.com), provides distribution maps of specific fossil mammoth localities for North America and for the Great Plains region (without isoclines, but also without documentation).

6.3.2. Mammoths in Arizona

Within Arizona, Saunders (1970) reviewed all mammoth fossils, their stratigraphy, and localities, and found that there were 70 confirmed localities with mammoth fossils. All but one of the fossil specimens are ascribed to the Columbian mammoth, *M. columbi* or an intermediate form between *M. columbi* and *M. floridanus*. Only a single individual from Cochise County could be ascribed unambiguously to *M. floridanus*. At the time of Saunders' review, the Cochise County specimen represented the western-most occurrence of *M. floridanus*. The general distribution of mammoth localities from the Pleistocene in Arizona (Figure 9) suggests that mammoths were widespread in Arizona during the late Pleistocene. They have been found in all counties except Gila County. The elevational range of the localities documented by Saunders (1970) and Lindsay and Tessman (1974) is from 38.1 m (125 feet) above sea level near Yuma to 1,920 m (6,300 feet) above sea level near Saint Johns.

The riparian area of Cave Creek within and near the 6L Ranch supports cattails, sedges, and grasses (particularly *Muhlenbergia rigens*). All of these were likely present along this portion of Cave Creek in late Pleistocene. Columbian mammoths are likely to have used this area while foraging. Mammoths are also likely to have included willows and cottonwoods in their diet from this area. One additional plant may have been included seasonally in the diet of mammoths within this area, much like the African elephants' use of *Senecio keniodendron*: agave (*Agave* spp.) (Mulkey et al., 1984), particularly the flowering stalks. Given the high rates of agave stalk consumption by mule deer, cattle, and bighorn sheep (all ruminants) in the Southwest, it would be interesting to know if either Asian or African elephants would utilize agave flowering stalks.



Mammoth (*Mammuthus* spp., especially *M. columbi*) localities from the Pleistocene in Arizona. Red: Localities based on Saunders (1970) and Lindsay and Tessman (1974). Blue: Localities based on Saunders (1970) but not included in Lindsay and Tessman (19745). Locality names are: **(red sites)** 3- Cat Wash and Double Adobe, 7- Charley Day Spring, 8- Cameron, 10- Richville gravels, 14- Shonto, 15- Goodwater Wash, 16- Keams Canyon, 17- Black Mountain, 18- Ft. McDowell, 19- Nichols site, 20- Cerros Negros, 21- Bain site, 24- Wellton Hills, 26- Tucson Brickyard, 29- Lopez site, 30- Cerro Colorado, Canez Wash, and Calera Ranch, 33-Murray Springs, Lewis Hill, Schaldack, Hurley, Donnet, South of Charleston, Big Tooth, San Rafael Aqueduct, Horsethief Draw, Lindsey Ranch, Escapule, and Mosan Wash, 34-Lehner Ranch, 35- Wilcox Gravel and Gardner Gravel, 36- Naco and Leikum, 38- Boquillas, Tombstone Gulch, and Choate Ranch, 39- Douglas and Pirtleville, 40-Gray site, Pomerene West, and Fenn site, 41- Ash Canyon and Wakefield. **(blue sites)** 3- Whitlock Valley, 32- Sonoita Creek Wash, 34- Mammoth locality, 36-Sells locality, 37- Porter Springs, 38-Phillips Pits, 41-Shill Ranch, 42- Chambers-McCarrel Pit, 43- Cameron Gravel pit, 46- Jarrett locality, 47- Ehrenberg Tusk locality, 50- Tsegi Canyon, 51- Tsegihatsosi Canyon, 52- Wupatki Monument, 53- Southeast of Black Point, 54- Guenther Mammoth, 55- Comobabi Mammoth, 58- Bill Williams Fork, 59-Elephant Hill, 60- Hack's U., 61- Hack's W. 68- Tucson Mammoth, 69- Roll Mammoth, 70- Yuma Mammoth. **Uncolored sites**: Sites with Pleistocene mammal fossils reported by Lindsay and Tessman (1974) but with no known fossils of mammoth.

Data Source:

Saunders, J. J. 1970. The distribution and taxonomy of *Mammuthus* in Arizona. Unpublished M. S. Thesis, University of Arizona, Tucson.

Lindsay, E. H. and N. T. Tessman. 1974. Cenozoic vertebrate localities and faunas in Arizona. Journal of the Arizona Academy of Science 9: 3-24.

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6L RANCH

Mammoth Localities From The Pleistocene In Arizona

Figure 9

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6.3.4. Time of Extinction for *Mammuthus columbi*

Agenbroad (1984) reviewed the carbon dates for mammoths of North America and found that the dates ranged from 26,075 to 8,815 years ago. The youngest date (8,815 ybp) may have been influenced by bone collagen in the sample, with some replacement of carbon. Agenbroad found that for a series of nine of the most recent dates for *M. columbi*, the "average carbon date was 11,242 ybp as a terminal date for the species". Man-mammoth associations (whether kill sites or butcher/scavenger sites) dates also cluster near 11,200 ybp. The most recent carbon dates for the sites examined by Hoppe (2004) are 10,000 and ca. 11,4000 ybp (two dates) for the Miami, Texas locality (Holliday et al., 1994); 11,380 and 11,290 ybp for two stratigraphic units at Blackwater Draw, New Mexico; and 10,980 to 11,2000 ybp for the Dent site in Colorado. It is possible that some populations of *M. columbi* survived into the Holocene, as may have occurred for *M. primigenius* in North America (with one date as recent as 7,7670 ybp [Agenbroad, 1984]); however, unequivocal evidence for a Holocene *M. columbi* occurrence is lacking.

Early humans in late Pleistocene North America were contemporaneous with and hunted mammoths (or at least scavenged their carcasses) and other now-extinct Pleistocene megafauna. Groups of humans were evidently small and mobile. The sites where mammoths or other large Pleistocene mammals were killed, scavenged, or butchered are relatively rare but often well studied. These well-documented sites include: the Dent site in Colorado (Figgins, 1933; Saunders, 1980, 1992; Haynes, 1987), Blackwater Draw site in northern New Mexico (Saunders 1980, 1992), Clovis site in eastern New Mexico (Saunders and Daeschler, 1994), Lehner site in southeastern Arizona (Haury et al., 1959), Colby site in Wyoming (Frison and Todd, 1986), and the Miami site in Texas (Sellards, 1952; Holliday et al., 1994). That early humans were present in North America at the time of extinction of mammoths, mastodonts, wooly rhinos, and other Pleistocene megafauna, has been elaborated by Paul Martin and others (Martin and Wright, 1967; Martin and Klein, 1984).

The possible responsibility of humans for extinction of these megafauna at the close of the Pleistocene has been described by various (essentially epidemiological) arguments for (1) human hunting (blitzkrieg fronts of Clovis people), (2) human-introduced diseases, or (3) disequilibria between predators and prey. As Frison (1998) succinctly notes, "the debate turns on whether the late Pleistocene extinctions were the results of paleoecological changes, human predation, or a mixture of both. The problem shows no signs of an immediate resolution."

6.4. Age and Significance of the Archaic Petroglyphs on the 6L Ranch

As mentioned, most of the petroglyph panels at the 6L Ranch appear to be from the Archaic period of human occupation. They are highly varnished, weathered, and are motifs associated with pre-Ceramic cultures. If the petroglyphs we have characterized as mammoths are indeed mammoths, it would suggest these two petroglyphs are at least 11,000 years old. Petroglyphs cannot usually be dated by association with stratified deposits, although globally such opportunities have been identified and successfully researched (papers in Strecker and Bahn, 1999). In addition, chronostylistic approaches per se have not been particularly successful in the southwest US (e.g., the considerable descriptive efforts but limited outcomes in Wallace and Holmlund, 1986; Wallace, 1989). The obvious exception to dating petroglyphs using chronostyles is when the petroglyph depicts unambiguously historic (after 1492 AD) figures such as rifles, men riding horses, cattle, automobiles, etc. Several approaches have been taken during the last two decades to directly date the rock varnish on petroglyphs; these dating techniques include:

- Radiocarbon dates of small quantities of organic matter trapped beneath the engraved portion of the petroglyph (with subsequent varnishing trapping the organic matter),
- Cation-ratio dates of the lowest layer of varnish in the engraved portion of the petroglyph, and
- Micromorphology of the rock varnish (particularly botryoidal-type deposition of varnish during the wetter Pleistocene versus lamellate-type deposition during the drier Holocene).

Cation-ratio dates have been used by various archaeologists interested in dating petroglyphs and developing local directly dated chronologies [for example, Loendorf (1991) and Faris (1995) for southeast Colorado, Whitley and Dorn (1987) for eastern California, Dorn et al. (1988) for South Australia; additional references in Harry (1995)]. Loendorf (1991) and Whitley et al. (1999) have identified changes over time in the relative frequencies of certain motifs in petroglyphs. Both note an increase in bighorn and anthropomorph petroglyphs during the last 1,500 to 1,000 ybp. Because envisioned motifs or "entoptics" and bighorns co-occur from the late Pleistocene to the recent past, Whitley et al. (1999) suggest these are art forms of a continuous religious tradition in North America, the art in shamanistic vision-questing.

Even with the understandable enthusiasm of archaeologists for applying these approaches to dating rock varnish in association with petroglyphs, many of the underlying assumptions are untested. Critiques of the dating approaches, particularly cation-ratio dating, have followed (Harry, 1995; Watchman, 2000; but see Bamforth, 1997 for counterpoint to Harry's criticism). At this point, carbon dating of substances embedded in rock engravings and cation-ratio dating are both considered problematical as direct dating approaches in petroglyphs. However, Tanzhuo Liu's varnish microlamination dating technique (Liu and Dorn, 1996) is "working very well; it just passed a blind test against cosmogenic techniques with flying colors last year" (Whitley, 2004).

We discussed these approaches to chronological dating of petroglyphs only to underscore the current state of the art. Based on our understanding of the various approaches, microlamination analysis appears to be the better approach for determining dates for the petroglyph engravings at the 6L Ranch.

In terms of other petroglyphs in North America that represent extinct Pleistocene megafauna, we are aware of only five others:

- A camelid petroglyph in the Mohave Desert (Whitley, 1999),
- A mammoth (?) petroglyph near Moab in southern Utah (Hubbard, 1929; Anonymous, 1935; Averett and Averett, 1947),
- A "wounded" mammoth petroglyph in Nevada (Tuohy, 1969),
- An undocumented (?) mammoth petroglyph for Thousand Lake Mountain, central Utah (Stokes and Stokes, 1980), and
- Several camelid petroglyphs in the Big Bend area of Texas (not included as photographs in Lowrance (1975), but described by Wellman (1979) as part of Lowrance's symposium presentation).

At least the first three of these show clear indications of varnish within the engraved surface, and therefore, like the 6L Ranch petroglyphs, are not likely to represent forgeries. We also want to emphasize that bighorn sheep petroglyphs appear to span all or most of the time span represented by rock art in the southwest. Whitley (2004) makes "one important point: species like bighorn sheep are Pleistocene faunal remnants; we literally may have thousands of unrecognized Ice Age motifs that just don't happen to represent extinct species, and so go unremarked." Because the animal is still extant, the bighorn sheep petroglyphs cannot be confidently ascribed solely to the Pleistocene unless or until reliable direct dating techniques are applied.

The petroglyphs on the 6L Ranch are significant because the majority appear to be highly varnished, probably late Pleistocene or early Holocene in age, and generally are in a good state of preservation. As discussed, two of the petroglyphs appear to represent mammoths; if this interpretation is correct, they belong to only a handful of petroglyphs that depict extinct Pleistocene mammals. An additional comment should be made with regards to the petroglyphs' state of preservation on 6L Ranch. Although some of the petroglyphs have been shot at and others have been damaged by attempts to pry off the panel face, or by attempts to steal the whole boulder (unsuccessfully), the 6L Ranch petroglyphs do not appear (after a cursory examination) to have been tampered with by highlighting the petroglyphs' features -either by re-working the engraved surface or by chalking the surface. The best known of the putative Pleistocene petroglyphs, the Moab mammoth, shows clearly in the photograph in Anonymous (1935) and possibly Hubbard (1929) an effort to enhance the petroglyph by chalking. Chalking disturbs, alters, or damages the surface of a petroglyph. This kind of alteration interferes with efforts for long-term conservation of these cultural sites. It may also so alter the petroglyph that direct dating using the microlamination approach may prove futile.

7. CONSERVATION VALUES AND OPPORTUNITIES

7.1. VALUES

7.1.1. Petroglyph Site

The petroglyphs on the 6L Ranch are significant because the majority appear to be highly varnished, probably late Pleistocene or early Holocene in age, and generally in a good state of preservation. As discussed, two of the petroglyphs appear to represent mammoths; if this interpretation is correct, they belong to only a handful of petroglyphs that depict extinct Pleistocene mammals. An additional comment should be made with regards to the petroglyphs' state of preservation on the 6L Ranch. Although some of the petroglyphs have been shot at and others have been damaged by attempts to pry off the panel face, or by (apparently unsuccessful) attempts to steal the whole boulder, the 6L Ranch petroglyphs do not appear to have been tampered with by highlighting the petroglyphs' features, either by re-working the engraved surface or by chalking the surface. The best known of the putative Pleistocene petroglyphs, the Moab mammoth, shows clearly in the photograph in Anonymous (1935) and possibly Hubbard (1929) an effort to enhance the petroglyph by chalking. Chalking disturbs, alters, or damages the surface of a petroglyph. This kind of alteration interferes with efforts for long-term conservation of these cultural sites. It may also so alter the petroglyph that direct dating using the microlamination approach may prove futile.

7.1.2. Habitat for rare or Diminishing Populations of Native Fish and Amphibians

The perennial pools and reaches of Cave Creek support both native and non-native fish as well as native amphibians. Two native fish have recently been reported in Cave Creek's watercourse, near the 6L Ranch: long-finned dace (*Agosia chrysogaster*) and Gila topminnow (*Poeciliopsis occidentalis occidentalis*). The Lowland leopard frog (*Rana yavapaiensis*) is also likely to occur on the Property. Obviously, these rare, aquatic species need perennial water for their continued existence.

A series of perennial pools are present in the 6L Ranch portion of Cave Creek. It is possible that these pools are fed by subsurface flow from water upstream; it is equally plausible, given the major fault that runs parallel to Cave Creek and the diversity of bedrocks exposed along the slopes and in the channel, that these same perennial pools may be fed by basal flow from adjacent bedrock, independent of channel flow from upstream.

Gaging stations exist downstream on Cave Creek. These stations provide a record of major flood events. However, because continuously monitored gaging stations do not exist for the 6L Ranch reach of Cave Creek (or above), flood events can be reconstructed only by careful attention to high-level debris deposits along the side of the channel. These debris deposits may suggest maximum flood height and may be used to bracket the timing of flood events. However, they are insufficient to describe flood events in terms of parameters (how quickly the water crested, how long it lasted, whether flood waters repeatedly surged over time, etc.) that provide insight into understanding the biology of the stream.

Floods - and the resulting seasonally flooded plains - are now understood to be very important for the ecology, evolution, and now (after two centuries of extensive alterations of rivers and streams in North America) the continued survival of many freshwater fish species (the rivers of Illinois: Forbes, 1925; Bennett, 1958; Bell, 1981; Kwak, 1988; Colorado River: Beland, 1953; Holden and Stalnaker, 1975; Atchafalaya Basin floodway: Lambou, 1963; Missouri River: Whitley, 1974; Green River in Utah: Modde et al., 2001). Floodwaters represent opportunities for some "flood-exploitative" species to disperse out from the river channel and forage or breed in waters of the flood plains. However, when systematic long-term monitoring of fish populations is undertaken, it is also evident that some fish do not exploit floodplains but remain in the channel (Ross and Baker, 1983). Floodwaters also can rework gravel bars, enhancing sites for ovipositioning and larval development for fish. With the introduction of green sunfish and several other non-native predatory fishes into river systems where they did not previously occur, evidence is accumulating to suggest that floods are periodically removing these non-native populations. Although not extirpating the non-natives, these recurrent flood events create conditions favorable for persistence of the native fish populations. Detailed comparative studies are only beginning to be done (ex. Brouder, 2001 for roundtail chub, *Gila robusta*, in the Verde River; Valdez et al., 2001, for native fish in the Grand Canyon along the Colorado River); however, there are earlier detailed monitoring of fish communities in response to floods (ex. Ross, 1983, for fish in streams in southeastern USA). There is likely to be a complex set of factors at play in determining persistence and demographic performance of native and non-native fish in these systems. It is plausible that native fish in impounded streams and reaches without significant flood events are more quickly displaced by the non-native fish than native fish in streams with forceful, recurrent floods. Cave Creek, with its large watershed and obvious recurrent large magnitude floods in the middle and upper reaches may actually provide conditions conducive for the maintenance or increase of the native Gila topminnow and long-finned dace. As such, major flood events in the middle and upper reaches of Cave Creek should be regarded as of biological value for its potential role in supporting native fish populations.

7.1.3. Only One Invasive Tree Species on the 6L Ranch

During our visit to the 6L Ranch on March 22, 2004, we saw only one species of invasive, non-native woody plant, salt cedar (*Tamarix ramosissima*). Along the channel of Cave Creek, this species occurred only as scattered small trees. Nowhere did we note solid stands of this species. Furthermore, a number of other invasive tree species that occur problematically in similar watersheds throughout Arizona are <u>not</u> present on the 6L Ranch (or other nearby reaches of Cave Creek). Thus, this relatively unaltered aspect of the 6L Ranch represents a unique value of the property.

For reference, we briefly describe the invasive potential of five species of non-native woody plants that either do or have the potential to occur within the 6L Ranch area of Cave Creek. As noted above, only tamarisk was observed on the Property.

a) *Tamarix ramosissima*. Salt cedar has become the dominant riparian tree species along many of the rivers and streams in the southwestern United States. Its ecology and historic spread has been described by Di Tomaso (1998). It has been demonstrated to be more drought tolerant than common native phreatophytes like *Pluchea sericea, Prosopis pubsecens*, and *Salix exigua* (Cleverly et al., 1997); although not competitively superior during high-water conditions, it can increase incrementally along water courses with each drought event. Efforts to eradicate salt cedar, once established, require persistence, manpower, logistics, and funding (Taylor and McDaniel, 1998), factors that are ever-limiting for public land agencies.

b) Pyracantha cf. *crenatoserrata.* Graber's Firethorn has become the dominant shrub along the channel in lower portions of Esperero Canyon and several other canyons in the Santa Catalina Mountains in south-central Arizona. Its fruit are spread by birds, and given its tolerance to cold, there is no reason to suppose this species will not continue to spread into most of the wetter drainages in the Santa Catalina Mountains. *P. crenatoserrata* has recently been reported as having become naturalized in California (Hrusa et al., 2002) and Hawaii (Herbarium Pacificum staff, 1999). It is very likely to eventually become a dominant canyon shrub in Arizona unless steps are taken to eradicate colonies as they become established.

c) Ailanthus altissima. Tree of Heaven is from China has become naturalized in many parts of the United States. It was planted in mining towns in Arizona (ex. Bisbee, Superior, Jerome) and has now become invasive in and around these settlements, both on hill slopes and along drainage channels. Once established, it forms large clones by root suckers. If published literature is any indication, only recently has its troubling ability to become a dominant species in deciduous forests of eastern North America begun to be monitored and studied (Huebner, 2003; Burch and Zedaker, 2003). Efforts are underway to eradicate it from some forests in eastern United States.

d) Ziziphus jujuba. Jujube is native from southeast Europe to China. It is not cold sensitive. Once established, it spreads by root suckers to form large clones of trees (Outlaw et al., 2002). Large clones of this species can be found in a number of yards and vacant lots in Tucson. Many of these clones in Tucson survive and spread with no supplemental watering. Efforts and strategies to eradicate a related species, *Z. mauritiana*, a species that has become a serious weed tree in Australia, are described by Grice (1998).

e) Catalpa speciosa. Northern Catalpa is native to the Mississippi Valley. It is not native to Arizona, but has become naturalized east of Superior along perennial watercourses (such as Devils Canyon). It has not (yet) become numerically abundant; however, with its large entire leaves and massive adult size it has the potential to become a significant consumer of water along perennial streams in Arizona as it continues to spread.

7.2. OPPORTUNITIES

7.2.1. Conservation of the Petroglyph Site

The current Property owners and their representative, Mr. Edward Childers (who has been actively involved for the last two decades in the management of the 6L Ranch) have done much to protect the petroglyph site on the 6L Ranch from vandalism and theft. They installed a massive welded pipe gate on the south end of the Property in order to deter people driving onto the 6L Ranch. Undoubtedly, this has hindered efforts by thieves to bring heavy machinery onto the Property with the intent to remove boulders with petroglyph panels. They also visited the 6L Ranch on a regular basis and, when encountered, would advise uninvited visitors at the petroglyph site to not climb on the petroglyphs or to leave.

Conservation of petroglyph sites on public lands presents a series of challenges. Unfortunately, some people have little regard for the intrinsic value of archaeological sites. On-the-spot transformation of such individuals into good stewards is unlikely; however, nor is the restriction of access by citizens usually feasible on public lands. There are several approaches that have been developed for managing archaeological and culturally sensitive sites on public lands. These approaches have been described in detail by Tate (1989), Loubser (2001), and others. Agencies such as the Bureau of Land Management, Forest Service, and National Park Service have developed plans for the conservation of specific petroglyph sites. An example of one such plan is the Bureau of Land Management's (1983) well-considered plan to protect and conserve a number of petroglyph sites in the Safford District. Additionally, it should be considered that petroglyph sites, as old as they may be, are often actively considered by Native Americans as integral features of their cultural and spiritual landscapes. Some petroglyph sites in portions of North America are still in use by Native Americans (Lewis, 1990; Whitley, 1996).

Several opportunities present themselves in the conservation of this archaeological site.

- Photographic documentation of all panels on the site with photographs deposited in the Arizona State Museum (Office of Records) and with the Tonto National Forest. Along with their research value, this photographic set constitutes a documentation of the condition of the petroglyphs at the time the photographs are taken and so can be used to monitor rates of vandalism over time.
- Non-obtrusive signage describing briefly the site, reminding visitors of the laws protecting archaeological sites, informing visitors that all panels have been photographically documented and archived, and suggesting appropriate behavior around the petroglyphs (not climbing on the petroglyphs, not enhancing petroglyphs with chalk, not shooting at them, etc.).
- Sign-in ledger at Spur Cross Ranch, a Maricopa County access point to Cave Creek downstream from the 6L Ranch. Sign-ins help build a sense of accountability in visitors to archaeological

sites. To our knowledge the only vehicular access to 6L Ranch is along the road that passes through Spur Cross Ranch.

- Encouragement of local volunteer groups to help with the conservation of this and other sites along Cave Creek. Monitoring, protection, and raising public awareness by local volunteer groups in the Phoenix area are described by Griffith (2004).

7.2.2. Non-native Fish Eradication

Control of sunfish would benefit the native Gila topminnow and long-finned dace. During low-flow seasons (especially May and June), when water in Cave Creek is only a series of small perennial pools and a few intermittent reaches, pools could be swept in order to recover topminnows and dace. These native fish could be held in tanks while a piscicide (e.g., Rotenone) could be applied to the pools and reaches to kill the remaining (largely non-native) populations of fish.

Although both of the topminnow and dace are probably very capable at dispersing naturally along flowing reaches of Cave Creek, a better hydrological understanding of Cave Creek is likely to enhance or better inform conservation efforts for these species. To that end, we suggest a simple hydrologic study of Cave Creek in the vicinity of the 6L Ranch. It would be helpful to know the source of water in the perennial pools on the 6L Ranch, and the flood behavior (duration and discharge over time):

- Systematic monitoring of water flow and water chemistry along Cave Creek and associated seeps and springs would provide the kind of information required in developing a realistic hydrological model of the Cave Creek watershed.

- If installed, continuous gaging stations would be useful monitoring devices for better describing flood behavior of this watershed. Flood force and behavior along specific portions of Cave Creek channel, if measured, would likely provide important insights into issues such as riparian tree dynamics in Cave Creek, and why the Gila topminnow and the long-finned dace continue to occupy specific reaches of Cave Creek when elsewhere these fish have been so rapidly extirpated with the introduction of non-native fish.

7.2.3. Eradication of Invasive Trees in Cave Creek

Under management by Tonto National Forest, there is an opportunity to systematically eradicate (using the appropriate herbicides) the incipient colonies of salt cedar along Cave Creek. The Cave Creek watershed is large. Although efforts to control this species within such a large watershed may at first seem daunting, three aspects make this program worthwhile:

(1) The tree still occurs in low numbers,

(2) The drainage is large enough that once the eradication is complete, the rate of seed reentry into the watershed will be likely low enough that small-scale control efforts in the future will suffice, and

(3) Conditions do not appear to favor continuous dense stands of salt cedar along upper Cave Creek, as is seen elsewhere along channels in Arizona.

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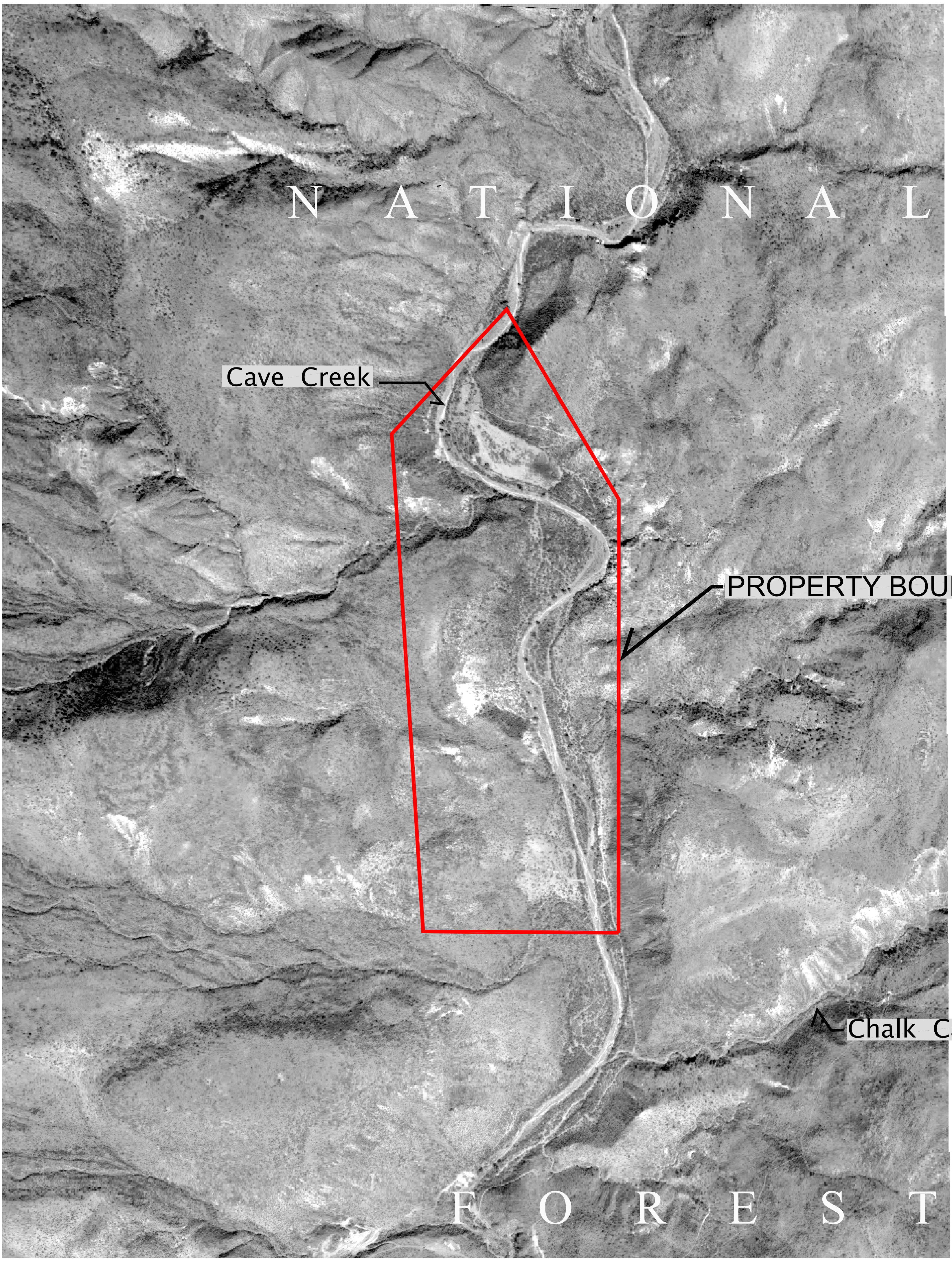
APPENDIX A

1962 AND 1992 AERIAL PHOTOGRAPHS



T.7N.,R.4E., Portion of Section 21,
Maricopa County, Arizona
Located on the New River Mesa
USGS Quadrangle

Photo Provided By: EROS Data Center, 1962.

PROPERTY BOUNDARY

0' 500' 1000'
SCALE: 1" = 1000'

N
W E
S

WestLand Resources Inc.
Engineering and Environmental Consultants
2343 E. Broadway Blvd. Suite 202
Tucson, Az 85719 (520) 206-9585

Resolution Copper Company

6L RANCH

1962 Aerial

Figure A-1

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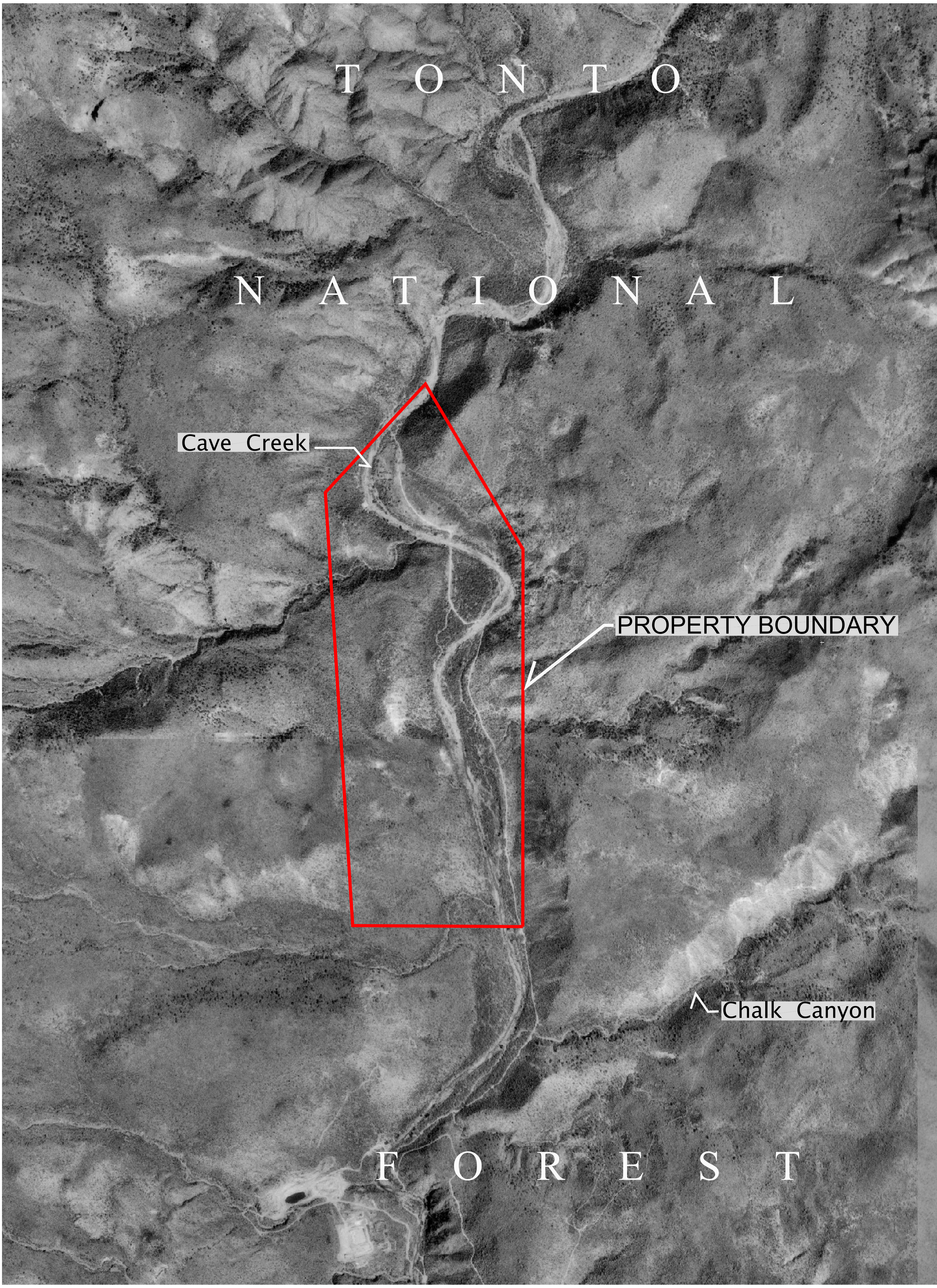

T.7N.,R.4E., Portion of Section 21,
Maricopa County, Arizona
Located on the New River Mesa
USGS Quadrangle

PROPERTY BOUNDARY

Photo Source: USGS Digital Ortho Quarter Quadrangle
New River Mesa NW & SW 1992.

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0' 500' 1000'
SCALE: 1" = 1000'

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Resolution Copper Company

6L RANCH

1992 Aerial

Figure A-2

M:\PROJECTS\807.06\6-L-EO\6-L-Ranch-aerial.DWG 7-06-04