

Pima County Ecological Monitoring Program

Leopard Frog Monitoring Protocol

December 2018



Chiricahua Leopard Frog
(*Lithobates chiricahuensis*)



Lowland Leopard Frog
(*Lithobates yavapaiensis*)

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Recommended Citation:

Gicklhorn, J.M. & I.W. Murray. 2018. Chiricahua and Lowland Leopard Frog Monitoring Protocol. Ecological Monitoring Program, Pima County Multi-species Conservation Plan. Report to the U.S. Fish and Wildlife Service, Tucson, AZ.

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Abstract

This protocol covers the structure and results for Pima County's first round of monitoring both Chiricahua and lowland leopard frogs, under its Multi-species Conservation Plan (MSCP) and Section 10 permit from the U.S. Fish and Wildlife Service (USFWS). Pima County has agreed to monitor the occupancy of lowland leopard frogs at six different riparian sites (Youtcy Canyon, Espiritu Canyon, Edgar Canyon, Buehman Canyon, Bullock Canyon, and Cienega Creek) on County lands every three years. The County has also agreed to monitor the occupancy of any newly established Chiricahua leopard frog populations on County lands on an annual basis for the first three years, and thereafter every three years. We used a visual encounter survey method during leopard frog surveys and although there was variation in how leopard frogs were distributed across a site, we confirmed that lowland leopard frogs occupied all six sites during 2018. Chiricahua leopard frogs are currently known to occupy two sites on County lands, and both of these sites were occupied during 2018. Although our 2018 leopard frog monitoring results are the first under the County's MSCP, as key riparian indicator species, County staff have been tracking occupancy of lowland leopard frogs at most of these sites on an annual basis since approximately 2011.

Acknowledgements

We would considerably like to thank David Hall (University of Arizona) for his efforts in surveying for Chiricahua leopard frog and managing invasive species at Hospital Tank and Goat Well Pond. We thank Don Carter for his critical role in developing the Goat Well Wildlife Pond as Chiricahua leopard frog habitat. We also acknowledge the many years of work that Brian Powell and Don Swann have invested in monitoring and tracking leopard frogs, especially lowland leopard frogs, on and off County lands. We thank Mead Mier and Melanie Alvarez of Pima Association of Governments, and Doug Siegel and Rachel Loubeau of NRPR, for organizing quarterly wet-dry mapping of Cienega Creek. Mike List provided key GIS expertise and guidance for plot placement. Pima County's Ecological Monitoring Program Science and Technical Advisory Team members for assistance with program design and protocol review.

Background & Objectives

Six species of leopard frogs (family: *Ranidae*, genus: *Lithobates*) occur in riparian habitats of Arizona. Of those species, the Chiricahua Leopard Frog (*Lithobates chiricahuensis*) and Lowland Leopard Frog (*Lithobates yavapaiensis*) occur in the Sonoran Desert and sky islands waters of eastern Pima County. Pima County's Sonoran Desert Conservation Plan identified both species for coverage due to widespread population declines and extirpations among both species as well as for their ecological significance in riparian systems. Additionally, the Chiricahua leopard frog is a federally protected species. The County's Multi-species Conservation Plan (MSCP) ensures that the County remains in compliance with its Section 10 incidental take permit that it has been issued from the U.S. Fish and Wildlife Service. As part of the MSCP, Pima County has agreed to monitor Chiricahua and lowland leopard frog populations on County conservation lands (Pima County 2016).

The Chiricahua leopard frog (CLF) is a mid-sized (maximum ~110 mm snout-vent length) frog known to historically occur broadly throughout the Gila and Verde River watersheds, as well as parts of Mexico. However, the species is estimated to be extirpated in ~88% of its historic localities (in the United States), and currently occurs primarily in stock tanks and other man-made waters in southern Arizona. The U.S. Fish and Wildlife Service listed CLF as threatened in 2002 due to chytridiomycosis exposure (i.e., chytrid fungus) and subsequent catastrophic population declines, non-native species predation and competition, and habitat loss and degradation (USFWS 2007). As of December 2018, CLF are currently known to occur in two sites on Pima County conservation lands: 1) Hospital Tank (Clyne Ranch), and 2) Goat Well Pond (Sands Ranch). Hospital Tank is a non-supplemented, rainwater-fed dirt livestock tank, while Goat Well Pond is a constructed, well-fed pond adjacent to an existing ephemeral livestock tank that Pima County built to provide habitat for CLF as well as a wildlife water source.

The lowland leopard frog (LLF) is a small (maximum ~86 mm snout-vent length) frog known to historically occur broadly throughout perennial waters in central and southern Arizona, southwestern New Mexico, parts of southeastern California, and Sonora, Mexico, from near sea level up to 2,000 m. The species' range has been reduced somewhat, due to the decrease in perennial water availability in many low lying streams, the introduction of nonnative and invasive species such as bullfrogs, crayfish, and various fishes, and from the chytrid fungus. Consequently, it is considered a species of conservation concern in Arizona. LLF is currently known to occur in mountain streams, ciénegas, and stock tanks in southern Arizona and northern Mexico. It is likely extirpated in California and New Mexico. Stressors can include non-native species predation and competition, catastrophic flooding of mountain streams (particularly after forest fires), loss of surface water availability, and chytridiomycosis-induced population die offs. As of January 2019, LLF are currently known to occur in at least six sites on Pima County conservation lands: 1) Cienega Creek Natural Preserve, 2) Youtcy Canyon Spring (A7 Ranch), 3) Espiritu Canyon (A7 Ranch), 4) Buehman Canyon (Buehman Canyon Preserve, Tesoro Nueve Ranch, and A7 Ranch), 5) Bullock Canyon (Buehman Canyon Preserve) and 6) Edgar Canyon (Six Bar Ranch and M Diamond Ranch). Cienega Creek is a lower elevation

intermittent, perennial stream in the Santa Cruz River watershed, while all other known sites are streams in higher elevation mountain canyons in the San Pedro River watershed. Lowland leopard frogs (apparently introduced and from a lower San Pedro River lineage) also occur, and are breeding in three small well-fed ponds at Catalina Regional Park, on the northwest side of the Santa Catalina Mountains. Frogs at this site are not included in Pima County's list of sites to be monitored.

Pima County's leopard frog monitoring objective is to detect biologically meaningful changes in the distributions of frog populations and where possible, to support other monitoring efforts at spatial scales beyond Pima County lands. Pima County has long invested resources in assessing and managing these frog species well before the finalization of the MSCP in 2016. For example, Pima County staff have been inventorying LLF occurrence during annual wet-dry mapping efforts across County preserve lands since 2011 (Powell 2018), and substantial amounts of time and resources have been put into restoring and creating habitat for CLF beginning in 2011. In 2014, Hospital Tank was pumped dry and nonnative and predatory green sunfish were removed from this site. Subsequent to the refilling of the tank, CLF from a nearby site on BLM land (Clyne Pond) recolonized this site in 2016. Nearby on Sands Ranch, Goat Well Pond was constructed in 2015-2016 and was reported as having been recolonized by CLF in April 2017. The six known LLF monitoring sites were inventoried regularly, however LLF were not detected during multiple years on several sites in the San Pedro River watershed, highlighting the sometimes-unpredictable small-scale patterns of occupancy of this species across the landscape.

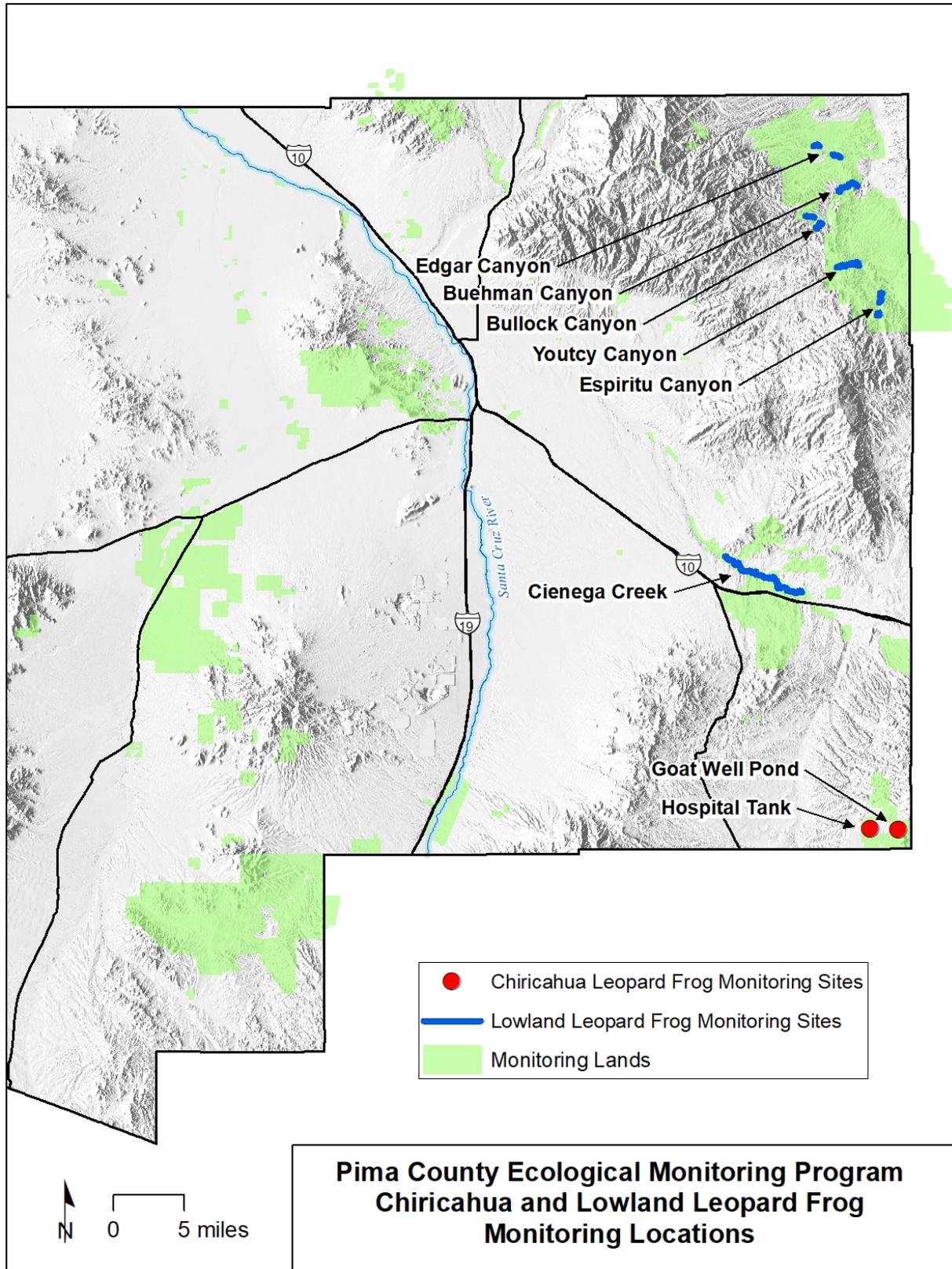


Figure 1. Map of Chiricahua and lowland leopard frog monitoring sites on Pima County Conservation Lands.

Monitoring Site Locations

Chiricahua Leopard Frog

Hospital Tank

Hospital Tank is an approximately 1.2 acre (when at 100% capacity) livestock tank on the County's Clyne Ranch. In 2011, the Pima County Natural Resources, Parks & Recreation (NRPR) department improved Hospital Tank on the Clyne Ranch, in part to improve potential CLF habitat. Herpetologist David Hall (University of Arizona) reported CLF having recolonized Hospital Tank as of September 2016. The tank is rainwater fed and fluctuates considerably in water level between wet and dry periods of the year (Figs. 2 & 3). When water levels are high, shrubby desert bankside vegetation can provide considerable cover for CLF; however, when water levels are low there is typically minimal above water vegetation to provide cover as a result of the broad exposed dirt bank. As many as 74 adult and juvenile CLF have been detected in a single survey (David Hall, personal communication), and CLF are reproducing at this site. Non-native American bullfrogs (*Lithobates catesbeianus*) have been a continuing management need on this site, and David Hall and his team of biologists have been leading efforts to regularly survey for and remove bullfrogs and their tadpoles as needed.



Figure 2. Hospital Tank on Clyne Ranch in early June when it is at its lowest point (June 2018).



Figure 3. Hospital Tank on Clyne Ranch in early fall after being filled by rainfall and runoff (October 2012).

Goat Well Pond

Goat Well Pond is an approximately 0.06 acre constructed pond in the County's Sands Ranch. The pond was constructed between 2015-2016 by Pima County NRPR staff and an Arizona Conservation Corps crew with funding from the USFWS's Partners for Fish and Wildlife Program. This site has permanent water supplied by a well (Figs. 4 & 5). Native riparian plant species were planted to create appropriate habitat for CLF. Additionally, this site is approximately 150 feet away from Goat Well Tank, an approximately 0.5 acre, rain-fed dirt tank. However, this tank does not hold permanent water. David Hall reported CLF present in Goat Well Pond in late April 2017, with as many as 20 adult CLF detected during subsequent nocturnal surveys in May of that year. As of January 2019, bullfrogs have not been detected in Goat Well Pond, although it remains a concern that this species could also colonize this pond.



Figure 4. Goat Well Pond on Sands Ranch in early December 2016.



Figure 5. Goat Well Pond on Sands Ranch in June 2018.

Lowland Leopard Frogs

Cienega Creek

Cienega Creek is a perennial stream located within the Cienega Creek Natural Preserve. Cienega Creek is classified as an Outstanding Arizona Water (ADEQ 2018) that includes extensive riparian habitat with high biodiversity. Cienega Creek drains the Empire and Whetstone Mountains through the Las Cienegas National Conservation Area before running through the County's Cienega Creek Natural Preserve lower in the watershed (Figs. 6 & 7). Cienega Creek represents one of the last perennial streams in southeastern Arizona and represents a key habitat and movement corridor for numerous protected species. The County and Pima Association of Governments (PAG) implement quarterly monitoring of surface water availability within the preserve. Monitoring efforts have shown long-term decreases in the linear extent of surface water in the creek, however some amount of surface water has always been present during monitoring at the driest time of year (i.e., June) and these stretches of perennial water, though fluctuating in extent from year to year, reliably occur in four disparate parts of Cienega Creek Preserve.



Figure 6. Pool below Del Lago diversion dam in Cienega Creek, Cienega Creek Natural Preserve.



Figure 7. Flowing reach of Cienega Creek, Cienega Creek Natural Preserve.

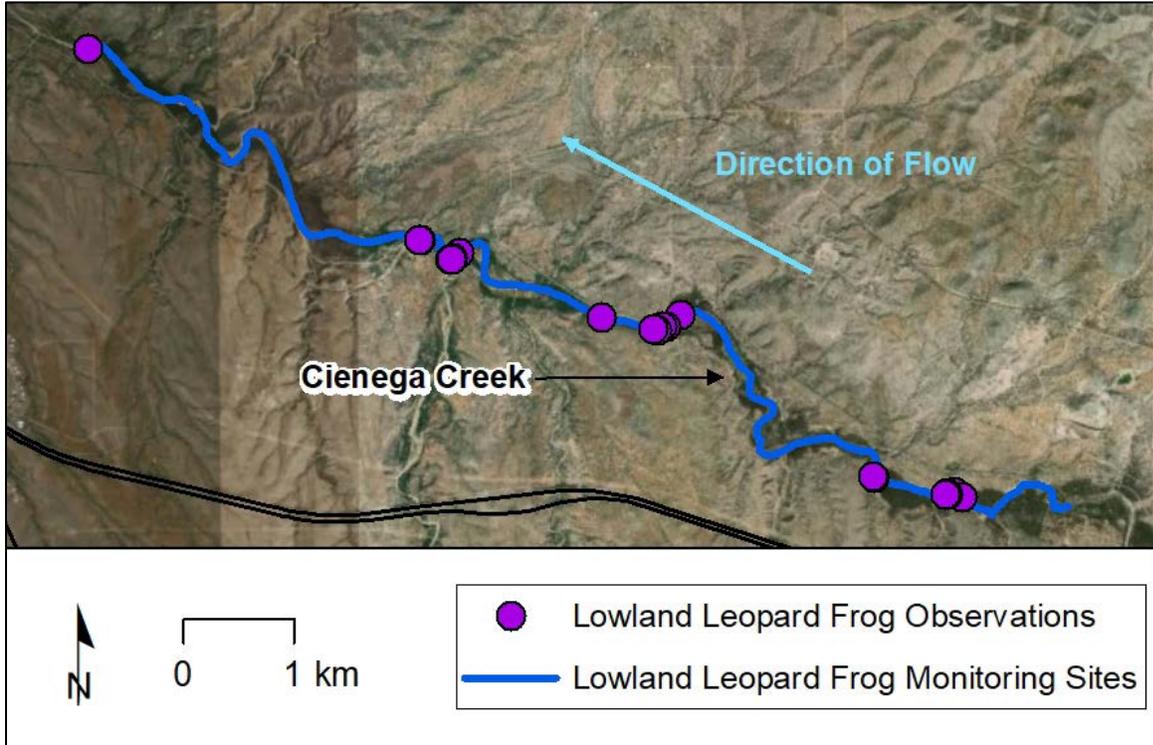


Figure 8. Cienega Creek monitoring site and all previous LLF observations made by County staff at this site.

Espiritu Canyon

Espiritu Canyon is located on the northeast side of the Rincon Mountains in the San Pedro River watershed on the County's A7 Ranch. Surface water flow is largely dependent on rainfall and snow melt in the upper portion of the watershed. This canyon is characterized by deep bedrock tinajas and fluctuating sediment flow, which can regularly change pool availability and depth. During wetter times of year surface water flow often connects these deeper pools, however during the pre-monsoon dry period (i.e., June) County staff have monitored two reaches (upper and lower) comprising approximately 2 km of suitable habitat. LLF have been found consistently in the lower reach (Figs. 9 & 10), but only intermittently in the upper reach with several individual frogs observed in one tinaja during fall of 2017.



Figure 9. Lower Espiritu Canyon on Pima County's A7 Ranch.



Figure 10. Lower Espiritu Canyon on Pima County's A7 Ranch.

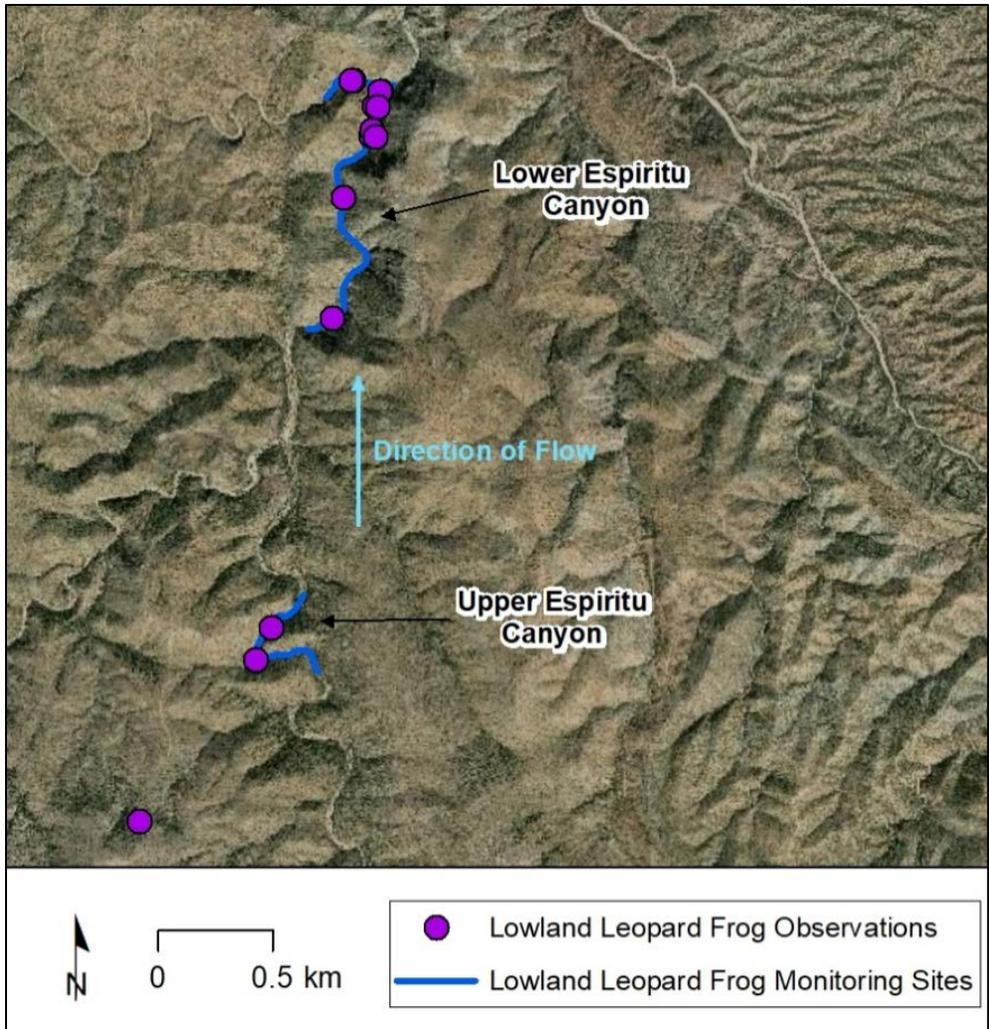


Figure 11. Upper and lower Espiritu Canyon monitoring reaches and all previous LLF observations made by County staff at this site.

Youtcy Canyon

Youtcy Canyon is located on the northeast side of the Rincon Mountains in the San Pedro River watershed on the County’s A7 Ranch. Surface water flow in the canyon is spring-fed from Youtcy Canyon Spring, providing a reliable perennial water source. The canyon is characterized by several bedrock tinajas higher up in the canyon and longer more continuous pools below the spring source. Leopard frogs have been consistently observed in Youtcy Canyon below the spring since 2011 (Figs. 12 & 13); however impacts from livestock have occasionally occurred in this reach due to broken livestock fencing and in some years frogs were not detected at this site.



Figure 12. Youtcy Canyon Spring (July 2011).

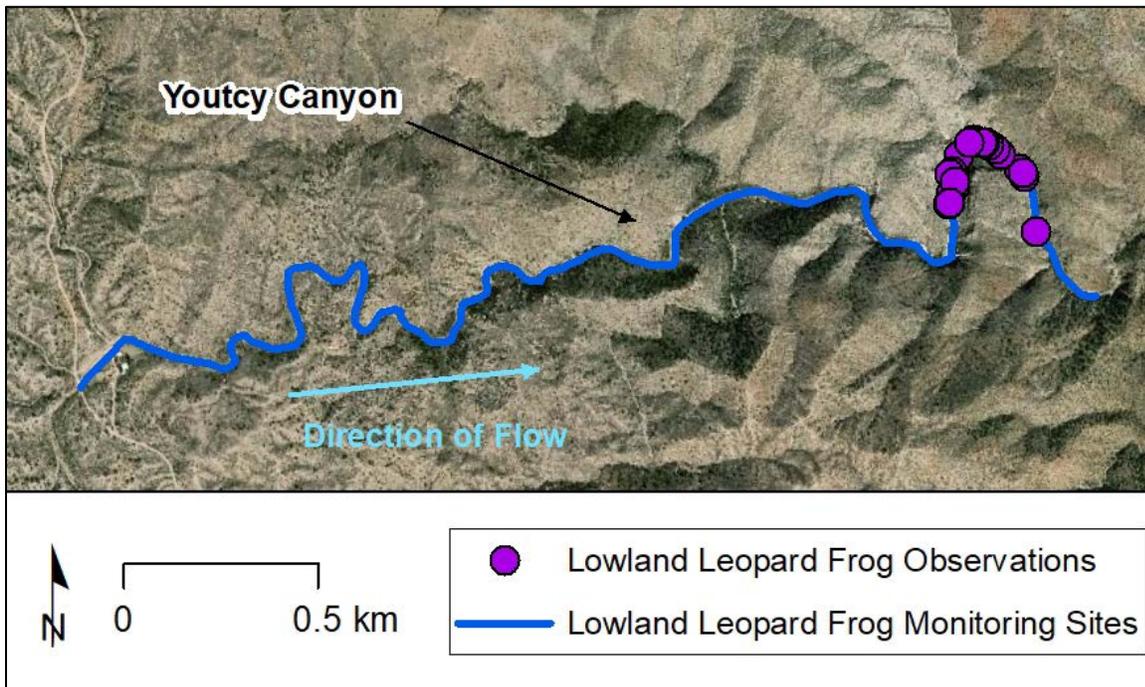


Figure 13. Youtcy Canyon monitoring site and all previous LLF observations made by County staff at this site.

Buehman Canyon

Buehman Canyon is located on the east side of the Santa Catalina Mountains in the San Pedro River watershed. Buehman Canyon is also classified as an OAW (ADEQ 2018). The canyon is characterized by numerous narrow wetted reaches as well as the largest spring-fed pool on the eastern slope of the Catalina range (Fig. 14). Much of the wetted reaches of Buehman Canyon occur on the Pima County Regional Flood Control District's Buehman Canyon Preserve and the County's Tesoro Nueve Ranch. Buehman canyon is divided into four wetted reaches: the upper, lower – upstream, lower – spring, and lower – tinajas reaches. Some parts of the lower reaches of Buehman Canyon also pass through the County's M Diamond and A7 Ranches. Leopard frogs have been consistently observed in the spring reach of lower Buehman Canyon, and this spring represents some of the best remaining riparian habitat in the surrounding area.



Figure 14. Lower Buehman Canyon (July 2011), Buehman Canyon Preserve.



Figure 15. Upper (March 2014) Buehman Canyon, Buehman Canyon Preserve.

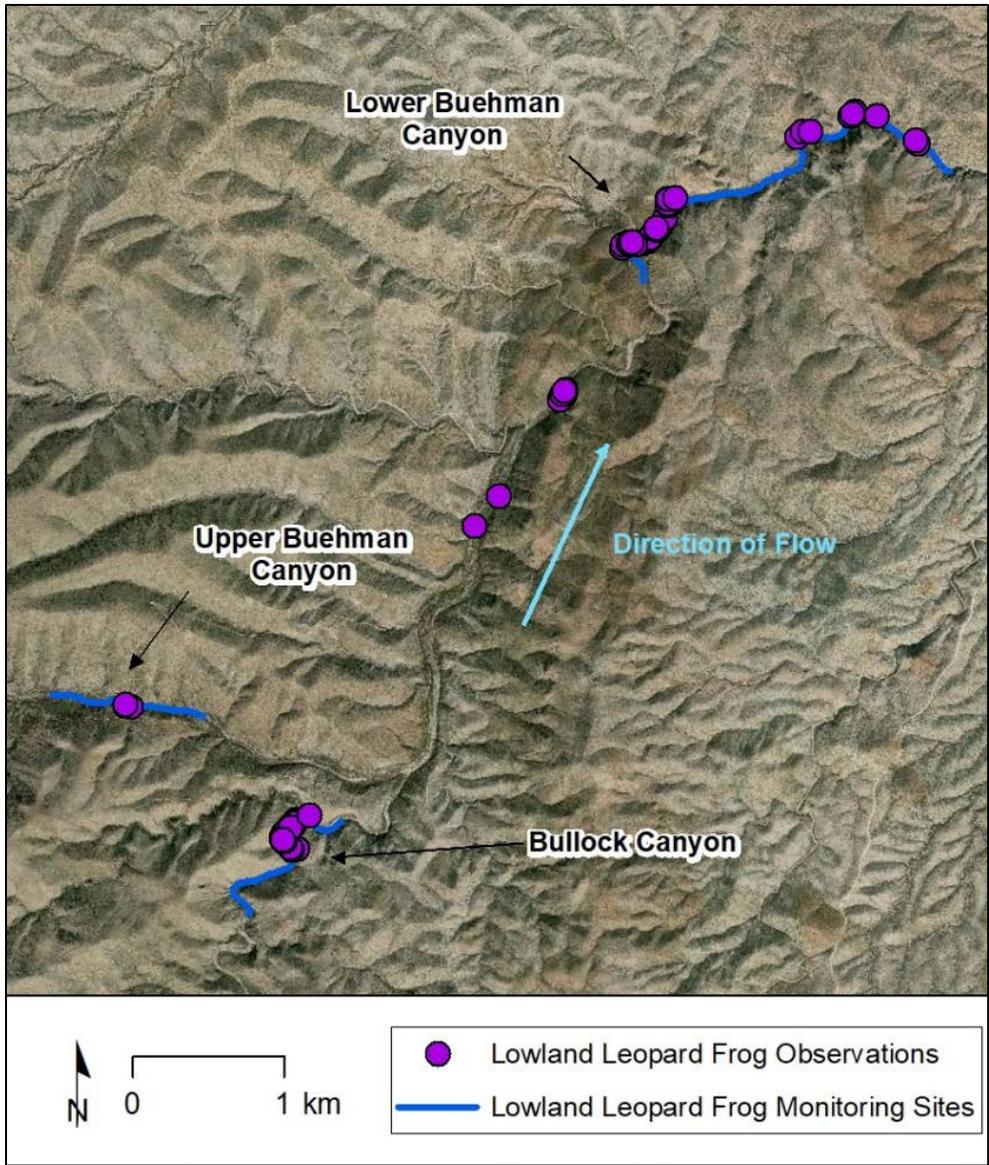


Figure 16. Upper and lower Buehman Canyon and Bullock Canyon monitoring reaches and all previous LLF observations made by County staff at these sites.

Bullock Canyon

Bullock Canyon is located on the east side of the Santa Catalina Mountains in the San Pedro River watershed and is a tributary to Buehman Canyon (Figs. 16 & 17). Part of this canyon, and most of the wetted riparian habitat, occur on the Pima County Regional Flood Control District’s Buehman Canyon Preserve.



Figure 17. Bullock Canyon (April 2008).

Edgar Canyon

Edgar Canyon is located on the east side of the Santa Catalina Mountains in the San Pedro River Watershed, north of Buehman Canyon, on the County's M Diamond and Six Bar Ranches. Lowland leopard frogs are periodically found occupying two cattle watering tanks in a portion of upper Edgar Canyon that is on Six Bar Ranch, but the majority of LLF occur in a wetted riparian stretch that is on M Diamond Ranch (Figs. 18 & 19).

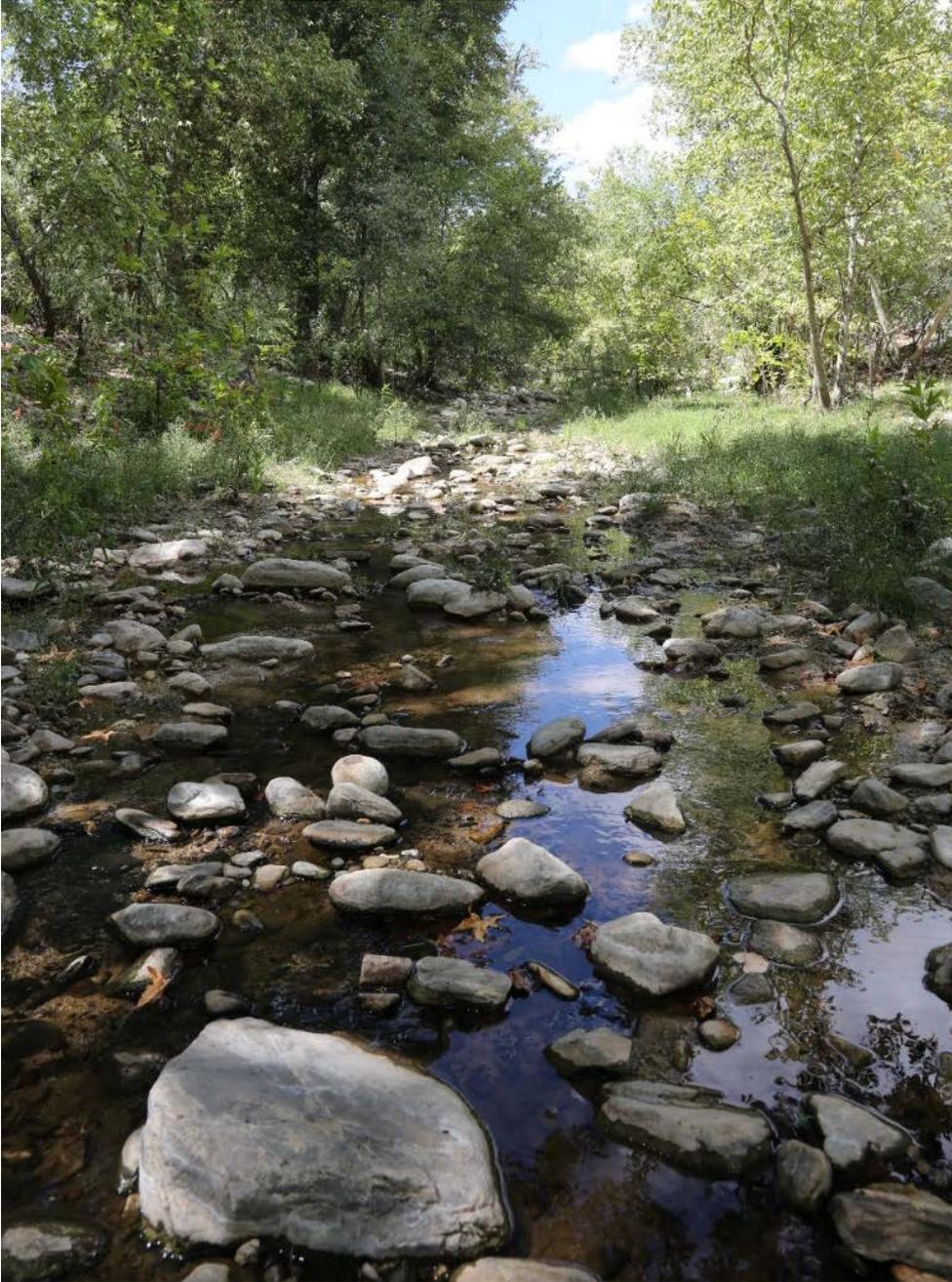


Figure 18. Edgar Canyon (September 2012).

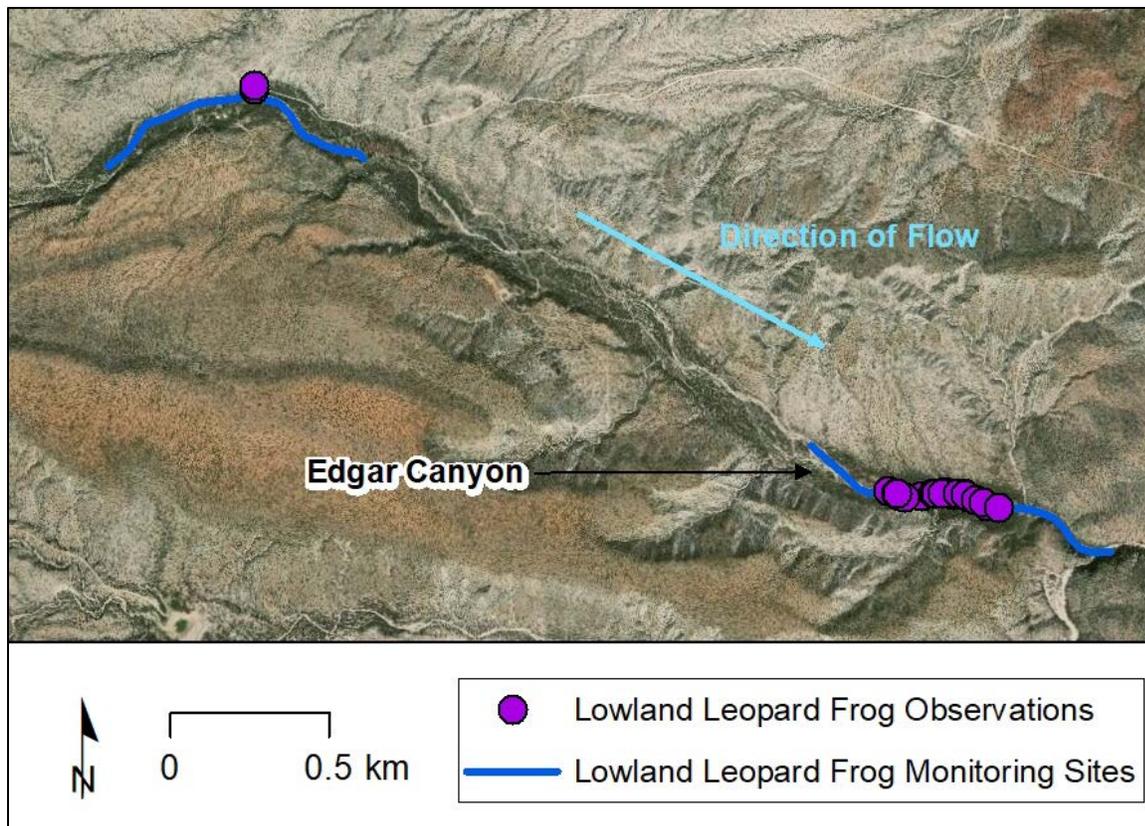


Figure 19. Edgar Canyon monitoring site and previous LLF observations made by County staff at this site.

Additional Sites

Lowland leopard frogs are also known to occasionally occur in other ephemeral livestock tanks as well as other springs within the watersheds of the above perennial streams. These tanks and springs are monitored on an ad-hoc basis as part of annual wet-dry mapping efforts. LLF detection at these sites has fluctuated based both on annual precipitation and the ephemeral nature of livestock tanks and generally includes only scattered observations of single frogs. These sites include a series of livestock tanks above Espiritu Canyon (Big, Upper, Youtcy Pasture and Jerry Tanks), Grapevine Spring above upper Espiritu Canyon, Peck Spring and associated tanks (M Diamond Ranch) and Davis Mesa Tank (Six Bar Ranch). Two livestock stocks that in the past had water from Peck Spring diverted into them contained a robust breeding population of LLF as recently as 2014, but the drying of these tanks has since eliminated frogs from this site. Geesaman Wash on the County's Oracle Ridge property used to hold small numbers of breeding LLF, but frogs were last noted here in 2011, likely due to a lack of surface water during subsequent years. All of the tanks listed here, and most others on County lands near LLF populations are supplied by runoff, and in dry years many of them are likely to be dry for part of the year, thereby limiting their potential for LLF establishment. County wet-dry mapping efforts include these other features as staffing and time allows, expanding the scope of aquatic habitat that is assessed for LLF occupancy. Pima County may become aware of populations of

LLF that are not included in the list of sites to be monitored through these or other efforts. The County will assess on a case-by-case basis whether to include any newly discovered LLF populations within its monitoring sample frame.

Field Survey Protocol

Chiricahua Leopard Frog

Pima County has agreed to monitor all reintroduced or naturally colonized populations of CLF every year for the first three years after establishment, followed by every three years thereafter. Surveys will be timed to coincide with annual pre-monsoon wet-dry mapping efforts in June. Staff will implement a diurnal visual encounter survey (Heyer 1994; USFWS 2007; https://www.fws.gov/southwest/es/arizona/Documents/SpeciesDocs/CLF/Final_CLF_Plan.pdf), and will consider a site to be occupied if an observation for any stage of the species' life cycle (eggs, tadpoles, adults) is confirmed. Surveys will also include an assessment of habitat conditions (water availability, vegetation condition) during each visit and the presence of threats (e.g., invasive species or adverse grazing). Frogs and/or tadpoles may be captured and handled, under permit, in order to determine species. Where possible, we will estimate the numbers of egg masses, tadpoles, juvenile, and adult frogs.

Staff will follow recommended guidelines which dictate that all field survey equipment be disinfected (i.e., 20% bleach solution, quaternary ammonium, and/or sunlight and drying for >24 hours) between surveys in order to prevent the potential spread of chytrid fungus or other pathogens, among CLF populations. Pima County staff maintain a hazard analysis and critical control point plan (HACCP) for ecological monitoring work in riparian habitats that is a part of its compliance with AZGFD and this rubric guides efforts to minimize the spread of pathogens.

While conducting surveys for Chiricahua leopard frogs (and lowland leopard frogs), Pima County will also note the presence of other aquatic species such as the Sonoran mud turtle and canyon treefrog, as well as nonnative invasive species such as American bullfrogs, sunfish, and crayfish. Pima County will investigate any sightings of Chiricahua leopard frogs on other preserve lands and, if presence is confirmed, Pima County will follow through with its above mentioned monitoring schedule.

Lowland Leopard Frog

Pima County has agreed to monitor occupancy of lowland leopard frogs at the six aforementioned sites every 3 years, beginning in 2018. Surveys will take place in the late spring and early summer, and will largely coincide with the wet-dry mapping inventory of riparian sites on County preserves during June. As part of wet-dry mapping, County staff assess many of these aquatic habitats more frequently than every three years, and during these status checks aquatic species presence, including of leopard frogs, is always noted. Occupancy will be for any

stage of the species' life cycle (eggs, tadpoles, adults) and employ a visual encounter survey method which is the same as for the Chiricahua leopard frog (see above). This monitoring protocol is primarily concerned with assessing leopard frog occupancy, but during site surveys we will estimate the numbers of tadpoles, juvenile, and adult frogs, where possible.

Particularly when moving along linear features, it is not difficult to reasonably estimate the number of juvenile and adult frogs, and in many places a specific area of aquatic habitat being examined is small enough that it is practical to closely estimate the numbers of frogs present. Additionally, where relevant, we will note the presence of different tadpole cohorts, as different developmental stages present in a single area may indicate multiple breeding events (i.e., small tadpoles without legs in the same pool as tadpoles with well-developed legs). Estimates of the numbers of tadpoles in a given area are less precise than those for frogs, and rather should be interpreted as a general barometer of the current status of LLF in a specific area.

As mentioned for CLF surveys, during lowland leopard frog surveys, Pima County will also note the presence of other aquatic species of interest, including invasive species. Pima County will investigate any sightings of the lowland leopard frogs on other preserve lands and, if presence is confirmed, Pima County may decide to pursue monitoring at that site.

Results

Chiricahua Leopard Frog

Table 1. Summary Chiricahua leopard frog monitoring results by site, 2018.

Site Name	Date Surveyed (Duration of Survey)	# Observed (by age class)*
Hospital Tank	23 May 2018 (N/A)	44 adults, 105 tadpoles (David Hall, personal comm.)
	8 June 2018 (33 min)	21 adult and juveniles, many tadpoles** (Pima Co staff)
Goat Well Pond	21 May 2018	21 adults (David Hall, personal communication)
	8 June 2018 (22 min)	3 adults, 3 potential adults, one egg mass (Pima Co staff)

*Numbers of tadpoles and juvenile leopard frogs are estimates.

** Tadpoles were not captured and some were likely bullfrog tadpoles.

Hospital Tank

We surveyed this site, on Pima County's Clyne Ranch, for 33 minutes on 8 June 2018. The edges of this earthen stock tank are mostly barren, with only sparse growth of Bermuda grass and forbs. There is no emergent aquatic vegetation, but there are large mats of the algae *Chara* sp. along much of this tank's aquatic shoreline. Nonnative mosquitofish remain abundant in this tank.

We observed 21 adult and juvenile Chiricahua leopard frogs at this site, and heard one male calling repeatedly. We saw one adult frog that may have been a bullfrog, but we were unable to confirm this. We saw many large tadpoles surfacing in the muddy waters of the tank. Seining efforts by David Hall and his team at this site on two dates in May 2018 demonstrated that there were both Chiricahua leopard frog and bullfrog tadpoles at this site, with bullfrog tadpoles numerically dominant (about 2.5 – 3 times more abundant) over Chiricahua leopard frogs (David Hall, personal communication). We did not capture any tadpoles, but it is likely we saw both species.

Goat Well Pond

We surveyed this site for 22 minutes on 8 June 2018. This is a small pond constructed with a liner. The water is moderately clear and about 40% of the pond's surface was covered with algal mats. Emergent vegetation includes some dense patches of cattails and sedges, primarily in submerged pots, as well as abundant shoreline vegetation. We saw many dragonfly nymphs. The pond is partially shaded by mesquite and netleaf hackberry. David Hall and his team from the University of Arizona first reported this site (built in 2016) as being occupied by adult Chiricahua leopard frogs in April of 2018. Subsequent nocturnal surveys in May revealed a maximum of 21 adult CLF at this site (David Hall, personal communication). We confirmed four adult CLF here on 8 June, including one very large female and two calling males. We also photographed one CLF egg mass in this pond. We caught brief glimpses of another five adult frogs that were also likely CLF, though we were unable to confirm that (However, bullfrogs have not been observed at this site.).

Lowland Leopard Frog

Table 2. Summary lowland leopard frog monitoring results by site, 2018.

Site Name	Reach (Length)	Date Surveyed (Time of Survey)	# Observed (by age class)*
Cienega Creek	12.9 km**	23 March 2018 5 June 2018 18 September 2018 17 December 2018	March: 1 adult June: unidentified frog tadpoles in 3 stretches; 1 unidentified adult/juvenile*** September: 4 adult/juveniles in 3 different stretches December: ~120 tadpoles in one pool
Buehman Canyon	Upper (2.02 km)	12 June 2018 (42 min)	None
	Lower – upstream (3.03 km)	12 June 2018 (47 min)	200 tadpoles
	Lower – spring (1.24 km)	12 June 2018 (39 min)	110 juvenile, 905 tadpoles
	Lower – tinajas (1.9 km)	12 June 2018 (123 min)	28 juvenile, 253 tadpoles
Bullock Canyon	(1.5 km)	12 June 2018 (117 min)	60-100 juvenile, 150-200 tadpoles
Edgar Canyon	(0.5 km)	13 June 2018 (51 min)	1 adult, 86 juveniles, 420 tadpoles
Espiritu Canyon	Upper (3.8 km)	7 June 2018 (120 min)	None
	Lower (1.83 km)	7 June 2018 (136 min)	2 juvenile, 250 tadpoles
Youtcy Canyon	Spring (1.08 km)	12 June 2018 (94 min)	10 adult, 220 juvenile, 1,050 tadpoles

*Numbers of tadpoles and juvenile leopard frogs are estimates.

**The length of stream that is monitored during quarterly wet-dry mapping efforts.

***A number of unidentified ranid frog tadpole observations were recorded, while they were not confirmed to be lowland leopard frog tadpoles, bullfrogs are not known to be currently reproducing in the creek channel and given the approximate tadpole size and the confirmed leopard frog tadpoles in nearby or similar sites by PCEMP surveyors, these observations are likely of LLF.

Cienega Creek Natural Preserve

Pima Association of Governments (PAG) coordinates quarterly monitoring of the extent of surface water in Cienega Creek Natural Preserve in March, June, September, and December. Pima County staff also contribute to this field effort, and a varying combination of staff and volunteers make up each of the quarterly walk-through teams. Approximately 12.9 km of Cienega Creek (spanning most of the width of the preserve) is traversed during each monitoring session. Here, Cienega Creek is a perennially intermittent stream passing through both mesquite bosque as well as substantial areas of native broadleaf deciduous riparian forest made up of Fremont cottonwood, Goodding's willow, and velvet ash. During the hottest and driest time of year (June) there are typically four disparate sections of Cienega Creek within the preserve that hold water, with a combined linear extent of as little as 1.6 km (fluctuating annually depending on rainfall and shallow groundwater levels).

Together with PAG, we surveyed the entire 12.9 km stretch of Cienega Creek during 17 December 2018. We observed lowland leopard frogs in only one stretch, which was a large and recently scoured pool immediately upstream of the Del Lago diversion dam near the western end of the preserve. This deep pool was approximately 5 m deep and 20 m long, and held at least two cohorts of leopard frog tadpoles. Approximately 20 were around 3 cm long and about 100 were around 2 cm long. PAG staff and volunteers also surveyed this entire stretch of Cienega Creek in March, June, and September of 2018. On 18 September an adult lowland leopard frog was photographed in a different stretch of permanent water, near where Marsh Station Rd. crosses over the creek. Across the March, June, and September wet-dry mapping efforts, PAG and their volunteers made at least 8 other observations of ranid frog tadpoles and unidentified frogs. We were not able to confirm the identity of these tadpoles and frogs (i.e., bullfrogs versus leopard frogs), but in recent years bullfrogs have not been known to reproduce in this part of the Cienega Creek main channel. Indeed, the flood and scour-prone nature of this riparian habitat does not lend itself to bullfrog reproduction, though adult and juvenile bullfrogs are seen on occasion in the main channel, likely dispersing into the creek from nearby ponds. It is likely that many of these ranid frog tadpole sightings were of lowland leopard frogs, and these unconfirmed observations occurred in all four of the preserve's stretches of permanent water. We also have one confirmed observation taken in 2018 of a juvenile bullfrog in Cienega Creek, near the Del Lago Diversion Dam. We assume that this individual dispersed here from the nearby golf course or other pond.

Buehman Canyon

Upper Buehman Canyon

We surveyed this 2.02 km stretch of Buehman Canyon on 12 June 2018 in 42 minutes. The entire stretch was dry except for an approximately 1.5 m long and 1.8 m wide (10 cm deep) pool at the spring which is located near the upper-most reaches of the surveyed stretch. The pool was shallow and muddied by cattle and other animals. We did not see any sign of lowland leopard frogs in this stretch. Lowland leopard frogs were observed at this spring-fed pool in the spring of 2016, and unknown tadpoles, possibly leopard frog, were noted in this same pool in June of 2017. Nonnative plants observed in this stretch included annual rabbitsfoot grass and oatgrass.

Lower Buehman Canyon – upstream reach

We divided lower Buehman Canyon into three reaches, and this is the upstream-most section where we surveyed about 3.03 km on 12 June 2018. This stretch primarily contained intermittent pools and the longest continuous wet stretch was about 47 m, with a very slight amount of flow. We observed approximately 200 lowland leopard frog tadpoles in this reach, as well as one juvenile leopard frog. There were also adult longfin dace (~200 dace) in parts of this stretch.

Lower Buehman Canyon – spring stretch

This stretch of lower Buehman Canyon extends from just upstream of the spring on the Tesoro Nueve Ranch property, downstream until Buehman Canyon crosses into Pima County's A7 Ranch. We surveyed this 1.24 km stretch in 39 minutes. This reach is a combination of intermittent pools as well as flowing and continuous stretches. The longest continually wetted reach was about 110 m and contained visible flow. Most of this stretch is shaded by a canopy of broadleaf deciduous trees, such as Arizona sycamore, Fremont cottonwood, velvet ash, and Goodding's willow. A small spring occurs up a short tributary of Buehman on the downstream side of the large, spring-fed pool pictured in Figure 20. This spring, Carpenter Spring, is more of a seep with some scattered small pools, and does not contain deeper pool habitat occupied by fish or leopard frogs.

We observed one adult lowland leopard frog, approximately 110 juvenile leopard frogs, and approximately 905 larval lowland leopard frogs. Small numbers of canyon treefrog tadpoles were noted, and large numbers of longfin dace (> 3000) observed throughout this reach. There are no bullfrogs or nonnative fish at this site. In the past, goldfish had occurred at this site, but are no longer there, presumably being wiped out by episodic flood scour.

Lower Buehman Canyon – tinajas stretch

This stretch of Buehman Canyon starts (on the upstream end) where Buehman Canyon crosses into A7 Ranch as well as including a small portion of M Diamond Ranch. Shortly thereafter, on the downstream side, Buehman Canyon opens up into a broad and sandy wash that does not contain permanent aquatic habitat. This lower-most reach of Buehman Canyon is largely a series of intermittent tinajas with no surface flow during our survey on 12 June 2018. Particularly the more downstream parts of this survey reach have little to no overhead canopy as the canyon becomes narrow and cuts through exposed bedrock. The largest tinaja was approximately 15 m long and 6 m wide, with water up to about 1.2 m deep (See Figure 21). Many of the tinajas were murky and clouded with algae, and appeared to be stagnant, and possibly anoxic. One drying pool contained large numbers of already dead Lowland leopard frog tadpoles.

In this stretch we observed 28 juvenile lowland leopard frogs, approximately 253 leopard frog tadpoles, and longfin dace in several of the larger pools (approximately 250 dace). Canyon treefrogs and treefrog tadpoles were also observed. This site had no nonnative fish or bullfrogs.



Figure 20. Large spring-fed pool on the part of Buehman Canyon that occurs on Tesoro Nueve Ranch. This is part of Buehman Canyon with the best and most permanent aquatic habitat that anchors large numbers of longfin dace and lowland leopard frogs.



Figure 21. Large tinaja in the downstream part of Buehman Canyon.

Edgar Canyon

We completed a 51 minute visual survey of this site on 13 June 2018. This is a stretch of aquatic habitat that is largely intermittent pools, with one portion containing a very light flow of surface water. All of the aquatic habitat is within an approximately 500 m stretch of the canyon. The largest continuous stretch of wetted habitat here was about 12 m long and 1.5 m wide. Depths were generally shallow, with the deepest pool being 0.7 m. Pool bottoms were largely sandy or in some places bedrock. We observed one adult lowland leopard frog, 86 juveniles, and approximately 420 tadpoles during this survey. This site contains no fish or bullfrogs.

Espiritu Canyon

Upper Espiritu Canyon

On 7 June 2018 we completed a visual survey of this site that included searching along about 3.8 km of canyon bottom. There were only three tinajas that held water, the largest being about 6 m long and 2.5 m wide, and the deepest being about 0.5 m deep. We did not observe any lowland leopard frog tadpoles in this stretch. During November 2017 field staff had reported several adult lowland leopard frogs in a deep tinaja in this stretch, but this pool was completely filled with sediment during this survey. There are no fish or bullfrogs in this stretch.

Lower Espiritu Canyon

On 7 June 2018 we completed a visual survey of this site. We canvassed a stretch of about 1.83 km of canyon over 136 minutes, including an unnamed tributary that contained multiple tinajas. We observed nonnative annual rabbitsfoot grass as well as fountain grass. Other than the unoccupied pools in the tributary (during November of 2017 several lowland leopard frog adults or large juveniles were observed in tinajas in this same stretch), there were only several isolated pools in lower Espiritu that had water. Substantial amounts of drying had occurred as evidenced by many decaying exposed algal mats. The largest of these was approximately 4.5 m long and 1.8 m wide and about 0.8 m at its deepest (Fig. 22).

This and a small satellite pool were the only part of lower Espiritu that we confirmed occupancy by lowland leopard frogs during an 18 minute visual inspection. We saw two leopard frog metamorphs in the satellite pool and about 250 leopard frog tadpoles in the large pool. Some of these tadpoles had hind limbs, and most were of similar size. We noted canyon treefrog tadpoles in the same stretch, but not in the same pool as the leopard frogs. We saw many resting adult canyon treefrogs on various rock faces in the canyon bottom. This site contains no fish or bullfrogs.



Figure 22. Intermittent pool in lower Espiritu Canyon with lowland leopard frog tadpoles.

Youtcy Canyon

We completed a 94 minute visual survey of Youtcy Canyon on 12 June 2018, covering about 1.08 km of canyon bottom. This site is a combination of intermittent pools and stream reaches, some with visible surface flow. The largest pool was about 4.5 m long and 0.8 m deep. The longest continuous stretch of water was about 163 m long and had visible flow in some parts. Reported numbers of juvenile lowland leopard frogs and tadpoles are estimates. Leopard frogs were much more abundant and occurred in a greater portion of available habitat relative to what has been observed in some past years. We saw multiple cohorts of tadpoles, from tadpoles that were < 2.5 cm long all the way to tadpoles that were in the process of metamorphosing into frogs. Relative to pools closer to the spring source, aquatic habitat in the more downstream stretches was more intermittent and showed signs of recent rapid drying (i.e., dried algae and stained gravel/rock around pool edges). The pool that was the furthest downstream contained large numbers of leopard frog tadpoles, but was isolated and rapidly drying. It is unlikely that these tadpoles would have survived.

We observed 10 adult lowland leopard frogs, approximately 220 juvenile leopard frogs, and about 1,050 leopard frog tadpoles. We also saw small numbers of canyon treefrog tadpoles. We saw signs of heavy cattle grazing in parts of the riparian area, including a herd of cattle in the downstream section. This site contains no fish or bullfrogs. There are nonnative and invasive plants at this site, including annual rabbitsfoot grass (*Polypogon monspeliensis*) and some extensive mats of Bermuda grass.

Bullock Canyon

On 12 June 2018 we surveyed this site that included traversing 1.5 km of Bullock Canyon, starting from its confluence with Buehman Canyon (survey time of 1 hour and 57 minutes). About 260 m of this canyon contained aquatic habitat, including the source of a spring located in this stretch that is situated on or near County land adjacent to the southernmost extent of this property that encompasses Bullock Canyon. The aquatic habitat includes two reaches of surface water with discernible flow in some places, as well as one large pool that is not continuous with either of the stretches of flow. This pool is associated with a concrete dam across the canyon (Fig. 23). One of the reaches with flow is above this pool, and the other is downstream of this pool (i.e., downstream of the dam). Parts of the upstream reach, near the property line, have a broadleaf deciduous canopy of velvet ash, Arizona sycamore, Goodding's willow, and Arizona walnut. Most of the rest of the aquatic habitat downstream has very little canopy cover, and is narrow and rocky in places. Here, there are scattered individuals of Goodding's willow and velvet ash, as well as seep willow and small patches of cattail and monkey flower.

We observed about 50-100 juvenile and 50-100 larval lowland leopard frogs distributed throughout the upstream reach of surface flow. The isolated and deep pool that is just upstream of the cement dam contained 10 juvenile, > 100 larval, and one adult lowland leopard frog. Many of the tadpoles were in the processing of metamorphosing. We did not observe any leopard frogs or tadpoles in the second reach of surface water, downstream of the dam.

We observed at least five longfin dace in the stretch of flow downstream of the cement dam. We did not see any fish in the pool or the second stretch of surface water that are both upstream of the dam. We have been observing longfin dace every year in pools below the dam since 2011 (although this site was not evaluated in 2012 and 2013), but have never observed them upstream of the dam. This feature is likely a barrier for the dace, and prevents them from accessing deeper and more continuous habitat upstream. We did not see any bullfrogs in Bullock Canyon, or other species of fish, and saw no signs of cattle grazing in the area. There are scattered patches of nonnative annual rabbitsfoot grass throughout the riparian habitat.



Figure 23. Large pool in Bullock Canyon, with cement dam visible in the background.

2018 Monitoring Season Summary

The 2018 monitoring season was a successful one for monitoring leopard frog populations on County conservation lands. CLF naturally established at Goat Well Pond and continued to reproduce, at Hospital Tank, thanks to the management efforts of NRPR staff and David Hall and his survey team. David Hall's dedicated bullfrog removal efforts are playing an important role in the suppression of this invasive species at Hospital Tank, and are likely positively contributing to the ability of CLF to successfully recruit at this site. County staff will survey both sites again in June of 2019.

Staff confirmed lowland leopard frog occupancy at all six permanent monitoring sites in 2018. Within those sites, we did not detect LLF in two of nine distinct reaches; however both channel morphology and detection in those sites are known to be dynamic. Winter and spring rainfall allowed for large amounts of sediment transport in these systems, and reaches such as upper Espiritu Canyon lost much suitable habitat through sedimentation of tinajas (including the only tinaja that LLF were observed in during 2017). In future LLF monitoring seasons, we plan to participate more actively in the PAG Cienega Creek June surveys to maintain consistency in

sampling time across all sites. Lastly, staff implement wet-dry mapping annually in many of these systems and will continue to collect ad-hoc LLF observations in tandem with these other monitoring efforts adding considerable scope and frequency to gain insight into the occupancy dynamics of this species.

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- Pima County. 2016. Multi-species Conservation Plan for Pima County, Arizona: Final. Submitted to the Arizona Ecological Services office of the U.S. Fish and Wildlife Service, Tucson, Arizona.
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- U.S. Fish and Wildlife Service. 2007. Chiricahua Leopard Frog (*Rana chiricahuensis*) Recovery Plan. U.S. Fish and Wildlife Service, Southwest Region, Albuquerque, NM. 149 pp. + Appendices A-M.

Appendix A

Date: ___/___/_____
 M M D D Y Y Y Y

RACH/Riparian Herpetofauna

NUM: _____ - _____

VES Datasheet

Arizona Game and Fish Department

Last updated April 2017 version 2.1.1

SITE:				SITE AT: (Additional location info)			
Observer(s):		Affiliation:		Email:		Phone:	
Time (24Hr) Start:		Stop:		Dry Site:		Y N	
ST-CNTY:		UTM ZONE (Circle one)		NAD (Circle one)		<i>Lotic sites use both start and stop</i>	
___ - _____		11 12 13		83		UTM Start:	
System Type: (circle one)		27		UTM Stop:		_____	
Lentic Lotic		Water Source:		Spring		Runoff Well Unknown	
		Water Type:		Wetland		Earthen tank Reservoir Artificial structure	
Surface Area (must be measured) <i>Lotic sites use width measurement</i>				VOUCHERS Habitat Photos: Y N Specimen Photos: Y N			
Length (m):				Width (m):			
Specimen(s) collected: Y N				# of Disease/Genetic Samples: Water _____ Swab/Tissue _____			
T_{Air}: °C °F		T_{Water}: °C °F		RH: %		Precipitation: (circle one) None Intermittent Steady	
						Wind: Still Breezy Windy	
Search Methods:		Visual		Seine		Trap Dipnet Snorkel Boat Call Playback	
Vegetation		%		Prominent Species (if known)		PREDATORS (Non-Herp)*	
Floating						Native fish Nonnative fish	
Submerged						Crayfish Birds	
Emergent						Aquatic invertebrates Mammals	
Perimeter						Grazing Enclosure: Y N Partial	
GRAZING ACTIVITY		Livestock: Animal Present		Sign		Native Ungulate: Animal Present Sign	
SITE/SURVEY NOTES: (*include any predator species from above)							
----- RIPARIAN HERPETOFAUNA (circle one life stage per line) -----							
Species		Certainty		Life Stage		Total #	
		Uncertain Certain		Egg Larvae Juvenile Adult			
		Uncertain Certain		Egg Larvae Juvenile Adult			
		Uncertain Certain		Egg Larvae Juvenile Adult			
		Uncertain Certain		Egg Larvae Juvenile Adult			
		Uncertain Certain		Egg Larvae Juvenile Adult			
		Uncertain Certain		Egg Larvae Juvenile Adult			
		Uncertain Certain		Egg Larvae Juvenile Adult			
		Uncertain Certain		Egg Larvae Juvenile Adult			
		Uncertain Certain		Egg Larvae Juvenile Adult			
		Uncertain Certain		Egg Larvae Juvenile Adult			
		Uncertain Certain		Egg Larvae Juvenile Adult			

RACH Release (circle one) Y N

CONDENSED INSTRUCTIONS for RACH / Riparian Herp VES Datasheet (Last updated: April 2017)

Review the COMPLETE INSTRUCTIONS for RACH / Riparian Herp VES Datasheet before filling out the datasheet. These CONDENSED INSTRUCTIONS are only for field reference.

LOCALITY AND VISIT DATA

- Num:** This field is used for central data management purposes. A site number is a unique code consisting of 3-letters describing the land manager and a 4-digit number assigned in ascending consecutive order within each management unit (e.g. TON-0001). NGB Herps survey personnel may enter the management unit code (See COMPLETE INSTRUCTIONS for list of management unit codes).
- Site:** A site is >1 mile from any other survey locality, or represents a distinct change in habitat types. Record site name as it is marked on the quad or land management map. If unnamed, write "unnamed" preceding the type of feature. If not marked on any map, write "unmarked" preceding the type of feature.
- Site At:** Always complete for unnamed and unmarked sites and for large/long aquatic systems. For other sites, use as needed to enhance the name and pin-point location. Use features such as the nearest road crossing, stream confluence, or topographic feature.
- Observers:** People present during the survey. Record names as: first initial, period, second initial, period, full last name (e.g. M.J.Sredl).
- Time Start:** Time the surveyor(s) began searching for riparian herps using a 24-hour clock.
- Time Stop:** Time the surveyor(s) stopped searching for riparian herps using a 24-hour clock.
- Dry:** Circle "Y" or "N" to indicate whether the site was dry. This field explains why other Visit Conditions field may have no data.
- St-Cnty:** State abbreviation followed by a hyphen and first 4 letters of the county name (e.g. AZ-MARI) for the starting point of the survey.
- UTM Zone:** Zone in which the starting point of the survey occurs: zone 11 (W of 114° longitude) includes the extreme western portion of AZ, zone 12 (E of 114° longitude, W of 108° longitude) includes most of AZ and the western portion of NM, zone 13 (E of 108° longitude) includes the remainder of NM. Check the GPS unit setting.
- UTM Datum:** Circle the datum of the UTM coordinates. NAD83 is preferred.
- UTM Easting:** UTM Easting (6-digit number) for the starting point of the survey. Use a GPS unit to determine the UTM coordinates.
- UTM Northing:** UTM Northing (7-digit number) for the starting point of the survey. Use a GPS unit to determine the UTM coordinates.
- System Type:** Circle 1 hydrological class that best describes the water system of the site: Lentic = still water, Lotic = flowing water.
- Water Source:** Circle the source of water at the site, if not known leave blank.
- Water Type:** Circle 1 category that best describes the type of water at the site. Artificial structure would consist of cement or metal structure designed to hold water.
- Surface Area:** Length (i.e. long axis) and width (i.e., short axis) of the system in meters. For both length and width, measure the entire system (not just portion surveyed) using the standing water present at the time of the visit as the boundary. Width should be the maximum distance perpendicular to the length axis. Use a rangefinder or measuring tape, DO NOT ESTIMATE.
- Vouchers:** Record if specimen photo vouchers and habitat photos are taken at the site. Photo vouchers are close-ups of diagnostic characteristics. Circle "Y" or "N" to indicate whether voucher specimens were collected; record number of disease (water/swabs/tail clips) and genetic samples (swabs/tail/toe clips) collected. Include disposition of specimen in Site/Survey Notes, if known.
- T_{AIR}:** Air temperature 1.5 m above ground and 1.5 m from the water. Circle appropriate measurement unit. Celsius is preferred. Thermometer should be shaded and dry.
- T_{WATER}:** Water temperature 1 cm below water's surface and 1 m from shore (or at center). Circle appropriate measurement unit. Celsius is preferred. Thermometer should be shaded.
- RH:** Relative humidity (%) 1.5 m above ground and 1.5 m from water.
- Precipitation:** Circle 1 category that best describes precipitation.
- Wind:** Circle 1 category. Estimate wind speed 1.5 m above the ground and 1.5 m away from the water. Still <3mph; Breezy is between 3-12mph; Windy >12mph.
- Search Methods:** Circle all methods used to search for riparian herps.
- Vegetation:** Percent of area potentially inhabited by target species that is covered by floating vegetation, submerged vegetation, emergent vegetation, perimeter vegetation up to 1 m from water's edge. Use increments of 5%. Percents do not have to total 100. Write genus or common name (only if positive ID) of 1 - 4 most prominent species for each vegetation type.
- Predators:** Circle all non-herp predators seen/detected at the site. List species in Site/Survey Notes.
- Grazing Exclosure:** Circle 1 category indicating if the site has a partial exclosure, full exclosure, or no exclosure for the purposes of eliminating grazing pressure.
- Grazing Activity:** Circle if sign or animals are present at site. This is distinguished between native ungulates and/or feral or domestic livestock.
- Site/Survey Notes:** Use as needed to describe significant features of a site or survey. Do not be redundant with info in other fields. Write short, specific notes that emphasize habitat quality and why you think you did or did not observe riparian herps, such as land use at or near the site, or differences between the survey area and total area.

RIPARIAN HERP OBSERVATIONS

- Species:** Riparian herp species observed during the survey using their unique 4-letter Genus-Species code or the code corresponding to the taxonomic classification for which you are certain in your ID. Refer to "GenusSpecies codes for Arizona herpetofauna". These codes are primarily based on Brennan and Holycross 2006, although there is a great deal of overlap with Stebbins 2003. Do not use historic info to bias your decision on species ID. Enter your own most confident observation and justify it in the Comments field. If no riparian herps are observed, record "NONE".
- Certainty:** Circle 1 word to indicate your level of certainty regarding your ID of each species. Certainty of ID should be based on species-specific diagnostic characteristics.
- Life Stage:** Circle 1 category that best describes the life stage of each species. Juvenile leopard frog <55 mm SVL. Adult leopard frog >55 mm SVL or has signs of breeding condition (e.g. swollen thumbpads, stretched vocal sacs).
- Total #:** Number of individuals of each species/life stage observed. Do not estimate total numbers within survey area. For egg masses, enter number of masses and then use the Comments field to record overall size and condition of masses, and stage of embryos (refer to Gosner 1960).
- Comments:** Use as needed to record relevant comments regarding species & life stages observed. Types of comments to include are: 1) criteria used to identify species; 2) if species ID is uncertain, note observed physical features & behaviors that could be useful (e.g. no RACA peep heard, ranid-like plop); 3) presence of any observed disease or deformity.

