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THE CURRENT AND HISTORICAL DISTRIBUTION OF SPECIAL STATUS AMPHIBIANS AT THE LIVERMORE SITE AND SITE 300

Ambystoma californiense - M. G. van Hattem

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By M. V. Hattem, L. Paterson, and J. Woollett

LAWRENCE LIVERMORE NATIONAL LABORATORY, ALAMEDA AND SAN JOAQUIN COUNTIES, CALIFORNIA

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The Current and Historical Distribution of Special Status Amphibians at the Livermore Site & Site 300

Livermore Site, Alameda County
Site 300 Experimental Test Site, Alameda and San Joaquin Counties

Principal Investigator (PI): Michael G. van Hattem, Wildlife Biologist, EPD

Contributors: Lisa Paterson, Wildlife Biologist, EPD
Jim Woollett, Wildlife Biologist, EPD

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Abstract

65 surveys were completed in 2002 to assess the current distribution of special status amphibians at the Lawrence Livermore National Laboratory's (LLNL) Livermore Site and Site 300. Combined with historical information from previous years, the information presented herein illustrates the dynamic and probable risk that amphibian populations face at both sites. The Livermore Site is developed and in stark contrast to the mostly undeveloped Site 300. Yet both sites have significant issues threatening the long-term sustainability of their respective amphibian populations. Livermore Site amphibians are presented with a suite of challenges inherent of urban interfaces, most predictably the bullfrog (*Rana catesbeiana*), while Site 300's erosion issues and periodic feral pig (*Sus scrofa*) infestations reduce and threaten populations. The long-term sustainability of LLNL's special status amphibians will require active management and resource commitment to maintain and restore amphibian habitat at both sites.

Introduction

To assist the Department of Energy (DOE)/ National Nuclear Security Administration (NNSA) and LLNL with the preparation of an Environmental Impact Statement (EIS) for continued operations, a comprehensive data set was compiled on the current and historical presence and distribution of special status amphibians at the Livermore Site and Site 300 Experimental Test Site (Site 300). For historical completeness, this report will address findings for the following species: California red-legged frog (*Rana aurora draytonii*), California tiger salamander (*Ambystoma californiense*), and western spadefoot toad (*Spea hammondii*).

The objective of this report is to discuss survey results from the 2002 field season and to augment those findings with the collective results of amphibian monitoring by LLNL biology staff since 1994. A multi-year approach is the most relevant way to address amphibian populations since their populations can fluctuate so dramatically from year to year based on hydroperiod, reproductive success, and metapopulation structure. Hereafter, we present the natural history of each species of special concern, survey results, distribution at each site, and management implications.

Species Accounts

California tiger salamander *(Ambystoma californiense)*

Status

Under the Federal Endangered Species Act (ESA) of 1973 as amended, Distinct Population Segments (DPS) (determined by genetic analysis to contain enough evolutionary divergence to warrant protection independently from the remainder of the population within the species range. In the case of the California tiger salamander all seven DPS of the California tiger salamander complex are species of special concern in the State of California and federal candidates for listing under the Federal ESA, excluding the Santa Barbara and Sonoma County DPS. The U.S. Fish and Wildlife Service listed the Santa Barbara County DPS as endangered in 2000, and the Sonoma County DPS currently receives protection under an emergency rule (U.S. Fish and Wildlife Service 2002a), which is likely to be finalized in March of 2003.

The most important threat to California tiger salamander populations is habitat loss and fragmentation (Holland et al. 1990), especially due to urban expansion and conversion of aquatic and upland habitat to agriculture (U. S. Fish and Wildlife Service 2000). Additional significant population threats include predation by introduced species such as fish (Schaffer et al. 1993) and bullfrogs (*Rana catesbeiana*) (Schaffer and Stanley 1991), vehicle-related mortality during breeding migrations (Gibbs 1998), and rodent control programs (Loredo et al. 1996).

Range, Habitat, Life History

The California tiger salamander is found in the Central Valley and adjacent foothills and coastal grasslands of California (Loredo and Van Vuren 1996). The range of this California endemic extends from Sonoma County and the Colusa-Yolo County border in the north, south through the Central Valley and the Coast Range to Santa Barbara and Tulare counties (Shaffer et al. 1993, Jennings and Hayes 1994). Alameda and Contra Costa County are among the remaining regions that support the greatest concentration of California tiger salamanders (Shaffer et al. 1993). California tiger salamanders are known to occur in several locations within the Corral Hollow Watershed.

California tiger salamanders breed in temporary rain pools and permanent waters of grasslands and open woodland of low hills and valleys (Stebbins 1985) in areas with a Mediterranean climate of cool wet winters and hot dry summers (Loredo and Van Vuren 1996). Breeding sites can include both natural (vernal pools) and artificial (stock ponds) lentic environments. California tiger salamander spend much of the year underground, in the burrows of ground squirrels (*Spermophilus beecheyi*), pocket gophers (*Thomys bottae*), and badgers (*Taxidea taxus*), and usually emerge for only brief periods to breed (Stebbins 1985) typically after the first rains of the year in November or December

(Jennings and Hayes 1994, Loredo and Van Vuren 1996) and can continue through April (Petranka 1998).

The larval period lasts from three to six months (Petranka 1998) and because of this, California tiger salamanders require breeding pools to remain hydrated for at least this length of time. Metamorphosis of salamander larvae begins in late spring or early summer and is followed by the dispersal of metamorphs from their natal ponds into terrestrial habitat (Holland et. al 1990, Loredo et al. 1996). Trenham (2001) recorded adult California tiger salamanders using burrows up to 248 meters from release points adjacent to breeding pools and juvenile salamanders have been reported to use burrows up to 1,200 meters from breeding sites (Jennings and Hayes 1994).

California red-legged frog (*Rana aurora draytonii)*

Status

In June of 1996, the California red-legged frog *(Rana aurora draytonii)* was listed as threatened under the federal Endangered Species Act (U.S. Fish and Wildlife Service 1996). Critical habitat was designated for the California red-legged frog in March of 2001 although most has been rescinded due to a recent court decision (U. S. Fish and Wildlife Service 2002b).

Distribution, Habitat, Life History

The current range of the California red-legged frog includes Pacific slope drainages from Napa and Sonoma Counties to Baja California, Mexico (U. S. Fish and Wildlife Service 2002c). Isolated populations are also found in the Sierra Nevada foothills north of Sacramento (U. S. Fish and Wildlife Service 2002c). Historically, the California red-legged frog was known to occur in 46 counties, but now has been extirpated from 24 of these or about 70% of its historic range (U. S. Fish and Wildlife Service 1996). The California red-legged frog is threatened within its remaining range by a wide variety of anthropogenic impacts, most importantly habitat loss and fragmentation and the introduction of exotic predators. California red-legged frogs are known to occur in several locations within the Corral Hollow watershed.

The California red-legged frog is found in areas below 1,500 meters elevation and uses a variety of aquatic, riparian and upland habitats. Aquatic systems used by California red-legged frogs include dune swales, ephemeral ponds, intermittent streams, seasonal wetlands, springs, seeps, permanent ponds, perennial creeks and man-made ponds (U. S. Fish and Wildlife Service 2002c). In their critical habitat designation for the California red-legged frog, the U. S. Wildlife Service (2001) describes the California red-legged frog as using virtually any freshwater aquatic system that is in close proximity to some permanent water source.

California red-legged frog habitat use can change as environmental conditions fluctuate. California red-legged frogs can complete their entire life cycle in one pond or utilize a mosaic of habitat types (U. S. Fish and Wildlife Service 2001). Where available, California red-legged frogs spend a considerable amount of time within riparian vegetation. California red-legged frogs have been observed in streams up to 2 miles from breeding habitat and in riparian vegetation adjacent to streams (U. S. Fish and Wildlife Service, 2002c). Conversely, in grazed areas, California red-legged frogs have been observed greater than 100 meters from breeding ponds, presumably foraging, seeking appropriate microhabitats or dispersing (van Hattem pers. obs 2001). California red-legged frogs can use California ground squirrel burrows, deep desiccation cracks, or woody vegetation as thermal refuge during less hospitable periods of the year.

Breeding adults are frequently associated with relatively deep (> 0.5 meters) slow moving water in areas of dense riparian vegetation, although breeding frogs are found in areas without dense emergent or riparian vegetation in water depths less than 0.5 meters (U. S. Fish and Service 2001 & 2002c). The breeding period for California red-legged frogs is from late November to late April although most frogs lay their eggs in March (Jennings and Hayes 1994; U. S. Fish and Wildlife Service 2002c). Emergent vegetation, twigs and roots are typically used for oviposition sites. Eggs develop into larvae in 20 to 22 days. Although over wintering tadpoles have been observed some areas, tadpoles typically develop into frogs in 11 to 20 weeks (U. S. Fish and Wildlife Service 2002c).

During periods of wet weather, California red-legged frogs can make significant movements over upland habitats to other aquatic habitats. During dry periods, California red-legged frogs can disperse from breeding habitat to forage or to seek summer habitat in response to declining water levels. A translocated radio-tagged California red-legged frog in the Guadalupe Dunes of California central coast was observed to move approximately 2,816 meters through upland and aquatic habitats over the course of a wet season (Rathbun and Schneider 2001). The California red-legged frog recovery plan (U. S. Fish and Wildlife Service 2002c) describes unpublished research by Bulger conducted in Santa Cruz County. In this study, California red-legged frogs were observed to travel distance of 402 meters to 3218 meters without regard to topography, vegetation type or riparian corridors.

Western Spadefoot Toad (*Spea hammondii*)

Status

The Western spadefoot toad is a State and Federal Species of Special Concern. Remaining populations are becoming increasingly fragmented and very few populations are protected in only a handful of preserves (Jenning and Hayes 1994).

Distribution, Habitat, Life History

The western spadefoot toad ranges from Redding, Shasta County, southward into northwestern Baja California, Mexico (Stebbins 1985). Western spadefoots are almost completely terrestrial occupying burrows for the majority of the year, entering water only to breed, and only become surface-active following warm spring and fall rains (Jennings and Hayes 1994). Eggs hatch in 0.6 - 6 days, and larval development can be completed in 3-11 weeks (Jennings and Hayes 1994). No data is available on the movement ecology or colonization abilities of the western spadefoot toad. Western spadefoot toads may be considered an obligate vernal pools species. And similar to the California tiger salamander, recruitment of metamorphs may not occur or may be severely limited in the presence of fish, bullfrogs, or crayfish. Western spadefoot toads are known to occur in several locations within the Corral Hollow watershed.

Methods

Visual Encounter Surveys (VES) (Crump and Scott 1994) were conducted for all special status amphibians. VES surveys consist of systematically searching all available habitat within the littoral zone, open water, and immediately adjacent terrestrial habitat in a standardized approach. Survey routes were walked singularly (one observer) or in unison (two observers) parallel and equidistant to each other. Nocturnal surveys were conducted with 2 or 3 cell Saberlite flashlights and Petzel Duo headlamps. Binoculars (Swarovski SLC 10 x 42) were used to identify and confirm the presence of amphibians within cover and at a distance. The number of individuals and approximate locations were noted for each observation. Positively identified amphibians were mapped with a handheld Global Positioning System (Garmin Etrex Vista, site-wide horizontal error $\leq$ 6.5 meters) at Site 300. Livermore Site amphibian detection was referenced to nearby facilities. Surveys were consistent with the 1997 interim guidance recommended by the USFWS (U. S. Fish and Wildlife Service 1997).

Results

Surveys for California red-legged frogs were conducted May-November 2002 on warm calm nights under conditions most suitable for *Ranid* detection. California tiger salamander surveys were diurnal only and conducted after the pools began to fill while eggs were easily observed. Specific surveys for western spadefoot toads were not conducted in 2002 since known breeding locations did not hydrate, but observations from previous years are included (Table 2). Wading was not required in any of the surveys since wetlands at both sites are relatively small and easily surveyed from the bank. Deviations from recommended survey protocols were: 1) the addition of visual diurnal egg searches for California red-legged frogs in the Arroyo Las Positas; and 2) the lack of dip netting for California tiger salamanders which is both redundant and destructive when populations are already accounted for through visual egg surveys. The use of artificial oviposition samplers was an additional technique used in the Percolation Ponds to exhaust every possibility of California tiger salamander detection. Nocturnal California red-legged frog surveys were not conducted in the Percolation Ponds in 2002, so additional diurnal surveys were conducted. Survey results for the Livermore Site (Table 1) and Site 300 (Table 2) are presented herein with supplemental information from previous years as noted.

Table 1. Livermore Site wetland features surveyed in 2002 for special status amphibians. Historical detection and year(s) provided by LLNL biology staff (J. S. Woollett pers. comm. 2003) (Note: CRLF= California red-legged frog, CTS= California tiger salamander).

Location	**Survey Dates** **N=Nocturnal** **D=Diurnal**	**CRLF** **A =Adult** **J=J\uvenile**	**CTS** **Eggs/larva** **A =Adult** **J=Juvenile**	**Historical Detection and Year(s)**
Arroyo Las Positas	07-25-02 (N) 08-26-02 (D) 09-09-02 (D) 10-30-02 (N)	11(A) & 2(J) 4(A) & 3(J) 5(A) & 1(J) 11(A)	0 0 0 0	CRLF 1996-present
Drainage Retention Basin	05-30-02 (N) 07-25-02 (N)	0 1 adult	0 0	CRLF 2000-present

	08-06-02 (N) 08-15-02 (N) 08-20-02 (N) 08-23-02 (D) 08-30-02 (D) 09-17-02 (N)	0 4(A) & 3(J) 2(A) & 4(J) 1(A) 1(A) 2(A)	0 0 0 0 0 0	
West Perimeter Drainage Ditch	05-30-02 (N) 08-29-02 (N) 10-08-02 (D) 10-15-02 (D)	0 1 adult 0 0	0 0 0 0	None
Arroyo Seco	05-30-02 (N) 06-27-02 (D) 07-25-02 (N) 07-29-02 (D)	0 0 0 0	0 0 0 0	None
Percolation Ponds (Sandia National Laboratory)	05-30-02 (D) 07-25-02 (D) 09-10-02 (D) 10-08-02 (D)	0 0 0 0	0 0 0 0	CTS 1995-1997

Table 2. Site 300 wetland features surveyed in 2002 for special status amphibians. For comparability, most location have a corresponding J&S #, which refers to the Jones and Stokes (2002) wetland delineation of Site 300. In addition jurisdictionl wetlands can based Historical detection and year(s) provided by LLNL biology staff (J. S. Woollett pers. comm. 2003) (Note: CRLF= California red-legged frog, CTS= California tiger salamander, WESP= Western spadefoot toad).

Location	**Survey Dates** **N=Nocturnal** **D=Diurnal**	**CRLF** **A =Adult** **J=Juvenile** **U=Unknown age/heard not seen**	**CTS** **Eggs/larva** **A =Adult** **J=Juvenile**	**Historical Detection and Year(s)** **(When hydrated)**
Drainy Canyon Complex Ambrosino Pool (J&S 1)	Dry mid-May	5(J)	3 (A), Eggs/ larva	CRLF & CTS 1994-present
Fire Trail Pools (South of J&S 1)	Dry by 4/1/02	N/A(1)	Eggs/ larva	CTS 1995-present
Harrier Pool (J&S 2)	Dry	N/A	N/A	CRLF & CTS 1995-present
Sink Pool (J&S 3)	Dry	N/A	N/A	CRLF & CTS 1995-present
Round Valley (J&S 4)	Dry	N/A	N/A	CRLF 2000
Upper Juniper Slide Pond (J&S 5)	05-21-02 (D) 07-30-02 (N) 08-27-02 (D) 10-21-02 (N)	13(A) 12(A) 10(A) 15(A)	0 0 0 0	CRLF 2001
Lower Juniper	05-21-02 (D)	1(J)	0	None

Slide Pond (South of J&S 5)	07-30-02 (N) 08-27-02 (D) 10-21-02 (N)	0 1(J) 2(J)	0 0 0	
Seeps (J&S 6-11)	Dry	N/A	N/A	N/A
Oasis (Mine Shaft) (Upstream of J&S 12)	05-21-02 (D) 07-30-02 (N) 08-27-02 (D) 10-21-02 (N)	4(A) 6(A) 4(A) 6(A)	0 0 0 0	CRLF 1997-present
Lower Drainy Canyon (J&S 12)	05-21-02 (D) 07-30-02 (N) 08-27-02 (D) 10-21-02 (D)	0 0 0 0	0 0 0 0	CRLF 1999
Seeps (J&S 13-15)	Dry	N/A	N/A	N/A
Drop Tower Canyon Complex Seep (J&S 16-17)	Dry	N/A	N/A	N/A
Seep 18	Wet soil	N/A	N/A	N/A
Lower Drop Tower Complex (J&S 19-20)	05-21-02 (D) 07-30-02 (N) 08-27-02 (D) 10-21-02 (D)	0 0 0 0	0 0 0 0	CRLF 1999
Seep (J&S 21)	Wet soil	N/A	N/A	N/A
Carnegie Park Residence [2]	Offsite	N/A	N/A	CRLF [3]
Long Canyon (J&S 22-25)	Wet soil	N/A	N/A	None
Elk Ravine Complex Danger Pool (upper and lower) (J&S 26)	01-11-02 Dry by 15 Feb 2002	0	Eggs/ larva	CRLF & CTS 1996-present (upper) CTS New (2002) (lower)
Elk Ravine @ ATA (J&S 27)	06-24-02 (D) 08-06-02 (D) 10-22-02 (N) 10-28-02 (N)	6(A), 4(J) 8(A), 1(J) 12(A) 13(A), 3(J), 6(U)	0 0 0 0	CRLF 1996-present
Sharp Gun @ ATA (J&S 28)	06-24-02 (D) 08-06-02 (D) 10-22-02 (N) 10-28-02 (N)	0 0 0 0	0 0 0 0	None
801 Cooling Tower	No survey/ Controlled Access	N/A	N/A	None

(J&S 29-30)	Area			
Elk Ravine @ B812 (J&S 31)	06-20-02 (D) 08-16-02 (D) 09-06-02 (D) 10-22-02 (N) 10-28-02 (N)	1 2(A) 1(A) 1(A) 0	0 0 0 0 0	None
Gooseberry Canyon (J&S 32-33)	Wet soil	N/A	N/A	N/A
Seep (J&S 34-36)	Dry	N/A	N/A	CRLF 1998
Seep (J&S 37-38)	Dry	N/A	N/A	N/A
Wetland (J&S 39)	Dry	N/A	N/A	N/A
Song Ponds (J&S 40-41)	Dry	N/A	N/A	CRLF, CTS & WESP 1995
Seep (J&S 42)	Dry	N/A	N/A	N/A
Wetland (J&S 43)	Dry	N/A	N/A	N/A
Seep (J&S 44-45)	Dry	N/A	N/A	CRLF & WESP 1995
Overflow Pond (J&S 46)	Dry	N/A	N/A	CRLF, CTS & WESP 1996
HE Ponds @ Building 817	1-11-02	0	0	CTS 1996-1998

(1) N/A refers to wetlands that were dry; access was limiting, or was inhospitable to amphibians. Also includes some seeps that had wet soil during survey period and are wetlands but were not likely to support special status amphibians.
(2) This breeding pool is located on the southern edge of Site 300; metamorphs produced from this breeding pool likely disperse into and across adjacent upland habitat on Site 300.
(3) California red-legged frogs present according to R. Cheatwood (2003).

Discussion

Amphibian presence during a particular year is dependent on a number of biotic and abiotic variables, most importantly hydroperiod, metapopulation structure, and survey effort. Many of the historic locations noted in Table 2 for special status amphibians at Site 300 were not hydrated in 2002 and therefore were not surveyed. It is important to note, however, that historic locations especially at Site 300 remain physically unchanged so amphibians are likely still there (i.e. estivating). Secretive terrestrial behavior and life spans ranging from years to decades (Trenham et al. 2000) make censusing difficult, but ultimately form each population’s adaptive resilience to the Mediterranean climate of California. The following discussion will focus on wetland features of both sites most important to special status amphibians.

Livermore Site

In 2002, California red-legged frogs were detected in several wetland locations at the Livermore Site (Figure1). The California red-legged frog is the only known special

Figure 1. The current (2002) and historic distribution of special status amphibians at the Livermore Site, Alameda County, California.

status amphibian known to occur within the boundaries of the Livermore Site. However, it is very probable that California tiger salamanders occur within close proximity to the Livermore Site; most notably individuals identified at the Sandia Percolation Ponds in 1995-1997 (J. S. Woollett pers. comm. 2003). See independent discussions below on pertinent amphibian habitat and populations at the Livermore Site.

Arroyo Las Positas

Figure 2. The Arroyo Las Positas from the northwest corner near Building 191 looking east, Livermore Site. (Photo MvH 2003)

The Arroyo Las Positas of the Livermore Site contains the largest population of California red-legged frogs detected at either site, although survey results presented in this report suggest otherwise (Figure 2). This can be attributed to the vegetative cover (i.e. density of cattail cover), secretive behavior, and the cryptic coloration of the species. For example, in 2002 during biological monitoring of the Arroyo Las Positas Maintenance Project (August-September), 243 meters of the channel were dredged in which 73 California red-legged frogs of various age classes were safely captured and translocated out of harms way. While detect ability is low for the frog life-stage in the Arroyo Las Positas, annual reproductive monitoring of conspicuous egg masses and oviposition sites has provided valuable trend data. In 2001, 37 egg masses were detected and in 2002, 31 egg masses were detected in the Arroyo Las Positas. As a result of the data presented here and monitoring that began in the mid-1990's, CRLF distribution in the Arroyo Las Positas is considered ubiquitous. CRLF population numbers have increased as a result of treatment facility water releases into the Arroyo Las Positas. Both California red-legged frog numbers and their distribution; along with the extent of wetland habitats have increased as a result of perennial water.

The secretive behavior may be typical of California red-legged frog populations found within the urban interface, which undoubtedly endure greater predation pressure by both native and non-native mammalian predators that are known to reach much greater densities within the urban interface. The perennial nature of these habitats has, however, allowed for the establishment and spread of invasive species such as the bullfrog, a known predator of the California red-legged frog and considered to be one of the major threats to the continued existence of this species. Presence of the bullfrog threatens the sustainability of California red-legged frog populations of the Livermore Site, and more broadly in the Arroyo Las Positas watershed. In addition, muskrats (*Ondatra zibethicus*) were observed during surveys in the Arroyo Las Positas and crayfish (*Procambarus spp.*) were also detected under the Patterson Pass Bridge. The impact of these two species is unknown, but crayfish are a known predator of early California red-legged frog age classes.

Erosion within the Arroyo Las Positas watershed and from the Livermore Site is a possible threat to the viability of California red-legged frog egg masses. Nearly every egg mass observed in the Arroyo Las Positas has a layer of silt on it; the exact tolerance of California red-legged frog egg masses to silt is unknown.

Drainage Retention Basin (DRB)

Figure 3. The centrally located Drainage Retention Basin, view looking southwest from the weir. (Photo MvH 2003)

The Drainage Retention Basin (DRB) has historically been considered poor habitat for the California red-legged frog mainly because of reduced water quality, lack of vegetation and cover, and exotic species (Figure 3). Since 2000, California red-legged frogs have been periodically observed within the basin and appear to be responding (increasing in numbers) positively to dewatering and removal of catfish (*Ictalurus sp.*), and ongoing removal of bullfrogs. California red-legged frog populations within the DRB may even be increasing, but continued bullfrog management is required or DRB California red-legged frogs will be extirpated. Recruitment from the Arroyo Las Positas is likely the most important factor to the continued existence of the DRB population. Management challenges within the DRB will continue. Largemouth bass (*Micropterus salmoides*), another non-native predator was recently discovered (S. Hall pers. comm. 2003) in the DRB, and now presents another significant problem for California red-legged frog populations within the basin and potentially the watershed.

West Perimeter Drainage Ditch

The West Perimeter Drainage Ditch is fed by the effluent from onsite treatment facility (TFA) and flows north to the Arroyo Las Positas near Patterson Pass Road. The lower half is concrete lined and has low habitat value. The upper portion of the west perimeter drainage line has developed into wetland habitat. During the 2002 nocturnal surveys, a single adult California red-legged frog was observed approximately 45 meters south of the West Gate Drive in littoral wetland vegetation. While other suspect splashes occurred during previous surveys, this observation constitutes the first verified sighting of California red-legged frog(s) within the west perimeter drainage ditch. California red-legged frog reproduction has not been documented to date in the west perimeter drainage line.

Arroyo Seco

Arroyo Seco is highly ephemeral and not likely to support California red-legged frogs or California tiger salamanders. The exception would be use a dispersal corridor. For this assumption to be met, a viable population would need to be within close proximity to Arroyo Seco. Currently, such a population is unknown or communication between populations is greatly prohibited by development.

Percolation Ponds

In the mid-1990s the Percolation Ponds at Sandia National Laboratory contained California tiger salamanders (J. Woollett pers. comm. 2003). No individuals were observed in 2002 or in recent years. Lack of observations should not be taken as evidence of local extirpation of this species. The original source of California tiger salamanders previously observed within the Percolation Ponds is undocumented or may have been developed in the last few decades. California red-legged frogs were not detected during multiple day surveys and egg mass surveys in 2002 although nocturnal surveys were not completed. California red-legged frog colonization of the Percolation Ponds is unlikely due to the isolation of the ponds and barriers to dispersal between the Percolation Ponds and the closest source populations, such as the Arroyo Las Positas.

Site 300

In contrast to the Livermore Site, Site 300 is mostly undeveloped and contains a mosaic of habitats and a number of ephemeral and perennial wetlands and seeps. In 2002, special status amphibians were detected in several wetland locations at Site 300 (Figure 4). As Figure 4 illustrates, Jones and Stokes (2002) identified wetland locations based on wetland delineation criteria (i.e. plant composition, soils, hydrology), but in turn several locations were inhospitable to amphibians at the time of the first survey as a result of average to below average precipitation.

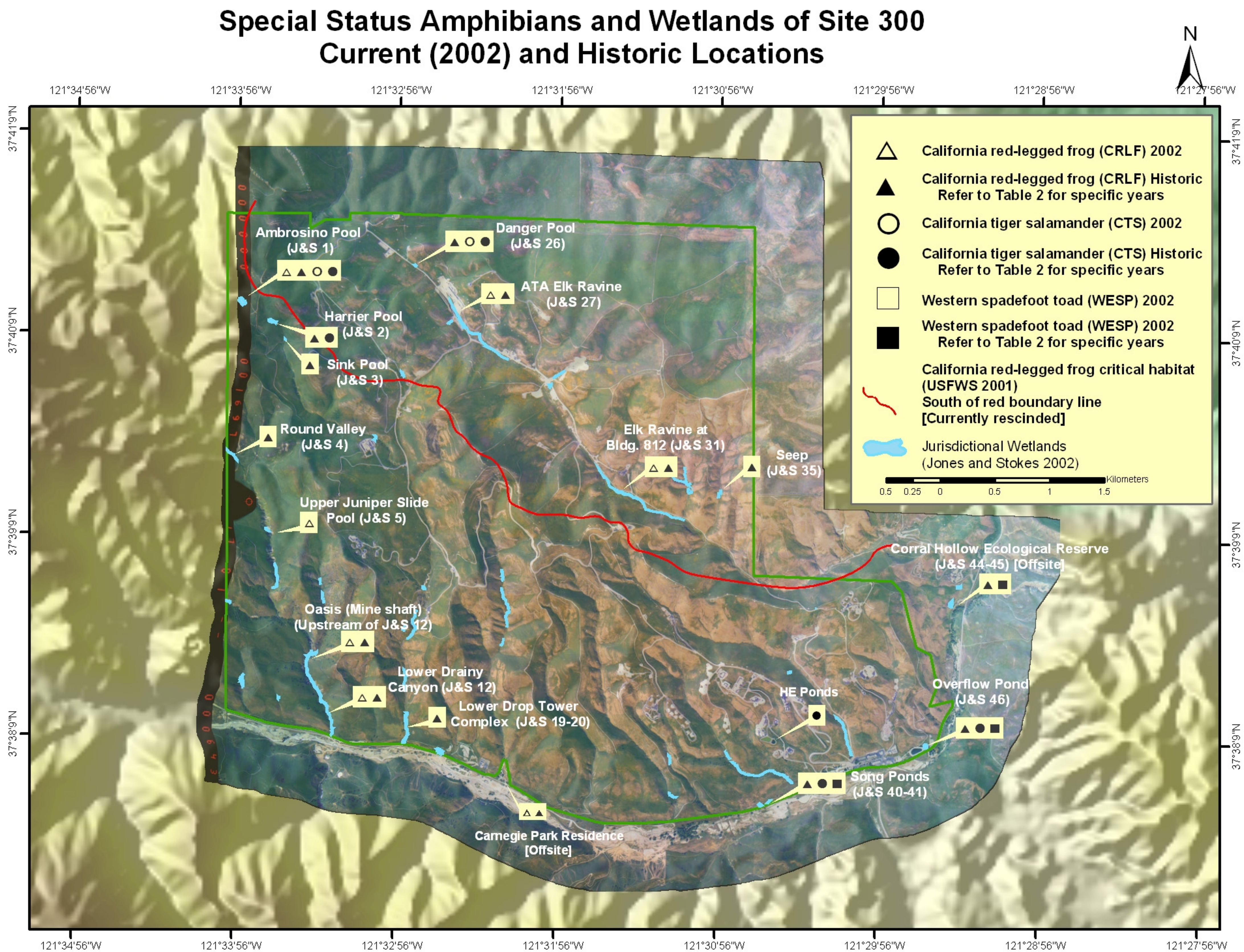

Figure 4. The current (2002) and historic distribution of special status amphibians at Site 300, Alameda and San Joaquin Counties, California.

Upper Drainy Canyon Complex
Ambrosino Pool

Figure 5. Ambrosino pool is located in the northeast corner of Site 300 and contains the most productive populations of California tiger salamanders at the site. (Photo MvH 2003)

Ambrosino pool (J&S 1), a modified (i.e. bermed) vernal pool, is strongly influenced by yearly hydroperiods. In years of average to above average rain totals, the pool fills and provides breeding habitat for both California red-legged frogs and California tiger salamanders. For example, the inset photo (Figure 5) was taken in February 2003, during a winter that had significant early season precipitation. In 2002, Ambrosino pool was approximately half as full as what is shown and dried by mid-May. Surveys for California red-legged frogs started at about that time and missed any true estimate of current California red-legged frog population level at Ambrosino pool. Five sub-adult (i.e. 2nd year) California red-legged frogs were observed during early season California tiger salamander egg surveys. Hydration patterns in 2003 appear to be better suited for California red-legged frogs; continued surveys may be able to better estimate occupancy.

California tiger salamanders on the other hand had an average/good year based on the observation of many eggs, although true California tiger salamander population levels at Ambrosino pool can not be estimated without multiple year drift fence and pit fall sampling efforts. Since this species breeding ecology is adapted to exploiting an ephemeral system such as Ambrosino pool, California tiger salamander breeding is nearly instantaneous with the filling of the pool. On above average rain years, Ambrosino pool likely produces many metamorphs of both California red-legged frogs and California tiger salamanders, and on average to below average years California tiger salamanders only. One interesting component of California tiger salamander dispersal capability was observed during spring surveys when a desiccated adult salamander was found on a ridge top southeast of Ambrosino pool near the upper middle elevation of the West Observation Post (West OP). Assuming this individual traveled a straight line; the adult California tiger salamander had traveled 568 meters and gained/lost 68 meters elevation. Even on marginal years, California tiger salamanders are capable of significant dispersal movements.

Direct threats to the Ambrosino pool population are probably low, although the recent invasion of cocklebur (*Xanthium strumarium*), an invasive non-native wetland plant, may have unforeseen effects.

Fire Trail pool (south of J&S 1), a large rain puddle located on an established fire trial 75 meters south of Ambrosino pool, probably best illustrates California tiger salamander productivity in Ambrosino pool since it contained a few hundred California tiger salamander eggs in 2002. No individuals reached metamorphoses in 2002. Although data is lacking, this pool probably only remains hydrated long enough for metamorphoses during the best rain years and in most breeding season's produces no recruits.

Harrier Pool

Figure 6. Harrier pool is located in the northeast corner of Site 300 southeast of Amborsino pool and is a productive California tiger salamander population on good years. (Photo MvH 2003)

Harrier pool (J&S 2) was dry in 2002 and not surveyed; Harrier pool had been dry since 1999. In wet years, such as the time of this photo in February 2003, Harrier pool provides breeding habitat for California tiger salamanders (Figure 6) as indicated by the presence of eggs. No threats or management actions have been identified for the habitat or breeding population of Harrier pool.

Sink Pool

Figure 7. Sink pool is located in the northeast corner of Site 300 southeast of Harrier pool and may be a productive California tiger salamander population on the wettest years. (Photo MvH 2003)

Sink pool (J&S 3) has California tiger salamander eggs during wet years and follows hydration patterns similar to Harrier pool. Sink pool on the best years might produce a limited number of metamophs but probably produces few recruits simply because of size (Figure 7). The pool is small and prone to desiccation prior to metamorph production unless supplemental rain events occur after oviposition.

Upper and Lower Juniper Slide Pool

Figure 8. Upper juniper slide pool is an isolated seep in the Upper Drainy Canyon watershed that has formed a pool and contains a substantial breeding population of California red-legged frogs. (Photo MvH 2003)

Upper Juniper Slide Pool (J&S 5) appears to be the result of a landslide that has deposited a mature juniper (*Juniperus californica*) downstream of a perennial seep resulting in a pool that can obtain depths of nearly one meter in the spring (Figure 8). The upper portion of the pool is composed of cattails (*Typha latifolia*) and rushes (*Juncus* *spp*.). Upland habitat adjacent to the wetland habitat is similar to other wetlands at Site 300, being mostly non-native annual grasses.

The largest California red-legged frogs of all LLNL surveys were observed at the Upper Juniper Slide Pool suggesting that these particular frogs have high adult survivorship. Up to 15 adults were observed at once at the Upper Juniper Slide Pool in 2002, as well as larva in the previous year (2001). During one nocturnal survey in 2002, a congregation of eight adults was observed within a square meter clearing in the cattails. Sub-adult California red-legged frog were not observed within the Upper Juniper Slide Pond with the exception of one anecdotal observation of a metamorph that was observed approximately 250 meters upstream within intermittent hydrophytic vegetation in April 2002.

Although the Upper Juniper Slide pool population produces metamorphs, this population is likely at carrying capacity simply because of the limited habitat size and lack of California red-legged frog age classes. For this reason, the Upper Juniper Slide pool would be an excellent source population for reestablishment efforts in the lower watershed. Although California red-legged frogs are capable of overland movements of 2816 meters (Rathbun and Schneider 2001), the Upper Juniper Slide pool population may be isolated during most years except during the wettest years, when aquatic connectivity would be greatest. Since this wetland lacks any aquatic connectivity with other suitable amphibians habitat, this California red-legged frog population is vulnerable to feral pig (*Sus scrofa*) predation and habitat degradation.

Lower Juniper Slide Pond (J&S 5) is a few hundred meters below the Upper Juniper Slide pool and has been formed by a similar landslide event. Pondweed (*Potomogeton spp.*) is found throughout the pool and cattails are lacking. Two sub-adult California red-legged frogs and no adults were observed during surveys which is somewhat expected since this habitat is less extensive in size and quality and more likely to be inhabited by dispersing sub-adults.

Oasis (Mineshaft)

Figure 9. The Oasis or Mine Shaft is the confluence of Drainy Canyon and a perennial seep exiting through an abandoned mine shaft from the Carnegie era. (Photo MvH 2003)

The Oasis (J&S 12) is the confluence of Drainy Canyon and the mineshaft, which provides perennial water to lower Drainy Canyon. The remnant mineshaft was excavated into bedrock (hidden) in the center of the picture (Figure 10), and now dilapidated, contains a small pool and perennial seep with resident California red-legged frogs. Breeding within the mineshaft has not been documented to date. Feral pigs are a significant threat to the Oasis population and continue to degrade wetland habitat.

Lower Drainy Canyon

Figure 10. Lower Drainy is downstream of the Oasis and Mine Shaft and is heavily degraded compared to the late 1990's when California red-legged frogs inhabited the silted filled pool below the culvert in the center of the picture. (MvH 2003)

No California red-legged frogs were observed in Lower Drainy Canyon (J&S 12) below the Oasis (upstream of the above inset photo). Lower Drainy Canyon remains perennial for it's entire duration to Corral Hollow Creek. The majority of the stream is densely vegetated providing good cover and overall habitat value for California red-legged frog although breeding habitat is limited. Wider channel sections are cattail dominated and subject to feral pig disturbance. In as late as 1999, the above inset picture had breeding California red-legged frogs, now the pool is silted in and water depths are minimal (Figure 10). Erosion from the fire trail crossing and a poorly designed culvert (pictured) has greatly degraded the immediate aquatic habitat and Lower Drainy Canyon.

Elk Ravine Complex
Upper and Lower Danger Pool

Upper and Lower Danger Pools (J&S 26) are small (5 meter x 3 meter) pools within the upper most extent of Elk Ravine upstream of the ATA facility. One of the pools, Upper Danger Pool was created by the grading of a fire trail perpendicular to the flow pattern of Elk Ravine. Lower Danger Pool appears to be a natural depression and California tiger salamander eggs were first discovered there in 2002 during early season egg searches. Both pools appear to be population sinks on most years and may produce metamorphs only during the wettest years. This population is currently isolated. This population is ideal for translocation experiments, and could be a source population for the proposed Sharp Gun Mitigation pool.

Elk Ravine at ATA

Figure 11. Wetland habitat in Upper Elk Ravine at ATA appears to be mostly the result of cooling tower effluent. A viable population of California red-legged frog occurs from the point of this picture downstream to where surface waters terminate and vegetation becomes annual grassland. (Photo MvH 2003)

Upper Elk Ravine at ATA (J&S 27) has a stable population of California red-legged frogs (Figure 11); upwards of 20 California red-legged frogs can be observed during most surveys. Surveys have occurred along this stretch of Elk Ravine since the onset of monitoring in 1996. Plant diversity is limited within the ATA wetland and is primarily cattail. California red-legged frogs in Upper Elk Ravine have benefited from removal of sediment at culvert ends associated with road crossings. Breeding occurs annually at these locations and several age classes of California red-legged frogs were observed during surveys. This population is found entirely within the wetland formed from cooling water effluent of the decommissioned ATA facility. The effluent that supports this wetland will likely be terminated in 2004 and replaced by a mitigation pool at the Sharp Gun that will be hydrated by a natural seep.

Elk Ravine at Building 812

Figure 12. Wetland habitat in Elk Ravine near Building 812 is the most extensive at the site with perennial water and dense vegetative cover. California red-legged frog reproduction in this wetland is unlikely due to sedimentation and the resulting lack of suitable breeding depths. (Photo MvH 2003)

Elk Ravine (J&S 31) near Building 812 constitutes the most extensive wetland and riparian habitat at Site 300. The habitat is composed of dense stands of cattails and stinging nettle (*Urtica dioica*), separated by intermittent red willows (*Salix laevigata*) (Figure 12). A perennial seep hydrates the wetland and is augmented by seasonal flows. The low number of California red-legged frogs (n=3) observed within this section of Elk Ravine during surveys is probably a result of 1) difficulty of detection due to channel morphology and cover 2) limitation of depth suitable for breeding. In much of the channel, dense vegetation and channel incision makes much of the wetland difficult to detect frogs. True California red-legged frog population levels are most likely underestimated in this section of Elk Ravine. An important factor shaping California red-legged demography and abundance in this wetland is the lack of breeding habitat. Sedimentation and gradient may currently be preventative for California red-legged frog breeding.

Restoration potential in this section of Site 300 may be critical to the continued existence of California red-legged frog within Elk Ravine. Two mitigation pools are scheduled to be built within this section of Elk Ravine in 2003. California red-legged frogs will benefit from deep-water habitat within Elk Ravine, but close monitoring will be necessary to determine if breeding occurs and if egg masses produce larva. Egg masses are negatively affected by suspended sediments, which in essence, suffocate the individual eggs.

Overflow Pond

The Overflow Pond (J&S 46) is located in the General Service Area (GSA) of Site 300 and functions as a containment structure for sewage treatment ponds in flooding situations. On wet years this pond will hydrate and can have California tiger salamanders, California red-legged frogs, and western spadefoot toads. In most years these individuals probably estivate within or around the GSA. One adult California tiger salamander was observed during the first rain of winter 2002 on the paved road in front of building 877 (C. Carter pers. comm. 2002). The natal pond for this observed individual in most likely the overflow pond.

Carnegie Park Residence Pond

Carnegie Park Residence Pond is located at the base of Long Canyon just offsite on the Site 300 side of Corral Hollow Road. This pond is of significance because it contains a large breeding population of California red-legged frogs (R. Cheatwood pers. com 2003). Metamorphs may disperse into Site 300 from this population. This population could function as a source of young life-stages (i.e. larva/eggs) for recovery actions within the Corral Hollow watershed, including Site 300. It is likely that additional populations of California red-legged frogs occur on the other three borders of Site 300, the Carnegie Park Residence is the only one documented at this time.

Building 817 HE Ponds

California tiger salamanders were observed in the HE ponds at building 817 in 1996-1998 (J.S. Woollett pers. comm. 2003). An initial California tiger salamander egg survey was completed during the 2002-breeding season but was discontinued due to access and habitat suitability.

In summary, LLNL's special status amphibian populations occupy a variety of wetland habitats at both sites. Site 300's amphibian populations are found primarily in Elk Ravine and Drainy Canyon where both populations could be declining due to erosion effects and predation pressure. Livermore Site amphibians, predominately the Arroyo Las Positas populations have been increasing in recent years but may have reached a population plateau and now may be entering a period of population decline as a result of introduced predators. Amphibian populations at both sites may be in jeopardy without adaptive management.

Management Recommendations

1. Non-native species such as bullfrogs, fish, and feral pigs are known to compete with, prey upon, displace, or destroy habitat of special status amphibians. Control and removal of these non-native species will continue to benefit native special status species.
2. Anthropogenic erosion and resulting sedimentation appears to be negatively impacting important wetland features such as depth, which is essential to California red-legged frog breeding. Reducing or eliminating unnatural erosion will benefit California red-legged frogs by deepening wetland features important for breeding, which may ultimately lead to improving the sustainability of these populations.
3. Promote employee education and awareness of wildlife conservation issues such as non-native species impacts, endangered species conservation, and biodiversity. Involving personnel can provide a sense of ownership and pride in the resource and even reduce the potential for additional non-native species introductions that can be costly and potentially irreversible.

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Personal Communications

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