A 2009 – 2015 Assessment of Northern Leopard Frog (*Rana pipiens*) Reproduction on Southern Nevada Water Authority Ranches in Spring Valley, Nevada

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SOUTHERN NEVADA WATER AUTHORITY

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ABSTRACT

The Southern Nevada Water Authority conducted northern leopard frog (*Rana pipiens*) egg mass surveys from 2009 to 2015 on several of its deeded ranch properties in Spring Valley (Hydrographic Basin #184), Nevada. The primary goal of these surveys was to assess northern leopard frog reproduction on the properties by documenting when and where they breed, the level of use of specific breeding areas, and long-term fidelity to breeding areas, and by tracking changes in the abundance of egg masses (and hence effective size of the breeding populations). Additionally, tadpole development was investigated at several sites in 2012. All of the properties investigated supported a breeding sub-population of leopard frogs that tended to use specific breeding areas across multiple years (where multiple year surveys were conducted). The number of egg masses (and hence breeding adult frogs) varied considerably across years, and followed a similar trend across the surveyed properties. Tadpole development from egg to metamorphosed frog spanned up to 18 weeks at select sites. The information derived from the surveys will help to manage northern leopard frog sub-populations and their breeding habitat on the ranch properties, and to better understand long-term breeding trends in Spring Valley.

INTRODUCTION

The northern leopard frog (*Rana pipiens*) is a widespread species that occurs throughout the northern U.S., western U.S., and southern Canada. Although abundant across much of its range, it is thought to be declining in portions of the western U.S. (Smith 2003; Rorabaugh 2005; USFWS 2011). In Nevada, the northern leopard frog (hereafter leopard frog) is considered a BLM Special Status Species (BLM 2012) and a Species of Conservation Priority (Wildlife Action Plan Team 2012), and it has been suggested that the species may be rare or even extirpated at many historical locations (Hitchcock 2001; USFWS 2011; Rogers and Peacock 2012). However, given variations in leopard frog behavior and detection rates, naturally high fluctuations of leopard frog populations, and frequency and intensity of drought over the past 15 years, follow-up surveys are needed to better understand occupancy rates and population sizes across the State. In Spring Valley (White Pine County, Nevada), leopard frog surveys have been conducted in 13 of the past 15 years (Hitchcock 2001; BIO-WEST 2007, 2009; SNWA 2007, 2008a, 2010, 2011, 2014, and this report). These surveys have demonstrated occupancy and reproduction at a number of sites, as well as large fluctuations across years.

The Southern Nevada Water Authority (SNWA) owns approximately 23,500 acres of deeded ranch properties in east-central Nevada, 95% of which are in Spring Valley. These ranch properties, along with associated groundwater and surface water rights, were purchased to support sustainable groundwater development in eastern Nevada. The properties discussed in this report were ranched from the late 1800's and early 1900's to the present, and purchased by SNWA in 2006 and 2007. SNWA continues to operate the properties as part of the SNWA Great Basin Ranch.

Many of the SNWA ranch properties include mesic habitats (including streams, ponds, marshes, and manmade reservoirs) maintained by the presence of natural spring systems, surface water runoff from the mountains, manmade surface water diversions, wells, and the artificial irrigation of native meadows and crops. These mesic habitats support a number of wildlife species, including

the leopard frog. Historical and current ranching practices on the ranch properties appear to have maintained, and in some cases enhanced, leopard frog sub-populations. Continued sustainable management of leopard frog habitat on the ranch properties contributes to the persistence of the species in Spring Valley.

To better manage leopard frog sub-populations and their habitat on the ranch properties, it is important to understand how and when the various areas are utilized by the leopard frog. Although a variety of mesic habitats are inhabited by leopard frogs, breeding habitat is integral to the long-term persistence of a population, as it supports the most vulnerable life stages (i.e., eggs and tadpoles). Consequently, SNWA conducted leopard frog surveys from 2009 to 2015, focusing on breeding habitat and reproduction on our ranch properties. The survey objectives were to: (1) identify breeding areas; (2) document the level of use of these areas; and (3) gain an understanding of long-term fidelity to specific breeding areas.

This effort included extensive leopard frog egg mass surveys. Some of the egg mass surveys were conducted under the Biological Monitoring Plan for the Spring Valley Stipulation (Biological Working Group [BWG] 2009) and provided some of the trend data. The trend data, besides addressing relative frog abundance, tracks the level of use of, and fidelity to specific breeding areas across multiple years. The following three leopard frog egg mass trend monitoring areas (trend areas) are on SNWA property: Keegan Spring Complex (Robison Ranch, Keegan property); Unnamed 5 Spring (El Tejón Ranch, Bastian Creek property); and Minerva Spring Complex (El Tejón Ranch, Shoshone property). Results specific to the trend areas in the monitoring plan are provided in several reports (SNWA 2010, 2011, 2014). To further assess leopard frog reproduction on the ranch properties, SNWA expanded the egg mass surveys in various years to include additional areas (assessment areas) within the aforementioned properties, as well as other ranch properties (O'Neil/Frog Pond, Home Ranch, and McCoy Creek properties on the Robison Ranch). Altogether, the findings regarding breeding habitat and reproduction on SNWA ranch properties are discussed herein.

METHODS

Study Area

The general study area (**Figure 1**) is within Spring Valley (Hydrographic Basin #184), White Pine County, Nevada, USA. Spring Valley is located in the Great Basin Desert, bordered by the Snake Range to the east and the Schell Creek Range to the west. The valley floor elevation ranges between 5,500 and 6,000 feet above mean sea level (ft-amsl), and the bordering mountain ranges exceed 11,000 ft-amsl. The valley floor is largely characterized by shrubland, with mesic areas scattered throughout, including springs, wetlands, meadows, irrigated pastures, and cultivated alfalfa (*Medicago sativa*). Less than 1% of the basin (approximately 8,000 acres) is lowland wetland habitat, and less than 1% (approximately 7,000 acres) is lowland meadow habitat; only a fraction of that includes springs and springbrooks (McLendon et al. 2011; SNWA 2004; SNWA et al. 2011). With a few exceptions, these mesic areas exist primarily along the margins of the alluvial fan in the northwestern and southeastern portions of the valley. Due to the large variation in precipitation and recharge in desert systems, the wetness and extent of these areas can vary considerably.

All of the irrigated pastures and cultivated areas, as well as many of the spring and wetland systems on the valley floor and valley floor / alluvial fan interface, are associated with ranches. Approximately 40% (over 4,000 acres) of the wetland/meadow habitat is on SNWA property (SNWA 2004; SNWA et al. 2011). All of the surveyed SNWA properties possess spring and wetland systems, and some include areas of irrigated pasture and cultivated alfalfa. Surface and groundwater in many of these properties are supplemented by irrigation, including the conveyance of water from mountain block streams. The conveyance and distribution of water has created and enhanced mesic habitat that leopard frogs use.

In this report, the surveyed areas are referred to by name. Upon purchasing the ranches, SNWA retained their names (e.g., Robison Ranch) to facilitate cultural surveys and ranch management. Many of the ranches are composed of smaller properties, which also have historically-significant names (e.g., Robison Ranch, Keegan property). Some of the properties are, in turn, comprised of more than one parcel. Together, the deeded properties comprise the SNWA Great Basin Ranch.

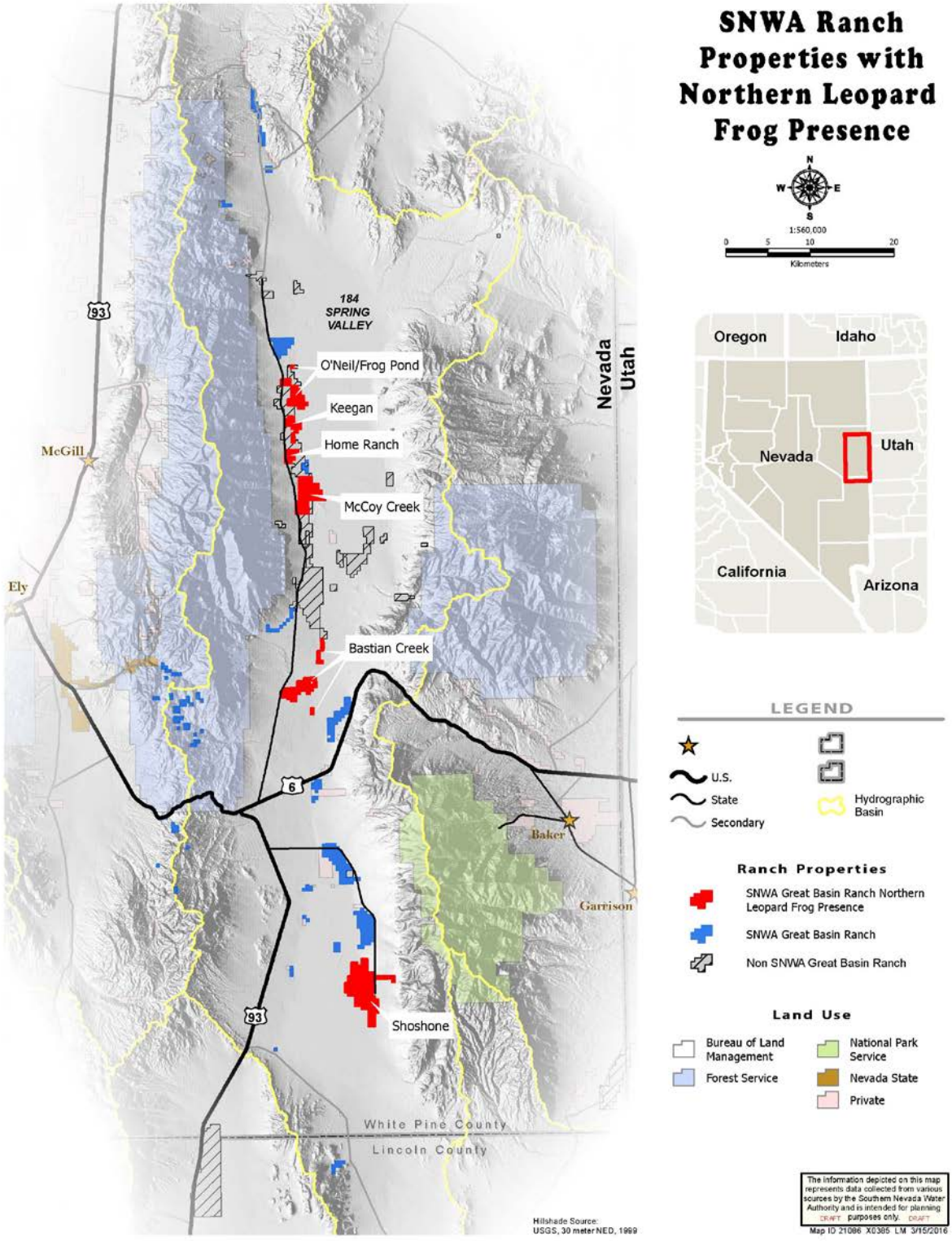

Figure 1. The general northern leopard frog study area showing the SNWA ranch properties of interest.

Properties of Interest

The surveys were focused on all SNWA deeded ranch properties in Spring Valley known to support leopard frogs. The presence of leopard frogs on SNWA ranch properties was determined by several previous surveys, as well as incidental observations (Hitchcock 2001; BIO-WEST 2007 and 2009; Nevada Department of Wildlife 2007; SNWA 2008a, 2008b, 2009, and 2010). Six properties within the SNWA Robison and El Tejón ranches were identified as supporting sub-populations of leopard frog. They are as follows: Keegan, O'Neil/Frog Pond, Home Ranch, and McCoy Creek properties of the Robison Ranch; and Bastian Creek and Shoshone properties of the El Tejón Ranch (**Figure 1**). The remaining SNWA properties do not appear to support leopard frog sub-populations.

SNWA Robison Ranch

The Keegan property is approximately 690 acres in size and dates to the 1870's. The property is composed of two parcels, both of which were surveyed. The majority of the survey effort was conducted on the northern parcel (approximately 570 acres), as the southern parcel did not appear to have permanent mesic habitat. On the northern parcel, mesic habitat is characterized by a series of springs (Keegan Spring Complex) that feed into a wet meadow and a main channel that flows into several ponds in the northern portion of the property. This channel then flows for another 0.6 miles before it terminates in a series of larger shallow ponds. There is a manmade ditch that diverts some spring water to irrigate additional portions of the meadow (~ 5 acres) in the northern portion of the property, and two additional ditches divert water from the main channel to irrigate a meadow (~ 10 acres) in the southern portion of the property. The leopard frog trend area is in the northern portion of the property.

The O'Neil/Frog Pond property is approximately 1,280 acres in size and dates to at least the 1870's. The property is composed of two parcels, both of which were surveyed. The majority of the survey effort was conducted on the southern parcel (approximately 1,240 acres), as the northern parcel did not have any mesic habitat at the time of the survey. On the southern parcel, mesic habitat is characterized by several springs that feed into channels and terminate in a series of vegetated ponds. Surface water can also reach the property seasonally by means of Piermont Creek, which is conveyed in a ditch from the mountain block and distributed on the northern portion of the property. Some water also originates from springs on a private property to the west.

The Home Ranch property is approximately 490 acres in size and dates to at least the 1870's. Mesic habitat is characterized by a scattering of shallow, vegetated pools that are fed by irrigation water from Odgers Creek. Water from Odgers Creek is conveyed in a pipe from the mountain block, and used to irrigate approximately 180 acres of native meadow on the northern portion of the property.

The McCoy Creek property is approximately 2,300 acres in size and dates to at least the 1870's. Mesic habitat is characterized by a series of seeps and springs that feed into wet meadows and form pools, ponds, and channels. This habitat also receives supplemental water from McCoy Creek (conveyed in a pipe from the mountain block) and O'Toole Creek (seasonal water that also originates in the mountain block), which irrigate approximately 1,100 acres of native meadow.

SNWA El Tejón Ranch

The Bastian Creek property is approximately 1, 950 acres in size and dates to at least the 1910's. The property is composed of four parcels, and one of the northern parcels (approximately 200 acres) was surveyed. Mesic habitat is characterized by several springs found in all four parcels of the property. Additionally, on one of the southern parcels, surface water from Bastian Creek (conveyed in a pipe from the mountain block) is used to irrigate approximately 200 acres of alfalfa and/or native meadow. However, only Unnamed 5 Spring (on the 200-acre northern parcel) appears to support a breeding sub-population of leopard frog on the property. This spring, along with its associated meadow, occupies less than 20 acres on the property. Unnamed 5 Spring, a trend area, consists of two spring pools that are joined by a broad, shallow channel with some flow. At the southern spring pool, a dike diverts the water into a shallow channel that flows for about 450 meters and terminates in a wetland with several shallow pools. This wetland extends past the southern property boundary, and in wet years may extend past the eastern property boundary.

The Shoshone property is approximately 4,700 acres in size and dates to at least the 1880's. Mesic habitat is characterized by a series of springs (Minerva Spring Complex) that run along the eastern edge of the property. Springs in the northeast flow west and terminate in a series of shallow ponds. Two of these springs are associated with the Minerva Spring Complex [North] trend area; they are dammed to form two small ponds, and are diverted along ditches to irrigate native meadow (some of this water eventually reaches the western ponds). Springs in the east-central portion of the property flow west, but are captured by a ditch that moves the water north for irrigation. Water can be released at several points along the ditch to irrigate native meadows to the west. The east-central portion of the property also contains a spring-fed stock pond, which comprises the Minerva Spring Complex [Middle] trend area. In addition, the eastern arm of the property receives water from Swallow Spring, which originates on the alluvial fan. Springs in southern portion of the property are dammed to form a large reservoir, with supplemental irrigation water supplied by Swallow Canyon (conveyed in ditches from the mountain block). Some of the outflow from this reservoir forms a smaller, more vegetated pond to the west. Water from the larger reservoir can be diverted to the south to irrigate native meadow, but is generally diverted north in the main north-running ditch. Water from the smaller pond may also be diverted to the south to irrigate native meadow. Water in the east-central and southern portions of the property is used to irrigate approximately 400 acres of native meadow via ditches, and approximately 410 acres of alfalfa and grass.

Egg Mass Surveys and Breeding Habitat

Leopard frog egg mass surveys were conducted on the SNWA ranch properties of interest from 2009 to 2015. Trend areas within the Keegan, Shoshone, and Bastian Creek properties were surveyed every year from 2009 to 2015. Additional mesic areas outside of the trend areas (assessment areas) were surveyed in all years except for 2010 at the Keegan property, and in all years except 2010 and 2014 at Shoshone and Bastian Creek properties. The ranch properties without trend areas (McCoy Creek, Home Ranch, and O'Neil/Frog Pond) were surveyed, at least in part, as assessment areas in one to four of the years from 2009 to 2015. In 2012, all six of the properties were surveyed in all areas of mesic habitat, including trend and assessment areas.

Mesic habitats (springs, pools, ponds, marshes, channels, etc.) were initially identified on each property through the use of previous survey information, maps, and visual reconnaissance. Larger

ponds were visible from a distance, but many of the shallow pools and marshes were only encountered once the walking surveys had begun. Even if water was not visible, its presence could usually be determined by the associated wetland vegetation. On a few occasions the presence of water was identified by the sound of calling male leopard frogs.

Egg mass surveys were conducted during the expected breeding period in Spring Valley (March-May). Surveys of the trend areas on Keegan, Bastian Creek, and Shoshone properties began in mid-March, and were conducted every 10 to 14 days until the end of the breeding season in mid-May. This resulted in three to six visits per site during the active breeding period. Visiting sites repeatedly throughout the breeding season allows for most of the egg masses to be documented; consequently, trends in annual reproductive output can be determined. Once breeding was documented at a trend area, assessment areas at the various properties were also surveyed. Depending on the site and year, assessment areas were surveyed from zero to four times during the active breeding season. Surveying the assessment areas once or twice provided minimum egg mass numbers, which allowed for the identification of additional breeding areas on a property, but not a trend comparison across years.

The egg mass survey protocol was derived from Utah Division of Wildlife Resources Columbia spotted frog monitoring protocol (UDWR 2004). The surveys consisted of one to four surveyors walking, at less than 20 meters per minute, around and through all aquatic habitats within a survey area to document egg masses. Special attention was given to those areas generally considered appropriate breeding habitat for leopard frog, such as ponds, pools, and marshes with shallow (< 60 cm), slow moving water and some emergent vegetation (Smith 2003). Areas of deeper water (> 1.0 meter in depth) were generally not walked, but circled and scanned by eye. When an egg mass (or cluster of egg masses) was located, it was aged to estimate deposition date, flagged, and its location was recorded with a GPS unit. Using UDWR (2004) protocol, age classes were as follows: AC 1= small, circular ova; AC 2 = kidney shaped ova; AC 3 = tailed embryos close to hatching; AC+3/hatched = hatching or hatched tadpoles; and dead = white embryos, fungus on egg mass. Marking and ageing egg masses allowed the surveyors to determine if new egg masses were present at the same location during subsequent visits. It also prevented the double counting of previously recorded egg masses. The ageing of egg masses also permitted an estimate of the earliest breeding date.

The documentation of egg masses allowed for the identification of general breeding areas on each ranch property. These general breeding areas are defined by adjacent egg mass deposition locations that are interconnected by mesic habitat. Within a specific property, general breeding areas may be separated by dry ground or longer, linear mesic habitat such as streams or ditches that do not offer breeding habitat.

Egg to Metamorph Investigation

The time it takes for a newly laid leopard frog egg to develop to a fully formed frog (metamorph) in the study area was investigated in 2012. Higher egg mass counts in 2012 provided ample opportunity for study. Keegan, Bastian Creek, and Shoshone properties were chosen for the investigation as they cover the north, middle, and south of Spring Valley respectively, and have displayed variation in egg mass deposition dates. Also, each of these properties have smaller breeding pools that are easily sampled for tadpoles.

In April 2012, egg mass deposition locations were identified in a small pond/pool on each property. For each location, the earliest egg mass deposition date was estimated based on the age of the first egg masses documented. Each location was subsequently visited once in July and once in August to check on tadpole development and for the presence of metamorphs. On each visit, tadpoles were captured with a long-handled dip-net by sweeping through submerged vegetation. A captured tadpole's total length was recorded in millimeters and the visible presence of hind legs was noted. Metamorphs were captured by hand or net, measured snout-vent in millimeters, and any remaining unabsorbed tail was measured in millimeters. Individuals with remaining tail were not considered fully developed metamorphs. Total time of development was estimated to the number of weeks elapsed from egg deposition to the observation of the first tailless metamorph.

RESULTS

Surveys conducted from 2009 to 2015 documented leopard frog egg masses and breeding habitat at all six of the SNWA properties investigated. A total of 6,325 leopard frog egg masses were documented across the seven years of survey effort, with the majority (93%) found in 2011 and 2012. All properties had multiple egg mass deposition locations that were usually associated with ponds, pools, or marshy areas with open water. Egg mass number data collected at the trend areas showed a general increase from 2009 to 2012 with a subsequent drop in 2013 to 2015. Estimated egg mass deposition dates fell between March 14 and May 15 across all survey years. An investigation of egg to metamorph development at select breeding locations in 2012 found that the entire process took approximately 15 to 18 weeks (March/April – July/August) across sites.

Egg Mass Surveys and Breeding Areas by Property

The following information presents the 2009-2015 leopard frog egg mass survey results for each SNWA deeded property investigated. Egg mass data collected in trend and assessment areas are presented for each property. Descriptions and maps of the surveyed areas and documented breeding areas within each property are also given.

Keegan property (Robison Ranch, Keegan Spring Complex)

The Keegan property was surveyed from 2009 to 2015. Surveys were conducted annually within the trend area, and all years except 2010 in assessment areas. **Table 1** presents the survey dates and documented egg mass numbers by year for both the trend and assessment areas. **Figure 2** shows the Keegan property with the survey areas by year, the trend area, and egg mass locations by year. The surveys fell between the dates of March 6 and May 28, with egg masses documented from April 1 to May 20. In any given survey year, the trend area was visited four to six times, and the assessment areas were visited zero to four times. All mesic areas on the property were surveyed in at least one of the years and on at least one occasion during the breeding season in that year.

Table 1. The survey year, area, dates, and northern leopard frog egg mass numbers for Keegan property (Robison Ranch, Keegan Spring Complex).

Survey Year	Survey Area[1]	Survey Dates[2]	Total Number of New Egg Masses[3]
2009	Trend	**4/14**, **4/30**, **5/6**, 5/13, 5/28	34
	Assessment	**5/8**	9
2010	Trend	3/23, **4/19**, **5/4**, **5/18**	70
	Assessment	No visits	na
2011	Trend	3/15, 3/27, **4/12**, **4/26**, 5/11	162
	Assessment	**4/12**, **4/14**, **4/26**, 5/11	552
2012	Trend	3/15, 3/27, **4/12**, **4/24**, **5/9**	416
	Assessment	**4/12**, **4/24**, **5/9**	1024
2013	Trend	3/6, 3/20, 4/3, **4/18**, **4/29**, 5/15	59
	Assessment	4/3, **4/18**, **4/29**, 5/15	7
2014	Trend	3/27, **4/16**, **4/23**, **5/5**, **5/20**	39
	Assessment	**4/16**, **4/23**, **5/5**, **5/20**	3
2015	Trend	3/18, **4/1**, **4/28**, 5/12	7
	Assessment	**4/1**, **4/28**, 5/12	7

[1] "Trend" refers to the areas visited 3 to 6 times on an annual basis to determine changes in egg mass numbers across years, and "Assessment" refers to all other survey areas which were visited 0 to 4 times in a particular year.

[2] All dates on which the surveys were conducted. The bold denotes the dates on which egg masses were documented. It should be noted that the entire "Assessment" area was not necessarily covered on each date, and some portions of the property were only visited once in a year.

[3] Totals include only egg masses recorded at first observation. The numbers presented for the "Assessment " areas may not be derived from multiple visits of the same areas within or across years, and therefore do not represent comparable trend data across years.

The surveys identified two general breeding areas on the property, both within the northern parcel and associated with the Keegan Spring Complex; one in the northern portion and one in the southeast portion (**Figure 2**). Breeding habitat in the northern portion of the parcel is comprised of a series of ponds, pools, and marshes associated with the trend area. It also includes a meadow with scattered shallow pools and marshy areas fed by a series of smaller springs along the west side of the property, outside of the trend area. Many of the mesic areas within the meadow were separated by areas of dry ground. This assessment area was also separated from the trend area by a strip of drier habitat in the northern portion of the meadow and by a series of low stabilized sand dunes on the east side of the meadow.

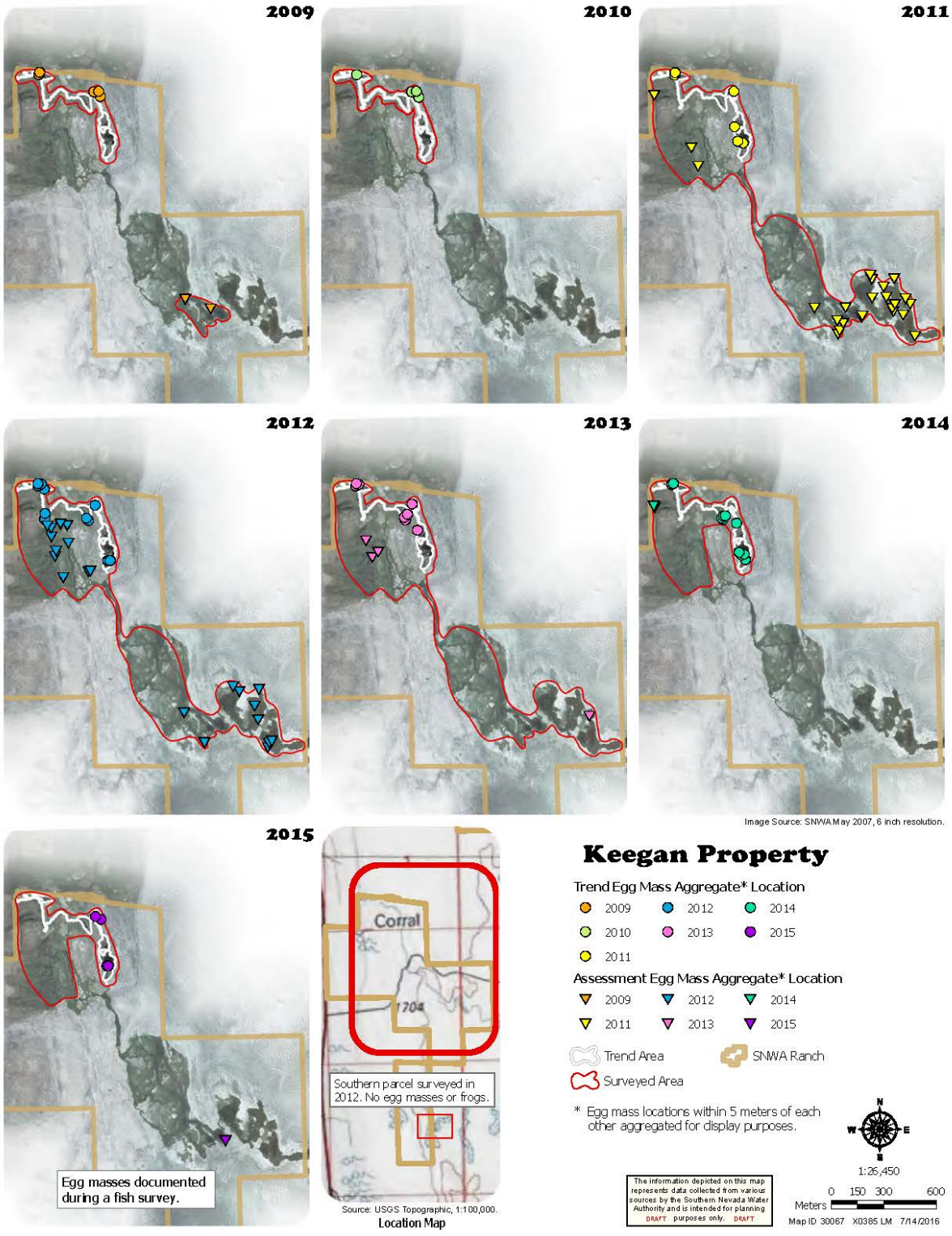

Figure 2. Keegan property (Robison Ranch, Keegan Spring Complex): survey areas and northern leopard frog egg mass locations by year, 2009-2015.

Note: The survey area within the southern Keegan parcel is shown in the location inset map.

Breeding habitat in the southeast portion of the parcel consists of several ponds with marshy margins that located near the terminus of the Keegan Spring Complex. These terminal ponds occasionally go dry, but they appeared to retain permanent water from 2009 to 2013. In the summer of 2014, the terminal ponds were found to be completely dry, but had refilled by March, 2015 (breeding was noted in April, 2015 but the ponds were once again dry in September 2015). The northern and southeastern breeding areas on the property are connected by a 0.6 mile section of flowing channel that appears to offer very little appropriate breeding habitat. No egg masses were documented along this channel during the surveys.

The portion of the northern breeding area that comprises the trend area was comprehensively surveyed in 2009 to 2015, thus providing annual egg mass counts of 34, 70, 162, 416, 59, 39, and 7 respectively. The remainder of the northern breeding area was first surveyed in 2011, with comprehensive surveys conducted in 2011 to 2015 at the same time of the trend area survey. Thus, annual egg mass counts were obtained for the entire northern breeding area in 2011 to 2015. The annual counts within the Keegan northern breeding area in 2011, 2012, 2013, 2014, and 2015 documented 200, 780, 65, 42, and 7 egg masses respectively.

The additional assessment areas of the property, mainly the breeding area in the southeast portion, were surveyed in 2009, 2011, 2012, and 2013. A single visit survey was conducted during the active breeding period in 2011, 2012, and 2013 with minimum egg mass counts of 514, 742, and 1 respectively. Only a portion of this area was surveyed in 2009, near the end of the breeding period, with nine egg masses documented. Seven egg masses were also documented in this area on April 28, 2015 during a fish survey.

Additionally, a large pond located in the southern Keegan parcel (shown in **Figure 2** inset) was surveyed during the active breeding period in 2012. No egg masses or northern leopard frogs were observed in this pond although appropriate habitat was present.

Figure 3 presents the egg mass count trend from 2009 to 2015 for the Keegan Spring Complex trend area within the Keegan property. The lowest count was recorded in 2015 with seven egg masses, and the highest count was recorded in 2012 with 416 egg masses. The trend was increasing from 2009 to 2012 with a subsequent decrease from 2012 to 2015.

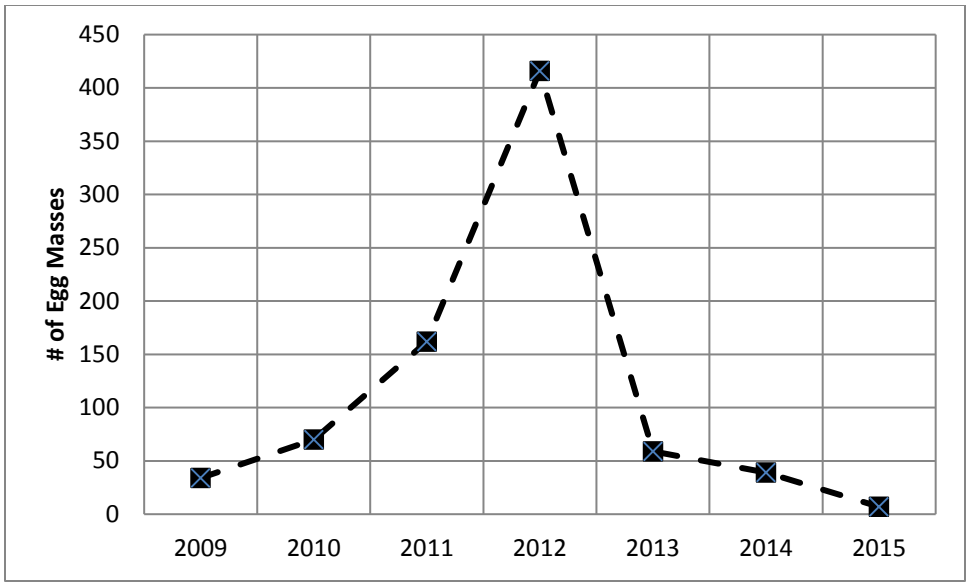

Figure 3. Northern leopard frog egg mass trend for the Keegan Spring Complex, 2009-2015 (Keegan property, Robison Ranch,).

O'Neil/Frog Pond property (Robison Ranch)

The O'Neil/Frog Pond property was surveyed in 2012. A single visit was made during the breeding season on April 25, 2012. No trend areas occur on this property. **Figure 4** shows the O'Neil/Frog Pond property with the survey area and egg mass locations. All mesic areas on the property were surveyed during the visit, with eight egg masses documented.

The surveys identified two general breeding areas on the property, both within the southern ("Frog Pond") parcel; one near the western property boundary and the other in the southeastern portion of the property (**Figure 4**). Breeding habitat along the western edge of the parcel is comprised of vegetated standing water in a small pool that turns into a narrow channel. The breeding area in the southeastern portion of the property is more extensive and is comprised of a series of ponds edged by patches of wet marsh. The two breeding areas appear to be joined by two separate channels that were largely dry at the time of the visit. It appears that areas in the central and southwest portions of the parcel may hold water during wetter periods, which could potentially provide additional breeding habitat. The northern parcel did not have any mesic habitat at the time of the visit. While the parcel occasionally supports a small amount of wetland habitat created by diverted runoff, it is unlikely that it would provide reliable breeding habitat.

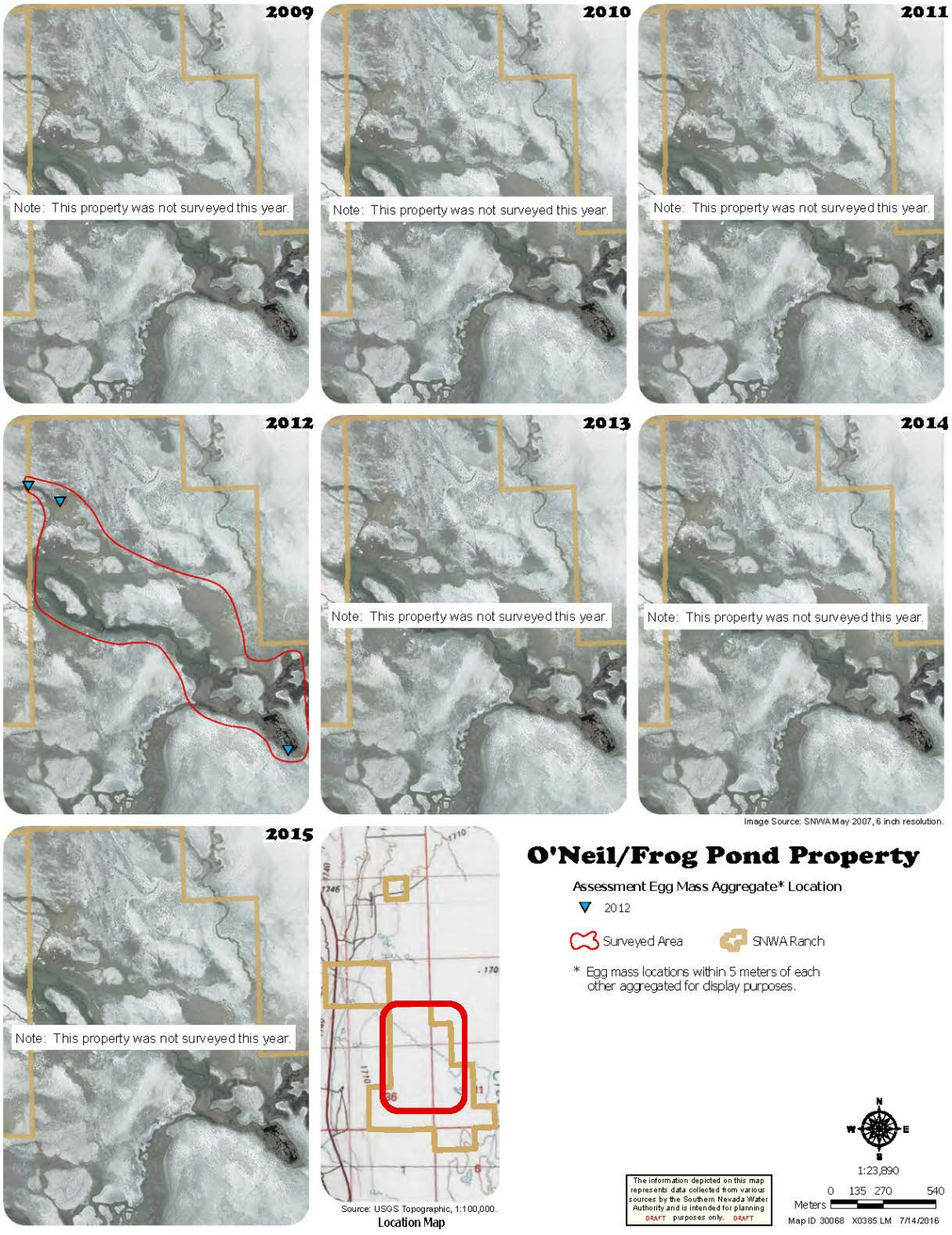

Figure 4. O'Neil/Frog Pond property (Robison Ranch): survey area and northern leopard frog egg mass locations by year, 2009-2015.

Note: This property was surveyed only in 2012.

Home Ranch property (Robison Ranch)

The Home Ranch property was surveyed in 2011 and 2012. A single visit was made near the end of the breeding season on May 11, 2011, and a single visit was made during the breeding season on April 24, 2012. No trend areas occur on this property. **Figure 5** shows the Home Ranch property with the survey area and egg mass locations by year. All mesic areas on the property were surveyed during the two visits.

On the May 11, 2011 visit, small tadpoles were documented in a shallow, vegetated pool on the east side of the property. No egg masses were found at this time, so it appears that any egg masses present had already hatched in the prior week(s). On the April 24, 2012 visit, 30 egg masses were documented. The 2012 survey documented breeding in several isolated pools across the northeast quarter of the property (**Figure 5**). The pools were generally associated with patches of wet meadow scattered across drier meadow habitat. The largest pools on the east side of the property contained the majority of the egg masses.

McCoy Creek property (Robison Ranch)

The McCoy Creek property was surveyed in 2009, 2011, 2012, and 2013. Portions of the property were surveyed in 2009, 2011, and 2013, and the entire property was surveyed in 2012. No trend areas occur on this property. **Figure 6** shows the McCoy Creek property with the survey areas and egg mass locations by year. The 2009 survey occurred on May 7, and was limited to the string of ponds in the extreme northwest portion of the property, just north of the ranch buildings. Seven egg masses were documented during this single day survey. In 2011, two larger portions of the property were surveyed over two days, with the northern portion surveyed on April 13 and the southern portion surveyed on April 15. The middle (central and eastern) portions of the property were not surveyed in 2011. The survey documented a total of 824 egg masses (495 in the north and 329 in the south). The most extensive survey of the property was conducted in 2012, which covered all areas of visible open water. The entire property was surveyed over two days, two weeks apart, with the northern and southern portions surveyed on April 11, and the middle (central and eastern) portions surveyed on April 26. A total of 2,578 egg masses were documented across the property in 2012, with 1,340 in the north, 784 in the middle, and 454 in the south. The 2013 survey took place on April 18 and was limited to several ponds in the northern portion of the property. The presence of several egg masses and many tadpoles confirmed breeding for the year.

The surveys identified three general breeding areas in the northern, middle (central and eastern), and southeastern portions of the property (**Figure 6**). The more extensive surveys conducted in 2011 and 2012 documented breeding in most wet areas of the property, including pools, ponds, open marsh, and even calm areas along flowing channels. However, the largest concentrations of egg masses were generally associated with the pools and ponds in the northern and southern portions of the property. Of note during the 2012 surveys, an egg mass cluster documented in one of the largest ponds in the northern portion of the property contained 267 egg masses, while the average egg mass cluster on the property in 2012 contained 13 egg masses.

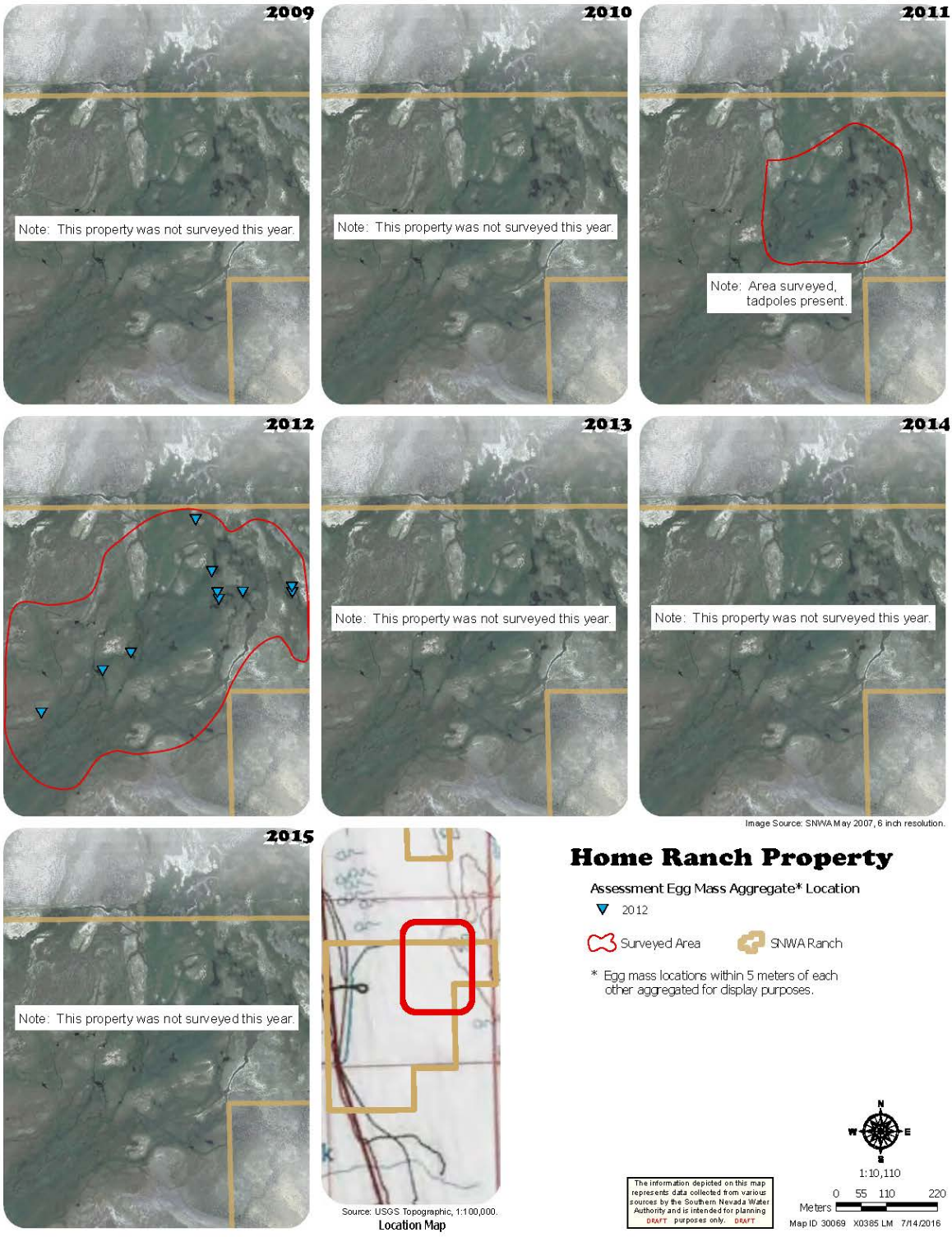

Figure 5. Home Ranch property (Robison Ranch): survey area and northern leopard frog egg mass locations by year, 2009-2015.

Note: This property was visited only in 2011 and 2012.

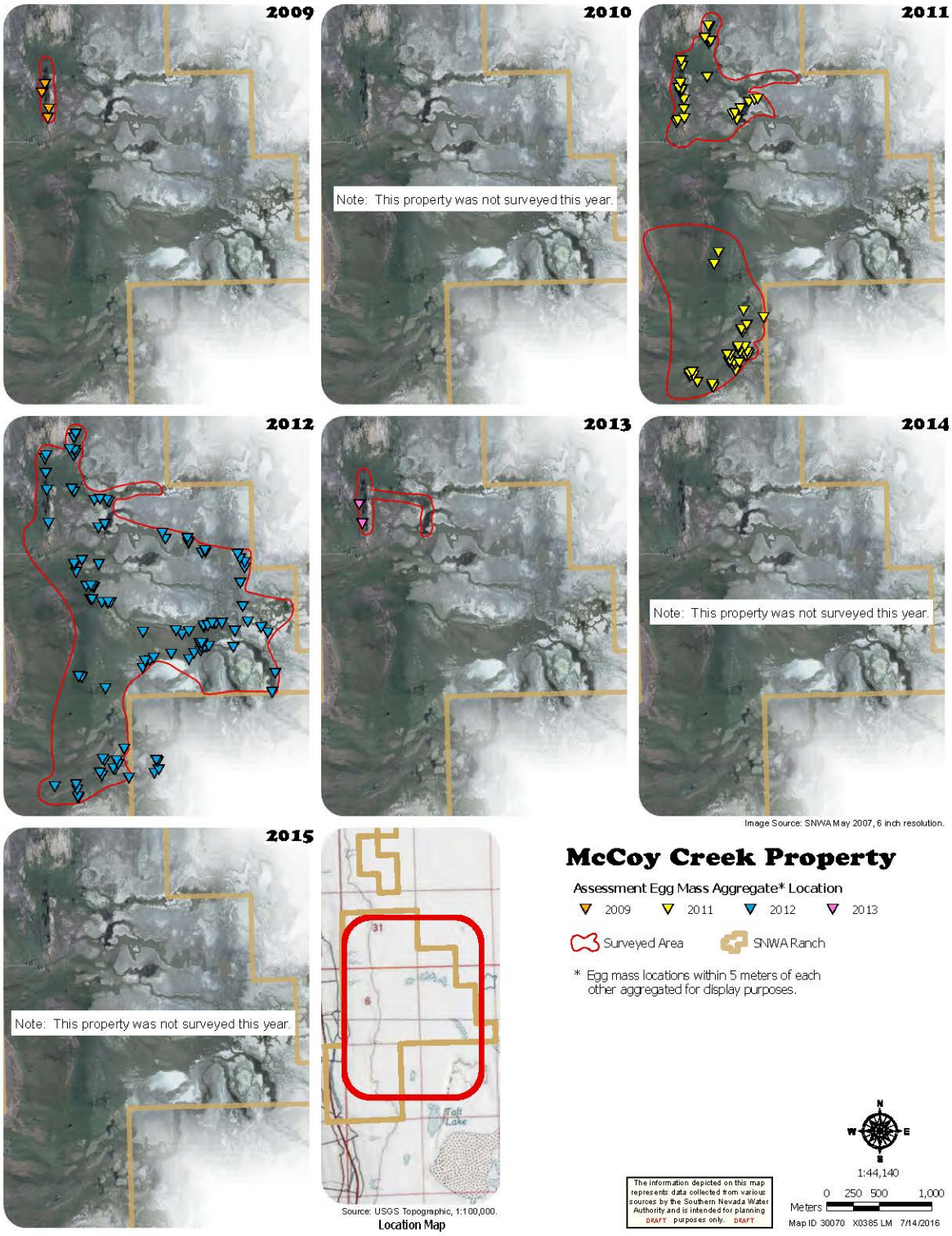

Figure 6. McCoy Creek property (Robison Ranch): survey areas and northern leopard frog egg mass locations by year, 2009-2015.

Note: This property was not surveyed in 2010, 2014, and 2015.

Bastian Creek property (El Tejón Ranch, Unnamed 5 Spring)

The Bastian Creek property was surveyed from 2009 to 2015. Surveys were conducted annually within the trend area, and all years except 2010 and 2014 in assessment areas. Leopard frogs have only been documented breeding on the Bastian Creek property in the vicinity of Unnamed 5 Spring, which is within one of the property's northern parcels. Thus, surveys focused on Unnamed 5 Spring and its outflow. **Table 2** presents the survey dates and documented egg mass numbers by year for both the trend area and the assessment area. **Figure 7** shows the Bastian Creek property with the survey areas by year, the trend area, and egg mass locations by year. The surveys fell between the dates of March 6 and May 28, with egg masses documented from March 26 to May 15. In any given survey year, the trend area was visited five to eight times, and the assessment area was visited zero to six times.

Table 2. The survey year, area, dates, and northern leopard frog egg mass numbers for Bastian Creek property (El Tejón Ranch, Unnamed 5 Spring).

Survey Year	Survey Area[1]	Survey Dates[2]	Total Number of Egg Masses[3]
2009	Trend	3/12, 3/24, **4/9**, **4/14**, **4/29**, **5/1**, 5/13, 5/28	9
	Assessment	4/9, 4/14, **4/29**, **5/1**, 5/13, 5/28	2
2010	Trend	3/10, 3/23, 4/6, **4/19**, 5/4, 5/18	13
	Assessment	No visits	na
2011	Trend	3/15, 3/29, **4/12**, **4/26**, 5/10	16
	Assessment	**4/12**, **4/26**, 5/10	5
2012	Trend	3/14, 3/26, **4/9**, **4/23**, 5/9	46
	Assessment	**4/9**, **4/23**, 5/9	14
2013	Trend	3/6, 3/21, **4/2**, **4/14**, **4/28**, **5/15**	69
	Assessment	4/2, **4/14**, **4/28**, 5/15	16
2014	Trend	**3/26**, **4/15**, **4/24**, 5/6, 5/20	67
	Assessment	No visits	na
2015	Trend	3/18, **3/31**, **4/15**, **4/28**, **5/12**	49
	Assessment	**3/31**, **4/15**, **4/28**, **5/12**	2

[1] "Trend" refers to the areas visited 3 to 6 times on an annual basis to determine changes in egg mass numbers across years, and "Assessment" refers to all other survey areas which were visited 0 to 4 times in a particular year.

[2] All dates on which the surveys were conducted. The bold denotes the dates on which egg masses were documented. It should be noted that the entire assessment area was not necessarily covered on each date, and some portions of the property were only visited once in a year.

[3] Totals include only egg masses recorded at first observation. The numbers presented for the assessment areas may not be derived from multiple visits of the same areas within or across years, and therefore do not represent comparable trend data across years.

The surveys identified two general breeding areas on the property, both within the 200-acre northern parcel associated with the Unnamed 5 Spring system; one in the western portion and one in the eastern portion of the system (**Figure 7**). Breeding habitat in the western portion of the system is comprised of springhead pools and channels associated with the trend area.

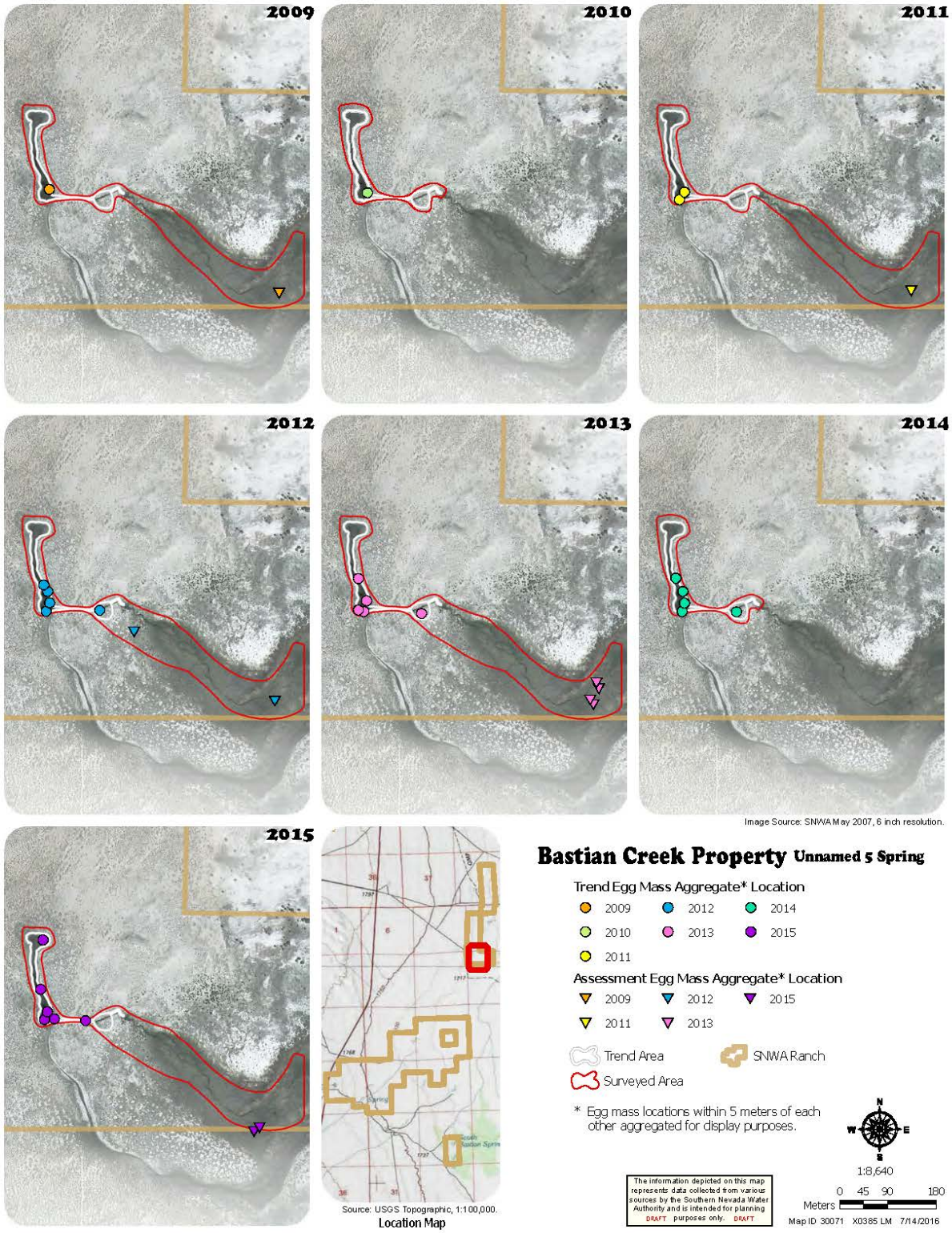

Figure 7. Bastian Creek property (El Tejón Ranch, Unnamed 5 Spring): survey areas and northern leopard frog egg mass locations by year, 2009-2015.

Most breeding occurred in the vegetated margins of the southern pool, where egg masses were deposited all six years. Limited breeding also occurred in the northern pool in 2015, and in the peripheral marsh along the outflow channel in 2012-2014. Breeding habitat in the eastern outflow terminus (assessment area) consists of open shallow water within vegetated pools. The two breeding areas are connected by a 350 meter section of flowing channel that appears to offer very little breeding habitat.

The trend area of Unnamed 5 Spring was comprehensively surveyed in 2009 to 2015, thus providing annual egg mass counts of 9, 13, 16, 43, 69, 67, and 49 respectively. The assessment area was also comprehensively surveyed in 2009, 2011, 2012, and 2013, and 2015, providing annual counts of 2, 5, 14, 16, and 2 egg masses respectively.

Figure 8 presents the egg mass count trend from 2009 to 2015 for the Unnamed 5 Spring trend area within the Bastian Creek property. The lowest count was recorded in 2009 with nine egg masses and the highest count was recorded in 2013 with 69 egg masses. The trend was increasing from 2009 to 2013, showed a minor drop in 2014 with 67 egg masses, and continued the decreasing trend in 2015 with 49 egg masses recorded.

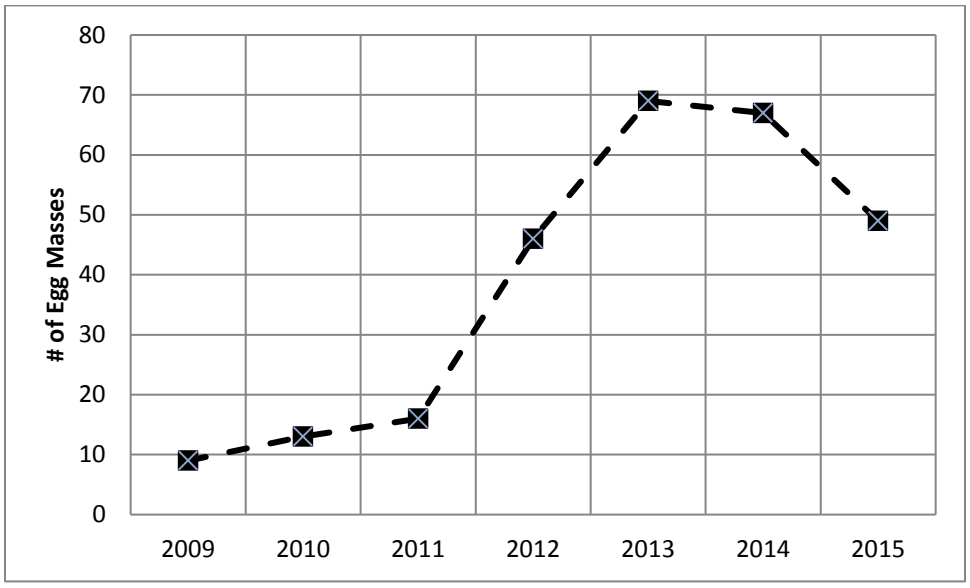

Figure 8. Northern leopard frog egg mass trend for Unnamed 5 Spring, 2009-2015 (Bastian Creek property, El Tejón Ranch).

Shoshone property (El Tejón Ranch, Minerva Spring Complex)

The Shoshone property was surveyed from 2009 to 2015. Surveys were conducted annually within the trend area, and all years except 2010 and 2014 in assessment areas. All mesic areas with potential breeding habitat were comprehensively surveyed in 2012. Limited surveys of assessment areas were conducted in 2009, 2011, and 2013. **Table 3** presents the survey dates and documented egg mass numbers by year for both the trend and assessment areas. **Figure 9** shows the Shoshone property with the survey areas by year, trend area, and egg mass locations by year. The surveys fell between the dates of March 15 and May 29, with egg masses documented from April 11 to May 14. In any given survey year, the trend area was visited three to five times, and the assessment areas were visited zero to two times.

Table 3. The survey year, area, dates, and northern leopard frog egg mass numbers for Shoshone property (El Tejón Ranch, Minerva Spring Complex).

Survey Year	Survey Area[1]	Survey Dates[2]	Total Number of Egg Masses[3]
2009	Trend	4/14, 4/21, 4/29, 5/12, 5/29	0
	Assessment	**4/29**	2
2010	Trend	**4/21**, 5/5, 5/17	7
	Assessment	No visits	N/A
2011	Trend	3/16, 3/29, **4/11**, 4/14, 4/25, 5/10	3
	Assessment	**4/14**	20
2012	Trend	**4/10**, **4/23**, **5/8**	36
	Assessment	**4/10**, **4/23**	122
2013	Trend	**4/2**, **4/15**, **4/28**, 5/14	23
	Assessment	**4/2**, **5/14**	66
2014	Trend	3/26, 4/15, 4/23, 5/6, 5/19	0
	Assessment	No visits	N/A
2015	Trend	3/15, 4/2, **4/15**, **4/29**, 5/12	7
	Stock Pond [4]	**3/19**, **4/2**, **4/15**, **4/29**, 5/12	44
	Assessment	No visits	N/A

[1] "Trend" refers to the areas visited 3 to 6 times on an annual basis to determine changes in egg mass numbers across years, and "Assessment" refers to all other survey areas which were visited 0 to 4 times in a particular year.

[2] All dates on which the surveys were conducted. The bold denotes the dates on which egg masses were documented. It should be noted that the entire assessment area was not necessarily covered on each date, and some portions of the property were only visited once in a year.

[3] Totals include only egg masses recorded at first observation. The numbers presented for the assessment areas may not be derived from multiple visits of the same areas within or across years, and therefore do not represent comparable trend data across years.

[4] The Stock Pond is separated out as it was not part of the Minerva Spring Complex [Middle] trend area until 2015 (BWG 2016).

The surveys identified four general breeding areas on the property, all associated with the Minerva Spring Complex; two in the northern portion (one in the northeast and one in the northwest), one in the middle (east-central) portion, and in the southern portion (**Figure 9**). Breeding habitat in the northeastern portion of the property is comprised of two spring-fed, man-made ponds

associated with the Minerva Spring Complex [North] trend area. Breeding habitat in the northwest (assessment area) consists a series of larger pools and marshes that are formed by outflows from springs in the northeast corner (including trend area springs), as well as a ditch that brings water from the middle of the property to the north. Breeding habitat in the middle (east-central) portion of the property is in a man-made stock pond that is spring-fed, which became part of the Minerva Spring Complex [Middle] trend area in 2015 (BWG 2016). Breeding habitat in the south is associated with two man-made irrigation reservoirs that are spring-fed. The general breeding areas in the northern, middle, and southern portions of the property are separated from each other by drier meadow and shrub habitat. However, they have some degree of connectivity by means of ditches that moves water from the middle and southern parts of the property to the northern part of the property.

The portion of the Shoshone northern breeding area that comprises the Minerva Spring Complex [North] trend area was comprehensively surveyed in 2009 to 2015, thus providing annual egg mass counts of 0, 7, 3, 36, 23, 0, and 7 respectively. The remainder of the northern breeding area (assessment area) was surveyed on single visits in 2009 and 2012 with documented egg mass counts of 2 and 63 respectively. The east-central breeding area (including the stock pond) was surveyed on single visits in 2011, 2012, and 2013 with documented egg mass counts of 6, 30, and 4 respectively. Within the east-central breeding area, egg masses were only documented at the stock pond. The stock pond was added as a Minerva Spring Complex [Middle] trend area in 2015, when it was comprehensively surveyed and yielded 44 egg masses. The two springs approximately 150 meters north of the stock pond had been the Minerva Spring Complex [Middle] trend area prior to 2015, and thus were comprehensively surveyed in 2009-2011 and 2013. The south breeding area associated with reservoirs (assessment area) was surveyed on visits made in 2011-2013, with documented egg mass counts of 14, 29, and 62, respectively.

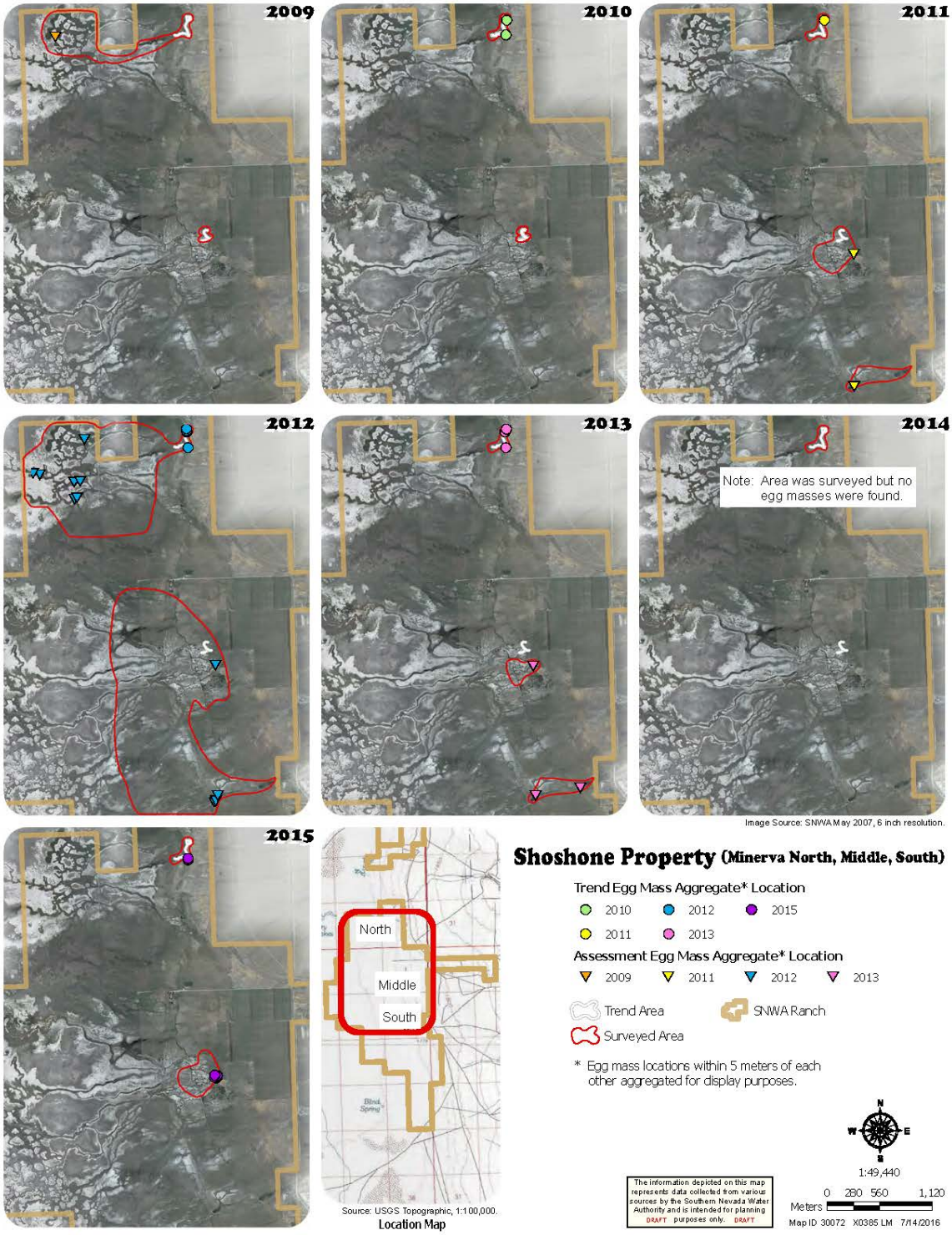

Figure 9. Shoshone property (El Tejón Ranch, Minerva Spring Complex): survey areas and northern leopard frog egg mass locations by year, 2009-2015.

Note: In 2015, the Minerva Spring Complex [Middle] trend area for leopard frog monitoring was moved to the stock pond.

Figure 10 presents the egg mass count trend from 2009 to 2014 for the Minerva Spring Complex [North] trend area within the Shoshone property. The lowest counts were recorded in 2009 and 2014 with 0 egg masses and the highest count was recorded in 2012 with 36 egg masses. The trend showed a general increase from 2009 to 2012; although, numbers were low in 2010 and 2011 with 7 and 3 egg masses documented respectively. The count for 2015 showed the first increase since 2012.

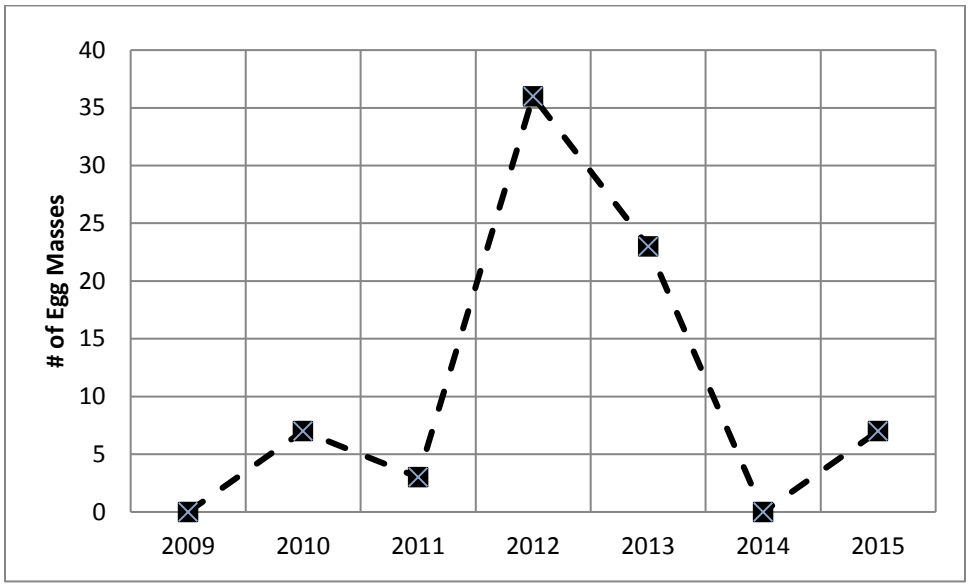

Figure 10. Northern leopard frog egg mass trend for the Minerva Spring Complex [North], 2009-2015 (Shoshone property, El Tejón Ranch,).

Egg to Metamorph Development

The following information presents developmental data for the selected breeding sites on the Keegan, Bastian Creek, and Shoshone properties in 2012. The estimate of earliest egg mass deposition date, tadpole length and development data, and dates of metamorph presence are given for each site.

Based on 2009-2015 egg mass development data and observations, it takes approximately two weeks (14 days) for leopard frog eggs to hatch in Spring Valley. Our observations match other studies that have demonstrated that leopard frog egg masses can hatch in as little as nine days at warmer temperatures, but generally take 13 to 20 days (reflecting various locations across their range, including colder climates) (Hine, 1981; Hammerson 1999; Hunter 1999; DeGraaf, 2001). In Spring Valley, egg masses recorded at age class (AC) 1 are typically 1-4 days old, and those recorded at AC 2 are typically 5-8 days old. At our 2012 study sites, the majority of egg masses (87%) were recorded at AC 1, followed by 7% recorded at AC 2. To estimate the earliest possible deposition dates, we assumed that egg masses recorded at AC 1 were laid 4 days earlier, and those recorded at AC 2 were laid 8 days earlier.

Keegan property (Robison Ranch, Keegan Spring Complex)

The northwest pond within the Keegan trend area was selected for investigation. A total of 72 egg masses were recorded from April 12 to May 9 at this location, with the earliest egg mass deposition date estimated to be April 4, 2012. A visit to this location on July 18, 2012 yielded 32 tadpoles that ranged in total length from 28 to 89 mm, with a mean total length of 60 mm (SE = 3 mm). At this time, 19% of the tadpoles had developing hind limbs, but there were no metamorphs present. The location was next visited on August 9 when two tadpoles of 65 mm and 71mm total length, with developing hind limbs, were documented. Fifteen metamorphs with no tail remnants were found as well. The estimated time needed for an egg to develop to a fully formed frog at this location in 2012 was 17 to 18 weeks.

Bastian Creek property (El Tejón Ranch, Unnamed 5 Spring)

The southwest pool of the Unnamed 5 Spring trend area was selected for investigation. A total of 44 egg masses were recorded from April 9 to April 23 at this location, with the earliest egg mass deposition date estimated to be April 1, 2012. A visit to this location on July 19, 2012 yielded seven tadpoles that ranged in total length from 70 to 88 mm, with a mean total length of 77 mm (SE = 3 mm). At this time, 29% of the tadpoles had developing hind limbs, and 18 metamorphs were present. Of the 18 metamorphs, 39% had no tail remnants. As fully metamorphosed frogs were documented on this visit, no further visits were made to this location. The estimated time needed for an egg to develop to a fully formed frog at Unnamed 5 Spring in 2012 was 15 to 16 weeks.

Shoshone property (El Tejón Ranch, Minerva Spring Complex)

The two ponds in the Minerva Spring Complex [North] trend area were selected for investigation. A total of 36 egg masses were recorded from April 10 to May 8 at this location, with the earliest egg mass deposition date estimated to be April 6, 2012. A visit to this location on July 19, 2012 yielded 29 tadpoles that ranged in total length from 38 to 82 mm, with a mean total length of 58 mm (SE = 2 mm). At this time, 3% of the tadpoles had developing hind limbs, but there were no metamorphs present. The location was next visited on August 8 when 28 tadpoles that ranged in total length from 51 to 94 mm, with a mean total length of 77 mm (SE = 2 mm), were documented. At this time, 75% had developing hind limbs and four metamorphs were found. Of the four metamorphs, only one had fully absorbed its tail. The estimated time needed for an egg to develop to a fully formed frog at Minerva Spring Complex [North] in 2012 was 16 to 17 weeks.

DISCUSSION

It appears that all of the SNWA properties with documented leopard frog presence support permanent breeding sub-populations of the species. Although the changes in egg mass numbers across years suggest that the number of breeding adult frogs within these sub-populations fluctuate greatly over time, there was always reproduction noted each year that a property was surveyed. It is unclear what drives the trend in egg mass numbers across years in our study area, but it appears to be a phenomenon that spans all survey sites. Natural fluctuations in population size such as this have been documented in many amphibian species (Pechman 1991, 1994; Stewart 1995; Semlitsch 1996). Although it is not always evident what drives these changes across years, it has been

suggested that a variety of climatic variables may affect breeding behavior directly or may impact successful recruitment in a previous year (Pechman 1991, 1994; Stewart 1995; Semlitsch 1996). It has also been observed that the breeding population size in a particular amphibian species may vary more than the overall adult population size (Semlitsch 1996), although detection tends to be more reliable when focusing on breeders and egg masses.

The general increase in egg mass numbers from 2009 to 2012/2013 with a subsequent decrease was seen across the trend areas. This suggests that the number of breeding adult frogs in assessment areas, which had not been surveyed on an annual basis, followed a similar trend. Thus, it was somewhat serendipitous that the most comprehensive surveys of the ranch properties took place in 2012 when the largest egg mass numbers to date were recorded. It seems reasonable to assume that the large number of egg masses recorded in 2012 was indicative of a substantial increase in reproducing adults from previous years.

With the large number of reproducing leopard frogs and extensive survey areas on the properties, the 2012 surveys provided a comprehensive assessment of leopard frog breeding habitat occurrence for each ranch. It is possible that if the extensive property surveys had taken place during a low reproductive year, many of the breeding areas would have been devoid of egg masses. This was apparent in the trend area on the Keegan property in 2015, a low reproduction year, when only seven egg masses were documented and many of the historical and confirmed breeding areas were not used, despite similar habitat conditions to those of previous years. In contrast, in the same area in 2012, most breeding habitat areas were utilized with 416 egg masses documented.

Within a single breeding season, the importance of a particular breeding area may not be obvious. When multiple years of use are taken into account, however, the relative importance of specific areas becomes apparent. Areas that are repeatedly used by a number of frogs for breeding likely have larger contributions to the long term persistence of the species on particular properties. The following figures (**Figures 11 – 21**) combine 2009-2015 egg mass data presented in **Figures 2**, **4**, **5**, **6**, **7**, and **9** to show the general breeding areas documented on each property, along with the aggregated egg mass locations for each year surveyed. It should be noted that only 2012 surveys covered all areas of potential breeding habitat. Furthermore, some areas surveyed in 2011 or 2012 were not surveyed in other years due to a lack of mesic habitat. The use of an area for breeding over two or more years suggests the persistence of mesic habitat and generally represents a pool, pond, or deeper marsh that is permanent or seasonally filled.

Figures 11-12 show the Keegan property (Robison Ranch). Breeding habitat and egg masses were documented in the northern and southern portions of the northern parcel, associated with the Keegan Spring Complex. In the northern portion of the parcel (**Figure 11**), there are several breeding pools within the trend area that are regularly used. Breeding habitat is associated with shallow, vegetated pond edges. The meadow southwest of the trend area also provides breeding habitat, although the frogs use it less consistently and intensively compared to the trend area. The terminal ponds in the southern portion of the parcel (**Figure 12**) (an assessment area) all appear to offer breeding habitat, at least in some years. The extensiveness of the habitat and intensive management makes effective monitoring in this area difficult. Although the terminal ponds have gone dry in some years, the frogs have returned to them to breed when water was again present.

Figure 13 shows the O'Neil/Frog Pond property (Robison Ranch). Breeding habitat and egg masses were documented on the southern ("Frog Pond") parcel. As this property was only visited

once in 2012, the intensity and frequency of leopard frog breeding on the southern parcel is unknown. The egg mass locations do provide information on breeding habitat in the western and eastern portions of the parcel, however. Additional surveys at this site are recommended.

Figure 14 shows the Home Ranch property (Robison Ranch). Tadpoles and egg masses were documented here in 2011 and 2012 respectively, in the northeast portion of the property. This suggests that the pools and larger seasonal pond in the northeast portion of the property provide reliable breeding habitat. Additional surveys at this site are recommended in the interest of ranch management. However, since the mesic habitat is entirely created from irrigation water conveyed from the mountain block, this property is not advised for trend monitoring.

Figures 15-17 show the McCoy Creek property (Robison Ranch). Although only portions of the property were surveyed over multiple years, there appears to be reliable breeding habitat north and east of the ranch house in the northern portion of the property (**Figure 15**), as well as in several pools within the meadow in the southern portion of the property (**Figure 17**). Numerous egg mass locations were found in the middle (central and eastern) portion of the property (**Figure 16**) in 2012; however, this area was not surveyed in other years. Many of the pools in the eastern middle portion were dry in 2011, so the contribution of this area to long term leopard frog persistence is unclear. The extensive breeding habitat on this property would make effective trend monitoring difficult, although intermittent surveys to document continued breeding ever few years would be beneficial.

Figure 18-19 shows the Bastian Creek property (El Tejón Ranch), specifically Unnamed 5 Spring in the 200-acre northern parcel. Breeding habitat and egg masses were documented in the western and eastern portions of the spring. The western trend area (**Figure 18**), which was used all six years by breeding frogs, provides reliable breeding habitat. Most of the egg masses in 2009-2015 were deposited within the shallow, vegetated margins on the east and south sides of the southern spring pool. In 2015, the vegetation had become dense around the southern spring pool, which may have prompted some frogs to breed in the northern spring pool as well. Breeding also occurs within the shallow marsh along the outflow channel, when habitat conditions are appropriate. In the eastern terminal marsh (assessment area) (**Figure 19**), most of the breeding in 2009-2013 occurred in a pool east of the channel terminus. However, water was diverted south in 2014 to provide livestock water, which moved the location of the terminal pools. Breeding use was documented at the new terminal pools in 2015.

Figures 20-22 show the Shoshone property (El Tejón Ranch). Breeding habitat and egg masses were documented in the northeastern, northwestern, middle (east-central), and southern portions of the property, associated with the Minerva Spring Complex. In the northern portion of the property (**Figure 20**), breeding regularly occurs in two eastern ponds within the Minerva Spring Complex [North] trend area. Breeding also occurs in the northwest terminal ponds, which are fed by the trend area springs and irrigation ditches. Although the northwestern ponds were only surveyed in 2009 and 2012, given the number of documented egg masses and extensive potential breeding habitat, it is likely that the majority of reproduction in the northern portion of the property takes place here when water is available. However, the extensiveness of the habitat and intensive management makes effective monitoring in this area difficult. Reproduction in the middle portion of the property (**Figure 21**) has only been documented in the stock pond. This suggests that the stock pond offers the most appropriate breeding habitat in the immediate area. Although there is seemingly appropriate breeding habitat nearby, the leopard frogs in this area seem to show a strong

preference for the stock pond and utilize it year after year. The two prominent southern reservoirs (**Figure 22**) appear to serve as the only breeding habitat this far south within the property. However, these reservoirs are intensively managed, leading to large fluctuations in water and habitat availability within and across breeding seasons.

Documenting egg masses and identifying breeding habitat provides for a better understanding of a specific property's potential to support and maintain a leopard frog sub-population. The annual egg mass surveys provided a good gauge of the abundance of breeding frogs in the trend areas of the Keegan, Bastian Creek, and Shoshone properties. Furthermore, surveys of assessment areas within these properties presented a more complete picture of the relative abundance of breeding leopard frogs within the general breeding areas. As most assessment areas were only surveyed once during a breeding season (and in only some years), the total reproductive effort could not be assessed. However, these one day visits did allow for a good assessment of the breeding habitat used and can allude to the reproductive potential of leopard frogs on a particular property. For example, a one-time visit to the Home Ranch property in 2012 revealed that a minimum of 30 breeding female leopard frogs were present, and that many of the pools in the northeast portion of the property were selected for breeding. The actual size of the breeding population of female frogs on Home Ranch was undoubtedly larger than 30 in 2012, but the survey probably captured most of the general breeding areas and most importantly documented that reproduction occurred.

Based on total egg mass numbers across years, single day visits to assessment areas, and the exceptionally high numbers documented in 2012, it appears that the Keegan and McCoy Creek properties have the potential to support the largest leopard frog sub-populations of all the properties surveyed. These properties both have extensive breeding habitat, general leopard frog habitat, and permanent ponds and pools. The 2,578 egg masses documented in two one-day visits to different portions of the McCoy Creek property in 2012 may represent the largest concentration of leopard frog egg masses ever reported in Nevada.

Based on the 2012 tadpole development study and 2009-2015 observations, development from egg deposition to metamorphosis typically takes approximately 15-18 weeks. The variation in development times between sites may have been due to water temperature and possibly food availability as shown in other studies (Smith-Gill 1979; Alvarez 2002). Across the three 2012 tadpole development study sites in northern, middle and southern Spring Valley, development spanned 20 weeks (April – July/August). Across all surveyed areas in 2009-2015, egg deposition began as early as March. Thus, the full development period from egg to metamorphosis appears to occur from March/April through July/August in Spring Valley. It should also be noted that air temperature during egg and tadpole development in 2012 was a few degrees higher than average (1981-2010 normal monthly temperatures for March - August = 36, 43, 51, 60, 68, and 66 °F, respectively; 2012 average monthly temperatures for March - August = 40, 46, 53, 63, 69, and 69 °F, respectively; Station 2631 Ely WBO Nevada, http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?nv2631). Thus, in colder years when development could potentially take longer, or in years when weather prompts a breeding surge in May, tadpoles could remain as late as September.

The investigation into egg to metamorph development suggests that breeding habitat is important to maintain well past the actual breeding season. The pools, ponds, and marshes where egg masses are deposited not only serve as egg nurseries for approximately two weeks, they also serve as

tadpole nurseries for at least an additional 15 weeks after hatching. Newly formed metamorphs probably continue to utilize these habitats, but are also capable of moving to new areas if necessary. Thus these breeding areas, if not used year round, are at the very least utilized for 5-6 months every year.

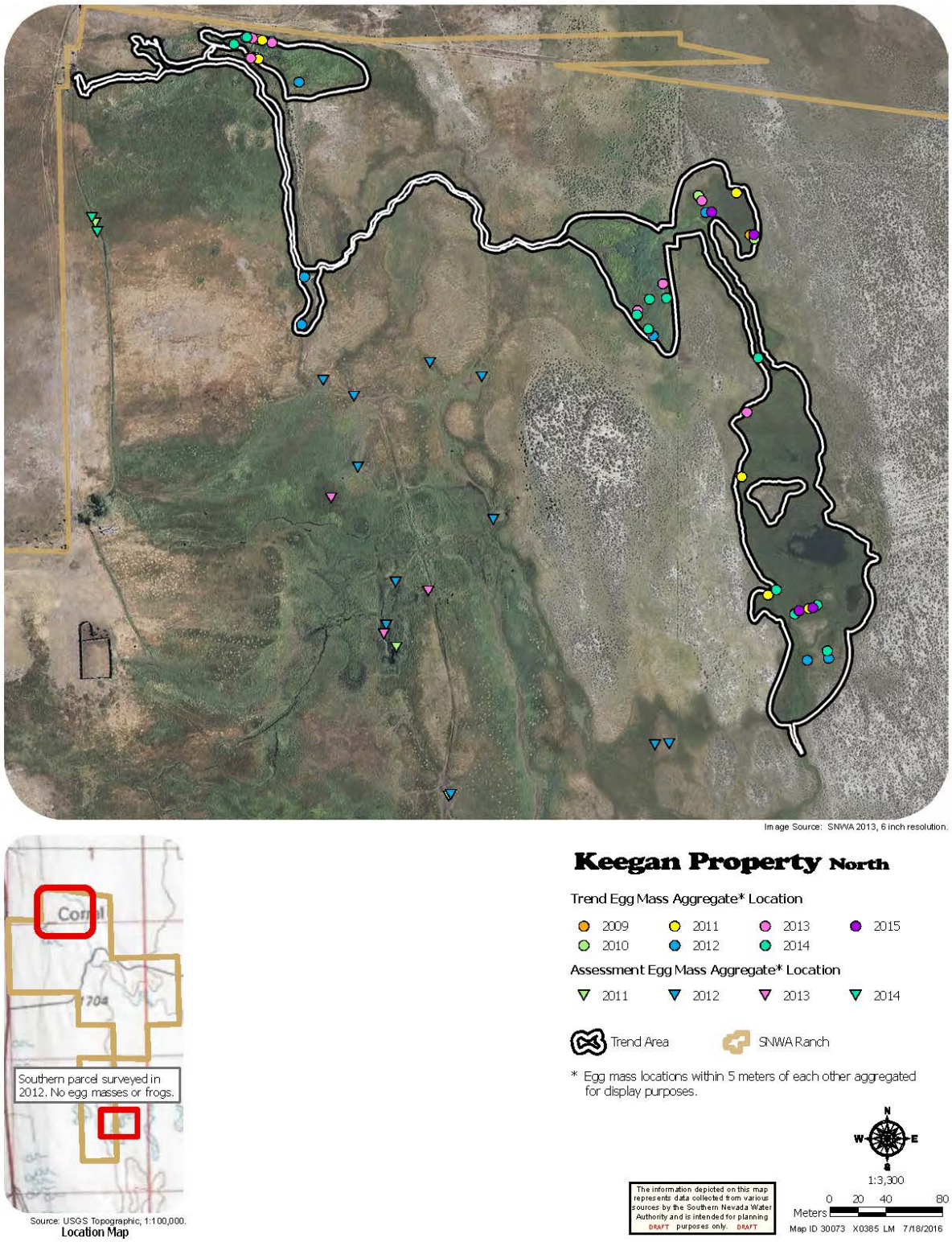

Figure 11. Keegan property, north (Robison Ranch, Keegan Spring Complex): all northern leopard frog egg mass locations documented in all survey years (2009-2015).

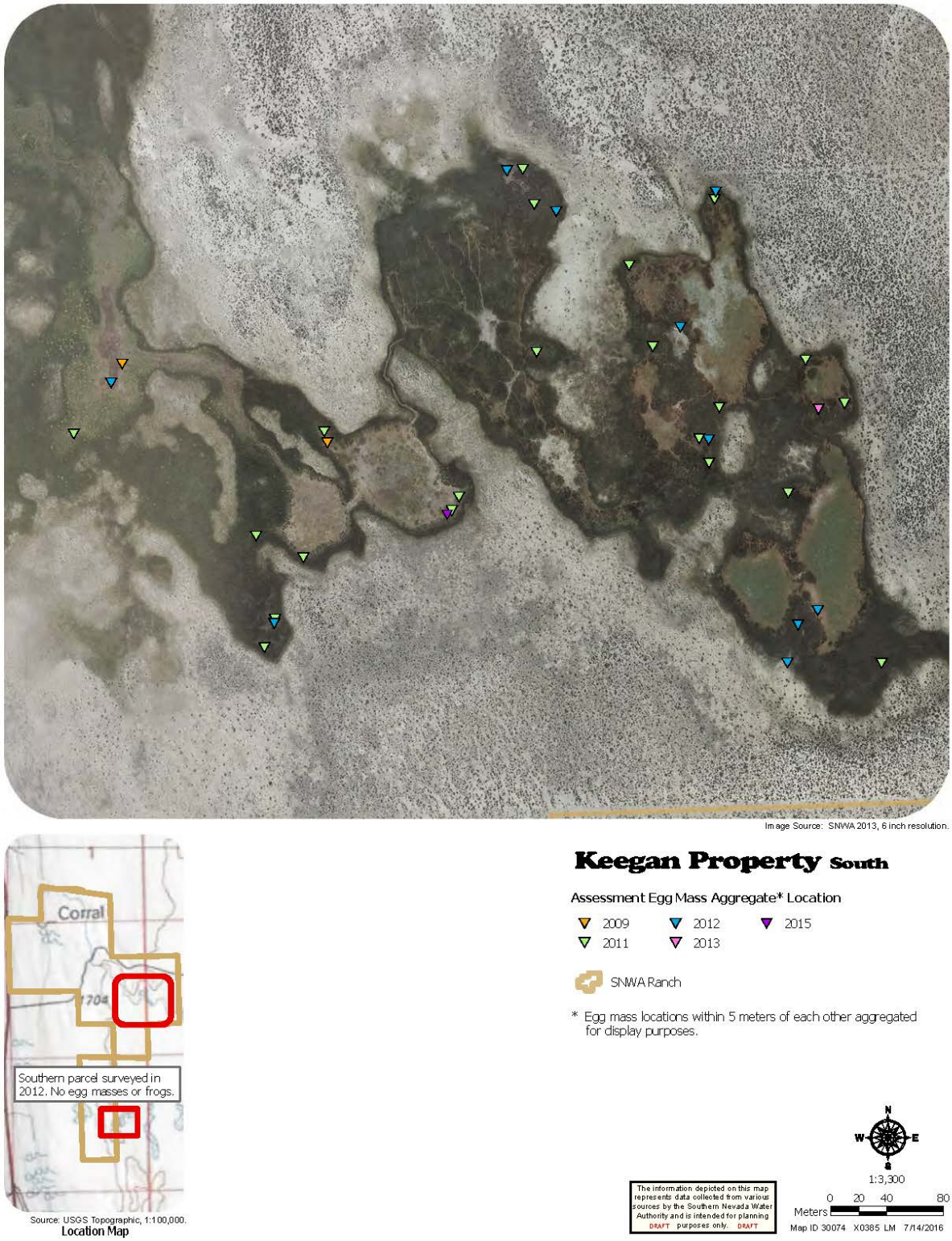

Figure 12. Keegan property, south (Robison Ranch, Keegan Spring Complex): all northern leopard frog egg mass locations documented in all survey years (2009-2015).

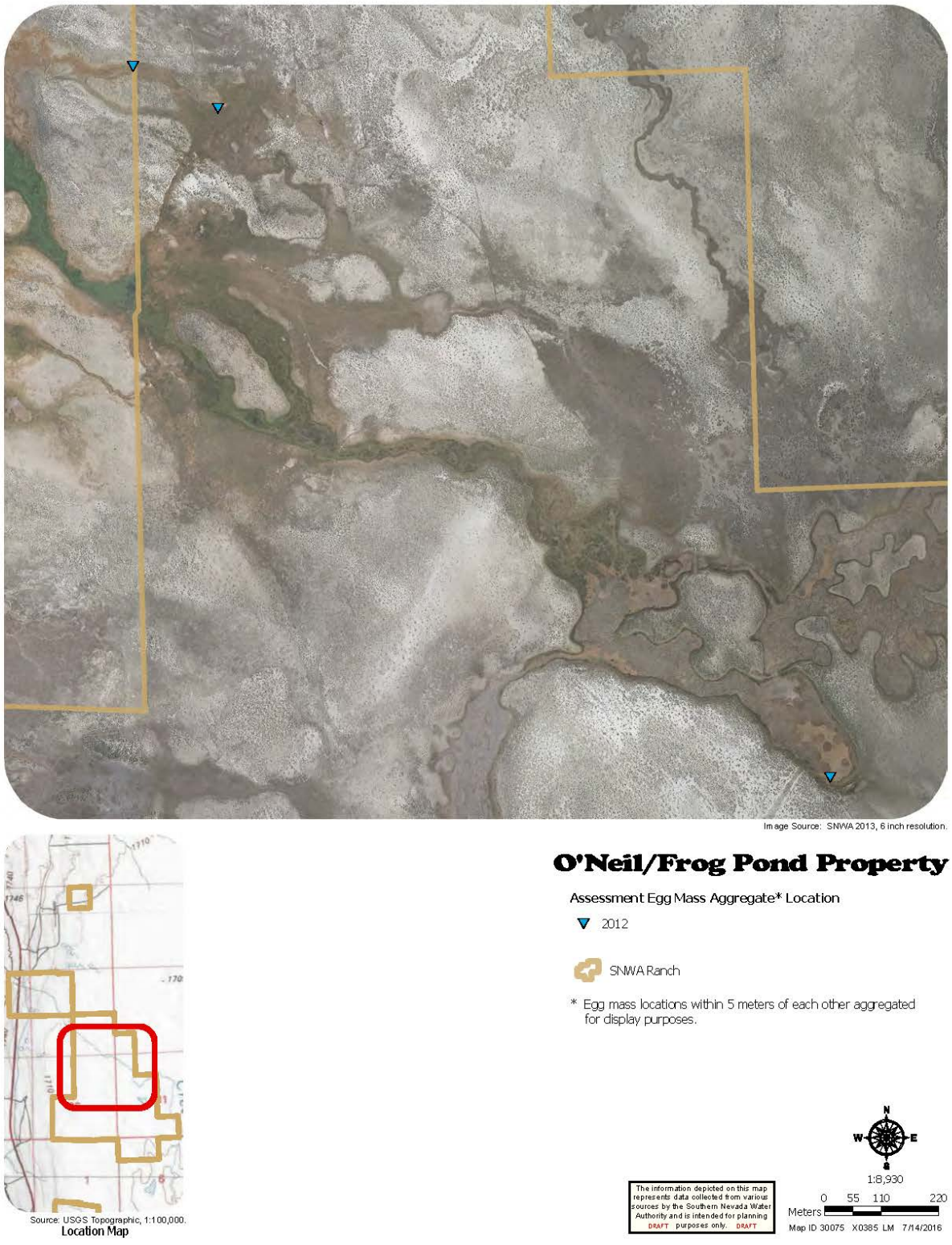

Figure 13. O'Neil/Frog Pond property (Robison Ranch, Keegan Spring Complex): all northern leopard frog egg mass locations documented in all survey years (2012).

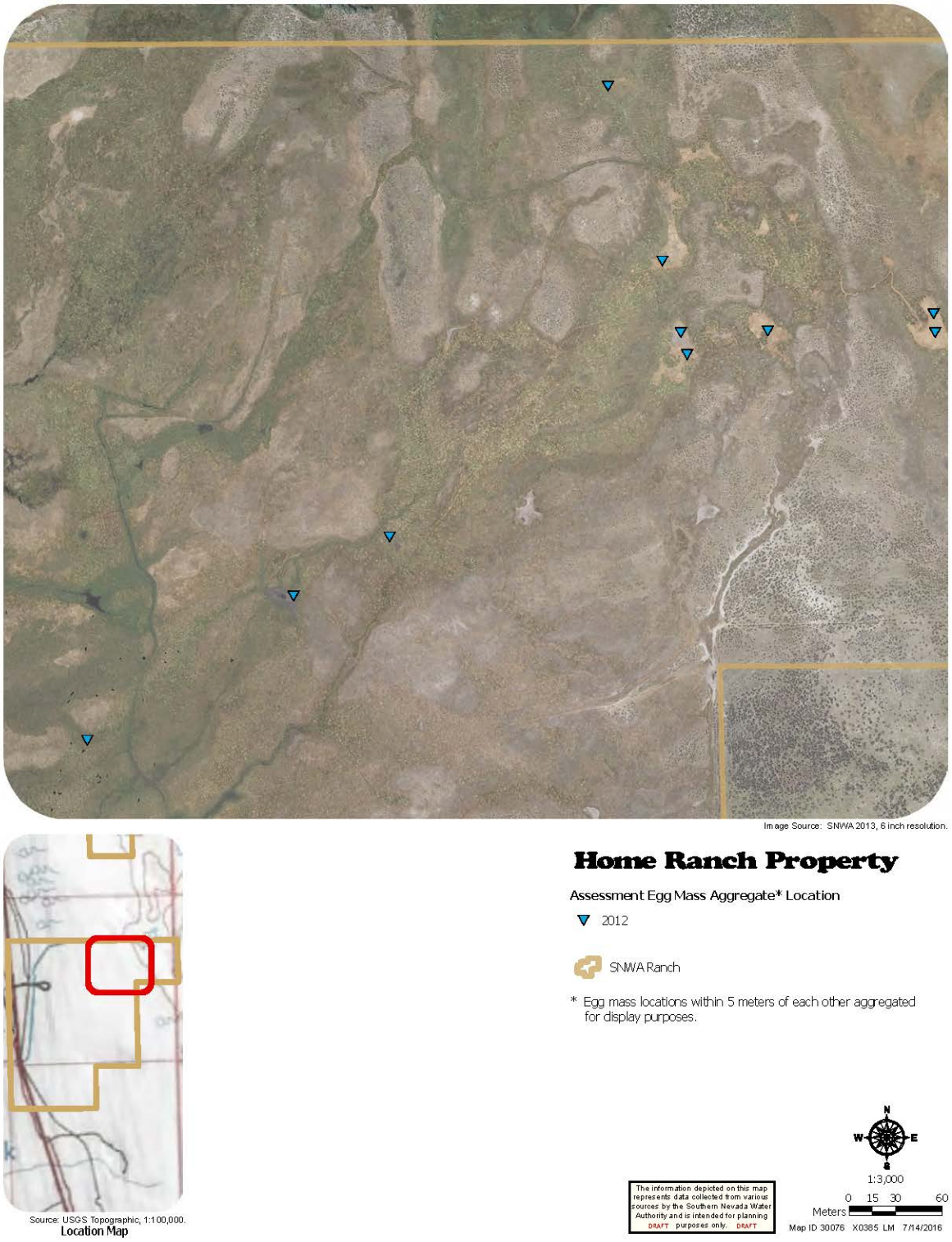

Figure 14. Home Ranch property (Robison Ranch): all northern leopard frog egg mass locations documented in all survey years (2012).

Note: This property was surveyed only in 2012.

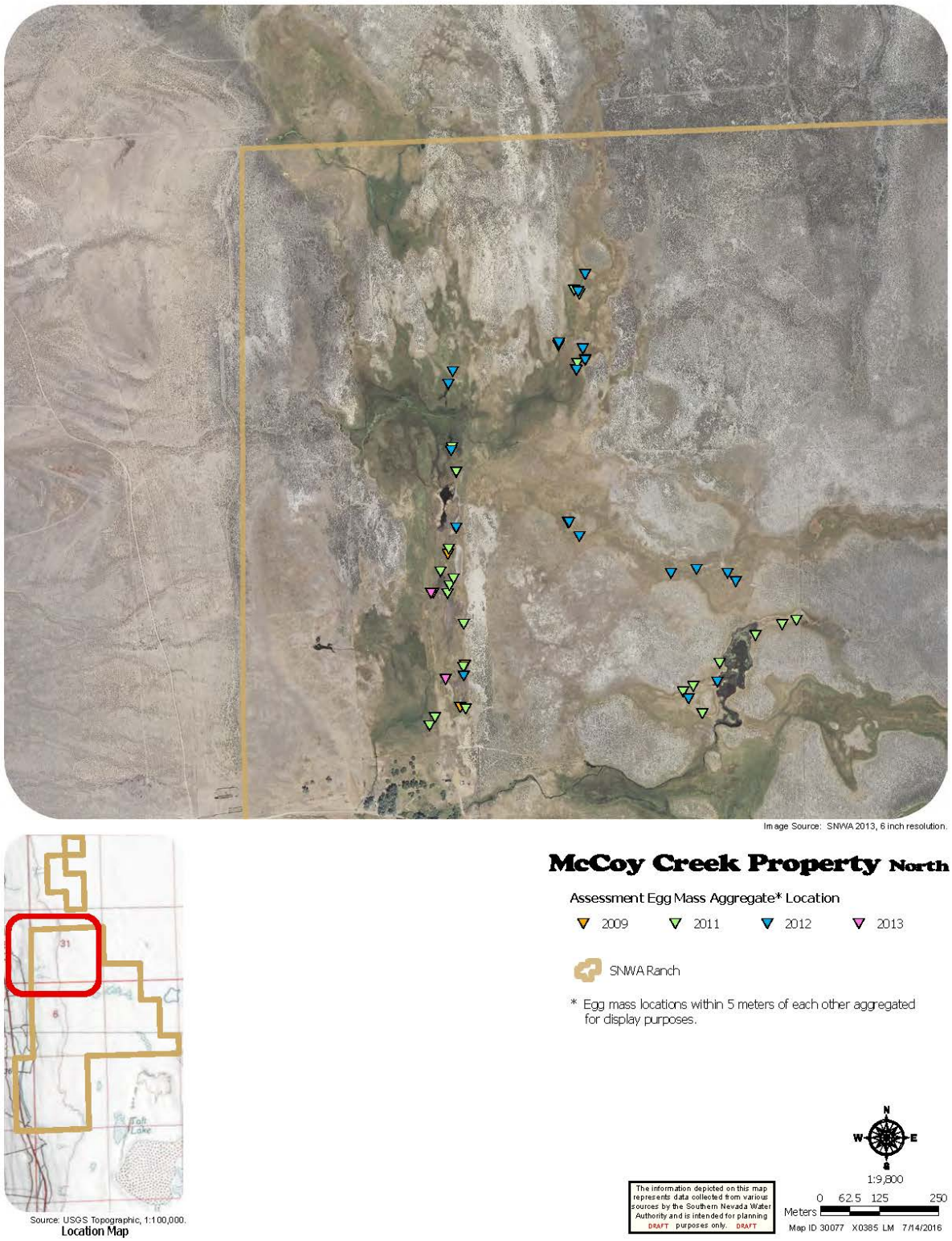

Figure 15. McCoy Creek property, north (Robison Ranch): all northern leopard frog egg mass locations documented in all survey years (2009-2013).

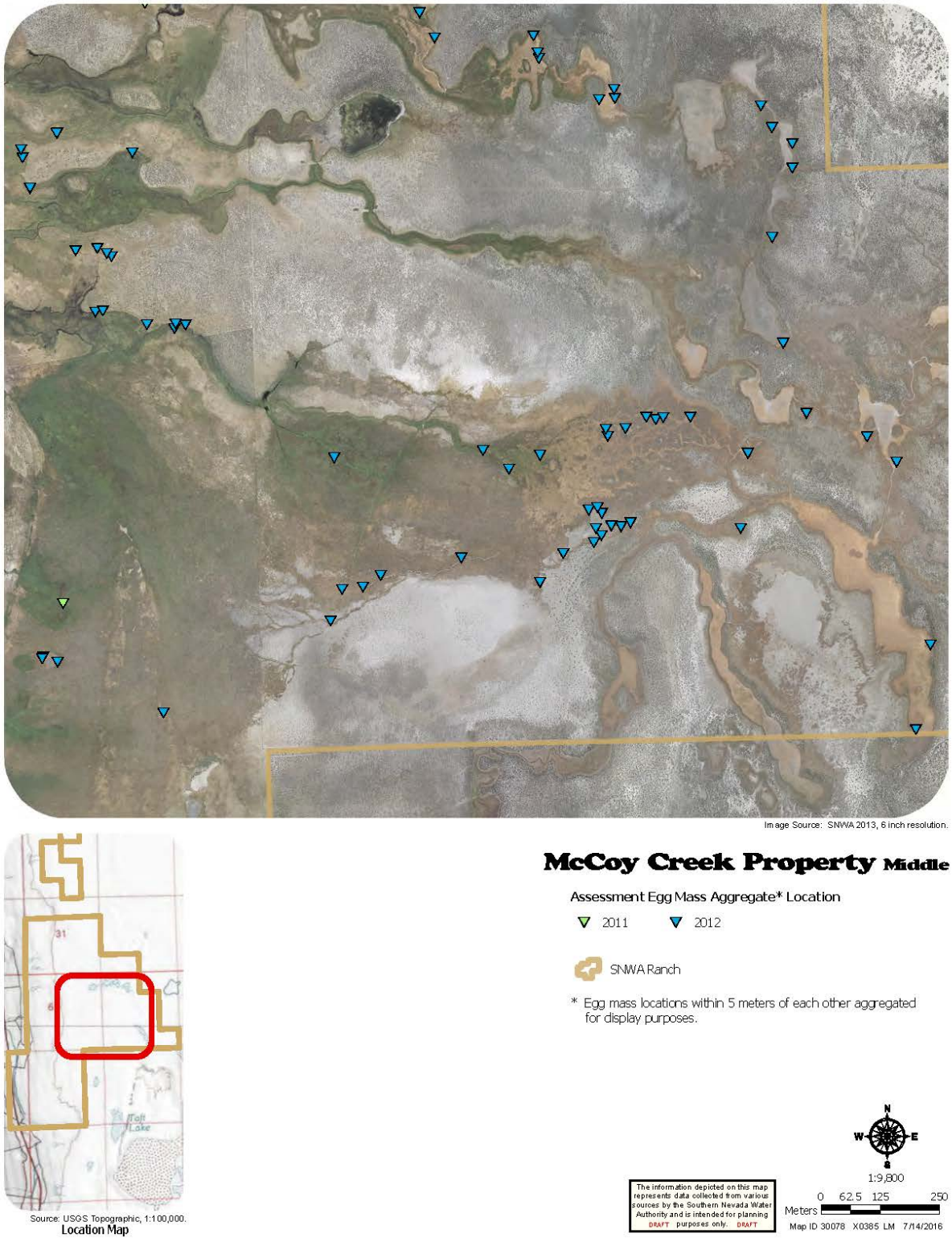

Figure 16. McCoy Creek property, middle (Robison Ranch): all northern leopard frog egg mass locations documented in all survey years (2011-2012).

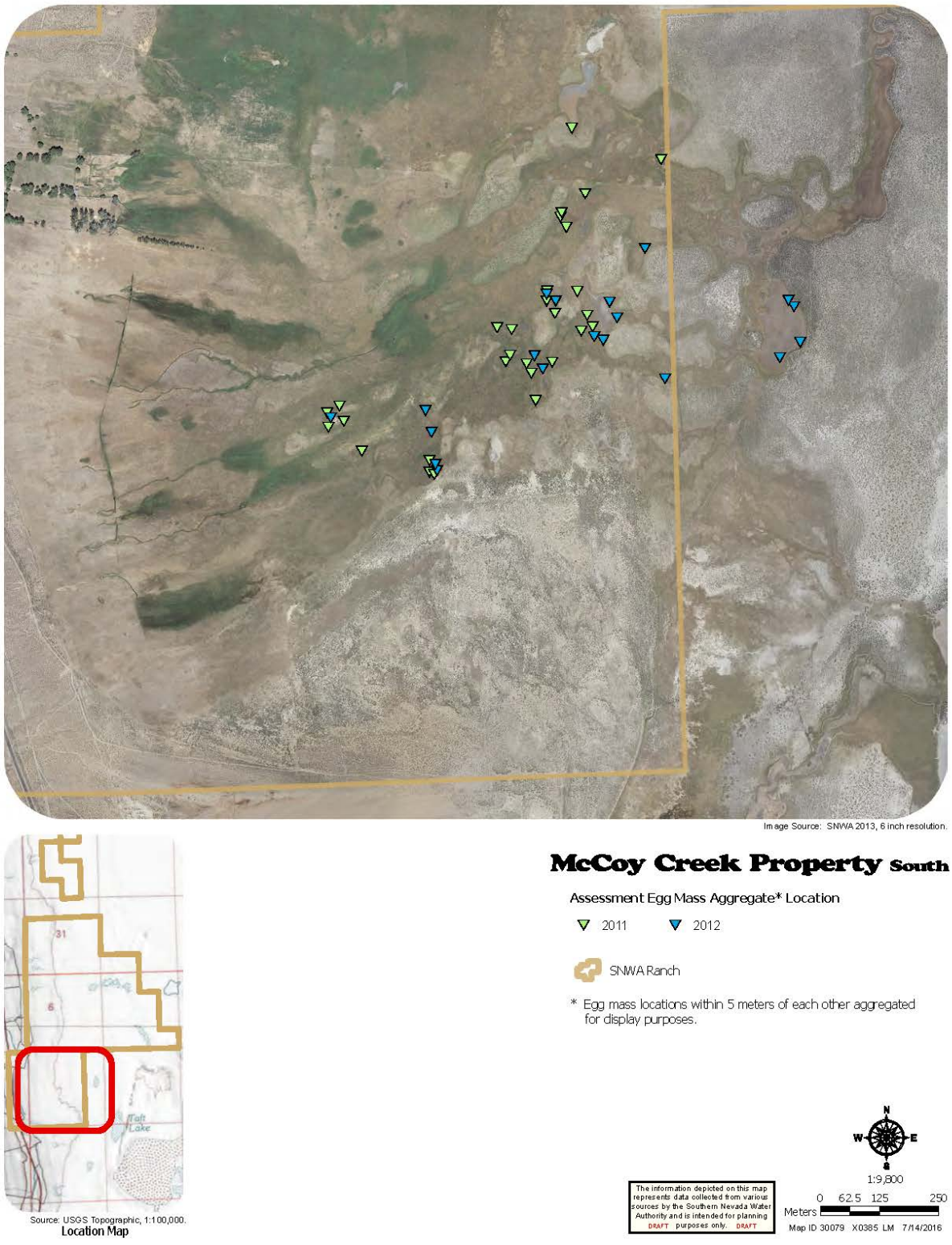

Figure 17. McCoy Creek property, south (Robison Ranch): all northern leopard frog egg mass locations documented in all survey years (2011-2012).

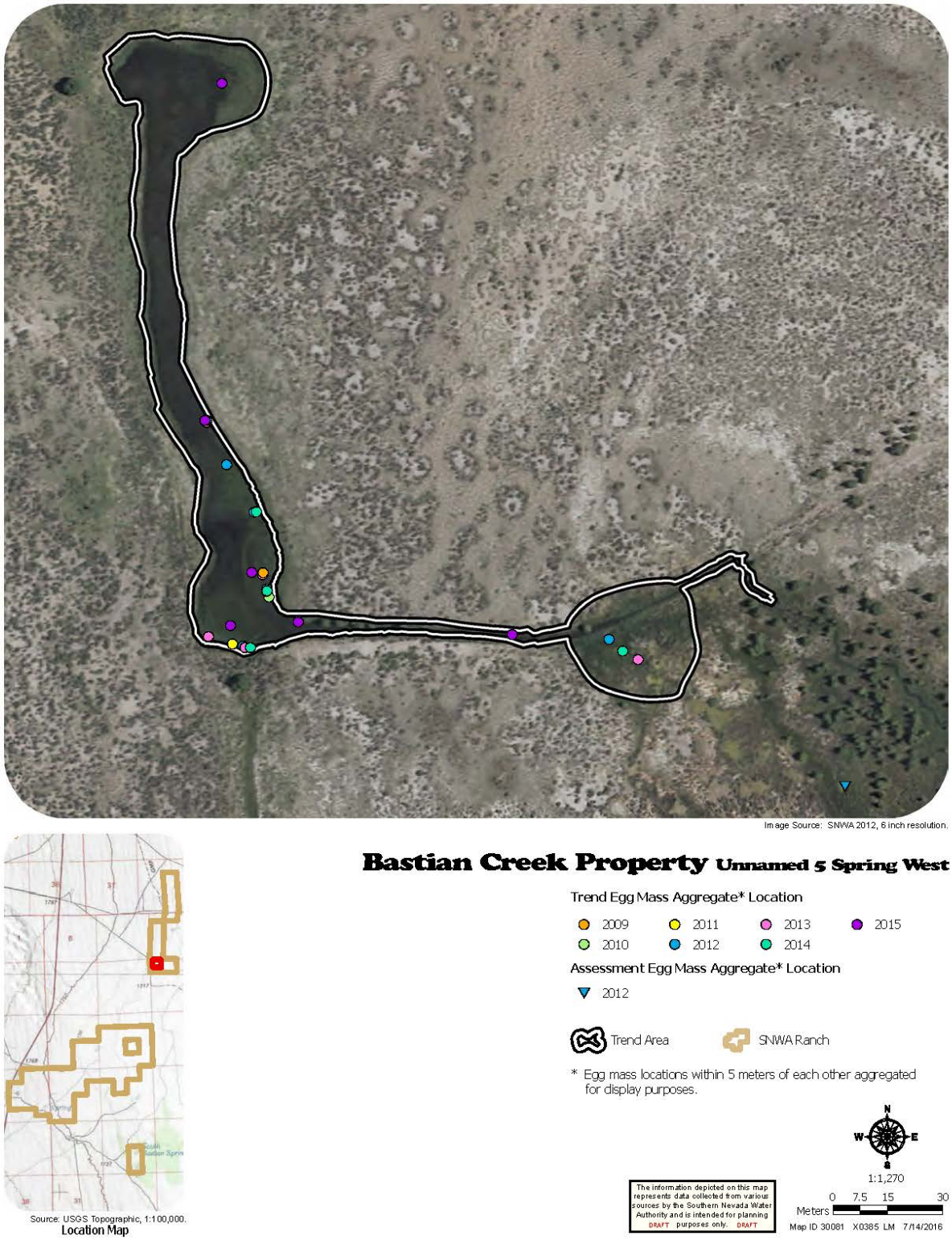

Figure 18. Bastian Creek property (El Tejón Ranch, Unnamed 5 Spring - west): all northern leopard frog egg mass locations documented in all survey years (2009-2015).

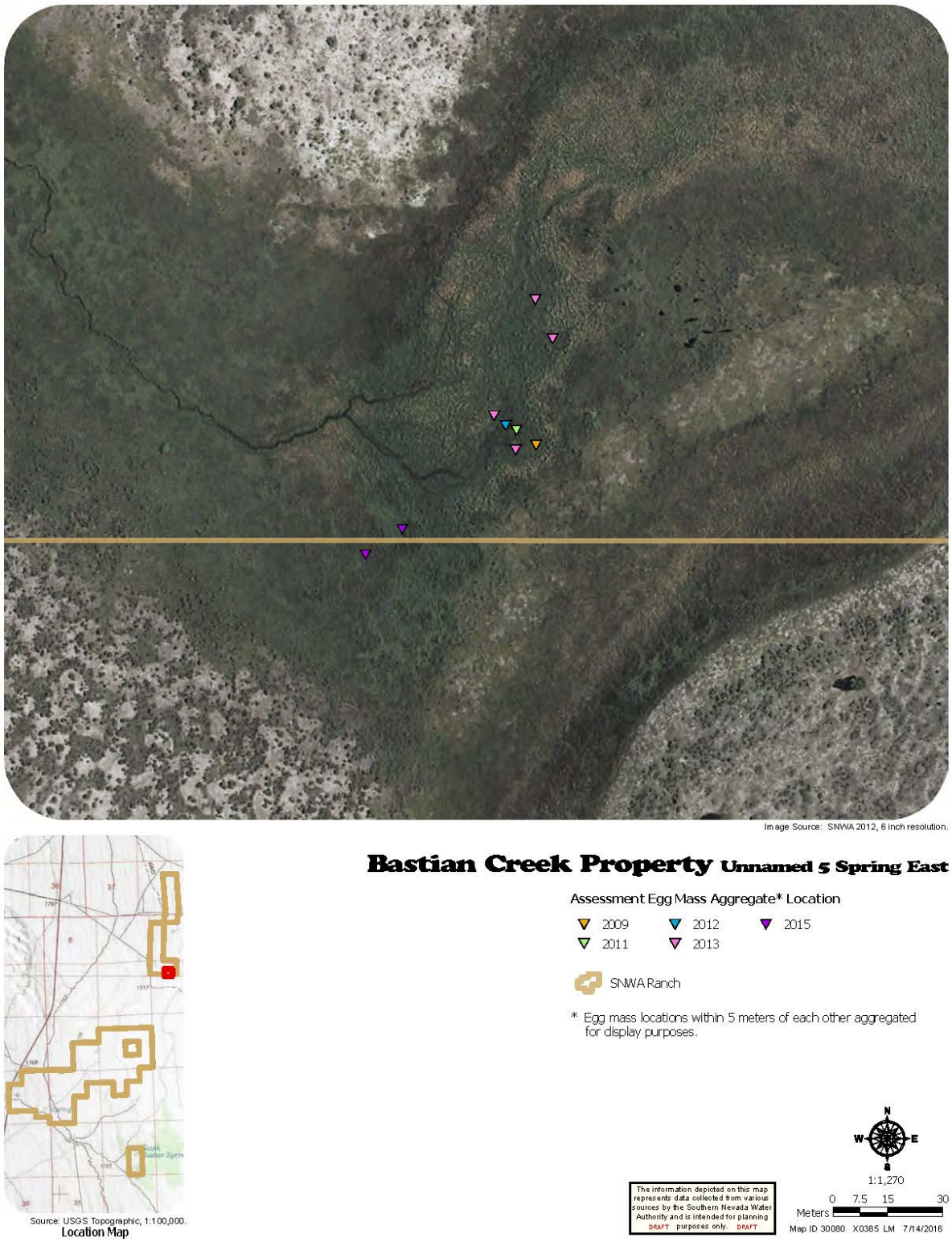

Figure 19. Bastian Creek property (El Tejón Ranch, Unnamed 5 Spring - east): all northern leopard frog egg mass locations documented in all survey years (2009-2015).

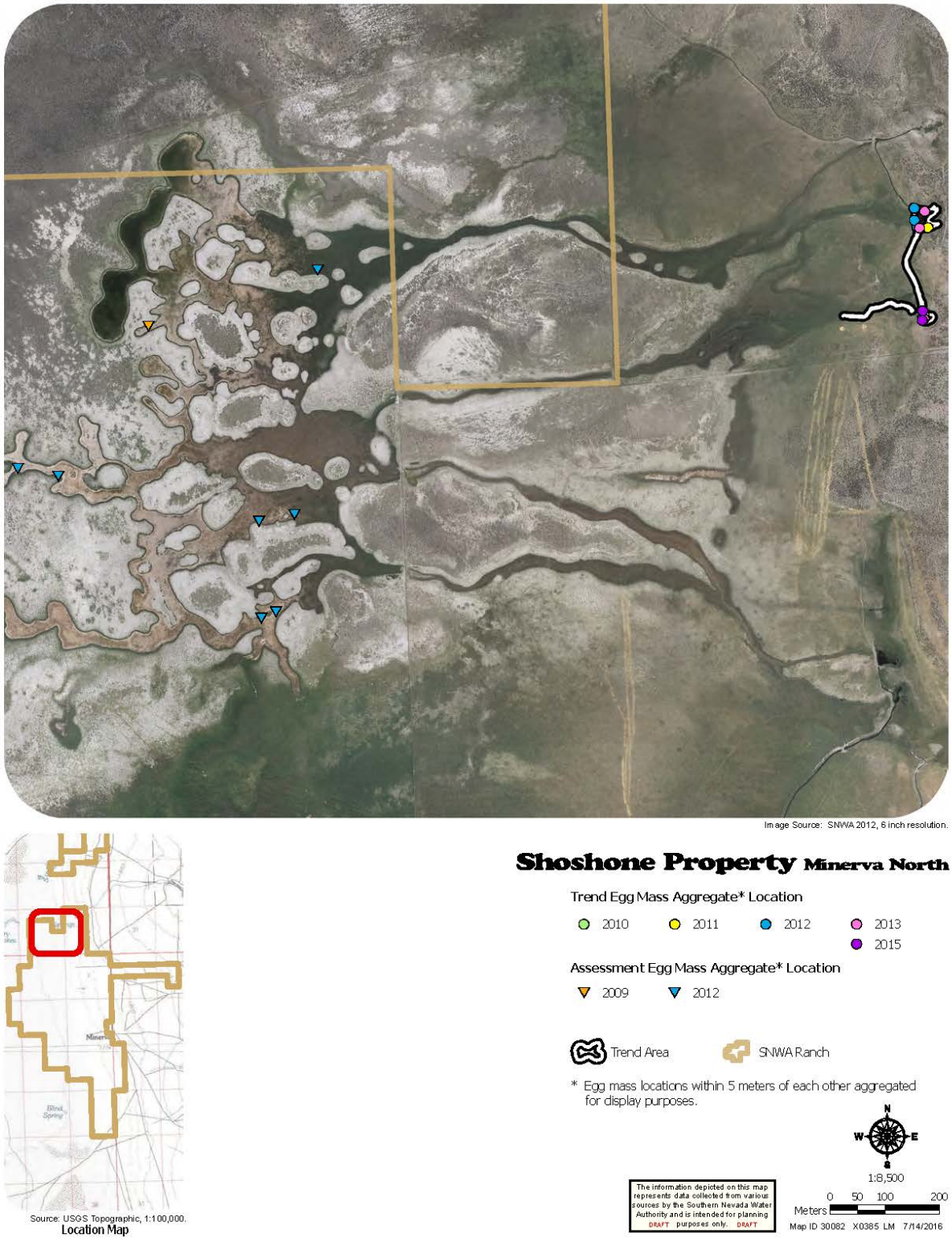

Figure 20. Shoshone property, north (El Tejón Ranch, Minerva Spring Complex): all northern leopard frog egg mass locations documented in all survey years (2009-2015).

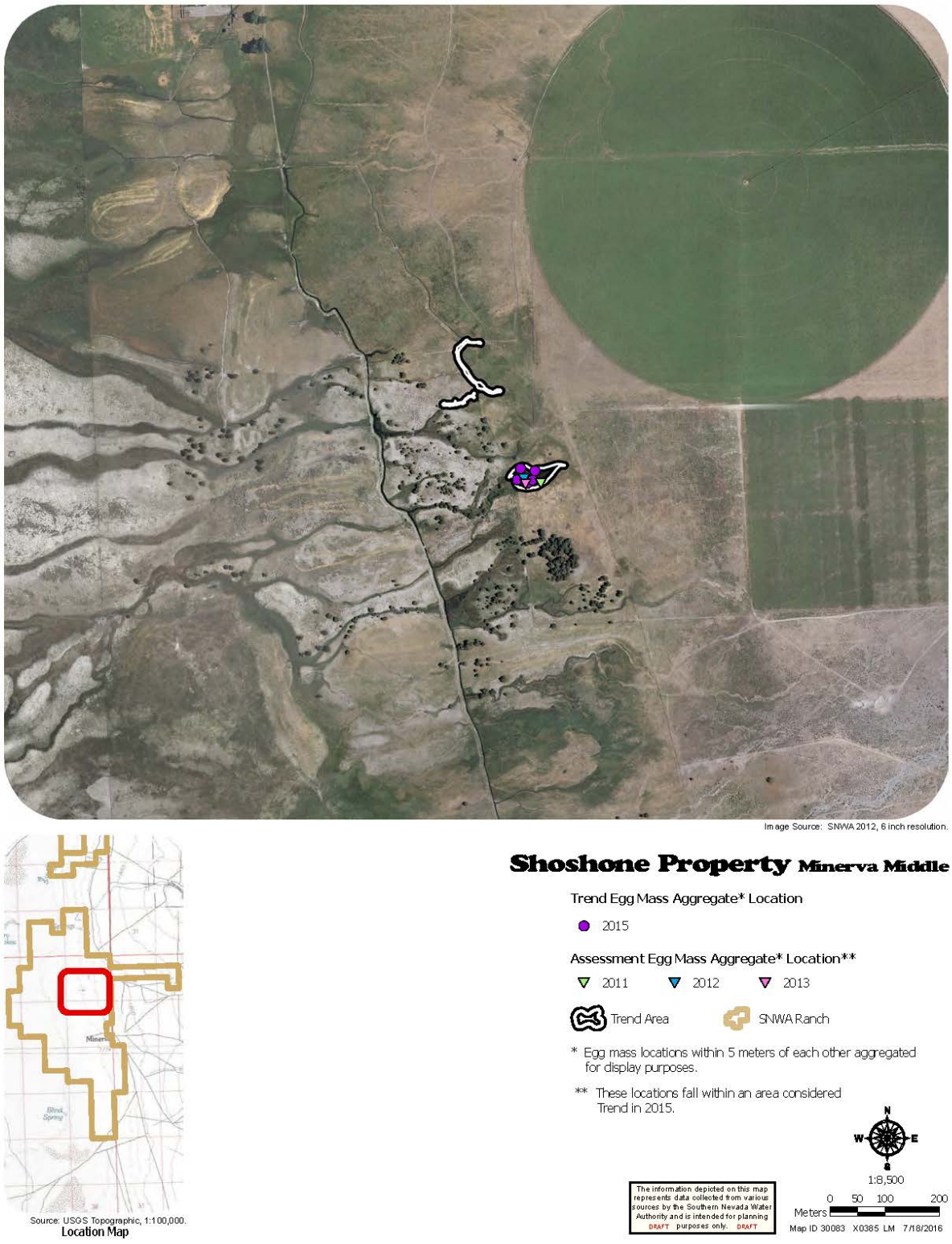

Figure 21. Shoshone property, middle (El Tejón Ranch, Minerva Spring Complex): all northern leopard frog egg mass locations documented in all survey years (2011-2015).

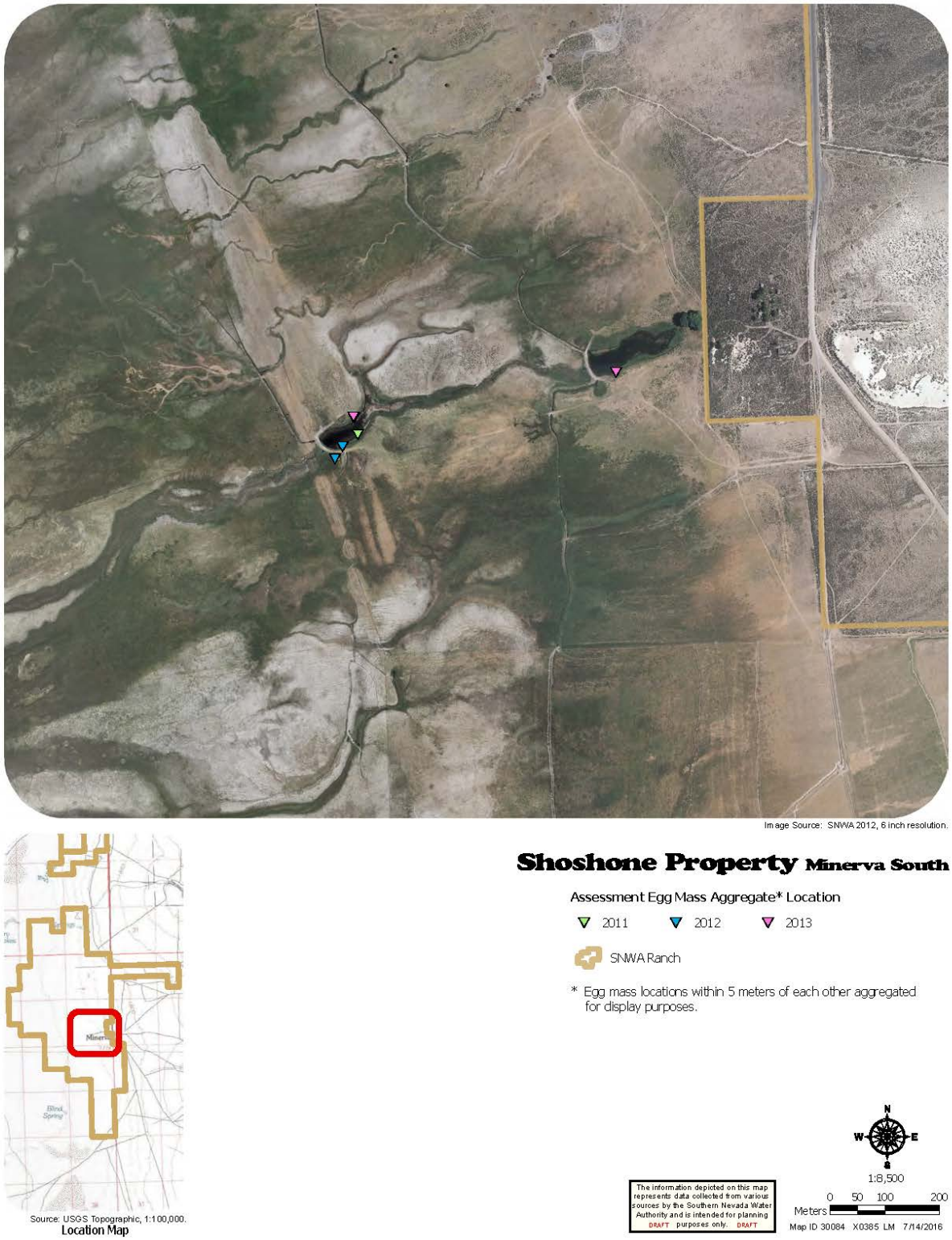

Figure 22. Shoshone property, south (El Tejón Ranch, Minerva Spring Complex): all northern leopard frog egg mass locations documented in all survey years (2011-2013).

CONCLUSION

All of the surveyed SNWA ranch properties in this study support breeding sub-populations of northern leopard frog. Several of the properties support extensive breeding habitat and demonstrated the potential to support large numbers of breeding adult leopard frogs. The documentation of large numbers of egg masses and the presence of widespread breeding habitat suggests that Spring Valley in general supports a robust northern leopard frog population, and that the breeding sub-populations on the various SNWA ranches may contribute to the overall persistence of leopard frog in the basin. This report identified specific areas that appear to provide reliable leopard frog breeding habitat across multiple years, and provides insight into when and how these areas are used. It also demonstrated that the effective breeding population size fluctuates naturally over time, and that the general trend in egg mass numbers appears to follow a similar pattern across sites. The insight into the timing of use and location of breeding areas, as well as tadpole development in these areas, may be useful to consider in land management decisions (e.g. water diversions, conversion of habitat) to avoid unintended and unnecessary impacts to leopard frog populations. This information may also be useful in the development of future mitigation opportunities associated with water development. Sustainable ranch management can continue to support breeding sub-populations of leopard frog on properties with appropriate mesic habitat and ensure the long-term presence of the species in Spring Valley.

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