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IVANPAH SOLAR ELECTRIC GENERATING SYSTEM
AVIAN & BAT MONITORING PLAN

2017 Spring Report

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Executive Summary

Avian and bat monitoring surveys were conducted from 21 March 2017 – 25 May 2017 (the spring season) at the Ivanpah Solar Electric Generating System facility (referred to in this report as "Ivanpah" or "Project") in accordance with the Project's Avian & Bat Monitoring and Management Plan (Plan) as revised November 2015.

Per the revised Plan, potential flux effects are investigated by surveying 100 percent of the tower area in all three units, and potential collision effects with facility structures (towers and heliostats) are evaluated by systematic sampling of 100% of the tower areas (154 acres) in each of the three units, and 20% of Unit 2 heliostat field (240 acres) as representative of the facility. The "tower area" consists of the power block and inner high-density (HD) heliostats surrounding each power block on approximately 154 acres; and the "heliostat area" consists of the inner and outer heliostat segments outside of the inner HD heliostats on approximately 2,991 acres. Searches were conducted within the spring season at intervals of approximately 7 days.

All bird and bat fatalities and injuries, referred to as "detections" in this report, including those found incidentally and during standardized facility searches, were documented and categorized as singed, collision, other project causes or unknown based on examination with a binocular microscope and evidence collected from the location of the detection. During the period 21 March 2017 – 25 May 2017, a total of 2 bat detections and 61 avian detections (which included 2 injured birds) were found. Of the 61 avian detections, 50 were discovered in the tower area, 10 in the heliostat area of Unit 2, and 1 on other project lands.

Per the specifications of the revised Plan, avian detections were categorized by facility structure and cause. These avian fatality search results, along with searcher efficiency and carcass removal rates from trials conducted onsite, were input into a fatality estimator model (Huso 2010) to provide an estimate of the fatalities for the facility.

Using the fatality estimator model, during the period 21 March 2017 – 25 May 2017, there were an estimated 221 fatalities (53%) from known causes and 196 fatalities (47%) from unknown causes. Of the known causes, 73 fatalities were estimated for the 154-acre tower areas. Due to the low number of detections of known cause ($N \leq 5$) in the heliostat area, a separate estimate is not provided.

Of the unknown causes, 11 fatalities were estimated for the tower area and the remaining were estimated for the heliostat area; however, due to the low number ($N \leq 5$) of detections with unknown cause in heliostat area, a separate estimate is not provided. Overall, based on the monitoring results and estimates for known causes for the spring season, the effect of the Project on birds does not rise above the "low" category.

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Section 1.0 Introduction

1.1 Project Background

The Ivanpah Solar Electric Generating System (referred to in this report as "Ivanpah" or "Project") consists of three solar power electrical generating facilities (Units 1, 2, and 3) with a combined net capacity of 377 megawatts. Each unit includes a central power tower with an air cooled condenser (ACC) and associated electrical generating equipment, surrounded by a heliostat array that reflects sunlight to a boiler at the top of the power tower. Ivanpah is located on approximately 1,457 hectares (3,600 acres) of Bureau of Land Management (BLM) land west of Interstate 15 near the town of Nipton in San Bernardino County, California (Figure 1). Construction was initiated in 2010 and completed in late 2013.

1.2 Monitoring Plan Overview and Goals

An Avian & Bat Monitoring and Management Plan (Plan) was prepared by the Project proponent in collaboration with the U.S. Fish and Wildlife Service (USFWS), California Department of Fish and Wildlife (CDFW), California Energy Commission (CEC), and Bureau of Land Management (BLM) to guide comprehensive monitoring of impacts to birds and bats associated with the operation of the Project. Revision 12 of the Plan (2013) was accepted by the agencies in November 2013 and required two years of monitoring, which were completed at the end of October 20, 2015. As part of the Plan, a Technical Advisory Committee (TAC) with representative from the agencies and the project was formed to guide implementation of the Plan. The TAC determined that the goals of the Plan (2013) were met, and in November 2015, the TAC-approved Revision 13 to the Plan (2015) to require a third year of monitoring to provide collision and flux mortality estimates. Revision 13 of the Plan (2015) reflects reduced monitoring requirements (i.e., heliostat areas for Units 1 and 3, the Unit 3 collector line, offsite control transects, and fenceline monitoring were removed from the monitoring for the third year) as informed by the first two years of intensive monitoring. Upon reviewing the third year of monitoring, it was provided in a letter from the TAC on 19 October 2016 that surveys in the heliostat area for Unit 2 will be removed after the second quarter (spring) of the fourth year.

Specifically, the Plan (2015) details the onsite and offsite surveys to be conducted and the data analysis and reporting processes that will be implemented by Ivanpah in collaboration with the USFWS, CDFW, CEC, and BLM and provides the following goals and objectives as excerpted from the Plan (2015):

Plan Goals

1. Provide Collision Mortality Estimates: Estimates of avian mortality from collision will be calculated from data obtained by monitoring and identifying avian mortality and injury associated with facility structure collisions.
2. Provide Solar Flux Mortality Estimates: Estimates of avian mortality from flux effects will be calculated from data obtained by monitoring and identifying avian mortality and injury associated with solar flux generated by the facility.

3. Provide a Framework for Management and Response to Risks**:** The designation and description of the functioning of the TAC provides a management and decision framework for the identification and implementation of potential adaptive management measures.

Plan Objectives

The first two years of monitoring documented that the mortality associated with the perimeter fences, transmission lines, and offsite transects was less than 5 detections a season. Additionally, the patterns associated with avian use have been consistent over the seasons and documented in the annual reports. Therefore, as revised, the Plan has the following objectives:

1. Estimate collision-related avian mortality and injury with the following facility structures (Figure 1), using empirical data to calculate facility-wide mortality and injury rates:

   a. Power towers
   b. Heliostats

2. Estimate flux-related avian mortality and injury using empirical data to calculate facility-wide mortality and injury rates.
3. Document patterns of collision or flux-related mortality and injury associated with species, age/sex, season, weather, and visibility.
4. Document spatial patterns associated with collision- or flux-related mortality and injury.
5. Provide quantitative information for developing and implementing adaptive management responses commensurate with identified impacts.

As approved by the TAC, the revised Plan (2015) continues to: 1) satisfy the BLM Right-of-Way (ROW) Permit requirement that the proponent develop an avian plan as well as a Migratory Bird Treaty Act (MBTA) Conservation Agreement; 2) satisfy the requirements for the Avian & Bat Monitoring and Management Plan approved by the CEC for Ivanpah per CEC Condition of Certification BIO-21; and 3) achieve the avian and bat protection objectives of the USFWS in relation to the MBTA, Bald and Golden Eagle Protection Act (Eagle Act), and Federal Endangered Species Act (FESA), including preparing written records of the actions that have been taken to avoid, minimize, and compensate for potential adverse impacts to avian and bat species. By developing a proactive management plan in close consultation with the USFWS and other relevant state and federal agencies, Project proponents can effectively comply with the intent of the federal MBTA, Eagle Act, FESA, and relevant state regulations (USFWS 2012).

1.3 Purpose of This Report

This report represents the second "quarterly" (i.e., seasonal) report for the fourth year of monitoring (or, the fourteenth quarterly report) summarizing monitoring methods and results for avian and bat fatalities and injuries based on the procedures and requirements specified in the Plan and as required by CEC Condition of Certification BIO-21. This report covers the 2017 spring season, which includes the period from 21 March 2017 – 25 May 2017.

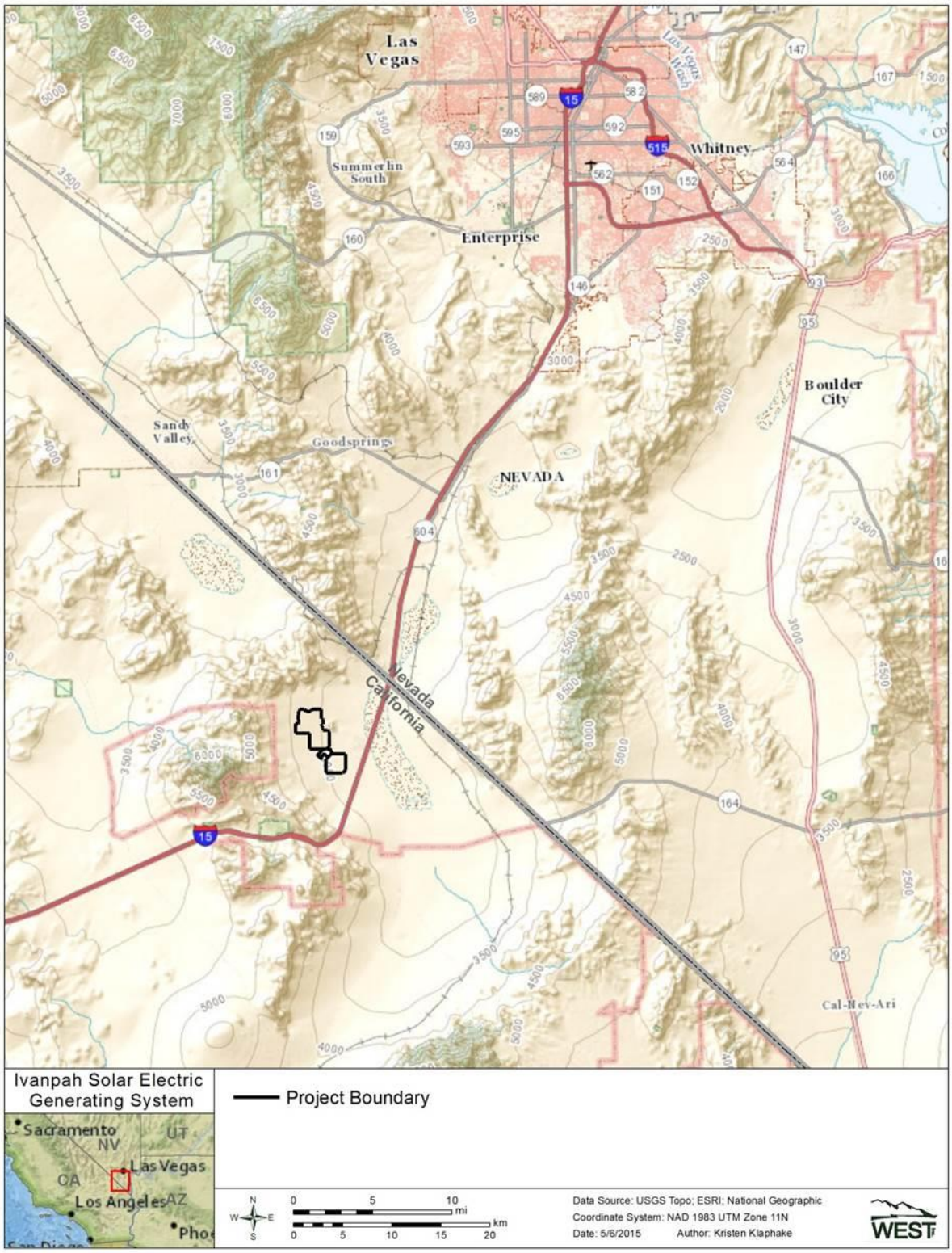

Figure 1. Ivanpah Vicinity Map.

Section 2.0 Methods

The Plan (2015) describes the methods by which monitoring and certain analyses, including compilation of the overall fatality estimate, will occur. Below is an abridged description.

2.1 Facility Monitoring

This section describes areas surveyed, the timing and frequency of the searches, and the methods by which standardized searches were conducted to identify dead/injured birds and bats (hereafter detections) at the Project. This section also describes the methods for conducting carcass removal and searcher efficiency trials; how data were reported and analyzed for incidental detections; and the methods for producing fatality estimates for the Project.

2.1.1 Standardized Searches

2.1.1.1 Areas Surveyed

Per the Plan (2015), monitoring was conducted in the "tower area" and a sample of the "heliostat area". The tower area is defined as the power block (the area consisting of the tower, the ACC unit, the associated control building, and immediately adjacent areas defined by the ring road and berm/slopes surrounding these facilities) and inner high-density (HD) heliostats surrounding each power block. The heliostat area is defined as the inner and outer heliostat segments outside of the inner HD heliostats. For year 3, 100% of the tower area at each unit was surveyed and approximately 24% of the Unit 2 heliostat area (8% of the total heliostat area) was surveyed. Table 1a provides the acreage searched within each of the survey areas, as well as the percent of the facility comprised by these search areas. Overall, approximately 12.9% of the Project was searched (Figure 2).

To ensure a balanced distribution of heliostat field survey plots, Unit 2 was divided into inner and outer heliostat fields, and approximately 20% of each sub-area was randomly selected for monitoring. The actual percentage of Unit 2 heliostat area being surveyed was 24%. Arc plots used for monitoring in Unit 2 were the same as previous years. This stratified random sampling design ensures that survey plots will not be clustered or biased in any distance or direction from the tower.

Table 1a. Monitoring Areas.

Area	Facility Locations Included	Acreage Searched	Percent of Facility
Tower Area	ACC, Power Block, Inner HD	154	4.80%
Heliostat Area	Unit 2 Inner and Outer Heliostat Segments	240	8.09%
Total		394	12.89%

*NA = Not applicable as offsite survey areas are located outside of the facility

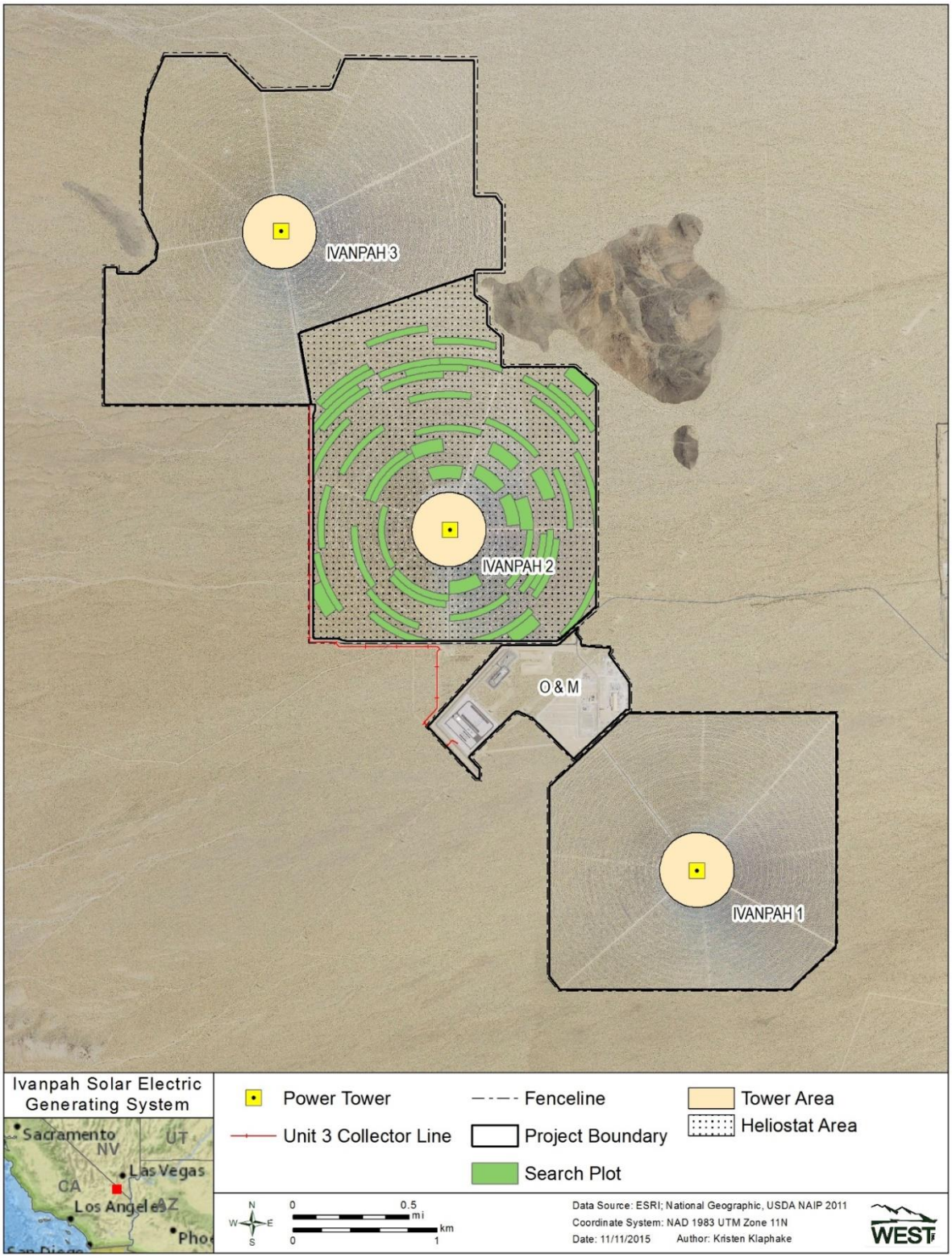

Figure 2. Ivanpah Search Areas.

2.1.1.2 Search Frequency and Timing

Consistent with the first two years of monitoring, standardized searches occurred at each unit on a nominal 7-day interval through the 2017 spring season. Variation in search interval and number of visits to each unit was anticipated to occur due to the transition between 21-day search and 7-day search interval between seasons of differing length, as well as the transition to Revision 13 of the Plan (2015), after November 15, 2015. The tower area of Units 1, 2 and 3 were visited a total of eight times, and the inner and outer heliostat segments of Unit 2 was visited eight times.

2.1.1.3 Search Methods

Biologists performed surveys in the tower area, and plots in the heliostat area. Standardized walking surveys for fatalities were performed by biologists approved by CEC and BLM, in accordance with the methods outlined in the Plan (2015). In the heliostat area, a pair of biologists walked a total of four transects oriented longitudinally along the complete length of each arc-plot, with the ring roads serving as the outer boundaries of each arc plot (Figure 3). While walking each transect, biologists walked a narrow search section approximately 10 meters (m) wide. Within the power block, biologists walked through and around the power tower and ACC unit looking for dead and injured birds and bats, and walked transects through the gravel surrounding the structures to achieve 100% coverage within physically accessible areas. Within the inner HD heliostats surrounding each power block, biologists walked transects to ensure 100% coverage. Thus, the tower area, comprising the area within 260 m of each tower, was completely covered during each survey, excepting any areas that were physically inaccessible or unsafe to survey. Inaccessible areas were, to the extent possible, scanned using binoculars.

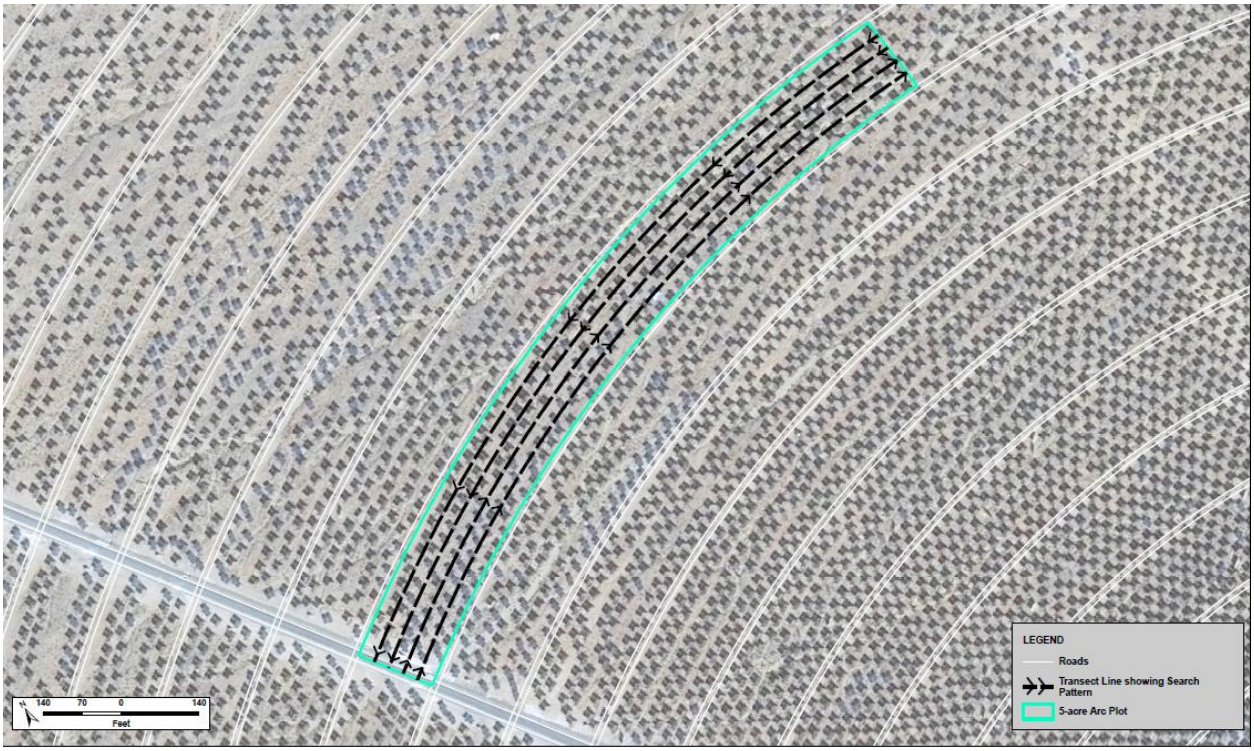

Figure 3. Monitoring Search Pattern for Arc Plots.

Carcass and Feather Spot Examination. Every carcass and feather spot was examined visually by a biologist approved by the CEC and BLM for evidence of singeing or collision. Singeing to feathers can occur when a bird enters the flux around the power tower. When no obvious evidence of singeing or collision was evident to the naked eye, the carcass or feather spot was then examined using an AmScope SE306R-AZ-E2 20X-40X-80X Digital Binocular Stereo Microscope. When singed detections involving carcasses (as opposed to only feather spots) were found, the singeing was assigned a grade based on Kagan et al. (2014), as follows.

- Grade 1 – curling of less than 50% of the flight feathers
- Grade 2 – curling of 50% or more of the flight feathers
- Grade 3 – curling and visible charring of contour feathers

Kagan et al. (2014) originally found no singeing of contour feathers in the absence of curling of 50% or more of the flight feathers. In contrast, we have found singeing of contour feathers with curling of less than 50% of flight feathers, and in the absence of curling or singeing of any flight feathers. We therefore assigned grade 3 independent of grades 1 and 2.

When a carcass was detected, biologists looked for evidence of collision, including obvious physical trauma or detection adjacent to a heliostat with a bird-strike imprint, smudge mark, and/or feathers on or near the surface of the mirror. If there was no evidence of collision or singeing (e.g., charring, curling, or melting of feathers), as confirmed through microscopic examination, the cause of injury or fatality was listed as "unknown".

For the purpose of these surveys, feather spots were considered detections when they met the following definition:

> At least two or more primary flight feathers, 5 or more tail feathers, or 10 or more feathers of any type concentrated together in an area 1-m^2 or smaller (Smallwood 2007), without any bone, beak, or significant amounts of flesh or skin.

In some cases, an individual detection was broken up into aggregations of feathers that would meet the criteria for a feather spot, but with pieces of the carcass that contained bone or significant amounts of flesh or skin also present. In these cases, the detection was categorized as a partial carcass (rather than a feather spot), per the "feather spot" definition above.

2.1.2 Carcass Persistence Trials

Carcass persistence trials were performed throughout the 2017 spring monitoring season. A total of 20 small bird carcass trials were conducted. The TAC approved discontinuing large bird carcass trials at the conclusion of the 2015 summer season due to the consistency of large bird persistence times collected over the previous seasons. In response to the previous TAC request of increased sample size, the number of small bird trials was increased relative to the 2013 – 2014 winter monitoring season.

The facility contains vegetated and unvegetated areas that could affect the ability to detect a carcass or the amount of time a carcass persists until it is scavenged. The tower area (power block and inner high density (HD) heliostat area, where most singed detections occur, is unvegetated; all other areas are considered vegetated. In order to examine carcass persistence times for vegetated and unvegetated areas, carcasses were also distributed through the facility, with 10 carcasses placed in the unvegetated tower area, and 10 carcasses placed in the vegetated heliostat arrays. Non-native house sparrows (*Passer domesticus*) were used for small carcass trials conducted during the 2017 spring monitoring season. A camera was placed at each carcass to record the time of scavenging and the scavenging species.

2.1.3 Searcher Efficiency Trials

A total of 65 searcher efficiency trials (23 small birds, 22 large birds, and 20 feather spots) were conducted during the 2017 spring monitoring season. Carcasses and feather spots were placed in various vegetation heights and in areas that had different soil and vegetation colors and values to represent the range of conditions under which searches occur. Trials were placed in the tower areas of all three units and in the heliostat area of Unit 2; however, no trials were placed in the ACC building since detection probability is assumed to be 100% in this area of the power block. Each trial carcass was placed by a Designated Biologist (a biologist responsible for implementing the conditions of certification) prior to a scheduled search without knowledge of the searchers. For trial carcasses that were not detected by searchers, the Designated Biologist returned to the trial location to see if the trial carcass was still available to be found. If the trial carcass was absent, it was assumed to have been removed prior to the search, and thus not available to be detected.

Overall, 30 trial carcasses/feather spots were placed in the tower area and 35 trial carcasses were placed in vegetated areas in the inner/outer segments of the heliostat area. Of the 65 trial carcasses placed, 62 (22 small carcasses, 20 large carcasses, and 20 feather spots) were available to be found; 3 carcasses (1 small carcasses and 2 large carcass) were removed (scavenged) from the trial location before searchers had an opportunity to find them.

2.1.4 Incidental Reporting

Some detections were made outside standardized search areas, or were within search areas but not during standardized searches. Detections at locations not searched under the Plan (2015) such as the fenceline and heliostat areas of Unit 1 and Unit 3, are considered incidental detections for this report. These detections were reported in accordance with the facility's Wildlife Incident Reporting System (described in Section 3.4 of the Plan) and were considered "incidental" detections. Data on these incidental detections were reported in the SPUT permit database. As described in Section 2.2.5, incidental data could be included in the fatality estimates when they were found in areas covered during standardized surveys (e.g., tower area). Incidental detections from outside the survey areas were not included in the fatality estimates as discussed in Section 2.2.5; however, all detections regardless of the method or source of detection are reported in the SPUT permit database.

2.1.5 Fatality Estimator

Fatality rate estimation is a complex task due to several variables inherent to every fatality monitoring study. Carcasses may persist for variable amounts of time due to local scavenger activity or environmental conditions leading to carcass degradation over time. Carcasses and feather spots are also

detected with varying levels of success based on carcass characteristics and ground cover (e.g., vegetated areas underneath heliostats versus cleared areas around towers). For these reasons, it is generally inappropriate to draw conclusions based on the raw number of fatalities alone. The desire to estimate fatalities given these variables has driven the development of several statistical methods for estimating fatalities (e.g., Smallwood 2007, Huso 2010, Korner-Nievergelt 2011). All of these fatality estimation methods share a similar underlying model. Generally, the fatality estimation for a given site may be written as:

$$F=C/rp,$$

where F is the total number of fatalities, C is the number fatalities detected and included in fatality estimation, r is the probability a carcass is unscavenged and available to be found at the end of the search interval, and p is the probability of detecting a carcass (Huso 2010).

The bias correction factors r and p are estimated by covariates that may influence the detectability and persistence of each carcass, such as carcass size, presence of vegetation, and stage of decay or scavenging (i.e., feather spot versus carcass). For this study, the Huso estimator was used to correct for detection and scavenging bias; the estimator was demonstrated to perform well under a variety of conditions (Huso 2010). The Huso model was developed in the context of estimating fatalities for post-construction fatality studies at wind energy facilities; however, the Huso estimator is suitable for other sources of anthropogenic avian mortality, including power lines and utility scale solar facilities (Huso 2010).

All fatality estimates were calculated using the Huso estimator, as well as 90% confidence using bootstrapping (Manly 1997). Bootstrapping is a computer simulation technique that is useful for calculating point estimates, variances, and confidence intervals for complicated test statistics. A total of 1,000 bootstrap replicates were used. The lower 5th and upper 95th percentiles of the 1,000 bootstrap estimates provide estimates of the lower limit and upper limit of an approximate 90% confidence interval on all estimates.

Estimating Carcass Persistence Times. Measurement of carcass persistence time is often subject to censoring. In this context, censoring refers to the fact that a value (e.g., days a carcass is present before being removed) may not be known exactly, but within a finite range. For example, suppose a carcass was checked on day 7 and was present, and was checked again on day 10, but was found to be missing. The exact time until removal is unknown; however, it is known that the carcass was available to be found for between 7 and 10 days. This carcass would be considered "interval censored". Similarly, if a carcass lasts the entire six-week trial period, that carcass is "right censored"—we know the carcass lasted at least six weeks, but it could have persisted longer. Due to the fact that camera traps (e.g., cameras that automatically document activity at the trial carcass) were used for carcass removal trials, the majority of scavenging times can be known precisely, and data are not censored. However, when cameras fail to record the moment of scavenging, trials are treated as interval censored between the last time the carcass was visible on the camera, and the earliest time at which it was known to be removed.

Survival regressions models are well-suited to accommodate censored carcass persistence data and are typically used to generate the average probability of persistence for fatality estimation (Huso et. al 2012). There are four commonly used distributions implemented in the survival models used to estimate the

value of r : exponential, Weibull, loglogistic, and lognormal. These four distributions exhibit varying degrees of flexibility in order to model a wide variety of removal time distributions. Akaike's Information Criterion adjusted for sample size (AICc; Akaike 1973) was used to rank the fit of each survival model fit to carcass removal data. The exact time of death for detected fatalities is usually unknown, so the probability of persistence cannot be calculated exactly for each carcass; however, it can be estimated from the selected survival model and bootstrapped to obtain a range of estimates of r for each carcass.

Estimating Searcher Efficiency. Searcher efficiency, or the proportion of carcasses detected, p, is represented most simply by the following equation:

$$p = \frac{Number\ of\ Carcass\ Observed}{Number\ of\ Carcasses\ Available}$$

Model Selection for Searcher Efficiency Trials. The Plan states that searcher efficiency trials will be conducted during each season in which vegetation differs from the prior season, because changes in vegetative cover may affect carcass detectability. *A priori* decisions were not made regarding whether vegetative cover would differ between seasons, but rather, searcher efficiency trials were conducted in all season. Following the completion of fall searcher efficiency trials, there was sufficient cumulative data for the year to assess whether searcher efficiency differed significantly by Project area (e.g., unvegetated tower area versus vegetated heliostat fields), season, and/or carcass size. The nearly complete lack of vegetation cover in the tower area suggested that searcher efficiency may be higher in the tower area than in other Project areas. If this hypothesis were true, accounting for this difference in searcher efficiency across Project areas would be important for producing accurate fatality estimates.

To evaluate various hypotheses regarding differences in carcass detectability among Project areas, seasons, and/or carcass size, logistic regression models were fit to searcher efficiency data and corrected Akaike's Information Criteria (AICc) was used to compare models. The Project area was defined using two categories to reflect the suspected differences in searcher efficiency due to differences in vegetation cover: the tower area, which consists of the power block and the inner HD heliostats, and other areas, which consists of all other Project areas not included in the tower area. Models were constructed for all combinations of year, season, carcass size, Project area, and compared to the null model (Table 8). The data for this analysis included all human searcher efficiency trials of carcasses from the beginning of trials in the winter 2013 – 2014 season through the 2017 spring season.

Fatality Estimates. Estimates for the number of detections in the tower area components (i.e., the power block and inner HD heliostats) are reported combined, because 100% of these areas were searched. A separate estimate was produced for the heliostat area of all three Units (the inner and outer heliostat segments combined), in which 8% of the total area was searched. Fatality estimates reported in the inner/outer heliostat areas were adjusted to account for the unsearched area in the inner/outer heliostat areas (i.e., divided by 0.08).

The ACC buildings are only marginally accessible to scavengers from the outside; therefore, they act primarily as a closed system with a scavenging rate that approaches zero. Furthermore, carcasses are, generally, visible against the industrial backgrounds. Thus, the fatalities found in the ACC were not adjusted using the Huso estimator; rather, raw counts of ACC detections were added to fatality estimates

for the power block. All detections within the ACC buildings are considered facility related, whether or not they showed evidence of singeing or collision.

Within the power block, during the 2017 spring season, incidental detections accounted for 9.1% of the detections recorded. Thus, as previously modeled, incidentals found within the power block were included in estimates, but treated differently from other fatalities. To reflect the high human activity in the power block—and frequent observation of the areas within the power block—the search interval for these detections was set to one day (Table 1b).

In previous seasons, incidental detections found outside of the power block but within standardized search areas were partially processed in the field and left in place to give searchers the opportunity to discover the carcass on the next scheduled search. As approved by the TAC, this method was discontinued in the 2015 fall season to prevent the scenario where an incidental detection is recorded, left in place, but scavenged before the next standard search and no carcass is associated with the data. In the 2015 fall season, incidental detections found outside of the power block, but within standardized search areas, were removed from field and included in fatality estimates under the conservative assumption that the search interval was the time between the last search of the area and the time of incidental discovery (Table 1b).

Table 1b. Treatment of Incidental Detections by Location

Location	Search Interval	Included in Analysis?
Power Block	1 Day	Yes, if carcass age is less than 24 hours
All Other Standardized Search Areas	Calculated days between date of detection and date of previous standard search in that location	Yes, if carcass age is less than calculated search interval

All fatality estimators have limitations, particularly when fatality counts are low. In particular, when detections are fewer than five, regardless of survey effort, estimates and confidence intervals can be unstable and must be interpreted with caution (Korner-Nievergelt et. al 2011). Rather than report estimates with little inferential value, no estimates were provided for combinations of covariates (e.g. size, location, cause) resulting in five or fewer detections.

The fatality estimator accounts for imperfect detection probability by using bias trials to estimate searcher efficiency. The Huso estimator is constructed under the assumption that searchers have a single opportunity to discover a carcass. Therefore, if a carcass is missed on the first search it was available and then found on the next search, it will effectively be over-counted. The method typically used to overcome multiple-detection-bias is to exclude any detection determined to be significantly older than the search interval. Each detection made during the 2017 spring season was evaluated for exclusion from the estimator based on the observed time since death (i.e., the length of time between an animal's death and when the detection was discovered), and the search interval associated with that detection. For example, if a detection determined to have been on the ground for > 1 month was made in the inner HD of Unit 2, which had been searched seven days earlier, that carcass would be excluded from analysis.

Determining the age of a carcass was based on detailed qualitative analysis of every detection (carcasses and feather spots) recovered onsite. Qualitative analysis began with in situ aging analysis in the field by biologists approved by the CEC and BLM, followed by a more detailed analysis in the lab. In the field, biologists noted the presence of rigor mortis, condition of eyes and feathers, and condition of blood or viscera (if present). In the lab, each carcass was further examined and compared to photographs of decomposed test carcasses. The test carcasses were used to document decomposition over time at Ivanpah to better inform biologist of site-specific characteristics of avian decomposition that could be expected at the Project.

Decomposition test carcasses were placed in tamper-proof containers, exposed to onsite environmental conditions, and allowed to decompose. Carcasses used in decomposition tests were placed to account for variation in space (e.g. underneath fans in the ACC unit versus shaded under a heliostat) and time (e.g. ephemeral weather patterns). As the test carcasses aged, the biologists photographed and recorded the condition of body tissue and fluids, eyes, feathers, and indications of rigor mortis. All decomposition specimens were placed during the 2015 spring monitoring season.

To correctly account for searcher efficiency in the fatality estimate model, when partial carcasses are initially identified as feather spots by the observer in the field, they are modeled (in the fatality estimates) as a feather spot. In other words, the primary means of identification of the detection (feather spot, small carcass, or large carcass) is the appropriate classification to utilize in the modeled estimates. The primary identification approach is appropriate since different searcher efficiency rates are estimated for feather spots as opposed to carcasses. Because searcher efficiency is an important component of the fatality estimator, what the surveyors detect first (i.e., feather spot versus a complete or partial carcass) influences how that detection should be included in the model. Such detections are noted in Appendix A as "partial carcass + feather spot" in the "Description of Carcass/Injury" column.

2.2 Deterrence Measures

2.2.1 Avian Measures

Ivanpah commenced an investigation of the use of various deterrence measures to reduce avian mortality at the facility in 2013. These initial investigations combined with the results of the monitoring conducted during 2014 resulted in a list of potential deterrence measures for adaptive management. As monitoring has identified patterns of detections, additional measures have been identified, tested and if effective are ultimately deployed as part of the adaptive management program.

Based on the location of greater roadrunner detections along the fenceline, an adaptive management measure was developed in 2016 to allow roadrunners to escape through the unit fence. Hawks were observed to pursue and entrap roadrunners along the fence and depredate them. The measure deployed consisted of installing egress routes through the fence with an elevated platform. The elevated platform allows the egress route to be installed without impacting the desert tortoise fencing. The shade cloth was installed to increase visibility of the egress route. The measure was initially tested at Unit 1 and monitored with a game camera. Evidence of roadrunners use was captured on camera, and this measure is now considered a best management practice and additional egress routes will be installed along fences for the remaining units during 2017.

Several other deterrence measures have been tested and, if effective, implemented for birds at Ivanpah. Specifically, new ground-level LED lighting and spikes were installed at Unit 1 on 5 February 2015. As approved by the TAC, after initial testing, a chemosensory deterrence measure commercially known as BirdBuffer was deployed on 12 October 2014 at Unit 1, and a sonic deterrence measure commercially known as BirdGard was deployed on 13 March 2015 at Unit 1. Bird Buffer was installed at Unit 2 and Unit 3 on 29 September 2015; BirdGard was installed at Unit 2 on 25 August 2015 and Unit 3 on 31 August 2015. The chemosensory deterrence measure is hypothesized to deter resident species, since the deterrent induces a conditioned response over time, and the sonic deterrence measure is hypothesized to deter transient and migrant species, as the sounds produced by the system are thought to startle and deter subjects. Together, the combination of BirdBuffer and BirdGard systems are intended to deter avian species from entering this area associated with elevated flux mortality.

Enhancements to BirdBuffer were designed in fall 2016 and implemented in early March of 2017. Enhancements included replacing the single output device at each Unit tower with two double output devices at each Unit tower. Enhancements to BirdGard were designed in fall 2016 and implemented in February of 2017. The enhancements included upgrading each speaker device containing 20 speakers to a new speaker device which combines 3 separate speaker towers containing 21 speakers. Each speaker tower has 7 hyper-directional speakers, for a total of 21 directional speakers targeted towards a specific path. The four independent three-speaker-devices will remain positioned on the north, east, south, and west side of each tower area.

2.2.2 Bat Measures

Bat fatalities were detected primarily in the ACC, and as the ACC provides a roosting location, a Binary Acoustic Technology Ultrasonic Bat Deterrence was tested at Unit 3. The bat deterrence measure is not designed to elicit a fear response in bats, but is designed to interfere with the echolocation capabilities of bats. As bats navigate utilizing sonar, the method deployed "jams" the sonar signals and bats species avoid the area as a result of the inherent difficulties to navigate under these conditions. Although bats can adjust echolocation under jamming conditions, the use of broadband ultrasound requires bats to shift frequencies to avoid overlap that interferes with echolocation and therefore deters within the area subject to broadband ultrasound (Arnett, et al, 2013). As a result of the broadband ultrasonic signal and the inherent "jamming" effect, adaptation to the deterrence measure is minimal. The deterrence measure has been tested and installed at all Units, and the installation dates are as follows: 10 September 2014 at Unit 1, 23 April 2015 at Unit 2, and 23 April 2015 at Unit 3. In November 2015, an ultrasonic testing protocol was implemented to ensure proper function of all deterrence units.

Section 3.0 Monitoring Results

3.1 Summary of Avian Detections

The average search interval in the tower area was 7.4 days (range 5 to 14, median 7.0 days), and in the heliostat arrays the average search interval was 7.7 days (range 3 to 25, median 7.0 days), during the 2017 spring season for the three solar units. Variation in search interval was anticipated to occur due to the transition between 7-day and 21-day search intervals associated with seasons of differing length.

During the 2017 spring season, a total of 61 avian detections (including injured birds and incidentals) of 21 identified species (Table 2) were recorded. Approximately 53% of detections were songbirds, with 40% being other types of bird; 7% could not be identified to an appropriate level. The most numerous detection of an identified species was mourning dove followed by Costa's hummingbird. Most detections occurred in the tower area (Figures 4, 5, 6, and 7), where approximately 154 acres were surveyed, representing 100% of the total tower area.

Table 2. Number of Individual Bird Detections, by Species, 2017 Spring Season.

Species	Scientific Name	Injuries	Fatalities	Songbird?
unidentified bird (small)	unidentified	0	11	NA
mourning dove	*Zenaida macroura*	2	6	No
Costa's hummingbird	*Calypte costae*	0	5	No
yellow-rumped warbler	*Setophaga coronata*	0	4	Yes
unidentified dove	*Columbina spp*	0	2	No
Eurasian collared-dove	*Streptopelia decaocto*	0	2	No
eared grebe	*Podiceps nigricollis*	0	2	No
unidentified grebe	unidentified	0	2	No
Wilson's warbler	*Cardellina pusilla*	0	2	Yes
American robin	*Turdus migratorius*	0	2	Yes
unidentified warbler	*unidentified*	0	2	Yes
common poorwill	*Phalaenoptilus nuttallii*	0	1	No
black-throated sparrow	*Amphispiza bilineata*	0	1	Yes
horned lark	*Eremophila alpestris*	0	1	Yes
house finch	*Haemorhous mexicanus*	0	1	Yes
barn swallow	*Hirundo rustica*	0	1	Yes
hooded oriole	*Icterus cucullatus*	0	1	Yes
brown-headed cowbird	*Molothrus ater*	0	1	Yes
sage thrasher	*Oreoscoptes montanus*	0	1	Yes
cliff swallow	*Petrochelidon pyrrhonota*	0	1	Yes
yellow warbler	*Setophaga petechia*	0	1	Yes
northern rough-winged swallow	*Stelgidopteryx serripennis*	0	1	Yes
tree swallow	*Tachycineta bicolor*	0	1	Yes
unidentified sparrow	unidentified	0	1	Yes

Species	Scientific Name	Injuries	Fatalities	Songbird?
American kestrel	*Falco sparverius*	0	1	No
unidentified shorebird	unidentified	0	1	No
black-chinned hummingbird	*Archilochus alexandri*	0	1	No
unidentified hummingbird	unidentified	0	1	No
unidentified large bird	unidentified	0	1	NA
unidentified duck	unidentified	0	1	No
Total		2	59	NA*

*NA – Not Applicable

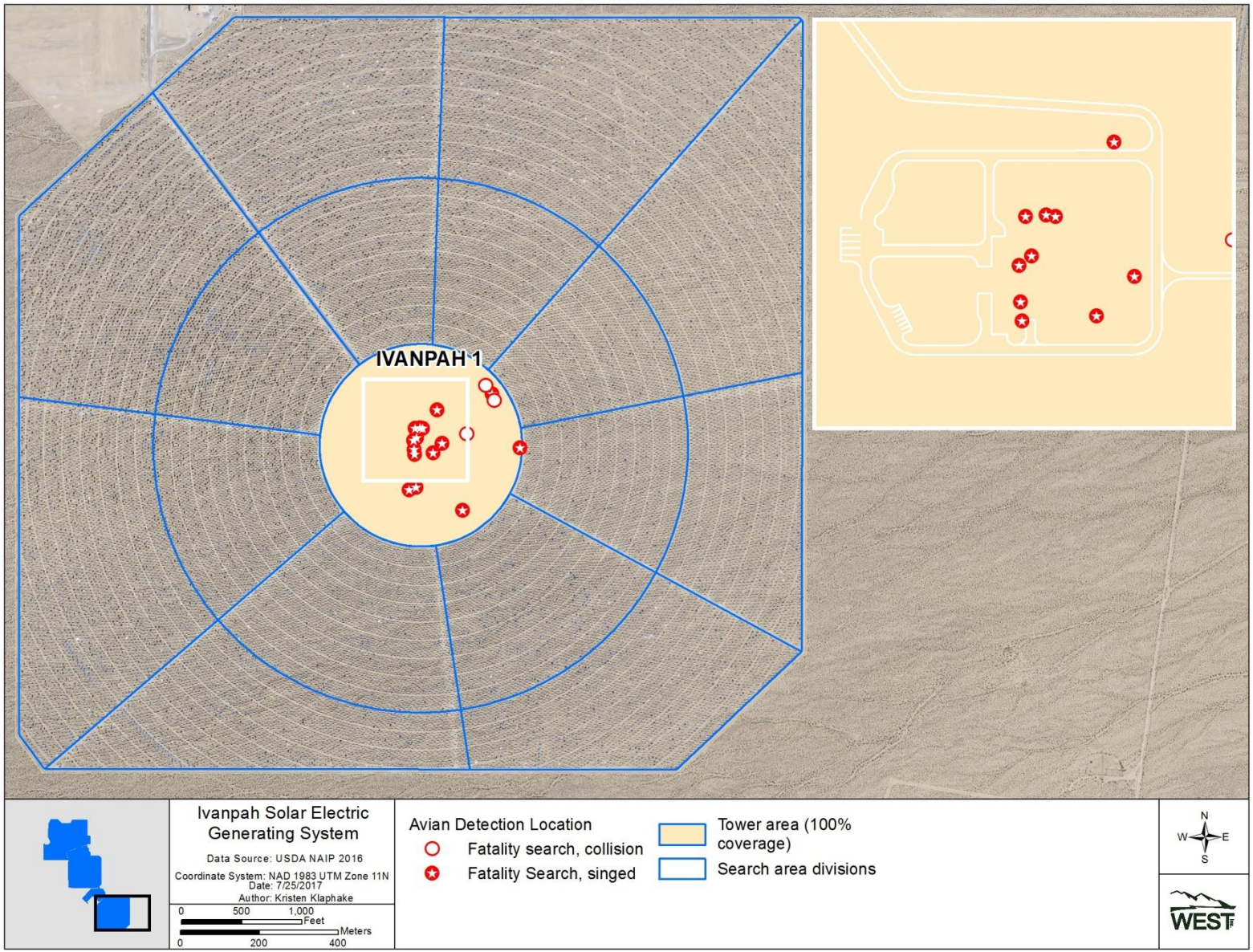

Figure 4. Ivanpah 1 Detections.

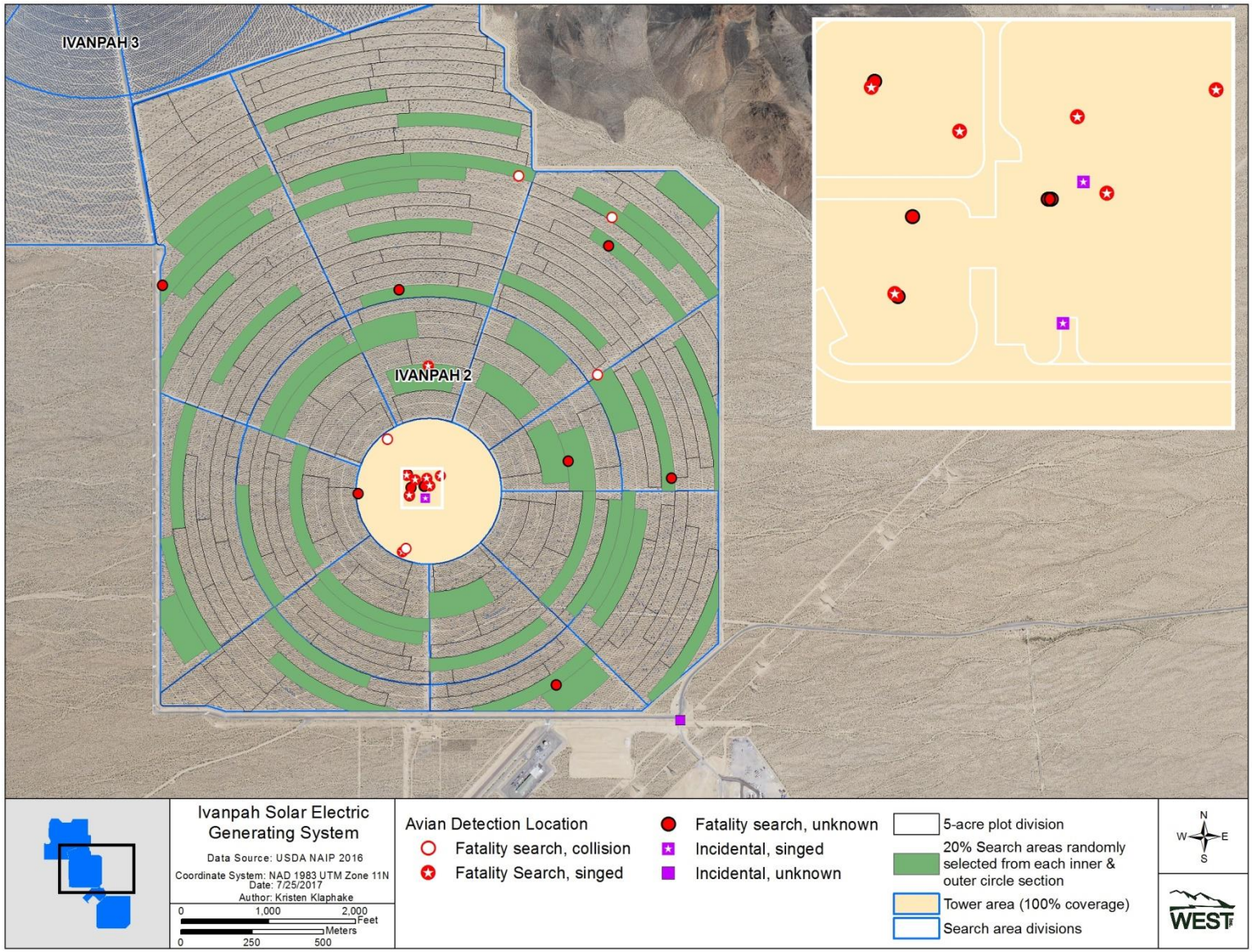

Figure 5. Ivanpah 2 Detections.

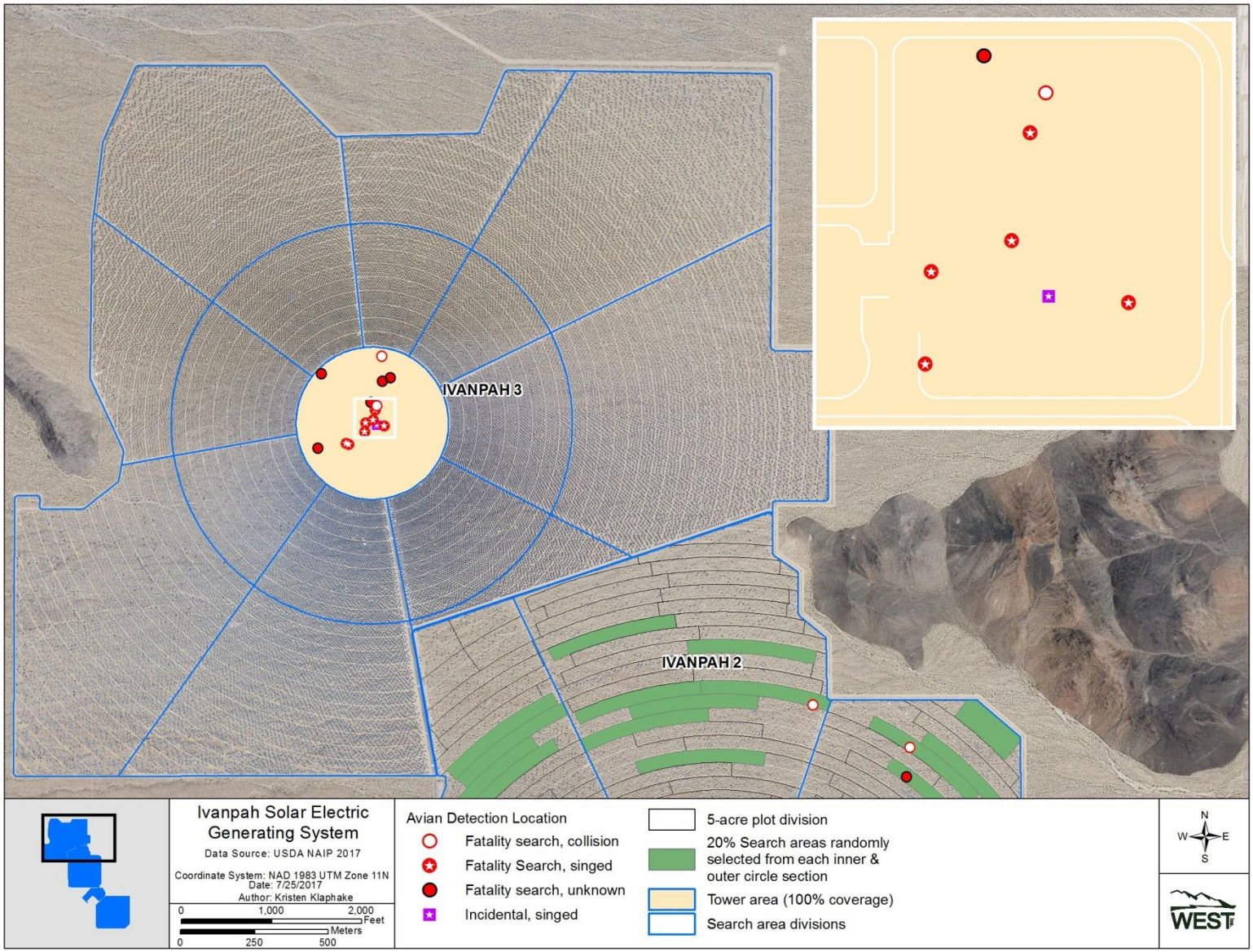

Figure 6. Ivanpah 3 Detections.

3.1.1 Temporal Patterns of Avian Detections

The number of detections reported per day was low throughout the 2017 spring season with limited peaks though early May. BirdCast reported local light to moderate movements of migrants in the Desert Southwest throughout the spring season except for moderate to locally heavy movements in the Desert Southwest from 5-7 May. The highest number of singed detections (four detections) was found following this period.

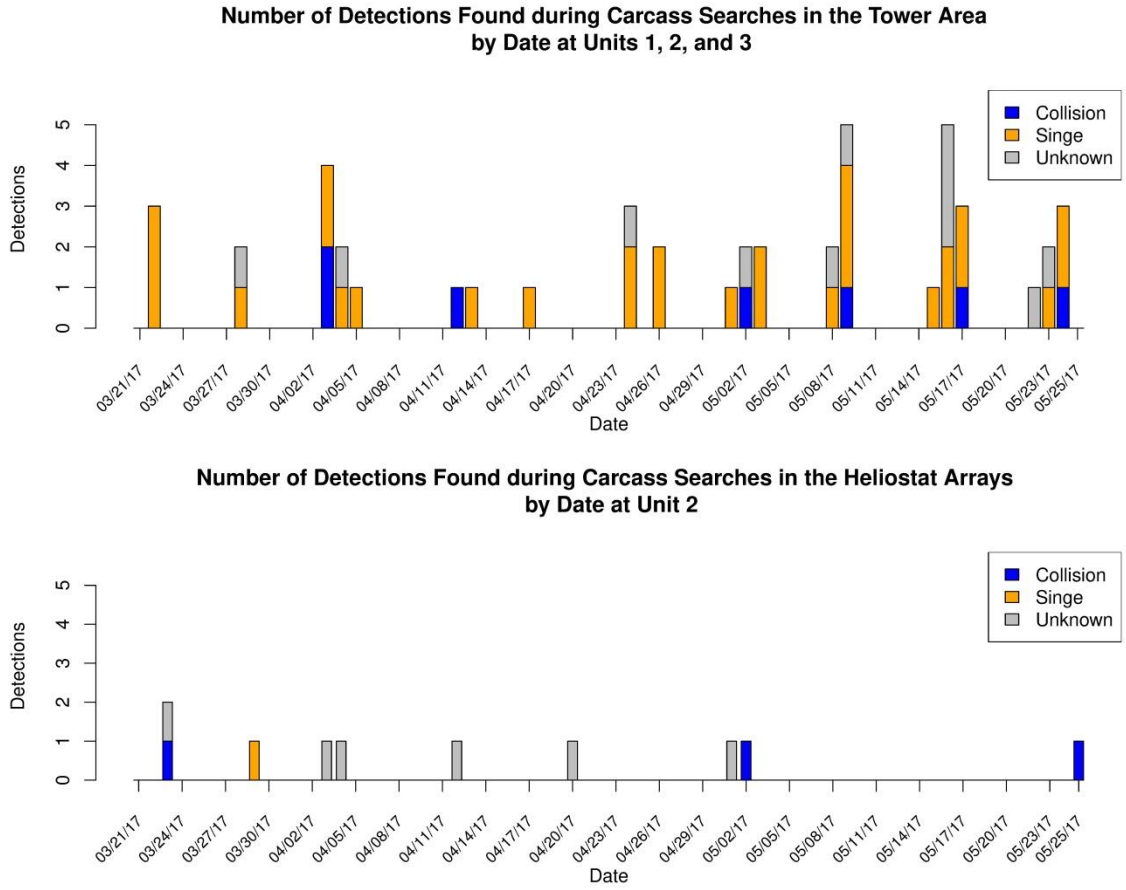

Figure 7. Number of Detections on Each Survey Date, 21 March – 25 May 2017.

Two injured mourning doves that appeared to have collided with heliostat infrastructure in the inner HD were detected and taken to taken to Animal Kingdom Veterinary Hospital during the 2017 spring season (Table 3).

Table 3. Avian Injuries Detected 21 March – 25 May 2017.

Date	Species	Age	Sex	Cause of Injury	Flux Grade	Fate
5/2/17	Mourning dove	Adult	Unknown	Collision	NA	Transported to rehab and subsequently released
5/9/17	Mourning dove	Adult	Unknown	Collision	NA	Transported to rehab and subsequently released

3.1.3 Summary of Bat Detections

Five bats representing three species were detected during the 2017 spring season. A California myotis and two Mexican free-tailed bats were found in the ACC of Unit 1. A California myotis and canyon bat were found in the ACC of Unit 3. Given the few detections of bats, they are not discussed further.

3.2 Locations of Avian Detections

3.2.1 Detections by Project Area

During spring 2017, of the 61 total detections, 50 detections (82.0%) were recorded at the tower area and 10 detections (16.4%) were recorded over the heliostat area (Table 4). Of the 61 avian detections, 18 (29.5%) were detected in Unit 1, 28 (45.9%) in Unit 2, and 15 (24.6%) in Unit 3.

Table 4. Locations of Avian Detections, 21 March 2017 – 25 May 2017.

Location	Carcasses	Injuries	Percent of Total
Tower Area	48	2	82.0%
Heliostat Area	10	0	16.4%
Other Project Lands	1	0	1.6%
Total	59	2	100%

3.3 Cause of Injury or Fatality

The following section describes the number of detections with evidence of singeing or collision; the number from other known causes; the number for which cause of injury or fatality is unknown; and the spatial distributions of detections with these causes. Figure 8 shows the distribution of detections by cause.

3.3.1 Singeing Effects

Of the 61 avian detections during the 2017 spring season, 33 detections (54.1%) showed signs of singed feather damage, and 97% of singed detections were recorded in the tower area (Table 5). One American kestrel (*Falco sparverius*) with evidence of singed feathers was detected in the inner heliostat segments of the Unit 2 heliostat area.

3.3.2 Collisions

Of the 61 avian detections, evidence of collision was observed in the case of 10 (16.4%). As described in Section 2.2.1.3, the evidence that was used to classify this detections as collisions was obvious physical trauma, proximity to heliostats that had smudge marks, body imprints, and/or feathers on or near the surface of the mirror (although birds that collide with structures do not always leave visible evidence).

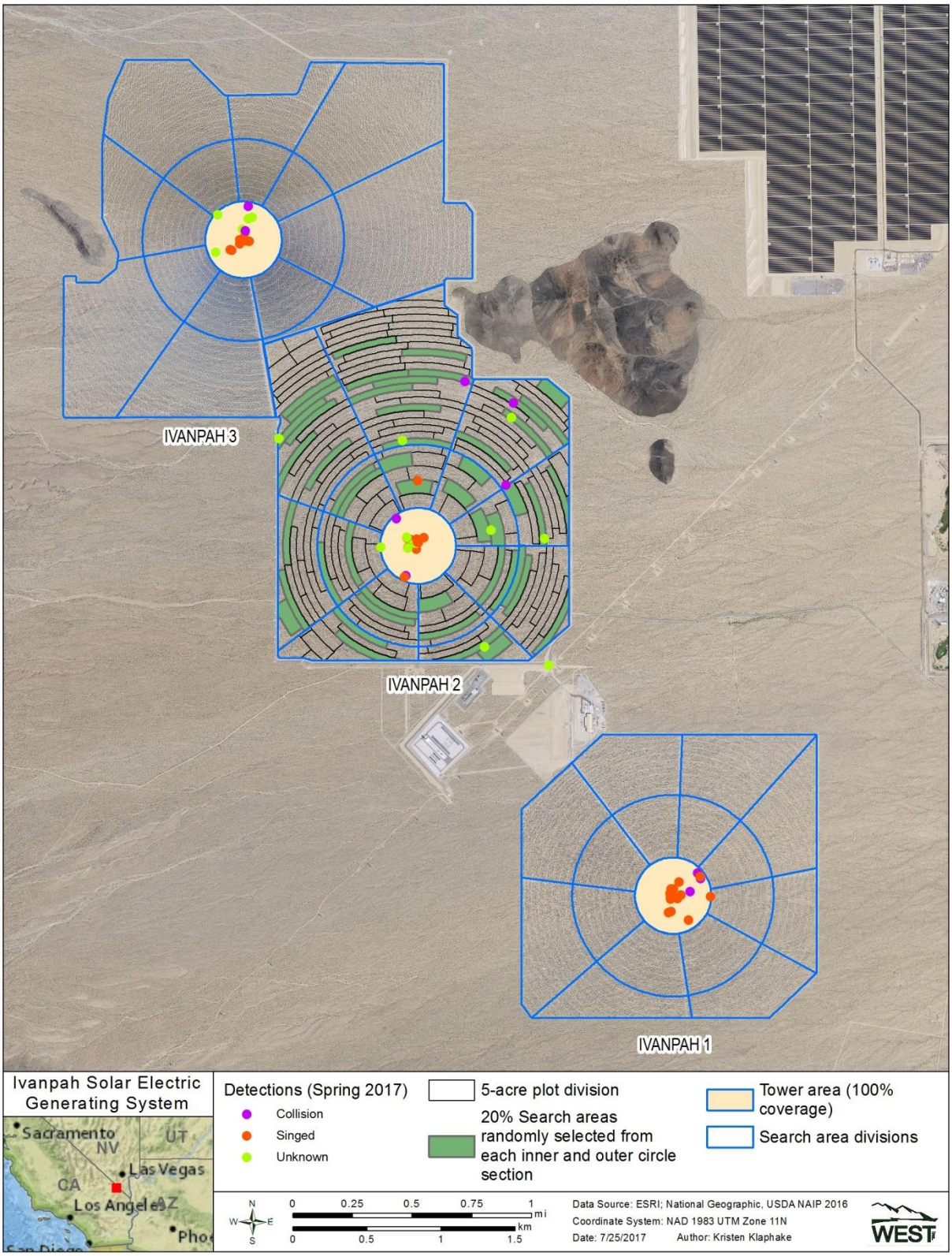

Figure 8. Locations of Singed and Unsinged Detections within Solar Units.

3.3.4 Detections of Unknown Cause

Of the 61 avian detections, evidence of singeing, collision, or other cause could not be assigned for 18 detections (29.5%; Table 5). Per the Plan section 2.1, these detections cannot be presumed with or presumed without a reasonable doubt to be caused by the facility; see Section 6.2 of this report for further discussion. These detections showed no evidence of collision effects, and microscopic analysis did not indicate signs of singeing. Of the unknown cause detections, 11 (61.1%) were recorded in the tower area and 6 (33.3%) were recorded in the heliostat area. One detection of unknown cause was found on the road near the common logistics area. Of these 18 unknown detections, 10 (55.6%) were feather spots, 7 (38.9%) broken-up carcasses that had been scavenged, and only 1 (5.6%) was of a whole carcass.

Table 5. Locations of Bird Detections, 21 March 2017 – 25 May 2017.

Location	Singed	Collision	Unknown	Total
Tower Area	32	7	11	50
Heliostat Area	1	3	6	10
Other Project Lands	0	0	1	1
Total	33	10	18	61

3.4 Types of Detections

Thirty-three (54.1%) of the 61 detections consisted only of feather spots (Table 6a). Feather spots accounted for 100% of the detections on other project lands, 90% of detections in the heliostats area, and 46% of the detections in the tower area. Percent of the detections that were feather spots was lowest in the tower area (46%), and no detections in the ACC were feather spots. Evidence of singeing was noted through direct and microscopic examination on one of these 13 feather spots; evidence of collision (i.e., an impact imprint on a nearby mirror) was noted in the case of three feather spots. Otherwise, the causes of the feather spots for the other 17 detections are unknown (Table 6b).

Table 6a. Percent Composition Feather Spots to Carcasses Relative to Site Locations.

Location	Carcasses	Feather Spots/Partial Carcasses	Total Detections	Percent Feather Spot*
Tower Area	27	23	50	46.0%
Heliostat Area	1	9	10	90.0%
Other Project Lands	0	1	1	100%
Total	28	33	61	54.1%

*Percent feather spot is total feather spots/partial carcasses divided by total detections.

Table 6b. Percent Composition Feather Spots to Carcasses Relative to Cause.

Cause	Carcasses	Feather Spots/Partial Carcasses	Total Detections	Percent Feather Spot*
Singed	20	13	33	39.4%
Collision	7	3	10	30.0%
Unknown	1	17	18	94.4%
Total	28	33	61	54.1%

*Total percent feather spot is total feather spots divided by total detections.

Section 4.0 Fatality Estimation

This section utilizes the detection data as described in Section 3 to develop an overall fatality estimate in accordance with the Plan (2015). The total estimate for the entire facility is presented separately for fatalities with evidence of singeing or collision effects, or for detections in the ACC buildings, and fatalities of unknown cause. Following presentation of the total fatality estimates, estimates are provided separately for the tower area and heliostat area.

4.1 Estimating Model Parameters

4.1.1 Carcass persistence Trials

A total of 20 small bird carcass persistence trials were conducted during the 2017 spring monitoring season. Trials were distributed throughout the facility. Consistent with previous seasons, scavengers included common ravens (*Corvus corax*, N=11), desert kit fox (*Vulpes macrotis*; N=4), and white-tailed antelope squirrels (*Ammospermophilus leucurus*; N=1). In 3 instances no scavenger was captured on film. Small bird carcass persistence ranged from less than one day in the case of 2 carcasses, to 49 days; two carcasses lasted the full six week trial period (Figure 9). Large bird carcass persistence trials were discontinued beginning fall 2015 per TAC approval because no seasonal effects were found in previous large bird models and most trial carcasses persisted at least 42 days (Figure 10).

In addition to the 2017 spring trials described above, carcass persistence trials from the first three years and the first season (winter) of the fourth year of monitoring were also used in the model. Carcass persistence data from 20 carcass persistence trials conducted during the 2016 - 2017 winter season (20 small birds), 92 carcass persistence trials conducted during the 2015 - 2016 monitoring year (92 small birds), carcass persistence data from 127 carcass persistence trials conducted during the 2014 - 2015 monitoring year (97 small birds and 30 large birds distributed throughout the facility), and data from 87 trials (57 small birds and 30 large birds distributed throughout the facility) performed during the first year of monitoring (29 October 2013 – 20 October 2014) were used to model carcass persistence time. Details on carcass persistence times can be found in each respective seasonal report.

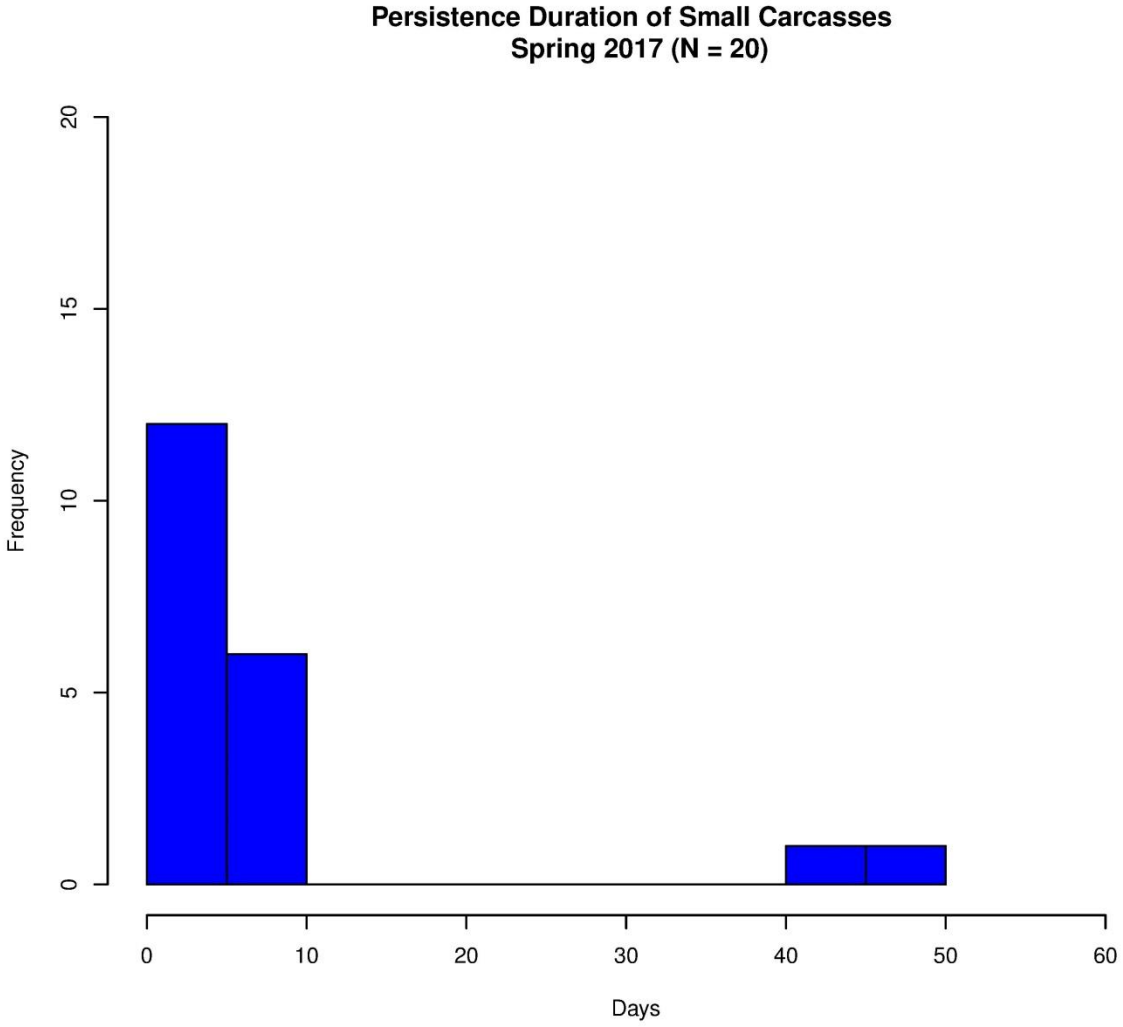

Figure 9. Persistence Durations for Small Carcasses Placed for 2017 Spring Carcass Persistence Trials (N = 20).

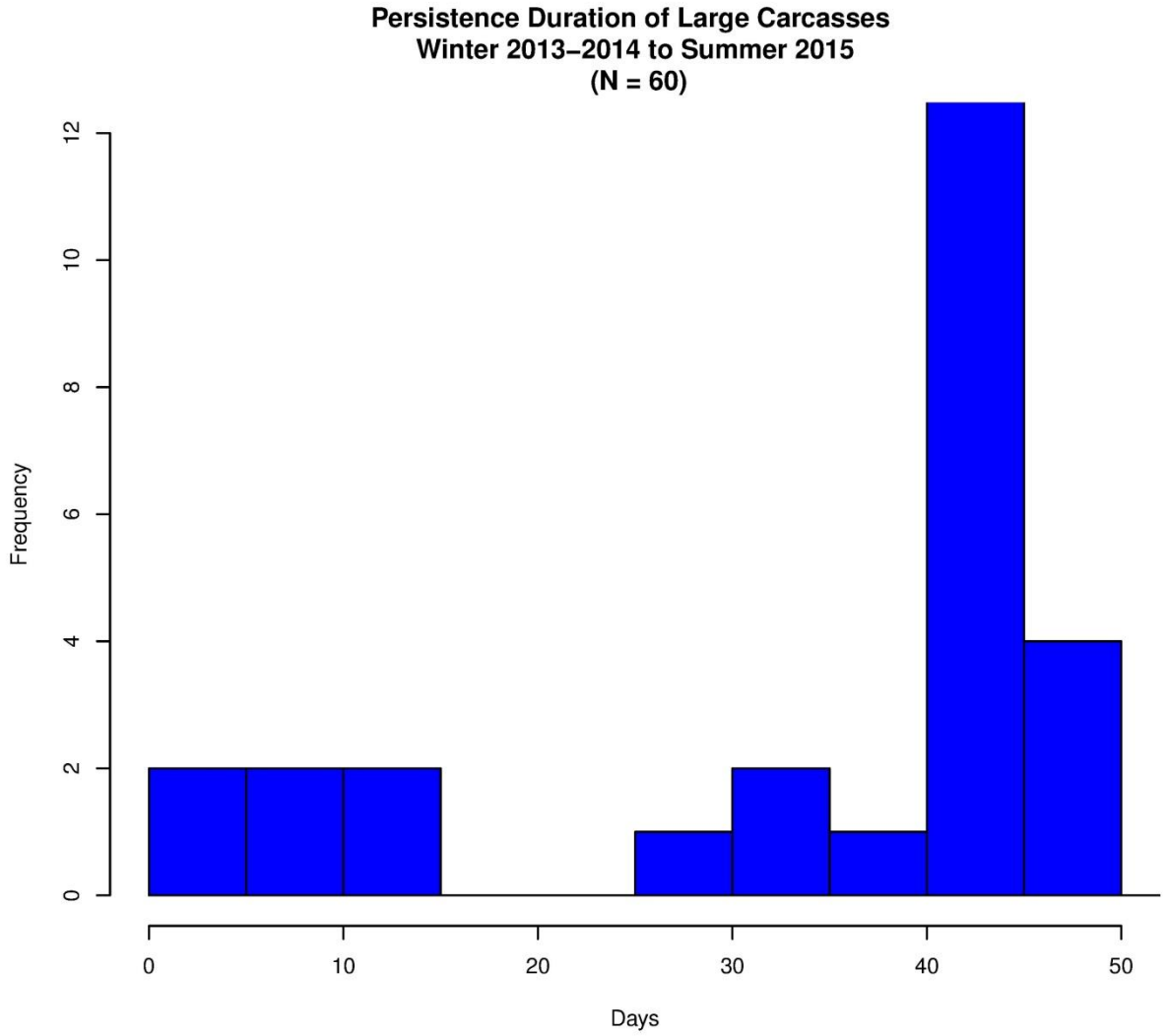

Figure 10. Persistence Durations for Large Carcasses Placed for All Carcass Persistence Trials.

4.1.2 Model Selection for Carcass Persistence Distribution

Consistent with the findings that the removal process for small birds and large birds has been markedly different, two separate carcass persistence models were fit to this dataset: one for small birds and one for large birds. Specifically, large birds consistently persist for long periods of time (typically greater than six weeks), while small birds tend to be removed with days or hours, and exhibit seasonal variability. Fitting separate models by size allows for more flexibility, enabling different distributions with different shapes to be fit to the small bird and large bird data, respectively.

Based on the carcass persistence data from the cumulative trials, 16 survival models were compared for the small bird and large bird datasets, respectively. Models were compared for relative explanatory power using the corrected Akaike information criterion (AICc) score (Akaike 1973), as suggested in Huso (2010). AICc provides a relative measure of model fit and parsimony among a selection of candidate models. Season was considered as a possible covariate due to cyclical variation in scavenging pressure and environmental conditions associated with seasons. Year was also incorporated as a covariate to

assess whether respective seasons could be pooled across the first three years (i.e. combine 2014 fall with 2015 fall and 2016 fall persistence trial results). At the conclusion of the first year of monitoring, the location of a carcass (unvegetated tower area or the vegetated heliostat area, fenceline, or collector line) was not present in the top models for carcass persistence. Thus, carcass location was not included as a covariate for this report.

The model with lowest AICc is typically chosen as the "best-fit" model relative to other models tested; however, any model within two AICc point of the best model is considered strongly supported (Burnham and Anderson 2004). For small birds the loglogistic model that included year+season had ΔAICc values ≤ 2; for large birds, the exponential, Weibull, loglogistic, and lognormal models with intercept only had ΔAICc values ≤ 2 (Tables 7a and 7b). Ultimately, a loglogistic model with year + season covariate was chosen for small birds, and an exponential model with no covariates was chosen for large birds. Thus, the selected model for small birds can be interpreted to treat as separate the persistence probability for each season in each year. For large birds, the top model does not have any temporal covariates, and thus uses all large bird data collected to date to estimate persistence probability. The chosen models predicted 98.8% of large carcasses persisted for the nominal search interval (7 days), and 49.3% of small bird carcasses persisted for the nominal search interval of during the 2017 spring monitoring season.

Table 7a. AICc Values for Small Bird Carcass Persistence Models

Small Bird Trials			
Covariates	Distribution	AICc	Δ AICc
Year + Season	loglogistic	1423.49	0
Season + Year + Project Area	loglogistic	1425.47	1.98
Season	loglogistic	1425.94	2.45
Season + Project Area	loglogistic	1427.47	3.98
Year + Season	lognormal	1427.97	4.48
Year + Season + Year*Season	loglogistic	1428.36	4.87
Season	lognormal	1428.64	5.15
Season + Year + Project Area	lognormal	1429.99	6.50
Season + Project Area	lognormal	1430.24	6.75
Year + Season + Year*Season	lognormal	1434.55	11.06
Intercept	loglogistic	1435.26	11.77
Year + Season	weibull	1435.35	11.86
Season + Year + Project Area	weibull	1436.37	12.88
Intercept	lognormal	1436.47	12.98
Year + Season + Year*Season	weibull	1443.86	20.37
Season	weibull	1448.09	24.60

Table 7b. AICc Values for Large Bird Carcass Persistence Models

Large Bird Trials			
Covariates	Distribution	AICc	Δ AICc
Intercept	exponential	97.00	0
Intercept	weibull	97.96	0.96
Intercept	loglogistic	98.03	1.03
Intercept	lognormal	98.15	1.15
Year + Season	exponential	101.15	4.15
Year + Season	lognormal	101.42	4.42
Season	exponential	101.48	4.48
Year + Season	loglogistic	102.22	5.22
Season	lognormal	102.38	5.38
Year + Season	weibull	102.60	5.60
Season	loglogistic	102.70	5.70
Season	weibull	102.73	5.73
Year + Season + Year*Season	exponential	107.18	10.18
Year + Season + Year*Season	lognormal	108.60	11.60
Year + Season + Year*Season	loglogistic	108.88	11.88
Year + Season + Year*Season	weibull	108.93	11.93

4.1.3 Searcher Efficiency Trials

During the 2017 spring season, a total of 74 searcher efficiency trials (22 small birds, 29 large birds, and 23 feather spots) were placed. Trials were placed in locations with various vegetation heights and with a range of contrast between the soil and vegetation to represent the various conditions under which searches occur. Carcasses were placed in most areas where searches occurred (tower area and heliostat area). Fourteen trials (2 small birds, 9 large birds, and 3 feather spots) were removed (scavenged) prior to a searcher having the opportunity to detect the carcass.

Trial data from the winter season of year four, and first three years of monitoring were used to fit a searcher efficiency model for the 2017 spring season. Of the 74 (22 small birds, 29 large birds, and 23 feather spots) trials placed in the 2016-2017 winter season, 60 (20 small birds, 20 large birds, 20 feather spots) were available to be found. Of the 306 human searcher efficiency trials conducted during the 2015-2016 monitoring year (124 small birds, 93 large birds, and 89 feather spots), 263 (95 small carcasses, 83 large carcasses, and 85 feather spots) were available to be found; 43 carcasses (29 small carcasses, 10 large carcasses, and 4 feather spot) were removed from the trial location before searchers had an opportunity to detect the carcass. Of the 320 human searcher efficiency trials conducted in the 2014 – 2015 monitoring year (129 small birds, 96 large birds, and 95 feather spots) 268 (129 small carcasses, 96 large carcasses, and 95 feather spots) were available to be found; 52 carcasses (42 small carcasses, 8 large carcass, and 2 feather spots) were removed from the trial location before searchers had an opportunity to detect the carcass. An additional 154 searcher efficiency trials from the first year of study (2013 – 2014)

were also included in searcher efficiency model building. Of 154 trials from the first year of monitoring, 144 were not removed and thus available to be found by a searcher.

Human searcher efficiency rates based on raw data collected during the 2017 spring season were variable by project area. Detection rates were equal or better for all size classes in the unvegetated tower area than the vegetated heliostat area. Based on the trials conducted during the 2017 spring season, in unvegetated areas, searcher efficiency was 80% for small birds, 100% for large birds, and 90% for feather spots. In the vegetated areas in the heliostat arrays, human searcher efficiency was 17% for small birds, 60% for large birds, and 90% for feather spots.

Table 8. Covariates, AICc Values, and ΔAICc values for the top ten searcher efficiency models. Data consist of all human searcher efficiency trials for carcasses from the initiation of trials through May 25, 2017.

Covariates	AICc	Δ AICc
Size + Project Area + Year + Size*Project Area	954.66	0.00
Size + Project Area + Year	954.70	0.04
Size + Project Area + Year + Size*Project Area + Size*Year	955.03	0.37
Size + Project Area	955.32	0.66
Size + Project Area + Size*Project Area	955.50	0.85
Size + Project Area + Year + Size*Year	956.25	1.59
Size + Project Area + Season + Year + Size*Project Area + Size*Year	956.43	1.77
Size + Project Area + Season + Year + Size*Project Area	957.51	2.86
Size + Project Area + Year + Project Area*Year	957.52	2.86
Size + Project Area + Season + Year	957.60	2.94

The selected model for searcher efficiency included carcass size and project area, with an AICc value 0.66 points higher than the lowest AICc model (Table 8); the model with covariates for size and project area was selected because it was the most parsimonious model within 2 AICc points of the lowest AICc model, and thus considered equally supported by the data. The most supported searcher efficiency model produces searcher efficiency estimates based on carcass size, project area (unvegetated tower area and vegetated heliostat area). Searcher efficiency values used to adjust detections to calculate a fatality estimate are provided in Table 9 and are based on all searcher efficiency data collected to date and the selected model described above.

Table 9. Human Searcher Efficiency Sample Sizes Used for Modeling, and Model Predictions for Size and Project Area Categories Winter 1 – Spring 4.

Size	Location	Found	Available	Placed	Predicted Searcher Efficiency (90% CI)
Feather spot	Tower area (Unvegetated)	97	134	138	0.76 (0.71-0.81)
Small bird	Tower area (Unvegetated)	101	135	174	0.71 (0.65-0.76)
Large bird	Tower area (Unvegetated)	107	123	138	0.87 (0.84-0.90)
Feather spot	Heliostat area (Vegetated)	71	141	146	0.47 (0.41-0.52)
Small bird	Heliostat area (Vegetated)	49	137	177	0.40 (0.34-0.46)
Large bird	Heliostat area (Vegetated)	83	127	146	0.65 (0.59-0.71)

4.2 Fatality Estimates of Known Causes for 2017 Spring Monitoring

Fatality estimates were calculated separately for the tower area (power block and inner HD heliostats) and heliostat area. Note that estimates are not provided for factor combinations with five or fewer detections; thus, marginal totals (e.g. total singed, total known cause in the heliostat area, etc.) for the tables below may not reflect the sum of estimates within a given row or column (and are generally higher).

4.3.1 Total Fatality Estimates for Known Causes

There were 43 bird detections where the cause of death or injury could be determined and were facility related, of which 36 were included in the fatality estimate model (Tables 10a and 10b); of these 36 detections, 4 were from the ACC that were added unadjusted to the estimator output, to produce the total fatality estimate of known cause (Tables 11 and 12). Seven detections were excluded because they were determined to be older than the search interval.

Table 10a. Number of Bird Detections Based on Known Causes in Each Project Element Included or Excluded from Fatality Estimates, by Cause.

	Included			Excluded			
Location	Collision	Singed	Other	Collision	Singed	Other	Total
Tower Area	7	25	0	0	7	0	39
Heliostat Area	3	1	0	0	0	0	4
Total	10	26	0	0	7	0	43

Table 10b. Number of Bird Detections Based on Known Causes in Each Project Element Included or Excluded from Fatality Estimates, by Carcass Size.

	Included			Excluded			
Location	Large Birds	Small Birds	Raptors*	Large Birds	Small Birds	Raptors*	Total
Tower Area	5	27	0	1	6	0	39
Heliostat Area	3	1	1	0	0	0	4
Total	8	28	0	1	6	0	43

* All raptors are considered "Large Birds;" therefore, the number of raptor detections in a row or column is not added to the total.

Table 11. 2017 Spring Season Avian Fatality Estimates by Cause and Project Element (with Lower and Upper 90% Confidence Intervals) Based on Detections of Known Causes Included in the Model.

Location	Collision	Singed	Total Known Cause
Tower Area	12 (11-13)	62 (53-74)	84 (73-99)
Heliostat Area	N ≤ 5	N ≤ 5	N ≤ 5
Total	132 (13-283)	89 (55-145)	221 (100-384))

* N ≤ 5 indicates 5 or fewer detections and no fatality estimate is provided

Table 12. 2017 Spring Season Avian Fatality Estimates by Carcass Size and Project Element (with Lower and Upper 90% Confidence Intervals) Based on Detections of Known Causes Included in the Model.

Location	Large Birds	Small Birds	Raptors	Total
Tower Area	N ≤ 5	67 (57-81)	0	73 (63-87)
Heliostat Area	N ≤ 5	N ≤ 5	N ≤ 5	N ≤ 5
Total	87 (29-177)	134 (60-273)	0	221 (100-384)

* N ≤ 5 indicates 5 or fewer detections and no fatality estimate is provided

4.3.2 Fatality Estimate for Tower Area and Heliostat Area

Tables 11 and 12 present the fatality estimates for known causes within the tower area, broken down by cause or carcass size, respectively. A subset of the incidental detections in the power block were included within the tower area total estimate, due to the assumption of a daily search interval; those incidental detections in the power block which were determined to be older than 24 hours were not included in the fatality estimator. Estimates from the tower area should be interpreted with caution due to the inclusion of numerous incidental discoveries in the power block.

During the period 21 March 2017 – 25 May 2017 (66 days of monitoring), there were an estimated 221 fatalities (90% confidence interval 100-384) based on detections from known causes (i.e., singeing, collision; Table 11). Of these, all 73 fatalities (100%) were estimated for the 154 acre tower area. Small birds accounted for 61% of the estimated fatalities of known causes (Table 12).

4.4 Fatality Estimates from Unknown Causes

Per Section 3.1 of the Plan, fatality estimates are also to be provided based on detections of birds that were injured or that died of unknown causes. Because no observable evidence of known causes (i.e., singeing, collision, entrapment, or predation) was noted in the case of these unknown detections, they cannot be clearly included in an estimate attributed to a specific cause. The methods for determining fatality estimates for these unknown detections are the same as those described in Section 5.2 for detections with direct evidence of the cause of the fatality (i.e., singeing, collision, or other).

There were 18 detections where the cause of death could not be determined, of which 11 were included in the fatality estimator (Tables 13a and 13b). Of the 7 detections of unknown cause excluded from the fatality estimator, 6 detections were determined to be older than the search interval, and one detection was found outside of standard search areas.

Table 13a Number of Detections from Unknown Causes in Each Project Element, and Number Included in Fatality Estimates, by Cause.

Location	Included	Excluded	Total
Tower Area	6	5	11
Heliostat Area	5	1	6
Other Project Lands	0	1	1
Total	11	7	18

Table 13b. Number of Detections from Unknown Causes in Each Project Element, and Number Included in Fatality Estimates, by Carcass Size.

	Included			Excluded			
Location	Large Birds	Small Birds	Raptors*	Large Birds	Small Birds	Raptors*	Total
Tower Area	4	2	0	1	4	0	11
Heliostat Area	3	2	0	1	0	0	6
Other Project Lands	0	0	0	1	0	0	1
Total	7	4	0	3	4	0	18

* All raptors are considered "Large Birds;" therefore, the number of raptor detections in a row or column is not added to the total.

4.4.1 Total Fatality Estimates from Unknown Causes

During the period of 21 March 2017 – 25 May 2017, the total estimate of fatalities from unknown cause was 195 (90% confidence interval 65-347; Table 14). A total of 11 (90% confidence interval 10-12) were estimated for the tower area, five or fewer detections were found in the heliostat area therefore no estimate is provided.

Table 14. Site-Wide Fatality Estimates from Unknown Causes by Location, 21 March – 25 May 2017.

Project Area	Estimate (90% CI)
Tower Area	11 (10-12)
Heliostat Area	N ≤ 5
Total	195 (65-347)

Table 15. Site-Wide Fatality Estimates from Unknown Causes by Size and Location, 21 March – 25 May 2017.

Location	Large Birds	Small Birds	Raptors	Total
Tower Area	N ≤ 5	N ≤ 5	0	11 (10-12)
Heliostat Area	N ≤ 5	N ≤ 5	0	N ≤ 5
Total	86 (29-164)	N ≤ 5	0	195 (65-347))

* N ≤ 5 indicates 5 or fewer detections and no fatality estimate is provided

4.6 Regional Awareness Monitoring

During the 2017 spring season, 2 injured birds were taken to rehab. In accordance with the Plan, the rehab centers to which injured birds were transported were asked if they had received any birds with singed feathers or evidence of concentrated-flux effects; no records of singed birds were reported by any rehab center. Furthermore, neither the Ivanpah facility nor its designated biologist was contacted by any veterinarian or rehab center about singed birds brought in by non-project staff.

Section 5.0 Discussion

The 2017 spring season represented the continuation of standardized monitoring of avian and bat detections of the Ivanpah site as revised per the Avian & Bat Monitoring and Management Plan (2015).

5.1 Temporal Patterns in Detections

The number of detections reported at the tower area was low throughout the 2017 spring season with several small peaks in May with no day exceeding four known cause detections. Scattered light to moderate migration movements in the Desert Southwest were reported by the BirdCast analysis through June 2. The 7-day search interval results in an accumulation of carcasses at the tower area, and peaks in detections are associated with tower searches. Thus, a tower area search during the 2017 spring season is a look back over approximately 7 days, so small lag effects in detections per day compared to the coarse migrant songbird activity reported by BirdCast is expected. In other words, it would be expected that singed detections of migrant birds would be found after migration has started, or slowed, regionally due to the search schedule.

5.2 Spatial Patterns Detections and Fatality Estimates

The distribution of known cause detections varied by facility area. Of singed detections, 93% (all but one detection, which was found in an inner heliostats segment) were found within the tower area, consistent with the location of flux exposure risk. More collision detections (70%) were found in the tower area compared to the heliostat area (30%), which could be attributed to the small sample of collision detections (n = 10).

Unknown cause detections accounted for approximately 29.5% of all detections during the 2017 spring season. Regardless of where unknown cause detections were found, all were closely examined for signs of singeing. Of the unknown cause detections, 94.4% were feather spots or partial carcasses that showed signs of scavenging. Determining a cause of mortality from a feather spot or partial carcass is challenging because sources of mortality such as collision or predation would rarely leave visible evidence on the feathers as compared to flux effects. Thus, feather spots with an unknown cause of mortality could be encountered anywhere birds occur, and an unknown cause of mortality is not unique to the Project. Further, the large proportion of feather spots among the detections for the Project as a whole may inflate the fatality estimate when unknown cause detections are included based on the potential for multiple feather spots resulting from one fatality, feather spots resulting from predation not associated with the facility, or other causes.

Section 6.0 Framework for Management and Risk Response

According to Section 5.3 of the Plan, migratory bird mortality at Ivanpah is categorized as high, medium, or low to provide an appropriate biological basis for TAC review and decision making, based on the following definitions:

1. "High: Estimated avian mortality or injury levels are facility-caused and likely to seriously and negatively affect local, regional, or national avian populations within a particular species or group of species."
2. "Medium: Estimated avian mortality or injury levels are facility-caused and have the potential to negatively affect local, regional, or national populations within a particular avian species or group of species."
3. "Low: Estimated avian mortality or injury levels that have minimal or no potential to negatively affect local, regional, or national populations within a particular species or group of species."

Only limited conclusions can be drawn from the 2017 spring season fatality data owing to the low numbers of detections within "a particular species or group of species"; however, the results indicate that the potential migratory bird mortality by species or groups of species from this project would be categorized as low. Approximately 53% of the species or species groups were songbirds, and in general songbirds are short-lived, have high reproductive output, and their population growth rates are less sensitive to changes in survival rates than to changes in reproductive rates (Stahl and Oli 2006). Therefore, mortality of most songbird species is expected to have negligible effects on population dynamics. A more complete analysis will be conducted for the annual report.

None of the three identifiable species represented by more than three detections is listed or particularly rare locally, regionally, or nationally. Rather, all three species are relatively abundant and widespread. Thus, the magnitude of detections of these species at Ivanpah during the 2017 spring season does not rise above the "low" category. Special-status species recorded as detections were a single yellow warbler (California species of special concern), a transient that breeds elsewhere.

Yellow warblers are one of the most abundant warblers in North America and occur as both migrants and summer residents in California (Shuford and Gardali 2008). Yellow warblers occur in the Mojave Desert as common migrants, but they typically do not breed there. An estimated 600,000 yellow warblers occur within California and an estimated 34,000,000 occur in the United States (Partners in Flight Science Committee 2013). The one yellow warbler detected represented a very small proportion of these populations; thus, the estimated yellow warbler fatalities during the 2017 spring season not rise above the "low" category, as loss of this magnitude would have a minimal effect on populations at all geographic scales (local, regional, national or global).

Section 7.0 Literature Cited

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Appendix A. Individual Avian Detections.

USFWS #	Common Name	Species Code	How Found	Detection Date	Collection Date	Condition	Time Since Death/Injury	Description of Carcass/Injury	Cause of Death/Injury	Burn Grade	Unit	Nearest Project Feature	UTM Coordinates	SPUT Revisions
2017_014_ISEGS	Unknown Small Bird	UNID	Carcass Survey	3/22/2017	3/22/2017	Broken up	2 weeks	Whole carcass minus section of head. Evidence of singeing to belly with primaries, secondaries, and rectrices singed off.	Scorched or singed	3	1	ACC Building	640372, 3933535	NA
2017_015_ISEGS	Unknown Small Bird	UNID	Carcass Survey	3/22/2017	3/22/2017	Broken up	1 month +	Partial carcass with legs and wings but missing heads. Evidence of singe over entire body.	Scorched or singed	3	1	ACC Building	640359, 3933534	NA
2017_016_ISEGS	Costa's Hummingbird	COHU	Carcass Survey	3/22/2017	3/22/2017	Dead, Semi-fresh (eyes desiccated, rigor mortis)	3-6 days	Whole carcass. Evidence of singeing to all parts of body with all flight feathers singed off.	Scorched or singed	3	2	Powerblock	638657, 3935869	NA
2017_017_ISEGS	Eurasian Collered Dove	ECDO	Carcass Survey	3/23/2017	3/23/2017	Feather spot	3-6 days	Feather spot size small consisting of 20 body feathers, 7 secondaries, and 5 coverts. Evidence of collision with imprint found on heliostat mirror matching feathers and size of species.	Collision with solar panel/heliostat		2	Heliostat	639298, 3936812	NA
2017_018_ISEGS	Sage Thrasher	SATH	Carcass Survey	3/23/2017	3/23/2017	Broken up	3-6 days	Broken up carcass consisting of partial wing pieces and many loose feathers, 6 primaries, 2 retrices, 11 secondaries, and 24 contour feathers. No evidence of collision or singe.	Unknown		2	Heliostat	638548, 3936557	NA
2017_020_ISEGS	Unknown Hummingbird	UNHU	Carcass Survey	3/28/2017	3/28/2017	Broken up	3-6 days	Broken up carcass consisting of a left wing. Evidence of singe on tips of primaries and secondaries.	Scorched or singed	1	2	Powerblock	638585, 3935835	NA
2017_021_ISEGS	Unidentified Small Bird	UNID	Carcass Survey	3/28/2017	3/28/2017	Feather spot	8-24 hours	Feather spot size large consisting of 16 body feathers. No evidence of collision or singe.	Unknown		2	Powerblock	638586, 3935834	NA
2017_022_ISEGS	American Kestrel	AMKE	Carcass Survey	3/29/2017	3/29/2017	Dead, Semi-fresh (eyes desiccated, rigor mortis)	3-6 days	Whole carcass with 4 rectrices and 200 contour feathers. Evidence of singeing to primaries, secondaries, wing coverts, and some contour feathers.	Scorched or singed	3	2	Heliostat	638652, 3936290	NA
2017_023_ISEGS	Tree Swallow	TRES	Carcass Survey	4/3/2017	4/3/2017	Dead, fresh (eyes moist)	3-6 days	Whole carcass. Evidence of collision by broken end section of bill.	Collision (other)		3	ACC Building	637490, 3937971	NA
2017_024_ISEGS	Costa's Hummingbird	COHU	Carcass Survey	4/3/2017	4/3/2017	Dead, Semi-fresh (eyes desiccated, rigor mortis)	2 days	Whole carcass. Evidence of curling to retrices, singeing to throat, flank, top of head, and underside.	Scorched or singed	3	3	Powerblock	637517, 3037903	NA
2017_025_ISEGS	Brown-headed cowbird	BHCO	Carcass Survey	4/3/2017	4/3/2017	Mummified	1 month +	Whole carcass. Evidence of singeing in wing flight feathers.	Scorched or singed	3	3	Powerblock	637453, 3937913	NA

2017_026_ISEGS	Horned Lark	HOLA	Carcass Survey	4/3/2017	4/3/2017	Dead, fresh (eyes moist)	0-8 hours	Whole carcass. Evidence of collision by broken neck and damage to bill.	Collision with solar panel/heliostat		3	Heliostat	637508, 3938139	NA
2017_027_ISEGS	Unknown Large Bird	UNLB	Carcass Survey	4/3/2017	4/3/2017	Feather spot	3-6 days	Feather spot size small consisting of 18 body feathers. No evidence of collision or singe.	Unknown		2	Heliostat	639101, 3935168	NA
2017_028_ISEGS	Costa's Hummingbird	COHU	Carcass Survey	4/4/2017	4/4/2017	Dead, fresh (eyes moist)	8-24 hours	Whole carcass. No evidence of collision or singe.	Unknown		2	Project Feature	638404, 3935840	NA
2017_029_ISEGS	Unknown Small Bird	UNID	Carcass Survey	4/4/2017	4/4/2017	Feather spot	3-6 days	Feather spot size large, consisting of 3 flight feathers, 12 contour feathers. Evidence of curling to flight feathers, singe to contour feathers.	Scorched or singed	3	1	Powerblock	640363, 3933509	NA
2017_030_ISEGS	Mourning Dove	MODO	Carcass Survey	4/4/2017	4/4/2017	Feather spot	8-24 hours	Feather spot size small consisting of 4 retrices and 36 body feathers. No evidence of singe or collision.	Unknown		2	Heliostat	637716, 3936572	NA
2017_031_ISEGS	House Finch	HOFI	Carcass Survey	4/5/2017	4/5/2017	Dead, Semi-fresh (eyes desiccated, rigor mortis)	3-6 days	Whole carcass. Singeing to flight feathers in wings and tail, back, and upperwing coverts.	Scorched or singed	3	1	Heliostat	640555, 3933621	NA
2017_032_ISEGS	Cliff Swallow	CLSW	Carcass Survey	4/12/2017	4/12/2017	Dead, Semi-fresh (eyes desiccated, rigor mortis)	3-6 days	Whole carcass. Evidence of collision with top left of skull fractured.	Collision with solar panel/heliostat		1	Heliostat	640559, 3933605	NA
2017_033_ISEGS	Common Poorwill	COPO	Carcass Survey	4/12/2017	4/12/2017	Feather spot	3-6 days	Feather spot small consisting 3 primaries and 4 coverts. No evidence of collision or singe.	Unknown		2	Heliostat	639285, 3936712	NA
2017_034_ISEGS	Unknown Small Bird	UNID	Carcass Survey	4/13/2017	4/13/2017	Feather spot	3-6 days	Feather spot size small consisting of 4 flight feathers and 16 contour feathers. Evidence of curling to flight feathers, singeing to contour feathers.	Scorched or singed	3	1	Powerblock	640355, 3933503	NA
2017_035_ISEGS	Costa's Hummingbird	COHU	Carcass Survey	4/17/2017	4/17/2017	Dead, Semi-fresh (eyes desiccated, rigor mortis)	2 days	Whole carcass, singed on nape, back, wings; tail singed off; flight feathers curled; contour feathers singed and missing in places.	Scorched or singed	3	3	ACC Building	637485, 3937958	NA
2017_036_ISEGS	Yellow-rumped Warbler	YRWA	Incidental	4/17/2017	4/17/2017	Dead, Semi-fresh (eyes desiccated, rigor mortis)	2 days	Whole carcass, retricies curled. Outer primaries curled. Secondaries, crown, breast and left flank singed	Scorched or singed	3	2	Powerblock	638649, 3935873	NA
2017_037_ISEGS	Eurasian Collered Dove	ECDO	Incidental	4/19/2017	4/19/2017	Feather spot	8-24 hours	Large Feather spot consisting of 1 primary, 1 secondary, 5 retricies and 50+ contour and covert feathers. No evidence of singe or collision.	Unknown		2	Unit 2 Perimeter Fence	639538, 3935043	NA
2017_038_ISEGS	Unknown Grebe	UNGR	Carcass Survey	4/20/2017	4/20/2017	Broken up	1 month +	Broken up carcass of partial wing consisting of 3 primaries, 1	Unknown		2	Heliostat	639507, 3935896	NA

								secondary, and 3 coverts held together by dried flesh. No evidence of collision or singe.						
2017_039_ISEGS	Mourning Dove	MODO	Carcass Survey	4/24/2017	4/24/2017	Broken up	2 days	Broken up carcass consisting of left wing, 4 retrices, 1 primary, and several hundred body feathers. No evidence of collision or singe.	Unknown		3	Heliostat	637509, 3938054	NA
2017_040_ISEGS	Costa's Hummingbird	COHU	Carcass Survey	4/24/2017	4/24/2017	Dead, Semi-fresh (eyes desiccated, rigor mortis)	2 days	Whole carcass. Evidence curling to rectrices, singeing and curling to body feathers.	Scorched or singed	3	3	Powerblock	637396, 3937841	NA
2017_041_ISEGS	Unknown Small Bird	UNID	Carcass Survey	4/24/2017	4/24/2017	Feather spot	3-6 days	Feather spot size small consisting of 40 contour feathers. Evidence of singe on most feathers.	Scorched or singed	Unk	3	Powerblock	637387, 3937844	NA
2017_042_ISEGS	Yellow-rumped Warbler	YRWA	Carcass Survey	4/26/2017	4/26/2017	Dead, Semi-fresh (eyes desiccated, rigor mortis)	3-6 days	Whole carcass with evidence of singeing on breast feathers.	Scorched or singed	3	2	ACC Building	638694, 3935904	NA
2017_043_ISEGS	American Robin	AMRO	Carcass Survey	4/26/2017	4/26/2017	Feather spot	2 weeks	Feather Spot consisting of 5 secondaries and 1 covert. Singe on the trailing edge of two of the secondaries.	Scorched or singed	Unk	2	Powerblock	638607, 3935890	NA
2017_044_ISEGS	Yellow-rumped Warbler	YRWA	Carcass Survey	5/1/2017	NA	Dead, Semi-fresh (eyes desiccated, rigor mortis)	NA	Whole carcass. Curling to flight feathers in wings and tail, singeing to upper breast.	Scorched or singed	Unk	2	ACC Building	638647, 3935895	NA
2017_045_ISEGS	Unknown Dove	UNDV	Carcass Survey	5/1/2017	5/1/2017	Feather spot	3-6 days	Feather spot size large consisting of 36 body feathers. No evidence of collision or singe.	Unknown		2	Heliostat	639144, 3935955	NA
2017_046_ISEGS	Mourning Dove	MODO	Carcass Survey	5/2/2017	5/2/2017	alive, injured	0-8 hours	Alive and injured bird found dazed at base of heliostat. Imprint matching size and shape of bird evident on heliostat mirror.	Collision with solar panel/heliostat		2	Heliostat	638508, 3936032	NA
2017_047_ISEGS	Mourning Dove	MODO	Carcass Survey	5/2/2017	5/2/2017	Feather spot	3-6 days	Feather spot size large consisting of 2 primaries, 1 secondary, 2 rectrices, 1 covert and ten contour feathers. No evidence of collision or singe.	Unknown		3	Heliostat	637536, 3938065	NA
2017_048_ISEGS	Hooded Oriole	HOOR	Incidental	5/2/2017	5/2/2017	Dead, fresh (eyes moist)	0-8 hours	Whole carcass. Evidence of singe to rectrices, tips of flight feathers, right side of face, bill, and upper chest.	Scorched or singed	3	2	Powerblock	638642, 3935825	NA
2017_049_ISEGS	Mourning Dove	MODO	Carcass Survey	5/2/2017	5/2/2017	Dead, Semi-fresh (eyes desiccated, rigor mortis)	3-6 days	Whole carcass with 20 loose contour feathers. Evidence of collision by matching imprint of size and shape of species.	Collision with solar panel/heliostat		2	Heliostat	639248, 3936258	NA
2017_050_ISEGS	Black-chinned	BCHU	Carcass	5/3/2017	5/3/2017	Dead, fresh	8-24 hours	Whole carcass. Evidence of singe on	Scorched or	3	1	Heliostat	640361,	NA

	Hummingbird		Survey			(eyes moist)		both flanks and left side of face. Some primaries and secondaries singed. Rects singed. Center rects curled.	singed				3933384	
2017_051_ISEGS	Unknown Small Bird	UNID	Carcass Survey	5/3/2017	5/3/2017	Broken up	3-6 days	Broken up carcass. Whole lower half minus head.	Scorched or singed	3	1	Heliostat	640480, 3933325	NA
2017_052_ISEGS	Yellow Warbler	YWAR	Incidental	5/6/2017	5/6/2017	Dead, Semi-fresh (eyes desiccated, rigor mortis)	3-6 days	Whole carcass. Evidence of curling to several retrices.	Scorched or singed	1	3	Powerblock	637491, 3937905	NA
2017_053_ISEGS	Mourning Dove	MODO	Carcass Survey	5/8/2017	5/8/2017	Broken up	2 weeks	Broken up carcass consisting of partial wing of 5 primaries, median and lesser coverts held together by dried flesh. No evidence of collision or singe.	Unknown		3	Powerblock	637470, 3937983	NA
2017_054_ISEGS	Northern Rough-winged Swallow	NRWS	Carcass Survey	5/8/2017	5/8/2017	Broken up	3-6 days	Broken up carcass missing head and several contour feathers. Evidence of curling to tertials and singeing to tail feathers.	Scorched or singed	1	3	Powerblock	637479, 3937923	NA
2017_055_ISEGS	Mourning Dove	MODO	Carcass Survey	5/9/2017	5/9/2017	alive, injured	0-8 hours	Injured bird. Evidence of collision with proximity to heliostat and observable wing strain.	Collision with solar panel/heliostat		2	Heliostat	638573, 3935648	NA
2017_056_ISEGS	Unknown Warbler	UNWA	Carcass Survey	5/9/2017	5/9/2017	Feather spot	3-6 days	Feather spot consisting of 1 primary, 2 secondaries, 1 retrix, 1 unidentified feather and 30 contour feathers. Some contour feathers singed. All flight feathers except the primary are curled.	Scorched or singed	3	1	Powerblock	640357, 3933468	NA
2017_057_ISEGS	Mourning Dove	MODO	Carcass Survey	5/9/2017	5/9/2017	Broken up	3-6 days	Broken up carcass consisting of 10 secondaries, 1 primary, 6 coverts, 35 body feathers, 1 detached foot, piece of keel. No evidence of collision or singe.	Unknown		3	Heliostat	637302, 3938080	NA
2017_058_ISEGS	Unknown Duck	UNDU	Carcass Survey	5/9/2017	5/9/2017	Broken up	2 weeks	Broken up carcass consisting of 2 secondaries, 2 underwing coverts and two SS coverts held together by skin. Singe present on edge of secondaries and tips of the underwing coverts.	Scorched or singed	Unk	1	Powerblock	640415, 3933581	NA
2017_059_ISEGS	Unknown Sparrow	UNSP	Carcass Survey	5/9/2017	5/9/2017	Broken up	3-6 days	Broken up carcass consisting of ~20 contour feathers attached by skin. Sing present of the edges of contour feathers.	Scorched or singed	Unk	2	Heliostat	638561, 3935637	NA
2017_060_ISEGS	Wilson's Warbler	WIWA	Carcass Survey	5/15/2017	5/15/2017	Dead, Semi-fresh (eyes desiccated, rigor mortis)	3-6 days	Whole carcass. Evidence of curling to both wings and in tail, singeing to left side of face and left flank.	Scorched or singed	3	3	Powerblock	637451, 3937883	NA

2017_061_ISEGS	Unknown Grebe	UNGR	Carcass Survey	5/16/2017	5/16/2017	Feather spot	3-6 days	Feather spot size small consisting of 40 contour feathers. No evidence of collision or singe.	Unknown		2	Powerblock	638637, 3935867	NA
2017_062_ISEGS	Unknown Small Bird	UNID	Carcass Survey	5/16/2017	5/16/2017	Broken up	1 month +	Broken up carcass consisting of partial right wing comprised of secondaries and coverts. No evidence of collision or singe.	Unknown		2	Powerblock	638638, 3935867	NA
2017_063_ISEGS	Unknown Warbler	UNWA	Carcass Survey	5/16/2017	5/16/2017	Feather spot	3-6 days	Feather spot size small consisting of 3 primaries and 9 body feathers. Evidence of singe on primary feather.	Scorched or singed	1	1	Powerblock	640356, 3933480	NA
2017_064_ISEGS	American Robin	AMRO	Carcass Survey	5/16/2017	5/16/2017	Broken up	2 weeks	Broken up carcass consisting of partial left wing comprised of outer primaries and coverts. No evidence of collision or singe.	Unknown		2	Powerblock	638591, 3935861	NA
2017_065_ISEGS	Wilson's Warbler	WIWA	Carcass Survey	5/16/2017	5/16/2017	Dead, fresh (eyes moist)	8-24 hours	Whole carcass. Evidence of curling to all major flight feathers with right primaries and rects singed off, singeing to top of head, right side of face, upper breast, and both flanks.	Scorched or singed	3	1	Powerblock	640404, 3933471	NA
2017_066_ISEGS	Unknown Shorebird	UNSB	Carcass Survey	5/17/2017	5/17/2017	Broken up	3-6 days	Broken up carcass consisting of partial right wing comprised of 5 primaries and several coverts, 20 body feathers. Evidence of singe on primaries.	Scorched or singed	1	1	Heliostat	640343, 3933377	NA
2017_067_ISEGS	Yellow-rumped Warbler	YRWA	Carcass Survey	5/17/2017	5/17/2017	Broken up	2 days	Whole carcass minus head. Evidence of singe on wings, retrices, and body.	Scorched or singed	3	1	Heliostat	640626, 3933484	NA
2017_068_ISEGS	Eared Grebe	EAGR	Carcass Survey	5/17/2017	5/17/2017	Broken up	2 days	Whole carcass with detached head. Evidence of probable collision with fresh carcass close to heliostat structure.	Collision with solar panel/heliostat		1	Heliostat	640538, 3933643	NA
2017_069_ISEGS	Unknown Small Bird	UNID	Carcass Survey	5/22/2017	5/22/2017	Feather spot	2 weeks	Feather spot size small consisting of 4 primaries and 3 coverts. No evidence of collision or singe.	Unknown		3	Heliostat	637291, 3937827	NA
2017_070_ISEGS	Unknown Dove	UNDV	Carcass Survey	5/23/2017	5/23/2017	Feather spot	3-6 days	Feather spot size small consisting of 20 body feathers. Evidence of singe on 1 body feather.	Scorched or singed	3	2	Powerblock	638577, 3935905	NA
2017_071_ISEGS	Unknown Small Bird	UNID	Carcass Survey	5/23/2017	5/23/2017	Feather spot	2 weeks	Feather spot size small consisting of 2 primary feathers. No evidence of collision or singe.	Unknown		2	Powerblock	638578, 3935907	NA
2017_072_ISEGS	Barn Swallow	BARS	Carcass Survey	5/24/2017	5/24/2017	Dead, Semi-fresh (eyes desiccated, rigor mortis)	2 days	Whole carcass. Evidence of curling to primaries, secondaries, and in tail, singeing to head, back, and chest.	Scorched or singed	3	1	ACC Building	640378, 3933534	NA
2017_073_ISEGS	Unknown Small	UNID	Carcass	5/24/2017	5/24/2017	Broken up	3-6 days	Broken up carcass consisting of	Scorched or	1	1	Powerblock	640428,	NA

	Bird		Survey					whole right wing and 1 primary from left wing. Evidence of singe on flight feathers of wing.	singed			3933496	
2017_074_ISEGS	Eared Grebe	EAGR	Carcass Survey	5/24/2017	5/24/2017	Dead, Semi-fresh (eyes desiccated, rigor mortis)	3-6 days	Whole carcass. Evidence of collision with imprint matching size and shape of carcass on mirror and close proximity to heliostat.	Collision with solar panel/heliostat	1	Heliostat	640490, 3933519	NA
2017_075_ISEGS	Black-Throated Sparrow	BTSP	Carcass Survey	5/25/2017	5/25/2017	Dead, fresh (eyes moist)	0-8 hours	Whole carcass. Evidence of collision with imprint consisting of feather stuck to mirror, fractured upper mandible and injury to chest and wing.	Collision with solar panel/heliostat	2	Heliostat	638969, 3936957	NA

Appendix B. Additional Detection Data for Fatality Estimates and Documentation of Fatality Estimates in Which Each Detection Was Included.

USFWS #	Species Code	Location	Distance from Tower (m)	Bird Size	Model Size	Cause of Death	How Found	Time Since Last Survey (days)	Used in Estimator	Tower Area	Power Block	Inner HD	Heliostat Area	Estimator Notes
2017_014_ISEGS	UNID	ACC	50	Small	Small Carcass	singed	Fatality Search	8	No	X	X			Older than Search Interval
2017_015_ISEGS	UNID	ACC	50	Small	Small Carcass	singed	Fatality Search	8	No	X	X			Older than Search Interval
2017_016_ISEGS	COHU	Power Block	24	Small	Small Carcass	singed	Fatality Search	14	Yes	X	X			
2017_017_ISEGS	ECDO	Outer Segment	1160	Large	Feather Spot	collision	Fatality Search	9	Yes				X	
2017_018_ISEGS	SATH	Outer Segment	733	Small	Feather Spot	unknown	Fatality Search	7	Yes				X	
2017_020_ISEGS	UNHU	Power Block	53	Small	Feather Spot	singed	Fatality Search	6	Yes	X	X			
2017_021_ISEGS	UNID	Power Block	52	Small	Feather Spot	unknown	Fatality Search	6	Yes	X	X			
2017_022_ISEGS	AMKE	Inner Segment	443	Large	Feather Spot	singed	Fatality Search	8	Yes				X	
2017_023_ISEGS	TRES	ACC	56	Small	Small Carcass	collision	Fatality Search	7	Yes	X	X			
2017_024_ISEGS	COHU	Power Block	32	Small	Small Carcass	singed	Fatality Search	7	Yes	X	X			
2017_025_ISEGS	BHCO	Power Block	34	Small	Small Carcass	singed	Fatality Search	7	No	X	X			Older than Search Interval
2017_026_ISEGS	HOLA	Inner HD	228	Small	Small Carcass	collision	Fatality Search	7	Yes	X		X		
2017_027_ISEGS	UNLB	Outer Segment	799	Large	Feather Spot	unknown	Fatality Search	10	Yes				X	
2017_028_ISEGS	COHU	Inner HD	255	Small	Small Carcass	unknown	Fatality Search	7	Yes	X		X		
2017_029_ISEGS	UNID	Power Block	23	Small	Feather Spot	singed	Fatality Search	7	Yes	X	X			

2017_030_ISEGS	MODO	Outer Segment	1887	Large	Feather Spot	unknown	Fatality Search	7	Yes				X	
2017_031_ISEGS	HOFI	Inner HD	225	Small	Small Carcass	singed	Fatality Search	7	Yes	X		X		
2017_032_ISEGS	CLSW	Inner HD	221	Small	Small Carcass	collision	Fatality Search	7	Yes	X		X		
2017_033_ISEGS	COPO	Outer Segment	1080	Small	Feather Spot	unknown	Fatality Search	6	Yes				X	
2017_034_ISEGS	UNID	Power Block	23	Small	Feather Spot	singed	Fatality Search	9	Yes	X	X			
2017_035_ISEGS	COHU	ACC	45	Small	Small Carcass	singed	Fatality Search	7	Yes	X	X			
2017_036_ISEGS	YRWA	Power Block	28	Small	Small Carcass	singed	Incidental	1(1)	No	X	X			Older than Search Interval
2017_037_ISEGS	ECDO	Outside Search - COLOSEUM ROAD	1189	Large	Feather Spot	unknown	Incidental	NA	No					Outside Standard Search Area
2017_038_ISEGS	UNGR	Outer Segment	849	Large	Feather Spot	unknown	Fatality Search	9	No				X	Older than Search Interval
2017_039_ISEGS	MODO	Inner HD	142	Large	Feather Spot	unknown	Fatality Search	7	Yes	X		X		
2017_040_ISEGS	COHU	Power Block	116	Small	Small Carcass	singed	Fatality Search	7	Yes	X	X			
2017_041_ISEGS	UNID	Power Block	124	Small	Feather Spot	singed	Fatality Search	7	Yes	X	X			
2017_042_ISEGS	YRWA	ACC	67	Small	Small Carcass	singed	Fatality Search	7	Yes	X	X			
2017_043_ISEGS	AMRO	Power Block	69	Small	Feather Spot	singed	Fatality Search	7	No	X	X			Older than Search Interval
2017_044_ISEGS	YRWA	Power Block	50	Small	Small Carcass	singed	Fatality Search	5	Yes	X	X			
2017_045_ISEGS	UNDV	Inner Segment	505	Large	Feather Spot	unknown	Fatality Search	6	Yes				X	
2017_046_ISEGS	MODO	Inner HD	244	Large	Large Carcass	collision	Fatality Search	7	Yes	X		X		
2017_047_ISEGS	MODO	Inner HD	162	Large	Feather Spot	unknown	Fatality Search	8	Yes	X		X		

2017_048_ISEGS	HOOR	Power Block	27	Small	Small Carcass	singed	Incidental	1(1)	Yes	X	X			
2017_049_ISEGS	MODO	Outer Segment	717	Large	Feather Spot	collision	Fatality Search	6	Yes				X	
2017_050_ISEGS	BCHU	Inner HD	107	Small	Small Carcass	singed	Fatality Search	7	Yes	X		X		
2017_051_ISEGS	UNID	Inner HD	197	Small	Small Carcass	singed	Fatality Search	7	Yes	X		X		
2017_052_ISEGS	YWAR	Power Block	14	Small	Small Carcass	singed	Incidental	1(1)	No	X	X			Older than Search Interval
2017_053_ISEGS	MODO	Power Block	68	Large	Feather Spot	unknown	Fatality Search	7	No	X	X			Older than Search Interval
2017_054_ISEGS	NRWS	Power Block	10	Small	Small Carcass	singed	Fatality Search	7	Yes	X	X			
2017_055_ISEGS	MODO	Inner HD	208	Large	Large Carcass	collision	Fatality Search	5	Yes	X		X		
2017_056_ISEGS	UNWA	Power Block	27	Small	Feather Spot	singed	Fatality Search	6	Yes	X	X			
2017_057_ISEGS	MODO	Inner HD	248	Large	Feather Spot	unknown	Fatality Search	7	Yes	X		X		
2017_058_ISEGS	UNDU	Power Block	100	Large	Feather Spot	singed	Fatality Search	6	No	X	X			Older than Search Interval
2017_059_ISEGS	UNSP	Inner HD	231	Small	Feather Spot	singed	Fatality Search	5	Yes	X		X		
2017_060_ISEGS	WIWA	Power Block	48	Small	Small Carcass	singed	Fatality Search	7	Yes	X	X			
2017_061_ISEGS	UNGR	Power Block	31	Large	Feather Spot	unknown	Fatality Search	8	Yes	X	X			
2017_062_ISEGS	UNID	Power Block	31	Small	Feather Spot	unknown	Fatality Search	8	No	X	X			Older than Search Interval
2017_063_ISEGS	UNWA	Power Block	18	Small	Feather Spot	singed	Fatality Search	7	Yes	X	X			
2017_064_ISEGS	AMRO	Power Block	71	Small	Feather Spot	unknown	Fatality Search	8	No	X	X			Older than Search Interval

2017_065_ISEGS	WIWA	Power Block	35	Small	Small Carcass	singed	Fatality Search	7	Yes	X	X		
2017_066_ISEGS	UNSB	Inner HD	116	Small	Feather Spot	singed	Fatality Search	6	Yes	X		X	
2017_067_ISEGS	YRWA	Inner HD	252	Small	Small Carcass	singed	Fatality Search	6	Yes	X		X	
2017_068_ISEGS	EAGR	Inner HD	224	Large	Large Carcass	collision	Fatality Search	6	Yes	X		X	
2017_069_ISEGS	UNID	Inner HD	210	Small	Feather Spot	unknown	Fatality Search	7	No	X		X	Older than Search Interval
2017_070_ISEGS	UNDV	Power Block	102	Large	Feather Spot	singed	Fatality Search	7	Yes	X	X		
2017_071_ISEGS	UNID	Power Block	103	Small	Feather Spot	unknown	Fatality Search	7	No	X	X		Older than Search Interval
2017_072_ISEGS	BARS	ACC	46	Small	Small Carcass	singed	Fatality Search	8	Yes	X	X		
2017_073_ISEGS	UNID	Power Block	56	Small	Feather Spot	singed	Fatality Search	8	Yes	X	X		
2017_074_ISEGS	EAGR	Inner HD	121	Large	Feather Spot	collision	Fatality Search	7	Yes	X	X		
2017_075_ISEGS	BTSP	Outer Segment	1153	Small	Small Carcass	collision	Fatality Search	8	Yes			X	