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Description:	Assessment of bird fatalities at solar projects including topics of: collisions with anthropogenic structures, mortality patterns at solar projects in the southwest, lake effect, and agricultural landscapes
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TETRA TECH

Memo

To:	Intersect Power
From:	Karl Kosciuch, PhD, Wildlife Program Manager, Tetra Tech, Inc.
Date:	September 5, 2024
Subject:	Avian Fatality Assessment for PV Solar Projects

On behalf of Intersect Power, Tetra Tech, Inc. developed this memo to evaluate bird fatality patterns at photovoltaic (PV) solar and provide a description bird mortality at PV solar facilities developed in agricultural landscapes. Based on my review of the current peer-reviewed and gray literature, and my experience studying bird interactions with solar facilities for nine years, I have reached primary conclusions to a reasonable degree of certainty, which I discuss in more detail in the memorandum that follows:

1. **Bird fatalities at tall features on the landscape (e.g., communications towers, buildings, wind turbines) are several orders of magnitude higher than at PV solar facilities, and comparative fatality events have not been observed at PV solar facilities (Gehring et al. 2009, Kosciuch et al. 2020, Loss 2016).**

2. **High rates of aquatic bird mortality are specific to one PV solar facility that has fixed panels and lacks anti-reflective coating in the Southwest, similar patterns have not been observed any other PV solar facility, and a similar rate of aquatic bird mortality is not expected at newly installed PV solar facilities (Kosciuch et al. 2020, Kosciuch et al. 2021).**

3. **Aquatic birds were observed inside and outside a PV solar facility in an agricultural landscape in the Imperial Valley, and bird carcasses were found inside and outside of the facility suggesting no clear pattern of attraction to the solar facility (Kosciuch et al. 2021).**

4. **A recent study concluded that populations of some species of birds are vulnerable to morality at solar energy developments (Conkling et al. 2022). However, the study examined species almost exclusively affected by concentrating solar power and not PV solar development and do not pertain to species most often detected as carcasses at PV solar.**

5. **An on-going camera monitoring study by Argonne National Lab at PV solar facilities has documented over 17,000 instances of bird activity but has recorded zero collision events, supporting conclusions from the fatality monitoring results that collisions are rare (Hamada et al. 2024).**

6. **The conversion of an agricultural landscape to a naturally vegetated landscape within a PV solar facility can improve habitat and increase bird species richness (Jarčuška et al. 2024) without increasing fatality risk.**

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BIRD COLLISIONS WITH ANTHROPOGENIC STRUCTURES

Bird fatalities resulting from tall anthropogenic structures have been extensively studied, with estimates reaching billions of fatalities annually. Loss (2016) reported U.S. fatality estimates from domestic free-ranging cats at 1.4 – 4.0 billion birds per year followed by buildings (365 – 988 million), automobiles (200 – 340 million), and power lines (8 – 57 million). Fatality estimates associated with PV solar installations, which are not vertical structures, have been significantly lower than with other anthropogenic structures. Walston et al. (2016) estimated between 37,800 – 138,600 bird fatalities per year for all utility-scale solar facilities (14-gigawatt capacity, including operational or under construction) in the U.S. at the time of publication. Similarly, Kosciuch et al. (2020) estimated 10,920 total bird fatalities per year based on a capacity of 6-gigawatts of PV solar in southern California. In the same region, fatality estimates produced by Walston et al. (2016) for buildings (~7.8 million), automobiles (~453,000), and wind turbines (~29,000) far exceed the bird fatality estimate for PV solar.

It is well-documented that large-scale mortality events occur at tall anthropogenic structures, particularly impacting nocturnal migrant birds. In contrast, bird carcasses found at PV solar facilities typically involve a small number of common ground-dwelling bird species. Erickson et al. (2001) reported hundreds of birds killed in a single night at tall structures such as communication towers, while the highest single mortality event in PV solar studies summarized by Kosciuch et al. (2020) was 13. In addition, no relatively large mortality events of aquatic birds at PV solar sites were documented by Kosciuch et al. (2020). Large-scale mortality events at tall structures such as buildings and communication towers are generally linked to lighting and nights with low cloud ceilings (Larkin 2000, Gehring et al. 2009), poor weather, or other factors, such as wet parking lots (Roberts et al. 2014). Since PV solar facilities do not contain tall structures such as buildings and communication towers nor extensive lighting, large-scale mortality events of nocturnal migrants have not occurred at PV solar facilities.

BIRD MORTALITY PATTERNS AT PHOTOVOLTAIC SOLAR FACILITIES IN THE SOUTHWEST

Current knowledge on how birds interact with PV solar facilities is primarily derived from a small number of observational studies in the southwestern U.S. The unexpected presence of aquatic birds, such as ducks, loons, and grebes, found stranded or deceased at a PV solar facility in the southwestern U.S., has sparked interest among stakeholders such as developers, government agencies, and non-governmental organizations. In 2014, Kagan et al. determined that nearly half (48% or 27/56) of the bird remains found at a single PV solar facility, Desert Sunlight, in southern California were from aquatic species. The unexpected presence of aquatic bird species at this PV solar facility prompted the "lake effect" hypothesis, which suggests aquatic birds could mistake the PV solar panels for water and collide with the panel surface (Upton 2014). Broadening the number of studies summarized, Kosciuch et al. (2020) reached four primary conclusions in an assessment of 13 fatality monitoring studies at 11 PV solar facilities in the southwestern U.S.; 1) most evidence of fatalities were feather spots with unknown cause of mortality, 2) most evidence of fatalities was from common ground-dwelling birds with large regional population sizes, 3) no relatively large fatality events were detected, and 4) most carcasses were detected in fall.

Bird fatality data from Desert Sunlight has been presented in several studies and is noted for the high numbers of aquatic bird carcasses (Kagan et al. 2014, Walston et al. 2016, Kosciuch et al. 2020). However, Desert Sunlight, developed in 2015 in Riverside County, California differs from development methods used for modern PV solar facilities. Most notably, Desert Sunlight uses fixed-tilt panels without anti-reflective coating as illustrated by the Google Earth image, which shows reflection off the solar panels (Figure 1). Therefore, it is reasonable to conclude that the panels can look like water. Unlike Desert Sunlight, most modern solar PV facilities (including the proposed Darden Solar Facility) use single axis tracking technology, which allows the panels to tilt in accordance with the angle of the sun, and panels with anti-reflective coating . Figure 2 shows the different panel orientation of fixed-axis and tracker panels at the same time of day. Single axis tracking technology and anti-reflective coatings reduce glint and glare reflected by the panels and allow panels to absorb more sunlight. Thus, the panel type and configuration used at Desert Sunlight, which creates glint and glare, will not be used at Darden.

Conkling et al. (2022) evaluated impacts of mortality at solar facilities on bird populations using data from different types of solar facilities in California including concentrating solar power tower (Ivanpah Solar Electric Generating System), concentrating solar trough (Genesis Solar), and PV solar (Blythe Solar, Desert Sunlight, McCoy Solar, Mojave Solar). After modeling the effects of additional mortality of 1,000 and 5,000 individuals on species identified as potentially sensitive, the authors concluded that populations of nocturnal migrant bird species were vulnerable to solar (Conkling et al. 2022). However, their conclusion requires specific context about solar technology and risk to birds. The migrant birds included in the analysis were primarily found at Ivanpah, which creates concentrated solar flux at receiver towers that causes singe mortality of birds, an effect not found at PV solar. Thus, concentrating solar power could affect populations of nocturnal migrant birds if additional concentrating solar power towers are developed and mortality patterns are similar. However, the conclusions about migrant bird population vulnerability do not apply to PV solar because PV facilities do not have concentrated solar flux.

LAKE EFFECT AND BIRD MORTALITY AT A PV SOLAR FACILITY IN AN AGRICULTURAL LANDSCAPE

The lake effect hypothesis was developed based on data from a single PV solar facility, Desert Sunlight, and it was unclear whether the presence of aquatic bird carcasses was unique to the Desert Sunlight facility or a widespread pattern in utility-scale solar energy projects. In a summary of 13 fatality monitoring studies, Kosciuch et al. (2020) found that in the Sonoran and Mojave Desert (SMD) Bird Conservation Region (BCR), 90% of studies reported aquatic bird carcasses at PV facilities, while outside the SMD BCR, this was noted in only one out of three studies. However, the fatality studies were not completed with the intent of examining ideas around lake effect and provided limited inference into potential causes of mortality.

The lack of specific questions about aquatic birds prompted a subsequent study (Kosciuch et al. 2021) comparing bird populations at PV solar facilities and a small regional lake. The authors found that aquatic bird diversity was lower at the solar facilities compared to the lake, and overall use by aquatic birds was an order of magnitude higher at the lake than at the PV solar facilities (Kosciuch et al. 2021). Aquatic birds did occur at solar facilities, but flocks did not exhibit landing behavior or circle the facilities (Kosciuch et al. 2021). However, though small numbers of aquatic bird carcasses were detected at PV solar facilities in the desert

environment, no carcasses were found in the reference areas, suggesting that aquatic birds may be attracted to the PV solar facilities in desert environments. The study concluded there is limited evidence of aquatic birds being broadly attracted to PV solar facilities. Rather, the findings suggest that attraction is likely a nuanced phenomenon that is species-specific and context-dependent; not a constant signal of water to all aquatic birds (Kosciuch et al. 2021). The specific causes of attraction to PV solar facilities and the conditions for such occurrences remain unclear, and additional studies are being conducted with federal funding.

A unique aspect of the study design in Kosciuch et al. (2021) was that fatality monitoring and bird use surveys were completed at a solar facility and reference areas in an irrigated agricultural landscape in the Imperial Valley of California, which is more similar to the Central Valley than the desert environments studied previously. The authors detected five carcasses and observed 715 birds flying over or within the facility and detected six carcasses and observed 860 birds flying over or within the reference area. In conclusion, the authors stated "Thus, in the agricultural landscape context, it is difficult to untangle attraction (i.e., lake effect) from other sources of mortality (e.g., predation) for some species…because possible attraction is obscured in agricultural landscapes, which can be hybrid or novel ecosystems inhabited by aquatic habitat birds."

INFERENCE INTO BIRD MORTALITY PATTERNS AT PV SOLAR FACILITIES IN AGRICULTURAL LANDSCAPES

Since Desert Sunlight was the first PV solar facility included in bird fatality summaries, there was an expectation that patterns of aquatic bird mortality at other facilities would be similar (Kagan et al. 2014, Upton 2014). However, recent studies in the southwestern U.S. and Alberta, Canada have shown that to not be the case (Kosciuch et al. 2021, Kosciuch et al. 2022). In fact, fatality patterns at Desert Sunlight have not been seen at any other PV solar facility with available monitoring data. It is likely that either two standard industry practices, which began around 2014, has reduced collision risk for birds. These are 1) installing of single-axis tracker panels, and/or, 2) the addition of anti-reflective coating.

Argonne National Laboratory is completing a study at seven PV solar facilities in four regions in the U.S. by installing cameras to monitor bird activity. The camera system detected 17,608 bird activities and no collisions with panels (Hamada et al. 2024). Birds were observed flying above, flying through, and perching on solar panels during the study (Figure 3). This study shows that collisions are rare, and that mitigation would not be needed at any of their study sites.

Kosciuch et al. (2021) demonstrated that birds live within agricultural landscapes and bird mortality occurs on this landscape independent of PV solar facilities. The authors observed birds flying over and within a PV solar facility and found a small number of carcasses compared to the number of live birds detected. Thus, it is possible that some evidence of bird fatalities will be detected at PV solar facilities developed in agricultural landscapes but based on existing studies, the mortality patterns are difficult to untangle from background mortality (EPRI 2021). In other words, determining the cause of mortality of a carcass found at a PV solar facility is complicated by the presence of background mortality. Further, the fatality rates are expected to be relatively low compared to the number of birds inhabiting the area. Converting an agricultural landscape to a natural landscape will remove inputs (e.g., fertilizer, pesticide) and potentially restore habitat for birds (Struthio and Knapp 2023) and overall should be a net positive for birds and biodiversity. Fatality monitoring

is costly for solar developers and reduces the funding available for other activities and studies that could create and demonstrate benefits to birds including revegetation, habitat restoration, and bird community monitoring.

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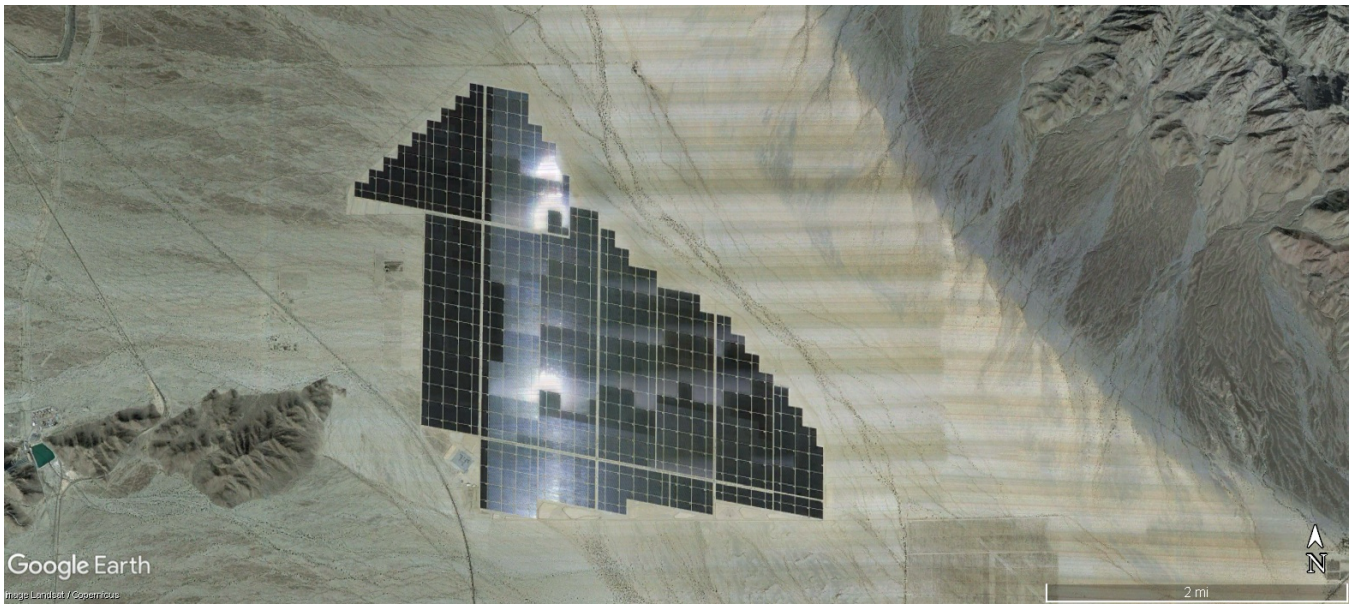

Figure 1. Aerial image of Desert Sunlight Solar Farm, Riverside County, California, taken February 6, 2016, which uses fixed-axis panels without anti-reflective coating.

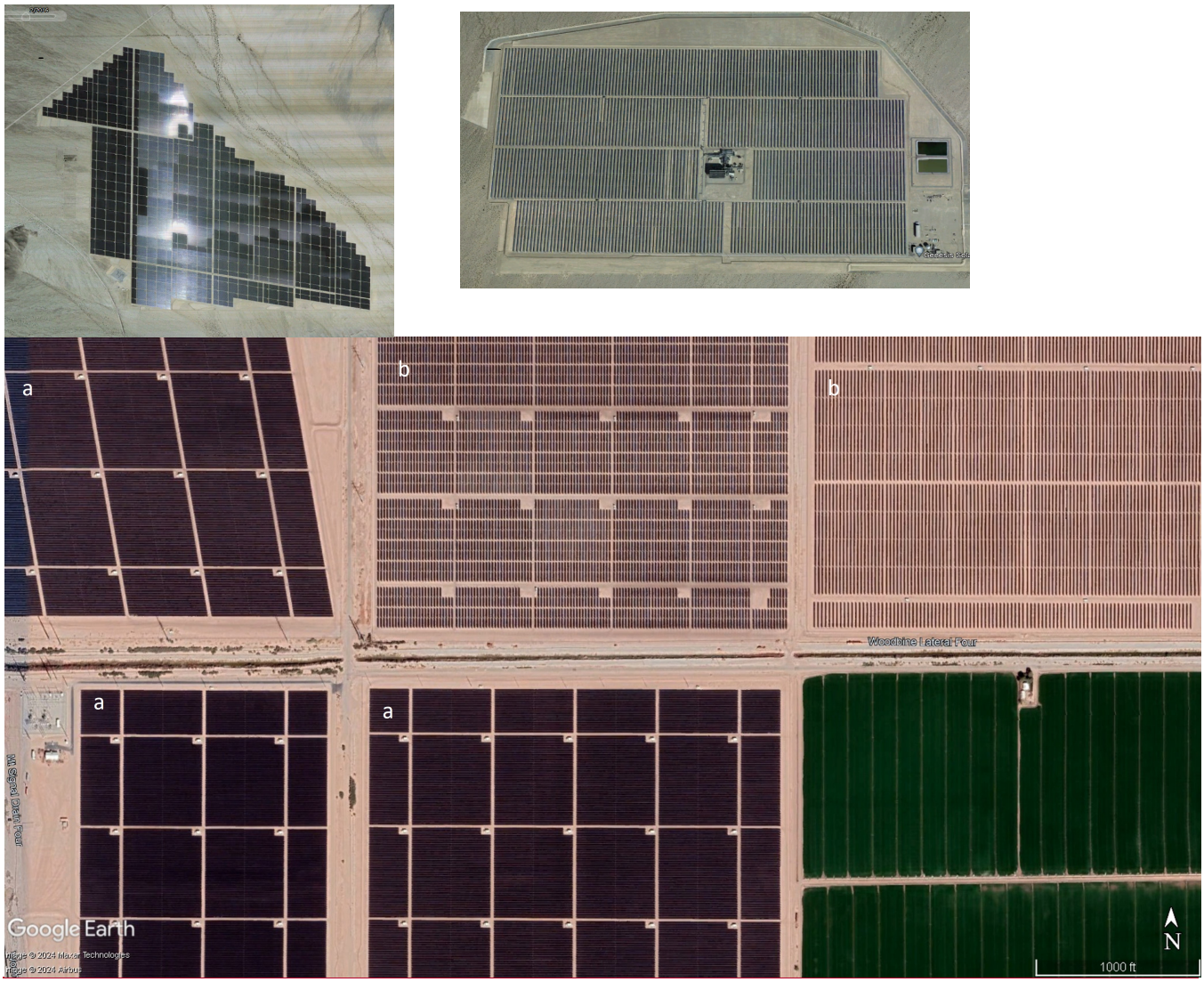

Figure 2. A mixture of fixed-axis (a) panels a tracker panels (b) at a solar facility in Imperial County, California.

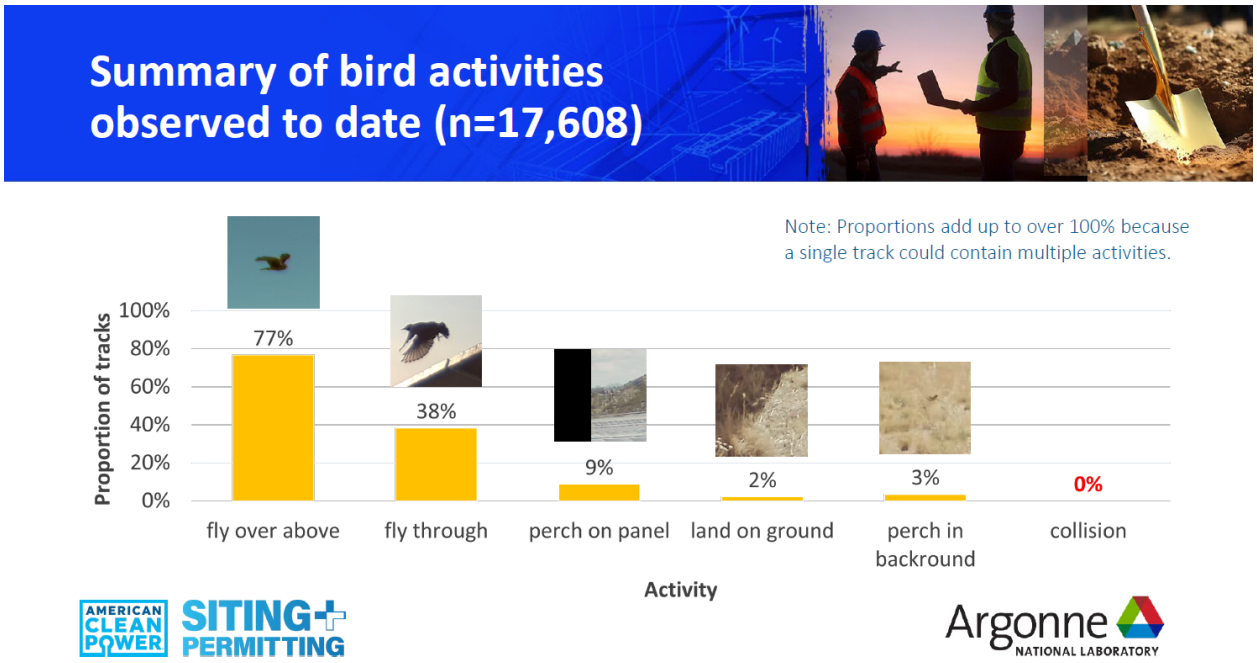

Figure 3. Slide from Hamada et al. (2024) showing bird activity during the study.