TETRA TECH

MEMO

To:	Kahana Solar LLC c/o Julia Mancinelli, Director - Environment, Innergex Renewable Energy, Inc. (Innergex)
Cc:	Jamie Horner, Senior Director – Storage and Innovation, Innergex
From:	Dr. Bob Pearson, Senior Project Manager, Tetra Tech
Date:	May 11, 2021
Subject:	EMF in Context to the Proposed Kahana Solar Project, Maui County, Hawai'i

Kahana Solar LLC (Kahana Solar) proposes to construct and operate the Kahana Solar Project (Project) on privately owned land near Napili-Honokōwai, on the island of Maui, Hawai'i. The Project will consist of a 20-megawatt (MW_{AC}[1]) solar photovoltaic system coupled with an 80-megawatt-hour battery energy storage system as well as ancillary support infrastructure. The Project will primarily be located on tax map key (TMK) 4-3-001:017, owned by Maui Land & Pineapple Company, approximately 1.2-miles mauka of the Kapalua Airport (Figure 1).

Solar energy is the conversion of sunlight into usable energy forms. The sun's rays transmit light energy, in the form of photons, which can be converted to electricity using certain materials that naturally release electrons when exposed to light. These materials are contained within the photovoltaic solar panels. When the sun shines on the solar panels, direct current (DC) electricity is produced at a low voltage. The DC electricity produced by the Project's solar panels will be converted to alternating current (AC) electricity[2] before it is sent into the Maui Electric grid. Electric fields and magnetic fields (EMF) are caused by electrical equipment and it is anticipated that low levels of EMF will be produced by the various items of electrical equipment at the Project.

As the Project is located within the Maui County Agricultural District and is a solar energy facility greater than 15 acres, it is considered a special use per Maui County Code (MCC) §19.30A.060(A)(12). Therefore, the Applicant is seeking a County Special Use Permit (CUP), as provided in MCC §19.510.070, to construct and operate the proposed Project. The Project also requires a State Special Permit (SUP) as provided in Hawai'i Revised Statutes (HRS) Chapter 205. Early in the Project's community outreach process, Kahana Solar received comments from a few community stakeholders expressing concern that EMF produced by the Project's solar panels and other electrical infrastructure may impact native plant and bird species. The purpose of this memorandum is to discuss the Project's potential to cause EMF and to what extent the EMF would impact native flora and fauna and/or nearby residential areas. A

[1] A 20-MW_{AC} project means the Project has a generation capacity of up to 20 megawatts of alternating current (AC) electricity at one moment in time.

[2] AC electricity is the form of electricity that is used by the power grid and household appliances.

Tetra Tech, Inc.
1750 Harbor Way, Suite 400, Portland, OR 97201
Tel 503.221.8696 Fax 503.227.1287 www.tetratech.com

detailed description of the Project and the Project area are provided below (Section 1) followed by a discussion of EMF produced by the Project (Section 2).

1.0 Description of the Project and the Project Area

Project Description

The Project's solar PV system and associated infrastructure will be sited within a 380-acre Project Area (Figure 2)[3]. The Project Area is located on and surrounded by mostly vacant, fallow agricultural land, previously used for commercial pineapple and sugar cane cultivation. Pineapple operations ceased in 2009, and the land is currently undeveloped (Munekiyo Hiraga 2019; Pacific Legacy 2021). The former agricultural fields in the Project Area are separated into four areas by the gulches that run east-west alongside and in between the Project Area boundaries. More information on the gulches is provided below in the *Project Area Description*. The solar PV system will consist of a series of photovoltaic panels mounted on a solar tracker racking system, as well as related electrical equipment. The panels will be arranged in north-south oriented rows within four solar array areas, each surrounded by security fencing set back a minimum of 100 feet from the top of the gulches. Each solar array area is labeled on Figure 2 as follows (south to north): Area 1, Area 2, Area 3, Area 4. The total area within the four fenced areas is 220 acres. For purposes of evaluating impacts and demonstrating compliance with the applicable county and state review criteria, Tetra Tech has analyzed a proposed Project layout, as shown in Figure 2. However, the final design is anticipated to have a smaller footprint. Kahana Solar assumes the Project solar panels will cover a maximum of 65 acres, will be located within the four solar array areas identified in Figure 2, and will be sited no closer than 100 feet from the top of the gulches. The closest residential areas include the Ala Hoku Place neighborhood and Kahana Ridge neighborhood, located approximately 1.4 miles makai of the Project Area and the Ka'anapali Coffee Farms agricultural community, located approximately 1 mile southwest of the Project Area.

The PV solar panels will be installed on a single-axis tracker racking systems and will rotate their orientation throughout the day to track the sun, facing east in the morning, facing straight up at solar noon, and facing west in the afternoon. The spacing between the solar trackers will be approximately 21 feet and the entire area below and around the solar panels will be revegetated after construction to reduce dust and sediment and erosion issues.

The DC electricity produced by the Project's solar panels will be fed into a power conversion system (PCS) via underground DC electric collector lines.[4] The Project will include up to 10 PCSs distributed

[3] The Project Study Area used for resource surveys (i.e. archaeological, biological, waters, etc.) encompasses approximately 412 acres. The Project Study Area includes the 380-acre Project Area referred to in this memorandum plus an additional 32 acres associated with the Project's main access road which would follow an existing agricultural road extending from the intersection of Honoapi'ilani Highway and Akahele Street, south of the Kapalua Airport, then mauka to the Project Area. This memorandum focuses on the portion of the Project where solar panels and electrical infrastructure would be sited and therefore refers to the 380-acre Project Area.

[4] In areas where the desired depth cannot be achieved (due to basalt rock or other prohibitive subsurface conditions), the collector lines may be housed in cable trays in accordance with the applicable National Electric Code provisions.

throughout the solar array areas. Each PCS includes three or four Photovoltaic Coupled Energy Storage System (PV-Coupled ESS) Units and a step-up transformer. The PV-Coupled ESS Units combine a lithium-ion battery system, inverter, and controller that can either a) store DC electricity for future use, or b) convert DC electricity to alternating current (AC) electricity and send the AC electricity to the step-up transformer, as required based on grid demand. The step-up transformer increases the AC voltage from the PV-Coupled ESS units to 34.5 kilovolts (kV), where it will then be conveyed via AC underground[5] medium voltage collector lines and combiner boxes to the Project's collector substation. The collector substation will include a main power transformer which will further increase the voltage to 69-kV in order to match the voltage of the Maui Electric electrical grid. A new switchyard will be constructed adjacent to the Project collector substation as part of the interconnection facilities. An 69-kV overhead transmission line will connect the electricity produced by the Project to the existing Maui Electric 69 kV overhead transmission line located less than 400 feet west of the switchyard (Figure 2).

Project Area Description

The climate in the Project Area ranges from arid and very dry near the western edges to seasonally mesic in the upper elevations (Price et al. 2012). According to the Online Rainfall Atlas of Hawai'i (Giambelluca et al. 2013), the Kapalua Airport receives a mean annual rainfall of approximately 29.3 inches and the upper elevations of the Project Area receive 72.1 inches. Rainfall is typically highest in December/January and lowest in June through September (Giambelluca et al. 2013).

In general, the Project Area's terrain slopes northwest toward the Pacific Ocean and is bisected by several gulches. The elevation of the Project Area ranges from approximately 700 feet above mean sea level (amsl) in the western portion to approximately 1,350 feet amsl near the eastern boundary. The fallow agricultural fields where the solar arrays will be sited have an average slope of 10% facing northwest. The slopes within the four gulches in the study area are over 15% and, in some places, reach close to 50% slope.

The gulches that run east-west through the study area separate the agricultural fields into four areas. Kahana Stream flows north of the Project Area, Pulepule Gulch flows between Areas 3 and 4, Kahanaiki Gulch flows between Areas 2 and 3, an unnamed gulch flows between Areas 1 and 2, and Māhinahina Gulch flows to the south of Area 1 (Figure 2). None of these gulches are associated with perennial streams and are likely ephemeral under the Navigable Waters Protection Rule (NWPR) because they only have surface flow in direct response to rainfall. Additional details can be found in the Project's Waters of the U.S. determination and delineation report (Tetra Tech, 2021a). The solar panels will be setback by a minimum of 100 feet from the top of the gulches.

A general biological survey was conducted by Tetra Tech and LeGrande Biological Surveys Inc. on June 16-20, 2020 and July 2-3, 2020. Biologists conducted a pedestrian survey and recorded all plant species, dominant vegetation types, and any listed or rare plant species within the Project Area. During the

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survey, biologists examined areas more likely to support native plants (e.g., rocky outcrops, gulches, and shady areas) more intensely. The biologists also documented all bird species seen or heard while walking or driving within the study area and conducted two-minute point count surveys to document listed waterbirds that could occur within or near the study area. Habitat of listed animals, if observed, was also documented. Additional details regarding survey methodology can be found in the Project's Biological Resources Survey Report (Tetra Tech 2021b).

The biological surveys found no listed plant species in the study area and found low concentrations of native plants mostly in the gulches and along the upper elevations of the Project Area. The fallow, overgrown pineapple fields are dominated by non-native plant species. Biological surveys documented 141 plant species within the study area: 18 of the observed plant species are native to the Hawaiian Islands, and the remaining 123 plant species are non-native to the Hawaiian Islands. Nineteen bird species were recorded within the study area, most of which are non-native to the Hawaiian Islands, and are species commonly found in rural or agricultural areas. Three native (endemic) birds were detected in the study area: the ʻapapane (*Himatione sanguinea*), Hawaiʻi ʻamakihi (*Chlorodrepanis virens*), and aeʻo or Hawaiian stilt (*Himantopus mexicanus knudseni*). Hawaiʻi ʻamakihi and ʻapapane were heard along the forested edges of Kahanaiki Gulch and Māhinahina Stream on the eastern edge of the study area. Additionally, the threatened Hawaiian goose or nēnē (*Branta sandwichensis*) was recorded in the immediate vicinity of the study area. Additional details regarding survey results can be found in the Project's Biological Resources Survey Report (Tetra Tech 2021b).

Surrounding Land Uses

Immediately surrounding the Project Area is mostly vacant fallow agricultural land to the north and south and west. There are six existing reservoirs located within 0.3 miles (or less of the Project Area, and one reservoir located within the Project Area, but outside the development footprint. West of the Project Area is the Kapalua Airport. East of the Project Area are mostly vacant forested lands including the Puʻu Kukui Watershed Preserve located approximately 0.75 miles mauka of the Project Area and a portion of the West Maui Forest Reserve approximately 650 feet southeast of the Project Area.

South of the Project Area is the Maui County Department of Water Supply Māhinahina Water Treatment facility, located on land owned by the Department of Hawaiian Homelands (DHHL). DHHL also owns land makai of the DWS Water Treatment facility down to Honoapiʻilani Road where DHHL is proposing to develop the Honokōwai Homestead Community, an agricultural/residential community on approximately 800 acres of land. There is no set timeline when this development will be constructed. The closest area of the DHHL parcel envisioned for future housing is approximately 1,300 feet from the closest Project fence line. The closest existing residential area to the Project is the Kaʻanapali Coffee Farms agricultural community, located approximately 1 mile southwest of the Project Area. There is also the Kahana Ridge neighborhood and houses off Ala Hoku Place, located 1.4 miles makai of the Project Area. The area between Honoapiʻilani Highway and Kapalua Airport is currently vacant land; however, the Pulelehua residential community is proposed in this area. The Napili-Honokōwai resort area is located 1.6 miles west of the Project Area.

2.0 Electric and Magnetic Fields (EMF)

Electric fields and magnetic fields are different phenomena caused by distinct aspects of electrical equipment and should be defined and evaluated separately. Electric fields are produced whenever a conductor such as a power line is connected to a source of electric voltage. A common example of this is a lamp plugged into a wall outlet in a home. When the lamp is plugged in, a voltage is induced in the cord to the lamp that causes an electric field to be created around the cord. The electric field remains constant as long as the lamp is plugged into the wall, even when the electricity is not being used. In other words, even if the lamp is off, there is an electric field around the lamp cord. Electric field strengths are measured in units of volts per meter (V/m) or kilovolts per meter (kV/m), where 1 kV/m = 1000 V/m. Magnetic fields are produced whenever an electric current flows in a conductor. In the lamp example, if the lamp is turned on, allowing electricity to flow to the lamp, a magnetic field is created around the lamp cord in addition to the electric field. Magnetic fields are measured in milligauss (mG). The strength of the magnetic field will vary with the amount of power flowing through the conductor. Electric fields are caused by the voltage of the line and are constant when the line is energized The strength of both electric and magnetic fields decreases rapidly with distance from the source.[6]

Varying levels of EMF will be produced by specific electrical infrastructure located within the Project Area. The Project solar panels and underground DC collector lines will produce low levels of DC EMF, while the Project's PCSs, AC collector lines, and the 69-kV overhead transmission line will produce low levels of AC EMF. EMF associated with DC electricity and AC electricity have different characteristics as explained below. DC electricity is considered "static" because it does not vary in the direction of the electric current. Static magnetic fields are created by magnets or by the flow of DC electricity. The Earth has a naturally occurring static magnetic field, which is what enables a compass to be used for directional finding. The Earth's DC magnetic field varies between 350 and 700 mG, depending on the location. Static electric fields are created by the separation of a positive and negative electric charge and are created naturally by the Earth's atmosphere during stormy conditions or by friction (e.g., "static cling" of clothes from the dryer).

Sources of DC Electricity

The DC magnetic fields produced by each solar panel will be a few mG near each solar panel. This magnetic field level is significantly less than the Earth's natural magnetic field. Therefore, the magnetic field from each panel would not be detectable above the baseline levels of the Earth's natural magnetic field. This will be true regardless of how many solar panels are constructed within the Project Area. Recall that the strength of the magnetic field is proportional to the amount of electric current passing through the conductor. As each solar panel will produce approximately the same amount of electricity when fully operational (i.e. fully exposed to sunlight), the magnetic field surrounding each solar panel

[6] For more information about EMF, please review the following publication: "EMF Electric and Magnetic Fields Associated with the Use of Electric Power Q&A," which is published by the National Institute of Environmental Health Sciences of the National Institutes of Health. This publication can be downloaded at: https://www.niehs.nih.gov/health/materials/electric_and_magnetic_fields_associated_with_the_use_of_electric_power_questions_and_answers_english_508.pdf

will be the same. There will be no increase or compounding effect of magnetic fields at any one location because the panels will not be stacked or concentrated into one small area but rather spread out over a large area, so they do not overlap (i.e. shade each other). The electric and magnetic fields in each local area of the Project solar arrays will be the same regardless of the total size of the Project. The electric fields produced by the panels do not compound with additional panels because the voltage is the same in all the panels and cables. The electric fields produced by each panel and the low voltage DC cables on the panels will be very low and unmeasurable within 50 feet of the panels. No electric or magnetic fields will be produced by the panels and their associated electric cables during the non-daylight hours when no solar energy is produced.

The low voltage DC cabling that feeds the electricity produced by the solar panels into the PCSs will have both positive and negative conductor lines located close together; therefore, they will have no measurable EMF aboveground because the magnetic and electric fields from the positive and negative lines will cancel each other out, a phenomenon called phase cancellation. This cancellation effect will occur at all low voltage DC cables in the Project and therefore will create no measurable EMF aboveground regardless of the Project's size.

Sources of AC Electricity

The PCSs distributed through the solar arrays (up to 10) and the main power transformer at the collector substation, will act as point sources of AC EMF as they each have discrete locations within the Project Area. Each of these components will produce low levels of AC EMF that will decrease with distance in proportion to the cube of the distance decay rate. In other words, for each doubling of the distance from the EMF source, the EMF will drop by a factor of eight. As an example, if the magnetic field level near a transformer is 10 mG at a distance of 10 feet, the field level will drop to one eighth of this, or 1.25 mG, at 20 feet and to 0.16 mG at 40 feet. This same decay rate would also apply to the electric fields from these same devices. Electric fields will also diminish from absorption by any vegetation (including low-growing vegetation) located in its path because the plants effectively ground the electric fields[7]. The discreet point source locations of AC EMF in the Project Area (i.e. the PCSs and the substation transformer) will be setback a minimum of 150 feet from the top of the gulches that run through the Project Area. The EMF field 150 feet from the PCSs would be close to zero. The collector substation's main power transformer is located over 300 feet from the closest gulch, approximately 1 mile from the closest existing residential properties (in Ka'anapali Coffee Farms), over 1.2 miles from the proposed Pulelehua residential community, and over 1,300 feet from the proposed Honokōwai Homestead Community. Therefore, no EMF from the Project's PCSs and main power transformer would reach the native plants in the gulches and nearby forested areas, or the homes along Ala Hoku Place or within the Kahana Ridge neighborhood or future homes in the Pulelehua or Honokōwai Homestead planned developments.

[7] As EMF from Project infrastructure is not anticipated to extend beyond the Project fence line, the vegetation that would potentially absorb the Project's electric field would be the vegetation planted by the Project below and near the solar arrays. The concentrations of native plants in the gulches and mauka of the Project would not be affected by EMF.

The linear 34.5-kV AC collector lines within the Project will also produce low levels of AC EMF. The AC collector lines running from the PCS step-up transformers to the Project collector substation will typically be buried underground and will thus produce very low levels of EMF fields, due to the earth absorbing the electric fields and the phase cancellation of both electric and magnetic fields. This absorption and cancellation effect will occur at all low voltage AC collector lines in the Project regardless of the Project's size. The AC collector lines will generally be sited a minimum of 100 feet from the top of the gulches except where the AC collector lines must cross the gulches to connect each solar array area to the Project's collector substation. However, EMF levels from these underground lines in the gulch crossings will be very low due to the earth absorbing the electric fields and the phase cancellation of both electric and magnetic fields. The AC collector lines will be sited approximately 1 mile from the closest residential property line (in Kaʻanapali Coffee Farms) and no EMF from the collector lines will reach the homes in Kaʻanapali Coffee Farms, along Ala Hoku Place or in the Kahana Ridge neighborhood or the Pulelehua residential community and DHHL's Honokōwai Homestead Community boundaries.

The 69-kV overhead transmission line connecting the proposed switchyard to the existing Maui Electric transmission line, located west of the switchyard, will produce low levels of EMF. However, these EMF fields will quickly dissipate to background levels within a hundred feet from the overhead transmission line. Since the overhead transmission line will be located several hundred feet from the closest gulch, over a mile from the closest residential area and the planned Pulelehua residential community, and over 1,200 feet from DHHL's Honokōwai Homestead Community boundary, the EMF from the overhead transmission line will drop to zero well before it reaches areas with high concentrations of native plants or areas with existing or future residential uses.

3.0 Conclusion

Given the low levels of EMF anticipated from the various units of electrical equipment at the Project and given the localized nature of EMF, no EMF from the proposed solar panels, collector lines, inverters, or transformers is anticipated to extend beyond the Project Area boundary. Furthermore, no Project related EMF is anticipated to reach the forests located mauka of the Project Area and only small amounts of EMF would occur in the gulches in discreet locations where the AC collector lines cross. However, EMF levels from these underground lines in the gulch crossings will be very low due to the earth absorbing the electric fields and the phase cancellation of both electric and magnetic fields.

The EMF levels outside the Project Area are not expected to change as a result of the Project. The existing levels of EMF in areas along the existing Maui Electric 69-kV power line are anticipated to be unchanged except for some small increases at the point of interconnection where the proposed 69-kV overhead transmission line connects the Project's electricity to the existing Maui Electric line. However, the EMF in this area is still anticipated to dissipate within a few hundred feet well before the edge of the nearest gulch. As the native flora and fauna (including native forest birds) concentrates in the gulches and forested areas mauka of the Project, no impacts from EMF to these natural resources is anticipated. Native waterbirds that use the existing reservoirs in the Project are not anticipated to be impacted by Project related EMF because the reservoirs are all located over 100 feet from the closest Project electrical equipment. No impacts to residential areas from Project related EMF is anticipated as the

existing residential areas are over a mile from the Project Area boundary. Even if future residential uses are constructed closer to the Project Area, such as on the DHHL parcel south of the Project or the Pulelehua residential community makai of the Project, Project related EMF would not reach these areas given the localized nature of EMF and the Project Area being over 1,200 feet from any future residential uses.

References

Giambelluca, T.W., Q. Chen, A.G. Frazier, J.P. Price, Y.L. Chen, P.S. Chu, J.K. Eischeid, and D.M. Delparte. 2013. Online Rainfall Atlas of Hawai'i. Bull. Amer. Meteor. Soc. 94, 313–316, doi: 10.1175/BAMS-D-11-00228.1. Available at: http://rainfall.geography.hawaii.edu. Accessed on May 21, 2019.

Munekiyo Hiraga. 2019. Final Environmental Assessment, Proposed West Maui Water Source Development Project (Mahinahina Well and Kahana Well), Lahaina, Maui.

NC Clean Energy Technology Center. 2017. Health and Safety Impacts of Solar Photovoltaics. Published by the N.C. Clean Energy Technology Center at N.C. State University. May 2017.

Pacific Legacy. 2021. Draft Archaeological Inventory Survey of the Proposed Kahana Solar Project on Maui Lands and Pineapple Company Lands in the Ahuapua'a of Kahana and Māhinahina 1-3. District of Lahaina (Ka'anapali), Island of Maui.

Price, J. P., Jacobi, J. D., Gon, S. M. III, Matsuwaki, D., Mehrhoff, L., Wagner, W., Lucas, M., and Rowe, B. 2012. Mapping plant species ranges in the Hawai'ian Islands—Developing a methodology and associated GIS layers. U.S. Geological Survey Open-File Report 2012–1192, 34 p., one appendix (species table), 1,158 maps. Available at: http://pubs.usgs.gov/of/2012/1192/.

Tetra Tech (Tetra Tech, Inc.), 2021a. Kahana Draft Delineation of Wetlands and Other Waters of the U.S. Prepared for Kahana Solar.

Tetra Tech, 2021b. Kahana Biological Resources Survey Report. Prepared for Kahana Solar.

Figures