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Subject: Revised Work Plan for TENORM and OCP Health and Safety Survey
Closed Berkeley Landfill
Berkeley, California

Dear Fangli,

On behalf of the City of Berkeley (City), SCS Engineers (SCS) submits this Work Plan (WP) in response to the San Francisco Bay Regional Water Quality Control Board's (RWQCB) letter, dated January 18, 2024. The letter, titled *Berkeley Landfill, Berkeley, Alameda County - Requirement for Technical Reports Pursuant to Water Code Section 13267*, mandates the development of a WP to conduct a survey detailed herein at the closed Berkeley Landfill/Cesar Chavez Park (Site). The Site is located north of Spinnaker Way in Berkeley, California. Enclosed are a Site Location Map (Figure 1) and a Site Plan showing the primary features of the Site (Figure 2).

BACKGROUND

The January 18,2024 RWQCB letter indicates new evidence that industrial waste from the Zeneca Richmond Plant may have been disposed of at the Site between 1960 and 1971. Enclosed with the letter was a correspondence from March 28, 1980, by Stauffer Chemicals, identifying the Berkeley Landfill Company site as a recipient of the Richmond Plant's process waste. This waste reportedly included "alum mud," a byproduct of aluminum extraction from bauxite ore, which typically contains certain radionuclides known as "technologically enhanced naturally occurring radioactive material" (TENORM).

Neither the City nor the RWQCB was previously aware of the potential presence of TENORM at the Site. Consequently, the RWQCB requires the City to submit a work plan as this document provides. It should be noted that groundwater and leachate samples were analyzed at the Site for organophosphorus pesticides in 2013, 2018, and 2023, with no detections reported.

SITE DESCRIPTION

The Site spans approximately 90 acres on the western edge of the City. The Site forms the northern portion of a man-made peninsula, bounded by San Francisco Bay on the west, north, and east, and the Berkeley Marina on the south. The landfill is designated as Facility No. 01-AC-0001 in the State of California Solid Waste Information System (SWIS) database.

Initially permitted by the California Integrated Waste Management Board (CIWMB) in 1978, the landfill was authorized to receive up to 180 tons per day (67,000 tons per year) of residential and commercial refuse, plant debris, and demolition debris. Historical records indicate that waste placement began as early as 1961, comprising a mixture of municipal, commercial, and industrial solid wastes. This continued until 1983. Between 1983 and 1985, soil, asphalt, concrete, and materials containing a combination of subgrade soil, concrete and/or asphalt were also accepted as waste per RWQCB approval. After 1985 only, clean fill was imported as cover.

The landfill was formally closed in phases during the period 1981 through 1989 per the California Code of Regulations (CCR) Title 14 and 23 requirements in effect at the time. Today, the Site is developed as North Waterfront Park/Cesar Chavez Park and continues to be subject to post-closure monitoring and maintenance. Oversight of these activities is provided through various programs administered by the RWQCB, the California Department of Resources Recycling and Recovery (CalRecycle), and the Bay Area Air Quality Management District (AQMD).

The final cover system, which was installed in phases, varies in thickness from 3 to over 30 feet. The cover system was placed to contour the Site for use as a public park and to meet regulatory requirements in effect at the time of closure. The final cover system includes both general fill soils and a minimum 1-foot-thick layer of clay material with a hydraulic conductivity of 1×10^{-6} centimeters/second.

For additional information please refer to the *Updated WDRs for the Site (Order No. R2-2010-0064),* published by the RWQCB on April 19, 2010.

SCOPE OF WORK

This WP proposes a sequential survey approach which includes establishing background radiation levels through a pilot study using a drone, conducting an initial gamma radiation survey also using a drone, and performing additional water sampling and analysis from existing monitoring features.

The City has partnered with the University of California at Berkeley's Nuclear Engineering Department (UCB) to perform the gamma drone survey (GDS). The purpose of the GDS is to identify sources of radiation on or near ground surface. The radionuclides of concern identified by the RWQCB emit gamma radiation, as well as alpha and beta radiation. Gama radiation is penetrating and can travel significant distances through air and soil making it easier to detect in the environment compared with alpha and beta radiation. The results of the GDS will assist in determining radiological risks to workers or members of the public from radioactive material potentially disposed of in the landfill and provide an estimate of the lateral extent of any surface radioactivity.

In addition, upcoming routine semi-annual monitoring is proposed to include additionally analyzing routinely collected samples for OCPs and additional parameters detailed below.

The proposed study includes the following:

- Establishment of Background Levels
- Surface Survey
- Follow-up Surface Survey (Based on results of Initial Survey)
- Liquids Sampling and Analysis
- Evaluation of Data and Report Preparation

Survey Instrumentation

This survey will employ a professional-grade drone with an advanced radiation detection system. The system features a 3 x 3 inch sodium iodide (NaI) spectrometer integrated with a GPS for sub-meter accuracy. The Theiss Validus Hex drone, battery-operated and able to carry up to 18 lbs, will carry the NaI(Tl) detector, which will operate in list mode with readout using an Ortec DigiBase. This readout method assigns time and energy to each detected gamma ray. Additionally, ground surface surveying with a SAM 945 Handheld Radiation Isotope Identifier (RIID) will be performed at select locations to validate drone data.

Survey Methodology

The GDS will involve the NaI detector suspended approximately 3 meters above the ground and with 6-meter line spacing. To enhance measurement sensitivity, the drone's speed will be limited to no more than 3 meters per second (m/s). Each 1-second measurement will cover an area of about 18 square meters (m^2).

The GDS aims to cover 100% of the accessible ground surface, providing a comprehensive assessment of the Site's radiological conditions. In areas where dense vegetation impedes the drone's flight path, the drone will fly at a safer height as determined by the pilot. If the understory is clear, surveyors will walk the understory with the NaI spectrometer to ensure thorough examination.

Background Establishment

Before surveying the entire Site, a preliminary survey was conducted in June 2024 to establish background levels in the northwest corner (Location A) as shown in Figure 2. This area was chosen because it contains only documented and confirmed clean soil or fill, with no landfill refuse present. Ground surface surveying was performed alongside the drone survey. For safety, the area was closed to the public while the drone operated at low altitudes. This preliminary survey was crucial for providing a baseline for comparison with subsequent surveys of the entire Site.

Analysis of the data collected during the background establishment survey (shown in Figure 3) revealed no significant spectral variations within the surveyed area, the gamma radiation detected was attributed to natural radioactivity found in all soils, with count rates remaining stable except when in proximity to or above water. The observed rates were compared with a handheld dosimeter near the background establishment effort launch point with readings of 7-10 microR/hr, which we associate with 200-285 counts per second (cps) in the spectrometer. Further investigation will be conducted in areas where readings exceed 3.5 sigma above the established local background. For example, in the area used to establish background, any reading above 345 cps will prompt further surveying. In regions closer to the shoreline, where typical readings of 200 cps were observed, the investigation threshold will be set at 250 cps. These count rate thresholds correspond to 1.25-2.0 microR/hr above the established background for triggering follow-up measurements.

Given the 3.5 sigma count rate threshold, approximately one false alarm per hour is anticipated due to statistical fluctuations. The initial approach for follow-up surveying will involve returning to the location of the anomalously high reading to check for reproducibility. If the elevated count rate is confirmed, handheld measurements with minute-scale dwell times will be conducted to further assess the anomaly. Based on these measurements, the existence and location of the anomaly will be reported, and further actions, such as soil sampling, will be considered.

Full Site Survey

With background levels established from the preliminary survey, the full Site survey will be conducted using the same drone and radiation detection system. The survey will be executed in phases due to the Site's size and public usage, ensuring minimal disruption. Each phase will require approximately 60 minutes of drone flight time, during which only limited areas will be closed to allow public access to other parts of the Site. Additionally, limited walking gamma surface surveys will be performed during each phase as previously described.

Data Evaluation

UCB will process the drone survey data, cross-checked with the ground surface survey data. A 3D map of the Site will be prepared to summarize all survey results. The map will use color to differentiate between results.

Additional Surveying

Survey results may results in follow up survey(s), to confirm initial data. The data will be processed and reported as described above.

Liquids Sampling and Analysis

During one future routine groundwater and leachate monitoring event, it is proposed to sample all Site groundwater and leachate monitoring well samples for the additional non-routine compounds listed below:

- Thorium-228, 230 and 232 and uranium-234, 235 and 238 by HASL-300 EML Radiological Manual Method A-01-R
- Radium-226 by Method Gamma Spec. 901.1
- Radium-228 by Method Gamma Spec. 901.1
- Lead-210 by Method LSC-Pb210
- Organochlorine Pesticides (OCPs) by EPA Method 8081

Liquid samples to be analyzed as listed above will be collected along with routine samples. For the groundwater samples, low-flow purging and sampling methodology, using existing dedicated bladder pumps will be used as routinely performed. Leachate samples will be collected using dedicated disposable plastic bailers, also as routinely performed. Samples will be collected in laboratory supplied, appropriate sample containers. Upon collection, samples will be labeled, logged, and placed in a chilled cooler prior to delivery or shipment to the analytical laboratory under proper chain-of-custody (COC) procedures. OCP samples will be delivered to McCampbell Analytical laboratory in Pittsburg, California for analysis. Remaining samples will be shipped to Eurofins Test America laboratory in Saint Louis, Missouri for analysis.

Completion Report and Additional Documents

A Completion Report will be prepared for submittal to the RWQCB following completion of the Survey and liquids sampling and analysis activities described above. The report will include a summary of performed activities, summary of data, 3D map summarizing Survey results, and copies of laboratory

reports. The report will conclude whether additional data collection appears warranted at which time an addendum to this WP will be submitted to the RWQCB. The addendum will document possible additional survey activities and/or, if warranted, will provide proposed soil borings and soil sample collection and analysis to further evaluate the potential for TENORM at the Site

OCP results will be compared to current Environmental Screen Levels (ESLs) provided by the RWQCB.

CLOSING

With this submittal we respectfully seek your approval for the WP outlined herein. If you have any questions, please contact Mary Skramstad with the City of Berkeley.

Very truly yours,

Ted Sison
Senior Project Manager
SCS Engineers

Patrick Harms, PG
Project Manager
SCS Engineers

Attachments Figures 1, 2 and 3

cc: Mary Ellen Skramstad - City of Berkeley
Daniel Akagi - City of Berkeley
Ronald Nevels - City of Berkeley
Tony Svorinich – SCS Field Services
Melissa St. John – SCS Engineers
Brian Quiter – UC Berkeley
Kai Vetter – UC Berkeley

Figures

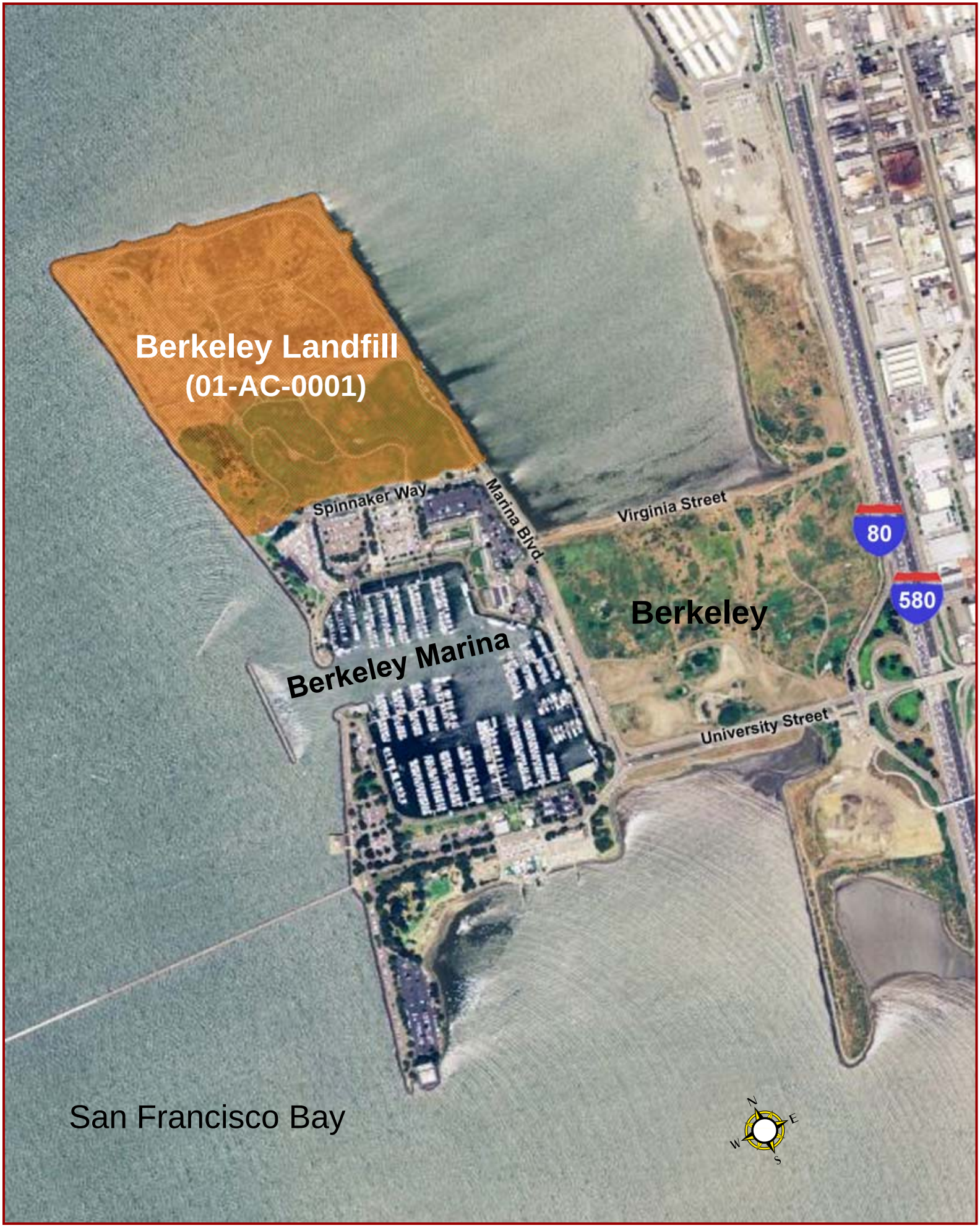

Figure 1: Berkeley Landfill Location Map

Figure 2

View with Site aerial photo from the drone planning software that shows the planned flight lines (in yellow), including Location A, which is circled in red on the zoomed-in right-hand figure. These lines were flown during the preliminary background survey.

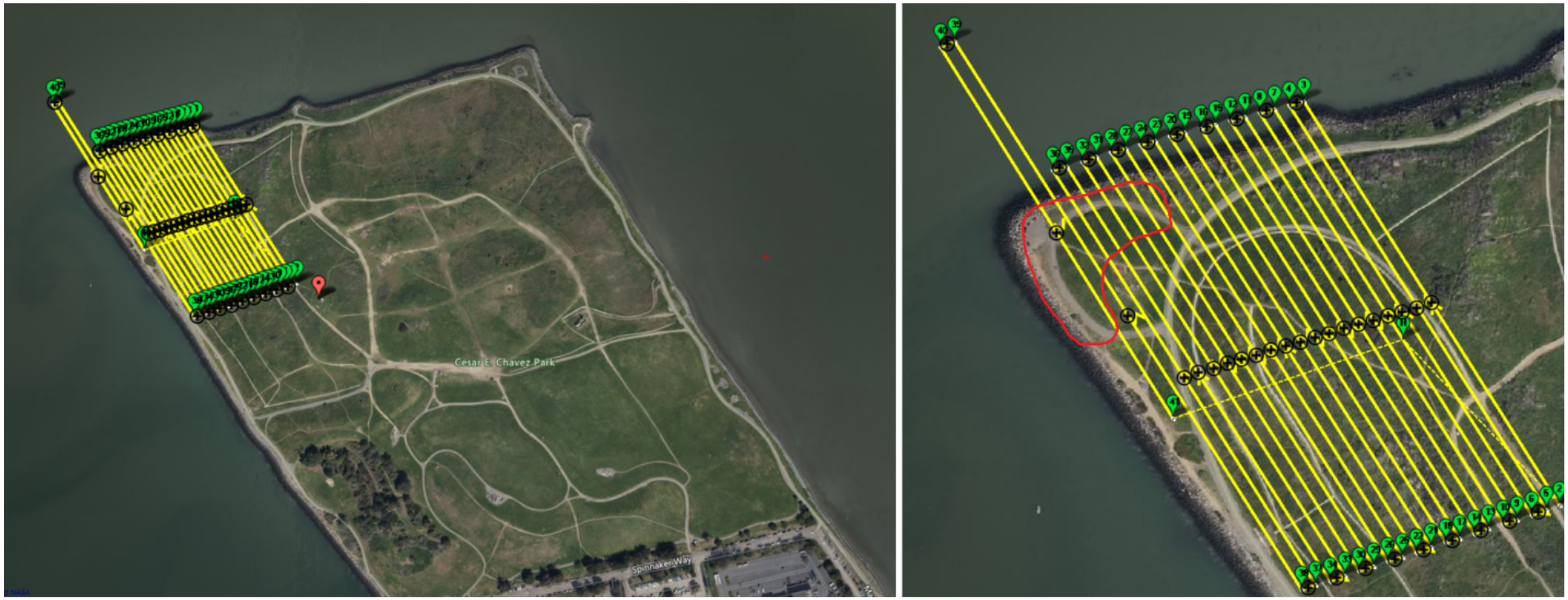

Figure 3 - Data Summary from Background Study.

(top) Count-rate profiles from one of the two flights during the background establishment survey. The list-mode data collect modality allows for data to be converted into count-rate profiles at any time interval. Shorter intervals allow for sensitivity to fast anomalies, but are subject to greater statistical uncertainty, which is evident in the amount of jitter in the 100ms strip-chart, shown in blue. Longer intervals, such as the 40s running average, in yellow establish a mean rate over a wide area and can help to guide searches for anomalous activity.

(bottom) Gamma-ray spectrum obtained from the entirety of the corresponding flight, the prominent peaks at 2615 and 1460 keV are due to decay of thorium and potassium-40, respectively. The less prominent peak near 600 keV is due to both uranium radioactive decay (609 keV) and thorium decay (583 keV). The peak-like feature at low energy is due only to gamma-ray physics and is not indicative of any isotope in particular. Other visible peaks at 240,350, 910, 1120, 1760 and 2200 keV are also due to uranium and thorium decay.