Kern Fenceline Monitoring Plan for Rule 4460

Monitoring Plan Prepared for the
San Joaquin Valley Air Pollution Control District
Bakersfield, CA

August 15, 2023

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Kern Fenceline Air Monitoring Plan for Rule 4460

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Air Monitoring Plan

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1. Rule 4460 Summary

On December 19, 2019, the San Joaquin Valley Air Pollution Control District (SJVAPCD or District) adopted Rule 4460, "Petroleum Refinery Fenceline Air Monitoring."[1] Kern Energy (Kern) implemented the SJVAPCD-approved fenceline monitoring system on January 27, 2022, in accordance with the original requirements specified in Rule 4460. Kern continues to operate the fenceline monitoring system in accordance with the approved plan.

Subsequently, the rule was amended on October 20, 2022, with an expanded target compound list based on guidance from the California Air Resources Board (CARB) and California Air Pollution Control Officers Association (CAPCOA). Rule 4460 and its amendment requires petroleum refineries within the District to establish measurement systems at the fenceline of their facility (at or near the property boundary) and provide real-time air quality information to the public and to the District. Data must be collected by the monitoring systems in accordance with an approved fenceline monitoring plan (this document) that follows District guidelines. This version of the plan, dated May 1, 2023, and re-submitted on August 16, 2023, has been updated to address the new requirements and feedback from the District.

According to Rule 4460, the monitoring plan must provide detailed information on several elements to justify the measurement and data dissemination approach. Section numbers in the following list indicate where each element is discussed in this plan.

- A plan for monitoring pollutants based on an evaluation of routine emission sources at the refinery (Section 1). Given the refinery's processes and emissions, Kern Energy will monitor many of the required pollutants highlighted in the Rule 4460 guidelines, including sulfur dioxide (SO_2), hydrogen sulfide (H_2S), BTEX compounds (benzene, toluene, ethylbenzene, and xylenes), acetaldehyde, ammonia, 1,3-butadiene, formaldehyde, naphthalene, and nitrogen dioxide (NO_2).
- A summary of fenceline air monitoring instruments proposed to continuously measure, record, and report air pollutant levels in real-time near the petroleum refinery facility perimeter (i.e., fenceline) (Section 2). *This plan relies on multiple open-path and point instruments to satisfy Rule 4460 requirements.*
- Proposed monitoring equipment siting and selected pathways for fenceline instruments, including the justification for selecting specific locations (Section 2). *This plan covers paths along the important refinery fencelines and has accounted for the measurements of all chemical species for which measurements have been deemed justified based on refinery processes and expected concentration levels.*

[1] San Joaquin Valley Air Pollution Control District (2019) Rule 4460: Petroleum refinery fenceline air monitoring. Final rule adopted December 19, 2019. Available at https://www.valleyair.org/rules/currntrules/4460.pdf.

- A summary of equipment used to measure and continuously log wind speed and wind direction data within the facility boundaries (Sections 2 and 4).
- Procedures for maintenance of all fenceline monitoring equipment. These procedures include routine maintenance requirements and timelines of periodic maintenance; length of monitoring equipment downtime during maintenance (when equipment is not operational); and temporary air monitoring measures that will be implemented should equipment fail and be used until normal operating conditions are restored (Section 5).
- Procedures for implementing quality assurance including independent audits of the fenceline monitoring system (Section 6 and **Appendix A**). *This plan includes a detailed draft Quality Assurance Project Plan (QAPP).*
- Methods for the distribution of data collected by the fenceline monitoring system to the public, local response agencies, and the District. (Sections 7 and 8). *This plan provides the key content of a web system for disseminating information and an email-based public notification system.*

1.1 Summary of Kern Energy

Kern Energy is an independent refining and marketing company located at 7724 E. Panama Lane, Bakersfield, CA 93307. As shown in **Figure 1**, the area within several miles of Kern is flat, mostly agricultural land, with two main rural, residential communities of Lamont and Fuller Acres located to the south and northeast of Kern, respectively. This area of the Central Valley often has winds flowing from the northwest and less often flowing from the southeast; other flow directions are much less frequent.

Kern is an important producer and supplier of California-approved gasoline and diesel fuel. Kern employs about 190 people and is committed to providing a safe working environment while working diligently to provide cleaner fuels. Kern's crude oil refining capacity is approximately 26,000 bpd. Kern processes light, sweet crude oil, which is low in sulfur. In addition, it produces renewable diesel from biomass, and blends additional volumes of biodiesel. Kern also produces an intermediate fuel oil stream, and a small quantity of sulfur as a co-product.

The facility layout with major process and storage areas is shown in **Figure 2**. There are no residences immediately adjacent to the facility process or storage areas. The main process area is located in the north-central area of the facility. Storage tanks are located on the west side of the facility (product storage tanks are in the areas labeled 12 and 13 in Figure 2), across Weedpatch Hwy on the east side of the facility (crude oil storage tanks are in the area labeled 1 in Figure 2), and in the central area of the facility.

In response to the amended Rule 4460 monitoring requirements (compounds listed in Table 2), Kern will continue to monitor SO_2, H_2S, and BTEX compounds, and will add instruments to measure acetaldehyde, ammonia, 1,3-butadiene, formaldehyde, naphthalene, and NO_2. A summary of 2022 emissions inventory estimates for several of these compounds is provided in Table 1.

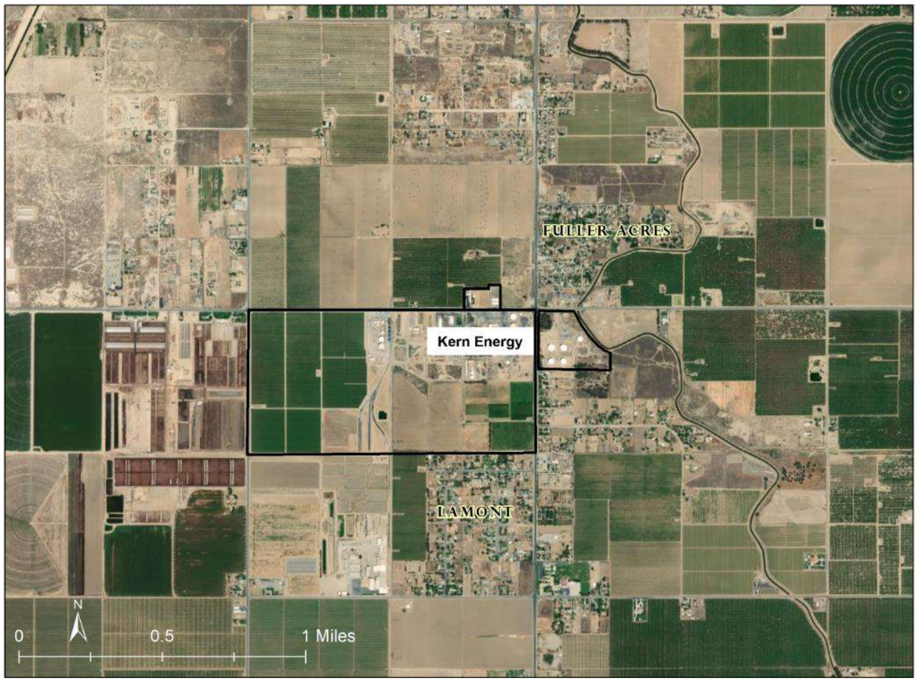

Figure 1. Location of the Kern Energy facility and surrounding communities.

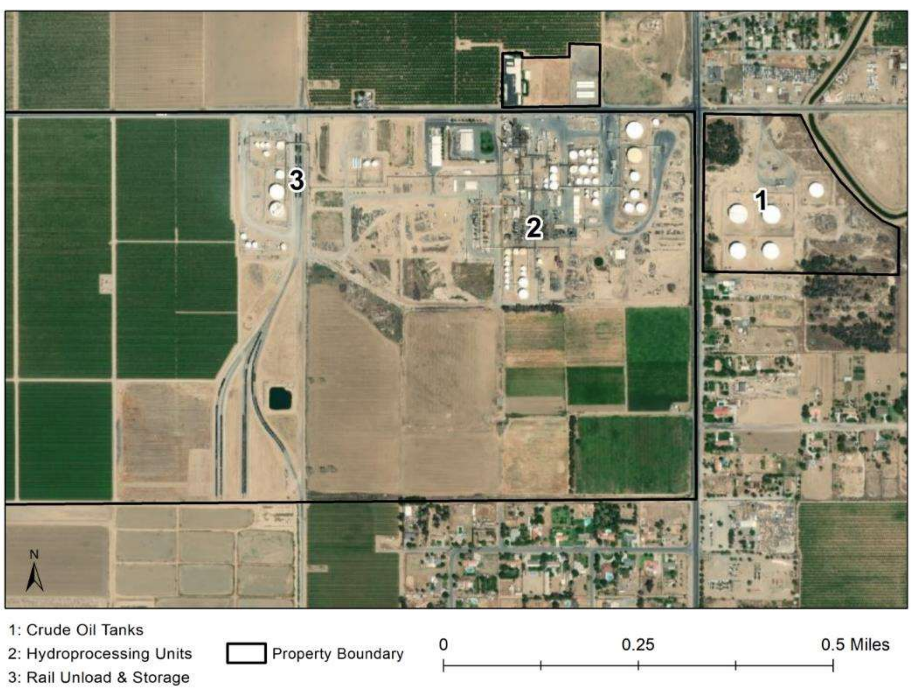

Figure 2. Map of the Kern Energy facility showing the general layout. Neighboring residences are also visible to the northeast, east, and south.

Table 1. A summary of reported emissions that contain Rule 4460 compounds.

Compound	2022 Emissions (tons/year)
VOC	38.3
SO_x	6.1
NO_x	39.4
NH_3	729.5

1.2 Summary of Monitoring Plan for Kern Energy Refinery

Kern's monitoring and data reporting system will meet many important Amended Rule 4460 requirements. Key elements include:

- Kern will measure required species including acetaldehyde, ammonia, 1,3-butadiene, formaldehyde, naphthalene, BTEX, SO_2, and H_2S.
- Instruments that will be used to measure these species will include open-path Ultraviolet-Differential Optical Absorption Spectroscopy (UV-DOAS) instruments for BTEX, naphthalene, NO_2, and SO_2; open-path Fourier-Transform Infrared (FTIR) for the remaining non-methane hydrocarbons; and ultraviolet (UV) fluorescence point analyzers for H_2S. The instruments are capable of measuring these pollutants in real time. Meteorological parameters and visibility will also be measured.
- Kern will monitor concentrations across three open paths and two-point monitor locations. These paths and point locations are shown in Figure 3. The monitoring will cover fenceline locations along the northeast, east, and south sides of the facility. Kern selected these locations after analyzing wind patterns, sources of potential air emissions on the refinery property, nearby local receptors, and logistical feasibility. These locations will provide coverage for nearby downwind communities under typical and atypical wind patterns.
- Data will be collected every 5 minutes.
- The data will be subjected to real-time automatic data quality control, and these preliminary data will be delivered to the public via a website within 10 minutes of collection. The data will also be used for any public notifications via an opt-in email notification system.
- Kern will perform more detailed quality control on a quarterly basis to produce final datasets and will make these data available within 45 days after the end of each calendar quarter.
- Kern will provide the District with quarterly data reports that will include a summary of periods when the instruments were inoperative, a list of routine maintenance periods, the nature of any repairs and adjustments, a summary of the data and health thresholds, data

completeness, and any special quality control efforts beyond those described in the QAPP. Hard copies of the report will be provided to the public at the refinery on an appointment basis.

- Kern's public website will provide real-time data, historic data for the most recent annual quarter, frequently asked questions (FAQs), links to additional resources, and a feedback mechanism for the public.
- Notifications will be issued when thresholds are exceeded or when major activities affect the monitoring or reporting system.
- Kern will operate and maintain equipment in accordance with a District-approved QAPP and associated standard operating procedures (SOPs).
- Kern will provide annual independent audits of the instruments to validate instrument performance. Internal audits and system checks will occur as part of regular operations and maintenance.
- Kern will provide temporary monitoring only during extended equipment downtimes (>96 hours) using 24-hr volatile organic compound (VOC) canister sampling. Note, extended downtimes are not anticipated.
- Kern will maintain all data records and chain-of-custody information for 5 years, consistent with other data record-keeping requirements.

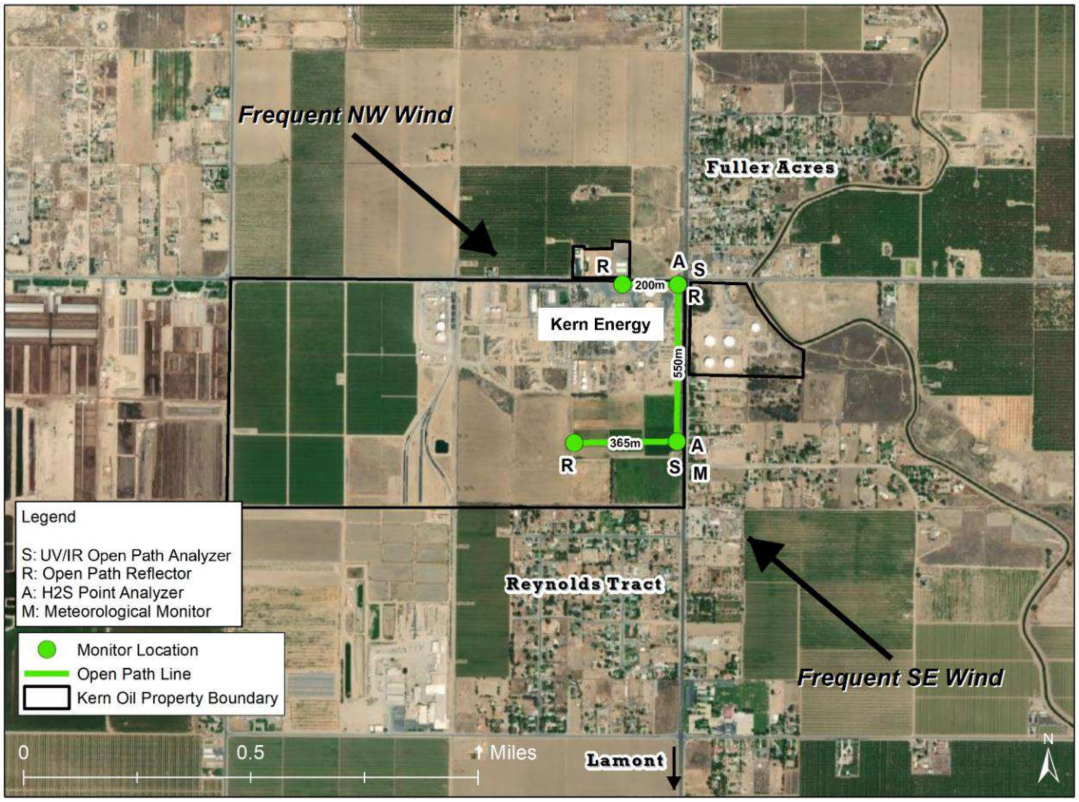

Figure 3. Monitoring paths for the Kern refinery in relation to the refinery equipment and property boundary. Note, instrument locations are approximate.

1.3 Justification for Pollutant Monitoring List

The list of pollutants required to be considered for monitoring as part of the Amended Rule 4460 is shown in Table 2. From the list of pollutants identified in Table 2, Kern proposes to add acetaldehyde, ammonia, 1,3-butadiene, and formaldehyde to the Kern fenceline monitoring network. The existing monitors for BTEX, SO_2, and H_2S will remain in service. The four additional compounds that will be added to the network can be measured by open-path FTIR analyzers. Kern will install three FTIR analyzers next to the existing UV-DOAS analyzers. Naphthalene and NO_2 will be measured by the existing UV-DOAS analyzers along each fenceline path.

The proposed monitoring actions to be taken by Kern for each of the compounds listed in Amended Rule 4460 are summarized in Table 2 below.

Table 2. List of pollutants included in Amended Rule 4460 and a summary of the fenceline monitoring approach proposed by Kern Energy.

Pollutant	Proposed Approach
Acetaldehyde	Add open-path FTIR analyzer
Ammonia	Add open-path FTIR analyzer
Benzene	Continue to measure with open-path UV analyzer
1,3-Butadiene	Add open-path FTIR analyzer
Cadmium	Not to be monitored given low health risk
Diethanolamine	Not to be monitored given lack of use at facility and absence of real-time monitoring capability
Ethylbenzene	Continue to measure with open-path UV analyzer
Formaldehyde	Add open-path FTIR analyzer
Hydrogen Fluoride	Not to be monitored given lack of use at facility
Hydrogen Sulfide	Continue to measure with open-path UV analyzer
Manganese	Not to be monitored given low health risk
Naphthalene	Measure with open-path UV analyzer
Nickel	Not to be monitored given low health risk
Nitrogen Oxides	Measure with open-path UV analyzer
Polycyclic Aromatic Hydrocarbons	Measure naphthalene with open-path UV analyzer
Particulate Matter	Not to be monitored; facility not a significant source
Sulfur Dioxide	Continue to measure with open-path UV analyzer
Sulfuric Acid	Not to be monitored given lack of use at facility and absence of real-time monitoring capability
Toluene	Continue to measure with open-path UV analyzer
Xylene	Continue to measure with open-path UV analyzer

Kern's proposed fenceline monitoring system has been tailored based on various factors deemed sufficient justification to provide appropriate monitoring of facility emissions specific to Kern's operation. Compounds to be excluded from fenceline monitoring and their exclusion criteria are:

- *Diethanolamine*: Kern does not use diethanolamine in its refining processes to remove H_2S from natural gas, and therefore would not have measurable emissions. Furthermore, the only currently known method for measuring and quantifying diethanolamine is through the use of offline filters, which then require laboratory-based analysis. Given that this monitoring does not meet the Rule 4460 requirements for continuous, real-time monitoring displayed on the public website, Kern cannot add this pollutant to the fenceline monitoring system.

- *Cadmium, Manganese, and Nickel*: Kern used the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD)[2] and CARB HARP[3] air dispersion and risk modeling tool to estimate the maximum offsite metals concentrations and the health risks from the refinery operating under maximum operation conditions.

  The results of these analyses showed that the maximum predicted concentrations of cadmium, manganese, and nickel were well below the health-based standards for sensitive receptors downwind and near the fenceline of the facility (see Section 3.2). The modeled health risk was below one-in-a-million for residential cancer risk. Results also showed a Hazard Index value below 1.0 at both acute and chronic thresholds, meaning the results are below the levels of toxicity. Figure 4 contains maps showing the health risks in and around Kern Energy at various distances from the facility.

  Further, the 1-hr maximum risk for these three metals were all at least one order of magnitude lower than chronic or 8-hr reference exposure levels (REL) set by the California Office of Environmental Health Hazard Assessment (OEHHA). In addition, for Cadmium specifically, the model results show a maximum concentration lower than the detection limit of the energy dispersive X-ray fluorescence (EDXRF) analyzer that is commercially available to provide continuous metals measurements.

  Therefore, these metals are not expected to be emitted from the refinery at levels that would pose any risk to public health or be measurable in any significant or detectable quantities by the fenceline monitoring system, and will be excluded.

- *Hydrogen Fluoride (HF)*: The Kern facility does not have any alkylation processes and does not use HF at the facility. Absent any source of HF, no emissions are expected to be emitted from the refinery or measurable by the fenceline monitoring system.

- *Polycyclic Aromatic Hydrocarbons (PAHs)*: Kern is not aware of any commercially available analyzer that can provide real-time measurements of total PAHs with accuracy comparable to non-real-time quantification methods. A continuous photoelectric aerosol sensor for particle-bound PAH identification is not highly selective, cannot be easily calibrated,[4] and does not provide information on the more abundant, gas-phase PAHs.[5] It is therefore not well suited for this fenceline monitoring application.

  Recent studies have shown an overall decrease in PAH concentrations in California, even in areas near refineries.[6] In addition, naphthalene has been reported as the most abundant PAH,

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[2] https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models#aermod

[3] https://ww2.arb.ca.gov/resources/documents/harp-air-dispersion-modeling-and-risk-tool

[4] Wallace, Lance (2005) Real-Time Measurements of Black Carbon Indoors and Outdoors: A Comparison of the Photoelectric Aerosol Sensor and the Aethalometer, Aerosol Science and Technology, 39:10, 1015-1025, DOI: 10.1080/02786820500365363

[5] Masri S, Li L, Dang A, Chung JH, Chen JC, Fan ZH, Wu J. (2018) Source characterization and exposure modeling of gas-phase polycyclic aromatic hydrocarbon (PAH) concentrations in Southern California. Atmospheric Environment. Mar 1;177:175-86.

[6] http://www.aqmd.gov/docs/default-source/planning/mates-v/mates-v-final-report-9-24-21.pdf

and is most frequently associated with refinery emissions compared to other PAHs.[7] Given this information, and the fact that the currently operating UV-DOAS systems are capable of providing continuous measurements of naphthalene, we propose to monitor for naphthalene and begin reporting these concentrations to the public. No additional PAHs will be monitored.

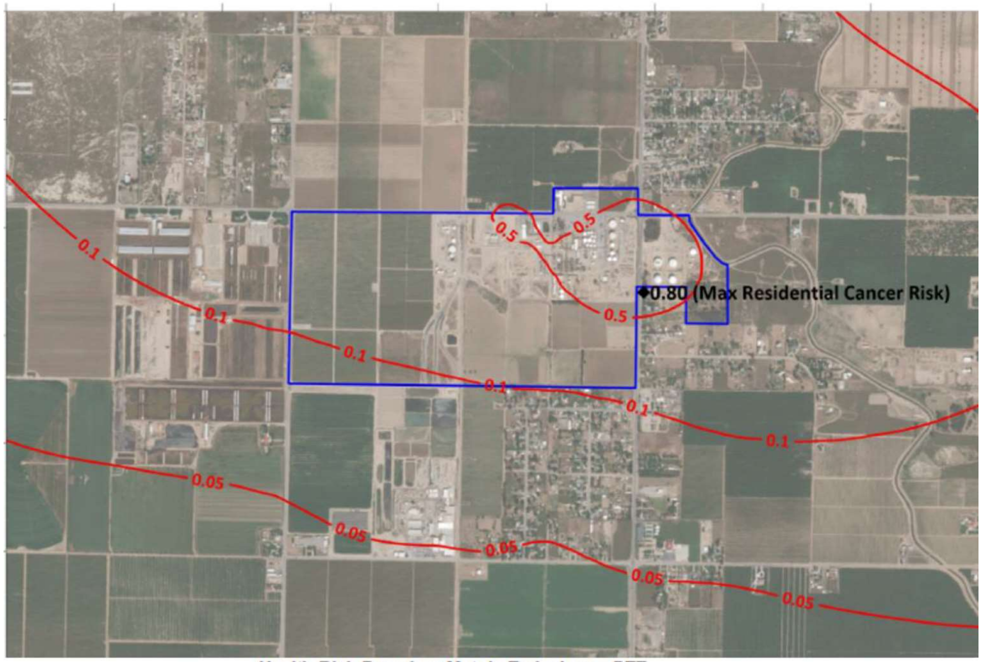
- *Particulate Matter (PM)*: Because Kern does not operate fluidized catalytic cracking units (FCCU) or a coker unit at this facility, and the fact that diesel generators are no longer used at the facility, the refinery is not expected to be a significant source of PM concentrations in the region. To assess potential PM concentrations, Kern also performed AERMOD and HARP modeling analysis. The model assumed the same maximum operating conditions noted above for metals. Modeling analyses showed that 24-hour maximum PM concentrations from the Kern facility were much lower than regional background PM concentrations, and significantly lower than the 24-hour National Ambient Air Quality Standards (NAAQS). More specifically, the maximum daily PM_{10} concentration from the facility was 4 $\mu g/m^3$ (compared to regional background values of 121 $\mu g/m^3$), and the maximum $PM_{2.5}$ concentration was 4 $\mu g/m^3$ (compared to regional background values of 10 $\mu g/m^3$). Results are summarized in **Table 3**. A map showing the dispersion of PM concentrations moving further away from the facility is found in **Figure 5**.

  Based on these results, PM measurements will be excluded from the fenceline monitoring system.

- *Sulfuric Acid*: The Kern facility does not have any alkylation processes that use sulfuric acid at the facility. Also, HARP analysis showed that the 1-hr maximum concentrations are several orders of magnitude below the acute REL for sulfuric acid. Furthermore, Kern is not aware of any monitoring methods that provide continuous measurements of sulfuric acid. Given the lack of use at this facility, the absence of a real-time measurement technique for monitoring, and minimal health impact, Kern will exclude sulfuric acid from the fenceline monitoring system.

[7] https://oehha.ca.gov/media/downloads/faqs/refinerychemicalsreport032019.pdf

Health Risk Based on Metals Emissions - PTE
Residential Cancer Risk (per Million)



Health Risk Based on Metals Emissions - PTE
Chronic Risk (Hazard Index)

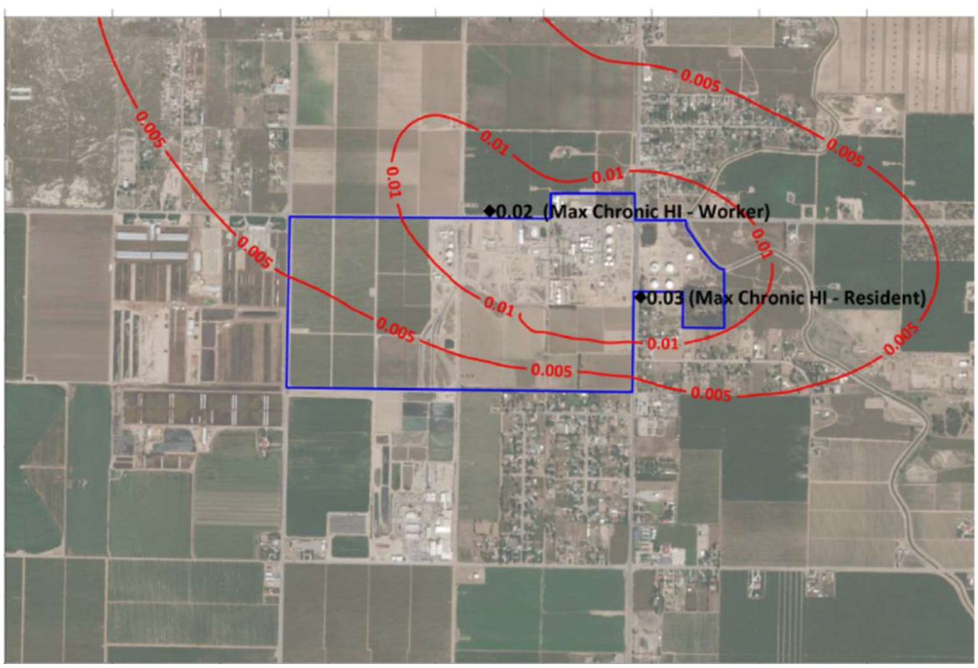


Figure 4. Maps showing AERMOD/HARP model results of health risks based on maximum metals emissions for sensitive receptors near the Kern Energy facility. The Kern facility is outlined in blue. For all residents and workers near the facility, the maximum potential residential cancer risk is less than one-in-a-million (top panel), and the Hazard Index is less than 1.0 (bottom panel).

Table 3. AERMOD/HARP model results of maximum PM_{10} and $PM_{2.5}$ concentrations from the Kern facility compared to regional PM concentrations and the NAAQS. Kern Energy is not predicted to be a significant source of PM concentrations in the region.

Pollutant	Modeled Max. 24-hr Concentration Emissions (µg/m^3)	Regional Background Concentration (µg/m^3)	24-hr NAAQS (µg/m^3)
PM_{10}	4	121	150
$PM_{2.5}$	4	14	35

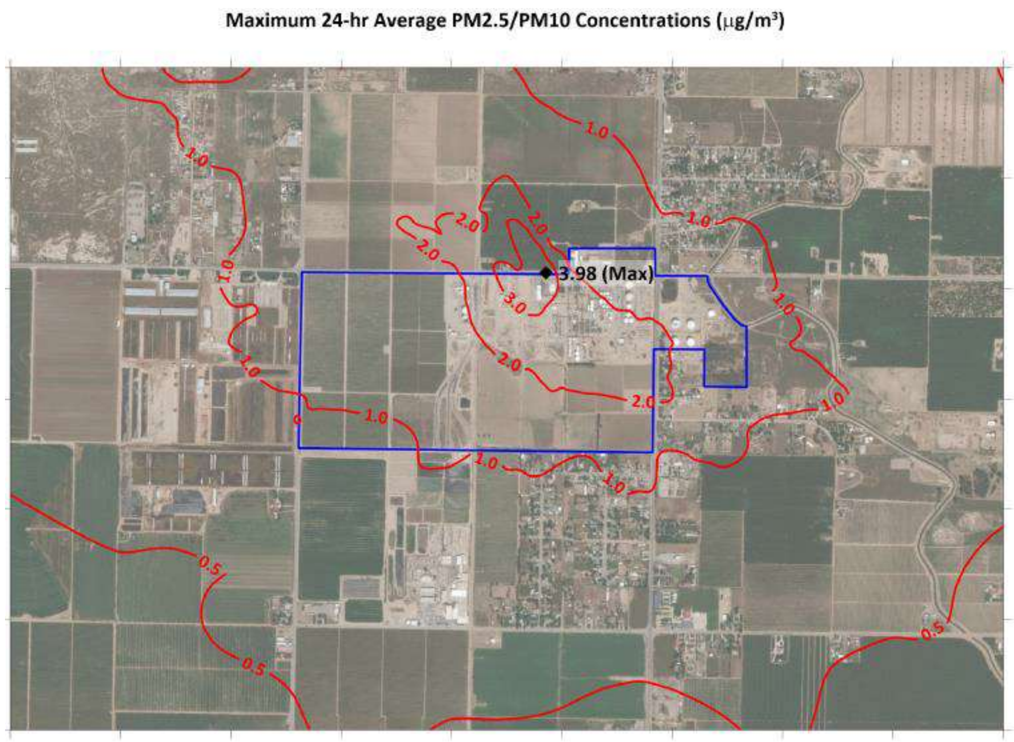


Figure 5. Map illustrating AERMOD/HARP model results of maximum PM concentrations at and near the Kern Energy facility. Estimated concentrations are well below the regional PM concentrations, as well as the NAAQS.

2. Summary of the Monitoring Network and Reporting System

This section describes the sampling locations, paths, and monitor types selected for the fenceline monitors, and the specifications and maintenance requirements for each monitor. The compounds that will be monitored along each path/location are also provided. Point measurements are only for H_2S. Open-path technology for H_2S has not been proven to have a minimum detection limit (MDL) at or below the California OEHHA acute exposure threshold of 30 ppb; therefore, this technology will not be used.

Kern will monitor concentrations across three open paths and two-point locations (shown in Figure 6). The Figure 6 legend indicates the type of monitor that will be placed at each location. The paths are described in Table 4, and specific monitor locations are listed in Table 5. A meteorological station will be installed and will include a visibility sensor in addition to sensors for measuring wind speed and direction, temperature, and relative humidity.

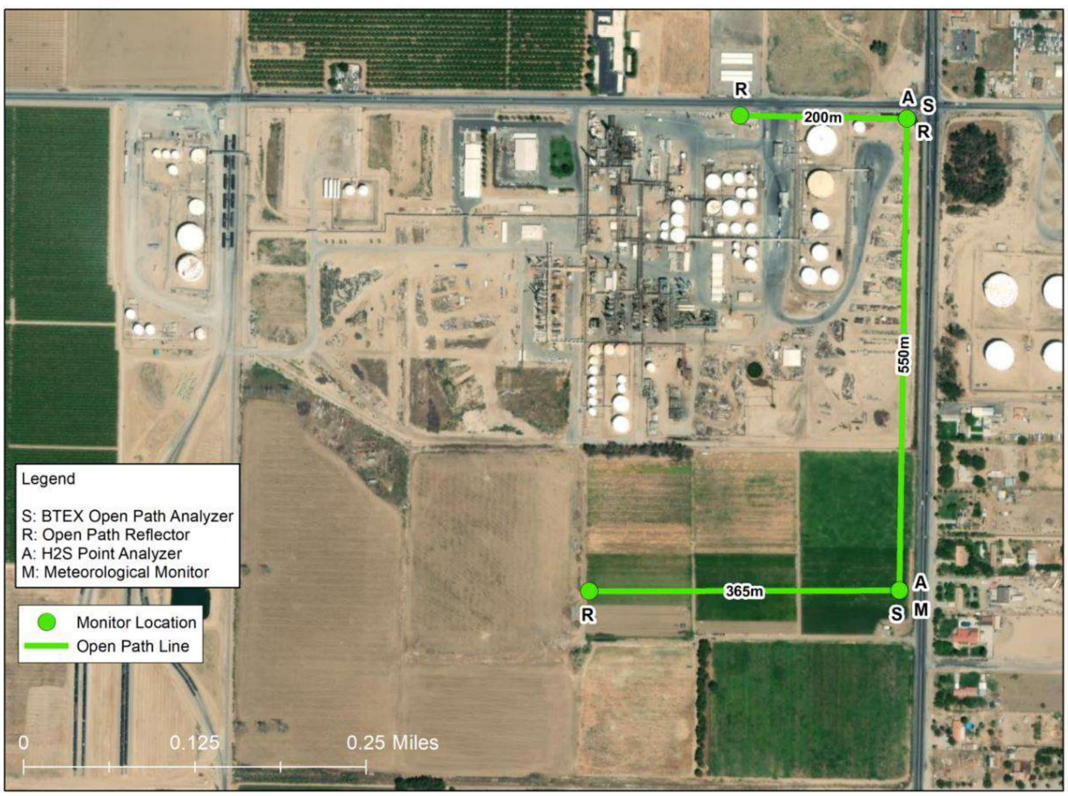


Figure 6. Locations of monitors covering the important fencelines around Kern.

Table 4. General monitoring locations and path lengths. All instruments and reflectors will be located between 2 m and 15 m above ground level depending on site logistics.

Path #	Monitor Location Description	Approximate Path Length (m)
1 (North-side)	East-West along N boundary, point in NE corner	200
2 (East-side)	North-South along E boundary, point and meteorological station in SE corner	550
3 (South-side)	East-West along S boundary	365

Table 5. Specific monitor locations.

Position	Monitor	Lat.	Long.
Northeast Location	• UV-DOAS open-path analyzer pointing west; another UV-DOAS analyzer pointing south • FTIR open-path analyzer pointing west; FTIR analyzer pointing south • UV fluorescence point analyzer	35.2959690	-118.9146818
Northwest Location	Open-path reflectors	35.2959670	-118.9168370
Southeast Location	• UV-DOAS open-path analyzer pointing west • FTIR open-path analyzer pointing west • UV fluorescence point analyzer • Meteorological monitor • Open-path reflector	35.2909736	-118.9146596
Southwest Location	Open-path reflectors	35.2909009	-118.9186648

Fenceline monitoring paths were chosen for the northeast, east, and south edges of the refinery property after considering dominant wind patterns (most frequently from the northwest and from the southeast), sources of potential air emissions on the refinery property, and nearby local receptors. Transmitter-detectors/analyzers will be located at sites labeled “S” (identified in Figures 3 and 6), and retroreflectors (mirrors) will be placed at the sites labeled “R”. Point analyzer locations are denoted with an “A.” Analyzers and reflectors will be mounted from about 2 m to 15 m above ground level.

The following is Kern’s rationale for selecting the monitoring locations identified in Figures 3 and 6.

- Overall, the measurement locations cover the areas where nearby downwind receptors are located. This was based on the analysis in Section 3.

- Paths along the northeast, east, and south sides of refinery cover all near-downwind communities, which include Fuller Acres to the northeast, low-density rural housing to the east, and Lamont to the south. There are no nearby residences or sensitive receptors to the west.
- The north fenceline path is adjacent to the Crude and Cogen units and the Gasoline and Diesel tank farms, and covers the main entrance into the refinery for truck and vehicle traffic. This path will include measurements from both UV-DOAS and FTIR open-path analyzers, and a point analyzer in the northeast corner will collect measurements of H_2S.
- The east fenceline path sits on the eastern side of Weedpatch Highway near the diesel tank farm, and crude oil tanks. This path provides coverage of nearby low-density housing located to the southeast of Kern under the dominant northwesterly flow and Fuller Acres under infrequent southwesterly flow. Measurements will be provided from UV-DOAS and FTIR open-path analyzers, and a point analyzer in the northeast corner will collect measurements of H_2S. Note that given the near proximity of these monitoring systems to the crude tank farm located immediately east of Weedpatch Highway, and because there are no downwind nearby receptors from the crude tanks under the common flow patterns (Northwest and Southeast), no additional monitoring is needed. Kern implemented a robust emissions reduction project in this crude tank farm to equip the tanks with a new vapor recovery system designed to capture and control 99% of tank emissions.
- The south fenceline path provides coverage for the residential area at the southern edge of the refinery property and the community of Lamont. Measurements will be provided by UV-DOAS and FTIR open-path analyzers, and a point analyzer for H_2S measurements near the southeast corner of the refinery property boundary.
- A meteorological station will also be positioned at the southeast corner for wind flow that is unobstructed by trees or structures. Visibility measurements will be included here to identify instances of low-level Tule fog that will limit the ability of the open-path analyzers to detect transmitted light.
- No monitors are needed on the western property boundary because the wind rarely blows in this direction and there are no downwind nearby sensitive receptors.

3. Local Topography, Meteorology, Local Communities, and Sensitive Receptors

To provide a fenceline monitoring network that best serves the community, these factors were considered: (1) the characteristics of the refinery location, including topography and meteorology, (2) emissions types and source areas, (3) locations of nearby communities and sensitive receptors, and (4) the spatial coverage of the monitors. Based on these considerations, monitoring along the eastern part of the northern fenceline of the main facility, the eastern fenceline of the main facility, and the southern boundary of the main facility provides the measurements to capture potential impacts of facility emissions on nearby residences.

3.1 Topography and Meteorology

Kern is located in a rural area outside of Bakersfield at the southern end of the San Joaquin Valley. The San Joaquin Valley extends northwest several hundred miles to the Sacramento River Delta. About 30 miles to the west lay the Coast Range that divides the Central Valley and the Pacific Ocean. Several mountain passes exist through the Coast Range throughout the San Joaquin Valley. To the northeast and east is the Sierra Nevada mountain range that abruptly rises to several thousand feet, with peaks above 10,000 feet. Roughly 10 miles to the south, the Tehachapi Mountain range bounds the southern end of the San Joaquin Valley. These strong geographic features greatly influence the local weather patterns.

Two dominant wind flow patterns influence the transport of any facility emissions, with some seasonal variations. In the spring, summer, and early fall, winds most often blow from the northwest toward the southeast. These winds are driven by large-scale weather patterns, the channeling of flow by the regional topography, and strong temperature gradients between the coastal areas of California and the Central Valley. The winds blowing from the northwest are often strongest in the afternoon and evening and lighter overnight and in the morning hours. Sometimes, especially overnight and during morning hours, the winds reverse direction and come from the southeast. The reverse winds are typically driven by or reinforced by drainage flow from the Sierra Nevada. Occasionally in the winter, the southeast winds can be driven by winter storm systems. Calm or light and variable winds also occur and are most frequent in the overnight and morning hours and more often occur in the winter.

Radial histograms (wind roses) were prepared to provide the frequencies of wind speeds and directions (i.e., annual mean wind direction distributed by 30-degree arcs) by season using data from

December 2016 through November 2019. Figures 7 through 11 show the 3-yr average annual wind rose and seasonal wind roses using wind data recorded at the Bakersfield Municipal Airport, which is about 10 miles northwest of the refinery. Key findings are summarized as follows:

- **Northwest winds (winds blowing from the northwest to the southeast)**: Northwest winds occur about 40% of the time annually. Winds from these directions are most common in spring, summer, and early fall. The downwind receptors under these conditions include the eastern side of Lamont and scattered residences southeast of the facility.
- **Southeast winds (winds blowing from southeast to the northwest)**: Southeast winds occur about 15% of the time annually. There are no nearby receptors downwind of the facility during southeasterly wind flow.
- **Calm or light winds (0 to 1 mph speed)**: These conditions occur about 20% of the time. Under these conditions, it is possible that air could flow through the northeast corner of the facility toward Fuller Acres, given the community's proximity to the facility.
- **All other wind directions**: Winds from other directions occur with lesser frequencies and account for the remaining 25% of the flow directions. Under northerly winds, scattered residences to the south of the facility are downwind. There are no other nearby receptors for other wind directions.

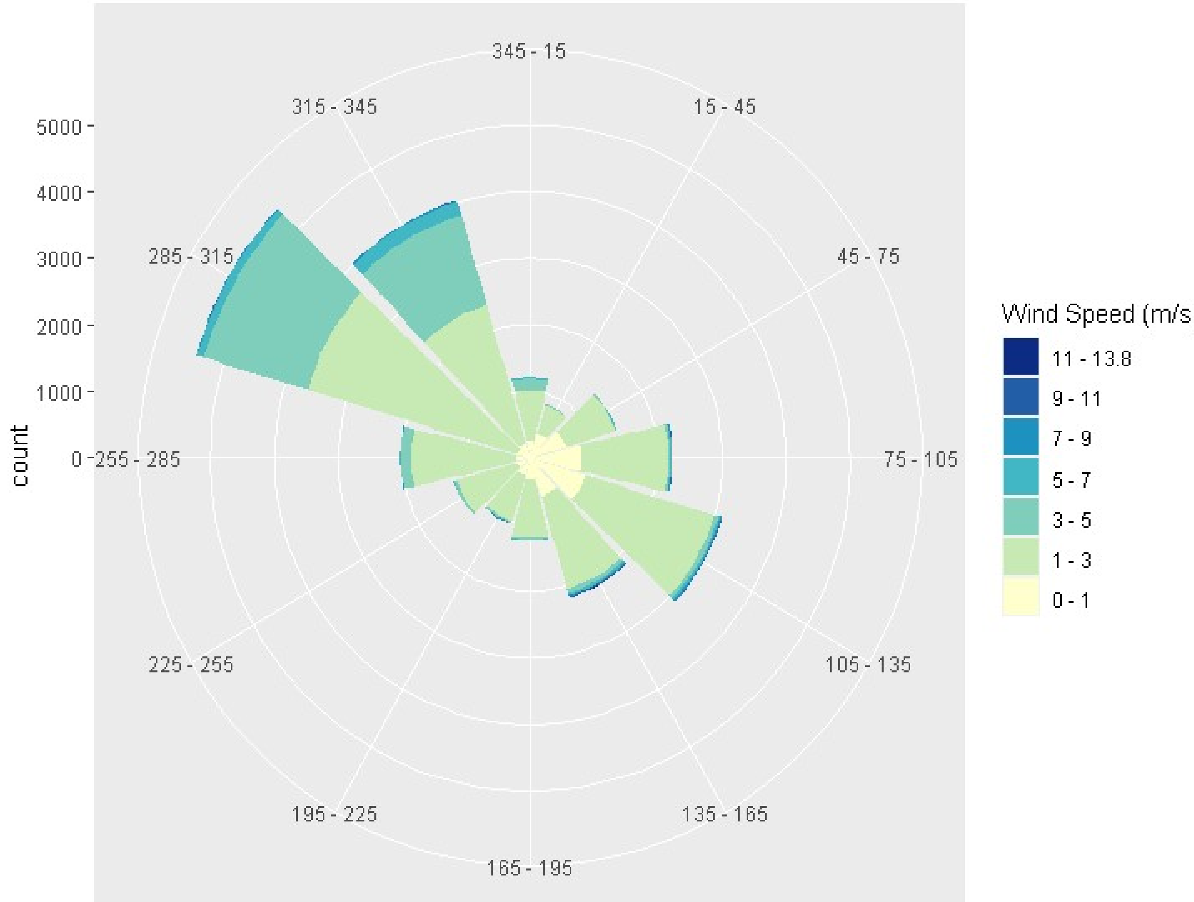


Figure 7. Annual (December 2016 through November 2019) wind rose for Bakersfield Municipal Airport. Source: U.S. Environmental Protection Agency's (EPA) AirNow-Tech.

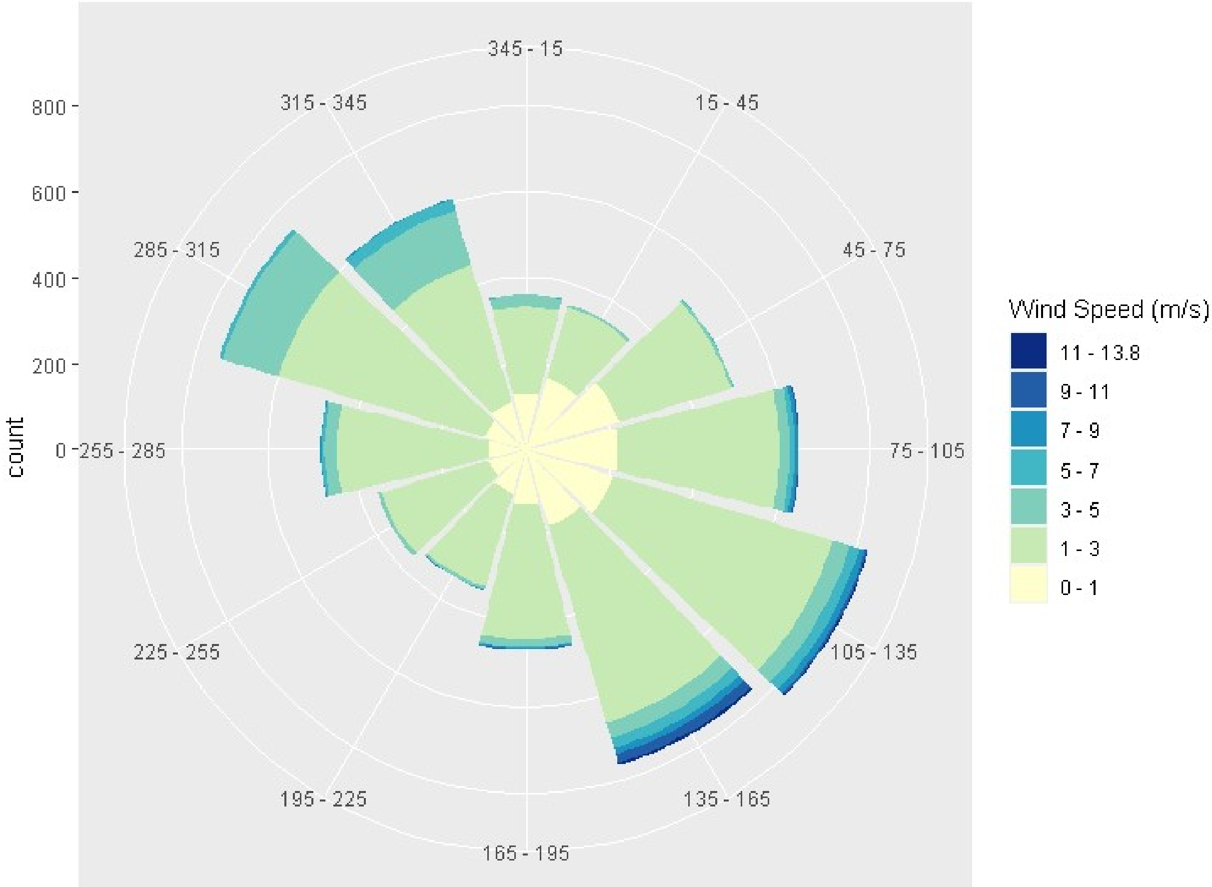


Figure 8. Winter (December through February) 2017-2019 wind rose for Bakersfield Municipal Airport. Source: EPA's AirNow-Tech.

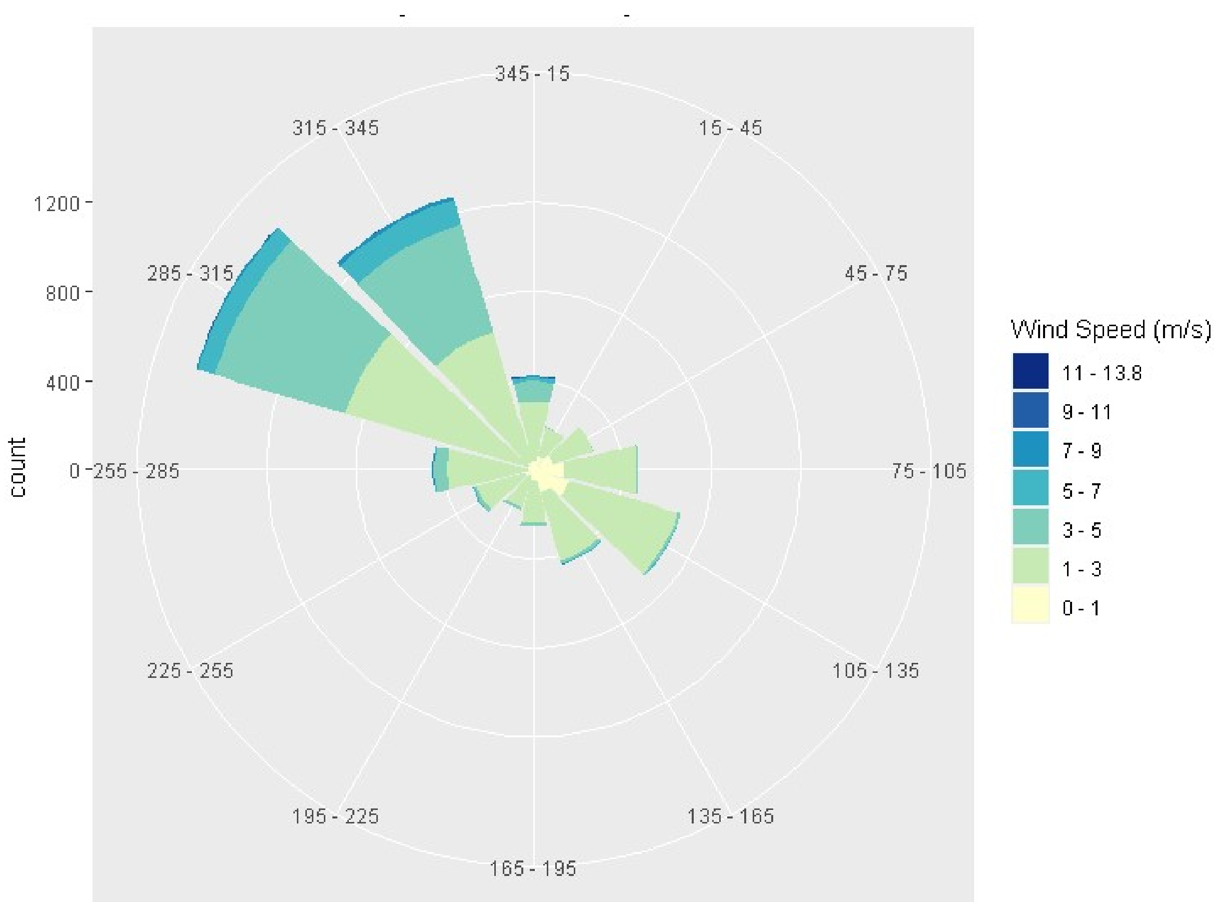


Figure 9. Spring (March through May) 2017-2019 wind rose for Bakersfield Municipal Airport. Source: EPA's AirNow-Tech.

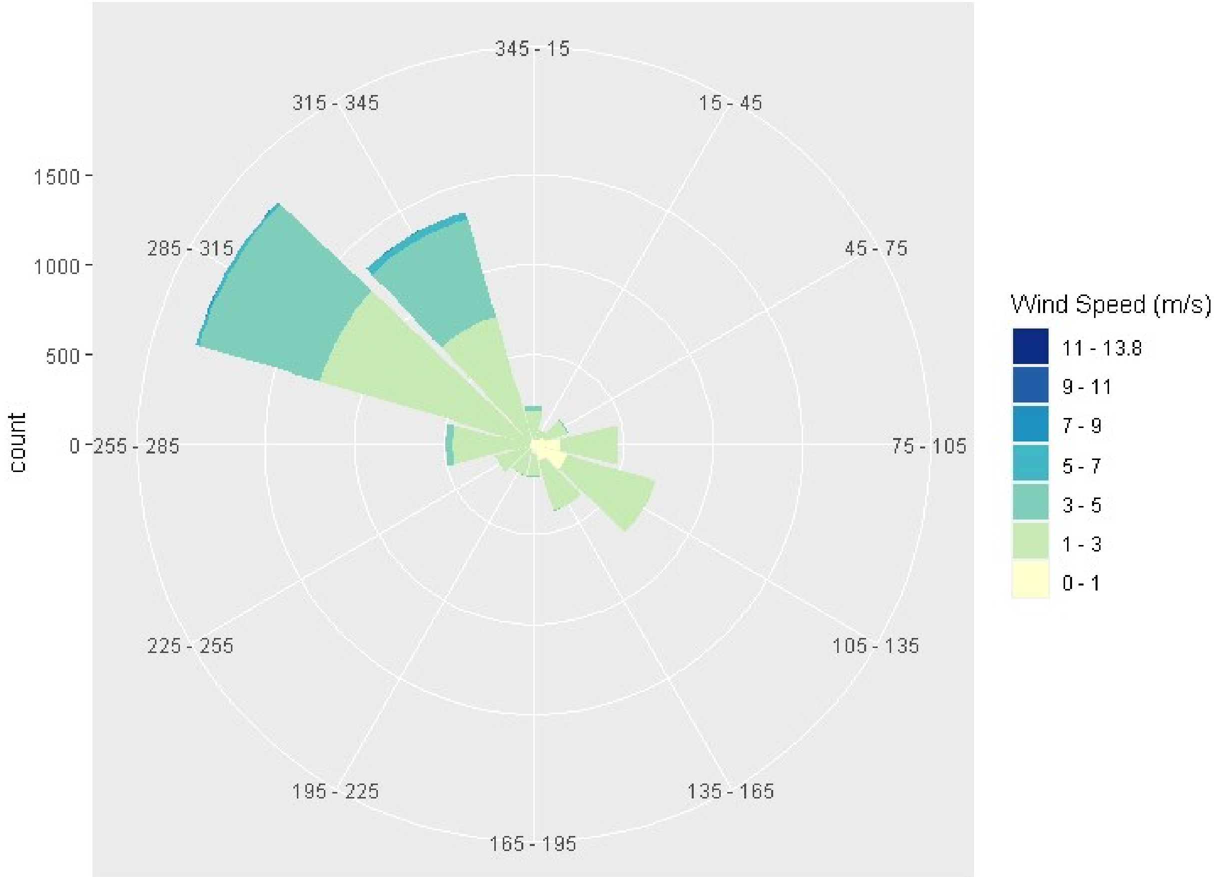


Figure 10. Summer (June through August) 2017-2019 wind rose for Bakersfield Municipal Airport. Source: EPA's AirNow-Tech.

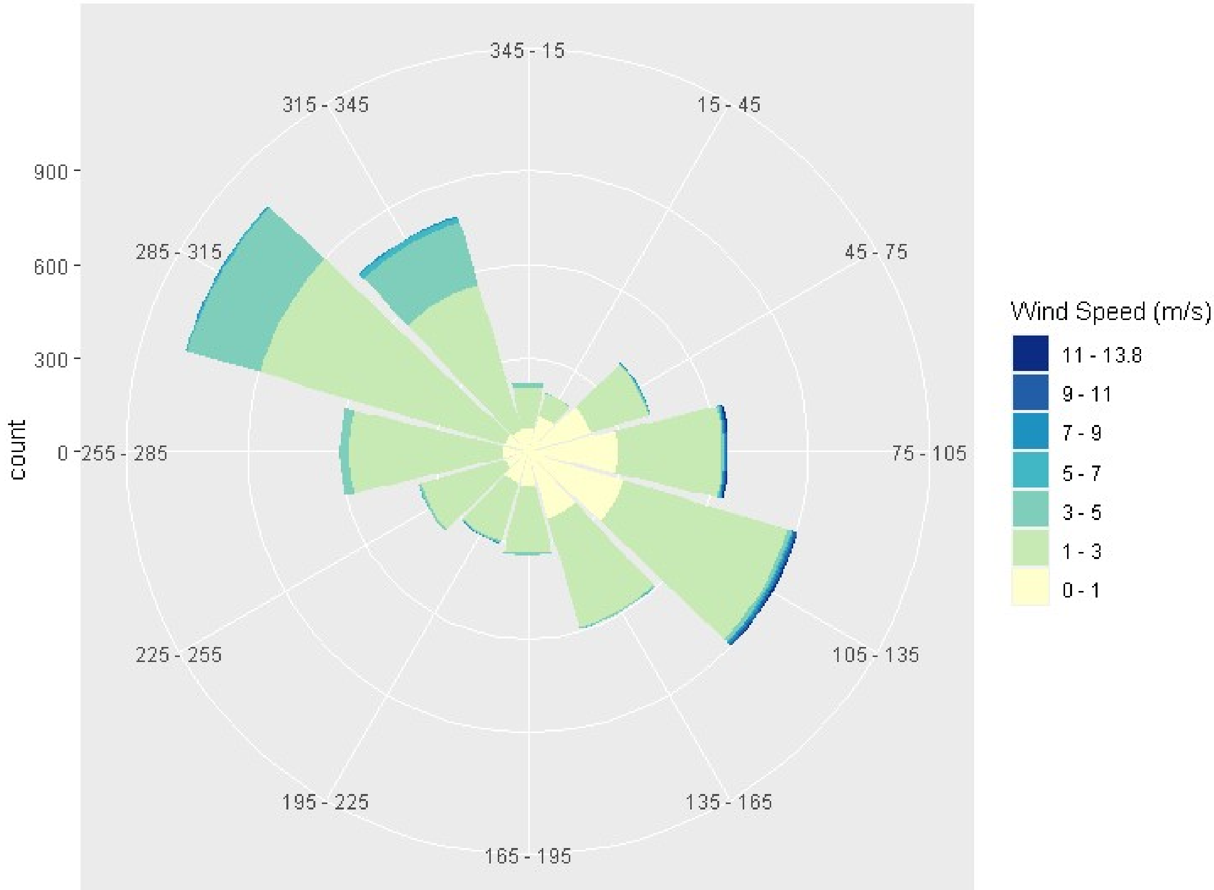


Figure 11. Fall (September through November) 2017-2019 wind rose for Bakersfield Municipal Airport. Source: EPA's AirNow-Tech.

3.2 Community and Sensitive Receptors

The nearby-populated public areas of Fuller Acres and Lamont represent air quality "receptor" communities that may be downwind from Kern. In addition to these areas, sensitive receptors were evaluated for all surrounding areas within about four miles of the facility. Sensitive receptors include daycare centers, youth centers, adult care facilities, hospitals, clinics, nursing homes, recreation areas, libraries, museums, and churches. Sensitive receptor data was collected from two main sources: https://www.infousa.com/ and the U.S. Geographic Names Information System (GNIS) via Esri Data and Maps for ArcGIS, 2018. Figure 12 shows the location of the nearby sensitive receptors with respect to the refinery. Few sensitive receptors are located within a mile of the facility. Most receptors are in Fuller Acres or Lamont, which are approximately two miles from the facility. There are no nearby sensitive receptors located to the west of the facility within about 4 miles.

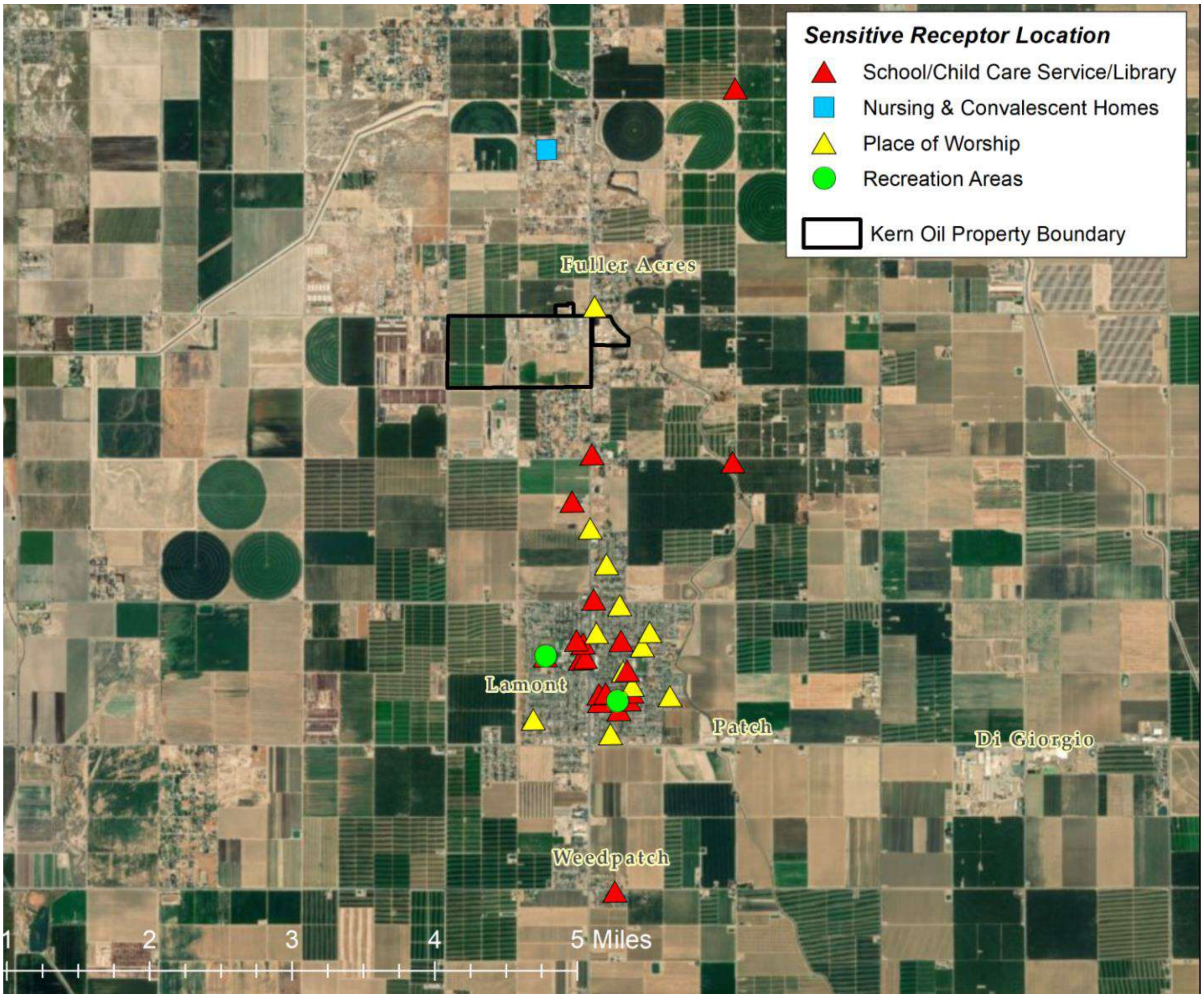


Figure 12. Locations of sensitive receptors near the Kern Refinery.

4. Details of Monitoring Equipment

Literature reviews, site surveys, and interviews with instrument manufacturers were performed to determine the instruments needed to meet the revised Rule 4460 requirements. Both fixed-site and open-path instruments were investigated. In light of the current state of measurement technology, UV-DOAS and FTIR open-path instruments were selected for measuring hydrocarbons, ammonia, NO_2, and SO_2, and UV fluorescence point monitors were selected for measuring H_2S.

4.1 Instrument Specifications

Along the measurement paths (see Section 2), BTEX, naphthalene, NO_2, and SO_2 will be measured by monostatic UV-DOAS instruments with a xenon light source. Acetaldehyde, ammonia, 1,3-butadiene, and formaldehyde will be measured by a monostatic FTIR open-path analyzer. Both analyzers can achieve measurements over paths that are about 300 to 600 meters long at adequate MDLs. For both systems, the principle of operation is similar. The analyzer records the intensity of UV or infrared (IR) light reflected back from a retroreflector array at discrete wavelengths. Any UV- or FTIR-absorbing gas that is present in the light beam absorbs at a specific wavelength of light. Each gas has a unique absorbance fingerprint (i.e., the ratios between the absorbance at several different wavelengths are unique to that gas). The analyzer compares regions within the sample absorbance spectra to the same regions within the reference absorbance spectra and uses a classical least squares regression analysis to compare the measured and calibrated reference spectra. Beer's Law is used to report accurate gas concentrations. Although the approach specified in the U.S. Environmental Protection Agency's (EPA) TO-16 Methodology[8] was not written specifically for UV-DOAS (or was intended for FTIR), the approach is the same.

A schematic showing the light source/analyzer and the retroreflector array is shown in **Figure 13**. The figure also illustrates that the analyzers record a concentration across the entire path length. Monostatic (as opposed to bistatic) open-path instruments have been selected to reduce the need for substantial power at the retroreflector sites and improve minimum detection limits by increasing effective path lengths. Thus, only the light-source/detector end of the monitoring path requires substantial power, communications, and shelter. Limited power is needed for heaters at the retroreflectors. The retroreflector needs to be aligned at the other end of the path for maximum performance and will be cleaned regularly to ensure optimum performance.

[8] Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. Compendium Method TO-16. Long-Path Open-Path Fourier Transform Infrared Monitoring Of Atmospheric Gases (1999) EPA/625/R-96/010b.

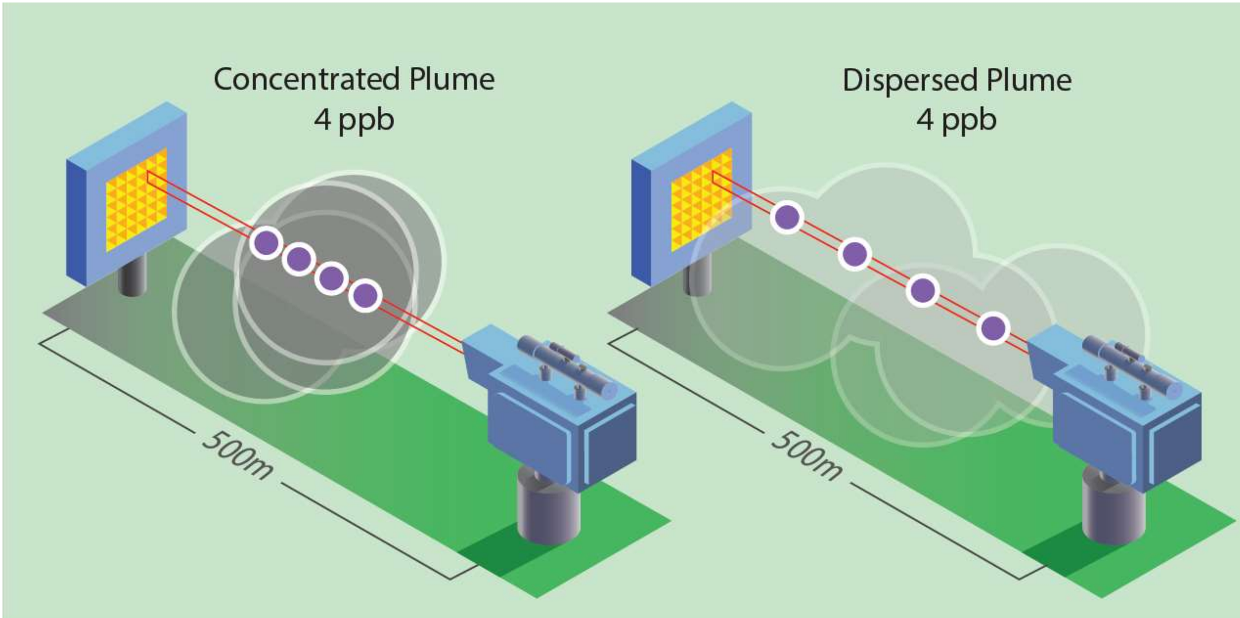


Figure 13. Schematic of an open-path monitoring system, depicting two types of path-integrated plumes measuring the gas concentration.

For H_2S concentrations, a point analyzer will be used, providing concentration information at the instrument location. The analyzer is based on UV fluorescence principles to detect H_2S at levels typical of ambient air monitoring. In this method, UV radiation excites chemicals in an object and causes them to release visible light, which can then be detected.

4.2 Pollutant Detection Limits

Table 6 summarizes the instrument specifications, including detection limits. The detection limits listed are approximate and are based on the theoretical capabilities of the instruments; however, they are supported by manufacturers' lab tests and real-world applications.

Actual detection limits will depend on atmospheric conditions and on the specific instrument brand used. Periods of poor visibility due to weather-related conditions (e.g., fog) are known to interfere with open-path measurements. Rule 4460 anticipates some data loss due to poor visibility and allows for such data loss if supported by visibility measurements. The Refinery will monitor visibility using a standard extinction measurement to identify periods of poor visibility that may cause data loss. For each of the meteorological sensors, operating ranges are provided. To provide context in relation to health benchmarks, the OEHHA chronic and acute Reference Exposure Levels (RELs) are also provided in Table 6. The analyzer detection limits are adequate for each of the gas species to be monitored as part of Rule 4460.

Table 6. Instrument specifications and the detection limit for each of the analyzer's detection methods compared to OEHHA health benchmarks.

Analyzer Detection Method	Compounds Measured	Instrument Detection Limit*	OEHHA Chronic REL (ppb)	OEHHA Acute 1-hr REL (ppb)
UV Fluorescence	H_2S	<0.5 ppb	7.2	30.1
UV Differential Optical Absorption Spectroscopy (UV-DOAS)	Benzene Toluene Ethylbenzene Xylenes SO_2 Naphthalene Nitrogen Dioxide	<0.5 ppb <1.0 ppb <0.5 ppb <0.5 ppb (m/p); <4.0 ppb (o) <1.0 ppb <0.5 ppb <4.0 ppb	0.9 79.6 460.6 161.2 - 1.7 -	8.5 9812 - 5067 251.9 - 250
Fourier Transform Infrared Spectroscopy (FTIR)	Acetaldehyde Ammonia 1,3-butadiene Formaldehyde	<1.0 ppb <0.5 ppb <1.0 ppb <0.5 ppb	77.7 287.1 0.9 7.3	261 4594 298 45.5
Infrared Forward-Scattering	Visibility	Range = <20 ft to 46 miles	-	-
Resistance Thermometer Capacitive Polymer	Temperature Relative humidity	Temp range = -39.2 to 60°C RH range = 0.8% to 100%	-	-
Wind Vane	Wind speed Wind direction	Wind speed: 0-50 m/s Azimuth: 0-360 degrees	-	-

*Open-path detection limits are based on a typical path length of 500 m.

5. Operations and Maintenance

Instrument operations, maintenance, and bump tests include daily checks to ensure that data are flowing consistently, as well as monthly, quarterly, and annual maintenance activities. Further details are provided in the following sections, which describe routine instrument and data management operations. Additional details and documentation, including standard operating procedures (SOPs), for example, will be included in the finalized Quality Assurance Project Plan (QAPP, Appendix A). Modest adjustments to the operating plans may be needed, depending on the brand of instruments ultimately selected.

5.1 UV-DOAS

The UV-DOAS system requires only modest service and maintenance. **Table 7** summarizes typical UV-DOAS maintenance activities as recommended by a manufacturer. Preventive maintenance frequency depends on the operating environment and may need to be adjusted beyond manufacturers' recommendations once the instruments are deployed in the field. System status alarms will alert operators to specific issues needing to be addressed. Bump tests will be performed on site.

Table 7. Schedule of maintenance activities for the UV-DOAS.

Activity	Monthly	Quarterly	Annually
Visually inspect the system.	✓		
Inspect optics on detector and retroreflector; clean if necessary. Ensure there are no obstructions between the detector and the retroreflector (such as equipment, vegetation, vehicles).	✓		
Inspect system filters.	✓		
Confirm the alignment to verify there has not been significant physical movement.	✓		
Download data from detector hard drive and delete old files to free space, if needed.	✓		
Change out the UV source.		✓	
Replace ventilation exit and intake filters.		✓	
Clean optics on detector and retroreflector.		✓	
Realign system after service.		✓	
Check system performance indicators.		✓	
Perform bump test (simulates system-observed gas content at the required path average concentration) to verify the system can detect at or below a lower alarm limit.		✓	
Review and test light and signal levels. Check average light intensity to establish baseline for bulb change frequency.		✓	
Verify system settings.			✓

5.2 FTIR

The FTIR requires maintenance activities similar to the UV-DOAS, but is also designed to require only modest service and maintenance. Table 8 summarizes the maintenance activities for an FTIR system, as recommended by a typical manufacturer. Preventative maintenance frequency depends on the operating environment and may need to be adjusted. System status alarms may alert operators to specific issues that need to be addressed. Bump tests will be performed on site.

Table 8. Schedule of maintenance activities for the FTIR.

Activity	Monthly	Quarterly	Annually	18-24 months	Five Years
Visually inspect the system	✓				
Inspect optics on detector and retro-reflector; clean if necessary	✓				
Confirm the alignment to maximize signal intensity; signal should be greater than 5%	✓				
Download data older than 6 months from the hard drive, move to a permanent archive, and delete old files from the analyzer	✓				
Ensure there are no obstructions between the detector and the retro-reflector (such as equipment, vegetation, vehicles)	✓				
Perform bump test to verify the system can detect at or below a lower alarm limit; take corrective action if % Accuracy outside criteria	✓				
Check system performance indicators (an evolving checklist will be maintained)		✓			
Inspect and clean AC system exterior heat sink		✓			
Review and test light and signal levels; check average light intensity to establish baseline for IR Source change frequency and retro-reflector wear			✓		
Replace cryocooler or swap detector module assembly				✓	
Change out the IR source					✓

5.3 UV Fluorescence Analyzer

Table 9 describes typical maintenance actions for an H_2S point analyzer, such as cleaning and inspections, as well as their required frequencies for routine system management. Preventive maintenance ensures operational integrity and is strongly urged by the manufacturer. Frequency of maintenance checks may need to be adjusted beyond manufacturers' recommendations once operations begin.

Table 9. Schedule of maintenance activities for an H_2S UV fluorescence analyzer.

Activity	Monthly	Quarterly	Annually
Inspect sample line tubing	✓		
Inspect particle filter at inlet and replace as necessary	✓		
Perform zero/span check	✓		
Inspect particle filter inside analyzer and replace as necessary		✓	
Perform flow check		✓	
Perform gas test for analyzer response		✓	
Replace pump diaphragm			✓

5.4 Meteorological and Visibility Sensors

Meteorological sensors provide information about wind direction and speed to help determine sources of any air contaminants. The meteorological sensors will be maintained on a monthly and biannual basis. Table 10 lists the maintenance activities that will be performed.

Table 10. Schedule of maintenance activities for the meteorological tower.

Item	Activity	Monthly	Biannually
Tower	Check that the tower is securely anchored to the shelter	✓	
	Check the tower for signs of damage or excessive wear	✓	
	Inspect all bolts at the tower base for any signs of corrosion (rust)	✓	
	Check the tower's vertical alignment	✓	
Anemometer	Note whether any component (tail, propeller) is missing or has suffered obvious damage	✓	
	Check that the whole sensor moves freely with a changing wind direction and the propeller rotates freely when windy	✓	
Temperature/ RH Sensor and Shield	Inspect the hardware holding the temperature/RH sensor shield assembly to the tower and tighten the bolts if necessary	✓	
	Check that the cable connections are secure	✓	
All Sensors	Audit and calibrate		✓

Fog events may affect open-path measurements especially during the nighttime and early morning hours. Visibility measurements will be made to verify fog events. Maintenance activities for the visibility sensor are included in Table 11. Monthly maintenance includes inspecting the sensor for dirt, spiderwebs, birds' nests, or other obstructions and cleaning if necessary. There are no major serviceable components in the sensor. The sensors are calibrated annually in the field using a manufacturer-specific calibration kit.

Table 11. Typical schedule of maintenance activities for the visibility sensor.

Activity	Monthly	Annually
Visually inspect the system, including all cables; clear out any obstructions and clean the glass windows	✓	
Check that the cable connections are secure	✓	
Perform the zero and light-level calibration		✓

5.5 Additional Maintenance and Failure Activities

Normal routine scheduled maintenance for open-path instruments occurs once per month (at least). Instrument downtime for routine maintenance is expected to be less than four hours per month. During those maintenance visits, the operator will carry normal repair parts to the site.

If, between routine visits, monitors fail to report data or appear to report erroneous data, both remote diagnosis and, if necessary, a site visit will be conducted. If the problem cannot be resolved with the equipment or parts on hand, then Kern will obtain replacement parts from the vendor. Kern will keep some spare parts available for emergency repairs. It is expected that with these measures, the problem can be resolved by the next business day. If downtime exceeds more than 96 hours, integrated 24-hr canister samples of VOCs will be taken once per day on the predominant upwind/downwind directions. VOC data will be reported to the District within 45 days after collection.

6. Data Quality

All data values not associated with bump tests or other instrument maintenance will be displayed to the public in near-real time (i.e., in about 10 minutes or less). If data are subsequently proven to be invalid, they will be removed from the public display, and the rationale for data removal will be provided. Common reasons for invalidation include instrument malfunction, power failure, and bump test data not identified as such.

6.1 Data Quality Objectives and Criteria

To ensure quantitative accuracy of field measurements, measurement performance criteria are established as part of the monitoring design. These criteria specify the data quality needed to minimize decision errors based on the data. The quantitative performance criteria for the data collected by the fenceline measurement systems are provided in this section. The principal quantitative indicators of data quality for this study are data completeness, precision, and accuracy. The objective of these measurements is to achieve 75% data completeness for all measurements at 1-hr and 24-hr intervals and 90% completeness of daily values for each annual quarter, excluding instrument downtime due to weather conditions.

In the field, a bump test simulates system-observed gas content at the required path average concentration and is used to verify that the system can detect concentrations at or below a set level of concern. Instrument bump tests (done quarterly) are used to evaluate performance regarding precision and accuracy. These will be done in adherence to the approved QAPP. Table 12 shows the performance criteria for the monitoring systems.

Table 12. Performance criteria for the fenceline monitoring systems.

Sensor	Test	Acceptance Criteria for Precision and Accuracy
UV-DOAS	100 ppm benzene; internal flow-through QA cell	±25%
FTIR	100 ppm ammonia; internal flow-through QA cell	±25%
H_2S Point Monitor	0, 250, 150, 50 ppb	±20%
Temperature	Two-point test	±0.5°C
Relative Humidity	Hygrometer	±7%
Wind Speed	Starting threshold test; transfer function test	±0.25 m/s below 5 m/s and ± 5% above 5 m/s
Wind Direction	Angle verification	±5 degrees
Visibility	Extinction	±10%

6.2 Data Quality Control Overview

In addition to the quarterly verification of instrument operations by conducting gas audits, more frequent review of the data will be conducted. The three levels of data quality control that will be performed are:

- QC1: Automated quality control of data
- QC2: Daily checks by analyst
- QC3: Quarterly review and reporting

6.2.1 QC1: Automated Quality Control

The first level of quality control checks are conducted automatically on the real-time data, using the data management system (DMS). The DMS can handle the large volumes of data that will be generated in this project. This allows data to be displayed within approximately 10 minutes of collection. Real-time data will be subjected to these tests:

- **MDL.** Values below the MDL will be flagged accordingly.
- **Range.** Ensure the instrument is not reporting values outside of reasonable minimum and maximum concentrations.

- **Sticking.** If values are repeated for several sampling intervals, data will be reviewed for validity. Typically, four or more intervals of sticking values are a reasonable time span to indicate that investigation is needed. Sticking checks will not be applied to data below the instrument detection limit.
- **Rate of Change.** Values that change rapidly without reasonable cause will be flagged as suspect and reviewed.
- **Missing.** If data are missing, data collected during those periods will be marked as missing.
- **Sensor OP Code.** If the instrument assigns operation (OP) codes to data automatically (e.g., for bump tests, internal flow rate checks, light extinction criteria, integration time criteria), the data will be reviewed, op codes confirmed, and data flags checked.
- **Visibility.** If visibility drops below threshold value, data will be marked as invalid.

Data that fail checks will be flagged in the DMS and brought to the attention of data reviewers. Data are invalidated only if a known reason can be found for the anomaly or automated screening check failure. If the data are anomalous or fail screening, but no reason can be found to invalidate the data, the data are flagged as suspect. Additional analysis may be needed to deem data valid or invalid. Screening checks are typically specific to the site, instrument, time of day, and season, and adjusted over time as more data are collected.

6.2.2 QC2: Daily Checks by Analyst

A non-public field operations website will be used for daily graphical review of the data (an example is provided in Figure 14). Common data problems include flat signal/constant values, no signal/missing data, extremely noisy signal, rapid changes (spikes or dips), and negative concentrations. An initial review, typically of a three-to five-day running time-series plot of selected parameters for each instrument, allows the analyst to see common problems and verify instruments are operational.

Types of items checked based on results of initial review of concentration data include:

- Instrument alignment.
- Spectral data if several acquisitions of compounds of concern are above detection.
- Signal intensity and integration time.
- Meteorology measurements.

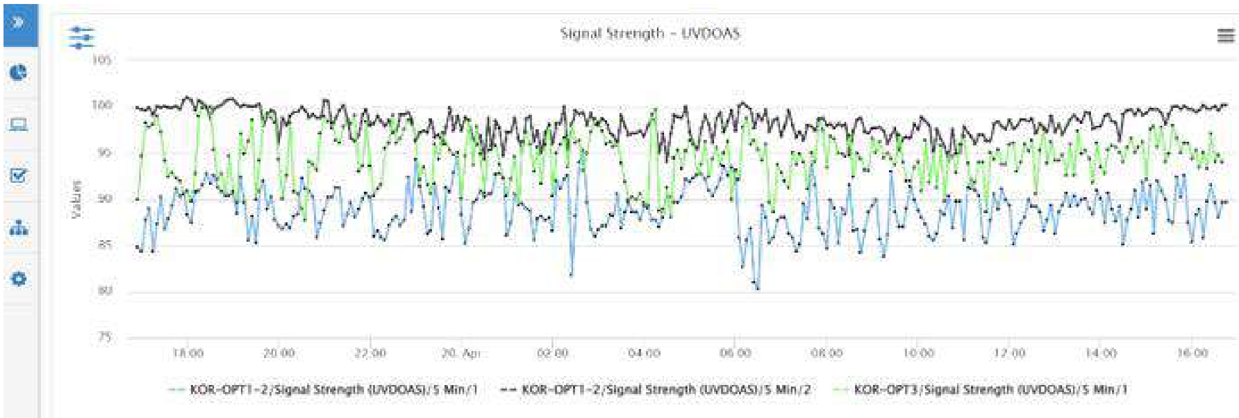


Figure 14. Example of a non-public field operations website used for daily review of open-path instrument operations.

The DMS will be used to automatically quality control data and detect outliers and problems, but will also create alerts. The DMS will feed auto-screened data to the field operations website and notification system to inform project and facility staff. These non-public, real-time auto alerts to the project team may be used to indicate any issues (e.g., missing data). If it appears that an instrument is not operating properly or the data are missing, the field operator will be notified and, if needed, further investigation and corrective action will be taken. DMS data will be backed up daily.

6.2.3 QC3: Quarterly Review and Reporting

In addition to auto-screening and daily visual checks, data will be subjected to more in-depth review on a quarterly basis and when data fail screening. Final data sets will be compiled quarterly, 30 days after each quarter's end. Kern will maintain a data record for five years.

These in-depth analyses typically require data that are not available in real time and ensure that the data on the website are updated. Validation checks will include:

- Looking for statistical anomalies and outliers in the data.
- Inspecting several sampling intervals before and after data issues, bump tests, or repairs.
- Evaluating monthly summaries of minimum, maximum, and average values.
- Ensuring data reasonableness by comparing to remote background concentrations and average urban concentrations.
- Referring to site and operator logbooks to see whether values may be unusual or questionable based on observations by site operator.
- Ensuring that data are realistically achievable, i.e., not outside the limits of what can be measured by the instrument.
- Confirming that bump tests were conducted and were within specifications.

On a quarterly basis, analysts will subject the data to final QC including:

- Verify routine instrument checks were acceptable and appropriate QC checks were applied.
- Review instrument bump test results for consistency.
- Fill in missing records with null values and add Null Codes.
- Inspect data consistency over three months.
- Review manual changes to operations/data and verify changes were logged and flagged appropriately.
    - Review ranges of values for consistency—ranges should remain consistent over months of monitoring.
    - Review data completeness.

6.3 Independent Quality Oversight

Kern will work with independent staff to perform annual systems and performance audits that include these elements:

- Review of the quality assurance procedures in the QAPP and SOPs.
- Observation of the routine instrument checks as performed by the normal field staff on each instrument type.
- Independent calibration checks or bump tests of instruments, following the criteria outlined in Section 6.1 and the QAPP (see Appendix A).
- Audit of data flow from the instruments through the data logger and database system to the public website.
- Review of the data validation procedures used for the latest quarterly or annual report.

6.4 Quality Assurance Project Plan

The QAPP is provided in Appendix A and contains the following key elements:

1. Project background and management
2. Technical approach
3. A description of the analytical equipment
4. Data quality objectives
5. Quality control procedures
6. Data management (QC, verification, validation)

7. Documentation and records (QA/QC, training)
8. SOPs (these will be provided once Kern selects the instrument make and model).

The QAPP will be reviewed annually and updated as needed.

6.5 SOPs for Equipment

SOPs for the instruments will be included with the QAPP once final instrument determinations are made after plan approval. SOPs will be reviewed and updated as needed.

7. Public Data Display

A public website will provide the data to the public, the District, and local response agencies in real time, in addition to other supporting information. Figure 15 is an image of the public-facing website. Key features on the website include:

- A summary of the program goals on the home page.
- A visual display of data in near-real time. Historical data for the prior quarter will also be provided.
- Information for the public to better understand the concentrations displayed.
- A mechanism for public feedback on the website.
- A description of monitoring techniques.
- A description of monitored pollutants.
- A discussion of typical background levels of each pollutant to provide context.
- A description of QA/QC procedures.
- Documentation of QC flags (valid, invalid, suspect, missing) for each data point displayed.
- Hyperlinks to related information from publicly available websites.
- FAQs.

The preliminary quality-controlled data will be presented as time-series and spatial plots of species concentrations and wind speed and direction. Data will be provided as 5-min averages and running hourly averages and will be available within 10 minutes after data collection. All real-time data will be preliminary until made final after quarterly data quality control is completed. Data will be color-coded to represent concentration levels and annotated for quality (valid, invalid, suspect, missing).

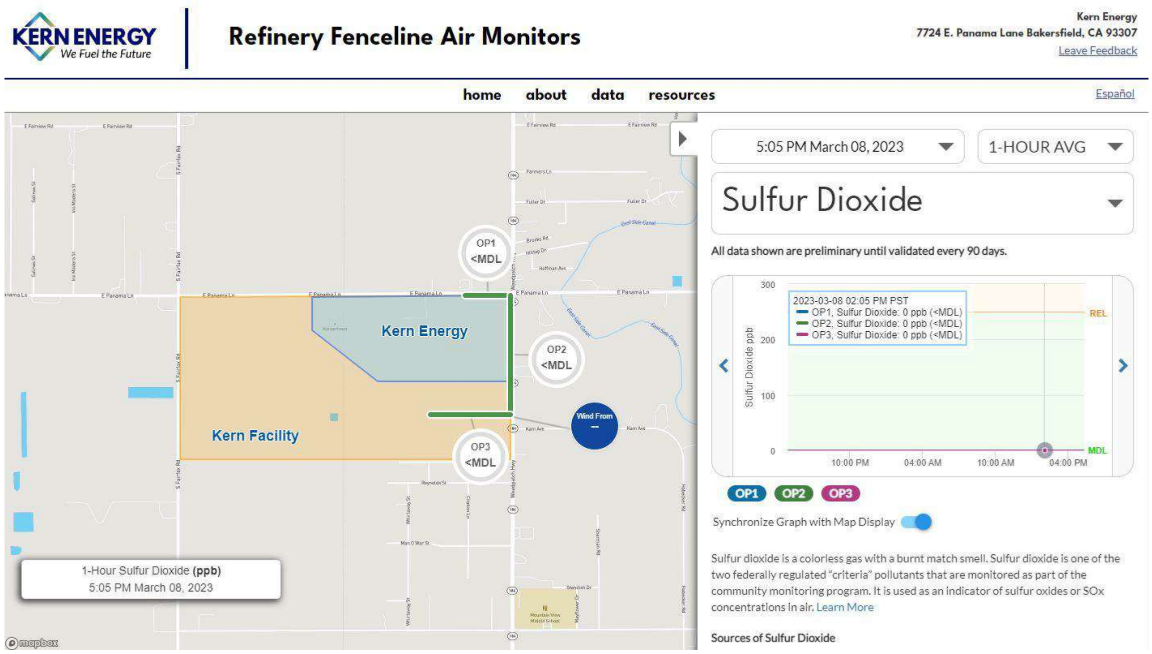


Figure 15. Example of a public data display of fenceline air monitoring data.

Information will be written at a public-friendly level with links to additional resources for members of the public who want to delve deeper into the science. Clarity and thoroughness will help to reduce the number of questions that arise.

The home page of the public-facing website will be dedicated to providing background on reasons the monitoring is taking place and the technology being used in the monitoring system. From the home page, a "Resources" page will be provided. The "Resources" page will include a frequently asked questions (FAQ) page, a definitions page, and other educational material.

To facilitate public feedback, a feedback button will be provided on the web page. When a user clicks on the button, an email form will pop up for the user to submit comments about the website. The email will be delivered to a Kern contact responsible for deciding how to respond to the public comments. The emails received through the website will be archived. Some comments may aid in creating additional FAQs.

8. Notification System

Kern will maintain a notification system in accordance with Rule 4460. The website will provide an opt-in sign-up for the public and agencies to receive notifications. The public, the District, and local response agencies will be notified via email when values exceed thresholds or when activities may have a major effect on the monitoring system, and may be notified in the event of a false alarm.

Notifications will be triggered automatically when concentrations exceed threshold levels listed in Table 13. The concentrations will be calculated as 1-hr rolling averages that are updated every five minutes. These notifications will come with a message on the home page of the public website. Concentration thresholds correspond to the OEHHA acute relative exposure limits (RELs).[9]

Table 13. Thresholds for triggering automated notifications. Values for gaseous species in this table are acute 1-hr RELs from OEHHA.

Measurement	Threshold Level (ppb)
Acetaldehyde	261
Ammonia	4,594
Benzene	8.5
1,3-Butadiene	298
Ethylbenzene	460
Formaldehyde	45.5
Hydrogen Sulfide	30
Naphthalene	1.7*
Nitrogen Dioxide	250
Sulfur Dioxide	250
Toluene	9,800
Total Xylene	5,067

*A potential notification threshold for naphthalene is the chronic REL, as no hourly REL value has been set.

In the event that an hourly concentration exceedance notification is issued to the public, trained data reviewers will investigate the concentration data and determine the validity of the event. As part of

[9] California Office of Environmental Health Hazard Assessment (2017) https://oehha.ca.gov/air/general-info/oehha-acute-8-hour-and-chronic-reference-exposure-level-rel-summary

that review and verification process, information about the pollutant detected, the health notification threshold exceeded, event time and date (including start and stop time), wind speed and direction during the event, and whether or not the source of the exceedance is suspected of stemming from within the refinery can be ascertained. Data reviewers, field technicians, and refinery operations personnel will work together to determine the best course of action needed to address the concentration exceedance event as appropriate. A brief report containing the aforementioned exceedance event data, the likely source of concentrations, and all corrective actions taken can be generated for submission to the District within 10 calendar days of the event.

Contents of the exceedance event report will also be included in the quarterly reports submitted to the District, within 45 days of the end of the calendar quarter.

9. Implementation Elements and Schedule

Once this monitoring plan is approved, Kern will proceed with the implementation of the amended monitoring and reporting system following the plan. An implementation schedule detailing the key milestones for implementation of the FTIR monitoring systems is shown in Table 14, which assumes approval of the AMP in Summer of 2023. If there are significant delays in getting the plan approved, the schedule may change.

Table 14. Approximate implementation schedule for Kern Rule 4460 monitoring project.

Project Element	Completion Date
Acquire additional instruments	Fall/Winter 2023
Install analyzers and associated equipment	Winter 2023/Spring 2024
Update data management system	Winter 2023/Spring 2024
Update internal and public-facing websites and notification system	Winter 2023/Spring 2024
Conduct final monitoring system checks for additional pollutants (including gas testing and confirming data flow)	Spring/Spring 2024
Start monitoring and reporting for additional pollutants	Spring/Summer 2024 (1 year from approval)
Operate, maintain, and audit equipment, data system, website, and notification system; perform daily data checks	Spring/Summer 2024; continuous

Appendix A. Quality Assurance Project Plan

Appendix A.
Quality Assurance Project Plan

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Approvals

Quality Assurance Project Plan
Fenceline Monitoring for the Kern Energy

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Will be signed upon plan acceptance

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1. Project Background and Management

1.1 Background

1.1.1 Purpose

Kern Energy (Kern) has been conducting air quality monitoring at its Bakersfield, California, refinery in response to the San Joaquin Valley Air Pollution Control District's (SJVAPCD) Rule 4460.[1] The rule was adopted in December 19, 2019, and amended on October 20, 2022. The monitoring follows a facility-specific air monitoring plan consistent with the SJVAPCD's Refinery Fenceline Air Monitoring Plan requirements. Rule 4460 requires routine monitoring near the fencelines of all San Joaquin Valley refineries for specific air pollutants, with data reported to the public. Monitoring operations began on January 28, 2022, with data flowing to a public-facing website on the same date.

1.1.2 Rationale

Rule 4460 requires real-time fenceline monitoring systems that provide air quality information to the public regarding concentrations of various air pollutants at or near property boundaries of petroleum refineries. The list of all pollutants to be monitored as part of the rule was amended in 2022 based on guidance from the California Air Resources Board (CARB) and California Air Pollution Control Officers Association (CAPCOA). The list includes criteria air pollutants and toxic air contaminants, including gases and particulates.[1] As outlined inn its monitoring plan, Kern will conduct open-path and point monitoring of pollutants and meteorological measurements to meet the regulations.

This quality assurance project plan (QAPP) documents the measures that the project team will take to ensure that the data collected are of the highest quality. This document will be reviewed annually and updated as needed.

1.2 Roles and Responsibilities

This project involves refinery staff; contractors; and quality-assurance, field, and website personnel. **Figure 1** shows an organization chart for the project.

[1] San Joaquin Valley Air Pollution Control District (2019) Rule 4460: Petroleum refinery fenceline air monitoring. Final rule adopted December 19, 2019; amended on October 20, 2022. Available at https://www.valleyair.org/rules/currntrules/4460.pdf.

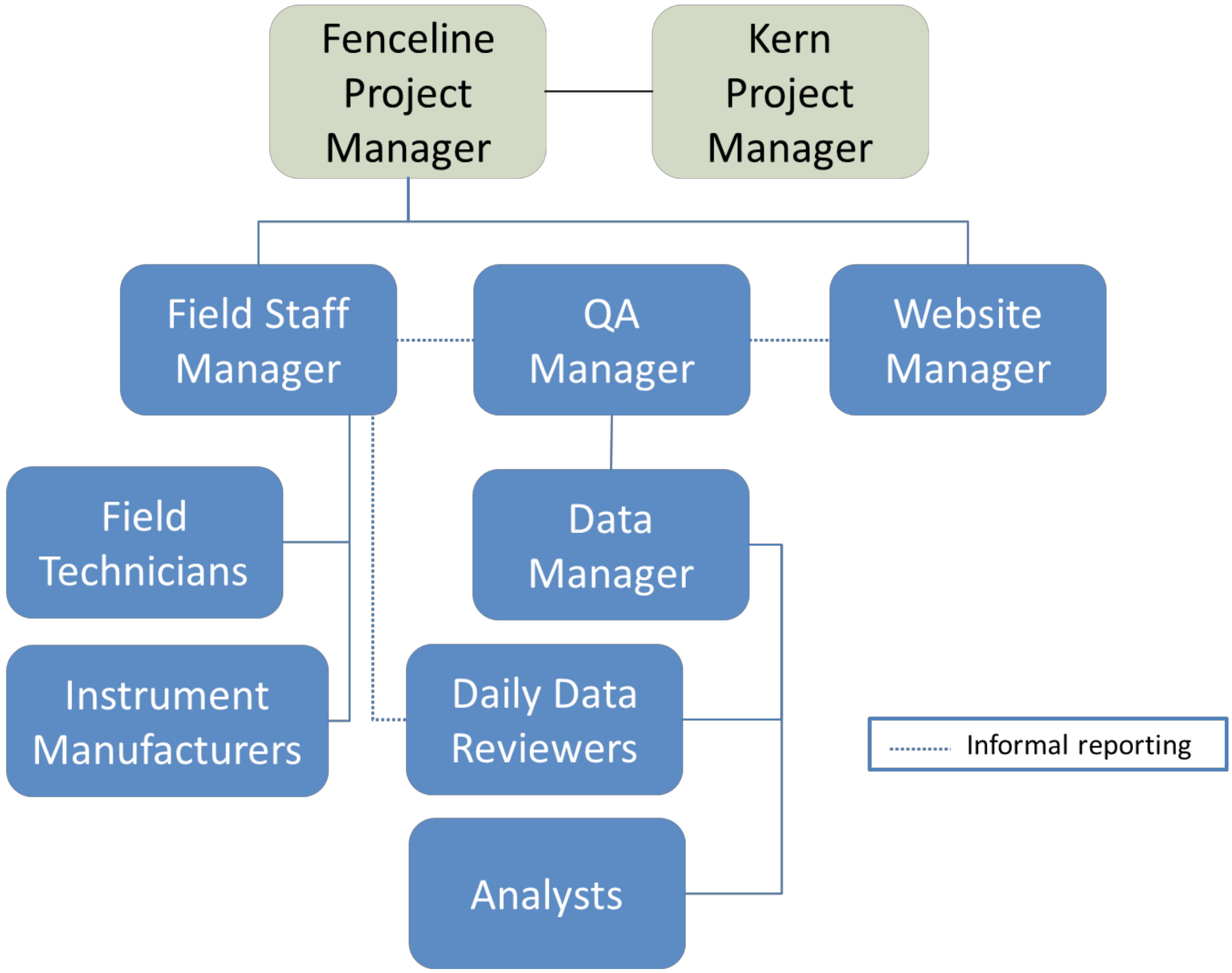

Figure 1. Organizational chart showing key roles for the Kern refinery monitoring project.

The overall project will be run by a **Fenceline Project Manager** (PM) appointed by the refinery. The Kern PM acts as the central point of contact for the SJVAPCD. The Fenceline PM is responsible for overseeing the project and reporting to the Kern PM.

The **QA Manager** is responsible for ensuring the quality of data collected in this project. The QA Manager oversees data collection and review, provides QA oversight during the study, and oversees and reports on QA activities to the Fenceline Project Manager and SJVAPCD QA Officer. The QA Manager oversees daily data review and data management; works with the Field Staff Manager to ensure that any data issues are addressed promptly by the field technicians; and works with the Website Manager to ensure that data provided to the public are of high quality.

The **Field Staff Manager** ensures that field technicians (site operators) are meeting the requirements of the project. The Field Staff Manager coordinates staff coverage and serves as a technical resource for site measurements.

Field Technicians/Site Operators perform instrument maintenance. The technicians ensure that all measurements are collected in accordance with standard operating procedures (SOPs), standard methods, and regulations, where applicable. Technicians perform the required quality checks on instruments and document all work in site logs.

The **Instrument Contractors** provide technical support for the instruments deployed in the field.

The **Data Manager** is responsible for ensuring that daily data review is conducted, that data that fail auto-screening are inspected, and that data validation follows the proper schedule and procedures. The Data Manager is also responsible for delivering the validated data to the PM.

Daily data review and data validation are conducted by experienced air quality analysts. The **Data Reviewers** communicate with the Data Manager when there are issues and may also interact with the Field Technicians when they notice an issue that needs to be addressed.

The **Website Manager** is responsible for properly displaying data on the website, managing inquiries from the public, and ensuring that validated data are available for download on a quarterly basis. Automated alerts will notify the Website Manager when the real-time data are not available on the website. This manager will be responsible for assessing and fixing data communication and other information technology–related issues concerning the website and data system.

2. Measurements

2.1 Instrument Selection and Descriptions

The list of compounds to be measured, including pollutants added as part of the Amended Rule 4460, is presented in Table 1. These compounds will be measured at a 5-min resolution. Because of the distances that need to be covered by measurements (hundreds of meters), the data time-resolution requirements (5 minutes), and the current state of measurement technology, open-path Ultraviolet-Differential Optical Absorption Spectroscopy (UV-DOAS) and Fourier Transform Infrared (FTIR) instruments were selected for measuring most compounds. The exception is hydrogen sulfide (H_2S), which will be measured by ultraviolet (UV) fluorescence point instruments.

Table 1. Pollutants to be monitored as part of Rule 4460.

Air Pollutants
Criteria Air Pollutants
Sulfur Dioxide (SO_2)
Nitrogen Dioxide (NO_2)
Volatile Organic Compounds (VOCs)
Acetaldehyde
Formaldehyde
Benzene, Toluene, Ethylbenzene, Xylenes (BTEX)
Naphthalene
1,3-butadiene
Other Compounds
Ammonia
Hydrogen Sulfide (H_2S)

Along all measurement paths, naphthalene, NO_2, SO_2, and benzene, toluene, ethylbenzene, and xylenes (collectively referred to as BTEX) will be measured by monostatic UV-DOAS instruments with a xenon light source. Acetaldehyde, ammonia, 1,3-butadiene, and formaldehyde will be measured by a monostatic FTIR instrument. For both systems, the UV or infrared (IR) light shines over a long path to a retroreflector and back to the instrument for analysis. The analyzers can take measurements over paths that are about 300 to 600 meters long and are able to achieve appropriate minimum detection limits (MDL). The analyzers record the intensity of light at discrete wavelengths, and any UV- or

IR-absorbing gas that is present in the beam absorbs at a specific wavelength of light. The analyzer compares regions within the sample absorbance spectra to the same regions within the reference absorbance spectra, using least squares regression analysis. Beer's Law is used to report gas concentrations. Closeness of fit is indicated by the correlation coefficient (R^2) of agreement between the measured spectra and the reference spectra. The R^2 is provided with each concentration so that interference can be detected if it is present. The selection of regions of analysis that are free of absorbance due to other gases within the sample is the primary means of avoiding cross-interference. Spectral subtraction is used in cases with overlapping absorbance features; the subtraction technique is proprietary to the instrument manufacturer.

Heavy fog may entirely block the signal from an open-path instrument and prevent data collection. Even light fog can absorb the signal partially and interfere with measurements. Given that the refinery is in an area prone to Tule fog, fog events may impact open-path measurements at times, especially during nighttime and early morning hours. Visibility measurements will be made in the southeast corner of the refinery to provide operational verification of low atmospheric visibility events.

In the northeast and southeast corners of the measurement paths, two UV fluorescence point analyzers will be used to measure H_2S.

Table 2 summarizes the estimated MDL for each species monitored by a typical UV or FTIR open-path analyzer or point UV instrument. For the open-path analyzers, the MDL is the lowest path-average concentration that can be measured at the path length. A 500-m path length was used in MDL calculations. Detection limits are approximate and are based on the theoretical capabilities of the instruments; however, they are supported by manufacturers' lab tests and real-world applications. Actual detection limits depend on atmospheric conditions and on the specific instrument used.

Table 2. Range of approximate instrument minimum detection limits (MDL) in parts per billion (ppb) by technology and species. Actual detection limits depend on atmospheric conditions.

Analyzer Detection Method	Compounds Measured	Instrument Detection Limit*
UV Fluorescence	H_2S	<0.5 ppb
UV Differential Optical Absorption Spectroscopy (UV-DOAS)	Benzene	<0.5 ppb
	Toluene	<1.0 ppb
	Ethylbenzene	<0.5 ppb
	Xylenes	<0.5 ppb (m/p); <4.0 ppb (o)
	SO_2	<1.0 ppb
	Naphthalene	<0.5 ppb
	NO_2	<4.0 ppb
Fourier Transform Infrared Absorption Spectroscopy (FTIR)	Acetaldehyde	<1.0 ppb
	Ammonia	<0.5 ppb
	1,3-butadiene	<1.0 ppb
	Formaldehyde	<0.5 ppb
Infrared forward-scattering	Visibility	Range = <20 ft to 46 miles
Resistance thermometer Capacitive polymer	Temperature	Temp range = -39.2 to 60°C
	Relative Humidity	RH range = 0.8% to 100%
Wind vane	Wind speed	Wind speed: 0-50 m/s
	Wind direction	Azimuth: 0-360 degrees

*Open-path detection limits are based on a typical path length of 500 m.

2.2 Monitor Siting Overview

Kern will monitor concentrations across three open paths and two point locations (detailed in Table 3 and shown in Figure 2). The type of measurement for each path is indicated by the legend in

Figure 2: transmitter-detectors/analyzers denoted with an "S", retroreflectors denoted with an "R", and point analyzers denoted with an "A". All instruments and reflectors will be located between 2 m and 15 m above ground level depending on site logistics.

Fenceline monitoring paths were chosen for the north, east, and south edges of the refinery property after considering dominant wind patterns (most frequently from the NW and SE), sources of potential air emissions on the refinery property, and nearby local receptors. A meteorological station, mounted on a tower approximately 10 m tall, will be installed. The station will also include a visibility sensor and sensors for measuring wind speed and direction, temperature, and relative humidity.

Table 3. Locations of equipment to be used in fenceline monitoring program at Kern refinery.

Path #	Description	Approximate Path Length (m)	Instrument(s)
1 (North side)	East-West along Northern boundary; Point analyzer in Northeast corner	200	UV-DOAS, FTIR, UV Fluorescence
2 (East side)	North-South along East boundary; Point analyzer and meteorological station in Southeast corner	550	UV-DOAS, FTIR, UV Fluorescence, Met. Station
3 (South side)	East-West along Southern boundary	365	UV-DOAS, FTIR

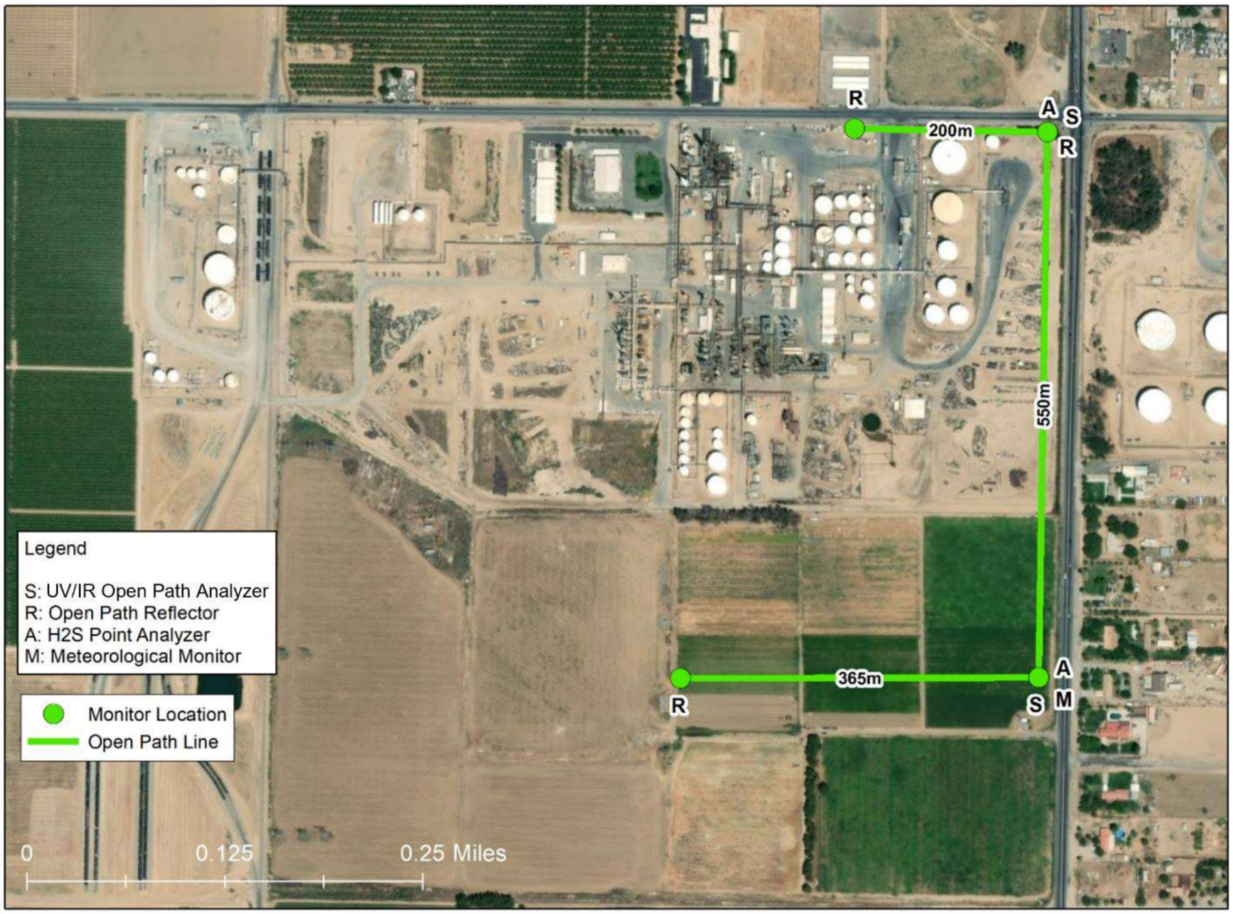

Figure 2. Location of sensors and measurement paths at the Kern Refinery. Each path consists of a transmitter-detector (S) and a retroreflector (R). Point analyzer locations (A) are in the northeast and southeast corners. The meteorology station is also shown (M).

2.3 Instrument Operations and Maintenance

The instrument systems included in this project are UV-DOAS, FTIR, UV fluorescence, and meteorological instruments, including visibility sensors. Quality assurance is built into the operation and maintenance of these instruments. For all instruments, scheduled maintenance will occur monthly, quarterly, and/or annually. Daily checks will be made to (1) ensure data are flowing consistently to the data management system and public website, and (2) verify that data are reasonable. Emergency maintenance will occur as needed when problems are identified during daily data review and auto-screening of real-time data.

2.3.1 UV-DOAS

The UV-DOAS system is designed to require only modest service and maintenance. **Table 4** summarizes typical UV-DOAS maintenance activities as recommended by a manufacturer. Preventive maintenance frequency depends on the operating environment and may need to be adjusted beyond the manufacturers' recommendations once the instruments are deployed in the field. System status alarms will alert operators to specific issues that need to be addressed. Bump tests will be performed on site.

Table 4. Schedule of maintenance activities for the UV-DOAS.

Activity	Monthly	Quarterly	Annually
Visually inspect the system	✓		
Inspect optics on detector and retro-reflector; clean if necessary; ensure there are no obstructions between the detector and the retro-reflector (such as equipment, vegetation, vehicles)	✓		
Inspect system filters	✓		
Confirm the alignment to verify there has not been significant physical movement	✓		
Download data from detector hard drive and delete old files to free space, if needed	✓		
Change out the UV source		✓	
Replace ventilation exit and intake filters		✓	
Clean optics on detector and retroreflector		✓	
Realign system after service		✓	
Check system performance indicators		✓	
Perform bump test (simulates system-observed gas content at the required path average concentration) to verify the system can detect at or below a lower alarm limit		✓	
Review and test light and signal levels; check average light intensity to establish baseline for bulb change frequency		✓	
Verify system settings			✓

2.3.2 FTIR

The FTIR requires maintenance activities similar to those for the UV-DOAS, but is also designed to require only modest service and maintenance. Table 5 summarizes the maintenance activities for an FTIR system, as recommended by a typical manufacturer. Preventative maintenance frequency depends on the operating environment and may need to be adjusted. System status alarms may alert operators on an as-needed basis to specific issues that need to be addressed. Bump tests will be performed on site.

Table 5. Schedule of maintenance activities for the FTIR.

Activity	Monthly	Quarterly	Annually	18-24 months	Five Years
Visually inspect the system	✓				
Inspect optics on detector and retro-reflector; clean if necessary	✓				
Confirm the alignment to maximize signal intensity; signal should be greater than 5%	✓				
Download data older than 6 months from the hard drive, move to a permanent archive, and delete old files from the analyzer	✓				
Ensure there are no obstructions between the detector and the retro-reflector (such as equipment, vegetation, vehicles)	✓				
Perform bump test to verify the system can detect at or below a lower alarm limit. Take corrective action if % Accuracy outside criteria	✓				
Check system performance indicators (an evolving checklist will be maintained)		✓			
Inspect and clean AC system exterior heat sink		✓			
Review and test light and signal levels; check average light intensity to establish baseline for IR Source change frequency and retro-reflector wear			✓		
Replace cryocooler or swap detector module assembly				✓	
Change out the IR source					✓

2.3.3 UV Fluorescence Analyzer

Table 6 describes typical maintenance actions for a H_2S UV fluorescence point analyzer, such as cleaning and inspections, as well as their required frequencies for routine system management. Preventive maintenance ensures operational integrity and is strongly urged by the manufacturer. The frequency of maintenance checks may need to be adjusted beyond the manufacturers' recommendations once operations begin. On an as-needed basis, system status alarms will alert operators to specific issues needing to be addressed.

Table 6. Schedule of maintenance activities for an H_2S UV fluorescence analyzer.

Activity	Monthly	Quarterly	Annually
Inspect sample line tubing	✓		
Inspect particle filter at inlet and replace as necessary	✓		
Zero/span check	✓		
Inspect particle filter inside analyzer and replace as necessary		✓	
Perform flow check		✓	
Perform gas test for analyzer response		✓	
Replace pump diaphragm			✓

2.3.4 Meteorological and Visibility Sensors

Meteorological sensors provide information about temperature, relative humidity, and wind direction and wind speed to help determine sources of any air contaminants. The meteorological sensors will be maintained on a monthly and biannual basis. Table 7 lists the maintenance activities that will be performed.

Table 7. Schedule of maintenance activities for the meteorological tower.

Item	Activity	Monthly	Annually
Tower	Check that the tower is securely anchored to the shelter	✓	
	Check the tower for signs of damage or excessive wear	✓	
	Inspect all bolts at the tower base for any signs of corrosion (rust)	✓	
	Check the tower's vertical alignment	✓	
Anemometer	Note whether any component (tail, propeller) is missing or has suffered obvious damage	✓	
	Check that the whole sensor moves freely with a changing wind direction and the propeller rotates freely when windy	✓	
Temperature/ RH Sensor and Shield	Inspect the hardware holding the temperature/RH sensor shield assembly to the tower and tighten the bolts if necessary	✓	
	Check that the cable connections are secure	✓	
All sensors	Audit and calibrate		✓

Visibility measurements will be made in order to provide operational verification of fog events. Maintenance activities for the visibility sensor are included in Table 8. Monthly maintenance includes inspecting the sensor for dirt, spider webs, birds' nests, or other obstructions, and cleaning the sensor if necessary. The sensors are calibrated in the field annually using a manufacturer-specific calibration kit.

Table 8. Typical schedule of maintenance activities for the visibility sensor.

Activity	Monthly	Annually
Visually inspect the system, including all cables; clear out any obstructions and clean the glass windows	✓	
Check that the cable connections are secure	✓	
Perform the zero and light-level calibration		✓

2.3.5 Overview of Spectrum Generation, and Quality Control Parameters for Open-Path Instruments

This section provides context for some of the parameters used in QA/QC procedures for open-path systems. Generation of spectra using UV-DOAS and FTIR is a distinctly different process that is dependent on the hardware used. However, in all cases, the result is a spectral file containing absorbance as a function of wavelength. To generate absorbance using FTIR or UV-DOAS, the logarithm of the ratio of two "single beam" transmission spectra is calculated (one spectra being the sample, and the other being the "background"). For ambient open-path measurements, one single beam must be measured or estimated using a spectrum that does not contain the analyte of interest—this is the "background." Different manufacturers have different methods for determining the appropriate background. In practice, the single gas MDL for one analyte in otherwise clean air will be lower than that for air that contains interfering species (species that absorb in the same spectral region as the analyte). Also affecting the MDLs is the total averaging time. The greater the number of scans averaged, the lower the MDL due to the reduction of noise.

For UV-DOAS measurements, light is collected for a period of time (the so-called "integration time"). The instrument software determines the integration time, based on a minimum amount of light needed. Long integration times can indicate low light levels and can be used to flag data as questionable (due to the presence of fog or an object blocking the beam). For example, each manufacturer specifies a range of acceptable integration times for their system. A related metric that is applicable to all open-path measurements is the overall intensity of the light received at the analyzer; this is termed "signal strength." For certain UV-DOAS measurements, signal strengths greater than 80% are generally acceptable. For typical FTIR measurements, the values are generally lower because of absorption by atmospheric gases (CO_2, H_2O, etc.). For example, acceptable values for a manufacturer's FTIR system may be between 2% and 100%.

In order to derive concentrations, spectra must be fit using a least squares procedure. A "library" spectra of known compounds is used to best fit the experimental spectra collected at the monitoring site. The goodness of fit is quantified using the well-known R^2 value, which is equal to 1 for a perfect fit and zero for a measurement that is not correlated to the library spectra. Some instrument manufacturers use the term "percent match," which is $100*R^2$. Therefore, a positive detection of an analyte must satisfy an R^2 threshold value. For example, the fit to methane might have an R^2 of 0.70 or greater to be considered a valid detection.

Acceptance criteria for UV-DOAS and FTIR measurements are listed in Section 3.

2.4 System Corrective Actions

When a major problem is discovered with the fenceline monitoring system, corrective actions and maintenance procedures are required. Because the fenceline monitoring system is composed of two major components—field hardware and the website software—two integrated rotating on-call teams will work to respond to any issues. Corrective action will be taken to ensure that data quality objectives are met. Table 9 lists the types of issues that require corrective actions. This table is not all-inclusive, and additional checks may be added as the project progresses. The daily data reviewers will review data to identify issues and will work with the field technicians and instrument contractors to resolve issues that need to be addressed on site.

Table 9. Potential sampling and data reporting problems and corrective actions.

Item	Problem	Action	Notification	Person Responsible
Failed acceptance criterion	Instrument malfunction	Execute corrective action plan, conduct root cause analysis, flag data	Field Staff Manager, Refinery Project Manager, QA Manager	Field Staff Manager
Erratic data	Possible instrument malfunction	Contact Field Manager and Instrument Contractor	Document in logbook, notify Field Manager	Field Technician
Power	Power interruptions	Check line voltage, reset or restart instruments	Document in logbook, notify Field Manager	Field Technician
Data downloading	Data will not transfer to the DMS	Contact Field Manager and Instrument Contractor	Document in logbook, notify Field Manager and Website/Data System Manager	Field Technician
Supplies and consumables	Essential supplies run low	Contact Field Manager	Document in logbook, notify Field Manager	Field Technician
Access to sites	Technician cannot access the sites	Contact Project Manager	Document in logbook, notify Project Manager	Field Technician
Instrument Light level	A low light level alert is observed	Site visit for realignment or source replacement - possible manufacturer support	Document in logbook, notify Field Manager	Field Technician
Website	Website is down	Contact Website Manager	Notify Project Manager	Website Manager

3. Quality Objectives and Criteria

3.1 Data and Measurement Quality Objectives

3.1.1 Discussion

To ensure success of field measurements, measurement performance criteria are established as part of the monitoring design. These criteria, referred to as measurement quality objectives (MQOs) and data quality objectives (DQOs), specify the data quality needed to minimize errors in decisions made that are based on the data. Data quality is defined in terms of the degree of precision, accuracy, representativeness, comparability, and completeness needed for the monitoring. Of these five data quality indicators, precision and accuracy are quantitative measures (Section 3.2), representativeness and comparability are qualitative measures, and completeness is a combination of quantitative and qualitative measures.

The quantitative performance criteria for the data collected by the fenceline measurement systems are provided in the following tables. The principal quantitative indicators of data quality for this study are data completeness, precision, and accuracy. Table 10 shows the data completeness objectives for all collected data for several time intervals. For communication purposes, the Percent Data Valid—the percentage of data values that are valid divided by the number of captured data values (corrected for low-visibility conditions and scheduled maintenance as outlined in this QAPP)—will also be computed and included in quarterly reports.

Table 10. Measurement quality objectives, including data completeness targets.

Measurement Method	Pollutant	Reporting Unit	Completeness Target, 1-hr	Completeness Target, Quarterly
Open-Path UV-DOAS	BTEX, Naphthalene, NO_2, SO_2	Parts per billion (ppb)	75% (of 5-min values)	90%
Open-Path FTIR	Acetaldehyde, Ammonia, 1,3-Butadiene, Formaldehyde	Parts per billion (ppb)	75% (of 5-min values)	90%
Point Monitor (UV Fluorescence)	H_2S	Parts per billion (ppb)	75% (of 5-min values)	90%
Meteorological Sensors	Wind Speed, Wind Direction, Visibility	m/s, Degrees, Miles	75% (of 1-min values)	90%

Other factors that affect data availability include instrument bump tests (approximately every quarter for a few hours), annual maintenance, and other maintenance (e.g., replacement of the UV light source on the UV-DOAS roughly every 2,000 hours of use, and replacement of the FTIR cryocoolers every 18-24 months). Regular maintenance and careful, responsive operation will minimize instrument downtime. Table 11 highlights additional measurement quality objects (precision and accuracy) for the fenceline monitoring systems. National Institute of Standards and Technology (NIST)-traceable certified gases will be used for bump tests and calibrations where possible. Bump-test levels for open-path analyzers are 5-10 times above the compound MDL; calibration levels for the H_2S point monitors cover the range from zero to about 8 times the REL. Meteorological checks are to be completed in accordance with the U.S. Environmental Protection Agency's (EPA) benzene fenceline monitoring requirements.

Table 11. Additional measurement and data quality objectives for the fenceline monitoring systems.

Sensor	Testing Method	Testing Frequency	Acceptance Criteria for Precision	Acceptance Criteria for Accuracy
UV-DOAS	100 ppm benzene; internal flow-through QA	Quarterly	±25%	±25%
FTIR	300-700 ppm Isobutylene; internal flow-through QA cell	Quarterly	±25%	±25%
H_2S point analyzer	0, 250, 150, 50 ppb	Quarterly	±20%	±20%
Temperature	Two point test	Annually	--	±0.5ºC
Relative Humidity	Hygrometer	Annually	--	±7%
Wind Speed	Starting threshold test; transfer function test	Annually	--	±0.25 m/s below 5 m/s and ±5% above 5 m/s
Wind Direction	Angle verification	Annually	--	±5 degrees
Visibility	Extinction	Annually	±10%	±10%

3.2 Precision Checks, Bump Tests, and Verification

All measurements outlined here are subjected to precision and accuracy tests. During these tests, a number (N) of replicated measurements (x_i) of a standard reference material of known magnitude (x_{std}) will be measured. Here, an acceptable number if trials will be defined as N≥15. The average value of these measurements is calculated as

$$\bar{x} = \frac{\sum_i x_i}{N} \quad (1)$$

and the standard deviation (σ) as:

$$\sigma = \sqrt{\frac{\sum_i (x_i - \bar{x})^2}{N-1}}. \quad (2)$$

From these definitions, %Accuracy is defined as:

$$\%Accuracy = \frac{\bar{x} - x_{std}}{x_{std}} \times 100\% \quad (3)$$

and precision as the coefficient of variation (CV) expressed as a percentage:

$$Precision \equiv \%CV = \frac{\sigma}{\bar{x}} \times 100\% \quad (4)$$

3.2.1 Open-Path Instruments

To gauge precision and accuracy for the UV-DOAS and FTIR open-path systems, bump tests will be performed quarterly using NIST-traceable standards (where possible) passing continuously through a flow-through cell. The exhaust of the cell will be scrubbed with activated carbon appropriate to the gas being used. Temperature control for both instruments is accomplished by systems within the instrument enclosure itself. During the measurements, the light beam passes from the source, through the cell, and across the entire atmospheric path length to the retroreflector. From the retroreflector, the light beam again passes through the atmosphere and cell to reach the detector. Since the light beam travels through the ambient atmosphere that includes other gases and particles, as it would during a normal measurement, this is a realistic test of the instrument's capabilities. These bump tests are used to verify that the system can reliably detect concentrations near the level of concern. Concentrations are selected such that they are well above the level of quantitation (LOQ = 5*MDL) but are near or below the alert thresholds for select species. For both the UV-DOAS and FTIR systems, a bump test will be performed quarterly.

For the open-path systems, precision will be measured by evaluating the variance of pollutant concentrations during a period of low variability, when atmospheric influence on variability is assumed to be minimal. Five-min data will be selected during periods of low variability, but when concentrations are well above the MDL. The precision can then be evaluated by calculating the coefficient of variation (CV) during the period of low variability, as shown in Equation 4 above. If there are no periods of low variability with concentrations above the MDL, bump test data will be used to calculate precision.

3.2.2 Point Analyzer for H_2S

A gas dilution calibrator is used to deliver calibration gas to the UV fluorescence H_2S analyzer. A certified gas cylinder of H_2S and source of zero air (cylinder or generator) will be connected to the dilution calibrator to generate a range of concentration set points. On a monthly basis, the analyzers will be checked against a zero set point and a span (concentration of about 150 ppb). Full calibration checks will be done quarterly and include a range of concentrations: 0 ppb, 50 ppb, 150 ppb, and 250 ppb. The acceptance criteria for these bump tests are ±20% accuracy.

3.2.3 Meteorological Equipment

Annual audits will be conducted for the meteorological stations. The meteorological instrumentation calibrations will be conducted with reference to the recommendations in the EPA's *Quality Assurance Handbook for Air Pollution Measurement Systems (QA Handbook), Volume IV.*[2]

As part of the calibration process, each instrument will be first tested to determine whether it is operating within the prescribed operational limits and whether non-routine maintenance or adjustments are required. Based on an instrument's response to the initial performance test with respect to the minimum acceptable performance criteria, the instrument would then be repaired, calibrated, or in rare cases, replaced. A standard form will be used to document the performance of each sensor before and after any adjustments.

Wind Speed

An anemometer drive will be used to simulate known wind speeds. The propeller torque disc will be used to determine the anemometer starting threshold. Sensor starting threshold is a shaft-bearing efficiency measurement only.

The wind speed propeller and tail assembly will be visually inspected to ensure that they are not cracked or damaged. The propeller will be removed and the sensor shaft immobilized to simulate zero wind speed. The anemometer drive will be connected to the sensor shaft to simulate wind speeds between 0 and 44.1 m/s. The wind speed will be determined from wind speed coefficients provided by the manufacturer. The remote processing unit (RPU) responses will then be compared to the calculated values.

[2] U.S. Environmental Protection Agency (2008) Quality assurance handbook for air pollution measurement systems, Volume IV: meteorological measurements version 2.0 (final). Prepared by the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Air Quality Assessment Division, Research Triangle Park, NC, EPA-454/B-08-002, March. Available at https://www3.epa.gov/ttn/amtic/qalist.html.

Wind Direction

A vane angle fixture will be used to set the vane to known directions at 45-degree intervals, moving clockwise and then counter-clockwise, through the full 360-degree range of the monitor. A pocket transit mounted on a tripod will be used in conjunction with a vane alignment rod to determine the orientation of the wind monitor on the tower mast. A vane torque gauge will be used to determine the vane starting threshold.

Ambient Temperature

A NIST-traceable thermometer will be used as the calibration transfer standard. The ambient temperature sensor will be tested by comparing the current ambient temperature, as measured by the digital thermometer, to the temperature reading from the RPU. The transfer standard will be placed near the temperature probe in a shaded location. Both sensors will be allowed to reach equilibration before the responses of the respective sensors are recorded.

Relative Humidity

A NIST-traceable psychrometer will be used as the calibration transfer standard. The relative humidity sensor will be tested by comparing the current relative humidity as measured by the psychrometer to the relative humidity reading from the RPU. The psychrometer will be placed near the temperature probe in a shaded location. Both sensors will be allowed to reach equilibration before their responses are recorded.

Visibility Sensors

An appropriate manufacturer-specific calibration kit will be used to test the visibility sensors. The calibration fixtures are instrument-specific. Generally, a calibration kit consists of a blocking plate or block for checking the sensor zero, and a scatter plate for checking the sensor span. The calibration fixture is assigned a factory-traceable extinction coefficient (ECO) used to calculate the expected values during calibrations.

3.2.4 Instrument or Standards Certifications

For factory calibrations, a certification of the standard gases used will be requested from the manufacturer. Standards will not be used past their expiration date. If an expired standard is used, it shall be recertified by the manufacturer. The spectral file numbers generated during tests will be documented and archived.

4. Data Management, Quality Control, and Verification

Data quality criteria are evaluated through (1) automatic data checks conducted through the data management system and (2) data review by trained analysts (daily data review and periodic, more thorough validation).

4.1 Overview of the Data Management Process

Raw data management occurs on a real-time, daily, monthly, quarterly, and annual basis. In near-real time, data are transferred from infield instruments through a data acquisition system (DAS) to a Data Management System (DMS) using cellular modem. Data are also stored onsite on instrument computers in case of cell modem failure. The DAS performs data averaging to 5-min values, and also assigns initial quality control (QC) codes and operational (OP) codes to each data value, based on operating characteristics information collected from the analyzers at the same time as the data values. Trained analysts can access QC and OP codes within the password-protected DMS during the validation process, which does not happen in real time. The DMS keeps track of any changes in QC and OP code. The DMS uses a Microsoft SQL relational database with stored procedures. These raw data are not yet intended for the public website. Only after the data undergoes automated quality control (described in Section 4.2) and aggregation to 5-min and running 1-hr values are the data displayed on the website, within 10 minutes of data collection. Any 1-hr average values that do not meet 75% completion criteria are considered invalid, due to insufficient data being collected.

4.1.1 QC and QA Processes

All data produced by the instruments are initially considered **Level 0**. All **Level 0** data values that are not associated with bump tests, other instrument maintenance, or instrument problems will be displayed to the public in near-real time. If data are subsequently proven to be invalid, they will be removed from the public website display.

As described in Section 4.2, the DMS automatically quality-controls data, detects outliers and problems, generates reports, and creates alerts. The auto-screening capabilities of the DMS will be used for continuous examination of data quality. As part of the auto-screening process, quality control flags are assigned as follows:

- **Valid (QC flag 0)** – data are within normal operating parameters.
- **Invalid (QC flag 9)** – data do not meet quality control criteria.

- **Missing (QC flag 8)** – data have not been received by the DMS for a time period greater than 10 minutes since the last data was received.
- **Suspect (QC flag 5)** – operating parameters are marginal and should be reviewed further.

The automatically quality-controlled air quality data will be displayed on the public website within 10 minutes after collection. At this point, these data are considered **Level 0.5**.

Further routine verification of the data is described in Section 4.3. The DMS serves a non-public operations website that is used for daily graphical review of the data by experienced analysts. The DMS also has a notification system to inform/alert project and facility staff of problems. After this routine data review is complete, data are considered **Level 1.0**.

During the last phase of data verification, data from longer time periods are validated by executing various QA procedures (described in Section 4.4) and instrument QC checks (described in Section 4.5). After these in-depth checks are complete and the data are annotated appropriately, the resulting data is considered **Level 2.0**. At this point, the data is considered final for reporting to the SJVAPCD. Data from all stages of validation are retained in the DMS.

4.1.2 Data Storage and Backup

On-site, raw analyzer backup files will be copied to offsite storage on a regular basis. The DMS data will be backed up on a daily basis. Stored and retained information includes raw and validated data; QC codes, OP codes, and metadata associated with each data value; metadata associated with each analyzer; and change-of-custody logs. The data will be stored for a period of five years after sampling.

Access to the DMS data is controlled by username and password (with strong encryption), and is restricted to the Field Staff Manager and those designated to perform data validation and analysis. As protection against incorrect modification or deletion, a chain-of-custody record is kept of all changes to the database, and backups are performed frequently.

4.1.3 Data Delivery and Reporting

Final data sets (Level 2.0 data) will be compiled quarterly, within 45 days after the close of each quarter, and made available to the public on the website in graph format. Validated data will be provided to the SJVAPCD quarterly. Each quarter, a report will be prepared and delivered to the SJVAPCD. These quarterly reports will provide a summary of measured data, threshold exceedances, quarterly and monthly statistics, accuracy and precision of instruments, outliers, anomalies, and data quality control. The quarterly reports will be written at a public-friendly level, but still reflect a high level of data validation and quality control.

Data graphs will be stored and available on the website for 90 days. Kern will maintain a data record for five years consistent with Rule 4460.

4.2 Automated Quality Control

Automated data screening is conducted within the DMS upon data ingest. Automated screening checks of data feeds are used to screen out invalid data for public display and are helpful to focus the data reviewer's efforts on the data that need the most attention. Initial screening checks, along with actions to be taken, are summarized in Table 12. The screening check concentration criteria are based on an analysis of expected instrument performance, concentration levels of concern by compound, and typical ambient concentrations by compound. All screening criteria (flags and rates of change) are preliminary and will be refined during the project based on actual observations. The DMS auto-screening checks that will be used include:

- MDL. Set up to check if data collected are above the reported detection limit of the analyzer. If the data is below the detection limit, it will be flagged as such.
- Range. These checks will verify that the instrument is not reporting values outside of reasonable minimum and maximum concentrations.
- Sticking. If values are repeated for a number of sampling intervals, data will be reviewed for validity. Typically, four or more intervals of sticking values are a reasonable time span to indicate that investigation is needed. Sticking checks will not be applied to data below the instrument detection limit.
- Rate of Change. Values that change rapidly without reasonable cause will be flagged and reviewed.
- Missing. If data are missing, data during those time periods will be coded as missing.
- Sensor OP codes and alarms. If the instrument assigns OP codes to data automatically (e.g., for bump tests, internal flow rate checks, light extinction criteria, integration time criteria), the data will be reviewed, codes confirmed, and data flags checked.
- Visibility impairment. While the exact relationship between visibility and open-path measurements is not established, the expectation is that there would be no measurements when visibility is less than the twice the path length (two times the path length is used because the open-path sensor light travels to the mirror and back to the analyzer).

Additional parameters that may be monitored as indicators of data quality include data quality value for each concentration as reported by the instrument (i.e., correlation between measured and reference spectra), signal strength, wavelength versus intensity, and visual review of peaks.

Data flags identified through auto-screening will be graphically reviewed during data validation (i.e., not in real time), and QC flags will be updated with daily and quarterly actions. DMS keeps track of data changes in its chain-of-custody feature—i.e., raw data are preserved as well as all changes.

Table 12. Initial screening checks for 5-min data. All valid and suspect data values will be displayed to the public in real time. If data are invalid, they will not be included in the public display. All screening values below (flags and rates of change) are preliminary and will be refined during the project. During data validation, flagged data will be further investigated.

Measurement Species (units)	Checks						
	Minimum Detection Limit (MDL): If concentration is below MDL, flag as below MDL	**Range:** If concentration is above value listed, flag as suspect and conduct investigation	**Sticking:** If same value observed for four or more intervals, flag as suspect and conduct investigation	**Rate of Change Between Intervals:** If concentration changes by more than value listed, flag as suspect and conduct investigation	**Missing:** If data are missing, flag as missing and investigate cause	**Sensor OP Code/Alarm:** If sensor indicates malfunction or bump test data, flag as appropriate	**Visibility:** If visibility is less than 1,000 m and data are missing, flag as appropriate
Acetaldehyde (ppb)	SAME FOR ALL POLLUTANTS	780	SAME FOR ALL POLLUTANTS	260	SAME FOR ALL POLLUTANTS	SAME FOR ALL POLLUTANTS	SAME FOR ALL POLLUTANTS
Ammonia (ppb)		1,380		460			
Benzene (ppb)		27		9			
1,3-butadiene (ppb)		900		300			
Ethylbenzene (ppb)		1,380		460			
Formaldehyde (ppb)		135		45			
H_2S (ppb)		90		30			
Naphthalene (ppb)		6		2			
NO_2 (ppb)		750		250			
SO_2 (ppb)		750		250			
Toluene (ppb)		29,400		9,800			
Total Xylenes (ppb)		15,000		5,000			
Visibility (meters)	If value is <0, flag as suspect	1,000	Not applicable	Not applicable	--	--	Not applicable

4.3 Routine Data Verification

4.3.1 Confirm Daily Operation

Operationally, data are reviewed daily by a data reviewer to assess instrument operation. This process leads to Level 1.0 data. This initial review, typically of a three- to five-day time-series plot of selected parameters for each instrument, allows the analyst to see common problems and verify instruments are operational. If it appears that an instrument is not operating, or the data are missing, the field operator will be notified and further investigation and corrective action, if needed, will be taken.

In addition to daily checks of the field website, an automated alerting system will let technicians and managers know when data have been missing for a specified period of time. Missing data may indicate a power issue, an instrument problem, or a data communication problem. The time period allowed for missing data will be set for six 5-min values (30 minutes).

4.3.2 Assess Data Reasonableness

Also operationally, the data reviewer quickly assesses whether the pollutant concentrations are reasonable with respect to the time of day, season, meteorology, and concentrations expected and observed along other paths. If anomalies are observed, additional analysis will be conducted to determine whether there is an instrument malfunction or the data are truly anomalous but explainable. Data reasonableness is also assessed more thoroughly during the data validation process.

4.4 Data QA Procedures

On a quarterly schedule, an experienced air quality analyst will validate data by building on the processes leading to Level 1.0 data. This process starts with an in-depth review of the data, which includes statistical tests to ensure the data are valid for the intended end use. The QA Manager will evaluate QA/QC procedures and ensure the methods for meeting data quality objectives are adhered to. Data validation activities will be reviewed and approved by the QA Manager.

Quarterly data validation activities include:

- Looking for statistical anomalies and outliers in the data and investigating them.
- Ensuring there are not several continuous 5-min averages of the same number.
- Evaluating monthly summaries of the minimum, maximum, and average values.
- Ensuring the data are not biased by exceptional conditions or events occurring off refinery property.

- Ensuring data reasonableness by comparing the data to remote background concentrations and average urban concentrations.
- Ensuring the data or measurements are realistically achievable and not outside the limits of what can be measured.
- Inspecting several sampling intervals before and after data issues or instrument bump tests or repairs to ensure all affected data have been properly flagged.
- Referring to site and operator logbooks to see if some values may be unusual or questionable based on observations by site operator.
- Assessing instrument meta-data to confirm reasonableness.
- Assessing visibility measurements to ensure adequate signal was obtained to quantify pollutant concentrations.
- Confirming that bump tests were conducted and were within specifications.

On a quarterly basis, to ensure all the daily QC tasks are complete, analysts will:

- Review any instrument bump test results (see Section 4.5).
- Verify that daily instrument checks were acceptable.
- Review manual changes to operations/data, and verify that the changes were logged and appropriately flagged.
- Ensure that instrument checks have the appropriate QC codes applied.

On a quarterly basis, analysts will subject the data to final QC by filling in missing records with null values and adding Null Codes. Analysts will:

- Assign invalid data a Null Code, which are assigned to give data a reason for being invalid.
- If a record is not created for a particular site/date/time/parameter combination, create a null record for data completeness purposes.
- Inspect data consistency over three months.
- Review ranges of values for consistency – ranges should remain consistent over months of monitoring.
- Check bump test values for consistency.
- Review quarterly data completeness.

General criteria for suspecting or invalidating data include:

- Monitor appears to have malfunctioned (acting erratic, spiking, or showing other evidence of questionable operation).
- Data are outside of plausible values (indicating a calculation error, averaging error, or instrument malfunction).

Common reasons for data invalidation include instrument malfunction, power failure, and bump test data that were not identified as such. As the measurements progress, screening checks will be updated and refined. Screening checks are typically specific to the site, instrument, time of day, and season, and will be adjusted over time as more data are collected.

Data are invalidated only if a reason can be found for the anomaly or automated screening check failure. If the data are anomalous or fail screening but no reason can be found to invalidate the data, the data are flagged. Additional analysis may be needed to deem data valid or invalid. Voided data will be flagged as invalid in the database. A summary of issues leading to invalidated data will be documented in the data file.

All actions will be documented in the DMS, which retains raw data and traceability of all actions that result in the final data. At the conclusion of activities covered in this section, the data are considered Level 2.0 data.

4.5 Instrument QC Checks

Additional QC checks for the instruments are summarized in **Table 13**. Data that fail checks will be flagged in the DMS and brought to the attention of the reviewer by color coding the graphic summaries.

On roughly an annual basis, the refinery or its designated contractor will review the performance of the network by (1) reviewing the data completeness by monitoring path, instrument, and species; (2) reviewing results of bump tests; (3) analyzing the reported values in context of refinery operations; and (4) analyzing the data in context of the meteorology. The contractor will also use analyses similar to those used to support the network design to evaluate the overall network performance and ensure it is meeting overall objectives. The results will be summarized in a technical memorandum and provided to the SJVAPCD upon request.

Table 13. Typical instrument QA/QC checks.

QA/QC Checks	Frequency	Acceptance Criteria
UV-DOAS		
Bump test (accuracy)	Quarterly and after major service	±25%*
Baseline stability	Continuous	±5%
Measurement quality (R^2)	Continuous	0.8 to 1.0
Integration time	Continuous	80-200 msec *300 msec integration time results in a warning notification*
Signal intensity	Continuous	>80% *Signal intensity below 30 results in a warning notification*
FTIR		
Bump test	Quarterly and after major service	±25%*
Measurement quality (R^2)	Continuous	0.7 to 1.0
Signal Intensity	Continuous	>2% *Signal intensity below 2% results in a warning notification*
UV Fluorescence H_2S Analyzer		
Bump test	Quarterly	20%
Meteorology		
Two point temperature test	Annually	±0.5°C
Relative humidity	Annually	±7%
Wind speed starting threshold and transfer function	Annually	±0.25 m/s below 5 m/s and ±5% above 5 m/s
Wind direction angle verification	Annually	±5 degrees
Visibility – extinction coefficient check	Annually	±10%

*Based on flow-through calibration system.

4.6 Independent Quality Oversight

As part of implementing quality assurance, Rule 4460 requires independent audits of the fenceline monitoring system. Kern will work with contractors or SJVAPCD to perform external annual systems audits that include the following elements:

- Audits or bump tests of instruments, following the criteria outlined in Sections 3 and 4 of this QAPP
- Audit of data flow from the instrument to website

5. Standard Operating Procedures

Standard Operating Procedures for maintenance and audits of the UV-DOAS instrument, FTIR instrument, UV fluorescence analyzer, visibility sensor, and meteorological sensors will be provided upon final implementation of all systems.