

Fenceline Monitoring Plan for the Chevron Refinery in El Segundo, California



October 15, 2019

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Monitoring Plan

October 15, 2019

Contents

Figures	v
Tables	vi
Introduction	1
1. Spatial Coverage.....	7
1.1 Characteristics of Refinery Location.....	7
1.1.1 Geographical Setting.....	7
1.1.2 Topography and Meteorology.....	8
1.1.3 Non-Refinery Pollution Sources.....	10
1.1.4 Sensitive Receptors.....	10
1.2 Historical Emission Patterns and Hotspots.....	11
1.2.1 Operations and Processes Within the Facility’s Perimeter	11
1.2.2 On-Site Emissions Sources and Emissions Levels	11
1.2.3 Dispersion Modeling.....	16
2. Monitoring Locations and Equipment.....	21
2.1 Selected Sampling Locations.....	21
2.2 Instrument Specifications and Pollutants to Be Measured.....	25
2.2.1 Pollutant Detection Limits.....	28
2.2.2 Hydrogen Sulfide.....	32
2.2.3 Black Carbon.....	32
2.2.4 Operations and Maintenance	32
2.2.5 Excluded Pollutants.....	38
3. Quality Assurance	39
3.1 Data QA Procedures	39
3.2 SOPs for Equipment	43
4. Data Display to the Public	45
4.1 Educational Material.....	45
4.2 Objectives and Capabilities of Monitoring System	45
4.3 Description of Pollutants, Measurement Techniques, and Data Archive.....	46
4.4 Pollutant Background Levels and Context for Fenceline Measurements.....	49
4.5 Data Upload Procedures and Quality Control for the Public Website.....	49
4.6 Further Information to Guide Public Understanding	50
4.7 Procedures for Public Comment, Feedback, and Response	51
4.8 Links to Quarterly Reports.....	51
5. Notification System	53

6. References..... 55

Appendix A. Fenceline Air Monitoring Plan Checklist 57

Appendix B. Quality Assurance Project Plan 59

Figures

1. Monitoring paths for the Chevron El Segundo refinery.....	4
2. Chevron El Segundo refinery and the surrounding area.....	8
3. Average monthly wind roses for 1/1/2007-12/31/2011 at LAX-Hastings.....	9
4. Map of sensitive receptors.....	10
5. Gridded emissions of ammonia.....	14
6. Gridded emissions of hydrogen sulfide.....	14
7. Gridded emissions of BTEX compounds.....	15
8. Gridded emissions of 1,3-butadiene.....	15
9. Gridded emissions of acrolein and acetaldehyde.....	16
10. Benzene 5-year average concentrations during 2007-2011, using LAX Hastings surface meteorological data	17
11. 1,3-butadiene 5-year average concentrations during 2007-2011, using LAX Hastings surface meteorological data.....	18
12. Hydrogen sulfide 5-year average concentrations for 2007-2011, using LAX Hastings surface meteorological data.	19
13. Ammonia 5-year average concentrations for 2007-2011, using LAX Hastings surface meteorological data.	20
14. Location of sensors and measurement paths.....	23
15. Basic premise for open-path instrument operation.....	30
16. An example of a UV-DOAS analyzer (may not be configuration of actual installation).	31
17. An example of a UV-DOAS retroreflector (may not be configuration of actual installation).	31
18. Screenshot showing an example of a home page of a public-facing fenceline monitoring site	46
19. An example of the data display for any subset of the variables measured as part of this monitoring program.....	47
20. An example of the data display for any subset of the variables measured as part of this monitoring program.....	48
21. Schematic representation of the flow of data from acquisition at the sensor to display on the public website.	49

Tables

1. Approximate implementation schedule for Chevron El Segundo Rule 1180 monitoring project.....	2
2. List of pollutants to be measured	5
3. Emissions of species listed in Rule 1180 at the Chevron El Segundo Refinery	12
4. Locations of equipment to be used in fenceline monitoring program at the El Segundo refinery.....	24
5. Summary of monitoring for species listed in Rule 1180.....	26
6. Range of approximate open-path instrument minimum detection limits and upper detection limits in parts per billion by technology, species, and path length.....	29
7. Schedule of maintenance activities for the UV-DOAS	33
8. Schedule of maintenance activities for the FTIR	34
9. Schedule of maintenance activities for Galvanic Applied Sciences ProTech 903W instrument.....	35
10. Schedule of maintenance activities for Aethalometers.....	36
11. Routine maintenance actions for meteorological and visibility instrumentation	36
12. Summary of outage response actions and timelines.....	37
13. Instrument QA/QC checks.....	41
14. Thresholds for triggering automated notifications	54

Introduction

Rule 1180 Requirements for Fenceline Monitoring Plans

On December 1, 2017, the South Coast Air Quality Management District (SCAQMD) adopted Rule 1180, "Refinery Fenceline and Community Air Monitoring" (South Coast Air Quality Management District, 2017a). Rule 1180 requires petroleum refineries within the SCAQMD to establish air monitoring systems at facility perimeters (fencelines); these systems will measure pollutant concentrations and provide the public with real-time information about air quality near the refineries. Rule 1180 also requires a detailed fenceline air monitoring plan (this document) that follows SCAQMD guidelines (South Coast Air Quality Management District, 2017b).

Following the SCAQMD's guidelines, this air monitoring plan includes detailed information on several elements to justify the measurement and data dissemination approach implemented to satisfy Rule 1180 requirements. Section numbers in the following list indicate where each element is discussed in this plan.

- An evaluation of routine emission sources at the refinery (e.g., utilizing remote sensing or other measurement techniques or modeling studies, such as those used for health risk assessments) (Section 1). *This plan relies on emissions used in Chevron's Voluntary Risk Reduction Plan.*
- An analysis of the distribution of operations and processes within the refinery to determine potential emissions sources (Section 1). *This plan describes refinery operations and processes and also assesses on-site emissions sources.*
- An assessment of air pollutant distribution in surrounding communities (e.g., mobile surveys, gradient measurements, and/or modeling studies used for health risk assessments) (Section 1). *This plan relies on pollutant concentrations modeled for the Voluntary Risk Reduction Plan.*
- A summary of fenceline air monitoring instruments and ancillary equipment that are deployed to continuously measure, monitor, record, and report air pollutant levels in real-time near the petroleum refinery facility perimeter (i.e., fenceline) (Section 2). *This plan relies on both open-path and point instruments to satisfy Rule 1180 requirements.*
- A summary of instrument specifications, detectable pollutants, minimum and maximum detection limits for all air monitoring instruments (Section 2). *This plan relies on information provided by reputable instrument manufacturers for instrument specifications.*
- Monitoring equipment siting and selected pathways (when applicable) for fenceline instruments, including the justification for selecting specific locations based on the assessments mentioned above (Section 2). *This plan covers all important fencelines around the refinery and has accounted for the measurement of all chemical species listed in Rule 1180.*

- Operation and maintenance (O&M) requirements for the monitoring systems; an implementation schedule consistent with the requirements of Rule 1180; procedures for implementing quality assurance and quality control of data (Table 1 below, Sections 2 and 3).
- A web-based system for disseminating information collected by the fenceline air monitoring system (Section 4). *This plan provides the key content of the web system; final design will be created during implementation, after this plan is approved.*
- Details of the public notification system (Section 5). *This plan provides the key content of the public notification system; final design will be created during implementation, after this plan is approved.*
- Demonstration of independent oversight (Section 3). *Independent oversight will be conducted by a Chevron contractor.*

An implementation schedule detailing the key milestones for implementation of the monitoring system is shown in [Table 1](#).

Table 1. Approximate implementation schedule for Chevron El Segundo Rule 1180 monitoring project.

Project Element	Completion Date
Develop monitoring plan and receive approval from SCAQMD	At time of approval
Select instrument types based on measurement needs; order instruments, shelters, and supplies	One month following approval.
Determine final site locations	At time of approval
Develop specifications for infrastructure (shelters, pads, power, mounts, etc.)	1 month prior to approval
Perform preliminary infrastructure design	1 month prior to approval
Perform detailed infrastructure design	1 month following approval
Perform engineering and construction work	2 months following approval
Complete site infrastructure	9 months following approval
Acquire instruments	8 months following approval
Complete and test data management system	9 months following approval

Project Element	Completion Date
Complete internal and external websites and internal notification system	9 months following approval
Install and test instruments and associated equipment	10 months following approval
Finalize Quality Assurance Project Plan	8 months following approval
Start monitoring and reporting	12 months following approval, or by January 1, 2020
Operate and maintain equipment, data system, website, notification system; perform daily data checks	12 months following approval, or by January 1, 2020; continuous

Summary of Monitoring Plan for Chevron El Segundo

Chevron’s El Segundo Refinery is surrounded by residential areas on three sides and is also bounded by commercial zones and several major industrial facilities. Chevron will monitor concentrations across 12 open paths and 6 point locations. These paths are shown in [Figure 1](#). The Refinery selected these locations after considering dominant wind patterns, sources of potential air emissions on the refinery property, nearby local receptors, and logistical feasibility. These locations will provide coverage for downwind communities under typical and atypical wind patterns. The instruments used will be capable of measuring the pollutants listed in Rule 1180 in real time and include open-path FTIR and UV-DOAS instruments, as well as point instruments for BC, H₂S, meteorological, and visibility. All required pollutants will be measured as shown in [Table 2](#).

The monitoring data will be quality-assured and displayed to the public via a website in real time. Links to educational materials will be provided so the data can be understood in context of health benchmarks and regional pollutant concentrations. Notifications will be issued when thresholds are exceeded, when other activities affect the monitoring system, and when quarterly reports are available.

The following sections provide details of the plan, including a discussion of all items in SCAQMD’s fenceline air monitoring plan checklist (see [Appendix A](#)).

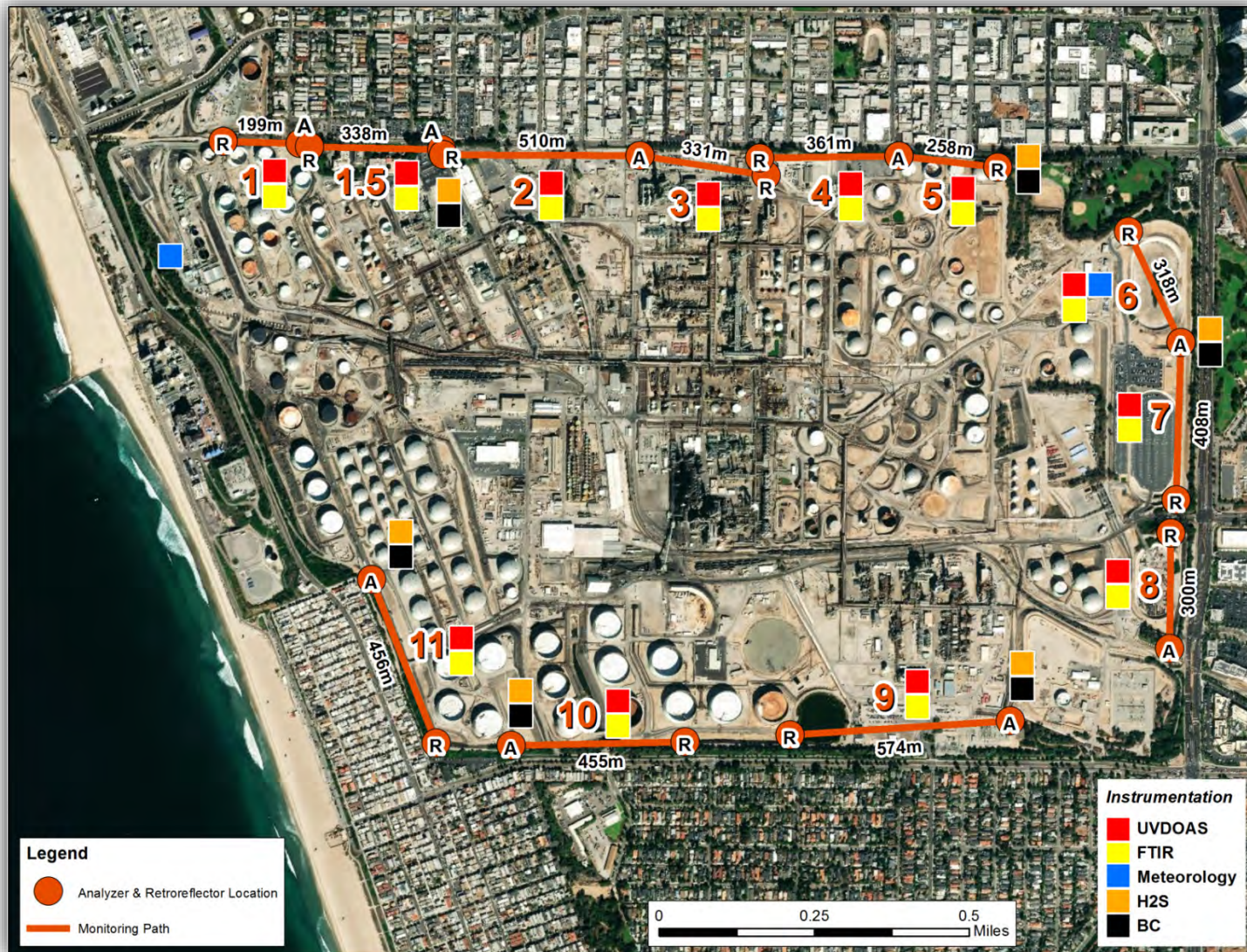


Figure 1. Monitoring paths for the Chevron El Segundo refinery.

Table 2. List of pollutants to be measured.

Pollutant	Instrument	Path/Location
Criteria Air Pollutants		
Sulfur Dioxide	OP UV-DOAS and FTIR	1-11
Nitrogen Dioxide	OP FTIR	1-11
Volatile Organic Compounds		
Total alkanes	OP FTIR	1-11
Formaldehyde	OP FTIR	1-11
Acetaldehyde	OP FTIR	1-11
Acrolein	OP FTIR	1-11
1,3-Butadiene	OP FTIR	1-11
Styrene	OP FTIR	1-11
BTEX Compounds	OP UV-DOAS and FTIR	1-11
Other Compounds		
Hydrogen Sulfide	Point Monitor	1.5, 5, 6, 9, 10, and 11
Carbonyl Sulfide	OP FTIR	1-11
Ammonia	OP FTIR	1-11
Black Carbon	Point Aethalometer	1.5, 5, 6, 9, 10, and 11
Hydrogen Cyanide	OP FTIR	1-11

1. Spatial Coverage

To provide a monitoring network that best serves the community by monitoring the emissions at the refinery fenceline, the following factors were considered while designing the monitoring network: (1) the characteristics of the refinery location, including topology and meteorology, (2) emissions characteristics, (3) sensitive receptors, and (4) the spatial coverage of the monitors. The monitors selected will be described in more detail in Section 2.

1.1 Characteristics of Refinery Location

This section characterizes the refinery location, emphasizing important factors controlling potential exposure of the nearby community to pollutants. These factors include the refinery's geographical setting with respect to other non-refinery sources, topography and meteorology, location of sensitive receptors, refinery emissions, and modeling of the dispersion of those emissions to surrounding areas.

1.1.1 Geographical Setting

Chevron's El Segundo Refinery is located at 324 W. El Segundo Blvd. in the city of El Segundo, California ([Figure 2](#)). Chevron's 929-acre property is mostly developed and can provide the infrastructure necessary for a fenceline monitoring program. The refinery is surrounded by residential areas on three sides: El Segundo to the north and east, and Manhattan Beach to the south and west. Santa Monica Bay is also to the west. The refinery is additionally bounded by commercial zones and several major industrial facilities.

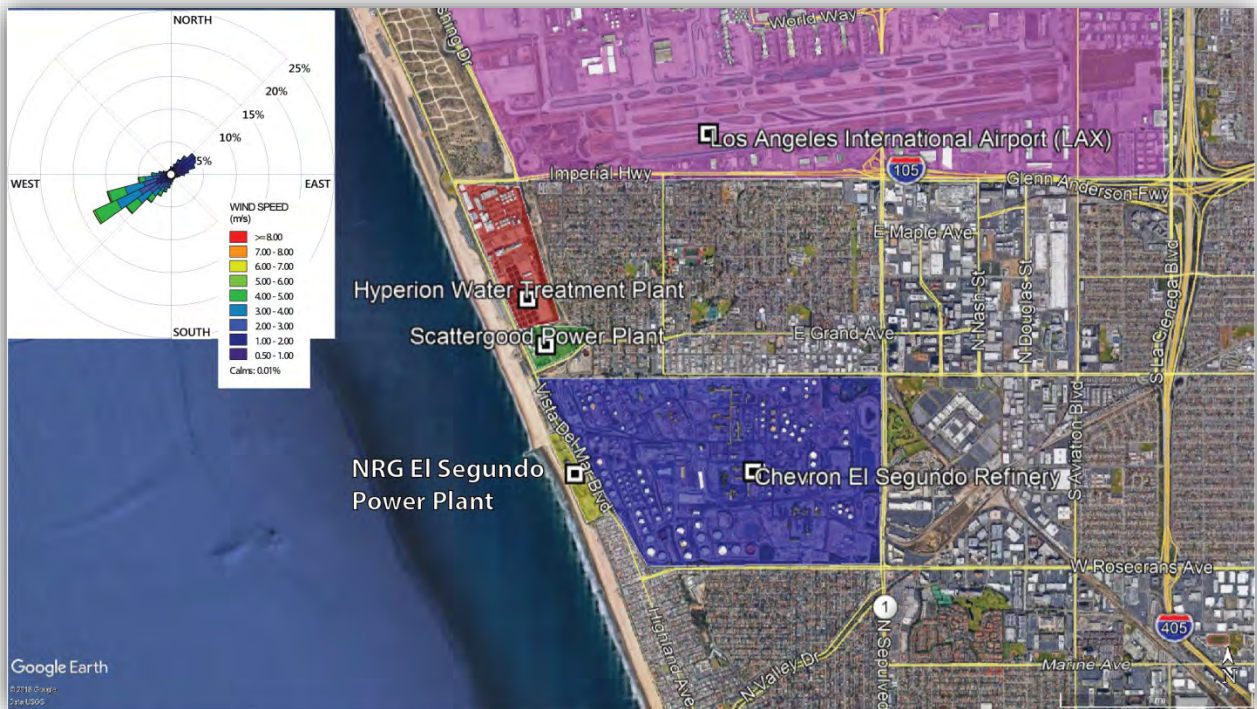


Figure 2. Chevron El Segundo refinery and the surrounding area. The wind pattern is dominated by west-southwesterly (sea-breeze) and northeasterly (land-breeze) winds.

1.1.2 Topography and Meteorology

The land within the refinery location is characterized by undulating hills approximately 100 to 160 feet above sea level. The refinery is positioned at a coastal site; thus, for the majority of the time, the winds are dominated by the sea breeze-land breeze pattern. To assess wind climatology, meteorological data from the LAX Hastings site (33.9550, -118.4303) from 1/1/2007 to 12/30/2011 were used to generate the wind roses shown in Figures 2 and 3; these are the same meteorological surface wind data that were used in Chevron’s 2017 Voluntary Risk Reduction Plan (VRRP) for this facility (ERM, 2017).¹ The LAX Hastings site is located only three miles north of the refinery and is one mile from the coast; thus, the meteorological data from this site is very representative of the conditions at the El Segundo refinery. The petals of a wind rose show the direction the wind is coming from. The annual average wind rose from the 2007–2011 period shows that onshore southwesterly winds and offshore northeasterly winds dominate for the majority of time:

- **Onshore winds.** Winds blow from southwest to northeast most frequently (approximately 51% of the time, as seen in Figure 2). These winds move across the refinery into the residential and commercial areas to the northeast of the refinery. These winds are associated

¹ Although text in the VRRP report indicates that Long Beach surface meteorological data were used, that is incorrect, as STI discovered that LAX Hastings surface meteorological data were actually used in the VRRP modeling.

with the sea breeze phenomenon and are strongest during the daytime, during the early evening, and during the summer.

- **Offshore winds.** Winds blowing from the northeast to the southwest (approximately 25% of the time) move from the Los Angeles Basin through the refinery out towards the ocean. These winds are associated with the land breeze phenomenon and tend to be stronger during the nighttime, during early morning hours, and during the winter

To capture the seasonal variability of the winds, average monthly wind roses were plotted for the data from 1/1/2007 to 12/31/2011 (Figure 3). During the coldest months (November, December, and January), the offshore wind pattern is the most prevalent because of the cooler land temperatures. During the early spring and late fall months, both onshore and offshore winds occur with roughly equal frequency. From late spring to early fall, the onshore wind pattern is the most frequent. In general, there is little deviation from the southwesterly onshore or northeasterly offshore flow throughout the year.

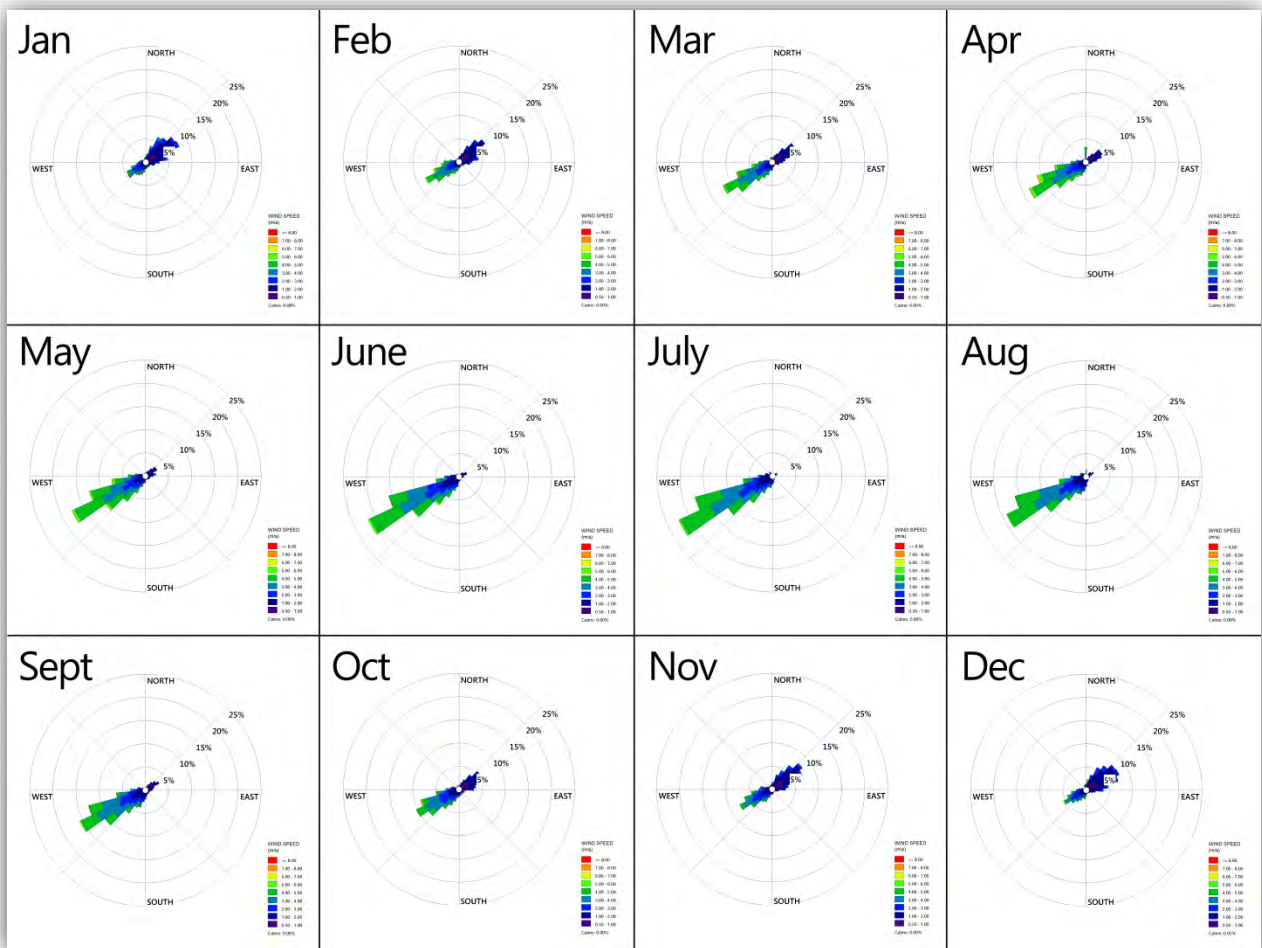


Figure 3. Average monthly wind roses for 1/1/2007-12/31/2011 at LAX-Hastings. Onshore flow (from the southwest) dominates most of the year except late fall and winter. Winds from the northwest and the southeast are infrequent.

1.1.3 Non-Refinery Pollution Sources

Major non-refinery pollutant sources include two power plants (Scattergood Generating Station and NRG El Segundo Power), Los Angeles International Airport (LAX), Hyperion water treatment plant, and Interstate 405 (Figure 2). Because the refinery is located in a densely populated area, typical urban emissions of pollutants are expected. The power plants generate electricity via combustion of natural gas and are thus expected to be significant sources of nitrogen oxides (NO_x). The Hyperion water treatment plant is one of the largest such plants in the area and is likely a significant source of hydrogen sulfide (H₂S) and sulfur oxides (SO_x) to the surrounding community. LAX contributes to NO_x pollution due to heavy traffic loads and air traffic emissions, and Interstate 405 is another major source of NO_x pollution due to heavy traffic. Interstate 405 is also a major source of diesel particulate matter due to the large volume of heavy-duty vehicle traffic. All of these sources, at times, may impact the fence-line monitoring network as well as the community.

1.1.4 Sensitive Receptors

Figure 4 shows the location of several types of sensitive receptors with respect to the refinery, including schools and childcare facilities, adult health facilities, recreation areas, and residential areas. At least one of each type of receptor is located within a mile of the refinery fence-line. The combination of winds and proximity of sensitive receptors helps guide the placement of fence-line monitoring systems.

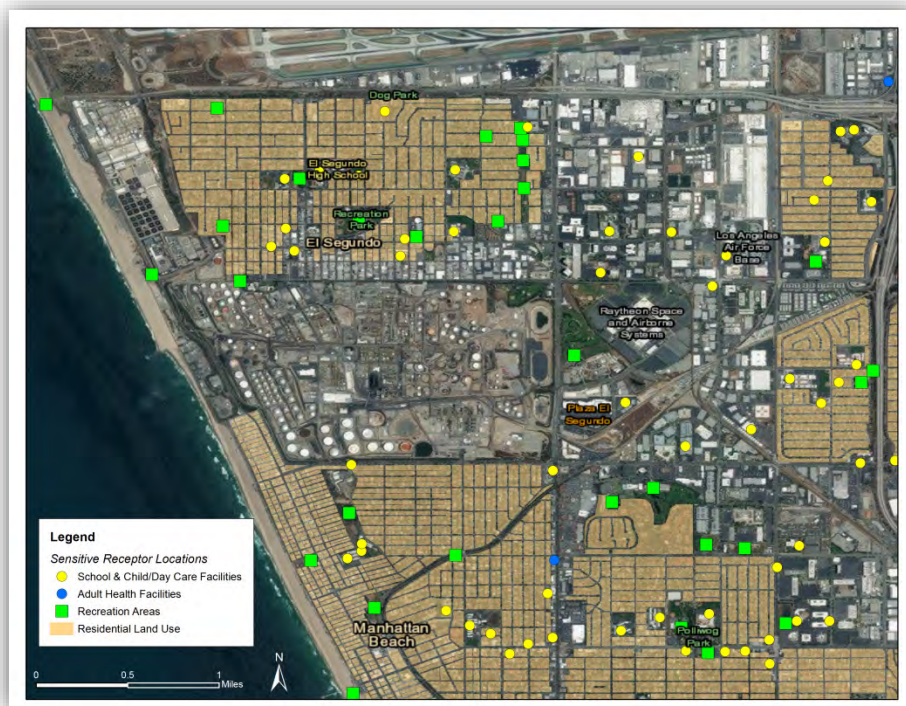


Figure 4. Map of sensitive receptors.

There are also several recreation areas along the fencelines that include small community parks, El Segundo and Manhattan beaches, and a golf course (to the east). There are schools located close to the northern fenceline in the city of El Segundo; these include preschools, elementary, middle, high, and nursery schools. There are slightly fewer schools to the south in the town of Manhattan Beach. Daycare facilities are present in both the residential and commercial neighborhoods. Based on the dominant wind directions and the location of sensitive receptors in residential areas, the residential areas along the northeast and southwest fencelines are the most important areas to monitor.

1.2 Historical Emission Patterns and Hotspots

This section describes refinery operations, processes, emissions sources, and dispersion modeling used to characterize the potential transport of specific pollutants beyond the refinery property. Emissions information, together with the information provided about the topology and geographic setting (Section 1.1), is used as additional basis for the placement of the fenceline monitoring systems.

1.2.1 Operations and Processes Within the Facility's Perimeter

Chevron's El Segundo Refinery is a petroleum refinery producing fuel products, such as liquefied petroleum gas (LPG), gasoline, jet fuels, diesel fuels, residual fuel oils, and coke through distillation of crude oil, coking, cracking, alkylation, and reforming. Crude oil, used to produce gasoline and other refinery products, is delivered by ship to the marine terminal or received via pipeline directly to the Refinery. The crude oil is then processed in the crude units, where it is heated and distilled into multiple feedstock components that are later processed elsewhere in the Refinery. The heavy residual oil leaving the crude units is further distilled in the vacuum units to yield additional, lighter hydrocarbon products and vacuum residuum. The vacuum residuum is processed in the Coker Unit, and the lighter hydrocarbon components from the crude units and vacuum units are fed to other Refinery units for further processing. Some of the major downstream processes are cracking in the Fluid Catalytic Cracking Unit (FCCU) and ISOMAX Unit, processing to recover sulfur in the hydrotreating units such as the Vacuum Residuum Desulfurization (VRDS) Unit, synthesizing in the Alkylation Unit, and reforming in the Continuous Catalytic Reforming (CCR) Unit. Auxiliary systems are also needed to support Refinery operations; these include hydrogen plants (to produce hydrogen needed for certain refinery reactions), boilers to produce steam, cogeneration plants to produce electricity and steam, and wastewater treatment systems.

1.2.2 On-Site Emissions Sources and Emissions Levels

In 2017, Chevron submitted a Voluntary Risk Reduction Plan (VRRP) to the South Coast Air Quality Management District (SCAQMD). As part of this plan, an extensive emissions inventory was generated under SCAQMD Rule 1402 for the 2015 reporting year (ERM, 2017). The emissions

information presented here is a result of that effort. **Table 3** lists the annual emissions of the chemical species listed under SCAQMD Rule 1180. The remainder of this section summarizes the main source areas of the major Rule 1180 species. **Figures 5 through 9** represent emissions of key Rule 1180 species gridded on a map of the facility. Reported facility toxics emissions in 2015, along with coordinate and dimension information, were obtained from the 2015 VRRP modeling data. Emissions were gridded in a geographic information system (GIS) by location and source type in order to locate sources within the facility fenceline that had the highest emissions, on a per-pollutant basis.

Table 3. Emissions of species listed in Rule 1180 at the Chevron El Segundo Refinery. NO_x and SO_x were not part of the VRRP and are thus not included in this table.

Pollutant Name	Emissions (kg/yr)
Ammonia	69796.5
Hydrogen Sulfide	13073.0
Xylenes	2343.3
Hexane	1805.7
Formaldehyde	1727.1
Toluene	1539.1
Ethyl Benzene	655.7
Carbonyl Sulfide	593.0
Benzene	408.0
Acrolein	276.3
DieselExhPM	266.4
Acetaldehyde	202.1
1,3-Butadiene	10.1
Styrene	2.3

For the purposes of dispersion modeling (see Section 1.2.3), 326 sources were developed, including 80 point sources, 155 volume sources, 79 area sources, and 12 poly-area sources. For both the current and proposed facility risk configurations, all of these sources were included in the risk impacts. All stationary sources where the emissions passed through a stack or a vent were modeled as point sources. This includes all stationary combustion sources.

All above-ground tanks were modeled as volume sources (155 in total), taking into consideration the tank height and diameter in determining the initial vertical and horizontal dimensions, following U.S.

EPA guidelines. Since emissions from tanks are generally released at the top of the tank, the release height was assumed to be at the roof height for each volume source.

Many of the fugitive emissions associated with specific common regions were modeled as area sources. For the El Segundo Refinery, a total of 79 specific areas sources were identified for a wide variety of rectangular regions, and the release heights were based upon each source's release geometry as identified in the VRRP submitted to the SCAQMD.

Other fugitive emissions that could not be identified with a specific location were assumed to occur within a plant region and were modeled as poly-area sources, and specific fugitive emissions releases were identified with the plant region. A poly-area source configuration was used for these releases because of the unusual footprint of each of the nine plant regions. Welding emissions occurred across eight of the nine plant areas, and the emissions were equally spread over the eight plant area sources, excluding the maintenance plant area. The release height for each plant area was assumed to be at the ground surface. Because of operations occurring at these areas, it was assumed that emissions would initially be dispersed evenly through a 10-meter height.

Portable diesel and gasoline internal combustion engine (ICEs) emissions could occur anywhere within the facility.

Ammonia is emitted at several locations throughout the refinery ([Figure 5](#)), including the fluidic catalytic cracker (FCC), process heaters and furnaces, and a number of other areas. Ammonia emissions are primarily related to uses in pollution control devices.

H₂S emissions are primarily due to processes involved with sulfur removal (H₂S plant, vacuum residual desulfurization, etc.). The spatial distribution of H₂S emissions is shown in [Figure 6](#); the spatial distribution of carbonyl sulfide matches closely the distribution for H₂S, albeit at lower levels.

The emission locations of benzene, toluene, ethylbenzene, and xylenes (BTEX) are shown in [Figure 7](#). Emissions of these hydrocarbons are widely distributed around the refinery property. Emissions maps of the individual BTEX compounds are similar to each other because they are typically emitted in the same process streams. The gridded emissions of 1,3-butadiene are shown in [Figure 8](#).

Acrolein and acetaldehyde gridded emissions show high spatial correlation to each other and are shown in [Figure 9](#). Both are simple aldehydes that are expected to be emitted from similar processes.

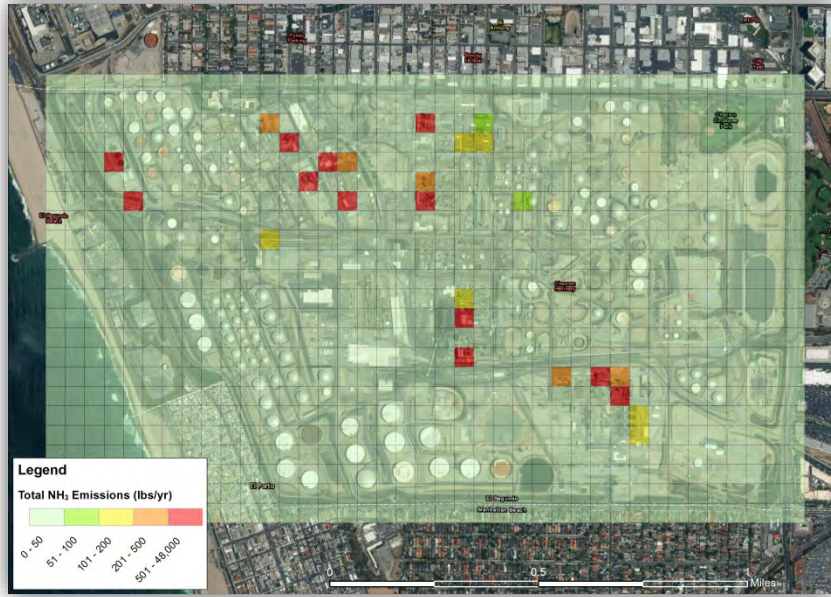


Figure 5. Gridded emissions of ammonia.

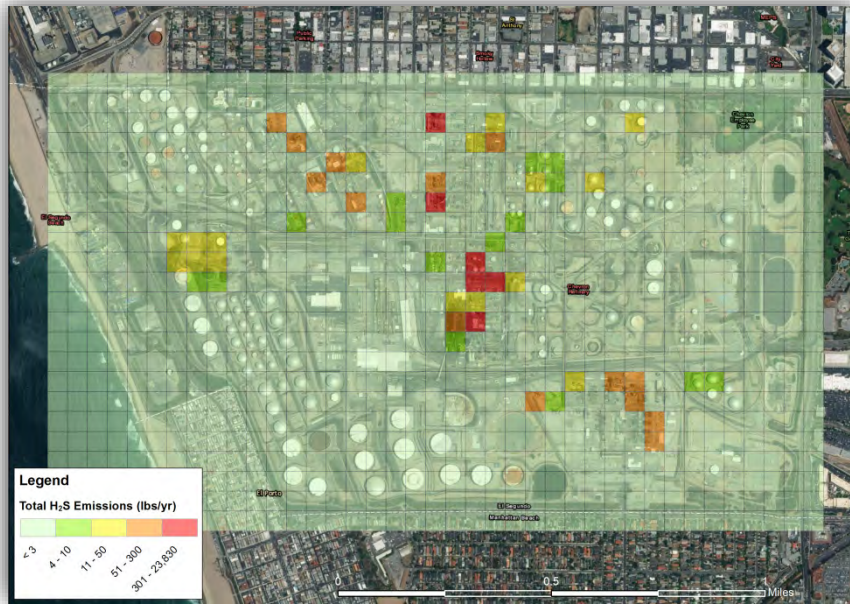


Figure 6. Gridded emissions of hydrogen sulfide.

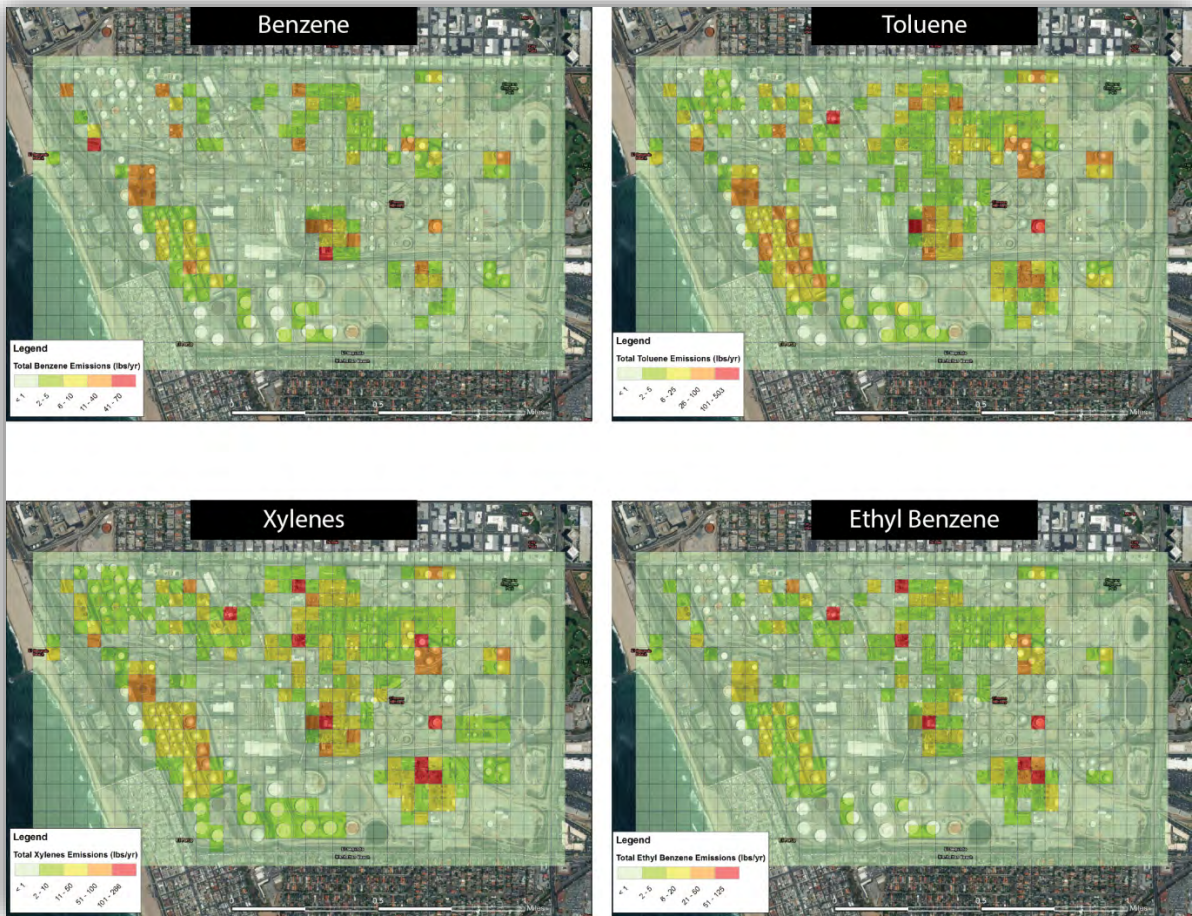


Figure 7. Gridded emissions of BTEX compounds.

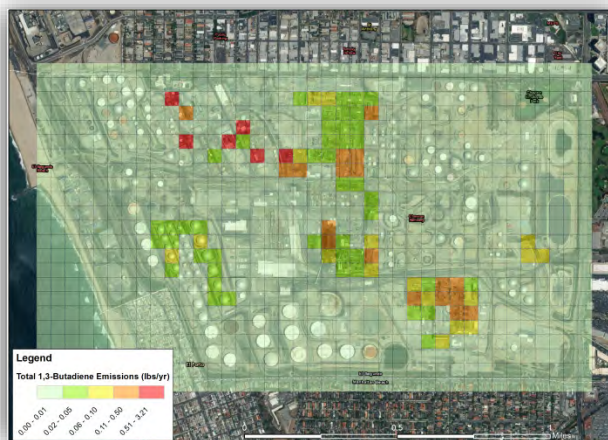


Figure 8. Gridded emissions of 1,3-butadiene.



Figure 9. Gridded emissions of acrolein and acetaldehyde.

1.2.3 Dispersion Modeling

Based on the emission source areas, receptors, and wind patterns, the most important areas for fenceline monitoring include the majority of the northern fenceline, the northern portion of the eastern fenceline, and the southwest fencelines. Additional evidence is provided by dispersion modeling.

Emissions data, topographic features, and meteorological measurements were used to model the spatial distribution of species that impact the community. To facilitate the combination of emissions and wind patterns, a modeling study was done as part of the 2015 VRRP (ERM, 2017). The current facility could not be fully evaluated with the emissions inventory module (EIM), as the EIM only provides emission source strengths and locations at the facility. Therefore, modeled facility concentrations using Air Dispersion Modeling and Risk Tool (ADMRT) results from the Hotspots Analysis and Reporting Program (HARP) model were plotted. Annual average unit concentrations were calculated using the SCAQMD 5-year hourly AERMOD-ready meteorological data set for LAX Hastings. Concentrations were calculated at each of 3,298 receptors that represented fenceline, commercial, and residential/sensitive receptors out to a distance of 2,800 m from the north and south boundaries, 1,700 m from the eastern boundary, and to the ocean on the west. The EPA's regulatory default parameters were used in the modeling, along with a single urban area, defined as Los Angeles with a population of 9,862,049.

The model results showing the five-year average concentration for each species are shown in [Figures 10 through 13](#). Key points are as follows:

- Modeled benzene concentrations ([Figure 10](#)) show significant concentrations along the northern fenceline and the southwest corner of the refinery.

- Modeled 1,3-butadiene concentrations (Figure 11) show a similar trend compared to benzene.
- H₂S and ammonia concentration maps are shown in Figures 12 and 13. The dispersion modeling results for these species reinforce the importance of covering the north/northwest and southwest fencelines.
- There are virtually no pollution impacts for the southeast corner of the refinery, because the winds rarely blow in this direction and there are no emission sources in the southeast corner of the refinery.

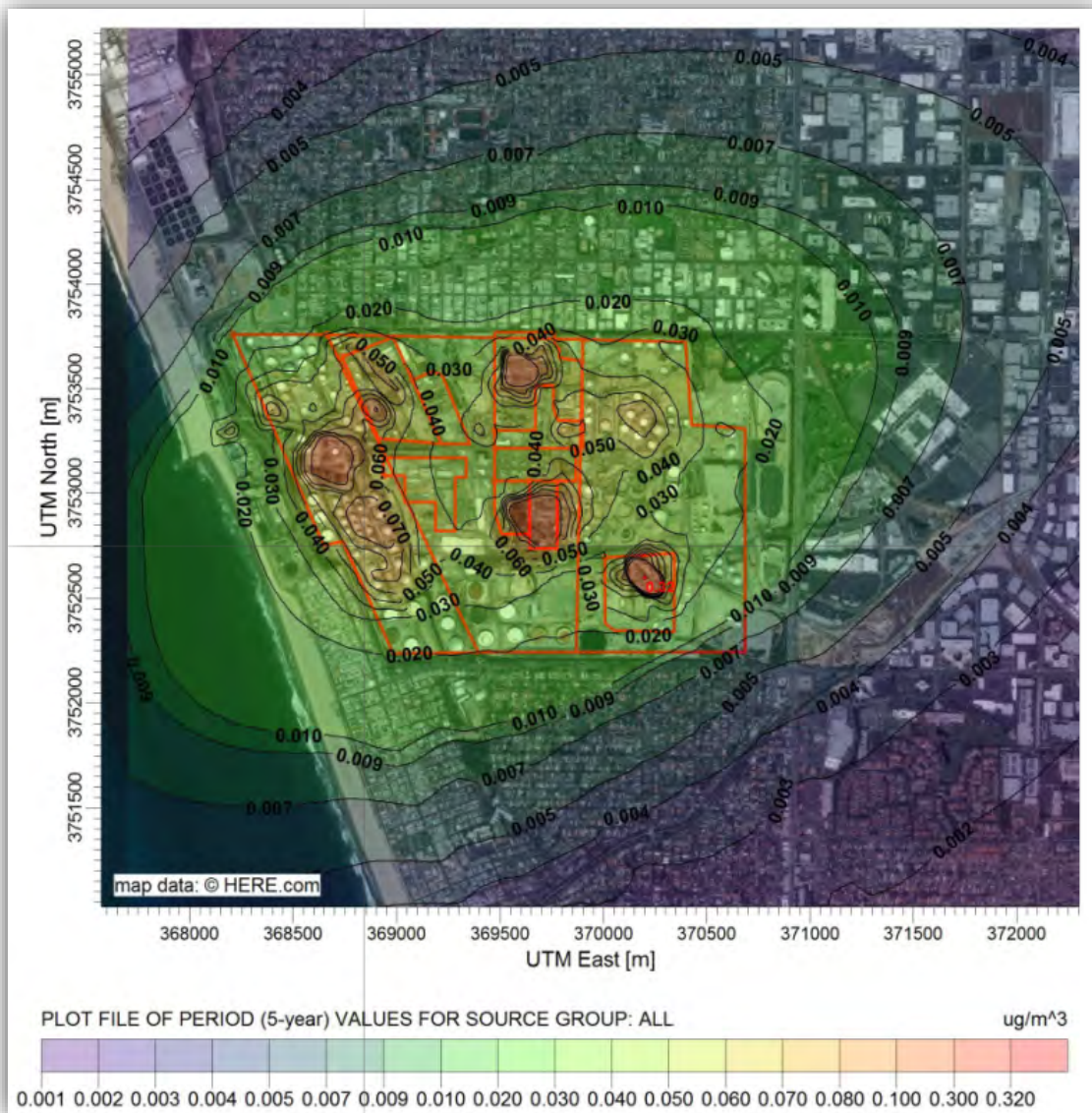


Figure 10. Benzene 5-year average concentrations during 2007-2011, using LAX Hastings surface meteorological data. Axes show the Universal Transverse Mercator (UTM) coordinates.

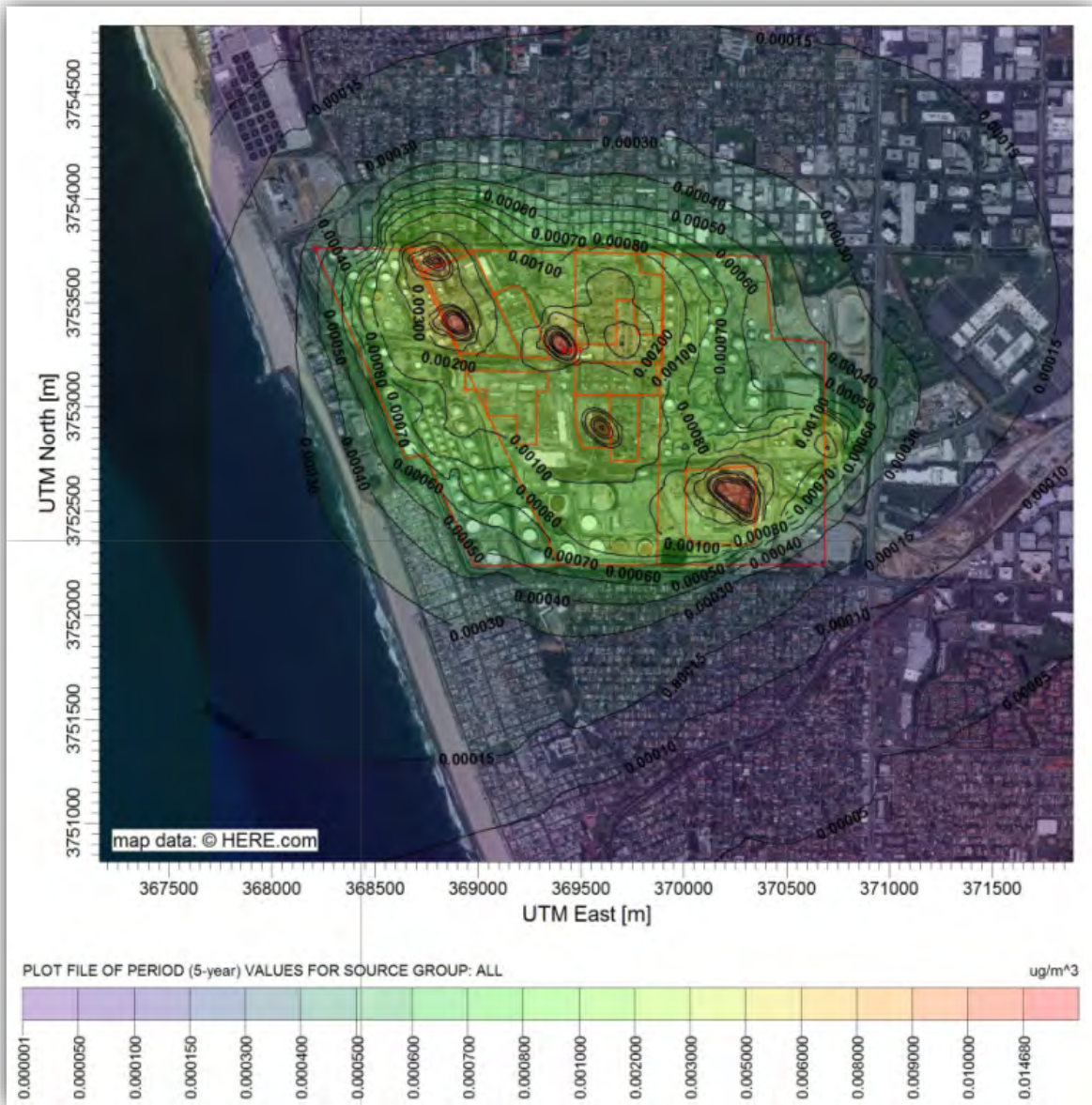


Figure 11. 1,3-butadiene 5-year average concentrations during 2007-2011, using LAX Hastings surface meteorological data.

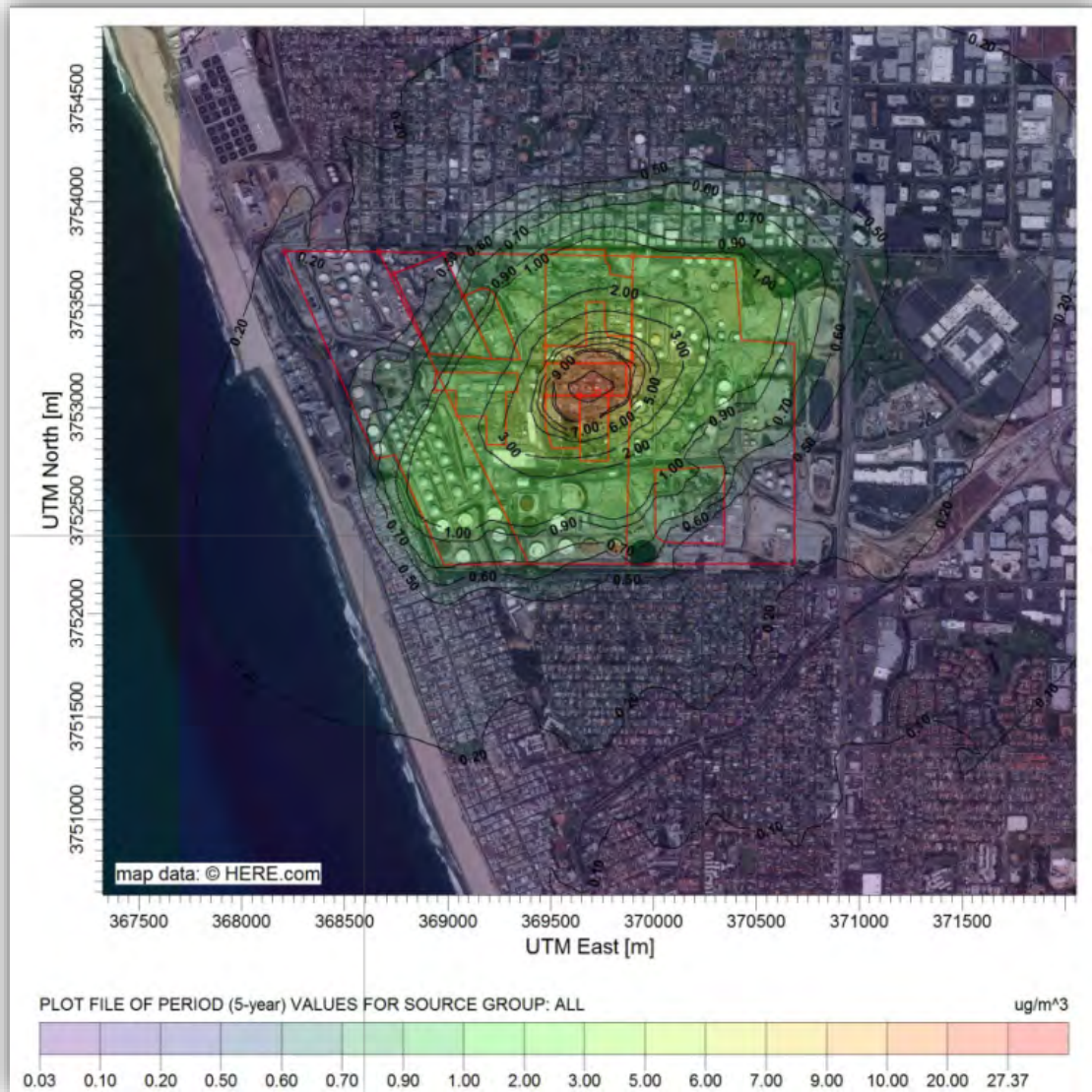


Figure 12. Hydrogen sulfide 5-year average concentrations for 2007-2011, using LAX Hastings surface meteorological data.

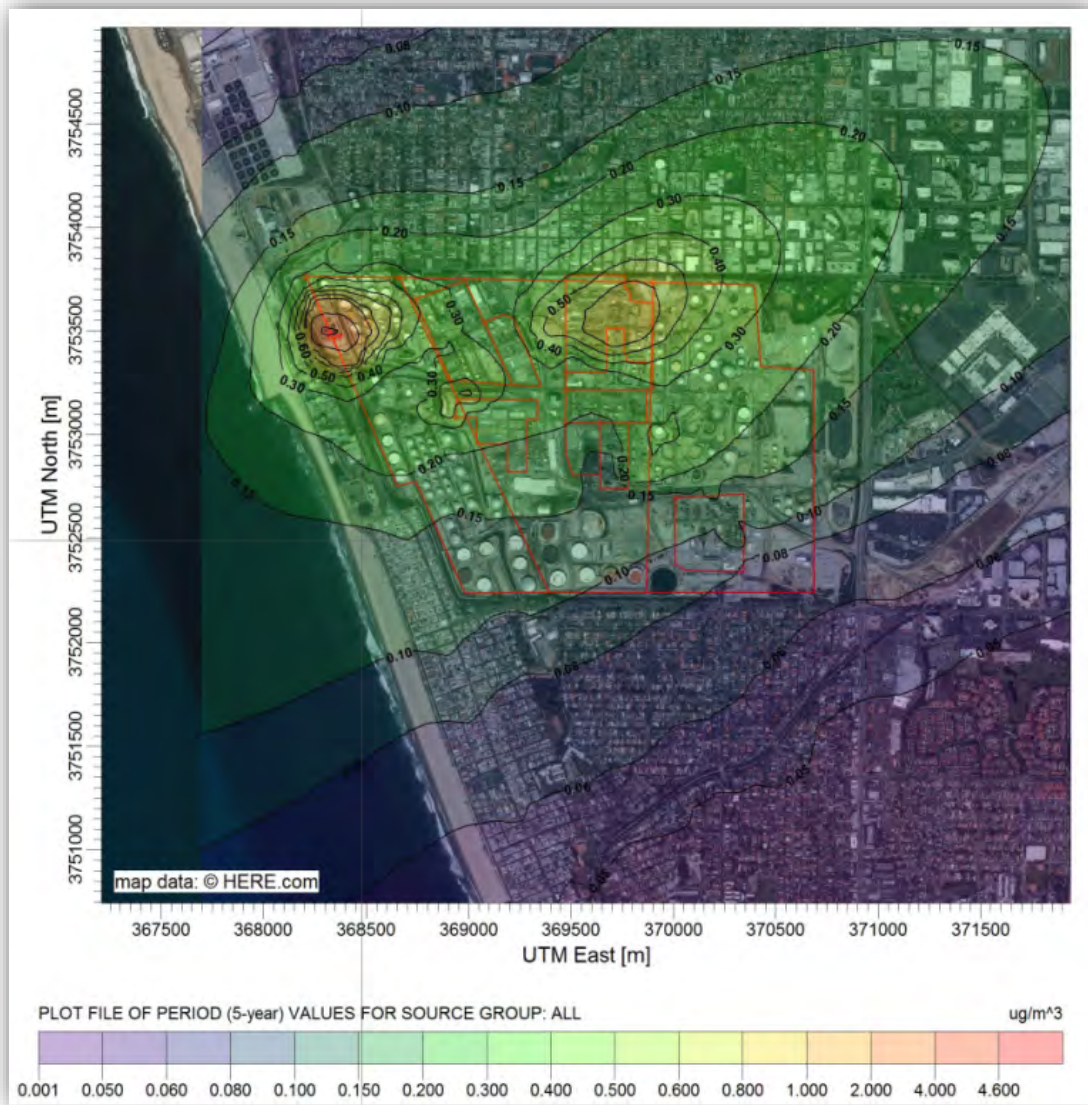


Figure 13. Ammonia 5-year average concentrations for 2007-2011, using LAX Hastings surface meteorological data.

2. Monitoring Locations and Equipment

This section describes the sampling locations, paths, and monitor types selected for the fence-line monitoring, as well as the specifications and maintenance requirements for each monitor. The compounds that will be monitored along each path/location are also provided. Since the Rule 1180 guidance stresses the use of open-path measurements wherever possible, point measurements are only for diesel particulate matter (DPM), meteorology measurements, and H₂S. Open-path technology for H₂S has not been proven to have a MDL at or below the California Office of Environmental Health Hazard Assessment's (OEHHA) acute exposure threshold of 30 ppb; therefore, this technology will not be used. H₂S concentrations will be monitored at select paths by Galvanic Protech 903W lead-acetate tape based systems. Moreover, DPM (using Black Carbon [BC] as a surrogate) cannot be measured using open-path technology. BC will be measured with a Magee Scientific Aethalometer. The selection of monitoring locations and instrument types was based on the emissions characteristics and dispersion modeling results presented in Section 1.

2.1 Selected Sampling Locations

Chevron will monitor concentrations across 12 paths (shown in [Figure 14](#)). The locations of these paths are also documented in [Table 4](#). The type of measurement at each path is indicated by the legend in Figure 14. Each meteorological station will include a visibility sensor in addition to measuring wind, temperature, and relative humidity. Chevron selected these locations after considering dominant wind patterns, sources of potential air emissions on the refinery property, and nearby local receptors. Transmitter-detectors/analyzers will be located at sites labeled "A" (identified in Figure 14), and retroreflectors will be placed at the sites labeled "R". The exact paths may need to be adjusted based on final site logistics and exact instrument capabilities, particularly in regard to the maximum path lengths for which the instruments can reliably measure the compounds of interest. Analyzers and reflectors will be mounted from about 2 m to 15 m above ground level depending on logistical constraints. Note that the height of the measurement along the light beam path will vary depending on topography.

The following is Chevron's rationale for selecting the open-path monitoring locations identified in Figure 14.

- Overall, these paths cover the areas of concern based on the analysis and modeling presented in Section 1 and also include areas where impact potential is very low.

- Path 1 is positioned between one of the refinery's tank farms and the community of El Segundo. H₂S and DPM are not a concern for this path, because this area is not downwind of any major sources of these species.
- Path 1.5A was added to provide coverage between the laboratory and crude unit areas of the refinery and the community of El Segundo. Additional H₂S and DPM point monitoring will be provided at this path.
- Paths 2-7 provide coverage for the most frequent onshore southwesterly winds. Paths 2-7 are between the refinery's process block and tank farms, and commercial and residential neighborhoods and other sensitive receptors. Open-path FTIR and UV-DOAS will provide measurements of all species required in Rule 1180. Additionally, site 6R will have a meteorological station (that includes a visibility monitor). Paths 5R and 6A will have an Aethalometer to measure for BC, and a Galvanic ProTech 903W for measuring H₂S. Sites 5R and 6A were chosen as the site for BC and H₂S monitoring based on emissions modeling discussed in Section 1.2.3, and because this site is downwind from the refinery for the majority of the time. Also, being free of major obstructions, 6R provides the best siting opportunity for measuring winds. Therefore, meteorological measurements of winds, temperature, visibility, and relative humidity will be sited at 6R.
- Path 8 is located between the refinery and areas to the southeast. While the analysis shows that this path is very unlikely to be impacted by refinery emissions, it has been included to ensure a very robust monitoring network.
- Paths 9, 10, and 11 are positioned between the refinery's main processing block and storage tanks, and the occupied areas of Manhattan Beach toward the southwest. As discussed in Section 1.1.2, frequent winds blowing from the refinery areas towards Paths 10 and 11 are associated with the land breeze phenomenon and tend to be stronger during the nighttime, during early morning hours, and during the winter. Open-path UV-DOAS and FTIR instruments will provide measurements of all species required in Rule 1180 along these paths. Additionally, sites 9A, 10A, and 11A will have Aethalometers for measuring BC and point instruments for measuring H₂S.
- A meteorological station will also be positioned between 1R and 11A to provide meteorological information closer to the coast.
- No monitors are needed on the western fenceline between Path 1 and Path 11 because there are no downwind sensitive receptors in this area. In addition, any aloft emissions generated by upwind offsite sources to the west would pass over any monitors located at the ground level.

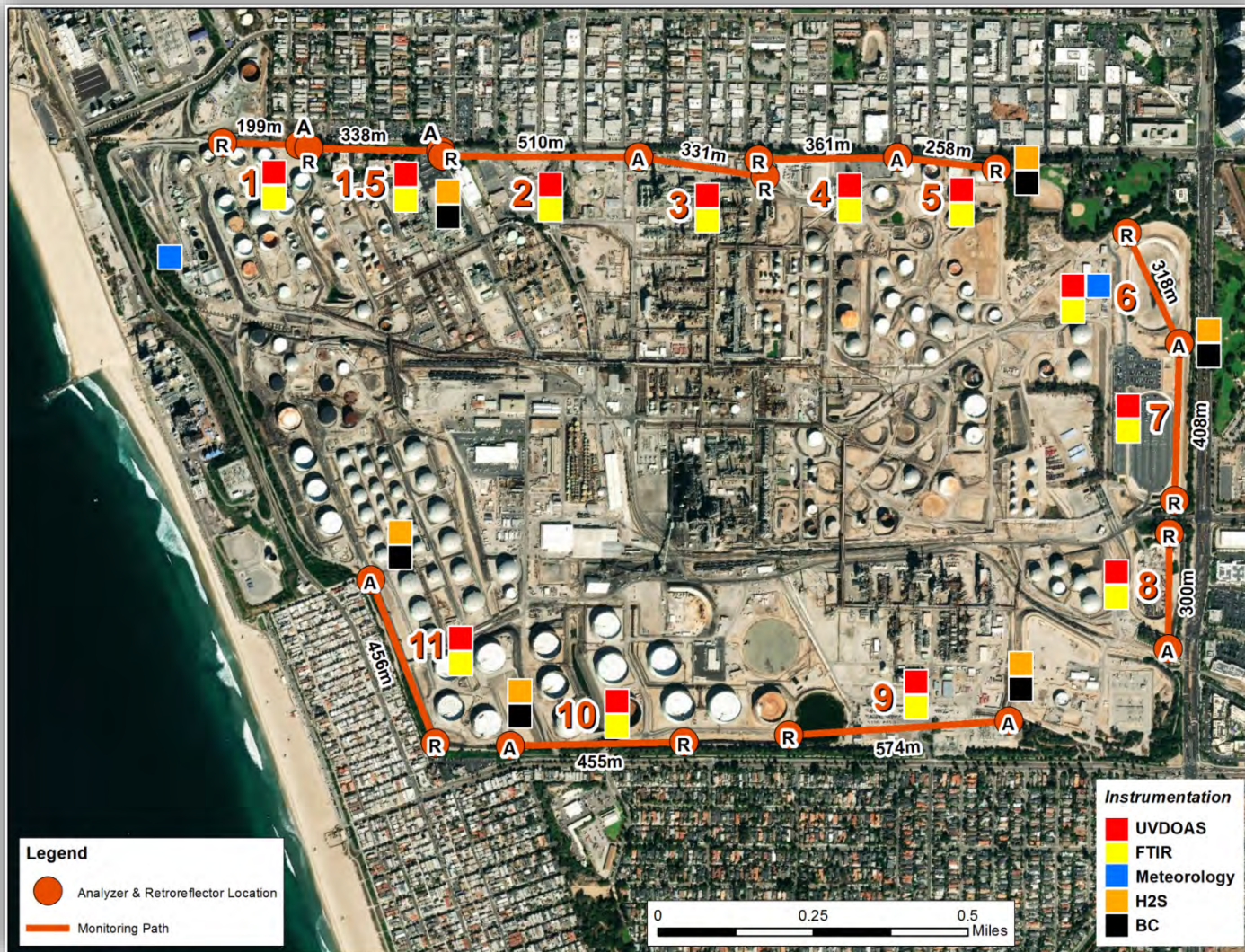


Figure 14. Location of sensors and measurement paths. Each path consists of a transmitter-detector (A) and a retroreflector (R). The wind rose shows annual average winds for 2007-2011.

Table 4. Locations of equipment to be used in fenceline monitoring program at the El Segundo refinery. All instruments and reflectors will be located between 2 m and 15 m above ground level depending on site logistics. Note that the height above ground level of the light beam will vary based on topography.

Path #	Analyzer Location	Retroreflector Location	Path Length (m)	Instrument(s)
1	33.916283, -118.421439	33.916303, -118.423593	199	FTIR, UV-DOAS, Meteorology,
1.5	33.916188, -118.417458	33.916212, -118.421169	338	FTIR, UV-DOAS, H ₂ S, BC
2	33.916115, -118.411899	33.916066, -118.417415	510	FTIR, UV-DOAS
3	33.916115, -118.411899	33.915688, -118.408355	331	FTIR, UV-DOAS
4	33.916183, -118.404639	33.916088, -118.408540	361	FTIR, UV-DOAS
5	33.916183, -118.404639	33.915951, -118.401860	258	FTIR, UV-DOAS, H ₂ S, BC
6	33.911914, -118.396659	33.914490, -118.398170	318	FTIR, UV-DOAS, Meteorology, H ₂ S, BC
7	33.911914, -118.396659	33.908235, -118.396726	408	FTIR, UV-DOAS
8	33.904759, -118.396856	33.907462, -118.396868	300	FTIR, UV-DOAS
9	33.903016, -118.401299	33.902623, -118.407473	574	FTIR, UV-DOAS, H ₂ S, BC
10	33.902283, -118.415289	33.902422, -118.410412	455	FTIR, UV-DOAS, H ₂ S, BC
11	33.906151, -118.419062	33.902366, -118.417347	456	FTIR, UV-DOAS, H ₂ S, BC

2.2 Instrument Specifications and Pollutants to Be Measured

Chevron’s El Segundo Refinery is a petroleum refinery producing fuel products—primarily gasoline, diesel, liquefied petroleum gas (LPG), residual fuel oils, and petroleum coke—through distillation of crude oil, coking, cracking, hydroprocessing, alkylation, and reforming processes. In consideration of the refinery’s products, processes, and potential emissions sources, the rationales summarized in [Table 5](#) were applied to determine which species are included in this Monitoring Plan. Literature reviews, site surveys, and interviews with instrument manufacturers were performed to determine the instruments needed to meet Rule 1180 requirements. Both fixed-site (point monitors) and open-path instruments were investigated. Based on the distances that need to be covered by measurements (hundreds of meters), data time-resolution requirements (5 minutes), and current measurement technology, two open-path instruments were selected to best measure the target species.

Table 5. Summary of monitoring for species listed in Rule 1180.

Species	Required by the SCAQMD	To Be Measured (Paths)	Instrument(s)	Rationale for Exclusion (If Not Required)
Benzene	Yes	Yes (1-11)	OP UV-DOAS with Xenon and FTIR	Required
Toluene	Yes	Yes (1-11)	OP UV-DOAS with Xenon and FTIR	Required
Ethylbenzene	Yes	Yes (1-11)	OP UV-DOAS with Xenon and FTIR	Required
Xylenes	Yes	Yes (1-11)	OP UV-DOAS with Xenon and FTIR	Required
H ₂ S	Yes	Yes (1.5A, 5R, 6A, 9A, 10A, and 11A)	Point, Galvanic Protech903	Required
NO _x	Yes	Yes (1-11)	OP FTIR	Measures NO ₂ only; however, most NO _x in the refinery is emitted from elevated sources and thus would not be measured by fenceline monitors regardless.
SO ₂	Yes	Yes (1-11)	OP UV-DOAS with Xenon	Required
NH ₃	Yes	Yes (1-11)	OP FTIR	Required
Acrolein	Yes	Yes (1-11)	OP FTIR	Required
Acetaldehyde	Yes	Yes (1-11)	OP FTIR	Required
1,3-butadiene	Yes	Yes (1-11)	OP FTIR	Required
Carbonyl Sulfide	Yes	Yes (1-11)	OP FTIR	Required

Species	Required by the SCAQMD	To Be Measured (Paths)	Instrument(s)	Rationale for Exclusion (If Not Required)
Formaldehyde	Yes	Yes (1-11)	OP FTIR	Required
Hydrogen Cyanide	Yes	Yes (1-11)	OP FTIR	Required
Hydrogen Fluoride	Yes, if used	No	NA	The refinery does not use hydrogen fluoride in any major processes.
Styrene	Yes	Yes (1-11)	OP FTIR	Required
Total VOCs (non-methane hydrocarbons)	Yes	Yes (1-11)	OP FTIR	Will report "total alkanes."
Black Carbon	Yes	Yes (1.5A, 5R, 6A, 9A, 10A, and 11A)	Point Aethalometer	Required. Black carbon (BC) is a surrogate for diesel particulate matter.

2.2.1 Pollutant Detection Limits

Table 6 summarizes the approximate minimum detectable levels (MDLs) and upper detection limits (UDLs) by open-path instrument for Chevron's monitoring program. 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. Again, actual detection limits will depend on atmospheric conditions and on the specific instrument brand used. The detection limits are for the average species concentration along a path; narrow plumes that only cover a portion of the path would need to have a higher concentration than the MDL to be detected.

Open-path instruments transmit light or infrared energy across a long open path. Absorption of light relates to the average concentration of gases of interest along the path according to the Beer-Lambert absorption law. Individual gases absorb most effectively at characteristic wavelengths; therefore, measurements of absorption at specific wavelengths can be used to infer path-average concentrations for species of interest. The transmitted light is typically either detected remotely by a targeted detector or reflected for detection elsewhere. Often a combined transmitter-detector unit is positioned at one end of a path, and a retroreflector—a type of mirror with a geometric shape that gathers and re-focuses the transmitted light—is positioned at the other end of the path. The retroreflector returns the transmitted light to the transmitter-detector unit for detection. **Figure 15** illustrates the basic concepts of open-path measurements.

Note that open-path instruments are not able to distinguish between a widely dispersed, low-concentration plume and a narrow, high-concentration plume. Rather, the instruments detect average concentrations across the entire distance from the transmitter to the detector (or the distance from the transmitter-detector to a retroreflector, and back again). Periods of poor visibility due to weather-related conditions (e.g., fog) are known to interfere with open-path measurements. Rule 1180 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. The visibility sensors will be located in the southwest and northeast corners of the refinery as part of the meteorological stations (Figure 15, Site 6R and near Site 1R).

Point monitor detection limits for H₂S will be less than 5 ppb. Point monitor detection limits for black carbon will be less 0.5 µg/m³.

Table 6. Range of approximate open-path instrument minimum detection limits (MDL) and upper detection limits (UDL) in parts per billion (ppb) by technology, species, and path length. UDLs for some species are not available (NA). Actual detection limits depend on atmospheric conditions.

	1180 Compound	Shortest Path (199 m)		Longest Path (574 m)	
		MDL	UDL	MDL	UDL
FTIR	1,3-Butadiene	5	24,000	2	8,300
	Acetaldehyde	3	500,000	1	170,000
	Acrolein	4	230,000	2	78,000
	Ammonia	1	140,000	0	48,000
	Benzene	53	75,000	18	26,000
	Carbonyl Sulfide	2	NA	1	NA
	Ethylbenzene	17	94,000	6	32,000
	Formaldehyde	2	63,000	1	22,000
	Hydrocarbons	10	15,000	3	5,000
	Hydrogen Cyanide	34	50,000	12	17,000
	Nitrogen Dioxide	15	NA	5	NA
	Styrene	6	29,000	2	10,000
	Total Xylenes	14	190,000	5	65,000
UV-DOAS	Acrolein	21	480,000	7	170,000
	Benzene	1	80,000	0.2	27,000
	Ethylbenzene	1	55,000	0.3	19,000
	Styrene	3	NA	2	NA
	Sulfur Dioxide	2	100,000	0.6	36,000
	Toluene	2	110,000	0.7	39,000
	Total Xylenes	2	19,000	0.8	6,500

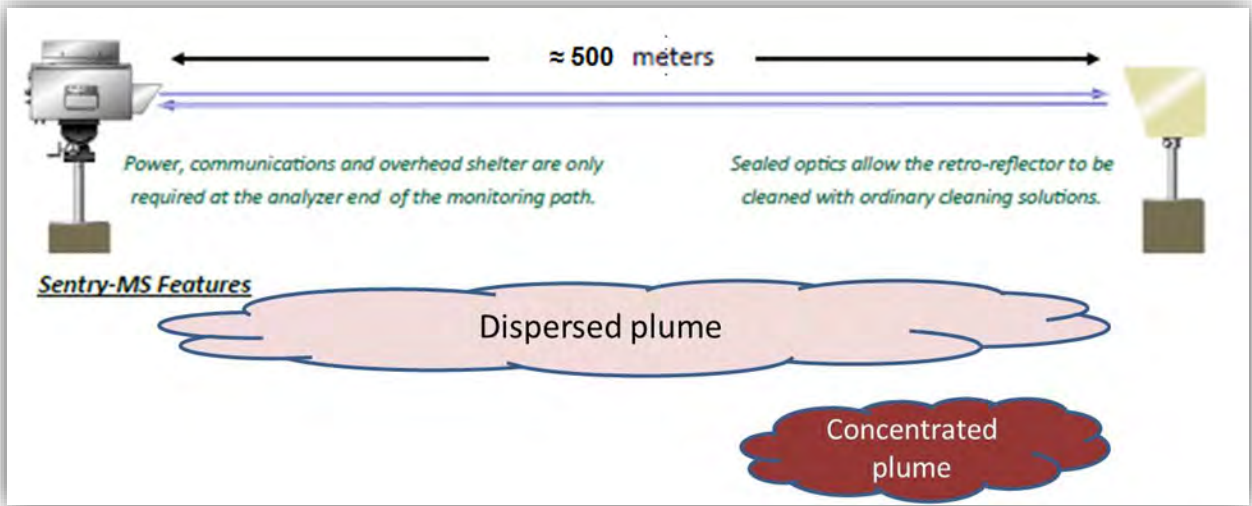


Figure 15. Basic premise for open-path instrument operation. Image from Cerex Sentry-MS monitoring brochure, used with permission (Cerex Monitoring Solutions, LLC).

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 should be cleaned regularly. An example of a UV-DOAS analyzer and receiver in a shelter is shown in [Figure 16](#), and a retroreflector is shown in [Figure 17](#).



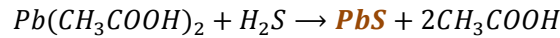
Figure 16. An example of a UV-DOAS analyzer (may not be configuration of actual installation).



Figure 17. An example of a UV-DOAS retroreflector (may not be configuration of actual installation).

2.2.2 Hydrogen Sulfide

H₂S will be measured with a point monitor that operates on the principle of light extinction resulting from a reaction between H₂S and lead acetate. The Galvanic ProTech 903W H₂S analyzer is designed to measure the concentration of H₂S. The instrument works by exposing a lead acetate [Pb(CH₃COOH)₂]-laden tape to the gas to be measured. If the sample gas contains H₂S, the following reaction occurs:



The lead sulfide (**PbS**) formed leaves a brown stain on the tape that can be measured optically. The rate of color change on the tape is directly proportional to the concentration of H₂S in the sample gas. Thus, if calibrated with known gas concentrations, the ProTech analyzer can determine the H₂S concentration in the sample gas stream.

2.2.3 Black Carbon

To measure black carbon, an Aethalometer will be used. An Aethalometer works by pulling the air through a filter tape where particulate matter is deposited. The transmission of the filter is monitored as several wavelengths. The black carbon concentration is calculated from the attenuation of light passing through the filter.

2.2.4 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 B](#)).

UV-DOAS

The UV-DOAS system is designed to require 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. On an as-needed basis, system status alarms will alert operators to specific issues needing to be addressed.

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.	✓		
Inspect system filters.	✓		
Confirm the alignment to verify there has not been significant physical movement. Note: this is automatically monitored as well.	✓		
Download data from detector hard drive and delete old files to free space, if needed.	✓		
Ensure there are no obstructions between the detector and the retroreflector (such as equipment, vegetation, vehicles).	✓		
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.			✓

FTIR

The FTIR has maintenance activities similar to those for the UV-DOAS. The FTIR system is also designed to require only modest service and maintenance. [Table 8](#) summarizes FTIR maintenance activities, as recommended by a typical manufacturer. Preventative maintenance frequency depends on the operating environment and may need to be adjusted. On an as-needed basis, system status alarms may alert operators to specific issues that need to be addressed. Bump tests are performed on site.

Table 8. Schedule of maintenance activities for the FTIR.

Activity	Monthly	Quarterly	Semi-Annually	Annually	18 Months	Five Years
Visually inspect the system.	✓					
Inspect and clean AC system exterior heat sink.			✓			
Inspect and clean AC system interior heat sink.				✓		
Confirm the alignment to verify there has not been significant physical movement. <i>Note: this is automatically monitored as well.</i>	✓					
Download data from detector hard drive and delete old files to free space, if needed.	✓					
Ensure there are no obstructions between the detector and the retro-reflector (such as equipment, vegetation, vehicles).	✓					
Change out the IR source.						✓
Realign system after service.		✓				
Check system performance indicators.		✓				
Perform bump test.		✓				
Review and test light and signal levels. Check average light intensity to establish baseline for IR Source change frequency and retroreflector wear.				✓		

Activity	Monthly	Quarterly	Semi-Annually	Annually	18 Months	Five Years
Verify system settings.		✓				
Replace cryocooler or swap detector module assembly.					✓	

Hydrogen Sulfide

Table 9 summarizes the maintenance activities and frequencies for routine system management of the Galvanic ProTech 903W H₂S analyzer. The frequency of preventive maintenance depends on the operating environment and may be adjusted beyond the manufacturers’ recommendations once the instruments are deployed in the field. System status alarms will alert operators on an as-needed basis to specific issues needing to be addressed.

Table 9. Schedule of maintenance activities for Galvanic Applied Sciences ProTech 903W instrument.

Activity	Daily	Monthly	Semiannual
Check for alarms	✓		
Inspect sample line tubing		✓	
Visually inspect the tape		✓	
Install new filter tape roll		✓	
Add 5% acetic acid to the humidifier		✓	
Inspect the sample chamber		✓	
Calibrate system with permeation tube device			✓
Inspect and clean the sampling system			✓
Clean air test			✓
Stability test			✓

Aethalometer

The Aethalometer system is designed to require only modest service and maintenance. **Table 10** summarizes typical Aethalometer 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.

On an as-needed basis, system status alarms will alert operators to specific issues needing to be addressed.

Table 10. Schedule of maintenance activities for Aethalometers.

Activity	Monthly	Semiannual	Annual
Visually inspect the system.	✓		
Inlet flow check	✓		
Clean size selective inlet	✓		
Clean cyclone	✓		
Verify date and time	✓		
Inspect optical chamber and clean as necessary		✓	
Calibrate flow		✓	
Change bypass cartridge filter			✓
Check tape roll, install new tape roll if necessary	✓		
Calibrate tape sensor		✓	

Meteorology and Visibility

The meteorological and visibility instrumentation will be maintained on a quarterly basis. [Table 11](#) lists the maintenance activities that will be performed.

Table 11. Routine maintenance actions for meteorological and visibility instrumentation.

Item	Action
Tower	Confirm 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 it is 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.

Item	Action
Visibility Sensors	Inspect the sensor for dirt, spider webs, birds' nests, or other obstructions. Clean the glass windows.
	Check that the cable connections are secure.
	Inspect the hardware holding the sensors to the tower, and tighten the bolts if necessary.
Data Logger Enclosure Cables	Verify that the enclosure is secured and the system inside is operational.
	Check that the cabling to the enclosure is secure and undamaged.
	Check the integrity of the cables connecting the data logger box to the sensors.
Data Logger Enclosure Guy Wires	Check that the sensor cables are attached to the tower.
	Where guy wires are used, check that they are taut and that the attachment points are tight. If the attachment points are loose, call STI for instructions.

Additional Maintenance and Failure Activities

The fenceline monitoring system described in this document is subject to both planned and unplanned outages resulting from events such as maintenance, power losses, equipment malfunctions, etc. In accordance with Rule 1180, Chevron has committed to the actions listed in [Table 12](#).

Table 12. Summary of outage response actions and timelines.

Event	Response Time	Action
Routine Maintenance	Within 48 hrs	Notify SCAQMD by calling 1-800-CUT-SMOG
Unplanned Outage	Within 2 hrs	Notify SCAQMD by calling 1-800-CUT-SMOG
Outage Lasting > 24 hrs	Within 24 hrs	Written notification to the SCAQMD
Widespread Outage Lasting > 48 hrs that Includes Paths 5, 6, 10, and 11	Within 48 hrs	Deploy summa polished canister samplers at upwind and downwind locations

Routine, scheduled maintenance for the open-path instruments occurs at least once per month. Chevron will notify the Executive Officer of the Air District 48 hours before any planned maintenance by calling 1-800-CUT-SMOG. During those maintenance visits, the operator will carry normal repair parts to the site. It is expected that routine maintenance periods, when the equipment might not be reporting data, will be about 2 hours.

If monitors fail to report data or appear to be reporting erroneous data between routine visits, remote diagnosis and, if necessary, a site visit will be conducted. Chevron will call 1-800-CUT-SMOG to notify the SCAQMD Executive Officer within two hours of discovering that the equipment failed to accurately provide real-time air monitoring information. Chevron will also provide the name of the petroleum refinery, the name of the air monitor, the date and time of the occurrence, and the reason for the lapse in collecting and/or reporting the real-time air monitoring information. If the problem cannot be resolved with the equipment or parts on hand, Chevron will obtain replacement parts from the vendor. Chevron's vendor will have spare parts, including major components, available for emergency repairs. It is expected that with these measures, instrumentation problems can be resolved by the next business day; if downtime exceeds 24 hours, Chevron will respond with the required written notification to the Air District.

Because UV-DOAS and FTIR will be installed along all paths, each FTIR instrument will serve as a backup to the UV-DOAS, and vice versa. In addition, if both instruments fail on a given path, monitors on the adjacent paths will provide backup data. In the event of a prolonged power outage or other issue affecting multiple monitors, passive sampling—conducted to comply with the EPA benzene rule—will provide backup data. In addition, in the event of widespread outages, integrated 12-hr canister samples of VOCs will be taken twice per day on the southwest and northeast sides of the refinery (predominant upwind/downwind directions).

Chevron will submit required written notification to the SCAQMD Executive Officer for any equipment failure that results in a failure to accurately provide continuous, real-time air monitoring information for 24 hours or longer. The written notification will be submitted to the Executive Officer within 24 hours of discovering the equipment failure, and will include the following:

- An explanation of activities currently being pursued or taken to remedy the equipment failure;
- Estimated time needed to restore the fenceline air monitoring equipment to normal operating conditions that comply with the approved fenceline and community air monitoring plan; and
- Temporary air monitoring measures to be implemented until the fenceline air monitoring system is restored to normal operating conditions (see above)

2.2.5 Excluded Pollutants

Hydrogen fluoride is not used in any major processes at the Chevron El Segundo refinery; therefore, it will not be measured. Any emissions of hydrogen fluoride are expected to be negligible.

3. Quality Assurance

This section outlines quality assurance (QA) procedures related to this monitoring program. A quality assurance project plan (QAPP) that covers these items as well as additional detail is available in Appendix B. The QAPP will be reviewed annually and updated as needed.

3.1 Data QA Procedures

Raw data management occurs on a 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) in real-time. Data are also stored onsite on instrument computers in case of data network failure.

The DMS can handle the large volumes of data that will be generated in this project. The DMS is used to automatically quality control data, detect outliers and problems, and create alerts. The auto-screening and graphical capabilities used for continuous examination of data quality. The DMS feeds auto-screened data to the field operations website and notification system to inform project and facility staff. As part of the auto-screening process, quality control flags are assigned as follows:

- **Valid** – data are within normal operating parameters.
- **Invalid** – data do not meet the quality control criteria.
- **Missing** – data have not been received by the DMS for a time period greater than 10 minutes since the last data was received.
- **Suspect** – operating parameters are marginal and should be reviewed further.

All data produced by the instrument are initially considered **Level 0**. All Level 0 data values that are not associated with bump tests or other instrument maintenance will undergo basic automatic quality control and will be displayed to the public in near-real time (i.e., about 10 minutes or less); these data are considered **Level 0.5**. Automated screening checks of data feeds are used to screen out invalid data, and are helpful to focus the analyst's efforts on the data that need the most attention. All data above notification threshold levels (see Section 5) are flagged as suspect for additional review and verification. Screening criteria (flags and rates of change) are preliminary and will be refined during the project based on actual observations and instrument performance. Data flagged through auto-screening checks are reviewed as described below. QC flags are updated as needed with daily, monthly, and quarterly actions, and will be updated on the public website as needed. The DMS keep track of data QC changes.

A non-public field operations website is used for daily graphical review of the data. 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. 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. Once it is clear that instruments are operational, the next step is to review whether the species concentration patterns are reasonable with respect to the time of day, season, current meteorological conditions, facility operations, and concentration levels expected and observed at other sites. If anomalies are observed, additional analysis will be conducted to determine whether there is an instrument malfunction, or if the data are truly anomalous, but explainable and valid. These subjectively reviewed data are considered **Level 1.0**. If data are subsequently proven to be invalid by subjective data review and/or post processing, they will be removed from the public display, and the rationale for data removal will be provided.

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

Table 13. Instrument QA/QC checks.

QA/QC Checks	Frequency	Acceptance Criteria
UV-DOAS		
Bump test (accuracy)	Quarterly and after major service	±20%*
Baseline stability	Continuous	±5%
Measurement quality (R ²)	Continuous	0.8 to 1.0
Integration time	Continuous	80-200 mS <i>400 mS integration time results in a warning notification</i>
Signal intensity	Continuous	>80% <i>Signal intensity below 30 results in a warning notification</i>
Aethalometer		
Flow rate		±10%
Span check		±10%
Zero check		<550 ng/m ³ for Channel 6
FTIR		
Bump test	Quarterly and after major service	±20%*
Baseline stability	Continuous	±5%
Measurement quality (R ²)	Continuous	0.7 to 1.0
Signal intensity	Continuous	>5% <i>Signal intensity below 5 results in a warning notification</i>
Galvanic ProTech 903W H₂S Analyzer		
Bump test	Quarterly	20%
Meteorology		
Two point temperature test	Quarterly	±0.5°C
Relative humidity	Quarterly	±7%
Wind speed starting threshold and transfer function	Quarterly	±0.25 m/s below 5 m/s and ±5% above 5 m/s
Wind direction angle verification	Quarterly	±5 degrees
Visibility – extinction coefficient check	Quarterly	±10%

*Based on flow-through calibration system.

In addition to auto-screening and daily visual checks, data are subjected to more in-depth review on a quarterly basis and when data fail screening. These data are considered **Level 2.0**. Final data sets will be compiled quarterly, 60 days after each quarter's end and will be provided to the SCAQMD. Chevron will maintain a data record for five years consistent with Rule 1180.

Any corrections or updates will be copied to the website. Quarterly 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 some 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.

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

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

- Review any instrument bump test results.
- 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 daily bump tests or instrument checks have the appropriate QC codes applied.

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

- If a record is not created for a particular site/date/time/parameter combination, a null record will be created for data completeness purposes.
- Invalid data will have a Null Code, or in other words, a reason for being invalid.
- 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 data completeness.

Actions will be documented to retain the raw data and support traceability of actions taken to produce the data on the website. Additional details on the final QC process are provided in the QAPP (Appendix B).

On an annual basis, Chevron or its designated contractor will review the performance of the network by reviewing the data completeness by monitoring path, instrument, and species; by reviewing results of bump tests; by analyzing the reported values in the context of refinery operations; and by analyzing the data in the context of the meteorology. The results will be summarized in a technical memorandum and provided to the SCAQMD upon request.

3.2 SOPs for Equipment

SOPs for the instruments are included with the QAPP in Appendix B.

4. Data Display to the Public

A key part of this monitoring program is disseminating the measured data to the public. This will be accomplished using a public-facing website that is linked to the DMS described in Section 3. This section describes how the information will be displayed to the public. For the public website, key components will include:

- Visual display of data in near-real time
- Context for the public to better understand the concentrations displayed
- A mechanism for public feedback on the website
- A mechanism for requesting data for further exploration
- A description of monitoring techniques
- A description of monitored pollutants
- A description of QA/QC procedures, including data management
- Documentation of QC flags
- Hyperlinks to related information
- Links to quarterly reports, information that relates measured concentrations to health thresholds, and other details related to QA/QC

4.1 Educational Material

Along with the actual monitoring data, educational material will be provided to provide context to the measurements. The objectives of the monitoring system, a description of the techniques, and some relevant information regarding the background concentrations of the monitored species will be provided.

Quarterly reports will be made available for public viewing at Chevron.

4.2 Objectives and Capabilities of Monitoring System

The home page of the public-facing website will be dedicated to providing background on reasons the monitoring is taking place and the type of technology being used in the monitoring system.

Figure 18 shows a mockup of a home page of a public-facing website. A brief paragraph written in plain English will explain the objectives of monitoring and give a short overview of the monitoring program. From the home page, a "Resources" page will include web links to Rule 1180 and the 1180 guidance. Links to other publicly available 1180 monitoring websites will be provided on the

“Resources” page. As part of the “Resources” page, a frequently asked questions (FAQ) topic will describe the nature of real-time data vs. non-real-time data so that the public appreciates the rapid nature of the reporting system. FAQs will not necessarily evolve based on public comment and Chevron may decide to modify FAQs at any time.

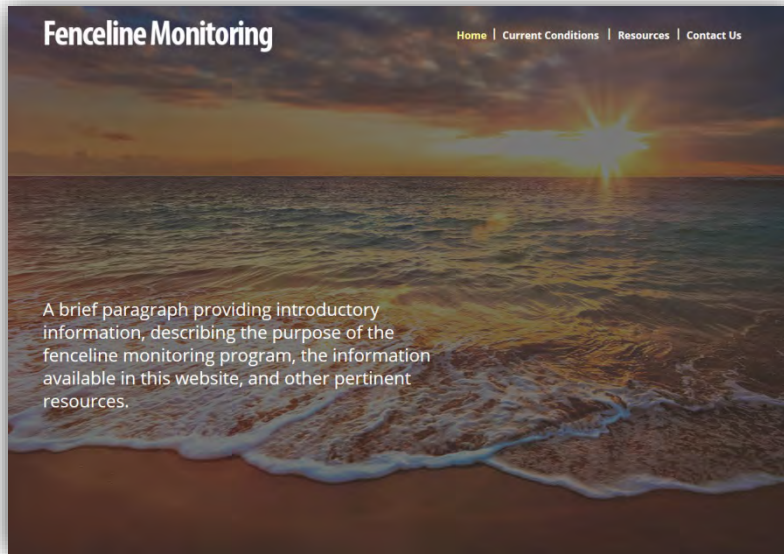


Figure 18. Screenshot showing an example of a home page of a public-facing fenceline monitoring site. The final website may have a different look and feel.

4.3 Description of Pollutants, Measurement Techniques, and Data Archive

Data for all pollutants measured will be displayed under a “current conditions” section of the website (**Figure 19**) that is readily available from the home page. In this view, a member of the public has the option of choosing either a graphical/spatial view of the data or a tabular view of the data. Under the “spatial view,” the user can select any one of a number of parameters (Benzene is shown in Figure 19) to display on the map. Once this action is complete, the concentrations for the selected species are displayed for each monitoring site with the meteorological information.

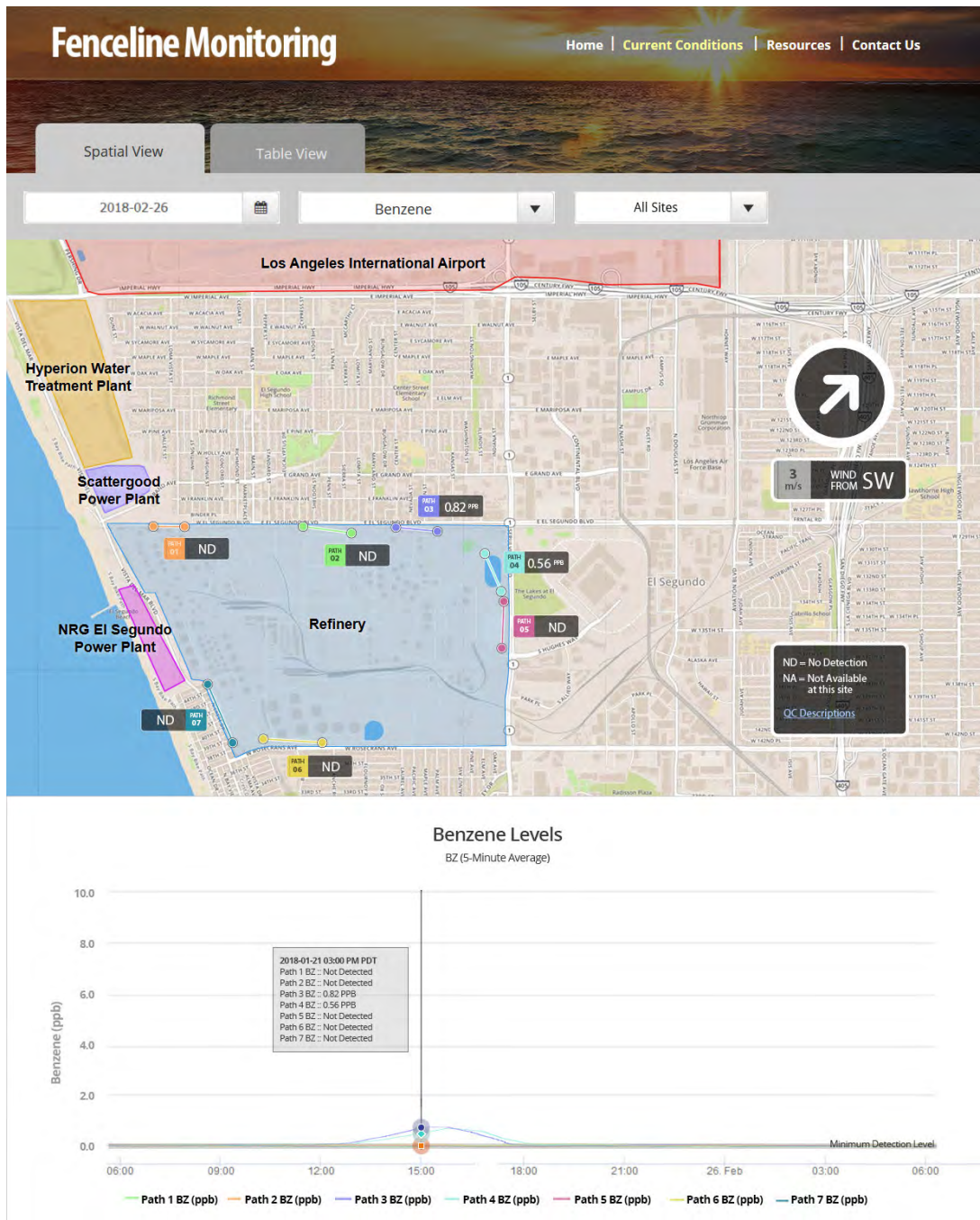


Figure 19. An example of the data display for any subset of the variables measured as part of this monitoring program. This example shows benzene concentrations by site, wind direction, and with a 1-day time series; a dialog box appears when the user hovers over a data point. The final website may have a different look and feel, but the type of content will be the same.

The "table view" provides a side-by-side display of all species measured at each site, along with on-site meteorological conditions (Figure 20).



Figure 20. An example of the data display for any subset of the variables measured as part of this monitoring program. This example shows the most recent measurements from multiple species by site, as well as meteorological conditions.

From both the spatial view and the tabular view, historical archived data will be available. As shown in Figure 19, when the user hovers over a data point, a dialog box will appear. This dialog box shows the value (concentration, etc.), time, and any pertinent QC flags.

4.4 Pollutant Background Levels and Context for Fenceline Measurements

Rule 1180 requires that concentration data be set in the context of pollutant concentrations measured elsewhere in the Los Angeles Basin. The public website will display the fenceline monitoring concentrations of the species listed in Rule 1180, along with links to other sources of data.

4.5 Data Upload Procedures and Quality Control for the Public Website

The pathway followed by the data from the sensor to the public website is shown in [Figure 21](#). Depending on the sensor used, data will be collected into a data processing server via a “pulling” or “pushing” method, depending on the source monitor. The data will then be archived and ingested into the DMS. Data will be screened in real time upon upload into the DMS, as described in previous sections. Automated procedures will be used to ensure that data are properly uploaded, stored, processed, and quality-assured, and that products are delivered to a public-facing website in near-real time (defined here as 10 minutes or less after data collection).

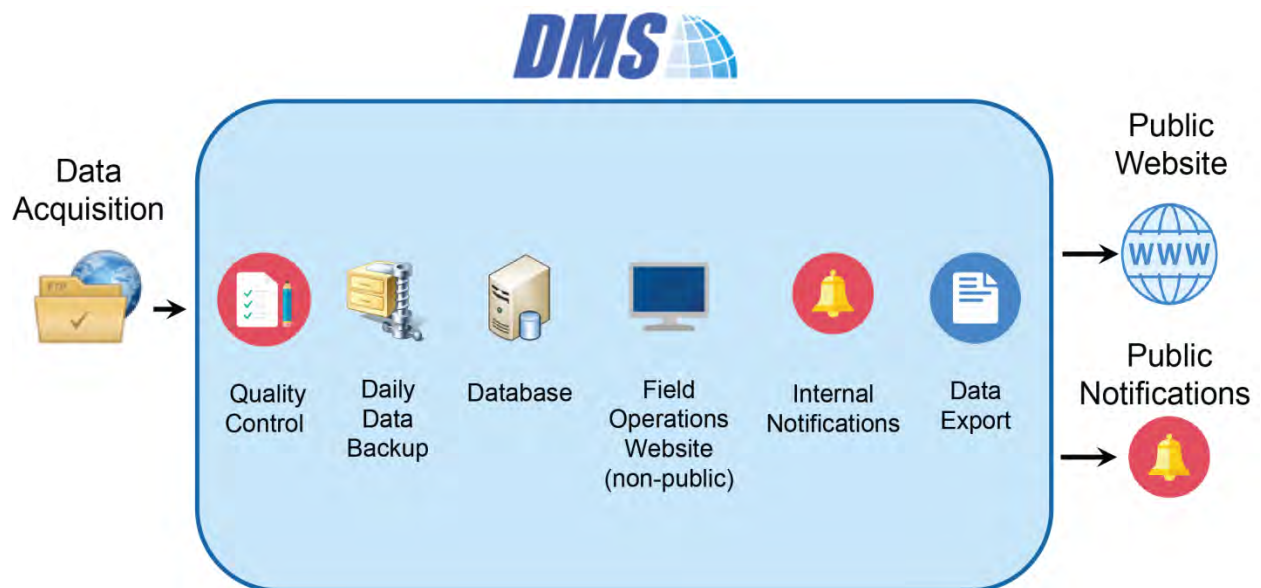


Figure 21. Schematic representation of the flow of data from acquisition at the sensor to display on the public website.

The preliminary quality-controlled data will be presented as time series of species concentrations, visibility, and wind speed and direction. Data will be provided as 5-minute averages. Data will be annotated for quality (valid, invalid, suspect, or missing). In the event that high concentration levels occur, Chevron will follow its existing procedures to determine whether any additional information needs to be provided to the public.

An example of a public-facing website that allows users to explore 5-minute data was shown in Figure 19. Displaying the data in a map format showing wind direction further helps to explain observed concentrations.

Web design will be finalized at a later date.

4.6 Further Information to Guide Public Understanding

The data to be collected have high time resolution, are spatially variable, and are chemically complex. To provide context to this complex data set for the public, the following information will be included through a combination of links, graphics, or captions:

- Information about the species measured and the measurement techniques.
- Context of what fenceline measurements represent as compared to other regional air quality measurements. This will include a discussion of: (1) species that are measured at the fenceline vs. regional monitors; (2) near-source vs. regional ambient air measurements; (3) the difference between open-path and point measurements; (4) 5-minute fenceline data versus longer time-averaged data that are collected by regional monitors; and (5) discussion of typical background concentrations.
- Discussion of levels of concern, via links to third-party sources such as the Office of Environmental Health Hazard Assessment website on the health effects of each species.
- Discussion of non-refinery sources that could affect the measured concentrations.
- Definitions of abbreviations.
- Discussion of data below MDL.
- Definition of data QC flags and their meaning.

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

4.7 Procedures for Public Comment, Feedback, and Response

Public feedback will be available through Chevron's corporate website and the community hotline. A log of comments will be made available upon request. The feedback will be delivered to a Chevron contact responsible for deciding whether and how to respond to the public comments. Chevron will determine whether some comments warrant a direct response and what that response procedure should be. Although not all comments have to be addressed, they will be made available to SCAQMD upon request.

4.8 Links to Quarterly Reports

As part of this monitoring program, quarterly reports will be generated in .pdf format. These reports will contain a statistical summary of the data from all sensors, chain of custody information, as well as graphical views of the historical data. Access to these reports will be available to the public in the form of web links.

5. Notification System

Chevron will develop a notification in accordance with Rule 1180 Guidelines. The public will be notified via the publicly accessible website when values exceed thresholds. Notifications will also be coordinated with the Certified Union Program Agency (CUPA).

As part of this fence-line monitoring project, a notification system will be used to issue notifications for:

- Activities that could affect the monitoring system
- The availability of periodic reports
- Exceedances in thresholds

Notifications will be triggered automatically when concentrations exceed threshold levels listed in [Table 14](#). An additional notification will be issued when concentrations return to below the threshold levels. The concentrations will be calculated to be a 1-hour rolling average that is updated every five minutes. These notifications will be accompanied by a message on the home page of the public website. Concentration thresholds correspond to the OEHHA acute relative exposure limits (RELS) (California Office of Environmental Health Hazard Assessment, 2017). Additional operational alarms will be in place for low visibility or drop in open path signal intensity.

Table 14. Thresholds for triggering automated notifications. Values for gaseous species in this table are acute 1-hour Reference Exposure Levels from OEHHA (OEHHA 2017, Table 3). Values in this table should be considered preliminary and may be refined either during the project implementation or after the instruments have been deployed.

Measurement	Level
1,3 –Butadiene	300 ppb
Acetaldehyde	260 ppb
Acrolein	1.1 ppb
Ammonia	4,600 ppb
Benzene	8.5 ppb
Black Carbon	N/A*
Carbonyl Sulfide	270 ppb
Ethylbenzene	TBD**
Formaldehyde	45 ppb
Hydrogen Cyanide	310 ppb
Hydrogen Sulfide	30 ppb
Nitrogen Dioxide	250 ppb
Sulfur Dioxide	250 ppb
Styrene	4,900 ppb
Toluene	9,800 ppb
Total Hydrocarbon	N/A*
Total Xylene	5,000

* Compounds listed as Not Applicable (N/A) do not have an OEHHA acute 1-hr REL and do not require notifications.

**Ethylbenzene does not have an OEHHA 1-hour REL. The notification threshold will be evaluated per SCAQMD guidance.

6. References

- California Office of Environmental Health Hazard Assessment (2017) Analysis of refinery chemical emissions and health effects. Draft report, September. Available at <https://oehha.ca.gov/media/downloads/faqs/refinerychemicalsreport092717.pdf>.
- ERM (2017) 2015 voluntary risk reduction plan for the Chevron El Segundo refinery. Prepared for Chevron USA, Inc., March.
- South Coast Air Quality Management District (2017a) Rule 1180: Refinery fenceline and community air monitoring. Final rule adopted December 1, 2017. Available at <http://www.aqmd.gov/docs/default-source/rule-book/reg-xi/r1180.pdf?sfvrsn=9>.
- South Coast Air Quality Management District (2017b) Rule 1180 refinery fenceline air monitoring plan guidelines. December. Available at <http://www.aqmd.gov/docs/default-source/rule-book/support-documents/1180/rule-1180-guidelines.pdf?sfvrsn=8>.
- U.S. Environmental Protection Agency (2000) Meteorological monitoring guidance for regulatory modeling applications. Office of Air Quality Planning and Standards, Research Triangle Park, NC, Document EPA-454/R-99-005, February. Available at <http://www.epa.gov/scram001/guidance/met/mmgrma.pdf>.

Appendix A. Fenceline Air Monitoring Plan Checklist

Fenceline Air Monitoring Plan Checklist	
Fenceline Air Monitoring Coverage (or Spatial Coverage) (Section 1)	
<input checked="" type="checkbox"/>	<p>Identify the facility's proximity to sensitive receptors affected by the refinery operation and provide the information below.</p> <ul style="list-style-type: none"> • Distance from facility to closest sensitive receptor(s) • Location of downwind and upwind communities • Eminent sources of non-refinery emissions surrounding the facility (e.g. non-refinery industrial facilities) • Dispersion modeling†
<input checked="" type="checkbox"/>	<p>Describe historical facility emission patterns and pollutant hotspots based on the following:</p> <ul style="list-style-type: none"> • On-site location of operations and processes within the facility's perimeter • On-site location of emissions sources and level of emissions • Facility plot plans and topography • Dispersion modeling†
Fenceline Air Monitoring Equipment Description (Section 2)	
<input checked="" type="checkbox"/>	<p>Select sampling locations along the perimeter of the facility based on the information above. Also, provide the following:</p> <ul style="list-style-type: none"> • Locations where equipment will be sited (e.g., GIS coordinates) and measurement pathways • Elevations of equipment and pathways • A description of how the monitoring system will cover all nearby downwind communities
<input checked="" type="checkbox"/>	<p>Select fenceline air monitoring equipment that is capable of continuously measuring air pollutants in real-time and provide the following:</p> <ul style="list-style-type: none"> • Specifications for the fenceline instruments (e.g., detection limits, time resolution, etc.) • Explanation of the operation and maintenance requirements for selected equipment • Substantiate any request to use alternative technologies

Monitor for the pollutants listed in Table 1 of Rule 1180 and include the following:

- Specify pollutant detection limits for all instruments and paths measured
- Substantiate any exclusion of chemical compounds listed in Table 1 of Rule 1180 or measurement of a surrogate compound

Quality Assurance (Section 3)

Develop a Quality Assurance Project Plan (QAPP) that describes the following:

- Quality assurance procedures for data generated by the fenceline air monitoring system (e.g. procedures for assessment, verification and validation data)
- Standard operating procedures (SOP) for all measurement equipment
- Routine equipment and data audits

Data Presentation to the Public (Section 4)

Design a data display website that includes the following:

- Educational material that describes the objectives and capabilities of the fenceline air monitoring system
- A description of all pollutants measured and measurement techniques
- A description of background levels for all pollutants measured and provide context to levels measured at the fenceline
- Procedures to upload the data and ensure quality control
- Definition of QC flags
- Hyperlinks to relevant sources of information
- A means for the public to provide comments and feedback; Procedures to respond
- Archived data that with data quality flags, explains changes due to QA/QC and provides chain of custody information
- Quarterly data summary reports, including relationship to health thresholds, data completeness, instrument issues, and quality control efforts

Notification System (Section 5)

Design a notification system for the public to voluntarily participate in that includes the following:

- Notifications for activities that could affect the fenceline air monitoring system (e.g., planned maintenance activities or equipment failures)
- Notifications for the availability of periodic reports that inform the community about air quality
- Triggers for exceedances in thresholds (e.g. Acute Reference Exposure Levels [RELs])
- Communication methods for notifications, such as, website, mobile applications, automated emails/text messages and social media

Appendix B. Quality Assurance Project Plan

Quality Assurance Project Plan

Prepared by

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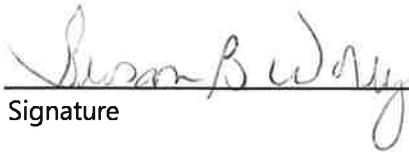
Prepared for

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October 15, 2019

Approvals


Quality Assurance Project Plan Fenceline Monitoring for the Chevron Refinery in El Segundo, California

 10/15/19

Signature Date

Susan B Worley H&S Manager

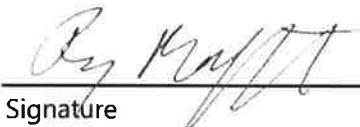
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Contents

1. Project Background and Management	1
1.1 Background.....	1
1.1.1 Purpose.....	1
1.1.2 Rationale	1
1.2 Roles and Responsibilities.....	1
2. Measurements.....	5
2.1 Instrument Selection and Descriptions.....	5
2.2 Monitor Siting Overview.....	9
2.3 Instrument Operations and Maintenance.....	9
2.3.1 UV-DOAS	9
2.3.2 H ₂ S Analyzer	11
2.3.3 FTIR.....	12
2.3.4 Aethalometer.....	13
2.3.5 Visibility and Other Meteorological Sensors.....	14
2.3.6 Overview of Data Flow, Spectrum Generation, and Quality Control Parameters for Open-Path Instruments	15
2.4 System Corrective Actions.....	16
3. Quality Objectives and Criteria	19
3.1 Data and Measurement Quality Objectives	19
3.1.1 Discussion.....	19
3.2 Precision Checks, Bump Tests, and Verification	20
3.2.1 Open-Path Instruments.....	21
3.2.2 Point Instrument for H ₂ S.....	21
3.2.3 Black Carbon.....	21
3.2.4 Meteorological Equipment	22
3.2.5 Instrument or Standards Certifications	23
4. Data Management, Quality Control, and Verification.....	25
4.1 Overview of the Data Management Process	25
4.1.1 QC and QA Processes	25
4.1.2 Data Storage and Processing.....	26
4.1.3 Data Delivery.....	26
4.2 Automated Quality Control	26
4.3 Routine Data Verification.....	29
4.3.1 Confirm Daily Operation.....	29
4.3.2 Assess Data Reasonableness.....	29
4.4 Data QA Procedures	29
4.5 Instrument QC Checks.....	31
5. Standard Operating Procedures	33

Appendix A. CEREX UV-DOAS QA Test Procedures A-1

Appendix B. CEREX AirSentry FTIR QA Test Procedures B-1

Appendix C. Standard Operating Procedures for Magee Scientific Aethalometer Model AE33..... C-1

Appendix D. Galvanic ProTech 903W Standard Operating Procedure D-1

Appendix E. Standard Operating Procedures for Meteorological Instruments at the Chevron
El Segundo Refinery E-1

Figures

1. Organizational chart for the Chevron El Segundo refinery monitoring project 2

2. Location of sensors and measurement paths 10

Tables

1. Pollutants listed in Table 1 of Rule 1180 5

2. Range of approximate open-path instrument minimum detection limits (MDL) and upper
detection limits (UDL) in parts per billion (ppb) by technology, species, and path length 8

3. Schedule of maintenance activities for the UV-DOAS. 11

4. Schedule of maintenance activities for Galvanic Applied Sciences ProTech 903W
instrument. 12

5. Schedule of maintenance activities for the FTIR 12

6. Schedule of maintenance activities for Aethalometers 14

7. Routine maintenance checklist 14

8. Potential sampling and data reporting problems and corrective actions 16

9. Data completeness objectives 19

10. Performance criteria for the fenceline monitoring systems 20

11. Initial screening checks for 5-minute data 28

12. Typical instrument QA/QC checks. 32

1. Project Background and Management

1.1 Background

1.1.1 Purpose

Chevron Corporation will conduct air quality monitoring at its El Segundo, California, refinery in response to the South Coast Air Quality Management District's (SCAQMD) Rule 1180.¹ The monitoring will follow a facility-specific air monitoring plan consistent with the SCAQMD's Refinery Fenceline Air Monitoring Plan Guidelines.² Rule 1180 requires routine monitoring near the fencelines of all South Coast refineries for specific air compounds, with data reported to the public.³

1.1.2 Rationale

Rule 1180 requires fenceline monitoring of multiple compounds to "provide air quality information to the public about levels of various criteria air pollutants, volatile organic compounds, and other compounds, at or near the property boundaries of petroleum refineries and in nearby communities."¹ In its monitoring plan, Chevron will conduct open-path and point pollutant monitoring 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 Refinery Fenceline and Community Air Monitoring (Rule 1180; approved by the SCAQMD on December 1, 2017). Available at <http://www.aqmd.gov/docs/default-source/rule-book/reg-xi/r1180.pdf?sfvrsn=9>.

² South Coast Air Quality Management District SCAQMD (2017) Refinery Fenceline Air Monitoring Plan Guidelines. December. Available at <http://www.aqmd.gov/docs/default-source/rule-book/support-documents/1180/rule-1180-guidelines.pdf>.

³ The exact timing for the start of fenceline monitoring depends on when the monitoring plan is approved by the SCAQMD.

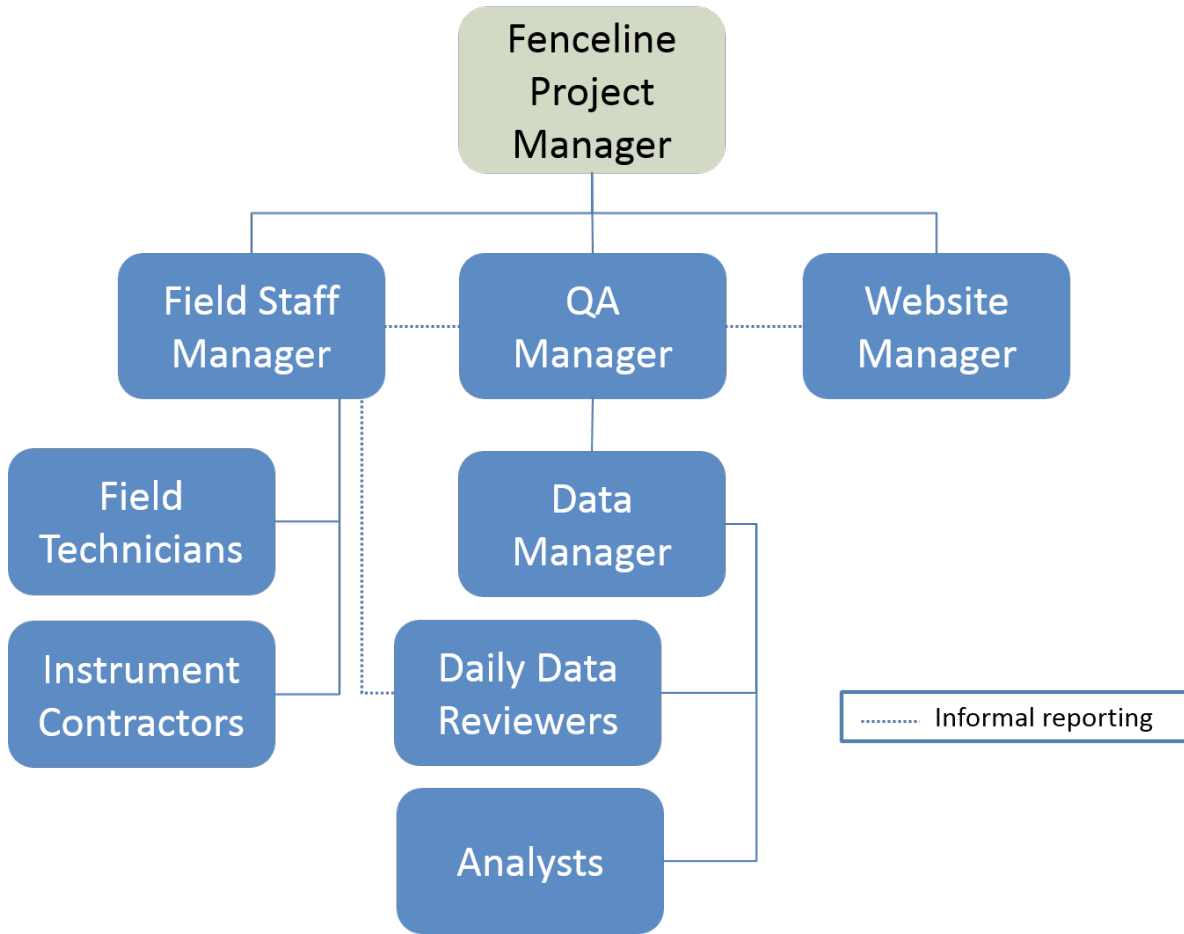


Figure 1. Organizational chart for the Chevron El Segundo refinery monitoring project.

The overall project will be run by a **Fenceline Project Manager** appointed by the refinery. This PM acts as the central point of contact for the SCAQMD and the QA Manager, Field Staff Manager, and Website Manager. The PM is responsible for overseeing the project and reporting directly to the SCAQMD.

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 SCAQMD 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 required list of compounds to be measured is presented in [Table 1](#). These compounds will be measured at a 5-minute resolution. Because of the distances that need to be covered by measurements (hundreds of meters), the data time-resolution requirements (5 minutes), and current state of measurement technology, open-path instruments (UV-DOAS and FTIR) were selected for measuring all compounds except for black carbon and H₂S, which will be measured by point instruments.

Table 1. Pollutants listed in Table 1 of Rule 1180.

Air Pollutants
Criteria Air Pollutants
Sulfur Dioxide
Nitrogen Oxides
Volatile Organic Compounds (VOCs)
Total VOCs (Non-Methane Hydrocarbons)
Formaldehyde
Acetaldehyde
Acrolein
1,3-Butadiene
Styrene
BTEX Compounds (Benzene, Toluene, Ethylbenzene, Xylenes)
Other Compounds
Hydrogen Sulfide
Carbonyl Sulfide
Ammonia
Black Carbon
Hydrogen Cyanide

Along all measurement paths (see Section 2.2), SO₂ and benzene, toluene, ethylbenzene, and xylenes (BTEX) will be measured by monostatic *Ultra Violet-Differential Optical Absorption Spectroscopy (UV-DOAS)* with a xenon light source. The xenon light is required to achieve measurements over paths that are about 300 to 600 meters long and to achieve the minimum detection limits (MDL) for BTEX. The analyzer records the intensity of light at discrete wavelengths. Any UV-absorbing gas that is present in the beam absorbs at a specific wavelength of light. Each species of 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. The analyzer uses a classical least squares regression analysis to compare the measured absorption spectrum to calibrated reference absorption spectra files. Beer's Law is used to report gas concentrations. Though not written specifically for UV-DOAS, this approach is the same as that specified in the U.S. Environmental Protection Agency's (EPA) TO-16 Methodology.⁴ 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. 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.

Total VOCs (non-methane hydrocarbons), formaldehyde, acetaldehyde, acrolein, styrene, carbonyl sulfide, hydrogen cyanide, NH₃, 1,3-butadiene, and BTEX will be measured with a *Fourier Transform Infrared spectroscopy (FTIR)* instrument. The FTIR operates by sending a beam of infrared light through the open air. The IR beam is reflected back to the analyzer by a retro-reflector array (monostatic), where the absorption due to target gases is measured and recorded. The analyzer uses a classical least squares regression analysis to compare the measured absorption spectrum to calibrated reference absorption spectra files according to the EPA's TO-16 Methodology. Beer's Law is used to report accurate gas concentrations. The FTIR operates on a similar premise as the UV-DOAS by using reference spectra. There are a variety of industry standard methods to mitigate interference from both water vapor and interference gases, including spectral subtraction, path length adjustments, and selecting isolated absorbance peaks for the gases of interest. Proprietary methods include multi-peak analytics.

Heavy fog may entirely block the signal from an open-path instrument and prevent data collection; however, even light fog can absorb the signal partially and interfere with measurements. Given the coastal location of the refinery, marine fog events are expected during the nighttime and early morning hours. Visibility measurements will be made at two representative locations in order to provide operational verification of fog events.

Hydrogen sulfide will be measured by a Galvanic Applied Sciences ProTech 903W H₂S analyzer instrument. Black carbon will be measured by Magee Scientific Aethalometers.

⁴ 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.

Table 2 summarizes the estimated range of MDL and upper detection limits (UDL) for each species by open-path instrument. The MDL is the lowest path-average concentration that can be measured at the path length, and the UDL is the highest path-average concentration that can be measured at the path length. 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. The detection limits are for the average species concentration along a path; narrow plumes that cover only a portion of the path would only be detected at a higher concentration than the MDL.

The Galvanic point monitor detection limit for H₂S is listed by the manufacturer as 5 ppb. The detection limit for black carbon is less than 0.5 µg/m³.

Table 2. Range of approximate open-path instrument minimum detection limits (MDL) and upper detection limits (UDL) in parts per billion (ppb) by technology, species, and path length. UDLs for some species are not available (NA). Actual detection limits depend on atmospheric conditions.

	1180 Compound	Shortest Path (199 m)		Longest Path (574 m)	
		MDL	UDL	MDL	UDL
FTIR	1,3-Butadiene	5	24,000	2	8,300
	Acetaldehyde	3	500,000	1	170,000
	Acrolein	4	230,000	2	78,000
	Ammonia	1	140,000	0	48,000
	Benzene	53	75,000	18	26,000
	Carbonyl Sulfide	2	NA	1	NA
	Ethylbenzene	17	94,000	6	32,000
	Formaldehyde	2	63,000	1	22,000
	Hydrocarbons	10	15,000	3	5,000
	Hydrogen Cyanide	34	50,000	12	17,000
	Nitrogen Dioxide	15	NA	5	NA
	Styrene	6	29,000	2	10,000
	Total Xylenes	14	190,000	5	65,000
	UV-DOAS	Acrolein	21	480,000	7
Benzene		1	80,000	0.2	27,000
Ethylbenzene		1	55,000	0.3	19,000
Styrene		3	NA	2	NA
Sulfur Dioxide		2	100,000	0.6	36,000
Toluene		2	110,000	0.7	39,000
Total Xylenes		2	19,000	0.8	6,500

2.2 Monitor Siting Overview

Chevron will monitor concentrations across 12 paths (shown in [Figure 2](#)). The type of measurement for each path is indicated by the colored legend in [Figure 2](#). H₂S and BC will be monitored separately, with point monitors located at six locations near the open path monitoring sites. Two meteorological stations will include visibility sensors in addition to wind, temperature, and relative humidity measurements. Chevron selected these locations after considering dominant wind patterns, sources of potential air emissions on the refinery property, and nearby local receptors. Transmitter-detectors/analyzers will be located at sites labeled "A" (identified in [Figure 2](#)), and retroreflectors will be placed at the sites labeled "R".

2.3 Instrument Operations and Maintenance

Five instrument systems are included in this project: UV-DOAS, FTIR, Galvanic ProTech 903W, Aethalometer, and meteorological instruments, including visibility. Quality assurance is built into operations and maintenance. For all instruments, scheduled maintenance will occur monthly, quarterly, and/or annually. 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 3](#) summarizes typical UV-DOAS maintenance activities as recommended by the manufacturer. These actions help ensure data integrity and maximize up-time. [Table 10](#) (see [Section 3](#)) lists performance criteria related to the maintenance activities.

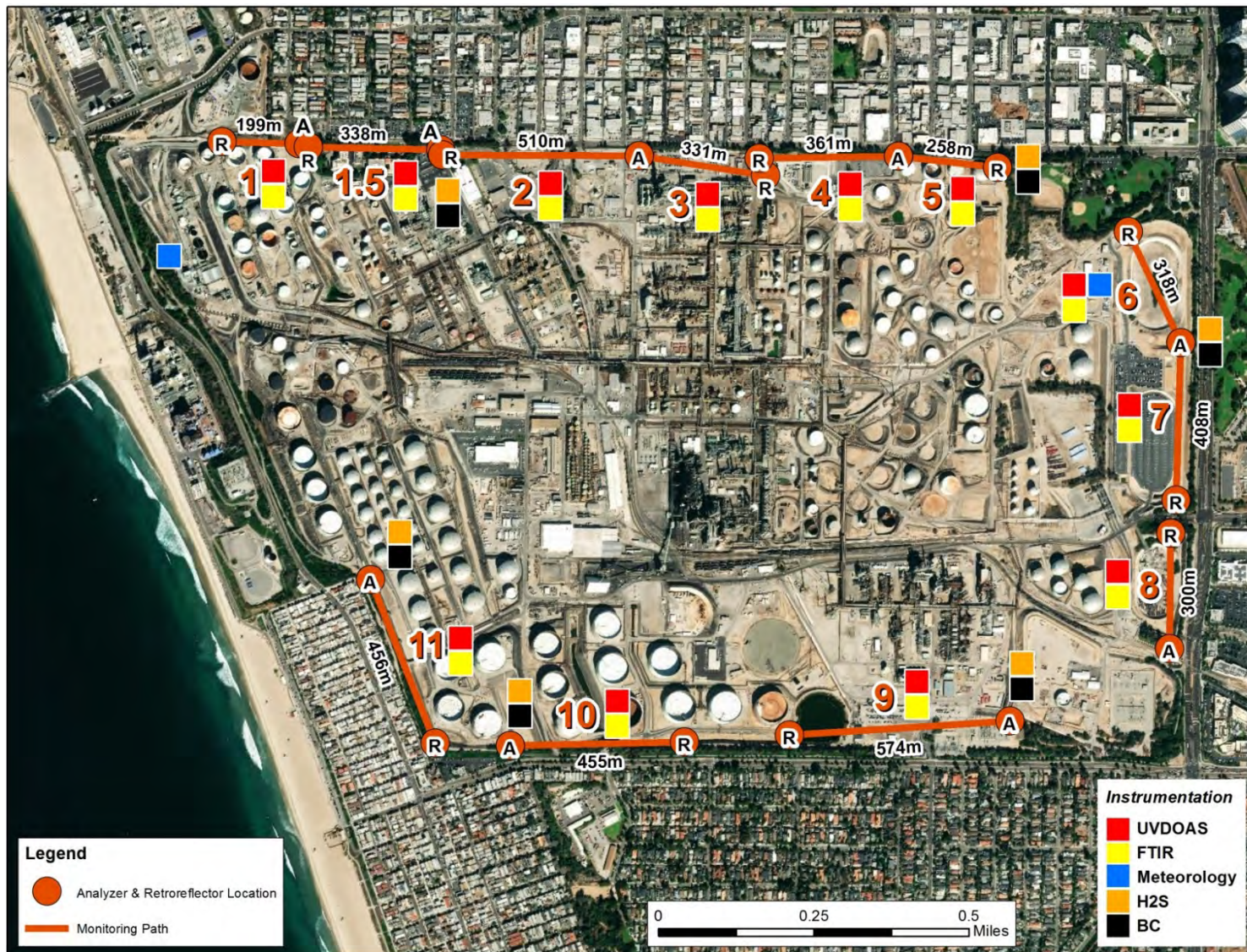


Figure 2. Location of sensors and measurement paths. Each path consists of a transmitter-detector (A) and a retroreflector (R).

Table 3. 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.	✓		
Inspect system filters.	✓		
Confirm the alignment to verify there has not been significant physical movement. Note: this is automatically monitored as well.	✓		
Download data from detector hard drive and delete old files to free space, if needed.	✓		
Ensure there are no obstructions between the detector and the retro-reflector (such as equipment, vegetation, vehicles).	✓		
Change out the UV source.		✓	
Replace ventilation exit and intake filters.		✓	
Clean optics on detector and retro-reflector.		✓	
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 H₂S Analyzer

Table 4 describes maintenance actions for the Galvanic ProTech 903W H₂S analyzer, including cleaning and inspections and their required frequencies for routine system management. The frequency of preventive maintenance depends on the operating environment and may be adjusted beyond manufacturers’ recommendations once the instruments are deployed in the field. On an as-needed basis, system status alarms will alert operators to specific issues needing to be addressed.

Table 4. Schedule of maintenance activities for Galvanic Applied Sciences ProTech 903W instrument.

Activity	Daily	Monthly	Semiannual
Check for alarms	✓		
Inspect sample line tubing		✓	
Visually inspect the tape		✓	
Install new filter tape roll		✓	
Add 5% acetic acid to the humidifier		✓	
Inspect the sample chamber		✓	
Calibrate system with permeation tube device			✓
Inspect and clean the sampling system			✓
Clean air test			✓
Stability test			✓

2.3.3 FTIR

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

Table 5. Schedule of maintenance activities for the FTIR.

Activity	Monthly	Quarterly	Semi-Annually	Annually	~18 months	Five Years
Visually inspect the system.	✓					
Inspect and clean AC system exterior heat sink.			✓			
Inspect and clean AC system interior heat sink.				✓		

Activity	Monthly	Quarterly	Semi-Annually	Annually	~18 months	Five Years
Confirm the alignment to verify there has been no significant physical movement. ^a	✓					
Download data from detector hard drive and delete old files to free space, if needed.	✓					
Ensure there are no obstructions between the detector and the retro-reflector (such as equipment, vegetation, vehicles).	✓					
Change out the IR source.						✓
Realign system after service.		✓				
Check system performance indicators.		✓				
Perform bump test.		✓				
Review and test light and signal levels. Check average light intensity to establish baseline for IR Source change frequency and retro-reflector wear.				✓		
Verify system settings.		✓				
Replace cryocooler or swap detector module assembly.					✓	

^a This is monitored both manually and automatically.

2.3.4 Aethalometer

The Aethalometer system is designed to require only modest service and maintenance. [Table 6](#) summarizes typical Aethalometer 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. 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 Aethalometers.

Activity	Monthly	Semiannual	Annual
Visually inspect the system	✓		
Inlet flow check	✓		
Clean size selective inlet	✓		
Clean cyclone	✓		
Verify date and time	✓		
Inspect optical chamber and clean as necessary		✓	
Calibrate flow		✓	
Change bypass cartridge filter			✓
Install new tape roll	✓		
Calibrate tape sensor		✓	

2.3.5 Visibility and Other Meteorological Sensors

Table 7 depicts the maintenance activities that will be performed during each quarterly site visit to ensure all visibility and meteorological instruments are performing correctly.

Table 7. Routine maintenance checklist.

Item	Action
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.

Item	Action
Visibility Sensors	Inspect the sensor for dirt, spider webs, birds' nests, or other obstructions. Clean the glass windows.
	Check that the cable connections are secure.
	Inspect the hardware holding the sensors to the tower, and tighten the bolts if necessary.
Data Logger Enclosure Cables	Verify that the enclosure is secured inside the shelter and is operational.
	Check that the cabling to the enclosure is secure and undamaged.
	Check the integrity of the cables connecting the data logger box from the data logger to the sensors.
Data Logger Enclosure Guy Wires	Check that the sensor cables are attached to the tower.
	Where guy wires are used, check that they are taut and that the attachment points are tight. If the attachment points are loose, call STI for instructions.

2.3.6 Overview of Data Flow, 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. Most open-path monitors generate an absorption spectrum; from this spectrum, concentrations are derived. 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 similar: a spectral file containing absorbance as a function of wavelength. To generate absorbance using FTIR and UV-DOAS, the logarithm of the ratio of two "single beam" transmission spectra is calculated (one 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 so-called "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. Several other parameters obtained during the collection of spectra may be used to quality-control the data.

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 DOAS measurements, signal strengths greater

than 92% are generally acceptable; below these values, the data will be flagged as questionable. For typical FTIR measurements, the values are generally lower because of absorption by atmospheric gases (CO₂, H₂O, etc.). For example, acceptable values for a manufacturer’s FTIR system may be between 10% 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 R² 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*R². Therefore, a positive detection of an analyte must satisfy an R² threshold value. For example, the fit to methane might have an R² of 0.70 or greater to be considered a valid detection.

2.4 System Corrective Actions

Corrective action will be taken to ensure that data quality objectives are met. **Table 8** lists the types of issues that require corrective actions. (This table is not all-inclusive; 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 8. Potential sampling and data reporting problems and corrective actions.

Item	Problem	Action	Notification	Person Responsible
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

Item	Problem	Action	Notification	Person Responsible
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 specify the data quality needed to minimize decision errors 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, 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 9** 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—will also be computed.

Table 9. Data completeness objectives.

Completeness Requirement	Relevant to
50% of scans (open-path) or of data (point monitors)	5-minute average data
75% of 5-minute data	1-hr average data
75% of daily data	Monthly, quarterly, or annual average data

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 UV bulbs for the UV-DOAS after every 2,000 hours of use, roughly quarterly, and replacement of the FTIR cryocoolers every 18 months). Regular maintenance and careful, responsive operation will minimize instrument downtime. **Table 10** shows the performance criteria for the fenceline monitoring systems.

Table 10. Performance criteria for the fenceline monitoring systems.

Sensor	Test	Acceptance Criteria for Precision and Accuracy
UV-DOAS	5 ppm benzene; 0.5 m QA cell for 500 m path	±20%*
FTIR	5 ppm NH ₃ ; 0.5 m QA cell for 500 m path	±20%*
Galvanic ProTech 903W H ₂ S analyzer	100 ppb	±20%
Aethalometer	Flow meter, internal leak check	±10%
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%

*Based on flow-through calibration system.

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 of trials will be defined as $N \geq 15$. The average value of these measurements is calculated as

$$\bar{x} = \frac{\sum_i x_i}{N} \tag{1}$$

and the standard deviation (σ) as:

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

From these definitions, %Accuracy is defined as:

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

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

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

3.2.1 Open-Path Instruments

For the UV-DOAS system, a bump test will be performed quarterly using a flow through cell the first year or so and semi-annually in later years as high-quality, reliable system performance is confirmed. In the field, a bump test (simulates system-observed gas content at the required path average concentration) is used to verify that the system can detect concentrations at or below a set level of concern.

For the FTIR, bump tests will be performed onsite quarterly using a flow through cell the first year or so and semi-annually in later years as high-quality, reliable system performance is confirmed.

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-minute 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](#) on the previous page. 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 Instrument for H₂S

A permeation device will be used for the calibration of the Galvanic ProTech 903W. Permeation devices are preferred over compressed gas cylinders because of their higher dynamic range and portability. A VICI Dynacal 120 portable calibration gas generator will be used with the permeation devices to generate the zero and span checks. Permeation devices contain the pure calibration chemical in a two-phase equilibrium between the gas and liquid phases. The permeation device emits the calibration compound through a semi-permeable membrane at a known constant rate, provided the temperature is constant. One of the main functions of the Dynacal 120 is to keep the permeation device at a fixed temperature with a known carrier gas flow so that a constant, known gas concentration is generated. When the permeation devices are not being used, they will be stored under dry nitrogen at a temperature between 20° and 25°C. Prior to calibration, the permeation device will be allowed to equilibrate for 24 hours. The permeation devices will be certified every six months either gravimetrically or against an acceptable reference method.

3.2.3 Black Carbon

The Aethalometers will be subjected to both a leak check and flow rate check once per month.

3.2.4 Meteorological Equipment

Semi-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), Volumes I, II, and IV*.^{5,6,7}

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.

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.

⁵ U.S. Environmental Protection Agency (1994) Quality assurance handbook for air pollution measurement systems, Volume I: a field guide to environmental quality assurance. Report prepared by the U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA/600/R-94/038a. Available at <https://www3.epa.gov/ttn/amtic/qalist.html>.

⁶ 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>.

⁷ U.S. Environmental Protection Agency (2017) Quality assurance handbook for air pollution measurement systems, Volume II: ambient air quality monitoring program. 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-17-001, January. Available at <https://www3.epa.gov/ttnamti1/qalist.html>.

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.

3.2.5 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 DMS uses a Microsoft SQL relational database with stored procedures. These raw data are not yet intended for the public website.

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 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** – data are within normal operating parameters.
- **Invalid** – data do not meet quality control criteria.
- **Missing** – data have not been received by the DMS for a time period greater than 10 minutes since the last data was received.
- **Suspect** – 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 SCAQMD. Data from all stages of validation are retained in the DMS.

4.1.2 Data Storage and Processing

The DMS data will be backed up on a daily basis. Backup media will be moved weekly to a secure offsite facility. The data will be stored for a period of five years after sampling.

4.1.3 Data Delivery

Final data sets (Level 2.0 data) will be compiled quarterly, 90 days after each quarter, and made available to the public on the website in graph format. Validated data will be provided to the SCAQMD annually.

Data graphs will be stored and available on the website for 90 days. Chevron will maintain a data record for five years consistent with Rule 1180.

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 11](#). 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:

- **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 operation (OP) codes to data automatically (e.g., for bump tests or internal flow rate checks), 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. There are no previously set data quality objectives for these parameters; we will need to develop objectives for these parameters if we find that they are useful indicators for automated data quality screening or for data validation.

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 11. Initial screening checks for 5-minute 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
SO ₂ (ppb)	SAME FOR ALL POLLUTANTS	750	SAME FOR ALL POLLUTANTS	250	SAME FOR ALL POLLUTANTS	SAME FOR ALL POLLUTANTS	SAME FOR ALL POLLUTANTS
Nitrogen Dioxide (ppb)		750		250			
Total VOCs (non-methane hydrocarbons) (ppb)		TBD		TBD			
Formaldehyde (ppb)		135		45			
Acetaldehyde (ppb)		780		260			
Acrolein (ppb)		3.3		1.1			
1,3-Butadiene (ppb)		900		300			
Styrene (ppb)		14,700		4,900			
Benzene (ppb)		27		9			
Toluene (ppb)		29,400		9,800			
Ethylbenzene (ppb)		1,380		460			
Total Xylenes (ppb)		15,000		5,000			
H ₂ S (ppb)		90		30			
Carbonyl Sulfide (ppb)				270			
NH ₃ (ppb)		1,380		460			
Black Carbon (µg/m ³)		30		10			
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 likely be adjusted as the project proceeds to reduce false or excessive alerting. The alerting will likely be set initially for 6 to 12 missing 5-minute values (i.e., 30 to 60 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-minute 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.⁸
- 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 progresses, we will update and refine the screening checks. 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.

⁸ Measurements below the method detection limit will be flagged in the DMS for review by an analyst.

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 12](#). 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 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 SCAQMD upon request.

Table 12. Typical instrument QA/QC checks.

QA/QC Checks	Frequency	Acceptance Criteria
UV-DOAS		
Bump test (accuracy)	Quarterly and after major service	±20%*
Baseline stability	Continuous	±5%
Measurement quality (R ²)	Continuous	0.8 to 1.0
Integration time	Continuous	80-200 mS <i>400 mS integration time results in a warning notification</i>
Signal intensity	Continuous	>80% <i>Signal intensity below 30 results in a warning notification</i>
Aethalometer		
Flow rate		±10%
Span check		±10%
Zero check		<550 ng/m ³ for Ch. 6
FTIR		
Bump test	Quarterly and after major service	±20%*
Baseline stability	Continuous	±5%
Measurement quality (R ²)	Continuous	0.7 to 1.0
Signal intensity	Continuous	>5% <i>Signal intensity below 5 results in a warning notification</i>
Galvanic ProTech 903W H₂S Analyzer		
Bump test	Quarterly	20%
Meteorology		
Two point temperature test	Quarterly	±0.5°C
Relative humidity	Quarterly	±7%
Wind speed starting threshold and transfer function	Quarterly	±0.25 m/s below 5 m/s and ±5% above 5 m/s
Wind direction angle verification	Quarterly	±5 degrees
Visibility – extinction coefficient check	Quarterly	±10%

*Based on flow-through calibration system.

5. Standard Operating Procedures

Instrument-specific SOPs for the systems listed below are provided as Appendices to this document.

- [Appendix A: UV-DOAS](#) – CEREX UV-DOAS
- [Appendix B: FTIR](#) – CEREX AirSentry FTIR
- [Appendix C: Aethalometer](#) – Magee Scientific Aethalometer Model AE33
- [Appendix D: H₂S Analyzer](#) – Galvanic ProTech 903W with a VICI Metronics Dynacalibrator Model 120
- [Appendix E: Meteorology](#) – Meteorological Instruments at the Chevron El Segundo Refinery

Appendix A. CEREX UV-DOAS QA Test Procedures



CEREX UV-DOAS QA Test Procedures

September 30, 2019
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Contents

QA Test Procedure Summary	A-4
Safe Work and Hazard Identification	A-4
Preliminary Preparation.....	A-5
Safe Operating Precautions.....	A-5
Test Apparatus Setup	A-5
Materials Required.....	A-5
Verify Proper Sentry Alignment.....	A-6
Gas Purge System Setup and Purge.....	A-6
Prepare CMS for Gas Testing.....	A-6
Configure CMS for Test.....	A-6
Configure Test Files.....	A-7
Gas Check and QA Test	A-7
Check Gas Test.....	A-7
Restore Normal Operation.....	A-8
Test Suspension.....	A-8
Data Evaluation and Reporting.....	A-8
Maintenance Activities.....	A-9
QA Test Record Template	A-10

QA Test Procedure Summary

This document addresses the commissioning and performance test procedure for Cerex Monitoring Solutions UV Sentry units. The procedure is intended to verify that the equipment is performing to expectations and that the detection and communication links are functioning correctly. Hard copies of this procedure and the associated test forms will be kept on site. Upon completion of the test procedure, a copy of the test form showing the results will be sent to the Refinery Project Manager.

***NOTE ***

THIS IS A WORKING DRAFT FOR INITIAL SYSTEM VALIDATION.
IT SHOULD BE REVIEWED FOR COMPLIANCE WITH LOCAL SAFETY AND QUALITY ASSURANCE PRACTICES.

This procedure should only be used by personnel with experience in the safe use of the analyzer and test equipment.

The purpose of the QA Test procedure is field verification of the factory calibration of the UV Sentry. The QA Test process challenges the instrument using known concentrations of select BTEX reference gases and/or Sulfur Dioxide to verify proper detection and quantification under field conditions.

QA tests (bump tests) are to be performed on a quarterly basis.

Safe Work and Hazard Identification

The following information should be noted when preparing work plans and permits for safe work practices.

Operator Qualifications

Installing, operating and servicing Cerex UV Sentry analyzers should only be performed by personnel trained in the operation of the system components and familiar with the handling of gas delivery and testing equipment.

Safe Work and Hazardous Environment Operation

Work should conform with manufacturer guidance and site health and safety practices.

The Cerex Monitoring Solutions UV Sentry Series Analyzers are not rated for safe operation in hazardous or explosive environments. Any uses in an area that may contain flammable mixtures or highly corrosive vapors require special preparation to address safety and ensure safe operation of the equipment.



WARNING – Eye hazard. Risk of eye injury. CEREX UV-DOAS Analyzers contain an ultra-violet light source that may cause eye injury after prolonged exposure. Always wear UVA/B/C eye protection when working on or near the operating equipment.

Procedure Warnings

This QA Test procedure requires the handling of toxic benzene, aromatic hydrocarbons, and sulfur dioxide gas, and it requires the operation of equipment designed for toxic gas containment and dispensation. Improper handling of materials or hardware may result in serious injury, destruction of property, or damage to the UV Sentry. Only qualified individuals should attempt or perform analyzer quality assurance test activities. Cerex assumes no liability for the use or misuse of this guidance document, or for operator-performed QA Tests, Calibration or Gas Handling activities. No claims are made by Cerex as to the compliance of this procedure with any regulations or engineering best practices. The operator is solely responsible for safety of personnel and property.

Preliminary Preparation

Safe Operating Precautions

1. Field at least 2 people for the validations.
2. Ensure that a clear escape path is identified.
3. Standard site personal protective equipment (PPE) is appropriate. If gloves are required, nitrile or latex should be used.

Test Apparatus Setup

Materials Required

1. Operator-supplied Standard Operating Procedure approved by the End-User and in compliance with End-User's Health and Safety Plan.
2. This procedure is for the Internal UV Sentry QA Cell.
3. Cell bump test purge apparatus, including:
 - a. Tubing as required: 1/8" PTFE tubing for gas supply from the bottle to the QA cell.
 - b. Tubing as required: 1/4" PTFE tubing with inline flow indicator from the QA cell to the vent.
 - c. Flow regulation system capable of delivering gas 0.1 to 5 L/min at a total system pressure of 3 psig or less.

- d. Activated carbon scrubber.
4. Purge gas.
5. Reference standard traceable gas blend in nitrogen for detection at about 5X instrument theoretical detection limit or higher.
6. All relevant PPE, hardware and procedural guidance per SOP, Safety Plan, and Safe Work Permit.
7. Local or remote network link device (as required).
8. External laptop computer with network interface device to the Sentry unit (as required).

Verify Proper Sentry Alignment

1. Open the CMS window.
2. Click on the **UV** tab.
3. If Run is active, press **STOP**.
4. Click the **ALIGN** button at the bottom left of the plot display.
5. Adjust the alignment until the signal intensity is optimized.
 - a. **Target intensity is 140,000 – 170,000.**
 - b. **Target integration time is between 10mS and 55mS.**
6. **Record** the intensity and integration time.
7. Press **OK and SAVE** or **ACCEPT** (if prompted) settings to exit the CMS Alignment window.
8. Press **RUN** to resume operation.

Gas Purge System Setup and Purge

1. Connect the reference cell vent line to the reference cell and route it through an appropriate vapor scrubber (as required) and outside the structure.
2. Connect the purge gas cylinder to the internal test cell.
3. Ensure the cell vent is open and unobstructed to atmosphere by monitoring vent flow.
4. Flow purge gas at vent flow of 1 L/min for ten 30 second acquisitions to purge the system.

Prepare CMS for Gas Testing

Configure CMS for Test (This may be concurrent with Gas Purge System setup)

1. The analyzer should be powered and running for **at least 30 minutes**.
2. Stop CMS data collection by pressing the **STOP** button.

Configure Test Files

1. Click **Advanced** on the left side of the CMS software window; password is *advanced*.
2. Under **Advanced** -> **Settings** -> **Runtime** -> **File**, turn off **Secondary Logging**. Change the primary file logging paths (both of them) to: C:\Users\CMS-USER\Documents\Cerex\Data\bumpstest. Then select **File** and select **Save**.
3. Start zero gas running through cell.
4. Click the **RUN** button and allow the analyzer to complete 10 or more acquisitions.

Gas Check and QA Test

Check Gas Test

1. Stop the instrument by pressing "stop" on the lefthand side of CMS.
2. Start Check Gas flow.
 - a. Close the purge gas to stop flow.
 - b. Allow residual pressure to vent (approximately 10 seconds).
 - c. Open the Check Gas flow control.
 - d. Set vent flow to 1 L/min.

*****NOTE ***** Pressurizing the cell to above 3 psig may cause breakage of the optical windows.
3. After 5 minutes of Check Gas flow, press **Start** in CMS.
4. Collect Check Gas data.
 - a. Observe the concentration reported on the **DATA** tab.
 - b. After the concentration becomes stable, allow the analyzer **to run until 15 stable measurements are made**.
 - c. **Verify that the value is near the expected concentration**. If the measurements do not meet specifications, repeat the procedure. If repeated measurements appear nonconforming, initiate corrective action investigation.
 - d. **Verify client system** is receiving and displaying instrument information correctly.
 - e. After 15 stable measurements are observed, **close the Reference bottle valve**. Allow the pressure to fall to zero and flow to stop.
5. Purge the Reference gas.
 - a. **Open the purge gas** valve to flow nitrogen through the system.
 - b. **Set the flow rate** to 1 L/min.

- c. **Purge the QA cell** with nitrogen until zero is verified on the instrument.
- d. **Verify that the target gas(es) concentration has returned to 0 ppm** with non-detect R2.

NOTE If not, ambient background target gas concentration has changed during the procedure; testing may need to be repeated to verify results.

- e. Once the target gas value returns to non-detect, stop flow.
- f. Remove the hoses and cap the connectors.

Restore Normal Operation

1. **Restore** Normal Operation.
2. **STOP** CMS.
3. On the CMS **OPERATION** tab enter the site name "UV# YearMoDy" and click **APPLY**. Click the **RUN** button and allow the analyzer to complete at least one acquisition.
4. Press **STOP**.
5. **Check the system alignment** as previously described.
6. Press **RUN** to begin monitoring.

Test Suspension

In the event of a leak or plant alarm requiring suspension of work, the process should be safely suspended.

1. If a plant or site alarm sounds during the validation, stop the test immediately as follows.
2. Close the reference gas bottle valve completely.
3. Allow the system to flow purge gas to the scrubber/vent.

Data Evaluation and Reporting

1. Concentration
 - a. Average the concentration of 15 consecutive stable measurements.
 - b. Report the percent difference between the average and the certified value.
2. Calculate the Limits of Detection and Quantitation.
 - a. Calculate the sample standard deviation of the 15 selected results.
 - b. Report the Detection Limit as three times the standard deviation.
 - c. Report the Quantitation Limit as five times the standard deviation.

3. Compile all configuration files, spectra files, and log files into a single folder.
 - a. The folder should be named "CUS LOC QATest UV# YearMonDy" where CUS is a three letter designator for the customer and LOC is a three letter designator for the facility location.

Maintenance Activities

A typical schedule of maintenance activities for the Cerex UV-DOAS, as recommended by the manufacturer, is provided in Section 2.3.1, Table 3, of the Quality Assurance Project Plan.

QA Test Record Template

UV Sentry Fenceline Detection System

DATE: _____

Location: _____

Test Technician 1 : _____

Test Technician 2 : _____

Sentry Alignment

Intensity _____ Target 140,000 – 170,000

Integration time _____ Target 10mS and 55mS.

Gas Purge System

Flow purge gas

Start Time _____

Stop Time _____

Prepare CMS

Saved "Run Configuration" in _____

Path length in the CMS Configuration _____ m

Save "Test Configuration" in the default directory. _____ init

Configure Test Files

Site File (QA Test UV# YearMoDy) _____

Optical Ringing Check _____ init

NOTES:

QA Test Record - UV Sentry Vapor Detection System - Page 2

Purge Flow Conditions

Initial Gas flow _____ L/min
 Start Time _____
 End Time _____
 Reduced Gas flow _____ L/min

Check Gas Test

Initial Gas flow _____ L/min
 Start Time _____
 End Time _____
 Reduced Gas flow time _____
 Start Time _____
 End Time _____
 Collect Check Gas data
 Start Time _____
 Concentration _____ ppm
 Verify Client _____ Init
 End Time _____ Init

Close Reference Gas

Start Time _____
 Open the **PURGE** gas
 Time _____
 End Test Gas Concentration _____ ppm R2
 _____ ppm R2
 _____ ppm R2
 _____ ppm R2
 _____ ppm R2
 _____ ppm R2
 _____ ppm R2

Restore Normal Operation

Settings > Configuration > File > Load > C:\User\Documents\Cerex\CMS\ > 'Run Configuration'
 Operation > Acrolein UV# > Apply.
 RUN > complete one acquisition > STOP
 Verify Acrolein Background Acrolein _____ ppm R2
 Press RUN to begin monitoring. _____ Init

Data Files (CUS LOC QATest UV# YearMonDy) _____

NOTES:

Results Record

Instrument ID _____ Location _____

Technician _____ Date _____

Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2
Time	_____	_____ ppm	R2

Reference Concentration _____ ppm
 Average Concentration _____ ppm
 % difference _____ %
 Std Deviation _____ ppm
 Estimated MDL (3X Std Dev) _____ ppm

NOTES:

Appendix B. CEREX AirSentry FTIR QA Test Procedures



CEREX AirSentry FTIR QA Test Procedures

August 6, 2019

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CONTENTS

- QA Test Procedure SummaryB-4**
- Safe Work and Hazard IdentificationB-4**
- Preliminary Preparation.....B-5**
 - Safe Operating Precautions..... B-5
- Test Apparatus SetupB-5**
 - Materials Required..... B-5
 - Verify Proper AirSentry Alignment..... B-6
 - Gas Purge System Setup and Purge..... B-7
- Prepare CMS for Gas Testing.....B-7**
 - Configure CMS for Test..... B-7
 - Configure Test Files..... B-7
- Gas Span and QA TestB-8**
 - Span Gas Test..... B-8
 - Checking for Optical Ringing..... B-9
 - Restore Normal Operation..... B-9
 - Test Suspension..... B-9
- Data Evaluation and Reporting..... B-10**
- Maintenance Activities..... B-10**
- QA Test Record Template B-11**

QA Test Procedure Summary

This document addresses the commissioning and performance test procedure for Cerex Monitoring Solutions AirSentry units. The procedure is intended to verify that the equipment is performing to expectations and that the detection and communication links are functioning correctly.

***NOTE ***

THIS IS A WORKING DRAFT FOR INITIAL SYSTEM VALIDATION.
IT SHOULD BE REVIEWED FOR COMPLIANCE WITH LOCAL SAFETY AND QUALITY ASSURANCE PRACTICES.

This procedure should only be used by personnel with experience in the safe use of the analyzer and test equipment.

The purpose of the QA Test procedure is field verification of the factory calibration of the AirSentry. The QA Test process challenges the instrument using known concentrations of Hexane, Ammonia and/or 1,3-butadiene to verify proper detection and quantification under field conditions.

Safe Work and Hazard Identification

The following information should be noted when preparing work plans and permits for safe work practices.

Operator Qualifications

Installing, operating, and servicing Cerex AirSentry FTIR analyzers should only be performed by personnel trained in the operation of the system components and familiar with the handling of gas delivery and testing equipment. This includes troubleshooting, cleaning, replacement of parts, IR light source installation, etc.

Safe Work and Hazardous Environment Operation

Work should conform with manufacturer guidance and site health and safety practices.

The Cerex Monitoring Solutions AirSentry Series Analyzers are not rated for safe operation in hazardous or explosive environments. Any uses in an area that may contain flammable mixtures or highly corrosive vapors require special preparation to address safety and ensure safe operation of the equipment.



CAUTION – Laser Radiation. Risk of eye injury with prolonged direct exposure. CEREX FTIR Analyzers contain a Class 3B invisible laser radiation when the interferometer cover is removed. Do not remove the interferometer cover. Eye protection is recommended when working near the IR source.

Procedure Warnings

This QA Test procedure requires the handling of a pressurized isobutylene. Improper handling of materials or hardware may result in serious injury, destruction of property, or damage to the AirSentry FTIR. Only qualified individuals should attempt or perform analyzer quality assurance test activities. Cerex assumes no liability for the use or misuse of this guidance document, or for operator-performed QA Tests, Calibration, or Gas Handling activities. No claims are made by Cerex as to the compliance of this procedure with any regulations or engineering best practices. The operator is solely responsible for safety of personnel and property.

Preliminary Preparation

Safe Operating Precautions

1. Field at least 2 people for the validations, and ensure that a clear escape path is identified.
2. Standard site PPE is appropriate. If gloves are required, nitrile or latex should be used.
3. Operator should be fully trained and experienced in the use of compressed gas cylinders, 1 and 2 stage regulators used in conjunction with the cylinders, flow controllers, tubing connections). Operator should be experienced with the parameters of flow and pressure, and how these relate to compressed gas and its use with calibrating gas analysis equipment.

Test Apparatus Setup

This procedure is to be carried out when using the Internal AirSentry FTIR QA Cell.

Materials Required

1. Operator-supplied Standard Operating Procedure approved by the End-User and in compliance with End-User's Health and Safety Plan.
2. Cell bump test purge apparatus, including:
 - a. Tubing as required: 1/4" PTFE tubing for gas supply from the bottle to the QA cell.

- b. Tubing as required: 1/4" PTFE tubing with inline flow indicator from the QA cell to the vent.
- c. Flow regulation system capable of delivering gas 0.1 to 5 L/min at a total system pressure of 3 psig or less.
3. Purge gas; typically nitrogen.
4. Reference standard traceable gas blend in nitrogen for detection at about 5X instrument theoretical detection limit or higher.
5. All relevant PPE, hardware and procedural guidance per SOP, Safety Plan, and Safe Work Permit.
6. Local or remote network link device (as required).
7. External laptop computer with network interface device to the AirSentry FTIR unit (as required).

Verify Proper AirSentry Alignment

1. Open the CMS window.
2. Click on the **FTIR** tab.
3. If Run is active, press **STOP**.
4. Click the **ALIGN** button at the bottom left of the plot display.
5. Select 32 cm^{-1} and wait for resolution change.
6. Aim the AirSentry FTIR at the retroreflector and adjust the alignment until the signal intensity is optimized.
 - a. **Target intensity should be between 20% and 80%. Once stable signal is obtained, select desired operating resolution – 1 cm^{-1} is required unless otherwise directed by Cerex.**
7. **Record** the signal intensity.
 - a. **Optional – at this point you may wish to record the current field pathlength, and create a backup of the existing configuration file.**
8. **Set** the QA Cell's path length to 0.15 m.
9. Press **OK and SAVE** or **ACCEPT** (when prompted) settings to exit the CMS Alignment window.
10. Press **RUN** to resume operation.
 - a. If the FTIR analyzer is accidentally bumped or moved in any way, then stop the procedure, and return to the Align to verify and correct if necessary.

Gas Purge System Setup and Purge

1. Connect the reference cell vent line to the reference cell and route it through an appropriate vapor scrubber (as required) and outside the structure.
2. Ensure that precision regulators are being used to deliver flow from the gas cylinders to the QA cell. Verify the flow rate is preset to 1 liter per minute prior to connecting to the FTIR and the pressure is less than 3 psi. **Failure to follow this step will result in permanent and costly damage to the QA cell.**
3. Connect the purge gas cylinder tubing to the AirSentry FTIR gas Inlet and tighten.
4. Slowly open the valve. Ensure the cell vent is open and unobstructed to atmosphere by monitoring vent flow. **Cell pressure must remain below 3 psi.**
5. Flow purge gas at vent flow of 1 L/min for 1 minute to purge the system.
6. Take a clean air background after a minimum of three volume exchanges have completed. Ensure the background is saved in the software, and that the software is using this updated, new background. Further instructions can be found in the CMS manual if required.
7. Reduce flow to 0.3 L/min.

Prepare CMS for Gas Testing

Configure CMS for Test - (This may be concurrent with Gas Purge System setup)

1. The analyzer should be powered and running for **at least 30 minutes**.
2. Stop CMS data collection by pressing the **STOP** button.

Configure Test Files

1. On the CMS **OPERATION** tab enter the site file name, "QA Test FTIR# YearMoDy" where # is the FTIR identification number and YearMnDy indicates the date of the test (i.e., 1969Aug09). Click the **APPLY** button.
2. Click the **RUN** button and allow the analyzer to complete 3 or more acquisitions.
 - a. If after 2 acquisitions the absorbance graph shows negative features greater than 3X the peak-to-peak baseline noise level, take another clean air background.
3. Repeat this process until sequential absorbance acquisition seen in the absorbance graph remain near zero. (straight baseline with only normal noise peaks).
4. Click the **FTIR** Tab and inspect the absorbance plot for background target gas detection or optical ringing (See page B-9).
5. If no target gas background or optical ringing is observed, proceed to the next step. If optical ringing is observed, delete the QA Test folder located in D:\Data\, take corrective action, and

start over from Step 2 of this section. If target gas or ringing is persistent, make note and continue.

6. Click the **RUN** button and allow the analyzer to continue operation.

Gas Span and QA Test

Span Gas Test

1. Start Span Gas flow.
 - a. Close the purge gas to stop flow and remove purge gas tubing from the Gas Inlet.
 - b. Allow residual pressure to vent (approximately 10 seconds).
 - c. Prior to connecting to the analyzer, ensure the span gas regulator is set to produce 1 liter per minute flow, and a pressure of less than 3 psi.
 - d. Connect Span gas's tubing to Gas Inlet and open the Span gas flow control slowly.

*****NOTE*** Cell pressure must remain below 1 psi, or optical windows may break.**

- e. Set vent flow to 1 L/min.
 - f. After 1 min, reduce flow to 0.3 L/min.
2. Collect Span Gas data.
 - a. Observe the concentration reported on the **DATA** tab.
 - b. After the concentration becomes stable, allow the analyzer **to run until at least 15 stable measurements are made.**
 - c. **Verify that the value is near the expected concentration (within 90%).** If the measurements do not meet specifications, repeat the procedure. If repeated measurements appear nonconforming, initiate corrective action investigation.
 - d. **Verify client system** is receiving and displaying instrument information correctly.
 - e. After 15 stable measurements are observed, **close the Reference bottle valve.** Allow the pressure to fall to zero and flow to stop.
 3. Purge the Reference gas.
 - a. **Open the purge gas** valve to flow nitrogen through the system.
 - b. **Set the flow** rate to 1 L/min.
 - c. **Purge the QA cell** with nitrogen for at least 2 minutes.
 - d. **Verify that the target gas(es) concentration has returned to 0 ppm** with non-detect R2.

NOTE If not, ambient background target gas concentration has changed during the procedure; testing may need to be repeated to verify results.

- e. Once the target gas value returns to non-detect, stop flow.
- f. Remove the hoses and cap the connectors.

Checking for Optical Ringing

Optical ringing may appear in the absorbance plot of the FTIR Tab. Ringing is the result of the angle of the cell optics with respect to the incoming light beam and appears as a sine wave or multiple sine waves of variable amplitude in the absorbance spectrum as displayed in the absorbance plot on the FTIR tab while the analyzer is in operation. Ringing is capable of causing patterns of detection and non-detection, as well as significant periodic false inflation of gas concentration reported as well as non-detection. The QA test procedure should not be performed if optical ringing is present in the absorbance spectra.

Restore Normal Operation

1. **Restore** Normal Operation.
2. **STOP** CMS.
3. On the CMS **OPERATION** tab enter the site name "FTIR# YearMoDy" and click **APPLY**. Click the **RUN** button and allow the analyzer to complete at least one acquisition.
4. Press **STOP**.
5. **Check the system alignment** as previously described.
6. Be sure to set the pathlength back to the field value (ie, not 0.15 m). Restore the field background file, or let auto-background perform this function (if enabled)
7. Press **RUN** to begin monitoring.

Test Suspension

In the event of a leak or plant alarm requiring suspension of work, the process should be safely suspended.

1. If a plant or site alarm sounds during the validation, stop the test immediately as follows.
2. Close the reference gas bottle valve completely.
3. Allow the system to flow purge gas to the scrubber/vent.

Data Evaluation and Reporting

1. Concentration
 - a. Average the concentration of 15 consecutive stable measurements.
 - b. Report the percent difference between the average and the certified value.
2. Calculate the Limits of Detection and Quantitation.
 - a. Calculate the sample standard deviation of the 15 selected results.
 - b. Report the Detection Limit as three times the standard deviation.
 - c. Report the Quantitation Limit as five times the standard deviation.
3. Compile all configuration files, spectra files, and log files into a single folder.
 - a. The folder should be named "CUS LOC QATest FTIR# YearMonDy" where CUS is a three letter designator for the customer and LOC is a three letter designator for the facility location.

Maintenance Activities

A typical schedule of maintenance activities for the CEREX AirSentry FTIR, as recommended by the manufacturer, is provided in Section 2.3.3, Table 5, of the Quality Assurance Project Plan.

QA Test Record Template

AirSentry FTIR Fenceline Detection System

DATE: _____

Location: _____

Test Technician 1 : _____

Test Technician 2 : _____

AirSentry Alignment

Intensity _____

Target 20% to 80%

Gas Purge System

Flow purge gas

Start Time _____

Stop Time _____

Prepare CMS

Saved "Run Configuration" in _____

Path length in the CMS Configuration _____ m

Save "Test Configuration" in the default directory. _____ initials

Configure Test Files

Site File (QA Test FTIR# YearMoDy) _____

Optical Ringing Check _____ initials

NOTES:

QA Test Record - AirSentry FTIR Vapor Detection System - Page 2

Purge Flow Conditions

Initial Gas flow _____ L/min
Start Time _____
Reduced Gas flow _____ L/min

Check Gas Test

Initial Gas flow _____ L/min
Start Time _____
Reduced Gas flow time _____
Start Time _____

Collect Check Gas data

Start Time _____
Concentration _____ ppm
Verify Client _____ Initial
Stop Time _____ Initial
Start Time _____

Close Reference Gas

Open the PURGE gas
End Test Gas Concentration

_____ ppm R2
_____ ppm R2
_____ ppm R2
_____ ppm R2
_____ ppm R2
_____ ppm R2
_____ ppm R2

Restore Normal Operation

Settings > Configuration > File > Load > C:\User\Documents\Cerex\CMS\ > 'Run Configuration'

Operation > Hexane FTIR# > Apply.

RUN > complete one acquisition > STOP

Verify Hexane Background

Press RUN to begin monitoring.

Ammonia _____ ppm R2
_____ Init

Data Files (CUS LOC QATest FTIR# YearMonDy) _____

NOTES:

Appendix C. Standard Operating Procedures for Magee Scientific Aethalometer Model AE33



Standard Operating Procedures for Magee Scientific Aethalometer Model AE33

August 6, 2019

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Contents

1.	Purpose and Method	C-4
2.	Equipment and Supplies	C-4
3.	Personnel Qualifications	C-4
4.	User Interface and Operation	C-5
4.1.	User Interface	C-5
4.2.	Instrument Status.....	C-6
4.3.	Downloading or Viewing Data	C-7
5.	Field Maintenance	C-8
5.1.	Inspect Sample Line Tubing.....	C-8
5.2.	Inspect and Clean the Insect Screen Assembly.....	C-9
5.3.	Install New Filter Tape Roll	C-9
5.4.	Perform Leak Test	C-10
5.5.	Perform Flow Verification Test	C-11
5.6.	Perform Flow Calibration	C-12
6.	Biannual Maintenance	C-13
6.1.	Clean Optical Chamber	C-13
6.2.	Perform Clean Air Test	C-14
6.3.	Perform Stability Test.....	C-14
6.4.	Perform Inlet Leakage Test.....	C-15
6.5.	Perform Neutral Density (ND) Filter Test	C-15
6.6.	Lubricate Optical Chamber Sliders.....	C-17
7.	Troubleshooting	C-18

1. Purpose and Method

This Standard Operating Procedure (SOP) describes the general maintenance of the Magee Scientific Aethalometer Model AE33 black carbon analyzer.

This manual is adapted from Magee Scientific's User Manual, version 1.54, which is available at http://www.mageesci.com/EACworkshop2016/MANUALS/AE33/AE33_UsersManual_Rev154.pdf.

The Magee Scientific Aethalometer Model AE33 is used to quantify black carbon (BC) in the air. The Aethalometer draws air through a spot on filter tape and then analyzes the aerosol present in the sampled air by measuring the transmission of light through the tape. The sample spot transmission is compared to an unloaded portion of the filter tape which acts as a reference. This analysis is performed at seven optical wavelengths, from the near-infrared to the near-ultraviolet. The Aethalometer calculates the instantaneous concentration of optically absorbing aerosols from the rate of change of the attenuation of light transmitted through the particle-laden filter. Two measurements are obtained simultaneously from two sample spots with different rates of accumulation of the sample. Both spots derive their samples from the same input air stream. The two results are combined mathematically to eliminate nonlinearities common in previous instrument measurements to provide the compensated particle light absorption and BC mass concentration.

The instrument will be operated with 1-minute time resolution.

2. Equipment and Supplies

Maintenance for the Magee AE33 is carried out with the following equipment:

- Instruments for flow checks
- New roll of filter tape
- Adhesive tape
- Screwdriver
- Flow calibration pad (black rubber)
- Flow meter

3. Personnel Qualifications

Installation, operation, maintenance, repair, or calibration of the instrument and all support equipment should be performed by properly trained personnel. Personnel should meet all minimum STI requirements and qualifications for an Air Quality Field Technician.

4. User Interface and Operation

4.1. User Interface

The four top-level tabs in the touch screen user interface are: **HOME**, **OPERATION**, **DATA**, and **ABOUT**. They are described as follows:

HOME has the following parameters:

- BC - the measured values for Black Carbon (measured at 880 nm)
- UVPM - UV particulate matter (calculated at 370 nm)
- REPORTED FLOW - Measured flow (in LPM)
- TIMEBASE - Timebase setting (in seconds)
- TAPE ADV. LEFT - The amount of remaining tape (in)
- STATUS - Instrument status: green (all OK), yellow (check status), and red (stopped) with a Status Condition (see Section 4.2, Instrument Status)
- Bottom of HOME screen shows date and time

Note: The BC and UVPM values are typically similar, but not exactly the same. When aromatic compounds are present in the sampled air (such as when sampling fresh wood smoke, for example), the UVPM concentration can exceed the BC mass concentration value significantly, depending upon the amount and type of organic material present.

OPERATION has four sub-tabs: GENERAL, ADVANCED, LOG, and MANUAL.

- GENERAL – with the following settings:
 - Flow (LPM) (see Note below on flow-reporting standard)
 - TimeBase (seconds)
 - Select one of three radio buttons:
 - TA ATNmax - maximum attenuation at which the Aethalometer advances tape
 - TA INT - the time interval at which the Aethalometer advances tape (hours)
 - TA Time - the time at which the Aethalometer advances tape
 - Start, Stop, Stability, Clean Air, and Change Tape buttons
- ADVANCED – All parameters which can be set in the Aethalometer
- LOG – The last operational reports of status, parameter changes, data download
- MANUAL – Basic commands to operate hardware (solenoids, pump, chamber, TA)

DATA has two sub-tabs: TABLE and EXPORT.

- TABLE – Raw measurement values, BC concentration calculated from each individual spot (BC1, BC2), and the compensated BC concentration. All three concentrations have the unit ng/m³.
- EXPORT – Selection data to be copied to USB

ABOUT – Features and contact information.

4.2. Instrument Status

The instrument's current status condition is displayed in decimal format on the front panel **HOME** screen and in the **Status** column of the data download. The status condition relates to various subcomponents of the instrument (Detector, Flow, LED, etc.). The decimal number represents a sum of all of the status conditions occurring at any given time. Multiple status conditions are interpreted using subtraction of the largest possible Status Condition value using the table below.

Table C-1. Status Conditions and Descriptions

Parameter	Status Condition	Description
Detector	0	Measuring
	1	Not measuring (due to tape advance, fast calibration in progress)
	2	Calibrating (LED, Flow, Tape Sensors)
	3	Stopped
Flow		Flow OK
	4	Flow low/high by more than 0.25 LPM
	8	Flow check status history
	12	Flow low/high and check status history
LED		LEDs OK
	16	Calibrating
	32	Calibration error in one or more channels (at least one channel OK)
	48	LED error (all channels calibration error, COM error)
Tape Advance		Tape advance OK
	128	Tape warning (less than 10 spots left)
	256	Tape last warning (card box visible, less than 5 spots left)
	384	Tape error (tape not advancing, end of tape)
Tests		No test
	1024	Stability test
	2048	Clean air test
	3072	Change tape

When Status Condition 3 is encountered, the Aethalometer stops. In all other statuses, it continues to operate with a warning, and the data is flagged accordingly. The status is represented by one value, which can point to one parameter or a combination of parameters.

4.2.1. Single Status Condition

If the value displayed matches a value in the **Status Condition** column, it indicates only one parameter and its description. Examples:

- Status = 0, all OK; front panel LEDs GREEN
- Status = 1, all OK, tape advancing; blinking GREEN LED
- Status = 128, machine is running, tape advance warning flag is set; YELLOW

4.2.2. Multiple Status Conditions

If the Status displayed does not match a value in the table, it means that there are multiple parameters whose Status Conditions are added together, forming a sum that must be broken down by subtraction. First, find the largest value in the **Status Condition** column that does not exceed the Status value, and subtract it from the sum. Then find the next largest value in the **Status Condition** column that does not exceed the remainder, and subtract again. Continue finding the next largest number and subtracting it until the remainder matches a value in the **Status Condition** column.

Examples:

- Status = 289, which breaks down as follows: $289 - 256 = 33$; $33 - 32 = 1$; therefore, the Status Conditions are 256, 32, and 1. This means the machine is not measuring (1), the LED calibration had errors in 1 or more (but not all) channels (32), and less than 5 tape advances are left (256).
- Status = 145, which breaks down as follows: $145 - 128 = 17$; $17 - 16 = 1$; therefore, the Status Conditions are 128, 17, and 1. This means the machine is not measuring (1), the LED calibration is in process (16), and less than 10 tape advances are left (128).

4.3. Downloading or Viewing Data

To download data, insert the USB stick in either of the front USB ports. Do not use the rear ports, as they are intended for the mouse and keyboard only and not for data transfer (surge protection).

Go to the "DATA/EXPORT" menu and press **Export to USB**. The data will be stored in a text file with a header. The file name is:

AE33_Sss- nnnnn_yyyymmdd.dat

where *ss* is the production series number, *nnnnn* is the serial number, and *yyyymmdd* is the date (for example, 20120901 means 1 Sept 2012). Please make sure that the transfer is finished before removing the USB stick from the USB port on the Aethalometer. The data file can now be transferred to a personal computer like any other file and processed with any preferred data processing application.

5. Field Maintenance

Table C-2 describes maintenance actions, including cleaning and inspections and their required frequencies for routine system management.

Table C-2. Regular maintenance schedule.

Maintenance Action	Frequency
Inspect sample line tubing	Monthly, or during a site visit
Visually inspect the tape	Monthly, or during a site visit
Inspect and clean the size selective inlet	Monthly, or during a site visit
Inspect and clean the insect screen assembly	Monthly, or during a site visit
Perform leak test	Monthly, or after maintenance or repair
Flow verification test	Monthly, or after maintenance or repair
Flow calibration	Monthly, or if any flow from the flow verification summary is >10%
Check/set the instrument date and time	Monthly
Install new filter tape roll	As needed upon instrument warning
Biannual to Annual Actions	
Inspect optical chamber, clean if necessary	Every six months (or as needed)
Clean air test	Every six months
Stability test	Every six months
Inlet leakage test	Annually
Neutral Density (ND) filter test	Annually
Lubricate optical chamber sliders	Annually
Change bypass cartridge filter	Annually

5.1. Inspect Sample Line Tubing

Visually inspect the sample line tubing for condensation, cracks, kinks, or other structural damage. Replace if needed.

5.2. Inspect and Clean the Insect Screen Assembly



The insect and water trap is installed in the sample inlet line, at a point close to the instrument and clearly visible. This trap prevents the entry of contamination (which will compromise the data); or entry of water (either rain or condensation), which can lead to serious damage of the flow sensors. Visually inspect the trap and remove and clean as necessary.

5.3. Install New Filter Tape Roll

Supplies for this procedure: new roll of filter tape, adhesive tape. See Section 9.2 of the user's manual for reference.

When you observe an instrument warning of tape change needed, follow these instructions to change the tape. This should occur roughly every 6 weeks or so.

1. If the instrument is running, press **Stop** on the front panel.
2. Open the front door of the instrument.
3. Loosen the thumb screws and remove the transparent plastic covers from both the "supply" spool (on the left hand side), and the "collection" spool (on the right-hand side).
4. Using thumb and fingers on both sides of the optical chamber, lift the chamber upwards against its springs.
5. When the chamber is fully raised, lock it in place by pushing the metal latch.
6. Remove the used tape from both spools. Place used tape in a Ziploc bag.
7. Take the new filter tape and place it on the supply spool. Take note of the metal spring leaf, which stabilizes the top surface of the roll.

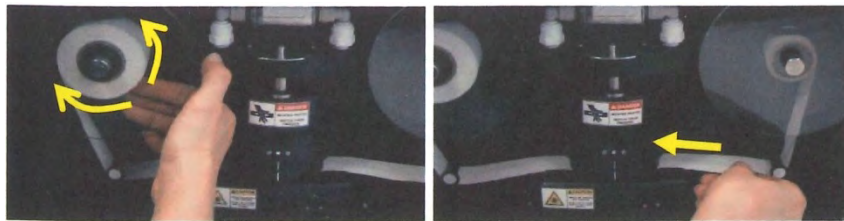


8. Make sure the roll is correctly oriented—the tape must unroll from the left-hand side.
9. Take the other cardboard spool center and attach the end of the filter to it using adhesive tape.

10. Place the empty center on the "take-up" spool axis (the right-hand side of the collection spool).



11. Make sure that the tape is fed beneath both the left and the right guide posts, and passes under the optical chamber.
12. Release the optical chamber by lifting up with thumbs and fingers on both sides. The spring-loaded latch will automatically release.
13. Replace both transparent plastic covers. Tighten the thumb screws by hand only.
14. Check that the left-hand supply spool can turn freely.
15. Make sure that the right-hand collection spool is firmly clamped to its axis: test by gently pulling the tape, and make sure the spool center does not move.



16. The filter tape replacement procedure is now completed. Press **Start** to resume operation.

5.4. Perform Leak Test

Supplies for this procedure: flow calibration pad, flow meter.

1. If the instrument is running, press **Stop** on the **Operation/General** screen.
2. On the **Operation/General** screen, press **Leakage test** to start the test.
3. A new screen appears. Choose **Manual**.
4. The instrument will measure the flow through the filter tape. Confirm by pressing **OK**.
5. Connect your external mass flow meter to the inlet port.
6. Connect the flow meter using well-sealed tubing and fittings. Make sure the connections are tight.
7. Press **OK**.
8. Choose the flow at which you want to perform the test. Normally this test is conducted at 5 LPM. Press **OK**.
9. Observe the flow measured by your flow meter.
IMPORTANT! Make sure that your flow readings are reported at the same "Standard" reporting conditions of Temperature (25°C) and Pressure (101325 Pa) that you are using in the Aethalometer. Many flow meters display flow at "actual" conditions (i.e. local T and P); and also display the same result corrected to "standard" conditions.

10. Press the input box field and enter the flow from the external flow meter.
IMPORTANT! Units are milliliters per minute (mLPM), not liters per minute (LPM).
11. Confirm by pressing **OK**.
12. Now measure the flow once again, but through the rubber flow calibration pad rather than the filter tape.
13. When prompted, remove the filter tape and install the rubber flow calibration pad with the notch facing toward you.
14. When ready, press **OK**.
15. Repeat the procedure as before when measuring the flow through the filter tape (Steps 4-11).
16. When finished, remove the flow calibration pad and replace the filter tape. Press **OK**.
17. The test is now complete. The report shows:
 - Instrument serial number
 - Date and time of the test
 - Results of the test: selected flow and flows through the filter tape and calibration padThis report is also saved on the CF card and is available for download with data files.
18. The leakage should be less than 10%. If the reported leakage is larger than 10%, contact Magee Scientific or your authorized distributor.

5.5. Perform Flow Verification Test

Supplies for this procedure: flow calibration pad, flow meter. See Section 9.3 in the user's manual for reference.

1. If the instrument is running, press **Stop** on the **Operation/General** screen.
2. Press the **Verify flow** button to start the test.
3. A new screen will appear. Choose **Manual**.
4. Measure the flow through the flow calibration pad.
5. Wait for the chamber to lift. When prompted, remove the filter tape and install the rubber flow calibration pad with the notch facing toward you.
6. When the pad is installed, press **OK**.
7. Connect the external flow meter to the inlet port using well-sealed tubing and fittings. Make sure that the connections are tight.
8. Press **OK**. The Flow Verification routine will measure the flow at three different values (approximately 1 LPM, 3 LPM, and 5 LPM), and compare the "internal" value (from the instrument's flow sensors) with the "external" value measured by the external flow meter.
9. Note the flow on your external mass flow meter.
IMPORTANT! Make sure that your flow readings are reported at the same reporting conditions of T and P as the instrument's setting.
10. Press the empty box marked **Flow** and enter the flow from the external flow meter.
IMPORTANT! Units are milliliters per minute (mLPM).
11. Confirm by pressing **OK**. The process will repeat at the three flow values.

12. After entering the last value (@5LPM) and pressing **OK**, the instrument will show the flow verification report. This report is also saved on the CF card and is available for download with data files.
13. The test is satisfactory if the difference of flow readings is less than $\pm 10\%$. If the difference is larger, re-calibration of the flow sensors is needed (see section 9.3 of the user's manual).
14. Confirm by pressing **OK**.
15. When prompted, remove the rubber flow calibration pad and re-install the filter tape. Press **OK** when done.

5.6. Perform Flow Calibration

Supplies for this procedure: Flow calibration pad (black rubber), flow meter.

1. If the instrument is running, press **Stop** on the **Operation/General** screen.
2. Press the **FlowCal** button to start the test.
3. A new screen will appear. Choose **Manual**.
4. The instrument will run through several procedures. The first is to measure the flow through the flow calibration pad.
 - If the rubber pad is already in place, you can press Skip.
 - If not, please wait for the chamber to lift. When prompted, remove the filter tape and install the rubber flow calibration pad with the notch facing toward you.
 - When the pad is installed, press OK.
5. Connect the external flow meter to the inlet port.
6. Connect the flow meter using well-sealed tubing and fittings. Make sure that the connections are tight. Press **OK**.
7. The instrument will measure the flow at three different points: close to 1 LPM, 3 LPM, and 5 LPM.
8. Observe the flow measured by your flow meter.
IMPORTANT! Make sure that your flow readings are reported at the same "Standard" reporting conditions of Temperature and Pressure that you are using in the Aethalometer.
9. Press the input box field and enter the flow from the external flow meter.
IMPORTANT! Units are milliliters per minute (mLPM), not LPM.
10. Confirm by pressing **Enter**.
11. After entering the last value (@ 5LPM) and pressing **OK**, the procedure is completed.
12. Remove the flow calibration pad and replace the filter tape. Press **OK** when done.
13. Press **Start** to resume sampling.
14. Repeat flow verification test.

6. Biannual Maintenance

Table C-3. Biannual maintenance schedule.

Maintenance Action	Frequency
Inspect optical chamber; clean if necessary	Every six months (or more frequently if needed)
Clean air test	Every six months
Stability test	Every six months
Inlet leakage test	Annually
Neutral Density (ND) filter test	Annually
Lubricate optical chamber sliders	Annually
Change bypass cartridge filter	Annually

6.1. Clean Optical Chamber

The optical chamber should be inspected if the data are uncharacteristically noisy. This procedure will ensure that there is no dust or contamination in the optical path. See Section 9.1 in the user's manual for reference.

Supplies: Can of dust-off spray, technical-grade ethanol, cotton swabs.

1. If the measurements are running, press **Stop**. This procedure can also be done when the instrument is powered off.
2. Open the front door to access the optical chamber.
3. Using thumb and fingers on both sides of the optical chamber, lift the chamber upward against its springs. When the chamber is fully raised, lock it in place by pushing the metal latch. The chamber is now locked.
4. Find the release button on the front of the chamber.
5. While pressing the release button upward, grasp the lower portion of the optical head and turn it clockwise so the front of the chamber moves to the left. The lower portion will loosen from its bayonet fitting and can be removed.
6. The lower portion of the optical head consists of a translucent block. Clean all surfaces with ethanol. Put a few drops of ethanol in the openings and remove any dust or debris by using soft cotton swabs.
7. Repeat this procedure from both sides.
8. Use compressed air to remove any debris from the openings.
9. To re-install the optical head, first align the notched marker to the left of center; push the optical head upwards to engage the three bayonet fittings; and turn counter-clockwise (so the front of the chamber moves to the right).

10. When the chamber is fully installed, the marker line will be at the front, and the locking pin will click back into place.
11. Using thumb and fingers on both sides of the optical chamber, lift the chamber upward. The locking latch will automatically release. Allow the chamber to return down to the tape.
12. Restart the instrument and resume measurements.

6.2. Perform Clean Air Test

The Clean Air test is conducted using the built-in filter to determine the stability and performance of the Aethalometer under the air flow conditions. The Clean Air test lasts for 20 minutes, during which time a Status Code of 2048 is shown. At the end of the test, a report is generated and saved to the CF card.

1. If the measurements are running, press **Stop**. If the Aethalometer is off, turn it on and wait a minimum of one hour for average BC values to stabilize.
2. Go to the **Operation/General** screen, and press the **Clean Air** button to start the test.
IMPORTANT: if you want the instrument to automatically proceed with BC measurements after the Clean Air test, please be sure to check the box "continue after test" before starting.
3. A new screen lists all relevant information about the test settings (test duration, flow, and timebase). When ready, press **OK**.
4. The instrument begins the test. The Clean Air test uses a built-in filter to determine the stability and performance of the Aethalometer under dynamic conditions of air flow. Air is drawn through a cartridge filter (mounted on the top of the optical chamber), and this particle-free air then flows through the analytical system.
5. After 20 minutes, the test stops automatically.
6. The Clean Air test procedure report is generated and appears on the screen. A separate report is generated and saved on the CF card for later download.
7. The test result is acceptable if the value of PPBC on Spot1 is lower than 550 ng/m³ for Channel 6. If the reported value of PPBC on Spot 1 is larger than this value, please contact Magee Scientific or your authorized distributor.
8. Confirm completion of the test by pressing **OK**. The **Average BC** values should be close to zero (less than ±100) if the Aethalometer is warmed up and stabilized for at least one hour. Occasionally, a short transient may be seen at first, due to a filter compression artifact.

6.3. Perform Stability Test

The stability test determines the performance of the light source and detector, without air flowing through the system. The Stability Test lasts for 20 minutes, during which time a Status Code of 1024 is shown. At the end of the test, a report is generated and saved to the CF card.

1. If the measurements are running, press **Stop**. If the Aethalometer is off, turn it on and wait a minimum of one hour for average BC values to stabilize.

2. Go to the **Operation/General** screen, and press the **Stability Test** button to start the test. **IMPORTANT: if you want the instrument to automatically proceed with BC measurements after the Stability Test, please be sure to check the box "continue after test" before starting.**
3. A new screen lists all relevant information about the test settings (test duration, flow, and timebase). When ready, press **OK**.
4. The instrument begins the test.
5. The test stops automatically after 20 minutes.
6. The Stability Test procedure report is generated and appears on the screen. A separate report is generated and saved on the CF card for later download.
7. The test result is acceptable if the value of PPBC on Spot1 is lower than 450 ng/m³ for Channel 6. If the reported value of PPBC on Spot 1 is larger than this value, please contact Magee Scientific or your authorized distributor.
8. Confirm completion of the test by pressing **OK**. The **Average BC** values should be close to zero (less than ± 100) if the Aethalometer is warmed up and stabilized for at least one hour.

6.4. Perform Inlet Leakage Test

Supplies: External flow meter.

The Inlet Leakage test is used to test the integrity of the inlet system, from the point of sample entry to the instrument's analytical area. In many cases, the sample entry point is outdoors, while the instrument is indoors. This test detects any leakage throughout the system.

The test routine compares two measurement values from an external flow meter: one taken at the rear port of the instrument, and the other taken at the sample point of entry (which may be outdoors). The routine requires the use of the black rubber Flow Calibration Pad. During this test, data will be flagged by status code 6144.

1. From the **Operation/General** screen, press **Inlet Leakage Test**.
2. Follow the instructions on the screen to insert the Flow Calibration Pad.
3. Measure the flows with an external flow meter at the two points.
4. When the test is finished, a report is generated. The leakage should be less than 10%. If the reported leakage is larger than 10%, please contact Magee Scientific or your authorized distributor.

6.5. Perform Neutral Density (ND) Filter Test

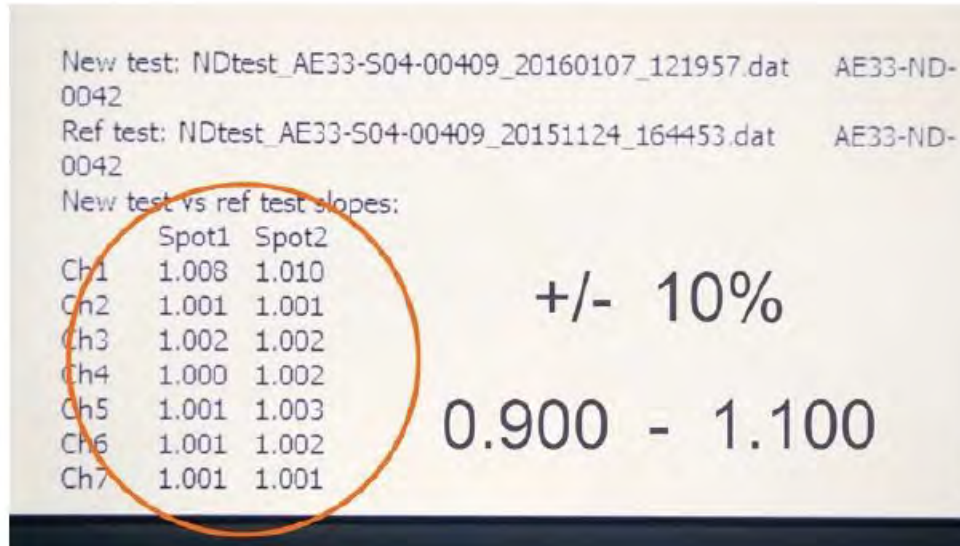
Supplies: ND filter test kit.

1. Go to the **Operation/General** screen on the Aethalometer. If the measurements are running, press **Stop**.
2. Press the **ND test** button to start the test.

3. A new screen prompts you to enter the ND Kit Serial Number, which is marked on the test kit box.
4. After entering the Serial Number of the ND Kit, confirm by pressing **Enter** and **OK**.
5. If this is the first time the ND Test has been performed on this instrument, you will be prompted for calibration parameters. These must be uploaded from the USB memory stick that is included in the ND kit box. Insert the USB stick into the USB port on the front panel, and press **Yes**.
6. The instrument will copy the calibration parameters file and then begin the test procedure.
7. Always keep the filter tape in position across the analytical area. When prompted, insert ND element No. 0 (zero) on top of the filter tape, with the "V" notch facing forward (see below). Do not touch the glass—hold the element by the metal studs.



8. Press OK when inserted. Watch the screen, and remove the filter disk when prompted.
9. Repeat the same procedure when prompted for ND elements Nos. 1, 2, and 3.
10. The test is complete after ND element No. 3 is removed.
11. The instrument will generate a report that shows the instrument serial number, the date and time of the test, and the results of the test. This report is also saved internally and is available for future download.
12. Report values on both Spot1 and Spot2 should be within $\pm 10\%$ of 1.000: i.e., between 0.9 and 1.1, for all seven wavelengths (Ch1 to Ch7). See below.
13. If the results fall outside this range, repeat the test. If the results still fall outside the range, contact Magee Scientific.



6.6. Lubricate Optical Chamber Sliders

Supplies: silicon grease, a cotton swab.

1. If the measurements are running, press **Stop**. This procedure can also be done when the instrument power is switched off.
2. Open the front door of the Aethalometer.
3. Put a small amount of grease on the cotton swab.
4. Apply the grease on all three sliders (vertical shafts) of the optical chamber (see below). Try to apply the grease uniformly over the whole length of the sliders.



5. Grasp the optical chamber with thumb and fingers on both sides, and move it up and down against its springs several times. This will distribute the grease over the full range of the sliders.



7. Troubleshooting

If there is an error code on the startup screen, refer to Section 13 of the manual for an extensive list of codes. Identify the code and problem from the list. Then, call STI.

Appendix D. Galvanic ProTech 903W Standard Operating Procedure



Standard Operating Procedure: Calibration of the Galvanic ProTech 903W with a VICI Metronics Dynacalibrator Model 120

August 6, 2019

Contact: Ryan Moffet
Sonoma Technology, Inc.
rmoffet@sonomatech.com
707-665-9900

Overview and Operating Principle

A permeation device will be used for the calibration of H₂S. Permeation devices are preferred over compressed gas cylinders because of their low cost, higher dynamic range, and portability. A VICI Dynacal 120 portable calibration gas generator will be used with the permeation devices to generate the zero and span checks. Permeation devices contain the pure calibration chemical in a two-phase equilibrium between the gas and liquid phases. The permeation device emits the calibration compound through a semi-permeable membrane at a known constant rate, provided the temperature is constant. One of the main functions of the Dynacal 120 is to keep the permeation device at a fixed temperature with a known carrier gas flow so that a constant, known gas concentration is generated. As recommended in the BAAQMD's Manual of Procedures (MOP), when the permeation devices are not being used, they will be stored under dry nitrogen at a temperature between 20° and 25°C. Prior to calibration, the permeation device will be allowed to equilibrate for 24 hours, as specified by the MOP. The permeation devices will be certified every six months either gravimetrically or against an acceptable reference method.

Figure D-1 shows a schematic of the Dynacalibrator 120 (Dynacal 120) dilution calibrator. The pump generates a flow of air through a scrubber to serve as dilution air that travels into the temperature-controlled permeation chamber. The temperature-controlled permeation tube chamber can be used to hold one or more permeation devices. The permeation chamber temperature is used to control the rate of diffusion from the permeation device. The temperature of the permeation chamber is set by the digital temperature controller on the front of the device (**Figure D-2**).

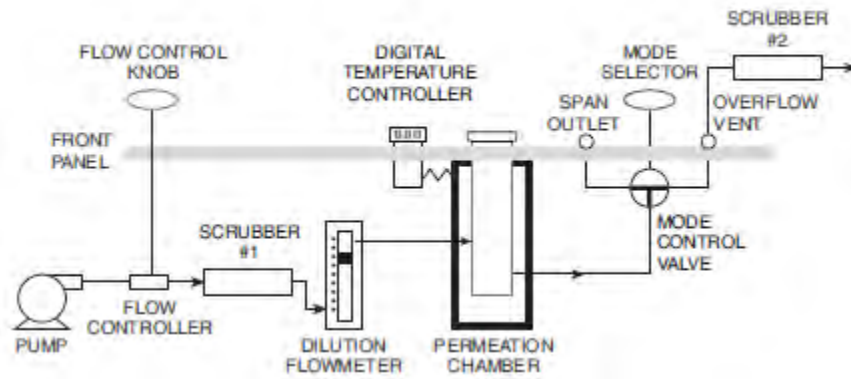


Figure D-1. Schematic of the Dynacalibrator 120 dilution calibrator.

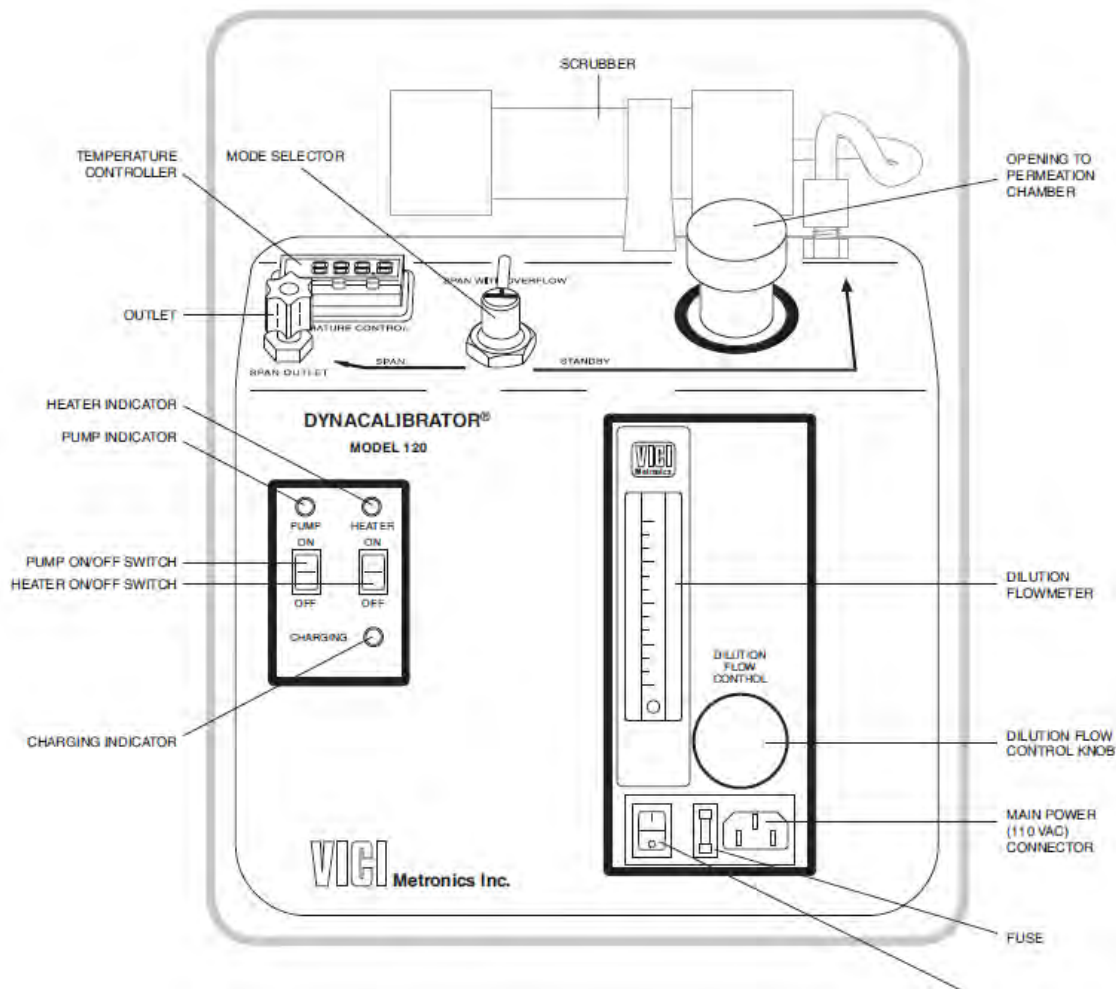


Figure D-2. The front panel of the Dynacal 120.

Concentration is calculated via the following equation:

$$\text{Concentration (ppm)} = \frac{K \times R_{perm}}{F}$$

Where K=24.45/M.W.(calibrant), R_{perm} is the permeation rate in ng/min (included with the permeation tube documentation), and F is the chamber carrier flow (mL/min). Flow must be corrected to standard temperature and pressure using:

$$F = (0.6262)F_c \sqrt{\frac{P}{T}}$$

Where F is indicated flow corrected to standard temperature and pressure, P is ambient pressure in mmHg, T is the temperature in Kelvin, and F_c is the calibrated flow when the flowmeter is at standard conditions.

Sample Calculation

Given: $R_{perm} = 20.17$ ng/min

Flow = 420 cc/min (from flow rate table of Dynacal 120 (Table D-1); this corresponds to a float setting of 0.40)

Ambient temperature = 17.5°C

Ambient pressure: 1013 hPa

H₂S gas M.W. = 34.081 g/mol

First, calculate the pressure: $1013 \text{ hPa} \left(\frac{100 \text{ Pa}}{1 \text{ hPa}} \right) \left(\frac{760 \text{ mmHg}}{101325 \text{ Pa}} \right) = 759.8 \text{ mmHg}$

Then, calculate the flow: $F = (0.6262) \times 420 \times \sqrt{\frac{759.8}{(273.15+17.5)}} = 425.23 \text{ mL/min}$

Now calculate the concentration:

$$\text{Concentration (ppm)} = \frac{K * R_{perm}}{F} = \frac{24.45 * 20.17}{34.081 * 425.24} = 0.03403 \text{ ppm (34.03 ppb)}$$

Supplies

1. Dynacal 120
2. Flow rate table for Dynacal 120
3. Large tweezers included with Dynacal 120
4. Certified permeation tube
5. ¼"ID x 5 cm PTFE wafer device spacer (tubing)
6. ¼" to 1/8" union for connecting to Galvanic
7. 1/8" to 1/8" union.
8. Length of 1/8" tubing with Swagelok nuts on both ends
9. 1/8" tee with a needle valve on one leg

Field Calibration

Initial Equilibration of the Permeation Device

1. Turn on the Dynacalibrator 120 by turning on the main power switch.
2. Turn on the pump and heater.
3. Put the Dynacal 120 on standby.
4. Set dilution flow to the lowest flow setting on the flow meter.
5. Set the temperature by pressing the UP and DOWN buttons on the temperature controller. Holding the buttons down longer will make the input temperature change faster.
6. If using a wafer permeation device, fit the 1/4" x 3.5 cm spacer on the non-permeating end of the stainless steel wafer device body. This positions the wafer device for optimal temperature control within the chamber.

NOTE: Be careful when placing the permeation device in the GLASS permeation chamber. Wafer devices are heavy and can break the permeation chamber if carelessly dropped inside.

7. Using forceps provided, GENTLY place the permeation device in the chamber, spacer end first. The wafer side should be facing upward.
8. Allow 30 minutes for the permeation chamber to equilibrate.

Span Calibration

This SOP is written for use with the Galvanic Applied Sciences ProTech instrument, which is diagrammed in [Figure D-3](#). The Dynacal is capable of producing 1000 cc/min span gas flow while the flow going to the tape in the ProTech sensor is only 62 cc/min. In order to adjust the flow, a needle valve must be attached to the span flow of the Dynacal system using an 1/8" tee fitting (the other end goes to the ProTech 903 W). To generate calibration gas in this mode of operation:

1. Notify FieldOpsAlerts@sonomatech.com and lowerpriorityops@sonomatech.com and request to disable alerts. You can also contact Gonzalo Parajon (ext 662). Ask for confirmation that alerts have been disabled prior to proceeding with the calibration.

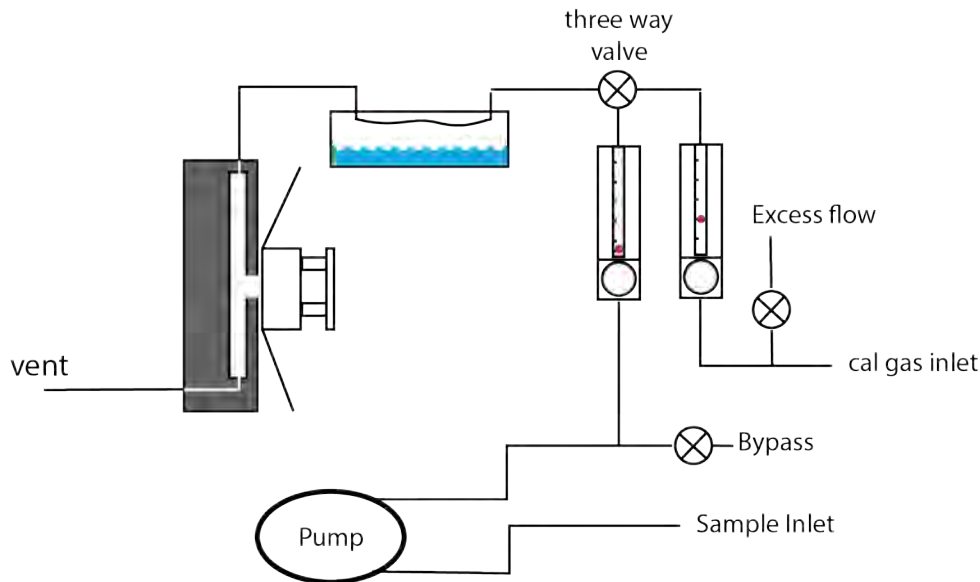


Figure D-3. The flow system of the Galvanic Applied Sciences ProTech 903W.

2. Connect a 1/8" tee to the calibration gas inlet of the ProTech instrument (just before the rotameter).
3. Connect a needle valve to one side of the tee and open it all the way.
4. Connect a sample line from the span outlet to the Dynacal.
5. Switch the mode selector on the Dynacal to **SPAN**.
6. Adjust the flow of the Dynacal such that it generates the desired concentration (using the example above, set to 0.40 for 34 ppb). At the same time, adjust the needle valve attached to the tee so that the rotameter of the Galvanic reads 2.0.
7. Once the concentration reading on the Galvanic has stabilized, allow the measurement to continue for 30 minutes.

The accuracy of the calibration is termed "% deviation" and is calculated as

$$\%Deviation = \frac{Analyzer\ Value - Reference\ Value}{Reference\ Value} \times 100\%$$

The acceptable limit for SO₂ calibrations is ±10% deviation, and the acceptable limit is ±15% for H₂S.

8. If the instrument is outside the acceptable limit of ±15%, adjust the gain according to the following equation:

$$\text{New Gain Factor} = \frac{\text{Calibration Gas Concentration (ppb)}}{\text{Current Analyzer Reading (ppb)}} \times \text{Current Gain Factor}$$

Zero Check

1. Remove the permeation device from the permeation chamber of the Dynacal system.
2. Connect a 1/8" tee to the calibration gas inlet of the ProTech instrument (just before the rotameter).
3. Connect a needle valve to one side of the tee and open it all the way.
4. Connect a sample line from the span outlet to the Dynacal.
5. Switch the mode selector on the Dynacal to SPAN.
6. Adjust the flow of the Dynacal to 0.40. At the same time, adjust the needle valve attached to the tee so that the rotameter of the Galvanic reads 2.0.
7. Once the concentration reading on the Galvanic has stabilized, allow the measurement to continue for 60 minutes. This data will be used to establish the zero precision of the instrument (3σ).

Standby Mode

When not in use, the Dynacal 120 can be placed in standby mode:

1. Set the mode selector to **STANDBY** position.
2. Turn the flow control knob counterclockwise to set the pump at the minimum setting.
3. Leave the permeation device in the chamber to maintain equilibrium until the next use.

Shut Down

1. Remove the permeation device from the chamber. For a wafer device, removal may be facilitated by inverting the entire Dynacal so that the device slides out.
2. Recharge the battery by connecting it to 120 VAC.

Table D-1. Example flow rate table for the Dynacal 120.

Float Setting	Calibrated Flow (cc/min)	Concentration Given (T=21C, P=1013 hPa)
0.2	241	59.66
0.4	420	34.23
0.6	622	23.12
0.8	840	17.12
1	1041	13.81

Appendix E. Standard Operating Procedures for Meteorological Instruments at the Chevron El Segundo Refinery

Appendix E. Standard Operating Procedures for Meteorological Instruments at the Chevron El Segundo Refinery

September 20, 2019

STI-919016-7179-SOP

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Contents

1. Scope and Applicability	E-4
2. Routine Service and Maintenance	E-4
2.1 Maintenance Checklist.....	E-5
2.2 Securing the Shelter	E-7
3. Calibration and Standard Operating Procedures for Meteorological Sensors	E-7
3.1 Wind Direction Calibration	E-8
3.1.1 Materials Needed	E-8
3.1.2 Procedure.....	E-8
3.2 Wind Speed Calibration	E-9
3.2.1 Materials Needed	E-9
3.2.2 Procedure.....	E-9
3.3 Temperature Calibration	E-10
3.3.1 Materials Needed	E-10
3.3.2 Procedure.....	E-10
3.4 Relative Humidity Calibration	E-11
3.4.1 Materials Needed	E-11
3.4.2 Procedure.....	E-11
3.5 Visibility Sensor Calibration.....	E-12
3.5.1 Materials Needed	E-12
3.5.2 Startup Checklist	E-12
3.5.3 System Verification Procedure.....	E-12
4. References	E-15

1. Scope and Applicability

This standard operating procedure (SOP) provides instructions for servicing the meteorological instruments at the Chevron El Segundo Refinery in El Segundo, CA. STI will install two standard 10-m meteorological towers for instruments that will measure wind speed, wind direction, temperature, relative humidity, and visibility. The towers will be integrated into the monitoring shelter design for stability. **Table E-1** lists the equipment make and model that will be installed on the towers; operating procedures for these instruments are listed in Section 3.

Table E-1. Meteorological equipment list.

Parameter	Manufacturer
Wind Speed / Direction	RM Young, Model 5305
Ambient Temperature / Relative Humidity, 2-m	Campbell Scientific, Model EE181
Visibility Sensor	Campbell Scientific, Model CS120A

2. Routine Service and Maintenance

Routine service tasks are designed to maintain the meteorological equipment in good working condition, which should lower the frequency of non-routine maintenance. The routine service tasks are described below. The site should be serviced once every two to four weeks. If no problems are encountered, the site visit will take about one hour.

2.1 Maintenance Checklist

Table E-2 depicts the maintenance activities that must be performed during each site visit to ensure all instruments are performing correctly.

Table E-2. Routine quarterly maintenance checklist.

Item	Action
Tower ^a	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.
Visibility	Visually inspect the system, including all cables.
	Inspect optics on detector and clean if necessary.
	Check calibration. An acceptable % accuracy is less than 25%
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/ Sensor 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.
	Check that the cable connections are secure.
	Clean the glass domes on the sensors with an alcohol wipe or a soft, clean towel and water. Replace the silica gel desiccant when needed (it will turn from blue to pink when it needs to be replaced).
	Check that the air intake tube at the bottom of the pressure sensor housing is not blocked. Clean with cotton swab and water if needed.
	Check that cable connections are secure.
Data Logger Enclosure	Verify that the enclosure is secured inside the shelter and is operational.
	Check that the cabling to the enclosure is secure and undamaged.
Cables	Check the integrity of the cables connecting the data logger box from the data logger to the sensors.
	Check that the sensor cables are attached to the tower.
Guy Wires	Where guy wires are used, check that they are taut and that the attachment points are tight. If the attachment points are loose, call STI for instructions.

^a Lowering the meteorological tower is not necessary for routine site maintenance visits. Do not attempt to lower the tower with fewer than two people.

After physically inspecting the meteorological sensors, the technician should

- Record the current weather observations on the Maintenance Site Visit form. This observation should include general wind direction, wind speed, approximate temperature, clouds, current weather, and the time. For example, an observation might read:

“Moderate southwest breeze, temps in the 50s F, damp with fog and rain at 1030 PST”

- Observe all of the meteorological data parameters on the data logger screen and determine whether or not they are physically plausible and reasonable (i.e., is a value that should be positive shown as negative, etc.).
- Monitor wind speed and wind direction on the screen and compare with the visually estimated orientation of the wind monitor and strength of the wind. **Note:** The typical range for wind speed is 0 m/s to 10 m/s. Use [Tables E-3 and E-4](#) to help estimate wind speed and temperature.

Table E-3. Wind speed estimation.

Description	Wind Speed Range (m/s)	How to Estimate Speed
Calm	0 to 0.2	Calm, smoke rises vertically
Light air	0.3 to 1.5	Smoke drifts with the wind
Light breeze	1.6 to 3.3	Wind felt on face; leaves rustle
Gentle breeze	3.5 to 5.4	Leaves and small twigs in constant motion; wind extends light flags
Moderate breeze	5.5 to 7.9	Raises dust and loose paper; small branches are moved
Fresh breeze	8.0 to 10.7	Small trees with leaves begin to sway

Table E-4. Temperature conversions.

	Temperature											
°F	25	30	35	40	45	50	55	60	65	70	75	80
°C	-4	-1	2	4	7	10	13	16	18	21	24	27

- If any parameter appears unreasonably high or low, or simply implausible, try to identify the cause (check cables, connections, etc.). If you cannot find the source of the problem, contact STI.

2.2 Securing the Shelter

Turn off the computer’s display monitor, and record your completion time in the Site Log form. Turn off the shelter lights and lock the shelter.

3. Calibration and Standard Operating Procedures for Meteorological Sensors

Quarterly audits will be conducted for the meteorological station. Each year, two of these audits will be conducted internally by STI, and two will be conducted by a third-party auditor. 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), Volumes I, II, and IV* (U.S. Environmental Protection Agency, 2017b, 1994, 2008) and in accordance with the *Technical Assistance Document for the National Air Toxics Trends Stations Program, Revision 3* (U.S. Environmental Protection Agency, 2016a) and the *Technical Assistance Document for Sampling and Analysis of Ozone Precursors for the Photochemical Assessment Monitoring Stations Program, Revision 2* (Battelle, 2018).

As part of the calibration process, each instrument will first be 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 will 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. The performance criteria for meteorological sensors are listed in [Table E-5](#).

Table E-5. EPA-recommended meteorological specifications.

Meteorological Variable	Recommended Accuracy	Measurement Resolution
Wind Speed	±0.2 m/s	0.2 m/s
Wind Direction	±5°	3°
Ambient Temperature	±0.5°C	0.3°C
Relative Humidity	±5% RH	1.0% RH
Barometric Pressure	±1 hPa	0.3 hPa
Vertical Temperature Difference	±0.1°C	0.1°C
Solar Radiation	10 W/m ³ below 200 W/m ³ above 200 W/m ³ ±5%	1.0 W/m ²

3.1 Wind Direction Calibration

The wind direction calibration will be performed by comparing the wind direction sensor readouts on the data acquisition system (DAS) and chart recorder (if applicable) with known wind directions established by using a theodolite or precision compass. Several points over the measurement range will be verified using a calibration fixture, assigned compass reference points, or established distant sighting targets. Differences between reference and sensor measured directions will be recorded. The starting threshold for the direction vane will be checked using a torque disc or watch gauge.

3.1.1 Materials Needed

- Pocket transit or precision compass with tripod
- RM Young Model 18212 Vane Angle Fixture
- RM Young Model 18331 Vane Torque Gauge
- Current magnetic declination angle for the site to be calibrated

3.1.2 Procedure

Calibration procedures are in accordance with the guidelines of the *EPA Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV, Version 2.0 Final* (U.S. Environmental Protection Agency, 2008b).

1. For wind direction instruments that have crossarms, prior to lowering the tower or the crossarm, determine the crossarm alignment by sighting along it using a precision compass corrected for magnetic declination. Current magnetic declination should be obtained using the latitude/longitude or UTM coordinates of the site and a magnetic declination calculation computer program. Optionally, if a solar viewing is possible, a theodolite can be set up and oriented using a solar angle computer program. Using this method, a technician can view the crossarm through the theodolite to verify alignment with reference to True North.
2. Once the crossarm is lowered, position the wind vane exactly parallel to the crossarm and record the reading.
3. Determine the sensor's accuracy and linearity by mounting a direction template or calibration fixture, and fixing the vane in 30-degree increments around the full 360- or 540-degree range of the sensor. The vane will be rotated sequentially through the increments clockwise and counter-clockwise, and the DAS readouts will be recorded. The tip and the tail of the vane may also be pointed at established distant sighting targets.
4. The difference between the station and calibration wind directions is calculated using the following equation:

$$\text{Difference} = \text{Station Wind Direction} - \text{Reference Wind Direction}$$

The differences calculated above will be compared with the EPA State and Local Air

Monitoring Stations (SLAMS)—recommended criteria of "5E for the entire system" (orientation plus linearity). If results exceed these criteria, recalibrate the sensor or replace the potentiometer or sensor.

5. Determine the starting threshold of the wind vane by measuring the shaft rotational torque of the sensor using a torque gauge or disc. The measured torque should be less than the maximum allowable torque provided by the manufacturer corresponding to a 0.5 m/s wind speed threshold.

If the measured torque exceeds this value, replace the bearings or sensor. If necessary, calculate the torque value that corresponds to the starting threshold of 0.5 m/s for a 10E deflection by using the "k" value provided by the manufacturer and the following equation:

$$T = kU^2 \text{ (Where: } T = \text{torque in gm-cm, } U = \text{wind speed in m/s, and } k = \text{constant)}$$

This torque gauge test determines if the wind vane starting threshold is less than or equal to the required specifications. The wind vane is considered to be within the recommended criteria if the indicated torque value is less than or equal to the calculated or stated maximum starting torque value.

3.2 Wind Speed Calibration

The wind speed calibration will be performed by temporarily replacing the anemometer cups or propeller with a synchronous motor, and comparing the speed corresponding to the rotation rate (supplied by the manufacturer) with the equivalent wind speed displayed by the instrument and recorded by the DAS. Starting thresholds will be checked using a torque disc to measure shaft rotational torque.

3.2.1 Materials Needed

- RM Young Model 18810 anemometer drive
- RM Young Model 18310 Torque Disc

3.2.2 Procedure

Calibration procedures conform to the guidelines of the *EPA Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV, Version 2.0 Final* (U.S. Environmental Protection Agency, 2008b).

1. The starting threshold will be calibrated by checking the sensor shaft's rotational torque with a torque disc. With the anemometer sensor in the horizontal position, remove the propeller and install the RM Young Model 18310 Torque Disc on the anemometer shaft. Use the manufacturer-provided allowable torque values, or calculate the torque value that corresponds to the starting threshold of 0.5 m/s using the "k" value provided by the

manufacturer and the following equation:

$$T = kU^2 \text{ (Where: } T = \text{torque in gm-cm; } U = \text{wind speed in m/s; and } k = \text{constant)}$$

Install the 0.1 gm screw weight in the appropriate hole of the torque disc that corresponds to the calculated torque value, and position the weight so that it is level with the anemometer shaft. Release the weight and note whether the torque disc and anemometer shaft rotate freely. To measure the actual starting torque, change the position of the screw weight starting at the location closest to the shaft, and move outward until the weight rotates freely from the horizontal. The weight of the screw multiplied by the distance from the shaft equals the torque in gm-cm.

2. The accuracy of wind speed measurements will be tested at zero and at least two speeds within the operational range of the sensor. The RM Young Model 18810 selectable speed anemometer drive will be used to generate stable calibration input speeds over the range of the sensor. Remove the propeller and join the wind speed sensor shaft to the calibration motor with a coupling device.
3. Calculate the difference between the system and calibration wind speeds using the following equation:

$$\text{Difference} = \text{Station Wind Speed} - \text{Reference Wind Speed}$$

The differences calculated above will be compared with the EPA SLAMS recommended criteria of "0.25 m/s when speeds are ≤ 5 m/s; $\pm 5\%$ when speeds are > 5 m/s, not to exceed ± 2.5 m/s."

3.3 Temperature Calibration

3.3.1 Materials Needed

- A NIST-traceable digital thermometer
- Three thermos bottles—one with hot water, one with warm water, and one with ice

3.3.2 Procedure

Calibration procedures are in accordance with the guidelines of the *EPA Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV, Version 2.0 Final* (U.S. Environmental Protection Agency, 2008b).

1. Temperature sensing systems will be calibrated by collocated intercomparison with a calibrated reference standard.
2. If immersion in water is possible:
 - a. The station temperature sensing system thermistor and the calibrated audit thermometer will be immersed in a common stirred water bath.

- b. Readings will be compared at 3 points over the expected temperature range.
3. If delta-temperature is measured, simultaneously insert both temperature sensors in the same medium and compare the outputs.
4. Calculate the difference between the station and audit temperatures using the following equation:

$$\text{Difference} = \text{Station Temperature} - \text{Reference Temperature}$$

5. The differences calculated above will then be compared with the EPA-recommended criteria of 1.0°C. If the delta temperature is calibrated, the difference between the output of the two sensors is compared with the EPA-recommended criteria of 0.1°C.

3.4 Relative Humidity Calibration

3.4.1 Materials Needed

- Calibrated digital relative humidity (RH) probe, or a Sato or similar motor aspirated psychrometer
- Booklet of psychrometric tables and a portable barometer (if motor aspirated psychrometer is being used)
- Water
- Large plastic bucket (approx. 5 gallon size)

3.4.2 Procedure

Calibration procedures are in accordance with the guidelines of the *EPA Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV, Version 2.0 Final* (U.S. Environmental Protection Agency, 2008b).

1. The relative humidity calibration will be performed by collocating the calibrated RH sensor or motor-aspirated psychrometer adjacent to the site sensor. The sensors will be placed in a shaded location and allowed to equilibrate.
2. Multiple readings will be taken over several hours. If an aspirated psychrometer is used, the readings will be converted into RH using the manufacturer's tables.
3. Calculate the difference between the station and reference relative humidity readings using the following equation:

$$\% \text{ RH Difference} = \text{Station \% RH} - \text{Reference \% RH}$$

4. Compare the mean of the percent differences calculated above with the EPA-recommended criteria of 10% relative humidity.

3.5 Visibility Sensor Calibration

3.5.1 Materials Needed

- Microfiber cloth
- Calibration bungs
- Calibration disk
- Micro-USB to USB-A cable

3.5.2 Startup Checklist

Verify that the following actions are completed when starting up the Campbell Visibility Sensor:

___ Verify that serial connections to the datalogger are correct (sensor TX to logger RX, sensor RX to logger TX, and sensor ground to any ground terminal on the logger).

___ Check datalogger to see if data is coming from the sensor.

___ Check the data to make sure it makes sense (visibility value is a reasonable number and the correct values are being recorded to the right parameters).

___ Make sure the lenses are clean and clear of obstructions (spider webs, etc.).

___ Use a microfiber cloth (you can use a blower first). Do not use abrasive cleaners; use isopropyl alcohol only if needed.

3.5.3 System Verification Procedure

The following tests will be performed as a verification of analyzer operation.

Calibration Prep

The sensor can be checked and adjusted using the optional sensor high-grade calibration kit Part Number 28678 from Campbell Scientific. The calibration must be run using the onboard menu system. You can access this menu via LoggerNet's terminal emulation program using the port the sensor is connected to. For more information on how to use this program, see LoggerNet's documentation, which can be accessed on Campbell Scientific's website.

The test should ideally be performed under the following conditions:

- Ambient temperature should be between 0°C and 50°C.
- The local visibility should be approximately 10,000 meters or more.

The system is self-regulating. However, it is recommended that the sensor be calibrated at least every two years.

The calibration is performed from Menu Item 3 on the main terminal screen.

Once you have selected Menu Item 3, the following screen should appear.

```
CS125 CALIBRATION - MENU 3
ID 0
S/N 1006
(1) Perform calibration
(2) Restore the factory calibration
(3) Perform dirty windows zero offset calibration
(4) Restore dirty windows factory calibration

(9) Refresh
(0) Return to main menu
```

Select Option 1 to start the calibration. You will then be asked to confirm that you would like to perform a calibration. Please note that once you have entered "Yes," you will not be able to exit until the test is complete. However, power cycling the unit at this point will have no adverse effect on the sensor.

Once you have started the tests, you will be asked for the sensor calibrator serial number and coefficient with a confirmation at each step giving you the chance to correct typing mistakes.

```
Starting calibration.
Input the sensor calibrator serial number ->E2002
Is E2002 correct? (Y/N)?
Input the sensor calibrator constant ->28.8
Is 28.8 correct? (Y/N)?
```

Place one calibration bung into each hood, and then press any key.

Dark Level Calibration

When you have entered the calibrator information, the sensor will wait for you to place the foam bungs into the sensor hoods. The bungs are designed to block all light from the outside from reaching inside the head. Place one bung into each hood. If either of the bungs is damaged or appears to have any gaps around the edge, contact Campbell Scientific.

Starting dark level calibration.
This test will take approximately two minutes

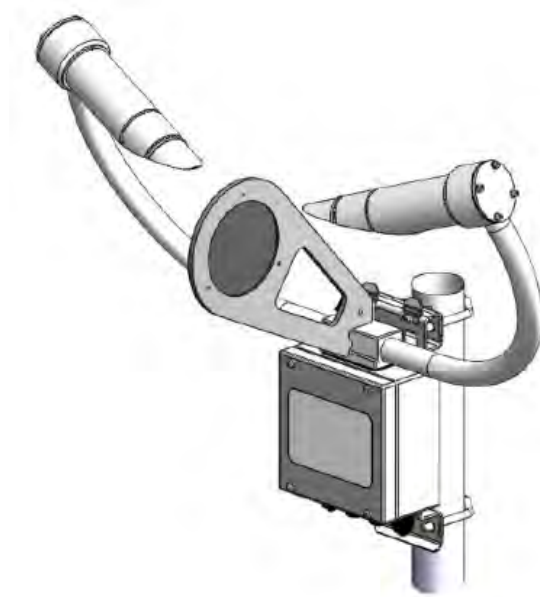
This part of the test will take approximately two minutes. Every ten seconds, a dot should appear indicating that the test is progressing as normal.

Dark level test complete. Please remove the bungs.
Now place the sensor calibrator into the sampling volume.
Press any key once this is done.

Remove the bungs once the sensor instructs you to.

Light Level Calibration

Place the sensor calibrator into the volume by fastening it to the central mounting point.



Starting light level calibration.
This test will take approximately two minutes.

This part of the test will take approximately two minutes. Every ten seconds, a dot should appear indicating that the test is progressing as normal.

```
Calibration is now complete.  
Saving user settings  
Press any key to exit.
```

Once the second stage of the test has been completed, the new calibration constants will be saved automatically. All calibration constants, including both the user and the factory setting, can be viewed from Menu Item 4 from the main menu once the test is completed. Document the new user calibration constant and the factory setting each time a calibration is done.

REMEMBER to remove the calibration disk once finished.

4. References

- U.S. Environmental Protection Agency (1994) Quality assurance handbook for air pollution measurement systems, Volume I: a field guide to environmental quality assurance. Report prepared by the U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA/600/R-94/038a. Available at <https://www3.epa.gov/ttn/amtic/qalist.html>.
- U.S. Environmental Protection Agency (2008a) Quality assurance handbook for air pollution measurement systems, Volume II: ambient air quality monitoring program. 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-08-003, December. Available at <http://www.epa.gov/ttn/amtic/files/ambient/pm25/qa/QA-Handbook-Vol-II.pdf>.
- U.S. Environmental Protection Agency (2008b) 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>.
- U.S. Environmental Protection Agency (2016) Technical assistance document for the National Air Toxics Trends Stations Program, Revision 3. Prepared for the Office of Air Quality Planning and Standards, Research Triangle Park, NC, by Battelle, Columbus, OH, October. Available at https://www3.epa.gov/ttnamti1/files/ambient/airtox/NATTS%20TAD%20Revision%203_FINAL%20October%202016.pdf.
- U.S. Environmental Protection Agency (2017) Quality assurance handbook for air pollution measurement systems, Volume II: ambient air quality monitoring program. 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-17-001, January. Available at <https://www3.epa.gov/ttnamti1/qalist.html>.