Rule 1180 Refinery Fenceline Air Monitoring Plan Guidelines

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Diamond Bar, California

November 2017

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1. Background

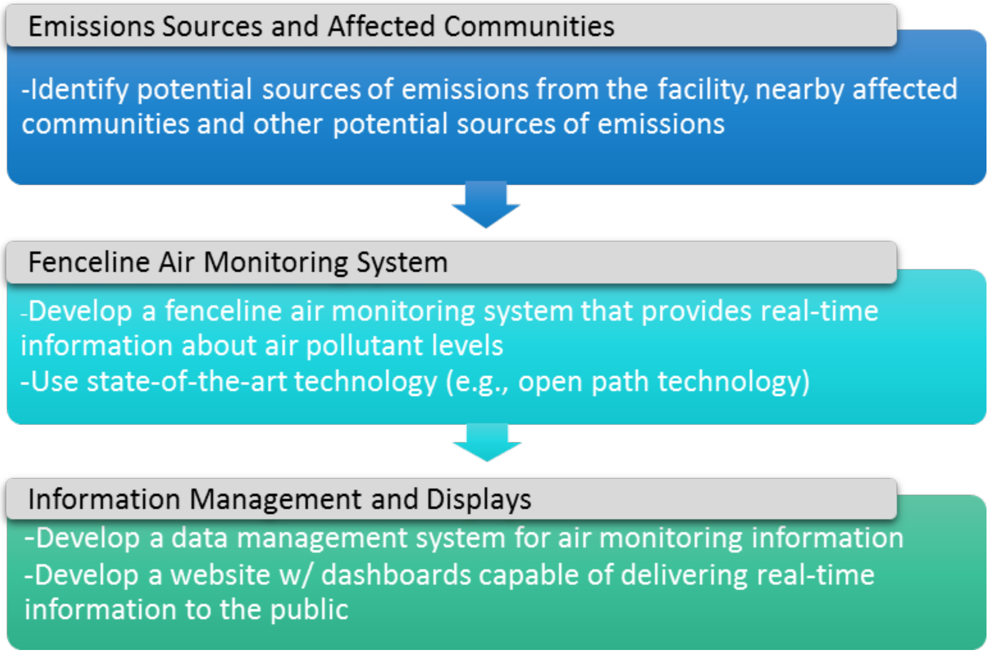
The South Coast Air Quality Management District (SCAQMD) Governing Board adopted Rule 1180 – Refinery Fenceline and Community Air Monitoring on (date of adoption). The purpose of Rule 1180 is to require real-time fenceline air monitoring systems and to establish a fee schedule to fund refinery-related community air monitoring systems that provide air quality information to the public and local response agencies 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.

Rule 1180 requires that refinery operators submit a written fenceline air monitoring plan (air monitoring plan) for establishing and operating a continuous, real-time fenceline air monitoring system. Therefore, SCAQMD staff developed the Rule 1180 – Refinery Fenceline Air Monitoring Plan Guidelines (Guidelines) as a written framework to be used by the Executive Officer to evaluate air monitoring plans required by Rule 1180. By design, these Guidelines will inform petroleum refinery operators subject to the Rule 1180 about the elements necessary to complete an air monitoring plan. SCAQMD recognizes the need for flexibility when designing an air monitoring plan, therefore, each plan will be evaluated on a case-by-case basis and tailored to each facility's size, operations, specific location, and its surrounding receptors. Therefore, a fenceline air monitoring system must be representative of the size of the affected facility and its emissions.

A fundamental requirement of Rule 1180 is that an air monitoring plan must provide detailed information about the installation, operation and maintenance of a fenceline air monitoring system. A fenceline air monitoring system is defined as a combination of equipment that measures and records air pollutant concentrations at or near the property boundary of a petroleum refinery. An effective fenceline air monitoring system should be capable of measuring routine emissions from refineries and detecting leaks, as well as unplanned releases from refinery equipment and other sources of refinery-related emissions. The fenceline air monitoring system would inform refinery operators and the public about air pollution impacts to nearby communities from refinery operations.

Developing an air monitoring plan requires three important steps; identification of emissions sources and affected communities, deriving a fenceline air monitoring system that can provide real-time information about certain air pollutant levels, and effectively communicating this information using data management technology and displays. Figure 1 - Overview of Key Steps to Developing an Air Monitoring Plan, below outlines important considerations for developing a fenceline air monitoring system.

Figure 1: Overview of Key Steps to Developing an Air Monitoring Plan



An approvable air monitoring plan shall meet the following key objectives:

- Provide continuous information about various air pollutant levels (i.e., determined by air pollutant concentration) measured in real-time in durations short enough to adequately address significant emissions changes from refinery operations;
- Gather accurate air quality and meteorological data to identify both the time(s) and location(s) of various air pollutant levels near refinery operations and provide a comparison of these levels to other pollutant levels monitored in the Basin;
- Track long-term air pollutant levels, variations, and trends over time at or near the property boundaries of petroleum refineries and in nearby communities;
- Provide context to the data so that local communities can distinguish air quality in their location from other locations in the Basin and understand the potential health impacts associated with local air quality near petroleum refinery operations;
- Provide a notification system for communities near refineries when emissions exceed thresholds (e.g., RELs); and
- Provide quarterly reports summarizing the measurements, data completeness, and quality assurance.

Rule 1180 sets-forth requirements for air monitoring plans. The air monitoring plan shall include detailed information for the following:

- 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);
- An analysis of the distribution of operations and processes within the refinery to determine potential emission 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);
- A summary of open-path air monitoring instruments and ancillary equipment that are proposed to continuously measure, monitor, record, and report air pollutant levels in real-time near the petroleum refinery facility perimeter (i.e., fenceline);
- A summary of instrument specifications, detectable pollutants, minimum and maximum detection limits for all air monitoring instruments;
- Proposed monitoring equipment siting and selected pathways for open-path instruments, including the justification for selecting specific locations based on the assessments mentioned above;
- Operation and maintenance requirements for the proposed monitoring systems;
- An implementation schedule consistent with the requirements of Rule 1180;
- Procedures for implementing quality assurance and quality control of data;
- A web-based system for disseminating information collected by the fenceline air monitoring system;
- Details of the proposed public notification system; and
- Demonstration of independent oversight.

This information will assist the Executive Officer in determining the approval status of an air monitoring plan during the plan review process required by paragraph (f) of Rule 1180.

2. Fenceline Air Monitoring Systems

Pursuant to the requirements of Rule 1180 discussed above, development of a fenceline air monitoring system shall take into account geospatial layout of the refinery site, potential release sources, local meteorology, atmospheric dispersion characteristics of the compounds of concern, the relative risk to likely receptors based on these criteria, and other considerations outlined below.

Fenceline Air Monitoring Plan Checklist	
Fenceline Air Monitoring Coverage (or Spatial Coverage)	
☑	Identify the facility’s proximity to sensitive receptors affected by the refinery operation and provide the information below.
	o Distance from facility to closest sensitive receptor(s)

	o Location of downwind and upwind communities
	o Eminent sources of non-refinery emissions surrounding the facility (e.g. non-refinery industrial facilities)
	o Dispersion modeling†
☑	Describe historical facility emission patterns and pollutant hotspots based on the following:
	o On-site location of operations and processes within the facility's perimeter
	o On-site location of emissions sources and level of emissions
	o Facility plot plans and topography
	o Dispersion modeling†
☑	Select sampling locations along the perimeter of the facility based on the information above. Also, provide the following:
	o Locations where equipment will be sited (e.g., GIS coordinates) and measurement pathways
	o Elevations of equipment and pathways
	o A description of how the monitoring system will cover all nearby downwind communities
Fenceline Air Monitoring Equipment Description	
☑	Select open-path air monitoring equipment that is capable of continuously measuring air pollutants in real-time and provide the following:
	o Specifications for the open-path instruments (e.g., detection limits, time resolution, etc.)
	o Explanation of the operation and maintenance requirements for selected equipment
	o Substantiate any request to use alternative technologies
☑	Monitor for the pollutants listed in Table 1 of Rule 1180 and include the following:
	o Specify pollutant detection limits for all instruments and paths measured
	o Substantiate any exclusion of chemical compounds listed in Table 1 of Rule 1180 or the use of an alternative air monitoring technology
Quality Assurance	
☑	Develop a Quality Assurance Project Plan (QAPP) that describes the following:
	o Quality assurance procedures for data generated by the fenceline air monitoring system (e.g. procedures for assessment, verification and validation data)
	o Standard operating procedures (SOP) for all measurement equipment
	o Routine equipment and data audits
Data Presentation to the Public	
☑	Design a data display website that includes the following:
	o Educational material that describes the objectives and capabilities of the fenceline air monitoring system

	o A description of all pollutants measured and measurement techniques
	o A description of background levels for all pollutants measured and provide context to levels measured at the fenceline
	o Procedures to upload the data and ensure quality control
	o Definition of QC flags
	o Hyperlinks to relevant sources of information
	o A means for the public to provide comments and feedback; Procedures to respond
	o Archived data that with data quality flags, explains changes due to QA/QC and provides chain of custody information
	o Quarterly data summary reports, including relationship to health thresholds, data completeness, instrument issues, and quality control efforts
Notification System	
☑	Design a notification system for the public to voluntarily participate in that includes the following:
	o Notifications for activities that could affect the fenceline air monitoring system (e.g., planned maintenance activities or equipment failures)
	o Notifications for the availability of periodic reports that inform the community about the air and provide updates on the performance and maintenance of the fenceline air monitoring system
	o Triggers for exceedances in thresholds (e.g. Acute Reference Exposure Levels (RELs))
	o Communication methods for notifications, such as, website, mobile applications, automated emails/text messages and social media

†Dispersion modeling shall be conducted using U.S. EPA's Preferred and Recommended Air Quality Dispersion Model (e.g., Health Risk Assessment)

Details about each of these key considerations are explained below.

a. Multi-Pollutant Monitoring

Multi-pollutant monitoring is a means to broaden the understanding of air quality conditions and pollutant interactions, furthering capabilities to evaluate air quality models, develop emissions control strategies, and support research, including health studies. Petroleum refineries and activities associated with them emit a wide range of air pollutants, including criteria pollutants (SO_2, NO_X, CO, and PM); volatile organic compounds (VOCs), including photochemically reactive VOCs that contribute to formation of tropospheric ozone (e.g., ethylbenzene, formaldehyde); carcinogenic hazardous air pollutants (e.g., benzene, 1,3-butadiene, naphthalene, polycyclic aromatic hydrocarbons, formaldehyde); non-carcinogenic air toxics (hydrogen fluoride, hydrogen cyanide); persistent bio-accumulative toxics (mercury), and other air pollutants (e.g., hydrogen sulfide and carbonyl sulfide).

Chemical compounds associated with health risk and those measured at other ambient air monitoring locations should be identified in the air monitoring plans. Identification of the health risk drivers can be informed by the health risk assessment studies performed at the refineries, as well as other information regarding potential health risk near refineries. At the minimum, compounds listed in Table 1 below, shall be considered for the fenceline air monitoring as part of the air monitoring plan. Therefore, exclusion of any of these chemical compounds must be thoroughly explained and justified within the Air Monitoring Plan. Additional chemicals may be of interest to monitor as a part of the fenceline air monitoring system, for example, if certain annual emissions exceed 10,000 lbs/year. Other chemicals may also be inherently monitored by the open-path systems and may be included in the reporting for additional public information.

i. Chemical Species of Interest

The California Environmental Protection Agency's (CalEPA) Office of Environmental Health Hazard Assessment (OEHHA) is collaborating with the California Air Resources Board (ARB) and the Interagency Refinery Task Force to identify and develop information on chemicals emitted from refineries and their health effects in order to assist air agencies in developing plans for air monitoring at refineries in California. OEHHA published the draft report[1] in September 2017 that presents a comprehensive list of chemicals emitted from California refineries, including emissions that occur routinely in daily operations, as well as accidental and other non-routine emissions. The list prioritizes the chemicals according to their emissions levels and toxicity, providing a list of chemicals that would be top candidates for air monitoring near refineries according to the volume of the chemicals emitted and their toxicity. The presence of a chemical on this comprehensive list does not necessarily mean it is released from all refineries, at all times, or in significant quantities.

The potential compounds emitted from refineries that pose the highest health risk in nearby communities should be identified along with the appropriate monitoring technologies selected to measure them. This assessment should be informed by the OEHHA report on Refinery Chemical Emissions and Health Effects Report. Measurements should be continuous and reported in real-time when available. The fenceline monitoring should be performed using open-path technology capable of measuring the pollutants associated with petroleum refinery operations. The chemical compounds of interest for Rule 1180 are presented in Table 1 below.

The air monitoring plan must provide specification about the open-path instruments selected for a fenceline air monitoring system, such as, detection limits of the equipment for each chemical and time-resolution capability. Also, the air monitoring plan must demonstrate that the instruments can measure the pollutants identified in Table 1. The selected open-path instruments should be able to record and store the measured spectral absorption and associated average concentrations of measured pollutants for retrospective investigations. Where open-path monitors are being operated, all factors that could affect air pollutant measurements, such

[1] Analysis of Refinery Chemical Emissions and Health Effects – Report. September 27, 2017 (https://oehha.ca.gov/media/downloads/faqs/refinerychemicalsreport092717.pdf)

as, the maximum path length the instruments are capable of measuring and potential interferences must be discussed in the air monitoring plan.

Further, the petroleum refinery air monitoring plan must explain exclusion or replacement of monitoring for any of the compounds identified in Table 1 below. For example, in certain instances a petroleum refinery operator may propose to exclude monitoring for specific compounds that are not likely to be measured at or above the detection limits of the fenceline air monitoring equipment. In these instance, the petroleum refinery operator would be required to provide an alternative measurement methodology or evidence (e.g., historical air monitoring data or operational information) to support the proposed exclusion.

Table 1- Refinery-Related Air Pollutants to be Addressed by Fenceline Air Monitoring Plans

Air Pollutants
Criteria Air Pollutants
Sulfur Dioxide
Nitrogen Oxides
Volatile Organic Compounds
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
Hydrogen Fluoride[+]

[+] If the facility uses hydrogen fluoride.

- **Sulfur Dioxide (SO_2)**

Heating and burning of fossil fuel releases the sulfur present in these materials and result in the formation of SO_2. SO_2 is the criteria pollutant that is the indicator of SOx concentrations in the ambient air and can have direct health impacts and can cause damage to the environment. As result, SO_2 is routinely measured in ambient air monitoring networks. The major sources of SO_2

at refineries are fuel fired in furnaces and boilers, FCC units, Sulphur Recovery Units, flares, etc. As a result, measurement of this compound will help identify potential contribution of refineries to the ambient concentrations in nearby communities.

- **Nitrogen Oxides (NOx)**

Both gasoline and diesel powered vehicles are the main source of NOx emissions, however substantial emissions are also added by stationary sources such as petroleum refineries. Nitrogen oxides is a group of highly reactive gases that contribute to the formation of secondary particles, as well as tropospheric ozone. Scientific evidence links NO_2 exposures with adverse respiratory effects and is one of the criteria pollutants, making it a compound that is routinely measured in ambient air monitoring networks. NO_2 measurements also typically include measurement of NO and NO_X. Measurement of these constituents will help determine if refineries add significant concentrations to nearby urban environments.

- **Volatile Organic Compounds (VOCs)**

VOCs include non-methane hydrocarbons (NMHC) and oxygenated NHMC such as alcohols, aldehydes and organic acids. They are emitted by a large number of sources, but many hydrocarbons are associated with fuels and the production of fuels. VOCs, mainly hydrocarbons, originate from production processes, storage tanks, transport pipelines and waste areas. As a result, measurement of these compounds is critical to determine the impacts that refineries have on nearby communities. While measurements of NMHC could provide valuable information about potential refinery emissions, for a refinery it is possible to distinguish a few and well defined number of specified VOCs to represent refinery fugitive emissions and/or health risk drivers. Measurement of these specified VOCs must be carried out continuously, using open-path technologies at the fenceline of the refineries

Unless it is demonstrated in the fenceline air monitoring plan that an alternative measurement technique (e.g. point monitors) can be effectively utilized. Automated gas chromatographs (Auto-GCs) is the best point monitor option to measure select VOC pollutant concentrations semi-continuously at a monitoring site. This technology has been developed by a number of manufacturers and U.S. EPA have evaluated current state and availability of several commercially available auto-GCs in order to determine their suitability for use in air monitoring stations and have published the results in the Photochemical Air Monitoring Station (PAMS) Gas Chromatography Evaluation Study Report[2]. Other methods for continuous measurement of speciated VOCs include, but not limited to, in-situ FTIR systems and quantum cascade laser instruments that can effectively measure selected VOCs simultaneously with high time resolution. The use of these measurement techniques can potentially provide real-time and continuous air quality data, however, a substantial number of auto-GC units (or other point

[2] RTI (2014). Gas Chromatograph (GC) Evaluation Study: Laboratory Evaluation Phase Report. Prepared for U.S. EPA PAMS Program. [https://www3.epa.gov/ttnamti1/files/ambient/pams/labevalreport.pdf]

monitors) would need to be deployed to achieve sufficient spatial coverage along the property boundary or fenceline of a petroleum refinery.

In some cases more traditional measurement techniques could be utilized, if the air monitoring plan successfully demonstrates the effectiveness of the measurement technique. For example, VOCs could be measured by the collection of ambient air using evacuated canister sampling and subsequent analysis on a gas chromatograph (GC). This method relies on acquiring air samples that often require a considerable amount of time depending on the measured concentrations (e.g., several hours with canisters to several days with adsorption cartridges) and subsequent chemical analysis in a certified laboratory. The sample collection time can vary from instantaneous grab samples to averaging times of 24 hours. If this sampling technique is selected, periodic 24-hour samples (e.g., 1 in 6 days) and instantaneous grab samples (e.g., 5- or 10-minute samples) that are triggered by elevated readings of continuous NMHC are required. The continuous NMHC measurement must achieve the temporal and spatial coverage requirements of the rule, while the periodic and triggered samples will provide information on the speciation of the measured VOCs.

Measurement of hydrocarbons will help determine if refineries add significant concentrations to nearby urban environments and can indicate leaks and emissions from refinery sources. The following are potential compounds of interest and are separated out based on their measurement and/or analytical techniques.

- **Aldehydes**

Aldehydes emitted into ambient air include, but are not limited to, formaldehyde, acetaldehyde, and acrolein that are identified as toxic air contaminants (TAC) and could be emitted from a refinery. These compounds are the products of incomplete combustion of natural gas and are both precursors of atmospheric radicals that accelerate the formation of ozone and toxic air pollutants that may cause respiratory symptoms and cancer. These compounds should be measured continuously at the fenceline of the refineries using open-path technologies. A more detailed listing of aldehydes with potential health concerns is provided by OEHHA.

- **Aromatic Hydrocarbons**

Some of the aromatic hydrocarbons known as BTEX (referring to benzene, toluene, ethylbenzene, and xylenes) occur naturally in crude oil and are associated with emissions from petroleum refineries. The BTEX compounds are products of incomplete combustion of natural gas, and also fugitive emissions from petroleum storage and transfer. Emissions also occur from different combustion sources, such as wood combustion, and stationary and motor vehicle fossil fuel combustion, and elevated levels of BTEX compounds are expected in vicinity of major roadways. This group of aromatic VOCs are important because not only they pose risk to human health, they also play a role in formation of tropospheric ozone.

Analytical methods for BTEX compounds in air include absorption traps and subsequent separation by gas chromatography (GC) with detection by flame ionization optical absorption or mass chromatography, as well as automatic-GC monitors. Optical methods such UV-DOAS and OP-FTIR monitors are more advanced techniques for measurement, however, UV-DOAS instruments are particularly more sensitive in detection of BTEX compounds at low concentrations and with good time resolution compared to OP-FTIR instruments.

- **Other Hazardous Air Pollutant VOCs**

Other VOC air toxics of concern that are often reported in refineries' emission inventories include 1,3-butadiene and styrene that have been detected in routine and non-routine refinery emissions and therefore must be measured and reported. A more detailed listing of potential VOCs of health concern is provided by OEHHA and the AB 2588 Health Risk Assessment reports will help inform other toxics specific to each facility. Depending on emissions from each facility, measurement of other VOC air toxics may be required. Such VOC compounds include, but are not limited to, methanol, phenol, naphthalene, and hexane. For example, these toxic gases shall be measured and reported if the reported emissions exceed 10,000 lbs/year and/or selected monitoring technologies are capable of detecting them.

- **Hydrogen Sulfide (H_2S)**

Hydrogen sulfide is a colorless, flammable, extremely hazardous gas with a "rotten egg" smell. It can result from the breakdown of organic matter in the absence of oxygen such as in swamps and sewers, occurs naturally in crude petroleum and natural gas, and is produced at oil refineries as a by-product of refining crude oil. As a result, low-level concentrations can occur continuously at petroleum refineries and its measurement will help identify potential leaks at refineries and address community odor concerns.

- **Carbonyl Sulfide (COS)**

Carbonyl sulfide (COS) is naturally found in crude oil and is a chemical intermediate and a byproduct of oil refining with a distinct sulfide odor. It is classified as a California Toxic Air Contaminant (TAC) and a federal hazardous air pollutant (HAP). COS can be released into atmosphere as fugitive emissions from refineries and at high concentration levels may cause narcotic effects in humans. COS can be measured using open-path technologies and should be measured and reported at the fenceline if the selected open-path monitors can detect it at desirable levels.

- **Ammonia (NH_3)**

While the main sources of ammonia are natural, primarily from the decay of organic matter, petroleum refineries can also emit considerable amounts, particularly from catalyst regenerator vent releases. It is colorless, pungent-smelling, and corrosive and even though it is unlikely to have adverse effect on health at background levels, exposure to high concentrations following an accidental release or in occupational settings may induce adverse health impacts.

- **Black Carbon (BC)**

Black carbon (BC) is a product of incomplete combustion of fossil fuels, biofuels, and biomass, and it is emitted directly into atmosphere in form of particles, mostly in the PM2.5 size range. BC is a major component of "soot", a complex mixture that also contains some organic carbon (OC). It is emitted in high quantities by diesel engines and biomass burning. Although BC is often associated with emissions from heavy-duty diesel engines, a portion of all combustion emissions contains these constituents. BC has been routinely used to estimate the contribution of diesel particulate matter (DPM) to total PM. DPM is the major contributor to air toxic health risk in the South Coast Air Basin, however it cannot be directly measured through atmospheric measurements and has to be estimated, usually based on BC measurements. The DPM contribution to PM in areas where the affected refineries are situated are expected to be high due to high total truck trips from the ports of Los Angeles and Long Beach for goods movement, as well as presence of other industrial activities in the region. Therefore, elevated BC levels are expected in communities near refineries. In order to help determine if refineries add significant BC concentrations to nearby urban environments and discern the contribution of refineries to observed BC levels in the community, the refinery operators are advised to determine potential BC hotspots on the facility fenceline (or within the facility), and perform BC measurements.

- **Hydrogen Cyanide (HCN)**

Hydrogen cyanide is colorless, highly flammable and can be explosive when exposed to air in high concentrations. It is released from various industrial activities, including refining. At high concentrations, such as from accidental releases, it is highly toxic. HCN can be effectively measured using open-path technologies and should be measured and reported at the fenceline if the selected open-path monitors can detect it at desirable levels.

- **Hydrogen Fluoride (HF)**

Hydrogen fluoride (HF) is a pungent, highly corrosive acid used at some oil refineries in a process called alkylation that boosts gasoline octane. HF also is used at chemical plants to manufacture compounds including refrigerants. The chemical poses a health risk to nearby residents and businesses because in the event of an accidental release, it can form a dense, fuming cloud capable of etching glass and causing severe damage to human skin and lung tissue. The facilities with alkylation units may already have monitors in place for detecting HF, such as could be associated with an accidental releases. Such monitors should ideally be placed near the alkylation unit, to ensure a rapid detection of accidental leaks to subsequently provide warning and real-time alerts to inform health concerns for the protection of refinery workers and the nearby communities in the vicinity of the refinery. All facilities that use hydrogen fluoride must monitor the ambient concentrations of HF or demonstrate in the air monitoring plan that HF concentrations are adequately monitored and reported at the alkylation unit to be exempt from HF measurements at the fenceline.

b. Continuous and Real-Time Measurement of Air Pollutants

Continuous air monitoring at or near the property boundaries of petroleum refineries can significantly improve rapid detection and communication of potential hazardous releases to refinery operators, responders, and the public in addition to providing long-term data be used to determine trends in emissions (e.g., diurnal, seasonal routine emissions variations). Therefore, the fenceline monitoring shall be operated continuously with a required time resolution of five-minute averaging when feasible. High time resolution monitoring reduces the chance of pollutant hot spots being undetected over the measured area and can provide real-time emissions information to refinery personnel and the nearby communities. If achieving the desired time-resolution is not feasible, refinery operators shall provide rationale in the air monitoring plan for any proposed time resolutions greater than five-minute averaging (e.g., based on the equipment employed, the number of paths covered by each open-path system, or other operational limitations).

c. Selection of Fenceline Air Monitoring Technologies

A petroleum refinery fenceline air monitoring system is a combination of equipment that measures and records air pollutant concentrations at or near the property boundary of a petroleum refinery. Multiple technologies may need to be employed to ensure adequate compound identification. Conventional fenceline air monitoring techniques rely on point monitors that only provide concentration information from a single point in the survey area, greatly increasing the chances of missing surface emissions hotspots or emissions plumes. Therefore, even after collecting data from multiple points in the survey area, the point sampling approaches may lack the spatial or temporal data necessary to obtain a complete picture of the emissions from large area sources.

Open-path technology is a well-established method to measure path-integrated trace gas absorptions and concentrations in the open atmosphere making it ideal for long-term fenceline air monitoring of emissions from refineries or other large area sources. Open-path technology is a type of Optical Remote Sensing (ORS) that measures air emissions along an open-path, significantly improving the spatial coverage. ORS instruments use a light signal to continuously detect and measure concentrations of chemical compounds along the distance covered by the light signal in real-time. As a result, open-path technologies can provide greater temporal and spatial resolution compared to conventional air monitoring techniques; for example, narrow pollutant plumes can be detected by an open-path fenceline air monitoring system that might otherwise be missed by point monitors. The light source emits light towards a detector either at the opposite end of the light path (bi-static configuration) or co-located with the light source (mono-static configuration) if the light is reflected back by a reflector, providing path-averaged concentrations of multiple pollutants, simultaneously. Although the open-path ORS techniques have been used for over 20 years and are well-established, they are constantly improving and gaining use for large area source monitoring applications that are not conductive to traditional point source testing methods. Improvements often include changes to technologies that improve detection limits or the type of compounds detected.

Another advantage of open-path measurements is the capability of monitoring pollutant concentrations due to point source and fugitive emissions at or near the property boundary of a petroleum refinery operation depending on the design of the monitoring system. Fugitive emissions are emissions of gases or vapors from leaks and other unintended or accidental releases of emissions. Leaks from pressurized process equipment generally occur through valves, pipe connections, mechanical seals, or related equipment, usually originating from the process area. Fugitive emissions also occur from storage tanks. These tanks are used to store crude oil prior to refining, intermediates between refining processes, and refined product streams. Except for a few process storage tanks, the storage tanks are generally located together in what is referred to as the "tank farm". Due to the large number of potential leak sources that are scattered over a wide area at large refineries and difficulties in detecting and repairing these leaks (which may become significant collectively), these emissions are best monitored over a large area or path, using the open path systems. U.S. EPA has published a comprehensive assessment of various open-path ORS technologies, outlining the advantages and limitations of each measurement method.[3]Based on the advantages that open-path technologies provide over conventional air monitoring techniques, SCAQMD staff recommends the use of open-path technology, when applicable, for implementing a fenceline air monitoring system required by Rule 1180. In certain instances a refinery owner or operator may demonstrate that other air monitoring techniques and/or technologies (e.g., emerging technologies) could be used in place of open-path technology depending on the pollutant(s) that are monitored.

d. Alternative Fenceline Air Monitoring Technologies

In certain instances, alternative monitoring technologies may be appropriate to cover areas along the perimeter of a refinery that are not well-suited to open-path technologies. In these instances, the refinery operator may propose an alternative air monitoring technology(s). The refinery operator must demonstrate the proposed alternative air monitoring technology(s) will meet the requirements of Rule 1180 and provide adequate sensitivity and adequate temporal and spatial coverage for the compounds identified in Table 1.

e. Fenceline Sampling Location(s) and Coverage

Air monitoring plans must specify the following information related to the locations selected for the fenceline air monitoring equipment:

- Areas along the perimeter that are likely to detect compounds associated with petroleum refinery operations;

[3] https://www3.epa.gov/ttnemc01/guidlnd/gd-052.pdf

- Proximity of proposed fenceline monitoring equipment to residences in the community and other sensitive receptors, such as schools, data care centers, hospitals, clinics, nursing homes, and recreation areas;
- Where equipment will be sited (e.g., GIS coordinates);
- Elevations at which equipment will be placed; and
- Length of each path that will be monitored with open-path instruments.

The air monitoring plan must provide a discussion that explains the rationale for choosing these equipment siting specifications. When considering a suitable open-path technology for sites along the petroleum refinery perimeter the refinery operator must address key considerations, such as, the distance necessary to accurately measure emissions and critical transport areas around the perimeter of the petroleum refinery. These considerations are further discussed below.

To ensure the highest level of accuracy when measuring emissions levels at or near the property boundary of a petroleum refinery facility the fenceline air monitoring system should be designed considering the following key factors:

i. Local Meteorological Conditions

Meteorological conditions can significantly affect the concentration of air pollutants in a region. Therefore, it is important that the petroleum refinery operators consider the typical meteorological conditions (e.g., wind patterns, temperature, rainfall, cloud cover, etc.) of a site. For example, if a facility is in an area that is prone to fog, the facility operator should ensure the equipment for the fenceline air monitoring system is not sensitive or easily impeded by low-lying cloud cover produced by fog.

Evaluating historical meteorological data is imperative in air monitoring equipment site selection and in determining whether certain candidate equipment locations are likely to experience higher measured pollutant concentrations from an emissions source. Wind can be the most critical meteorological element for the transport of refinery emissions to the surrounding communities. Often, peak concentrations occur during stable, low wind speed conditions when pollutants can build up and meander in any direction. To the extent feasible, both long- and short-term wind measurements should be assessed in the air monitoring plan. Frequency distributions of winds and associated graphic analyses (i.e., wind roses) can be analyzed to evaluate predominant wind patterns, as well as diurnal and seasonal variability.

ii. Topography

Concentrations of pollutants can be greater in valleys than for areas of higher ground. This is because, under certain weather conditions, pollutants can become trapped in low lying areas. Therefore, the topography of the petroleum refinery can affect the distribution and dispersion of pollutants from refinery operations. To ensure that maximum pollutant levels along the perimeter of the facility are measured, the petroleum refinery operator should design the fenceline air monitoring system to ensure fenceline air monitoring equipment is sited such that it captures the highest concentrations of pollutants along the perimeter of the facility to the extent feasible.

iii. Pollutant Hotspots

It is essential for the refinery operators to identify potential pollutant hotspots within the facility to ensure fenceline monitoring of these emissions and to provide effective information to the neighboring communities with sufficient spatial coverage. Therefore, in developing the air monitoring plan the refinery operator should survey the facility with special attention to areas where emissions are most likely, such as, tank storage, processing, wastewater treatment, and loading areas. Information gathered from the survey should be used to establish the facility's overall emissions profile. The survey should also consider geographical and topographical parameters, as well as the elevation of potential pollutant hotspots.

iv. Spatial Coverage of Monitors

The fenceline monitoring system should be designed to ensure adequate coverage of the area along the facility perimeter, to the extent feasible. Considerations, such as, the proximity of refinery emissions sources to sensitive receptors (i.e., residents, schools, hospitals, etc.) and type of pollutants to be measured could require additional open-path monitors for a facility. Also, information available from dispersion modeling, gradient sampling and mobile measurements, should be taken into consideration when assessing adequate coverage of a facility perimeter with a fenceline air monitoring system.

Sampling locations should be away from certain supporting structures and have an open, unobstructed path. Ideally, each air monitoring path should be at least 1 meter vertically and horizontally from any supporting structure, and away from dusty or dirty areas. Moreover, the air monitoring plans must identify potential disruption of airflow and the potential effect on measured concentrations caused by obstacles or traffic. Also, potential interferences caused by meteorological (e.g., fog or rain) or process issues (e.g., process steam) associated with the selected location(s) must be addressed. The air monitoring plan should describe how the proposed fenceline air monitoring system will effectively provide relevant information for all nearby downwind communities given the expected meteorological conditions. Due to the high prevalence of marine fog in the areas where the Basin refineries are located, heaters and fans may be required to keep the instrument optics and reflector mirrors free of moisture to maximize data recovery.

f. Emerging Technologies

Some emerging next-generation monitoring technologies could possibly meet the requirements for this rule. For example, low-cost sensors could potentially allow cost-effective, real-time monitoring at numerous fixed locations along the perimeter (i.e., the fenceline) of a petroleum refinery. Despite substantial progress, at this time, none of these methods can provide the level of sensitivity and accuracy required to measure the pollutants required by Table 1 of Rule 1180 at the levels expected during normal refinery operations. However, gaseous sensors are expected to improve in the near future and fenceline air monitoring plans could be augmented to employ these sensors, therefore, SCAQMD may consider approving emerging technologies for future compliance with Rule 1180.

SCAQMD has established an Air Quality Sensor Performance Evaluation Center (AQ-SPEC)[4] to inform the public about commercially available low-cost sensors. Under this program, the performance of these sensors is compared against Federal Reference Method (FRM), Federal Equivalent Method (FEM), and Best Available Technology (BAT) instruments to determine their performance relative to more established measurement techniques. Some of these commercially available low-cost sensors can provide measurements for criteria pollutants (e.g., PM2.5, PM10, ozone, NO_2, and CO) which correlate well with FRM, FEM, and BAT methods, however, the situation is different for gaseous air toxics, where sensors with sufficiently low detection limits for specific compounds (e.g., benzene) are generally not available at this time. Total VOC concentrations can be measured using sensors based on Photon Ionization Detection (PID) at parts-per-billion (ppb) levels, although they do not provide VOC speciation and are not considered "low-cost" sensors. These sensors can serve as a temporary measurement technique in the event of an equipment failure or during extended maintenance activities until the fenceline air monitoring system is restored to normal operating conditions. However, as a substitute for the ORS-based approach, the refinery operators would have to deploy a network of traditional point monitors simultaneously at the fenceline of a facility. This would likely result in substantially increased sampling and analysis costs in order to achieve same level of temporal and spatial resolution and speciation of the target pollutants achieved with the ORS methods. In comparing the costs of an ORS-based measurement approach with traditional point monitoring approaches for long-term fenceline measurements, an ORS-based approach is likely to be more cost-effective.

3. Meteorological Measurements

Exposures to air contaminants within an urban area can vary greatly due to proximity to emission sources, the magnitude and specific mix of emissions, structures and terrain influences, and meteorological conditions. Variability in wind speed and direction in particular, pose significant challenges for the analysis of data from air quality monitoring programs and exposure assessments that rely on the ability to determine upwind and downwind locations in relation to emissions sources at any time. Therefore, an understanding and assessment of the general meteorological patterns in and around each facility is a critical component in not only the design of the measurement systems but also interpreting the measurement results, including the transport and dispersion of air pollutants from the refinery to the community. Therefore, the

[4] http://www.aqmd.gov/aq-spec

sub-paragraph (d)(2)(D) of Rule 1180 requires fenceline monitoring locations to continuously record wind speed and wind direction data.

The Air Monitoring Plan must provide information on siting considerations and equipment to be employed for real-time meteorological data collection at high time resolution (at minimum, matching the time resolution of the air quality monitors), in order to provide high quality data. Wind sensor quality, siting, and quality assurance shall meet the specifications and guidelines that are typically required by air quality regulatory measurements and modeling purposes (for reference, see the U.S. EPA Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements[5].

4. Quality Assurance/Quality Control (QA/QC)

The measurements from the fenceline air monitoring system shall reflect a commitment to quality data that is outlined in the air monitoring plan. The air monitoring plan shall address quality assurance, including training of personnel, development and maintenance of proper documentation [i.e., instrument manuals, Standard Operating Procedures (SOP), and a Quality Assurance Project Plan (QAPP)], routine maintenance and calibration checks, technical audits, data verification and validation, and data quality assessment. A QAPP for each refinery fenceline monitoring project must be developed that outlines the QA/QC plan, following U.S.EPA guidelines[6]. The QAPP provides a blueprint for conducting and documenting a study or program that produces quality results and must outline the specific goals of the monitoring networks and instrumentation, the data quality that is required and how that relates to when data generated by the instrumentation is accepted, and how the data will be reviewed and managed by the refineries. The QAPP should provide clear definitions and procedures for QA/QC that are necessary to indicate why some data may be missing, suspect, or invalid.

The critical functions to be addressed in the QAPP are summarized below:

- **Project background and management:** The QAPP should provide background information and define the problem(s) to be addressed and the general goals of the fenceline and community monitoring, and describe project organization, quality objectives and acceptance criteria for measurement data, and plans for documentation, record keeping, and data dissemination.
- **Technical Approach:** The QAPP should demonstrate that the appropriate approaches and methodologies are employed for performing measurements, data handling, and quality control are selected and address the design and implementation of the measurement systems.
- **Assessment/Oversight:** The QAPP should offer appropriate QA/QC steps for ensuring the effectiveness of the monitoring plan covering experimental design, representativeness of

[5] https://www3.epa.gov/ttn/amtic/files/ambient/met/Volume_IV_Meteorological_Measurements.pdf
[6] U.S. EPA (2002). Guidance for Quality Assurance Project Plans. EPA/240/R-02/009. [https://www.epa.gov/sites/production/files/2015-06/documents/g5-final.pdf]

the data, instrument operation and data acquisition, calibration check procedures, data quality indicators, independent systems and performance audits, and peer-review.

- **Data Validation and Usability:** The QAPP should describe what steps will be taken to ensure that the individual data elements conform to the criteria specified in the monitoring plans.

All monitoring data must be collected, managed and archived in a standard electronic format after necessary data processing and validation. Processing the data involves collecting the data, assuring its quality, storing the data in a standardized format, and interpreting the data for communication to the public. The most critical steps in this process include:

- Automatically retrieving data from the fenceline monitors containing the measured levels of each air pollutant along with meteorological parameters;
- Validating data file completeness and integrity;
- Transferring file contents to a database;
- Flagging data that do not meet pre-defined quality control limits;
- Copying quality assured data and indices into a database for use by data display and dissemination program;
- Generating and recording logs to monitor system operation;
- Notifications when measured concentrations are above pre-defined concentrations limits.

To ensure that the collected data meets the highest quality possible, each piece of monitoring equipment must be operated in strict accordance with an in-depth operating protocol. To achieve the appropriate level of detail and standardization, and to consequently ensure that the monitoring equipment provides high quality data, Standard Operating Procedures (SOPs) must be prepared for each specific measurement method. The SOPs should be informed by general operating instructions that are typically provided by the manufacturers of equipment, by operational experience and audits, and by general operational guidelines and performance specifications that are available for U.S. EPA and State approved methods. The SOPs should address specific topics such as calibration procedures and quality control procedures (indicating standards and checks, acceptance criteria and schedule), as well as data reduction (indicating validation procedures, reporting and schedule).

Rule 1180 requires that the measurements from the fenceline monitoring system be available to the public on a real-time basis with Quality Assurance/Quality Control (QA/QC) measures implemented to provide confidence in the data collected. Publicly available quarterly measurement reports should reflect a higher level of data validation, including a manual review of the data by qualified personnel. The real-time and near-real-time disseminated measurement data should not be considered final, but it is important that the preliminary real-time measurement data distributed to the public be of an acceptable quality. Also, it is important that instrument failures are detected quickly, with automated screening where feasible, to prevent grossly invalid data from being presented to the public. This can be accomplished by utilizing built-in status flags on the instrument operational parameters and by providing real-time data screening for outliers, impossible values, stuck values, negative values, rates of change, excessive short-term noise, etc.

5. Data Display and Dissemination

The primary goal of Rule 1180 is to provide continuous and real-time emissions data to the community, local responders, and industry that can be used to evaluate and adaptively manage the impacts of refineries' emission on the community. Therefore, it is essential that the collected must be made available and displayed online in a relevant, useful and understandable manner to the public in real-time or near-real-time and clearly identified as preliminary data. The real-time or near-real-time data must be submitted to SCAQMD in an approved format. The refinery operators must also publish quarterly reports written at a public-friendly level on the data dissemination website. The air monitoring plan must include information and examples of how the quality controlled data will be displayed and the steps taken to provide context to the real-time measurements to the public. Also, the air monitoring plan shall address means for providing automated, reliable, useful, and understandable information, including, the intent and limitations of the data collected and an explanation of how background concentrations and/or contributions from other sources may affect measured concentrations.

The refinery operators must provide quarterly data reports after rigorous review of calibration data, data processing calculations (such as conversion calculations of instrument signal to pollutant concentration), data consistency, field data sheets and logbooks, instrument performance checks, and equipment maintenance and calibration forms. All changes to the reported real-time data must be explained in quarterly reports. The major goals of the outreach program include:

- Developing multiple communication venues to ensure widespread access to environmental information and to appeal to the various communication preferences (e.g., text messages, email, website, etc.) among the end users;
- Promoting access to and awareness of the measurements and use of the real-time air pollution data through an active outreach and education program;
- Developing contextual material to assist interpretation and understanding of the real-time data and its limitations;
- Designing an effective public outreach program (e.g., informational meetings, workshops, etc.) that informs the public about the health impacts associated with emissions levels detected by the fenceline air monitoring system and informs decision related to reducing community exposure;
- Identifying designated personnel to address SCAQMD's and public questions about monitoring equipment and readings.

The air monitoring data must be provided in a manner that the public can readily access and understand. Websites for all refineries should be designed in a user-friendly format. In order to make the data provided in this outreach as accessible as possible, the project websites should use data visualization tools to graphically depict information using maps and time series plots of measured pollutants and wind data. In order to provide context to this complex data set for the public, the designed website should contain information regarding the species measured and the measurement techniques, discussion of levels of concern for each measured species, typical background levels, potential non-refinery sources that could contribute to measured concentrations, and definition of data QC flags. This should be written at a public-friendly level with clarity and thoroughness and with links provided to additional sources of information. In addition, the air monitoring plan and the data website should include details of how the public can report experiences and provide comments and feedback for improvement of the website and other data dissemination tools, and the monitoring activities in general.

6. Notification System

The website should offer an opt-in notification system that is integrated with the data collected by the air monitoring network that automatically generates and issues notifications to subscribers when pollutant levels are above specified thresholds pursuant to the approved air monitoring plan. Resources that should inform the thresholds include the National Ambient Air Quality Standards (NAAQS), California Ambient Air Quality Standards (CAAQS), and the acute, chronic or carcinogenic Reference Exposure Levels (RELs) as assessed by California Office of Environmental Hazard Assessment (OEHHA[7]), as well as unusually high concentrations (e.g. once a major leak is detected).

An REL is an airborne concentration level of a chemical at or below which no adverse health effects are anticipated for a specified exposure duration as developed by RELs are based on the most sensitive, relevant, adverse health effect reported in the medical and toxicological literature. RELs are designed to protect the most sensitive individuals in the population by the inclusion of margins of safety. Therefore, exceeding the REL does not automatically indicate an adverse health impact. The REL is not the threshold where population health effects would first be seen. However, levels of exposure above the REL levels have an increasing but undefined probability of resulting in an adverse health impact, particularly in sensitive individuals (e.g., the very young, the elderly, pregnant women, and those with acute or chronic illnesses). OEHHA has developed acute RELs for assessing potential non-cancer health impacts for short-term, one-hour peak exposures to air pollutants including facility emissions, therefore if the one hour average concentration of any of the measured pollutants exceed its corresponding acute REL, notifications should be sent out to the subscribers. By definition, an acute REL is an exposure that is not likely to cause adverse health effects in a human population, including sensitive subgroups, exposed to that concentration for the specified exposure duration on an intermittent basis.

[7] OEHHA, 2008; http://www.oehha.ca.gov/air/allrels.html

Chronic RELs are developed for assessing non-cancer impacts from long-term exposure, at or below which no adverse health impacts are anticipated following long-term exposure. Long-term exposure for these purposes has been defined by U.S. EPA as at least 12% of a lifetime, or about eight years for humans. However, for assessment and reporting programs, such as those required by AB 2588, 1-year emissions assessments are typically used for modeling ambient conditions in nearby communities for long-term exposures. Therefore, chronic RELs must be compared to annual average concentrations of measured toxic pollutants and be reported in the periodic reports once one year of data is available.

The notification system should be designed to provide information to the public via email, text message or other communication venues, with, at minimum, the ability to be notified regarding: (1) data availability and release of periodic reports; (2) acute or chronic REL exceedances; and (3) monitoring system status. The timely notifications will inform the public when certain pollutants exceed those concentration thresholds or may pose a potential health concern, allowing the public to consider further actions to protect their health. The notifications would also provide information to refinery operators to rapidly identify and mitigate any undetected and/or accidental emissions. This can have a significant impact on the reduction of refinery fugitive emissions.

Websites should not simply provide graphical information about current conditions. Air monitoring plans should include a plan for how residents can access historical data directly and in a user-friendly manner. The archived data should include data quality control flags, explain changes, and provide information to identify data that should be removed or was removed after QA/QC. The data must also be made available to SCAQMD in an approved format.

The air monitoring plan should also identify alternative methods of accessing data without a computer for those members of the community who may not have internet access (e.g., automated phone systems for dial-in information, or displays in libraries or community centers).

Some examples of methods for communicating the data to the public include the following:

- Website data displays;
- Mobile application;
- Automated email/fax/text notification system;
- Social media feeds;
- Public data displays in community locations;
- Automated call-in phone system;
- Television and radio reports; and
- Published data summary reports.

As provided by state law, emergency response agencies such as local fire agencies, have the primary responsibility for scene management during an accidental release of emissions or other emergency incidents. The refinery operators must identify the primary local agency that provide emergency preparedness and response services for each refinery, and outline the process to be developed to integrate with and augment the existing public alert systems and communication mechanisms to provide the public with timely alerts and public safety information during refinery upsets and accidental releases of pollutants and not to conflict or duplicate the first response alert systems in case of an accidental release of emissions.

The California Air Resources Board (CARB) Monitoring and Laboratory Division and the California Air Pollution Control Officers Association (CAPCOA) have completed the first volume and a draft a second volume of the Refinery Emergency Air Monitoring Assessment Report. . The Objective 1: Delineation of Existing Capabilities report, released in May 2015, provides a comprehensive inventory of emergency air monitoring assets and capabilities located in and around California's major oil refineries. The draft report for Objective 2: Evaluation of Air Monitoring Capabilities, Gaps, and Potential Enhancements became available in September 2017. Also in September 2017 OEHHA released a related draft report: Analysis of Refinery Chemical Emissions and Health Effects. These are available from the CARB Refinery Air Monitoring website.[8]

7. Other Regulatory Programs

The U.S. EPA adopted a rule in December 2015 (40 CFR §63.658) with fenceline monitoring provisions that require sampling for benzene at refinery property boundaries. Considering that open-path technologies are currently the best available and the most accurate method for fenceline monitoring of benzene and other pollutants, SCAQMD will assist the refineries in seeking U.S. EPA approval for monitoring systems proposed as part of Rule 1180 through the refinery's fenceline air monitoring plan to also meet U.S. EPA requirements for monitoring of benzene.

8. Future Updates to Rule 1180 – Fenceline Air Monitoring Guidelines

Revisions and updates to this guidance are expected and will be required as new instrumentation, methodologies and monitoring strategies are developed.

[8] https://www.arb.ca.gov/fuels/carefinery/crseam/crseam.htm

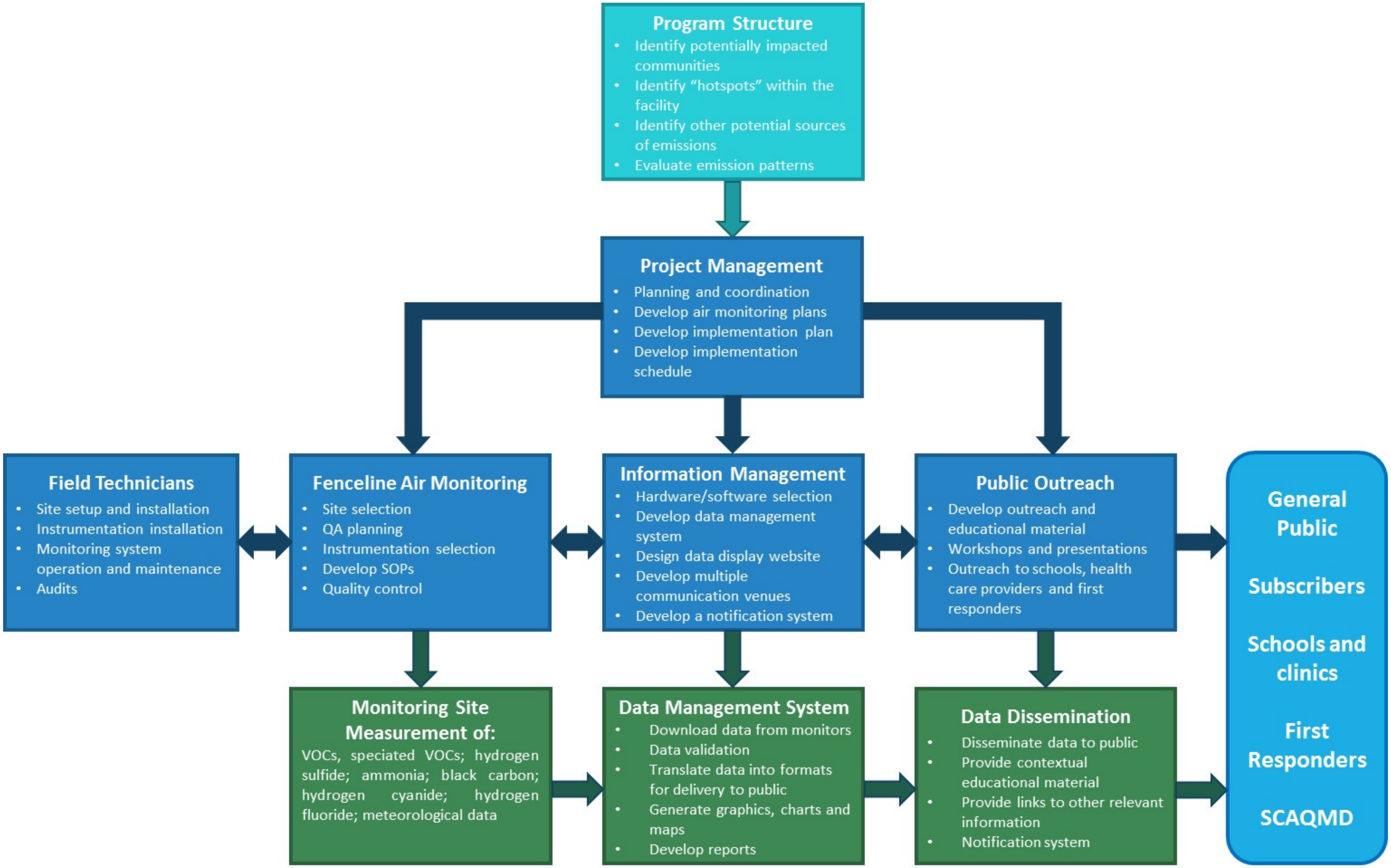


Figure 2 - Overview of the Refinery Fenceline Air Monitoring Programs

9. References and Other Resources

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U.S. EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5, EPA/240/B-01/003)
[https://www.epa.gov/sites/production/files/2016-06/documents/r5-final_0.pdf]

U.S. EPA Guidance for the Data Quality Objectives Process (EPA QA/G-4, EPA/600/R-96/055)
[https://archive.epa.gov/epawaste/hazard/web/pdf/epaqag4.pdf]

U.S. EPA Guidance on Technical Audits and Related Assessments for Environmental Data Operations (EPA QA/G-7, EPA/600R-99/080)
[https://www.epa.gov/sites/production/files/2015-07/documents/g7-final.pdf]

Network Design for State and Local Monitoring Stations (SLAMS), National Air Monitoring Stations (NAMS), and Photochemical Assessment Monitoring Stations (PAMS).
Code of Federal Regulations. Title 40, Part 58, Subpart E, Appendix D.

Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Part 1 (EPA-454/R-98-004)
[https://goo.gl/HGCNrR]

Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air (EPA/625/R-96/010b)
[https://www3.epa.gov/ttn/amtic/airtox.html]

Guidance for Preparing Standard Operating Procedures (SOPs) (EPA QA/G-6, EPA/240/B-01/004)
[https://www.epa.gov/sites/production/files/2015-06/documents/g6-final.pdf]

U.S.EPA Handbook: Optical Remote Sensing for Measurement and Monitoring of Emissions Flux
[https://www3.epa.gov/ttnemc01/guidlnd/gd-052.pdf]

CARB/CAPCOA Refinery Air Monitoring Assessment Reports
[https://www.arb.ca.gov/fuels/carefinery/crseam/crseam.htm]

OEHHA Report: Analysis of Refinery Chemical Emissions and Health Effects
[https://oehha.ca.gov/air/analysis-refinery-chemical-emissions-and-health-effects]