



BAY AREA
AIR QUALITY
MANAGEMENT
DISTRICT

Air Monitoring Guidelines for Petroleum Refineries

AIR DISTRICT REGULATION 12, RULE 15: PETROLEUM REFINING EMISSIONS TRACKING

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Bay Area Air Quality Management District

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Air Monitoring Guidelines for Petroleum Refineries

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Executive Summary

On August 6, 2012, a substantial fire occurred due to a hydrocarbon leak at a crude oil processing unit at the Chevron Refinery in Richmond, California. The fire resulted in a large plume of black smoke and visible emissions from a refinery flare. The August 6, 2012 incident prompted the Bay Area Air Quality Management District (Air District) staff and Board of Directors to identify a series of follow-up actions to enhance the Air District's response to similar incidents (Board of Directors, October 17, 2012). One of these actions was to convene a panel of air monitoring experts (Expert Panel) to recommend technologies, methodologies and tools to enhance community air monitoring capabilities near refineries. In order for the Expert Panel to have a uniform starting point for their discussion, the Air District contracted with Desert Research Institute (DRI) to compile a report that provided background on current air monitoring capabilities near refineries and potential air monitoring technologies, methodologies and tools that could be used at refinery fence-lines and in the community to determine impacts from normal refinery operations and episodic incident-based releases. Another related follow-up action was the development of a new Air District Petroleum Refining Emissions Tracking rule, which would include a requirement that Bay Area refineries establish and operate fence-line and community air monitoring systems consistent with guidelines to be developed by the Air District.

The purpose of this *Guidance for Air Monitoring Near Bay Area Refineries* is to provide a framework on how these air monitoring systems should be developed and deployed and what metrics the Air District will use to evaluate the ability of those systems to meet the goals outlined below. The Guidance provides refineries with information to be used to develop an air monitoring plan that the Air District will review, provide feedback and/or recommendations and approve once the monitoring plan meets the goals of the monitoring effort.

Background

On August 6, 2012, a substantial fire occurred due to a hydrocarbon leak at a crude oil processing unit at the Chevron Refinery in Richmond, California. The fire resulted in a large plume of black smoke and visible emissions from a refinery flare. The Contra Costa County Health Department issued a community warning and ordered a shelter-in-place for approximately five hours in Richmond and San Pablo. Thousands of residents sought medical treatment, with most suffering respiratory and/or eye discomfort.

The August 6, 2012 incident prompted the Bay Area Air Quality Management District (Air District) staff and Board of Directors to identify a series of follow-up actions to enhance the Air District's response to similar incidents (Board of Directors, October 17, 2012). One of these actions was to convene a panel of air monitoring experts (Expert Panel) to recommend technologies, methodologies and tools to enhance community air monitoring capabilities near refineries. Another related follow-up action was to expedite the development of a new Air District Petroleum Refining Emissions Tracking rule, and to include a requirement that Bay Area refineries establish and operate fence-line and community air monitoring systems consistent with guidelines to be developed by the Air District. This guidance document is intended to provide a framework on how these air monitoring systems would be developed and deployed and what metrics the Air District will use to evaluate the ability of those systems to meet the goals outlined below.

As part of the effort to develop this guidance, the Air District contracted with Desert Research Institute (DRI) to compile a report that provides background on current air monitoring capabilities near refineries and potential air monitoring technologies, methodologies and tools to:

- Provide air quality information for communities near refineries
- Gather data to evaluate health impacts associated with air quality near refineries
- Track air quality changes and trends over time near refineries

The DRI report reviewed and evaluated measurement approaches and methods for assessing the impacts of refinery emissions on ambient concentrations of criteria and air toxics pollutants in nearby communities and is included in Appendix A. Available data for refinery emissions along with ambient air concentrations were reviewed and compared to established levels for acute and chronic health effects to identify the species that should be considered for air monitoring. Various monitoring options were associated with the following monitoring objectives: short-term characterization of emission fluxes; long-term continuous fence-line monitoring of refinery emission releases to the community; community-scale monitoring with varying time scales to evaluate potential chronic or acute health impacts; and episodic monitoring during catastrophic events. With these objectives in mind, air quality data from existing Air District criteria and air toxics pollutant monitoring programs, and air monitoring (both regulatory and voluntary) by the refineries were then used to identify existing gaps in information or useful supplemental data. Published results from relevant applications of the monitoring approaches were reviewed and the specifications for selectivity, sensitivity,

precision, accuracy and costs of commercially-available continuous or semi-continuous monitors, and time-integrated sampling and analysis methods were compared for each target pollutant to determine the positive and negative attributes of each monitoring approach and method. Potential augmentations to existing monitoring in the Bay Area were suggested with scalable options. It was the intent of the Air District to utilize the DRI report to provide the Expert Panel with a starting point for further discussion.

The Expert Panel was convened on July 11, 2013 and included monitoring experts from around the nation representing academia, community advocates, industry and government. The final report of the Expert Panel, including, a list of participants is provided in Appendix B. The Expert Panel reviewed the DRI report, received a presentation by one of its authors, Mr. David Campbell, and then addressed questions developed by the Air District to further explore potential air monitoring methodologies and instrumentation that could be developed to provide the public, refineries and regulators information about exposures to the public near refineries. The questions that the Expert Panel addressed were:

- What should the size and spatial orientation of a network of monitors be around refineries?
- What network components should be considered (compounds measured, technology and instrumentation used, methodologies applied, air quality assessment tools utilized, etc.)?
- How should the data be provided to the public?
- What should be considered when developing measurement quality objectives, such as:
 - What type of instrument siting criteria should be used?
 - What should the time resolution of the equipment be?
 - How often should the instrumentation be calibrated?
 - What should the accuracy/precision/completeness requirements of the data be?
 - What other quality control/quality assurance requirements should be put in place?
- What technologies, methodologies and tools could be employed to augment any fixed network to better quantify pollutant variations over space and time, especially during short duration incidents?
- What emerging technologies might be utilized in the future to further enhance community air monitoring capabilities?

The Expert Panel believed that open path monitoring capable of measuring representative compounds at near-ambient background levels of detection likely to be emitted by refineries should be employed at, or near, refinery fence-lines. Measurements of these compounds should be collected at a time resolution of 5 minutes. Data should be displayed to the public real-time, with appropriate QA/QC parameters defined and context provided so that the public can more easily understand when concentration from refineries reach levels of concern.

The Expert Panel believed that defining chemical composition and concentration gradients as distance away from refinery fence-lines increased was critical and that monitoring within the

community be tied to these gradients. The DRI report and the Expert Panel acknowledged that there were available methods that could be utilized to represent gradients, such as flux measurements around refinery property. For purposes of this Guidance Document, the term “gradient” will be used to represent any of these techniques that can adequately represent gradients as distance increases from the fence-line into the community.

The Expert Panel also believed that no more than three community monitoring locations were necessary. They believed that compounds associated with risk and measured at other air monitoring locations should be included in the community monitoring locations, even if those compounds were not emitted by the refinery, so that the community could compare concentrations and associated risk to other locations.

The Air District has developed this Guidance Document for monitoring near refineries based on the DRI report and the input provided by the Expert Panel. This Guidance Document be used by the refineries to develop Air Monitoring Plans as described in Air District Regulation 12, Rule 15. The guidance is intended to identify what should be included in the Air Monitoring Plan and what must be provided to the Air District in order to deviate from specific considerations. The Air District recognizes that, in certain circumstance, flexibility must be provided in order to allow for operational or technical limitations of instrumentation or sampling methodologies and has identified where that flexibility may be used as long as acceptable rationale is provided that outlines the operational or technical limitations.

In addition, the Air District will use this Guidance Document as a basis to evaluate whether Air Monitoring Plans and the monitoring systems contained therein adequately address the monitoring goals of measuring impacts near refineries and reporting them to the public. The Air District encourages the inclusion of the community and other interested parties in the development of Air Monitoring Plans to help ensure that the community’s concerns and desires are adequately addressed.

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

Section 1: Basic Requirements for an Approvable Air Monitoring Plan

This section describes the criteria for an approvable Air Monitoring Plan. Plans that meet these criteria will be considered by the Air District. However, as part of the approval process, the Air District will consider comments received during the public comment period and may find the plan not approvable based on those comments or other considerations. Where air monitoring requirements are not met, the refinery must provide a rationale for why the program should be approved. Such rationale will be evaluated on a case-by-case basis.

This Guidance Document provides additional information in later sections that demonstrates pathways to alternatives and outlines processes and considerations for meeting the requirements of developing an Air Monitoring Plan.

1.1 Fence-line Monitoring

Refinery operators must measure **benzene, toluene, ethyl benzene, and xylenes (BTEX)** and **H₂S** concentrations at refinery fence-lines with open path technology capable of measuring in the parts per billion range regardless of path length. Open path measurement of **SO₂, alkanes or other organic compound indicators, 1, 3-butadiene,** and **ammonia** concentrations are to be considered in the Air Monitoring Plan. Refinery operators must provide a rationale in the Air Monitoring Plan for not measuring all of the above compounds that addresses: why these compounds are not be contained in the compositional matrix of emissions; are not at expected concentrations measured by available equipment; and/or, address the technical or other considerations that make specific measurements inappropriate or unavailable.

Fence-line measurements must be continuously measured with a time resolution of five minutes. If this is not the case, refinery operators must provide rationale in the Air Monitoring Plan for lesser time resolutions based on equipment or other operational limitations. These measurements must be provided to the public on a real-time basis, with appropriate Quality Assurance/Quality Control (QA/QC) measures taken to provide assurance of data accuracy. A Quality Assurance Project Plan (QAPP) that follows EPA guidelines must be developed that outlines the QA/QC parameters. Instrumentation must meet a minimum of 75% completeness on an hourly basis, 90% of the time based on annual quarters.

Measurements must cover populated areas within 1 mile of the refinery fence-line likely to be affected when the annual mean wind direction lies in an arc within 22.5 degrees of a direct line from source to receptors 10% of the time, or greater, based on the most representative meteorological measurements for sources likely to emit the compounds listed above at the refinery. If this is not the case, refinery operators must provide rationale for not providing this coverage in the Air Monitoring Plan that addresses why receptors would not be affected by emissions from the sources covered by this placement.

1.2 Community Monitoring

Refinery operators must appropriately site and operate at least one permanent community air monitoring station that provides a reference for exposures for residents living near the refinery. Concentration gradients from the refinery fence-line will be used by the refinery to develop correlations to the compounds (see below) measured within the community to determine where and how many stations must be installed. Other measurement techniques may be used to determine gradients, such as component flux across the fence-line. The methodology chosen for determining gradients, and the rationale for this choice, must be provided and approvable in the Air Monitoring Plan. The term “gradient” will be used throughout this Guidance Document to represent the approved methodology.

The Air Monitoring Plan must outline how permanent site(s) will be chosen and correlations and relationships with gradients established. In addition, methodologies must be provided to determine how often gradient measurement must be repeated to demonstrate that correlations and relationships continue to be valid. Gradient measurements must be repeated every seven years, at a minimum.

Multiple stations must be considered where chemical component mixtures differ in composition by more than 4 of the compounds listed below and/or differ in concentration by more than a factor of 5. Rationale supporting the number and location(s) of community monitoring stations as well as the methodology for determining correlations to gradients, must be supported and approvable in the Air Monitoring Plan.

Measurements of a surrogate for **diesel particulate matter (DPM), such as black carbon, total hydrocarbon, or other representative hydrocarbon measurement, speciated hydrocarbons based on TO-15 including BTEX, 1, 3 butadiene and carbon tetrachloride, oxides of nitrogen, SO₂ and particulate matter less than 2.5 microns in diameter (PM_{2.5})** shall be measured at community monitors. Filter-based measurements that can be analyzed for metals, semi-volatiles, and other PM species must also be considered in the Air Monitoring Plan. If this is not the case, refinery operators must provide a rationale for not measuring the above compounds that addresses: why these compounds may not be contained in the compositional matrix of ambient air; and/or, are not at concentrations measured by the equipment and analytical techniques available. In addition, if multiple community monitoring locations are indicated and not proposed, refinery operators must explain how developed correlations will adequately represent the number of locations proposed.

Community monitoring locations must continuously measure total hydrocarbons, or other representative hydrocarbon measurement, and oxides of nitrogen and provide at least hourly measurement of PM_{2.5} using a federal reference or equivalent method. Black carbon must be measured on at least an hourly averaged basis unless a filter based Elemental Carbon/Organic Carbon (EC/OC) method is used. Samples collected for TO-15 analysis and filter based sampling must be conducted every twelve days, at a minimum, and must be a twenty-four hour integrated sample. Federal and/or State sample collection and analytical methods must be

used, where available. If Federal and/or State methods are not available, best industry practice must be utilized and rationale as to why a method is an “industry best practice’ provided as part of the Air Monitoring Plan. Results must be provided to the public on a real-time basis, where possible, and when results become available for parameters that require laboratory or other analysis to provide results. All QA/QC techniques must be outlined in a QAPP that follows EPA guidelines. Data completeness must be maintained at 80% for all compounds with continuous measurements meeting 75% completeness on an hourly basis 80% of the time on a quarterly basis.

Measurements must be taken in a location that is representative of the population living near the refinery and be correlated to gradients caused by emissions from the refinery as described in this document. The siting of this location must meet the requirements of 40 CFR Part 58, or the refinery operator must provide rationale on why there should be allowable deviations from these requirements explaining how those deviations do not bias measurements to be lower than expected.

1.3 Display of Monitoring Information

The data must be displayed to the public as defined above and available to the Air District in an approved format. The refinery operator must include in the Air Monitoring Plan the steps taken to provide context of the measurements to the public and a means for the public to provide comments and feedback for improvement of the data display and compound measurements. These comments must be made available to the Air District upon request.

Section 2: Air Monitoring Guidance Document and Development of Air Monitoring Plans

The Air District is providing this Guidance Document to enable Air District staff, the community, industry and other interested parties to determine if Air Monitoring Plans submitted by Bay Area refineries adequately collect the data needed to determine air pollutant exposures associated with living or working near Bay Area refineries. Information gathered by the equipment and methodologies outlined in the Air Monitoring Plan will be used to evaluate the need for additional actions to reduce emissions and exposures.

This Guidance Document outlines where documentation and rationale for decision making must be included in the Air Monitoring Plan. The Air District understands that there is a need for flexibility when designing air monitoring networks. Air Monitoring Plans should document the considerations that were taken, the process involved with determining the proposed course of action and the potential affects the different choices may have on the data produced to support the decisions made.

The Expert Panel was clear that not all measurements need to necessarily utilize high cost instrumentation, provide real-time results or be located on a permanent basis as long as technologies met monitoring goals, measurements for gradients represented spatially “dense” information and provide correlations to accurate long term measurements or demonstrate strong agreement with Health Risk Assessment (HRA) modeling. The Expert Panel stressed the need to leverage all monitoring activities available, be they regulatory or informational. Examples of this type of monitoring strategy are also provided in the DRI report. If alternatives monitoring strategies, such as those outlined in the DRI report or discussed by the Expert Panel, are proposed to replace measurement and/or equipment required for consideration, an acceptable rationale for this substitution must be supplied and approvable in the Air Monitoring Plan.

It is important to note that the Expert Panel generally agreed that information collected utilizing the techniques addressed in this Guidance Document could not be effectively utilized to take direct enforcement action but could be an effective tool to potentially identify areas where actions could be taken to reduce emissions. In addition, this Guidance Document is not intended to provide a representation of exposures within refinery property.

The following Sections and Appendices are intended to provide guidance on specific considerations that should be investigated and thoroughly addressed in the Air Monitoring Plan. It is required that a Quality Assurance Project Plan (QAPP) that follows EPA guidelines be provided with the Air Monitoring Plan that outlines 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.

2.1 Components of Monitoring Near Refineries

The Expert Panel made clear that there should be two measurement components to monitoring near refineries, at a minimum, and both are required to be addressed in the Air Monitoring Plan. One component should address real-time information about compounds moving from refinery property to the surrounding community. This Guidance Document addresses this type of monitoring in *Section 3: Fence-line Monitoring*. This component has currently been addressed with open path type monitoring at two Bay Area refineries. Most available methods are addressed in the DRI report.

The other measurement component identified by the Expert Panel, and required to be addressed in the Air Monitoring Plan deals with determining the near-field gradients and compound concentrations that represent air pollutants associated with ambient air exposure risk. This is addressed in *Section 4: Monitoring Based in the Communities around Refineries* and is divided into two distinct monitoring networks. One network would be designed to specifically represent gradients of compounds of interest as distance increases away from the refinery fence-line and will be used to establish the second component; fixed site(s) within the community.

The gradients will be used to establish relationships and correlations with the fixed site(s). As a result, the fixed site(s) would be representative of correlations and relationships with the gradients over time. Once the correlations and relationships are established, the measurements to determine gradients can be discontinued. The refinery must provide in the Air Monitoring Plan a schedule of how often the measurements representing gradients must be employed to demonstrate that correlations and relationships continue to exist, with a minimum of every five (5) years, when there is substantial change of this Guidance Document or refinery processes.

2.2 Data Display and Dissemination

The Expert Panel discussed how measurement results should be displayed to the public. The Air Monitoring Plan must address the measurements of compounds as well as the display and dissemination of this information. This Guidance Document provides information on this subject in *Section 5: Data Display/Reporting*. Providing context for the measurements is an important consideration when displaying the information. The Air Monitoring Plan submitted by the refinery operators must describe how the refinery will provide the air monitoring data in a way that the public can readily access and understand. This would require involving interested parties in the design of data dissemination. The plan must also provide a means for the public to provide input toward improving the way data is displayed to aid in understanding and a means for suggestions to be made on system performance.

Section 3: Considerations for Fence-line Monitoring

As stated above, the main goals of fence-line monitoring is:

- to provide continuous information on a short enough time scale
- to provide data of sufficient accuracy to identify when concentrations of compounds associated with refinery operations are elevated

- to provide context to the data so that the community can determine if there is cause for concern
- to aid in identifying corrective actions that will lower emissions

It is expected that the fence-line monitoring will be permanently installed and continually operated.

As pointed out in the DRI report, multiple technologies need to be employed to ensure adequate compound identification at appropriate levels of detection and accuracy. The Expert Panel also agreed that each refinery should identify compounds of interest and define correlations and relationships of compounds prior to choosing measurement technologies and that potential interference(s) should be identified to ensure representative results. Air Monitoring Plans must include which organic and other refinery generated compounds likely to impact the health and wellbeing of people are likely to cross fence-lines, whether or not the proposed equipment is capable of measuring those compounds.

Technologies proposed in the air monitoring plan should be able to measure, at a minimum, benzene, toluene, ethyl benzene, and xylenes (BTEX), alkanes or other organic compound indicators, H₂S and potentially SO₂ and ammonia. Exclusion of any of these compounds by fence-line monitoring must be thoroughly explained in the air monitoring plan.

3.1 Open Path Monitoring

The Expert Panel agreed with the DRI report that open path monitors best addressed the goal of monitoring potential impacts from refineries and also believed that shorter time scale resolution was very desirable. Open path equipment should provide appropriately accurate data on an hourly basis, at a minimum, and the Expert Panel believed that 5 minute data resolution was reasonable. Rationale for the technology chosen and the associated time resolution should be included in the air monitoring plan.

Investigation prior to fence-line installation should address areas more likely to emit compounds of interest and identify the appropriate open path distance necessary to accurately and precisely capture those emissions. The results of the investigation must be provided in the Air Monitoring Plan, providing support for the technologies chosen. In addition, the elevation of likely emissions as well as topographical changes should also be incorporated into the evaluation to ensure maximum coverage.

Meteorological measurements should also be used and addressed in the Air Monitoring Plan to ensure proper location of fence-line systems, looking at long term measurements such as annual average wind rose, but also taking into account more seasonal and recurring short term meteorological events. It was also suggested, and is likely in the best interest of the facilities, to locate additional fence-line monitoring in a predominately upwind location to measure contributions from upwind sources that could impact downwind refinery fence-line

measurements. The following guidance and metrics will be used by the Air District to evaluate the expected performance of the community monitoring portion of the air monitoring plan.

The EPA has recently proposed a rule requiring monitoring for benzene at refinery fence-lines. The Air District believes that the best methodology for this is the use of open path technologies, and will work to ensure that monitoring systems proposed as part of the Air Monitoring Plan meet all applicable EPA requirements for monitoring of benzene.

A summary of fence-line monitoring considerations appears in Table 1.

Table 1. – Fence-Line Monitoring Considerations

Evaluate	Information Needed	Additional Considerations
Compounds likely to be emitted	Compound relations and correlations within the facility	Likely interferences
Precision, accuracy and minimum levels of detection of equipment	Information that is represented of compounds of interest at concentrations likely to cause concern	Maximum path length allowed to provide precision and accuracy
Time resolution of data produced	Resolution will be adequate to appropriately capture short duration events	Data management
Identify likely emission sources and compounds likely to be emitted from those sources	Compounds potentially unique to emission sources to ensure appropriate technology will be representative	Potential to utilize multiple technologies to capture relevant information
Topography of measurement area and elevation of equipment	Measurements will likely capture emissions from sources of concern	Power and security
Meteorology	Annual average and likely to occur wind patterns	Variations of wind from location to location

3.2 Appropriate Sampling Locations

Air Monitoring Plans must include locations of equipment, elevations of equipment and expected path length and the rationale behind these choices. Potential disruption of airflow and the potential effect on measured concentrations cause by obstacles must also be addressed. Any interferences cause by meteorological or process issues associated with the chosen location must be addressed. For example, an explanation should be included if a chosen measurement area is likely to be affected by fog or process steam. In addition, the Air Monitoring Plan should include how the open path monitoring will effectively provide relevant information for all nearby downwind communities during expected meteorological conditions.

3.3 Appropriate Sampling Methodologies

Air Monitoring Plans must address why a particular measurement method was chosen for a given location based on likely emissions from nearby contributing sources, desires to reach appropriate levels of detection and ability to measure compounds that have potentially unique relationships that apply to the particular facility. Factors that affect measurements, such as path length and potential interferences, should also be addressed. Errors associated with the measurement technologies as well as accuracy, repeatability and precision should be documented and presented and ways to address these issues provided in the Air Monitoring Plan.

3.4 Quality Assurance/Quality Control (QA/QC)

Methodologies for ensuring appropriate levels of QA/QC must be provided in the Air Monitoring Plan to ensure data are of high enough quality and representative and defensible enough to meet the goals described in Section 3.3. The QA/QC plan should set data acceptance levels as well as appropriate levels of data quality. In addition, the QA/QC plan should address data management issues and provide the levels of review that data will go through to determine validity. This should be outlined in a Quality Assurance Project Plan (QAPP) that follows EPA guidelines submitted in the Air Monitoring Plan. It is critical that this portion of the monitoring plan identify a clear and transparent manner when data does not meet quality requirements and should be removed from the data set, to ensure the community understands why data is removed.

Section 4: Monitoring Based in the Communities around Refineries

Measurements conducted as part the fixed site(s) located in communities around refineries would have a number of goals, not all associated with direct emissions from the refineries themselves. These goals are:

- Provide air quality information for communities near refineries
- Gather data to evaluate health impacts associated with air quality near refineries
- Track air quality changes and trends over time near refineries
- Demonstrate correlations and/or relationships with emissions from the refineries
- Compare air quality measurements near refineries to other air quality measurements in the Bay Area
-

The DRI report and the Expert Panel agreed that monitoring within the communities around refineries was critical in identifying the health risks associated with living near such large, industrial sources. Vital to this evaluation is developing an approach that identifies and quantifies health risk drivers, regardless of origin, so that comparisons can be made to other locations that also measure those risk drivers. In addition, the gradients of compounds moving

away from the refinery's boundaries must also be evaluated and quantified to compare to emissions estimates from the facility and to estimate the spatial extent of those impacts.

It is expected that two networks will need to be developed – one where gradients are measured/estimated as distance increases away from the fence-line of the refinery that informs where permanent site(s) are located within the community and linked by relationships and correlations to the results of the gradient measurements. The gradient measurements must be of long enough duration to properly determine the gradients, inform the location of the permanent site(s) and develop relationships and correlations. Once this has been accomplished, only periodic gradient measurements need to take place to confirm those relationships and correlations remain valid.

Risk drivers and rough estimates of gradients should be investigated and included in the Air Monitoring Plan to inform where effective gradient measurements should take place, allowing a more definitive determination of compounds of interest and gradients/compound relationships. Previous health risk assessments or other modeling techniques would be appropriate to use to inform gradient measurements.

The DRI report provides a number of options that could be utilized for both determining gradients and measuring at fixed site(s), and any combination of methodologies that meets the goals of defining a gradient of compounds likely emitted by the refinery and measuring risk drivers within the community could be acceptable to the Air District. The following guidance and metrics will be used by the Air District to evaluate the expected performance of the community monitoring portion of the Air Monitoring Plan.

4.1 Likely Risk Drivers and Near-field Gradients

The DRI report provides information on health risk assessments that were performed at the refineries as well as other information regarding potential risk near these facilities. The Air District also has information on risk associated with the Air Toxics "Hot Spots" Program and Community Air Risk Evaluation (CARE) program. This information, along with information about compounds that are measured at locations throughout the Bay Area and the state should be used to determine what compounds should be measured at permanent sites. The Expert Panel suggested that a maximum of three such permanent sites should be located in communities near refineries, with a maximum of two being located in the predominately downwind location. The siting of new monitoring stations could leverage measurements at stations already in place.

Determining gradients of compounds moving away from refinery boundaries towards communities was also addressed in the DRI report and discussed by the Expert Panel. This task is associated more with spatial issues as opposed to temporal issues. As a result, Air Monitoring Plans must identify how proposed measurements will best capture concentration changes with distance. Consideration should be given to areas prone to fugitive emissions or other difficult to quantify emission sources, as these gradients and compound profiles tend to be less understood and potentially steep. In addition, areas that have been identified by HRAs or

emission studies to have expected high concentrations of compounds of interest should also be considered and adequately addressed in the Air Monitoring Plan. Again, variations in emissions associated with source operations that may impact compounds of interest and concentration should be addressed to demonstrate appropriate measurement methods.

Since the changes in compound concentration are expected to remain proportional to emissions over time, measurement of gradients is expected to be of shorter duration, allowing enough time to adequately determine likely gradients and potential relationships and correlations with the permanent community monitoring. It is also assumed that these shorter duration gradient studies will be repeated over time to ensure conditions have not changed significantly and that relationships and correlations remain. The Air Monitoring Plan must contain rationale for determining when gradient studies will be repeated, based on time, process or emission source changes or other relevant parameters. At a minimum, gradient measurements must be repeated every five years to ensure correlations and relationship remain valid with the permanent monitoring location(s).

The DRI Report identifies many measurement techniques that could be used for gradient measurements. They range from utilizing passive sampling techniques in a spatial dense arrangement to measuring concentration fluxes across fence-lines. The rationale for the choice made must be provided in the Air Monitoring Plan.

4.2 Fixed Community Monitoring

Fixed community location(s) should represent relationships and correlations built from previous studies and the gradient measurements. In addition fixed site measurements will be used to represent changes over time and to compare to other measurement locations throughout the Bay Area, state and nation.

Refineries must develop methodologies that include population exposure and likely concentration based on the gradient measurements to determine how fixed site(s) will best meet the monitoring goals described in Section 4 and include them in the Air Monitoring Plan. The Air District recognizes that flexibility must be provided to accommodate the many variables that can affect the appropriateness of a monitoring location, such as vehicle traffic, vegetation, and available power. As a result, it is critical that the Air Monitoring Plan address potential issues up front so that all interested parties know the parameters of site location at the beginning of the process. It is highly suggested that the community be involved in the process and able to provide feedback and understand the issues. The Air Monitoring Plan should include the methods that will be used to involve the public in this process.

The refinery must submit to the Air District their proposed location of the fixed monitoring site(s) prior to site development while still meeting the monitoring deadlines contained in Regulation 12, Rule 15. The refineries are encouraged to work with the Air District and community throughout this process. The proposed location must be based on the area of highest likely exposure of compounds of concern emitted from the refinery to the population

located near the refinery based on normal operations utilizing the gradient measurements, available risk information and available modeling. Rationale for siting must be contained in the Air Monitoring Plan that includes an analysis of the variables involved and how they affected the choice of the ultimate locations. For example, if the most appropriate location is determined to be near another source, the analysis should provide an explanation of how that source would affect the measurements and how that influenced the choice of the proposed monitoring location. Correlations and relationships to gradient measurements must be included in the Air Monitoring Plan if the fixed site(s) are proposed in the Plan.

Since the location(s) will be based on information developed as part of the Air Monitoring Plan, the proposed location may be submitted after the Air Monitoring Plan has received approval and will be considered an “Addendum to the Air Monitoring Plan”. The Addendum to the Air Monitoring Plan must contain the rationale for the proposed siting, analysis of the variables involved and how they affected the choice, and outline the correlations and relationships to the gradient measurements as described above. If an Addendum to the Air Monitoring Plan will be submitted, it must be stated in the Air Monitoring Plan and the refinery must still meet the deadlines contained in Regulation 12, Rule 15.

A summary of community monitoring consideration appears in Table 2.

Table 2 – Community Monitoring Considerations

Evaluate	Information Needed	Additional Considerations
Compounds associated with highest risk in nearby communities	Risk drivers in Bay Area and compounds of interest likely emitted by the facility	Monitoring technologies needed to measure identified compounds
Identifying appropriate long-term fixed sites and associated shorter-term sites	Where compounds may be emitted at higher concentrations and building relationships of emitted compounds to shorter-term measurements	Measurement must represent spatial density required to develop concentration gradients
Precision, accuracy and minimum levels of detection of equipment	Information that is represented of compounds of interest at concentrations likely to cause concern	Issues associated with reduced temporal resolution of shorter-term measurements
Siting issues	Locations are appropriate with minimum interferences and appropriate air flow so that measurements are representative	Infrastructure, security and long term availability of use of sites
Meteorology	Annual average and likely to occur wind patterns	Variations of wind from location to location

4.3 Appropriate Sampling Locations

Air monitoring plans must provide methodologies for identifying appropriate locations of sampling equipment and monitoring sites. Many sources of information are available that provide representative sampling locations, such as EPA regulations dealing with ambient air monitoring. Air Monitoring Plans must address how chosen locations provide adequate air flow, are not unduly impacted by localized emissions from non-refinery sources, are not impacted by surfaces or areas that may cause chemical reactions that bias the data low or high (such as trees) and that will provide a representative sample of concentrations that occur in that area over the time period that sampling occurs. This applies to both the gradient network as well as the permanent monitoring location(s). Additional siting information and requirements are contained in Section 6.

4.4 Appropriate Sampling Methodologies

Air Monitoring Plans must provide information on how the chosen sampling method will provide data of high enough quality and measure compounds at levels appropriate for expected concentrations. Errors associated with the measurement technologies as well as accuracy, repeatability and precision must be documented and presented and ways to address these issues provided in the Air Monitoring Plan. For example, if a less precise method is chosen, the number of collocated methods should be determined and outlined to ensure that enough measurements are collected to address the lack of precision. This applies to both the gradient measurements as well as the permanent monitoring location(s).

4.5 Quality Assurance/Quality Control (QA/QC)

Methodologies for ensuring appropriate levels of QA/QC must be provided in the Air Monitoring Plan to ensure data are of high enough quality and representative and defensible enough to meet the goals described in Section 4. The QA/QC plan should set data acceptance levels as well as appropriate levels of data quality. In addition, the QA/QC plan should address data management issues and provide the levels of review that data will go through to determine validity. This must be outlined in a QAPP that follows EPA guidelines submitted in the Air Monitoring Plan. This applies to both the gradient measurements as well as the permanent monitoring location(s).

Section 5: Data Display/Reporting

The Expert Panel discussed the importance of providing relevant, useful and understandable monitoring information to the public. This was especially important for fence-line information, but also applies to gradient measurements and more permanent real-time monitoring activities located within the community. Monitoring that requires laboratory analysis, or involves time integrated sampling methods and therefore would not be presented to the community real-time, would also need to be made available to the public, but would most likely require a

different display format. The Expert Panel stressed the need for QA/QC requirements to be stated clearly up front, so that if data removal were required due to failed QA/QC objectives, the rationale for the data removal would be done in a transparent way with proper notation.

Providing context to measurements that the public could readily understand was also stressed, with graphics to allow residents to determine when concentrations were within normal ambient ranges and what constituted concentrations that might indicate potential issues. There was also a realization that more complex data should also be provided, so that residents that had the understanding and ability could perform additional analysis. There was also general agreement by the Expert Panel that any data display should contain a means for residents to provide feedback so that improvements could be made to data display as well as monitoring activities over time.

Air Monitoring Plans must provide an explanation of how data will be provided to the public, how that data will be provided context, and how the public will be able to provide feedback to improve the process. Feedback regarding the website or other data presentation must be made available to the Air District upon request.

5.1 Time Resolution and Data Availability

Monitoring plans should provide information on how real-time data will be distributed to the community and how other data generated by this air monitoring will be made available. It is assumed that this will likely result in data being presented on a website on a real-time basis and many examples of these types of websites exist. Ideally, the websites for all refineries would be similar in nature, so that the public could compare the various locations to each other. In addition, the Air Monitoring Plan must contain alternatives for those members of the community who may wish to have access to data while not having computer access. The data must also be made available to the Air District in an approved format.

As stated previously, continuous instrumentation should be capable of producing data on an hourly basis, at a minimum, with data resulting from fence-line instrument measurements available on a shorter time period, ideally at 5 minutes. Data completeness for displayed data should be upwards of 95%, given the reliability of current equipment. Members of the Expert Panel representing the community provided input that as long as QA/QC data removal requirements were provided up front and were reasonable, removal of questionable data was not usually an issue. As a result, Air Monitoring Plans must incorporate how data can be displayed real-time, while incorporating necessary QA/QC to ensure representative data. Air Monitoring Plans must also address timeframes that data will be provided and the rationale behind those decisions as well as minimum expected uptime for the website. While QA/QC and data completeness must be addressed in the QAPP, how these will be applied to real-time display must also be provided in the Air Monitoring Plan.

The Air Monitoring Plans must also include how the refineries will provide context that the community can utilize to understand what the data mean. This must include a mechanism for

feedback and improvement of the site and a means for residents to report experiences and provide information regarding potential impacts from the refinery that could be used to improve data display and the monitoring activities themselves.

Air Monitoring Plans should also include how residents can access historical data directly, as websites should not simply provide graphical information about current conditions. The Expert Panel suggested that data should be “layered” so that interested parties with expertise could access more complex and complete datasets and these considerations must be incorporated into the Air Monitoring Plan. It is recognized and expected that this will likely involve appropriate annotation of data to convey limitations and issues associated with these more complex datasets.

Section 6: Siting Considerations

In general, siting consideration contained in EPA’s ambient air monitoring regulations, 40 CFR Part 58, must be followed and should meet the smaller scales of representativeness presented for compounds of interest. In addition, requirements contained in EPA’s proposed 40 CFR Part 63 should also be considered and addressed where the use of passive sampling techniques are proposed. Vertical placement of sampling equipment should attempt to be between 2 and 7 meters above ground level. These criteria match that of microscale PM_{2.5} siting criteria, and encompass the current microscale CO siting criteria. Probe placement at or near a 2 meter height above ground level is generally considered to be at or near “breathing height,” which is a human exposure consideration. Rationale for any deviations from EPA siting criteria must be provided in the Air Monitoring Plan along with likely effects of the deviations on data.

Sampling should be spaced away from certain supporting structures and have an open, unobstructed fetch to the target area. At least 90 percent of the monitoring path (for open path, remote sensing instruments), should be at least 1 meter vertically and/or horizontally away from any supporting structure, and away from dusty or dirty areas. Rationale for siting equipment, including how it meets EPA criteria as well as why deviations from EPA criteria are necessary, should be included in the Air Monitoring Plan.

6.1 Nearby Structures

Structures may be present that can significantly impact pollutant concentrations. These structures include sound walls or noise barriers, vegetation, and buildings. Physical barriers affect pollutant concentrations around the structure by blocking initial dispersion and increasing turbulence and initial mixing of the emitted pollutants. While these structures can trap pollutants upwind of the structure, these effects are very localized and likely do not contribute to representative peak exposures for the nearby population. In general, these structures should be avoided when establishing fence-line and near-field monitoring systems. Air Monitoring Plans must address how any effects caused by structures were identified and addressed.

6.2 Terrain

As described previously, local topography can greatly influence pollutant transport and dispersion. However, large-scale terrain features may also impact where peak concentrations can occur. Air Monitoring Plans must address how the effects of terrain were taken into consideration and addressed.

6.3 Meteorology

Evaluating historical meteorological data is useful in determining whether certain candidate locations may experience a higher proportion of direct impacts from emissions from a given source or process. Often, peak concentrations occur during stable, low wind speed conditions. Thus, historical wind directions should be a consideration in establishing any monitoring site but should not be the only considerations. Therefore, monitor placement on the climatologically down-wind side of sources might be preferential when the option is available; however, this should not preclude consideration of sites located in the predominant climatologically upwind direction or in directions where meteorological conditions are expected to occur on a non-routine basis. Rationale for how meteorological measurements were used to determine sampling locations should be included in the Air Monitoring Plan.

Section 7: 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. The DRI report and the Expert Panel recognized the need to employ a multi-pollutant monitoring strategy at and near refineries for these reasons and this Guidance Document provides the following list of compounds for consideration as part of the Air Monitoring Plan. All compounds must be considered and evaluated for the permanent site(s) with rationale for chosen measurements, and, as a result, the gradient measurement network. Those marked with an asterisk (*) should also be considered for the fence-line monitoring network. This is not intended to be a complete list, and the Air District would consider adding or deleting compounds dependent on the rationale provided for inclusion and/or exclusion in the Air Monitoring Plan.

7.1 Black Carbon

Black carbon (BC), often referred to as “soot,” is a common constituent emitted from motor vehicles and other processes that burn fuel. Another measurement is elemental carbon (EC), which is detected using different techniques. Both BC and EC are operationally-defined, and represent the graphitic-containing portion of PM. BC uses light absorption as a measurement technique. Although BC and EC are often associated with emissions from heavy-duty diesel engines, a portion of all combustion emissions contains these constituents. Other sources of BC or EC exist in urban areas, but emissions from motor vehicles usually dominate these sources, especially in near-road locations, thus making BC or EC measurements a useful parameter for

identifying impacts from motor vehicle emissions. Measurement of this constituent will help determine if refineries add significant concentrations to nearby urban environments.

7.2 H₂S*

H₂S is a colorless gas with a strong “rotten egg” odor and can be smelled at very low concentrations. It is poisonous, discolors paints and can tarnish metals. Although it is produced at sewage treatment plants and through anaerobic processes, it is also produced at oil refineries as a by-product of refining crude oil. As a result, measurement of this compound will help identify potential leaks at refineries.

7.3 NO₂ (Nitrogen Oxides)*

Scientific evidence links NO₂ exposures with adverse respiratory effects, making it a compound that is routinely measured in ambient air monitoring networks. NO₂ measurements also typically include measurement of NO and NO_x. It is emitted during combustion and is therefore of interest near refineries, though there are many sources of nitrogen oxides. Measurement of these constituents will help determine if refineries add significant concentrations to nearby urban environments.

7.4 Particulate Matter (PM)

Combustion sources emit significant amounts of PM. Motor vehicles may also contribute to elevated PM concentrations by re-suspending dust present on the road surface. There are regulations that address ambient concentrations of PM less than 10 μm in diameter (PM₁₀) and PM less than 2.5 μm in diameter (PM_{2.5}). While both of these PM size fractions are emitted during combustion, the majority will generally be in the PM_{2.5} size fraction. Since combustion-emitted particles typically occur at less than 0.1 μm in diameter, these emissions tend to contribute little to ambient PM_{2.5} mass concentrations, but do contribute significantly to PM number concentrations, and may impact the chemical composition of the PM_{2.5} mass collected relative to urban background conditions. PM emitted through mechanical processes (brake wear, tire wear, re-suspended road dust) will tend to be in the PM₁₀ size fraction and can lead to elevated mass concentrations. As a result, PM_{2.5} mass measurements may be useful for estimating potential refinery contributions to nearby urban environments.

Most PM₁₀ and PM_{2.5} mass measurements use filter-based, gravimetric analyses over a 24-hour sample collection period. Diurnal variations in meteorology can have a tremendous impact on air quality that may not be identifiable in 24-hour average measurements. Thus, continuous PM measurements provide useful information for refinery emission measurement applications; however, care must be taken in choosing a sampling method. Optical PM mass samplers typically cannot detect particles less than approximately 0.2-0.5 μm in diameter. Therefore, these measurement devices may not capture a significant amount of the PM mass related to primary combustion emissions. In addition, some continuous PM samplers heat the inlet air prior to analysis. Since PM emissions can contain a significant amount of semi-volatile organic

compounds, these samplers can underestimate the PM mass by volatilizing the organic PM prior to collection in the sampler.

7.5 PM constituents

PM present near refineries contains a number of organic and inorganic constituents that may pose a public health risk. Organic PM samples are most often collected on filters backed by a cartridge to collect gas-phase constituents. Sample collection typically uses high-volume samplers to maximize the amount of PM mass obtained for detailed chemical and physical analysis; thus, collection times can be from 24-hours to over a week to collect an ample amount of mass. Inorganic PM samples are also usually collected on filters using high-volume samplers and longer sampling times to collect sufficient mass for elemental analyses. A detailed listing of organic and inorganic PM compounds of health concern is provided by the California Office of Environmental Health Hazard Assessment (OEHHA). Detailed speciation of organic and elemental PM compounds can be useful in conducting or evaluating source apportionment studies to estimate the impacts of PM concentrations, although the long sample averaging times required for this analysis may limit the ability to discern differences of source activity of PM impacts.

7.5.1 Elemental Carbon/Organic Carbon (EC/OC)

Elemental Carbon/Organic Carbon (EC/OC) usually involves analysis of PM filters. EC differs from BC in how it is defined through analysis. EC uses thermal measurement techniques and has less potential for interference from other compounds than BC. OC is a complicated mixture of thousands of individual molecules and is a combination of both primary particulate emissions and gaseous precursors that can form secondary aerosols. OC is often the largest component of PM in urban areas in the Western United States, especially near roadways. Measurement of these constituents will help determine if refineries add significant concentrations to nearby urban environments.

7.5.2 Metals

Measurement of metals usually involves analysis of PM filters. Many metals have negative health impacts associated with exposure and can be emitted in trace amounts when contained in compounds being burned or processed. Of particular interest are nickel, hexavalent chromium and arsenic, since these metals are associated with most of the risk in the urban environment. Since many metals are contained in crude oil and the fuels needed to process crude oil, measurement of these constituents will help determine if refineries add significant concentrations to nearby urban environments.

7.5.3 PM number concentration

As previously discussed, PM emitted through the combustion process occurs primarily in the ultrafine size range (i.e. less than 0.1 μm in diameter); thus, the impact on PM mass may be

negligible. However, emissions of these small particles occur in extremely large quantities; therefore, PM number concentration measurements often provide a good indication of primary PM emissions. In addition, several health studies suggest that ultrafine particles may lead to adverse health effects. A number of devices exist to measure PM number concentrations, ranging from inexpensive industrial hygiene monitors to research-grade ambient air monitors. Most of these devices can provide number concentration measurements in near real-time, although the range of particle sizes and concentrations detected do vary. When comparing measurements from different devices, any differences in particle size ranges detected must be noted. Measurement of PM numbers may help determine if refineries add significant concentrations to nearby urban environments.

7.5 Speciated Hydrocarbons*

Speciated hydrocarbons are pollutants that are made up of hydrogen and carbon and can be associated with adverse health effects. They are emitted by a large number of sources, but many hydrocarbons are associated with fuels and the production of fuels. As a result, measurement of these compounds is critical to determining the impacts refineries have on nearby communities. The following are potential compounds of interest and are separated out based on their measurement and/or analytical techniques. Measurement of hydrocarbons will help determine if refineries add significant concentrations to nearby urban environments and can indicate leaks and emissions from refinery sources.

7.5.1 Aldehydes*

Aldehydes emitted into ambient air include, but are not limited to, formaldehyde, acetaldehyde, and acrolein. A more detailed listing of aldehydes with potential health concerns is provided by OEHHA. Aldehydes are typically measured using cartridges containing dinitrophenyl hydrazine (DNPH). However, other methods, including evacuated canisters and cartridges containing other compounds, have been used to measure ambient concentrations of some of these compounds. Sample collection periods of 24-hours or more are typically required for assessing ambient aldehyde concentrations, although a few manufacturers advertise semi-continuous analyzers for select compounds.

7.5.2 Polycyclic Aromatic Hydrocarbons (PAH)*

Polycyclic Aromatic Hydrocarbons (PAHs) are hydrocarbons with multiple aromatic rings that have been associated with potential health effects. They are present in fossil fuels and can be formed as part of the combustion process, though there are many sources of PAHs. Sampling and analysis for PAHs requires very specific techniques and methodologies, though there are some non-specific, real-time instruments available. A more detailed listing of PAHs with potential health concerns is provided by OEHHA.

7.5.3 Volatile organic compounds (VOCs)*

These air toxics are found in the gas phase in ambient air. Typical VOCs of concern include, but are not limited to, benzene, toluene, ethylbenzene, xylenes (BTEX), 1, 3 butadiene, acrolein and styrene. A more detailed listing of potential VOCs of health concern is provided by the OEHHA. VOCs are typically measured by the collection of ambient air using evacuated canister sampling and subsequent analysis on a gas chromatograph (GC). For evacuated canister sampling, the sample collection time can vary from instantaneous grab sample to averaging times of more than 24-hours depending on the collection orifice used. As discussed for PM sampling, shorter averaging times can be important to discern the impacts of varying environmental conditions. Auto-GCs can be used to measure select VOC pollutant concentrations semi-continuously at a monitoring site. A number of manufacturers also advertise semi-continuous analyzers for one or more VOCs of interest using various GC technologies.

7.6 SO₂*

Heating and burning of fossil fuel releases the sulfur present in these materials and result in the formation of SO₂. SO₂ can have direct health impacts as well as cause damage to the environment and, as result, is routinely measured in ambient air monitoring networks. Like H₂S, SO₂ is produced at refineries, though there are other sources. As a result, measurement of this compound will help identify potential leaks and issues at refineries.

7.7 Surrogate Measurements*

A number of surrogate measurements can also be considered to assist in interpreting emission impacts on air quality and to determine possible causes of adverse health effects. A common surrogate has been the use of CO to represent the impacts of other non-reactive gas emissions that are more difficult to measure from emission sources. While studies do show that CO and other non-reactive VOC concentrations tend to correlate in some near combustion source environments, the magnitude of VOC concentrations relative to CO concentrations may be difficult to discern because of varying impacts from control strategies and emission sources. Regulations that have led to reductions in CO emissions may not equally affect VOC emission rates. In addition, CO is emitted by fuel combustion, whereas VOCs are emitted from both combustion and evaporation processes.

Other surrogate measurements focus on PM constituents that are primarily emitted from motor vehicles and other combustion processes and may pose a public health concern. These surrogate measurements were discussed in the above sections.

If surrogate measurements are proposed in the Air Monitoring Plan, the relationship to compounds of interest must be identified and confirmed for the application desired.

Appendix 1: DRI Report

Appendix 2: Expert Panel Report

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