Derivation of Comparison Values for Evaluation of Ambient Air Chemical Concentrations Collected by Mobile Monitoring Instruments

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Acronyms and Abbreviations

Acronyms and Abbreviations	Definitions
ACGIH	American Conference of Governmental Industrial Hygienists
AEGL	acute exposure guideline level
AHBCV	acute health-based comparison value
AMCV	air monitoring comparison value
ASPECT	airborne spectral photometric environmental collection technology
ATSDR	Agency for Toxic Substances and Disease Registry
BMC	benchmark concentration
C	ceiling value
CalEPA	California Environmental Protection Agency
DOSH or Cal/OSHA	California Division of Occupational Safety and Health
DUVAS	differential ultra-violet absorption spectrometer
^{EM}HBAL	health-based action levels for exposure mitigation
^{EM}HBAL$_{10min}$	10-minute exposure mitigation health-based action level
^{EM}HBAL$_{1hr}$	1-hour exposure mitigation health-based action level
^{EM}HBAL$_{1sec}$	1-second exposure mitigation health-based action level
HBAL	health-based action levels
HEC	human equivalent concentration
iBDIL	instantaneous baseline-derived investigation level
iHBAL	instantaneous health-based action level
iHPIL	instantaneous health-protective investigation level
LOAEL	lowest-observed-adverse-effect-level
MOE	margin of exposure
MRL	minimal risk level
N	baseline noise
NIOSH	National Institute for Occupational Safety and Health
NOAEL	no-observed-adverse-effect-level
OSHA	Occupational Safety and Health Administration

Acronyms and Abbreviations	Definitions
PBPK	physiologically-based pharmacokinetic
ppb	parts per billion
ppbv	parts per billion by volume
PTR-MS	proton transfer reaction mass spectrometer
RfC	reference concentration
RfD	reference dose
S/N	signal to noise
SIFT-MS OR SIFT	selected ion flow tube-mass spectrometer
STEL	short-term exposure limit
TAGA	trace atmospheric gas analyzer
TCEQ	Texas Commission on Environmental Quality
USEPA	United States Environmental Protection Agency
UF	uncertainty factor

Executive Summary

Background

The Texas Commission on Environmental Quality (TCEQ) has several ambient air monitoring instruments in specialized vehicles that can collect instantaneous data while in-motion (termed mobile monitoring) for activities such as field investigations and emergency events. The two primary instruments are the Selected Ion Flow Tube-Mass Spectrometer (SIFT-MS or SIFT)[1] and the Differential Ultra-Violet Absorption Spectrometer (DUVAS).[2] These instruments can provide accurate, real-time, instantaneous concentrations (typically in 1-30 second intervals) of select chemicals in ambient air while the vehicle is in motion. These instruments produce important information for assessing air quality in areas near emergency events (e.g., industrial accidents, natural disasters such as hurricanes, etc.) and during investigations. The DUVAS instrument also provides monitoring staff with concentration-based, color-coded maps (called caterpillar trails) in real-time, which can be used as a practical tool to geographically map concentrations of targeted chemicals for evaluation by agency staff and to help communicate concentration data to the public. Both the SIFT and DUVAS can be used to rapidly identify abnormally high concentrations of targeted chemicals in ambient air and help expedite efforts to address them. However, evaluating these instantaneous measurements to determine abnormal levels and/or potential health concern offers some challenges, which are addressed herein.

Instantaneous data present unique challenges for interpretation, primarily due to their very short sample duration. Historically, concentrations with very short sampling durations (i.e., 1-30 seconds) have not been evaluated for the potential to cause adverse health or welfare (e.g., vegetation) effects because there is a lack of relevant toxicity studies with equivalent or very brief exposure durations. Health-based comparison values have historically been based on a chronic exposure duration (e.g., United States Environmental Protection Agency [USEPA] reference concentrations [RfCs] and reference doses [RfDs]), with some agencies such as the TCEQ also developing short-term/acute health-based comparison values (e.g., TCEQ's 1-hour air monitoring comparison values [AMCVs]). In addition, field staff conducting the monitoring need to be able to continuously review incoming instantaneous air monitoring data and short-term averages so they may take appropriate actions in the field. There is also a need to provide context and meaning to these data to facilitate risk communication to the public.

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[1] SIFT-MS or SIFT – Selected-Ion Flow-Tube Mass Spectroscopy from Syft Technologies; the SIFT uses ultra-soft, precisely controlled chemical ionization coupled with mass spectrometric detection to rapidly quantify volatile organic compounds and permanent gases.

[2] DUVAS – Differential UV Absorption Spectroscopy instrument from DUVAS Technologies; the DV3000 offers real time, constant, simultaneous measurement of multiple gaseous species detectable using ultraviolet spectroscopy.

Types of mobile monitoring comparison values

To develop comparison values for mobile monitoring data that are reliable screening tools, it is necessary to have a good understanding of the collection and interpretation challenges of the data and how the data needs to be used. Based on these considerations, the TCEQ developed four different types of fit-for-purpose air data screening levels. These levels can be used in near real-time to help the TCEQ, the USEPA, and others to take actions to identify and characterize sources, initiate stationary monitoring or collection of canister samples to obtain longer duration measurements for toxicity evaluations, and/or mitigate exposure to staff when chemical concentrations are at higher levels. This document derives values specifically for use by monitoring staff and field investigators (a general public focus is outside the scope of this document). These screening levels are:

- instantaneous baseline-derived investigation levels (iBDILs)
- instantaneous health-protective investigation levels (iHPILs)
- instantaneous health-based action levels (iHBALs)
- exposure mitigation health-based action levels (^{EM}HBALs), associated with different short-term concentration durations:
    - 10-minute exposure mitigation health-based action level ($^{EM}HBAL_{10min}$)
    - 1-hour exposure mitigation health-based action level ($^{EM}HBAL_{1hr}$)
    - 1-second exposure mitigation health-based action level ($^{EM}HBAL_{1sec}$)

Baseline-derived comparison values

One use for the mobile monitoring comparison values is to identify the presence of an abnormally high concentration of any monitored chemical in the ambient air, so that a follow-up source investigation/characterization and any necessary emission mitigation can be implemented. To identify an abnormally high level of a chemical,[3] the baseline level of the chemical needs to be established first. A chemical baseline is considered to include both the low-level concentrations of that chemical in the environment, as well as the electronic and mechanical "noise" generated by the monitoring instrument. Therefore, the baseline concentration level is specific to each chemical and to the instrument being used. Before applying the SIFT and DUVAS instrument-specific baseline comparison values to other instantaneous sampling instruments (e.g., the USEPA Trace Atmospheric Gas Analyzer [TAGA] or the proton transfer reaction mass spectrometer [PTR-MS]), the appropriateness of these comparison values for other instruments will need to be evaluated.

After identifying chemical- and instrument-specific baselines, the instantaneous baseline derived investigation levels (iBDILs) were set at levels 10-times higher than the identified baseline. Setting the iBDIL 10-times higher than the baseline is intended to ensure that the

[3] Concentrations more than 10-fold higher than chemical- and instrument-specific baseline concentrations were considered "abnormal".

agency investigates abnormally high chemical concentrations in ambient air, while balancing the need to avoid using agency resources to investigate potentially spurious increases in chemical concentrations. The iBDIL values are not related to the toxicity of a chemical, although the majority of the iBDIL values that have been derived for the monitored chemicals thus far have been lower than toxicity-based comparison values.

Health-based comparison values

Other comparison values were derived to provide context in terms of potential chemical toxicity, and so included health-based, fit-for-purpose levels, that if exceeded could prompt longer duration stationary monitoring (i.e., 10 minutes to 1 hour) or consideration of exposure mitigation by staff.

Acute health-based comparison values (AHBCVs) are based on chemical-specific toxicity data and are typically developed for comparison to concentrations with 1-hour averaging times (e.g., TCEQ's 1-hour AMCVs), not 1-30 second averaging times. However, these 1-hour values can be utilized to help derive screening values for mobile monitoring data of different durations, including instantaneous measurements. The TCEQ used criteria that were fit-for-purpose for selection of AHBCVs (derived by TCEQ or other state or federal agencies) (See Appendix D) that are appropriate for use in emissions-related investigations and emergency response events. Those AHBCVs then served as the basis for the health-based mobile monitoring comparison values.

Several types of instantaneous and longer duration health-based mobile monitoring comparison values were derived to provide context to measured concentrations and to help inform actions by mobile monitoring staff. The first is the instantaneous health-protective investigation level (iHPIL), which is conservatively set as equal to the 1-hour AHBCV. An exceedance of an iHPIL could prompt stationary monitoring for up to 1 hour or more, as determined by field staff, with the resulting average concentrations then compared to the mobile monitoring comparison value of appropriate duration discussed below.

To indicate when more immediate or greater action may be required, four health-based action levels (HBALs) were developed. Instantaneous health-based action levels (iHBALs) are set at 3-times the AHBCV. As with the iHPIL, exceedance of the iHBAL triggers the need for stationary sampling, as well as increased vigilance for potential exceedance of an exposure mitigation value (discussed below). When the data can be averaged in the field, an iHBAL exceedance triggers an evaluation for potential toxicity after the first 5-10 minutes of stationary sampling, rather than after 1 hour (as with the iHPIL). Health-based action levels for exposure mitigation (^{EM}HBALs) were developed to help inform field staff of chemical concentrations where they may consider decreasing their exposure. ^{EM}HBALs were derived for three durations: 5-10-minute average ($^{EM}HBAL_{10min}$), 1-hour average ($^{EM}HBAL_{1hr}$), or instantaneous concentrations ($^{EM}HBAL_{1sec}$). The $^{EM}HBAL_{10min}$ is set based on the lesser of: 3-times the AHBCV, one-half an

appropriate 15-minute occupational short-term exposure limit (STEL)[4] if available, or one-half an appropriate occupational ceiling value (C),[5] if available. A 1-hour exposure mitigation health-based action level ($^{EM}HBAL_{1hr}$) was also derived for comparison to 30-minute to 1-hour average concentrations measured while the vehicle is stationary. The $^{EM}HBAL_{1hr}$ is set at 2-times the AHBCV. If the mobile instrument being used is not capable of averaging concentrations for comparison to the 10-minute or 1-hour ^{EM}HBALs, a 1-second exposure mitigation health-based action level ($^{EM}HBAL_{1sec}$) was also derived for comparison with instantaneous concentrations measured while the vehicle is stationary or mobile. The $^{EM}HBAL_{1sec}$ is based on 3-times the $^{EM}HBAL_{1hr}$.

A measured 5-10-minute average concentration that exceeds the $^{EM}HBAL_{10min}$, a 30-minute to 1-hour average concentration that exceeds the $^{EM}HBAL_{1hr}$, or a 1-30 second concentration that exceeds the $^{EM}HBAL_{1sec}$ can trigger evaluation of staff safety (i.e., staff may choose to take steps to mitigate their potential for exposure in the field) and the need to communicate information to regional managers and/or incident command. Importantly, adverse health effects are not expected with a marginal exceedance of any of the mobile monitoring comparison values. Unlike the baseline-derived values, all the fit-for-purpose health-based comparison values (iHPILs, iHBALs, ^{EM}HBALs, and AHBCVs) are applicable across platforms capable of collecting instantaneous measurements.

Table 1 and Table 2 provide a summary of the basis for each of the mobile monitoring comparison values, and Table 1 shows the associated chemical concentration color designation for use with the DUVAS caterpillar trail data visualizations. While these color designations are specific to the DUVAS caterpillar trail output, for consistency in communication they have been adopted for use with all mobile monitoring comparison values, regardless of instrument. Table 3 lists the comparison values for chemicals that are currently measured by the SIFT and DUVAS instruments (i.e., some volatile organic compounds and sulfur dioxide). In addition to the chemicals shown in Table 3, mobile monitoring comparison values were also derived for several other chemicals, as well as for chemicals measured by other monitoring instruments, and the full list can be found in Appendix A.

Altogether, these fit-for-purpose comparison values can help the TCEQ, USEPA, and others in prioritizing resources for identifying sources, characterizing chemical concentrations, and/or mitigating exposure to staff from events that cause chemical releases. All derived mobile monitoring comparison values are intended to be used as guidance. *Field investigators and mobile monitoring staff should use their own discretion when deciding to mitigate exposure, such as when experiencing health effects or intense odors, regardless of measured*

[4] 15-minute short-term exposure limits (STELs) are derived by occupational safety agencies such as the American Conference of Governmental Industrial Hygienists (ACGIH), the Occupational Safety and Health Administration (OSHA), California Division of Occupational Safety and Health (DOSH; also known as Cal/OSHA), and the National Institute for Occupational Safety and Health (NIOSH).

[5] Ceiling value (C) is an occupational exposure level that represents the concentration that shall not be exceeded during any part of the working exposure. Sources of these values include ACGIH, OSHA, and NIOSH.

concentrations. All screening values will provide context to the color-coded, real-time visualization of monitored data and will aid in communicating risk. An illustrative decision guide for both SIFT and DUVAS that highlights the comparison levels and corresponding actions to be taken if an exceedance occurs can be found in Appendix C.

Table 1. Basis of instantaneous mobile monitoring comparison values and recommended actions if exceeded.

Comparison Value (Acronym)	DUVAS Caterpillar Trail Colors [a]	Basis	Recommended Actions with Exceedance
[Concentrations below instantaneous comparison values]	**GREEN**	N/A	No associated action
Instantaneous baseline-derived investigation level (iBDIL)	**ORANGE**	10× baseline level	Source investigation/characterization
Instantaneous health-protective investigation level (iHPIL)	**RED**	1× selected AHBCV	• Stationary monitoring/canister sample collection (30-min to 1-hour) • Source investigation/characterization
Instantaneous health-based action level (iHBAL)	**PURPLE**	3× selected AHBCV	• Increased vigilance for EM concentrations • Stationary monitoring (5-10 min) • Stationary monitoring/canister sample collection (30-min to 1-hour) • Source investigation/characterization

[a] Colors represent values that are greater than or equal to the indicated appropriate comparison value; the DUVAS caterpillar trail color designations have been adopted for use with all of the mobile monitoring comparison values to have consistency in communication.; AHBCV – acute health-based comparison value; DUVAS – Differential Ultra-Violet Absorption Spectrometer; EM – exposure mitigation; and N/A – not applicable.

Table 2. Basis of exposure mitigation values and recommended actions if exceeded.

Comparison Value (Acronym)	Basis	Recommended Actions
10-min health-based action level for exposure mitigation ($^{EM}HBAL_{10min}$)	Lower of 3**×** AHBCV**,** ½ STEL, or ½ C	Consider exposure mitigation for staff
1-hour health-based action level for exposure mitigation ($^{EM}HBAL_{1hr}$)	**2×** AHBCV	Consider exposure mitigation for staff
1-sec health-based action level for exposure mitigation ($^{EM}HBAL_{1sec}$)	**3×** $^{EM}HBAL_{1HR}$	Consider exposure mitigation for staff

AHBCV – acute health-based comparison value; STEL – 15-minute short-term occupational exposure limit; C – ceiling value; and there is no separate DUVAS caterpillar trail designated color for ^{EM}HBAL values.

Table 3. Comparison values for select chemicals measured using mobile monitoring instruments by TCEQ.

Chemical(s) COLOR	CAS No.	iBDIL - DUVAS (ppb) ORANGE	iBDIL - SIFT (ppb) ORANGE	iHPIL (ppb) RED	iHBAL (ppb) PURPLE	$^{EM}HBAL_{10MIN}$ (ppb) N/A	$^{EM}HBAL_{1HR}$ (ppb) N/A	$^{EM}HBAL_{1SEC}$ (ppb) N/A
Acetylene	74-86-2	--	80	25,000	75,000	75,000	50,000	150,000
Benzene	71-43-2	80 [a]	80	180	540	500 [b]	360	1,080
1,3-Butadiene	106-99-0	40 [a]	40	1,700	5,100	2,500 [b]	3,400	10,200
1-Butene	106-98-9	--	110	27,000	81,000	81,000	54,000	162,000
C3-C4 saturated	--	--	960	--	--	--	--	--
Cyclohexane	110-82-7	--	120	1,000	3,000	3,000	2,000	6,000
Ethylbenzene	100-41-4	350	--	20,000	60,000	60,000	40,000	120,000
n-Hexane	110-54-3	--	340	5,400	16,200	16,200	10,800	32,400
Isobutane	75-28-5	--	280	33,000	99,000	99,000	66,000	198,000
n-Octane	111-65-9	--	160	4,100	12,300	12,300	8,200	24,600
Propane	74-98-6	--	540	--	--	--	--	--
Styrene	100-42-5	60 [a]	60	5,100	15,300	10,000 [b]	10,200	30,600
Sulfur dioxide	7446-09-5	70	--	--	--	--	--	--
Toluene	108-88-3	70 [a]	70	4,000	12,000	12,000	8,000	24,000
Xylenes + Ethylbenzene	1330-20-7 + 100-41-4	--	60	5,000 [c]	15,000 [c]	15,000 [c]	10,000 [c]	30,000 [c]
Xylenes	1330-20-7	--	--	5,000	15,000	15,000	10,000	30,000

[a] Based on SIFT;.[b] Based on ½ STEL;.[c] Values based on xylenes AHBCV; DUVAS - Differential Ultra-Violet Absorption Spectrometer; $^{EM}HBAL_{1hr}$ – 1-hour exposure mitigation health-based action level; $^{EM}HBAL_{10min}$ – 10-minute exposure mitigation health-based action level; $^{EM}HBAL_{1sec}$ – 1-second exposure mitigation health-based action level; iBDIL – instantaneous baseline-derived investigation level; iHBAL – instantaneous health-based action level; iHPIL – instantaneous health-protective investigation level; N/A – not applicable; ppb – parts per billion; SIFT- Selected Ion Flow Tube-Mass Spectrometer; and "--"no value available.

Acknowledgments

We would like to acknowledge the efforts of the TCEQ air monitoring and regional staff who contributed to this effort through data gathering, quality assurance, and extensive discussions about what kind of comparison values would be most useful for TCEQ field staff. We further acknowledge the expert input on the MMCV derivations from the staff at EPA Region 6.

The work to derive and document the MMCVs was completed principally by many staff (current and former) in the TCEQ Toxicology, Risk Assessment, and Research Division.

Background

As part of the TCEQ's field investigations and/or response to emergency events (i.e., natural events such as hurricanes and storms; and industrial events such as chemical releases, fires, and similar situations), the Emergency Management Support Section, Monitoring Division, and regional offices all may offer monitoring, oversight, and technical/regulatory assistance to the response. For monitoring support, environmental investigators may be deployed to the affected area with handheld monitoring devices, and/or with specialized vehicles that are equipped with air monitoring instruments that collect instantaneous data for a variety of chemicals. Measurements from these tools are often collected in addition to any nearby stationary ambient air monitoring data, if available, because mobile vans and environmental investigators with handheld instruments can move around an affected area and provide more dynamic data (e.g., moving downwind/upwind of sources). Recent advancements in ambient air mobile monitoring instruments in specialized vehicles allow investigators and monitoring staff to collect instantaneous concentrations while said vehicles are in-motion. These instruments provide an important ambient air monitoring data stream captured in real-time to assess air quality. In addition, depending on the magnitude of the event, other entities (e.g., federal agencies, industry, municipalities) may deploy such resources. For instance, the USEPA may also deploy their Airborne Spectral Photometric Environmental Collection Technology (ASPECT) aircraft to aid in surveillance of the affected area. Collectively, all these data streams are important in the characterization of an event and the affected area(s).

The TCEQ has acquired instrumentation (e.g., Selected Ion Flow Tube-Mass Spectrometer [SIFT-MS or SIFT] and the Differential Ultra-Violet Absorption Spectrometer [DUVAS]) capable of reporting chemical concentrations in ambient air on an instantaneous basis (e.g., 1-30 second concentrations) while in a moving vehicle. These instruments help to geographically map chemical concentrations in areas during field investigations and in the aftermath of emergency events (i.e., industrial fires, hurricanes) by assessing air quality in near real time. This additional data stream can inform the decision-making process of staff in the field. For instance, the data can guide where best to deploy additional agency resources to identify and address chemical releases related to natural and industrial events, as well as to assess when exposure mitigation strategies may need to be considered.

These instantaneous data require appropriate interpretation and necessitate the development of fit-for purpose instantaneous comparison values, in addition to longer duration comparison values (i.e., 5-10 minute and 30-minute to 1-hour) for data that are obtained when the mobile monitoring instrument is stationary. In the past, instantaneous comparison values have not been derived by the TCEQ or other regulatory agencies for a variety of reasons. One reason is that 1-30 second(s) is a historically irrelevant exposure duration both environmentally and occupationally when considering typical air sampling durations (e.g., 24-hour, 8-hour, 1-hour), hence a lack of historical regulatory need. Another reason is the lack of relevant toxicity studies with exposure durations of less than 30-60 minutes. Health-based values are derived using available toxicity data, which can include exposures for hours to days (acute), or months to years (chronic). Using this data, health-based values are often derived for a chronic exposure duration (e.g., 1- to 70-year durations, such as the USEPA reference concentrations [RfCs] and reference doses [RfDs]), and some agencies, such as the TCEQ and CalEPA, have also derived short-term/acute (e.g., 1-hour and 24-hour) health-based comparison values.

In addition to developing comparison values for mobile monitoring that match the measurement durations, the appropriate actions to be taken and the potential need for public risk communication based on the use of these comparison values was also considered.

Altogether, the TCEQ developed four types of fit-for-purpose air data screening levels to be used as comparison values in the evaluation of data collected by mobile monitoring vehicles. The purpose of this document is to explain these mobile monitoring comparison values, how they were derived, and potential actions that may be considered and taken when the comparison values are exceeded.

Section 3 discusses investigation levels that are derived using chemical- and instrument-specific baselines and are independent of chemical-specific toxicity. Section 4 describes the choice of acute air comparison values that are used as the basis for many of the health-based mobile monitoring comparison values. Section 5 describes the derivation of health-based investigation levels, action levels, and levels where exposure mitigation may need to be considered. Appendix A includes a comprehensive list of the chemicals and the mobile monitoring comparison values that TCEQ derived. Altogether, these fit-for-purpose mobile monitoring comparison values can help the TCEQ, USEPA, and other environmental agencies in prioritizing resources for identifying and addressing chemical emission source(s), characterizing chemical concentrations, and/or mitigating exposure to staff from events that cause chemical releases.

Baseline-derived mobile monitoring comparison values

The first type of mobile monitoring comparison value is the instantaneous baseline-derived investigation level (iBDIL). The purpose of the iBDIL is to identify the presence of an abnormally high concentration of any monitored chemical in the ambient air, so that a follow-up source investigation and emission mitigation can be carried out if necessary. To identify an abnormal level of a chemical in the air, the normal baseline level of the chemical needs to be determined first. A chemical baseline is a combination of the measured levels of that chemical in the environment under normal circumstances (i.e., in the absence of a chemical release) plus the

electronic and mechanical “noise” generated by the monitoring instrument. The baseline is both chemical- and instrument-specific; therefore, chemical baseline analyses were conducted using the data for chemicals measured by each of monitoring instruments during mobile monitoring surveys.

Baseline evaluation

The TCEQ mobile monitoring staff conducted surveys for investigations and emergency events in the Beaumont, Houston, and Corpus Christi regions of Texas (TCEQ regions 10, 12, and 14, respectively) starting from 2019 using the SIFT and DUVAS instruments. These TCEQ regions are along the Gulf Coast and contain various industrial, petrochemical, and oil and gas facilities, as well as ports for transport of industrial chemicals and other materials. The data from each mobile monitoring survey included: date, survey ID, time, location, latitude, longitude, detected concentration in parts per billion by volume (ppbv, subsequently referred to as “ppb”) for each chemical monitored, and minimum and maximum concentrations measured for each chemical. To determine the baseline of each chemical for the SIFT and DUVAS, surveys with a wide range of maximum values and from different days and locations were selected. Preference was given to surveys with lower maximum values because those with higher concentrations indicated a potential chemical emission source nearby that would inflate the concentrations above baseline. The time and the corresponding concentration from selected surveys were graphed to evaluate the baseline.

The regular baseline noise (N) of a time-concentration plot is the low-level detections and the inherent noise of the instrument that can be seen over time. TCEQ defined a real concentration peak as a chemical concentration signal (S) that is ≥3-times the level of the baseline detection noise before and after the signal peak (i.e., a signal to noise [S/N] ratio ≥3). The baseline value for a specific chemical and monitoring method was defined as the highest non-signal peak among the monitoring surveys analyzed and is referred to herein as the 1× baseline. This method for determining the 1× baseline value was chosen because it represents the highest concentration in the range of non-signal baseline levels, with the 1× baseline serving as a value from which abnormal levels of chemical can be determined.

When analyzing the baseline, some characteristics of the concentration-time measurements were considered when evaluating the suitability of the survey for analysis. Surveys with the following example conditions were excluded from baseline noise analysis: 1) high intensity signals with a long tail, which may distort the baseline; 2) significantly raised baseline where both the high and the low concentrations are much higher than zero; 3) lowest measured concentrations drifting up or down and appearing as a large broad peak rather than a flat line; 4) frequent negative measurements; 5) abrupt changes in baseline levels from low-to-high or high-to-low; and 6) time-concentration plots with many isolated non-peak spikes (i.e., single high intensity signal without peak width). Surveys with a high intensity signal at the very beginning or end of the survey were still considered suitable, but the area near these signals was excluded from the baseline analysis in the event that those signals were measurement artefacts.

Derivation of instantaneous baseline-derived investigation levels (iBDILs) for SIFT and DUVAS monitoring instruments

For the selected surveys, the regular baseline noise was evaluated following the considerations outlined above, and the maximum noise level that was clearly not a signal peak (i.e., the S/N ratio ≤3) was determined. The highest value among all the surveys analyzed (that were not excluded under the considerations above) is the 1× baseline for that chemical and instrument. The chemical-specific iBDIL was set at concentrations 10-times the 1× baseline, because such levels were considered to indicate abnormally high levels that require evaluation. This level is intended to maintain a balance between appropriately investigating abnormally high chemical concentrations in ambient air, while not using agency resources to investigate potentially spurious or insignificant chemical concentrations. The 1× baselines and iBDILs that were determined for the SIFT and DUVAS are shown in Table 4, and specific details for each chemical and instrument evaluation can be found in Appendix B. For chemicals that are measured by both the SIFT and DUVAS instruments, a single iBDIL was selected for use with both instruments to provide consistency for field staff implementing these values. This decision applied to four chemicals (benzene, 1,3-butadiene, styrene, and toluene), and the iBDIL from the SIFT instrument was chosen because the SIFT (which is a more quantitative and precise instrument) had a lower baseline than the DUVAS.

Table 4. Baseline and iBDIL values of chemicals monitored by SIFT and DUVAS instruments.

Chemical(s)	Applicable instrument(s)	SIFT baseline (ppb)	DUVAS baseline (ppb)	iBDIL (ppb)
Acetylene	SIFT	8	N/A	80
Benzene	SIFT, DUVAS	8	14	80 [a]
1,3-Butadiene	SIFT, DUVAS	4	6	40 [a]
1-Butene	SIFT	11	N/A	110
C3-C4 saturated	SIFT	96	N/A	960
Cyclohexane	SIFT	12	N/A	120
Ethylbenzene	DUVAS	N/A	35	350
n-Hexane	SIFT	34	N/A	340
Isobutane	SIFT	28	N/A	280
n-Octane	SIFT	16	N/A	160
Propane	SIFT	54	N/A	540
Styrene	SIFT, DUVAS	6	8	60 [a]
Sulfur dioxide	DUVAS	N/A	7	70
Toluene	SIFT, DUVAS	7	40	70 [a]
Xylenes + Ethylbenzene	SIFT	6	N/A	60

[a] iBDIL derived using baseline from the SIFT instrument; DUVAS - Differential Ultra-Violet Absorption Spectrometer; iBDIL – instantaneous baseline-derived investigation level; N/A – not applicable; ppb – parts per billion; and SIFT-

Selected Ion Flow Tube-Mass Spectrometer.

Derivation of instantaneous baseline-derived investigation levels (iBDILs) for other mobile monitoring instruments

In addition to the SIFT and DUVAS, the TCEQ has other monitoring instruments that are used to evaluate chemical concentrations during in-motion and stationary monitoring surveys. This includes a Picarro[6] instrument that measures hydrogen sulfide, and a nephelometer[7] instrument that measures particulate matter less than 10 micrometers (µm) in diameter (PM_{10}) and particulate matter less than 2.5 µm in diameter ($PM_{2.5}$).

Upon evaluation of the instantaneous hydrogen sulfide concentration data measured using the Picarro during mobile monitoring surveys, it was determined that the baseline levels were inconsistent and highly variable. As such, an iBDIL was not derived for hydrogen sulfide monitored via the Picarro instrument. Further details are provided in Appendix B.

Evaluation of PM_{10} and $PM_{2.5}$ instantaneous concentrations measured via nephelometer demonstrated that the instrument noise was very low (in the range of 20 ng/m^3), in comparison to the measured PM concentrations (in the µg/m^3 range). However, the measured concentrations of PM could vary substantially on a day-to-day basis, and sometimes within a single day. Such variability is consistent with the known variance in ambient PM concentrations, but it precludes the identification of a constant baseline for derivation of an iBDIL. As such, an iBDIL was not derived for PM_{10} or $PM_{2.5}$ monitored via the nephelometer instrument. Further details are provided in Appendix B.

Acute health-based comparison values (AHBCVs)

For emergency and investigational preparedness, it is important to have appropriate ambient air comparison values in place prior to the occurrence of an event. Acute ambient air comparison values for evaluating the potential for adverse health effects of exposure to the general public, monitoring staff, and field investigators are one of the most immediate needs in these situations. These values can help first responders, federal, state, and local governmental regulatory authorities, and others to:

- Primarily, assess the potential for acute health effects to monitoring staff and field investigators in the near-term.

[6] Picarro – A gas concentration analyzer that uses Cavity Ring-Down Spectroscopy technology from Picarro to provide precise measurement of methane (CH_4) and hydrogen sulfide (H_2S) at parts per billion (ppb) sensitivity.

[7] 2-WIN Nephelometer – A Two Wavelength Integrating Nephelometer from Ambilabs; it determines particulate concentration by measuring the total scatter from aerosols and using a selectable wavelength for either PM_{10} or $PM_{2.5}$ at µg/m^3 level.

- Secondarily, help prioritize the responses to environmental impacts occurring due to unintended industrial releases, especially during a widespread event (e.g., a natural disaster).
- Thirdly, inform decision-making on the potential need and urgency of mitigating public exposure.

To best inform the needs discussed above, this document focuses on the perspective of the monitoring staff and field investigators (a public exposure focus is generally outside the scope of this document). The acute ambient air comparison values utilized (hereafter referred to as acute health-based comparison values or AHBCVs) should be both scientifically sound and fit-for-purpose. Such values can inform an assessment in real time for both the potential for acute adverse health effects and subsequent decision-making (e.g., the need for exposure mitigation, appropriate prioritization of environmental concerns, etc.). After these values were selected, they were used as the basis for the derivation of the health-based mobile monitoring comparison values.

Considerations for selection of AHBCVs

AHBCVs to be used in emergency response and investigational situations should be health-protective (i.e., set at levels below which adverse health effects are expected to occur) and fit-for-purpose, without being unduly conservative. Available acute (1-hour) health-based comparison values were reviewed in the context of developing the health-protective comparison values to be used in evaluation of data collected instantaneously. The USEPA acute exposure guideline levels (AEGLs) were considered for use, but all AEGLs represent levels where health effects are expected to occur. Even the AEGL-1 values, which are for the least severe effects, are not health-protective comparison values. [8] Although AEGLs are of short duration (10- or 30-minutes, 1-, 4-, or 8-hours), they do not represent health-protective concentrations (where effects are not expected to occur). Because of this, AEGLs cannot be used as comparison values meant to protect the general public, monitoring staff, and field investigators from acute health effects. Consequently, AEGLs are not considered further for derivation of health-protective comparison values. On the other hand, while the Agency for Toxic Substances and Disease Registry (ATSDR) “acute” inhalation minimal risk levels (MRLs) are protective for acute exposure (i.e., ≤24 hours), these values are derived to be health-protective for up to 14 days of exposure and are therefore unduly conservative for evaluation of mobile monitoring data that is of shorter duration (e.g., perhaps no more than a few hours in duration), which are more relevant to an emergency response. Consequently, the acute MRLs may be considered for adoption if air sampling results from much longer durations require a health effects evaluation; however, the acute MRLs are not considered for adoption herein unless they are based on

[8] AEGLs are dictated by the severity of the toxic effects caused by the exposure, with AEGL-1 values being the least severe, but potentially still involving notable discomfort, irritation, or certain asymptomatic non-sensory effects. Effects associated with AEGL-1 values are not disabling and are transient and reversible upon cessation of exposure.

acute effects that occur over a duration of perhaps an hour or several hours, but less than a day.

To identify acute ambient air comparison values that result in a more realistic assessment of the potential for acute adverse health effects, as well as inform decision making and priority-setting during an investigation or emergency response, the following characteristics were identified as important guiding considerations:

- Standard practices: Preference for available acute ambient air comparison values derived using standard practices and procedures (e.g., under USEPA, TCEQ, or similar toxicity factor derivation guidance).
- Acute inhalation basis: Preference for an inhalation study as the basis, wherein inhalation exposure was adequately characterized and the exposure duration/regimen was similar to that of the acute health effects assessment (e.g., a single exposure of a few hours).[9]
- Appropriate duration adjustment: Similarly, preference for values where any duration adjustments for the comparison value are to an exposure duration similar to that of the acute health effects assessment (e.g., 1 hour).
- Adverse, human-relevant, dose-response: Critical health effect(s) used as the basis for the acute ambient air comparison value should clearly be both adverse and relevant to humans, with a preference for a clear dose-response over multiple doses. Such health effect endpoints are preferred over those where no chemical effects were seen (i.e., a free-standing no-observed-adverse-effect-level [NOAEL]), or where all the tested doses showed a health effect (i.e., a free-standing lowest-observed-adverse-effect-level LOAEL]).
- True short-term effect: Critical effect(s) should clearly be a true short-term effect wholly attributable to short-term exposure to the chemical in question.[10]
- Less uncertainty: Preference for acute ambient air comparison values associated with less total uncertainty (e.g., lower total uncertainty factor (UF), physiologically-based

[9] Acute is defined here as exposure to a chemical for less than or equal to 24 hours, although studies with repeated exposures over several days with a sufficiently similar total exposure duration may be utilized in some instances. Using study results from weeks, months (subchronic), or years (chronic) of exposure generally is not appropriate for acute health-based risk assessment, unless for example it can be reasonably demonstrated that the effect(s) are not due to the cumulative effect of repeated daily toxic insult or accumulation of the putative toxic parent and/or chemical metabolite(s) over time.

[10] For example, not from a study in which humans or laboratory animals were exposed subchronically or chronically on a daily basis and the effect(s) may be due to the cumulative effect of repeated daily toxic insult and/or accumulation of the putative parent and/or toxic chemical metabolites over time, or not from a study in which co-exposure may have confounded the cause-and-effect relationship.

pharmacokinetic [PBPK] modeling for interspecies extrapolation, smaller duration adjustment required for the acute duration of interest, etc.).[11]

- Human data: A preference for human data over laboratory animal data, in the absence of some overriding factor (e.g., the only available epidemiological studies do not have quantitative exposure estimates, or a study in which co-exposure may have confounded the cause-and-effect relationship).
- Lowest margin of exposure: There is a strong preference for selecting the acute health-based air comparison value associated with the lowest margin of exposure (MOE). Although a MOE may be calculated in different ways (e.g., RfC/lifetime exposure level), here the primary MOE of interest is the difference between the selected comparison value and the concentration at which health effects have been shown to occur, with a lower MOE indicating a smaller difference between the two. Selecting the lowest MOE ideally means utilizing the lowest study human equivalent concentration (HEC) LOAEL ($LOAEL_{HEC}$) or benchmark concentration (BMC_{HEC}) among the key studies. Values that were derived using lower UFs (discussed above) will also typically have a lower MOE. Although still health-protective, exceedance of a comparison value with a lower MOE carries a greater potential for the occurrence of an acute adverse health effect than a comparison value with a higher MOE. As such the lower-MOE values are more conducive to identifying emissions representing a real-world environmental health issue (i.e., exposures associated with a greater probability of acute effects), which should be given priority during an emergency situation. An overriding consideration is that the selected AHBCV must result in MMCV values, particularly those for appreciable exposure durations (10 minutes, 1-hour), with an MOE greater than 1 to demonstrate any level of health protection, with MOE ideally being defined as equal to the lowest $LOAEL_{HEC}/BMC_{HEC}$ value identified across the AHBCVs being considered divided by the relevant (i.e., non-instantaneous) MMCV values resulting from the derivation procedures herein. See Appendix D for an example of how this overriding consideration can determine the AHBCV selected (i.e., for ammonia).

Because acute studies with an exposure duration of an hour to less than 24 hours are frequently lacking, an ideal acute air comparison value may not be available for selection. However, the considerations listed above may be used together as part of a weight-of-evidence judgment for choosing the most appropriate available ambient air comparison value to assess the potential for acute adverse health effects and subsequent development of comparison values for evaluation of data collected instantaneously.

[11] There is greater confidence in air comparison values with less uncertainty, including greater confidence in their ability to result in a more realistic assessment of health hazard and the potential for adverse health effects (e.g., greater confidence that exceedance of the comparison value could have real-world health consequences).

Selected AHBCVs

The 26 chemicals listed in Table 5 were evaluated using the considerations outlined above to select the fit-for-purpose AHBCVs. These 26 chemicals were assessed due to the analysis capabilities of the SIFT and DUVAS and/or importance during industrial emission events. Although some of the chemicals listed in Table 5 have 1-hour TCEQ AMCVs that were developed using TCEQ's guidelines for toxicity factors (TCEQ 2015)[12], these 1-hour AMCVs were not always selected as an AHBCV, based on the considerations listed in the previous section (e.g., other values might have a lower MOE). As noted above, the AHBCVs were selected to be fit-for-purpose for use in investigational and emergency response situations and are considered health-protective (i.e., set at levels below which health effects are expected to occur) without being unduly conservative. The selected AHBCVs can more realistically inform both the potential for acute adverse health effects and subsequent decision-making (e.g., the need for exposure mitigation, appropriate prioritization of environmental concerns, etc.). Appendix D provides additional details on the evaluation and selection of each AHBCV.

Table 5. Acute health-based comparison values and source of value selected for each chemical.

Compound	CAS No.	Value (ppb)	Source
Acetylene [a]	74-86-2	25,000	TCEQ
Ammonia	7664-41-7	850	TCEQ
Benzene	71-43-2	180	TCEQ
1,3-Butadiene	106-99-0	1,700	TCEQ
Butane	106-97-8	92,000	TCEQ
1-Butene	106-98-9	27,000	TCEQ
Chlorine	7782-50-5	70	CalEPA
Cyclohexane[a]	110-82-7	1,000	TCEQ
Ethylbenzene	100-41-4	20,000	TCEQ
Ethylene dichloride	107-06-2	540	TCEQ
Ethylene glycol	107-21-1	1,900	MI EGLE
Ethylene oxide	75-21-8	910	TCEQ
Formaldehyde	50-00-0	44	CalEPA
n-Hexane	110-54-3	5,400	TCEQ

[12] TCEQ 2015 Guidelines to develop toxicity factors. RG-442: Texas Commission on Environmental Quality (TCEQ).

Compound	CAS No.	Value (ppb)	Source
Hydrochloric acid	7647-01-0	440	TCEQ
Hydrogen sulfide	7783-06-4	70	ATSDR
Isobutane	75-28-5	33,000	TCEQ
n-Octane	111-65-9	4,100	TCEQ
Propane	74-98-6	Simple asphyxiant [b]	TCEQ
Propylene	115-07-1	Simple asphyxiant [b]	TCEQ
Sodium hydroxide	1310-73-2	5	CalEPA
Styrene	100-42-5	5,100	TCEQ/CalEPA
Sulfuric acid	7664-93-9	30	CalEPA
Toluene	108-88-3	4,000	TCEQ
Vinyl chloride	75-01-4	72,000	CalEPA
Xylenes	1330-20-7	5,000	CalEPA

[a] AHBCV derived by dividing an occupational exposure level by uncertainty factors (UFs), not by using the full process outlined in the TCEQ guidelines (no other agency had an applicable comparison value for use).; [b] As noted in TCEQ Guidelines to Develop Toxicity Factors (TCEQ 2015), simple asphyxiants are chemicals that only pose an inhalation health risk if exposure occurs in an enclosed space where the gas is present at concentrations that displace oxygen in the air, reducing oxygen levels in the air to levels below those necessary for normal breathing. No health-based comparison values were derived for simple asphyxiant chemicals.; ATSDR – Agency for Toxic Substances and Disease Registry; CalEPA – California Environmental Protection Agency; MI EGLE – Michigan Department of Environment, Great Lakes, and Energy; ppb – parts per billion; and TCEQ - Texas Commission on Environmental Quality.

Health-based mobile monitoring comparison values

Two primary types of health-based mobile monitoring comparison values were derived using the AHBCVs or applicable occupational exposure limits (OELs) as their basis. TCEQ used a tiered approach for deriving values that are progressively closer to levels where health effects may occur, with associated actions that are reflective of the decreased margin between exposure and effect.

Instantaneous health-protective investigation levels (iHPILs)

The instantaneous health-protective investigation levels (iHPILs) are the first tier of health-based values. The iHPILs are conservatively set equal to the 1-hour AHBCVs. Instantaneous chemical concentrations below the iHPIL represent levels that will not cause health effects. The risk of health effects from instantaneous chemical concentrations that exceed the iHPILs cannot be directly judged, and so could trigger source investigation/characterization as well as stationary monitoring to collect data with longer averaging times (e.g., 30 minutes, 1 hour, etc.). The longer duration samples can then be compared to 1-hour AHBCVs or health-based

mobile monitoring comparison values of appropriate duration. Such values are discussed in the following section. For chemicals that do not have an iBDIL, exceedance of an iHPIL is used as the initial investigation trigger level.

iHPILs for Particulate Matter (PM)

PM_{10} and $PM_{2.5}$ are two of the air pollutants regulated under the National Ambient Air Quality Standards (NAAQS). The NAAQS use four metrics – indicator, form, averaging time, and level – to set primary health-based standards that apply to ambient concentrations of air pollutants, which are requisite to protect public health with an adequate margin of safety. Because PM_{10} and $PM_{2.5}$ are regulated by the NAAQS, other federal and state agencies have not set 1-hour values that can be used as AHBCVs for derivation of mobile monitoring comparison values. However, both PM_{10} and $PM_{2.5}$ have NAAQS that are based on a 24-hour averaging time: for PM_{10} the standard associated with a 24-hour average is set at a level of 150 $\mu g/m^3$, not to be exceeded more than once per year on average over 3 years; and for $PM_{2.5}$ the standard associated with a 24-hour average is set at a level of 35 $\mu g/m^3$ for the 98^{th} percentile, averaged over 3 years. Although data obtained using mobile monitoring instruments for PM cannot be compared to the full parameters of the respective standards, the level of the 24-hr standards (150 and 35 $\mu g/m^3$ for PM_{10} and $PM_{2.5}$, respectively) can be used as approximate health-based comparison values. Because these are 24-hour values instead of 1-hour values, an additional 3-fold factor is applied to the averaging time difference, as explained in section 5.2. Therefore, the iHPILs are set at 105 $\mu g/m^3$ for $PM_{2.5}$ and 450 $\mu g/m^3$ for PM_{10}.

Selected iHPILs

Examples of iHPILs are shown in Table 6 for selected chemicals with an AHBCV. Appendix A provides a complete list of calculated iHPILs.

Table 6. iHPILs calculated for fifteen chemicals and PM.

Chemical	CAS No.	Unit	AHBCV	iHPIL
Acetylene	74-86-2	ppb	25,000	25,000
Benzene	71-43-2	ppb	180	180
1,3-Butadiene	106-99-0	ppb	1,700	1,700
1-Butene	106-98-9	ppb	27,000	27,000
Cyclohexane	110-82-7	ppb	1,000	1,000
Ethylbenzene	100-41-4	ppb	20,000	20,000
n-Hexane	110-54-3	ppb	5,400	5,400
Hydrochloric acid	7647-01-0	ppb	440	440
Isobutane	75-28-5	ppb	33,000	33,000
n-Octane	111-65-9	ppb	4,100	4,100

Chemical	CAS No.	Unit	AHBCV	iHPIL
$PM_{2.5}$	N/A	µg/m^3	35 [a]	105
PM_{10}	N/A	µg/m^3	150 [a]	450
Sodium hydroxide	1310-73-2	ppb	5	5
Styrene	100-42-5	ppb	5,100	5,100
Toluene	108-88-3	ppb	4,000	4,000
Xylenes + Ethylbenzene	1330-20-7 + 100-41-4	ppb	5,000 [b]	5,000 [b]
Xylenes	1330-20-7	ppb	5,000	5,000

[a] NAAQS 24-hour averaging time, used as approximate health-based comparison values; [b] Values are based on AHBCV for xylenes.

Health-based action levels (HBALs)

To ensure emergency and investigational preparedness, it is also important to have health-based action levels (HBALs) that indicate when more rapid or greater action may be required. Two instantaneous and two longer duration HBALs were established with a lower MOE than the iHPILs, to help inform actions by mobile monitoring staff. Furthermore, while not representative of levels that are expected to cause immediate health effects, some of the HBALs discussed in the following sections may also assist TCEQ field staff (who are not first responders) and others in considering exposure mitigation strategies. Depending upon the magnitude and duration of a HBAL exceedance, the strategies may include action(s) deemed necessary to mitigate the potential for adverse human health effects to those impacted by a chemical emissions event.

It is important to note that HBALs are based on the consideration of chemical-specific, direct adverse health effects and do not consider potential odors. Strong and persistent odors have the potential to cause indirect health effects like headache and nausea, regardless of the chemical causing them or how the reported levels of the chemicals being analyzed compare to health-based values. As always, in all circumstances, personnel are encouraged to use their best judgment in determining whether to leave the area, shelter in place, or otherwise mitigate exposure (e.g., reports of headaches, feeling faint, etc.).

Instantaneous health-based action levels (iHBALs)

The next tier of health-based values, with a lower MOE than iHPILs, are instantaneous health-based action levels (iHBALs). A measured instantaneous chemical concentration that exceeds an iHBAL can potentially trigger a more immediate action than for an iHPIL exceedance. The iHBAL is derived based on the concept that if an instantaneous concentration exceeded the iHBAL, an exceedance of a longer-duration, health-based screening level such as the 1-hour AHBCV may also occur. The TCEQ has relied on a robust and historical dataset that has set a precedence for deriving short-term values to protect against long-term concentrations. For example, in air permitting a modeled maximum ground-level *hourly concentration* for the year

that is no more than 10-times a desired annual comparison value helps predict that the *annual chemical concentrations* will remain below that annual value (taking into account considerations such as meteorological variability).[13] In the case of iHBALs, such a basis would entail deriving a 1-30 second duration concentration that, if not exceeded, may be expected to be associated with a hourly concentration that is no higher than the 1-hour AHBCV. Conversely, the iHBAL represents a 1-30 second duration concentration that, if exceeded, might be an indication that 1-hour concentrations would exceed the 1-hour AHBCV. The TCEQ has collected and analyzed instantaneous and hourly concentration data to determine the relationship(s) between instantaneous and hourly concentrations.

Instantaneous vs. hourly data

The temporal difference in sampling between 1-30 seconds and a 1-hour duration is 120- to 3,600-fold. Using data collected for 1,3-butadiene, benzene, toluene, styrene, and xylenes + ethylbenzene from 69 SIFT surveys, the fold difference between the range of the 95th percentile instantaneous values to the 1-hour average of a stationary survey was 0.35 to 6.53 (Table 7). However, the average 95th instantaneous/1-hour average fold difference for these chemicals was 2.27 to 3.62. This suggests that on average, approximately 3-times the 1-hour AHBCV concentration would be representative of an instantaneous 95th percentile value where the hourly average may approximate the 1-hour AHBCV. Therefore, an instantaneous concentration greater than approximately 3-times the 1-hour AHBCV could predict that the hourly average concentration would exceed the 1-hour AHBCV.

Table 7. Ratio of 95th percentile instantaneous values to 1-hour average data for 1,3-butadiene, benzene, toluene, styrene, and xylenes + ethylbenzene from 69 SIFT stationary surveys.

	1,3-Butadiene [a]	Benzene	Toluene	Styrene	Xylenes + Ethylbenzene
Minimum 95th instantaneous/1-hour average	0.35	0.77	1.36	1.54	1.45
Maximum 95th instantaneous/1-hour average	6.53	6.04	4.43	5.26	5.15
Average 95th instantaneous/1-hour average	3.62	2.60	2.31	2.65	2.27

[a] Based on data from 68 surveys, with 1 survey excluded because >90% of the values were zero

[13] USEPA. 1992. Screening procedures for estimating the air quality impact of stationary sources, revised. U.S. ENVIRONMENTAL PROTECTION AGENCY, Office of Air and Radiation, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. EPA-454/R-92-019.

Conclusions regarding comparisons of instantaneous vs. hourly concentration data

Based on the data analyzed above, a 1-30 second concentration that is greater than approximately 3-times the 1-hour AHBCV might suggest the hourly average could be greater than the 1-hour AHBCV. Based on the analysis above, an instantaneous air concentration greater than 3-times the 1-hour AHBCV is: (1) assumed to be greater than the 95th percentile of the distribution of instantaneous concentrations associated with the 1-hour AHBCV; (2) considered an abnormally high value for a distribution associated with an air concentration equal to the 1-hour AHBCV; and (3) assumed to be part of a distribution associated with a short-term 1-hour concentration that exceeds the short-term 1-hour AHBCV.

Selected iHBALs

Based on the analysis described above, the iHBALs are conservatively calculated to be 3-times the selected 1-hour AHBCV for a given chemical. Examples of iHBALs are shown in Table 8for selected chemicals with an AHBCV. Appendix A provides a complete list of calculated iHBALs.

Table 8. iHBALs calculated for fifteen chemicals for comparison to samples collected for a duration of 1-30 seconds.

Chemical	CAS No.	AHBCV (ppb)	iHBAL (ppb)
Acetylene	74-86-2	25,000	75,000
Benzene	71-43-2	180	540
1,3-Butadiene	106-99-0	1,700	5,100
1-Butene	106-98-9	27,000	81,000
Cyclohexane	110-82-7	1,000	3,000
Ethylbenzene	100-41-4	20,000	60,000
n-Hexane	110-54-3	5,400	16,200
Hydrochloric acid	7647-01-0	440	1,320
Isobutane	75-28-5	33,000	99,000
n-Octane	111-65-9	4,100	12,300
Sodium hydroxide	1310-73-2	5	15
Styrene	100-42-5	5,100	15,300
Toluene	108-88-3	4,000	12,000
Xylenes + Ethylbenzene	1330-20-7 + 100-41-4	5,000 [a]	15,000 [a]
Xylenes	1330-20-7	5,000	15,000

[a] Values are based on AHBCV for xylenes; AHBCV – acute health-based comparison value; iHBAL – instantaneous health-based action level; and ppb – parts per billion.

Health-based action levels for exposure mitigation (^{EM}HBALs)

Health-based action levels for exposure mitigation (^{EM}HBALs) are intended to help inform field staff of chemical concentrations where they may consider decreasing their exposure. Although ^{EM}HBALs are set at concentrations higher than the iHPILs and iHBALs (i.e., with a lower MOE), the ^{EM}HBALs are not set at effect levels and as such are still designed to be more conservative than USEPA AEGLs, which are specific concentrations of airborne chemicals at which health effects may occur.[14] ^{EM}HBAL values assume a short-term/acute exposure duration and are derived based on either the 1-hour AHBCV, or on appropriate, available occupational exposure levels (15-minute short-term exposure limits [STELs] or ceiling values [C])[15]. These values are principally derived for comparison to stationary sampling data that can be averaged over longer durations (i.e., 10 minutes or 1 hour). An additional 1-second value was also derived for use with mobile monitoring equipment that is not capable of averaging data for longer durations while in use. Exceedance of an ^{EM}HBAL triggers field staff to consider decreasing their exposure to the measured chemical.

10-minute exposure mitigation health-based action levels (^{EM}HBALs$_{10min}$)

Concentrations collected for 5-10 minutes will be compared to the 10-minute exposure mitigation health-based action levels (^{EM}HBALs$_{10min}$). The ^{EM}HBAL$_{10min}$ is set as the *lowest* of the following values:

- 3× AHBCV[16];
- ½× 15-minute occupational STEL (to help ensure that the STEL is not exceeded). Potential sources of the STEL include: American Conference of Governmental Industrial Hygienists (ACGIH), Occupational Safety and Health Administration (OSHA), California Division of

[14] https://www.epa.gov/aegl/about-acute-exposure-guideline-levels-aegls

[15] For example, helping to prevent exceedances of 15-minute STELs through consideration of ½ the STEL as a comparator value is important as STELs consider effects that can occur due to elevated shorter-term exposure concentrations such as irritation, irreversible (or chronic) tissue damage, dose-rate-dependent toxic effects, or narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue or materially reduce work efficiency. Similarly, ½ the ceiling value is also an appropriate comparator value for consideration. Substances with occupational ceiling values are predominantly fast-acting and whose occupational comparison values are more appropriately based on the concentrations associated with the particular response. These substances and their potential health effects are best controlled through use of a ceiling value. Ceiling values and 15-minute STELs should not be exceeded (https://www.acgih.org/science/tlv-bei-guidelines/tlv-chemical-substances-introduction/).

[16] Using this calculation, the value will somewhat exceed a 1-hour value extrapolated to 5-10 minutes using Haber's law with n=3 under the TCEQ (2015) Guidelines to Develop Toxicity Factors, but it is still conservative given that generally there is a margin of exposure ≥3 even for a 1-hour exposure. A person who chooses to leave an area or otherwise mitigate exposure based on an exceedance of the ^{EM}HBAL$_{10min}$ may or may not be exposed to concentrations that meet/exceed the hourly AHBCV, depending upon the magnitude of exceedance and the promptness of leaving or otherwise mitigating exposure. This calculation generates a concentration that is consistent with the iHBAL concentration.

Occupational Safety and Health (DOSH; also known as Cal/OSHA), or the National Institute for Occupational Safety and Health (NIOSH); or

- ½× occupational ceiling value (C; to help ensure that the ceiling value is not exceeded). Potential sources of the ceiling value include: ACGIH, OSHA, or NIOSH

The lowest of these values is used as the $^{EM}HBAL_{10min}$. Selected examples of $^{EM}HBALs_{10min}$ can be found in Table 9. Appendix A provides additional $^{EM}HBALs_{10min}$ that were calculated and Appendix E provides the STELs and ceiling values available for all chemicals listed in Appendix A.

Table 9. $^{EM}HBALs_{10min}$ calculated for fourteen chemicals for comparison to samples collected for a duration of 5-10 minutes.

Chemical	CAS No.	iHBAL (ppb)	½ STEL (ppb)	½ C (ppb)	$^{EM}HBAL_{10min}$ (ppb)
Acetylene	74-86-2	75,000	--	--	75,000
Benzene	71-43-2	540	500	--	500
1,3-Butadiene	106-99-0	5,100	2,500	--	2,500
1-Butene	106-98-9	81,000	--	--	81,000
Cyclohexane	110-82-7	3,000	--	--	3,000
Ethylbenzene	100-41-4	60,000	62,500	--	60,000
n-Hexane	110-54-3	16,200	--	--	16,200
Hydrochloric acid	7647-01-0	1,320	--	1,000	1,000
Isobutane	75-28-5	99,000	500,000	--	99,000
n-Octane	111-65-9	12,300	187,500	--	12,300
Sodium hydroxide	1310-73-2	15	--	600	15
Styrene	100-42-5	15,300	10,000	--	10,000
Toluene	108-88-3	12,000	75,000	--	12,000
Xylenes + Ethylbenzene	1330-20-7 + 100-41-4	15,000 [a]	75,000 [a]	--	15,000 [a]
Xylenes	1330-20-7	15,000	75,000	--	15,000

[a] Values are based on AHBCV for xylenes; C – ceiling value; $^{EM}HBAL_{10min}$ – 10-minute exposure mitigation health-based action level; iHBAL – instantaneous health-based action level; ppb – parts per billion; STEL – 15-minute short-term exposure level; and "--"no value available.

1-hour exposure mitigation health-based action levels ($^{EM}HBALs_{1hr}$)

Concentrations collected and averaged for 30 minutes to 1 hour will be compared to 1-hour exposure mitigation health-based action levels ($^{EM}HBALs_{1hr}$). The $^{EM}HBAL_{1hr}$ is set as the following value:

- 2× AHBCV

This comparison value is still conservative because generally there is a margin of exposure ≥3 for a 1-hour exposure. Examples of $^{EM}HBALs_{1hr}$ can be found in Table 10, and Appendix A provides additional $^{EM}HBALs_{1hr}$ that were calculated.

Table 10. $^{EM}HBALs_{1hr}$ calculated for fourteen chemicals for comparison to samples collected for a duration of 30 minutes to 1 hour.

Chemical	Cas No.	AHBCV (ppb)	$^{EM}HBAL_{1hr}$ (ppb)
Acetylene	74-86-2	25,000	50,000
Benzene	71-43-2	180	360
1,3-Butadiene	106-99-0	1,700	3,400
1-Butene	106-98-9	27,000	54,000
Cyclohexane	110-82-7	1,000	2,000
Ethylbenzene	100-41-4	20,000	40,000
n-Hexane	110-54-3	5,400	10,800
Hydrochloric acid	7647-01-0	440	880
Isobutane	75-28-5	33,000	66,000
n-Octane	111-65-9	4,100	8,200
Sodium hydroxide	1310-73-2	5	10
Styrene	100-42-5	5,100	10,200
Toluene	108-88-3	4,000	8,000
Xylenes + Ethylbenzene	1330-20-7 + 100-41-4	5,000 [a]	10,000 [a]
Xylenes	1330-20-7	5,000	10,000

[a] Values are based on AHBCV for xylenes; AHBCV – acute health-based comparison value; $^{EM}HBAL_{1hr}$ – 1-hour exposure mitigation health-based action level; and ppb – parts per billion.

1-second exposure mitigation health-based action levels ($^{EM}HBALs_{1sec}$)

For mobile monitoring instruments that are not capable of averaging concentrations for comparison to the 10-minute or 1-hour $^{EM}HBALs$ while in operation, 1-second exposure mitigation health-based action levels ($^{EM}HBALs_{1sec}$) were also derived for comparison with instantaneous concentrations measured while the vehicle is stationary or mobile. The $^{EM}HBAL_{1sec}$ is set as the following value:

- 3× $^{EM}HBAL_{1hr}$

Like the iHBAL, a 1-30 second concentration that is greater than approximately 3-times the $^{EM}HBAL_{1hr}$ might suggest the hourly average could be greater than the $^{EM}HBAL_{1hr}$. Examples of $^{EM}HBALs_{1sec}$ can be found in Table 11. Appendix A provides additional $^{EM}HBALs_{1sec}$ that were calculated.

Table 11. $^{EM}HBALs_{1sec}$ calculated for fifteen chemicals for comparison to samples collected for a duration of 1-30 seconds when longer duration averaging is not available.

Chemical	CAS No.	$^{EM}HBAL_{1hr}$ (ppb)	$^{EM}HBAL_{1sec}$ (ppb)
Acetylene	74-86-2	50,000	150,000
Benzene	71-43-2	360	1,080
1,3-Butadiene	106-99-0	3,400	10,200
1-Butene	106-98-9	54,000	162,000
Cyclohexane	110-82-7	2,000	6,000
Ethylbenzene	100-41-4	40,000	120,000
n-Hexane	110-54-3	10,800	32,400
Hydrochloric acid	7647-01-0	880	2,640
Isobutane	75-28-5	66,000	198,000
n-Octane	111-65-9	8,200	24,600
Sodium hydroxide	1310-73-2	10	30
Styrene	100-42-5	10,200	30,600
Toluene	108-88-3	8,000	24,000
Xylenes + Ethylbenzene	1330-20-7 + 100-41-4	10,000 [a]	30,000 [a]
Xylenes	1330-20-7	10,000	30,000

[a] Values are based on AHBCV for xylenes; $^{EM}HBAL_{1hr}$ – 1-hour exposure mitigation health-based action level; $^{EM}HBAL_{1sec}$ – 1-second exposure mitigation health-based action level; and ppb – parts per billion.

Summary of calculated iHBALs and $^{EM}HBALs$

Table 12 provides the 1-hour AHBCV and a summary of the calculated iHBALs and $^{EM}HBALs$ for a selection of chemicals. The full list of calculated iHBALs and $^{EM}HBALs$ can be found in Appendix A.

Table 12. Summary of calculated iHBALs and ^{EM}HBALs for fifteen chemicals, including the 1-hour AHBCV for comparison.

Chemical	CAS No.	AHBCV (ppb)	iHBAL (ppb)	$^{EM}HBAL_{10min}$ (ppb)	$^{EM}HBAL_{1hr}$ (ppb)	$^{EM}HBAL_{1sec}$ (ppb)
Acetylene	74-86-2	25,000	75,000	75,000	50,000	150,000
Benzene	71-43-2	180	540	500 [a]	360	1,080
1,3-Butadiene	106-99-0	1,700	5,100	2,500 [a]	3,400	10,200
1-Butene	106-98-9	27,000	81,000	81,000	54,000	162,000
Cyclohexane	110-82-7	1,000	3,000	3,000	2,000	6,000
Ethylbenzene	100-41-4	20,000	60,000	60,000	40,000	120,000
n-Hexane	110-54-3	5,400	16,200	16,200	10,800	32,400
Hydrochloric acid	7647-01-0	440	1,320	1,000 [b]	880	2,640
Isobutane	75-28-5	33,000	99,000	99,000	66,000	198,000
n-Octane	111-65-9	4,100	12,300	12,300	8,200	24,600
Sodium hydroxide	1310-73-2	5	15	15	10	30
Styrene	100-42-5	5,100	15,300	10,000[a]	10,200	30,600
Toluene	108-88-3	4,000	12,000	12,000	8,000	24,000
Xylenes + Ethylbenzene	1330-20-7 + 100-41-4	5,000 [c]	15,000 [c]	15,000 [c]	10,000 [c]	30,000 [c]
Xylenes	1330-20-7	5,000	15,000	15,000	10,000	30,000

[a] Based on ½ STEL; [b] Based on ½ C; [c] Values are based on AHBCV for xylenes; AHBCV – acute health-based comparison value; $^{EM}HBAL_{1hr}$ – 1-hour exposure mitigation health-based action level; $^{EM}HBAL_{10min}$ – 10-minute exposure mitigation health-based action level; $^{EM}HBAL_{1sec}$ – 1-second exposure mitigation health-based action level; iHBAL – instantaneous health-based action level; and ppb – parts per billion.

Comparison of iHBALs and ^{EM}HBALs to federal AEGLs

The USEPA has developed threshold exposure limits for airborne chemicals for the general public that are applicable to emergency exposure periods ranging from 10 minutes to 8 hours. These thresholds, called AEGLs, are intended for use for once-in-a-lifetime or rare exposures to airborne chemicals. These values are used by emergency responders for exposures from chemical spills or other catastrophic events.

There are three AEGL levels, depending on the severity of effects: AEGL-1, AEGL-2, and AEGL-3. The levels represent the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience health effects that increase in severity from AEGL-1 to AEGL-3. These include:

- AEGL-1 – notable discomfort, irritation, or certain asymptomatic, non-sensory effects. These effects are not disabling and are transient and reversible upon cessation of exposure.
- AEGL-2 – irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
- AEGL-3 – life-threatening health effects or death.

While AEGL values represent threshold levels for the general public, including susceptible subpopulations (e.g., infants, children, the elderly, persons with asthma, and those with other illnesses), it is recognized that some individuals with unique or idiosyncratic responses could experience the effects described at concentrations below the corresponding AEGL.

As shown in Table 13, the TCEQ-derived iHBALs and ^{EM}HBALs are designed to be more conservative and health protective than AEGLs; that is, they are set below levels at which health effects are expected to occur. Appendix F provides the 10- and 60-minute AEGLs available for all chemicals discussed herein.

Table 13. Comparison of calculated iHBALs and ^{EM}HBALs to USEPA AEGLs with similar durations.

Chemical(s)	CAS No.	iHBAL (ppb)	$^{EM}HBAL_{10\ min}$ (ppb)	10 Min AEGL-1 (ppb)	10 Min AEGL-2 (ppb)	10 Min AEGL-3 (ppb)	$^{EM}HBAL_{1hr}$ (ppb)	60 Min AEGL-1 (ppb)	60 Min AEGL-2 (ppb)	60 Min AEGL-3 (ppb)
Acetylene	74-86-2	75,000	75,000	-- [a]	--	--	50,000	--	--	--
Benzene	71-43-2	540	500 [a]	130,000	2,000,000	9,700,000	360	52,000	800,000	4,000,000
1,3-Butadiene	106-99-0	5,100	2,500 [a]	670,000	6,700,000	27,000,000	3,400	670,000	5,300,000	22,000,000
1-Butene	106-98-9	81,000	81,000	--	--	--	54,000	--	--	--
Cyclohexane	110-82-7	3,000	3,000	--	--	--	2,000	--	--	--
Ethylbenzene [b]	100-41-4	60,000	60,000	33,000	2,900,000	4,700,000	40,000	33,000	1,100,000	1,800,000
n-Hexane	110-54-3	16,200	16,200	NR	4,000,000	12,000,000	10,800	NR	2,900,000	8,600,000
Hydrochloric acid	7647-01-0	1,320	1,000 [c]	1,800	100,000	620,000	880	1,800	22,000	100,000
Isobutane	75-28-5	99,000	99,000	--	--	--	66,000	--	--	--
n-Octane	111-65-9	12,300	12,300	--	--	--	8,200	--	--	--
Sodium hydroxide	1310-73-2	15	15	--	--	--	10	--	--	--
Styrene	100-42-5	15,300	10,000 [a]	20,000	230,000	1,900,000	10,200	20,000	130,000	1,100,000
Toluene	108-88-3	12,000	12,000	67,000	1,400,000	10,000,000	8,000	67,000	560,000	3,700,000
Xylenes + Ethylbenzene [d]	1330-20-7 + 100-41-4	15,000	15,000	130,000	2,500,000	7,200,000	10,000	130,000	920,000	2,500,000
Xylenes	1330-20-7	15,000	15,000	130,000	2,500,000	7,200,000	10,000	130,000	920,000	2,500,000

[a] Based on ½ STEL; [b] iHBAL and ^{EM}HBALs are higher than AEGL-1 because the AEGL-1 study provides no basis for the expectation of adverse effects at the 10-minute and 1-hr values (see Appendix D for additional information).;[c] Based on ½ C; [d] Based on xylenes; AEGL – acute exposure guideline level; $^{EM}HBAL_{1hr}$ – 1-hour exposure mitigation health-based action level; $^{EM}HBAL_{10min}$ – 10-minute exposure mitigation health-based action level; $^{EM}HBAL_{1sec}$ – 1-second exposure mitigation health-based action level; iBDIL – instantaneous baseline-derived investigation level; iHBAL – instantaneous health-based action level; iHPIL – instantaneous health-protective investigation level; NR – not recommended (see AEGL document); ppb – parts per billion; and "--"no value available.

Appendix A: Comprehensive list of all mobile monitoring comparison values developed by TCEQ

Chemical(s)	CAS No.	BASELINE - DUVAS (ppb)	BASELINE - SIFT (ppb)	iBDIL - DUVAS (ppb)	iBDIL - SIFT (ppb)	iHPIL (ppb)	iHBAL (ppb)	$^{EM}HBAL_{10MIN}$ (ppb)	$^{EM}HBAL_{1HR}$ (ppb)	$^{EM}HBAL_{1SEC}$ (ppb)
COLOR		GREEN	GREEN	ORANGE	ORANGE	RED	PURPLE	N/A	N/A	N/A
Acetylene	74-86-2	--	8	--	80	25,000	75,000	75,000	50,000	150,000
Ammonia	7664-41-7	--	--	--	--	850	2,550	2,550	1,700	5,100
Benzene	71-43-2	14	8	80 [a]	80	180	540	500 [b]	360	1,080
1,3-Butadiene	106-99-0	6	4	40 [a]	40	1,700	5,100	2,500 [b]	3,400	10,200
Butane	106-97-8	--	ND	--	--	92,000	276,000	276,000	184,000	552,000
1-Butene	106-98-9	--	11	--	110	27,000	81,000	81,000	54,000	162,000
C3-C4 Saturated	--	--	96	--	960	--	--	--	--	--
Chlorine	7782-50-5	--	--	--	--	70	210	200 [b]	140	420
Cyclohexane	110-82-7	--	12	--	120	1,000	3,000	3,000	2,000	6,000
Ethylbenzene	100-41-4	35	--	350	--	20,000	60,000	60,000	40,000	120,000
Ethylene Dichloride	107-06-2	--	--	--	--	540	1,620	1,000 [b]	1,080	3,240
Ethylene Glycol	107-21-1	--	--	--	--	1,900	5,700	5,700	3,800	11,400

Chemical(s)	CAS No.	BASELINE - DUVAS (ppb)	BASELINE - SIFT (ppb)	iBDIL - DUVAS (ppb)	iBDIL - SIFT (ppb)	iHPIL (ppb)	iHBAL (ppb)	$^{EM}HBAL_{10MIN}$ (ppb)	$^{EM}HBAL_{1HR}$ (ppb)	$^{EM}HBAL_{1SEC}$ (ppb)
Ethylene Oxide	75-21-8	--	--	--	--	910	2,730	2,500 [b]	1,820	5,460
Formaldehyde	50-00-0	ND	--	--	--	44	132	50	88	264
n-Hexane	110-54-3	--	34	--	340	5,400	16,200	16,200	10,800	32,400
Hydrochloric Acid	7647-01-0	--	--	--	--	440	1,320	1,000 [c]	880	2,640
Hydrogen Sulfide	7783-06-4	--	--	--	-- [e]	70	210	210	140	420
Isobutane	75-28-5	--	28	--	280	33,000	99,000	99,000	66,000	198,000
n-Octane	111-65-9	--	16	--	160	4,100	12,300	12,300	8,200	24,600
$PM_{2.5}$	N/A	--	--	--	--	105 $\mu g/m^3$	--	--	--	--
PM_{10}	N/A	--	--	--	--	450 $\mu g/m^3$	--	--	--	--
Propane [f]	74-98-6	--	54	--	540	--	--	--	--	--
Propylene [f]	115-07-1	--	ND	--	--	--	--	--	--	--
Sodium Hydroxide	1310-73-2	--	--	--	--	5	15	15	10	30
Styrene	100-42-5	8	6	60 [a]	60	5,100	15,300	10,000 [b]	10,200	30,600
Sulfur Dioxide	7446-09-5	7	--	70	--	--	--	--	--	--
Sulfuric Acid	7664-93-9	--	--	--	--	30	90	90	60	180

Chemical(s)	CAS No.	BASELINE - DUVAS (ppb)	BASELINE - SIFT (ppb)	iBDIL - DUVAS (ppb)	iBDIL - SIFT (ppb)	iHPIL (ppb)	iHBAL (ppb)	$^{EM}HBAL_{10MIN}$ (ppb)	$^{EM}HBAL_{1HR}$ (ppb)	$^{EM}HBAL_{1SEC}$ (ppb)
Toluene	108-88-3	40	7	70 [a]	70	4,000	12,000	12,000	8,000	24,000
Vinyl Chloride	75-01-4	--	--	--	--	72,000	216,000	216,000	144,000	432,000
Xylenes + Ethylbenzene	1330-20-7 + 100-41-4	--	6	--	60	5,000 [d]	15,000 [d]	15,000 [d]	10,000 [d]	30,000 [d]
Xylenes	1330-20-7	--	--	--	--	5,000	15,000	15,000	10,000	30,000

[a] DUVAS iBDIL based on SIFT; [b] Based on ½ STEL; [c] Based on ½ C; [d] Values are based on AHBCV for xylenes; [e] no iBDIL was derived for H2S monitored via Picarro – see Appendix B; [f] Simple asphyxiant, non-toxic in ambient air; DUVAS - Differential Ultra-Violet Absorption Spectrometer; $^{EM}HBAL_{1hr}$ – 1-hour exposure mitigation health-based action level; $^{EM}HBAL_{10min}$ – 10-minute exposure mitigation health-based action level; $^{EM}HBAL_{1sec}$ – 1-second exposure mitigation health-based action level; iBDIL – instantaneous baseline-derived investigation level; iHBAL – instantaneous health-based action level; iHPIL – instantaneous health-protective investigation level; N/A – not applicable; ND – not determined; ppb – parts per billion; SIFT- Selected Ion Flow Tube-Mass Spectrometer; and "--"no value available

Appendix B: Derivation of chemical- and instrument-specific baselines for investigation level derivation

The purpose of setting an instantaneous baseline-derived investigation level (iBDIL) is to identify the presence of an abnormally high concentration of any monitored chemical in the ambient air. This allows for identification of non-spurious concentrations that warrant a follow-up source investigation, with further actions carried out if needed. To set the iBDIL, the maximum non-signal baseline noise (baseline level) must be determined for each chemical and for each monitoring instrument. This appendix addresses chemical measurements made using the Selected Ion Flow Tube-Mass Spectrometer (SIFT), Differential Ultra-Violet Absorption Spectrometer (DUVAS), Picarro, and nephelometer instruments. The iBDIL is set 10-times higher than the chemical- and instrument- specific baseline. The baseline and iBDIL for a number of chemicals measured by the SIFT and the DUVAS are provided in Table B - 1. The following sections describe the specific baseline determinations for each chemical and instrument.

Table B - 1. Baseline and iBDIL values of chemicals monitored by SIFT and DUVAS instruments.

Chemical(s)	Applicable Instrument(s)	SIFT Baseline (ppb)	DUVAS Baseline (ppb)	iBDIL (ppb)
Acetylene	SIFT	8	N/A	80
Ammonia	DUVAS	N/A	ND	ND
Benzene	SIFT, DUVAS	8	14	80 [a]
1,3-Butadiene	SIFT, DUVAS	4	6	40 [a]
Butane	SIFT	ND	N/A	ND
1-Butene (1-Butylene)	SIFT	11	N/A	110
C3 - C4 Saturated	SIFT	96	N/A	960
Cyclohexane	SIFT	12	N/A	120
Ethane + Ethylene	SIFT	ND	N/A	ND
Ethylbenzene	DUVAS	N/A	35	350
Ethylbenzene + Xylenes	SIFT	6	N/A	60
Formaldehyde	DUVAS	N/A	ND	ND
Hexane	SIFT	34	N/A	340
Isobutane	SIFT	28	N/A	280
Octane	SIFT	16	N/A	160
Propane	SIFT	54	N/A	540
Propylene	SIFT	ND	N/A	ND

Chemical(s)	Applicable Instrument(s)	SIFT Baseline (ppb)	DUVAS Baseline (ppb)	iBDIL (ppb)
Styrene	SIFT, DUVAS	6	8	60 [a]
Sulfur Dioxide	DUVAS	N/A	7	70
Toluene	SIFT, DUVAS	7	40	70 [a]
***m*-Xylene**	DUVAS	N/A	ND	ND
***o*-Xylene**	DUVAS	N/A	ND	ND
***p*-Xylene**	DUVAS	N/A	ND	ND

[a] iBDIL derived using baseline from the SIFT instrument.; iBDIL – instantaneous baseline derived investigation level; N/A – not applicable; ND – not derived; ppb – parts per billion; SIFT – Selected Ion Flow Tube-Mass Spectrometer; and DUVAS – Differential Ultra-Violet Absorption Spectrometer.

SIFT Instrument Chemical Baseline Derivations

The SIFT instrument was utilized to conduct more than 300 mobile monitoring surveys between September 10, 2020, and November 10, 2021, in the Beaumont, Houston, and Corpus Christi areas of Texas (TCEQ regions 10, 12, and 14, respectively). Some or all these surveys measured the following chemicals: acetylene, benzene, 1,3-butadiene, butane, 1-butene (1-butylene), C3-C4 saturated, cyclohexane, ethane + ethylene, ethylbenzene + xylenes, hexane, isobutane, isobutene, octane, propane, propylene, styrene, and toluene. Not all surveys were evaluated to determine the baseline for each chemical, but rather a subset of surveys were chosen based on criteria discussed in Section 3.2. A summary of the monitoring surveys identified as having the maximum non-signal baseline noise, and therefore used for the derivation of chemical-specific baseline levels, is provided in Table B - 2.

Table B - 2. SIFT monitoring surveys used to derive chemical-specific baseline levels.

Chemical(s)	Event	Date	Location	Survey Number	Baseline (ppb)
Acetylene	Hurricane Laura	9/16/2020	Orange, TX	A	8
Benzene	Hurricane Laura	9/10/2020	Port Arthur, TX	E (Stat)	8
1,3-Butadiene	Winter Storm Uri	2/23/2021	Houston, TX	A (Stat)	4
Butane					ND
1-Butene (1-Butylene)	Hurricane Delta	10/11/2020	Port Arthur, TX	A	11
C3 – C4 Saturated	Hurricane Laura	9/10/2020	Port Neches, TX	B	96
Cyclohexane	Hurricane Laura	9/10/2020	Port Arthur, TX	C (Stat)	12

Chemical(s)	Event	Date	Location	Survey Number	Baseline (ppb)
Ethane + Ethylene					ND
Ethylbenzene + Xylenes	N/A	6/16/2021	Port Neches, TX	9-L	6
Hexane	Hurricane Laura	9/10/2020	Port Arthur, TX	C (Stat)	34
Isobutane	Winter Storm Uri	2/23/2021	Houston, TX	A	28
Octane	Winter Storm Uri	3/7/2021	Corpus Christi, TX	BG	16
Propane	Winter Storm Uri	3/9/2021	Port Neches, TX	AM	54
Propylene					ND
Styrene	N/A	10/25/2021	Channelview, TX	B	6
Toluene	Winter Storm Uri	3/30/2021	Channelview, TX	BJ	7

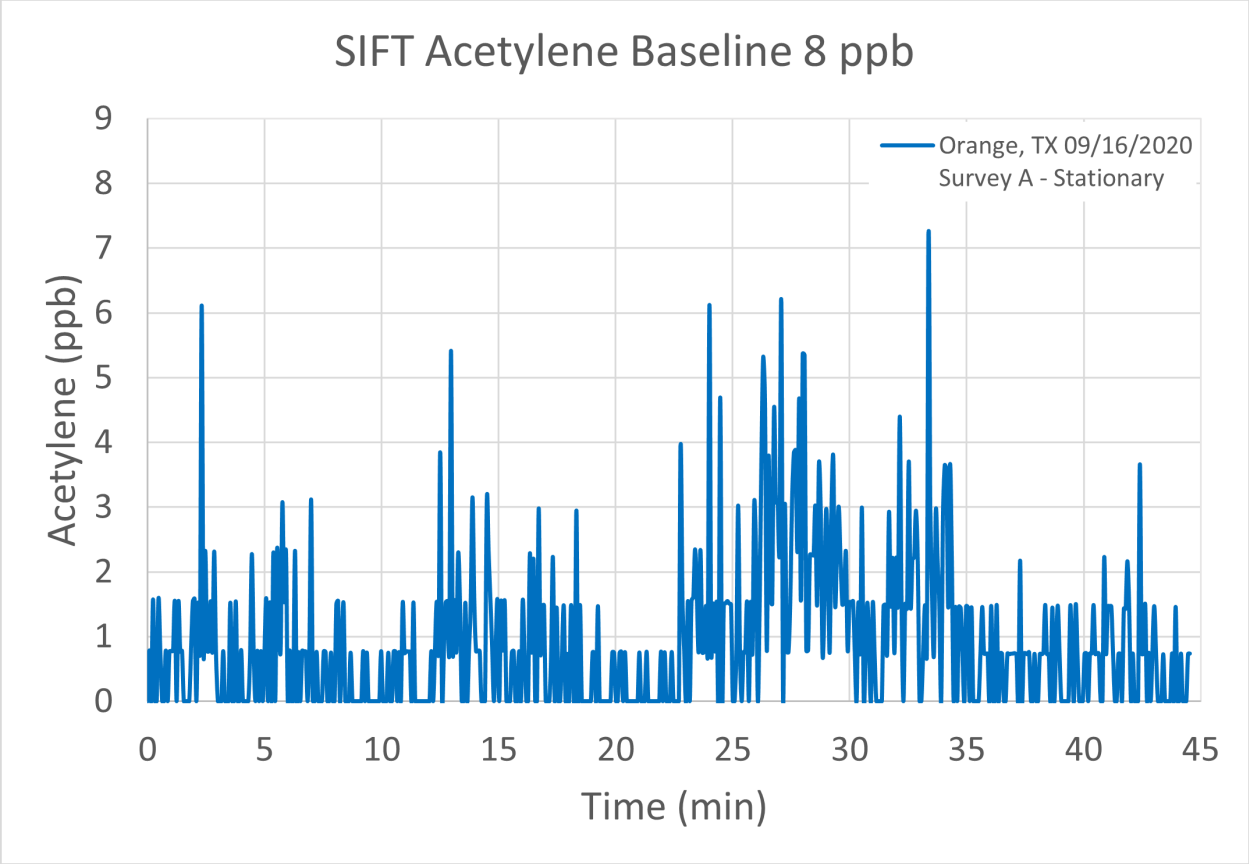
Stat – Stationary survey; ND – not derived; N/A – not applicable; and ppb – parts per billion.

Acetylene

Of the 145 SIFT surveys that measured acetylene, a total of 20 surveys were selected and evaluated to determine the acetylene baseline level. The survey with the maximum non-signal baseline noise was survey A from September 16, 2020, in Orange, TX (Region 10), shown below (Figure B - 1). The maximum noise from the survey was 7.24 ppb, which was rounded[1] to 8 ppb to generate the baseline level for acetylene. The iBDIL for acetylene was calculated as 10-times the baseline level and therefore the acetylene iBDIL was set at 80 ppb.

[1] Because the baseline value represents the top of the range of instrument noise and background ambient concentrations, we rounded the highest non-signal concentrations observed for that chemical and instrument up to the nearest part per billion. Exceptions to this rounding convention are noted for specific chemicals/instruments.

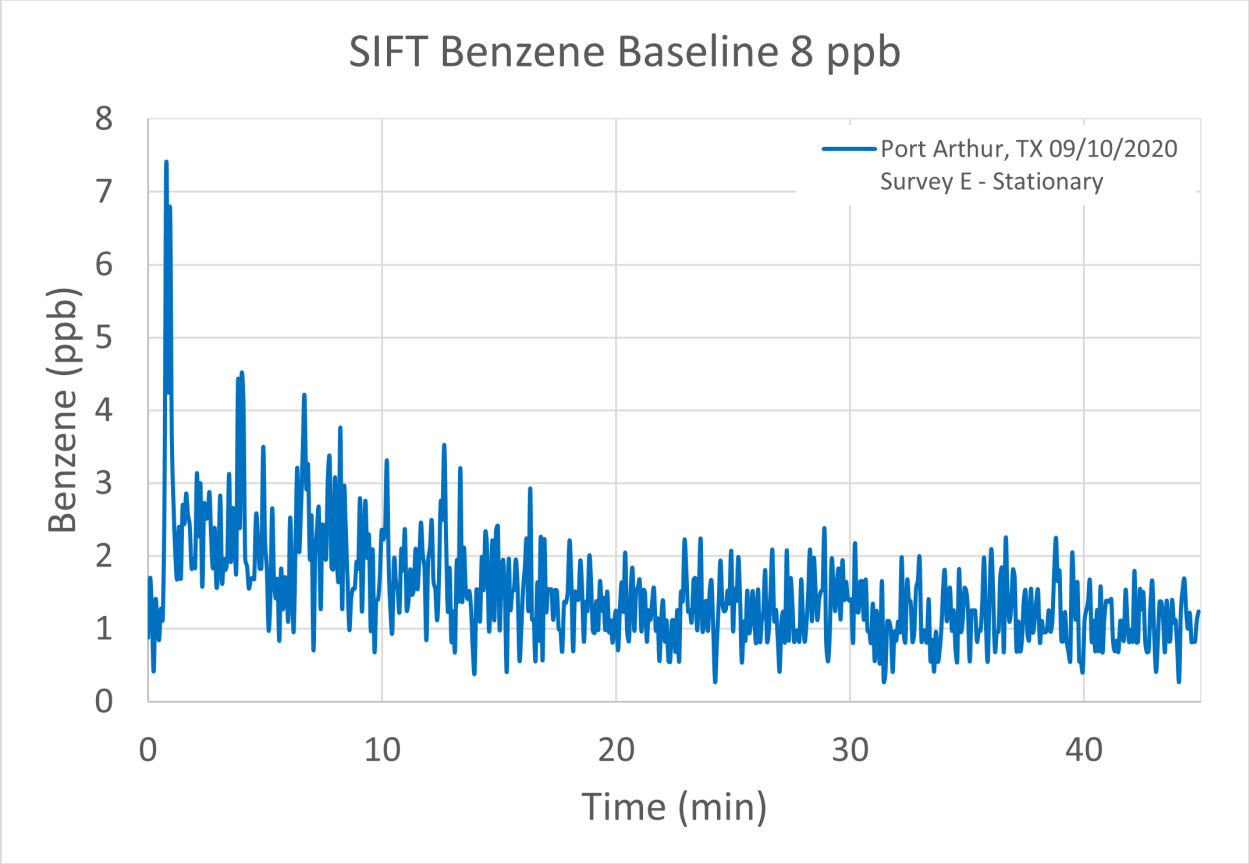
Figure B - 1. Time-concentration graph of acetylene collected during a SIFT instrument survey that was selected as the acetylene maximum non-signal baseline level.



Benzene

Of the 304 SIFT surveys that measured benzene, a total of 18 surveys were selected and evaluated to determine the benzene baseline level. The survey with the maximum non-signal baseline noise was Survey E -Stationary from September 10, 2021, in Port Arthur, TX (Region 10), shown below (Figure B - 2). The maximum noise from the survey was 7.40 ppb, which was rounded to 8 ppb to generate the baseline level for benzene. The iBDIL for benzene was calculated as 10-times the baseline level and therefore the benzene iBDIL was set at 80 ppb.

Figure B - 2. Time-concentration graph of benzene collected during a SIFT instrument survey that was selected as the benzene maximum non-signal baseline level.

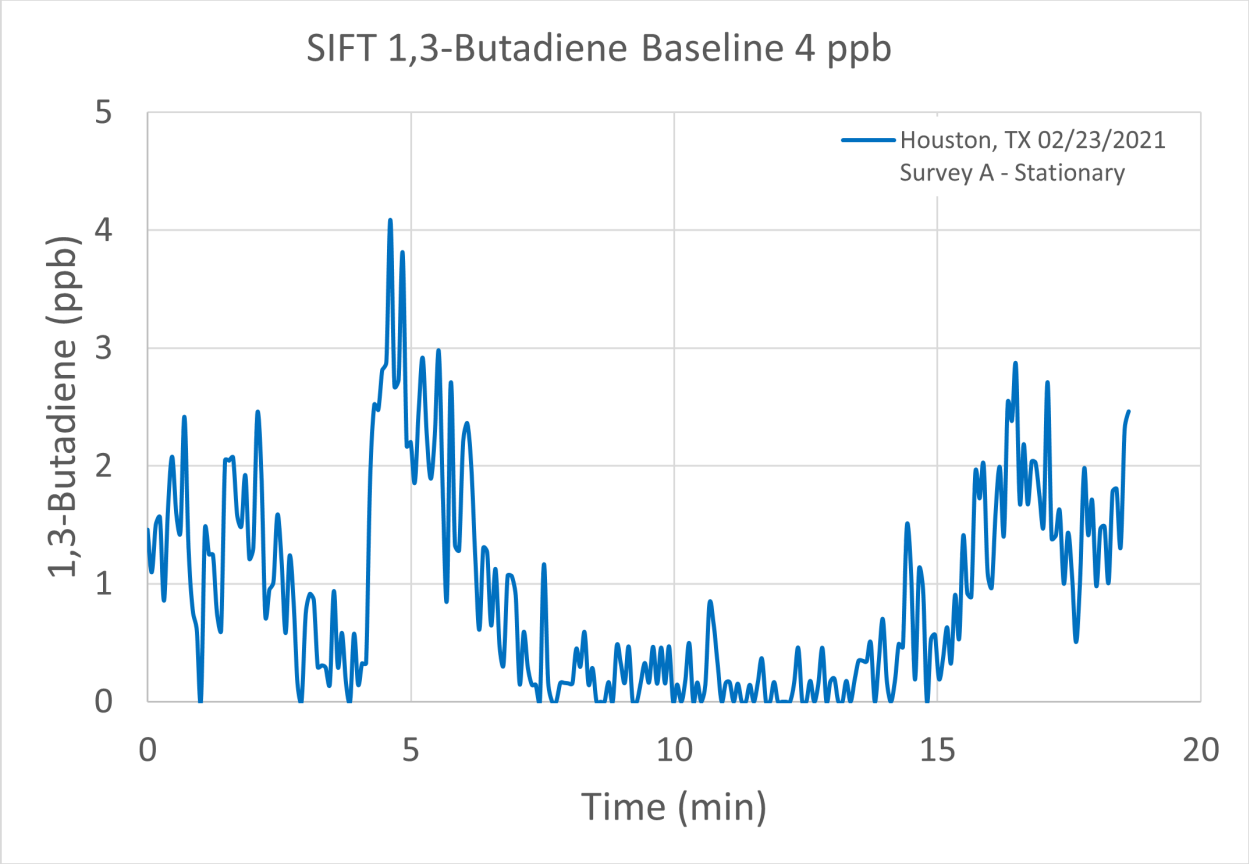


1,3-Butadiene

Of the 304 SIFT surveys that measured 1,3-butadiene, a total of 12 surveys were selected and evaluated to determine the 1,3-butadiene baseline level. The survey with the maximum non-signal baseline noise was Survey A-Stationary from February 23, 2021, in Houston, TX (Region 12), shown below (Figure B - 3). The maximum noise from the survey was 4.09 ppb, which was rounded down to 4 ppb to generate the baseline level for 1,3-butadiene.[2] The iBDIL for 1,3-butadiene was calculated as 10-times the baseline level and therefore the 1,3-butadiene iBDIL was set at 40 ppb.

[2] Because the maximum non-signal baseline for 1,3-butadiene was < 0.1 ppb higher than 4 ppb, the decision was made to round the baseline level down to 4 ppb.

Figure B - 3. Time-concentration graph of 1,3-butadiene collected during a SIFT instrument survey that was selected as the 1,3-butadiene maximum non-signal baseline level.



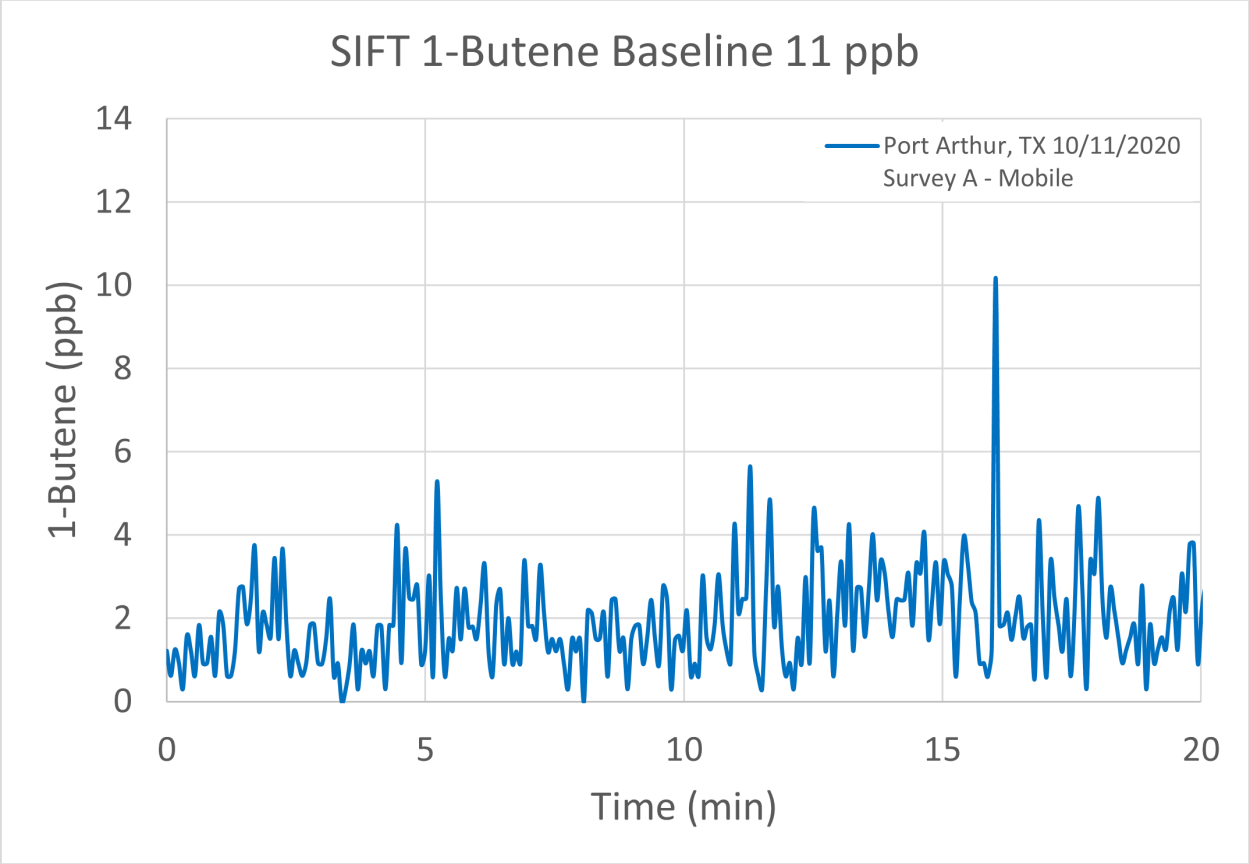
Butane

The baseline was not determined for butane due to the variation observed in the baseline noise among surveys.

1-Butene

Of the 151 SIFT surveys that measured 1-butene, a total of 26 surveys were selected and evaluated to determine the 1-butene baseline level. The survey with the maximum non-signal baseline noise was survey A from October 11, 2020, in Port Arthur, TX (Region 10), shown below (Figure B - 4). The maximum noise from the survey was 10.18 ppb, which was rounded to 11 ppb to generate the baseline level for 1-butene. The iBDIL for 1-butene was calculated as 10-times the baseline level and therefore the 1-butene iBDIL was set at 110 ppb.

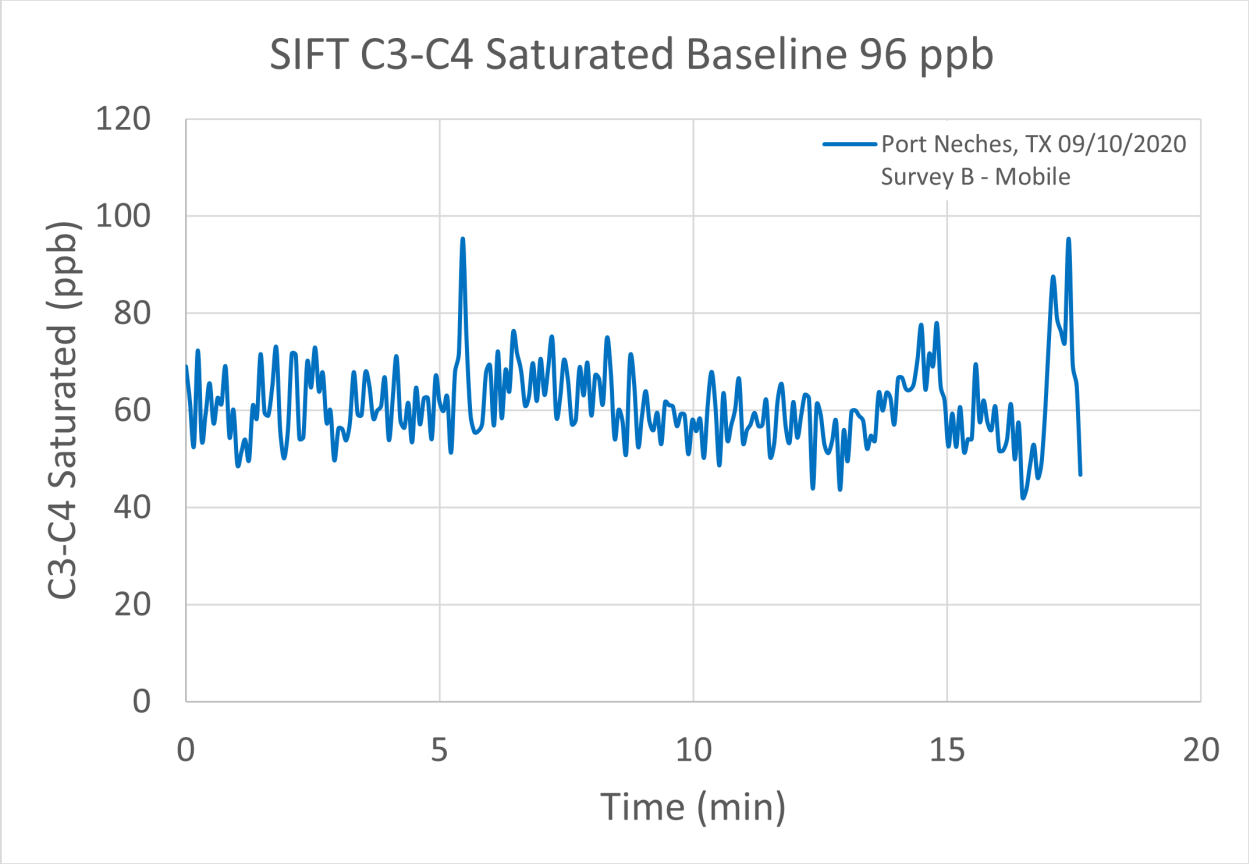
Figure B - 4. Time-concentration graph of 1-butene collected during a SIFT instrument survey that was selected as the 1-butene maximum non-signal baseline level.



C3-C4 Saturated

Of the 77 SIFT surveys that measured C3-C4 saturated, a total of 28 surveys were selected and evaluated to determine the C3-C4 saturated baseline level. The survey with the maximum non-signal baseline noise was Survey B from September 10, 2020, in Port Neches, TX (Region 10), shown below (Figure B - 5). The maximum noise from the survey was 95.40 ppb, which was rounded to 96 ppb to generate the baseline level for C3-C4 saturated. The iBDIL for C3-C4 saturated was calculated as 10-times the baseline level and therefore the C3-C4 iBDIL was set at 960 ppb.

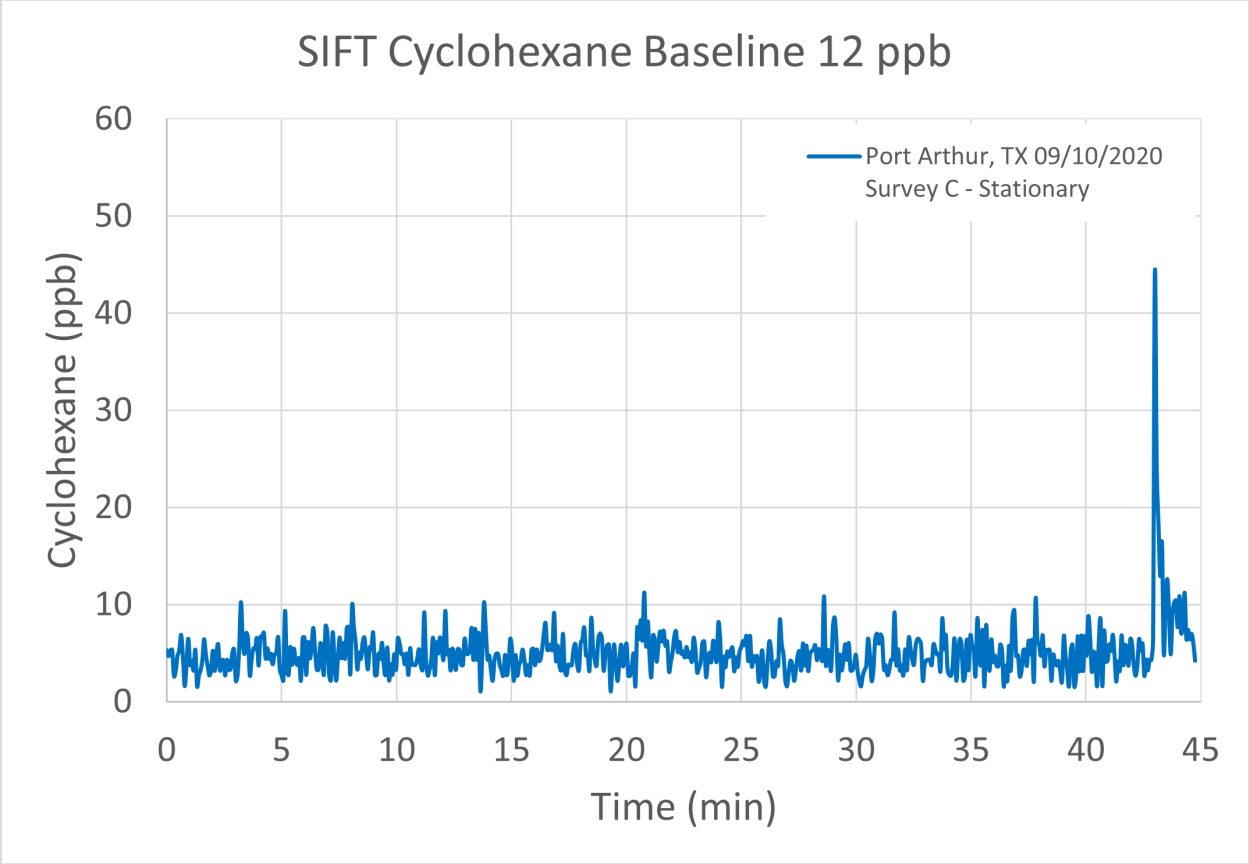
Figure B - 5. Time-concentration graph of C3-C4 saturated collected during a SIFT instrument survey that was selected as the C3-C4 saturated maximum non-signal baseline level.



Cyclohexane

Of the 100 SIFT surveys that measured cyclohexane, a total of 28 surveys were selected and evaluated to determine the cyclohexane baseline level. The survey with the maximum non-signal baseline noise was survey C (stationary) from September 10, 2020, in Port Arthur, TX (Region 10), shown below (Figure B - 6). The maximum noise from the survey was 11.30 ppb, which was rounded to 12 ppb to generate the baseline level for cyclohexane. The iBDIL for cyclohexane was calculated as 10-times the baseline level and therefore the iBDIL was set at 120 ppb.

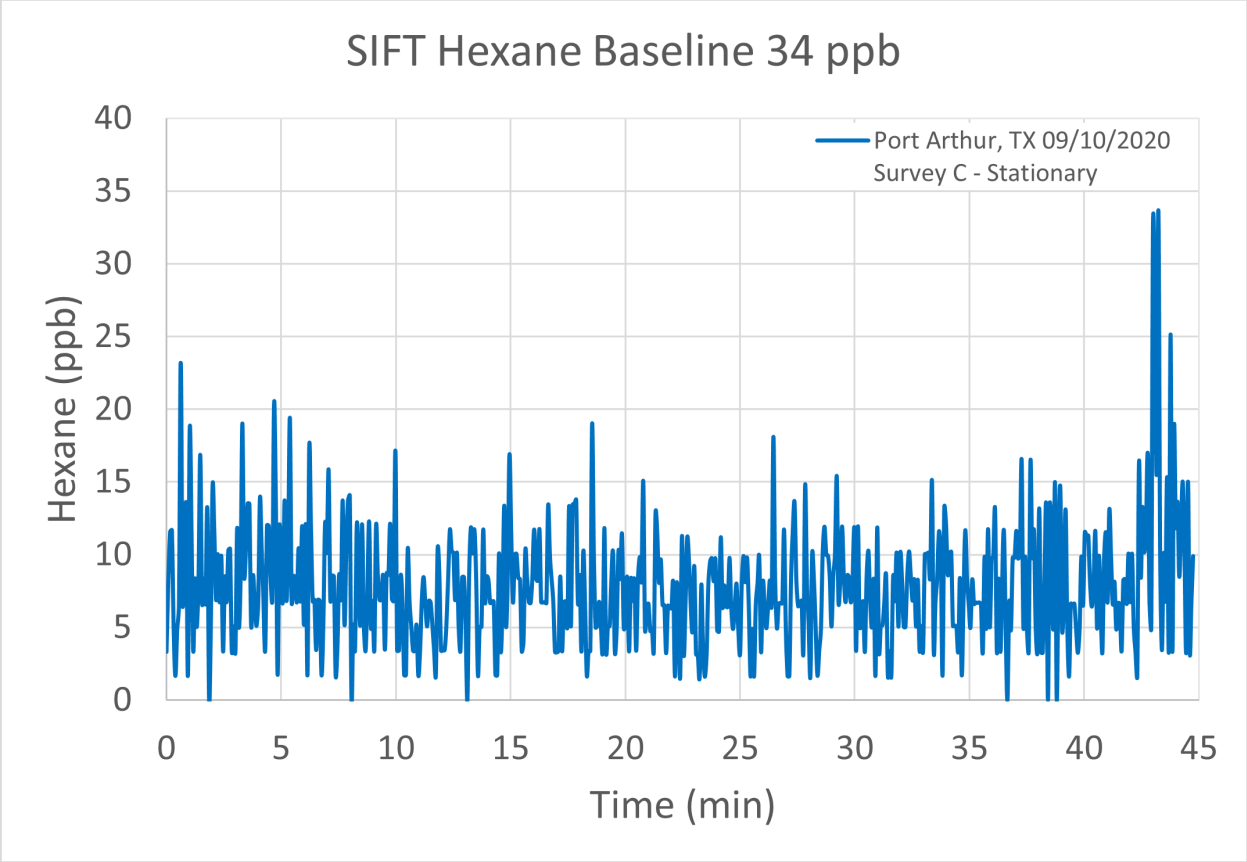
Figure B - 6. Time-concentration graph of cyclohexane collected during a SIFT instrument survey that was selected as the cyclohexane maximum non-signal baseline level.



n-Hexane

Of the 104 SIFT surveys that measured n-hexane, a total of 23 surveys were selected and evaluated to determine the n-hexane baseline level. The survey with the maximum non-signal baseline noise was survey C (stationary) from September 10, 2021, in Port Arthur, TX (Region 10), shown below (Figure B - 7). The maximum noise from the survey was 33.65 ppb, which was rounded to 34 ppb to generate the baseline level for n-hexane. The iBDIL for n-hexane was calculated as 10x the baseline level and therefore the n-hexane iBDIL was set at 340 ppb.

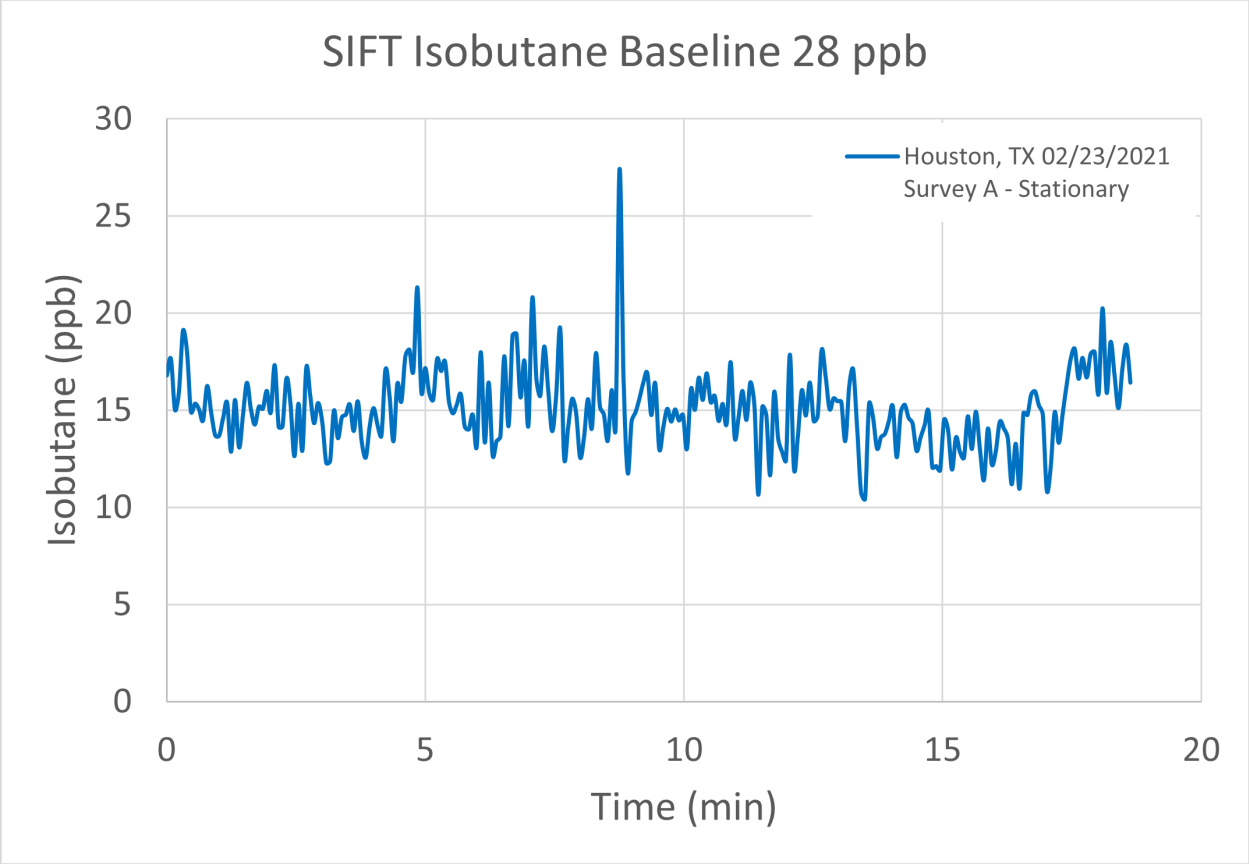
Figure B - 7. Time-concentration graph of n-hexane collected during a SIFT instrument survey that was selected as the n-hexane maximum non-signal baseline level.



Isobutane

Of the 145 SIFT surveys that measured isobutane, a total of 27 surveys were selected and evaluated to determine the isobutane baseline level. The survey with the maximum non-signal baseline noise was survey A (stationary) from February 23, 2021, in Houston, TX (Region 12), shown below (Figure B - 8). The maximum noise from the survey was 27.42 ppb, which was rounded to 28 ppb to generate the baseline level for isobutane. The iBDIL for isobutane was calculated as 10-times the baseline level and therefore the isobutane iBDIL was set at 280 ppb.

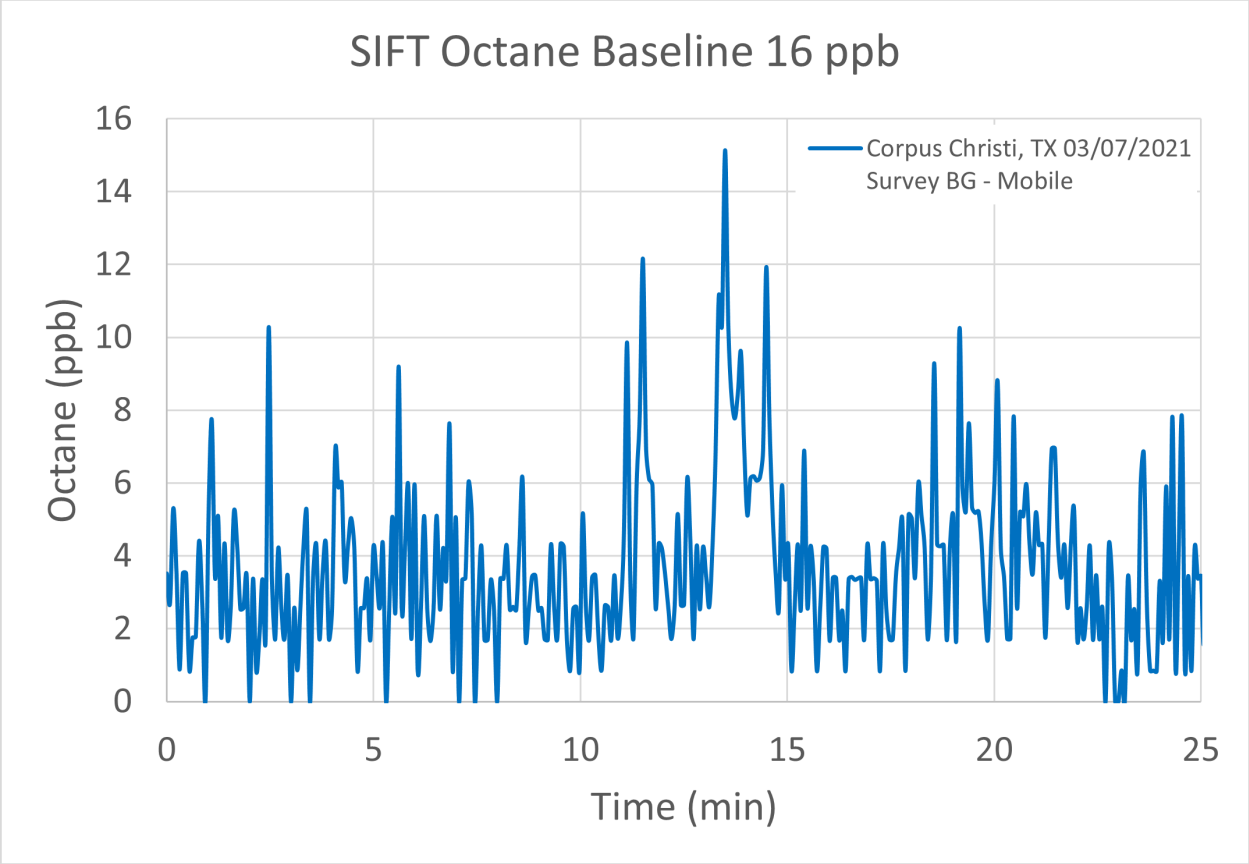
Figure B - 8. Time-concentration graph of isobutane collected during a SIFT instrument survey that was selected as the isobutane maximum non-signal baseline level.



n-Octane

Of the 100 SIFT surveys that measured n-octane, a total of 45 surveys were selected and evaluated to determine the n-octane baseline level. The survey with the maximum non-signal baseline noise was survey BG from March 7, 2021, in Corpus Christi, TX (Region 14), shown below (Figure B - 9). The maximum noise from the survey was 15.14 ppb, which was rounded to 16 ppb to generate the baseline level for n-octane. The iBDIL for n-octane was calculated as 10-times the baseline level and therefore the n-octane iBDIL was set at 160 ppb.

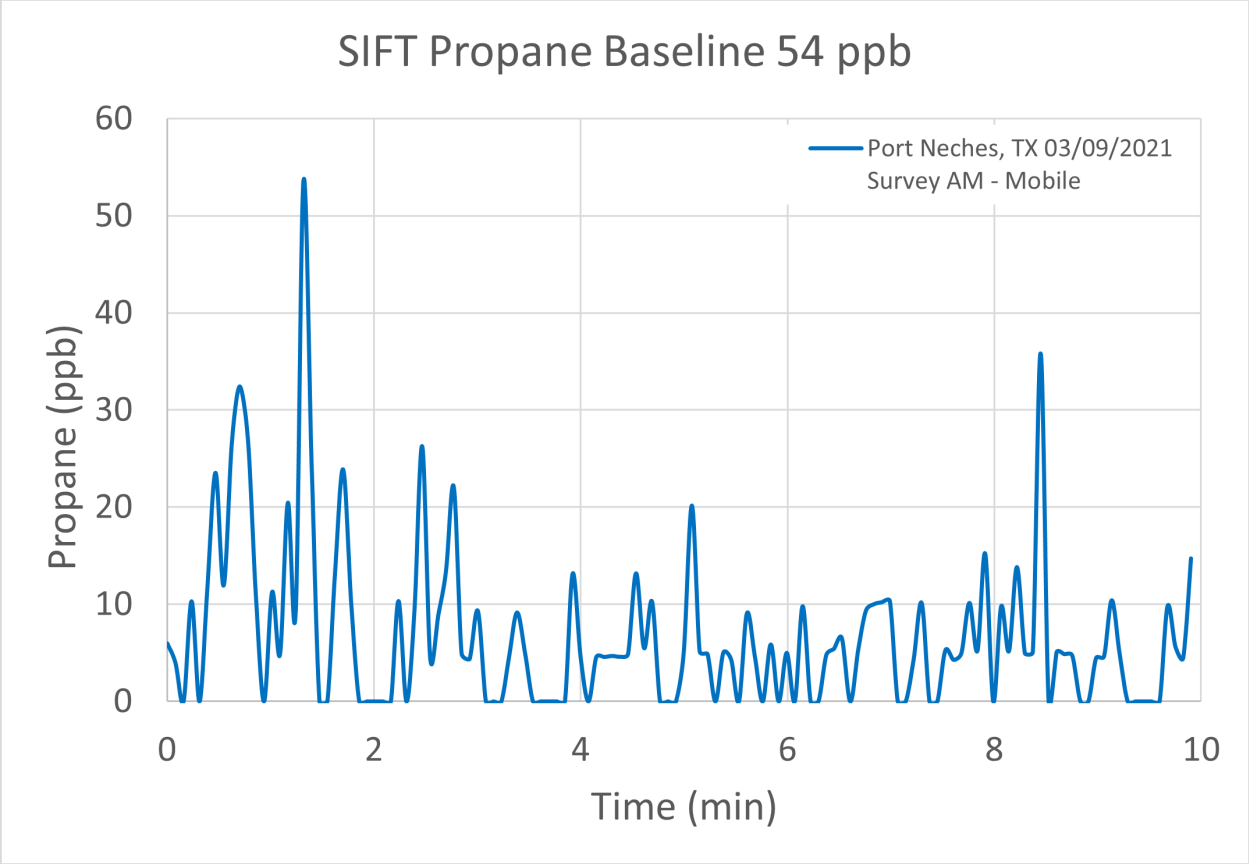
Figure B - 9. Time-concentration graph of n-octane collected during a SIFT instrument survey that was selected as the n-octane maximum non-signal baseline level.



Propane

Of the 304 SIFT surveys that measured propane, a total of 18 surveys were selected and evaluated to determine the propane baseline level. The survey with the maximum non-signal baseline noise was survey AM from March 9, 2021, in Port Neches, TX (Region 10), shown below (Figure B - 10). The maximum noise from the survey was 53.63 ppb, which was rounded to 54 ppb to generate the baseline level for propane. The iBDIL for propane was calculated as 10-times the baseline level and therefore the propane iBDIL was set at 540 ppb.

Figure B - 10. Time-concentration graph of propane collected during a SIFT instrument survey that was selected as the propane maximum non-signal baseline level.



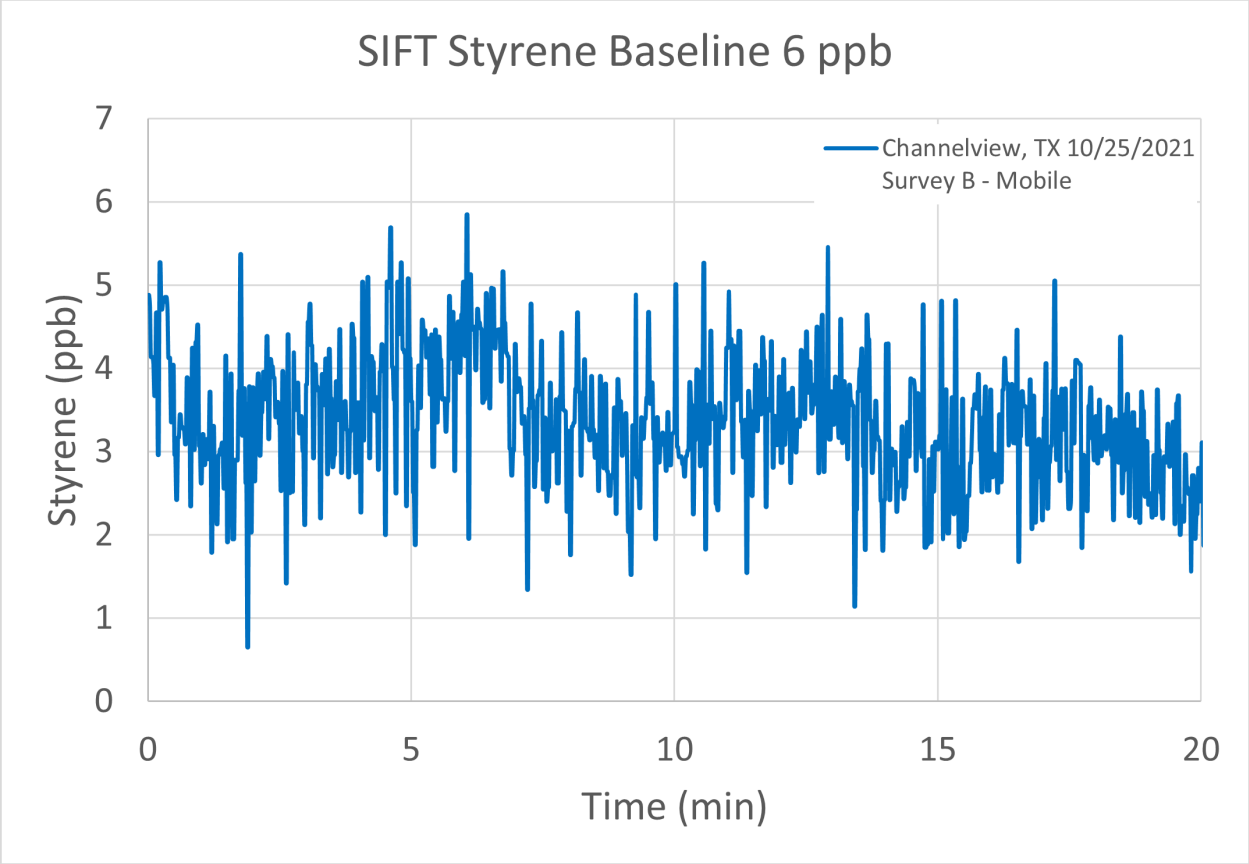
Propylene

The baseline was not determined for propylene due to the large variability observed in the baseline between regions and events.

Styrene

Of the 304 SIFT surveys that measured styrene, a total of 27 surveys were selected and evaluated to determine the styrene baseline level. The survey with the maximum non-signal baseline noise was survey B from October 25, 2021, in Channelview, TX (Region 12), shown below (Figure B - 11). The maximum noise from the survey was 5.8 ppb, which was rounded to 6 ppb to generate the baseline level for styrene. The iBDIL for styrene was calculated as 10-times the baseline level and therefore the styrene iBDIL was set at 60 ppb.

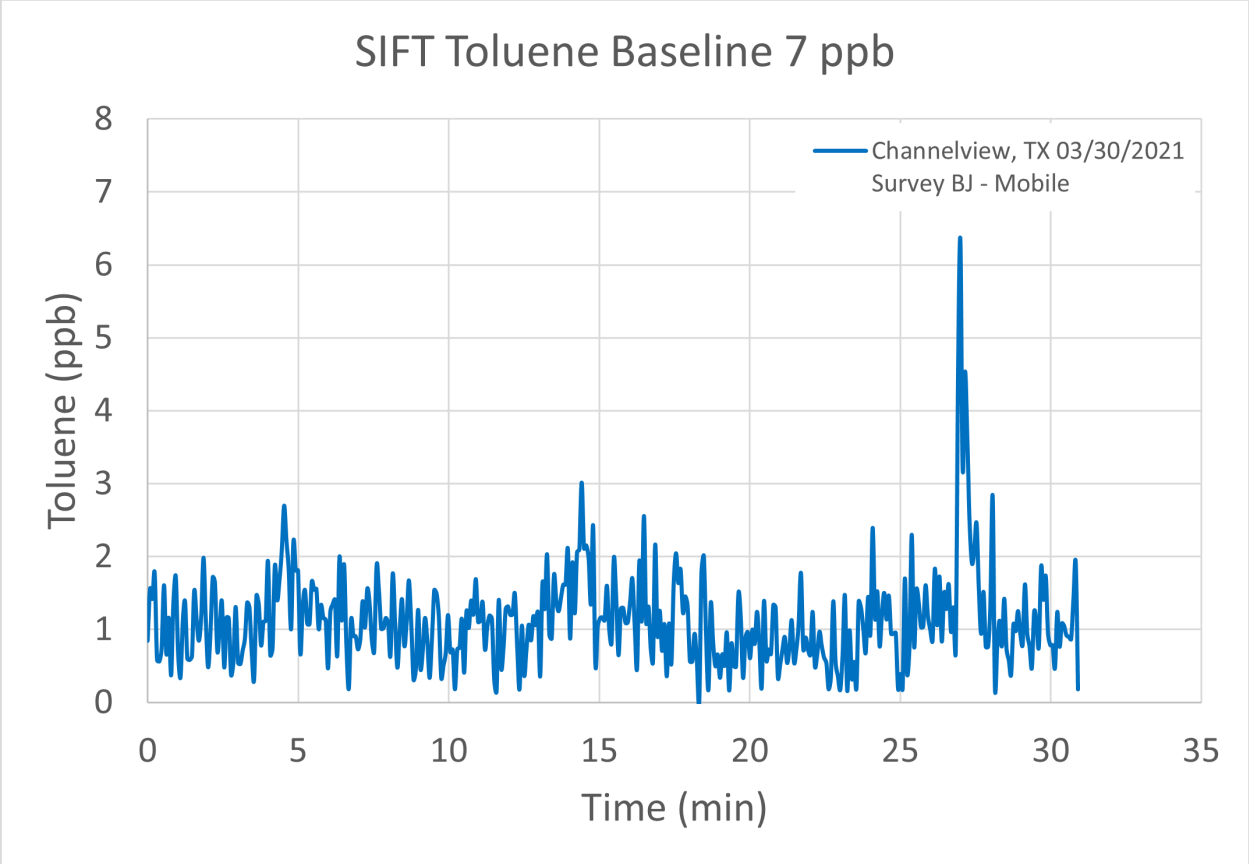
Figure B - 11. Time-concentration graph of styrene collected during a SIFT instrument survey that was selected as the styrene maximum non-signal baseline level.



Toluene

Of the 304 SIFT surveys that measured toluene, a total of 29 surveys were selected and evaluated to determine the toluene baseline level. The survey with the maximum non-signal baseline noise was Survey BJ from March 30, 2021, in Channelview, TX (Region 12), shown below (Figure B - 12). The maximum noise from the survey was 6.35 ppb, which was rounded to 7 ppb to generate the baseline level for toluene. The iBDIL for toluene was calculated as 10-times the baseline level and therefore the toluene iBDIL was set at 70 ppb.

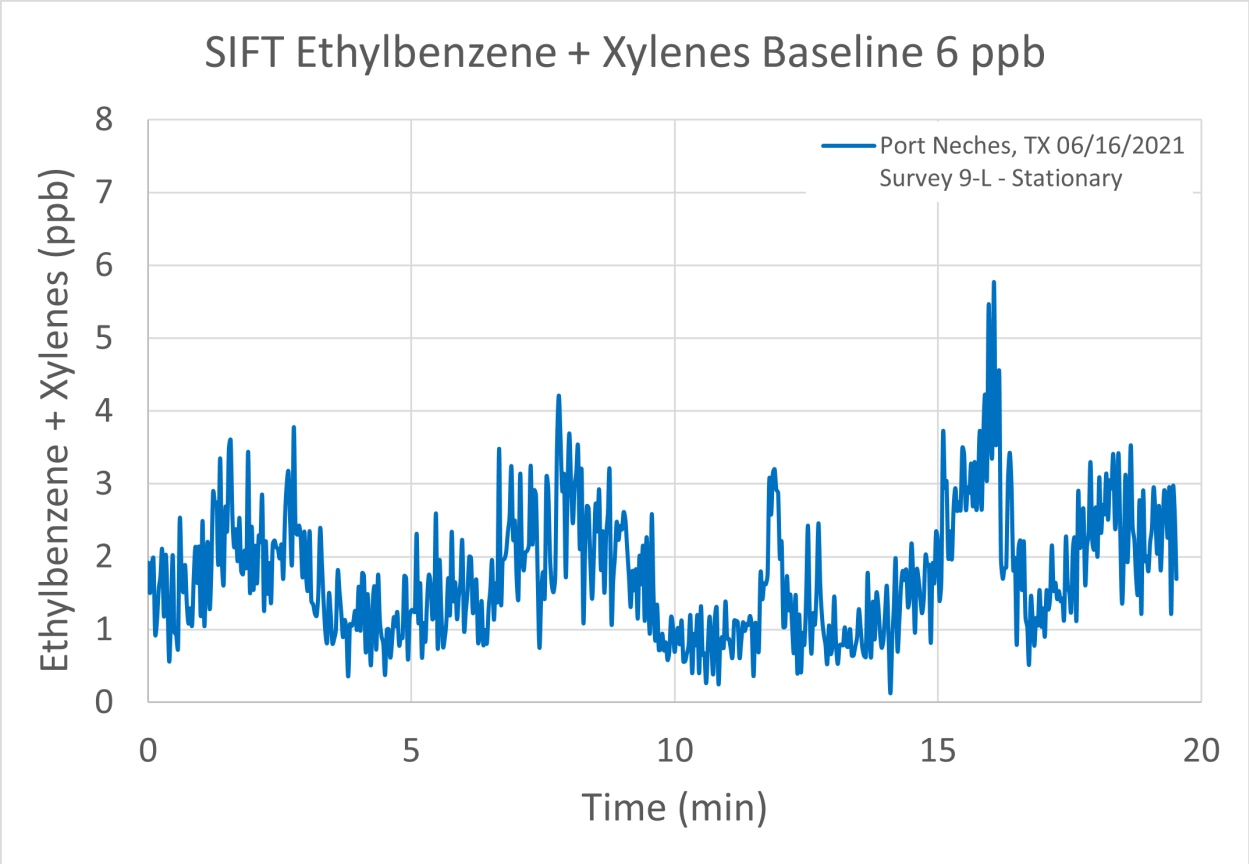
Figure B - 12. Time-concentration graph of toluene collected during a SIFT instrument survey that was selected as the toluene maximum non-signal baseline level.



Xylenes + Ethylbenzene

Of the 304 SIFT surveys that measured xylenes + ethylbenzene, a total of 54 surveys were selected and evaluated to determine the xylenes + ethylbenzene baseline level. The survey with the maximum non-signal baseline noise was survey 9-L (stationary) from June 16, 2021, in Port Neches, TX (Region 10), shown below (Figure B - 13). The maximum noise from the survey was 5.77 ppb, which was rounded to 6 ppb to generate the baseline level for xylenes + ethylbenzene. The iBDIL for xylenes + ethylbenzene was calculated as 10-times the baseline level and therefore the xylenes + ethylbenzene iBDIL was set at 60 ppb.

Figure B - 13. Time-concentration graph of xylenes + ethylbenzene collected during a SIFT instrument survey that was selected as the xylenes + ethylbenzene maximum on-signal baseline level.



DUVAS Instrument Chemical Baseline Derivations

The DUVAS instrument was utilized to conduct more than 500 mobile monitoring surveys between August 28, 2020, and March 4, 2022, in the Beaumont, Houston, and Corpus Christi, areas of Texas (TCEQ Regions 10, 12, and 14 respectively). Of those, 198 surveys conducted in Beaumont and Houston beginning in September 2021 had one-second data available for analysis and so those surveys were used for the DUVAS baseline derivations. Some or all these surveys measured the following chemicals: ammonia, benzene, 1,3-butadiene, ethylbenzene, formaldehyde, styrene, sulfur dioxide, toluene, and xylenes. Not all surveys were evaluated to determine the baseline for each chemical, but rather a subset of surveys were chosen based on criteria discussed in Section 3.2. A summary of the monitoring surveys identified as having the maximum non-signal baseline noise, and therefore used for the derivation of chemical-specific baseline levels is provided in Table B - 3. For consistency, the TCEQ chose to designate a single iBDIL for chemicals measured by both the SIFT and DUVAS (benzene, 1,3-butadiene, styrene, and toluene).

Table B - 3. DUVAS monitoring surveys used to derive chemical-specific baselines.

Chemical(s)	Date	Location	Survey Number	Baseline (ppb)
Ammonia				ND
Benzene	10/12/2021	Port Neches, TX	Datalog 4-3	14
1,3-Butadiene	10/13/2021	Port Neches, TX	Datalog 6-3	6
Ethylbenzene	9/16/2021	Texas City, TX	H	35
Formaldehyde				ND
Styrene	10/13/2021	Beaumont, TX	Datalog 1-3	8
Sulfur Dioxide	10/28/2021	Pasadena, TX	10	7
Toluene	11/12/2021	Channelview, TX	4	40
***m*-Xylene**				ND
***o*-Xylene**				ND
***p*-Xylene**				ND

ND – not derived and ppb – parts per billion.

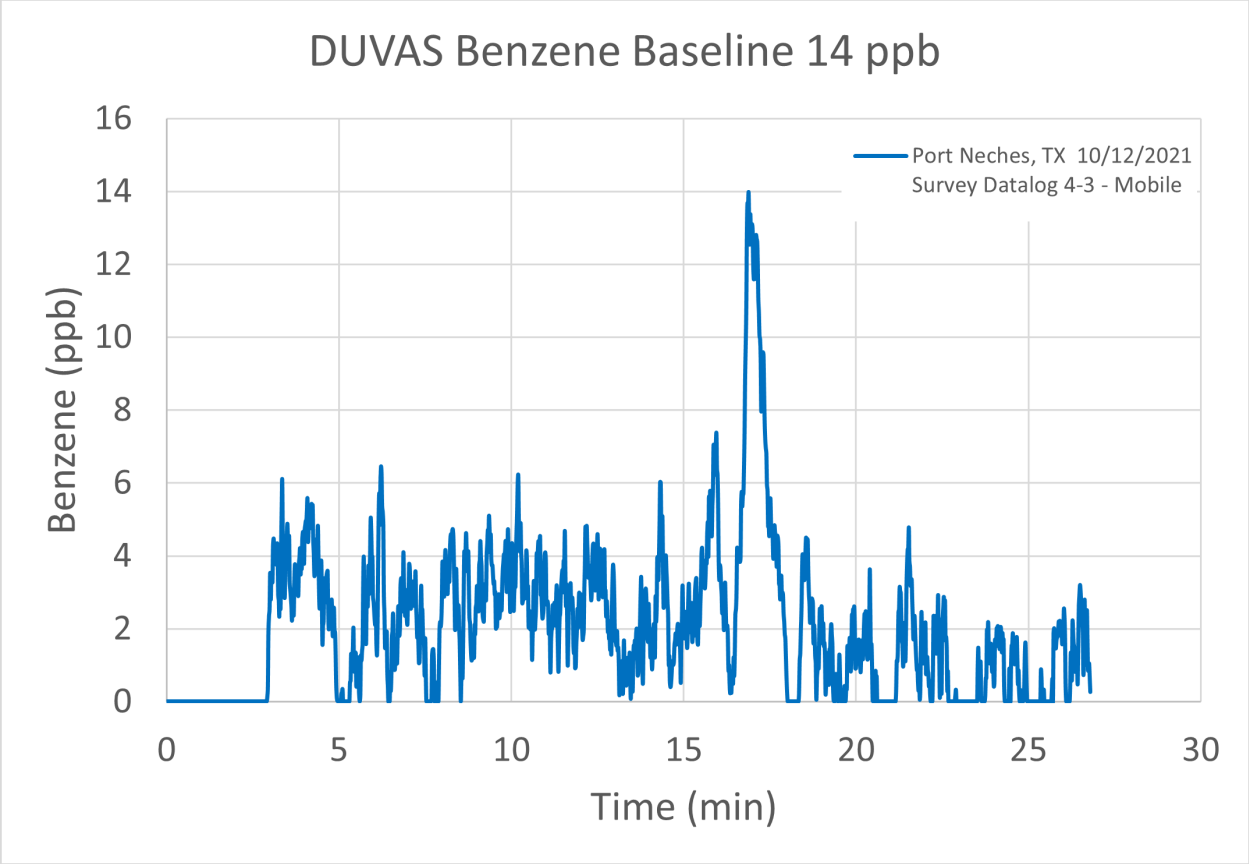
Ammonia

The baseline was not determined for ammonia due to the large variation observed among the baseline surveys, with many surveys reporting a concentration of zero for most if not all of the survey.

Benzene

Of the 198 DUVAS surveys that measured benzene and reported one-second data, a total of 23 surveys were selected and evaluated to determine the benzene baseline level. The survey with the maximum non-signal baseline noise was survey Datalog 4-3 from October 12, 2021, in Port Neches, TX (Region 10), shown below (Figure B - 14). The maximum noise from the survey was 13.98 ppb, which was rounded to 14 ppb to generate the baseline level for benzene. The baseline level for benzene is similar between the SIFT and the DUVAS. Because using the SIFT baseline level for benzene generates a lower iBDIL and so triggers a source investigation at a lower chemical concentration, the SIFT baseline was used to set the benzene iBDIL at 80 ppb.

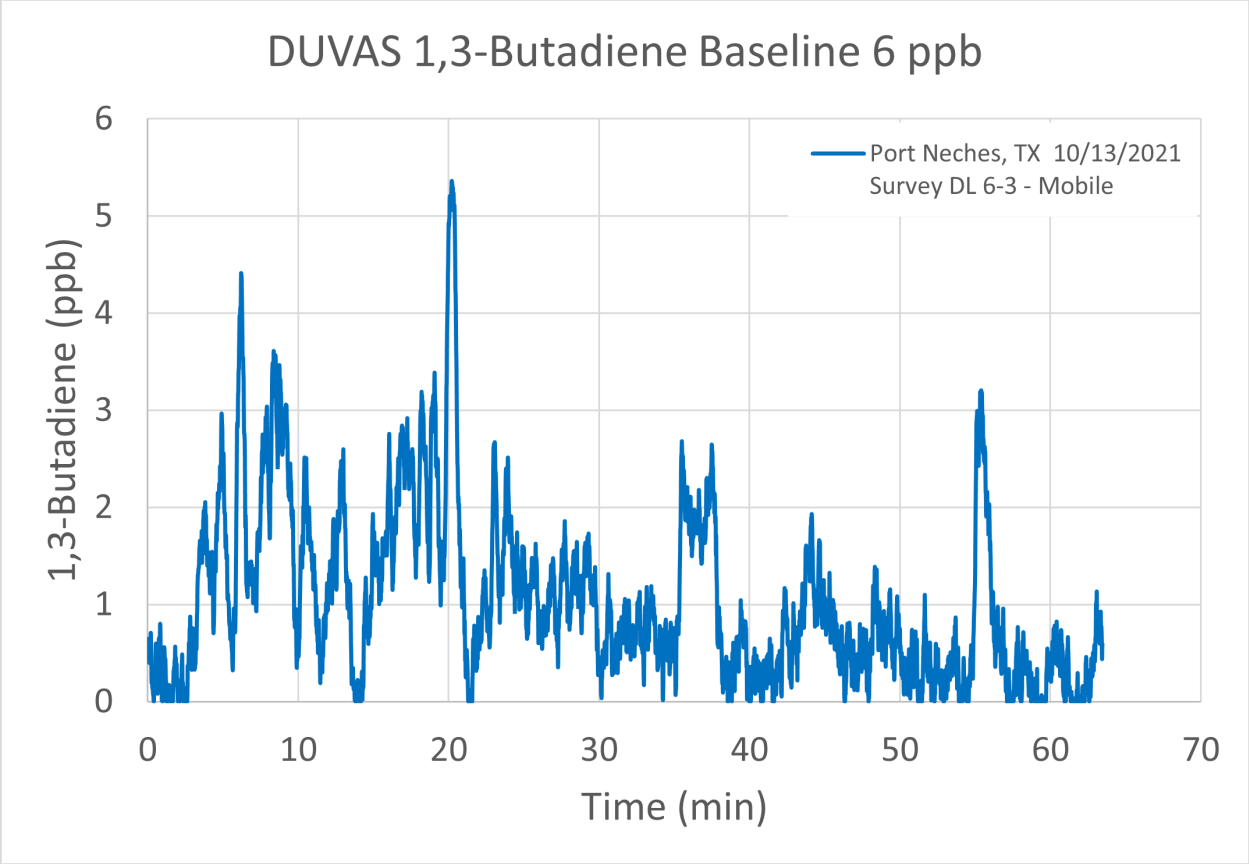
Figure B - 14. Time-concentration graph of benzene collected during a DUVAS instrument survey that was selected as the benzene maximum non-signal baseline level.



1,3-Butadiene

Of the 190 DUVAS surveys that measured 1,3-butadiene and reported one-second data, a total of 24 surveys were selected and evaluated to determine the 1,3-butadiene baseline level. The survey with the maximum non-signal baseline noise was survey Datalog 6-3 from October 13, 2021, in Port Neches, TX (Region 10), shown below (Figure B - 15). The maximum noise from the survey was 5.36 ppb, which was rounded to 6 ppb to generate the baseline level for 1,3-butadiene. The baseline level for 1,3-butadiene is similar between the SIFT and the DUVAS. Because using the SIFT baseline level for 1,3-butadiene generates a lower iBDIL and so triggers a source investigation at a lower chemical concentration, the SIFT baseline was used to set the 1,3-butadiene iBDIL at 40 ppb.

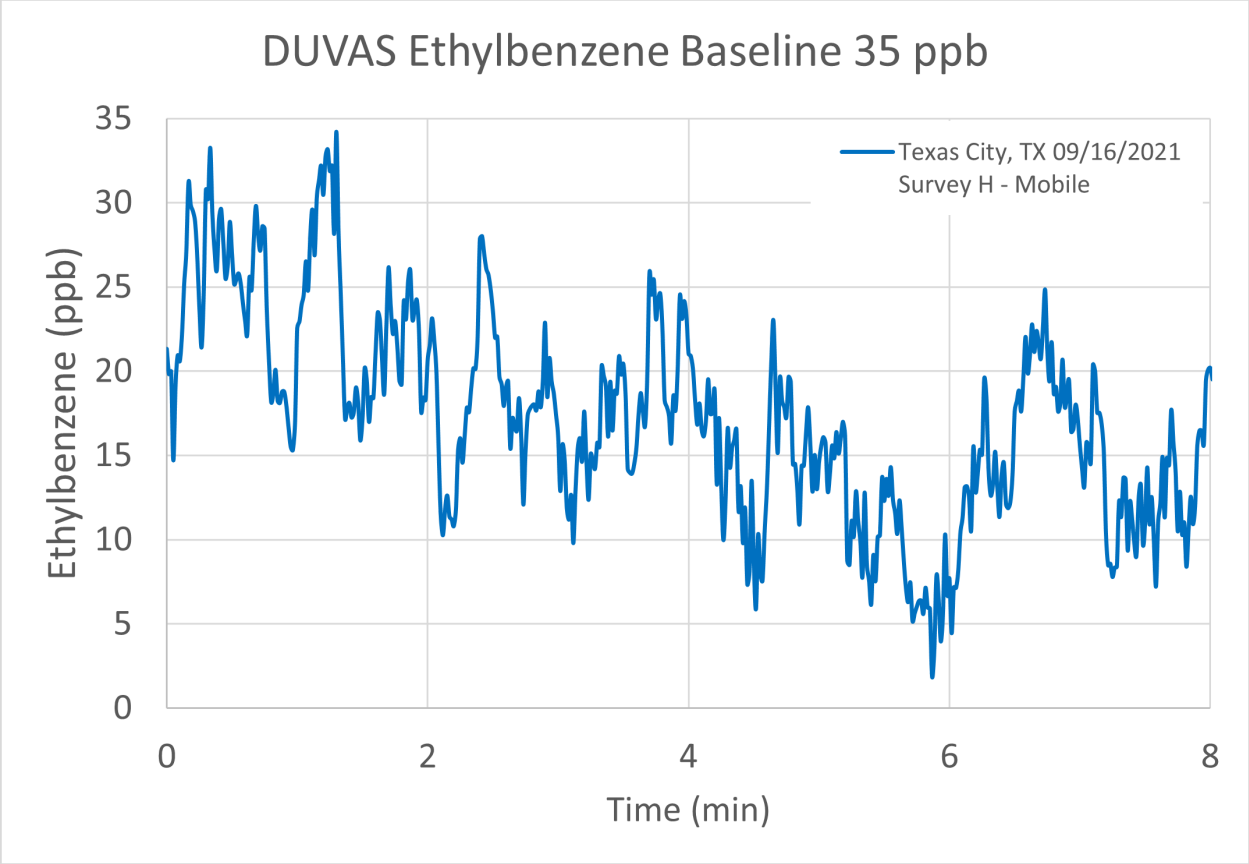
Figure B - 15. Time-concentration graph of 1,3-butadiene collected during a DUVAS instrument survey that was selected as the 1,3-butadiene maximum non-signal baseline level.



Ethylbenzene

Of the 198 DUVAS surveys that measured ethylbenzene and reported one-second data, a total of 42 surveys were selected and evaluated to determine the ethylbenzene baseline level. The survey with the maximum non-signal baseline noise was survey H from September 16, 2021, in Texas City, TX (Region 12), shown below (Figure B - 16). The maximum noise from the survey was 34.21 ppb, which was rounded to 35 ppb to generate the baseline level for ethylbenzene. The iBDIL for ethylbenzene was calculated as 10-times the baseline level and therefore the ethylbenzene iBDIL was set at 350 ppb.

Figure B - 16. Time-concentration graph of ethylbenzene collected during a DUVAS instrument survey that was selected as the ethylbenzene maximum non-signal baseline level.



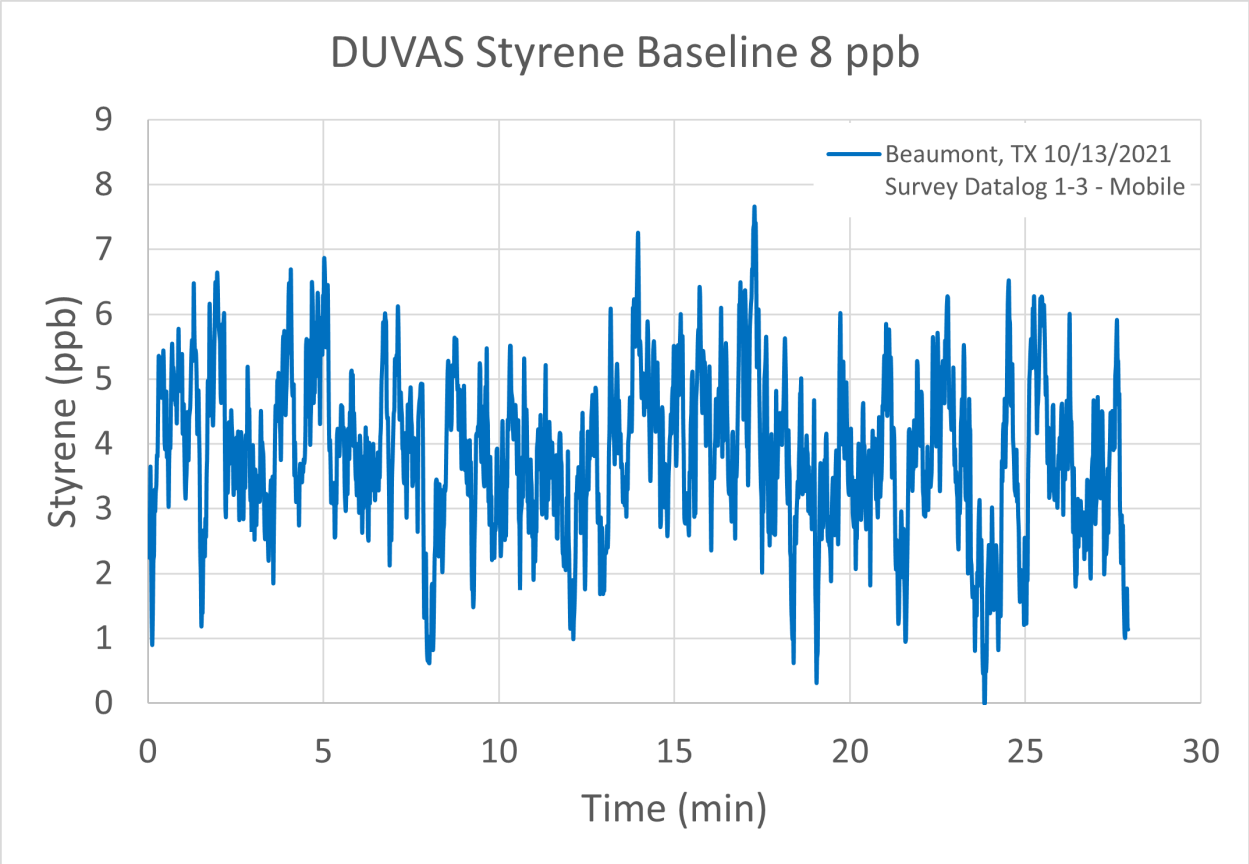
Formaldehyde

The baseline was not determined for formaldehyde due to the large variation observed among the baseline surveys, with many surveys reporting a concentration of zero for most if not all of the survey.

Styrene

Of the 190 DUVAS surveys that measured styrene and reported one-second data, a total of 22 surveys were selected and evaluated to determine the styrene baseline level. The survey with the maximum non-signal baseline noise was survey Datalog 1-3 from October 13, 2021, in Beaumont, TX (Region 10), shown below (Figure B - 17). The maximum noise from the survey was 7.66 ppb, which was rounded to 8 ppb to generate the baseline level for styrene. The baseline level for styrene is similar between the SIFT and the DUVAS. Because using the SIFT baseline level for styrene generates a lower iBDIL and so triggers a source investigation at a lower chemical concentration, the SIFT baseline was used to set the styrene iBDIL at 60 ppb.

Figure B - 17. Time-concentration graph of styrene collected during a DUVAS instrument survey that was selected as the styrene maximum non-signal baseline level.

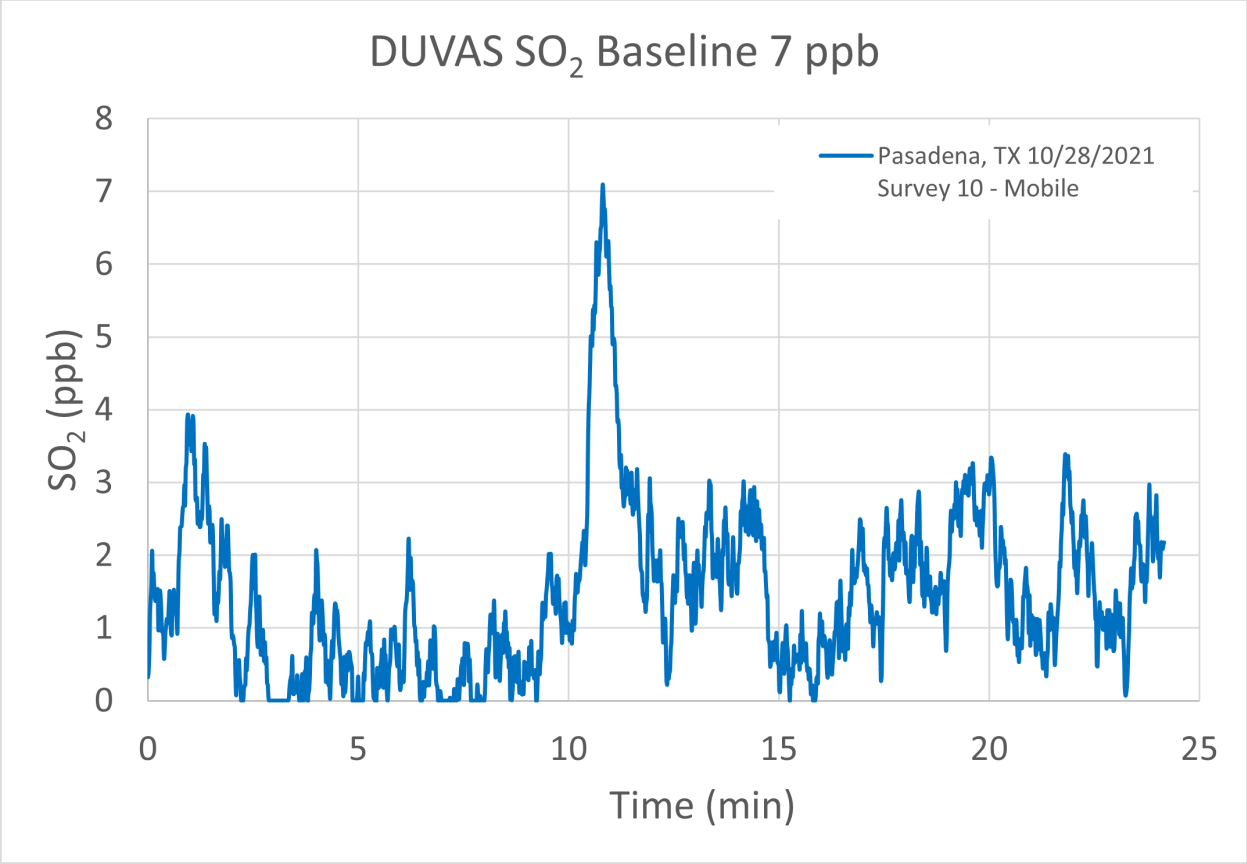


Sulfur dioxide

Of the 167 DUVAS surveys that measured sulfur dioxide (SO_2) and reported one-second data, a total of 23 surveys were selected and evaluated to determine the sulfur dioxide baseline level. The survey with the maximum non-signal baseline noise was survey 10 from October 28, 2021, in Pasadena, TX (Region 12), shown below (Figure B - 18). The maximum noise from the survey was 7.09 ppb, which was rounded down to 7 ppb to generate the baseline level for sulfur dioxide. The iBDIL for sulfur dioxide[3] was calculated as 10-times the baseline level and therefore the sulfur dioxide iBDIL was set at 70 ppb.

[3] Because the maximum non-signal baseline for sulfur dioxide was < 0.1 ppb higher than 7 ppb, the decision was made to round the baseline level down to 7 ppb.

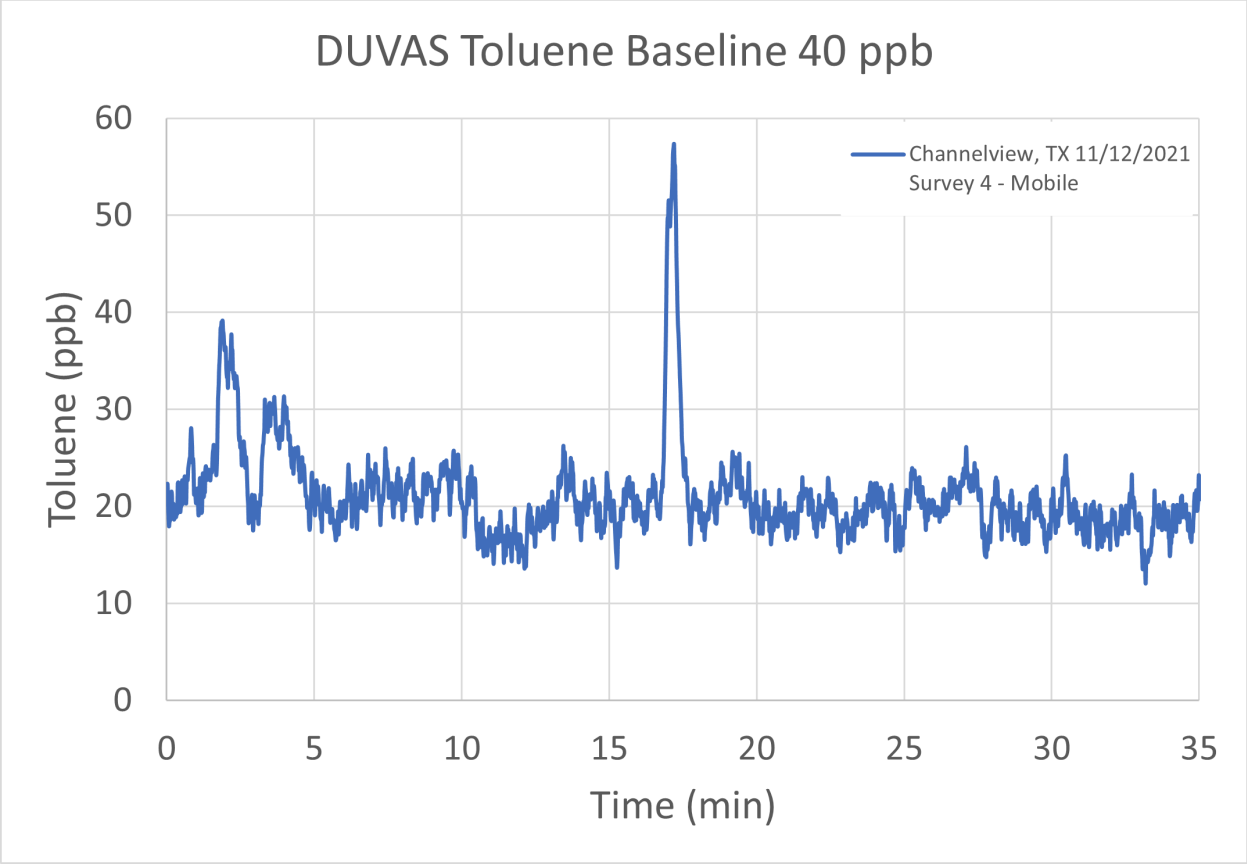
Figure B - 18. Time-concentration graph of sulfur dioxide collected during a DUVAS instrument survey that was selected as the sulfur dioxide maximum non-signal baseline level.



Toluene

Of the 190 DUVAS surveys that measured toluene and reported one-second data, a total of 54 surveys were selected and evaluated to determine the toluene baseline level. The survey with the maximum non-signal baseline noise was survey 4 from November 12, 2021, in Channelview, TX (Region 12), shown below (Figure B - 19). The maximum noise from the survey was 39.15 ppb, which was rounded to 40 ppb to generate the baseline level for toluene. Because using the SIFT baseline level for toluene generates a lower iBDIL and so triggers a source investigation at a lower chemical concentration, the SIFT baseline was used to set the toluene iBDIL at 70 ppb.

Figure B - 19. Time-concentration graph of toluene collected during a DUVAS instrument survey that was selected as the toluene maximum non-signal baseline level.



Xylenes

The baseline was not determined for any of the three xylenes due to the large variation observed among the baseline surveys, with many surveys reporting a concentration of zero for most if not all of the survey.

Picarro Instrument Chemical Baseline Derivation

Hydrogen Sulfide

The Picarro instrument was utilized to conduct 97 mobile monitoring surveys (31 stationary, 66 mobile) between October 12, 2021, and October 13, 2022, in El Paso, West Odessa, Port Neches, and Nederland, Texas (TCEQ Regions 6, 7, 10, and 10, respectively). Twenty-seven surveys (6 stationary, 21 mobile) were analyzed for evaluation of baseline concentrations. The baseline concentrations were inconsistent and highly variable and ranged from 3.3 to 64 ppb; therefore, a straight-forward iBDIL (10-times the baseline concentration) cannot be determined. The selected AHBCV/iHPIL for hydrogen sulfide is 70 ppb, and this can be used as the value to trigger source investigation/characterization.

Nephelometer Instrument Baseline Derivation

Particular Matter 2.5 and 10 ($PM_{2.5}$ and PM_{10})

The Nephelometer instrument was utilized to conduct 40 surveys between November 2, 2022, and February 22, 2023, in the Houston area (TCEQ Region 12). $PM_{2.5}$ and PM_{10} data from 19 surveys were analyzed for evaluation of baseline concentrations. The baseline noise from the instruments was extremely low at an approximately 20 ng/m^3 level, while the concentrations of PM detected during the surveys were in the µg/m^3 range. Together, the baseline concentrations (noise plus background ambient concentrations) of PM varied greatly, from 5 to 40 µg/m^3 for $PM_{2.5}$ and from 10 to 100 µg/m^3 for PM_{10} over the course of a day, reflecting known ambient variability in PM concentrations within a day and from day to day. Because of this variability in daily PM concentrations, we concluded that the method for setting an iBDIL using constant chemical baseline cannot be applied to the nephelometer PM data; therefore, no iBDIL for $PM_{2.5}$ or PM_{10} was derived. Instead, the initial investigation level for $PM_{2.5}$ and PM_{10} will be set at the iHPIL as discussed in Section 3.3.

Appendix C: Example decision guides and chemical fact sheets for staff use while monitoring in the field

Data Decision Guides

These figures (Figure C - 1, Figure C - 2, and Figure C - 3) represent decision guides to help staff determine actions to take while in the field when applying mobile monitoring comparison values (MMCVs). There are three guides, to be used based on the instrument's averaging capabilities in real-time (e.g., instantaneous, 30-min, 1-hour, etc.) and the monitoring capabilities of the instruments in the vans. These general decision guides provide a visual representation of the associated actions for MMCV exceedances. They are not meant to be a stepwise decision tree; they are meant to help guide the user to determine the most appropriate action. These decision guides are intended for use by TCEQ field personnel.

Figure C - 1. Data decision guide for mobile monitoring team (MMT) staff for use when only instantaneous data are available. This guide is for use by MMT staff who have the instrument capabilities to do remote monitoring and stationary monitoring.

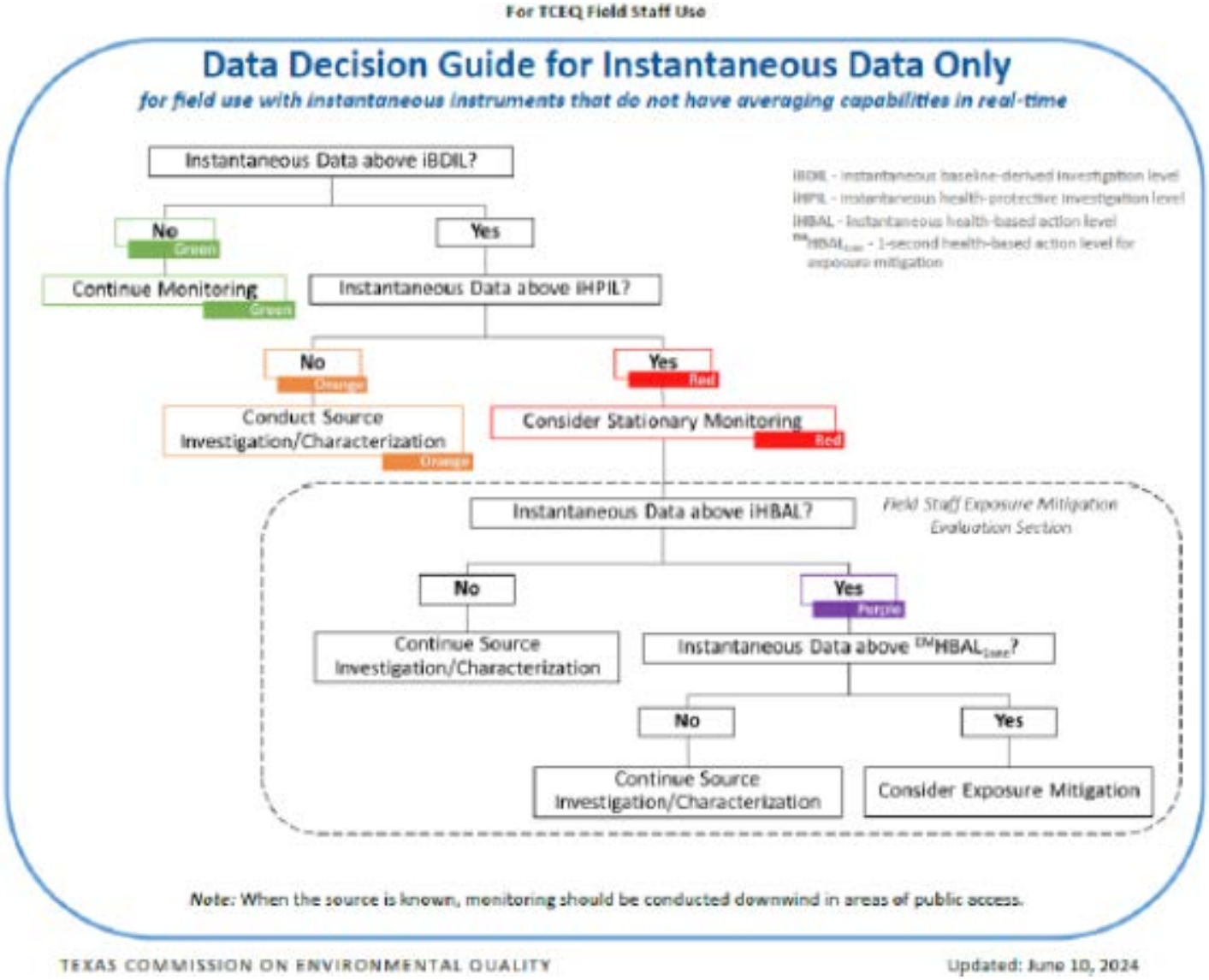


Figure C - 2. Data decision guide for mobile monitoring team (MMT) staff for use when both instantaneous and average data are available. This guide is for use by MMT staff who have the instrument capabilities to do remote monitoring and stationary monitoring.

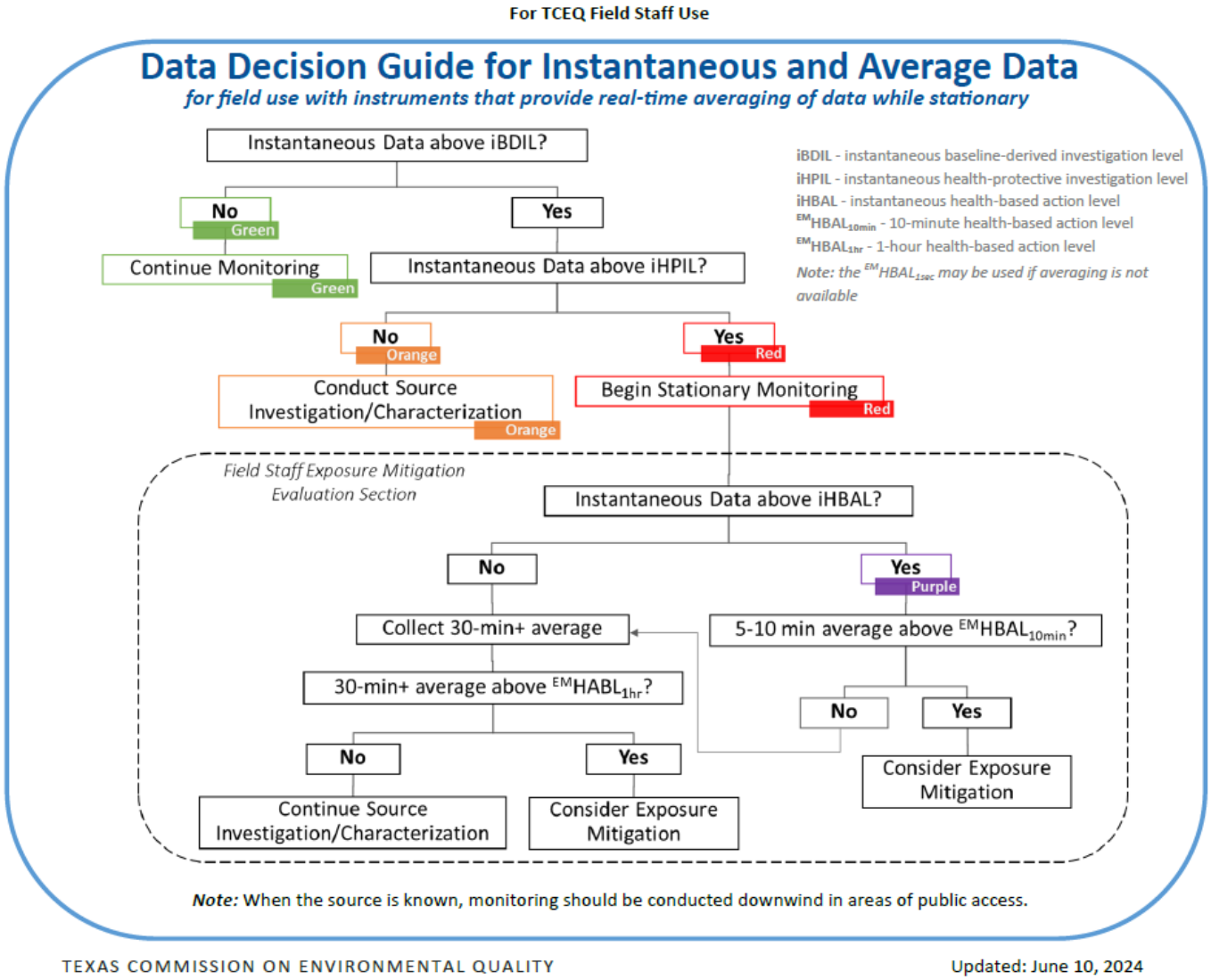
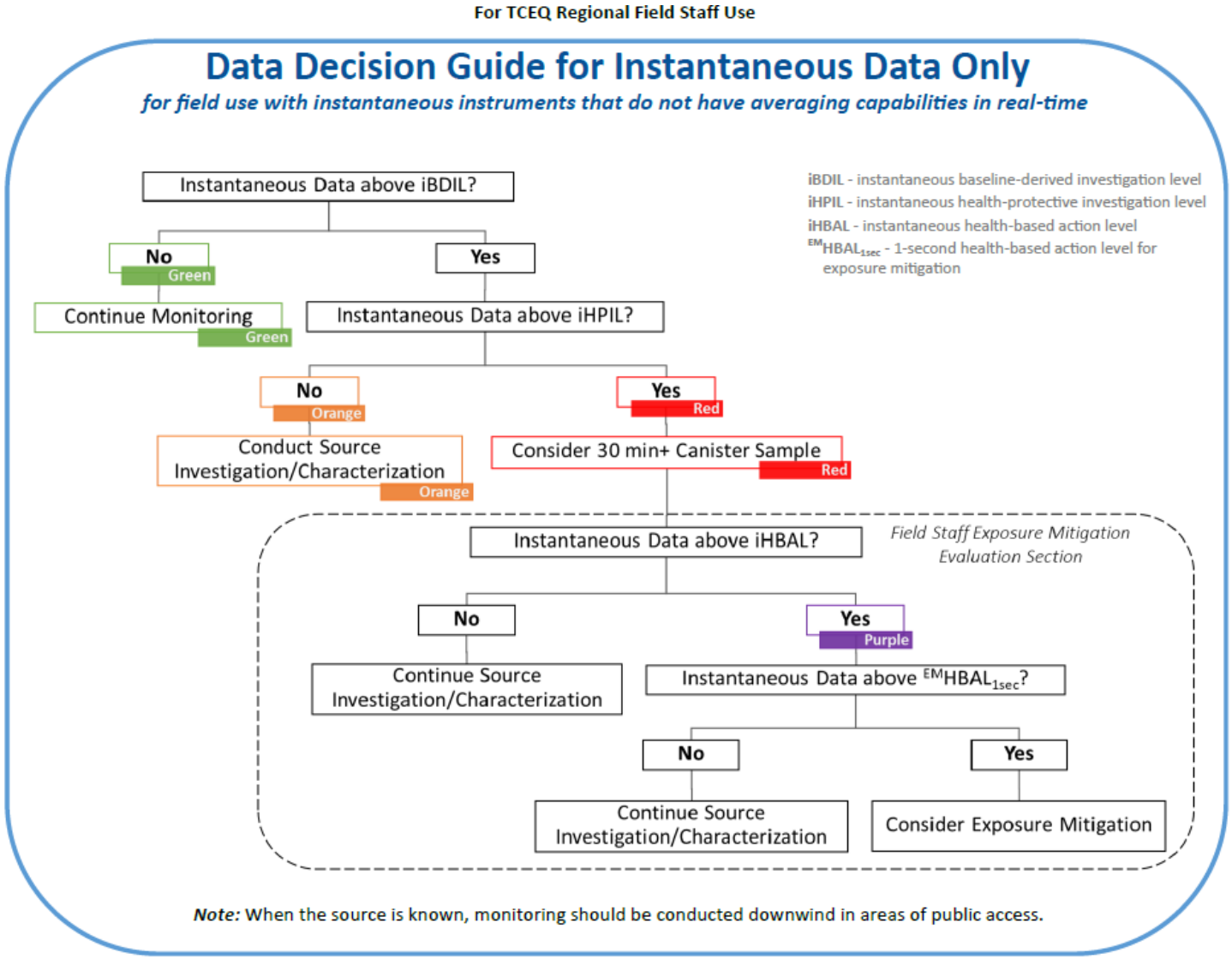


Figure C - 3. Data decision guide for TCEQ regional staff for use when only instantaneous data are available. This guide is for use by TCEQ regional staff who do not have the instrument capabilities to do remote monitoring or stationary monitoring.



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Chemical-Specific Fact Sheet – Benzene as an Example

This figure (Figure C - 4) represents the chemical-specific fact sheet, using benzene as an example chemical. The document is intended as a quick reference guide on the chemical by providing information on what the chemical is, the known health effects levels, the MMCV safe levels, and other agency safe levels for reference. This fact sheet is for use by TCEQ field personnel.

Figure C - 4. Benzene fact sheet.

For TCEQ Field Staff Use

Benzene Fact Sheet

for field use with mobile monitoring instruments

This Field Guide provides a summary of the different mobile monitoring comparison values developed by the Toxicology, Risk Assessment, and Research Division for use in evaluating real-time mobile monitoring data in the field.

***All derived mobile monitoring comparison values are intended to be used as guidance.** Field investigators and mobile monitoring staff should use their own discretion when deciding to mitigate exposure, such as when experiencing health effects or intense odors, regardless of measured concentrations.*

What is Benzene?

- Benzene can be found everywhere in the environment
- Benzene rapidly degrades in the atmosphere
- Benzene has an aromatic, paint-thinner-like, sweet odor

At What Levels Can Benzene Cause Harm?

Breathing high levels of benzene for a short period of time can affect the central nervous system. Repeated exposure to high levels over several days or longer can cause damage to blood cells. Long-term exposure (e.g., many years) is associated with an increased risk for cancer (i.e., acute myelogenous and monocytic leukemia).

Mobile Monitoring Comparison Values

	Benzene
iBDIL (ppb) Orange	80
iHPIL (ppb) Red	180
iHBAL (ppb) Purple	540
$^{EM}HBAL_{10min}$ (ppb)	500
$^{EM}HBAL_{1hr}$ (ppb)	360
$^{EM}HBAL_{1sec}$ (ppb)	1,080

iBDIL - instantaneous baseline-derived investigation level

iHPIL - instantaneous health-protective investigation level

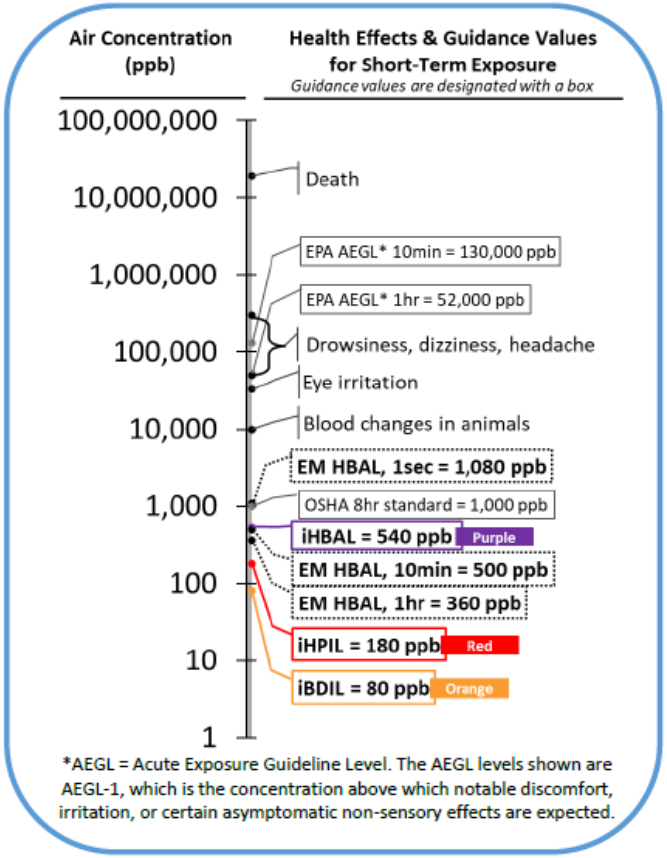
iHBAL - instantaneous health-based action level

$^{EM}HBAL_{10min}$ - 10-minute health-based action level for exposure mitigation

$^{EM}HBAL_{1hr}$ - 1-hour health-based action level for exposure mitigation

$^{EM}HBAL_{1sec}$ - 1-second health-based action level for exposure mitigation

All MMCVs are **safe levels**; AEGLs are health effects levels



*AEGL = Acute Exposure Guideline Level. The AEGL levels shown are AEGL-1, which is the concentration above which notable discomfort, irritation, or certain asymptomatic non-sensory effects are expected.

For more information on EPA's AEGL values, please see EPA's website.

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Mobile Monitoring Comparison Value Table Field Guide

These figures represent the MMCV table field guide. The main table (Table C - 1) includes a listing of MMCVs and their associated actions, for use with instantaneous data. The next table (Table C - 2) includes a listing of the exposure mitigation health-based action levels and their associated actions, for use with real-time averaged data. The last two tables (Table C - 3) are universal to all MMCVs and can be used for instruments that provide instantaneous and averaging data outputs in real time. These tables provide a quick reference to the user on the basis for the MMCVs. These tables are for use by TCEQ field personnel.

Table C - 1. Table of the mobile monitoring comparison values for instantaneous data.

For TCEQ Field Staff Use

Mobile Monitoring Comparison Values for Instantaneous Data

for field use with instruments that cannot average data in real-time or for in-motion measurements

Chemical(s) DUVAS COLOR	UNITS	iBDIL ORANGE	iHPIL RED	iHBAL PURPLE	$^{EM}HBAL_{1sec}$ N/A
Acetylene	ppb	80	25,000	75,000	150,000
Ammonia	ppb	--	850	2,550	5,100
Benzene	ppb	80	180	540	1,080
1,3-Butadiene	ppb	40	1,700	5,100	10,200
Butane	ppb	--	92,000	276,000	552,000
1-Butene	ppb	110	27,000	81,000	162,000
C3-C4 Saturated	ppb	960	--	--	--
Chlorine	ppb	--	70	210	420
Cyclohexane	ppb	120	1,000	3,000	6,000
Ethylbenzene	ppb	350	20,000	60,000	120,000
Ethylene Dichloride	ppb	--	540	1,620	3,240
Ethylene Glycol	ppb	--	1,900	5,700	11,400
Ethylene Oxide	ppb	--	910	2,730	5,460
Formaldehyde	ppb	--	44	132	264
n-Hexane	ppb	340	5,400	16,200	32,400
Hydrochloric Acid	ppb	--	440	1,320	2,640
Hydrogen Sulfide	ppb	--	70	210	420
Isobutane	ppb	280	33,000	99,000	198,000
n-Octane	ppb	160	4,100	12,300	24,600

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Chemical(s) DUVAS COLOR	UNITS	iBDIL ORANGE	iHPIL RED	iHBAL PURPLE	$^{EM}HBAL_{1sec}$ N/A
Propane [a]	ppb	540	--	--	--
Propylene [a]	ppb	--	--	--	--
Sodium Hydroxide	ppb	--	5	15	30
Styrene	ppb	60	5,100	15,300	30,600
Sulfur Dioxide	ppb	70	--	--	--
Sulfuric Acid	ppb	--	30	90	180
Toluene	ppb	70	4,000	12,000	24,000
Vinyl Chloride	ppb	--	72,000	216,000	432,000
Xylenes + Ethylbenzene	ppb	60	5,000 [b]	15,000 [b]	30,000 [b]
Xylenes	ppb	--	5,000	15,000	30,000
$PM_{2.5}$	µg/m³	--	105	--	--
PM_{10}	µg/m³	--	450	--	--
Associated Actions		Conduct source investigation/ characterization	Consider stationary monitoring	Consider stationary monitoring & evaluation for $^{EM}HBAL$ levels	Consider exposure mitigation if 1 sec value > level

[a] Simple asphyxiant, non-toxic in ambient air; [b] Values are based on xylenes; "--"no value available; ppb – parts per billion; N/A – not applicable
***iBDIL** – instantaneous baseline-derived investigation level;* ***iHPIL** – instantaneous health-protective investigation level;*
***iHBAL** – instantaneous health-based action level;* $^{EM}HBAL_{1sec}$ *– 1-second exposure mitigation health-based action level*

***Special Note for Nephelometer:** The nephelometers may be used to provide $PM_{2.5}$ and PM_{10} estimates during fires, smoke events, and/or emissions events resulting from incidents where PM-related air quality impacts are expected. The nephelometers are not intended for use to assess nuisance complaints. $PM_{2.5}$ and PM_{10} are NAAQS compounds; instantaneous and exposure mitigation HBAL levels could not be derived for these compounds.*

Note: If a value does not exist and one is needed for screening, please contact the Toxicology Division for a trip-specific value at TOX@tceq.texas.gov or 512-239-1795.

Table C - 2. Table of the mobile monitoring comparison values for averaged data.

For TCEQ Field Staff Use

Exposure Mitigation Health-Based Action Levels for Averaged Data

for field use with instruments that provide real-time averaging of data while stationary

These values should not be directly compared to instantaneous data

Chemical(s)	$^{EM}HBAL_{10min}$ (ppb)	$^{EM}HBAL_{1hr}$ (ppb)
Acetylene	75,000	50,000
Ammonia	2,550	1,700
Benzene	500 [b]	360
1,3-Butadiene	2,500 [b]	3,400
Butane	276,000	184,000
1-Butene	81,000	54,000
C3-C4 Saturated	--	--
Chlorine	200 [b]	140
Cyclohexane	3,000	2,000
Ethylbenzene	60,000	40,000
Ethylene Dichloride	1,000 [b]	1,080
Ethylene Glycol	5,700	3,800
Ethylene Oxide	2,500 [b]	1,820
Formaldehyde	50	88
n-Hexane	16,200	10,800
Hydrochloric Acid	1,000 [c]	880

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Chemical(s)	$^{EM}HBAL_{10min}$ (ppb)	$^{EM}HBAL_{1hr}$ (ppb)
Hydrogen Sulfide	210	140
Isobutane	99,000	66,000
n-Octane	12,300	8,200
Propane [a]	--	--
Propylene [a]	--	--
Sodium Hydroxide	15	10
Styrene	10,000 [b]	10,200
Sulfur Dioxide	--	--
Sulfuric Acid	90	60
Toluene	12,000	8,000
Vinyl Chloride	216,000	144,000
Xylenes + Ethylbenzene	15,000 [d]	10,000 [d]
Xylenes	15,000	10,000
Associated Actions	Consider exposure mitigation if 5-10 min avg > level	Consider exposure mitigation if 30+ min avg > level

[a] Simple asphyxiant, non-toxic in ambient air; [b] Based on ½ occupational short-term exposure level (STEL); [c] Based on ½ occupational ceiling value;
[d] Values are based on acute health-based comparison values (AHBCV) for xylenes; "--"no value available; ppb – parts per billion;
$^{EM}HBAL_{10min}$ – 10-minute exposure mitigation health-based action level;
$^{EM}HBAL_{1hr}$ – 1-hour exposure mitigation health-based action level

Table C - 3. Tables showing the basis of the instantaneous and exposure mitigation mobile monitoring comparison values and recommended actions if they are exceeded.

Basis of instantaneous mobile monitoring comparison values and recommended actions if exceeded:

Comparison Value (Acronym)	DUVAS Caterpillar Color [a]	Basis	Recommended Actions with Exceedance
Concentrations below instantaneous comparison values	GREEN	N/A	No associated action
Instantaneous baseline-derived investigation level (iBDIL)	ORANGE	10× baseline level	Source investigation/characterization
Instantaneous health-protective investigation level (iHPIL)	RED	1× selected AHBCV	• Stationary monitoring or canister sample (30-min to 1-hour) • Source investigation/characterization
Instantaneous health-based action level (iHBAL)	PURPLE	3× selected AHBCV	• Increased vigilance for exceedance of an exposure mitigation value • Stationary monitoring (5-10 min) • Stationary monitoring or canister sample (30-min to 1-hour) • Source investigation/characterization

[a] Colors represent values that are ≥ the appropriate comparison value; AHBCV – acute health-based comparison value; DUVAS – Differential Ultra-Violet Absorption Spectrometer; N/A – not applicable

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Basis of exposure mitigation values and recommended actions if exceeded:

Comparison Value (Acronym)	Basis	Recommended Actions
10-min health-based action level for exposure mitigation ($^{EM}HBAL_{10min}$)	Lower of 3×AHBCV [a], ½ STEL [b], or ½ C [c]	Consider exposure mitigation for staff
1-hour health-based action level for exposure mitigation ($^{EM}HBAL_{1hr}$)	2×AHBCV	Consider exposure mitigation for staff
1-sec health-based action level for exposure mitigation ($^{EM}HBAL_{1sec}$)	3×$^{EM}HBAL_{1hr}$	Consider exposure mitigation for staff

AHBCV – acute health-based comparison value; C – occupational ceiling value; STEL – 15-minute short-term occupational exposure limit

Appendix D: Selection of acute health-based comparison values (AHBCVs)

Summary

To aid in emergency preparedness and investigations, it is important to have appropriate acute ambient air comparison values in place and available for use in evaluating air concentration data generated by mobile monitoring equipment. The goal here is to identify fit-for-purpose acute ambient air comparison values that result in a more realistic assessment of the potential for acute adverse health effects, which can help to inform decision making during an investigation or a potentially widespread emergency event. The selection of these acute health-based comparison values (AHBCVs) is documented herein. The AHBCVs selected were derived by TCEQ or other state or federal agencies (Table D - 1) The considerations used to select these fit-for-purpose values are described in Section 4.1. Toxicity factors that are derived using defined guidelines are preferred for AHBCV development. It is noted, however, that short-term occupational comparison values for exposure durations shorter than that typically used to develop AHBCVs (i.e., ≤15 minutes (min) versus the ≥1-hour (hr) duration often used for AHBCV development) may also be important considerations for limiting shorter-term exposure for staff during emergency response and investigations.[1]

Table D - 1. Agencies researched in development of Acute Health-Based Comparison Values (AHBCVs).

ACRONYMS	AGENCY
ATSDR	Agency for Toxic Substances and Disease Registry[2]
AZ DHS	Arizona Department of Health Services[3]
CALEPA	California Environmental Protection Agency[4]

[1] For example, an important consideration is preventing exceedances of occupational 15-minute short-term exposure limits (STELs) through consideration of ½ the STEL as a comparator value when developing AHBCVs. STELs consider effects that can occur due to elevated shorter-term exposure concentrations such as irritation, irreversible (or chronic) tissue damage, dose-rate-dependent toxic effects, or narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue, or materially reduce work efficiency. Similarly, ½ the occupational ceiling value is also an appropriate comparator value for consideration. Substances with occupational ceiling values are predominantly fast-acting and whose occupational comparison values are more appropriately based on the concentrations associated with the particular response. These substances and their potential health effects are best controlled through use of a ceiling value. Ceiling values and 15-minute STELs should not be exceeded (https://www.acgih.org/science/tlv-bei-guidelines/tlv-chemical-substances-introduction/).

[2] https://www.atsdr.cdc.gov/mrls/index.html

[3] https://agriculturedefensecoalition.org/sites/default/files/pdfs/28A_1999_Arizona_Ambient_Air_Quality_Guidelines_1999_Draft.pdf

[4] https://oehha.ca.gov/chemicals

ACRONYMS	AGENCY
NIOSH	The Centers for Disease Control and Prevention's National Institute for Occupational Safety and Health[5]
NC DEQ	North Carolina Department of Environmental Quality[6]
NY DEC	New York State Department of Environmental Conversation[7]
MI EGLE	Michigan Department of Environment, Great Lakes, and Energy[8]
TCEQ	Texas Commission on Environmental Quality[9]

AHBCVs Derived Using Defined Guidelines Approach

Ammonia

The TCEQ identified six acute ambient air toxicity factors for ammonia from state governments: AZ DHS,[3] NY DEC,[7] NC DEQ,[6] MI EGLE,[8] CalEPA,[4] and TCEQ.[10] Two of the values were not derived using defined guidelines: the AZ DHS and NY DEC values are based on an occupational exposure level ((short-term exposure level (STEL) that was divided by uncertainty factors (UF) (i.e., STEL/UF)). The derivation method is unknown for NC DEQ and MI EGLE values. Two of the values, TCEQ and CalEPA, were derived using defined guidelines.

Summary

The two acute (1-hour) air comparison values for ammonia that were identified by TCEQ for use as the AHBCV are the acute CalEPA reference exposure level (REL) of 4,500 parts per billion (ppb) and the short-term TCEQ reference value (ReV) of 850 ppb. The basis for the derivation of the CalEPA and TCEQ AHBCV can be found in Table D - 2 and Table D - 3, respectively.

The CalEPA value for ammonia was based on four human studies with multiple doses (30-500 parts per million (ppm)) administered, exposure durations (5 min-120 min) that encompass the 1-hr duration of interest, and a lower total UF was utilized. The TCEQ value was based on a study with 2 doses administered (5 ppm and 25 ppm) and exposure durations of 3 hours (minimal lowest observed adverse effect level (LOAEL) = 5 ppm), somewhat longer than the duration of interest (i.e., 1-hr) but certainly toxicologically relevant. The dosimetry adjustments result in point of departure values of 13.6 ppm and 5 ppm, respectively, from CalEPA and TCEQ. The CalEPA REL used a lower total UF (3), resulting in a lower margin of exposure (MOE)[11] when

[5] https://www.cdc.gov/niosh/npg/npgsyn-a.html

[6] https://files.nc.gov/ncdeq/Air%20Quality/toxics/haps-taps/AALs.pdf

[7] https://www.dec.ny.gov/docs/air_pdf/dar1.pdf

[8] https://www.egle.state.mi.us/itslirsl/

[9] https://www.tceq.texas.gov/toxicology/esl/list_main.html or https://www.tceq.texas.gov/toxicology/dsd/final#top

[10] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/ammonia.pdf

[11] MOE- Margin of exposure is typically calculated as some comparison value (e.g., RfC, RfD) divided by the actual or projected environmental exposure of interest. While the MOEs of most interest here are

compared to its own point of departure, which is an important general consideration for a AHBCV being fit-for-purpose.[12] However, in this case, the CalEPA REL value (4,500 ppb) is just below the minimal LOAEL identified by the TCEQ. This would cause, for example, the 1-hour exposure mitigation health-based action level ($^{EM}HBAL_{1hr}$) value (9,000 ppb) derived using documented methods (see Section 5.2.2.2 to be higher than the lowest human equivalent concentration LOAEL ($LOAEL_{HEC}$) or human equivalent concentration benchmark concentration (BMC_{HEC}) value identified (5,000 ppb) across the key studies used to derive the AHBCVs being considered. This is inappropriate since a resulting mobile monitoring comparison value (MMCV) (e.g. the $^{EM}HBAL_{1hr}$) would not be considered health protective (i.e., the MOE would not be > 1 when using the lowest $LOAEL_{HEC}$ or BMC_{HEC} value identified across the AHBCVs being considered for adoption, with MOE here being equal to the lowest $LOAEL_{HEC}$ or BMC_{HEC}/MMCV). Thus, the TCEQ acute ReV of 850 ppb was selected as the AHBCV for ammonia (Table D - 4) and the resulting $^{EM}HBAL_{1hr}$ value (1,700 ppb) was then lower than the $LOAEL_{HEC}$/BMC_{HEC} value.

Table D - 2. Summary table for CalEPA derivation of the acute reference exposure level (REL) for ammonia.

Parameter	Summary
Studies	Industrial Biotest Laboratories (1973); MacEwen et al. (1970); Silverman et al. (1949); Verberk (1977)
Study population	Humans
Exposure method and duration	Inhalation of 30 - 500 ppm; 5 – 120 min
Critical effect(s)	Eye and respiratory irritation
POD	13.6 ppm ($BMCL_{05}$)
Extrapolation to 1 hr (POD_{ADJ})	13.6 ppm
Total UFS:	3
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	3
Acute REL	4,500 ppb (3,200 µg/m³)

the differences between the AHBCVs and the lowest concentration at which health effects have been shown to occur across the key studies used for the AHBCVs, for the sake of simplicity and comparison, in tables herein the MOE for each AHBCV it is represented by the total UF applied to the given AHBCV's point of departure.

[12] For the purpose of selecting a AHBCV, there is a preference for acute air comparison levels associated with a lower MOE given that an exceedance of a comparison value with a smaller MOE can be considered more likely to be associated with the potential for actual occurrence of acute adverse health effects and as such is more conducive to identifying emissions representing a real-world environmental health issue (i.e., exposures associated with a greater probability of acute effects) that should be given priority in the midst of a potentially widespread emergency situation.

$BMCL_{05}$ – benchmark concentration lower confidence limit with a benchmark response of 5%; LOAEL – lowest observed adverse effect Level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL-reference exposure level; and UF – uncertainty factor.

Table D - 3. Summary table for TCEQ derivation of the acute reference value (ReV) for ammonia.

Parameter	Summary
Study	Sundblad et al. (2004)
Study population	12 healthy human volunteers
Exposure method and Duration	Inhalation of 0, 5, or 25 ppm ammonia; 3 hrs, with exercise
Critical effect(s)	Mild, transient upper respiratory symptoms and central nervous system effects (eye discomfort, smell, headache, dizziness, and feelings of intoxication)
POD	5 ppm (minimal LOAEL)
Extrapolation to 1 hr (POD_{ADJ})	5 ppm
Total UFs:	6
LOAEL to NOAEL (L)	2
Interspecies (A)	N/A
Intraspecies (H)	3
Database (D)	1
Acute ReV	830 ppb (590 µg/m^3)
TAMIS acute ReV[a]	850 ppb (590 µg/m^3)

LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; ReV – reference value; TAMIS – Texas Air Monitoring Information System; and UF – uncertainty factor. [a]Due to the calculation from µg/m3 (microgram per cubic meter) to ppb (parts per billion) in the TAMIS database, ppb values listed in a Development Support Document (DSD) may differ slightly from those listed in the TAMIS database. The TAMIS database values are the official values.

Table D - 4. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for ammonia.

Criteria	CalEPA REL	TCEQ ReV
Year derived	1999	2015
Standard practices and procedures used	Yes	Yes
Inhalation key study	4 human inhalation studies, 30 - 500 ppm for 5 - 120 min	Sundblad et al. 2004, humans exposed to 0, 5, or 25 ppm for 3 hrs while exercising
Critical effect(s) relevant to humans	Eye and respiratory irritation	Mild, transient upper respiratory symptoms and CNS effects

Criteria	CalEPA REL	TCEQ ReV
Dose-response	Yes	Yes
POD adjusted to 1 hr	Consolidated 4 studies, 13.6 ppm ($BMCL_{05}$)	5 ppm (minimal LOAEL)
Lower total uncertainty	UF (3) (H = 3); lowest	UF (6) (H = 3, L = 2)
Lower MOE	Yes	No
MMCVS < minimum LOAEL/BMC	No	Yes
1-hr TOX value	4500 ppb	850 ppb
Selected AHBCV		**850 ppb**

AHBCV – acute health-based comparison value; BMC – benchmark concentration; $BMCL_{05}$ – benchmark concentration lower confidence limit with a benchmark response of 5%; CNS – central nervous system; H – Intraspecies uncertainty factor (UF); L – lowest observed adverse effect level (LOAEL) to no observed adverse effect level (NOAEL) UF; LOAEL – lowest observed adverse effect level; MMCV – mobile monitoring comparison value; MOE – margin of exposure; NOAEL – no observed adverse effect level; POD – point of departure; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; ReV – reference value; and UF – uncertainty factor.

Benzene

The TCEQ identified four acute ambient air toxicity factors for benzene, all from state governments: AZ DHS,[3] NY DEC,[7] CalEPA,[13] and TCEQ.[14] Two of the values were not derived using defined guidelines: the AZ DHS value is based on a STEL/UF and the NY DEC adopted the CalEPA value. Two of the values, TCEQ and CalEPA, were derived using defined guidelines. Toxicity factors that are derived using defined guidelines are preferred for AHBCV development.

Summary

The two acute air comparison values for benzene that were identified by TCEQ for use as the AHBCV are the acute CalEPA REL of 8 ppb and the short-term TCEQ ReV of 180 ppb. The basis for the derivation of the CalEPA and TCEQ AHBCV can be found in Table D - 5 and Table D - 6, respectively. CalEPA used a pregnant mouse developmental study as the key study, in which a LOAEL of 5 ppm was identified. TCEQ used a male mouse hematotoxicity study as the key study in which a mild LOAEL (10.2 ppm) was identified. The exposure duration for the study used by CalEPA was 4 days longer (6 hrs per day for 10 days, from gestational day 6-15), compared to 6 hrs/day for 6 days for TCEQ. The total exposure duration of 60 hours (vs the 1-hr duration of interest) and higher total UF (600, using a high intrahuman UF of 30) for the CalEPA value made for a very conservative 1-hr REL (8 ppb). By contrast, the study used by TCEQ had a 1.7-fold shorter total exposure duration (36 hours) and the total UF (100) was 6-fold lower. The CalEPA

[13] https://oehha.ca.gov/media/downloads/crnr/appendixd1final.pdf

[14] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/benzene.pdf

1-hr REL is even lower than the 1-14 day ATSDR[15] minimum risk level (MRL)[16] (9 ppb), although the ATSDR REL is not considered appropriate for a 1-hr AHBCV per the guidelines since it is designed for up to 2 weeks of exposure. The TCEQ 1-hr ReV (180 ppb) was based on a study with an exposure duration more similar to the duration of interest and incorporates lower total uncertainty (total UF of 100) than the CalEPA value (total UF of 600). The weight-of-evidence assessment suggests that the TCEQ ReV (180 ppb) is health-protective with a lower MOE and thus is more fit-for-purpose.[12] Accordingly, the TCEQ ReV (180 ppb) was selected as the AHBCV for benzene (Table D - 7).

Table D - 5. Summary table for CalEPA derivation of the acute reference exposure level (REL) for benzene.

Parameter	Summary
Study	Keller and Snyder (1988)
Study population	Pregnant female Swiss Webster mice
Exposure method and Duration	Inhalation of 0, 5, 10, or 20 ppm benzene; 6 hr/day for 10 days (6-15 days of gestation)
Critical effect(s)	Decreased early nucleated red cell counts
POD	5 ppm (LOAEL)
Extrapolation to 1 hr (POD_{ADJ})	5 ppm
POD_{HEC}	5 ppm (used RGDR= 1, systemic effect)
Total UFs:	600
LOAEL to NOAEL (L)	√10
Interspecies (A)	6
Intraspecies (H)	10 x √10
Database (D)	1
Acute REL	8 ppb (27 µg/m^3)

LOAEL – lowest observed adverse effect level; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; RGDR – regional gas deposition ratio; and UF – uncertainty factor.

Table D - 6. Summary table for TCEQ derivation of the acute reference value (ReV) for benzene.

Parameter	Summary
Studies	Rozen et al. (1984), supported by Dempster and Snyder (1991) and Corti and Snyder (1996)
Study population	C57BL/6J mice (male)

[15] https://www.atsdr.cdc.gov/ToxProfiles/tp3.pdf (page A-3)

[16] ATSDR defines an MRL as an estimate of daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects over a specified route and duration of exposure.

Parameter	Summary
Exposure method and duration	Inhalation of 0, 10.2, 31, or 301 ppm; 6 hrs per day for 6 days
Critical effect(s)	Decreased peripheral lymphocytes and decreased mitogen-induced blastogenesis of femoral B-lymphocytes
POD	10.2 ppm (LOAEL)
Extrapolation to 1 hr (POD_{ADJ})	18.5 ppm
POD_{HEC}	18.5 ppm (used RGDR = 1, systemic effect)
Total UFs:	100
LOAEL to NOAEL (L)	3
Interspecies (A)	3
Intraspecies (H)	10
Database (D)	1
Acute ReV	180 ppb (580 µg/m^3)

LOAEL – lowest observed adverse effect level; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; ReV – reference value; RGDR – regional gas deposition ratio; and UF – uncertainty factor.

Table D - 7. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for benzene.

Criteria	CalEPA REL	TCEQ ReV
Year derived	2014	2007
Standard practices and procedures used	Yes	Yes
Inhalation key study	Keller and Snyder, 1988, pregnant mice exposed to 0, 5,10, 20 ppm for 6 hrs/10 days (GD 6-15)	Rozen et al. (1984), male mice exposed to 0, 10.2, 31, 100, 301 ppm, for 6 hrs, 6 days
Critical effect(s) relevant to humans	Decreased early nucleated red cell counts	Decreased peripheral lymphocytes and decreased mitogen-induced blastogenesis of femoral B-lymphocytes
Dose-response	Yes	Yes
POD	5 ppm (mild LOAEL)	10.2 ppm (mild LOAEL)
POD_{HEC}	5 ppm	18.5 ppm
Lower total uncertainty	UF (600) (A = 6, L = 3, H = 30)	UF (100) (A = 3, L = 3, H = 10); lowest
Lower MOE	No	Yes
MMCVS < minimum LOAEL/BMC	Yes	Yes
1-hr TOX value	8 ppb	180 ppb

Criteria	CalEPA REL	TCEQ ReV
Selected AHBCV		**180 ppb**

A – Interspecies uncertainty factor (UF); AHBCV – acute health-based comparison value; BMC – benchmark concentration; GD – gestational days; H – Intraspecies UF; L – lowest observed adverse effect level (LOAEL) to no observed adverse effect level (NOAEL) UF; LOAEL – lowest observed adverse effect level; POD – point of departure; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; MOE – margin of exposure; MMCV – mobile monitoring comparison value; REL – reference exposure level; ReV – reference value; and UF – uncertainty factor.

1,3-Butadiene

The TCEQ identified two acute ambient air toxicity factors for 1,3-butadiene that were derived using defined guidelines: TCEQ[17] and CalEPA.[18]

Summary

The two acute air comparison values for 1,3-butadiene that were identified by TCEQ for use as the AHBCV are the acute CalEPA REL of 300 ppb and the short-term TCEQ ReV of 1,700 ppb. The basis for the derivation of the CalEPA and TCEQ AHBCV can be found in Table D - 8 and Table D - 9, respectively. Both acute values were based on the Hackett et al. (1987) reproductive/developmental study. The TCEQ used original data to perform benchmark dose (BMD) modeling using benchmark dose software (BMDS) Version 1.4.1c, which resulted in a benchmark concentration lower confidence limit with a benchmark response of 1 standard deviation ($BMCL_{1SD}$) of 51.3 ppm and a BMCL with a benchmark response of 5% ($BMCL_{05}$) of 54.7 ppm for decreased extragestational weight gain and for decreased fetal body weight, respectively. CalEPA used a reanalysis of the Hackett et al. (1987) data by Green (2003) to perform BMD using a newer BMDS version (Version 2.3.1). A $BMCL_{05}$ of 17.7 ppm for decreased male fetal weight was derived. The CalEPA $BMCL_{05}$ (17.7 ppm) is lower than the TCEQ $BMCL_{1SD}$ of 51.3 ppm. Additionally, a higher total UF of 100 was used by CalEPA as compared to that by TCEQ (UF of 30). The 1-hr REL was much lower than the TCEQ ReV. Other considerations being similar, the TCEQ ReV of 1,700 ppb used a lower total uncertainty factor (30) than the CalEPA REL (100). The TCEQ ReV is health-protective with a lower MOE and is more fit-for purpose as the AHBCV. For the purpose of selecting an AHBCV, there is a preference for acute air comparison levels associated with a lower MOE given that an exceedance of a comparison value with a smaller MOE can be considered more likely to be associated with the potential for actual occurrence of acute adverse health effects. As such, a lower MOE is more conducive to identifying emissions representing a real-world environmental health issue (i.e., exposures associated with a greater probability of acute effects) that should be given priority in the midst of a potentially widespread emergency situation. Accordingly, the TCEQ ReV of 1,700 ppb was selected as the AHBCV for 1,3-butadiene (Table D - 10).

[17] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/butadiene.pdf

[18] https://oehha.ca.gov/media/downloads/crnr/072613bentcrel.pdf

Table D - 8. Summary table for CalEPA derivation of the acute reference exposure level (REL) for 1,3-butadiene.

Parameter	Summary
Study	Hackett et al. (1987)
Study population	Cd-1 mice (18-21 pregnant mice per dose group)
Exposure method and Duration	0, 40, 200, and 1,000 ppm on GD 6-15 for 6 hr/day; 6 hr
Critical effect(s)	Lower male fetal weight at GD 18
POD	17.7 ppm ($BMCL_{05}$)
Extrapolation to 1 hr (POD_{ADJ})	No adjustment because the critical effect was a maternal/developmental endpoint
POD_{HEC}	29.7 ppm (17.7 ppm x 1.68 DAF)
Total UFs:	100
Interspecies (A)	√10
Intraspecies (H)	10 x √10
Acute REL	300 ppb (660 µg/m^3)

$BMCL_{05}$ – benchmark concentration lower confidence limit with a benchmark response of 5%; DAF – Dosimetric Adjustment Factor; GD – gestational days; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; and UF – uncertainty factor.

Table D - 9. Summary table for TCEQ derivation of the acute reference value (ReV) for 1,3-butadiene.

Parameter	Summary
Study	Hackett et al. (1987)
Study population	CD-1 mice (18-21 pregnant mice per dose group)
Exposure method and Duration	0, 40, 200, and 1,000 ppm on GD 6-15 for 6 hr/day; 6 hr
Critical effect(s)	Reduction in extragestational weight gain and fetal body weight; developmental toxicity
POD	51.3 ppm ($BMCL_{1SD}$)
Extrapolation to 1 hr (POD_{ADJ})	No adjustment because the critical effect was a maternal/developmental endpoint
POD_{HEC}	51.3 ppm
Total UFs:	30
LOAEL to NOAEL (L)	N/A
Interspecies (A)	3
Intraspecies (H)	10
Database (D)	1
Acute ReV	1,700 ppb (3,700 µg/m^3)

$BMCL_{1SD}$ – benchmark concentration lower confidence limit with a benchmark response of 1 standard deviation; GD – gestational days; LOAEL- lowest observed adverse effect level; N/A – not applicable; NOAEL- no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; POD_{HEC}

– point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; ReV – reference value; and UF – uncertainty factor.

Table D - 10. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for 1,3-butadiene.

Criteria	CalEPA REL	TCEQ ReV
Year Derived	2013	2008
Standard practices and procedures used	Yes	Yes
Inhalation key study	Hackett et al. (1987), pregnant female CD-1 mice, 0, 40, 200, or 1000 ppm 1,3-butadiene for 6 hr/d on GD 6-15	Hackett et al. (1987), pregnant female CD-1 mice, 0, 40, 200, or 1000 ppm 1,3-butadiene for 6 hr/d on GD 6-15
Critical effect(s) relevant to humans	Lower male fetal weight on GD 18	Reduction in extragestational weight gain and fetal body weight; developmental toxicity
Dose-response	Yes	Yes
POD	$BMCL_{05}$ (17.7 ppm)	$BMCL_{1SD}$ (51.3 ppm)
POD_{HEC}	29.7 ppm	51.3 ppm
Lower total uncertainty	UF (100) (A = 3, H = 30)	UF (30) (A = 3; H = 10); lowest
Lower MOE	No	Yes
MMCVS < minimum LOAEL/BMC	Yes	Yes
1-hr TOX value	300 ppb	1,700 ppb
Selected AHBCV		**1,700 ppb**

A – Interspecies uncertainty factor (UF); AHBCV – Acute health-based comparison value; BMC – benchmark concentration; $BMCL_{05}$ – benchmark concentration lower confidence limit with a benchmark response of 5%; $BMCL_{1SD}$ – benchmark concentration lower confidence limit with a benchmark response of 1 standard deviation; GD – gestational days; ; H – Intraspecies uncertainty factor (UF); LOAEL – lowest observed adverse effect level; MOE – margin of exposure; MMCV – mobile monitoring comparison value; POD – point of departure; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; ReV – reference value; and UF – uncertainty factor.

Butane

The TCEQ[19] ambient air toxicity factor was the only value identified for butane, and the value was derived using defined guidelines. Thus, the acute air comparison value for butane selected by TCEQ for use as the AHBCV is the short-term TCEQ ReV of 92,000 ppb. The basis for the derivation of the TCEQ AHBCV can be found in Table D - 11.

[19] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/butanes.pdf

Table D - 11. Summary table for TCEQ derivation of the acute reference value (ReV) and acute health-based comparison value (AHBCV) for isobutane.

Parameter	Summary
Study	Hoffman 2008
Study population	Male and female SD CD rats (10/sex/group)
Exposure method and duration	Exposure via inhalation at 0, 90, 900, or 9,000 ppm (target concentrations) for 6 h/d, 7 d/week for two weeks
Critical effect(s)	Free-standing NOAEL
POD	9,197 ppm (free-standing NOAEL, mean analytical concentration)
Extrapolation to 1 hr (POD_{ADJ})	9,197 ppm
Total UFs:	100
LOAEL to NOAEL (L)	N/A
Interspecies (A)	3
Intraspecies (H)	10
Database (D)	3
Acute ReV	92,000 ppb (220,000 µg/m3)
Selected AHBCV	**92,000 ppb**

AHBCV – acute health-based comparison value; LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; ReV – reference value; and UF – uncertainty factor.

1-Butene

The TCEQ's[20] ambient air toxicity factor was the only value identified for 1-butene, and it was derived using defined guidelines. Thus, the acute air comparison value for 1-butene selected by TCEQ for use as the AHBCV is the short-term TCEQ ReV of 27,000 ppb. The basis for the derivation of the TCEQ AHBCV can be found in Table D - 12.

Table D - 12. Summary table for TCEQ derivation of the acute reference value (ReV) and acute health-based comparison value (AHBCV) for 1-butene.

Parameter	Summary
Study	American Chemistry Council (2003)
Study population	Sprague Dawley male and female rats
Exposure method and duration	Inhalation of 0, 524, 2,062, or 8,271 ppm; 6 hr/day, 7 days/week for approximately 42 days
Critical effect(s)	Free-standing NOAEL, no observed effects in parental or in offspring generation. High concentrations produce central nervous system effects.

[20] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/butene-1.pdf

Parameter	Summary
POD	8,271 ppm (free-standing NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	8,271 ppm (no adjustment since the POD was a free-standing NOAEL)
POD_{HEC}	8,271 ppm (used RGDR = 1; systemic effects)
Total UFs:	300
LOAEL to NOAEL (L)	N/A
Interspecies (A)	3
Intraspecies (H)	10
Database (D)	10
Acute ReV	27,000 ppb (62,000 µg/m^3)
Selected AHBCV	**27,000 ppb**

AHBCV – Acute health-based comparison value; LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; ReV – reference value; RGDR – regional gas deposition ratio; and UF – uncertainty factor.

Chlorine

The TCEQ identified five acute ambient air toxicity factors for chlorine from state governments: AZ DHS,[3] NY DEC,[7] NC DEQ,[21] CalEPA,[4] and TCEQ.[22] Three of the values were not derived using defined guidelines: the AZ DHS and NY DEC values are based on a STEL/UF; the NC DEQ value was based on a STEL and adjusted to 1 hr. Two of the values, TCEQ and CalEPA, were derived using defined guidelines. Toxicity factors that are derived using defined guidelines are preferred for AHBCV development.

Summary

The two acute air comparison values for chlorine that were identified by TCEQ for use as the AHBCV are the acute CalEPA REL of 70 ppb and the short-term TCEQ ReV of 50 ppb**.** The basis for the derivation of the CalEPA and TCEQ AHBCV can be found in Table D - 13 and Table D - 14, respectively. CalEPA and TCEQ used the same key study and critical effects for chlorine. TCEQ considered 0.5 ppm to be a no observed adverse effect level (NOAEL) (selected as POD) and 1 ppm to be the LOAEL for sensory irritation without pulmonary function changes after 1 hr of exposure. CalEPA, however, considered the 30-min 1 ppm exposure to be a NOAEL for itching or burning of the throat and selected it as the POD. Both TCEQ and CalEPA use the same UF of 10, but a duration adjustment was applied for 30- min to 1 hr for the CalEPA REL, while no duration adjustment was applied to the TCEQ ReV. Although a duration adjustment can introduce some uncertainty, in this case the CalEPA REL MOE is lower than the MOE for the

[21] https://files.nc.gov/ncdeq/Air%20Quality/toxics/haps-taps/htdocs/Chlorine_7782-50-5_risk.pdf

[22] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/chlorine.pdf

TCEQ value, making the health-protective CalEPA REL more fit-for-purpose. Therefore, the CalEPA REL of 70 ppb is selected as the AHBCV for chlorine (Table D - 15).

Table D - 13. Summary table for CalEPA derivation of the acute reference exposure level (REL) for chlorine.

Parameter	Summary
Study	Anglen (1981)
Study population	31 adult volunteers
Exposure method and duration	Inhalation of 0, 0.5, 1, or 2 ppm chlorine gas; 15 min to 8 hr
Critical effect(s)	Itching or burning of the throat
POD	1 ppm (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	0.71 ppm
Total UFs:	10
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	10
Acute REL	70 ppb (210 µg/m³)

LOAEL – lowest observed adverse effect level; **N/A – not applicable;** NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; and UF – uncertainty factor.

Table D - 14. Summary table for TCEQ derivation of the acute reference value (ReV) for chlorine.

Parameter	Summary
Study	Anglen (1981)
Study population	31 human volunteers (ages 20-32 years)
Exposure method and duration	Inhalation of 0, 0.5, 1, or 2 ppm chlorine gas; 15 min to 8 hr
Critical effect(s)	Sensory irritation
POD	0.5 ppm (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	N/A
Total UFs:	10
Intraspecies (H)	10
Database (D)	1
Acute ReV	50 ppb (140 µg/m^3)
TAMIS acute ReV [a]	48 ppb (140 µg/m^3)

[a] Due to the calculation from µg/m3 (microgram per cubic meter) to ppb (parts per billion) in the TAMIS database, ppb values listed in the Development Support Document (DSD) may differ slightly from those listed in the TAMIS database. The TAMIS database values are the official values.; N/A– not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per

billion; ppm – parts per million; ReV – reference value; TAMIS – Texas Air Monitoring Information System; and UF – uncertainty factor.

Table D - 15. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for chlorine.

Criteria	CalEPA REL	TCEQ ReV
Year derived	1999	2017
Standard practices and procedures used	Yes	Yes
Inhalation key study	Anglen (1981), humans exposed to 0, 0.5, 1, or 2 ppm for 15 min to 8 hr	Anglen (1981), humans exposed to 0, 0.5, 1, or 2 ppm for 15 min to 8 hr
Critical effect(s) relevant to humans	Itching or burning of throat	Sensory irritation
Dose-response	Yes	Yes
POD	1 ppm	0.5 ppm
POD_{HEC}	0.71 ppm	0.5 ppm
Lower total uncertainty	UF (10) (H = 10)	UF (10) (H = 10)
Lower MOE	Yes	No
MMCVs < minimum LOAEL/BMC	Yes	Yes
1-hr Tox value	70 ppb	48 ppb
Selected AHBCV	**70 ppb**	

AHBCV – Acute health-based comparison value; BMC – benchmark concentration; H – Intraspecies uncertainty factor; LOAEL – lowest observed adverse effect level; MOE – margin of exposure; MMCV – mobile monitoring comparison value; POD – point of departure; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; ReV – reference value; and UF – uncertainty factor.

Ethylbenzene

The TCEQ identified two acute ambient air toxicity factors for ethylbenzene from state governments: AZ DHS[3] and TCEQ.[23] The AZ DHS value is based on a STEL/UF, while the TCEQ value was derived using defined guidelines.

Summary

The acute air comparison value for ethylbenzene that was identified by TCEQ for use as the AHBCV is the short-term TCEQ ReV of 20,000 ppb**.** TCEQ developed the toxicity factor following guidelines, which is preferred, thus the TCEQ 1-hr acute ReV of 20,000 ppb was selected as the AHBCV for ethylbenzene. The basis for the derivation of the TCEQ AHBCV can be found in Table D - 16.

[23] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/ethylbenzene.pdf

Use of the 1-hr ReV for ethylbenzene ultimately results in a 10-minute exposure mitigation health-based action level ($^{EM}HBAL_{10min}$) of 60,000 ppb, and a $^{EM}HBAL_{1hr}$ 1-hr of 40,000 ppb. In this case, the 10-minute and 1-hr acute exposure guideline level (AEGL)-1 values[24] for ethylbenzene (33,000 ppb) are lower than the $^{EM}HBAL_{10min}$ (60,000 ppb) and the $^{EM}HBAL_{1hr}$ (40,000 ppb). While AEGL values are typically not considered appropriate for selection of an AHBCV since they are characterized by EPA to be threshold levels at which health effects are expected to occur, and are generally significantly higher than the 1-hr ReV as well as the comparison values derived based on it, in this case the AEGL-1 values for ethylbenzene were evaluated further since they were lower than the two mobile monitoring comparison values. These AEGL-1 values were based on a study (Bardodej and Bardodejova 1961) wherein eleven individuals were exposed to 180 ppm ethylbenzene for 8 hours, with some individuals complaining of irritation of the upper respiratory tract and eyes, as well as headache, and sleepiness towards the end of the exposure; transient feelings of drunkenness were also reported. The study LOAEL is 180 ppm. No effects were reported at the study NOAEL of 100 ppm. This study provides no actual basis for the expectation of adverse effects at the 10-minute and 1-hr AEGL-1 value of 33,000 ppb (33 ppm), or at any of the mobile monitoring comparison levels (20,000-60,000 ppb) based on the TCEQ 1-hr ReV. Given the results of the underlying study (e.g., effects towards the end of the 8-hr exposure), the most appropriate, but still conservative, comparison is to the $^{EM}HBAL_{1hr}$ of 40,000 ppb. The MOE between the study LOAEL (180 ppm) and the $^{EM}HBAL_{1hr}$ (40,000 ppb or 40 ppm) is 4.5, which suggests that the $^{EM}HBAL_{1hr}$ and similarly derived values are not expected to cause adverse health effects, but rather are adequately health-protective for use in emergency situations and as such are fit-for-purpose. The AEGL-1 values for ethylbenzene were not considered further.

Table D - 16. Summary table for TCEQ derivation of the acute reference value (ReV) and acute health-based comparison value (AHBCV) for ethylbenzene.

Parameter	Summary
Study	Cappaert et al. (2000)
Study population	32 Wag/Rij rats
Exposure method and duration	Inhalation exposures of 0, 300, 400, and 550 ppm; 8 hr/day for 5 days
Critical effect(s)	Ototoxicity
POD	300 ppm (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	600 ppm
POD_{HEC}	600 ppm (used RGDR= 1, systemic effect)
Total UFs:	30
LOAEL to NOAEL (L)	N/A
Interspecies (A)	3

[24] AEGL -the United States Environmental Protection Agency's Acute Exposure Guideline Levels for Airborne Chemicals (https://www.epa.gov/aegl/access-acute-exposure-guideline-levels-aegls-values#chemicals)

Parameter	Summary
Intraspecies (H)	10
Database (D)	1
Acute ReV	20,000 ppb (86,000 µg/m^3)
Selected AHBCV	**20,000 ppb**

AHBCV – Acute health-based comparison value; LOAEL – lowest observed adverse effect level; N/A– not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; RGDR – regional gas deposition ratio; ReV – reference value; and UF – uncertainty factor.

Ethylene dichloride

The TCEQ identified two acute ambient air toxicity factors for ethylene dichloride from state governments: AZ DHS[3] and TCEQ.[25] The AZ DHS value is based on a STEL/UF, while the TCEQ value was derived using defined guidelines.

Summary

The acute air comparison values for ethylene dichloride that was identified by TCEQ for use as the AHBCV is the short-term TCEQ ReV of 550 ppb, because it was the only value derived using defined guideline methods**.** The basis for the derivation of the TCEQ AHBCV can be found in Table D - 17.

Table D - 17. Summary table for TCEQ derivation of the acute reference value (ReV) and acute health-based comparison value (AHBCV) for ethylene dichloride.

Parameter	Summary
Study	Hotchkiss et al. (2010)
Study population	Male and female Fischer 344 rats, acute inhalation and acute neurotoxicity studies
Exposure method and duration	Inhalation of 0, 50, 100, 150, 200, 600, or 2,000 ppm; 4 or 8 hrs
Critical effect(s)	Sight degeneration and necrosis of olfactory epithelium
POD	50 ppm (NOEL)
Extrapolation to 1 hr (POD_{ADJ})	100 ppm
POD_{HEC}	100 ppm (used RGDR= 1, systemic effect)
Total UFs:	180
Interspecies (A)	3
Intraspecies (H)	10
Database (D)	6
Acute ReV	550 ppb (2,200 µg/m^3)
TAMIS ReV [a]	540 ppb (2,200 µg/m^3)
Selected AHBCV	**540 ppb**

[25] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/edc.pdf

[a] Due to the calculation from µg/m3 (microgram per cubic meter) to ppb (parts per billion) in the TAMIS database, ppb values listed in the Development Support Document (DSD) may differ slightly from those listed in the TAMIS database. The TAMIS database values are the official values.; NOEL – no observed effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; RGDR – regional gas deposition ratio; ReV – reference value; TAMIS – Texas Air Monitoring Information System; and UF – uncertainty factor.

Ethylene glycol

The TCEQ identified three acute ambient air toxicity factors for ethylene glycol from state governments: NY DEC,[7] MI EGLE,[26] and TCEQ.[27] The NY DEC value is based on a STEL/UF, while the MI EGLE and TCEQ values were derived using defined guidelines.

Summary

The two acute air comparison values for ethylene glycol that were identified by TCEQ for use as the AHBCV are the MI EGLE initial threshold screening level (ITSL) of 1,900 ppb and the short-term TCEQ ReV of 590 ppb. The basis for the derivation of the TCEQ AHBCV can be found in Table D - 18. The MI EGLE ITSL and TCEQ ReV used the same key study, critical effects, and POD (LOAEL) for ethylene glycol. TCEQ considered 29 ppm to be a NOAEL and 55 ppm to be the LOAEL for sensory irritation without pulmonary function changes after 1 hr of exposure. There was no duration adjustment performed by MI EGLE or TCEQ. MI EGLE used a lower UF of 30, while TCEQ used a higher UF of 90 by applying an additional database UF of 3. Therefore, the MI 1-hr ITSL of 1,900 ppb has a lower total UF and MOE, is more fit-for-purpose, and was selected as the AHBCV for ethylene glycol (Table D - 19).

Table D - 18. Summary table for TCEQ derivation of the acute reference value (ReV) for ethylene glycol.

Parameter	Summary
Study	Wills et al. (1974)
Study population	24 human volunteers
Exposure method and duration	Inhalation at 0.8-75 mg/m^3, 188, 244, 308 mg/m^3 (aerosol); Unclear duration, likely 1 hr
Critical effect(s)	Respiratory irritation
POD	140 mg/m^3
Extrapolation to 1 hr (POD_{ADJ})	140 mg/m^3
Total UFs:	90
LOAEL to NOAEL (L)	3
Interspecies (A)	N/A
Intraspecies (H)	10
Database (D)	3

[26] https://www.egle.state.mi.us/aps/downloads/ATSL/107-21-1/107-21-1_1hr_ITSL.pdf

[27] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/eg.pdf

Parameter	Summary
Acute ReV	590 ppb (1500 µg/m^3)

N/A – not applicable; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ReV – reference value; and UF – uncertainty factor.

Table D - 19. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for ethylene glycol.

Criteria	TCEQ ReV	MI EGLE
Year derived	2016	2017
Standard practices and procedures used	Yes	Yes
Inhalation key study	Wills et al. 1974, humans exposed to 0.8-75, 188, 244, 308 mg/m^3 for 1 hr	Wills et al. 1974, humans exposed to 0.8-75, 188, 244, 308 mg/m^3 for 1 hr
Critical effect(s) relevant to humans	Respiratory irritation	Respiratory irritation
Dose-response	Yes	Yes
POD	140 mg/m^3	140 mg/m^3
POD_{ADJ}	140 mg/m^3	140 mg/m^3
Lower total uncertainty	UF (90) (H = 10, L = 3, D = 3)	UF (30) (H = 10, L = 3); lowest
Lower MOE	No	Yes
MMCVs < Minimum LOAEL/BMC	Yes	Yes
1-hr Tox value	1,500 µg/m^3 (590 ppb)	4,700 µg/m^3 (1900 ppb)
Selected AHBCV		**1,900 ppb**

AHBCV – Acute health-based comparison value; BMC – benchmark concentration; D – Database uncertainty factor (UF); H – Intraspecies UF; L – lowest observed adverse effect level (LOAEL) to no observed adverse effect level (NOAEL) UF; LOAEL – lowest observed adverse effect level; MOE – margin of exposure; MMCV – mobile monitoring comparison value; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ReV – reference value; and UF – uncertainty factor.

Ethylene oxide

The TCEQ identified four acute ambient air toxicity factors for ethylene oxide from state governments: AZ DHS,[3] NY DEC,[7] and TCEQ.[28] The AZ DHS value is based on a STEL/UF, and the derivation method is unknown for NY DEC. The TCEQ value was derived using defined guidelines, which is preferred for AHBCV development.

Summary

The acute air comparison values for ethylene oxide that was identified by TCEQ for use as the AHBCV is the short-term TCEQ ReV of 910 ppb, because it was the only value derived using

[28] www.tceq.texas.gov/downloads/toxicology/dsd/final/eto.pdf/view

defined guideline methods**.** The basis for the derivation of the TCEQ AHBCV can be found in Table D - 20.

Table D - 20. Summary table for TCEQ derivation of the acute reference value (ReV) and acute health-based comparison value (AHBCV) for ethylene oxide.

Parameter	Summary
Study	Snellings et al. (1982)
Study population	Fischer F344 Rats (female)
Exposure method and duration	Inhalation of 0, 10, 33, or 100 ppm; 6 hrs/day for 10 days (GDs 6 – 15)
Critical effect(s)	Developmental effects (decreased fetal body weight)
POD	45.12 ppm ($BMCL_{05}$)
Extrapolation to 1 hr (POD_{ADJ})	81.99 ppm
POD_{HEC}	81.99 ppm (used RGDR= 1, systemic effect)
Total UFs:	90
LOAEL to NOAEL (L)	N/A
Interspecies (A)	3
Intraspecies (H)	10
Database (D)	3
Acute ReV	910 ppb (1.7 mg/m^3)
Selected AHBCV	**910 ppb**

AHBCV – acute health-based comparison value; $BMCL_{05}$ – benchmark concentration lower confidence limit with a benchmark response of 5%; GD – gestational days; LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; ReV – reference value; RGDR – regional gas deposition ratio; and UF – uncertainty factor.

Formaldehyde

The TCEQ identified acute ambient toxicity factors for formaldehyde from state governments: AZ DHS,[3] NC DEQ,[6] NY DEC,[7] MI EGLE,[8] CalEPA,[29] and TCEQ[30]. There was also one value from ATSDR[31] with an applicable exposure duration. The AZ DHS value is based on a STEL/UF and the NC DEQ value is based on a TLV/UF. The derivation method is unknown for the NY DEC value. The MI EGLE value is a 24-h comparison value and the derivation method is unknown.

Summary

The three acute air comparison values for formaldehyde that were identified by TCEQ for use as the AHBCV are the ATSDR acute MRL of 40 ppb, the CalEPA REL of 44 ppb, and the short-term

[29] https://oehha.ca.gov/media/downloads/crnr/appendixd1final.pdf
[30] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/formaldehyde.pdf
[31] https://www.atsdr.cdc.gov/ToxProfiles/tp111.pdf

TCEQ ReV of 41 ppb. The bases for the derivations of the ATSDR, CalEPA, and TCEQ AHBCV can be found in Table D - 21, Table D - 22, and Table D - 23, respectively. Both ATSDR and TCEQ used the same key study in nonsmoking humans in which approximately half the participants had skin hypersensitivity to formaldehyde (Pazdrak et al. 1993), but TCEQ also used an additional key study in humans in which half the participants had bronchial asthma and suspected respiratory formaldehyde sensitization (Krakowiak et al. 1998). The CalEPA REL was derived based on a different key study in nonsmoking humans with no history of allergy or asthma (Kulle et al. 1987). The LOAEL of 0.4 ppm for nasal and eye irritation and rhinitis was the same POD used by ATSDR and TCEQ. In the key study used by CalEPA (Kulle et al. 1987), the NOAEL and LOAEL for eye irritation were 0.5 ppm and 1.0 ppm, respectively, and for derivation of the AHBCV, CalEPA used a $BMCL_{05}$ of 0.44 ppm based on eye irritation. In the derivation of all three AHBCVs, no duration adjustments were made because the effects seen (nasal and/or eye irritation) are considered to be concentration dependent only. Also, for all three AHBCVs the composite uncertainty factor used was the same. Both ATSDR and TCEQ used a UF_L of 3 and a UF_H of 3, while CalEPA used a UF_H of 10 to account for asthma exacerbation in children. Although the POD used by ATSDR and TCEQ was the same, after application of the composite uncertainty factor the AHBCV derived by TCEQ was slightly larger due to differences in rounding. The MOE for all AHBCVs are the same (10). The AHBCVs are similar and range from 40 to 44 ppb. The CalEPA REL of 44 ppb was selected as the AHBCV (Table D - 24) as it is more fit-for-purpose (e.g., it has a lower MOE calculated as the lowest LOAEL across key studies/REL) while still being health-protective because it is 9-fold lower than the lowest LOAELs identified in the key studies used by ATSDR and TCEQ.

Table D - 21. Summary table for ATDSR derivation of the minimal risk level (MRL) for formaldehyde.

Parameter	Summary
Study	Pazdrak et al. (1993)
Study population	20 human volunteers (9 with skin hypersensitivity to formaldehyde)
Exposure method and duration	Inhalation exposure to placebo (0 ppm) or 0.4 ppm; 2 hr
Critical effect(s)	Nasal and eye irritation
POD	0.4 ppm (minimal LOAEL)
Extrapolation to 1 hr (POD_{ADJ})	No extrapolation applied
Total UFs:	10
LOAEL to NOAEL (L)	3
Interspecies (A)	N/A
Intraspecies (H)	3
Database (D)	1
Acute MRL	40 ppb (49 µg/m^3)

LOAEL – lowest observed adverse effect level; MRL – minimal risk level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; and UF – uncertainty factor.

Table D - 22. Summary table for CalEPA derivation of the acute reference exposure level (REL) for formaldehyde.

Parameter	Summary
Study	Kulle et al. (1987)
Study population	19 healthy human volunteers
Exposure method and Duration	Inhalation exposure to clean air (0 ppm) or various concentrations ranging from 0.5 to 3 ppm; 3 hr
Critical effect(s)	Mild and moderate eye irritation
POD	0.44 ppm ($BMCL_{05}$)
Extrapolation to 1 hr (POD_{ADJ})	No extrapolation applied
Total UFs:	10
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	10
Database (D)	1
Acute REL	44 ppb (55 µg/m^3)

$BMCL_{05}$ – benchmark concentration lower confidence limit with a benchmark response of 5%; LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; and UF – uncertainty factor.

Table D - 23. Summary table for TCEQ derivation of the acute reference value (ReV) for formaldehyde.

Parameter	Summary
Study	Pazdrak et al. (1993) and Krakowiak et al. (1998)
Study population	Pazdrak et al. (1993): 20 human volunteers (9 with skin hypersensitivity to formaldehyde); Krakowiak et al. (1998): 20 human volunteers (10 with bronchial asthma and suspected respiratory formaldehyde sensitization)
Exposure method and duration	Inhalation exposure to placebo (0 ppm) or 0.4 ppm; 2 hr
Critical effect(s)	Eye and nose irritation, symptoms of rhinitis
POD	0.4 ppm (minimal LOAEL)
Extrapolation to 1 hr (POD_{ADJ})	No extrapolation applied
Total UFs:	10
LOAEL to NOAEL (L)	3
Interspecies (A)	N/A
Intraspecies (H)	3
Database (D)	1
Acute ReV	41 ppb (50 µg/m^3)

LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; ReV – reference value; and UF – uncertainty factor.

Table D - 24. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for formaldehyde.

CRITERIA	ATSDR MRL	CALEPA REL	TCEQ REV
Year derived	1999	2008	2008
Standard practices and procedures	Yes	Yes	Yes
Inhalation key study	Pazdrak et al. (1993)	Kulle et al. (1987)	Pazdrak et al. (1993) and Krakowiak et al. (1988)
Critical effect(s) relevant to humans	Nasal and eye irritation	Mild and moderate eye irritation	Eye and nose irritation, symptoms of rhinitis
Dose-response	No	Yes	No
POD	0.4 ppm (free standing LOAEL)	0.44 ppm ($BMCL_{05}$)	0.4 ppm (free standing LOAEL)
POD_{ADJ}	0.4 ppm	0.44 ppm	0.4 ppm
Lower total uncertainty	UF (10) (H = 3, L = 3)	UF (10) (H = 10)	UF (10) (H = 3, L = 3)
Lower MOE	No	Yes [a]	No
1-hr Tox value	40 ppb	44 ppb	41 ppb
Selected AHBCV		**44 ppb**	

[a] Although the MOE for the CalEPA REL based on the $BMCL_{05}$ (0.44 ppm) is 10, the MOE of the CalEPA REL compared to the lowest LOAEL (0.4 ppm) is 9.; AHBCV – Acute health-based comparison value; $BMCL_{05}$ – benchmark concentration lower confidence limit with a benchmark response of 5%; H – Intraspecies uncertainty factor; L – lowest observed adverse effect level (LOAEL) to no observed adverse effect level (NOAEL) UF; LOAEL – lowest observed adverse effect level; MOE – margin of exposure; MRL- minimal risk level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; ReV – reference value; and UF – uncertainty factor.

n-Hexane

The TCEQ identified two acute ambient air toxicity factors for n-hexane from state governments: AZ DHS[3] and TCEQ.[32] The AZ DHS value is based on a STEL/UF, while the TCEQ value was derived using defined guidelines.

Summary

The acute air comparison values for n-hexane that was identified by TCEQ for use as the AHBCV was the short-term TCEQ ReV of 5,400 ppb, because it was the only value derived using defined

[32] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/hexane-n.pdf

guideline methods. The basis for the derivation of the TCEQ AHBCV can be found in Table D - 25.

Table D - 25. Summary table for TCEQ derivation of the acute reference value (ReV) and acute health-based comparison value (AHBCV) for n-hexane.

Parameter	Summary
Study	Glowa (1991)
Study population	Adult male CD-1 mice
Exposure method and duration	Incrementally increasing exposure inhalation from 100 ppm up to 10,000 ppm; 30 min
Critical effect(s)	Neuroendocrine effects
POD	1,000 ppm (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	500 ppm
POD_{HEC}	500 ppm (used RGDR= 1, systemic effect)
Total UFs:	90
LOAEL to NOAEL (L)	N/A
Interspecies (A)	3
Intraspecies (H)	10
Database (D)	3
Acute ReV	5,400 ppb (19,000 µg/m^3)
Selected AHBCV	**5,400 ppb**

AHBCV – acute health-based comparison value; LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; ReV – reference value; RGDR – regional gas deposition ratio; and UF – uncertainty factor.

Hydrochloric acid

The TCEQ identified four acute ambient air toxicity factors for hydrochloric acid from state governments: AZ DHS,[3] MI EGLE,[8] NY DEC,[7] and TCEQ.[33] The AZ DHS value is based on a STEL/UF, and the derivation method is unknown for MI EGLE and NY DEC. The TCEQ value was derived using defined guidelines.

Summary

The acute air comparison value for hydrochloric acid that was identified by TCEQ for use as the AHBCV was the short-term TCEQ ReV of 440 ppb, because it was the only value derived using defined guideline methods**.** The basis for the derivation of the TCEQ AHBCV can be found in Table D - 26.

[33] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/hydrogen_chloride.pdf

Table D - 26. Summary table for TCEQ derivation of the acute reference value (ReV) and acute health-based comparison value (AHBCV) for hydrochloric acid.

Parameter	Summary
Study	Stevens et al. (1992)
Study population	10 humans with asthma
Exposure method and duration	Inhalation exposure to 0, 0.8, or 1.8 ppm; 45 min
Critical effect(s)	Upper respiratory symptoms (sore throat, nasal discharge) and lower respiratory symptoms (pulmonary function, cough, chest pain)
POD	1.8 ppm (free-standing NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	1.35 ppm
Total UFs:	3
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	1
Database (D)	3
Acute ReV	450 ppb (660 µg/m^3)
TAMIS ReV [a]	440 ppb (660 µg/m^3)
Selected AHBCV	**440 ppb**

[a] Due to the calculation from µg/m3 (microgram per cubic meter) to ppb (parts per billion) in the TAMIS database, ppb values listed in a Development Support Document (DSD) may differ slightly from those listed in the TAMIS database. The TAMIS database values are the official values.; AHBCV – acute health-based comparison value; LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; ReV – reference value; TAMIS – Texas Air Monitoring Information System; and UF – uncertainty factor.

Hydrogen sulfide

The TCEQ identified five acute ambient air toxicity factors for hydrogen sulfide from state governments: AZ DHS,[3] NY DEC,[7] NC DEQ,[6] CalEPA,[4] and TCEQ.[9,34] There was also one value from ATSDR[35] with an applicable exposure duration. Three of the state values were not derived using defined guidelines: the AZ DHS value is based on a STEL/UF, while NY DEC and TCEQ have state standards with no documentation of how the standards were derived. The NC DEQ and ATSDR values were derived using defined guidelines. Although the CalEPA state standard was derived using defined guidelines, it was based on an odor threshold for hydrogen sulfide, rather than on health effects, thus making it not fit-for-purpose for use as an AHBCV.

[34] https://texreg.sos.state.tx.us/public/readtac$ext.ViewTAC?tac_view=5&ti=30&pt=1&ch=112&sch=B&rl=Y

[35] https://www.atsdr.cdc.gov/toxprofiles/tp114.pdf

Summary

The two acute air comparison values for hydrogen sulfide that were identified by TCEQ for use as the AHBCV are the NC DEQ acceptable ambient level (AAL) of 40 ppb and the ATSDR MRL of 70 ppb. The basis for the derivation of the ASTDR MRL can be found in Table D - 27. Both NC and ATSDR used the same key study (Jappinen et al., 1990) of 10 people with asthma exposed to 2 ppm (LOAEL) for up to 30 min to test pulmonary function. The free-standing LOAEL was selected as the POD. No dose-response was observed (because only one dose was tested). While ATSDR is typically excluded as a potential source of acute (≤ 24 hr) values because the MRL's are typically designed to be protective for 14 days, in this case, they did not use a duration adjustment of the 30-min results and so the MRL (70 ppb) was considered for use as a 1-hr AHBCV. ATSDR used a lower total uncertainty factor (30) than that used by NC (UF of 50), even though ATSDR used an additional UF of 3 for database completeness due to concern for the short (30-minute) exposure duration in the principal study, which is within a factor of 2 of the duration of interest (i.e., 1 hr) in the present case. Therefore, the ATSDR acute MRL has a lower MOE, is considered more fit-for-purpose, and was selected as the AHBCV (Table D - 28).

Table D - 27. Summary table for ATDSR derivation of the minimal risk level (MRL) for hydrogen sulfide.

Parameter	Summary
Study	Jappinen et al., 1990
Study population	10 human subjects with asthma
Exposure method and duration	Inhalation of 2 ppm H_2S; 30 min
Critical effect(s)	Significant change in airway resistance and conductivity for 2/10 subjects
POD	2 ppm (free-standing LOAEL)
Extrapolation to 1 hr (POD_{ADJ})	2 ppm
Total UFs:	27
LOAEL to NOAEL (L)	3
Interspecies (A)	N/A
Intraspecies (H)	3
Database (D)	3
Acute MRL	70 ppb

LOAEL – lowest observed adverse effect level; H_2S – hydrogen sulfide; MRL – minimal risk level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; ReV – reference value; and UF – uncertainty factor.

Table D - 28. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for hydrogen sulfide.

Criteria	NC DEQ AAL	ATSDR MRL
Year derived	2001	2016

Criteria	NC DEQ AAL	ATSDR MRL
Standard practices and procedures	Yes	Yes
Inhalation key study	Jappinen et al., 1990, humans with asthma exposed to 2 ppm for 30 min	Jappinen et al., 1990, humans with asthma exposed to 2 ppm for 30 min
Critical effect(s) relevant to humans	Significant change in airway resistance and conductivity	Significant change in airway resistance and conductivity
Dose-response	No (only one dose used)	No (only one dose used)
POD	2 ppm (minimal LOAEL)	2 ppm (minimal LOAEL)
POD_{ADJ}	2 ppm	2 ppm
Lower total uncertainty	UF (50) (H = 10, L = 5)	UF (30) (H = 3, L = 3, D = 3); lowest
Lower MOE	No	Yes
MMCVs < Minimum LOAEL/BMC	Yes	Yes
1-hr Tox value	40 ppb	70 ppb
Selected AHBCV		**70 ppb**

AHBCV – Acute health-based comparison value; BMC – benchmark concentration; D – Database uncertainty factor (UF); H – Intraspecies UF; L – lowest observed adverse effect level (LOAEL) to no observed adverse effect level (NOAEL) UF; LOAEL – lowest observed adverse effect level; MOE – margin of exposure; MMCV – mobile monitoring comparison value; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; and UF – uncertainty factor.

Isobutane

The TCEQ[36] ambient air toxicity factor was the only value identified for isobutane, and the value was derived using defined guidelines. Thus, the acute air comparison value for isobutane selected by TCEQ for use as the AHBCV is the short-term TCEQ ReV of 33,000 ppb. The basis for the derivation of the TCEQ AHBCV can be found in Table D - 29.

Table D - 29. Summary table for TCEQ derivation of the acute reference value (ReV) and acute health-based comparison value (AHBCV) for isobutane.

Parameter	Summary
Study	Stewart et al. (1977)
Study population	Eight healthy adult male and female humans
Exposure method and duration	Inhalation to 250, 500, or 1,000 ppm; 1 hr, 2 hr, or 8 hr
Critical effect(s)	No effects
POD	1,000 ppm (free-standing NOAEL)

[36] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/butanes.pdf

Parameter	Summary
Extrapolation to 1 hr (POD_{ADJ})	1,000 ppm
Total UFs:	30
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	10
Database (D)	3
Acute ReV	33,000 ppb (78,000 µg/m^3)
Selected AHBCV	**33,000 ppb**

AHBCV – acute health-based comparison value; LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; ReV – reference value; and UF – uncertainty factor.

n-Octane

The TCEQ identified two acute ambient air toxicity factors for n-octane from state governments: AZ DHS[3] and TCEQ.[37] The AZ DHS value is based on a STEL/UF, while the TCEQ value was derived using defined guidelines.

Summary

The acute air comparison value for n-octane that was identified by TCEQ for use as the AHBCV was the short-term TCEQ ReV of 4,100 ppb, because it was the only value derived using defined guideline methods**.** The basis for the derivation of the TCEQ AHBCV can be found in Table D - 30.

Table D - 30. Summary table for TCEQ derivation of the acute reference value (ReV) and acute health-based comparison value (AHBCV) for n-octane.

Parameter	Summary
Study	Glowa (1991)
Study population	Adult male CD-1 mice
Exposure method and duration	Incrementally increasing exposure inhalation from 100 ppm up to 10,000 ppm; 30 min
Critical effect(s)	Transient behavioral impairment
POD	1,000 ppm (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	500 ppm
POD_{HEC}	369 ppm (RGDR = 0.74)
Total UFs:	90
LOAEL to NOAEL (L)	N/A
Interspecies (A)	3

[37] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/octane.pdf

Parameter	Summary
Intraspecies (H)	10
Database (D)	3
Acute ReV	4,100 ppb (19,000 µg/m^3)
Selected AHBCV	**4,100 ppb**

AHBCV – acute health-based comparison value; LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; ReV – reference value; RGDR – regional gas deposition ratio; and UF – uncertainty factor.

Sodium hydroxide

The TCEQ identified five acute ambient air toxicity factors for sodium hydroxide from state governments: AZ DHS,[3] NY DEC,[7] MI EGLE,[8] CalEPA,[4] and TCEQ.[38] Four of the values were not derived using defined guidelines: the AZ DHS and NY DEC values are based on a STEL/UF, TCEQ's interim 1-hr ESL is based on the NIOSH ceiling limit (CL)/100, and the MI EGLE adopted the CalEPA value. The CalEPA value was derived using defined guidelines.

Summary

The acute air comparison value for sodium hydroxide that was identified by TCEQ for use as the AHBCV was the acute CalEPA REL of 5 ppb (8 µg/m^3), because it was the only value derived using defined guideline methods**.** The basis for the derivation of the CalEPA AHBCV can be found in Table D - 31.

Table D - 31. Summary table for CalEPA derivation of the acute reference exposure level (REL) and acute health-based comparison value (AHBCV) for sodium hydroxide.

Parameter	Summary
Study	Ott et al. (1977)
Study population	291 humans occupational
Exposure method and duration	Occupational exposure estimated range of 0.5 – 2 mg/m^3; 8 hr time-weighted average
Critical effect(s)	Subjective reports of mild to moderate-severe irritation of the eyes and skin; mild respiratory irritation
POD	0.5 mg/m^3
Extrapolation to 1 hr (POD_{ADJ})	0.5 mg/m^3
Total UFs:	60
LOAEL to NOAEL (L)	6
Interspecies (A)	N/A
Intraspecies (H)	10

[38] https://www.tceq.texas.gov/toxicology/esl/list_main.html

Parameter	Summary
Acute REL	5 ppb (8 µg/m³)
Selected AHBCV	**5 ppb**

AHBCV – Acute health-based comparison value; LOAEL – lowest observed adverse effect level; N/A– not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; REL – reference exposure level; and UF – uncertainty factor.

Styrene

The TCEQ identified four acute ambient air toxicity factors for styrene from state governments: AZ DHS,[3] NC DEQ,[39] CalEPA,[40] and TCEQ.[41] Two of the values were not derived using defined guidelines: the AZ DHS and NC DEQ values are based on a STEL/UF. The CalEPA and TCEQ values were derived using defined guidelines.

Summary

The two acute air comparison values for styrene that were identified by TCEQ for use as the AHBCV are the acute CalEPA REL of 5,100 ppb and the short-term TCEQ ReV of 5,200 ppb. The basis for the derivations of the CalEPA REL and TCEQ ReV can be found in Table D - 32 and Table D - 33, respectively. The CalEPA REL was derived based on the same key study and same application of uncertainty factors and the final values differ by 100 ppb due to rounding in the TCEQ Toxicity Factor Database. Because the value of 5,100 ppb was originally generated by both CalEPA and TCEQ (based on using the NOAEL of 51 ppm and dividing by a total UF of 10), the level of 5,100 ppb was selected as the AHBCV for styrene (Table D - 34).

Table D - 32. Summary table for CalEPA derivation of the acute reference exposure level (REL) for styrene.

Parameter	Summary
Study	Stewart et al. (1968)
Study population	9 human volunteers
Exposure method and duration	Exposure via inhalation at 51, 216, or 375 ppm for 1 hr, at 116 ppm for 2 hr, or at 99 ppm for 7 hr
Critical effect(s)	Eye and throat irritation
POD	51 ppm (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	51 ppm
Total UFs:	10
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	10

[39] https://files.nc.gov/ncdeq/Air%20Quality/toxics/haps-taps/htdocs/Styrene_100-42-5_risk.pdf

[40] https://oehha.ca.gov/media/downloads/crnr/appendixd2final.pdf

[41] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/styrene.pdf

Parameter	Summary
Acute REL	**5,100 ppb**

LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; and UF – uncertainty factor.

Table D - 33. Summary table for TCEQ derivation of the acute reference value (ReV) and acute health-based comparison value (AHBCV) for styrene.

Parameter	Summary
Study	Stewart et al. (1968)
Study population	9 healthy male volunteers
Exposure method and duration	Exposure via inhalation at 51, 216, or 375 ppm for 1 hr, at 116 ppm for 2 hr, or at 99 ppm for 7 hr
Critical effect(s)	Eye and nasal irritation
POD	51 ppm (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	51 ppm
Total UFs:	10
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	10
Database (D)	1
Acute ReV	**5,100 ppb (22,000 µg/m^3)**
TAMIS AMCV [a]	5,200 ppb

[a] Due to the calculation from µg/m^3 (microgram per cubic meter) to ppb (parts per billion) in the TAMIS database, ppb values listed in the Development Support Document (DSD) may differ slightly from those listed in the TAMIS database. The TAMIS database values are the official values; however, the DSD value was utilized for this purpose because it is the same as the CalEPA value.; AHBCV – Acute health-based comparison value; LOAEL – lowest observed adverse effect level; N/A– not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; ReV – reference value; TAMIS – Texas Air Monitoring Information System; and UF – uncertainty factor.

Table D - 34. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for styrene.

Criteria	CalEPA REL/NY AGC	TCEQ ReV
Year derived	2008	2008
Standard practices and procedures	Yes	Yes
Inhalation key study	Stewart et al. (1968)	Stewart et al. (1968)
Critical effect(s) relevant to humans	Eye and throat irritation	Eye and nasal irritation
Dose-response	Yes	Yes
POD	51 ppm (NOAEL)	51 ppm (NOAEL)
POD_{ADJ}	51 ppm	51 ppm
Lower total uncertainty	UF (10) (H = 10)	UF (10) (H = 10)

Criteria	CalEPA REL/NY AGC	TCEQ ReV
Lower MOE	Same	Same
MMCVs < Minimum LOAEL/BMC	Yes	Yes
1-hr Tox value	5,100 ppb	5,100 ppb
Selected AHBCV	**5,100 ppb**	**5,100 ppb**

AHBCV – Acute health-based comparison value; BMC – benchmark concentration; H – Intraspecies uncertainty factor; LOAEL – lowest observed adverse effect level; MOE – margin of exposure; MMCV – mobile monitoring comparison value; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; ReV – reference value; and UF – uncertainty factor.

Sulfuric acid

The TCEQ identified six acute ambient air toxicity factors for sulfuric acid from state governments: AZ DHS,[3] NC DEQ,[42] NY DEC,[7] MI EGLE,[8] CalEPA,[4] and TCEQ.[43] Five of the values were not derived using defined guidelines: the AZ DHS and NC DEQ values are based on a STEL/UF and TLV/UF, respectively. The TCEQ value is a state standard with no documentation of how the value was derived. NY DEC and MI EGLE adopted the CalEPA value. The CalEPA value was derived using defined guidelines.

Summary

The acute air comparison value for sulfuric acid that was identified by TCEQ for use as the AHBCV is the acute CalEPA REL of 120 µg/m^3 (30 ppb), because it was the only value derived using defined guideline methods. The basis for the derivation of the CalEPA REL can be found in Table D - 35.

Table D - 35. Summary table for CalEPA derivation of the acute reference exposure level (REL) and acute health-based comparison value (AHBCV) for sulfuric acid.

Parameter	Summary
Study	Utell et al. (1984)
Study population	17 humans with asthma
Exposure method and duration	Inhalation to 100, 450, or 1000 µg/m^3; 16 min
Critical effect(s)	Small changes in airway function
POD	450 µg/m^3 (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	120 µg/m^3
Total UFs:	1
LOAEL to NOAEL (L)	1
Interspecies (A)	N/A

[42] https://files.nc.gov/ncdeq/Air%20Quality/toxics/haps-taps/htdocs/Sulfuric_Acid_risk.pdf

[43] https://texreg.sos.state.tx.us/public/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=30&pt=1&ch=112&rl=41

Parameter	Summary
Intraspecies (H)	1
Acute REL	30 ppb (120 µg/m^3)
Selected AHBCV	**30 ppb**

AHBCV – Acute health-based comparison value; LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; REL – reference exposure level; and UF – uncertainty factor.

Toluene

The TCEQ identified five acute ambient air toxicity factors for toluene from state governments: AZ DHS,[3] NC DEQ,[44] NY DEC,[7] CalEPA,[45] and TCEQ.[46] Two of the values were not derived using defined guidelines: the AZ DHS and NC DEQ values are based on a STEL/UF. The derivation method of the NY DEC value is unknown. The CalEPA and TCEQ values were derived using defined guidelines.

Summary

The two acute air comparison values for toluene that were identified by TCEQ for use as the AHBCV are the acute CalEPA REL of 1,300 ppb and the short-term TCEQ ReV of 4,000 ppb. The bases for the derivations of the CalEPA and TCEQ AHBCV can be found in Table D - 36 and Table D - 37, respectively. CalEPA and TCEQ used the same key study, critical effects, and POD for their toluene values, but the CalEPA total UF was 30 while the TCEQ UF was 10. CalEPA used a UF_H of 30 instead of the common standard UF_H of 10 used by other agencies, including TCEQ. The TCEQ ReV is health-protective with a lower MOE and thus is more fit-for-purpose.[11] Accordingly, the TCEQ ReV was selected as the AHBCV for toluene (Table D - 38).

Table D - 36. Summary table for CalEPA derivation of the acute reference exposure level (REL) for toluene.

Parameter	Summary
Study	Andersen et al. (1983)
Study population	16 healthy male humans
Exposure method and duration	Inhalation of 0, 10, 40, or 100 ppm; 6 hr
Critical effect(s)	Impaired reaction time and symptoms of headache, dizziness, feeling of intoxication, sensory irritation (eye and nose irritation)
POD	40 ppm

[44] https://files.nc.gov/ncdeq/Air%20Quality/toxics/haps-taps/htdocs/Toluene_risk.pdf

[45] https://oehha.ca.gov/media/downloads/crnr/toluenerel082020.pdf

[46] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/toluene.pdf

Parameter	Summary
Extrapolation to 1 hr (POD_{ADJ})	40 ppm
Total UFs:	30
LOAEL to NOAEL (L)	1
Interspecies (A)	N/A
Intraspecies (H)	30
Acute REL	1,300 ppb (5,000 µg/m^3)

LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; and UF – uncertainty factor.

Table D - 37. Summary table for TCEQ derivation of the acute reference value (ReV) for toluene.

Parameter	Summary
Study	Andersen et al. (1983)
Study population	16 healthy male humans
Exposure method and duration	Inhalation exposures of 0, 10, 40, or 100 ppm; 6 hr
Critical effect(s)	Eye and nose irritation, plus headaches, dizziness, and intoxication
POD	40 ppm (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	40 ppm
Total UFs:	10
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	10
Database (D)	1
Acute ReV	4,000 ppb (15,000 µg/m^3)

LOAEL – lowest observed adverse effect level; N/A– not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; ReV – reference value; and UF – uncertainty factor.

Table D - 38. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for toluene.

Criteria	CalEPA REL	TCEQ ReV
Year derived	2020	2008
Standard practices and procedures	Yes	Yes
Inhalation key study	Andersen et al. (1983), humans exposed to 0, 10, 40, or 100 ppm for 6 hr	Andersen et al. (1983) humans exposed to 0, 10, 40, or 100 ppm for 6 hr

Criteria	CalEPA REL	TCEQ ReV
Critical effect(s) relevant to humans	Eye and nose irritation, plus headaches, dizziness, and intoxication	Eye and nose irritation, plus headaches, dizziness, and intoxication
Dose-response	Yes	Yes
POD	40 ppm (NOAEL)	40 ppm (NOAEL)
POD_{ADJ}	40 ppm	40 ppm
Lower total uncertainty	UF (30) (H=30)	UF (10) (H=10); lowest
Lower MOE	No	Yes
1-hr Tox value	1,300 ppb	4,000 ppb
MMCVs < Minimum LOAEL/BMC	Yes	Yes
Selected AHBCV		**4,000 ppb**

AHBCV – Acute health-based comparison value; BMC – benchmark concentration; H – Intraspecies uncertainty factor; LOAEL – lowest observed adverse effect level; MOE – margin of exposure; MMCV – mobile monitoring comparison value; POD – point of departure POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; ReV – reference value; and UF – uncertainty factor.

Vinyl chloride

The TCEQ identified five acute ambient air toxicity factors for vinyl chloride from state governments: AZ DHS,[3] MI EGLE,[8] NY DEC,[7] CalEPA,[4] and TCEQ.[47] The AZ DHS value is based on a STEL/UF and was not derived using defined guidelines. The derivation method of MI EGLE is unknown, while NY DEC adopted the CalEPA value. The CalEPA and TCEQ values were derived using defined guidelines.

Summary

The two acute air comparison values for vinyl chloride that were identified by TCEQ for use as the AHBCV are the acute CalEPA REL of 72,000 ppb and the short-term TCEQ ReV of 26,000 ppb. The basis for the derivation of the CalEPA and TCEQ values can be found in Table D - 39 and Table D - 40, respectively. The CalEPA and TCEQ used the same key study, critical effects, and POD (NOAEL) for their vinyl chloride values, as well as the same total UF of 10. However, a duration adjustment was applied to convert the 7.5-hr exposure to 1 hr for the CalEPA REL. While this can introduce some uncertainty, in this case it makes the MOE lower than that for the TCEQ value, making this health-protective value more fit-for-purpose. Therefore, the CalEPA REL was selected as the AHBCV for vinyl chloride (Table D - 41).

Table D - 39. Summary table for CalEPA derivation of the acute reference exposure level (REL) for vinyl chloride.

Parameter	Summary
Study	Baretta et al., 1969

[47] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/vinyl_chloride.pdf

Parameter	Summary
Study population	4-8 healthy human volunteers
Exposure method and duration	Inhalation of 59, 261, 491, or 493 ppm; 3.5 - 7.5 hr
Critical effect(s)	Subjective reports of mild headaches and dryness of eyes and nose
POD	261 ppm (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	715 ppm
Total UFs:	10
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	10
Acute REL	72,000 ppb (180,000 µg/m³)

LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; and UF – uncertainty factor.

Table D - 40. Summary table for TCEQ derivation of the acute reference value (ReV) for vinyl chloride.

Parameter	Summary
Study	Baretta et al. (1969)
Study population	4-8 healthy human volunteers
Exposure method and duration	Inhalation of 59, 261, 491, or 493 ppm; 3.5 - 7.5 hr
Critical effect(s)	Mild headache and dryness of eyes and nose
POD	261 ppm (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	261 ppm (no duration adjustment)
Total UFs:	10
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	10
Database (D)	1
Acute ReV	26,000 ppb (68,000 µg/m³)

LOAEL – lowest observed adverse effect level; N/A– not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; ReV – reference value; and UF – uncertainty factor.

Table D - 41. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for vinyl chloride.

Criteria	CalEPA REL/NY AGC	TCEQ ReV
Year derived	1999	2009

Criteria	CalEPA REL/NY AGC	TCEQ ReV
Standard practices and procedures	Yes	Yes
Inhalation key study	Baretta et al. (1969), humans exposed to 59, 261, 491, or 493 ppm for 3.5 - 7.5 hr	Baretta et al. (1969), humans exposed to 59, 261, 491, or 493 ppm for 3.5 - 7.5 hr
Critical effect(s) relevant to humans	Mild headache and dryness of eyes and nose	Mild headache and dryness of eyes and nose
Dose-response	Yes	Yes
POD	261 ppm	261 ppm
POD_{ADJ}	715 ppm	261 ppm
Lower total uncertainty	UF (10) (H = 10)	UF (10) (H = 10)
Lower MOE	Yes	No
MMCVs < Minimum LOAEL/BMC	Yes	Yes
1-hr Tox value	72 ppm	26 ppm
Selected AHBCV	**72,000 ppb**	

AHBCV – Acute health-based comparison value; BMC – benchmark concentration; H – Intraspecies uncertainty factor; LOAEL – lowest observed adverse effect level; MOE – margin of exposure; MMCV – mobile monitoring comparison value; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; ReV – reference value; and UF – uncertainty factor.

Xylenes

The TCEQ identified five acute ambient air toxicity factors for vinyl chloride from state governments: AZ DHS,[3] NC DEQ,[48] NY DEC,[7] CalEPA,[4] and TCEQ.[49] Two of the values were not derived using defined guidelines: the AZ DHS and NC DEQ values are based on a STEL/UF. The NY DEC adopted the CalEPA value. The CalEPA and TCEQ values were derived using defined guidelines.

Summary

The two acute air comparison values for xylenes that were identified by TCEQ for use as the AHBCV are the acute CalEPA REL of 5,000 ppb and the short-term TCEQ ReV of 1,700 ppb. The basis for the derivation of the CalEPA and TCEQ values can be found in Table D - 42 and Table D - 43, respectively. The CalEPA value for xylenes was based on the Hastings et al. (1984) study, where multiple doses were administered to healthy human volunteers with an exposure duration of 30 min; a NOAEL (100 ppm) and LOAEL (200 ppm) were established. The TCEQ value is based on the Ernstgard et al. (2002) study, where they administered one concentration (50 ppm) to human volunteers with an exposure duration of 2 hours (LOAEL = 50 ppm). While the

[48] https://files.nc.gov/ncdeq/Air%20Quality/toxics/haps-taps/htdocs/Xylene_risk.pdf

[49] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/xylenes.pdf

dosimetry adjustments result in the same POD_{adj} of 50 ppm for both CalEPA and TCEQ, the CalEPA REL POD exposure duration is closer to the duration of interest (i.e., a 30-min difference as opposed to a 1-hr difference), and a lower total UF (10) was used by CalEPA REL (compared to 30 used by TCEQ). The CalEPA REL of 5,000 ppb is health-protective with a lower MOE compared to the lowest LOAEL (50 ppm) and thus is more fit-for-purpose. Thus, the CalEPA REL of 5,000 ppb was selected as the AHBCV for xylenes (Table D - 44).

Table D - 42. Summary table for CalEPA derivation of the acute reference exposure level (REL) for xylenes.

Parameter	Summary
Study	Hastings et al. (1984) (with support from Carpenter et al. (1975); Nelson et al. (1943))
Study population	50 healthy human volunteers
Exposure method and duration	Inhalation of 430, 860, or 1720 mg/m^3 xylene; 30 min
Critical effect(s)	Subjective reports of eye, nose, and throat irritation
POD	430 mg/m^3 (100 ppm; NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	50 ppm
Total UFs:	10
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	10
Acute REL	5,000 ppb (22,000 µg/m³)

LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; and UF – uncertainty factor.

Table D - 43. Summary table for TCEQ derivation of the acute reference value (ReV) for xylenes.

Parameter	Summary
Study	Ernstgard et al. (2002)
Study population	28 male and 28 female human volunteers
Exposure method and duration	Inhalation of 0 or 50 ppm; 2 hr
Critical effect(s)	Mild respiratory and subjective neurological effects
POD	50 ppm (LOAEL)
Extrapolation to 1hr (POD_{ADJ})	50 ppm
Total UFs:	30
LOAEL to NOAEL (L)	3
Interspecies (A)	N/A
Intraspecies (H)	10

Parameter	Summary
Database (D)	1
Acute ReV	1,700 ppb (7,400 µg/m^3)

LOAEL – lowest observed adverse effect level; N/A– not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; ReV – reference value; and UF – uncertainty factor.

Table D - 44. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for xylenes.

Criteria	CalEPA REL/ NY AGC	TCEQ ReV
Year derived	1999	2009
Standard practices and procedures	Yes	Yes
Inhalation key study	Hastings et al. (1984), humans exposed to 0, 100, 200, or 400 ppm for 30 min	Ernstgard et al. (2002), humans exposed to 0 or 50 ppm for 2 hrs
Critical effect(s) relevant to humans	Subjective eye/ nose/ throat irritation	Mild respiratory/ subjective neurological effects
Dose-response	Yes	No
POD	100 ppm (NOAEL)	50 ppm (free standing LOAEL)
POD_{ADJ}	50 ppm	50 ppm
Lower total uncertainty	UF (10) (H=10); lowest	UF (30) (H = 10, L = 3)
Lower MOE	Yes	No
MMCVS < minimum LOAEL/BMC	Yes	Yes
1-hr TOX value	5,000 ppb	1,700 ppb
Selected AHBCV	**5,000 ppb**	

AHBCV – Acute health-based comparison value; BMC – benchmark concentration; H – Intraspecies uncertainty factor; L – lowest observed adverse effect level (LOAEL) to no observed adverse effect level (NOAEL) UF; LOAEL – lowest observed adverse effect level; MOE – margin of exposure; MMCV – mobile monitoring comparison value; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; ReV – reference value; and UF – uncertainty factor.

AHBCVs Derived Using OEL/UF Approach

Acetylene

The TCEQ's ambient air toxicity factor was the only value identified for acetylene. The 1-hr ESL was derived based on a NIOSH ceiling value of 2,500 ppm divided by a total UF of 100. Thus, the level of 25,000 ppb is selected as an AHBCV for acetylene.

Cyclohexane

The TCEQ's ambient air toxicity factor was the only value identified for cyclohexane. The 1-hr ESL was derived based on a TLV of 100 ppm divided by a total UF of 100. Thus, the level of 1,000 ppb is selected as an AHBCV for cyclohexane.

AHBCVs Not Derived

C3-C4 Saturated

C3-C4 Saturated is a mixture that includes 3 possible chemicals: propane, isobutane, and butane. There are no toxicity studies available for C3-C4 saturated, and there are no existing toxicity factors to evaluate. Therefore, developing an AHBCV is not possible.

Propane

Propane is a simple asphyxiant that is non-toxic in ambient air, and only causes toxicity in an enclosed space where concentrations are high enough to decrease oxygen levels to critically low amounts. Therefore, an AHBCV is not needed.

Propylene

Propylene is a simple asphyxiant that is non-toxic in ambient air, and only causes toxicity in an enclosed space where concentrations are high enough to decrease oxygen levels to critically low amounts. Therefore, an AHBCV is not needed.

Sulfur Dioxide

Sulfur dioxide is a federally regulated compound that has a national ambient air quality standard (NAAQS). Because of this, an AHBCV was not developed.

Appendix E: List of the available $^{EM}HBALs_{10min}$, STELs, and ceiling values

Chemical(s)	CAS No.	$^{EM}HBAL_{10min}$ (ppb)	ACGIH STEL (ppb)	CAL/OSHA STEL (ppb)	NIOSH STEL (ppb)	ACGIH C (ppb)	CAL/OSHA C (ppb)	NIOSH C (ppb)	OSHA C (ppb)
Acetylene	74-86-2	75,000	--	--	--	--	--	2,500,000	--
Ammonia	7664-41-7	2,550	35,000	35,000	35,000	--	--	--	--
Benzene	71-43-2	500	2,500	5,000	1,000	--	--	--	--
1,3-Butadiene	106-99-0	2,500	--	5,000	--	--	--	--	--
Butane	106-97-8	276,000	1,000,000	--	--	--	--	--	--
1-Butene	106-98-9	81,000	--	--	--	--	--	--	--
C3-C4 Saturated	--	--	--	--	--	--	--	--	--
Chlorine	7782-50-5	200	400	1,000	--	--	--	--	--
Cyclohexane	110-82-7	3,000	--	--	--	--	--	--	--
Ethylbenzene	100-41-4	60,000	--	125,000	125,000	--	--	--	--
Ethylene Dichloride	107-06-2	1,000	--	2,000	2,000	--	--	--	--
Ethylene Glycol	107-21-1	5,700	50,000	--	--	--	--	--	--
Ethylene Oxide	75-21-8	2,500	--	5,000	--	--	--	--	--
Formaldehyde	50-00-0	50	300	2,000	--	--	--	100	--
n-Hexane	110-54-3	16,200	--	--	--	--	--	--	--

Chemical(s)	CAS No.	$^{EM}HBAL_{10min}$ (ppb)	ACGIH STEL (ppb)	CAL/OSHA STEL (ppb)	NIOSH STEL (ppb)	ACGIH C (ppb)	CAL/OSHA C (ppb)	NIOSH C (ppb)	OSHA C (ppb)
Hydrochloric Acid	7647-01-0	1,000	--	--	--	2,000	2,000	5,000	5,000
Hydrogen Sulfide	7783-06-4	210	5,000	15,000	--	--	--	--	--
Isobutane	75-28-5	99,000	1,000,000	--	--	--	--	--	--
n-Octane	111-65-9	12,300	--	375,000	375,000	--	--	--	--
Propane	74-98-6	--	--	--	--	--	--	--	--
Propylene	115-07-1	--	--	--	--	--	--	--	--
Sodium Hydroxide	1310-73-2	15	--	--	--	1,200	1,200	1,200	--
Styrene	100-42-5	10,000	20,000	100,000	100,000	--	--	--	--
Sulfur Dioxide	7446-09-5	--	250	5,000	5,000	--	--	--	--
Sulfuric Acid	7664-93-9	90	--	--	750	--	--	--	--
Toluene	108-88-3	12,000	--	150,000	150,000	--	--	--	--
Vinyl Chloride	75-01-4	216,000	--	--	--	--	--	--	5,000 [a]
Xylenes + Ethylbenzene	1330-20-7 + 100-41-4	15,000	--	--	--	--	--	--	--
Xylenes	1330-20-7	15,000	150,000	150,000	150,000	--	--	--	--

[a] Basis not yet verified, but is likely based on protection against long-term exposures that can cause cancer and therefore, the OSHA ceiling value was not considered; ACGIH – American Conference of Governmental Industrial Hygienists; C – ceiling value; Cal/OSHA – California Division of Occupational Safety and Health; $^{EM}HBAL_{10min}$ – 10-minute exposure mitigation health-based action level; NIOSH – National Institute for Occupational Safety and Health; OSHA – Occupational Safety and Health Administration; ppb – parts per billion; STEL – 15-minute short-term exposure limits; and "--"no value available.

Appendix F: List of the available $^{EM}HBALs_{10min}$, $^{EM}HBALs_{1hr}$, and AEGLs

Chemical(s)	CAS No.	$^{EM}HBAL_{10min}$ (ppb)	10 min AEGL-1 (ppb)	10 min AEGL -2 (ppb)	10 min AEGL-3 (ppb)	$^{EM}HBAL_{1hr}$ (ppb)	60 min AEGL-1 (ppb)	60 min AEGL -2 (ppb)	60 min AEGL-3 (ppb)
Acetylene	74-86-2	75,000	--	--	--	50,000	--	--	--
Ammonia	7664-41-7	2,550	30,000	220,000	2,700,000	1,700	30,000	160,000	1,100,000
Benzene	71-43-2	500	130,000	2,000,000	9,700,000	360	52,000	800,000	4,000,000
1,3-Butadiene	106-99-0	2,500	670,000	6,700,000	27,000,000	3,400	670,000	5,300,000	22,000,000
Butane	106-97-8	276,000	10,000,000	24,000,000	77,000,000	184,000	5,500,000	17,000,000	53,000,000
1-Butene	106-98-9	81,000	--	--	--	54,000	--	--	--
C3-C4 Saturated	--	--	--	--	--	--	--	--	--
Chlorine	7782-50-5	200	500	2,800	50,000	140	500	2,000	20,000
Cyclohexane	110-82-7	3,000	--	--	--	2,000	--	--	--
Ethylbenzene	100-41-4	60,000	33,000	2,900,000	4,700,000	40,000	33,000	1,100,000	1,800,000
Ethylene Dichloride	107-06-2	1,000	--	--	--	1,080	--	--	--
Ethylene Glycol	107-21-1	5,700	--	--	--	3,800	--	--	--
Ethylene Oxide	75-21-8	2,500	NR	80,000	360,000	1,820	NR	45,000	200,000
Formaldehyde	50-00-0	50	900	14,000	100,000	88	900	14,000	56,000
n-Hexane	110-54-3	16,200	NR	4,000,000	12,000,000	10,800	NR	2,900,000	8,600,000

Chemical(s)	CAS No.	$^{EM}HBAL_{10min}$ (ppb)	10 min AEGL-1 (ppb)	10 min AEGL -2 (ppb)	10 min AEGL-3 (ppb)	$^{EM}HBAL_{1hr}$ (ppb)	60 min AEGL-1 (ppb)	60 min AEGL -2 (ppb)	60 min AEGL-3 (ppb)
Hydrochloric Acid	7647-01-0	1,000	1,800	100,000	620,000	880	1,800	22,000	100,000
Hydrogen Sulfide	7783-06-4	210	750	41,000	76,000	140	510	27,000	50,000
Isobutane	75-28-5	99,000	--	--	--	66,000	--	--	--
n-Octane	111-65-9	12,300	--	--	--	8,200	--	--	--
Propane	74-98-6	--	10,000,000	17,000,000	33,000,000	--	5,500,000	17,000,000	33,000,000
Propylene	115-07-1	--	--	--	--	--	--	--	--
Sodium Hydroxide	1310-73-2	15	--	--	--	10	--	--	--
Styrene	100-42-5	10,000	20,000	230,000	1,900,000	10,200	20,000	130,000	1,100,000
Sulfur Dioxide	7446-09-5	--	200	750	30,000	--	200	750	30,000
Sulfuric Acid	7664-93-9	90	50	2,170	67,310	60	50	2,170	39,890
Toluene	108-88-3	12,000	67,000	1,400,000	10,000,000	8,000	67,000	560,000	3,700,000
Vinyl Chloride	75-01-4	216,000	450,000	2,800,000	12,000,000	144,000	250,000	1,200,000	4,800,000
Xylenes + Ethylbenzene [a]	1330-20-7 + 100-41-4	15,000	130,000	2,500,000	7,200,000	10,000	130,000	920,000	2,500,000
Xylenes	1330-20-7, 106-42-3, 95-47-6	15,000	130,000	2,500,000	7,200,000	10,000	130,000	920,000	2,500,000

[a] Based on xylenes; AEGL – acute exposure guideline level; $^{EM}HBAL_{1hr}$ – 1-hour exposure mitigation health-based action level; $^{EM}HBAL_{10min}$ – 10-minute exposure mitigation health-based action level; NR – not recommended (see AEGL document); ppb – parts per billion; and "--"no value available.