This document references Chapters and Sections from the ITRC Vapor Intrusion Technical and Regulatory Guidance, and Fact Sheets and Technology Information Sheets from the ITRC Vapor Intrusion Toolkit, published January 2026. These resources can be accessed at: **https://itrcweb.org/vapor-intrusion-toolkit**.

REAL-TIME MONITORING FACT SHEET

Introduction

Vapor intrusion (VI) data sets consisting of a small number of soil vapor and/or indoor air analyses per site/building can be difficult to interpret. Cost and access limitations can preclude a larger number of sampling locations and/or multiple rounds of data collection. For sites with these challenges, real-time data collection tools may be a good option to assess for VI. This fact sheet presents several technologies available for real-time monitoring (RTM), as well as their advantages and disadvantages. For the purposes of this fact sheet, RTM refers to monitoring for which all analysis and data evaluation occurs on site so that results can be acted upon, if necessary.

Real-Time Analyzers

A variety of real-time analyzers exist, including the following:

- Handheld portable detectors (e.g., photoionization detectors [PIDs])
- Automated sample collection gas chromatographs (GCs) equipped with various detectors / portable mass spectrometers (GC/MS)
- Field mobile systems, which may include various types of MSs deployed in repurposed vehicles, such as the following:
    - Proton transfer reaction MS
    - Ion trap MS
    - Cavity ring spectrometers

Table 1 and **Figure 1** through **Figure 3** provide examples. Each analyzer will have levels of applicability related to their sensitivity, compound selectivity, field robustness, cost, and overall project objective. As such, it is important to understand what questions practitioners are trying to answer.

Many handheld portable detectors are ideal for initially screening a site for potential VI but are not appropriate for collecting data in support of risk assessments or mitigation design/confirmation. Many of these will have applicability that is limited by their sensitivity or cost. For example, compounds such as trichloroethene (TCE), tetrachloroethylene (PCE), and vinyl chloride have indoor vapor screening levels below the sensitivity of a PID. Other types of detectors (e.g., electron-capture dissociation [ECD] and dry electrolytic conductivity detector [DELCD]) and analytical methods (e.g., U.S. Environmental Protection Agency [USEPA] Method 8021) commonly used by field GC operators allow for on-site analysis of these compounds with detection levels below agency screening levels. The on-site analysis performed by some of these tools can provide real-time detection of vapor-forming compounds (VFCs) that allow practitioners to locate vapor entry pathways (i.e., preferential pathways as described in **Chapter 4: Conceptual Site Model** of the Interstate Technology & Regulatory Council's (ITRC's) *Vapor Intrusion Toolkit* and to distinguish between VI and indoor sources.

Table 1. List of handheld and laboratory devices used as part of vapor intrusion evaluations.

Detector Acronym	Detector Name	Principal	Specificity	Sensitivity	Comments
DELCD	Dry electrolytic conductivity detector	Relies on unique properties of the chlorine and/or bromine released by high-temperature reaction of the input gas. The response is proportional to the concentration of chlorine and/or bromine in the sample.	Responds to all chlorinated and brominated compounds.	High for CVOCs and no response to most PHCs	Currently, the only field option for measuring indoor vinyl chloride to the detection levels required by most agencies.
ECD	Electron capture detector	Uses a small beta emitter to generate electrons that are captured by analytes with a high electronegativity, and the response is proportional to the concentration of those charged analytes.	Only responds to molecules containing halogen atoms (e.g., chlorine).	Very sensitive to molecules containing 3 or more chlorine atoms such as PCE and TCE.	• GC-ECD is often used to study indoor air at PCE and TCE sites. • It contains a 10 microcurie radioactive source that may require some additional certification. • GC-ECD’s dynamic range is narrower than GC-MS; therefore, stability may be an issue, and special attention should be paid to instrument calibration.
FID	Flame ionization detector	The sample is subject to a flame, and the response is proportional to the intensity of the flame.	Very limited—responds to anything it can burn; often used to give a TPH concentration if used with a GC.	Variable, but still limited	
PID	Photoionization detector	Exposes the sample to a light bulb, and the intensity of the response is proportional to the concentration of gases in the sample with an ionization potential equal to or less than the energy of the light provided by the bulb.	Depends on the choice of bulb used, but ideal for BTEX and CVOCs.	Variable, but still limited	• Not sufficiently sensitive for compliance measurements. • May help identify VI pathways for many common chemicals. • Isobutylene is often used to calibrate a PID. • When evaluating for a target chemical, a conversion factor may be needed. Refer to the manufacturer’s instructions for applicable conversion factors.
MS	Mass spectrometer	Identify the sample constituents by mass/charge ratio.	High; often coupled with GC to achieve separation of constituents and more accurate identification.	High	• Too heavy to be handheld but available as a portable GC-MS. Analysis by GC-MS is routine work at certified environmental laboratories.

Notes: BTEX = benzene, toluene, ethylbenzene, and xylenes; CVOC = chlorinated volatile organic compound; GC = gas chromatograph/chromatography; GC-ECD = gas chromatograph / electron-capture detector; GC-MS = gas chromatograph / mass spectrometer; PCE = tetrachloroethene (also called perchloroethene and tetrachloroethylene); PHC = petroleum hydrocarbon; PID = photoionization detector; TCE = trichloroethylene or trichloroethene; TPH = total petroleum hydrocarbons; VI = vapor intrusion.

Flexibility afforded by real-time field measurements enables the collection of additional sampling locations, rapid recognition of temporal variability, measurement of leak-test compounds to ensure valid soil vapor samples are collected, and adjustment and adaption by field personnel in real time. For instance, when field screening indicates total volatile organic compounds (VOCs) are in excess of 1,000 parts per million, field personnel can opt to switch from an evacuated canister (which is analyzed via USEPA Method TO-15) to an absorbent tube (which is analyzed via USEPA Method TO-17). They can also begin evaluating potential remedies while still deployed.

Handheld Instruments

Simple portable instruments can provide both qualitative and quantitative data, depending upon the target compound and the required detection levels. Handheld field meters, such as PIDs, multi-gas meters, flame ionization detectors, and colorimetric (Draeger) tubes are available tools for collecting screening data prior to or during the sampling process when high parts per million by volume concentrations are expected. The collection of field measurements from indoor air sampling points, soil vapor probes, or soil can play an important role in evaluating VI at a site. For example, PID readings collected from soil cuttings, known as "headspace readings," can help direct field personnel when determining the best depth intervals to install vapor probes during the drilling process.

Most handheld field-screening instruments are limited to the parts per million by volume range for VFCs, which may not provide sufficient resolution and can result in false negative results. Helium detectors are available with a range of 0.01%–100% by volume.

When using these meters to collect screening data in the field, personnel should take a few steps/precautions:

- A multi-gas meter may be better suited for soil vapor sampling, whereas a PID may be better for soil sampling. This includes different versions of the same meter. When sampling soil vapor, a PID set to read in parts per million may suffice, but for indoor air, parts per billion is better. PIDs use a high-energy ultraviolet (UV) light source to ionize compounds and come with a variety of lamps that vary in ionization potential (measured in electron-volts [eV]). The most common (default) is the 10.6 eV lamp, but 9.8 eV (limited chemicals detected) and 11.7 eV (broad range of chemicals detected) are also available. PIDs will only detect chemicals that can be ionized by the UV lamp in the respective unit, so selecting the appropriate lamp eV is critical for detection of the site VFCs.
- At a minimum, always calibrate the meter at the beginning of a field day. Most manufacturers also recommend checking the calibration of the meter throughout the day, particularly after a series of elevated readings, and at the end of the day.
- Always know the action levels for a given contaminant. These should be established and easily found in the health and safety plan for a site.
- When collecting headspace readings from soil, be sure to allow the soil to sit in the sample container for at least 10 minutes to allow for VFCs to come to equilibrium within the headspace of the sample container.
- Never attach the handheld meter directly to the tubing of a soil vapor probe. Soil vapor should first be collected in a separate container (e.g., an air sampling bag or syringe), and then the reading should be collected from said container.

Photographs of some of these handheld logging tools are shown in Figure 1.

Figure 1. Examples of handheld screening devices for use in the field, including two photoionization detectors (top left and bottom left), two multi-gas meters (top center and top right), a flame ionization detector (middle left), colorimetric gas detection tubes with pump (middle center and middle right), and an MGD-2002 helium detector (bottom right).

Source: Pine Environmental, LLC, used with permission.

Portable Field Gas Chromatographs

Real-time chemical analyzers vary in design, output, accuracy, and application; thus, not all analyzers are appropriate for all types of investigations. As presented in **Section 2.2** of ITRC's *Vapor Intrusion Toolkit*, although several real-time analytical devices have been commercially available for decades, most are not analyte-specific and have been more suitable for general screening purposes. In recent years, newer portable GC and GC/MS devices have been introduced that meet very specific chemical detection objectives. Several of these are capable of detecting and quantifying specific VFCs. These devices use GC to separate chemical compounds in a mixed chemical gas stream.

A GC is typically composed of tubing with an internal coating to separate mixtures of chemicals into specific compounds of interest that can be identified by the time required for each compound of interest to pass through the column. In general, compounds with heavier molecular weight pass through the column later than lighter compounds. Some GC devices are equipped with a stream selector valve that allows for automated sampling and analysis from multiple locations with a single analytical instrument (Eklund and Hale 2020; Hosangadi et al. 2017; Kram et al. 2016; 2019; 2020; 2022) and adhere to USEPA Method TO-14A protocol. The sensitivity and selectivity will depend upon the analytical method used.

When continuous monitoring for VFC concentrations with a GC and appropriate detector is conducted, sampling tubing is deployed between the stream selector valve and the specific sampling location, which is commonly referred to as the "data collection point" (**Figure 2**). Sample tubing can be run along walls, over cubicles, along ceiling beams, and through windows (e.g., to capture and measure outside air samples) and to sub-slab ports and to other areas within and outside of buildings where VFC concentration measurements are of interest.

The tubing is connected to a stream selector valve on the GC via sample inlets, as shown in **Figure 2** and **Figure 3**. Once the tubing is set in place and connected to the monitoring system, pumps are programmed to automatically draw samples for analyses (see **Figure 2**). Before each sample is analyzed by the GC, lines are purged, and samples are drawn from the next location in the sequence as part of the continuous monitoring process. Once a sample is automatically collected and injected into the GC, the valve rotates to the next port in the sequence and repeats the process.

Figure 2. Automated gas chromatography sample tubing deployment (left) and the monitoring system in the field with tubing connected to stream selector valve sample inlets (right). Note that each tubing run is labeled and assigned a valve port so that each analytical result is associated with a specific monitoring location.

Source: VaporSafe, used with permission.

Depending on the timing requirements for the analyses, it is common to automatically analyze up to 150 samples per day for key VFCs (e.g., PCE, TCE, and vinyl chloride) with this configuration. For some projects it is desirable to dedicate a port to a calibration standard prepared to track instrument stability. Several of the commercially available portable field GC and GC/MS devices are shown below in [Figure 3](#).

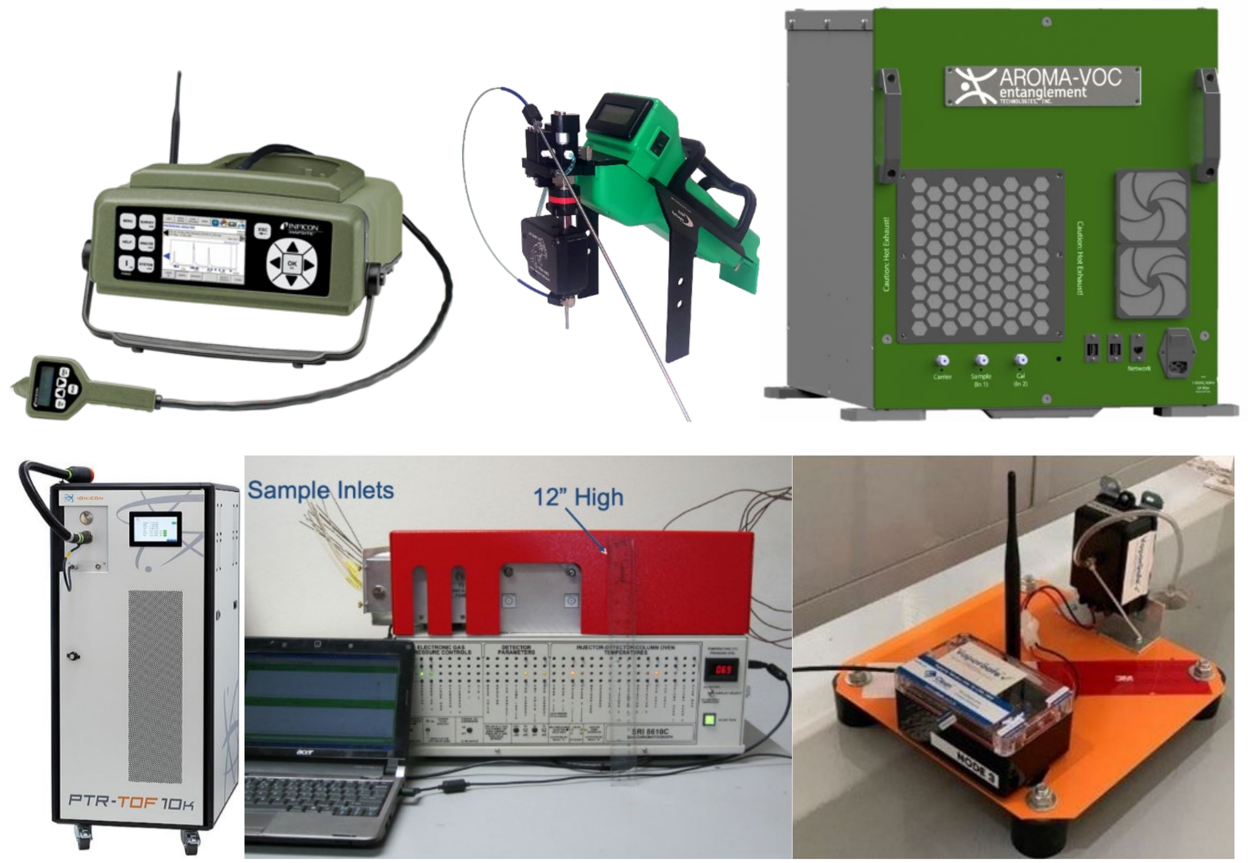

Figure 3. Inficon Hapsite (top left), Defiant Technology’s portable gas chromatograph/frog (top middle), cavity ring-down spectroscopy system (top right), proton transfer reaction mass spectroscopy system (bottom left right), automated continuous field gas chromatograph with stream selector valve and internet connection (bottom middle), wireless differential pressure sensor connected to subsurface port (bottom right).

Sources in same order: Inficon, Defiant Technology, Entanglement Technologies, Ionicon, and VaporSafe, used with permission.

An important advantage to using a portable GC or GC/MS is the ability to collect location-specific continuous monitoring data in a reduced number of mobilizations, which, for some projects, can greatly reduce costs, risks, and liabilities. These data can be useful for answering key VI-related questions, often in a single mobilization (see [Mobile Laboratories](#) section below). For instance, real-time continuous location-specific data allows for identifying problem buildings, locations of vapor entry and transport pathways, and indoor sources of VFCs; evaluating mitigation performance; and empirically estimating the range of building-specific attenuation factors (AFs) as well as factors controlling concentration dynamics (e.g., “controlling factors”). When data are automatically collected over time, continuous analyzers can determine temporal variations both indoors and below foundations. These can also be used to initially screen buildings for potential indoor VFC sources. Larger data sets allow trends in the results to be recognized and correlated to other variables such as pressure differential, barometric pressure trend (Kram and Solgi 2025), wind speed, and heating, ventilation, and air conditioning (HVAC) system operation, and they allow forensic approaches to be applied.

Currently, less-common real-time on-site analytical methods can also be used to meet specific VI investigative objectives. These include mobile spectrometer systems (e.g., proton transfer reaction MS, ion trap MS, cavity ring, and USEPA's trace atmospheric gas analyzer platform). In addition, continuous monitoring systems can be used during building pressure control, high-purge volume sampling, and for monitoring radon (radon-222), thoron (radon-220), hydrogen, and other types of tracer tests. Some of these approaches can be operated in continuous monitoring mode, while others require manual sampling prior to on-site analysis.

Detectors operate via various physical and chemical principles related to interrogation as the contaminants of concern are introduced to the detectors. For instance, some chemicals emit photons, some absorb photons, some will yield unique signals when exposed to electrical current, some will yield a unique signal following a reaction, and others will break compounds apart into unique fragments that can be identified based on weight. Detailed discussion of detection principles is beyond the scope of this document but can be found in the literature.

Several options exist for identifying vapor entry pathways through building foundations. One of these includes use of a chemical screening method and collection of measurements along foundation cracks, utility penetrations, expansion joints, and floor drains. Analytical approaches include using a direct GC/MS measurement at the suspected vapor entry location as well as discrete sample collection with a glass syringe and direct injection into a compound-specific analyzer such as a field GC equipped with an ECD, DELCD, MS, or other type of detector. It is critical that the analytical system be calibrated for the specific chemicals of concern and that at least one calibration standard be of a concentration below the desired screening level. While searching for potential vapor entry pathways such as cracks, utility penetrations, expansion joints, and floor drains can be productive, it is important to recognize that materials can pass through foundation locations that may not be obvious. For instance, removing power outlet plates and sampling in wall spaces is recommended when attempting to locate vapor entry pathways, as the flooring is not always sealed within those spaces. In addition, chemicals spilled during past operations can be impregnated into foundation materials and continue to off-gas, which can lead to confusing results. As such, one good option includes starting with a continuous monitoring campaign comprising multiple data collection points (Kram et al. 2019). These data can be mapped or contoured to provide important clues regarding where to direct a more focused measurement and confirmation effort.

For the very low levels of detection required for some of the more common VI compounds of concern (particularly for indoor air samples), preconcentration may be required. This often consists of flowing sampled air over a trap that is then allowed to release the compounds prior to being run through a GC and ultimately introduced to the detector. Depending on the specific compounds of interest, whether the sample is from the subsurface or indoor environment, and the level of sensitivity and range of chemical concentrations encountered at a site, some devices will be better suited than others. In addition, it is important to consider that carry-over can occur when a sample with elevated concentration is analyzed prior to a sample with lower concentration. Carry-over describes a situation where sampled material remains in the analytical system or device vapor flow path before the next sample is analyzed. This residual material can result in a higher concentration reading than the true concentration. As such, careful quality control that includes heating of the trap for sufficient durations and frequent blank and calibration analytical runs are recommended when real-time and continuous analyzers are deployed in situations where elevated concentrations might be encountered.

Given that VI is dynamic, when searching for vapor entry pathways it is important to time the monitoring and sampling efforts to coincide with conditions favorable to VI. This can be achieved by tracking differential pressure across the foundation and confirming that upward flux conditions are occurring, by timing the campaign to coincide with a rapidly dropping barometric pressure, or by artificially adjusting the pressure gradient between the building and subsurface. For instance, building pressure control or HVAC adjustment can be set to encourage upward vapor flux while monitoring the spatial distribution of indoor vapors and while confirming vapor entry pathways using the various continuous and discrete measurement options described above.

When data patterns such as contour images of VOC concentration spatial distributions reveal potential vapor entry locations, discrete measurement with syringe samplers and chromatographic analyses can be used to verify these pathways. Handheld devices may also be used in situations where elevated concentrations are migrating through the preferential pathway. When walls serve as potential conduits for vapor pathways (e.g., vapors pass through the foundation behind walls), removing electrical utility plates to sample can be very helpful. In some cases, removal of sections of drywall can allow for access to vapor entry pathways.

Once a potential vapor entry pathway has been located, verification can be achieved by covering that portion of the foundation with plastic sheeting and performing continuous VOC monitoring.

Mobile Laboratories

For sites that require lower detection limits, particularly for soil vapor and sub-slab vapor, practitioners may choose to use mobile laboratories, which are capable of producing near real-time data while meeting fixed laboratory method-required quality assurance/quality control. These mobile units, as shown in **Figure 4** and **Figure 5**, are equipped with laboratory-grade instruments, including GCs and MSs, and are capable of detection limits as low as 0.1–100 micrograms per cubic meter (µg/m^3). Mobile laboratory samples are typically collected from temporary and/or permanent soil vapor and/or sub-slab vapor probes. For details on probe installation methods, refer to the **Soil Vapor Probe Installation Toolbox Fact Sheet**. For additional information on sampling and analytical methods used by mobile laboratories, refer to **Sections 7.2.3**, **7.4**, and **10.0** of ITRC's *Vapor Intrusion Toolkit*.

Figure 4. Exterior (top) and interior (bottom) of a typical mobile laboratory.

Source: H&P Mobile Geochemistry, used with permission.

Figure 5. Mobile laboratory technician inserting a vapor sample into the mass spectrometer.

Source: H&P Mobile Geochemistry, used with permission.

Applying Real-Time Monitoring

There are many types of real-time measurement devices that allow for the rapid assessment of concentration at a specific location at a specific time. Not all of these are appropriate for monitoring, where the objective is to evaluate changes in concentration over time. To monitor, the measurement device should be stable (i.e., holds calibration), appropriate for the range of anticipated concentrations, and capable of alerting practitioners when the device requires maintenance or attention. This is particularly important when building occupants may be exposed to chemicals considered to be acute risk drivers.

Monitoring data collected during a single mobilization can reveal answers to fundamental questions, such as the following:

- Is there an indoor chemical risk level exceedance?
- Is the exceedance due to an indoor source or to VI?
- Where/what is the indoor source?
- Where and when are vapors entering the building?
- Did the remedy meet risk-reduction objectives in all areas where potential exposure might occur?

There are also a number of important limitations of RTM to consider:

- **Access limitations:** At many sites, the time during which samples can be collected is very restricted. The window of time available may make RTM either impractical or impossible. Further, it may not be possible to coincide the sampling with the barometric pressure events RTM is often used to explore.
- **Correlation not causation:** Employing RTM is a significant effort. RTM may help identify a correlation, but RTM alone is not enough to uncover a causality. RTM is often part of the data collection process used to uncover that causality, but it will need to be combined with other project management tools.
- **Availability and cost:** Although RTM data may be helpful, there are other ways to get similar data that are not real time. At many sites the resources are not available to employ RTM, and while this may extend the project timeline, it by no means is an insurmountable obstacle.
- **Finite limitations:** RTM produces an abundance of data in a short time, but it is still important to consider optimal timing. Further, when evaluating RTM data, it is important to realize it may not have coincided with relevant occupant actions.

Some RTM devices can be operated in both an automated, continuous fashion and a discrete mode in which the instrument is dedicated to analysis of samples on an ad hoc basis. This can be useful when an unexpected detection is registered during monitoring and there is a need to identify the source. For instance, when monitoring continuously and automatically with a multiplexed GC, following a detection in a specific building location, the GC can be reset to discrete mode, and samples can be manually collected and directly injected into the instrument for a rapid analysis.

Discrete mode can also be used to efficiently determine the spatial distribution of the subsurface concentrations. This is accomplished by sampling sub-slab access ports and directly injecting the samples into the GC for analysis. Since analytical runs typically only require 10 minutes or less to measure common chemicals such as PCE or TCE and daughter products such as dichloroethane, trichloroethane, and vinyl chloride, the spatial distribution of subsurface concentrations can typically be determined in one field day for most buildings without having to wait for laboratory results.

Several types of monitoring systems are equipped with an internet connection and software that automatically uploads data to the web, triggers alerts, turns on machines (e.g., blowers or samplers, etc.), and processes the data into report-ready graphical formats. This allows stakeholders to remotely collaborate and track project progress. The monitoring data can also be combined with other types of dynamic measurable controlling factor data such as differential pressure across the foundation, temperature, barometric pressure trend, wind speed and direction, and radon (Figure 6). Combining this kind of multivariate data through a web browser can help move the project forward by providing answers to the questions above.

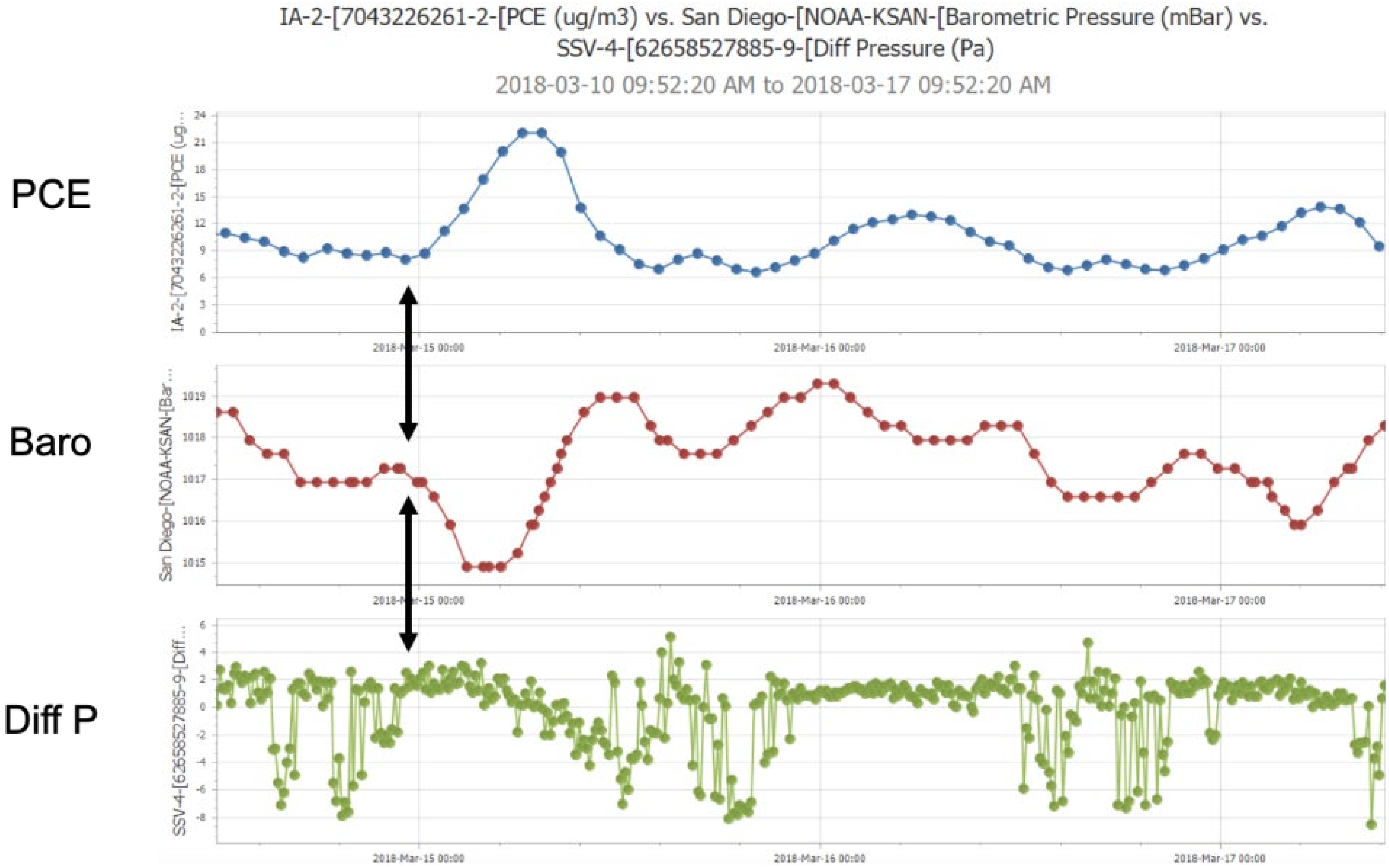

Figure 6. Web dashboard stacked time-series display of real-time PCE, barometric pressure, and differential pressure. Arrows depict inflection point where barometric pressure drops, differential pressure exhibits upward vapor flux conditions, and indoor PCE concentration rises.

Source: Team VaporSafe, used with permission.

Measurement Timing

Indoor air concentration of volatile chemicals can be dynamic and spatially variable (Holton et al. 2013; Hosangadi et al. 2017; Kram et al. 2019; 2020; 2022; USEPA 2015). One of the challenges that must be faced in VI investigations is deciding whether the variability is nonspecific noise or if that variability is due to the variations in some controlling factor. One way to do this is by combining data from concentration measurements with data from other sources. RTM can be used here to expedite this process.

The USEPA's Indicator, Tracer, Surrogate (ITS) program focuses on the use of readily obtainable data to improve sample and measurement timing. One approach advocated by ITS includes the application of indicators and surrogates to improve sample timing to coincide with conditions most likely to produce controlling factors that result in upward advective flow of VFCs into the building. Examples would include simultaneously collecting data on radon concentration, barometric pressure trend, differential pressure, and temperature. In certain cases, even tidal movement is a potential controlling factor, so tidal data are collected. The sampling event is then scheduled based on data patterns found in the data produced by these measurements.

When the barometric pressure begins to drop, upward flux of vapors into overlying buildings can occur (**Figure 7** and **Figure 8**) (see Hosangadi et al. 2017; Kram et al. 2019; 2020; 2022). Differential and barometric pressure trends, when combined with concentration patterns, allow practitioners to distinguish between VI and indoor sources of VFCs by using the ITS approach (**Figure 9**). Recent efforts have demonstrated that the rate of barometric pressure drop can correspond to building-specific maximum differential pressure and maximum indoor VOC concentration observed over a specific monitoring duration (Kram and Solgi 2025). In some cases, these can be linearly correlated. Documenting this type of empirical building-specific correlation allows practitioners to predict indoor concentrations based on historical or upcoming barometric pressure patterns.

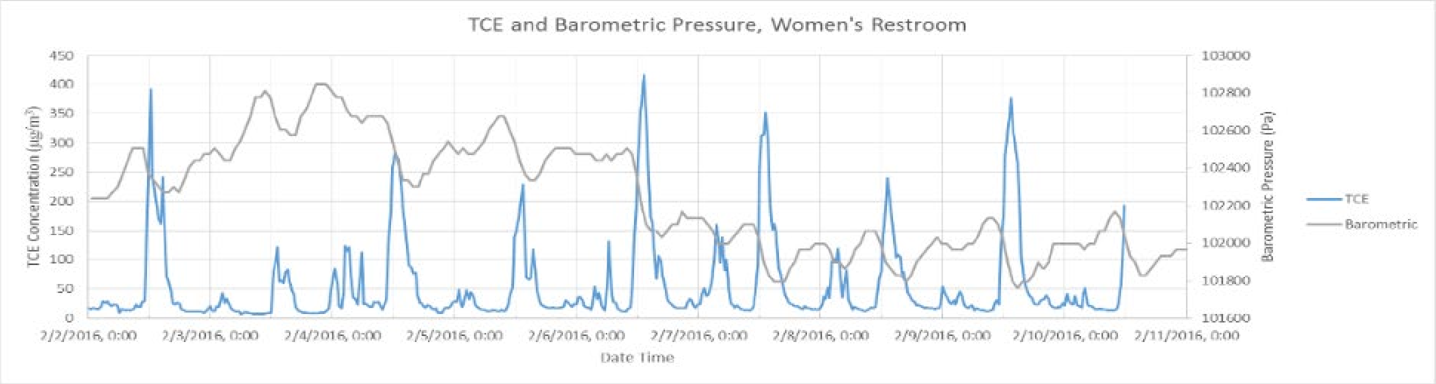

Figure 7. Indoor TCE versus barometric pressure.

Source: Hosangadi et al. (2017).

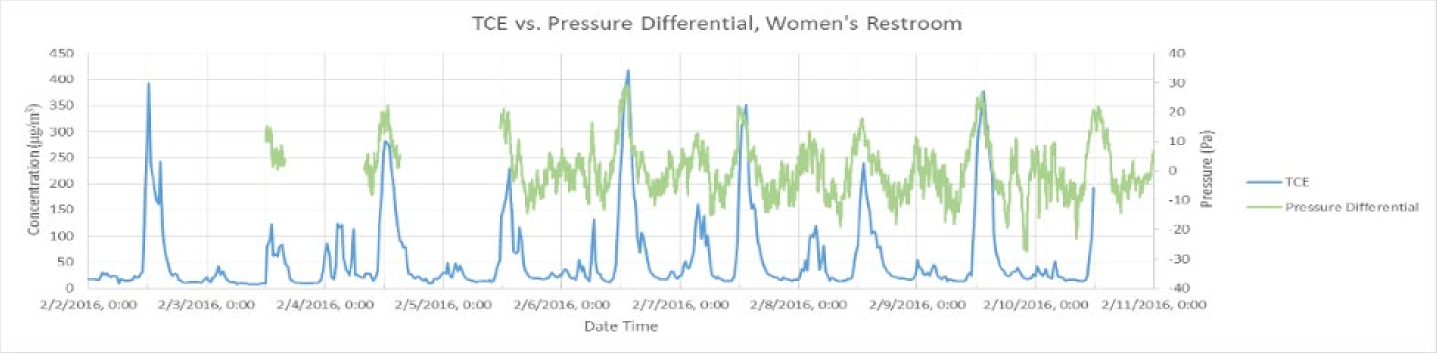

Figure 8. Indoor TCE versus differential pressure.

Source: Hosangadi et al. (2017).

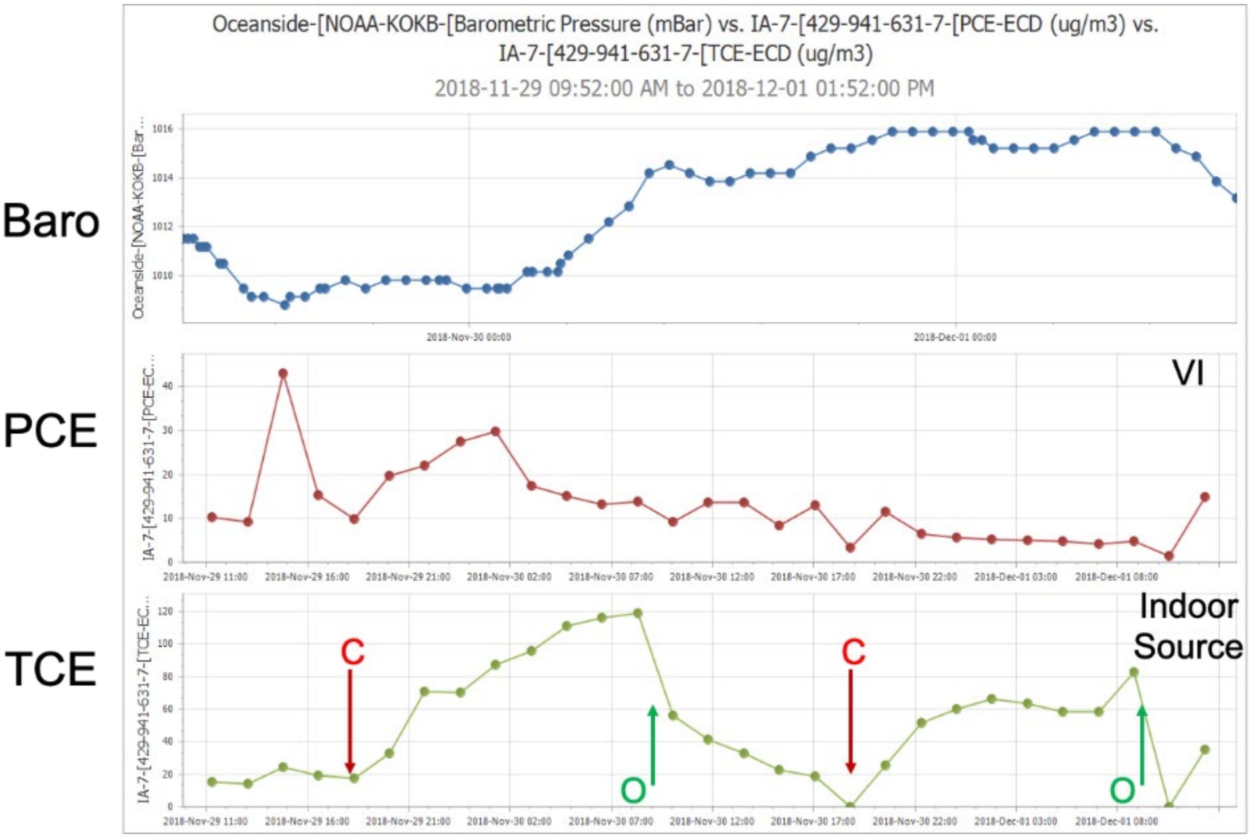

Figure 9. Stacked time series of barometric pressure, PCE, and TCE. PCE drop correlates with barometric pressure rise, indicating that PCE is from vapor intrusion. The TCE pattern coincides with closing and opening of the business, indicating that TCE is from an indoor source and not from vapor intrusion.

Source: Team VaporSafe, used with permission.

Determination of Attenuation Factors Using Continuous Monitoring with Controlling Factors

Every building exhibits a unique range of AF values. Dynamic indoor air concentrations can range by several orders of magnitude and typically depend upon whether upward vapor flux conditions exist and the proximity of the sample collection location to the vapor entry location. Subsurface concentrations are typically less dynamic than indoor concentrations. When releases originate from a building under investigation, spatial variability of subsurface VFC concentrations can be significant (e.g., multiple orders of magnitude). Investigations can therefore be performed to determine a range of empirical building-specific AF values that account for indoor air concentration dynamics and indoor air and subsurface spatial variability. More specifically, high-frequency continuous monitoring of chemical and physical parameters and controlling factors can be performed in lieu of the use of a default screening AF value.

To determine building-specific AF estimates, a laboratory-grade multiplexed continuous analytical monitoring and response platform can be deployed to measure indoor air and subsurface vapor concentrations at frequencies sufficient to capture changing pressure conditions (Kram et al. 2020) and to address uncertainties inherent to building-specific AF estimates based on randomly timed time-integrated samples under temporally dynamic and spatially variable conditions. The continuous monitoring technology uses a multiplexed GC analyzer to generate spatial and temporal concentration patterns as well as concurrent patterns of VI-controlling factors such as temperature, barometric pressure, and differential pressure trends across a building foundation. Specific detectors are selected based on the compounds of interest, the anticipated concentration range, and other logistical requirements. The data management component can be integrated with a cloud-based internet of things dashboard, which provides project teams with immediate access to field analytical results and measurements that have been telemetered, mapped, and archived for remote on-demand web access. The combination of stable analytical components, high-frequency automated continuous chemical and physical parameter monitoring, and automated real-time web-based processing and visualization serves to expedite assessment and derivation of conclusive responses to key questions while field efforts are in progress. Pairing of dynamic indoor air and subsurface concentrations with coincident controlling factors over a few days of monitoring allows for determination of a range of building-specific AF values.

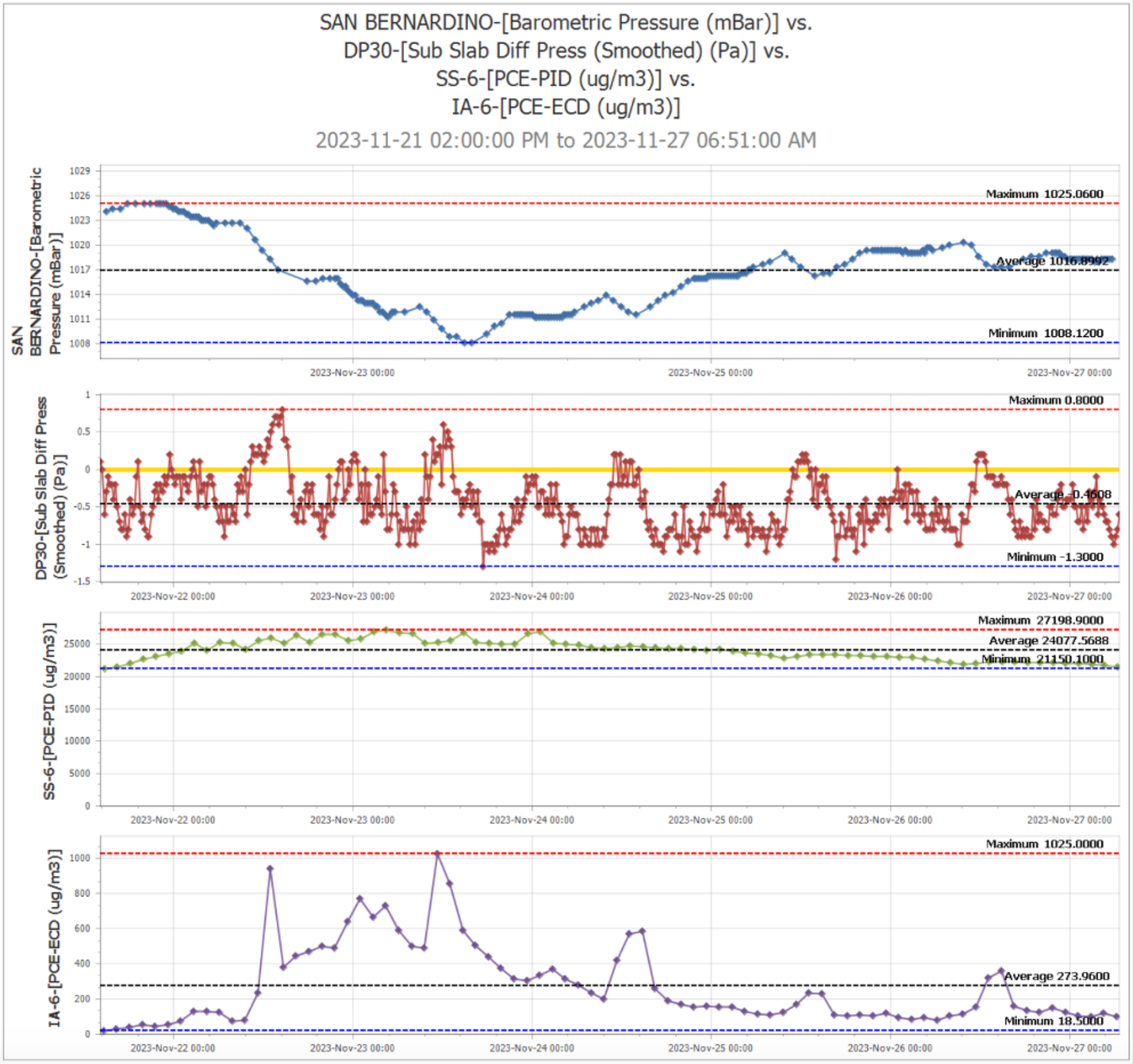

Figure 10. Stacked time-series charts for simultaneous continuous monitoring of barometric pressure, differential pressure, sub-slab PCE concentration indoor, and indoor air PCE concentration.

Source: Team VaporSafe, used with permission.

Figure 10 displays continuous monitoring results that include barometric pressure, differential pressure across the foundation, sub-slab PCE vapor concentration measured via GC/PID, and indoor air concentration measured by GC/ECD. All data were collected concurrently. For this building, a drop in barometric pressure induces a rise in differential pressure and a coincident rise in indoor air concentration. Conversely, a rise in barometric pressure coincides with a drop in differential pressure and indoor air concentration. Absolute values of indoor air concentration and coincident sub-slab PCE concentration can be used to estimate empirical building-specific AF values and an average AF estimate over a select time range.

When estimating building-specific AF, it is important to determine the spatial distribution of the subsurface concentration, as this can have a profound impact on the results. For instance, sub-slab and indoor sample pairs located closer to the source area will exhibit a lower AF result than sample pairs located some distance away from the source. This is because the concentration range for indoor samples can be far less than the concentration range observed in the subsurface soil vapors—particularly for buildings overlying or near the source area. As such, as one moves farther from the source area, the subsurface concentration drops more significantly than the indoor concentration, so the ratio of indoor concentration divided by the subsurface concentration (the AF estimate) increases. Figure 11 shows how this was observed at a warehouse where the source area was located at one side of the building. More specifically, the farther from the source area the sample pairs were located, the higher the resulting AF estimate.

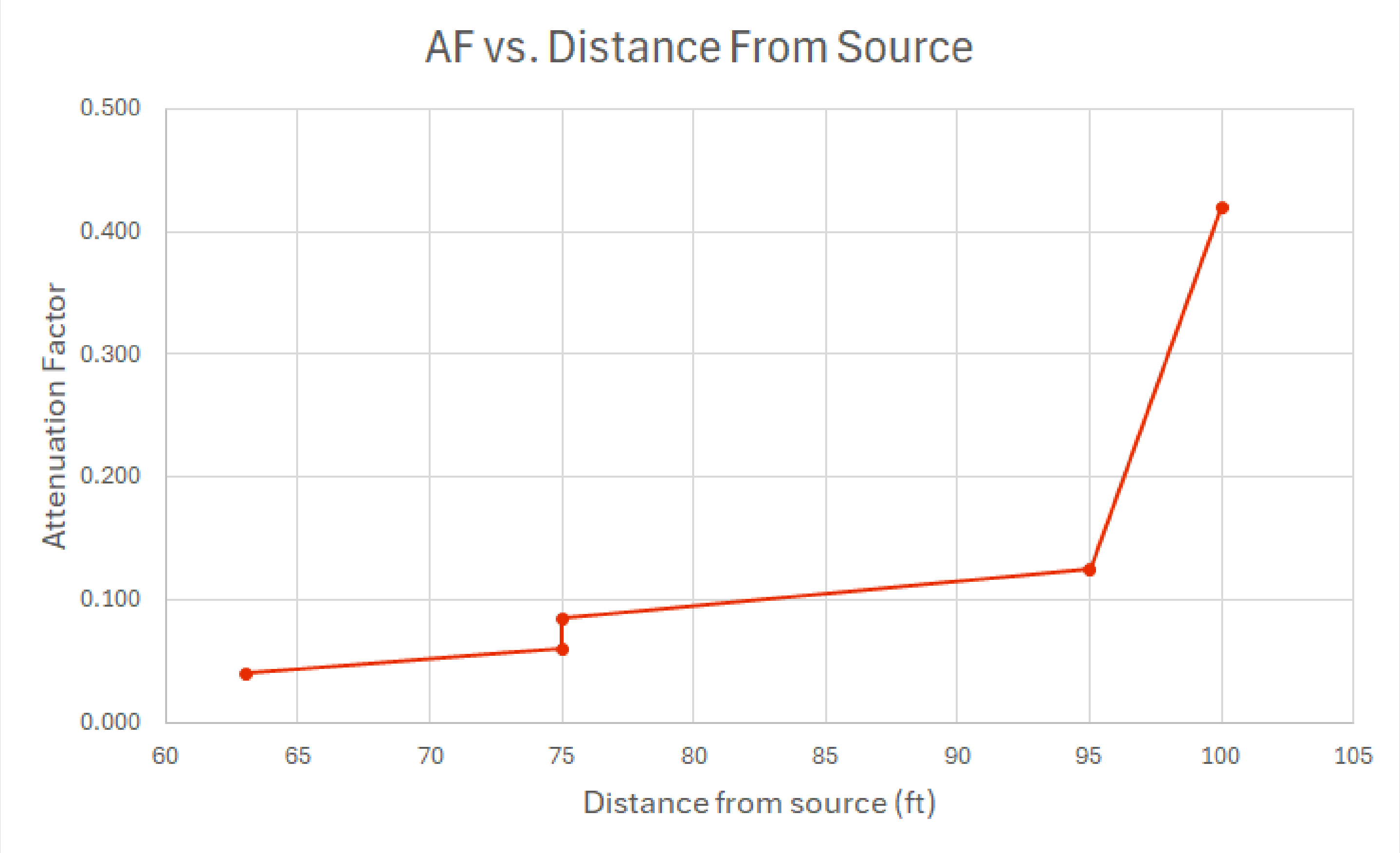

Figure 11. AF estimates vs. distance from source area for five sample pairs at a warehouse in Southern California.

Source: Team VaporSafe, used with permission.

Examples of How High-Frequency Continuous Monitoring Time-Series Graphs Can Assist vapor Intrusion Investigations

Example 1: Distinguishing Between Indoor Sources and Vapor Intrusion

High-frequency continuous monitoring can be used to distinguish between indoor sources of VFCs and VI from exterior (beyond the building envelope) sources. The building in this example was a former dry cleaner that is currently being used as a retail store. Prior to deploying a continuous monitoring system, multiple rounds of canister samples were collected and analyzed, revealing both PCE and TCE in indoor air.

Figure 12 shows stacked time-series charts representing barometric pressure and indoor PCE and TCE concentrations in µg/m^3. The patterns reveal that PCE concentration drops when the barometric pressure rises, which is a common indicator that PCE is due to VI. TCE, however, rises when the building is closed (and sealed) at night and drops when the building is open for business and has more airflow. The TCE pattern is typical of an indoor TCE source.

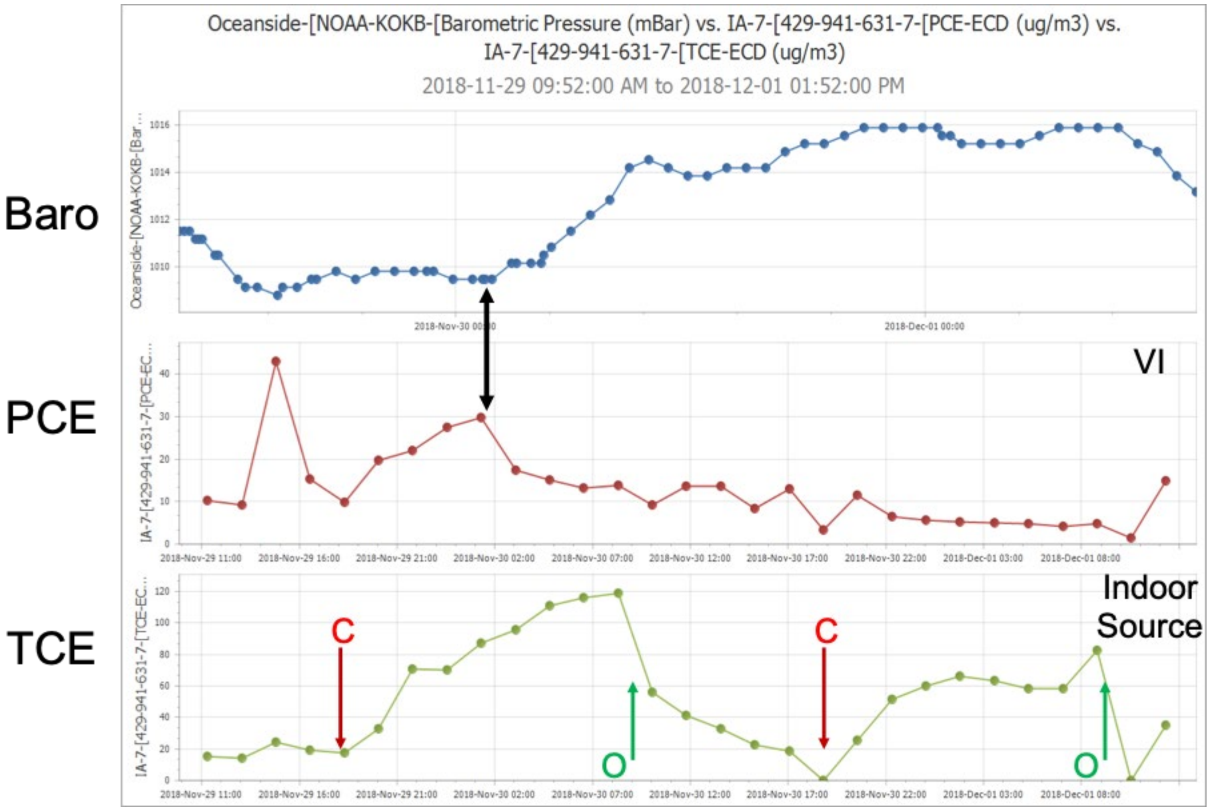

Figure 12. Stacked time series of barometric pressure and indoor air concentrations of PCE and TCE.

Source: Kram and Solgi (2025).

Example 2: Demonstrating That Mitigation is Meeting Risk-Reduction Objectives

A facility had experienced a TCE release, and the consultant had designed a sub-slab depressurization (SSD) system to intercept the subsurface vapors before they could enter the occupied indoor space.

Given the large building foundation footprint (greater than 20,000 square feet), there was concern that the SSD system might not be able to meet risk-reduction objectives due to short-circuiting or incomplete vapor control.

Figure 13 shows stacked time-series charts of TCE concentration from four locations of key concern within the building. Continuous monitoring was performed for several days to generate a good understanding of baseline conditions. Shortly after the SSD system was engaged, the TCE concentrations dropped to nondetect levels at each of the four selected locations, thereby demonstrating that the system was able to meet the desired risk-reduction objectives.

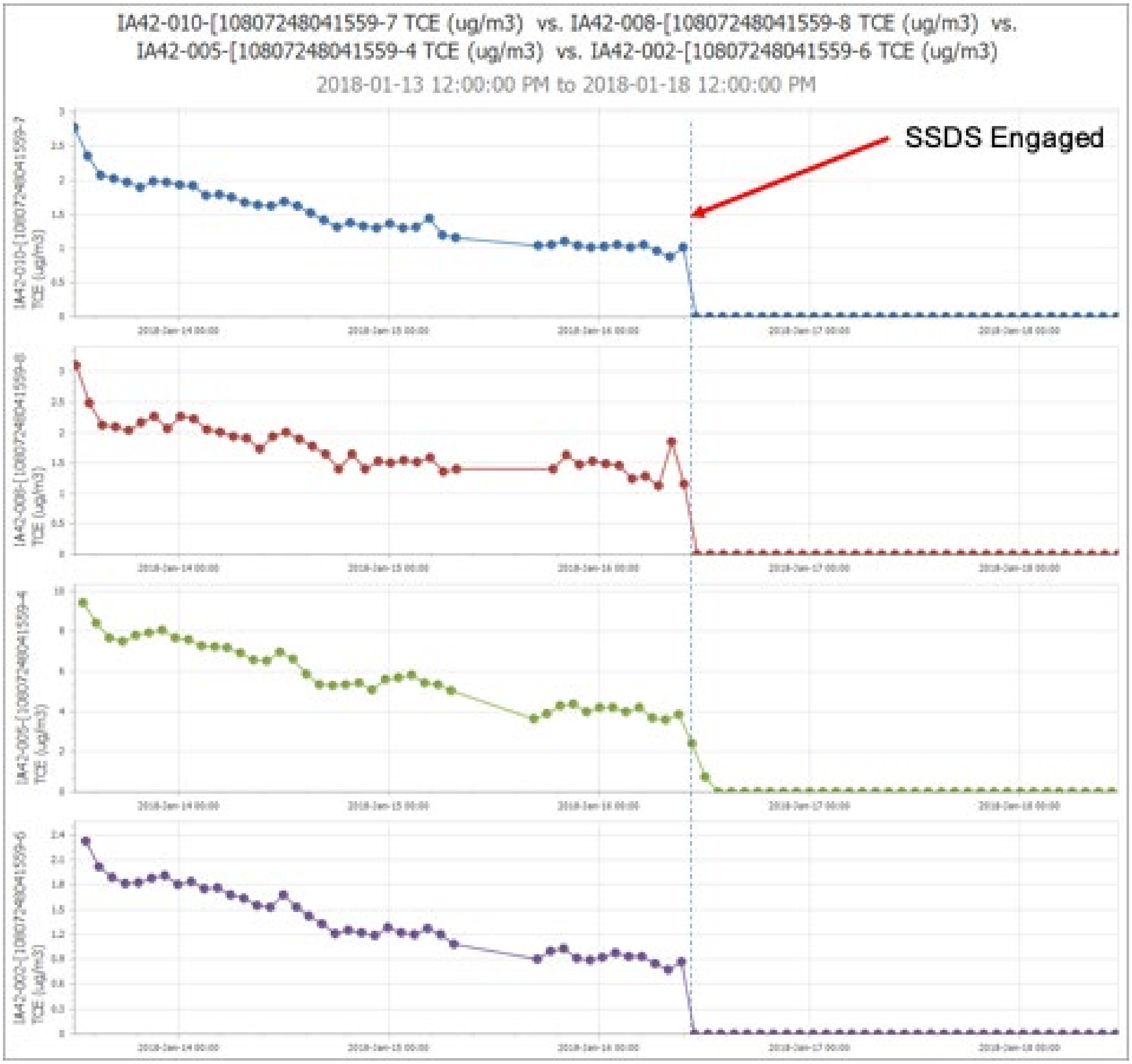

Figure 13. Stacked time series of indoor air concentrations of TCE at four different locations within one building.

Source: Team VaporSafe, used with permission.

Example 3: Locating a Vapor Entry Pathway

A large (greater than 150,000-square-foot) government facility overlying groundwater with TCE concentrations below risk-screening levels was monitored for VI every 3 to 12 months over several years. Every few monitoring events (e.g., approximately every 6 months, with some random exceptions), TCE concentrations exceeded indoor air risk screening levels in random locations throughout the facility. A field GC was used to screen various suspected vapor entry pathway candidates in the building using discrete syringe samples and on-site analysis. Within a few hours, a floor drain in one of the labs was tentatively identified as a potential source. To be certain, the GC was put into high-frequency monitoring mode at a location in the lab a few feet from the drain. This was performed to determine whether the drain served as a vapor entry conduit based on the concentration pattern over time.

As shown in **Figure 14**, once the room with the drain was closed at the end of the day (5 p.m. local time), a steady rise in TCE concentration occurred. This concentration continued to rise until the room was opened the following morning. Twenty minutes later the door to the room was closed again and a steady rise in TCE concentration was observed again.

The data pattern confirmed that the floor drain was a vapor entry pathway. More specifically, the steady rise in TCE concentration occurred when the room was isolated from the rest of the building. When the room's door was opened, concentrations dropped due to changes in airflow and dilution as air in the room was mixed with air outside the room. This approach (e.g., discrete samples to locate potential vapor entry pathways followed by continuous monitoring for confirmation) allowed the consultants to gain sufficient understanding of the situation and begin developing mitigation strategies.

Figure 14. Indoor air concentrations of TCE throughout an entire day from a single room within a building.

Source: Team VaporSafe, used with permission.

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