Designation: D7203 – 11

Standard Practice for Screening Trichloroethylene (TCE)-Contaminated Media Using a Heated Diode Sensor[1]

This standard is issued under the fixed designation D7203; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice describes procedures for screening media known to contain the halogenated volatile organic compound (HVOC), trichloroethylene (TCE). Procedure A is to be used for screening soil known to contain TCE and Procedure B is to be used for screening water known to contain TCE.

1.1.1 Both Procedures A and B involve measuring the TCE concentration in the headspace above a sample using a heated diode sensor device. From this measurement, an estimated concentration of TCE in the sample can be determined. Any TCE remaining in the sample is not measured. Any other HVOC present in the sample will be reported as TCE.

1.2 Procedure A can also be used for screening the headspace above a soil suspected of containing HVOC contamination to indicate the presence or absence of HVOC contamination in the soil. Procedure B can also be used for screening the headspace above a water suspected of containing HVOC contamination to indicate the presence or absence of HVOC contamination in the water. For both procedures, any HVOC contamination remaining in the soil or water is not detected by this practice.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3.1 *Exception*—Certain inch-pound units are provided for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—The diode sensor is heated to temperatures ranging between approximately 600 and 1000 °C (see 6.1.5) and as a result could be a source of ignition.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D4547 Guide for Sampling Waste and Soils for Volatile Organic Compounds

D5681 Terminology for Waste and Waste Management

3. Terminology

3.1 *Definitions*—For definitions of terms used in this screening practice, refer to Terminology D5681.

4. Summary of Practice

4.1 *Procedure A*—To estimate the concentration of TCE in a soil known to contain TCE contamination, a sample of the soil is added to a glass jar having an open-top cap with a PTFE-bonded silicone septum. At the time of screening, the temperature of the soil in the jar should be approximately 50 to 120 °F (10 to 49 °C). The soil in the jar is shaken and allowed to settle for 10 min, so the TCE can partition into the headspace above the soil. After 10 min, the TCE concentration in the headspace is measured using a heated diode sensor device, which gives a numerical voltage reading. The voltage reading from the device is converted to a mg/m^3 value of TCE in the headspace in the container. Using this value, an estimated concentration of TCE in the soil in mg/Kg can be calculated. Any TCE remaining in the soil sample is not measured by this practice. Any other HVOC present in the soil will be reported as TCE.

4.1.1 To use Procedure A to screen a soil suspected of containing HVOC contamination, a sample of the soil is added to a glass jar having an open-top cap with a PTFE-bonded silicone septum. At the time of screening, the temperature of the soil in the jar should be approximately 50 to 120 °F (10 to 49 °C). The soil in the jar is shaken and allowed to settle for 10 min, so the HVOC can partition into the headspace above the soil. After 10 min, the heated diode sensor device is used to screen the headspace in the container. The numerical voltage reading from the device indicates the presence or absence of

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[1] This practice is under the jurisdiction of ASTM Committee D34 on Waste Management and is the direct responsibility of Subcommittee D34.01.05 on Screening Methods.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

HVOC contamination in the soil. Any HVOC contamination remaining in the soil is not detected by this procedure.

4.2 *Procedure B*—To estimate the concentration of TCE in water known to contain TCE contamination, a sample of the water is added to a glass jar having an open-top cap with a PTFE-bonded silicone septum. At the time of screening, the temperature of the water in the jar should be approximately 50 to 120 °F (10 to 49 °C). The water in the jar is shaken, allowed to settle for 1 min, shaken again, and allowed to settle for 1 min, so the TCE can partition into the headspace above the water. After the sample is allowed to settle for the second time, the TCE concentration in the headspace is measured using a heated diode sensor device, which gives a numerical voltage reading. The voltage reading from the device is converted to a mg/m^3 value of TCE in the headspace in the container. Using this value, an estimated concentration of TCE in the water in mg/L can be calculated. Any TCE remaining in the water sample is not measured by this procedure. Any other HVOC present in the water will be reported as TCE.

4.2.1 To use Procedure B to screen water suspected of containing HVOC contamination, a sample of the water is added to a glass jar having an open-top cap with a PTFE-bonded silicone septum. At the time of screening, the temperature of the water in the jar should be approximately 50 to 120 °F (10 to 49 °C). The water in the jar is shaken, allowed to settle for 1 min, shaken again, and allowed to settle for 1 min, so the TCE can partition into the headspace above the water. After the sample is allowed to settle for the second time, the heated diode sensor device is used to screen the headspace in the container. The numerical voltage reading from the device indicates the presence or absence of HVOC contamination in the water. Any HVOC contamination remaining in the water is not detected by this procedure.

5. Significance and Use

5.1 The heated diode sensor device used in this practice is selective for HVOCs. Other electronegative compounds, such as alcohols, ketones, nitrates, and sulfides, may cause a positive interference with the performance of the heated diode sensor to detect HVOCs, but to do so, they must be present at much higher concentrations than the HVOCs.

NOTE 2—For volatile organic compound (VOC) screening purposes, a flame ionization detector (FID) selectively responds to flammable VOCs; a photoionization detector (PID) selectively responds to VOCs having a double bond; and a heated diode sensor selectively responds to halogenated VOCs.

5.2 This practice can be used for screening media known to contain TCE to estimate the concentration of TCE in the media. Procedure A is to be used for screening soil known to contain TCE and Procedure B is to be used for screening water known to contain TCE. Both Procedures A and B involve measuring the TCE concentration in the headspace above a sample. From this measurement, an estimated concentration of TCE in the sample can be determined. Any TCE remaining in the sample is not measured by this practice. Any other HVOC present in the sample will be reported as TCE.

5.3 This practice can also be used for screening the headspace above a soil or water suspected of containing HVOC contamination to indicate the presence or absence of HVOC contamination in the soil (Procedure A) or water (Procedure B). Any HVOC contamination remaining in the sample is not detected by this practice.

5.4 *Detection Limit*—The detection limit of the heated diode sensor for TCE is 0.1 mg/m^3 in air, based on a signal-to-noise ratio of 2. For a 25-g TCE-contaminated soil sample in a 250-mL container, the detection limit of Procedure A for TCE is 0.001 mg/Kg, assuming complete partitioning of TCE into the headspace. For a 25-g TCE-contaminated water sample in a 250-mL container, the detection limit of Procedure B for TCE is 0.001 mg/L, assuming complete partitioning of TCE into the headspace.

5.5 This practice can be used to screen moist soil samples and water samples. Water vapor does not interfere with the performance of the heated diode sensor.

5.6 Hydrocarbon fuels, including fuels containing aromatic compounds, such as gasoline, are not detected by the practice.

6. Apparatus

6.1 *Procedure A and B:*

6.1.1 *Glass Jars,* 250-mL (8-oz), approximately 14 cm (5½ in.) tall, with open-top caps having PTFE-bonded silicone septa.

6.1.2 *Scale,* capable of weighing to 0.1 g.

6.1.3 *Thermometer,* with temperature given in divisions of 0.1 ºC

6.1.4 *Barometer,* such that pressure in atmospheres can be determined to 0.001 atm.

6.1.5 *Heated Diode Sensor Device,* a device having a diode sensor that is heated between temperatures ranging from approximately 600 to 1000 ºC generating an alkali metal vapor stream that selectively reacts with halogens present in HVOC molecules, creating ionized product species that cause a current to flow between a cathode and an anode. The numerical output from the sensor in volts is proportional to a microamp current from the diode and ranges from 0.001 to 20 V with a resolution of 0.001 V. The HVOC molecules in the headspace above the sample are drawn through a probe to the heated diode sensor by a pump in the device. The heated diode sensor device should have a needle attached to the probe of the device so the septum in the cap of the sample jar can be pierced and the needle can be inserted into the headspace above the sample. This needle must be designed to allow make-up air to enter the sample jar from the top so that back pressure will not build up within the jar. Back pressure in the jar will change the air flow rate of the device and in turn affect the voltage reading.

6.1.6 *Tedlar Bags,* 1 L in volume and having a stainless steel valve with a nipple fitting that can be opened and closed.

6.1.7 *Gas Regulators,* for use with the TCE standard gas cylinders (see 7.1). Each regulator should have a short length, about 1¼ in., of ¼-in. inner diameter fluoroelastomer tubing attached to the nipple fitting.

6.2 *Procedure A:*

6.2.1 *Metal or Rigid Plastic Coring Tools,* designed for collecting and transferring a 25-g soil VOC sample (see Guide D4547 and 8.1.1).

7. Reagents and Materials

7.1 *TCE Standard Gas Cylinders—*These are transportable cylinders containing certified concentrations of TCE in air pressurized to about 320 psi. If the practice is being used to screen a TCE-contaminated media to estimate the concentration of TCE in the media, two concentrations of TCE are required. One concentration is 220 ± 10 vapor part per million (ppmv) TCE in air. This is the high concentration TCE standard gas. The other concentration is 22 ± 1 ppmv TCE in air, which is the mid concentration TCE standard gas. These concentrations correlate with the upper and mid range of sensor response for the device. A 220 ppmv TCE standard gas at 25 °C corresponds to about 890 mg/m^3 TCE in air at 0.75 atm of pressure and to about 1200 mg/m^3 TCE in air at 1 atm of pressure. A 22 ppmv TCE standard gas at 25 °C corresponds to about 90 mg/m^3 TCE in air at 0.75 atm of pressure and to about 120 mg/m^3 TCE in air at 1 atm of pressure. See Note 3 and Note 4. If the practice is being used to screen a media suspected of containing HVOC contamination to indicate the presence or absence of HVOC contamination, only the high concentration TCE standard gas, 220 ± 10 ppmv TCE in air, is required.

NOTE 3—For HVOC concentrations in air that are greater than 10 mg/m^3, the current that is generated by the reaction between the halogen and the alkali metal vapor when the sensor is exposed to the HVOC is a function of the log of the concentration of the halogen in air. The log of 890 is 2.9, and the log of 1200 is 3.1, showing that the log values of these concentrations vary only slightly. Similarly, the log of 90 is 1.9, and the log of 120 is 2.1. These values show that the log of the TCE concentration in air varies only slightly at different elevations (atmosphere of pressure).

NOTE 4—The mg/m^3 concentrations of the TCE in the standard gas cylinders can be calculated using the ppmv concentrations of TCE in the cylinders, the atmospheric pressure, the temperature, and Eq 5 and Eq 6, which are given in 13.6 or Eq 20 and Eq 21, which are given in 18.6.

7.1.1 Transportation of the TCE gas cylinders must comply with current Department of Transportation (DOT) regulations.

8. Sample Collection and Preparation

8.1 *Procedure A:*

8.1.1 Collect a soil sample of approximately 25 g using a metal or rigid plastic coring tool. See Guide D4547 for recommended devices. If the sample will be stored in the coring tool prior to screening, it should be collected using a coring tool designed for sample storage as described in Guide D4547 and should be stored as specified in Guide D4547.

8.1.2 Preweigh a 250-mL glass jar with an open-top cap having a PTFE-bonded silicone septum. Record the mass of the jar with the cap to ±0.1 g.

8.1.3 Extrude the soil sample from the coring tool into the pre-weighed 250-mL glass jar and immediately seal the jar making sure that there are no soil particles on the sealing surfaces.

8.1.4 Weigh the jar-plus-soil sample and record the mass of the jar-plus-soil sample to ±0.1 g.

8.1.5 Determine the mass of soil added to the jar, and record the mass of the soil sample to ±0.1 g.

8.1.6 The temperature of the soil in the sample jar should be approximately 50 to 120 °F (10 to 49 °C) prior to screening the sample using the heated diode sensor, so that HVOC partitioning into the headspace above the sample will occur (see Note 5). The sample jar should not be opened to determine the soil temperature. The ambient temperature where the screening is to be performed should be in the range of 50 to 120 ° F (10 to 49 °C) (see Note 6), and the soil sample should be allowed to come to approximately that temperature prior to screening (Section 12).

NOTE 5—The temperature at which the screening is performed may affect the HVOC concentration in the headspace. For example, the vapor pressure of TCE at 120 °F (49 °C) is about seven times greater than the vapor pressure of TCE at 50 °F (10 °C). Therefore, more TCE would be expected in the headspace at higher temperatures.

NOTE 6—The ambient temperature where the screening is to be performed will be recorded as specified in 11.3

8.2 *Procedure B:*

8.2.1 Mark a 250-mL glass jar having an open-top cap containing a PTFE-bonded silicone septum to show the filling level to give approximately 25-g of water in the jar. Preweigh the marked 250-mL jar with its cap. Record the mass of the jar with the cap to ±0.1 g.

8.2.2 Collect a water sample of approximately 25 g directly into the pre-weighed glass jar and immediately seal the jar making sure that the sealing surfaces are clean.

8.2.3 Weigh the jar-plus-water sample and record the mass of the jar-plus-water sample to ±0.1 g.

8.2.4 Determine the mass of water added to the jar, and record the mass of the water sample to ±0.1 g.

8.2.5 The temperature of the water in the sample jar should be approximately 50 to 120 °F (10 to 49 °C) prior to screening the sample using the heated diode sensor, so that HVOC partitioning into the headspace above the sample will occur (see Note 5). The sample jar should not be opened to determine the water temperature. The ambient temperature where the screening is to be performed should be in the range of 50 to 120 °F (10 to 49 °C) (see Note 6), and the water sample should be allowed to come to approximately that temperature prior to screening (Section 17).

9. Operation of the Heated Diode Sensor Device

9.1 The heated diode sensor device used to perform this practice should be calibrated and operated according to the manufacturer's instructions.

9.2 After a sample or standard gas has been screened using the heated diode sensor device, the voltage reading of the device must be allowed to return to zero, indicating that the sensor has been flushed with intake air so that any contamination from the previous sample or standard gas has been removed from the system.

10. Preparation of Tedlar Bags Containing the TCE Standard Gases

10.1 If the practice is being used to screen a TCE-contaminated soil or water to estimate the concentration of TCE in the soil or water, a 1-L Tedlar bag containing each of the TCE standard gases (7.1) should be prepared. If the practice is being used to screen a soil or water suspected of containing HVOC contamination to indicate the presence or absence of HVOC contamination, a 1-L Tedlar bag containing the high concentration TCE standard gas, 220 ± 10 ppmv TCE in air, (7.1) should be prepared.

10.1.1 To prepare a Tedlar bag containing the TCE standard gas, attach a regulator (see 6.1.7) to the TCE standard gas cylinder.

10.1.2 Open the valve on a 1-L Tedlar bag. Press the bag against a flat, hard surface to make sure the bag is empty.

10.1.3 With the valve on the Tedlar bag in the open position, attach the bag to the regulator by connecting the nipple fitting on the valve with the tubing on the regulator. Carefully fill the Tedlar bag with the standard gas. Remove the bag from the regulator. With the valve on the Tedlar bag in the open position, once again press the bag against a flat, hard surface to empty the bag. After the bag has been flushed with the standard gas, it should be refilled with the standard gas, as described above, and the valve on the bag should be closed.

11. Heated Diode Sensor Device Calibration Check and Voltage Measurement of TCE Standard Gases

11.1 After the heated diode sensor device has been calibrated (see 9.1), open the valve on the Tedlar bag containing the high concentration TCE standard gas and connect the nipple fitting on the bag to the probe of the heated diode sensor device. The device is calibrated if the voltage reading for the high concentration TCE standard gas is between 9 and 12 V. If the voltage reading is 9 V or less or 12 V or greater, the device should be re-calibrated until the reading for the high concentration TCE standard gas is between 9 and 12 V. Record this voltage reading from the device for the high concentration TCE standard gas as $V_{\mathrm{HighTCEStd}}$.

11.2 If the practice is being used to screen a TCE-contaminated soil or water to estimate the concentration of TCE in the soil or water, a voltage reading for the mid concentration TCE standard gas is required. This reading is made after it is determined that the heated diode sensor device is calibrated (11.1), the voltage reading from the device for the high concentration TCE standard gas ($V_{\mathrm{HighTCEStd}}$) has been recorded, and the voltage reading of the heated diode sensor device has returned to zero. The valve on the Tedlar bag containing the mid concentration TCE standard gas (Section 10) should be opened and the nipple fitting on the bag should be connected to the probe of the heated diode sensor device. The voltage reading from the device for the mid concentration TCE standard gas should be recorded as $V_{\mathrm{MidTCEStd}}$. If the practice is being used to screen a soil or water suspected of containing HVOC contamination to indicate the presence or absence of HVOC contamination, a voltage reading for the mid concentration TCE standard gas is not required.

11.3 If the practice is being used to screen a TCE-contaminated soil or water to estimate the concentration of TCE in the soil or water, record the temperature in ºC to 0.1ºC and pressure in atmospheres to 0.001 atm at the time that the voltage readings for the high concentration and mid concentration TCE standard gases are recorded. If the practice is being used to screen a soil or water suspected of containing HVOC contamination to indicate the presence or absence of HVOC contamination, record the temperature in ºC to 0.1 ºC at the time that the voltage reading for the high concentration TCE standard gas is recorded.

11.4 The voltage reading of the high concentration TCE standard gas should be checked after 10 samples have been screened, or if the sensor is exposed to a sample that gives a voltage reading above the reading for the high concentration TCE standard gas, $V_{\mathrm{HighTCEStd}}$, recorded in 11.1 (see Note 7). If during this check, the reading for the high concentration TCE standard gas is not within 10 % of the value recorded for the standard gas during the previous check, the device must be re-calibrated.

NOTE 7—If a sensor is exposed to a sample that gives a voltage reading above the reading for the high concentration TCE standard gas, $V_{\mathrm{HighTCEStd}}$, indicating that the concentration of TCE in the headspace above the sample is greater than the TCE concentration in the high concentration standard gas, the sensor response may become unstable.

PROCEDURE A—SCREENING SOIL

12. Soil Screening

12.1 When the sample temperature is estimated to be 50 to 120 ºF, (10 to 49 ºC), shake the jar-plus-soil sample for at least 20 s. Allow the jar to sit for a minimum of 10 min for HVOC partitioning into the headspace above the soil sample.

12.2 After 10 min, insert the needle attached to the probe of the heated diode sensor device through the septum in the cap of the sample jar and into the headspace above the sample. The tip of the needle should be approximately 3 in. below the cap of the jar. The tip of the needle should never contact the surface of the soil. The voltage reading for the headspace above the soil sample should be recorded as V_s.

12.3 If the practice is being used to screen a soil suspected of containing HVOC contamination, the voltage reading for the headspace above the 25-g soil sample, V_s, determined in 12.2 can be used to indicate the presence or absence of HVOC contamination in the soil (see Note 8). If the practice is being used to screen a TCE-contaminated soil to estimate the concentration of TCE in the soil, the calculations provided in Section 13 should be performed.

NOTE 8—The voltage reading of a heated diode sensor device is specific to the particular device, the particular sensor, and the amount of use the sensor has encountered. For this reason, the voltage reading for a soil sample, V_s, can be used to indicate the presence or absence of HVOC contamination; however, to compare readings made during different screening episodes, the relative response values for the samples, R_s, (see 13.4) should be calculated and compared.

13. Calculations for Soil Screening

13.1 Data interpretation in this practice is based on the response characteristic of the particular sensor used in the device. Fig. 1 is a qualitative plot of the response, R, versus the base 10 log of the concentration of TCE in air, log C_H (mg/m^3). This figure shows three possible heated diode sensor response profiles for a concentration of 100 mg/m^3 TCE in air (log C_H = 2.00): R greater than 0.550 (profile 1); R equal to 0.550 (profile 2); and R less than 0.550 (profile 3). These profiles are specific to TCE and any heated diode sensor meeting the specifications given in 6.1.5.

13.2 Calculate the relative response for the mid concentration TCE standard gas, $R_{\mathrm{MidTCEStd}}$, using the voltage reading for the mid concentration TCE standard gas, $V_{\mathrm{MidTCEStd}}$ (11.2), and the voltage reading for the high concentration TCE standard gas, $V_{\mathrm{HighTCEStd}}$ (11.1), as shown in Eq 1.

$$R_{\mathrm{MidTCEStd}} = V_{\mathrm{MidTCEStd}}/V_{\mathrm{HighTCEStd}} \quad (1)$$

13.3 The relative response, $R_{\mathrm{HighTCEStd}}$, for the high concentration TCE in air standard gas is equal to 1.00, based on the calculation shown in Eq 2.

$$R_{\mathrm{HighTCEStd}} = V_{\mathrm{HighTCEStd}}/V_{\mathrm{HighTCEStd}} = 1.00 \quad (2)$$

13.4 Calculate a relative response, R_s, for the sample using the voltage reading for the 25-g sample (V_s, 12.2) and the voltage reading for the high concentration TCE in air standard ($V_{\mathrm{HighTCEStd}}$) as shown in Eq 3.

$$R_s = V_s/V_{\mathrm{HighTCEStd}} \quad (3)$$

13.5 If R_s calculated in 13.4 is less than or equal to 1.00, go to 13.6 and continue the calculations. If R_s is greater than 1.00, the concentration of TCE in the headspace above the sample is greater than the TCE concentration in the high concentration standard gas. The concentration of TCE in mg/m^3 in the high concentration TCE standard gas should be calculated using Eq 5 shown in 13.6. Then the estimated concentration of TCE in the soil sample, C_s, mg/Kg, should be reported as the greater than value calculated using Eq 4.

$$C_s,\ \mathrm{mg/Kg} > (C_{\mathrm{HighTCEStd}},\ \mathrm{mg/m^3})(\text{Vol of headspace in the container, L}) \quad (4)$$

$$/(\text{Kg of soil})(1000\ \mathrm{L/m^3})$$

where: $C_{\mathrm{HighTCEStd}}$, mg/m^3, is the concentration of TCE in the high concentration standard gas, calculated using Eq 5 in 13.6;

Vol of headspace in the sample container, L, is 0.235 L for a 25.0-g sample in a 250-mL jar, assuming a soil density of 1.7 g/mL;

Mass of soil sample in Kg: for a 25.0-g sample, this is 0.025 Kg.

13.6 Calculate the concentration of TCE in mg/m^3 in the high concentration and mid concentration TCE in air standard gas cylinders using Eq 5 and Eq 6, respectively.

$$C_{\mathrm{HighTCEStd}},\ \mathrm{mg/m^3} = (\mathrm{ppmv}_{\mathrm{HighTCEStd}})\ (131.39\ \mathrm{g/mol})\ (P)/(R)\ (T) \quad (5)$$

$$C_{\mathrm{MidTCEStd}},\ mg/m^3 = (\mathrm{ppmv}_{\mathrm{MidTCEStd}})\ (131.39\ \mathrm{g/mol})\ (P)/(R)\ (T) \quad (6)$$

where:

$\mathrm{ppmv}_{\mathrm{HighTCEStd}}$ = the TCE concentration in the high concentration TCE standard gas in ppmv
$\mathrm{ppmv}_{\mathrm{MidTCEStd}}$ = the TCE concentration in the mid concentration TCE standard gas in ppmv
P = pressure in atmospheres (recorded in 11.3)
R = the gas constant, 0.082057 ppmv L atm/mol °K
T = temperature in °K (T °C + 273.15) (T °C recorded in 11.3)

13.7 To interpret the data, equations corresponding to specific line segments, such as those shown in Fig. 2 for concentrations of TCE in the headspace above the soil sample (C_H) ranging from greater than 10 to 1000 mg/m^3, and the line shown in Fig. 3 for concentrations of TCE in the headspace above the soil sample (C_H) ranging from 0 to 10 mg/m^3, are used depending on the relative response for the sample, R_s.

13.7.1 If the relative response, R_s, for the sample (calculated in 13.4) is equal to or between the relative response values, $R_{\mathrm{MidTCEStd}}$ and $R_{\mathrm{HighTCEStd}}$ (1.00) (Eq 1 and Eq 2, respectively), calculate the slope and y intercept of the line segment appropriate for the sample response (segments **a**

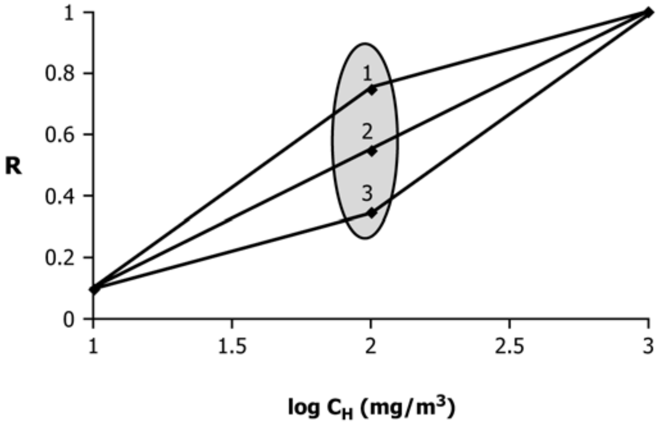

FIG. 1 Qualitative Heated Diode Sensor Response Profiles for TCE Headspace Concentrations (C_H) Ranging from Greater than 10 to 1000 mg/m^3 Showing Three Possible R Values for C_H = 100 mg/m^3 (log C_H = 2.00)

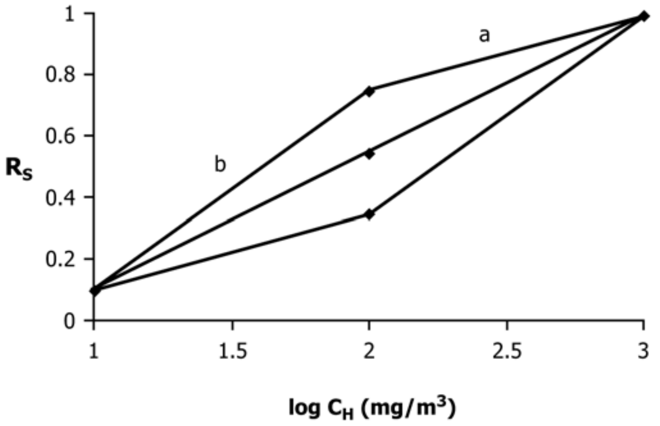

FIG. 2 Qualitative Heated Diode Sensor Response Profiles for Sample TCE Headspace Concentrations (C_H) Ranging from Greater than 10 to 1000 mg/m^3 Showing Specific Line Segments for TCE Concentrations Equal to or Between 100 and 1000 mg/m^3 (line segments a) and TCE Concentrations Between 10 and 100 mg/m^3 (line segments b)

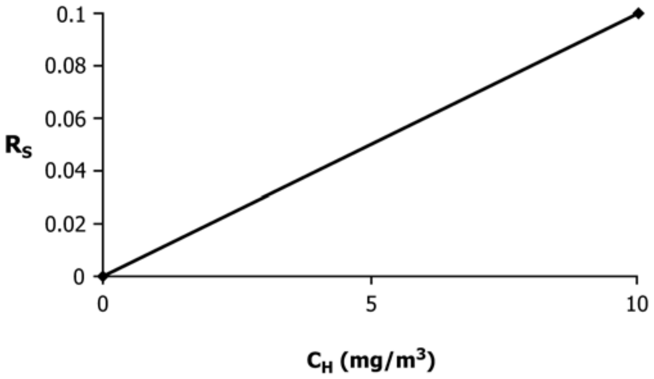

FIG. 3 Heated Diode Sensor Response Profile for Sample TCE Headspace Concentrations (C_H) Ranging from 0 to 10 mg/m^3

shown in Fig. 2) using Eq 7 and Eq 8. Then calculate the base 10 log of the concentration of TCE in the headspace above the soil sample (log C_H) using Eq 9.

$$\text{slope, } m_a = (1.00 - R_{\text{MidTCEStd}})/(\log C_{\text{HighTCEStd}} - \log C_{\text{MidTCEStd}}) \tag{7}$$

$$y \text{ intercept, } b_a = 1.00 - [(m_a)(\log C_{\text{HighTCEStd}})] \tag{8}$$

$$\log C_H = (R_s/m_a) - (b_a/m_a) \tag{9}$$

13.7.2 If the relative response, R_s, for the sample (calculated in 13.4) is between $R_{\text{midTCEStd}}$ (Eq 1) and 0.100, calculate the slope and y intercept of the line segment appropriate for the sample response (segments **b** shown in Fig. 2) using Eq 10 and Eq 11. Then calculate the base 10 log of the concentration of TCE in the headspace above the soil sample (log C_H) using Eq 12.

$$slope,\ m_b = (R_{\text{MidTCEStd}} - 0.100)/(logC_{\text{MidTCEStd}} - 1.00) \tag{10}$$

$$y\ intercept,\ b_b = 0.100 - m_b \tag{11}$$

$$logC_H = (R_s/m_b) - (b_b/m_b) \tag{12}$$

13.7.3 If the relative response, R_s, for the sample (calculated in 13.4) ranges from 0 to 0.100 (line shown in Fig. 3), calculate the concentration of TCE in the headspace above the soil sample (C_H) in mg/m^3 using Eq 13.

$$C_H = (R_s)(100) \tag{13}$$

13.7.4 If a log C_H value was determined in either 13.7.1 or 13.7.2, the concentration of TCE in the headspace above the soil sample (C_H) in mg/m^3 can be calculated using Eq 14.

$$C_H = 10^{logCH} \tag{14}$$

13.8 Using the C_H value calculated in either 13.7.3 or 13.7.4, the estimated concentration of TCE in the soil sample, C_s, in mg/Kg, can be calculated using Eq 15.

$$C_s,\ \text{mg/Kg} = (C_H,\ \text{mg/m}^3)\ (\text{Vol of headspace in the container, L}) \tag{15}$$

$$/(\text{Kg of soil})\ (1000\ \text{L/m}^3)$$

where: C_H, mg/m^3, is the concentration of TCE in the headspace above the soil sample determined in 13.7.3 or in 13.7.4;

Vol of headspace in the sample container, L, is 0.235 L for a 25.0-g sample in a 250-mL jar, assuming a soil density of 1.7 g/mL;

Mass of soil sample in Kg: for a 25.0-g sample, this is 0.025 Kg.

14. Record

14.1 Record the following information:

14.1.1 Mass of the empty 250-mL sample jar with the cap, g,

14.1.2 Mass of the sample jar with cap-plus-soil sample, g,

14.1.3 Mass of the soil sample, g,

14.1.4 Voltage reading for the high concentration TCE standard gas, $V_{\text{HighTCEStd}}$,

14.1.5 Voltage reading for the mid concentration TCE standard gas, $V_{\text{MidTCEStd}}$ (see Note 9),

14.1.6 Temperature in °C and pressure in atmospheres at the time that the voltage readings for the mid concentration and high concentration TCE standard gases are recorded (see Note 9), and

14.1.7 Voltage reading for the headspace above the 25-g soil sample, V_s.

NOTE 9—If the practice is being used to screen a soil suspected of containing HVOC contamination to indicate the presence or absence of HVOC contamination in the soil, a reading for the mid concentration TCE standard gas, $V_{\text{MidTCEStd}}$, and a pressure reading at the time that the voltage reading for the high concentration TCE standard gas is recorded are not required.

15. Report

15.1 If the practice is used to screen soil known to contain TCE to estimate the concentration of TCE in the soil, report the estimated TCE concentration in mg/Kg to two significant figures. Any other HVOC present in the soil will be reported as TCE.

15.2 If the practice is used for screening soil to indicate the presence or absence of HVOC contamination, report the voltage reading recorded for the soil and the indicated presence or absence of HVOC contamination. To compare heated diode sensor readings made during different screening episodes, the relative response values for the samples (R_s) should be reported (see Note 8).

16. Precision and Bias

16.1 No information is presented about either the precision or bias of Practice D7203 for measuring TCE or HVOCs since the test result is nonquantitative. However, data have been generated to provide information on the performance of the procedure to screen soil collected at a TCE-contaminated site. The screening procedure was evaluated based on a comparison of the screening data with data generated from analysis of samples collected side-by-side from the same location and analyzed in the laboratory using gas chromatography/mass spectrometry (GC/MS). These data[3] are shown in Appendix X1.

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[3] A copy of the research report on the study described in Appendix X1 is available from ASTM Headquarters. Request RR:D34-1017.

PROCEDURE B—SCREENING WATER

17. Water Screening

17.1 When the sample temperature is estimated to be 50 to 120 °F (10 to 49 °C), shake the jar-plus-water sample vigorously for at least 20 s, allow the sample to sit for a minimum of 1 min, vigorously shake the jar again for at least 20 s, and allow the jar to sit for a minimum of 1 min for HVOC partitioning into the headspace above the water sample.

17.2 Insert the needle attached to the probe of the heated diode sensor device through the septum in the cap of the sample jar and into the headspace above the sample. The tip of the needle should be approximately 3 in. below the cap of the jar. The tip of the needle should never contact the surface of the water. The voltage reading for the headspace above the water sample should be recorded as V_s.

17.3 If the practice is being used to screen a water suspected of containing HVOC contamination, the voltage reading for the headspace above the 25-g water sample, V_s, determined in 17.2 can be used to indicate the presence or absence of HVOC contamination in the water (see Note 10). If the practice is being used to screen a TCE-contaminated water to estimate the concentration of TCE in the water, the calculations provided in Section 18 should be performed.

NOTE 10—The voltage reading of a heated diode sensor device is specific to the particular device, the particular sensor, and the amount of use the sensor has encountered. For this reason, the voltage reading for a water sample, V_s, can be used to indicate the presence or absence of HVOC contamination; however, to compare readings made during different screening episodes, the relative response values for the samples, R_s, (see 18.4) should be calculated and compared.

18. Calculations for Water Screening

18.1 Data interpretation in this practice is based on the response characteristic of the particular sensor used in the device. Fig. 1 is a qualitative plot of the response, R, versus the base 10 log of the concentration of TCE in air, log C_H (mg/m^3). This figure shows three possible heated diode sensor response profiles for a concentration of 100 mg/m^3 TCE in air (log C_H = 2.00): R greater than 0.550 (profile 1); R equal to 0.550 (profile 2); and R less than 0.550 (profile 3). These profiles are specific to TCE and any heated diode sensor meeting the specifications given in 6.1.5.

18.2 Calculate the relative response for the mid concentration TCE standard gas, $R_{MidTCEStd}$, using the voltage reading for the mid concentration TCE standard gas, $V_{MidTCEStd}$ (11.2), and the voltage reading for the high concentration TCE standard gas, $V_{HighTCEStd}$ (11.1), as shown in Eq 16.

$$R_{MidTCEStd} = V_{MidTCEStd}/V_{HighTCEStd} \tag{16}$$

18.3 The relative response, $R_{HighTCEStd}$, for the high concentration TCE in air standard gas is equal to 1.00, based on the calculation shown in Eq 17.

$$R_{HighTCEStd} = V_{HighTCEStd}/V_{HighTCEStd} = 1.00 \tag{17}$$

18.4 Calculate a relative response, R_s, for the sample using the voltage reading for the 25-g sample (V_s, 17.2) and the voltage reading for the high concentration TCE in air standard ($V_{HighTCEStd}$) as shown in Eq 18.

$$R_s = V_s/V_{HighTCEStd} \tag{18}$$

18.5 If R_s calculated in 18.4 is less than or equal to 1.00, go to 18.6 and continue the calculations. If R_s is greater than 1.00, then the concentration of TCE in the headspace above the sample is greater than the TCE concentration in the high concentration standard gas. The concentration of TCE in mg/m^3 in the high concentration TCE standard gas should be calculated using Eq 20 shown in 18.6. Then the estimated concentration of TCE in the water sample, C_w, mg/L, should be reported as the greater than value calculated using Eq 19 shown below.

$$\begin{aligned} C_w,\ \text{mg/L} > & (C_{HighTCEStd},\ \text{mg/m}^3) \\ & (\text{Vol of headspace in the container},\ \ \text{L})/ \\ & (\text{L of water})\ (1000\ \text{L/m}^3) \end{aligned} \tag{19}$$

where $C_{HighTCEStd}$, mg/m^3, is the concentration of TCE in the high concentration standard gas, calculated using Eq 20 in 18.6; and Vol of headspace in the sample container, L, is 0.225 L for a 25.0-g sample in a 250-mL jar, assuming a water density of 1.0 g/mL; and Vol of water sample in L: for a 25.0-g sample, this is 0.025, assuming a water density of 1.0 g/mL.

18.6 Calculate the concentration of TCE in mg/m^3 in the high concentration and mid concentration TCE in air standard gas cylinders using Eq 20 and Eq 21, respectively.

$$C_{HighTCEStd},\ \text{mg/m}^3 = (\text{ppmv}_{HighTCEStd})\ (131.39\ \text{g/mol})\ (P)/(R)\ (T) \tag{20}$$

$$C_{MidTCEStd},\ \text{mg/m}^3 = (\text{ppmv}_{MidTCEStd})\ (131.39\ \text{g/mol})\ (P)/(R)\ (T) \tag{21}$$

where:

$\text{ppmv}_{HighTCEStd}$ = the TCE concentration in the high concentration TCE standard gas in ppmv,

$\text{ppmv}_{midTCEStd}$ = the TCE concentration in the mid concentration TCE standard gas in ppmv,

P = pressure in atmospheres (recorded in 11.3),

R = gas constant, 0.082057 ppmv L atm/mol °K, and

T = temperature in °K (T °C + 273.15) (T °C recorded in 11.3).

18.7 To interpret the data, equations corresponding to specific line segments, such as those shown in Fig. 2 for concentrations of TCE in the headspace above the water sample (C_H) ranging from greater than 10 to 1,000 mg/m^3, and the line shown in Fig. 3 for concentrations of TCE in the headspace above the water sample (C_H) ranging from 0 to 10 mg/m^3 are used, depending on the relative response for the sample, R_s.

18.7.1 If the relative response, R_s, for the sample (calculated in 18.4) is equal to or between the relative response values, $R_{MidTCEStd}$ and $R_{HighTCEStd}$ (1.00) (Eq 16 and Eq 17, respectively), calculate the slope and y intercept of the line segment appropriate for the sample response (segments **a** shown in Fig. 2) using Eq 22 and Eq 23. Then calculate the base 10 log of the concentration of TCE in the headspace above the water sample (log C_H) using Eq 24.

$$\text{slope, } m_a = (1.00 - R_{\text{MidTCEStd}})/(logC_{\text{HighTCEStd}} - logC_{\text{MidTCEStd}}) \quad (22)$$

$$y \text{ intercept, } b_a = 1.00 - [(m_a)(\log C_{\text{HighTCEStd}})] \quad (23)$$

$$\log C_H = (R_s/m_a) - (b_a/m_a) \quad (24)$$

18.7.2 If the relative response, R_s, for the sample (calculated in 18.4) is between $R_{\text{midTCEStd}}$ (Eq 16) and 0.100, calculate the slope and *y* intercept of the line segment appropriate for the sample response (segments **b** shown in Fig. 2) using Eq 25 and Eq 26. Then calculate the base 10 log of the concentration of TCE in the headspace above the water sample (log C_H) using Eq 27.

$$\text{slope, } m_b = (R_{\text{MidTCEStd}} - 0.100)/(\log C_{\text{MidTCEStd}} - 1.00) \quad (25)$$

$$y \text{ intercept, } b_b = 0.100 - mb \quad (26)$$

$$\log C_H = (R_s/m_b) - (b_b/m_b) \quad (27)$$

18.7.3 If the relative response, R_s, for the sample (calculated in 18.4) ranges from 0 to 0.100 (line shown in Fig. 3), calculate the concentration of TCE in the headspace above the water sample (C_H) in mg/m^3 using Eq 28.

$$C_H = (R_s)(100) \quad (28)$$

18.7.4 If a log C_H value was determined in either 18.7.1 or 18.7.2, the concentration of TCE in the headspace above the water sample (C_H) in mg/m^3 can be calculated using Eq 29.

$$C_H = 10^{\log CH} \quad (29)$$

18.8 Using the C_H value calculated in either 18.7.3 or 18.7.4, the estimated concentration of TCE in the water sample, C_w, in mg/L, can be calculated using Eq 30.

$$C_w\text{, mg/L} = (C_H\text{, mg/m}^3)(\text{Vol of headspace in the container, L})/ \quad (30)$$

$$(\text{L of water})(1000 \text{ L/m}^3)$$

where C_H, mg/m^3, is the concentration of TCE in the headspace above the water sample determined in 18.7.3 or 18.7.4; and Vol of headspace in the sample container, L, is 0.225 L for a 25.0-g sample in a 250-mL jar, assuming a water density of 1.0 g/mL; and Vol of water sample in L: for a 25.0-g sample, this is 0.025 L, assuming a water density of 1.0 g/mL.

19. Record

19.1 Record the following information:

19.1.1 Mass of the empty 250-mL sample jar with the cap, g,

19.1.2 Mass of the sample jar with cap-plus-water sample, g,

19.1.3 Mass of the water sample, g,

19.1.4 Voltage reading for the high concentration TCE standard gas, $V_{\text{HighTCEStd}}$,

19.1.5 Voltage reading for the mid concentration TCE standard gas, $V_{\text{MidTCESTd}}$ (see Note 11),

19.1.6 Temperature in °C and pressure in atmospheres at the time that the volage readings for the mid concentration and high concentration TCE standard gases are recorded (see Note 11), and

19.1.7 Voltage reading for the headspace above the 25-g water sample, V_s.

NOTE 11—If the practice is being used to screen a water suspected of containing HVOC contamination to indicate the presence or absence of HVOC contamination in the water, a reading for the mid concentration TCE standard gas, $V_{\text{MidTCEStd}}$, and a pressure reading at the time that the voltage reading for the high concentration TCE standard gas is recorded are not required.

20. Report

20.1 If the practice is being used to screen water known to contain TCE to estimate the concentration of TCE in the water, report the estimated TCE concentration in mg/L to two significant figures. Any other HVOC present in the water will be reported as TCE.

20.2 If the practice is used for screening water to indicate the presence of absence of HVOC contamination, report the voltage reading recorded for the water and the indicated presence or absence of HVOC contamination. To compare heated diode sensor readings made during different screening episodes, the relative response values for the samples (R_s) should be reported (see Note 10).

21. Precision and Bias

21.1 No information is presented about either the precision or bias of Practice D7203 for measuring TCE or HVOCs since the test result is nonquantitative. However, data have been generated to provide information on the performance of the procedure to screen water collected at contaminated field sites. The screening procedure was evaluated based on a comparison of the screening data with data generated from analysis of samples collected from the same location and analyzed in the laboratory using gas chromatography/mass spectrometry (GC/MS). These data are shown in Appendix X2.[4]

22. Keywords

22.1 field screening; halogenated volatile organic compounds (HVOCs); heated diode sensor; soils; trichloroethylene (TCE); water

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[4] A copy of the research report on the study described in Appendix X2 is available from ASTM International Headquarters. Request RR:D34-1018.

APPENDIXES

(Nonmandatory Information)

X1. APPLICATION OF THE PRACTICE FOR SCREENING TRICHLOROETHYLENE (TCE)-CONTAMINATED MEDIA USING A HEATED DIODE SENSOR TO SOIL COLLECTED AT A TCE-CONTAMINATED FIELD SITE

X1.1 A study was conducted to evaluate the performance of the practice to screen soil collected at a TCE-contaminated site. The screening practice was evaluated by comparing the screening data with data generated from analysis of samples collected side-by-side from the same location and analyzed in the laboratory using gas chromatography/mass spectroscopy (GC/MS).

X1.1.1 The site selected for the study was contaminated with TCE more than 20 years ago. Contamination is near the soil surface and is known to be relatively uniform so that adjacent samples having similar contaminant levels can be collected. The soil at the site is characterized as a cohesive silty-clay with an organic carbon content of less than 1.0 % and ranging in moisture from 10 to 20 %.

X1.1.2 For the study, contaminated soil samples were collected at depths ranging from approximately 2 to 12 in. at 18 locations within the site. At each of the contaminated locations, three side-by-side samples were collected in 25-g En Core®[5] samplers to evaluate the screening practice. One of these samples was placed in a cooler for shipment to a commercial laboratory for TCE analysis by GC/MS; one of these was placed in a cooler for shipment to a research laboratory for TCE analysis by GC/MS; and one of the samples was placed in a third cooler for on-site screening. The sample coolers contained frozen cold packs to maintain cooler temperatures at 4 ± 2 °C during sample storage.

X1.1.3 In addition to the 18 contaminated locations, two locations believed to be uncontaminated were also sampled. Three side-by-side samples were collected at each of these locations, two samples for laboratory analysis and one sample for on-site screening.

X1.1.4 After sample collection, the samples for laboratory analysis were shipped for next day delivery to the laboratories. Each cooler contained a mini digital temperature data logger so storage temperatures could be monitored. Upon receipt by the laboratories, the samples were extruded from the En Core[5] samplers and analyzed for TCE using EPA SW-846 Method 8260B, Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)[6]. SW-846 Method 5035A, Closed-System Purge-And-Trap and Extraction for Volatile Organics in Soil and Waste Samples[7] was used as the sample introduction technique for analysis.

X1.1.5 On-site screening was performed in a laboratory at the site. The soil samples were extruded into 250-mL glass jars having open-top caps with PTFE-bonded silicone septa. The exact sample mass in each container was determined using a portable balance. The samples were screened as specified in the practice using Procedure A. Because they were stored in a cooler during sample collection, the samples were allowed to sit at room temperature (20.0 ºC) for approximately 30 min prior to being shaken. After shaking, the samples were allowed to sit for 10 min before screening. Due to recent rains in the area, the samples collected on the first day were extremely wet and did not break apart with shaking. Instead, the wet soil formed one or more round clumps in the containers, with free moisture condensed on the inner walls. The samples collected on the second day were not as wet and easily broke apart with shaking. An X-Wand heated diode sensor device was used to screen the samples in this study[8].

X1.1.6 The data generated in this study are specific to the experimental design of the study. The data give information on the performance of the heated diode screening practice to estimate TCE concentrations in soil collected at a TCE-contaminated site and also on use of the practice to determine the presence or absence of HVOC contamination at a site suspected of containing HVOC contamination. The data generated in this study are also specific to the soil used in the study, TCE concentrations, and the heated diode sensor device that was used to screen the soil samples. For other soil types, analyte concentrations, and heated diode sensor devices, these data may not apply.

X1.1.7 The TCE concentrations determined in the three side-by-side soil samples collected from the sample locations are listed in Table X1.1. The first column of data shows the estimated concentrations of TCE determined by screening the samples using the heated diode screening practice. The second and third columns of data show the TCE concentrations determined in the samples by laboratory GC/MS analysis. The data reported by the laboratories are on an as received basis. There were no moisture content corrections performed on the data.

X1.1.7.1 The data given in Table X1.1 show that the practice performs well for screening TCE-contaminated soil samples to give an estimated TCE concentration in the samples. The screening practice gave no false negative or false positive results and provided estimated TCE concentrations that as screening data correlate well with the laboratory data, especially considering that the data for each of the sample locations were determined for three different samples taken within close proximity to one another. In addition, as discussed

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[5] En Core is a registered trademark of En Novative Technologies, Inc., Green Bay, WI. The En Core sampler is covered by a patent.

[6] U.S. EPA, 1996, Method 8260B: Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS). *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods (SW-846)*, Vol 1B, Final Update III.

[7] U.S. EPA, 2002, Method 5035A: Closed-System Purge-And-Trap and Extraction for Volatile Organics in Soil and Waste Samples. *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods (SW-846)*, Vol 1B, Draft Revision 1.

[8] X-Wand is a trademark of Western Research Institute, Laramie, WY. The X-Wand device is covered by a pending patent.

TABLE X1.1 TCE Concentrations Determined in TCE-Contaminated Soil Samples, mg/Kg

Sample Location	Sample Screened using a Heated Diode Sensor Device[A] (Estimated Concentration)	Sample Analyzed by Commercial Laboratory GC/MS Analysis	Sample Analyzed by Research Laboratory GC/MS Analysis
1	0.091	0.32	0.27
2	0.23	1.0	2.0
3	0.13	0.47	0.55
4	0.71	1.6	1.8
5	1.4	2.0	2.0
6	0.12	0.66	0.67
7	0.30	1.3	1.2
8	0.14	0.58	0.63
9	0.091	0.10	0.11
10	0.13	0.40	0.41
11[B]	<0.005[C]	<0.05[D]	0.011
12	0.31	0.88	1.0
13	2.1	1.5	1.9
14	0.023	0.059	0.057
15	0.30	0.77	0.54
16	0.16	0.40	0.41
17	0.10	0.40	0.41
18	0.14	0.17	0.17
19	1.3	2.8	2.4
20[B]	<0.005[C]	<0.05[D]	<0.01[E]

[A] The X-Wand heated diode sensor device was used to screen samples in this study. X-Wand is a trademark of Western Research Institute, Laramie, WY. The X-Wand device is covered by a pending patent.

[B] Sample locations 11 and 20 were believed to be uncontaminated.

[C] Method quantitation limit is 0.005 mg/Kg.

[D] Commercial laboratory estimated quantitation limit is 0.05 mg/Kg.

[E] Research laboratory estimated quantitation limit is 0.01 mg/Kg.

TABLE X1.2 Percent TCE Determined in TCE-Contaminated Soil Samples Using the Heated Diode Sensor Device as Compared with GC/MS Data

Sample Location	Concentration Determined Using Heated Diode Sensor Device[A] (Estimated Concentration, mg/Kg)	Average Concentration Determined by Laboratory GC/MS Analysis, mg/Kg[B]	Percent TCE Determined by Heated Diode Sensor Device[C]
1	0.091	0.30	30 %
2	0.23	1.5	15
3	0.13	0.51	25
4	0.71	1.7	42
5	1.4	2.0	70
6	0.12	0.67	18
7	0.30	1.3	23
8	0.14	0.61	23
9	0.091	0.11	83
10	0.13	0.41	32
11[D]	---	---	---
12	0.31	0.94	33
13	2.1	1.7	124
14	0.023	0.058	40
15	0.30	0.66	45
16	0.16	0.41	39
17	0.10	0.41	24
18	0.14	0.17	82
19	1.3	2.6	50
20[D]	---	---	---

[A] The X-Wand heated diode sensor device was used to screen samples in this study. X-Wand is a trademark of Western Research Institute, Laramie, WY. The X-Wand device is covered by a pending patent.

[B] Average concentration determined using commercial and research laboratory data

[C] Percent of average concentration determined using commercial and research laboratory data

[D] Sample locations 11 and 20 were believed to be uncontaminated.

in X1.1.5, some of the samples were extremely wet. These are samples 1-11 listed in Table X1.1. There is no apparent difference in the data for samples 1-11, as compared with the data for samples 12-20, which were much drier samples. The results show that moisture does not interfere with the performance of the heated diode sensor for use in screening TCE-contaminated soil for TCE.

X1.1.8 Table X1.2 shows the percent of TCE determined in the TCE-contaminated soil samples using the screening practice as compared with the average concentrations of TCE determined in the samples by the commercial and research laboratory GC/MS analysis. As shown in Table X1.2, these values range from 15 to 124 %. For all but one of the samples, the values are less than 100 % due to TCE remaining in the soil during screening.

X1.1.9 The heated diode sensor method can also be used to screen soil suspected of containing HVOC contamination for the presence or absence of contamination. The voltage reading from the device is used to indicate the presence or absence of HVOC contamination. The voltage reading of a heated diode sensor device is specific to the particular device, the particular sensor, and the amount of use the sensor has encountered. For this reason, the voltage reading can be used to indicate the presence or absence of HVOC contamination; however, to compare readings made during different screening episodes, the relative response values for the samples, R_s, (see 13.4 of the practice) should be calculated and compared. The voltage readings and the relative response values for the samples that were screened from each of the sampling locations at the TCE-contaminated site are listed in Table X1.3.

X1.1.9.1 The data given in Table X1.3 show the usefulness of the screening practice for indicating the presence or absence of HVOC contamination in soil. The soil samples containing TCE contamination gave sample voltage readings ranging from 0.237 to 7.818 V, indicating the presence of HVOC contamination. One of the soil samples believed to be uncontaminated, Sample 11, gave a voltage reading of 0.029, indicating an extremely low concentration of HVOC in the soil. The second soil sample believed to be uncontaminated, Sample 20, gave a voltage reading of 0.000 V, indicating no HVOC contamination in the soil.

TABLE X1.3 Sample Voltage Readings[A] and Sample Relative Response Values Determined using the Heated Diode Sensor Screening Method for Indicating the Presence or Absence of HVOC Contamination in Soil

Sample Location	Sample Voltage Reading, V_s	Sample Relative Response, R_s ($R_s = V_s/V_{HighTCEStd}$)
1	0.960	0.0971[B]
2	3.377	0.3416[B]
3	1.807	0.1828[B]
4	5.443	0.5126[C]
5	6.825	0.6428[C]
6	2.056	0.2079[B]
7	4.153	0.4200[B]
8	2.337	0.2364[B]
9	1.078	0.1015[C]
10	1.967	0.1853[C]
11[D]	0.029	0.0029[B]
12	4.252	0.4475[E]
13	7.818	0.8229[E]
14	0.237	0.0249[E]
15	3.718	0.3913[E]
16	2.248	0.2366[E]
17	0.996	0.1048[E]
18	2.121	0.2232[E]
19	7.200	0.7578[E]
20[D]	0.000	0.0000[E]

[A] The X-Wand heated diode sensor device was used to screen samples in this study. X-Wand is a trademark of Western Research Institute, Laramie, WY. The X-Wand device is covered by a pending patent.
[B] $V_{HighTCEStd}$ = 9.887
[C] $V_{HighTCEStd}$ = 10.618
[D] Sample locations 11 and 20 were believed to be uncontaminated.
[E] $V_{HighTCEStd}$ = 9.501

X2. APPLICATION OF THE PRACTICE FOR SCREENING TRICHLOROETHYLENE (TCE)-CONTAMINATED MEDIA USING A HEATED DIODE SENSOR TO WATER COLLECTED AT A TCE-CONTAMINATED FIELD SITE AND AN HVOC-CONTAMINATED FIELD SITE

X2.1 A study was conducted to evaluate the performance of the practice to screen TCE-contaminated groundwater. The screening practice was evaluated by comparing the screening data with data from analysis of corresponding groundwater samples collected from the same groundwater well and analyzed in the laboratory using gas chromatography/mass spectroscopy (GC/MS).

X2.1.1 The groundwater samples were collected by members of an environmental consulting firm contracted to conduct groundwater monitoring at the site. At each groundwater well, four precleaned 40-mL volatile organic analysis (VOA) vials were filled with water for laboratory analysis. Two of these were sent to a commercial laboratory for GC/MS analysis and two were sent to a research laboratory for GC/MS analysis. At each groundwater well, a 250-mL glass jar having an open-top cap with a PTFE-bonded silicone septum was filled with approximately 25 g of water for on-site screening using the practice. The 250-mL jars were marked using a laboratory marker to show the filling level to give approximately 25 g of water in the containers. After the jars were marked, the mass of each empty jar with its lid was recorded. Groundwater sampling at each well took approximately 1 to 2 h. After the samples were collected from a well, they were placed in a cooler with ice packs. Five wells were sampled over a period of two days, and duplicate samples were collected from one of the wells that was sampled each day. For sampling wells at which duplicate samples were collected, eight VOA vials and two 250-mL glass jars were provided to the sampling team.

X2.1.2 When a cooler from a well was received from the sampling team, it was taken to a field trailer where the samples were screened. The samples in the 250-mL jars were removed from the cooler, checked to make sure their lids were tight, and placed on a table in the trailer so they could reach room temperature. The sample temperature specified in the screening practice is 10 to 49 ºC (50 to 120 ºF). The temperature in the field trailer was 22 ºC on both days when the samples were screened. The samples in the VOA vials were removed from the cooler and checked to make sure that their lids were tight and that they did not contain any air bubbles. The samples were labeled, wrapped in bubble wrap, and packed in coolers with ice packs for overnight shipment to the analytical laboratories. Coolers were shipped to the laboratories at the end of each sampling day. Each cooler contained a mini digital temperature data logger so the storage temperature in the coolers could be monitored to ensure that the proper temperature was maintained. Upon receipt by the laboratories, the samples were analyzed for TCE using EPA SW-846 Methods 8260B, Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)[6], and 5030B, Purge-and-Trap for Aqueous Samples.[9]

X2.1.3 When the water samples for screening were at room temperature, the samples were weighed to determine the mass of water in each of the containers. The sample mass was converted to sample volume in milliliters based on an assumed density of water of 1.0 g/mL. Because the water from this site is contaminated with TCE, the procedure described in the practice for screening water known to contain TCE was performed, and estimated concentrations of TCE in the water samples were determined. An X-Wand heated diode sensor device was used to screen the water samples.[8]

X2.1.4 The data generated in this study are specific to the experimental design of the study. The data give information on the performance of the heated diode screening practice to estimate TCE concentrations in water collected at a TCE-contaminated site and also on use of the method to determine the presence or absence of HVOC contamination at a site suspected of containing HVOC contamination. The data generated in this study are also specific to the water used in the study, TCE concentrations, and the heated diode sensor device that was used to screen the water samples. For other waters, analyte concentrations, and heated diode sensor devices, these data may not apply.

X2.1.5 The estimated concentrations of TCE in the water samples calculated using the screening practice, along with the TCE concentrations in the water samples determined by the commercial and research laboratory GC/MS analysis are shown in Table X2.1. The first column of data shows the estimated concentrations of TCE determined by screening the samples using the heated diode screening practice. The second and third columns of data show the TCE concentrations determined in the samples by laboratory GC/MS analysis.

X2.1.5.1 The data given in Table X2.1 show that the method performs well for screening TCE-contaminated water samples to give an estimated TCE concentration in the samples. The screening method gave no false negative or false positive results and provided estimated TCE concentrations that as screening data correlate well with the laboratory data.

X2.1.6 Table X2.2 shows the percent of TCE determined in the TCE-contaminated water samples using the screening method as compared with the average concentrations of TCE determined in the samples by the commercial and research laboratory GC/MS analysis. As shown in Table X2.2, these values range from 50 to approximately 200 %.

X2.1.7 The heated diode sensor method can also be used to screen water suspected of containing HVOC contamination for the presence or absence of contamination. The voltage reading from the device is used to indicate the presence or absence of HVOC contamination. The voltage reading of a heated diode sensor device is specific to the particular device, the particular sensor, and the amount of use the sensor has encountered. For this reason, the voltage reading can be used to indicate the presence or absence of HVOC contamination; however, to compare readings made during different screening episodes, the relative response values for the samples, R_s, (see 18.4) should be calculated and compared. The voltage readings and the relative response values for the water samples that were screened (Table X2.1 and Table X2.2) are listed in Table X2.3.

X2.1.7.1 The data given in Table X2.3 show the usefulness of the screening method for indicating the presence or absence of HVOC contamination in water. The water samples gave sample relative response values ranging from 0.0109 to 0.8281, indicating the presence of HVOC contamination.

X2.2 The screening practice was used to screen groundwater samples from a second site that was contaminated primarily with vinyl chloride and other HVOCs. Because the primary contaminant at this site was not TCE, the procedure described for screening water to indicate the presence or absence of

TABLE X2.1 TCE Concentrations Determined in TCE-Contaminated Water Samples, mg/Lg

Well	Sample Screened using a Heated Diode Sensor Device[A] (Estimated Concentration)	Sample Analyzed by Commercial Laboratory GC/MS Analysis	Sample Analyzed by Research Laboratory GC/MS Analysis
1	2.2	2.60	2.68
2	1.5	1.50	1.73
3	0.020	0.009	0.017
3 duplicate	0.023	0.010	0.011
4	0.93	1.50	1.57
5	0.50	0.880	0.972
6	0.002	0.002	0.006
6 duplicate	0.002	0.002	0.003

[A] The X-Wand heated diode sensor device was used to screen samples in this study. X-Wand is a trademark of Western Research Institute, Laramie, WY. The X-Wand device is covered by a pending patent.

TABLE X2.2 Percent TCE Determined in TCE-Contaminated Water Samples Using the Heated Diode Sensor Device as Compared with GC/MS Data

Sample Location	Concentration Determined Using Heated Diode Sensor Device[A] (Estimated Concentration, mg/L)	Average Concentration Determined by Laboratory GC/MS Analysis, mg/L[B]	Percent TCE Determined by Heated Diode Sensor Device[C]
1	2.2	2.64	83 %
2	1.5	1.62	93
3	0.020	0.013	154
3 duplicate	0.023	0.011	209
4	0.93	1.54	60
5	0.50	0.926	54
6	0.002	0.004	50
6 duplicate	0.002	0.003	67

[A] The X-Wand heated diode sensor device was used to screen samples in this study. X-Wand is a trademark of Western Research Institute, Laramie, WY. The X-Wand device is covered by a pending patent.

[B] Average concentration determined using commercial and research laboratory data.

[C] Percent of average concentration determined using commercial and research laboratory data.

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[9] U.S. EPA, 2002, Method 5030B: Purge-And-Trap for Aqueous Samples, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods (SW-846)*, Vol 1B, Draft Revision 1.

TABLE X2.3 Sample Voltage Readings[A] and Sample Relative Response Values Determined using the Heated Diode Sensor Screening Method for Indicating the Presence or Absence of HVOC Contamination in Water

Sample Location	Sample Voltage Reading, V_s	Sample Relative Response, R_s ($R_s = V_s / V_{HighTCEStd}$)
1	7.617	0.7603[B]
2	7.730	0.8087[C]
3	0.197	0.0206[C]
3 duplicate	0.126	0.0132[C]
4	6.379	0.6673[C]
5	7.916	0.8281[C]
6	0.109	0.0109[B]
6 duplicate	0.113	0.0113[B]

[A] The X-Wand heated diode sensor device was used to screen samples in this study. X-Wand is a trademark of Western Research Institute, Laramie, WY. The X-Wand device is covered by a pending patent.

[B] $V_{HighTCEStd} = 10.019$.

[C] $V_{HighTCEStd} = 9.559$.

HVOC contamination was used. The screening practice was evaluated by comparing the screening data with data from analysis of corresponding groundwater samples collected from the same groundwater well and analyzed in the laboratory using GC/MS.

X2.2.1 The groundwater samples were collected by members of an environmental consulting firm contracted to conduct groundwater monitoring at the site. At each groundwater well, four precleaned VOA vials were filled with water for laboratory analysis. Two of these were sent to a commercial laboratory for GC/MS analysis and two were sent to a research laboratory for GC/MS analysis. At each groundwater well, a 250-mL glass jar having an open-top cap with a PTFE-bonded silicone septum was filled with approximately 25 g of water for on-site screening using the practice. The 250-mL jars were marked using a laboratory marker to show the filling level to give approximately 25 g of water in the containers. After the jars were marked, the mass of each empty jar with its lid was recorded. Groundwater sampling at each well took approximately 2 to 3 h. After the samples were collected from a well, they were placed in a cooler with ice packs. Eight wells were sampled over a period of three days, and duplicate samples were collected from one of the wells that was sampled each day, giving three duplicate samples from the site. For sampling wells at which duplicate samples were collected, eight VOA vials and two 250-mL glass jars were provided to the sampling team.

X2.2.2 When a cooler from a well was received from the sampling team, it was taken to a field trailer where the samples were screened. The samples in the 250-mL jars were removed from the cooler, checked to make sure their lids were tight, and placed on a table in the trailer so they could reach room temperature. The sample temperature specified in the screening practice is 10 to 49 °C (50 to 120 °F). The temperatures in the field trailer ranged from 21 to 25 °C during the three days that samples were screened. The samples in the VOA vials were removed from the cooler and checked to make sure that their lids were tight and that they did not contain any air bubbles. The samples were labeled, wrapped in bubble wrap, and packed in coolers with ice packs for overnight shipment to the analytical laboratories. Coolers were shipped to the laboratories at the end of each sampling day. Each cooler contained a mini digital temperature data logger so the storage temperature in the coolers could be monitored to ensure that the proper temperature was maintained. Upon receipt by the laboratories, the samples were analyzed for HVOCs using EPA SW-846 Methods 8260B, Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)[6], and 5030B, Purge-and-Trap for Aqueous Samples.[9] The research laboratory also analyzed the water samples for BTEX (benzene, toluene, ethyl benzene, and xylene) so the effect of these compounds on the response of the heated diode sensor could be evaluated.

X2.2.3 The procedure to indicate the presence or absence of HVOC contamination involves using the voltage reading for the headspace above the water sample. The voltage reading is specific to the particular heated diode sensor device used, the particular sensor, and the amount of use the sensor has encountered. For this reason, the voltage reading for a water sample can be used to indicate the presence or absence of HVOC contamination; however, to compare readings made during different screening episodes, that is, on different days, the relative response values for the samples, R_s, (see 18.4) should be calculated and compared.

X2.2.4 The data generated in this study are specific to the experimental design of the study. The data give information on the performance of the heated diode screening practice to determine the presence or absence of HVOC contamination at a site suspected of containing HVOC contamination. The data generated in this study are also specific to the water used in the study, HVOC concentrations, and the heated diode sensor device that was used to screen the water samples. For other waters, analyte concentrations, and heated diode sensor devices, these data may not apply.

X2.2.5 When the water samples for screening were at room temperature, they were screened to determine the voltage reading for the headspace above each sample using an X-Wand heated diode sensor device.[8] The relative response values, R_s, for the samples were calculated and are listed in Table X2.4, along with the total HVOC concentrations in the water samples determined by the commercial and research laboratory GC/MS analysis.

X2.2.6 The sample response values listed in Table X2.4 show the usefulness of the screening practice for indicating the presence or absence of HVOC contamination in water samples. The samples containing HVOC concentrations ranging from approximately 0.015 (average of the commercial and research laboratory data for well 6) to 1.54 mg/L (average of commercial and research laboratory data for well 1) have sample response values ranging from 0.0136 to 0.3483, indicating the presence of HVOC contamination in the samples. The laboratory data for the water from well 8 show <0.001 mg/L total HVOC. This correlates with the screening data, which show very low sample response values for the water from this well at 0.0011 and 0.0007, indicating very low or no HVOC

TABLE X2.4 Sample Voltage Readings[A] and Sample Relative Response Values Determined using the Heated Diode Sensor Screening Method for Indicating the Presence or Absence of HVOC Contamination in Water; Primary HVOC Contaminant is Vinyl Chloride

			Total HVOC Content (mg/L)		
Well	Sample Voltage Reading, V_s	Sample Relative Response, R_s ($R_s = V_s/V_{HighTCEStd}$)	Commercial Lab GC/MS	Research Lab GC/MS	Research Lab BTEX (mg/L)
1	3.563	0.3483[B]	1.37	1.72	1.30
2	2.468	0.2412[B]	0.910	1.15	0.262
3	2.550	0.2492[B]	0.589	0.624	0.079
3 duplicate	2.552	0.2494[B]	0.404	0.484	0.066
4	0.741	0.0719[C]	0.028	0.030	0.235
5	0.369	0.0361[D]	0.065	0.079	<0.001
5 duplicate	0.175	0.0171[D]	0.044	0.067	<0.001
6	0.139	0.0136[D]	0.016	0.014	<0.001
7	0.226	0.0219[C]	0.038	0.046	<0.001
8	0.011	0.0011[C]	<0.001	<0.001	<0.001
8 duplicate	0.007	0.0007[C]	<0.001	<0.001	<0.001

[A] The X-Wand heated diode sensor device was used to screen samples in this study. X-Wand is a trademark of Western Research Institute, Laramie, WY. The X-Wand device is covered by a pending patent.

[B] $V_{HighTCEStd} = 10.231$.

[C] $V_{HighTCEStd} = 10.311$.

[D] $V_{HighTCEStd} = 10.220$.

contamination present in the water. The data in Table X2.4 show no false negative or false positive results from the screening.

X2.2.7 The last column in Table X2.4 shows the BTEX concentrations determined by the research laboratory's GC/MS analysis of the water samples. The screening practice states that hydrocarbon fuels, including fuels containing aromatic compounds, such as gasoline, are not detected by the practice (see 5.6). This is shown by the data given in Table X2.4. The water from wells 2 and 4 contain approximately the same amount of BTEX, 0.262 and 0.235 mg/L, respectively; however, the response value for the water from well 2 is 0.2412 and the response value from well 4 is 0.0719, showing no contribution by BTEX to the response for the water from well 4.