Methodology for Identifying the Area of Concern Around a Property Potentially Impacted by Vapor Migration from Nearby Contaminated Sources

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ABSTRACT

The ASTM E 2600-10 vapor encroachment screening standard was published in June 2010 and provides guidance on evaluating vapor migration from contaminated properties and media. The standard specifically focuses on screening for the likelihood of migrating vapors from nearby contaminated properties and media, such as soil and groundwater, to encroach upon the subsurface of a property involved in a real estate transaction. Two tiers for screening are included in the practice. The first tier is based upon the existence of known or suspect contaminated sites in an identified area of concern. The second tier is more comprehensive and investigates specific characteristics associated with the contaminated plumes from these sites, or if no plume information is available, relies on sampling. If the likelihood exists for vapors to reach the subsurface of the property, further investigation would be necessary to determine if intrusion is occurring into any buildings on the property.

This paper is directed at the ASTM screening methodology and the implications for environmental professionals conducting property due diligence in real estate transactions.

INTRODUCTION

Vapor migration and intrusion into structures on a property can potentially create significant liability and have a material impact on property value. As such, it is a growing concern for property owners, prospective purchasers of property and environmental professionals conducting due diligence.[1,2] To respond to this industry concern, in June 2010, ASTM published *E 2600-10, Standard Guide for Vapor Encroachment Screening on Property Involved in Real Estate Transactions.*[3]

The standard is specifically directed at property involved in real estate transactions and consists of two tiers to evaluate the potential for a vapor encroachment condition (i.e.,VEC) to exist on such property.

TIER 1 SCREENING UNDER E 2600-10

The information required for Tier 1 screening in E 2600-10 is essentially the same information collected as part of an ASTM E 1527 Phase I.[4] The first check in the screening process is a search distance test to identify if there are any known or suspected contaminated sites with volatile or semi-volatile hazardous chemicals of concern (COC) in the area of concern (AOC). If there are none, no further action is required.

The most commonly found sites within the AOC that can potentially impact a target property from a vapor migration viewpoint include:

- Present and former gas station sites (with benzene, toluene, ethylbenzene and xylenes (BTEX), etc.)
- Present and former dry cleaner sites (with perchloroethylene (PCE), etc.)
- Present and former industrial sites, particularly those using chlorinated solvents (such as trichloroethylene (TCE), PCE, dichloroethane (DCA), etc.)
- Former manufactured gas plant sites (with naphthalene, etc.)
- Former hazardous waste disposal sites (with COCs)
- Present and former garbage landfills (with COCs)

The AOC for contaminated sites with [non-petroleum hydrocarbon] COC, such as chlorinated solvents, is 1,760 feet around a target property (TP), extending from its boundary. For sites with petroleum hydrocarbon COC, such as BTEX, the AOC is 528 feet around a TP, extending from its boundary. Hence, for example, a gas station site with a leaking underground storage tank would be in the AOC if the gas station was located anywhere within 528 feet from the TP boundary. The AOC is smaller for petroleum hydrocarbons because they are known to undergo significant biodegradation in the presence of oxygen. If groundwater flow direction is known or can be inferred, the AOC for both [non-petroleum hydrocarbon] COC-contaminated sites and petroleum hydrocarbon-contaminated sites can be reduced significantly in the down-gradient and cross-gradient directions.

Technical Basis for the AOC

There is a sound technical basis for establishment of the AOC. The AOC search distances were determined based upon conservative consideration of both plume lengths and the distances vapors volatilized from contaminated plumes might travel along a path of least resistance in relatively permeable soil from a source (such as contaminated groundwater) through the vadose zone directly to a TP. Plume length research was conducted for both volatile chemical plumes (such as chlorinated solvent plumes from dry cleaners) and volatile petroleum hydrocarbon plumes from leaking underground storage tank sites. In order to be conservative, the plume length selected to determine the AOC was based upon the 90th percentile distance.[6,7,8,9] For [non-petroleum hydrocarbon] COC-contaminated plumes (such as may be associated with dry cleaners), 90% of the time the plume length was less than approximately 1,590 feet, and for volatile petroleum hydrocarbon-contaminated COC plumes, 90% of the time it was less than approximately 390 feet. Using experience from vapor intrusion sites in the U.S. on the distances vapors may reasonably be expected to migrate through a vadose zone consisting of relatively permeable soil, and adding this distance to the 90^{th} percentile plume length, the AOC search distance was determined, i.e., 1,760 feet for [non-petroleum hydrocarbon] COC, and 528 feet for petroleum hydrocarbon COC.

As indicated previously, if groundwater flow direction is known or can be inferred, then the AOC can be reduced significantly in the down-gradient and cross-gradient directions. This is important because each known or suspect source of contamination within the AOC must be investigated, and may require a file review at state regulatory offices.

For Contaminated Sources Located Up-gradient of the TP

For contaminated sources (such as a dry cleaner with a PCE release or a gas station with a leaking underground storage tank releasing BTEX) located up-gradient of the TP, the focus would be on those contaminated sites within the AOC distances (i.e., 1,760 feet for COC sources and 528 feet for petroleum hydrocarbon COC sources).

For Contaminated Sources Located Cross-gradient of the TP

When a source of COC contamination (such as a dry cleaner with a PERC release or a gas station with a leaking underground storage tank) is located cross-gradient from the TP, the length of the plume associated with the cross-gradient source is not relevant. However, the plume’s width is relevant. According to the E 2600-10 standard, what matters for cross-gradient sources is whether the nearest edge of the contaminated plume is within the critical distance to the nearest boundary of the TP. The critical distance, as defined in E 2600-10, effectively is the upper limit distance a vapor can reasonably be expected to migrate in relatively permeable soil assuming the path of least resistance is directly from the nearest edge of the contaminated media (such as groundwater) to the nearest TP boundary. The distance of concern from the TP boundary to the property that created the contamination (e.g., a dry cleaner) would be the critical distance plus a distance to account for the plume width at that point. While the critical distance numbers are specifically identified in E 2600-10 for both petroleum hydrocarbon and non-petroleum hydrocarbon contamination, nothing prescriptive is mentioned in the standard about how to deal with plume width if such information is not available. A suggested approach is described below.

Suggested Methodology for Dealing with Plume Width at Cross-gradient Sources

For contaminated sites located cross-gradient from the TP, contaminated plume width must be taken into consideration in selecting an appropriate distance of concern ($D_{concern}$) for screening. The question is what would be a reasonably conservative estimate for plume width (a default value) to use in the screening process assuming no actual contaminated plume information is available? A conservative methodology for estimating a default contaminated plume width has been proposed by Buonicore.[5]

This approach bases the default maximum plume width as approximately equal to 1/3rd of the plume length[10,11,12] and, to be conservative, uses the 90th percentile plume length (P_{L90}) discussed previously. For additional conservativism, this default maximum plume width is used regardless of where the contaminated site is located in the cross-gradient quadrant.

Assuming symmetry of the contaminated plume from the contaminated site, one-half of the plume width (P_W) would be added to the critical distance ($D_{critical}$) to establish the distance of concern for screening purposes. This can be expressed as:

$$D_{concern} = D_{critical} + \tfrac{1}{2} P_W = D_{critical} + \tfrac{1}{2} (P_{L90}/3) \qquad \textbf{(Eq. 1)}$$

Comparing this approach for default maximum plume width with actual plume data[3,4,5,6)] suggests the approach is reasonable.

For non-petroleum hydrocarbon COC-contaminated sites (such as a dry cleaner) located cross-gradient from the TP:

$$D_{critical} = 100 \text{ ft.}$$

$$P_{L90} = 1{,}590 \text{ ft.}$$

Therefore:

$$D_{concern} = 100 + \tfrac{1}{2} (1{,}590/3) = 365 \text{ ft.}$$

The default E 2600-10 AOC search distance in the cross-gradient quadrant can then be reduced from 1,760 feet to 365 feet for sites contaminated with [non-petroleum hydrocarbon] COC, such as chlorinated solvents.

For petroleum hydrocarbon-contaminated sites (such as a gas station with a leaking underground storage tank) located cross-gradient from the TP where LNAPL or "free product" exists on the water table:

$$D_{critical} = 100 \text{ ft.}$$

$$P_{L90} = 390 \text{ ft.}$$

Therefore:

$$D_{concern} = 100 + \tfrac{1}{2} (390/3) = 165 \text{ ft.}$$

Using this approach, the default E 2600-10 AOC search distance in the cross-gradient quadrant can then be reduced from 520 feet to 165 feet for petroleum hydrocarbon-contaminated sites where LNAPL exists.

If only dissolved petroleum hydrocarbons (in groundwater) are present:

$$D_{critical} = 30 \text{ ft.}$$

$$P_{L90} = 390 \text{ ft.}$$

Therefore:

$$D_{concern} = 30 + ½ (390/3) = 95 \text{ ft.}$$

Using this approach, the default E 2600-10 AOC search distance in the cross-gradient quadrant can then be reduced from 520 feet to 95 feet for sites with only dissolved petroleum hydrocarbon contamination.

For Contaminant Sources Located Down-gradient of the TP

For contaminated sites (such as a dry cleaner with a PERC release or a gas station with a leaking underground storage tank) located down-gradient of the TP, plume length and width matter little and the focus would only be on the critical distance. Hence, the AOC can be reduced from 1,760 feet to 100 feet for COC contaminated sites, except for petroleum hydrocarbon COC contaminated sites where the AOC search distance can be reduced from 528 feet to either 100 feet (when LNAPL or "free product" is presumed to be present above the water table) or 30 feet (when only dissolved petroleum hydrocarbons are presumed to be present in the groundwater).

Application of Professional Judgment

If a known or suspected contaminated site with COC is located in the AOC, judgment may be applied based upon experience. For example, there may be a hydraulic or physical barrier between the TP and the contaminated site. A river can act as a hydraulic barrier to any migrating contaminant vapors. The same may be true if a clay barrier or fresh water lens exists in the sub-surface. If such a barrier exists, the professional may choose to eliminate that contaminated site in the AOC from concern.

The professional must also be aware of the possible existence of major man-made or natural preferential vapor pathways between the contaminated site and the TP. Natural preferential pathways may include, for example, fractured bedrock or karst terrain. Man-made pathways may include, for example, major utility corridors or sewer lines. If such significant preferential pathways do exist, then proceeding directly to invasive sampling (e.g., soil gas sampling) under Tier 2 may be necessary to determine if vapors have encroached upon the TP.

The environmental professional may also be able to eliminate a contaminated site within the AOC from further consideration using experience with local subsurface geology and soil characteristics. For example, if the overlaying soil is highly impermeable clay, this may inhibit vapor migration. The same may be true for a fresh water lens located above a contaminated groundwater plume.

The conclusion from Tier 1 screening is that a VEC exists or is likely to exist or that it can not be ruled out, or that it can be ruled out because it does not exist or is unlikely to exist. If a VEC exists or is likely to exist or can not be ruled out, the client and the environmental professional must decide if further investigation, such as proceeding to Tier 2 screening, is warranted. A user may, for example, decide alternatively to proceed pre-emptively to mitigation.

TIER 2 SCREENING UNDER E 2600-10

Tier 2 screening may be either a non-invasive or an invasive investigation, depending upon the availability of contaminated plume data associated with the contaminated site creating the VEC identified in Tier 1. If contaminated plume data are available in state regulatory files or elsewhere that can provide insight into the extent of contamination associated with the source and the status of any remediation, then non-invasive screening can be conducted by assessing whether the contaminated plume edge nearest the boundary of the TP is within or beyond the critical distance.

If no plume information is associated with the source of contamination (or if there are preferential pathways), then it may be appropriate to evaluate whether invasive sampling (e.g., soil gas and/or groundwater sampling at or near the TP boundary) is a viable option. Sampling should not be pursued unless it is believed that useful information can be collected. If sampling is conducted, the results may be used to determine if a VEC still exists or if it can be ruled out because it does not exist. If it still exists, the client and environmental professional must decide on what further investigation, if any, is appropriate. It may, for example, now be appropriate to follow vapor intrusion guidance established by the state regulatory agency where the property is located.

IMPLICATIONS FOR ENVIRONMENTAL PROFESSIONALS

Environmental professionals conducting a Phase I environmental site assessment investigation on a target property today must evaluate the potential impact of vapor migration analogous to the way that contaminated groundwater migration has been considered. The only question that needs to be answered is what methodology the professional will use to conduct this evaluation. Will it be their own methodology based upon experience, or will professional rely on the vapor encroachment screening methodology in ASTM E 2600-10? If the EP’s methodology is used, it needs to be fully documented in the Phase I report. The preferred approach, however, from a liability management standpoint would be to rely on the screening methodology included in ASTM E 2600-10 developed using an industry consensus approach.

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KEYWORDS

ASTM standard, vapor migration, vapor encroachment, vapor intrusion, area of concern, vapor encroachment screening, VEC