Letter Health Consultation

Review of Soil Gas Data Collected in 2013

LEE'S LANE LANDFILL SITE

LOUISVILLE, JEFFERSON COUNTY, KENTUCKY

JULY 28, 2014

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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LETTER HEALTH CONSULTATION

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LOUISVILLE, JEFFERSON COUNTY, KENTUCKY

Prepared By:

Central Branch
Division of Community Health Investigations
Agency for Toxic Substances and Disease Registry

Ms Donna Seadler
EPA Region IV
61 South Forsyth Street
Atlanta, GA 30303

RE: Health Consultation for Lee's Lane Landfill, Louisville, KY
KYD980557052

Dear Ms. Seadler:

SUMMARY: This health consultation is in response to your request for our review of soil gas data collected in 2013 from the Lee's Lane Landfill site. Various volatile organic compounds were found, mostly in deeper wells, in an area where subsurface contaminant migration to homes in the nearby Riverside Gardens subdivision is possible. The contaminant concentrations in the soil gas are high enough and may be close enough to the homes to warrant further investigation under both EPA and ATSDR current guidance related to vapor intrusion. Seasonal variations may increase the potential of vapor intrusion into the homes, but there is only limited data available to evaluate this possibility.

BACKGROUND: On December 16, 2013, EPA and ATSDR discussed the recent soil gas data collected by EPA Region IV near the Lee's Lane Landfill site outside Louisville, KY. The Agency for Toxic Substances and Disease Registry (ATSDR) was asked to review the soil gas data for possible human health implications. [1]

The 112-acre Lee's Lane Landfill Superfund site (the Site) is located on the Kentucky bank in the Ohio River floodplain approximately 4 miles downriver from Louisville, Kentucky (i.e., on the River side of the flood control levees near River Mile 615 along the left descending bank of the Ohio River). Riverside Gardens is a residential community separated from the site by the flood control levees. The Site was initially a sand and gravel quarry with operations dating back at least to the early 1940's. Landfill operations occurred between 1948 and 1975. At least 212,400 tons of domestic, commercial, solid municipal and industrial wastes were disposed of at the landfill by industrial firms and residents in and around the Louisville area.

In 1975, nearby residents reported flash fires in their basements. Methane, apparently from the landfill, was being ignited by the pilot lights of their water heaters. Subsequently, the State of Kentucky closed the landfill and local authorities evacuated and purchased seven nearby homes because of the presence of explosive levels of methane. In October 1980, the Kentucky Department of Hazardous Materials and Waste Management (KDHMWM) installed a gas collection system on the Ohio River side of the flood control levee.

The EPA placed the Site on the National Priorities List (NPL) in 1983. Following a remedial investigation and feasibility study (RI/FS), EPA issued a Record of Decision (ROD) in 1986. Following completion of the cleanup activities outlined in the ROD, the EPA placed the Site into the Operation and Maintenance (O&M) phase of the remedial process and deleted the Site from the NPL in 1996. Since entering the O&M phase, EPA has been conducting reviews of the Site every five years to insure the selected remedial activities are still protective. As part of the fifth five year review, soil gas samples along the levee were collected and analyzed for volatile organic compounds (VOCs). (See Figure 1) [2,3] With almost 40 years of work on this site, the amount of historical data is extensive.

The RI in the 1980's identified soil, ground water, and surface water contaminated with benzene, inorganic chemicals, and heavy metals, including lead and arsenic, from the landfill. Methane gas venting from the landfill also impacted air quality. [2] Information pertinent to the migration of soil gas includes groundwater depth and flow direction, local geology, and the proximity of nearby homes. The geology of the site area consists of approximately 110 feet of Ohio River alluvium; mostly highly permeable sands and gravels with less permeable clays in lens along the riverbank. The water table is approximately 50 feet below land. Flow in the aquifer is predominantly toward the Ohio River. Up to seven feet of variation in groundwater levels were observed during the RI close to the River but only about two feet near the levee. Seasonal fluctuations of water levels can be up to about 10'. [3] (See Figure 2)

Figure 2 shows these layers of sand and clay in a cross-section diagram taken from the 1986 RI report with key features highlighted. The cross-section is from the south and central portions of the site. According to the estimates in the RI, the depth of fill (or presumed depth of waste) in the southern or downstream portion of the site was fairly uniform at 25 feet. The depth of waste in the central portion between the two access roads in figure 1 ranged from 5 to 25 feet. The depth of waste in the northern or upstream portion of the site ranged from 25 to 40 feet. A clay layer just below the surface appears to be much thinner at the northern end of the landfill. Assuming the clay layer indicated above the water table in Figure 2 is continuous under the entire site, the fill materials (i.e., the wastes) in the northern portion of the landfill could extend below this clay layer. [3] Conditions, especially groundwater levels, can change over time due to droughts, flooding, or erosion of surface soils amongst other causes and may differ from those reported in the 1986 RI..

Also of importance in evaluating soil gas data is information related to points of contact between soil gas and humans. In a previous five year review, the Metropolitan Sewer District (MSD) for Louisville/Jefferson County provided a map indicating which homes near the Site had full or partial basements. This map is shown in Figure 3. [4]

The June 2013 soil gas sampling event by EPA Region IV utilized the thirteen existing permanent soil gas monitoring wells located generally along the levee and five temporary soil gas monitoring points located in the neighborhood adjacent to the site. The permanent wells include the "G" series wells installed in 1987, which were actually two separate co-located wells. One well at each location was screened at a shallow interval at approximately

5-15 feet below ground surface (bgs); the second well was screened at a greater depth of 30-40 feet bgs. Wells G1 through G4 are located along the levee on the side away from the River. Well G5 is located north of Lee's Lane about two blocks west of the levee. The "GMW" series permanent wells were installed in 2010 around well G-1 with a screen interval of approximately 4-20 feet bgs. The temporary "LLL" or "SG" series wells were installed by a Geoprobe® with a sampling interval of 6-24 feet bgs. See Figure 1 for well locations. [5]

In the following discussion, ATSDR will refer to the G series wells as the deep well (i.e., 30-40' bgs) and the shallow well (i.e., 5-15' bgs) for clarity. In the report by EPA Region IV's Science and Ecosystem Support Division (SESD), the nomenclature was different to avoid confusion in the field. Based on Table 2 of the SESD report, the deep wells in each cluster are the left hand well as you face the River at stations G1-G3 (Samples G1L, G2L, G3L) and the right hand well at stations G4 and G5 (Samples G4R and G5R). [5] Based on the information in the RI, it is unclear whether the shallow gas wells in the G series of wells extend below the surface clay layer seen in figure 2. [2,5]

Discussion

ATSDR screened the contaminants identified in the soil gas against ambient air inhalation Health Guideline Values (HGV) as described in our Public Health Assessment Guidance Manual. [6] Because no individual would be inhaling the soil gases collected at a depth of 15 feet or more below the ground, no exposure to the concentration reported is possible at the actual sample location. However, because vapor intrusion into homes is possible, it is a very conservative (health protective) assumption to screen contaminants using inhalation (breathing zone) HGVs. [7,8,9,10,11,12,13,14,15,16,17,18,19] This approach ensures that all of the possible chemicals of concern are evaluated for the public health implications. The soil vapor contaminants that exceeded HGVs are listed in Table 1 and the sampling point moving from downstream to upstream is indicated on Figure 1.

It is important to note in Table 1 that, of the sample locations of potential concern, none of the gas wells screened to 15 feet or less (i.e., the "G" series shallow wells) detected these chemicals at concentrations significantly (i.e., more than an order of magnitude) above their respective HGVs. This implies that the vapors and gases are deeper than that and may be below the relatively impermeable clay layer beneath the site as shown in Figure 2. Coupled with the relatively stable (e.g., variations of less than 4' near the levee) and shallow (less than 40' near the levee) water table characteristic of alluvial aquifers, these soil gases could be trapped between the clay layer and water table which act as two confining layers. This may imply a preferential channel exists that, under certain conditions, may allow these soil gases to migrate past the levee. [2]

Table 1
2013 Soil-Gas Sampling Results
Chemicals of Concern
All values in ug/m3

Chemical	Range of Concentrations (Number of detections in 19 wells)	Health Guideline Value for Inhlalation	Sample locations above HGV*
Benzene	0.4-12 (8)	9.6[1], 130[2] 0.13[3]	**LLL-5, LLL-4**, *LLL-3, LLL-2*, G-*3 deep, G-4 shallow, G-5 deep,* LLL-1
1,3 –Butadiene	7.6-28 (4)	2[2] 0.033[3]	**LLL-5**, LLL-4, LLL-3, LLL-2
Carbon Tetrachloride	0.25-20,000 (9)	190[1], 100[2] 0.17[3]	*G-2 deep, LLL-3, LLL-2, G-3 deep*, *G-3 shallow*, **G-4 deep,** *G-4 shallow, G-5 deep* LLL-1,
Chloroform	0.34-160 (14)	98[1] 0.043[3]	*LLL-5, GMW-3, G-1 deep, G-1 shallow, LLL-4*, *GMW-2, GMW-1, G-2 deep, G-3 deep*, G-4 deep, *G-4 shallow, G-5 Shallow,* **LLL-1**,
Tetrachloroethene	0.39-560 (19)	270[1], 40[2] 3.8[3]	*LLL-5,* GMW-3, G-1 deep, G-1 shallow, GMW-2, **GMW-1**, G-2 deep, G-2 shallow, *LLL-3, LLL-2,* G-3 deep, G-3 shallow, G-4 deep, *G-4 shallow, G-5 deep*, G-5 shallow, LLL-1,
Trichloroethylene	4.1-5.6 (2)	2[1,2] 0.24[3]	GMW-3, **G-1 deep**
Vinyl Chloride	1.5-12 (2)	100[2] 0.11[3]	***G1 deep,*** *G-5 deep*

1 – ATSDR Chronic Minimal Risk Level (MRL)
2 – EPA's Reference Concentration (RfC)
3 – ATSDR Cancer Risk Evaluation Guide (CREG) [lifetime 10^{-6} risk]
* - Maximum concentration location or locations in **Bold**; locations between non-cancer and cancer guidelines in *italics.*

Since no one is directly exposed to vapors 15 feet or more below the ground, the potential concern is related to the migration of contaminants through the unsaturated soils and subsequent impact on indoor air quality. All of these compounds are virtually insoluble in water and vaporize easily. The vapors or gases heavier than air. Butadiene and vinyl chloride are gases under most environmental conditions while the rest are liquids. All of these compounds would be expected to volatilize and migrate from soils with unrestricted access to the open air (e.g., surface soils or soils above a confining layer) and have a half-life in the open environment measured in days or weeks. [20,21,22,23,24,25,34] All of these chemicals will seek the path of least resistance Under some conditions, that path of least resistance could be through the neighborhood and may be into the homes themselves. This process of migration into the homes (where soil gases become an indoor air quality issue) is called vapor intrusion. Conditions which may enhance the migration of these soil gases into the homes near this site include: high water in the Ohio River, which may restrict horizontal migration; and saturated or frozen soils, which may act as a cap and restrict vertical migration. [26, 27] Once in the home, these contaminants may persist for some time. The fact that these chemicals, especially butadiene, with their short half-lives were detected at all indicates there may be a source of continuing emissions near the sampling locations.

Most of the vapor intrusion guidance developed over the years either excludes gases generated in a landfill or treat it as a special case. EPA's Landfill Gas Emissions guidance (available at http://www.epa.gov/nrmrl/pubs/600r05123.html) summarizes the reasons for the exclusion. [28]

Landfill gases, which typically consist of up to 80% methane for portions of the landfill life cycle, consist of multiple compounds. It is likely that this site is past that part of the life cycle of a landfill where methane is generated. This would explain why the methane levels in soil gas samples from this landfill are so low (e.g., less than 0.0001 % of the Lower Flammable Limit for methane). [29] Depending on the wastes in the landfill, other constituents of landfill gas like those in Table 1 may still be present.

The degradation of wastes can also increase temperatures and pressures within the landfill. Increased temperature can increase the volatization from volatile and semivolatile organic compounds. This can lead to increased pressures in the landfill and can force soil gases from areas of high pressure to areas of lower pressure. [29]

In December 2013, EPA issued their vapor intrusion screening level tool. ATSDR uses a similar screening process to evaluate vapor intrusion. The tool is based on a conceptual model developed in draft guidance in 2002 and expanded for the current tool. The model makes certain assumptions, as described at the vapor intrusion website (www.epa.gov/oswer/vaporintrusion). The thrust of these assumptions is that the concentration of contaminants in soil gases would be reduced significantly before becoming indoor air contaminants. [30] The degree to which these assumptions are valid for this site is unclear as discussed below.

Based on the information from the RI subsurface investigation, it seems unlikely that the sand and gravel found below the clay layer closest to the surface would "…reduce or attenuate …" the vapor concentrations significantly. Such soils tend to be fairly permeable and there is little organic content to capture the chemicals as they move through the strata. Given the age of the homes of the homes closest to the site (i.e., "receptor buildings" in the EPA guidance), the assumption that there is a vapor barrier below the homes may not be accurate. One of the factors that may result in enhanced transport of vapors is the presence of a preferential channel through the subsurface. [26,28,30] While the Lee's Lane Landfill appears to be near the end of a landfill's life cycle, past exposures by this route may have been enhanced by higher soil gas pressures in the landfill itself due to the decomposition of wastes. [28]

Another concept of importance in evaluating vapor intrusion is that receptor buildings must be "near" the source of the vapors. In most guidance documents on vapor intrusion, an assumption is made that 100 feet from the contaminant source to the receptor building is considered "near". However, based on the possible differences between landfills and site specific conditions described in the preceding paragraph, the homes near the central and southern sampling locations (i.e., near wells G1-3, GMW 1-3, and LLL 2-5) could be considered sufficiently close to the source to warrant further evaluation. The homes near the northern sampling locations (i.e., wells G4-5 and LLL-1) would be considered near a source. The assumptions and factors affecting the ability to evaluate vapor intrusion (especially a possible preferential channel and potential absence of a vapor barrier) also influence the adequacy of the 100 foot assumption for "nearness". In addition, the presence of chemicals with a high vapor pressure like butadiene or vinyl chloride may act as something of a carrier gas that could transport the other chemicals further and at a higher concentration than would be possible under other conditions. Because of these site specific characteristics, the soil gas screening values will be applied to the maximum soil gas concentration found in any soil gas well

Table 2 provides ATSDR's soil gas screening values based on ATSDR's comparison values [32] and the attenuation factor of 0.1 recommended by EPA for screening [33].

Table 2
ATSDR Vapor Intrusion Screening Levels
Chemicals of Concern

Chemical	Inhalation Cancer Risk Evaluation Guide (CREG)[1]	Inhalation Health Guideline Value (noncancer)	Soil Gas Screening Concentration[2] (10 X CREG)	Max Soil Gas Concentration
Benzene [3]	0.13	9.6	1.3	12
1,3 –Butadiene [4]	0.033	2	0.33	28
Carbon Tetrachloride [3]	0.17	190	1.7	20,000
Chloroform [3]	0.043	98	0.43	160
Tetrachloroethene [3]	3.8	270	38	560
Trichloroethylene [3,4]	0.24	2	2.4	5.6
Vinyl Chloride [4]	0.11	100	1.1	12

All concentrations in ug/m^3
[1] – Inhalational 10^{-6} Lifetime Cancer Risk.
[2] – ATSDR, 2013. Vapor Intrusion (VI) Updates for ATSDR Health Assessors, Monthly Exposure Investigations Conference Call, June 2013.
[3] – Health Guideline Value based on ATSDR Inhalation Chronic Minimal Risk Level (MRL)
[4] – Health Guideline Value based on EPA's Reference Concentration (RfC)
ATSDR's Toxicological profiles available at http://www.atsdr.cdc.gov/toxprofiles/index.asp

The soil gas contaminant screening concentrations shown in Table 2 is based on the 10^{-6} lifetime cancer risk evaluation guideline taking into account the attenuation factor recommended in the vapor intrusion guidance. [33.35] The maximum soil gas concentration of butadiene, carbon tetrachloride, chloroform, and tetrachloroethene greatly exceeds this screening value and warrants further investigation. Benzene, vinyl chloride, and trichloroethylene do not exceed the screening value by an amount that warrants by themselves further investigation. However, it may be more cost effective to include all volatile compounds in any investigation at this site. Additional investigation of nearby buildings, preferably to include concurrent indoor air, subslab gas, and outdoor (background) air samples, should be considered to determine if a health hazard does exist. Buildings with full or partial basements may offer a preferred path for vapor intrusion to occur. [35]

CONCLUSION:

The basic conceptual model for vapor intrusion assumes soil gas concentrations are reduced by soil conditions and the characteristics of the structures. It is unclear to what extent that may be true at this site. Based on the geologic conditions and the soil gas measurements, vapor intrusion is likely a route of exposure to the residents living near the landfill. The health hazard posed by this route cannot be determined from this data.

RECOMMENDATIONS:

ATSDR recommends:

- Further investigation of the vapor intrusion route of exposure, incorporating to the extent feasible evaluation of seasonal changes that affect soil gas migration. Such seasonal changes may include high water levels in the Ohio River and frozen or saturated surface soils around the site and the homes.

- Although not discussed at length, pressure and temperature differences in landfills may also affect soil gas migration and, by extension, vapor intrusion. To the extent feasible, evaluate pressure and temperature measurements in the homes and the subsurface of the landfill in order to determine any differentials between the homes and the landfill that may increase migration of the soil gases.

- Given the extensive amount of environmental data over the years, consider a historical review of past sampling events to determine if a duration of exposure can be estimated and if any trends are apparent in the data.

The conclusions and recommendations in this health consultation are based on the information reviewed. New or additional pertinent information may result in a change of these conclusions or recommendations. ATSDR is available to review additional information upon request.

Richard A. Nickle
Environmental Health Scientist

References

[1] Electronic mail message from R. Nickle, ATSDR, to R. Safay and R. Gillig, ATSDR re: Lee's Lane Soil Gas dated 12/16/2013 at 1101 EDT describing a telephone conversation between ATSDR IV and EPA IV.

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[4] MSD, 2010. Map of Lee's Lane Landfill indicating nearby homes with basements. Metropolitan Sewer District. Louisville, KY Nov. 2011

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Figures

Figure 1
Lees Lane Landfill Soil Gas Sampling Stations
June 2013

Figure 1: June 2013 Soil Gas sample locations. (Figure 1 of EPA/SESD report dated Nov. 12, 2013)

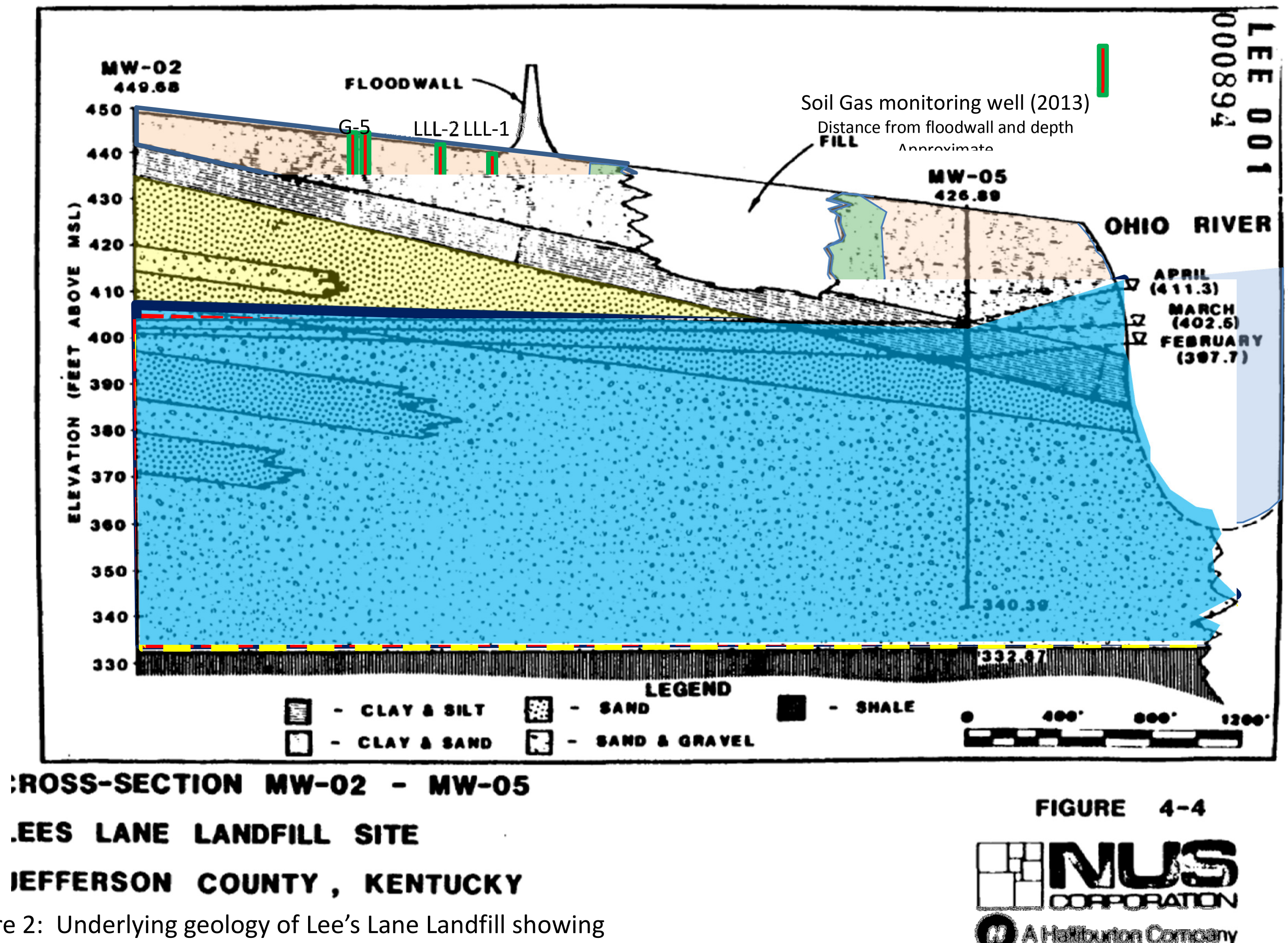

Figure 2: Underlying geology of Lee's Lane Landfill showing approximate water table at low (yellow dashes) and high water (dark blue line) during 1984-85 RI. Fill indication in original was depth found in southern tract. Green area indicates approximate fill depth in northern tract of the site, width of green area not to scale. Green boxes with red fill show selected 2013 soil gas monitoring locations. Distance from floodwall and depth are approximate and based on comparison of common features in Figure 1 and scale drawings in RI.

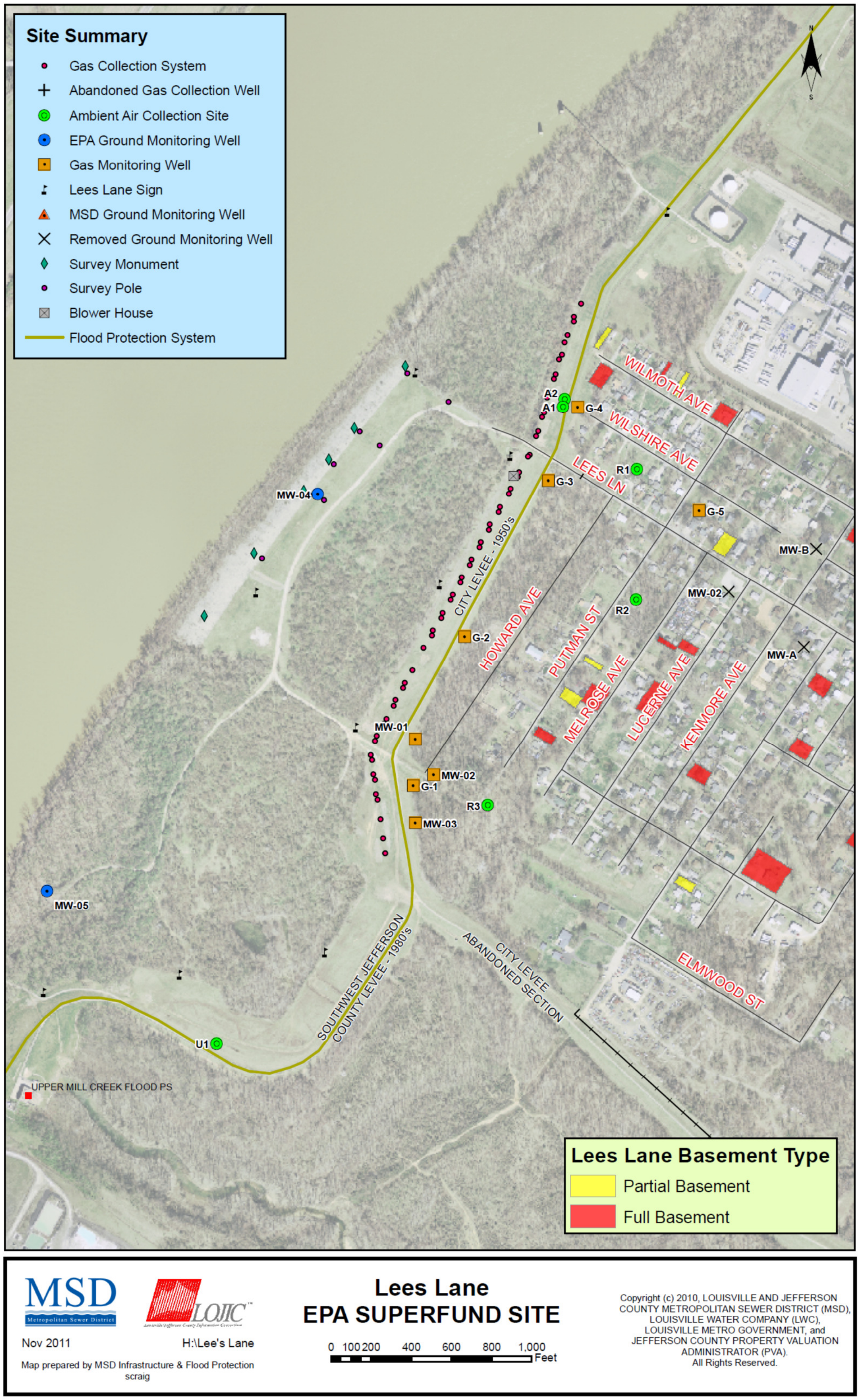

Figure 3: Homes with full or partial basements near Lee's Lane Landfill.