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### BEFORE THE PUBLIC UTILITIES COMMISSION OF OHIO

In the Matters of the Applications of Duke : Case No. 15-452-GA-RDR Energy Ohio, Inc., for : Case No. 17-596-GA-RDR Adjustments to Rider MGP : Case No. 18-283-GA-RDR Rates.

: Case No. 14-375-GA-RDR : Case No. 15-452-GA-RDR

: Case No. 19-174-GA-RDR

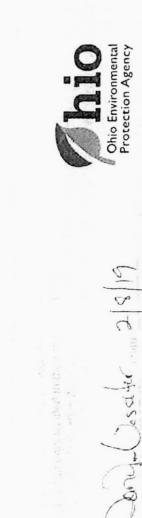
: Case No. 14-376-GA-ATA In the Matters of the : Case No. 15-453-GA-ATA Applications of Duke : Case No. 16-543-GA-ATA Energy Ohio, Inc., : Case No. 17-597-GA-ATA for Tariff Approval. : Case No. 18-284-GA-ATA : Case No. 19-175-GA-ATA

### PROCEEDINGS

before Ms. Megan J. Addison, Attorney Examiner, at the Public Utilities Commission of Ohio, 180 East Broad Street, Room 11-A, Columbus, Ohio, called at 9:00 a.m. on Thursday, November 21, 2019.

### VOLUME IV

ARMSTRONG & OKEY, INC. 222 East Town Street, 2nd Floor Columbus, Ohio 43215-5201 (614) 224-9481 - (800) 223-9481







Ohio Environmental Protection Agency

# Division of Environmental Response & Revitalization Voluntary Action Program

Under the authority of Ohio Revised Code Section 3746.04 (B)(5) and Ohio Administrative Code Rule 3745-300-05

Recognizes

# James R. Campbell

# Certified Professional

(Number CP 355)

ssuance Date Certificate

Director, Ohio Environmental Protection Agency

Date of Expiration

ACL MCC/C. Manager, Voluntary Action Program

SCOPE, LIMITATION, OBLIGATIONS AND RESPONSIBILITIES OF CERTIFICATION ON REVERSE SIDE

authorizes the certified professional to render voluntary action opinions consistent with Ohio Revised Code (ORC) Chapter 3746. and rules adopted in the Ohio Administrative Code (OAC) Chapter 3745-300 Scope. This certificate applies only to the Ohio EPA Voluntary Action Program, and so long as this certificate remains effective it

the "Scope" section. This certificate is subject to an annual renewal under OAC rule 3745-300-005 Limitation. This certificate does not apply to any other Ohio EPA program nor does it serve any purpose other than that described in

obligations and responsibilities include, but are not limited to: of a certified professional in the Voluntary Action Program, as set forth in ORC Chapter 3746. and OAC Chapter 3745-300. These Obligations and Responsibilities. As a condition of certification, the certified professional accepts all obligations and responsibilities

- Thorough knowledge of and compliance with ORC Chapter 3746. And OAC Chapter 3745.300;
- Holding paramount public health, safety, welfare and the environment in the performance of professional services
- of certification, standards of conduct, document retention and production obligations, and the design and use of a certified Compliance with all requirements of OAC rule 3745-300-05 regarding the criteria and procedures for initial certification and renewal professional's seal;
- qualified persons to perform or review work when the voluntary action involves an area of professional practice for which the certified professional is not qualified by education, training, or experience; Rendering objective voluntary action opinions based upon personal performance or review of all work, and relying upon other
- Cooperation with all audits and inspection performed by Ohio EPA as authorized by ORC Chapter 3746. And OAC Chapter 3745-
- \* Submission of all affidavits as required by ORC Chapter 3746, and OAC Chapter 3745-300; and
- \* of ORC Chapter 3746. and OAC Chapter 3745-300. Issuance of no further letters only when consistent with applicable standards of the Voluntary Action Program, and the requirements

authorization provided by this certificate ceases upon the effective date of the suspension or revocation Revocation or Suspension. This certificate is subject to suspension or revocation in accordance with OAC Chapter 3745-300. The

This certificate is the property of Ohio EPA and must be surrendered to Ohio EPA upon the expiration, revocation, or suspension of the professional's certification.

# HALEY& ALDRICH

REPORT ON

FOCUSED REMEDIAL ALTERNATIVES ANALYSIS EAST END GAS WORKS CINCINNATI, OHIO

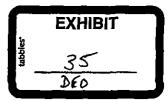
BY

Haley & Aldrich, Inc. Portland, Maine

FOR

Duke Energy Ohio, Inc.

File No. 40674-005 7 August 2014



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### 1. INTRODUCTION

Haley & Aldrich, Inc. (Haley & Aldrich) has prepared this Focused Remedial Alternatives Analysis for the East End Gas Works site (EEGW, the Site) located in Cincinnati, Ohio. This alternatives analysis has been prepared for Duke Energy Ohio (Duke) to support decision-making on remedial actions to address impacted soil, oil-like material (OLM) and tar-like material (TLM) impacts in soil, and non-aqueous-phase liquid (NAPL), to the extent currently feasible, on upland portions of the Site.

The Site, which is owned by Duke, is comprised of three areas, referred to (for environmental cleanup purposes only) as the West Parcel, the Middle Parcel and the East Parcel, as shown on Figure 1. Also included in this alternatives analysis is a portion of the Riverside Drive property owned by Duke that is located east of the former Munson Street and west of the West Parcel. This area is shown on Figure 1 and is hereinafter referred to as "the area west of the West Parcel". This area has been impacted by the EEGW former MGP operations.

The West Parcel and the East Parcel have undergone prior remediation of OLM/TLM and other impacts in soils to a depth of 40 feet (ft) or shallower (i.e., above the water table and the normal water level in the adjacent Ohio River to the south). These completed remedial activities are documented in the West Parcel Remediation Construction Summary Report (Haley & Aldrich, 2012) and the East Parcel Remediation Construction Summary Report (Haley & Aldrich, 2013).

The following locations and impacted media are considered in this alternatives analysis:

- Soil and OLM and/or TLM impacts west of the West Parcel impacted by the former MGP operations, between the former Munson Street right of way and the West Parcel;
- Remaining deep OLM impacts, below previous remediation depths, that remain on the West Parcel:
- Soil and OLM and/or TLM impacts on the Middle Parcel;
- Remaining OLM and/or TLM impacts on the west portion of the East Parcel outside the limits of prior remediation on the East Parcel; and
- NAPL observed in monitoring wells on the West and Middle Parcels.

Groundwater impacts will only be addressed at this time through recovery and/or isolation of NAPL, and to the extent that the soil and/or OLM/TLM remedies aid in the remediation of, or isolation of impacted groundwater. Additional direct remediation of impacted groundwater will not be considered until source area remediation is completed and further analysis of on-site groundwater impacts and the potential for off-site downgradient impacts is investigated.

### 1.1 Previous Site Investigations

Site characterization activities for those areas considered in this remedial alternatives analysis have been documented in several prior reports as follows:

- 2007 Site Investigation Summary Report, East End Gas Works Site (AMEC, 2008);
- Letter Report, East End Gas Works Site Investigation (AMEC, 2008);
- Phase II Property Assessment Report, East End Gas Works, West Parcel (Burns & McDonnell, 2009);



- Phase II Property Assessment Report, East End Gas Works, East Parcel (Burns & McDonnell, 2009);
- West Parcel Remediation Construction Summary Report (Haley & Aldrich, 2012);
- East Parcel Remediation Construction Summary Report (Haley & Aldrich, 2013);
- Subsurface Investigation Results, Former DCI Property/Keck Street Property (Haley & Aldrich, 2011); and
- Phase II Property Assessment Report, East End Gas Works, Middle Parcel (Haley & Aldrich, 2014).

The following paragraphs present a brief summary of Site conditions pertinent to the evaluation of remedial alternatives. More in-depth information can be found in the reports referenced above.

### 1.2 Site History and Current Site Use

The Site is generally located at 2801 Riverside Drive (f/k/a Eastern Ave) in Cincinnati, Ohio. The Site appears to have been first developed as a residential and/or agricultural property before 1875. In 1875, Cincinnati Gas Light and Coke Company purchased the property. Construction of the gas works began before 1882 and was completed after 1884. The facility operated as a manufactured gas plant (MGP) until 1909, when the arrival of natural gas halted MGP production. MGP production began again around 1925 and continued until the 1960s. Gas was manufactured using the coal carbonization, water gasification, carbureted water gas and oil gas processes. Other historical operations at the Site have been associated with the Cincinnati Consolidated Street Railway Company, B.P. Clapp Ammonia Company, Pendleton Car House and Generation Station, and John Frederick Manufacturer of Yellow Prussiate of Potash.

Currently, the Middle Parcel is used as a synthetic natural gas peaking plant in which propane, air, and natural gas are mixed to make synthetic natural gas. This facility is also a city gate station, which is a point where gas coming into the state of Ohio is measured and regulated (custody transfer point from Kentucky to Ohio). Also, the Site is used as a district headquarters for field operations (Construction & Maintenance [C&M]) – pipeline repair, installation, maintenance, etc. Propane is stored at the Site in a cavern. The East Parcel is currently used for gas pipelines. The West Parcel contains a vaporizer facility that was constructed in 2012.

The area west of the West Parcel appears to have been first developed as residential properties before 1891 and continued with this use until 2006, while the remaining portions of the Riverside Drive property was utilized for commercial purposes (see Phase I report for the Riverside Drive property). A portion of the area west of the West Parcel appears to have been part of the former MGP. In April 2006 and April 2007, two building permits were issued by the Cincinnati Building Department for excavation and filling activities by the then owner, DCI Properties, on the Riverside Drive property (including the area west of the West Parcel). The filling activity included the placement of 80,000 cubic yards of fill across the property. Duke acquired this property from DCI Properties in 2011. This property is not currently being used for any active gas operations, but has been utilized since its purchase by Duke for staging equipment for gas pipeline projects.

### 1.3 Site Setting

Topographically, the Site is fairly level except for a steep slope along the southern portion of the Site, leading to the Ohio River. Site elevations range from approximately 508 ft above mean sea level (MSL) near Riverside Drive to approximately 456 ft MSL, near the river (Newark Kentucky-Ohio Topographic Quadrangle), which corresponds to the normal Ohio River pool elevation in this area.



The main portion of the Site is located approximately 35 to 50 ft above the river's normal pool elevation. Based on investigative activities, bedrock beneath the Site slopes toward the south. Along Riverside Drive, gray limestone bedrock is encountered at depths of between 20 and 25 ft below ground surface (bgs), while nearer to the river, in the southern portion of the Site, bedrock is encountered at depths from 65 ft to more than 100 ft bgs.

Unconsolidated material beneath the Site consists of fill material ranging from 10 to 15 ft thick near Riverside Drive to more than 30 ft thick near the center/southern portions of the Site. The fill material generally consists of sand and gravel, with varying amounts of ash, slag, cobbles, boulders, and demolition debris from former MGP facilities and crushed limestone spoils from construction of the propane cavern. A confining clay layer is encountered below the fill material and ranges in thickness from 20 to 40 ft. Along the northern portion of the Site, this clay layer is deposited directly on bedrock, whereas in the southern portion of the Site, this clay layer overlies an outwash layer. Alternating layers of sand and gravel outwash deposits underlie the clay layer and range in thickness of 30 to greater than 70 ft along the southern portion of the Site.

Based on surface topography, surface water flow at the Site is to the south, toward the Ohio River. Also based on topography, river flow direction, and groundwater monitoring events conducted at the Site, shallow groundwater flow is expected to be to the south-southwest. The water table generally occurs within the lower portion of the clay or the upper portion of the outwash sand and gravel, with water levels influenced by the Ohio River stage.

The Middle Parcel contains numerous active and abandoned buried utilities, including gas lines, water lines, brick storm sewer lines, concrete storm sewer lines, sanitary sewer lines, drain lines, electrical lines, and critical infrastructure for storage and transfer of gas and water.

### 1.4 Potential Source Areas

Historical MGP operations performed on the West, Middle, and East Parcels resulted in releases of MGP-related residuals including ash, slag, purifier materials, and coal tar. The coal tar impacts include sheens and staining of soils, the presence of OLM and/or TLM in soils, and the presence of a dense NAPL (DNAPL) in some monitoring wells. The known MGP structures containing MGP residuals on the East and West Parcels were removed during prior remedial actions on these parcels, however, some impacts remain outside of or beneath previously remediated areas.

Potential remaining sources of environmental impacts identified in soil and groundwater at the Site are located on the Middle Parcel and include the eastern and western gas holders, eastern and western tar wells, former tar separators, tar settling tanks, a former retort building, and former coal storage areas, as well as the former purifiers in the eastern, northern, and western buildings. Based on the results of Middle Parcel investigation activities completed, potential sources of MGP residuals include the following gas production and storage features:

- Former Retort House: Retort buildings typically contained retorts (or ovens) that were used to generate coal gas by heating the coal under anoxic conditions to volatilize gaseous constituents of coal. The main byproducts of these procedures were coke, ash, cinders, and clinkers.
- Tar Separators and Tar Settling Tanks: Tar separators and settling tanks (presumably below grade) were located adjacent to the retort building. Presumably, tar produced by the MGP



processes was separated in this area. Tar treatment areas may be a source of OLM, TLM and NAPL, and other MGP residuals, observed on Site.

- Tar Wells: Tar wells, two currently identified, were located east of the eastern holder and west of the western holder. In general, tar wells were below-grade structures, used to store tar for later sale or use. Tar storage areas may be a source of OLM, TLM and NAPL, and other MGP residuals, observed on Site.
- Eastern and Western Gas Holders: Two historical gas holders have been identified at the Middle Parcel. These structures were used to store gas, after manufacture, at fairly low pressures prior to distribution. Such structures may be a source of NAPL and other MGP residuals.
- Coke/Coal Storage: Coal and coke storage areas were on Site throughout the operational life of the MGP. Coal and coke fragments were observed in various borings and test pits installed during investigation activities. Such structures may be a source of MGP residuals observed at the Site.
- Purifiers: After manufacture, the gas was purified (noxious materials were removed) utilizing purification media, which resulted in a purifier waste, often a source of cyanide contamination. Based on experience with other MGP sites, this waste was often disposed in pits or on the ground at some distance from purifier buildings, due to its noxious odor. While no obvious purifier waste disposal areas have been identified at the Site, this material, intermixed with Site fill and demolition debris may be a source of COCs in soil.

### 1.5 Distribution of MGP Residuals

MGP residuals such as ash, slag, and purifier materials are present primarily in the fill resulting from previous MGP operations. Releases of OLM and/or TLM have impacted primarily the fill and underlying clay (through fractures and interbedded sandy seams). OLM has also migrated into the outwash sand and gravel unit to the top of bedrock, and has been observed in bedrock fractures in some locations where bedrock coring was performed. The lateral distribution of OLM and/or TLM in the fill and clay, in the outwash, and atop bedrock is shown on Figures 2, 3, and 4, respectively. OLM and/or TLM in the fill and clay is present over a large portion of the Middle Parcel, eastward to the limits of in-situ solidification on the East Parcel, westward to the excavation limits on the West Parcel, and in the southeast corner of the area west of the West Parcel (see Figure 2). OLM has been observed in the outwash sand and gravel in the southern half of the Site, from the southeast corner of the area west of the West Parcel to the western edge of the Pittsburgh Street driveway. The OLM in this soil unit generally occurs in lenses from a few inches to more than 15 ft in thickness (see Figure 3). The OLM atop the bedrock surface generally occurs in the southern portion of the Site, from the southeast corner of the area west of the West Parcel eastward to Pittsburgh Street and the southwest corner of the East Parcel (see Figure 4). The OLM and/or TLM limits in fill, clay, outwash, and atop bedrock has not been fully delineated to the south as investigation activities to date have been limited to the upland portions of the Site.

Numerous groundwater monitoring wells have been installed at the Site. Based on monitoring performed to date, DNAPL has been observed to accumulate in the following deep wells screened in the outwash: MW-3D (West Parcel – abandoned), MW-3DR (West Parcel), MW-10D (West Parcel – abandoned), MW-22D (Middle Parcel), and MW-23D (Middle Parcel). These well locations are shown



on Figure 2. Three shallow wells previously located on the West Parcel, MW-13S, MW-14S, and MW-15S, also contained DNAPL, however, these wells were screened within zones excavated during 2010-2011 remediation of the West Parcel.

Several cross-sections have been prepared illustrating the geology and distribution of OLM, TLM and NAPL, as shown in Figures 5 through 8. Soil containing OLM and/or TLM does not meet applicable VAP standards.

### 1.6 Distribution of Contaminants of Concern in Soils

### 1.6.1 Area West of the West Parcel

Soil sampling was performed in the area west of the West Parcel in 2011. Sample intervals were selected to characterize the 0 to 2-ft zone for commercial/industrial worker exposure, the 0 to 15-ft zone for construction worker exposure and deeper zones for OLM and/or TLM impacts. In general, samples containing OLM and/or TLM were not analyzed due to the presence of visible impacts and it was assumed that soils containing OLM and/or TLM would likely exceed VAP Commercial/Industrial GNS. Additionally, soil containing OLM and/or TLM does not meet applicable VAP standards. The soil analytical data for the area west of the West Parcel is summarized in Appendix A. Risks to a commercial worker associated with potential exposures to soil from 0 to 2 ft bgs, and to a construction worker associated with potential exposures to soil from 0 to 15 ft bgs were evaluated by comparing the Ohio VAP Generic Standards (GNS) for commercial workers and construction workers (published in Table 3 of VAP Rule 8) to the constituent concentrations reported in each sample using a multiple chemical adjustment (MCA) approach. The MCA was completed by establishing a ratio of the reported result for each constituent to the generic standard. Separate ratios were calculated for cancer and non-cancer health effects, based on the specific effect that each VAP generic standard is based on. Ratios were calculated for each chemical detected in each sample within the 0 to 2 ft bgs and 0 to 15 ft bgs data sets, and then summed among all constituents to derive total cancer and non-cancer risk ratios for each sample. Using this approach, total cancer risk ratios greater than 1 indicate that cancer risks exceed the Ohio Environmental Protection Agency (Ohio EPA) cancer risk limit of 1x10<sup>-5</sup>; non-cancer risk ratios greater than 1 indicate that the hazard index exceeds the Ohio EPA non-cancer risk limit of a hazard index of 1. Conversely, total risk ratios of 1 or less indicate that Ohio EPA risk limits are not exceeded.

Appendix A provides documentation of this evaluation for the area west of the West Parcel. Total risk ratios for soil 0 to 2 ft bgs, for potential exposures by a commercial worker, are below 1 for each sample, indicating that soil within this area would not pose a health risk to workers if left unpaved. Similarly, total risk ratios for soil 0 to 15 ft bgs, for potential exposures by a construction worker, are below 1 for each sample, indicating that soil within this area would not pose a health risk to workers who may excavate into it. No OLM was observed in borings within the 0 to 15-ft zone. No remediation of this shallow soil is necessary to allow for commercial use or excavation. However, the presence of OLM in the soils below 15 ft bgs poses a risk to construction workers that may excavate and come into contact with these materials, if encountered. Soil containing OLM and/or TLM does not meet applicable VAP standards.



### 1.6.2 West Parcel

For the West Parcel to the top of the riverbank, soil impacts up to 40 ft bgs, as detailed in the West Parcel Remediation Construction Summary Report, have been mitigated through a combination of excavation and a 2-ft thick soil cover. OLM is present at depths greater than 40 ft. Soil containing OLM does not meet applicable VAP standards. Potential soil impacts beyond the top of the riverbank outside the current fence line have not been investigated and, therefore, are not addressed in this alternatives analysis.

### 1.6.3 East Parcel

For the East Parcel to the top of the riverbank, soil impacts up to 22 ft bgs, as detailed in the East Parcel Remediation Construction Summary Report, have been mitigated through a combination of excavation, in-situ solidification, and a 2-ft thick soil cover. A small area in the western portion of the East Parcel adjacent to Pittsburgh Street contains OLM and/or TLM and was not included in the East Parcel remedial construction due to facility operational considerations. Soil containing OLM and/or TLM does not meet applicable VAP standards. This area will be addressed in conjunction with the Middle Parcel remediation and has been considered in the development of alternatives evaluated in this report. Potential soil impacts beyond the top of the riverbank outside the current fence line have not been investigated and, therefore, are not addressed in this alternatives analysis.

### 1.6.4 Middle Parcel

For the Middle Parcel, remedial investigations conducted during 2012 and 2013 included soil sampling to characterize the 0 to 2-ft zone for commercial/industrial worker exposure, the 0 to 15 ft-zone for construction worker exposure and deeper zones beneath OLM/TLM impacts. In general, samples containing OLM/TLM were not analyzed due to the presence of visible impacts and it was assumed that soils containing OLM and/or TLM would likely exceed VAP Commercial/Industrial GNS. Additionally, soil containing OLM and/or TLM does not meet applicable VAP standards. The soil analytical data for the Middle Parcel is summarized in the Middle Parcel Phase II Property Assessment Report (Phase II PA). Exceedance of VAP Commercial/Industrial GNS occurred for benzo(a) pyrene in several samples and naphthalene in one sample. Exceedances of VAP Construction Worker GNS were detected for naphthalene, 1,2,4-trimethylbenzene, and lead.

As documented in the Phase II PA, total risk ratios for unpaved soil 0 to 2 ft bgs, for potential exposures by a long-term full time commercial/industrial worker, exceed 1, indicating that soil within the unpaved areas would pose an unacceptable risk to full time commercial/industrial workers. Risks are primarily contributed by benzo(a)pyrene, which are substantially influenced by the concentrations reported in sample HA-SB-E34 adjacent to the Pittsburgh Street driveway. If this sample was excluded from the calculated exposure point concentration (EPC), then the risk ratios would not exceed 1. That is, precluding direct contact with soil in this area would reduce risks to commercial/industrial workers to within acceptable levels for this pathway.

For the soils that are presently paved, the MCA evaluated contact with soil assuming that the pavement is removed. As documented in the Phase II PA, total risk ratios for unpaved soil 0 to 2 ft bgs, for potential exposures by a long-term full time commercial/industrial worker, are less



than 1, indicating that soil within this area would not pose an unacceptable risk to full time commercial/industrial workers if the pavement was not maintained. Total risk ratios for soil 0 to 15 ft bgs, for potential exposures by a construction worker, do not exceed 1, indicating that soil within this area would not pose an unacceptable risk to construction workers who may excavate into it. However, the presence of OLM and TLM in the Site soils within the 0 to 15 ft bgs interval and below poses a risk to construction workers that may excavate and come into contact with these materials, if encountered. Soil containing OLM and/or TLM does not meet applicable VAP standards.

Visitors or trespassers may enter the Middle Parcel. Complete exposure pathways for on-site visitors may include: incidental ingestion and dermal contact with soil; inhalation of fugitive dust in ambient air generated due to wind erosion of non-vegetated portions of the Site; and inhalation of VOCs emanating from soil into ambient air. Based on evaluation of Site sampling data and associated MCA activities presented in the Middle Parcel Phase II PA, it is assumed that visitors and trespassers would remain on paved areas/on-site areas for much less time than Site workers. Therefore, impacts in soils present at the Site do not exceed VAP standards for visitors/trespassers.

### 1.6.5 OLM/TLM

To facilitate calculation of the approximate percentage of OLM and/or TLM removed or treated as part of the remedial alternatives evaluated in Section 4, percentages of soil volume containing OLM and/or TLM were determined for various depth intervals. Depth intervals were selected based on excavation/treatment depths of the various remedial technologies evaluated in the detailed alternatives analysis. Percentages were determined based on a review of the geologic cross-sections depicted in Figures 5 through 8; and are listed below:

- 0 to 15 ft bgs: approximately 15% of the soil volume contains OLM and/or TLM
- 15 to 40 ft bgs: approximately 20% of the soil volume contains OLM
- 40 to 60 ft bgs: approximately 5% of the soil volume contains OLM
- 60 ft bgs Bedrock; approximately 5% of the soil volume contains OLM

### 1.7 Distribution of Contaminants of Concern in Groundwater

MGP-related COCs have been detected in groundwater samples collected from shallow and deeper monitoring wells installed at the Middle and West Parcels at concentrations exceeding unrestricted potable use standards (UPUS). The most recent groundwater monitoring was performed as part of the Middle Parcel Phase II investigations in November 2012 and February and May 2014. Review of the groundwater analytical results indicates that groundwater samples collected from shallow wells are impacted with MGP-related COCs (typically benzene and other VOCs, various PAHs, and certain metals) at concentrations in excess of UPUS. Groundwater impacts in excess of UPUS were typically encountered in monitoring wells MW-20S, MW-21S, MW-22S, MW-24S, and MW-26S. Groundwater samples collected from the deeper groundwater were impacted with MGP-related COCs (typically benzene, ethylbenzene, toluene, and 1,2,4-trimethlybenzene, and naphthalene, and other compounds) at concentrations in excess of UPUS. Samples were not collected from monitoring wells MW-22D or MW-23D because NAPL was present in these wells during gauging. A groundwater sample was collected from MW-3DR in November 2012, as no NAPL was observed at that time; however, NAPL was encounter in MW-3DR during the February and May 2014 gauging events. Under the VAP rules,



NAPL presence in a well is considered an UPUS exceedence. The presence of the NAPL in the deep wells also documents the apparent mobile nature of the OLM in the subsurface of the Site.

These results indicate that groundwater has been impacted by former MGP operations and that risks to current and future Site users may exist if groundwater is used or contacted. In addition, several wells are located on the southern boundary of the Site, closest to the Ohio River. Therefore, remediation is needed to meet VAP applicable standards. The east-west lateral extent of impacted groundwater appears to be bracketed by well MW-K09S/D in the area west of the West Parcel, and MW-7S/D on the East Parcel. Quarterly groundwater monitoring is being performed at the Site in 2014 and will be reported separately.

### 1.8 Contaminant Transport

The occurrence, migration and accumulation of MGP residual materials in the subsurface are typically controlled by several factors, including:

- The texture and porosity of the overburden materials:
- The presence of capillary barriers and confining units which inhibit vertical migration and influence horizontal migration;
- The occurrence of groundwater within the overburden materials; and,
- The physical nature and distribution of MGP-residual materials (density relative to water).

In general, MGP-residual materials introduced to the surface or subsurface materials migrate vertically downward under the force of gravity through the overburden material until the material intersects a zone of lower permeability, such as the clay layer underlying Site fill. Once encountering a lower permeability zone, DNAPL has the potential to migrate laterally along the top of a lower permeability zone if sufficient diving head and a gradient exist. Based on review of site data, it appears that the MGP residuals have migrated beyond the extent of the former MGP footprint (horizontally) and below the native clay layer (vertically), indicating that vertical conduits (which could include fractured clays or desiccation cracks in unsaturated clay as well as former MGP structures, such as gas holder foundations, tar well foundations, etc.) may exist. It should be noted that desiccation cracks or clay fractures were observed in the unsaturated clay on the West Parcel in the tar lagoon area, both during the investigation and excavation activities.

If a continual source of residual material is present, the horizontal migration of the residual materials in the subsurface is expected to continue along the zones of increased porosity and/or permeability, and downward through vertical conduits. Removal or containment of the source(s) enables both vertical and lateral migration to reach equilibrium, as determined by the surface tension, density and viscosity of the material, porosity and permeability of the subsurface soils, and presence/absence of a continual source of the material.

### 1.9 Land Use Considerations

Current land use is for industrial purposes. All the property being considered in this remedial alternatives analysis is owned by Duke. The area surrounding the Site to the west, north, and east is a mix of commercial and residential properties. The Ohio River abuts the Site to the south. The Middle Parcel contains numerous active and abandoned utilities including drains, natural gas, propane, water, sewer, and critical gas and water infrastructure. Remediation of the Site, and in particular the Middle



Parcel, will need to be sequenced to accommodate relocation or protection of affected utilities as needed to ensure no disruption of operations or service.



### 2. REMEDIAL STRATEGY AND OBJECTIVES

### 2.1 VAP Remedial Considerations

Based on the soil and groundwater impacts summarized in the previous Section, remediation will be required to meet all applicable standards under the VAP. It should be noted that under the VAP, remediation can include a combination of active remediation (e.g. source removal or containment) and passive remediation (institutional or engineering controls) designed to meet all applicable standards and to mitigate risks to current and future site users. A summary of applicable VAP standards is presented in Table I. Remedial activities that may be required to meet applicable VAP standards include:

- Surface soil in unpaved areas poses an unacceptable risk to current Site workers and does not meet applicable VAP standards. To meet applicable commercial/industrial Site worker standards under the VAP, remediation of unpaved surface soil is required, especially focused on the vicinity of HA-SB-E34 which drives the EPC risk exceedance.
- Construction workers could come into contact with OLM and/or TLM observed in certain areas of the Site within the upper 15 ft. Where OLM or TLM are present, VAP applicable standards for construction workers are not met. Therefore, to meet applicable VAP construction worker standards, remediation is required in areas with OLM or TLM present at depths of less than 15 ft
- OLM and/or TLM are present within the soil column and have migrated from source areas and may continue to migrate, both horizontally and vertically. Further, OLM and TLM represent continuing sources of dissolved constituents in groundwater that exceed applicable standards. The VAP requires that current and future on-site and off-site receptors be protected. Remediation of OLM and TLM impacts is required in order to meet applicable VAP standards.
- The Ohio EPA defines "free product" as "a separate liquid hydrocarbon phase that has a measurable thickness of greater than one one-hundredth of a foot." Measurable free product (NAPL) was observed in deep monitoring wells MW-3DR, MW-22D and MW-23D. VAP rules state that properties with free product exceed applicable unrestricted potable use standards (UPUS) for ground water (O.A.C. 3745-300-08(B)(2)(c)). Further, the VAP generally requires that free product be removed, or mitigated to the extent practicable, prior to issuance of an NFA (OAC 1301:7-9-13(G)(3)(a)). As such, NAPL remediation is required to meet applicable VAP standards.
- Site shallow groundwater is classified as a Class B under the VAP; however, the deeper groundwater is classified as a Critical Resource under the VAP. Because Site groundwater is impacted above UPUS, response requirements (including but not limited to institutional or engineering controls) are required to prevent on-site human exposure to groundwater exceeding UPUS, in accordance with VAP rules (OAC 3745-300-10 (E)(2)(a)). In addition, the extent of groundwater impacts, particularly to the south, has not been determined. Therefore, further response requirements related to on-site and off-site groundwater cannot currently be determined until the extent of groundwater impacts have been defined and after evaluating the effect of the source remediation activities.



### 2.2 Remedial Action Objectives

Remedial Action Objectives (RAOs) are overall protection of human health and the environment, including meeting all applicable VAP standards. For the areas of the Site considered in this Remedial Alternatives Analysis, the threshold criteria for achieving RAOs include the following (VAP applicable standards included in parentheses):

- Overall protection of human health and the environment;
- Mitigate exposure that exceeds applicable standards for Site workers, trespassers, and construction workers (OAC 3745-300-08 and OAC 3745-300-09);
- Mitigate the potential for future vapor intrusion risks if Site uses change (OAC 3745-300-07(I)(1)(a)(iii));
- Mitigate the potential for COCs in soil to leach into groundwater (OAC 3745-300-08, OAC 3745-300-09, and OAC 3745-300-10);
- Mitigate NAPL impacts to groundwater and the potential for migration of NAPL off-site (OAC 3745-300-08 and OAC 1301:7-9-13(G)(3)(a));
- Mitigate potential future exposure to impacted groundwater for potable and non-potable uses (OAC 3745-300-08, OAC 3745-300-09, and OAC 3745-300-10), and
- Evaluate the potential for Site groundwater to impact downgradient receptors (this investigation/evaluation will be performed in the future and, therefore, is not included in remedial alternatives identified in this report) (OAC 3745-300-08 (A)(1) and (H), and OAC 3745-300-09 (E)).

The above RAOs are then further evaluated and screened using the criteria in Section 4.1 of this report.



### 3. TECHNOLOGY SCREENING

### 3.1 General Response Actions

General response actions (GRAs) describe the broad range of actions that individually, or in combination, will satisfy the RAOs and applicable VAP standards. GRAs may include no action, institutional controls, engineering controls, containment, removal, treatment, disposal, monitoring or a combination of these. Similar to RAOs, GRAs are typically medium-specific; however, specific GRAs as applied to a given site may address multiple impacted media. The GRAs presented below may be applied to multiple media and pathways.

To meet the RAOs for the Site, the following potential GRAs have been identified for consideration in remedial alternatives:

- No Action. Used for baseline comparison. No remedial measures are implemented in the No Action GRA. This would not satisfy the RAOs, nor the applicable VAP standards.
- Institutional Controls. Institutional controls may involve administrative actions that restrict access to, contact with or use of contaminated areas. Examples of common institutional controls include environmental covenants regarding land or groundwater use, a soil management plan establishing protocols for disturbing impacted media, among others. The VAP allows implementation of such controls to meet some or all applicable standards, as appropriate.
- Engineering Controls. Engineering controls involve physical measures to restrict access to, contact with or use of contaminated areas. Examples of common engineering controls include fencing, soil or paving covers, capping, engineered barriers, and vapor intrusion barriers, among others. The VAP allows implementation of such controls to meet some or all applicable standards, as appropriate. VAP compliant operation and maintenance (O&M) requirements, after receipt of the No Further Action (NFA) or Covenant Not To Sue (CNS), may be necessary.
- Containment. Containment actions include control, isolation and encapsulation technologies (such as vertical barrier walls combined with engineering controls) that involve little or no treatment but provide protection of human health and the environment by reducing mobility of contaminants and/or eliminating pathways of exposure. The VAP allows containment remedies to meet applicable standards, although VAP compliant O&M, after receipt of NFA or CNS, may be necessary.
- **Removal.** These actions are taken to physically remove the contaminated media. These actions reduce the volume, and in some cases, the mobility of contaminants. The VAP encourages removal actions by not requiring subsequent actions beyond the receipt of the NFA or CNS.
- Treatment. These are *in-situ* or *ex-situ* actions taken to treat groundwater, soil or NAPL using physical, chemical, thermal and/or biological processes to reduce the toxicity, mobility and/or volume of contamination and the availability of these contaminants for contact, consumption and environmental transport and uptake. The VAP encourages treatment actions, through use of consolidated site permits and by not requiring subsequent actions beyond the receipt of the NFA or CNS.



### 3.2 Technology Screening Criteria

Each GRA (except for No Action) can be addressed by various remedial technologies. Remedial technologies are defined as the general categories of remedies under a GRA, such as a barrier wall, cap, in-situ solidification etc. Many technology types and process options are available to implement the GRAs described in Section 3.1. Table II provides an initial list of technologies and process options considered. The purpose of initially considering a wide range of technologies and process options is to ensure that potentially applicable options for the site media and COCs are not overlooked. Technologies were screened using the criteria of effectiveness, implementability and relative cost; which are further defined as follows:

- Effectiveness Considers 1) the ability of a process option to address the estimated areas or volumes of contaminated media and meet the RAOs and applicable VAP standards; 2) the potential impacts to human health and the environment during the construction and implementation phases; and, 3) the reliability and demonstrated success the process has shown with respect to the types of contamination and site conditions that will be encountered.
- Implementability Implementability includes both the technical and administrative feasibility of implementing a technology process option. The administrative feasibility considers the administrative or institutional aspects of using a process option such as potential restrictions of future land use, the availability and capacity of treatment, storage and disposal services and the availability of the equipment and workers to implement the technology.
- Relative Cost Cost plays a role in the screening of process options, but not to the same level as the other criteria. Relative capital and operation and maintenance (O&M) costs are used rather than detailed estimates. The costs for each process option are evaluated on the basis of engineering judgment as high, medium or low relative to the other process options in the same technology type.

### 3.3 Technology Screening Results Summary

The technology screening is presented in Table II. The technology screening resulted in the selection of the following effective and implementable technologies for use in developing remedial alternatives to be included in the detailed alternatives evaluation presented in Section 4. No Action is also retained for baseline comparison, although it is not effective at meeting RAOs or applicable VAP standards.

- No Action
- Institutional Controls Access and use restrictions in the form of deed restrictions or environmental covenants (also referred to as institutional controls), a soil management/risk mitigation plan and long-term groundwater monitoring. These remedial actions will be included in all the alternatives, except No Action;
- Engineering Controls Durable covers, fencing/signs and potential future building vapor intrusion barriers are retained for consideration in remedial alternatives. Durable cover types may include buildings, paving, hardscapes, soil covers and multi-layered engineered covers;



- Containment Installation of NAPL monitoring and recovery wells at the southern edge of the Middle and West Parcels and in the area west of the West Parcel was retained to address containment of potentially mobile NAPL by interception and removal;
- Removal Excavation of OLM/TLM-impacted soils above the water table with off-site landfill
  disposal was retained as a viable technology for remediation of MGP residual source areas and
  is consistent with remedies implemented on adjacent parcels of the Site and at other MGP sites;
- Treatment In-situ solidification (ISS) to depths up to 60 ft was retained as an effective in-situ treatment technology for OLM/TLM-impacted soil and is consistent with remedies implemented on and adjacent parcel of the Site and at other MGP sites.



### 4. REMEDIAL ALTERNATIVES

In this section, remedial alternatives are assembled to address the RAOs and comply with applicable VAP standards. There are many possible combinations of technologies and process options that could be used to formulate the alternatives. It is not practical to assemble every possible combination, nor is it necessary for the purposes of the alternative development and evaluation because many of the possible combinations are similar in performance and cost. The intent of the alternative assembly process is to create a set of alternatives that represents a range of performance and cost options so that the feasible, effective and implementable alternatives can be comparatively evaluated against each other to determine a preferred alternative while meeting the RAOs and addressing applicable VAP standards. Once a preferred alternative is selected, changes to the specific process options within a given technology type can be made during remedial design and subsequently implemented without compromising the remedy selection process in the remedial alternatives analysis. Likewise, the remedy selection process would be the same if areas identified in this analysis were remediated with multiple mobilizations.

Remedial alternatives have been assembled to span the range of GRAs identified in Section 3 including no action, institutional and engineering controls, containment, treatment and removal. A total of five alternatives, including a No Action Alternative, were developed.

The following alternatives were developed and are described in the following sections.

- Alternative 1 No Action.
- Alternative 2 -Durable Covers, Institutional and Engineering Controls and Groundwater Monitoring.
- Alternative 3 OLM/TLM Excavation in Construction Worker Zone, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring.
- Alternative 4 OLM/TLM Excavation to Water Table, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring.
- Alternative 5 In-Situ Solidification, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring.

These remedial action alternatives are depicted in Figures 9 through 12 and are described below.

Alternative 1 - No Action: The No Action Alternative includes no remedial activities and will leave the Site in its present condition. Contaminated media will remain in place with no treatment to prevent further contaminant migration and will not provide any additional protection to human health and the environment over current conditions. Site conditions will not be monitored to document the natural attenuation or mobility of contamination. No action is required to implement the technology and there is no associated cost. This alternative is retained as a baseline for comparison to other remedial alternatives, but would not meet applicable VAP standards or be protective of human health or the environment.

Alternative 2 - Durable Covers, Institutional and Engineering Controls and Groundwater Monitoring: This alternative is intended to provide the minimum actions necessary to address risks to site workers associated with soils impacted by MGP residuals. Similar to the No Action alternative, this alternative does not meet all RAOs or address all applicable VAP standards and is retained for comparison. Alternative 2 includes the following remedial technologies:



- Engineering controls (fencing and signs, durable covers) and institutional controls (land use restriction for commercial/industrial use only, groundwater use restriction for potable or nonpotable uses, and a soil management/risk mitigation plan for future intrusive activities).
- The surface soils (0 to 2 ft bgs) in paved areas of the Middle Parcel and on the area west of the West Parcel do not pose a risk to visitors or Site workers, and the existing surface soils in these areas constitute a current durable cover. For unpaved portions of the Middle Parcel, risks to Site workers from exposure to surface soils are primarily driven by the benzo(a)pyrene concentration at boring location HA-SB-E34 (see Section 1.6). Therefore, removal of the top 2 ft of soil in the area between the east edge of Pittsburgh Street and the East Parcel fenceline between the northern property line at Riverside Drive and the sewer manhole west of boring HA-SB-E10 is included;
- A 2-ft soil cover in the area of soil excavation east of Pittsburgh Street.
- Groundwater monitoring will be performed for up to 30 years using the existing monitoring well network at the Site, which includes the following 21 wells:
  - o West Parcel: MW-19S, MW-3DR, MW-4DR;
  - o Area west of the West Parcel (east of Munson Street): MW-K09S, MW-K09D;
  - o East Parcel: MW-6, MW-7S, MW-7D, MW-8S, MW-8D; and
  - Middle Parcel: MW-20S, MW-20D, MW-21S, MW-21D, MW-22S, MW-22D, MW-23D, MW-24S, MW-24D, MW-25D, and MW-26S.

The components of this remedial alternative are illustrated on Figure 9.

Alternative 3 – OLM/TLM Excavation in Construction Worker Zone, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring: This alternative is intended to provide the minimum amount of remedial construction required to meet applicable VAP standards. Alternative 3 includes the following remedial technologies:

- Engineering controls (fencing and signs) and institutional controls (land use restriction for commercial/industrial use only and groundwater use restriction for potable or non-potable uses and a soil management/risk mitigation plan for future intrusive activities).
- Excavation of OLM/TLM in soil to potential construction worker exposure depth of 15 ft, backfill with imported clean soil, and surface restoration with paving, gravel, or vegetated cover, varying based on current Site use.
- Installation of a 2-ft clean soil cover between the east edge of the Pittsburgh Street paving and the East Parcel fenceline from the northern limit of OLM/TLM excavation to the northern property limit at Riverside Drive;
- NAPL monitoring and recovery in up to 8 wells (Middle Parcel, West Parcel, west of the West Parcel); and
- Groundwater monitoring will be performed for up to 30 years in up to 13 wells, including:
  - West Parcel: MW-19S, MW-3DR, MW-4DR;
  - Area west of the West Parcel (east of Munson Street): MW-K09S, MW-K09D;
  - o East Parcel: MW-6, MW-7S, MW-7D, MW-8S, MW-8D; and
  - o Middle Parcel: Up to 3 new groundwater monitoring wells installed post-remediation.

The components of this remedial alternative are illustrated on Figure 10.

Alternative 4 - OLM/TLM Excavation to Water Table, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring: This alternative includes the following remedial technologies:



- Engineering controls (fencing and signs) and institutional controls (land use restriction for commercial/industrial use only and groundwater use restriction for potable or non-potable uses and a soil management/risk mitigation plan for future intrusive activities).
- Excavation of OLM/TLM in soil that is present above the water table, to a maximum depth of approximately 40 ft, backfill with imported clean soil, and surface restoration with paving, gravel, or vegetated cover, varying based on current Site use.
- Installation of a 2-ft clean soil cover between the east edge of the Pittsburgh Street paving and the East Parcel fenceline from the northern limit of OLM/TLM excavation to the northern property limit at Riverside Drive;
- NAPL monitoring and recovery in up to 8 wells (Middle Parcel, West Parcel, west of the West Parcel); and
- Groundwater monitoring will be performed annually for up to 30 years in up to 13 wells, including:
  - o West Parcel: MW-19S, MW-3DR, MW-4DR;
  - o Area west of the West Parcel: MW-K09S, MW-K09D;
  - o East Parcel: MW-6, MW-7S, MW-7D, MW-8S, MW-8D; and
  - o Middle Parcel: Up to 3 new groundwater monitoring wells installed post-remediation.

The components of this remedial alternative are illustrated on Figure 11.

Alternative 5 - In-Situ Solidification, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring: This alternative includes the following remedial technologies:

- Engineering controls (fencing and signs) and institutional controls (land use restriction for commercial/industrial use only and groundwater use restriction for potable or non-potable uses and a soil management/risk mitigation plan for future intrusive activities).
- Excavation of OLM/TLM in soil that is present in the upper 20 ft, followed by ISS of OLM in soil to a maximum depth of 60 ft which generally includes OLM impacts to the bottom of the clay layer or the upper portion of the outwash layer). ISS swell placement will be limited to no shallower than 15 ft bgs. The upper 15 ft will be backfilled with imported clean soil and surface restoration with paving, gravel, or vegetated cover, varying based on current Site use.
- Installation of a 2-ft clean soil cover between the east edge of the Pittsburgh Street paving and the East Parcel fenceline from the northern limit of OLM/TLM excavation to the northern property limit at Riverside Drive;
- NAPL monitoring and recovery in up to 8 wells (Middle Parcel, West Parcel, west of the West Parcel); and
- Groundwater monitoring will be performed annually for up to 30 years in up to 13 wells, including:
  - West Parcel: MW-19S, MW-3DR, MW-4DR:
  - o Area west of the West Parcel: MW-K09S, MW-K09D;
  - o East Parcel: MW-6, MW-7S, MW-7D, MW-8S, MW-8D; and
  - Middle Parcel: Up to 3 new groundwater monitoring wells installed post-remediation.

This alternative considers the use of ISS to remediate NAPL impacts. Including ISS increases the maximum practical depth of remediation to the bottom of the clay layers, or approximately 60 ft bgs (i.e., 20 ft below the water table). The alternative would be implemented with excavation to approximately 15 to 20 ft bgs, then ISS to the bottom of clay or approximately 60 ft bgs where NAPL



extends to this deep (not on Pittsburgh Street), leaving room for ISS swell, and leaving the upper 15 ft (future construction worker zone) to be backfilled with clean soil. This approach would apply to both the Middle Parcel and NAPL area west of the West Parcel.

The components of this remedial alternative are illustrated on Figure 12.

### 4.1 Evaluation Criteria

The remedial alternatives were subjected to a detailed evaluation against a series of criteria, which were divided into two categories; threshold criteria and balancing criteria. Threshold criteria define the minimum level of acceptable performance for an alternative that must be met for an alternative to be considered eligible for selection, and include:

Overall Protection of Human Health and the Environment – This criterion must be met for an alternative to be eligible for selection and is used to assess whether and how the alternative, as a whole, achieves and maintains protection of human health and the environment, including the attainment of the RAOs and applicable VAP standards. The overall assessment of protection draws on the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness and compliance with applicable VAP standards. The evaluation of this criterion is also based on the evaluation of how risks are eliminated, reduced or controlled through treatment, engineering or administrative controls. Overall protection of human health and the environment considers reduction in baseline risks and protection of human health and the environment from effects caused by implementing the remedial alternative. This criterion is intended to ensure that the selected remedial action alternative would:

- Protect human health and the environment;
- Attain media cleanup goals; and
- Control sources of releases.

Compliance with RAOs and Applicable VAP Standards — Evaluates the degree to which an alternative meets the RAOs and applicable VAP standards identified in Section 2.2.

The balancing criteria are used to weigh trade-offs among the alternatives that meet the threshold criteria and include:

Long-term Effectiveness - This criterion is an evaluation of the long-term effectiveness of an alternative in maintaining protection of human health and the environment after RAOs and applicable VAP standards have been met. It assesses whether the alternative provides reliable protection over time. This criterion addresses:

- Magnitude of residual risk remaining from untreated media or treatment residuals at the conclusion of remedial activities; and,
- Adequacy and reliability of controls such as containment systems and institutional controls necessary to manage the untreated media or treatment residuals which remain on-site.

The residual risk from treatment residuals or untreated media can be measured by chemical concentrations or material volume remaining at the Site after remedial action is complete.



Reduction of Toxicity, Mobility, or Volume Through Removal or Treatment – This criterion considers the degree to which alternatives employ removal or treatment technologies, as well as the anticipated performance of the removal or treatment technologies, by evaluating the amount of hazardous material removed or treated and the amount remaining on-site. The evaluation considers the magnitude of the reductions in toxicity, mobility or chemical volume and the extent to which the treatment is irreversible as follows:

- Amount of impacted media removed, destroyed or treated;
- Degree of expected reduction in toxicity, mobility and volume;
- Degree to which treatment is irreversible; and,
- Type and quantity of residual remaining after treatment.

**Short-term Effectiveness** – This criterion evaluates the effects of an alternative during the construction and implementation period of the remedial action before and until the time the RAOs are achieved and applicable VAP standards are addressed. This criterion addresses:

- Time until RAOs are achieved and whether any short-term risks are promptly addressed;
- Protecting the community and Site workers during remedial action by evaluating effects such as dust or other emissions, visual considerations or transportation;
- Protecting workers during remedial action by evaluating reliability of health and safety protective measures during implementation; and,
- Protecting the environment during remedial action by evaluating potential effects on sensitive resources, including disturbance to cultural resources and wildlife.

Implementability – This criterion evaluates the technical and administrative feasibility of alternatives and the availability of various services and materials required during its implementation. This criterion addresses:

- Technical feasibility as the ability to construct, operate and maintain the technology and the ability to monitor its effectiveness;
- Administrative feasibility as the ability to obtain approvals, rights-of-way and permits; and,
- Availability of services and materials considering off-site treatment, storage capacity, disposal capacity, equipment and specialists.

Community Acceptance - This criterion evaluates the issues and concerns the public may have regarding each alternative. Impacts to or concerns of the community may include construction traffic and noise, odors and site emissions, hauling contaminated soils through the community to the disposal facility, degree to which human health or ecological risks are mitigated, among others.

Cost – This criterion evaluates the direct and indirect capital costs required to implement the alternative as well as the projected operation, maintenance and monitoring costs. This criterion addresses:

- Direct costs, including expenditures for the equipment, labor and materials necessary to install/perform remedial actions;
- Indirect costs, including expenditures for engineering, administrative and other services required to complete the implementation of remedial alternatives; and,
- Periodic operation, maintenance and long-term monitoring costs.



The costs of the remedial action include the direct and indirect costs. The operation, maintenance and monitoring costs have not been discounted for present worth, but are presented in total present day amounts for a 30-year period. The estimated costs provided for the remedial alternatives have an accuracy of -30% to +50%, which is typical for an alternatives analysis stage. Costing detail is provided in Appendix B.

### 4.2 Evaluation of Alternatives

The results of the alternatives evaluation through comparison to the eight criteria is presented in Table III and discussed below. A relative scoring is used on Table III to provide a relative ranking of the alternatives. The numeric scoring for the various criteria ranges from 0 through 4, with a score of 0 indicating the criteria is not met and a score of 4 indicating the criteria is substantially achieved by the alternative. The scoring is not intended to identify the preferred alternative, rather, it provides a semi-quantitative means to illustrate and compare the relative benefits and short-comings of the various alternatives. This evaluation assumes that the property use remains industrial.

### 4.2.1 Alternative 1: No Action

The No Action alternative does not satisfy any of the RAOs nor does it meet applicable VAP standards and is not protective of human health or the environment. This alternative is the lowest cost to implement as there are no remedial actions implemented.

## **4.2.2** Alternative 2: Durable Covers, Institutional and Engineering Controls and Groundwater Monitoring

Implementation of engineering and institutional controls mitigates potential risks associated with direct contact with impacted media thru installation of durable covers, implementation of a soil management/risk mitigation plan, groundwater use restrictions, and land use restrictions. However, this alternative does not remove or treat any OLM/TLM impacted soils and does not address the potential migration of NAPL or the potential leaching of COCs from soil to groundwater. As such, Alternative 2 is not considered to be protective of the environment and only marginally meets some of the RAOs and VAP applicable standards. Additionally, despite the implementation of engineering and institutional controls, the presence of OLM/TLM in shallow Site soils within the construction zone will continue to pose a potential risk to construction workers, even with the implementation of a soil management/risk management plan. The cost of this alternative is estimated at \$1.3 million.

# 4.2.3 Alternative 3: OLM/TLM Excavation in Construction Worker Zone, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring

Excavation of the top 15 ft of OLM/TLM-impacted soil mitigates the potential for construction workers to be exposed to impacted soils during maintenance or future infrastructure improvements. This alternative will remove approximately 30% of the identified OLM/TLM-impacted soils at the Site, and will remove former MGP structures containing MGP residuals including the tar wells, tar settling tank, tar separator, and the upper portion of the gas holders in the Middle Parcel. However, a significant proportion of OLM impacts will remain, which are mobile and are a source of COCs to groundwater. Inclusion of NAPL monitoring and recovery wells may address potential NAPL migration off-site. RAOs and applicable VAP standards are partially met with this alternative and to a greater extent than Alternative 2. This



alternative will have moderate impacts to Site workers and the community during excavation and off-site hauling of impacted soils and will required phased construction to accommodate active facility operations and infrastructure. The cost of this alternative is estimated at \$18.3 million.

## 4.2.4 Alternative 4: OLM/TLM Excavation to Water Table, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring

Excavation of OLM/TLM-impacted soil above the water table (up to approximately 40 ft bgs) will mitigate the potential for Site and construction workers to be exposed to impacted soils during maintenance or future infrastructure improvements. This alternative will remove approximately 85% of the identified OLM/TLM impacted soils at the Site, and will remove former MGP structures containing MGP residuals including the tar wells, tar settling tank, tar separator, and the gas holders in the Middle Parcel. A portion of OLM impacts will remain, which are mobile and are a source of COCs to groundwater. Inclusion of NAPL monitoring and recovery wells may address potential NAPL migration off-site. RAOs and applicable VAP standards are partially met with this alternative and to a greater extent than Alternatives 2 and 3. The proportion of OLM -impacted soil that will remain in this alternative is significantly less than in Alternative 3; as such, this alternative is expected to result in a greater reduction in the potential for NAPL migration and COC leaching to groundwater. This alternative will have the greatest impacts to Site workers and the community during excavation and off-site hauling of impacted soils and will required phased construction to accommodate active facility operations and infrastructure. This alternative is also the most prone to delays or extended construction schedules due to river flooding potential between November and May. This alternative has the highest cost of all the alternatives estimated at \$44.6 million.

# 4.2.5 Alternative 5: In-Situ Solidification, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring

Excavation of OLM/TLM-impacted soil in the upper 20 ft and solidification of impacted soils to a maximum depth of 60 ft bgs will mitigate the potential for Site and construction workers to be exposed to impacted soils during maintenance or future infrastructure improvements. Use of ISS to address OLM-impacted soils allows for a larger proportion of source material to be addressed as compared to excavation. This alternative will remove or treat approximately 90% of the OLM/TLM impacted soils at the Site, and will remove former MGP structures containing MGP residuals including the tar wells, tar settling tank, tar separator, and the gas holders. A portion of OLM impacts will remain, which are mobile and are a source of COCs to groundwater. Inclusion of NAPL monitoring and recovery wells may address potential NAPL migration off-site. RAOs and applicable VAP standards are partially met with this alternative and to a greater extent than Alternatives 2, 3 and 4. The proportion of OLM -impacted soil that will remain in this alternative is significantly less than in Alternative 3 and Alternative 4; as such, this alternative is expected to result in a greater reduction in the potential for NAPL migration and COC leaching to groundwater. This alternative will have moderate impacts to Site workers and the community during excavation and off-site hauling of impacted soils. although less than Alternative 4, and will required phased construction to accommodate active facility operations and infrastructure. This alternative is somewhat prone to delays or extended construction schedules due to river flooding potential between November and May. The cost of this alternative is estimated at \$44.5 million.



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Haley & Aldrich, Inc., Draft Phase II Property Assessment Report, East End Gas Works, Middle Parcel, prepared for Duke Energy, August, 2013.

Haley & Aldrich, Inc., Phase II Property Assessment Report, East End Gas Works, Middle Parcel, prepared for Duke Energy, May 2014.

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Applicable Standard (1)	Media	Pathway / Exposure Route	Receptor	Comment
VAP GNS and GNS Soil with MCA	==	Direct contact, ingestion, inhalation of particulates	Current and future land users	Must consider relevant standards related to current and reasonably anticipated future land use and potential receptors: Residential, Commercial, Industrial and Construction Worker scenarios.
Vapor intrusion to Inc	Indoor Air	Inhalation	Future residential	Indoor air sampling data indicates no current risk to current land use
indoor air			land users	but potential future VI risks may remain associated with possible fut residential land uses, and related to near-surface MGP residuals (OLI TLM, NAPL). Ohio EPA May 2010 Guidance "Sample Collection and Evaluation of Vapor Intrusion to Indoor Air"
POGWMPUS	Groundwater	Future groundwater users	Groundwater resources	This is an anti-degradation rule that protects currently unimpacted groundwater from future degradation.
Potable Gr groundwater use standards	Groundwater	On-site potable and non- potable groundwater users	Current and future land users	Groundwater must meet VAP unrestricted potable use standards (UPUS).
Non-potable Gr groundwater use standards	Groundwater	On-site non-potable groundwater users	Current and future land users	Non-potable use of groundwater must pose no unacceptable risk to receptors.
NAPL standard Gr	Groundwater	Potable, non-potable groundwater users and ecological resources	Current and future land users and offsite users, Ohio River	VAP rules (3745-300-08(B)(2)) indicates that the presence of NAPL ogroundwater is indicative of an UPUS exceedence. Further, BUSTR rules, incorporated into the VAP standards, require the removal of figroduct to the maximum extent practicable.
Groundwater Gr response	Groundwater	Contact with groundwater through applicable potable	Current and future on-site and off-site	Response requirements are based on groundwater classification, so of the contaminants (on site, off-site, or mixed) and presence of an
requirements		and non-potable groundwater uses	groundwater receptors (e.g., Ohio River)	urban setting designation. Additionally, groundwater exceeding UP that emanates into a surface water body adjoining the property trig assessment of impacts to the surface water body.
Pathways / Soil, exposure routes Grou	Soil , Groundwater,	All potentially complete pathways, if any, not	Current and future land users	Evaluated through sampling and analysis and (if needed) a human hirsk assessment (HHRA), following VAP rules, for current and reason
not considered by and GNS or UPUS Gas	and /or Soil Gas	calculations		anticipated future land uses.

TABLE I VAP APPLICABLE STANDARDS AND REMEDIAL CONSIDERATIONS EAST END GAS WORKS SITE CINCINNATI, OHIO

Applicable Standard (1)	Media	Pathway / Exposure Route	Receptor	Comment	Standard Currently Met?	Remediation Consideration (2)	Regulatory Reference
VAP GNS and GNS with MCA	Soil	Direct contact, ingestion, inhalation of particulates	Current and future land users	Must consider relevant standards related to current and reasonably anticipated future land use and potential receptors: Residential, Commercial, Industrial and Construction Worker scenarios.	ON	Remedy Required for current and future users (active remediation and restrictions likely)	Ohio Administrative Code (OAC) 3745-300- 08
Vapor intrusion to indoor air	Indoor Air	Inhalation	Future residential land users	Indoor air sampling data indicates no current risk to current land users, but potential future VI risks may remain associated with possible future residential land uses, and related to near-surface MGP residuals (OLM, TLM, NAPL). Ohio EPA May 2010 Guidance "Sample Collection and Evaluation of Vapor Intrusion to Indoor Air"	No	Land use restrictions required for future users	OAC 3745-300-07 (I)(1)(a)(iii)
POGWMPUS	Groundwater	Future groundwater users	Groundwater resources	This is an anti-degradation rule that protects currently unimpacted groundwater from future degradation.	ON	Groundwater response	OAC 3745-300-10 (D)
Potable groundwater use standards	Groundwater	On-site potable and non- potable groundwater users	Current and future land users	Groundwater must meet VAP unrestricted potable use standards (UPUS).	No	requirements required as described in OAC 3745-300-10.	OAC 3745-300-08
Non-potable groundwater use standards	Groundwater	On-site non-potable groundwater users	Current and future land users	Non-potable use of groundwater must pose no unacceptable risk to receptors.	No	these actions may include removal of NAPL, active	OAC 3745-300-09
NAPL standard	Groundwater	Potable, non-potable groundwater users and ecological resources	Current and future land users and off- site users, Ohio River	VAP rules (3745-300-08(B)(2)) indicates that the presence of NAPL on groundwater is indicative of an UPUS exceedence. Further, BUSTR rules, incorporated into the VAP standards, require the removal of free product to the maximum extent practicable.	No	remediation, and institutional or engineering controls.	OAC 3745-300-08 and OAC 1301:7-9- 13(G)(3)(a)
Groundwater response requirements	Groundwater	Contact with groundwater through applicable potable and non-potable groundwater uses	Current and future on-site and off-site groundwater receptors (e.g., Ohio River)	Response requirements are based on groundwater classification, source of the contaminants (on site, off-site, or mixed) and presence of an urban setting designation. Additionally, groundwater exceeding UPUS that emanates into a surface water body adjoining the property triggers assessment of impacts to the surface water body.	No, to be determined.		OAC 3745-300-10
Pathways / exposure routes not considered by GNS or UPUS	Soil, Groundwater, and /or Soil Gas	All potentially complete pathways, if any, not considered in GNS or UPUS calculations	Current and future land users	Evaluated through sampling and analysis and (if needed) a human health risk assessment (HHRA), following VAP rules, for current and reasonably anticipated future land uses.	No, to be determined	These have not been evaluated.	OAC 3745-300-09

TABLE I
VAP APPLICABLE STANDARDS AND REMEDIAL CONSIDERATIONS
EAST END GAS WORKS SITE
CINCINNATI, OHIO

Applicable	Media	Pathway / Exposure Route	Receptor	Comment	Standard Currently	Remediation	Regulatory Reference
Standard (1)					Met?	Consideration (2)	
Risk to ecological	Sediment /	Ecological and human health   Ecological resources	Ecological resources	Also reference Ohio EPAs "Guidance of Conducting Ecological Risk	Unknown –	The potential for	OAC 3745-300-08
resources	Surface	exposure pathways	and potential	Assessments," US EPA Region 5 ecological screening levels, and other	impacts beyond	impacts to ecological	(A)(1) and (H), and 09
	Water		current or future	standards listed in the referenced rules.	the upland top of	receptors is	(E)
	_		users		bank have not	undetermined because	
					been investigated	insufficient data have	
						been collected	
						between the site top of	
						bank and the river	

Notes:

GNS – VAP Single Chemical Generic Numerical Standard

MCA – Multiple Chemical Adjustment

POGWMIPUS – Protection Of Groundwater Meeting Potable Uses Standards

UPUS – Unrestricted Potable Use Standards

(1) Determination of applicable standards are discussed in OAC 3745-300-07 (F)(4).

(2) Remediation considerations are based on evaluation of the individual applicable standard noted for each consideration.

TABLE II
REMEDIAL TECHNOLOGY SCREENING
EAST END GAS WORKS SITE
CINCINNATI, OHIO

				Screening Criteria		
General Response Action	Technology/Approach	Description	Effectiveness	Technical and Administrative Implementability	Relative Cost	Retained (Y/N)
		No remedial investigative or monitoring	Noteffective	No activity to implement		Y (for baseline
No Action	None	4	DA	accard to implement	No cost	comparison)
	Deed Notice/Activity Use Limitations	Covenants, conditions, and restrictions including groundwater use restrictions, excavation restrictions, and vapor intrusion mitigation evaluations for future struction construction or occupancy.	a <u>5</u> a	Readily implementable for soil and groundwater. However, requires added costs to future intrusive activities related to site operations due to need for additional environmental and health and safety confrots related to soil management during construction.	Low	>
Institutional Controls	Soil Management Plan	Implementation of a long-term risk management plan for future intrusive activities necessary to support on-going facility operations, maintenance and improvements.	Addresses PAO of mitigating potential future exposure to impacted soil in event of future site construction.	Soil management plans are common practice and considered highly implementable. However, requires added costs to future intrusive activities related to site operations due to need for additional environmental and health and safety controls related to soil management during construction.	Pow	>-
	Monitoring	Monitor wells over time to evaluate presence, concentrations and migration of contaminants.	Not effective at reducing toxicity, mobility or volume for any media, however, can monitor trends in concentrations and effectiveness of remedial actions. Does not directly contribute to meeting RAOs.	Readily implementable and necessarily a part of any alternative that does not consist of clean closure.	Low to Moderate	<b>&gt;</b>
	Site Fencing /Signs	Physical barrier placed around contaminated area to prevent access and alert to potential hazards.	Somewhat effective at mitigating direct exposures to soil if maintained and monitored. Supports addressing RAOs for reducing exposure risk to all media.	Implementable with local contractors and materials. Compatible with current facility use and security provisions already in place.	Low	<b>&gt;</b>
Engineering controls	Durable Covers	Durable covers may include existing pavements and building, new paving, hardscapes or building foundations, solilaggregate covers, or multi-layered engineered covers. Durable covers provide a horizontal barrier that prevents direct contact with the subsurface soils.	Effective means of addressing RAO of mitigating potential exposure to impacted site soils by industrial/commercial site workers and construction workers. Low permeability covers, such as pavement, reduce infiltration thus reducing potential for mobilization of contaminants in soils above the water table.	Easily implementable - much of the study area is already paved. Must be used in combination with institutional controls for future development to effectively address soil exposure potential.	Low	<b>&gt;</b>
	Vapor Intrusion Barriers	Multi-layered systems including sprayed sealers and impermeable liners installed during new construction to mitigate risk of vapor intrusion. A vapor intrusion assessment would be needed for future building construction to determine if mitigation is necessary.	If installed correctly during construction, foundation membranes have been proven to reduce vapor intrusion risk. Supports addressing RAO for future vapor intrusion risk.	Readily implementable for new construction and applicable for soil gas contaminant concentrations that exceed risk criteria for indoor workers.	Low	Y (for future structures where VI risk exists)

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TABLE II REMEDIAL TECHNOLOGY SCREENING EAST END GAS WORKS SITE CINCINNATI, OHIO

Г		
Retained (Y/N)	z	z
Relative Cost	High	High
Screening Criteria Technical and Administrative Implementability	Administratively, this would not be crimplementable due to the sensitive, critical infrastructure at the southern edge of the site that is very vibration sensitive. This would fimit the areas where a vertical barrier will could be installed. The depth of the wall (up to 110 feet) and the need to key in to the bedrock surface along which the NAPL has migrated poses significant technical challenges. The southern edge of the site adjacent to the riverbank contains fill and hubble, and there will fikely be remnant MGP structures and piping that will pose challenges to constructing a continuous barrier wall.	Administratively, this would not be implementable due to the sensitive, critical infrastructure at the southern edge of the site that is very vibration sensitive. This would limit the areas where a recovery trench could be installed. The depth of the trench (up to 110 feet) and the need to key in to the bedrock surface along which the NAPL has migrated poses significant technical challenges. The southern edge of the and rubble, and there will likely be remnant MGP structures and piping that will pose challenges to constructing a
Effectiveness	Effective in mitigating future migration of NAPL and redirecting groundwater flow. Verification of wall continuity would be required during construction. The technical fimilations to wall continuity would limit its effectiveness at this site.	Effective at intercepting NAPL in the cutwash deposits, however, NAPL has also been observed in shallow fractured bedrock. The depth to bedrock would not be conducive to installing a trench into shallow bedrock. The technical limitations to tench continuity would limit its effectiveness at this site.
Description	Low permeability wall installed by excavating trench supported by bentonie slurry and backfilling with a low permeability material (or other suitable construction innethods such as sheet pile walls) to prevent lateral NAPL migration and intercept and/or redirect groundwater flow for containment, collection, or controlled discharge.	Continuous permeable trench with NAPL collection piping and recovery risers to intercept DNAPL migration and allow for recovery by pumping.
Technology/Approach	Vertical Barrier Wall	NAPL Recovery - Trench
General Response Action		Containment

TABLE II REMEDIAL TECHNOLOGY SCREENING EAST END GAS WORKS SITE CINCINNATI, OHIO

	Retained (Y/N)	>	>
	Relative Cost	Low to Moderate	Moderate to High
Screening Criteria	Technical and Administrative implementability	Construction of the recovery wells is implementable with local contractor and materials, and would have minimal impact on existing site structures and activities. Recovery wells can be instaffed into bedrook in some areas of the site. Ability to recover NAPL may be limited in the area of sensitive, critical infrastructure due to vibration concerns. The NAPL recovery program will likely require long term operation and maintenance.	Excavation is an easily implementable technology, however, the difficulty increases with increasing depth.  Accavation below the water table, and the presence of known and unknown subsurface obstructions which can hamper shoring system installation. Officially acceptance capacity can reduce productivity. Excavation above the water table is known to be implementable at the site as a similar approach was previously used for remediation of a portion of the West Parcel, however, river flooding potential and gas plant operations restrictions can limit available construction periods. Due to active subsurface infrastructure on the Middle Parcel, excavation activities would need to be phased to accommodate infrastructure protection and/or relocation and continued facility operations.
	Effectiveness	Effective at reducing volume of NAPL and intercepting potentially mobile NAPL, in the vicinity of the well. Supports addressing NAPL ringration RAO. Assessment of NAPL recoverability and zones of potential migration necessary for NAPL recovery wells to be effective and to determine whether active or passive recovery is appropriate. NAPL recovery well effectiveness will be limited in the effectiveness will be limited in the effectiveness will be limited in the southern portion of the site where existing sensitive, critical infrastructure limits the locations where well could be installed.	Effective at reducing toxicity, mobility, and Excavation is an easily implementable volume of contaminated media. Supports increases with increasing depth, excavalion below the water table, and the presence of known and unknown subsurface obstructions which can hamper shoring system installation. O site disposal facilities are available to accept the excavated soil, however, defacility acceptance capacity can reduce productivity. Excavation above the wat table is known to be implementable at the site as a similar approach was previously used for remediation of a portion of the West Parcel, however, river flooding potential and gas plant operations restrictions can limit availat construction periods. Due to active facility operations and active subsurfact infrastructure on the Middle Parcel, excavation address infrastructure on the Middle Parcel, excavation address reduced to be phased to accommodate infrastructure protection and or relocation and continued facility operations.
	Description	Extraction wells used to bail or pump coperate phase DIAAPL to the surface for collection and offsite disposal.	Excavation of soil and subsurface structures containing OLM and/or TLM above the water table. Excavated soils transported off-site for local permitted landfill disposal.
	Technology/Approach	NAPL Recovery - Wells (Passive or Active)	Shalfow Excavation
	General Response Action	Containment	Removal

TABLE II REMEDIAL TECHNOLOGY SCREENING EAST END GAS WORKS SITE CINCINNATI, OHIO

	Retained (Y/N)	z	>
	Relative Cost	High	Moderate
Screening Criteria	Technical and Administrative Implementability	Excavation of OLM-impacted soils below the water table to bedrock (40-110 ft bgs) is not administratively practical due to the presence of sensitive, critical infrastructure at the site. Technically, deep excavations below the water table require significant shoring and deep excavations below the water table require significant shoring and adacent ground movements and affects on nearby buildings and affects on nearby buildings and affects on nearby buildings and sensitive, critical infrastructure. River flooding potential and the depth of excavation and shoring operations. Due to active facility operations and active subsurdace infrastructure on the Middle Parcel, excavation and storing operations. Due to be phased to accommodate infrastructure protection and/or relocation and continued facility	ISS is technically and administratively feasible and is a commonly used treatment technology on MGP sites. Qualified contractors and equipment are available regionally. Subsurface obstructions and structures could limit the suitability of this equipment in some arreas or require prior removal of obstructions or structures. Due to active facility operations and active subsurface infrastructure on the Middle Parcel, excavation activities would need to be phased to accommodate infrastructure priotection and/or relocation and continued facility operations.
	Effectiveness	Effective at reducing toxicity, mobility, and volume of contaminated media. Supports addressing RAOs for all media.	ISS is technically and administratively another local MGP site in Cincinnati in feasible and is a commonly used similar flaid and clay strata, and depths to 60 treatment technology on MGP sites. Itset are generally achievable in similar soil Qualified contractors and equipment are types. ISS of OLM/TLM impacted soils to eliminating the NAPL phase, mitigating the NAPL phase, mitigating the the suitability of this equipment in some potential for OLM/TLM migration and areas or require prior removal of imiting leaching of contaminants to infrastructure on the Middle Parcel, encreavation and or the Middle Parcel, encreavation and or the Middle Parcel, encreavation and or octive phased to accommodate infrastructure protection and/or relocation and continued facility operations.
	Description	Excavation of soil containing OLM below the water table. Excavated soils transported the water table. Excavated soils transported of contaminated media. Supports off-site for local permitted landfill disposal. addressing RAOs for all media.	Mix OLMTLM-impacted soil within the fill and clay layers to depths up to 60 feet insitu with soildfying reagents using large diameter augers to reduce permeability and reduce water contact with contaminated soils, thereby containing the impacted soils in a soildified matrix with timited groundwater contact.
	Technology/Approach	Deep Excavation	In-Situ Solidification (ISS) via Auger Soil Mixing - Shallow
	General Response Action		Treatment

TABLE II REMEDIAL TECHNOLOGY SCREENING EAST END GAS WORKS SITE CINCINNATI, OHIO

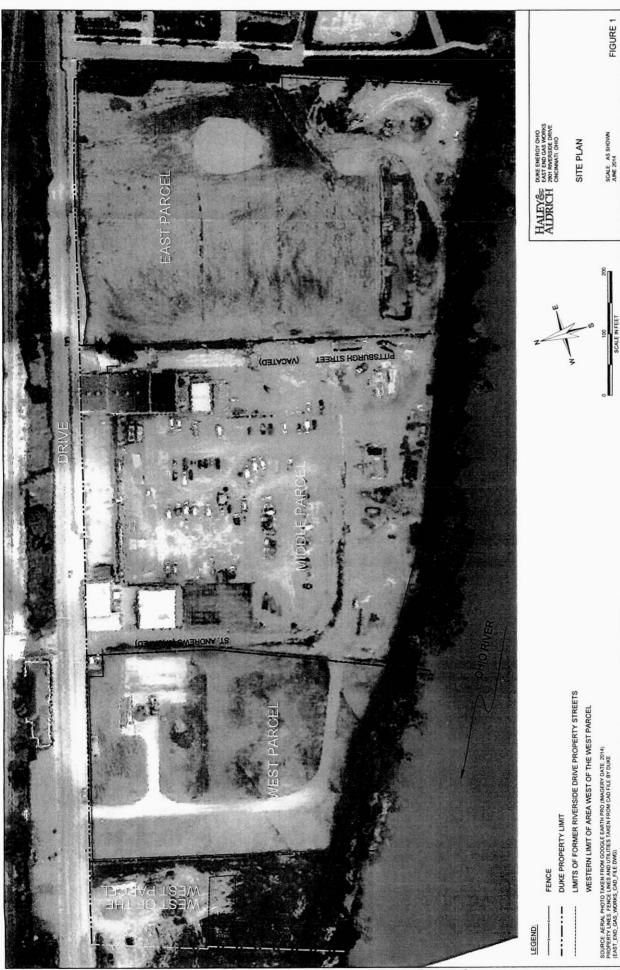
Г				
	Retained (Y/N)	z	z	z
	Relative Cost	High	High	High
Screening Criteria	Technical and Administrative Implementability	ISS of sand and gravel soils below 60 feet using soil mix augers is challenging and requires a site-specific chilling evaluation. Smaller diameter augers and large amounts of drilling fluids (grout) are typically required to achieve these depths, resulting in greater than 50% spoils generation.	Jet grouting of deep impacts is considered to be administratively feasible but technically infeasible. Jet grouting results in large spoils volumes and can be difficult to achieve complete horizontal and vertical treatment of deep zones with varying soil gradations.	Thermal treatment is not considered to be implementable at this site due to the active gas infrastructure present over large portions of the Middle Parcel. Additionally, heating of large volumes of varying fill and clay soils over extended periods presents potential settlement issues and associated risks to structures and active gas piping.
	Effectiveness	ISS is effective at treating sand and gravel is of sand and gravel soils below 60 soils containing OLM, however, would be feet using soil mix augers is challeng is of fimited effectiveness at this site due to and requires a site-specific drilling technical limitations with implementation. An augustion is challenged to child in the large amounts of drilling fluids (grout) coutwash soils would require treatment of typically required to achieve these large zones of overlying clean soil to reach depths, resulting in greater than 50% deep OLM lenses.	ISS via jet-grout is not an effective means of mitgaining deep product impacts due to the infeasibility of locating and targeting the thin disconnected lenses of product in the outwash at the site.	For impacted soils above the water table, thermal treatment is not considered to the compounds as temperatures above the compounds as temperatures above the compounds as temperatures above the boiling point of water can be achieved.  Below the water table, thermal treatment is Additionally, heating of large volumes of limited to the boiling point of water and enhanced recovery of NAPL, but nonvoidile organic compound destruction is issues and associated risks to structures immited. Proximity to the river and high effectiveness of this technology and may present increased risks for contaminant migration to the river during treatment.
	Description	Mix OLM-impacted soil within the outwash layer to depths up to 110 feet in-situ with solldifying reagents using large diameter augers to reduce permeability and reduce water contact with contaminated soils, thereby containing the impacted soils in a solidified matrix with limited groundwater contact.	Mix OLM/TLM-impacted soil within the within to outwash layer to depths up to 110 feet in-situ with solidfying reagents using jet grouting to reduce permeability and reduce water contact with contaminated soils, thereby containing the impacted soils in a solidified matrix with fimited groundwater contact.	An electrical current is passed between arrays of electrodes (electrical resistance heating) or heat is applied directly through wells and radiates outward (thermal conductive heating) for the purpose of heating the subsurface. The resultant heat reduces the viscosity of the DNAPL, reduces the residual saturation, and volatilizes contaminants. Groundwater and NAPL are recovered as treatment progresses.
	Technology/Approach	ISS via Auger Soil Mixing - Deep	ISS via Jet Grouting - Deep	in-Situ Thermal Treatment of OLM/TLM-Impacted Soil
	General Response Action			Treatment

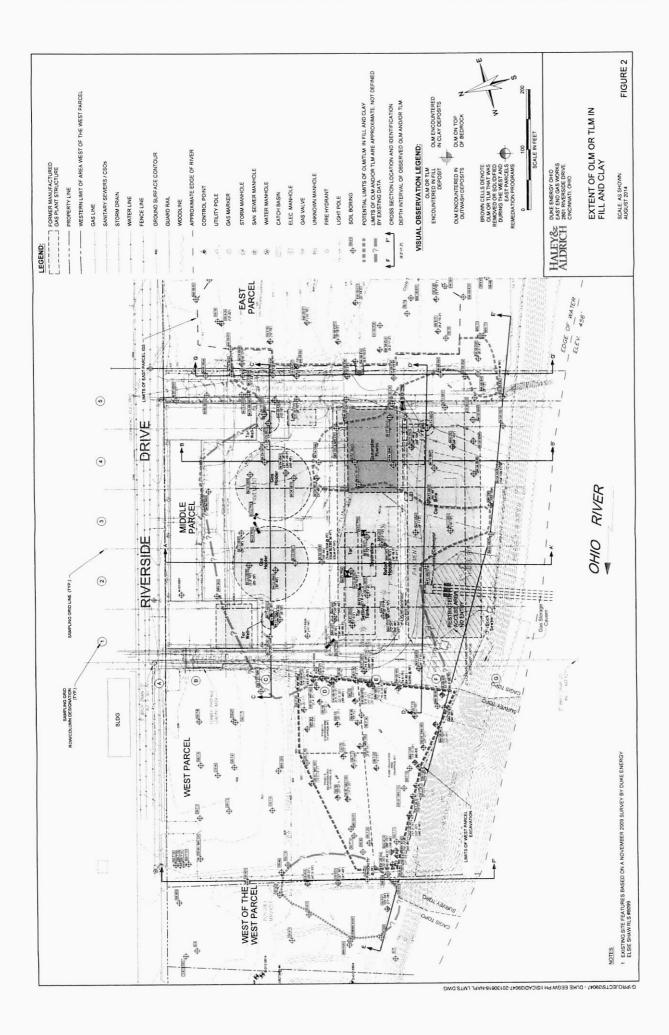
	Alternative 1	Abenaber 2	Abenative 3	Alternative 4	Alternative 5	
Criteria	No Action	Durable Covers, Institutional and Engineering Controls and Groundwater Monitoring	OLMTLM Exercition in Construction Wenter Zone NATL Mentering and Recovery, ing institutional and Engineering Controls and Groundwater Monitoring	OLMTLM Exercision to Water Takin NAPL Monitoring and Receivery, bettindows and Engineering Controls and Groundwater Monitoring	In 5th Soldification, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Droundwater Monitoring	ğu,
THEEBACLD CHITTERA Overall Projection of Numer Neath and the Environment	Control of magain planning that to two exceptions:	Alteriorar risk to known health by calcifoling registrum to required meta town the second-second second-second second-secon	A federate that to seem exact by containing separate in regulated media do no Containing and Containing separate in regulated media do no Containing and Containing separate in containing separate in the electronic separate in the containing media to see of memis media to containing media to see a resemple a containing separate in the containin	- Adjustment of the peak health by containing appearing to respected model con-  - On COUNTY as alreaded about the contribution county of the   - OL COUNTY as alreaded about the contribution county county and   - OL COUNTY as alreaded and the county and   - OL COUNTY as a respect as the contribution county county and   - OL COUNTY as a respect to the contribution of the   - OL COUNTY as a respect to the contribution of the   - OL COUNTY as a respect to the contribution of the   - OL COUNTY as a second county as a response to   - OL COUNTY as a respect to the contribution of the   - OL COUNTY as a second county as a resolution of the   - OL COUNTY as a respect to   - OL COUNTY as a resp	Allegace on the humble health by comprising exposure to experiod mode on the COLMITA and exposure to experiod mode on the COLMITA and exposure to experiod mode on the COLMITA and exposure the cold is 150 feet the feet the humblest decount on the COLMITA and the feet the humblest decount of the cold is 150 feet the feet the humblest decount of the cold is 150 feet cold. The requested belongs and the cold is 150 feet to the cold in the cold is 150 feet to	
Addigate reposes that access applicable interaction between and control contro	Ones and surplus parties and assessed to the security parties of the control of t	Advances and propose properties and deposes through the expensional protection of the expensional protection services concluding services of the expensional protection services concluding services and feeting services to confidence and services and services and services are serviced to the expensional services and services are services and services and services are services and services are services and services and services are services are services and services are services and services are services are services and services are services are services and services are services are services are services are services and services are s	citics of rescriber in migated brough the exception of impacted solo- white the potential contribution white might be 151 and the potential contribution white might be 151 and the potential form you will be the potential of the	data of regioner is imaginal through the incaretion of all impacted to the way is the control of the impacted to the way is the control of th	a close of resource in indigental through the resources and of all proportions than the protection school with which the potential confliction would think ages interest make through the proportional of indifficult contents and secretary and school-toon.	
Compliance with Antiques potential for COCs in soil to lead Applicate vide of groundwater Standards Standards	#Dees not reduce these, or contain source material bat has the potential to learn COCs to generalize	Proper expormations does be treated as the first of the first of principles of the first of the	Adaptive nations when the lag 55 Adaptive rackoes potential to COCci to lead to providentive through the instanction of bottom material in the lag 57 however invalues (commanded neeper than 55 may optimize to act as source of potential providential containmation.	source melatival ventro the specific control of the sp	3.2 Relation polinists for CCs; to lead to provide after through the recent polinists for CCs; to lead to provide after through the recent polinists for the CCs; to lead to provide after through the recent polinists and subdividuous of burst entering in the tag (00 however, recent polinists and provide after the CCs; to lead	9
•Mrigate NAPL impacts to groundwater and the potential for impracon of NAPL off-ate	Does not reduce, treat, or contain NAPI.	Does not reduce treat, or contain NAPL.	sliephby reduces potential for HAPI, mayabon by removing source material in the top 15' potentially recibile HAPI, betoe 15' will remain	Reduces potential for NAPI, impation by removing source material in the top 40" potentially mobile NAPIL balow 40" will remain.	Attachers potential for MAPI, impration by removing source material in     the top 40, potentially mothe NAPI, below 50's set remain.	
<ul> <li>Midigate potential future exposure to impacted gnoundwater for potable and non-potable uses</li> </ul>	expected e Aptenuative does not include any measures to mitgate potential future exposure to groundwater.	<ul> <li>Through the implementation of natitutional control including deed restriction. Van affectional substantially religiates potential future response to impaction groundwater.</li> </ul>	Through the implementation of institutional controls, withinking deed restrictions this administrates substantially intigates potential future response to impacted groundeaths.	Intrough the implementation of institutional controls recipiding deep respictions for bin affertative migates potential future expecture to respict of proudwatering.	Through the imprimediation of estitutional confront including deed restriction this affection migrates potential future exposure to impractly groundwater.	
THRESHOLD CRITERIA COMBINED SCORE		0	2.4 4.8	6.2	7.6	ဖ
BALANCHIO CRITEBIA Long Jem Effictiveness	The attraction is reflected at telecory trug-term risks to human health and the exercisest sector in remarkat action are operated as	elepane is measted as ed prockeder by the selects in decimally considerable measures to CAUT Managards data Long term source efection and section to prockeder in and secure places.	dispense to propose as and goodwale by the worker and contriction works a dispense to propose as a second control of control of propose and propose as a second control of propose and control of propose as a second control of propose and control of pro	of greuze is measured and and goodware by all women and contraction receiver a effective operation by compression control and attent secure amount MAT, receiver, a respectable to recover code MAT, where it waster for opin motion control and searching to provide use in most in register with the secure relation and searching to provide use in most in register of the secure of the secure of the secure of the security of the secure of the terms and the secure of the secure of the security of the secure of the security	disposer to reputate tool tool produced by the workers and electricism extract and inchesion containing by enthances control and parts soons recover MAX receiving an explorated to service and parts soons recover MAX receiving an explorated to service to dispose to the state to copy may come reaction to be serviced by producers in extractional program explores and the abstraction.	
Reduction of Taskoth, Mobility, or Volume Through Removal or Teatment	O security was a president or production to president or product of the control o	element of implated unities who along the puriet size where rea is a complete or the alonement of the Vertical or the vertical	Processed in present team through council at an execution of an execution of a contract of the annual council and a contract or an execution or present or transmission to termine council of the annual view of the annual council or council of the annual view of the annual council or cou	defined of inspired sea in evil permit sea some and defined of inspired sea some and constitution of the control of the contro	Removed of regarded lasts from 50 feet and 14 feet and 15 feet and 15 feet and 15 feet and 16 feet and	
	% of OLMTUN impacted Soil Treated/Removed DN:	% of OLMTLM impacted Sol Treated/Removed Offs	N of OCMITAL Impacted Sol Tredbod Removed 30%	% of OLMTLM impacted Sol Treated/Removed 85%	N. of OLMTLM impacted Soil Treated/Removed 90%	
Short darm Effectiveress	The property to conversable before a representation of the property and the property of t	Montal applit is commody works, and excepted is becomed the universities of department of adjoint of the property of the	* Impermetation of this attention will report other condition with facility operations and the condition will report of the control of the condition of th	emperation of the abundance of repair store controllers with builty appropriate of the abundance of the abun	Implementation of the distribute will report into contribution off build operation of the contribution of the contributio	2
Lightmaniphic	egizmendini (play v oruz is . •	<ul> <li>Placement of purples cover and establishment of mobilishmin probabilities and any operation activities.</li> </ul>	Property of all and provide the state of controlled and the state of t	Proposed of public come and exhibitionism of entitional contents are supplying an experimental profiles, the proper partial supplying an experimental profiles of the profiles of the company from any an experimental profiles of the pr		8
Community Acceptance	<ul> <li>This alternative presents no construction impacts to the community however lang-term sits risks are not addressed.</li> </ul>	This alternative presents mornal controction impacts to the community species long-term stir risks are only partially addressed.	-This aberuative prosents misor contraction repaids to the community during contaminated soil encavation however congisem site rate are only partially addressed.	This absentive present moderate contraction impacts to the community damp contaminated soil exceeding and facility towards inoquem site mass are reduced by the extent of source removal accomplished.	The attentive presents moderate construction impacts to the community during conteminated dis execution and hauling that less than the st. Attentive is the forecast impact with make st. Attentive in the construction and are reduced by the conteminate of section of second accomplished.	2
Cont	N001	3134	3 518346 2	344.64	34500	_
BALANCING CRITERIA COMBINED SCORE		1	11.5		15.0	0.0

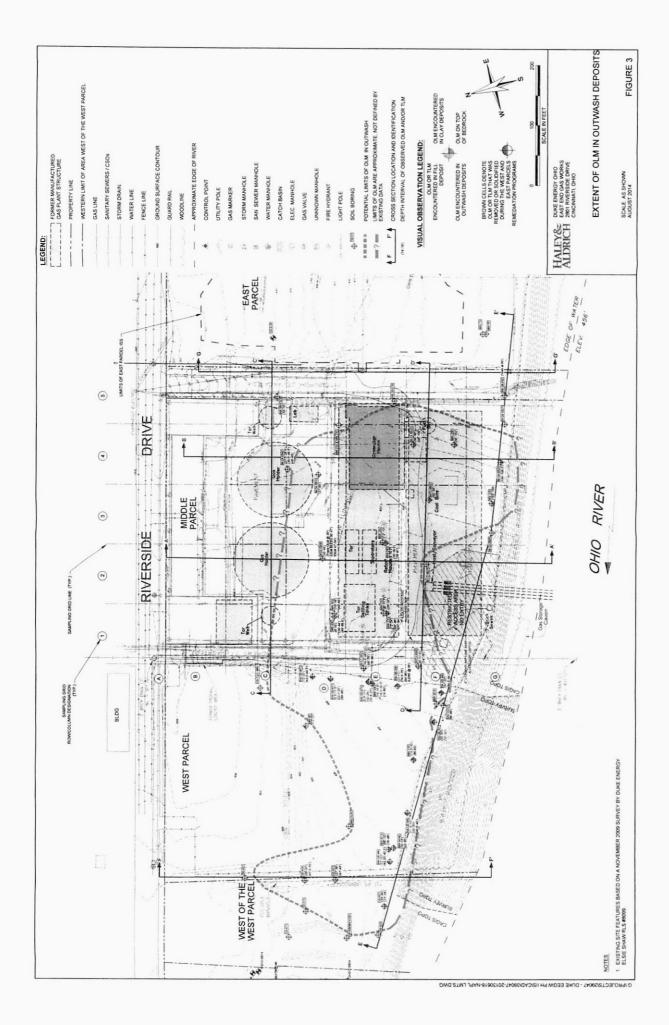
Abernative substantially meetilablewises of throp 2 Abernative parkety meetilablewises of throp 2 Abernative parkety meetilablewises of them
2 Attentative partially meets/addresses
3 Abernative mostly meets/addresses to

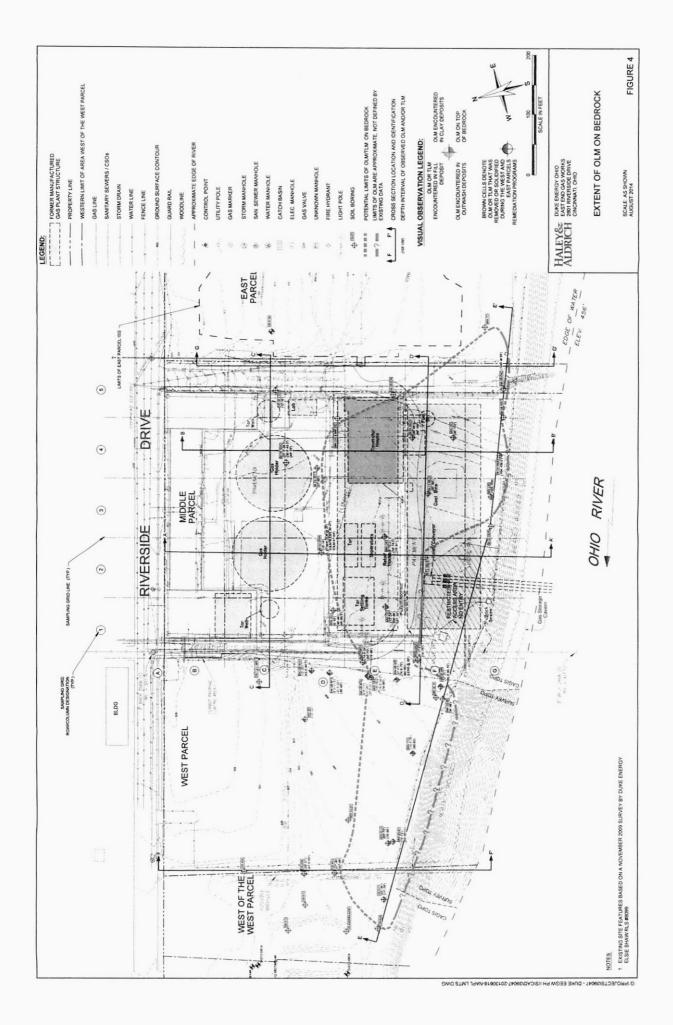
use See Section 4.1 for description of evaluation criteria

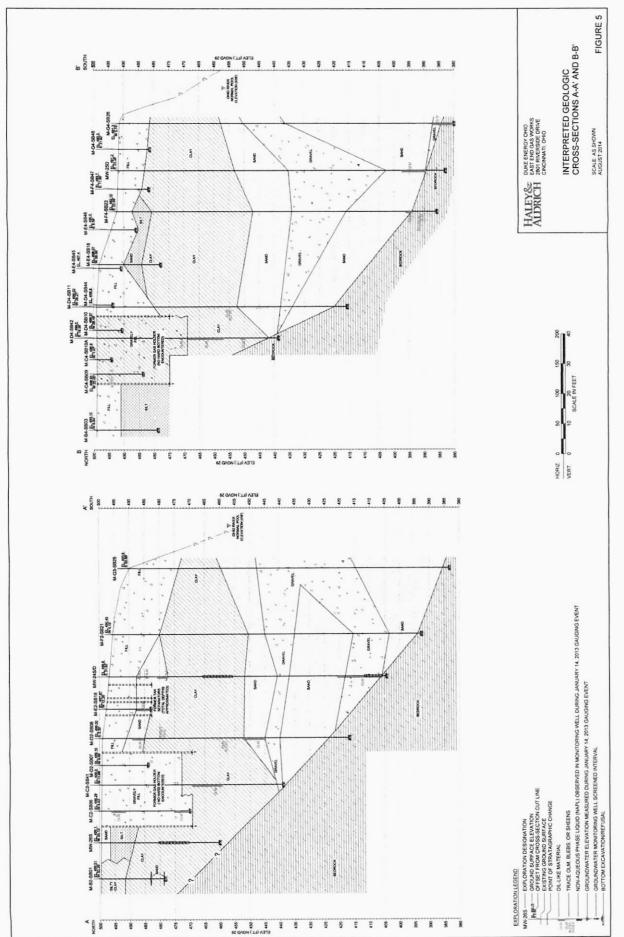
Page 1 of 1

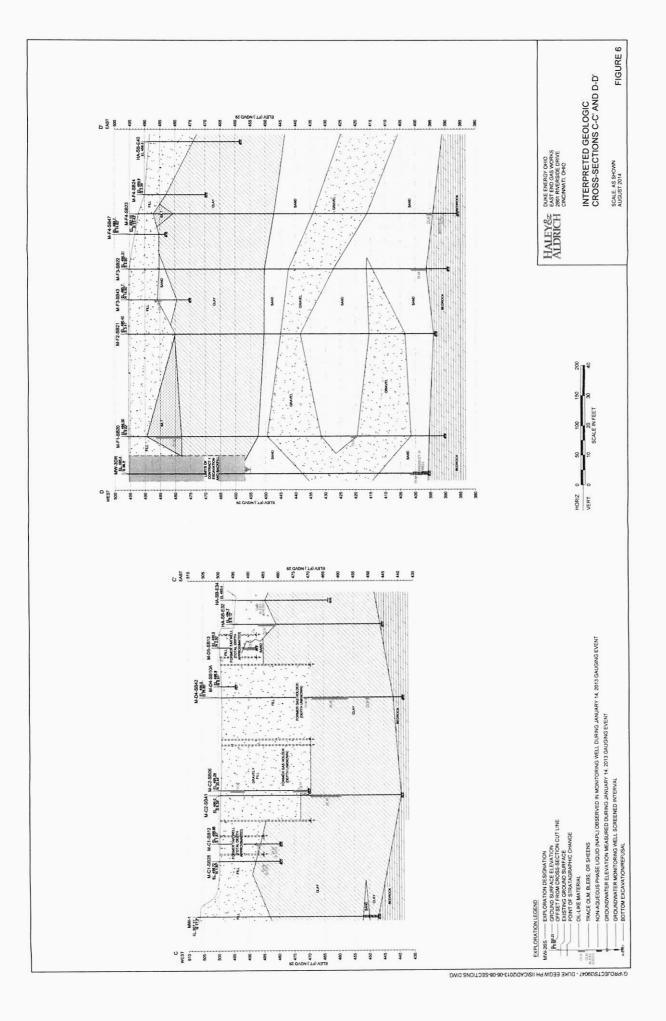


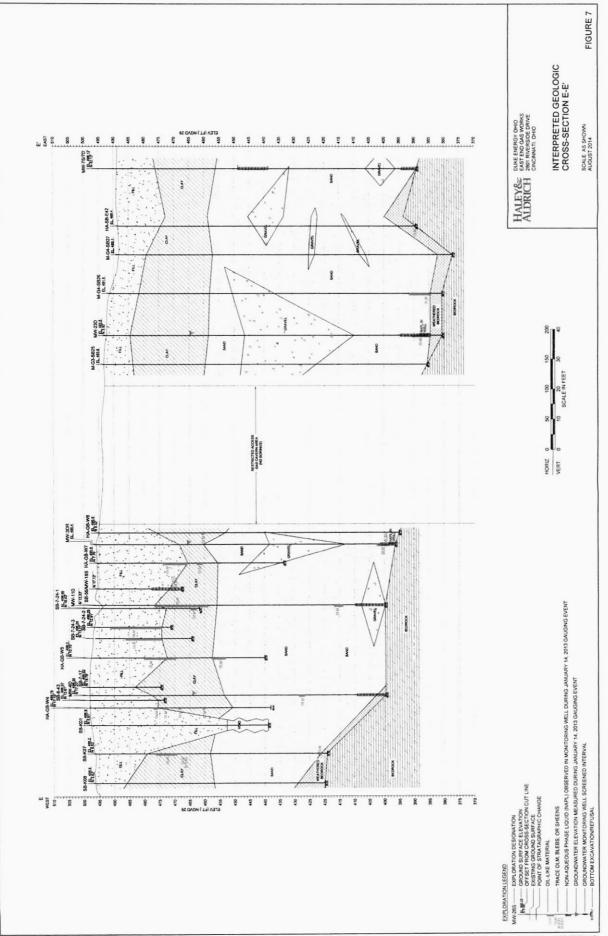


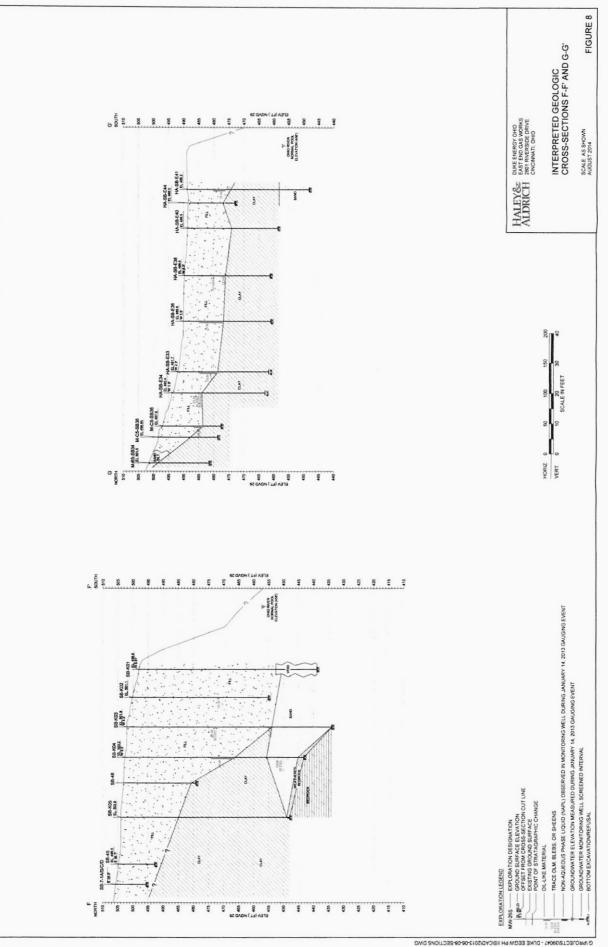


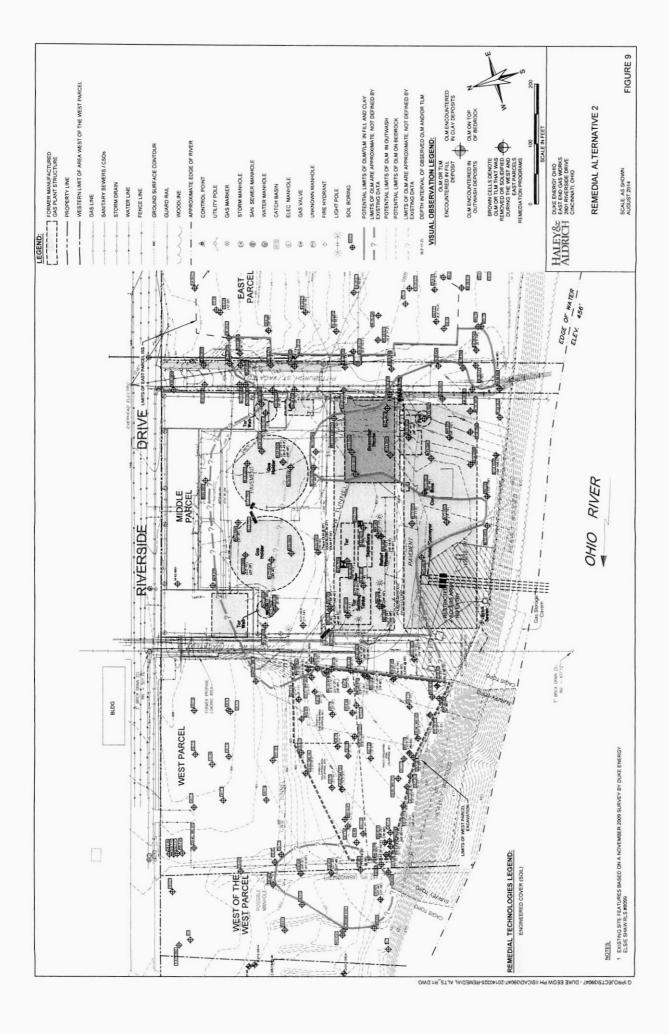


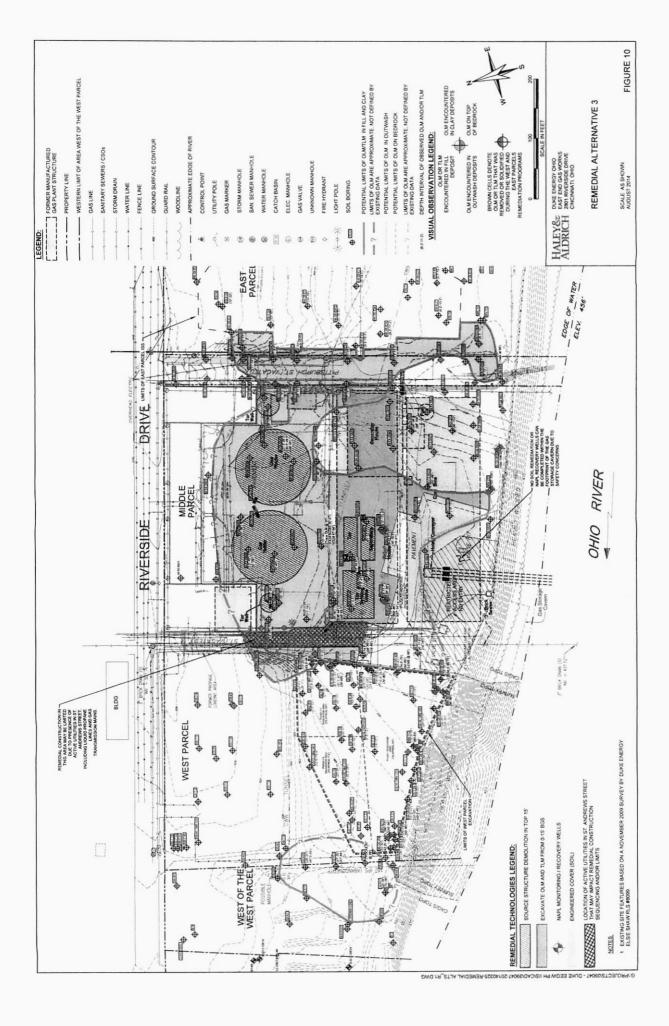


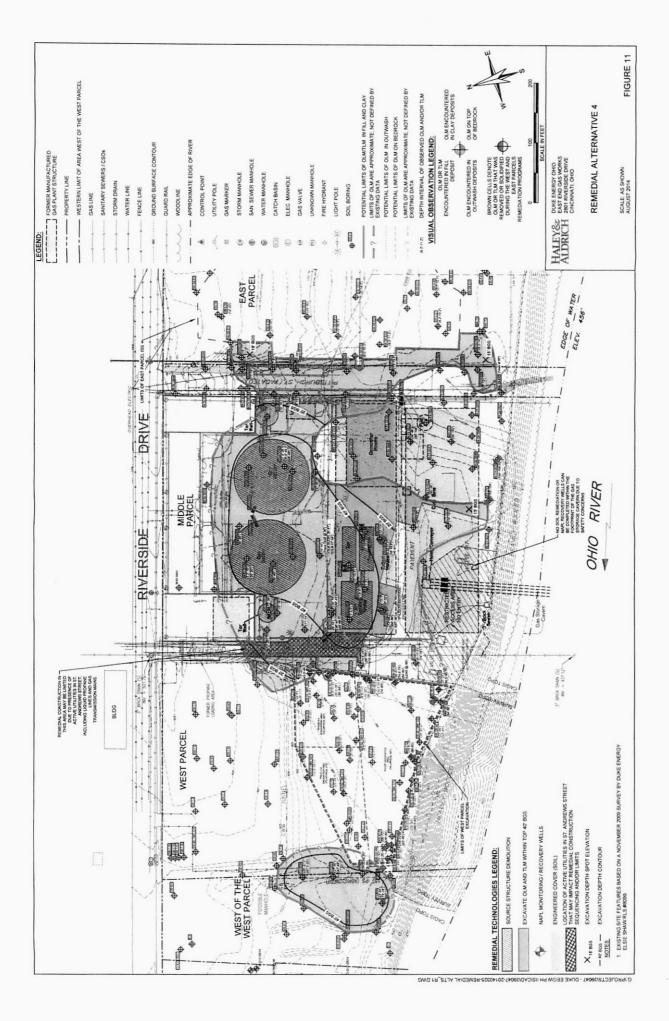












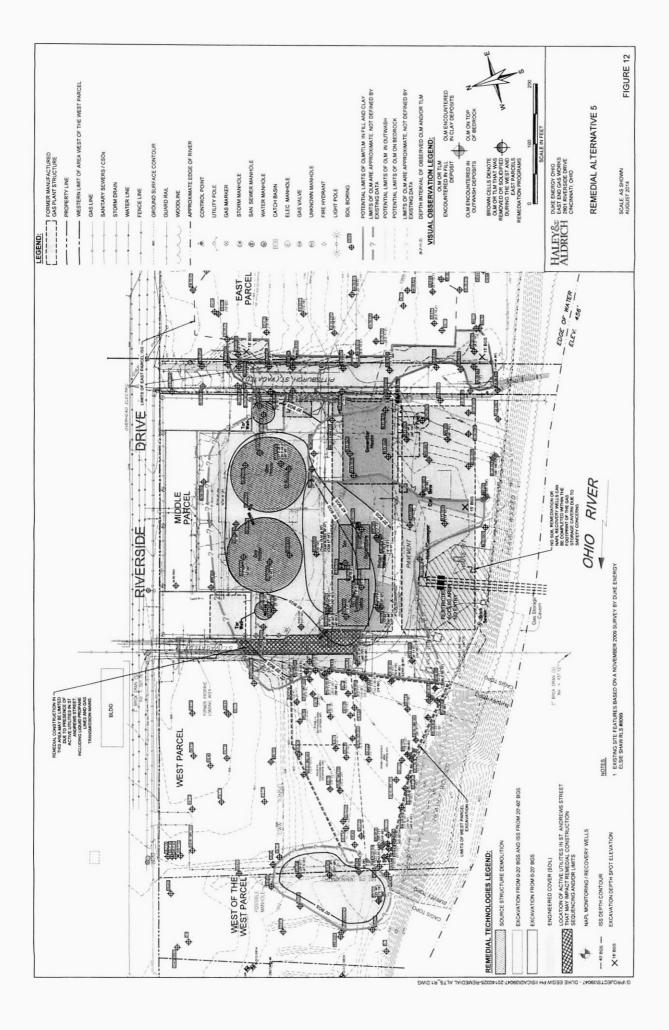


TABLE A-1 MCA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 2 FEET AREA WEST OF THE WEST PARCEL DDUKE ENERGY CINCINNATI, OHIO

Commercial         Cancer         Non-Cancer         1-2(ft)         Cancer         Non-Cancer         1-2(ft)         Cancer         Non-Cancer         1-2(ft)         Cancer         Non-Cancer         Non-	Location Name Sample Date	me ate VAP	Standard Basis	SB-K02 7/29/2011 N	Risk Ratio	Risk Ratio (SB-K02)	SB-K04 8/1/2011 N	Risk Rat	Risk Ratio (SB-K04)	SB-K07 8/2/2011 N	Risk Ratio (SB-K07)	(SB-K07)
12500	Sample Depth (bg		Cancer (C or NC)	0 - 2 (ft)	Cancer	Non-Cancer	0 - 2 (ft)	Cancer	Non-Cancer	0-2(ft)	Cancer	Non-Cancer
82         C         4,76         0.068         1,34         0.090           370000         NC         4,46         0.068         1,34         0.090           5100         NC         4,46         0.00013         7,34         0.090           5100         NC         1,41         0.0002         0.00013         1,43         0.00024           73000         NC         1,41         0.0002         0.00013         1,43         0.00024         0.00021           73000         NC         1,41         0.0002         0.00044         15,1         0.00024         0.00024           1800         1,47         0.0004         15,3         0.00044         0.00024         0.00024           1800         1,47         0.0004         15,4         0.00044         0.00044         0.00064           1800         1,47         0.0004         0.0002         0.00044         0.00064         0.00064         0.00064           1800         1,47         0.00064         1,43         0.00064         0.00064         0.00064         0.00064         0.00064         0.00064         0.00064         0.00064         0.00064         0.00064         0.00064         0.00064         0.00064 <td>(pd/pm) spanoamoj circural</td> <td></td>	(pd/pm) spanoamoj circural											
Stock	Aluminum. Total	,		12600			16400		•	18200		
370000         NC         48.4         000013         72.6         000020           7900         C         16.1         0.0020         0.0013         1.05         0.0020           7900         C         16.1         0.0020         0.0012         1.0002         0.0021           7300         NC         16.1         0.0020         0.0002         0.0002         0.0002           1800         1.400         0.0002         0.0002         0.0002         0.0002         0.0002           1800         1.400         0.0002         0.0002         0.0002         0.0002         0.0002           2300         NC         0.000         0.0002         0.0002         0.0002         0.0002           1500         NC         0.000         0.0002         0.0002         0.0002         0.0002           1500         NC         0.000         0.0002         0.0002         0.0002         0.0002           1500         NC         0.000         0.0002         0.0001         0.0002         0.0002           1500         NC         0.000         0.0002         0.0001         0.0002         0.0001           1500         NC         0.0004         0	Arsenic, Total	82	O	4.76	0.058		7.34	0.090		5.35	0.065	
5100         NC         0.6644         . 000013         1,165         . 000021           73000         C         16,1         0.0020         . 16,1         0.00064         . 000064           73000         NC         14,18         0.00020         . 16,1         0.00064         . 000064           1800         NC         14,10         . 0.0006         . 16,1         . 0.00064         . 0.00064           1800         . 34,4         . 0.0006         . 0.0006         . 0.0006         . 0.00064         . 0.00064           1800	Barium, Total	370000	NC	48.4		0.00013	72.6		0.00020	56.6	,	0.00015
7900         C         15.70         .         4330         . <th< td=""><td>Beryllium, Total</td><td>5100</td><td>NC</td><td>0.684</td><td></td><td>0.00013</td><td>1.05</td><td></td><td>0.00021</td><td>0.895</td><td>,</td><td>0.00018</td></th<>	Beryllium, Total	5100	NC	0.684		0.00013	1.05		0.00021	0.895	,	0.00018
7900         C         14.8         0.0020         18.9         0.0024           23000         NC         14.8         0.0020         14.8         0.0066           1800         18.7         0.0060         0.0052         14.3         0.0066           1800         18.7         0.06         0.00021         0.012         0.001           290         NC         22.4         0.00021         23.7         0.00041           44000         NC         22.4         0.00015         23.7         0.00068           1500         NC         22.4         0.00015         23.7         0.00068           1500         NC         22.4         0.00016         1.46         0.00068           200         NC         22.4         0.00016         1.46         0.00068           200         NC         0.00069         23.9         0.00016         1.00           200         NC         0.00663         0.00016         1.00         0.0017           200         NC         0.00683         0.00000         1.00         0.00000           200         NC         0.00683         0.000000         0.00000           200         NC <td>Calcium, Total</td> <td>3.</td> <td></td> <td>73700</td> <td></td> <td>•</td> <td>43300</td> <td>•</td> <td>•</td> <td>43400</td> <td>,</td> <td></td>	Calcium, Total	3.		73700		•	43300	•	•	43400	,	
23000         NC         14.8         0.00064         15.1         0.00066           1800         -         30800         -         1420         -         0.0007         -         0.001           1800         -         14700         -         0.052         1453         -         0.001           1800         -         14700         -         0.00021         0.052         1627         -         0.001           220         NC         0.06         -         0.00051         0.0007         0.0004	Chromium, Total	7900	O	16.1	0.0020		18.9	0.0024	•	20.5	0.0026	
1800   1.0   1877   1878   1.0   1	Cobalt, Total	23000	NC	14.8		0.00064	15.1		0.00066	16.2		0.00070
1800   1800	Copper, Total			18.7			25.8			23.4		
1800   1800	Iron, Total			30600			31200		•	35300		
290         NC         620         6.00         6.77         6.70         6.00           290         NC         0.06         0.006         23.7         0.0004         0.006           44000         NC         180         0.006         0.006         0.006         0.0004         0.0004           15000         NC         1.24         0.0001         0.006         0.006         0.0004         0.0004           230         NC         1.98         0.0000         0.006         0.006         0.006         0.0004           230         NC         0.024         0.0000         0.000         0.001         0.001           880000         NC         0.0241         0.0000         0.001         0.001         0.001           360         NC         0.0241         0.0000         0.014         0.0001         0.001         0.0001           360         NC         0.0241         0.017         0.0000         0.002         0.0000         0.0001           28000         NC         0.0462         0.001         0.0000         0.002         0.0000         0.002           28000         NC         0.0462         0.001         0.0000         0.	Lead, Total	1800		94.4		0.052	163		0.091	49.5	,	0.028
290         NC         620         .         620         .         000041         527         .         0 00041           44000         NC         216         .         0 00061         3320         .         0 00064           45000         NC         224         .         0 00015         0.681         .         0 000045           1500         NC         224         .         0 00015         0.681         .         0 000045           2500         NC         198         .         .         0 00015         .         .         0 000045           2500         NC         108         .	Magnesium, Total			14700			9410			9110	,	
290         NC         0.06         -         0.00061         29.7         -         0.00061           44000         NC         1860         -         0.00061         29.7         -         0.00068           15000         NC         1860         -         0.0015         0.681         -         0.00068           230         NC         20.3         -         0.0015         1.88         -         0.00040           230         NC         20.3         -         0.0017         1.00         -         0.0011           280         NC         20.3         -         0.00069         28.9         -         0.0011           280         NC         0.0241         -         0.00069         28.9         -         0.0011           280         NC         0.0241         -         0.00001         2.89         -         0.0011           280         NC         0.0241         -         0.000018         0.0145         -         0.0011           280         NC         0.0452         -         0.000018         0.0145         -         0.000018           280         NC         0.0452         -         0.00001	Manganese, Total			620			527			529		
4000         NC         27         -         0 000061         29,7         -         0 000068           1500         NC         2.24         -         0 00015         3320         -         0 000045           230         NC         2.24         -         0 00016         28,9         -         0 000045           230         NC         20,9         -         0 000010         28,9         -         0 00011           28000         NC         20,9         -         0 000010         28,9         -         0 00011           880000         NC         20,9         -         0 000010         28,9         -         0 00011           360         NC         20,9         -         0 00000         28,9         -         0 00011           360         NC         0,00241         -         0 000000         28,9         -         0 00011           360         NC         0,00241         -         0 000000         28,9         -         0 00011           360         NC         0,00241         -         0 000000         0 00000         -         0 000000           28000         NC         0,00341         0 0011	Mercury, Total	290	N	90.0	•	0.00021	0.12		0.00041	6200		0.00027
15000   NC   2.24	Nickel, Total	44000	S	27	٠	0.00061	29.7		0.00068	28.4		0.00065
15000   NC   2.24   .   0.00015   0.681   .   0.00045   NC   198   .     146   .     146   .     150   .     146   .       150   .     146   .       146   .         146   .	Potassium, Total			1860			3320			3600		
230         NC (2.36)         NO (2.36)         146         1           26000         NC         20.9         0.00000         28.9         0.00011           26000         NC         0.0241         0.00000         28.9         0.00011           360         NC         0.00653         0.00000         0.0015         0.00003           360         NC         0.00653         0.00000         0.0015         0.00003           28000         NC         0.00653         0.0000         0.00003         0.00003           28000         NC         0.0407         0.000000         0.00003         0.00003           28000         NC         0.0407         0.000003         0.00003         0.00003           77         C         0.0364         0.011         0.226         0.00003           77         C         0.0739         0.0010         0.228         0.00003           770         C         0.0841         0.00003         0.017         0.00003           770         C         0.0441         0.00003         0.0000         0.0000           77         C         0.0441         0.000003         0.0000         0.0000           <	Selenium, Total	15000	NC	2.24		0.00015	0.681		0.000045	ND (2.18)	,	
230         ND (236)	Sodium, Total			198			146	•		233	,	,
26000         NC         20.9         -         0 00000         28.9         -         0 00011           880000         NC         88.1         -         0 00000         100         -         0 00011           360         NC         0.00643         -         0 000018         0.0145         -         0 000032           360         NC         0.0367         -         0 0000018         0.0146         -         0 0000033           28000         NC         0.0367         -         0 0000004         0.00653         -         0 0000033           28000         NC         0.0366         0.0012         -         0 00000034         -         0 00000031           77         C         0.0366         0.0011         -         0.0000034         -         0 0000034           77         C         0.0373         -         0.0000026         0.027         -         0.0000034           77         C         0.0368         0.00001         -         0.000034         -         0.000034           77         C         0.0478         0.000038         -         0.000034         -         0.0000034           77         C <td< td=""><td>Thallium, Total</td><td>230</td><td></td><td>ND (2.36)</td><td></td><td></td><td>ND (2.2)</td><td></td><td></td><td>ND (2.18)</td><td></td><td></td></td<>	Thallium, Total	230		ND (2.36)			ND (2.2)			ND (2.18)		
880000         NC         88.1         -         0 00010         100         -         0 00011           360         NC         0,00653         -         0 000016         0,0145         -         0 000032           360         NC         0,00653         -         0 0000016         0,0145         -         0 0000032           28000         NC         0,0467         -         0 00000066         0,0243         -         0 0000033           28000         NC         0,107         -         0 00000036         0 000659         -         0 00000031           28000         NC         0,107         -         0 00000034         -         0 00000031           77         C         0,0739         0 0011         -         0 000003         0 000003           77         C         0,0739         0 0010         -         0 000003         0 000003           770         C         0,082         0 0000081         -         0 000003         0 000003           77         C         0,0441         -         0 0000018         -         0 000003           77         C         0,0441         -         0 0000012         0 000001	Vanadium, Total	26000	NC	20.9	٠	0.00080	28.9		0.0011	36.7		0.0014
350         NC         0,0043         -         0,000058         0,0115         -         0,000038           360         NC         0,0367         -         0,0000066         0,0413         -         0,0000043           26000         NC         0,0462         -         0,00000066         0,0424         -         0,00000034           28000         NC         0,0462         -         0,00000024         0,0243         -         0,00000034           77         C         0,0966         0,001         -         0,00000024         0,0293         -         0,00000034           77         C         0,0739         0,001         -         0,0000026         0,219         0,0029           770         C         0,0739         0         0,0000026         0,177         0,0029         0           770         C         0,0739         0         0         0,0000026         0,177         0         0           770         C         0,0739         0         0         0         0         0           770         C         0,0746         0         0         0         0         0         0           777	Zinc, Total	880000	S	88.1		0.00010	100		0.00011	98.3	,	0.00011
360         NC         0,0241         -         0,000057         0,0145         -         0,000032         0           580         NC         0,00653         -         0,00000068         0,0146         -         0,0000038         0,0000038           58000         NC         0,017         -         0,00000068         0,0045         -         0,00000033           28000         NC         0,0482         -         0,00000024         0,0243         -         0,00000033           77         C         0,0364         0,011         -         0,0000026         0,239         0,0000033           770         C         0,0739         0,001         -         0,0000026         0,177         0,0000033           770         C         0,0739         0,001         -         0,0000026         0,177         0,000003           77         C         0,0176         0,000031         -         0,000003         -         0,000003           77         C         0,0176         0,00003         -         0,000003         0,00003         -         0,000003           77         C         0,0176         0,000003         -         0,000003         -	Semi-Volatile Organic Compounds (SIM) (mg/kg)											
360         NC         0,00653         - 0,0000018         0,0136         - 0,0038         - 0,0000038         - 0,0000038         - 0,0000038         - 0,0000038         - 0,0000038         - 0,0000038         - 0,0000033         - 0,0000033         - 0,0000033         - 0,00000033         - 0,0000033         - 0,0000033         - 0,0000033         - 0,0000033         - 0,0000033         - 0,0000033         - 0,0000033         - 0,00000033         - 0,00000033         - 0,0000033         - 0,0	1-Methylnaphthalene	360	NC	0.0241		0.000067	0.0115		0.000032	0.00847	,	0.000024
55000         NC         0,0367         0,00000066         0,0243         0,0000043           280000         NC         0,107         0,0000038         0,00859         0,0000031           280000         NC         0,0062         0,0012         0,0092         0,0095           77         C         0,0044         0,011         0,229         0,0027           77         C         0,0739         0,017         0,000         0,073           77         C         0,0739         0,017         0,000         0,073           70         C         0,0739         0,000         0,177         0,000           70         C         0,0739         0,000         0,177         0,000           70         C         0,0739         0,000         0,177         0,000           77         C         0,0176         0,000         0,000         0,000           77         C         0,0441         0,000         0,0486         0,000           77         C         0,0441         0,000         0,000         0,000           77         C         0,0441         0,000         0,000         0,000           28000 <td< td=""><td>2-Methylnaphthalene</td><td>360</td><td>NC</td><td>0.00653</td><td>•</td><td>0.000018</td><td>0.0136</td><td></td><td>0.000038</td><td>0.0106</td><td>•</td><td>0.000029</td></td<>	2-Methylnaphthalene	360	NC	0.00653	•	0.000018	0.0136		0.000038	0.0106	•	0.000029
28000         NC         0.077         0.0000034         0.00859         0.0000031           rene         76         C         0.0847         0.0011         0.0000024         0.0285         0.0000033           rene         77         C         0.0947         0.0011         0.028         0.0035         0.0000033           rene         77         C         0.0739         0.0010         0.178         0.0029         0.0029           rene         77         C         0.0739         0.0000         0.178         0.0029         0.0029           rene         770         C         0.0739         0.00001         0.26         0.00001         0.26         0.00003           rene         770         C         0.062         0.00001         0.026         0.00003         0.00003           rene         77         C         0.016         0.0003         0.00003         0.00003         0.00003           rene         77         C         0.0176         0.0003         0.00003         0.00003         0.00003           rene         77         C         0.0443         0.00003         0.00003         0.00000           rene         0.0450         <	Acenaphthene	26000	NC	0.0367		0.00000066	0.0243		0.00000043	0.0346	•	0.00000062
permission         NC         0.0682         0.0000024         0.0923         0.0000033           free         C         0.0684         0.0012         0.268         0.0029         0.027           vrene         77         C         0.0739         0.0010         0.029         0.027           vrene         77         C         0.0739         0.0010         0.029         0.027           vrene         77         C         0.0739         0.0010         0.0226         0.0029           vranthene         770         C         0.088         0.00011         0.178         0.00003           vranthene         77         C         0.088         0.00001         0.178         0.00003           vranthracene         77         C         0.045         0.00001         0.045         0.0000           rel         37000         NC         0.044         0.00000         0.045         0.0000           rel         150         C         0.047         0.0000         0.000         0.000           rel         150         C         0.047         0.0000         0.000         0.001           rel         150         C         0.047	Acenaphthylene	28000	NC	0.107		0.0000038	0.00859		0.00000031	0.0173		0.00000062
Tright         C         0.0906         0.0012         -         0.268         0.0335         -           Tright         C         0.0739         0.0714         -         0.225         0.0237         -           Iperylene         Tright         C         0.0739         0.0014         -         0.268         0.0000           Iperylene         Tright         C         0.0808         0.0001         -         0.177         0.0000           Iperylene         Tright         C         0.0808         0.0001         -         0.268         0.0000           Iperylene         Tright         C         0.0808         0.0001         -         0.268         0.0000           Iperylene         Tright         C         0.0808         0.0001         -         0.060         0.0000           Iperylene         Tright         Iperylene	Anthracene	280000	NC	0.0682		0.00000024	0.0923		0.00000033	0.101		0.00000036
year         77         C         0.0341         0.011         -         0.209         0.027           Jperylene         77         C         0.0739         0.0010         -         0.225         0.0029         -           Jperylene         28000         NC         0.0739         0.0010         -         0.225         0.00003           Jordalprine         77         C         0.076         0.00001         -         0.046         0.00003           Janthracene         77         C         0.0476         0.0003         -         0.0465         0.0000           Jack         150         C         0.0441         -         0.00001         0.025         0.0000           Jack         150         C         0.0441         -         0.0000         0.000         0.0000           Jack         150         C         0.0478         0.0000         0.000         0.000         0.000           Jack         150         C         0.0478         0.0000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000 </td <td>Benzo(a)anthracene</td> <td>92</td> <td>ပ</td> <td>9060.0</td> <td>0.0012</td> <td>(0.0)</td> <td>0.268</td> <td>0.0035</td> <td>•</td> <td>0.342</td> <td>0.0045</td> <td>•</td>	Benzo(a)anthracene	92	ပ	9060.0	0.0012	(0.0)	0.268	0.0035	•	0.342	0.0045	•
voranthene         77         C         0.0739         0.0010         -         0.225         0.0029           /jberylene         28000         NC         0.0739         0.0010         -         0.177         -         0.000063           /jberylene         770         C         0.082         0.000031         -         0.178         0.00003           // road planthracene         77         C         0.086         0.00001         -         0.0465         0.0060           // road planthracene         77         C         0.0476         0.00001         0.0000         0.0000           // road planthracene         77         C         0.0478         0.00005         0.023         0.0015           // road planthracene         77         C         0.0478         0.00005         0.0000         0.0016           // road planthracene         150         C         0.0478         0.00005         -         0.015         -           // road planthracene         150         C         0.0478         0.00005         -         0.015         -           // road planthracene         150         C         0.0478         -         0.00005         -         0.0015         - </td <td>Benzo(a)pyrene</td> <td>7.7</td> <td>O</td> <td>0.0841</td> <td>0.011</td> <td></td> <td>0.209</td> <td>0.027</td> <td></td> <td>0.313</td> <td>0.041</td> <td></td>	Benzo(a)pyrene	7.7	O	0.0841	0.011		0.209	0.027		0.313	0.041	
Decylene   170	Benzo(b)fluoranthene	77	O	0.0739	0.0010		0.225	0.0029		0.307	0.0040	
Loranthene         770         C         0.0828         0.000031         -         0.78         0.000033         -           Janthracene         7,7         C         0.0176         0.0017         0.00003         0.0060         0.0060           Ine         7,7         C         0.0176         0.0000         0.0000         0.0060         0.0060           Ine         7,7         C         0.044         0.0000         0.0000         0.0000           Ine         77         C         0.0478         0.0000         0.0001         0.0016           Ine         150         C         0.0478         0.00015         0.0016         0.0016           Ine         28000         NC         0.198         0.000064         0.000091         0.00019	Benzo(g,h,i)perylene	28000	NC	0.0739		0.0000026	0.177		0.0000063	0.305	. !	0.000011
Nanthracene         7600         C         0.0368         0.000011         -         0.26         0.000034           Individual cone         77         C         0.0476         0.0033         -         0.0465         0.0060           37000         NC         0.041         -         0.000012         0.025         -         0.000013           150         C         0.022         0.0015         -         0.015         -         0.0016           ne         28000         NC         0.198         -         0.000071         0.0015         -           28000         NC         0.178         -         0.000064         0.000017         -         0.00016           28000         NC         0.178         -         0.000064         0.000017         -         0.00019	Benzo(k)fluoranthene	270	O ·	0.062	0.000081		0.178	0.00023		0.253	0.00033	
7.7 C 0.0476 0.0023 0.000068 0.0486 0.00601 0.000013 0.00601 0.000013 0.00601 0.00601 0.000013 0.00601 0.00601 0.000013 0.000013 0.00014 0.000012 0.00015 0.00016 0.00016 0.00016 0.00016 0.00016 0.00016 0.00016 0.00017 0.00017 0.00017 0.00017 0.00017 0.00017 0.00017 0.00017 0.000017 0.00017 0.000017	Chrysene	1600	U ·	0.0808	0.000011		0.26	0.000034		0.325	0.000043	
37000 NC 0,213 - 0,0000058 0,486 - 0,0000077	Dibenz(a,h)anthracene	7.7	O	0.0176	0.0023		0.0465	0.0060		0.0717	0.0093	
37000 NC 0.0441 - 0.0000012 0.025 - 0.0000017 0.025 - 0.00000017 0.025 - 0.0000017 0.025 - 0.0000017 0.025 - 0.0000017 0.025 - 0.0000017 0.025 - 0.0000017 0.025 - 0.0000017 0.025 - 0.0000017 0.025 - 0.0000017 0.025 - 0.0000017 0.025 - 0.0000017 0.025 - 0.0000017 0.025 - 0.00001	Fluoranthene	37000	S S	0.213		0.0000058	0.486		0.000013	0.718		9100000
77 C 0.0478 0.00052 - 0.171 0.0015 28000 NC 0.188 - 0.0000571 0.327 0.00012 28000 NC 0.198 - 0.0000064 0.541 - 0.000019	Fluorene	37000	NC P	0.0441		0.0000012	0.025		0.000000	0.0272		0.00000074
150 C. 0.198 C. 0.0000071 0.327 7.72-03 0.000012 2.80000 NC 0.179 C. 0.0000064 0.541 0.000019	Indeno(1,2,3-cd)pyrene	77	U (	0.0478	0.00062		0.121	0.0016		0.193	0.0025	
28000 NC 0.179 - 0.0000064 0.541 - 0.000019	Naphthalene	051	و د	0.022	0.00015	***************************************	577.0	/./E-05		0.0152	0.000.0	
	Phenanthrene	28000	2 5	0.130		0.00000	0.527		0.000012	0.557		0 000023
	Pyrene	70007	2			10000000				,,,,	ts.	0.000

Haley & Aldrich. Inc. G:PROJECTS/39047 - Duke EEGW PH IIs/Remedial Alts Analysis/Appendix A - DCI East Risk Calcs/2014-0630-HAI-Analytical\_SO\_KeckSI\_VAPCommercial 0-15-D xisx 0-2

TABLE A-1 MICA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 2 FEET AREA WEST OF THE WEST PARCEL DUKE ENERGY CINCINNATI, OHIO

Location Name			SB-K02	Risk Ratio (SB-K02)	(SB-K02)	SB-K04	Risk Ratio (SB-K04)	(SB-K04)	SB-K07	Risk Ratio	Risk Ratio (SB-K07)
Sample Date		Standard Basis	7/29/2011			8/1/2011			8/2/2011		
Sample Type	VAP	Cancer or Non-	z		3	z			z		
Sample Depth (bgs)	Commercial	Cancer (C or NC)	0 - 2 (ft)	Cancer	Non-Cancer	0 - 2 (ft)	Cancer	Non-Cancer	0 - 2 (ft)	Cancer	Non-Cancer
Volatile Organic Compounds (mg/kg)											
1,2,4-Trimethylbenzene	120	S	ND (0.00257)			ND (0.0021)			ND (0.00196)		
1,3,5-Trimethylbenzene	92	S	ND (0.00257)			0.00107		0.000011	ND (0.00196)		
2-Butanone (Methyl Ethyl Ketone)	100000	S	ND (0.0642)			ND (0.0524)			0.00701		0.000000000
Acetone	100000	S	0.0589	,	0.00000059	0.0477		0.00000048	0.0445		0.00000045
Benzene	140	ပ	0.00442	3.2E-05		0.00354	2.5E-05		0.00405	2.9E-05	
Carbon disulfide	1400	S	0.00697		0.0000000	0.00506		0.0000036	0.00878		0.0000063
Cymene (p-Isopropyltoluene)			ND (0.00257)			ND (0.0021)	ï		0.00303		
Ethylbenzene	230	S	0.00155		0.0000067	0.00128		0.0000056	0.0017		0.0000074
Tetrachloroethene	53	O	0.0014	2.6E-05		ND (0.0021)			ND (0.00196)		
Toluene	520	S	0.00565		1.1E-05	0.00442		0.0000085	0.00519		0.000010
Xylene (total)	370	NC	0.00297	,	8.0E-06	0.00223		0.0000000	0.00223		0.0000000
		Total Risk	SB-K02	920.0	0.055	SB-K04	0.13	0.094	SB-K07	0.13	0.031

Notes and Abbreviations:

1. Values from AAC 374-300-08(C)(3) (Current rules. April 18, 2013) and CIDARS data base (downloaded June 6, 2013) for constituents not published in Rule 08.

Value for pyrane used as a surrogate for acenaphthylene, phenanthrene, and benzo(g.h.)penylene.

Value for pyrane used sea surrogate for calculations are for total chromium.

C. Standard is based on a non-cancer risk of 1E-06.

N.C. Standard is based on a non-cancer rest of 1E-06.

N.C. Standard is based on a non-cancer hazard index of 1.

S. Risk ratio activated as EPC IVAP standard.

S. Risk ratio activated as EPC IVAP standard.

S. Results in bold are detected above the laboratory reporting limit.

TABLE A-1 MCA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 2 FEET AREA WEST OF THE WEST PARCEL DIDIKE ENERGY CINCINNATI, OHIO

	Location Name			SB-K08	Kisk Katio	Risk Ratio (SB-R08 N)	SB-K08	KISK Katio	KISK Katio (SB-K08 FD)
	Sample Date		Standard Basis	8/3/2011			8/3/2011		
	Sample Type	VAP	Cancer or Non-	z			9		
		Commercial	Cancer (C or NC)	0 - 2 (ft)	Cancer	Non-Cancer	0 - 2 (ft)	Cancer	Non-Cancer
norganic Compounds (mg/kg)									
Aluminum, Total				16700			14200		
Arsenic, Total		82	ပ	8.55	0.10		7.19	0.088	
Barium, Total		370000	SC	80.2		0.00022	87.8	,	0.00024
Beryllium, Total		5100	NC	0.905		0.00018	0.746	•	0.00015
Calcium, Total				39400			45500	,	
Chromium. Total		7900	O	18.9	0.0024		16.6	0.0021	
Cobalt Total		23000	S	15.2		0.00066	12.5		0.00054
Copper Total			! .	22.1	,		20.6		
Copper, 1 cos				35000	•	,	28700		
1011, 10121		1800		40.4		7000	65.2		0.036
Lead, I otal		000		1130		0.02	44200		9
Magnesium, Total				0011			0001		
Manganese, Total		,		265			512		
Mercury, Total		290	S	0.14		0.00048	0.099		0.00034
Nickel, Total		44000	NC	25.8		0.00059	21.2		0.00048
Potassium, Total				2570			2350		
Selenium, Total		15000	NC	ND (2.21)			ND (2.19)		
Sodium Total				156			150	,	
Thallium Total		230		ND (2.21)			ND (2.19)		
Vanadium Total		26000	CZ	29.5	,	0 0011	27.9		0.0011
Zinc Total		88000	O C	108		0.00012	112		0.00013
Semi-Volatile Organic Compounds (SIM) (mg/kg)	ds (SIM) (mg/kg)								
1-Methylnaphthalene		360	NC	0.0239		0.0000664	0.0184		0.000051
2-Methylnaphthalene		360	NC	0.0307		0.0000853	0.0221		0.000061
Acenaphthene		56000	NC	0.0931		0.0000017	0.185		0.0000033
Acenaphthylene		28000	NC	0.0333		0.0000012	0.0685	,	0.0000024
Anthracene		280000	NC	0.322		0.0000012	1.35		0.0000048
Benzo(a)anthracene		76	ပ	1.08	0.014		3.66	0.048	
Benzo(a)pyrene		7.7	ပ	0.897	0.12		2.68	0.35	
Benzo(b)fluoranthene		77	O	0.916	0.012		2.65	0.034	
Benzo(g,h,i)perylene		28000	SC	0.677		0.000024	1.69		0.000060
Benzo(k)fluoranthene		770	O	0.699	0.00091		2.03	0.0026	
Chrysene		7600	ပ	0.886	0.00012	,	2.61	0.00034	
Dibenz(a,h)anthracene		7.7	O	0.142	0.018		0.511	0.066	
Fluoranthene		37000	NC	2.21		0.0000597	6.26		0.00017
Fluorene		37000	NC	0.114		0.0000031	0.238		0.0000064
Indeno(1,2,3-cd)pvrene		77	U	0.486	0.0063	,	1.39	0.018	
Naphthalene		150	O	0.0613	0.00041	,	0.0302	0.00020	
Phenanthrene		28000	NC	1.39		0.000050	3.26		0.00012
Director		28000	C	1 97		0,00000	5.2	,	0.00019
TO THE PARTY OF TH		70007	) .	10.1		0.00000	4.0		2.000.0

Haley & Aldrich. Inc G:IPROJECTS/39047 - Duke EEGW PH IIs/Remedial Alts Analysis/Appendix A - DCI East Risk Calcs/2014-0630-HAI-Analytical\_SO\_KeckSI\_VAPCommercial 0-15-D xisx-0-2

TABLE A-1 MCA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 2 FEET AREA WEST OF THE WEST PARCEL DUKE ENERGY CINCINNATI, OHIO

Location Name			SB-K08	KISK Katic	Risk Ratio (SB-K08 N)	SB-K08	Risk Ratio	Risk Ratio (SB-K08 FD)
Sample Date		Standard Basis	8/3/2011			8/3/2011		
Sample Type	VAP	Cancer or Non-	z			5		
Sample Depth (bgs)	Commercial	Cancer (C or NC)	0 - 2 (ft)	Cancer	Non-Cancer	0 - 2 (ft)	Cancer	Non-Cancer
Volatile Organic Compounds (mg/kg)								
1,2,4-Trimethylbenzene	120	S	0.00152		0.000013	0.00162		0.000014
1,3,5-Trimethylbenzene	92	SC	ND (0.00207)			ND (0.00242)		
2-Butanone (Methyl Ethyl Ketone)	100000	NC	0.0179		0.00000018	ND (0.0605)		
Acetone	100000	SC	0.0784		0.00000078	0.0524		0.0000005
Benzene	140	O	0.00622	4.4E-05		0.00685	4.9E-05	
Carbon disulfide	1400	S	0.0131			0.0222		0.000016
Cymene (p-Isopropyltoluene)			ND (0.00207)			ND (0.00242)		
Ethylbenzene	230	NC	0.00226		0.0000098	0.00206		0.00000
Tetrachloroethene	53	O	ND (0.00207)	,		ND (0.00242)		
Toluene	520	NC	0.00763		0.000015	0.00726		0.000014
Xylene (total)	370	NC	0.00393		0.000011	0.00418		0.000011
		Total Risk	SB-K08	0.28	0.031	SB-K08	0.61	0.040

Notes and Abbreviations:

1. Values from OAC 3745-300-08(C)(3) (Current rules: April 18, 2013) and ClDARS data base (c Value for preview used as a surrogate for acenaphthylene, phenanthrene, and benzo(g,h,i)peryler Value for 1-methylnaphthalene used for 2-methylnaphthalene
Value for 1-methylnaphthalene used for 2-methylnaphthalene
Value for hexavalent chromium used for 1E-05

NC - Standard is based on a cancer risk of 1E-05

NC - Standard is based on a non-cancer mazed index of 1

2. Risk ratio calculated as EPC VAP standard

3. Results in bold are detected above the laboratory reporting limit.

TABLE A-2 MCA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 15 FEET REA WEST OF THE WEST PARCEL DUKE ENERGY CINCINNATI, OHIO

	Location Name Sample Date		Standard Basis	SB-K01 7/28/2011	Risk Rati	Risk Ratio (SB-K01)	SB-K02 7/29/2011	Risk Rati	Risk Ratio (SB-K02)
	Sample Type Sample Depth (bgs)	VAP	Cancer or Non- Cancer (C or NC)	N 13 - 15 (ft)	Cancer	Non-Cancer	N 0 - 2 (ft)	Cancer	Non-Cancer
Inorganic Compounds (mg/kg)									
Aluminum, Total				15500			12600		,
Arsenic, Total		420	NC	5.22	,	0.012	4.76		0.011
Barium, Total		120000	NC	102	,	0.00085	48.4		0.00040
Beryllium, Total		3100	NC	0.933		0.00030	0.684	٠	0.00022
Calcium, Total				25700	•		73700		,
Chromium. Total		13000	O	20.8	0.0016		16.1	0.0012	,
Cobalt Total		4000	SN	6		0.0048	14.8		0 0037
Copper Total			2 .	34.4			18.7		,
Iron Total				39100			30600		
Lead Total		750	C	447		0 90	944		0 13
Monopolium Total		2	?	0530		9	00277		2
Manageresium, Total				6330			2004		
Managariese, lotal		00+	, CI	350	,	00000	070		660000
Mercury, Iolai		0610	200	0.00	,	0.0029	0.00		0.00032
Nickel, Iotal		21000	S	37.1		8100.0	27		0.0013
Potassium, Total		. ;	. !	2370			1860		. !
Selenium, Total		9200	S	0.933		0.00010	2.24	r	0.00023
Sodium, Total				197	•		198		
Vanadium, Total		17000	NC	26.8	*	0.0016	20.9		0.0012
Zinc, Total		580000	NC	387	,	0.00067	88.1	٠	0.00015
Called Oranic Company (SIM) (mail	(SIM) (ma/kg)								
1 Mothydosophholoso	(Rushin) (min)	250	CIA	00000		*000000	*****		200000
1-metnyinaphthalene		360	S S	0.00293		0.000008	0.0241		0.000067
2-wellyllapilulaiene		2000	2 2	0.0033	,	0.00000000	0.00633		0.0000000
Aceraphinene		220000	2 2	0.00200		0.000000000	0.0367		0.00000000
Acenaphiniyiene		220000	2 2	0.0000	,	0.00000000	0.107		0.00000049
Anthracene		000001	<u>ک</u> ر	0.00628		0.0000000003	0.0682		0.000000000
Benzo(a)anthracene		089	ی د	0.0243	0.000036		0.0906	51000.0	
Benzo(a)pyrene		69	<b>U</b>	0.0243	0.00035		0.0841	0.0012	
Benzo(b)fluoranthene		069	O	0.0239	0.000035		0.0739	0.00011	
Benzo(g,h,i)perylene		220000	S	0.0264	,	0.00000012	0.0739		0.00000034
Benzo(k)fluoranthene		0069	O	0.0201	0.0000029		0.062	0.0000000	
Chrysene		00069	O	0.0268	0.00000039		0.0808	0.0000012	×
Dibenz(a,h)anthracene		69	O	0.00586	0.000085		0.0176	0.00026	,
Fluoranthene		290000	NC	0.0557		0.00000019	0.213		0.00000073
Fluorene		290000	SC	0.00251		0.00000000000	0.0441		0.00000015
Indeno(1,2,3-cd)pyrene		069	ပ	0.0155	0.000022		0.0478	0.000069	
Naphthalene		84	NC	0.00335	,	0.000040	0.022	٠	0.00026
Phenanthrene		220000	NC	0.0331		0.00000015	0.198		0.00000000
Pyrene		220000	C	0 049		0.00000022	0.179		0.00000081
Fyrene		250000	7	0.040		0.000000026	0.1.0		0.0000000

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TABLE A.2
ACA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 15 FEET
AREA WEST OF THE WEST PARCEL
DUKE ENERGY
CINCINNATI, OHIO

Locati	ocation Name		SB-K01	Risk Rati	Risk Ratio (SB-K01)	SB-K02	Risk Ratio	Risk Ratio (SB-K02)
San		Standard Basis	7/28/2011			7/29/2011		
San			Z	3	and and a	Z	,	Mon Cancer
Sample Depth (bgs)	eptn (pgs) Construction	Cancer (Cor NC)	(11) (2) - (2)	Caricei	NOII-CALICE	0 - 2 (11)	Californ	MOILCAILCE
(olatile Organic Compounds (mg/kg)								
1,2,4-Trimethylbenzene	35	S	ND (0.00214)		,	ND (0.00257)		•
.3.5-Trimethylbenzene	200	S	ND (0.00214)			ND (0.00257)	,	
2-Butanone (Methyl Ethyl Ketone)	15000	NO	0.013	,	0.00000087	ND (0.0642)		
Acetone	100000	NC	0.0822		0.00000082	0.0589	*	0.00000059
Benzene	150	NC	0.00171		0.000011	0.00442		0.000029
Bromobenzene			ND (0.00214)			ND (0.00257)		
Carbon disulfide	190	SC	0.0011		0.0000058	0.00697	,	0.000037
Symene (p-Isopropyltoluene)			ND (0.00214)		,	ND (0.00257)		
Ethylbenzene	230	NC	ND (0.00214)			0.00155		0.0000067
lexane	190	S	0.00975	٠	0.000051		,	
sopropylbenzene	260	S	ND (0.00214)			ND (0.00257)	,	٠
Vaphthalene	84	S	ND (0.00536)		,	ND (0.00642)		
etrachloroethene	220	U	ND (0.00214)			0.0014	0.0000064	
roluene	520	NO	0.0014	,	0.0000027	0.00565	,	0.000011
(ylene (total)	370	NO	ND (0.00536)	,		0.00297	•	0.0000080
		Total Rick	SB-K01	0.0021	0.62	SB-K02	0 0030	0.15

Notes and Abbreviations:

1. Values from OAC 3745-300-08(C)(3) (Current rules: April 18, 2013) and CIDARS data base (downloaded June 6, 2013) for constituents not published in Rule 08. Value for pre-availant careaphity-liberine, phenarithrene, and benzolg, hi)pery/ene.

Value for transvirus that a surgate for careaphity-liberine, phenarithrene, and benzolg, hi)pery/ene.

Value for transvirus phinalene used for dail chromium

C. Slandard is based on a concernisk of 12-05

NC. - Standard is based on a concernisk of 12-05

NC. - Standard is based on a non-cancer hazad rindex of 1

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S. NC - Standard is based on

TABLE A-2 MICA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 15 FEET AREA WEST OF THE WEST PARCEL DUKE ENERGY CINCINNATI, OHIO

	Location Name		SB-K02	Risk Ratio	o (SB-K02)	SB-K03	RISK KAIIO	Risk Ratio (SB-K03)	SB-K04	KISK Kali	Risk Ratio (SB-K02)	SB-K04	KISK Kal	KISK Katio (SB-K02)
	Sample Date Sample Type	VAP	7/29/2011 N		1	N N			N N			N		:
Sa	Sample Depth (bgs)	Construction	5 - 7 (ft)	Cancer	Non-Cancer	13 - 15 (ft)	Cancer	Non-Cancer	0 - 2 (ft)	Cancer	Non-Cancer	6 - 8 (ft)	Cancer	Non-Cancer
Compounds (ma/ka)														
Aluminum. Total			9810	,		15800			16400			10400		,
Arsenic Total		420	5.57		0.013	3.94		0.0094	7.34		0.017	7.17		0.017
Barring Total		120000	55.1	,	0.00046	50.1	,	0.00042	72.6		0.00061	71.3		0.00059
Beryllim Total		3100	0.542		0.00017	0.867	٠	0.00028	1.05		0.00034	0.528	٠	0.00017
Calcium Total			79200			26500			43300			89100		
Cardoni, Coai		13000	12.1	0 00093		20	0.0015		18.9	0.0015		11.8	0.00091	
Chall Total		4000	10.5		0.0026	17.9		0.0045	15.1		0.0038	8.8		0.0022
Coodil, Iolai			25.6			23.7			25.8			25.9		,
Copper, lotal			23000			35800			31200			22000	٠	
Iron, lotal		750	2000		0.038	442		0 15	163		0.22	87.9		0.12
Lead, lotal		00.7	5.07		0.00	71.0		2	200			19200		
Magnesium, Total			21200			0018			01 46			2076		
Manganese, Total			610	,		534	٠	. !	527			400		, 00
Mercury, Total		190	0.028	٠	0.00015	0.52	٠	0.0027	0.12		0.00063	0.15		0.00079
Nickel Total		21000	17.9		0.00085	36.5		0.0017	29.7		0.0014	13.9		0.00066
Potassium Total			1790			2670			3320			1190		
Selection Total		9700	1.35		0.00014	1.71		0.00018	0.681		0.000000	ND (2.2)		,
Coding Total		,	208			199			146	٠		135	٠	
Sodium, Total		17000	23.8		0 0014	25.7	,	0.0015	28.9		0.0017	23.6		0.0014
Vanadium, Lotal		00000	20.0		10000	100		0,000	200		0 00017	71.7		0.00012
Zinc, Total		280000	2.59		11000.0	103	,	0.000.0	20		2000			1000
Semi-Volatile Organic Compounds (SIM) (mg/kg)	M) (mg/kg)		-								000000	2000		0,000,0
1-Methylnaphthalene		360	0.0105		0.000029	0.00572	*:	0.000016	0.0115		0.000032	0.0465	,	0.00013
2-Methylnaphthalene		360	0.0113		0.0000314	0.00245	*:	0.0000068	0.0136		0.000038	0.0645		0.00018
Acenaphthene		440000	0.0723	,	0.00000016	0.00939	**	0.000000021	0.0243		0.00000000	0.226	,	0.00000051
Acenaphthylene		220000	0.1		0.00000045	0.0139		0.000000063	0.00859	ř	0.000000039	0.179		0.000000081
Anthracene		1000000	0.328		0.00000033	0.0196		0.000000000	0.0923		600000000	0.974		0.0000010
Benzo(a)anthracene		680	1.78	0.0026		0.0327	0.000048		0.268	0.00039	,	6	0.0044	
Benzo(a)pyrene		69	1.89	0.027		0.0294	0.00043	,	0.209	0.0030		2.78	0.040	,
Benzo(b)fluoranthene		069	1.73	0.0025		0.0274	0.000040		0.225	0.00033		2.44	0.0035	,
Benzo(a.h.i)pervlene		220000	1.75		0.0000080	0.0274		0.00000012	0.177		0.000000000	2.55		0.000012
Benzo(k)fluoranthene		0069	1.35	0.00020		0.0237	0.0000034		0.178	2.6E-05	٠	2.27	0.00033	
Chysene		00069	1.6	0.000023		0.0314	0.00000046		0.26	3.8E-06		2.67	0.000039	
Dibenz(a hlanthracene		69	0.404	0.0059		ND (0.00408)			0.0465	6.7E-04		0.602	0.0087	
Flioranthone		290000	3.42		0.000012	0.0715		0.00000025	0.486		0.0000017	5.88		0.000020
Fliorage		290000	0.064		0.00000022	0.0131		0.000000045	0.025		0.000000086	0.283	,	0.0000010
Indens/1 2 3-rd/payrene		690	1 14	0.0017		0.0172	0.000025		0.121	0.00018		1.67	0.0024	
Naphthalane		84	0.0226		0 00027	0,00653		0.000078	0.0115		0.00014	0.15	,	0.00179
Naprinialerie		220000	0 8 0		0 0000041	0.0649		0.0000030	0.327		0 0000015	2.75		0.000013
Friendrimene		220000	0.00		200000	2000		80000000	0 544		2000000	2 18		0 000033
		2222222	7.4.7		0.000016	0.0625		D DAMANAZA	40.0		TO THE REAL PROPERTY.			1. 27 11 11 11 11

TABLE A-2
AGA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 15 FEET
AREA WEST OF THE WEST PARCEL
DUKE ENERGY
GINCINNATI, OHIO

	Location Name		SB-K02	Risk Ratio	(SB-K02)	SB-K03	Risk Ratit	Risk Ratio (SB-K03)	SB-K04	Risk Ratio	Risk Ratio (SB-K02)	SB-K04	KISK Kat	KISK Katio (SB-KUZ)
	Sample Date		7/29/2011			7/29/2011			8/1/2011			1107/1/0		
	Sample Type	VAP	z			z			z			2 0		
Samp		Construction	5 - 7 (ft)	Cancer	Non-Cancer	13 - 15 (ft)	Cancer	Non-Cancer	0 - 2 (ft)	Cancer	Non-Cancer	6 - 8 (II)	Cancer	Non-Cancer
Volatile Organic Compounds (mg/kg)						Control Control Control Control						101000000000000000000000000000000000000		
1.2 4-Trimethylbenzene		35	ND (0.00164)	,		ND (0.00202)	٠		ND (0.0021)			ND (0.00219)		
3 & Trimethylhenzene		200	ND (0.00164)			ND (0.00202)			0.00107		0.00000054	ND (0.00219)	٠	
State of the State of Contract of State		000	NO 00 0411)			ND 00 05051		,	ND (0.0524)			ND (0.0549)		
2-Butanone (Methyl Ethyl Netone)		0000	(1) (0:04) (N		0000000	(2000)			0.0477		0 0000005	0.0377		0.00000038
Acetone		100000	0.0318		0.00000032	(c0c0.0) ON					***************************************	0 00544		0.000038
Benzene		150	0.00348		0.000023	0.00352		0.000023	0.00354		0.000024	0.00341		000000
Domoborzopo			ND (0.00164)	,		ND (0.00202)		,	ND (0.0021)			ND (0.00219)	٠	
Compose distribute		190	0.00126		0 0000066	ND (0.00505)			0.00506		0.000027	0.00737	٠	0.000039
annous models		3	(A3400 0) CIA			(CUCOU O) CIN			ND (0.0021)			ND (0.00219)		
Cymene (p-Isopropyitoluene)			ND (0.00164)			(0.00202)		0,00000	0 00428		0 0000058	0.0015	,	0.0000065
Ethylbenzene		230	0.00121		0.0000053	0.00113		0.0000049	0.00128		0.000000	0.00.0		0.000
Hoxano		190	0.0157		0.000083	0.0133	210	0.000070	,					
Adire		260	ND (0 00164)	,		ND (0.00202)		٠	ND (0.0021)			ND (0.00219)		,
Sopiopy Denzerie		2	0.00475		0.000021	ND (0.00505)			ND (0,00524)	•		ND (0.00549)		,
Naphinalene		***	0.0000	0000000	2000	(COCOO O) CIN			ND (0,0021)			ND (0.00219)		,
Tetrachloroethene		077	0.000658	0.000000		(0.0020Z)		000000	0.00112		30000000	0.00542		01000010
Toluene		520	0.00417	,	0.0000080	0.00382		0.0000073	0.00442		0.0000083	7.0000		000000
Xylene (total)		370	0.00211		0.0000057	ND (0.00505)			0.00223		0.0000060	0.00244		0.0000066
											-	107.00	.000	
			0000	*****	0.000	007 00	10000	0 17	SPIKON	0 0061	0.24	SH-KO4	000	0.14

Notes and Abbreviations:

1. Values from OAC 3745-300-08(C)(3) (Current rules: April 16, 2013) and C Values from OAC 3745-300-08(C)(3) (Current rules: April 16, 2013) and C Value for typrene used as a surrogate for acenaphylaphylane, phenarthrene, an Value for hexavalent chromium used for total chromium C - Standard is based on a cancert risk of 1E-05 NC - Standard is based on a non-cancer hazard index of 1

2. Risk ratio calculated as EPC / VAP standard

3. ND (#) Result is not detected above the indicated reporting limit.

4. Results in bold are detected above the laboratory reporting limit.

5. ".". Indicates information not available or analysis not performed.

TABLE A-2 MCA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 15 FEET AREA WEST OF THE WEST PARCEL DUKE ENERGY CINCINNATI, OHIO

Sample Depth (bgs)   Construction   Sample Depth (bgs)   Construction   Constru	Cancer 0 0016	Non-Cancer 0.013 0.00047 0.00029 0.0041	9 - 10 (ft) 11400 15.8 140	Cancer	Non-Cancer	0 - 2 (ft)	0	Non-Cancer	FD		Tools of the second
(bgs) Construction 420 (120000 3100 3100 3100 40000 40000 40000 5500000 550000 550000 550000 550000 550000 550000 550000 550000 5500000 550000 550000 550000 550000 550000 550000 550000 550000 5500000 550000 550000 550000 550000 550000 550000 550000 550000 5500000 550000 550000 550000 550000 550000 550000 550000 550000 5500000 550000 550000 550000 550000 550000 550000 550000 550000 5500000 550000 550000 550000 550000 550000 550000 550000 550000 55000000	Cander	0.013 0.013 0.00029 0.00041 0.0041	11400 15.8 140 170 170 170	Cancer	Non-Cancer	0-2(11)		- Calloci		Cancer	
420 120000 3100 13000 4000 13000 40000 1700 17000 17000 17000 17000 17000 17000 17000 17000 17000 17000 1700	0 00 0 00 16	0.013	11400 15.8 140				Carca		(1) - (1)		
420 120000 3100 13000 4000 1900 21000 1700	0 0016	0.0037	11400 15.8 140								
1420 13000 3100 13000 4000 4000 21000 9700 17000 580000 120000000 1200000 1200000 1200000 1200000 1200000 1200000 1200000 12000000 120000 1200000 120000 120000 120000 120000 120000 120000 120000 120000 1200000 120000 120000 120000 120000 120000 120000 120000 120000 1200000 120000 120000 120000 120000 120000 120000 120000 120000 1200000 120000 120000 120000 120000 120000 120000 120000 120000 1200000 120000 120000 120000 120000 120000 120000 120000 120000 1200000 1200000 120000 1200000 1200000 1200000 1200000 1200000 1200000 1200000 12	0 0000	0.00047	15.8 140 0.879			16700			14200		
170000 1300 1300 1300 1300 1500 1500 1500	0 00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0.00047	140		0.038	8.55		0.020	7.19		0.017
3100 13000 4000 1900 21000 21000 9700 1700 9700 17000 580000 12000000 1200000 1200000 1200000 1200000 1200000 1200000 12000000 1200000 1200000 1200000 1200000 1200000 1200000 12000000 1200000 1200000 1200000 1200000 1200000 1200000 12000000 1200000 1200000 1200000 1200000 1200000 1200000 12000000 1200000 1200000 1200000 1200000 1200000 1200000 120000000 1200000000 120000000000		0.0066	0.879	٠	0.0012	80.2		0.00067	87.8		0.00073
13000 4000 4000 750 750 750 750 750 750 750 750 750	0.0016	0.0041	0.0.0		0.00028	0.905		0.00029	0.746		0.00024
13000 4000 	0.0016	0.0041	18000	٠		39400	٠		45500		
40000 40000 750 750 190 21000 210000 17000 580000 1200000 1200000 680 69 69 69 69 69 69 69 69 69 69 69 69 69	2	0.0041	14.6	0.0011		18.9	0.0015		16.6	0.0013	
4000 750 190 21000 9700 17000 17000 580000 580000 220000 10000000 680 69 69 690 690 690 690 690 690		0.066	42.3		0.0031	15.2		0.0038	12.5		0.0031
750 190 21000 21000 9700 17000 580000 580000 1000000 680 69 69 69 69 60 60 60 60 60 60 60 60 60 60		990.0	2.3			22.4			20.6		
750 190 21000 21000 17000 17000 17000 17000 17000 190000 1000000 1000000 1000000 1000000 1000000	er er er er tet er e	0.066	2000			25000			28700		
750 190 21000 21000 9700 17000 580000 1200000 1200000 1200000 680 69 69 69 69 69 69 69 69 69 69 69 69 69	e e e e e	990.0	30,200			00000			20107		2000
190 21000 21000 10000 9700 17000 58000 58000 1000000 1000000 680 690 690 690 220000 220000 220000			150	*:	0.20	49.1		0.065	7.50		0.007
190 2 1000 9700 1700 17000 580000 360 360 440000 1000000 680 69 69 69 69 69 69 69 69 69 69 69 69 69			3500	,		7730		•0	11300		
2 1000 2 1000 9 700 17000 580000 360 360 440000 1000000 680 69 690 690 220000 220000 220000			680			265			512		•
21000 9700 17000 17000 580000 360 360 440000 220000 1000000 680 69 69 690 220000 220000	S #1 #	0.00042	0.57		0.0030	0.14		0.00074	0.099		0.0005
9700 1 7000 580000 360 360 440000 1220000 680 69 69 69 69 69 690 690 690 690 690 690		0.0014	21.5		0.0010	25.8		0.0012	21.2		0.0010
9700 17000 580000 580000 360 440000 220000 1000000 69 69 69 69 69 69 220000			1770			2570			2350		
1,7000 580000 360 360 440000 1,000000 680 69 69 69 69 690 2,20000			ND (2.31)			ND (2.21)		11.51	ND (2.19)		
17000 580000 380 380 440000 2220000 10000000 69 69 690 220000 220000 22000 20000 2000			149			156			150		
5,80000 3,80 4,40000 2,20000 1,00000 6,9 6,9 6,9 6,9 6,000 6 6 6		0 0000	300		0 0017	29.5		0.0017	27.9	٠	0 0016
580000 380 440000 220000 1000000 69 69 690 220000 20000 20000		0.0022	23.0		20000	7.00		0,000	4.5		0,000,0
360 360 440000 220000 1000000 680 69 69 69 69 69 60 220000 20000		0.0001/	134	,	0.00023	108		0.000	71		000
360 360 440000 220000 1000000 680 69 69 220000 220000											
360 360 440000 220000 1000000 69 69 69 220000 20000					,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,			000000	2000		0 000064
440000 440000 1000000 680 69 69 69 69 60 270000	×	0.000024	0.0157	,	0.000044	0.0239		0.000000	0.0104		0.00003
4240000 2220000 1000000 660 69 690 2200000 6000		0.000029	0.0201	,	0.000058	0.0307		0.000085	0.0221		0.0000014
1000000 1000000 68 69 69 69 69 69 69 69 690 700000 700000 700000 70000 70000 70000 70000 70000 70000 70000 70000 70000 70000 700000 70000 70000 70000 70000 70000 70000 70000 70000 70000 700000 700000 7000		0.000000000	0.102		0.00000023	0.0931		0.00000021	0.103		0.0000042
1000000 680 69 69 6900 220000 6000		0.000000000	0.00725		0.0000000033	0.0333		0.00000000	0.0685		0.00000031
680 69 690 2 2 2 2 2000 0		0.00000000	0.381		0.00000038	0.322		0.00000032	1.35		0.0000014
69 690 220000 6000	0.00050		0.882	0.0013		1.08	0.0016		3.66	0.0054	
690 220000 6000	0.0045		0.685	0.0099		0.897	0.013		2.68	0.039	
222000	0.00044		0.616	0.00089		0.916	0.0013		2.65	0.0038	
0000		0.0000014	0.519		0.0000024	0.677		0.000003	1.69		0.0000077
	3.7E-05		0.568	0.000082		0.699	0.00010		2.03	0.00029	
00069	4.7E-06		0.793	0.000011		0.886	0.000013		2.61	0.000038	
lanthracene	1.0E-03		0.141	0.0020		0.142	0.0021		0.511	0.0074	
290000 0.718		0.0000025	2.18		0.0000075	2.21		0.0000076	6.26		0.000022
290000		0 000000004	0.0829		0.00000029	0.114	٠	0.00000039	0.238		0.00000082
000000	0.00028		0.395	0.00057		0.486	0.00070		1.39	0.0020	0.0020
84		0.00018	0.0173		0.00021	0.0613		0.00073	0.0302		0.00036
220000	10.1	0.000016	1.21		0.0000055	1.39		0.0000063	3.26		0.000015
220000		0.000000	90		0600000	1.97		0.0000000	5.2		0.000024
_	,	0.000000	60:						!		

TABLE A-2 MCA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 15 FEET MEA WEST OF THE WEST PARCEL DUKE INTERGY CINCINNATI, OHIO

Sample Date Sample Date Sample Type VAP Sample Depth (bgs) Construction Olattle Organic Compounds (mg/kg) 35	8/2/2011									The same of the same of		
Sample Type mple Depth (bgs)				8/2/2011			8/3/2011			8/3/2011		
mple Depth (bgs)	z			z			z			5	20	
atile Organic Compounds (mg/kg)  4. Trimehlublenzene	0 - 2 (ft)	Cancer	Non-Cancer	9 - 10 (ft)	Cancer	Non-Cancer	0 - 2 (ft)	Cancer	Non-Cancer	0 - 2 (ft)	Cancer	Non-Cancer
atile Organic Compounds (mg/kg) 2.4.Trimethylbenzene												
2 4. Trimethylbenzene									0,0000			0,000
	ND (0.00196)			ND (0.00202)		,	0.00152		0.000043	0.00162		0.000046
200	(0.00196)		,	ND (0.00202)			ND (0.00207)			ND (0.00242)		
Ketonel	0 00701		0 00000047	0.00798		0.00000053	0.0179		0.0000012	ND (0.0605)	,	
nie (menyl cary) versite)	0.0445		0 0000045	0.0802		0 000000000	0.0784		0.00000078	0.0524		0.00000052
	0.00405		0.000000	0.00482		0.000032	0.00622		0 000041	0.00685		0.000046
	0.00403		0.000027	200.0		200000	10000			1000000		
Bromobenzene	ND (0.00196)	1)1		ND (0.00202)			ND (0.00207)			ND (0.00242)		
Carbon disulfide	0.00878		0.000046	0.00259		0.000014	0.0131		0.000069	0.0222		0.00012
novitolisene)	0.00303			ND (0.00202)			ND (0.00207)			ND (0.00242)	×	
Chilbotrapa	0 0017		0.0000074	ND (0.00202)			0.00226	,	0.0000098	0.00206		0.0000000
				(======================================								
Hexane 190												
sopropylbenzene 260	ND (0.00196)			ND (0.00202)			ND (0.00207)			ND (0.00242)		
Naphthalene 84	ND (0.0049)			ND (0.00506)	٠	4	ND (0.00517)			ND (0.00605)	e:	6
Petrachloroethene 220	ND (0.00196)		9	ND (0.00202)			ND (0.00207)			ND (0.00242)		
	0.00519		1.0E-05	0.00129		0.0000025	0.00763		0.000015	0.00726		0.000014
Xylene (total) 370	0.00223		6.0E-06	ND (0.00506)	· ¥2		0.00393		0.000011	0.00418		0.000011

Notes and Abbreviations:

1. Values from OAC 3745-300-08(C)(3) (Current rules. April 18, 2013) and C Value for pyreter used as a surrogate for acenaphthylene, phenanthrene, an Value for 1-methylnaphthalene used for 2-methylnaphthalene used for 2-methylnaphthalene C-Standard is based on a cancer risk of 18-05.

C. Standard is based on a cancer risk of 18-05.

N.C. Standard is based on a non-cancer hazard index of 1 Section 2 Risk ratio calculated as EPC / VAP standard

3. NO (4); Result is not detected above the indicated reporting limit.

4. Results in bold are detected above the laboratory reporting limit.

5. "..." Indicates information not available or analysis not performed.

TABLE A-2 MCA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 15 FEET AREA WEST OF THE WEST PARCEL DUKE ENERGY CINCINNATI, OHIO

	Sample Date		SB-K09 8/4/2011	KISK Kati	Risk Ratio (SB-K02)
	Sample Type Sample Depth (bgs)	VAP	N 4.5 - 6.5 (ft)	Cancer	Non-Cancer
norganic Compounds (mg/kg)					
Aluminum, Total			12100		
Arsenic, Total		420	6.46		0.015
Barium, Total		120000	40.5		0.00034
Beryllium, Total		3100	0.698		0.00023
Calcium, Total		,	75000		
Chromium, Total		13000	14.3	0.0011	
Cobalt, Total		4000	11.6		0.0029
Copper, Total			21.1		
Iron, Total			25800		
Lead, Total		750	61.3		0.082
Magnesium, Total			8430		
Manganese, Total			534		
Mercury, Total		190	0.15		0.00079
Nickel, Total		21000	18		0.00086
Potassium, Total			2370		
Selenium, Total		9700	ND (2.33)		
Sodium, Total			194		
Vanadium, Total		17000	24.3		0.0014
Zinc, Total		580000	86.3		0.00015
Semi-Volatile Organic Compounds (SIM) (mg/kg)	s (SIM) (mg/kg)				
1-Methylnaphthalene		360	7.09		0.020
2-Methylnaphthalene		360	12.7		0.035
Acenaphthene		440000	5.29		0.000012
Acenaphthylene		220000	2.27		0.000010
Anthracene		1000000	18.4		0.000018
Benzo(a)anthracene		680	19.5	0.029	
Benzo(a)pyrene		69	69.6	0.14	
Benzo(b)fluoranthene		069	7.65	0.011	
Benzo(g,h,i)perylene		220000	4.21		0.000019
Benzo(k)fluoranthene		0069	7.39	0.0011	
Chrysene		00069	11.6	0.00017	
Dibenz(a,h)anthracene		69	2.15	0.031	
Fluoranthene		290000	26.7		0.000092
Fluorene		290000	7.95		0.000027
Indeno(1,2,3-cd)pyrene		069	4.03	0.0058	
Naphthalene		84	12		0.14
Phenanthrene		220000	32.3		0.00015

Haley & Aldrich, Inc.
G-IPROJECTS\(\)39047 - Duke EEGW PH IIs\(\)Remedial Alts Analysis\(\)Appendix A - DCI East Risk Calcs\(\)2014-0630-HAI-Analytical\_SO\_Keck\(\)S\(\)\_Veck\(\)S\(\)\_VAPCommercial 0-15-D xisx 0-15

TABLE A-2 MCA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 15 FEET BUNKE NERGY CINCINNATI, OHIO

	Location Name Sample Date		SB-K09 8/4/2011	Risk Ratio	Risk Ratio (SB-K02)
	Sample Type Sample Depth (bgs)	VAP	N 4.5 - 6.5 (ft)	Cancer	Non-Cancer
Volatile Organic Compounds (mg/kg)	kg)				
1,2,4-Trimethylbenzene		35	0.0423	,	0.0012
1,3,5-Trimethylbenzene		200	0.0185	,	0.000093
2-Butanone (Methyl Ethyl Ketone)		15000	0.0188		0.0000013
Acetone		100000	0.137		0.0000014
Benzene		150	0.00452		0.000030
Bromobenzene			0.00131		
Carbon disulfide		190	ND (0.00456)		
Cymene (p-Isopropyltoluene)		,	0.00315	,	
Ethylbenzene		230	0.00333		0.000014
Hexane		190			
sopropylbenzene		260	0.00159	,	0.0000061
Naphthalene		84	2.19		0.026
Tetrachloroethene		220	0.000857	0.0000039	
Toluene		520	0.0115		0.000022
Xylene (total)		370	0.0431		0.00012

Notes and Abbreviations:

1. Values from OAC 3745-300-08(C)(3) (Current rules: April 18, 2013) and C Values from Pote 3 as surrogate for accentativelyne, phenanthrene, an Value for Trienthynaphthalene used for 2-methynaphthalene Value for Trexavalent chromium co. Standard is based on a cancer risk of 1E-05.

N.C. Standard is based on a concern risk of 1E-05.

N.C. Standard is based on a concern risk of 1E-05.

N.C. Standard is based on a concern risk of 1E-05.

N.C. Standard is based on a concern risk of 1E-05.

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N.C. Standard is based on a concern risk of 1E-05.

Haley & Aldrich, Inc. G.PROJECTS\\(\)39047 - Duke EEGW PH IIs\\(\)Remedial Alts\(\)Analysis\(\)Appendix\(\) A - DCI East Risk\(\) Calcs\(\)2014-\(\)030-HAI-Analytical\_SO\_KeckS\(\)\_VAPCommercial\(\)0-15-D\(\)Xisx\(\)0-15

Remedial Cost Evaluation Client Site Location

Duke Energy Ohio, Inc. East End Gas Works Cincinnati, OH

# Alternative 2 - Engineered Covers and Deed Restrictions

Items	ă	Quantity	Unit	Unit Cost	Total Cost Notes	Notes	
Mobilization/Demobilization		1	SI	\$ 5,000.00	\$	5,000.00 Engineering judgment, prior project experience	
Soil Excavation (top 2-feet) (1)		250	δ	\$ 10.00	s	2,500.00 Engineering Judgment, prior project experience	
Soil Treatment and Disposal		425	ton	\$ 35.00	\$ 14,875.00	10 Preliminary engineering estimate based on similar remediation projects	
Backfill (0.5-2' BGS) (2)		188	ò	\$ 23.00	s	4,312.50 Engineering judgment, prior project experience	
Topsoil Placement and Grading (top 6")		360	sy	\$ 7.30	\$ 2,628.00	10 Engineering judgment, prior project experience	
Seeding		360	sy	\$ 1.11	\$ 399.60	0 Engineering judgment, prior project experience	
Paving (3)		0	sf	\$ 5.50		Engineering judgment, prior project experience	
Environmental Controls (dust, erosion, odor, vapor, stormwater) (4)		1	weeks	\$ 2,500.00	\$ 2,500.00	10 Preliminary engineering estimate based on similar remediation projects	
Air Monitoring		1	weeks	\$ 5,000.00	s	5,000.00 Preliminary engineering estimate based on similar remediation projects	
Groundwater Monitoring <sup>(5)</sup>		30	year	\$ 30,000.00	\$ 900,000.00	0	
Subtotal					\$ 937,215.10	0	
Design and Permitting	12%				\$ 112,465.81	112,465.81 EPA/ACOE FS Cost Guide July 2000, EPA 540-R-00-002, Exhibit 5-8, Remedial Design	
Contingency	15%				\$ 140,582.27	140,582.27 15% contingency assumed due to limited complexity of this alternative	
PM/CM	14%				\$ 131,210.11	131,210.11 EPA/ACOE FS Cost Guide July 2000, EPA 540-R-00-002, Exhibit 5-8	
Total - Alternative 2					\$ 1322,000	[e	

 <sup>0-2&#</sup>x27; BGS excavation area includes grass strip between Pittsburgh St. and the East Parcel.
 Sand/gravel backfill includes all cap areas.

Alternative does not require paving.
 Project duration assumes excavation rate of 500 cy/day, 1,500 cy/day for backfill and topsoil placement.
 Groundwater monitoring assumes existing 21 wells sampled semi-annually and is based sampling and reporting costs from current monitoring program.

Remedial Cost Evaluation Client Site Location

Duke Energy Ohio, Inc. East End Gas Works Cincinnati, OH

# Alternative 3 - Excavation of NAPL Impacted Soils in Top 15'

Items		Quantity	Chit	Unit Cost	Total Cost Notes
Makilisstian/Nemohilisstian			5	\$ 75,000,000 \$	75 000 00 Ensineering judament, orlor project experience
Soil Exercation (0.15 feet) (1)		71,400	5	\$ 10.00 \$	714,000.00 Engineering judgment, prior project experience
Support of Excavation		42,000	sf	\$ 75.00 \$	3,150,000.00 Engineering judgment, prior project experience
Soil Treatment and Disposal		121,380	ton	\$ 35.00 \$	4,248,300.00 Preliminary engineering estimate based on similar remediation projects
Backfill		71,400	ò	\$ 23.00 \$	1,642,200.00 Engineering judgment, prior project experience
Topsoil Placement and Grading		2,000	sy	\$ 7.30 \$	14,600.00 Engineering judgment, prior project experience
Seeding		2,000	ks	\$ 1.11 \$	2,220.00 Engineering judgment, prior project experience
MGP Structures Foundation Demolition and Loading		3,500	ton	\$ 60.00 \$	210,000.00 Engineering judgment, prior project experience
Demo Debris Transportation and Disposal		3,500	ton	\$ 30.00 \$	105,000.00 Engineering judgment, prior project experience
NAPL Monitoring and Recovery Wells		∞	each	\$ 3,000.00 \$	24,000.00 Engineering judgment, prior project experience
Paving (2)		98,300	ş	\$ 5.50 \$	540,650.00 Engineering Judgment, prior project experience
Environmental Controls (dust, erosion, odor, vapor, stormwater) (3)		45	weeks	\$ 5,000.00 \$	225,000.00 Preliminary engineering estimate based on similar remediation projects
Air Monitoring		45	weeks	\$ 15,000.00 \$	675,000.00 Preliminary engineering estimate based on similar remediation projects
Groundwater Monitoring (4)		30	year	\$ 23,000.00 \$	690,000.00
NAPL Monitoring and Recovery		30	year	\$ 12,000.00 \$	360,000.00
Subtotal				s	12,675,970.00
Design and Permitting	%8			\$	1,014,077.60 EPA/ACOE FS Cost Guide July 2000, EPA 540-R-00-002, Exhibit 5-8, Remedial Design
Contingency	25%			s	3,168,992.50 25% contingency assumed due to potential variability in excavation volume and disposal costs.
PM/CM	11%			v.	1,394,356.70 EPA/ACOE FS Cost Guide July 2000, EPA 540-R-00-002, Exhibit 5-8
Total - Alternative 3				s	18,254,000

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 <sup>9.15&#</sup>x27; BGS excavation area includes NAPL areas on the Middle parcel.
 Pavement area is assumed to include the existing operations area of the Middle Parcel.
 Project duration assumes excavation rate of 500 cy/day, 1,500 cy/day for backfill, and 2 weeks for paving.
 Groundwater monitoring assumes 13 wells sampled semi-annually and is based sampling and reporting costs from current monitoring program.

Remedial Cost Evaluation Site Location

Duke Energy Ohio, Inc. East End Gas Works Cincinnati, OH

Alternative 4 - Excavation of NAPL Impacted Soils Above the Water Table

Items		Quantity	Unit	Uni	Unit Cost	Total Cost	Notes
Mobilization/Demobilization		1	รา	\$ 100	100,000.00	100,000.0	100,000.00 Engineering judgment, prior project experience
Soil Excavation (1)		178,700	δ	s	30.00 \$	5,361,000.0	5,361,000.00 Engineering judgment, prior project experience
Support of Excavation		83,700	st	s	\$ 00.58	7,114,500.0	7,114,500.00 Engineering judgment, prior project experience
Soil Treatment and Disposal		303,790	ton	s	35.00 \$	10,632,650.0	10,632,650.00 Preliminary engineering estimate based on similar remediation projects
Topsoil Placement and Grading (top 6") (2)		4,000	sy	s	7.30 \$	29,200.0	29,200.00 Engineering judgment, prior project experience
Seeding		4,000	sy	s	1.11 \$	4,440.0	4,440.00 Engineering Judgment, prior project experience
Backfill		178,700	δ	s	23.00 \$	4,110,100.0	4,110,100.00 Engineering judgment, prior project experience
MGP Structures Foundation Demolition and Loading		4,800	ton	s	\$ 00.09	288,000.0	288,000.00 Engineering judgment, prior project experience
Demo Debris Transportation and Disposal		4,800	ton	s	30.00 \$	144,000.0	144,000.00 Engineering judgment, prior project experience
NAPL Monitoring and Recovery Wells		∞	each	s	\$ 00.000.8	24,000.00	30 Engineering judgment, prior project experience
Paving (3)		98,300	ş	s	5.50 \$	540,650.00	
Environmental Controls (dust, erosion, odor, vapor, stormwater) (4)		100	weeks	s	5,000.000,5	500,000.0	500,000.00 Preliminary engineering estimate based on similar remediation projects
Air Monitoring		100	weeks	\$ 15	15,000.000 \$	1,500,000.0	,500,000.00 Preliminary engineering estimate based on similar remediation projects
Groundwater Monitoring (5)		30	year	\$ 23	23,000.00 \$	690,000.00	
NAPL Monitoring and Recovery		30	year	\$ 12	12,000.00 \$	360,000.00	00
Subtotal					S	31,398,540.00	00
Design and Permitting	%9				s,	1,883,912.4	,883,912.40 EPA/ACOE FS Cost Guide July 2000, EPA 540-R-00-002, Exhibit 5-8, Remedial Design
Contingency	25%				S	7,849,635.0	,849,635.00 25% contingency assumed due to potential variability in excavation volume and disposal costs.
PM/CM	11%				\$	3,453,839.4	3,453,839.40 EPA/ACOE FS Cost Guide July 2000, EPA 540-R-00-002, Exhibit 5-8
Total . Atomospins					-	44 505 000	F

44 505 000	300,000,44
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1. Excavation volume includes all NAPL impacted soils above the water table on the Middle Parcel and the area west of the West Parcel. Increase in unit cost compared to other Alternatives is due to complexity associated with a 40' deep excavation.

2. Loam and seed is limited to portion of DCI East included in excavation program, grassed area east of Pittsburgh Street, and portion of West Parcel included in excavation program.

3. Pavement area is assumed to include the existing operations area of the Middle Parcel.

4. Project duration assumes excavation rate of 500 cy/day, 1,500 cy/day for backfill, and 2 weeks for paving.

5. Groundwater monitoring assumes 13 wells sampled semi-annually and is based sampling and reporting costs from current monitoring program.

Site Location Remedial Cost Evaluation

Duke Energy Ohio, Inc. East End Gas Works Cincinnati, OH

Alternative 5 - ISS of NAPL Impacted Soils Above the Outwash

### 1,880,338.86 EPA/ACOE FS Cost Guide July 2000, EPA 540-R-00-002, Exhibit 5-8, Remedial Design 7,834,745.25 25% contingency assumed due to potential variability in deep soil mixing costs. 6,687,800.00 Preliminary engineering estimate based on similar remediation projects 710,000.00 Preliminary engineering estimate based on similar remediation projects 2,130,000.00 Preliminary engineering estimate based on similar remediation projects 3,447,287.91 EPA/ACOE FS Cost Guide July 2000, EPA 540-R-00-002, Exhibit 5-8 805,000.00 Engineering judgment, prior project experience 4,995,000.00 Engineering judgment, prior project experience 110,000.00 Engineering judgment, prior project experience 1,564,000.00 Engineering judgment, prior project experience 288,000.00 Engineering judgment, prior project experience 150,000.00 Engineering judgment, prior project experience 229,900.00 Engineering judgment, prior project experience 139,430.00 Engineering judgment, prior project experience 21,201.00 Engineering judgment, prior project experience 11,750,000.00 Engineering judgment, prior project experience 144,000.00 Engineering judgment, prior project experience 24,000.00 Engineering judgment, prior project experience 540,650.00 Engineering judgment, prior project experience 31,338,981.00 360,000.00 Total Cost 35.00 \$ 100.00 10.00 23.00 60.00 30.00 5.50 3,000.00 5,000.00 15,000.00 23,000.00 12,000.00 Unit Cost Chit वृद्ध द्र ton 19,100 11,000 66,600 20,900 19,100 117,500 68,000 98,300 191,080 4,800 6% Environmental Controls (dust, erosion, odor, vapor, stormwater) (7) MGP Structures Foundation Demolition and Loading Topsoil Placement and Grading (top 6") (4) Demo Debris Transportation and Disposal NAPL Monitoring and Recovery Wells Pittsburgh Street Soil Excavation NAPL Monitoring and Recovery Soil Treatment and Disposal (3) Mobilization/Demobilization Groundwater Monitoring (8) Pre-ISS Excavation Support Post ISS Swell Removal (5) Pre-ISS Soil Excavation (1) Design and Permitting ISS of NAPL Impacts Air Monitoring Contingency Subtotal PM/CM

1. Excavation volume includes all ISS areas excavated to 15' BGS.

Total - Alternative 5

44.502.000

2. Excavation volume includes the Pittsburgh Street area excavted to 18' BGS

Soil treatment and disposal includes Pre-ISS, Pittsburgh St., and Post-ISS swell excavation volumes.

Loam and seed is limited to the area west of the West Parcel included in ISS program and grassed area east of Pittsburgh Street.

Assumes that approximatly 2' of swell will need to be removed over the ISS area.

6. Pavement area is assumed to include the existing operations area of the Middle Parcel.

7. Project duration assumes excavation and ISS rate of 500 cy/day, 1,500 cy/day for backfill, and 2 weeks for paving. 8. Groundwater monitoring assumes 13 wells sampled semi-annually and is based sampling and reporting costs from current monitoring program.

# Focused Remedial Alternatives Analysis for the Phase 3 and Tower Areas

Prepared for

Duke Energy West End Property Cincinnati, OH

November 2017



CH2M HILL Engineers, Inc. 400 E Business Way Suite 400 Cincinnati, OH 45241 US



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# Acronyms and Abbreviations

BAP benzo(a)pyrene

bgs below ground surface

CH2M CH2M HILL Engineers, Inc.

CNS Covenant Not to Sue

COC chemical of concern

GRA general response action

ISS in situ stabilization

MGP Manufactured Gas Plant
NAPL nonaqueous phase liquid

NFA no further action

OAC Ohio Administrative Code

OLM oil-like materials

O&M operation and maintenance

PAH polycyclic aromatic hydrocarbon

RAA Remedial Alternatives Analysis

RAO remedial action objective

TLM tar-like materials

UPUS unrestricted potable use standards

VAP Voluntary Action Program

PR0719172211CIN V

## Introduction

On behalf of Duke Energy Ohio, Inc. (Duke), CH2M HILL, Inc. (CH2M) completed this remedial alternatives analysis (RAA) for the Phase 3 Area and Tower Area (collectively referred to as the Subject Area) at Duke's West End Property (West End Property). The West End Property is located at 646 West Mehring Way in Cincinnati, Ohio. This remedial alternatives analysis has been prepared for Duke based on the results of a Phase II Property Assessment to address source areas, keep sources from migrating, and meet applicable standards under the Voluntary Action Program (VAP).

This report presents and analyzes remedial alternatives for the Subject Area, specifically, the Tower Area and the Phase 3 Area. The report is organized into the following sections:

- Section 1 Introduction and Background information
- Section 2 Remedial Strategy and Objectives
- Section 3 Technology Screening
- Section 4 Remedial Alternatives
- Section 5 References

### 1.1 West End Property Setting

The West End Property is in Hamilton County, Ohio, approximately 0.5 mile southwest of downtown Cincinnati and directly west of the Brent Spence Bridge (Interstate 71/75). The West End Property is bisected by Mehring Way, with the northern part referred to as the "Front and Rose Parcel," and the southern part the "West End Parcel."

On the Front and Rose Parcel, the remedial action will focus on the southeast portion of the parcel, in what is referred to as the "Tower Area." A tower was erected (circa 1965), following the removal of historical structures. The tower has since been removed and the parcel contains no other structures and is used as an equipment storage and lay down area. The Tower Area is bounded by Mehring Way to the south and Rose Street to the east. Surface grades are generally flat with a slight slope towards the southwest.

On the West End Parcel, the remedial action will focus on the eastern portion of the parcel, identified as "Phase 3 Area." The Phase 3 Area is bounded by Mehring Way to the north, Rose Street to the east, and the Ohio River to the south. The surface is covered mostly with gravel, except for a few paved areas. It most recently housed the former eastern substation which was de-energized and removed following the construction of a new substation immediately adjacent to the west of the Phase 3 Area. Surface grades are generally flat, with a steep slope along the southern edge leading to the Ohio River.

### 1.2 West End Property History and Current Use

The West End Property was home to a manufactured gas plant (MGP), which began operations in the mid-1800s, and continued until the early-1900s, when it was transitioned to use as an electric-generating station. In the 1970s, all aboveground structures associated with the MGP operations were removed. Today, two large substations (Middle Station and West Station) operate in the central and western portions of West End Property, south of Mehring Way. The Front and Rose Parcel, to the north, is currently used as an equipment storage and lay down area by Duke.

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## 1.3 Previous Investigations

**VAP Phase I Environmental Assessment Report (Phase I)** – The Phase I was completed in May 2010 by AECOM for the entirety of the West End Property. The Phase I identified no known previous environmental investigations at the site. It was found that a geotechnical investigation had been conducted in 1992 on the western end of the West End Property for the installation of a proposed transformer and circuit breaker pad (AECOM, 2010a).

The Phase I resulted in the recognition of two Identified Areas for the West End Property, consisting of the Front and Rose Parcel (Identified Area #1) and the West End Parcel (Identified Area #2). Under the VAP, an Identified Area is defined as a location where a release of a hazardous substance or petroleum has or may have occurred.

VAP Phase II Property Assessment Report (Phase II) – The Phase II was completed in December 2010 by AECOM on the West End Property, except for the Phase 3 and Tower Areas which were not accessible at that time. The Phase II assessment concluded that chemicals of interest associated with the former MGP processes were present above the Ohio EPA VAP standards in both surface and subsurface soil, including the presence of oil-like material (OLM) and tar-like material (TLM) at the site (AECOM, 2010b).

Remedial Action Completion Report – Based on the results of the Phase II, remedial activities were undertaken on the Phase 1, Phase 2 and Phase 2A Areas at the West End Property and a Remedial Action Completion Report was completed by Burns and McDonnell (2014) in July 2014. The Remedial Action Completion Report summarizes the remedial action that took place on the West End Property, immediately to the west of the Phase 3 Area and the Tower Area.

**2017 VAP Phase II Property Assessment** – A Phase II Property Assessment was completed by CH2M HILL Engineers, Inc. (CH2M) in 2017 on the Tower Area and the Phase 3 Area. Soil and TarGOST borings were advanced, and groundwater monitoring wells were installed and sampled to obtain additional information to allow for evaluation of conditions in these two areas and to evaluate remedial requirements applicable to the Subject Area.

### 1.4 Potential Source Areas

Historical MGP operations resulted in releases of the following MGP residuals to the environment: ash, slag, purifier materials, and coal tar. Both the West End and Front and Rose Parcels have undergone Ohio EPA VAP site assessments, and it was determined that chemicals of interest associated with these processes were present above the Ohio EPA VAP standards in both surface and subsurface soil. Several remediation projects have occurred on these parcels (Phase 1, 2, and 2A areas) to remove and/or stabilize contaminated materials and remove MGP structures known to contain residuals; however, it was likely that some residuals existed outside the footprint of these previously remediated areas based on historical operations and as confirmed in the 2017 Phase II Property Assessment.

The following gas production and storage features have been identified in previous investigations onsite and other MGP sites as potential sources of MGP residuals. Residuals may be present, even though some of these features have since been removed from the sites.

- Former Retort House: Retort buildings typically contained retorts (or ovens) that were used to
  generate coal gas by heating the coal under anoxic conditions to volatilize gaseous constituents of
  coal. The main byproducts of these procedures were coke, ash, cinders, and clinkers. Several retort
  buildings were historically present in the Phase 3 Area, but have since been demolished.
- Fuel and Oil Storage: Both a fuel oil house and an oil storage house were present on the southern edge of the Phase 3 Area. Only the fuel oil house currently remains. Presumably, fuel and oil

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produced by or needed for the MGP processes was stored in these buildings. These areas may be a source of OLM, TLM, nonaqueous phase liquid (NAPL), and other MGP residuals.

- Tar Wells: Several former tar wells are in the Tower Area. In general, tar wells were below-grade structures used to store tar for later sale or use. Tar storage areas may be a source of OLM, TLM, NAPL, and other MGP residuals observed onsite.
- Coal/Coke and Ash Storage: Coal/coke and ash storage areas were onsite throughout the operational
  life of the MGP. Several coal piles, a coke bin, and an ash pit were present along the southern edge of
  the Phase 3 Area, and may be a source of MGP residuals. Additionally, a Coal House was present along
  the western edge of the Phase 3 Area and may be a source of MGP residuals.

### 1.5 Distribution of MGP Residuals

MGP residuals include ash, slag, and purifier materials resulting from previous MGP operations. Significant MGP residuals were identified in previous studies in the area to the west of both the Tower Area and Phase 3 Area. In the Phase 3 Area, MGP residuals were found to be present along the western edge. At most of the borings where probable MGP impacts were observed, the impacts were at or near the boring termination depth.

### 1.6 Distribution of Chemicals of Concern in Soils

Chemicals of concern associated with MGP sites typically consist of naphthalene; polycyclic aromatic hydrocarbons (PAHs), which include benzo(a)anthracene, benzo(a)pyrene (BAP), benzo(b)fluoranthene, benzo(g,h)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene; and heavy metals.

#### 1.6.1 Tower Area

In general, elevated PAH concentrations were found to be present within the upper 20 feet in the Tower Area, with the main constituent being BAP. BAP does not generally partition to groundwater; however, analytical results indicated concentrations exceeding the Industrial/Commercial direct-contact standards for Construction/Excavation. Considering the analytical results from previous investigations for the site, it is likely that elevated BAP concentrations exist in the upper 20 feet across the entirety of the Tower Area. It should be noted that concentrations of benzene and naphthalene were found below action levels in the Tower Area.

#### 1.6.2 Phase 3 Area

The main chemicals of concern found in the Phase 3 Area is BAP and is found at depths reaching up to 55 feet below ground surface (bgs). Likewise, the Phase 3 Area exhibited high concentrations of benzene as well. It should be noted that the locations exhibiting higher benzene concentrations generally also exhibited high naphthalene concentrations and exceedances of lead.

The surficial soil in the Phase 3 Area (0 to 15 feet bgs) exhibits high concentrations of chemicals of concern over most of the site. High concentrations of BAP are limited to the northwest portion of the site in the 16- to 30-foot depth interval. Below 30 feet, the contaminants are generally found along the western edge of the Phase 3 Area.

### 1.6.3 Oil-like Materials/Tar-like Materials

TarGOST testing performed during the Phase II Investigation was used to identify and delineate the extent of OLM and TLM at the Subject Area. The data obtained from the TarGOST investigation was evaluated to allow for a more accurate estimation of the extent of OLM and TLM impacts. The process

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used is described in the VAP Phase II Property Assessment Report for the Phase 3 and Former Tower Areas (CH2M, 2017). Confirmatory soil borings were used to confirm the findings of the TarGOST results. During that investigation, no direct evidence of TLM was identified; however, OLM was observed (NAPL or free-product) at several locations within the Phase 3 Area (primarily along the western boundary). No TLM or OLM was identified within the Tower Area. Figure 1 shows the two-dimensional depiction of the TarGOST results, Figure 2 shows the depth, thickness, and interpreted distribution of OLM/TLM, and cross sections are presented in Figures 3 and 4.

### 1.7 Distribution of Chemicals of Concern in Groundwater

Collectively, the data produced during investigations shows evidence of MGP-related impacts to groundwater, and concentrations do not meet VAP standards. Natural attenuation appears to be limiting the migration of dissolved organic constituents within the groundwater. It is likely that several biodegradation pathways are occurring at the site.

## 1.8 Chemicals of Concern Subsurface Transport

The occurrence, migration, and accumulation of MGP residual materials in the subsurface are typically controlled by several factors, including the following:

- · The texture and porosity of the overburden materials
- The presence of capillary barriers and confining units that inhibit and influence vertical and horizontal migration
- The occurrence of groundwater within the overburden materials
- The physical nature and distribution of MGP-residual materials (density relative to water)

Generally, MGP residuals tend to migrate vertically (infiltrate) into surface and subsurface materials until they intersect a barrier. Barriers can consist of lower-permeability soil, such as clay, or bedrock or other impenetrable surfaces. Once MGP residuals encounter a barrier, they have the potential to travel laterally along the barrier if sufficient gradient exists. If the MGP residual source remains present, the lateral migration will continue along the barrier through zones of increased porosity, and vertical migration will continue through cracks or other vertical conduits. Only by removing the source of the MGP residuals can the migration of residuals be stopped.

### 1.9 Land Use Considerations

Current land use is for industrial purposes. The Subject Area being considered in this remedial alternatives analysis is owned and will be owned in the future by Duke, although construction of the new bridge is anticipated to cross over the Subject Area and would impede Duke's ability to remediate or address the area in the future.

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# Remedial Strategy and Objectives

Given the Subject Area is anticipated to be the future location of a new bridge, the main remedial strategy is to manage exposures on the Subject Area relating to future construction and to manage long-term liability associated with the source areas and groundwater impacts. Additionally, the remedial action will be conducted in a manner to adhere to the VAP regulations. To accomplish this, remedial action objectives (RAOs) have been developed to serve as goals of the remediation.

## 2.1 Remedial Action Objectives

RAOs serve to ensure the overall protection of human health and the environment, including meeting all applicable VAP standards. This RAA will focus only on soil remedies, with groundwater remedies following completion under a separate RAA. Threshold criteria for achieving RAOs include the following Ohio EPA VAP applicable standards:

- Ohio Administrative Code (OAC) 3745-300-08 Generic numerical standards
- OAC 3745-300-09 Property-specific risk assessment procedures
- OAC 3745-300-10 Groundwater classification and response requirements
- OAC 1301:7-9-13(G)(3)(a) Petroleum UST corrective action

The RAOs for the Subject Area include the following:

- Overall protection of human health and the environment for future industrial/commercial land use.
- Mitigate exposure that exceeds applicable soil standards for site workers, trespassers, and construction workers.
- Mitigate the future potential for chemicals of concern (COCs) in soil to leach into groundwater.
- Mitigate the potential for migration of NAPL.

The above RAOs are further evaluated and screened using the criteria in Section 4.1 of this report.

Groundwater will continue to be monitored and evaluated for site groundwater impacts.

## 2.2 Voluntary Action Program Remedial Considerations

Remediation of the Subject Area is required to meet the standards set under the VAP. It should be noted that under the VAP, remediation can include a combination of active remediation (e.g., source removal or containment) and passive remediation (e.g., institutional or engineering controls) designed to meet all applicable standards and to mitigate risks to current and future site users. A summary of applicable VAP standards is presented in Table 1. Remedial activities that may be required to meet applicable VAP standards include the following:

- Surface soil in unpaved areas poses an unacceptable risk to current site workers and does not meet
  applicable VAP standards. To meet applicable commercial/industrial site worker standards under
  the VAP, remediation of unpaved surface soil is required.
- Construction workers could come into contact with OLM and/or TLM observed in certain areas of the Subject Area within the upper 20 feet. Where OLM or TLM are present, VAP applicable standards for construction workers are not met. Therefore, to meet applicable VAP construction

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worker standards, remediation is required in areas with OLM or TLM present at depths of less than 20 feet.

- OLM and/or TLM are present within the soil column and have migrated from source areas and may continue to migrate, both horizontally and vertically. Further, OLM and TLM represent continuing sources of dissolved constituents in groundwater that exceed applicable standards. The VAP requires that current and future onsite and offsite receptors be protected and that future degradation of unimpacted groundwater does not occur. Remediation of OLM and TLM impacts is required to meet applicable VAP standards.
- The Ohio EPA defines "free product" as "a separate liquid hydrocarbon phase that has a measurable thickness of greater than one one-hundredth of a foot" [Ohio Administrative Code (OAC) 3745-300-01(A)(53)]. Measurable free product (NAPL) was not observed in monitoring wells; however, it was observed in soil borings onsite. VAP regulations state that properties with free product exceed applicable unrestricted potable use standards (UPUS) for groundwater [OAC 3745-300-08(B)(2)(c)]. Further, the VAP generally requires that free product be removed, or mitigated to the extent practicable, prior to issuance of a no further action (NFA) [OAC 3745-300-07(I)(4)]. As such, NAPL remediation is required to meet applicable VAP standards.

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# **Technology Screening**

## 3.1 General Response Actions

General response actions (GRAs) describe the broad range of actions that individually, or in combination, will satisfy the RAOs and applicable VAP standards. GRAs may include no action, institutional controls, engineering controls, containment, removal, treatment, disposal, monitoring, or a combination of these activities. Similar to RAOs, GRAs are typically medium-specific; however, specific GRAs as applied to a given site may address multiple impacted media. The GRAs presented below may be applied to multiple media and pathways.

To meet the RAOs for the West End Property, the following potential GRAs have been identified for consideration in remedial alternatives:

- No Action. Used for baseline comparison. No remedial measures are implemented in the No Action GRA. This would not satisfy the RAOs, nor the applicable VAP standards.
- Institutional Controls. Institutional controls may involve administrative actions that restrict access
  to, contact with, or use of contaminated areas. Examples of common institutional controls include
  environmental covenants regarding land or groundwater use and a soil management plan
  establishing protocols for disturbing impacted media, among others. The VAP allows
  implementation of such controls to meet some or all applicable standards, as appropriate.
- Engineering Controls. Engineering controls involve physical measures to restrict access to, contact
  with, or use of contaminated areas. Examples of common engineering controls include fencing, soil,
  or paving covers, capping, engineered barriers, and vapor intrusion barriers, among others. The VAP
  allows implementation of such controls to meet some or all applicable standards, as appropriate.
  VAP-compliant operation and maintenance (O&M) requirements, after receipt of the NFA or
  Covenant Not to Sue (CNS), may be necessary.
- Containment. Containment actions include control, isolation, and encapsulation technologies (such
  as vertical barrier walls combined with engineering controls) that involve little or no treatment but
  provide protection of human health and the environment by reducing mobility of contaminants
  and/or eliminating pathways of exposure. The VAP allows containment remedies to meet applicable
  standards, although VAP-compliant O&M, after receipt of NFA or CNS, may be necessary.
- Removal. These actions are taken to physically remove the contaminated media. These actions
  reduce the volume, and in some cases, the mobility of contaminants. The VAP encourages removal
  actions by not requiring subsequent actions beyond the receipt of the NFA or CNS.
- Treatment. These are in situ or ex situ actions taken to treat groundwater, soil, or NAPL using
  physical, chemical, thermal, and/or biological processes to reduce the toxicity, mobility, and/or
  volume of contamination and the availability of these contaminants for contact, consumption, and
  environmental transport and uptake. The VAP encourages treatment actions, through use of
  consolidated site permits and by not requiring subsequent actions beyond the receipt of the NFA
  or CNS.

## 3.2 Technology Screening Criteria

Each GRA (except for No Action) can be addressed by various remedial technologies. Remedial technologies are defined as the general categories of remedies under a GRA, such as a barrier wall, cap, in situ stabilization, etc. Many technology types and process options are available to implement the

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GRAs described in Section 3.1. Table 2 provides an initial list of technologies and process options considered. The purpose of initially considering a wide range of technologies and process options is to ensure that potentially applicable options for the site media and COCs are not overlooked. Technologies were screened using the criteria of effectiveness, implementability, and relative cost, which are further defined as follows:

- Effectiveness Considers (1) the ability of a process option to address the estimated areas or
  volumes of contaminated media and meet the RAOs and applicable VAP standards; (2) the potential
  impacts to human health and the environment during the construction and implementation phases;
  and, (3) the reliability and demonstrated success that the process has shown with respect to the
  types of contamination and site conditions that will be encountered.
- Implementability Implementability includes both the technical and administrative feasibility of
  implementing a technology process option. The administrative feasibility considers the
  administrative or institutional aspects of using a process option such as potential restrictions of
  future land use, the availability of treatment, storage, and disposal services, and the availability of
  the equipment and workers to implement the technology.
- Relative Cost Relative cost refers to the net-present cost to implement each technology.

## 3.3 Initial Evaluation of Technologies

Potential remedial technologies for addressing the impacted soils at the Subject Area are identified by drawing on a variety of sources including previous experience, EPA guidance documents, references specifically developed for application to the VAP and other contaminated sites, vendor-supplied data, and standard engineering texts. To help streamline the evaluation and screening of potential remedial technologies, and in consideration of the previous evaluations conducted, the initial identification of technologies in this RAA has been focused to include only those technologies with a reasonable potential for achieving the remedial action objectives.

#### 3.3.1 Institutional Controls

Institutional action technologies reduce potential exposure to site contaminants by way of indirect methods rather than by containment or treatment of the contaminants or contaminated media. These technologies do not meet applicable standards by themselves, however, they may be combined with other technologies to meet standards.

#### 3.3.1.1 Deed Restrictions

<u>Description</u>: Deed restrictions place legal limitations on future West End Property use. These restrictions would prohibit future uses of the property that could result in increased exposure to site contaminants (e.g., residential development, underground utility installation). The established boundaries and approved deed restriction language would be recorded on the property deed(s) and filed in accordance with applicable laws in the office of the recorder of deeds, and/or any other offices as required by applicable law where land ownership and transfer records are maintained for real property. Deed restrictions can be implemented with consent of the West End Property owner, but their effectiveness is dependent upon continued monitoring and enforcement.

<u>Initial Screening</u>: Deed restrictions can be effective in reducing the potential for disturbance of contaminated media. By restricting and/or controlling future site uses and activities, exposure risks can be controlled. Based on its effectiveness, this technology is **retained** for further consideration.

#### 3.3.1.2 Soil Management Plan

<u>Description</u>: The purpose of a soil management plan (SMP) is to provide the requirements needed to ensure that soil disturbed during any construction activities does not adversely impact human health or

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the environment and that soils are handled, stored, and disposed of, or reused onsite, in accordance with applicable laws, and regulations. In addition, all requirements for soil specified in the SMP will also apply to the use of fill material as well, since some disturbance of in-place soils may occur during those activities.

<u>Initial Screening</u>: Soil Management Plans can be effective in managing the risks regarding the potential disturbance of contaminated media. By managing the site activities, exposure risks can be controlled. Based on its effectiveness, this technology is **retained** for further consideration.

#### 3.3.1.3 Monitoring

<u>Description</u>: Environmental monitoring can be defined as the systematic sampling of air, water, soil, and biota in order to observe and study the environment conditions at a particular site. Monitoring can be conducted for a number of purposes, including to establish environmental baselines, trends, to test environmental modeling processes, to educate the public about environmental conditions, to ensure compliance with environmental regulations or to conduct an inventory of natural resources.

<u>Initial Screening</u>: Monitoring can be effective in assessing changed conditions, thus assessing the risks regarding the potential exposure of contaminated media. By monitoring the environmental media, exposure risks can be controlled. Based on its effectiveness, this technology is **retained** for further consideration

### 3.3.2 Engineering Controls

Engineering actions reduce the potential for direct exposure to site contaminants and the potential for migration of contaminants by removing hazardous conditions or by placing a barrier between the individual and the hazard. These technologies do not meet applicable standards by themselves, however, they may be combined with other technologies to meet standards.

#### 3.3.2.1 Site Fencing

<u>Description</u>: A security fence provides an easily implemented, low cost method for restricting pedestrian traffic across areas of concern, thus decreasing the potential for exposure to contaminants or damage to on-site storage or containment structures. Periodic inspection and maintenance is required to maintain the integrity of a fence.

<u>Initial Screening</u>: Fencing is an effective method of restricting site access. Access to the West End Property is currently restricted by a chain-link fence, but repairs to this fence and some additional fencing may be required to adequately restrict site access. Thus, this technology is **retained** for further consideration.

#### 3.3.2.2 Durable Covers

<u>Description</u>: Durable covers may include existing pavements and building, new paving, hardscapes or building foundations, soil/aggregate covers, or multi-layered engineered covers.

<u>Initial Screening</u>: Durable covers provide an effective method of restricting exposure to site contaminants. Low-permeability covers, such as pavement, reduce infiltration thus reducing potential for mobilization of contaminants in soils above the water table. Thus, this technology is **retained** for further consideration.

#### 3.3.3 Containment

Containment technologies reduce the potential for direct exposure to site contaminants and the potential for migration of contaminants by physically isolating the contaminated media or wastes.

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#### 3.3.3.1 Vertical Barrier Wall

<u>Description</u>: A low-permeability wall is installed by excavating a trench supported by bentonite slurry and backfilling with a low-permeability material (or other suitable construction methods such as sheet pile walls) to prevent lateral NAPL migration and intercept and/or redirect groundwater flow for containment, collection, or controlled discharge.

<u>Initial Screening</u>: A vertical barrier wall would reduce the potential for migration of site contaminants through groundwater movement. However, the site is bounded by the Ohio River on the south side with several pipeline discharges along the waterfront that would penetrate the wall and would require significant excavation through a thick rubble fill layer that could potentially compromise the long-term integrity of the wall as large debris could penetrate softer low-permeable materials. Therefore, a vertical barrier wall is **eliminated** from further consideration.

#### 3.3.3.2 NAPL Recovery Trench

<u>Description</u>: A NAPL recovery trench is installed by excavating trench supported by slurry consisting of a biodegradable guar and backfilling with a permeable material (such as pea gravel or other suitable materials) to prevent lateral NAPL migration and intercept NAPL flow for containment, collection, or controlled discharge.

<u>Initial Screening</u>: A NAPL recovery trench would reduce the potential for migration of site contaminants through NAPL movement. However, the site is bounded by the Ohio River on the south side with several pipeline discharges along the waterfront that would penetrate the trench, thus allowing potential bypass through the collection trench. There are collars and sealants available for use, however, long-term settlement of the pipelines would provide an avenue for NAPL breakthrough. Therefore, a NAPL recovery trench is **eliminated** from further consideration.

#### 3.3.3.3 NAPL Recovery Wells

<u>Description</u>: A NAPL recovery well network is installed by drilling a series of vertical wells that are screened along the interface where NAPL is known to exist. The wells are slotted to an adequate size opening to allow for NAPL collection and filter pack materials are tailored to NAPL collection to avoid clogging to prevent lateral NAPL migration and capture NAPL flow for containment, collection, or controlled discharge.

<u>Initial Screening</u>: A NAPL recovery well system would reduce the potential for migration of site contaminants through NAPL movement. However, placement of the wells is critical to the performance of the system. Due to the heterogeneity of the NAPL occurrence at the site, there is a high potential that pockets of NAPL may not be completely captured and such systems are typically operated over an extended period of time. Despite this, a NAPL recovery well system is **retained** for further consideration.

#### 3.3.4 Removal

Removal technologies focus on the physical removal of contaminated media. Removal technologies are commonly required to facilitate treatment and/or disposal actions.

#### 3.3.4.1 Excavation - Shallow

<u>Description</u>: Shallow excavation of contaminated soils would be required for subsequent treatment and/or disposal actions. Contaminated soils could be excavated using standard practices and equipment, although a large volume of material to be removed may necessitate staged excavation or other special handling requirements. The disturbance of contaminated materials during excavation activities could result in fugitive dusts and increased inhalation and direct contact exposure risks, although engineering controls (e.g., keeping excavation faces damp) and personal protective equipment (e.g., dust masks) can mitigate the magnitude and impacts of such fugitive emissions.

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<u>Initial Screening</u>: Although excavation alone is not a remedial technology, it may be required in conjunction with containment, treatment and/or disposal actions. Therefore, shallow excavation will be **retained** for further consideration.

#### 3.3.4.2 Excavation - Deep

<u>Description</u>: Deep Excavation of contaminated soils would be required for subsequent treatment and/or disposal actions. Deep excavation of contaminated soils would require extraordinary means to achieve the goal of removing all impacted soils. In addition, significant dewatering would be necessary to manage soil excavations required. The disturbance of contaminated materials during excavation activities could result in fugitive dusts and increased inhalation and direct contact exposure risks, although engineering controls (e.g., keeping excavation faces damp) and personal protective equipment (e.g., dust masks) can mitigate the magnitude and impacts of such fugitive emissions.

<u>Initial Screening</u>: Deep excavations would require use of deep sheet pile systems or secant pile wall systems to provide lateral support for side wall soils adjacent to the excavation area. Likewise, groundwater within the excavation would need to be removed to allow excavation to continue to the necessary depths. Extraordinary safety precautions would be necessary for both equipment and workers in and near the excavation area. Therefore, deep excavation will be **eliminated** from further consideration

#### 3.3.4.3 Off-Site Landfill

<u>Description</u>: This technology refers to the transportation and disposal of contaminated soils at an approved off-site landfill. An off-site landfill could provide for the secure containment of contaminated materials, thereby restricting the migration of constituents into the environment. The risk of exposure to chemicals of concern in the Subject Area would be eliminated by removing the affected soils from them. Excavation would be required prior to the off-site disposal of materials, and approvals would be required for the transportation and disposal of wastes at a permitted facility. Dewatering may be required prior to the off-site transportation and/or disposal of contaminated soils.

Initial Screening: Based on the current understanding of the previous operations conducted at the Subject Area, the contaminated soils would not be considered to be RCRA-listed hazardous waste. Under current regulations regarding manufactured gas plant waste [40 CFR 261.24(a)], hazardous waste characterization testing such as the toxicity characteristic leaching procedure (TCLP) is not considered applicable. As a result, it is likely that materials excavated from the Subject Area could be disposed of off-site as non-hazardous waste in a non-hazardous waste landfill. Because this technology provides an effective and proven means of containing contaminated soils that are removed from the Subject Area, it is **retained** for further consideration.

#### 3.3.5 Treatment

Treatment technologies reduce the toxicity, mobility, or volume of contaminated media or wastes, thus reducing the potential for exposure to contaminants. Removal and disposal technologies are commonly used in conjunction with treatment alternatives.

#### 3.3.5.1 Biological Treatment

<u>Description</u>: Biological treatment, sometimes referred to as bioremediation, generally refers to the breakdown of organic constituents by microorganisms. The most common processes are based on aerobic or anaerobic bacteria, such as those processes utilized in the treatment of municipal wastewaters. In-situ, pump and treat, solid-phase, slurry-phase, and soil heaping biological treatment techniques have been used to remediate contaminated soils at other sites, but this technology has not proven effective to address OLM and TLM. Soil flushing and soil washing/chemical extraction technologies (discussed below) may utilize biological degradation processes to enhance the remediation efficiency.

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<u>Initial Screening</u>: The effectiveness of biological treatment can be influenced by a number of parameters including pH, temperature, availability of nutrients, and the presence of heavy metals. The potential effectiveness of biological treatment at the site is limited by unfavorable hydrogeologic conditions, specific contaminants that are resistant to biological degradation. Because this technology is not expected to be effective for the site conditions and contaminants, it is **eliminated** from further consideration.

#### 3.3.5.2 In-Situ Soil Flushing

<u>Description</u>: Soil flushing involves the in-situ injection or percolation of a flushing solution into an area of waste or soil requiring remediation. This process could be applicable to the removal of contaminants from the soils and sludges in the vadose zone. The flushing solution is used to increase the mobility of constituents as it passes through the affected media, and the mobilized contaminants and flushing solution are subsequently collected. Water is a potential flushing solution, although aqueous surfactant solutions, organic solvents and biological processes (e.g., solutions of microorganisms, nutrients, and oxygen) have also been used. Well points, subsurface drains, or another type of collection system typically must be installed in the subsurface to collect the constituent-laden solution. In-situ soil flushing has not been proven effective at addressing OLM and TLM. The recovered solution would require treatment. This technology is typically not appropriate for soils with low permeabilities.

<u>Initial Screening</u>: By introducing a potentially toxic flushing solution into the ground, and increasing the mobility of contaminants, this technology could contribute to ground water contamination if the contaminant-laden solution is not completely recovered. Based on the relatively fine-grained nature of many of the site soils, the effectiveness of this technology would be limited by inadequate distribution of the flushing solution and incomplete contaminant removal. This technology would require long-term system operation. Due to the unfavorable site conditions, potential contribution to ground water contamination, long implementation time, and high costs associated with solution recovery, treatment and disposal, this technology is **eliminated** from further consideration.

#### 3.3.5.3 In-Situ Stabilization/Solidification - Shallow

<u>Description</u>: Shallow in-situ stabilization/solidification can be employed to immobilize organic and inorganic compounds in wet or dry media, using reagents to produce a stable mass. The most common stabilization/solidification methods include cement-based methods, silicate-based (pozzolanic) methods, thermoplastic methods and organic polymer methods. Waste materials and/or affected soils can be mixed in-place with various soil mixing systems. Typically, this technology does not destroy constituents, but incorporates them into a dense, homogeneous, low-porosity structure that reduces their mobility. Because a reagent must be added to the soil, the volume of treated material may be greater than the original material volume by as much as 20 to 100 percent. This process is readily available and can sometimes be implemented for a relatively low cost.

<u>Initial Screening</u>: Shallow augering stabilization/solidification processes are potentially effective for inorganic and organic constituents identified at the site, have been shown to be effective in the Cincinnati area to depths of 60 ft and the number and type of constituents present can readily be optimized into a solidification mix. The heterogeneity of material types (e.g., sands, clays, etc.) and constituent types and concentrations across the site would require adequate mixing, but sites with similar conditions (e.g., East End) have been shown to be successful in treating in-place contaminants effectively. Because of its effectiveness and long-term benefits, this technology is **retained** for further consideration.

#### 3.3.5.4 In-situ Stabilization/Solidification - Deep

<u>Description</u>: Deep in-situ stabilization/solidification can be employed to immobilize organic and inorganic compounds in wet or dry media, using reagents to produce a stable mass in deeper portions of the soil profile at the site. Similar to shallow in-situ stabilization/solidification, the most common

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stabilization/solidification methods include cement-based methods, silicate-based (pozzolanic) methods, thermoplastic methods and organic polymer methods. This process is readily available, however, deeper penetration at the site would require treatment through clean soil layers to the required depth of 110 ft below ground surface. Treatment of these cleaner portions of the soil strata cannot be avoided due to the mixing requirements of the equipment and process.

<u>Initial Screening</u>: The available stabilization/solidification processes are potentially effective for inorganic and organic constituents identified at the site and the number and type of constituents present can readily be optimized into a solidification mix, however, the feasibility of reaching the deeper contaminated pockets of OLM result in treatment of clean soil areas which result in significant additional costs with very limited environmental benefit. Because of its limited effectiveness and significantly higher costs, this technology is **eliminated** from further consideration.

#### 3.3.5.5 Thermal Desorption

Description: In general, thermal desorption employs a process in which soils, sludges and solids with organic contamination are heated to temperatures of 300 to 1,200°F (depending on the unit and the constituents of concern), driving off water and organic contaminants. The vapors are conveyed to a gas handling system where they are scrubbed to remove particulate solids. With some units, the scrubbed off-gases are cooled to condense water and the organics, and then passed through a carbon adsorption system to remove the remaining organics. In other units, the exhaust gases are sent to a secondary burner where the residual organics are oxidized, followed by quenching and acid gas scrubbing, if required. Several full-scale, mobile thermal desorption (or thermal separation) units are commercially available. Treated soils may be returned to their original location if the levels achieved meet the cleanup criteria. Treatment residuals such as the recovered organics and the spent carbon from the gas treatment step require further treatment before disposal. Organic contaminants that can be effectively treated by this system range from relatively high-boiling point, semi-volatile compounds to low-boiling point, volatile compounds. This technology is not effective for the removal of heavy metals or OLM and TLM. Treatability studies are typically required to determine the effectiveness of this technology.

<u>Initial Screening:</u> Based on engineering experience and discussions with various vendors of this technology, thermal desorption is potentially effective for the treatment of the contaminated soils at the site. Vendors have preliminarily indicated that, given the material types, constituents and concentrations present at the site, thermal desorption would be challenging. Fine-grained soils, as well as soils with relatively high moisture contents, may require additional processing prior to treatment. Recovered organics will require additional treatment and/or disposal. Because of its potential low level of effectiveness and relative cost comparison to other equally appropriate treatment technologies, thermal desorption is **eliminated** from further consideration.

## 3.4 Technology Screening Results Summary

The technology screening is presented in Table 2. The technology screening resulted in the selection of the following effective and implementable technologies for use in developing remedial alternatives to be included in the detailed alternatives evaluation presented in Section 4. The No Action alternative is also retained for baseline comparison, although it is not effective at meeting RAOs or applicable VAP standards.

- No Action
- Institutional Controls Access and use restrictions in the form of deed restrictions or environmental
  covenants (also referred to as institutional controls), a soil management/risk mitigation plan, and
  long-term groundwater monitoring. These remedial actions will be included in all the alternatives,
  except No Action.

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#### SECTION 3 - TECHNOLOGY SCREENING

- Engineering Controls Durable covers and fencing/signs are retained for consideration in remedial alternatives. Durable cover types may include buildings, paving, hardscapes, soil covers, and multilayered engineered covers.
- Containment Installation of NAPL monitoring and recovery wells at the Phase 3 Area was retained to address containment of NAPL by interception and removal.
- Removal Excavation of OLM/TLM-impacted soils above the water table with offsite landfill disposal
  was retained as a viable technology for remediation of MGP residual source areas and is consistent
  with remedies implemented on adjacent parcels of the West End Property and at other MGP sites.
- Treatment In situ stabilization (ISS) to depths ranging up to 55 feet was retained as an effective
  in situ treatment technology for OLM/TLM-impacted soil and is consistent with remedies
  implemented on an adjacent parcel of the West End Property and at other MGP sites.

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## Remedial Alternatives

This section presents the remedial alternatives for the Subject Area that were developed to address the RAOs, applicable VAP standards, and future land use considerations. Since there are many possible combinations of technologies that can be used in each alternative, the alternatives presented represent a range of performance and cost options that feasibility, effectiveness, and implementability can be evaluated to determine the best alternative. Once an alternative is selected, the specific technologies implemented may be changed during the remedial design, assuming the change does not substantially alter the intent of the original alternative.

### 4.1 Evaluation Criteria

The remedial alternatives were subjected to a detailed evaluation against a series of criteria, which were divided into two categories: threshold criteria and balancing criteria. Threshold criteria define the minimum level of acceptable performance for an alternative that must be met for an alternative to be considered eligible for selection, and include the following:

- Overall Protection of Human Health and the Environment This criterion must be met for an alternative to be eligible for selection and is used to assess whether and how the alternative achieves and maintains protection of human health and the environment, including the attainment of the RAOs and applicable VAP standards. The overall assessment of protection draws on the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with applicable VAP standards. The evaluation of this criterion is also based on the evaluation of how risks are eliminated, reduced, or controlled through treatment, engineering, or administrative controls. Overall protection of human health and the environment considers reduction in baseline risks and protection of human health and the environment from effects caused by implementing the remedial alternative. This criterion is intended to ensure that the selected remedial action alternative would:
  - Protect human health and the environment.
  - Attain media cleanup goals.
  - Control sources of releases.
- Compliance with RAOs and Applicable VAP Standards Evaluates the degree to which an alternative meets the RAOs and applicable VAP standards identified in Section 2.2.

The balancing criteria are used to weigh trade-offs among the alternatives that meet the threshold criteria and include the following:

- Long-term Effectiveness This criterion is an evaluation of the long-term effectiveness of an
  alternative in maintaining protection of human health and the environment after RAOs and
  applicable VAP standards have been met. It assesses whether the alternative provides reliable
  protection over time. This criterion addresses the following:
  - Magnitude of residual risk remaining from untreated media or treatment residuals after remedial activities
  - Adequacy and reliability of controls such as containment systems and institutional controls necessary to manage the untreated media or treatment residuals that remain onsite

The residual risk from treatment residuals or untreated media can be measured by chemical concentrations or material volume remaining at the site after the remedial action is complete.

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- Reduction of Toxicity, Mobility, or Volume Through Removal or Treatment This criterion
  considers the degree to which alternatives employ removal or treatment technologies, as well as the
  anticipated performance of the removal or treatment technologies, by evaluating the amount of
  hazardous material removed or treated and the amount remaining onsite. The evaluation considers
  the magnitude of the reductions in toxicity, mobility, or chemical volume and the extent to which
  the treatment is irreversible as follows:
  - Amount of impacted media removed, destroyed, or treated
  - Degree of expected reduction in toxicity, mobility, and volume
  - Degree to which treatment is irreversible
  - Type and quantity of residual remaining after treatment
- Short-term Effectiveness This criterion evaluates the effects of an alternative during the
  construction and implementation period of the remedial action before and until the time the RAOs
  are achieved and applicable VAP standards are addressed. This criterion addresses the following:
  - Time until RAOs are achieved and whether any short-term risks are promptly addressed
  - Protecting the community and site workers during remedial action by evaluating effects such as dust or other emissions, visual considerations, or transportation
  - Protecting workers during remedial action by evaluating reliability of health and safety protective measures during implementation
  - Protecting the environment during remedial action by evaluating potential effects on sensitive resources, including disturbance to cultural resources and wildlife.
- Implementability This criterion evaluates the technical and administrative feasibility of alternatives and the availability of various services and materials required during its implementation. This criterion addresses the following:
  - Technical feasibility as the ability to construct, operate, and maintain the technology and the ability to monitor its effectiveness
  - Administrative feasibility as the ability to obtain approvals, rights-of-way, and permits
  - Availability of services and materials considering offsite treatment, storage capacity, disposal capacity, equipment, and specialists.
- Community Acceptance This criterion evaluates the issues and concerns the public may have
  regarding each alternative. Impacts to or concerns of the community may include construction
  traffic and noise, odors and site emissions, hauling contaminated soils through the community to
  the disposal facility, and the degree to which human health or ecological risks are mitigated, among
  others.
- Cost Cost encompasses all engineering, construction, and O&M costs incurred over the life of the
  project. The assessment, with respect to this criterion, is based on the qualitative cost for each
  alternative. These qualitative costs are reflected as "low, medium, or high".

## 4.2 Description of Selected Alternatives

Remedial alternatives have been assembled to span the range of GRAs identified in Section 3, including no action, institutional and engineering controls, containment, removal, and treatment. A total of five alternatives for the Tower Area and six for the Phase 3 Area, including a No Action alternative, were developed.

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The following alternatives were developed for the Tower Area and are described in the following subsections.

- Alternative 1 No Action
- Alternative 2 Institutional Controls
- Alternative 3 Engineering Controls
- Alternative 4 Limited Soil Excavation, Institutional and Engineering Controls
- Alternative 5 Soil Excavation, Institutional and Engineering Controls

The following alternatives were developed for the Phase 3 Area:

- Alternative 1 No Action
- Alternative 2 Institutional Controls
- Alternative 3 Engineering Controls
- Alternative 4 Limited OLM/TLM and Soil Excavation, NAPL Monitoring and Recovery, Institutional and Engineering Controls
- Alternative 5 OLM/TLM and Soil Excavation, NAPL Monitoring and Recovery, Institutional and Engineering Controls
- Alternative 6 OLM/TLM and Soil Excavation, ISS, Institutional and Engineering Controls

These remedial action alternatives are depicted in Figures 5 through 9 and are described in the following subsections.

#### 4.2.1 Tower Area

Alternative 1 – No Action: The No Action alternative includes no remedial activities and will leave the site in its present condition. Contaminated media will remain in place with no treatment to prevent further contaminant migration and will not provide any additional protection to human health and the environment over current conditions. Site conditions will not be monitored to document the natural attenuation or mobility of contamination. No action is required to implement the technology, and there is no associated cost. This alternative is retained as a baseline for comparison to other remedial alternatives, but would not meet applicable VAP standards or be protective of human health or the environment.

Alternative 2 – Institutional Controls: The Institutional Controls alternative includes implementing deed restrictions, a soil management/risk mitigation plan, and long-term groundwater monitoring plan. No remedial activities will occur and the site will remain in its present condition. Contaminated media will remain in place with no treatment to prevent further contaminant migration and no additional protection to human health and the environment over current conditions will be provided. In and of itself, this alternative will not meet applicable VAP standards or be protective of human health or the environment.

Alternative 3 – Engineering Controls: The Engineering Controls alternative includes implementing durable covers and fences to limit access to contaminants. No remedial activities will occur on site and contaminated media will remain in place with no treatment to prevent further contaminant migration. In and of itself, this alternative will not meet applicable VAP standards or be protective of human health or the environment.

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Alternative 4 – Limited Soil Excavation, Institutional and Engineering Controls: This alternative is intended to provide the minimum amount of remedial construction required to meet applicable VAP standards. Alternative 4 includes the following remedial technologies:

- Engineering controls (fencing and signs) and institutional controls (land use restriction for commercial/industrial use only and groundwater use restriction for potable or non-potable uses, and a soil management/risk mitigation plan for future intrusive activities).
- Limited excavation of contaminated soil in areas, as shown in Figure 5, to potential construction worker exposure depth of 20 feet, backfill with imported clean soil, and surface restoration with paving or gravel.

The components of this remedial alternative are illustrated in Figure 5.

Alternative 5 – Soil Excavation, Institutional and Engineering Controls: This alternative is similar to Alternative 4, but the difference is to completely remove contaminated material in order to meet applicable VAP standards. Alternative 5 includes the following remedial technologies:

- Engineering controls (fencing and signs) and institutional controls (land use restriction for commercial/industrial use only and groundwater use restriction for potable or non-potable uses, and a soil management/risk mitigation plan for future intrusive activities).
- Excavation of contaminated soil to potential construction worker exposure depth of 20 feet, backfill
  with imported clean soil, and surface restoration with paving or gravel.

The components of this remedial alternative are illustrated in Figure 6.

#### 4.2.2 Phase 3 Area

Alternative 1 – No Action: The No Action alternative includes no remedial activities and will leave the site in its present condition. Contaminated media will remain in place with no treatment to prevent further contaminant migration and will not provide any additional protection to human health and the environment over current conditions. Site conditions will not be monitored to document the natural attenuation or mobility of contamination. No action is required to implement the technology, and there is no associated cost. This alternative is retained as a baseline for comparison to other remedial alternatives, but would not meet applicable VAP standards or be protective of human health or the environment.

Alternative 2 – Institutional Controls: The Institutional Controls alternative includes implementing deed restrictions, a soil management/risk mitigation plan, and long-term groundwater monitoring plan. No remedial activities will occur and the site will remain in its present condition. Contaminated media will remain in place with no treatment to prevent further contaminant migration and no additional protection to human health and the environment over current conditions will be provided. In and of itself, this alternative will not meet applicable VAP standards or be protective of human health or the environment.

Alternative 3 – Engineering Controls: The Engineering Controls alternative includes implementing durable covers and fences to limit access to contaminants. No remedial activities will occur on site and contaminated media will remain in place with no treatment to prevent further contaminant migration. In and of itself, this alternative will not meet applicable VAP standards or be protective of human health or the environment.

Alternative 4 – Limited OLM/TLM and Soil Excavation, NAPL Monitoring and Recovery, Institutional and Engineering Controls: This alternative is intended to provide the minimum amount of remedial construction required to meet applicable VAP standards. Alternative 4 includes the following remedial technologies:

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- Engineering controls (fencing and signs) and institutional controls (land use restriction for commercial/industrial use only and groundwater use restriction for potable or non-potable uses, and a soil management/risk mitigation plan for future intrusive activities).
- Limited excavation of OLM/TLM in soil in areas, shown in Figure 7, to potential construction worker exposure depth of 20 feet, backfill with imported clean soil, and surface restoration with paving or gravel.
- NAPL monitoring and recovery in up to 2 wells.

The components of Alternative 4 are illustrated in Figure 7.

Alternative 5– OLM/TLM and Soil Excavation, NAPL Monitoring and Recovery, Institutional and Engineering Controls: Alternative 5 is similar to Alternative 4, but is intended to remove more impacted soil and includes the following remedial technologies:

- Engineering controls (fencing and signs) and institutional controls (land use restriction for commercial/industrial use only and groundwater use restriction for potable or non-potable uses, and a soil management/risk mitigation plan for future intrusive activities).
- Excavation of OLM/TLM in soil to potential construction worker exposure depth of 20 feet, backfill
  with imported clean soil, and surface restoration with paving or gravel.
- NAPL monitoring and recovery in up to 2 wells.

The components of Alternative 5 are illustrated in Figure 8.

Alternative 6 – OLM/TLM and Soil Excavation, In Situ Stabilization, Institutional and Engineering Controls: This alternative includes the following remedial technologies:

- Engineering controls (fencing and signs) and institutional controls (land use restriction for commercial/industrial use only and groundwater use restriction for potable or non-potable uses, and a soil management/risk mitigation plan for future intrusive activities).
- Excavation of OLM/TLM in soil that is present in the upper 20 feet, followed by ISS of OLM in soil to
  a maximum depth of 55 feet. ISS swell placement will be limited to no shallower than 20 feet bgs.
  The upper 20 feet will be backfilled with imported clean soil and surface restoration with paving or
  gravel.

Alternative 6 considers the use of ISS to remediate NAPL impacts to a depth of 1 foot below the lowest depth at which OLM was identified in borings. Including ISS increases the maximum practical depth of remediation to 55 feet bgs at the deepest area. The alternative would be implemented with excavation to 20 feet bgs, then ISS ranging from 22 to 55 feet bgs, leaving room for ISS swell, and leaving the upper 20 feet (future construction worker zone) to be backfilled with clean soil.

The components of this Alternative 6 are illustrated in Figure 9.

### 4.3 Evaluation of Selected Alternatives

The results of the alternatives evaluation through comparison to the eight criteria is presented in Table 3 and discussed in the following subsections. A relative scoring is used in Table 3 to provide a relative ranking of the alternatives. The numeric scoring for the various criteria ranges from 0 through 4, with a score of 0 indicating the criteria is not met, and a score of 4 indicating the criteria is substantially achieved by the alternative. The scoring is not intended to identify the preferred alternative, rather, it provides a semi-quantitative means to illustrate and compare the relative benefits and short-comings of the various alternatives.

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#### 4.3.1 Tower Area

#### 4.3.1.1 Alternative 1: No Action

The No Action alternative does not satisfy any of the RAOs, nor does it meet applicable VAP standards and is not protective of human health or the environment. This alternative is the lowest cost to implement as there are no remedial actions implemented.

#### 4.3.1.2 Alternative 2: Institutional Controls

The Institutional Controls alternative does not satisfy any of the RAOs, nor does it meet applicable VAP standards and is not protective of human health or the environment. This alternative has a low cost to implement as there are no remedial actions implemented.

#### 4.3.1.3 Alternative 3: Engineering Controls

The Engineering Controls alternative does not satisfy any of the RAOs, nor does it meet applicable VAP standards and is not protective of human health or the environment. This alternative has a low cost to implement as the work only requires the use of durable covers and fencing/signs as remedial alternatives. Therefore, this alternative is not considered acceptable to meet all the VAP requirements.

#### 4.3.1.4 Alternative 4: Limited Soil Excavation, Institutional and Engineering Controls

Excavation of the top 20 feet of contaminated soil in a limited area to mitigate the potential for construction workers to be exposed to impacted soils. RAOs and applicable VAP standards are met with this alternative. This alternative will have moderate impacts to site workers and the community during excavation and offsite hauling of impacted soils and will require phased construction due to the excavation depth and active operations on and/or adjacent to the site.

#### 4.3.1.5 Alternative 5: Soil Excavation, Institutional and Engineering Controls

Excavation of the top 20 feet of contaminated soil across the Tower Area to mitigate the potential for construction workers to be exposed to impacted soils. RAOs and applicable VAP standards are met with this alternative. This alternative will have moderate impacts to site workers and the community during excavation and offsite hauling of impacted soils and will require phased construction due to the excavation depth and active operations on and/or adjacent to the site.

#### 4.3.2 Phase 3 Area

#### 4.3.2.1 Alternative 1: No Action

The No Action alternative does not satisfy any of the RAOs, nor does it meet applicable VAP standards and is not protective of human health or the environment. This alternative is the lowest cost to implement as there are no remedial actions implemented.

#### 4.3.2.2 Alternative 2: Institutional Controls

The Institutional Controls alternative does not satisfy any of the RAOs, nor does it meet applicable VAP standards and is not protective of human health or the environment. This alternative has a low cost to implement as there are no remedial actions implemented.

#### 4.3.2.3 Alternative 3: Engineering Controls

The Engineering Controls alternative does not satisfy any of the RAOs, nor does it meet applicable VAP standards and is not protective of human health or the environment. This alternative has a low cost to implement as the work only requires the use of durable covers and fencing/signs as remedial alternatives. Therefore, this alternative is not considered acceptable to meet all the VAP requirements.

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# 4.3.2.4 Alternative 4: Limited OLM/TLM and Soil Excavation, NAPL Monitoring and Recovery, Institutional and Engineering Controls

Excavation of the top 20 feet of a limited area of OLM/TLM-impacted soil mitigates the potential for construction workers to be exposed to impacted soils. However, a significant proportion of OLM impacts will remain, which are mobile and are a source of COCs to groundwater. NAPL monitoring and recovery wells will monitor NAPL migration offsite. RAOs and applicable VAP standards are partially met with this alternative. This alternative will have moderate impacts to site workers and the community during excavation and offsite hauling of impacted soils and will require phased construction due to the excavation depth and active operations on and/or adjacent to the site.

# 4.3.2.5 Alternative 5: OLM/TLM Excavation, NAPL Monitoring and Recovery, Institutional and Engineering Controls

Excavation of the top 20 feet of OLM/TLM-impacted soil across the Tower Area mitigates the potential for construction workers to be exposed to impacted soils. A significant proportion of OLM impacts will remain, which are mobile and are a source of COCs to groundwater, but less than Alternative 4. NAPL monitoring and recovery wells will monitor NAPL migration offsite. RAOs and applicable VAP standards are partially met with this alternative. This alternative will have moderate impacts to site workers and the community during excavation and offsite hauling of impacted soils and will require phased construction due to the excavation depth and active operations on and/or adjacent to the site.

# 4.3.2.6 Alternative 6: OLM/TLM Excavation, In Situ Stabilization, NAPL Monitoring and Recovery, Institutional and Engineering Controls

Excavation of OLM/TLM-impacted soil in the upper 20 feet and stabilization of impacted soils to a maximum depth of 55 feet bgs will mitigate the potential for site and construction workers to be exposed to impacted soils during maintenance or future infrastructure improvements. Use of ISS to address OLM-impacted soils allows for a larger proportion of source material to be addressed as compared to excavation. OLM impacts will not remain. RAOs and applicable VAP standards are met with this alternative. This alternative is expected to result in a greater reduction in the potential for NAPL migration and COC leaching to groundwater. This alternative will have moderate impacts to site workers and the community during excavation and offsite hauling of impacted soils, and will require phased construction due to the excavation depth and active operations on and/or adjacent to the site.

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**SECTION 5** 

# References

AECOM. 2010a. VAP Phase I Property Assessment, Duke Energy West End Site 646 Mehring Way, Cincinnati, Ohio. May 10.

AECOM. 2010b. Ohio Voluntary Action Program (VAP) Phase II Property Assessment Report Duke Energy West End Site 646 Mehring Way, Cincinnati, Ohio. December.

Burns and McDonnell, 2014. Remedial Action Completion Report, West End Site. July.

CH2M HILL Engineers, Inc. (CH2M). 2017. VAP Phase II Site Assessment Phase 3 and Former Tower Areas. November.

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Tables

Table 1. VAP Applicable Standards and Remedial Considerations Phase 3 and Tower Areas, West End Subject Areas

Cincinnati, Ohio		The second secon	The second secon				
Applicable Standard*	Media	Pathway/Exposure Route	Receptor	Comment	Standard Currently Met?	Remediation Consideration <sup>b</sup>	Regulatory Reference
VAP GNS and GNS with MCA	Soil	Direct contact, ingestion, inhalation of particulates	Current and future land users	Must consider relevant standards related to current and reasonably anticipated future land use and potential receptors: Residential, Commercial, Industrial, and Construction Worker scenarios.	ON	Remedy required for current and future users (active remediation and restrictions likely).	OAC 3745-300-08
POGWMPUS	Groundwater	Future groundwater users	Groundwater resources	This is an anti-degradation rule that protects currently unimpacted groundwater from future degradation.	No		OAC 3745-300-10 (D)
Potable groundwater use standards	Groundwater	On-site potable and non-potable groundwater users	Current and future land users	Groundwater must meet VAP unrestricted potable use standards (UPUS).	o <sub>N</sub>		OAC 3745-300-08
Non-potable groundwater use standards   Groundwater	s Groundwater	On-site non-potable groundwater users	Current and future land users	Non-potable use of groundwater must pose no unacceptable risk to receptors.	N <sub>O</sub>	required as described in OAC	OAC 3745-300-09
NAPL standard	Groundwater	Potable, non-potable groundwater users and ecological resources	Current and future land users and offsite users, Ohio River	Potable, non-potable groundwater users and [Current and future land users and [VAP rules (3745-300-08(B)[2)] indicate that the presence of NAPL on ecological resources	ON	Implementation of these actions may include removal of NADI active	OAC 3745-300-08
Groundwater response requirements	Groundwater	Contact with groundwater through applicable potable and non-potable groundwater uses	Current and future onsite and offsite groundwater receptors (e.g., Ohio River)	Response requirements are based on groundwater classification, source of the contaminants to lostle, offsite, or mixed) and resente of an urban setting designation. Additionally, groundwater exceeding UPUs that emanates into a surface water body adjoining the property triggers assessment of impacts to the surface water body.	No; to be determined.	emediation, and institutional or engineering controls.	OAC 3745-300-10
Surface water standards	Surface Water	Ecological resources	Current and future offsite users, Ohio River	Evaluated through sampling and analysis and (if needed) an ecological risk assessment, following VAP rules.	to be determined	These have not been evaluated.	OAC 3745-300-07
Pathways/exposure routes not considered by GNS or UPUS	Soil, Groundwater, and/or Soil Gas	Soil, Groundwater, and/or All potentially complete pathways, if any, not coll Gas  Considered in GNS or UPUS calculations	not Current and future land users	Evaluated through sampling and analysis and (if needed) a human health risk assessment, following VAP rules, for current and reasonably anticipated future land uses.	No; to be determined.	These have not been evaluated.	OAC 3745-300-09
Nation.							

Notes:

Note: See Super Chemical Generic Numerical Standard
MCA – Multiple Chemical Adjustment
MCA – Multiple Chemical Adjustment
POCWMPUS. – Protection of Coundwater Meeting Potable Uses Standards UPUS. – Unrestricted Potable Use Standards
\* Oetermination of applicable standards are discussed in OAC 3745-300-07 (PJ[S].

\* Remediation considerations are based on evaluation of the individual applicable standard noted for each consideration.

Yes (for baseline comparison) Retained (Y/N) Yes Yes Yes Yes ž, 2 Yes 2 Yes Yes 2 ž Yes 2 2 ž Low to Moderate Low to Moderate Low to Moderate Relative Cost Moderate No cost 3 5 High 103 10 10 High Low 5 ₩ H Permitting and approvals are need prior to implementation, and analytical testing will be required to determine an appropriate facility. Dewastering may be required prior to transport Thermal treatment is not considered to be angiementable at this sate as hearing furge volumes of verying fill and clay solis over extended periods to resents potential settlement issues and associated risks to structures and active gas piping. No ethicks

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Ready-energy control and a sell ISS of sand and gravel solds below 60 feet using soil mix augers is challenging and requires a stee-specific diffing evaluation. Smaller dannels useres and large amounts of diffing fusics (grout) are hybridaly required to achieve these depths, resulting in greater than 50% spoils generation. Readily implementable and necessarily a part of any alternative that does not consist of clean closure. Election means of addressing BOLO of mitigating potential excessive to professional assets of page processing and professional assets by hostistician comments are soften as the profession of the page professional comments are as a page professional comments and page professional comments are as a page professional comments and page professional comments are as a page professional comments and page professional comments are as a page professional comments and page professional comments are as a page professional comments and page professional comments are as a page professional comments and page professional comments are as a page professional comments and page professional comments are as a page professio Plathyre is impact on assisting boal contractor and malerials, and would have minimal impact on assisting also structures and activities. Recovery have constituted in surface of its ecovery program will likely require long term of malerials and malerials. ISS is technically and administratively feasible and is a commonly used treatment betwooking to MED sites Localified contributions and equipment are available reponally. Schaufface obstructions and structures could inno the suitability of this equipment in some areas or require prior removal or No efficient at reducing boddy, modelly, or volume for any media.

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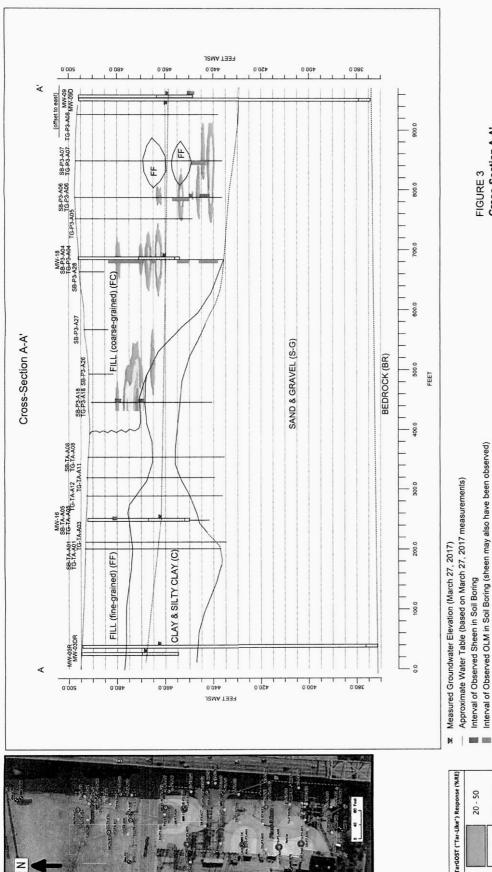
May CAVILA-Amperded sol within the fit and day latent to the depth up to 60 feet in situ with solidifying responts using target dismate may select not sure with solidifying response to single target dismates may be to 60 feet in situ with solidifying response to single target dismates may be to contact with contaminated soil, thereby containing the contact with contaminated soil, thereby containing the impacted soils in a solidified matrix with limited groundwater. No remedial, evestigative, or monitoring activity.

Covenants, conditions, and restrictions, including groundwater
use restrictions, excernation restrictions, and vapor intusion
minister overshabitions for future structure construction or
occupancy. implementation of a long-term risk management plan for future intrusive activities necessary to support origoing facility operations, maintenance, and improvements Continuous permeable trench with NAPL collection piping and recovery risers to intercept DNAPL impastion and allow for recovery by pumping. Excavation of soil and subsurface structures containing OUM and/or TLM above the water table. Excavated soils transported off-site for local permitted landfill disposal. Monitor wells over time to evaluate presence, concentrations, and migration of contaminants. Extraction we'lls used to ball or pump separate phase DNAPL, to the surface for collection and offsite disposal. Physical barrier placed around contaminated area to prevent access and alert to potential hazards. Excavation of soil containing OLM below the water table. Excavated soils transported offsite for local permitted landfill disposal. injection or perculation of a flushing solution into the soil requiring remediation in order to increase the mobility of the confaminants. The mobilized confaminants and flushing Milize aerobic or anaerobic bacteria and/or other nicroorganisms to breakdown organic constituents nsportation and disposal roved off-site landfill. In-Situ Thermal Treatment of OLM/TLM-Impacted Soil NAPL Recovery - Wells (Passive or via Auger Soil Moring - Deep APL Recovery - Trench Situ Soil Fluishing pical Treatment Site Fending /Signs -Situ Stabilization lixing - Shallow able Covers Site Landfill Buud able 2. Remedial Technology Screening hate 3 and Tower Areas, West End Subject General Response Action

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	Militarie exponer that exceed applicable standards for the workers, the persent, and construction workers.	obses not mitigate potential exponue for for alter workens, trespensers, or construction workers to all customed QUAP Commercial/Industrial and construction? Received With Commercial/Industrial and construction?		Objects not miligate potential exposure for for the vice worken, trespanent, or construction workers to safe expressing VAP Commercial/Industrial and Construction/Streams Worker (Orld.)		Dees and militate puterious espoure for for size workers, trespessers, or construction workers to sold exceeding VAP Commercial/Industrial (NE)		eith of expouse k miligated through the excession of impacted sofs within the potential construction worker one (10g 207)		within of exposure is mitigated through the excession of impacted soft within the potential construction worker sone (top 20?)		
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Compilance with BAOs and Applicable VAP Standards	eMiligate potential for COCs in soil to leach into grandwater	a closes not reduce, there, or contain source material that has the potential to leach COCs is a proaches are:		• Once not reduce, treat, or contain source material that has the proceeds it is leading OOS, to groundwater	•	Does not reduce, treat, or contain source material that has the potential to leach     (OX to grounds are:	•	eleborar potential for COCs to leach to groundwater through the escandism of source material in the top 70. No identified contamination deeper than 20 on other		electures potential for COCs to leach to groundwater through the excending of source material in the top 20". No identified contamination deeper than 20 on ide.		
	Militate NAV impacts to groundwater and the codesital for maration of NAV office.	* Does not reduce, treat, or contain NAP,		Does not reduce, treat, or contain NAPI.		Down not enthure, treat, or contain NAVT.		Medium potential for NAPI, migration by removing source material in the top     XP. No identified NAPI below 30 intentified on site.		extension potential for NAPT, magnetion by removing source material in the top 20. No identified NAPT, below 20' identified on site.		
	Milgate potential future exposure to impacted groundwater for potable and non-potable uses	Alternative does not include any measures to intligate potential future exposure     In groundwater		Abbrevioles does not include any measures to militare potential future reposure to approximate to a providence.		Abbreviolative door not include any measures to militate potential future exposure in groundwater		<ul> <li>Enough the implementation of instrutional controls, including deed restriction, this atemative substantish intigates potential future exposure to impachel groundwater.</li> </ul>		<ul> <li>Through the implementation of entitytional control. Including their entitytion, the afternative substantials whigher potential share reposure to entact of proud anter.</li> </ul>		188
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ā	Short form Effectiveness	An execution of the property of the second sec		<ul> <li>An input I commodity within a management accorded with implementation of this distriction, however, committees as an indicated with the distriction as incommendate action, are implemented.</li> </ul>		in the legal is commet, writen or intercent accidate the inclinated in the defendable of the Adentifier, beautiful states are inclinated accident to the desirable as not interested action are inclinated as in the defendable as not interested action are inclinated.	•	a ingeneration of this development of require cheer conclusion with faithy operation both to consciously express and express and the second consciously development of the property of the development regimen of their promote of consciously cheek principies of the property of the development regimen of their transport of consciously the American the second control of the development of the second consciously the matter of the principle of the second control of the second control of providents are resistant.	the passes of	to exploration that destinate and asset into includes and that person bits for controlled and the second of the entire the controlled and the entire the controlled and the entire the entire that the entire the entire that	111	
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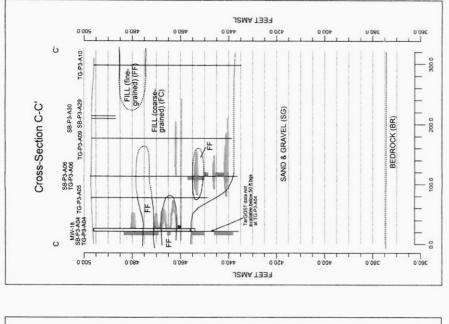


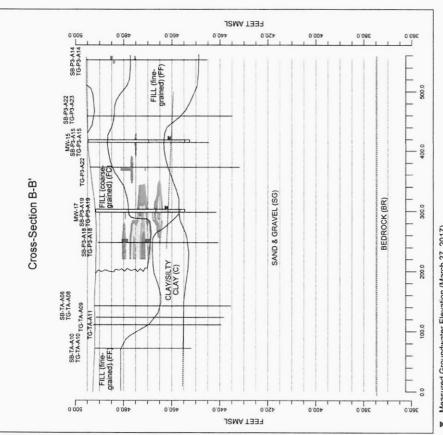
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General Stratigraphy:
The first of the consists primarily of clays, sills, sands, some gravel
FC - coarse-grained fill; consists primarily of concrete, brick, wood, slag, cinders, with sand, silt, gravel, some clay
C - claysisity clay
C - Sand & gravel: varying intervals of sandy gravel and gravelly sand
BR - bedrock

Cross-Section A-A'
Remedial Alternatives Analysis Report
Duke West End Site - Phase 3 and Tower Areas
Cincinnati, Ohio







▼ Measured Groundwater Elevation (March 27, 2017)

- Approximate Water Table (based on March 27, 2017 measurements)
  - Interval of Observed Sheen in Soil Boring
- Interval of Observed OLM in Soil Boring (sheen may also have been observed)

rGOST ("Petro-Like") Response (%RE)

200 - 500

20 - 50

TarGOST ("Tar-Like") Response (%RE

General Stratigraphy:

For inequalization of clays, silts, sands, some gravel
FC - coarse-grained filt, consists primarily of concrete, brick, wood, slag, cinders, with sand, silt, gravel, some clay
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C - claysisity clay
FG - sand & gravel: varying intervals of sandy gravel and gravelly sand
BR - bedrock

50 - 100

20 - 50

Remedial Alternatives Analysis Report Duke West End Site - Phase 3 and Tower Areas Cincinnati, Ohio Cross-Sections B-B' and C-C' FIGURE 4