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Corrective Action Plan

Kuhlman Electric Corporation Facility
Crystal Springs, Mississippi

MDEQ Order No. 4449-02

29 October 2010

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Our Ref.:
LA002889.0001.00001

Date:
29 October 2010

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AS	Air Sparge
bgs	Below Ground Surface
CAP	Corrective Action Plan
COC	Chemical of Concern
CSM	Conceptual Site Model
CT	Carbon Tetrachloride
ft/day	feet per day
ft/ft	foot per foot
ft/year	feet per year
HASP	Health and Safety Plan
ISCO	In-situ Chemical Oxidation
KEC	Kuhlman Electric Corporation
K_{oc}	Organic Carbon-to-Water Partitioning Coefficient
K_{ow}	Octanol-to-Water Partitioning Coefficient
MDEQ	Mississippi Department of Environmental Quality
MNA	Monitored Natural Attenuation
O&M	Operations and Maintenance
PCB	Polychlorinated Biphenyls
PLC	Programmable Logic Control
PVC	Polyvinyl Chloride
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
ROI	Radius/Radii of Influence
SIM	Selected Ion Method
SVE	Soil Vapor Extraction
TRG	Target Remediation Goal
µg/L	Micrograms per Liter
USEPA	U.S. Environmental Protection Agency
VOC	Volatile Organic Constituent/Compound

1. Introduction

This Corrective Action Plan (CAP) describes activities to remediate groundwater impacts from the Kuhlman Electric Corporation (KEC) facility (the site) located in Crystal Springs, Mississippi (Figure 1). The KEC facility was constructed in the 1950s and has operated as an electric transformer manufacturing plant since that time. The future of the property is expected to remain industrial. This CAP was prepared in response to the Mississippi Commission on Environmental Quality Order No. 4449-02, issued to KEC on July 23, 2002. A preliminary groundwater assessment was performed at the KEC facility in 2004 (Martin & Slagle 2004) and was followed by a comprehensive assessment completed in 2009 (Martin & Slagle 2009). The assessments found that polychlorinated biphenyls (PCBs) were not migrating to groundwater but that certain volatile organic compounds (VOCs) associated with the manufacturing processes were, notably, 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethene (1,1-DCE), and 1,4-dioxane. The assessments identified a VOC plume extending southwest from the KEC site. This CAP addresses remediation of the source area and the VOC impacts to groundwater.

1.1 Objectives/Rationale

As described in the groundwater assessment report (Martin & Slagle 2009), the source of groundwater contamination at the KEC site has been identified beneath the southwest corner of the KEC manufacturing building (Figure 2). Soil beneath the floor slab in this area contains the following chemicals of concern (COCs): 1,1,1-TCA, 1,1-DCE, 1,4-dioxane, and carbon tetrachloride (CT). The approximate extent of soil impacts is shown on Figure 3. Contaminants have migrated downward through unconsolidated sediments to groundwater. Contaminant migration has continued via the groundwater flow pathway off the facility property to the southwest with a portion of the plume also moving south (Figure 4). The 1,1-DCE plume extends approximately 2,800 feet southwest and 2,600 feet south of the KEC property boundary (Figure 5). The smaller 1,4-dioxane plume is contained within the limits of the 1,1-DCE plume.

The general objective of corrective action for VOC impacts to groundwater at the KEC site is to mitigate the risk of any potential COC exposure to human and environmental receptors above risk-based standards. Specific objectives are the following:

1. Ensure COC concentrations in soil and groundwater in the contaminant source area beneath the KEC manufacturing building are at levels protective of site workers.

2. Reduce COC concentrations in soil in the contaminant source area beneath the KEC manufacturing building to the extent that remaining concentrations no longer contribute to, or exacerbate, COC concentrations in off-site groundwater.

3. Reduce COC concentrations in off-site groundwater to be protective of downgradient groundwater receptors.

To achieve these objectives, this CAP proposes to design, construct, and operate an air sparging (AS) and soil vapor extraction (SVE) system in the contaminant source area beneath the KEC manufacturing building to reduce COC concentrations in on-site soil and groundwater. Monitored natural attenuation (MNA) is proposed for the off-site groundwater contaminant plume to track the expected decrease in COC concentrations in groundwater resulting from the reduction of COCs in the contaminant source area beneath the KEC manufacturing building. This CAP also includes contingencies for expanding active treatment into the off-site plume, as necessary, to ensure MNA is viable.

2. Conceptual Design

ARCADIS is proposing an adaptable remedy that will be designed to meet the risk based clean up objectives for the source area beneath the KEC manufacturing building and groundwater plume in a reliable and cost effective manner. This section of the CAP provides an overview of the proposed remedy’s conceptual design. In order to better understand the design basis for the proposed remedy, a concise summary of the Conceptual Site Model (CSM) is provided in Section 2.1. The CSM has been used to define the extent of soils and groundwater that will be subject to treatment by the proposed remedy (Section 2.2). The anticipated effectiveness of applicable remediation technologies ARCADIS considered for addressing soil and groundwater impacts will be further discussed in Section 2.3. An overview of the proposed remedial approach, developed based on current understanding of site conditions and technology effectiveness expectations, is provided in Section 2.4. A discussion of the pre-design activities that will be performed in order to validate the viability of the proposed approach and guide the subsequent installation and implementation requirements is presented in Section 2.5.

2.1 Conceptual Site Model

In order to understand how the proposed remedial approach will be used to meet the closure objectives for this project, it is important to understand how the current extent of COC impacts have evolved in light of site-specific conditions. The CSM provides a basis for understanding the nature and extent of COC fate and transport, and identifies how these impacts can potentially affect receptors. It depicts the site and its environment(s) and delineates potential chemical sources, chemical release and transport mechanisms, affected media, migration routes, and potential human and ecological receptors. Ultimately the CSM provides a framework for problem definition and aids in the identification of data gaps. More importantly, it identifies key exposure pathways and associated media on which to focus assessment and remediation activities. Those elements of the CSM considered most applicable to understanding the extent of cleanup and establishing the basis for the proposed remedy are discussed below. This information has been condensed from the investigation data. The information provided in this report is the basis for this short data summary and the conceptual site model descriptions below.

2.1.1 Site Geology and Hydrogeology

The geology of the site consists of unconsolidated sediments to approximately 111 feet below ground surface (bgs). Silts and clays of low plasticity occupy the upper horizons (2 to 16 feet bgs) and are underlain by interbedded fine sands, sandy gravel, silty sand, and thin layers of plastic clay.

The water table at the site exists at approximately 62 feet bgs in the unconsolidated sediments. Groundwater flow is to the southwest and south with an average hydraulic gradient of 0.0032 foot/foot (ft/ft). Hydraulic conductivities range from 7.5 to 44 feet per day (ft/day) with an average of 27 ft/day based on slug tests. Vertical gradients are minimal.

The City of Crystal Springs has five municipal wells screened in the upper, unconsolidated aquifer and located 2,400 feet to 7,200 feet south and southwest of the KEC site. Pumping of these municipal wells does affect the groundwater flow direction within the study area. Two other municipal water supply wells are located farther to the southeast and are screened in the lower aquifer. These two deeper municipal wells do not appear to influence the groundwater flow in the upper aquifer.

2.1.2 Nature and Extent of Contamination

A series of site assessments were conducted between 2004 and 2008 to define the nature and extent of contamination in the study area. The assessments included soil, groundwater, and soil gas sampling. The impacts identified are related primarily to the use of 1,1,1-TCA at the KEC site.

Compounds detected in soils above unrestricted Mississippi Department of Environmental Quality (MDEQ) Target Remediation Goals (TRGs) are limited to the source area located beneath the KEC facility and are the following: 1,1,1-TCA, 1,1-DCE, 1,4-dioxane, and CT.

1,1-DCE is a breakdown product of 1,1,1-TCA and 1,4-dioxane is a compound that was a commonly used as a stabilizer in 1,1,1-TCA. The primary source compound, 1,1,1-TCA, has attenuated to concentrations below TRGs in both soil and groundwater. Figure 3 depicts the approximate lateral extent of all COC impacts in soil above TRGs. The extents are based primarily on 1,1-DCE concentrations, because 1,4-dioxane and CT are limited to detections in individual direct push borings contained within the bounds of the 1,1-DCE delineation.

The soil vapor survey results generally correlate with the vadose zone soil results and supplement the delineation of potential soil sources that could result in vapor intrusion or soil-to-groundwater contaminant migration.

Compounds detected in groundwater above TRGs beneath the KEC facility are the following: 1,1-DCE, 1,4-dioxane, 1,1,2-trichloroethane (1,1,2-TCA), and 1,2-dichloroethane (1,2-DCA).

Figure 4 depicts the approximate lateral extent of all groundwater impacts to groundwater exceeding TRGs within the study area. The extents are based primarily on 1,1-DCE and 1,4-dioxane concentrations, because the 1,1,2-TCA and 1,2-DCA constituents attenuate in groundwater to concentrations below TRGs prior to reaching the property boundary. The only compounds currently off site above TRGs in groundwater are 1,1-DCE and 1,4-dioxane. The 1,1-DCE plume extends from the KEC property west approximately 2,800 feet and southwest approximately 2,600 feet, whereas the 1,4-dioxane plume generally resides within the limits of the 1,1-DCE plume (Figure 5). Groundwater is impacted to depths of 85 to 100 feet bgs.

Previous investigations have determined that the average total porosity of the unconsolidated aquifer sediments is 43% (Martin & Slagle 2009). Groundwater flow and advective contaminant transport occurs through the migratory, interconnected pore spaces, commonly termed the mobile or effective porosity. During plume advancement, dissolved VOCs migrating in groundwater through the interconnected mobile pore spaces diffuse into the immobile pore spaces. No site-specific data for mobile porosity have been collected, but based on the lithology types encountered, it is reasonable to assume the average (mobile or effective) porosity, indicative of groundwater transport, likely ranges between 10 and 20%. The average groundwater flow velocity, based on average hydraulic conductivity, gradient, and anticipated mobile porosity values, is approximately 250 feet per year (ft/year). Actual dissolved contaminant plume velocities are typically much less, depending on a variety of fate and transport mechanisms (e.g., adsorption, retardation, biodegradation, and diffusion) governed in part by site conditions and chemical characteristics. For this study area, the velocity of the 1,1-DCE plume is migrating at a much slower rate than groundwater. 1,4-Dioxane on the other hand is miscible in water, and has a relatively low partitioning coefficient (K_{oc}), so it does not exhibit significant sorption to organic matter in the aquifer matrix. Moreover, 1,4-dioxane does not biodegrade significantly under natural conditions; consequently, its primary attenuation mechanisms in groundwater are dispersion and dilution. As a result of these characteristics, the 1,4-dioxane plume, while also slower than groundwater, is likely advancing at a faster rate than the 1,1-DCE plume.

The highest core concentrations of 1,1-DCE and 1,4-dioxane are currently located off site, approximately 400 to 600 feet downgradient in the vicinity of Monitor Wells MW-11A/B and MW-15A/B. Concentrations of 1,1-DCE are approximately 7 to 15 times the TRG of 7 micrograms per liter (µg/L) in this core while concentrations of 1,4-dioxane are generally only 2 times the TRG of 6.09 µg/L. Concentrations in the KEC site source area and at the toe of the plume are generally stable to decreasing; however, the core of the mass appears to be moving within the study area.

1,1-DCE and 1,4-dioxane were detected in the Crystal Springs municipal Well No. 7 in November 2005. Well No. 7 was subsequently shut down and the remaining municipal wells and combined influent water supply flow to the municipal treatment plant have been monitored monthly since that time. Over the course of the monthly monitoring program, 1,1-DCE and 1,4-dioxane have been detected at concentrations below laboratory reporting limits in groundwater from Well No. 1. The detections in Well No. 1 have all been below the 1,1-DCE and 1,4-dioxane TRGs. No 1,1-DCE or 1,4-dioxane has ever been detected in the combined influent water supply line to the water treatment plant. The COC concentrations in sentinel Monitor Wells MW-25 and MW-27, installed upgradient of the water supply wells, have been declining or non-detect since shutting down Well No. 7. Sampling of sentinel well MW-26 identified COC detections below laboratory reporting limits (and below TRGs) in this well in 2009 and 2010. The COC concentrations in this well have historically been below laboratory detection limits. In response to the apparent rise in COC concentrations, sentinel wells MW-28 and MW-29 were installed in 2009. Sampling of these two sentinel wells has not identified detectable COCs in groundwater at these locations. Based on the evaluation of spatial and temporal COC trends in the sentinel wells, it appears there may be a contributing source to 1,1-DCE and 1,4-dioxane groundwater impacts located between the off-site groundwater plume originating from the KEC site and the municipal well field. Further investigation of this unrelated source will need to be conducted by MDEQ or the third party (or parties) responsible for this source, which is unrelated to the KEC plume.

During the previous groundwater assessments, petroleum hydrocarbons (benzene and naphthalene) were detected above their TRGs in groundwater from MW-19 and in Waterloo Profiler samples collected at/near the intersection of US Highway 51 and West Georgetown Street. The petroleum hydrocarbon detections are likely attributable to the present and historical commercial gasoline stations located in the vicinity of these sample locations and are not associated with the KEC plant activities. Further investigation and/or remediation of these petroleum impacts will need to be conducted by MDEQ or the parties responsible for these impacts.

2.1.3 Exposure Pathway Considerations

Exposure can occur only when the potential exists for a receptor to directly contact released constituents or when a mechanism exists for the released constituents to be transported to a receptor. Without exposure, there is no risk. All potential exposure pathways for the site have been combined into an integrated and dynamic exposure model. The exposure pathway evaluation presented on Figure 5 indicates potentially complete and incomplete pathways and represents the cumulative information needed to evaluate whether exposure pathways warrant further consideration. Complete pathways are designated by a solid dot, while an open space designates incomplete or minor pathways. The exposure pathway evaluation is based on site-specific information that combines information on primary sources of constituents, constituent release mechanisms, transport media, potential receptors, exposure routes, and potentially complete exposure pathways.

The VOC impacts in the upper groundwater aquifer of Crystal Springs stem from releases associated with the KEC manufacturing facility. The groundwater isoconcentration maps plainly show the beginning of the plume of VOCs starting at the southwest corner of the KEC manufacturing facility. The VOCs migrated downward through the sands beneath the KEC manufacturing facility until they reached the upper groundwater aquifer. Migration continued via the groundwater flow path to the southwest.

2.2 Extent of Cleanup

ARCADIS proposes defining the corrective action extents based on the current understanding of impacts and in a manner that is consistent with the CAP objectives. The approximate extent of aggregated soil and groundwater impacts subject to this CAP are presented on Figures 3 and 4. From a geographic perspective, ARCADIS proposes implementing a remediation strategy that will satisfy (1) on-site objectives related to treatment of the source area impacts to soil and groundwater beneath the KEC manufacturing facility floor, and (2) off-site objectives pertinent to mitigation of groundwater impacts related to the KEC site. These objectives are further explained in Section 1.1 and Section 5.

2.3 Proposed Technologies

In support of developing this CAP, ARCADIS screened a range of applicable remediation technologies for treatment of the COCs in question. There are multiple remediation technologies involving treatment via physical, chemical, and biological processes that could be employed to meet anticipated remediation objectives for the study area. However, given the relative magnitude and extent of impacts, physical constraints posed by the source location, and the subsurface geology, many of these technologies are either less desirable or cost-prohibitive relative to others capable of delivering comparable results. The relative distribution and extent of 1,4-dioxane impacts beneath the KEC manufacturing facility floor are of note due to the physical and chemical characteristics of 1,4-dioxane, which is a relatively recalcitrant compound to treat. As a result, many of the individual technologies, which would otherwise be capable of addressing the source area COCs at the KEC site and the off-site 1,1-DCE plume, may have limited applicability toward treating the 1,4-dioxane. Implementation of multiple technologies may be necessary in order to achieve all of the CAP objectives.

Technologies aimed at addressing the source area will be designed to address both soil and groundwater as an aggregate media, with performance objectives based on achieving the restricted Tier 1 TRGs (for industrial sites). The source area soils will be treated to the extent required to ensure the numerical groundwater standards can be met, and reliably maintained following treatment, at the KEC property boundary. The technologies aimed at addressing the off-site groundwater impacts will be designed to meet the numerical groundwater standards for Tier 1 unrestricted TRGs as described in Section 5.

ARCADIS has identified a subset of technologies that are best suited for meeting the CAP objectives based on experience with remediation of similar projects. The following provides an overview of how and why these technologies are being proposed for this project.

2.3.1 Soil Vapor Extraction

ARCADIS anticipates the use of SVE for purposes of direct physical treatment of the source area (impacted, unsaturated zone soils) beneath the KEC manufacturing facility building, as well as air sparging as a complementary technology. Based on the understanding of geologic conditions, ARCADIS anticipates that the underlying soils are amenable to successful and effective application of this technology. This technology is also well suited to treat the majority of the COCs that are either directly, or indirectly affecting groundwater quality beneath and downgradient from the KEC manufacturing facility building, with 1,4-dioxane being the possible exception. Further considerations are summarized as follows:

- Application of SVE to treat the source area will have an immediate impact on reducing the concentrations of 1,1-DCE and CT in soils.

- The 1,1,1-TCA soil concentrations do not presently exceed the Tier 1 TRGs for soil; however, its daughter products (1,1,2-TCA and 1,2-DCA) are currently exceeding the Tier 1 TRGs for groundwater on site. One of its daughter products, 1,1-DCE, also exceeds Tier 1 TRGs for groundwater off site. The 1,1,1-TCA is also highly susceptible to treatment by SVE. Accordingly, the SVE technology will further reduce any residual 1,1,1-TCA concentrations, and will likely have an immediate indirect impact on the ability to achieve the on-site treatment objectives for 1,1,2-TCA and 1,2-DCA, as well as the off-site treatment objectives for 1,1-DCE.

- SVE is expected to have a moderate to high impact on removing 1,4-dioxane from the soils beneath the KEC manufacturing facility building. This COC typically migrates through soil and enters groundwater rapidly because it has a relatively high solubility and boiling point, and a low octanol-to-water partitioning coefficient (i.e., Log K_{ow}) and Henry's Law constant. When it is present in soil, however, its physical properties indicate that it is volatile enough to be removed in situ using SVE, even though its vapor pressure is lower than many other VOCs. The observed extent of 1,4-dioxane in soils above the Tier 1 TRG is limited to one borehole location. Given the magnitude and extent of 1,4-dioxane impacts in the source area (unsaturated zone soils), ARCADIS anticipates that by deploying this technology to remediate the other VOCs (i.e., 1,1-TCA, 1,1-DCE, 1,1,2-TCA, and 1,2-DCA), SVE will also mitigate the residual 1,4-dioxane concentrations in the unsaturated zone soils such that the qualitative risk-based treatment objective for 1,4-dioxane can be achieved.

2.3.2 Monitored Natural Attenuation

ARCADIS anticipates that MNA will play an instrumental role in this project. Given the current size of – and relatively low concentrations within – the off-site plume, to the extent MNA can be demonstrated to be reliable; it may prove more desirable than a more aggressive, active treatment technology. Further considerations are summarized as follows:

- Typically MNA relies upon one or more of several naturally occurring physical processes, including advection, dispersion, dilution, diffusion, volatilization, sorption/desorption, as well as naturally occurring biodegradation or chemical transformation reactions.

- The off-site 1,1-DCE plume appears to be stable at this time. ARCADIS anticipates that the predominant mechanisms for further reducing concentrations of 1,1-DCE will be the physical MNA processes, although to a lesser extent biological degradation to vinyl chloride and chemical transformation to carbon dioxide may continue to play a role in the natural attenuation of this COC.

- The off-site 1,4-dioxane plume appears to be unstable at this time. This COC is not particularly susceptible to biological degradation. Therefore, the MNA strategy for 1,4-dioxane will require reduction of the source area concentrations to meet the objectives of the cleanup goal. This will in turn reduce the potential for ongoing contributions to the off-site plume. Absent an ongoing source, the off-site 1,4-dioxane plume is expected to stabilize, followed by declining magnitude and extent of impact over time.

- Ultimately whether or not more active off-site treatment is warranted will depend upon (1) the ability of the source area remedy to reduce concentrations of the source area COCs to the extent the off-site plumes become stable, and (2) once determined stable, whether or not naturally occurring processes are able to continue to reduce the overall footprint of the plumes over a reasonable time period. Even if active treatment of the off-site plumes is warranted, MNA will still play a critical role in reducing the scale/scope of any off-site in-situ remedy.

2.3.3 Air Sparging

ARCADIS anticipates the use of in-situ AS for purposes of direct physical treatment of dissolved phase COC impacts beneath the KEC manufacturing facility building, with potential expansion, as necessary, to help treat selected areas of the off-site COC plumes. Based on our understanding of hydrogeologic conditions, we anticipate aquifer impacts at the site are amenable to successful and effective application of this technology. It is also well suited to treat the majority of the COCs that are currently exceeding the TRGs for groundwater, both on and off site, with 1,4-dioxane being the possible exception. Further considerations are summarized as follows:

- Application of AS beneath the KEC manufacturing facility building will have a direct and immediate impact on reducing the concentrations of 1,1-DCE, 1,1,2-TCA, and 1,2-DCA.

- The AS technology will have limited to moderate impact on the dissolved phase 1,4-dioxane concentrations. Once 1,4-dioxane becomes dissolved in water it is relatively difficult to treat. This COC has only recently come under scrutiny and evaluation by regulatory agencies; as a result, the track record for in-situ treatment within the environmental industry is relatively limited. Ongoing studies by the environmental industry as a whole tend to suggest there are few technologies available to effectively and consistently remediate 1,4-dioxane in situ.

- Nonetheless, some studies have shown moderate success at treatment by AS. ARCADIS has actually been able to demonstrate significant reductions (between 50 and 80%) in dissolved phase 1,4-dioxane concentrations at other sites by using this technology. Ultimately, we expect that the successful application of AS to treat the 1,4-dioxane will be constrained by site-specific considerations. At this time it is reasonable to assume that AS could prove successful at reducing the source area concentrations to the extent that off-site MNA is sustainable and CAP objectives can be met.

2.4 Remedial Approach

During the technology screening process, those technologies which were determined to be potentially effective were grouped and sequenced in a manner designed to meet the project objectives. The proposed grouping, sequence, and implementation of multiple technologies are considered as remediation alternatives. ARCADIS also evaluated several alternatives, based primarily on their relative ability to reliably satisfy all CAP objectives. Supplemental evaluation criteria were also considered, namely:

1. Relative short-term and long-term treatment effectiveness of the individual technologies and the overall reliability of the aggregate alternatives.

2. Relative complexity of implementation with respect to physical access, site-specific constraints, stakeholder limitations, and regulatory considerations.

3. Relative cost considerations as they relate to overall lifecycle cost, capital expenditure, operation, maintenance, and monitoring costs, technology contingency costs, and potential cost uncertainty.

Ultimately the remedial alternatives evaluation was used to refine the technical basis and rationale for the proposed remedial approach set forth in this CAP. ARCADIS is proposing a risk-based, adaptive approach to remediation of the source area beneath the KEC manufacturing facility building and the off-site groundwater impacts. The remainder of this CAP provides the framework for how the proposed approach will be implemented, including an overview of the anticipated schedule, pre-design requirements, performance monitoring expectations, and a discussion of key project milestones and the decision process used to make implementation or operation decisions (e.g., whether or not contingency plans warrant implementation).

As stated in Section 2.3, all of the proposed technologies have limitations in application or efficiency. Therefore, knowing the advantages and limitations to a particular technology and using them selectively or in sequence is crucial. ARCADIS anticipates that technology sequencing will prove to be a critical component to the overall strategy of meeting closure objectives for this project. The overriding strategy will be to apply and sequence remediation technologies in a manner that maximizes the treatment efficiency and focuses primarily on treating the COCs and hydrostratigraphic units that are contributing to off-site risks, while balancing remedy costs over the lifetime of the project.

The two primary drivers for off-site risk are 1,1-DCE and 1,4-dioxane. The off-site 1,1-DCE plume appears to be stable. The off-site 1,4-dioxane plume, while less extensive in area than the 1,1-DCE plume, appears to be increasing in size/extent. It is important to reiterate that the 1,4-dioxane plume concentrations are only slightly above the Tier 1 TRG. Given the current state, extent, and configuration of the off-site plumes, ARCADIS is proposing a relatively aggressive approach toward remediation of the source area impacts, coupled with an adaptive MNA approach for the off-site plumes.

The proposed approach is outlined as follows:

1. Design, install, and operate an AS/SVE system to treat soil and groundwater impacts in the source areas beneath the KEC facility building and on the KEC property.

   – The primary treatment objective of this technology will be to treat the VOC-impacted source area beneath the building responsible for the off-site 1,1-DCE plume.

   – This technology may only have a limited impact on reducing the 1,4-dioxane concentrations in the source area. However, given that downgradient 1,4-dioxane concentrations are only slightly exceeding the Tier 1 TRGs, AS/SVE in the source area may mitigate future 1,4-dioxane contributions to the off-site plume.

   – The source area AS/SVE system will be designed, constructed, and operated in a manner designed to achieve aggressive treatment goals. The SVE remedy component will target a minimum pore volume exchange rate throughout the source area soils of approximately one pore volume per day. The AS component will target complete/overlapping treatment of the impacted extent of the saturated zone in the upper aquifer.

2. In the event more aggressive source area treatment is needed to control/mitigate the off-site COC contributions to groundwater, ARCADIS will recommend implementation of a contingency treatment technology in the source area to further treat any recalcitrant COCs (e.g., 1,4-dioxane). Source area in-situ chemical oxidation (ISCO) may be considered as a contingency technology, implementation of which will be dictated or refined based on the success of the physical (i.e., AS/SVE) treatment efforts.

3. Rely on MNA initially for the off-site plumes.

   – The success of the overall remedy will depend largely on how the off-site plume responds to aggressive source area treatment. During the initial period of performance, off-site monitoring will be used to further assess whether or not COC concentrations stabilize (in the case of 1,4-dioxane), remain stable (in the case of 1,1-DCE), and/or demonstrate an appreciable decline in concentration in response to the on-site efforts.

- This monitoring period will also be used to evaluate and further assess how pumping operations by the Crystal Springs water system are affecting plume migration.

4. In the event off-site MNA is not a viable long-term solution, expand the in-situ technologies to treat off-site groundwater. In-situ treatment of the off-site plumes will be considered a contingency alternative; actual implementation of AS/SVE and/or an alternative technology will depend in part on technology demonstration/performance in the source area.

5. The need for off-site treatment will likely be determined based on the stability of the 1,4-dioxane plume as source area treatment with AS/SVE progresses. If it turns out the 1,4-dioxane plume is not stabilizing in a manner amenable to long-term MNA, in-situ measures will be considered to treat the off-site plume to the extent necessary to ensure MNA viability.

2.5 Pre-design Requirements

As will be discussed in Section 5, the remediation objectives are based primarily on achieving unrestricted Tier 1 TRGs in groundwater, with the expectation that on-site soil treatment will be performed to the extent groundwater objectives can be met. While ARCADIS anticipates unrestricted Tier 1 TRGs for soils will be readily met during implementation of this remedy, we further expect that it will be necessary to conduct a more thorough risk evaluation in order to definitively rule out the need for quantitative, numerical cleanup goals for soils. Following MDEQ's approval of this CAP, a more thorough Tier 2 risk evaluation will be performed to develop site-specific, restricted TRGs for soils. Preliminary expectations are that any restricted Tier 2 soil TRGs developed during this evaluation will be higher than the current concentrations observed on site.

As discussed in Section 2.4, the recommended approach relies upon aggressive source area in-situ treatment using AS/SVE. In order to adequately design and implement these technologies, ARCADIS proposes a pilot study for purposes of refining the design criteria that will be used to determine AS/SVE well placement, injection and extraction flow requirements, mechanical and electrical component needs, and other operational considerations. The AS/SVE pilot study will entail installation of an AS/SVE well pair and several pilot observation wells. Short-term step testing, using temporary skid mounted equipment, will be used to estimate achievable AS treatment extents (i.e., radii of influence [ROIs]) at a range of pressures and flows. Step testing will also be used to determine achievable vacuum ROIs under a range of applied vacuums and extraction flow rates from the SVE well. The vacuum observations will be used to estimate pneumatic conductivity of the vadose zone soils. The pneumatic conductivity will be used, in turn, to model extraction flow requirements, and refine full-scale SVE well placement, in order to achieve optimal pore volume exchange rates throughout the source area treatment extents. The pilot test will also be used to conservatively assess potential VOC emission rates during full-scale operation of the AS/SVE system. These data will be used to assess emission permit requirements in context of allowable thresholds and to determine if and how emission controls need to be factored in to the full-scale design.

3. System Components

A variety of system components will be used in the various areas requiring remediation. A general description of these components is provided in the subsections below. The actual construction details, and the extent to which these components are installed, will be refined during the ensuing design effort. Additional consideration will need to be given to access constraints posed by installation in an active manufacturing facility.

3.1 AS Wells

ARCADIS is proposing source area treatment of groundwater using in-situ AS. While the exact placement and number of AS wells required in the source areas is subject to pilot test determinations and KEC facility constraints, ARCADIS anticipates the source area remedy will require installation of approximately 23 AS wells, as shown on Figure 6. AS wells will be constructed with 2-foot long, machine slotted, screen intervals, installed to an approximate total depth of 90 feet bgs, and will target treatment of the impacted extent of the saturated unconsolidated sediments. Wells will be spaced in a manner designed to achieve overlapping AS treatment ROIs throughout the entire source area when operating under the optimal flow rates, as will be determined by the pilot test. Preliminary expectations are that the source area AS wells will be spaced approximately 35 to 40 feet apart, and that well locations/spacing will need to be adjusted to minimize obstructions to KEC manufacturing operations. The wells will be constructed using a combination of 1-inch and 2-inch diameter, Schedule 40 polyvinyl chloride (PVC) materials, and the annular borehole space above the well screens will be sealed using a compressed bentonite product with a high expansion ratio.

As described in Section 2.4 and Section 9, this remedy may require future expansion of AS treatment into off-site areas. In the event AS treatment is required downgradient, any AS wells installed in support of this type of expansion will be drilled and constructed similarly to the source area wells. However, these wells will likely be installed in a transect fashion, as opposed to the grid approach that is planned for the source area beneath the KEC manufacturing facility building. The transect orientation will entail placement of a line, or curtain, of AS treatment wells in a manner designed to intersect plume migration through areas (e.g., zones, depths) of preferential migration where the off-site contaminant mass flux is greatest.

3.2 SVE Wells

ARCADIS is proposing source area treatment of residual soil impacts using SVE. The SVE will also be used to capture vapors from the AS system. The exact placement and number of SVE wells required in the source areas will be subject to pilot test determinations and KEC facility constraints; however, at this time ARCADIS anticipates the source area remedy will entail installation of approximately 10 SVE wells, as shown on Figure 6. SVE wells will be constructed with 50- to 70-foot long, 2-inch diameter, stainless steel wire-wrapped well screen intervals and will be installed into the saturated reach of the upper aquifer, to an approximate total depth up to 80 feet bgs. Wells will be spaced in a manner designed to achieve overlapping SVE treatment ROIs throughout the entire source area when operating under the optimal flow rates, as will be determined by the pilot test. Preliminary expectations are that the source area SVE wells will be spaced approximately 70 to 80 feet apart, and that well locations/spacing will need to be adjusted to minimize obstructions to KEC manufacturing operations.

As described in Section 2.4 and Section 9, this remedy may require future expansion of AS/SVE treatment into off-site areas. In the event AS treatment is required downgradient of the KEC plant property, SVE wells will be installed as warranted to manage the collection of AS vapors. Any SVE wells required for this purpose will likely be drilled and constructed in a manner similar to the source area SVE wells.

Given the anticipated number of SVE wells, ARCADIS anticipates that vertical wells are the most desirable means for treating impacted soils, and collecting AS vapors. However, we also recognize that targeting treatment beneath the existing KEC facility building may present a number of physical implementation constraints. Upon the culmination of the pilot testing effort, and during the ensuing design, ARCADIS may re-evaluate whether or not horizontal or directionally drilled wells are a more cost-effective and less intrusive means for accomplishing the AS/SVE treatment objectives.

3.3 Engineered Treatment Systems

The AS/SVE system proposed by this CAP will entail forced air delivery and extraction using above grade electrical and mechanical systems. ARCADIS anticipates the design effort will fully evaluate how these systems can be installed within and/or beneath the active manufacturing facility without obstructing manufacturing operations. To the extent practical, we anticipate the well field piping systems will be installed overhead or above grade on pipe rack systems. AS distribution and SVE conveyance piping will be sized in a manner to minimize pressure and vacuum losses at the anticipated flow rates, and ARCADIS anticipates using centralized flow control and monitoring manifolds to distribute/collect air from the AS/SVE well field. The flow control manifolds will be co-located with the mechanical systems and individual well piping runs will be extended throughout the plant and connected to the individual wells.

The AS/SVE manifolds will be capable of monitoring, adjusting, and distributing flow from the entire SVE well network. The AS manifold will be equipped with automated pulsing capabilities. The SVE manifold will be capable of manually operated selective extraction in the event focused SVE extraction or cycling is warranted. The SVE equipment will collect extracted vapors from the manifold and convey them through a level controlled liquid separator and inlet filter installed prior to the blower inlet. A separate filter/silencer will be installed on the discharge side of the SVE blower and extracted vapors will be routed through a discharge stack. At this time, no emission control technologies are expected to be necessary; however, this will be further assessed during pilot testing and full-scale design of the AS/SVE system. The size and type of blower used will also be determined based on pilot test determinations. ARCADIS anticipates the SVE blower will be sized in a manner that will ensure adequate capacity for expansion should the need arise. The blower motor will be equipped with a variable speed drive, and the SVE control systems will be interlocked using process logic control (PLC) based programming.

The AS treatment system will be installed using a skid mounted compressed air package. The size and type of compressor used will be determined during the ensuing design effort, and will be specified in a manner to ensure the system is capable of providing higher flow in the event future expansion of the well field is necessary. Depending on the type of compressor used, the system will be equipped with coalescing filters, heat exchangers, and receiver tank components, as warranted, to ensure delivery of oil-free, clean, dry air to the AS injection manifold. The AS equipment operation, and well field pulsing controls, will be integrated into the SVE control panel. The AS/SVE control systems will be equipped with remote monitoring capabilities for purposes of communicating system status, alarm conditions, and basic real-time operating conditions.

4. Schedule

A Gantt chart showing the project schedule is provided in Appendix A. The activities listed in Appendix A are contingent on MDEQ approval of this CAP. Following approval of the CAP, ARCADIS will commence with the pre-design activities described in Section 2.5. The compliance monitoring program will be implemented right away and is not contingent on the pre-design activities. Preliminary expectations are that the pre-design activities will be completed within 3 to 6 months. The design of the full-scale source area AS/SVE system is expected to take another 3 to 9 months. Actual installation of the AS/SVE remedy will be performed by drilling and construction subcontractors, under direct oversight by ARCADIS. The construction planning, procurement, and installation process is anticipated to take between 3 and 9 months. ARCADIS anticipates that the source area remedy could be in operation by the end of the 2011 calendar year. Following installation of the AS/SVE system, ARCADIS will conduct periodic operation, maintenance, and performance monitoring on the source area systems. The performance monitoring program will be used to assess AS/SVE performance, which will in turn be used to (1) identify opportunities for optimization of the installed systems and (2) determine if implementation of the contingency treatment measures are necessary. The operation, maintenance, and monitoring period will continue through the duration of active treatment, until such time the treatment objectives for these systems have been met.

5. Remedial Goals

MDEQ has established risk-based soil and groundwater standards known as Tier 1 TRGs. VOC contamination in soil above the groundwater table is confined to the contaminant source area beneath the KEC manufacturing building. Maximum concentrations of 1,1-DCE, 1,4-dioxane, and CT detected in soil exceed unrestricted TRGs (Martin & Slagle 2009). Maximum concentrations of 1,1-DCE and CT also exceed restricted TRGs. Corrective action objectives for soil remediation in the contaminant source area (Section 1.1) include both reducing COC concentrations to reduce any potential on-site worker exposures and reducing COC concentrations to the extent that remaining concentrations no longer contribute to or exacerbate COC concentrations in off-site groundwater.

The KEC facility continues to operate and the site is expected to remain industrial in the future. Consequently, Tier 1 restricted TRGs may be appropriate for soil remediation in the contaminant source area to address any potential for worker exposure. Concentrations of COCs in soil that are protective of off-site groundwater have not been established. At this time, soil remediation to Tier 1 restricted TRGs is proposed as protective of both on-site workers and off-site groundwater. However, additional site-specific risk evaluation may be warranted to establish more appropriate remedial goals for soil in the contaminant source area at the KEC facility.

Concentrations of 1,1-DCE, 1,4-dioxane, 1,1,2-TCA, and 1,2-DCA in on-site groundwater beneath the contaminant source area currently exceed Tier 1 TRGs (Martin & Slagle 2009). However, only 1,1-DCE and 1,4-dioxane concentrations currently exceed Tier 1 TRGs in off-site groundwater. The corrective action objective for groundwater remediation in the on-site contaminant source area is to reduce COC concentrations to address any potential for on-site worker exposure (Section 1.1). The objective for off-site groundwater remediation is to reduce COC concentrations to address any potential downgradient groundwater receptors.

Currently, groundwater from the impacted upper, unconfined aquifer downgradient of the KEC facility is pumped for municipal use. Consequently, remediation to Tier 1 TRGs for off-site groundwater is appropriate. Remediation to Tier 1 TRGs may also be appropriate for on-site groundwater due to the close proximity of the contaminant source area to the property boundary. At this time, remediation to Tier 1 TRGs for on-site groundwater is proposed, although additional site-specific risk evaluation may be warranted to establish more appropriate remedial goals for on-site groundwater at the KEC facility.

6. Operation and Maintenance (O&M) Plan

An O&M plan for all AS/SVE treatment equipment will be prepared during the design of the treatment system. In addition to detailing system operating instructions, the O&M plan will detail equipment maintenance requirements. The level of detail will be sufficient for ensuring proper and efficient treatment throughout the life of the project. The O&M plan will include a system maintenance schedule, detailing manufacturer recommended mechanical and electrical maintenance requirements based on equipment hours of operation, and will also document equipment make, model, troubleshooting, and manufacturer contact information for all treatment system components. A copy of the O&M plan will be provided to MDEQ prior to the initiation of startup and full-scale operation of the AS/SVE system.

In the event supplemental treatment using ISCO is warranted, the O&M plan will be amended as appropriate to detail O&M requirements for the various ISCO components. The need for ISCO system O&M amendments will be re-assessed and prepared during the design of this remedy expansion and, if necessary, an amended O&M plan will be provided to MDEQ prior to initiation of ISCO activities.

7. Performance Monitoring Plan

The primary objective of AS/SVE operation is to remove as much COC mass from the subsurface as effectively as possible, thereby reducing or eliminating source loading to groundwater. Physical removal of COCs from the subsurface can be expected to progress in an asymptotic manner, with maximum removal rates observed during the initial treatment period, followed by decline to a lower threshold level that may or may not include detectable COC concentrations. Moreover, the rate of decline is expected to decrease over time. The AS/SVE system effectiveness will be determined by (1) the rate and magnitude of this decline, (2) the ability to obtain low-level or non-detectable COC concentrations in extracted vapors, and (3) the ability to reduce or eliminate residual COC source loading to groundwater.

Performance monitoring of the AS/SVE system will be conducted on a monthly basis for the first quarter of operations in order to (1) evaluate system operating characteristics, and (2) identify treatment optimization opportunities. Performance monitoring will entail measurement of individual SVE well extraction and AS well injection flow rates; separator liquid collection rates; system-wide extraction vacuum and temperature; system-wide injection pressure and temperature; individual SVE well emissions; and total SVE system emissions. Vapor samples will be collected from the SVE emission stack for laboratory analysis on a quarterly basis to track VOC air emission discharge rates and the cumulative mass of COCs removed. The treatment system will also be inspected to ensure reliable operation and performance in accordance with performance-based design specifications. Following the first three months of system operations, performance monitoring will be conducted on a quarterly basis.

Groundwater monitoring will also be conducted to evaluate AS/SVE system performance. Groundwater performance monitoring will use existing well MW-10A and two new wells to be constructed: MW-30 and MW-31 (Figure 7). As shown on Figure 7, these wells will be located near the downgradient boundary of AS/SVE system operation. New wells MW-30 and MW-31 will be constructed similarly to existing on-site groundwater monitor wells. That is, these wells will be constructed with 15-foot-long screened intervals located across the uppermost portions of the aquifer. As indicated during groundwater assessment activities (Martin & Slagle 2009), COC detections in groundwater occur near the top of the saturated zone near the contaminant source area. Groundwater monitoring for AS/SVE performance assessment will be coordinated with compliance monitoring as described in Section 8.

Performance monitoring data will primarily be used to verify that the AS/SVE system is performing properly. A comprehensive system performance evaluation will be performed semiannually in order to assess treatment progress toward meeting cleanup objectives. This semiannual evaluation will consider all data collected to date, estimate the total mass of COCs removed, and ultimately determine if AS/SVE is achieving cleanup objectives in a timely and cost-effective manner. Data collected monthly/quarterly will be evaluated and used to optimize system operational parameters during subsequent operation, maintenance, and monitoring events to maintain optimal system performance.

The AS/SVE system will be operated continuously until asymptotic mass removal rates have been achieved, or until groundwater cleanup objectives have been met. Post treatment monitoring will continue in order to assess rebound, and if additional treatment is necessary, either the system will be turned back on or technology enhancements may be implemented as appropriate.

8. Compliance Monitoring Plan

The goal of the Compliance Monitoring Plan is to demonstrate that groundwater with COC concentrations greater than the MDEQ Tier 1 TRGs is not migrating from the KEC property. This will be measured by sampling the groundwater at regularly scheduled intervals from the existing monitoring well network. A description of the monitoring network, the proposed sampling and analysis plan, and associated reporting effort are described in the following subsections.

8.1 Monitor Well Network

The existing groundwater monitor well network of 38 wells shown on Figure 2 was installed during previous groundwater assessment efforts (Martin & Slagle 2009). The existing network includes nine nested well locations for assessing the vertical distribution of COCs in the upper aquifer. Based on a review of the well network, groundwater monitoring results to date, and the remedial measures presented in this CAP, the existing well network appears sufficient as a compliance plan well network. At this time, no additional wells are proposed (other than wells MW-30 and MW-31 installed for AS/SVE performance monitoring purposes as described in Section 7). Also, no existing wells are proposed for abandonment. Table 1 summarizes construction details for all existing monitoring network wells.

Existing monitor wells located hydraulically upgradient of the contaminant source area that have not previously detected COC concentrations exceeding TRGs that may serve as background wells are (see Table 1 and Figure 7): MW-05, MW-07, MW-08, and MW-12.

Wells interior to the existing contaminant plume that may be used to assess changes in the plume as attenuation proceeds are (see Table 1 and Figure 7): MW-02, MW-03, MW-04, MW-06, MW-10A, -10B, and -10C, MW-11A and -11B, MW-15A and -15B, MW-17A and -17B, MW-18A and -18B, MW-20A and -20B, MW-21A and -21B, and MW-23A and -23B. Proposed new AS/SVE performance monitor wells, MW-30 and MW-31, will be sampled as in-plume wells with the list identified above.

Wells peripheral to the existing contaminant plume that may be used as sentinel wells to detect the migration of COCs outside the predicted area of containment are (see Table 1 and Figure 7): MW-09, MW-13, MW-14A and -14B, MW-16, MW-19, MW-22, MW-24, MW-25, MW-26, MW-27, MW-28, and MW-29.

8.2 Sample Parameters and Schedule

Previous groundwater sampling has detected 1,1-DCE and 1,4-dioxane in off-site monitor wells at concentrations exceeding Tier 1 TRGs. Background and in-plume wells will be sampled to evaluate contaminants and breakdown products to evaluate natural attenuation progress. Sentinel wells will be sampled to detect the migration of COCs outside the predicted area of containment. Samples will be analyzed for VOCs using U.S. Environmental Protection Agency (USEPA) Method 8260B with analysis for 1,4-dioxane using the USEPA Method 8270C selected ion method (SIM). Compliance monitoring will be conducted on a semiannual basis for a minimum period of 2 years using all existing and newly constructed wells. At that time, the compliance monitoring program will be reviewed and adjustments may be proposed, including the reduction or addition of monitor wells and potentially changes in the monitoring frequency to annual sampling.

8.3 Compliance Reporting

Groundwater data collected during the performance and compliance monitoring programs will be summarized and reported to MDEQ within 60 days of receiving all off-site analytical laboratory results from any individual compliance monitoring event. The reporting effort will also summarize remediation system performance data collected during the associated monitoring period.

9. Contingency Plan

Previous sections of this CAP have discussed contingency technologies and/or treatment expansion considerations in the event the proposed source area AS/SVE and off-site MNA strategy requires augmentation. This section of the CAP provides a concise overview of the anticipated contingency measures that may be employed to ensure CAP objectives are met. The performance and compliance monitoring programs described in Sections 7 and 8 will provide the framework for evaluating how the proposed remedy is performing. Data from the performance monitoring program will be assessed primarily for purposes of determining if the as-built AS/SVE systems are meeting the on-site treatment objectives for soil and groundwater. These data will be used first and foremost to identify opportunities for optimizing or enhancing the on-site AS/SVE system. Every effort will be exhausted to maximize the treatment benefits from the existing systems before expansion is considered. If AS/SVE expansion beyond the source area is warranted, the data from the performance monitoring and compliance monitoring programs will be used to identify the likely areas where mass flux contributions to the off-site plume are located. Additional well installations and delineation may also be used to refine the extent to which these systems should be expanded.

Use of an additional in-situ treatment technology in the source area, following AS/SVE, or to treat off-site groundwater may be also required at some point during this project. The performance and compliance monitoring programs will be used to assess whether or not supplemental treatment using a contingency technology is necessary. ARCADIS may also propose supplemental pilot testing and/or bench scale treatability testing to evaluate how and where such a technology will be most effectively applied in order to meet the CAP objectives.

Prior to implementation of any of these contingencies, ARCADIS will work with the MDEQ and other project stakeholders to ensure the proposed alternatives and path forward remains in line with expectations for how the CAP objectives will ultimately be met.

10. Quality Assurance Project Plan (QAPP)

Following approval of this CAP, ARCADIS will prepare and submit a QAPP. The QAPP will provide a description of all data quality objectives and procedures that will be associated with sample collection, laboratory analysis, monitor and treatment well installations, installation of AS/SVE system components, treatment system O&M, and quality assurance (QA) responsibilities associated with this project. The QAPP will be prepared in accordance with the requirements and guidelines established by the USEPA and MDEQ for data collection, analysis, and management, and will integrate quality assurance/quality control (QA/QC) procedures for all field and laboratory activities. All project personnel and subcontractors shall strictly adhere to it throughout the course of remedy implementation. A copy of the QAPP will be provided prior to implementation of the proposed remedy, and periodic amendments will be provided as necessary to account for remedy enhancements over the course of the project.

11. Health and Safety Plan (HASP)

Following approval of this CAP, and prior to implementation of any field work, ARCADIS will prepare a project specific HASP. All project personnel and subcontractors shall strictly adhere to it throughout the course of remedy implementation. The HASP will be periodically reviewed and amended as necessary prior to construction events or other events that can have an adverse impact on human health or the environment.

12. References

Martin & Slagle. 2004. “Preliminary Groundwater Assessment Report; Kuhlman Electric Corporation, Crystal Springs, Mississippi.” Prepared for BorgWarner Inc., by Martin & Slagle GeoEnvironmental Associates, LLC.

Martin & Slagle. 2009. “Groundwater Assessment Report; Kuhlman Electric Corporation, Crystal Springs, Mississippi.” Prepared for BorgWarner Inc., by Martin & Slagle GeoEnvironmental Associates, LLC. April 2009.

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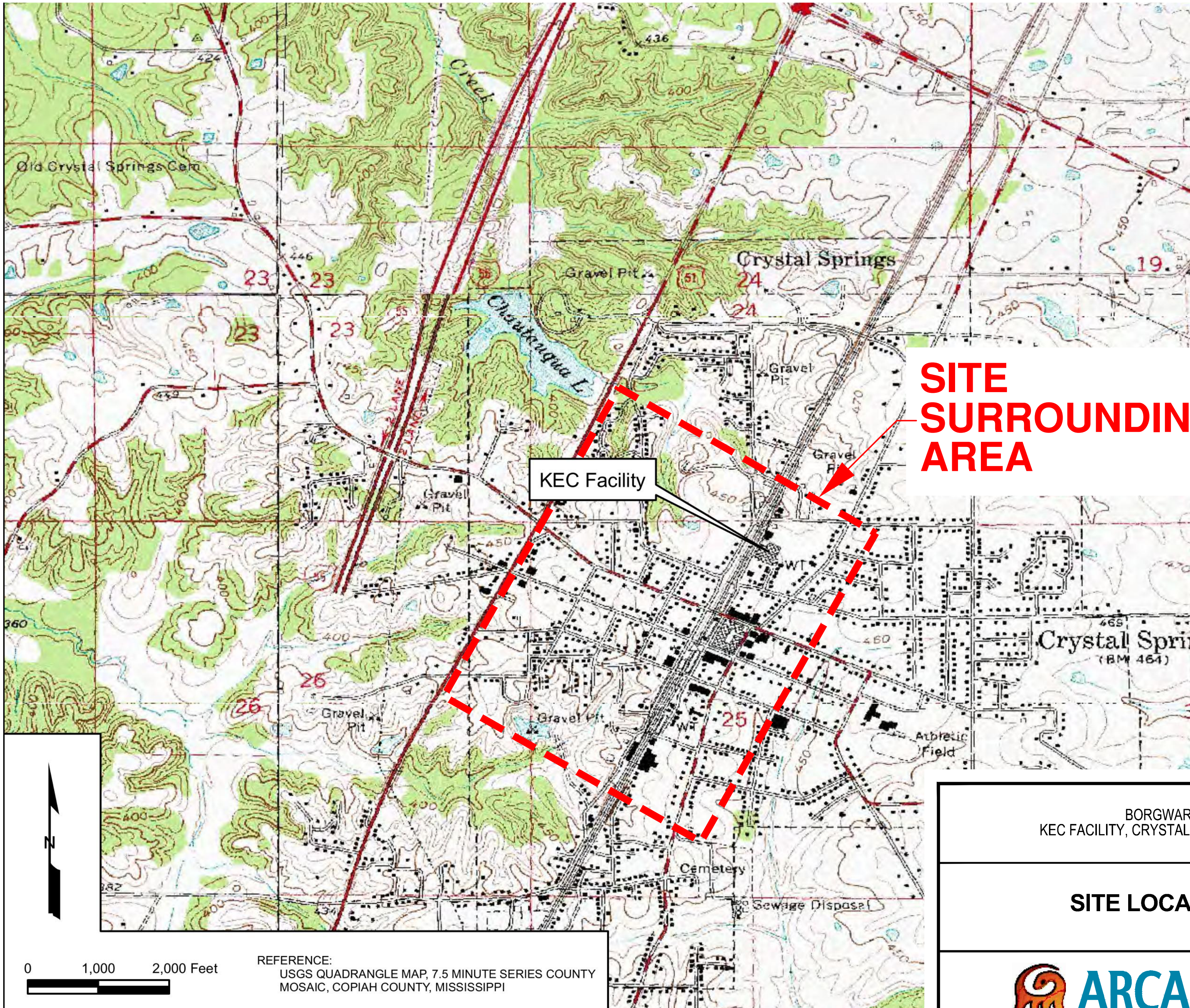
Table 1.
Monitor Well Network Summary, Corrective Action Plan for the KEC Facility, BorgWarner Inc.
Crystal Springs, Mississippi.

Well No.	Date Installed	Screen Length (ft)	Screen Interval (ft bgs)	Depth of Surface Casing (ft bgs)	Ground Surface Elevation (ft msl)	Top of Casing Elevation (ft msl)	Monitoring Objective
MW-1	3/11/2004	15	58-73	•	467.76	467.47	Well abandoned March 2005
MW-2	3/16/2004	15	57-72	•	465.59	465.23	Interior Plume Trends
MW-3	3/18/2004	15	59-74	•	458.70	458.32	Interior Plume Trends
MW-4	3/17/2004	15	55-70	•	465.82	465.67	Interior Plume Trends
MW-5	3/18/2004	15	18-33	•	457.02	456.55	Perched Water Zone, Upgradient/Background
MW-6	3/25/2004	15	43-58	•	457.61	457.28	Interior Plume Trends
MW-7	3/24/2004	15	51-66	•	463.00	462.70	Upgradient/Background
MW-8	3/26/2004	15	47-62	•	455.04	454.46	Upgradient/Background
MW-9	3/3/2005	15	61-76	•	470.21	470.03	Sentinel Well
MW-10A	7/7/2007	10	62-72	•	471.25	470.95	AS/SVE Performance, Interior Plume Trends
MW-10B	7/7/2007	5	76-81	•	471.25	470.78	Interior Plume Trends
MW-10C	7/17/2007	5	94-99	90	471.25	470.97	Interior Plume Trends
MW-11A	7/5/2007	10	75-85	•	470.46	470.08	Interior Plume Trends
MW-11B	7/18/2007	5	100-105	95	470.46	470.01	Interior Plume Trends
MW-12	6/4/2007	10	65-75	•	465.65	465.35	Upgradient/Background
MW-13	7/7/2007	10	62-72	•	465.38	465.12	Sentinel Well
MW-14A	6/8/2007	10	69.5-79.5	•	464.20	464.03	Sentinel Well
MW-14B	6/11/2007	5	97-102	•	464.20	463.99	Sentinel Well
MW-15A	6/18/2007	10	65-75	•	467.53	467.29	Interior Plume Trends
MW-15B	6/20/2007	5	86-91	•	467.53	467.29	Interior Plume Trends
MW-16	6/5/2007	10	55-65	•	460.51	460.24	Sentinel Well
MW-17A	6/28/2007	10	60-70	•	460.31	460.02	Interior Plume Trends
MW-17B	6/28/2007	5	83-88	•	460.31	460.04	Interior Plume Trends
MW-18A	6/25/2007	10	62-72	•	459.95	459.46	Interior Plume Trends
MW-18B	6/26/2007	5	80-85	•	459.95	459.67	Interior Plume Trends
MW-19	6/6/2007	10	85.5-95.5	•	454.38	454.02	Sentinel Well
MW-20A	6/22/2007	10	57-67	•	462.41	462.12	Interior Plume Trends
MW-20B	6/21/2007	5	100-105	•	462.41	462.00	Interior Plume Trends
MW-21A	7/2/2007	10	58-68	•	459.00	458.72	Interior Plume Trends
MW-21B	7/16/2007	5	88-93	85	459.00	458.65	Interior Plume Trends
MW-22	6/12/2007	10	85.5-95.5	•	447.92	447.54	Sentinel Well
MW-23A	6/15/2007	10	35-45	•	440.61	440.12	Interior Plume Trends
MW-23B	6/14/2007	5	79-84	•	440.61	440.41	Interior Plume Trends
MW-24	7/5/2007	5	77-82	•	433.41	433.14	Sentinel Well
MW-25	7/13/2007	10	98-108	•	451.26	450.95	Sentinel Well
MW-26	6/13/2007	10	92-102	•	459.61	459.37	Sentinel Well
MW-27	7/17/2007	10	99-109	•	433.48	433.56	Sentinel Well
MW-28	11/2/2009	30	80-110	•	463.10	462.82	Sentinel Well
MW-29	11/3/2009	25	81-106	•	460.47	459.82	Sentinel Well
MW-30	Installation Pending	•	•	•	•	•	AS/SVE Performance, Interior Plume Trends
MW-31	Installation Pending	•	•	•	•	•	AS/SVE Performance, Interior Plume Trends

Notes:
ft = feet
ft bgs = feet below ground surface
ft msl = elevation in feet above mean sea level
• = information does not exist or is not applicable under the defined parameters



0 1,000 2,000 Feet

REFERENCE:
USGS QUADRANGLE MAP, 7.5 MINUTE SERIES COUNTY MOSAIC, COPIAH COUNTY, MISSISSIPPI

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KEC FACILITY, CRYSTAL SPRINGS, MISSISSIPPI

SITE LOCATION MAP

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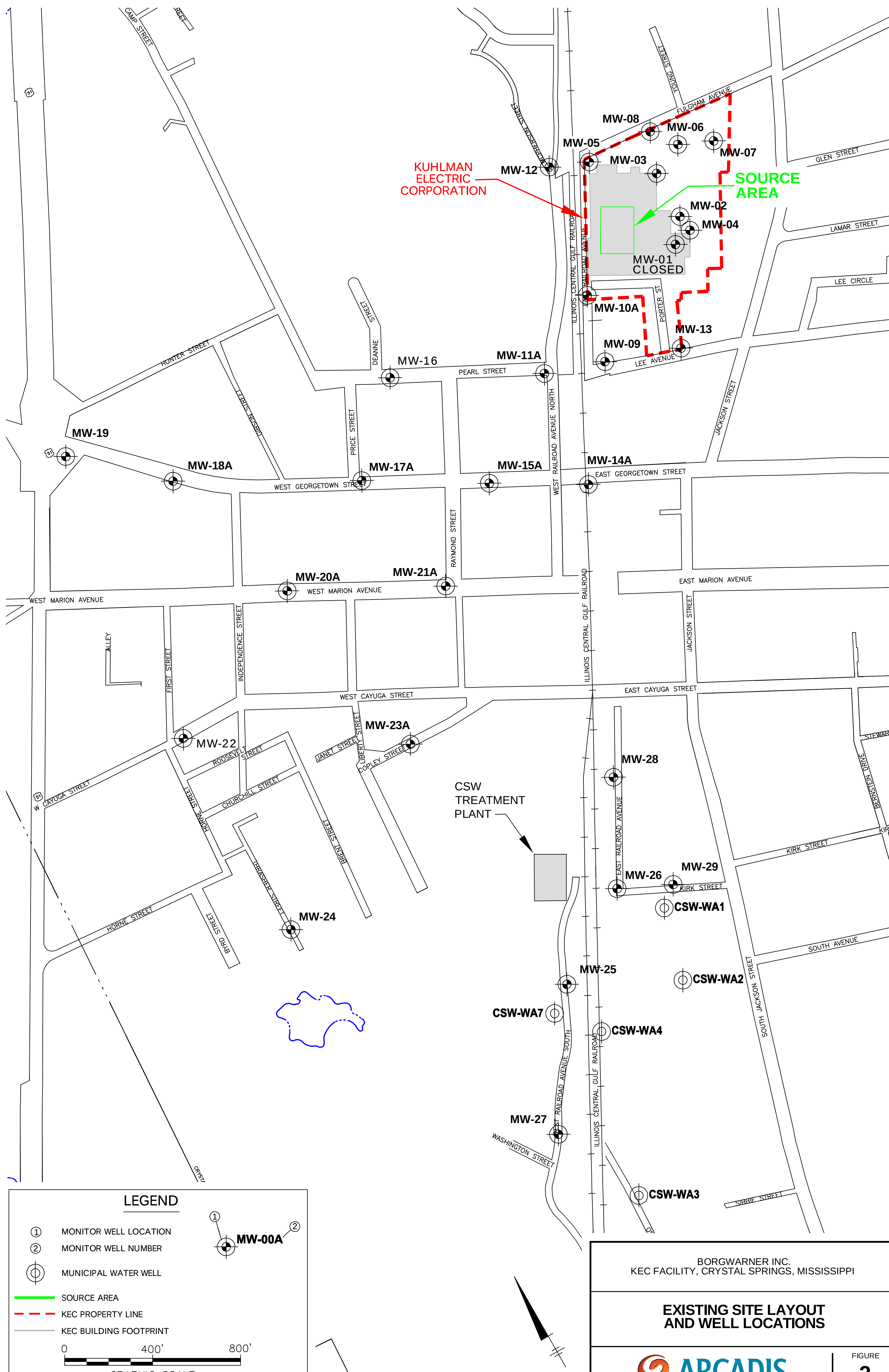
FIGURE
1



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KEC FACILITY, CRYSTAL SPRINGS, MISSISSIPPI

EXISTING SITE LAYOUT AND WELL LOCATIONS

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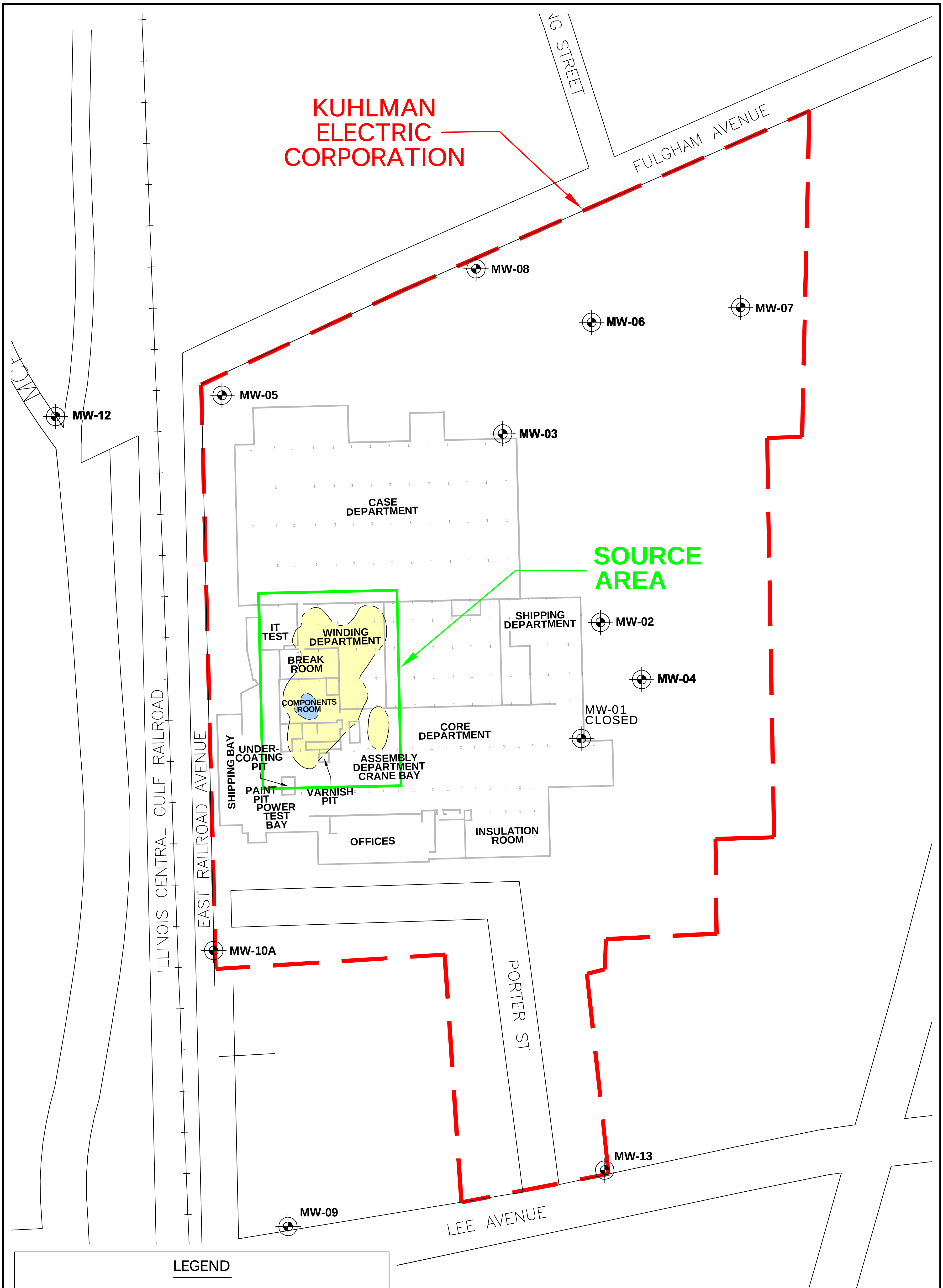
FIGURE
2



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EXTENT OF SOURCE AREA SOIL IMPACTS

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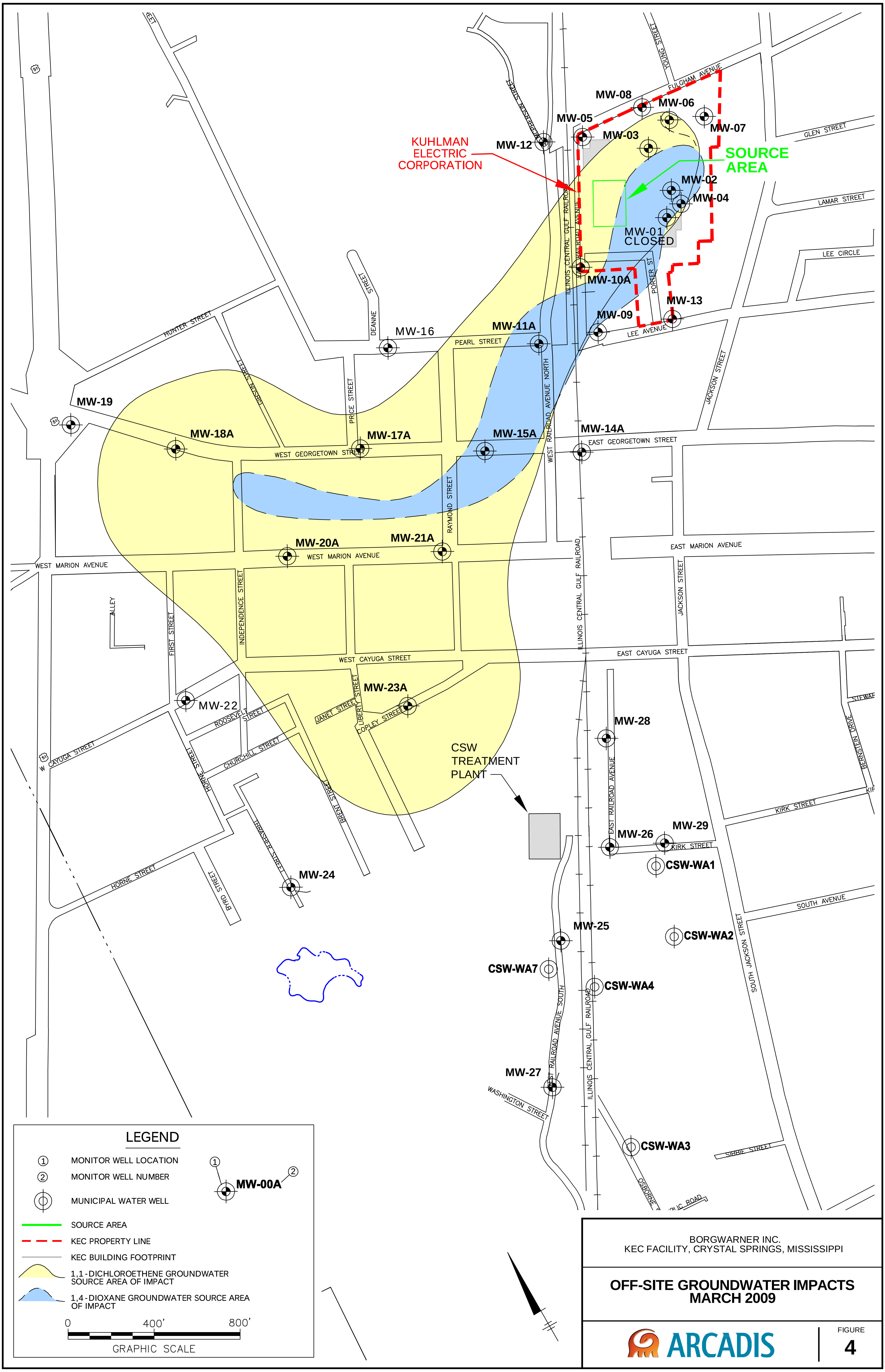
FIGURE 3



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OFF-SITE GROUNDWATER IMPACTS
MARCH 2009

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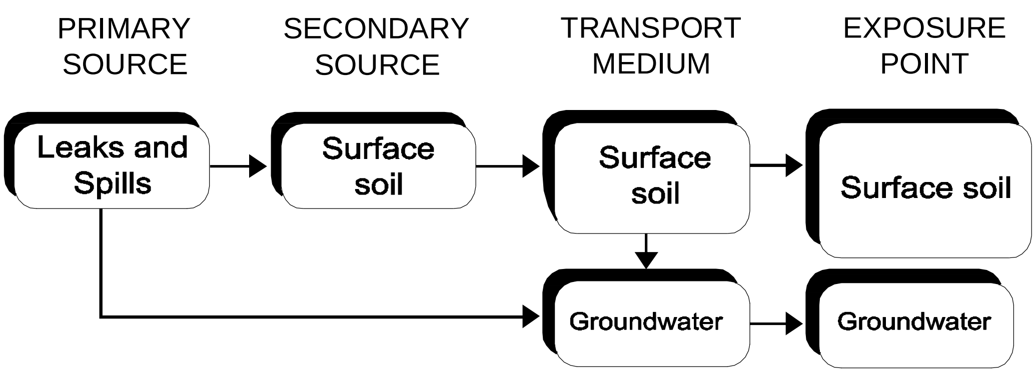
FIGURE
4

EXPLANATION

● Current or Hypothetical Future Complete Exposure Pathway
○ Incomplete Exposure Pathway



POTENTIAL RECEPTORS

EXPOSURE POINT	EXPOSURE ROUTE	HUMAN – CURRENT – SITE WORKER	HUMAN – CURRENT – RESIDENTIAL RECEPTOR	HUMAN – FUTURE – SITE WORKER	HUMAN – FUTURE – OFF-SITE RESIDENTIAL RECEPTOR	BIOTA – TERRESTRIAL	BIOTA – AQUATIC
Surface soil	Oral	●	○	●	●	○	○
Surface soil	Dermal	●	○	●	●	○	○
Surface soil	Inhalation	●	○	●	●	○	○
Groundwater	Oral	○	○	○	●	○	○
Groundwater	Dermal	○	○	○	●	○	○
Groundwater	Inhalation	●	○	●	●	○	○

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PRELIMINARY EXPOSURE PATHWAY ASSESSMENT

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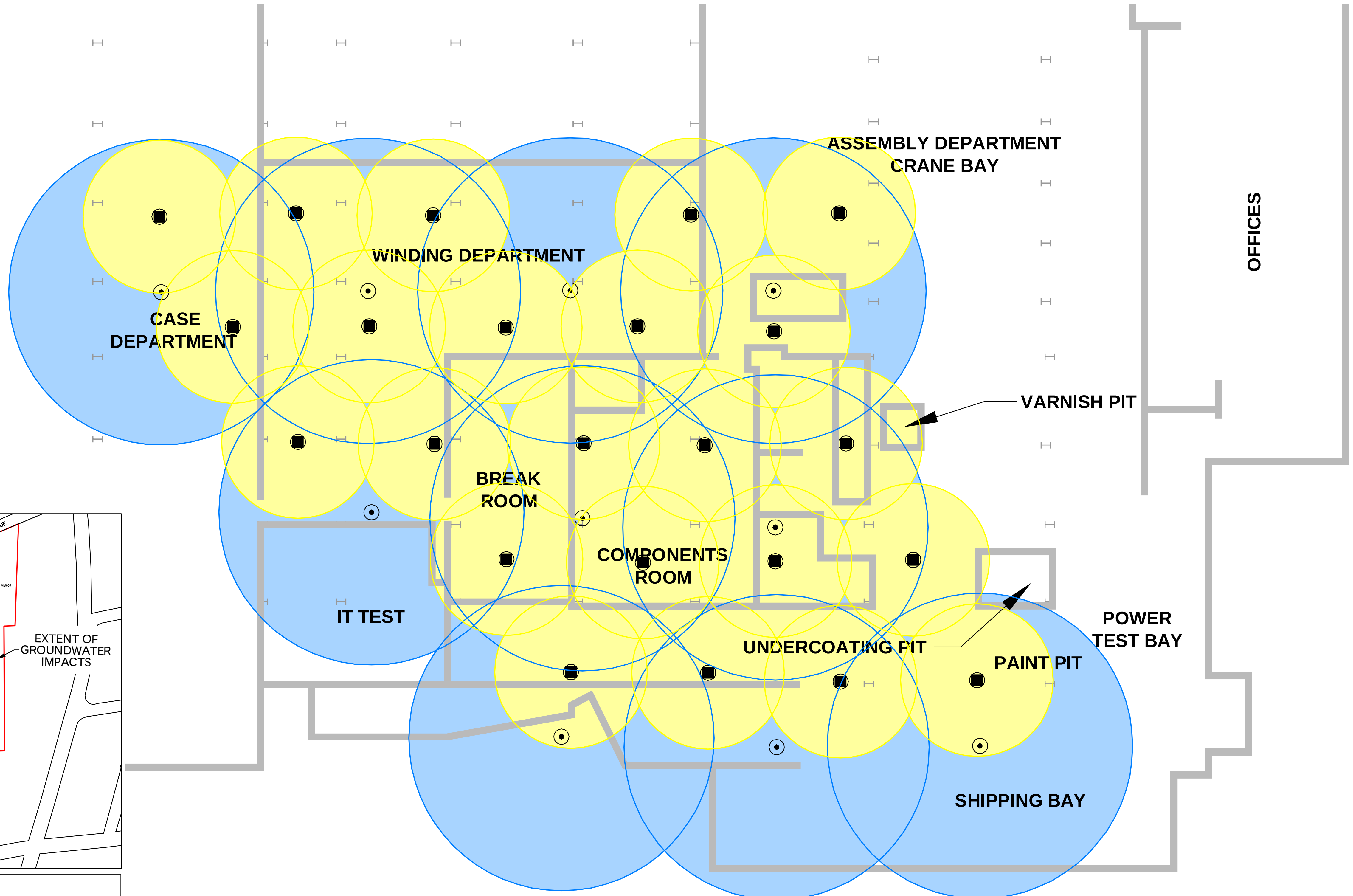
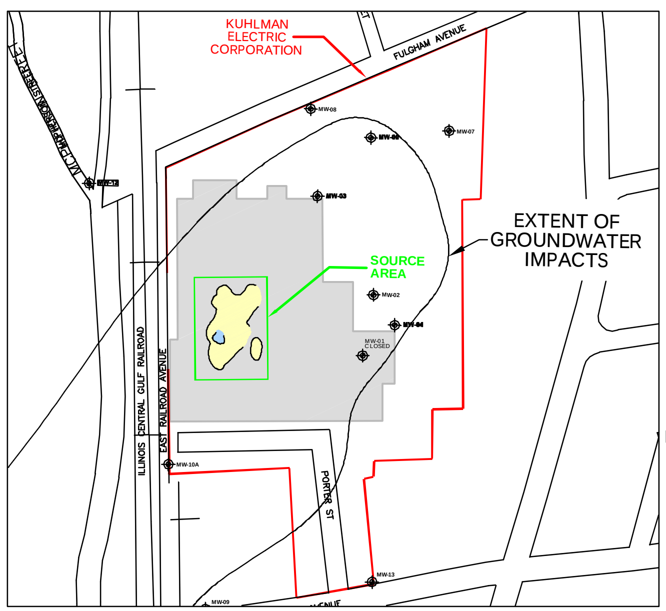
FIGURE 5





LEGEND

- BUILDING OUTLINE AND INTERIOR PARTITIONS
- INTERIOR COLUMNS
- SOIL VAPOR EXTRACTION WELL
- AIR SPARGE WELL
- SVE WELL RADIUS-OF-INFLUENCE (40')
- AIR SPARGE WELL RADIUS-OF-INFLUENCE (20')

0 30' 60'

GRAPHIC SCALE

FLOOR PLAN - KEC PLANT

NOTE:

THE TREATMENT OBJECTIVE IS TO COMPLETE COVERAGE OVER THE SOURCE AREA WITH OVERLAPPING AS/SVE TREATMENT ROIs. THE WELL LOCATIONS AND SPACINGS DEPICTED ON THIS FIGURE ARE CONCEPTUAL. ACTUAL WELL LOCATIONS WILL BE DETERMINED DURING THE DESIGN. OFFSET LOCATIONS AND DIRECTIONAL OR HORIZONTAL DRILLING METHODS MAY BE NECESSARY IN ORDER TO OVERCOME ACCESS CONSTRAINTS AND MINIMIZE OBSTRUCTIONS TO ACTIVE MANUFACTURING OPERATIONS.

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CONCEPTUAL LAYOUT FOR AS AND SVE WELL INSTALLATIONS

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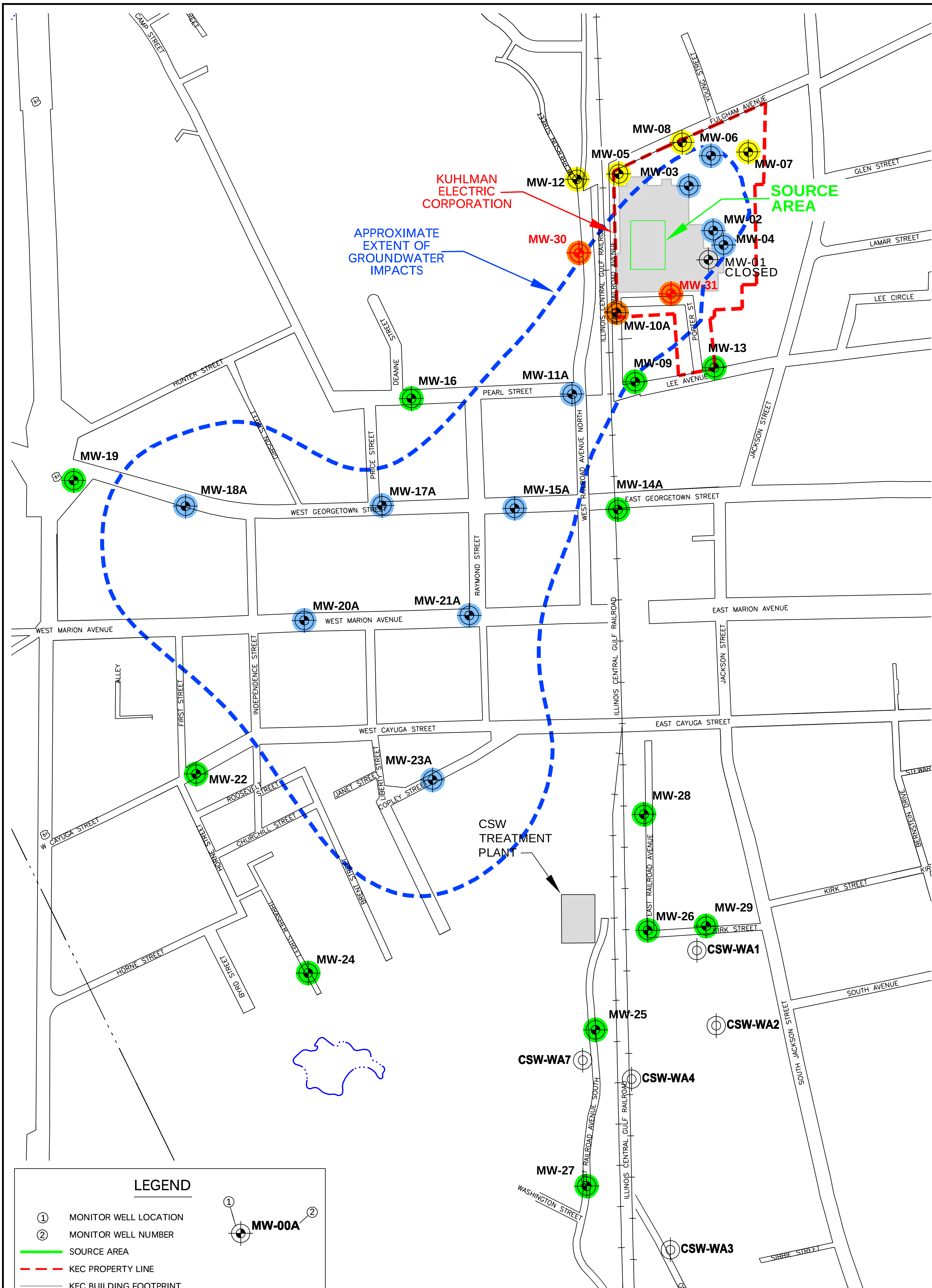
FIGURE
6



BORGWARNER INC.
KEC FACILITY, CRYSTAL SPRINGS, MISSISSIPPI

PROPOSED MONITOR WELL NETWORK

ARCADIS

FIGURE 7

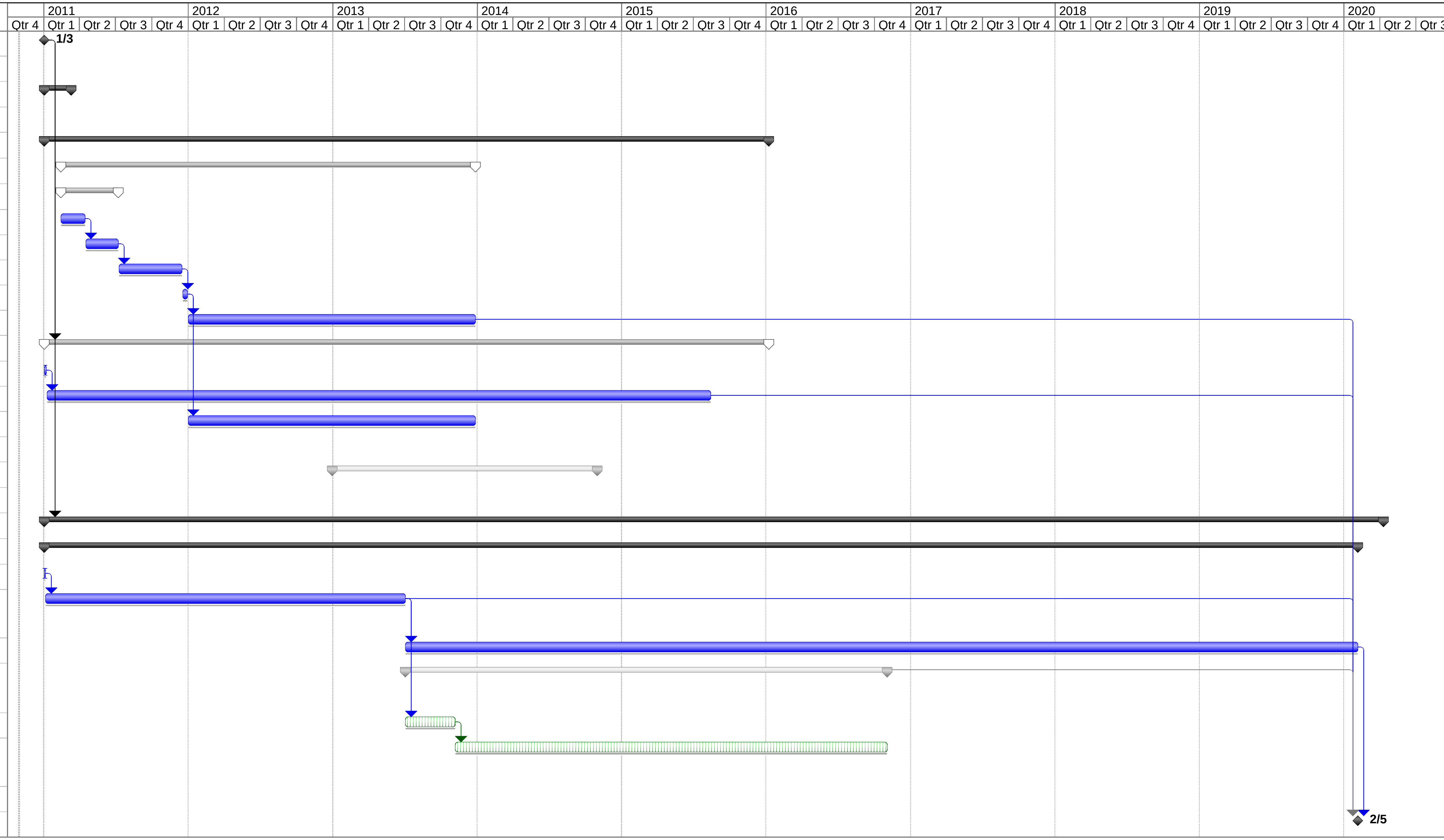
ARCADIS

Appendix A

Project Schedule

Appendix A
Generalized Implementation Schedule for Proposed Conceptual Approach

ID	Task Name
1	CAP Approval
2	
3	**Pre-Design Activities**
7	
8	**Source Area**
9	**AS/SVE**
10	**Design**
11	Conceptual Draft (60%)
12	Draft Final (90%)
13	Procurement/Construction
14	Startup & Optimization
15	O&M
16	**Performance Monitoring**
17	Monitoring Well Installations
18	Property Boundary Monitoring
19	AS/SVE Monitoring
21	
22	**ISCO (Contingencies)**
27	
28	**Offsite Plumes**
29	**Monitored Natural Attenuation**
30	Monitoring Well Installations
31	Initial Period of Demonstration and Evaluation
32	Long Term Monitoring
59	**In Situ Treatment (Contingencies)**
60	Refine Offsite In Situ Approach
61	Implement in Situ Treatment Offsite
62	
63	Tentative Project Closure



Client: BorgWarner Inc.
Project: KEC Groundwater Remediation
Location: Crystal Springs, MS