U.S. DEPARTMENT OF ENERGY
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TECHNICAL EXPERTISE PROJECT 610

PADUCAH 2006 SITE WIDE REMEDY REVIEW

APRIL 13, 2006

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1.0 PADUCAH 2006 SITE WIDE REMEDY REVIEW

This report summarizes the priority recommendations of a site wide review of groundwater and soil remediation plans for the Paducah Gaseous Diffusion Plant (PDGP or Paducah; Figures 1 and 2). The Department of Energy (DOE) Office of Environmental Management (EM–1) requested the Review Team to conduct a site wide technical and regulatory review of groundwater and soil remediation approaches at Paducah. The review did not include an evaluation of how DOE Paducah plans to integrate natural resource concerns into their response actions. The Review Team visited the site from February 27-March 3, 2006. As part of the visit, the Team toured the facility, received summary presentations, and obtained critical references, as well as DOE Paducah staff insights on the site wide soil and groundwater and remediation program. The Review Team is composed of the following members:

- Mr. Larry Bailey, DOE/EM-22; Director of the Office of Engineering (DOE Review Lead with expertise in environmental regulatory compliance)
- Ms. Beth Moore, DOE/EM-22 (DOE Review Project Manager; Hydrogeologist with expertise in modeling and risk assessment)
- Dr. Steve Golian, DOE/EM-24 (Ecologist with expertise in CERCLA compliance)
- Dr. Hans Stroo, HydroGeologic, Inc. (Review Technical Lead; Soil Scientist with expertise in Dense Non-Aqueous Phase Liquid remediation)
- Mr. Chuck Coyle, US Army Corps of Engineers (USACE; Environmental Engineer with expertise in bioremediation and natural attenuation)
- Ms. Kira Lynch, USACE (Toxicologist with expertise in management of large-scale thermal treatment systems)
- Mr. Cary Talbot, USACE, Environmental Research & Development Center (ERDC); Hydrogeologist with expertise in groundwater modeling at Paducah)
- Dr. Tom Ivory, Concurrent Technologies Corporation (Review Contract Lead and Environmental Microbiologist)

Figure 1: PGDP Location and Vicinity.

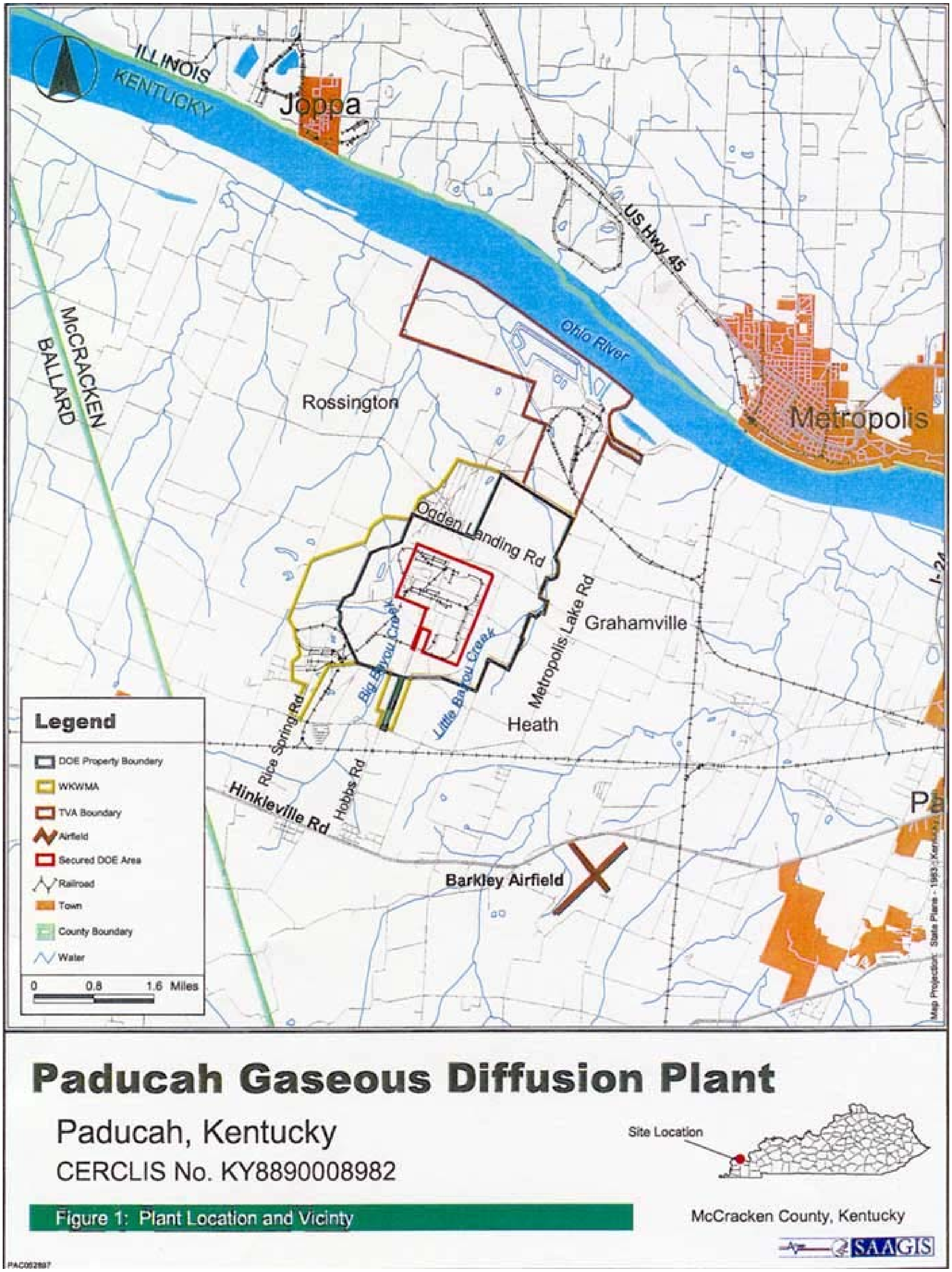
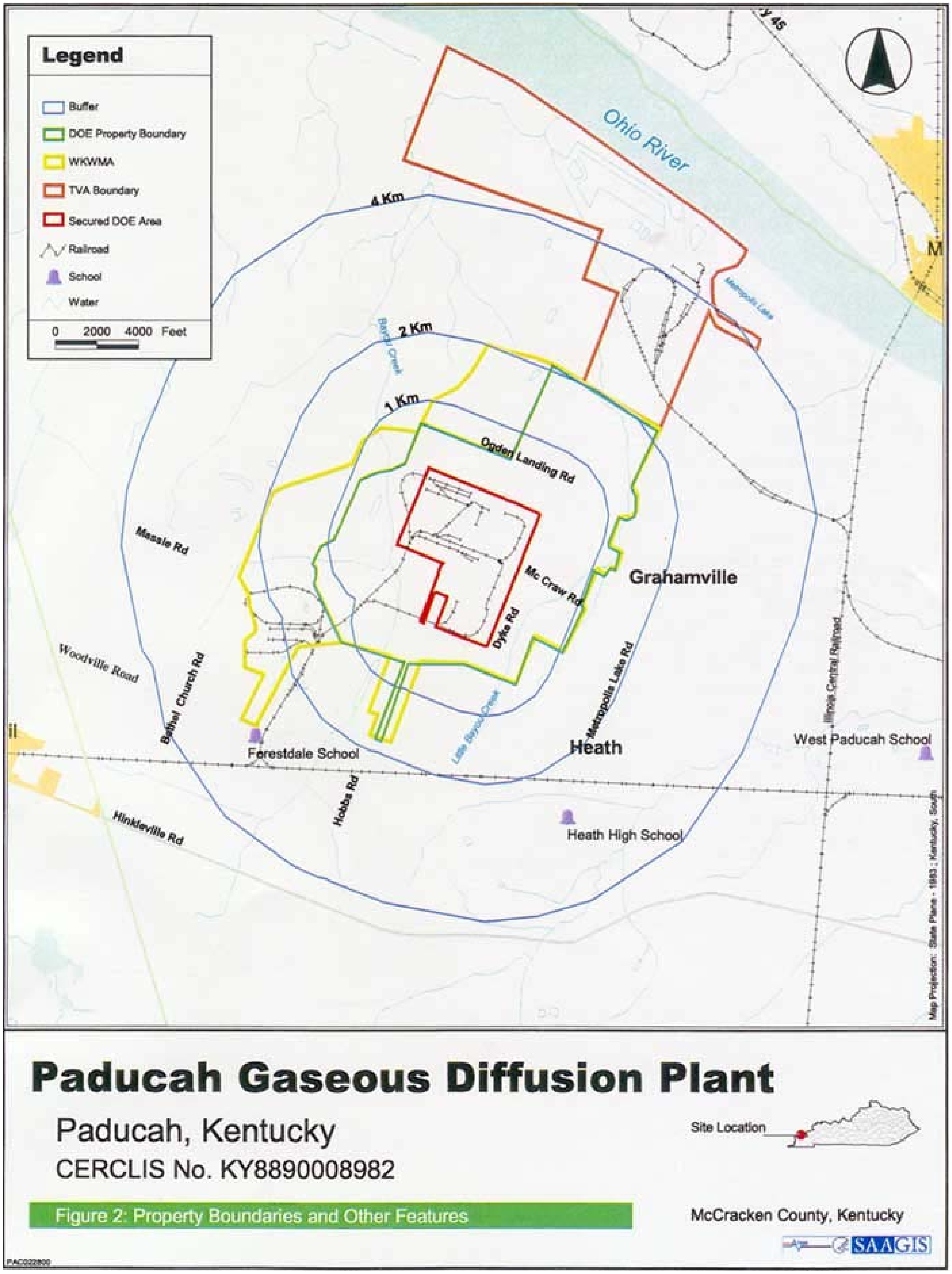


Figure 2: PGDP Property Boundaries and Other Features.



1.1 Site Background

The Paducah site has soil and groundwater contamination by chlorinated solvents, principally trichloroethylene (TCE; Figure 3), as well as technetium-99 (Tc-99; Figure 4). Contaminated groundwater extends beyond the plant boundaries, with some discharge to surface waters downgradient, primarily Big and Little Bayou Creeks to the west and northeast of the DOE property boundaries, respectively (Figure 3). To date, the principal offsite risk is due to TCE, and the predominant source of TCE is near and under Building C-400. Building C-400 is coincident with the highest TCE concentrations (i.e., the centroid) in the northwest plume (Figure 3). There is also Tc-99 contamination of groundwater in the C-400 area. The site also has numerous hazardous and radioactive burial grounds, some of which are confirmed sources contributing contaminants, primarily TCE and Tc-99, to soil and groundwater. The burial grounds are likely future sources of solvents, metals, and radioisotopes that have the potential to further contaminate the soil and groundwater.

The subsurface of the site has three principal zones (Figure 5): 1) the Upper Continental Recharge System (UCRS is 0-50 feet deep at C-400); 2) the Regional Gravel Aquifer (RGA is 50-100 feet deep); and 3) the underlying McNairy Formation. Contaminants (TCE and Tc-99 primarily) have been detected in all three zones. To the north of the plant, TCE and Tc-99 are present in the RGA beyond the DOE property boundary. TCE is migrating offsite via the northwest and northeast plumes (Figure 3) that discharge to the Ohio River and/or associated river valley deposits. Tc-99 is migrating offsite primarily via the northwest plume (Figure 4), and to a lesser degree, via a small northeast plume. TCE and Tc-99 (Figures 3 and 4, respectively) are also found in RGA groundwater of the southwest plume that is migrating in a west-northwest direction. The plume is believed to be contained within the DOE property boundary. Particle tracking of the southwest plume (Figure 6) indicates that a portion of the plume may migrate to the northwest, and then to the north; another portion of plume may merge into the northwest plume before reaching the Ohio River and/or associated river deposits. It is important to note that contaminants derived from some source areas in the northwest and northeast plumes are also sources for the southwest plume.

Figure 3: Trichloroethylene Plume Locations at the PGDP.

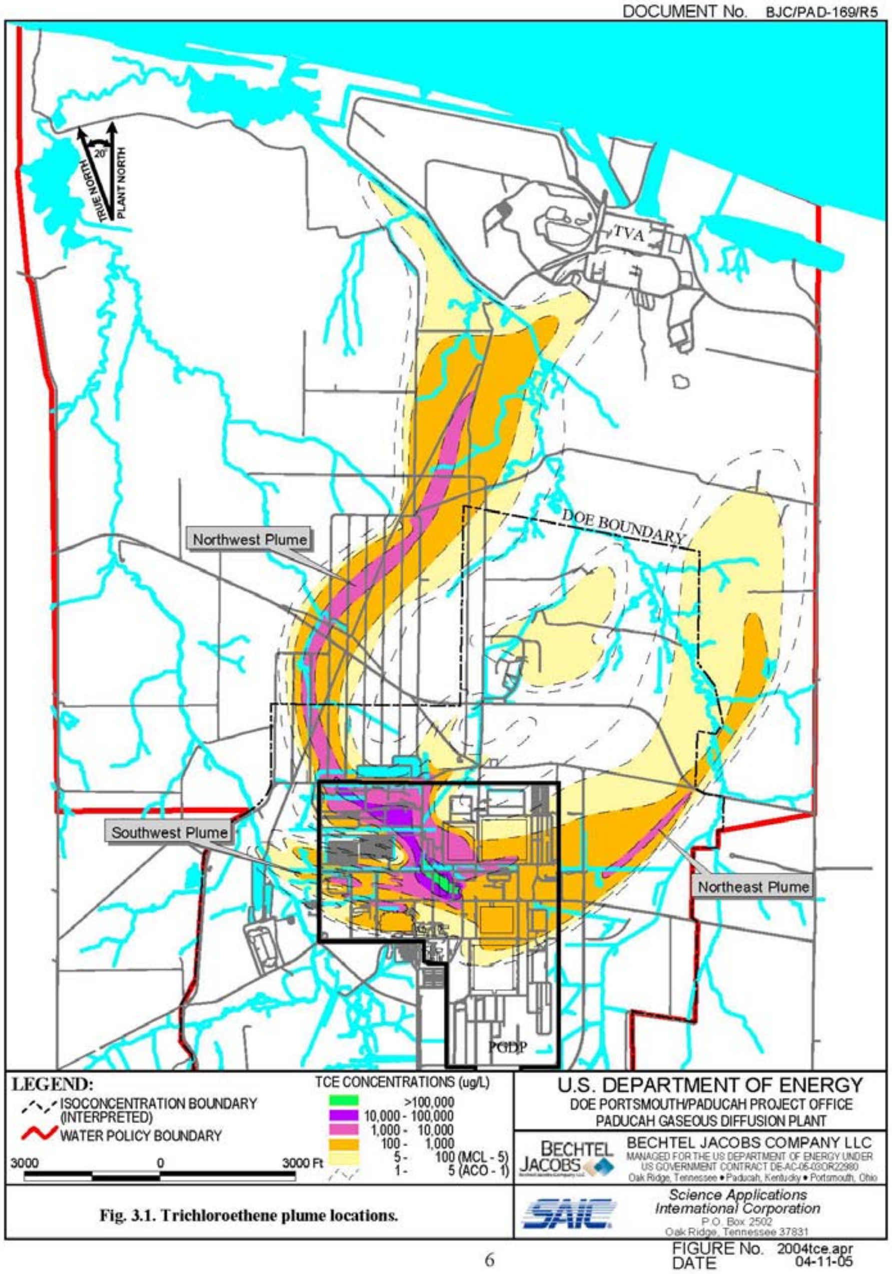


Figure 4: Technetium-99 Plume Locations at the PGDP.

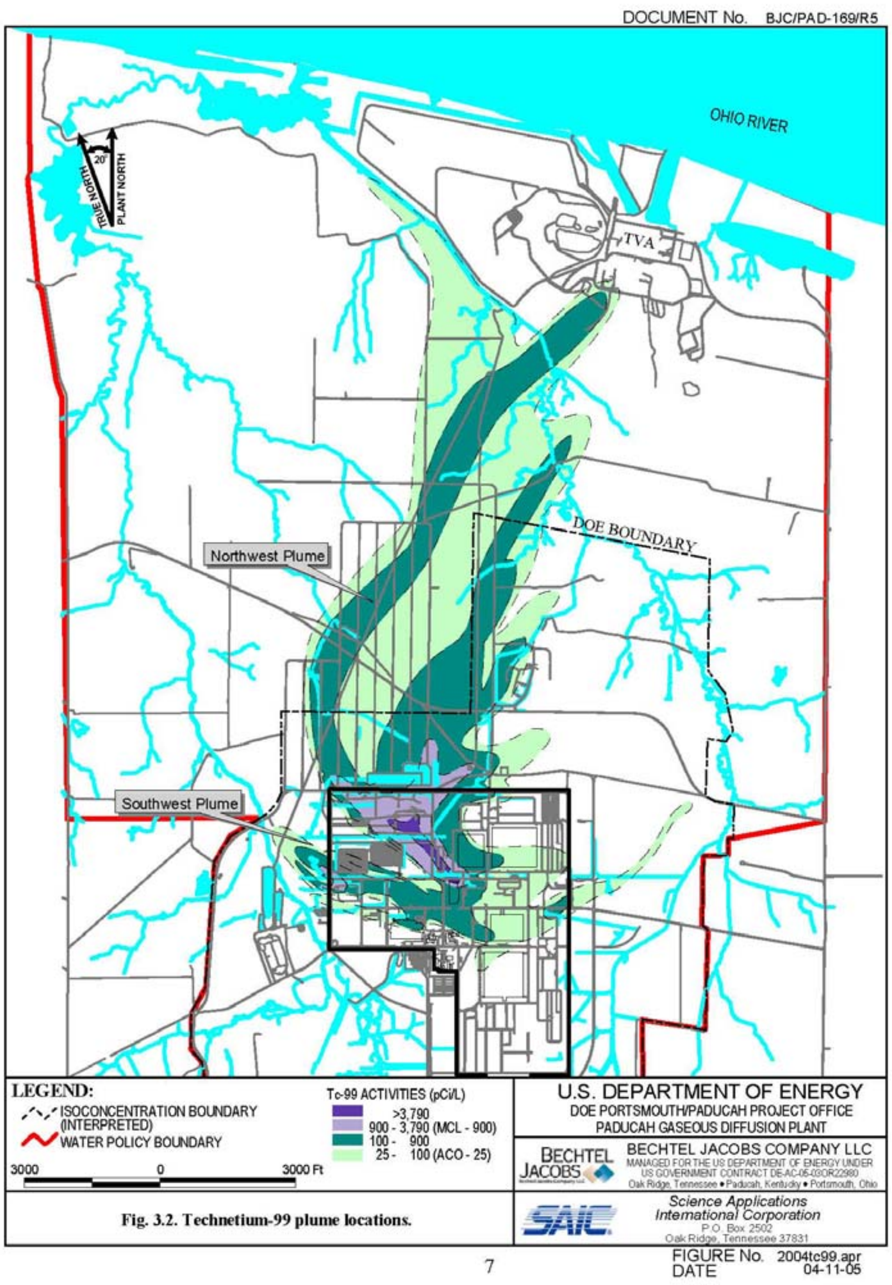


Fig. 3.2. Technetium-99 plume locations.

Figure 5: Schematic of Conceptual Site Model Near the PGDP.

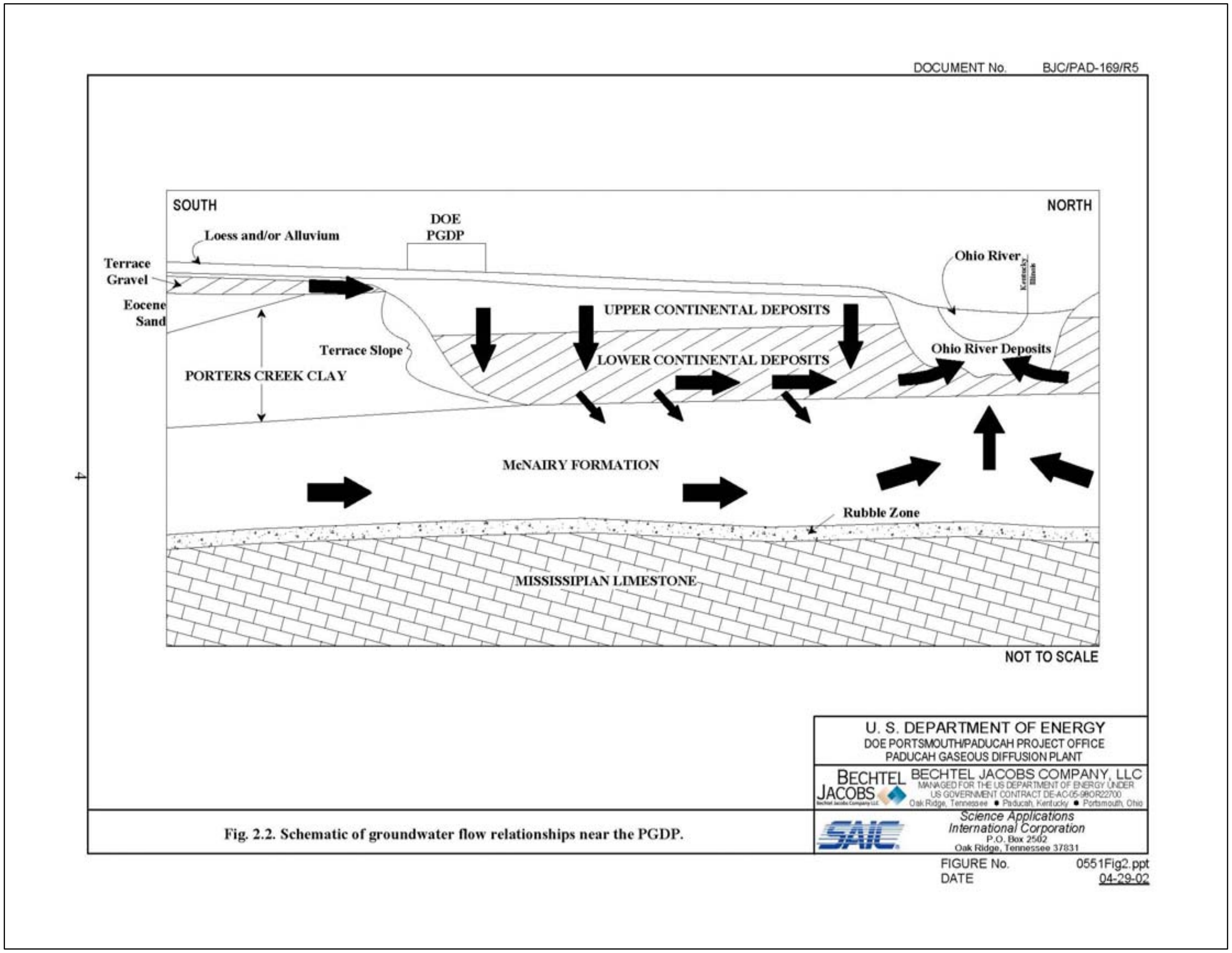


Figure 6: Particle Tracking for the Southwest Plume at the PGDP.

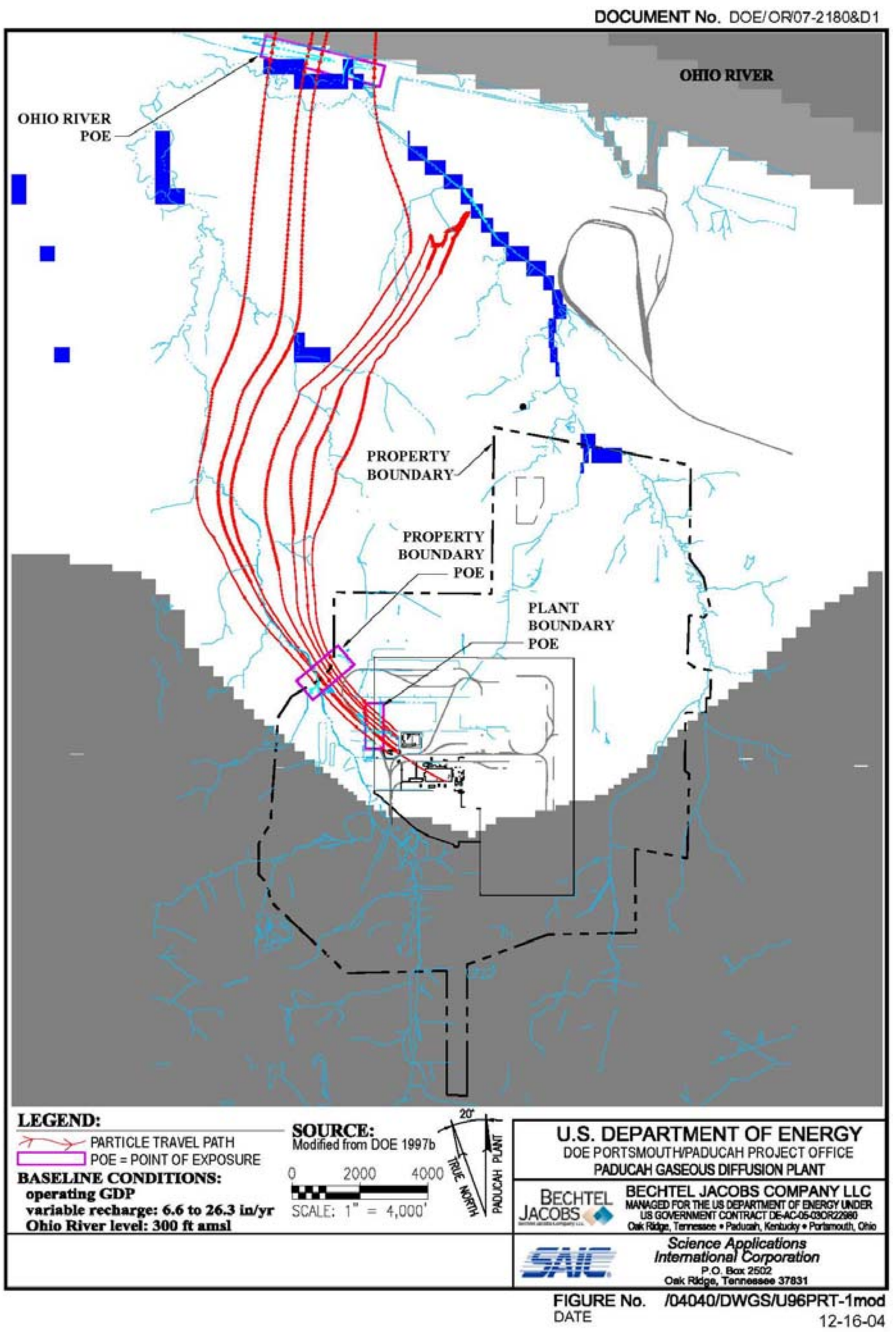


Fig. 5.1. Points of exposure used in SWMU 1, SWMU 4, and C-720 are fate and transport modeling.

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In 2002, the Agency for Toxic Substances and Disease Registry (ATSDR) published a Public Health Assessment for the PGDF, and concluded that "the facility poses no apparent public health hazard for the surrounding community from exposure to groundwater, surface water, soil, biota, or air." The following select ATSDR recommendations are pertinent as background information:

- Prevent installation of new wells in the contaminated groundwater plume areas through institutional controls.
- Prevent the future use of contaminated wells by disconnecting water pipes to homes or businesses and plugging or dismantling wells.
- Continue groundwater monitoring, including monitoring in areas possibly affected by the plumes and areas near Little and Big Bayou Creeks, and the North-South Diversion Ditch.
- Ensure that detection limits of degradation products of TCE, such as vinyl chloride, in the groundwater analyses are low enough to determine whether concentrations exceed health-based guidelines.
- Continue monitoring the McNairy Aquifer wells to detect possible migration of contaminants from the RGA—if monitoring wells do not create a conduit for vertical migration.
- Continue to restrict access to Little Bayou Creek, the outfalls, and the North-South Diversion Ditch. Determine if the existing signage adequately restricts public access to the southwest inactive landfill and the adjoining area.
- Continue monitoring biota to ensure that it is safe to consume.

2.0 RECOMMENDATIONS

2.1 Evaluate and Redesign the Interim Remedy.

The Interim Remedy for the C-400 area has been approved by EPA Region IV and the Kentucky Department of Environmental Protection (KDEP) as a formal Record of Decision (ROD). The Interim ROD calls for in situ thermal treatment using Electrical Resistance Heating (ERH) of both the UCRS and RGA around portions of Building C-400. ERH treatment was field demonstrated southwest of C-400. Efficacy was proven for the technology to remove most of the TCE in the UCRS. However, TCE removal with ERH in the RGA proved more challenging due the greater depth of access. Target temperatures were not achieved at the deepest intervals of the RGA in the treatment zone**.** The ROD states that this treatment will reduce concentrations in soils and ground waters, and therefore reduce the remedial time frames by hundreds of years.

The Review Team identified significant barriers to the success of the remedial actions described in the Interim ROD. The action proposed in the Interim ROD appears to be overly costly as compared to similar systems of size and design, incomplete in terms of expected TCE removal, and not fully justified based on the available information. The most challenging aspect is that a significant fraction of the TCE within the RGA is beneath the footprint of Building C-400, and this source will not be removed per the remediation approach identified in the Interim ROD. ERH was not fully proven in pilot testing for treatment of TCE in the RGA and McNairy. The suspected source of TCE beneath C-400 will continue to pose a long-term risk until the building is deactivated and decommissioned. Moreover, the distribution of the TCE within the RGA and McNairy is not well-understood. This may lead to either costly contract modifications during implementation, and/or to not addressing significant hot spots of TCE.

Given these constraints, the Review Team recommends a formal comparison of the efficacy and cost of other in situ thermal technologies, such as steam injection, for which development has been rapid. Also, a combination of thermal technologies should be evaluated, such as ERH for the UCRS and steam injection for the RGA. Other complementary treatment technologies, such as in situ bioremediation (ISB) and in situ chemical reduction (ISCR), may further reduce remaining TCE mass, if used in combination with thermal technologies as a follow-on polishing step. The Review Team concluded that increased characterization of the RGA source area is warranted prior to any remediation approach. This characterization could reduce overall costs and/or improve performance by better defining the areas needing more aggressive treatment.

If the Interim ROD is implemented, the Review Team recommends confining ERH treatment to the UCRS at this time, unless Building C-400 is removed. The Review Team also recommends defining hot spots for treatment based on risk analysis, which should provide a more cost-effective partial removal action.

2.2 Optimize and Replace the Existing Pump and Treat Systems.

The two existing pump and treat systems are an overly costly remediation approach that results in only partial TCE mass removal and hydrologic control of migration. They were originally designed as an interim remedy that would eventually be replaced by a more complete containment system, such as an in situ passive treatment barrier. The Review Team considers it likely that more effective treatment and control will eventually be required. For current and near term operation, performance of the existing systems can be improved and savings realized through optimization. In situ treatment alternatives, particularly bioremediation, should also be evaluated as they are likely to provide more effective containment at a lower total life-cycle cost.

The current systems were designed as an interim action to remove contaminant mass. However, since 1997, there has been a decline of about 75% in the mass of TCE being extracted, at a continuing cost of $2 million per year for operation and maintenance. Also, the high-concentration core of the northwest plume has shifted to the east, outside the effective capture zone of the northern extraction wells. There is a high probability of reducing costs and improving performance by optimizing these systems, until they can be replaced.

The existing systems should eventually be replaced because they provide only partial containment, and do not fully control the risks to downgradient receptors. The recent failure to demonstrate that the site had met EPA's Environmental Indicators related to groundwater control suggests there will be increasing pressure over time for more effective containment of contaminant plumes. In situ treatment technologies, such as permeable reactive barriers or bioremediation, are likely to be more cost-effective long-term.

The Review Team recommends that an independent optimization review of the pump and treat systems be conducted. Specific recommendations include: 1) expand the monitoring and characterization program to better define the plume conditions; 2) perform a formal remedial process optimization (RPO) review; 3) use RPO recommendations to improve the performance of the current pump and treat systems; (4) consider improving the effectiveness of plume containment using in situ technologies; and 4) expand the evaluation of natural attenuation processes.

2.3 Improve Source Term Estimates and Conceptual and Mathematical Site Models.

The conceptual site model (CSM) and contaminant pathways evaluation serve as the basis for development of the mathematical (modeling) and engineering framework to estimate offsite contaminate migration and to assess risks to human health and the environment. In addition, the site modeling framework should serve the objectives of remedy technology review, selection, design, and optimization to assure performance, minimize operation time and lifecycle costs.

The Review Team found that the current CSM includes little understanding of source locations and distribution, particularly within the lower RGA and the McNairy, where most of the contaminant burden exists and is migrating offsite. The understanding of local hydrogeology also appears inadequate for selecting and designing remedies. Greater analysis of existing data is encouraged, because it appears that some existing information is not incorporated in the CSM. Greater site characterization, modeling, and monitoring will reduce the costs and improve the performance of interim and final remedies.

An example of this review finding is a request by the regulators to include a characterization investigation scope of work in the Interim ROD for thermal treatment near Building C-400 to determine TCE distributions in the RGA. It is estimated that TCE mass loading there to the UCRS and RGA is 56,000 and 200,000 gallons, respectively. These estimates are uncertain, because there is little process knowledge or spatial characterization data from the RGA to confirm contaminant volume and distribution. TCE volumes and distribution for the upper McNairy have not been estimated to the knowledge of the Review Team. Site risk models predict that 90% removal of TCE in the UCRS and RGA will reduce cleanup time by over 750 years and reduce offsite TCE concentrations to about 110 parts per billion (ppb). The Review Team recognizes the need to estimate cleanup targets to evaluate and select a remedy; however, these risk model predictions are believed to be unrealistic because they neglect the mass of TCE in the upper McNairy. The Review Team found that TCE mass will remain after treatment, not only beneath Building C-400 and in untreated downgradient areas, but also in the upper McNairy, which has not been fully characterized to date. Conceptually, TCE release rates from the McNairy as a secondary source are expected to be much slower than that for the RGA, given the higher sand, clay, and organic contents.

This review finding is reflected in the four goals of the draft 2005 Burial Grounds Operable Unit (BGOU) Remedial Investigation and Feasibility Study (RI/FS): (1) to characterize the source zones; (2) to define the extent of the contamination in all sources, soil, and groundwater; (3) to determine the surface and subsurface transport mechanisms and pathways, and (4) to evaluate remedial technologies. Significant data gaps exist for six of the Solid Waste Management Units (SWMUs) in the BGOU; characterization, sampling, and monitoring tasks are designed to address these data gaps in the RI/FS. The regulators have commented that the types and number of characterization and monitoring points proposed in the BGOU RI/FS are insufficient to assess the unit contaminant contributions to the southwest groundwater plume. There appears to be significant disagreement between the regulators and DOE Paducah regarding what additional scopes are needed to satisfy the goals of the RI/FS.

The regulators state that the BGOU RI/FS is critical to assessment of the southwest plume, as well as disposition and remediation decisions for the burial grounds. The regulators also state, and the Review Team confirms, that some compliance monitoring wells adjacent to the burial ground units are ineffective in determining impacts from the individual cells, because background wells are contaminated by upgradient sources contributing to the southwest plume. An example is the RCRA burial ground, SWMU 3, where monitoring is conducted and reported to the regulators. The Review Team questions the effectiveness of the 14-well RCRA monitoring network to demonstrate compliance for SWMU 3, and generally, other compliance wells in the RGA. Compliance monitoring for the burial ground units may be more effective in permanent angle-borehole characterization wells installed under the units to sample the uppermost affected groundwater in the UCRS to assess unit impacts and leaching. Finally, the proposed number of characterization points in the BGOU RI/FS is probably not adequate to provide spatial coverage of the area being investigated.

The groundwater and risk models used at Paducah are of intermediate rigor and complexity. They have been used primarily for scoping and decision-making for baseline risk assessments, simple flow and transport predictions, source delineation, setting initial cleanup goals, and so on. As the site moves into full-scale remediation design and implementation, the Review Team recommends that more sophisticated risk and modeling platforms be used in fate and transport modeling of the northwest, northeast, and southwest plumes. Future efforts should include the use of models that are calibrated and validated against observed water-levels and contaminant concentrations trends. Also, the use of three-dimensional flow and transport codes with transient capabilities, as well as parameter and uncertainty estimation is recommended.

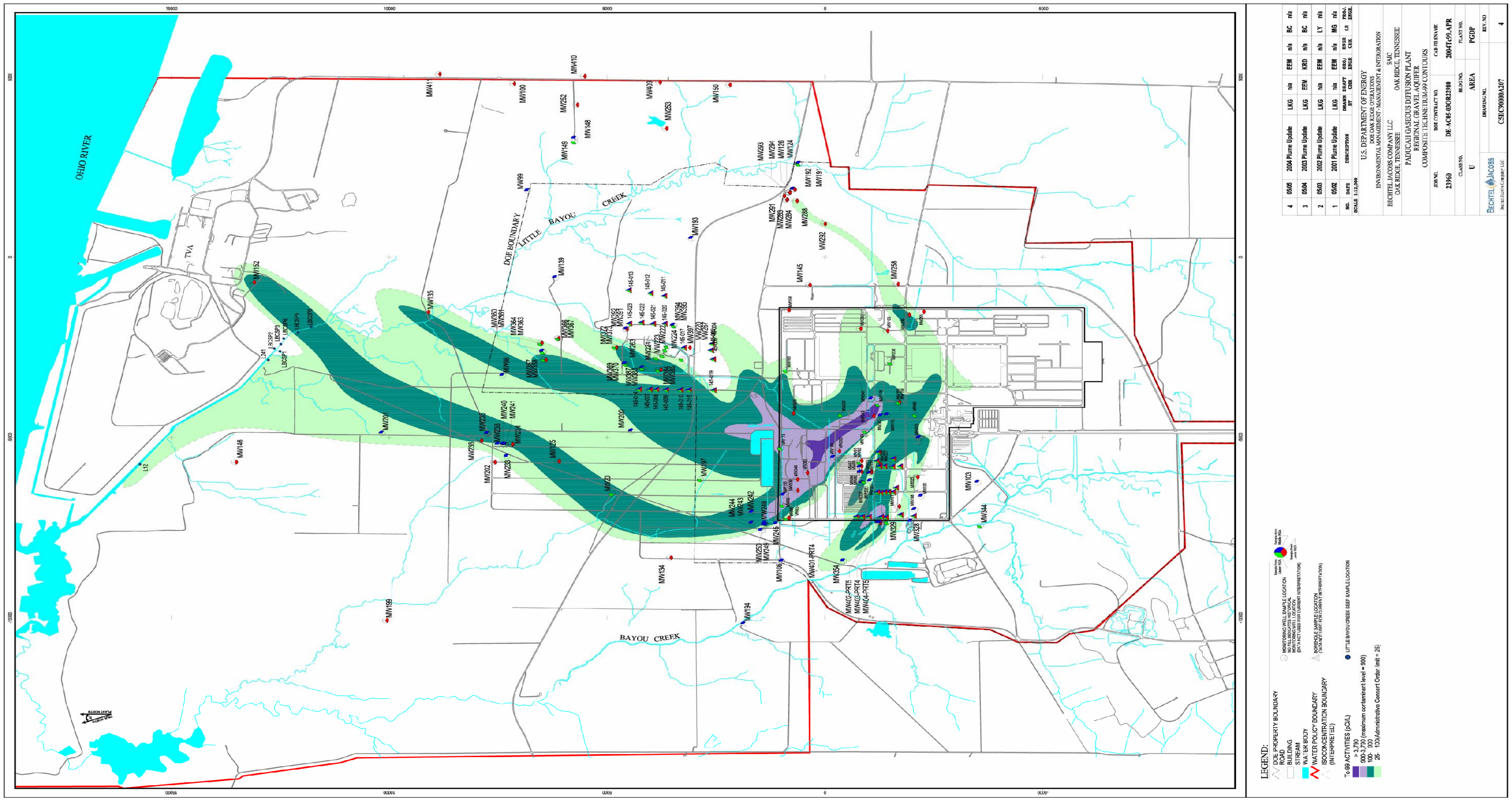
2.4 Demonstrate Future Stability of the Technetium-99 (Tc-99) Groundwater Plume.

Time-trend analysis and annual updates to the groundwater plume maps generally indicate that the Tc-99 plume (Figure 7) moving northward offsite is stable (i.e., levels remain uniform or decrease). A few monitoring wells in the RGA exhibit increasing levels of Tc-99 in the northwest and northeast plumes. Concentrations of Tc-99 exceeding 900 picoCuries/liter (pCi/L) associated with the primary source area, Building C-400 and environs, are within the DOE property boundary. [Note: 900 pCi/L is the EPA-established target cleanup level, or maximum concentration limit (MCL), for Tc-99, assumed to yield a dose equivalent to the 4 millirem per year (mrem/yr) for beta-emitting radionuclides.] Therefore, at the time of this review, DOE can demonstrate compliance against the groundwater MCL for Tc-99 for offsite plume migration to the northwest and northeast.

The Review Team found that significant uncertainties remain in the conceptual and mathematical models for predicting, with reasonable assurance, that the Tc-99 groundwater plume will remain stable, and within the confines of the DOE Boundary in the future. It is well documented that discharges, leaks, and spills to the ground, associated with Tc-99 extraction processes at Building C-400, are primarily responsible for the northwest and northeast plume extensions. It does not appear that other sources believed to be contributing Tc-99 to the northern plumes, such as the C-616 lagoon, SWMU 7, SWMU 99, and SWMU 4 (a primary source of Tc-99 contamination in the southwest plume) have been adequately characterized and quantified.

The influences of near-surface water flow on plume rate and migration direction are not well understood. For example, process water discharges adjacent to the sources and the unsaturated zone, as well as reduced infiltration from Building C-400 itself may prove to be parameters that can be engineered to stabilize the plumes. Plume data visualization performed by the USACE in 2002, suggests that the Tc-99 plume is migrating faster to the north in the lower unit of the RGA than in the upper and middle units. Preferential and faster Tc-99 migration in the lower RGA appears to be controlled by a significant downward gradient to the north of the facility (potentially caused by large quantities of process water discharging to the unsaturated zone), higher hydraulic conductivities associated with the basal gravels of the aquifer, and perhaps, geologic and stratigraphic controls.

Figure 7: Composite Contours for Technetium-99 for the Regional Gravel Aquifer at the PGDP.



Since Tc-99 is a nonreactive tracer with a long radioactive decay half-life, it lends itself to the simplest of predictive models: water particle transport that is not complicated by processes of decay, retardation, dispersion, etc. The Review Team recommends that predictive flow modeling of the Tc-99 plume be conducted (including calibration and verification) sufficient to confirm that the Tc-99 plume migration is stable in the out years. The benefits of predictive modeling are (1) to provide defense-in-depth that offsite risk to groundwater degradation from potential plume expansion is controlled and decreasing, and (2) to confirm that remedy evaluation for Tc-99 source and plume treatment beyond the existing pump and treat systems is unwarranted.

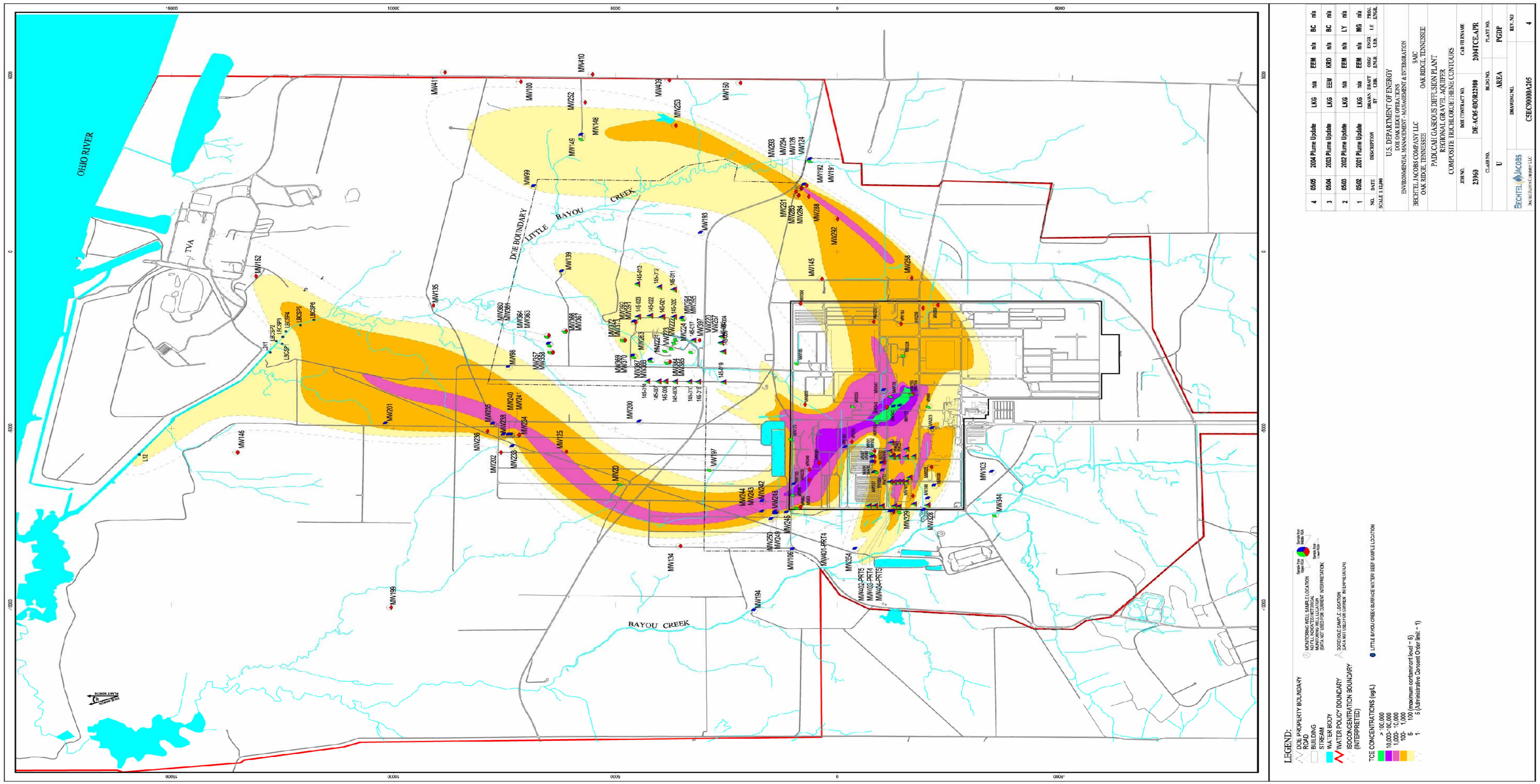
2.5 Evaluate the Cap, Monitor, and Leave In Place Disposition for All Burial Units.

The Review Team believes that current information about the nature of the hazardous, low-level, and other potential radioactive sources present in, particularly, the uranium (SWMU 2), RCRA (SWMU 3), and classified burial grounds (SWMUs 4 and 5), is insufficient for a defensive analysis of the cap, monitor, and leave in place disposition option. The Review Team recommends that this option be evaluated against public protection standards derived under the Atomic Energy Act (e.g., DOE Orders 5400 and 435.1). Regulatory analyses and decisions required under the Atomic Energy Act have historically been evaluated by DOE under the CERCLA process, through a comparative cross-walk of dose exposures against applicable performance objectives.

2.6 Optimize the Groundwater and Surface Water Monitoring Programs.

Contour maps for the TCE (Figure 8) and Tc-99 (Figure 7) plumes are somewhat misleading in their depictions. Contaminant contours shown on site maps are dashed and closed around the most northerly offsite and westerly onsite monitoring wells, indicating that the plumes terminate before reaching the Ohio River, Big Bayou Creek, and the western DOE property boundary. The CSM for Paducah (Figure 5) reflects an understanding that both the TCE and Tc-99 plumes discharge to the Ohio River and/or associated river deposits, but they do not appear to be monitored just upgradient of these discharge areas. There are no monitoring wells at these locations. On the western side of the facility, particle tracking of the southwest plume (Figure 6) indicates that a portion of the plume will likely migrate toward Big Bayou Creek. Insufficient monitoring wells exist in the western and northwestern areas adjacent to the facility to monitor plume migration for accurate depiction, compliance, remedy performance, and public health reasons.

Figure 8: Composite Contours for Trichloroethylene for the Plant Regional Gravel Aquifer at the PGDP.



Three-dimensional flow modeling of the Tc-99 and TCE plumes performed by the USACE indicates longitudinal spreading with depth in the lower units of the RGA north of the PGDP facility due to significant downward hydraulic gradients, and higher hydraulic conductivities due to basal gravels. Therefore, additional lower RGA and McNairy wells are needed offsite to correctly monitor and depict the spatial distribution of contaminant concentrations at depth. This is particularly important to evaluate potential contaminate migration to the underlying McNairy formation from the RGA, as recommended by the ATSDR in the Public Health Assessment report.

Onsite monitoring wells adjacent to the burial ground units appear to be ineffective in determining impacts from the individual cells because background wells are contaminated by upgradient sources and groundwater plumes. Nonetheless, monitoring is conducted and reported to the regulators. The Review Team recommends that an assessment be performed of the RCRA facility-specific monitoring program and then be further discussed with the regulators.

Onsite and offsite (USACE) groundwater flow models provide water balance evidence of discrete surface points where recharge, or infiltration, is about 5 times larger than background. That is, large water lines (i.e., 3 feet in diameter and 50 years old) bringing process water from the Ohio River continue to leak large volumes of water to the unsaturated zone. This appears to be a contributing factor in driving the contaminants down into the RGA. Monitoring of operations-induced recharge to the UCRS, potentially resulting in groundwater mounding and accelerated movement of contaminants is an important hydrologic process to quantify so that source term and plume spreading can be mitigated.

The CSM reflects the potential for dynamic exchange of surface and ground waters (e.g., losing and gaining stream sections) where the two intersect at Little and Big Bayou Creeks (Figures 3 and 6), the outfalls, and the North-South Diversion Ditch. In fact, TCE levels at upwelling springs along Little Bayou Creek are about 340 ppb, compared to the surface water limit of about 80 ppb. This is especially important for reaches of Big Bayou Creek, where the southwest plume may have hydraulic interconnection based on the predictions of plume migration (Figure 6). At a minimum, surface and groundwater sampling points should be increased in these areas, especially outside the DOE boundary to assure public protection. Restricting access to affected, and potentially affected, surface water should be considered, instead of posting signs, as the monitoring network is expanded and data are collected to reassess offsite risk exposures.

The Review Team found that both Spatial Analysis and Decision Assistance (SADA) and Visual Sample Plan (VSP) software are being used by the site to guide sampling and characterization tasks. Nonetheless, the regulators have expressed the concern that data and informational gaps will remain after the BGOU RI/FS is complete. Deficiencies in the groundwater and surface water monitoring programs, as well as characterization of sources and plumes, are discussed in all section recommendations. The Review Team recommends that the site develop a more strategic approach to fill data gaps in the network, and similarly, to remove redundancy.

Monitored natural attenuation (MNA) is being considered by DOE as part of the overall risk management strategy. MNA can be a cost-effective approach to minimize receptor exposure to contaminated groundwater. The Review Team agrees that there is compelling evidence for MNA of TCE in the source area within the UCRS, and inconclusive data for MNA within the plume in the RGA. Benefits can be realized for remedial decision planning, if the monitoring program is modified to collect needed data to further evaluate the efficacy of MNA as a viable remedy, especially for the RGA.

The Review Team recommends that an independent optimization review be conducted of the monitoring program using either public-domain codes available from the Air Force Center for Environmental Excellence: Monitoring and Remediation Optimization System (MAROS) or Geostatisical Temporal/Spatial (GTS) methodologies. In addition, the site might consider the value of an optimization decision tree to recommend the addition or elimination of wells, analytes, or sampling frequencies within the program. Such a program was developed at Vandenberg Air Force Base, with regulator buy-in and approval to streamline monitoring decisions.

2.7 Strengthen the Site Wide Exit Strategy.

The Review Team recognizes that DOE Paducah has studied, and is developing a remediation approach for the site that is reflected in numerous characterization, feasibility study, risk assessment, and end state documents. However, it is not apparent to the Review Team that interim remediation decisions, reflected in the present ROD for TCE removal at Building C-400, were made in the context of a strategic site wide exit strategy. For example, how are the interim ROD cleanup performance objectives at Building C-400 for soil and groundwater strategically linked to longer term site wide cleanup levels? Given the potential environmental and economic risks posed by the site, development of a comprehensive performance-based exit strategy is strongly encouraged.

A site wide exit strategy is a well-planned and detailed approach to measure progress in accomplishing overall goals (e.g., RAOs) within a desired time period to achieve approval for response completion (e.g., remediation, closeout, reuse, etc.). The strategy is best developed by integrating stakeholder and regulatory agency concerns, resource constraints, technical realities (such as impracticability, natural attenuation, reuse, and so on.), with a means to measure progress along a timeline. For each environmental condition that poses an unacceptable risk that requires remediation, a well-developed exit strategy should include the following steps:

- Identify remedial goals to mitigate the risk.
- Identify remedial methods to achieve the goals.
- Identify metrics (i.e., compliance monitoring and operational parameters) and a timeline to demonstrate success.
- Identify contingency actions, if goals are not achievable.

Exit strategies are dynamic; they are flexible so that as site knowledge and remedy performance are assessed, "course corrections" can be implemented.

In general, the site has defined the environmental risks and regulatory concerns. However, definition of the sources, receptors, and pathways (elements of the CSM) is not always sufficient to select and design interim and final remedies. Examples include the following:

- Uncertainty in TCE mass estimates from the RGA and McNairy to the groundwater plumes
- Undetermined sources of Tc-99 and plume stability
- Impacts of anthropogenic recharge on contaminant migration
- Knowledge gaps in the CSM regarding pathways
- Lack of decision logic to guide optimization and termination of response actions.

The effort to develop a performance-based, site wide exit strategy should help to move the site to the next level of remedial decision planning, as well as to maximize dialogue and buy-in from the regulators and stakeholders. If the site wide strategy includes a Technical Impractability (TI) waiver and associated Alternative Concentration Limits (ACLs), the TI rationale should be openly discussed, and data should be collected specifically to support the TI decision process.

The Review Team believes that DOE Paducah has not identified site wide remedial goals to address the major risks. Long term remedial goals are intended to meet regulatory criteria established to protect human health and the environment, but in some cases these criteria cannot be met in a reasonable time frame. For example, the MCLs for TCE in groundwater are 100 to 1,000 times lower than the levels reached in the ERH field demonstration. If ultimate criteria (e.g., MCLs) are not achievable, intermediate goals (e.g., ACLs) should be established for any interim or source-specific remedy. These intermediate goals can help guide decisions regarding when to transition from one phase of the project to the next, without incurring unnecessary costs by continuing to operate technologies beyond the point of diminishing returns.