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BUILDING A BETTER WORLD

TECHNICAL MEMORANDUM

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Subject: Detailed Analysis and Comparison of Remedial Action Alternatives
Peoples Natural Gas, Dubuque, Iowa Former Manufactured Gas Plant Site
Civil Action C92-1048

This Technical Memorandum presents the detailed analysis and comparison of the remedial action alternatives for the Peoples Natural Gas (PNG) Former Manufactured Gas Plant (FMGP) site in Dubuque, Iowa. The site layout is depicted in Figure 1. The remedial alternatives reviewed in this Technical Memorandum were previously evaluated in the Technical Impracticability (TI) Evaluation Report (TI Report) submitted to the United States Environmental Protection Authority (USEPA) in May 2006. On December 1, 2006, MidAmerican Energy Company (MidAmerican) submitted a petition to the USEPA to modify the groundwater component of the remedial action by waiving compliance with performance standards for groundwater on a portion of the PNG site, identified as the TI Zone. In the TI Report, MidAmerican proposed a technically practicable alternative remedial strategy that is protective of human health and the environment.

1.0 DETAILED ANALYSIS OF ALTERNATIVES

The remedial action alternatives presented in this Technical Memorandum are assessed according to the nine evaluation criteria developed by USEPA to address Comprehensive Environmental Response, Compensation Liability Act of 1980 (CERCLA) requirements:

1. Overall Protection of Human Health and the Environment
2. Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)
3. Long-Term Effectiveness and Permanence
4. Reduction of Toxicity, Mobility, or Volume Through Treatment
5. Short-Term Effectiveness
6. Implementability
7. Cost
8. State Acceptance
9. Community Acceptance

Criteria 1 and 2 are referred to as threshold criteria. Criteria 3 through 7 are referred to as the primary balancing criteria. Criteria 8 and 9 are referred to as modifying criteria. The first seven of the nine criteria are assessed in this Technical Memorandum. The remaining two criteria, State Acceptance and Community Acceptance, will be evaluated following regulatory review of the Technical Memorandum and public comment on the proposed plan.

The no-action alternative that typically provides a baseline for comparing other alternatives in a Nine Criteria Evaluation is not applicable to this evaluation due to multiple remediation efforts that have been completed at the site, including soil removal, groundwater extraction and treatment, and ozone sparging with soil vapor extraction (SVE). Further details regarding the remediation efforts at the site were presented in the TI Report. Cost estimates for each groundwater alternative were provided in Appendix I of the TI Report.

1.1 GROUNDWATER ALTERNATIVE 1 – ACCESS RESTRICTIONS WITH ADDITIONAL EXCAVATION

This alterative consists of both additional excavation of impacted soil and access restrictions to prevent exposure to impacted groundwater. The access restrictions described in this alternative are a component of each of the four alternatives presented.

1.1.1 Existing Access Restrictions

As stated in the September 16, 1991 Record of Decision (ROD), institutional controls are required at the site to impose groundwater and land used restrictions. The property is listed in the Iowa Department of Natural Resources (IDNR) registry of abandoned or uncontrolled disposal sites. In addition, access to the site is controlled with site fencing as required (USEPA, 1991). A Memorandum For Record of Property Restriction and an Iowa Real Estate Transfer Groundwater Hazard Statement were recorded with the County Recorder, Dubuque County, Iowa on May 14, 1991, for both the site owned by the City of Dubuque (City), and the Highway Corridor owned by the Iowa Department of Transportation (IDOT). These documents restrict both excavations and disturbances at a depth of 6 feet or below, and installation of public and private water supply wells at the site, and serve as notification to future landowners.

In the vicinity of Dubuque, Iowa, water is obtained from the alluvial and bedrock aquifers for municipal, domestic, and industrial use. The City has a well field consisting of four bedrock and five alluvial wells approximately 1.5 miles northeast of the site. The site is served by the municipal water supply, and no water wells are present on site or on adjacent properties. The existing deed restrictions prohibit the installation of water wells on site. There is currently no known household use of groundwater in the vicinity of the impacted plume as discussed in Section 1.7.1 of the TI Report. City Ordinance Chapter 42-21 requires all major and minor subdivisions within the City limits to be properly connected with an approved and functioning public water supply system. There is no City Ordinance preventing the installation of private water wells. The IDNR has existing authority to prohibit private and public water well installation in the vicinity of contamination [Rule 567—38.12 (455B) of the Iowa Administrative Code (IAC) and Subrule 567—43.3(7) of the IAC].

1.1.2 Proposed Access Restrictions

In 2005 the Iowa state legislature passed the Uniform Environmental Covenants Act (UECA), which has been certified under Iowa Code Title XI, Chapter 445I (Iowa Code), providing a legally enforceable means to restrict land use or access under a real estate instrument called an environmental covenant. Implementation of environmental covenants to restrict access to residual contamination are proposed for the site. In addition to the environmental covenant, MidAmerican will formally notify the IDNR Water Supply Section, the City Water Department and the Dubuque County Health Department of the area of contamination for consideration when reviewing new water well permit applications.

The second component of this alternative is additional excavation. In order to achieve the numerical remediation goals specified in Table 1-1, the source areas for groundwater contamination must be addressed. As discussed in Section 3.1 of the TI Report, soil excavation was a component of the original remedy to address contamination at the site, both in the Highway Corridor area and in the Remedial Action Area. Excavation activities have removed approximately 45 percent of the original source contamination from the site. As discussed in Section 5.3 of the TI Report, the source material remaining at the site includes dense nonaqueous phase liquid (DNAPL) located in the area northeast of the maintenance building and below the base of the excavations. The estimated 614,290 pounds of residual source material have the potential to be a source of further releases to surface water or groundwater, with the quantity of contaminants either staying the same or decreasing over time due to physical, chemical, and biological natural attenuation processes. Much of the remaining material is inaccessible and further excavation would leave an estimated 206,230 pounds of source material at the site.

1.1.3 Protection of Health and Environment

This alternative achieves adequate protection of human health and the environment by eliminating the groundwater exposure pathway thus preventing future exposure to impacted groundwater. Adequate protection will be achieved because currently, there are no known groundwater wells within the plume area and a municipal water supply is available within the entire plume area, the IDNR Water Supply Section, the City Water Department and the Dubuque County Health Department will be notified, and an environmental covenant on the site will effectively prevent future well installations. The existing deed restrictions prohibit the installation of water wells on site but the City does not have a city ordinance that would prevent the installation of private water wells off site. The proposed access restrictions listed would effectively prevent future well installation, thus eliminating the potential groundwater exposure pathway.

The additional excavation component of this alternative may not be protective of health and environment if there is damage to structures and sewer lines, mobilization of contaminants, and damage to the protective Lower Confining Unit (LCU). Several excavations conducted over the course of remedial activities removed approximately 521,192 pounds of contaminant from the site; however, DNAPL remains. The remaining DNAPL may be at a steady state and disruption of the area due to excavation may result in increased groundwater concentrations and potentially initiate both lateral and vertical migration of the DNAPL. The extent of DNAPL is projected to extend beneath the City maintenance garage and along the 30-inch sanitary sewer force main; excavation of this material would compromise the structural integrity of the building and sewer. DNAPL detected in the Drain Sump is assumed to be accumulating from the lateral drainpipe installed under U.S. Highway 61. Since much of this material is inaccessible, further excavation would not eliminate source material from the site.

Excavation of impacted soil in the Upper Confining Unit (UCU) and silty sand aquifer would require significant removal of clean overburden in areas previously remediated, would require extensive dewatering, and would risk compromise of the LCU unless pressure equal to or greater than the hydraulic head of the underlying alluvial aquifer is maintained on the LCU to prevent upheaval. If the LCU was compromised during excavation activities, risk to health and environment may increase if DNAPL and site contamination migrated laterally and vertically.

1.1.4 Compliance with ARARs

ARARs or remediation goals for soil accessible for excavation could be achieved in a relatively short period, but it is unlikely chemical-specific ARARs or remediation goals for groundwater would be achieved in a reasonable time frame because a significant amount of contaminant mass in the dissolved and residual phase would remain. Time to achieve groundwater remediation goals after excavation would likely take in excess of a thousand years.

1.1.5 Long-Term Effectiveness and Permanence

Access restrictions will provide long-term effectiveness. Exposure to groundwater is highly unlikely without installation of groundwater wells in the site vicinity; therefore, the overall risk to human health is low. One or more of the following access restrictions in addition to the existing deed restrictions and IDNR rules may be utilized to provide multiple layers of protection:

1) Environmental covenants.
2) Notification of site contaminants to the City Water Department, the Dubuque County Health Department, and IDNR Water Supply Section.

The existing IDNR rules require evaluation of potential sources of contamination prior to permitting a well; this regulation is anticipated to be effective because the rule is codified, increasing the anticipated permanence. Because an environmental covenant is a legally binding document, approved by IDNR, and standardized in Iowa Code, a high level of long-term effectiveness and reliability is expected.

The excavation portion of the alternative does not provide long-term effectiveness. Contaminated groundwater at the site will continue to exist. A large spatial area potentially impacted with residual and free-phase DNAPL is inaccessible to excavation and will exist as a long-term source of dissolved polynuclear aromatic hydrocarbons (PAH) and volatile organic compounds (VOCs) affecting a large aquifer volume. Excavation may compromise the LCU allowing remaining residual and free-phase DNAPL to migrate downward into the alluvial aquifer. The additional excavation could be completed within several months, but it would likely take in excess of a thousand years to achieve remediation goals for groundwater in the silty sand aquifer due to the large amount of contaminant mass left in place under this alternative. Assuming 1) source decay can be approximated by a first order equation, including biodegradation of dissolved constituents; and 2) groundwater concentrations are ideally equal to single compound solubility concentrations, a mass balance box model evaluation provides a mid-range estimate of 39,750 years to remediate benzo(a)pyrene to the remediation goal. Calculations were detailed in Appendix L of the TI Report. The option will require ongoing five-year reviews.

1.1.6 Reduction in Toxicity, Mobility, or Volume through Treatment

This excavation portion of this alternative would remove the principal threats to the environment or future health in accessible areas of soil; approximately 65 percent of the estimated 614,180 pounds of contaminant mass would be permanently removed from the site. Approximately 35 percent of the total contaminant mass is inaccessible to excavation and would remain adsorbed to the soil matrix or as DNAPL within the Highway Corridor area, beneath the City maintenance garage, and along the 30-inch sanitary sewer force main, providing an ongoing source for groundwater contamination. However, natural attenuation processes will gradually reduce the contaminant concentrations. No treatment residuals would remain following the excavation.

1.1.7 Short-Term Effectiveness

There would be no additional risks posed to the community, the workers, or the environment as the result of the access restriction portion of this alternative being implemented. The majority of health risks associated with the excavation process can be addressed through a site specific Health and Safety Plan and training. Potential risks to the environment as a result of the excavation, which cannot be addressed, are discussed below.

There would be additional risks posed to the community, the workers, or the environment as the result of this alternative being implemented. Additional risk would occur during the excavation process. Excavation of impacted materials would present the risk of dermal contact, inhalation, and ingestion of VOCs and PAHs from contaminated soil and groundwater for site workers and workers involved with the treatment or disposal of the contaminated soil and groundwater. Additional risks from the community during excavation may come from the volatilization from impacted soil and groundwater or accidental contact with impacted soil and water during transport from the site. Depending on the treatment or disposal method of the contaminated soil and groundwater, varying levels of risks to the environment would be created through VOCs released to the air during thermal desorbtion, the volume of fuel required to run a thermal desorbtion unit, and the potential for spills during transport from the site. Risks to site workers and the community would be addressed during the excavation process by adherence to a site-specific Health and Safety Plan that would determine the necessary levels of personal protective equipment (PPE) needed for each action. Air monitoring in the work space and at the site perimeter would be necessary to determine when site actions were posing a risk to workers and the community. An excavation plan would also be developed that would determine the procedures to reduce volatilization of the contaminant mass, and prevent or reduce exposure to the contaminated soil and groundwater during handling, excavation, and disposal activities.

Excavation of impacted soil in the UCU and silty sand aquifer would require significant removal of clean overburden in areas previously remediated, would require extensive dewatering, and would risk compromise of the LCU unless pressure equal to or greater than the hydraulic head of the underlying alluvial aquifer is maintained on the LCU to prevent upheaval. In addition, the extent of DNAPL is projected to extend beneath the City maintenance garage and along the 30-inch sanitary sewer force main; excavation of this material would compromise the structural integrity of the building and sewer.

The remedial response objectives for accessible soil could be achieved in a relatively short period, but it is unlikely chemical-specific ARARs or remediation goals for groundwater would be achieved in a reasonable time frame because a significant amount of contaminant mass in the dissolved and residual phase would remain. Time to achieve groundwater remediation goals would likely take in excess of a thousand years.

1.1.8 Implementability

The access restriction portion of this alternative is implementable and will provide layered access restrictions, creating a reliable barrier to future well installation. There are no technical issues to address under the access restriction portion of this alternative. Many other sites are relying on future enforcement of the Iowa Code for continued protection; therefore, it is unlikely to be changed to a degree that would permit well installation near the site in the future. The environmental covenant is unlikely to be changed once approved.

New well permits would be reviewed as a part of the USEPA five-year review process, to verify whether drinking water wells have been placed within the impacted area. Coordination would be required with the City Water Department, the Dubuque County Health Department City, County, and IDNR Water Supply Section to implement the alternative with no foreseeable difficulty.

This excavation portion of this alternative is technically feasible to implement and would use available technologies, equipment, and services that have been used to remediate other sites. The additional excavation field activities could be completed within several months but would require extensive excavation of clean overburden in previously remediated areas and require extensive dewatering efforts. The excavation may cause new migration pathways to develop that would not be addressed with the current monitoring network and site conceptual model. The excavation would leave approximately 35 percent of the source material. It is not anticipated that future remedial action alternatives would be available to remove the remaining source material. Monitoring wells would be used to monitor the effectiveness of the remedy and may require the installation of new monitoring wells if implementation of the remedy creates new migration and exposure pathways that are not covered in the current site conceptual model. It is anticipated that sufficient services and materials, storage areas, and disposal services would be available.

1.1.9 Cost

The present value cost of access restrictions plus additional excavation is estimated to be $2,523,000. Detailed cost breakout and assumptions utilized in the estimating process were presented in Appendix I of the TI Report.

1.1.10 Key Performance Limitations

The access restriction portion of this alternative achieves the Remedial Action Objectives (RAOs) without active remediation, but without waiver of the ARARs, this alternative would not meet the threshold criteria required in the Feasibility Study (FS) guidance. There are no site-specific conditions limiting the effectiveness of the access restrictions proposed in this alternative.

The following site characteristics significantly limit the ability of additional excavation to restore site groundwater to the remediation goals within a reasonable time frame:

- Additional excavation into the deeper DNAPL areas will likely compromise the integrity of the LCU.
- Approximately 35 percent of the estimated 614,180 pounds of contaminant mass remaining as DNAPL or adsorbed to the soil matrix is inaccessible to excavation because of the presence of U.S. Highway 61, the City maintenance garage, and the 30-inch sanitary sewer force main. Contaminant mass calculations were detailed in Appendix K of the TI Report.
- A large spatial area potentially impacted with residual and free-phase DNAPL is inaccessible to excavation and will exist as a long-term source of dissolved PAH and BTEX compounds affecting a large aquifer volume.
- Additional excavation would require extensive excavation of clean overburden in previously remediated areas, and require extensive dewatering efforts.

1.2 GROUNDWATER ALTERNATIVE 2 – ACCESS RESTRICTIONS WITH IN-SITU SOLIDIFICATION

This alternative combines access restrictions with in-situ solidification. In-situ solidification is accomplished by mixing a combination of Portland Cement, cement kiln dust, lime, fly ash, or other binding agents into the subsurface soil. A heavy-duty, large-diameter auger is used to mix the soil while injecting the binding agent, effectively distributing the binding agent throughout the soil. The binding agent subsequently solidifies upon reaction with water (hydration). Impacted groundwater within the treatment zone participates in the hydration reaction and is, therefore, bound within the resulting structure. This technology reduces contaminant mobility by binding the contaminant into a solid mass with low permeability that resists leaching, and/or chemically binding contaminants to the solidification reagents. Stabilization neither reduces contaminant mass nor completely prevents leaching or volatilization, and may become less effective over time as the binding agents degrade. This technology is effective to 55 feet below ground surface (bgs). The auger can be positioned adjacent to the exterior wall of a building, and mixing of subsurface soil can extend up to approximately 4 feet beneath the building foundation; however, this will be limited by the presence of the building piles. The technology is limited by subsurface debris greater than 3 feet in diameter. To implement the technology at the site, the unimpacted areas would be excavated and stockpiled prior to start of the project.

Approximately 30,500 square feet (ft^2) of impacted material would be accessible to the treatment auger. The source material extends to a depth of up to 35 feet bgs with an approximate treatment volume of 22,600 cubic yards (yd^3). Approximately 65 percent of the total mass remaining at the site is accessible for treatment. Of the total mass, 35 percent would remain untreated after solidification.

1.2.1 Protection of Health and Environment

The access restriction portion of this alternative will achieve adequate protection of human health and the environment. The existing and proposed access restrictions provide multiple layers of protection and are expected to effectively achieve the RAOs in the future.

The in-situ solidification portion of the treatment may not be protective of health and environment. The in-situ solidification treatment may cause new migration pathways to develop that would not be addressed with the current monitoring network and site conceptual model. Because the in-situ solidification treatment zone will become a low permeability zone relative to the untreated materials, groundwater flow direction would likely change at the site. The proximity of the stage changes in the Mississippi River, which is hydraulically connected to the silty sand and alluvial aquifers, may result in multiple flow directions at the site, causing additional contaminant migration from untreated areas. Although employment of in-situ solidification technology would reduce the mobility of remaining source material, untreated source material would remain in the inaccessible area beneath the City maintenance garage, along the 30-inch sanitary sewer force main, and within the Highway Corridor area and a significant amount of contaminant mass in the dissolved and residual phase would remain. An estimated 2 million gallons of water would be needed for this alternative. Time to achieve groundwater remediation goals would likely take in excess of a thousand years.

1.2.2 Compliance with ARARs

ARARs or remediation goals for accessible soil could be achieved in a relatively short period, but it is unlikely chemical-specific ARARs or remediation goals for groundwater would be achieved in a reasonable time frame. Although employment of in-situ solidification technology would reduce the mobility of approximately 65 percent of the total remaining source material, 35 percent of the total remaining source material would remain untreated in the inaccessible area beneath the City maintenance garage, along the 30-inch sanitary sewer force main, and within the Highway Corridor area and a significant amount of contaminant mass in the dissolved and residual phase would remain. Time to achieve groundwater remediation goals would likely take in excess of a thousand years.

1.2.3 Long-Term Effectiveness and Permanence

Exposure to groundwater is highly unlikely in the site vicinity and the overall risk to human health is low. The proposed access restrictions provide multiple layers of protection and are expected to effectively achieve the RAOs in the future. Since an environmental covenant is a legally binding document, approved by IDNR, long-term effectiveness and reliability is expected. New well permits could easily be verified through the five-year review process to ensure no drinking water wells have been placed within the impacted area.

This in-situ portion of the alternative would not provide long-term effectiveness and permanence. Stabilization neither reduces contaminant mass nor completely prevents leaching or volatilization, and may become less effective over time as the binding agents degrade. Although employment of in-situ solidification technology would reduce the mobility of remaining source material beneath and northeast of the City maintenance garage. Thirty-five percent of the total contaminant mass would remain untreated.

Because the in-situ solidification treatment zone will become a low permeability zone relative to the untreated materials, groundwater flow direction would likely change at the site. The proximity of the stage changes in the Mississippi River, which is hydraulically connected to the silty sand and alluvial aquifers, may result in multiple flow directions at the site, causing additional contaminant migration from untreated areas. The option will require ongoing five-year reviews.

1.2.4 Reduction in Toxicity, Mobility, or Volume through Treatment

This technology would reduce contaminant mobility by binding the contaminant into a solid mass with low permeability that resists leaching, and/or chemically binding contaminants to the solidification reagents. Stabilization neither reduces contaminant mass nor completely prevents leaching or volatilization, and may become less effective over time as the binding agents degrade. Approximately 206,230 pounds of untreated source material would remain in the inaccessible area beneath the City maintenance garage, along the 30-inch sanitary sewer force main, and within the Highway Corridor area, leaving an ongoing source for groundwater contamination.

1.2.5 Short-Term Effectiveness

Impacts to site workers during implementation of this alternative would be addressed with a site safety plan requiring use of proper PPE and safety procedures. Workers would be exposed to typical mechanical equipment risks. Impact to the surrounding community would be minimal because soil and DNAPL would not be excavated and transported off site. Access to the site during the in-situ solidification process would be controlled. Although the technology is available and has been proven effective at other FMGP sites, untreated source material would remain in the inaccessible area beneath the City maintenance garage, along the 30-inch sanitary sewer force main, and within the Highway Corridor area, leaving an ongoing source for groundwater contamination. An estimated 2 million gallons of water would be needed to complete this alternative and would require an on-site diesel generator to run the batch plant and trailers. It would likely take in excess of a thousand years to achieve remediation goals for groundwater in the silty sand aquifer due to the large amount of residual contaminant mass inaccessible under this alternative.

1.2.6 Implementability

The in-situ solidification is technically feasible and could be completed within months but it would likely take in excess of a thousand years to achieve remediation goals for groundwater in the silty sand aquifer due to the large amount of residual contaminant mass inaccessible under this alternative. The proposed access restrictions create a reliable barrier to prevent a groundwater exposure pathway. New well permits could easily be verified through the five-year review process to ensure no drinking water wells have been placed within the impacted area. The technology has been effectively used at other FMGP sites where access to the impacted soil was not restricted by roads and buildings and the impacted material was located at a relatively shallow depth. The in-situ solidification of accessible portions of the site would prohibit any future remedial actions at the site in the treated areas. Monitoring wells would be used to monitor the effectiveness of the remedy and may require the installation of new monitoring wells if implementation of the remedy creates new migration and exposure pathways that are not covered in the current site conceptual model. It is anticipated sufficient services and materials, storage areas, and disposal services would be available.

1.2.7 Cost

The present value cost of in-situ solidification is estimated to be $3,840,000; details were provided in Appendix I of the TI Report.

1.2.8 Key Performance Limitations

The following site characteristics significantly limit the ability of in-situ solidification to restore site groundwater to the remediation goals within a reasonable time frame:

- Approximately 35 percent of the estimated 614,180 pounds of contaminant mass remaining as DNAPL or adsorbed to the soil matrix is inaccessible to in-situ solidification because of the presence of U.S. Highway 61, the City maintenance garage, and the 30-inch sanitary sewer force main. Contaminant mass calculations were detailed in Appendix K of the TI Report.

- A large spatial area potentially impacted with residual and free phase DNAPL is inaccessible to in-situ solidification, which will exist as a long-term source of dissolved PAH and BTEX compounds affecting a large aquifer volume.

- Because the in-situ solidification treatment zone will become a low permeability zone relative to the untreated materials, groundwater flow direction would likely change at the site. The proximity of the stage changes in the Mississippi River, which is hydraulically connected to the silty sand and alluvial aquifers, may result in multiple flow directions at the site. The change in flow directions may cause additional contaminant migration from untreated areas.

1.3 GROUNDWATER ALTERNATIVE 3 – ACCESS RESTRICTIONS WITH IN-SITU THERMAL TREATMENT

This alternative combines access restrictions with in-situ thermal treatment. In-situ thermal treatment is possible east of the City maintenance garage and could extend beneath the building. However, the presence of U.S. Highway 61 would limit treatment in the Highway Corridor area. In-situ thermal treatment utilizes heat to volatilize volatile contaminants, decrease the viscosity of DNAPL, and desorb/thermally destruct contaminants adsorbed to soil. The technology can use heater wells or electrodes to generate heat in the subsurface. Volatilized contaminants are extracted in the vapor phase, and recovery wells can be used to capture mobile product. In-situ thermal treatment is most effective in unsaturated soils, where the higher temperatures required for soil desorbtion and contaminant destruction can be achieved. In saturated soils, the operating temperature is limited to 212 degrees Fahrenheit (°F). In-situ heating technologies have been used to successfully remediate chlorinated solvent DNAPL sites. The success of this technology on FMGP contaminants or in restoring groundwater to drinking water standards is not certain.

Tar-Specific Green Optical Screening Tool (TarGOST™) data suggests DNAPL remains in both the unsaturated fill material above the UCU and in the silty sand aquifer. Dewatering the silty sand aquifer would be required to achieve temperatures greater than 212°F. Dewatering is not practical and risks damage to the LCU due to upward force from the underlying alluvial aquifer. Therefore, the highest temperature that could be achieved in the silty sand aquifer is 212°F. At this temperature, volatile constituents would be removed, and free-phase DNAPL would be mobilized for collection. However, residual DNAPL and adsorbed contaminants would remain. Thermal treatment would remove approximately 361,670 pounds or 59 percent of the total remaining mass.

1.3.1 Protection of Health and Environment

The access restriction portion of this alternative would achieve adequate protection of human health and the environment. The existing and proposed access restrictions provide multiple layers of protection and are expected to effectively achieve the RAOs in the future. The In-situ thermal treatment portion of the alternative would not be protective of health and the environment. Although the upper-unsaturated fill layer would be amenable to in-situ thermal treatment, residual DNAPL would remain in the silty sand aquifer providing an ongoing source for groundwater contamination. In-situ thermal treatment is possible east of the City maintenance garage and could extend beneath the building; however, the presence of U.S. Highway 61 would limit treatment in the Highway Corridor area.

1.3.2 Compliance with ARARs

Although the upper fill layer would be amenable to in-situ thermal treatment, residual DNAPL would remain in the silty sand aquifer, providing an ongoing source for groundwater contamination. In addition, inaccessible source material would remain in the Highway Corridor and 30-inch sanitary sewer force main corridor areas. Therefore, in-situ thermal treatment would not be expected to achieve the groundwater remediation goals established for the site within a reasonable time frame based on the remaining inaccessible source materials.

1.3.3 Long-Term Effectiveness and Permanence

The access restriction portion of this alternative would achieve adequate protection of human health and the environment in the future. Exposure to groundwater is highly unlikely in the site vicinity and the overall risk to human health is low. The proposed access restrictions provide multiple layers of protection and are expected to effectively achieve the RAOs in the future. Since an environmental covenant is a legally binding document approved by IDNR, long-term effectiveness and reliability is expected. In-situ thermal treatment would not achieve long-term effectiveness and permanence. Residual DNAPL would remain in the silty sand aquifer, providing an ongoing source for groundwater contamination. Inaccessible source material would remain in the Highway Corridor and 30-inch sanitary sewer force main corridor areas. The success of this technology on FMGP contaminants or in restoring groundwater to drinking water standards in the portions of the site where the treatment would be most effective is not certain.

1.3.4 Reduction in Toxicity, Mobility, or Volume through Treatment

In-situ thermal treatment would irreversibly reduce the principal threat at the site by 59 percent. The highest temperature that could be achieved in the silty sand aquifer is 212°F. At 212°F, volatile constituents would be irreversibly removed and free-phase DNAPL would be mobilized for collection in the accessible areas. However, in-situ thermal treatment would not be expected to achieve the groundwater remediation goals established for the site within a reasonable time frame based on the remaining inaccessible source materials. Approximately 41 percent of the estimated 614,290 pounds of contaminant mass remaining at the site is located under

U.S. Highway 61 and east of the City maintenance garage. The contaminant mass will remain as a combination of residual DNAPL that was inaccessible to in-situ thermal treatment, adsorbed material, and adsorbed material that was not susceptible to treatment due to the temperature limitation of 212°F.

1.3.5 Short-Term Effectiveness

Workers would be exposed to typical mechanical equipment risks plus electrical work exposure. The estimated implementation would use 6,860,000 kilowatt-hour (kW-hr) of electricity. Potential Impacts to site workers during implementation of this alternative would be addressed in a site-specific safety plan, requiring proper PPE and safety procedures. There is potential for this alternative to impact the surrounding community through exposure to potentially impacted drill cuttings from installation of the system, during transport of soil cuttings, exposure to untreated-extracted groundwater, and untreated volatilized contaminants during implementation of the alternative. Impacts to the surrounding community would be addressed with proper safety procedures and an air monitoring program. Any groundwater extracted for dewatering during the course of the treatment would be treated prior to discharge. Contaminants volatilized during operation of the thermal system would be treated to reduce air emissions. Access to the site during the in-situ thermal treatment process would be controlled. Although the technology is available, it has not been proven effective at other FMGP sites. Untreated source material would remain in the inaccessible area beneath the City maintenance garage, along the 30-inch sanitary sewer force main, and within the Highway Corridor area, leaving an ongoing source for groundwater contamination. It would likely take in excess of a thousand years to achieve remediation goals for groundwater in the silty sand aquifer due to the large amount of residual contaminant mass inaccessible under this alternative.

1.3.6 Implementability

The proposed access restrictions create a reliable barrier to prevent a groundwater exposure pathway. New well permits could easily be verified through the five-year review process to ensure no drinking water wells have been placed within the impacted area. The in-situ thermal treatment is technically feasible for portions of the site and could be completed within six to nine months, although, only one contractor is licensed to use the in-situ thermal treatment. The success of this technology on FMGP contaminants or in restoring groundwater to drinking water standards in the portions of the site where the treatment would be most effective is not certain. Pilot scale testing may be required to properly implement this technology at the site. It would likely take in excess of a thousand years to achieve remediation goals due to the large amount of contaminant mass left untreated under this alternative. Assuming 1) source decay can be approximated by a first order equation, including biodegradation of dissolved constituents, and 2) groundwater concentrations are ideally equal to single compound solubility concentrations, a mass balance box model evaluation provides a mid-range estimate of 49,500 years to remediate benzo(a)pyrene to the remediation goal. Calculations are detailed in Appendix L of the TI Report. Monitoring wells would be used to monitor the effectiveness of the remedy. It is anticipated that sufficient services and materials, storage areas, and disposal services would be available. Implementation of this alternative would require air discharge permits, sewer discharge permits, and building permits. It is not anticipated that future remedial actions to address the remaining contaminant mass would be available. Assuming damage to the LCU did not occur during implementation, this alternative is not expected to interfere with the implementation of future remedial actions.

1.3.7 Cost

The present value cost of in-situ thermal treatment as presented in Appendix I of the TI Report is estimated to be $3,545,000 for a 30-year period.

1.3.8 Key Performance Limitations

The following site characteristics significantly limit the ability of in-situ thermal treatment to restore site groundwater to the remediation goals within a reasonable time frame:

- Approximately 41 percent of the estimated 614,290 pounds of contaminant mass remaining at the site is present under U.S. Highway 61, remains east of the City maintenance garage as residual DNAPL or adsorbed material that is either inaccessible to in-situ thermal treatment or not susceptible to treatment due to the temperature limitation of 212°F. Contaminant mass calculations are detailed in Appendix K of the TI Report.
- Dewatering of the Silty Sand Aquifer above the LCU would be necessary to achieve temperatures greater than 212°F. Dewatering of the Silty Sand Aquifer would likely damage the LCU.
- A large spatial area potentially impacted with residual and free-phase DNAPL is inaccessible to in-situ thermal treatment, which will exist as a long-term source of dissolved PAH and BTEX compounds affecting a large aquifer volume.

1.4 GROUNDWATER ALTERNATIVE 4 - ACCESS RESTRICTIONS WITH MONITORED NATURAL ATTENUATION

This alternative combines access restrictions with Monitored Natural Attenuation (MNA). As part of the alternative remedial strategy, MNA will monitor plume stability through groundwater sampling and analysis to detect changes in groundwater concentrations or plume migration. Natural attenuation reduces contaminant concentrations in groundwater and limits migration via natural processes such as biodegradation, chemical transformation, sorption, dispersion, diffusion, and volatilization. Biodegradation is the primary mechanism that reduces contaminant mass. Low permeability and adsorptive clayey soil can be the primary physical attenuation mechanisms, which limit migration rates and greatly increase the time available for on-site biodegradation.

Existing data indicates the dissolved plume is generally stable or decreasing, and supports the ability of natural attenuation processes to contain the contaminated groundwater plume to prevent further migration of the groundwater plume to potential receptors. Concentrations at P-112 increased from 2004 through 2006, apparently as a result of the change in flow direction due to shutdown of the FDL Foods (FDL) wells and on-site extraction system. However, the concentrations at P-112 have stabilized in more recent samples. The current direction of groundwater flow is not expected to change with abandonment of the FDL wells completed, and plume stability is expected to be reestablished over time.

As discussed in Section 5.6 of the TI Report, groundwater conditions at the PNG site appear conducive to microbial activity, and initial geochemical data suggest various microbial processes are occurring. Continued groundwater monitoring would be required to confirm contaminant migration is not occurring, concentrations are stable, and concentrations will eventually decrease. The majority of contamination remains in the upper fill layer and the silty sand aquifer, with the underlying low permeability UCU and LCU providing a mechanism for physical attenuation at the site. DNAPL retention as residual material will also limit the degree of both vertical and horizontal migration.

1.4.1 Protection of Health and Environment

The proposed access restrictions would eliminate potential exposure routes to groundwater. The access restrictions and monitoring are expected to be protective of human health and the environment. Natural attenuation processes may reduce groundwater concentrations over time for some compounds.

1.4.2 Compliance with ARARs

Compliance with chemical-specific ARARs/remediation goals is possible in areas conducive to natural attenuation. However, compliance is not likely to be achieved in a reasonable time frame in areas where significant contamination remains.

1.4.3 Long-Term Effectiveness and Permanence

Exposure to groundwater is highly unlikely in the site vicinity and the overall risk to human health is low. The proposed access restrictions provide multiple layers of protection. Since an environmental covenant is a legally binding document, approved by IDNR, long-term effectiveness and reliability is expected. MNA will ensure frequent assessment of groundwater conditions and identification of trends that affect intrinsic remediation. The option will require ongoing five-year reviews. As discussed in Section 5.5 of the TI Report, the majority of residual source material remaining at the site will likely be contained by the site geology. If the DNAPL remaining east of the City maintenance garage were to migrate over time, site data suggests the LCU would limit downward migration of contaminants to the alluvial aquifer. Further lateral migration of DNAPL would likely be contained due to the slope of the LCU as the elevation climbs on the east side of Kerper Boulevard. The degree of both vertical and horizontal migration will be limited by the extent of DNAPL retention as residual material.

1.4.4 Reduction in Toxicity, Mobility, or Volume through Treatment

No reduction in toxicity, mobility, or volume would occur since no treatment process is required for this alternative. However, natural attenuation process will gradually reduce the contaminant concentrations.

1.4.5 Short-Term Effectiveness

There would be no additional risks posed to the community or the environment as the result of this alternative being implemented. Simple precautions can be taken when collecting groundwater samples that would adequately protect workers and the public.

1.4.6 Implementability

The proposed access restrictions create a reliable barrier to prevent a future groundwater exposure pathway. New well permits could be reviewed as a part of the EPA five-year review process, to verify whether drinking water wells have been placed within the impacted area. Coordination would be required with the City, County, and IDNR to implement the alternative with no foreseeable difficulty. There are no significant obstacles to continuing the ongoing monitoring program. Natural attenuation processes would likely result in a gradual reduction in contaminant mass. However, mass reduction is expected to occur very slowly, and attainment of the numerical remediation goals is not expected within a reasonable time frame for the main portion of the site. Attainment of remediation goals for BTEX may be possible at the perimeter of the plume in a reasonable time frame. Assuming a groundwater BTEX concentration equal to the maximum measured benzene concentration of 18,000 micrograms per liter (μg/l), a mass balance box model evaluation suggests BTEX concentrations could reach remediation goals in 41 years. However, assuming groundwater concentrations ideally equal to single compound solubility concentrations, a mid-range estimate to remediate benzo(a)pyrene to the remediation goals is 120,200 years. Calculations are detailed in Appendix L of the TI Report.

1.4.7 Cost

The present value cost of additional monitored natural attenuation (MNA) for 30 years is estimated to be $622,000; details are provided in Appendix I of the TI Report. The total cost of MNA is largely dependent on well installation and time required for additional groundwater monitoring. Changes in the number of monitoring wells needed, groundwater sampling frequency and duration, and analytical parameters monitored could affect the total cost considerably.

1.4.8 Key Performance Limitations

This alternative relies on natural attenuation processes to remediate groundwater over time. The following site characteristics significantly limit the ability of natural attenuation to restore site groundwater to remediation goals within a reasonable time frame:

- Approximately 99 percent of the estimated 614,290 pounds of contaminant mass remaining at the site is comprised of PAHs.
- PAHs have a higher propensity to remain bound to the soil matrix than to dissolve into groundwater due to characteristic high molecular weights, low aqueous solubilities, Henry's Law Constants, high K_{oc} values, and high K_{ow} values (Table 5-1 of the TI Report). Natural attenuation of PAHs is limited by

PAH solubility because microbial degradation predominantly occurs within the dissolved phase.

- Although biological degradation of contaminants by microbes is proven and effective for many VOCs such as BTEX at other sites, the rate of degradation and overall biodegradability of most PAHs present at the FMGP site is variable and not a certainty (Barden, 2002).
- Cometabolism of PAHs is dependent on an adequate supply of a primary microbial metabolism "target," such as short-chain VOCs. Site analytical results indicate the mass of PAHs is several orders of magnitude greater than the mass of VOCs remaining at the site.
- A large spatial area is potentially impacted with residual and free-phase DNAPL, which will exist as a long-term source of dissolved PAH and BTEX compounds affecting a large aquifer volume.

2.0 COMPARISON OF ALTERNATIVES

In this section, a comparative analysis is conducted to evaluate the relative performance of each alternative in relation to each of the seven criteria (State and Public Acceptance will be evaluated during the public review/comment process). A summary of the comparative analysis of remedial alternatives for groundwater is provided in Table 2-1.

2.1 PROTECTION OF HEALTH AND ENVIRONMENT

All of the alternatives provide adequate protection of human health and the environment by utilizing layered access restrictions to prohibit future well placement in the area. Alternatives 1 through 3 include remediation of the site combined with access restrictions and are effective due to the access restrictions. Alternative 4 couples access restrictions and monitoring.

Alternatives 1 through 3 may pose a potential threat to the environment through mobilization of DNAPL and the large volumes of contaminant mass that would remain following implementation. Excavation is likely to disturb the steady-state DNAPL distribution and result in increased risk to human health and the environment by promoting migration and increasing the risk of contaminant dissolution if the LCU is compromised. In-situ solidification is likely to create low permeability areas and change the flow paths at the site. In-situ thermal treatment is limited in effectiveness by water in the surrounding aquifer. Dewatering the aquifer would compromise the LCU and promote migration and contaminant dissolution. The presence of DNAPL in inaccessible areas suggests no groundwater alternative is likely to achieve remedial cleanup goals for groundwater contaminants at the site.

2.2 COMPLIANCE WITH ARARS

None of the alternatives will achieve chemical-specific ARARs/remediation goals for all compounds due to the nature and distribution of contaminants at the site. ARARs/remediation goals for biodegradable VOCs are likely to be achieved given sufficient time at the edges of the plume; however, given the presence of DNAPL at the site, it is not certain how long it would take to achieve ARARs/remedial goals for VOCs and PAHs onsite since the DNAPL will continue to serve as a source of VOC and PAH impact. It is unlikely ARARs/remediation goals will be achieved for all compounds, especially carcinogenic PAHs.

Achieving ARARs/remedial goals on a site-wide basis is not practical because DNAPL source material is located within inaccessible areas. To achieve all chemical-specific ARARs/remedial goals, the source material would need to be removed, which is not feasible with available technologies. Technologies that can address a portion of the contaminant mass on site are likely to disturb the existing geology that is containing the site impacts and enabling the current plume stabilization

2.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

The access restriction portion of all alternatives adequately protects human health and the environment because the proposed access restriction plan would effectively prevent any future groundwater exposure pathway. This plan may consist of existing IDNR rules and environmental covenants which prohibit future well installation on-site. The City Water Department, the Dubuque County Health Department, and IDNR Water Supply Section would be notified of impacts at the site. The institutional controls are layered to increase their reliability. The existing IDNR rules are expected to provide long-term effectiveness and permanence. Because an environmental covenant is a legally binding document, approved by IDNR, and standardized in Iowa Code, a high level of long-term effectiveness and reliability is expected. All alternatives will require a five-year review.

Alternatives 1, 2, and 3 may mobilize DNAPL, exacerbate current conditions, and require long-term monitoring and management. Additional excavation and in-situ thermal treatment activities may damage the LCU and allow DNAPL to migrate downward into the alluvial aquifer. Alternative 2 will create a low permeability zone that may encourage the development of new vertical and lateral pathways. Mobilization of DNAPL is likely to increase the total volume of impacted groundwater. Disturbing the steady-state conditions will likely cause greater dissolution into groundwater, thus increasing contaminant concentrations. All alternatives leave a large volume of contaminated mass in the ground that will continue to exist as a long-term source of dissolved PAH and BTEX compounds that will affect a large aquifer volume.

2.4 REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

Alternatives 1, 2 and 3 will remove or immobilize over half of the total contaminant mass, but contaminant mass remaining as DNAPL or adsorbed to the soil matrix is inaccessible to these alternatives because of the presence of U.S. Highway 61, the City maintenance garage, and the 30-inch sanitary sewer force main. Alternatives 1, 2 and 3 may potentially increase contaminant mobility by mobilizing DNAPL into new lateral and vertical migration paths. Alternative 4 does not involve active treatment and, therefore, no reduction in toxicity, mobility, or volume. Contaminant mass containing PAHs and VOCs will remain at the site under all alternatives.

2.5 SHORT-TERM EFFECTIVENESS

Alternative 4 poses minimal risk to the community or environment from monitoring; however, a slight risk of field and laboratory worker exposure to contaminants is present while sampling and analyzing the groundwater. Alternatives 1, 2, and 3 potentially expose site workers to soil and groundwater contamination during implementation, but risk to the community is minimal and can be mediated through air monitoring, Health and Safety Plans, and standard operating procedures. The risk to workers for alternatives 1, 2 and 3 is increased during equipment installation, equipment repair, cleaning, and material handling. The opportunity is present for contaminants to be transferred to the vapor phase during Alternatives 1 and 3. Therefore, some additional community exposure is likely. Alternative 3 includes DNAPL recovery resulting in potential exposure to site workers, the community, and the environment in the event of an accidental release during recovery or storage. These risks can be minimized with proper PPE, standard operating procedures, and secure storage prior to transport.

2.6 IMPLEMENTABILITY

All alternatives include access restrictions. The access restrictions provided by the IDNR rules are already in place. Environmental covenants on the FMGP site property should not be difficult to enact with cooperation of the site owner.

Alternative 3, in-situ thermal desorbtion, is the most difficult to implement because of the complexity of the equipment, borehole installation, and the lack of historical use of the technology on FMGP contaminants. Alternative 1, excavation, is the next most difficult to implement due to the amount of clean overburden that will need to excavated and the volume of impacted soil and groundwater that will either need to be treated or disposed of. Alternative 2 would not remove mass from the site and not require an extensive site preparation period. Alternative 4 includes ongoing monitoring, which is relatively easily completed and already implemented. Alternatives 1, 2 and 4 have been implemented at other FMGP sites and a familiarity with the process would increase their implementability.

2.7 COST

A detailed itemization of costs and assumptions for each alternative was included as Appendix I of the TI Report. The costs are based on 30 years of operation, though in all cases, the numerical remedial goals will not be met within that time frame. The 30-year cost estimate is developed for comparison purposes; the costs for each alternative will be significantly more in the long-term. In all four alternatives, the RAO for groundwater will be achieved upon implementation of the access restrictions. The least costly option is Alternative 1 – Access Restrictions with Monitored Natural Attenuation with a present value cost estimated as $622,000. The most costly option is Alternative 3 – Access Restrictions with in-situ solidification, with a present value cost estimated as $3,840,000. The remaining 30-year costs are estimated as $3,545,000 for Alternative 3 – Access Restrictions with in-situ thermal treatment and $2,523,000 for Alternative 1 – Access Restrictions with Additional Excavation. Each of the four groundwater alternative cost estimates were provided in Appendix I of the 2006 TI Report.

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Attachments:

Table 1-1 Remediation Goals
Table 2-1 Summary of Detailed Analysis of Remedial Alternatives for Groundwater

Figure 1 Site Map

TABLE 1-1

REMEDIATION GOALS
MIDAMERICAN ENERGY COMPANY
PEOPLES NATURAL GAS SITE
DUBUQUE, IOWA

Constituent	Remediation Level (µg/L)
Benzene	5[1]
Ethylbenzene	700[2]
Toluene	2,000[2]
Xylene	10,000[2]
Naphthalene	100[1]
Benzo(a)pyrene	0.2[2]
Benzo(a)anthracene	0.1[2]
Benzo(b)fluoranthene	0.2[2]
Benzo(k)fluoranthene	0.2[2]
Crysene	0.2[2]
Dibenz(a,h)anthracene	0.2[2]
Indenopyrene	0.4[2]

Notes:

µg/L = Micrograms per liter.

1 United States Environmental Protection Agency (USEPA), 2004. Updated Remediation Goals.

2 USEPA, 1991. *Record of Decision, Peoples Natural Gas Co.* September 16, 1991.

TABLE 2-1

SUMMARY OF DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES FOR GROUNDWATER
MIDAMERICAN ENERGY COMPANY
PEOPLES NATURAL GAS SITE
DUBUQUE, IOWA

Criteria	Alternative 1 Access Restrictions and Additional Excavation	Alternative 2 Access Restrictions and In-Situ Solidification	Alternative 3 Access Restrictions and In-Situ Thermal Treatment	Alternative 4 Access Restrictions and Monitored Natural Attenuation
OVERALL PROTECTIVENESS				
Groundwater Ingestion for Existing Users	High because no existing users to protect.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Groundwater Ingestion for Future Users	High because access restrictions prohibit use of groundwater.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1
Environmental Protection	Moderate. DNAPL and groundwater plume contained by site geology. Low to moderate if the LCU is damaged.	Moderate. DNAPL and groundwater plume contained by site geology. Low to moderate if the LCU is damaged and/or created area of low permeability changes flow paths.	Same as Alternative 1.	Moderate. DNAPL and groundwater plume contained by site geology.
COMPLIANCE WITH ARARs				
Chemical-Specific	ARARs for accessible soil could be achieved. ARARs for groundwater would take in excess of a thousand years.	Same as Alternative 1.	Same as Alternative 1.	ARARs not likely achieved in a reasonable time frame. Natural attenuation processes will reduce the overall contaminant mass over time.
Action-Specific	None identified.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Location-Specific	None identified.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Other	None identified.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
LONG-TERM EFFECTIVENESS				
Magnitude of Residual Risk	The low potential for future use of groundwater near the site remains. Restrictions on accessing contaminated groundwater will remove exposure risk.	Same as Alternative 1.	Same as Alternative 1	Same as Alternative 1
Adequacy and Reliability of Control	Multiple layers of protection: existing IDNR rules and Environmental covenants. Contaminant mass removed through excavation.	Multiple layers of protection: existing IDNR rules and Environmental covenants. Contaminant mass immobilized by in-situ solidification.	Multiple layers of protection: existing IDNR rules and Environmental covenants. Contaminant mass volatilized and/or mobilized for extraction by in-situ thermal treatment.	Multiple layers of protection: existing IDNR rules and Environmental covenants. MNA increases reliability of predicting future plume concentrations, assessment of plume size and applicability of access restrictions.
Need for 5-Year Review	Review required to ensure adequate protection of human health and environment.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.

TABLE 2-1 (CONTINUED)

SUMMARY OF DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES FOR GROUNDWATER
MIDAMERICAN ENERGY COMPANY
PEOPLES NATURAL GAS SITE
DUBUQUE, IOWA

Criteria	Alternative 1 Access Restrictions and Additional Excavation	Alternative 2 Access Restrictions and In-Situ Solidification	Alternative 3 Access Restrictions and In-Situ Thermal Treatment	Alternative 4 Access Restrictions and Monitored Natural Attenuation
REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT				
Treatment Process and Materials Treated	Excavation of accessible soil contaminant mass.	Solidification of accessible soil and groundwater contaminant mass.	Extraction and volatilization of accessible contaminant mass.	None.
Amount of Hazardous Materials Destroyed or Treated	65% of the total remaining contaminant mass will be removed. 206,230 pounds of contaminant mass remains. DNAPL will remain and mobilization is possible.	65% of the total remaining contaminant mass will be immobilized but not destroyed. 206,230 pounds of contaminant mass remains mobile. DNAPL will remain and mobilization is possible.	59% of the total remaining contaminant mass will be removed. 252,620 pounds of contaminant mass remains. DNAPL will remain and mobilization is possible.	None.
Degrees of Expected Reduction	Untreated source material would remain in the inaccessible area beneath the City maintenance garage, along the 30-inch sanitary sewer force main, and within the Highway Corridor area, leaving an ongoing source for groundwater contamination.	None.	Temperatures are limited to 212°F. Approximately 41% of the estimated 614,290 pounds of contaminant mass remaining at the site is present under U.S. Highway 61 or remains east of the City maintenance garage as residual DNAPL or adsorbed material.	None.
Degree to which Treatment is Reversible	Mass removal is irreversible but may mobilize DNAPL. DNAPL will remain as an ongoing source for groundwater contamination.	Immobilization is irreversible. Low permeability may encourage mobilization of DNAPL. DNAPL will remain as an ongoing source for groundwater contamination.	Thermal treatment of contaminant mass is irreversible. The DNAPL may be mobilized. DNAPL will remain as an ongoing source for groundwater contamination.	None.
Type/Quantity of Residuals	206,230 pounds of untreated source material would remain in the inaccessible area beneath the City maintenance garage, along the 30-inch sanitary sewer force main, and within the Highway Corridor area,	Same as Alternative 1.	225,620 pounds of untreated source material would remain present under U.S. Highway 61, remains east of the City maintenance garage as residual DNAPL or adsorbed material and either inaccessible to in-situ thermal treatment and/or not susceptible to treatment due to the temperature limitation of 212°F.	Current conditions persist with natural degradation.
Statutory Preference for Treatment	Does not satisfy.for inaccessible areas of the site. Alternative 2 would satisfy the preference by reducing the contaminant mass in the accessible soil by 66% of the total site contaminant mass.	Does not satisfy.for inaccessible areas of the site. Alternative 3 would satisfy the preference by irreversibly reducing contaminant mobility in accessible soil and groundwater by 66% of the total site contaminant mass.	Does not satisfy.for inaccessible areas of the site. Alternative 4 would satisfy the preference by destroying and reducing the contaminant mass in accessible soil by 59% of the total site contaminant mass.	Does not satisfy.
SHORT-TERM EFFECTIVENESS				
Protection of Community During Remedial Actions	Minor, controllable exposure risks from excavated soil and vapor migration	Minor, controllable exposure risks from soil cuttings and vapor migration	Minor, controllable exposure risks from soil cuttings, extracted groundwater and vapor migration	Risk to community by remedy is not increased.
Protection of Workers During Remedial Actions	Risks controlled through use of PPE and Standard Operating Procedures.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative1.
Environmental Impacts	LCU may be damaged allowing DNAPL to migrate into the Alluvial Aquifer. Excavation may facilitate DNAPL migration.	LCU may be damaged allowing DNAPL to migrate into the Alluvial Aquifer. Low permeability area may alter groundwater flow direction locally.	LCU may be damaged allowing DNAPL to migrate into the Alluvial Aquifer. Heated soil may facilitate DNAPL migration.	No short term environmental impact.
Time until RAOs Achieved	As soon as restrictions are in place.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.

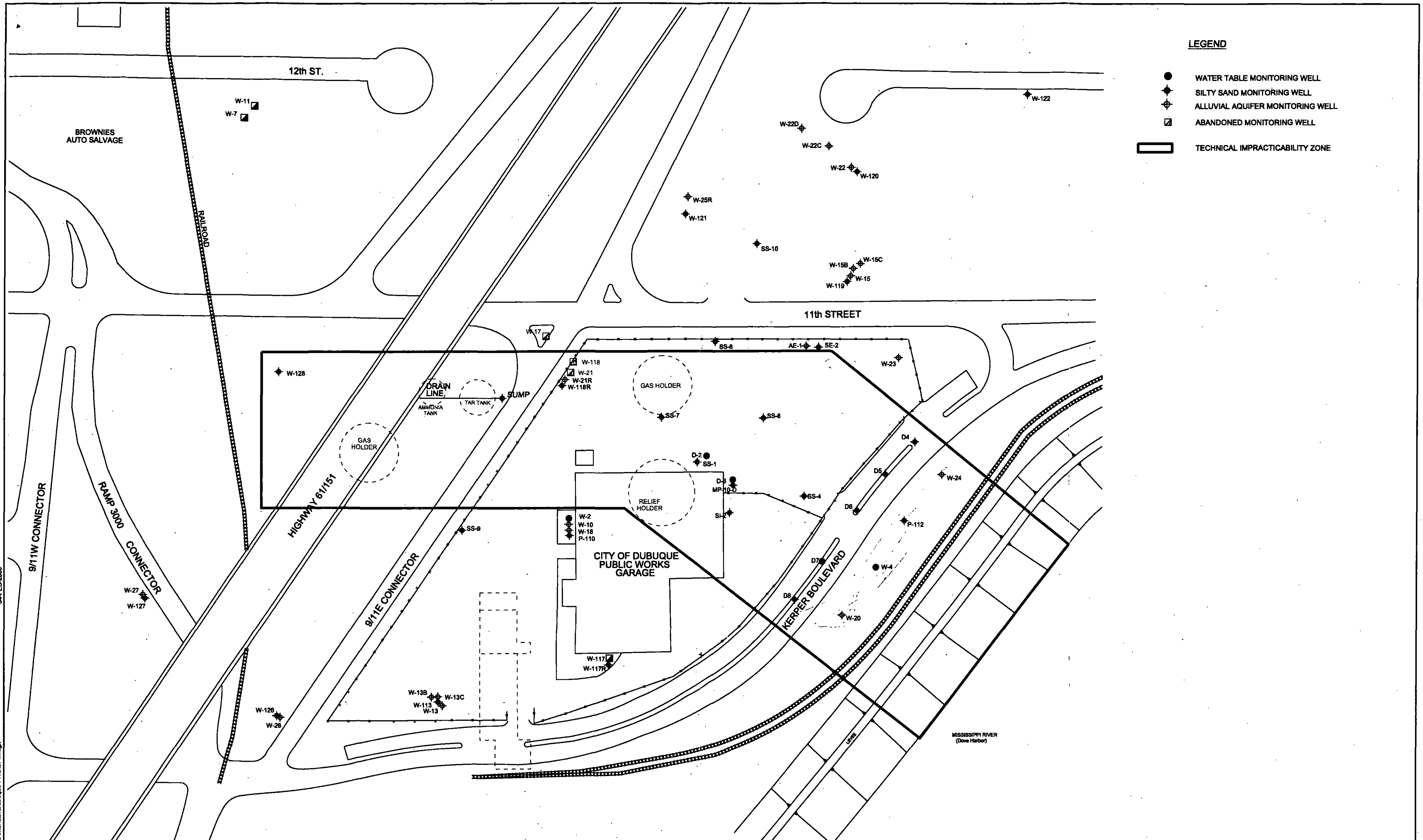
TABLE 2-1 (CONTINUED)

SUMMARY OF DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES FOR GROUNDWATER
MIDAMERICAN ENERGY COMPANY
PEOPLES NATURAL GAS SITE
DUBUQUE, IOWA

Criteria	Alternative 1 Access Restrictions and Additional Excavation	Alternative 2 Access Restrictions and In-Situ Solidification	Alternative 3 Access Restrictions and In-Situ Thermal Treatment	Alternative 4 Access Restrictions and Monitored Natural Attenuation
IMPLEMENTABILITY				
Ability to Construct and Operate the Technology	Difficult. Equipment and process is common but there is a large volume of overburden to remove and excavators must protect LCU.	Difficult. Equipment and process is specialized. The treatment process is relatively complex.	Difficult. Equipment and process is uncommon for FMGP sites. The treatment process is relatively complex.	Easy. Monitoring wells already installed and groundwater sampling previously conducted at the site.
Reliability	High. Multiple layers of protection and appropriate authorities notified. Excavation equipment is reliable.	Moderate. Multiple layers of protection and appropriate authorities notified. Equipment reliable.	Moderate. Multiple layers of protection and appropriate authorities notified. Equipment is reliable, but untested at an FMGP site.	High. Multiple layers of protection and appropriate authorities notified. Monitoring assures current plume conditions are known.
Ease of Undertaking Additional Remedial Action if Necessary	Difficult - access to the remaining contamination limited by the LCU, maintenance garage and highway corridor.	Difficult - solidified areas of the site not easily penetrated. Access to the remaining contamination limited by the LCU, maintenance garage and highway corridor.	Possible, but restricted by conveyance piping and well layout during implementation. Access to the remaining contamination limited by the LCU, maintenance garage and highway corridor.	High.
Ability to Monitor Effectiveness	New well permits could easily be verified to be outside of known area of contamination. Groundwater monitoring used to insure impacted areas are addressed.	New well permits could easily be verified to be outside of known area of contamination. Groundwater monitoring used to insure impacted areas are addressed.	New well permits could easily be verified to be outside of known area of contamination. Groundwater monitoring used to insure impacted areas are addressed.	New well permits could easily be verified to be outside of known area of contamination. MNA increases predictability of future concentrations.
Ability to Obtain Approvals from other Agencies	High.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Coordination with other Agencies	Required coordination with City, Dubuque County, and IDNR for implementation of access restrictions plus excavation permits.	Same as Alternative 1 plus groundwater discharge permits and building permits.	Same as Alternative 2 plus air discharge permits.	Required coordination with City, Dubuque County, and IDNR for implementation of access restrictions.
Availability of Off-Site Treatment/Disposal	Required coordination for off-site treatment/disposal of impacted soil.	Not applicable.	Same as Alternative 1.	Not applicable.
Availability of Necessary Equipment/Specialists	Readily available.	Potential for low availability as it is not a common technology.	Potential for low availability as there is only one licensed contractor.	Same as Alternative 1.
Availability of Prospective Technologies	Commonly utilized.	Available technology, but will require bench scale testing.	Same as Alternative1, but not specifically for FMGP contaminants, pilot scale testing may be required.	Same as Alternative 1.
COST				
Capital, Operation & Maintenance, Present Worth Cost	$2,523,000.	$3,840,000.	$3,545,000.	$622,000.

Notes:

% = Percent.
°F =-Degrees Fahrenheit.
ARAR = Applicable or relevant and appropriate requirements.
City = City of Dubuque.
DNAPL = Dense nonaqueous phase liquid.
FMGP = Former Manufactured Gas Plant.
IDNR = Iowa Department of Natural Resources.
LCU = Lower Confining Unit.
MNA = Monitored natural attenuation.
PPE = Personal protective equipment.
RAOs = Remedial action objectives.



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MANAGING OFFICE
DES MOINES, IOWA

PROJECT
MIDAMERICAN ENERGY COMPANY
PEOPLES NATURAL GAS SITE
DUBUQUE, IOWA

TITLE
SITE MAP

FIGURE
1

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