Penta Wood Remedial Action Optimization Evaluation

Penta Wood Products Site, Town of Daniels, Wisconsin
Work Assignment No. 004-LRLR-05WE, Contract No. EP-S5-06-01

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Purpose

The responsibility for remedy operation at the Penta Wood Products (PWP) Superfund Site will be transferred from the U.S. Environmental Protection Agency (USEPA) to the Wisconsin Department of Natural Resources (WDNR) in 2014. USEPA has requested a preliminary evaluation of alternatives that would accelerate the site cleanup activities, reduce the long-term operations and maintenance (O&M) costs associated with continued operation, or both. To accomplish that request, this memorandum identifies potential options for optimizing the remedial action at the PWP site. As part of identifying options for optimizing the PWP site remedial action, the following questions were considered:

- How is the existing remedy performing compared with projections in the Record of Decision (ROD)?
- What is the estimated time and cost to complete active remediation under the existing remedy?
- Based on the existing remedy, what will the remaining risks and costs from PWP be in 2014 when the State of Wisconsin assumes operational responsibility?
- Can the remedy be optimized so that operational costs after 2014 are significantly decreased or eliminated while adequately addressing risks?
- When can monitored natural attenuation be implemented while ensuring plume expansion will not put offsite residents at risk?

This evaluation identifies options for optimizing the overall PWP site remedial action, potential costs savings for the time remaining on the existing work assignment, and consideration of system operation by the State of Wisconsin after 2014. The results of this evaluation provided information for the second 5-year review of the PWP site dated March 2010.

Record of Decision

In September 1998, the ROD was finalized specifying remedies for both soil and groundwater contamination. The remedial approach implemented at the site addresses light nonaqueous phase liquid (LNAPL) and contaminants in the groundwater by the following means:

- Extraction and treatment of the highly contaminated groundwater
- Monitored natural attenuation of contaminants in the groundwater
- LNAPL recovery
- Bioventing

The objective of the PWP site remedial action is as follows:

- Reduce or eliminate the potential risk to human health and ecological receptors associated with exposure to pentachlorophenol (PCP) and fuel oil components in surface water and groundwater.
- Reduce or control the source of contaminants.
- Meet the applicable or relevant and appropriate requirements (ARARs), including the reduction of concentrations of contaminants in the site's groundwater plume to WDNR's Preventative Action Limits (PAL).

Groundwater is the sole drinking water source in the area. The risk assessment estimated that PCP groundwater concentrations in residential drinking water pose carcinogenic and noncarcinogenic risk, with levels greater than the USEPA target risk range.

ROD comments regarding the No Action alternative include the following: "Given the 4-acre LNAPL area that contains an estimated 550,000 gallons of residual-phase and free-phase LNAPL, continual loading of contaminants to the groundwater would likely occur for hundreds of years. It is unlikely that natural attenuation processes would reduce PCP concentrations in the center of the LNAPL area to PALs within a time frame regarded as reasonable." The ROD noted that additional remedial actions would be considered if PCP concentrations did not decrease at an acceptable rate.

Background

Between 1953 and 1992, posts and telephone poles were treated at the PWP site with a 5 or 7 percent PCP solution in a No. 2 diesel fuel oil carrier, or with a waterborne salt treatment called chemonite, consisting of ammonia, copper oxide II, arsenate, and zinc. Excess amounts of this solution were leaked directly to the ground and as a result of past operations, an LNAPL layer, smear zone, and dissolved-phase PCP plume exists in the groundwater.

The remedial action selected to address PCP contamination at the PWP site includes groundwater extraction and treatment, LNAPL recovery, bioventing, and natural attenuation. The groundwater system extracts and treats groundwater containing dissolved-phase PCP and depresses the water table in the LNAPL area to promote LNAPL removal. Decreasing rainfall at the site in recent years has caused a declining water table, exposing more of the residual phase LNAPL and resulting in larger thicknesses of LNAPL on the surface of the groundwater. The bioventing system was installed to provide oxygen for the aerobic biodegradation of residual diesel fuel petroleum hydrocarbons and PCP in the LNAPL smear zone. The remedial action objectives of the groundwater collection and treatment system are to contain, collect, and treat the most concentrated areas (defined in the feasibility study report as exceeding 1,000 micrograms per liter [μg/L] PCP) of the PCP groundwater plume and reduce the concentrations to a level that allows natural attenuation to achieve maximum contaminant levels (MCLs) of 1 µg/L PCP and PALs of 0.1 µg/L PCP within a reasonable time.

The groundwater extraction and treatment system operated for about 1 year before September 2001, when it was shut down for pilot testing and plant modifications intended to help meet effluent criteria. The system was restarted on February 27, 2004, and has been running continuously since, except for scheduled downtime from routine maintenance and repairs. The biovent system started in September 2007. It has been operated during the summer and turned off during the winter.

The PWP site groundwater treatment system treats groundwater containing emulsified oils and dissolved PCP. The primary treatment train consists of coalescing oil/water separation, chemical conditioning (coagulation with ferric sulfate and flocculation with cationic polymer), dissolved air flotation (DAF), float dewatering using rotary drum vacuum filtration, granular activated carbon (GAC) adsorption of the DAF effluent, and final pH adjustment with the addition of caustic soda to the GAC effluent. Treated groundwater is discharged to an infiltration basin in the northwestern part of the site. The treatment system influent and effluent is monitored in accordance with a Wisconsin Pollution Discharge Elimination System permit issued by the WDNR.

Groundwater monitoring at the PWP site includes semiannual sampling of up to 14 monitoring wells, 5 residential wells, and 1 onsite potable well, measuring static water levels in all monitoring wells, and measuring product levels in monitoring wells with LNAPL.

The groundwater treatment system, bioventing system operation, hazardous waste generation and disposal, groundwater monitoring, reporting, site inspection and O&M activities at the PWP site are performed by CH2M HILL for USEPA under Work Assignment No. 004-LRLR-05WE. The average annual O&M cost, including monitoring and reporting, for these systems is roughly $1,100,000 per year.

System Performance

Evaluation of the concentration trend data in conjunction with the water level and LNAPL measurements indicates that the groundwater extraction system is maintaining capture levels and the plume boundary is decreasing. The LNAPL layer is in equilibrium with pore pressures and is not expected to continue to spread horizontally and vertically; however, it continues to be a source of PCP in groundwater.

The PCP plume exceeding 1,000 µg/L in the unconfined aquifer has receded slightly since 2004 because of continued groundwater extraction and NAPL removal, although significant reductions in the plume size is limited because of the continued presence of LNAPL in the smear zone. The extent of the plume, as defined by the 1-µg/L contour, has shrunk somewhat historically but is similar to the 1,000 µg/L and is not expected to shrink further. The PCP plume is affected significantly by the presence of LNAPL and, therefore, further reductions in PCP concentrations in the groundwater most likely will be minimal until a significant portion of the remaining LNAPL is removed.

The PCP plume in the semiconfined aquifer has steadily diminished in size since 2004, and in 2009 no wells exceeded 1,000 µg/L for PCP. The 1 µg/L PCP plume in the semiconfined aquifer has also been greatly reduced since 2004. The greater reductions in concentration of PCP in the semiconfined aquifer can be attributed to the fact that the semiconfined aquifer is not in direct contact with the LNAPL or smear zone because of a semiconfining layer of glacial till.

A significant reduction in groundwater PCP concentrations is reflected in the steady decline of influent concentrations to the treatment system (reduced from 9,200 µg/L in 2004 to 2,900 µg/L in 2009). The groundwater extraction and treatment system has removed an estimated 7,000 pounds of PCP mass and an estimated 5,900 pounds of PCP removed through the extraction of LNAPL from the environment from 2004 through 2009.

More rapid plume remediation resulting from the groundwater extraction is limited by the continued dissolution of PCP from the LNAPL. Benzene, toluene, ethyl benzene, and xylene (BTEX) and naphthalene were present in several wells in the area of concentrated PCP but are not present in any monitoring wells along or outside the plume perimeter.

Natural attenuation parameters including nitrate, dissolved manganese, dissolved iron, sulfate, methane, chloride, and field parameters (specific conductance, dissolved oxygen, and oxidation reduction potential) are measured during each sampling event. The results are evaluated each year to determine whether the conditions in the aquifer can support natural attenuation. Evaluation of the data generated during 2008 suggested that areas at the perimeter or outside the PCP plume are under slight to strong oxidizing conditions and that natural attenuation is occurring, which is similar to conditions observed in 2007.

The bioventing system operated for about 5 months in 2008. During that time, the intermediate and deep wells and the shallow wells outside of the wood chip area showed a pattern of increasing oxygen levels and decreasing carbon dioxide levels during the months the biovent blower was running. Oxygen generally stabilized for each well at roughly 20 percent. Methane was not detected or was found in the wells at very low concentrations. The shallow wells within the wood chip area showed similar trends, but oxygen concentrations increased only slightly during operation of the biovent blower. Oxygen depletion and an increase in carbon dioxide and methane during the time the blower was turned off indicate that aerobic degradation is occurring.

Results from the residential wells sampled in May 2008 indicated the presence of PCP at very low concentrations in one residential well (less than the PAL of 0.1 µg/L). However, results of the semiannual sampling of residential wells in December 2008, June 2009, and October 2009 showed no detection of PCP, benzene, toluene, ethylbenzene, and xylene, and naphthalene in the residential wells or in the onsite potable well.

Alternative Remediation/Operation Scenarios

Numerous technologies were evaluated during the feasibility study as part of the technology screening or the detailed evaluation of alternatives. Technology screening was performed separately for the soil, groundwater, and LNAPL media. Table 1 summarizes that screening as it relates to the evaluation of technologies focused on improving performance of the existing system.

Based on a review of the site conditions, technical feasibility, and long-term cost objectives, several site remediation alternatives that could be considered individually or in combination

TABLE 1
Summary of Technologies Evaluated in Feasibility Study
Penta Wood Remedial Action Optimization Evaluation

Remedial Technology	Description	Evaluation Summary
Containment—vertical subsurface barriers (e.g., grout curtain, slurry walls, sheet piling)	Create subsurface barrier to horizontal flow of LNAPL.	Not feasible because of the depth of installation (140 feet below ground).
Containment—hydraulic control (e.g., injection to create barrier)	Inject groundwater to create barrier.	Further expansion of LNAPL is unlikely. Hydraulic barrier is too difficult to control for marginal benefit in containment.
Collection—LNAPL recovery wells	Install vertical or horizontal wells, or both, equipped with pumps designed to extract LNAPL.	**Selected remedy.**
Collection—injection and extraction	Inject water around LNAPL plume (to create groundwater high) to force LNAPL to flow toward LNAPL extraction wells.	Not feasible because of high flows required in the permeable sands to create sufficient hydraulic gradient.
Vacuum enhanced extraction	Create vacuum on LNAPL to attempt to concentrate it in the cone of depression of the LNAPL recovery well and enhance collection.	Potentially feasible as an addition to LNAPL recovery technology.
Air sparging	Inject air into groundwater to provide oxygen for aerobic treatment of dissolved PCP.	Not cost-effective because of the large number of sparging wells (260) required and great depths for well completion.
Groundwater extraction	Extract groundwater from LNAPL recovery well to create a cone of depression to cause LNAPL to flow toward well.	**Selected remedy.**
In situ treatment—washing/flushing	Wash or flush soil with surfactant or solvent.	Difficult to measure effectiveness and to control surfactants and solvents in complex stratigraphy.
Soil vapor extraction	Use vapor extraction system to extract LNAPL remaining as residual phase in soil matrix.	The No. 2 fuel oil carrier LNAPL is not sufficiently volatile. May be used in conjunction with steam air stripping.
Thermal treatment	Apply hot air or steam stripping.	Potentially feasible for LNAPL residual zone at water table. Included in remedial alternative that was not selected because of excessive cost relative to overall effectiveness.

Source: CH2M HILL. 1998. *Feasibility Study Report, Penta Wood Products RI/FS, Town of Daniels, Wisconsin*. June.

for future site planning and discussion purposes have been identified. Table 2 summarizes each alternative along with screening level pros and cons, and achievement of objectives.

Table 3 summarizes the estimated costs for each of the alternatives. It breaks down the estimated capital, O&M, alternative life, and present net worth cost.

TABLE 2
Summary of Alternatives Considered
Penta Wood Remedial Action Optimization Evaluation

Remedial Alternative	Description	Pros	Cons	Achievement of Objectives
Maintain and Operate Existing System	Perform groundwater extraction and treatment, LNAPL recovery, and bioventing.	No additional capital costs. No changes needed.	Could require years of operation to meet cleanup objectives. Long-term O&M costs are high. State might not be able to afford long-term O&M costs.	Groundwater plume capture maintained; offsite residents protected. Time to reach 1,000 µg/L PCP is estimated to be 10 years based on current trends in treatment system influent. Groundwater below site remains above 1 µg/L PCP MCL for at least 30 years.
Install Additional LNAPL Recovery Wells	Install additional LNAPL recovery wells equipped with skimmer pumps and connected to existing system.	Limited design necessary for implementation. Could increase recovery rate and potentially provide a small reduction in long-term system operation costs and operation time to achieve cleanup objectives.	Will require continued operation of existing LNAPL recovery system.	Groundwater plume capture maintained; offsite residents protected. Time to reach 1,000 µg/L PCP is estimated to be slightly less that the estimated 10 years based on current trends in treatment system influent. Groundwater below site remains above 1 µg/L PCP MCL for at least 30 years.
Modified Operation of Existing System	Operate the system on short-term periods (e.g., operate for 4 to 6 months and shut down for the balance). The rate of PCP migration at the site is slow; therefore, the footprint of the PCP plume would not significantly change during shutdown. Once the system is turned back on, the pumping rate can be increased to provide a slightly larger capture zone, if needed.	Significant reduction in operating costs if system is not operating during the winter months and no additional capital cost. The change in groundwater levels could result in improved LNAPL collection.	An alternative staffing strategy would need to be considered for the site operator. A part-time operation could result in multiple operators being trained to operate the system, and temporary placement requiring travel expenses. Can prolong cleanup as a result reduced groundwater pore exchanges.	Groundwater plume could expand slightly, but not to offsite residents who will remain protected. Time to reach 1,000 µg/L PCP is estimated to double to 20 years based on current trends in treatment system influent. Groundwater below site remains above 1 µg/L PCP MCL for at least 30 years.

TABLE 2
Summary of Alternatives Considered
Penta Wood Remedial Action Optimization Evaluation

Remedial Alternative	Description	Pros	Cons	Achievement of Objectives
Shut Down Existing System Residential Water Treatment if Needed	Shut down treatment system, and allow natural attenuation to provide further reduction in PCP concentration. Continue groundwater sampling to monitor natural attenuation. It is unlikely that the PCP plume will expand, but carbon filters could be supplied to nearby residents if needed.	Significant cost savings. Addresses risk pathway through ingestion or dermal contact.	Can expose future groundwater users if plume expands. Limits use of groundwater resource and would require institutional controls. Residual LNAPL will still remain, and continue to release dissolved PCP. May require Explanation of Significant Differences or ROD amendment.	Groundwater plume unlikely to expand to offsite residences; offsite residents will remain protected. Residential water treatment will be added to protect residents if plume expands sufficiently. Time to reach 1,000 µg/L PCP is estimated to be at least 30 years. Groundwater below site remains above 1 µg/L PCP MCL for at least 30 years.
Air Sparge Curtain for PCP Migration Control	Install an air sparge curtain around the PCP plume using vertical or horizontal wells to limit future migration of PCP.	It could be used as a stand-alone contingency option at a significantly reduced operating cost compared with the existing system.	Residual LNAPL will still remain, and continue to release dissolved PCP. Installation of vertical wells is costly and limited radius of influence requires many wells to effectively treat groundwater.	Groundwater plume perimeter is treated; offsite residents protected. Time to reach 1,000 µg/L PCP is estimated to be 30 years. Groundwater below site remains above 1 µg/L PCP MCL for at least 30 years.
Air Sparging of LNAPL Area	Inject air into the saturated media to enhance volatilization and promote aerobic biodegradation. Given the low volatility of PCP and No. 2 fuel oil, air sparging would be limited to the enhancement of aerobic degradation.	Oxygen is supplied to the saturated zone, increasing the biological degradation of the PCP contained in the LNAPL residual. Air is delivered to the capillary zone containing LNAPL residuals for aerobic biological degradation. The zone is difficult to treat through bioventing.	Need for high density vertical injection wells for sufficient oxygen distribution in the source zone; however, horizontal wells could be used.	Groundwater plume is treated and offsite residents protected. Time to reach 1,000 µg/L PCP is estimated to be 5 to 10 years. Groundwater below site remains above 1 µg/L PCP MCL for at least 30 years.

TABLE 2
Summary of Alternatives Considered
Penta Wood Remedial Action Optimization Evaluation

Remedial Alternative	Description	Pros	Cons	Achievement of Objectives
Air Sparge Curtain with Reduced Operation of Existing LNAPL Recovery System	Install an air sparge curtain around the PCP plume to limit future migration and continue LNAPL removal.	Significantly reduces operation costs of treatment system. Change in water level can enhance LNAPL recovery. Addition of oxygen enhances biodegradation of PCP.	An alternative staffing strategy may need to be considered. May result in travel costs for a part-time operator and training costs to have multiple operators with availability.	Groundwater plume is treated and offsite residents protected. Time to reach 1,000 µg/L PCP is estimated to be 20 years. Groundwater below site remains above 1 µg/L PCP MCL for at least 30 years.
Groundwater and LNAPL Recovery without Active Aboveground Water Treatment	Operate the LNAPL and groundwater recovery in current mode; re-infiltrate recovered groundwater (without treatment) over the LNAPL area. Bioventing system will aerate the infiltrating water allowing it to be treated in situ through aerobic biological degradation.	Significant operational cost savings by eliminating ex situ water treatment and minimal capital cost.	Require an ARAR waiver to discharge on CAMU. An alternative staffing strategy might need to be considered. Could result in travel costs for a part-time operator and training costs to have multiple operators with availability.	Groundwater plume unlikely to expand to residents; offsite residents will remain protected. Time to reach 1,000 µg/L PCP is estimated to be on the order of 10 to 20 years. Groundwater below site remains above 1 µg/L PCP MCL for at least 30 years
LNAPL Recovery without Water Treatment	Only operate the LNAPL recovery wells and separate LNAPL supernatant from the underflow water in oil/water separator. The oil phase would be collected in storage tank and the water phase would be discharged and infiltrated above the LNAPL plume to enhance driving force to flush LNAPL to recovery wells.	Significant operational cost savings by eliminating ex situ water treatment and minimal capital cost. Faster LNAPL recovery.	Require an ARAR waiver to discharge on CAMU. No groundwater plume control. It is unlikely that the PCP plume will expand but carbon filters could be supplied to nearby residents if needed.	Groundwater plume unlikely to expand to residents; offsite residents will remain protected. Time to reach 1,000 µg/L PCP is estimated to be 30 years. Groundwater below site remains above 1 µg/L PCP MCL for at least 30 years.

TABLE 2
Summary of Alternatives Considered
Penta Wood Remedial Action Optimization Evaluation

Remedial Alternative	Description	Pros	Cons	Achievement of Objectives
Enhanced Thermal Treatment	Inject steam or electrical resistance heating to enhance LNAPL extraction.	Heat reduces the viscosity of the LNAPL and increases mobility for recovery Heat improves the recoverability of the lighter fraction polycyclic aromatic hydrocarbon and reduce the overall mass flux as the remaining contaminants (heavier fraction) are less soluble in groundwater. However, some PCP would remain in the residual LNAPL.	Very expensive technology. PCP mass removal on the scale of 75% would still result in a large mass of residual LNAPL present in subsurface Considered in the feasibility study but not selected because of very high cost relative to overall effectiveness	Groundwater plume is treated and offsite residents will remain protected. Time to reach 1,000 µg/L PCP is estimated to be 2 years. Groundwater below site remains above 1 µg/L PCP MCL for at least 30 years.
In Situ Chemical Oxidation (ISCO)	Inject persulfate or surfactant enhanced ISCO (S-ISCO) into the saturated and smear zone to oxidize the compounds.	Immediate reaction occurs that results in destruction of contaminants resulting in reduced time to achieve cleanup.	Very expensive technology for large area and depth of contaminants. Injection into the source zones requires large amounts of oxidants to meet the oxidant demand and multiple field events would be required. Removal efficiency on the order of 75% would result in a large mass of LNAPL remaining.	Groundwater plume is treated and offsite residents will remain protected. Time to reach 1,000 µg/L PCP is estimated to be 1 year. Groundwater below site remains above 1 µg/L PCP MCL for at least 30 years.
In Situ Solidification/ Stabilization	Use large-diameter soil mixing to stabilize the LNAPL area in situ.	Would reduce the overall mass flux of contaminants to the groundwater.	Very expensive technology for large area and depth of contaminants. Could require excavation of overburden material above the LNAPL area, which includes contaminated soils and wood chips.	Groundwater plume is treated and offsite residents will remain protected. Time to reach 1,000 µg/L PCP is estimated to be 1 yr. Groundwater below site remains above 1 µg/L PCP MCL for at least 30 years.

TABLE 3
Alternative Cost Table
Penta Wood Remedial Action Optimization Evaluation

Description	Capital Cost[e]	O&M Cost[a]	Assumed Alternative Life (years)[b]	Net Present Worth Through 2014 (5years)[f]	Net Present Worth[f]	Key Assumptions
Maintain and operate existing system	$0	$950,000	30	$4,500,000	$20,000,000	No changes to existing system.
Install additional LNAPL recovery wells	$520,000[d]	$980,000	25	$5,200,000	$19,000,000	Three additional LNAPL wells and connected to existing system. Includes operation of existing system with increased annual disposal costs for removal of additional LNAPL.
Modified operation of existing system	$0	$480,000	40	$2,300,000	$12,000,000	Reduced operation of existing system to 6 months/year, includes additional time to shut down/dewater system for non-operating period. Additional savings on annual operating costs could be realized when only the groundwater extraction system is operated to control plume migration.
Residential water treatment—shut down existing system	$47,000[c]	$5,000	30	$67,000	$140,000	Installation and annual filter replacement of carbon filter systems at five residential wells.
Air sparge curtain for PCP migration control	$1,600,000[c,d]	$180,000	30	$2,400,000	$5,300,000	Four horizontal wells surrounding the perimeter of the PCP plume and monthly O&M site visits. Alternative configurations could be considered to provide additional cost savings.
Air sparging of LNAPL area	$2,700,000[c,d]	$210,000	30	$3,700,000	$7,200,000	Seven horizontal air sparging wells beneath the plume and monthly O&M site visits.
Air sparge curtain with reduced operation of existing LNAPL recovery system	$1,600,000[c,d]	$640,000	30	$4,600,000	$15,000,00	Four horizontal wells surrounding perimeter of plume. Reduced operation of existing system to 6 months/year, includes additional time to shut down/dewater system for non-operating period.
Groundwater and LNAPL recovery without water treatment	$1,200,000[c,d]	$250,000	30	$2,400,000	$6,500,000	Untreated water from the groundwater extraction system and oil/water separator will be discharged to an infiltration gallery on the CAMU above the LNAPL area and includes monthly O&M site visits. Biovent system would continue to operate.

TABLE 3
Alternative Cost Table
Penta Wood Remedial Action Optimization Evaluation

Description	Capital Cost[e]	O&M Cost[a]	Assumed Alternative Life (years)[b]	Net Present Worth Through 2014 (5years)[f]	Net Present Worth[f]	Key Assumptions
LNAPL recovery without water treatment	$1,200,000[c,d]	$180,000	30	$2,100,00	$5,100,000	Untreated water from the oil/water separator will be sent to an infiltration gallery over plume. LNAPL will continue to be collected and sent offsite for disposal. No operation of groundwater extraction system and no monthly O&M site visits are required. Biovent system would continue to operate.
Enhanced thermal treatment	$5,500,000[c,d]	$3,800,000	5	$13,000,000	$23,000,000	Existing groundwater treatment system would be operated for 2 years.
In situ chemical oxidation (ISCO)	$100,000,000[c]	$0	0		$100,000,000	Costs are for injection of catalyzed hydrogen peroxide (CHP) (Fenton's Reagent) at 14% solution. Assumes complete oxidation of LNAPL plume using 6 lb CHP/lb LNAPL. Pilot study would be performed and is not included in this cost estimate.
In situ solidification/ stabilization	$13,000,000[b]	$0	0		$13,000,000	Volume to be stabilized is LNAPL zone and area of the plume 30 feet thick (roughly 67,000 cubic yards). Soil mixing can occur to the depth of the LNAPL plume without overburden soil removal.

Note: The estimates presented are considered an order-of-magnitude cost estimate, suitable for use in project evaluation and planning. It has been prepared without equipment specifications, layout, design or engineering calculations. Expected level of accuracy is +100% / -50%. Actual construction costs will vary from this estimate due to market conditions, actual costs of purchased materials, quantity variations, regulatory requirements, final design details and other project-specific factors existing at the time of construction.

[a]O&M costs do not include annual reporting and groundwater sampling.

[b]Relative to a baseline operation of 30 years.

[c]Does not include dismantling or disposal of existing system. Does not include salvaged equipment costs.

[d]Assumes investigation-derived waste water will be treated in existing groundwater treatment system. Soil cuttings will be disposed of offsite as hazardous waste.

[e]Does not include predesign activities such as pilot studies, pump testing, and laboratory.

[f]Based on 2.7% discount factor.

The alternative life is an estimate of the potential effect of the alternative relative to the existing operation, which has an assumed baseline operation of 30 years and is intended for discussion purposes only. For example, additional LNAPL recovery wells will increase the overall site cleanup rate; therefore, the selected alternative life shows the potential to reduce the overall operation period. However, these are simplified assumptions and not based on actual calculated timeframes for cleanup.

The cost estimates presented in Table 3 are order-of-magnitude estimates developed strictly for comparing the alternatives. They were prepared without equipment specifications, layout, design, or engineering calculations. The expected level of accuracy is +100/-50 percent. The range applies only to the alternatives as defined and does not account for changes in the scope of the alternatives. Selection of specific technologies or processes to configure remedial alternatives is intended not to limit flexibility during remedial design, but to provide a basis for preparing cost estimates.

The final costs of the project and the resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, the implementation schedule, the firm selected for final engineering design, and other variables. Therefore, final project costs will vary from the cost estimates. Because of these factors, project feasibility and funding needs must be reviewed carefully before specific financial decisions are made or project budgets are established to help ensure proper project evaluation and adequate funding.

Alternatives Selection

Based on the evaluations and costs presented in Tables 2 and 3, the following four alternatives were selected for more detailed consideration according to their ability to meet the objectives (i.e., accelerate the site cleanup activities, reduce O&M costs associated with continued operation) established for this optimization evaluation:

- Alternative 1—Modify existing system by installing additional LNAPL recovery wells and reduce operating period to 4 to 6 months/year
- Alternative 2—Same as above, except the LNAPL recovery and groundwater extraction system is shut down when the LNAPL recovery becomes ineffective
- Alternative 3—Air sparge curtain for PCP migration control
- Alternative 4—Groundwater and LNAPL recovery without water treatment

Alternative 1 includes installation of additional recovery wells into the existing system to increase LNAPL recovery. The new LNAPL wells would be operated continuously for about 2 years to maximize recovery. After 2 years, system operation would be reduced to 4 to 6 months a year (late spring to early fall). Since the rate of PCP plume migration is slow (on the order of 7 ft/yr), the plume footprint would not significantly change during the nonoperational period; however, operating the system would ensure the plume did not expand. The reduced operation would reduce operating costs to $320,000 to $480,000 per year.[1] Alternative 1 includes continued operation of the biovent system along with the

[1] Estimated operating costs do not include annual reporting and groundwater sampling costs.

groundwater extraction system. Once the LNAPL recovery becomes ineffective (i.e., LNAPL recovery reaches asymptotic levels), the LNAPL system would be shut down, eliminating the annual operating cost.

Alternative 2 is same as Alternative 1, except that the entire system, including groundwater extraction, is shut down once the amount of LNAPL recovered has declined to an asymptotic level whereby further significant removal is not possible. Ineffective LNAPL removal could either be a result of the amount of LNAPL removed or an effect caused by a naturally rising water table. Although some expansion of the plume is expected because of the continued presence of the residual LNAPL, Alternative 2 relies on the slow rate of PCP plume migration and monitored natural attenuation to limit the migration of the PCP to the nearby residents. Alternative 2 would take the existing system out of operation, but the equipment would remain in place for future use if plume expansion is greater than anticipated. If the system needs to be restarted to contain the groundwater plume, it may be more cost-effective at that time to operate only the groundwater extraction and treatment part of the system. During the years of operation of the entire LNAPL and groundwater extraction and treatment system (i.e., operating 4 to 6 months per year), the annual operating cost would be $320,000 to $480,000 per year.[2]

Alternative 3 involves installation of a horizontal air sparge well curtain around the PCP plume in the upper unconfined aquifer to limit its future migration. The LNAPL and the groundwater extraction wells would be shut down after the installation of the air sparge curtain. Shutdown of the extraction system would significantly reduce annual operation and maintenance costs ($180,000 per year[3]). Alternative 3 does not provide source reduction; therefore, long-term operation would be expected to be greater than that for the other alternatives. However, under any alternative, PALs are not expected to be reached in the area with LNAPL present in the foreseeable future.

Alternative 4 consists of operating the groundwater extraction and LNAPL recovery system, with the recovered groundwater being infiltrated back into the LNAPL area without treatment. The bioventing system will aerate the untreated infiltrating water for in situ treatment through aerobic biological degradation.

These four alternatives were presented to Wisconsin DNR and USEPA in a meeting on April 7, 2010. Alternative 3 was eliminated from further consideration because it may not be needed to control migration of the plume; i.e., the plume is unlikely to migrate significantly once the collection and treatment system is shut down. Alternative 4 was eliminated because of regulatory concern relative to reinjecting untreated water into the CAMU.

The Wisconsin DNR and USEPA selected Alternative 2 as the optimum approach. Alternative 2 provides a low annual operating cost approach while optimizing removal of PCP and preparing for monitored natural attenuation. Alternative 2 consists of the following:

- Three new LNAPL recovery wells
- Continued operation of LNAPL and groundwater recovery and treatment system at full capacity for 2 years

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[2] Estimated operating costs do not include annual reporting and groundwater sampling costs.

[3] Estimated operating costs do not include annual reporting and groundwater sampling costs.

- Reduced operation to the 4 to 6 warm weather months after 2 years of full operation
- Shutdown of the LNAPL and groundwater treatment system and removal from operation when LNAPL recovery is no longer sufficiently productive, to be restarted if plume expansion threatens offsite migration
- Semiannual groundwater monitoring until shutdown, annual monitoring thereafter
- Continued biovent operations during the summer

Three new LNAPL recovery and groundwater extraction wells will be installed to remove additional mobile LNAPL. The new wells will be integrated into the extraction and treatment system and the entire system will be operated for 2 years to maximize the LNAPL recovery from the newly installed wells. After the first 2 years, the treatment system operations will be reduced to 4 to 6 months to reduce costs. The system would be systematically shut down and winterized in the fall and restarted in the spring, since operating costs are higher during cold weather.

As the LNAPL recovery system continues to extract LNAPL, the volume of mobile LNAPL is expected to diminish. Once the productivity of the LNAPL recovery becomes relatively ineffective, the LNAPL recovery and groundwater extraction and treatment systems will be shut down, winterized, and prepared for long-term shutdown. Once the treatment system is shut down, monitored natural attenuation and long-term monitoring will be used to evaluate the continued natural degradation of the plume.

Groundwater monitoring, including the sampling of residential wells, will continue annually to determine if expansion of the plume might affect surrounding residences. If the plume expands to a point at which it could affect surrounding residences, the groundwater extraction system can be reinitiated to contain the plume without LNAPL recovery.

Summary

This memorandum presents an evaluation of alternatives that would (1) accelerate site cleanup and (2) reduce long-term O&M costs associated with continued operation. To help identify options for optimizing the PWP site remedial action, the evaluation answered the following questions:

- *How is the existing remedy performing compared with projections in the ROD?*

  Results from operating the existing remedy have been consistent with the ROD's estimated time period of 30 to 40 years of operation for the alternative.

- *What is the current estimated time and cost to complete active remediation under the existing remedy?*

  There is a high level of uncertainty in determining how long (in years) it will take to remove the LNAPL present at the groundwater surface and in the zone of water table fluctuation. Removal of the LNAPL is an important factor in determining how long the treatment system must be operated under the existing remedy in order to reach 1,000 µg/L PCP in the groundwater plume. Current annual operating costs of $1.1 million for the remedy are not expected to decrease until after the LNAPL has been removed. The time to reach 1,000 µg/L PCP in the groundwater plume is estimated to be 10 years, based on current trends in treatment system influent. However, PCP in the groundwater below the site is estimated to remain above the 1 μg/L ES (and MCL) for at least 30 years and above the 0.1 μg/L PAL for many decades beyond. Once the remedy has diminished the amount of productive LNAPL recovery, the recovery system will be shut down.

- *Based on the existing remedy, what will be the remaining risks and costs from PWP in 2014 when the State of Wisconsin assumes operational responsibility?*

  The plume is expected to remain relatively stable and not to pose risk to nearby residents, even if the treatment system is shut down before 2014. Continued operation of the remedy until 2014 is estimated not to reduce significantly the potential for the plume to migrate offsite. There is a high level of uncertainty in determining how long it will take to remove the LNAPL at the groundwater surface and in the zone of water table fluctuation. It is unlikely that free phase LNAPL, and the difficult to treat residual LNAPL, will be removed or treated by 2014. The biovent system is targeted to the residual LNAPL in the unsaturated zone, but residual LNAPL within the capillary zone and trapped below the water table as a result of the fluctuating water levels can be treated only when the water table drops sufficiently or through the slower process of dissolution and removal through groundwater collection. Until the LNAPL is removed, it will remain the ongoing source of PCP to the groundwater. Current annual operating costs of $1.1 million for the existing remedy, including groundwater monitoring and reporting, are not expected to decrease until after the LNAPL has been treated or removed.

- *Can the remedial action be optimized to address the current remaining risks from PWP?*

  Several remedial alternatives were identified that would adequately address the current remaining potential risk at the PWP site. Some would likely require a ROD amendment or explanation of significant difference (ESD) before implementation. The selected alternative addresses the remaining risk at the site and does not require a ROD amendment or an ESD because it is sufficiently similar to the ROD remedy.

  The plume is expected to remain relatively stable and not to pose risk to nearby residents, even if the system is shut down now. The alternatives to the existing system vary mainly in the time it will take to reduce the plume to 1,000 μg/L PCP. None of the alternatives achieves the ES or drinking water MCL of 1 μg/L for at least 30 years or the PAL of 0.1 μg/L for many decades after that time. The selected alternative removes LNAPL at an accelerated rate in order to reduce the time to achieve the MCL and PAL.

- *Can the remedy be optimized so that operational costs after 2014 are significantly decreased or eliminated while adequately addressing risks?*

  Several remedial alternatives were identified that would significantly decrease operational costs upon implementation. The identified alternatives range from those that would maintain onsite groundwater treatment to the degree currently being accomplished, to those that would rely on monitored natural attenuation and, if necessary, point-of-use treatment to control risk. The selected alternative is optimized so that LNAPL recovery is maximized before 2014. After 2 years of LNAPL recovery with the new extraction wells, operation is reduced to 4 to 6 months annually by 2014, thus, significantly reducing operational costs. Once LNAPL can no longer be effectively removed, the LNAPL and groundwater recovery systems will be shut down. Natural attenuation will maintain PCP concentrations below the PALs in the groundwater used by offsite residents. Groundwater sampling would be continued to monitor natural attenuation and to assess risk for offsite migration. Although it is unlikely that the PCP plume will expand to reach the offsite residences, if it expands sufficiently, the groundwater recovery and treatment system can be restarted.

- *When can monitored natural attenuation be implemented while ensuring plume expansion will not put offsite residents at risk?*

  If the system is shut down now, the plume is expected to expand slightly but not enough to pose a risk to the nearby residents. However, the remediation system will be maintained for future use to allow it to be restarted if plume expansion is greater than anticipated or until the plume migration estimates can be verified.

Conclusions

The selected alternative meets the two objectives of the optimization evaluation: (1) accelerate the site cleanup activities, and (2) reduce the O&M costs associated with continued operation. The selected remedial alternative includes the following features:

- Three new LNAPL recovery wells
- Continued operation of LNAPL and groundwater recovery and treatment system at full capacity for 2 years
- Reduced operation to the 4 to 6 warm weather months after 2 years of full operation
- Shutdown of the LNAPL and groundwater treatment system and removal from operation when LNAPL recovery is no longer sufficiently productive, to be restarted if plume expansion threatens offsite migration
- Semiannual groundwater monitoring until shutdown, annual monitoring thereafter
- Continued bioventing operations during the summer

The selected alternative addresses the remaining risk at the site and does not require a ROD amendment or an ESD because it is sufficiently similar to the ROD alternative. It removes LNAPL at an accelerated rate to cost-effectively reduce the time to achieve the MCL and PAL. Operation is reduced to 4 to 6 months a year by 2012, thus significantly reducing operational costs. The selected alternative is protective of public health and the environment while significantly reducing operational costs by 2014.