4.0 DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

A range of technologies and process options were evaluated in Section 3.0, and the most appropriate technologies and process options were retained for further evaluation as remedial alternatives within the FS evaluation framework. This section describes the combination of those technologies retained from Section 3.0 into potentially viable remedial alternatives to address Remedial Action Objectives at the Site as discussed in Section 2.0, and the initial screening of those alternatives in order to eliminate combinations from the detailed analysis that may not be technically effective, cost-effective, or implementable.

4.1 Review of Remedial Action Objectives

The focus of the proposed remedial effort, and of this FS, is the mitigation of risks imposed by the presence of specific contaminants in soils and sludges, particularly within the Lagoon Area. The human health and ecological risk assessments prepared as part of the RI indicated the presence of the following contaminants in the lagoon area soil/sludge at concentrations resulting in an unacceptable cancer risk or hazard index.

- Benzo (a) anthracene
- Benzo (a) pyrene
- Pentachlorophenol
- N-nitroso-di-n-propylamine
- Dioxin (TEQ)
- Arsenic
- Lead

In general, the contaminants are found at the greatest concentrations within Lagoons 1 and 5, and to a lesser extent in Lagoon 3. The remainder of this section discusses the development and screening of alternatives designed to mitigate the risks posed by these contaminants.

4.2 Development of Remedial Action Alternatives

A series of remedial alternatives were assembled to address the threats posed by contaminants within the soil and sludge of the lagoon area. Remediation Action Alternatives (RAAs) were developed to provide a range of treatment and containment options for the affected media. The alternatives were assembled using the technologies surviving the screening process presented in Section 3.0, which comprise a focused list of technologies which appear to satisfy minimal requirements of effectiveness, implementability, and cost.

4.3 Initial Assembly of Remedial Action Alternatives

Table 4.3-1 shows a matrix of the potentially feasible technologies correlated with the assembled RAAs. These alternatives represent combinations of technologies that would be able to approach or exceed ARARs. Table 4.3-2 presents a summary of the selected components of the assembled RAAs.

TABLE 4.3-1
RANGE OF ALTERNATIVES
Pownal Tannery Site
Pownal, Vermont

		NCP Criteria:	No/Minimal Action		Approach ARARs			Attain or Exceed ARARs				
		Guidance Criteria	No Action	Institutional Controls	Containment with little or no treatment			Minimize Long Term Management Treatment is Primary Component				
Technology Type [(1)]	**Description**	Alternative [(2)]	1	2	3	4	5	6	7	8	9	10
No Action	No remedial activities		x									
Institutional Controls	Limit future exposure by land use restrictions			x	x	x	x	x	x			x
Capping	Placement of multimedia cap				x	x			x			
Excavation	Removal of impacted materials without dewatering					x	x	x	x	x		
Disposal	Disposal of impacted materials in off-site landfill						x					
Consolidation	Movement of impacted materials to selected areas					x		x	x			
Ex-situ Stabilization/Solidifi	Ex-situ S/S using cement-based reagents							x	x			
On-Site Treatment	Treatment using in-situ chemical oxidation										x	
On-Site Treatment	Treatment using ex-situ chemical oxidation									x		
In-situ Stabilization/Solidific	In-situ S/S using cement-based reagents											x

Notes:
1. The technologies included in this table represent the range of technologies surviving the screening process performed in Section 3.0.

TABLE 4.3-2
REMEDIAL ALTERNATIVE SUMMARY TABLE
Pownal Tannery Site
Pownal, Vermont

Alternative	1:	No Action
Alternative	2:	Limited Action
Alternative	3:	Capping in place and institutional controls
Alternative	4:	Excavation, consolidation, capping and institutional controls
Alternative	5:	Excavation, disposal in off-site landfill and institutional controls
Alternative	6:	Excavation, stabilization/solidification, consolidation and land use restrictions
Alternative	7:	Excavation, stabilization/solidification, consolidation, capping and institutional controls
Alternative	8:	Excavation and ex-situ chemical oxidation
Alternative	9:	In-situ chemical oxidation
Alternative	10:	In-situ solidification/stabilization and institutional controls

4.4 Description of Remedial Action Alternatives

The initial assembly of RAAs is described further below.

4.4.1 RAA-1 – No Action

This alternative requires that no further action be taken at the site, including monitoring, or the implementation of institutional controls. Any reduction in risk at the site would be accomplished through natural attenuation. Although this alternative does not accomplish any of the RAOs, it is retained as a baseline alternative for comparison in accordance with the NCP and the RI/FS Guidance.

4.4.2 RAA-2 – Limited Action

This alternative requires only the implementation of institutional controls (commonly enacted through deed restrictions) at the property to mitigate risks due to dermal contact, and incidental ingestion. Land use restrictions may include health and safety requirements for any future subsurface work, as well as restrictions on future use and redevelopment of the site. Alternatives 3 through 7 also include some form of land use restrictions.

4.4.3 RAA-3 – Capping in Place, and Institutional Controls

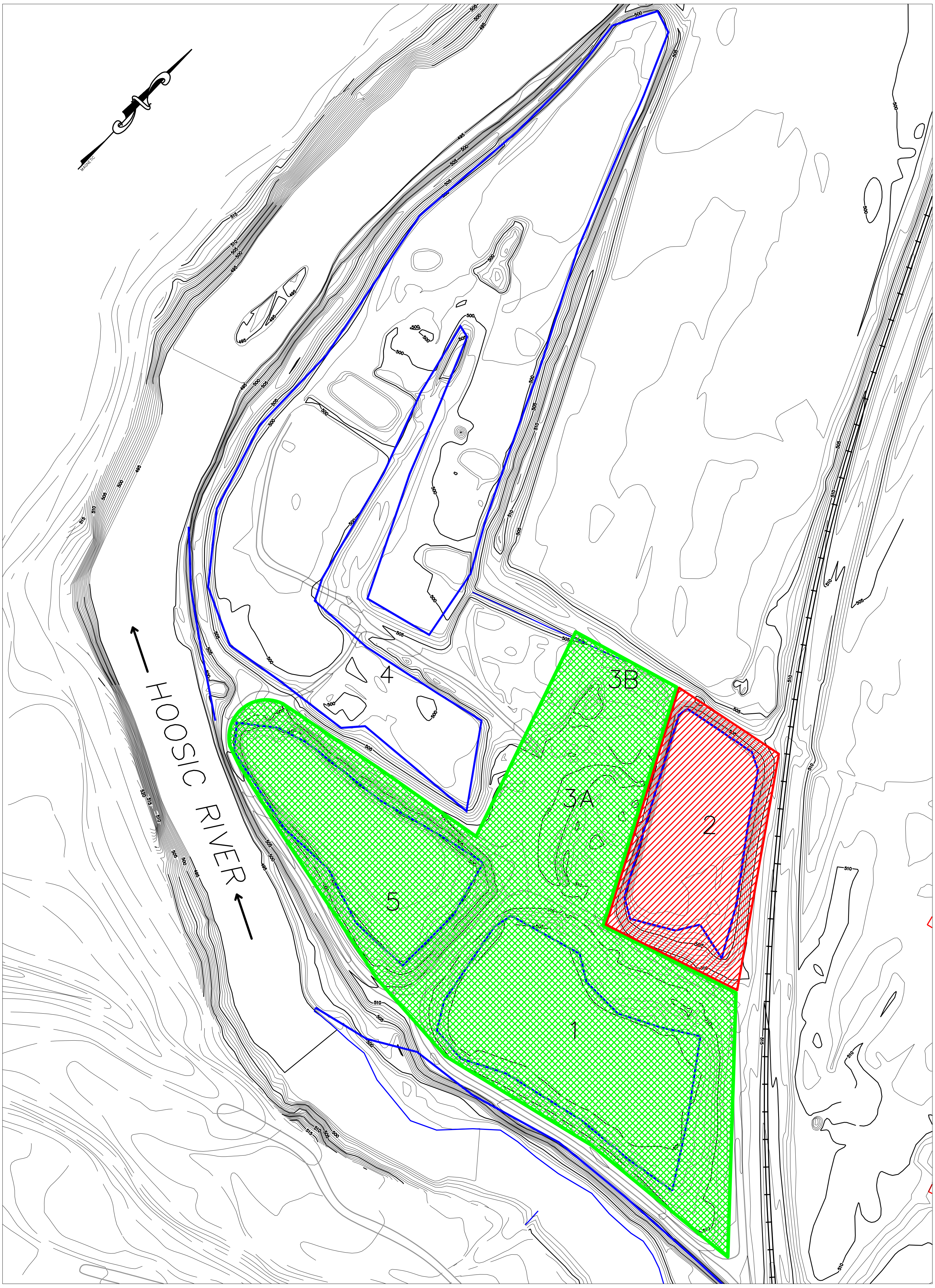
Figure 4.4-1 shows a conceptual layout of this alternative. Impacted material would generally be left in place, with a soil cap constructed above the material in order to limit surficial exposures. A small staging area would be created at Lagoon 2.

4.4.4 RAA-4 – Excavation, Screening, Consolidation, Capping, and Institutional Controls

Figure 4.4-2 shows a conceptual layout of this alternative. This alternative involves the excavation of impacted material above identified threshold concentrations. Excavation would be performed using conventional earth removal equipment, and would likely be performed "in the wet" (without dewatering). Permeabilities within the site soils are generally low, which would hamper traditional dewatering activities. In addition, a significant treatment process train would need to be developed for treating the extracted ground water prior to discharge to the Hoosic River. Under the wet excavation scenario, dewatering pads would be required, where excavated soils could drain prior to further remediation processes. Runoff from the dewatering pads would likely require collection and treatment prior to discharge.

Following excavation and sufficient dewatering impacted soil would be consolidated in selected areas of the site, and a soil cap would be constructed to limit exposure to the contaminated material and to prevent erosion. Consolidation provides the benefit of reducing cap size (and associated costs) as well as leaving more of the site open and available for wetlands reconstruction.

Total Area of Wetlands Lost= 124,857 s.f.



0 40 80 120 160

SCALE IN FEET

LEGEND

Waste Capped In Place

STAGING AREA

Wetland Delineation

1 LAGOON REFERENCE NUMBER

TRC

Boott Mills South
Foot of John Street
Lowell, MA 01852
978-970-5600

TRC PROJ. NO.: 02136-0220-01N93

EPA CONTRACT NO.: 68-W6-0042

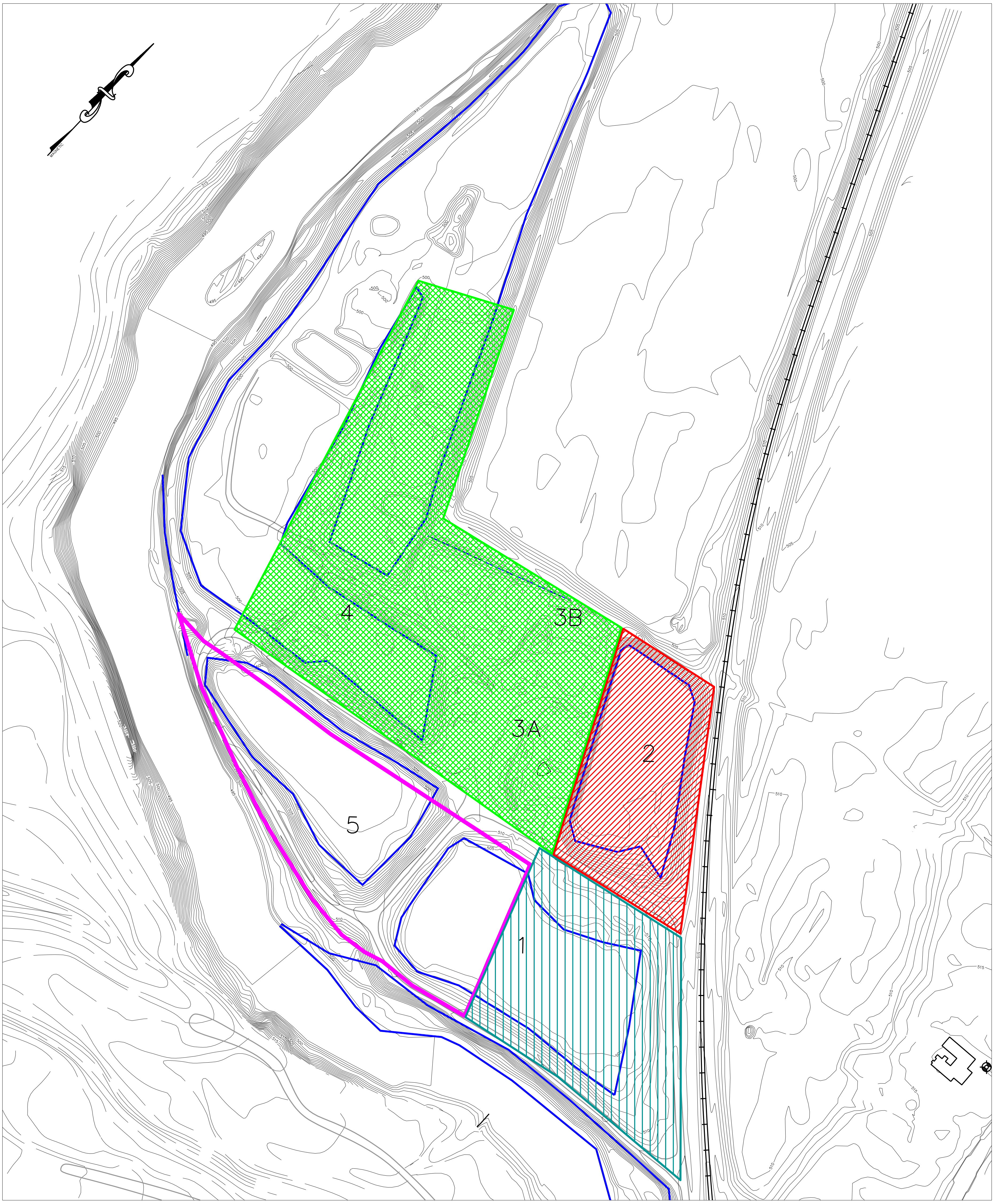
RAC SUBCONTRACTOR NO.: 107061

FIGURE 4.4-1
REMEDIAL ALTERNATIVE IMPLEMENTATION LAYOUT-RAA 3
POWNAL TANNERY
POWNAL, VERMONT

M&E Metcalf & Eddy

J:\OPROJECTS\POWNAL\FIGURES\LANDFILLOPTIONS\CAP IN PLACE_DESIGN

Net Loss of Wetlands= 86,873 s.f.



LEGEND

0 40 80 120 160

SCALE IN FEET

CLEAN FILL TO GRADE

STAGING AREA

LANDFILL 5

1 LAGOON REFERENCE NUMBER

Wetland Delineation

Wetlands Created

J:\OPROJECTS\POWNAL\FIGURES\LANDFILLOPTIONS\LANDFILL_5_DESIGN

TRC

Boott Mills South
Foot of John Street
Lowell, MA 01852
978-970-5600

TRC PROJ. NO.: 02136-0220-01N93

EPA CONTRACT NO.: 68-W6-0042

RAC SUBCONTRACTOR NO.: 107061

FIGURE 4.4-2
REMEDIAL ALTERNATIVE
IMPLEMENTATION
LAYOUT-RAA 4

POWNAL TANNERY
POWNAL, VERMONT

M&E Metcalf & Eddy

4.4.5 RAA-5 – Excavation, Disposal in an Off-Site Landfill, and Institutional Controls

This scenario is similar to RAA-4, with the exception that the impacted soil would be disposed in an existing off-site solid waste landfill, providing increased containment. It is possible that a portion of the material could be placed in Cell 4 of the existing Pownal Tannery landfill.

4.4.6 RAA-6 – Excavation, Solidification/Stabilization, Consolidation, and Institutional Controls

This alternative involves the excavation, and dewatering methods as described above. Following excavation and dewatering, the contaminated material would undergo an on-site Solidification/Stabilization process. The Solidification/Stabilization reagents that may effectively solidify and encapsulate site constituents are currently being evaluated in a treatability study. The treated material would be less susceptible to leaching and erosion, and would limit exposure risks for humans and the environment. The stabilized material may also provide an effective foundation material for construction of future buildings at the site, specifically the proposed wastewater treatment facility.

4.4.7 RAA-7 – Excavation, Solidification/Stabilization, Consolidation, Soil Cover and Institutional Controls

Following the Solidification/Stabilization process described above for RAA-6, the treated material would be consolidated and backfilled on site and a soil cover would be placed over the material. The soil cover would be adequately vegetated and protected with riprap to guard against erosion during normal runoff and flood events. The use of a soil cover further limits potential exposure risks that may continue to exist following Solidification/Stabilization of the impacted material, and provides more suitable site grading options.

4.4.8 RAA-8 – Excavation, Screening, Ex-Situ Chemical Oxidation

This alternative involves the excavation, and dewatering methods as described above. Following those activities, the material would be treated on site using chemical reduction/oxidation methods to convert the identified contaminated materials to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert. These reactions involve the transfer of electrons from one compound to another, resulting in one reactant being oxidized (i.e., losing electrons) and one being reduced (gaining electrons). The oxidizing agents most commonly used for treatment of hazardous contaminants are ozone, hydrogen peroxide, hypochlorites, chlorine, and chlorine dioxide. This technology is particularly effective for inorganics, and moderately effective for organics. Its effectiveness in treating dioxins is considered low, but is relatively unproven. Treatability testing would be required to determine the most effective oxidizing agent, and the effectiveness of the method to treat dioxins. Following completion of the treatment process, the soil could be returned to the site for use as backfill.

4.4.9 RAA-9 – In-Situ Chemical Oxidation

The same basic technology is used for this alternative as in RAA-8. However, under this scenario, the oxidizing agent is delivered to the impacted soil in the subsurface, without prior excavation. This method has the advantage of limiting excavation activities, and the potential exposure risks that may be associated with them. However, an adequate distribution of the oxidizing agent within a heterogeneous soil matrix can be difficult to achieve, which may render certain portions of the subsurface untreated. Introduction of the oxidizing agent into the subsurface can also result in other real and perceived risks, particularly to the site ecology. This method suffers from the same uncertainties regarding effectiveness as RAA-8.

4.4.10 RAA-10 – In-Situ Solidification/Stabilization and Land Use Restrictions

This alternative involves the use of in-situ solidification/stabilization techniques to stabilize the soil on site. A treatability study would be required to determine the most effective reagent mix, which would likely be some variation of a typical concrete mixture. There are several established methods for delivering the stabilizing mixture to the subsurface, including the deep soil mixing technique, which involves the use of large-diameter augers to simultaneously mix the soil and deliver reagent. As the name implies this technique is most applicable for deep soils (i.e., several tens to hundreds of feet deep). Jet grouting is another method typically used for deep soils, where solidification reagents are delivered to the subsurface by a high-pressure nozzle within a borehole. Given the relatively shallow nature of the site contamination, a backhoe mounted mixing tool would provide the most effective means of stabilizing the material insitu. Once stabilized, the material could be left in place, however, the widespread extent of contamination would leave little available area for on-site wetlands restoration.

4.5 Screening of Remedial Action Alternatives

Screening of RAAs is required to reduce the range of alternatives selected for detailed analysis in the following sections. The alternatives developed above were evaluated against three criteria (effectiveness, implementability, and cost), in accordance with the EPA RI/FS guidance. These are the same criteria used for the process option screening in Section 3, and represent the minimum requirements for consideration.

Each of the individual process options within the assembled RAAs meets these minimum requirements on a technology-specific basis. That is, the process options are capable of addressing the specific contaminants and impacted media at the site. The task undertaken here is to evaluate the assembled alternatives from a site-wide perspective, considering the interactions between different contaminants and media, logistical aspects relative to the specific site, and overall implementation issues. The relative effectiveness, implementation, and cost of the RAAs are evaluated on an alternative by alternative basis in the following sub-sections.

4.5.1 RAA-1 – No Action

Effectiveness: The no-action alternative would not be effective at reducing the identified risks at the site. This alternative relies on natural attenuation to reduce the concentration of the contaminants of concern, which can typically require timeframes on the order of 10s to 100s of years to reduce concentrations to acceptable levels. Two of the primary COCs at the site, arsenic and dioxins, are particularly resistant to natural attenuation. Despite its minimal effectiveness, this alternative will be carried forward into the detailed evaluation as a baseline option, for comparison with more aggressive containment and Solidification/Stabilization alternatives.

Implementability: This alternative is readily implemented since it involves no further remedial activities to be conducted at the site.

Cost: The cost of this alternative would be low.

4.5.2 RAA-2 – Limited Action

Effectiveness: Institutional controls, in the form of land use restrictions, represent a legal tool to limit future site activities and uses to those that pose no unacceptable risks of exposure. While institutional controls do not eliminate contamination, they can provide an effective means of reducing exposure potential, and thus risk, in certain cases, if properly maintained and enforced. Land use restrictions would be effective in both the short- and long-term for limiting potential exposure pathways. Potential future direct exposure pathways would be significantly reduced with this alternative, thus resulting in a condition of no significant risk. However, the site would be largely unavailable to most types of beneficial reuse. Furthermore, land use restrictions cannot reduce risks to the environment, or prevent the redistribution of impacted material due to natural causes, such as erosion and deposition of contaminated material into the Hoosic River during flood events.

Implementability: Land use restrictions are easily implemented in the form of deed restrictions. No on-site activities are required.

Cost: This option is very cost effective, requiring drafting and filing of appropriate deed restrictions, and the preparation of supporting technical opinions. The cost of this alternative would be low.

4.5.3 RAA-3 – Capping in Place, Institutional Controls

Effectiveness: This alternative would be accomplished by the placement of a multimedia cap across the impacted areas of the site without any prior handling of the impacted media. This alternative would be effective over the long term in mitigating human health and ecological risks by limiting exposure pathways. It would also be effective over the short-term by limiting handling of the impacted material and reducing real and perceived risks to remedial workers and the neighboring community (due to fugitive dust, potential odor generation, and erosion of material into the Hoosic River). Land use restrictions would be required for maintenance of the cap and to prohibit activities at the site that would disrupt the integrity of the cap.

Implementability: Capping of the impacted areas is readily implementable.

Cost: The cost of this alternative would be moderate.

4.5.4 RAA-4 – Excavation, Consolidation, Capping, and Institutional Controls

Effectiveness: The long-term effectiveness of this alternative is similar to that for RAA-3 (discussed above), providing that the structural and operational integrity of both caps are adequately maintained. In this scenario, however, more flexibility in maintaining ecological resources (e.g., wetlands) and flood storage capacity, and structuring the site towards future uses is allowed. Short-term risks are increased relative to RAA-3 due to the increased handling of impacted media, particularly during the excavation and screening phases, and the potential for fugitive dust and odor generation. Land use restrictions would be required for maintenance of the cap and to prohibit activities at the site that would disrupt the integrity of the cap.

Implementability: This alternative requires excavation of impacted material, much of which is below the water table. Excavation without dewatering will require ample room for staging areas, construction of dewatering pads to allow saturated soils to drain following excavation, and an on-site collection and treatment system for dealing with ground water discharged from the dewatering pads, prior to its ultimate discharge into the Hoosic River. Although all of these components are implementable, logistical issues always increase with systems of increasing complexity.

Cost: The cost of this alternative would be moderate.

4.5.5 RAA-5 – Excavation, Disposal in an Off-Site Landfill, and Institutional Controls

Effectiveness: This alternative is similar to RAA-6, but requires that the consolidated impacted material be placed in an off-site landfill. The primary goals of any of the containment options at the Pownal Tannery site include limiting the exposure pathways available both to humans and local wildlife, and the mitigation of leaching potential by use of an impermeable barrier. In this respect, only a marginal increase in long-term effectiveness would be expected from the use of an off-site landfill as opposed to the other containment options discussed in RAAs 3 and 4. Short-term effectiveness is similar to RAA-4 because excavation and handling of impacted material would be required.

Implementability: Material could be excavated, transported, and disposed in an off-site solid waste landfill. One landfill cell is available in the existing on-site landfill previously constructed near the former warehouse area during earlier remediation activities. It is expected that some portion of the impacted soil and sludge within the lagoon area could be contained within the remaining cell. Implementation aspects of the excavation phase would be similar to those discussed in RAA-4, requiring adequate room for staging areas and dewatering pads.

Cost: The cost of this alternative would be moderate.

4.5.6 *RAA-6 – Excavation, Solidification/Stabilization, Consolidation, and Institutional Controls*

Effectiveness: Solidification/Stabilization can be an effective means of controlling exposure risks. Utilization of an effective reagent mix, which can be pre-determined through a treatability study, is essential to the effectiveness of this alternative. An effective reagent produces a stabilized product with high compressive strength and low susceptibility to leaching, resulting in limited exposure pathways, and a reduction in risk. Thus, consolidation and placement of the solidified material on site provides an effective means of risk reduction. Over long time periods, the solidified material may weather, crack, and fragment, potentially increasing exposure risks to human health and the environment. The short-term effectiveness of this alternative is related to the handling required during the excavation, screening, and Solidification/Stabilization activities, and is similar to that discussed under RAA-4.

Implementability: Implementation of this alternative would require the construction of an on-site pug mill for processing of the impacted material into a stabilized mass, which will require an adequately sized on-site staging area. The logistical complexities involved with the excavation process remain the same as described under RAA-4. In general, Solidification/Stabilization is a proven technology, which is considered technologically implementable, providing that the treatability study results in the selection of an effective reagent mix. It is only the logistical implementability, if any, which could pose potential problems if this alternative were to be chosen for the Pownal Tannery site.

Cost: The cost of this alternative would be high.

4.5.7 *RAA-7 – Excavation, Solidification/Stabilization, Consolidation, Soil Cover and Institutional Controls*

Effectiveness: This alternative is similar to RAA-6, with the exception that the final disposition of stabilized material is placed beneath a soil cover. The soil cover will be vegetated and rip-rapped appropriately to prevent erosion. The soil cover serves several purposes, including protection of the stabilized material from weathering, and increasing options for beneficial site reuse. As such, this alternative provides a marginally more effective solution that RAA-6.

Implementability: The implementability concerns associated with this alternative are similar to those discussed under RAA-6. Addition of the soil cover is easily implemented.

Cost: The cost of this alternative would be high.

4.5.8 *RAA-8 – Excavation, Screening, Ex-Situ Chemical Oxidation*

Effectiveness: Chemical reduction/oxidation is a treatment scheme that utilizes reduction/oxidation chemistry to render COCs less toxic. The method is most effective for inorganics, and thus would have the greatest effectiveness at the site for treating arsenic, which is widespread throughout soils and sludge in the lagoon area, particularly lagoons 1, 3, and 5. The effectiveness of chemical reduction/oxidation for dioxins and SVOCs is less established, and would require a treatability study prior to full-scale implementation of this alternative. In some cases, incomplete oxidation or formation of intermediate contaminants may occur depending on the reagent used, potentially compromising the alternative's effectiveness. Short-term risks may include the potential for fugitive dust and odor generation particularly during the excavation and screening phases of the alternative (as described under RAA-4).

Implementability: Implementation of ex-situ chemical reduction/oxidation would be feasible. This technology is well established and commonly used for disinfection of drinking water and wastewater as well as treatment for cyanide and chromium wastes. This technology is best suited for addressing concerns relating to arsenic; treatment of SVOCs and dioxins using this method may prove challenging. Logistically, a staging area for soil and sludge processing would be required on site.

Cost: The cost of this alternative would be high.

4.5.9 RAA-9 – In-Situ Chemical Oxidation

Effectiveness: The technology supporting this alternative is similar to the ex-situ treatment process described in RAA-8. As discussed under that alternative, the effectiveness of chemical reduction/oxidation in treating SVOCs and dioxins is largely unknown. In addition, this technology relies on the delivery of an oxidation reagent to the subsurface, which serves as a catalyst for the reduction/oxidation reactions. In heterogeneous and low-permeability soils, an even distribution of the reagent can be difficult to achieve, further compromising the effectiveness of the method. The effectiveness of this alternative is also a function of the redox state of the site ground water. In highly reduced environments, effectiveness for treating arsenic is greatly reduced.

Implementability: Implementation concerns regarding this alternative include the difficulty of delivering reagents to low-permeability, heterogeneous soils. Implementation of this method in-situ, would require a series of injection and recovery wells for application of the reagent. To limit short-circuiting of the reagent through high-permeability channels in the subsurface, tighter spacing of the injection/recovery wells is recommended, increasing costs substantially. A pilot test would be required following a treatability study, and prior to full scale implementation to evaluate design parameters.

Cost: The cost of this alternative would be high.

4.5.10 RAA-10 – In-Situ Solidification/Stabilization

Effectiveness: The end product of in-situ Solidification/Stabilization is similar to that for the ex-situ process discussed under RAA-6; both processes result in the creation of a monolithic structure that renders encapsulated contaminants immobile. Both methods rely on the same reagent mixture, and essentially only differ in the method used to deliver the reagents to the affected media. There are several methods that can be used to accomplish in-situ soil mixing, with a backhoe mounted mixing tool the most favorable for the relatively shallow zone of contamination at this site, as described under the description of this alternative in Section 4.4.10.

Overall, it is unlikely that this in-situ process would be able to provide as thorough mixing as could be achieved in the ex-situ scenario, potentially leaving zones of contaminated material untreated.

Implementability: Although in-situ Solidification/Stabilization is a technically sound and proven alternative, there are several logistical issues that could complicate its implementation at this site. As mentioned above, complete mixing may be difficult to achieve using in-situ stabilization techniques. Without excavation and consolidation, stabilization would be required across a large portion of the lagoon area, which could compromise the current wetland ecology and flood storage capacity of the area. Loss of flood zone storage volume would be driven by the fact that stabilized materials undergo a volume increase of 20% or more, due to the addition of significant amounts of stabilization reagent, and expansion during curing. In the in-situ scenario, this volume increase is confined to the vertical dimension, causing an increase in site grade of up to several feet.

Cost: The cost of this alternative would be high.

4.6 Summary of Remedial Action Alternatives Retained for Detailed Evaluation

Ten RAAs were assembled and evaluated in accordance with the EPA RI/FS Guidance (EPA, 1998). The screening criteria used included effectiveness, implementability, and cost. Six alternatives (RAA-1, RAA-2, RAA-3, RAA-4, RAA-5, and RAA-7) were retained for further consideration (Detailed Evaluation of Alternatives).

Based on the primary process option involved, there are four main RAA categories: no action/limited action (RAAs 1 and 2), capping/landfilling (RAAs 3, 4 and 5), solidification/stabilization (RAAs 6, 7 and 10), and chemical oxidation (RAAs 8 and 9).

Of the no action/limited action options, the no action alternative (RAA-1) is retained for detailed evaluation, as required by the NCP. RAA-2 is also retained since it is a more practical means of implementing the no action/limited action alternative, despite limitations on future site use and development.

The capping/landfilling subgroup of RAAs is an important one, as it represents one of the most effective and cost efficient group of alternatives. The distinction between the three RAAs in this subgroup may be subtle, but they each offer unique advantages that cannot be adequately compared through the initial screening criteria discussed above. For this reason, all three of the capping/landfilling alternatives were retained.

The two ex-situ Solidification/Stabilization alternatives (RAA-6 and RAA-7) are very similar, differing only in the construction of a soil cover above the stabilized material within RAA-7. Use of the soil cover can allow for greater latitude in options for beneficial site reuse, and limit weathering and fracturing of the stabilized material. For this reason, RAA-7 was chosen over RAA-6 to be retained for detailed evaluation.

RAA-10 consisted of in-situ Solidification/Stabilization. While the basis of this technology is comparable to the ex-situ variety and is a sound and proven option, use of in-situ techniques is not warranted at this site. The relatively shallow extent of contamination and the potential mixing inefficiencies of in-situ Solidification/Stabilization techniques for shallow soils, as well as the wide area extent which would require treatment, point to ex-situ Solidification/ Stabilization options as better suited for the Pownal Tannery site. RAA-10 was not retained for further evaluation.

The final category of alternatives consists of the two chemical oxidation options. RAAs 8 and 9 both rely on the effectiveness of chemical oxidation in targeting the COCs at the site, which is questionable for SVOCs and dioxins. Given the availability of the proven and effective options contained in RAAs 3 through 7, accepting the risk involved with the questionable effectiveness of chemical oxidation is not warranted, and neither RAA will be retained.