Memo

To: Mr. Dustin Armstrong (PADEP)

From: Timothy Uhler (GES)

cc: Denise Good (GES), Brian Hecker (GES)

Date: November 10, 2020

Re: Technology Assessment
GTAC 7-1-342 – Bishop Tube HSCA Site
East Whiteland Township, Chester County, Pennsylvania

Groundwater & Environmental Services, Inc. (GES) has prepared this Technology Assessment memorandum on behalf of the Commonwealth of Pennsylvania Department of Environmental Protection (DEP) for the Former Bishop Tube Property (the Property), located at 1 South Malin Road in East Whiteland Township, Chester County, Pennsylvania. The purpose and primary focus of this Technology Assessment is to provide estimated costs and timeframes for four (4) potential remedial alternatives, as requested by DEP, to mitigate the potential risks to human health and the environment caused by the presence of identified contaminants in the source soils including:

1. Excavation with offsite disposal of impacted saturated and unsaturated zone soils;
2. Excavation with onsite treatment of impacted saturated and unsaturated zone soils;
3. In situ chemical reduction/oxidation (ISCR/ISCO) via soil mixing of impacted saturated and unsaturated zone soils; and
4. In-situ thermal treatment (ISTT) to address groundwater and solid chlorinated volatile organic compound (CVOC) source zone media (including bedrock) to a depth of 80 feet below ground surface (ft bgs).

Background

The Property is approximately 13.7 acres in size. Current features include two large vacant structures identified as Building 5 and Building 8 that cover approximately 3.7 acres of the Property. The area immediately surrounding the two buildings predominantly consists of concrete covered surfaces formerly used for facility driveways, parking and loading areas. The remainder of the Property, primarily in the southern and eastern portions, is overgrown with vegetation and trees. The Property was historically zoned industrial; however, the Property was rezoned by East Whiteland Township for residential use in 2014. As directed by DEP, this Technical Memo considers residential use of the Property. It is anticipated that a site-specific standard via pathway elimination will be used to attain a residential standard. A site plan of the Property is included as **Figure 1**.

The results of the historical remedial investigations summarized in the Remedial Investigation Report (RIR) prepared by Roux Associates, Inc. (Roux), identified seven (7) volatile organic compounds (VOCs) and ten (10) inorganics as the primary constituents-of-concern (COCs) in soil and groundwater at the Property. These COCs include: trichloroethene (TCE), tetrachloroethylene (PCE), cis-1,2-dichloroethylene (cDCE), 1,1,2-trichloroethane (1,1,2-TCA), 1,1,1-trichloroethane (TCA), vinyl chloride (VC), 1,1-dichloroethylene (1,1-DCE), fluoride, chromium, vanadium, arsenic[1], nickel, cobalt, lead, antimony, manganese, and thallium. Due to limited soil analytical data, fluoride is only considered a potential COC for soil Additional soil sampling may need to be conducted during pre-design activities to confirm concentration and distribution of COCs which may include fluoride and hexavalent chromium in soils on the Property.

A detailed summary of the Property description, setting, history, and extent of the soil and groundwater COCs is provided in the following documents:

- Remedial Investigation Report, prepared by Roux, dated June 10, 2019[2];
- Feasibility Study Report, prepared by Roux, dated June 17 2019[3]; and
- Final Remedial Alternatives Analysis (RAA), prepared by GES, dated August 5, 2020.

Comparison to RAA

Three of the four treatment technologies discussed in this memo were also evaluated in the Final RAA. There are notable differences in the costs presented in the two documents that are primarily related to the following:

- The RAA costs were for treatment of unsaturated soils, while this memo addresses unsaturated and saturated soils, adding significant costs to incorporate full-scale dewatering efforts;
- The RAA included a high level, conservative estimate of the treatment area volume and assumed a treatment depth of 12 ft bgs. The costs presented in this memo include a more refined evaluation of the treatment area volumes (including differentiating the depth to water and depth to bedrock among the treatment areas).
- The RAA included a substantially larger treatment volume as large areas were included to address inorganics. As described later in this memo, arsenic, chromium, and vanadium are assumed to be a naturally-occurring condition and resulted in smaller treatment areas for the inorganic constituents.
- A correction was made to the calculation for the backfill line item for Excavation with Offsite Treatment, resulting in a significant cost reduction.

[1]Chromium, arsenic, and vanadium represent suspected naturally occurring conditions. It is assumed a future demonstration of a background standard will be achieved for these compounds.
[2] The June 2019 RIR, referenced in this document, will likely be revised in 2020. The updated version of the RIR will be a part of the Administrative Record.
[3]The June 2019 Feasibility Study Report, referenced in this document, will likely be revised in 2020. The updated version of the Feasibility Study Report will be part of the Administrative Record.

- Costs were further reviewed overall and in the case of Excavation with Onsite Treatment approach, further research and additional cost source references resulted in a notable increase in the unit cost for onsite treatment.

Based on these changes outlined above, the costs for Excavation with Offsite Disposal and ISCO/ISCR Soil Mixing decreased while the cost for Excavation with Onsite Treatment increased.

Treatment Areas

The objective of the remedial technology approaches included in this assessment is to substantially reduce or remove COCs from source soil (unsaturated and saturated). As such, the treatment areas are approximated based on historical soil data as presented in the RIR, outlined in more detailed below, and are shown in **Figure 2**. The ISTT alternative includes extension of the treatment zone depth into the shallow bedrock as a more robust treatment option that excavation and soil mixing cannot achieve.

In order to assess the overall timeframes and costs associated with the four remedial technologies, the following property characteristics were considered:

- The Property is occupied by two adjoining industrial buildings (Building 5 and Building 8) and surrounding various paved areas related to the former manufacturing activities. The remainder of the Property consists of both paved and unpaved areas.
- The Property is bordered to the east by tributary of Little Valley Creek and residential properties (General Warren Village), to the west by South Malin Road, to the north by a Norfolk Southern rail line, and to the south by an undeveloped wooded parcel.
- Review of available site characterization information indicates four (4) potential pathways for exposure to the soil COCs on the Property:
    - Inhalation of volatilized vapors from soil;
    - Leaching of constituents from surface and subsurface soil to groundwater and indirectly through dermal contact and/or ingestion of contaminated water;
    - Dermal contact, ingestion, and/or inhalation of particulates from contaminated soil; and
    - Dermal contact with surface water contaminated by runoff from contaminated surface soil.
- Treatment area areal extents were generally determined based on review of soil analytical data against the following PADEP standards:
    - Residential Direct Contact (RDC) Medium Specific Concentrations (MSCs) for soil (0-15 feet) found on Tables 3a (organics) and 4a (inorganics) of Appendix A of Chapter 250, last revised August 27, 2016; and

  - Residential Used Aquifer (RUA) (total dissolved solids <2500 milligrams per liter) Soil-to-Groundwater MSCs for soil found on Tables 3b (organics) and 4b (inorganics) of Appendix A of Chapter 250, last revised August 27, 2016.

- Review of soil analytical results collected during soil boring and monitoring well installation events at the Property indicate that impact of COCs is present in the saturated and unsaturated zones. The majority of the available data is from soil samples collected in the unsaturated zone. In general, sample exceedance depth did not factor into determining the treatment area depth. If a soil sample exceeded the standard, it was conservatively assumed to be representative of the unconsolidated zone and included in the treatment area. Refinement of treatment area extents and depths would be completed during future work plan, pre-design, and design efforts. In the absence of saturated soil sample results, the areal extent of unsaturated contamination will also define the areal extent of saturated soils.

- As described in the RIR, arsenic and vanadium may represent suspected naturally occurring conditions based on the relatively uniform concentrations observed on the Property. Widespread total chromium observed on the Property may in part be attributable to suspected naturally occurring conditions in addition to discrete source areas containing elevated chromium concentrations which may not be naturally occurring. It is assumed that future demonstration of a background standard will be achieved. Taking this into account, the treatment areas for these three COCs were accounted for as follows:
  - Exceedances of RDC (most stringent standard) were attributable to suspected naturally occurring conditions and were not used to define the extent of the treatment areas.
  - Vanadium – There were no exceedances above the RDC MSC and therefore vanadium is not included in the treatment areas.
  - Arsenic – Two sample locations had an exceedance above RUA SGW MSC. Those two locations are included in the treatment areas.
  - Total Chromium[4] – All sample locations that exceed RUA SGW MSC for hexavalent chromium are included in the treatment areas. Since historical soil samples were not speciated and represent total chromium values, additional soil sampling may need to be conducted during pre-design activities to confirm hexavalent chromium concentration and distribution, if present.

- The ISTT alternative was assumed to be implemented in treatment areas where the primary driver is CVOCs, as ISTT is not effective for addressing inorganic impact present on the Property. The treatment area extends significantly deeper (to 80 ft bgs), addressing groundwater and shallow bedrock impacts within the ISTT treatment areas.

[4] As described in RIR, soil samples were analyzed for total chromium without speciation and as a conservative measure, the total chromium results were compared to the more stringent hexavalent chromium MSCs for soil.

- The depth to water at Building 5 (including the drum storage area) and Building 8 were estimated to be 12 and six (6) feet bgs, respectively[5].
- The depth to bedrock at Building 5 (including the drum storage area) and Building 8 were estimated to be 26 and 12 feet bgs, respectively[6].

Remedial Alternative Assessment

The cost estimate for the implementation of each remedial alternative was generated based on target treatment areas, professional judgement, experience from similar sites and/or current accepted industry construction cost information. Additionally, certain Property-specific attributes were considered, including the low bridge clearance at the South Malin Road railroad underpass, which may restrict access to the Property by large vehicles/equipment. Further, there is a concrete vault in which a vapor degreaser was housed, which would likely require removal in order to implement each of the technologies, except ISTT. Other Property-specific unknowns are likely to be encountered and are addressed by including a contingency in the costs. Outlines of approximate targeted treatment areas utilized for this evaluation are presented on **Figure 2.**

Excavation with Offsite Disposal

Excavation of impacted unsaturated and saturated overburden soil is a viable remedial alternative for the Property. To implement excavation in the identified treatment areas, it would require the removal of the onsite structures (i.e., Building 5 and Building 8), excavation shoring/sloping, and continuous excavation dewatering of infiltrating groundwater, significantly contributing to the overall alternative cost. For estimating purposes, it is assumed that the onsite structures contain negligible amounts of hazardous substances[7] (e.g., asbestos and lead paint), the building materials (e.g., concrete, steel) can be readily disposed or recycled as construction and demolition waste.

It is assumed that the contamination elevation is consistent with the historical characterization work completed and that the depth of the excavation will extend to the top of the bedrock. Following the completion of excavation activities, certified clean fill material would be utilized as backfill to match existing surface grades. The excavated soil would be transported and disposed of as a non-hazardous waste. Within treatment area 1 in Building 8, it was assumed that 20% of the excavated soil would require hazardous waste disposal at a regional disposal facility.

Dewatering would be necessary to allow removal of saturated soils. This would require installation of temporary extraction wells as well as treatment and disposal of the recovered water. It is assumed that the water treatment necessary for removal would be of moderate complexity consisting of filtration for suspended solids removal, dissolved-phase COC removal utilizing granular activated carbon, and dissolved-phase inorganics removal utilizing a specialty filtration

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[5] As depicted on Figure 19 through Figure 20 of RIR, prepared by Roux, dated June 10, 2019.
[6] It is recognized that pinnacled bedrock is present at the Property and therefore depth to bedrock is highly variable. For preparing cost estimates, an average bedrock depth in the immediate area was utilized.
[7] Disposal of building demolition debris was assumed to be non-hazardous. Additional cost for items such as asbestos abatement cannot be accurately provided until a building assessment is completed as the cost has a very wide margin based on site-specifics.

media such as activated alumina, ion exchange resin or zeolite. Following treatment, the water would then be discharged to the sanitary sewer or re-injected (costs assume sanitary sewer discharge). Temporary water storage will be required to initially contain the treated water prior to discharge until the permittee can verify the water meets discharge criteria and based on sewer authority capacity during the project.

Potential negative impacts to the tributary of Little Valley Creek would primarily be from runoff following contact with excavated soils. These impacts would require a soil and erosion management plan during implementation, as well as a fugitive dust management plan. Monitoring of the creek should also be completed to monitor for potential impacts.

In order to access the Property due to the South Malin Road low bridge clearance restriction, smaller equipment may be required. As a result, this may extend the duration for the completion of the remedy. A remedy timeline of up to four (4) years is anticipated, with one (1) year of planning/design, less than one (1) year for remedy implementation, and two (2) years for post construction monitoring and reporting.

The evaluation of this option estimated the removal of approximately 35,000 cubic yards of impacted unsaturated and saturated soils at an estimated cost of $7,301,243. A breakdown of estimated costs for this alternative is provided as **Table 1**. The primary contributors for the cost are for the transportation and off-site disposal of the excavated soils, the demolition of the former facility structures, and backfill soil.

Excavation with Onsite Treatment

Excavation of impacted unsaturated and saturated overburden soil is a viable remedial alternative for the Property. To implement excavation in the identified treatment areas, it would require the removal of the onsite structures (Building 5 and Building 8) excavation shoring/sloping, and continuous excavation dewatering of infiltrating groundwater, significantly contributing to the overall alternative cost. For estimating purposes, it is assumed that the onsite structures contain negligible amounts of hazardous substances (e.g., asbestos and lead paint), the building materials (e.g., concrete, steel) can be readily disposed or recycled as construction and demolition waste.

It is assumed that the contamination elevation is consistent with the characterization work recently completed and that the depth of the excavation will extend to the top of the bedrock. Prior to remedy execution, bench scale testing would be completed to identify the most effective soil treatment technology (e.g., thermal, stabilization). For the purposes of this analysis, it is assumed that the soils will be blended with a stabilizing agent, such as Portland cement, fly ash, or other additive, to eliminate the direct contact and leaching exposure pathways for the COCs and to make it suitable for backfill. Excavated soils and other materials determined unsuitable for onsite treatment (e.g., large rocks, high organic content soils, buried debris and/or refuse), will be transported to an offsite disposal facility as non-hazardous waste (estimated to be 5% of total excavated volume).

Dewatering would be necessary to allow removal of saturated soil. This would require installation of temporary extraction wells as well as treatment and disposal of the recovered water. It is assumed that the water treatment necessary for removal would be of moderate complexity consisting of filtration for suspended solids removal, dissolved-phase COC removal utilizing granular activated carbon, and dissolved-phase fluoride removal utilizing a specialty filtration media such as activated alumina, ion exchange resin or zeolite. Following treatment, the water would then be discharged to the sanitary sewer or re-injected (costs are based on sanitary sewer discharge). Temporary water storage will be required to initially contain the treated water prior to discharge until the permittee can verify the water meets discharge criteria. Also, there may be periods of non-discharge as dictated by the sanitary sewer authority, so water storage would be required then as well.

Potential negative impacts to the tributary of Little Valley Creek would primarily be from runoff following contact with excavated soils. These impacts would require a soil and erosion management plan during implementation, as well as a fugitive dust management plan.

While completing an excavation of this size and complexity with the number of known COCs, does present challenges, including razing the existing facility structures, this alternative is considered to be implementable. In order to access the Property due to the South Malin Road low bridge clearance restriction, smaller equipment may be required. As a result, this may delay the completion of the remedy. The potential negative impact to Little Valley Creek should be limited to runoff and dust. There could also be a potential change in the surface water pH if additive dust or runoff that contacted the additives entered the creek. These potential impacts should be mitigated with a properly executed soil and erosion control and fugitive dust control. Monitoring of the creek (clarity, pH, etc.) can also be completed to monitor for potential impacts.

A remedy timeline of up to four (4) years is anticipated, with one (1) year of planning/design, less than one (1) year for remedy implementation, and two (2) years for post construction monitoring and reporting.

The evaluation of this option estimated the removal of approximately 35,000 cubic yards of impacted unsaturated and saturated soils at an estimated cost of $6,043,006. A breakdown of estimated costs for this alternative is provided as **Table 2**. The primary contributors for the cost are for ex-situ soil treatment and demolition of the former facility structures.

In-situ Chemical Oxidation/Reduction via Soil Mixing

Soil mixing can be used to treat unsaturated and saturated zone soil impacts using oxidants (ISCO) or reductants (ISCR). Soil mixing can effectively homogenize impacted soil and uniformly distribute reagents to targeted treatment zones. ISCO is based on the oxidative power of specific chemicals. Through the process of oxidation, contaminants are ultimately broken down into less toxic compounds (e.g., carbon dioxide and water). The four major oxidants used for ISCO are permanganate, persulfate, hydrogen peroxide and ozone. ISCR involves the transfer of electrons to contaminants from reduced metals (e.g., zero valent iron [ZVI], ferrous iron) or reduced minerals (e.g., magnetite, pyrite etc.) to degrade toxic organic compounds to potentially nontoxic or less toxic compounds or immobilizing metals such as hexavalent chromium by adsorption or precipitation. One of the most common ISCR reagents is ZVI.

The use of ISCO/ISCR reagents for the treatment of unsaturated and saturated soils via in-situ mechanical soil mixing has been shown to be effective at remediating the various COCs identified at the Property. Bench testing and pilot testing would be necessary as part of the pre-design work to determine the most suitable reagent(s) and, if necessary, any additional amendments to decrease soil permeability and/or prevent the leaching of reagent(s) into area groundwater. As part of the pre-design, a close review of the estimated treatment areas and available characterization data should be completed to narrow down and select reagents for bench testing. As described below for the purposes of this evaluation, a reagent that can address both CVOCs and metals was assumed; however it may be beneficial and more cost-effective to use different reagents in different areas depending on the COCs present, proximity to the creek, etc. A treatment area that is predominantly metals may use a reagent specific for metals stabilization. Several factors to be considered in selecting and evaluating suitable reagents include, but are not limited to, the following:

- COC effectiveness (e.g., not all oxidants are effective for remediating chlorinated ethanes);
- Capitalizing on existing conditions (i.e., use of a reducing agent may be more appropriate for anoxic conditions);
- Promotion of natural attenuation processes downgradient (e.g., introduction of reducing agents and providing a reducing environment may encourage reductive dechlorination);
- Formation of daughter products;
- Metals mobilization and/or conversion (e.g., introduction of an oxidant could have the potential to convert trivalent chromium to hexavalent chromium);
- Natural oxidant demand (NOD) (if the NOD is particularly high, use of an oxidant that may not be effective or may be cost-prohibitive);
- Soil reagent compatibility with potential groundwater remediation reagents; and
- Overall cost and volume of reagent required.

For estimating purposes, the soil mixing approach in this evaluation assumes the use of the reagent MetaFix® by Peroxychem of Philadelphia, Pennsylvania, as it is capable of treating comingled plumes of multiple, heavy metals and chlorinated solvents utilizing a blend of iron, carbon, and calcium-based compounds based on site-specific conditions. Following the blending of the reagent into the treatment zone, metals present in the soil are subjected to reduction, adsorption, precipitation, and conversion to stable sulfide and iron-sulfide precipitates. Additionally, with the creation of reducing conditions, the reagent will also reduce the identified chlorinated ethenes and ethanes present in the soil.

Implementing ISCO/ISCR via soil mixing could have potential negative effects on the tributary of Little Valley Creek, more so in the saturated soils than the unsaturated zone. Possible negative effects may include changes in geochemistry (e.g., pH, dissolved oxygen), amendment excursion (short-circuiting) into the tributary of Little Valley Creek, or increased mobility of metals, and temporary effects on naturally-occurring biodegradation. The latter two are primarily associated with oxidants (ISCO). Potential negative effects can be evaluated as part of bench and/or pilot testing to be conducted during pre-design.

Following the implementation of soil mixing, the surface and subsurface soils would not be suitable for redevelopment due to the reduction in bulk soil density. It is not uncommon following a soil mixing application (demonstrating successful treatment), that the treated soils are then stabilized via an in-situ application of cementitious reagent(s) to achieve a desired unconfined compressive strength. As the plans for the future property use have not been finalized, the additional costs for in-situ stabilization are not included with this remedial technology.

To implement, identified treatment areas would be divided into manageable cells to promote even reagent application, adequate dosing for the contaminant mass within the cell, thorough soil mixing, and track treatment performance (e.g., post treatment cell soil sampling). The depth of the soil mixing will extend to the top of bedrock. Following the completion of soil mixing activities, the site surface would be finished to match existing unpaved surface grades.

ISCO/ISCR via soil mixing using a reagent such as MetaFix® is considered to be implementable. The area where contamination is present would be relatively accessible following demolition of the existing facility structures and can accommodate the installation of temporary equipment during the remedy implementation. For estimating purposes, it is assumed that the onsite structures contain negligible amounts of hazardous substances (e.g., asbestos and lead paint), the building materials (e.g., concrete, steel) can be readily disposed or recycled as construction and demolition waste. The South Malin Road low bridge clearance for large equipment access to the Property was also considered into the alternative feasibility and cost. Based on information gathered, the clearance should not be a limiting factor for this approach. A remedy timeline of up to four (4) years is anticipated, with one (1) year of planning/design, less than one (1) year for remedy implementation, and two (2) years for post construction monitoring and reporting.

The estimated total cost to complete the activities outlined above is $2,817,713. A breakdown of estimated costs for this alternative is provided as **Table 3**. The primary contributors for the cost are the reagent, reagent application (soil mixing), and the demolition of the former facility structures.

In-situ Thermal Treatment (ISTT)

The Final RAA (GES, August 2020) screened, evaluated, and provided preliminary cost estimates for applicable technologies to address unsaturated soil impact only. In addition, some initial discussion of several potential cross-over technologies that could address both unsaturated and saturated soil was provided, including ISTT. Given its applicability to address contaminated soils and its ability to extend treatment into the bedrock, at the request of DEP, a more thorough evaluation and cost estimate of ISTT have been provided in this memo.

Implementation of ISTT of soils in the unconsolidated zone and the upper bedrock zone would serve as a viable remedial alternative for the Property. ISTT consists of heating the subsurface to facilitate volatilization followed by contaminant extraction and treatment. For the given site conditions, a Thermal Conductive Heating (TCH) approach would be very effective at remediating VOC impacts in unsaturated and saturated soil and upper bedrock (up to 80 ft bgs). Additional topsoil would likely need to be imported to provide adequate capture of the volatized contaminants in order to overcome the limited vadose zone in some areas of the Property. One of the primary limitations to ISTT is that it will not be effective at addressing metals/inorganics impact. Costs for the ISTT alternative were based on implementing this technology in treatment areas with primarily VOC impacts including treatment areas 1, 4, 6, and 9 as shown on **Figure 2**. An alternative additional technology may be required to address inorganic impacts in treatment areas 2, 3, 5, 7, 8, and 10.

To implement this approach in the identified treatment areas, it would require the removal of the onsite structures, contributing to the overall alternative cost. For estimating purposes, it is assumed that the existing facility structures contain negligible amounts of asbestos and lead paint, the building materials (e.g., concrete, steel) can be readily disposed or recycled as construction and demolition waste.

A potential negative impact to the tributary of Little Valley Creek could be due to the significant subsurface heating that occurs during ISTT. However, based on information received from a thermal remediation provider, increases in creek temperatures would not be expected, provided active treatment is not conducted within approximately 20 feet of the creek. Given the location of impacts and direction of groundwater flow, this concern could be addressed, but does warrant careful consideration and evaluation.

An approach of ISTT using TCH is considered to be implementable. The area where contamination is present would be relatively accessible following demolition of the existing facility structures and can accommodate the installation of temporary equipment during the remedy implementation. The South Malin Road low bridge clearance for large equipment access to the Property was also considered into the alternative feasibility and cost. Based on information gathered, the clearance should not be a limiting factor for this approach. Additionally, ISTT does not require long term work or continued maintenance. Therefore, this remedial alterative is considered to be permanent. A remedy timeline of up to five (5) years is anticipated, with one (1) year of planning/design, less than two (2) years for remedy implementation, and two (2) years for post construction monitoring and reporting.

The estimated total cost to complete the activities outlined above is $13,931,652. A breakdown of estimated costs for this alternative is provided as **Table 4**. The primary contributors for the cost are the thermal treatment system construction and operation, thermal treatment system utilities, and the demolition of the former facility structures.

Summary

The following table presents an overall comparison of the remedial technologies presented above to provide a summary of total alternative costs and timeframes (including pre-design, remedy implementation, and long-term operation and maintenance).

Remedial Technology Comparison

	Alternative	Estimated Total Cost	Timeframe (years)[1]
1	Excavation with offsite disposal of impacted soils	$7,301,243	4
2	Excavation with onsite treatment of impacted soils	$6,043,006	4
3	ISCR/ISCO via soil mixing of impacted soils	$2,817,713	4
4	Excavation with offsite disposal of impacted surface soil combined with ISTT to address groundwater and solid CVOC source zone media	$13,931,652	5

NOTE:
1. Estimated total cost includes design, construction, operation, maintenance, and monitoring costs as applicable for each alternative.

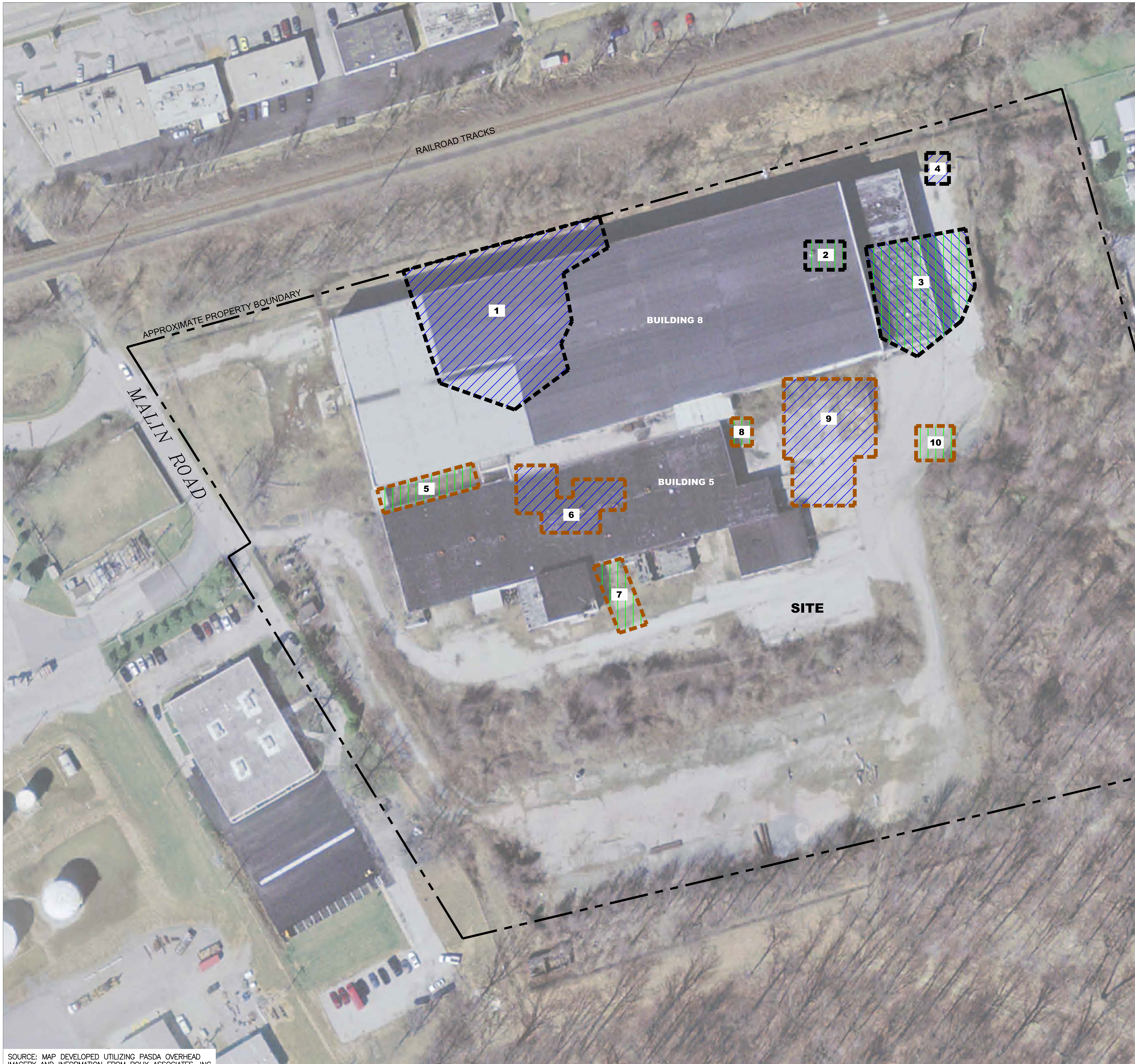
The table below presents a more detailed breakdown of the costs by treatment area for each of the technologies. The costs are approximate and for comparison purposes. Common costs such as planning, reporting, closure activities, building demolition, and dewatering were distributed among the treatment areas based on the percentage of total area each individual treatment area represents.

Treatment Area Comparison

Treatment Area Number	Primary Driver COC	Excavation w/Offsite Disposal	Excavation w/Onsite Treatment	ISCR/ISCO via Soil Mixing	ISTT
1	VOCs	$3,128,729	$1,802,352	$841,018	$8,141,248
2	Inorganics	$81,576	$82,120	$37,143	n/a
3	VOCs and Inorganics	$771,366	$783,903	$365,253	n/a
4	VOCs	$54,965	$55,992	$25,949	$249,483
5	Inorganics	$35,357	$36,740	$17,701	n/a
6	VOCs	$844,138	$857,397	$399,027	$1,844,861
7	Inorganics	$346,696	$352,642	$164,478	n/a
8	Inorganics	$99,726	$101,983	$47,940	n/a
9	VOCs	$1,717,230	$1,744,283	$813,731	$3,696,060
10	Inorganics	$221,460	$225,594	$105,473	n/a
	Total	$7,301,243	$6,043,006	$2,817,713	$13,931,652

n/a – not applicable

N:_Corporate\Graphics-Exton\Exton\PADEP-GTAC-IRRSC\GTAC\GTAC Bishop Tube\1 South Malin Rd SM.dwg, C(SM 60)



LEGEND

BLACK OUTLINE	UNSATURATED OVERBURDEN = 0–6 FEET BGS SATURATED OVERBURDEN = 6–12 FEET BGS TOP OF BEDROCK = 12 FEET BGS
ORANGE OUTLINE	UNSATURATED OVERBURDEN = 0–12 FEET BGS SATURATED OVERBURDEN = 12–26 FEET BGS TOP OF BEDROCK = 26 FEET BGS
(blue diagonal hatch)	VOCs ARE THE PRIMARY DRIVER
(green vertical hatch)	INORGANICS ARE THE PRIMARY DRIVER
(blue and green hatch)	VOCs AND INORGANICS ARE THE PRIMARY DRIVER
BGS	BELOW GRADE SURFACE
VOCs	VOLATILE ORGANIC COMPOUNDS

NOTES:

1) THE TARGETED TREATMENT AREAS ARE APPROXIMATE AND BASED ON REMEDIAL INVESTIGATIONS BY OTHERS. ADDITIONAL SOIL SAMPLING MAY NEED TO BE CONDUCTED DURING PRE–DESIGN ACTIVITIES TO CONFIRM TREATMENT AREA BOUNDARIES.

2) PINNACLED BEDROCK IS PRESENT AT THE PROPERTY AND THEREFORE THE DEPTH TO BEDROCK IS HIGHLY VARIABLE. THE TOP OF BEDROCK IN EACH AREA REPRESENTS AN ESTIMATED AVERAGE IN THE IMMEDIATE AREA.

SOURCE: MAP DEVELOPED UTILIZING PASDA OVERHEAD IMAGERY AND INFORMATION FROM ROUX ASSOCIATES, INC.

Target Treatment Areas Map

Pennsylvania Dept of Environmental Protection
Bishop Tube
1 South Malin Road
Frazer, Pennsylvania

Drawn
T.P.
Designed
B.A.H.
Approved
D.N.G.

Date
11/09/20
Figure
2

Scale In Feet
0 30 60

Groundwater & Environmental Services, Inc.

TABLE 1
TECHNOLOGY 1 - SOIL EXCAVATION WITH OFFSITE DISPOSAL
GTAC 7-1-342
Former Bishop Tube Property
East Whiteland Township, Chester County, Pennsylvania

REMEDIATION COSTS

PHASE / TASK / SUBTASK	COST/UNIT		SCHEDULE COST/YEAR: Planning/Design		Implementation		Post Construction Monitoring									
			1		2		3		4		5		6-10		11-30	
			UNITS	COSTS	UNITS	COSTS	UNITS	COSTS	UNITS	COSTS	UNITS	COSTS	UNITS	COSTS	UNITS	COSTS
Background Investigation																
Regulatory Agency Meeting	**$1,500**	**/meeting**	**2**	**$3,000**	**2**	**$3,000**	**1**	**$1,500**	**1**	**$1,500**		**$0**		**$0**		**$0**
Remedial Action Plan & Permitting																
Remedial Design	**$45,000**	**/each**	**1**	**$45,000**		**$0**		**$0**		**$0**		**$0**		**$0**		**$0**
Permitting/Permitting Equivalency	**$6,000**	**/each**	**1**	**$6,000**		**$0**		**$0**		**$0**		**$0**		**$0**		**$0**
Remedial Action/Cleanup Plan Report	**$10,000**	**/each**	**1**	**$10,000**		**$0**		**$0**		**$0**		**$0**		**$0**		**$0**
Soil Excavation & Disposal																
Site Prep/Facility Demo	**$310,000**	**/site**		**$0**	**1**	**$310,000**		**$0**		**$0**		**$0**		**$0**		**$0**
Excavation Dewatering & Treatment	**$327,700**	**/site**		**$0**	**1**	**$327,700**		**$0**		**$0**		**$0**		**$0**		**$0**
Excavation, >10 ft	**$3.10**	**/cu yd**		**$0**	**35000**	**$108,500**		**$0**		**$0**		**$0**		**$0**		**$0**
Soil Disposal	**$57.00**	**/ton**		**$0**	**49368**	**$2,813,976**		**$0**		**$0**		**$0**		**$0**		**$0**
Soil Disposal -Hazardous (20% of Area 1)	**$380.00**	**/ton**		**$0**	**3132**	**$1,190,160**		**$0**		**$0**		**$0**		**$0**		**$0**
Fill Material, Backfill, & Soil Cover	**$16.00**	**/cu yd**		**$0**	**35000**	**$560,000**		**$0**		**$0**		**$0**		**$0**		**$0**
Plantings/Site Stabilization	**$10,000**	**/site**		**$0**	**1**	**$10,000**		**$0**		**$0**		**$0**		**$0**		**$0**
Closure Assessment (unsaturated soils only)																
Soil Attainment Sampling	**$45,000**	**/event**		**$0**		**$0**	**1**	**$45,000**		**$0**		**$0**		**$0**		**$0**
Risk Assessment	**$5,000**	**/event**		**$0**		**$0**	**1**	**$5,000**		**$0**		**$0**		**$0**		**$0**
Final/Closure Report	**$12,000**	**/report**		**$0**		**$0**		**$0**	**1**	**$12,000**		**$0**		**$0**		**$0**
TOTAL				**$64,000**		**$5,323,336**		**$51,500**		**$13,500**		**$0**		**$0**		**$0**
CONTINGENCY (30%)				**$19,200**		**$1,597,001**		**$15,450**		**$4,050**						
CUMULATIVE TOTAL W/ INFLATION (3%)				**$83,200**		**$7,211,147**		**$7,282,114**		**$7,301,243**						

ASSUMPTIONS

An estimated 35,000 cubic yards of unsaturated and saturated soil will be excavated from Treatment Areas 1 through 10.
Weight of soil assumed to be 1.5 tons per cubic yard
Excavation dewatering for accumulated water from precipitation, surface runoff, and shallow groundwater.
Dewatering assumes 20 dewatering wells, treatment system, sanitary sewer discharge, and 3 months of operation.
Facility demo includes raze and disposal of building material and concrete slab
Onsite facility structures contain negligible amounts of hazardous substances (e.g., asbestos and lead paint), the building materials (concrete, steel) can be readily disposed or recycled.
Building abatement costs cannot be accurately estimated until a building assessment is completed as the cost varies widely based on site specifics.
Offsite soil disposal is non-hazardous, except for 20% of Treatment Area 1 volume (Building 8) is assumed to require disposal at hazardous waste facility.
Certified clean fill will be used as backfill.
Soil disposal costs includes transport and soil backfill costs include delivery.
Soil attainment sampling includes one round of post-treatment unsaturated soil sampling for COCs based on Treatment Areas

TABLE 2
TECHNOLOGY 2 - SOIL EXCAVATION WITH ONSITE TREATMENT
GTAC 7-1-342
Former Bishop Tube Property
East Whiteland Township, Chester County, Pennsylvania

REMEDIATION COSTS

PHASE / TASK / SUBTASK	COST/UNIT		SCHEDULE COST/YEAR													
			Planning/Design		Implementation		Post Construction Monitoring									
			1		2		3		4		5		6-10		11-30	
			UNITS	COSTS	UNITS	COSTS	UNITS	COSTS	UNITS	COSTS	UNITS	COSTS	UNITS	COSTS	UNITS	COSTS
Background Investigation																
Regulatory Agency Meeting	$1,500	/meeting	2	$3,000	2	$3,000	1	$1,500	1	$1,500		$0		$0		$0
Remedial Action Plan & Permitting																
Remedial Bench Testing	$35,000	/each	1	$35,000		$0		$0		$0		$0		$0		$0
Remedial Design	$55,000	/each	1	$55,000		$0		$0		$0		$0		$0		$0
Permitting/Permitting Equivalency	$7,000	/each	1	$7,000		$0		$0		$0		$0		$0		$0
Remedial Action/Cleanup Plan Report	$10,000	/each	1	$10,000		$0		$0		$0		$0		$0		$0
Soil Excavation & Treatment																
Site Prep/Facility Demo	$310,000	/site		$0	1	$310,000		$0		$0		$0		$0		$0
Excavation, >10 ft	$3.10	/cu yd		$0	35000	$108,500		$0		$0		$0		$0		$0
Excavation Dewatering & Treatment	$411,200	/site		$0	1	$411,200		$0		$0		$0		$0		$0
Soil Disposal	$57.00	/ton		$0	2625	$149,625		$0		$0		$0		$0		$0
Ex-Situ Soil Treatment (via Stabilization)	$65.00	/ton		$0	49875	$3,241,875		$0		$0		$0		$0		$0
Backfill Treated Soil	$2.00	/cu yd		$0	33250	$66,500		$0		$0		$0		$0		$0
Fill Material, Backfill, & Soil Cover	$16.00	/cu yd		$0	1750	$28,000		$0		$0		$0		$0		$0
Plantings/Site Stabilization	$10,000	/site		$0	1	$10,000		$0		$0		$0		$0		$0
Closure Assessment (unsaturated soils only)																
Soil Attainment Sampling	$55,000	/event		$0		$0	1	$55,000		$0		$0		$0		$0
Risk Assessment	$5,000	/event		$0		$0	1	$5,000		$0		$0		$0		$0
Final/Closure Report	$12,000	/report		$0		$0		$0	1	$12,000		$0		$0		$0
TOTAL				$110,000		$4,328,700		$61,500		$13,500		$0		$0		$0
CONTINGENCY (30%)				$33,000		$1,298,610		$18,450		$4,050						
CUMULATIVE TOTAL W/ INFLATION (3%)				$143,000		$5,939,129		$6,023,876		$6,043,006						

ASSUMPTIONS

An estimated 35,000 cubic yards of unsaturated and saturated soil will be excavated from Treatment Areas 1 through 10.
Weight of soil assumed to be 1.5 tons per cubic yard
Excavated material deemed unsuitable for onsite treatment (e.g., large rocks, high organic content soils, buried debris) will be disposed offsite as non-hazardous waste. Assumed to be 5% of total volum
Excavation dewatering for accumulated water from precipitation, surface runoff, and shallow groundwater.
Dewatering assumes 20 dewatering wells, treatment system, sanitary sewer discharge, and 4 months of operation.
Facility demo includes raze and disposal of building material and concrete slab
Onsite facility structures contain negligible amounts of hazardous substances (e.g., asbestos and lead paint), the building materials (concrete, steel) can be readily disposed or recycled.
Building abatement costs cannot be accurately estimated until a building assessment is completed as the cost varies widely based on site specifics.
Soil disposal costs includes transport and soil backfill costs include delivery.
Soil attainment sampling includes one round of unsaturated post-treatment soil sampling for COCs based on Treatment Areas

TABLE 3
TECHNOLOGY 3 - IN-SITU CHEMICAL OXIDATION/REDUCTION (SOIL MIXING)
GTAC 7-1-342
Former Bishop Tube Property
East Whiteland Township, Chester County, Pennsylvania

REMEDIATION COSTS

PHASE / TASK / SUBTASK	COST/UNIT		SCHEDULE COST/YEAR													
			Planning/Design		Implementation		Post Construction Monitoring									
			1		2		3		4		5		6-10		11-30	
			UNITS	COSTS	UNITS	COSTS	UNITS	COSTS	UNITS	COSTS	UNITS	COSTS	UNITS	COSTS	UNITS	COSTS
Background Investigation																
Regulatory Agency Meeting	**$1,500**	**/meeting**	**2**	**$3,000**	**2**	**$3,000**	**1**	**$1,500**	**1**	**$1,500**		**$0**		**$0**		**$0**
Remedial Action Plan & Permitting																
Remedial Bench Testing	**$35,000**	**/each**	**1**	**$35,000**		**$0**		**$0**		**$0**		**$0**		**$0**		**$0**
Remedial Design	**$45,000**	**/each**	**1**	**$45,000**		**$0**		**$0**		**$0**		**$0**		**$0**		**$0**
Permitting/Permitting Equivalency	**$3,000**	**/each**	**1**	**$3,000**		**$0**		**$0**		**$0**		**$0**		**$0**		**$0**
Remedial Action/Cleanup Plan Report	**$10,000**	**/each**	**1**	**$10,000**		**$0**		**$0**		**$0**		**$0**		**$0**		**$0**
In-situ Soil Treatment																
Site Prep/Facility Demo	**$310,000**	**/site**		**$0**	**1**	**$310,000**		**$0**		**$0**		**$0**		**$0**		**$0**
In-situ Chemical Reduction (MetaFix)	**$44.00**	**/cu yd**		**$0**	**35000**	**$1,540,000**		**$0**		**$0**		**$0**		**$0**		**$0**
Soil Cover (2 feet)	**$16.00**	**/cu yd**		**$0**	**4410**	**$70,560**		**$0**		**$0**		**$0**		**$0**		**$0**
Plantings/Site Stabilization	**$10,000**	**/site**		**$0**	**1**	**$10,000**		**$0**		**$0**		**$0**		**$0**		**$0**
Closure Assessment (unsaturated soils only)																
Soil Attainment Sampling	**$55,000**	**/event**		**$0**		**$0**	**1**	**$55,000**		**$0**		**$0**		**$0**		**$0**
Risk Assessment	**$5,000**	**/event**		**$0**		**$0**	**1**	**$5,000**		**$0**		**$0**		**$0**		**$0**
Final/Closure Report	**$12,000**	**/report**		**$0**		**$0**		**$0**	**1**	**$12,000**		**$0**		**$0**		**$0**
TOTAL				**$96,000**		**$1,933,560**		**$61,500**		**$13,500**		**$0**		**$0**		**$0**
CONTINGENCY (30%)				**$28,800**		**$580,068**		**$18,450**		**$4,050**						
CUMULATIVE TOTAL W/ INFLATION (3%)				**$124,800**		**$2,713,837**		**$2,798,584**		**$2,817,713**						

ASSUMPTIONS

An estimated 35,000 cubic yards of unsaturated and saturated soil in Treatment Areas 1 through 10 will be treated.
No soils will be excavated and disposed offsite
Soil will not be stabilized following in-situ mixing treatment
Facility demo includes raze and disposal of building material and concrete slab
Onsite facility structures contain negligible amounts of hazardous substances (e.g., asbestos and lead paint), the building materials (concrete, steel) can be readily disposed or recycled.
Building abatement costs cannot be accurately estimated until a building assessment is completed as the cost varies widely based on site specifics.
Soil attainment sampling includes one round of post-treatment unsaturated soil sampling for COCs based on Treatment Areas

TABLE 4
TECHNOLOGY 4 - IN-SITU THERMAL TREATMENT
GTAC 7-1-342
Former Bishop Tube Property
East Whiteland Township, Chester County, Pennsylvania

REMEDIATION COSTS

PHASE / TASK / SUBTASK	COST/UNIT		SCHEDULE COST/YEAR													
			Planning/Design		Implementation				Post Construction Monitoring							
			1		2		3		4		5		6-10		11-30	
			UNITS	COSTS	UNITS	COSTS	UNITS	COSTS	UNITS	COSTS	UNITS	COSTS	UNITS	COSTS	UNITS	COSTS
Background Investigation																
Regulatory Agency Meeting	**$1,500**	**/meeting**	**2**	**$3,000**	**2**	**$3,000**	**1**	**$1,500**	**1**	**$1,500**		**$0**		**$0**		**$0**
Remedial Action Plan & Permitting																
Remedial Design	**$65,000**	**/each**	**1**	**$65,000**		**$0**		**$0**		**$0**		**$0**		**$0**		**$0**
Permitting/Permitting Equivalency	**$6,000**	**/each**	**1**	**$6,000**		**$0**		**$0**		**$0**		**$0**		**$0**		**$0**
Remedial Action/Cleanup Plan Report	**$10,000**	**/each**	**1**	**$10,000**		**$0**		**$0**		**$0**		**$0**		**$0**		**$0**
In-situ Soil Treatment & Soil Excavation																
Site Prep/Facility Demo	**$310,000**	**/site**		**$0**	**1**	**$310,000**		**$0**		**$0**		**$0**		**$0**		**$0**
In-situ Thermal Treatment (TCH)	**$9,920,000**	**/site**			**1**	**$9,920,000**										
Plantings/Site Stabilization	**$10,000**	**/site**		**$0**		**$0**	**1**	**$10,000**		**$0**		**$0**		**$0**		**$0**
Closure Assessment (unsaturated soils only)																
Soil Attainment Sampling	**$55,000**	**/event**		**$0**		**$0**		**$0**	**1**	**$55,000**		**$0**		**$0**		**$0**
Risk Assessment	**$5,000**	**/event**		**$0**		**$0**		**$0**	**1**	**$5,000**		**$0**		**$0**		**$0**
Final/Closure Report	**$12,000**	**/report**		**$0**		**$0**		**$0**		**$0**	**1**	**$12,000**		**$0**		**$0**
TOTAL				**$84,000**		**$10,233,000**		**$11,500**		**$61,500**		**$12,000**		**$0**		**$0**
CONTINGENCY (30%)				**$25,200**		**$3,069,900**		**$3,450**		**$18,450**		**$3,600**				
CUMULATIVE TOTAL W/ INFLATION (3%)				**$109,200**		**$13,811,187**		**$13,827,034**		**$13,914,180**		**$13,931,652**				

ASSUMPTIONS

An estimated 25,843 cubic yards of unsaturated and saturated soil and 92,291 cubic yards of saturated bedrock will be treated using ISTT for VOCs in Treatment Areas 1, 4, 6, and 9.
An alternative technology would need to be implemented in Treatment Areas 2, 3, 5, 7, 8, and 10 to address inorganic impact and are not included in these costs
Facility demo includes raze and disposal of building material and concrete slab
Onsite facility structures contain negligible amounts of hazardous substances (e.g., asbestos and lead paint), the building materials (concrete, steel) can be readily disposed or recycled.
Building abatement costs cannot be accurately estimated until a building assessment is completed as the cost varies widely based on site specifics.
Soil attainment sampling includes one round of post-treatment unsaturated soil sampling for COCs based on Treatment Areas