FINAL

Evaluation of Groundwater Treatment System Alternatives for the Remedial Design Activities at Marsh Run Park (former landfill) Defense Distribution Region East New Cumberland, Pennsylvania

Prepared for

U.S. Army Corps of Engineers
Omaha District
Baltimore District

Prepared by

EA Engineering, Science, and Technology
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LIST OF ACRONYMS AND ABBREVIATIONS

cfm	Cubic Feet Per Minute
DCE	Dichloroethene
DDRE	Defense Distribution Region East
DO	Dissolved Oxygen
DS	Decontaminating Solution
DW	Dewatering Well
EW	Extraction Well
FRP	Fiberglass Reinforced Plastic
FS	Feasibility Study
ft	Foot/Feet
gal	Gallon(s)
gpm	Gallons Per Minute
GWTF	Groundwater Treatment Facility
Hg	Mercury
Hp	Horsepower
hr	Hour(s)
in.	Inch(es)
Kw	Kilowatt(s)
lb	Pound(s)
LF	Liner Foot/Feet
O&M	Operation and Maintenance
ORP	Oxidation-Reduction Potential
PADEP	Pennsylvania Department of Environmental Protection
PCA	Tetrachloroethane
PCE	Tetrachloroethene
ppb	Parts Per Billion
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SVE	Soil Vapor Extraction

LIST OF ACRONYMS AND ABBREVIATIONS (continued)

TCA	Trichloroethane
TCE	Trichloroethene
TIC	Total Inorganic Carbon
TOC	Total Organic Carbon
USACE	U.S. Army Corps of Engineers
VC	Vinyl Chloride
VOC	Volatile Organic Compound
yd	Yard(s)

1. INTRODUCTION

The remedial design for the Marsh Run Groundwater Treatment Facility, Operable Unit No. 1, at Marsh Run Park (former landfill), Defense Distribution Region East (DDRE), New Cumberland, Pennsylvania, was completed in April 1994. Construction of the Marsh Run Groundwater Treatment Facility was completed on 30 July 1995. The Remedial Action Contractor performed the operation and maintenance of the Groundwater Treatment Facility for a 1-year period following the completion of the facility startup and testing period. The first year operations and maintenance period was completed on 20 July 1996. Following the first year operational period, an interim operation and maintenance contract was put into place with the U.S. Army Corps of Engineers (USACE), Baltimore PRAC. On 28 November 1996, the Marsh Run Groundwater Treatment Facility was destroyed by fire. Discussions have been ongoing since December 1996 to determine an approach for resumption of groundwater remediation activities at the Marsh Run Park site.

This document evaluates two groundwater treatment alternatives for resumption of groundwater treatment at the Marsh Run Park site. The two groundwater treatment alternatives that are evaluated include (1) integration of a vacuum enhanced soil vapor extraction (SVE) system for remediation of the source area with a new groundwater treatment facility to continue remediation of the bedrock aquifer, and (2) remediation of the bedrock aquifer through natural attenuation and remediating the source area through a vacuum enhanced SVE system. The objective of this document is to evaluate the technical and economic feasibility of the Groundwater Treatment Facility alternatives, presenting a detailed cost comparison among the alternatives under consideration, and to provide information to USACE and the Pennsylvania Department of Environmental Protection (PADEP) for use in decision-making in moving forward with the continuation of the remedial program at the Marsh Run Park site.

Based upon the present worth analysis presented in this report, and the estimated duration for implementation, Alternative No. 2 (Remediation of Bedrock Aquifer Through Natural Attenuation and Remediation of Source Area With Vacuum Enhanced SVE System) is recommended for implementation. Alternative No. 2 consists of evaluating the feasibility of natural attenuation as a remedial alternative for the bedrock aquifer in conjunction with implementing a long-term monitoring plan while treating the source areas within the landfill through a vacuum enhanced SVE system. The total present worth of the capital costs and operation and maintenance costs for Alternative No. 1 is $2,945,300, while the total present worth of the capital costs and operation and maintenance costs for Alternative No. 2 is $1,853,000. Therefore, the total present worth of capital and operation and maintenance (O&M) costs for Alternative No. 2 is $1,092,300 less than Alternative No. 1.

2. BACKGROUND

2.1 SITE DESCRIPTION

Marsh Run Park, the former landfill of DDRE, formerly called the New Cumberland Army Depot, is located in Fairview Township, York County, Pennsylvania. It is situated adjacent to and east of DDRE. The site is bounded to the south and southeast by Marsh Run Creek and Marsh Run Road and to the north and northeast by Conrail (formerly Penn Central) railroad tracks. The Susquehanna River is immediately north of the railroad tracks. The site location is shown in Figure 1.

The site is approximately 14 acres in size and is situated in a relatively flat area that consisted primarily of swampy land prior to land filling in the early 1980s. The filled area extends over an approximate area of 4-5 acres, with an average height of 3-4 ft above the prefill surface. The present surface of the landfill is relatively flat with slight grading to facilitate drainage.

The immediate surrounding area is semi-rural, although the site can be considered in suburban Harrisburg, Pennsylvania. Single-family dwellings are located to the south and southeast of the site along Marsh Run Creek. The site is situated east of and adjacent to DDRE. A DDRE access road borders the site to the east immediately outside of the DDRE fence. Marsh Run Creek, which flows in a general west-to-east direction, bounds the southwest of the site (inside the fence), passes beneath the access road, and borders the landfill immediately to the south and east (Figure 1).

2.2 SITE CHARACTERISTICS AND GEOLOGY

The topography of Marsh Run Park is generally flat with topographic relief varying less than 10 ft across the site. The ground surface is covered with at least 6 in. of topsoil (silty loam) material brought in from an offsite location by Fairview Township. The topsoil material has promoted a good thick growth of fescue grass. Below the topsoil is a 1- to 2-ft-thick cover of brown silty soils that were apparently excavated from the local area north of the site. Underlying the topsoil and cover fill in the central, south-central portion of the site is 2-6 ft of waste fill material. The waste fill material appears to be contained within the Marsh Run Park property boundaries. Based on boring and visual observations, the waste fill material appears to be primarily domestic-type debris, construction debris, and industrial debris derived from DDRE

(USACE Confirmation Study Report 1988). Estimation of the extent of the waste fill area during the Feasibility Study (FS) identified a total waste area volume of approximately 30,000 yd^3.

Outside of the waste fill proper, natural silt, clay, and sand up to 8 ft thick overlay the Triassic shaley sandstone of the Gettysburg Formation. The Gettysburg Formation is typically a maroon silty or shaley fine sandstone. It forms the hills south of the site that rise abruptly several hundred feet in elevation.

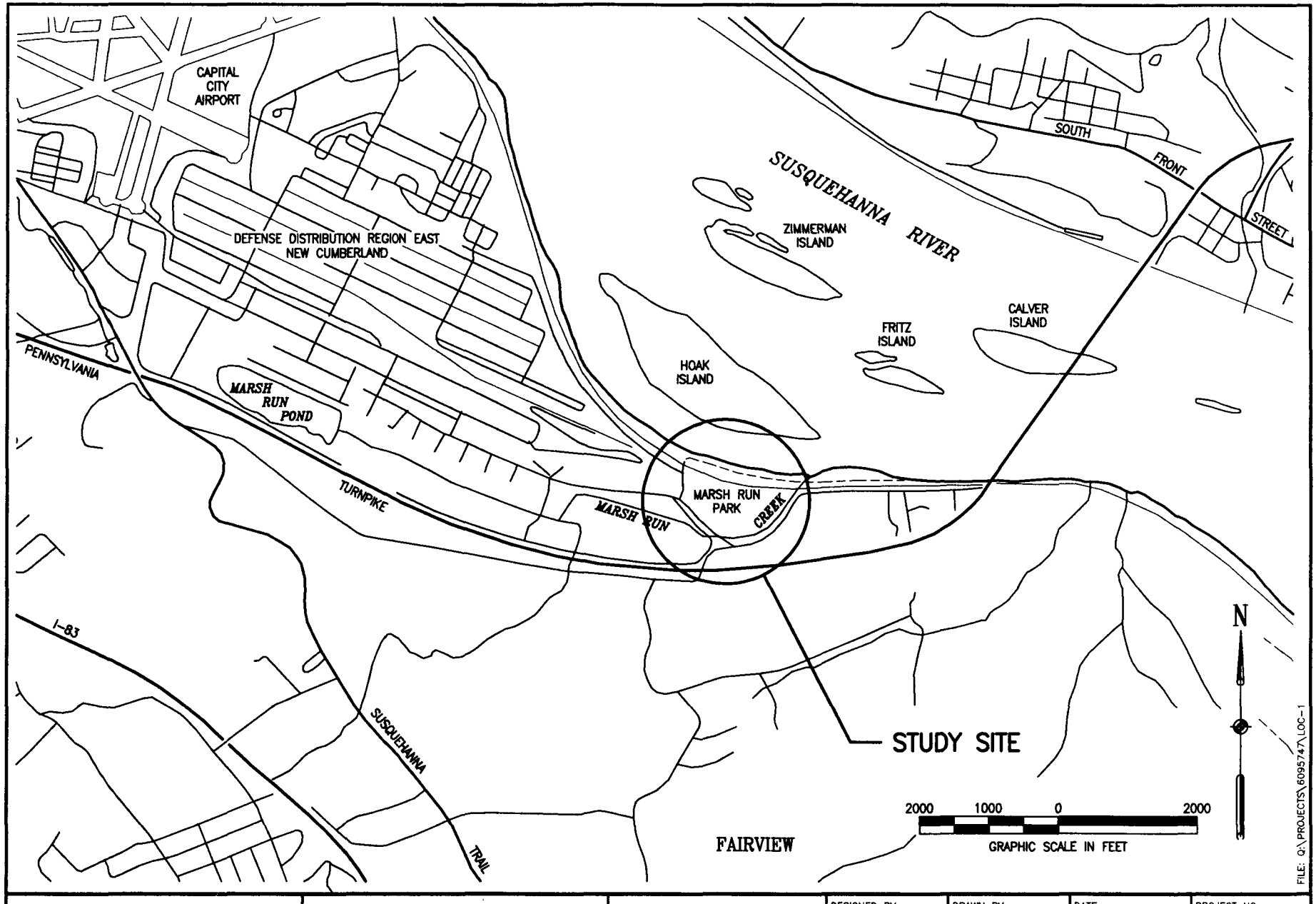
The two distinct groundwater zones at the site are the shallow saturated zone (located in the fill and soils) and the underlying bedrock aquifer (Gettysburg Formation). Figures 2 and 3 depict schematic representations of subsurface conditions at the Marsh Run Park site in the vicinity of the waste fill. In the vicinity of Marsh Run Park, the saturated fill and soils are segregated from the bedrock aquifer by an apparently continuous clay layer (i.e., marsh and swamp sediments) 2-5 ft thick. Some local residents obtain their water from wells installed in the Gettysburg Formation.

The movement of groundwater within and between the two distinct groundwater zones comprises the overall groundwater flow system at the site. It should be noted that although the two groundwater zones are distinct, there is significant hydraulic communication between zones. Historically, depth to the overburden water table ranged from 4 to 7 ft across the fill area. Based on two sets of historical water-level data, the shallow water table was observed to fluctuate 1.5-2.0 ft in a 6-month period (i.e., February to August).

2.3 SITE HISTORY

The Marsh Run Park site was previously owned by the Army, who used it as a landfill for disposal of installation-derived waste materials from DDRE starting in the early 1900s and ceasing in the late 1950s. The waste materials were deposited in a marshy area to a height of several feet above the standing-water level of the swampy areas. The landfill material has subsequently been mixed with soil excavated form a borrow area directly adjacent to and north of the fill.

In 1976, the Marsh Run Park site was sold to Fairview Township. The site was used by the Township as a soccer field. The Township graded the site and brought in topsoil from an offsite location to make a suitable playing surface.



EA ENGINEERING, SCIENCE, AND TECHNOLOGY	EVALUATION OF GROUNDWATER TREATMENT SYSTEM ALTERNATIVES FORMER LANDFILL, MARSH RUN PARK NEW CUMBERLAND, PENNSYLVANIA	SITE LOCATION MAP	DESIGNED BY KMW	DRAWN BY MSM	DATE 7-18-97	PROJECT NO. 60957.47
			CHECKED BY GAT	PROJECT MGR. JPC	SCALE AS SHOWN	FIGURE 1

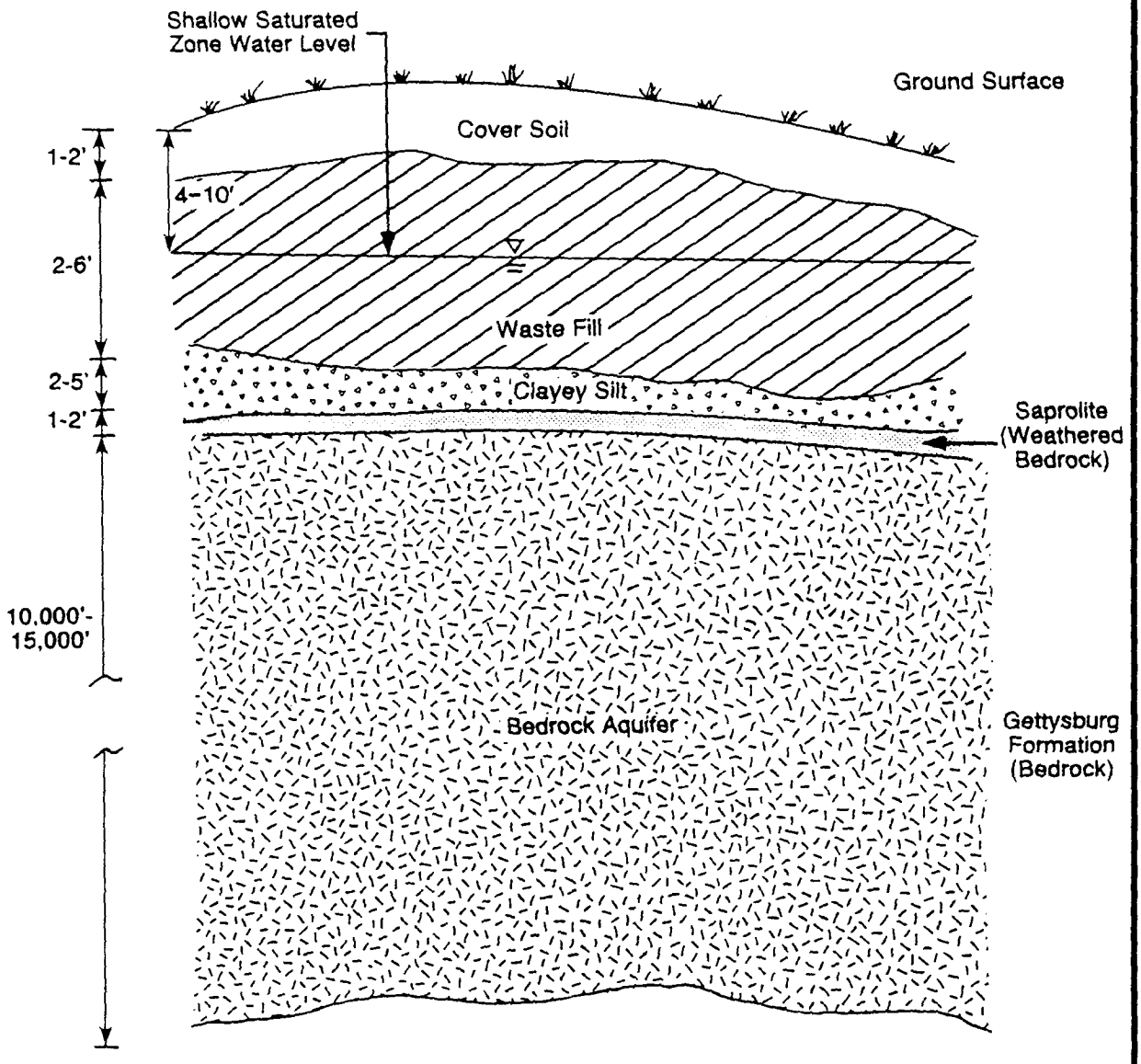
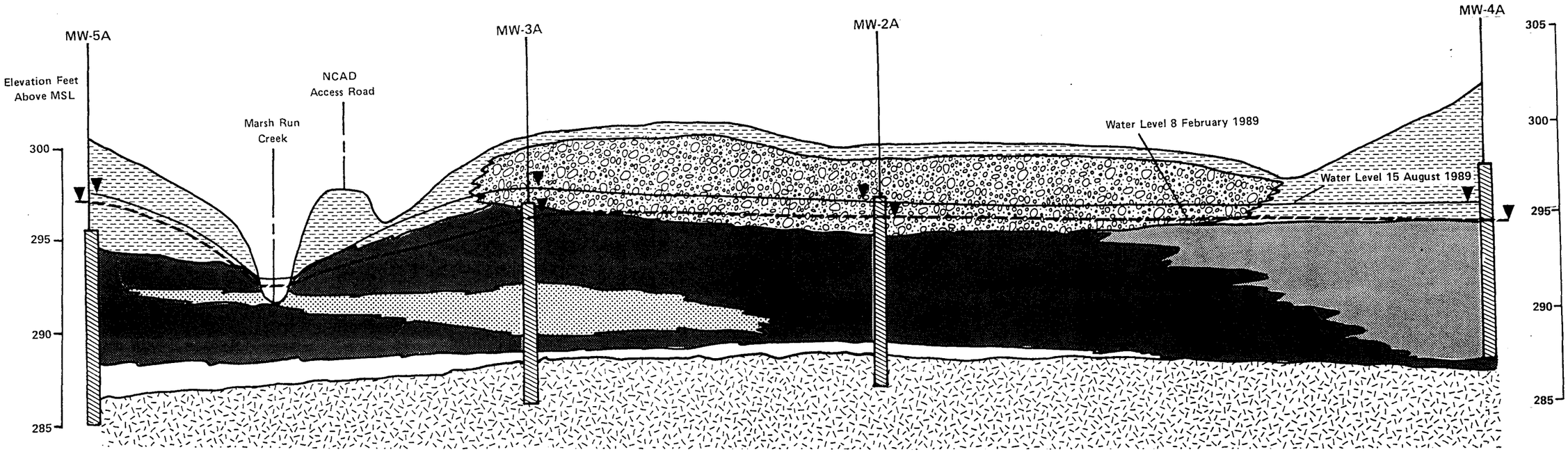
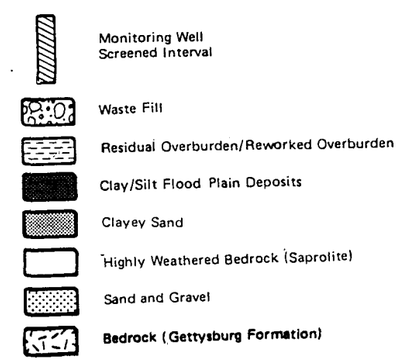


Figure 2 **Schematic representation of subsurface conditions in the vicinity of the "waste fill" - Marsh Run Park.**





Schematic representation of subsurface conditions in the vicinity of the "waste fill" - Marsh Run Park.

Figure 3

In August 1986, DDRE identified Marsh Run Park as an excess federal property eligible for the Defense Environmental Restoration Program, and in April 1987, the Army commenced testing of the site. In August 1987, the Army received and shared preliminary test results with Fairview Township, and closed the park. In April 1988, formal preliminary test results were received and shared with Fairview Township. Results showed that low levels of volatile organic compounds (VOCs) and metals existed in the subsurface soil and groundwater. On 9 May 1988, PADEP tested the wells of Marsh Run Park neighbors for trace metals and VOCs. On 10 May 1988, results confirmed that the wells were not contaminated. As a result of the low levels of VOCs and metals found by the preliminary Marsh Run Park investigation, the Army recommended that a follow-up study be performed to determine the extent of the VOCs and metals. On 11 May 1988, the Army released funds to perform the follow-up environmental studies of Marsh Run Park.

A Remedial Investigation/Feasibility Study (RI/FS) was conducted by EA for USACE–Omaha District between 1988 and 1990 at the site. A Record of Decision (ROD) dated June 1991 was signed by PADEP in November 1991 and by the Department of the Army in July 1992. The ROD stipulated the preferred remedial action to be groundwater treatment combined with source area soil vapor extraction.

As stipulated by the ROD, a remedial design for a Groundwater Treatment Facility was conducted. The design of the Marsh Run Park Groundwater Treatment Facility (GWTF), also known as Operable Unit No. 1, was completed on 30 July 1994. The remedial design was implemented as a remedial action and construction was completed on 30 July 1995. The GWTF then operated for approximately 1 year and 4 months, when on 28 November 1996 it was destroyed by fire. Consequently, assessments are ongoing whether or not to construct a new GWTF or to allow natural attenuation to complete the remediation of groundwater within the bedrock aquifer.

2.4 SOURCE AREA TREATMENT

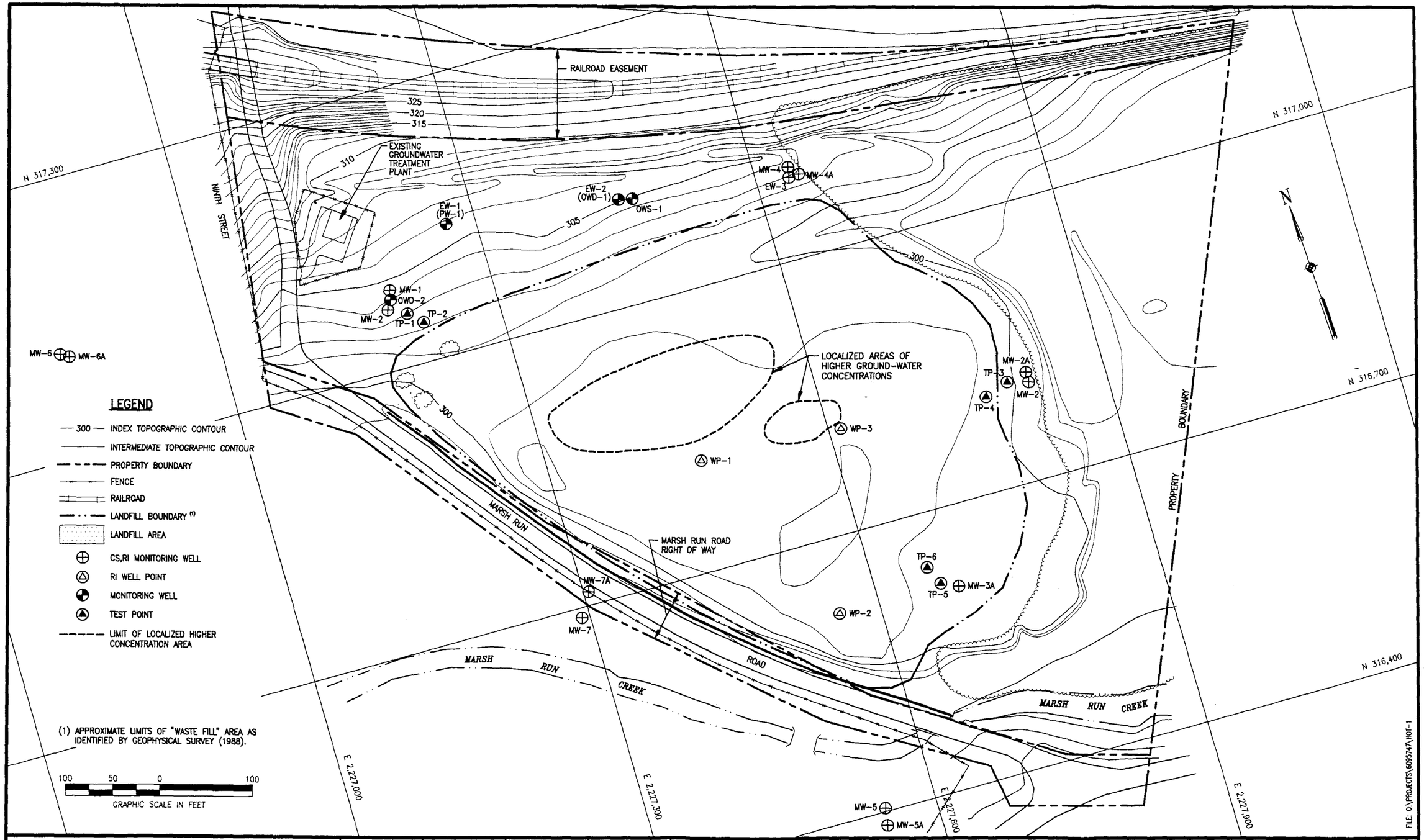
The 1989 ROD specified that remedial action at this site will consist of a groundwater collection and treatment system coupled with a source area treatment system. The original intent was for SVE to be applied as the source area treatment methodology, and for this system to be installed after the groundwater system had been operational sufficiently long to depress the water table in the shallow saturated zone. Pre-design of a source area treatment system has been completed and detailed design was underway at the time of the fire at the groundwater treatment system.

The goal of the source area treatment is to optimize the groundwater and source area VOC recovery in the identified "hot spot" source areas of the landfill. These "hot spot" source areas are shown in Figure 4. The contaminants of concern are halocarbons including tetrachloroethene (PCE), trichloroethene (TCE), and 1,2-dichloroethene (12DCE), and their breakdown products. The source area treatment system is proposed to continue operation until asymptotic levels are obtained in the source area soil vapor.

A field SVE test was to be conducted to collect design data for the SVE system. The SVE test was originally scheduled for April 1996. However, due to the unusually wet weather and associated high water table at the site, the test was delayed. On 18 July 1996 a conference call was held between EA and USACE to discuss the status of the test. The issues of the continued high water table and course of action for the test were addressed. Based on the present and historical elevated water table at the site, EA recommended using a vacuum enhanced SVE technique. An agreement was reached between EA and USACE to proceed with the modified SVE field test utilizing vacuum enhanced SVE to extract both air and water from the SVE wells. The field vacuum enhanced SVE test was conducted in August 1996.

Based on the results of the field test data, a network of wells in the area of the higher groundwater concentration was considered adequate for treatment of the subsurface VOC source. The wells are proposed to be installed on 30-ft centers to maintain coverage over the low permeability areas of the target area. Approximately 25-30 wells are proposed for installation in rows north and south of the existing Dewatering Well, DW-1. The wells will be installed in a triangular, alternating pattern to maximize coverage. Due to concerns over the potential for air intrusion, or "short circuiting," the wells will be screened from 3 ft below grade to approximately 10 ft below grade. The reduction in the screened interval in the vadose zone is expected to promote more capacity for dewatering of the capillary zone. In addition, a 20-mil geomembrane overlain by 2 ft of soil will be used over the target area encompassed by the wells to minimize the potential for air intrusion.

As discussed in the SVE Design Criteria Report (October 1996), the wells are proposed to be manifolded into small groups and each group will be connected to a separate vacuum blower to extract both soil vapor and groundwater. The process equipment is to be located in an equipment building near the target area. Extracted vapors from each group of wells will be piped to a central influent line and passed through a treatment system before discharge to the atmosphere. Based on the observed low mass removal, carbon adsorption was initially recommended as the treatment option for the extracted vapors. Groundwater removed as part of the vacuum enhanced



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DESIGNED BY	DRAWN BY	DATE	PROJECT NO.	FILE NAME
KMW	MSM	7-30-97	60957.47	HOT-1
CHECKED BY	PROJECT MGR.	SCALE	DRAWING NO.	FIGURE
JPC	GAT	AS SHOWN	–	4

EVALUATION OF GROUNDWATER TREATMENT SYSTEM ALTERNATIVES
FORMER LANDFILL, MARSH RUN PARK
NEW CUMBERLAND, PENNSYLVANIA

FIGURE 4
APPROXIMATE LOCATION OF "HOT SPOTS" WITHIN THE LANDFILL AREA

SVE system was to be treated either by integrating the vacuum enhanced SVE system with the existing groundwater system (i.e., air stripping followed by liquid and vapor phase carbon adsorption), or by use of a separate dedicated system for treatment of extracted groundwater from the vacuum enhanced SVE system. Since the destruction of the GWTF by fire, further preliminary engineering evaluations of the proposed treatment systems for the extracted soil vapor have indicated that a catalytic oxidation system would be more economical for treatment of soil vapor when combined with the off-gas recovered from air stripping of extracted groundwater. The preliminary design basis of the vacuum enhanced SVE system, along with other modifications of the design criteria presented in the SVE Design Criteria Report (October 1996), is discussed further in this document.

As discussed, the purpose of the source area remedial program is to optimize groundwater and soil vapor recovery within the targeted "hot spot" source area. The objective of the vacuum enhanced SVE system is to facilitate dewatering of the shallow overburden and enhance soil vapor extraction operations and the potential for soil vapor recovery. As discussed in the SVE Design Criteria Report (October 1996), the field test data indicate that vacuum enhanced SVE is a viable remedial strategy to treat the residual source area at the Marsh Run Park site. USACE is proceeding with the design and implementation of a vacuum enhanced SVE system for remediation of the source area at the former landfill site.

3. OBJECTIVES

The objectives of this evaluation are to:

- Provide a detailed cost comparison of the groundwater treatment facility alternatives to evaluate the technical and economic feasibility of future groundwater treatment activities at the Marsh Run former landfill site, and

- Provide information to USACE and PADEP for use in decision-making in moving forward with continuation of the remedial program at the Marsh Run Park site.

This evaluation presents a technical evaluation supported by detailed capital cost estimates and operational and maintenance cost estimates on each alternative considered, with supporting cost assumptions. Technical and economic comparisons are presented for each alternative. A recommendation is offered in Chapter 7 for the resumption of remediation activities at the Marsh Run Park site based upon consideration of the most technically feasible and cost-effective remedial alternative.

4. DESCRIPTION OF ALTERNATIVES

Two alternatives were considered for resumption of groundwater treatment at the Marsh Run Park site. These alternatives are: (1) the integration of a source area vacuum enhanced SVE system with a new groundwater treatment system, and (2) remediation of the bedrock aquifer through natural attenuation and remediation of the source area with vacuum enhanced SVE. Reconstruction of the groundwater system as originally designed was also considered, but was not retained for further consideration since it would have been necessary to redesign the system to accept source area water generated through vacuum enhanced SVE in addition to the groundwater from the bedrock wells. The cost analyses are presented for the two viable alternatives including estimated engineering design and investigation costs, capital costs, and annual operation and maintenance (O&M) costs.

4.1 ALTERNATIVE NO. 1: INTEGRATION OF A VACUUM ENHANCED SVE SYSTEM WITH A NEW GROUNDWATER TREATMENT FACILITY

Alternative No. 1 consists of integrating the vacuum enhanced SVE system design into a new Groundwater Treatment Facility which will treat both the bedrock aquifer and the dewatered landfill overburden. The designs of the new GWTF and the vacuum enhanced SVE system will be conducted as a single remedial design, thus allowing the construction and startup of the integrated vacuum enhanced SVE system and new GWTF to be concurrent. It is anticipated that the treatment of the bedrock aquifer would continue for a period of 10 years, while the vacuum enhanced SVE system is estimated to achieve the cleanup criteria specified in the ROD within a 2-year period.

The capital costs and operation and maintenance costs for Alternative No. 1 are presented in Table 1 and Table 2, respectively. The capital costs include costs for site work, a 20-mil geosynthetic cap with a minimum 2-ft soil cover mounded over the extraction area which consists of approximately 1 acre over the landfill surface, and groundwater/vacuum enhanced SVE treatment equipment. The operation and maintenance costs include costs for operation of the treatment facility for a continuous 10-year period. However, after 2 years of operation, the vacuum enhanced SVE system is assumed to cease operations and the GWTF would operate at a reduced flow rate to treat groundwater from the three groundwater extraction wells for a remaining 8-year period. It was assumed that the analytical costs associated with the 30 vacuum enhanced SVE wells would only be required for 2 years while the analytical costs associated with the groundwater treatment system would be required for 10 years.

The proposed site layout for the integrated groundwater/vacuum enhanced SVE treatment system is shown in Figures 5A and 5B. A flow diagram illustrating the proposed treatment process for Alternative No. 1 is shown in Figure 6. The liquid and vapor phase treatment processes associated with Alternative No. 1 are described in the following paragraphs.

Vacuum Enhanced SVE System

The design basis for the vacuum enhanced SVE system was established in the SVE Design Criteria Report (EA 1996). Based on field testing, an airflow and vacuum of 10 cfm per vacuum enhanced SVE well at 5-in. Hg was chosen as the basis for design. Accounting for friction loss in piping a total air flow rate of 300 cfm at 7-in. Hg was assumed. The liquid flow rate is assumed to be 1 gpm per well or 30 gpm total. Once the liquid and vapor phase extraction rates were established, the economics of utilizing several smaller vacuums to control a small cluster of vacuum enhanced SVE wells was compared to that for utilizing fewer vacuums to control a larger number of vacuum enhanced SVE wells. Specifically, the use of six (6) liquid ring pumps, each with a capacity of 50 cfm at 7-in. Hg, with each pump extracting vapor from five (5) vacuum enhanced SVE wells was compared to providing two (2) liquid ring pumps, with a total capacity of 300 cfm at 7-in. Hg, with the two pumps extracting vapor from thirty (30) vacuum enhanced SVE wells. Each of the 50 cfm pumps would require 5 Hp motors, at a total cost of $15,000 per pump or $90,000 for the six pumps. Alternatively, the 300 cfm pumps require 15 Hp motors, at a total cost of $22,000 per pump or $44,000 for the two pumps. Therefore, based upon this cost comparison, it was assumed that the vacuum enhanced SVE system would consist of 30 vacuum enhanced SVE wells and two liquid ring pumps extracting liquid and vapor from the wells at the above mentioned flow rates. The vapor extracted from the vacuum enhanced SVE wells is routed to the catalytic oxidation unit where it is combined with air stripping off-gas for treatment. Each liquid ring pump will be proceeded by a knock-out tank and an explosion proof liquid transfer pump to pump liquid collected in the knock-out tank to the flow equalization tank.

Groundwater Phase Treatment

The groundwater and vacuum enhanced SVE system liquid treatment process design consists of utilizing two new liquid ring pumps to withdraw soil vapor and water from 30 vacuum enhanced SVE wells placed in the source area within the landfill overburden. Water from the vacuum enhanced SVE wells will be extracted at a rate of 1 gpm per well, or a total estimated flow rate of 30 gpm. Groundwater will be extracted from the bedrock aquifer utilizing the three existing groundwater extraction wells, EW-1, EW-2, and EW-3, at a maximum rate of 13.3 gpm per well, or a total estimated flow rate of 40 gpm. Thus, the combined design flow rate for the

TABLE 1

CAPITAL COSTS

ALTERNATIVE NO. 1 - INTEGRATION OF VACUUM ENHANCED SVE SYSTEM SYSTEM WITH NEW GROUNDWATER TREATMENT FACILITY

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL PRICE
1	**Site Work**				
1.1	Site Preparation	AC	1.3	$ 1,000.00	$ 1,300.00
1.2	Additional Fill, Grading	CY	4300	$ 12.00	$ 51,600.00
1.3	Exterior Piping for Bioslurping System	LF	1000	$ 25.00	$ 25,000.00
1.4	Electrical Distribution	LS	1	$ 0.00	$ 0.00
1.5	Sediment & Erosion Control	AC	1.3	$ 2,000.00	$ 2,600.00
1.6	New Pavement	SY	160	$ 20.00	$ 3,200.00
1.7	New Security Fencing	LF	15	$ 230.00	$ 3,450.00
1.8	Well Rehabilitation and Cleaning	LS	1	$ 5,000.00	$ 5,000.00
1.9	Limited Offsite Diposal of Contaminated Soils	TON	100	$ 664.00	$ 66,400.00
	Subtotal - Site Work				$ 158,550.00
2	**20 mil geosynthetic cap**	SF	43560	$ 0.35	$ 15,246.00
3	**10 oz. geotextile**	SF	43560	$ 0.20	$ 8,712.00
4	**Groundwater Treatment Building and Equipment**				
4.1	New Treatment Building	SF	1080	$ 35.00	$ 37,800.00
4.2	3000-gallon Flow Equalization Tank	EA	1	$ 5,500.00	$ 5,500.00
4.3	Bag Filters	EA	4	$ 2,000.00	$ 8,000.00
4.4	Air Stripper Influent Pumps	EA	2	$ 5,000.00	$ 10,000.00
4.5	Low Profile Air Stripper w/ Blowers and Two Liquid Carbon Transfer Pumps	LS	1	$ 30,000.00	$ 30,000.00
4.6	Liquid Phase Carbon - (2) 1500 lb units	EA	2	$ 8,500.00	$ 17,000.00
4.7	Offgas Vapor Treatment -1000 CFM Catalytic Oxidation (No Scrubber)	EA	1	$ 130,000.00	$ 130,000.00
4.8	Interior Piping and Valving	LF	250	$ 12.00	$ 3,000.00
4.9	Wash Water Storage Tank, Pressure Tank, and Wash Water Pump	LS	1	$ 2,200.00	$ 2,200.00
	Subtotal - Groundwater Treatment Building and Equipment				$ 243,500.00
5	**Vacuum Enhanced SVE System**				
5.1	30 Vacuum Enhanced SVE Wells @ 10 LF each well	LF	300	$ 100.00	$ 30,000.00
5.2	Masonry Vacuum Enhanced SVE Equipment Building & Foundation	SF	390	$ 36.00	$ 14,040.00
5.3	Vapor Phase Treatment Concrete Pad	SF	330	$ 9.00	$ 2,970.00
5.4	Liquid Ring Extraction Pumps w/ Knock-Out Package and X-P Transfer Pump	EA	2	$ 22,000.00	$ 44,000.00
5.5	Vapor Treatment (included under GWTS costs)				$ 0.00
5.6	Instrumentation and Controls	LS	1	$ 25,000.00	$ 25,000.00
5.7	Electrical	LS	1	$ 25,000.00	$ 25,000.00
5.8	System Startup	LS	1	$ 25,000.00	$ 25,000.00
	Subtotal - Vacuum Enhanced SVE System				$ 166,010.00
6	**Restoration of Existing Groundwater Treatment Building**	LS	1	$ 20,000.00	$ 20,000.00
7	**SUBTOTAL- CAPITAL COSTS**				$ 612,018.00
8	**PRECONSTRUCTION SUBMITTALS**				$ 15,000.00
9	**MOBILIZATION/DEMOBILIZATION, CONSTRUCTION MANAGMENT, SITE SERVICES (20 % OF SUBTOTAL)**				$ 122,403.60
10	**DESIGN (20% OF SUBTOTAL)**				$ 122,403.60
11	**CONTINGENCY (25% OF SUBTOTAL)**				$ 153,004.50
12	**TOTAL**				**$ 1,024,800.00**

TABLE 1 (continued)

NOTES:

1.1 Site Preparation based on Means 021-108-0400 and includes light clearing with a dozer.

1.2 Additional fill for grading based on earthwork quantities considering new facility site plan, and for 2-ft of cover over a one acre area on the landfill. Cost assumes select fill is obtained at contractor's offsite borrow source within 10 miles of site. Includes borrow material, haul, and rough grading.

1.3 Exterior piping from vacuum enhanced SVE wells to the liquid ring pumps includes costs of piping and trenching.

1.4 Assume electrical distribution for original groundwater treatment plant will be available for reuse.

1.5 Sediment and Erosion Control consists of placing 200 LF of silt fence @ $2.00/LF and temporary seeding @ $1,700/acre.

1.6 New pavement cost based on 1½-in. surface course, 4½-in. base course, 8-in. graded aggregate placed over a compacted subgrade.

1.7 Cost for new security fencing based on Means Cost Data.

1.8 Costs for well rehabilitation and cleaning are based on the costs to flush and redevelop three existing extraction wells. Costs assume that development water is containerized and later disposed of onsite in the new treatment facility.

1.9 Limited offsite disposal of contaminated material based on assumption that 20% of the materials excavated for the vacuum enhanced SVE pipe network will require offsite disposal based on 1000-ft of trench, 4-ft deep, 2-ft wide. Costs for offsite disposal of contaminated soils are based on bid quotes from the original GWTF project.

2 20-mil geosynthetic cap costs are based on quotes from National Seal on 7/3/97.

3 10-oz geosynthetic costs are based on quotes from National Seal 7/3/97.

4.1 Building cost based on Means square foot price for commercial/industrial warehouse construction and includes foundation, slab on grade, walls, roof, mechanical, and electrical. (Building square foot cost also agrees with square foot price used in original treatment plant estimate.)

4.2 3,000-gal FRP flow equalization tank, double cost of original 1,500-gal tank cost escalated 3% for 3 years.

4.3 Bag filter cost based on original treatment plant cost escalated 3% for 3 years.

4.4 Air stripper transfer pump based on centrifugal pump capacity of 75 gpm @ 70 ft TDH.

4.5 Air stripper cost based on 5/16/97 estimate from Carbonair and includes 10 HP blower and transfer pump (75 gpm @ 75 ft TDH).

4.6 Liquid Carbon costs based on 5/16/97 estimate from Carbonair. Vessel is carbon steel, 1,500 lb of reactivated carbon per vessel, 90 gpm max. flow rate and includes piping headers between carbon units.

4.7 Off-gas vapor treatment includes treatment of air stripper off-gas and vacuum enhanced SVE vapors @ combined flow of 950 cfm through a catalytic oxidation unit. Costs based on 5/23/97 quote from Anguil Environmental. Costs assume propane is utilized to fuel the unit.

4.8 Interior piping assumed to be 3-in. diameter polypropylene. Costs based on linear foot cost of original estimate for piping and an additional 20% for valving.

4.9 Wash-down water equipment including storage tank, pressure tank, and pump based on costs of original equipment escalated 3% for 3 years.

5.1 30 SVE/Vacuum enhanced SVE Wells based on EA October 1996 report.

5.2 Masonry Building assumed to be 19.5 ft x 20 ft x 10 ft high to house SVE/Slurping Blowers. Consists of 6-in. precast concrete roof, 8-in.-thick reinforced CMU walls, and 10-in.-thick slab reinforced with welded wire fabric.

5.3 Vapor phase reinforced concrete treatment pad for catalytic oxidation unit.
Pad to be 16.5 ft x 20 ft by 10 ft thick reinforced with #4 welded wire fabric and
Costs per Means A2.1-200 Slab on Grade. 10-in.-thick slab, reinforced, heavy industrial use.

5.4 Liquid Ring Pumps are assumed to be 15 HP each, 230/460 V, 3 phase, XP motor. Package includes knock-out tank with liquid transfer pump. Cost based on quote from Carbonair on 5/16/97.

5.5 Cost for catalytic oxidation unit included under groundwater treatment system costs.

5.6 Instrumentation and Controls based on EA October 1996 report and are inclusive for the groundwater treatment and vacuum enhanced SVE system.

5.7 Electrical based on EA October 1996 report and are inclusive for the groundwater treatment and vacuum enhanced SVE system.

5.8 System Startup based on EA October 1996 report and are inclusive for the groundwater treatment and vacuum enhanced SVE system.

6 Restoration of existing groundwater treatment building includes: removal of remaining debris and performing building cleanings at an estimated cost of $5,000; sandblasting, priming, and repainting of interior structural steel at an estimated cost of $4,000; removal and replacement of interior lining panel and insulation at an estimated cost of $6,000; replacement of lighting and interior building electric system at an estimated cost of $5,000. The existing groundwater treatment building is intended to be salvaged and used for office facilities and storage space for continued operations of remedial treatment units at the Marsh Run Park site.

TABLE 2

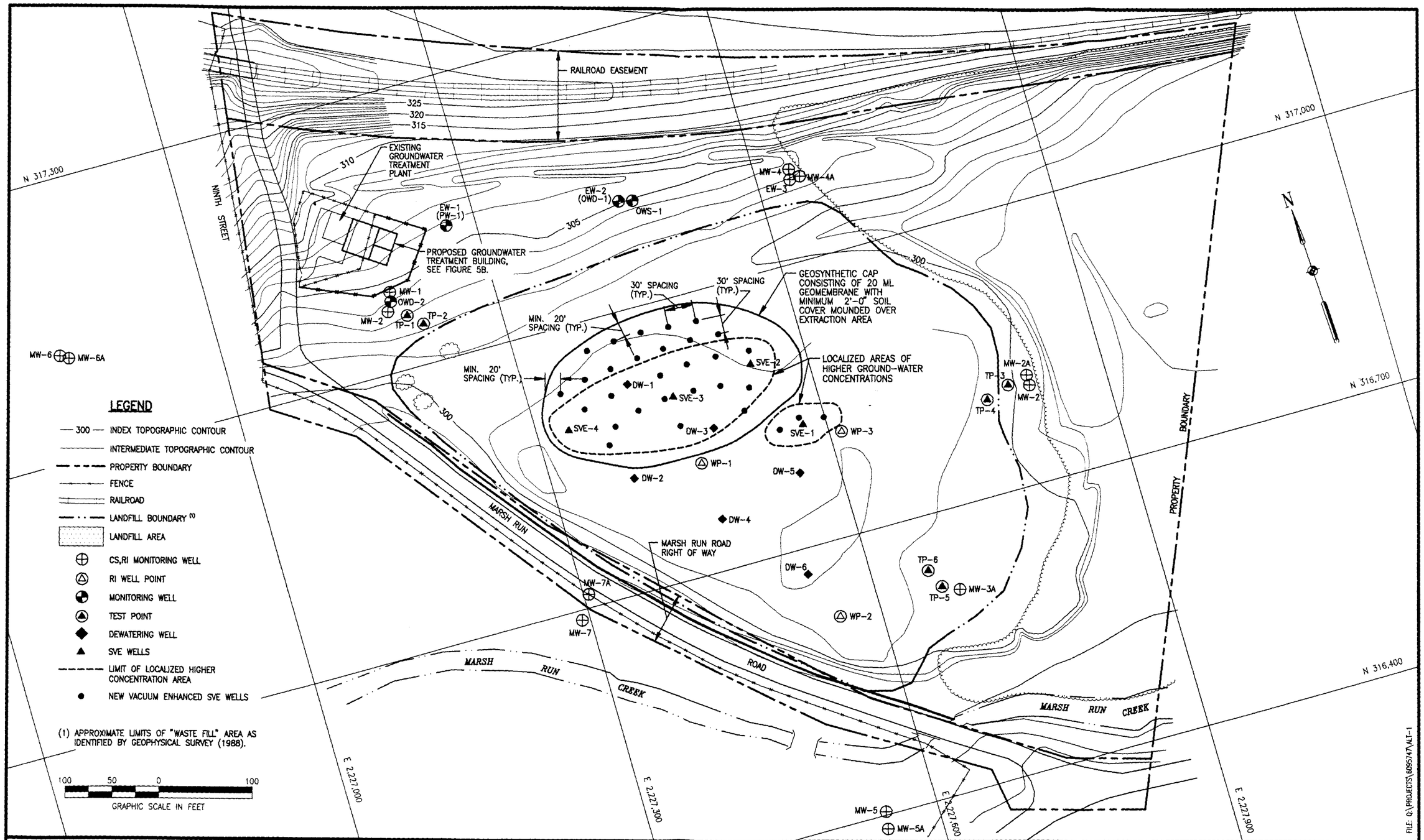
OPERATION AND MAINTENANCE COSTS
ALTERNATIVE NO. 1 - INTEGRATION OF VACUUM ENHANCED SVE SYSTEM WITH NEW GROUNDWATER TREATMENT FACILITY

ITEM		DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL PRICE
1		**O&M Costs - 10-year Duration**				
	1.1	Supervision, Operator, and Support Labor	LS	1	$ 34,000.00	$ 34,000.00
	1.2	Electrical Costs (Except Catalytic Oxidation Unit)	LS	1	$ 22,000.00	$ 22,000.00
	1.3	Filter Bag Replacement	LS	1	$ 30,000.00	$ 30,000.00
	1.4	Carbon Usage	LS	1	$ 24,000.00	$ 24,000.00
	1.5	Operation Costs for Catalytic Oxidation Unit	LS	1	$ 19,000.00	$ 19,000.00
	1.6	Groundwater Treatment System Analytical	LS	1	$ 59,400.00	$ 59,400.00
		SUBTOTAL - O&M COSTS - 10-YEAR DURATION				$ 188,400.00
	1.7	CONTINGENCY @ 20%				$ 37,680.00
	1.8	TOTAL ANNUAL COSTS FOR 10-YEAR CYCLE				$ 226,080.00
	1.9	10-YEAR PRESENT WORTH OF ANNUAL O&M COSTS				$ 1,745,721.94
2		**O&M Costs - 2-year Duration**				
	2.1	Vacuum Enhanced SVE System Analytical	LS	1	$ 75,200.00	$ 75,200.00
		SUBTOTAL - O&M COSTS - 2-YEAR DURATION				$ 75,200.00
	2.2	CONTINGENCY @ 25%				$ 18,800.00
	2.3	TOTAL ANNUAL COSTS FOR 2 YEAR DURATION				$ 94,000.00
	2.4	2-YEAR PRESENT WORTH OF ANNUAL O&M COSTS				$ 174,783.60
3		**TOTAL PRESENT WORTH OF ANNUAL O&M COSTS (Item 1.9 and Item 2.4)**				**$ 1,920,500.00**

TABLE 2 (continued)

NOTES:

1.1	Costs for Supervision, Operator, and Support persons include 256 hours per year for a Supervisor @ $25/hr, 480 hours per year for Operational Assistance @ $15/hr, 160 hours per year for a Technician @ $15/hr, and 1,040 hours per year for an operator @ $15/hr.
1.2	Electrical costs account for electrical consumption from air stripper transfer pumps, air stripper blower, carbon transfer pumps, knock-out tank pumps, and liquid ring pumps assuming 70% efficiency, operating 12 hours per day, 365 days per year @$0.10/Kw/hr.
1.3	Filter bag replacement costs are based on the original groundwater treatment system estimates.
1.4	Carbon Usage assumes changing out a 1,500-lb lead carbon unit 5 times per year and changing out at 1,500-lb lag carbon unit 3 times per year @ $2.00/lb of carbon.
1.5	Operating Costs for Catalytic Oxidation Unit based on July 1997 estimates provided by Global Technologies @ $4.25/hr for propane fuel and electric. Costs assume operating 12 hr/day, 365 days/year.
1.6	Sample collection and analytical costs for the GWTF include costs to sample and analyze 6 dewatering wells and 3 extraction wells on a quarterly basis, and 6 monitoring wells on a semi-annual basis. The wells are monitored for VOCs. Reporting of analytical results is included in the cost. GWTF analytical costs are presented in Appendix B.
Subtotal	10-year present worth = Annual Costs X (P/A, 5%, 10 yr); (P/A, 5%, 10 yr) = 7.7217.
2.1	Analytical Costs represent costs for quarterly monitoring 30 wells of the vacuum enhanced SVE wells for VOCs. Vacuum enhanced SVE analytical costs are presented in Appendix B.
Subtotal	2-year present worth = Total Annual Costs for 2 Year Duration X (P/A, 5%, 2 yr); P/A, 5%, 2 yr) = 1.8594.

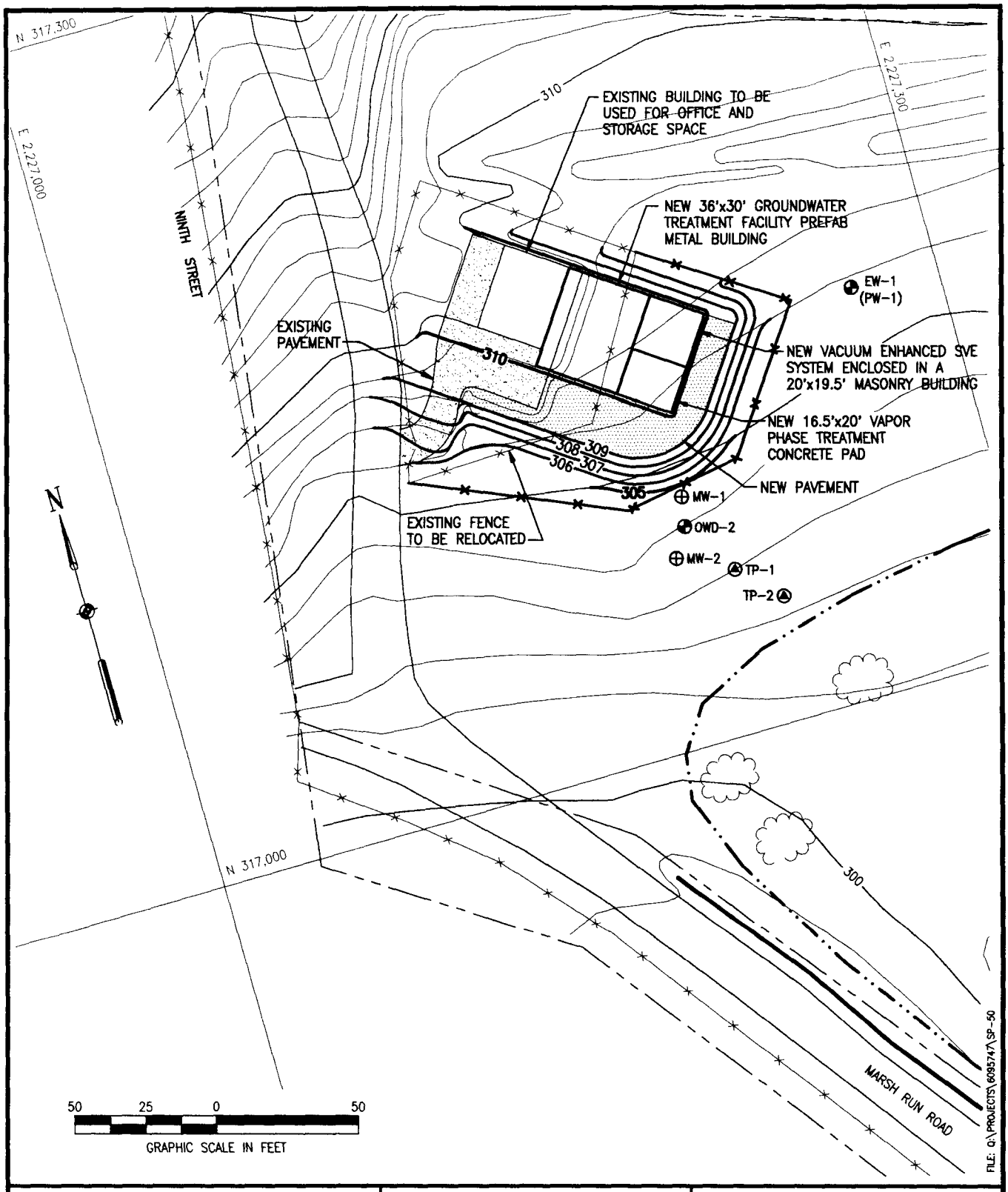


EA ENGINEERING, SCIENCE, AND TECHNOLOGY

DESIGNED BY	DRAWN BY	DATE	PROJECT NO.	FILE NAME
KMW	MSM	10-16-97	60957.47	ALT-1
CHECKED BY	PROJECT MGR.	SCALE	DRAWING NO.	FIGURE
JPC	GAT	AS SHOWN	–	5A

EVALUATION OF GROUNDWATER TREATMENT SYSTEM ALTERNATIVES
FORMER LANDFILL, MARSH RUN PARK
NEW CUMBERLAND, PENNSYLVANIA

FIGURE 5A
PROPOSED SITE PLAN
ALTERNATIVE NO. 1

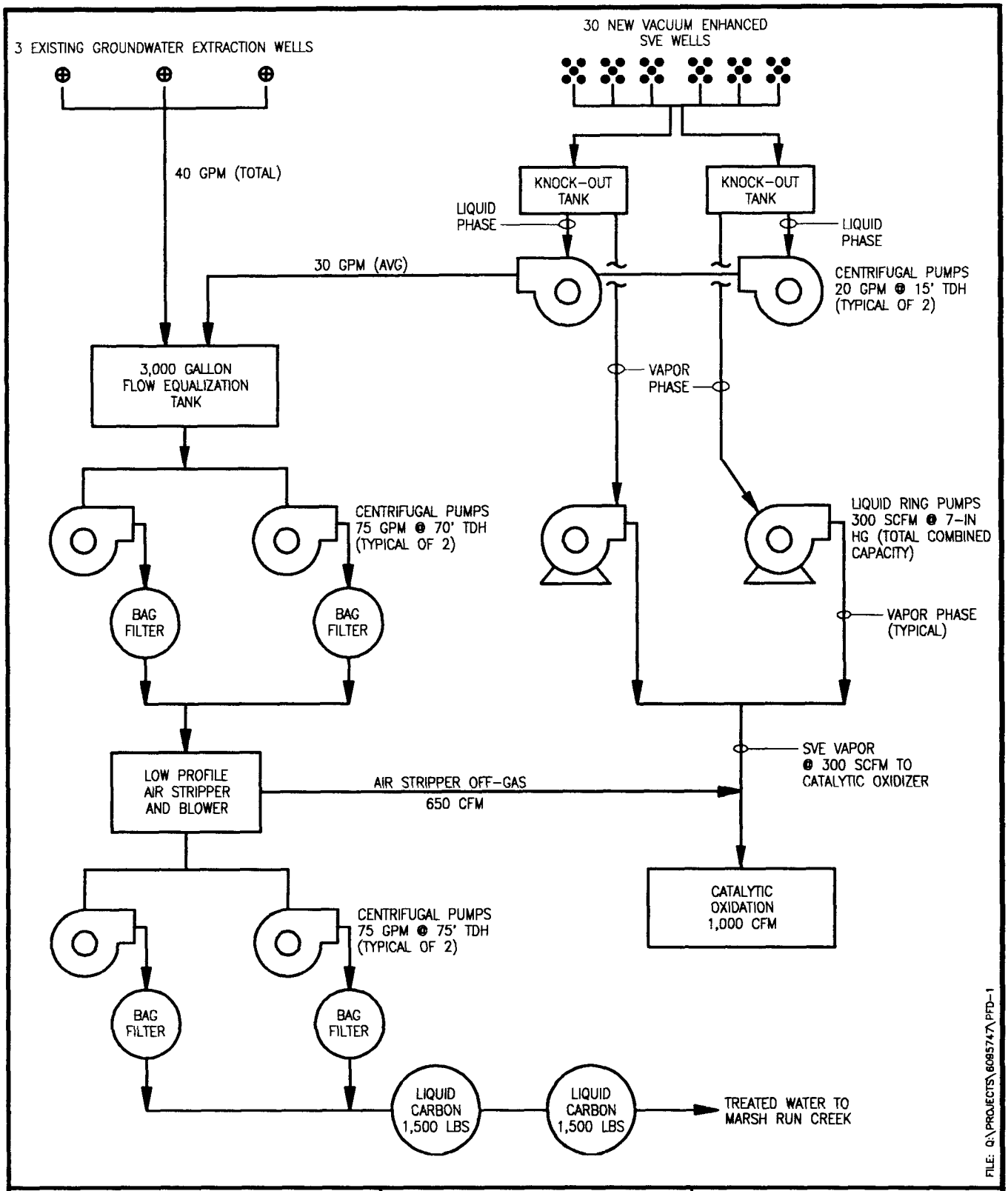


EA ENGINEERING, SCIENCE, AND TECHNOLOGY

EVALUATION OF GROUNDWATER TREATMENT SYSTEM ALTERNATIVES
FORMER LANDFILL, MARSH RUN PARK
NEW CUMBERLAND, PENNSYLVANIA

PROPOSED TREATMENT BUILDING AREA PLAN

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
JPC	KMW	MSM	GAT	AS SHOWN	11-24-97	60957.47	5B



EA ENGINEERING, SCIENCE, AND TECHNOLOGY	EVALUATION OF GROUNDWATER TREATMENT SYSTEM ALTERNATIVES FORMER LANDFILL, MARSH RUN PARK NEW CUMBERLAND, PENNSYLVANIA	PROCESS FLOW DIAGRAM ALTERNATIVE NO. 1

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
JPC	KMW	MSM	GAT	NONE	10-13-97	60957.47	6

groundwater treatment system is estimated as 70 gpm. The groundwater and vacuum enhanced SVE water which is withdrawn is combined within a 3,000-gal flow equalization tank. Once the two water sources are combined, it is pumped through bag filters prior to air stripping. Similar to the original groundwater treatment system design, and based on a design flow rate of 70 gpm, the concentrations of contaminants of concern, and knowing that the groundwater treatment system would operate for 10 years, air stripping followed by liquid phase carbon was determined to be more economical than liquid phase carbon alone for treatment of the combined liquid stream. This fact is demonstrated further in Alternative No. 2, where at lower flow rates and relatively similar concentrations, air stripping followed by liquid phase carbon is determined to be more economical than liquid phase carbon alone. A low profile air stripper designed to treat a total liquid flow rate of 75 gpm with an air flow rate of 650 cfm is recommended. The air stripper treats the contaminants of concern to less than 1 ppb except for 1,1,2-trichloroethane (112TCA) and 1,1,2,2-tetrachloroethane (1122PCA). The process water is then introduced to two 1,500-lb liquid phase carbon vessels for treatment of the residual contamination prior to discharge to Marsh Run Creek.

Vapor Phase Treatment

The off-gas from the air stripper is combined with the vapor from the vacuum enhanced SVE system and is treated by a catalytic oxidation unit.

The economics of vapor phase carbon was compared to catalytic oxidation for treatment of the combined air stream from the vacuum enhanced SVE wells (10 cfm per well, or 300 cfm total) and air stripper off-gas (650 cfm). Two 5,000-lb vapor phase carbon vessels operating in series would have been required, with change out occurring on both vessels at a frequency of approximately nine times per year. Over a 10-year period, the present worth of the capital and O&M costs (primarily carbon change out) for vapor phase carbon far exceed that for the capital and O&M costs (primarily fuel and electricity) for catalytic oxidation. The present worth of vapor phase treatment through carbon adsorption considering a $35,000 capital expense for purchase of two 5,000-lb carbon units and a $180,000 per year cost for carbon replacement for a 10-year period, assuming a 5% interest rate, is $1,425,000. The present worth of vapor phase treatment through catalytic oxidation considering a $130,000 capital expense for a 1,000 cfm catalytic oxidation unit and a $12,000 per year operational expense for a 10-year period, assuming a 5% interest rate, is $223,000. Therefore, a Catalytic Oxidation Unit with 99% destruction efficiency at 1,000 cfm was selected as the preferred vapor phase treatment technology. The vapor phase treatment cost comparison for Alternative No. 1, as described above, is presented in detail in Appendix A.

A general equipment arrangement plan showing a proposed layout of the liquid phase and vapor phase treatment processes is shown in Figure 7.

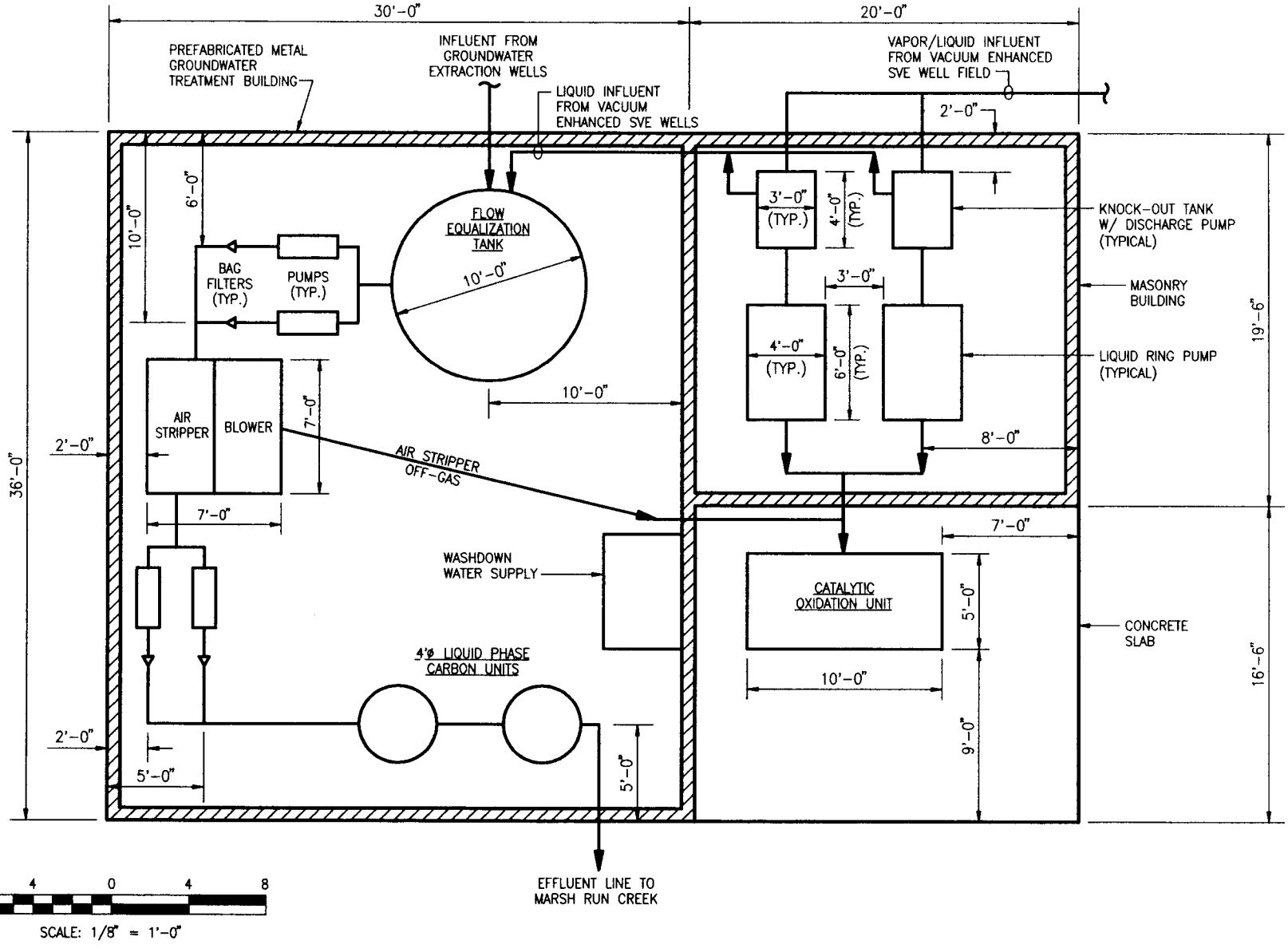
4.2 ALTERNATIVE NO. 2: REMEDIATION OF BEDROCK AQUIFER THROUGH NATURAL ATTENUATION AND REMEDIATION OF SOURCE AREA WITH VACUUM ENHANCED SVE SYSTEM

Alternative No. 2 consists of evaluating the feasibility of natural attenuation as a remedial alternative for the bedrock aquifer and developing a long-term monitoring plan for the site. Treatment of the source areas within the landfill will be accomplished through a vacuum enhanced SVE system, concurrent with the natural attenuation evaluation. The vacuum enhanced SVE system consists of processes to extract and treat both the liquid and vapor phase from the landfill overburden. It is anticipated that the vacuum enhanced SVE system would operate for a duration up to 2 years, at which time it is estimated that asymptotic levels in the soil vapor of the source area will be achieved. Long-term monitoring of natural attenuation of the bedrock aquifer would continue for a 10-year period. For purposes of this evaluation, a 10-year period was used for continuing the monitoring of natural attenuation in order to conduct a cost comparison on an equivalent basis with the pump-and-treat system, for the bedrock aquifer, proposed under Alternative No. 1.

The capital cost and operation and maintenance costs for Alternative No. 2 are presented in Table 3 and Table 4, respectively. The capital costs include costs for site work, a 20-mil geosynthetic cap overlain by 2 ft of soil over the landfill surface, vacuum enhanced SVE treatment equipment, and the costs associated with evaluating the feasibility of natural attenuation. The annual operation and maintenance costs include costs for operating the vacuum enhanced SVE treatment facility for a 2-year period and for implementing a long-term monitoring plan for natural attenuation for a continuous 10-year period. The proposed site layout for the vacuum enhanced SVE treatment system, including 10 additional monitoring wells to evaluate the application of natural attenuation at the site, is shown in Figure 8. A flow diagram illustrating the proposed treatment process for Alternative No. 2 is presented in Figure 9. The liquid and vapor phase treatment processes are described in the following paragraphs.

Natural Attenuation

Based upon a review of the data collected at the site since 1991, there is evidence of the breakdown of TCE into its daughter compounds. The occurrence of daughter products is a significant observation as TCE is a very stable solvent. The carbon atoms in TCE are relatively



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EA ENGINEERING, SCIENCE, AND TECHNOLOGY	EVALUATION OF GROUNDWATER TREATMENT SYSTEM ALTERNATIVES FORMER LANDFILL, MARSH RUN PARK NEW CUMBERLAND, PENNSYLVANIA	ALTERNATIVE 1 INTEGRATE VACUUM ENHANCED SVE SYSTEM WITH NEW GROUNDWATER TREATMENT FACILITY	DESIGNED BY KMW	DRAWN BY MSM	DATE 11-24-97	PROJECT NO. 60957.47
			CHECKED BY GAT	PROJECT MGR. JPC	SCALE AS SHOWN	FIGURE 7

TABLE 3

CAPITAL COSTS
ALTERNATIVE NO. 2 - REMEDIATION OF BEDROCK AQUIFER THROUGH NATURAL ATTENUATION AND AND REMEDIATION OF SOURCE AREA WITH VACUUM ENHANCED SVE SYSTEM

DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL PRICE
Site Work				
Site Prep	AC	1.3	$ 1,000.00	$ 1,300.00
Additional Fill, Grading	CY	4300	$ 12.00	$ 51,600.00
Exterior Piping	LF	1000	$ 25.00	$ 25,000.00
Electrical Distribution	LS	1	$ 0.00	$ 0.00
Sediment & Erosion Control	AC	1.3	$ 2,000.00	$ 2,600.00
New Pavement	SY	160	$ 20.00	$ 3,200.00
New Security Fencing	LF	15	$ 230.00	$ 3,450.00
Well Rehabilitation and Cleaning	LS	1	$ 5,000.00	$ 5,000.00
Limited Offsite Diposal of Contaminated Soils	TON	100	$ 664.00	$ 66,400.00
Subtotal - Site Work				$ 158,550.00
20 mil geosynthetic cap	SY	43560	$ 0.35	$ 15,246.00
10 oz. geotextile	SY	43560	$ 0.20	$ 8,712.00
Groundwater Treatment Building and Equipment				
New Pre-Fabricated Metal Groundwater Treatment Building	SF	1080	$ 35.00	$ 37,800.00
1500-gallon Flow Equalization Tank	EA	1	$ 3,000.00	$ 3,000.00
Bag Filters	EA	4	$ 2,000.00	$ 8,000.00
Air Stripper Influent Pumps	EA	2	$ 5,000.00	$ 10,000.00
Air Stripper w/ Blowers and Two Liquid Carbon Transfer Pumps	EA	1	$ 13,000.00	$ 13,000.00
Liquid Phase Carbon - (2) 900 lb units	EA	2	$ 7,000.00	$ 14,000.00
Offgas Vapor Treatment -600 CFM Catalytic Oxidation (No Scrubber)	LS	1	$ 105,000.00	$ 105,000.00
Interior Piping and Valving	LF	250	$ 12.00	$ 3,000.00
Wash Water Storage Tank, Pressure Tank, and Wash Water Pump	LS	1	$ 2,200.00	$ 2,200.00
Subtotal - Groundwater Treatment Building and Equipment				$ 196,000.00
Vacuum Enhanced SVE System				
30 Vacuum Enhanced SVE Wells @ 10 LF each well	LF	300	$ 100.00	$ 30,000.00
Masonry Vacuum Enhanced SVE Equipment Building & Foundation	SF	390	$ 36.00	$ 14,040.00
Vapor Phase Treatment Concrete Pad	SF	330	$ 9.00	$ 2,970.00
Liquid Ring Extraction Pumps w/ Knock-Out Package and X-P Transfer Pump	EA	2	$ 22,000.00	$ 44,000.00
Vapor Treatment (included under GWTS costs)				$ 0.00
Instrumentation and Controls	LS	1	$ 25,000.00	$ 25,000.00
Electrical	LS	1	$ 25,000.00	$ 25,000.00
System Startup	LS	1	$ 25,000.00	$ 25,000.00
Subtotal - Vacuum Enhanced SVE System				$ 166,010.00
Evaluate Feasibility of Natural Attenuation Including Installation of Additional Monitoring Points	LS	1	$ 112,000.00	$ 112,000.00
Restoration of Existing Groundwater Treatment Building	LS	1	$ 20,000.00	$ 20,000.00
SUBTOTAL - CAPITAL COSTS				$ 676,518.00
PRECONSTRUCTION SUBMITTALS				$ 15,000.00
MOBILIZATION/DEMOBILIZATION, CONSTRUCTION MANAGMENT, SITE SERVICES (20% OF SUBTOTAL)				$ 135,303.60
DESIGN (20% OF SUBTOTAL)				$ 135,303.60
CONTINGENCY (25% OF SUBTOTAL)				$ 169,129.50
TOTAL				**$ 1,131,300.00**

TABLE 3 (continued)

NOTES:

1.1 Site Preparation based on Means 021-108-0400 and includes light clearing with a dozer.

1.2 Additional fill for grading based on earthwork quantities considering new facility site plan, and for 2-ft of cover over a one acre area of the landfill. Costs assume select fill is obtained at contractor's offsite borrow source within 10 miles of site. Includes borrow material, haul, and rough grading.

1.3 Exterior piping from vacuum enhanced SVE wells to the liquid ring pumps includes costs of piping and trenching.

1.4 Assume electrical distribution for original groundwater treatment plant will be available for reuse.

1.5 Sediment and Erosion Control consists of placing 200 LF of silt fence @ $2.00/LF and temporary seeding @ $1,700/acre.

1.6 New pavement cost based on 1½-in. surface course, 4½-in. base course, 8-in. graded aggregate placed over a compacted subgrade.

1.7 Cost for new security fencing based on Means Cost Data.

1.8 Costs for well rehabilitation and cleaning are based on the costs to flush and redevelop three existing extraction wells. Costs assume that development water is containerized and later disposed of onsite in the new treatment facility.

1.9 Limited offsite disposal of contaminated material based on assumption that 20% of the materials excavated for the vacuum enhanced SVE pipe network will require offsite disposal based on 1000-ft of trench, 4-ft deep, 2-ft wide. Costs for offsite disposal of contaminated soils are based on bid quotes from the original GWTF project.

2 20-mil geosynthetic cap costs are based on quotes from National Seal on 7/3/97.

3 10-oz geosynthetic costs are based on quotes from National Seal 7/3/97.

4.1 Building cost based on Means square foot price for commercial/industrial warehouse construction and includes foundation, slab on grade, walls, roof, mechanical, and electrical. (Building square foot cost also agrees with square foot price used in original treatment plant estimate.)

4.2 1,500-gal FRP flow equalization tank, cost from original estimate and escalated 3% for 3 years.

4.3 Bag filter cost based on original treatment plant cost escalated 3% for 3 years.

4.4 Air stripper transfer pump based on centrifugal pump capacity of 35 gpm @ 70 ft TDH.

4.5 Air stripper cost based on 5/16/97 estimate from Carbonair and includes 10 HP blower and transfer pump (35 gpm @ 75 ft TDH).

4.6 Liquid Carbon costs based on 5/16/97 estimate from Carbonair. Vessel is carbon steel, 900 lb of reactivated carbon per vessel, 70 gpm max. flow rate and includes piping headers between carbon units.

4.7 Off-gas vapor treatment includes treatment of air stripper off-gas and vacuum enhanced SVE vapors @ combined flow of 600 cfm through a catalytic oxidation unit. Costs based on 5/23/97 quote from Anguil Environmental. Assumes propane is utilized to fuel the unit. Leasing options were considered, however, monthly leasing payments would be approximately $4900/month. Therefore, over a 24-month period it is more economical to buy the catalytic oxidation unit.

4.8 Interior piping assumed to be 3-in. diameter polypropylene. Costs based on linear foot cost of original estimate for piping and an additional 20% for valving, escalated 3% for 3 years.

4.9 Wash-down water equipment including storage tank, pressure tank, and pump based on costs of original equipment escalated 3% for 3 years.

5.1 30 SVE/Vacuum enhanced SVE Wells based on EA October 1996 report.

5.2 Masonry Building assumed to be 19.5 ft x 20 ft x 10 ft high to house SVE/Slurping Blowers. Consists of 6-in. precast concrete roof, 8-in.-thick reinforced CMU walls, and 10-in.-thick slab reinforced with welded wire fabric.

5.3 Vapor phase reinforced concrete treatment pad for catalytic oxidation unit. Pad to be 16.5 ft x 20 ft by 10 ft thick reinforced with #4 welded wire fabric. Costs per Means A2.1-200 Slab on Grade. 10-in.-thick slab, reinforced, heavy industrial use.

5.4 Liquid Ring Pumps are assumed to be 15 HP each, 230/460 V, 3 phase, XP motor. Package includes knock-out tank with liquid transfer pump. Cost based on quote from Carbonair on 5/16/97.

5.5 Cost for catalytic oxidation unit included under groundwater treatment system costs.

5.6 Instrumentation and Controls based on EA October 1996 report.

5.7 Electrical based on EA October 1996 report.

5.8 System Startup based on EA October 1996 report.

6 Cost to evaluate feasibility of natural attenuation based on EA proposal March 1997, Optional Tasks which include additional site characterization, refining the conceptual model, and preparing a long-term monitoring plan. The results of the natural attenuation feasibility evaluation are assumed to be summarized in a report.

7 Restoration of existing groundwater treatment building includes: removal of remaining debris and performing building cleanings at an estimated cost of $5,000; sandblasting, priming, and repainting of interior structural steel at an estimated cost of $4,000; removal and replacement of interior lining panel and insulation at an estimated cost of $6,000; replacement of lighting and interior building electric system at an estimated cost of $5,000. The existing groundwater treatment building is intended to be salvaged and used for office facilities and storage space for continued operations of remedial treatment units at the Marsh Run Park site.

TABLE 4

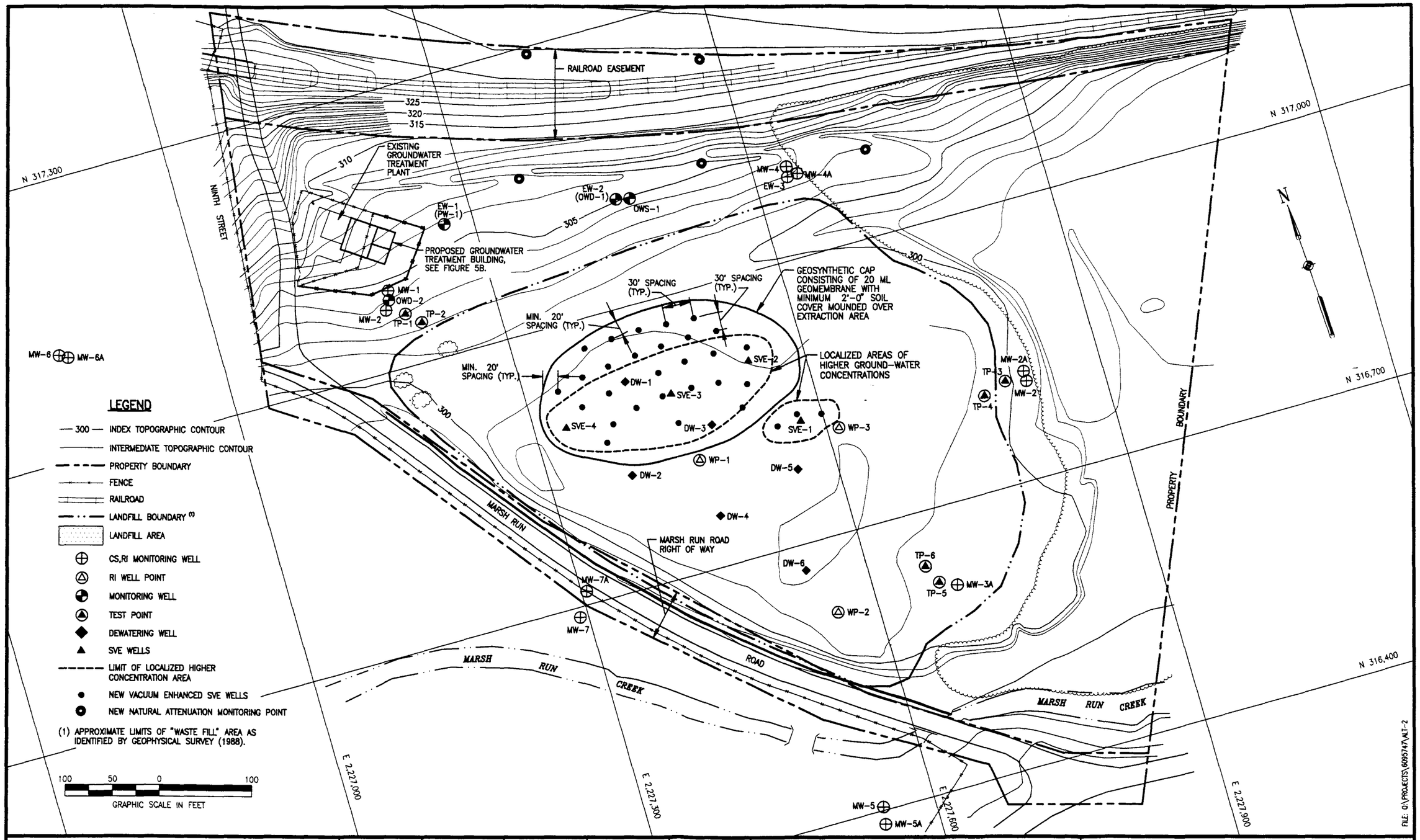
ANNUAL OPERATION AND MAINTENANCE COSTS
ALTERNATIVE NO. 2 - REMEDIATE BEDROCK AQUIFER THROUGH NATURAL ATTENUATION AND REMEDIATE SOURCE AREA WITH VACUUM ENHANCED SVE SYSTEM

ITEM		DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL PRICE
1		**Operation and Maintenance Costs for Natural Attenuation of Bedrock Aquifer - 10-Year Duration**				
	1.1	Analytical for Natural Attenuation Only- 10 YEARS	LS	1	$ 30,800.00	$ 30,800.00
		SUBTOTAL - O&M COSTS - 10-YEAR DURATION				$ 30,800.00
	1.2	CONTINGENCY @ 20%				$ 6,160.00
	1.3	TOTAL ANNUAL NATURAL ATTENUATION OPERATION AND MAINTENANCE COSTS				$ 36,960.00
	1.4	10-YEAR PRESENT WORTH OF ANNUAL NATURAL ATTENUATION O&M COSTS				$ 285,394.03
2		**Two Year Operation and Maintenance of the Vacuum Enhanced SVE System For Treatment of Source Area**				
	2.1	Surpervision, Operator, and Support Labor	LS	1	$ 34,000.00	$ 34,000.00
	2.2	Electrical Costs (except Catalytic Oxidation Unit)	LS	1	$ 20,000.00	$ 20,000.00
	2.3	Filter Bag Replacement	LS	1	$ 30,000.00	$ 30,000.00
	2.4	Carbon Usage	LS	1	$ 17,000.00	$ 17,000.00
	2.5	Operation Costs for Catalytic Oxidation Unit	LS	1	$ 11,500.00	$ 11,500.00
	2.6	Analytical for Vacuum Enhanced SVE Only	LS	1	$ 75,200.00	$ 75,200.00
		SUBTOTAL - O&M COSTS - 2-YEAR DURATION				$ 187,700.00
	2.7	CONTINGENCY @ 25%				$ 46,925.00
	2.8	TOTAL ANNUAL VACUUM ENHANCED SVE OPERATION AND MAINTENANCE COSTS				$ 234,625.00
	2.9	2-YEAR PRESENT WORTH OF ANNUAL VACUUM ENHANCED SVE O&M COSTS				$ 436,261.73
3		**TOTAL PRESENT WORTH OF ANNUAL O&M COSTS (Item 1.10 and Item 2.5**				**$ 721,700.00**

TABLE 4 (continued)

NOTES:

1.1	Natural Attenuation Analytical Costs include costs for a one-time sampling event to establish a baseline for natural attenuation parameters and VOCs in 25 wells. Also includes quarterly sampling of 10 natural attenuation monitoring points for VOCs and Natural Attenuation Parameters in Year 1, semi-annual sampling of the same 10 monitoring points for VOCs and Natural Attenuation Parameters in Years 2-4, annual sampling of the same 10 monitoring points for VOCs and Natural Attenuation Parameters in Years 5-8, no sampling in Year 9, and one sampling event in Year 10. Natural attenuation analytical costs are presented in Appendix B.
Subtotal	10-year present worth = Annual Natural Attenuation Costs (P/A, 5%, 10 yr).
2.1	Costs for Supervision, Operator, and Support persons include 256 hours per year for a Supervisor @ $25/hr, 480 hours per year for Operational Assistance @ $20/hr, 160 hours per year for a Technician @ $15/hr, and 1,040 hours per year for an operator @ $15/hr.
2.2	Electrical costs account for electrical consumption from air stripper transfer pumps, air stripper blower, carbon transfer pumps, knock-out tank pumps, and liquid ring pumps assuming 70% efficiency, operating 12 hours per day, 365 days per year @$0.10/Kw/hr.
2.3	Filter bag replacement costs are based on the original groundwater treatment system estimates.
2.4	Carbon Usage assumes changing out a 900-lb lag carbon unit 3 times per year @ $2.00/lb of carbon.
2.5	Operating Costs for Catalytic Oxidation Unit based on July 1997 estimates provided by Global Technologies @ $2.61/hr for propane fuel and electric. Costs assume operating 12 hr/day, 365 days/year.
2.6	Sampling and analytical costs represent costs for quarterly monitoring 30 wells of the vacuum enhanced SVE wells for VOCs. Vacuum enhanced SVE analytical costs are presented in Appendix B.
Subtotal	2-year present worth = Annual Vacuum enhanced SVE System Costs X (P/A, 5%, 2 yr); (P/A, 5%, 2 yr) = 1.8594.

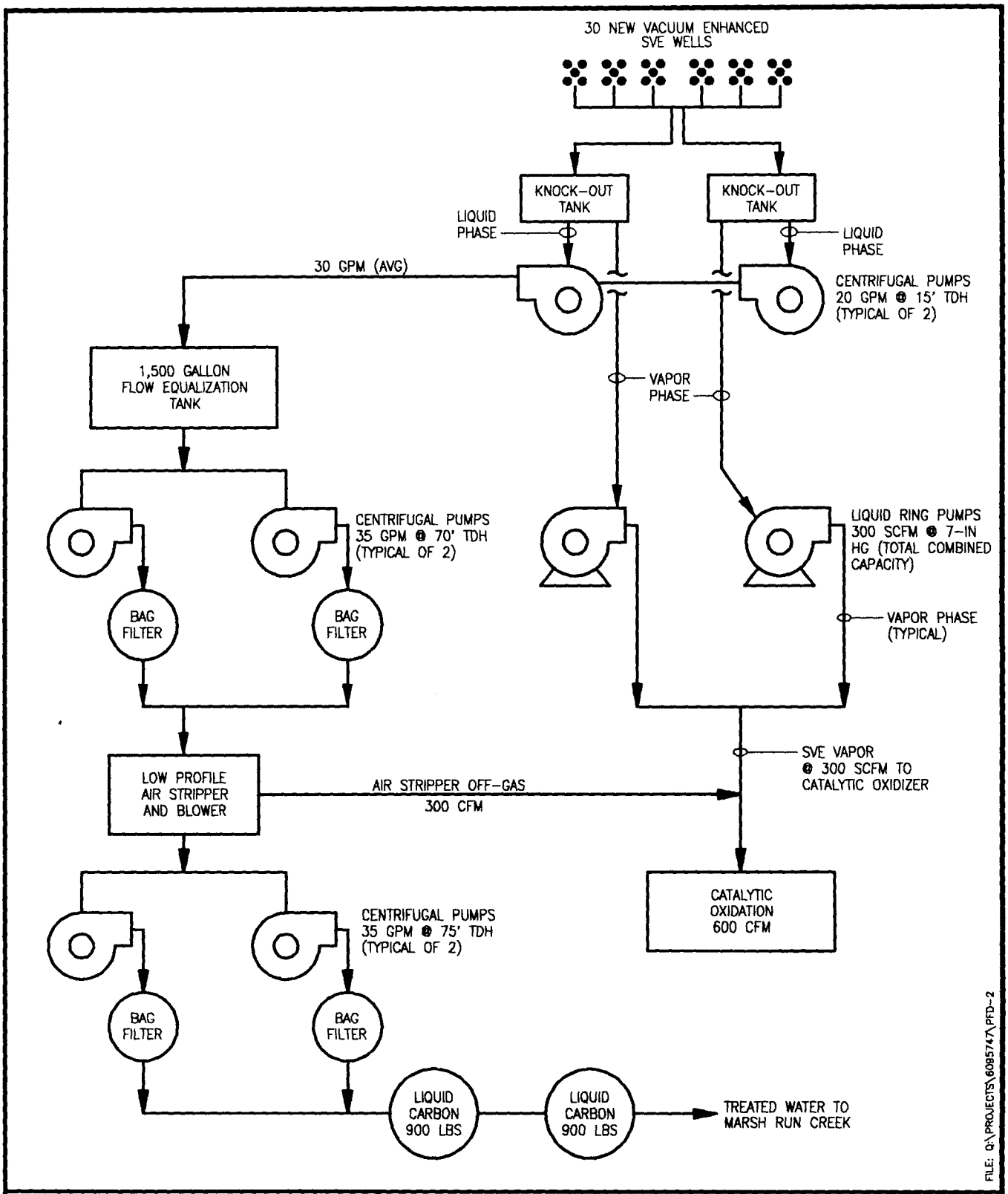


EA ENGINEERING, SCIENCE, AND TECHNOLOGY

DESIGNED BY	DRAWN BY	DATE	PROJECT NO.	FILE NAME
KMW	MSM	10-16-97	60957.47	ALT-2
CHECKED BY	PROJECT MGR.	SCALE	DRAWING NO.	FIGURE
JPC	GAT	AS SHOWN	–	8

EVALUATION OF GROUNDWATER TREATMENT SYSTEM ALTERNATIVES
FORMER LANDFILL, MARSH RUN PARK
NEW CUMBERLAND, PENNSYLVANIA

FIGURE 8
PROPOSED SITE PLAN
ALTERNATIVE NO. 2



EA ENGINEERING, SCIENCE, AND TECHNOLOGY

EVALUATION OF GROUNDWATER TREATMENT SYSTEM ALTERNATIVES
FORMER LANDFILL, MARSH RUN PARK
NEW CUMBERLAND, PENNSYLVANIA

PROCESS FLOW DIAGRAM
ALTERNATIVE NO. 2

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
JPC	KMW	MSM	GAT	NONE	10-13-97	60957.47	9

oxidized, transformation by oxidation will occur at a much reduced rate, compared to processes involved in reductive dechlorination. Reductive transformation processes are more likely to occur given the appropriate environment. This environment will depend on the presence of certain electron acceptor and donor species. These are described in more detail below. When TCE is reduced, hydrogen atoms are substituted for chlorine atoms, and TCE is reduced to dichloroethene (DCE) of which there are three isomers. DCE is further reduced to vinyl chloride (VC). The ground-water sampling data from Marsh Run Park shows that TCE is being transformed to DCE and VC. Furthermore, the data suggests that two types of transformation behavior maybe controlling the degradation of TCE. In the source area, where the concentration of organics is the highest, vinyl chloride is accumulating as a byproduct of reductive dechlorination, while downgradient near the property boundary both TCE and DCE are present, but VC is noticeably absent. VC will accumulate under the reducing conditions, which are typical of a source zone. In a downgradient zone near the extraction wells (EW1 and EW2) there will be a certain degree of ground water recharge, especially around the well screens. This may promote more oxidizing conditions, which promote the rapid oxidation of VC to carbon dioxide. TCE and DCE present at these downgradient wellpoints will primarily be subject to oxidative processes. While aerobic metabolism of TCE and DCE is significantly slower than reductive dechlorination, it is still a viable mechanism. To monitor whether an chlorinated compounds exist where the groundwater contacts the Susquehanna River, four monitoring wells have been proposed for the railway easement.

As a result of the attenuation evidence described above, it appears that this site may be suitable for remediation by natural attenuation. It is necessary, however, to show that in addition to the presence of daughter products, geochemical conditions are appropriate for continued attenuation and that the rate of attenuation is sufficient to protect sensitive receptors like the Susquehanna River. These can be shown through the collection of additional parameters.

Degradation of organic compounds brings about measurable changes in concentrations and distribution of contaminants, daughter products, and groundwater geochemical parameters. Geochemical parameters include electron donor and acceptor concentrations (e.g. oxygen, nitrate, iron, manganese, sulfate, and methane). At the circumneutral pH and low temperatures of most groundwaters, many of the most significant anoxic redox reactions such as nitrate reduction, Fe(III) and Mn(III/IV) reduction, sulfate reduction, and methane production are catalyzed by microorganisms. Microorganisms catalyzing these reactions also consume hydrogen at a rate dependent on the species of electron donor or acceptor being utilized. Specific redox processes have characteristic hydrogen concentrations which may be used as an indicator of terminal

electron accepting processes. By measuring these changes it is possible to document and quantitatively evaluate the occurrence of natural attenuation.

Adequate site characterization to support documentation of natural attenuation viability will require that the following site-specific parameters be assessed:

- Define the type and extent of groundwater contamination. Results of groundwater characterization shall be included into the RAND3D solute fate and transport model to substantiate calculated attenuation rates..

- Measure volatile and semivolatile organic compounds to assess type, concentration, and distribution of contaminants and daughter products to show long-term trends in support of natural attenuation. At a minimum, the volatile organic compound analysis method SW8260a will be used.

- Measure total organic carbon (TOC) and total inorganic carbon (TIC).

- Measure dissolved oxygen (DO) during well purging and immediately before and after sample acquisition using a direct reading meter to avoid aeration of collected groundwater samples.

- Measure nitrate, nitrite, and total ammonia concentrations in groundwater.

- Measure iron (II) and manganese (II) concentrations released into solution.

- Measure sulfate and sulfide concentrations in groundwater.

- Measure methane concentrations in groundwater.

- Measure oxidation-reduction potential (ORP) during well purging and immediately before and after sample acquisition using a direct reading meter to avoid aeration of collected groundwater samples. ORP measurement shall be used to provide real time data on the location of the contaminant plume and identify areas undergoing anaerobic degradation.

- Measure concentrations of dissolved hydrogen in groundwater.

- Measure volatile fatty acid concentrations in groundwater.

- Measure concentration of carbon dioxide in groundwater.

- Measure pH, temperature, and conductivity within a short time following sample acquisition. These parameters will be measured in the field in unfiltered, unpreserved, "fresh" water collected by the same technique as the samples taken for DO and ORP analyses.

- Measure chloride, as elevated chlorine concentrations above background can be indicative of degradation of chlorinated hydrocarbons.

Remediation of the bedrock aquifer through natural attenuation will include preparation of a long-term monitoring plan designed to monitor plume migration over time and to verify that natural attenuation is occurring at rates sufficient to protect downgradient receptors. Analytical costs associated with monitoring natural attenuation are presented in detail in Appendix B. As part of the long-term monitoring, 10 additional monitoring points (5 shallow and 5 deep points) will be installed to the north of the site as shown in Figure 8. The greatest concentrations of contaminants have been reported in some of the most downgradient wells. Additional wells are necessary even further downgradient (along the property boundary) to show that the plume is attenuating prior to the completion of sensitive receptor pathways at the Susquehanna River..

Vacuum Enhanced SVE System

The vacuum enhanced SVE system proposed under Alternative No. 2 is the same as that described under Alternative No. 1. The vacuum enhanced SVE system will consist of 30 vacuum enhanced SVE wells and two liquid ring pumps for extraction of soil vapor and groundwater from the source area.

Liquid Phase Treatment

Initially, consideration was given to the treatment of the liquid phase from the vacuum enhanced SVE system by carbon adsorption. The liquid phase treatment via carbon adsorption would have required the use of two 2,500-lb carbon units operating in series, with an expected carbon exchange frequency of six times per year for the lead unit and four times per year for the lag unit. The present worth of this scenario considering a $21,000 capital expense for the carbon units and

$50,000 per year cost for carbon replacement for a 2-year period, assuming a 5% interest rate, is $114,000.

Consideration was then given to treatment of the liquid phase via air stripping followed by liquid phase carbon adsorption. This treatment scenario required the use of a low profile air stripper with six trays, a liquid flow rate of 30 gpm, and an airflow rate of 300 cfm as well as two 900-lb carbon units operating in series, with an expected carbon exchange frequency of six times per year for the lead unit and four times per year for the lag unit. The present worth of this treatment scenario, considering a $24,000 capital expense for a low profile air stripper and two carbon units at $18,000 per year cost for carbon replacement for a 2-year period, assuming a 5% interest rate is $58,000. Therefore, air stripping followed by liquid phase carbon adsorption was chosen as the preferred method for treatment of the liquid phase from the vacuum enhanced SVE system. The liquid phase treatment cost comparison for Alternative No. 2, as described above, is presented in detail in Appendix A.

Based on the preceding economic analysis, the vacuum enhanced SVE system liquid treatment process consists of the use of two liquid ring pumps to withdraw soil vapor and water from 30 vacuum enhanced SVE wells placed in the source area within the landfill overburden. Water from the vacuum enhanced SVE wells will be extracted at a rate of 1 gpm per well, or a total estimated flow rate of 30 gpm. The vacuum enhanced SVE water which is withdrawn is routed to a 1,500-gal flow equalization tank. From the flow equalization tank, the process water is pumped through bag filters prior to air stripping. A low profile air stripper designed to treat a total design flow rate of 35 gpm with an air flow rate of 300 cfm is recommended. The air stripper treats the contaminants of concern to less than 1 ppb except for 112TCA and 1122PCA. The process water is then introduced to two 900-lb liquid phase carbon vessels for treatment of the residual contamination prior to discharge to Marsh Run Creek.

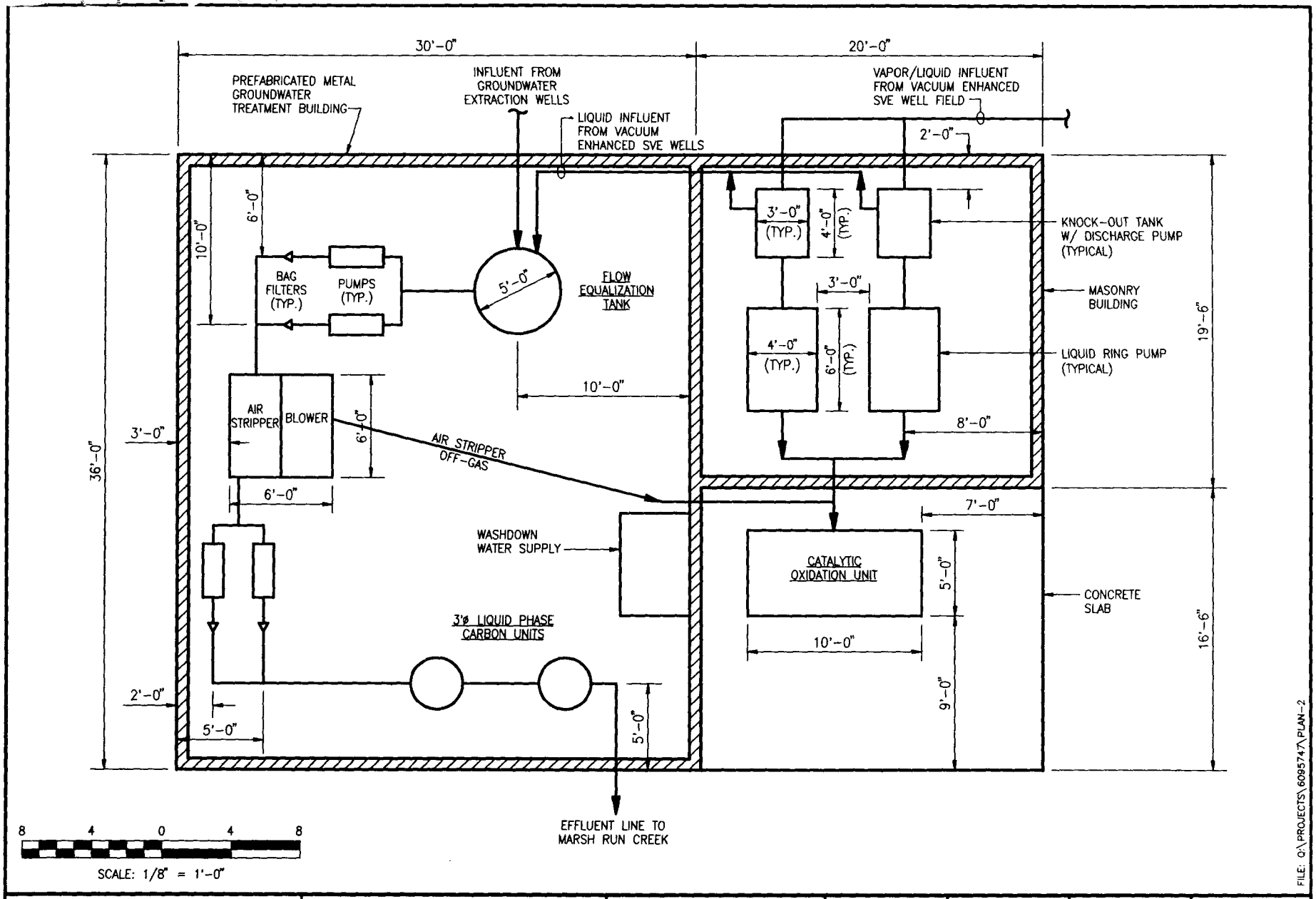
Vapor Phase Treatment

The off-gas from the air stripper is combined with the vapor from the vacuum enhanced SVE system and is treated by a catalytic oxidation unit.

Once air stripping following by liquid carbon adsorption was selected as the preferred liquid phase treatment technology, the economics of Vapor Phase Carbon Adsorption was compared to Catalytic Oxidation for treatment of the combined air stream from the vacuum enhanced SVE wells (10 cfm per well, or 300 cfm total) and air stripper off-gas (300 cfm). Two 5,000-lb vapor phase carbon vessels operating in series would have been required with a carbon change out

frequency on both vessels approximately seven times per year. Over a 10-year period the present worth of the capital and O&M costs (primarily carbon change out) for vapor phase carbon far exceed that for the capital and O&M costs (primarily fuel and electricity) for catalytic oxidation. The present worth of vapor phase treatment through carbon adsorption considering a $35,000 capital expense for two 5,000-lb carbon units and a $140,000 per year cost for carbon replacement for a 2-year period, assuming a 5% interest rate, is $295,000. The present worth of vapor phase treatment through the use of catalytic oxidation, considering a $105,000 capital expense for a 600 cfm catalytic oxidation unit and an $8,000 per year energy expense for a 2-year operational period, assuming a 5% interest rate, is $120,000. Therefore, a Catalytic Oxidation Unit with 99% destruction efficiency at 600 cfm was selected as the preferred vapor phase treatment technology. The vapor phase treatment cost comparison for Alternative No. 2, as described above, is presented in detail in Appendix A.

A general equipment arrangement plan showing the layout of the liquid phase and vapor phase treatment processes is presented in Figure 10.



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EA ENGINEERING, SCIENCE, AND TECHNOLOGY	EVALUATION OF GROUNDWATER TREATMENT SYSTEM ALTERNATIVES FORMER LANDFILL, MARSH RUN PARK NEW CUMBERLAND, PENNSYLVANIA	ALTERNATIVE 2 REMEDIATE SOURCE AREA WITH VACUUM ENHANCED SVE SYSTEM	DESIGNED BY KMW	DRAWN BY MSM	DATE 11-24-97	PROJECT NO. 60957.47
			CHECKED BY GAT	PROJECT MGR. JPC	SCALE AS SHOWN	FIGURE 10

5. COMPARISON OF ALTERNATIVES

Table 5 presents an itemized comparison of the basis of design for Alternative No. 1 and Alternative No. 2. The basis for the liquid and vapor phase process flows, liquid and vapor phase influent concentrations, and the liquid and vapor phase process equipment is presented for each alternative. Both alternatives consist of generally similar treatment processes for both the liquid and vapor phase systems. The major difference between Alternative No. 1 and Alternative No. 2 is the liquid design flow rate. The liquid flow rate for Alternative No. 1 is 75 gpm, while the flow rate for Alternative No 2 is 35 gpm. Therefore, Alternative No. 2 requires a smaller flow equalization tank, air stripper, liquid phase carbon vessels, and catalytic oxidation unit. Table 6 presents a present worth cost comparison for both alternatives. Although the estimated capital cost of the treatment system equipment is less under Alternative No. 2, the total capital cost of Alternative No. 2 is slightly greater than Alternative No. 1 since an evaluation of the feasibility of natural attenuation is required under Alternative No. 2. The present worth of the annual operation and maintenance costs is significantly greater for Alternative No. 1, due to the operation of the treatment system for a period of 10 years, as opposed to a 2-year period under Alternative No. 2.

TABLE 5 BASIS OF DESIGN SUMMARY

DESIGN ITEM	BASIS OF DESIGN	
	ALTERNATIVE 1 **Integration of Vacuum Enhanced SVE System With A New Groundwater Treatment Facility**	**ALTERNATIVE 2** **Remediation of Bedrock Aquifer Through Natural Attenuation and Remediation of Source Area With Vacuum Enhanced SVE System**
Liquid Phase Process Flows		
Extraction Well Flow Rates	Flow rate is the same as described in the April 1994 Design Analysis Report for the Ground-Water Treatment System: 40 gpm total for three wells, or 13.3 gpm per well.	Not applicable under this scenario.
Vacuum Enhanced SVE Well Flow Rates	Typically wells in the area yield 1-2 gpm based upon the results presented in the October 1996 Design Criteria Report for the Soil Vapor Extraction System. Six shallow dewatering wells currently operate at 1 gpm. Therefore, each vacuum enhanced SVE well is designed based on a 1 gpm flow rate. The total design flow based on 30 wells will be a maximum of 30 gpm.	Typically wells in the area yield 1-2 gpm based upon the results presented in the October 1996 Design Criteria Report for the Soil Vapor Extraction System. Six shallow dewatering wells currently operate at 1 gpm. Therefore, each vacuum enhanced SVE well is designed based on a 1 gpm flow rate. The total design flow based on 30 wells will be a maximum of 30 gpm.
Liquid Phase Influent Concentrations		
Influent Concentrations From Extraction Wells	Utilizing quarterly sampling results from EW-1, EW-1, and EW-3 between 7/17/95, 11/195, 2/9/96, and 5/6/96 and omitting non-detects, the average concentration at each well was determined for TCE, 12DCE, 112TCA, and 1122PCA. Then the weighted average concentration from all three wells was determined. The total flow rate from three extraction wells is 40 gpm with the following influent concentrations: TCE: 200 μg/L 12DCE: 97 μg/L 112TCA: 4.5 μg/L 1122PCA: 4.8 μg/L	Not applicable under this scenario.

TABLE 5 (Continued)

DESIGN ITEM	BASIS OF DESIGN	
	ALTERNATIVE 1 **Integration of Vacuum Enhanced SVE System With A New Groundwater Treatment Facility**	**ALTERNATIVE 2** **Remediation of Bedrock Aquifer Through Natural Attenuation and Remediation of Source Area With Vacuum Enhanced SVE System**
Influent Concentrations From Vacuum Enhanced SVE Wells	It was assumed that 10 vacuum enhanced SVE wells were associated with DW-1, DW-2, and DW-3 each. Therefore, each set of 10 wells would be influenced by the concentrations observed at the respective dewatering well. The average concentrations of TCE, 12DCE, 112TCA and 1122PCA were determined for each dewatering well based on the sampling results of 7/17/95, 11/195, 2/9/96, and 5/6/96. Then the weighted average concentration from all three wells was determined. This weighted average concentration was compared to the average 1995 concentrations seen in well SVE-1. The maximum concentration was used as the influent concentration from the vacuum enhanced SVE wells. The total flow rate from the vacuum enhanced SVE wells is 30 gpm with the following influent concentrations: TCE: 2,733 μg/L 12DCE: 1,272 μg/L 112TCA: 126 μg/L 1122PCA: 970 μg/L	It was assumed that 10 vacuum enhanced SVE wells were associated with DW-1, DW-2, and DW-3 each. Therefore, each set of 10 wells would be influenced by the concentrations observed at the respective dewatering well. The average concentrations of TCE, 12DCE, 112TCA, and 1122PCA were determined for each dewatering well based on the sampling results of 7/17/95, 11/195, 2/9/96, and 5/6/96. Then the weighted average concentration from all three wells was determined. This weighted average concentration was compared to the average 1995 concentrations seen in well SVE-1. The maximum concentration was used as the influent concentration from the vacuum enhanced SVE wells. The total flow rate from the vacuum enhanced SVE wells is 30 gpm with the following influent concentrations: TCE: 2,733 μg/L 12DCE: 1,272 μg/L 112TCA: 126 μg/L 1122PCA: 970 μg/L
Overall Influent Concentrations into Air Stripper From Vacuum Enhanced SVE and Extraction Wells Combined	The influent concentrations into the airstripper are based on a weighted average of the influent concentrations from each set of wells as described above. The total flow rate of the system is 70 gpm with the following influent concentrations: TCE: 1,286 μg/L 12DCE: 601 μg/L 112TCA: 56.6 μg/L 1122PCA: 418.3 μg/L	Not applicable under this scenario.

TABLE 5 (Continued)

DESIGN ITEM	BASIS OF DESIGN	
	ALTERNATIVE 1 Integration of Vacuum Enhanced SVE System With A New Groundwater Treatment Facility	ALTERNATIVE 2 Remediation of Bedrock Aquifer Through Natural Attenuation and Remediation of Source Area With Vacuum Enhanced SVE System
Liquid Phase Process Equipment		
Flow Equalization Tanks	3,000-gal FRP tank. Flow rate increased to 70 gpm from 40 gpm under the original GWTF design. Therefore, the required storage volume doubled to 3,000 gal from 1,500 gal due to the increased flow rate.	1,500-gal FRP tank. The estimated 30 gpm total flow rate from the Vacuum Enhanced SVE System is similar to the 40 gpm design flow rate under original GWTF design. Therefore, the design flow rate required storage volume remains consistent with the original design.
Air Stripper Transfer Pumps	Two pumps with capacity of 75 gpm @ 75 ft TDH (3 Hp, 460V, 3⌀ motor) to transfer water from the flow equalization tank, through bag filters, into the air stripper.	Two pumps with capacity of 35 gpm @ 70 ft TDH (2 Hp, 460V, 3⌀ motor) to transfer water from the flow equalization tank, through bag filters, into the air stripper.
Bag Filters	Four bag filters are used. Two bag filters are used prior to the air stripper, and two are used prior to liquid phase carbon. Filters are required to handle a minimum flow rate of 75 gpm.	Four bag filters are used. Two bag filters are used prior to the air stripper, and two are used prior to liquid phase carbon. Filters are required to handle a minimum flow rate of 35 gpm.
Low Profile Air Stripper	The air stripper is designed to treat a total liquid flow rate of 75 gpm with the following estimated influent concentrations: TCE: 1,286 μg/L 12DCE: 601 μg/L 112TCA: 56.6 μg/L 1122PCA: 418.3 μg/L The airflow rate of 650 cfm will reduce the compounds of concern to <1 ppb with the exception of 112TCA and 1122PCA which will be treated by liquid phase carbon. The stripper will consist of 6 trays and a 10 Hp blower (460V, 3⌀ motor) mounted on a common skid.	The air stripper is designed to treat a total liquid flow rate of 35 gpm with the following influent concentrations: TCE: 2,733 μg/L 12DCE: 1,272 μg/L 112TCA: 126 μg/L 1122PCA: 970 μg/L The airflow rate of 300 cfm will reduce the compounds of concern to <1 ppb with the exception of 112TCA and 1122PCA which will be treated by liquid carbon. The stripper will consist of 6 trays and a 7.5 Hp, 460V, 3⌀ blower mounted on a common skid.
Liquid Carbon Transfer Pumps	Two pumps with capacity of 75 gpm @ 75 ft TDH (2 Hp, 460V, 3⌀ motor) to transfer process water from the air stripper through the bag filters and through the liquid phase carbon vessels.	Two pumps with capacity of 35 gpm @ 75 ft TDH (2 Hp, 460V, 3⌀ motor) to transfer process water from the air stripper through the bag filters and through the liquid phase carbon vessels.

TABLE 5 (Continued)

DESIGN ITEM	BASIS OF DESIGN	
	ALTERNATIVE 1 **Integration of Vacuum Enhanced SVE System With A New Groundwater Treatment Facility**	**ALTERNATIVE 2** **Remediation of Bedrock Aquifer Through Natural Attenuation and Remediation of Source Area With Vacuum Enhanced SVE System**
Liquid Carbon Vessels	Two 1,500-lb liquid phase carbon vessels, approximately 4 ft diameter and 7.5 ft tall, operated in series for the final treatment of 112TCA and 1122PCA. Carbon exchange will be required approximately every 80 days (5 times per year) for the lead vessel.	Two 900-lb liquid phase carbon vessels, approximately 3 ft diameter and 7.3 ft tall, operated in series for the final treatment of 112TCA and 1122PCA. Carbon exchange will be required approximately every 70 days (6 times per year) for the lead vessel.
Vapor Phase Process Flows		
Vapor Phase Influent Flows From Vacuum Enhanced SVE System	Based on the October 1996 Design Criteria Report for the Soil Vapor Extraction System and associated field testing, a conservative flow and vacuum from the vacuum enhanced SVE system is assumed to be 300 cfm @ 5-in. Hg total, which accounts for 10 cfm from each of 30 wells. Accounting for head loss in the air piping a final total air flow rate of 300 cfm @ 7-in. Hg was assumed.	Based on the October 1996 Design Criteria Report for the Soil Vapor Extraction System and associated field testing, a conservative flow and vacuum from the vacuum enhanced SVE system is assumed to be 300 cfm @ 5-in. Hg total, which accounts for 10 cfm from each of 30 wells. Accounting for head loss in the air piping a final total air flow rate of 300 cfm @ 7-in. Hg was assumed.
Vapor Phase Influent from Air Stripper Off-Gas	The air stripper air flow rate is 650 cfm.	The air stripper air flow rate is 300 cfm.
Total Vapor Phase Influent Flow	950 cfm	600 cfm
Vapor Phase Influent Concentrations		
Influent Concentrations From Vacuum Enhanced SVE Wells	Based on the October 1996 Design Criteria Report for the Soil Vapor Extraction System and associated field testing, the following maximum concentrations detected in vapor samples were used as the design basis: TCE: 2.44 ppmv = 14.4 μg/L DCE (total): 49.6 ppmv = 215 μg/L TCA: 0.02 ppmv = 37.6 μg/L Methylene Chloride: 9.9 ppmv = 37.6 μg/L Carbon Tetrachloride: 0.01 ppmv = 0.07 μg/L	Based on the October 1996 Design Criteria Report for the Soil Vapor Extraction System and associated field testing, the following maximum concentrations detected in vapor samples were used as the design basis: TCE: 2.44 ppmv = 14.4 μg/L DCE (total): 49.6 ppmv = 215 μg/L TCA: 0.02 ppmv = 37.6 μg/L Methylene Chloride: 9.9 ppmv = 37.6 μg/L Carbon Tetrachloride: 0.01 ppmv = 0.07 μg/L
Influent Concentrations From Air Stripping Off-Gas	Based on air stripper off-gas concentration: TCE: 18.64 μg/L DCE (total): 8.7 μg/L 112TCA: 0.7647 μg/L 1122PCA: 3.92 μg/L	Based on air stripper off-gas concentration: TCE: 36.44 μg/L DCE (total): 16.95 μg/L 112TCA: 1.57 μg/L 1122PCA: 7.22 μg/L

TABLE 5 (Continued)

DESIGN ITEM	BASIS OF DESIGN	
	ALTERNATIVE 1 Integration of Vacuum Enhanced SVE System With A New Groundwater Treatment Facility	ALTERNATIVE 2 Remediation of Bedrock Aquifer Through Natural Attenuation and Remediation of Source Area With Vacuum Enhanced SVE System
Vapor Phase Process Equipment		
Knock-Out Tanks	One knock-out tank is required prior to each liquid ring pump. It is assumed that each pump is associated with 15 wells, each generated 1 gpm of liquid. A 150-gal knock-out tank will provide 10 minutes of storage capacity and allow pumps to cycle on/off no more than 7 times per hour.	One knock-out tank is required prior to each liquid ring pump. It is assumed that each pump is associated with 15 wells, each generated 1 gpm of liquid. A 150-gal knock-out tank will provide ten minutes of storage capacity and allow pumps to cycle on/off no more than 7 times per hour.
Knock-Out Tank Transfer Pumps	One pump for each knock-out tank (two total) each with a capacity of 20 gpm @ 15 ft TDH, equipped with explosion proof motor. Flow rate of 20 gpm is based on the assumption that each well will generate 1 gpm of flow, assuming 15 wells are associated with each blower. Pumps will transfer liquid from the knock-out tank to the flow equalization tank.	One pump for each knock-out tank (two total) each with a capacity of 20 gpm @ 15 ft TDH, equipped with explosion proof motor. Flow rate of 20 gpm is based on the assumption that each well will generate 1 gpm of flow, assuming 15 wells are associated with each blower. Pumps will transfer liquid from the knock-out tank to the flow equalization tank.
Liquid Ring Pumps	Two liquid ring pumps with a total capacity of 300 cfm @ 7-in. Hg. Each pump is 15 Hp, 230/460V, 3⌀, explosion proof motor.	Two liquid ring pumps with a total capacity of 300 cfm @ 7-in. Hg. Each pump is 15 Hp, 230/460V, 3⌀, explosion proof motor.
Catalytic Oxidation Unit	The economics of Vapor Phase Carbon was compared to Catalytic Oxidation for treatment of the combined air stream (950 cfm) from the vacuum enhanced SVE wells and air stripper off-gas. Two 5,000-lb vapor phase carbon vessels operating in series would have been required with change out on both vessels approximately 9 times per year. Over a 10-year period the present worth of the capital and O&M costs (primarily carbon change out) for vapor phase carbon far exceed that for the capital and O&M costs (primarily fuel and electricity) for catalytic oxidation. Therefore, a Catalytic Oxidation Unit with 99% destruction efficiency at 1,000 cfm was selected.	The economics of Vapor Phase Carbon was compared to Catalytic Oxidation for treatment of the combined air stream (600 cfm) from the vacuum enhanced SVE wells and air stripper off-gas. Two 5,000-lb vapor phase carbon vessels operating in series would have been required with change out on both vessels approximately 7 times per year. Over a 10-year period the present worth of the capital and O&M costs (primarily carbon change out) for vapor phase carbon far exceed that for the capital and O&M costs (primarily fuel and electricity) for catalytic oxidation. Therefore, a Catalytic Oxidation Unit with 99% destruction efficiency at 600 cfm was selected.

TABLE 5 (Continued)

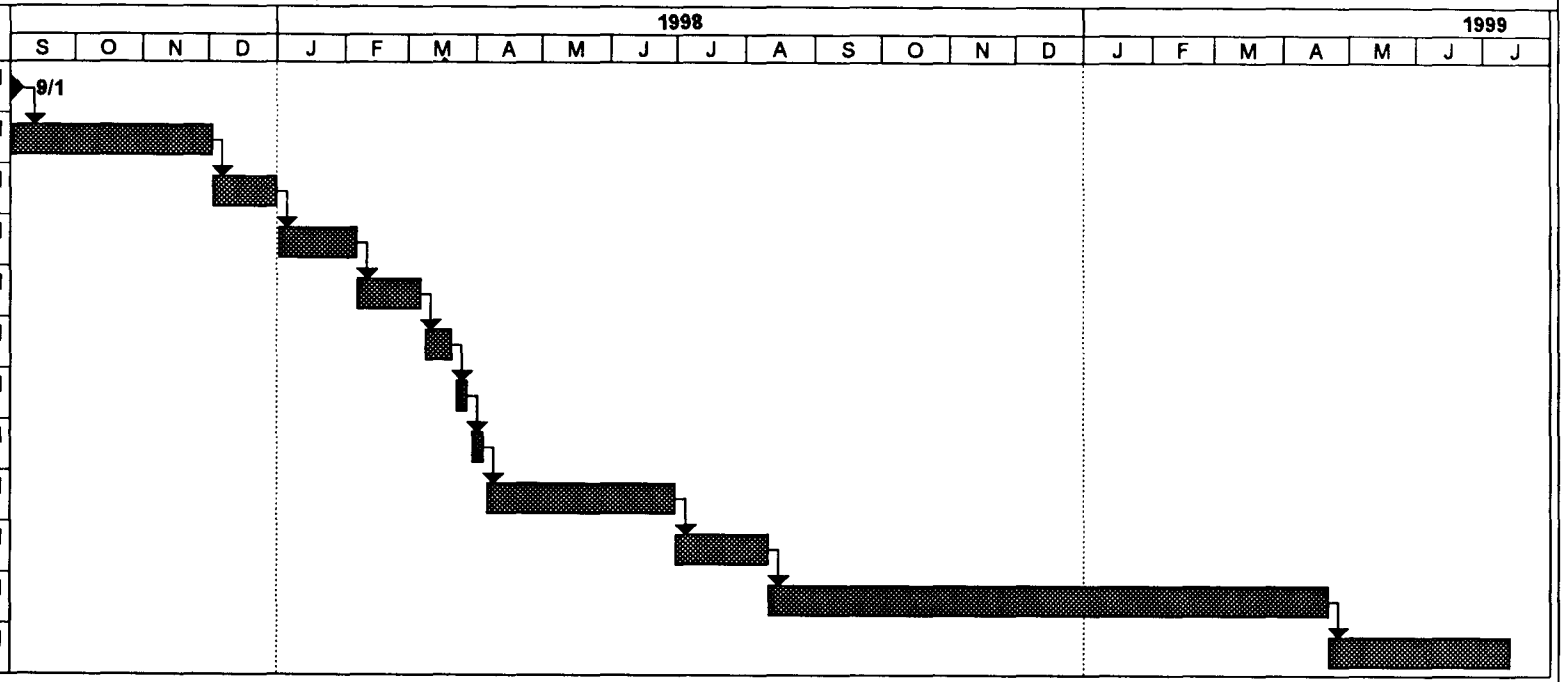
DESIGN ITEM	BASIS OF DESIGN	
	ALTERNATIVE 1 Integration of Vacuum Enhanced SVE System With A New Groundwater Treatment Facility	ALTERNATIVE 2 Remediation of Bedrock Aquifer Through Natural Attenuation and Remediation of Source Area With Vacuum Enhanced SVE System
Natural Attenuation		
Remediation of the source area through natural attenuation	Not applicable	The ground-water sampling data from Marsh Run Park shows that TCE is being transformed to DCE and VC. Furthermore, the data suggests that two types of transformation behavior maybe controlling the degradation of TCE. In the source area, where the concentration of organics is the highest, vinyl chloride is accumulating as a byproduct of reductive dechlorination, while downgradient near the property boundary both TCE and DCE are present, but VC is noticeably absent. VC will accumulate under the reducing conditions, which are typical of a source zone. In a downgradient zone near the extraction wells there will be a certain degree of ground water recharge, especially around the well screens. This may promote more oxidizing conditions, which promote the rapid oxidation of VC to carbon dioxide. As a result of the attenuation evidence described above, it appears that this site may be suitable for remediation by natural attenuation. It is necessary, however, to show that in addition to the presence of daughter products, geochemical conditions are appropriate for continued attenuation and that the rate of attenuation is sufficient to protect sensitive receptors like the Susquehanna River. These can be shown through the collection of additional parameters.

6. PROPOSED SCHEDULE

The proposed project schedules for Alternative No. 1 and Alternative No. 2 are presented in Figures 11 and 12, respectively. The project schedules include the estimated durations for the design, review, and implementation of both alternatives. It is anticipated that the project will be reviewed at the 60%, 90%, and 100% stages of completion, with bid document preparation incorporating any comments from the 100% review. Construction and startup of Alternative No. 1 is anticipated to require 6 months and 2 months respectively, while construction and startup of Alternative No. 2 is anticipated to require 3 months and 1 month, respectively. The total project duration from design through startup for Alternative No. 1 is estimated as approximately 18 months. The total project duration from design through startup for Alternative No. 2 is estimated as approximately 13 months. Under Alternative No. 1 the operation and maintenance of the groundwater treatment system is anticipated to be conducted continuously for a 10-year duration, while the operation and maintenance for the Vacuum Enhanced SVE System is anticipated to be conducted on a continuous basis for up to a 2-year period. Under Alternative No. 2, the operation and maintenance for the Vacuum Enhanced SVE System is anticipated to be conducted on a continuous basis for up to a 2-year period, while the sampling and analysis for natural attenuation is anticipated to be for a 10-year duration.

PROPOSED PROJECT SCHEDULE
ALTERNATIVE 1 - INTEGRATION OF BIOSLURPING SYSTEM WITH NEW GROUNDWATER TREATMENT FACILITY

Task Name	Duration
Notice to Proceed	0d
Preparation of 60% Design	65d
Review of 60% Design	20d
Preparation of 90% Design	25d
Review of 90% Design	21d
Preparation of Final (100%) Design	10d
Preparation of Bid Documents	5d
Review of Final Design	5d
Bid Solicitation	60d
Bid Award	30d
Construction	180d
Start Up	60d



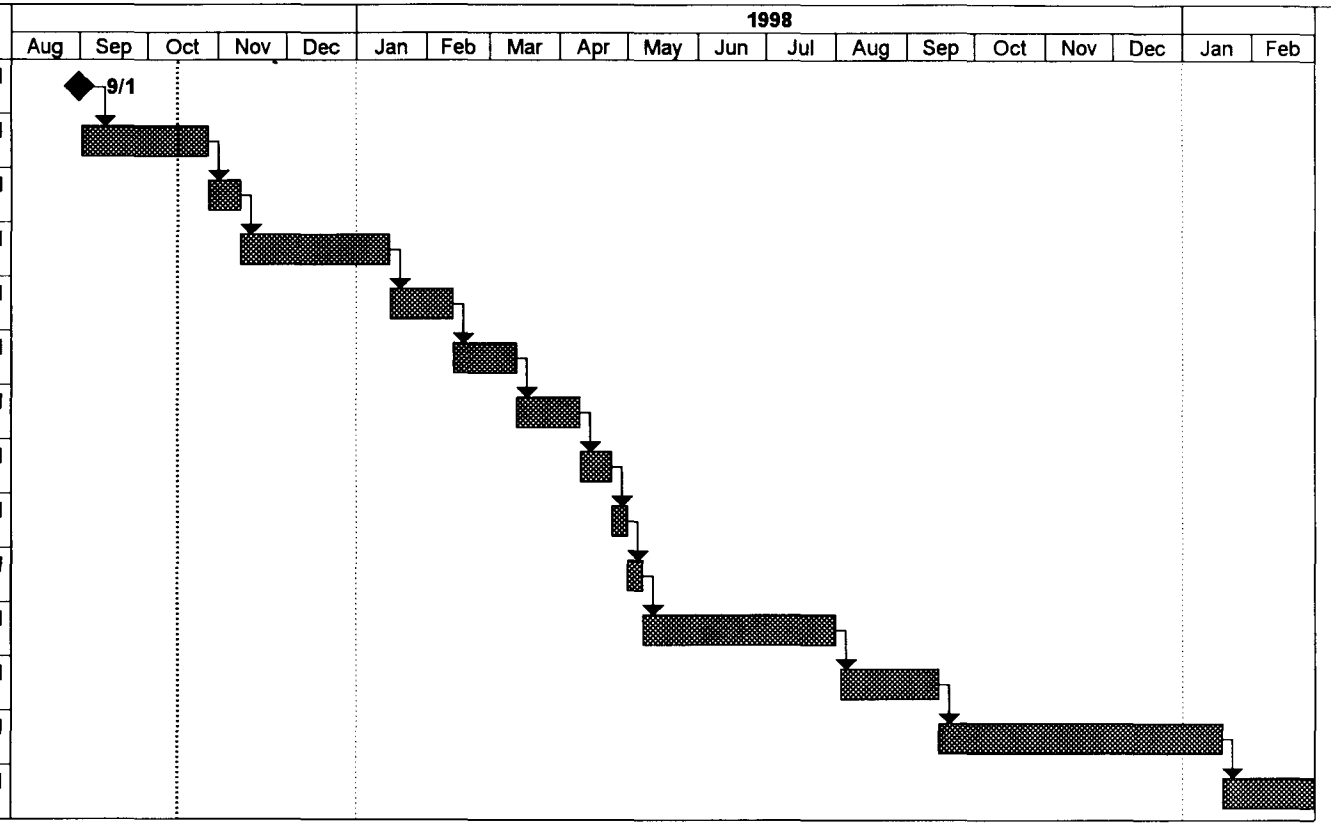
Project: Marsh Run, Project # 60957.47.0001
Date: 7/30/97

Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Milestone
Rolled Up Progress

FIGURE 11

PROPOSED PROJECT SCHEDULE
ALTERNATIVE 2 - REMEDIATION OF GROUNDWATER AQUIFER THROUGH NATURAL ATTENUATION, REMEDIATE SOURCE AREA WITH BIOSLURPING SYSTEM

Task Name	Duration
Notice to Proceed	0d
Field Investigation to Confirm Appropriateness of Natural Attenuation	40d
Final Recommendation on Natural Attenuation	10d
Preparation of 60% Design	45d
Review of 60% Design	20d
Preparation of 90% Design	20d
Review of 90% Design	20d
Preparation of Final (100%) Design	10d
Review of Final Design	5d
Preparation of Bid Documents	5d
Bid Solicitation	60d
Bid Award	30d
Construction	90d
Start Up	30d



Project: March Run, Project # 60957.47.0001
Date: 10/14/97
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Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Milestone
Rolled Up Progress

FIGURE 12

7. RECOMMENDATION

The ground water chemistry described in Chapter 4 indicates that processes of Natural Attenuation are occurring at Marsh Run Park. TCE transformation such as DCE and VC are present in dewatering wells in the source area and DCE is present in downgradient extraction wells. TCE is a stable solvent and would not transform without the presence of an appropriate reducing agent. Hence, conditions applicable for Natural Attenuation must be present otherwise daughter products would not form. Processes of Natural Attenuation will continue for as long as there are sources of electron acceptor and donor. Addressing the source area using vacuum enhanced SVE will remove the continuous source of dissolved phase organics in the ground water and allow processes of Natural Attenuation to degrade those organics present in the dissolved phase. In addition the vacuum enhanced SVE within the source zone may reduce the existing ground water gradient, slowing the migration of dissolved phase organics.

Based on the present worth analysis summary presented in Table 6, and the estimated duration for implementation, Alternative No. 2 (Remediation of Bedrock Aquifer Through Natural Attenuation and Remediation of the Source Area With Vacuum Enhanced SVE) is recommended for implementation. Alternative No. 2 consists of evaluating the feasibility of natural attenuation as a remedial alternative for the bedrock aquifer in conjunction with implementing a long-term monitoring plan while treating the source areas within the landfill through a vacuum enhanced SVE system. The total present worth of the capital costs and operation and maintenance costs for Alternative No. 1 is $2,945,300, while the total present worth of the capital costs and operation and maintenance costs for Alternative No. 2 is $1,853,000. Therefore, the total present worth of capital and O&M costs for Alternative No. 2 is $1,092,300 less than Alternative No. 1.

TABLE 6 PRESENT WORTH COST COMPARISON

Item	Alternative No. 1 Integration of A Vacuum Enhanced SVE System With A New Groundwater Treatment Facility	Alternative No. 2 Remediation of Bedrock Aquifer Through Natural Attenuation and Remediation of Source Area With Vacuum Enhanced SVE System	Cost Difference Between Alternative Nos. 1 and 2
Capital Costs	$1,024,800	$1,131,300	$106,500
Present Worth of O&M Costs	$1,920,500	$721,700	$1,198,800
Total Present Worth of Capital and O&M Costs	$2,945,300	$1,853,000	$1,092,300

REFERENCES

EA Engineering, Science, and Technology. 1996. *Design Criteria Report for Soil Vapor Extraction System, Defense Distribution Region East, Former Landfill, Marsh Run Park, New Cumberland, Pennsylvania.* Prepare for U.S. Army Corps of Engineers, Omaha District. October.

Appendix A

Detail of Cost Analysis for

- Alternative No. 1–Vapor Phase Treatment
- Alternative No. 2–Liquid Phase Treatment
- Alternative No. 2–Vapor Phase Treatment

Project	Marsh Run Cost Analysis		
Subject	Vapor Phase Treatment Comparison	Sheet No. 1 of	
		Drawing No.	
Computed by kmw	Date	Checked by	Date

Alternative No. 1- Vapor Phase Treatment Comparison

Objective: Compare the costs of vapor phase carbon to catalytic oxidation for treatment of the vapor from airstripping offgas and the bioslurping system.

Vapor Phase Carbon:

1. Capital Cost of Two 5000 lb carbon units = $35,000

2. Annual O&M = based on cost of carbon changeout - need to change both vessels 9 times per year, therefore:

   10,000 lb x 9 changeouts/year x $2.00/lb = $180,000/year

Present Worth = $35,000 + (P/A, 5%, 10 yr) $180,000
= $35,000 + (7.7217)($180,000)
= $1,425,000

Catalytic Oxidation:

1. Capital Cost = $130,000

2. Annual O&M =based on fuel and electricity costs
   =$2.69/hr x 12 hr/day x 365 day/year = $12,000/year

Present Worth = $130,000 + (P/A, 5%, 10 yr) $12,000
= $130,000 + (7.7217)($12,000)
= $223,000

Project	Marsh Run Cost Analysis		
Subject	Liquid Phase Treatment Comparison	Sheet No. 1 of	
		Drawing No.	
Computed by kmw	Date	Checked by	Date

Alternative No. 2 Liquid Phase Treatment Comparison

Objective: Compare the costs of liquid phase carbon to airstripping for treatment of the liquid from the bioslurping system.

Liquid Phase Carbon:

1. Capital Cost of Two 2500 lb carbon units = $21,000

2. Annual O&M = based on cost of carbon changeout - need to change lead vessel 6 times per year and lag vessel 4 times per year, therefore:

   2,500 lbs x 10 changeouts/year x $2.00/lb = $50,000/year

Present Worth = $21,000 + (P/A, 5%, 2 yr) $50,000
= $35,000 + (1.8594)($140,000)
= $114,000

Airstripping followed by Liquid Phase Carbon:

1. Capital Cost for Airstripper = $11,000
   Capital Cost for two 900 lb carbon vessels = $13,000
   TOTAL CAPITAL COSTS = $24,000

2. Annual O&M = based on cost of carbon changeout - need to change lead vessel 6 times per year and lag vessel 4 times per year, therefore:

   900 lbs x 10 changeouts/year x $2.00/lb = $18,000/year

Present Worth = $24,000 + (P/A, 5%, 2 yr) $18,000
= $24,000 + (1.8594)($18,000)
= $58,000

Project	Marsh Run Cost Analysis		
Subject	Vapor Phase Treatment Comparison	Sheet No. 1 of	
		Drawing No.	
Computed by kmw	Date	Checked by	Date

Alternative No. 2 Vapor Phase Treatment Comparison

Objective: Compare the costs of vapor phase carbon to catalytic oxidation for treatment of the vapor from airstripping offgas and the bioslurping system.

Vapor Phase Carbon:

1. Capital Cost of Two 5000 lb carbon units = $35,000

2. Annual O&M = based on cost of carbon changeout - need to change both vessels 9 times per year, therefore:

   10,000 lb x 7 changeouts/year x $2.00/lb = $140,000/year

Present Worth = $35,000 + (P/A, 5%, 2 yr) $140,000
= $35,000 + (1.8594)($140,000)
= $295,000

Catalytic Oxidation:

1. Capital Cost = $105,000

2. Annual O&M =based on fuel and electricity costs
   =$1.72/hr x 12 hr/day x 365 day/year = $8,000/year

Present Worth = $105,000 + (P/A, 5%, 2 yr) $8,000
= $105,000 + (1.8594)($8,000)
= $120,000

Appendix B

Detail of Analytical Costs

GROUNDWATER TREATMENT SYSTEM ANALYTICAL COSTS

Semi-Annual Sampling & Reporting Costs for GWTS - 6 Monitoring Wells
Marsh Run Park Natural Attenuation O&M Evaluation
DDRE, New Cumberland, PA

(1) Direct Labor	Total Hours	Rate	Cost
Program Manager	1	$ 43.39	$ 43.39
Project Manager	4	$ 30.23	$ 120.92
Senior Engineer	1	$ 41.45	$ 41.45
Senior Geologist		$ 37.90	$ 0.00
Mid-level Engineer		$ 28.31	$ 0.00
Mid-level Scientist		$ 27.03	$ 0.00
Mid-level Geologist		$ 25.66	$ 0.00
Junior Engineer	20	$ 18.75	$ 375.00
Junior Geologist		$ 18.15	$ 0.00
Technician	48	$ 16.83	$ 807.84
Contracts Manager		$ 29.27	$ 0.00
Administrative Assistant		$ 18.77	$ 0.00
CADD Operator		$ 18.04	$ 0.00
Clerical Support		$ 13.27	$ 0.00
Subtotal Direct Labor	74		$ 1,388.60
Overhead on Direct Labor @ 120.00%			$ 1,666.32
Subtotal Direct Labor and Labor Overhead			$ 3,054.92

(2) Other Direct Costs	Quantity		Rate		Cost
Telephone	30	minutes @	$ 0.57	/min.	$ 17.10
Fax	5	pages @	$ 2.29	/page	$ 11.45
Reproduction		pages @	$ 0.12	/page	$ 0.00
Computer, CADD		hours @	$ 21.76	/hour	$ 0.00
Vehicle Usage	8	days @	$ 41.24	/day	$ 329.92
Vehicle Mileage	1280	miles @	$ 0.13	/mile	$ 166.40
Per Diem		days @	$ 105.00	/day	$ 0.00
Field Equipment Usage	1		$ 1,676.00	ls	$ 1,676.00
Postage/Shipping		each @	$ 86.29	/each	$ 0.00
Subcontractors					
Analytical	1		$ 2,310.00	ls	$ 2,310.00
Subtotal Other Direct Costs					$ 4,510.87
Subtotal (1) & (2)					$ 7,565.79
G&A @ 14.50% (Excluding Travel and Analytical)					$ 762.09
Profit @ 10.00% (Excluding Travel and Analytical)					$ 601.79
TOTAL LABOR and ODCs					**$ 8,929.67**

Note:

Total Annual Cost =[$8929.67 x 2] + [$10,348.35 x 4] =$59,400

Description	Method	Matrix	Number of Samples	Number of Trip Blanks	Number of Field Blanks	Number of Field Duplicates	Unit Cost(a)	Extended Cost
Volatile Organics by GC/MS	SW 8260	Water	6	2	1	1	$ 162.00	$ 1,620.00
DO, pH, Eh, temp, cond, turb.	YSI	Water	6	-		1	$ 98.57	$ 690.00
						Total Cost of Analyses:		$ 2,310.00

GROUNDWATER TREATMENT SYSTEM ANALYTICAL COSTS

Quarterly Sampling & Reporting Costs for GWTS - 6 Dewatering Wells, 3 Extraction Wells
Marsh Run Park Natural Attenuation O&M Evaluation
DDRE, New Cumberland, PA

(1) Direct Labor	Total Hours	Rate	Cost
Program Manager	1	$ 43.39	$ 43.39
Project Manager	4	$ 30.23	$ 120.92
Senior Engineer	1	$ 41.45	$ 41.45
Senior Geologist		$ 37.90	$ 0.00
Mid-level Engineer		$ 28.31	$ 0.00
Mid-level Scientist		$ 27.03	$ 0.00
Mid-level Geologist		$ 25.66	$ 0.00
Junior Engineer	20	$ 18.75	$ 375.00
Junior Geologist		$ 18.15	$ 0.00
Technician	68	$ 16.83	$ 1,144.44
Contracts Manager		$ 29.27	$ 0.00
Administrative Assistant		$ 18.77	$ 0.00
CADD Operator		$ 18.04	$ 0.00
Clerical Support		$ 13.27	$ 0.00
Subtotal Direct Labor	94		$ 1,725.20
Overhead on Direct Labor @ 120.00%			$ 2,070.24
Subtotal Direct Labor and Labor Overhead			$ 3,795.44

(2) Other Direct Costs	Quantity		Rate		Cost
Telephone	30	minutes @	$ 0.57	/min.	$ 17.10
Fax	5	pages @	$ 2.29	/page	$ 11.45
Reproduction		pages @	$ 0.12	/page	$ 0.00
Computer, CADD		hours @	$ 21.76	/hour	$ 0.00
Vehicle Usage	8	days @	$ 41.24	/day	$ 329.92
Vehicle Mileage	1280	miles @	$ 0.13	/mile	$ 166.40
Per Diem		days @	$ 105.00	/day	$ 0.00
Field Equipment Usage	1		$ 1,676.00	ls	$ 1,676.00
Postage/Shipping		each @	$ 86.29	/each	$ 0.00
Subcontractors					
Analytical	1		$ 2,796.00	ls	$ 2,796.00
Subtotal Other Direct Costs					$ 4,996.87
Subtotal (1) & (2)					$ 8,792.31
G&A @ 14.50% (Excluding Travel and Analytical)					$ 869.46
Profit @ 10.00% (Excluding Travel and Analytical)					$ 686.58
TOTAL LABOR and ODCs					**$ 10,348.35**

Description	Method	Matrix	Number of Samples	Number of Trip Blanks	Number of Field Blanks	Number of Field Duplicates	Unit Cost(a)	Extended Cost
Volatile Organics by GC/MS	SW 8260	Water	9	2	1	1	$ 162.00	$ 2,106.00
DO, pH, Eh, temp, cond, turb.	YSI	Water	9	-		1	$ 69.00	$ 690.00
						Total Cost of Analyses:		$ 2,796.00

VACUUM ENHANCED SVE ANALYTICAL COSTS

Quarterly Sampling, Analysis, & Reporting for 30 Vacuum Enhanced SVE Wells Only
Marsh Run Park Natural Attenuation O&M Evaluation
DDRE, New Cumberland, PA

(1) Direct Labor	Total Hours	Rate	Cost
Program Manager	1	$ 43.39	$ 43.39
Project Manager	4	$ 30.23	$ 120.92
Senior Engineer	1	$ 41.45	$ 41.45
Senior Geologist		$ 37.90	$ 0.00
Mid-level Engineer		$ 28.31	$ 0.00
Mid-level Scientist		$ 27.03	$ 0.00
Mid-level Geologist		$ 25.66	$ 0.00
Junior Engineer	48	$ 18.75	$ 900.00
Junior Geologist		$ 18.15	$ 0.00
Technician	128	$ 16.83	$ 2,154.24
Contracts Manager		$ 29.27	$ 0.00
Administrative Assist		$ 18.77	$ 0.00
CADD Operator		$ 18.04	$ 0.00
Clerical Support		$ 13.27	$ 0.00
Subtotal Direct Labo	182		$ 3,260.00
Overhead on Direct Labor @ 120.00%			$ 3,912.00
Subtotal Direct Labor and Labor Overhead			$ 7,172.00

(2) Other Direct Cost	Quantity		Rate		Cost
Telephone	30	minutes	$ 0.57	/min.	$ 17.10
Fax	5	pages @	$ 2.29	/page	$ 11.45
Reproduction		pages @	$ 0.12	/page	$ 0.00
Computer, CADD		hours @	$ 21.76	/hour	$ 0.00
Vehicle Usage	8	days @	$ 41.24	/day	$ 329.92
Vehicle Mileage	1280	miles @	$ 0.13	/mile	$ 166.40
Per Diem		days @	$ 105.00	/day	$ 0.00
Field Equipment Usa	1		$ 1,540.00	ls	$ 1,540.00
Postage/Shipping		each @	$ 86.29	/each	$ 0.00
Subcontractors					
Analytical	1		$ 7,170.00	ls	$ 7,170.00
Subtotal Other Direct Costs					$ 9,234.87
Subtotal (1) & (2)					$ 16,406.87
G&A @ 14.50% (Excluding Travel and Analytical)					$ 1,339.35
Profit @ 10.00% (Excluding Travel and Analytical)					$ 1,057.62
TOTAL LABOR and ODCs					**$ 18,803.84**

NOTE:
TOTAL ANNUAL COST : $18,803.84 X 4 = $75,200

Description	Method	Matrix	Number of Samples	Number of Trip Blanks	Number of Field Blanks	Number of Field Duplicates	Unit Cost(a)	Extended Cost
Volatile Organics by GC/MS	SW 8260	Water	30	5	2	3	$ 162.00	$ 6,480.00
DO, pH, Eh, temp, cond, turb.	YSI	Water	30	-		3	$ 20.91	$ 690.00
						Total Cost of Analyses:		$ 7,170.00

Project _____ Project No. _____
Subject _____ Sheet No. 1 of 2
_____ Drawing No. _____
Computed by: _____ Date _____ Checked by _____ Date _____

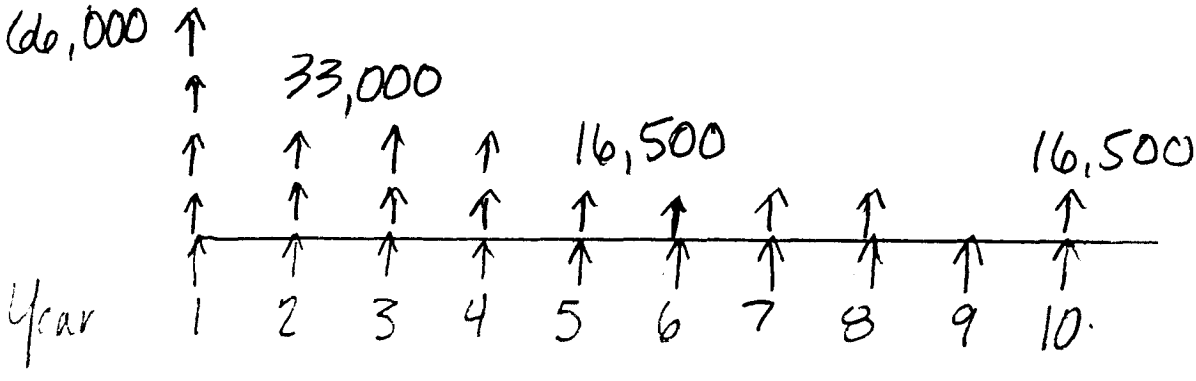
Natural Attenuation Analytical Costs.

Assume:

(1) A one time initial sampling cost of $27,320.

(2) A sampling & reporting cost of $16,500 per event with:

Year 1	Quarterly Sampling	(4x)
Years 2-4	Semi Annual Sampling	(2x)
Years 5-8	Annual Sampling	(1x)
Year 10	Annual Sampling	(1x)



$$PW = 66{,}000 + 33{,}000\,[(P/A, 3yr, 5\%)(P/F, 1yr, 5\%)] + 16{,}500\,[(P/A, 4yr, 5\%)(P/F, 4yr, 5\%)] + 16{,}500\,(P/F, 9yr, 5\%)$$

$$PW = 66{,}000 + 33{,}000\,(2.7232)(.9524) + 16{,}500\,(3.5460)(.8227) + 16{,}500\,(.6446)$$

$$PW = 210{,}400$$

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Project _____ Project No. _____
Subject _____ Sheet No. 2 of 2
_____ Drawing No. _____
Computed by: _____ Date _____ Checked by _____ Date _____

Total Annual Cost = Annual Cost of one time initial event + Annual cost of monitoring

Total Annual Cost =

$= \$27,320\ (A/P, 5, 10yr) + \$210,400\ (A/P, 5, 10yr)$

$= \$27,320\ (.1295) + \$210,400\ (.1295)$

$= \$30,800$

NATURAL ATTENUATION ANALYTICAL COSTS

Task 1: Initial Sampling Costs
Marsh Run Park Natural Attenuation O&M Evaluation
DDRE, New Cumberland, PA

(1) Direct Labor	Total Hours	Rate	Cost
Program Manager	1	$ 43.39	$ 43.39
Project Manager	4	$ 30.23	$ 120.92
Senior Engineer	1	$ 41.45	$ 41.45
Senior Geologist		$ 37.90	$ 0.00
Mid-level Engineer		$ 28.31	$ 0.00
Mid-level Scientist		$ 27.03	$ 0.00
Mid-level Geologist		$ 25.66	$ 0.00
Junior Engineer	40	$ 18.75	$ 750.00
Junior Geologist		$ 18.15	$ 0.00
Technician	128	$ 16.83	$ 2,154.24
Contracts Manager		$ 29.27	$ 0.00
Administrative Assistant		$ 18.77	$ 0.00
CADD Operator		$ 18.04	$ 0.00
Clerical Support	8	$ 13.27	$ 106.16
Subtotal Direct Labor	182		$ 3,216.16
Overhead on Direct Labor @ 120.00%			$ 3,859.39
Subtotal Direct Labor and Labor Overhead			$ 7,075.55

(2) Other Direct Costs	Quantity		Rate		Cost
Telephone	30	minutes @	$ 0.57	/min.	$ 17.10
Fax	5	pages @	$ 2.29	/page	$ 11.45
Reproduction		pages @	$ 0.12	/page	$ 0.00
Computer, CADD		hours @	$ 21.76	/hour	$ 0.00
Vehicle Usage	8	days @	$ 41.24	/day	$ 329.92
Vehicle Mileage	1280	miles @	$ 0.13	/mile	$ 166.40
Per Diem		days @	$ 105.00	/day	$ 0.00
Field Equipment Usage	1		$ 1,676.00	ls	$ 1,676.00
Postage/Shipping		each @	$ 86.29	/each	$ 0.00
Subcontractors					
Analytical	1			ls	$ 15,639.00
Subtotal Other Direct Costs					$ 17,839.87
Subtotal (1) & (2)					$ 24,915.42
G&A @ 14.50% (Excluding Travel and Analytical)					$ 1,345.08
Profit @ 10.00% (Excluding Travel and Analytical)					$ 1,062.15
TOTAL LABOR and ODCs					**$ 27,322.65**

Description	Method	Matrix	Number of Samples	Number of Trip Blanks	Number of Field Blanks	Number of Field Duplicates	Unit Cost(a)	Extended Cost
Volatile Organics by GC/MS	SW 8260	Water	25	5	2	3	$ 162.00	$ 5,670.00
Sulfate (SO4) by IC	EPA 300.0	Water	25	-		3	$ 18.00	$ 504.00
Total Chloride by IC	EPA 300.0	Water	25	-		3	$ 18.00	$ 504.00
Nitrate (NO3) by IC	EPA 300.0	Water	25	-		3	$ 18.00	$ 504.00
Nitrite (NO2) by IC	EPA 300.0	Water	25	-		3	$ 18.00	$ 504.00
Total Iron	EPA 200.7	Water	25	-		3	$ 12.00	$ 336.00
Total Manganese	EPA 200.7	Water	25	-		3	$ 12.00	$ 336.00
Total Ammonia NH3	EPA 350.2	Water	25	-		3	$ 26.00	$ 728.00
Total Organic Carbon (TOC)	EPA 415.2	Water	25	-		3	$ 36.00	$ 1,008.00
Total Inorganic Carbon (TIC)	EPA 415.2	Water	25	-		3	$ 36.00	$ 1,008.00
Hydrogen Sulfide	EPA 376.2	Water	25	-		3	$ 23.00	$ 644.00
Dissolved Ferrous Iron	Hach Kit	Water	25	-		3	$ 8.00	$ 224.00
Dissolved Hydrogen (b)	Field GC	Water	25	-		3	$ 17.86	$ 500.00
Methane/Ethane/Ethene (c)	Field GC	Water	25	-		3	$ 40.36	$ 1,130.00
Dissolved Carbon Dioxide	Hach Kit	Water	25	-		3	$ 8.00	$ 224.00
DO, pH, Eh, temp, cond, turb.	YSI	Water	25	-		3	$ 24.64	$ 690.00
Volatile Fatty Acids	ASTM 94	Water	25				$ 45.00	$ 1,125.00
						Total Cost of Analyses:		$ 15,639.00

NATURAL ATTENUATION ANALYTICAL

Sampling of 10 Natural Attenuation Monitoring Points & Reporting
Marsh Run Park Natural Attenuation O&M Evaluation
DDRE, New Cumberland, PA

(1) Direct Labor	Total Hours	Rate	Cost
Program Manager	1	$ 43.39	$ 43.39
Project Manager	4	$ 30.23	$ 120.92
Senior Engineer	1	$ 41.45	$ 41.45
Senior Geologist		$ 37.90	$ 0.00
Mid-level Engineer	8	$ 28.31	$ 226.48
Mid-level Scientist		$ 27.03	$ 0.00
Mid-level Geologist		$ 25.66	$ 0.00
Junior Engineer	40	$ 18.75	$ 750.00
Junior Geologist		$ 18.15	$ 0.00
Technician	88	$ 16.83	$ 1,481.04
Contracts Manager		$ 29.27	$ 0.00
Administrative Assistant		$ 18.77	$ 0.00
CADD Operator		$ 18.04	$ 0.00
Clerical Support	10	$ 13.27	$ 132.70
Subtotal Direct Labor	152		$ 2,795.98
Overhead on Direct Labor @ 120.00%			$ 3,355.18
Subtotal Direct Labor and Labor Overhead			$ 6,151.16

(2) Other Direct Costs	Quantity		Rate		Cost
Telephone	30	minutes @	$ 0.57	/min.	$ 17.10
Fax	4	pages @	$ 2.29	/page	$ 9.16
Reproduction		pages @	$ 0.12	/page	$ 0.00
Computer, CADD		hours @	$ 21.76	/hour	$ 0.00
Vehicle Usage	8	days @	$ 41.24	/day	$ 329.92
Vehicle Mileage	1280	miles @	$ 0.13	/mile	$ 166.40
Per Diem		days @	$ 105.00	/day	$ 0.00
Field Equipment Usage	1		$ 1,676.00	ls	$ 1,676.00
Postage/Shipping		each @	$ 86.29	/each	$ 0.00
Subcontractors					
Analytical	1		$ 5,971.00	ls	$ 5,971.00
Subtotal Other Direct Costs					$ 8,169.58
Subtotal (1) & (2)					$ 14,320.74
G&A @ 14.50% (Excluding Travel and Analytical)					$ 1,210.71
Profit @ 10.00% (Excluding Travel and Analytical)					$ 956.04
TOTAL LABOR and ODCs					**$ 16,487.49**

Description	Method	Matrix	Number of Samples	Number of Trip Blanks	Number of Field Blanks	Number of Field Duplicates	Unit Cost(a)	Extended Cost
Volatile Organics by GC/MS	SW 8260	Water	10	2	1	1	$ 162.00	$ 2,268.00
Sulfate (SO4) by IC	EPA 300.0	Water	10	-		1	$ 18.00	$ 198.00
Total Chloride by IC	EPA 300.0	Water	10	-		1	$ 18.00	$ 198.00
Nitrate (NO3) by IC	EPA 300.0	Water	10	-		1	$ 18.00	$ 198.00
Nitrite (NO2) by IC	EPA 300.0	Water	10	-		1	$ 18.00	$ 198.00
Total Iron	EPA 200.7	Water	10	-		1	$ 12.00	$ 132.00
Total Manganese	EPA 200.7	Water	10	-		1	$ 12.00	$ 132.00
Total Ammonia NH3	EPA 350.2	Water	10	-		1	$ 26.00	$ 286.00
Total Organic Carbon (TOC)	EPA 415.2	Water	10	-		1	$ 36.00	$ 396.00
Total Inorganic Carbon (TIC)	EPA 415.2	Water	10	-		1	$ 36.00	$ 396.00
Hydrogen Sulfide	EPA 376.2	Water	10	-		1	$ 23.00	$ 253.00
Dissolved Ferrous Iron	Hach Kit	Water	10	-		1	$ 8.00	$ 88.00
Dissolved Carbon Dioxide	Hach Kit	Water	10	-		1	$ 8.00	$ 88.00
DO, pH, Eh, temp, cond, turb.	YSI	Water	10	-		1	$ 62.73	$ 690.00
Volatile Fatty Acids	ASTM 94	Water	10				$ 45.00	$ 450.00
						Total Cost of Analyses:		$ 5,971.00