Methodology for Estimating the Costs of Treatment of Mine Drainage

Prepared for:

U.S. Office of Surface Mining
Pittsburgh, PA 15220

Disclaimer

This document presents the methodology for estimating the costs of treatment of mine drainage. This document does not represent either U.S. Office of Surface Mining or state official guidance and policy for the design or approval of acid mine drainage treatment systems.

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1.0 INTRODUCTION

Tetra Tech EM Inc. (Tetra Tech) received Contract No. 143868-CT99-12063 from the United States Department of the Interior, Office of Surface Mining (OSM), in part to assist OSM in developing a methodology for estimating the costs of treatment of mine drainage from coal mines. The Surface Mining Control and Reclamation Act of 1977 (SMCRA) established bonding requirements for operators of coal mines. Regulations under SMCRA, set forth in 30 Code of Federal Regulations (CFR) part 800, require that operators of coal mines prepare site-specific estimates of the costs of reclaiming areas affected by mining operations and managing any pollutants that may emanate from them. Once the cost estimates have been prepared, OSM, or authorized state regulatory authorities, reviews the estimates and determines the amounts of bonding that are necessary for reclamation activities at each mine. Operators of coal mines may use a number of financial mechanisms to meet the bonding requirements, including surety bond, letter of credit, and self bond.

OSM has determined that the estimated costs of reclamation for a number of coal mines have been significantly lower than the actual costs of effecting reclamation activities at those facilities. To a large extent, failures in the development of estimates of the costs of the long-term treatment of mine drainage account for the discrepancies. The main purpose of this document is to provide OSM and state regulatory authorities with a consistent, accurate, and rapid method of estimating the costs of the long-term treatment of mine drainage at coal mines.

The methodology set forth herein provides a variety of worksheets that may be used to estimate the costs of specific activities that are known to be conducted in treating mine drainage at coal mines. It is unlikely, however, that all of the worksheets provided in the methodology will be needed to estimate the costs of the treatment of mine drainage for any particular site. In applying the methodology, the user must select from among the worksheets available only those worksheets that pertain to activities that will be conducted to address mine drainage at any particular site. Once the worksheets for each specific activity have been completed, the costs estimated for those activities are combined on unit summary worksheets to derive cost estimate for each unit, then combined on a site summary worksheet to derive a comprehensive cost estimate for each site.

Because the types of activities that may be required to address mine drainage may vary significantly from one site to the next, and it may be necessary to conduct unusual or uncommon types of activities at certain sites to address the specific circumstances at that site, the methodology may not include worksheets that address all of the activities that may be required at any given site. In such cases, cost estimates for unusual or uncommon activities should be developed based on alternative approaches. Over time, the methodology may be enhanced as more information about treatment technologies for mine drainage and the costs incurred to treat mine drainage at individual sites becomes available.

The methodology as currently designed is a general approach to estimating costs. The issue of treatment cost versus time can be addressed by running the methodology model using different time frames, flow rates, and acidity based on site-specific conditions.

1.1 BACKGROUND

In the past, it had been common practice among owners of coal mines to abandon mines or cease operations at them without making adequate provisions for the long-term protection of the public and the environment. By failing to assure that mining operations were closed or reclaimed properly, and that pollution discharges emanating from mining operations were properly treated, mining operations have imposed significant adverse impacts on the public and the environment. In particular, failure to effect long-term treatment of mine drainage at mining sites has resulted in significant damage and risks to the public and the environment. In many cases, the implementation of basic steps to address mine drainage has been delayed or disrupted because operators failed to plan properly for the long-term treatment of mine drainage after operations at their facilities had ceased. The risk that operators will fail to properly address the long-term treatment of mine drainage is increased by the fact that such obligations may become apparent only after a mine has been closed and has ceased to be an economic asset.

One of the primary goals of bonding requirements is to address the problems that arise when, at the end of the operating life of a mine, the operator does not have adequate financial resources to address environmental concerns properly. Currently, under SMCRA, operators of coal mines are required to post bonds for reclamation. The primary purpose of such bonds is to make available to regulatory authorities a source of funds sufficient to pay for the conduct of reclamation or abatement activities when the operator of a mine is unwilling or unable to conduct those activities in accordance with its permit.

To determine the amount of bonding required for each mine, the operator of that mine must prepare a detailed reclamation plan. The reclamation plan must identify all activities related to reclamation that will be performed after the active life of a mine has ended. The reclamation plan helps to ensure that an operator has made adequate preparations for implementing reclamation activities at its mine and that those activities will be conducted in a manner that is most protective of human health and the environment. It is important that the reclamation plan address in detail how the operator will provide for adequate control of polluted mine drainage that may be released to the environment over a long period of time after mining operations have ceased.

Using the reclamation plan as a guide, the regulatory authority ultimately must estimate the costs of reclamation activities at a mine. Because the cost estimate is the basis for determining the amount of bonding needed, the estimate must be thorough and must account for the costs of all necessary reclamation and abatement activities. However, because there has been no standard method of estimating the costs of treatment of mine drainage, requirements for bonding have been inconsistent, and it is probable that funds provided through bonding mechanisms will be insufficient to finance, in full, the costs of such treatment at a large number of sites.

1.2 COST WORKSHEETS

Worksheets are the primary tools provided by the methodology to help estimate the costs of the treatment of mine drainage. This document presents seven types of cost worksheets, each of which corresponds to different activities that might be undertaken to address discharges of mine drainage at coal mines. The types of worksheets are: 1) source control, 2) active treatment, 3) passive treatment, 4) general treatment and polishing units, 5) discharge methods, 6) system operations, and 7) support activities. A site summary worksheet also is provided to sum all the costs of treatment of mine drainage that are associated with a particular site. Table 1-1 presents a list of all the cost estimating worksheets provided in the methodology.

TABLE 1-1
COST ESTIMATING WORKSHEETS

Category	Number	Title
Source Control	SC-1	Source Control Unit Summary
	SC-2A-I	Capping of Acid-Producing Material
	SC-3	Regrading and Backfilling
	SC-4	Grouting and Mine Seals
	SC-5	Stormwater and Runoff Diversion
	SC-6A/B	Alkaline Addition for Spoils
Active Treatment	AT-1	Active Treatment Unit Summary
	AT-2A/B	Soda Ash Neutralization
	AT-3A/B	Caustic Soda Neutralization
	AT-4	Hydrated Lime or Pebble Quicklime Neutralization
	AT-5A/B	Ammonia Neutralization
	AT-6A/B	Aeration Basins
	AT-7	Pebble Quicklime Neutralization - Aquafix System
Passive Treatment	PT-1	Passive Treatment Unit Summary
	PT-2A/B	Alkalinity-Producing Diversion Wells
	PT-3A-C	Anoxic Limestone Drains (ALD)
	PT-4A/B	Successive Alkalinity-Producing Systems (SAPS)
	PT-5A/B	Aerobic and Anaerobic Wetlands
General Treatment and Polishing	GTU-1A/B	Ponds
	GTU-2A/B	Clarifiers
	GTU-3A/B	Rock Drains

Table 1-1
Cost Estimating Worksheets (continued)

Category	Number	Title
	GTU-4A/B	Filter Fields
	GTU-5A-C	Open Limstone Channels (OLC)
Discharge Methods	DM-1A/B	Infiltration Galleries
	DM-2A/B	Irrigation Applications
	DM-3	Pipe Systems

Table 1-1
Cost Estimating Worksheets (continued)

Category	Number	Title
System Operations	OP-1	Chemical Consumption
	OP-2	System Maintenance and Replacement
	OP-3	Electricity
	OP-4	Removal of Sludge
	OP-5A-D	Sampling and Analysis
Support Activities	SW-1	Land Access
	SW-2	Monitoring Wells
	SW-3	Site Security
	SW-4	Access Roads
Summary	SS-1	Site Summary

Many activities performed to treat mine drainage involve basic field construction work. Therefore, in the worksheets, typical construction costs are used to estimate the costs of the activities performed to treat mine drainage that most closely resemble field construction activities. Although several sources of information provide estimates of typical construction costs, hourly rates for labor and equipment set forth in *Mean's Cost Guides* are used frequently in the worksheets. *Mean's Cost Guides* are recognized industry standards for cost estimating. Because they are updated annually, updating the cost components of the worksheets can be accomplished readily. Further, because current rates from *Mean's Cost Guides* can be applied through the use of the worksheets, the methodology can be used to calculate more accurately the costs of the treatment of mine drainage. That capability can increase the accuracy of the cost estimates significantly because basic construction work can account for a significant percentage of the total cost of the treatment of mine drainage. When certain costs, such as those for laboratory analysis of water or soil samples, cannot be found in *Mean's*, representative costs provided by a number of vendors have been obtained and averaged.

Costs of activities not found in *Mean's* can be updated by obtaining current quotes from vendors or by multiplying those costs by a factor that accounts for the effects of inflation. One method that can be used to derive such an inflation factor is described at 40 CFR 264.142(b)(1) and (2). The method is based on the use of the implicit price deflators of gross national product that are published annually by the United States Department of Commerce in its *Survey of Current Business*. Other methods to derive an inflation factor include information from major journals, such as, *Chemical and Engineering News* and *Chemical Engineering*.

In the methodology, the source control, active treatment, and passive treatment unit summary worksheets each apply a factor of 16 percent to the subtotal of all capital costs to account for the costs of management and engineering design. That percentage is based on factors derived from *Mean's*. Further, in accordance with standard engineering practices, the source control, active treatment, and passive treatment unit summary worksheets each apply to all capital and annual operating costs an additional factor of 20 percent to account for contingencies and unforseen expenses.

The total calculated costs for source control, treatment, and system operations are adjusted to net present value to determine the long-term costs of treatment in current dollars. This method is widely used to evaluate the value of long-term investments and is useful in this analysis for determining the amount of bonding that is necessary for reclamation activities at a particular site. The three main components in the net present value adjustment are:

- The number of years that the system is planned to operate
- The annual inflation rate
- The estimated annual discount rate which represents the cost to the facility's owner of borrowing money.

The use of different figures for years of treatment, the inflation rate, or the discount rate could have a significant effect on the cost estimate generated for an individual facility. The cost estimates are highly sensitive to small variations in those parameters and the user should carefully select values used for the net present value calculation to provide the most realistic cost estimate.

To generate cost estimates for the treatment of mine drainage, the methodology uses third-party costs and assumes that the materials and equipment required to conduct each activity will be brought to the site. Although the operator may have equipment and materials available to conduct such activities while the facility is operational, there is no guarantee that the same equipment or materials will be available to a regulatory authority once a facility has been abandoned. The use of third-party costs therefore is essential to the development of a cost estimate that reflects a "reasonable worst-case scenario," and to ensure that financial assurance mechanisms can be counted upon to provide to regulatory authorities sufficient funds to conduct the required mine drainage treatment activities.

1.3 USING THE WORKSHEETS TO ESTIMATE COSTS

The methodology is designed to offer a flexible and rapid means of generating reasonable accurate estimates of the costs of the treatment of mine drainage. The methodology prescribes the following four basic steps to use the worksheets to develop cost estimates:

1) Using information in the reclamation plan or other information available about the site, the user must determine the specific treatment processes that are to be conducted to address mine drainage at the site and the specific source control techniques (if any) that will be implemented. The user must also identify any conditions at the site (for example, difficult access to the site) that may require the conduct of additional activities or require capital expenditures that will add to the expense of implementing the selected treatment processes. In addition, the user must identify related data that is absent and needs to be generated or assumed to develop a reasonable cost estimate.

2) The user must identify and assemble all the worksheets that are needed to calculate the cost estimate. Table 1-2 identifies the worksheets for specific activities that are addressed in the methodology and that might be appropriate for the treatment of mine drainage at surface mines, underground mines, and coal refuse facilities, respectively. The user should review the applicable worksheets to become familiar with the data inputs that are required to use them and the assumptions upon which the cost data incorporated into the worksheets are based.

3) Using information in the reclamation plan or other information available about the site, the user must obtain the data that are required to use the worksheets and enter those data. The user should review all cost data that are incorporated into the worksheets to ensure that those data reflect accurately the tasks to be performed at the site. If necessary, the user may adjust or replace the costs incorporated into the worksheets with other cost data that are more accurate for the site. Once all the appropriate data have been entered, the user may estimate the costs of each activity by applying the method prescribed in the worksheets.

4) The user must transfer the estimated costs of each activity to the source control, active treatment, and passive treatment summary worksheets, as appropriate, to derive cost estimates for each unit, apply allowances to those estimates to account for engineering expenses and contingencies, and adjust those estimates to net present value. The user should review the default factors applied on the source control, active treatment, and passive treatment summary worksheets to ensure that those factors are appropriate. If necessary, the user may adjust or replace the default factors with more appropriate factors. Finally, the user must transfer the costs for each unit to the site summary worksheet to derive a comprehensive cost estimate for each site.

Two decision trees also are provided to assist the user in identifying alternatives for the treatment of mine drainage on the basis of the characteristics of a particular site. Figure 1-1 presents a general decision tree for selecting alternatives for treatment of mine drainage based on its characteristics. Mine drainage is classified as net acidic mine drainage, which is defined as conditions where total acidity is greater than total alkalinity, and net alkaline mine drainage, which is defined as conditions where total acidity is less than total alkalinity. Figure 1-2 presents a decision tree for selecting alternatives for treatment of net acidic mine drainage on the basis of industry practices. Figure 1-3 presents a decision tree for selecting alternatives for treatment of net alkaline mine drainage on the basis of industry practices.

TABLE 1-2
WORKSHEETS APPLICABLE TO THE TREATMENT OF MINE DRAINAGE AT SURFACE MINES, UNDERGROUND MINES, AND COAL REFUSE PILES

Worksheet	Code	Surface Mines			Underground Mines			Coal Refuse Piles		
		Source Control	Active Treatment	Passive Treatment	Source Control	Active Treatment	Passive Treatment	Source Control	Active Treatment	Passive Treatment
Capping of Acid-Producing Material	SC-2	!						!		
Regrading and Backfilling	SC-3	!						!		
Grouting and Mine Seals	SC-4				!					
Stormwater and Runoff Diversion	SC-5	!			!			!		
Alkaline Addition for Spoils	SC-6A/B	!			!			!		
Soda Ash Neutralization	AT-2A/B		!			!			!	
Caustic Soda Neutralization	AT-3A/B		!			!			!	
Hvdrated Lime or Pebble Quicklime Neutralization	AT-4A/B		!			!			!	
Ammonia Neutralization	AT-5A/B		!			!			!	
Aeration Basins	AT-6A/B		!			!			!	
Pebble Ouicklime Neutralization - Aquafix System	AT-7		!			!			!	
Alkalinity-Producing Diversion Wells	PT-2A/B			!			!			!
Anoxic Limestone Drains (ALD)	PT-3A-C			!			!			!
Successive Alkalinity-Producing Systems (SAPS)	PT-4A/B			!			!			!
Aerobic and Anaerobic Wetlands	PT-5A/B			!			!			!

Table 1-2

Worksheets Applicable to the Treatment of AMD at Surface Mines, Underground Mines, and Coal Refuse Piles (continued)

Worksheet	Code	Surface Mines			Underground Mines			Coal Refuse Piles		
		Source Control	Active Treatment	Passive Treatment	Source Control	Active Treatment	Passive Treatment	Source Control	Active Treatment	Passive Treatment
Ponds	GTU-1A/B		!	!		!	!		!	!
Clarifiers	GTU-2A/B		!			!			!	
Rock Drains	GTU-3A/B		!	!		!	!		!	!
Filter Fields	GTU-4A/B		!	!		!	!		!	!
Open Limestone Channels (OLC)	GTU-5A-C		!	!		!	!		!	!
Infiltration Galleries	DM-1A/B		!	!		!	!		!	!
Irrigation Applications	DM-2A/B		!	!		!	!		!	!
Pipe Systems	DM-3		!	!		!	!		!	!
Chemical Consumption	OP-1		!	!		!	!		!	!
System Maintenance and Replacement	OP-2	!	!	!	!	!	!	!	!	!
Electricity	OP-3		!	!		!	!		!	!
Sludge Removal	OP-4		!	!		!	!		!	!
Sampling and Analysis	OP-5	!	!	!	!	!	!	!	!	!
Land Access	SW-1	!	!	!	!	!	!	!	!	!
Monitoring Wells	SW-2	!	!	!	!	!	!	!	!	!
Site Security	SW-3	!	!	!	!	!	!	!	!	!

Table 1-2

Worksheets Applicable to the Treatment of AMD at Surface Mines, Underground Mines, and Coal Refuse Piles (continued)

Worksheet	Code	Surface Mines			Underground Mines			Coal Refuse Piles		
		Source Control	Active Treatment	Passive Treatment	Source Control	Active Treatment	Passive Treatment	Source Control	Active Treatment	Passive Treatment
Access Roads	SW-4		!	!		!	!		!	!

Figure 1-1
Decision Tree for Selection of Alternatives for Treatment of Net Acidic and Net Alkaline Mine Drainage

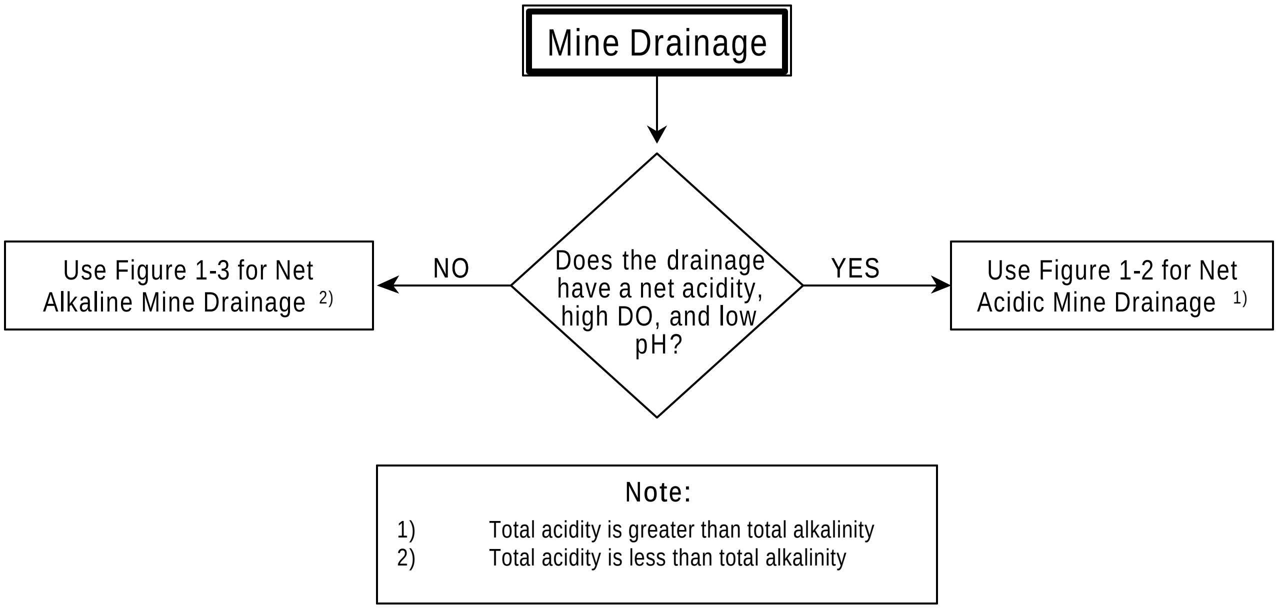
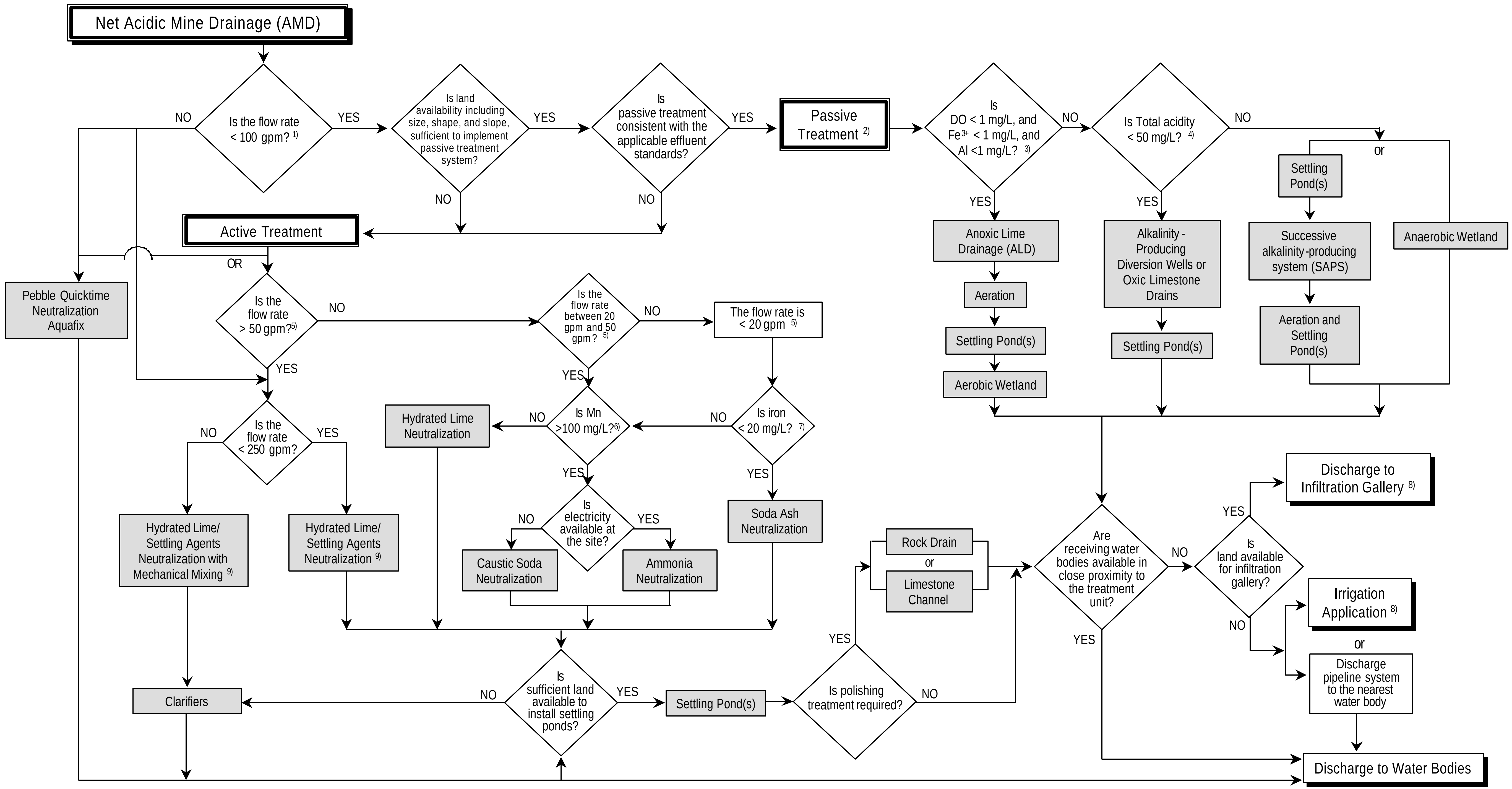


FIGURE 1-2
DECISION TREE FOR THE SELECTION OF ALTERNATIVES FOR THE TREATMENT OF NET ACIDIC MINE DRAINAGE BASED ON INDUSTRY PRACTICES



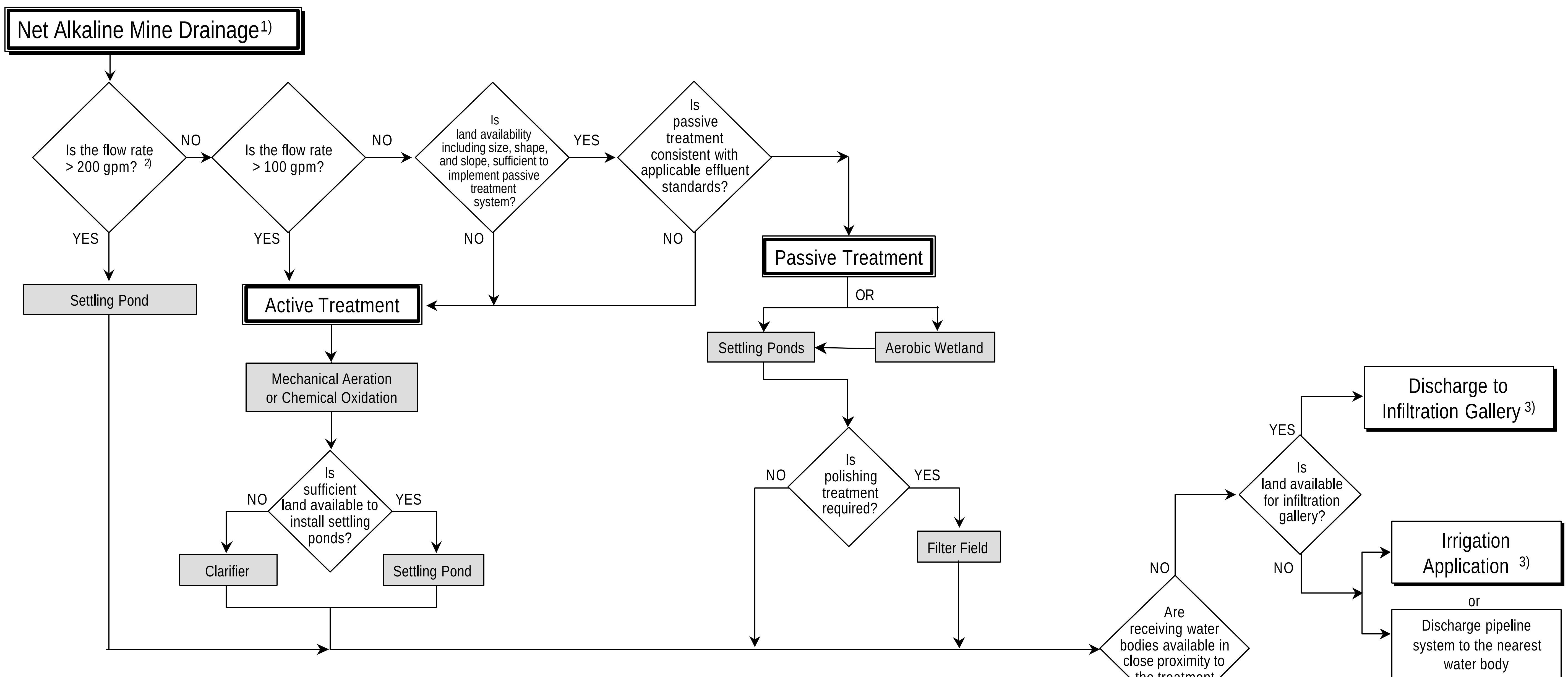
NOTE AND LEGEND

1) Skousen & others, Acid Mine Drainage Control & Treatment, 1996, p.262
2) Treating larger flow than 100 gpm may be possible. Not applicable for total acidity greater than 500 mg/L.
3) Figure 5.2 (Hedin et al. 1994), Skousen & others, A Handbook of Technologies for Advance and Remediation of Acid Mine Drainage, National Mine Land Reclamation Center at West Virginia, p. 104
4) Skousen and Others, Acid Mine Drainage Controls & Treatment, 1996, p.164
5) Remine V.2.1, PA DEP
6) Professional Judgment, Controls & Treatment, 1996, p.166
7) Skousen & others, Acid Mine Drainage Controls & Treatment, 1996, p.166
8) Not a common application in the eastern regions.
9) Settling agents include flocculants and coagulants.

Treatment unit

gpm = gallon per minute
mg/L = milligrams per liter
DO = dissolved oxygen
Al = aluminum
Fe^{3+} = Ferric (Iron III)

FIGURE 1-3
DECISION TREE FOR THE SELECTION OF ALTERNATIVES FOR THE TREATMENT OF NET ALKALINE MINE DRAINAGE BASED ON INDUSTRY PRACTICES



NOTE AND LEGEND

1) OSM; Review and Commentary of Draft Methodology for Estimating the Costs of Treatment of Acid Mine Drainage, Jan. 2000, Comment No. 9f
2) Not a common application in the eastern regions.
3) Net alkaline mine drainage is defined as drainage with high total dissolved solids containing metals, no or low oxygen content but high pH.

Treatment unit

2.0 SOURCE CONTROL

Source control activities are those activities designed to prevent or mitigate the formation of mine drainage at its source by isolating acid-producing materials from air or water or by adding agents to such materials to neutralize acid when it does form. Source control techniques may be implemented at sites at which the formation of mine drainage occurs Such techniques, while not always entirely successful in preventing the formation of mine drainage, may offer cost-effective alternatives to the conduct of long-term treatment of mine drainage and can be combined with treatment technologies to improve the effectiveness or cost performance of those technologies. For example, a source control technique can be combined with an active treatment system to reduce the amounts of soda ash or caustic soda required to neutralize mine drainage using that system. A number of source control techniques, both experimental and conventional, have been implemented at mine drainage sites, with varying degrees of success. The source control techniques addressed in this document are techniques that commonly are implemented at mine drainage sites. Those techniques include capping, regrading, grouting and backfilling, stormwater or runoff diversion, and alkaline amendment.

Presented below are descriptions of the cost estimating worksheets to be used in determining the costs of conducting source control activities at surface mines, underground mines, and coal refuse piles:

- **Source Control Unit Summary -** The Source Control Unit Summary worksheet is used to record the costs calculated for each individual source control activity worksheet, apply allowances to those costs to account for engineering expenses and contingencies, and calculate the total costs of source control activities adjusted to net present value.

- **Capping of Acid-Producing Material -** Engineered barriers such as caps can be used for source control at surface mines and coal refuse piles. By preventing water from reaching acid-producing material, such barriers can eliminate or mitigate the extent of production of mine drainage at a site. The cost of constructing a cap may include the costs of many or all of the following components: a layer of neutral material; a clay layer; a synthetic membrane, a drainage layer, topsoil, and a vegetative cover.

  Neutral Material Layer: The worksheet calculates the cost of installing a layer of neutral material (typically borrow) over acid-producing material in preparation for the installation of a cap. The cost of the activity includes that of purchasing the neutral material from an off-site source and of hauling, spreading, and compacting that material.

  Clay Layer: Although the worksheet was developed based on the cost of installing a layer of clay over acid-producing material, clay, fly ash, and kiln dust also have been used to cap acid-producing materials in the reclamation practice of coal mining. The cost of the activity includes that of purchasing the clay from an off-site source and of hauling, spreading, and compacting it.

The compacted clay layer also must be tested to determine whether the engineering design specifications and permeability requirements have been met.

Geomembrane: The cost of installing the geomembrane includes the costs of purchasing and installing a flexible, 40-millimeter, low-density polyethylene liner.

Drainage Layer: The drainage layer is designed to prevent contact between acid-producing materials and water that infiltrates the impermeable layer. In calculating the cost of installing a drainage layer, it is assumed that the material of the drainage layer will consist of gravel or sand overlain by geotextile fabric. Drainage pipes will be installed around the perimeter of the cover. The costs of installation of the drainage layer include the costs of purchasing the material from an off-site source, hauling and spreading the sand or gravel, and purchasing and installing the geotextile filter fabric and the drainage tiles.

Topsoil Layer: The costs of installing the topsoil layer include the costs of purchasing the topsoil from an off-site source and of hauling, spreading, and compacting that topsoil. Biosolids may be substituted for top soil as a soil amendment in locations where this practice is used.

Establishment of Vegetative Cover: The costs of installing the vegetative cover include the costs of raking the topsoil to prepare for seeding and spreading seed, fertilizer, and mulch over the entire area of the cover.

- **Regrading and Backfilling[1] -** Regrading and backfilling may be used to create the smooth surfaces needed to prevent erosion, promote revegetation, and return the mining area to a more natural and more visually agreeable contour that is consistent with planned and potential future uses. Regrading and backfilling activities may be conducted to recontour exposed areas where rainwater may accumulate to create smooth areas that have minimal slopes. In many cases, fill material will be found on site. However, it may be necessary to purchase additional material if the volume of fill material available on site is insufficient to fill all voids. Fill material on site may be material that was excavated during the conduct of mining operations or may be present as unexcavated soil that is higher in elevation than the planned final contour of the site.

  To estimate the volumes of previously excavated soil, it is important to account for the expansion of volume that occurs when soils are excavated. Generally, an expansion factor of 30% is appropriate. Therefore, an excavated pile of soil that occupies 1 cubic yard (yd^3), occupied only 0.70 yd^3 before excavation. The worksheet provides a procedure for estimating the amounts of in-place and previously excavated (stockpiled) materials that are available on site. The worksheet also provides procedures for estimating the cost of purchasing such materials from off-site sources. The worksheet provides separate cost multipliers to account for the differences in the costs of filling voids with stockpiled and unexcavated materials. Materials purchased from off site are treated as stockpiled fill. The total costs of regrading and backfilling include the sum of the costs incurred for the use of on-site unexcavated and stockpiled materials and the costs incurred for the purchase, delivery, and use of off-site materials.

- **Grouting and Mine Seals[1] -** Pressure grouting may be required at former mining sites to fill

[1] Although grouting and mine seals (both wet and dry) are discrete categories of source control, for the purposes of this methodology, they are considered together. Based on further direction from OSM, this discussion was not expanded because of design complexities associated with site-specific conditions.

various subsurface cracks or channels that may serve as pathways for the flow of mine drainage. The process generally includes the forcing of any of various mixtures of concrete into voids at pressures as high as 160 pounds per square inch (psi). The worksheet requires an estimate of the total volume of voids to be filled through the use of pressure grouting equipment. The costs of pressure grouting include the costs of a grout mixer, a 160-psi air compressor, and a five-person crew. Mine seals may be installed at former underground mines to prevent inflow and outflow of surface and groundwaters into and out of deep mine cavities. The worksheet provides basic design parameters for the installation of hydraulic mine seals. The installation of such seals usually requires the drilling into and grouting of mine cavities as conditions specific to the site indicate are necessary. Each mine seal is unique. The design of each mine seal depends on a number of factors, including the numbers and configurations of subsurface joints, bedding planes, hydraulic pressures, and flowpath distances. Therefore, cost estimates for mine seals must be based on a thorough understanding of all relevant factors specific to the site. Those factors should be described thoroughly in the design drawings for any proposed mine seal. Further, the design drawings and associated cost estimates should be reviewed by a certified mining engineer who is familiar with the hydrogeologic properties of the area. The worksheet is intended to be used only as a guide to provide information about some common components of mine seal designs and additional information about factors that may affect the costs of those components.

C **Stormwater and Runoff Diversion** - In addition to regrading and backfilling, systems for managing stormwater and runoff may be required to minimize erosion at a former mining site. Generally, such drainage systems consist of channels that intercept and collect surface runoff from drainage areas. The channels typically are cut and lined with rip rap or vegetation in such a way that, even under severe storm conditions, the total volume of surface water from drainage areas is collected and removed without overflowing. The slopes of the drainage channels must be gentle enough to prevent erosion in the channel. Therefore, the capacities of the channels generally are determined by their width and depth.

The worksheet allows for the calculation of the costs of installing a number of storm water channels that must transverse a drainage area to accommodate a 24-hour storm of a severity having the probability of occurring once every 10 years. The dimensions of the drainage channels were set with an average slope equivalent to one foot per second.

C **Alkaline Addition** - Addition with alkaline materials such as limestone, fluidized bed combustion (FBC) ash, kiln dust, and phosphate rocks has been used as a technique to control the formation of mine drainage at its source. The technique often is used in conjunction with such source control techniques as capping, regrading, grouting, and mine seals that prevent and minimize the formation of mine drainage.

Phosphate rock application is commonly combined with bactericides, because they inhibit the growth of *Thiobacillus sp*, microbes that catalyze certain reaction steps in acid generation process. Although phosphate and bactericides technique is established, it is not widely used. Therefore, the worksheet was developed based on alkaline addition using limestone, because it is a common practice and more readily available than most other alkaline materials suitable for this process. The cost of alkaline addition includes the costs of the purchase and delivery of limestone, the hauling of spoils to a mixing zone and final staging area, and the mixing of limestone and spoils

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However, the worksheet may be modified and applied according to site-specific design information.

with a dozer or loader.

SOURCE CONTROL

UNIT NAME: ______________________

	Activity	Worksheet Number	Cost
	Capital Costs		
1.	Capping of acid producing material	SC-2A-I	
2.	Regrading and backfilling	SC-3	
3.	Grouting and mine seals	SC-4	
4.	Stormwater and runoff diversion	SC-5	
5.	Alkaline addition	SC-6A/B	
6.	Installation of ponds (sedimentation ponds)	GTU-1A/B	
7.	Land access	SW-1	
8.	Installation of monitoring wells	SW-2	
9.	Site security	SW-3	
10.	Access roads	SW-4	
11.	**Subtotal of Capital Costs (Add lines 1 through 10)**		**$ -**
	FOR EXISTING TREATMENT SYSTEM, LINE 11 IS NOT INCLUDED IN THE TOTAL NET PRESENT WORTH CALCULATION.		
	Annual Operating Costs		
12.	System maintenance and replacement (from OP-2, line 3c)	OP-2	
13.	Sampling and analysis	OP-5	
14.	**Subtotal of Annual Operating Costs (Add lines 12 and 13)**		**$**
	Allowances and Contingencies		
15.	Allowance for engineering expenses[a]	**16%**	
16.	Allowance for engineering expenses for capital costs (multiply line 11 by line 15)	$ -	
17.	Capital costs adjusted for allowance for engineering expenses (add lines 11 and 16)	$ -	
18.	Allowance for contingencies[b]	**20%**	
19.	Allowance for contingencies for capital costs (multiply line 17 by line 18)	$ -	
20.	Allowance for contingencies for annual operating costs (multiply line 14 by line 18)	$ -	
21.	**Capital Costs Adjusted for Allowances for Engineering Expenses and Contingencies (add lines 17 and 19)**		**$ -**
22.	**Annual operating costs adjusted for allowance for contingencies (add lines 14 and 20)**		$ -

UNIT NAME: ______________________

	Activity	Worksheet Number	Cost
	Net Present Value Calculation		
23.	Number of years the system will remain in operation (n)	**0**	
24.	Expected annual inflation rate (%)	**0.00**	
25.	Estimated annual discount rate (%)	**0.00**	
26.	Net discount rate (Subtract line 24 from line 25) (i)	**0.00**	
27.	Net Present Value Multiplier, Equal to $\frac{1-(1+i)^{-n}}{i}$	0.00	
28.	**Net Present Value of Annual Operating Costs Over Life of System (multiply line 22 by line 27)**		**$ -**
	TOTAL COST OF SOURCE CONTROL SYSTEMS ADJUSTED TO NET PRESENT VALUE (add lines 21 and 28)		**$ -**

[a] R.S. Means Company, Inc., *Site Work and Landscape Cost Data*, back cover. Factors range from 11 to 16 percent and include costs of engineering and logistical support and staff requirements.

[b] In accordance with standard engineering practices, a factor of 20 percent is applied to account for contingencies and unforeseen expenses.

CAPPING OF ACID-PRODUCING MATERIAL

1.	**AREA OF COVER**		
a	Length	**0 ft**	
b	Width	**0 ft**	
c	Area of cover (multiply line 1a by line 1b)		0.0 ft^2
d	Area of cover in yd^2 (divide line 1c by 9)		0.0 yd^2
e	Area of cover in acres (divide line 1c by 43,560)		0.0 acres
2.	**VOLUME OF NEUTRAL OVERBURDEN LAYER**		
a	Thickness of neutral overburden layer	**0.0 ft**	
b	Volume of neutral overburden layer (multiply line 1c by line 2a)		0.0 ft^3
c	Volume of neutral overburden layer in yd^3 (divide line 2b by 27)		0.0 yd^3
3.	**VOLUME OF CLAY OR OTHER LOW-PERMEABILITY MATERIAL LAYER INCLUDING FLY ASH AND KILN DUST**		
a	Thickness of clay or other low-permeability material layer	**0.0 ft**	
b	Volume of clay or other low-permeability material layer (multiply line 1c by line 3a)		0.0 ft^3
c	Volume of clay or other low-permeability material layer in yd^3 (divide line 3b by 27)		0.0 yd^3
4.	**VOLUME OF SAND OR GRAVEL LAYER**		
a	Thickness of sand or gravel layer	**0.0 ft**	
b	Volume of sand or gravel layer (multiply line 1c by line 4a)		0.0 ft^3
c	Volume of sand or gravel layer in yd^3 (divide line 4b by 27)		0.0 yd^3
5.	**VOLUME OF TOPSOIL LAYER AND LIMESTONE LAYER**		
	Limestone is ammended prior to top soil layer.		
a	Thickness of topsoil layer	**0.0 ft**	
b	Dosage of limestone amendment	**6.0 tons/acres**	
c	Volume of topsoil layer (multiply line 1c by line 5a)		0.0 ft^3
d	Volume of topsoil layer in yd^3 (divide line 5b by 27)		0.0 yd^3
e	Amount of limestone required (multiply line 1e by line 5b and by 2000)		0.0 lbs

CAPPING OF ACID-PRODUCING MATERIAL

1. CLEARING AND GRUBBING				
a	Area of cover (from SC-2A,line 1c)	0.0	ft^2	
b	Area of cover in acres (divide line 1a by 43,560)	0.0	acres	
c	Unit cost of clearing and grubbing[a]	5,650.00	$/acre	
TOTAL COST OF CLEARING AND GRUBBING (multiply line 1b by line 1c)				**$0.00**

a R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 39, Item No. 021 104 0260. The cost is that of clearing and grubbing of dense brush and removal of stumps.

CAPPING OF ACID-PRODUCING MATERIAL

1.	**PURCHASE AND DELIVERY OF NEUTRAL MATERIAL**			
a	Volume of neutral material required (from SC-2A, line 2c)	0.0	yd^3	
b	Compaction factor[a]	**25%**		
c	Volume of additional neutral material required (multiply line 1a by line 1b)	0.0	yd^3	
d	Total volume of neutral material required (add lines 1a and 1c)	0.0	yd^3	
e	Unit cost of neutral material[b]	12.78	$\$/yd^3$	
f	**Total Cost of Purchase and Delivery of Neutral Material (multiply line 1d by line 1e)**			**$0.00**
2.	**SPREADING AND COMPACTING OF NEUTRAL MATERIAL LAYER**			
a	Unit labor and equipment cost for spreading of neutral material[c]	1.40	$\$/yd^3$	
b	Subtotal of labor and equipment costs for spreading of neutral material (multiply line 1d by line 2a)	0.00	$	
c	Unit labor and equipment cost for compacting of neutral material[d]	0.29	$\$/yd^3$	
d	Subtotal of labor and equipment costs for compacting of neutral material (multiply line 1d by line 2c)	0.00	$	
e	**Total Cost of Spreading and Compacting of Neutral Material Layer (add lines 2b and 2d)**			**$0.00**
TOTAL COST OF INSTALLATION OF NEUTRAL MATERIAL LAYER (add lines 1f and 2e)				**$0.00**

a U.S. Environmental Protection Agency, *Final Guidance Manual: Cost Estimates for Closure and Post-Closure Plans (Subparts G and H), Volume III,* EPA/530-SW-87-009, January 1987, pages 7-10. Compaction factor provided is that for native slope and fill.

b R.S. Means Company, Inc., *Means Building Construction Cost Data* , 1999, pg. 50, Items Nos. 022 212-0200 and 212-0900 Cost is $\$9.00/yd^3$ for common borrow, plus \$3.78 per yd^3 for hauling the material a distance of five miles for a total cost of \$12.63 per yd^3.

c R.S. Means Company, Inc., *Means Site Work and Landscape Cost Data* , 1999, pg. 53, Item No. 022 262-0010 The cost is that of spreading dumped material with a 200-HP dozer.

d R.S. Means Company, Inc., *Means Site Work and Landscape Cost Data* , 1999, pg. 39, Item No. 022 226-5000 The cost is that of compaction with a riding vibrating roller with 6-inch lifts and 2 passes per lift.

CAPPING OF ACID-PRODUCING MATERIAL

(Recommended permeability of 1 x 10^{-9} m/s or less)

1.	**PURCHASE AND DELIVERY OF LOW-PERMEABILITY MATERIAL, INCLUDING CLAY AND FLY ASH**			
a	Volume of clay required (from SC-2A, line 3c)	0.0	yd^3	
b	Compaction factor[a]	**40%**		
c	Volume of additional clay required (multiply line 1a by line 1b)	0.0	yd^3	
d	Total volume of clay required (add lines 1a and 1c)	0.0	yd^3	
e	Unit cost of low-permeability material (select from below):	6.00	$/$yd^3$	
	1. Unit cost of clay [b]	6.00	$/$yd^3$	
	2. Unit cost of other low-permeability material		**$/$yd^4$**	
f	Total cost of clay (multiply line 1d by line 1e)	0.00	$	
g	Unit cost of delivery of low-permeability material [c]	11.35	$/$yd^3$	
h	Total cost of delivery of low-permeability material (multiply line 1d by line 1g)	0.00	$	
i	**Total Cost of Purchase and Delivery of Low-permeability Material (add lines 1f and 1h)**			**$0.00**
2.	**SPREADING AND COMPACTING OF LOW-PERMEABILITY MATERIAL**			
a	Unit labor and equipment cost for spreading [d]	116.95	$/hr	
b	Work rate required to spread one yd^3 of low-permeability material[e]	0.012	hr/yd^3	
c	Number of hours required to spread clay or other low-permeability material (multiply line 1d by line 2b)	0.0	hrs	
d	Total cost of labor and equipment for spreading clay or other low-permeability material (multiply line 2a by line 2c)	0.00	$	
e	Unit cost of labor and equipment for compacting[f]	72.30	$/hr	
f	Work rate required to compact one yd^3 of clay or other low-permeability material[g]	0.009	hr/yd^3	
g	Number of hours required for compacting low-permeability material (multiply line 1d by line 2f)	0.0	hrs	
h	Total cost of labor and equipment for compacting low-permeability material (multiply line 2e by line 2g)	0.00	$	
i	**Total Cost of Spreading and Compacting of Low Permeability Layer (add lines 2d and 2h)**			**$0.00**

CAPPING OF ACID-PRODUCING MATERIAL

(Recommended permeability of 1 x 10^{-9} m/s or less)

3.	**TESTING OF LOW PERMEABILITY LAYER**			
a	Area to be capped (from SC-2A, line 1c)	0.0	ft^2	
b	Maximum area per test for compaction[h]	**12,000**	**ft^2**	
c	Number of tests per clay lift (divide line 3a by line 3b and round up to the nearest whole number)	0		
d	Number of lifts required to construct a compacted 2-ft layer	**6**		
e	Total number of tests required (multiply line 3c by line 3d)	0		
f	Unit cost of compaction testing[i]	771.84	$/test	
g	**Total Cost to Perform Tests (multiply line 3e by line 3f)**			**$0.00**
	TOTAL COST OF INSTALLATION OF LOW PERMEABILITY LAYER (add lines 1i, 2j, and 3g)			**$0.00**

a U.S. Environmental Protection Agency, *Final Guidance Manual: Cost Estimates for Closure and Post-Closure Plans (Subparts G and H), Volume III* , EPA/530-SW-87-009, January 1987, pages 7-10. Compaction factor provided is that for off-site clay.

b R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 46, Item No. 022 216-6000. The cost is that for purchasing clay and loading it on a 12-yd^3 hauler with a 1-yd^3 shovel.

c R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 54, Item No. 022 266-1255. The cost is that for hauling material in a 20-yd^3 dump truck for a 20-mile round trip.

d R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 540, crew B-10B. Crew B-10B consists of one medium equipment operator, one laborer, and one 200-HP dozer.

e R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 46, Item No. 022 262-0010. The activity described is spreading dumped material with a 200-HP dozer.

f R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 541, Crew B-10Y. Crew B-10Y consists of one medium equipment operator, one laborer, and one vibratory drum roller.

g R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1997, pg. 40, Item No. 226-6220. Activity described is compaction with a vibrating roller, 6-inch lifts, and 4 passes per lift.

h The maximum area per test for compaction is based on professional judgement.

i R.S. Means Company, Inc., *Means Site Work and Landscape Cost Data* , 1997, pages 10-11, Item No. 108-4400, Atterberg limits, $58.00; Item No. 108-4510, hydrometer analysis, $120.00; Item No. 108-4600, washed sieve analysis, $65.00; Item No. 108-4720, density and clasification of undisturbed sample, $75.00; Item No. 108-4750, moisture content, $35.00; Item No. 108-4850, recompacted permeability, $275.00; Item No. 108-4950, Proctor compacting, 6-inch modified, $75.00; Item No. 014-108-4735, soil density testing by the nuclear method ASTM D2922-71; and Item No. 014-108-470, soil density testing by the sand cone method ASTM D15560-64. The total cost per set of tests is $771.89.

CAPPING OF ACID-PRODUCING MATERIAL

1. INSTALLATION OF GEOMEMBRANE				
a	Area of cover (from SC-2A, line 1c)	0.0	ft^2	
b	Unit cost of installation of 40-mil VFPE liner [a]	0.45	$\$/ft^2$	
c	Total cost of installation of 40-mil VFPE liner (multiply line 1a by line 1b)	0.00	**$**	
d	Cost of engineering controls, inspection, and testing (25% applied) (multiply line 3 by 0.25)[b]	0.00	**$**	
TOTAL COST OF INSTALLATION OF GEOMEMBRANE (add lines 1c and 1d)				**$0.00**

a Cost is obtained from Gundle Lining System, Inc. for 40-mil VLDPE liner and includes the cost of delivery and installation.

b Engineering controls, inspection, and testing costs typically average 25 percent of liner installation costs.

CAPPING OF ACID-PRODUCTING MATERIAL

1.	**PURCHASE AND DELIVERY OF SAND OR GRAVEL**			
a	Volume of sand or gravel required (from SC-2A, line 4c)	0.0	yd^3	
b	Compaction factor[a]	**7.5%**		
c	Volume of additional sand or gravel required (multiply line 1a by line 1b)	0.0	yd^3	
d	Total volume of sand or gravel required (add lines 1a and 1c)	0.0	yd^3	
e	Unit cost of sand or gravel [b]	9.70	$\$/yd^3$	
f	Total cost of sand or gravel (multiply line 1d by line 1e)	0.00	$	
g	Unit cost of delivery of sand or gravel [c]	11.35	$\$/yd^3$	
h	Total cost of delivery of sand or gravel (multiply line 1d by line 1g)	0.00	$	
i	**Total Cost of Purchase and Delivery of Sand or Gravel (add lines 1f and 1h)**			**$0.00**
2.	**SPREADING AND COMPACTING OF SAND OR GRAVEL LAYER**			
a	Unit labor and equipment cost for spreading of sand or gravel[d]	1.40	$\$/yd^3$	
b	Total costs of labor and equipment for spreading of sand or gravel (multiply line 1d by line 2a)	0.00	**$**	
c	Unit labor and equipment cost for compacting sand or gravel[e]	0.29	$\$/yd^3$	
d	Total costs of labor and equipment for compacting sand or gravel (multiply line 1d by line 2c)	0.00	**$**	
e	**Total Cost of Spreading and Compacting Clay Layer (add lines 2b and 2d)**			**$0.00**
3.	**PURCHASE, DELIVERY, AND INSTALLATION OF GEOTEXTILE FILTER FABRIC**			
a	Area of cover (from SC-2A, line 1d)	0.0	yd^2	
b	Unit cost of geotextile filter fabric [f]	1.60	$\$/yd^2$	
c	**Total Cost of Purchase, Delivery, and Installation of Geotextile Filter Fabric (multiply line 3a by line 3b)**			**$0.00**
4.	**PURCHASE AND DELIVERY OF DRAINAGE PIPING**			
a	Length of cover (from SC-2A, line 1a)	0.0	ft	
b	Width of cover (from SC-2A, line 1b)	0.0	ft	
c	Length of drainage pipe required (add lines 4a and 4b and multiply the sum by 2)	0.0	ft	
d	Unit cost of drainage pipe[g]	2.45	$/ft	
e	**Total Cost of Purchase and Installation of Drainage Piping (multiply line 4c by line 4d)**			**$0.00**
TOTAL COST OF INSTALLATION OF DRAINAGE LAYER (add lines 1i, 2e, 3c, and 4e)				**$0.00**

a U.S. Environmental Protection Agency, *Final Guidance Manual: Cost Estimates for Closure and Post-Closure Plans (Subparts G and H), Volume III, EPA/530-SW-87-009, January 1987, pages 7-10* . Compaction factor provided is average of compaction factor for sand, 0.10, and gravel, 0.05. The average compaction factor is calculated as follows: (0.10+0.05)/2 = 0.075.

CAPPING OF ACID-PRODUCTING MATERIAL

b R.S. Means Company, Inc., *Means Site Work and Landscape Cost Data* , 1999, pg. 45, Item No. 022 216-5000. The cost is that for purchase of select granular fill and loading it on a 12-yd^3 hauler with a 1-yd^3 bucket.

c R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 54, Item No. 022 266-1255. The cost is that for hauling material in a 20-yd^3 dump truck for a 20-mile round trip.

d R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 53, Item No. 022 262-0010. The cost is that for spreading dumped material, using a 200-HP dozer.

e R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 46, Item No. 022 226-5000. The cost is that for compaction with a riding vibrating roller, 6-inch lifts, and 2 passes per lift.

f R.S. Means Company, Inc., *Means Site Work and Landscape Cost Data* , 1999, pg. 97, Item No. 027 054-0110. The cost is that for installation of a geotextile drainage fabric in a trench, ply-bonded to a 3-dimensional nylon mat, under adverse conditions. The cost provided includes the cost of materials and two laborers.

g R.S. Means Company, Inc., *Means Site Work and Landscape Cost Data* , 1999, pg. 98, Item No. 027 111-0060. The cost is that for installation of 6-inch diameter perforated plastic tubing. The cost provided includes the cost of materials and two laborers.

CAPPING OF ACID-PRODUCING MATERIAL

1. PURCHASE AND DELIVERY OF TOPSOIL AND LIMESTONE				
a	Volume of topsoil required (from SC-2A, line 5d)	0.0	yd^3	
b	Unit cost of topsoil [a]	17.20	$\$/yd^3$	
c	Total cost of topsoil (multiply line 1a by line 1b)	0.00		
d	Unit cost of delivery of topsoil [b]	8.80	$\$/yd^3$	
e	Total of cost of delivery of topsoil (multiply line 1a by line 1d)	0.00	$	
f	Total cost of purchase and delivery of topsoil (add lines 1c and 1e)	0.00	$	
g	Total amount of limestone required (from SC-2A, line 5e)	0	lbs	
h	Unit cost of purchase and delivery of limestone[c]	0.006	$/lbs	
i	Total cost of purchase and delivery of limestone (multiply line 1g by line 1h)	0.00	$	
j	**Total Cost of Purchase and Delivery of Topsoil and Limestone (add lines 1f and 1il)**			**$0.00**
2. SPREADING OF TOPSOIL AND LIMESTONE				
a	Unit labor and equipment cost for spreading topsoil[d]	1.40	$\$/yd^3$	
b	Total costs of labor and equipment for spreading topsoil (multiply line 1d by line 2a)			**$0.00**
TOTAL COST OF INSTALLATION OF TOPSOIL AND LIMESTONE (add lines 1j and 2b)				**$0.00**

a R.S. Means Company, Inc., *Means Site Work and Landscape Cost Data* , 1999, pg. 39, Item No. 022 216-7000. The cost is that for purchase of topsoil and loading it on a 12-yd^3 hauler using a 1-yd^3 shovel.

b R.S. Means Company, Inc., *Means Site Work and Landscape Cost Data* , 1999, pg. 53, Item No. 022 266-0560. The cost is that for hauling material in a 20-yd^3 dump truck for a 20-mile round trip.

c Brent Means of Harrisburg Field Office of OSM for Remine Version V. 1.21, Pennsylvania Department of Environmental Protection. The cost is that for purchase and delivery within a 50-mile radius.

d R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1997, pg. 46, Item No. 262-0010. The cost is that for spreading dumped material, using a 200-HP dozer.

CAPPING OF ACID-PRODUCING MATERIAL

1.	**SOIL PREPARATION**			
a	Area of cover (from SC-2A, line 1c)	0	ft^2	
b	Area of cover in thousand square feet (MSF) (divide line 1a by 1,000)	0	MSF	
c	Unit labor and equipment cost [a]	34.00	$/MSF	
d	**Total Cost of Soil Preparation (multiply line 1b by line 1c)**			**$0.00**
2.	**SEEDING, FERTILIZING, AND MULCHING**			
a	Unit labor and equipment cost [b]	51.50	$/MSF	
b	**Total Cost of Seeding, Fertilizing, and Mulching (multiply line 1b by line 2a)**			**$0.00**
	TOTAL COST OF ESTABLISHMENT OF VEGETATIVE COVER (add lines 1d and 2b)			**$0.00**

a R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 125, Item No. 029 204-0100. The cost is that for soil preparation, raking of topsoil, and harley rock raking with a 48-HP backhoe loader under ideal conditions.

b R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 126, Item No. 029 308-5400. The cost is that for seeding with a utility seed mix by hydro- or air-seeding equipment, mulch and fertilizer, a hydromulcher, and a 4x2 tractor truck.

REGRADING AND BACKFILLING

1.	**VOLUME OF FILL NEEDED**			
a	Estimated total volume of cavities to be filled	**0**	**yd^3**	
b	Estimated volume of bank fill above final grade	**0**	**yd^3**	
c	If line 1a is greater than line 1b, estimated volume of suitable fill stockpiled on site	**0**	**yd^3**	
d	Total available fill on-site (add lines 1b and 1c)	0	yd^3	
e	Additional fill needed (If line 1a is greater than line 1d, subtract line 1d from line 1a)	0	yd^3	
2.	**PURCHASE AND DELIVERY OF FILL MATERIAL**			
	Skip line 2a through 2f if fill material is available on site.			
a	Additional fill required (from line 1e)	0	yd^3	
b	Unit cost of fill[a]	5.15	$/$yd^3$	
c	Total cost of fill (multiply line 2a by line 2b)	0.00	$	
d	Unit cost of delivery of fill[b]	19.00	$/$yd^3$	
e	Total cost of delivery of fill (multiply line 2a by line 2d)	0.00	$	
f	**Total Cost of Purchase and Deliver of fill (add lines 2c and 2e)**			**$0.00**
3.	**GRADING (ON-SITE CUT AND FILL AND STOCKPILED FILL)**			
a	Volume of fill on site (from line 1b) that is not stockpiled.	0	yd^3	
b	Unit costs of cutting and filling[c]	4.57	$/$yd^3$	
c	Total cost of cutting and filling (multiply line 3a by line 3b)	0.00	$	
d	Volume of fill on site (from line 1c) that is stockpiled	0	yd^3	
e	Volume of purchased fill (from line 1c)	0	yd^3	
f	Volume of stockpiled fill to be regraded (add lines 3d and 3e)	0	yd^3	
g	Unit costs of backfilling[d]	0.89	$/$yd^3$	
h	Total cost of regrading stockpiled fill (multiply line 3f by line 3g)	0.00	$	
i	**Total Cost of Regrading (add lines 3c and 3h)**			**$0.00**
4.	**SURVEYING, CLEARING, AND GRUBBING**			
a	Area to be cleared and surveyed	**0**	**acre**	
b	Daily surveying rate	**1**	**acre/day**	
c	Days required to complete survey	0	days	
d	Unit cost of clearing and grubbing[e]	5,650.00	$/day	
e	Unit cost of surveying[f]	648.36	$/acre	
f	**Total costs of surveying, clearing, and grubbing**			**$0.00**
TOTAL OF REGRADING AND BACKFILLING (add lines 2f, 3i, and 4f)				**$0.00**

a R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 45, Item No. 022 216 4000. The cost is that for borrowing, loading, and spreading of common earth with a 1-yd^3-bucket shovel.

b R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 54 Item No. 022 266 0560. The cost is that for hauling with 12 yd^3-dump truck, 20 miles round trip.

c R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 412, Item No. 12.1-214 1100. The cost is that for cutting and filling common earth, 8" lifts, with 2 passes.

d R.S. Means Company, Inc., *Heavy Construction Cost Data* , 1999, pg. 47-48, Item No. 022 208 5020 and 022 226 5000. The cost is that for backfilling common earth, 6" lifts, with 2 passes, by a 300-HP dozer and roller compactor, with a 50-ft haul.

e R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 39, Item No. 021 104 0260. The cost is that for clearing and grubbing of dense brush including stumps.

REGRADING AND BACKFILLING

f R.S. Means Company, Inc., *Environmental Remediation Data Unit Cost* , 1999, pg. 10-10, Item No. 99 24 1201. The cost is that for surveying with a two-person crew.

GROUTING AND MINE SEALS

1.	**DRILLING OF ACCESS HOLES AND GROUTING TESTS**				
a	Linear feet of access holes required (from the design for the mine seal, add the depths of all access and monitoring wells)	**0**	**lf**		
b	Number of access holes to be advanced	**0**	**ea**		
c	Number of hours required for grout testing	**0**	**hrs**		
d	Cost per linear foot of drilling, PVC casing, 10-foot sceen, bentonite seals, and plug (assume 6-inch diameter holes drilled with an air rotory drill rig)[a]	64.59	lf		
e	Total cost for drilling and installing casing, screen, and plug (multiply line 1a by line 1d).	0.00	$		
f	Unit cost of protective cover, well pad, and guard posts (assume 4 per well)[a]	639.32	$/hole		
g	Total cost of installation of protective cover, pad, and guard posts (multiply line 1b by line 1f)	0.00	$		
h	Unit cost of field testing of grout (from design plan for the mine seal)[b]	130	$/hr		
I	Total cost of grout field testing (multiply line 1c by line 1h)	0.00	$		
j	**Total Cost for Drilling of Access Holes and Grouting Tests (add lines 1e, 1g, and 1i)**			**$0.00**	
2.	**MATERIALS AND EQUIPMENT COST**				
a	Estimated total volume of void areas to be grouted (from the design plan for the mine seal)[c]	**0**	yd^3		
b	Unit cost of grouting[d]	142	$/$yd^3$		
c	Total cost of grouting (multiply line 2a by line 2b)	0.00	$		
d	Pumps and piping (assume each well is 300 feet deep)[e]	1,000	$/hole		
e	Valves (assume each well is 300 feet deep)[f]	500	$/hole		
f	Monitoring equipment (assume each well is 300 feet deep)[g]	1,500	$/hole		
g	Total cost of pumps/piping, valves, and monitoring equipment (mulitply line 1b by the sum of lines 2d through 2f)	0.00	$		
h	**Total Costs of Material and Equipment (add lines 2c and 2g)**			**$0.00**	
TOTAL COST FOR GROUTING AND INSTALLATION OF MINESEALS (add lines 1j and 2h)				**$0.00**	

[a] R.S. Means Company, Inc. and Delta Technologies Group, Inc., *The Environmental Cost Handling Options and* Solutions, *Environmental Restoration Assemblies Costbook* , 1997, page 2-6, 2-7, Item Nos. 33230203, 33230113, 33231149, 33231181, 33230303, 33231825, and 33232103.
Assume the well is PVC. The cost is that for a 10-ft well screen, a bentonite seal, and a 4-inch well plug, as well as a protective cover, a 4-ft-by-4-ft well pad, and 4 guard posts.

[b] Field testing of the grouting is required to verify the design and determine the quantities of material needed and grouting parameters.

[c] Quantities of cement and water mixture needed are determined during the field test and cannot be estimated here with any confidence.

[d] R.S. Means Company, Inc., *Means Heavy Construction Cost Data* , 1999, Item No. 022 408 0500.

[e] Length and cost of piping depends on the depth of the mine, the areas to be sealed, the head of water to be dealt with, and several other site-specific parameters.

[f] Valves (number and type) are selected according to the design of the system and the mixture to be used for sealing the mine.

GROUTING AND MINE SEALS

- Monitoring equipment to determine the effectiveness of the grouting is selected according to the type of seal, the depth of the mine, and other site-specific parameters.

STORMWATER AND RUNOFF DIVERSION

1. DRAINAGE AREA AND EXPECTED VOLUMES				
a	Maximum precipitation (assume a 24-hour storm with a probability of occurrence of once every 10 years)	**0**	**inch**	
b	Drainage basin area (multiply drainage basin area in acres by 43,560)	**0**	**ft^2**	
c	Maximum volume of water to be diverted from drainage area (divide line 1a by 12 and multiply the result by line 1b and 7.48)	0	gals	
d	Maximum rate of flow into drainage system (divide line 1c by 24 and 60)	0	gpm	
	The user may skip lines 1a through 1d if the total length of diversion ditch is already known.			
e	Total length of drainage ditch required (distance across drainage area)[a]	**0**	**ft**	
2. DRAINAGE DITCH				
a	Enter width of ditch	**0**	**ft**	
b	Enter depth of ditch	**0**	**ft**	
c	Unit cost of cutting drainage ditch[b]	5.4	$/yd^3	
d	Conversion of costs in 2c to cost per ft of drainage ditch[c]	0.00	$/ft	
e	Unit cost of purchase and spreading of blasted rock (rip rap)[d]	5.80	$/yd^3	
f	Conversion of costs in 2e to cost per ft of drainage ditch[c]	0.00	$/ft	
g	Unit cost of compaction of base and sides of drainage ditch[e]	0.29	$/yd^3	
h	Conversion of costs in 2e to cost per ft of drainage ditch[c]	0.00	$/ft	
i	Total costs per ft (add lines 2d, 2f, and 2h)	0.00	$/ft	
j	Capacity of drainage ditch (assume 1 ft/sec flow rate, multiply lines 2a and 2b, and multiply the product by 7.48 and 60)	0	gpm	
k	If line 2j is greater than 1d, determine number of drainage ditches required (divide line 1d by line 2j, round the number up)	1		
l	Total linear feet of drainage ditch required (multiply line 1e by line 2k)	0	ft	
m	**Total cost of drainage system (multiply 2i by 2l)**			**$0.00**
TOTAL COST OF STORMWATER AND RUNOFF DIVERSION (enter line 2m):				**$0.00**

a The user may skip lines 1a through 1d if the total length diversion ditch is already known.

b R.S. Means Company, Inc., *Means Heavy Construction Cost Data* , 1999, pg. 53, Item No. 022 254 0050. The cost is that for excavtion of a trench 1 to 4 feet deep with a 3/8 yd^3 tractor loader-backhoe.

STORMWATER AND RUNOFF DIVERSION

c Conversion to cost per foot is performed by multiplying the cost per cubic yard by the cross sectional area of the drainage ditch , and by one foot of drainage ditch length, then dividing the result by 27 ft^3/yd^3.

d R.S. Means Company, Inc., *Means Heavy Construction Cost Data* , 1999, pg. 48, Item No. 022 216 6010. The cost is that of the total borrowing, loading, and spreading of clay, till, or blasted rock with a 1.5-yd^3 bucket.

e R.S. Means Company, Inc., *Means Heavy Construction Cost Data* , 1999, pg. 48, Item No. 022 226 5000. The cost is that of compaction by riding with a vibrating roller with 6" lifts and 2 passes.

ALKALINE ADDITION FOR SPOILS

1.	**Characteristics of Spoil or Overburden**		
a	% Sulfur (S)	**0%**	
2.	**Estimated Quantity of Spoil for Active Mine**		
a	Spoils production rate (for active mines)	**0 tons/day**	
b	Estimated life time of mine	**0 years**	
c	Estimated quantity of spoil		0 tons
3.	**Quantity of Spoil for Abandoned Mine**		
a	Quantity of spoil	**0 tons**	
4.	**Alkaline Addition**		
	Particle size, chemical composition, and purity will significantly affect the amount of alkalinity generated and the speed of neutralization reactions. Other neutralization reagents, such as fly ash or kiln dust is also commonly used for this application.		
a	Limestone required to neutralize 1,000 tons spoil with 1% S content (Skousen)[a]		31.25 tons
b	Total theoretical quantity of limestone required in tons (divide the sum of lines 2c and 3a by 1000, multiply the quotient by lines 4a and 1a, and divide the product by 1%)		0 tons
c	Efficiency[b]	**30%**	
d	Limestone purity	**90%**	
e	Total actual limestone required in lbs (multiply line 4b by 2000 and divide the result by the product of lines 4c and 4d)		0 lbs
f	Density of limestone	**168.02 lbs/ft^3**	
g	Volume of limestone in ft^3 (divide line 4e by line 4f)		0 ft^3
h	Volume of limestone in yd^3 (divide line 4g by 27)		0 yd^3

ALKALINE ADDITION FOR SPOILS

1.	**PURCHASE AND DELIVERY OF LIMESTONE**			
a	Quantity of limestone required (from SC-6A, line 4e)	0	lbs	
b	Unit cost of purchase and delivery of limestone (50-mile radius)[a]	0.006	$/lbs	
c	**Total Cost of Purchase and Delivery of Limestone (multiply line 1a by line 1b)**			**$0.00**
2.	**LIMESTONE MIXING**			
a	Volume of limestone required (from SC-6A, line 4h)	0	yd^3	
b	Unit cost of loading by loader[b]	0.55	$/$yd^3$	
c	Unit cost of hauling to mixing zone (0.5-mile round trip)[c]	3.03	$/$yd^3$	
d	Unit cost of mixing by dozer (loading onto trucks included)[d]	2.71	$/$yd^3$	
e	Unit cost of hauling to final staging area[c]	3.03	$/$yd^3$	
f	**Total Cost of Mixing Limestone (multiply line 2a by the sum of lines 2b, 2c, 2d, and 2e))**			**$0.00**
TOTAL COST OF ALKALINE AMENDMENT (add lines 1c and 2e)				**$0.00**

Note:

Particle size, purity, and chemical composion of alkaline reagent will affect the amount of alkalinity generated and the speed of neutralization reactions.

[a] Remine Version V. 1.21. Average cost of pebble lime from Greybeck Lime (Bellefonte, PA) and Constone (Erinsburg, PA). The cost is that for purchase and delivery within a 50-mile radius.

[b] R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 45, item no. 022 216 4080. The cost is that of loading of common earth from stockpile onto trucks (use only labor and equipment cost and multiply by 1.15 to account O&P).

[c] R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 53, item no. 022 266 0320. The cost is that of hauling with a 12 yd^3 dump truck for a roundtrip of 0.5 mile.

[d] R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 48, item no. 022 238 0300. The cost is that for mixing by hydraulic, crawler mounted backhoe with a 3 yd^3 cap and adding 15% to include loading onto trucks.

3.0 ACTIVE TREATMENT

The active treatment of mine drainage is conducted through the implementation of several types of treatment processes, including chemical neutralization, oxidation, and precipitation of metals. To a great extent, active treatment techniques for mine drainage have been adapted from industrial and municipal wastewater treatment technologies and require the continuous or frequent addition of chemicals to neutralize the drainage. The methodology provides worksheets for estimating the costs of active treatment of net acidic mine drainage through the use of any of four types of neutralizing chemicals: soda ash (sodium carbonates), caustic soda (sodium hydroxide), hydrated lime (calcium hydroxide), or ammonia. The methodology also provides a worksheet for estimating the costs of the installation of an aeration tank. Such tanks can be used as an alternative for the treatment of net alkaline mine drainage (a circumstance under which the drainage contains dissolved metals but is low in oxygen content).

Selection of the chemicals to be used in an active treatment system is guided by several criteria, including the quantity and quality of the mine drainage to be treated, the location of the site, and the effluent standards to be achieved. Calcium compounds, while generally less expensive than sodium compounds, also generally dissolve at slower rates under atmospheric conditions. Calcium compounds, therefore usually are used in large treatment systems and may be used in conjunction with mixing to improve their reactivity and aeration units to improve metal precipitation. Carbonate compounds do not raise the pH of water above 8.5 and therefore are less effective for use in the removal of manganese. The use of limestone with advance aeration technique, however, has been proven to successfully remove manganese to below effluent standard (Kleinman and others, 1985).[1] Hydroxide compounds and ammonia are more effective in removing manganese from streams of mine drainage without mixing and aeration units.

Presented below are descriptions of the cost estimating worksheets to be used in determining the costs of conducting active treatment at surface mines, underground mines, and coal refuse piles:

- **Active Treatment Unit Summary** - The Active Treatment Unit Summary worksheet is used to record the costs calculated for each individual active treatment activity worksheet, apply allowances to those costs to account for engineering expenses and contingencies, and calculate the total costs of active treatment, adjusted to net present value.

- **Soda Ash (Sodium Carbonate - Na_2CO_3) Neutralization** - Soda ash neutralization generally is used when the volume of the flow of mine drainage is small and the iron content of the drainage is low. To generate a cost estimate for the activity, it is assumed that soda ash briquettes will be used. The costs of the activity include the costs of installation of a soda ash neutralization pit, the purchase and delivery of soda ash briquettes, and the installation of a clay-lined neutralization pit.

- **Caustic Soda (Sodium Hydroxide - NaOH) Neutralization** - Caustic soda is a highly effective and soluble neutralization chemical. It usually is applied in remote areas where electricity is unavailable and under conditions in which the flow of mine drainage is low and the manganese content of the drainage is high. However, caustic soda may freeze at rather mild

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[1] Kleinman and others. 1985. Treatment of Mine Water to Remove Mn. In *Proceedings on Surface Mining, Hydrology, Sedimentation, and Reclamation. Lexington, Kentucky.* pp. 173-179.

temperatures, therefore antifreeze is often added to the caustic soda solution in the winter. The worksheet provides for the costs of installing a neutralization pit and storage tank suitable for a 20-percent solution of caustic soda. The cost of the activity includes the costs of the purchase and delivery of caustic solution, the installation of a caustic soda tank that has secondary containment, and the installation of a clay-lined neutralization pit.

- **Hydrated Lime (Calcium Hydroxide - $Ca(OH)_2$) or Pebble Quicklime (Calcium Oxide - CaO) Neutralization** - Treatment with hydrated lime or pebble quicklime may be used to neutralize mine drainage and remove metals, of which iron typically is the most significant in terms of the generation and management of sludge. Hydrated lime system is particularly cost effective in large flow and high acidity drainage conditions, where a mixer or aerator is integrated into the treatment plant. Pebble quicklime has been used as neutralization reagent as well. Quicklime is very reactive and since it is in dehydrated form, it minimizes the tendency to clog the treatment system, and reagent consumption, which means less storage area required.

  The hydrated lime process is not recommended for mine drainage that has a manganese content higher than 100 milligrams per liter (mg/L). The system presented in the worksheet consists of an electrical control panel, a lime storage silo (see Figure 3-1), a volumetric screw feeder, a slurry mixing tank, a flash mix tank (where lime slurry and various flocculants are mixed with the mine drainage stream), an aerator (for oxidation of iron), and a sludge thickener or settling pond. The costs of various components of the system will vary according to the flow rate and acidity of the mine drainage stream. The worksheet reflects that relationship and will produce the most accurate results when applied to streams of mine drainage of as much as 500 gallons per minute.

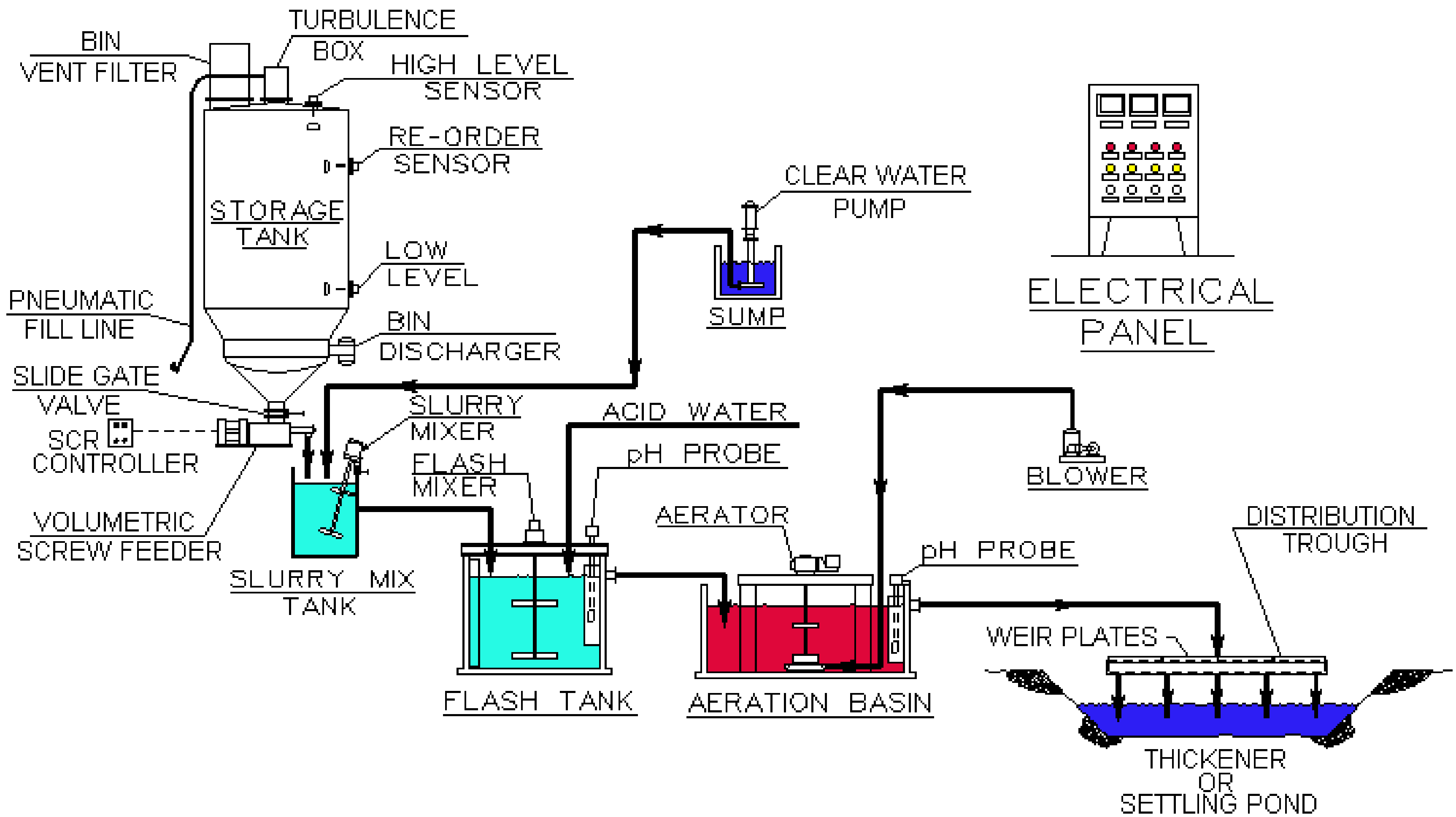
- **Ammonia Neutralization** - Ammonia is highly effective for the removal of manganese from mine drainage because it is highly soluble and can reach a pH of 9.5 or higher. The use of ammonia, however, also involves hazards associated with its handling and may entail uncertainty related to biological reactions. Additional analyses of temperature, ammonia-N, and total hot acidity at the point of discharge, as well as downstream monitoring will be required to assess the effects of the treatment on biological conditions. Because of the factors mentioned above, conformation with the state regulatory agency is required prior to construction of the system. The cost of the activity includes the costs of the installation of a reaction pit and ammonia storage tank and the purchase and delivery of liquified ammonia.

- **Aeration Basins** - Aeration can be used to precipitate metals from net alkaline mine drainage. Net alkaline mine drainage is a condition where total alkalinity is greater than total acidity. Aeration treats net alkaline mine drainage with low dissolved oxygen and high dissolved metal concentrations. The aeration process supplies the drainage with oxygen that, in turn, precipitates the metals. The cost of the activity includes the cost of the installation of a mechanical aeration system. The components of such a system include a mixing tank, a mechanical mixer, and a blower unit that supplies air.

- **Pebble Quicklime Neutralization - Aquafix System -** The Aquafix system consists of water wheel application system and quicklime storage, which can be a hopper or silo. The advantages of the Aquafix system include: (1) no electricity required to operate the system, (2) ability to manage high flow and high acidity conditions, and (3) minimum system maintenance.

Figure 3-1

Diagram of a Hydrated Lime Neutralization System



ACTIVE TREATMENT

UNIT SUMMARY WORK SHEET - Page 1 of 2

SITE NAME: ______________________

	Activity	Worksheet Number	Costs
	Capital Costs		
1.	Installation of soda ash neutralization systems	AT-2A/B	
2.	Installation of caustic soda neutralization systems	AT-3A/B	
3.	Installation of hydrated lime neutralization systems	AT-4	
4.	Installation of ammonia neutralization systems	AT-5A/B	
5.	Installation of aeration basins	AT-6A/B	
6.	Installation of Aquafix - pebble quicklime neutralization systems	AT-7	
7.	Installation of ponds (storage, equalization, settling, and sludge drying ponds or beds)	GTU-1A/B	
8.	Installation of clarifiers	GTU-2A/B	
9.	Installation of rock drains (riprapped channel)	GTU-3A/B	
10.	Installation of filter fields	GTU-4A/B	
11.	Installation of limestone channels	GTU-5A/B/C	
12.	Installation of infiltration galleries	DM-1A/B	
13.	Installation of irrigation application systems	DM-2A/B	
14.	Installation of piping systems	DM-3	
15.	Land access	SW-1	
16.	Installation of monitoring wells	SW-2	
17.	Site security	SW-3	
18.	Access roads	SW-4	
19.	**Subtotal of Capital Costs (add lines 1 through 18)**		**$ -**
	FOR EXISTING TREATMENT SYSTEM, LINE 19 IS NOT INCLUDED IN THE TOTAL NET PRESENT WORTH CALCULATION.		
	Annual Operating Costs		
20.	Chemical consumption and replacement	OP-1	
21.	System maintenance (enter amount from line 1.c of worksheet OP-2)	OP-2	
22.	Electricity	OP-3	
23.	Sludge removal	OP-4	
24.	Sampling and analysis	OP-5	
25.	**Subtotal of Annual Operating Costs (add lines 20 through 25)**		**$ -**

SITE NAME: ______________________

	Activity	Worksheet Number	Cost
	Allowances and Contingencies		
26.	Allowance for engineering expenses[a]	**16%**	
27.	Allowance for engineering expenses for capital costs (multiply line 19 by line 26)	$ -	
28.	Capital costs adjusted for allowance for engineering expenses (add lines 19 and 27)	$ -	
29.	Allowance for contingencies[b]	**20%**	
30.	Allowance for contingencies for capital costs (multiply line 28 by line 29)	$ -	
31.	Allowance for contingencies for annual operating costs (multiply line 25 by line 29)	$ -	
32.	**Capital Costs Adjusted for Allowances for Engineering Expenses and Contingencies (add lines 27 and 29)**		**$ -**
33.	**Annual operating costs adjusted for allowance for contingencies (add lines 25 and 31)**		**$ -**
	Net Present Value Calculation		
34.	Number of years the system will remain in operation ***(n)***	**0**	
35.	Expected annual inflation rate (%)	**0.0**	
36.	Estimated annual discount rate (%)	**0.0**	
37.	Net discount rate (subtract line 35 from line 36) ***(i)***	**0.0**	
38.	Net present value multiplier, equal to $\frac{1-(1+i)^{-n}}{i}$	0.00	
39.	**Net Present Value of Annual Operating Costs over Life of System (multiply line 33 by line 38)**		**$ -**
TOTAL COST OF ACTIVE TREATMENT ADJUSTED TO NET PRESENT VALUE (add lines 32 and 39)			**$ -**

[a] R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , back cover. Factors range from 11 to 16 percent and include costs of engineering and logistical support and staff requirements.

[b] In accordance with standard engineering practices, a factor of 20 percent is applied to the cost of active treatment to account for contingencies and unforeseen expenses.

SODA ASH (SODIUM CARBONATE) NEUTRALIZATION

1. CONSUMPTION OF SODA ASH (SODIUM CARBONATE)			
	Assume that soda ash briquettes will be used.		
a	Design flow rate	**0.0 gpm**	
b	Total acidity of mine drainage acidity	**0.0 mg/L as $CaCO_3$**	
c	Molar acid equivalents loading (multiply line 1a times 3.785 L/gal, times line 1b, times 0.01 mole $CaCO_3$/g $CaCO_3$, times 0.001 g/mg, times 512,640 min/year)		0 equivalents of acid/year
d	Theoretical amount of soda ash needed per equivalent of acid[a]		0.389 lb/equivalent
e	Factor to account for excess alkalinity required in the effluent (20 to 30% - OSM)	**0%**	
f	Actual annual amount of soda ash needed (add line 1e to 1, multiply the result by line 1c and by line 1d)		0 lbs
g	Density of soda ash briquettes	**157.05 lb/ft^3**	
h	Annual volume of soda ash briquettes (divide line 1f by line 1g and y 27)		0 yd^3
2. REACTION POND			
	Reaction pond is assumed to be a small circular pond with the bottom diameter equal to its depth. Alternate setups are possible.		
a	Porosity of soda ash briquettes (professional judgement)	**40%**	
b	Actual volume of reaction pond required (divide line 1h by line 1a)		0 yd^3
c	Side wall slope (S)	**0.5 ft rise /ft run**	
d	Depth of open pit (d); calculate as $2\left[\sqrt[3]{\frac{V}{p\left(1+2/S^2\right)}}\right]$		0 ft
e	Surface area of open pit; calculate as $2p\left(0.5d + d\sqrt{\frac{1+S^2}{S^2}}\right)$		0 ft^2
f	Depth of excavation (add lines 2d, 3a, and 3b)		0 ft
g	Excavation volume; calculate as $\frac{p\,d^3}{4S^2}$ (then divide by 27 to yield cubic yard)		0 yd^3
h	Excavation footprint; calculate as $dp\left(\frac{S+2}{S}\right)$		0 ft^2

SODA ASH (SODIUM CARBONATE) NEUTRALIZATION

3. LINER			
a	Thickness of clay liner (a minimum of 0.5 ft)	**0 ft**	
b	Thickness of liner cover	**0 ft**	
c	Surface area of reaction pond (line 2e)		0 ft^2
d	Volume of clay compacted (multiply line 3a by line 3c and divide by 27)		0 yd^3
e	Swelling factor[b]	**40%**	
f	Volume of clay required (add 100% to the percentage in line 3e and multiply that percentage by line 3d)		0 yd^3
g	Volume of liner cover (multiply line 3b and 3c and divide by 27)		0 yd^3
h	Include synthetic liner? (Y or N)	**Y**	
i	Surface area of synthetic liner (multiply line 2e by 1.25, a factor that accounts for liner anchor)		0 ft^2
4. SITE WORK REQUIREMENT			
a	Volume to be excavated (Line 2g)		0 yd^3
b	Multiplier for clearing and grubbing (professional judgement: 200% for small site and 25% for regular site)	**200%**	
c	Area to be cleared in ft^2 (multiply line 2h by line 4b)		0 ft^2
d	Area to be cleared in acres (divide line 4c by 43,560)		0 acres
e	Area to be surveyed (equal to line 4c)		0.00 acres
f	Survey rate	**1 acre/day**	
g	Days required to conduct survey (multiply line 4e by line 4f)		0.00 days

[a] 106 g/mole*1 mole/mole /.6 efficiency / 1000g/kg * 2.2 lb/kg

[b] U.S. Environmental Protection Agency, *Final Guidance Manual*: *Cost Estimates for Closure and Post-Closure Plans (Subparts G and H),* January 1987, EPA/530-SW-87-009, Volume III, pg. 7-10. Compaction factor provided is for off-site clay.

SODA ASH (SODIUM CARBONATE) NEUTRALIZATION

1.	**EXCAVATE REACTION PIT**			
a	Volume to be excavated (from AT-2A, line 4a)	0	yd^3	
b	Excavation footprint (from AT-2A, line 4c)	0	ft^2	
c	Unit cost of clearing and grubbing[a]	0.380	$\$/ft^2$	
d	**Total cost of clearing and grubbing (multiply line 1b by line 1c)**	**0.00**	**$**	
e	Unit cost of excavation[b]	4.330	$\$/yd^3$	
f	**Total cost of excavation (multiply line 1a by line 1e)**	**0.00**	**$**	
g	**Total Cost to Excavate Reaction Pit (add lines 1d and 1f)**			**$0.00**
2.	**LINE PIT**			
a	Volume of clay required (from AT-2a, line 3f)	0	yd^3	
b	Unit cost of purchase and placement of clay[c]	17.28	$\$/yd^3$	
c	**Total cost of clay liner (multiply line 2a by line 2b)**	**0.00**	**$**	
d	Volume of liner cover (from AT-2a, line 3g)	0	yd^3	
e	Unit cost of purchase and placement of liner cover[d]	6.57	$\$/yd^3$	
f	**Total cost for liner cover (multiply line 2d by line 2e)**	**0.00**	**$**	
g	Include synthetic liner? (Y or N)	**Y**		
h	Surface area of synthetic liner (from AT-2A, line 3i)	0	ft^2	
i	Unit cost of purchase and placement of synthetic liner[e]	1.73	$\$/ft^2$	
j	**Total cost of synthetic liner (multiply line 2h by line 2i)**	**0.00**	**$**	
k	**Total Cost to Line Reaction Pit (add lines 2c, 2f, and 2j)**			**$0.00**
3.	**FILL PIT WITH SODA ASH BRIQUETTES**			
a	Quantity of soda ash for one year (from AT-2a, line 1f)	0	lbs	
b	Unit cost of purchase and delivery of soda ash briquettes[f]	0.140	$/lb	
c	Unit cost of filling and spreading by dozer[g]	0.0003	$/lb	
c	**Total Cost of Purchase and Delivery of a One Year Supply of Neutralization Chemical (add lines 3b and 3c, and multiply the result by line 3a)**			**$0.00**
TOTAL COST OF SODA ASH NEUTRALIZATION SYSTEM (add lines 1g, 2k, and 3c)				**$0.00**

a R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 4-1 & 4-9, Item No. 17 01 0103 and 17 03 0101. The cost is that for medium brush with average grub and some trees, clearing, and rough grading with a D6 dozer.

b R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 4-15, Item No. 17 03 0276. The cost is that for excavation with a 1-yd^3 crawler-mounted, hydraulic excavator.

c R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 9-78, Item No. 33 08 0507. The cost is that for construction of a clay liner of 10e-7 conductivity, with 6" lifts, and purchase and delivery of clay material from an off-site location.

d R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 4-23, Item No. 17 03 0422. The cost is that for unclassified fill, 6" lifts, on-site with spreading and compaction.

e R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 9-81, Item No. 33 08 0572. The cost is that for purchase, delivery, and installation of a 60 mil polymeric HDPE liner.

SODA ASH (SODIUM CARBONATE) NEUTRALIZATION

f Remine Version V. 1.21. Unit cost of caustic soda was obtained from Midstate Chemical, Pennsylvania. The cost is that for purchase and delivery within a 50-mile radius.

g R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 53, Item No. 022 262 0010. The cost is that of spreading dumped material by dozer with no compaction.

CAUSTIC SODA (SODIUM HYDROXIDE) NEUTRALIZATION

1. CONSUMPTION OF CAUSTIC SODA			
Assume that 20% caustic soda solution will be used.			
a	Design flow rate	**0.0 gpm**	
b	Total mine drainage acidity	**0.0 mg/L as $CaCO_3$**	
c	Molar acid equivalents loading (multiply line 1a times 3.785 L/gal, times line 1b, times 0.01 mole $CaCO_3$/g $CaCO_3$, times 0.001 g/mg, times 512,640 min/year)		0 equivalents of acid/year
d	Theoretical amount of caustic soda needed per equivalent of acid[a]		0.176 lb/equivalent
e	Factor to account for excess alkalinity required in the effluent (20 to 30% - OSM)	**0%**	
f	Actual annual amount of caustic soda needed (add 1 to line 1e, multiply the result by lines 1c and 1d, and divide the product by 2,000)		0 tons
g	Volume of caustic (multiply 1f by 5 and divide the product by .00417 tons/gal)		0 gallons
h	Density of caustic soda (solid)	**1.83 lbs/gallon**	
i	Amount of caustic soda needed per year (multiply line 1g by line 1h)		0 lbs
2. CHEMICAL STORAGE TANK			
a	Frequency of delivery of chemical	**12 per year**	
b	Maximum tank capacity (default)	**2,500 gallons**	
c	Number of tanks (divide line 1g by the product of lines 2a and 2b)		0 ea

CAUSTIC SODA (SODIUM HYDROXIDE) NEUTRALIZATION

3. REACTION PIT			
	Note: Reaction pit is assumed to be a sloped-walled circular pit with a bottom diameter equal to its depth.		
a	Design retention time	**0 hr**	
b	Volume of open pit required (multiply line 1a by line 3a and multiply by 60 min/hr and 0.00495 yd^3/gal)		0 yd^3
c	Porosity of soda ash briquettes	**40.00 %**	
d	Actual volume of open pit required (divide line 3b by [line 3c/100]) (*V*)		0 yd^3
e	Side wall slope (*S*)	**0.5 ft rise /ft run**	
f	Depth of open pit; calculate as (*d*) $2\left[\sqrt[3]{\frac{V}{p\left(1+\frac{2}{S^2}\right)}}\right]$		0 ft
g	Surface area of open pit; calculate as $2p\left(0.5d + d\sqrt{\frac{1+S^2}{S^2}}\right)$		0 ft^2
h	Depth of excavation (add lines 3f, 4a, and 4b)		0 ft
i	Volume to be excavated; calculate as $\frac{p\,d^3}{4S^2}$		0 yd^3
j	Excavation footprint; calculate as $dp\left(\frac{S+2}{S}\right)$		0 ft^2
4. REQUIREMENT OF LINER			
a	Thickness of clay layer	**0 ft**	
b	Thickness of liner cover	**0 ft**	
c	Surface area of open pit (line 3g)		0 ft^2
d	Volume of compacted clay (multiply line 4a by line 4c and divide by 27)		0 yd^3
e	Swelling factor [b]	**40%**	
f	Volume of clay required (add 100% to the percentage in line 4e and multiply that percentage by line 4d)		0 yd^3
g	Volume of liner cover (multiply line 4b by line 4c and divide by 27)		0 yd^3
h	Include synthetic liner? (Y or N)	**Y**	
i	Surface area of synthetic liner (multiply line 3g by 1.25, a factor that accounts for liner anchor)		0 ft^2
5. SITE WORK REQUIREMENT			
a	Volume to be excavated (line 3i)		0 yd^3
b	Multiplier for clearing and grubbing	**200%**	
c	Area to be cleared in ft^2 (multiply line 5a by line 5b)		0 ft^2
d	Area to be cleared in acres (divide line 5c by 43,560)		0 acres
e	Area to be surveyed (equal to line 5d)		0.00 acres
f	Survey rate	**1 acre/day**	
g	Survey duration (multiply lines 5e and 5g)		0.00 days

a 40 g/mole*2 mole/mole / 1 efficiency / 1000g/kg * 2.2 lb/kg

b U.S. Environmental Protection Agency, *Final Guidance Manual. Cost Estimates for Closure and Post- Closure Plans (Subparts G and H).* January 1987. EPA/530-SW-87-009. Volume III. pg. 7-10.

CAUSTIC SODA (SODIUM HYDROXIDE) NEUTRALIZATION

1.	**EXCAVATE REACTION PIT**				
	a	Volume of excavation (from AT-3A, line 5a)	0	yd^3	
	b	Excavation footprint (from AT-3A, line 3j)	0	ft^2	
	c	Unit cost of clearing and grubbing[a]	0.380	$\$/ft^2$	
	d	**Total cost for clearing and grubbing (multiply line 1b by line 1c)**	**0.00**	**$**	
	e	Unit cost of excavation[b]	4.330	$\$/yd^3$	
	f	**Total cost for excavation (multiply line 1a by line 1e)**	**0.00**	**$**	
	g	**Total Cost to Excavate Reaction Pit (add lines 1d and 1f)**			**$0.00**
2.	**LINE PIT**				
	a	Volume of clay required (from AT-3A, line 4f)	0	yd^3	
	b	Unit cost for purchase and placement of clay[c]	17.28	$\$/yd^3$	
	c	**Total cost of clay liner (multiply line 2a by line 2b)**	**0.00**	**$**	
	d	Volume of liner cover (from AT-3A, line 4g)	0	yd^3	
	e	Unit cost for purchase and placement of liner cover[d]	6.57	$\$/yd^3$	
	f	**Total cost of liner cover (multiply line 2d by line 2e)**	**0.00**	**$**	
	g	Include synthetic liner? (Y or N)	Y		
	h	Surface area of synthetic liner (from AT-3A, line 2i)	0	ft^2	
	i	Unit cost for purchase and placement of synthetic liner[e]	1.73	$\$/ft^2$	
	j	**Total cost of synthetic liner (multiply line 2h by line 2i)**	**0.00**	**$**	
	k	**Total Cost to Line Reaction Pit (add lines 2c, 2f, and 2j)**			**$0.00**
3.	**INSTALLATION OF CAUSTIC TANK**				
	Assume a 2,500-gallon Nalgene tank will be used. User may also specify another type of tank including lined metal tank.				
	a	Quantity of tanks	0	**ea**	
	b	Unit cost of purchase, delivery, and installation of tank[f]	3,364	$/ea	
	c	**Total Cost of Purchase, Delivery, and Installation of Caustic Storage Tank (multiply line 3a by line 3b)**			**$0.00**
4.	**PURCHASE AND DELIVERY OF CAUSTIC SODA**				
	a	Quantity of caustic soda per year (From AT-3A, line 1i)	0	**lbs**	
	b	Unit cost of purchase and delivery of 20% solution of caustic soda[g]	**0.15**	**$/lbs**	
	c	**Total Annual Cost of Purchase and Delivery of Caustic Soda (multiply line 4a by line 4b)**			**$0.00**
5.	**PIPING AND INSTRUMENTATION**				
	a	Allowance factor for piping and instrumentation (of tank installation)[h]	**100%**		
	b	**Total Cost of Piping and Instrumentation (multiply line 3c by line 5a)**			**$0.00**

CAUSTIC SODA (SODIUM HYDROXIDE) NEUTRALIZATION

6.	**SECONDARY CONTAINMENT AND FOUNDATION**			
a	Allowance factor for piping and instrumentation (of tank installation)[h]	**100%**		
b	**Total Cost of Secondary Containment and Foundation (multiply line 3c by line 6a)**			**$0.00**
TOTAL COST OF CAUSTIC NEUTRALIZATION SYSTEM (add lines 1g, 2k, 3c, 4c, 5b, and 6b)				**$0.00**

a R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 4-1 & 4-9, Item No. 17 01 0103 and 17 03 0101. The cost is that for medium brush with average grub and some trees, clearing, and rough grading using a D6 dozer.

b R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 4-15, Item No. 17 03 0276. The cost is that for excavation using a 1 yd^3 crawler-mounted, hydraulic excavator.

c R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 9-78, Item No. 33 08 0507. The cost is that for construction of clay liner 10e-7 conductivity with 6" lifts, and purchase and delivery of clay material from off-site location.

d R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 4-23, Item No. 17 03 0422. The cost is that for unclassified fill, 6" lifts, on-site with spreading and compaction.

e R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 9-81, Item No. 33 08 0572. The cost is that for purchase, delivery, and installation of a 60 mil polymeric HDPE liner.

f R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 6-34, Item No. 19 04 0425. The cost is that for purchase, delivery, and installation of a 2,500-gallon Nalgene horizontal XLPE tank without legs.

g Remine Version V. 1.21. Unit cost of caustic soda was obtained from Midstate Chemical, Pennsylvania. The cost is that for purchase and delivery within a 50-mile radius.

h This cost is based on engineering judgment.

HYDRATED LIME OR PEBBLE QUICKLIME NEUTRALIZATION

1. HYDRATED LIME OR PEBBLE QUICKLIME CONSUMPTION			
a	Design flow rate	**0**	**gpm**
b	Total mine drainage acidity	**0**	**mg/L as $CaCO_3$**
c	Molar acid equivalents loading (line 1a times 3.785 L/gal, times line 1b, times 0.01 mole $CaCO_3$/g $CaCO_3$, times 0.001 g/mg, times 512,640 min/year, and divide by 0.9 (hydrated lime and pebble quicklime efficiency))	0	equivalents of acid/year
d	Select neutralization chemical:		
	1. Hydrated lime ($Ca(OH)_2$)	**N**	
	2. Pebble quicklime (CaO)	**N**	
FOR HYDRATED LIME NEUTRALIZATION:			
d	Amount of hydrated lime needed per equivalent of acid[a]	**0.163**	**lbs/equivalent**
e	Theoretical amount of hydrated lime needed annually (multiply line 1c by line 1d, divide the product by 2,000)	0	tons
f	Purity	**90%**	
g	Factor to account for excess alkalinity required in the effluent (20 to 30% OSM)	**30%**	
h	Actual amount of hydrated lime needed annually (divide line 1e by line 1f, and multiply the result by (1 + line 1h))	0	tons
FOR PEBBLE QUICKLIME NEUTRALIZATION:			
i	Amount of pebble quicklime needed per equivalent of acid[b]	**0.137**	**lbs/equivalent**
j	Theoretical amount of pebble quicklime needed annually (multiply line 1c by line 1i, divide the product by 2,000)	0	tons
k	Purity	**90%**	
l	Factor to account for excess alkalinity required in the effluent (20 to 30% OSM)	**30%**	
m	Actual amount of pebble quicklime needed annually (divide line 1j by line 1k, and multiply the result by (1 + line 1l))	0	tons

HYDRATED LIME OR PEBBLE QUICKLIME NEUTRALIZATION

2.	**PURCHASE, DELIVERY, AND INSTALLATION OF SILO AND SLURRY MIX ASSEMBLIES**			
a	Frequency of delivery of chemical	**12**	**deliveries/yr**	
b	Minimum storage capacity required (divide 1h by line 2a for hydrated lime system or divide line 1m by line 2a for pebble quicklime system)	0	tons	
c	Number of 35-ton silos	**0**	**ea**	
d	Unit cost of 35-ton silo[c]	63,000	$/ea	
e	Number of 20-ton silos	**0**	**ea**	
f	Unit cost of 20-ton silo[c]	55,000	$/ea	
g	Number of 10-ton silos	**0**	**ea**	
h	Unit cost of 10-ton silo[c]	50,000	$/ea	
i	Total cost of silos (multiply line 2c by line 2d, multiply line 2e by line 2f, multiply line 2g by line 2h, and add the products)	0.00	$	
j	Add $6,000 for slurry mix tank assembly with slurry mixer[d]	0.00	$	
k	**Total Cost of Silos and Slurry Mix Tank Assembly (add 2i and 2j)**			**$0.00**
3.	**PURCHASE, DELIVERY, AND INSTALLATION OF FLASH TANK, AERATION BASIN, THICKNENER/CLARIFIER, AND ELECTRICAL PANEL[c]**			
a	Design flow rate	**0**	**gpm**	
b	Enter volume of flash tank: 500 gals. if line 1a is <50gpm; 2,500 gals. if line 1a is 50 to 250 gpm; 10,000 gals. if line 1a is >250 and < 500 gpm	**0**	**gal**	
c	Enter cost of flash tank: $20,000 if line 2b is 500 gals.; $27,000 if line 2b is 2,500 gals.; $35,000 if line 2b is 10,000 gals.	0.00	$	
d	Enter cost of aeration basin assembly: $27,000 if line 2b is 500 gals.; $50,000 if line 2b is 2,500 gals.; $65,000 if line 2b is10,000 gals.	0.00	$	
e	Enter cost of electrical panel assembly: $13,000 if line 2b is 500 gals.; $17,000 if line 2b is 2,500 gals.; $24,000 if line 2b is 10,000 gals.	0.00	$	
f	Included thickener? (Y or N)	**N**		
	Enter cost of thickener with weir plates and trough assembly: $130,000 if line 2b is 500 or 2,500 gals.; $300,000 if line 2b is 10,000 gals.	0.00	$	
g	**Total Cost of Purchase, Delivery, and Installation of Flash Tank, Aeration Basin, Thickener/Clarifier, and Electrical Panel (add lines 3c through 3f)**			**$0.00**
	TOTAL COST OF INSTALLATION OF HYDRATED LIME OR PEBBLE QUICKLIME NEUTRALIZATION (add lines 2k and 3g)			**$0.00**

a 74 g/mole*1 mole/mole /.95 efficiency / 1000g/kg * 2.2 lb/kg

b 56 g/mole*1 mole/mole /.90 efficiency / 1000g/kg * 2.2 lb/kg

HYDRATED LIME OR PEBBLE QUICKLIME NEUTRALIZATION

c 1999 Vendor quote obtained from Slogan Systems includes purchace, delivery, and installation of silo and all ancillary items (including bin, vent filter, turbulence box, high-level sensor, reorder sensor, low-level sensor, pneumatic fill line, bin discharger, slide gate valve SCR controller, and volumetric screw feeder.)

d Vendor quote obtained from Slogan Systems, 300 Mt. Lebanon Blvd., Pittsburgh, Pennsylvania, (412) 563-3947.

AMMONIA NEUTRALIZATION

1.	**AMD CHARACTERISTICS**		
a	Total mine drainage acidity	**0 mg/L**	
b	Design flow rate	**0 gpm**	
c	MACID/minute (multiply line 1a by line 1b times 3.785, and divide the product by 100,000)[a]		0.0000
2.	**AMMONIA CONSUMPTION**		
a	Molecular weight of ammonia	17 g/mol	
b	Theoretical requirement for ammonia in lbs/min[b]		0.0000 lbs/min
c	Theoretical requirement for ammonia in lbs/day (multiply line 2b by 1,440 min/day)		0.00 lbs/day
d	Efficiency[c]	**100%**	
e	Factor to account for excess alkalinity required in the effluent (20 to 30% - OSM)	**0%**	
f	Actual requirement for ammonia (multiply line 2c by addition of 1 and line 2e, and divide the product by line 2d)		0 lbs/day
g	Density of ammonia	**37.02 lbs/ft^3**	
h	Volume of ammonia (divide line 2f by line 2g)		0 ft^3/day
i	Volume of ammonia (multiply line 2h by 7.481)		0.00 gals/day
3.	**AMMONIA TANK REQUIREMENT**		
	Note: Tank is assumed to be a horizontal double-wall steel tank. To simplify calculations, assume the volume is equal to that of a cylinder		
a	Holding time	**0 days**	
b	Capacity of tank (multiply line 2h by line 3a)		0 gals
c	Design safety factor	**15%**	
d	Actual capacity of tank (add 100% to the percentage in line 3C and multiply that percentage by line 3b)		0 gals
e	Volume of tank (divide line 3d by 7.481)		0 ft^3
f	Diameter of tank	**4 ft**	
g	Length of tank (divide line 3e by 3.1415 times the square of line 3f divided by 2)		0 ft
h	Foundation area		0 ft^2
I	Quantity of ammonia required (multiply line 3e by line 2f)		0 lbs

AMMONIA NEUTRALIZATION

4.	**DIMENSION OF REACTION CHAMBER OR TANK**		
	Reaction chamber, a fiber glass tank with a mixer, is assumed to be used to present worst-case scenario. User may also use a small pond as the reaction pit. If this is the case, skip lines 4a through 6f and use GTU-1A/B to estimate the installation cost of ponds.		
a	Contact or residence time	**0 minutes**	
b	Diameter	**0 ft**	
c	Volume of chamber in gals (multiply line 1b and by line 4a)		0 gals
d	Volume of chamber in ft^3 (divide line 4c by 7.481)		0 ft^3
e	Chamber of cross section of (equal to area of a circle having the diameter of line 4b)		0 ft^2
f	Height of chamber (divide line 4d by line 4d)		0 ft
5.	**STRUCTURAL CONCRETE SLAB**		
a	Thickness of foundation	**0 ft**	
b	Surface area of foundation (add lines 3h and 4e)		0 ft^3
c	Volume of concrete required (multiply line 5a by line 5b divide by 27)		0 yd^3
6.	**SECONDARY CONTAINMENT BERM**		
a	Height of berm	**0 ft**	
b	Thickness of berm	**0 ft**	
c	Perimeter of containment for ammonia tank (multiply line 3f by line 3g and by 2)		0 ft
d	Perimeter of containment for reaction tank (multiply line 4b by 4)		0 ft
e	Volume of concrete required for secondary containment berm (multiply lines 6a, 6b, and the sum of lines 6c and 6d)		0 ft^3
f	Volume of concrete required for berm (divide line 6e by 27)		0 yd^3
7.	**SITE WORK INFORMATION**		
a	Volume to be excavated (multiply line 5a by the sum of lines 4d and 5b and divide the product by 27)		0 yd^3
b	Multiplier for clearing and grubbing (default)	**200%**	
c	Area to be cleared (divide the sum of lines 4d and 5b by 43,560 and multiply the quotient by line 7b)		0.00 acres
d	Area to be surveyed (equal to line 6c)		0 acres
e	Survey rate	**1 acre/day**	
f	Days required to conduct survey (multiply line 6d by line 6e)		0 days

[a] MACID is number of moles of $CaCO_3$ equivalent acidity
Volume in above equation must be in liters

$$MACID = \frac{AcidityxVolume}{100{,}000}$$

(Skousen and others. 1996. Acid Mine Drainage Control and Treatment, Second Edition. West Virginia University. Pg. 159)

[b] Calculated using the following equation:
(Line 1c x Line 2a x 2.2)/1000

[c] Skousen and others. 1996. Acid Mine Drainage Control and Treatment. Second Edition. West Virginia University. Pg. 238.

AMMONIA NEUTRALIZATION

1.	**SURVEY**				
a	Unit cost to survey[a]	648.36	$/day		
b	Days required to conduct survey (from AT-5A, line 7f)	0	days		
c	**Total Cost to Survey (multiply line 1a by line 1b)**				**$0.00**
2.	**CLEARING AND GRUBBING**				
a	Unit cost to clear and grub[b]	5,650.00	$/acre		
b	Area to be cleared and grubbed (from AT-5A, line 7d)	0	acres		
c	**Total Cost to Clear and Grub**				**$0.00**
4.	**PURCHASE AND DELIVERY OF AMMONIA**				
a	Quantity of ammonia (from AT-5A, line 3I)	0	lbs		
b	Unit cost of purchase and delivery (within 50-mile radius)[c]	0.28	$/lbs		
c	**Total Cost to Purchase and Deliver Ammonia (multiply line 4a by line 4b)**				**$0.00**
5.	**PURCHASE AND DELIVERY OF AMMONIA TANK**				
a	Quantity of tanks	**0**	**ea**		
b	Capacity of tank (from AT-5A, line 3d)	0	gals		
c	Unit cost of purchase and delivery of steel tank (select the cost from the following options)[d]	0.00	$/ea		
	1. 550-gallon double wall steel tank	1,493.00	$/ea		
	2. 1,000-gallon double-wall steel tank	2,028.00	$/ea		
	3. 2,000-gallon double-wall steel tank	3,126.00	$/ea		
	4. 3,000-gallon double-wall steel tank	4,212.00	$/ea		
d	**Total Cost to Purchase and Deliver Ammonia Tank (multiply line 5a by line 5c)**				**$0.00**
6.	**PURCHASE AND DELIVERY OF REACTION CHAMBER OR TANK**				
a	Capacity of individual tank (more than 1 tank in parallel might be required)	1,500	gals		
b	Total chamber capacity of tanks (from AT-5A, line 4c)	0	gals		
c	Number of chambers	**0**	**ea**		
d	Unit cost to purchase and deliver fiber glass reaction chamber (select the cost from the following options)[e]				
	1. 550-gallon single-wallled fiberglass tank	4,214.00	$/ea		
	2. 1,000-gallon single-walled fiberglass tank	5,647.00	$/ea		
	3. 2,000-gallon single-walled fiberglass tank	9,824.00	$/ea		
	4. 3,000-gallon single-walled fiberglass tank	12,830.00	$/ea		
e	**Total Cost to Purchase and Deliver Reaction Chamber or Tank (multiply line 6a and by line 6d)**				**$0.00**
7.	**PURCHASE, DELIVERY, AND INSTALLATION OF MIXER**				
a	Quantity of mixers (one mixer per reaction chamber or tank) - (from line 6c)	0	ea		
b	Cost of 2-HP, single-propeller, 6.5"-diameter mixer[f]	2,551.00	$/ea		
c	**Total Cost to Install Mixer (multiply line 7a by line 7b)**				**$0.00**
8.	**INSTALLATION, PIPING, AND INSTRUMENTATION**				
a	Allowance for installation, piping, and instrumentation[g]	**50%**			
b	**Total Cost to Install Tank, Piping, and Instrumentation (multiply line 8a by the sum of lines 5d and 6e)**				**$0.00**

AMMONIA NEUTRALIZATION

9.	**CONCRETE WORKS**			
a	Volume of ready mix concrete (from AT-5A, the sum of lines 5c and 6 f)	0	yd^3	
b	Unit cost of purchase and delivery of ready mix concrete, 8,000 psi[h]	138.00	$\$/yd^3$	
c	Unit cost of placement concrete, pumped[i]	20.50	$\$/yd^3$	
d	**Total Cost to Purchase, Deliver, and Place Concrete (multiply line 9a by the sum of lines 9b and 9c)**			**$0.00**
e	Quantity of reinforcing steel and WWF (from GTU-2A, the sum of lines 5c and 6a, divided by 100)	0	$c.ft^2$	
f	Unit cost of reinforcing steel and WWF[j]	64.50	$\$/c.ft^2$	
e	**Total Cost of concrete works (multiply line 9e by line 9f)**			**$0.00**
10.	**EXCAVATION, BACKFILLING, AND COMPACTION**			
a	Volume to be excavated (from AT-5A, line 7a)	0	yd^3	
b	Unit cost to excavate[k]	4.33	$\$/yd^3$	
c	Unit cost of spreading and backfilling by dozer[l]	1.40	$\$/yd^3$	
d	Unit cost of compacting backfill material[m]	1.18	$\$/yd^3$	
e	Unit cost of compaction testing by nuclear method[n]	0.77	$\$/yd^3$	
f	Cost of compaction testing by sand cone method[o]	0.30	$\$/yd^3$	
g	**Total Cost of Excavation, Backfilling, and Compaction (multiply line 10a by the sum of lines 10b through 10f)**			**$0.00**
	TOTAL AMMONIA NEUTRALIZATION INSTALLATION (add lines 1c, 2c, 4c, 5d, 6e, 7c, 8b, 9e, and 10g)			**$0.00**

a R.S. Means Company, Inc., *Environmental Remediation Data Unit Cost* , 1999, pg. 10-10, Item No. 99 24 1201. The cost is that for surveying with a two-person crew.

b R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 39, item no. 021 104 0260. The cost is that for clearing and grubbing of dense brush, including stumps.

c Remine Version V. 1.21. The cost of ammonia was obtained from Mid State Chemical, Pennsylvania.

d R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 9-99, Items No. 33 10 9730 through 9733. The cost is that for purchase and delivery of a 550- to 3,000-gallon double-walled steel aboveground tank within a 50-mile radius.

e R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 9-100, Item No. 33 10 9740 through 9743. The cost is that for purchase and delivery of a 550- to 3,000-gallon single-walled fiber glass aboveground tank.

f R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 9-118, Item No. 33 13 0421. The cost is that for purchase and delivery of a 2-HP, single-propeller 6.5"-diameter mixer.

g This cost is based on engineering judgment.

h R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 206, Item No. 033 126 0412. The cost is that for the purchase and delivery of regular weight, 8,000-psi, ready-mix concrete.

I R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 209, Item No. 033 172 2950. The cost is that for the placement and vibrating of concrete, including labor and equipment for pumped foundation mats.

j R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 204, Item No. 032 207 0700. The cost is that for purchase and delivery of welded, 4x4 - W4xW4, wire fabric, ASTM A185.

AMMONIA NEUTRALIZATION

[k] R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data*, 1999, pg. 4-15, Item No. 17 03 0276. The cost is that for excavation with a 1-yd^3 crawler-mounted, hydraulic excavator.

[l] R.S. Means Company, Inc., *Site Work and Landscape Cost Data*, 1999, pg. 53, Item No. 022 262 0010. The cost is that for spreading dumped material by dozer, without compaction

[m] R.S. Means Company, Inc., *Site Work and Landscape Cost Data*, 1999, pg. 46, Item No. 022 226 6220. The cost is that for compaction by towed vibrating roller with 6" lifts and 4 passes per lift.

[n] R.S. Means Company, Inc., *Means Heavy Construction Cost Data*, 1999, Item No. 014 108 4735. Cost assumes one test per 50 cubic yards.

[o] R.S. Means Company, Inc., *Means Heavy Construction Cost Data*, 1999, Item No. 014 108 4740. Cost assumes one test per 100 cubic yards.

AERATION BASINS

1.	**DESIGN REQUIREMENT**		
a	Design flow rate	**0 gpm**	
b	Design-required dissolved oxygen (DO) level	**0 mg/L**	
c	Residence time	**0 min**	
2.	**AERATION BASIN**		
a	Volume of aeration basin in gal		0 gallons
b	Volume of aeration basin in ft^3 (divide line 2a by 7.481)		0 ft^3
c	Depth of aeration basin (minimum of 10 ft)	**10 ft**	
d	Surface area of aeration basin (divide line 2b by line 2c)		0 ft^2
e	Diameter of aeration basin (square root of line 2d, divided by 3.1415 and multiplied by 2)		0 ft
3.	**AIR SUPPLY SYSTEM**		
	A blower will be used to supply air to the aeration basin.		
a	Oxygen requirement in mg (multiply line 2a by line 1b, and multiply the result by 3.785)		0 mg
b	Oxygen requirement in lbs (divide line 3a by 1,000,000 and multiply the quotient by 2.2)		0.00 lbs
c	Density of oxygen (default)	**0.0892 lbs/ft^3**	
d	Theoretical volume of oxygen (divide line 3b by line 3c)		0 ft^3
e	Oxygen transfer efficiency (default)	**25%**	
f	Percent volume of oxygen in air (default)	**21%**	
g	Actual air supplied (divide line 3d by the product of multiplying of line 3e by line 3f)		0 ft^3
h	Air flow rate (equal to line 3g)		0 scfm
i	Blower capacity (multiply line 3h by 1.2)		0 scfm
4.	**EFFLUENT PUMP**		
a	Capacity of pump (multiply line 1a by 1.25)		0 gpm
5.	**STRUCTURAL CONCRETE SLAB**		
a	Area of aeration basin foundation (from line 2d)		0 ft^2
b	Area of foundation desludging pump house (multiply line 5a by 0.25)	**25%**	0 ft^2
c	Total surface area of foundation (add lines 5a and 5b)		0 ft^2
d	Thickness of foundation	**2 ft**	
e	Volume of foundation in ft^3 (multiply line 5c by line 5d)		0 ft^3
f	Volume of foundation in yd^3 (divide line 5e by 27)		0 yd^3
6.	**PIPING**		
a	Distance from previous unit	**0 ft**	
b	Distance to settling unit	**0 ft**	
c	Total length of piping (add lines 6a and 6b)		0 ft

AERATION BASINS

7. SITE WORK			
a	Volume to be excavated for foundation (multiply line 5f by 1.2)	**Add 20%**	0 yd^3
b	Area to be cleared (multiply line 7a by 2)	**Add 100%**	0 ft^2
c	Area to be surveyed (equal to line 7b)		0 acres
d	Days required to conduct survey (divide line 7c by 1 acre per day)	**1 acre/day**	0 days

AERATION BASINS

1.	**SURVEYING**				
	a	Unit cost of surveying[a]	648.36	$/day	
	b	Days required to conduct survey (from AT-6A, line 7d)	0.00	days	
	c	**Total Cost of Surveying (multiply line 1a by line 1b)**			**$0.00**
2.	**CLEARING AND GRUBBING**				
	a	Unit cost of clearing and grubbing[b]	5,650.00	$/acre	
	b	Area to be cleared and grubbed (from AT-6A, line 7b)	0	acres	
	c	**Total Cost of Clearing and Grubbing (multiply line 2a by line 2b)**			**$0.00**
3.	**EXCAVATION**				
	a	Volume to be excavated (from AT-6A, line 7a)	0	yd^3	
	b	Unit cost of excavation[c]	2.05	$/$yd^3$	
	c	**Total Cost of Excavation (multiply line 4a by line 4b)**			**$0.00**
4.	**INSTALLATION OF AERATION BASIN**				
	a	Capacity of aeration basin	0	gallons	
	b	Number of aeration basins to be installed	**0**	**ea**	
	c	Unit costs of purchase, delivery, and installation of an aeration basin (select from the costs listed below) [d] **6. 10,000-gallon single-walled fiber glass tank**	**0.00**	**$/ea**	
		1. 550-gallon single-walled fiber glass tank	4,214.00	$/ea	
		2. 1,000-gallon single-walled fiber glass tank	5,647.00	$/ea	
		3. 2,000-gallon single-walled fiber glass tank	9,824.00	$/ea	
		4. 3,000-gallon single-walled fiber glass tank	12,830.00	$/ea	
		5. 5,000-gallon single-walled fiber glass tank	16,587.00	$/ea	
		6. 10,000-gallon single-walled fiber glass tank	17,953.00	$/ea	
	d	**Total Cost of Installation of Aeration Basin (multiply line 4b by line 4c)**			**$0.00**
5.	**INSTALLATION OF BLOWER**				
	a	Blower capacity (from AT-6A, line 3i)	0	scfm	
	b	Number of blowers	**0**	**ea**	
	c	Cost of purchase, delivery, and installation of a blower system (select from the costs listed below) [f] **1. 50 scfm, 3/4 HP blower**	**0.00**	**$/ea**	
		1. 50 scfm, 3/4 HP blower	716.71	$/ea	
		2. 100 scfm, 1/3 HP blower	1,956.00	$/ea	
		3. 150 scfm, 3/4 HP blower	785.44	$/ea	
		4. 250 scfm, 1.5 HP blower	884.72	$/ea	
		5. 500 scfm, 2 HP blower	1,040.00	$/ea	
		6. 750 scfm, 5 HP blower	1,304.00	$/ea	
	d	**Total Cost for Installation of Blower (multiply line 5b by line 5c)**			**$0.00**
6.	**INSTALLATION OF MIXER**				
	a	Number of mixers (equal to line 4b)	0	ea	
	b	Cost of purchase, delivery, and installation of a 2 HP, double propeller, 6-inch diameter mixer[g]	2,681.00	$/ea	
	c	**Total Cost of Installation of Mixer (multiply line 6a by line 6b)**			**$0.00**

AERATION BASINS

7.	**INSTALLATION OF EFFLUENT PUMP**			
a	Capacity of pump (from AT-6A, line 4a)	0	gpm	
b	Number of pumps	**0**	**ea**	
c	Cost of purchase, delivery, and installation of an effluent pump (select the from the costs listed below)[h]		**$/ea**	
	1. 10 gpm, 0.5 HP centrifugal pump	786.45	$/ea	
	2. 50 gpm, 3 HP centrifugal pump	1,845.00	$/ea	
	3. 100 gpm, 5 HP centrifugal pump	2,685.00	$/ea	
	4. 200 gpm, 10 HP centrrifugal pump	4,011.00	$/ea	
	5. 250 gpm, 10 HP centrifugal pump	4,531.00	$/ea	
	6. 300 gpm, 15 HP centrifugal pump	5,098.00	$/ea	
	7. 500 gpm, 20 HP centrifugal pump	6,798.00	$/ea	
	8. 750 gpm, 30 HP centrifugal pump	8,699.00	$/ea	
	9. 1050 gpm, 40 HP centrifugal pump	10,578.00	$/ea	
	10. 1500 gpm, 60 HP centrifugal pump	13,951.00	$/ea	
	11. 2000 gpm, 75 HP centrifugal pump	16,600.00	$/ea	
d	**Total Cost of Installation of Effluent Pump (multiply line 7b by line 7c)**			**$0.00**
8.	**CONCRETE WORK**			
a	Volume of ready-mix concrete (from AT-6A, line 7a)	0.00	yd^3	
b	Unit cost of purchase and delivery of ready-mix concrete, 8000 psi[i]	138.00	$/yd^3$	
c	Unit cost of placement of concrete, pumped[j]	20.50	$/yd^3$	
d	**Total Cost of Purchase, Delivery, and Placement of Concrete (multiply line 8a by the sum of lines 8b and 8c)**			**$0.00**
9.	**INSTALLATION OF INFLUENT AND EFFLUENT PIPING**			
a	Length of piping (From AT-6A, line 6c)	0.00	ft	
b	Unit cost of purchase, delivery, and installion of 1" to 4" PVC pipe[k]	17.40	$/ft	
c	Allowance factor for fittings and insulation (default)[l]	50%		
d	Unit cost for fittings and insulation (multiply line 9b by line 9c)	8.70	$/ft	
e	**Total Cost of Installation pf Influent and Effluent Piping (multiply line 9a by the sum of lines 9b and 9d)**			**$0.00**
10.	**INSTRUMENTATION**			
a	Allowance factor for instrumentation (percentage of clarifier cost)[l]	**25%**		
b	**Total Cost of Instrumentation (multiply line 6d by line 10a)**			**$0.00**
	TOTAL COST OF INSTALLATION OF AERATION BASIN (add lines 1c, 2c, 3c, 4e, 5d, 6c, 7d, 8d, 9e, and 10b)			**$0.00**

a R.S. Means Company, Inc., *Environmental Remediation Data Unit Cost* , 1999, pg. 10-10, Item No. 99 24 1201. The cost is that for a survey by a two-person crew.

b R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 39, Item No. 021 104 0260. The cost is that for clearing and grubbing of dense brush, including stumps.

c R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 49, Item No. 022 242 20200. The cost is that for bulk common earth excavation by a 75 HP dozer and hauling 50 feet.

d R.S. Means Company, Inc., *Environmental Remediation Data* , 1999, pg. 9-100, Items No. 33 10 9740 through 9745. The cost is that of the purchase and delivery of a single-walled fiber glass aboveground tank.

AERATION BASINS

e R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, back cover. Installation cost was based on the assumption of a crew of two skilled workers for one day per tank.

f R.S. Means Company, Inc., *Environmental Remediation Data Unit Cost* , 1999, pg. 9-286, Items No. 33 31 0101 through 0108. The cost is that of the purchase, delivery, and installation of a blower.

g R.S. Means Company, Inc., *Environmental Remediation Data Assemblies Cost* , 1999, pg. 3-62, Item No. 33 13 0428. The cost is that for purchase, delivery, and installation of a 2 HP, double propeller 6" diameter mixer.

h R.S. Means Company, Inc., *Environmental Remediation Data Assemblies Cost* , 1999, pg. 3-64, Items No. 33 29 0102 through 0115. The cost is that of the purchase, delivery, and installation of a centrifugal pump.

i R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 206, Item No. 033 126 0412. The cost is that of the purchase and delivery of regular weight, 8,000 psi, ready-mix concrete.

j R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 209, Item No. 033 172 2950. The cost is that of the placement and vibrating of concrete, including labor and equipment for pumped foundation mats.

k R.S. Means Company, Inc., *Mechanical Cost Data* , 1999, pg. 123, Items No. 151 550 1090 through 1150. The cost is that for the purchase and delivery of Sch. 80, high-impact/pressure PVC pipes in a range of 1" through 4".

l This cost is based on engineering judgment.

PEBBLE QUICKLIME NEUTRALIZATION - AQUAFIX SYSTEM

1.	**PEBBLE QUICKLIME CONSUMPTION**			
a	Design flow rate	**0**	**gpm**	
b	Total mine drainage acidity	**0**	**mg/L as $CaCO_3$**	
c	Molar acid equivalents loading (line 1a times 3.785 L/gal, times line 1b, times 0.01 mole $CaCO_3$/g $CaCO_3$, times 0.001 g/mg, times 512,640 min/year, and divide by 0.9 (pebble quicklime efficiency))	0	equivalents of acid/year	
e	Amount of pebble quicklime needed per equivalent of acid[a]	**0.137**	**lbs/equivalent**	
f	Theoretical amount of pebble quicklime needed annually (multiply line 1c by line 1e, divide the product by 2,000)	0	tons	
g	Purity	**0%**		
h	Factor to account for excess alkalinity required in the effluent (20 to 30% OSM)	**30%**		
i	Actual amount of pebble quicklime needed annually (divide line 1f by line 1g, and multiply the result by (1 + line 1h))	0	tons	
2.	**PURCHASE, DELIVERY, AND INSTALLATION OF SILO ASSEMBLIES[b]**			
	Silo assemblies may be optional depending on the quantity of pebble quicklime required. The Aquafix hopper is capable of storing up to approximately 1 ton of quicklime.			
a	Frequency of delivery of chemical	**12**	**deliveries/yr**	
b	Minimum storage capacity required (divide 1i by line 2a)	0	tons	
c	Number of 35-ton silos	**0**	**ea**	
d	Unit cost of 35-ton silo	63,000	$/ea	
e	Number of 20-ton silos	**0**	**ea**	
f	Unit cost of 20-ton silo	55,000	$/ea	
g	Number of 10-ton silos	**0**	**ea**	
h	Unit cost of 10-ton silo	50,000	$/ea	
i	**Total cost of silos (multiply line 2c by line 2d, multiply line 2e by line 2f, multiply line 2g by line 2h, and add the products)**			**$0.00**

PEBBLE QUICKLIME NEUTRALIZATION - AQUAFIX SYSTEM

3.	**PURCHASE, DELIVERY, AND INSTALLATION OF AQUAFIX UNIT**[c]			
a	Minimum storage capacity required (line 2b)	0	tons	
b	Unit cost of small Aquafix pebble quicklime feed system (500-lbs capacity)	**10,000.00**	**$/ea**	
c	Number of small Aquafix units	**0**	**ea**	
d	Unit cost of large Aquafix pebble quicklime feed system (2,000-lbs capacity)	**17,000.00**	**$/ea**	
e	Number of large Aquafix units	**0**	**ea**	
f	Total cost of Aquafix unit (multiply line 3b by line 3c, multiply line 3d by line 3e, and add the products)	0.00	$	
g	Allowance factor for piping and instrumentation (maximum of 30% - professional judgement)	**10%**		
h	Total allowance cost for piping and instrumentation (multiply line 3f by line 3g)	0.00	$	
i	Allowance factor for delivery and installation (maximum of 40% - professional judgement)	**15%**		
j	Total allowance cost for delivery and installation (multiply line 3f by line 3i)	0.00	$	
k	**Total Cost of Purchase, Delivery, and Installation of Aquafix quicklime feed system (add lines 3d, 3f, and 3h)**			**$0.00**
TOTAL COST OF INSTALLATION OF PEBBLE QUICKLIME NEUTRALIZATION (add lines 2i and 3k)				**$0.00**

a 56 g/mole*1 mole/mole /.90 efficiency / 1000g/kg * 2.2 lb/kg

b 1999 Vendor quote obtained from Slogan Systems includes purchace, delivery, and installation of silo and all ancillary items (including bin, vent filter, turbulence box, high-level sensor, reorder sensor, low-level sensor, pneumatic fill line, bin discharger, slide gate, valve SCR controller, volumetric screw feeder, and weather-tight enclosure.

c 1999 Vendor quote obtained from Aquafix, 301 Maple Lane, Kingwood, West Virginia 26537
Phone: (304) 329-1056

4.0 PASSIVE TREATMENT

The application of passive treatment systems, while still highly innovative, is gaining wider acceptance as practicable alternatives for the treatment of mine drainage. Passive systems, which do not require the continuous application of chemicals, tend to require less maintenance and tend to be more cost effective than many active treatment systems. The implementation of passive systems may be problematic, however, because the effectiveness of such systems often is uncertain and because large physical areas often are required to implement them. Passive treatment systems are most applicable for mildly to moderately polluted mine drainage (less than 500 mg/l of total acidity). Severely polluted waters are generally poor candidates for passive treatment neutralization. To date, passive treatment systems have been applied at abandoned mine sites or at sites at which: 1) the volume of flow of mine drainage is low, 2) bodies of water receiving the drainage have a high capacity for dilution, or 3) variations in the quality of the effluent discharged are acceptable.

The methodology provides worksheets that can be used to estimate the costs of five common alternatives for passive treatment: anoxic lime drainage (ALD) systems; successive alkalinity-producing systems (SAPS); open limestone channels (OLC), and anaerobic and aerobic wetlands. Each passive treatment system can be implemented unilaterally or, depending on the acidity of the mine drainage and the desired quality of the discharge, can be implemented in conjunction with other treatment units.

Presented below are descriptions of the cost estimating worksheets to be used in determining the costs of conducting passive treatment activities at surface mines, underground mines, and coal refuse piles:

- **Passive Treatment Unit Summary** - The Passive Treatment Unit Summary worksheet is used to record the costs calculated for each individual passive treatment activity worksheet, apply allowances to those costs to account for engineering expenses and contingencies, and calculate the total costs of passive treatment, adjusted to net present value.

- **Alkalinity-Producing Diversion Wells (Diversion Wells) -** Application of diversion wells for mine drainage treatment has been adopted from a treatment method for stream acidity caused by acid rain developed in Norway and Sweden. The well can be constructed in or beside a stream or may be buried in the ground. Continuous high-velocity of water in the well enhances the neutralization reaction. Constant agitation of limestone will aid limestone dissolution and help remove iron oxide coating (armor), therefore fresh limestone surfaces are always available (Skousen and others, 1998).

- **ALDs** - ALDs function differently from OLCs. The drain is buried to create oxygen-precluding conditions and therefore prevent the armoring of limestone. The design of an ALD consists of a rectangular trench with plastic liner, filled with 6 to 15 cm-diameter crushed limestone, then covered with plastic or filter fabric, and finally with soil and vegetation (Skousen and others, 1998). The cost of the activity includes the cost of: excavation of the trench, the purchase and delivery of limestone, the placement of the liner, and the backfilling and compacting of the soil used to bury the drain.

- **SAPSs** - A SAPS combines the use of ALD and anaerobic compost wetlands. A SAPS is constructed as a pond in which a 3- to 6-foot layer of compost overlies an 18- to 24-inch layer of limestone. Mine drainage enters the systems in a downflow configuration. The compost layer is designed to create anaerobic or oxygen-deficient water, a condition that will keep the limestone unarmored and therefore more effective in neutralizing the mine drainage. Additional bicarbonate alkalinity also will be generated through the action of sulfate-reducing bacteria. A SAPS usually is constructed with perforated, underdrain piping and backflush pump units. The cost of the activity includes the costs of: excavation; installation of a clay-lined pond; purchase and delivery of compost, limestone, clay, piping, and a backflush pump; installation of the back flush pump; and installation of the compost and limestone layers.

- **Aerobic and Anaerobic Wetlands** - Anaerobic and aerobic wetlands remove metals from mine drainage both by promoting the absorption of metals by organic materials and by facilitating the oxidation or reduction of metals through microbial reactions. Aerobic wetlands are designed to collect net alkaline mine drainage water and promote sufficient residence time to precipitate metals from the drainage. To provide additional organic matter and for purposes of aesthetics, species of plants that are indigenous to wetlands are established. Anaerobic wetlands are designed to treat net acidic mine drainage and are constructed with layers of limestone on the bottom. An anaerobic wetland operate in much the same way as a SAPS. Alkalinity is generated through bacterial sulfate-reduction reactions and through neutralization with limestone. The cost of the activity includes the costs of: excavation of the pond; purchase and delivery of materials; installation of the clay, limestone, and layers of compost and organic materials; planting of cattails and other species of plants indigenous to wetlands; and installation of influent and effluent piping.

SITE NAME: ______________________________

	Activity	Worksheet Number	Cost
	Capital Costs		
1.	Installation of alkalinity-producing diversion wells	PT-2A/B	
2.	Installation of anoxic limestone drains (ALD)	PT-3A/B/C	
3.	Installation of successive alkalinity producing systems (SAPS)	PT-4A/B	
4.	Installation of aerobic and anaerobic wetlands	PT-5A/B	
5.	Installation of ponds (storage, settling, equalization, and sludge drying ponds or beds)	GTU-1A/B	
6.	Installation of clarifiers	GTU-2A/B	
7.	Installation of rock drains	GTU-3A/B	
8.	Installation of filter fields	GTU-4A/B	
9.	Installation of limestone channels	GTU-5A/B/C	
10.	Installation of infiltration galleries	DM-1A/B	
11.	Installation of irrigation application systems	DM-2A/B	
12.	Installation of pipe systems	DM-3	
13.	Land access	SW-1	
14.	Installation of monitoring wells	SW-2	
15.	Site security	SW-3	
16.	Access roads	SW-4	
17.	**Subtotal of Capital Costs (add lines 1 through 16)**		**$ -**
	FOR EXISTING TREATMENT SYSTE, LINE 17 IS NOT INCLUDED IN THE TOTAL NET PRESENT WORTH CALCULATION.		
	Annual Operating Costs		
18.	Chemical Consumption	OP-1	
19.	System maintenance and replacement (enter amount from line 2c of worksheet OP-2)	OP-2	
20.	Electricity	OP-3	
21.	Removal of sludge	OP-4	
22.	Sampling and Analysis	OP-5A-D	
23.	**Subtotal of Annual Operating Costs (add lines 18 through 22)**		**$ -**

SITE NAME: ____________________

	Activity	Worksheet Number	Cost
	Allowances and Contingencies		
24.	Allowance for engineering expenses[a]	**11%**	
25.	Allowance for engineering expenses for capital costs (multiply line 17 by line 24)	$ -	
26.	Capital Costs adjusted for allowance for engineering expenses (add lines 17 and 25)	$ -	
27.	Allowance for contingencies[b]	**20%**	
28.	Allowance for contingencies for capital costs (multiply line 26 by line 27)	$ -	
29.	Allowance for contingencies for annual operating costs (multiply line 23 by line 27)	$	
30.	**Capital Costs Adjusted for Allowances for Engineering Expenses and Contingencies (Add lines 26 and 28)**		**$ -**
31.	**Annual operating costs adjusted for allowance for contingencies (add lines 23 and 29)**		**$**
	Net Present Value Calculation		
32.	Number of years the system will remain in operation (n)	**0**	
33.	Expected annual inflation rate (%)	**0**	
34.	Estimated annual discount rate (%)	**0**	
35.	Net discount rate (subtract line 33 from line 34) (i)	0	
36.	Net present value multiplier, equal to $\frac{1-(1+i)^{-n}}{i}$	0.00	
37.	**Net Present Value of Annual Operating Costs over Life of System (multiply line 31 by line 36)**		**$ -**
	TOTAL COST OF PASSIVE TREATMENT ADJUSTED TO NET PRESENT VALUE (add lines 30 and 37)		**$ -**

a R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , back cover. Factors range from 11 to 16 percent and include costs of engineering and logistical support and staff requirements.

b In accordance with standard engineering practices, a factor of 20 percent is applied to the cost of passive treatment to account for contingencies and unforeseen expenses.

ALKALINITY-PRODUCING DIVERSION WELLS

1. CHARACTERISTICS OF AMD			
a	Total mine drainage acidity	**0 mg/L**	
b	Design flow rate	**0 gpm**	
c	MACID/minute (multiply line 1a by line 1b times 3.785, and divide the product by 100,000)[a]		0.0000
2. LIMESTONE CONSUMPTION			
a	Molecular weight of limestone	**100 g/mol**	
b	Theoretical requirement for limestone per minute (multiply lines 1c, 2a, and 2.2, and divide the result by 1,000)[b]		0.0000 lbs/min
c	Theoretical requirement for limestone per day (multiply line 2b by the product of 60 multiplied by 24)		0.00 lbs/day
d	Design neutralization capacity (refill duration)	**0 days**	
e	Efficiency[b]	**30%**	
f	Limestone purity	**0%**	
g	Factor to account for excess alkalinity required in the effluent (20 to 30% - OSM)	**0%**	
h	Actual requirement for limestone (multiply line 2c by line 2d, divide the product by line 2e and line 2f, multiply the result by addition of 1 and line 2g)		0 lbs
i	Limestone required in tons (divide line 2h by 2,000)		0 tons
j	Density of limestone	**168.02 lbs/ft^3**	
k	Volume of limestone in cubic feet (divide line 2h by line 2j)		0 ft^3
l	Volume of limestone in cubic yards (divide line 2k by 27)		0 yd^3
3. DIMENSION OF DIVERSION WELLS			
Assume that diversion well is to be fabricated from HDPE large diameter pipe.			
a	Diameter	**0 ft**	
b	Surface area (area of a circle of the diameter of diversion well)		0 ft^2
c	Design safety factor	**20%**	
d	Volume of diversion well in cubic feet (add line 2k and the product of line 2k times line 3c)		0 ft^3
e	Volume of diversion well in gallons (multiply line 3d by 7.481)		0 gallons
f	Height of diversion well (divide line 3d by line 3b)		0 ft
4. INFLUENT AND EFFLUENT PIPING			
Assume that piping will be buried in 2-ft wide by 3-ft deep trench.			
a	Distance from influent to the well	**0 ft**	
b	Distance from the well to next treatment unit	**0 ft**	
c	Total piping (add line 4a by line 4b)		0 ft

ALKALINITY-PRODUCING DIVERSION WELLS

5. SITE WORK			
a	Volume to be excavated for diversion well (multiply line 3d by 1.2 and divide the result by 27)		0 yd^3
b	Volume to be excavated for pipe trench (Multiply line 4c by 2 and 3, and divide the result by 27)		0.00 yd^3
c	Total volume to be excavated (add line 5a by line 5b)		0.00 yd^3
d	Area to be cleared and grubbed (add line 3b and the product of 2 times line 4c, and divide the result by 43,560 and multiply by 1.3)		0.00 acres
e	Area to be surveyed (equal to 5d)		0.00 acres
f	Survey rate	**1 acre/day**	
g	Days required to conduct survey (multiply lines 7d and 7e)		0.00 days

[a] MACID is the number of moles of $CaCO_3$ equivalent acidity.
Volume in the above equation must be in liters.

$$MACID = \frac{AcidityxVolume}{100{,}000}$$

(From: Skousen and others. 1996. *Acid Mine Drainage Control and Treatment. Second Edition.* p. 159. West Virginia University)

[b] Skousen and others. 1996. A*cid Mine Drainage Control and Treatment. Second Edition* . p. 238. West Virginia University.

ALKALINITY-PRODUCING DIVERSION WELLS

1.	**SURVEYING**				
	a	Unit cost of surveying[a]	648.36	$/day	
	b	Days required to conduct survey (from PT-2A, line 5g)	0.00	days	
	c	**Total Cost of Surveying (multiply line 1a by line 1b)**			**$0.00**
2.	**CLEARING AND GRUBBING**				
	a	Unit cost of clearing and grubbing[b]	5,650.00	$/acre	
	b	Area to be cleared and grubbed (from PT-2A, line 5d)	0.00	acres	
	c	**Total Cost of Clearing and Grubbing (multiply line 2a by line 2b)**			**$0.00**
3.	**LIMESTONE PURCHASE AND DELIVERY**				
	a	Quantity of limestone (from PT-2A, line 2h)	0	lbs	
	b	Unit cost of purchase and delivery (50-mile radius)[c]	0.04	$/lbs	
	c	**Total Cost of Purchase and Delivery of Limestone (multiply line 3a by line 3b)**			**$0.00**
4.	**EXCAVATION**				
	a	Volume to be excavated (from PT-2A, line 5c)	0	yd^3	
	b	Unit cost of excavation[d]	4.68	$\$/yd^3$	
	c	**Total Cost of Excavation (multiply line 7a by line 7b)**			**$0.00**
5.	**SPREADING, BACKFILLING, AND COMPACTING OF THE PIPE TRENCH**				
	a	Quantity of backfill (from PT-2A, line 5b)	0	yd^3	
	b	Unit cost of filling and spreading by dozer[e]	1.40	$\$/yd^3$	
	c	Unit cost of compacting [f]	1.18	$\$/yd^3$	
	d	Unit cost of compaction testing by nuclear method[g]	0.77	$\$/yd^3$	
	e	Unit cost of compaction testing by sand cone method[h]	0.30	$\$/yd^3$	
	f	**Total Cost of Spreading and Compacting Clay Layer (multiply line 5a by the sum of lines 5b through 5e)**			**$0.00**
6.	**INSTALLATION OF LIMESTONE LAYER**				
	a	Quantity of limestone (from PT-2A, line 2l)	0	yd^3	
	b	Unit cost of filling and spreading limestone[i]	22.50	$\$/yd^3$	
	c	**Total Cost of Installation of Limestone Layer (multiply line 9a by line 9b)**			**$0.00**
7.	**INSTALLATION OF INFLUENT AND EFFLUENT PIPING**				
	a	Length of piping (From PT-2A, line 4c)	0.00	ft	
	b	Unit cost of purchase, delivery, and installion of 1" to 4" PVC pipe[j]	17.40	$/ft	
	c	Allowance factor for fittings and insulation (default)[k]	**50%**		
	d	Unit cost for fittings and insulation (multiply line 7b by line 7c)	8.70	$/ft	
	e	**Total Cost of Installation of Influent and Effluent Piping (multiply line 7a by the sum of lines 7b and 7d)**			**$0.00**

ALKALINITY-PRODUCING DIVERSION WELLS

8.	**INSTALLATION OF DIVERSION WELLS**			
a	Number of diversion wells	1.00	ea	
b	Diameter of diversion well	0	ft	
c	Height of diversion well	0	ft	
d	Unit cost of purchase and delivery of diversion well - HDPE pipe & bottom cap (select from unit cost listed below)[l]	**190.00**	$/lft	
	1. 12" diameter	11.25	$/ft	
	2. 24" diameter	37.50	$/ft	
	3. 36" diameter	47.50	$/ft	
	4. 48" diameter	146.00	$/ft	
	5. 54" diameter	190.00	$/ft	
e	Allowance factor for installation and fabrication[k]	**100%**		
f	Unit cost for installation and fabrication (multiply line 8e by line 8d)	11.25	$/ft	
g	**Total cost of installation of diversion wells (multiply lines 8a, 8c, and the sum of line 8d and line 8f)**			**$0.00**
TOTAL COST OF INSTALLATION OF ALKALINITY-PRODUCING DIVERSION WELLS (add lines 1c, 2c, 3c, 4c, 5f, 6c, 7e, and 8g)				**$0.00**

a R.S. Means Company, Inc., *Environmental Remediation Data Unit Cost* , 1999, pg. 10-10, Item No. 99 24 1201. The cost is that of a survey performed by a two-person crew.

b R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 39, Item No. 021 104 0260. The cost is that of clearing and grubbing of dense brush, including stumps.

c Remine Version V. 1.21. The cost is the average of quotes for pebble lime provided by Greybeck Lime (Bellefonte, Pennsylvania) and Constone (Erinsburg, Pennsylvania). The cost is that of purchase and delivery of the limestone within a 50-mile radius.

d R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 51, Item No. 022 254 0060. The cost is that of excavation of a trench 1- to 4-feet deep by a 0.5 yd^3 tractor loader-backhoe.

e R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg.53, Item No. 022 262 0010. The cost is that of spreading dumped material by dozer with no compaction.

f R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 46, Item No. 022 226 6220. The cost is that of compaction by a towed vibrating roller with 6" lifts and 4 passes.

g R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 11, Item No. 014 108 4735. The cost is that of soil density testing by the nuclear method, ASTM D2922-71. One test per 50 yd^3 compaction is assumed.

h R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 11, Item No. 014 108 4740. The cost is that of soil density testing by sand cone method ASTM D1556064. One test per 100 yd^3 compaction is assumed.

I R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg.53, Item No. 022 262 0100. The cost is that of spreading dumped material by hand with no compaction.

ANOXIC LIMESTONE DRAINS (ALD)

1. CHARACTERISTICS OF AMD			
a	Total mine drainage acidity	**0 mg/L**	
b	Design flow rate	**0 gpm**	
c	MACID/minute (multiply line 1a by line 1b times 3.785, and divide the product by 100,000) [a]		0.0000
2. LIMESTONE CONSUMPTION			
	The amount of alkalinity generated will depend on the partial pressure of CO2, temperature, and retention time.		
a	Molecular weight of limestone	**100 g/mol**	
b	Theoretical requirement for limestone[b]		0.0000 lbs/min
c	Theoretical requirement for limestone per day (multiply line 2b by 1,440 mins/day)		0.00 lbs/day
d	ALD design lifespan	**0 days**	
e	Neutralization efficiency[c]	**30%**	
f	Purity of limestone	**0%**	
g	Factor to account for excess alkalinity required in the effluent (20 to 30% - OSM)	**0%**	
h	Actual requirement for limestone (multiply line 2c by line 2d, divide by lines 2e and 2f, and multiply by the addition of 1 and line 2g)		0 lbs
			0 tons
i	Density of limestone	**168.02 lbs/ft3**	
j	Quantity of limestone (divide line 2h by line 2i)		0 ft^3
k	Quantity of limestone in yd^3 (divide line 2j by 27)		0 yd^3
3. DIMENSION OF TRENCH			
a	Depth (D)	**0 ft**	
b	Width (W)	**0 ft**	
c	Volume of trench (multiply line 2j by 1.2)		0 ft^3
d	Length (L) - (divide line 3c by the product of lines 3a and 3b)		0 ft
e	Volume of trench in yd^3 (divide line 3c by 27)		0 yd^3
f	Surface area of trench (=2x[(D.W)+(D.L)+(W.L)])		0 ft^2
4. SITE WORK INFORMATION			
a	Volume to be excavated (equal to line 3e):		0 yd^3
b	Multiplier for clearing and grubbing	**100%**	
c	Area to be cleared (multiply lines 4b, 3f and divide the product by 43,560)		0 acres
d	Area to be surveyed (equal to 6c)		0 acres
e	Survey rate	**1 acre/day**	
f	Days required to conduct survey (multiply line 4d by line 4e)		0 days

a MACID is number of moles of $CaCO_3$ equivalent acidity

$$MACID = \frac{AcidityxVolume}{100{,}000}$$

Volume in above equation must be in liters

(From: Skousen and others. 1996. *Acid Mine Drainage Control and Treatment, Second Edition* , p. 159. West Virginia University)

b Calculated using the following equation:

(Line 1c x Line 2a x 2.2)/1,000

ANOXIC LIMESTONE DRAINS (ALD)

c Skousen and others. 1996. *Acid Mine Drainage Control and Treatment, Second Edition*. pg. 238. West Virginia University.

ANOXIC LIMESTONE DRAINS (ALD)

1. SURVEYING				
a	Unit cost to surveying[a]	648.36	$/day	
b	Days required to conduct survey (from PT-3A, line 4f)	0	days	
c	**Total Cost of Surveying (multiply line 1a by line 1b)**			**$0.00**
2. CLEARING AND GRUBBING				
a	Unit cost of clearing and grubbing[b]	5,650.00	$/acre	
b	Area to be cleared and grubbed (from PT-3A, line 4c)	0	acres	
c	**Total Cost of Clearing and Grubbing (multiply line 2a by line 2b)**			**$0.00**
3. PURCHASE AND DELIVERY OF LIMESTONE				
a	Quantity of limestone (from PT-3A, line 2h)	0	lbs	
b	Unit cost of purchase and delivery (50-mile radius)[c]	0.04	$/lbs	
c	**Total Cost of Purchase and Delivery of Limestone (multiply line 3a by line 3b)**			**$0.00**
4. PURCHASE AND DELIVERY OF SYNTHETIC LINER				
a	Surface area of liner (from PT-3A, line 3f)	0	ft^2	
b	Unit cost of purchase, delivery and installation of synthetic liner [d]	1.73	$\$/ft^2$	
c	**Total Cost to Purchase, Deliver, and Install Synthetic Liner (multiply line 4a by line 4b)**			**$0.00**
5. EXCAVATION/BACKFILL/COMPACTION				
a	Volume to be excavated (from PT-3A, line 3e)	0	yd^3	
b	Unit cost of excavation[e]	4.68	$\$/yd^3$	
c	Unit cost of spreading and backfilling by dozer[f]	1.40	$\$/yd^3$	
d	Unit cost of compacting backfill material[g]	1.18	$\$/yd^3$	
e	Unit cost of compaction testing by nuclear method[h]	0.77	$\$/yd^3$	
f	Unit cost of compaction testing by sand cone method[i]	0.30	$\$/yd^3$	
g	**Total Cost of Excavation, Backfilling, and Compaction (multiply line 5a by the sum of lines 5b through 5f)**			**$0.00**
TOTAL INTALLATION OF ALD (add lines 1c, 2c, 3c, 4c, and 5g)				**$0.00**

a R.S. Means Company, Inc., *Environmental Remediation Data Unit Cost* , 1999, pg. 10-10, Item No. 99 24 1201. The cost is that of a survey conducted by a two-person crew.

b R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 39, Item No. 021 104 0260. The cost is that of clearing and grubbing of dense brush, including stumps.

c Remine Version V. 1.21. The cost is the average of quotes for pebble lime provided by Greybeck Lime (Bellefonte, PA) and Constone (Erinsburg, PA). The cost is that of purchase and delivery of the limestone within a 50-mile radius.

d R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 9-81, Item No. 33 08 0572. The cost is that for the purchase, delivery, and installation of 60-mil polymeric HDPE liner.

e R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 51, Item No. 022 254 0060. The cost is that of excavation of a trench 1 to 4 feet in depth by a 0.5 yd^3 tractor loader-backhoe.

f R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg.53, Item No. 022 262 0010. The cost is that of spreading dumped material by dozer with no compaction.

g R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 46, Item No. 022 226 6220. The cost is that of compaction by towed vibrating roller, with 6" lifts and 4 passes per lift.

ANOXIC LIMESTONE DRAINS (ALD)

[h] R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 11, Item No. 014 108 4735. The cost is that of soil density testing by nuclear method, ASTM D2922-71. Assume 1 test per 50 yd^3 compaction.

[I] R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 11, Item No. 014 108 4740. The cost is that of soil density testing by sand cone method ASTM D1556064. Assume 1 test per 100 yd^3 compaction.

ANOXIC LIME DRAINS (ALD) FOR EXISTING SYSTEM

1.	**EXCAVATION OF ALD CHANNEL**			
a	Length (L)	**0**	**ft**	
b	Width (W)	**0**	**ft**	
c	Depth (D)	**0**	**ft**	
e	Side wall slope (S)	**1**	**ft run/ft rise**	
f	Volume in cubic feet[a] V = (L.W.D) + 0.5(D.L.S.D) + 0.5(D.L.2D) + (D.W.S.D) + (2/3Dx(S.D)^2) + (2/3.D.2D.S.D)	0	ft^3	
g	Volume in cubic yard	0	yd^3	
h	Surface area of each channel [L +(2DS)] . [W +(2DS]	0	ft^2	
i	Number of ALD channels	**1**	**ea**	
j	Total volume of excavation (multiply line 1g by line 1i)	0	yd^3	
k	Total area to be cleared and grubbed (multiply line 1h by line 1i)	0	ft^2	
s	Unit cost of clearing and grubbing[b]	0.380	\$/ft^2	
t	Total cost of clearing and grubbing (multiply line 1k by line 1s)	0.00	\$	
u	Unit cost of excavation[c]	4.330	\$/yd^3	
v	Total cost of excavation (multiply line 1u by line 1j)	0.00	\$	
w	**Total Cost of Excavation of ALDs (add lines 1t and 1v)**			**\$0.00**
2.	**LINING OF ALD CHANNELS**			
a	Total surface area of channels (multiply lines 1h by line 1i)	0	ft^2	
b	Unit cost of purchase and placement of synthetic liner[d]	1.730	\$/ft^2	
c	**Total Cost of Lining ALD Channels (add lines 2a and 2b)**			**\$0.00**
3.	**BACKFILLING/COMPACTING OF ALD CHANNELS**			
a	Depth of cover	**4**	**ft**	
b	Volume of compacted backfill (multiply lines 3a, 1a, and 1b, and divide the product by 27)	0	yd^3	
c	Compaction factor[e]	**40%**		
d	Actual volume of backfill (multiply line 3b by the sum of 1 and line 3c)	0	yd^3	
e	Unit cost of spreading and backfilling by dozer[f]	1.40	\$/yd^3	
f	Unit cost of compacting backfill material[g]	1.18	\$/yd^3	
g	Unit cost of compaction testing by nuclear method[h]	0.77	\$/yd^3	
h	Unit cost of compaction testing by sand cone method[i]	0.30	\$/yd^3	
i	**Total Cost of Excavation, Backfilling, and Compaction (multiply line 3d by the sum of lines 3e through 3h)**			**\$0.00**

ANOXIC LIME DRAINS (ALD) FOR EXISTING SYSTEM

4.	**PURCHASE AND DELIVERY OF LIMESTONE**			
a	Density of limestone	**168.02**	**lbs/ft3**	
b	Quantity of limestone (multiply line 1f by line 4a)	0	lbs	
c	Quantity of limestone in cubic yard (line 1g)	0	yd^3	
d	Unit cost of purchase and delivery (50-mile radius)[j]	0.006	$/lbs	
e	Unit cost of spreading and backfilling by dozer[f]	1.40	$\$/yd^3$	
f	**Total Cost of Purchase, Delivery, and Spreading of Limestone (add the product of lines 4b and 4d and the**			**$0.00**
TOTAL COST OF ALD INSTALLATION (add lines 1w, 2c, 3i, and line 4f)				**$0.00**

a Pond actual volume is designed using standard volume equation for furstrum. Back slope is assumed to be 2:1.

b R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pgs. 4-1 and 4-9, Item Nos. 17 01 0103 and 17 03 0101. The cost is that for medium brush with average grub and some trees, clearing, and rough grading with a D6 dozer.

c R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 4-15, Item No. 17 03 0276. The cost is that for excavation with a 1 yd^3 crawler-mounted, hydraulic excavator.

d R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 9-81, Item No. 33 08 0572. The cost is that for purchase, delivery, and installation of 60-mil polymeric HDPE liner.

e U.S. Environmental Protection Agency, *Final Guidance Manual: Cost Estimates for Closure and Post-Closure Plans (Subparts G and H), Volume III* , EPA/530-SW-87-009, January 1987, pages 7-10. Compaction factor provided is that for off-site clay.

f R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg.53, Item No. 022 262 0010. The cost is that of spreading dumped material by dozer with no compaction.

g R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 46, Item No. 022 226 6220. The cost is that of compaction by towed vibrating roller, with 6" lifts and 4 passes per lift.

h R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 11, Item No. 014 108 4735. The cost is that of soil density testing by nuclear method, ASTM D2922-71. Assume 1 test per 50 yd^3 compaction.

I R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 11, Item No. 014 108 4740. The cost is that of soil density testing by sand cone method ASTM D1556064. Assume 1 test per 100 yd^3 compaction.

j Remine Version V. 1.21. The cost is the average of quotes for pebble lime provided by Greybeck Lime (Bellefonte, PA) and Constone (Erinsburg, PA). The cost is that of purchase and delivery of the limestone within a 50-mile radius.

SUCCESSIVE ALKALINITY-PRODUCING SYSTEMS (SAPS)

1. AMD CHARACTERISTICS			
a	Total mine drainage acidity	**0 mg/L**	
b	Design flow rate	**0 gpm**	
c	Residence time (15 hours contact time in limestone - Skousen)	**0 hrs**	
d	MACID/minute (multiply line 1a by line 1b times 3.785, and divide the product by 100,000)[a]		0.0000
2. DIMENSION OF SAPS			
a	Volume of pond required per gpm AMD (divide line 1c by 7.48 and 60)		0.00 ft^3/gpm
b	Volume of pond at the design flow rate (multiply line 1b by line 2a)		0 ft^3
c	Effective depth	**7 ft**	
d	Side slope (ft run over ft rise)	**2 :1**	
e	Average width (depends on availability of land)	**35 ft**	
f	Average length (divide line 2b by line 2c and line 2e)		0 ft
g	Average surface area of pond (multiply line 2e by line 2f)		0 ft^2
h	Surface area of empty pond (multiply line 2g by 1.2)		0 ft^2
3. LIMESTONE LAYER			
a	Thickness of limestone layer (1 to 2 ft - Skousen)	**1.5 ft**	
b	Molecular weight of limestone	**100 g/mol**	
c	Theoretical requirement for limestone (multiply lines 1d, 3b, and 2.2, and divide the result by 1,000)		0.0000 lbs/min
d	Estimated volume of limestone (multiply line 3a by line 2g)		0 ft^3
e	Density of limestone	**168.02 lbs/ft^3**	
f	Efficiency[b]	**30%**	
g	Limestone purity	**90%**	
h	Estimated weight of limestone in lbs. (multiply line 3d by line 3e, and divide the result by lines 3f and 3g)		0 lbs
i	Estimated weight of limestone in tons (divide line 3g by 2000)		0 tons
j	Neutralization capacity (divide line 3h by the product of line 3c times line 3f times 60 times 24 times 365)		0.00 years
4. COMPOST LAYER			
a	Thickness of compost (0.5 to 1 ft - Skousen)	**1.00 ft**	
b	Estimated volume of compost (multiply line 4a by line 2g)		0 ft^3
c	Density of compost (default)	**93 lbs/ft^3**	
d	Estimated weight of compost in lbs. (multiply line 4b by line 4c)		0 lbs
e	Estimated weight of compost in tons (divide line 4d by 2000)		0 tons

SUCCESSIVE ALKALINITY-PRODUCING SYSTEMS (SAPS)

5. CLAY LINER			
a	Thickness of clay liner (a minimum of 0.5 ft)	**0.75 ft**	
b	Estimated volume of compacted clay (multiply line 5a by line 2h)		0 ft^3
c	Swelling factor[c]	**40%**	
d	Actual volume of clay required in ft^3 (add 100% to the percentage in line 5c, and multiply line 5b by the resulting percentage)		0 ft^3
e	Actual volume of clay required in yd^3 (divide line 5d by 27)		0 yd^3
6. SAND LAYER			
a	Thickness of sand bedding layer	**0.5 ft**	
b	Actual volume of sand bedding material in ft^3 (multiply line 6a by line 2h)		0 ft^3
c	Actual volume of sand bedding material in yd^3 (divide line 6b by 27)		0 yd^3
7. PIPING			
a	Distance from settling pond to SAPS pond	**0 ft**	
b	Distance from SAPS pond to aeration/settling pond	**0 ft**	
c	Estimated influent and effluent piping (50% safety factor) - (Add line 7a and 7b and then multiply the sum by 1.5)		0 ft
d	Estimated length underdrain piping (multiply line 2e by line 2f and divide the product by 10) (underdrain pipes are installed parallel to the pond for the length of the pond, with 10-foot spacing)		0 ft
8. SITE WORK			
a	Volume (multiply line 2b by 1.2)		0 ft^3
	Add 20%		0 yd^3
b	Area to be cleared in ft^2 (multiply line 2e by line 2f and add 50% safety factor)		0 ft^2
c	Area to be cleared in acres (divide line 8b by 43,560)		0 acres
d	Area to be surveyed (same as line 8c)		0 acres
e	Survey rate	**1 acre/day**	
f	Days required to complete survey (divide line 8d by line 8e)		0 days

[a] MACID is number of moles of $CaCO_3$ equivalent acidity
Volume in above equation must be in liters

$$MACID = \frac{Acidity \times Volume}{100,000}$$

(From: Skousen, Acid Mine Drainage Control and Treatment, Second Edition. 1996. West Virginia University. pg. 159).

[b] Skousen and others. 1996. Acid Mine Drainage Control and Treatment. Second Edition. West Virginia University, pg. 238.

[c] U.S. Environmental Protection Agency. *Final Guidance Manual: Cost Estimates for Closure and Post-Closure Plans (Subparts G and H), January 1987. Volume III. EPA/530-SW-87-009. pg. 7-10.*

SUCCESSIVE ALKALINITY-PRODUCING SYSTEMS (SAPS)

1.	**SURVEY**				
a	Unit cost of surveying[a]	648.36	$/day		
b	Days required to conduct survey (from PT-4A, line 8f)	0	days		
c	**Total Cost to Survey (multiply line 1a by line 1b)**			**$0.00**	
2.	**CLEARING AND GRUBBING**				
a	Unit cost of clearing and grubbing[b]	5,630.00	$/acre		
b	Area to be cleared and grubbed (from PT-4A, line 8c):	0	acres		
c	**Total Cost of Clearing and Grubbing (multiply line 2a by line 2b):**			**$0.00**	
3.	**PURCHASE AND DELIVERY OF CLAY**				
a	Volume of clay required (from PT-4A, line 5e):	0	yd^3		
b	Unit cost of purchase of clay[c]	6.00	$\$/yd^3$		
c	Delivery of clay (50-mile radius)[d]	19.40	$\$/yd^3$		
d	**Total Cost of Purchase and Delivery of Clay (multiply line 3a by the sum of lines 3b and 3c)**			**$0.00**	
4.	**PURCHASE AND DELIVERY OF SAND**				
a	Volume of sand bedding material required (from PT-4A, line 6c)	0	yd^3		
b	Unit cost of purchase and delivery of sand (30-mile radius)[e]	26.00	$\$/yd^3$		
c	**Total Cost of Purchase and Delivery of Sand (multiply line 4a by line 4b)**			**$0.00**	
5.	**PURCHASE AND DELIVERY OF LIMESTONE**				
a	Quantity of limestone required in lbs(from PT-4A, line 3g)	0	lbs		
b	Unit cost of purchase and delivery of limestone (50-mile radius)[f]	0.006	$/lbs		
c	**Total Cost of Purchase and Delivery of Limestone (multiply line 5a by line 5b)**			**$0.00**	
6.	**INSTALLATION OF HUMUS PEAT OR COMPOST LAYER**				
a	Quantity of humus peat or compost required (from PT-4A, line 4b divided by 27)	0	yd^3		
b	Unit cost of purchase and spreading of the layer[g]	60.12	$\$/yd^3$		
c	Delivery (50-mile radius)[h]	19.40	$\$/yd^3$		
d	**Total Cost of Purchase and Delivery of Humus Peat or Compost (multiply line 6a by the sum of lines 6b and 6c)**			**$0.00**	
7.	**EXCAVATION**				
a	Volume to be excavated (from PT-4A, line 8a):	0	yd^3		
b	Unit cost of excavation[i]	4.68	$\$/yd^3$		
c	**Total Cost of Excavation (Multiply line 7a by line 7b):**			**$0.00**	
8.	**SPREADING AND COMPACTING OF CLAY LAYER**				
a	Volume of clay layer (from line 5a)	0	yd^3		
b	Unit cost of filling and spreading the clay by dozer[j]	1.40	$\$/yd^3$		
c	Unit cost of compacting the clay layer[k]	1.18	$\$/yd^3$		
c	Unit cost of compaction testing by nuclear method[l]	0.77	$\$/yd^3$		
d	Unit cost of compaction testing by sand cone method[m]	0.30	$\$/yd^3$		
e	**Total Cost of Spreading and Compacting the Clay Layer (multiply line 8a by the sum of lines 8b through 8d)**			**$0.00**	

SUCCESSIVE ALKALINITY-PRODUCING SYSTEMS (SAPS)

9.	**SPREADING OF SAND BEDDING LAYER AND LIMESTONE LAYER**			
a	Volume of sand bedding material (from line 6c)	0	yd^3	
b	Quantity of limestone (from PT-4A, divide line 3g by line 3e and then divide that quotient by 27)	0	yd^3	
c	Cost of filling and spreading the sand and limestone by dozer[n]	1.40	$\$/yd^3$	
d	**Cost for Spreading Sand Bedding Layer (multiply line 9c by the sum of lines 9a and 9b)**			**$0.00**
10.	**INSTALLATION OF INFLUENT AND EFFLUENT PIPING**			
a	Length of piping (from PT-4A, add lines 7c and 7d)	0	ft	
b	Unit cost of purchase, delivery, and installation of 1" to 4" PVC pipe[o]	17.40	$/ft	
c	Allowance factor for fittings and insulation (default)[p]	20%		
d	Unit cost of fittings and insulation (multiply line 10a by line 10c)	3.48	$/ft	
e	**Total Cost of Installation of Piping (multiply line 10a by the sum of lines 10b and 10d)**			**$0.00**
11.	**INSTALLATION OF BACKFLUSH PUMP**			
a	Capacity of pump (from PT-4A, line 1b)	0	gpm	
b	Number of pumps	0	pumps	
c	Unit cost of purchase, delivery, and installation of a backflush pump (see table below)[q]	4,011.00	$/ea	
d	**Total Cost for Installation of Backflush Pump (multiply line 11b by line 11c)**			**$0.00**
TOTAL COST OF INSTALLATION OF SAPS (add lines 1c, 2c, 3d, 4c, 5c, 6d, 7c, 8e, 9d, 10e, and 11d)				**$0.00**

a R.S. Means Company, Inc., *Environmental Remediation Data Unit Cost* , 1999, pg. 10, Item No. 99 24 1201. Cost includes surveying with 2-man crew.

b R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 39, Item No. 021 104 0260. Cost includes clearing and grubbing of dense brush including stumps

c R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 46, Item No. 022 216 6000. The cost is that for purchasing clay, till or blasted rock and loading the material onto dump truck.

d R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 54, Item No. 022 216 6000. Cost includes purchasing clay, till or blasted rock, and loading onto dump truck.

e R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 216, Item No. 041 032 0300. The cost is that for purchase and delivery of screened and washed sand, within a 30-mile radius.

f Remine Version V. 1.21. Average cost of pebble lime from Greybeck Lime (Bellefonte, PA) and Constone (Erinsburg, PA). Cost includes purchase and delivery within a 50-mile radius.

g R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 128, Item No. 029 516 0400. The cost is that for purchase and delivery, and its placement 1" deep by push spreader. Convert the cost into per yd^3 units by dividing $1.67/$yd^2$ by 9 (ft^2/yard) times (1/12); then multiply the results by 27.

h R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 54, Item No. 022 216 6000. Cost includes hauling with 12 C.Y. dump truck, 20 miles roundtrip.

i R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 51, Item No. 022 254 0060. The cost is that for excavation of a trench 1 to 4 ft deep with a 0.5 yd^3 tractor loader-backhoe.

SUCCESSIVE ALKALINITY-PRODUCING SYSTEMS (SAPS)

j R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg.53, Item No. 022 262 0010. The cost is that for spreading dumped material by dozer, with no compaction

k R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 46, Item No. 022 226 6220. Cost includes compaction using towed vibrating roller, 6" lifts, 4 passes per lift.

l R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 11, Item No. 014 108 4735. Cost includes soil density testing using nuclear method, ASTM D2922-71. Assume 1 test per 50 cy compaction.

m R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 11, Item No. 014 108 4740. Cost includes soil density testing using sand cone method ASTM D1556064. Assume 1 test per 100 cy compaction.

n R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg.53, Item No. 022 262 0010. Cost includes spreading dumped material, by dozer, no compaction.

o R.S. Means Company, Inc., *Mechanical Cost Data* , 1999, pg. 123, Item No. 151 550 1090 through 1150. Cost includes purchase and delivery of PVC, Sch. 80, high impact/pressure pipes with a range of 1" through 4".

p This cost is an engineering judgment.

q R.S. Means Company, Inc., *Environmental Remediation Cost Data - Assemblies* , 1999, pages 3-63, Items No. 33 29 0102 through 0115. The cost is that for purchase, delivery,B78 and installation of a sludge pump.

GPM	Cost	GPM	Cost
10	$786	500	$6,798
50	$1,845	750	$8,699
100	$2,685	1050	$10,578
200	$4,011	1500	$13,951
250	$4,531	2000	$16,600
300	$5,098		

AEROBIC AND ANAEROBIC WETLANDS

1.	**AMD CHARACTERISTICS**		
a	Iron concentration of mine drainage	**0 mg/L**	
b	Manganese concentration of mine drainage	**0 mg/L**	
c	Design flow rate	**0 gpm**	
d	Design iron removal (grams of iron removed per square meter per day of wetland) - 20 gmd for alkaline drainage and 5 gmd for acidic drainage[a]	**20 gmd**	
e	Design manganese removal (grams of iron removed per square meter per day of wetland)[a]	**0.5 gmd**	
f	Iron loading (multiply line 1a by line 1c, 3.785 l/gal, and 1,440 min/day, and divide the product by 1,000 mg/g)		0 grams
g	Manganese loading (multiply line 1b by line 1c, 3.785 l/gal, and 1,440 min/day, and divide the product by 1,000 mg/g)		0 grams
2.	**SURFACE AREA OF WETLAND**		
a	Surface area of wetland required for iron removal (divide line 1f by line 1d and multiply the result by 10.76 square feet/square meter)		0 ft^2
b	Surface area of wetland required for manganese removal (divide line 1g by line 1e and multiply the result by 10.76 square feet/square meter)		0 ft^2
c	Total surface area of wetland (add lines 2a and 2b)		0 ft^2
3.	**HUMUS OR COMPOST LAYER REQUIREMENT**		
a	Thickness of compost layer (0.5 to 1 ft - Skousen; 12 to 18 inch - Brodie)	**0.00 ft**	
b	Surface area of compost layer in ft^2 (from line 2c)		0 ft^2
c	Surface area of compost layer (multiply line 3b by 0.111)		0 yd^2
d	Volume of compost required (multiply line 3a by line 3b, and divide the product by 27)		0 yd^3
4.	**LIMESTONE LAYER (FOR ANAEROBIC WETLAND ONLY)**		
a	Thickness of limestone layer (0.5 to 1 ft - Skousen)	**0.0 ft**	
b	Estimated volume of limestone (multiply line 4a by line 2c)		0.00 ft^3
c	Density of limestone	**168.02 lbs/ft^3**	
d	Efficiency[b]	**0%**	
e	Purity of limestone	**0%**	
f	Estimated limestone weight of limestone (multiply line 4b by line 4c)		0 lbs

AEROBIC AND ANAEROBIC WETLANDS

5.	**CLAY LINER**		
a	Thickness of clay liner (a minimum of 0.5 ft)	**0 ft**	
b	Estimated volume of compacted clay (multiply line 2c by line 5a)		0 ft^3
c	Swelling factor[c]	**40%**	
d	Actual volume of clay required (add 100% to the percentage in line 5c and multiply line 5b by that percentage and divide the result by 27)		0 yd^3
6.	**DIMENSION OF WETLAND**		
a	Free board (1 to 3 inch - Skousen)	**0 ft**	
b	Effective depth (add lines 3a, 4a, 5a, and 6a)		0 ft
c	Total volume of wetland (multiply line 2c by line 6b)		0 ft^3
d	Total volume of wetland in cubic yard (divide line 6c by 27)		0 yd^3
e	Average width (depends on availability of land)	**0 ft**	
f	Average length (divide line 3c by the product of lines 6b and 6e)		0 ft
7.	**PIPING REQUIREMENT**		
a	Distance from influent or previous treatment unit	**0 ft**	
b	Distance from wetland to discharge point or next treatment unit	**0 ft**	
c	Estimated length of influent and effluent piping required (50% safety factor)		0 ft
8.	**PLANT AND VEGETATION**		
a	Density of cattails	**1 plant/ft^2**	
b	Number of cattails required (multiply line 7a by line 2c)		0 plants
c	Labor rate (default)	**250 plants/hrs**	
d	Labor hours required		0 hrs
9.	**SITE WORK**		
a	Volume to be excavated in ft^3 (with 20% design factor) (line 2c x (addition of 3a + line 4a + line 5a)		0 ft^3
b	Volume to be excavated in yd^3 (divide line 9a by 27)		0 yd^3
c	Area to be cleared in ft^2 (50% inflated) - (multiply line 2c by 1.5)		0 ft^2
d	Area to be cleared in areas (divide line 9c by 43.560)		0.00 acres
e	Area to be surveyed (same as Line 9d)		0.00 acres
f	Survey rate	**1 acre/day**	
g	Days required to complete survey (multiply line 9e by line 9f)		0.000 day

a Skousen, and others. 1996 Acid Mine Drainage Control and Treatment, Second Edition West Virginia University. P. 253 - 254.

b Skousen and other. 1996. Acid Mine Drainage Control and Treatment. Second Edition. West Virginia University. Pg. 238.

c U.S. Environmental Protection Agency. *Final Guidance Manual: Cost Estimates for Closure and Post-Closure Plans (Subparts G and H)* . January 1987. Volume III - EPA/530-SW-87-00g. Pg. 7-10.

AEROBIC AND ANAEROBIC WETLANDS

1.	**SURVEYING**				
a	Unit cost of surveying[a]	648.36	$/day		
b	Days required to conduct survey (from PT-5A, line 9g)	0.00	days		
c	**Cost of surveying (multiply line 1a by line 1b)**				**$0.00**
2.	**CLEARING AND GRUBBING**				
a	Unit cost of clearing and grubbing[b]	5,630.00	$/acre		
b	Area to be cleared and grubbed (from PT-5A, line 9d)	0.00	acres		
c	**Total Cost of Clearing and Grubbing (multiply line 2a by line 2b)**				**$0.00**
3.	**PURCHASE AND DELIVERY OF CLAY**				
a	Volume of clay required (from PT-5A, line 5d)	0	yd^3		
b	Unit cost of clay purchase[c]	6.00	$/$yd^3$		
c	Unit cost of delivery of clay (20-mile radius)[d]	19.40	$/$yd^3$		
d	**Total Cost of Purchase and Delivery of Clay (multiply line 3a by the sum of lines 3b and 3c)**				**$0.00**
4.	**PURCHASE AND DELIVERY OF LIMESTONE (FOR ANAEROBIC WETLAND ONLY)**				
a	Quantity of limestone (from PT-5A, line 4f)	0	lbs		
b	Unit cost of purchase and delivery of limestone (50-miles radius)[e]	0.006	$/lbs		
c	**Total Cost of Purchase and Delivery of Limestone (multiply line 4a by line 4b)**				**$0.00**
5.	**INSTALLATION OF HUMUS PEAT OR COMPOST LAYER**				
a	Volume of humus peat or compost (from PT-5A, line 3d)	0	yd^3		
b	Unit cost of purchase and spreading of the layer[f]	60.12	$/$yd^3$		
c	Unit cost of delivery of humus peat or compost (20 miles radius)[g]	19.40	$/$yd^3$		
d	**Cost of Purchase and Delivery Compost (multiply line 5a by the sum of lines 5b and 5c)**				**$0.00**
6.	**EXCAVATION**				
a	Volume to be excavated (from PT-5A, line 9b)	0	yd^3		
b	Unit cost of excavation[h]	2.05	$/$yd^3$		
c	**Total Cost of Excavation (multiply line 6a by line 6b)**				**$0.00**
7.	**SPREADING AND COMPACTING OF CLAY LAYER**				
a	Volume of clay layer (from PT-5A, line 5d)	0	yd^3		
b	Unit cost of filling and spreading the clay by dozer[i]	1.39	$/$yd^3$		
c	Unit cost of compacting the clay layer[j]	1.16	$/$yd^3$		
d	Unit cost of compaction testing by nuclear method[k]	0.85	$/$yd^3$		
e	Unit cost of compaction testing by sand cone method[l]	0.33	$/$yd^3$		
f	**Total Cost of Spreading and Compacting Clay Layer (multiply line 7a by the sum of lines 7b through 7e)**				**$0.00**
8.	**INSTALLATION OF LIMESTONE LAYER (FOR ANAEROBIC WETLAND ONLY)**				
a	Quantity of limestone (divide PT-5A, line 4b by 27)	0	yd^3		
b	Unit cost of filling and spreading limestone[m]	1.39	$/$yd^3$		
c	**Total Cost of Installation of Limestone Layer (multiply line 7a by line 7b)**				**$0.00**

AEROBIC AND ANAEROBIC WETLANDS

9.	**PLANTS AND VEGETATION**			
a	Labor hours required (from PT-5A, line 8d)	0	hrs	
b	Unit cost of planting of cattails[n]	88.50	$/hr	
c	**Total Cost of Plants and Vegetation (multiply line 9a by line 9b)**			**$0.00**
10.	**INSTALLATION OF INFLUENT AND EFFLUENT PIPING**			
a	Length of piping (from PT-5A, line 7c)	0	ft	
b	Unit cost of purchase, deliver, and install 1" to 4" PVC pipe[o]	17.40	$/ft	
c	Allowance factor for fittings and insulation (default)[p]	**15%**		
d	Unit cost for fittings and insulation (multiply line 10b by line 10c)	2.61	$/ft	
e	**Total Cost of Installation of Piping (multiply line 10a by the sum of lines 10b and 10d)**			**$0.00**
	TOTAL COST OF WETLAND INSTALLATION (add lines 1c, 2c, 3d, 4d, 5d, 6d, 7d, 8c, and 10e)			**$0.00**

a R.S. Means Company, Inc., *Environmental Remediation Data Unit Cost* , 1999, pg. 10-10, Item No. 99 24 1201. The cost is that for surveying with a two-person crew.

b R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 39, Item No. 021 104 0260. The cost is that for clearing and grubbing of dense brush including stumps.

c R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 46, Item No. 022 216 6000. The cost is that for purchasing clay, till, or blasted rock, and loading onto a dump truck.

d R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 54, Item No. 022 216 6000. The cost is that for hauling with a 12-yd^3 dump truck for a 20-mile roundtrip.

e Remine Version V. 1.21. Average cost of pebble lime from Greybeck Lime (Bellefonte, PA) and Constone (Erinsburg, PA). The cost is that for purchase and delivery within a 50-mile radius.

f R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 128, Item No. 029 516 0400. The cost is that for purchase, delivery, and placement of 1" deep, push spreader. Convert the cost into per cubic yard unit by dividing 1.67 $\$/yd^2$ by 9 (ft^2/yd^2) times (1/12), then multiply the results by 27.

g R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 54, Item No. 022 216 6000. The cost is that for hauling with a 12-yd^3 dump truck for a 20-mile roundtrip.

h R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 49, Item No. 022 242 20200. The cost is that for bulk common earth excavation with a 75 HP, 50-ft hauling dozer.

I R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg.53, Item No. 022 262 0010. The cost is that for spreading dumped material, by dozer, no compaction.

j R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 46, Item No. 022 226 6220. The cost is that for compaction using towed vibrating roller with 6" lifts and 4 passes per lift.

k R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 11, Item No. 014 108 4735. The cost is that for soil density testing using nuclear method, ASTM D2922-71. One test per 50 yd^3 compaction is assumed.

l R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 11, Item No. 014 108 4740. Cost includes soil density testing using sand cone method ASTM D1556064. One test per 100 yd^3 compaction is assumed.

m R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 53, Item No. 022 262 0010. The cost is that for spreading dumped material by dozer, without compaction.

AEROBIC AND ANAEROBIC WETLANDS

n This cost is an engineering estimate based on the use of a crew consisting of two skilled workers. The hourly rate for a skilled worker was taken from R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, back cover.

o R.S. Means Company, Inc., *Mechanical Cost Data* , 1999, pg. 123, Item No. 151 550 1090 through 1150.

p The cost is that for purchase and delivery of Sch. 80, high impact/pressure PVC pipes with a range of 1" through 4".

5.0 GENERAL TREATMENT AND POLISHING

General treatment and polishing units may be integral components of treatment systems or may be used in conjunction with other treatment units to enhance the level of effectiveness of both active and passive mine drainage treatment systems. Clarifiers, belt presses, the use of polymers, and settling ponds can be used as the primary units for removal of metal precipitates from mine drainage. Rock drains and filter fields, on the other hand, function as “polishing” units that enhance the efficiencies of the treatment systems with which they are associated. The methodology provides worksheets that can be used to estimate the costs of four types of general treatment and polishing units: 1) settling ponds, 2) clarifiers, 3) rock drains, and 4) filter fields.

Presented below are descriptions of the cost estimating worksheets to be used in determining the costs of conducting general treatment and polishing activities at surface mines, underground mines, and coal refuse piles:

- **Ponds** - When drainage that contains suspended solids (for example, metal precipitates) is placed in a quiescent state, those solids that are of a higher density than the liquid will tend to settle out over time. Settling ponds are designed to provide sufficient detention and residence time to remove settleable solids from mine drainage. Settling ponds can be used in conjunction with active or passive mine drainage treatment technologies. The cost of the activity includes the costs of excavation, construction and installation of clay-lined settling ponds, purchase and delivery of materials, and installation of influent and effluent piping.

- **Clarifiers** - Clarifiers accomplish much the same effects as settling ponds. Claifiers, however, are able to handle larger flows than settling ponds and require smaller physical settings. Clarifiers often are used in conjunction with active mine drainage treatment technologies. The cost of the activity includes the costs of the purchase and delivery of a clarifier and its accessories, installation of the clarifier, and installation of sludge drying beds.

- **Rock Drains** - A type of polishing unit, a rock drain can be added to active or passive mine drainage treatment systems to provide additional aeration. A rock drain is constructed as an open channel that is filled with rocks. The cost of this activity includes excavation, the purchase and delivery of rocks, and the filling of the drain with rocks.

- **Filter Fields** - A type of polishing unit, a filter field can be added to active or passive mine drainage treatment systems to remove additional metal hydroxides. Filter fields are constructed as clay-lined earthen pits that are filled with sand or anthracite that acts as a filter media. The cost of the activity includes the costs of excavating the pit, purchasing and delivering the sand and clay, filling the pit with sand, and installing influent and effluent piping.

- **OLCs** - OLCs can be used to reduce the content of metals in mine drainage as a pretreatment or polishing unit in conjunction with active treatment technologies. Under conditions in which oxidation may occur, limestone that is exposed to mine drainage gradually becomes coated with metal hydroxides, a process known as “armoring.” Armoring reduces the capacity of limestone to neutralize mine drainage. In addition, among neutralization chemicals, limestone can have a low level of efficiency because it is not highly soluble. OLCs generally are applied to low flows and low acidity conditions. The worksheet provides a method of calculating the cost of the installation of an OLC on the basis of the acidity and rate of flow of mine drainage. The cost of the activity include the cost of: excavating a channel, installing a geosynthetic or clay liner, purchasing and delivering limestone, and filling the channel with limestone.

PONDS FOR NEW TREATMENT SYSTEM

(SETTLING PONDS, EQUALIZATION BASIN, POLISHING PONDS, STILLING PONDS, AND SEDIMENT PONDS)

1.	**EXCAVATION OF POND**			
a	Design flow rate	**0.0**	**gpm**	
b	Design retention time (24 hours - default)	**0**	**hr**	
c	Volume of open pit required for flow (multiply line 1a by line 1b and by 60 and 0.00495)	0	yd^3	
	FOR NON-SETTLING PONDS, SKIP LINES 1e THROUGH 1i.			
e	Mine drainage acidity	**0**	**mg/L as $CaCO_3$**	
f	Mass acid loading (multiply line 1a by 3.785 and by line 1e)	0	mg acid/min	
g	Volume of sludge generated annually (multiply line 1f by the multiplier for the appropriate neutralization chemical below) **b. Caustic (20% solution)a**	0	(yd^3/year)	
	1. Soda ash briquettes[a]	0.072	(yd^3/year) / (mg acid/min)	
	2. Caustic (20% solution)[a]	0.095		
	3. Ammonia[a]	0.090		
	4. Hydrated lime or pebble quicklime[a]	0.116		
	5. Limestone[b]	0.220		
	6. Other reagent			
h	Months of sludge-holding capacity	**0**	**months**	
i	Volume of open pit required to hold sludge (multiply line 1g by line 1h and divide the result by 12)	0	yd^3	
j	Total volume of open pit required (for settling ponds: add lines 1c and line 1i; for non-settling ponds: line 1c) (*V*)		yd^3	
k	Side wall slope (*S*)	0.5	ft rise /ft run	
l	Depth of open pit (d_p)		**ft**	
m	Surface area of open pit; calculate as[c] $[(27V/d_p)^{0.5} + d_p/S]^2 + 4d[(27V/d_p)^{0.5} + dp/S]$	0	ft^2	
n	Thickness of clay liner		**ft**	
o	Thickness of liner cover	**0**	**ft**	
p	Depth of excavation (add lines 1l, 1n, and 1o) (d_e)	0	ft	
q	Volume to be excavated; calculate as $(d_e/27) \times [(27V/d_p)^{0.5} + d_p/S]^2$	0	yd^3	
r	Excavation footprint; calculate as $[(27V/d_p)^{0.5} + 2d_p/S]^2$	0	ft^2	
s	Unit cost of clearing and grubbing[d]	0.380	$\$/ft^2$	
t	Total cost of clearing and grubbing (multiply line 1m by line 1n)	0.00	$	
u	Unit cost of excavation[e]	4.330	$\$/yd^3$	
v	Total cost of excavation (multiply line 1p by line 1u)	0.00	$	
w	**Total Cost of Excavation of Pond (add lines 1t and 1v)**			**$0.00**

PONDS FOR NEW TREATMENT SYSTEM

(SETTLING PONDS, EQUALIZATION BASIN, POLISHING PONDS, STILLING PONDS, AND SEDIMENT PONDS)

2.	**LINING OF POND**			
a	Surface area of open pit (line 1m)	0	ft^2	
b	Thickness of clay liner (line 1n)	0	ft	
c	Volume of clay required (multiply line 2a by line 2b and divide by 27)	0	yd^3	
d	Unit cost for purchase and placement of clay[f]	17.280	$\$/yd^3$	
e	**Total cost for clay liner (multiply lines 2c and 2d)**	0.00	$	
f	Thickness of liner cover (line 1o)		ft	
g	Volume of clay required (multiply line 2a and 2f and divide by 27)	0	yd^3	
h	Unit cost for purchase and placement of clay[g]	6.570	$\$/yd^3$	
i	**Cost of clay liner (multiply line 2f by line 2h)**	0.00	$	
j	Included synthetic liner? (Y or N)	**n**		
k	Unit cost of purchase and placement of synthetic liner[h]	1.730	$\$/ft^2$	
l	**Total cost of synthetic liner (multiply line 2a by line 2k)**	0.00	$	
m	**Total Cost of Lining Pond (add lines 1w)**			**$0.00**
3.	**NUMBER OF PONDS**			
a	Number of ponds		**ea**	
	TOTAL COST OF PONDS (add lines 1w and 1m, and multiply the sum by line 3a)			**$0.00**

a West Virginia University and The National Mine Land Reclamation Center. Acid Mine Drainage Control and Treatment, Skousen and Ziemkiewicz, 1996, pg. 217 - 224.

b 100 (MW of limestone) x 2.2 lbs/kg / 1000.

c Calculated as a squared out pit with vertical walls at midpoint of side slope -- bottom plus sidewalls.

d R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pgs. 4-1 and 4-9, Item Nos. 17 01 0103 and 17 03 0101. The cost is that for medium brush with average grub and some trees, clearing, and rough grading with a D6 dozer.

e R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 4-15, Item No. 17 03 0276. The cost is that for excavation with a 1 yd^3 crawler-mounted, hydraulic excavator.

f R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 9-78, Item No. 33 08 0507. The cost is that for construction of a clay liner of 10 e-7 conductivity, with 6" lifts and purchase and delivery of clay material from an off-site location.

g R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 4-23, Item No. 17 03 0422. The cost is that for unclassified fill, 6" lifts, on site with spreading and compaction.

h R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 9-81, Item No. 33 08 0572. The cost is that for purchase, delivery, and installation of 60-mil polymeric HDPE liner.

PONDS FOR NEW TREATMENT SYSTEM

(SETTLING PONDS, EQUALIZATION BASIN, POLISHING PONDS, STILLING PONDS, AND SEDIMENT PONDS)

1.	**EXCAVATION OF POND**			
a	Design flow rate	**0.0**	**gpm**	
b	Design retention time (24 hours - default)	**0**	**hr**	
c	Volume of open pit required for flow (multiply line 1a by line 1b and by 60 and 0.00495)	0	yd^3	
	FOR NON-SETTLING PONDS, SKIP LINES 1e THROUGH 1i.			
e	Mine drainage acidity	**0**	**mg/L as $CaCO_3$**	
f	Mass acid loading (multiply line 1a by 3.785 and by line 1e)	0	mg acid/min	
g	Volume of sludge generated annually (multiply line 1f by the multiplier for the appropriate neutralization chemical below) **b. Caustic (20% solution)a**	0	(yd^3/year)	
	1. Soda ash briquettes[a]	0.072	(yd^3/year) / (mg acid/min)	
	2. Caustic (20% solution)[a]	0.095		
	3. Ammonia[a]	0.090		
	4. Hydrated lime or pebble quicklime[a]	0.116		
	5. Limestone[b]	0.220		
	6. Other reagent			
h	Months of sludge-holding capacity	**0**	**months**	
i	Volume of open pit required to hold sludge (multiply line 1g by line 1h and divide the result by 12)	0	yd^3	
j	Total volume of open pit required (for settling ponds: add lines 1c and line 1i; for non-settling ponds: line 1c) (*V*)		yd^3	
k	Side wall slope (*S*)	0.5	ft rise /ft run	
l	Depth of open pit (d_p)		**ft**	
m	Surface area of open pit; calculate as[c] $[(27V/d_p)^{0.5} + d_p/S]^2 + 4d[(27V/d_p)^{0.5} + dp/S]$	0	ft^2	
n	Thickness of clay liner		**ft**	
o	Thickness of liner cover	**0**	**ft**	
p	Depth of excavation (add lines 1l, 1n, and 1o) (d_e)	0	ft	
q	Volume to be excavated; calculate as $(d_e/27) \times [(27V/d_p)^{0.5} + d_p/S]^2$	0	yd^3	
r	Excavation footprint; calculate as $[(27V/d_p)^{0.5} + 2d_p/S]^2$	0	ft^2	
s	Unit cost of clearing and grubbing[d]	0.380	$\$/ft^2$	
t	Total cost of clearing and grubbing (multiply line 1m by line 1n)	0.00	$	
u	Unit cost of excavation[e]	4.330	$\$/yd^3$	
v	Total cost of excavation (multiply line 1p by line 1u)	0.00	$	
w	**Total Cost of Excavation of Pond (add lines 1t and 1v)**			**$0.00**

PONDS FOR NEW TREATMENT SYSTEM

(SETTLING PONDS, EQUALIZATION BASIN, POLISHING PONDS, STILLING PONDS, AND SEDIMENT PONDS)

2.	**LINING OF POND**			
a	Surface area of open pit (line 1m)	0	ft^2	
b	Thickness of clay liner (line 1n)	0	ft	
c	Volume of clay required (multiply line 2a by line 2b and divide by 27)	0	yd^3	
d	Unit cost for purchase and placement of clay[f]	17.280	$\$/yd^3$	
e	**Total cost for clay liner (multiply lines 2c and 2d)**	0.00	$	
f	Thickness of liner cover (line 1o)		ft	
g	Volume of clay required (multiply line 2a and 2f and divide by 27)	0	yd^3	
h	Unit cost for purchase and placement of clay[g]	6.570	$\$/yd^3$	
i	**Cost of clay liner (multiply line 2f by line 2h)**	0.00	$	
j	Included synthetic liner? (Y or N)	**n**		
k	Unit cost of purchase and placement of synthetic liner[h]	1.730	$\$/ft^2$	
l	**Total cost of synthetic liner (multiply line 2a by line 2k)**	0.00	$	
m	**Total Cost of Lining Pond (add lines 1w)**			**$0.00**
3.	**NUMBER OF PONDS**			
a	Number of ponds		**ea**	
TOTAL COST OF PONDS (add lines 1w and 1m, and multiply the sum by line 3a)				**$0.00**

a West Virginia University and The National Mine Land Reclamation Center. Acid Mine Drainage Control and Treatment, Skousen and Ziemkiewicz, 1996, pg. 217 - 224.

b 100 (MW of limestone) x 2.2 lbs/kg / 1000.

c Calculated as a squared out pit with vertical walls at midpoint of side slope -- bottom plus sidewalls.

d R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pgs. 4-1 and 4-9, Item Nos. 17 01 0103 and 17 03 0101. The cost is that for medium brush with average grub and some trees, clearing, and rough grading with a D6 dozer.

e R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 4-15, Item No. 17 03 0276. The cost is that for excavation with a 1 yd^3 crawler-mounted, hydraulic excavator.

f R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 9-78, Item No. 33 08 0507. The cost is that for construction of a clay liner of 10 e-7 conductivity, with 6" lifts and purchase and delivery of clay material from an off-site location.

g R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 4-23, Item No. 17 03 0422. The cost is that for unclassified fill, 6" lifts, on site with spreading and compaction.

h R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 9-81, Item No. 33 08 0572. The cost is that for purchase, delivery, and installation of 60-mil polymeric HDPE liner.

PONDS FOR NEW TREATMENT SYSTEM

(SETTLING PONDS, EQUALIZATION BASIN, POLISHING PONDS, STILLING PONDS, AND SEDIMENT PONDS)

1. EXCAVATION OF POND				
a	Design flow rate	**0.0**	**gpm**	
b	Design retention time (24 hours - default)	**0**	**hr**	
c	Volume of open pit required for flow (multiply line 1a by line 1b and by 60 and 0.00495)	0	yd^3	
	FOR NON-SETTLING PONDS, SKIP LINES 1e THROUGH 1i.			
e	Mine drainage acidity	**0**	**mg/L as $CaCO_3$**	
f	Mass acid loading (multiply line 1a by 3.785 and by line 1e)	0	mg acid/min	
g	Volume of sludge generated annually (multiply line 1f by the multiplier for the appropriate neutralization chemical below) **b. Caustic (20% solution)a**	0	(yd^3/year)	
	1. Soda ash briquettes[a]	0.072	(yd^3/year) / (mg acid/min)	
	2. Caustic (20% solution)[a]	0.095		
	3. Ammonia[a]	0.090		
	4. Hydrated lime or pebble quicklime[a]	0.116		
	5. Limestone[b]	0.220		
	6. Other reagent			
h	Months of sludge-holding capacity	**0**	**months**	
i	Volume of open pit required to hold sludge (multiply line 1g by line 1h and divide the result by 12)	0	yd^3	
j	Total volume of open pit required (for settling ponds: add lines 1c and line 1i; for non-settling ponds: line 1c) (*V*)		yd^3	
k	Side wall slope (*S*)	0.5	ft rise /ft run	
l	Depth of open pit (d_p)		**ft**	
m	Surface area of open pit; calculate as[c] $[(27V/d_p)^{0.5} + d_p/S]^2 + 4d[(27V/d_p)^{0.5} + dp/S]$	0	ft^2	
n	Thickness of clay liner		**ft**	
o	Thickness of liner cover	**0**	**ft**	
p	Depth of excavation (add lines 1l, 1n, and 1o) (d_e)	0	ft	
q	Volume to be excavated; calculate as $(d_e/27) \times [(27V/d_p)^{0.5} + d_p/S]^2$	0	yd^3	
r	Excavation footprint; calculate as $[(27V/d_p)^{0.5} + 2d_p/S]^2$	0	ft^2	
s	Unit cost of clearing and grubbing[d]	0.380	$\$/ft^2$	
t	Total cost of clearing and grubbing (multiply line 1m by line 1n)	0.00	$	
u	Unit cost of excavation[e]	4.330	$\$/yd^3$	
v	Total cost of excavation (multiply line 1p by line 1u)	0.00	$	
w	**Total Cost of Excavation of Pond (add lines 1t and 1v)**			**$0.00**

PONDS FOR NEW TREATMENT SYSTEM

(SETTLING PONDS, EQUALIZATION BASIN, POLISHING PONDS, STILLING PONDS, AND SEDIMENT PONDS)

2.	**LINING OF POND**			
a	Surface area of open pit (line 1m)	0	ft^2	
b	Thickness of clay liner (line 1n)	0	ft	
c	Volume of clay required (multiply line 2a by line 2b and divide by 27)	0	yd^3	
d	Unit cost for purchase and placement of clay[f]	17.280	$/yd^3$	
e	**Total cost for clay liner (multiply lines 2c and 2d)**	0.00	$	
f	Thickness of liner cover (line 1o)		ft	
g	Volume of clay required (multiply line 2a and 2f and divide by 27)	0	yd^3	
h	Unit cost for purchase and placement of clay[g]	6.570	$/yd^3$	
i	**Cost of clay liner (multiply line 2f by line 2h)**	0.00	$	
j	Included synthetic liner? (Y or N)	**n**		
k	Unit cost of purchase and placement of synthetic liner[h]	1.730	$/ft^2$	
l	**Total cost of synthetic liner (multiply line 2a by line 2k)**	0.00	$	
m	**Total Cost of Lining Pond (add lines 1w)**			**$0.00**
3.	**NUMBER OF PONDS**			
a	Number of ponds		**ea**	
	TOTAL COST OF PONDS (add lines 1w and 1m, and multiply the sum by line 3a)			**$0.00**

a West Virginia University and The National Mine Land Reclamation Center. Acid Mine Drainage Control and Treatment, Skousen and Ziemkiewicz, 1996, pg. 217 - 224.

b 100 (MW of limestone) x 2.2 lbs/kg / 1000.

c Calculated as a squared out pit with vertical walls at midpoint of side slope -- bottom plus sidewalls.

d R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pgs. 4-1 and 4-9, Item Nos. 17 01 0103 and 17 03 0101. The cost is that for medium brush with average grub and some trees, clearing, and rough grading with a D6 dozer.

e R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 4-15, Item No. 17 03 0276. The cost is that for excavation with a 1 yd^3 crawler-mounted, hydraulic excavator.

f R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 9-78, Item No. 33 08 0507. The cost is that for construction of a clay liner of 10 e-7 conductivity, with 6" lifts and purchase and delivery of clay material from an off-site location.

g R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 4-23, Item No. 17 03 0422. The cost is that for unclassified fill, 6" lifts, on site with spreading and compaction.

h R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 9-81, Item No. 33 08 0572. The cost is that for purchase, delivery, and installation of 60-mil polymeric HDPE liner.

CLARIFIERS

1.	**FLOW INFORMATION**		
a	Design flow rate	**0 gpm**	
2.	**CLARIFIER SPECIFICATION**		
a	Diameter of clarifier (select from the table)[a]	**0 ft**	
b	Surface area of clarifier (surface area of a circle having the diameter of the clarifier)		0 ft^2
3.	**SLUDGE STORAGE AND DRYING BASIN**		
	Structure with concrete berm and compacted clay liner on the bottom that also can serve as sludge evaporation area		
a	Sludge holding time	**0 days**	
b	Ratio of sludge per gpm entering clarifier	**0.1 gpm**	
c	Estimated volume of sludge generated (multiply line 1a by line 3b)		0 gpm
d	Capacity for storage of sludge (multiply line 3a by line 3c, and multiply the product by 60 times 24)		0 gal
e	Volume of sludge storage (divide line 3d by 7.48)		0 ft^3
f	Width (depends on the availability of land)	**0 ft**	
g	Depth (depends on the availability of land)	**0 ft**	
h	Length (depends on the availability of land)	**0 ft**	
i	Surface area of sludge-holding storage (multiply line 3f by line 3h)		0 ft^2
4.	**SLUDGE PUMP**		
a	Capacity of pump (multiply line 3c by 25%)		0 gpm
5.	**STRUCTURAL CONCRETE SLAB**		
a	Foundation area of clarifier unit (from line 2b)		0 ft^2
b	Area of foundation of desludging pump house (multiply line 5a by 0.25)	**25%**	0 ft^2
c	Total surface area of foundation (add lines 5a and 5b)		0 ft^2
d	Thickness of foundation	**2 ft**	
e	Volume of foundation in ft^3 (multiply line 5c by line 5d)		0 ft^3
f	Volume of foundation in yd^3 (divide line 5e by 27)		0 yd^3
6.	**CONCRETE WALLS**		
a	Concrete walls for sludge holding storage area (multiply line 3f by line 3g and add the product to the product of multiplication of lines 3f, 3h, and 2)		0 ft^2
b	Thickness of walls	**1 ft**	
c	Volume of walls in ft^3 (multiply line 6a by line 6b)		0 ft^2
d	Volume of walls in yd^3 (divide line 6c by 27)		0 yd^3

Table for line 2a:

GPM	Dia, ft	GPM	Dia, ft
25	9	305	30
45	12	546	40
70	15	850	50
130	20	1,194	60
208	25	1,645	70

CLARIFIERS

7.	**CLAY LINER**		
a	Thickness of clay liner	**1 ft**	
b	Volume of compacted clay in ft^3 (multiply lines 3f, 3h, and 7a)		0 ft^3
c	Volume of compacted clay in yd^3 (divide line 7b by 27)		0 yd^3
d	Swelling factor[b]	**40%**	
e	Volume of clay required (add 100% to the percentage in line 7d and multiply line 7b by that percentage)		0 yd^3
8.	**PIPING**		
a	Distance from previous unit	**0 ft**	
b	Distance to sludge-holding area	**0 ft**	
c	Total length of piping (add lines 8a and 8b)		0 ft
9.	**SITE WORK**		
a	Volume to be excavated for foundation and walls (multiply line 5f by 1.2)	**Add 20%**	0 yd^3
b	Area to be cleared (multiply line 9a by 2)	**Add 100%**	0 ft^2
c	Area to be surveyed (same as line 8b)		0 acres
d	Survey rate (divide line 9c by 1 acre/day)	**1 acre/day**	0 days

a R.S. Means Company, Inc., *Environmental Remediation Cost Data - Assemblies* , 1999, pg. 3-61&3-62, item no. 33 13 0401 thorugh 0410.

b U.S. Environmental Protection Agency, *Final Guidance Manual: Cost Estimates for Closure and Post-Closure Plans (Subparts G and H)* , Volume III, EPA/530-SW-87-009, January 1987, pages 7-10.

CLARIFIERS

1.	**SURVEYING**				
a	Unit cost to surveying[a]	648.36	$/day		
b	Days required to conduct survey (from GTU-2A, line 9d)	0	days		
c	**Cost of Surveying (multiply line 1a by line 1b)**				**$0.00**
2.	**CLEARING AND GRUBBING**				
a	Unit cost of clearing and grubbing[b]	5,650	$/acre		
b	Area to be cleared and grubbed (from GTU-2A, line 9b)	0	acres		
c	**Cost of Clearing and Grubbing (multiply line 2a by line 2b)**				**$0.00**
3.	**PURCHASE AND DELIVERY OF CLAY**				
a	Volume of clay required (from GTU-2A, line 7e)	0	yd^3		
b	Unit cost for purchase of clay[c]	6	$/$yd^3$		
c	Unit cost of clay delivery (50-mile radius)[d]	19.4	$/$yd^3$		
d	**Cost of Purchase and Delivery of Clay (multiply line 3a by the sum of lines 3b and 3c)**				**$0.00**
4.	**EXCAVATION**				
a	Volume to be excavated (from GTU-2A, line 9a)	0	yd^3		
b	Unit cost of excavation[e]	4.68	$/$yd^3$		
c	**Total Cost of Excavation (multiply line 4a by line 4b)**				**$0.00**
5.	**SPREADING AND COMPACTING OF CLAY LAYER**				
a	Volume of clay layer (from line 3a)	0	yd^3		
b	Unit cost of filling and spreading the clay by dozer[f]	1.4	$/$yd^3$		
c	Unit cost of compacting the clay layer[g]	1.18	$/$yd^3$		
c	Unit cost of compaction testing by nuclear method[h]	0.77	$/$yd^3$		
d	Unit cost of compaction testing by sand cone method[i]	0.30	$/$yd^3$		
e	**Total Cost of Spreading and Compacting of Clay Layer (multiply line 5a by the sum of line 5b through 5d)**				**$0.00**
6.	**INSTALLATION OF CLARIFIER**				
a	Diameter of clarifier (from GTU-2A, line 2a)	0	ft		
b	Number of clarifiers	**0**	**ea**		
c	Unit cost of purchase, delivery, and intallation of clarifier (see table below)[j]	176,479.00	$/ea		
d	**Total Cost of Clarifier Installation (multiply line 6b by line 6c)**				**$0.00**
7.	**INSTALLATION OF SLUDGE PUMP**				
a	Capacity of pump (from GTU-2A, line 4a)	0	gpm		
b	Quantity of pump	**0**	**ea**		
c	Unit cost of purchase, delivery, and intallation of sludge pump (see table below)[k]	1,845.00	$/ea		
d	**Total Cost of Installation of Sludge Pump (multiply line 7b by line 7c)**				**$0.00**

CLARIFIERS

8.	**CONCRETE WORK**			
a	Volume of ready-mix concrete required (from GTU-2A, add lines 5e and 6c)	0	yd^3	
b	Unit cost of purchase and delivery of ready-mix concrete, 8000 psi[l]	138	$\$/yd^3$	
c	Unit cost of placement of concrete, pumped[m]	20.5	$\$/yd^3$	
d	**Total Cost to Purchase, Delivery, and Placement Concrete (multiply line 8a by the sum of line 8b and 8c)**			**$0.00**
e	Quantity of reinforcing steel and WWF required (from GTU-2A, add lines 5c and 6a and divide the sum by 100)	0	$c.ft^2$	
f	Unit cost of reinforcing steel and WWF[n]	64.5	$\$/100\ ft^2$	
e	**Total Cost of Reinforcement (multiply line 8e by line 8f)**			**$0.00**
9.	**INSTALLATION OF INFLUENT AND EFFLUENT PIPING**			
a	Length of piping (from GTU-2A, line 8c)	0	ft	
b	Unit cost of purchase, delivery, and installation of 1" to 4" PVC pipe[o]	17.4	$/ft	
c	Allowance factor for fittings and insulation (default)	50%		
d	Unit cost for fittings and insulation (multiply line 9b by line 9c)	8.7	$/ft	
e	**Total Cost of Installation of Piping (multiply line 9a by the sum of lines 9b and line 9d)**			**$0.00**
10.	**INSTRUMENTATION**			
a	Allowance factor for instrumentation (% of clarifier cost)	**25%**		
b	**Cost of Instrumentation (multiply line 6d by line 10a)**			**$0.00**
TOTAL INSTALLATION OF CLARIFIERS (add lines 1c, 2c, 3d, 4c, 5e, 6d, 7d, 8e, 9e, and 10b)				**$0.00**

a R.S. Means Company, Inc., *Environmental Remediation Data Unit Cost* , 1999, pg. 10-10, Item No. 99 24 1201. The cost is that for surveying with a two-person crew.

b R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 39, Item No. 021 104 0260. The cost is that for clearing and grubbing of dense brush, including stumps.

c R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 46, Item No. 022 216 6000. The cost is that for purchasing clay, till, or blasted rock, and loading onto dump truck.

d R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 54, Item No. 022 216 6000. The cost is that for hauling with a 12 yd^3 dump truck for a 20-mile roundtrip.

e R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 51, Item No. 022 254 0060. The cost is that for excavating a 1- to 4-feet deep trench with a 0.5-yd^3 tractor loader-backhoe.

f R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg.53, Item No. 022 262 0010. The cost is that for spreading dumped material by dozer, without compaction.

g R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 46, Item No. 022 226 6220. The cost is that for compaction using towed a vibrating roller with 6" lifts and 4 passes per lift.

h R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 11, Item No. 014 108 4735. The cost is that for soil density testing by nuclear method ASTM D2922-71. One test per 50-yd^3 compaction is assumed.

I R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 11, Item No. 014 108 4740. The cost is that for soil density testing using sand cone method ASTM D1556064. One test per 100-yd^3 compaction is assumed.

CLARIFIERS

j Cost of purchase, delivery, and installation of a clarifier

R.S. Means Company, Inc., *Environmental Remediation Cost Data - Assemblies* , 1999, pg. 3-61&3-62, item no. 33 13 0401 thorugh 0410 Cost includes purchase, delivery and installation of waste flow contact clarifier.

Dia, ft	Cost, $	Dia, ft	Cost, $
9	$69,619	30	$176,479
12	$88,873	40	$213,390
15	$98,573	50	$271,120
20	$123,145	60	$350,477
25	$150,723	70	$421,847

k Cost of purchase, delivery, and installation of a sludge pump

R.S. Means Company, Inc., *Environmental Remediation Cost Data - Assemblies* , 1999, pg. 3-63, item no. 33 29 0102 through 0115. Cost includes purchase, delivery and installation of a sludge pump.

GPM	Cost,$	GPM	Cost,$
10	$786	500	$6,798
50	$1,845	750	$8,699
100	$2,685	1050	$10,578
200	$4,011	1500	$13,951
250	$4,531	2000	$16,600
300	$5,098		

ROCK DRAINS

1.	**CHARACTERISTICS OF AMD**		
a	Design flow rate	**0 gpm**	
b	Design retention time	**0 hrs**	
2.	**DIMENSION OF ROCK DRAIN**		
a	Width	**0 ft**	
b	Depth	**0 ft**	
c	Volume of rock drain (multiply line 1a by line 1b and 60)		0 ft^3
d	Volume of rock drain (divide line 2c by 27)		0 yd^3
e	Length (divide line 2c by the product of line 2a and 2b)		0 ft
f	Surface area of channel		0 ft^2
3.	**SITE WORK**		
a	Volume to be excavated (add 20%)		0 yd^3
b	Area to be cleared (add 50%) - (multiply line 2f by 1.5)		0 ft^2
c	Area to be cleared (divide line 3b by 43,560)		0.00 acres
d	Area to be surveyed (same as line 3b)		0.00 acres
e	Survey rate	**1 acre/day**	
f	Days required to complete survey (divide line 3d by line 3e)		0.000 day
4.	**ROCK FILL**		
a	Thickness of rock fill	**0 ft**	
b	Volume of rock fill in ft^3 (multiply lines 2a, 2e, and 4a)		0.0 ft^3
c	Volume of rock fill in yd^3 (divide line 4b by 27)		0.0 yd^3
d	Density of rocks	**2 tons/yd^3**	
e	Weight of rock fill (multiply line 4c by line 4d)		0 tons

ROCK DRAINS

1.	**CONDUCT SURVEY**			
a	Unit cost of surveying[a]	648.36	$/day	
b	Days required to conduct survey (from GTU-3A, line 3f)	0	days	
c	**Total Cost of Surveying (multiply line 1a by line 1b)**			**$0.00**
2.	**CLEARING AND GRUBBING**			
a	Unit cost of clearing and grubbing[b]	5,650.00	$/acre	
b	Area to be cleared and grubbed (from GTU-3A, line 3c)	0	acres	
c	**Total Cost of Clearing and Grubbing (multiply line 2a by line 2b)**			**$0.00**
3.	**PURCHASE AND DELIVERY OF ROCKS**			
a	Quantity of rocks (from GTU-3A, line 4c)	0	yd^3	
b	Unit cost of purchase of rocks[c]	15.70	$/$yd^3$	
c	Unit cost of delivery of rocks (30-mile radius)[d]	19.04	$/$yd^3$	
c	**Total Cost of Purchase and Delivery of Rocks (multiply line 3a by 3b)**			**$0.00**
4.	**EXCAVATION**			
a	Volume to be excavated (from GTU-3A, line 3a)	0	yd^3	
b	Unit cost of excavation[e]	4.68	$/$yd^3$	
c	**Total Cost of Excavation (multiply line 4a by line 4b)**			**$0.00**
5.	**ROCK FILLING**			
a	Quantity of rocks (from line 3a)	0	yd^3	
b	Unit cost of loading and filling rocks[f]	5.95	$/$yd^3$	
c	**Total Cost of Loading and Filling Rocks (multiply line 5a by line 5b)**			**$0.00**
	TOTAL COST OF INSTALLATION OF ROCK DRAIN (add lines 1c through 5c)			**$0.00**

[a] R.S. Means Company, Inc., *Environmental Remediation Data Unit Cost* , 1999, pg. 10-10, Item No. 99 24 1201. Cost includes surveying with a two-person crew.

[b] R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 39, Item No. 021 104 0260. The cost is that for clearing and grubbing of dense brush, including stumps.

[c] R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 57, Item No. 022 308 2023. The cost is that for purchase of crushed stone with a maximum size of 1.5", and 12" deep (cost of material only).

[d] R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 54, Item No. 022 216 6000. The cost is that for hauling with a 12-yd^3 dump truck for a 20-mile roundtrip.

[e] R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 51, Item No. 022 254 0060. The cost is that for excavating a 1 to 4 ft deep trench with a 0.5-yd3 tractor loader-backhoe.

[f] R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 46, Item No. 022 216 6035. The cost is that for loading and spreading rocks with a front end loader having a 3/4-yd^3 bucket.

FILTER FIELDS

1. CHARACTERISTICS OF FLOW			
a	Design flow rate	**0 gpm**	
b	Design retention time	**0 hrs**	
2. DIMENSION OF FILTER FIELD			
a	Volume of pond required per gpm AMD (mulitply line 1a by 1b by 60 and divide the product by 7.48)		0.00 ft^3/gpm
b	Volume of pond at the design flow rate (Multiply line 2a by line 1a)		0 ft^3
c	Effective depth (including filter/sand media and freeboard)	**5 ft**	
d	Side slope (horizontal : vertical)	**2 :1**	
e	Average width (depends on the availability of land)	**0 ft**	
f	Average length (divide line 2b by the product of lines 2c and 2e)		0 ft
g	Average surface area of pond (multiply line 2e by line 2f)		0 ft^2
3. FILTER MEDIA			
a	Thickness of sand layer	**0.00 ft**	
b	Surface area of sand layer in ft^2 (from line 2g)		0 ft^2
c	Surface area of sand layer in yd^3 (multiply line 3b with 0.111)		0 ft^2
d	Volume of sand required (multiply line 3a by line 3b, and divide the product by 27)		0 yd^3
4. CLAY LINER			
a	Thickness of clay liner	**0 ft**	
b	Estimated volume of compacted clay (multiply line 2g by		0 ft^3
c	Swelling factor	**30%**	
d	Actual volume of clay required (add 100% to the percentage in line 4c and multiply line 4b by that percentage)		0 yd^3
5. PIPING REQUIREMENT			
a	Distance from influent or previous treatment unit	**0 ft**	
b	Distance from filter field to discharge point or next treatment unit	**0 ft**	
c	Surface pipe distribution (to avoid channelling) - network of perforated pipes with 2-ft spacing along the length of the field - (divide line 2e by 2 and multiply the quotient by line 2f)		0 ft
d	Allowance factor for fittings	**50%**	
e	Estimated total piping (Add lines 4a, 4b, and 4c and multiply the sum by 1.5)		0 ft

FILTER FIELDS

6. SITE WORK			
a	Volume to be excavated in ft^3 (with 20% design factor)		0 ft^3
b	Volume to be excavated in yd^3 (divide line 5a by 27)		0 yd^3
c	Area to be cleared in ft^2 (50% inflated) - (multiply line 2g by 1.5)		0 ft^2
d	Area to be cleared in acres (divide line 6c by 43,560)		0.00 acres
e	Area to be surveyed (from line 6d)		0.00 acres
f	Survey rate	**1 acre/day**	
g	Days of surveying required (divide line 6e by line 6f)		0.000 day

FILTER FIELDS

1.	**SURVEYING**			
a	Unit cost of surveying[a]	648.36	\$/day	
b	Days required to conduct survey (from GTU-4A, line 6g)	0	days	
c	**Total Cost of Surveying (multiply line 1a by line 1b)**			**\$0.00**
2.	**CLEARING AND GRUBBING**			
a	Unit cost of clearing and grubbing[b]	5,650.00	\$/acre	
b	Area to be cleared and grubbed (from GTU-4A, line 6c)	0.00	acres	
c	**Total Cost of Clearing and Grubbing (multiply line 2a by line 2b)**			**\$0.00**
3.	**PURCHASE AND DELIVERY OF SAND**			
a	Volume of filter media (sand) - (from GTU-4A, line 3d)	0	yd^3	
b	Unit cost of purchase and delivery of sand (30-mile radius)[c]	26.00	$\$/yd^3$	
c	**Total Cost of Purchase and Delivery of Sand (multiply line 3a by line 3b)**			**\$0.00**
4.	**PURCHASE AND DELIVERY OF CLAY**			
a	Volume of clay (from GTU-4A, line 4d)	0	yd^3	
b	Unit cost of purchase of clay[d]	6.00	$\$/yd^3$	
c	Unit cost of delivery of clay (50-mile radius)[e]	19.04	$\$/yd^3$	
d	**Total Cost of Purchase and Delivery Clay (multiply line 4a by the sum of lines 4b and 4c)**			**\$0.00**
5.	**INSTALLATION OF DRAINAGE LAYER**			
a	Surface area of drainage fabric (from GTU-4A, line 2g)	0	yd^2	
b	Unit cost of geotextile drainage fabric[f]	2.00	$\$/yd^2$	
c	**Total Cost of Purchase and Installation of Drainage Layer (multiply line 5a by line 5b)**			**\$0.00**
6.	**EXCAVATION**			
a	Volume to be excavated (from GTU-4A, line 6b)	0	yd^3	
b	Total unit cost of excavation[g]	2.05	$\$/yd^3$	
c	**Total Cost of Excavation (multiply line 6a by line 6b)**			**\$0.00**
7.	**SPREADING AND COMPACTING OF CLAY LAYER**			
a	Volume of clay layer (from GTU-4A, line 4d)	0	yd^3	
b	Unit cost of filling and spreading the clay by dozer[h]	1.40	$\$/yd^3$	
c	Unit cost of compacting the clay layer[i]	1.18	$\$/yd^3$	
d	Unit cost of compaction testing by nuclear method[j]	0.77	$\$/yd^3$	
e	Unit cost of compaction testing by sand cone method[k]	0.30	$\$/yd^3$	
f	**Total Cost of Spreading and Compacting Clay Layer (multiply line 7a by the sum of lines 7b through 7e)**			**\$0.00**

FILTER FIELDS

8.	**INSTALLATION OF INFLUENT AND EFFLUENT PIPING**			
a	Length of piping (from GTU-4A, line 5e)	0	ft	
b	Unit cost of purchase, delivery, and installation of 1" to 4" PVC pipe[l]	17.40	$/ft	
c	Allowance factor for insulation[m]	**15%**		
d	Unit cost of insulation	2.61	$/ft	
e	**Total Cost of Installation of Piping (multiply line 8a by the sum of lines 8b and 8d)**			**$0.00**
	TOTAL COST OF INSTALLATION OF FILTER FIELDS (add lines 1c, 2c, 3c, 4d, 5c, 6c, 7f, and 8e)			**$0.00**

a R.S. Means Company, Inc., *Environmental Remediation Data Unit Cost* , 1999, pg. 10-10, Item No.. 99 24 1201. The cost is that for surveying with a two-person crew.

b R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 39, Item No. 021 104 0260. The cost is that for clearing and grubbing of dense brush, including stumps.

c R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 216, Item No. 041 032 0300. The cost is that for purchase and delivery of screened and washed sand within a 30-mile radius.

d R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 46, Item No. 022 216 6000. The cost is that for purchasing clay, till, or blasted rock, and loading onto dump truck.

e R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 54, Item No. 022 216 6000. The cost is that for hauling with 12 yd^3 dump truck for a 20-mile round trip.

f R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 3-41, Item No. 33 08 0535. The cost is that for purchase and delivery of 16-oz/yd^2 geotextile drainage fabric (170 mil).

g R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 49, Item No. 022 242 20200. The cost is that for excavation of bulk common earth using a 75 HP, 50-ft hauling dozer.

h R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg.53, Item No. 022 262 0010. The cost is that for spreading dumped material by dozer, without compaction.

i R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 46, Item No. 022 226 6220. The cost is that for compaction by towed vibrating roller with 6" lifts and 4 passes per lift.

j R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 11, Item No. 014 108 4735. The cost is that for soil density testing by nuclear method ASTM D2922-71. One test per 50-yd^3 compaction is assumed.

k R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 11, Item No. 014 108 4740. The cost is that for soil density testing by sand cone method ASTM D1556064. One test per 100-yd^3 compaction is assumed.

l R.S. Means Company, Inc., *Mechanical Cost Data* , 1999, pg. 123, Item Nos. 151 550 1090 through 1150. The cost is that for purchase and delivery of Sch. 80, high impact/pressure PVC pipes with a range of 1" through 4."

m The allowance factor is based on professional judgment.

OPEN LIMESTONE CHANNELS (OLC) FOR NEW SYSTEM

Armored Limestone system may bind up a maximum of 5% of the acidity as minerals.[1]

1.	**CHARACTERISTICS OF AMD**		
a	Total mine drainage acidity	**0 mg/L**	
b	Design flow rate	**0 gpm**	
c	MACID/minute (multiply line 1a by line 1b times 3.785, and divide the product by 100,000)[a]		0.0000
2.	**LIMESTONE CONSUMPTION**		
	The amount of alkalinity generated and the rate of neutralization will depend on the particle size, and retention time.		
a	Molecular weight of limestone	**100 g/mol**	
b	Theoretical requirement for limestone per minute (multiply lines 1c, 2a, and 2.2, and divide the result by		0.0000 lbs/min
c	Theoretical requirement for limestone per day (multiply line 2b by the product of 60 multiplied by 24)		0.00 lbs/day
d	Neutralization capacity	**0 days**	
e	Efficiency[b]	**30%**	
f	Actual requirement for limestone (multiply line 2c by line 2d, and divide by line 2e)		0 lbs
g	Limestone required in tons (divide line 2f by 2,000)		0 tons
h	Density of limestone	**168.02 lbs/ft^3**	
i	Volume of limestone in cubic feet (divide line 2f by line 2h)		0 ft^3
j	Volume of limestone in cubic yards (divide line 2i by 27)		0 yd^3
3.	**DIMENSION OF OLC**		
a	Top width (TW)	**0 ft**	
b	Depth (D)	**0 ft**	
c	Porosity of limestone placement in the channel (default)	**30%**	
d	Side slope (horizontal : vertical)	**0.25 :1**	
e	Bottom width (BW) - (subtract 2 times lines 3b and 3d from line 3a)		0.0 ft
d	Length[c]		0 ft
f	Volume of OLC (multiply lines 3a, 3b, and 3d)		0 ft^3
g	Surface area of channel (add 2 times lines 3d and 3b, 2 times lines 3a and 3b, and line 3d times line 3a)		0 ft^2
4.	**LINER OPTION AND REQUIREMENT**		
a	Use geosynthetic liner (GSL)? (Yes or No)	**Yes**	
b	Use clay liner? (Yes or No)		No
5.	**GEOSYNTHETIC LINER**		
a	Surface area of GSL (add 25 percent to line 3g for anchoring)		0 ft^2
b	Thickness of sand bedding layer	**4 inches**	
c	Volume of sand bedding layer (multiply line 4a by line 4b, and divide by 12 and 27)		0 yd^3

OPEN LIMESTONE CHANNELS (OLC) FOR NEW SYSTEM

Armored Limestone system may bind up a maximum of 5% of the acidity as minerals.[1]

6.	**CLAY LINER (TO BE COMPLETED IF ANSWER AT LINE 4B IS YES)**		
a	Thickness of clay layer	**6 inches**	
b	Volume of compacted clay layer (multiply line 3g by line 6a, and divide by 12 and 27)		0 yd^3
c	Compaction factor[d]	**40%**	
d	Quantity of clay required (add line 6c to 1 and multiply the result by line 6b)		0 yd^3
7.	**SITE WORK TO BE EXCAVATED**		
a	Volume to be excavated (divide line 3f by 27 and add the result to line 6b)		0 yd^3
b	Multiplier for clearing and grubbing	**200%**	
c	Area to be cleared (multiply lines 3a, 3b, and 3d, and divide by 43,560)		0 acres
d	Area to be surveyed (equal to 7c)		0 acres
e	Survey rate	**1 acre/day**	
f	Days required to conduct survey (multiply lines 7d and 7e)		0 days

[a] MACID is the number of moles of $CaCO_3$ equivalent acidity.
Volume in the above equation must be in liters.
(From: Skousen and others. 1996. *Acid Mine Drainage Control and Treatment. Second Edition.* p. 159. West Virginia University

$$MACID = \frac{AcidityxVolume}{100{,}000}$$

[b] Skousen and others. 1996. A*cid Mine Drainage Control and Treatment. Second Edition*. p. 238. West Virginia University.

[c]
$$Length = \frac{Volume}{(1-Porosity)((BWxD)+D(1+S))}$$

BW = Bottom width
D = Depth
S = slope (horizontal)

[d] U.S. Environmental Protection Agency. *Final Guidance Manual: Cost Estimates for Closure and* Post-Closure Plans *(Subparts G and H)*, January 1987, EPA/530-SW-87-009, Vol. III, pg. 7-10.

[1] Based on the research conducted by the Pennsylvania State University.

OPEN LIMESTONE CHANNELS (OLC) FOR NEW SYSTEM

Armored Limestone system may bind up a maximum of 5% of the acidity as minerals.[1]

1.	**SURVEYING**				
a	Unit cost of surveying[a]	648.36	$/day		
b	Days required to conduct survey (from GTU-5A, line 7f)	0.00	days		
c	**Total Cost of Surveying (multiply line 1a by line 1b)**				**$0.00**
2.	**CLEARING AND GRUBBING**				
a	Unit cost of clearing and grubbing[b]	5650.00	$/acre		
b	Area to be cleared and grubbed (from GTU-5A, line 7c)	0.00	acres		
c	**Total Cost of Clearing and Grubbing (multiply line 2a by line 2b)**				**$0.00**
3.	**LIMESTONE PURCHASE AND DELIVERY**				
a	Quantity of limestone (from GTU-5A, line 2f)	0	lbs		
b	Unit cost of purchase and delivery (50-mile radius)[c]	0.006	$/lbs		
c	**Total Cost of Purchase and Delivery of Limestone (multiply line 3a by line 3b)**				**$0.00**
4.	**GEOSYNTHETIC LINER (ONLY IF ANSWER AT LINE 4a OF PT-2A IS YES)**				
a	Surface area of GSL (from GTU-5A line 4a)	0	ft^2		
b	Unit cost of purchase, delivery, and installation of GSL[d]	1.73	$\$/ft^2$		
c	**Total Cost of Purchase, Delivery, and Installation of GSL (multiply line 4a by line 4b)**				**$0.00**
5.	**PURCHASE AND DELIVERY OF SAND (ONLY IF LINE 4a OF PT-2A IS YES)**				
a	Quantity of sand bedding material (From GTU-5A, line 5c)	0	yd^3		
b	Unit cost of purchase and delivery of sand (30-mile radius)[e]	26.00	$\$/yd^3$		
c	**Total Cost of Purchase and Delivery of Sand (multiply line 5a by line 5b)**				**$0.00**
6.	**PURCHASE AND DELIVERY OF CLAY**				
a	Quantity of clay (From GTU-5A, line 6d)	0	yd^3		
b	Unit cost of purchase and loading of clay[f]	6.00	$\$/yd^3$		
c	Unit cost of delivery of clay (20-mile radius)[g]	19.40	$\$/yd^3$		
d	**Total Cost of Purchase and Delivery of Clay (multiply line 6a by the sum of lines 6b and 6c)**				**$0.00**
7.	**EXCAVATION**				
a	Volume to be excavated (from GTU-5A, line 7a)	0	yd^3		
b	Unit cost of excavation[h]	4.68	$\$/yd^3$		
c	**Total Cost of Excavation (multiply line 7a by line 7b)**				**$0.00**
8.	**SPREADING AND COMPACTING OF THE CLAY LAYER**				
a	Quantity of clay (from GTU-5A, line 6d)	0	yd^3		
b	Unit cost of filling and spreading the clay by dozer[i]	1.40	$\$/yd^3$		
c	Unit cost of compacting the clay layer[j]	1.18	$\$/yd^3$		
c	Unit cost of compaction testing by nuclear method[k]	0.77	$\$/yd^3$		
d	Unit cost of compaction testing by sand cone method[l]	0.30	$\$/yd^3$		
e	**Total Cost of Spreading and Compacting Clay Layer (multiply line 8a by the sum of lines 8b through 8d)**				**$0.00**

OPEN LIMESTONE CHANNELS (OLC) FOR NEW SYSTEM

Armored Limestone system may bind up a maximum of 5% of the acidity as minerals.[1]

9.	**INSTALLATION OF LIMESTONE LAYER**			
a	Quantity of limestone (from GTU-5A, line 2i)	0	yd^3	
b	Unit cost of filling and spreading limestone[m]	1.40	$\$/yd^3$	
c	**Total Cost of Installation of Limestone Layer (multiply line 9a by line 9b)**			**$0.00**
TOTAL COST OF INSTALLATION OF OLC (add lines 1c through 7c, 8e, and 9c)				**$0.00**

a R.S. Means Company, Inc., *Environmental Remediation Data Unit Cost* , 1999, pg. 10-10, Item No. 99 24 1201. The cost is that of a survey performed by a two-person crew.

b R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 39, Item No. 021 104 0260. The cost is that of clearing and grubbing of dense brush, including stumps.

c Remine Version V. 1.21. The cost is the average of quotes for pebble lime provided by Greybeck Lime (Bellefonte, Pennsylvania) and Constone (Erinsburg, Pennsylvania). The cost is that of purchase and delivery of the limestone within a 50-mile radius.

d R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 9-81, Item No.33 33 08 0572. The cost is that of the purchase, delivery, and installation of 60-mil polymeric liner high density polyethylene (HDPE).

e R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 216, Item No. 041 032 0300. The cost is that of purchase of screened and washed sand and delivery within a 30-mile radius.

f R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 46, Item No. 022 216 6000. The cost is that of the purchase of clay, till, or blasted rock and of loading on a dump truck.

g R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 54, Item No. 022 216 6000. The cost is that of hauling by 12-yd^3 dump truck, for a round trip of 20 miles.

h R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 51, Item No. 022 254 0060. The cost is that of excavation of a trench 1- to 4-feet deep by a 0.5 yd^3 tractor loader-backhoe.

i R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg.53, Item No. 022 262 0010. The cost is that of spreading dumped material by dozer with no compaction.

j R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 46, Item No. 022 226 6220. The cost is that of compaction by a towed vibrating roller with 6" lifts and 4 passes.

k R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 11, Item No. 014 108 4735. The cost is that of soil density testing by the nuclear method, ASTM D2922-71. One test per 50 yd^3 compaction is assumed.

l R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 11, Item No. 014 108 4740. The cost is that of soil density testing by sand cone method ASTM D1556064. One test per 100 yd^3 compaction is assumed.

m R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg.53, Item No. 022 262 0010. The cost is that of spreading dumped material by dozer with no compaction.

1 Based on the research conducted by the Pennsylvania State University.

OPEN LIMESTONE CHANNEL (OLC) FOR EXISTING SYSTEM

1. EXCAVATION OF LIMESTONE CHANNEL				
a	Length (L)	**0**	**ft**	
b	Width (W)	**0**	**ft**	
c	Depth (D)	**0**	**ft**	
e	Side wall slope (S)	**0**	**ft run/ft rise**	
f	Volume in cubic feet[a] V = (L.W.D) + 0.5(D.L.S.D) + 0.5(D.L.2D) + (D.W.S.D) + (2/3Dx(S.D)^2) + (2/3.D.2D.S.D)	0	ft^3	
g	Volume in cubic yard (line 1f divided by 27)	0	yd^3	
h	Surface area of each channel [L +(2DS)] . [W +(2DS)]	0	ft^2	
i	Number of limestone channels	**0**	**ea**	
j	Total volume of excavation (multiply line 1g by line 1i)	0	yd^3	
k	Total area to be cleared and grubbed (multiply line 1h by line 1i)	0	ft^2	
s	Unit cost of clearing and grubbing[b]	0.380	\$/ft^2	
t	Total cost of clearing and grubbing (multiply line 1k by line 1s)	0.00	\$	
u	Unit cost of excavation[c]	4.330	\$/yd^3	
v	Total cost of excavation (multiply line 1u by line 1j)	0.00	\$	
w	**Total Cost of Excavation of Limestone Channel (add lines 1t and 1v)**			**$0.00**
2. INSTALLATION OF CLAY LINER				
a	Thickness of clay liner	**0.5**	**ft**	
b	Volume of compacted clay (multiply lines 2a, 1h, and 1i, and divide the product by 27)	0	yd^3	
c	Compaction factor[d]	**40%**		
d	Actual volume of clay (multiply line 2b by the sum of 1 and line 2c)	0	yd^3	
e	Unit cost of purchase and loading of clay[e]	6.00	\$/yd^3	
f	Unit cost of delivery of clay (20-mile radius)[f]	19.40	\$/yd^3	
g	Unit cost of spreading and backfilling by dozer[g]	1.40	\$/yd^3	
h	Unit cost of compacting backfill material[h]	1.18	\$/yd^3	
i	Unit cost of compaction testing by nuclear method[i]	0.77	\$/yd^3	
j	Unit cost of compaction testing by sand cone method[j]	0.30	\$/yd^3	
k	**Total Cost of Backfilling, Compaction, and Installation of Clay Liner (multiply line 2d by the sum of lines 2e through 2j)**			**$0.00**

OPEN LIMESTONE CHANNEL (OLC) FOR EXISTING SYSTEM

3. PURCHASE AND DELIVERY OF LIMESTONE				
a	Density of limestone	**168.02**	**lbs/ft3**	
b	Quantity of limestone (multiply line 1f by line 3a)	0	lbs	
c	Quantity of limestone in cubic yard (line 1g)	0	yd^3	
d	Unit cost of purchase and delivery (50-mile radius)[k]	0.006	$/lbs	
e	Unit cost of spreading and backfilling by dozer[g]	1.40	$/yd^3$	
f	**Total Cost of Purchase, Delivery, and Spreading of Limestone (add the product of lines 3b and 3d and the product of lines 3c and 3e)**			**$0.00**
TOTAL COST OF INSTALLATION OF LIMESTONE CHANNEL (add lines 1w, 2i, and line 3f)				**$0.00**

a Pond actual volume is designed using standard volume equation for furstrum. Back slope is assumed to be 2:1.

b R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pgs. 4-1 and 4-9, Item Nos. 17 01 0103 and 17 03 0101. The cost is that for medium brush with average grub and some trees, clearing, and rough grading with a D6 dozer.

c R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 4-15, Item No. 17 03 0276. The cost is that for excavation with a 1 yd^3 crawler-mounted, hydraulic excavator.

d U.S. Environmental Protection Agency, *Final Guidance Manual: Cost Estimates for Closure and Post-Closure Plans (Subparts G and H), Volume III* , EPA/530-SW-87-009, January 1987, pages 7-10. Compaction factor provided is that for off-site clay.

e R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 46, Item No. 022 216 6000. The cost is that of the purchase of clay, till, or blasted rock and of loading on a dump truck.

f R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 54, Item No. 022 216 6000. The cost is that of hauling by 12-yd^3 dump truck, for a round trip of 20 miles.

g R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg.53, Item No. 022 262 0010. The cost is that of spreading dumped material by dozer with no compaction.

h R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 46, Item No. 022 226 6220. The cost is that of compaction by towed vibrating roller, with 6" lifts and 4 passes per lift.

i R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 11, Item No. 014 108 4735. The cost is that of soil density testing by nuclear method, ASTM D2922-71. Assume 1 test per 50 yd^3 compaction.

j R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 11, Item No. 014 108 4740. The cost is that of soil density testing by sand cone method ASTM D1556064. Assume 1 test per 100 yd^3 compaction.

k Remine Version V. 1.21. The cost is the average of quotes for pebble lime provided by Greybeck Lime (Bellefonte, PA) and Constone (Erinsburg, PA). The cost is that of purchase and delivery of the limestone within a 50-mile radius.

6.0 DISCHARGE METHODS

Discharge methods are systems used to provide a suitable means of managing treated mine drainage. Treated mine drainage can be discharged to bodies of surface water; dispersed to groundwater; or used for other applications, including agricultural irrigation. If the site is located in close proximity to a body of surface water, the treated mine drainage can be discharged directly to that body of water so long as the effluent is sufficiently treated to meet the established effluent standards. If, however, the effluent meets water quality standards but the site is not located in close proximity to a suitable body of surface water, discharge may be accomplished through the use of an infiltration gallery. Through that technique, treated mine drainage will be allowed to percolate into the groundwater. Finally, in the event the site is located near agricultural facilities, treated mine drainage may be discharged through irrigation applications.

Presented below are descriptions of the cost estimating worksheets to be used in determining the costs of conducting discharge activities at surface mines, underground mines, and coal refuse piles:

- **Infiltration Galleries** - Infiltration galleries sometimes are used as a method of discharge for mine drainage treatment systems when the closest body of surface water that is suitable to receive the discharge is located at a distance that makes the construction of a system to convey water cost prohibitive. The construction of an infiltration gallery, however, may require significant amounts of land. Infiltration galleries are designed as gravel-filled pits that provide an infiltration area sufficient to serve as a means of discharge for the treatment system. The cost of the activity includes the costs of excavating the gallery pit, purchasing and delivering gravel, installing a gravel layer, and installing influent and effluent piping.

- **Irrigation Applications** - In some case, irrigation applications provide feasible alternatives for the discharge of treated mine drainage. Irrigation applications, however, require the use of treatment systems that are highly effective in removing metals. Further, additional monitoring of the effluent will be necessary to ensure that the effluent meets applicable standards for irrigation water. Because the major cost associated with the use of such systems is the cost of constructing an irrigation reservoir, irrigation applications will be most cost effective when an irrigation reservoir near the site already is available. The cost of the activity includes the costs of installing a water storage basin, a water conveyance system, and pump stations.

- **Pipe Systems** - Pipe systems used to transfer mine drainage between components of treatment systems are included in the individual worksheets for each system. The worksheet for pipe systems that is provided in the methodology, on the other hand, applies to pipe systems that may be needed to transfer effluents from the point of treatment to the point of discharge. The worksheet provides costs per linear foot for installing underground pipe systems at as much as 4 feet below the surface of the ground. The worksheet provides flow pipe diameters based on the assumption that the effluents will be flowing through half-full pipes under gravity conditions and at an average of three feet per second. The cost of the activity includes the costs of clearing and grubbing, surveying, excavating a trench, purchasing and installing piping, and backfilling and compacting the fill.

INFILTRATION GALLERIES[1]

1.	**FLOW CHARACTERISTICS**		
a	Design flow rate	**0 gpm**	
b	Residence time	**0 hrs**	
2.	**DIMENSION OF INFILTRATION FIELD**		
a	Volume of pond required per gpm AMD (multiply line 1a by 1b by 60 and divide the product by 7.48)		0.00 ft^3/gpm
b	Volume of pond at the design flow rate (multiply line 2a by line 1a)		0 ft^3
c	Effective depth (including filter/medium and freeboard)	**0 ft**	
d	Side slope (horizontal : vertical)	**2 :1**	
e	Average width (depends on the land availability)	**0 ft**	
f	Average length (divide line 2b by line 2c and line 2e)		0 ft
g	Average surface area of pond (multiply line 2e by line 2f)		0 ft^2
3.	**POROUS BACKFILL**		
a	Thickness of gravel layer	**2.50 ft**	
b	Surface area of gravel layer in ft^2 (from line 2g)		0 ft^2
c	Surface area of gravel layer in yd^2 (multiply line 3b by 0.111)		0 yd^2
d	Volume of gravel (multiply line 3a by line 3b, and divide by 27)		0 yd^3
4.	**PIPING REQUIREMENT**		
a	Distance from influent or previous treatment unit	**0 ft**	
b	Distance from filter field to discharge point or next treatment unit	**0 ft**	
c	Surface pipe distribution (to avoid channelling) - network of perforated pipes with 5-ft spacing along the length of the field (divide line 2e by 2 and multiply the quotient by line 2f)		0 ft
d	Allowance factor for fittings (professional judgement)	**50%**	
e	Estimated total piping required (add lines 4a, 4b, and 4c and multiply the product by 1.5)		0 ft
5.	**SITE WORK INFORMATION**		
a	Volume to be excavated in ft^3 (with 20% design factor)		0 ft^3
b	Volume to be excavated in yd^3 (divide line 5a by 27)		0 yd^3
c	Area to be cleared (50% inflated) - (multiply line 2g by 1.5)		0 ft^2
d	Area to be cleared in (divide line 5c by 43,560)		0.00 acres
e	Area to be surveyed (same as line 5d)		0.00 acres
f	Survey rate	**1 acre/day**	
g	Days required to complete survey (divide line 5e by line 5f)		0.000 day

1 Not a common practice in eastern regions. Hydrologic assessment may need to be performed to evaluate its feasibility. Hydrologic assessment may need to be performed and costed to forecast the impact (chemically and physically) of the additional water on the ground water system.

INFILTRATION GALLERIES

1.	**CONDUCT SURVEY**			
a	Unit cost of surveying[a]	648.36	$/day	
b	Days required to complete survey (from DM-1A, line 5g)	0	days	
c	**Total Cost of Surveying (multiply line 1a by line 1b)**			**$0.00**
2.	**CLEARING AND GRUBBING**			
a	Unit cost of clearing and grubbing[b]	5,650.00	$/acre	
b	Area to be cleared and grubbed (from DM-1A, line 5d)	0.00	acres	
c	**Total Cost of Clearing and Grubbing (multiply line 2a by line 2b)**			**$0.00**
3.	**GRAVEL PURCHASE AND DELIVERY**			
a	Volume of gravel fill (from DM-1A, line 3d)	0	yd^3	
b	Unit cost of purchase and delivery of gravel (30 miles radius)[c]	21.09	$\$/yd^3$	
c	**Total Cost of Purchase and Delivery of Gravel (multiply line 3a by line 3b)**			**$0.00**
4.	**DRAINAGE LAYER INSTALLATION**			
a	Surface area of drainage fabric (from DM-1A, line 2g)	0	yd^2	
b	Unit cost of geotextile drainage fabric[d]	2.00	$\$/yd^2$	
c	**Total Cost of Purchase and Delivery of Drainage Fabric (multiply line 4a by line 4b)**			**$0.00**
5.	**EXCAVATION**			
a	Volume to be excavated (from DM-1A, line 5b)	0	yd^3	
b	Unit cost of excavation[e]	4.68	$\$/yd^3$	
c	**Total Cost of Excavation (multiply line 5a by line 5b)**			**$0.00**
6.	**SPREADING GRAVEL FILL**			
a	Volume of gravel fill (from DM-1A, line 3d)	0	yd^3	
b	Unit cost of filling and spreading gravel by dozer[f]	1.40	$\$/yd^3$	
c	**Total Cost of Spreading Gravel (multiply line 6a by line 6b)**			**$0.00**
7.	**INSTALLATION OF INFLUENT AND EFFLUENT PIPING**			
a	Length of piping required (from DM-1A, line 4e)	0	ft	
b	Unit cost of purchase, delivery, and installation of 1" to 4" PVC pipe[g]	33.00	$/ft	
c	Allowance factor for insulation (default)[h]	**15%**		
d	Unit cost of insulation	4.95	$/ft	
e	Unit cost of installation of piping (average for 1" through 4" PVC Class 200 pipe)[I]	4.5	$/ft	
f	**Total Cost of Installation of Piping (multiply line 7a by the sum of lines 7b, 7d, and 7e)**			**$0.00**
	TOTAL COST OF INSTALLATION OF INFILTRATION GALLERY (add lines 1c, 2c, 3b, 4c, 5c, 6c, and 7f)			**$0.00**

a R.S. Means Company, Inc., *Environmental Remediation Data Unit Cost* , 1999, pg. 10-10, Item No. 99 24 1201. Cost includes surveying with a two-person crew.

b R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 39, Item No. 021 104 0260. Cost includes clearing and grubbing of dense brush, including stumps.

c R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 5-1, Item No. 18 01 0102. The cost is that for purchase, delivery, and unloading or dumping of gravel.

INFILTRATION GALLERIES

[d] R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 3-41, Item No. 33 08 0535. Cost includes purchase and delivery of 16 oz/yd^2 geotextile drainage fabric (170 Mil).

[e] R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 49, Item No. 022 242 20200. The cost is that of excavation of bulk common earth with a 75-HP dozer and hauling 50 ft.

[f] R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 53, Item No. 022 262 0010. The cost is that of spreading dumped material by dozer, with no compaction.

[g] R.S. Means Company, Inc., *Mechanical Cost Data* , 1999, pg. 123, Items No. 151 550 1090 through 1150. The cost is that for purchase and delivery of Sch. 80, high impact/pressure PVC pipes with a range of 1" through 4".

[h] Allowance for insulation is based on professional judgment.

[i] R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 6-1, Items No. 19 01 0201 through 19 01 0207. The cost is that for purchase and installation of 1" through 4" PVC Class 200 pipes.

IRRIGATION APPLICATIONS[1]

1.	**CHARACTERISTICS OF FLOW**		
a	Design flow rate	**0 gpm**	
2.	**CROPS AND ENVIRONMENTAL FACTORS**		
a	Distance from WW treatment plant to area of irrigation	**0 lf**	
b	Area to be irrigated	**0 acres**	
c	Type of crop		
d	Amount of water required for growth and survival of crop	**0 gals/acre/day**	
e	Growing season	**0 days**	
f	Annual precipitation	**0 inches**	
g	Assumption that 3/4 of precipitation evaporates, is lost as runoff, or occurs in winter (multiply line 2f by 0.75)		0 in/year
h	Actual precipitation (substract line 2g from line 2f, and divide the result by 365)		0.00 in/day
I	Daily amount of water required by crops (multiply line 3b by line 3d)		0 gals
j	Annual amount of water required by crops (multiply line 3e by line 3i)		0 gals
k	Amount of irrigation water required (divide line 3h by line 3g then multiply by 75 times 43,560, substract the result from line 3i)		0 gals/acre/day
3.	**DIMENSION OF STORAGE BASIN**		
	Storage basin will be constructed in a manner similar to that of a gravel-lined surface impoundment.		
a	Duration of storage	**0 days**	
b	Volume of pond at the design flow rate (multiply line1a by line 3a times 60 and 24)		0 ft^3
c	Effective depth (including clay layer and freeboard)	**0 ft**	
d	Side slope (horizontal : vertical)	**2 :1**	
e	Average width (depends on the availability of land)	**0 ft**	
f	Average length (divide line 2b by the product of lines 2c and 2e)		0 ft
g	Average surface area of pond (multiply line 3e by line 3f)		0 ft^2
h	Average surface area of pond in acres (divide line 3g by 43,560)		0 acres
4.	**GRAVEL LAYER**		
a	Thickness of gravel layer	**0.50 ft**	
b	Surface area of gravel layer in ft^2 (from line 2g)		0 ft^2
c	Surface area of gravel layer in yd^2 (multiply line 3b by 0.111)		0 yd^2
d	Volume of gravel required (multiply line 3a by line 3b by line and divide product by 27)		0 yd^3

IRRIGATION APPLICATIONS[1]

5. PIPING REQUIREMENT			
a	Distance from influent or previous treatment unit	**0 ft**	
b	Distance from storage basin to irrigation network	**0 ft**	
d	Allowance factor for valves and fittings	**50%**	
e	Estimated total piping required (add lines 4a, 4b, and 4c, and multiply the product by 1.5)		0 ft
6. PUMP STATIONS			
a	Capacity of pump (line 1a)		0 gpm
b	Interval of pumping stations	**250 ft**	
c	Number of pumping stations or pumps		0 ea
7. SITE WORK INFORMATION			
a	Volume to be excavated in ft^3 (with 20% design factor)		0 ft^3
b	Volume to be excavated in yd^3 (divide line 6a by 27)		0 yd^3
c	Area to be cleared (50% inflated) - (multiply line 2g by 1.5)		0 ft^2
d	Area to be cleared in acres (divide line 6c by 43,560)		0.00 acres
e	Area to be surveyed (same as line 6d)		0.00 acres
f	Survey rate	**1 acre/day**	
g	Days required to complete survey (divide line 6e by line 6f)		0.000 day

1 Effluent from neutralization treatment using caustic soda or soda ash briquettes may be a poor candidate for irrigation because of its high sodium content.

IRRIGATION APPLICATIONS

1.	**CONDUCT SURVEY**				
a	Unit cost surveying [a]	648.36	$/day		
b	Days required to complete survey (from DM-2A, line 7g)	0	days		
c	**Total Cost of Surveying (multiply line 1a by line 1b)**				**$0.00**
2.	**CLEARING AND GRUBBING**				
a	Unit cost of clearing and grubbing[b]	5,650.00	$/acre		
b	Area to be cleared and grubbed (from DM-2A, line 7d)	0.00	acres		
c	**Total Cost of Clearing and Grubbing (multiply line 2a by 2b)**				**$0.00**
3.	**PURCHASE AND DELIVERY OF GRAVEL**				
a	Quantity of gravel (from DM-2A, line 4d)	0	yd^3		
b	Cost of purchase and delivery of gravel (30-mile radius)[c]	21.09	$\$/yd^3$		
c	**Total Cost of Purchase and Delivery of Gravel (multiply line 3a by line 3b)**				**$0.00**
4.	**EXCAVATION**				
a	Volume to be excavated (from DM-2A, line 7b)	0	yd^3		
b	Unit cost of excavation[d]	4.68	$\$/yd^3$		
c	**Total Cost of Excavation (multiply line 5a by line 5b)**				**$0.00**
5.	**HAULING OF EXCAVATED SPOILS TO ON-SITE STAGING AREA**				
a	Volume of spoils (line 4a, with 20 % swelling factor added)	0	yd^3		
b	Unit cost of loading and hauling[e]	3.99	$\$/yd^3$		
c	**Total Cost of Excavation (multiply line 5a by line 5b)**				**$0.00**
6.	**SPREADING GRAVEL FILL**				
a	Volume of gravel fill (from DM-2A, line 4d)	0	yd^3		
b	Cost of filling and spreading gravel by dozer[f]	2.39	$\$/yd^3$		
c	**Total Cost of Spreading Gravel (multiply line 6a by line 6b)**				**$0.00**
7.	**INSTALLATION OF INFLUENT AND EFFLUENT PIPING**				
a	Length of piping required (from DM-2A, line 5e)	0	ft		
b	Cost as purchase, delivery, and installation of 1" to 4" PVC pipe[g]	17.40	$/ft		
c	Allowance factor for irrigation accessories (including sprinkler and other filtings)	**20%**			
d	Unit cost of insulation	3.48	$/ft		
e	Cost of installation of piping (average for 1" through 4" PVC Class 200 pipe)[h]	4.5	$/ft		
f	**Cost of Installation of Piping (multiply line 7a by the sum of lines 7b, 7d, and 7e)**				**$0.00**

IRRIGATION APPLICATIONS

8.	**INSTALLATION OF PUMPS**			
a	Capacity of pumps (from GTU-2A, line 6a)	0	gpm	
b	Number of pumps	**0**	**ea**	
c	Unit cost of purchase, delivery, and installation of irrigation pump (select from the costs listed below)[i]	**717**	**$/ea**	
	1. 50 scfm, 3/4 HP blower	716.71	$/ea	
	2. 100 scfm, 1/3 HP blower	1,956.00	$/ea	
	3. 150 scfm, 3/4 HP blower	785.44	$/ea	
	4. 250 scfm, 1.5 HP blower	884.72	$/ea	
	5. 500 scfm, 2 HP blower	1,040.00	$/ea	
	6. 750 scfm, 5 HP blower	1,304.00	$/ea	
d	**Total Cost of Installation of Irrigation Pump (multiply line 8b by line 8c)**			**$0.00**
	TOTAL INFILTRATION GALLERY INSTALLATION (add lines 1c, 2c, 3c, 4c, 5c, 6c, 7b, and 8d)			**$0.00**

[a] R.S. Means Company, Inc., *Environmental Remediation Data Unit Cost* , 1999, pg. 10-10, item no. 99 24 1201. Cost includes surveying with a two-person crew.

[b] R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 39, Item No. 021 104 0260. Cost includes clearing and grubbing of dense brush, including stumps.

[c] R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 5-1, Item No.18 01 0102. The cost is that for purchase, delivery, and unloading or dumping of gravel.

[d] R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 51, Item No. 022 254 0060. Cost includes excavation of a 1 to 4 ft deep trench using a 0.5 yd^3 tractor loader-backhoe.

[e] R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 45, Item No. 022 216 4080 and pg. 53, Item No. 022 266 0020. The cost is that for loading onto trucks with a 5-yd^3 dozer and hauling by a 6-yd^3 dump truck for a 0.25 mile round trip.

[f] R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 53, Item No. 022 262 0170. The cost is that for spreading dumped material from stockpile by 130-HP dozer and hauling 300 feet.

[g] R.S. Means Company, Inc., *Mechanical Cost Data* , 1999, pg. 123, Items No. 151 550 1090 through 1150. The cost is that for purchase and delivery of PVC, Sch. 80, high impact/pressure pipes with a range of 1" through 4".

[h] R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 3-41, Item No.33 08 0535. The cost is that for purchase and delivery of 16 oz/yd^2 geotextile drainage fabric (170 Mil).

[i] R.S. Means Company, Inc., *Environmental Remediation Data Unit Cost* , 1999, pg. 9-286, Items No. 33 31 0101 through 0108. The cost is that for purchase, delivery, and installation of a blower.

PIPE SYSTEMS

1.	**CLEARING AND GRUBBING**			
a	Distance from treatment system to point of discharge	**0**	**ft**	
b	Unit cost to chip and cut medium trees[a]	4,300	$/acre	
c	Unit cost to grub and remove stumps[b]	2,625	$/acre	
d	Cost of clearing and grubbing (assuming 20-ft-wide clearing) - (divide the sum of lines 1b and 1c by 43,560 and multiply by 20)	3.18	$/ft	
e	**Total Cost of Clearing and Grubbing (multiply line 1a by line 1d)**			**$0.00**
2.	**CONDUCT SURVEY**			
a	Cost of surveying[c]	648.36	$/day	
b	Area to be surveyed (multiply line 1a by 20 and divide by 43,560)	0.0	acre	
c	Survey rate	**1**	**acre/day**	
d	Days required to complete survey (multiply line 2b by line 2c)	0.0	days	
e	**Total Cost of Surveying (multiply line 2a by line 2d)**			**$0.00**
3.	**EXCAVATION**			
a	Width of trench	**0**	**ft**	
b	Depth of trench	**0**	**ft**	
c	Volume to be excavated (multiply lines 1a, 3a, and 3b and divide by 27)	0	yd^3	
d	Unit cost of excavation[d]	4.68	$/$yd^3$	
e	**Total Cost of Excavation (multiply line 3c by line 3d)**			**$0.00**
4.	**PURCHASE AND PLACEMENT OF PIPE**			
a	Length of piping	0	ft	
b	Flow rate	**0**	**gpm**	
c	Select pipe diameter from the following flow-rate options:			
	1. <20 gpm (4")[e]	4.84	$/ft	
	2. 20 to 50 gpm (6")[f]	7	$/ft	
	3. 50 to 250 gpm (8")[g]	7.1	$/ft	
	4. 250 to 500 gpm (12")[h]	9.45	$/ft	
d	Allowance factor for fittings[i]	**50%**		
e	Unit cost of fittings (multiply line 4c by line 4d)	0.00	$	
f	**Total Cost of Excavation (multiply line 4a by the sum of lines 4c and 4e)**			**$0.00**
5.	**BACKFILL AND COMPACTION**			
a	Volume of backfill (multiply line 3c by 1.3 to account for swelling)	0	yd^3	
b	Unit cost of spreading and backfilling by dozer[j]	$1.40	$/$yd^3$	
c	Unit cost of compacting backfill material[k]	$1.18	$/$yd^3$	
d	Unit cost of compaction testing by nuclear method[l]	$0.85	$/$yd^3$	
e	Unit cost of compaction testing by sand cone method[m]	$0.33	$/$yd^3$	
f	**Total Cost of Excavation, Backfilling, and Compaction (multiply line 5a by the sum of lines 5b through 5e)**			**$0.00**
	TOTAL COST OF INSTALLATION OF PIPE SYSTEM (add lines 1e, 2e, 3e, 4f, and 5f)			**$0.00**

a R.S. Means Company, Inc., *Means Heavy Construction Cost Data* , 1999, Item No. 021 104 0200. The cost is that for chipping medium trees up to 12" diameter.

PIPE SYSTEMS

[b] R.S. Means Company, Inc., *Means Heavy Construction Cost Data* , 1999, Item No. 021 104 0250. The cost is that for grubbing and removal of tree stumps.

[c] R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg.10-10, Item No. 99 24 1201. The cost is that for surveying with a two-person crew.

[d] R.S. Means Company, Inc., *Means Heavy Construction Cost Data* , 1999, Item No. 022 254 0060. The cost is that for excavating a 1 to 4 foot trench with a 0.5-yd^3 tractor loader-bachoe.

[e] R.S. Means Company, Inc., *Means Heavy Construction Cost Data* , 1999, Item No. 027 168 2000. The cost is that for laying and connecting ten-foot lengths of polyvinyl chloride pipe, not including excavation or backfill.

[f] R.S. Means Company, Inc., *Means Heavy Construction Cost Data* , 1999, Item No. 027 168 2040. The cost is that for laying and connecting ten-foot lengths of polyvinyl chloride pipe, not including excavation or backfill.

[g] R.S. Means Company, Inc., *Means Heavy Construction Cost Data* , 1999, Item No. 027 168 2080. The cost is that for laying and connecting ten-foot lengths of polyvinyl chloride pipe, not including excavation or backfill.

[h] R.S. Means Company, Inc., *Means Heavy Construction Cost Data* , 1999, Item No. 027 168 2160. The cost is that for laying and connecting ten-foot lengths of polyvinyl chloride pipe, not including excavation or backfill.

[i] Allowance for fitting is based on professional judgment.

[j] R.S. Means Company, Inc., *Means Heavy Construction Cost Data* , 1999, Item No. 022 262 0010. The cost is that for spreading of filling with a dozer (no compaction).

[k] R.S. Means Company, Inc., *Means Heavy Construction Cost Data* , 1999, Item No. 022 226 6220. The cost is that for 4 passes made on 6-inch lifts with a vibrating roller.

[l] R.S. Means Company, Inc., *Means Heavy Construction Cost Data* , 1999, Item No. 014 108 4735. Cost assumes one test per 50 cubic yards.

[m] R.S. Means Company, Inc., *Means Heavy Construction Cost Data* , 1999, Item No. 014 108 4740. Cost assumes one test per 100 cubic yards.

7.0 SYSTEM OPERATIONS

Operating activities are specific functions that are performed on a periodic or continuous basis to maintain and perpetuate the treatment of mine drainage. For example, certain treatment systems seek to neutralize mine drainage through the continuous addition of chemicals to the drainage. Such chemicals must be supplied periodically to ensure that treatment operations will continue. In addition, equipment required to operate treatment systems must be maintained regularly, and eventually replaced, if treatment is to continue over long periods of time. Finally, treatment systems must be monitored regularly to ensure that they are effective. In general, active treatment systems require more care and oversight than passive treatment systems. Operating activities therefore will tend to represent a larger component of the costs of active treatment systems than of passive treatment systems. The methodology provides worksheets that address five types of operating activities: 1) chemical consumption, 2) system maintenance and replacement, 3) electricity, 4) sludge removal, and 5) sampling and analysis.

Presented below are descriptions of the cost estimating worksheets to be used in determining the costs of operating activities for the treatment of mine drainage at surface mines, underground mines, and coal refuse piles:

- **Chemical Consumption** - The chemical consumption worksheet can be used to estimate the annual costs of chemicals required to operate mine drainage treatment systems.

- **System Maintenance and Replacement -** This worksheet is used to estimate the annual costs of maintaining, and eventually of replacing, active treatment, passive treatment, and source control systems used to effect the treatment of mine drainage. The costs of maintenance and replacement are based on a percentage of the estimated capital costs incurred to install each system.

- **Electricity** - This worksheet accounts for the costs of electricity necessary to operate such equipment as pumps, blowers, mixers, clarifiers, and instruments.

- **Removal of Sludge** - Removal of sludge can represent a major component of the costs of treatment of mine drainage. For the methodology, rates of production of sludge for each neutralization chemical were obtained from empirical data on generation of sludge.[1] For the methodology, sludge is assumed to be removed wet by a vacuum truck or dry by a loader and dump truck. Removal of wet sludge typically is conducted in conjunction with the operations of small treatment units. Estimates of the costs of disposal are based on the assumption that the sludge will be disposed of at an off-site landfill.

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[1] *Acid Mine Drainage Control and Treatment, Second Edition*, 1996, Jeffrey G. Skousen and Paul F. Ziemkiewicz, West Virginia University and the National Mine Land Reclamation Center, Chapter 21 (Volume and Composition of Flocs From Chemical Neutralization of Acid Mine Drainage).

C **Sampling and Analysis -** Worksheets have been provided for calculating specific costs for the collection and analysis of samples. An attachment to the worksheets provides representative costs for various analyses that are known to be associated with the treatment of mine drainage. A summary worksheet is provided for calculating the total of all sampling and analysis costs. Cost estimating worksheets have been provided for aqueous samples, sludge and soil samples, and groundwater samples. If the reclamation plan does not specify the types of samples to be collected in implementing treatment for mine drainage, the quantity of samples to be taken, or the methods of analysis, the user may find it necessary to make assumptions to estimate sampling and analysis costs. The cost of sampling and analysis activities includes the costs of collection include collection and handling of samples, sampling equipment, shipment of samples, and rental of necessary vehicles.

Aqueous Samples: Aqueous samples are samples of drainage water and surface water. Various sampling jars can be used to collect aqueous samples.

Sludge and Soil Samples: Various equipment, such as scoops, hand augers, an Eckman dredge, or Shelby tubes, can be used to collect samples of sludge or soil.

Groundwater Samples: Groundwater samples are collected from monitoring wells. Equipment used may include a submersible pump, a bailer, or a Waterra pump. The activity also includes purging the well before the groundwater sample is collected.

CHEMICAL CONSUMPTION

1.	**PURCHASE AND DELIVERY OF NEUTRALIZATION CHEMICAL**			
a	Operating flow rate	**0.0**	**gpm**	
b	Total mine drainage acidity	**0.0**	**mg/L as $CaCO_3$**	
c	Molar acid equivalents loading (multiply line 1a times 3.785 liters/gallon times line 1b times 0.01 mole $CaCO_3$/g $CaCO_3$ times 0.001 g/mg times 512,640 min/year)	0.0	equivalents of acid/year	
d	Theoretical amount of neutralization chemical needed per equivalent of acid (choose the multiplier for the appropriate chemical below) **6. Pebble quicklimef**	**0.137**	**lb/equivalent**	
	1. Soda ash briquettes[a]	0.389	lb/equivalent	
	2. Caustic (20% sol.)[b]	0.176	lb/equivalent	
	3. Ammonia[c]	0.075	lb/equivalent	
	4. Hydrated lime[d]	0.163	lb/equivalent	
	5. Limestone[e]	0.733	lb/equivalent	
	6. Pebble quicklime[f]	0.137	lb/equivalent	
	7. Other reagent		lb/equivalent	
e	Reagent purity	**90%**		
f	Factor to account for excess alkalinity required in the effluent (20 to 30% - OSM)	**0%**		
g	Actual amount of neutralization chemical needed per equivalent of acid (divide line 1d by line 1e, and multiply by addition of 1 and line 1f)	0.152	lb/equivalent	
h	Unit cost of chemical (choose the appropriate unit cost from below)[g]	0.12	$/lb	
	1. Soda ash briquettes	0.14	$/lb	
	2. Caustic (20% sol.)	0.15	$/lb	
	3. Ammonia	0.16	$/lb	
	4. Hydrated lime	0.03	$/lb	
	5. Limestone	0.006	$/lb	
	6. Pebble quicklime	0.12	$/lb	
	7. Other reagent		$/lb	
i	**Total Cost of Purchase and Delivery of a One-Year Supply of Neutralization Chemical (multiply lines 1c, 1g, and 1h)**			**$0.00**

CHEMICAL CONSUMPTION

2.	**PURCHASE AND DELIVERY OF SETTLING AGENT**			
a	Operating flow rate	**0.0**	**gpm**	
b	Dosage of coagulant needed (choose the dosage for the appropriate settling agent below)	**0.00**	**mg/L**	
	1. Aluminum sulfate[h]	6.00	mg/L	
	2. Ferric sulfate[h]	6.00	mg/L	
	3. Other coagulant agent		mg/L	
c	Dosage of flocculant needed (choose the dosage for the appropriate settling agent below)	**0.00**	**mg/L**	
	1. Polymer[h]	1.00	mg/L	
	2. Other settling agent		mg/L	
d	Amount of coagulant needed per year (multiply line 2a by line 2b times 3.785 L/gal times 2.2×10^{-6} lb/mg times 512,640 min/year)	0	lb/yr	
e	Amount of flocculant needed per year (multiply line 2a by line 2c times 3.785 L/gal times 2.2×10^{-6} lb/mg times 512,640 min/year)	0	lb/yr	
f	Cost of coagulant per year (multiply line 2d by the appropriate unit cost below)	**0.00**	**$/yr**	
	1. Aluminum sulfate[i]	0.12	$/lb	
	2. Ferric sulfate[j]	0.10	$/lb	
	3. Other coagulant agent		$/lb	
g	Cost of flocculant per year (multiply line 2e by the appropriate unit cost below)	**0.00**	**$/yr**	
	1. Polymer[k]	3.12	$/lb	
	2. Other settling agent		$/lb	
h	**Total Cost of Purchase and Delivery a One-Year Supply of Settling Agents (add lines 2f and 2g)**			**$0.00**
TOTAL ANNUAL COSTS OF PURCHASE AND DELIVERY OF CHEMICAL (Add lines 1f and 2h)				**$0.00**

a 106 g/mole*1 mole/mole /.6 efficiency / 1000g/kg * 2.2 lb/kg

b 40 g/mole*2 mole/mole / 1 efficiency / 1000g/kg * 2.2 lb/kg

c 17 g/mole*2 mole/mole /1 efficiency / 1000g/kg * 2.2 lb/kg

d 74 g/mole*1 mole/mole /.95 efficiency / 1000g/kg * 2.2 lb/kg

e 100 g/mole*1 mole/mole /.30 efficiency / 1000g/kg * 2.2 lb/kg

f 56 g/mole*1 mole/mole /.90 efficiency / 1000g/kg * 2.2 lb/kg

g Brent Means of Harrisburg Field Office of OSM for Remine Version V. 1.21, Pennsylvania Department of Environmental Protection. The cost is that for purchase and delivery within a 50-mile radius and Mike Jenkins of Aquafix system for the pebble quicklime.

h American Water Works Association (AWWA), *Water Quality and Treatment, A Handbook of Community Water Supplies* . 1990. P 509, McGraw Hill.

CHEMICAL CONSUMPTION

[i] R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg.9-298, Item No. 33 33 0119. The cost is that for purchase and delivery of bulk aluminum sulfate.

[j] R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg.9-298, Item No. 33 33 0120. The cost is that for purchase and delivery of bulk ferric sulfate.

[k] R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 9-298, Item No. 33 33 0127. The cost is that for purchase and delivery of nonionic polymeric flocculant.

SYSTEM MAINTENANCE AND REPLACEMENT

1.	**MAINTENANCE AND REPLACEMENT OF ACTIVE TREATMENT SYSTEMS**			
a	Capital costs for installation of active treatment systems (from AT-1, line 19)			
b	Allowance for annual costs of maintenance and replacement for active treatment systems (% of capital costs for installation of active treatment systems)[a]	**9%**		
c	**Annual Cost of Maintenance for Active Treatment Systems (multiply line 1a by line 1b)**			**$0.00**
2.	**MAINTENANCE AND REPLACEMENT OF PASSIVE TREATMENT SYSTEMS**			
a	Capital costs for installation of passive treatment systems (from PT-1, line 17)			
b	Allowance for annual costs of maintenance and replacement for passive treatment systems (% of capital costs for installation of passive treatment systems)[a]	**9%**		
c	**Annual Cost of Maintenance for Passive Treatment Systems (multiply line 2a by line 2b)**			**$0.00**
3.	**MAINTENANCE AND REPLACEMENT OF SOURCE CONTROL SYSTEMS**			
a	Capital costs for installation of source control systems (from SC-1, line 11)			
b	Allowance for annual costs of maintenance and replacement for source control systems (% of capital costs for installation of source control systems)[a]	**5%**		
c	**Annual Cost of Maintenance for Source Control Systems (multiply line 3a by line 3b)**			**$0.00**
	TOTAL ANNUAL COSTS OF SYSTEM MAINTENANCE AND REPLACEMENT (Add lines 1c, 2c, and 3c)			**$0.00**

a *Plant Design and Economics for Chemical Engineers, Fourth Edition* , Max S. Peters and Klaus D. Timmerhaus, McGraw-Hill, Inc., New York, pg. 203. Maintenance costs as a percentage of fixed capital investment on an annual basis range from 5 to 9 percent and are based on average processes under normal operating conditions.

ELECTRICITY

1. TOTAL SYSTEM HORSEPOWER REQUIREMENT			
a Design system flow rate	0	gpm	
b Operating flow rate	0	gpm	
c Number of pumps	0		
d Estimated horsepower per pump (select from the table)[a]	0	HP	
e Number of mixers or motors	0	ea	
f Estimated horsepower per mixer/motor	0	HP	
Skip lines 1c through 1f if total horsepower requirement is available from system design information.			
g Estimated total horse power (add the products of multiplication of line 1c times line 1d and line 1e times line 1f)[b]	0	HP	
g Estimated wattage requirement (multiply line 1f by 745.7, then divide by 1,000)	0.00	kW	
h Annual total days of operation	0	days	
i Utilization percentage (divide line 1b by 1a)[c]	0%		
j Annual hours of operation (assuming 24 hours of operation per day) - (multiply line 1h by 24)	0	hours	
k Electricity cost[d]	0.09	$/kWh	
TOTAL COST OF ELECTRICITY (multiply lines 1g, 1i, 1j, and 1k)			**$0.00**

a Pump Horsepower Requirrement (from ECHOS 1999, *Environmental Remediation Assemblies Cost Book* , p. 3-63)

GPM	HP	GPM	HP
10	0.5	500	20.0
50	3	750	30
100	5	1050	40
200	10	1500	60
250	10	2000	75
300	15		

b Skip lines 1c through 1f if total horsepower requirement is available from system design information.

c Utilization percentage can be estimated by dividing the actual operating capacity of the system by the maximum design capacity of the system.

d R.S. Means Company, Inc., *Environmental Remediation Assemblies Cost Data* , 1999, pg. 3-161, item no. 33 42 0101.

REMOVAL OF SLUDGE

1.	**REMOVAL OF SLUDGE**			
	Line 1a through 1d are used for ACIDIC MINE DRAINAGE ONLY			
a	Operating flow rate	**0**	**gpm**	
b	Total mine drainage acidity	**0.00**	**mg/L as $CaCO_3$**	
c	Mass acid loading (multiply line 1a by 3.785 liters/gallon and then by line 1b)	0.00	mg acid/min	
d	Volume of sludge generated annually (multiply line 1c by the multiplier for the appropriate neutralization chemical below)[a]			
	5. Limestone - FOR PASSIVE SYSTEM ONLY	**0**	**yd^3/year**	
	1. Soda ash briquettes	0.072	(yd^3/year) / (mg acid/min)	
	2. Caustic (20% solution)	0.095		
	3. Ammonia	0.090		
	4. Hydrated lime or pebble quicklime	0.116		
	5. Limestone - FOR PASSIVE SYSTEM ONLY	0.220		
	Line 1e through 1g are used for ALKALINE MINE DRAINAGE ONLY.			
e	Quantity of sludge generated in tons	**0**	**tons**	
f	Quantity of sludge generated in lbs (multiply line 1e by 2000)	0	lbs	
g	Density of sludge	**93**	**lbs/ft3**	
h	Volume of sludge generated annually (divide line 1f by line 1g and divide the result by 27)	0.00	yd^3	
i	Cost of removal and loading of sludge (select unit cost for appropriate method below)	11.73	$/yd^3$	
	1. Excavator and dump truck[b]	5.64	$/yd^3$	
	2. Vacuum truck[c]	11.73	$/yd^3$	
	3. Sludge pump[d]	0.00	$/yd^3$	
	4. Other[e]	0.00	$/yd^3$	
j	**Cost of Removal of One-Year's Production of Sludge (multiply line 1d by line 1i for acidic mine drainage or multiply line 1h by 1i for alkaline mine drainage)**			**$0.00**
2.	**DISPOSAL OF SLUDGE**			
a	Unit cost for transportation and disposal of sludge (select unit cost for appropriate disposal method below)	1.16	yd^3/year	
	1. On-site management[f]	1.16	$/yd^3$	
	2. Off-site management[g]	7.21	$/yd^3$	
	3. Disposal in off-site RCRA D landfill[h]	3.45	$/yd^3$	
	4. Other disposal[e]	0.00	$/yd^3$	
b	**Cost of Disposal of One-Year's Production of Sludge (multiply lines 1d by line 2a)**			**$0.00**
	TOTAL ANNUAL COSTS OF REMOVAL OF SLUDGE (add lines 1f and 2c)			**$0.00**

a West Virginia University and The National Mine Land Reclamation Center, *Acid Mine Drainage Control and Treatment*, Skousen and Ziemkiewicz, 1996, pg. 217 - 224. Limestone factor is derived by multiplying MW of limestone (100 g/mol) by 2.2 and dividing the product by 1,000.

REMOVAL OF SLUDGE

b R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 4-15, Item No..17 03 0276. The cost is that for excavation by a 1-yd^3 crawler-mounted, hydraulic excavator.
R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 9-167, Item No. 33 19 0102. The cost is that for loading bulk solid into truck.

c R.S. Means Company, Inc., Environmental Remediation Unit Cost Data, 1999, pg. 9-167, Item No. 33 19 0101. The cost is that for loading liquid into 5,000-gallon bulk tank truck.

d The sludge disposal cost using sludge pumps consists of cost of purchase of pumps and electricity cost to operate the pumps. Disposal cost using sludge pump is zero, because the cost to purchase pumps is covered in AT worksheets and the electricity cost is covered in OP-3 worksheet.

e User specified input.

f R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, Item No. 02221 6004. The cost is that for spreading borrow with a dozer.

g R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, Item No. 02221 6004 and 02225 3202. The cost is that for spreading borrow with a dozer and hauling with a 12-yd^3 truck for a 4-mile roundtrip (base wide rate).

h R.S. Means Company, Inc., *Environmental Remediation Unit Cost Data* , 1999, pg. 9-202, Item No. 33 19 7270. The cost is that for disposal of nonhazardous solid bulk waste by yd^3 to a landfill.

SAMPLING AND ANALYSIS

1.	**COLLECTION OF AQUEOUS SAMPLES**			
a	Number of sample locations	**0**		
b	Unit cost of labor and equipment [a]	91.29	$/hr	
c	Work rate to collect samples from one sample location (divide total number of sampling parameters by 2)[b]	**0.0**	**hrs/loc**	
d	Number of hours required to collect all samples (multiply line 1a by line 1c)	0	hrs	
e	Cost of collection per sampling event (multiply line 1b by line 1d)	0.00	$/event	
f	Number of sampling events per year	**0**		
g	**Total Cost of Collection of Aqueous Samples (Multiply line 1e by line 1f)**			**$0.00**
2.	**ANALYSIS OF AQUEOUS SAMPLES**			
a	Cost of analysis per sampling event for aqueous samples (total from Aqueous Samples worksheet, page 2 of 2)	0.00	$	
b	**Total Annual Cost of Analysis of Aqueous Samples (multiply line 1f by line 2a)**			**$0.00**
	TOTAL ANNUAL COST OF COLLECTION AND ANALYSIS OF AQUEOUS SAMPLES (add lines 1g and 2b)			**$0.00**

a Includes cost of collection and handling of samples and vehicle rental. Cost is derived from price quotes from vendors. Crew consists of two sampling technicians.

b Work rate was obtained by assuming two sampling parameters can be collected in an hour. Various sample collection devices (bailers, kemmerer samples, Van Dorn samples, peristaltic pump, and others) can be used to collect the wastewater and other aqueous samples. Samples are collected with the appropriate device and the liquid is poured into sample containers. The samples then are preserved, labled, and placed in an ice chest cooled to 4^{o}C. Sample documentation is completed and the samplers move to the next location.

SAMPLING AND ANALYSIS

Analytical Parameter and Method Reference[a]	Cost of Analysis per Parameter ($)[b]	Number of Analyses, Including QC Analyses[c]	Total Cost of Analysis per Parameter per Event ($)
1	$0.00	0	$0.00
2	$0.00	0	$0.00
3	$0.00	0	$0.00
4	$0.00	0	$0.00
5	$0.00	0	$0.00
6	$0.00	0	$0.00
TOTAL COST OF ANALYSIS OF AQUEOUS SAMPLES			**$0.00**

[a] List analytical parameters and method numbers from the sampling and analysis attachments that correspond most closely to those specified in the reclamation plan or permit. If a method of analysis is not specified, choose an appropriate method from the attachment.

[b] Choose a unit analysis cost from the sampling and analysis attachment for each parameter. Note that unit cost may differ according to the method of analysis used, the type of medium (solid or liquid) sampled, and the number of analyses performed.

[c] Identify the number of sampling locations and analyses specified in the reclamation plan or permit. The number of quality control (QC) samples typically is 20 percent of the total number of samples to be analyzed for a large number of samples or a minimum of three QC samples per facility for each round of sampling at the facility..

SAMPLING AND ANALYSIS

1.	**Collection of Sludge and Soil Samples**			
a	Number of sample locations	**0**		
b	Unit cost of labor and equipment[a]	91.29	$/hr	
c	Work rate to collect samples from one sample location[b]	**1.0**	**hrs/loc**	
d	Number of hours required to collect all samples (multiply line 1a by line 1c)	0	hrs	
e	Unit cost of collection per sampling event (multiply line 1b by line 1d)	0.00	$/event	
f	Number of sampling events per year	**0**	**events**	
g	**Total Cost of Collection of Sludge and Soil Samples (multiply line 1e by line 1f)**			**$0.00**
2.	**Analysis of Sludge and Soil Samples**			
a	Cost of analysis per sampling event for sludge and soil samples (total from Sludge and Soil Samples worksheet, page 2 of 2)	0.00	$	
b	**Total Cost of Analysis of Sludge and Soil Samples (multiply line 1f by line 2a)**			**$0.00**
	TOTAL ANNUAL COST OF COLLECTION AND ANALYSIS OF SLUDGE AND SOIL SAMPLES (add lines 1g and 2b)			**$0.00**

a Includes cost of collection and handling of samples and vehicle rental. Cost is derived from price quotes from vendors. Crew consists of two sampling technicians.

b U.S. Environmental Protection Agency, *Final Guidance Manual: Cost Estimates for Closure and Post-Closure Plans (Subparts G and H), Volume III* , January 1987, EPA/530-SW-009, pg. 2-16.

SAMPLING AND ANALYSIS

Analytical Parameter and Method Reference[a]	Cost of Analysis per Parameter ($)[b]	Number of Analyses, Including QC Analyses[c]	Total Cost of Analysis per Parameter per Event ($)
1	$0.00	0	$0.00
2	$0.00	0	$0.00
3	$0.00	0	$0.00
4	$0.00	0	$0.00
5	$0.00	0	$0.00
6	$0.00	0	$0.00
TOTAL COST OF ANALYSIS OF SLUDGE AND SOIL SAMPLES			**$0.00**

[a] List analytical parameters and method numbers from the sampling and analysis attachments that correspond most closely to those specified in the reclamation plan or permit. If a method of analysis is not specified, choose an appropriate method from the attachment.

[b] Choose a unit analysis cost from the sampling and analysis attachment for each parameter. Note that unit cost may differ according to the method of analysis used, the type of medium (solid or liquid) sampled, and the number of analyses performed.

[c] Identify the number of sampling locations and analyses specified in the reclamation plan or permit. The number of quality control (QC) samples typically is 20 percent of the total number of samples to be analyzed for a large number of samples or a minimum of three QC samples per facility for each round of sampling at the facility.

SAMPLING AND ANALYSIS

1.	**Collection of Groundwater Samples**			
a	Number of sample locations	**0**		
b	Unit cost of labor and equipment [a]	91.29	$/hr	
c	Work hours required to collect samples from one sample location[b]	**4.0**	**hrs/loc**	
d	Number of hours required to collect all samples (multiply line 1a by line 1c)	0	hrs	
e	Cost of collection per sampling event (multiply line 1b by line 1d)	0.00	$/event	
f	Number of sampling events per year	**0**	**events**	
g	**Total Annual Cost of Collection of Groundwater Samples (multiply line 1e by line 1f)**			**$0.00**
2.	**Analysis of Groundwater Samples**			
a	Cost of analysis per sampling event for aqueous samples (total from Groundwater Samples worksheet, page 2 of 2)	0.00	$	
b	**Total Annual Cost of Analysis of Groundwater Samples (multiply line 1f by line 2a)**			**$0.00**
TOTAL ANNUAL COST OF COLLECTION AND ANALYSIS OF GROUNDWATER SAMPLES (add line 1g and line 2b)				**$0.00**

a Includes cost of equipment rental (portable pump), collection and handling of samples and vehicle rental. Cost is derived from price quotes from vendors.
Crew consists of two sampling technicians.

b U.S. Environmental Protection Agency, *Final Guidance manual: Cost Estimates for Closure and Post-Closure Plans (Subparts G and H), Volume III,* January 1987, EPA/530-SW-009, pages 2-4. The rate includes the time required to purge the well, allow recovery, sample the well, document the sampling, and move to the next sampling location.

SAMPLING AND ANALYSIS

Analytical Parameter and Method Reference[a]	Cost of Analysis per Parameter ($)[b]	Number of Analyses, Including QC Analyses[c]	Total Cost of Analysis per Parameter per Event ($)
1	$0.00	0	$0.00
2	$0.00	0	$0.00
3	$0.00	0	$0.00
4	$0.00	0	$0.00
5	$0.00	0	$0.00
6	$0.00	0	$0.00
TOTAL COST OF ANALYSIS OF GROUNDWATER SAMPLES			**$0.00**

a List analytical parameters and method numbers from the sampling and analysis attachments that correspond most closely with those specified in the reclamation plan or permit. If a method of analysis is not specified, choose an appropriate method from the attachment.

b Choose a unit analysis cost from the sampling and analysis attachment for each parameter. Note that unit cost may differ according to the method of analysis used, the type of medium (solid or liquid) sampled, and the number of analyses performed.

c Identify the number of sampling locations and analyses specified in the reclamation plan or permit. The number of quality control (QC) samples typically is 20 percent of the total number of samples to be analyzed for a large number of samples or a minimum of three QC samples per facility for each round of sampling at the facility..

SAMPLING AND ANALYSIS

Activity		Cost
1	Aqueous Samples	$0.00
2	Sludge and Soil Samples	$0.00
3	Groundwater Samples	$0.00
TOTAL COST OF SAMPLING AND ANALYSIS (add lines 1 through 3)		**$0.00**

Parameter (or Test)	Method Reference		Cost ($)/Analysis			
			Water		Soil/Sludge	
	Water	Soil/Sludge	Range	Average	Range	Average
CLP Metals (Total)	CLP SOW 390	CLP SOW 390	$136.00 - $158.00	$141.75	$141.00 - $158.00	$145.55
CLP Metals (Filtered)	CLP SOW 390	CLP SOW 390	$136.00 - $158.00	$141.75	$141.00 - $158.00	$145.55
CLP Metals - low level	CLP SOW 390	CLP SOW 390	$149.00 - $189.00	$153.76	$154.00 - $189.00	$162.33
CLP Metals - individual metals	--	--	$11.00 - $21.00	$19.99	$11.00 - $20.00	$20.00
Nitrate-N/Nitrite-N	EPA 353.2	ASA Monograph No. 9, Method 33-8.1	$15.00 - $28.00	$20.05	$15.00 - $30.00	$15.00
Major Anions (Chloride and Sulfate)	EPA 300.0/375.3	Not Applicable	$20.00 - $34.00	$28.45	--	--
Total Dissolved Solids (TDS)	160.1	Not Applicable	$10.00 - $15.00	$12.93	--	--
Total Suspended Solids (TSS)	160.2	Not Applicable	$10.00 - $15.00	$12.29	--	--
Acid Sulfides	--	--	$15.00 - $53.00	$34.00	$15.00 - $66.00	$40.40
Ammonia as Nitrogen	EPA 350.1	ASA Monograph No. 9, Method 33-7.33	$20.00 - $24.00	$21.19	$20.00 - $27.00	$25.64
Sulfide	376.1/376.2	Not Applicable	$15.00 - $29.00	$21.19	--	--
Corrosivity, pH	9040/160.1	9045	$4.00 - $10.00	$5.99	$7.00 - $15.00	$7.85
Nitrates	363.2/353.3	353.2	$27.00 - $40.00	$85.00	$40.00 - $40.00	$40.00
Alkalinity, Total HCO_3, CO_3, OH	EPA 310.1	Not Applicable	$10.00 - $15.00	$13.37	--	--
Conductivity	EPA 120.1	ASA Monograph No. 9, Method 10-3.3	$10.00 - $12.00	$11.16	$10.00 - $26.00	$10.00
Turbidity	EPA 180.1	Not Applicable	$8.00 -13.00	$12.30	--	--
Hardness	EPA 200.7	Not Applicable	$10.00 - $17.00	$11.29	--	--
Acidity, Total as $CaCO_3$	EPA 305.1	Not Applicable	$11.00 - $16.00	$14.25	--	--
TCLP Extraction	Not Applicable	1311	--	--	$75.00 - $100.00	$95.00
RCRA Metals	6010/7000 series	6010/7000 series	$100.00 - $200.00	$140.00	$125.00 - $200.00	$150.00
Primary Drinking Water Metals (7-12 metals)	200 series	Not Applicable	$150.00 - $202.00	$185.00	--	--
Priority Pollutant Metals (13 metals)	200.7	6010/7000 series	$200.00 - $269.00	$220.00	$220.00 - $285.00	$235.00
Specific Conductance	120.1	9050	$5.00 - $12.00	$10.00	$10.00 - $15.00	$15.00
Sulfate	375.2/375.4	Not Applicable	$13.00 - $30.00	$20.00		
Ferrous Iron	STD MET 3500 Fe-D	Not Applicable	$15.00 - $30.00	$20.00	--	--
Acid-Base Accounting	Not Applicable	Modified Sobek Method	--	--	$50.00 - $100.00	$60.00

8.0 SUPPORT ACTIVITIES

Under the methodology, support activities are identified as those activities that on occasion may be necessary to implement the long-term treatment of mine drainage but that may not be associated with the implementation of any particular mine drainage treatment process. For example, in certain cases, regulatory authorities have experienced significant difficulty in implementing the treatment of mine drainage because they lack access to the site. Under such circumstances, the regulatory authority may find it necessary to purchase or lease land to implement the treatment process or obtain access to the site. Although such activities may not be necessary at every mine drainage treatment site, the need to purchase or lease land, install monitoring wells, establish site security, or construct access roads can increase significantly the cost of conducting long-term treatment of mine drainage. If, therefore, it is anticipated that any "support" activities will be conducted in doing so, the costs of such activities should be accounted for when an estimate of the total costs for the site is prepared.

Presented below are descriptions of the cost estimating worksheets to be used in determining the costs of support activities that may be necessary for the treatment of mine drainage at surface mines, underground mines, and coal refuse piles:

- **Land Access -** Costs for land access may be incurred when land must be acquired to permit the implementation of a specific treatment activity or to establish rights-of-way to gain access to the site. The cost of land access may include the costs of the purchase or leasing of land.

- **Monitoring Wells -** Monitoring wells must be installed whenever the treatment of mine drainage includes the sampling of groundwater. The cost of installing a monitoring well includes the costs of the following components: preproject engineering, drilling and installation of wells, and well completion. The worksheet is suitable for determining the cost of installing vertical monitoring wells. The costs of preproject engineering include the costs of initial determination of elevations and staking of well locations in the field, development of drawings, and preparation of engineering reports and recommendations for well construction. The costs of drilling may be adjusted to account for use of any of the following three methods: 1) hollow-stem augering, 2) BX-size rock cores, 3) NX-size rock cores, and 4) air-rotary. For estimating the costs of well construction, the worksheet assumes the use of PVC as the construction material, a 10-foot well screen, and a 2-foot bentonite seal.

- **Site Security -** When treating mine drainage, it may be necessary to implement security measures to restrict entry by persons or livestock in the area of the site. The estimate of the cost of this activity is based on the installation of an industrial chain-link fence around the site or a portion of the site, equipped with signs that prohibit unauthorized entry. If a site is located in an area where controls already are present, or if controls are not deemed necessary, construction of a fence around the site may not be necessary.

- **Access Roads -** When treating mine drainage, it may be necessary to install roads to facilitate access to the site. In particular, roads may be required to make possible the regular removal of sludge from active treatment systems. The cost of construction include the costs of surveying, clearing and grubbing, purchasing from an off-site source an aggregate course base, and placing that base to create a road surface.

LAND ACCESS

1.	**PURCHASE OF LAND**			
a	Estimated amount of land that will be purchased to implement a treatment system	0	acres	
b	Estimated unit cost of land[a]	0.00	$acre	
c	Subtotal cost of purchase of land (multiply line 1a by line 1b)	0.00	$	
d	Estimated closing and settlement costs[b]	0.00	$	
e	**Total Cost of Purchase of Land (add lines 1c and 1d)**			**$0.00**
2.	**LEASING OF LAND**			
a	Estimated annual cost of leasing of land required to implement a treatment system[c]	0.00	$/year	
b	Number of years land will be leased	0	years	
c	**Total Cost of Leasing Land (multiply line 2a by line 2b)**			**$0.00**
TOTAL COSTS OF LAND ACCESS (add lines 1e and 2c)				**$0.00**

a The cost of land must be established case by case and may depend on a wide variety of factors, including the location and current use of the land, the environmental condition of the land, and the willingness of the current owner of the land to sell it. An estimate of the fair market value of a parcel of land might be derived by surveying the costs of properties that have similar characteristics and are located in the same general area.

b Costs include settlement or closing fees, title search and examination fees, costs of title insurance, city or county taxes or tax stamps, costs for the survey plat or improvement location certificate, document preparation and filing fees, and application fees.

c The annual cost of leasing land must be established case by case and may depend on a variety of factors, including the location and current use of the land, the environmental condition of the land, the willingness of the current owner of the land to lease it for the specified purpose, and the potential effects of the use of that land on its future value or on the future values of adjacent properties. An estimate of the annual cost of leasing a parcel of land might be derived by surveying the lease costs of properties that have similar characteristics and are located in the same general area.

MONITORING WELLS

1.	**PREPROJECT ENGINEERING**			
	The user may skip line 1a through line 1h for a simple well construction.			
a	Number of wells	0	wells	
b	Unit cost for labor and equipment[a]	74.38	$/work hr	
c	Work rate for initial determination of well elevation and field stakeout[b]	0.80	hr/boring	
d	Number of hours required for initial determination of well elevation and initial field stakeout (multiply line 1a by line 1c) (one hour minimum; round up to the 0.5 hour)	0	work hrs	
e	Cost of determining well elevation and initial field stakeout (multiply line 1b by line 1d)	0.00	$	
f	Cost of development of drawings, including details of borings[c]	240.00	$	
g	Cost of engineering recommendation[d]	530.00	$	
h	**Total Cost to Perform Preproject Engineering (add lines 1e, 1f, and 1g)**			**$0.00**
2.	**MOBILIZATION AND DEMOBILIZATION OF EQUIPMENT**			
a	Cost of mobilization and demobiization cost within a 100-mile radius[e]	340.00	$	
b	Distance for mobilization and demobilization beyond a 100-mile radius	0	mi > 100	
c	Cost of mobilizing and demobilizing equipment for distances of more than 100 miles (multiply line 2b by $3.04/mile)f	0.00	$/mi	
d	**Total Cost of Mobilizing and Demobilizing Equipment (add lines 2a and 2c)**			**$0.00**
3.	**INSTALLATION OF WELLS**			
a	Diameter of wells		**inches**	
b	Total number of boreholes to be drilled	**0**	**boreholes**	
c	Total depth of all boreholes (add the depths of all wells)	**0**	**ft**	
d	Unit cost of labor and equipment (select from below): **4. NX-Size Rock Core - 4-inc**	48.68	$/ft	
	1. Hollow Stem Auger - 2.5-inch	19.18	$/ft	
	2. Hollow Stem Auger - 4-inch	28.08	$/ft	
	3. BX-Size Rock Core - 2.5-inch	36.13	$/ft	
	4. NX-Size Rock Core - 4-inc	48.68	$/ft	
	5. Air Rotary - 6-inch (unconsolidated)	31.21	$/ft	
e	Total cost of drilling (multiply line 3c by line 3d)	0.00	$	
f	Unit cost of well plug, screen, and seal[g]	211.04	$/well	
g	Cost of plugging, screening, and sealing all wells (mulitply line 3b by line 3f)	0.00	$	
h	**Total Cost of Installation Wells (add lines 3e and 3g)**			**$0.00**
4.	**COMPLETION OF WELLS**			
a	Total number of wells	0	wells	
b	Well completion cost[i]	455.10	$/well	
c	**Cost of Completion of Wells (multiply line 4a by line 4b)**			**$0.00**
	TOTAL COST OF INSTALLATION OF GROUNDWATER WELL (add lines 1h, 2d, 3h, and 4c)			**$0.00**

[a] Cost derived from R.S. Means Company, Inc., *Means Building Construction Cost Data* , 1997, pg. 28, item no. 123-0010. Activity includes initial staking of field location and determination of elevations. Assume cost of $595.00/day ÷ 8 hrs/day = $74.38 work hr.

MONITORING WELLS

[b] Work rate based on engineering judgement. Assume that a crew can survey, on average, 10 wells or elevations per day. The work rate is 8 hr/day ÷ 10 wells/day = 0.80 work hr/well.

[c] R.S. Means Company, Inc., *Means Building Construction Cost Data* , 1997, pg. 28, item no. 123-0100. Activity includes drawing showing boring details. Assume only one set of drawings per groundwater monitoring system will be prepared.

[d] R.S. Means Company, Inc., *Means Building Construction Cost Data* , 1997, pg. 28, item no. 123-0200. Activity includes a report and recommendations from a professional engineer. Assume only one engineering report per groundwater monitoring system will be prepared.

[e] R.S. Means Company, Inc., *Means Building Construction Cost Data* , 1997, pg. 28, item no. 123-0300. Activity includes mobilization and demobilization of truck mounted auger.

[f] R.S. Means Company, Inc., *Means Building Construction Cost Data* , 1997, pg. 28, item no. 123-0350. Activity includes mobilization and demobilization of truck mounted auger, per mile if travel exceeds 100 miles.

[g] R.S. Means Company, Inc. and Delta Technologies Group, Inc., *The Environmental Cost Handling Options and Solutions, Environmental Restoration Assemblies Costbook* , 1997, page 2-6, 2-7, items number 33230201, 33230301, and 33232101. Assume the well is polyvinyl chloride (PVC). Cost includes a 10-ft well screen, bentonite seal, and a 2-inch well plug.

[h] R.S. Means Company, Inc. and Delta Technologies Group, Inc., *The Environmental Cost Handling Options and Solutions, Environmental Restoration Assemblies Costbook* , 1997, page 2-6, 2-7, items number 33230202, 33230302, and 33232102. Assume the well is polyvinyl chloride (PVC). Cost includes a 10-ft well screen, bentonite seal, and a 4-inch well plug.

[i] R.S. Means Company, Inc. and Delta Technologies Group, Inc., *The Environmental Cost Handling Options and Solutions, Environmental Restoration Assemblies Costbook* , 1996, page 2-6, 2-7, items number 33231502, 33232203, and 33232301. Assume the well is polyvinyl chloride (PVC). Cost includes a protective cover and a 4-ft-by-4-ft well pad, and 4 guard posts.

MONITORING WELL INSTALLATION

Drilling Costs - Reference for Line 3d

Drilling Method	Borehole Diameter (inches)	Drilling Labor and Equipment Cost Per Work Hour ($) for 2-1/2-Inch and 4-Inch Diameter Boreholes	Drilling Rate (Work Hour/Linear Foot)	Drilling Cost ($/ft) - (multiply drilling labor and equipment by drilling rate)
Hollow-Stem Auger	2.5	62.88[a]	0.305[c]	19.18
	4	62.88[a]	0.356[d]	22.39
BX-Size Rock Core	2	78.89[b]	0.458[e]	36.13
NX-Size Rock Core	4	78.89[b]	0.617[f]	48.68
Air Rotary (recommended for unconsolidated drilling)	6			31.21[g]

[a] R.S. Means Company, Inc., Means Building Construction Cost Data, 1999, pg. 590, crew B-55. Crew B-55 consists of two laborers, one truck driver, one flatbed truck with auger, and one 3-ton truck.

[b] R.S. Means Company, Inc., Means Building Construction Cost Data, 1999, pg. 590, crew B-56. Crew B-56 consists of one laborer, one light equipment operator, one 4-inch crawler-type drill, one 600 cfm air compressor, and one 3-inch diameter, 50-ft air hose.

[c] R.S. Means Company, Inc., Means Building Construction Cost Data, 1999, pg. 28, item no. 123-0600. Work rate is based on a three-person crew. Activity includes augering 2-1/2-inch holes in earth.

[d] R.S. Means Company, Inc., Means Building Construction Cost Data, 1999, pg. 28, item no. 123-0650. Work rate is based on a three-person crew. Activity includes augering 4-inch holes in earth.

[e] R.S. Means Company, Inc., Means Building Construction Cost Data, 1999, pg. 29, item no. 123-1000. Work rate is based on a two-person crew. Activity includes drilling a "BX" core in rock.

[f] R.S. Means Company, Inc., Means Building Construction Cost Data, 1999, pg. 29, item no. 123-1200. Work rate is based on a two-person crew. Activity includes drilling an "NX" core in rock.

[g] R.S. Means Company, Inc., Environmental Remediation: Unit Cost Book, 1999, pg. 9-237, item no. 33 23 1147.

SITE SECURITY

1.	**FENCING**			
a	Length of fencing	**0**	**ft**	
b	Unit cost of labor, materials, and equipment[a]	13.30	$/ft	
c	**Total Cost of Fencing Site (multipy line 1a by line 1b)**			**$0.00**
2.	**CORNER POSTS**			
a	Number of corner posts required	**0**	**posts**	
b	Unit cost of corner post[b]	96.50	$/posts	
c	**Total Cost of Erecting Corner Posts (multiply line 2a by line 2b)**			**$0.00**
3.	**GATES**			
a	Number of gates required	**0**	**gate(s)**	
b	Unit cost of labor, materials, and equipment[c]	265.00	$/gate	
c	**Total Cost of Installing Gates (multiply line 3a by line 3b)**			**$0.00**
4.	**REFLECTOR SIGNS**			
a	Number of signs required	**0**	**signs**	
b	Unit cost of labor, materials, and equipment[d]	48.50	$/signs	
c	**Total Cost of Installing Signs (multiply line 4a by line 4b)**			**$0.00**
	TOTAL COST OF SITE SECURITY (add lines 1c, 2c, 3c, and 4c)			**$0.00**

a R.S. Means Company, Inc., *Means Building Construction Cost Data* , 1997, pg. 80, Item No. 308-0600. Activity described is the installation of industrial chain-link fencing, 6 ft high, plus three strands of barbed wire, 9 gauge wire, galvanized steel. Fencing includes 2-in link posts, 10 ft on center, and a 1-5/8-in top rail. Crew B-80 consists of one labor foreman, one laborer, one light truck driver, one light equipment operator, one 3-ton flatbed truck, and one post driver. If Regional Default Values is chosen in the Facility Information Window, this cost has been adjusted using the index guide found in the Means Cost Data Books.

b R.S. Means Company, Inc., *Means Building Construction Cost Data* , 1997, pg. 80, Item No. 308-1100. Activity described is the installation of 3-inch-diameter, galvanized steel, corner fence posts. Crew B-80 consists of one labor foreman, one laborer, one light equipment operator, one 3-ton flatbed truck, and one post driver.

c R.S. Means Company, Inc., *Means Building Construction Cost Data* , 1997, pg. 80, Item No. 308-2400. Activity described is the installation of a 4-ft wide by 5-ft high, 2-in frame, galvanized steel gate. Crew B-80 consists of one labor foreman, one laborer, one light truck driver, one light equipment operator, one 3-ton flatbed truck, and one post driver.

d R.S. Means Company, Inc., *Means Building Construction Cost Data* , 1997, pg. 83, Item No. 412-0010. Activity described is the installation of a 24-in-by-24-in, reflectorized sign with no posts. Crew B-80 consists of one labor foreman, one laborer, one light truck driver, one light equipment operator, one 3-ton flatbed truck, and one post driver.

ACCESS ROADS

1.	**SURVEYING**			
a	Length of access road	**0**	**ft**	
b	Width of access road	**0**	**ft**	
c	Thickness of access road	**0**	**ft**	
d	Area to be surveyed (multiply line 1a by line 1b times 2, survey factor, then divide by 43,560)	0	acres	
e	Survey rate	1	acre/day	
	Days required to conduct survey (divide line 1d by line 1e)	0	days	
f	Unit cost of surveying[a]	648.36	$/day	
c	**Total Cost to Survey (multiply line 1e by line 1f)**			**$0.00**
2.	**CLEARING AND GRUBBING**			
a	Unit cost of clearing and grubbing[b]	5,650.00	$/acre	
b	Area to be cleared and grubbed (line 1d)	0.00	acres	
c	**Total Cost of Clearing and Grubbing (multiply lines 2a by line 2b)**			**$0.00**
3.	**PURCHASE AND PLACEMENT OF AGGREGATE COURSE BASE**			
a	Quantity of aggregate course (multiply line 1a by line 1b and divide the product by 9)	0	yd^2	
b	Quantity of aggregate course (multiply lines 1a, 1b, 1c, and divide the product by 27)	0	yd^3	
c	Unit cost of purchase of aggregate base course (compacted 12" deep)[c]	14.35	$\$/yd^2$	
d	Unit cost of delivery (20 mile-radius)[d]	19.40	$\$/yd^3$	
e	**Total Cost of Purchase and Placement of Aggregate Base Course (multiply line 3a by line 3c, multiply line 3b by line 3d, and add the products)**			**$0.00**
TOTAL COST OF INSTALLING ACCESS ROAD (add lines 1c, 2c, and 3e)				**$0.00**

a R.S. Means Company, Inc., *Environmental Remediation Data Unit Cost* , 1999, pg. 10-10, Item No. 99 24 1201. The cost is that for surveying with a two-person crew.

b R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 39, Item No. 021 104 0260. The cost is that for clearing and grubbing of dense brush, including stumps.

c R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 56, Item No.022 308 0304. The cost is that for purchase and placement of crushed stone with 1.5-inch-base and 12-inch-depth, including spreading and compacting.

d R.S. Means Company, Inc., *Site Work and Landscape Cost Data* , 1999, pg. 54, Item No. 022 216 6000. The cost is that for hauling by a 12 yd^3 dump truck for a round trip of 20 miles.

9.0 SITE SUMMARY

The methodology can be used to estimate the costs of the treatment of mine drainage in cases in which more than one source control, active treatment, or passive treatment unit is located at a site. The site summary worksheet is used to record the costs calculated for each source control, active treatment, and passive treatment unit located at a site and to total the cost of treatment of mine drainage for all those units.

SITE SUMMARY

SITE NAME: ____________________

Unit ID/Name		Costs	
1. SOURCE CONTROLS (Enter totals for each unit from worksheets SC-1)			
a		$	
b		$	
c		$	
d		$	
e	**Subtotal for Source Controls** (Add lines 1a through 1d)		**$ -**
2. ACTIVE TREATMENT UNITS (Enter totals for each unit from worksheets AT-1)			
a		$	
b		$	
c		$	
d		$	
e	**Subtotal for Active Treatment Units** (Add lines 2a through 2d)		**$ -**
3. PASSIVE TREATMENT UNITS (Enter totals for each unit from worksheets PT-1)			
a		$	
b		$	
c		$	
d		$	
e	**Subtotal for Passive Treatment Units** (Add lines 3a through 3d)		**$**
TOTAL COST OF TREATMENT OF AMD AT ALL UNITS (add lines 1e, 2e, and 3e)			**$**