New York State

Department of Environmental Conservation

Division of Hazardous Waste Remediation

REMEDIAL INVESTIGATION/FEASIBILITY STUDY

Tuxedo Waste Disposal Site

Orange County, New York

Site I.D. No. 3-36-035

Volume III

Feasibility Study

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EXECUTIVE SUMMARY

As part of the State of New York's program to remediate hazardous waste sites, the New York State Department of Environmental Conservation (NYSDEC, entered into a contract with Metcalf & Eddy of New York, Inc. (M&E) to undertake a multi-phased Remedial Investigation and Feasibility Study (RI/FS) for the Tuxedo Waste Disposal Site, aka the Barone/Sacco Dump Site, located in the Town of Tuxedo, Orange County, New York. The site is an inactive hazardous waste landfill covering approximately 13 acres.

Hazardous waste and construction and demolition (C&D) debris were deposited on two separate parcels. The main portion of the site is the Barone/Khcurouzian (B/K) Parcel which contains approximately 480,000 cubic yards of waste. The northeastern section of the adjacent property, known as the Georgia Tech Parcel, received approximately 14,600 cubic yards of material which is largely C&D waste.

Volumes I and II of the RI/FS present the Remedial Investigation and its appendices This report, Volume III, is the Feasibility Study. The purposes of an FS are to:

- Identify and evaluate potentially applicable remedial alternatives which may be employed to attain site remedial goals.
- Select a preferred remedial alternative based upon eight selection criteria classed as Threshold Criteria, Balancing Criteria and Modifying Criteria
- Provide sufficient information for the decision making agency to select a remedial action for the site.

The multi-phased FS involved the following tasks:

- Phase I FS - Identification of applicable remedial technologies, initial screening, and review of initial alternatives after completion of the remedial investigation phase.

- Phase II FS - Preliminary screening of alternatives for ability to attain site clean-up objectives, for implementability, and for short/long term effectiveness
- Phase III FS - Detailed analysis of alternatives based on eight evaluation criteria, including cost of implementation.
- Selection of Remedy - A preferred remedial alternative is selected based on the results of the Phase III FS, and a conceptual design is developed.

FS Tasks

The Phase I FS, Development of Remedial Alternatives done as part of Task 2 of the RI/FS, identified remedial action alternatives which potentially could be applied to the Tuxedo Waste Disposal Site, taking into account site specific considerations. This phase included the following steps

- Identification and characterization of areas and environmental media requiring remediation.
- Development of remedial action objectives, specifying the contaminants and media of concern.
- Development of general response actions for each exposure medium.
- Identification and initial screening of potentially applicable remedial action technologies for applicability and feasibility.
- Formulation of potentially applicable remedial action alternatives, consisting of the more promising technologies for each of the media of concern.

The purpose of the Phase II FS, Preliminary Screening of Alternatives (Task 5 of the Project Work Plan), was to evaluate each potentially applicable alternative on the basis of effectiveness and implementability. The screening in Task 5 also included a review of the alternatives' ability to achieve remedial objectives, a literature review of treatment technologies; an evaluation of the feasibility of complete or partial removal of wastes from both the B/K and Georgia Tech parcels; and a public information meeting. As a result of this preliminary screening phase, seven alternatives for the B/K Parcel and four alternatives for the Georgia Tech Parcel were retained for further detailed analysis.

The purpose of the Phase III FS, the detailed evaluation of alternatives, was to present the results of the assessment such that logical comparisons can be made among the different alternatives developed. In this way, the agencies responsible for the ultimate selection of the cleanup alternative are provided with sufficient information to compare the alternatives and select an appropriate remedy. The alternatives that were developed and described in Phase II, Preliminary Screening of Alternatives, were further refined and analyzed according to eight criteria. These criteria are:

Threshold Criteria

- Overall protection of human health and the environment
- ARARs compliance

Balancing Criteria

- Short-term effectiveness
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Implementability
- Cost

Modifying Criterion

- Community acceptance

Alternatives were compared in the context of the above criteria. Uncertainties regarding alternative designs were identified, discussed, and summarized in the comparison of alternatives. Additional data needs were described for each alternative.

As a result of the detailed analysis, three alternatives were retained for further consideration. These alternatives were:

- Landfill Cap with Passive Gas Venting/Treatment
- Landfill Cap with Active Gas Treatment
- Landfill Cap with Active Gas Treatment and Groundwater Treatment

These three alternatives incorporate a suitable landfill cap with gas venting (passive or active) and treatment. One of the alternatives provides for groundwater collection and treatment; the others provide for groundwater, river water and sediment monitoring, with treatment added in the future if degradation of the monitored media warrants it.

The selection of the preferred alternative from those listed above focused on two factors:

1. Based upon a review of available data, identified present health risks, and environmental quality, the additional cost of a groundwater treatment system does not appear to be justified at the present time.

2. Since it appears that soil gas remediation goals can be attained with passive venting coupled with activated carbon treatment, no particular advantage to using the active extraction system is evident.

Alternative 3, the preferred alternative for the B/K parcel, would provide a landfill cap with a passive gas collection and treatment system. Prior to cap placement, landfill material encroaching on the railroad right-of-way and in the northeastern section of the B/K Parcel will be excavated and redeposited in the landfill. These areas and the remaining landfill will then be regraded before the cap and passive gas collection and treatment system are installed. The passive gas collection and treatment system would include 19 interior vents and 18 perimeter vents. The vents will be connected via a manifold system to 12 sets of activated carbon treatment units. The cap and treatment system could be installed in approximately one year

This alternative would eliminate uncontrolled emissions of landfill gases and prevent direct contact with landfill wastes, thereby reducing the public health and environmental risks. This alternative should comply with the provision of 6 NYCRR Part 360 which regulates landfill closure procedures. In addition, surface run-on to the site from an area west of Route 17 would be diverted south out of the site. The estimated present net worth of this alternative is

$8,168,000. The detailed cost breakdown is presented in Appendix A. This includes the capital costs and annual operation and maintenance costs.

With implementation of this preferred alternative, groundwater, surface water, and sediment would be monitored for 30 years Should future conditions warrant it, a groundwater treatment system could be installed at that time. If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after initiation of the selected remedial action.

For the wastes deposited on Georgia Tech Parcel, the proposed remedial activity involves removal of the wastes for redeposition on the B/K Parcel, prior to implementing B/K Alternative 3. It is estimated that Georgia Tech Alternative 2 could be implemented within a year and would have a present net worth of $367,000. The detailed breakdown is presented in Appendix A. The present net worth includes all capital and annual operation and maintenance costs.

1.0 INTRODUCTION AND SITE BACKGROUND INFORMATION

1.1 SCOPE OF WORK

As part of the State of New York's program to remediate hazardous waste sites, the New York State Department of Environmental Conservation (NYSDEC) entered into a contract with Metcalf & Eddy of New York, Inc. (M&E) to undertake a Remedial Investigation and Feasibility Study (RI/FS) for the Tuxedo Waste Disposal Site, aka the Barone/Sacco Dump Site, located in the Town of Tuxedo, Orange County, New York.

The RI/FS project was structured as a multi-task program. The specific tasks listed below focus on the FS activities.

- Task 2 - Scoping the Phased RI/FS. A work plan was submitted to NYSDEC in June 1990. Volume 3 of the Work Plan, Summary Analysis - Potential Remedial Alternatives, identified applicable remedial technologies for the Tuxedo Waste Disposal Site and performed initial screening of these technologies.

- Task 3 - Site Characterization and IRM Activities. This task involved the field work performed in the summer and fall of 1990 and in early 1991. It also included a baseline emission estimate and baseline public health and environmental risk assessments.

- Task 4 - Development of Alternatives. This task involved generation of the First Phase Draft RI/FS report submitted in June 1991. The task included a review of remedial alternatives developed in Task 2 for completeness.

- Task 5 - Preliminary Screening of Alternatives (Second Phase FS).

- Task 7 - Detailed Analysis of Alternatives (Third Phase FS).

- Task 8 - Selection of Remedy.

In addition, seven interim remedial measures (IRMs) to address site security and improve surface drainage were completed.

One objective of Task 4 of the M&E RI/FS scope of work was to determine if the list of potential remedial measures identified in the work plan was complete, and if not, to identify additional candidates. Results of the M&E RI were generally found to be consistent with previous investigations at the site. The remedial technologies identified in the Phase I Feasibility Study were judged to be adequate to address the contamination found.

FS Tasks

The Phase I FS, Development of Remedial Alternatives was done as part of Task 2 and reported in Volume 3 of the Project Work Plan (June 1990). It identified remedial action alternatives which potentially could be applied to the Tuxedo Waste Disposal Site. The remedial alternatives were based on results of previous site investigations mainly the LMS Phase II report, and knowledge of site contamination at the time The Phase I FS included the following steps:

- Identification and characterization of areas and environmental media requiring remediation (based on the results of previous investigations).
- Development of remedial action objectives, specifying the contaminants and media of concern.
- Development of general response actions for each exposure medium.
- Identification of potentially applicable remedial action technologies. Limitations of technologies were indicated, as well as those technologies which were judged infeasible or inapplicable.
- Formulation of potentially applicable remedial action alternatives, consisting of the more promising technologies for each medium of concern.

The purpose of the Phase II FS, Preliminary Screening of Alternatives (Task 5 of the Project Work Plan), was to evaluate each potentially applicable alternative on the basis of effectiveness and implementability. The screening performed in

Task 5 was done in accordance with the NYSDEC TAGM on "Selection of Remedial Actions at Inactive Hazardous Waste Sites", according to the following agenda:

1. The alternatives which passed the initial screening with respect to their potential to achieve state standards and guidance values and other clean-up objectives identified in Tasks 2 and 4 were reviewed.

2. A literature review was performed to identify data on treatment technologies. The list of preliminary alternatives identified in Task 2 was screened and narrowed.

3. The feasibility and costs of moving the wastes deposited on the Georgia Tech Parcel to the Barone/Khourouzian Parcel, as well as complete or partial removal of wastes from both properties, were evaluated.

4. A public information meeting was held to present and procure comment on the preliminary alternatives.

The purpose of the Phase III FS, the detailed evaluation of alternatives, is to present the assessment results so that the agencies responsible for selecting the cleanup alternative have sufficient information to compare the alternatives and select an appropriate remedy. The alternatives developed and described in Phase II, Preliminary Screening of Alternatives, are further refined and analyzed according to eight criteria. These criteria are:

Threshold Criteria

- Overall protection of human health and the environment
- ARARs compliance

Balancing Criteria

- Short-term effectiveness
- Long term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Implementability
- Cost

Modifying Criterion

- Community acceptance

Alternatives are compared according to the above criteria. Uncertainties regarding alternative designs are identified, discussed, and summarized in the comparison of alternatives. Additional data needs are described for each alternative.

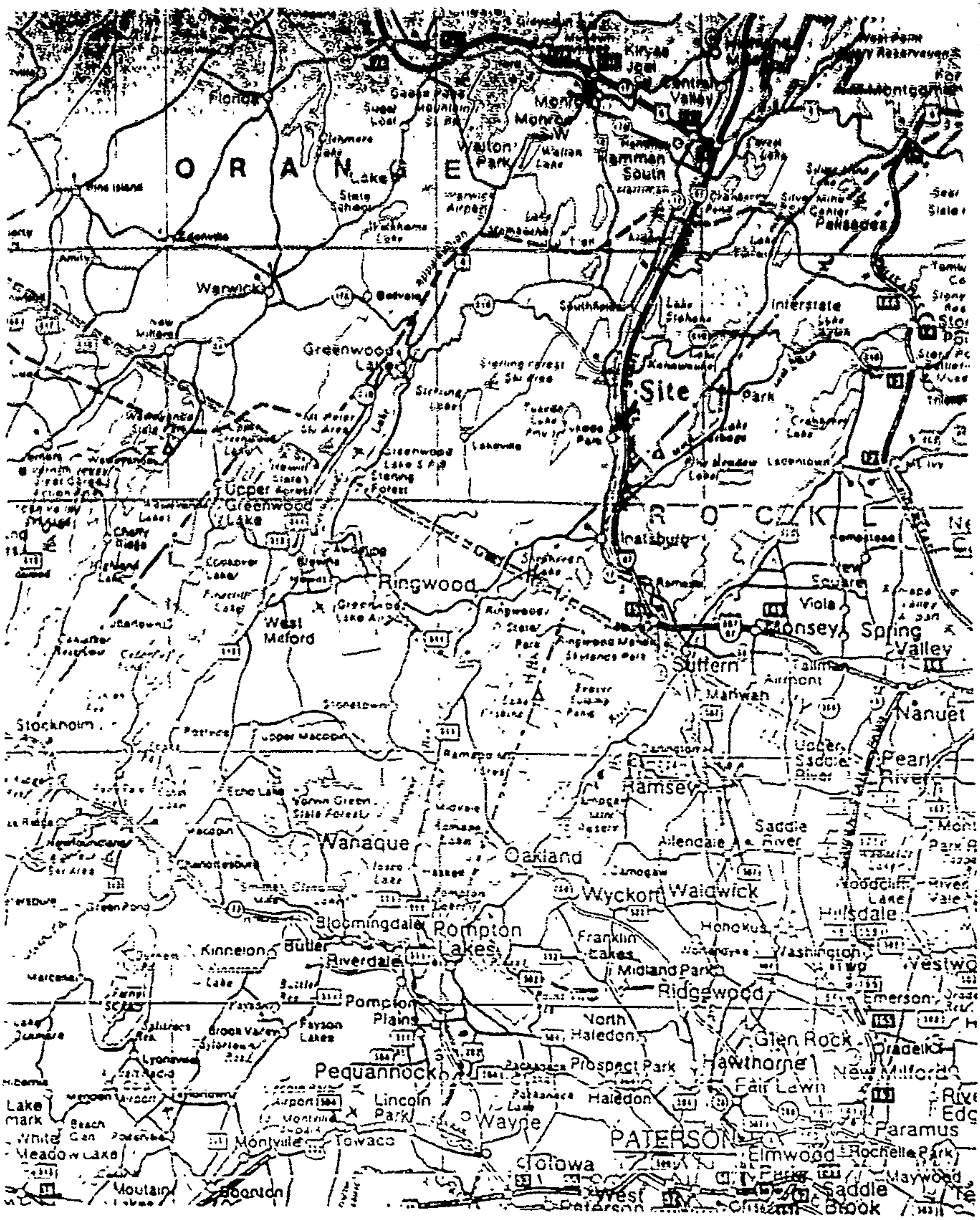
1.2 SITE BACKGROUND

Background information, summarized briefly in this section, is provided in more detail in the Remedial Investigation report, Volume 1 of this RI/FS. The Tuxedo Waste Disposal Site is a 12+ acre landfill located in the Town of Tuxedo, Orange County, New York (see Figure 1-1, Regional Location Map). As shown in Figure 1-2, the site is located along Route 17 within 200 feet of the Ramapo River (Latitude 41° 12' 36" N, Longitude 74° 11' 02" W). The site is located in the southeastern part of the county, close to the Rockland County border and approximately 4.5 miles from the New Jersey State border.

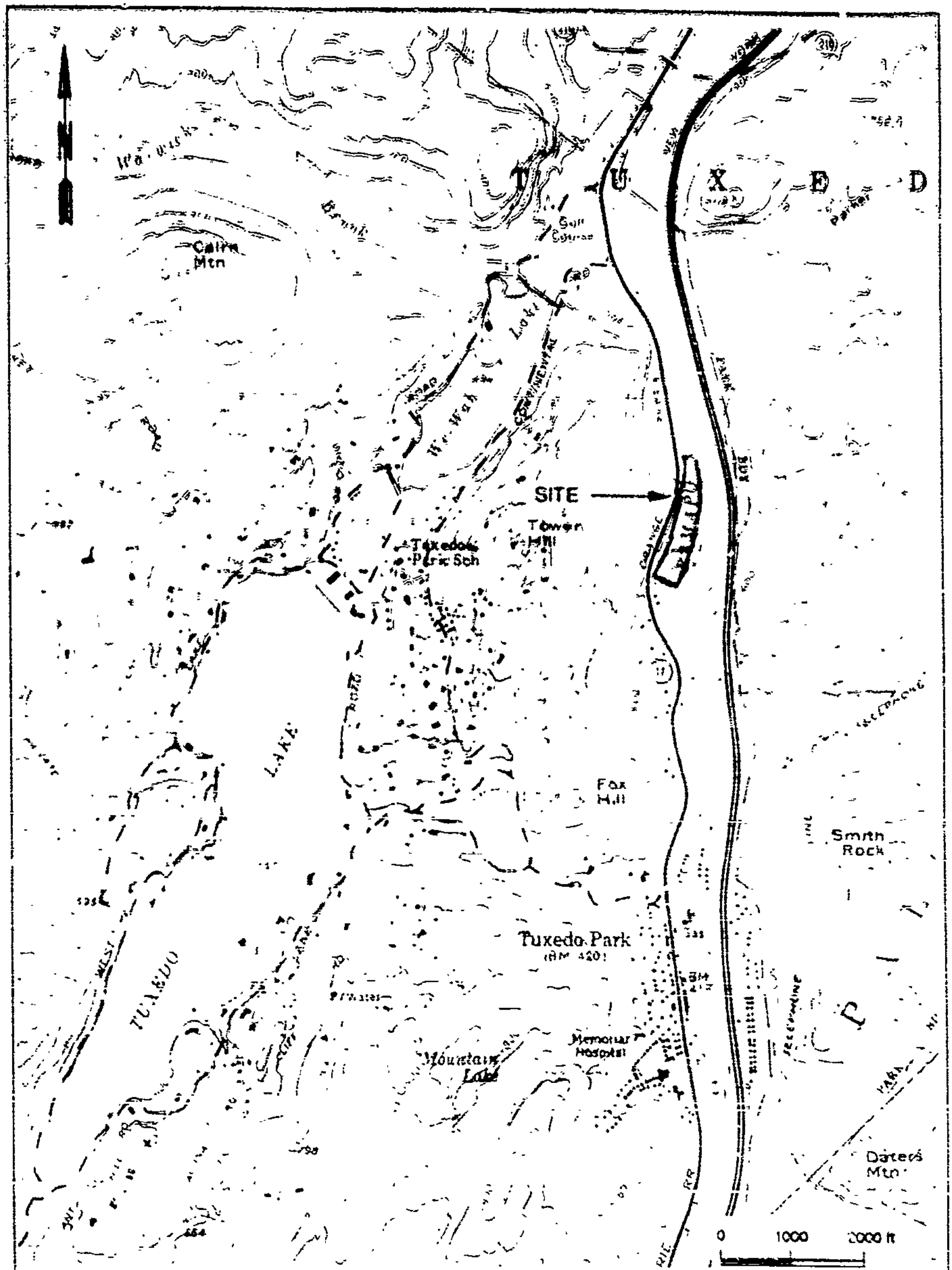
The site is privately owned and is also known as the Barone/Sacco Dump Site. It includes two parcels of land, which are identified according to their current owners. The main portion of the site is the Barone Khourouzian parcel and the parcel adjacent to it is the Georgia Tech parcel. The site is a landfill that operated during the period from February to October 1987. Although it was to be operated as a construction and demolition landfill, it has received hazardous waste. In addition, the site is known to be the source of odor problems that have resulted in citizen complaints. Prior to its use as a landfill, the site was an abandoned sand and gravel quarry.

Topography in the region forms characteristic narrow parallel ridges trending northeast-southwest. The Ramapo River flows from north to south through the study area. The surface drainage and topographic regimes east and west of the river provide natural positive flow to the Ramapo River through various drainage tributaries. Within the study area the Ramapo River is classified by New York State as a Class A surface water body.

The 1990 Census lists the population of the Town of Tuxedo as 3,023 people, distributed over an area of 47.5 sq. miles. Some residential/commercial



M&E Metcalf & Eddy	TUXEDO WASTE DISPOSAL SITE ORANGE COUNTY, NEW YORK	FIGURE 1-1 REGIONAL LOCATION MAP



Metcalf & Eddy of New York, Inc.

TUXEDO WASTE DISPOSAL SITE
ORANGE COUNTY, NEW YORK

FIGURE 1-2
SITE LOCATION MAP

establishments are located within 1/4 mile of the site. These include the Duck Cedar Inn and antique shops immediately north of the site, a property owned by Georgia Tech immediately south of the site, and a residential community along Stevens Lane approximately 1/4 mile southwest of the landfill.

The Village of Tuxedo Park is one-half mile west of the site. According to 1990 Census figures, Tuxedo Park has a population of 706 distributed over a 2.7 square mile area.

Other concentrations of development are at least one mile from the site. Approximately one mile south of the site is the Town of Tuxedo central business district. Laurel Ridge and Clinton Woods are communities within the Town of Tuxedo approximately two miles directly northwest of the landfill. The nearest residential community to the north is Southfields, a locality approximately 2¼ miles from the site within the Town of Tuxedo. Harriman State Park encompasses areas east of the site. Visitors to the park would likely be at least one-half mile from the site. The nearest current residences to the east are at least two miles away.

The site lies between two north-south roadways: 1) Route 17, a 4-lane state highway bordering the site on the west; and 2) NYS Thruway (I-87), a 6-lane state highway passing approximately 500 feet east of the site. In addition, an active railroad exists between the site and the Ramapo River.

2.0 IDENTIFICATION OF POTENTIAL REMEDIAL ACTION ALTERNATIVES INITIAL SCREENING

2.1 INTRODUCTION

Identification of Potential Action Alternatives and Initial Screening of Technologies was performed during Task 2 at the inception of the project. The results were reported in Volume 3 of the Work Plan, Summary Analysis-Potential Remedial Alternatives. Pertinent material from that document is included here in an updated format reflecting present knowledge of the site.

The identification of Potential Remedial Action Alternatives - Initial Screening was based on prior site investigations, mainly the Phase II report by Lawler, Matusky, and Skelly (LMS). These earlier studies found the presence of the following contaminants at the Tuxedo Waste Disposal:

Hydrogen Sulfide Gas
Heavy Metals
Volatile Organic Compounds
Semi-Volatile Organic Compounds

Identification of Potential Remedial Action Alternatives - Initial Screening consisted of five steps:

1. Development of remedial action objectives
2. Development of general response actions (GRAs) for each media of interest
3. Identification of volumes or areas of media to which general response actions may be applied
4. Identification and initial screening of technologies to eliminate those not technically feasible
5. Assemblage of the selected representative technologies into appropriate alternatives

The following subsections elaborate on the five steps and present the results of implementation of these steps for the Tuxedo Waste Disposal Site

2.2 DEVELOP REMEDIAL ACTION OBJECTIVES

Defining remedial action objectives included defining the contaminants, the media of interest, pathways of exposure, and remediation goals for the particular site. The objectives were based on contaminant-specific SCGs

Table 2-1 lists the media of concern and representative contaminants identified in the media for the site. This table is an updated version of the one appearing in Volume 3 of the Work Plan. The highest priority was directed to elimination of potential hazards to known human receptors off-site. A secondary objective was to protect the ecosystem. The initial remedial objectives were designed to prevent:

- Significant hazards both on- and off-site to human populations
- Contamination of off-site drinking water supplies
- Significant hazards both on- and off-site to fish and wildlife

Specifically, the initial remedial action objectives could be described as:

- Protecting the surface and groundwater from contamination at the site which would adversely affect their uses
- Eliminating the odor nuisance emanating from the site
- Protecting the ecosystems at the site and potentially impacted by the site

2.3 DEVELOP GENERAL RESPONSE ACTIONS (GRAs)

GRAs were developed for each medium of interest to satisfy the remedial action objectives for the site. These represented general concepts which are implemented by specific technologies as developed in a subsequent step. Table 2-2 lists GRAs for the Tuxedo Waste Disposal Site in an updated version. Although the actions are listed for specific media, the contamination in the

TABLE 2-1

MEDIA AND CONTAMINANTS OF CONCERN
TUXEDO WASTE DISPOSAL SITE

Contaminants of Concern	Media				
	Air/ Soil Gas	Soil	Groundwater	Surface Water	Surface Water Sediment
Hydrogen Sulfide	X				
Methane	X				
Volatile Organic Compounds	X	X	X		
Semi-Volatile Organic Compounds		X	X	X	X
Metals		X	X	X	X
PCBs		X			

Volatile Organic Compounds:

Toluene
Trichloroethylene
Carbon tetrachloride*
1-2 dichloroethane
Xylene
Benzene
Ethyl benzene
Freon 113
Chloroform

Semi-Volatile Organic Compounds:

Fluoranthene
Pyrene*
Chrysene
Phenols
Naphthalene
2-methylnaphthalene
Acenapthene
Dibenzofuran
Fluorene
Phenanthrene
Bis (2-ethylhexyl)phthalate
Benzo(a) anthracene
Benzo(b) fluoranthene
Benzo(a) pyrene

Metals:

Aluminum
Arsenic
Cadmium
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Sodium
Selenium*
Silver
Zinc

* Listed based on prior investigations. The M&E Remedial Investigation did not find contaminant at levels of concern.

TABLE 2-2

GENERAL RESPONSE ACTIONS (GRAs)

TYPE OF GRA	MEDIA: AIR	MEDIA: GROUNDWATER	MEDIA: SURFACE WATER	MEDIA: SURFACE WATER SEDIMENT	MEDIA: SOIL & FILL MATERIAL
NO ACTION	No Action	No Action	No Action	No Action	No Action
INSTITUTIONAL	Institutional constraints	Alternate water supply or treat water supply	Institutional constraints Alternate water supply or treat water supply	Institutional constraints	Institutional constraints
DESTRUCTION	Active gas control with exhaust incineration			Removal with incineration	Removal with incineration
SEPARATION/ TREATMENT	Active perimeter gas control Active interior gas control Gas treatment	Collection with treatment	Collection with treatment	Removal and treatment	Removal for treatment
STABILIZATION/ SOLIDIFICATION CHEMICAL FIXATION	Source stabilization on-site	Source stabilization on-site	Source stabilization on-site	Source stabilization on-site	Source stabilization on-site
CONTROL/ ISOLATION	Passive gas control Source removal	Containment Collection with off-site disposal Source removal	Leachate confinement Source removal	Cover Removal and disposal Source removal	Cover Removal for off-site disposal

various media are interrelated For example, contaminants in the landfill affect the groundwater, which is in hydraulic connection with the surface water (Ramapo River); similarly, contaminants in the soil can volatilize and affect ambient air via soil gases. Also, river water contamination affects and is affected by sediment

2.4 IDENTIFY VOLUMES AND AREAS OF MEDIA.

Specific site areas or volumes that were proposed targets for the GRAs are listed in Table 2-3 as extracted from Volume 3 of the Project Work Plan and modified to reflect present knowledge of site conditions. The entire site has the potential for affecting air quality Although field test work did identify hot-spot areas of highest gas generation and VOC contamination, no particular areas can be distinguished as a remediation target, based on existing data, other than the entire fill area.

2.5 IDENTIFICATION AND INITIAL SCREENING OF TECHNOLOGIES.

This process identified and screened specific types and classes of technologies which might be employed to implement the general response actions targeted for the Tuxedo Waste Disposal Site. Relevant technologies for each environmental medium and GRA are presented in Table 2-4 For the purposes of initial screening, Table 2-4 indicates whether specific technologies are likely to effect compliance with SCGs, based on the knowledge of the site conditions at the time. Technological feasibility and limitations for the technologies were also identified.

As with their respective GRAs, certain technologies may affect more than one environmental medium. For example, removing contaminated soil and fill wastes would eliminate the source of landfill air emissions, groundwater contamination, and surface water (Ramapo River) contamination. It would also have a positive impact on river surface water sediment by eliminating releases of site contaminated groundwater to the Ramapo River. On the other hand, the excavation activities during this source removal could have significant short-term impacts on workers at the site, the ecology, and the surrounding community. Remedial

TABLE 2-3

AFFECTED VOLUMES/AREAS

MEDIUM	AFFECTED VOLUME/AREAS
Air	Entire site and surrounding areas [1]
Groundwater	East side of site (downgradient)
Surface Water[2]	Ramapo River[3]
Surface Water Sediment	Ramapo River bed and banks
Surface Soil (and Fill)	Entire B/K Parcel - 480,000 cu. yds.[4]

Notes:

(1) For the extent of possible off-site effects, see Chapter 7 of the Remedial Investigation and Feasibility Study, Volume 1: Remedial Investigation, October 1991

(2) The Ramapo River is not targeted as a medium for direct treatment.

(3) At the present time, the quality of river water has not been significantly affected. However, actions taken on other site media may impact the river system, particularly with respect to possible future contamination effects.

(4) This does not include waste materials deposited on the eastern side of Georgia Tech Parcel, which are discussed separately.

TABLE 2-4

IDENTIFICATION AND INITIAL SCREENING OF TECHNOLOGIES

Medium	Remedial Action	Technologies	Not Feasible or May Not Attain Objectives	Attainment of SCGs	Technical Feasibility and Limitations
Air (and Soil Gas)	No Action	Monitoring	X	Will Not Attain Off-Site Objectives	
	Institutional Constraints	Population Relocation	X		Not Feasible
		Limit Access to Site	X	Will Not Attain Off-Site Objectives	
	Passive Gas Control	Perimeter Trenches/Wells		Should Attain Off-Site Objectives	
		Interior, Wells W/WO Treatment		Should Reduce H_2S Releases	Questionable Effectiveness
	Active Perimeter Gas Control	Surface Capping + Gas Extraction Wells + Gas Collection + Treatment (Listed Below)		Should Reduce H_2S Releases to Acceptable Levels	Some Releases of Soil Gases Possible. Landfill Fire Issue If Not Handled Properly
	Active Interior Gas Control	W/WO Surface Capping + Gas Extraction Wells + Gas Collection + Treatment (Listed Below)		Will Attain Objectives	Potential Hazards Installing Gas Wells Landfill Fire Issue If Not Handled Properly
	Gas Treatment	Carbon Adsorption		Will Attain Objectives For Organic Contaminants and H_2S	Regeneration Will Re-Release Contaminants; Requires Post Treatment
		Scrubbing		Will Attain Objectives	May Require Sophisticated Scrubber System
		Thermal Destruction, Flare/Afterburner		Will Attain Objectives	Oxidation of H_2S Will Generate SO_2; May Require Additional Controls

* Landfill Wastes

TABLE 2-4 (continued)

IDENTIFICATION AND INITIAL SCREENING OF TECHNOLOGIES

Medium	Remedial Action	Technologies	Not Feasible or May Not Attain Objectives	Attainments of SCGs	Technical Feasibility and Limitations
Air (and Soil Gas) (Continued)	Gas Treatment (Continued)	Catalytic Oxidation	X	Should Attain Objectives	Oxidation of H_2S Will Generate SO_2; May Require Additional Controls; Catalytic Systems May Not Be Effective with Gases of Varying Composition and Concentration. Sulfur is a Poison for Certain Catalysts
	Source* Removal	Excavation of Fill in Whole or Part W/WO Treatment: Incineration, Chemical Treatment, Disposal		Will Attain Objectives in Various Media	Need Suitable Disposal Site; May Involve Very Large Volumes to be Transported. Complex Technical Undertaking Which May Induce Adverse Environmental Impacts On and Off-Site
	Source* Stabilization: In Situ	Vitrification	X	May Attain Objectives	May Not Be Feasible Requires Pilot Testing Demonstration
	On-Site	Solidification		Should Attain Objectives	
	Source* Treatment	Extraction	X	May Attain Objectives	May Not Be Feasible Requires Pilot Testing Demonstration
	In Situ	Thermal Stripping	X	May Attain Objectives	May Not Be Feasible Requires Pilot Testing Demonstration
		Biological Treatment	X	May Attain Objectives	May Not Be Feasible Requires Pilot Testing Demonstration
	Enhanced Decomposition With Collection and Treatment	Active Ventilation	X	May Attain Limited Objectives	May Not Be Feasible Requires Pilot Testing Demonstration
		Active Ventilation + Biological Treatment	X	May Attain Objectives	May Not Be Feasible Requires Pilot Testing Demonstration
Groundwater	No Action	Monitoring	X	Will Not Attain Objectives	
	Alternate Water Supply or Treat Water Supply	Physical-Chemical Air Stripping Carbon Adsorption	X	Will Not Attain Objectives for River Ecosystem	

* Landfill Wastes

TABLE 2-4 (continued)

IDENTIFICATION AND INITIAL SCREENING OF TECHNOLOGIES

Medium	Remedial Action	Technologies	Not Feasible or May Not Attain Objectives	Attainment of SCGs	Technical Feasibility and Limitations
Groundwater (Continued)	Containment	Upgradient Barrier (Influx)		Will Not Attain Objectives by Itself	To Be Used In Conjunction With Other Actions
		Downgradient Barrier		Will Not Attain Objectives by Itself	To Be Used In Conjunction With Other Actions
		Surface Capping		Will Not Attain Objectives by Itself	To Be Used In Conjunction With Other Actions
		Stormflow Diversion		Will Not Attain Objectives by Itself	To Be Used In Conjunction With Other Actions
		Upgradient Recharge		Should Attain Objectives Off Site	Most Effective When Used In Conjunction With Other Actions
	Collection With Off-Site Disposal	Pumping (Wells)		Should Attain Objectives Off Site	Most Effective When Used In Conjunction With Other Actions
		Disposal to POTW		May Not Meet Pretreatment Standards for POTW	
	Collection With Treatment and Disposal	Pumping (Wells)		Should Attain Objectives with Treatment	
		Treatment: Air Stripping		Will Attain Objectives For VOCs	
		Treatment: Carbon Adsorption		Will Attain Objectives For Organic Compounds	
		Treatment: Biological Treatment	X	Should Attain Objectives For Organic Compounds	Difficult to Operate on Variable Chemical Species and Concentrations With Low Nutrient Levels
		Physical/Chemical Treatment-Chemical Precipitation		Will Attain Objectives For Metals	Other Treatment Required For Organic Compounds
		Ion Exchange Treatment		Will Attain Objectives For Metals	Probably Not Feasible With Type of Waste

* Landfill Wastes

TABLE 2-4 (continued)

IDENTIFICATION AND INITIAL SCREENING OF TECHNOLOGIES

Medium	Remedial Action	Technologies	Not Feasible or May Not Attain Objectives	Attainment of SCGs	Technical Feasibility and Limitations
Groundwater (Continued)	Collection With Treatment and Disposal (Continued)	Disposal of Treated Water: To POTW To Ramapo River Recharge to Groundwater			
	Source* Removal	Excavation of Fill in Whole or Part W/WO Treatment: Incineration, Chemical Treatment, Disposal		Will Attain Objectives in Various Media	Need Suitable Disposal Site; May Involve Very Large Volumes to be Transported Complex Technical Undertaking Which May Induce Adverse Environmental Impacts On- and Off-Site
	Source* Stabilization				
	In Situ	Vitrification	X	May Attain Objectives	May Not Be Feasible Requires Pilot Testing Demonstration
	On-Site	Solidification		Should Attain Objectives	
	Source* Treatment In Situ	Extraction	X	May Attain Objectives	May Not Be Feasible Requires Pilot Testing Demonstration
		Thermal Stripping	X	May Attain Objectives	May Not Be Feasible Requires Pilot Testing Demonstration
		Biological Treatment	X	May Attain Objectives	May Not Be Feasible Requires Pilot Testing Demonstration
Surface Water	No Action	Monitoring	X	May Not Attain Objectives	
	Alternate Water Supply (or Treat Supply)	Physical Chemical Air Stripping Carbon Adsorption			
	Institutional Constraints	Restrict Access	X		Not likely to be Acceptable

* Landfill Wastes

TABLE 2-4 (continued)

IDENTIFICATION AND INITIAL SCREENING OF TECHNOLOGIES

Medium	Remedial Action	Technologies	Not Feasible or May Not Attain Objectives	Attainment of SCGs	Technical Feasibility and Limitations
Surface Water (Continued)	Collect With Treatment	Dam + Treatment: Air Stripping Carbon Adsorption Biological Treatment Physical Chemical Treatment Ion Exchange	X		Not Feasible to Implement on Broad Scale. Water Used For Drinking Could be Treated
	Source* Removal	Excavation of Fill in Whole or Part W/WO Treatment: Incineration, Chemical Treatment, Disposal		Will Attain Objectives in Various Media	Need Suitable Disposal Site. May Involve Very Large Volumes to be Transported. Complex Technical Undertaking Which May Induce Adverse Environmental Impacts On and Off Site
		Remove River Sediment			
	Source* Stabilization In Situ	Vitrification	X	May Attain Objectives	May Not Be Feasible Requires Pilot Testing Demonstration
	On Site	Solidification		Should Attain Objectives	
	Stabilize River Sediment				
	Source* Treatment In Situ	Extraction	X	May Obtain Objectives	May Not Be Feasible Requires Pilot Testing Demonstration
		Thermal Stripping	X	May Obtain Objectives	May Not Be Feasible Requires Pilot Testing Demonstration
		Biological Treatment	X	May Obtain Objectives	May Not Be Feasible Requires Pilot Testing Demonstration
	Leachate Confinement	See Groundwater Section			

* Landfill Wastes

TABLE 2-4 (continued)

IDENTIFICATION AND INITIAL SCREENING OF TECHNOLOGIES

Medium	Remedial Action	Technologies	Not Feasible Or May Not Attain Objectives	Attainment of SCGs	Technical Feasibility and Limitations
Surface Water Sediment	No Action	Monitoring	X	May Not Attain Objectives	
	Removal	Excavation (Dredging) For Disposal, On-Site or Off-Site		Will Attain Objectives With Treatment	During Operation May Release Contaminants to Surface Water (Ramapo River)
	Removal and Treatment	Excavation (Dredging)		Will Attain Objectives	During Operation May Release Contaminants to Surface Water (Ramapo River)
		Treatment: Incineration		Should Attain Objectives for Organic Compounds	
		~~Extraction and Flushing~~		Should Attain Objectives for Organic Compounds and Metals	
		Solidification		Should Attain Objectives	
	Source* Removal	Excavation of Fill in Whole or Part W/WO Treatment: Incineration, Chemical Treatment, Disposal		Will Attain Objectives in Various Media	Need Suitable Disposal Site. May Involve Very Large Volumes to be Transported, Complex Technical Undertaking Which May Induce Adverse Environmental Impacts On- and Off-Site
	Source* Stabilization				
	In Situ	Vitrification	X	May Attain Objectives	May Not Be Feasible Requires Pilot Testing Demonstration
	On Site	Solidification		Should Attain Objectives	
	Source* Treatment In Situ	Extraction	X	May Attain Objectives	May Not Be Feasible Requires Pilot Testing Demonstration
		Thermal Stripping	X	May Attain Objectives	May Not Be Feasible Requires Pilot Testing Demonstration
		Biological Treatment	X	May Attain Objectives	May Not Be Feasible Requires Pilot Testing Demonstration

* Landfill Wastes

TABLE 2-4 (continued)

IDENTIFICATION AND INITIAL SCREENING OF TECHNOLOGIES

Medium	Remedial Action	Technologies	Not Feasible Or May Not Attain Objectives	Attainment of SCGs	Technical Feasibility and Limitations
Surface Soil (and Fill)	No Action	Monitoring	X	Will Not Attain Objectives	
	Institutional Constraints	Restrict Access	X	May Not Attain Objectives Regarding Ecosystem	
	Remove For Off-Site Disposal	Excavate in Whole or Part W/WO Treatment: Incineration Chemical Treatment		Will Attain Objectives	Complex Technical Undertaking Which May Induce Adverse Environmental Impacts On and Off Site
	Removal For Treatment	Excavate in Whole or Part * Treatment: ~~On-Site Incineration~~		Will Attain Objectives For Organic Compounds	Will Require Additional Treatment for Metals
		Off-Site Incineration		Will Attain Objectives For Organic Compounds	
		On Site Extraction/Flushing (Chemical Treatment)		Should Attain Objectives	Will Require Additional Treatment for Metals
	In Situ Treatment	Solvent Extraction	X	May Attain Objectives	May Not be Practical With Type of Fill
		Thermal Stripping	X	May Attain Objectives for Organics	May Not be Practical With Type of Fill
		Biological Treatment W/WO Active Ventilation	X	May Attain Objectives for Organics	May Not be Practical With Type of Fill
	Stabilization In Situ	Vitrification	X	May Attain Objectives	May Not Be Feasible - Requires Pilot Testing Demonstration
	On-Site	Solidification		Should Attain Objectives	Requires Pilot Testing Demonstration

* Landfill Wastes

actions for Ramapo River surface water sediments, as another example, could cause contaminant release to the surface waters during sediment excavation.
Some remediation alternatives included the supplemental treatment of drinking water supplies. This would be necessary if off-site drinking water wells, for example, were affected by site contamination.

2.6 COMBINATIONS OF APPROPRIATE ALTERNATIVES

In this step, selected representative technologies were assembled into appropriate alternatives, which are shown in Table 2-5. The table is divided into three categories which represent technology classes:

- A. Groundwater containment with soil gas treatment
- B Groundwater containment with treatment and soil gas treatment
- C Source removal or stabilization

Source removal or stabilization (part C) is subdivided into two subcategories:

- C.1 Off-site Removal (Without Treatment)
- C.2 Treatment

The Treatment subcategory is subdivided into technologies suitable for off-site or on-site disposal.

Vertical columns in Table 2-5 list specific alternate technologies applicable to a given medium. A composite treatment process is derived by selecting a technology from each column, moving across the page from left to right. Within technology classes, as grouped between the horizontal lines, a sequence of processing steps can be constructed by this method. When the alternates were proposed, some uncertainty existed regarding whether specific treatment steps would be required. This is also indicated in the table.

The three categories of Remedial Alternatives represent different conceptual approaches to site remediation. Groups A and B both address problems at the site through soil gas treatment and groundwater containment. However, Group B

TABLE 2.5 COMBINATIONS OF APPROPRIATE ALTERNATIVES

COMBINATION	MEDIA: AIR / SOIL GAS	GROUNDWATER	SURFACE WATER	SURFACE WATER SEDIMENT	SOIL (& FILL)
A. GROUND WATER CONTAINMENT WITH SOIL-GAS TREATMENT	PERIMETER GAS CONTROL GAS SCRUBBING THERMAL INCINERATION SO2 CONTROL (AS REQ'D) INTERIOR GAS CONTROL CARBON ADSORPTION THERMAL INCINERATION SO2 CONTROL (AS REQ'D)	EXTRACTION AT EAST BOUNDARY WITH RECHARGE UPGRADIENT EXTRACTION AT LIMITED SECTIONS OF EAST BOUNDARY WITH RECHARGE UPGRADIENT SLURRY WALL BARRIER ENTIRE EAST BOUNDARY OR PART THEREOF GROUND WATER BARRIER UPGRADIENT ON PROPERTY AND DIVERSION OF SURFACE WATER FLOW ONTO SITE (IF FEASIBLE) TREATMENT OF WATER SUPPLY (IF REQ'D)	TREATMENT OF WATER SUPPLY (IF REQ'D)	DREDGING AND REMOVAL (IF REQ'D)	CAPPING IN WHOLE OR PART
B. GROUNDWATER CONTAINMENT WITH TREATMENT AND SOIL-GAS TREATMENT	PERIMETER GAS CONTROL GAS SCRUBBING THERMAL INCINERATION SO2 CONTROL (AS REQ'D) ACTIVE INTERIOR GAS CONTROL CARBON ADSORPTION THERMAL INCINERATION SO2 CONTROL (AS REQ'D)	EXTRACTION AT EAST BOUNDARY EXTRACTION AT LIMITED SECTIONS OF EAST BOUNDARY SLURRY WALL BARRIER ENTIRE EAST BOUNDARY OR PART THEREOF GROUND-WATER BARRIER UPGRADIENT ON PROPERTY AND DIVERSION OF SURFACE WATER FLOW ONTO SITE (IF FEASIBLE) AIR STRIPPING CARBON ADSORPTION CHEMICAL PRECIPITATION RECHARGE TO GROUND-WATER DISCHARGE TO RIVER		DREDGING AND REMOVAL (IF REQ'D)	CAPPING IN WHOLE OR PART

TABLE 2-5 COMBINATIONS OF APPROPRIATE ALTERNATIVES (CONT'D)

COMBINATION		MEDIA: AIR/ SOIL GAS	MEDIA: GROUND WATER	MEDIA: SURFACE WATER	MEDIA: SURFACE WATER SEDIMENTS	MEDIA: SOIL (& FILL)		
C. SOURCE REMOVAL OR STABILIZATION	C 1 OFF SITE REMOVAL (WITHOUT TREATMENT)				DREDGING AND REMOVAL (IF REQ'D)	FILL EXCAVATION IN WHOLE OR PART (HOT SPOTS)	DISPOSAL (OFF SITE) AT RCRA LANDFILL	
	C 2 TREATMENT				DREDGING AND REMOVAL (IF REQ'D)	FILL EXCAVATION IN WHOLE OR PART (HOT SPOTS) FOR TREATMENT	OFF SITE INCINERATION ON SITE INCINERATION	DISPOSAL (OFF-SITE)
					DREDGING AND REMOVAL (IF REQ'D)	FILL EXCAVATION IN WHOLE OR PART (HOT SPOTS) FOR TREATMENT	INCINERATION ON-SITE CHEMICAL EXTRACTION OF METALS SOLIDIFICATION ON-SITE	DISPOSAL ON SITE

provides for treatment of groundwater prior to disposal. Group C addresses problems at the site by treating the contaminated soils and fill wastes. Of the three remedial action alternatives shown in Table 2-5, Group C, Source Removal or Stabilization, is the most site intrusive set of activities. Such activities present the highest potential for short-term contaminant exposures and for fire.

3.0 REASSESSMENT OF REMEDIAL OBJECTIVES

3.1 MEDIA AND CONTAMINANTS OF CONCERN

The contaminants of concern in each media, identified from the M&E Remedial Investigation and previous investigations, are summarized in Table 2-1. The listed compounds include contaminants found in all media, any given medium may contain some or all of the materials listed. Hydrogen sulfide, methane, and volatile organic compounds (VOCs) are contaminants of concern in air. VOCs are also contaminants of concern in soil and groundwater. Metals and semi-volatile organic compounds are contaminants of concern in soil, groundwater, surface water, and sediment.

3.2 EXPOSURE PATHWAYS

Exposure pathways are discussed in Section 6.0, Contaminant Fate and Transport, and are summarized in Section 9.0, Remedial Investigation Summary, of Volume I: Remedial Investigation, October 1991. The following excerpts were taken from that report.

3.2.1 Soil Gas/Ambient Air

Air contaminant transport was addressed by modeling ambient air concentrations of contaminants at various distances from the site. Modeled concentrations presented in Section 7.0 of the M&E RI are for the minimum modeled distance from the source, 100 meters. Concentrations diminish with distance from the site and follow prevailing wind directions. The immediate topography of this area influences wind direction into a NW-S pattern.

Long-term off-site concentrations were modeled for calculated average and worst-case landfill gas emission scenarios. Soil gas contaminants examined included 1,2-dichloroethylene, trichloroethylene, tetrachloroethylene, benzene, toluene, ethylbenzene, xylenes, 1,1,1-trichloroethane, styrene, freon (113), 1,1-dichloroethylene, methylene chloride, vinyl chloride and hydrogen sulfide. The results indicate that no current or proposed State guidelines or standards would be exceeded for average or maximum emission scenarios (long-term basis) for the individual contaminants evaluated.

Estimated maximum and average hydrogen sulfide emissions were also modeled for one-hour (short-term) exposure scenarios. The maximum predicted hydrogen sulfide concentration exceeds the 1-hour NYS standard (0.01 ppm). Hydrogen sulfide releases have resulted in an odor nuisance at the site and surrounding areas in the past, and modeled H_2S releases are consistent with these observations.

3.2.2 Groundwater

Groundwater is a pathway for contaminant transport into the Ramapo River. Groundwater in the site's overburden deposits is contaminated with metals and organics, as detected in monitoring wells. At the site, the groundwater gradients and conductivities in the overburden deposits enhance contaminant migration. As discussed in Section 4.0 of the RI, the primary component of groundwater flow is horizontal towards the Ramapo River.

3.2.3 Surface Water and Sediments

The Ramapo River is the only surface water affected by contaminant migration from the landfill. The migration and discharge of contaminated groundwater to the river is evidenced by the elevated levels of certain metals in the river water, as well as elevated levels of metals and semi-volatile organic compounds detected in river sediment samples collected along the banks at mid-site and downstream sampling locations. During field activities, leachate seep appeared to be emanating from the landfill site near the river bank, and the river water and sediment samples obtained near this apparent seep contained elevated levels of contaminants. Although background and upstream sources of some contaminants may be contributing factors, the mid-site levels are indicative of contamination migration from the landfill.

Contaminants in the river water sediments can become disturbed during periods of high flow, high velocity conditions, when the contaminated sediment may be entrained, suspended, and transported in the surface water to downstream locations. Sediments contained PAH levels above NYS Guidelines (human health residue basis).

3.2.4 Soils

Emissions of volatile organic soil contaminants were previously discussed in Section 3.2.1. Migration of non-volatile soil contaminants into the air is considered negligible because the landfill is covered with clean soil. However, soil contaminants are a major factor affecting groundwater contamination.

3.3 IDENTIFICATION OF ARARs AND SCGs

This section presents applicable or relevant and appropriate requirements (ARARs) for the Tuxedo Waste Disposal Site based on federal and state regulations. ARARs associated with the Tuxedo Waste Disposal Site are listed in Table 3-1. The ARARs cited refer to specific regulations or classes of regulations related to landfills. For example, 6 NYCRR Part 360 delineates capping requirements for such sites.

The ARARs can be categorized as location-specific, action-specific or chemical (contaminant)-specific. In addition, chemical (contaminant)-specific standards, criteria and guidelines (SCGs) have been identified which address public health and environmental standards that are applicable and appropriate to the Tuxedo Waste Disposal Site. A number of potential federal and New York State standards and guidance values, as well as guidance values from other sources, were considered. The New York State SCGs for groundwater, surface water, sediment, ambient air, and water supply were the primary source for preparation of this FS. The standards and guidance values selected for the various media were originally proposed in Section 7.3 of the draft M&E Phase I RI/FS dated June 1991.

TABLE 3-1

ARARS ASSOCIATED WITH THE TUXEDO WASTE DISPOSAL SITE

Statute, Regulation, or Program	Pertinence	Specificity
CERCLA/NCP/SARA	Applicable to remedial actions taken at CERCLA sites. While the site is not an EPA-designated CERCLA site, applicable regulations will be applied.	• Action-specific
RCRA Subtitle C/HSWA/NY HW Mgmt. Regs.	Applicable to the treatment, storage, transportation and disposal of hazardous wastes and wastes per 40 CFR 260-264 and 6 NYCRR Part 370-373.2. These regulations are applicable to the site's remedial actions. Certain RCRA regulations have been delegated to NYS.	• Action-specific
RCRA Subtitle D/ NY Solid Waste Mgmt. Regs.	Pertains to the management and disposal of solid wastes. The site contains RCRA Subtitle D construction and demolition waste. 6 NYCRR Part 360 is relevant and appropriate. Regulations regarding site closure will be applied. Certain RCRA regulations have been delegated to NYS.	• Action-specific
TSCA	Applicable to disposal of PCB-contaminated items. The bottom layer of the site's cover has low levels of PCB contamination.	• Action-specific • Contaminant-specific
SDWA	Applicable to surface water and area wells which may be utilized for public drinking water. One known private well is in the vicinity of the site. An adjacent water body, the Ramapo River, is a public water supply in New Jersey.	• Contaminant-specific • Action-specific • Location-specific
CAA	Applicable where remedial activities will impact the ambient air quality. Remedial activity options may impact air quality.	• Action-specific • Contaminant-specific

TABLE 3-1 (Continued)

ARARS ASSOCIATED WITH THE TUXEDO WASTE SITE

Statute, Regulation, or Program	Pertinence	Specificity
CWA	Applicable for alternatives involving all treatment with point-source discharges to surface water.	• Action-specific
OSHA	Applicable to workers and the work place throughout implementation of remedial measures.	• Action-specific • Location-specific
Haz. Materials Transportation	Applicable to the off-site transport of hazardous materials.	• Action-specific
Fish & Wildlife Coordination Act	Applicable to fish and wildlife in the vicinity of any proposed remedial actions, particularly on-site.	• Location-specific
NY Water Quality Regulations	Applicable to sources of potable water supply and for alternatives involving treatment with point source discharges to the waters of NY.	• Action-specific
NY Uniform Procedures Act	Applicable to projects needing an SPDES permit and to the construction/operation of hazardous waste treatment facilities. The site will not require a SPDES permit but will need to comply with the substantive requirements thereof.	• ion-specific

Tables 3-2 to 3-5 list SCGs for air quality, groundwater, surface water, and sediment. No soil clean-up guidelines are proposed. Although monitoring off-site groundwater wells was not a part of the M&E RI Phase I field activities, potential effects on such drinking water sources are a consideration. The standards or Maximum Contaminant Levels (MCLs) for drinking water supplies would be those adopted by the New York State Department of Heath (NYSDOH).

3.4 REMEDIAL ACTION OBJECTIVES AND GOALS

Remedial action objectives are site specific goals that address the protection of human health and the environment. These objectives are typically media specific. Establishing remedial action objectives includes considering the chemical contaminants of concern at a site, evaluating exposure pathways and receptors, and presenting acceptable contaminant levels or ranges for each exposure route. For the Tuxedo Waste Disposal Site, the highest priority has been given to elimination of potential hazards to known human [illegible] off-site. A secondary objective is to protect the ecosystem.

Basically, the remedial action objectives can be described as:

- Closing the site in conformance with applicable NYS regulations
- Preventing unacceptable health risks to exposed populations from airborne contaminants
- Eliminating an odor nuisance emanating from the site
- Protecting the surface water from site contamination which would adversely affect its uses
- Protecting the river ecosystem at the site and potentially impacted by the site

Specifically, the remedial objectives are to prevent:

- Significant hazards to off-site human populations;
- Significant hazards to fish and wildlife, both on- and off-site.

TABLE 3-2

STANDARDS AND GUIDANCE VALUES FOR AIR QUALITY
TUXEDO WASTE DISPOSAL SITE

AIR CONTAMINANT	NYSDEC STANDARD OR PROPOSED GUIDELINE ($\mu g/m^3$)
Benzene	- 12 G
1,2-Dichloroethylene	.,800 G
Ethyl benzene	1,036 G
Freon 113	17,905 G
Hydrogen sulfide	13.9 S
Toluene	7,500 G
Trichlorethylene	0.45 G
Xylenes	1,036 G

G - NYSDEC Proposed Guideline (AirGuide-1)
S - NYSDEC 1-Hour Standard (AirGuide-1) - equivalent to 0.01 ppm

Source: New York State Department of Environmental Conservation Division of Air Resources. New York State Air Guide-1: Guidelines for the Control of Toxic Air Contaminants. 1985-1986 Edition; Albany, NY. September 1989 Printing.

TABLE 3-3

STANDARDS AND GUIDANCE VALUES FOR GROUNDWATER
TUXEDO WASTE DISPOSAL SITE

CONTAMINANT	STANDARD OR GUIDANCE VALUE (µg/l)	CONTRACT* LIMITS (µg/l)
Arsenic	25	2/10
Iron	300	20/100
Magnesium	35,000	1,000/5,000
Manganese	300	3/15
Sodium	20,000	1,000/5,000
Cadmium	10	1/5
Lead	25	1/5
Mercury	2	0.1/0.2
Phenols	1	10
Acenaphthene	20	10
Benzene	Not Detectable	5
Naphthalene	10	10
Chloroform	100	5
Chrysene	0.002	10

* Contract Detection Limits from Tables 5-1, 5-2 and 5-3 of M&E's "Remedial Investigation/Feasibility Study, Volume 1: Remedial Investigation," October 1991. Where two values are given, the first is for the LMS Phase II study and the second is for the M&E RI/FS.

Source: NYSDEC Technical and Operational Guidance Series (TOGS) - Ambient Water Quality Standards and Guidance Values.

TABLE 3-4

STANDARDS AND GUIDANCE VALUES FOR SURFACE WATER
TUXEDO WASTE DISPOSAL SITE

METALS	SCG (µg/l)	CONTRACT DETECTION LIMITS (µg/l)
Mercury	0.2	0.2
Silver	0.1*	10
Aluminum	100*	200
Iron	300	100

* Ionic species

Source: Technical and Operational Guidance Series (TOGS) - Ambient Water Quality Standards and Guidance Values.

TABLE 3-5

STANDARDS AND GUIDANCE VALUES FOR SURFACE WATER SEDIMENT
TUXEDO WASTE DISPOSAL SITE

CONTAMINANT	NYS GUIDANCE VALUE (mg/kg)	CONTRACT DETECTION LIMIT (mg/kg)
Cadmium	0.8	5
Copper	19	25
Lead	27	5
Manganese	428	15
Mercury	0.11	0.2
Nickel	22	40
Zinc	85	20
CONTAMINANT	**NYS GUIDANCE VALUE (μg/kg)**	**CONTRACT DETECTION LIMIT (μg/kg)**
Benzo(a)anthracene	15.1	330
Chrysene	15.1	330
Benzo(b)fluoranthene	15.1	330
Benzo(a)pyrene	15.1	330

Source: New York State Department of Environmental Conservation. Sediment Criteria Used as Guidance by the Bureau of Environmental Protection, Division of Fish and Wildlife. Albany, NY. December 1989.

Four media are targeted for consideration in this Feasibility Study. They are:

- Soil Gas/Ambient Air
- Groundwater
- Soil/Fill Waste
- Ramapo River Surface Water Sediment

The Ramapo River surface water is not targeted as a medium for direct treatment since it is not currently significantly degraded in water quality. However actions taken on other media may impact river water quality.

3.4.1 Soil Gas/Ambient Air

The remediation objectives are attain conditions which will not present a significant on-site or off-site risk to health and safety. The proposed off-site goals are to:

- Prevent exceedance of NYSDEC air standards and guidance values
- Reduce adverse health risks to minimum levels for exposures to carcinogens and non-carcinogens from site contaminants.

Remediation goals for possible future uses of the site are to:

- Prevent off-site migration of subsurface gas
- Prevent accumulation of gas in any surface or subsurface structures
- Prevent unacceptable safety risks associated with accumulation of methane, which is a flammable gas

NYS ambient air standards and guidance values are listed in Table 3-2.

3.4.2 Groundwater

The groundwater remediation objective is to control contamination in groundwater and leachate to the Ramapo River system to levels which would not significantly degrade the quality of river water and sediment as discussed below. Table 3-3 shows the applicable NYS SCGs, which could be applied to groundwater.

3.4.3 Ramapo River Surface Water and Sediment

Site remediation objectives and goals are to prevent significant degradation of water quality in the Ramapo River based upon NYSDEC surface water standards and guidelines, as well as NYSDEC sediment guideline values. These values are shown in Tables 3-4 and 3-5.

3.4.4 Fill Waste

The remedial objective with regard to fill waste and soil contamination are to:

- Close the site in compliance with 6 NYCRR Parts 360 and 373.2.
- Mitigate the amount of contamination that is transmitted to air, soil, groundwater, and surface water.

4.0 PRELIMINARY SCREENING OF POTENTIAL REMEDIAL ACTION ALTERNATIVES

4.1 INTRODUCTION

Remedial alternatives for the Tuxedo Waste Disposal Site, developed during Task 2, were based on results of previous investigations performed at the site, mainly the LMS Phase II report. The initial screening was based upon knowledge of site contamination at the time. The Phase II preliminary screening of alternatives, performed in accordance with NYSDEC guidelines, evaluated process alternatives for effectiveness in achieving remedial objectives and for feasibility of implementation at the site. The Phase II screening was based in part, on the results of the M&E Remedial Investigation performed in 1990 and on the results of previous site investigations.

Specific objectives of the preliminary screening included the following steps:

1. The alternatives which passed the initial screening with respect to their potential to achieve state standards and guidance values and other clean-up objectives were reviewed.
2. A literature review was performed to identify data on treatment technologies.
3. The list of preliminary alternatives was screened and narrowed.
4. The feasibility (and cost) of moving the wastes deposited on the Georgia Tech Parcel to the Barone/Khcu[illegible]ian Parcel were evaluated, as well as the feasibility of complete or partial removal of wastes from both properties.
5. The implementability of the short- and long-term effectiveness of the preliminary remedial alternatives was evaluated.

Part of the preliminary screening process involved a reassessment of remedial objectives. This reassessment was performed in consultation with NYSDEC, based on the results of the M&E RI study. The remedial objectives focus on protecting public health and environmental quality. Reassessment of remedial objectives covered the following:

- Media and Contaminants of Concern
- Exposure Pathways
    - Soil Gas/Ambient Air
    - Groundwater
    - Surface Water and Sediments
    - Soils
- Identification of Standards, Criteria, and Guidelines
- Remedial Action: Objectives and Goals
    - Soil Gas/Ambient Air
    - Groundwater
    - Ramapo River and Sediment
    - Fill Waste
    - Reduce risk of subsurface fire

The remedial action goals proposed for the Tuxedo Waste Disposal Site are summarized as follows.

- Ambient Air
    - Prevent exceedance of NYSDEC air standards and guidance values
    - Reduce potential adverse health risks to minimum levels for exposures to carcinogenic and non-carcinogenic site contaminants
    - Provide adequate control of methane releases to reduce potential safety risks associated with accumulation of this flammable gas, consistent with possible future uses of the site.
- Groundwater
    - Control contamination in groundwater and leachate to Ramapo River system to levels which would not significantly degrade the quality of river water and sediment as discussed below

- Ramapo River Surface Water and Sediment
    - Prevent significant degradation of water quality in the Ramapo River based upon:
        - NYSDEC surface water standards and guidelines
        - NYSDEC sediment guideline values
- Fill Waste
    - Reduce risk of subsurface fire
    - Site closure in compliance with 6 NYCRR Parts 360 and 373.

Prior to performing the actual Screening of Alternatives, previously developed General Response Actions and Affected Volumes and Areas were reviewed and modified to reflect present knowledge of site conditions.

The screening analyses, summarized in Tables 4-1 to 4-4, are specific for each medium of concern at the site. Based on present knowledge of site conditions, those treatment alternatives which were judged to be: (1) ineffective for attaining remedial goals and objectives; (2) significantly less effective than other processes for attaining remediation goals and objectives; or (3) infeasible to implement either administratively or because of site conditions, were eliminated from further consideration in the Detailed Analysis of Alternatives. The analyses also cover alternatives for dealing with waste materials deposited on the adjoining Georgia Tech property.

Combinations of appropriate alternatives were selected for further detailed analysis. The No Action Alternative was retained for comparison purposes even though it may not be consistent with stated remediation goals in all cases.

4.2 SOIL GAS REMEDIAL ALTERNATIVES

Available alternatives are No Action, Institutional Actions, and Collection, Treatment, and Discharge. Table 4-1 presents available remedial technologies applicable to landfill gas remediation.

TABLE 4-1

PRELIMINARY SCREENING OF REMEDIAL ALTERNATIVES
FOR LANDFILL AND SOIL GASES

Response Media	General Response Action	Remedial Technology	Process Options	Effectiveness	Implementability
Soil Gas	No Action	None required	Not Applicable	Will not achieve remediation objectives in the short term.	None related to specific GRA
	Institutional Actions	Land use restrictions	Deed restrictions/notices	Effective in restricting potential land use.	Dependent upon legal authority
		Access Restrictions	Fencing	Effective in limiting access to areas of elevated contaminant levels. May not achieve remedial action objectives in the short term.	Readily implementable, however subject to violations and vandalism
		Monitoring	Ambient air monitoring	Effective in documenting conditions. Does not reduce contamination. May not achieve remedial action objectives in the short term.	Readily implemented
	Collection/ Discharge (Passive)	Perimeter	Gas wells/trenches manifold Would meet all of the remedial action objectives if used with properly designed cap	Effective in reducing uncontrollable lateral migration of landfill gases from site boundaries. May not effectively control releases from interior portions without soil cap. Treatment of collected gases may be required. May meet all of the remedial action objectives if used with properly designed cap.	Moderate implementability. Right of way permits may be required. May not comply with closure requirements. Subject to vandalism
		Interior	Gas collection header/manifold system	Effective in preventing the buildup of landfill gases when installed in conjunction with a properly designed cap. May meet all of the remedial action objectives if used with properly designed cap.	Moderate implementability. Installation of interior wells may present potential hazards. Subject to vandalism.
		Discharge	Vent to atmosphere	Effective in releasing gases from the subsurface. May require treatment to attain emission limits. May meet all of the remedial action objectives if used with properly designed cap.	Readily implementable. Would require maintenance and monitoring to assure emission limits are met.
			Treatment	See carbon adsorption below.	

TABLE 4-1 (continued)

PRELIMINARY SCREENING OF REMEDIAL ALTERNATIVES
FOR LANDFILL AND SOIL GASES

Response Media	General Response Action	Remedial Technology	Process Options	Effectiveness	Implementability
Soil Gas Continued	Extraction Discharge (Active)	Perimeter	Gas collection header/manifold system	Effective in controlling the lateral migration of landfill gases. May require soil cap to effectively control releases from interior sections of site. May meet all of the remedial action objectives if used with properly designed cap. Treatment of collected gases may be required to attain emission limits. Increased activity and noise levels at site due to vacuum system.	Moderate implementability. Right of way permits may be required. Requires operation and maintenance of extraction system. Additional effluent monitoring needed. May not comply with closure requirements.
		Interior	Gas collection wells/trenches /header/manifold system	Effective in controlling the release of landfill gas emissions as a single point emission when installed with a properly designed cap. May meet all of the remedial action objectives if used with properly designed cap. May require treatment of collected gases to attain emission limits. Increased activity and noise levels at site due to vacuum system.	Moderate implementability. Installation of interior wells may present potential hazards. Gas venting layer may create additional exposure pathways, resulting in increased VOC emissions, therefore increased operation and maintenance requirements and increased effluent monitoring.
		Discharge	Exhaust to atmosphere	Effective in the active removal of landfill gases from beneath the surface. May meet all of the remedial action objectives if used with properly designed cap. May require treatment to attain emission limits. Increased activity due to vacuum system maintenance and monitoring.	Readily implementable. Would require maintenance and monitoring to assure emission limits are met.
			Treatment	See "treatment" below	

TABLE 4-1 (continued)

PRELIMINARY SCREENING OF REMEDIAL ALTERNATIVES
FOR LANDFILL AND SOIL GASES

Response Media	General Response Action	Remedial Technology	Process Options	Effectiveness	Implementability
Soil Gas Continued	Treatment	Thermal, Physical	Thermal destruction	Effective in destruction of organic components contained in gas stream. May attain remedial action objectives with properly designed cap.	Moderately implementable due to frequent monitoring of process control equipment. May result in sulfur oxide emissions requiring additional controls. May require supplemental fuel. May not be used with passive collection system.
			Solvent absorption	Effective in removal of toxic organic vapors and certain inorganic gases from gas stream.	Implementability dependent upon specific contaminant solvent system. Requires disposal of absorber effluent. May not be used with passive collection system.
			Carbon adsorption	Effective as commonly employed pollution control technique. Effective in removal of toxic organic vapors and certain inorganic gases from gas stream. May attain remedial action objectives with properly designed cap.	Implementability dependent on gas stream components. Disposal or regeneration required. May require specially treated carbon for H_2S removal. May be used with passive collection system (carbon canisters).
	Source Removal	Various	See Table 4-7		

4.2.1 No-Action Alternative

Under this alternative, landfill gas will not be collected, treated or controlled in any manner. Periodic, ambient air monitoring of specific contaminants may be performed to track local air quality. The potential hazards and odor nuisance status addressed in Sections 6 and 7 of the RI report (Volume 1) will not change.

Generation of landfill gases at the site has likely passed its peak, particularly with respect to hydrogen sulfide. Peak hydrogen sulfide generation for a landfill containing construction and demolition waste typically occurs in 1.5 to 2.5 years, followed by a fairly rapid reduction in gas production. As production of landfill gases (methane, hydrogen sulfide) decreases with the depletion of nutritional sources for microbial activity, the atmospheric releases of toxic volatile organics in the soil gases are also reduced. Furthermore, the prior releases of toxic volatile organics may tend to deplete the level of these contaminants in the soil. This alternative would not achieve the remedial action objectives for ambient air in the short term. Natural attenuation may achieve these objectives over a long period of time. This alternative will be retained for further evaluation.

4.2.2 Institutional Action Alternatives

Institutional actions for the site include land use restrictions, access restrictions (such as fencing and warning signs on all or part of the site), and air monitoring. These actions will not, of themselves, mitigate contaminant release problems, but may restrict exposure to highest use areas and situations.

The land use restrictions may be difficult to implement due to potential legal restraints. Monitoring would be required to assure that land use restrictions were enforced.

Fencing would be easy to implement using readily available technology and would restrict exposure to ambient air contaminants. However fences can be breached and are subject to vandalism. Maintenance would be required.

Ambient air monitoring would be effective at monitoring concentrations of contaminants at the boundary of the site and could be implemented easily using available technology. Based on the above discussions, institutional action alternatives will be retained for further evaluation.

4.2.3 Collection and Extraction Alternatives

Soil vapor extraction and collection techniques can be used to collect and remove landfill gases (methane and hydrogen sulfide) and volatiles in the vapor phase in the void space of the soil in the unsaturated zone. Gas collection/extraction can be performed in a passive or active manner Passive approaches for the collection of gases depend upon the gas generating processes occurring in the landfill. Active approaches would be required if the volumes and concentrations of contaminants released from the site were greater than practically managed by a passive system.

A typical soil vapor extraction system consists of extraction vents installed in the subsurface soil. Vents are placed around the periphery or within the contaminated area. Individual emissions can be treated with activated carbon or the vents can be connected via a manifold to a central treatment unit. In the case of an active extraction system, the vents are connected to a common blower via a manifold system. The blower induces air flow in the soil, stripping and volatilizing the organic compounds into the air stream. Stripped contaminants from the blower are either discharged directly to the atmosphere or passed through a treatment system, based on contaminant levels in the gas stream and applicable air pollution control regulations.

Although passive gas collection systems were judged in the initial screening to be ineffective for dealing with the site, this collection technique was reassessed in the Preliminary Screening of Alternatives. Passive collection systems may require a gas impermeable cap over the site, particularly in conjunction with passive perimeter collection.

Control technologies such as vertical and horizontal barriers may be used to reduce the lateral and vertical mobility of landfill generated gas. Such barriers may require the use of synthetic liners. In using a gas impermeable cap to facilitate passive gas collection, the gas venting layer would be located directly below the barrier layer of the final cover and above the waste layer.

Passive Perimeter Collection

Lateral migration of subsurface landfill gases beyond the site may be controlled with a passive perimeter gas collection system. Passive systems do not use mechanical components to induce flow, but operate on the principle that material of a higher permeability than the surrounding soil can naturally direct the flow of soil gas. This type of system would be constructed along the periphery of the landfill or around specific areas. Trenches or vents filled with a highly permeable medium such as coarse stone are commonly used as conduits to collect gas. Treatment of collected gases may be required. However, implementing this would not be a problem. The placement of vents along the western perimeter of the site should take into consideration that the bedrock along this side is acting as a barrier to soil gas migration, thereby causing a flux off of the road.
If a closure soil cap with gas collection is required per 6 NYCRR Part 360, perimeter soil gas collection/extraction alone would not comply with venting requirements and would not meet all remedial action objectives for the ambient air. However, it would be effective in reducing some of the adverse health effects due to site contaminants. If used in conjunction with other remedial measures, it could effectively meet all remedial action objectives.

This alternative could be implemented with readily available equipment. Special procedures to reduce the potential for subsurface fire, explosion, or additional methane releases would be required when placing the vents. A monitoring program would be required to ensure that the system functions properly and all emission requirements are met. Based on the above discussion, this system would be feasible for the site and will be retained.

Passive Interior Collection

Similar in certain respects to passive perimeter gas collection, passive interior collection systems consist of a series of vents filled with a highly permeable medium to facilitate gas removal. These vents are distributed over the entire surface of the landfill. Treatment of collected gases may be required, although this would not pose any problems. If a closure soil cap with gas collection is required, per 6 NYCRR Part 360, passive interior soil gas collection would comply with the venting requirements.

This alternative alone may not meet the remedial action objectives for the site. However, if used in conjunction with a passive perimeter collection system, exhaust gas treatment, and a cap, it would meet the remedial action objectives. This alternative could be implemented with readily available equipment although care would be required when installing the vents deep into the waste fill due to possible increased release of landfill gases. Air monitoring would also be required to assure that emission limits are met. This alternative is feasible and will be retained for further evaluation.

Active Perimeter Extraction

Active perimeter collection systems utilize mechanical components to alter pressure gradients, thereby inducing flow of landfill-produced gas through gas extraction trenches or vents. Centrifugal blowers are frequently used to create a vacuum in the extraction trenches or vents to accomplish the removal of landfill gases and other volatile contaminants. This system design is similar to the passive perimeter system except for the use of a blower to extract the landfill gases and volatile organic contaminants. Treatment of collected gases would probably be required, and although this would not be a problem, it would require additional operating requirements and monitoring.

This system alone would not meet all remedial action objectives for the site. However, it would reduce adverse health effects from site contaminants. If used in conjunction with other remedial measures screened, it could meet all of the remedial action objectives for ambient air. This system could be implemented with currently available technologies although care would be required when installing the vents to avoid additional releases of landfill gases. Additionally the vacuum system would generate noise and would require maintenance and monitoring to assure that it is functioning properly. It is also subject to mechanical breakdown. Strict monitoring of the effluent gases generated would also be required In addition, if a closure soil cap with gas collection is required, per 6 NYCRR PART 360, perimeter soil gas collection/extraction alone would not comply with venting requirements This alternative is feasible and will be retained for further evaluation.

Active Interior Extraction

This system is similar in its operating components to the active perimeter collection system, except that gas extraction vents are placed throughout the landfill. Installation of vents is similar to the passive interior system described previously. Once extracted through a collection system, treatment of landfill-produced gases and volatile organic vapors probably will be required to control potential risks or nuisance to the public and to comply with applicable air quality standards. If emission limits are not met, an additional treatment system would be installed. This approach would require some effluent monitoring.

This system alone may not meet all remedial action objectives for ambient air. However, it would reduce the adverse health effects by collecting the gases and if necessary treating them as necessary. If used in conjunction with other remedial measures screened, it would meet all remedial action objectives. It could be implemented with readily available equipment. However care would be required when installing the system to prevent an increase in gaseous releases from the landfill and to avoid danger of fires. The use of the blowers to collect the gas would generate additional noise, and maintenance would be required to assure that the system is functioning properly. The blowers are also subject to mechanical breakdown. Monitoring would be required to assure compliance with emission limits. If a closure soil cap with gas collection is required, per 6 NYCRR Part 360, active interior soil gas collection/extraction would comply with venting requirements. Based on the above discussions, this alternative is feasible and will be retained for further evaluation.

4.5.4 Treatment Alternatives

After collection, landfill gases may be directed to an on-site treatment facility. Treatment of gas may be accomplished by incineration, by scrubbing, and by granular activated carbon adsorption, which is effective with certain organic and inorganic compounds.

Incineration

Collected flammable gases, including methane, may be thermally oxidized by flaring. Flaring is a combustion process that exposes waste gases to an open flame with no specialized controls for temperature or time of combustion. Design parameters for flaring, such as number of flares, stack diameter, and height, are dictated by the gas production and flow rate More technologically sophisticated incineration systems involve process control of such items as combustion temperature and gas residence time, and they may utilize afterburners.

Incineration of gases and vapors under proper conditions can result in 99+% destruction, but some combustion byproducts can present problems. Incinerating hydrogen sulfide will result in generation of gaseous sulfur oxides. Oxidizing halogenated hydrocarbons can result in hazardous combustion products such as hydrochloric acid vapor and phosgene. Although the combustion products may present problems, incineration will destroy the target soil gas contaminants.

Although methane and some relatively simple hydrocarbons are easily destroyed, flaring may not be sufficient to meet stringent air quality guidelines for hazardous constituents. Since organic vapors of concern at the site include halogenated hydrocarbons, a more sophisticated gas incineration system may be required. Gases with a low heating value may require supplemental fuel to sustain a flame. In addition low flow streams such as those that would result from the passive venting system would not be able to sustain a flame.

The equipment and materials necessary to design an incineration system for this site are proven and commercially available from several vendors and could be implemented for use with an active collection system. Therefore, based on the above discussions, incineration is retained for further analysis for use with an active collection system only.

Scrubbing (Solvent Absorption)

Absorption is widely used in separation and purification of gaseous streams containing high concentrations of VOCs. As an emission control technique, it is much more commonly employed for inorganic vapors (e.g., hydrogen sulfide) than for organic vapors. Removal efficiencies in excess of 99 percent can be achieved with absorption under proper conditions.

The suitability of absorption for controlling organic vapor emissions is determined by several factors. The most important factor is the availability of a suitable solvent. The pollutants (chlorinated and aromatic hydrocarbons) should be readily soluble in the solvent for effective absorption rates, and the spent solvent should be easily regenerated or disposed. Another factor is the availability of vapor/liquid equilibrium data for the specific contaminant/solvent system in question

In organic vapor control applications, low outlet concentrations will typically be required to meet applicable emission limits. The treatment technology can be implemented using commercially available materials and equipment. However, trying to meet emission requirements with absorption alone may lead to impractically tall absorption towers, long contact times, and high liquid-gas ratios. Additional levels of screening will be required to evaluate the technical feasibility of absorption for dealing with soil gas contaminants using an active venting system. This technology would not be feasible for a passive system because a blower would be needed to collect the gas.

Carbon Adsorption

Carbon adsorption is commonly employed as a pollution control technique. It is applied to dilute mixtures of VOCs in air. Removal efficiencies of 95 to 99 percent can be achieved using this technique. The maximum practical inlet concentrations are typically limited by the adsorption capacity of the carbon bed.

If the gas being treated contains high molecular-weight compounds that have low volatility and are strongly adsorbed onto carbon (such as semi-volatile organics), removing them during regeneration may be difficult. On the other hand, highly volatile materials such as methane may not adsorb readily on carbon.

Carbon adsorption is relatively sensitive to emission stream conditions. The presence of liquid or solid particles or high boiling organics may require prefiltration or pretreatment. Dehumidification may be necessary if the emission stream has a high humidity (relative humidity > 50 percent) because the presence of water vapor can reduce the carbon's sorptive capacity for organics. Packaged carbon adsorption systems are available from several vendors. These systems can handle emission streams with flow rates from a few hundred to above 100,000 scfm.

Specially treated activated carbon can be effective for removing hydrogen sulfide gas. Katasorbon activated carbon reportedly[1] has a sulfur adsorbing capacity of 100% of its weight. Caustic treated carbons, typically used for H_2S adsorption, tend to function well under conditions of high relative humidity. Methane, however, would not be readily adsorbed by activated carbon at low concentrations[2]. Based on the above discussion, this will be retained for further evaluation.

4.2.5 Source Removal

Excavating the fill wastes for on site stabilization or treatment, or for removal and disposal, would eliminate the sources of landfill gas generation and VOCs among other contaminants. Removal or stabilization of the fill wastes represents a permanent solution to soil gas emissions. A more extensive discussion of this

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(1) Illinois Institute for Environmental Quality, Document 75-6 (December 1974).

(2) Calgon Carbon-ventsorb Bulletin 23-56d (1988).

approach is found in Section 4.5. Based on this discussion, this alternative will be retained for further evaluation.

4.2.6 Potential Risks

Site intrusive activities performed during implementation of soil gas remediation operations may present potential risks which could affect site workers. Boring and trenching operations required to install a soil gas collection and treatment system may expose site workers to hazardous materials such as fugitive dusts and releases of volatile organic corpounds. Such intrusive construction work could expose surface run-on and groundwater to landfill contaminants Installation of an interior gas collection system would be more intrusive of the waste fill areas than a perimeter collection system. Furthermore, the presence of methane and combustible fill materials increases the risk of a landfill fire during waste intrusive activities.

4.2.7 Preliminary Screening

The screening results for the soil gas treatment technologies were shown in Table 4-1. Based on evaluation of treatment effectiveness for attaining clean-up goals, on implementability, and on EPA[1] and NYSDEC[2] screening criteria, the following technologies will be retained for further analysis as components of overall remedial alternatives for soil gas:

- No Action, with institutional actions (as appropriate) and air monitoring
- Access restrictions with or without air monitoring
- Perimeter gas collection/extraction (passive or active)

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(1) Guidance for Conducting Remedial Investigations and Feasibility Studies under CERLCA. EPA I140/G-89/004, October 1988.

(2) NYSDEC TAGM for Selection of Remedial Actions at Inactive Hazardous Waste Sites, September 13, 1989.

- Soil cap with or without passive interior gas collection, with or without treatment, and with provisions for upgrade to active collection and treatment if required

- Soil cap with active interior gas collection and treatment

- Collected/extracted soil gas treatment by carbon absorption

- Extracted soil gas treatment by solvent absorption (for active venting system only)

- Extracted soil gas treatment by thermal destruction (for active system only)

- Source removal

4.3 GROUNDWATER REMEDIATION ALTERNATIVES

Groundwater remedial alternatives were screened for attaining the remedial action objectives cited in Section 3.4.2, Groundwater, and for feasibility of implementation. Individual technologies will be screened in this section. Combinations of alternatives for treatment of the classes of contaminants will be addressed in Section 5. However, some treatment methods which would have limited effectiveness on their own will be evaluated in the context of supplements to other treatment technologies. Disposal options will also be discussed in this section. Table 4-2 presents and screens technologies applicable to groundwater remediation.

The primary objective is to control contamination in groundwater and leachate to levels which will not significantly degrade the quality of the Ramapo River water and sediment. The groundwater remediation alternatives focus on treating the contaminants of concern in the groundwater. These include heavy metals, base neutral semi-volatile organics (mainly PAHs), and volatile organics (benzene, chloroform) in the overburden zone portion of the aquifer. Due to the variety of contaminant types found in the groundwater, a treatment train consisting of two or more technologies may be required for complete treatment of the groundwater. Although limited data indicate that water quality in the fractured bedrock is being affected by site contamination, the extent of contamination in this groundwater zone is not judged to be extensive at the present time.

TABLE 4-2

PRELIMINARY SCREENING OF REMEDIAL ALTERNATIVES FOR GROUNDWATER AT TUXEDO SITE

Response Media	General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability
Groundwater	No Action	None	Not applicable	May not achieve remediation objective.	No implementability requirement
	Institutional Actions	Land use restrictions	Deed restrictions	May not achieve remedial action objective. Effectiveness dependent upon continued monitoring and site impacts on off-site groundwater and surface water quality.	Legal requirements and authority may be difficult to implement
		Alternate water supply	Public water system	Effective in preventing use of potentially contaminated groundwater. No contaminant reduction. May not achieve remedial action objective	Easily implemented, conventional construction, requires local approval. Municipal water available along Route 17
		Treatment of Water Supply (Private Wells)	Ion exchange Carbon adsorption Others	Effective in the removal of contamination from drinking water supply. May not achieve long term environment objectives. May not achieve remedial action objective.	Point of use treatment involves installing, monitoring and maintaining multiple individual treatment units.
		Monitoring/Sampling	Groundwater/private well monitoring	Useful for documenting conditions. Does not reduce contamination. May not achieve remedial action objective.	Easily implemented. Existing wells can be used
	Collection/ Discharge	Extraction	Downgradient extraction wells	Effectiveness of downgradient flow interception and capture may be dependent upon influence and variability of surface water flow. Will be most effective with flow barrier. May achieve remedial objective using flow barrier.	Moderately difficult to implement. Right of way permits may be required.
		On-site discharge	Injection well/infiltration gallery	Does not reduce contamination. Not effective unless used in conjunction with treatment. May not achieve remedial action objective.	Readily implementable; permit requirements must be met

TABLE 4-2 (Continued)

PRELIMINARY SCREENING OF REMEDIAL ALTERNATIVES
FOR GROUNDWATER AT TUXEDO SITE

Response Media	General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability
Groundwater Continued	Collection/Discharge Continued	Off-site discharge	Pipeline to river	Effective and reliable discharge method. Probably not effective without treatment (regarding surface water quality)	Readily implementable. May require treatment to attain discharge limits. Permit requirements must be met
	Containment/Diversion	Vertical Barrier	Slurry wall, sheet piling, concrete cut off wall	Can be effective in restricting downgradient groundwater flow. Marginally useful upgradient.	An upgradient barrier would be extremely difficult to implement. A downgradient barrier may be difficult to implement; requires keying into relatively impermeable base. Right of way permit may be required
		Drainage reconfiguration	Surface drainage network	Effective in reducing volume of surface water run on to site. May meet remedial action objective	Can be implemented, conventional construction, requires state/local approval.
	Collection Treatment/Discharge	Extraction	Extraction wells	See extraction under "Collection/discharge" above.	
		Physical/Chemical Treatment	Precipitation	Effective and reliable for metals removal. Requires sludge disposal	Readily implementable; proven commercially available, technology. Sludge byproducts would require treatment and disposal.
			Ion exchange	Effective for metals removal.	Materials and equipment readily available. Probably requires pretreatment for suspended solids removal. Treatment byproducts may require subsequent treatment prior to disposal.
			Carbon adsorption	Effective and reliable for organics; proper pretreatment required.	Readily implementable using commercially available equipment; requires carbon disposal or regeneration
			Air stripping	Effective and reliable for volatile organics. Proper pretreatment required. Not effective for semi-volatile organics	Readily implementable; may require treatment of stack gases to meet emission limits.

TABLE 4-2 (Continued)

PRELIMINARY SCREENING OF REMEDIAL ALTERNATIVES
FOR GROUNDWATER AT TUXEDO SITE

Response Media	General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability
Groundwater Continued	Collection Treatment/Discharge Continued	On site Discharge	Injection well/infiltration gallery	Not effective since adds to volume of leachate on site	Moderately difficult to implement Permit requirements must be met
		Off-site Discharge	Pipeline to river	Effective and reliable discharge method	Easily implemented due to proximity of river Permit requirements must be met
	Source Removal	Various	See Table 4 7		

4.3.1 No Action Alternative

Under this alternative, groundwater at the site would not be contained, collected, treated, or disposed of. Because of the nature of the fill waste contaminants, the quality of groundwat . in the overburden layer may become further degraded with time, and degr.dation could become more pronounced than at present in the bedrock water zones. If the No Action alternative is selected, groundwater and privat/ well monitoring should be performed at and in the vicinity of the site to assure the protection of public health and environmental concerns identi.ied in the M&E RI report. The No Action alternative option includes the option of having any potentially affected residents with private wells switch over to Tuxedo's municipal water supply system as discussed below.

4.3.2 Institutional Action Alternative

Institutional actions for groundwater include land use restrictions, alternate water supply for potentially affected off-site private wells, treatment of water supply from potentially affected private wells, and monitoring of groundwater contamination. By themselves, these actions will not mitigate contaminant release problems, but they may protect potentially exposed populations from hazards related to ingestion of contaminated well water. These actions may not achieve the remedial action objective for the site groundwater.

Land use restrictions may be difficult to implement because of zoning laws and the need to obtain owner consent and cooperation. Furthermore, it could restrict the future use of the land indefinitely. The other institutional actions discussed above could be readily implemented and are all proven methods. All equipment and materials are commercially available, and these actions could be implemented quickly if necessary. Therefore, they will be retained for further evaluation.

Private Wells

The private well at the adjacent antique shop property is the only one identified as potentially at risk from site contamination Since this well is side gradient and relatively deep, the threat appears to be minimal. Testing during the LMS Phase II study indicated it was not contaminated The well water quality was not tested by M&E in the 1990 Phase I Remedial Investigation. If other potable water wells downgradient of the site are found to be contaminated in the future, the affected users could be connected to an alternate water supply, or a point of use treatment system could be installed. Municipal water service is available along Route 17, and depending on delivery capacity and user needs, this approach could provide a readily accessible alternative.

Point of use treatment can be used for removing heavy metals and organic contaminants in well water Such a treatment train typically consists of one or more ion exchange beds to remove metals and a carbon adsorption bed for organics. Generally, a disinfection step such as ultraviolet treatment is also included. Such systems are proven and are readily available from several vendors. Based on the above discussions, these alternatives are feasible and will be retained.

Municipal Water System

The Tuxedo municipal water system, which is supplied by the spring-fed Tuxedo Lake, would not be affected by site contamination This is because the lake is southwest of the site and more than one mile away from it. Regional groundwater flow patterns cause contamination to flow east of the site, in the opposite direction from the lake.

4.3.3 Extraction with Upgradient Recharge

This alternative is a groundwater recirculation system without treatment. Contaminated groundwater would be extracted at the east (downgradient) boundary of the site and reinjected into the groundwater system upgradient. Unless all infiltration to the site groundwater system could be excluded, excess groundwater would collect and would probably require treatment and disposal. The volume of excess groundwater generated would be equal to the rate of infiltration over time.

With this type of recirculation approach, the groundwater contamination would tend to become more concentrated over time. Reinjection could possibly contaminate soil upgradient and would also increase potential for contaminating the lower portions of the aquifer. The concentration build-up would be a function of time and the ratio of the infiltration rate to the quantity of groundwater in the soils beneath the site -- a feed and bleed system. This approach is judged to be inadequate for addressing site groundwater contamination problems and would not meet applicable regulations (i.e., Land Ban Requirements). Therefore, it is excluded from further consideration.

4.3.4 Subsurface Barrier Downgradient

The purpose of a downgradient subsurface barrier would be to contain contaminated groundwater in the overburden layer on the site. Installing a downgradient subsurface barrier in conjunction with a pump and treat system could accomplish the following objectives:

- Better containment of groundwater on-site for extraction and treatment
- Mitigation of contaminant migration from the site to the Ramapo River system

Subsurface barriers refer to low permeability cut-off walls that contain or control the flow of groundwater. Common types include slurry walls, concrete cut-off (diaphragm) walls, and sheet pilings (construction interference). Grouting seals can be used at the base of the barriers.

The M&E Remedial Investigation determined that the overburden layer is as deep as 65 feet in certain areas on the east (downgradient) side of the site. Installing a vertical barrier to this depth presents some technical problems but is still within the range of technical feasibility. Special equipment may be required for excavating the lower reaches of the cut and would be reflected in higher installation costs.

nature of the confining layer is an issue. The layer must be of sufficiently low permeability to significantly retard downward migration of groundwater. It must also have sufficient thickness to allow for excavation of an adequate key-in (2 to 3 feet). The depth of the confining layer will also determine the type of excavation equipment used and the completed wall costs. Most slurry wall contractors have modified hydraulic backhoes capable of excavating to depths of sixty to seventy feet or more. Excavation below this level requires additional equipment such as clamshell grabs.

The Soil-Bentonite (SB) slurry walls are constructed by excavating a narrow vertical trench to the appropriate lines and grades while the trench is kept filled with a slurry suspension of bentonite in water which is maintained in the trench at ground surface elevation. As excavation proceeds through the slurry, additional slurry is added to make up for the volume of soil removed. Once excavation proceeds a suitable distance, a soil and bentonite backfill is pushed into the trench, displacing the slurry. The soil-bentonite forms the final impermeable wall. Wall thickness is generally five feet. A compacted clay cap with a flaring completes the construction of the trench.

Excavation down to an impermeable cut-off layer or to bedrock is typically done with hydraulic backhoes for depths less than 60 feet. At depths greater than 60 feet, excavation usually requires specially extended backhoes and/or clamshell equipped cranes.

The excavated material, if suitable, is typically prepared by sluicing the soil with the trench slurry and, if required, can be augmented or blended with imported soils and mixed with bentonite powder to achieve the design hydraulic conductivity. Soil-bentonite backfill can achieve a hydraulic conductivity in the range of 10^{-6} to 10^{-8} cm/sec with proper mixes and proper construction.

Cement-Bentonite (CB) Slurry Walls, an alternate to the above SB procedure, are constructed by excavating through a slurry composed of portland cement and bentonite, which sets overnight to a semi-rigid material to form the "backfill". The excavation procedures and wall depth are the same as for SB walls. The trench width generally ranges from 2 to 3 feet. A typical range of hydraulic conductivities for CB backfill is between 10^{-5} to 10^{-6} cm/sec. To achieve a permeability lower than 10^{-7} cm/sec, special mixes incorporating fly-ash would be required. The primary advantage in constructing a cement-bentonite wall is that backfill mixing is not required. This may be a major consideration where space is critical, the mixing must be performed at some distance from the wall, and the backfill transported to the trench. The major disadvantage of a CB wall is that disposal of all the excavated soil is required, resulting in a higher cost.

Concrete Diaphragm Walls

Diaphragm walls are constructed with a process similar to slurry walls in which the excavation of a narrow trench is done under a hydraulic head of bentonite slurry. After completing a segment of a 2-foot wide trench excavated by clamshell and keyed into an aquiclude at the bottom, cast-in-place concrete (tremie process) is used to displace the bentonite slurry and form a load-bearing wall. The permeability of the concrete cut-off walls would depend on the continuity and integrity (windows, honeycombs, defective joints) of the wall. However, most leakage through diaphragm walls occurs at the panel joints. Various positive panel construction connection techniques can be specified to ensure a watertight connection between adjacent panel sections

Use of a concrete diaphragm wall offers the following technical advantages:

- The required depth can be obtained using clamshell equipment. Consequently, the working platform can be placed, if feasible, at a higher elevation in the landfill, thus reducing the landfill removal needed to create the work area for the platform.

- The bottom of each panel is keyed several inches into the bedrock, resulting in a positive cut-off.

- The space required for the construction of the working platform is reasonable.

- The construction involves installing discrete panels, through all kinds of overburden, with somewhat flexible scheduling. Multiple rigs can work the site simultaneously.

- No backfill or mixing area is required.
- Continuity of the diaphragm wall can be easily checked.

Construction Interferences

Site intrusive activities present potential risks affecting surface water, groundwater, and air emissions. However construction safeguards, safety protection equipment, and applicable regulations (i.e. OSHA) would be strictly enforced and followed. These potential risks could affect both site workers and people in the immediate area. Excavation activities required to install a downgradient barrier treatment system for groundwater may expose site workers to hazardous materials. Such intrusive construction work could further expose surface run-on and groundwater to landfill contaminants. In addition, physically disturbing the waste materials could result in release of volatile organics, as well as in fugitive air emissions of contaminated soils and dusts, which could migrate off-site.

Installation of a downgradient soil-bentonite slurry wall will require a large working area for a stable, level platform for the trench excavation, as well as for mixing and blending the backfill. Removal of backfill material that is encroaching on the railroad right-of-way will be required. This will move the eastern toe of the landfill back approximately 65 feet, which will provide sufficient room for the working platform. The level of the working platform would correspond to the nearby roadbed for the Conrail tracks. From that level, the deepest portion of the trench to bedrock is about 55 feet. Consequently, the excavation would require using a backhoe with an extended boom and/or a clamshell attached to a rig for the completion of the deepest parts.

In addition, the boreholes drilled during the RI phase indicate fractured bedrock near the surface in some places. Therefore, a positive cut-off would also require sealing of the pervious upper zone of the bedrock with cementitious grouting.

4.3.5 Groundwater Barrier Upgradient and Diversion of Surface Water Flow

Upgradient Subsurface Vertical Barrier

Upgradient placement of a subsurface vertical barrier refers to one installed on the groundwater source side of the wastes. This placement could be used to divert clean groundwater around a site. This method will not halt the generation of a leachate but could slow its generation by stagnating groundwater behind the wall and reducing recharge into the fill waste. The impounded groundwater would have to be diverted to bypass the site.

Field work performed by M&E during installation of RI-5, an upgradient bedrock well located on the western edge of the mid-site region, indicated that some of the groundwater recharge to the site occurred in the fractured bedrock rather than the overburden zone. An additional groundwater source was located significantly deeper into the competent bedrock zone An effective upgradient barrier would need to control flow in the bedrock zone. Therefore, construction and installation of such a barrier is probably not feasible. This alternative will not be retained for further evaluation.

Diversion of Surface Water Flow

Surface water run-on from drainage areas west and south of the site can infiltrate the fill waste and contaminated soils, thereby entering the site's groundwater system. Diverting this run-on would reduce the infiltrations. Three means of controlling the infiltration from surface run-on are available, as described below.

Installation of Impervious Soil Cap: Run-on can be controlled by the impervious soil cap which would be used to close the site. This would prevent the flow from seeping through the surface of the site. The amount of such infiltration presently occurring is not known, however the cap would be designed to mitigate seepage due to run-on.

Diversion of Run-On from West Drainage Area: Diverting run-on from a 23-acre drainage area west of Route 17 would reduce the volume of water entering the site. This does appear to be technically feasible, but would affect state and town roads, and it would require approval from the appropriate government agencies.

Diversion of Run-On from South Drainage Area: Since repair and/or replacement of the existing damaged drain pipe running through the site has been deemed impractical, consideration must be given to the 4.5 acre drainage area just south of the site which feeds the drain pipe. At the present time, the amount of water infiltrating the fill waste is unknown. Since diversion of run-on from this area is not cost-effective, an alternative approach is to permit this infiltration to the groundwater to occur.

Diversion of run-on will not, in itself, remediate groundwater contamination problems at the Tuxedo Waste Disposal Site. However, these techniques may significantly reduce the volume of groundwater which would require extraction and treatment by restricting groundwater recharge rates.

4.3.6 Extraction with Treatment

Extraction

Groundwater pumping technology involves the installation of extraction wells to remove a plume of contaminated groundwater for treatment and subsequent reintroduction (recharge) into the aquifer or discharge to surface waters. A system consisting of interconnected recovery wells is typically used to capture the contaminant plume. The extraction wells would be located downgradient on the east side of the site. The groundwater would be pumped with submersible pumps at a rate determined by slug tests and/or pump tests. Based on the desired flow rate and the hydrogeologic flow configuration, the required number of extraction wells can be determined.

Additional field studies would be needed prior to design and implementation of an extraction well system. The effectiveness of groundwater extraction would be enhanced if used in conjunction with a down-gradient subsurface barrier and with controls on the groundwater recharge rate via diversion of run-on to the site.

Intrusive activities during installation of extraction wells present potential risks affecting surface water and groundwater. However, all potential risks would be mitigated using construction safeguards, personal protection equipment, and enforcement of all applicable regulations (i.e., OSHA). Boring operations required to install a downgradient extraction system for groundwater may expose site workers to hazardous materials. Intrusive construction work could further expose surface run-on and groundwater to landfill contaminants.

Treatment

Three types of groundwater contaminants are of concern in the groundwater at the Tuxedo Waste Disposal Site:

- Heavy metal compounds, or ionic species, with solubilities in water dependent on the specific metal, pH of the aqueous medium, and anions present in the medium
- Volatile organic compounds having limited water solubility
- Semi-volatile organic compounds (mainly PAHs) having relatively high molecular weights, moderate to low water solubilities, and low vapor pressures.

Each of these contaminant types lends itself to specific treatment processes which may be ineffective for the other classes of contaminants. Since the presence of one contaminant type may interfere with the treatment of another contaminant class, this situation may dictate the order of treatment steps. For some of the treatment techniques, such as chemical precipitation, it may be necessary to perform a treatability study in order to design an operating system.

All of the treatments discussed below are of a separation rather than a destruction nature. They represent a displacement of the contaminant from the aqueous phase to an immobile solid phase in three of the processes, and to a vapor phase with the fourth technique (air stripping). The latter typically results in a diluted form of the contaminant in the stripping air, while the solid immobilization techniques tend to concentrate the contaminant species.

Since any on-site groundwater and/or leachate treatment facility may need to handle variable flow conditions, some type of equalization/detention may be desirable. This may be achieved using holding tanks to average the flow over time. The various groundwater streams are commingled into a single flow which reflects an average flow and concentration of contaminants and will tend to prevent the upsetting of treatment units. The techniques for flow equalization involve the use of either on-line or off-line equalization tanks. On-line equalization is performed by passing flow through the equalization basin, and off-line equalization is used only when the waste streams have above average flow rates. In the latter case, excess flows are diverted to the equalization basin and subsequently fed back into the main waste stream.

A sedimentation process might be required at the site to remove suspended solids from the aqueous streams to be treated prior to the actual treatment itself. Sedimentation is performed by allowing suspended solids in an aqueous solution to settle in a quiescent regime. The equipment used for sedimentation typically includes a basin to maintain the aqueous waste to be treated in a quiescent state and a means of physically separating the liquid and the settled particles (i.e., either removing the settled particles or removing the liquid). The sedimentation system can be a conventional settling basin, a clarifier (usually circular), or a high-rate gravity settler. Sedimentation basins and clarifiers are typically designed with built-in mechanical solids removal devices such as a sludge scraper and/or a sludge draw-off mechanism. Sedimentation can be aided through the use of flocculating agents such as polymers which conglomerate smaller particles and make them easier to settle.

Treatment by Chemical Precipitation: Groundwater at the site contains elevated levels of several metals at concentrations exceeding groundwater standards. The presence of these metals may also interfere with effective operation of treatment processes such as organics removal. Therefore, treatment for metals removal may be to maintain the effectiveness of subsequent treatment processes, as well as to reduce the concentrations of these metals to acceptable levels.

Chemical precipitation for heavy metals removal using pH adjustment is a well-established technology. There are three types of metals precipitation systems: the carbonate system, hydroxide system, and sulfide system. Each adjusts the pH of the water to the level at which the metals in the water have their lowest solubility. The carbonate system is difficult to control and relies on the use of soda ash to adjust the pH of the water to the range of 8.2 to 8.5 to facilitate metals precipitation. The hydroxide system is most widely used in the removal of metals. This system uses either lime, sodium hydroxide, or magnesium hydroxide to raise the pH of the water to precipitate the metals. Except for arsenic, the sulfide system is effective in removing metals. It uses sulfide ions to precipitate metals, generally resulting in lower metal solubilities. The increased removal of this process is offset by the susceptibility of sulfide sludges to oxidize, resulting in the resolubilization of the metals.

One disadvantage of a chemical precipitation system is the different pH levels at which the various metals have their minimum solubilities. At a given pH, some of the metals are more soluble than others. Metals that do not have their minimum solubility at the pH of the treatment may not be effectively removed. Another disadvantage is the volume of sludge generated. The sludge may be hazardous and may require treatment and disposal at a suitable facility.

Oxidation/Reduction may be used as part of a precipitation process. These processes involve changing the oxidation state of a contaminant. Oxidation usually employs an oxidizing agent, such as hydrogen-peroxide, ozone, or hypochlorites. Chemical reducing agents are applicable mainly to treat certain inorganics such as chromium or selenium.

Iron-based coprecipitation involves the addition of soluble ferrous ions to the waste stream at a predetermined rate (usually about four times the total amount of all the metals). Such systems usually operate in a pH range of 7.0 to 8.0. The oxidation of ferrous ions in the waste stream results in the precipitation of iron and the other metals. Heavy metals are entrapped in an insoluble matrix when iron is precipitated from the solution This gelatinous iron matrix can occlude other metals which become attached or adsorbed to the iron precipitate.

Iron-based coprecipitation has several advantages over pH adjustment and precipitation It generates a smaller volume of sludge in comparison with pH adjustment and precipitation systems, and its effectiveness depends on the solubility of iron, not on the solubility of all the metals present in the water

A typical heavy metals precipitation system consists of a reaction tank(s), flocculator, and a sludge handling system for thickening and dewatering. Separation of the precipitated metal sludge from the treated liquor can be accomplished by such equipment as a settling tank, a chevron plate settler, or a vacuum filter. The metal sludge would then require further treatment prior to disposal. This treatment could include metals recovery or stabilization and landfilling.

<u>Treatment By Ion Exchange</u>: The ion exchange process involves the reversible exchange of ions in solution with ions retained on a solid ion exchange resin. Ion exchange resin can be either a cationic or anionic exchange type. Typically, ion exchange systems consist of a fixed bed or beds of ion exchange resin in a column. As wastewater passes through the resin, metal ions exchange with the cations in the resin. When the resin reaches its breakthrough point and is exhausted, it must be regenerated. The regeneration solution then must be treated prior to discharge or disposal.

Ion exchange systems are used primarily for treatment of industrial wastewater and demineralization of process water. The technology may encounter difficulties in treating groundwater at the Tuxedo Waste Disposal Site. Colloidal particles and bacteria may foul the resin, necessitating pretreatment such as filtration. If metals, metal complexes (e.g., chromates), and anionic species (e.g., arsenic) are present, both anion and cation exchange resins would be needed for treatment of the water.

Air Stripping: air stripping is most effectively used for removing volatile organic compounds from groundwater First, groundwater is pumped to the top of a stripping tower such as a packed tower. Packed towers are vertical columns filled with a medium that creates a large surface area. Air stripping can also be performed in towers containing a number of perforated plates (trays).

Next, the water cascades over the bed of packing media (or through the series of trays) while air is forced through the tower in the opposite direction. As the water flows downward, air from a blower enters the bottom of the tower and moves countercurrently upward. When the water contacts the air, volatile compounds transfer from the liquid phase to the vapor phase and are carried in the air stream out of the top of the tower The propensity of an organic compound to volatilize is a function of its concentration in the aqueous medium, the temperature of the medium, Henry's Law constants for the compound in water, the concentration of the compound in the air stream, and the effective contact area for mass transfer.

The air leaving the tower may be discharged directly to the atmosphere or may be treated prior to discharge, depending on effluent concentrations and air pollution regulations. Treatment of effluent air can be accomplished by carbon adsorption or incineration (see Section 4.2)

Packed columns can achieve very high removals of volatile organic compounds under the right conditions. Removal efficiencies in excess of 99 percent have been reported Field applications of air stripping with counter-current packed towers have been successful in removing halogenated and non-halogenated volatile compounds from contaminated groundwater. In many cases, the use of air stripping has been applied in conjunction with carbon adsorption to remove other less volatile organics.

Volatile organic compounds such as chloroform and benzene have been detected in monitoring wells at the site. These compounds can effectively be removed by air stripping. However, the groundwater also contains semi-volatile organics, such as PAHs, that are not effectively removed by air stripping and would require additional treatment by a method such as activated carbon adsorption which is discussed below.

Carbon treatment would also remove the volatile organic compounds. Since the detected levels of VOCs in the groundwater were relatively low, their presence would not add significantly to the carbon's loading. Air stripping, although feasible for some of the groundwater contaminants, would not remediate all of the contaminants and would pose additional emission problems. Therefor., it is not as effective or implementable as carbon adsorption. Based on the above, air stripping will be eliminated from further consideration

Carbon Adsorption: Field experience at numerous hazardous waste sites has shown activated carbon adsorption to be effective for removing a large variety of organic compounds from groundwater. Many organics can be reduced to a level of 1 to 10 ppb, depending on the waste stream characteristics. Most organics (volatiles, and semi-volatiles) can be removed from groundwater by adsorption on carbon.

In a typical carbon adsorption system, water is pumped through a vessel containing a bed of activated carbon. The vessel is sized to provide sufficient retention time for adsorption of organics from the water. Depending on the cleanup levels, the effluent from the carbon column may pass through another carbon column prior to discharge. When the carbon bed becomes exhausted, it is regenerated for reuse, incinerated, or disposed of in a RCRA landfill.

Isotherms are used to predict carbon requirements in terms of adsorptive capacity for specific compounds. Compounds most easily adsorbed by carbon are those with relatively high molecular weights and boiling points. Ideally, the higher the concentration of the compound to be adsorbed, the greater the capacity of the carbon to remove it. Carbon adsorption capacities for organics can vary by several orders of magnitude, depending on the specific compound.

When more than one adsorbate is present in solution, competition for available surface on the carbon results in preferential adsorption of a particular adsorbate. Isotherms can be used to predict the carbon usage rates for individual known compounds, but would not necessarily give an accurate determination of the carbon usage rate for a mixture of compounds. In such cases, pilot treatability tests are recommended prior to system design

4.3.7 Disposal of Treated Groundwater

Once extracted and treated to applicable New York State standards or guidance values, groundwater can be discharged to a surface water body, or reinjected or recharged back into the groundwater. Discharge of effluent from an on-site groundwater treatment system to the Ramapo River, directly or indirectly, would need to meet the substantive requirements of a State Pollution Discharge Elimination System (SPDES) permit but would not require a permit per se. These requirements would set discharge limitations for the contaminants either in terms of contaminant concentrations (e.g., mg/l) or total mass limits (e.g., lbs/day).

SPDES permits commonly set total flow discharge limitations as well. The flow limitations are set to minimize impacts on the receiving water. Such discharge limitations may be useful guides in selecting the appropriate treatment technology. The Ramapo River is physically very close to the site. Therefore, a discharge system could be easily designed and would be relatively inexpensive to install and control.

This technology is feasible for this site due to the proximity of the Ramapo River and the ability to design a treatment system to meet applicable regulations and required flow rates. Therefore, it will be retained for further evaluations.

Another option is to reinject or to allow treated groundwater to infiltrate the overburden soils to recharge the aquifer. Direct injection could be done through the use of diffusion or injection wells. Infiltration can be facilitated by the use of infiltration galleries, leaching fields, or recharge basins. Since recharge would add to the potential volume of leachate at the site, this option has been eliminated from further study.

4.3.8 Source Removal

Excavating the fill wastes for on-site stabilization treatment or for removal and disposal would eliminate the sources of groundwater and leachate contamination. Once the source of contamination is removed, dilution by recharge would tend to mitigate existing groundwater contamination Removal or stabilization of the fill wastes represents a permanent solution to groundwater contamination that could be implemented in a relatively short time frame A more extensive discussion of this approach is found in Section 4.5

4.3.9 Preliminary Screening Results

The screening results for groundwater treatment technologies are shown in Table 4-2. Based on evaluation of treatment effectiveness for attaining clean-up goals, on implementability, and on EPA[1] and NYSDEC[2] screening criteria, the following technologies will be retained for further analysis as components of remedial alternatives.

- No action with monitoring and alternate water supply for affected wells, as required
- Diversion of surface run-on to site
- Impermeable surface cap
- Vertical downgradient barrier with groundwater extraction and treatment
- Treatment by metals precipitation
- Treatment by ion exchange
- Treatment by carbon adsorption
- Discharge of treated water by off-site discharge to Ramapo River
- Source Removal

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(1) Guidance for conducting Remedial Investigations and Feasibility Studies under CERCLA, EPA/540/G-89/004, October 1988.

(2) NYSDEC TAGM for selection of remedial actions at inactive hazardous waste sites, September 13, 1989.

4.4 REMEDIAL ACTION ALTERNATIVES FOR SURFACE WATER AND SEDIMENT

Surface water and surface water sediment will be considered together because these media interact closely and are part of the same riverine system. However, the dynamics of contamination by the Tuxedo Waste Disposal Site, the self cleansing potential of the respective media, and applicable remedial measures can be different for the two media. Table 4-3 presents and screens technologies applicable to surface water and sediment remediation

No removal or treatment alternatives are evaluated for the sediment in this report for the following reasons: 1) The data shows exceedances of the sediment guidances for PAHs but the highest concentrations are upstream; and 2) a comparison of mid/downstream metals concentrations with upstream concentrations, guidance criteria, background data and limit of tolerance data indicates very marginal, if any, impacts can be directly attributed to the site. Therefore, the next action to be performed as part of the ROD would be further monitoring of river water and sediment.

If future sampling and analysis indicates contaminant levels of concern, a benthic macroinvertebrate survey could then be performed. If the data and survey show that the site is significantly impacting the sediment, a removal and treatment option for the sediment would be considered. This could include excavating the sediments using established mechanical or hydraulic dredging technologies. Mechanical dredging involves the use of excavation equipment such as backhoes, drag lines, clam shells, and bucket ladder dredges. Hydraulic dredging involves using centrifugal pumps to produce a vacuum to move the sediment in a liquid slurry form. Control measures would also be implemented during dredging to minimize contaminant migration and resuspension. After removal, the sediment could be treated using treatment options similar to those discussed in section 4.5. Furthermore, in conjunction with remediating the sediment adjacent to the site, upgradient sediment should also be remediated, and source control measures should be reconsidered to prevent further recontamination.

TABLE 4-3

PRELIMINARY SCREENING OF REMEDIAL ALTERNATIVES
FOR SURFACE WATER AND SEDIMENT AT TUXEDO SITE

Response Media	General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability
Surface Water (Ramapo River)	No Action	None	Not Applicable	May not achieve long term remedial action objective	Not related to specific GRA
	Institutional Actions	Use Restrictions	Recreational Restrictions	Effective in restricting exposure through contact or ingestion. May not achieve long term environmental objectives	Readily implementable, however difficult to enforce.
			Alternate Water Supply	Effective in preventing potential risks involving contaminated well water supply. May not achieve long term environmental objectives	Municipal water supply available along Route 17 to which residents would be easily connected to.
		Treatment of Water Supply	Ion Exchange Carbon Adsorption Others	Probably not required	
		Monitoring	Sampling	Useful for documenting conditions. Does not directly address contamination, or meet remedial action objective	Readily implementable
	Isolation/Diversion (Groundwater and Leachate)	Vertical Barrier	Slurry Wall	Effective in restricting downgradient migration of leachate from source area when used in conjunction with other groundwater control techniques. May meet remedial action objective.	Moderate to difficult implementability because of active railway. Right of way permits may be required or removal of portions of waste fill from eastern side of site. Special composition may be required to achieve permeability levels required.
			Sheet Piles/Concrete Cut-Off Wall	Effective in minimizing the flow of surface leachate from the source area to the river in conjunction with other leachate controls. May meet remedial action objective.	Moderate implementability complicated by active railway. Right-of way permits may be required
			Retaining Dike/Berm	Effective in minimizing the flow of surface leachate from the source area to the river in conjunction with other leachate controls. May meet remedial action objective.	Readily implementable. Right-of-way permits may be required.
	Source Removal	Various	See Table 4-7		
River Sediment	No Action	None	Not applicable	May not achieve remedial action objective.	Not related to specific GRA

TABLE 4-3 (Continued)

PRELIMINARY SCREENING OF REMEDIAL ALTERNATIVES
FOR SURFACE WATER AND SEDIMENT AT TUXEDO SITE

Response Media	General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability
	Isolation	Cap	Point dumping/submerged diffuser	Effective in minimizing river water contact with contaminated sediments. When combined with chemically reactive materials, can treat/stabilize in situ. Will attain short term objectives. Isolation or removal of source and upgradient contamination may be required to attain long term objectives.	Moderate implementability. Permits may be required. Bench Scale testing may be required for treatment stabilization.
		Surface Seal or In Situ Stabilization with Binding Agent	Pneumatic	Effective in forming physical barrier between currently contaminated sediments and surface water. Addition of stabilization compounds may reduce mobility of contaminants. Will attain short term objectives. Isolation or removal of source and upgradient contamination may be required to attain long term objectives.	Moderate implementability. Permits may be required. Bench scale testing may be required for stabilization.
	Removal	Dredging		Effective in removing contaminated sediments. Will attain short term objectives. Isolation or removal of source may be required to attain long term objectives.	Moderate implementability. Permits may be required. Implementation may present potential risks. Disposal or treatment required.
	Source Removal	Various	See Table 4-7		

Treatment of the water supply relates to uses and potential uses of the Ramapo River as a drinking water supply. Within New York State, no communities are currently known to use the Ramapo River as a direct drinking water source. The North Jersey District Water Supply Commission draws some of its water from the Ramapo River approximately 22 miles downstream of Tuxedo. The water quality of the river near the site, as measured during the M&E sampling program, does not pose a health concern based on regulatory standards. Dilution of river water from downstream watersheds would reduce potential contamination effects downstream.

4.4.1 No Action

River Water

Under the No-Action Alternative, surface water (Ramapo River) which flows east of the Tuxedo Waste Disposal Site would not be treated in any manner. However, surface water contamination attributable to the site would tend to attenuate over a period of time following site remediation programs that address sources of river contamination. This alternative may not achieve the remedial action objective for the river water. Long-term monitoring and/or institutional controls are recommended with this option since contamination of the river may increase over time without remedial actions at the site. Institutional controls relating to the river, as discussed below, could include restrictions on use as a drinking water source and on recreational fishing for the protection of public health.

Sediment

Under the No-Action Alternative, the contaminated sediments in the Ramapo River would remain untouched. Remediation of the contamination sources from the site will eliminate or minimize future releases of hazardous constituents over time to the river sediment. Naturally occurring processes may be effective in reducing sediment contamination through the continued slow erosion and downstream migration of the contaminated sediments or by covering of the contaminated sediments with clean silts/soils. Over time, therefore, this alternative may achieve the remedial action objective for this media In addition, some organics may be biodegraded. If the sources of contamination are not addressed, the sediment could be further degraded.

4.4.2 Institutional Action Alternative

Institutional actions for Ramapo River water and sediment include use restrictions (such as restrictions on use as a water supply and on recreational uses such as fishing), treatment of water supply, and monitoring. While these actions will not reduce contamination from the site, they can protect populations from possible exposure risks. This alternative alone may not meet the remedial action objective for the site. However, if used in conjunction with other source control remedial measures, it would eventually achieve this objective.

Treatment of the water supply relates to uses and potential uses of the Ramapo River as a drinking water supply. Within New York State, no communities are currently known to use the Ramapo River as a drinking water source. The North Jersey District Water Supply Commission draws some of its water from the Ramapo River approximately 22 miles downstream of Tuxedo. The water quality of the river near the site, as measured during the M&E sampling program, does not pose a health concern based on regulatory standards. Dilution of river water from downstream watersheds would reduce potential contamination effects downstream

The institutional actions described above could be implemented. However, they would be difficult to monitor and enforce. This alternative will be retained for further evaluation.

4.4.3 Source Removal

Excavating the fill wastes for on-site treatment, or for removal and off-site treatment and disposal, would eliminate the site-related sources of groundwater and leachate contamination. Since the groundwater is in hydraulic connection with the riverine system, and leachate appears to be discharging directly to the river bank, removal and/or off-site treatment of fill wastes would prevent further contamination and degradation of the river and sediment. A more extensive discussion of this approach is presented in section 4.5.

4.4.4 Source Isolation

The containment methods in this subsection are applicable to Ramapo River water and to sediment contamination. Also included are physical isolation methods for sediments to minimize the contact of surface waters with contaminants and to reduce their transport. Isolation methods to be considered include surface sealing and cover methods.

Downgradient Groundwater Barrier

Since contaminated groundwater from the Tuxedo Waste Disposal Site is in hydraulic connection with the Ramapo River and surface leachate may be impacting bank sediments, physical barriers can be considered as a mitigation method. Such methods typically include subsurface vertical barriers, such as slurry walls. Downgradient groundwater barriers are discussed in Section 4.3.4. Use of a downgradient subsurface groundwater barrier would necessitate ancillary pump and treat techniques unless infiltration to the site groundwater can be totally eliminated, which is probably not feasible.

Retaining Dikes and Berms

This isolation technology can include earthen embankments and other methods that can be used to minimize the flow of surface leachate emanating from the landfill to the river system. With such barriers, collection and treatment of leachate would be required.

Cover Methods

This technology involves use of inert materials to cover contaminated sediments to minimize leaching and prevent erosion and subsequent transport. In addition, chemically reactive materials can be used both to cover and treat/stabilize contaminated sediments in situ. Such materials include limestone, greensand, oyster shells, gypsum, ferric sulfate, and alum. The methods used to place these cover materials include point dumping and submerged diffuser systems. This alternative would meet the remedial action objective for this media and could be implemented using commercially available equipment. However for the reasons discussed in section 4.4 (i.e., uncertainties of site impact on the sediments, upgradient sediment contamination), this alternative is not retained for further evaluation.

Surface Sealing or Stabilization

This process involves applying cement or other grouting materials to areas of identified sediment or bank contamination, or mixing these materials with contaminated bottom sediments to create a seal, thereby minimizing leaching, erosion, and subsequent downstream dispersion of contaminated sediments. This is typically accomplished by pneumatically applying a layer of either concrete or grout to form a surface seal. A variant of the above is to mix the contaminated sediments with binding agents, such as concrete, quicklime, or a grout to stabilize the contaminants and prevent their release to the river water.

Construction of a coffer dam may be necessary before excavating, treating, in situ or covering river bottom sediments. These structures can be constructed from soil, sheet piling, earth filled sheet pile cells, and sand bags for installation in streams to isolate contaminated areas from stream flow. The area(s) can then be dewatered, dredged, excavated, or capped.

This alternative would meet the remedial action objective for the media and could be implemented with commercially available equipment, but for the reasons stated in section 4.4 (i.e., uncertainties regarding impact of site on sediment and upgradient sediment contamination), this alternative will not be retained for further evaluation at this point in time.

4.4.5 Preliminary Screening Results

The screening results for surface water and sediment treatment technologies are shown in Table 4-3. Based on an evaluation of treatment effectiveness for attaining clean-up goals, on implementability, and on EPA[1] and NYSDEC[2] screening criteria, the following technologies will be retained for further analysis as components of remedial alternatives

- No action with monitoring of river water and sediment, and use restrictions as appropriate
- Source isolation/diversion (see groundwater section)
- Source removal (see fill waste/soil section)
- Source isolation/diversion/removal, treatment and disposal, if required based on results of monitoring

Sediment removal or capping/sealing/stabilization would be feasible for attaining long-term goals only if the pathway of contamination is eliminated or controlled (see Section 4.4.3). Treatment of municipal water supply is not applicable or required under present river water quality conditions

4.5 FILL WASTE/SOIL REMEDIAL ACTION ALTERNATIVES

The fill wastes of concern are those deposited on the Barone/Khourouzian parcel and those wastes deposited on the adjoining Georgia Tech parcel. Because the site is already covered with clean soil, except for a small area in the southeast corner and on the Georgia Tech property, fill waste and contaminated soil do not currently represent a direct exposure risk. However, the effects of the fill waste and soil contamination are manifested in other media, primarily soil gas and groundwater, at the present time. Removal or stabilization of the waste materials and contaminated soil would eliminate the source of contamination in the other media.

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(1) Guidance for conduction Remedial Investigations and Feasibility Studies under CERCLA, EPA/540/G-89/004, October 1988.

(2) NYSDEC TAGM for selection of remedial actions at inactive hazardous waste sites, September 13, 1989.

The nature and extent of soil contamination at the site is described in Volume 1, Remedial Investigation. Tests performed on Georgia Tech waste[1] in 1988 indicated that while fill waste contamination may be similar to the materials on the Barone/Khourouzian parcel, an EP toxicity analysis did not identify the Georgia Tech materials as hazardous waste

Table 4-4 presents and screens technologies applicable to fill waste/soil remediation

4.5.1 No Action Alternative

With the No Action Alternative, the fill waste and contaminated soil would remain undisturbed. With no action, groundwater contamination in the overburden layer may increase with time. Limited data indicate that groundwater in fractured bedrock is becoming affected by communication with the contaminated groundwater above it Contamination in the lower portions of the aquifer (fractured bedrock) could also increase over time. The groundwater contamination will migrate to river sediment, particularly near the west bank, and may adversely affect river water quality if no other remedial actions are undertaken.

With the No Action Alternative, long-term monitoring of groundwater and river system parameters would be performed per CERCLA requirements so that trends in the extent of media contamination can be detected and anticipated. Should significant identified risks to public health or the environment develop, remedial actions could then be undertaken.

As discussed in Section 4.2, generation of landfill gases apparently has passed its peak. If this is the case, emissions of soil gases containing toxic organic vapor should diminish with time, and potential exposures to air contaminants should be reduced, even with the fill wastes remaining in place.

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(1) Summary NYSDEC Phase II Report, M&E Project Work Plan, Volume 2, June 1990.

TABLE 4-4

PRELIMINARY SCREENING
FILL WASTE/SOIL TREATMENT ALTERNATIVES

Response Media	General Response Action	Remedial Technology	Process Options	Effectiveness	Implementability
Fill Waste/Soil (Tuxedo Site)	Institutional	None	Not applicable	May not achieve remedial action objectives	None related to specific GRA
		Access Restriction	Fencing	Effective in restricting access to exposed areas of contamination. May not achieve remedial action objectives	Readily implementable using locally available materials and equipment. Susceptible to vandalism. Requires maintenance and monitoring
		Land Use Restrictions	Deed restrictions	Effectiveness dependant upon continued future implementation. Does not reduce contamination	Dependent upon legal requirements and authority. Difficult to implement. Requires owner's consent
	Containment	Surface Cap	Layered soil	Effective in providing a physical barrier between fill waste and surface when properly maintained and implemented in conjunction with institutional GRAs. Least susceptible to cracking. May not meet remedial action objectives alone.	Readily implementable using conventional construction requirements. Materials and equipment available.
			Asphalt	Effective in providing a physical barrier between fill waste and surface when properly maintained. ~~Susceptible to cracking.~~ May not meet remedial action objectives alone.	Implementability dependant upon availability of materials. Soil gas collection system may be needed.
			Synthetic material	Effective in providing a low permeability barrier between fill waste and surface. ~~Increased effectiveness~~ when implemented in conjunction with alternate process options. May not meet remedial action ~~objectives alone. Does not~~ reduce volume or toxicity of waste alone.	Readily implementable. Soil gas collection system probably necessary.

TABLE 4-4 (continued)

PRELIMINARY SCREENING
FILL WASTE/SOIL TREATMENT ALTERNATIVES

Response Media	General Response Action	Remedial Technology	Process Options	Effectiveness	Implementability
Fill Waste/Soil (Tuxedo Site) Continued	Removal	Excavation	Excavation/Transportation/ Disposal	Effective in removing source of contamination. Short-term exposure risks high. May achieve remedial action objectives. Massive potential risks if accident occurs while transporting untreated material off-site. Does not reduce volume or toxicity of waste alone.	Questionable implementability made difficult by presence of combustible gases, unknowns within the landfill, off site exposure hazards and active railway. Requires on site treatment prior to disposal or identification of suitable TSD facility for disposal of fill waste/soil.
			Excavation/ Treatment/Disposal (Transportation if off site treatment)	Same as above with treatment options. See "Off-site Incineration" below	Similar potential operational hazards as above.
	Treatment	Thermal	Incineration (on site)	Effective in removal and destruction of certain contaminants. Reduction of volume through incineration of fill waste. Increase in metals toxicity through concentration in ash residue.	Implementability moderately difficult. May need prior crushing and grinding. Disposal of incinerator bottom and fly ash required. Permits may be required and difficult to meet limits. Requires construction of processing unit and staging areas on site. Disposal of ash may be a problem due to metals content.
			Incineration (off site)	Same as above with transportation to TSD facility.	Difficult to implement due to off-site facility's ability to take this type of material with these types and levels of contaminants. May need prior crushing and grinding.
		Stabilization (on site)	Various	Effective in reducing mobility of certain contaminants by combining with stabilizing agents. Large increase in volume of waste through addition of stabilizing agent. May not be suitable for certain types of waste.	Moderate implementability. Need to construct processing and staging areas on site. May need prior crushing and grinding. Volume of treated material may not be landfilled due to lack of landfill space.

TABLE 4-4 (continued)

PRELIMINARY SCREENING
FILL WASTE/SOIL TREATMENT ALTERNATIVES

Response Media	General Response Action	Remedial Technology	Process Options	Effectiveness	Implementability
Georgia Tech Fill Waste	No action	None	Not applicable	Does not achieve remedial action objective	Readily implementable
	Institutional	Access/Land Use Restrictions	Fencing/deed restriction	See "Institutional GRA" under fill waste/soil response media	See "Institutional GRA" under fill waste/soil response media
	Containment	Surface Cap	Layered soil asphalt synthetic material	See "Containment GRA" under fill/waste soil response media.	Difficult to implement due to slope problems, proximity of property to rail line, and drainage problems.
	Relocation	Excavation	Conventional construction	Effective in relocating fill waste from Georgia Tech property to Tuxedo Site fill waste area	Readily implementable but may require special equipment to excavate materials
	Removal	Excavation	Excavation; Transportation Disposal	See "Removal GRA" under fill waste/soil response media. However, short-term risk is lower than B/K Parcel	Smaller volumes involved may make landfill disposal feasible.
	Treatment	Thermal	Incineration (Off-Site)	See "Treatment GRA" under fill waste/soil response media.	Smaller volumes involved may make off site incineration more feasible
			Incineration (On-Site)	See "Treatment GRA" under fill waste/soil response media.	Practical only if performed together with Tuxedo fill waste.
		Stabilization	Various (On-Site)	See "Treatment GRA" under fill waste/soil response media.	Most practical if performed together with Tuxedo fill waste, but could be done separately

This alternative would not meet remedial action objectives for soil gas release in the short term and would take a long time to reduce current risks. However, it could be easily implemented in a short period of time and the monitoring would be an effective tool for assessing site changes. This alternative is feasible and will be retained for further evaluation.

4.5.2 Institutional Action Alternatives

Institutional actions for the fill waste include land use and access restrictions. These actions will not deal with the contamination directly, but will limit exposures to potential on-site hazards.

Land use restrictions may include zoning regulations and deed restrictions to prevent further exposure to the contamination. These types of restrictions may be difficult to enforce. In most cases, they would require property owners' consent. For these reasons they may be difficult to implement.

Access restrictions such as fencing would physically restrict exposure to the site contaminants thereby reducing exposure risks. They could be implemented easily using readily available equipment and materials. However, maintenance and monitoring would be required. In addition, these types of restrictions are easily breached and are subject to vandalism.

Both land use and access restrictions are feasible for this media and therefore will be retained for further evaluation.

4.5.3 Surface Cap

Surface capping is a proven containment technology that utilizes clean soil, concrete, asphalt, or synthetic materials individually or in combination to limit and/or control the migration of soil contaminants. In generic terms, it represents a horizontal barrier. Surface capping may effectively be used alone or in conjunction with other technologies to control or prevent the erosion and transport of contaminated soils by wind and stormwater runoff; to control releases of soil gases directly to the atmosphere; and to retard groundwater contamination resulting from the infiltration of precipitation or surface run-on into the contaminated soils The equipment and materials necessary to install a surface cap are readily available. Materials include soil, soil-cement-bentonite mixtures, asphalt, chemical sealants and stabilizers, and synthetic membranes.

The overall site remediation plan would most likely include a final cover system to satisfy the landfill closure requirements of 6 NYCRR Part 360 Sections 360-2.15, 360-7.11, and Section 373 2 A final cover system designed to satisfy these requirements generally consists of a gas venting layer and a . permeability barrier layer overlain by a topsoil layer. Low permeability barrie. materials typically consist of soils or clays compacted to a minimum thickness of 18 inches. As an alternative, a geomembrane may be used which satisfies the specifications in Section 360-2.13(r). Closure of a C&D landfill does not require a gas venting layer, per NYS regulations, unless migration off-site of significant concentrations of methane (as soil gas) are a problem. However, the presence of hazardous waste prevents the site from being classified as a C&D landfill.

An effective surface cap in conjunction with a passive gas collection/treatment system could control releases of toxic vapors to the atmosphere. Such a passive gas collection system could be designed and configured for future conversion to an active gas collection systems should conditions warrant this.

Based on the above discussion, this alternative would achieve all remedial action objectives for this media if it includes a gas collection/treatment system. It would reduce exposure risks, and it could be implemented using commercially available equipment and materials. For these reasons, it will be retained for further evaluation.

4.5.4 Waste Materials on Georgia Tech Parcel

During the operation of the landfill activities on the Barone/Khourouzian Parcel, wastes were also deposited on the northwestern and northeastern sides of the Georgia Tech property. Approximately 3,500 cubic yards of fill material are located in the southwestern section of the Barone/Khourouzian parcel and encroach on the northwestern part of the Georgia Tech parcel. These materials on the Georgia Tech property abut Route 17 and the drainage ravine feeding the 24-inch drain pipe running through the B/K parcel. The waste materials deposited here are covered with fill and will be treated a part of the Barone/Khourouzian (B/K) Parcel and are included in the approximated 480,000 cy of material discussed as the B/K parcel. Therefore, all alternatives proposed for the B/K parcel are applicable for this area.

The materials on the northeastern portion of the Georgia Tech property will be evaluated separately and discussed as Georgia Tech Alternative. They are partially uncovered and exposed at the present time. The area is unsightly and presents potential physical hazards. These materials can be excavated and relocated on the B/K Parcel between (e.g.) Tuxedo grid lines 200N to 550N and 300E to 500E. The thickness of the fill material layers will vary from 4 to 8 feet, depending on location, and will cover approximately 60,000 square feet. After placement of a final cover, this will bring the existing elevation of 487 feet in this zone to 496 feet.

It is not feasible to install a surface cap in this area due to slope problems involving the borrow pit. The proximity of this area to the rail line and the drainage situation in this area would pose additional problems with installation of a cap.

Other alternatives for dealing with the waste on the northeast side of the Georgia Tech property are listed below:

- Access restrictions (fences)
- Land use restrictions
- Excavation and transport for treatment (incineration) and disposal
- Excavation and treatment on the Barone/Khourouzian Parcel by incineration

Incineration of the Georgia Tech parcel wastes on the Barone/Khourouzian parcel would be feasible if performed in conjunction with similar treatment of the fill wastes on the main portion of the site (B/K Parcel).

4.5.5 Excavation with Transportation Off-Site, Disposal and/or Treatment

Excavation and transportation off-site would be part of an alternative involving off-site treatment and/or disposal. This alternative potentially could be applied to the waste on both parcels. However, since the volumes involved in these two wastes are radically different, this could affect the feasibility of the alternative in each case. The waste volume which can feasibly be removed from the Georgia Tech parcel is estimated at 14,600 cubic yards. The volume of waste fill on the Barone/Khourouzian parcel has been estimated at approximately 480,000 cubic yards.[1]

Excavation and transportation of large volumes of waste from the site may present formidable problems

- The amount of hazardous waste in the fill is not fully known.
- Excavating the landfill could result in significant risks to on-site workers and significant releases of contaminants.
- Physically implementing the excavation of the landfill would be very difficult and would require specialized equipment and construction safeguards.
- Transportation of large volumes of heterogeneous, potentially hazardous waste materials may require several different types of containerization.
- A preliminary estimate based on a typical vehicle capacity of 30 cubic yards indicates transportation of the entire volume of waste fill on the B/K Parcel would involve about 16,000 truck loads. Transportation of the Georgia Tech waste would involve about 490 additional truck loads. There is significant potential for an accident to occur during the transport of this material, with the resulting potential for exposure to the contaminated materials.

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(1) Remedial Investigation and Feasibility Study, Volume 1, Remedial Investigation (M&E, October 1991)

Disposal Off-Site

Disposal at an off-site landfill would require separating contaminated wastes from non-contaminated materials and identifying a landfill or landfills with sufficient capacity to accept the volumes of fill waste. Contaminated soil and materials would require treatment prior to landfilling due to land ban regulations. These regulations are applicable and would restrict the disposal of certain types of materials and contaminants. This is not feasible for either parcel due to lack of available landfill space, difficulties with separating contaminated materials from non-contaminated materials, and compliance with land disposal restrictions. A new secure landfill might be sited in the Tuxedo area, but complying with all applicable regulations and obtaining necessary permits may be very difficult. In addition, the size of the landfill needed to accommodate the volume of material requiring disposal may present a problem due to limited land availability in the area.

Incineration Off-Site

This approach would involve excavating the waste and transporting it to a facility permitted for incinerating hazardous wastes. The incineration process involves oxidizing toxic organic chemical compounds at high temperatures and converting them to innocuous substances such as carbon dioxide, water, and inorganic ash. However, oxidation of chlorinated organics can release toxic gases, and metals present can contaminate the ash. Two important operating parameters in incineration are residence time and operating temperature. An additional option is use of an after-burner or secondary combustion chamber. Incineration technologies that can be utilized include the following:

- Rotary Kiln Incineration
- Multiple Hearth Incineration
- Fluidized Bed Incineration

A number of high temperature incinerators currently in use are available for the treatment of hazardous waste. Two major types of units are rotary kiln incinerators and multiple hearth furnaces. Rotary kilns are capable of handling waste material in virtually any physical form. Rotary kiln incinerators are often equipped with wet scrubbers or bag houses to control emissions. Multiple hearth furnaces are also usually equipped with air pollution control devices, and they can be used for all types of combustible waste.

Fluidized bed incinerators typically consist of a vertical cylinder, refractory-lined, with a bed of inert granular material (normally sand) on a perforated metal plate. Combustion air is introduced at the bottom of the chamber, fluidizing the bed while maintaining turbulence. The waste material is injected into this granular material, and combustion takes place within the fluidized bed.

Treatment by off-site incineration often requires that pilot tests be performed to choose the most effective operational parameters. Trial burn tests typically include submitting a representative sample to a facility to determine if emission requirements can be attained, to optimize the method of incineration, and to characterize the resultant ash. Examples of such incineration facilities are as follows:

- Rollins Environmental Services, Inc. (RES) operates a federally permitted hazardous waste incinerator in Deerpark, Texas. This incinerator operates at temperatures in excess of 2,000°F, effectively destroying such compounds and materials as halogenated solvents, plastics, pesticides, petroleum wastes, and other organic compounds.
- Ross Incineration Service, Inc. operates a RCRA permitted hazardous waste incinerator in Grafton, Ohio. This incinerator utilizes a rotary kiln reactor to destroy wastes.
- Chem-Waste operates a federally permitted hazardous waste incinerator in Oakbrook, Illinois.

Discussions with several off-site facilities have indicated that the type, size, and sheer volume of material requiring treatment may present a problem. Based on this information, the material may need to be incinerated at several different facilities. The vendors listed above indicated that some of the contaminants and levels of contaminants in the waste (e.g., chromium) might present a problem for their facilities. This material would then have to be decontaminated on-site prior to disposal. Some vendors could not handle certain materials (i.e., structural steel) expected to be in the landfill. In addition, some vendors require the material to be drummed and the material in the drums be no larger then 6 inch by 6 inch pieces This would require on-site grinding and shredding prior to transport. Based on these reasons, off-site incineration would be very difficult to implement However, it will be retained for further evaluation.

4.5.6 Excavation with Treatment and Disposal On-Site

While the excavation of the fill waste and contaminated soils would pose the same problems discussed in the preceding section (4.5.5), off-site transportation would not be involved Nevertheless, on-site treatment would involve moving and staging a very large volume of waste materials, as well as possible crushing and grinding of waste materials to comply with requirements of the treatment facility. Decontamination of certain landfill materials may also be required In addition, a suitable treatment area(s) on the site would be required. Two classes of technologies have been previously identified as being potentially applicable for on-site treatment of Tuxedo Fill waste and contaminated soils:

- Incineration
- Solidification (stabilization)

Incineration On-Site

A brief discussion of incineration technology is presented in Section 4.5.4. Incineration would destroy the toxic organic contaminants in the fill waste and soils at the site. However, the relative toxicity of metals (on a unit weight basis) would actually increase due to the concentrating effect of incineration on metals in the ash residue. The presence of metals in the ash residue may preclude disposal at the site without additional chemical treatment. Emissions from on-site incineration processes can be controlled with existing technology; e.g. scrubbers, bag houses, etc.

On-site incineration generally requires a minimum of 10,000 cubic yards of contaminated soils to be considered economically attractive. Units are reportedly available which process 5 tons of waste per hour.

The equipment for on-site incineration could be constructed or brought to the site and designed based on all site conditions (e.g., contaminants, contaminant levels and types of landfill materials) A potential uncertainty is the availability of a suitable area for siting the treatment system and for staging the wastes. On-site incineration systems may require as much as 40,000 square feet of area for set-up, depending on the system selected. It may be necessary to excavate an area of the site and then backfill with clean soil from off-site to create a space for the system.

Such an incinerator would need to meet the substantive requirements of an air permit from NYSDEC Also, off-site transportation and disposal of residues, if required, would have to comply with USDOT hazardous materials shipment regulations and RCRA regulations for the shipment, disposal, and treatment of hazardous waste. This alternative would be difficult to implement for this site However it is feasible and will be retained for further evaluation.

On-Site Solidification and Immobilization

The main objective of solidification and chemical fixation techniques is to reduce the mobility of inorganic and (low levels of) organic waste constituents. Solidification (stabilization) techniques may decrease the surface area across which transfer of hazardous constituents can occur and may limit the solubility or toxicity of the hazardous waste constituents. Solidification of site wastes would result in a substantial increase in the total volume of wastes due to the addition of solidification materials.

Solidification implies that the hazardous waste is integrated into a solid matrix of high structural integrity. Encapsulation involves surrounding the waste materials with an impervious covering. Microencapsulation infers that the hazardous constituents are mechanically locked within a solidified matrix structure. Immobilization technologies primarily limit the solubility or mobility of metals and organic wastes with or without change or improvement in the physical characteristics of the waste.

For heterogeneous waste materials, crushing and grinding of the waste prior to treatment is generally necessary. If large metal objects or drums containing concentrated hazardous waste are present, these materials may require segregation and decontamination or disposal

Solidification: Solidification is a process in which the waste is sealed in a hardened mass. The process mechanically binds and seals the material rendering the contaminated mass immobile Solidification technologies are designed to prevent leaching of contaminants from the waste matrix, improve handling, and decrease surface area. A disadvantage of solidification is that the addition of various agents usually results in a substantial increase in total volume of material.

Solidification technologies can be divided into the following major classifications, based on the binding agents added to the waste:

- Pozzolanic-based
- Silicate-based
- Thermoplastic-based
- Organic polymer-based

Combinations of additives may be used, depending on the nature of the waste stream to be treated. Historically, the cement-based and pozzolanic-based stabilization/solidification processes have been most widely used because of their effectiveness in treating inorganic waste streams. Recently introduced proprietary additives are resulting in effective treatment for some organics. However, some of the volatile organics found in the site materials may not be immobilized by this process. In addition, some of these volatile organics may volatilize during the actual treatment process thus creating other potential risks. Silicates in combination with lime, cement, and other materials are reportedly effective with soils contaminated with solvents. Other materials used in the solidification processes are clays, emulsifiers, surfactants, and adsorbents.

Typically, a dike is constructed around the contaminated zone to control the mixing area. The binding agent can be mixed in place with a backhoe or bulldozer for uniform contact with the contaminated mass. The mixture is left to set or cure, creating a hardened mass

Immobilization: Immobilization processes are designed to prevent leaching of contaminants by lowering their solubilities or leachabilities. Treatment methods include precipitation and adsorption. Precipitation can be used to immobilize heavy metals using sulfide, phosphate, hydroxide, or carbonate. Adsorption is usually achieved by the introduction of an adsorbent into, in this case, a solid medium causing the contaminants to bind to the adsorbent, thereby limiting the potential for contaminant leaching

Disposal

Solidified or stabilized wastes can be disposed of on-site or removed for off-site disposal. On-site disposal of the stabilized waste would require the design and construction of containment cells. The design parameters and integrity requirements for the cells would depend on the leaching and compressibility tests performed on the final product. However, on-site and off-site disposal of the treated wastes may be prohibited by the land ban, depending upon results of TCLP tests. In addition, the stabilization process will significantly increase the volume of material requiring disposal. The land available at the site is insufficient to handle this volume, and existing off-site landfills cannot handle this kind of volume. Furthermore, all new landfills require permits which are difficult to obtain. For these reasons, this technology will not be retained for further evaluation.

4.5.7 Potential Risks

Site intrusive activities during remediation operations may present risks affecting surface water, groundwater, and air quality. These potential risks could affect both site workers and the community. Excavation and handling activities for removal and/or treatment of buried waste and contaminated soil would probably expose site workers to hazardous materials. Such intrusive construction work could result in releases of volatile organic compounds and further expose surface run-on and groundwater to landfill contaminants. In addition, physically disturbing the waste materials could result in fugitive airborne emissions of contaminated soils and dusts, which could migrate off-site. Dust can be controlled by keeping the excavated material wetted. Workers can minimize their exposure to contaminants by wearing personal protective equipment.

4.5.8 Preliminary Screening Results

The screening results for fill waste/soil treatment technologies are shown in Table 4-4. For the purpose of this study, the fill waste/soil system for the site will be considered to consist of two separate operable units:

- Barone/Khourouzian Parcel fill waste/soil
- Georgia Tech Parcel fill waste

The reasons for making this distinction are as follows:

- Fill waste was improperly deposited on the Georgia Tech property, which is not part of the main (Barone/Khourouzian) waste disposal site.
- A portion of the Georgia Tech waste is currently uncovered and exposed.
- The volume of waste on the Georgia Tech property is significantly smaller than fill waste contents on the main site, permitting additional options to be considered for the former

Based on an evaluation of treatment effectiveness for attaining clean-up goals, on implementability, and on EPA[1] and NYSDEC[2] screening criteria, the technologies listed below will be retained for further analysis as components of remedial alternatives.

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(1) Guidance for conducting Remedial Investigations and Feasibility Studies under CERCLA, EPA/540/G-89/004, October 1988.

(2) NYSDEC TAGM for selection of remedial actions at inactive hazardous waste site, September 13, 1989.

Barone/Khourouzian Parcel Waste

The following technologies are retained for detailed analysis:

- No Action with land use restrictions, access restrictions (as appropriate), and monitoring of affected media.
- Surface soil cap without gas collection and monitoring of affected media. The cap may consist of one or more of the following: layered soil, asphalt, synthetic membrane.
- Surface soil cap with gas collection and treatment, and monitoring of affected media.
- Excavation and transport of fill waste/soils off-site for treatment (incineration) and disposal.
- Excavation and incineration on-site with residue disposal on-site or off-site

Minimum action for the waste fill on this parcel would be an impervious cap to comply with 6 NYCRR Part 360 regulations for closing a landfill.

Excavation of the fill waste/soil for transport and disposal at other landfill sites without treatment has been eliminated for further analysis based on the preliminary screening process. The reasons for eliminating this option are:

- Without treatment, neither the volume nor the toxicity of the wastes will be reduced. EPA land ban restrictions would apply.
- The mobility of the contaminants would be reduced only to the extent that the materials are placed in a suitable hazardous waste landfill.
- The availability of suitable landfills to accept the volume of waste materials involved is questionable. It is unlikely a site would be available to create a new landfill for these materials based on RCRA Land Ban considerations.

Georgia Tech Parcel Wastes

The following alternatives are retained for further analysis:

- No action with monitoring

- Removal of all or part of waste for redeposition on the B/K parcel.
- Removal for off-site treatment (incineration) and disposal
- If applicable, removal for incineration on the main site along with the waste materials on the B/K parcel

4.6 COMBINATIONS OF APPROPRIATE ALTERNATIVES

Based on this preliminary screening of the treatment options and alternatives (Phase II Feasibility Study), the list of Combinations of Appropriate Alternatives developed in Task 2 of the RI/FS (see Table 4-3) has been narrowed down for further detailed analysis. The Appropriate Alternatives retained for further study are shown in Table 4-5 for fill waste/soil on the Barone/Khourouzian parcel and Table 4-6 for Georgia Tech Site Wastes.

4.6.1 Barone/Khourouzian Parcel Fill Waste/Soil

Aside from the No Action Alternative, the minimum treatment retained is a surface soil cap without collection/venting of soil gas. This is supplemented in Alternatives 3 to 5 with various combinations of treatment levels for soil gas, and groundwater.

The non-treatment alternatives for each medium involve monitoring, and possibly use restrictions and institutional remedies where appropriate. The non-treatment or passive treatment alternatives would be designed for possible upgrading to active extraction and treatment should the need arise.

Within each treatment alternative are included one or more process options; e.g., treatment of soil gas by thermal destruction, carbon adsorption, or liquid absorption (scrubbing). These process options have been deemed feasible at this present level of screening. Further analysis, taking costs into effect, will refine the selection.

Alternatives 6 and 7 involve excavation (removal) of the fill wastes and contaminated soil at the site with treatment and disposal on-site, or removal and

TABLE 4-5

COMBINATIONS OF APPROPRIATE ALTERNATIVES
FROM PRELIMINARY SCREENING - TUXEDO FILL WASTE/SOIL

Alternative	Fill Waste/Soil	Soil Gas/Air	Groundwater	Surface Water/Sediment
1	No action	Monitoring as required	Monitoring as required	Monitoring as required
2	Surface soil cap without soil gas collection/venting. Use and access restrictions as appropriate.	Monitoring as required	Monitoring as required. Use restrictions if required (alternate drinking water supply, or drinking water point-of-use treatment for affected wells)	Monitoring as required
3	Surface soil cap with soil gas collection/venting. Use and access restrictions as appropriate.	Passive interior and perimeter collection system, with activated carbon treatment of vented gas. Monitoring as required, with option to upgrade to active extraction system and treatment	Monitoring as required. Use restrictions if required (alternate drinking water supply, or drinking water point-of-use treatment for affected wells).	Monitoring as required
4	Surface soil cap with soil gas collection/venting. Use and access restrictions as appropriate.	Active interior and passive perimeter soil gas collection with treatment by thermal destruction, carbon adsorption or solvent absorption	Monitoring as required. Use restrictions if required (alternate drinking water supply, or drinking water point of use treatment for affected wells). Provisions to upgrade to extraction treatment system, if required	Monitoring as required
5	Surface soil cap with soil gas collection venting. Use and access restrictions as appropriate.	Active interior and passive perimeter soil gas collection with treatment by thermal destruction, carbon adsorption or solvent absorption	Downgradient vertical barrier. Diversion of run-on to site. Downgradient extraction with treatment for metals (precipitation or ion exchange) and organics (activated carbon). Discharge of treated groundwater to Ramapo River.	Monitoring as required
6	Excavation of fill waste/soil. Transportation off-site for treatment (incineration) and disposal.	Engineering controls during remedial action	Site groundwater extraction, treatment and discharge	Monitoring as required.
7	Excavation of fill waste/soil for treatment (incineration) on-site with ash disposal on- or off-site	Engineering controls during remedial action	Site groundwater extraction, treatment and discharge	Monitoring as required

TABLE 4-6

COMBINATIONS OF APPROPRIATE ALTERNATIVES FROM PRELIMINARY SCREENING - GEORGIA TECH SITE WASTE

Alternative	Georgia Tech Site Waste
1	No Action
2	Removal of all or part of waste for redeposition on Barone/Khourouzian Parcel
3	Removal and transportation off site for incineration treatment and disposal
4	Removal to Barone/Khourouzian Parcel for incineration and disposal

transport off-site for treatment and disposal.

Some options are tentative at this point: for example, the need to remove or stabilize/cover contaminated river sediments.

4.6.2 Georgia Tech Parcel Waste

A portion of the waste on the Georgia Tech property is currently uncovered and exposed. This issue must be dealt with at a minimum. The treatment alternatives shown in Table 4-6 are similar to those for the fill waste/soil on the B/K Parcel. In addition, all of the Georgia Tech waste can be removed and redeposited on the Barone/Khourouzian parcel. Incineration of the Georgia Tech wastes on the Barone/Khourouzian parcel would only be most feasible if performed in conjunction with similar treatment of the wastes on that parcel.

5.0 DETAILED ANALYSIS OF ALTERNATIVES

The purpose of the detailed evaluation of alternatives is to present the assessment results so the different alternatives can be compared by the agencies responsible for selecting a preferred alternative. In this section, the alternatives that were developed and described in Section 4.0 are further refined and analyzed according to eight criteria. These criteria, based on NCP 40 CFR, Part 300, are:

- Overall protection of human health and the environment
- ARARs compliance
- Short-term effectiveness
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Implementability
- Cost effectiveness
- Community acceptance

These eight evaluation criteria are defined and described in detail in Section 5.1. Detailed evaluations of the alternatives, based on these criteria, are presented in Sections 5.2 and 5.3 for the Barone/Khourouzian (B/K) Parcel and the Georgia Tech Parcel, respectively Alternatives are compared in Section 5.4. Given existing knowledge of the site, uncertainties exist for many of the alternative designs presented. These uncertainties are discussed in the evaluations in Sections 5.2 and 5.3 and are summarized in the comparison of alternatives in Section 5.4. In a similar fashion, additional data needs are described for each alternative within Sections 5.2 and 5.3. and summarized in Section 5.4.

5.1 EVALUATION CRITERIA

The eight criteria described in this section provide the bases for evaluating and comparing remedial alternatives under CERCLA as described in current USEPA guidance (USEPA, 1988) (40 CFR Part 300). Of the eight criteria, two are considered threshold criteria that must be met by a selected alternative. These threshold criteria are: 1) protection of human health and the environment, and 2) compliance with ARARs. Five criteria are termed primary balancing criteria, short-term effectiveness; long-term effectiveness; reduction of toxicity, mobility, or volume through treatment; implementability; and costs. They do not establish threshold acceptance criteria, but provide a basis for comparing the alternatives. The final criterion, community acceptance, is considered a modifying criterion because it provides for public input that may influence the selection of a remedial alternative.

5.1.1 Threshold Criteria

Threshold criteria establish specific criteria that must be met before an alternative can be selected. These two criteria are protection of human health and the environment and compliance with ARARs.

Overall Protection of Human Health and the Environment

This criterion addresses the provision of adequate protection of human health and the environment. It draws on assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. It also includes an assessment of site use after remediation and a habitat based assessment in accordance with New York State guidance.

Each alternative is evaluated with regard to protection of human health. Risks of adverse health effects due to exposure to site contaminants from carcinogens and non-carcinogens are evaluated in terms of likelihood of exposure, assumptions in the analysis, and any mitigating factors. The remedial alternatives are evaluated in terms of their ability to feasibly reduce risks to minimum levels.

ARARs Compliance

ARARs have been identified for the Tuxedo Waste Disposal Site and are listed in Table 3-1 in Section 3 of this document. Three types of ARARs have been identified for the site. These are:

- Chemical (contaminant)-specific ARARs (e.g., maximum contaminant levels)
- Action-specific ARARs (e.g., minimum technology standards)
- Location-specific ARARs (e.g. exposures to humans and wildlife)

The ARARs of primary concern at the site are those addressing landfill closure, ambient air standards, and groundwater and surface water standards. Other ARARs of concern address, surface water sediment guidance, H_2S concentrations, and health risk assessments. If an alternative cannot meet an ARAR, the evaluation should indicate whether a waiver of the ARAR would be appropriate.

5.1.2 Primary Balancing Criteria

The five primary balancing criteria are the bases for comparing the advantages and disadvantages of the alternatives relative to each other. In addition, the results of these evaluations provide information needed to evaluate each alternative against the two threshold criteria discussed in Section 5.1.1.

Short-Term Effectiveness

Short-term effectiveness refers to the effectiveness of the alternative in protecting human health and the environment during the construction and implementation period before the response objectives are met. The following factors are evaluated under short-term effectiveness:

- Protection of the community during remedial actions.
- Protection of the workers during remedial actions.
- Environmental impacts of the remedial action.
- Time until remedial response objectives are achieved.

Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence refers to an alternative's effectiveness in the protecting human health and the environment (i.e., the amount of residual risk) after the response objectives have been met The three components of this criterion that will be addressed for each alternative are:

- Magnitude of residual risk
- Adequacy
- Reliability of long-term controls

Reduction of Toxicity, Mobility, and Volume

This criterion is used to evaluate the anticipated performance of the technologies which comprise an alternative. Treatment technologies that successfully reduce the toxicity, mobility, and volume of the waste are preferred over remedial technologies that merely limit contact with contaminated material by containment This evaluation will focus on the following factors:

- Ability of treatment processes and remedies to address principal threats.

- Amount and types of hazardous materials that will be destroyed or treated.

- Degree of expected reduction in toxicity, mobility, and volume.

- Degree of irreversibility of the treatment process.

- Type and quantity of residuals remaining after treatment.

- Statutory preference for treatment as a principal element.

Implementability

Implementability is evaluated by considering the following factors:

- Technical feasibility, including the ability to construct and operate the technology, reliability of the technology, the ease with which additional remedial action may be taken (if required) and monitoring considerations.

- Administrative feasibility, primarily coordination with other agencies and the ability to obtain their approval.
- Availability of services and materials.
- Availability of proposed technologies.

Costs

Costs are presented for each alternative based on the procedures in applicable USEPA guidance (USEPA, 1988). A summary cost table is included in Section 5.4. Appendix A provides detailed cost tables.

Three types of costs are examined in evaluating the alternatives. These include:

- Capital costs (present and future)
- Operating and maintenance costs
- Present worth

Capital costs include direct and indirect expenses. Direct expenses typically include the equipment, labor, and materials used in installing the remedial actions while indirect costs include engineering, financial, and other associated costs. Operating and maintenance (O&M) costs are those necessary to ensure the continued effectiveness of the remedial action after it has been installed. The accuracy of these costs should be +50% to -30 percent.

The present worth analysis is used to evaluate expenditures that occur over different time periods by discounting all future costs to the current year. This reduces the total cost of each alternative to a single figure that can be used for comparative purposes. Capital costs and O&M costs are presented and combined into a total present worth for each alternative. Present worths can then be readily compared among alternatives with different capital and O&M costs required over different time periods. For this report, net worth calculations were based on a 5% interest rate and a 0% inflation rate.

In addition to presenting costs for each alternative, a sensitivity analysis is done based on information available for each alternative. The sensitivity analysis assesses the effects of varying an alternative's design and costing assumptions on a present worth basis. Sensitivity analyses typically focus on factors that could change by a small amount and cause significant changes in the overall cost of an alternative. For the Tuxedo Waste Disposal Site, the factors chosen for the sensitivity analysis include process variations, the discount rate and the inflation rate. The results are discussed in the comparison of alternatives in Section 5.4.

5.1.3 Modifying Criterion

The last criterion details the feedback received from the community concerning the proposed remedial action plan (PRAP) These comments will be addressed in the responsiveness summary in the Record of Decision (ROD).

5.2 BARONE/KHOUROUZIAN PARCEL ALTERNATIVES

This section presents the analyses of the alternatives being considered for the Barone/Khourouzian (B/K) Parcel. For each of the seven alternatives discussed, the alternative is described first, followed by an evaluation of the alternative with respect to the threshold and balancing criteria described above.

5.2.1 B/K Alternative 1: No Action

The No Action Alternative is included to evaluate the effects of taking no remedial action on the B/K Parcel. It consists of no remedial action for any media, but does include monitoring of soil gas/air, groundwater, and surface water/sediments. The following discussion details the design of this alternative for the various media.

Description

Soil Gas/Air: For Alternative 1, soil gas/air activities will consist of quarterly ambient air monitoring of gases emitted into the air from the landfill and quarterly monitoring of perimeter soil gas for the first two years, followed by annual monitoring for the next 28 years. Every 5 years, the data will be reevaluated, and any changes would be implemented.

Monitoring the landfill gas emissions will require construction of five passive vapor probes for gas monitoring along the perimeter of the landfill. The vents will be constructed to a depth of two feet above the high water table or bedrock surface. They will have 1" stainless steel screen with a slot size of .020 and will be screened continuously up to five feet from the surface. One-inch stainless steel riser will be used for the five-foot interval between the screen and the surface, and will extend two feet above grade. The probes will be sand packed and grouted with cement bentonite slurry. An overcasing at each probe will consist of a locking, protective casing made of 3" steel locking Royer cap. Probes will be constructed at locations identified in the RI as having produced: 1) gas with a combustible gas concentration which exceeded 25% of the LEL for methane, and/or 2) an H_2S reading which exceeded background concentrations.

Monitoring of perimeter soil gases will include monitoring of soil probes for H_2S and combustible gas concentrations. Field monitoring events will be performed at times when highest concentrations would be expected and when requested by NYSDEC. Field instruments will include a flame ionization detector (FID) to detect methane and non-methane hydrocarbons, a photoionization detector (PID) to detect non-methane hydrocarbons, a combustible gas indicator (CGI) to detect methane and oxygen levels (lack of oxygen may affect the readings of other instruments), and a hydrogen sulfide monitor. If the field monitoring instruments show high levels of non-methane hydrocarbons, a sample will be collected for laboratory analysis to determine if the emissions exceed acceptable levels for the contaminants of concern. Acceptable levels will be determined by back-calculating concentrations that would exceed NYSDEC's proposed Ambient Air Guideline Concentrations (AGCs).

Exceedance of AGCs would trigger a health risk assessment and, potentially, remedial action. Frequent exceedance of 25% of the LEL in perimeter soil gas will result in reassessment of potential risks, and possibly additional remedial action to prevent landfill gas migration. Detection of H_2S concentrations that exceed the AGC for H_2S will require an evaluation of the odor nuisance to the surrounding environment.

The results of the monitoring program will be assessed annually and reevaluated every 5 years for a period of 30 years, and changes to the program may be implemented.

<u>Groundwater:</u> Samples will be collected from selected existing monitoring wells at the site on a quarterly basis for the first two years and annually thereafter for 28 years. Samples will be analyzed for volatiles, semi-volatiles, and metals. In addition, on an annual basis, groundwater from selected wells will be analyzed for all of the contaminants on the target compound list.

<u>Surface Water/Sediment:</u> Sediment and surface water samples will be collected quarterly for the first two years and annually thereafter for 26 years. Sediment samples will be collected at the same five locations as were sampled in the RI: (1) near the bank upstream of the site, (2) near the bank next to the site, (3) near the bank downstream of the site, (4) near mid-stream next to the site and, (5) near mid-stream downstream of the site. Surface water samples will be collected at the same locations as the surface water sediments, with the addition of an upstream sample at the midstream location. All of these samples (surface water and sediment) will be analyzed for volatiles, semi-volatiles and metals.

Threshold Criteria

<u>Overall Protection of Human Health and the Environment:</u> Acute health effects due to exposure to the maximum predicted hydrogen sulfide concentrations were modeled and evaluated in the RI. This evaluation concluded that no significant adverse human health effects would result from H_2S exposures modeled in this study.

However, occasional high concentrations of H_2S would constitute an odor nuisance to the surrounding communities.

Migration of landfill gases into the surrounding environment can occur via natural vents in the soil cover. Displacement of in situ soil gas by landfill gas can also be detrimental to vegetation. Loss of vegetation due to the gases can lead to subsequent erosion of the clean fill covering the landfill. Since no gas migration controls will be implemented as part of Alternative 1, it is not protective of the environment surrounding the landfill.

No reduction in contaminant levels in the landfill or groundwater will result from implementing this alternative. Contaminant levels currently exceed groundwater standards and potentially exceed surface water standards near the site. Therefore, future contamination of the Ramapo River could occur, potentially affecting aquatic life in the river and public use of the river.

Based on the currently available data presented in the RI report, the site is only marginally impacting the surface water sediment. The data show that heavy metals in groundwater from the site may be impacting the sediment. However, exceedances of this guidance criteria are not sufficient to cause significant adverse impacts. The data also show exceedances of the guidance criteria for PAHs in the sediment; however, the highest concentrations of these contaminants are found in upstream sediment.

Information and data collected for surface water near the site show no potential significant adverse impacts based on regulatory standards. Although the North Jersey District Water Supply Commission currently draws some water from the Ramapo River approximately 22 miles downstream of Tuxedo, the river water meets current regulatory standards, and dilution of river water from downstream watersheds further reduces any potential levels of contamination. Therefore, no additional action is recommended at this point in time. As a follow up, however, additional sampling is recommended as part of the ROD to determine if any additional data is required.

__ARARs Compliance:__ This alternative will comply with all ARARs except as discussed in the following paragraphs. Current estimates of air emissions of concern and subsequent modeling show no violations of current or proposed NYSDEC Ambient Guideline Concentrations (AGCs) for predicted off-site concentrations except for hydrogen sulfide The maximum predicted off-site concentration of H_2S exceeds the 1-hour maximum AGC for this contaminant. Since no control of H_2S emissions is included, this alternative does not comply with the NYSDEC air quality standard for H_2S.

Groundwater concentrations at the site currently exceed NYSDEC standards. Since no cleanup of groundwater is included in this alterative, compliance with these standards is not likely. Because no reduction in contaminant levels in the landfill or groundwater will result from implementing this alternative, potential future contamination of the Ramapo River could exceed surface water standards.

6 NYCRR Part 360 requires installation of landfill gas control systems to prevent migration of concentrated amounts of landfill gases off-site. Systems must also prevent accumulation of gases greater than 25 percent of the lower explosive limit (LEL) in structures on-site and off-site, prevent damage to vegetation, and control objectionable odors. Therefore, this alternative would not be in compliance as it does not provide a system for gas ventilation and/or treatment.

Balancing Criteria

Short-Term Effectiveness: Since Alternative 1 will not disturb the materials in the landfill, no special protection of the surrounding community during remedial activities would be necessary. However, installation of probes along the perimeter of the landfill may cause releases of landfill gases. This could contribute to the odor nuisance problem caused by H_2S. However, no adverse effects associated with significant human health risks are anticipated. On-site workers installing the monitoring probes would be subject to on-site hazards from air emissions, soil contamination, and exposed materials. They would be protected by using appropriate levels of personnel protective equipment, (e.g., respirators, cover-alls, etc.).

No additional impacts to the environment are anticipated during the installation of the monitoring probes because the landfilled materials would not be disturbed.

Implementation of the No Action Alternative requires minimal construction and site activity. It could be achieved within 4 weeks.

Long-Term Effectiveness and Permanence: Residual risks to the environment will remain after implementation of Alternative 1. These risks are associated with groundwater, surface water, and surface water sediments. Continued movement of groundwater through contaminated material in the landfill could increase contaminant concentrations in groundwater, as well as surface water and sediments in the Ramapo River However, the natural movement of water through the landfill and the biodegradation of some landfill contaminants will eventually reduce the potential for off-site contamination.

Residual risks to human health, based on landfill gas emissions, would be the same as calculated for the health risk assessment, and would be within an acceptable range based on EPA-based calculations and risk factors. However, as the age of the wastes deposited in the landfill increases, the production of gases should decrease, eventually approaching zero. At that time, continued monitoring of gases may be unnecessary because the production of gas would be essentially zero. Therefore, the long-term effectiveness of this alternative may be satisfactory with regard to air emissions. The time frame depends on the rate of decomposition.

The adequacy and reliability of Alternative 1 for managing the residual risk is questionable. The clean cover placed on the site as an interim measure may be subject to erosion, which would expose contaminated materials to the environment. The cover could also be breached by plant roots and burrowing animals. The quarterly and subsequent annual frequency of the monitoring program may be insufficient to identify exceedances of ARARs in time to implement preventative measures. In addition, the monitoring may not identify temporary increases in contaminant concentrations of short durations. A review would be required every five years for a 30-year period.

Reduction of Toxicity, Mobility, or Volume: No direct reduction in toxicity, mobility, or volume of any contaminant will occur as a result of this alternative. Any such reduction will only occur as a result of natural phenomena that are not affected by the alternative. The alternative is readily reversible and can be modified in the future if necessary.

Implementability: From a technical perspective, this alternative can be implemented easily due to the limited on-site activity required. It requires construction of several permanent monitoring points along the perimeter of the landfill. No other construction will occur. It will not interfere with any future implementation of additional remedial actions, if required.

Short-term administrative coordination would be required with NYSDEC regarding installation of the monitoring system. Since the contaminated material would remain on-site, long-term coordination among responsible agencies would also be necessary. This would include annual inspections, monitoring, sampling, and site reviews to be carried out by NYSDEC and NYSDOH.

Services and materials needed for implementing this alternative include installation of the monitoring system, monitoring and sampling equipment, laboratory services, and technical personnel. These are available from a variety of vendors.

Cost: Initial capital costs for Alternative 1 are estimated to be $41,000. This includes:

- constiuction of five soil gas monitoring probes along the landfill's perimeter
- preparation of a groundwater sampling plan.

Costs assume that existing groundwater monitoring wells will be used for routine monitoring.

During the implementation year and two following years, annual (O&M) costs are estimated to be $519,000 and will include:

- labor and materials for quarterly sampling and monitoring
- laboratory analysis
- annual reports

These costs will drop to $256,000 during remediation years 3 and 4 and $95,000 for the remaining years.

One gas sample per quarterly event is assumed to require laboratory analysis. In addition, groundwater samples, sediment and river water samples will be collected and analyzed as described above.

The first-year implementation costs for this alternative are estimated to be $214,000, including capital costs and O&M costs.

Future lump sum costs of $5,000 to $13,000 per year include replacement of one monitoring well and all perimeter gas monitoring probes every 5 years due to vandalism or environmental damage. The cost estimate assumes this monitoring program will remain the same throughout the 30-year remediation period.

Based on a 30-year remediation period, the present net worth of Alternative 1 is estimated to be $1,972,000.

5.2.2 B/K Alternative 2: Landfill Cap

Alternative 2 prevents further infiltration of precipitation and reduces leachate by installing a cap in accordance with 6 NYCRR Part 360-7.3. No gas or groundwater collection or treatment systems are included, although monitoring of various media is included as described in B/K Alternative 1. A temporary fence and gate will be set up during remedial actions to restrict access to the site until the alternative has been implemented. The following discussion details the design of this alternative for each of four media: fill waste/soil, soil gas/air, groundwater, and surface water/sediment.

Description

__Fill Waste/Soil:__ The cap, which would be placed above the original cover, would consist of a vegetated top cover, a protective layer of soil, and a low permeability barrier layer which includes a drainage layer. These components are shown in Figure 5-1 under the discussion of B/K Alternative 3. This design for a solid waste landfill cap is regulated by New York Compilation of Rules and Regulations (NYCRR), Title 6, Part 360-7.3. The landfill cap functions by minimizing infiltration of precipitation through the landfilled material and preventing human and animal contact with the landfilled material.

The underlying base for the cap will consist of fill composed of construction and demolition debris and some household waste. The landfilled materials within the railroad right-of-way and possibly from the Georgia Tech Parcel (Georgia Tech Alternative 2) will be used as fill material. Regrading of the existing slopes and of this fill material will be done to ensure that the slope does not exceed 33%, to control surface drainage, and to provide a good even base for supporting the overlying cap. Borrow material from off-site sources will not be necessary. This base will be capable of supporting the weight of the cap without damaging the geomembrane.

The low permeability barrier layer in this cap will consist of a drainage layer and a geomembrane to prevent infiltration of precipitation. This geomembrane is specified by 6 NYCRR Part 360 to have a maximum coefficient of permeability of 1×10^{-12} centimeters per second. However, other selection criteria for membrane properties, such as chemical and physical resistance to the landfilled materials, and the ability to accommodate the expected forces and stresses caused by settlement of the landfilled materials, may necessitate an appropriate waiver of permeability requirements. The low permeability barrier layer will minimize the amount of precipitation infiltration to the landfilled material.

Above the geomembrane is a drainage layer to carry infiltrating water to the boundaries of the site. Above the drainage layer is a filter fabric layer to protect the permeability of the drainage layer from plugging by fine particles of soil.

The barrier protection layer of soil is located directly below the vegetated top cover and has a minimum thickness of 24 inches, as regulated by 6 NYCRR Part 360. The lower six inches of this layer will be reasonably free of stones . Sand would be a suitable material for this layer.

The vegetated top cover will have a minimum thickness of six inches and consist of topsoil that can support vegetation. The vegetation will provide a dense root system to anchor the soil and minimize wind and water erosion. The final top slope, after allowances for settling and subsidence, will not exceed 33%, as regulated by 6 NYCRR Part 360. The slopes on the top of the cap are designed to have a final grade of 7% to 15% and the slopes of the cap's toe to have a final grade of 33%.

Temporary berms or drainage swales would be constructed as necessary during remediation activities to divert run-on from on-going work areas.

Permanent berms oriented along the length of the cap will be constructed at all major slope breaks, such as where side slopes meet the top of the cap. Their purpose is to control the surface runoff on the cap, therefore minimizing erosion of the top and toe of the cap. These berms will be trapezoidal and consist of top cover material and vegetation. The dimensions and final locations of these berms will be determined during final design.

The final elevation of the landfill will not exceed the elevation of Route 17 on the west side of the site. The drainage pattern will direct run-off to the east towards the Ramapo River.

As interim remedial measures, surface drainage controls on-site were improved. Those existing features, especially along Route 17, will be evaluated during final design to determine their effectiveness for future site conditions and the need for any necessary upgrading.

The fill deposited on the northern tip of the site is very shallow. A component of this alternative is to remove this section of fill and redeposit it elsewhere on the site. This will provide a large, flat area for staging supplies and equipment.

Soil Gas/Air: The soil gas/air activities for Alternative 2 consist of constructing a low permeability landfill cap with 18 passive perimeter vents in conjunction with ambient air monitoring similar to that described in B/K Alternative 1. The air/soil gas and ambient air monitoring program will include quarterly monitoring of the 18 passive perimeter vents at times when concentrations would be expected to be high during the first 2 years.

All vents will be sampled in the field using a portable CGI to determine combustible gas concentrations as methane, an H_2S monitor to evaluate odor nuisance, an FID to determine total hydrocarbons (both methane and non-methane), and an HNu to determine total non-methane hydrocarbons. If, during field monitoring, a vent emits gas that has high levels of hydrogen sulfide or non-methane hydrocarbons, a sample will be collected for laboratory analysis. Results of the laboratory analysis will be used to evaluate whether the concentrations exceed acceptable levels as determined by air dispersion modeling. Exceedance of the air quality standards would trigger a health risk assessment to determine if remedial action is necessary. Detection of combustible gas in excess of 25 percent of the gases LEL in any of the passive vents may also require further review.

The results of the quarterly monitoring program will be assessed annually and changes to the program may be implemented.

Groundwater: Groundwater monitoring, as described in Alternative 1, is included in Alternative 2 also. Restrictions on the use of groundwater for drinking may be included at a later time, if required. Such restrictions may involve the use of an alternate water supply or the addition of treatment systems at the point of use. Currently, however, no one is obtaining drinking water from off-site wells that may be affected by the site. The only identified off-site private well which may be potentially impacted by the groundwater contamination is at the antique store directly north of the site.

<u>Surface Run-on Diversion:</u> The RI indicates that a 24-inch culvert crossing Route 17 south of the site will discharge 49 cfs to the site, based on a 100-year rain storm, from an area of 23 acres west of Route 17. A drainage ditch 3 feet deep and 6 feet wide was considered to carry this water to the south, diverting it around the site Based on a 100-year storm, such a ditch would pick up an additional 260 cfs of water, and the 24-inch pipe under Route 17 (at Stevens Lane) would not be able to accommodate the resulting water volume. The proposed solution would be to install, via borehole, an 80-foot, 36-inch, Class 56, ductile iron pipe with a slope of 0.026 under Route 17. This pipe would carry 105 cfs and would alleviate the flooding problem that currently exists in the area.

<u>Surface Water/Sediment:</u> Surface water and sediment monitoring as described in the No Action Alternative are included in Alternative 2 also.

Threshold Criteria

<u>Overall Protection of Human Health and the Environment:</u> This alternative would result in the same risks to human health as described in Alternative 1. However, it would provide more protection to human health by reducing contact with the landfill wastes. Although the landfill would have a cap, the lack of interior venting would result in increased potential for lateral migration of landfill gas, which would be emitted at the edges of the landfill. The volume of landfill gases emitted would be similar to the volume estimated in the Health Risk Assessment. As indicated in the Health Risk Assessment, H_2S would pose an occasional odor nuisance, but no significant adverse health impacts were indicated by the air quality dispersion modeling.

The cap will prevent direct contact with contamination by humans or animals, and it limits infiltration of surface water into the landfill debris, thus reducing the potential for additional groundwater contamination and subsequent contamination of the Ramapo River. Contamination of surface water runoff is also prevented. However, this alternative does not eliminate the possibility of future groundwater, sediment, and surface water contamination due to movement of groundwater through the wastes beneath the cap. Current contaminant levels exceed groundwater standards and could potentially exceed surface water standards near the site in the future. This could affect aquatic life and future public uses of the river.

Because no gas migration controls will be implemented as part of this alternative, it is not protective of the environment surrounding the landfill because it does not prevent damage to vegetation and does not control objectionable odors.

__ARARs Compliance:__ This alternative will comply with all applicable ARARs, except as discussed in the following paragraphs. Groundwater concentrations at the site currently exceed NYSDEC standards. Since no clean-up of groundwater is included in this alternative, compliance with these standards is not likely.

Current estimates of air emissions of concern and air dispersion modeling show no violations of current or proposed NYSDEC Ambient Guideline Concentrations (AGCs) for predicted off-site concentrations except for hydrogen sulfide. The maximum predicted off-site concentration of H_2S exceeds the 1-hour maximum AGC for this contaminant. Since no treatment of gas is included in this alternative, it does not comply with NYSDEC air quality standards.

Although 6 NYCRR Part 373 is an applicable regulation, Part 360 is also relevant and appropriate regarding closure requirements. Alternative 2 may not comply with the provisions of 6 NYCRR Part 360 requiring installation of landfill gas control systems to prevent migration of concentrated amounts of landfill gases off-site. This alternative would not be in compliance as there is no proposed system for gas collection and/or treatment.

Groundwater moving beneath site will continue to be exposed to contaminated wastes and will discharge to the Ramapo River. Although surface water and sediment standards do not currently exceed ARARs, future compliance with these ARARs cannot be assured.

Balancing Criteria

Short-Term Effectiveness: Protection of workers and the community during excavation activities must be considered. Several pathways of exposure are of concern. Workers and the general population could be exposed to contaminated soils in the form of fugitive dust, during construction of the cap, which could be minimized with wetting or other dust suppressant methods. Respirators would be required to protect workers from toxic landfill gases, as well as the dust, which could be released by excavation activities. Direct exposure of workers to contaminated soils and landfilled materials is also likely, requiring protective covering and subsequent decontamination procedures. Another problem is the potential physical hazard to workers posed by materials exposed at the surface (rusted metal pipes, etc.). Protection of the general population from direct contact with contaminated materials can be accomplished by restricting public access to the site.

This alternative can be implemented within a short period of time. Temporary fencing will be used to restrict site access before and during remediation. This can be placed in approximately 3 weeks, and completion of the cap can be accomplished within one year.

Long-Term Effectiveness and Permanence: Landfill wastes will remain on-site. Therefore, the impacts of these residual risks will continue. Because this alternative does not treat or control the ventilation of landfill gases, the long-term risks identified in the health risk assessment would still be applicable. No significant adverse human health risks were identified in the health risk assessment, but H_2S concentrations occasionally create a nuisance odor problem in the community. As the age of the wastes disposed in the landfill increases, however, the production of gases will decrease, eventually approaching zero. The long-term effectiveness of this alternative, therefore, may be satisfactory with regard to soil gas emissions. The time needed to achieve this would depend on the rate of decomposition.

This alternative would not remediate groundwater contamination or prevent additional contamination of groundwater that comes into contact with the waste materials. Thus, contaminated groundwater would continue to migrate into the Ramapo River surface water and sediments, and may impact aquatic life in these media.

The installation and proper maintenance of a cap in compliance with 6 NYCRR provides a reliable means of preventing direct contact with the contaminated waste materials. Once capped, the site access restrictions can be eliminated. However, the alternative does not prevent release of landfill gases or off-site migration of contaminated groundwater.

The permanence of the cap depends upon effective maintenance. Annual inspection and maintenance procedures should address erosion, subsidence, burrowing animals, vegetation roots that pierce the cap, and clear drainage channels. Regrading or patching of the cap may be necessary due to subsidence. Revegetation of some areas may be needed to prevent erosion.

This alternative will be reevaluated every five years For the purpose of this study, a 30-year remediation period has been estimated.

Reduction of Toxicity, Mobility, or Volume: Because installation of the cap provides reliable long-term containment of wastes, this alternative will reduce the potential mobility of contaminants via fugitive dust, erosion, root uptake, and surface run-off. Reduction of surface infiltration of precipitation will reduce the potential volume of contaminated groundwater. However, the extent of this reduction is unknown and is thought to be very small because the clean cover placed on the site currently inhibits surface water infiltration.

The nature and volume of contaminated groundwater reaching the Ramapo River would likely remain the same under this alternative because no groundwater controls are included.

Because this alternative does not include construction of any passive or active gas collection and/or treatment system, no reduction in landfill gases will occur. The toxicity and volume of gas produced is dependent on waste content and age, as well as environmental factors including moisture and temperature, and will therefore be largely unaffected by this alternative.

Implementability: The technical feasibility of implementing Alternative 2 is good because capping is a proven technology for containing waste materials. A maintenance program would be required to assure the cap's effectiveness. The cap is subject to cracking and damage due to subsidence, erosion, burrowing animals and vegetation roots.

No technical problems are anticipated that would lead to schedule delays or with maintaining the effectiveness of the cap. Implementation of this landfill alternative would not preclude the use of additional remedial actions, if necessary, in the future.

From an administrative perspective, the need for coordination and approval with applicable agencies is similar to Alternative 1. An additional requirement for this alternative is permission from Conrail to carry out excavation activities within the railroad right-of-way. This would be necessary for removal of wastes that encroach upon the railroad's property. Annual site reviews, monitoring, sampling, and reports would be the responsibility of NYSDEC and NYSDOH.

Services and materials needed for this alternative include temporary fencing, cap materials, construction equipment, monitoring and sampling equipment, laboratory analyses, and specialized personnel. These are available from a variety of vendors.

Costs: The initial capital costs for implementing the fill/waste soil remediation in Alternative 2 are estimated to be $2,930,793. This includes:

- Installation of final cover.

- Cost of removing material on northern tip of site and redepositing it at another site location.

- Cost of removing material from the railroad right-of-way and redepositing it at another on-site location.

- Temporary fencing and gates to restrict access during implementation of remediation.

Additional costs include:

- Preparation of a groundwater sampling plan.

- Installation of 18 perimeter passive vents.

The annual operation and maintenance cost estimate of $213,000 includes

- Cap maintenance

- Labor and materials for quarterly monitoring and annual reports.

- Collecting and analyzing four samples for laboratory analysis.

This will drop to $168,000 in years 3 and 4 and $135,000 for the remaining years. Therefore, the total costs for the first year are $3,405,000.
Future lump sum costs of $14,000 to $22,000 include the following:

- Labor and materials to replace vents as needed
- Replacement of one monitoring well every five years

Based on a 30-year remediation period, the present net worth value is estimated to be $5,917,000.

5.2.3 B/K Alternative 3: Landfill Cap with Passive Gas Venting/Treatment

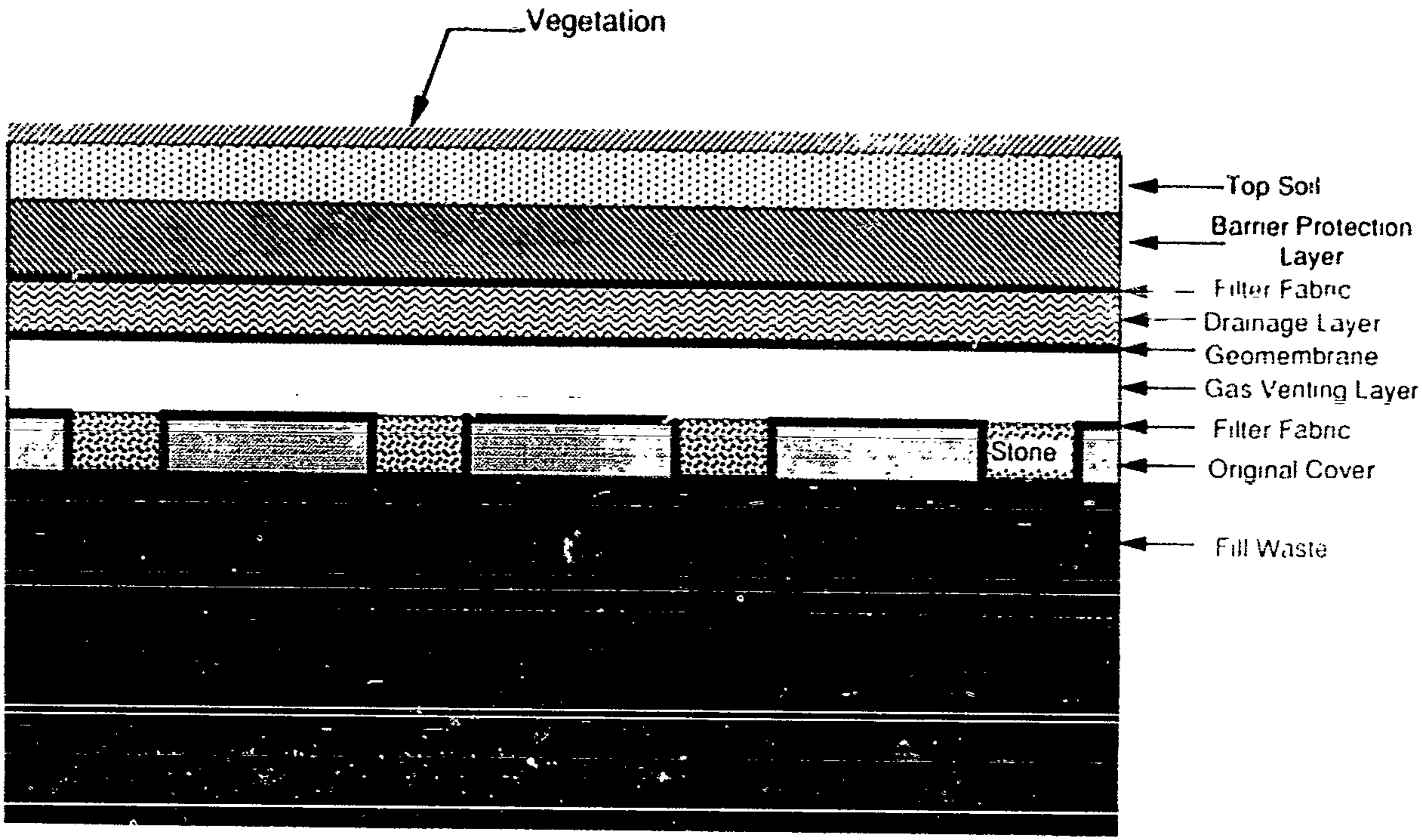
Alternative 3 consists of a cap to contain fill waste and soil with the addition of a passive gas collection and treatment system. Monitoring is included as necessary for all media. A temporary fence and gate will be set up during the remedial actions to restrict access to the site until the alternative has been implemented. The following discussion details the design of this alternative for the various media.

Description

Fill Waste/Soil: The solid waste landfill cap consists of a vegetated top cover, a protective layer of soil, a filter layer and a drainage layer, a low permeability barrier layer and a gas venting layer as shown in Figure 5-1. The vegetated top cover, protective layer of soil, filter layer, drainage layer, and low permeability barrier layer are the same as described in B/K Alternative 2. The gas venting layer is described below. The barrier layer consists of a drainage layer and a geomembrane to prevent infiltration of precipitation.

Directly below the low permeability barrier layer and above the landfilled material is the gas venting soil layer with a minimum thickness of 12 inches. This venting layer will have a minimum coefficient of permeability of 1×10^{-3} centimeters per second and a maximum of five percent by weight passing the No. 200 sieve. The upper and lower surfaces of the gas venting soil layer will be bounded with a filter layer, per 6 NYCRR Part 360. The filter layer is designed to prevent the migration of fine soil particles into a coarser grained material and to allow gases to freely enter the gas venting layer without clogging.

Excavation of shallow trenches through the existing cover of 0 to 3 feet to vent soil gas to the collection layer would be performed at specific intervals across the landfill prior to placing the cap over it. This would enable landfill gases to reach the gas venting layer. The depth and spacing of the trenches would be determined during the final design phase. Preliminary review of site data suggests that trenches two feet wide, three feet deep, and 100 feet long, spaced



Metcalf & Eddy of New York, Inc.

FIGURE 5-1
SECTION VIEW LANDFILL CLOSURE CAP

TUXEDO WASTE DISPOSAL SITE
ORANGE COUNTY, NEW YORK

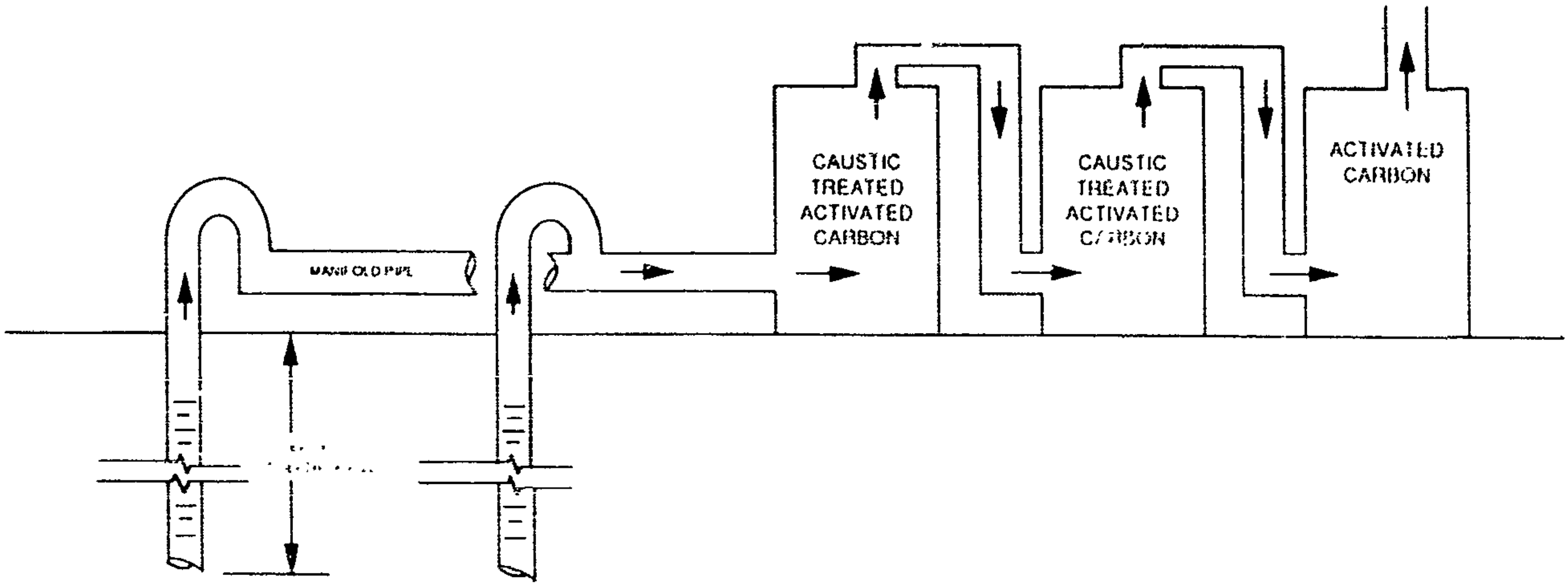
at 100-foot intervals would be required. Gas venting riser pipes will be installed as described below in the description of the soil gas/air media. Other design features of the cap (underlying base, slopes, berms, etc.) are the same as for B/K Alternative 2.

As described in Alternative 2, the shallow layer of fill materials on the northern tip of the site would be removed and redeposited on-site. This action would ensure a suitable staging area.

Soil Gas/Air: For Alternative 3, soil gas/air remediation activities will consist of constructing a passive landfill gas venting system in the interior of the landfill and along the perimeter of landfill in areas where there are elevated concentrations of H_2S and volatile organic compounds have been detected. The passively vented gas will be treated using activated carbon to remove hydrogen sulfide and volatile organic contaminants (VOCs). Figure 5-2 shows a flow diagram of this process.

To install the passive gas vents, 8-inch holes must be drilled into the interior and along the perimeter of the landfill. Since construction materials and debris were deposited in the landfill, drilling through large pieces of building materials (e.g. concrete and structural steel) may be necessary. Therefore, a large diameter auger or bucket machine would be used to drill down to the required depth. Another approach is to drive in a steel-pointed casing and then use a perforator to drill through these anticipated materials.

The passive gas vents will be constructed of 6-inch diameter polyvinyl chloride (PVC) and installed in the drilled holes. The interior vents will extend at least 2/3 the depth of the waste and three feet above the finished grade of the surface soil cap. The vent will be finished above grade using a gooseneck cap fitted with flexible HDPE piping which will connect the activated carbon unit to the vent. The vent will be screened the entire length extending into the refuse and the 1-foot section of the pipe in the gas venting layer to the extent possible. The interior vents will also vent the trenches to be installed in the present cover layer. A total of 19 passive interior gas vents are proposed; a



Metcalf & Eddy of New York, Inc.

FIGURE 5-2 FLOW DIAGRAM - PASSIVE GAS COLLECTION AND TREATMENT WITH ACTIVATED CARBON

TUXEDO WASTE DISPOSAL SITE
ORANGE COUNTY, NEW YORK

minimum of 12 vents are required to meet the NYSDEC requirement of 1 vent per acre. The 7 additional vents are included in this conceptual design to facilitate venting in areas of the landfill where high gas production is anticipated.

Treatment units consisting of three carbon canisters will be employed in this treatment design. Two canisters will contain carbon specially treated to remove hydrogen sulfide. For this application, carbon impregnated with a caustic (sodium hydroxide) would be effective. These two canisters will be followed by a third activated carbon canister to remove any remaining VOCs. This sequence would be desirable if caustic treated carbon is used since this medium functions well under conditions of highly relative humidity. However, field testing may dictate other configurations.

The emission rate of hydrogen sulfide and VOCs from each vent was estimated based on volume of the gas produced in each subsection of the landfill, as presented in the RI. Using these production rates, and the physical layout of the site, a manifold system is proposed to balance the hydrogen sulfide and VOC loadings to the treatment canisters. As an alternate approach, separate treatment canisters for each interior vent might also be considered.

The remediation of soil gas in Alternative 3 also includes construction of 18 passive vents along portions of the perimeter of the landfill. The passive perimeter vents will extend to the groundwater table or bedrock surface to allow ventilation throughout the vadose zone. Emissions from the perimeter vents will be collected into a manifold system and vented through carbon canisters.

Monitoring of this system during the first year of operation will include:
1) sampling of the landfill gas both before and after the activated carbon unit during varying barometric pressures, and 2) sampling of additional perimeter soil gas monitoring probes. Four rounds of samples will be collected. The samples will be screened in the field using an FID, PID, CGI, and H_2S monitor. Representative samples before and after the carbon canisters will be sent for laboratory analysis to confirm the identity and concentrations of contaminants. Adjustment of the manifold system or the number of activated carbon canisters will then be made to insure that the vent gas is properly treated.

After this initial round of sampling, quarterly monitoring of pre- and post-filter vent gas will be conducted during years 2 through 4 and then once annually during years 4 through 30. Monitoring will consist of field screening using FID, PID, CGI, and H_2S monitors on the interior and perimeter vents. Results will be reviewed annually and adjustment of system or monitoring program will be made if necessary. The annual monitoring for combustible gases on the perimeter passive vents will be used to determine if off-site migration of combustible gases beyond 25% of the LEL is occurring.

This system was designed based on available data. During the detailed design phase, a pilot program will be carried out to obtain additional data necessary for developing the design.

Groundwater: Groundwater and sediment provisions in Alternative 3 are identical to those in Alternative 2.

Surface Run-On Diversion: Surface run-on diversion provisions in Alternative 3 are identical to those in Alternative 2.

Surface Water/Sediment: Surface water and sediment provisions in Alternative 3 are identical to those in Alternative 2.

Threshold Criteria

Overall Protection of Human Health and the Environment: Alternative 3 provides protection to human health and the environment. The cap prevents direct contact with contamination by humans or animals. The gas collection/treatment system should reduce the air emissions of H_2S and VOCs, ensuring compliance with all regulatory requirements and therefore eliminating risks associated with the air pathway.

Some landfill gas migration may still occur, but the passive gas collection system should mitigate the extent of gas migration. In addition, the cap limits infiltration of surface water into the landfill debris, thus reducing the potential for groundwater contamination and subsequent contamination of the Ramapo River. Contamination of surface water runoff is also limited. However, the potential for future contamination of the groundwater and the Ramapo River is not eliminated

ARARs Compliance: The activities conducted under Alternative 3 will comply with all ARARs (see Table 3-1) except for groundwater. Groundwater concentrations at the site currently exceed NYSDEC standards. Since no clean-up of groundwater is included in this alternative, compliance with these standards is not likely.

Treatment of vent gases with the specially treated activated carbon should reduce H_2S emissions and bring the emissions into compliance with NYSDEC AGCs. With the passive gas collection system, this alternative should comply with the provisions of 6 NYCRR Part 360 requiring installation of landfill gas control systems to prevent migration of concentrated amounts of landfill gases off-site.

Balancing Criteria

Short-Term Effectiveness: On a short-term basis, landfill gas emissions may increase during construction of the cap and venting layers. Of more concern, however, is the fact that intrusive drilling activities into landfills present danger because explosive levels of combustible gases may be present, and the types of material that may be disturbed during drilling activities may not be known in advance. However, with sufficient safety precautions, personnel protection equipment, and strict adherence to applicable regulations (e.g., OSHA), such drilling can be accomplished. These safety precautions might include, but are not limited to, water and inert gas suppression techniques during drilling, dust suppressants, cordoning off areas where drilling is proceeding, and strict monitoring of gas levels during drilling operations.

Protection of the community during activities to excavate the toe of the landfill must be considered. Workers and the general population could be exposed to contaminated soils in the form of fugitive dust, which could be minimized with wetting or other dust suppressant methods. Releases of VOCs are likely and are more difficult to control. Respirators would be required to protect workers from toxic landfill gases, as well as the dust, which could be released by excavation activities. Direct exposure of workers to contaminated soils and landfilled materials is also likely, requiring protective covering and subsequent decontamination procedures. Another problem is the potential physical hazard to workers posed by materials exposed at the surface (rusted metal, pipes, etc.)

Once implemented, Alternative 3 will eliminate uncontrolled emissions of landfill generated gases from the interior of the landfill and along the perimeter at certain locations. Migration of landfill gases will be partially controlled by the construction of passive gas vents. This alternative should be effective at controlling odors caused by the landfill gas based on current estimates of the H_2S emissions. The carbon canisters will also remove most of the volatile organic compounds from the landfill gas. The proposed monitoring program will provide results which can be used to assess the effectiveness of the activated carbon canisters at controlling the emission of both odor-causing compounds and volatile organic compounds. The monitoring program for the perimeter passive gas vents will provide results which will indicate if landfill gas migration has been effectively eliminated.

The passive gas collection system may require some time to reach maximum effectiveness at preventing gas migration off-site. Monitoring of the system will be required.

As discussed in the description of this alternative, temporary berms or swales will prevent surface water run-on from infiltrating subsoils during site remedial actions (i.e., excavating toe). These temporary measures will eliminate other potential short-term risks such as further migration of contaminants.

Long-Term Effectiveness and Permanence: The long-term effectiveness of this option is adequate for gas, but only marginally adequate for groundwater, surface water, and sediment. This alternative should eliminate uncontrolled emission of odor-causing compounds if the activated carbon system is properly maintained. The monitoring program proposed should be adequate to estimate breakthrough time for each vent or group of vents. The alternative may not be totally effective at limiting migration of landfill gas. Gas generation should decline over time, and treatment may eventually become unnecessary. Components of the passive gas collection system should have a useful life of approximately 15 years, providing maintenance is conducted.

Similar to Alternative 2, the effectiveness and permanence of the cap depend upon effective maintenance. Annual inspection and maintenance procedures should address subsidence, erosion, burrowing animals, and vegetation roots.

The site will be reevaluated every five years, and for the purpose of this study, a 30-year remediation period has been estimated.

Reduction of Toxicity, Mobility, or Volume: No reduction in the volume of the contaminants in the groundwater, surface water, or sediment will result from this alternative. Mobility of the contaminants will be reduced as a result of the cap, however.

Activated carbon treatment of vent gas will reduce the mobility of H_2S and some volatile organic compounds in the landfill gas. As explained above, the migration of gas from the landfill to the surrounding soils should be reduced by the passive gas vents. The volume of gas being emitted to the air will not be affected by this alternative, but the emission of toxic compounds will be substantially reduced.

Implementability: Alternative 3 will be moderately difficult to implement and will require special precautions during construction activities. Installation of the interior vents will require penetrating the flexible membrane liner and boring 2/3 of the depth into the fill at each vent location. Drilling into landfills can be dangerous and difficult due to the presence of explosive gases and large obstructions, but can be done. Non-sparking drilling equipment may be used, and other special types of equipment and processes may be required to drill through large obstructions. This equipment is available to drilling firms and should not cause a delay. Non-sparking equipment, however, may not be readily available from local sources.

The activated carbon treatment system proposed for this alternative is readily available from vendors in the greater NYC area. All pipes and fittings used in the construction of this system are commercially available. There should be no substantial delays in implementing this alternative in acquiring these materials.

From an administrative perspective, the need for coordination and approval with applicable agencies would be required. In addition, similarly to Alternative 2, permission from Conrail to carry out excavation activities within the railroad right-of-way is needed. This may be necessary for removal of wastes that encroach upon the railroad's property. Annual monitoring and maintenance programs would be the responsibility of NYSDEC and NYSDOH.

Cost: The initial capital cost for the system is estimated to be $4,221,121 and the major components of these costs are listed below.

The cost for implementing Alternative 3 includes the following capital costs:

- Moving the toe of the landfill fifty feet back from the railroad right-of-way
- Closing the landfill with a vented cap
- Construction of 19 passive interior gas vents and manifold system in the landfill
- Construction of 18 passive gas vents along the landfill perimeter
- Installation of 12 activated carbon treatment units (3 canisters per unit to be changed as required)
- Installation of perimeter soil gas monitoring probes
- Temporary fencing and gates to restrict access during implementation of remediation

The annual operation and maintenance cost estimate is $181,000 and includes the following:

- Maintenance of cap
- Labor and materials for replacing activated carbon in the canisters
- Labor and materials for monitoring as previously described
- For the initial four rounds of sampling which will occur the first year, costs assume that a total of eight samples will be submitted to a laboratory for quantitative analysis

The first-year costs are therefore estimated at $5,013,000.

Future lump sum costs are estimated to have a base level of $27,000/year and include replacement of one interior gas vent and one perimeter gas vent each year due to damage caused by vandalism, landfill settlement and corrosion due to H_2SO_4. Every third year, the costs will increase to $50,000, and in the 15th year, they will be $143,000. These additional costs are for system replacement parts.

The present net worth for this alternative is estimated to be $8,168,000.

5.2.4 B/K Alternative 4. Landfill Cap with Active Gas Treatment

This alternative prevents further infiltration of precipitation and reduces leachate production by installing a cap. The cap is the same as described in B/K Alternative 3 except that an active gas venting and treatment system is added. Groundwater, surface water, and sediments are monitored as described in B/K Alternative 2. A temporary fence and gate will be set up during the remedial actions to restrict access to the site until the alternative has been implemented. The following discussion details the design of this alternative for the various media.

Description

<u>Fill Waste/Soil:</u> The cap design and treatment of waste on the site's northern tip are identical to that described in B/K Alternative 3.

<u>Soil Gas/Air:</u> The soil gas treatment portion of this alternative as shown in the process flow diagram Figure 5-3 consists of the following:

- Construction of an active landfill gas venting system consisting of 19 vents on the interior of the landfill
- Treatment of actively vented gas using carb... absorption
- Construction of 18 passive vents along the perimeter of the landfill where methane concentrations in soil gas exceed 25 percent of the LEL.
- Treatment of passively vented soil gas along landfill perimeter using activated carbon as described in B/K Alternative 3.
- Monitoring of interior and perimeter gas venting/treatment systems.

All drilling will be performed in the same manner as described in Alternative 3 All vents will be constructed of 6-inch diameter PVC. The active vents will be constructed to a depth equal to 2/3 of the waste depth or to within 2 feet of the groundwater or leachate level, whichever is shorter. Active vents will be screened from the bottom of the vent through the 1-foot gas venting layer Each vent will extend a minimum of three feet above the finished grade of the soil cap. Each active vent will have a PVC butterfly valve to permit the applied vacuum to be throttled.

Passive perimeter vents will be constructed to a depth of two feet above the seasonal high water table or bedrock surface. The passive vents will be screened from the bottom of the vent to three feet below the ground surface. All vents will be finished above grade with a gooseneck cap. The purpose of these vents is to collect any gas outside the sphere of influence of the active interior vents.

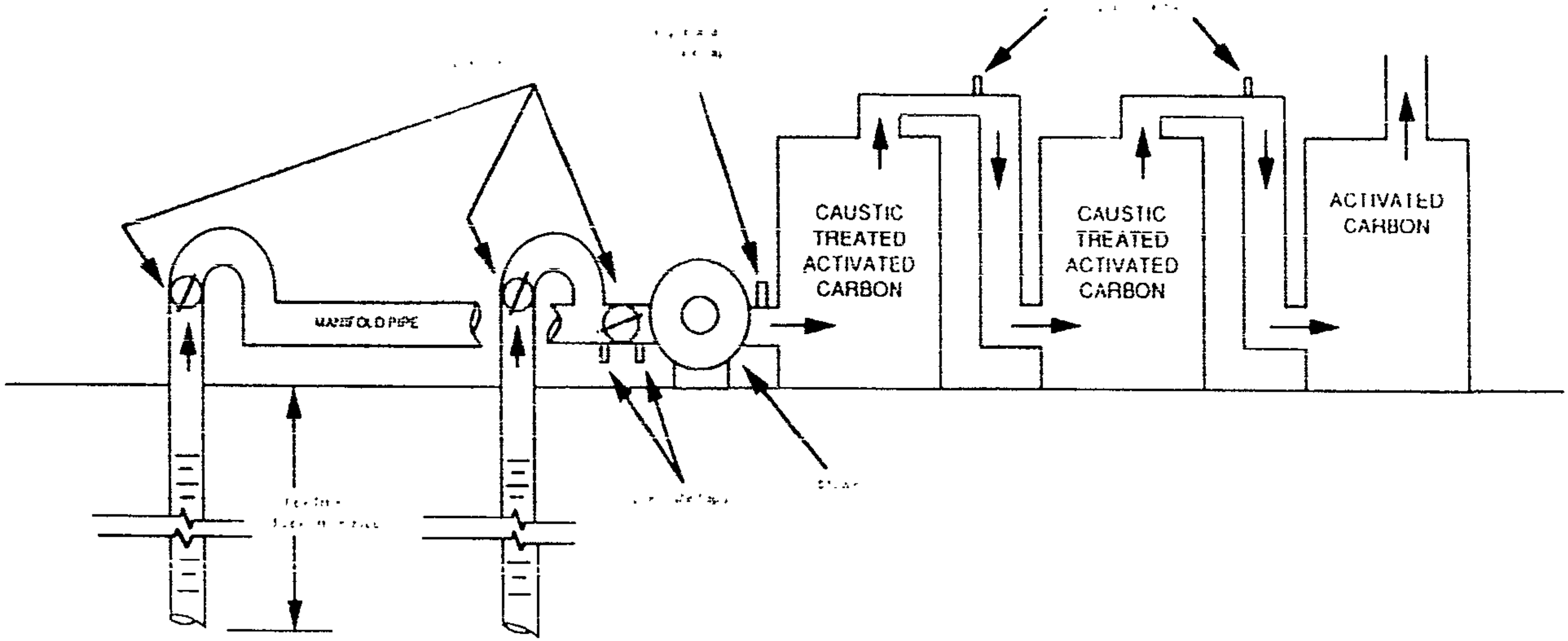


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FIGURE 5-3 FLOW DIAGRAM - ACTIVE GAS COLLECTION AND TREATMENT WITH ACTIVATED CARBON

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Flexible, high-density polyethylene piping will be used to construct manifold systems for both the active and passive system.

A 6 to 7 1/2 Hp vacuum blower motor will be used to extract gases from the interior of the landfill. The blower will be adjustable to operate at flow rates up to 100 cfm and to pull a vacuum of up to 18 inches of water. The blower will be equipped with a silencer to limit noise.

Any moisture condensing from the gas stream is likely to be extremely corrosive due to the hydrogen sulfide present in the gas. Operation of the blower will be adjusted as needed to minimize the presence of moisture in the gas stream. Liquid traps will also be included in the design to prevent leachate or groundwater from reaching the blower

Four gas treatment technologies were considered for this alternative: carbon adsorption, solvent scrubbing, flaring and incineration Carbon adsorption and solvent scrubbing technologies provide treatment by adsorbing or otherwise chemically reacting the contaminants in the landfill gas with a solid sorbent medium or a liquid solvent. The effectiveness of the treatment is dependent on replenishing or regenerating the adsorbent or solvent after its capacity is depleted. The spent materials may be disposed in landfills or reclaimed. The contaminants removed from the landfill gas are not destroyed in the process; however, some are chemically altered to less toxic or odorous forms.

Flaring and incineration technologies provide thermal oxidative treatment by burning the landfill gas. The effectiveness of the treatment is dependent on the operating temperature of the burn. Generally, these technologies provide more complete removal of organics from the waste stream. However emission limits must be strictly monitored. All permit requirements pertaining to incineration would need to be met although a permit per se is not needed.

In assessing these technologies for treatment of the Tuxedo Waste Disposal Site landfill gas, consideration was given to field testing results which indicated that the methane content of the landfill gas would be below the minimum 18% methane by volume required to sustain a low temperature flame in a thermal unit and therefore requiring a supplemental fuel source. Flaring and incineration would not convert hydrogen sulfide to sulfur oxides and would generate HCl vapor by oxidizing chlorinated hydrocarbons.

Flaring and incineration were eliminated as options for treating the landfill gas prior to assessing detailed costs because: 1) the apparent low methane content of the landfill gas would require the addition of a substantial amount of supplemental fuel, 2) substantive requirements of a permit may be difficult to meet, 3) the additional treatment for volatiles is not required to be protective of human health and the environment, and 4) other treatments (i.e., carbon adsorption) are available and could achieve the same levels of effectiveness with fewer adverse impacts. Furthermore, both units require a substantial capital investment.

Both activated carbon and alkaline wet scrubber technologies were evaluated in detail. The evaluation included developing conceptual operating conditions for both technologies so their costs and efficiencies could be compared. The evaluation concluded the following:

1. Both activated carbon and alkaline wet scrubber technologies will reduce the H_2S and VOC concentrations in the landfill gas so resulting ambient air concentrations will comply with air quality standards.

2. The effectiveness of both technologies is dependent on regenerating or replacing the carbon or solvent.

3. The PW analysis of both technologies is similar. However, an alkaline wet scrubber requires more capital investment. The long-term O&M costs for treating the gas may be overestimated because they do not account for diminishing landfill gas production.

4. Actively vented gas can be pulled through the activated carbon before the blower, reducing corrosion of the blower bearings.

5. Treatment of some VOCs is more effective by carbon adsorption.

Given the similarity in treatment efficiency and the estimated higher capital cost for the wet scrubber system, activated carbon is recommended as the treatment. The activated carbon system will be designed to remove the H_2S and VOCs. H_2S is difficult to remove by activated carbon alone, and this system addresses the problem by using carbon that has been impregnated with a caustic (sodium hydroxide). Given the levels of H_2S found during the RI, annual carbon replacement is assumed to be sufficient to prevent breakthrough of these gases Caustic treated carbon can be regenerated by alkaline flushing.

The active gas extraction system will be monitored during the first year by sampling gas before and after treatment at various pressures. Four sampling rounds will be conducted. The samples will be screened in the field using an FID, PID, CGI, and H_2S monitor. Samples having the highest FID readings will be submitted for laboratory analysis for a full scan of organics.

In addition, a pilot program will be performed prior to the detailed design to obtain additional data which will be used in the system design.

Groundwater: Groundwater provisions in this alternative are identical to those in Alternative 2.

Surface Run-On Diversion: Surface run-on diversion provisions are identical to those in Alternative 2.

Surface Water/Sediment: Surface water and sediment provisions in Alternative 4 are identical to those in Alternative 2.

Threshold Criteria

Overall Protection of Human Health and the Environment: Alternative 4 prevents further infiltration of precipitation and reduces leachate production by installing a cap. This reduces the potential for further groundwater contamination and subsequent contamination of the Ramapo River. Contamination of surface water runoff is also limited. The gas collection/treatment system eliminates risks associated with the air pathway. Some landfill gas migration may still occur, but the active gas collection system and passive perimeter vents should mitigate the extent of gas migration. Therefore Alternative 4, if properly maintained and monitored, significantly reduces risks to the public health and environment that are associated with air emissions.

ARARs Compliance: The activities conducted under this option will comply with all ARARs except for groundwater Installation of a venting system and treatment of vent gases with the specially treated activated carbon should reduce H_2S emissions and bring the emissions into compliance with NYSDEC AGCs The active gas collection system would comply with the provisions of 6 NYCRR Part 360 requiring installation of landfill gas control systems to prevent migration of concentrated amounts of landfill gases off-site. Groundwater concentrations at the site currently exceed NYSDEC standards. Since no clean-up of groundwater is included in this alternative, compliance with these standards is not likely

Balancing Criteria

Short-Term Effectiveness: On a short-term basis, emissions of landfill gases may increase slightly during construction of the vented cap. Of more concern, however, is the fact that intrusive drilling activities into landfills are inherently dangerous due to the potential presence of explosive levels of combustible gases, an increase in landfill gas emissions during landfill penetration, and lack of knowledge about the materials that may be disturbed during construction activities. However, the proposed drilling can be accomplished with sufficient safety precautions. Safety precautions might include cordoning off areas while drilling is proceeding, water and inert gas suppression technique during drilling, construction safeguards, personnel protection equipment, adherence to applicable regulations (e.g., OSHA), and strict monitoring of gas levels during remedial activities.

Protection of the community during activities to excavate the toe of the landfill must be considered. Workers and the general population could be exposed to contaminated soils in the form of fugitive dust, which could be minimized with wetting or other dust suppressant methods. Respirators would be required to protect workers from toxic landfill gases, as well as the dust which could be released by excavation activities. Direct exposure of workers to contaminated soils and landfilled materials is also likely, requiring protective covering and subsequent decontamination procedures. Another problem is the potential physical hazard to workers posed by materials exposed at the surface (rusted metal, pipes, etc.).

The active gas collection system may require some time to reach maximum effectiveness at preventing gas migration off-site. Monitoring of the system and adjustments of flow rates will be required.

Long-Term Effectiveness and Permanence: The long-term effectiveness of Alternative 4 is adequate for gas, but only marginally adequate for groundwater, surface water and sediment. This alternative should eliminate uncontrolled emissions of odor-causing compounds if the activated carbon system is properly maintained. The proposed monitoring program should be adequate to estimate breakthrough time for each vent or group of vents. The alternative also should be effective at limiting migration of landfill gas. Gas generation should decline over time, and gas treatment may become unnecessary at some point

Components of the active gas collection system should have a useful life of approximately 15 years, providing maintenance is conducted. Replacement of the blower may be required sooner if corrosion becomes a problem.

The long-term effectiveness and permanence of the cap is dependent upon effective maintenance. Annual inspection and maintenance procedures should address subsidence, erosion, vegetation roots, and burrowing animals.

This alternative will be reevaluated every five years to determine if this treatment is still necessary. For purposes of this study, a 30-year remediation period has been estimated.

Reduction of Toxicity, Mobility, or Volume: There will be no reduction in the volume or toxicity of the contaminants in the groundwater, surface water, or sediment from this alternative. However, the cap will reduce the potential for additional contamination via surface runoff or infiltration.

Migration of the landfill gases into surrounding soils will be reduced by the active vent system. Activated carbon treatment of the vent gas will also reduce the mobility of H_2S and some organic compounds in the landfill gas. The volume of gaseous air emissions may not be affected, the emissions of toxic compounds to the atmosphere will be substantially reduced.

Implementability: Alternative 4 can be implemented. However, as discussed earlier, special precautions are necessary due to the nature of the landfill materials and the contaminants found in these materials. The interior vents will require penetration of the flexible membrane liner and boring 2/3 of the depth of the fill at each vent location. Drilling operations into landfills can be dangerous and difficult due to the presence of explosive gases and large obstructions. It can be accomplished using non-sparking drilling equipment and/or water or inert gas suppression technique during drilling activities to reduce the potential for explosions and using other types of equipment or procedures to penetrate large obstructions (e.g. concrete, structural steel, etc.). Except for non-sparking equipment, which may not be available locally, this equipment is usually available to drilling firms and should not cause a delay.

The activated carbon treatment system proposed for this alternative is readily available from vendors in the greater NYC area. All pipes and fittings used in the construction of this system are commercially available. There should be no substantial delays in acquiring these materials.

As discussed in Alternative 3, coordination and approval with applicable agencies would be required.

Cost. The initial capital cost is estimated as $5,322,000 and includes the following major components:

- Temporary fencing and gates to restrict access during implementation of remediation
- Construction of 18 passive gas vents along the landfill perimeter

- Construction of 19 active gas vents in the landfill, a manifold system, and a blower

- Installation of an activated carbon treatment system

The annual operation and maintenance cost estimate for the first four years is $189,000 and includes the following:

- Labor and materials for replacing activated carbon

- Labor and materials for maintaining blowers, temporary fencing, gates, and other equipment

- Labor and materials for monitoring as previously described

For the initial four rounds of sampling during the first year, the estimates assumed that a total of eight samples will be submitted to a laboratory for quantitative analysis.

The annual operation and maintenance cost estimate for the remaining years is $176,000, and this assumes that the volume of soil gas requiring treatment will decrease as discussed in this alternative.

First-year costs are $5,511,000

Future lump sum costs are estimated to range from $27,000 to $228,000 per year as shown in the detailed cost breakdown in Appendix A Costs.

The present net worth for this alternative is $8,914,000.

5.2.5 B/K Alternative 5: Landfill Cap with Active Gas and Groundwater Treatment

This alternative prevents infiltration and reduces leachate by installing a cap as described in B/K Alternative 3 and an active gas collection system as described in B/K Alternative 4. It also includes groundwater collection and treatment coupled with a vertical barrier system to prevent groundwater flow through the waste and into the Ramapo River. Monitoring is included as necessary for all media. A temporary fence and gate will be set up during the remedial actions to restrict access to the site until the alternative has been implemented. The following discussion details the design of this alternative for each of four media: fill waste/soil, soil gas/air, groundwater, and surface water/sediment.

Description

<u>Fill Waste/ Soil:</u> The cap design and treatment of fill wastes on the northern tip are identical to that described in B/K Alternative 3.

<u>Soil Gas/Air:</u> Soil gas collection and treatment provisions are identical to those described in B/K Alternative 4.

<u>Groundwater:</u> Groundwater remedial measures include a down-gradient vertical barrier, groundwater extraction and treatment, and surface water run-on diversion. Each of these components is discussed separately below.

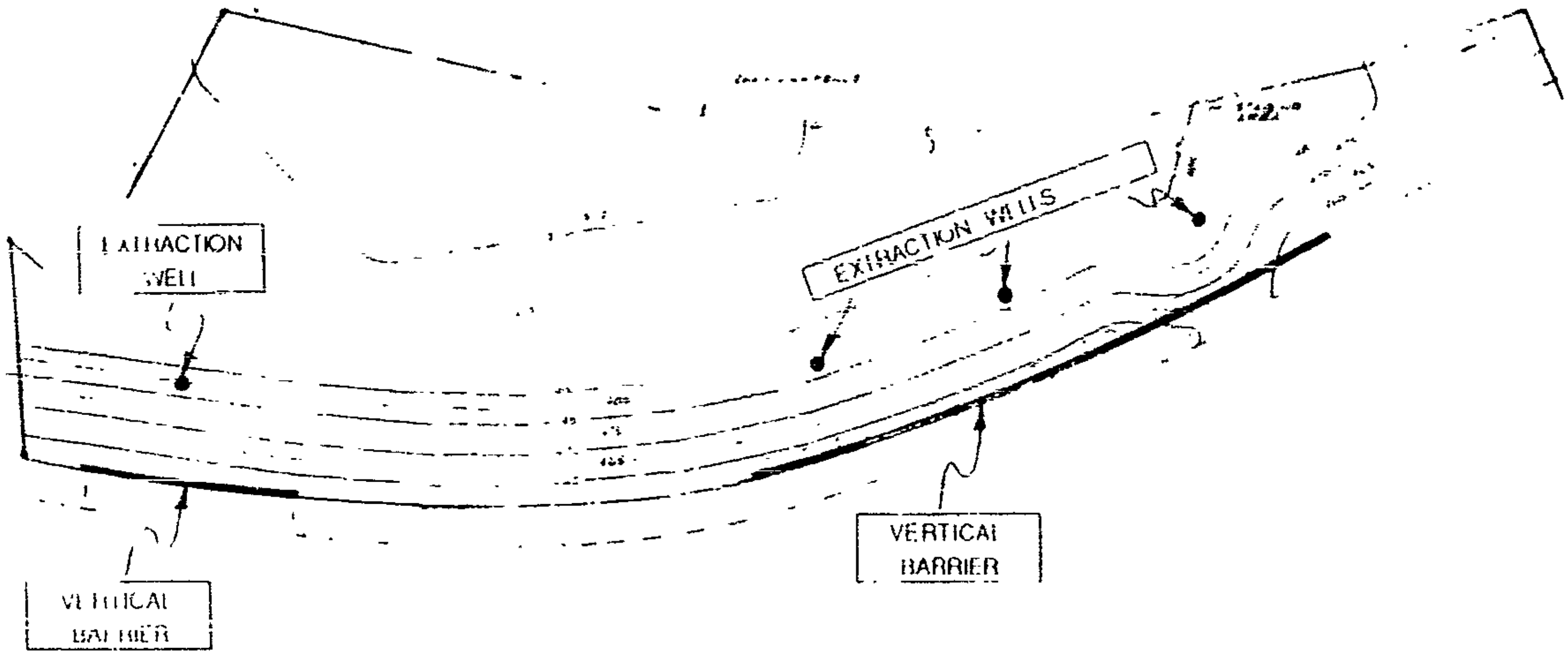
- <u>Downgradient Vertical Barriers:</u> Three techniques were evaluated for use as vertical barriers at this site: soil-bentonite (SB), cement-bentonite (CB), and concrete diaphragm (CD) walls. SB walls offer low cost, easy maintenance, and low permeability. However, they do not have the strength of other barriers and must, therefore, be thicker. SB walls require large areas for installation, possibly presenting difficulties at this site due to the proximity of the waste to the railroad tracks. CB walls offer greater strength but higher permeability. They are also more susceptible to degradation from contaminated groundwater. CD walls are composed of reinforced concrete panels placed using slurry trenching techniques. They offer great strength, low permeability, and ease of installation. Therefore, a CD wall barrier is retained in this alternative.

  To satisfy demands placed on permeability, durability, and performance, a plastic concrete diaphragm wall will be installed parallel to the railroad tracks at two locations on the east side of the landfill. The wall will be approximately 1,000 feet long (in two sections) and extend to an average depth of 50 feet. The longer section will be in the north-central area in the vicinity of MW-5-RJ4. The shorter southern section will be in the vicinity of MW-3-MW-4.

The barrier will be keyed into stable bedrock to prevent leakage beneath the wall. It will be constructed in panels varying from 5 to 30 feet in length, depending on construction sequence, depth, and excavating bucket size, under a head of bentonite slurry. The backfill will consist of cement, bentonite, soil, and aggregates, with the cement to bentonite ratio equal to about 5:1 on a dry weight basis. First, concrete guide walls will be constructed to ensure correct alignment of the wall and verticality of the panels. Then, two-foot wide trenches will be excavated using a clamshell to bedrock, followed by penetration of the bedrock surface with a chisel and finally concreting of panels by tremie. Steel grout pipes can be positioned in the panels prior to concreting for grout injection.

- Groundwater Extraction: The downgradient groundwater extraction with treatment option consists of removing contaminated groundwater moving toward the Ramapo River. The objective of the extraction system is to prevent flow from the landfill into the river. Figure 5-4 shows the proposed downgradient vertical barrier and the groundwater extraction wells.

If a cut-off wall is constructed along the toe of the landfill between wells MW-5 and MW-7, groundwater will rise behind the wall, perhaps overtopping it in places, unless extraction wells are drilled on the landfill side of the wall. The pumping rate necessary to keep the water level to the desired height above the base of the aquifer will depend upon the volume of water moving into the landfill from the west. Regional flow may be fairly constant, but it will be augmented from time to time by local recharge from rainfall, which could be an



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ORANGE COUNTY, NEW YORK

FIGURE 5 4
SKETCH OF DOWN GRADIENT VERTICAL BARRIER
AND GROUNDWATER EXTRACTION WELLS

important factor in the design of the pumping system. The initial pumping rate required to lower the water table will likely be far higher than the rate required to sustain the drawdown after dewatering occurs.

Although elements of a pumping (extraction) system can be presented in principle, based on an idealized aquifer system, the actual number of wells and their pumping rates must be determined empirically. Water levels will have to be monitored carefully to determine the effectiveness of the pumping system and to allow for adjustments in the pumping rates seasonally and probably at other times as well.

The estimate of groundwater recharge to a particular area is based on the ability of the drainage basin watershed to recharge a specific aquifer. The water table in an unconfined aquifer tends to follow the topographic elevations. In the area of the Tuxedo Waste Disposal Site, water generally drains from ridges, namely from the higher elevations of Tower Hill towards the study area located at lower locations. The drainage basin area as determined from the USGS Ramapo Quadrangle is estimated to be 6,840,000 ft^2 or 0.245 $mi.^2$ The recharge rate in this area of till and bedrock is approximately 400,000 gpd/mi^2 or 8 inches/year (Snavely, 1980). Therefore, the recharge to the drainage basin in the project area is calculated to be 98,000 gpd.

Using an alternative method, groundwater flow in the area was determined to be 110,000 gal/day. This calculation was based on Darcey's Law, Q = KIA, where Q is the flow rate in m^3/d, K is the average hydraulic gradient (7.21 m/d), A is the cross-sectional area of the saturated material (2,090 m^2 calculated from site map), and I, the gradient, is 0.03.

To estimate the number of groundwater extraction wells, and pump rates per well, a site groundwater recharge rate of 111,000 gpd was used.

Groundwater beneath the site flows through overburden material composed of fill and soil of varying composition, and fractured bedrock. Therefore, the hydraulic properties of the overburden are expected to be different than in the bedrock. The following assumptions have been made:

- <u>Hydraulic Conductivity:</u> Hydraulic conductivity is calculated as 176 gpd/ft ^{2}(8.35 x 10^{-3} cm/sec) which is an average of the five overburden wells completed in sand and gravel, listed in Table 4-1 of the RI

Assuming the aquifer is 30 feet thick with a hydraulic conductivity of 176 gpd/ft.^{2} drawdown in the pumping well, the radius of influence, and the drawdown at the cut-off well are calculated as follows:

Calculation of Drawdown at Pumping Well(s) for an Unconfined Aquifer:

$$KD = \frac{1.22\,Q}{s'_{mw}}$$

Where

K	-	hydraulic conductivity - 7.21 m/d
D	-	saturated thickness of aquifer - 9.1 m
Q	-	discharge - 159 m^3/d
s'_{mw}	-	drawdown in pumping well in meters

$$(7.21\ m/d)(9.1\ m) = \frac{(1.22)(100.7\ m^3/d)}{s'_{mw}}$$

$$s'_{mw} = 1\ 87\ m \text{ or } 6.14\ ft.$$

Calculation for Radius of Influence at Pumping Well:

$$\ln R_o = \left(\frac{K\,(H^2 - h^2_w)}{458\,Q}\right) + \ln r_w$$

Where	R_o	-	radius of influence in ft.
	K	-	hydraulic conductivity - 176 gpd/ft ^{2} (7.21 m/d)
	H	=	saturated thickness = 30 ft
	h_w	-	head in well - 23.86 ft.
	Q	-	pumping rate - 19 gpm
	r_w	-	well radius - 0.167 ft.

$$\ln R_o = \frac{(176\ gpd/ft^2)(330.7\ ft.^2)}{(458)(19\ gpm)} + \ln 0.167\ ft. = 6.69 + (1.79)$$

$$\ln R_o = 4.9\ ft.$$
$$R_o = 134\ ft.$$

The radius of influence of a well pumping at 19 gpm is 134 feet with a drawdown of 6.14 feet.

A well system using 3 extraction wells on the northern end of the site, pumping at 19 gpm each, spaced 250 feet apart, 75-100 feet from the cut-off wall, and one well at the southern part of the site at the same discharge rate and distance, will be used to contain any contaminant migration. The extraction wells are designed so their radii of influence or capture zones overlap. Before a more detailed design of a vertical barrier and extraction system is prepared, pumping tests should be made on at least three sites along the proposed barrier, utilizing a pumping well and observation wells at each site. Besides determining aquifer properties, water levels should be observed at least through the winter and spring to see the magnitude of the seasonal fluctuations. These data are necessary to adequately assess the need and design criteria for a cut-off wall.

- <u>Groundwater Treatment.</u> The groundwater extracted in the system described above will be treated by ion exchange prior to discharge. This process is shown in Figure 5-5. This treatment is to protect the river, which is considered a potential drinking water source, from contamination above NYSDEC standards and guidelines. Based on this design goal, the contaminants of concern are metals (Fe, Al, Na, Mn,

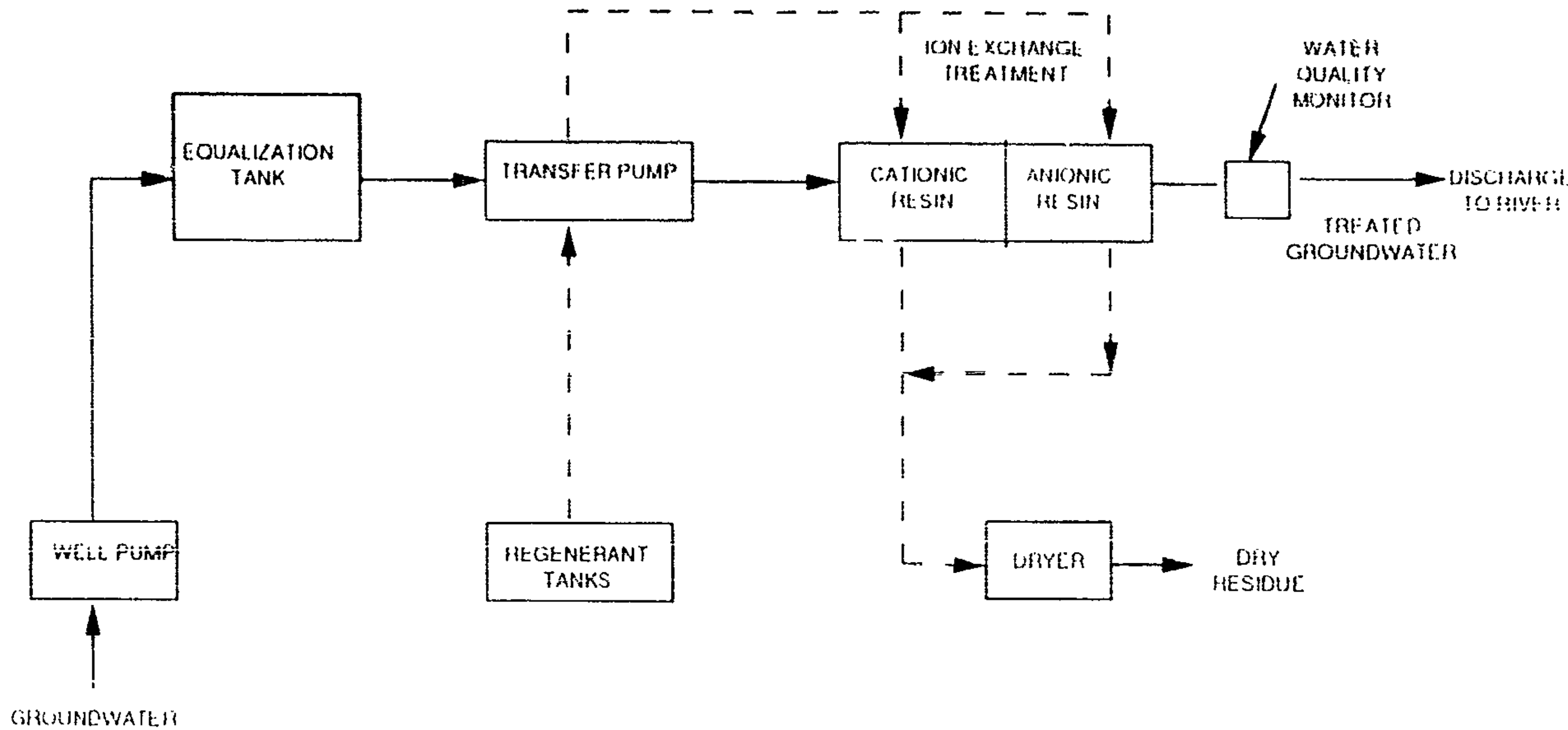

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FIGURE 5-5 FLOW DIAGRAM FOR ION-EXCHANGE TREATMENT OF GROUNDWATER

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Ag, As, and Hg). Organics are not considered because available data suggest that organics are present in very low concentrations in only a few wells.

The treatment unit consists of an equalization tank, a transfer pump, an ion exchange unit, and an evaporator-dryer. The treated water will be discharged to the Ramapo River. The equalization tank provides a more consistent mass loading to the ion exchange unit. The transfer pump will be used to control flow to the ion exchange unit and to pump the concentrated waste to the evaporator-dryer. The ion exchange unit will consist of both a cationic and anionic treatment resins. The cationic resin will extract the positively charged ions from the waste stream and replace them with a hydrogen ion (H^+). The anionic treatment resin will remove any complex metals (anionic) and replace them with a hydroxide ion (OH^-).

When the resins are spent, recharging is necessary. The recharging replaces the metals that were absorbed to the resins with the hydrogen and hydroxide ions. The resulting waste stream is highly concentrated in metals and will be processed into a solid by the evaporator-dryer. The resulting solid is expected to be a non-hazardous waste based on the constituents present in the groundwater sampled during the RI. If necessary, the waste can be stabilized to reduce the mobility of the metals. Testing must be done to determine the resins necessary for removal of the metals present, equipment sizing, and appropriate disposal for the waste solid.

The piping from the wells and from the treatment unit to the river must be placed approximately five feet underground to escape the effects of freezing. The treatment unit should also be enclosed to prevent freezing.

Other treatment technologies, such as chemical precipitation and activated carbon, were also considered. Chemical precipitation was eliminated because it is not effective at removing sodium, which is a contaminant of concern. Activated carbon was also considered but was determined to be unnecessary because the organics concentrations present in the groundwater are low and only detected in a few wells. Because the water entering the treatment system would come from several wells, the organics concentrations are likely to be below detectable levels in the effluent to the treatment system. Any organics that are present would be diluted well below levels of concern after they are discharged into the river.

- Surface Run-On Diversion: Surface run-on diversion provisions in Alternative 5 are identical to those in Alternative 2.

Surface Water/Sediment: Surface water and sediment provisions in Alternative 5 are identical to those in Alternative 2.

Threshold Criteria

Overall Protection of Human Health and the Environment: The overall protection of human health and the environment is good. The potential for contaminated groundwater to reach the Ramapo River is virtually eliminated because the water discharged by the groundwater extraction and treatment system will meet NYSDEC surface water standards. In addition, the cap and surface water run-on diversion system limit infiltration of surface water into the landfill debris, thus reducing additional groundwater contamination. Contamination of surface water runoff is also limited. Potential contact with contaminated groundwater by personnel near the treatment facility can be minimized by restricting access to the site. The personnel operating the system will be trained to prevent exposure.

The cap prevents direct contact with contamination by humans or animals. The gas collection/treatment system essentially eliminates health risks associated with the air pathway. Some landfill gas migration may still occur, but the active gas collection system and perimeter vents should minimize it. This would also reduce the H_2S odor nuisance problem.

ARARs Compliance: The activities conducted under this option should comply with all ARARs However, clean-up of groundwater to NYSDEC standards is dependent on how long the extraction system is operated and how quickly contaminant levels are reduced in both groundwater and landfill material. This FS uses an estimated remediation time of 30 years, and this time frame may not achieve complete groundwater remediation Therefore, compliance with groundwater ARARs after that period is uncertain

Treatment of vent gases with the specially treated activated carbon should reduce H_2S emissions and bring the emissions into compliance with NYSDEC ambient air standards.

With the active gas collection system and perimeter vents, Alternative 5 should comply with the provisions of 6 NYCRR Part 360 requiring installation of landfill gas control systems to prevent migration of concentrated amounts of landfill gases off-site

Disposal of the wastes derived from the installation of the extraction wells, underground piping, and treatment equipment will be handled in a manner consistent with applicable hazardous waste management regulations The treated water discharged into the river will not require a State Pollutant Discharge Elimination System (SPDES) permit but will have to meet the substantive requirements thereof. All applicable OSHA regulations would be followed during all remedial activities.

Balancing Criteria

<u>Short-Term Effectiveness:</u> Risks to the community during remedial actions include exposures from off-site migration of landfill gases and contaminated dusts during excavation and installation activities. The greatest potential for release of dust is during excavation of the toe of the landfill near the railroad tracks. Fugitive dust can be minimized with dust suppressant methods such as wetting and use of surfactants. Dust from the trenching and treatment system activities will be minimal. No waste is expected to be taken off-site during the installation

of the system. Protection of the community during the implementation of this alternative is also accomplished by restricting access to the site.

On a short-term basis, emissions of landfill gases may increase slightly during construction of the vented cap. This would increase the potential odor nuisance from H_2S, and would also increase the health risks associated with landfill gas emissions.

Hazards to on-site workers include exposure to contaminated dusts and landfilled gases during excavation activities. Workers would be required to use personnel protection equipment when necessary, and monitoring of site activities would be performed to determine if upgrading of protection is necessary. Direct exposure to contaminated soils and landfilled materials is likely, requiring protective covering and subsequent decontamination procedures. Another problem is the potential physical hazard to workers posed by materials exposed at the surface (rusted metal, pipes, etc.)

Of particular concern is the fact that intrusive drilling into landfills is inherently dangerous due to the potential presence of explosive levels of combustible gas. However, with sufficient safety precautions, such drilling can be accomplished as discussed under previous alternatives.

With regard to the environment, excavation activities would be temporarily disruptive to vegetation and wildlife on the site. However, these communities would be expected to reestablish themselves following completion of the remedial activities. Release of landfill gases during remediation could affect vegetation.

Implementation time for this alternative is approximately one year, assuming multiple site tasks are performed concurrently. The time to complete all remedial activities is estimated to be 30 years. The active gas collection system may not reach maximum effectiveness at preventing gas migration off-site immediately after implementation. Monitoring of the system and adjustments of flow rates as needed over the first year of operation will be done as necessary.

Long-Term Effectiveness and Permanence: Alternative 5 will eliminate some long-term residual risks associated with landfill gas emissions and groundwater contamination. The groundwater extraction will prevent the contaminants from migrating to the river. However, if the wells are shut off, groundwater will well up behind the subsurface barrier and eventually continue to migrate towards the river. This groundwater could be contaminated by any remaining contaminants in the landfill. The metals sludge generated will not be considered hazardous because the contaminants will not be leachable and, therefore, will not be of concern.

The long-term effectiveness is excellent for landfill gas emissions. This alternative should eliminate uncontrolled emissions of odor-causing compounds if the activated carbon system is properly maintained. The monitoring program proposed should be adequate to estimate breakthrough time for each vent or group of vents. Alternative 5 should be also effective at limiting migration of landfill gas. Gas generation should decline over time until gas treatment eventually becomes unnecessary.

For the purposes of this study, the remediation period is assumed to be 30 years. The site will be monitored and reevaluated every 5 years to determine when all objectives have been achieved. Most components of the active gas collection system should have a useful life of at least 15 years, assuming routine maintenance is carried out. The blower may need replacement sooner if corrosion becomes a problem. The long-term effectiveness and permanence of the cap depends upon effective maintenance. Annual inspection and maintenance procedures should address subsidence, erosion, burrowing animals, and vegetation roots.

Reduction of Toxicity, Mobility, or Volume: The volume of the contaminants in the groundwater will decrease as a result of groundwater extraction and treatment. However, the toxicity and mobility of contaminants in groundwater remain the same. In addition, mobility of the contaminants in the fill will be reduced as a result of the cap, surface water diversions system, vertical barrier, and groundwater pumping system. The volume of some of the contaminants may also be reduced due to degradation and leaching out via groundwater. The toxicity of the contaminants in the fill will remain the same.

Activated carbon treatment of vent gas will reduce the emissions of H_2S and some organic compounds in the landfill gas by trapping them on the carbon. As explained above, the migration of gas from the landfill to the surrounding soils should be reduced by the active gas vents. The volume of gas emitted to the air may not be affected by this alternative, but the emission of toxic compounds to the atmosphere will be substantially reduced.

__Implementability:__ This option is implementable from a technical perspective. The techniques for hydraulic control of the groundwater and removal of the contaminants are well established. The removal of metals from the ion exchange resin and subsequent solidification in the vacuum dryer provides a large reduction in volume, making subsequent disposal much cheaper. However, substantial amounts of data are required for the detailed design of such technologies.

Alternative 5 requires installation of interior vents, which will require penetrating the flexible membrane liner and boring through several feet of refuse at each vent location. Drilling operations in landfills can be dangerous and difficult due to the presence of explosive gases and large obstructions. It can be done using non-sparking drilling equipment and/or water or inert gas suppression techniques to reduce the potential for explosions, as well as a variety of different drilling methods and equipment to penetrate large obstructions. This equipment is usually available to drilling firms and should not cause a delay However, non-sparking drilling equipment may not be readily available from local sources.

The activated carbon treatment system proposed for this alternative is readily available from vendors in the greater NYC area. All pipes and fittings used in the construction of this system are commercially available. There should be no substantial delays in implementing this alternative in acquiring these materials.

The required amount of sulfuric acid may not be readily available from local vendors and may have to be transported by rail.

As discussed in Alternative 3 from an administrative standpoint coordination and approval with applicable agencies would be required.

Cost: The initial capital cost for implementing this alternative is estimated to be $10,048,000 and includes the following.

- Temporary fencing and gates to restrict site access during implementation of remedial activities.
- Construction of 19 active interior gas vents, a manifold system, and a blower.
- Installation of an activated carbon treatment system.
- Construction of 18 passive gas vents along the landfill perimeter.
- Construction of subsurface CD vertical groundwater barrier.
- Construction of surface water run-on diversion.
- Construction of 4 downgradient groundwater extraction wells.
- Installation of pumps and piping.
- Installation of equalization tank.
- Installation of an ion exchange treatment system.
- Installation of a sludge dryer.

The annual operation and maintenance cost estimate for the first five years is $818,000 and includes the following:

- Labor and materials for replacing activated carbon.
- Labor and materials for maintaining blowers, an ion exchange regeneration pump, temporary fencing, gates and other equipment
- Labor and materials for monitoring as previously described.

- Labor and materials for operating and maintaining an ion exchange groundwater pump and treat system.
- Costs of sludge disposal

For the initial four rounds of sampling which will occur the first year, the cost estimate assumes that a total of eight samples will be submitted to a laboratory for quantitative analysis. In year five following remediation, the costs will drop by $13,000 due to the expected decrease in soil gas requiring treatment.

The total first-year implementation costs are therefore $10,866,000.

Future lump sum costs are estimated to range from $27,000 to $249,000 per year for the gas treatment system described in Alternative 4. This includes replacement of one interior gas vent and one perimeter gas vent each year due to damage caused by vandalism, landfill settlement and corrosion due to H_2SO_4. Replacement of the blower every 5 years is also included. An additional $29,000 will be required every fifth year for maintaining the groundwater treatment system.

The present worth for this alternative is estimated to be $23,992,000.

5.2.6 B/K Alternative 6: Excavation with Off-Site Fill Waste/Soil Treatment and On-Site Groundwater Treatment

This alternative treats soil and groundwater, thereby remediating existing contamination and eliminating the potential for future contamination. A temporary fence and gate will be set up during the remedial actions to restrict access to the site until this alternative has been implemented.

Description

<u>Fill Waste/Soil:</u> The landfill would be excavated in horizontal cuts from the highest elevation down. Excavation will use a variety of equipment types. This equipment may include backhoes, cranes and attachments (draglines and clamshells), bulldozers, and front-end loaders. Prior to excavation, distinct

operating areas will be constructed and controlled to minimize contaminant releases and protect workers and neighboring communities. These operating areas will also be designed to facilitate temporary storage of excavated materials prior to any treatment, decontamination, or disposal

This analysis assumes the entire landfill (460,000 cy) will be excavated, although the possibility exists that only a portion of this material may need excavation. This uncertainty is discussed further in Section 5.4.3 of this report. Following excavation, the landfill materials may require grinding, shredding separation, and/or decontamination, depending on the type of material and its size. Most incineration facilities cannot accept material larger than six inches by six inches. Some facilities cannot accept certain types of materials such as structural steel.

Some materials may be easier to decontaminate than to grind or chop into very small pieces. If decontamination is required, it will be achieved using steam and industrial detergents. The rinsate from this process will be collected and transported to an off-site wastewater treatment plant where it will be treated to applicable standards and then discharged The decontaminated material will be tested to assure it passes the TCLP test and will then be placed either in the excavated area or at an off-site landfill.

Incineration is a treatment method which uses high temperature oxidation under controlled conditions to degrade organic compounds into carbon dioxide and water. It is capable of destroying organics, with very high efficiencies, in liquid, gaseous, and solid waste streams. The high destruction efficiencies are achieved by using high temperatures, usually 1,500 to 3,000°F, and long material residence times However, incineration would not destroy the metals contamination. Therefore, the residue (ash) would probably require stabilization prior to disposal. The ash could be stabilized using a variety of different compounds (e.g., pozzolanic agents) and then landfilled.

In this alternative, off-site incineration at a commercial incineration facility permitted to treat the wastes from this landfill is considered. The excavated waste could be sent to incinerators in Ohio, South Carolina, and Texas.

Currently, these are the closest incinerators that would accept the waste. Based on conversations with several vendors[1], the volume of waste requiring incineration could not be handled by one facility alone. Therefore, the wastes would be sent to multiple incinerators to allow for timely remediation. This portion of Alternative 6 would take approximately seven years if the entire volume (480,000 cy) must be incinerated and three incinerators are available.

Soil Gas/Air: Soil gas and air monitoring is included in this alternative during remedial activities. Real-time monitoring will be done for H_2S, volatile organics (methane and non-methane), and particulate matter. No long-term monitoring will be required because all wastes will be removed.

Groundwater: Alternative 6 includes a groundwater extraction system similar to that described in B/K Alternative 5. This system will be designed to adjust to changes in groundwater flow which may arise as the landfill is excavated. Since this alternative does not include a vertical groundwater barrier, the position and number of extraction wells may be slightly different from the system described in Alternative 5. The design would attempt to minimize drawback of river water into the site groundwater. During a detailed design phase, the actual locations and number of these wells would be determined.

Based on available data and the fact that the source (i.e. fill waste/soil) will be excavated and remediated over a seven-year period, operation of the groundwater extraction and treatment system for a period of 15 years should be sufficient to remediate the groundwater. The site will be monitored annually and reevaluated every five years to determine if remediation has been implemented. Based on this monitoring and reevaluations, any necessary changes can be implemented to achieve groundwater remediation.

Surface Water/Sediment: Surface water and sediment provisions are identical to those in Alternative 2.

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1 Chem-Waste, Oakbrook Illinois, Rollins Environmental Service, Bridgeport, NJ, and Ross Incineration Services, Grafton, Ohio.

Threshold Criteria

Overall Protection of Human Health and the Environment: The overall protection to human health and the environment is good. Incineration offers a permanent solution for the organic contaminants which would be destroyed. For metal contaminants of concern, special consideration of ash disposal (i.e., stabilization prior to disposal) would probably be required based on available data. Stabilization and disposal of the ash would be a permanent solution and would provide protection to human health and the environment against these contaminants.

Real-time monitoring during excavation activities will provide information necessary to ensure worker health. Dust suppressants or water with surfactants may be required during some activities to protect workers or to prevent unhealthy concentrations of air contaminants. Decontamination procedures would be used to remove any contaminated soil from the trucks transporting material to the incinerator.

The high volume of trucks entering and exiting the site for fill transportation may present a highway safety hazard on Route 17. Location of site ingress and egress points should provide appropriate lines of site and acceleration/deceleration lanes. In addition, should an accident occur, the potential for short-term contaminant exposures to neighboring communities and the environment would increase.

ARARs Compliance: Procedures for removal, incineration, and disposal of the waste would comply with applicable ARARs.

Balancing Criteria

Short-Term Effectiveness: Considerable short-term risk is involved in excavating and transporting potentially contaminated waste from the B/K parcel. These risks are caused by the increased potential for release of contaminants into other environmental media and by the risk of fire during excavation operations.

Contaminants would be released into the air during remediation when volatile organic materials are exposed and allowed to volatilize, when contaminated dust becomes airborne, and when landfill gases are released abruptly instead of gradually migrating through cover material. Such releases can lead to significant health risks from inhalation, both for workers on-site and for the general population off-site. On-site exposures can be limited to safe levels through use of real-time monitoring and personal protective equipment, e.g., respirators. Off-site exposures can be limited by adjusting operations according to real-time monitoring results and applying engineering controls as needed. Such engineering controls may include dust suppression using water with added surfactants. Traffic accidents during truck transport are also potential means of off-site contamination.

To estimate the increased risks of off-site exposures to VOCs during excavation activities on the site, the analysis assumes that the B/K parcel, which was filled in three whole or partial lifts, would be excavated in horizontal cuts from the highest elevation down. When half of the waste is removed, at least 50-60% of the fill waste surface would be uncovered. For this estimate, a conservative value of 50% exposed surface is used.

EPA estimates (EPA, 1989)[2] that, on average, VOC emissions from exposed waste are 342 times higher than from covered waste. Therefore, during the period of excavation, VOC emissions would be 171 times higher than baseline conditions.

$$342 \times (50\% \text{ of area exposed}) = 171$$

The estimated excavation time for Alternative 6 is seven years. Assuming the calculated cancer risk is proportional to exposure doses established by the time

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2 Air/Superfund National Technical Guidance Study Series, EPA-450/1-89-003, Jan A89, p. 104.

period of exposure, cancer risks associated with excavating the site would be 17 times higher than for baseline conditions:

$$171\left(\frac{7\,years}{70\,years}\right) = 17$$

Chronic health effects, which are proportional to receptor dose, would follow similar patterns. Assuming the same generation rate for hydrogen sulfide as under baseline conditions (which is a conservative assumption), estimated long-term maximum concentrations of this gas could exceed a California guidance value for chronic health effects.

The time to implement the overall remedial action may range up to 15 years depending on the effectiveness of the groundwater remediation. A review every five years would be required

<u>Long-Term Effectiveness and Permanence:</u> The long-term effectiveness of this option is good. All contaminated wastes will be excavated, treated, and removed. Therefore no long-term risk will remain at the site

<u>Reduction of Toxicity, Mobility, or Volume:</u> This alternative significantly reduces toxicity, mobility, and volume of contaminants in the soil and groundwater Residuals of the incineration process will be disposed in an approved manner. They will probably be stabilized and placed in an approved off-site landfill.

<u>Implementability:</u> This alternative is difficult to implement. Commercial incineration facilities are available, although significant problems may arise during all steps of remediation. Excavation of the landfill material is a major task which will require steps to avoid increasing health and environmental risks. A large fraction of the excavated material would require on-site shredding, and/or grinding, and/or decontamination before it would be acceptable to the off-site commercial facilities. Based on conversations with several vendors, the closest incinerators capable of handling the fill are located in Cleveland, Ohio, Rock Hill, South Carolina, and Deerpark, Texas. These incinerators would be used

because one facility alone could not handle the volume of material requiring treatment.

If the entire waste volume is excavated, the volume of material requiring transport to the incinerator facilities is very large. Therefore, the traffic problems and coordination involved with moving this material would have significant impacts on the neighboring communities Coordination with several agencies may be necessary to comply with policies on excavating, labeling, transport, and approved truck routes.

Several vendors in the metropolitan area have equipment and material necessary for excavating and preparing the waste for off-site incineration A few vendors across the country have indicated that they would accept these types of material although some issues (e.g., types of materials and contaminant levels) would have to be addressed prior to shipment.

Cost: The capital cost of implementing fill waste/soil remediation for this alternative is estimated to be $1,199,000,000 and includes the following major components:

- temporary fencing and gates
- excavation of waste
- on-site shredding and grinding equipment
- transportation to off-site incinerator
- incineration services
- placement of clean backfill cover in areas of excavated waste

Additional capital costs include:

- installation of groundwater extraction and treatment system as previously described
- installation of air monitoring system

The capital costs for incineration are distributed over 7 years in increments of $171,264,000

The annual operation and maintenance cost estimate is $692,000 and includes the following:

- Truck transportation costs
- Labor and materials for monitoring, maintenance and implementation of appropriate engineering controls, if needed, during excavation
- Labor and materials for maintaining groundwater treatment system as described in B/K Alternative 5
- Repair and maintenance of on-site shredding and grinding equipment

Thus, the total costs for the year of implementation include $172,575,000.

Future lump sum costs included as part of this alternative are $29,000 for years 5 and 10 primarily for replacement of monitoring wells

The present net worth for this alternative is $1,049,256,000.

5.2.7 B/K Alternative 7: Excavation with On-Site Incineration of Fill Waste/Soil, On-Site Disposal of Ash, and Groundwater Treatment

This alternative is identical to B/K Alternative 6, except that the incineration will take place on-site rather than off-site. A temporary fence and gate will be installed to restrict access during implementation of remedial actions.

Description

Fill Waste/ Soil: Fill waste and soil treatment provisions are identical to those described in B/K Alternative 6, except that the incinerator will be located on-site. In addition, all incinerator ash will also be stabilized on-site and placed back into the excavated fill area and capped. TCLP testing will be part of the stabilization process to ensure that the stabilized ash meets all applicable ARARs, and is no longer hazardous.

The analysis assumes that a rotary kiln incinerator will be used with a high efficiency wet scrubber for acid gas and particulate control. However, other incineration designs may be acceptable Prior to designing the incinerator, additional limited excavation will be performed to provide additional information about the composition of the waste to be incinerated will be necessary for designing the incinerator. Assuming that all of the landfilled wastes (480,000 cy) will need incineration, the incineration activities will take approximately five years using three incinerator facilities. The rate of waste excavation should be planned to maintain a minimal storage pile of waste ready for incineration, thereby minimizing potential exposures to the contamination. Prior to implementation, a test burn would be performed to obtain additional data to be used in the detailed design

Soil Gas/Air. Soil gas and air quality provisions are similar to those in Alternative 6, except that additional air monitoring is required for the incinerator stack emissions to demonstrate compliance with ARARs

Groundwater: Groundwater provisions are identical to those in Alternative 6.

Surface Water/Sediment: Surface water and sediment provisions are identical to those in Alternative 1.

Threshold Criteria

Overall Protection of Human Health and the Environment: The overall protection to human health and the environment is good. Incineration offers a permanent solution for destroying all of the organic contaminants. However, for metal contaminants of concern, special consideration of the disposal of ash may be required. This would probably include stabilizing and TCLP testing the ash prior to disposal. Air contaminants potentially emitted from the on-site facility would have to be controlled to ensure compliance with state and federal standards.

Real-time monitoring during excavation activities will provide information necessary to ensure worker health. Dust suppressants or water with surfactants may be required to protect workers or to prevent unhealthy concentrations of air contaminants off-site due to excavation and materials handling operations Detailed evaluation of the risks associated with incinerator stack emissions will be required after the design is established.

ARARs Compliance: Alternative 7 would be in compliance with most ARARs. Removal and/or treatment of the waste would comply with applicable RCRA, TSCA, and CAA requirements However, the disposal of decontaminated material and stabilized ash may require an ARAR waiver The applicable RCRA land ban regulations require that all disposed material (i.e decontaminated materials and/or stabilized ash) be placed in a lined landfill which has a leachate collection system. The land available at the site and the volume of landfill materials being excavated and/or treated and/or disposed of at the site would make it very difficult to fully comply with this part of this ARAR. Therefore, a waiver may be needed.

Balancing Criteria

Short-Term Effectiveness: Considerable short-term risk is involved in excavating, handling (i.e., grinding, shredding, and/or decontamination), and moving potentially contaminated waste from the B/K parcel. These risks are caused by the increased potential for release of contaminants into other media and by the risk of explosion during excavation operations.

Contaminants may be released into the air when volatile organic materials are exposed and allowed to volatilize, when contaminated dust is entrained, and when landfill gases are released abruptly instead of gradually migrating through cover material. Such releases can lead to significant health risks from inhalation, both for workers on-site and for the general population off-site. On-site exposures can be limited to safe levels through use of real-time monitoring and personal protective equipment, e.g., respirators. Off-site exposures can be limited by adjusting operations according to real-time monitoring results and applying engineering controls as needed Such engineering controls may include, but are not limited to, dust suppression using water with added surfactants.

Potential cancer risks associated with excavation activities on the site were estimated in a manner similar to Alternative 6. For the five-year period associated with the on-site incineration alternative, estimated cancer risks would be 12 times higher than baseline conditions.

The implementation time may be up to 30 years depending on the effectiveness of the groundwater remediation. Further information on the nature of the contaminated material would be needed for incinerator design. Significant time is required for developing performance specifications, obtaining responsible bids from vendors, addressing the concerns of citizens, constructing the incinerator on-site, and performing required trial burn and performance tests. Air pollution control equipment and continuous monitoring of stack gases would be included in the incinerator design. Once the incinerator system is designed and maximum emission rates are estimated, health risks due to emissions from the incinerator stack and from excavation and handling operations must be evaluated in detail to minimize all short-term effects.

Long-Term Effectiveness and Permanence. The long term effectiveness of this option is good. Because contaminated wastes will be treated, little or no long-term risk should remain. Proper disposal of the ash, which will still contain most of the metals contaminants, will be necessary However, this will not present a problem. The stabilization, TCLP testing and disposal of the ash will essentially eliminate any risks associated with it. Monitoring will be performed to assess this point.

Reduction of Toxicity, Mobility, or Volume: This alternative significantly reduces toxicity, mobility, and volume of contaminants in the soil and groundwater. Residuals of the incineration process will be treated, TCLP tested, and disposed in an approved manner, such as stabilization to reduce the leachability of the metals, followed by landfilling.

Implementability: Alternative 7 is implementable However as discussed in Alternative 6, excavation and handling of the landfill material is a major task. In addition, sufficient space for the incinerators and staging areas is assumed to be available on-site. A section of the site may have to be cleared and excavated to provide sufficient space for the incinerators. This excavated material would be stored temporarily until the treatment facility was operational.

Commercial mobile incineration facilities are available from several vendors. The system would be designed specifically for site conditions, waste materials, and contaminant levels. It would be designed to meet all air permitting requirements, and a test burn would be required to ensure that these requirements have been met.

Significant time may be required to excavate the entire site, prepare the materials for incineration, and process them through the incinerator. Based on the throughputs of incinerators currently in operation, approximately five years would be needed to incinerate the waste assuming a processing rate of 20 tons/hour. This alternative assumes that all landfill materials (480,000 cy) would require excavation and incineration. As discussed in Section 5.4.3, only a fraction of this material may require incineration. The remaining fraction could possibly be decontaminated. This uncertainty could greatly affect the cost and implementability of this alternative. In addition, the incineration of ash, which would contain metals, would be stabilized and TCLP tested prior to disposal in order to meet all land ban regulations.

Cost: The capital cost of implementing fill waste/soil remediation for this alternative is estimated to be $261,055,000 and includes the following major components:

- Excavation and on-site incineration of waste
- Equipment for grinding and shredding
- Placement of incinerator ash into lined landfill constructed on site

Additional capital costs include

- Installation of groundwater extraction and treatment system as previously described
- Installation of air monitoring system

The capital cost estimate for fill waste/soil assumes a waste processing rate of 20 tons/hour, which will achieve desired remediation in five years. Capital costs estimated for the incineration are distributed in equal increments of $52,211,000 over the five-year period. The first-year implementation costs, including O&M, would be $53,561,000

The annual operation and maintenance cost estimate for the first 15 years is $731,000 and includes the following:

- Environmental monitoring of soil gas and groundwater as previously described
- Labor and materials for maintenance of lined landfill cap.
- Labor and materials for preparation of annual engineering reports.
- Operations and maintenance of grinding and shredding equipment.

After the fifteenth year, the annual operation and maintenance cost estimates decrease to an estimated $102,000 because groundwater is expected to be remediated at this point.

Future lump costs included as part of this alternative include $29,000 every five years for repair and/or replacement of groundwater monitoring wells.

The present net worth for this alternative is $246,869,000.

5.3 GEORGIA TECH PARCEL ALTERNATIVES

This section presents the analyses of the alternatives being considered for the Georgia Tech Parcel. For each of the four alternatives discussed, the alternative is described first, followed by an evaluation of the alternative with respect to the threshold and modifying criteria described in Section 5.1. Table 5-2 provides a summary of the alternatives.

5.3.1 Georgia Tech Alternative 1: No Action

This alternative is included to allow evaluation of the effects of taking no remedial action on the Georgia Tech Parcel.

Description

This alternative consists of no remedial action for any media. However, the open pit on the east side of the parcel would be covered with clean soil and seeded to prevent erosion.

Threshold Criteria

Overall Protection of Human Health and the Environment: This alternative should have no significant effect on chronic human health risk. The potential exists for migration of landfill gases into the surrounding environment, which could cause an adverse impact. However, the emissions of these gases are expected to be small. Displacement of in situ soil gas by landfill gas can be detrimental to vegetation. Since no gas migration controls will be implemented as part of this alternative, it is not protective of the environment surrounding the landfill.

ARARs Compliance: This alternative will meet all ARARs except as discussed in the following paragraphs.

This alternative would not meet the applicable closure requirements of NYCRR Part 360 which requires capping of the landfill.

Decomposition of waste materials on this parcel are contributing to the H_2S emissions from the Tuxedo Waste Disposal Site, which exceed the 1-hour ambient air standard and cause an odor nuisance. The volume of waste on the Georgia Tech parcel is small relative to the B/K parcel, and therefore its contribution to the odor nuisance is similarly small. Some emissions of H_2S would continue to occur under the No Action alternative and compliance with this ARAR may not be met.

Balancing Criteria

Short-Term Effectiveness: This alternative will have no short-term effect on the existing groundwater, sediment, surface water, air, or soil gas quality. The alternative will not be effective at reducing releases of any contaminants into any environmental medium.

Long-Term Effectiveness and Permanence: This alternative may have some marginal long-term effect on the existing groundwater, sediment, surface water, air, or soil gas quality. As the age of the wastes in the landfill increases, the production of gases should decrease. The biodegradation of some landfill contaminants should reduce the potential for any off-site H_2S contamination gradually. There is a small potential for contaminants to have an adverse impact on groundwater or surface water. Therefore, the long-term effectiveness of this alternative may be satisfactory.

Reduction of Toxicity, Mobility, or Volume: No direct reduction in toxicity, mobility, or volume of any contaminant will occur as a result of implementing this alternative. Any such reduction will only occur as a result of natural phenomena that are not affected by the alternative.

Implementability: Due to the limited on-site activity required, this alternative can be readily implemented. The materials and equipment needed to fill the open pit on the east side of the parcel are readily available from several vendors.

Cost: The total present net worth for this alternative is $26,000. This is a capital cost for filling the open pit. No operation and maintenance costs are anticipated for this alternative.

5.3.2 Georgia Tech Alternative 2: Removal to B/K Parcel

This alternative involves moving the Georgia Tech wastes to the B/K Parcel for redeposition and capping. The advantages in this approach are that the Georgia Tech waste can be used as fill material for slope control on the B/K Parcel.

Description

Approximately 14,600 cubic yards of material were placed on the northeastern portion of the Georgia Tech Parcel. This material can be excavated and re-landfilled on the B/K Parcel prior to its capping. The affected area on the Georgia Tech property would require limited backfilling for slope consideration and erosion control.

Threshold Criteria

Overall Protection of Human Health and the Environment: The overall protection of human health and the environment would be good. The excavation and transport of the waste materials would present some short-term risks such as releases of H_2S during excavation and potential truck accidents while transporting the materials. However, these risks would be minimized using real-time monitoring. Loss of vegetation and habitat during remedial activities would be temporary in nature. This alternative would provide long-term permanent protection to human health and the environment because no residual risks would remain on-site.

ARARs Compliance: The excavation and transport of the Georgia Tech waste would comply with all applicable ARARs.

Balancing Criteria

Short-Term Effectiveness: Some short-term risk is involved in excavating and moving waste from the Georgia Tech parcel. These risks are caused by the increased potential for release of contaminants into the air and by the risk of fire during excavation operations.

Fugitive dust may be released during remediation, and contaminants may be released into the air when landfill gases are released abruptly instead of gradually migrating through cover material. Such releases could lead to health risks from inhalation, both for workers on-site and for the general population off-site. On-site exposures can be limited to safe levels through use of real-time monitoring, personal protective equipment, e.g., respirators and other engineering controls during excavation. Off-site exposures can be limited by adjusting operations according to real-time monitoring results and applying engineering controls as needed. Such engineering controls may include dust suppression using water with added surfactants. There may be a slight increase in adverse environmental impacts due to contaminant releases during implementation of this alternative. However, this would be a temporary situation with no permanent or lasting effects expected.

Long-Term Effectiveness and Permanence: The long-term effectiveness of this alternative is good. It provides permanent protection and no residual risks remain.

Reduction of Toxicity, Mobility, or Volume: Moving the waste to the B/K parcel reduces the toxicity, mobility, or volume of any potentially contaminated material in this area.

Implementability: The overall implementability of this option is good. Equipment needed to excavate and move the material from this area is readily available from several vendors. From an administrative perspective, coordination with applicable agencies and local traffic authorities would be needed.

Cost: The capital cost for this alternative is estimated to be $367,000, and items included in this cost are:

- Fill excavation
- Transport to the B/K Parcel
- Engineering design and oversight

There are no operation and maintenance or future capital costs for this alternative.

The total present net worth to implement this alternative is estimated to be $367,000.

5.3.3 Georgia Tech Alternative 3: Off-Site Treatment and Disposal

Description

Waste would be excavated from this area and transported off-site for incineration exactly as described for the B/K waste in B/K Alternative 6. An estimated 14,600 cubic yards of material would be incinerated. Grinding and shredding of large items may be required on-site before the wastes are transported to an incinerator.

Threshold Criteria

Overall Protection of Human Health and the Environment: The overall protection to human health and the environment is good. Incineration offers a permanent solution to the wastes. If any metal contaminants of concern are discovered, special consideration of the ash disposal may be required. However, this should not present any problems.

As a safety precaution, real-time monitoring during excavation activities will provide information necessary to ensure worker health. Dust suppressants, such as water with surfactants, may be required during some activities to minimize generation of fugitive dust. Workers would be provided with personnel protective equipment during remedial activities.

<u>ARARs Compliance</u>: This alternative would comply with all applicable ARARs.

Balancing Criteria

<u>Short-Term Effectiveness.</u> The community and remediation workers will be well protected during remedial activities. Dust suppressants can be used to reduce the exposure of the workers and general population to fugitive dust. In addition, respiratory protection may be required for workers to prevent inhalation of dusts or landfill gases, emissions of which would likely increase during excavation activities. As discussed in B/K Alternative 6, excavating and preparing (i.e. grind and/or shred or decontaminate) this material prior to incineration may be very difficult. However, since this is a smaller volume of waste, it may be less of a problem. Any adverse environmental impacts during implementation of this alternative would be temporary and should not be significant based on present knowledge of site condition.

<u>Long-Term Effectiveness and Permanence:</u> The long-term effectiveness of this option is good. Because all potentially contaminated wastes will be removed, no long-term risks will remain.

<u>Reduction of Toxicity, Mobility, or Volume:</u> This alternative reduces toxicity, mobility, and volume of any contaminants in the waste materials. Residuals of the incineration process will be disposed of in an approved manner by the off-site treatment facility.

<u>Implementability:</u> This alternative is implementable. Commercial incineration facilities are available, although significant time may be required to excavate the entire site, handle it (i.e., grind and/or decontaminate) and transport it to the incinerator. Several facilities have acknowledged that they can accept this volume of material. However, they have strict size requirements for the waste. Equipment to excavate the landfill materials and to grind, shred, or

decontaminate them prior to off-site treatment is available through several vendors.

No local incineration facilities are currently available. Therefore the material would be transported to facilities in Ohio, South Carolina, or Texas as discussed in B/K Alternative 6 This would require coordination with traffic and transportation authorities. The incinerators' capacity would determine the rate of excavation and removal.

__Cost:__ The capital cost for this alternative is estimated to be $41,544,000 and includes:

- Excavation
- Incineration
- Engineering design and oversight

There are no operation and maintenance costs or future capital costs for this alternative.

The total present net worth to implement this alternative is estimated to be $41,544,000.

5.3.4 Georgia Tech Alternative 4: On-Site Treatment and Disposal

Description

This alternative involves excavating the Georgia Tech waste and moving it to the B/K Parcel for on-site incineration. Thus, an additional 14,600 cubic yards of material would be added to the B/K treatment process. This alternative would be considered only in conjunction with B/K Alternative 7, the on-site treatment alternative.

Threshold Criteria

Overall Protection of Human Health and the Environment: The overall protection to human health and the environment for this section is identical to Georgia Tech Alternative 2

ARARs Compliance: Compliance with ARARs for this section is the same as described in B/K Alternative 7

Balancing Criteria

Short-Term Effectiveness: As described in Georgia Tech Alternative 2, some short-term risks result from the excavation and movement of the Georgia Tech waste. In addition, the length of time required to complete the treatment of all waste at the Tuxedo Waste Disposal site would increase by about 10 percent.

Long-Term Effectiveness and Permanence. Long-term effectiveness and permanence should be good for this alternative because no residual risks would remain in this area.

Reduction of Toxicity, Mobility, or Volume: This alternative would reduce toxicity, mobility, and volume of waste as described in B/K Alternative 7.

Implementability: The implementability of this alternative is the same as described in Georgia Tech Alternative 2 and B/K Alternative 7.

Cost: The capital cost for this alternative is estimated to be $12,753,000 and includes:

- Excavation
- Movement to the B/K Parcel
- Incineration
- Engineering design and oversight

TABLE 5-1

Summary of B/K Remedial Alternatives

Alternative	Overall Protection	ARARs Compliance	Short-Term Effectiveness	Long-Term Effectiveness	Toxicity, Mobility, or Volume Reduction	Implementability	Relative Cost	Recommendation
1	I	I	I	M	I	A	Low	Reject
2	M	I	A	M	M	A	Moderate	Reject
3	A	M	A	M	A	A	Moderate	Accept
4	A	M	A	M	A	A	Moderate	Accept
5	A	A	A	M	A	A	Moderate	Accept
6	I	A	I	A	A	M	High	Reject
7	M	A	I	A	A	M	High	Reject

Description of Alternatives

1: No Action
2: Landfill Cap
3: Landfill Cap with Passive Gas Venting/Treatment
4: Landfill Cap with Active Gas Venting/Treatment
5: Landfill Cap with Active Gas Venting/Treatment and Groundwater Treatment
6: Excavation with Off-Site Fill Waste/Soil Treatment and On-Site Groundwater Treatment
7: Excavation with On-Site Fill Waste/Soil and Groundwater Treatment

Key

I – Inadequate
M = Marginally Adequate
A = Adequate

TABLE 5-2

Summary of Georgia Tech Remedial Alternatives

Alternative	Overall Protection	ARARs Compliance	Short-Term Effectiveness	Long-Term Effectiveness	Toxicity, Mobility, or Volume Reduction	Implementability	Relative Cost	Recommendation
1	I	I	I	M	I	A	Low	Reject
2	A	A	M	A	A	A	Moderate	Accept
3	A	A	M	A	A	M	High	Reject
4	A	A	M	A	A	M*	High	Reject

I = Inadequate

M = Marginally Adequate

A – Adequate

* = Only feasible if B/K Alternative 7 is selected

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The following three alternatives are recommended for further consideration. They provide, at a minimum, for a vented landfill cap with gas collection and treatment.

- Alternative 3, Landfill Cap with Passive Gas Venting/Treatment
- Alternative 4, Landfill Cap with Active Gas Venting/Treatment
- Alternative 5, Landfill Cap with Active Gas Venting/Treatment and Groundwater Treatment

The remainder of this section compares the seven alternatives according to each of the evaluation criteria.

5.4.1 Threshold Criteria

Overall Protection of Human Health and the Environment

Currently, there are marginal public health and environmental risks at the site due to gas emissions from the landfill. Therefore, only the gas treatment alternatives (B/K alternatives 3, 4, and 5) and the soil treatment alternatives (B/K alternatives 6 and 7 and Georgia Tech alternatives 3 and 4) offer any reduction in modeled health risks and environmental risks.

The only current exposure route of concern is inhalation of volatile contaminants. Current cancer risks off-site were estimated by EPA methods to be about 10^{-6}. Non-carcinogenic risks were estimated to be acceptable with a Hazard Index of much less than one. An odor nuisance problem is related to hydrogen sulfide releases. Given the decline in landfill gas production expected to occur over time, air pathway risks may decline without any remedial action being taken. If administrative controls are used to ensure that future land use does not lead to additional exposure routes (e.g., use of groundwater for drinking water or construction of a residential structure on the site), then no remediation may be needed, based on the baseline risk assessment of present conditions.

If current conditions and risks are deemed unacceptable, remediation may be required. Only the gas treatment alternatives (B/K Alternatives 3, 4, and 5) and the soil treatment alternatives (B/K alternatives 6 and 7) offer any reduction in existing modeled health risks. All of these alternatives should be capable of addressing potential air pathway risks.

If no action is taken at the B/K parcel, the potential exists for further contamination of groundwater in the future and, hence, of the Ramapo River. The only alternatives that reduce or eliminate this threat are the groundwater extraction alternatives and soil treatment alternatives (B/K Alternatives 5 through 7). Capping would limit the potential by limiting surface water infiltration through the cap, but groundwater would still be free to move through the landfill.

The most protective alternatives in the long-term are the soil excavation and treatment alternatives (B/K Alternatives 6 and 7, and Georgia Tech Alternatives 3 and 4). However, significant short-term risks are associated with moving the volumes of waste. Such risks arise from potentially contaminated fugitive dust and releases of noxious and toxic landfill gases. In addition, if the material is hauled off-site (B/K Alternative 6 and Georgia Tech Alternative 3), additional risks arise due to the increased potential for traffic accidents.

Table 5-3 provides a concise comparison of the potential health risks among the alternatives. Alternative 1, the No Action Alternative, represents a baseline against which the other six alternatives are compared. In comparison to the No Action Alternative, the health risks associated with Alternatives 2 through 7 are identified as significantly lower (<<), lower (<), similar (baseline), higher (>), or significantly higher (>>).

The column for risks from carcinogenic contaminants is based on a 70-year exposure period. Risks for noncarcinogenic contaminants include both acute (short-term, high concentrations) and chronic (long-term, lower concentrations) exposures. The comparisons are based on modifications of emission rates from the baseline emission estimate. The water pathway column is divided into short-term risks, which are associated with remedial activities such as excavation, and

TABLE 5-3

COMPARISON OF RISKS FOR POTENTIAL REMEDIAL ALTERNATIVES

Alternative	Air Pathway			Groundwater and Surfac Water Pathway	
	Carcinogens (70 Year Risk)	Non-Carcinogens			
		Acute Risk	Chronic Risk	Short-Term Risk	Long-Term Risk
1. No Action	Base	Base	Base	Base	Base
2. Landfill Cap (C & D)	Base	Base	Base	Base	<
3. Landfill Cap (C & D); Passive Gas Venting and Treatment	<	<	<	Base	<
4. Landfill Cap (C & D); Active Gas Venting and Treatment	<	<	<	Base	<
5. Landfill Cap; Active Gas Venting and Treatment; Groundwater Collection and Treatment On-Site	<	<	<	< <	< <
6. Fill/Waste Excavation With Off-Site Incineration; Groundwater Collection and Treatment On-Site	> >	> >	> >	>	< <
7. Fill/Waste Excavation With Off-Site Incineration; Groundwater Collection and Treatment On-Site	> >	> >	> >	>	< <

Key

< < Significantly lower
< Lower
Base Similar to baseline
> Higher
> > Significantly higher

long-term risks, which are due primarily to the continued migration of contaminants from the site's groundwater to the Ramapo River.

Results show that Alternatives 1 and 2 have similar results. The placement of a clean cap as part of the 6 NYCRR Landfill Closure requirements would have little long-term effect on health risks. These two alternatives are not recommended because they are ineffective in reducing potential health risks for the contaminant pathways of concern.

Alternatives 3, 4, and 5 are very similar because their gas collection systems reduce the risks from air contaminants. In addition, the passive gas collection system in Alternative 3 will be designed in a manner that facilitates upgrading to an active extraction system (as described in Alternative 4) should future needs warrant this. Alternative 5, which also includes groundwater treatment, would also significantly reduce potential contamination of off-site groundwater and surface water.

Alternatives 6 and 7 would generally increase risks from exposure to air contaminants, especially for short-term exposures to contaminated fugitive dust and landfill gases. Although these alternatives would significantly reduce potential long-term risks to off-site groundwater and surface water, the short-term risks would be increased due to surface runoff and infiltration at exposed areas of fill/waste. These two alternatives are not recommended due to their overall increase in risks for the air pathway of contamination, which is the pathway of primary concern.

The best balance of reducing current risks and ensuring future protection of the Ramapo River seems to be provided by a combination of B/K Alternative 3, 4, or 5 with Georgia Tech Alternative 2 (removal of waste to the B/K Parcel). B/K Alternative 3 provides moderate reduction in current risks (passive gas collection and gas treatment) along with monitoring of media. B/K Alternative 4 offers more current risk reduction (active gas extraction and treatment system) and provides monitoring of other media, which would allow for additional remediation in the future if conditions warrant. B/K Alternative 5 offers the best current and future risk reduction with both gas and groundwater collection and treatment.

ARARs Compliance

Results of the 1990 RI indicate that contamination in various media at the Tuxedo Waste Disposal Site exceeded NYS standards (ARARs) and guidance values (SCGs). The conclusion is tentative since metals levels can be used only as estimated values. In addition, certain exceedances can be attributed to non-site related sources.

Air:	Short-term (1 hour) standard for hydrogen sulfide
Groundwater:	Various metals (estimated values) semi-volatile organics (two PAHs exceeded guidance values, an estimated phenol level exceeded the standard)
Surface water:	Iron (standard exceeded including upstream sample), Mercury exceeds the guidance value for aquatic species
Sediments:	Various metals (seven metals exceeded guidance values for fish and wildlife; four of these metals exceeded guidelines in upstream sample)
	Semi-volatile organics (PAH exceedances were only in upstream sample)

The only air ARAR currently likely to be violated at the site is a short-term H_2S AGC. Air dispersion modeling indicated it may be exceeded under certain conditions. Given the uncertainties in the modeling, particularly in the emission rate used, violation of this ARAR is by no means certain. Only the gas treatment alternatives (B/K Alternatives 3, 4, and 5) and the soil treatment alternatives (B/K alternatives 6 and 7, and Georgia Tech Alternatives 3 and 4) ensure compliance with this ARAR. However, ARAR compliance would probably not be affected by remedial activities on the Georgia Tech Parcel by itself.

Estimated concentrations for several metals and one semi-volatile organic compound exceeded NYS groundwater standards (ARARs) based on the 1988 LMS and 1990 and 1991 M&E data. However, only one identified off-site private well could potentially be affected, and this user can readily be connected to a municipal water supply. The main concern over groundwater contamination is its potential impact on the Ramapo River. The 1990 M&E river water data, which are usable as estimated values, showed that certain metals marginally exceeded NYS standards. In addition, iron levels in the Ramapo River water, as reported in both the 1988 LMS and 1990 M&E studies, are comparable to background and upstream levels.

Concentrations of seven metals in river sediments exceeded NYS guidance values (SCGs) for fish and wildlife, but four of these metals also exceeded guideline values in the upstream sample Semi-volatile organics in sediment exceeded NYS guidance values only in the upstream sample.

Other ARARs could potentially be violated in the future because landfill contaminants that may be present in groundwater beneath the site may migrate to the Ramapo River. The groundwater extraction and treatment alternative (B/K Alternative 5) and the soil treatment alternatives (B/K Alternatives 6 and 7 and Georgia Tech Alternatives 3 and 4) would address compliance with such ARARs in the future. However, based on existing data, such measures may not be required. The groundwater and sediment monitoring that is included in virtually every alternative, including No Action, would be sufficient to detect contaminants and allow for future remediation as necessary.

5.4.2 Balancing Criteria

Short-Term Effectiveness

Short-term risks are inherent in any remedial alternative that requires extensive work on-site, particularly those alternatives that include excavation of wastes for on-site or off-site treatment (B/K Alternatives 6 and 7 and Georgia Tech Alternatives 2, 3 and 4). Such risks are highest for the on-site incineration alternative because of the potential air emissions associated with the incineration facility.

Installation of a cap, which is included in B/K Alternatives 2 through 5 will require some excavation and movement of waste material to comply with Part 360 regulations for sl... ...ol, but has lower short-term risks than B/K Alternatives 6 and 7 b... ...e smaller volumes of potentially contaminated wastes must be disturbed.

Short-term effectiveness of the gas control and groundwater extraction systems is generally good. The No Action alternative and simple capping without gas treatment have relatively poor short-term effectiveness, but do not have significant short-term risks either.

The best balance between short-term risks and effectiveness seems to be obtained by a combination of B/K Alternatives 3, 4, or 5 (which include gas collection/treatment with and without groundwater collection/treatment) with Georgia Tech Alternative 2 (removal of waste to the B/K Parcel).

Long-Term Effectiveness and Permanence

The most effective alternatives in the long term are the soil excavation/incineration alternatives (B/K Alternatives 6 and 7 and Georgia Tech Alternatives 3 and 4). The groundwater and gas collection and treatment alternative is expected to have reasonably good long-term effectiveness because the amounts of soil gas contaminants generated by the waste should decline over time until they are essentially gone. At that time, gas collection could cease without fear of future contamination problems.

However, as noted above, if administrative controls are used to ensure that future land use does not lead to additional exposure routes (e.g., groundwater used for drinking or on-site residential uses), then no remediation is needed, based on the baseline risk assessment.

Reduction of Toxicity, Mobility, and Volume

Capping, included in B/K Alternatives 2 through 5 would reduce mobility of contaminants in the groundwater, but only alternatives with a gas collection component would limit mobility of landfill gases. The volume of contaminated waste material is reduced by the incineration alternatives. Toxicity of the contaminants is eliminated if they are destroyed, which only occurs in the incineration alternatives, and then only for organics. The gas and groundwater treatment alternatives reduce toxicity by removing contaminants from the affected media. Removing the contaminants affects toxicity of the target media at the site, but may transfer the contamination elsewhere (to an approved off-site disposal location).

Implementability

All of the alternatives are implementable, some more easily than others. The easiest to implement is No Action, which requires only monitoring activities as well as covering the exposed northeastern area of the Georgia Tech Parcel. The most difficult to implement are the soil excavation/treatment alternatives because of the large volume of waste, the probable heterogeneity of the waste in terms of contaminant composition and physical size, and the controls required to limit short-term risks during implementation. Capping and gas and groundwater collection/treatment alternatives are implementable, but will require additional data for final design. They will also require field testing and adjustment.

Cost

Obviously, the least expensive alternative is No Action, although its cost is not zero due to the monitoring that is included. The highest cost alternatives are the soil remediation alternatives, which are extremely expensive. The most reasonable alternatives from a cost standpoint are B/K Alternatives 3 and 4, which cap the waste, collect and treat landfill gas, and monitor groundwater and sediments. Adding a groundwater extraction and treatment system in Alternative 5 increases the cost approximately 2.7 times as compared with Alternative 4.

5.4.3 Summary of Uncertainties

Uncertainties are inherent in the designs and costs presented in this feasibility study. The uncertainties in design are due to limitations in data availability. For example, estimated volumes of landfill gas generation may be overly conservative (high), in which case the gas treatment system design may be overly protective. Similarly, limited test data is available upon which to base a groundwater extraction treatment system, so pumping rates and numbers of wells given in the extraction system must be viewed as approximations. An actual system, using field data for refinement of the design, may be quite different than the one presented here.

The estimates of landfill material requiring excavation and treatment are very conservative. This report assumes that all site waste must be incinerated. Since the volume of contaminated material is unknown, the actual fraction of waste requiring incineration cannot be determined without further study. For example, if only 25% of the waste requires incineration, the remaining 75% could be separated out, decontaminated, and disposed of as non-hazardous material in the existing on-site landfill or at an off-site landfill. If this is the case, then Alternatives 6 and 7 are estimated to have significantly lower total present net worths of $304,228,000 and $93,675, respectively. The detailed cost breakdowns for these alternatives are presented in Appendix A under Alternatives 6B and 7B, respectively. Determining the volume of waste to be incinerated cannot be addressed until additional data have been acquired or the actual remedial action is begun. Therefore, the evaluation criteria for this alternative, in particular the implementability and the costs, may change based on this uncertainty. The design proposed can be adjusted to handle this uncertainty, however

Alternative 3 was designed using manifolded carbon treatment systems. Another approach would be to use individual carbon treatment units at each interior vent. An analysis performed to evaluate the cost difference between using a manifold system versus using individual carbon treatment units at each vent found that using a manifold system was less expensive than using individual carbon treatment units at each vent. The present net worth values for the manifold system and for using the individual treatment units are $8,168,000, and $8,236,000, respectively. The detailed cost breakdowns for these two approaches are presented in Appendix A as Alternatives 3A (manifold system) and 3B (individual units).

Alternatives 5, 6, and 7 all include a pump and treat system for the groundwater. The system design and costs are based on limited available data and modeling. Therefore, the volume of water requiring extraction and treatment is an uncertainty that could change and therefore impact the proposed design and subsequent costs The pump rates used in this analysis may be conservative.

As discussed in the report, additional data and possibly a macrobenthic survey are required to further address the site's impact on the river sediment. If this information leads to a conclusion that the sediment would require additional treatment (e.g., removal), costs will increase by an estimated $4,117,000.

All of the capping alternatives, based on currently available data, are expected to be implemented within one year However, if they take two years, this is not expected to impact the present worth of the alternatives to any significant degree.

Assumptions of inflation and discount rates also affect the present worth estimates that were derived from capital, operation and maintenance, and future capital costs. A sensitivity analysis was done to evaluate the effects of these factors and is presented in Table 5-4. It shows that present worth estimates, at 0% inflation rate, can vary by as much as 178 percent over the range of discount rates of from 3% to 10% (for B/K Alternative 1). The variation is a function of the relative amounts of capital, operation and maintenance, and future capital costs included in each alternative. The maximum variation for Alternative 1 (No Action Alternative) for the entire range of inflation rates and discount rates considered is approximately eightfold. Variations for most alternatives range from 25 to 50 percent. Alternatives with a higher percentage of the cost in earlier years show less variation.

5.4.4 Summary of Additional Data Requirements

To prepare preliminary designs and cost estimates of the remedial technologies described in this report, many assumptions were required. Additional site-specific data are needed to assess the accuracy of the designs and costs presented. These data needs are mentioned in the descriptions of the

TABLE 5-4

SENSITIVITY ANALYSIS OF PRESENT WORTH ESTIMATES

B/K Alternative	Discount Rate (d)	Present Worth (in thousands) Inflation Rate 0%	Inflation Rate 5%	Inflation Rate 10%
1	3%	2,409	4,597	10,314
	5%	1,972	3,476	7,226
	10%	1,351	2,016	3,476
2	3%	6,560	9,796	18,271
	5%	5,917	8,137	13,691
	10%	5,004	6,982	8,137
3a	3%	9,023	13,323	24,556
	5%	8,168	11,119	18,491
	10%	6,960	8,254	11,119
3b	3%	9,091	13,391	24,623
	5%	8,236	11,167	18,559
	10%	7,028	[illegible]	11,187
4a	3%	9,846	14,520	26,678
	5%	8,914	12,126	20,120
	10%	7,598	9,009	12,126
4b	3%	9,794	14,333	26,154
	5%	8,889	12,008	19,776
	10%	7,611	8,981	12,008
5a	3%	27,599	45,793	93,519
	5%	23,992	36,456	67,729
	10%	18,913	24,356	36,456
5c	3%	25,145	43,339	91,065
	5%	21,538	34,002	65,275
	10%	16,459	21,902	34,002
6a	3%	1,108,921	1,285,334	1,495,088
	5%	1,049,256	1,211,122	1,402,692
	10%	923,831	1,056,041	1,211,122
6b	3%	322,226	376,741	445,485
	5%	304,228	353,532	414,527
	10%	266,901	306,266	353,532
7a	3%	257,238	288,159	327,352
	5%	246,869	275,045	309,570
	10%	224,852	248,050	275,045
7b	3%	99,838	119,559	147,442
	5%	93,675	110,947	134,402
	10%	81,315	94,366	110,947

alternatives in Sections 5.2 and 5.3. They are summarized below for each environmental medium.

Fill Waste/Soil

A better understanding of contaminant levels in the waste, and the fraction that would have to be treated as hazardous, would be essential in designing an on-site incinerator. Small concentrations of metals may present no difficulty. If larger concentrations occur, more efficient air pollution controls may be required, or the alternative may not meet ARARs. In addition, the size and volume of oversized materials in the landfill will affect the implementability of these alternatives.

Discussions above assume that all the waste must be treated. As discussed previously, only a fraction of the waste may require incineration, and the remaining wastes could be separated, decontaminated, and disposed of as non-hazardous. If this is true, significant cost savings could result and the implementability of this alternative may change. Future changes in technology may affect the amount of preparation required prior to treatment and the availability of off-site treatment facilities or design of an on-site incinerator.

Soil Gas/Air

The soil gas data collected during the RI are not sufficient to adequately determine gas generation rates, landfill gas composition, and gas migration rates in order to size a gas collection and treatment system. The remedial alternatives in this study are based on estimates of landfill gas generation for a sanitary landfill, not landfill composed of construction and demolition debris. Thus, the gas generation rates used in the designs may be conservatively high. Furthermore, violations of AGCs and the marginally acceptable baseline risk computed for the air pathway are based on modeling of these conservatively high gas emission rates. Additional information on gas generation rates and a pilot study program would enable a more precise design of a gas remediation system. Similarly, the number of gas collection wells should be based on a more detailed understanding of soil gas migration rates so that the radii of influence can be estimated. The horsepower ratings of the fans may need adjustment if more or less pressure drop is required to capture the soil gas, thus affecting both capital and O&M costs.

Sediment

Available data show exceedances of the sediment guidance for PAHs, but the highest concentrations are upgradient of the site. For metal contaminants, a comparison of mid/downstream concentrations with upstream concentrations, guidance criteria, background data, and limit of tolerance data indicates the site is only marginally, if at all, impacting the surface water sediments. Therefore, any action to be implemented should include additional analytical data to better determine the site's impact on the sediment. If this new data were to result in recommending additional analyses or surveys, such as a benthic macroinvertebrate survey, and subsequently recommend other remedial actions for the sediment, these facts would need to be incorporated into the alternatives presented.

Groundwater

The design of the groundwater extraction system and the vertical barrier is based on assumptions about how pumping wells would affect groundwater levels in the landfill. Before the vertical barrier and groundwater extraction systems can be designed, pumping tests should be conducted at a minimum of three sites along the proposed barrier, using a pumping well and several observation wells at each site. In addition, water levels in the wells should be observed during the winter and spring to see the magnitude of the seasonal fluctuations.

Alternatives 6 and 7, include a groundwater treatment system similar to Alternative 5. Although no vertical barrier is included, groundwater flow through this area will change during excavation and the groundwater extraction and treatment system must be designed to accommodate this changing flow. In addition, without a downgradient vertical barrier, large volumes of river water may be drawn into the treatment system. The placement of wells and other design considerations may require additional data.

The groundwater treatment system for Alternatives 5, 6, and 7 must accommodate the volume of groundwater extracted. Therefore, significant uncertainties are in the design because of the uncertainties in the extraction system design. The actual volume of water that would need to be extracted is an estimate based on limited available data. In addition, contaminant concentrations should be determined in the pumping wells before final design of the treatment system. This will ensure that the best technology is used and that tanks and other equipment are properly sized to achieve desired treatment goals. Furthermore, in Alternatives 6 and 7, the source (i.e. fill/soil) will be removed. Based on the current available data the pump and treat system could remediate the groundwater within 15 years. This is an uncertainty that would have to be considered during the detailed design phase.

5.4.5 Future Land Values

According to town officials, the B/K parcel on the Tuxedo Waste Disposal Site is presently worth approximately $100. The low value is due to the presence of contaminated materials on-site. If the site were remediated, it would be worth approximately $40,000/acre or $560,000. This value takes into account the fact that the site has good depth and access to the municipal water supply, but no present access to gas or sewer services. It is zoned for highway business use.

The future value of the site would depend upon future developments in the area, as well as the extent of remediation. Major new developments are planned just north of the site. They include an interchange with the NYS Thruway, a new train station between the site and the Route 17A interchange, and a high-rise apartment complex across from the new train station. If the NYS Thruway interchange is approved, Sterling Forest intends to develop approximately 12,000 of the 18,000 acres of forest under its jurisdiction. The Sterling Forest development, to be known as Sterling Points, would include 14,500 dwelling units and 8 square miles of office/commercial uses.

If these plans are realized, the value of the remediated Tuxedo Waste Disposal Site will increase due to its proximity to the interchange, new RR station, and new residential units. Under these conditions, the best use for the site, based on discussions with Town officials, is for strip commercial development. The site offers good depth, long frontage, and sufficient space for on-site parking. Access to and from the site would be located on the northern part of the B/K parcel because the roadway curvature limits the sight safety distances on the southern part of the parcel. The site would not be suitable for housing due to noise and other issues associated with its proximity to two state highways.

Construction of commercial structures on the B/K Parcel would have to account for potential subsidence. This could be accomplished by driving piles to bedrock. If the site has been capped, the use of piles and other intrusive construction techniques that would penetrate the cap may be prohibited due to their potential to release residual contaminants. However, other techniques, such as floating slab contraction, may be suitable.

Designating the site for use as a park or nature preserve would avoid the problems inherent in building structures on the area of fill. Although nearby Harriman State Park offers camping, hiking, and other activities, the proposed Sterling Points development may generate sufficient demand to support a playground or pocket park. Use as a park would not generate state and local tax revenues.

If the plans for the NYS Thruway interchange fail to materialize, then Sterling Forest will not develop Sterling Points, and the site may be less desirable as a park. The existing mini-park in the hamlet and the park on Route 17A two miles north of the site would be sufficient to satisfy demand. In addition, the lack of a new interchange will necessitate widening Route 17 to accommodate traffic traveling to and from points north of Tuxedo. Given the steep topography west of Route 17, any widening would be likely to encroach upon the site and reduce the amount of land available for commercial development. This would affect the value of the land.

Under the No Action Alternative, site access would be restricted, and the site would most likely revert to a natural habitat for wildlife. At the other end of the spectrum is Alternative 6A, which is the only alternative that would remove all contaminants from the site. Under Alternative 6A, the site's development and future value would depend upon economic conditions and local zoning regulations Alternatives 2, 3, 4, 5, 6B, and 7 would permit some development of the site following remediation, but issues related to subsidence, landfill penetration, and the 3:1 slope at the landfill toe remain. As a result, site development may be restricted to uses that do not require on-site structures, such as a park, nature preserve, ball field, or nature trail. These uses would likely enhance the development of adjacent parcels of land.

6.0 RECOMMENDED ALTERNATIVE

Selection of a remedial action for the Tuxedo Waste Disposal Site is based upon consideration of three sets of criteria.

- Threshold Criteria
- Balancing Criteria
- Modifying Criteria

Threshold Criteria concerns for the proposed remedy:

- Protect public health and the environment
- Attain compliance with ARARs and SCGs if possible and feasible

The balancing criteria used in the Detailed Analysis of Alternatives and Selection of a Remedy consider the following:

- Short-term effectiveness
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Implementability
- Cost analysis

The modifying criterion for this project will consist of community acceptance. Community input will be obtained in the following way:

- Based on the threshold and balancing criteria, and in consultation with NYSDEC, a preferred alternative for the site is identified, and a conceptual plan is developed.

- A proposed Remedial Action Plan (PRAP) is developed based on the preferred alternative and conceptual plan. Comments on the PRAP will be solicited from the affected community via both written response from Town government officials and a public meeting. These comments will be addressed during the Record of Decision (ROD) process.

The Detailed Analysis of Alternatives (Phase III FS), based on an elimination process, recommended that three alternatives for the B/K parcel be retained for further consideration. These are:

- Alternative 3, Landfill Cap with Passive Gas Treatment
- Alternative 4, Landfill Cap with Active Gas Treatment
- Alternative 5, Landfill Cap with Active Gas and Groundwater Treatment

These three alternatives incorporate a suitable landfill cap with gas venting, passive or active gas collection, and treatment. One of the three alternatives provides for groundwater collection and treatment, the others for groundwater, river water and sediment monitoring, with treatment to be added in the future if degradation of the monitored media warrants it.

The first issue to be decided is whether a groundwater collection system involving a down-gradient vertical barrier, extraction wells, and an effluent treatment system should be installed. Since no significant health issues have been identified for groundwater and Ramapo River surface water, based on present knowledge of site conditions, the basis for including a groundwater collection and treatment system focuses on potential environmental degradation and compliance with ARARs and SCGs if feasible.

Present data on groundwater contamination indicate that NYS standards for metals are exceeded. The term "indicates" is used because data evaluations limited the metals data in groundwater and surface water to use as estimated values. Data also indicate that certain metals in surface water sediment exceed NYS guidelines for fish and wildlife. However, based on comparisons of groundwater and surface water analyses over the period 1988-1991, no increases in contaminant levels in these media are evident. Therefore, groundwater contamination appears to be affecting the Ramapo River water and sediment in only a marginal way at the present time, and no surface water standards appear to be exceeded due to site related contamination. The additional costs of $32 million for groundwater treatment do not appear to be justified based on present knowledge of site conditions. Should future monitoring show a degradation of river water quality, groundwater controls can be instituted at that time.

Alternative 3 differs from Alternative 4 in the method of gas venting; passive in 3, active in 4 and 5. Since passive venting coupled with activated carbon treatment should attain soil gas remediation goals, and perimeter vents should be adequate to deal with off-site gas migration problems, no significant advantage is provided by the active extraction system with its attendant operating aspects (e.g., running an exhaust blower continuously) and monitoring requirements. The passive extraction system will be installed in a manner that facilitates upgrading to an active extraction system should future needs warrant this. Therefore, the recommended alternative is Alternative 3 - Landfill Cap with Passive Gas Venting and Treatment.

For the wastes deposited on the Georgia Tech parcel, the proposed remedial activity should be compatible with actions to be performed on the B/K parcel, as well as the three major evaluation criteria. In terms of compliance with ARARs, protection of public health and the environment, cost of implementation, and compatibility with the proposed alternatives for the B/K parcel, Georgia Tech Alternative 2 is recommended. This alternative involves removing the wastes deposited on the northeastern side of the Georgia Tech site for redeposition on the B/K parcel. The implementation of B/K Alternative 3 along with Georgia Tech Alternative 2 will reduce all health and environmental risks associated with the Georgia Tech parcel. The implementation of Georgia Tech Alternative 2 along with B/K Alternative 3 is expected to comply with all ARARs.

7.0 CONCEPTUAL DESIGN OF PREFERRED ALTERNATIVE

7.1 GENERAL

The purpose of the conceptual design is to assist NYSDEC and the engineer selected to perform the remedial design to understand the concepts included in the remedial alternative proposed for the Tuxedo Waste Disposal Site. The conceptual design also helps to link the study phases of the project (Remedial Investigation and Feasibility Study) to the remedial design phase.

7.2 DESCRIPTION OF THE PREFERRED REMEDIAL ALTERNATIVE

The preferred remedial alternative consists of B/K Alternative 3, Landfill Cap Passive Gas Venting and Treatment, and Georgia Tech Alternative 2, Removal to B/K Parcel. This alternative contains the B/K waste in the landfill by installing a cap with a passive gas collection and treatment system. Groundwater treatment is not included. Prior to installing the cap on the B/K parcel, the Georgia Tech wastes will be excavated and redeposited on the B/K parcel. Monitoring is included as necessary for all media. Should future monitoring indicate significant degradation of river water and/or sediments groundwater, controls could be instituted. The passive gas collection/treatment system will be installed so that it may be upgraded to active gas extraction/treatment if necessary.

This alternative complies with ARARs and protects human health with the possible exceptions of ARARs related to groundwater quality and future contamination of the Ramapo River. It is effective on both a short-term and long-term, basis and it reduces toxicity and volume of landfill gas contaminants. The alternative is expected to be readily implementable at moderate cost, with additional data collection prior to detailed design.

The following discussion details the design of this alternative for the various media.

7.2.1 Fill Waste/Soil

Prior to installing the cap, the toe of the landfill will be brought back 50 feet from the railroad right-of-way. The excavated soil will be redeposited on the site. In addition, the northern portion of the site will be excavated and backfilled with clean fill to serve as a staging area.

The soil gas extraction vents will be installed prior to installing the cap. This is described below in the description of the soil gas/air media.

The solid waste landfill cap will consist of a vegetated top cover, a protective layer of soil, a drainage layer low permeability barrier layer and a soil venting layer. This design for a solid waste landfill cap is regulated by New York Compilation of Rules and Regulations (NYCRR), Title 6, Part 360. The landfill cap functions by minimizing infiltration of precipitation through the landfilled material and preventing human and animal contact with the landfilled material, as well as controlling releases of soil gas.

The final top slope, after allowances for settling and subsidence, will not exceed 33%, as regulated by 6 NYCRR Part 360. The slopes on the top of the cap are designed to have a final grade of 7% to 15% and the slopes of the cap's toe to have a final grade of 33%. The vegetated top cover will have a minimum thickness of six inches and consist of topsoil that can support vegetation. This vegetation will provide a dense root system to anchor the soil and minimize wind and water erosion.

The barrier protection layer of soil is located directly below the vegetated top cover and has a minimum thickness of 24 inches, as regulated by 6 NYCRR Part 360. The lower six inches of this layer will be reasonably free of stones. Sand would be a suitable material for this layer. Below the barrier protection layer will be a filter fabric and a water drainage layer.

The low permeability barrier layer in this cap will be a geomembrane. This geomembrane is specified to have a maximum coefficient of permeability of 1×10^{-12} centimeters per second. This requirement may be waived to accommodate required physical/chemical properties. Such requirements include, 1) chemical and physical resistance to the landfilled materials, and 2) ability to accommodate the expected forces and stresses caused by settlement of the landfilled materials, as regulated by 6 NYCRR Part 360. This low permeability barrier layer will minimize the amount of infiltration of precipitation to the landfilled material.

Directly below the low permeability barrier layer and above the landfilled material is the gas venting layer with a minimum thickness of 12 inches. This venting layer will have a minimum coefficient of permeability of 1×10^{-3} centimeters per second and a maximum of five percent by weight passing the No. 200 sieve. To facilitate gas release to the venting layer, 3 to 4 foot wide channels will be cut into the present landfill cover (up to 3 feet deep). These channels will be placed at 100-foot intervals. The channels will be backed filled with 1 1/2 inch stone. The lower surfaces of the gas venting layer and channels will be bounded with a filter layer, per 6 NYCRR Part 360. These filter layers will consist of a granular soil material having no more than five percent by weight passing the No. 200 sieve, no soil particle larger than three inches in any dimension, and a minimum thickness of six inches. The filter layer is designed to prevent the migration of fine soil particles into a coarser grained material and allow gases to freely enter the gas venting layer without clogging.

The water drainage layer will discharge to the toe of the landfill. Drainage from the southern third of the site will be directed south to the Ramapo River. Drainage from the remainder of the site will be directed eastward through a drain pipe to be installed under the railroad bed to be Ramapo River.

Berms oriented along the length of the cap will be constructed at all major slope breaks, such as where the toe of the cap meets the top of the cap. These berms will control the surface runoff on the cap, therefore minimizing erosion of the top and the toe of the cap. These berms will be trapezoidal and consist of top cover material and vegetation. The dimensions and final locations of these berms will be determined during final design.

As interim remedial measures, surface drainage controls on-site were improved. These existing features, especially along Route 17, will be evaluated during final design to determine their effectiveness for future site conditions and any necessary upgrading.

7.2.2 Soil Gas/Air

For Alternative 3, soil gas/air remediation activities will consist of constructing a passive landfill gas venting system in the interior of the landfill and along the perimeter of landfill in areas where landfill gas is currently exceeding or expected to exceed 25 percent of the LEL. The passively vented gas will be treated using activated carbon specially impregnated with a caustic (sodium hydroxide) to remove hydrogen sulfide and untreated activated carbon to removed residual VOCs. The passive gas vents will be constructed of 6-inch diameter polyvinyl chloride (PVC). The vent will extend to approximately 2/3 of the depth of the waste and 3 feet above the finished grade of the surface soil cap. The vent will be finished above grade using a gooseneck cap. The gooseneck cap will be fitted with flexible HDPE piping which will connect the activated carbon unit to the vent. The vent will be screened the entire length extending into the refuse and the 1-foot section of the pipe in gas venting layer. If feasible, the vents will be located in the channels cut into the present cover layer. A total of 19 passive gas interior vents are proposed; a minimum of 12 vents are required to meet the NYSDEC requirement of 1 vent per acre. The seven additional vents are i.cluded in this conceptual design to facilitate venting in areas of the landfill where high gas production is anticipated.

The emission rate of hydrogen sulfide from each of the 19 vents was estimated based on the assumption that all of the gas produced in each subsection of the landfill, as presented in the RI, would escape through the vent(s) located in the proximity of that subsection. Using these production rates, a manifold system was established based on vent proximity and also to balance the hydrogen sulfide emissions.

The remediation of soil gas in Alternative 3 also includes construction of 18 passive vents along the perimeter of the landfill. The passive perimeter vents will extend to the groundwater table to allow ventilation throughout the vadose zone. Emissions from the perimeter vents will be collected into a manifold system and vented through carbon canisters.

Each treatment system will consist of two treated activated carbon canisters in series to remove hydrogen sulfide followed by an untreated activated carbon canister to strip residual VOCs. However, based on future field testing, the order of treatment units may be changed. The service life of the canisters is estimated as at least one year. Twelve carbon treatment systems will be used to treat the interior and perimeter vent gases.

Monitoring of this system during the first year of operation will include sampling of the landfill gas both before and after the activated carbon unit during varying barometric pressures. Four rounds of samples will be collected. The samples will be screened in the field using an FID, PID, CGI, and H_2S monitor. Samples having a high FID reading will be submitted to a laboratory for quantitative analysis to determine the presence of any organic compounds which may result in decreasing the time until breakthrough of the activated carbon unit. Adjustment of the manifold system or the number of activated carbon canisters will then be made to insure that the vent gas is properly treated.

After this initial round of sampling, quarterly monitoring of pre- and post-filter vent gas will be conducted during years 2 through 4 and then once annually during years 4 through 30. Monitoring will consist of field screening using an FID, PID, and H_2S monitor on the interior vents and an FID, PID, CGI, and H_2S monitor on the perimeter vents. Results will be reviewed annually and adjustment of system or monitoring program will be made if necessary. Annual monitoring for methane will also be conducted on the perimeter passive vents to insure that migration of methane beyond 25% of the LEL is not occurring. As discussed earlier, the passive system can be easily converted to an active system should future needs warrant this.

This conceptual design is based on current site conditions and available data. A pilot program will be performed prior to the detailed design to ensure that the system is designed for site specific conditions

7.2.3 Groundwater

Samples will be collected from twelve existing monitor wells (eight located downgradient of the site and four located upgradient) at the site on a quarterly basis for the first two years and annually thereafter for 30 years. Samples from selected wells will be analyzed for the full Target Compound List (TCL).

Under present conditions, surface run-off from areas west of Route 17 south of the site feed a 24-inch drain pipe running through the B/K Parcel. Tests indicate that the drain pipe is damaged and an unknown amount of water is currently infiltrating the fill waste. As part of the preferred alternative, it is proposed to divert the surface run-off from west of Route 17, the major portion of the flow, away from the site. This will be accomplished by installing a 36-inch, Class 56 ductile iron drain pipe under Route 17 via a borehole. This 80-foot long drain pipe, with a slope of 0.026, will be installed south of the site, feeding natural drainage to the Ramapo River. The above 36-inch pipe could handle 105 cfs flow.

The run-on from the 4.5 acres south of the site, on the east side of Route 17, which feeds the site drain pipe cannot easily be diverted. It is proposed to continue to allow this flow to feed the 24-inch drain pipe. The entrance and exit sections of the site drain pipe will be modified to incorporate a hydrostatic seal to prevent gas releases from the extremities of the pipe. The pipe itself will be vented to the gas collection/treatment system.

7.2.4 Surface Water/Sediment

Sediment and surface water samples will be collected quarterly for the first two years and annually thereafter for thirty years. Sediment samples will be collected at the same five locations as were sampled in the RI: (1) near the bank upstream of the site, (2) near the bank next to the site, (3) near the bank downstream of the site, (4) near mid-stream next to the site, and (5) near mid-stream downstream of the site.

Surface water samples will be collected at the same locations as the surface water sediments, plus and upstream sample at the mid-stream location.

A conceptual plan of the site is shown in Figure 7-1. The drawing presents approximate topographical features of the completed site closure, indicating slopes and other features. Also included are the approximate locations of interior and perimeter soil gas vents, and a proposed manifold system for the vents.

7.3 ADDITIONAL DESIGN SUPPORT ACTIVITIES

Certain design support activities will need to be performed prior to the final design and implementation of remediation. The activities, predominantly field oriented, are required to provide information in areas where data limitations exist. A pilot gas venting-treatability study should be performed at the site. The purpose of this work would be to better define typical volumes of soil gases generated and to evaluate the effectiveness of treating the evolved gases with the proposed activated carbon treatment. A limitation of such a study is that an impermeable cap will not be in place over the site which could affect results of such a study.

7.4 COORDINATION OF REMEDIAL ACTIVITIES

The activities of the recommended remedial alternative require a coordinated effort to achieve successful remediation of the Tuxedo Waste Disposal Site. The major activities which will require logistical phasing include: (1) construction of facilities, (2) limited excavation, redeposition of waste and backfilling, (3) installation of soil cap, (4) installation of soil gas vents, (5) installation of exhaust gas treatment system (6) drainage diversion south of the site, and (7) media monitoring and system maintenance. An activity list identifying the activities and their precedence is shown in Table 7.1

TABLE 7-1

REMEDIATION SEQUENCE OF ACTIVITIES

No.	Activity	Depends On
1	Site Preparation	N/A
2	Remove fill waste from railroad right-of-way and re-deposit on B/K parcel	1
3	Remove fill waste on Georgia Tech Parcel and re-deposit on B/K Parcel	1,2
4	Backfill Georgia Tech excavation	1,3
5	Regrade B/K Parcel for capping	1,2,3
6	Install soil gas extraction vents	1,2,3,5
7	Construct cap on site	1,2,3,5,6
8	Install gas treatment system	1,2,3,5,6,7

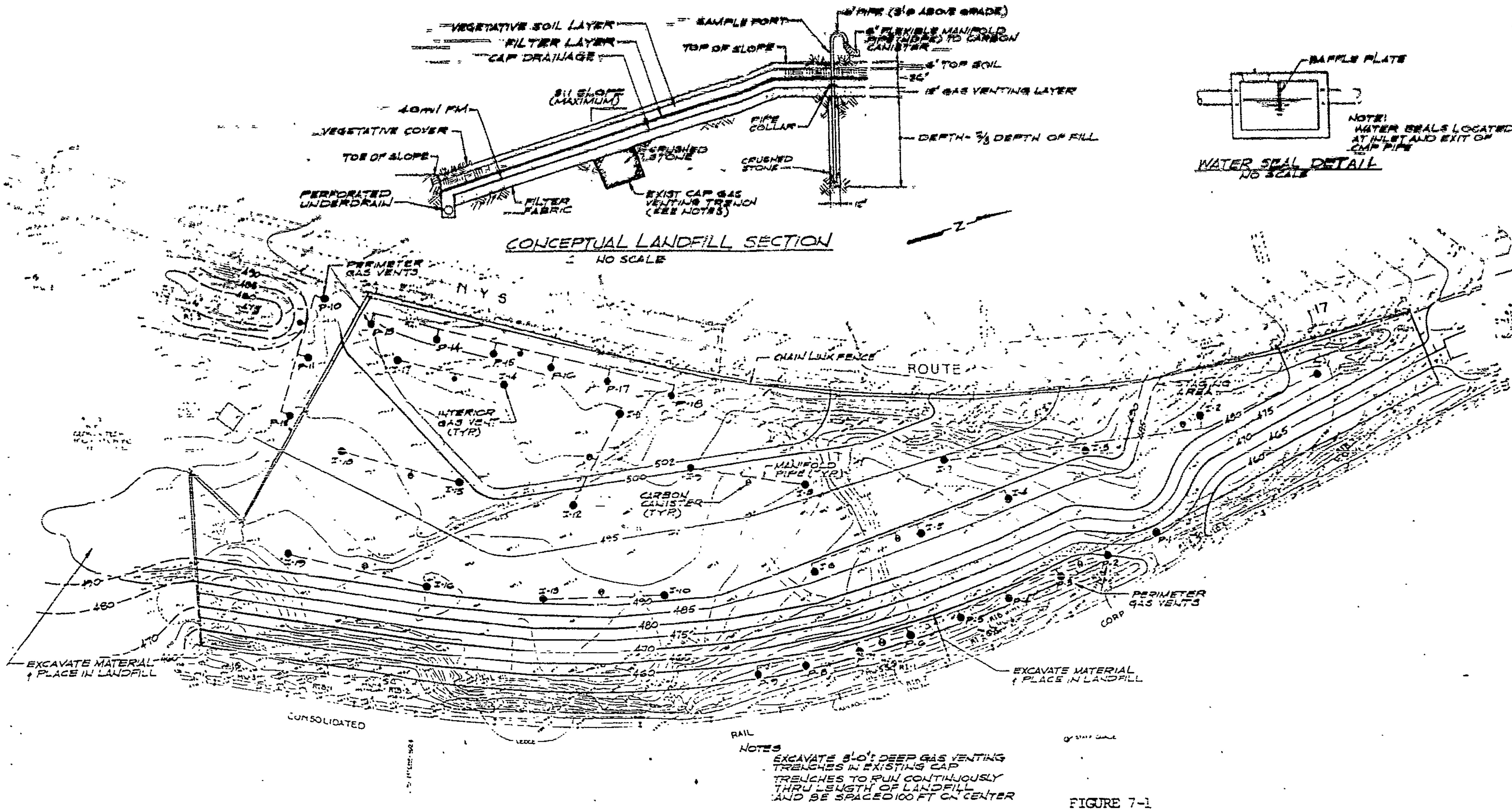

FIGURE 7-1

CONCEPTUAL LANDFILL CLOSURE PLAN
TUXEDO WASTE DISPOSAL SITE, ORANGE CO. N.Y.

SECTION 8

8.0 REFERENCES

United States Environmental Protection Agency. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final. EPA/540/G-89/004, OSWER Directive 9355.3-01, October.

APPENDIX A
COST SPREAD SHEETS FOR ALTERNATIVES

ALTERNATIVE 1

Fill Waste/Soil: No Action
Soil Gas/Air: Monitor
Groundwater: Monitor
Surface Water/Sediment: Monitor

INFLATION RATE 0.0%
DISCOUNT RATE 5.0%

TUXEDO LANDFILL PHASE II FEASABILITY STUDY
PRESENT WORTH ANALYSIS
COST AND YEAR COST INCURRED (IN THOUSANDS)

MEDIA/TREATMENT	0 1991	1 1992	2 1993	3 1994	4 1995	5 1996	6 1997	7 1998	8 1999	9 2000	10 2001	11 2002	12 2003	13 2004	14 2005	15 2006
Fill Waste/Soil																
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Gas/Air																
-Capital Costs	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	110	110	110	65	65	32	32	32	32	32	32	32	32	32	32	32
-Future Capital Costs	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Groundwater																
-Capital Costs	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
-Future Capital Costs	0	0	0	0	0	8	0	0	0	0	8	0	0	0	0	8
Surface Water/Sediment																
-Capital Costs	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	214	178	178	133	133	108	100	100	100	100	108	100	100	100	100	108
PRESENT WORTH VALUE	214	170	161	115	109	85	75	71	68	64	66	58	56	53	51	52

MEDIA/TREATMENT	16 2007	17 2008	18 2009	19 2010	20 2011	21 2012	22 2013	23 2014	24 2015	25 2016	26 2017	27 2018	28 2019	29 2020	30 2021
Fill Waste/Soil															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Gas/Air															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
-Future Capital Costs	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Groundwater															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
-Future Capital Costs	0	0	0	0	8	0	0	0	0	8	0	0	0	0	0
Surface Water/Sediment															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	100	100	100	100	108	100	100	100	100	108	100	100	100	100	100
PRESENT WORTH VALUE	46	44	42	40	41	36	34	33	31	32	28	27	26	24	23

TOTAL PRESENT NET WORTH OF ALTERNATIVE: $1,972

ALTERNATIVE 2

Fill Waste/Soil: Cap, Restrict Use and Access
Soil Gas/Air: Monitor
Groundwater: Monitor, Restrict Use
Surface Water/Sediment: Monitor, Apply Administrative Action

INFLATION RATE 0.0%
DISCOUNT RATE 5.0%

TUXEDO LANDFILL PHASE II FEASABILITY STUDY
PRESENT WORTH ANALYSIS
COST AND YEAR COST INCURRED (IN THOUSANDS)

MEDIA/TREATMENT	0 1991	1 1992	2 1993	3 1994	4 1995	5 1996	6 1997	7 1998	8 1999	9 2000	10 2001	11 2002	12 2003	13 2004	14 2005	15 2006
Fill Waste/Soil																
-Capital Costs	2,931	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Gas/Air																
-Capital Costs	136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	110	110	110	65	65	32	32	32	32	32	32	32	32	32	32	32
-Future Capital Costs	0	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Groundwater																
-Capital Costs	118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
-Future Capital Costs	0	0	0	0	0	8	0	0	0	0	8	0	0	0	0	8
Surface Water/Sediment																
-Capital Costs	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	3,405	227	227	182	182	157	149	149	149	149	157	149	149	149	149	157
PRESENT WORTH VALUE	3,405	216	206	157	150	123	111	106	101	96	96	87	83	79	75	76

MEDIA/TREATMENT	16 2007	17 2008	18 2009	19 2010	20 2011	21 2012	22 2013	23 2014	24 2015	25 2016	26 2017	27 2018	28 2019	29 2020	30 2021
Fill Waste/Soil															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Gas/Air															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
-Future Capital Costs	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Groundwater															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
-Future Capital Costs	0	0	0	0	8	0	0	0	0	8	0	0	0	0	0
Surface Water/Sediment															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	149	149	149	149	157	149	149	149	149	157	149	149	149	149	149
PRESENT WORTH VALUE	68	65	62	59	59	53	51	49	46	46	42	40	38	36	34

TOTAL PRESENT NET WORTH OF ALTERNATIVE: $5,917

ALTERNATIVE 3a
Fill Waste/Soil: Cap, Restrict Use and Access
Soil Gas/Air: Passive Vent, GAC Treat, Monitor
Groundwater: Monitor, Restrict Use, Provision to Upgrade
Surface Water/Sediment: Monitor, Apply Administrative Action

INFLATION RATE 0.0%
DISCOUNT RATE 5.0%

TUXEDO LANDFILL PHASE II FEASABILITY STUDY
PRESENT WORTH ANALYSIS
COST AND YEAR COST INCURRED (IN THOUSANDS)

MEDIA/TREATMENT	0 1991	1 1992	2 1993	3 1994	4 1995	5 1996	6 1997	7 1998	8 1999	9 2000	10 2001	11 2002	12 2003	13 2004	14 2005	15 2006
Fill Waste/Soil																
-Capital Costs	4,221	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Gas/Air																
-Capital Costs	488	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	78	78	78	78	78	60	60	60	60	60	60	60	60	60	60	60
-Future Capital Costs	0	27	27	50	27	27	50	27	27	50	27	27	50	27	27	135
Groundwater																
-Capital Costs	118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Surface Water/Sediment																
-Capital Costs	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	5,015	208	208	231	[illegible]	198	213	190	190	213	198	190	213	190	190	306
PRESENT WORTH VALUE	5,015	198	189	200	171	155	159	135	129	137	122	111	119	101	96	147

MEDIA/TREATMENT	16 2007	17 2008	18 2009	19 2010	20 2011	21 2012	22 2013	23 2014	24 2015	25 2016	26 2017	27 2018	28 2019	29 2020	30 2021
Fill Waste/Soil															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Gas/Air															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
-Future Capital Costs	27	27	50	27	27	50	27	27	50	27	27	50	27	27	27
Groundwater															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Surface Water/Sediment															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	190	190	213	190	198	213	190	190	213	198	190	213	190	190	190
PRESENT WORTH VALUE	87	83	89	75	75	76	65	62	66	58	53	57	48	46	44

TOTAL PRESENT NET WORTH OF ALTERNATIVE: $8,168

ALTERNATIVE 3b

Fill Waste/Soil: Cap; Restrict Use and Access
Soil Gas/Air: Passive Vent, GAC Treat, Monitor
Groundwater: Monitor, Restrict Use, Provision to Upgrade
Surface Water/Sediment: Monitor, Apply Administrative Action

TUXEDO LANDFILL PHASE II FEASABILITY STUDY
PRESENT WORTH ANALYSIS
COST AND YEAR COST INCURRED (IN THOUSANDS)

INFLATION RATE 0.0%
DISCOUNT RATE 6.0%

MEDIA/TREATMENT	0 1991	1 1992	2 1993	3 1994	4 1995	5 1996	6 1997	7 1998	8 1999	9 2000	10 2001	11 2002	12 2003	13 2004	14 2005	15 2006
Fill Waste/Soil																
-Capital Costs	4,221	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Gas/Air																
-Capital Costs	556	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	78	78	78	78	78	60	60	60	60	60	60	60	60	60	60	60
-Future Capital Costs	0	27	27	50	27	27	50	27	27	50	27	27	50	27	27	135
Groundwater																
-Capital Costs	118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
-Future Capital Costs	0	0	0	0	0	8	0	0	0	0	8	0	0	0	0	8
Surface Water/Sediment																
-Capital Costs	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	5,083	208	208	231	208	198	213	190	190	213	198	190	213	190	190	306
PRESENT WORTH VALUE	5,083	196	185	200	171	155	150	135	129	137	122	111	119	101	96	147

MEDIA/TREATMENT	16 2007	17 2008	18 2009	19 2010	20 2011	21 2012	22 2013	23 2014	24 2015	25 2016	26 2017	27 2018	28 2019	29 2020	30 2021
Fill Waste/Soil															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Gas/Air															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
-Future Capital Costs	27	27	50	27	27	50	27	27	50	27	27	50	27	27	27
Groundwater															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
-Future Capital Costs	0	0	0	0	8	0	0	0	0	8	0	0	0	0	0
Surface Water/Sediment															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	190	190	213	190	198	213	190	190	213	198	190	213	190	190	190
PRESENT WORTH VALUE	87	83	89	75	75	76	65	62	66	58	53	57	48	46	44

TOTAL PRESENT NET WORTH OF ALTERNATIVE: $8,206

ALTERNATIVE 4e

Fill Waste/Soil: Cap, Restrict Use and Access
Soil Gas/Air: Active Vent, GAC Treat, Monitor
Groundwater: Monitor, Restrict Use, Provision to Upgrade
Surface Water/Sediment: Monitor, Apply Administrative Action

INFLATION RATE 0.0%
DISCOUNT RATE 5.0%

TUXEDO LANDFILL PHASE II FEASIBILITY STUDY
PRESENT WORTH ANALYSIS
COST AND YEAR COST INCURRED (IN THOUSANDS)

MEDIA/TREATMENT	0 1991	1 1992	2 1993	3 1994	4 1995	5 1996	6 1997	7 1998	8 1999	9 2000	10 2001	11 2002	12 2003	13 2004	14 2005	15 2006	16 2007	17 2008	18 2009	19 2010	20 2011	21 2012	22 2013	23 2014	24 2015	25 2016	26 2017	27 2018	28 2019	29 2020	30 2021
Fill Waste/Soil																															
-Capital Costs	4,221	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Gas/Air																															
-Capital Costs	976	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	86	86	86	86	86	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73
Future Capital Costs	0	27	27	50	27	27	50	27	27	50	55	27	50	27	27	220	27	27	50	27	55	50	27	27	50	27	27	50	27	27	27
Groundwater																															
-Capital Costs	118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
Future Capital Costs	0	0	0	0	0	8	0	0	0	0	8	0	0	0	0	8	0	0	0	0	8	0	0	0	0	8	0	0	0	0	0
Surface Water/Sediment																															
-Capital Costs	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	5,511	216	216	239	216	211	226	203	203	226	239	203	226	203	203	404	203	203	226	203	239	226	203	203	226	211	203	226	203	203	203
PRESENT WORTH VALUE	5,511	206	196	206	178	165	169	144	137	146	147	119	126	108	103	194	93	89	94	80	90	81	69	66	70	62	57	61	52	49	47

TOTAL PRESENT NET WORTH OF ALTERNATIVE: $8,914

ALTERNATIVE 4b

Fill Waste/Soil: Cap, Restrict Use and Access
Soil Gas/Air: Active Vent, Alkaline Wet Scrubber Treat, Monitor
Groundwater: Monitor, Restrict Use, Provision to Upgrade
Surface Water/Sediment: Monitor, Apply Administrative Action

INFLATION RATE 0.0%
DISCOUNT RATE 5.0%

TUXEDO LANDFILL PHASE II FEASABILITY STUDY
PRESENT WORTH ANALYSIS
COST AND YEAR COST INCURRED (IN THOUSANDS)

MEDIA/TREATMENT	0 1991	1 1992	2 1993	3 1994	4 1995	5 1996	6 1997	7 1998	8 1999	9 2000	10 2001	11 2002	12 2003	13 2004	14 2005	15 2006	16 2007	17 2008	18 2009	19 2010	20 2011	21 2012	22 2013	23 2014	24 2015	25 2016	26 2017	27 2018	28 2019	29 2020	30 2021
Fill Waste/Soil																															
-Capital Costs	4,221	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Gas/Air																															
-Capital Costs	1,054	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	81	81	81	81	81	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63
-Future Capital Costs	0	27	27	50	27	27	50	27	27	50	88	27	50	27	27	220	27	27	50	27	88	50	27	27	50	27	27	50	27	27	50
Groundwater																															
-Capital Costs	118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
-Future Capital Costs	0	0	0	0	0	8	0	0	0	0	8	0	0	0	0	8	0	0	0	0	8	0	0	0	0	8	0	0	0	0	0
Surface Water/Sediment																															
-Capital Costs	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	5,584	211	211	234	211	201	216	193	193	216	262	193	216	193	193	394	193	193	216	193	262	216	193	193	216	201	193	216	193	193	216
PRESENT WORTH VALUE	5,584	201	191	202	174	157	161	137	131	139	161	113	120	102	97	190	88	84	90	76	99	78	66	63	67	59	54	58	49	47	50

TOTAL PRESENT NET WORTH OF ALTERNATIVE $8,889

ALTERNATIVE 5a

Fill Waste/Soil: Cap, Restrict Use and Access
Soil Gas/Air: Active Vent, GAC Treat, Monitor
Groundwater: Downgradient Plastic Conc. Vert. Barrier, Extract & Treat, Runon Diversion
Surface Water/Sediment: Monitor, Apply Administrative Action

TUXEDO LANDFILL PHASE II FEASIBILITY STUDY
PRESENT WORTH ANALYSIS
COST AND YEAR COST INCURRED (IN THOUSANDS)

INFLATION RATE 0.0%
DISCOUNT RATE 5.0%

MEDIA/TREATMENT	0 1991	1 1992	2 1993	3 1994	4 1995	5 1996	6 1997	7 1998	8 1999	9 2000	10 2001	11 2002	12 2003	13 2004	14 2005	15 2006
Fill Waste/Soil																
-Capital Costs	4,221	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Gas/Air																
-Capital Costs	967	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	86	86	86	86	86	73	73	73	73	73	73	73	73	73	73	73
-Future Capital Costs	0	27	27	50	27	27	50	27	27	50	55	27	50	27	27	220
Groundwater																
-Capital Costs	4,853	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	658	658	658	658	658	658	658	658	658	658	658	658	658	658	658	658
-Future Capital Costs	0	0	0	0	0	29	0	0	0	0	29	0	0	0	0	29
Surface Water/Sediment																
-Capital Costs	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	10,866	845	845	868	845	861	855	832	832	855	889	832	855	832	832	1,054
PRESENT WORTH VALUE	10,866	805	766	750	695	675	638	591	563	551	546	486	476	441	420	507

MEDIA/TREATMENT	16 2007	17 2008	18 2009	19 2010	20 2011	21 2012	22 2013	23 2014	24 2015	25 2016	26 2017	27 2018	28 2019	29 2020	30 2021
Fill Waste/Soil															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Gas/Air															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73
-Future Capital Costs	27	27	50	27	55	50	27	27	50	27	27	50	27	27	27
Groundwater															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	658	658	658	658	658	658	658	658	658	658	658	658	658	658	658
-Future Capital Costs	0	0	0	0	29	0	0	0	0	29	0	0	0	0	0
Surface Water/Sediment															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	832	832	855	832	889	855	832	832	855	861	832	855	832	832	832
PRESENT WORTH VALUE	381	363	355	329	335	307	284	271	265	254	234	229	212	202	193

TOTAL PRESENT NET WORTH OF ALTERNATIVE $20,992

ALTERNATIVE 5c

Fill Waste/Soil: Cap, Restrict Use and Access
Soil Gas/Air: Active Vent, GAC Treat, Monitor
Groundwater: Downgradient SB Slurry Wall, Extract & Treatment, Run-on Diversion
Surface Water/Sediment: Monitor, Apply Administrative Action

TUXEDO LANDFILL PHASE II FEASIBILITY STUDY
PRESENT WORTH ANALYSIS
COST AND YEAR COST INCURRED (IN THOUSANDS)

INFLATION RATE 0.0%
DISCOUNT RATE 5.0%

MEDIA/TREATMENT	0 1991	1 1992	2 1993	3 1994	4 1995	5 1996	6 1997	7 1998	8 1999	9 2000	10 2001	11 2002	12 2003	13 2004	14 2005
Fill Waste/Soil															
-Capital Costs	4,221	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Gas/Air															
-Capital Costs	967	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	86	86	86	86	86	73	73	73	73	73	73	73	73	73	73
-Future Capital Costs	0	27	27	50	27	27	50	27	27	50	55	27	50	27	27
Groundwater															
-Capital Costs	2,399	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	658	658	658	658	658	658	658	658	658	658	658	658	658	658	658
-Future Capital Costs	0	0	0	-	0	29	0	0	0	0	29	0	0	0	0
Surface Water/Sediment															
-Capital Costs	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	8,412	845	845	868	845	861	855	832	832	855	889	832	855	832	832
PRESENT WORTH VALUE	8,412	805	766	750	695	675	638	591	563	551	546	486	476	441	420

MEDIA/TREATMENT	15 2006	16 2007	17 2008	18 2009	19 2010	20 2011	21 2012	22 2013	23 2014	24 2015	25 2016	26 2017	27 2018	28 2019	29 2020	30 2021
Fill Waste/Soil																
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Gas/Air																
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73
-Future Capital Costs	220	27	27	50	27	55	50	27	27	50	27	27	50	27	27	27
Groundwater																
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	658	658	658	658	658	658	658	658	658	658	658	658	658	658	658	658
-Future Capital Costs	29	0	0	0	0	29	0	0	0	0	29	0	0	0	0	0
Surface Water/Sediment																
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	1,054	832	832	855	832	889	855	832	832	855	861	832	855	832	832	832
PRESENT WORTH VALUE	507	381	363	355	329	335	307	284	271	265	254	234	229	212	202	193

TOTAL PRESENT NET WORTH OF ALTERNATIVE $21,538

ALTERNATIVE 6a

Fill Waste/Soil: Excavate, Off Site Incineration
Soil Gas/Air: Monitor
Groundwater: Extraction With Treatment
Surface Water/Sediment: Monitor; Apply Administrative Action

INFLATION RATE 0.0%
DISCOUNT RATE 5.0%

TUXEDO LANDFILL PHASE II FEASABILITY STUDY
PRESENT WORTH ANALYSIS
COST AND YEAR COST INCURRED (IN THOUSANDS)

MEDIA/TREATMENT	0 1991	1 1992	2 1993	3 1994	4 1995	5 1996	6 1997	7 1998	8 1999	9 2000	10 2001	11 2002	12 2003	13 2004	14 2005	15 2006
Fill Waste/Soil																
-Capital Costs	171,264	171,264	171,264	171,264	171,264	171,264	171,264	0	0	0	0	0	0	0	0	0
-O & M Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Gas/Air																
-Capital Costs	210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater																
-Capital Costs	422	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657
-Future Capital Costs	0	0	0	0	0	29	0	0	0	0	29	0	0	0	0	0
Surface Water/Sediment																
-Capital Costs	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	172,575	171,958	171,958	171,958	171,958	171,985	171,958	692	692	692	721	692	692	692	692	692
PRESENT WORTH VALUE	172,575	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

MEDIA/TREATMENT	16 2007	17 2008	18 2009	19 2010	20 2011	21 2012	22 2013	23 2014	24 2015	25 2016	26 2017	27 2018	28 2019	29 2020	30 2021
Fill Waste/Soil															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Gas/Air															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Surface Water/Sediment															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
PRESENT WORTH VALUE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TOTAL PRESENT NET
WORTH OF ALTERNATIVE $1,049,254

ALTERNATIVE 6b

Fill Waste/Soil: Excavate 25% Off-Site Incineration, 75% Onsite Landfill
Soil Gas/Air: Monitor
Groundwater: Extraction With Treatment
Surface Water/Sediment: Monitor Apply Administrative Action

INFLATION RATE 0.0%
DISCOUNT RATE 5.0%

TUXEDO LANDFILL PHASE II FEASABILITY STUDY
PRESENT WORTH ANALYSIS
COST AND YEAR COST INCURRED (IN THOUSANDS)

MEDIA/TREATMENT	0 1991	1 1992	2 1993	3 1994	4 1995	5 1996	6 1997	7 1998	8 1999	9 2000	10 2001	11 2002	12 2003	13 2004	14 2005	15 2006	16 2007	17 2008	18 2009	19 2010	20 2011	21 2012	22 2013	23 2014	24 2015	25 2016	26 2017	27 2018	28 2019	29 2020	30 2021
Fill Waste/Soil																															
-Capital Costs	44,417	44,422	44,422	44,422	44,422	44,422	44,422	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	4,123	4,123	4,123	4,123	4,123	4,123	4,123	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Gas/Air																															
-Capital Costs	210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater																															
-Capital Costs	407	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
-Future Capital Costs	0	0	0	0	0	29	0	0	0	0	29	0	0	0	0	29	0	0	0	0	29	0	0	0	0	29	0	0	0	0	0
Surface Water/Sediment																															
-Capital Costs	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	49,856	49,237	49,237	49,237	49,237	49,266	49,237	731	731	731	760	731	731	731	731	760	102	102	102	102	131	102	102	102	102	131	102	102	102	102	102
PRESENT WORTH VALUE	49,856	46,892	44,658	42,533	40,507	38,601	36,741	520	495	471	467	427	407	388	369	366	47	45	42	40	49	37	35	33	32	39	29	27	26	25	24

TOTAL PRESENT NET
WORTH OF ALTERNATIVE $304,228

ALTERNATIVE 7a
Fill Waste/Soil: Excavate, On Site Incineration, On Site Ash Disposal
Soil Gas/Air: Monitor
Groundwater: Extraction With Treatment
Surface Water/Sediment: Monitor, Apply Administrative Action

INFLATION RATE 0.0%
DISCOUNT RATE 5.0%

TUXEDO LANDFILL PHASE II FEASABILITY STUDY
PRESENT WORTH ANALYSIS
COST AND YEAR COST INCURRED (IN THOUSANDS)

MEDIA/TREATMENT	0 1991	1 1992	2 1993	3 1994	4 1995	5 1996	6 1997	7 1998	8 1999	9 2000	10 2001	11 2002	12 2003	13 2004	14 2005	15 2006	16 2007	17 2008	18 2009	19 2010	20 2011	21 2012	22 2013	23 2014	24 2015	25 2016	26 2017	27 2018	28 2019	29 2020	30 2021
Fill Waste/Soil																															
-Capital Costs	52,211	52,211	52,211	52,211	52,211	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Gas/Air																															
-Capital Costs	210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater																															
-Capital Costs	402	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
-Future Capital Costs	0	0	0	0	0	29	0	0	0	0	29	0	0	0	0	29	0	0	0	0	29	0	0	0	0	29	0	0	0	0	0
Surface Water/Sediment																															
-Capital Costs	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	53,561	52,942	52,942	52,942	52,942	760	731	731	731	731	760	731	731	731	731	760	102	102	102	102	131	102	102	102	102	131	102	102	102	102	102
PRESENT WORTH VALUE	53,561	50,421	48,020	45,733	43,556	596	545	520	495	471	467	427	407	388	369	366	47	45	42	40	49	37	35	33	32	39	29	27	26	25	24

TOTAL PRESENT NET
WORTH OF ALTERNATIVE $746,669

ALTERNATIVE 7b

Fill Waste/Soil	Excavate 75% On-Site Incineration/Ash Disposal; 25% Off-Site Landfill
Soil Gas/Air	Monitor
Groundwater	Extraction With Treatment
Surface Water/Sediment	Monitor Apply Administrative Action

INFLATION RATE	0.0%
DISCOUNT RATE	5.0%

TUXEDO LANDFILL PHASE II FEASABILITY STUDY
PRESENT WORTH ANALYSIS
COST AND YEAR COST INCURRED (IN THOUSANDS)

MEDIA/TREATMENT	0 1991	1 1992	2 1993	3 1994	4 1995	5 1996	6 1997	7 1998	8 1999	9 2000	10 2001	11 2002	12 2003	13 2004	14 2005	15 2006	16 2007	17 2008	18 2009	19 2010	20 2011	21 2012	22 2013	23 2014	24 2015	25 2016	26 2017	27 2018	28 2019	29 2020	30 2021
Fill Waste/Soil																															
Capital Costs	10,665	10,665	10,665	10,665	10,665	10,665	10,665	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O & M Costs	3,225	3,225	3,225	3,225	3,225	3,225	3,225	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39
Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Gas/Air																															
Capital Costs	210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O & M Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater																															
Capital Costs	402	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O & M Costs	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
Future Capital Costs	0	0	0	0	0	29	0	0	0	0	29	0	0	0	0	29	0	0	0	0	29	0	0	0	0	29	0	0	0	0	0
Surface Water/Sediment																															
Capital Costs	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O & M Costs	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	15,201	14,582	14,582	14,582	14,582	14,611	14,582	731	731	731	760	731	731	731	731	760	102	102	102	102	131	102	102	102	102	131	102	102	102	102	102
PRESENT WORTH VALUE	15,201	13,888	13,226	12,596	11,997	11,448	10,881	520	495	471	467	427	407	388	369	366	47	45	42	40	49	37	35	33	32	39	29	27	26	25	24

TOTAL PRESENT NET WORTH OF ALTERNATIVE $93,675

Sediment Removal Option
Fill Waste/S-4 NA
Soil Gas/Air NA
Groundwater NA
Surface Water/Sediment Monitor

INFLATION RATE 0.0%
DISCOUNT RATE 5.0%

TUXEDO LANDFILL PHASE II FEASIBILITY STUDY
PRESENT WORTH ANALYSIS
COST AND YEAR COST INCURRED (IN THOUSANDS)

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MEDIA/TREATMENT	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Surface Water/Sediment																
-Capital Costs	4,082	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	4,117	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRESENT WORTH VALUE	4,117	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
MEDIA/TREATMENT	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Surface Water/Sediment															
-Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-O & M Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRESENT WORTH VALUE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TOTAL PRESENT NET
WORTH OF ALTERNATIVE $4,117

GEORGIA TECH ALTERNATIVES

INFLATION RATE 0.0%
DISCOUNT RATE 5.0%

TUXEDO LANDFILL PHASE II FEASABILITY STUDY
PRESENT WORTH ANALYSIS
COST AND YEAR COST INCURRED (IN THOUSANDS)

ALTERNATIVE	0 1991	1 1992	2 1993	3 1994	4 1995	5 1996	6 1997	7 1998	8 1999	9 2000	10 2001	11 2002	12 2003	13 2004	14 2005	15 2006	16 2007	17 2008	18 2009	19 2010	20 2011	21 2012	22 2013	23 2014	24 2015	25 2016	26 2017	27 2018	28 2019	29 2020	30 2021
1 No Action																															
Capital Costs	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O & M Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Annual Cost	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Present Worth	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total NPW of Alternative	$20																														
2 Remove Fill to Tuxedo for Redeposition																															
Capital Costs	367	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O & M Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Annual Cost	367	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Present Worth	367	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total NPW of Alternative	$367																														
3 Remove Fill Off Site for Treatment and Disposal																															
Capital Costs	41,544	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O & M Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Annual Cost	41,544	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Present Worth	41,544	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total NPW of Alternative	$41,544																														
4 Remove Fill to Tuxedo for Incineration & Disposal																															
Capital Costs	12,753	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O & M Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Future Capital Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Annual Cost	12,753	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Present Worth	12,753	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total NPW of Alternative	$12,753																														

APPENDIX B
COST WORK SHEETS

Fill Waste/Soil Remediation

Alternative		
1	Capital Costs	$0
	O&M Costs	$0
	Future Costs	$0
2	Capital Costs	$2,931
	O&M Costs	$39
	Future Costs	$0

Capital Costs Direct	No. Units	Units	Unit Cost	Total Cost
Landfill Cap				
Geomembrane (40 mil)	457,600	SF	0.60	274,560
Protection Layer	33,900	CY	10.96	371,544
Filter Fabric	503,360	SF	1.00	503,360
Topsoil	8,500	CY	23.05	195,925
Vegetation/Seed	11	Acres	2,100.00	23,100
Toe Landfill Inc. RR				
Excavation	59,100	CY	1 67	98,697
Haul	59,100	CY	2.27	134,157
Staging Area				
Excavation	6,600	CY	1 67	11,022
Clean Backfill	6,600	CY	10 96	72,336
Haul (on-site)	6,600	CY	2.27	14,982
Fencing/Rails	2,115	LF	21 28	45,000
N.W. Geotech - Grade & Cap				18,200
Subtotal				1,762,883
Overhead & Profit (22%)				387,834
Total				$2,150,717

Capital Costs Indirect		
Engineering	(15% Constr.)	264,432
Oversight	(12% Constr.)	211,546
Contingency	(15% Eng.&Constr.)	304,097
Total		$780,076
Total		$2,930,793

Operation & Maintenance	No. Units	Units	Unit Cost	Total Cost
Annual Maintenance	11	Acres	3,000.00	33,000
Annual Engineering Report	40	hrs	150.00	6,000
Total				$39,000

Alternative

3 - 5	Capital Costs	$4,221
	O&M Costs	$39
	Future Costs	$0

Capital Costs Direct	No. Units	Units	Unit Cost	Total Cost
Landfill Cap				
Geomembrane (40 mil)	457,600	SF	0.60	274,560
Protection Layer	33,900	CY	10.96	371,544
Filter Fabric	1,006,720	SF	1.00	1,006,720
Topsoil	8,500	CY	23.05	195,925
Vegetation/Seed	11	Acres	2,100.00	23,100
Gas Venting (Gravel)	17,000	CY	15.14	257,380
Crushed Stone	1,017	CY	15.14	15,397
Toe Landfill Incl. RR				
Excavation	59,100	CY	1.67	98,697
Haul	59,100	CY	2.27	134,157
Staging Area				
Excavation	6,600	CY	1.67	11,022
Clean Backfill	6,600	CY	10.96	72,336
Haul (on-site)	6,600	CY	2.27	14,982
Fencing/Rails	2,115	LF	21.28	45,000
N.W. Geotech - Grade & Cap				18,200
Subtotal				2,539,020
Overhead & Profit (22%)				558,584
Total				$3,097,605

Capital Costs Indirect		Total Cost
Engineering	(15% Constr.)	380,853
Oversight	(12% Constr.)	304,682
Contingency	(15% Eng.&Constr.)	437,981
Total		$1,123,517
Total		$4,221,121

Operation & Maintenance	No. Units	Units	Unit Cost	Total Cost
Annual Maintenance	11	Acres	3,000.00	33,000
Annual Engineering Report	40	hrs	150.00	6,000
Total				$39,000

Alternative

Alternative						
6a	Capital Costs	$1,198,849				
	O&M Costs	$0				
	Future Costs	$0				
	Capital Costs Direct		No. Units	Units	Unit Cost	Total Cost
	Landfill Cap					
	Excavation		480,000	CY	1 67	801,600
	Clean Backfill		8,500	CY	10 96	93,160
	Transportation		504,000	CY	334 10	168,386,400
	Incineration		504,000	CY	1,400 00	705,600,000
	Subtotal					874,881,160
	Overhead & Profit (22%)					192,473,855
	Total					$1,067,355,015
	Capital Costs Indirect					
	Engineering	(15% Excav &Backfill)				134,214
	Oversight	(12% Excav &Backfill)				107,371
	Contingency	(15% Constr &Eng)				131,252,306
	Total					$131,493,891
	Total					$1,198,848,907
6b	Capital Costs	$310,956				
	O&M Costs	$4,153	Years 0-7			
		$39	Years 8-30			
	Future Costs	$0				
	Capital Costs Direct		No. Units	Units	Unit Cost	Total Cost
	Landfill Cap					
	Geomembrane (40 ml)		457,600	SF	0.60	274,560
	Protection Layer		33,900	CY	10 96	371,544
	Filter Fabric		503,360	SF	1 00	503,360
	Topsoil		8,500	CY	23.05	195,925
	Vegetation/Seed		11	Acres	2,100.00	23,100
	Excavation		480,000	CY	1.67	801,600
	Transportation		126,000	CY	334.10	42,096,600
	Incineration		126,000	CY	1,400.00	176,400,000
	Decon Landfill		378,000	CY	1.07	404,460
	Construction Landfill		11	Acres	400,000.00	4,400,000
	Subtotal					225,471,149
	Overhead & Profit (22%)					49,603,653
	Total					$275,074,802
	Capital Costs Indirect					
	Engineering	(15% Excav.&Backfill)				1,046,182
	Oversight	(12% Excav.&Backfill)				836,946
	Startup	(5% Decon.)				20,223
	Contingency	(15% Constr.&Eng.)				33,977,600
	Total					$35,880,951
	Total					$310,955,753
	Operation & Maintenance		Years 0-7			

Alternative

Decon Landfill (200 CY/Day)	68,571	CY	60.00	4,114,286
Annual Maintenance	11	Acres	3,000.00	33,000
Annual Engineering Report	40	hrs	150.00	6,000
Total				$4,153,286
Operation & Maintenance	Years 8-30			
Annual Maintenance	11	Acres	3,000.00	33,000
Annual Engineering Report	40	hrs	150.00	6,000
Total				$39,000

Alternative

7a	Capital Costs	$261,055				
	O&M Costs	$39				
	Future Costs	$0				
	Capital Costs Direct		No. Units	Units	Unit Cost	Total Cost
	Landfill Cap					
	Excavation		480,000	CY	1.67	801,600
	Incineration		504,000	Ton	325.00	163,800,000
	Clean Backfill		8,500	CY	10.96	93,160
	Construction Landfill		11	Acres	400,000.00	4,400,000
	Subtotal					169,094,760
	Overhead & Profit (22%)					37,200,847
	Total					$206,295,607
	Capital Costs Indirect					
	Engineering	(15% Excavation &Backfill)				794,214
	Startup	(5% Incin.)				8,190,000
	Oversight	(12% Constr.)				20,291,371
	Contingency	(15% Constr &Eng.)				25,483,346
	Total					$54,758,931
	Total					$261,054,539
	Operation & Maintenance					
	Annual Maintenance		11	Acres	3,000.00	33,000
	Annual Engineering Report		40	hrs	150.00	6,000
	Total					$39,000

Alternative

7b	Capital Costs	$74,678	
	O&M Costs	$3,279	Years 0-7
		$39	Years 8-30
	Future Costs	$0	

Capital Costs Direct	No. Units	Units	Unit Cost	Total Cost
Landfill Cap				
Geomembrane (40 ml)	457,600	SF	0 60	274,560
Protection Layer	33,900	CY	10.96	371,544
Filter Fabric	503,360	SF	1.00	503,360
Topsoil	8,500	CY	23.05	195,925
Vegetation/Seed	11	Acres	2,100 00	23,100
Excavation	480,000	CY	1.67	801,600
Incineration	126,000	CY	325 00	40,950,000
Decon Landfill	378,000	CY	1.07	404,460
Construction Landfill	11	Acres	400,000.00	4 400,000
Subtotal				47,924,549
Overhead & Profit (22%)				10,543,401
Total				$58,467,950

Capital Costs Indirect		Total Cost
Engineering	(15% Excavation & Backfill)	1,046,182
Startup	(5% Incin.&Decon.)	2,067,723
Oversight	(12% Constr.)	5,750,946
Contingency	(15% Constr &Eng)	7,345 610
Total		$16,210,461
Total		$74,678,411

Operation & Maintenance	Years 0-7			
Decon Landfill (200 CY/Day)	54,000	CY	60.00	3,240,000
Annual Maintenance	11	Acres	3,000.00	33,000
Annual Engineering Report	40	hrs	150.00	6,000
Total				$3,279,000

Operation & Maintenance	Years 8-30			
Annual Maintenance	11	Acres	3,000.00	33,000
Annual Engineering Report	40	hrs	150.00	6,000
Total				$39,000

Alternative

Capital Costs	$12				
O&M Costs	$110	Year 0-2			
	$65	Year 3-4			
	$32	Year 5-30			
Future Costs	$5	Each year			

Capital Costs Direct	No Units	Units	Unit Cost	Total Cost
Landfill Monitoring Probes	5	Unit	1 500 00	7 500
Overhead & Profit (22%)				1 650
Total				$9 150

Capital Costs Indirect		Total Cost
Engineering	15% Constr.	1 125
Oversight	12% Constr.	900
Contingency	15% Eng &Constr	1 294
Total		$3 319
Total		$12 469

Operation & Maintenance Years 0-2				
Monitoring Analysis and Reporting				
Field Monitoring	4	X Year	14 400 00	57 600
Annual Report	4	X Year	6 000 00	24 000
Total				$108 800

Operation & Maintenance Years 3-4				
Monitoring Analysis and Reporting				23 800
Field Monitoring	2	X Year	14 400 00	28 800
Annual Report	2	X Year	6 000 00	12 000
Total				$64 600

Operation & Maintenance Years 5-30				
Monitoring Analysis and Reporting				11 300
Field Monitoring	1	X Year	14 400 00	14 400
Annual Report	1	X Year	6 000 00	6 000
Total				$31 700

Future Costs				
Replace Probes	3	Each	1 500 00	$4 500

Alternative

2	Capital Costs	$136			
	O&M Costs	$110	Year 0-2		
		$65	Year 3-4		
		$32	Year 5-30		
	Future Costs	$14	Each year		

Capital Costs Direct	No. Units	Units	Unit Cost	Total Cost
Perimeter Vent System				81 838
Overhead & Profit (22%)				18 004
Total				$99 842
Capital Costs Indirect				
Engineering (15% Constr.)				12 276
Oversight (12% Constr.)				9 821
Contingency (15% Eng &Constr.)				[illegible]
				$36 2[illegible]3
Total				$136 055
Operation & Maintenance Years 0-2				
Monitoring Analysis and Reporting				[illegible]
Field Monitoring	4	X Year	14 400 00	57 600
Annual Report	4	X Year	6 000 00	24 000
Total				$108 800
Operation & Maintenance Years 3-4				
Monitoring Analysis and Reporting				23 800
Field Monitoring	2	X Year	14 400 00	28 800
Annual Report	2	X Year	6 000 00	12 000
Total				$64 600
Operation & Maintenance Years 5-30				
Monitoring Analysis and Reporting				11 300
Field Monitoring	1	X Year	14 400 00	14 400
Annual Report	1	X Year	6 000 00	6 000
Total				$31 700
Future Costs				
Replace Perimeter Vents	2		7 000 00	$14 000

Alternative			
3a	Capital Costs	$488	
	O&M Costs	$78	Year 1-4
		$60	Year 4-30
	Future Costs	$27	Every Year
		$23	Add every 3 years
		$85	Add every 15 years

Capital Costs Direct	No. Units	Units	Unit Cost	Total Cost
Perimeter Vent System				81,838
Perimeter AC System				14,760
Interior Vent System				131,432
Interior AC System				29,520
Subtotal				257,550
Overhead & Profit (22%)				56,661
Total				$314,211

Capital Costs Indirect		
Engineering	15% Constr.	38,632
Oversight	12% Constr.	30,906
Startup		60,000
Contingency	15% Eng & Constr.)	44,427
		$173,966
Total		$488,176

Operation & Maintenance Years 1-4	No. Units	Units	Unit Cost	Total Cost
Perimeter AC Caustic	8	Can	1,132.50	9,060
Perimeter AC VOC	4	Can	1,144.17	4,577
Interior AC Caustic	24	Can	1,132.50	27,180
Interior AC VOC	8	Can	1,144.17	9,153
Monitoring Analysis and Reporting				28,000
				$77,970

Operation & Maintenance Years 5-30	No. Units	Units	Unit Cost	Total Cost
Perimeter AC Caustic	8	Can	1,132.50	9,060
Perimeter AC VOC	4	Can	1,144.17	4,577
Interior AC Caustic	24	Can	1,132.50	27,180
Interior AC VOC	8	Can	1,144.17	9,153
Monitoring Analysis and Reporting				10,000
				$59,970

Future Costs Every Year	No. Units	Units	Unit Cost	Total Cost
Replace Perimeter Vents	2	Vent	7,000.00	14,000
Replace Interior Vent	1	Vent	13,000.00	13,000
				$27,000

Future Costs Every 3 Years Additional	No. Units	Units	Unit Cost	Total Cost
Replace Per. Can. Housing	2	Housing	$4,650	9,300
Replace Inter. Can Housing	1	Housing	$13,700	13,700
				$23,000

Future Costs Every 15 Years Additional	Total Cost
Replace All Vents and manifold	$85,000

Alternative

3b	Capital Costs	$556	
	O&M Costs	$78	Year 1-4
		$60	Year 4-30
	Future Costs	$27	Every Year
		$23	Add every 3 years
		$85	Add every 15 years

Capital Costs Direct		No. Units	Units	Unit Cost	Total Cost
Perimeter Vent System					81,838
Perimeter AC System					14,760
Interior Vent System					131,432
Interior AC System					70,110
Subtotal					298,140
Overhead & Profit (22%)					65,591
Total					$363,730
Capital Costs Indirect					
Engineering	(15% Constr.)				44,721
Oversight	(12% Constr.)				35,777
Startup					60,000
Contingency	(15% Eng &Constr.)				51,429
					$191,927
Total					$555,657
Operation & Maintenance	Years 1-4				
Perimeter AC Caustic		8	Can	1,132.50	9,060
Perimeter AC VOC		4	Can	1,144.17	4,577
Interior AC Caustic		24	Can	1,132.50	27,180
Interior AC VOC		8	Can	1,144.17	9,153
Monitoring Analysis and Reporting					28,000
					$77,970
Operation & Maintenance	Years 5-30				
Perimeter AC Caustic		8	Can	1,132.50	9,060
Perimeter AC VOC		4	Can	1,144.17	4,577
Interior AC Caustic		24	Can	1,132.50	27,180
Interior AC VOC		8	Can	1,144.17	9,153
Monitoring Analysis and Reporting					10,000
					$59,970
Future Costs	Every Year				
Replace Perimeter Vents		2	Vent	7,000.00	14,000
Replace Interior Vent		1	Vent	13,000.00	13,000
					$27,000
Future Costs	Every 3 Years Additional				
Replace Per. Can. Housing		2	Housing	$4,650	9,300
Replace Inter. Can Housing		1	Housing	$13,700	13,700
					$23,000
Future Costs	Every 15 Years Additional				
Replace All Vents and manifold					$85,000

Alternative			
4a,5a,5c	Capital Costs	$967	
	O&M Costs	$86	Year 1-4
		$73	Year 4-30
	Future Costs	$27	Every Year
		$23	Add every 3 years
		$28	Add every 10 years
		$170	Add every 15 years

Capital Costs Direct	No. Units	Units	Unit Cost	Total Cost
Perimeter Vent System				81.838
Perimeter AC System				14 760
Install Blower Housing				38.000
Interior Vent System				131 432
Interior AC Sys Caustic IVP	3	Unit	9.500 00	28.500
Interior AC Sys VOC BCP	2	Unit	8.200 00	16.400
Subtotal				310 930
Overhead & Profit 22%				68 405
Total				$379 334

Capital Costs Indirect		Total Cost
Engineering	15% Constr.	46.639
Oversight	12% Constr.	37 312
Startup		150 000
Contingency	15% Eng &Constr.	53.635
Pre-Design Study		300 000
		$587 586
Total		$966 92[illegible]

Operation & Maintenance Years 1-4	No. Units	Units	Unit Cost	Total Cost
Blower Maint. & Energy Req				23 000
Perimeter AC Caustic	8	Can	1 132 50	9.060
Perimeter AC VOC	4	Can	1 144 17	4 577
Interior AC Caustic	2 400	Lbs	14 45	34 680
Interior AC VOC	1 200	Lbs	12 28	14 736
				$86.053

Operation & Maintenance Years 5-30	No. Units	Units	Unit Cost	Total Cost
Blower Maint. & Energy Req.				23.000
Perimeter AC Caustic	8	Can	1 132.50	9.060
Perimeter AC VOC	4	Can	1 144 17	4 577
Interior AC Caustic	24	Can	1 132.50	27.180
Interior AC VOC	8	Can	1 144 17	9 153
				$72.970

4a 5a,5c	Future Costs Every Year	No. Units	Units	Unit Cost	Total Cost
	Replace Perimeter Vents	2	Vent	7 000 00	14 000
	Replace Interior Vent	1	Vent	13 000 00	13 000
					$27.000
	Future Costs Every 3 Years Additional				
	Replace Per. Can Housing	2	Housing	$4.650	9.300
	Replace Inter. Can Housing	1	Housing	$13.700	13.700
					$23.000
	Future Costs Every 10 Years Additional				
	Replace Blower				$28.000
	Future Costs Every 15 Years Additional				
	Replace All Vents & Manifold				$170.000

Alternative

4b	Capital Costs	$1,054	
	O&M Costs	$81	Year 1-4
		$63	Year 4-30
	Future Costs	$27	Every Year
		$23	Add every 3 years
		$61	Add every 10 years
		$170	Add every 15 years

Capital Costs Direct		No. Units	Units	Unit Cost	Total Cost
Perimeter Vent System					81,838
Perimeter AC System					14,760
Install Blower housing					71,000
Interior Vent System					131,432
Install Alkaline Wet Scrubber					47,250
Subtotal					346,280
Overhead & Profit (22%)					76,182
Total					$422,461
Capital Costs Indirect					
Engineering	15% Constr.				51,942
Oversight	12% Constr.				41,554
Startup					178,000
Contingency	15% Eng &Constr				59,733
Pre-Design Study					300,000
					$631,229
Total					$1,053,690

4b	Operation & Maintenance	Years 1-4			
	Perimeter AC Caustic	8	Can	1,132.50	9,060
	Perimeter AC VOC	4	Can	1,144.17	4,577
	Blower Maint. & Energy Req.				23,000
	Alkaline Wet Scrubber Replace				15,000
	Alkaline Wet Scrubber Dispose				1,000
	Monitoring Analysis and Reporting				28,000
					$80,637
	Operation & Maintenance	**Years 5-30**			
	Perimeter AC Caustic	8	Can	1,132.50	9,060
	Perimeter AC VOC	4	Can	1,144.17	4,577
	Blower Maint. & Energy Req.				23,000
	Alkaline Wet Scrubber Replace				15,000
	Alkaline Wet Scrubber Dispose				1,000
	Monitoring Analysis and Reporting				10,000
					$62,637
	Future Costs	**Every Year**			
	Replace Perimeter Vents	2	Vent	7,000.00	14,000
	Replace Interior Vent	1	Vent	13,000.00	13,000
					$27,000
	Future Costs	**Every 3 Years Additional**			
	Replace Per. Can. Housing	2	Housing	$4,650	9,300
	Replace Inter. Can Housing	1	Housing	$13,700	13,700
					$23,000
	Future Costs	**Every 10 Years Additional**			
	Replace Blower				$61,000
	Future Costs	**Every 15 Years Additional**			
	Replace Perimeter & interior sys.				$170,000

Alternative

6	Capital Costs	$210				
	O&M Costs	$0				
	Future Costs	$0				

Capital Costs Direct	No. Units	Units	Unit Cost	Total Cost
Establish Air monitoring Sta				75,000
High expansion Foam-Mat'l	11	Can	3,050.00	32,025
High expansion Foam-Equip				28,800
Subtotal				135,825
Overhead & Profit (22%)				29,882
Total				$165,707

Capital Costs Indirect		
Engineering	(15% Constr.)	20,374
Contingency	(15% Eng &Constr.)	23,430
		$43,804
Total		$209,510

-	Capital Costs	$839				
	O&M Costs	$0				
	Future Costs	$0				

Capital Costs Direct	No. Units	Units	Unit Cost	Total Cost
Establish Air monitoring Sta				368,000
High expansion Foam-Mat'l	11	Can	3,050.00	32,000
High expansion Foam-Equip.				144,000
Subtotal				544,000
Overhead & Profit (22%)				119,680
Total				$663,680

Capital Costs Indirect		
Engineering	15% Constr.	81,600
Contingency	15% Eng &Constr.)	93,840
		$175,440
Total		$839,120

Alternative

Construct Perimeter Vent System

Item	No. Units	Units	Unit Cost	Total Cost
Mobilization/Demolition				4 000
Drill/Install Vents	270	FT	200 00	54.000
Sand & Bentonite				750
Level "B" Surcharge	120	Hrs	103 75	12 450
Manifold Piping	1 150	FT	9 25	10 638
				$81 838

Construct Interior Vent System

Item	No. Units	Units	Unit Cost	Total Cost
Mobilization/Demolition				4 000
Drill/Install Vents	407	FT	200 00	81.429
Sand & Bentonite				1.357
Level "B" Surcharge	163	Hrs	103 75	16.896
Manifold Piping	3.000	FT	9 25	27.750
				$131 432

Construct Perimeter AC Cannister System

Item	No. Units	Units	Unit Cost	Total Cost
Caustic	8	Can	1 385 00	11 080
VOC	4	Can	920 00	3 680
				$14 760

Construct Interior AC Cannister System

Item	No. Units	Units	Unit Cost	Total Cost
Caustic	16	Can	1 385 00	22.160
VOC	8	Can	920 00	7 360
				$29.520

3b Construct IndividualInterior AC Cannister

Item	No. Units	Units	Unit Cost	Total Cost
Caustic	38	Can	1 385 00	52.630
VOC	19	Can	920.00	17 480
				$70.110

Alternative

Alternative			
1	Capital Costs	$18	
	O&M Costs	$28	
	Future Costs	$8	Every 5 Years

Capital Costs Indirect	No. Units	Units	Unit Cost	Total Cost
Prepare Sampling Plan				16,000
Contingency (15% Eng.)				2,400
Total				$18,400

Operation & Maintenance	No. Units	Units	Unit Cost	Total Cost
Groundwater Monitoring	20	Samples	1,000.00	20,000
Annual Report	80	Hrs	100.00	8,000
Total				$28,000

Future Costs Every 5 Years	Total Cost
Replace Monitoring Well	$8,000

Alternative			
2,3,4	Capital Costs	$118	
	O&M Costs	$29	
	Future Costs	$8	Every 5 Years

Capital Costs Direct	No. Units	Units	Unit Cost	Total Cost
Run on Diversion				60,000
Overhead & Profit (22%)				13,200
Total				$73,200

Capital Costs Indirect	No. Units	Units	Unit Cost	Total Cost
Prepare Sampling Plan				16,000
Engineering (15%)				9,000
Oversight (12%)				7,200
Contingency (15% Eng.&Constr.)				12,750
Total				$44,950
Total				$118,150

Operation & Maintenance	No. Units	Units	Unit Cost	Total Cost
Groundwater Monitoring	20	Samples	1,000.00	20,000
Annual Report	80	Hrs	100.00	8,000
Maintain Run on Diversion				1,000
Total				$29,000

Future Costs Every 5 Years	Total Cost
Replace Monitoring Well	$8,000

Alternative			
5a	Capital Costs	$2,399	
	O&M Costs	$658	
	Future Costs	$29	Every 5 Years

Capital Costs Direct	No. Units	Units	Unit Cost	Total Cost
SB Slurry Wall Construction				775,000
Run on Diversion				60,000
Extraction/Treatment				608,729
Subtotal				' 443,729
Overhead & Profit (22%)				317,620
Total				$1,761,349
Capital Costs Indirect				
Prepare Sampling Plan				16,000
Engineering (15%)				216,559
Oversight (12% less $275,000 IE Equip.)				140,247
Startup (5% IE Equip.)				13,750
Contingency (15% Eng &Constr.)				251,443
Total				$638,000
Total				$2,399,349
Operation & Maintenance				
Groundwater Monitoring	20	Samples	',000.00	20,000
Annual Report	80	Hrs	'00.00	8,000
Maintain Run on Diversion				' 000
Maintain Ext. and Treat Sys.				628,500
Total				$657,500
Future Costs Every 5 Years				
Replace Extraction Well	1	Well	21,000.00	21,000
Replace Monitoring Well				8,000
				$29,000

Alternative

5c	Capital Costs	$4,853				
	O&M Costs	$658				
	Future Costs	$29 Every 5 Years				

Capital Costs Direct	No. Units	Units	Unit Cost	Total Cost
Plastic Concrete Barrier				2,251 000
Run on Diversion				60,000
Extraction/Treatment				608 729
Subtotal				2 919 729
Overhead & Profit (22%)				642 340
Total				$3 562 069
Capital Costs Indirect				
Prepare Sampling Plan				16 000
Engineering (15%)				437 959
Oversight (12% less $275 000 IE Equip.)				317 367
Startup (5% IE Equip.)				13,750
Contingency (15% Eng &Constr.)				506 053
Total				$1 291 130
Total				$4 853 199
Operation & Maintenance				
Groundwater Monitoring	20	Samples	1 000 00	20,000
Annual Report	80	Hrs	100 00	8,000
Maintain Run on Diversion				1 000
Maintain Ext and Treat Sys				628 500
Total				$657,500
Future Costs Every 5 Years				
Replace Extraction Well	1	Well	21 000 00	21,000
Replace Monitoring Well				8 000
				$29 000

Alternative

6 7	**Capital Costs**	$402				
	O&M Costs	$657	Years 0-15			
		$28	Years 16-30			
	Future Costs	$29	Every 5 Years			

Capital Costs Direct	No Units	Units	Unit Cost	Total Cost
Extraction/Treatment				608 729
Overhead & Profit (22%)				133 920
Total				$133 920

Capital Costs Indirect				
Prepare Sampling Plan				16 000
Engineering (15%)				91 309
Oversight (12% less $275 000 IE Equip)				40 047
Startup (5% IE Equip)				13 750
Contingency (15% Eng & Constr)				107 406
Total				$268 512
Total				$402 433

Operation & Maintenance	Years 0-15			
Groundwater Monitoring	20	Samples	1 000 00	20 000
Annual Report	80	Hrs	100 00	8 000
Maintain Ext and Treat Sys				628 500
Total				$656 500

Operation & Maintenance	Years 16-30			
Groundwater Monitoring	20	Samples	1 000 00	20 000
Annual Report	80	Hrs	100 00	8 000
Total				$28 000

Future Costs	Every 5 Years			
Replace Extraction Well		Well	21 000 00	21 000
Replace Monitoring Well				8 000
				$29 000

Alternative

Downgradient Extraction Pump & Treat Costs

Item	No. Units	Units	Unit Cost	Total Cost
Extraction Wells (6"D 50 ft dee	4	Wells	1150 00	4 600
Trenching (6 ft	1635	FT	4 36	7 129
Jacking at RR Tracks	60	FT	64 00	3 840
PVC pipe (2")	1800	FT	40 70	73 260
PVC pipe (24")	400	FT	15 00	6 000
Well Pumps	4	Wells	1600 00	6 400
Equilization Tank				40 000
Ion-Exchange System				175 000
Ion-Exchange Installation				100 000
Concentrator-Double Drum Dryer				100 000
Install Dryer				10 000
Boiler				5 000
Neutralization Tank Mixers Meters etc				2 500
Building (50' X 30'	1500	SF	50 00	75 000
				$608 729

Alternative						
1 - 7	Capital Costs	$7				
	O&M Costs	$35				
	Future Costs	$0				
	Capital Costs Direct		No Units	Units	Unit Cost	Total Cost
	Total					$C
	Capital Costs Indirect					
	Engineering To develop Surface Water Plan					6 000
	Contingency (15% Eng)					900
	Total					$6.900
	Total					$6 900
	Operation & Maintenance					
	Surface Water Monitoring		12	Samples		29 000
	Annual Report		60	Hrs	100 00	6 000
	Total					$35 000

Surface Water Sediment Remediation

Alternative

Sediment Removal Option	Capital Costs	$4 082
	O&M Costs	$35
	Future Costs	$0

Capital Costs Direct	No Units	Units	Unit Cost	Total Cost
Sed Removal Exc by Drag Line	6 750	CY	2 76	18 630
Sed Removal Exc by Backhoe	144	CY	1 67	240
Transport to Facility	400	CY	2 27	908
Sediment Treatment	9.652	Tons	85 00	820 420
Sediment Disposal	15 443	Tons	80 00	1 235 440
Disposal Transport	15.443	Tons	24 30	375 265
Subtotal				2.450.903
Overhead & Profit (22%)				539 199
Total				$2.990.102
Capital Costs Indirect				
Engineering (15%)				367 636
Oversight (12%)				294 108
Engineering To develop Surface Water Plan				6 000
Contingency 15% Eng &Constr)				423,681
Total				$1,091.425
Total				$4 081 527
Operation & Maintenance				
Surface Water Monitoring	12	Samples		29.000
Annual Report	60	Hrs	100 00	6.000
Total				$35.000

Project
Subject Comptd. By Date
Detail Ck'd By Date

NONREPRODUCIBLE GRID FORM 149

METCALF & EDDY, ENGINEERS

COST COMPUTATIONS
FOR GEORGIA TECH
REMEDIATION

Alternative: 1

Media: Georgia Tech

Remediation: No action

Capital Costs – Direct	Value
	~~0~~
Capital Costs – Indirect	Value
	~~0~~
[illegible] Total	$ [illegible],000
Operations + Maintenance	Value
	~~0~~
Future Costs	Value/Year
	~~0~~

Alternative: 2

Media: Georgia Tech

Remedial: Removal of Waste for Redeposition in the Tuxedo Waste Site

Capital Costs - Direct	Value
1 Excavation of Waste, Haul, Backfill, Loam + Seed	$216,000
+ 22% O+P	$47,520
	$263,520
	SAY $264,000

Capital Costs - Indirect	Value
1. Engineering @ 15% Construction	$32,400
2. Oversight @ 12% Construction	$25,920
3 Contingency @ 15% " +Eng.	$44,460
	$102,780
	SAY $103,000

Operations + Maintenance	Value
None	Ø

Future Costs	Value/Year
None	Ø

Alternative: 3

Media: Georgia Tech

Remediation: Removal and Transportation off site for Treatment and Disposal

Capital Costs - Direct	Value
1. Excavation of Waste, Haul, Backfill, Loam and Seed	$216,000
2. Transportation	$4,301,500
3. Incineration	$21,507,570
	$26,025,070
+22% O+P	5,725,515
	$31,750,585
SAY	$31,750,000

Capital Costs - Indirect	Value
1. Engineering @ 15% Construction	$3,903,760
2. Oversight @ 12% Construction (less incin.)	$542,100
3. Contingency @ 15% " + eng.	$5,348,064
	$9,793,924
SAY	$9,794,000

Operations + Maintenance	Value
None	-0-

Future Costs	Value/Year
None	-0-

Project TOLEDO LANDFILL   Acct No.   Page   of
Subject GEORGIA TECH   Compd By KML   Date 9.19.91
Detail TRANSPORT TO OFFSITE INCIN   Ckd By   Date

ALTERNATIVE 3

CAPITAL COSTS* — DIRECT

1. TRANSPORTATION — $4,301,500
14,631 CY @ $280/TON
ASSUME ρ = 1.05 TONS/CY
350 MI

2. INCINERATION — $21,507,570
15,362 TONS @ $1400/TON

*ASSUMES OPERATIONS CAN BE CONDUCTED IN ONE CALENDAR YEAR — $25,809,070

CAPITAL COSTS* — INDIRECT

1. ENGINEERING @ 15% CONSTRUCTION
2. OVERSIGHT @ 12% " (LESS INCIN)
3. CONTINGENCY @ 15% " + ENG

OPERATIONS + MAINTENANCE

NONE

FUTURE LUMP SUM

NONE

Alternative: 4

Media: Georgia Tech

Remediation: Removal to Tuxedo Site for Incineration and Disposal

Capital Costs - Direct		Value
1. Excavation of Waste, Haul, Backfill, Loam + Seed		$216,000
2. Incineration		$7,681,000
3 Backfill Ash		$405,278
		$8,302,278
	+22% O+P	1,826,501
		$10,128,779
	SAY	$10,130,000

Capital Costs - Indirect	Value
1 Engineering @ 15% Items 1 and 3	$93,192
2 Oversight @ 12% construction	$996,273
3 Contingency @ 15% construction + eng	$1,533,479
	$2,622,944
	SAY $2,623,000

Operations + Maintenance	Value
None	Ø

Future Costs	Value/Year
None	

Project
Subject GEORGIA TECH Comptd By KMC Date 9.19.91
Detail TRANSPORT TO ONSITE INCIN Ckd By Date

ALTERNATIVE 4

CAPITAL COSTS - DIRECT

1 INCINERATION
15,362 TONS @ $500 / TON = $7,681,000

2. BACKFILL INTO LINED LANDFILL
1463 CY @ $2.77 / CY = $405,278

ASSUME ADD'L BACKFILL FROM GEORGIA TECH SITE CAN BE FILLED INTO LANDFILL @ TUXEDO SITE W/O SUBSTANTIALLY CHANGING SIZE OF LANDFILL

CAPITAL COSTS - INDIRECT

1 ENGINEERING @ 15% ITEMS 1 + 3
2 OVERSIGHT @ 12% CONSTRUCTION
3 CONTINGENCY @ 15% " + ENG.

OPERATIONS + MAINTENANCE

NONE

FUTURE LUMP SUM

NONE

Project ______
Subject GEORGIA TECH   Comp'd By KMC   Date 9.19.91
Detail EXCAVATION OF WASTE   Ck'd By ______   Date ______

NONREPRODUCIBLE GRID FORM 145

METCALF & EDDY, ENGINEERS

ALTERNATIVE-4

CAPITAL COSTS - DIRECT

1 EXCAVATION
14,631 CY x 1.67/CY = $24,435

2. HAUL (ON-SITE)
14,631 CY x 2.27/CY = $33,212

3. BACKFILL
14,631 CY x 10.67/CY = $156,113

4. VEGETATION/SEED
1 ACRE x 2100/ACRE = $2,100

$215,860

SAY $216,000

CAPITAL COSTS - INDIRECT

1. ENGINEERING @ 15% CONSTRUCTION
2. OVERSIGHT @ 12% "
3. CONTINGENCY @ 15% " + ENG

OPERATIONS + MAINTENANCE

NONE

FUTURE LUMP SUM

NONE