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FEASIBILITY STUDY

ECC SITE

ZIONSVILLE, INDIANA

WA 18.5M30.0

December 5, 1986

CONTENTS

Chapter		Page
1	EXECUTIVE SUMMARY	1-1
2	INTRODUCTION	2-1
	Purpose of the FS Report	2-1
	Background	2-2
	Remedial Investigations	2-2
	Contaminant Transport and Fate	2-5
	Endangerment Assessment	2-6
3	REMEDIAL ACTION OBJECTIVES	3-1
	Soil	3-1
	Groundwater	3-1
	Aquifer Classification	3-2
4	REMEDIAL TECHNOLOGY DEVELOPMENT	4-1
	General Response Actions	4-1
	Applicable Remedial Technologies	4-1
5	REMEDIAL TECHNOLOGY SCREENING	5-1
	Soil Operable Unit	5-2
	Groundwater Operable Unit	5-14
	Remedial Technology Screening Summary	5-24
6	ASSEMBLY OF REMEDIAL ACTION ALTERNATIVES	6-1
	Cost-Effectiveness Evaluation of Contaminated Soil Removal Volumes	6-2
	Comparison of Capping Options	6-4
	Comparison of Thermal Volatilization and Soil Vapor Extractions	6-7
	Slurry Wall Groundwater Containment	6-7
	Groundwater Collection System Design	6-8
	French Drain System	6-9
	Extraction Well System	6-10
	Extraction-Injection Well System	6-11
	Groundwater Treatment Technologies	6-11
	Effluent Discharge Criteria	6-12
	Air Stripping	6-12
	Granular Activated Carbon	6-13
	Offsite Treatment at a Publicly Owned Treatment Works	6-14
	Offsite Treatment at a RCRA Facility	6-16
	Assembly of Remedial Action Alternatives	6-17

CONTENTS (continued)

Section		Page
7	DETAILED ANALYSIS OF ALTERNATIVES	7-1
	Technical Evaluation	7-1
	Public Health and Welfare and Environmental Analysis	7-1
	Institutional Issues	7-2
	Cost Analysis	7-3
	Detailed Analysis Summary	7-4

Appendixes

A Soil Removal/Leachate-Groundwater Interaction Analysis
B Groundwater Collection System Configuration Calculations
C Technical Public Health and Welfare, Environmental, and Institutional Evaluation Criteria
D Detailed Cost Summary Tables

CONTENTS (continued)

Tables		Follows Page
1-1	Detailed Evaluation Summary Matrix	1-6
2-1	Indicator Chemicals at ECC	2-5
3-1	Soil Contaminant Levels at which Criteria or Risks Could be Met	3-2
3-2	Surface Water and Groundwater Contaminant Levels at which Standards, Criteria, and Risks for Ingestion Could Be Met	3-2
4-1	Identification of General Response Actions	4-1
4-2	Site and Waste Characteristics	4-1
6-1	Soil Removal Cost Comparison	6-4
6-2	Capping Cost Comparison	6-6
6-3	Thermal Volatilization and Soil Vapor Extraction Cost Comparison	6-7
6-4	Projected Groundwater Contaminant Concentrations and Water Quality Criteria	6-11
6-5	Granular Activated Carbon Process Sizing Summary	6-14
6-6	Groundwater Treatment by Granular Activated Carbon Cost Summary	6-14
6-7	Groundwater Contaminant Treatment in a POTW	6-15
6-8	POTW Groundwater Treatment Cost Summary	6-16
6-9	RCRA Facility Groundwater Treatment Cost Summary	6-17
7-1	Technical Evaluation of Alternatives	7-1
7-2	Public Health and Welfare and Environmental Impacts of Alternatives	7-2
7-3	Federal Agency Coordination	7-3

CONTENTS (continued)

Tables (continued)		Follows Page
7-4	Laws, Regulations, Policies, and Standards Reviewed and Found Not Applicable to Alternatives	7-3
7-5	Alternative Compliance with Applicable Laws and Regulations	7-3
7-6	Summary of Institutional Impacts of Alternatives	7-3
7-7	Alternative 2, Access Restrictions, Cost Summary	7-3
7-8	Alternative 3, Capping, Cost Summary	7-3
7-9	Alternative 4, Groundwater Collection and Treatment, Cost Summary	7-3
7-10	Alternative 5, Groundwaer Collection and Treatment - Soil Vapor Extraction, Cost Summary	7-3
7-11	Alternative 6, Soil Excavation With Disposal Offsite - Groundwater Collection and Treatment, Cost Summary	7-3
7-12	Alternative 7, Soil Excavation with Onsite Incineration and Onsite Disposal - Groundwater Collection and Treatment, Cost Summary	7-3
7-13	Detailed Evaluation Summary Matrix	7-4

CONTENTS (continued)

Figures		Follows Page
2-1	Flow Diagram for ECC FS	2-1
2-2	Site Map	2-2
2-3	Groundwater Contours, December, 1984	2-3
2-4	Potential Pathways for Contaminant Migration	2-5
4-1	Soil Operable Unit, Remedial Technologies and Process Options	4-1
4-2	Groundwater Operable Unit, Remedial Technologies and Process Options	4-1
4-3	Identification of Applicable Remedial Technologies and Process Options - Soil Operable Unit	4-1
4-4	Identification of Applicable Remedial Technologies and Process Options - Groundwater Operable Unit	4-1
4-5	Applicable Remedial Technologies and Process Options - Soil Operable Unit	4-1
4-6	Applicable Remedial Technologies and Process Options - Groundwater Operable Unit	4-1
5-1	Multilayer Caps	5-4
5-2	Cross Section of Typical RCRA Landfill	5-7
5-3	Screening Summary of Remedial Technologies and Process Options - Soil Operable Unit	5-24
5-4	Screening Summary of Remedial Technologies and Process Options - Groundwater Operable Unit	5-24
5-5	Remedial Technologies and Process Options for Detailed Analysis - Soil Operable Unit	5-24
5-6	Remedial Technologies and Process Options for Detailed Analysis - Groundwater Operable Unit	5-24

CONTENTS (continued)

Figures		Follows Page
6-1	Areas Identified for Evaluation of Contaminated Soil Removal	6-2
6-2	Areas of Suspected Groundwater Contamination from ECC	6-8
6-3	Groundwater Collection System	6-9
6-4	Remedial Technologies and Process Options for Assembly into Remedial Action Alternatives - Soil Operable Unit	6-18
6-5	Remedial Technologies and Process Options for Assembly into Remedial Action Alternatives - Groundwater Operable Unit	6-18
6-6	Alternative 2, Access Restrictions	6-19
6-7	Alternative 3, Capping	6-20
6-8	Alternative 3, Cross Section	6-20
6-9	Alternative 4, Groundwater Collection and Treatment	6-21
6-10	Alternative 4, Cross Section	6-21
6-11	Alternative 5, Groundwater Collection and Treatment - Soil Vapor Extraction	6-21
6-12	Alternative 5, Cross Section	6-21
6-13	Alternatives 6 and 7	6-24
6-14	Alternatives 6 and 7 Cross Sections	6-24

GLT533/38

Chapter 1
EXECUTIVE SUMMARY
ECC FEASIBILITY STUDY

INTRODUCTION

This Feasibility Study (FS) report for the Environmental Conservation and Chemical Corporation (ECC) site, near Zionsville, Indiana, presents and discusses the study methods for identifying and evaluating remedial technologies and remedial action alternatives. The U.S. Environmental Protection Agency (EPA) uses this report to recommend a cost-effective remedial action alternative for the ECC site in accordance with the National Oil and Hazardous Substances Contingency Plan (NCP)(latest revisions effective February 18, 1986). Section 300.68(i) of the NCP states the appropriate extent of remedy is defined as a "cost effective remedial alternative that effectively mitigates and minimizes threats to and provides adequate protection of public health and welfare and the environment."

The methodology consists of a step-by-step evaluation of remedial technologies, process options, and remedial action alternatives. The initial screenings prevent infeasible or unacceptable technologies from being carried forward to the detailed evaluation step. Specific criteria are used to evaluate remedial technologies and the magnitude and importance of effects expected from the implementation of remedial technologies. The use of specific criteria allows all remedial technologies and assembled alternatives to be evaluated on a common basis. Upon completion of the technology and process option screenings, a detailed analysis of the resulting assembled alternatives is performed.

The alternatives developed in this report will be combined with alternatives developed for the adjacent Northside Sanitary Landfill (NSL) site. The methodology for combining the alternatives and the results of the detailed analysis of the combined alternatives will be presented in the ECC-NSL Combined Alternatives Analysis Report (CAA). The CAA Report will present the recommended alternative. The intent of combining the alternatives for the adjacent sites is to ensure the remedies are consistent with each other and to avoid duplication of remedial action elements that could be more cost effectively implemented for both sites.

This FS report is based on the information and data presented in the Remedial Investigation (RI) report for the ECC site dated March 14, 1986.

SITE BACKGROUND

The ECC site occupies 6.5 acres alongside the 168 acre Northside Sanitary Landfill (NSL), an ongoing solid waste disposal facility. The site is bounded on the east by the landfill. An unnamed ditch separates the two facilities along the east boundary. The site is bounded on the north and west sides by several residential homes, located within one-half mile of the facility.

ECC began operations in 1977 and was engaged in the recovery/reclamation/brokering of primary solvents, oils, and other wastes received from industrial clients. Waste products were received in drums and bulk tankers and prepared for subsequent reclamation or disposal. Reclamation processes included distillation, evaporation, and fractionation to reclaim solvents and oil.

Accumulation of contaminated stormwater onsite, inadequate management of the drum inventory and several spill incidents caused initial state and EPA investigations that later led to civil suits and finally placement of ECC into receivership in July 1981. Drum shipments to the site were halted in February 1982. The company was found insolvent in August 1982 and the state and EPA began plans for cleanup. Numerous site investigations, including sampling and analysis were conducted during the period.

Removal measures at the site began in March 1983 and continued through 1984. Actions included removal and treatment or disposal of cooling pond waters, approximately 30,000 drums of waste, 220,000 gallons of hazardous waste from tanks and 5,650 cubic yards of contaminated soil and cooling pond sludge. A silty clay cover, placed over the site, was compacted in July 1985.

RESULTS OF REMEDIAL INVESTIGATIONS

Remedial investigations began in 1983 and continued until December 1984. Soil, hydrogeologic, and surface water and sediment investigations were conducted.

Soil contaminants found onsite were primarily volatile organic compounds (VOC's) and phthalates. Migration of VOC's in the soil to the shallow saturated silty clay zone has occurred onsite. The shallow sand and gravel deposit (approximately 18 feet below ground surface) has also been found to be contaminated with VOC's though the source may have been the former cooling pond onsite rather than downward migration from the shallow saturated zone. Organic contaminants were also found in Finley Creek immediately downstream of the site.

Under existing site conditions, the VOC's and certain phthalates will tend to leach from subsurface soil into the groundwater and slowly migrate to the unnamed ditch or Finley Creek downgradient of the site. Once in the surface waters, contaminants will either volatilize, adsorb to sediments, or experience dilutions on the order of 20 to 1 before reaching the downstream Eagle Creek Reservoir (about 10 miles).

The endangerment assessment found that under the no action alternative potential risk to human health and the environment exist at the ECC site (excess lifetime cancer risk levels as high as 4×10^{-1} were estimated). For public health concerns, the exposure routes that resulted in an excess lifetime risk greater than 1×10^{-6} were:

- Soil via ingestion. Excess lifetime cancer risk of 4×10^{-3} to 8×10^{-6}. Requires soil below existing cap to be uncovered for exposure to occur.

- Groundwater in the shallow saturated zone and shallow sand and gravel deposit via ingestion or dermal absorption. Excess lifetime cancer risk of 4×10^{-1} to 3×10^{-3}. Requires installation of a potable water well in area of contamination.

- Ingestion of fish with bioconcentrated contaminants. Excess lifetime cancer risk of 3×10^{-6}. Requires regular fishing in the unnamed ditch or Finley Creek downstream to confluence with Eagle Creek.

Risk from dermal absorption of VOC's during wading in the unnamed ditch or Finley Creek downstream to Eagle Creek was calculated to be between 1×10^{-6} and 1×10^{-7}.

For environmental concerns the projected release of contaminants to the surface water in the unnamed ditch should not exceed the ambient water quality criteria for protection of aquatic life.

DEVELOPMENT AND SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

Remedial action objectives were developed to address the site problems identified in the endangerment assessment. Applicable general response actions, technologies, and associated process options addressing the objectives were identified according to applicability to site conditions, site contaminants and the ability of the technology to adequately protect human health and the environment. The technologies and process options were screened on the basis of technical, public health, environmental, institutional and cost criteria.

ASSEMBLY OF REMEDIAL ACTION ALTERNATIVES

To further reduce the number of technologies and to define cleanup strategies, detailed analyses were performed. The results of these analyses together with the other remaining technologies and process options were used to assemble remedial action alternatives. The alternatives assembled are described below.

ALTERNATIVE 1 - NO ACTION

The no action alternative provides a baseline for comparison of other alternatives. Since remedial actions would not be taken at the site, the public health and environmental risks would be identical to those described in the endangerment assessment.

ALTERNATIVE 2 - ACCESS RESTRICTIONS

This alternative reduces public health risks by controlling access to the contaminants through fencing and deed restrictions, prohibiting excavation, building onsite and installation of wells. Groundwater and surface water monitoring are also performed. Though risks resulting from exposure are unchanged from no action, the potential for exposure is reduced.

ALTERNATIVE 3 - CAPPING

The capping alternative reduces public health risks by greatly reducing leaching of contaminants from onsite soils to the groundwater. Public health risks associated with ingestion of contaminated groundwater, dermal absorption of surface water contaminants, and ingestion of fish are reduced by capping the site. The alternative includes components of Alternative 2 and adds a soil-synthetic membrane-clay cap over the site and removal of any remaining contaminated sludge in the former cooling pond. The existing process building would be demolished before cap construction.

ALTERNATIVE 4 - GROUNDWATER COLLECTION AND TREATMENT

This alternative further reduces public health risks associated with the site by collecting and treating contaminated groundwater. It greatly reduces the time period for drinking water quality criteria for groundwater to be met while also eliminating migration of groundwater contaminants to surface water. Alternative 4 includes a french drain and extraction well system for collection of contaminated groundwater in the shallow saturated zone and the sand and gravel deposit. The groundwater would be treated in a granular activated carbon (GAC) system and discharged to the unnamed ditch. A silty clay cap would be placed over the existing cap to

prevent surface erosion of contaminants found on the cap or direct contact with those contaminants.

ALTERNATIVE 5 - GROUNDWATER COLLECTION AND TREATMENT - SOIL VAPOR EXTRACTION

Alternative 5 includes all components of Alternative 4. In addition, a soil vapor extraction system is added to reduce soil VOC contaminants to the 10^{-6} cancer risk level for ingestion or dermal absorption. The lower soil contaminant levels in turn cause a reduction in the period necessary to meet groundwater drinking water quality criteria. The vapor extraction system would operate for 2 to 4 years.

ALTERNATIVE 6 - SOIL EXCAVATION AND DISPOSAL OFFSITE - GROUNDWATER COLLECTION AND TREATMENT

Additional public health benefits are provided by Alternative 6 since nonvolatile contaminants would be removed from the site. Alternative 6 includes excavation of 17,500 cubic yards of contaminated soil with disposal at a RCRA-permitted landfill. Groundwater collection and treatment would be as described in Alternative 4. The site would be capped with a silty clay cap.

ALTERNATIVE 7 - SOIL EXCAVATION WITH ONSITE INCINERATION AND ONSITE DISPOSAL - GROUNDWATER COLLECTION AND TREATMENT

The public health benefits provided by Alternative 7 are similar to Alternative 6 with the exception that contaminants contributing to cancer risks are permanently destroyed and do not have the potential for creating exposures in the future at an offsite location. It is similar to Alternative 6 except that the contaminated soil is incinerated and disposed onsite. This alternative assumes the incinerated soil could be delisted as a non-hazardous waste.

DETAILED ANALYSIS OF ALTERNATIVES

Each alternative is evaluated using technical, public health and welfare, environmental, institutional, and cost criteria. The detailed cost analysis for each alternative includes estimates of operation and maintenance (O&M) costs, capital costs, replacement costs, and development of present worth.

The results of the detailed analysis are summarized in Table 1-1.

GLT533/37

	1 No Action	2 Access Restrictions	3 Capping	4 Groundwater Collection and Treatment
TECHNICAL CRITERIA	— — Allows release of hazardous constituents causing unacceptable public health risk.	— Effectiveness and reliability depends on fence maintenance, regular monitoring and enforcement of deed restrictions for 200 years. Possibility of lax maintenance or deed restriction enforcement in future may lead to exposures.	o Reduces leaching of contaminants from soil to groundwater. Excavation of former cooling pond sludge prevents further contamination of sand and gravel aquifer. Cap has proven performance and no substantial implementation problems. Access restriction components have similar technical evaluations as Alternative 2.	+ Reduces exposure risk to groundwater and surface water. GAC treatment has proven performance. Implementation will require performance testing and discharge permitting. Components mutual with Alternative 3 have similar technical evaluation.
PUBLIC HEALTH AND WELFARE CRITERIA	— — Public health risks exist for direct contact with excavated soil, ingestion or dermal absorption of groundwater contaminants, and dermal absorption of surface water contaminants. Exposure limited to local population. Duration of potential exposure exceeds 100 years for excavated soil contact and 200 years for the groundwater and surface water risks.	— Lifetime cancer risks the same as No Action if exposure occurs. Exposure prevention depends on successful enforcement of deed restrictions and maintenance of fencing for over 200 years.	o Capping decreases health risks associated with groundwater and surface water contamination but the period where exceedance of groundwater WQC remains greater than 200 years. Exposure prevention depends on successful enforcement of deed restrictions and maintenance of fencing for over 200 years.	+ WQC for groundwater in the saturated zone are met in 130 years. Groundwater sand and gravel aquifer cancer risks reduced to $< 10^{-6}$ after 4-year operation period. Surface water health risks greatly reduced since all contaminanted groundwater is intercepted before discharge. Deed restrictions and fencing needed during operation. Risks from soil exposure unchanged.
ENVIRONMENTAL CRITERIA	— Local vegetation and burrowing animals may be affected through uptake or direct contact with onsite soil. Food chain bioconcentration may affect other local terrestrial animals.	o Fencing may limit exposure to some terrestrial animals.	+ Cap will reduce exposure of terrestrial animals.	+ Same as Alternative 2.
INSTITUTIONAL CRITERIA	— — Uncontrolled hazardous waste site does not meet goals of CERCLA or RCRA. Groundwater in violation of drinking water standards.for protection of human health. The public and elected officials in area around ECC are in opposition to its presence.	— The site is not "cleaned up" so policy goal of CERCLA is not met. Standards and criteria still violated. Would need to acquire land and implement deed restrictions.	o The site is not cleaned up. Contaminant migration greatly reduced but groundwater may continue to exceed WQC far into future, possibly resulting in public opposition.	+ Same as Alternative 3 except cleanup is more complete since groundwater is included. This CERCLA cleanup goal is achieved, but over a long time frame.
ORDER-OF-MAGNITUDE COST ESTIMATE[a]				
TOTAL CAPITAL[b]	0	$107,000	$1,050,000	$2,300,000
ANNUAL O&M	0	22,000	26,000	105,000
PRESENT WORTH[c]	0	293,000	1,270,000	3,290,000

RATINGS

++ An extremely positive benefit
+ A positive or moderately positive benefit
o Of very little apparent positive or negative effects, but inclusion can be justified for some special reason; or no change from existing conditions.
— Negative effects but not strong enough or certain enough to be the sole justification for eliminating an alternative; or of only moderate significance.
— — Extremely negative effects even with mitigating measures; capable of eliminating an alternative.

NOTES:

[a] The American Association of Costs Engineers define an Order-of-Magnitude Estimate as an approximate estimate made without detailed engineering data. It is normally expected that an estimate of this type is accurate within +50% to -30%. Sources of cost information include the U.S. EPA's "Compendium of Cost of Remedial Technologies at Hazardous Waste Sites," the 1985 Means Site Work Cost Data Guide, Cost Reference Guide for Construction Equipment 1985, and vendor estimates.

[b] Total Capital Cost include indirect cost for engineering services, legal fees, administration costs and contingency (45% of total construction cost.)

[c] Total Present Worth Cost is based on 30-year period of 10% interest. Uniform series present worth factor 9.4269. In some cases, a portion of the annual O&M is for a period less than 30 years. See individual cost tables for details.

TABLE 1-1 (Page 1 of 2)
DETAILED EVALUATION SUMMARY MATRIX
ECC FS

	5 Groundwater Collection and Treatment - Soil Vapor Extraction	6 Soil Excavation and Disposal Offsite - Groundwater Collection and Treatment	7 Soil Excavation with Onsite Incineration and Onsite Disposal - Groundwater Collection and Treatment
TECHNICAL CRITERIA	+ + Reduces risk associated with direct contact with soil or leaching of soil contaminants to groundwater. Vapor extraction proven effective and reliable under different site conditions. Pilot-testing would be necessary. Implementation also requires air discharge permit. Components mutual with Alternative 4 have similar technical evaluation.	+ + Reduces risk associated with direct contact with soil or leaching of contamination to groundwater. Soil excavation and transport is effective, reliable and easily implementable. Disposal at a RCRA landfill does not result in contaminant destruction. Performance of ultimate disposal at a RCRA landfill is considered reliable. Components mutual with Alternative 4 have similar technical evaluation.	+ + Reduces risks associated with direct contact with soil or leaching of contamination to groundwater. Incineration has been proven effective for removal of organic contaminants to 99.99 percent. Operation is complex. Implementation requires performance testing and air discharge permit. Onsite disposal of incinerated soil requires delisting as hazardous waste. Components mutual with Alternative 6 have similar technical evaluation.
PUBLIC HEALTH AND WELFARE CRITERIA	+ + Cancer risk from soil reduced to $< 10^{-6}$. ADI exceedance of lead and cadmium unchanged. WQC for groundwater in the shallow saturated zone met in 30 years. All other health risks same as Alternative 4. Minor soil release during french drain and extraction well construction.	+ + Cancer health risks from soil reduced to $< 10^{-6}$ onsite. No exceedance of ADI's. Health risks from soil direct contact remain at RCRA landfill though expsure potential is lower. WQC for groundwater in the shallow saturated zone met in 30 years. All other health risks the same as Alternative 4. Public welfare impacts from truck traffic and noise along route to RCRA landfill.	+ + All cancer health risk reduced to $< 10^{-6}$. ADI's for lead and cadmium may be exceeded. Potential for impacts from air emissions if incinerated system is run improperly. WQC for groundwater in the shallow saturated zone met in 30 years. All other health impacts same as Alternative 4.
ENVIRONMENTAL CRITERIA	+ Soil exposure risk reduced for terrestrial animals.	+ Same as Alternative 5.	+ Same as Alternative 5.
INSTITUTIONAL CRITERIA	+ CERCLA cleanup goal achieved in shorter time frame than previous alternatives.	+ + All standards will be met. Because waste is removed permanently, the public reaction should be positive. CERCLA goals will be met in relatively short time. Because waste is to go offsite, RCRA generator and transporter requirements will require compliance. Waste must go to a RCRA facility.	+ Same as Alternative 6 except because waste is detoxified onsite there may be some local opposition. CERCLA goals will be met. Requires delisting of residue to dispose onsite. No permits required but need to follow technical requirements.
ORDER-OF-MAGNITUDE COST ESTIMATE[a]			
TOTAL CAPITAL[b]	$3,330,000	$6,030,000	$35,400,000
ANNUAL O&M	152,000	105,000	105,000
PRESENT WORTH[c]	5,440,000	7,020,000	36,400,000

RATINGS

++ An extremely positive benefit
+ A positive or moderately positive benefit
0 Of very little apparent positive or negative effects, but inclusion can be justified for some special reason; or no change from existing conditions.
— Negative effects but not strong enough or certain enough to be the sole justification for eliminating an alternative; or of only moderate significance.
—— Extremely negative effects even with mitigating measures; capable of eliminating an alternative.

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[b] Total Capital Cost include indirect cost for engineering services, legal fees, administration costs and contingency (45% of total construction cost.)

[c] Total Present Worth Cost is based on 30-year period of 10% interest. Uniform series present worth factor 9.4269. In some cases, a portion of the annual O&M is for a period less than 30 years. See individual cost tables for details.

TABLE 1-1 (Page 2 of 2)
DETAILED EVALUATION SUMMARY MATRIX
ECC FS

Chapter 2
INTRODUCTION

The ECC site is in Boone County, 865 South U.S. 421, near Zionsville, Indiana, about 10 miles northwest of Indianapolis. The EPA and the Indiana State Board of Health (ISBH) have determined that the site poses a threat to the public health, welfare, and environment. Under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Executive Order 12316, EPA is given the authority to control the actual or potential release of hazardous substances that pose a substantial threat to human health, welfare, or the environment. Pursuant to Section 105 of CERCLA, EPA promulgated revisions to the NCP effective February 18, 1986, to effectuate the response powers and responsibilities created by CERCLA. Subpart F, Section 300.68 of the NCP outlines procedures for determining the nature and extent of contamination at a site and the appropriate extent of remedy for the site.

EPA has developed a program of emergency response, remedial response, and enforcement to implement CERCLA. As part of this program, EPA's Hazardous Site Control Division, through Contract No. 68-01-6692, has employed CH2M HILL to conduct remedial planning activities (Remedial Investigations and Feasibility Studies) in EPA Regions V through X. The Feasibility Study presented herein has been performed under this contract.

PURPOSE OF THE FS REPORT

This FS report is based on the information and data presented in the RI report for the ECC site submitted to EPA in July, 1985. This report presents and discusses the methodology used for identifying and evaluating remedial technologies and alternatives. The alternatives developed for ECC will be combined with NSL alternatives and evaluated in the ECC-NSL Combined Alternatives Analysis Report. EPA is the lead agency for both sites and will select, after public comment and concurrence from ISBH, the cost-effective remedial alternative.

Figure 2-1 presents a flow chart of the FS process for the ECC site. This process is a step-by-step evaluation of remedial technologies, process options, and remedial action alternatives for site cleanup. Specific criteria are used to evaluate remedial technologies and to determine the magnitude and importance of any effect resulting from the implementation of a remedial alternative.

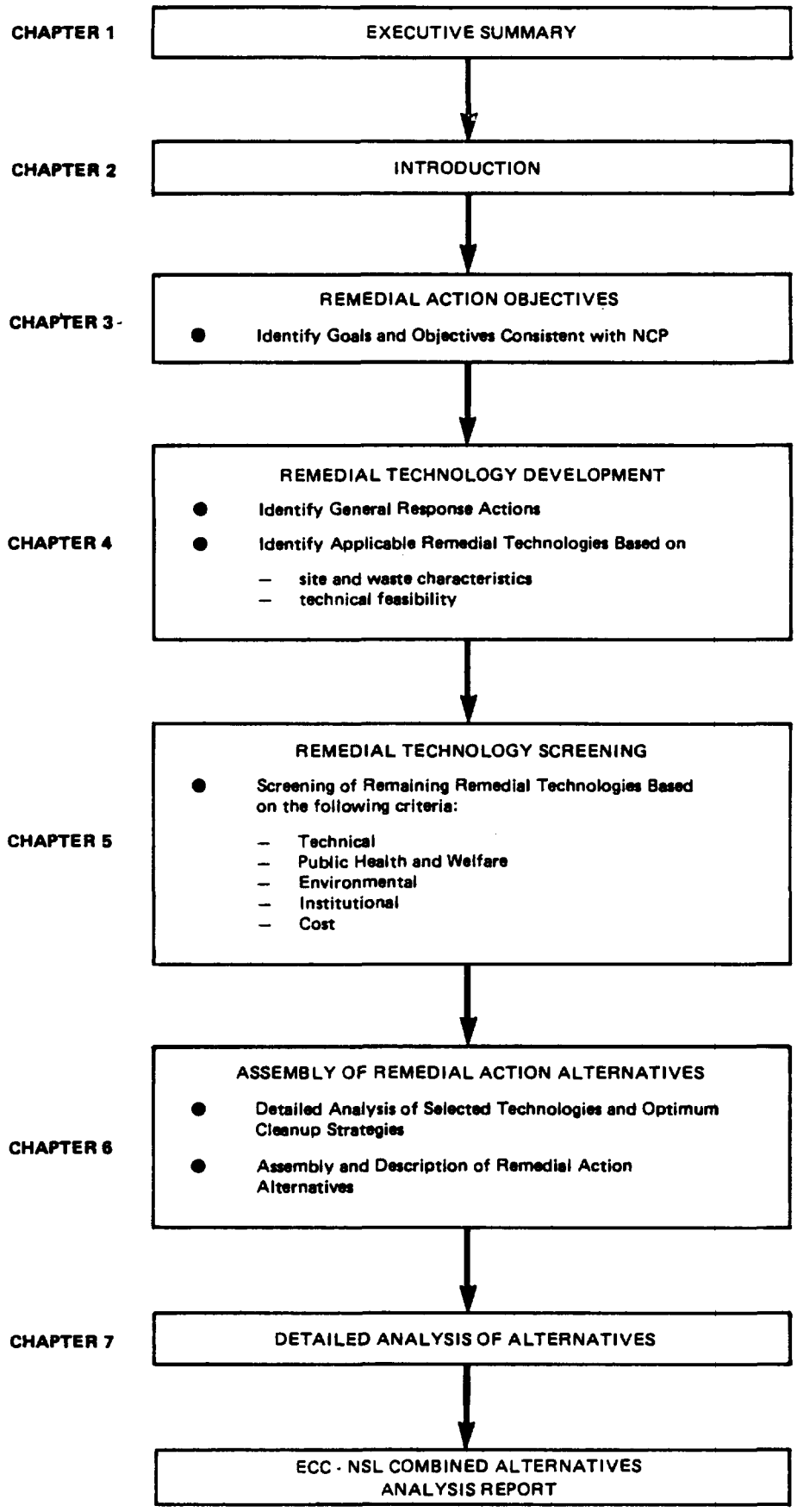


FIGURE 2-1
FLOW DIAGRAM FOR ECC FS
ECC FS

BACKGROUND

The ECC site occupies 6.5 acres alongside the 168 acre Northside Sanitary Landfill (NSL), an ongoing solid waste disposal facility (Figure 2-2). The site is bounded on the east by the landfill. An unnamed ditch separates the two facilities along the east boundary. The site is bounded on the north and west sides by several residential homes, located within one-half mile of the facility.

ECC began operations in 1977 and was engaged in the recovery/reclamation/brokering of primary solvents, oils and other wastes received from industrial clients. Waste products were received in drums and bulk tankers and prepared for subsequent reclamation or disposal. Reclamation processes included distillation, evaporation and fractionation to reclaim solvents and oil.

Accumulation of contaminated stormwater onsite, poor management of the drum inventory and several spill incidents caused initial state and EPA investigations that later led to civil suits and finally placement of ECC into receivership in July 1981. Drum shipments to the site were halted in February 1982. The company was found insolvent in August 1982 and the state and EPA began plans for cleanup. Numerous site investigations, including sampling and analysis were conducted during the period.

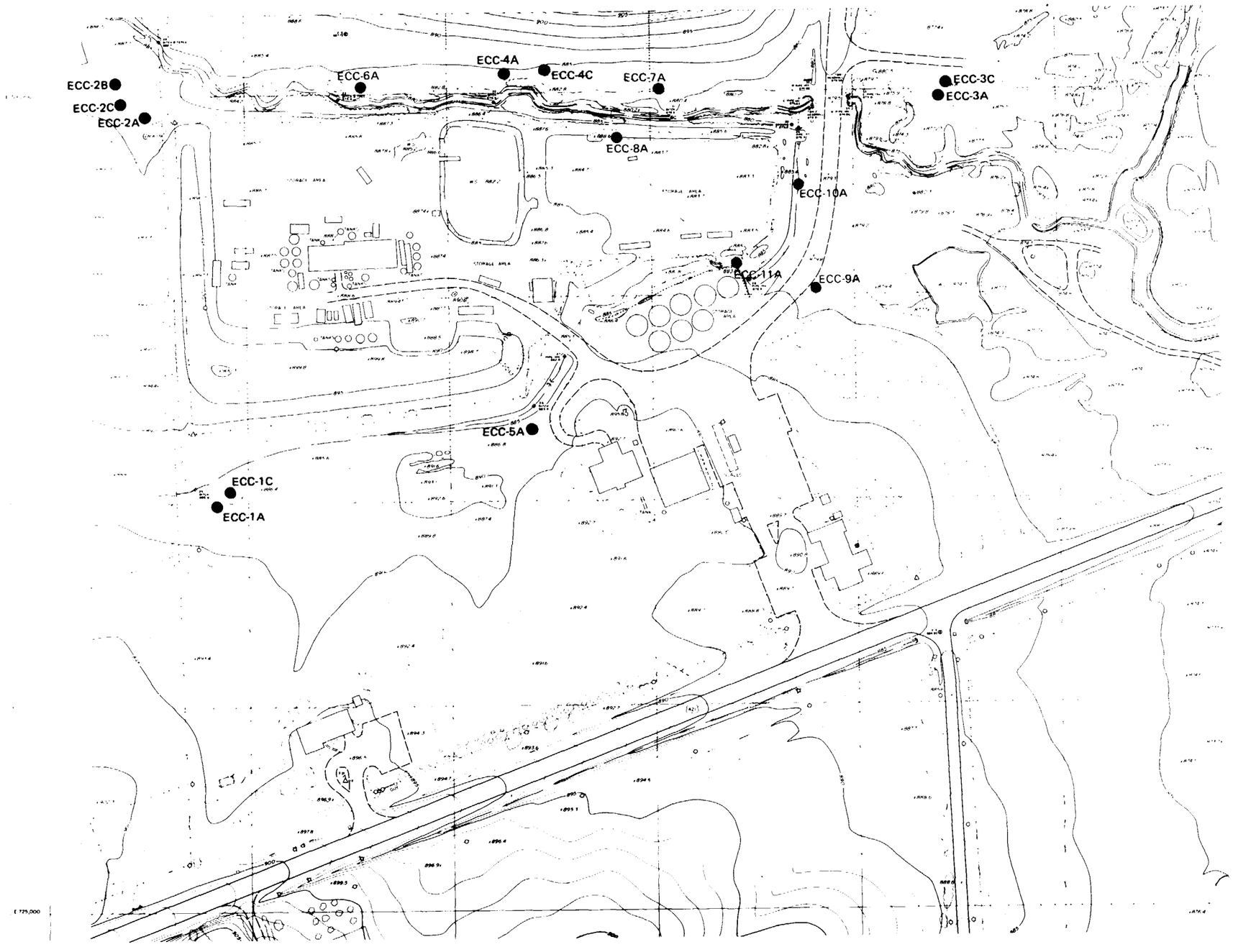
Removal measures at the site began in March 1983 and continued through 1984. Actions included removal and treatment or disposal of cooling pond waters, approximately 30,000 drums of waste, 220,000 gallons of hazardous waste from tanks and 5,650 cubic yards of contaminated soil and cooling pond sludge. Some contaminated sludge remains in the backfilled cooling pond. A silty clay cap, placed over the site, was compacted in July 1985.

REMEDIAL INVESTIGATIONS

SCOPE

Remedial investigations began in 1983 and continued until December 1984. Soil, hydrogeologic, and surface water and sediment investigations were conducted.

Two phases of soil sampling were conducted. Phase 1 consisted of 15 surficial soil samples and 15 shallow (2.5 foot depth) borings and was conducted before removal of 2 feet of contaminated surface soil from most of the site. Phase 2, conducted after soil removal, consisted of 9 soil borings (up to 12 feet in depth) through the concrete pad on the south 1/3 of the site and 12 test pits to depths up to 10 feet in the remaining areas.



LEGEND

ECC-7A ● REMEDIAL INVESTIGATION MONITORING WELL

NOTE: Map represents topography and onsite features prior to surface cleanup.

All well locations are approximate.

N

0 100 200
50 150
SCALE IN FEET

FIGURE 2-2
SITE MAP
ECC FS

Hydrogeologic investigations included an electrical resistivity survey, test drilling, monitoring well installation, monitoring well sampling and residential well sampling. A total of 16 2-inch diameter PVC monitoring wells were installed in 3 phases. Wells were placed to monitor the shallow saturated zone, the shallow sand and gravel deposit and the deep confined aquifer. Groundwater sampling was also performed in 3 phases. In addition, 5 residential wells were sampled.

Surface water investigations included three onsite and four offsite surface water samples and 6 offsite sediment samples.

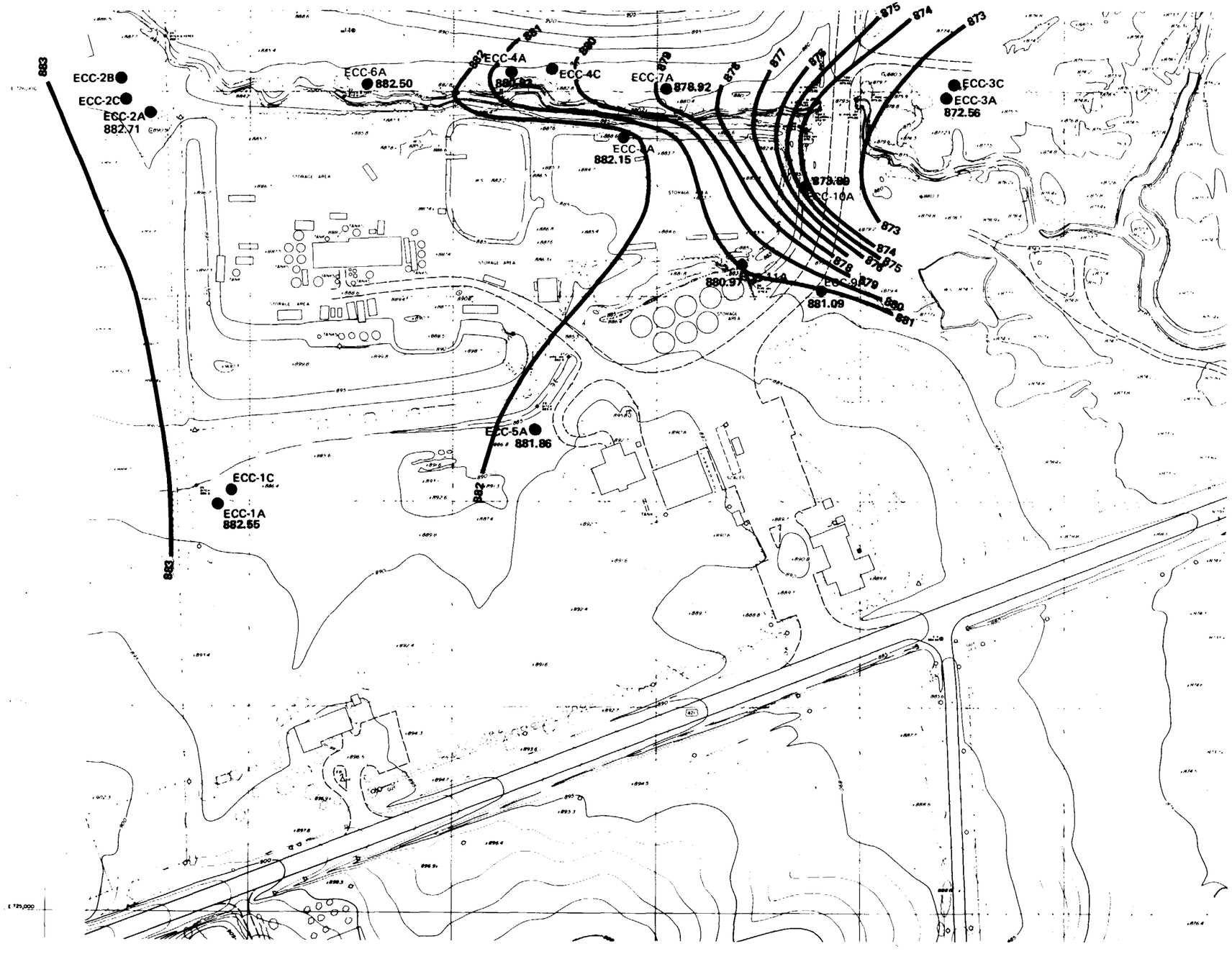
RESULTS

Onsite soil sample inorganic analysis results showed only antimony, cadmium, cobalt, copper, lead, manganese, and zinc were present at concentrations exceeding their typical range in soil. Of these, cadmium, lead, and zinc were reported in more than one sample at concentrations exceeding their typical range in soils. Exceedance of typical ranges in soil samples of inorganic constituents beneath the concrete pad is considered minor relative to the soil contamination in the northern drum and tank storage areas. Inorganic contamination of the soil is apparently greatest in the near surface (0-3 feet) soil in northern portions of the site. Inorganic contamination does appear to extend to depths of at least 5 feet in the northern portions of the site, although it is less widespread with depth than observed in the overlying near-surface soil.

Primary organic contaminants found in site soils are volatile organic compounds and phthalates. These compound groups are the most widespread organic contaminants and are generally present in the highest concentrations. Total VOC's ranged from 16 to 14,600,000 ug/kg. Total phthalates ranged from "not detected" to 370,000 ug/kg. Organic contamination decreases in the variety of compounds and their associated concentrations with depth. However, organic contaminants were detected to the maximum depth of sample analysis (8.5 feet).

Results of the hydrogeologic investigation indicate that the site is underlain by glacial till. Within the till at a depth of 12 to 20 feet below the ground surface is a deposit of sand and gravel which constitutes a discrete water bearing unit. This deposit is part of a lens of sand and gravel which extends beneath the ECC site and the southwest portion of the NSL site. The deposit is underlain by till, which in turn is underlain by a deep confined sand and gravel aquifer.

Elevation contours of the piezometric surface of the sand and gravel lens beneath the site are shown in Figure 2-3.



LEGEND

● ECC-7A REMEDIAL INVESTIGATION MONITORING WELL

882 CONTOURS FOR DECEMBER 1984 DATA

NOTE: Map represents topography and onsite features prior to surface cleanup.

All well locations are approximate.

N

0 100 200
50 150
SCALE IN FEET

FIGURE 2-3
GROUNDWATER CONTOUR OF DECEMBER 1984
ECC FS

Groundwater below the site generally appears to travel south and discharge into Finley Creek or the unnamed ditch near its confluence with Finley Creek. Along the eastern edge of the southern half of the site, groundwater appears to flow in an eastern direction and discharge into the unnamed ditch.

Groundwater within the sand and gravel deposit is locally confined and hydrologic gradients from the deposit to the overlying till are vertically upward. Horizontal hydraulic gradients in the till vary between approximately 0.01 ft/ft and 0.06 ft/ft. The actual gradients directly beneath the site are uncertain.

Water level data in the deep, confined aquifer indicate that flow is generally north to south. The maximum observed gradient in the deep confined aquifer was found to be 0.005 between wells ECC-3C and ECC-4C. Vertical gradients are upward since the potentiometric surface of the zone is above ground surface.

Migration of soil contaminants to the shallow saturated till zone has occurred onsite as evidenced by high levels of organic contaminants in one well onsite completed in the till. The sand and gravel deposit has been shown to be contaminated with inorganics and organics in one well downgradient to the south of ECC and near the southwest corner of NSL and lesser amounts of organics in one well onsite and another immediately adjacent and downgradient of the site. Because of the presence of the NSL site east of ECC, it cannot be definitively stated that the source of offsite contamination near the southwest corner of NSL is ECC , though the offsite contaminants are consistent with those found onsite at ECC. Organic contamination in the other two wells is likely due to onsite soils at ECC since they are directly downgradient of ECC contaminated soils.

Contamination of the shallow sand and gravel deposit may have occurred either via migration through the silty clay till onsite or through contaminated water and sediment in the former cooling water pond. The cooling pond had intersected the sand and gravel deposit before removal of contaminated water and sludge and backfilling with clean soil during removal actions.

The deep confined aquifer below the site has not been found to be contaminated. Future migration of onsite contaminants to the deep aquifer is highly unlikely because of an upward vertical hydraulic gradient from the aquifer.

GLT655/23

Migration of contaminants to the nearest residential wells surrounding the site is not indicated by the results of the residential well sampling.

Surface water sampling results from the ECC and NSL Remedial Investigations indicate that cyanide at levels below 30 ug/l is the only inorganic contaminant found in the surface water of the unnamed ditch and Finley Creek. The source of the cyanide may be either NSL or both ECC and NSL since cyanide was also found upstream of ECC. Inorganic sediment contamination is limited to chromium and lead in the unnamed ditch and Finley Creek. Since these contaminants were found upstream as well as downstream of ECC, the source may be NSL. It is possible that downstream of ECC, these sediment contaminants could also have originated from ECC.

Organic contamination of offsite surface water was found in Finley Creek near Highway 421. Contaminants consist almost entirely of chlorinated hydrocarbons and may be from ECC. A sample in Finley Creek upstream of the ECC drainage area but downstream of NSL did not show organic contamination. Also, surface water ponded on the ECC silty-Clay cap onsite was found to be contaminated with a variety of semivolatiles and VOC's. Sediment from Finley Creek near Highway 421 contained two VOC's and several semivolatiles at levels up to 300 ug/kg. Sediment samples upstream of ECC yet downstream of NSL did not show similar organic contamination. These data imply the source of the organic sediment contamination is ECC although sampling was not extensive enough to be certain.

CONTAMINANT TRANSPORT AND FATE

Analytical results of the remedial investigations characterize current site contamination. Future conditions assuming no action is taken at the site were estimated based on potential transport pathways and the natural attenuation and degradation of contaminants. Potential pathways for contaminant migration are summarized in Figure 2-4. Because of the large numbers of site contaminants, 14 indicator chemicals from four major contaminant groups were used in the estimation of transport and fate (Table 2-1). Transport and fate are briefly summarized here for VOC's, phenols, phthalates, and polychlorinated biphenyl's (PCB's). Transport of inorganic constituents from the soil is considered negligible due to the low levels found and the adsorptive capacity of the onsite soils.

Transport and fate of the indicator chemicals are based on a literature review and site characteristics. Due to the relatively limited literature available and the many estimates and assumptions necessary, the transport and fate calculated

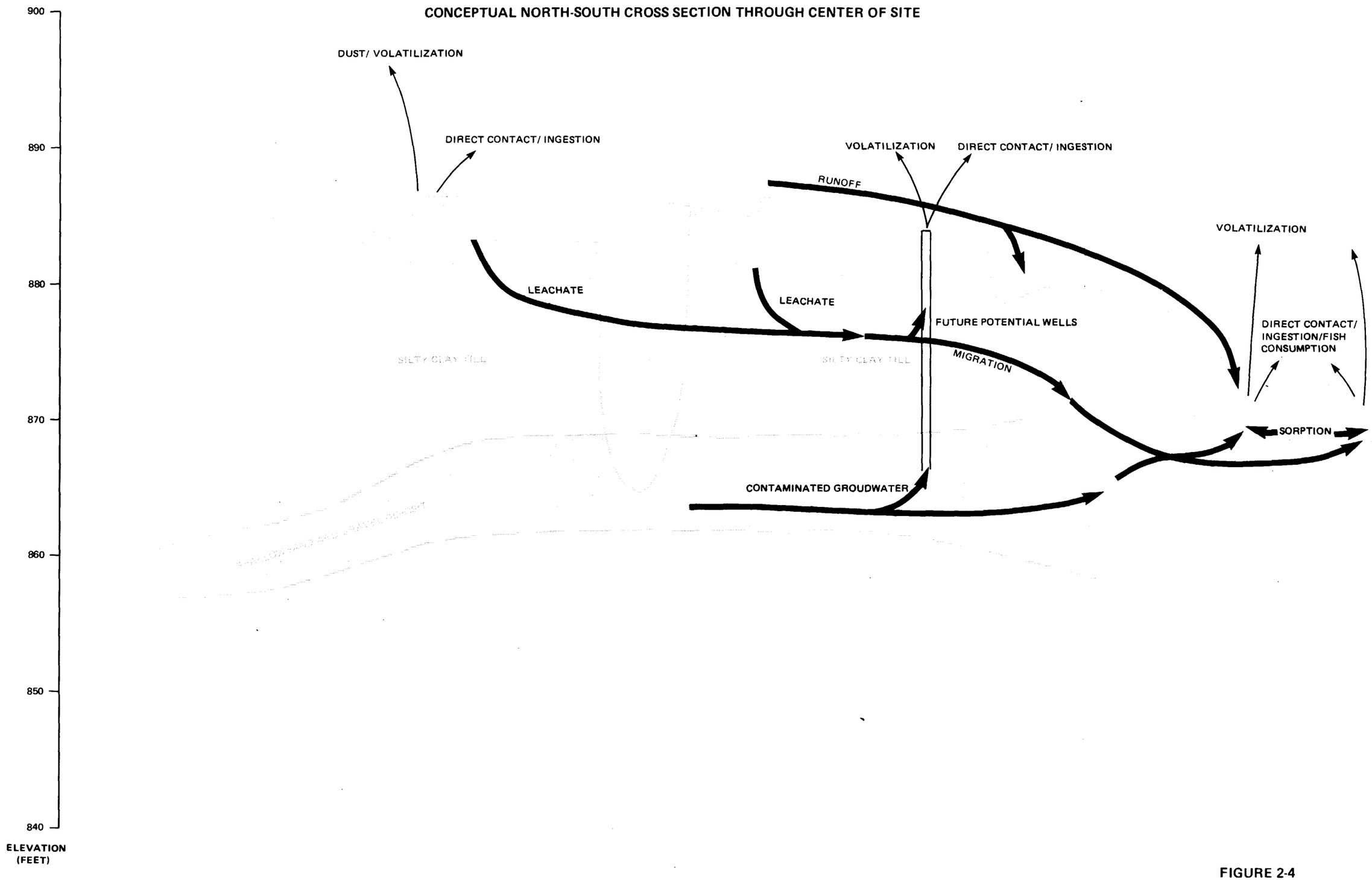


FIGURE 2-4
POTENTIAL PATHWAYS FOR CONTAMINANTS MIGRATION
ECC FS

Table 2-1
INDICATOR CHEMICALS AT ECC

Chloroform

Methylene Chloride

1,1,2-Trichloroethane (1,1,2 TCA)

1,1,1-Trichloroethane (1,1,1 TCA)

Trichloroethene (TCE)

Tetrachloroethene (PCE)

Ethylbenzene

Toluene

Phenol

PCB's

Bis(2-ethylhexyl)phthalate

Di-n-butyl phthalate

Diethyl phthalate

Dimethyl phthalate

GLT533/42

here are gross best estimates only. Actual transport and fate may vary by orders of magnitude.

Degradation of volatiles in soil is highly variable. If leaching is prevented, most of the indicator volatiles will degrade to 10^{-6} cancer risk levels relatively rapidly (possibly within 10 years). Several of the indicator volatiles will take much longer to degrade to 10^{-6} cancer risk levels. Degradation products, however, may pose new risks. Phenols and phathalates in the subsurface soil are already below 10^{-6} cancer risk levels. PCB's will tend to persist in the soil at the site.

Under existing site conditions, the volatiles, phenols, and certain phthalates will tend to leach from subsurface soil into the groundwater and slowly migrate to the unnamed ditch or Finley Creek (PCB's and most phthalates will only leach in trace amounts). Estimates for travel time vary from 10 years to over 1,000 years depending upon the compound, hydraulic conductivity, and travel distance. Once in the surface waters, contaminants will either volatilize, adsorb to sediments, degrade or experience dilutions on the order of 20 to 1 before reaching the Eagle Creek Reservoir, about 9 miles downstream.

ENDANGERMENT ASSESSMENT

The endangerment assessment found that under the no action alternative potential risks to human health and the environment exist at the ECC site. The affected media are soil, groundwater and surface water. They were assessed based on comparison of concentrations at potential exposure points to lifetime excess cancer risks, acceptable daily intake values, and relevant or applicable standards, criteria or guidelines. For the public health concerns, residential and occupational use settings were used in assessing risk. An excess lifetime cancer risk of 1×10^{-6} is often used to reflect a level of concern for carcinogen risk. The risk analysis performed for the endangerment assessment is conservative and tends to reflect upper bound exposures. However, given the uncertainty in both risk estimation and fate and transport calculations, the actual risks may be lower or higher than estimated.

For public health concerns, the exposure routes that resulted in an excess lifetime cancer risk greater than 1×10^{-6} are listed below:

- Soil via ingestion: the south concrete pad soil in a residential setting; and north test pit area in residential and occupational use settings. Excess lifetime cancer risks range from 4×10^{-3} to 8×10^{-6}.

- Groundwater via ingestion: the shallow saturated zone and shallow sand and gravel deposit at current concentrations in both use settings; the shallow saturated zone at future projected concentrations in both use settings. Excess lifetime cancer risks range from 4×10^{-1} to 7×10^{-5}.

- Groundwater via dermal absorption of VOC's: during bathing, the shallow saturated zone and shallow sand and gravel deposit at current conditions in the residential setting; the shallow saturated zone at future projected concentrations in the residential setting. Excess lifetime cancer risks range from 4×10^{-1} to 7×10^{-7}.

- Ingestion of fish potentially bioconcentrating contaminants from the surface water: Finley Creek under the lowest dilution situation at projected concentrations. Excess lifetime cancer risks range from 1×10^{-6} to 3×10^{-6}.

Risk from dermal absorption of VOC's via wading in the surface water does not exceed 1×10^{-6}. However, wading in the unnamed ditch and in Finley Creek under the lowest dilution situation has excess lifetime cancer risks between 1×10^{-6} and 1×10^{-7}.

For environmental concerns, the projected release of contaminants to the surface water in the unnamed ditch should not exceed the ambient water quality criteria for protection of aquatic life and other known LC_{50} values.

The current impact of the site is limited due to the low population at risk. Site location and environmental media characteristics (for example, low groundwater flow velocity) limit the population at risk if there is future development of the site and the surrounding area under the no action alternative.

GLT533/40

Chapter 3
REMEDIAL ACTION OBJECTIVES

The NCP states the general goal and objectives of remedial actions where it defines the appropriate extent of remedies in 40 CFR300.68(i) as a cost-effective remedial alternative that effectively mitigates and minimizes threats to and provides adequate protection of public health and welfare and the environment."

The nature and extent of site hazards summarized in the previous section form the basis for identifying more specific objectives for the soil and groundwater operable units. The objectives for the ECC site are listed below for the two operable units and each has been given a title for ease of reference later in the report.

SOIL

- MINIMIZE DIRECT CONTACT - Minimize risk to public health from direct contact with soil or risks associated with dust generation or volatilization of contaminants.

- CONTROL MIGRATION TO GROUNDWATER - Minimize leaching of contaminants from soil to groundwater to adequately protect public health.

- CONTROL MIGRATION TO SURFACE WATER - Minimize overland migration of contaminants from soil to the unnamed ditch, Finley Creek or Eagle Creek to adequately protect public health and the environment.

GROUNDWATER

- MINIMIZE CONSUMPTION OF CONTAMINANTS - Minimize risk to public health from future direct consumption of contaminated groundwater.

- CONTROL MIGRATION TO SURFACE WATER - Manage migration of contaminated groundwater to the unnamed ditch, Finley Creek or Eagle Creek so public health and the environment are adequately protected from surface water and sediment contamination and ingestion of contaminated aquatic life.

Each remedial objective is stated in terms of actions, including no action, that can be accomplished and not in terms of absolute removal, or restoration to pristine conditions. Instead, the objectives reflect the NCP objectives to "mitigate and minimize threats" and "provide(s) adequate protection." To assist in quantifying the various risks to the

public health Tables 3-1 and 3-2 present concentrations of contaminants in the various environmental media at which certain standards, criteria, or risks are met. These concentrations, representing various levels of risk at the ECC site, were derived using the same methodology as that used in the endangerment assessment of the ECC RI report.

AQUIFER CLASSIFICATION

EPA has provided additional guidance on meeting the NCP objectives for the groundwater operable unit. Groundwater cleanup objectives are defined in EPA's Groundwater Protection Strategy (1984) for each of three aquifer classifications.

The three aquifer classifications are as follows:

- o Class I Special groundwaters are those that are highly vulnerable to contamination because of the hydrological characteristics of the areas under which they occur and that are characterized by either of the following two factors:
  - Irreplaceable, in that no reasonable alternative source of drinking water is available to substantial populations
  - Ecologically vital, in that the aquifer provides the base flow for a particularly sensitive ecological system that, if polluted, would destroy a unique habitat
- o Class II These are all other groundwaters that are current or potential sources of drinking water and waters having other beneficial uses.
- o Class III Groundwaters not considered potential sources of drinking water and of limited beneficial use, are groundwaters that are heavily saline, (with total dissolved solids (TDS) levels over 10,000 mg/L) or are otherwise contaminated beyond levels that allow cleanup using methods reasonably employed in public water system treatment. These groundwaters also must not migrate to Class I or II groundwaters or have a discharge to surface water that could cause adverse effects on human health or the environment.

The contaminated shallow saturated zone and shallow sand and gravel deposit underlying the ECC site do not meet the first criterion for a Class I aquifer because a large source of drinking water is readily (and cost-effectively) available from the uncontaminated deep confined aquifer. It does not

Table 3-1 (1 of 2)
SOIL CONTAMINANT LEVELS AT WHICH CRITERIA OR RISKS COULD BE MET

Chemical	Soil Concentrations in mg/kg Based on Acceptable Daily Intakes (ADI's) at Soil Ingestion Rates of			Soil Concentrations in mg/kg Based on Potency Derived Cancer Risks[1,2]		
	10 grams/day	1 gram/day	0.1 gram/day	10^{-4} Risk Level	10^{-6} Risk Level	10^{-8} Risk Level
Organics						
Volatiles						
1,1,1-trichloroethane	3,800	38,000	380,000			
1,1,2-trichloroethane				134	1.34	0.013
Chloroform				110	1.1	0.011
Ethylbenzene	950	9,500	95,000			
Methylene chloride				12,200	122	1.2
Tetrachloroethene				220	2.2	0.022
Toluene	3,000	30,000	300,000			
Trichloroethene				400	4.0	0.04
Chlorobenzene	100	1,000	10,000			
Acids						
Phenol	700	7,000	70,000			
Base/Neutrals						
Isophorone	1,100	11,000	110,000			
Bis(2-ethyl hexyl)phthalate	4,200	42,000	420,000			
Di-n-butyl phthalate	8,800	88,000	880,000			
Diethyl phthalate	88,000	880,000	8,800,000			
Dimethyl phthalate	70,000	700,000	7,000,000			
Total PCB's				1.7	0.018	0.00018

Table 3-1 (2 of 2)

Chemical	Soil Concentrations in mg/kg Based on Acceptable Daily Intakes (ADI's) at Soil Ingestion Rates of			Soil Concentrations in mg/kg Based on Potency Derived Cancer Risks[1,2]		
	10 grams/day	1 gram/day	0.1 gram/day	10^{-4} Risk Level	10^{-6} Risk Level	10^{-8} Risk Level
Inorganic						
Antimony	29	290	2,900			
Arsenic				0.5	0.005	0.00005(H)
Beryllium				2.9	0.029	0.00029
Cadmium	17	170	1,700			
Chromium+6	17.5	175	1,750			
Chromium+3	12,500	125,000	1,250,000			
Cyanide	760	7,600	76,000			
Lead	10	100	1,000			
Mercury	2	20	200			
Nickel	150	1,500	15,000			
Silver	10	100	1,000			

[1] U.S. EPA Cancer Assessment Group. Health Assessment Document for Epicthorhydrin EPA 500/8-83-032f December 1984 Final Report

[2] Based on a lifetime soil ingestion rate of 0.013 grams of soil per kilogram of body weight a day

(I) based on animal inhalation studies. (W) based on human occupational exposure 8 hours per day 5 days per week.

(H) based on human drinking water exposure.

GLT533/19

Table 3-2 (1 of 2)
SURFACE WATER AND GROUNDWATER CONTAMINANT LEVELS AT WHICH STANDARDS, CRITERIA, AND RISKS FOR INGESTION COULD BE MET

Chemicals	Safe Drinking Water Act or Maximum Contaminant Limit (MCL) ug/L[1]	Clean Water Act Water Quality Criteria for Human Health for Drinking Water Only (10^{-6} carcinogenic risk level) ug/L	Acceptable Daily Intake (ADI) in ug/day at 2 liters/day ug/L	Recommended Maximum Contaminant Limit (RMCL) ug/L	Potency Based[2] Excess Lifetime Cancer Risk of 10^{-4} at concentration in ug/L and consumption of 0.035 liters per kilogram of body weight a day	10^{-6}	10^{-8}	Safe Drinking Water Act Health Advisories - Chronic (ug/L)
Organics								
Volatiles								
1,1,1-Trichloroethane	200[4]	(19,000)	19,000	200				1,070
1,1,2-Trichloroethane		(0.6)			50	0.5	0.005	
1,1-Dichloroethane								
Chloroform	100[3]	(0.19)			41	0.41	0.0041	
Trans-1,2-Dichloroethene								
Ethylbenzene		2,400	4,750					
Methylene Chloride		(0.19)			4,500	45	0.45	150
Tetrachloroethene	10[4]	(0.88)		0	82	0.82	0.0082	20
Toluene		15,000	15,000					340
Trichloroethene		(2.8)	850	0	150	1.5	0.015	75
Xylenes, total								620
Vinyl Chloride	1[4]	(2.0)		0	160	1.6	0.016	
Acids								
Phenol		3,500	3,500					
2,4-dimethylphenol		400 (organoleptic)						
Base/Neutral								
Bis(2-ethyl hexyl) phthalate		21,000	21,000					
Di-n-butyl phthalate		44,000	44,000					
Di-n-octyl phthalate								

Table 3-2 (2 of 2)

Chemicals	Safe Drinking Water Act or Maximum Contaminant Limit (MCL) ug/L[1]	Clean Water Act Water Quality Criteria for Human Health for Drinking Water Only (10^{-6} carcinogenic risk level) ug/L	Acceptable Daily Intake (ADI) in ug/day at 2 liters/day ug/L	Recommended Maximum Contaminant Limit (RMCL) ug/L	Potency Based[2] Excess Lifetime Cancer Risk of 10^{-4} at concentration in ug/L and consumption of 0.035 liters per kilogram of body weight a day	10^{-6}	10^{-8}	Safe Drinking Water Act Health Advisories - Chronic (mg/L)
Inorganics								
Antimony		14.6	145					
Arsenic	50	(0.0025)			0.19	0.0019	0.000019 (H)	
Chromium +6	50	50	88					
Chromium +3		179,000	625,000					
Copper		1,000 (organoleptic)						
Iron	300							
Lead	50	50	50					
Manganese	50							
Nickel		15.4	750					
Selenium	10							
Silver	50	50	50					
Thallium		17.8	18					
Zinc		5,000 (organoleptic)						

[1] U.S. EPA National Primary Drinking Water Regulations for Volatile Synthetic Organic CHemicals. Proposed Rules June 12, 1984.
[2] U.S. EPA Cancer Assessment Group. Health Assessment Document for Epichlorhydrin EPA 600/8-83-032F, December 1984 Final Report.
[3] This value refers to total sum of trihalomethanes.
(H)-Based on human drinking water exposure.
[4] Proposed MCL.

GLT533/18

meet the second criterion for a Class I aquifer since no unique habitats are in danger of being destroyed.

The aquifer also does not meet the requirements for Class III since it is not heavily saline and could be cleaned using proven technology.

As a result, the aquifer is a Class II aquifer. EPA's clean-up objectives for Class II aquifers under CERCLA and RCRA are to develop remedial actions that protect human health and the environment. Remedial actions for Class II aquifers may include removing the contaminated water or isolating the contamination through physical or institutional means.

GLT533/17

Chapter 4
REMEDIAL TECHNOLOGY DEVELOPMENT

In this chapter remedial technologies are identified that address the remedial action objectives for each of the operable units and the specific site and waste characteristics of the ECC site. The specific methodology includes the following steps:

- Identification of general response actions for each operable unit and each objective
- Identification of applicable remedial technologies for each operable unit based on site and waste characteristics and technical criteria

GENERAL RESPONSE ACTIONS

General response actions were identified for each of the operable units (Table 4-1). Each action is intended to specifically address the contaminants and their migration pathways within each operable unit. Though each action is capable of meeting the objective alone, combinations of actions may later prove to be more cost effective in meeting all the objectives of the operable units.

APPLICABLE REMEDIAL TECHNOLOGIES

For each general response action within the operable units, remedial technologies were listed that may be applicable to the site. Figures 4-1 and 4-2 present technologies for the soil and groundwater operable units, respectively. Process options for remedial technologies are also listed where potentially applicable to the site. Combinations of technologies may be necessary to complete a general response action.

The applicability of each technology and process option to the site and waste characteristics and the technical feasibility of meeting the remedial action objectives were evaluated. Site and waste characteristics of importance are given in Table 4-2. Technical feasibility includes general assessment of reliability in the categories of effectiveness, durability, and whether or not the technology is proven.

Summaries of the evaluation of applicability for each remedial technology and associated process options are presented in Figure 4-3 for the soil operable unit and in Figure 4-4 for the groundwater operable unit. Each figure includes a description of the technology or process option followed by comments for any technology or option considered not applicable. Figures 4-5 and 4-6 present remaining technologies and options.

GLT533/20

Table 4-1
IDENTIFICATION OF GENERAL
RESPONSE ACTIONS

Operable Unit	Remedial Action Objective	General Response Action
Soil	Direct Contact	No Action Access Restrictions Containment Removal/Disposal Soil Treatment/Disposal In Situ Soil Treatment
	Migration to Groundwater	No Action Containment Removal/Disposal Soil Treatment/Disposal In Situ Soil Treatment
	Migration to Surface Water	No Action Access Restrictions Containment Removal/Disposal Soil Treatment/Disposal In Situ Soil Treatment Surface Water Runoff Collection/Treatment/ Discharge
Groundwater	Consumption	No Action Access Restrictions Containment Collection/Treatment/ Discharge Collection without Treatment/Discharge Groundwater In Situ Treatment
	Migration to Surface Water	No Action Access Restrictions Containment Collection with Treatment Groundwater In Situ Treatment Surface Water In Situ Treatment

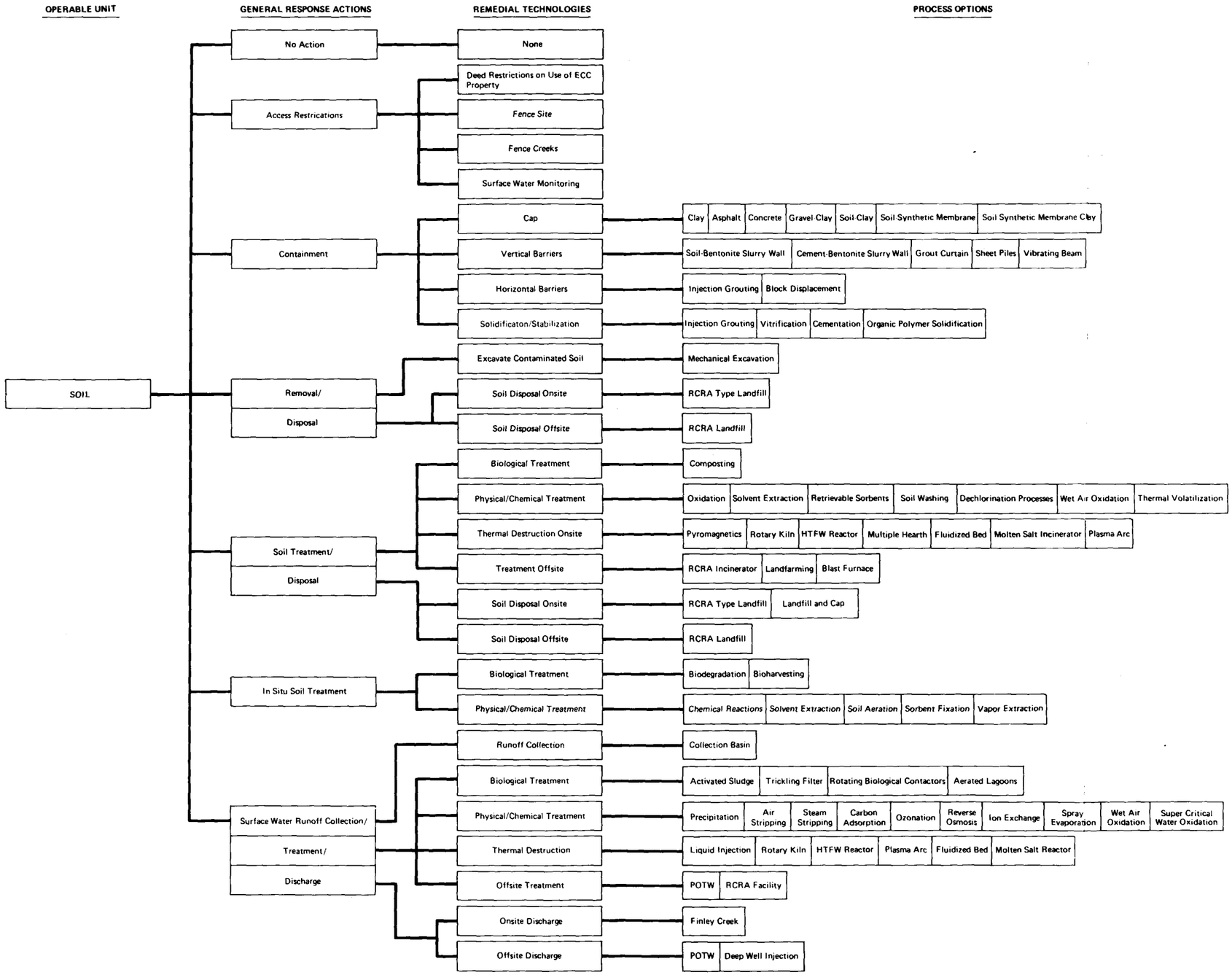


FIGURE 4-1
SOIL OPERABLE UNIT
REMEDIAL TECHNOLOGIES
AND PROCESS OPTIONS
ECC FS

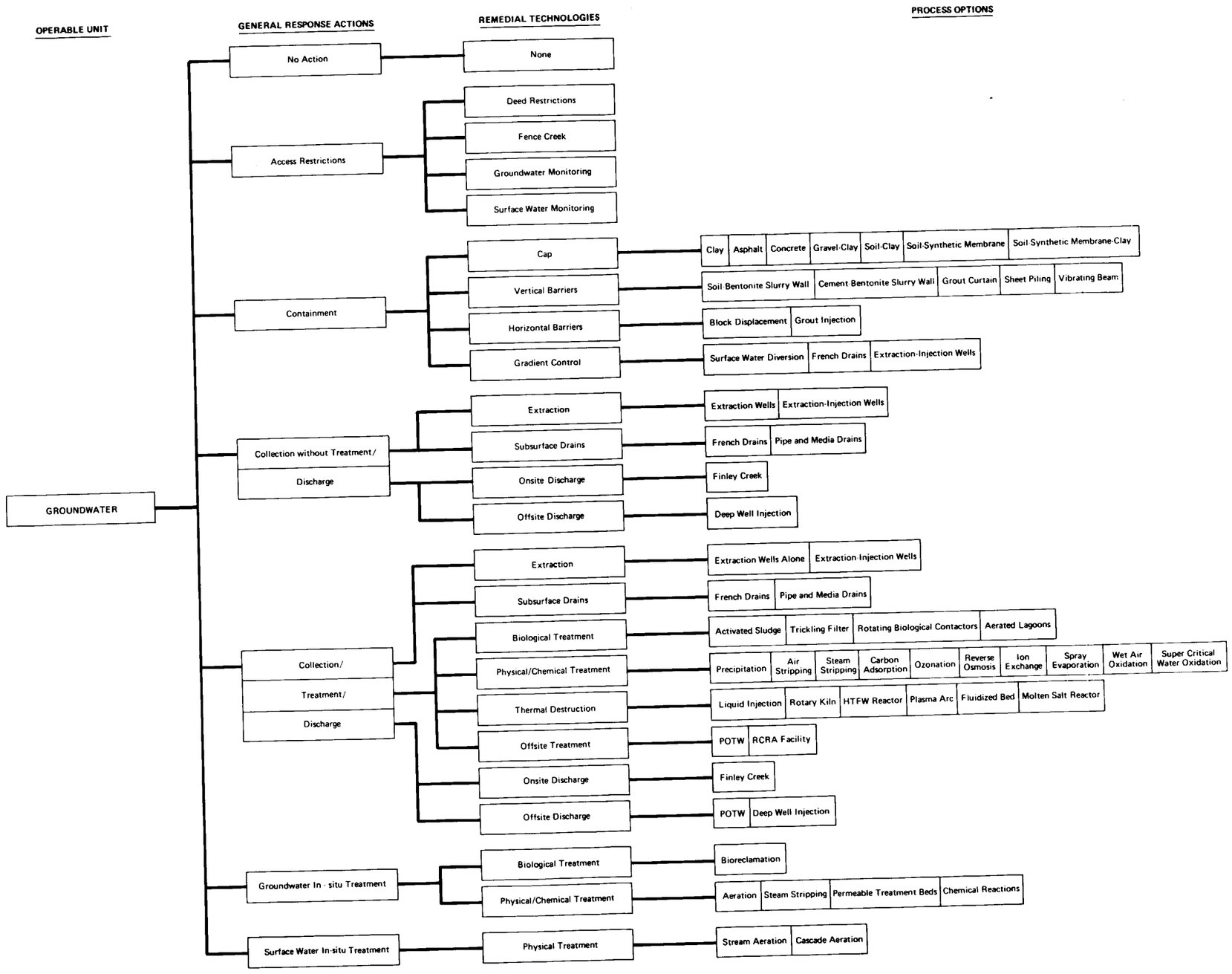


FIGURE 4-2
GROUNDWATER OPERABLE UNIT REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
ECC FS

Table 4-2
SITE AND WASTE CHARACTERISTICS

Waste Characteristics

Quantity
Chemical Composition
Concentrations
Acute Toxicity
Long-Term Toxicity
Persistence
Biodegradability
Ignitability
Reactivity - Cyanide, H_2S
Ease of Transport
Solubility
Volatility
Compatibility with other Chemicals
Treatability
Carcinogenicity
Physical State
Corrosivity

Site Physical Characteristics

Site Volume
Site Area
Climate
Soil Properties
Drainage
Slope
Vegetation (or lack of)
Depth to Aquifer
Degree of Contamination
Direction and Flow of Groundwater
Receptors
Offsite Water Wells and Location
Surface Waters

GLT533/24

SOIL GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	COMMENTS
NO ACTION	None		No action	NCP requires No Action to be carried through to detailed analysis of alternatives.
ACCESS RESTRICTIONS	Deed Restrictions		All deeds for property within potentially contaminated areas would include restrictions on use of property.	Potentially viable
	Fence Site		Present site fence would be maintained and upgraded where necessary.	Potentially viable
	Fence Creek		Unnamed ditch downstream to Finley Creek and Finley Creek to Hwy 421 fenced to prevent fishing or wading in stream reaches.	Potentially viable
	Surface Water Monitoring		Long-term monitoring of organic contamination in SW and bioaccumulation in fish.	Potentially viable
CONTAINMENT	Cap	Clay	Compacted clay over site (excepting concrete pad area).	Ineffective due to lack of erosion and moisture control.
		Asphalt	Spray application of a layer of asphalt over site (excepting concrete pad area).	Potentially viable
		Concrete	Installation of a concrete slab over site (excepting concrete pad area).	Potentially viable
		Gravel-Clay	Compacted clay covered with gravel to provide erosion and moisture control.	Potentially viable
		Soil-Clay	Compacted Clay covered with soil to provide erosion and moisture control.	Potentially viable
		Soil-Synthetic Membrane	Impermeable synthetic membrane covered with soil to provide protection of the liner.	Potentially viable
		Soil-Synthetic Membrane-Clay	Compacted clay covered with a synthetic membrane followed by 1 foot of gravel and sand, and 2 feet of top soil to provide erosion and moisture control.	Potentially viable
	Vertical Barriers	Soil-Bentonite Slurry Wall	Trench around site is excavated while filled with a bentonite water slurry. Trench is backfilled with a soil-bentonite mix	Potentially viable
		Cement-Bentonite Slurry Wall	Trench around site is excavated while filled with a bentonite water slurry. Trench is backfilled with a cement-bentonite mix.	Potentially viable
		Grout Curtain	Pressure injection of grout along site boundaries in a regular pattern of drilled holes.	Not appropriate to poorly permeable (fine textured) soils and difficult to determine integrity of barrier.
		Sheet Piles	Steel sheet piling installed along site boundaries. Interlocking piles are placed with pile driver or drop hammer.	Interlocks difficult to seal and cause leakage. Corrosion of sheet piles is also a problem.
		Vibrating Beam	Vibratory force used to advance steel beam into ground and injection of relatively thin wall of asphalt, cement or bentonite as beam is withdrawn.	Potentially viable
	Horizontal Barriers	Block Displacement	Used in conjunction with vertical barriers. Controlled injection of slurry in notched injection holes to produce horizontal barrier beneath site.	Not appropriate to fine textured soils and difficult to determine integrity of barrier.
		Grout Injection	Pressure injection of grout at depth through closely spaced drilled holes.	Not appropriate to fine textured soils and difficult to determine integrity of barrier.
	Solidification/Stabilization	Injection Grouting	Stabilization of contaminated soil by injecting grout into the ground through well points.	Not appropriate to fine textured soils and difficult to determine integrity of barrier.
		Vitrification	Contaminated soil is fused into a glassy stable matrix by heating it in place with an electric current.	Laboratory stage of development and not appropriate to large volume of contaminated soils onsite.
		Organic Polymer Solidification	Contaminated soils excavated, mixed with an organic polymer and replaced onsite.	Long-term effectiveness of the organic polymer is questionable. Undemonstrated for waste types in soil.
		Cementation	Contaminated soils excavated, mixed with cement or lime, water, and silicious material for solidification and replaced onsite.	Potentially viable
REMOVAL/ DISPOSAL	Excavate Contaminated Soil	Mechanical Excavation	Employ construction equipment such as a backhoe or dragline crane to dig up contaminated soil.	Potentially viable
	Soil Disposal Onsite	RCRA Type Landfill	Permanent storage facility onsite, double lined with clay and a synthetic membrane liner and containing a leachate collection/detection system.	Potentially viable
	Soil Disposal Offsite	RCRA Landfill	Transport excavated soil to a RCRA approved landfill.	Potentially viable

Technology or process option found to be not applicable to site.

FIGURE 4-3 (Page 1 of 3)
IDENTIFICATION OF APPLICABLE REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS - SOIL OPERABLE UNIT
ECC FS

SOIL GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	COMMENTS
SOIL TREATMENT/ DISPOSAL	Biological Treatment	Composting	Soils placed in controlled environment with addition of heat and air to aid microbial degradation of organics.	Not proven on large scale for destruction of wide variety of contaminants found onsite.
	Physical/Chemical Treatment	Oxidation	Oxidizer such as ozone, hydrogen peroxide, or permaganate is introduced into a contactor where it mixes with soil and oxidation occurs.	Not proven on large scale for destruction of wide variety of contaminants found onsite. Byproducts produced by oxidation are not well studied.
		Solvent Extraction	Solvent is introduced into a contactor where it mixes with soil and elutriate is collected and later treated.	Potentially viable
		Retrievable Sorbents	Absorbent materials with ability to concentrate contaminants are mixed with soil. Use of magnetic particles in sorbents allows their collection and removal.	Not applicable to wide variety of contaminants found onsite.
		Soil Washing	Use of water or steam to wash or volatilize and flush contaminants from soil or gravel.	Potentially viable
		Dechlorination Processes	Sodium reagent used to strip chlorine atoms from chlorinated hydrocarbons.	Not applicable to wide variety of contaminants found onsite. Residues after dechlorination are not well studied.
		Wet Air Oxidation	Oxidation of organics in a reactor under high temperature and pressure.	Not proven on large scale for destruction of wide variety of soil contaminants found onsite. Incomplete oxidation of some organics.
		Thermal Volatilization	VOC volatilization in a soil drying unit.	Potentially viable.
	Thermal Destruction	Pyromagnetics	Destruction of soil contaminants in chamber containing molten iron. Sand is added in addition to wastes and nonvolatiles are slagged off.	Not proven on large scale for destruction of wide variety of contaminants found onsite.
		Rotary Kiln	Combustion of solids in a horizontally rotating cylinder designed for uniform heat transfer.	Potentially viable.
		HTFW Reactor	Soil fed into a high temperature fluid wall reactor where rapid and thorough heating occur.	Potentially viable.
		Multiple Hearth	Thermal destruction of soils moving slowly through vertically stacked hearths.	Not proven on large scale for destruction of wide variety of contaminants found onsite. Poor mixing of wastes in hearth may inhibit complete oxidation.
		Fluidized Bed	Soils added to hot agitated bed of sand where heat transfer and combustion occur.	Potentially viable.
		Molten Salt	Soil fed into furnace with a molten salt bed acting as a catalyst and dispersing medium for destructing wastes by oxidation.	Not proven on large scale for destruction of wide variety of soil contaminants found onsite. No commercial unit available.
		Plasma Arc	Thermal destruction of contaminants using high energy free electrons for molecular fracture.	Not proven on large scale for destruction of wide variety of soil contaminants found onsite and no commercial unit.
	Treatment Offsite	Blast Furnace	Thermal destruction of contaminats in a steel mill blast furnace.	No mills presently known willing to be RCRA permitted and accept hazardous waste.
		RCRA Incinerator	Incineration of excavated soils offsite at a RCRA licensed facility.	Potentially viable.
		Landfarming	Soils spread over land in a licensed landfarm. Biological degradation with micro-organisms in aerated and nutrient rich soils.	Not applicable to wide variety of contaminants found onsite.
	Soil Disposal Onsite	RCRA Type Landfill	Permanent storage of treated soils onsite. Double lined with clay and synthetic membrane liners and containing leachate collection/detection system.	Potentially viable
		Landfill and Cap	Landfill treated soils onsite and cap.	Potentially viable
	Soil Disposal Offsite	RCRA Landfill	Transport treated soil to a RCRA approved landfill.	Potentially viable
IN SITU SOIL TREATMENT	Biological Treatment	Biodegradation	Soil seeded with micro-organisms and nutrients to allow biological degradation.	Potentially viable
		Bioharvesting	Use of plant and animal species to accumulate contaminants in their tissues, species are harvested and disposed of.	Not applicable to volatile organics of low octonal water partition coefficient (Kow) found onsite.
	Physical/Chemical Treatment	Chemical Reactions	Application via underground injection of chemicals such as ozone, hydrogen peroxide, or permanganate for degradation of organics.	Not applicable to wide variety of contaminants found onsite. Byproducts produced by oxidation is not well demonstrated.
		Solvent Extraction	Application of solvent either via surface flooding or injection and collection of elutriate at extraction wells with later treatment.	Control of downward migration of solvents not assured. Difficult to determine extent to which solution makes contact with wastes; not well demonstrated.
		Soil Aeration	Aeration of soil via injection wells used to promote microbial biodegradation and to strip volatile organics from soil.	Potentially viable
		Sorbent Fixation	Soil mixed with absorbent material which can concentrate and fix contaminants.	Not applicable to wide variety of contaminants found onsite. Complete immobilization of contaminants may not occur.
		Vapor Extraction	Removal of VOC's by application of a vacuum on soils through a system of wells.	Potentially viable

Technology or process option found to be not applicable to site.

FIGURE 4-3 (Page 2 of 3)
IDENTIFICATION OF APPLICABLE REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS - SOIL OPERABLE UNIT
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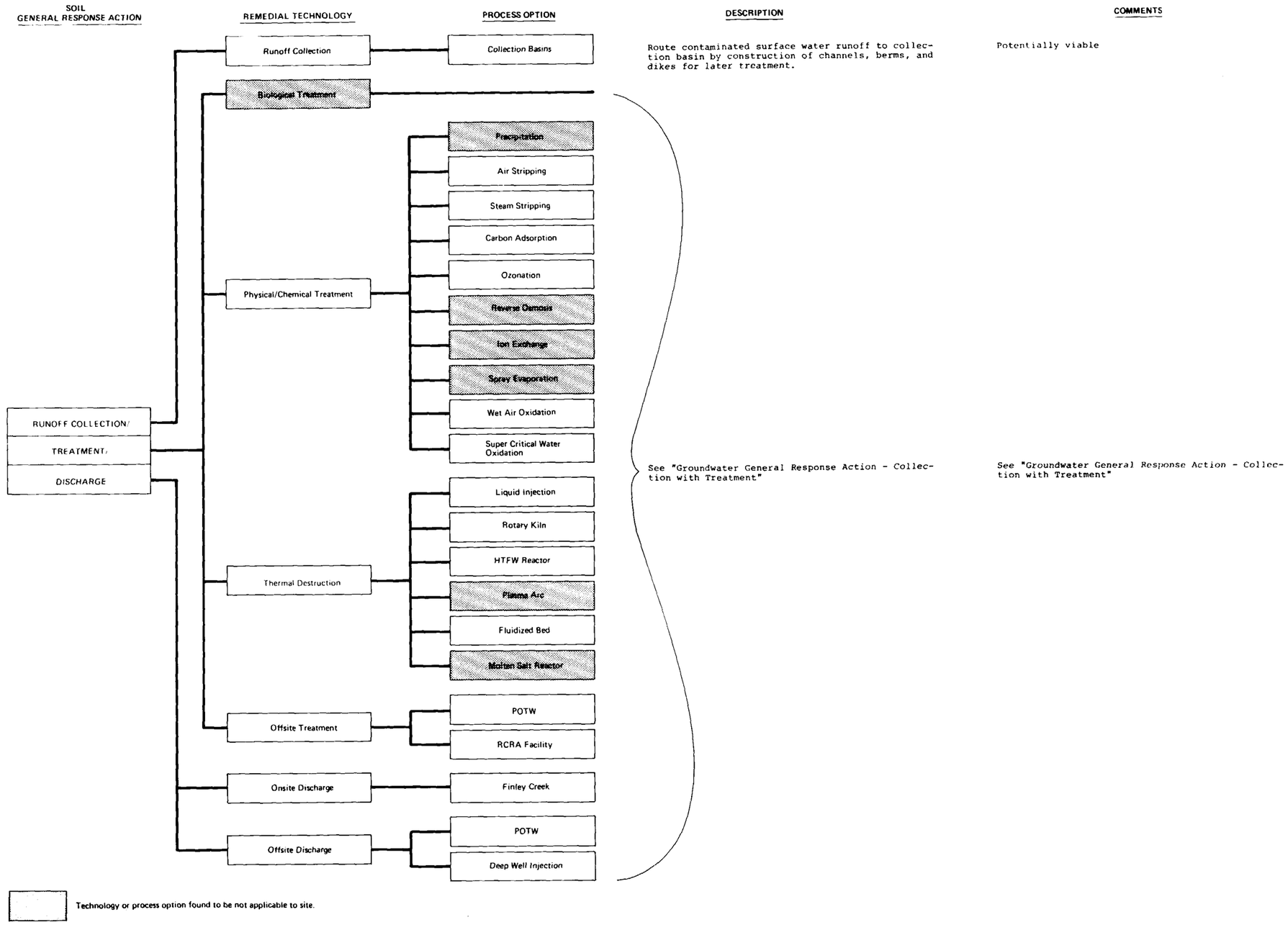

FIGURE 4-3 (Page 3 of 3)
IDENTIFICATION OF APPLICABLE REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS - SOIL OPERABLE UNIT
ECC FS

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGIES	PROCESS OPTIONS	DESCRIPTION	COMMENTS
NO ACTION	None		No action	NCP requires No Action to be carried through to detailed analysis of alternatives.
ACCESS RESTRICTIONS	Deed Restrictions		All deeds for property within potentially contaminated areas would include restrictions on domestic use of groundwater.	Potentially viable
	Fence Creek		Unnamed ditch downstream to Finley Creek and Finley Creek to Hwy 421 fenced to prevent fishing or wading in stream reaches.	Potentially viable
	Groundwater Monitoring		Groundwater monitoring of existing shallow wells to detect changes in groundwater movement or contamination.	Potentially viable
	Surface Water Monitoring		Surface water monitoring in unnamed ditch, Finley Creek, and Eagle Creek to detect changes in contamination.	Potentially viable
CONTAINMENT	Cap	Clay	See "Soil General Response Actions"	See "Soil General Response Actions"
		Asphalt		
		Concrete		
		Gravel-Clay		
		Soil-Clay		
		Soil-Synthetic Membrane		
		Soil - Synthetic Membrane - Clay		
	Vertical Barriers	Soil-Bentonite Slurry Wall	See "Soil General Response Actions"	See "Soil General Response Actions"
		Cement-Bentonite Slurry Wall		
		Grout Curtain		
		Sheet Piles		
		Vibrating Beam		
	Horizontal Barriers	Block Displacement	Used in conjunction with vertical barriers. Controlled injection of slurry in notched injection holes to produce horizontal barrier beneath site.	Horizontal barriers beneath shallow saturated zone contamination unnecessary since vertical gradients are upward where the barriers would be placed.
		Grout Injection	Pressure injection of grout at depth through closely spaced drilled holes.	
	Gradient Control	Surface Water Diversion	Diversion and filling of ditches along site perimeter to eliminate ditches as groundwater discharge areas.	Incomplete solution to objective. Not appropriate to site conditions.
		French Drains	Placement of drains upgradient of site to prevent groundwater inflow to site.	Not appropriate to site conditions.
		Extraction-Injection Wells	Control of groundwater flow through offsite extraction upgradient and injection of uncontaminated groundwater downgradient of site.	Not appropriate to site conditions.
COLLECTION W/O TREATMENT	Extraction	Extraction Wells	Series of wells to extract contaminated groundwater.	Potentially viable
		Extraction Injection Wells	Injection wells onsite used to inject uncontaminated water to increase flow rate to extraction wells.	Potentially viable
	Subsurface Drains	French Drains	System of perforated pipe laid in trenches and backfilled with permeable media to intercept and collect contaminated groundwater.	Potentially viable
		Pipe and Media Drains	System of tile or perforated pipe laid in trenches onsite to collect contaminated groundwater and lower water table.	Not appropriate for contaminant source location and fine textured soils onsite.
DISCHARGE	Onsite Discharge	Finley Creek	Extracted contaminated groundwater discharged untreated to Finley Creek.	Does not satisfy objective of protection of public health and environment.
	Offsite Discharge	Deep Well Injection	Extracted contaminated groundwater discharged untreated to regulated deep well injection system.	Potentially viable

Technology or process option found to be not applicable to site.

FIGURE 4-4 (Page 1 of 3)
IDENTIFICATION OF APPLICABLE REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS - GROUNDWATER OPERABLE UNIT
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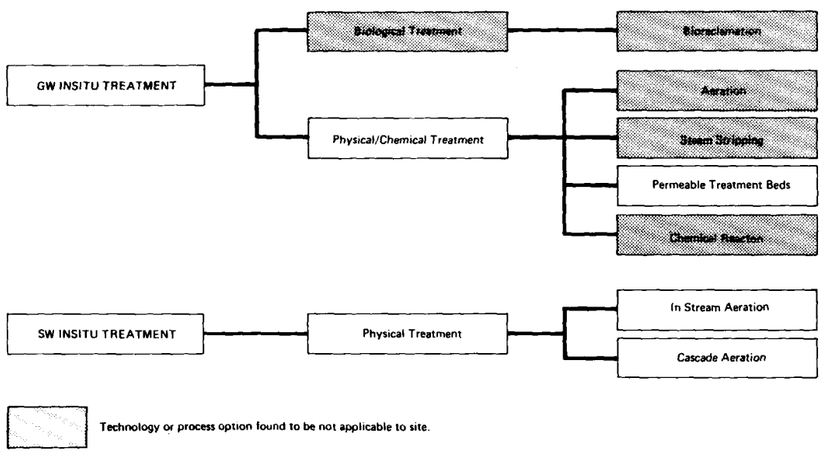

DESCRIPTION	COMMENTS
System of injection and extraction wells used to inject aerated water seeded with bacteria and nutrients to biodegrade contaminants.	Not applicable to wide variety of contaminants or site conditions.
System of injection wells used to inject air into groundwater where volatiles are removed via air stripping.	Not applicable to wide variety of contaminants. Low permeability materials would not allow effective aeration of groundwater. Precipitates of oxidized metals may reduce permeability further.
Similar to aeration system except steam is injected to increase effectiveness of stripping volatiles from the groundwater.	Not applicable to wide variety of contaminants. Low permeability materials would not allow effective aeration of groundwater.
Trenches downgradient of site backfilled with activated carbon remove contaminants as groundwater migrates through.	Potentially viable
System of injection wells used to inject oxidizers such as ozone, permanganate or hydrogen peroxide for degradation of organics.	Not applicable to wide variety of contaminants. Byproducts of oxidation not well studied.
Construction of aeration contact basin in unnamed ditch channel to air strip volatiles from the creek.	Potentially viable
Construction of stepped dams in unnamed ditch to cause aeration as the water falls with attendant air stripping.	Potentially viable

FIGURE 4-4 (Page 2 of 3)
IDENTIFICATION OF APPLICABLE REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS - GROUNDWATER OPERABLE UNIT
ECC FS

GROUNDWATER GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	COMMENTS
COLLECTION	Extraction	Extraction Wells	See "Collection without Treatment/Discharge."	See "Collection without Treatment/Discharge."
		Extraction-Injection Wells		
	Subsurface Drains	French Drains	See "Collection without Treatment/Discharge."	See "Collection without Treatment/Discharge."
		Pipe and Media Drains		
TREATMENT	Biological Treatment		Treatment processes all use micro-organisms to degrade organics	Insufficient organic content in groundwater to sustain biological growth.
	Physical/Chemical Treatment	Precipitation	Alteration of chemical equilibria to reduce solubility of the constituent.	Primarily applicable to removal of metals which are not anticipated to require treatment.
		Air Stripping	Mixing of large volumes of air with water in a packed column or through diffused aeration to promote transfer of VOC's to air.	Potentially viable
		Steam Stripping	Similar to air stripping except steam is pumped into stripping column to add heat in the promotion of VOC's from liquid to air.	Potentially viable
		Carbon Adsorption	Passage of contaminated water over column of activated carbon where contaminants adsorb on surface of carbon.	Potentially viable
		Ozonation	Oxidation of contaminants using ozone.	Potentially viable
		Reverse Osmosis	Use of high pressure to force clean water through a membrane leaving contaminants behind.	Not applicable to a wide variety of contaminants, membrane may allow passage of some select organics.
		Ion Exchange	Contaminated water is passed through a bed of resin material where exchange of ions occurs between the bed and the water.	Not applicable to removal of organics since they do not ionize in groundwater.
		Spray Evaporation	Contaminated water sprayed into air where volatile compounds are transferred from the water. Large collection ponds receive spray water.	Process control difficult since it is exposed to changing weather conditions. Air pollution by volatilized organics may require control.
		Wet Air Oxidation	Oxidation of organics in aerator under high temperature and pressure.	Potentially viable
		Super Critical Water Oxidation	Oxidation of contaminants in super critical environment (374°F and 218 atm) where organic wastes are readily dissolved in water.	Potentially viable
	Thermal Destruction	Rotary Kiln	Combustion of liquid in a horizontally rotating cylinder designed for uniform heat transfer.	Potentially viable
		HTFW Reactor	Liquid waste stream fed into a high temperature fluid wall reactor where rapid and thorough heating occur.	Potentially viable
		Plasma Arc	Thermal destruction of contaminants using high energy free electrons for molecular fracture.	Not proven on a large scale for destruction of wide variety of contaminants.
		Fluidized Bed	Liquid injected into hot agitated bed of sand where heat transfer and combustion occur.	Potentially viable.
		Molten Salt Reactor	Liquid fed into furnace with a molten salt bed acting as a catalyst and dispersing medium for destruction of wastes by oxidation.	Not proven on a large scale for destruction of wide variety of contaminants and no commercial unit.
	Offsite Treatment	POTW	Extracted groundwater discharged to local POTW for treatment.	Potentially viable
		RCRA Facility	Extracted groundwater discharged to RCRA licensed facility for treatment and/or disposal.	Potentially viable
DISCHARGE	Onsite Discharge	Finley Creek	Onsite discharge of treated groundwater to Finley Creek.	Potentially viable
	Offsite Discharge	POTW	Offsite discharge of treated groundwater to local POTW.	Potentially viable
		Deep Well Injection	Offsite discharge of treated groundwater to a regulated deep well injection system.	Potentially viable

Technology or process option found to be not applicable to site.

FIGURE 4-4 (Page 3 of 3)
IDENTIFICATION OF APPLICABLE REMEDIAL TECHNOLOGY AND PROCESS OPTIONS - GROUNDWATER OPERABLE UNIT
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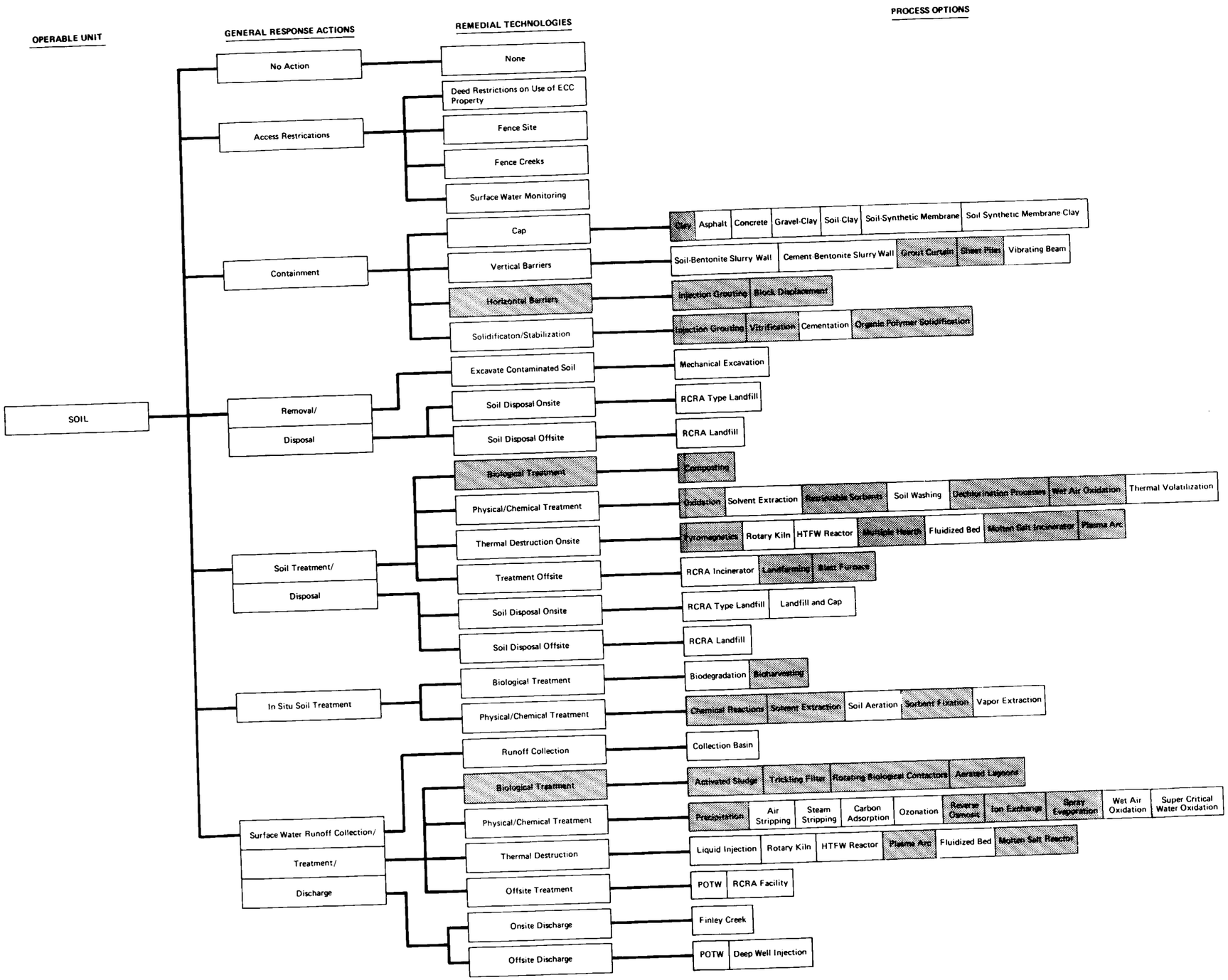

FIGURE 4-5
APPLICABLE REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS - SOIL OPERABLE UNIT
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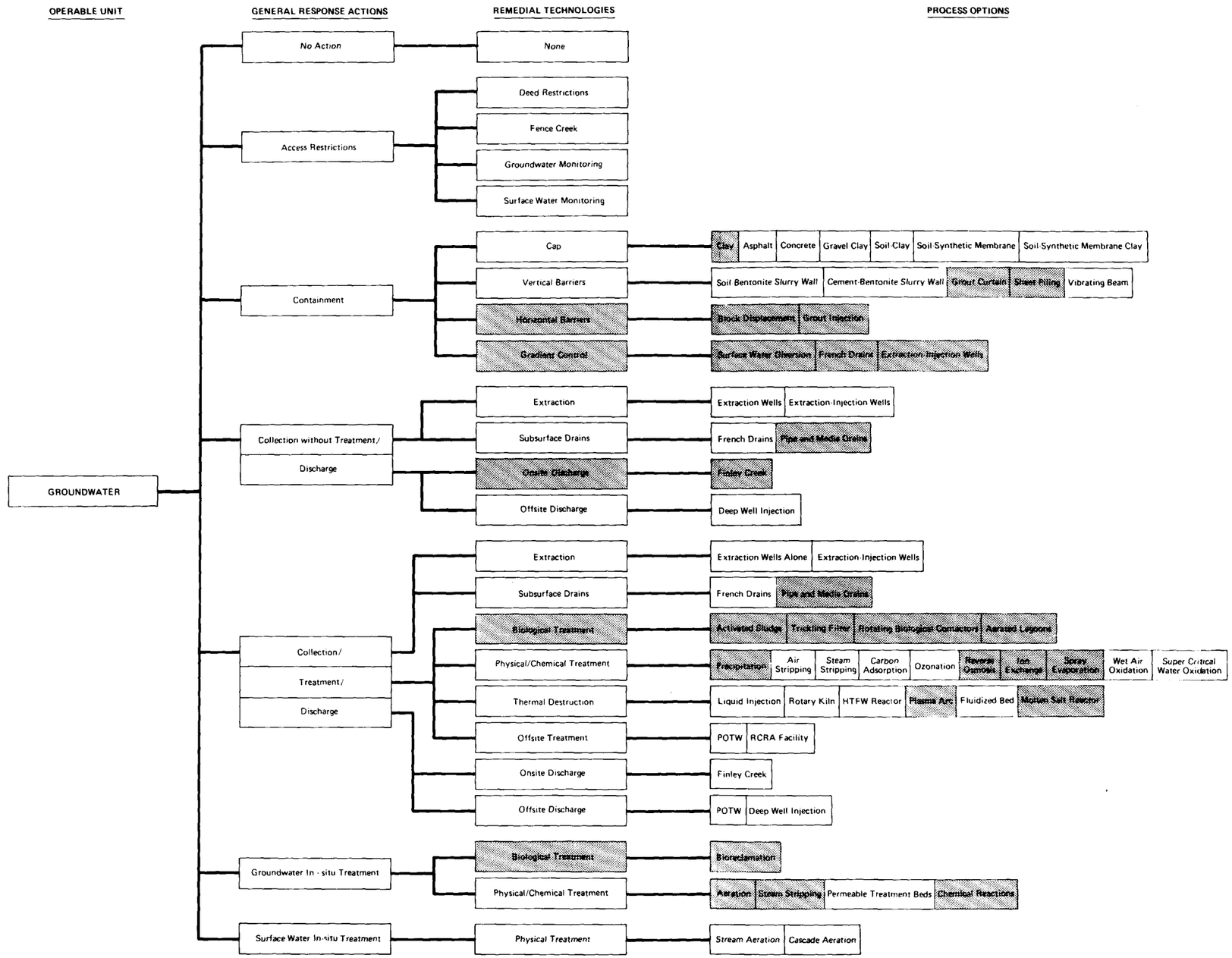

Technology or process option found to be not applicable to site.

FIGURE 4-6
APPLICABLE REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS - GROUNDWATER OPERABLE UNIT
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Chapter 5
REMEDIAL TECHNOLOGY SCREENING

Applicable remedial technologies are screened in this chapter to arrive at a workable number for later assembly into remedial action alternatives. Screening criteria include technical, public health and welfare, environmental, institutional, and cost criteria. Technical criteria include evaluation of performance, reliability, implementability and safety as follows:

- Performance. Performance is assessed on the basis of effectiveness and useful life. Effectiveness is related to the degree with which the technology will prevent or minimize release of hazardous substances to current or future receptors. Useful life relates to the length of time that the level of effectiveness can be maintained.

- Reliability. Reliability is assessed on the basis of operation and maintenance and demonstrated performance. Operation and maintenance are evaluated for labor availability, frequency, necessity, and complexity. Demonstrated performance includes proven performance, probability of failure, and pilot testing.

- Implementability. Implementability is based on the ease of installation and time to implement. Ease of installation relates to constructibility, applicability to site conditions, external conditions such as permits and access to offsite disposal facilities, and equipment availability. The time to implement and the time to achieve beneficial results are also evaluated.

- Safety. Safety during construction and operation as well as safety upon failure is also assessed.

Public health and welfare, environmental and institutional screening criteria are described as follows:

- Public Health and Welfare. Short-term (construction related) and long-term health risks from exposure to contaminants. Short or long-term effects could include odor, noise, air pollution; disruption of households, business and services; use of natural resources; alteration of parks, transportation and urban facilities; relocation of households, businesses, or services; and aesthetic changes.

- Environment. Short-term and long-term effects on the natural environment. Impacts could include toxic effects on plant and animal life from exposure to contaminated soil, surface water, or sediment. Also, alteration of wildlife habitat and effects on threatened or endangered species are considered.

- Institutional. Institutional impacts were evaluated relative to surface and groundwater standards; air quality, odor, and noise standards; land acquisition, land use, and zoning; and federal, state, or local laws or polices.

Costs are used in the screening for comparative purposes only and reflect judgement based on experiences at other sites. Costs are judged to be low, moderate, or high relative to other process options or technologies within a general response action. To distinguish between technologies where public health, welfare, environmental or institutional criteria are not significantly different, installation and operation costs are estimated. These costs are of relative accuracy and do not reflect actual "construction" cost estimates. Screening cost estimates reflect relative rather than absolute costs because elements common among technologies performing the same remedial function may not be included in the estimates.

The screening criteria are used to evaluate remedial technologies relative to other technologies accomplishing the same objective. Since each remedial technology does not address all objectives, the evaluation of the technologies assumes other technologies necessary to meet the objective are implemented. The effect of combining technologies will be considered in the detailed analysis.

Important assumptions in the screening process that were not presented in the RI Report are:

- Bulk tanks presently onsite will be removed before beginning remedial action construction.

- The former cooling pond contains contaminated sludge near its bottom along the north and east sides.

SOIL OPERABLE UNIT

ACCESS RESTRICTIONS

The Access Restriction general response action is intended to limit exposure to contaminants either through direct contact with contaminated soil or through inhalation or

absorption of VOC's or contaminated dust from the site. Deed restrictions limiting the use of the site property, together with fencing the site, the unnamed ditch, and a portion of Finley Creek, would greatly reduce the potential public health risks associated with onsite contaminated soil or its migration to groundwater or surface water. The deed restrictions would restrict future excavation of soils on-site and the fencing would prevent people or animals from traversing the site, or wading and fishing in the creeks. Long-term monitoring of the surface water and sediment for organic contaminants and analysis of fish samples for bio-accumulation would be necessary to allow early warning of changes in offsite hazards.

The Access Restriction general response action addresses all objectives by controlling receptors rather than controlling the soil contaminants. It would be effective provided implementation is maintained into the future. Its relative cost is very low due to the low cost of fencing and very low maintenance cost.

CONTAINMENT

Capping

Capping technologies may encompass either single layer or multi-layer caps. Both address all three remedial action objectives for the soil operable unit: minimize direct contact, control migration to groundwater, and control migration to surface water.

Single-Layer Caps. Construction of the single-layer cap would include regrading the site before laying the cap. The cap would be placed over the northern 2/3 of the site. The existing concrete pad would act as a single layer on the southern portion of the site and would be left in place. Process options potentially viable include sprayed asphalt membrane and concrete. Other single-layer capping options are possible and should be considered in predesign and final design if the single layer capping technology is included in the recommended remedial action.

The sprayed asphalt membrane technology involves spray application of a 1/4 to 1/2 inch thick layer of asphalt over the existing clay onsite. It requires little material handling, a small labor force, and is easy to implement. However, the membrane is not very durable because it is photosensitive, has poor weathering resistance, becomes brittle with age, and is susceptible to severe progressive cracking. It does not address the potential for direct contact if the site is excavated in the future since it allows all contaminants to remain onsite. Some leaching of

contaminants to the groundwater will occur if the cap is not properly maintained.

The concrete single layer cap involves placement of a 6-inch-thick base course and a 4-inch thick concrete slab with steel mesh. The technology is durable and resistant to chemical and mechanical damage. However, Portland concrete is susceptible to cracking from settlement, shrinkage, and frost heave. Installation requires the placement of forms, steel, and construction of expansion joints. Proper design and installation generally produces relatively low maintenance costs. Public health and environmental impacts would be similar to the sprayed asphalt membrane technology.

Multilayer Caps. Multilayer caps would cover the entire site, including the concrete pad. Construction of all caps would include proper site grading and preparation before cap construction. Cross sections of the multilayer caps are shown in Figure 5-1.

The gravel-clay multilayer cap includes a geotextile between the layers for moisture control and separation of the gravel and clay. Clay is effective, is less susceptible to cracking from influences such as settlement and frost heave, and tends to be "self-healing" if cracked. Gravel provides erosion control and aids in moisture control. Construction of this cap would require three operations or passes to complete. This technology has limited proven long-term experience. Public health and environmental impacts would be similar to the single layer caps.

The soil-clay cap provides 0.5 foot of soil over 1.5 feet of fill over a 1 foot clay cap for moisture and erosion control. The technology is effective; it has longevity and durability assuming proper design, installation, and maintenance. It is effective because it is less susceptible to cracking from settlement and frost heave than asphalt or concrete and tends to be "self-healing." Long-term maintenance would be required to prevent growth of deep rooting trees and shrubs that could penetrate the clay seal. Public health and environmental impacts would be similar to the single layer caps.

The soil-synthetic membrane cap uses the synthetic membrane as an impermeable layer. The technology is effective; however, installation of the membrane is more time consuming and difficult to implement than clay impermeable layer installation. The seams in the membrane would require careful installation and sealing. Flexibility of the membrane makes this technology relatively less susceptible to cracking from settlement and frost heave; however, the "self-healing" capability of clay is lost. There is limited long-term experience

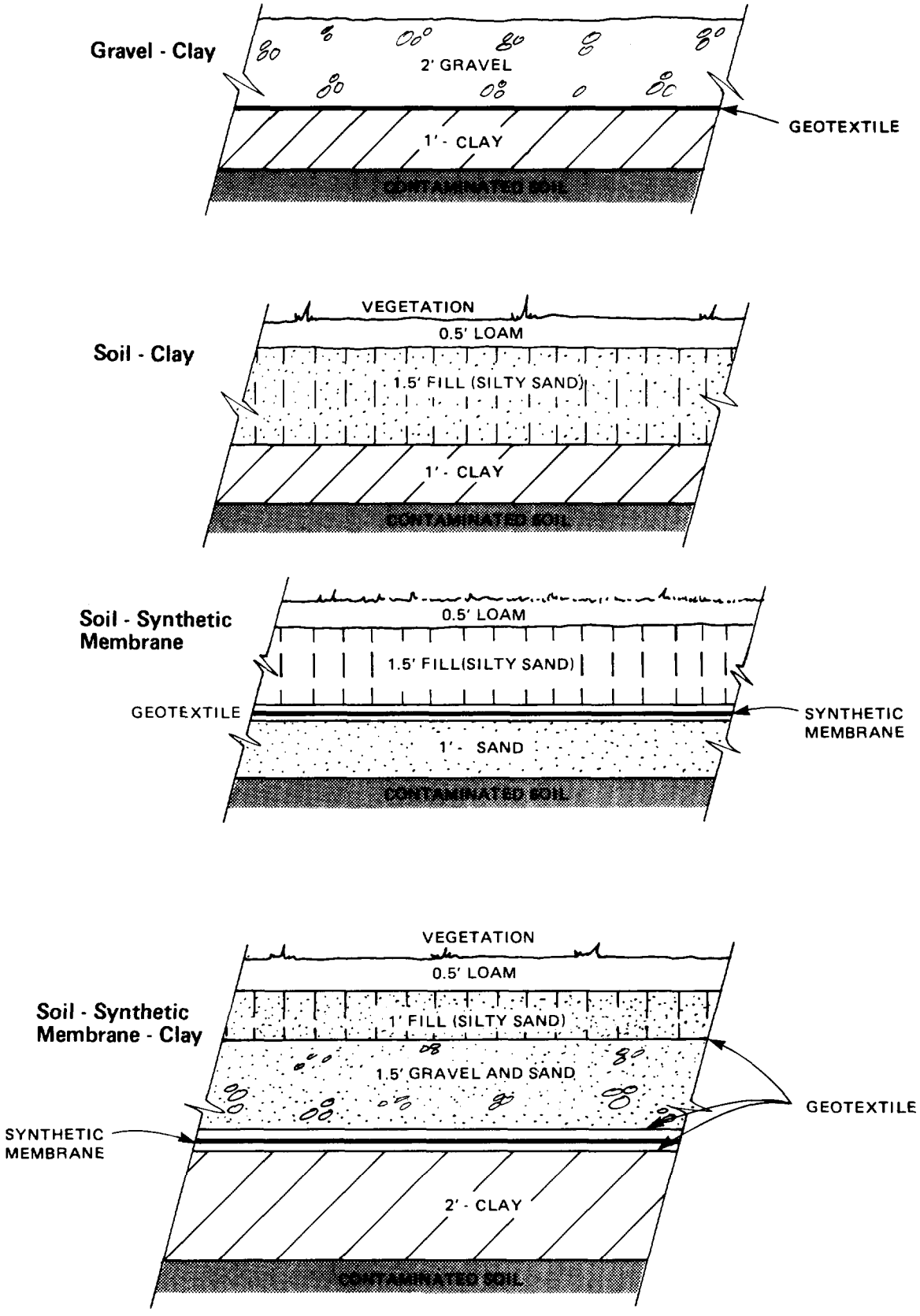

FIGURE 5-1
MULTI - LAYER CAPS
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with synthetic membranes. Public health and environmental impacts are similar to the single layer cap.

The soil-synthetic membrane-clay cap includes 2 low permeability layers, a synthetic membrane and 2 feet of compacted clay. The technology is effective; however, it would be the most time consuming of all to implement. The cap would have the advantages of flexibility of the membrane and the "self-healing" capability of clay. The 5-foot depth of the cap would require careful attention to sideslope construction on the east and southern boundaries where slopes are presently steep. Public health impacts related to direct contact with soil would be the same as the other capping technologies. The potential for migration of soil contaminants to groundwater would be much less than the other technologies due to the addition of a second low permeability layer.

Capping Summary. Costs of the single-layer caps are roughly similar as are the public health and environment impacts. Since the sprayed asphalt membrane has poorer durability it will not be considered further. Overall, the first three multilayer caps are roughly equivalent in cost and public health and environmental impacts. Technical feasibility of the caps also does not vary greatly. The lack of clear advantages or disadvantages requires that additional detailed evaluations of capping technologies be performed during final design if one of these is retained in a selected final alternative. For analysis purposes, of the first three multilayer caps, the soil-clay cap will be carried forward for detailed evaluation. In addition, the soil-synthetic membrane-clay cap will be retained since it offers public health and environment advantages because of the incorporation of an additional low permeability layer and less risk of failure.

The single layer concrete cap and the multilayer soil-clay cap were compared to reduce the number of cap options for later incorporation into remedial action alternatives. The soil-clay cap was retained since costs were similar and the concrete cap is subject to cracking. Though regular maintenance could mitigate this negative impact, the soil-clay cap does not necessitate this reliance on regular maintenance in the future.

The soil-clay and the soil-synthetic membrane-clay caps are retained for further detailed analysis.

Vertical Barriers

Vertical barriers may be used in conjunction with horizontal barriers to contain contaminated soil. The inapplicability of horizontal bottom sealing at the site (as shown in Chapter 4, Figure 4-3), however, eliminates the use of vertical barriers for this purpose. Vertical barriers may also

be used alone to control horizontal migration of contaminants in the unsaturated zone (particularly migration eastward to the unnamed ditch) caused by hydration/dehydration effects. They would not be necessary however, if an effective cap is in place onsite, since the cap would control hydration/dehydration by preventing infiltration. Capping would be necessary for the Containment general response action since vertical barriers by themselves are not capable of meeting the objectives for prevention of contaminant migration to groundwater and surface water. Because capping is required, vertical barriers are not necessary for containment of soil contamination migrating in the unsaturated zone.

Solidification/ Stabilization

Cementation is the only solidification/stabilization process option for containment of contaminated soil that was found to be potentially viable at the site. Cementation involves mixing portland cement or pozzolanic (fly ash) materials (with or without lime or cement) with the contaminated soil. The effectiveness of the technology is not documented for the wide variety of organic contaminants onsite. Some leaching of organic contaminants may occur after solidification.

Public health and environmental objectives are met but the wastes still remain since they are not destroyed but rather are fixed in place. Eventual weathering and cracking would occur with potential for release of contaminants before natural degradation. Resulting disposal costs are high because of the increased volume of the soil. Disposal at a RCRA landfill is assumed to be required due to the potential for eventual release of contaminants from the matrix. Disposal in an onsite RCRA-type landfill would be difficult because of limited space. This technology will not be carried forward because of the much higher costs and lack of onsite space for disposal.

REMOVAL/DISPOSAL

The Removal/Disposal general response action requires an excavation technology and one disposal technology.

Excavate Contaminated Soil

The technology includes one broadly defined process option, mechanical excavation. Specific equipment types and techniques employed are final design considerations or the contractor's prerogative. Contaminated soil would be removed from all areas of the site. Complete removal of the unsaturated zone will be assumed with an average excavation

depth of 5 foot across the site resulting in a total excavation volume of 24,000 cubic yards. Effects of changing the depth of removal will be evaluated in Chapter 6. The concrete pad would also be removed and is included in the excavation volume estimate.

The technology is a reliable and effective remedial technology. It greatly reduces the source of contaminants available for migration. Reducing the mass of contaminants available for migration additionally improves confidence in capping for protection against contaminant movement to the groundwater.

Excavation of contaminated soil together with a proper disposal action would greatly reduce public health risks associated with future direct contact with the contaminated soil, fugitive dust or volatile emissions. Also, the potential of soil contaminants migrating to groundwater or surface water would be greatly reduced. Excavation would have short-term effects because of potential contaminant release via odors and dust generated by construction equipment though these could be reduced but not eliminated with good construction practices. Excavation of contaminated soil is a potentially cost-effective control technology and will be retained for further analysis.

Soil Disposal Onsite

Excavated soil discussed in the foregoing technology would be disposed onsite in an RCRA type landfill. An RCRA type landfill would include construction of a double liner, leachate collection system, leachate detection systems, and multimedia cap as shown in Figure 5-2. The facility would be built with the bottom liner at elevation 888 to keep it 5 feet above the high groundwater table. Construction would be difficult because of the limited space onsite for storing the excavated contaminated soil while the landfill cells are constructed. The stored soils would require an impermeable cover and a leachate collection system. The concrete pad would be used as the storage location and the landfill would be constructed on the northern two-thirds of the site.

The technology should be effective and reliable given proper construction techniques and long-term operation and maintenance. Operation and maintenance is especially critical for this alternative since erosion of the berm along the unnamed ditch could lead to direct contaminant migration to surface waters. Though the technology would greatly reduce contaminant migration to the groundwater and surface water, soil contaminants would remain untreated onsite. Future excavation of the site would be a public health risk if contaminants are exposed or spread over the ground surface.

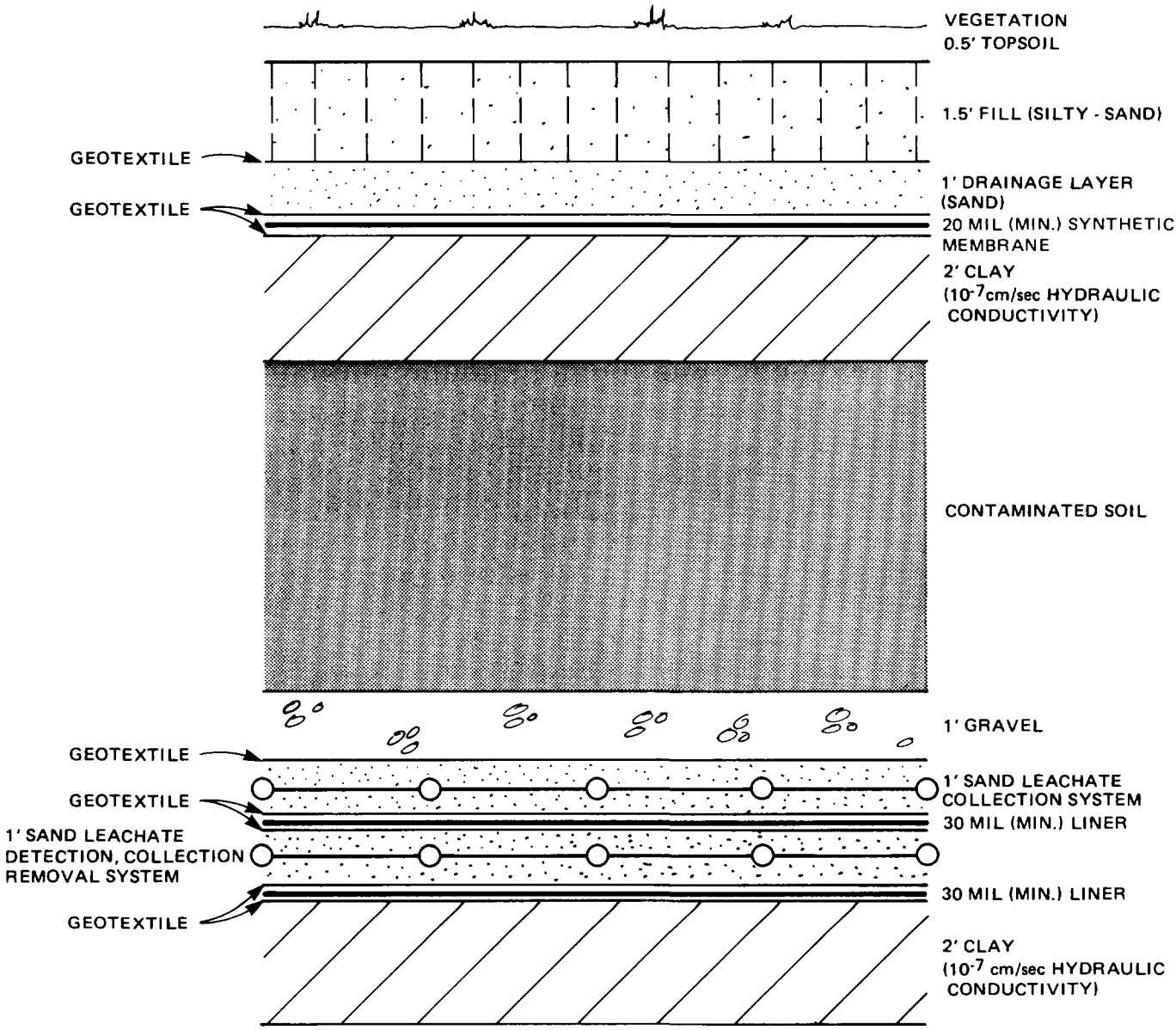

FIGURE 5-2
CROSS SECTION OF RCRA TYPE LANDFILL
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Soil Disposal Offsite

Excavated soil would be transported to an offsite RCRA-permitted landfill facility for disposal. There are three such facilities currently in compliance with RCRA and state regulations located within 200 miles of the ECC site. The technology is an effective and reliable means of controlling contaminated soil although contaminants are not destroyed. Transport offsite would have negative short-term impacts because of the potential release of contaminants in dust and odors associated with the truck transport.

Removal/Disposal Summary

Soil disposal onsite in an RCRA type landfill would not be as secure as an offsite RCRA facility since RCRA landfills are specifically sited to minimize hazards to the public health and environment. Because of the onsite RCRA facilities proximity to the unnamed ditch and Finley Creek, it would result in much greater public health risks than the offsite RCRA facility if inadequate operation and maintenance practices at some time in the future lead to failure of the containment system. Though costs are higher for offsite disposal at an RCRA facility, the technology will be retained for further analysis since it offers greater public health advantages than onsite disposal in an RCRA-type facility.

SOIL TREATMENT/DISPOSAL

The Soil Treatment and Disposal general response action involves excavation of soils and onsite treatment followed by disposal either onsite or offsite. The excavation technology would be similar to that described earlier.

Physical/Chemical Treatment.

Process options found potentially viable were solvent extraction, soil washing, and thermal volatilization.

Solvent Extraction. Solvent extraction onsite would involve mixing contaminated soil with an organic solvent and collecting and treating the elutriate. The contaminants are mobilized in the elutriation process either through solubilization or chemical reaction. Though the technology would be effective in removing high levels of contaminants, the solvent could not be completely removed from the soil without further treatment. The solvent would likely pose public health and environmental risks in addition to the contaminants left in the soil. For these reasons, the technology will not be considered further.

Soil Washing. Soil washing is similar to solvent extraction although the solvent is high pressure steam or water. Since the solvent is water, the technology does not have the problem of the retention of a potentially hazardous organic solvent in the soil. The technology has not been demonstrated on a large scale for removal of organic contaminants from soil. However, washing of gravels is done regularly for removal of soil before use in mixing concrete. Also, high pressure steam is used regularly to remove contaminants from concrete.

A system incorporating both these techniques would be effective in removing organic contaminants from an estimated 6,000 cy of gravel and concrete on the site. The system would include conveyors, a tank with paddle mixers where water is used to remove soil particles and gross contamination, and a vibrating screen where high pressure steam would be used to remove remaining contaminants. Concrete would be broken into fragments no larger than 3-inch diameter prior to cleaning. Water from the system would be collected, stored, and later transported to a licensed RCRA facility for treatment.

Short-term public health impacts may be caused during steam washing of the concrete and gravels because of volatile emissions. These could be mitigated with an air treatment system. Because of large volumes of water generated during the washing and steam cleaning operations, costs are comparable to offsite disposal at an RCRA facility. Since the system does not offer cost advantages, is more operationally complex, and may require VOC emission control, it will not be considered further.

Thermal Volatilization. Thermal volatilization is a treatment process using relatively low temperatures (approximately 400°F) to vaporize VOC's from the soil to the atmosphere. This process uses a rotary dryer to remove VOC's from the soil, in contrast to incineration which destroys organic compounds through combustion at higher operating temperatures (1,600 to 3,000°F). Since VOC's are not destroyed in thermal volatilization, they are discharged to the atmosphere at concentrations dependent on the extent of soil contamination, the feed rate, and the gas discharge rate. Particulate emissions are collected by a cyclone and baghouse.

Overall, the system could greatly reduce public health and environmental risks associated with direct contact with VOC contaminated soil or ingestion and contact of VOC's migrating to groundwater or surface water. Short-term public health risks are associated with the VOC emissions and would be mitigated through air monitoring for VOC's and control of process feedrates. Pilot testing would be required to determine actual VOC emissions and the need for treatment to

remove VOC's from the discharge. Costs of the system are relatively low compared to thermal destruction technologies, assuming treatment of the emissions for VOC removal is not necessary. Per EPA guidance, thermally treated soils could be disposed onsite provided capping and monitoring consistent with requirements of RCRA land disposal closure is included (CFR 264.310). This process will be retained for further analysis.

Physical/Chemical Treatment Summary. In summary the physical/chemical treatment technology with thermal volatilization as a process option will be retained for further analysis.

Thermal Destruction

Potentially viable thermal destruction process options carried forward are rotary kiln, HTFW reactor, and fluidized bed incinerators.

Rotary Kiln. The rotary kiln incinerator consists of a refractory-lined steel cylinder, positioned at a slight incline and rotated by trunnion rollers. The rotary kilns would be equipped with a secondary combustion chamber or afterburner to ensure complete combustion of wastes. The incineration process offers a controllable solids retention time which can be as long as 1 to 4 hours. The rotary action of the kiln provides good air turbulence and solids mixing and tumbling that enhances heat transfer to soil particles.

Overall, the system offers good reliability and effectiveness for destruction of organic contaminants in soil. Disadvantages of the system include high capital and operating costs, highly trained personnel must be used to ensure proper operation, and the refractory lining must be replaced frequently if very abrasive or corrosive conditions exist in the kiln.

HTFW Refractor. The high-temperature fluid wall reactor (HTFW) consists of a tubular core of porous refractory material insulated in a fluid-tight vessel. This technology differs from incineration technology since the energy is transferred to the waste by radiation rather than conduction or convection. The advantage is very rapid and thorough heating of the waste stream for complete combustion. Process control is also good since the energy source for radiation is electricity. A mobile reactor capable of handling up to 50 tons of contaminated soil per day is currently available. The process is especially applicable to soils and silts with low heating values (Btu-content) as in the case with ECC soil.

Fluidized Bed Incinerator. A fluidized bed incinerator system is a refractory-lined steel reactor vessel containing a bed of inert material such as a silica sand. The inert material is heated to desired temperatures and then suspended in the reactor by blowing an air stream (along with combustion air) up through the bed. The large bed volume provides for good heat transfer to the wastes along with good mixing, resulting in very good combustion of organic wastes. Solid wastes must be ground before injection to ensure that the bed remains fluid. Disadvantages of the system include poor control on solids retention time, high operational costs, limitations on suitable waste types, and high emissions of particulate matter.

Thermal Destruction Summary. Of the three thermal destruction technologies considered, the rotary kiln and HTFW reactor are technically best suited to the destruction of organic contaminants in soil at the ECC site. Public health, environmental, and institutional impacts will be similar since all would be designed to meet identical destruction efficiencies and emission allowances. Costs of the two technologies appear to be competitive with each other. Differences identified in this screening are not sufficient to allow recommendation of one technology over the other. For analysis purposes, the rotary kiln incinerator was chosen to be carried forward because of its greater proven performance. Should onsite incineration of soils be the recommended soil operable unit remedial action, the predesign and final design efforts should include evaluation of the HTFW reactor.

Treatment Offsite

Offsite treatment of excavated soils would consist of transporting the wastes to an RCRA permitted incineration facility for disposal. Within a 700-mile radius, there are three RCRA-permitted incinerators capable of handling contaminated waste from the ECC site. The three operating facilities only will accept contaminated soil that has been containerized or drummed. Incineration costs at these facilities have been estimated to range from $700 to $1,300 per cubic yard of waste material. This does not include the material or labor cost for containerizing the soil, nor the transportation costs. Considering offsite incinerator capacities, potential transportation and shipping constraints, and scheduling coordination with other users of the incineration facilities, offsite incineration of the excavated soil is expected to require a minimum of 10 years to complete.

Offsite incineration is an effective and reliable technology resulting in ultimate destruction of contaminants. Short-term public health impacts would be associated with noise, dust and volatile emissions generated from the hauling of the soil. The offsite incineration of contaminated soil

will not be considered further because of the long period for completion of the remedial action in addition to the high costs. If incineration of soils is included in the recommended remedial action for ECC, offsite incineration should be reconsidered in the predesign and final design efforts.

Soil Disposal Onsite

Onsite disposal of treated soil or residual includes the potentially viable process options of an RCRA-type landfill or a non-RCRA landfill and capping with an RCRA-type cap and a non-RCRA landfill with no cap. If testing of the treated soil is performed and the material is delisted as a hazardous waste, then the onsite facility may be considered a solid waste landfill and monitored as such. If the residual is considered hazardous waste, then the onsite landfill could be either capped and monitored or constructed as a RCRA-type landfill, depending on the types and levels of contaminants remaining.

RCRA-Type Landfill. The RCRA type landfill onsite would be similar to that discussed under the Excavation/Disposal general response action with a possible slight reduction in size if the treatment option reduces soil volume. As before, offsite RCRA landfilling is more advantageous than an onsite RCRA landfill. It will not be retained for further analysis.

Landfill and Cap. A non-RCRA landfill onsite would involve replacement of the treated soils to their original location. A soil-clay cap or soil-synthetic membrane-clay cap would be placed over the soil returned to the site. The reliability and effectiveness of this process option are dependent on cap installation techniques, cap maintenance, and the remaining contaminant concentrations in the treated soil and their potential for leaching into the groundwater. Since the treatment option and the level of treatment has not been fixed, these impacts cannot be evaluated at this time. The non-RCRA landfill onsite will be retained for further analysis.

Landfill. This onsite disposal option would require delisting of the residue as a non-hazardous waste. No further management of the residue would be required if it was delisted. For the purposes of the feasibility study, however, it will be assumed that delisting would not be possible.

Soil Disposal Offsite

Disposal of treated soil offsite would be at an RCRA licensed landfill. This technology is similar to that described for the Excavation/Disposal general response

action, although soil volume may be reduced slightly depending on the treatment option. It will be retained for further analysis.

IN SITU SOIL TREATMENT

The in situ soil treatment general response action involves treating the soil in place; no excavation of soil would be done.

Biological Treatment

Biodegradation is the only remaining potentially viable biological treatment process option. It involves seeding contaminated soil in place with microorganisms and nutrients via an injection/extraction well system. The dependence of microbial activity on soil moisture content would require close process control and an acclimation period to establish the appropriate microbial population. The shallow depth of contaminants and the relatively low permeability soils would require close spacing of the injection/extraction wells. Estimates of the time required for degradation of the organics to acceptable levels are not available since the technology has not been demonstrated with similar contaminants or on a similar scale. Due to the lack of demonstrated performance and process design criteria, the technology will not be considered further.

Physical/Chemical Treatment

Soil aeration and vapor extraction are the potentially viable process options.

Soil Aeration. Soil aeration involves injection of air into the contaminated soil through injection wells. Air injection would remove VOC's primarily through air stripping, although aerobic microbial degradation would be enhanced with the addition of the air. The shallow depth of contaminants and the relatively low permeability soils would require close spacing of the air injection wells. Soil aeration alone would not be effective in reducing nonvolatile organic contaminants to acceptable levels. Short-term public health risks may occur during operation due to the evolution of volatile organics. Mitigation of this impact could be accomplished only by reducing the air flowrate and thus the effectiveness of the system.

Vapor Extraction. The vapor extraction system involves a system of shallow wells where soil gas containing volatile organics is extracted from contaminated soil in the unsaturated zone under vacuum. The extracted vapors may require treatment depending on the effectiveness of removal and the resultant concentration of VOC's in the extracted

soil gas. The technology has been demonstrated to be effective for removal of VOC's but would not be effective in removing other organic contaminants. Short-term public health risks associated with discharge of volatiles in the extracted soil gas could be mitigated with a treatment system using activated carbon adsorption. Long-term public health impacts associated with nonvolatile organics would remain unchanged from the no action alternative.

Physical/Chemical Treatment Summary. A comparison of the two process options for physical/chemical treatment based on technical and public health impacts shows the vapor extraction system to be more advantageous. The primary advantage is the ability to control volatile emissions from the process and its greater proven performance. Costs are not expected to be greatly different.

RUNOFF COLLECTION/TREATMENT

The surface water Runoff Collection and Treatment general response action is intended to meet the remedial action objective for mitigating impacts associated with migration of soil contaminants to surface waters. It would involve technologies for collection, treatment, and disposal of treated runoff. Runoff collection and treatment is necessary to meet this objective for the soil operable unit only if the present cap is maintained at the site, or another alternative is chosen that results in exposure of contaminated soils. Present worth costs of runoff collection, treatment, and disposal exceed the cost of capping the site by an order of magnitude. Other alternatives, such as partial removal of contaminated soil would be more cost-effectively designed if they include capping rather than runoff collection and treatment. For these reasons, this general response action will not be considered further.

GROUNDWATER OPERABLE UNIT

ACCESS RESTRICTIONS

The Access Restrictions general response action for groundwater is the same as for soil with the addition of groundwater monitoring. The deed restrictions are intended to eliminate any direct consumption of contaminated groundwater by preventing the construction of onsite or nearby offsite potable wells. Fencing the unnamed ditch and Finley Creek downstream to the confluence with Eagle Creek would greatly reduce the potential public health risk associated with wading or fishing in creek water or sediment contaminated from groundwater. The monitoring program would involve regular sampling and analysis of groundwater in the existing monitoring wells and the installation of several new wells.

It would also include the development of a sampling program to monitor bioaccumulation of contaminants in fish.

The Access Restriction general response action addresses the remedial action objectives by controlling receptors rather than controlling groundwater contaminants. It could be effective provided implementation is maintained in the future. The cost of Access Restriction is very low relative to other general response actions. Additional actions would be necessary, however, if contaminants appear to be migrating offsite.

CONTAINMENT

The containment general response action was found applicable to the prevention of migration of contaminants in the shallow saturated zone to the unnamed ditch or Finley Creek. Containment technologies were not found applicable to prevention of migration of contaminants in the shallow sand and gravel aquifer.

Capping

The intent of capping as a containment technology for the groundwater operable unit is to reduce the migration rate of groundwater contaminants in the shallow saturated zone to the unnamed ditch and Finley Creek. Though this is also accomplished by capping in the soil operable unit, it is possible that a remedial action including complete removal of contaminated soils in the unsaturated zone would not require a cap placed over the underlying soils. In this case, capping may still be viable to aid in the containment of contaminated groundwater by reducing groundwater flowrates.

Since the technical objective is similar (the minimization of water infiltration) within the two operable units, the same capping process options will be carried forward, the soil-clay cap and the soil-synthetic membrane-clay cap.

Vertical Barriers

Three types of vertical barriers are potentially viable for groundwater containment; soil-bentonite slurry walls, cement-bentonite slurry walls, and the vibrating beam wall.

Soil-Bentonite Slurry Wall. This process option involves excavation of a trench using bentonite slurry for temporary stabilization. The trench is then backfilled with a soil-bentonite mix to provide a low permeability confining wall. At this site, much of the shallow soil is expected to be silty clay till. Clay till has a low permeability but fractures and/or sandy lenses are considered general seepage paths. Generally, a soil-bentonite slurry wall is effective

in containment applications, but the high clay content of the excavated soil at the site may negatively affect performance of a soil-bentonite slurry wall. The high clay content could, through a combination of sidewall shear and postconstruction settlement, result in segregation zones or voids in the slurry wall. Special construction measures, which increase construction costs, might mitigate performance problems.

Cement-Bentonite Slurry Wall. This option involves the excavation of a trench using bentonite slurry for temporary stabilization. The trench is then backfilled with a cement-bentonite mix to displace the slurry and provide a confining wall. A cement-bentonite slurry wall requires less operation space and has a less complicated construction operation than a soil-bentonite slurry wall. The cement-bentonite slurry wall will typically cost more than the soil-bentonite slurry wall, but the potential of failure due to high clay content in soil at the site is eliminated.

Vibrating Beam. This process option uses vibrating force to advance a steel beam into the ground followed by injection of a relatively thin wall of asphalt (or cement and/or bentonite) as the beam is withdrawn. The wall is constructed in successive placement of adjacent segments. The technology is most applicable to clean fine to medium sands and has the inherent problem of maintaining alignment of the beam and continuity of adjacent segments. It has limited performance experience and effectiveness is questionable considering silty clay materials at the site.

Vertical Barrier Summary. The contaminated soil would not be removed and would remain a potential source for future groundwater pollution and public exposure in all three process options. The site would require strict control of future development. All the technologies are intended to restrict or limit the migration of groundwater contaminants.

Due to the questionable effectiveness of the vibrating beam option and its similarity in cost with the soil-bentonite slurry wall, it will not be considered further. The cement-bentonite slurry wall, although higher in cost, would have a greater degree of reliability than the soil-bentonite slurry wall for the ECC site and will be retained for further analysis.

COLLECTION WITHOUT TREATMENT

This general response action requires a combination of collection and discharge technologies. It is applicable to both the shallow saturated zone and the shallow sand and gravel aquifer.

Extraction

The extraction technology may include extraction wells alone or extraction wells in combination with injection wells.

Extraction Wells. Extraction wells alone would involve the installation and operation of extraction wells, pumps, and collector pipes to allow removal of contaminated water for treatment or disposal. Properly designed and constructed, it is reliable, effective, and durable. However, due to the low permeability soils at the ECC site, it is estimated that the maximum pumping rate attainable is 0.1 gpm in the shallow saturated zone. The low pumping rate results in a lengthly collection period.

Extraction wells would perform much more effectively in the shallow sand and gravel deposit where more permeable material exist. Extraction alone in the shallow sand and gravel deposit beneath the site, however, would reverse the present upward vertical gradient, thus, creating the potential for downward migration of contaminants from the shallow saturated zone above. Extraction wells would have to be placed downgradient of the site to avoid changing the vertical hydraulic gradient onsite.

Extraction-injection Wells. This option involves extraction as previously described with the addition of injection wells to increase the hydraulic gradient and thus the extraction rates. The injection system involves distribution piping to allow clean water to be injected to the groundwater system. The source of clean water for injection would be the deep confined aquifer and would require installation of a well. The technology is reliable, effective, and durable. As with extraction wells alone, the low permeability soils in the shallow saturated zone would result in a lengthly collection period.

Extraction and injection wells would be effective in the shallow sand and gravel deposit where more permeable materials exist. The injection wells would be used to maintain the upward vertical gradient, thus, preventing migration of contaminants from the shallow saturated zone to the shallow sand and gravel deposit under the site.

Subsurface Drains

The french drain process option was the only option found to be potentially viable for the shallow saturated zone. It involves the use of a trench filled with permeable media to collect contaminated groundwater. The drains would be simple earthen trenches filled with gravel in which water flows by gravity to a wet well where it is pumped to a holding tank. Considering the soils characteristics of the site and the

fact that french drains are a passive action, a network of drains across the site would be necessary to collect contaminated groundwater more efficiently and thus mitigate the contamination quicker. The capital and operational costs would be low in relation to the extraction well process.

Collection Technology Summary. In the long-term, all collection technologies would result in a reduction of risks to public health and the environment by removing contaminated groundwater. For the shallow saturated zone, the french drain collection system results in cleanup in a much shorter time period for lower capital, operation and maintenance cost. It will be retained for further analysis. Both the extraction well and the extraction/injection well process options may be appropriate for the shallow sand and gravel deposit and are retained for further analysis.

Offsite Discharge

The only potentially viable discharge technology for the Collection Without Treatment general response action is offsite deep well injection. It involves the transport of contaminated groundwater to a deep well injection facility for disposal. The closest facilities are within 200 miles of the site. Construction of a closer deep well injection system would require placing wastes in a geological formation that prevents the migration of the wastes to groundwater supplies. The most suitable site is a porous zone sealed above and below by unbroken strata of low hydraulic conductivity.

The injection technology is well developed and widely used for disposal of toxic wastes. However, because of high costs for preliminary geological investigations, well construction and monitoring, deep well injection proves economical only for long-term disposal of relatively untreatable wastes. Also, it does not result in the destruction of contaminants, but, transfers them to another location where public health risks are less. The technology will not be considered further.

COLLECTION/TREATMENT/DISCHARGE

This general response action requires collection, treatment, and disposal technologies. It is applicable to the shallow saturated zone and the shallow sand and gravel deposit.

Collection

The collection technologies evaluation for the previous general response action are applicable for collection with treatment also. One difference, however, occurs for the extraction/injection well collection system for the shallow

sand and gravel deposit. In this case, the treated groundwater could be reinjected, rather than clean water from the deep confined aquifer. The reinjection of treated water would minimize the need for a disposal technology.

Physical/Chemical Treatment

Each of the following treatment technologies assumes equal extracted groundwater flow rates and treatment of organic contaminants.

Air stripping. Air stripping is a well established process in which large volumes of air are mixed with contaminated water in either a packed tower or a basin arrangement. In packed tower aeration the contaminated feedwater is distributed over the top of a loosely packed fill material in a tower. As the water cascades down through the packing it breaks up into small droplets that provide a large surface area for mass transfer. Air is forced through the packing from the tower base, and volatile organics transfer from the water to the air at the air/water interface. In the basin arrangement, air is introduced near the bottom of the basin using a diffused air system.

The technology has good durability and has been effective in removing VOC's; the base/neutral organic contaminants would not be effectively removed. Also, this technology is not difficult to install and implement. Performance of this system, however, is dependent on the ability to effectively and practically extract the groundwater. The risk to public health from direct consumption of VOC's would be greatly reduced through the treatment of contaminated groundwater. Public health and environmental risks from migration of contaminants to surface water would likewise be greatly reduced. Operation and maintenance costs associated with this process are moderate, relative to other process options.

Steam stripping. This process is similar to air stripping except that steam is used to raise the water temperature to boil off contaminants. The gases given off are then passed through carbon filters before discharge. Relative to air stripping, this process is more effective in removing volatile organic contaminants, but durability and ease of installation are reduced. Steam stripping can remove other "semivolatile" organics such as phenols, although, base/neutral compounds are not effectively removed. Additional mechanical equipment, boilers, and distribution systems are needed. Relatively large energy requirements are necessary.

Public health and environmental risks are similar to air stripping. Both capital and operation costs are greater for steam stripping than for air stripping. Because of the greater operational complexity, higher costs and the

relatively minor public health advantage, the steam stripping process will not be considered further.

Carbon Adsorption. Granular activated carbon treatment is an existing, conventional treatment process that will remove organics from dilute aqueous solutions. It involves the adsorption of the contaminants on the surface of carbon particles. The feedwater is passed through a bed of carbon using either pressurized or gravity tanks.

The process is effective and durable for a wide range of contaminants. Carbon adsorption achieves a high level of contaminant removal and is capable of producing water that is of drinking water quality. Installation difficulty is comparable to other onsite treatment processes, but operation is somewhat more difficult than air stripping. Operation requires a higher level of mechanical attention because of carbon replacement. Further, operation requires more frequent performance monitoring to track contaminant breakthrough due to periodic carbon exhaustion.

The risks to public health from direct consumption or migration of organic contaminants to surface water would be greatly reduced through treatment of contaminated groundwater. The relatively high operation and maintenance costs are primarily associated with replacement of carbon.

Ozonation. Ozonation is an effective treatment process for chlorinated hydrocarbons, alcohols, chlorinated aromatics, and pesticides. This technology involves the addition of ozone into the waste stream. Ozone is a powerful oxidizing agent and it breaks down many refractory organic compounds not treated with biological treatment technologies. Ozone reacts with oxidizable materials present in the waste stream. To ensure adequate reaction time, large contactor vessels are required for the process.

This technology would reduce the risks to public health by treating the groundwater. Ozonation can however create additional hazards by formation of byproducts. Due to high capital and operational costs, as well as complexity in operation, the system has rarely been used for hazardous waste applications and has been eliminated from further screening.

Wet air oxidation. Wet air oxidation (WAO) is a commercially proven technology for the destruction of organics in wastewater and sludges; however, higher temperature and pressures are needed to destroy more environmentally persistent chlorinated organic compounds. This difficulty can be overcome in many cases with the use of catalysts. WAO using catalysts will destroy chlorinated compounds, such as PCB's, at relatively low temperatures, and will oxidize essentially all organic materials.

The process involves a liquid-phase combustion implemented through the addition of high-pressure air and a catalyst, if necessary, at elevated temperatures. The reaction products are steam, nitrogen gas, carbon dioxide, and an oxidized liquid waste stream. WAO was developed for higher strength wastes too concentrated for or not readily treated by conventional biological treatment and, therefore, may not be economically practical for treating the dilute waste streams encountered at ECC.

This technology would reduce risks to public health by treating the groundwater. Capital and operational costs for such a system would be very high. Wet air oxidation will not be considered further due to the high costs and lack of proven performance for dilute waste streams.

Super Critical Water Oxidation. This process is similar to WAO except higher temperatures and pressures are used. Water becomes an excellent oxidizing agent at temperatures and pressures above its critical point. It can break down large organic molecules of low molecular weight. The technology has proven effective in bench-scale testing, but it not believed to have been used on the scale required for ECC.

The process would reduce the risks to public health by treating the groundwater. Capital and operational costs associated with this process are very high. Super critical water oxidation will not be considered further due to the high costs and lack of proven performance on a large scale.

Thermal Destruction

Each process is discussed in more detail under the soil treatment/disposal general response action in the soil operable unit. The thermal destruction unit in each would be fitted with a liquid injection nozzle to ensure good atomization of the contaminated groundwater before its destruction.

Considering the volume of groundwater and the concentration of contaminants, all of the thermal destruction processes would be expected to exceed the cost of treatment processes such as air stripping or carbon adsorption by an order of magnitude. To be economically viable, the groundwater would have to be incinerated only in conjunction with contaminated soil. The rotary kiln incinerator could be used to treat contaminated groundwater in conjunction with the onsite soils providing the appropriate system modifications were made. However, thermal treatment of the soils is estimated to take 2 years. Extraction of the groundwater before incineration is expected to take in excess of 30 years, resulting in incineration of the groundwater alone for a majority of the time. Air stripping or carbon adsorption

are expected to be less than one-tenth of the cost of incineration. Though thermal destruction of groundwater would be effective and reliable, it is not cost-effective because of order-of-magnitude greater costs and will not be considered further.

Offsite Treatment

Offsite treatment of the collected groundwater may be at a publicly owned treatment works (POTW) or an RCRA facility. Each assumes equal groundwater flowrates.

POTW treatment. This option would involve some air stripping in the POTW trickling filter system in combination with biological adsorption and degradation. The POTW under consideration is located in Zionsville and is expected to upgrade within a few years to an activated sludge plant that would enhance air stripping of volatiles.

The effectiveness of this technology is uncertain and is contingent upon approval from the POTW. It would be easy and timely to implement, but additional monitoring for VOC's at the POTW would likely be required. This technology would remove the treatment operation to an offsite location; however, it would require assurance of no detrimental effect on the POTW. Contaminated groundwater would either be trucked or piped to the POTW, depending on results of a cost-effectiveness analysis.

Short-term public health impacts may result from volatilization of contaminants at the POTW, though this is not expected to be significant.

Treatment at an RCRA Facility. Offsite treatment at an RCRA facility would include transport of contaminated groundwater to a licensed RCRA facility. Several facilities within a 200 miles radius of the site were used during surface cleanup activities at ECC and it is assumed these would be available for treatment in the future. Short-term public health impacts would result from the transport of the contaminated groundwater as noise and dust would be generated from the truck traffic.

Onsite Discharge

Discharge of treated groundwater to either the unnamed ditch or Finley Creek is a viable technology. It would be easy to implement but is contingent upon approval of a discharge permit from state agencies. No increase in risks to public health or environment would occur provided adequate treatment of the groundwater is accomplished.

Offsite Discharge

Discharge of treated groundwater offsite may be either to a POTW or deep well injection.

POTW. Discharge of treated groundwater to the POTW would be easily accomplished provided approval is granted. Treatment operations would not be effected since contaminant concentrations would be very low. Short-term public health impacts would result if the groundwater were transported to the POTW in trucks. Costs of discharging to the POTW are substantially higher than onsite discharge and offers no public health or environmental advantages. Because of greater costs and short-term public health impact, it will not be considered further.

Deep well injection. Disposal of treated groundwater at a deep well injection facility would involve substantially higher costs. This is not considered necessary provided adequate treatment of groundwater is accomplished. This option will not be considered further.

GROUNDWATER IN SITU TREATMENT

Physical/Chemical Treatment

The permeable treatment beds process option is the only in situ treatment process considered potentially viable.

It involves excavating a trench to intercept the flow of the contaminated groundwater, filling the trench with activated carbon and then capping the trench. The technology is only in a developmental stage and has not been proven effective in large scale applications such as this one. Permeable treatment beds are applicable in relatively shallow aquifers, since the trench must be constructed down to an impermeable layer. Problems with activated carbon result from plugging of the bed.

The carbon bed would require excavation and replacement periodically, and regular groundwater monitoring would be necessary to check performance. It is not very suitable for soils characteristic of the site since it would take a long time for contaminants to migrate to the trench. In the long-term, this technology would prevent contaminants from being transported in the groundwater; but it is a passive action and would not actively remove contaminants within the groundwater onsite. The risk from direct consumption of contaminated groundwater would not be mitigated. The process will not be considered further because of the questionable effectiveness and time required before groundwater treatment is obtained.

SURFACE WATER IN SITU TREATMENT

Physical Treatment

Two in situ treatment processes were evaluated for surface water; in-stream aeration and cascade aeration.

In-Stream Aeration. The aeration system would involve construction of a concrete basin through which the stream flow would be routed. An impeller would be used to provide mixing energy to the contact basin to insure a homogeneous concentration throughout the basin. Mass transfer of VOC's occurs at the air/water interface of the basin. Design variables include mobility of the contaminants, surface area of the basin, hydraulic residence time, and mixing energy of the impeller. An instream aeration system was designed based on required removal of three organic contaminants (methylene chloride, trichloroethene and 1,1-dichloroethene) that are projected to exceed water quality criteria.

An aeration basin 20 feet square by 6 feet deep with two 25 horsepower aerators would provide sufficient mass transfer to achieve the desired removals of both trichloroethene and 1,1-dichloroethene assuming a design flow of 0.5 cfs. Methylene chloride, however, would only experience a 30 percent reduction. In order to achieve the required removals of methylene chloride, the basin would have to be much larger and require more aerators than is practical for this application.

The low removals of methylene chloride would result in little mitigation of public health risks associated with this contaminant. Aquatic life in the unnamed ditch would experience extreme detrimental effects from the instream aerators and channel alteration. Due to the public health and environmental impacts of this technology, it will not be considered further.

Cascade Aeration. This process involves construction of a stair-step cascade system in the stream bed. Air stripping of VOC's would occur as the stream cascades over small dams. The system would not be as effective as in-stream aeration, because of the limited stream slope needed for the stair step cascades and lack of process control.

This alternative would reduce risk to public health by physically removing VOC's from the surface water as it leaves the site and before discharge to Finley Creek. Access restrictions, such as fencing would still be required to prevent direct contact with surface water upstream of the cascade system. The cost would be less than in-stream aeration since it has no operation cost. The process will not be considered further because of questionable technical effectiveness.

REMEDIAL TECHNOLOGY SCREENING SUMMARY

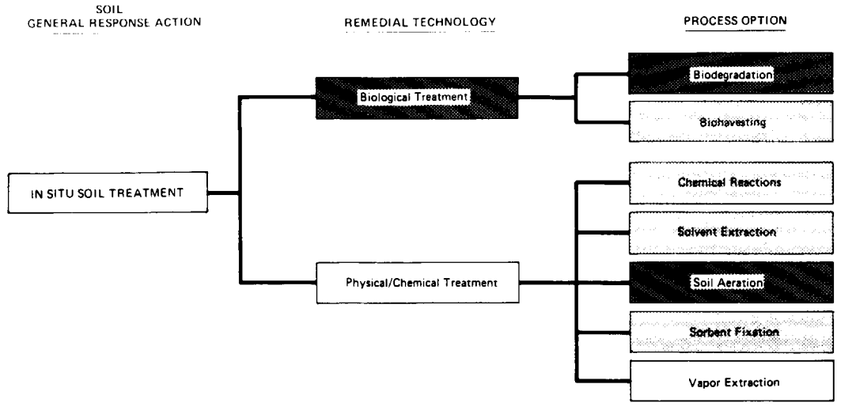
Figure 5-3 summarizes the remedial technology screening for the soil operable unit and Figure 5-4 summarizes the remedial technology screening for the groundwater operable unit. The remedial technologies surviving screening are presented in Figures 5-5 and 5-6.

SOIL GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	SCREENING CRITERIA: TECHNICAL	SCREENING CRITERIA: PUBLIC HEALTH, ENVIRONMENT, INSTITUTIONAL	SCREENING CRITERIA: RELATIVE COST
NO ACTION	None			Risks are identified in Endangerment Assessemnt.	None.
ACCESS RESTRICTIONS	Deed Restrictions		Effectiveness dependent on implementation in future.	Reduces risk from direct contact with contaminated soil. Contaminants remain onsite.	Very low capital and operation cost.
	Fence Site		Effectiveness dependent on implementation in future.	Reduces risk from direct contact with contaminated soil. Contaminants remain onsite.	Very low capital and operation and maintenance cost.
	Fence Creek		Effectiveness dependent on implementation in future.	Reduces risk from direct contact with contaminated surface water and sediments resulting from onsite soil erosion.	Very low capital and operation and maintenance cost.
	Surface Water Monitoring		Effectiveness dependent on implementation in future.	Monitoring allows risk to be identified before adverse impact occurs.	Very low capital and operation cost.
CONTAINMENT	Cap	Clay			
		Asphalt	High maintenance requirement due to poor weathering characteristics, brittleness with age, photosensitivity and cracking.	Contaminants remain onsite. Restrictions on future use required.	Low capital cost. High maintenance cost.
		Concrete	Potential for cracking.	Contaminants remain onsite. Restrictions on future use required.	Low capital cost. Moderate maintenance cost.
		Gravel Clay	Less susceptible to cracking and is "self-healing" if cracked.	Contaminants remain onsite. Restrictions on future use required.	Low capital and maintenance cost.
		Soil Clay	Less susceptible to cracking and is "self-healing" if cracked.	Contaminants remain onsite. Restrictions on future use required.	Low capital and maintenance cost.
		Soil Synthetic Membrane	Long-term reliability undocumented. Membrane puncture or seal leaking difficult to locate and correct.	Contaminants remain onsite. Restrictions on future use required.	Low capital and maintenance cost.
		Soil Synthetic Membrane Clay	Least susceptible to cracking and is "self-healing" if cracked. Requires greater time to implement.	Contaminants remain onsite. Restrictions on future use required. Potential for migration of contaminants to GW much less than other process options.	Moderate capital and operation and maintenance cost.
	Vertical Barriers	Soil Bentonite Slurry Wall	Ineffective in preventing migration of soil contaminants to groundwater without horizontal barriers below. Not necessary in preventing horizontal migration of contaminants in unsaturated zone if cap is present.	Contaminants remain onsite. Restrictions of future use required.	Low capital and maintenance cost.
		Cement Bentonite Slurry Wall			
		Grout Curtain			
		Sheet Pile			
		Vibrating Beam			
	Horizontal Barriers	Block Displacement			
		Grout Injection			
	Solidification/Stabilization	Injection Grouting			
		Vitrification			
		Organic Polymer Solidification			
		Cementation	Waste volume increased. Potential for leaching of organic contaminants from cement. Eventual weathering and cracking of matrix.	Contaminants remain onsite. Restriction's on future use required.	High capital cost when disposal is included.
REMOVAL/DISPOSAL	Excavate Contaminated Soil	Mechanical Excavation	Reliable and effective.	Short-term impacts associated with excavation due to noise, odors, and dust creation. Eliminates or greatly reduces soil contaminants as a source for contaminant migration.	Low capital cost.
	Soil Disposal Onsite	RCRA Type Landfill	Limited space onsite makes proper construction and operation very difficult. Proximity to SW sources makes siting poor.	Short-term impacts due to creation of noise, odors and dust from landfill construction.	Moderate capital cost. High operation and maintenance cost.
	Soil Disposal Offsite	RCRA Landfill	Reliable and effective given proper landfill construction.	Contaminants are not treated, but relocated to secure site. Short-term impacts due to creation of noise, odors and dust from trucking soil.	High capital and operation and maintenance cost.

Technology or process option found to be not applicable to site.

Technology or process option not carried forward from screening.

FIGURE 5-3 (Page 1 of 3)
SCREENING SUMMARY OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS - SOIL OPERABLE UNIT
ECC FS



SCREENING CRITERIA		
TECHNICAL	PUBLIC HEALTH, ENVIRONMENT, INSTITUTIONAL	RELATIVE COST
Evaluation of effectiveness and reliability not possible due to lack of demonstrated performance and process design criteria for degradation of organic contamination in soil.	Requires many years before soil contaminants are reduced substantially during which risks are not fully mitigated.	Low capital and operation and maintenance cost.
Potentially effective for removal of VOC's. Non-VOC's likely not substantially treated.	Short-term public health risk from evolution of volatile organics. Mitigation would require lower rates of treatment. Risks associated with non-VOC's unchanged.	Low capital and operation and maintenance cost.
Potentially effective for removal of VOC's. Non-VOC's likely not substantially treated.	Short-term public health risks from discharge of VOC's could be easily mitigated.	Low capital and operation and maintenance cost.
Runoff collection required if present cap is maintained at the site or another alternative is used resulting in exposure of contaminated soils. Erosion of contaminated soils could occur with present cap.	Lack of effective cap over contaminated soils could result in volatilization from soils with public health risks. Treatment of contaminated sediment in collection basin would be required.	Very high capital cost and very high operation and maintenance cost relative to capping.

RUNOFF COLLECTION
TREATMENT
DISCHARGE

Technology or process option found to be not applicable to site.

Technology or process option not carried forward from screening.

FIGURE 5-3 (Page 2 of 3)
SCREENING SUMMARY OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS - SOIL OPERABLE UNIT
ECC FS

SOIL GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	SCREENING CRITERIA: TECHNICAL	SCREENING CRITERIA: PUBLIC HEALTH, ENVIRONMENT, INSTITUTIONAL	SCREENING CRITERIA: RELATIVE COST
SOIL TREATMENT/ DISPOSAL	Biological Treatment	Composting			
	Physical/Chemical Treatment	Oxidation			
		Solvent Extraction	Difficult to remove all of the extraction solvent from soil. Not effective for removal of low levels of organics.	The extraction solvent may pose public health and environmental risk.	High capital and operation and maintenance cost.
		Renewable Sorbents			
		Soil Washing	Unproven for soils, likely reliable and effective for removal of contaminants from concrete and gravel though unproven as a system for organic contaminant removal.	Short-term impacts from volatile emissions could be mitigated with collection and treatment of gases.	Moderate capital costs. High operation and maintenance cost.
		Dechlorination Processes			
		Wet Air Oxidation			
		Thermal Volatilization	Effective for up to 99 percent VOC removal. Does not remove non-volatile contaminants.	Short-term impacts from volatile emissions could be mitigated with collection and treatment of gases. Treatment of air emissions would greatly increase costs.	Moderate capital cost. High operation and maintenance cost.
	Thermal Destruction	Pyromagnetics			
		Rotary Kiln	Reliable and effective. Requires trained operating personnel and maintenance on a regular basis.	Requires several years before incineration of contaminated soils is complete during which risks are not fully mitigated.	High capital and operation and maintenance cost.
		HTFW Reactor	Reliability and effectiveness good in limited number of applications. Requires trained operators. Very good process control.	Requires several years before incineration of contaminated soils is complete during which risks are not fully mitigated.	High capital and operation and maintenance cost.
		Multiple Hearth			
		Fluidized Bed	Limited demonstrated performance on soils. Poor process control on solids retention time.	Requires several years before incineration of contaminated soils is complete during which risks are not fully mitigated.	Very high capital capital cost. High operation and maintenance cost.
		Molten Salt			
		Plasma Arc			
	Treatment Offsite	Blast Furnace			
		RCRA Incinerator	Reliable and effective. RCRA incinerator not presently available with capacity to handle large volumes of contaminated soil.	Requires at least 10 years before incineration of contaminated soils is complete during which risks are not fully mitigated. Short-term impacts due to creation of noise and dust from trucking of soil.	High capital and operation and maintenance cost.
		Landfarming			
	Soil Disposal Onsite	RCRA Type Landfill	Reliable and effective given proper installation though proximity to SW sources makes siting poor.	Public health and environmental risks low although higher than an offsite RCRA landfill.	Moderate capital cost. High operation and maintenance cost.
		Landfill and Cap	Reliability and effectiveness dependent on installation techniques, cap maintenance, and remaining soil contaminant concentrations.	Remaining soil contaminants could cause public health or environmental impact in future. RCRA requires treated soils to be delisted as hazardous or disposed in a RCRA licensed facility.	Low capital cost. Moderate operation and maintenance cost.
	Soil Disposal Offsite	RCRA Landfill	Reliable and effective given proper operation and maintenance.	Public health impacts dependent on landfill siting, construction, and operation and maintenance quality.	High capital cost and operation and maintenance cost.

Technology or process option found to be not applicable to site.

Technology or process option not carried forward from screening.

FIGURE 5-3 (Page 3 of 3)
SCREENING SUMMARY OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS - SOIL OPERABLE UNIT
ECC FS

GROUNDWATER GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGIES	PROCESS OPTION	SCREENING CRITERIA: TECHNICAL	SCREENING CRITERIA: PUBLIC HEALTH, ENVIRONMENT, INSTITUTIONAL	SCREENING CRITERIA: RELATIVE COST
NO ACTION	None		Effectiveness dependent on implementation well into the future.	Risks are identified in the Endangerment Assessment.	None.
ACCESS RESTRICTIONS	Deed Restrictions		Effectiveness dependent on implementation well into the future.	Reduces risk for direct contact or ingestion from construction of an onsite well.	Very low capital and operation cost.
	Fence Creek		Effectiveness dependent on implementation well into the future.	Reduces risk for direct contact or ingestion of surface water.	Very low capital and maintenance cost.
	Groundwater Monitoring		Effectiveness dependent on implementation well into the future.	Monitoring provides tracking of contaminant migration so risks can be identified before any adverse impacts occur.	Low capital and maintenance cost.
	Surface Water Monitoring			Monitoring provides tracking of contaminant migration so risks can be identified before any adverse impacts occur.	
CONTAINMENT	Cap	Clay	See "Screening Summary of Remedial Technologies and Process Options - Soil Operable Unit"		
		Asphalt			
		Concrete			
		Gravel Clay			
		Soil Clay			
		Soil-Synthetic Membrane			
		Soil Synthetic Membrane-Clay			
	Vertical Barriers	Soil Bentonite Slurry Wall	High clay content of onsite soils may reduce containment effectiveness.	Contaminants remain onsite. Restrictions on future use required.	Low capital and maintenance cost.
		Cement Bentonite Slurry Wall	Reliable and effective.	Contaminants remain onsite. Restrictions on future use required.	Moderate capital and maintenance cost.
		Grout Curtain			
		Sheet Piles			
		Vibrating Beam	Questionable effectiveness due to silty clay soils onsite. Limited performance experience.	Contaminants remain onsite. Restrictions on future use required.	Low capital and maintenance cost.
	Horizontal Barriers	Block Displacement			
		Grout Injection			
	Gradient Control	Surface Water Diversion			
		French Drains			
		Extraction-Injection Wells			
COLLECTION W/O TREATMENT DISCHARGE	Extraction	Extraction Wells	Effectiveness in the shallow saturated zone is limited by low permeability of onsite soils. In the shallow sand and gravel zone they may induce migration of water table contaminants downward.	Public health risks from direct consumption of GW remain during lengthy period of GW extraction from water table aquifer. Downward migration of GW contaminants increases public health and environmental risks.	Moderate capital and operation and maintenance cost.
		Extraction Injection Wells	Effectiveness in the shallow saturated zone is limited by low permeability of onsite soils. In shallow sand aquifer, injection wells would prevent water table contaminants from migrating downward to sand and gravel aquifer.	Public health risks from direct consumption of GW remain during lengthy period of GW extraction from the shallow saturated zone. Public health risks associated with the shallow sand and gravel aquifer greatly reduced.	Moderate capital and operation and maintenance cost.
	Subsurface Drains	French Drains			
		Pipe and Media Drains	More effective than extraction for groundwater collection in shallow saturated zone. Not effective for shallow sand and gravel aquifer.	Public health risks associated with shallow saturated zone greatly reduced.	Low capital and operation and maintenance cost.
	Onsite Discharge	Fitney Creek			
	Offsite Discharge	Deep Well Injection	No technical difficulties.	Short-term impacts due to creation of noise and dust from trucking of groundwater. Contaminants are not destroyed, but removed to a more inaccessible location.	Very high capital cost. High operation cost.

Technology or process option found to be not applicable to site.

Technology or process option not carried forward from screening.

FIGURE 5-4 (Page 1 of 2)
SCREENING SUMMARY OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS - GROUNDWATER OPERABLE UNIT
ECC FS

GROUNDWATER GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	SCREENING CRITERIA: TECHNICAL	SCREENING CRITERIA: PUBLIC HEALTH, ENVIRONMENT, INSTITUTIONAL	SCREENING CRITERIA: RELATIVE COST
COLLECTION	Extraction	Extraction Wells	See "Collection Without Treatment."		
		Extraction Injection Wells	See "Collection Without Treatment."		
	Subsurface Drains	French Drains	See "Collection Without Treatment."		
		Pipe and Slotted Drains			
TREATMENT	Biological Treatment				
	Physical Chemical Treatment	Precipitation			
		Air Stripping	Well established, effective and durable, easily implemented and installed. Does not remove semi-volatiles.	Reduces risk by treating contaminated groundwater. Lack of removal of semi-volatile not an important public health impact.	Moderate capital and operation and maintenance cost.
		Steam Stripping	Effective and durable, more difficult to implement and install.	Reduces risk by treating contaminated groundwater.	Moderate capital cost, high operation and maintenance cost.
		Carbon Adsorption	Well established, effective and durable, easily implemented and installed; more difficult operation.	Reduces risk by treating contaminated groundwater.	Moderate capital and operation and maintenance cost.
		Ozonation	Effective but complex operation and difficult to implement and install.	Reduces risk by treating contaminated groundwater.	High capital and operation and maintenance cost.
		Reverse Osmosis			
		Ion Exchange			
		Spray Evaporation			
		Wet Air Oxidation	Effective but not practical for dilute waste streams, more difficult operation.	Reduces risk by treating contaminated groundwater.	High capital and operation and maintenance cost.
		Super Critical Water Oxidation	Developmental, more difficult operation.	Reduces risk by treating contaminated groundwater.	High capital and operation and maintenance cost.
	Thermal Destruction	Liquid Injection	Requires large amounts of fuel to maintain incineration temperatures.	Reduces risk by treating contaminated groundwater.	Very high capital and operation and maintenance cost.
		Rotary Kiln	Could be used in conjunction with onsite soil incineration, not cost-effective for groundwater treatment alone. Since groundwater treatment would still be necessary long after soil incineration is completed, thermal destruction is not appropriate.	Reduces risk by treating contaminated groundwater.	Very high capital and operation and maintenance cost.
		HTFW Reactor			
		Plasma Arc			
		Fluidized Bed			
		Molten Salt Reactor			
	Offsite Treatment	POTW	Reliable and effective given POTW with activated sludge process. Monitoring would be required to check performance. Easy to implement.	Reduces risk by treating contaminated groundwater; contingent upon approval from POTW; short-term impacts due to creation of noise and dust from trucking of groundwater.	High capital and operation cost.
		RCRA Facility	Effective; easy and quick to implement.	Reduces risk by treating contaminated groundwater; Short-term impacts due to creation of noise and dust from trucking of groundwater.	High capital and operation cost.
	Onsite Discharge	Finley Creek	Quickly and easily implemented; no technical problems.	No adverse effects provided adequate treatment in accomplished prior to discharge. Requires state issuance of an NPDES discharge permit.	Very low capital and operation and maintenance cost.
DISCHARGE	Offsite Discharge	POTW	No technical problems.	Short-term impacts due to creation of noise and dust from trucking of groundwater.	Moderate capital and operation cost.
		Deep Well Injection	No technical problems.	Short-term impacts due to creation of noise and dust from trucking of groundwater.	High capital and operation cost.
GW INSITU TREATMENT	Biological Treatment	Bioremediation			
	Physical Chemical Treatment	Aeration			
		Steam Stripping			
		Permeable Treatment Beds	Developmental, plugging or fouling are likely to occur, not suitable for soils onsite, requires monitoring and periodic replacement of bed.	Reduces risk by treating contaminated groundwater ad it migrates. Risks associated with direct consumption would not be mitigated for many years.	Moderate capital cost. High operation and maintenance cost.
		Chemical Fractions			
SW INSITU TREATMENT	Physical Treatment	In Stream Aeration	Effective; air emissions may be required. Not effective for removal of all VOC's.	Reduces risk by treating surface water. Poor removal efficiency of methylane chloride would not mitigate public health risks associated with this contaminant. Public health impacts from volatile emissions may require mitigation.	Moderate capital and operation and maintenance cost.
		Cascade Aeration	Small stream slopes may not allow effective VOC removal. Poor process control.	Public health impacts from volatile emissions may require mitigation.	Low capital and operation and maintenance cost.

Technology or process option found to be not applicable to site.

Technology or process option not carried forward from screening

FIGURE 5-4 (Page 2 of 2)
SCREENING SUMMARY OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS - GROUNDWATER OPERABLE UNIT
ECC FS

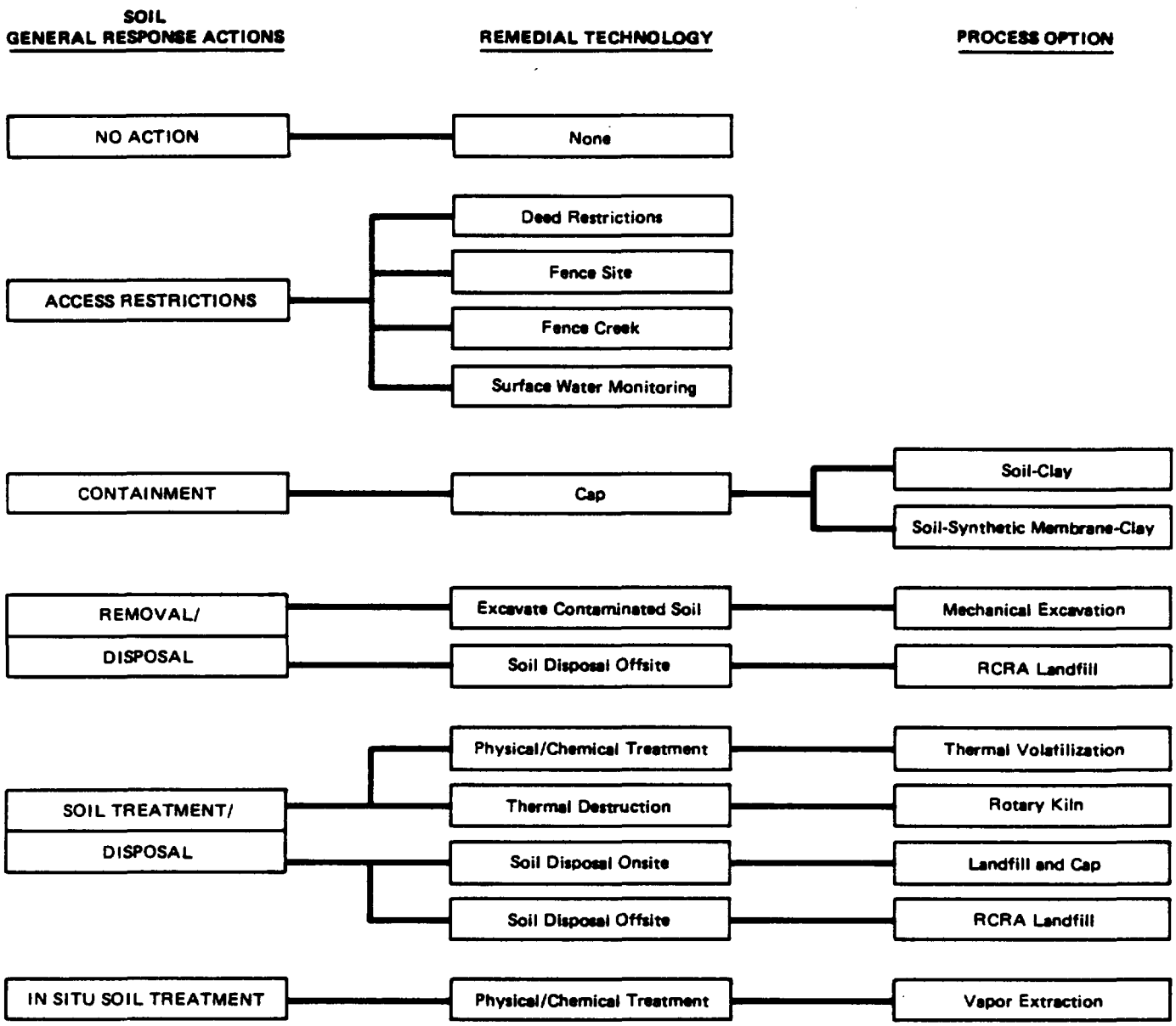


FIGURE 5-5
REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR DETAILED ANALYSIS - SOIL OPERABLE UNIT
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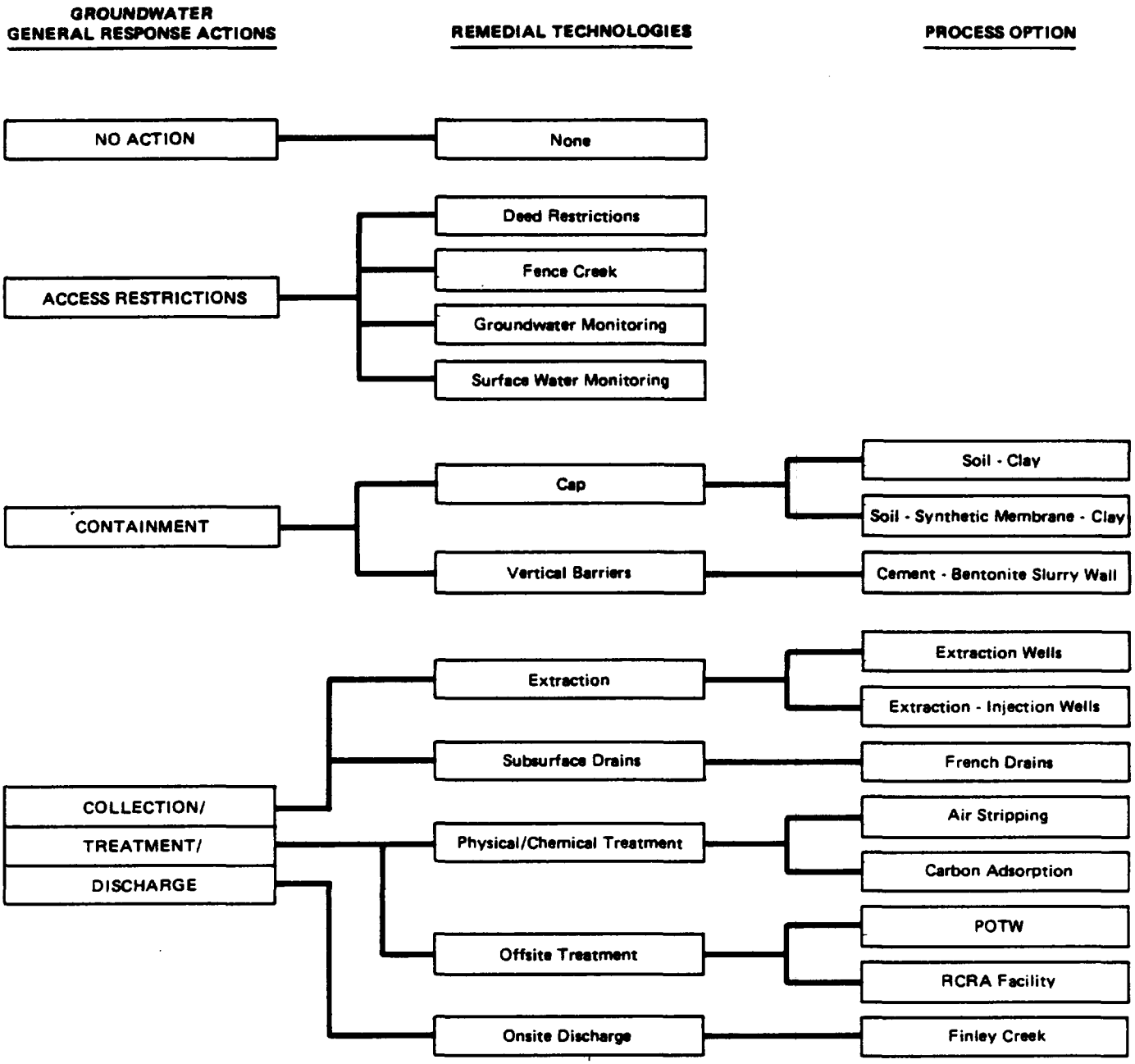


FIGURE 5-6
REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR DETAILED ANALYSIS - GROUNDWATER OPERABLE UNIT
ECC FS

Chapter 6
ASSEMBLY OF REMEDIAL ACTION ALTERNATIVES

This chapter develops remedial action alternatives for the ECC site. Detailed analysis of several technologies was done before assembly of remedial action alternatives to either further reduce the number of process options/technologies or to define cleanup strategies. It includes detailed evaluation of public health and welfare, environmental, institutional, and cost criteria. The criteria are as described in Chapter 5 with the exception of cost.

Cost estimates for the alternatives were prepared from cost information included in the U.S. EPA's "Compendium of Costs of Remedial Technologies at Hazardous Waste Sites," the 1985 Means Site Work Cost Data guide, Cost Reference Guide for Construction Equipment 1985, estimates for similar projects, and estimates provided by equipment vendors, POTW's, and hazardous waste transporters and treatment facilities. The costs are order-of-magnitude level estimates, i.e., the cost estimates have an expected accuracy of +50 and -30 percent. Further refinement of cost estimates occurs during the design process. The estimated present worth of all remedial alternatives was based on a 30-year period and 10-percent discount rate. Inflation was not considered in preparing present worth estimates.

Total capital costs are those expenditures required to initiate and install a remedial action. Both direct and indirect costs are considered in the development of capital costs. Direct costs include construction costs or expenditures for equipment, labor, and materials required to install a remedial action. Indirect costs consist of engineering, permitting, supervising, and other services necessary to carry out a remedial action.

Because this feasibility study is conceptual and based on data available at the time, bid and scope contingencies were estimated to account for unknown costs. Bid contingencies account for costs associated with constructing a given project scope, such as adverse weather conditions, strikes by material suppliers, and geotechnical unknowns. Scope contingencies cover changes which invariably occur during final design and implementations. Scope contingencies include provisions for items such as inherent uncertainties in defining wastes and waste volumes and regulatory or policy changes which may impact FS assumptions. Allowances for price inflation, and abnormal technical difficulties are not accounted for in the contingencies.

The following detailed evaluations were performed prior to assembly of remedial alternatives:

- Cost effectiveness evaluation of contaminated soil removal volumes.
- Comparison of capping options.
- Comparison of thermal volatilization and soil vapor extraction soil treatment technologies.
- Evaluation of cement-bentonite slurry wall containment of contaminated groundwater in the shallow saturated zone.
- Contaminated groundwater collection system design.
- Comparison of groundwater treatment options, including onsite treatment with air stripping or carbon adsorption and offsite treatment at a POTW or an RCRA facility.

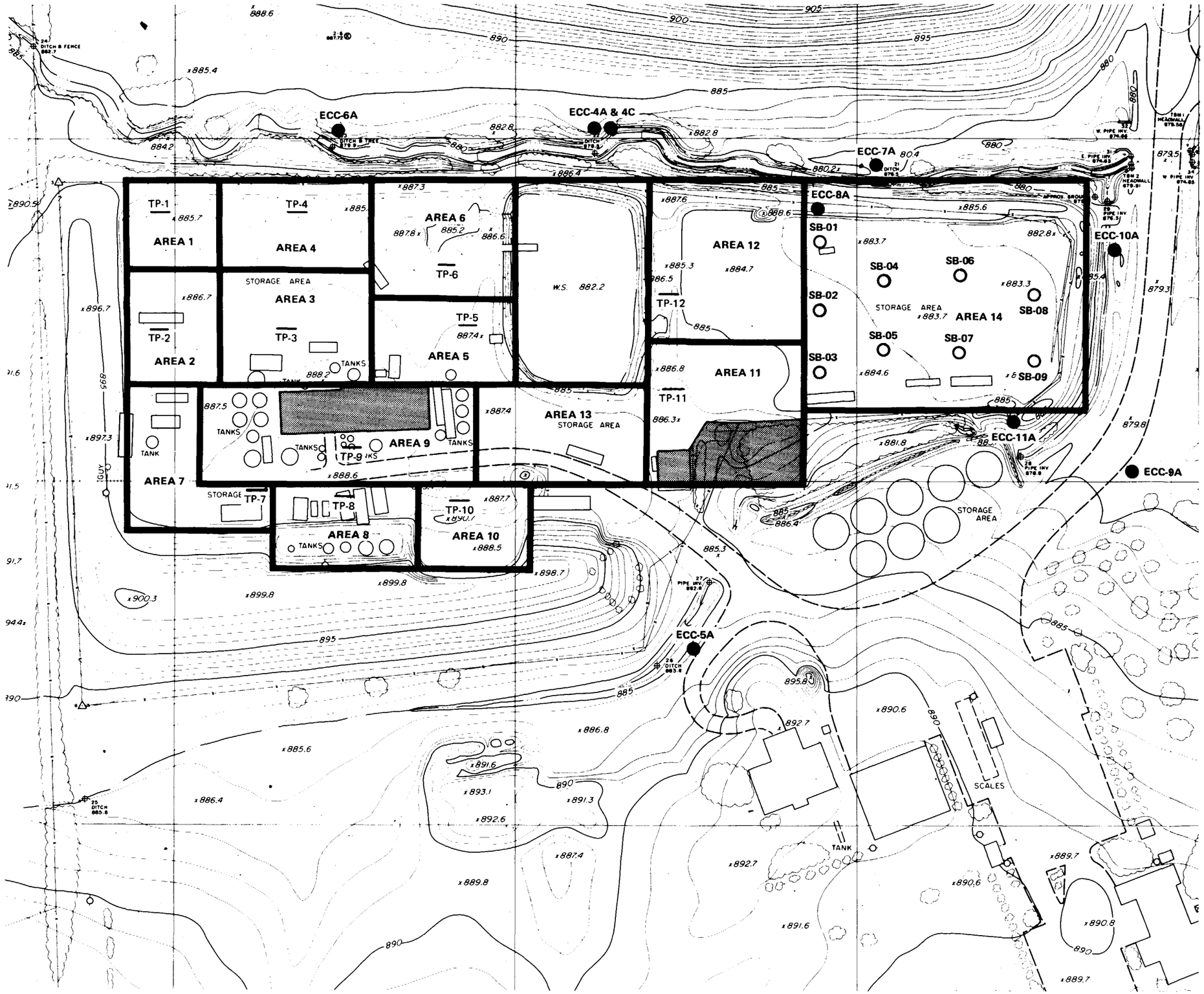
The cleanup strategies and the surviving technologies are described in the above evaluations then used in the assembly of remedial action alternatives.

COST EFFECTIVENESS EVALUATION OF CONTAMINATED SOIL REMOVAL VOLUMES

Three contaminated soil removal options are identified and evaluated: contaminated soil removal to background levels, contaminated soil removal to the 10^{-6} cancer risk level (see Table 3-1), and no soil removal. Areas identified for evaluation of contaminated soil removal are shown in Figure 6-1. The contaminated soil removal to background option involves excavation of an estimated 24,000 yd^3 of soil below the existing cap and concrete pad. The contaminated soil removal to the 10^{-6} risk level involves excavation of an estimated 11,500 yd^3 of soil with contaminant concentrations having a calculated excess lifetime cancer risk of 10^{-6} for a scenario of residents ingesting soil. The no soil removal option consists of leaving the existing contaminated soil in place. Methodology and assumptions used to analyze these soil removal options are presented in Appendix A.

TECHNICAL EVALUATION

The effectiveness of the three soil removal options in removing organic soil contaminants is summarized as follows:



LEGEND

- TEST PIT LOCATION
- SOIL BORING LOCATION
- MONITORING WELL LOCATION
- AREAS EXCLUDED FROM ANALYSIS

NOTE: Map represents topography and onsite features prior to surface cleanup.

All well locations are approximate.

N

0 25 50

SCALE IN FEET

FIGURE 6-1
AREAS IDENTIFIED FOR EVALUATION OF CONTAMINATED SOIL REMOVAL
ECC FS

	Estimated Soil Volume Excavated (yd^3)	Maximum Lifetime Cancer Risk
No Soil Removal	-0-	4×10^{-3}
Contaminated Soil Removal to 10^{-6} Risk Level	11,500	10^{-6}
Contaminated Soil Removal to Background Level	24,000	0

PUBLIC HEALTH, ENVIRONMENTAL, AND INSTITUTIONAL EVALUATION

The no soil removal option does nothing to reduce the potential public health risk if contaminated soils at the site are excavated and exposed in the future. Excess lifetime cancer risk from ingestion of contaminated soil is estimated to be 10^{-3} or less. The contaminated soil removal to the 10^{-6} risk level option reduces the excess lifetime cancer risk due to direct contact or ingestion of soil at the site to below 10^{-6}. The contaminated soil removal to background option eliminates the public health risks due to contaminated soil at the site.

The impact of soil removal on groundwater and surface water contamination was also evaluated. Assuming the site is not capped and a groundwater collection system is installed, time periods necessary for groundwater contaminant concentrations in the shallow saturated zone resulting from soil leachate to reach drinking water quality criteria were estimated:

- No soil removal >100 years
- Soil removal to 10^{-6} risk level 30 years

Estimates of this kind are very tentative and limited in accuracy because of the uncertainties associated with sample data, site characterization, and the developmental nature of the science; however, they are presented here as a practical tool for assessing the relative impacts associated with various remedial actions. A detailed description of the assumptions and methodology used in analyzing the impact of leachate on groundwater is presented in Appendix A.

As discussed in the endangerment assessment of the ECC RI report, public health risks associated with groundwater contaminant migration to surface water under the no action alternative are either at or below the 10^{-6} cancer risk level. This corresponds to the no soil removal option. The soil removal to the 10^{-6} risk level would decrease contaminant levels in surface water by 1 to 4 orders-of-magnitude, with a resulting decrease in cancer risk levels of approximately 2 orders-of-magnitude.

COST

Capital, operation and maintenance, and present worth costs are summarized in Table 6-1. Capital and present worth costs do not reflect the impact of contaminated soil removal or no removal on other potential remedial actions, such as groundwater extraction and treatment.

SOIL REMOVAL OPTION SUMMARY

No soil removal and soil removal to the 10^{-6} cancer risk level are carried forward for incorporation into remedial action alternatives. The no soil removal option is retained to allow comparison of public health impacts for a low-cost option versus a more expensive soil removal option. Removal of soil to the 10^{-6} risk level is carried forward since additional soil removal to background concentrations does not provide substantial public health or environmental benefits, yet costs an additional $4.5 million in present worth.

COMPARISON OF CAPPING OPTIONS

One objective of capping the site is to cost effectively protect public health from soil contaminant migration to groundwater and surface water. A second objective is to protect against direct contact with contaminated soil.

Two capping options were carried forward from screening (Chapter 5), the soil-clay cap and the soil-synthetic membrane-clay cap (see Figure 5-1). Analysis of leachate-groundwater interaction suggests that a more permeable cap may be beneficial in reducing the duration of groundwater extraction and treatment for alternatives with groundwater extraction. Therefore, a cap constructed of materials with a permeability similar to the existing soil at the site (assumed more permeable than the soil-clay and/or soil-synthetic membrane-clay caps) is brought forward for further consideration.

This last option, referred to as the silty-clay cap, would include an additional 1 foot of silty clay and 6 inches of loam over the existing silty-clay cap to prevent surface erosion and runoff of contaminants found on the present cap and to prevent direct contact with the present cap. Prior to construction of the caps, the site would be graded to result in slopes of 4 percent to allow surface runoff from the cap. The cap would be placed over the existing silty-clay cap and concrete pad and would cover an area of 157,000 ft^2.

TECHNICAL EVALUATION

The assumed hydraulic conductivity of the caps effective over their operational life are:

Table 6-1
SOIL REMOVAL
COST COMPARISON

	Contaminated Soil Removal to Background Construction Cost	Contaminated Soil Removal to 10^{-6} Risk Level Construction Cost
Site Preparation		
Soil Testing Prior to Excavation	$ 43,000	$ 43,000
Building and Foundation Removal	35,000	35,000
Concrete Pad Removal	95,000	95,000
Soil Excavation		
Soil Removal/Stockpile	63,000	37,000
Decontamination of Equipment	6,000	3,000
Disposal of RCRA and Landfill		
Truck Lining and Loading	300,000	140,000
Haul Soil and Waste	1,320,000	650,000
Disposal Fee	2,380,000	1,150,000
CONSTRUCTION SUBTOTAL	$4,240,000	$2,150,000
Mobilization/Demobilization (5%)	210,000	110,000
Health and Safety (15%)	640,000	320,000
Bid Contingency (15%)	640,000	320,000
Scope Contingency (25%)	1,060,000	540,000
CONSTRUCTION TOTAL	$6,790,000	$3,440,000
Permitting (2%)	140,000	70,000
Services During Construction	200,000	100,000
TOTAL IMPLEMENTATION COST	$7,130,000	$3,610,000
Engineering Design Cost	60,000	50,000
TOTAL CAPITAL COST	$7,190,000	$3,660,000

GLT533/48

- Silty-clay cap 10^{-5} cm/sec
- Soil-clay cap 10^{-7} cm/sec
- Soil-synthetic membrane-clay cap 10^{-9} cm/sec

The soil-synthetic membrane-clay cap offers greatest effectiveness in limiting infiltration of water to underlying contaminated soil because of the synthetic membrane used in addition to the clay cap. Reliability is good for all the caps although an extra degree of reliability is obtained by having two relatively impermeable layers. Long-term maintenance and monitoring is required for all caps to prevent trees, shrubs, and burrowing animals from penetrating the clay or synthetic membrane and insure the performance of the capping system.

PUBLIC HEALTH, ENVIRONMENT, INSTITUTIONAL EVALUATION

Public health impacts of the capping options were evaluated for both the no soil removal and the soil removal to the 10^{-6} risk level. Impacts related to groundwater contamination from leaching of soil contaminants were assessed based on estimated concentrations of selected indicator VOC's in the groundwater and the time period necessary to meet drinking water quality criteria. It is emphasized that these durations are very limited in accuracy because of the many layers of uncertainty imposed by the necessary assumptions and developmental state of the science. They are presented as a practical tool for assessing the relative impacts associated with the various remedial options.

For the no soil removal option, the following summed peak concentrations of TCE, PCE, TCA, methylene chloride and ethyl benzene were calculated:

- Silty-clay cap 1,200,000 ug/L
- Soil-clay cap 1,200,000 ug/L
- Soil-synthetic membrane-clay cap 45,000 ug/L

Assuming groundwater is not collected and treated, the period during which drinking water quality criteria for groundwater is exceeded would be greater than 200 years for all options. The soil-synthetic membrane-clay cap would offer the greatest public health benefit in this case since VOC groundwater concentrations are greatly reduced. The soil-synthetic membrane-clay cap also reduces impacts from migration of contaminated groundwater to surface water. Cancer risks from dermal absorption of surface water contaminants are reduced from 6×10^{-7} for the silty-clay and soil-clay caps to 2×10^{-8} for the soil-synthetic membrane-clay cap. Cancer risks from ingestion of fish are reduced from 3×10^{-6} to 1×10^{-6}.

Assuming groundwater is collected and treated, surface water contamination from groundwater discharge is essentially eliminated and the time period for collection and treatment of groundwater becomes a more appropriate evaluation criteria of the capping options. In this case, the estimated groundwater collection period for the silty-clay cap option is about 130 years, while the other capping options are estimated to require periods greatly in excess of 200 years. As discussed previously, estimates of groundwater collection periods are very tentative and are intended for comparative purposes only.

Groundwater collection and treatment periods are also less under the silty-clay capping option if limited soil removal (soil removed to 10^{-6} risk level) is undertaken. In this case, the groundwater collection and treatment periods are:

o	Silty-clay	30 years
o	Soil-clay cap	40 years
o	Soil-synthetic membrane-clay cap	>200 years

Effects on terrestrial or aquatic biota are not expected with any of the capping options because groundwater is collected and treated. Institutional considerations of importance are related to meeting requirements of RCRA. All caps meet requirements for contaminated soil left in place.

COST

Capital, operation and maintenance and present worth costs are summarized in Table 6-2.

CAPPING OPTION SUMMARY

Based on the previous evaluations the capping option included for alternatives not including groundwater collection and treatment is the soil-synthetic membrane-clay cap. Though the silty-clay and soil-clay caps can be an effective cap given good maintenance, the uncertainties in long-term maintenance and calculations of transport and public health risks make the additional safety factor of the soil-synthetic membrane-clay cap desirable, even though the costs are greater.

For alternatives incorporating groundwater collection and treatment, the soil-synthetic membrane-clay cap appears less desirable than a more permeable silty-clay cap since it would require a greater collection and treatment period (>200 years). In this case, the silty-clay cap is retained to reduce the period for groundwater collection and treatment.

Table 6-2 (Page 1 of 3)
CAPPING
COST COMPARISON

	Construction Costs	Annual Operation & Maintenance
SOIL - CLAY CAP		
Site Preparation		
Building Removal/Disposal	$ 23,000	
Cap Construction		
Compacted Clay, 1 foot	76,000	
Fill, 1.5 feet	44,000	
Top soil, 0.5 foot	15,000	
Vegetative Cover	5,000	
Decon Equipment and Waste Disposal	9,000	
Inspection, Repairs, and Maintenance		6,000
CONSTRUCTION SUBTOTAL	$172,000	
Mobilization/Demobilization (5%)	9,000	
Health and Safety (15%)	26,000	
Bid Contingencies (15%)	26,000	
Scope Contingencies (20%)	34,000	
CONSTRUCTION TOTAL	$267,000	
Permitting and Legal (3%)	8,000	
Services During Construction	75,000	
TOTAL IMPLEMENTATION COST	$350,000	
Engineering Design Cost	50,000	
TOTAL CAPITAL COST	$400,000	
ANNUAL OPERATION AND MAINTENANCE		6,000
PRESENT WORTH[a]		$460,000

Table 6-2 (Page 2 of 3)

	Construction Costs	Annual Operation & Maintenance
SOIL - SYNTHETIC MEMBRANE-CLAY CAP		
Site Preparation		
Building Removal/Disposal	$ 23,000	
Cap Construction		
Compacted Clay, 2 feet	151,000	
Synthetic Membrane, 30 mil PVC	32,000	
Sand and Gravel, 1.5 feet	122,000	
Fill, 1 foot	29,000	
Vegetative Cover	5,000	
Geotextile	53,000	
Decon Equipment and Waste Disposal	18,000	
Inspection, Repairs, and Maintenance		6,000
CONSTRUCTION SUBTOTAL	$433,000	
Mobilization/Demobilization (5%)	22,000	
Health, and Safety (10%)	43,000	
Bid Contingencies (15%)	65,000	
Scope Contingencies (20%)	87,000	
CONSTRUCTION TOTAL	$650,000	
Permitting and Legal (5%)	33,000	
Services During Construction (10%)	125,000	
TOTAL IMPLEMENTATION COST	$810,000	
Engineering Design Cost	80,000	
TOTAL CAPITAL COST	$890,000	
Present Worth of Cap Replacement[b]	24,000	
ANNUAL OPERATION AND MAINTENANCE		6,000
PRESENT WORTH[a]		$970,000

Table 6-2 (Page 3 of 3)

	Construction Costs	Annual Operation & Maintenance
SILTY-CLAY CAP		
Site Preparation		
Building and Foundation Removal/Disposal	$ 35,000	
Cap Construction		
Silty-clay, 1.5 ft	113,000	
Topsoil, 0.5 ft	15,000	
Vegetative cover	5,000	
Decon Equipment and Waste Disposal	7,000	
Inspection, Repairs, and Maintenance		6,000
CONSTRUCTION SUBTOTAL	$175,000	
Mobilization/Demobilization (5%)	9,000	
Health, and Safety (15%)	26,000	
Bid Contingencies (15%)	26,000	
Scope Contingencies (20%)	35,000	
CONSTRUCTION TOTAL	$270,000	
Permitting and Legal (3%)	8,000	
Service During Construction	80,000	
TOTAL IMPLEMENTATION COST	$360,000	
Engineering Design Cost	50,000	
TOTAL CAPITAL	$410,000	
ANNUAL OPERATION AND MAINTENANCE		6,000
PRESENT WORTH[a]		$470,000

[a]Present worth at 10 percent interest over 30 years.
[b]Present worth of replacing cap at year 30.

GLT533/64

COMPARISON OF THERMAL VOLATILIZATION AND SOIL VAPOR EXTRACTION

Thermal volatilization and soil vapor extraction are compared here since their public health and environmental benefits are similar and the cost effectiveness of the technologies are not dependent on other components of potential remedial action alternatives. The technologies are described in Chapter 5.

TECHNICAL EVALUATION

Both technologies have similar performance in removing VOC's from soil. Reliability of vapor extraction is considered greater due to more proven performance and less of a need for trained operating personnel. Both would result in removal of some semi-volatiles although thermal volatilization would likely be more effective. The time necessary to achieve results is less for thermal volatilization (operation period of 6 months) than for vapor extraction (up to 4 years). Both would require similar time for permitting and startup.

PUBLIC HEALTH, WELFARE, ENVIRONMENT, AND INSTITUTIONAL EVALUATION

Public health benefits are similar for the two technologies. Each results in removal of VOC's from soils to the 10^{-6} cancer risk levels for direct contact. Public health impacts resulting from air emissions from either of the technologies would be mitigated with granular activated carbon (GAC) treatment. Costs for GAC treatment of air emissions are expected to be similar and were not included for this comparison.

COST EVALUATION

Costs of soil vapor extraction and thermal volatilization are presented in Table 6-3. Soil vapor extraction present worth costs are substantially less than thermal volatilization costs. Since technical and public health evaluations are not appreciably different, thermal volatilization will not be considered further.

SLURRY WALL GROUNDWATER CONTAINMENT

This section evaluates the containment of contaminated groundwater at the site using a slurry wall technology. Slurry walls are implemented to contain contaminated groundwater and reduce the volume of water contacting contaminated material in the saturated zone. Generally, efficient and cost-effective application of slurry wall technologies involves an environmental setting where a relatively impermeable base layer at a reasonable depth is available for the wall to be

Table 6-3 (Page 1 of 2)
THERMAL VOLATILIZATION AND SOIL VAPOR EXTRACTION
COST COMPARISON

	Construction Cost	Annual Operation & Maintenance
THERMAL VOLATILIZATION		
Rotary Dryer System		
Equipment	$ 100,000	
Soil Treatment	1,400,000	
Soil Excavation		
Site Preparation		
Soil Testing Prior to Excavation	$ 43,000	
Building and Foundation Removal	35,000	
Concrete Pad Removal	95,000	
Soil Excavation		
Soil Removal/Stockpile	37,000	
Decontamination of Equipment	3,000	
Disposal of Treated Soil Onsite	23,000	
CONSTRUCTION SUBTOTAL	$1,740,000	
Mobilization/Demobilization (5%)	90,000	
Health, and Safety (15%)	260,000	
Bid Contingencies (15%)	260,000	
Scope Contingencies (25%)	430,000	
CONSTRUCTION TOTAL	$2,780,000	
Permitting (2%)	60,000	
Services During Construction	250,000	
TOTAL IMPLEMENTATION COST	$3,090,000	
Engineering Design Cost	150,000	
TOTAL CAPITAL COST	3,240,000	
ANNUAL OPERATION AND MAINTENANCE		0
TOTAL PRESENT WORTH		$3,240,000

Table 6-3 (Page 2 of 2)

	Construction Cost	Annual Operation & Maintenance
SOIL VAPOR EXTRACTION		
Vapor Extraction System		
Soil Testing Prior to Installation	$ 43,000	
Pilot Plant and Start up	75,000	
Extraction and Inlet Wells	41,000	
Pipeline	12,000	
Blower Assembly	41,000	23,000
Air Monitoring	4,000	76,000
Startup	8,000	
CONSTRUCTION SUBTOTAL	$224,000	
Mobilization/Demobilization (5%)	11,000	
Health, and Safety (5%)	11,000	
Bid Contingencies (15%)	34,000	
Scope Contingencies (25%)	56,000	
CONSTRUCTION TOTAL	$336,000	
Permitting (3%)	10,000	
Services During Construction	50,000	
TOTAL IMPLEMENTATION COST	$396,000	
Engineering Design Cost	100,000	
TOTAL CAPITAL COST	$496,000	
ANNUAL OPERATION AND MAINTENANCE		99,000[a]
TOTAL PRESENT WORTH[a]		$810,000

[a]Operation of vapor extraction system for 4 years.

GLT533/63

keyed into and where the in situ saturated material permeability is high relative to the slurry wall permeability.

Slurry wall technologies to contain contaminated groundwater at the ECC site appear not cost-effective. An impermeable layer to tie the slurry wall into is not available at a feasible depth at the site and the permeability of the shallow saturated zone (estimated 10^{-5} to 10^{-6} cm/sec) is not expected to be much different than that of an installed slurry wall (10^{-6} to 10^{-7} cm/sec).

As a result, the slurry wall is unlikely to result in substantial restriction of groundwater flow and contaminant transport in the shallow saturated zone, and will not be considered further for incorporation into remedial action alternatives.

GROUNDWATER COLLECTION SYSTEM DESIGN

INTRODUCTION

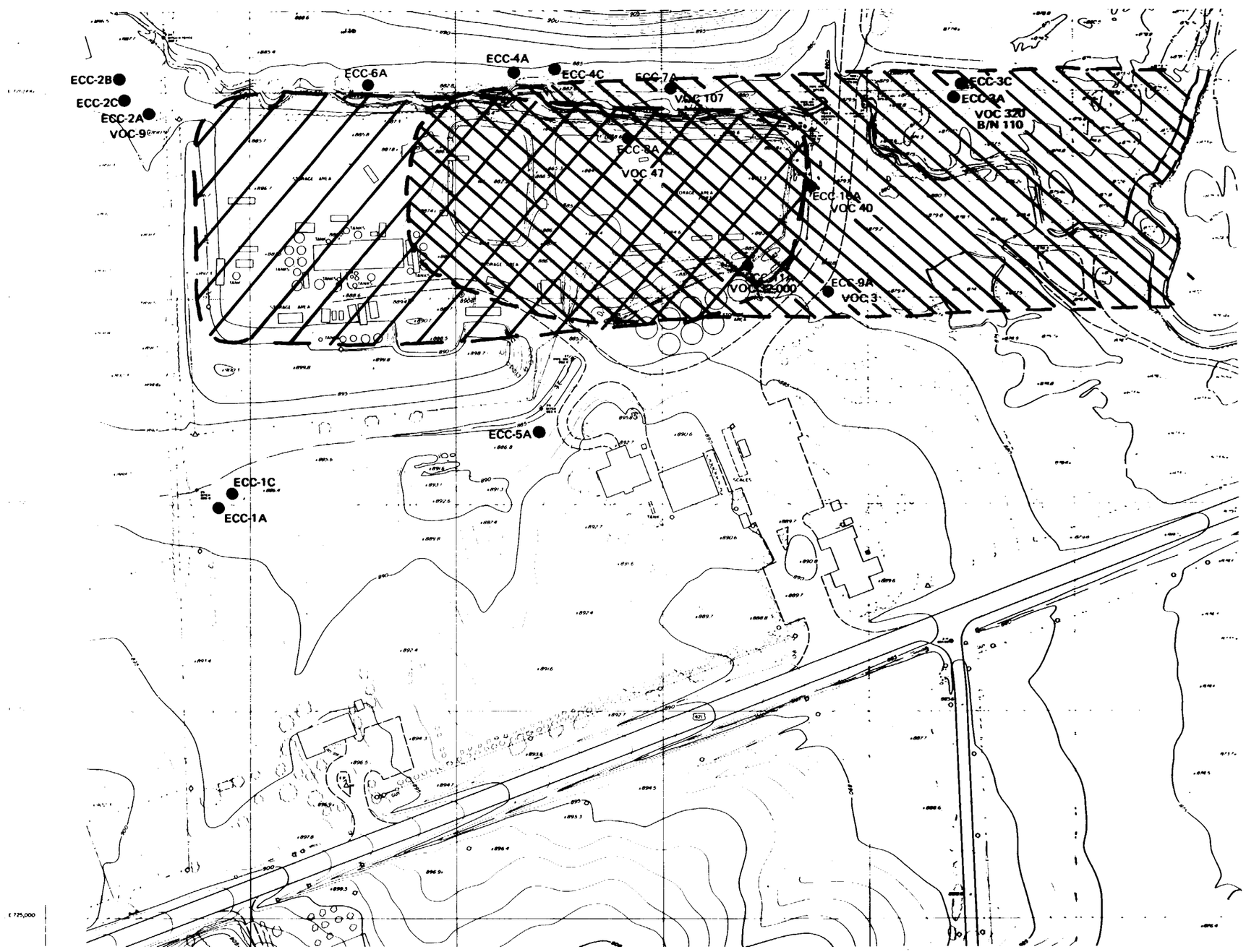
Sampling of groundwater at the ECC site indicates that the shallow saturated zone and underlying sand and gravel deposit are contaminated with compounds from the site. The shallow saturated zone consists of approximately 10 to 18 feet of silty clay. This zone is underlain by approximately 9 feet of sand and gravel. Water level observations during monitoring well installation indicated upward vertical hydraulic gradients of approximately 0.25 ft/ft are present between the two saturated zones. Areas of suspected groundwater contamination based on monitoring well sample results and knowledge of the groundwater flow system are shown in Figure 6-2.

Contamination of the shallow saturated zone is related to contaminants migrating downward through the unsaturated soil onsite. The observation of upward hydraulic gradients between the shallow saturated zone and the sand and gravel deposit suggest that contamination of groundwater in the sand and gravel is related to the cooling water pond. The cooling water pond penetrated through the shallow saturated zone and into the underlying sand and gravel allowing potential contaminant access to this zone.

Average horizontal gradients onsite are estimated to range from 0.02 ft/ft over the majority of the site to 0.05 ft/ft near the southern boundary of the site. Groundwater flow is primarily to the south.

Three groundwater collection systems were carried forward from screening and are evaluated here.

- French drains



LEGEND

ECC-7A ● REMEDIAL INVESTIGATION MONITORING WELL

REMEDIAL INVESTIGATION MONITORING WELL SAMPLE RESULTS

VOC- TOTAL VOLATILE ORGANICS (ug/l)

B/N- TOTAL BASE/NEUTRALS (ug/l) (NOT INCLUDING BLANK, FIELD OR LABORATORY INDUCED CONTAMINATION)

AREA OF SUSPECTED SHALLOW SATURATED ZONE CONTAMINATION

AREA OF SUSPECTED SHALLOW SAND AND GRAVEL ZONE CONTAMINATION

NOTE: Map represents topography and onsite features prior to surface cleanup.

All well locations are approximate.

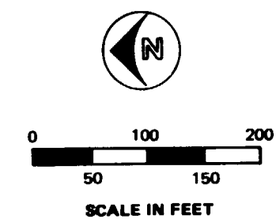


FIGURE 6-2
AREAS OF SUSPECTED GROUNDWATER CONTAMINATION
ECC FS

- Extraction wells
- Extraction wells with injection wells

The objective of the collection system is the efficient containment and removal of existing contaminants in the shallow saturated zone and the sand and gravel deposit. This section summarizes the evaluation of each system.

FRENCH DRAIN SYSTEM

The French drain design was evaluated to estimate its effectiveness in withdrawing water from the shallow saturated zone. As discussed earlier in the screening chapters, French drains were not considered for the sand and gravel deposit since they are generally not cost-effective in high permeability materials.

French drains placed in the saturated zone would allow extraction of existing contaminants as well as maintaining upward vertical gradients from the underlying sand and gravel zone. The vertical gradients would assist in the flushing of contaminants from the shallow saturated zone. The assumptions made in the configuration of the French drain system are as follows:

- The water table is assumed to begin 5 feet below ground surface.
- The saturated zone thickness of the silty-clay layer is 12 feet.
- The hydraulic conductivity, K, of the shallow saturated zone is 1×10^{-5} cm/sec and is isotropic and homogeneous over the entire site area.
- The water table at the midpoint between drains would remain at the present elevation.
- An upward vertical gradient of 0.25 ft/ft exists between the shallow saturated zone and the underlying sand and gravel.
- The drains are 2 feet wide and 16 feet deep.

The calculations for the configuration of the French drain system are based on a mass balance approach. The groundwater discharge into the drains is equal to the recharge due to infiltration through the unsaturated zone and flow upward from the sand and gravel deposit. The drain spacing is sensitive to changes in the value for the vertical gradient used in the calculation of the recharge from the sand and gravel aquifer. Assuming that the upward gradient was 0.25 ft/ft, the drain spacing was calculated to be 40 ft. Containment and collection of contaminated groundwater in

the shallow saturated zone requires an estimated 17 drains with a 40-foot spacing between drains (Figure 6-3). The total discharge into each drain was estimated to be about 0.5 gpm, yielding a total discharge of 8 gpm for all the drains. This extraction rate is approximately equivalent to one pore volume exchange per year.

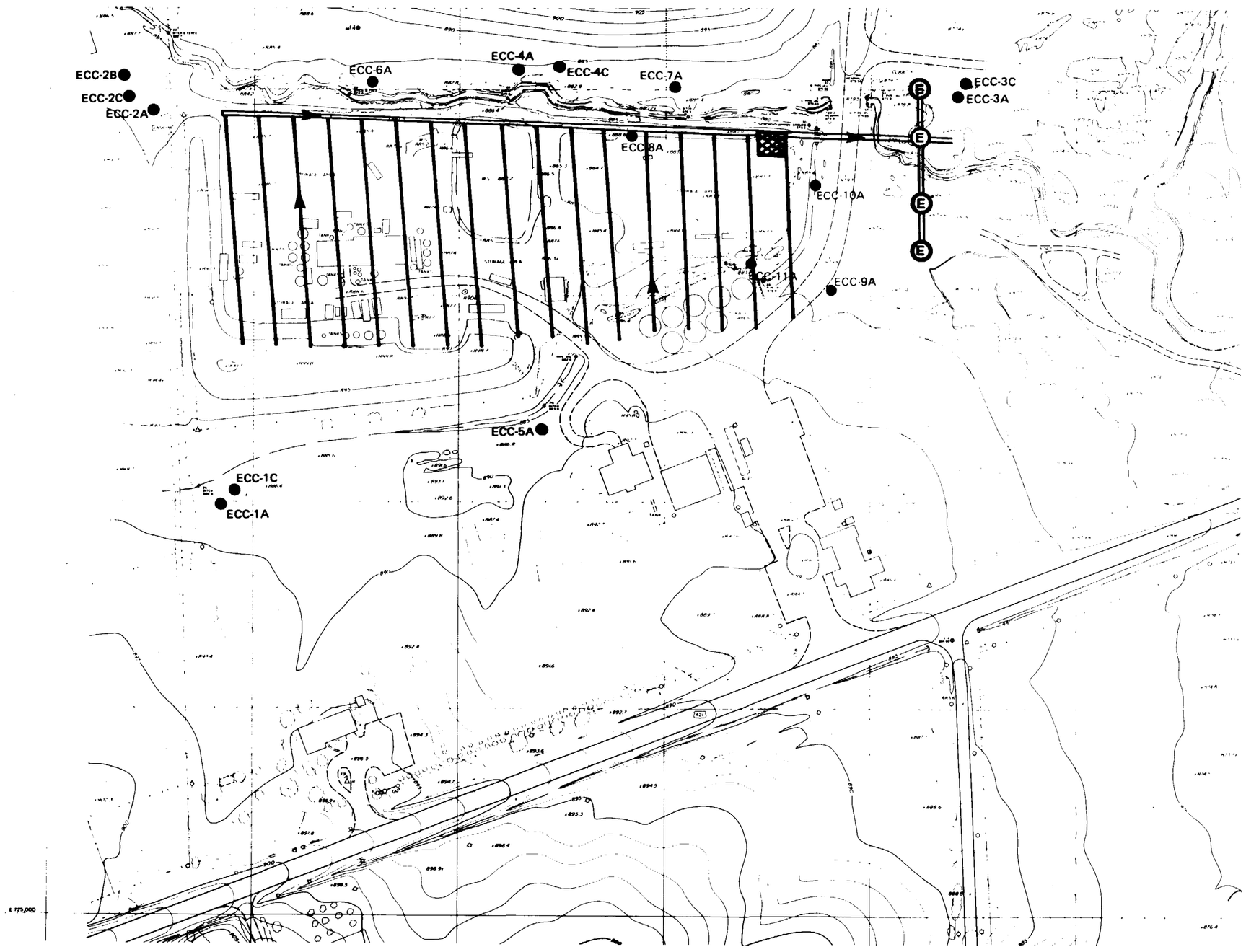
EXTRACTION WELL SYSTEM

Extraction wells were evaluated for use in the shallow saturated zone and the sand and gravel deposit. The use of extraction wells in the shallow saturated zone would not be effective because of the low hydraulic conductivity of the silty clays. Based on the estimated hydraulic conductivity of 1×10^{-5} cm/sec for the saturated zone, a maximum pumping rate of about 0.1 gpm could be attained. This rate is too low to allow effective withdrawal of contaminated groundwater from the shallow saturated zone.

An extraction well collection system was configured for the sand and gravel aquifer. The assumptions made were:

- The sand and gravel deposit was assumed to hydraulically behave as a confined aquifer.
- The hydraulic conductivity of the sand and gravel deposit was 1×10^{-2} cm/sec and the aquifer was assumed to be isotropic and homogeneous with respect to the hydraulic conductivity.
- The average saturated thickness of the sand and gravel deposit was 9 feet.
- The average regional gradient varies from 0.02 on the northern area of the site to 0.05 near the southern site boundary.

The steady-state flow equations for wells in a regional flow field were used to calculate the pumping rate and well spacing. Assuming that the wells are 4 inches in diameter and fully penetrating (to the bottom of the sand and gravel deposit), a pumping rate of 12 gpm was calculated. With a pumping rate of 12 gpm, four extraction wells spaced at approximately 60 feet apart would be sufficient to capture the contaminant plume (see Figure 6-3). The wells would be placed downgradient from the site to contain contaminated groundwater and to avoid drawing contaminants in the saturated zone beneath the site downward into the sand and gravel zone. The drawdowns for each well would be about 7 feet and the capture zones of the wells would extend approximately 60 feet down gradient from the wells. The wells are not expected to noticeably affect flows in Finley Creek.



LEGEND

- ECC-7A — REMEDIAL INVESTIGATION MONITORING WELL
- SUMP
- FRENCH DRAINS
- PIPING
- GROUNDWATER EXTRACTION WELLS

NOTE: Map represents topography and onsite features prior to surface cleanup.

All well locations are approximate.

0 100 200
50 150
SCALE IN FEET

FIGURE 6-3
GROUNDWATER COLLECTION SYSTEM
ECC FS

Based on the pumping rate of 12 gpm, an estimated three months would be required to develop a steady state drawdown of 7 feet. The extraction well system is estimated to operate 4 years to reduce contaminant concentrations in the sand and gravel deposit to below Ambient Drinking Water Quality Criteria. This estimate is based on several simplifying assumptions and is intended for comparative purposes. Actual time to groundwater cleanup may be greater.

EXTRACTION-INJECTION WELL SYSTEM

A collection system incorporating extraction wells together with injection wells was considered for the sand and gravel deposit. Extraction-injection wells are not reasonable for the saturated zone for the same reasons the extraction wells alone were not considered.

The objective of an extraction-injection well system is two-fold:

- To expedite the removal of contaminants from the sand and gravel deposit beneath the site.
- To prevent reversal of the upward gradients from the sand and gravel deposit to the saturated zone.

Public health, environmental, and cost benefits of the extraction-injection well system would be related to the decreased collection period for the contaminated groundwater in the sand and gravel zone onsite. At ECC, however, decreasing the collection period is not considered cost-effective since contaminants would still remain in the overlying shallow saturated zone and collection and treatment of contaminated groundwater would still be required. The sand and gravel deposit beneath the site is essentially unuseable for the entire collection period of the shallow saturated zone (in excess of 100 years.) As a result the greater costs of an extraction-injection well system are not justified.

GROUNDWATER TREATMENT TECHNOLOGIES

Four groundwater treatment options survived the screening process. They are:

- Onsite air stripping treatment
- Onsite activated carbon adsorption treatment
- Offsite treatment at a POTW
- Offsite treatment at an RCRA facility

Each would treat groundwater collected in French drains from the shallow saturated zone and groundwater collected from the sand and gravel zone extraction wells. The treatment system must be capable of treating 56 gallons per minute

from the combined collection systems for the first 4 years of operation and 8 gallons per minute from the French drains for over 100 years.

Groundwater contaminant concentrations are based on RI data and leachate calculation projections presented in the ECC RI report. Table 6-4 presents groundwater contaminant concentrations for indicator chemicals for both collection cases.

EFFLUENT DISCHARGE CRITERIA

Discharge limits for treatment are set during the NPDES permit process. There is no list of standards or criteria applicable for all waterways. The permit writer would consider the water use designation for the particular receiving water, relevant state water quality standards and federal water quality criteria and other scientific data.

Finley Creek and Eagle Creek are "waters of the State of Indiana" and have been given the aquatic life (warm water fishery) and partial body contact recreation water use designation. Any discharge of treated groundwater should help maintain those uses.

Indiana water quality standards are for concentrations outside the mixing zone. Because both Eagle Creek and Finley Creek seasonally may have no flow, no mixing factor will be considered and effluent discharges will be compared directly to criteria.

Table 6-4 list criteria that will be used in this feasibility study for accessing discharge concentrations of groundwater treatment alternatives. The first two categories (1/10 LC_{50} and AWQC aquatic life) address aquatic population effects. The next two (AWQC aquatic life-human use and 10^{-6} excess life cancer risk levels from fish consumption) address human use of the fishery. The final category (excess lifetime cancer risk levels from wading) addresses the partial body contact recreation use. Because the NPDES permit process would consider all these factors, the feasibility study assumes treatment facility discharges must meet all of these categories.

Neither Finley Creek or Eagle Creek are designated for domestic (potable water) uses. It does not appear that domestic use will be a reasonable future use of either creek. While Eagle Reservoir is a water source, permitted discharge to Finley Creek would undergo an average dilution of 1,300 to 1 (assuming average flow at the reservoir of 150 cfs) by the time it arrives at the reservoir. Contaminant levels would be further reduced in the reservoir due to degradation and volatilization during the estimated minimum 45 day residence time. A conservative estimate of treatment system

Table 6-4

PROJECTED GROUNDWATER (GW) CONTAMINANT CONCENTRATIONS AND WATER QUALITY CRITERIA (ug/L)

	French Drain Collection Average GW Concentration[h]	Extraction Wells and French Drains Collection Average GW Concentration	Water Quality Criteria Applicable to Treatment Effluent						AWQC Drinking Water[d]	Drinking Water Act MCL's[g]
			One-Tenth 96 hr LC 50[c]	Protection of Aquatic Life[d]		Consumption[d] of Aquatic Organisms	10^{-6} Excess Lifetime Cancer Risk Fish Consumption[e]	10^{-6} Excess Lifetime Cancer Risk Wading[f]		
				Acute	Chronic					
1,1,1 Trichloroethane	40,200	5,760	5,280	18,000	-	1,030,000[b]	-	-	19,000[b]	200
1,1,2 Trichloroethane	25	4	9,400	18,000	9,400	41.8[a]	43	51	0.6[a]	-
Chloroform	190	27	-	28,900	1,240	15.7[a]	43	42	0.19[a]	100
Ethylbenzene	5,500	790	4,230	32,000	-	3,280[b]	-	-	2,400[b]	-
Methylene Chloride	101,300	14,500	19,300	-	-	15.7[a]	3,610	4,669	0.19[a]	-
Tetrachloroethene	4,000	580	1,840	5,280	840	8.85[a]	11	84	0.8[a]	10
Toluene	28,300	4,000	3,400	17,500	-	-	-	-	15,000[b]	-
Trichloroethene	100,000	14,300	4,020	45,000	-	80.7[a]	56	155	2.8[a]	5
Phenol	76,300	10,900	570	10,200	2,560	769,000[b]	-	-	3,500[b]	-
Bis-2-ethylhexyl phthalate	0.005	0.0007	-	11,100	-	50,000[b]	-	-	21,000[b]	-
Di-n-butyl phthalate	0.5	0.007	-	940	-	154,000[b]	-	-	44,000[b]	-
Diethyl phthalate	50	7	-	52,100	-	1,800,000[b]	-	-	434,000[b]	-
Dimethyl phthalate	125	18	-	33,000	-	2,900,000[b]	-	-	350,000[b]	-

[a] Represents 10^{-6} excess lifetime cancer risk level
[b] Toxic effects
[c] Based on published 96 hour median lethal concentration, (Verschueren, 1983)
[d] 1980 Federal Ambient Water Quality Criteria
[e] Based on 6.5 grams fish/per person adjusted for age and body wet, using published bioconcentration factors (ICF, 1984)
[f] Based on same criteria as in endangerment assessment
[g] Proposed maximum contaminant level (MCL)
[h] Source: ECC RI Report, March 14, 1986
___ Underline designates the lowest AWQC of applicable categories.

GLT533/39

discharge limits for protection of drinking water use at the reservoir was calculated using the dilution factor multiplied by drinking WQC. None of the resulting limits were below the lowest of the aforementioned WQC.

AIR STRIPPING

Air stripping is a unit process in which water and air are brought into contact for the purpose of transferring volatile substances from a solution in a liquid to a solution in a gas. The driving force in this process is the tendency for a volatile compound in solution to reach its equilibrium concentration relative to the partial pressure of this compound in the air in contact with the solution. The partition, or Henry's Law constant, indicates how volatile a compound is by expressing the equilibrium ratio of the compound in the air and water. This constant is, therefore, the primary parameter for determining how efficiently a compound can be removed by an air stripper.

An air stripper was sized for treatment of the effluent from the French drains and extraction well collection system. The air stripper was designed based on removal of chloroform, methylene chloride, 1,1,2-trichloroethane, trichloroethylene, tetrachloroethylene and phenol. These contaminants were chosen based on one or more of the following criteria:

- Carcinogenic
- Low Henry's Law constant
- High concentration levels
- Exceeds water quality criteria

The air stripper was sized initially for removal of methylene chloride. A packed tower with a column height of 30 feet, diameter of 3 feet, and air flow rate of 1,600 scfm was found necessary to remove 99.99 percent of methylene chloride and achieve effluent WQC. It would also achieve WQC for chloroform, 1,1,2-trichloroethane, trichloroethene, and tetrachloroethene. WQC for phenol, however, would not be met as removal efficiency is limited to 5 percent. To meet WQC for phenol, a removal efficiency of 96 percent is needed. This would require over 200 towers, each with a column height of 21 feet. A system this large is clearly not cost-effective and as a result, air stripping is not considered a feasible treatment technology.

GRANULAR ACTIVATED CARBON

The granular activated carbon (GAC) process removes contaminants from groundwater by contacting the stream with a solid, activated absorbent. Organic compounds and some inorganic species become bound to the surface of the carbon particles (adsorption) and are subsequently removed along with the

adsorbent. Activated carbon has a finite capacity to adsorb organics. The actual capacity varies depending on the specific contaminants in the water and their tendency to adhere to the carbon.

The primary design criteria for carbon systems are surface loading and empty bed contact time. Other important design considerations are bed volume, vessel configuration, and pore structure of the carbon particle. Granular carbon systems generally consist of vessels in which the carbon is placed, forming a "filter" bed. Usually, multiple carbon vessels are used to allow continuous operation. Columns can be operated in series or parallel modes and with upward or downward flow. Vessels are backwashed periodically. Once the carbon adsorption capacity has been fully utilized, the carbon must be disposed of or regenerated. Because of the low carbon usage rate at ECC, the carbon would be disposed of after use at a licensed RCRA facility.

A packaged adsorber system was chosen to minimize design and development requirements. The GAC module consists of two pressure adsorbers operating upflow in a series arrangement. Table 6-5 provides more descriptive details for this system.

Technical Evaluation

The GAC system would remove all contaminants to levels below water quality criteria. Reliability of the system is good, although regular effluent testing is required during operation. Implementation could be accomplished quickly with treatment begun within 6 months.

Public Health, Welfare, Environment and Institutional Evaluation

Public health risks above the 10^{-6} cancer risk level are not expected from the GAC effluent discharge. No adverse impacts on aquatic life are anticipated for the effluent.

Cost

Capital, operation and maintenance, and present worth costs are presented in Table 6-6.

OFFSITE TREATMENT AT A PUBLICLY-OWNED TREATMENT WORKS

The Zionsville POTW is a potential facility for offsite treatment of the groundwater. It is approximately 5 miles from the site. The POTW is a secondary trickling filter plant serving the Zionsville corporate community. The system is undergoing proposed expansion to include activated sludge reactors, doubling its present capacity of 0.5 mgd. Two

Table 6-5
GRANULAR ACTIVATED CARBON PROCESS SIZING SUMMARY

Pressure Rating	75 psig
Packed Carbon Bed Volume	120 ft^3/vessel
Number of Vessels	2
Bed Diameter	5 feet
Carbon Weight	3,500 lb/bed
Bed Depth	6 feet each
Flowrate	70 gpm (design)
Residence Time	30 minutes
Carbon Replacement Period	9 months

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Table 6-6
GROUNDWATER TREATMENT BY GRANULAR
ACTIVATED CARBON
COST SUMMARY

	Construction Cost	Annual Operation & Maintenance
Pilot Testing	$ 10,000	
Activated Carbon Adsorber	70,000	29,000
Carbon Replacement	11,000	24,000
Pumps and Piping	20,000	
Backwash Pulse System	11,000	
Building and Chlorination System	15,000	
Surge Tank	12,000	
Carbon Transfer Tanks	7,000	
Startup	2,000	
CONSTRUCTION SUBTOTAL	$158,000	
Mobilization/Demobilization (5%)	8,000	
Health and Safety (15%)	24,000	
Bid Contingencies (15%)	24,000	
Scope Contingencies (20%)	32,000	
CONSTRUCTION TOTAL	$250,000	
Permitting (3%)	10,000	
Services During Construction	50,000	
TOTAL IMPLEMENTATION COST	$310,000	
Engineering Design Cost	100,000	
TOTAL CAPITAL COST	$410,000	
ANNUAL OPERATION AND MAINTENACNE		53,000
TOTAL PRESENT WORTH[a]		$910,000

[a]Present worth at 10 percent interest over 30 years.

GLT533/49

methods of transport of the contaminated groundwater to the POTW were considered, trucking and piping. Piping was chosen because of much lower present worth costs and fewer adverse environmental impacts.

All contaminants will receive some degree of removal as long as concentrations do not exceed levels shown to be inhibitory to biological sludges. Removals in the plant will be primarily due to air stripping in aeration basins, adsorption onto biological floc, and biological degradation. Approximate removal rates and occurrences of selected priority pollutants in wastewater treatment plants similar to the municipal wastewater treatment plant in Zionsville were evaluated and are included in Table 6-7. The fate processes applicable for groundwater contaminants at ECC are also contained in Table 6-7. Expected POTW effluent concentrations are shown where removal rates are available for a combination trickling filter and activated sludge plant. The plant effluent is also shown after dilution in Big Eagle Creek at average and low stream flow.

Technical Evaluation

The removal efficiencies of the indicator groundwater contaminants varies from 52 percent for methylene chloride to 99 percent for 1,1,1-trichloroethane. Resulting effluent concentrations for several contaminants do not attain water quality criteria. Treatment at the POTW would require no different operation or maintenance requirements with the exception of additional effluent and sludge analysis. Implementation would be delayed for at least 2 years until the new activated sludge expansion is completed. VOC emissions to the atmosphere at levels posing a health threat to workers are not anticipated though air monitoring at the POTW would be advisable.

Public Health, Welfare, Environment and Institutional Evaluation

Methylene chloride and tetrachloroethene concentrations in the POTW effluent and in the creek would exceed water quality criteria for consumption of aquatic organisms. Exceedance of these criteria suggest an endangerment to human health exists if the creek was used for fishing. Impacts on aquatic life are not expected from the projected POTW effluent concentrations.

The major institutional concern is the permitting of the discharge to the POTW. Prior arrangements must be made for permitting the discharge with the facility and regional agencies. The current procedure requires review by a detailed advisory committee on behalf of the Town Board, approval of the application to discharge by the Zionsville

Table 6-7
GROUNDWATER CONTAMINANT TREATMENT IN A POTW

Extracted Groundwater Contaminant	Occurrence and Removal of Priority Pollutants in POTWS[d]				Pollutant Fate Process	Treatment of Groundwater at Zionsville POTW				
	% Occurrence in POTWs	Average Concentration (ug/L)	Average Removal TF Plant	Average Removal AS/TF Plant		Average GW Concentration (ug/L)	Influent Concentration (ug/L)	Effluent Concentration[a] (ug/L)	Average Creek[b] Concentration (ug/L)	Maximum Creek[c] Concentration (ug/L)
1,1,1 Trichloroethane	85	343	92	99	V O	40,200	460	4.6	0.067	4.1
1,1,2 Trichloroethane	7				V S	25	0.3			
Chloroform	91	18	75	75	V B	190	2	0.55	0.008	0.49
Ethylbenzene	80	32	90	97	V S B	5,500	63	1.85	0.027	1.60
Methylene Chloride	11	246	76	52	V B	101,300	1200	560	8.10	500
Tetrachloroethene	95	188	82	76	V B P	4,000	46	11	0.16	9.8
Toluene	96	289	88	97	V S B	28,300	320	9.8	0.14	8.7
Trichloroethene	90	86	96	97	V P B	100,000	1150	35	0.51	31
Phenol	79	70	89	94	B P O	76,300	880	53	0.76	47
Bis-2-ethylhexyl phthalate	92	51	72	87	B S	0.005	0.0001	0.000008	0.0000001	0.000007
Di-n-butyl phthalate	64	10	50	97	B S	0.5	0.006	0.00018	0.000003	0.0002
Diethyl phthalate	53	3		91	B S	50	0.6	0.05	0.0007	0.045
Dimethyl phthalate	11				S	125	1.4			

[a] Assuming 8 gpm treated in a 1 mgd TF/AS plant
[b] Assuming 99.4 ft^3/sec average stream flow
[c] Assuming 0.19 ft^3/sec minimum stream flow
[d] Source: "Fate of Priority Pollutants in Publicly Owned Treatment Works", EPA 440/1-82/303.

TF - Trickling filter
AS - Activated sludge
V - Volatilization
B - Biological degradation, transformation, or accumulation
S - Sorption
O - Oxidation/Reduction
P - Photolysis

GLT360/81

Town Board, and permitting through the Town Clerk's office. The existing plant operates at hydraulic loadings in excess of the design capacity during periods of high rainfall and outside contributions to the system have not been accepted for the past 12 years. It is doubtful that approval of any additional discharge would be made until the plant expansion is complete.

Discharge is constrained by sewer use ordinance. Provisions of the ordinance restrict discharges that may damage operation of the biological system or cause deterioration of the effluent. Four compounds expected to appear in the extracted groundwater exceed the average concentration in studied plants; they are, however, within the maximum amounts found during the study. These are ethyl benzene, methylene chloride, trichloroethene, and phenol. These contaminants have been shown to be biodegradable in biological systems and are not considered inhibitory given adequate introduction to the plant to allow for acclimation of the biomass.

Cost

Charges for treatment may be based on established industrial recovery charges for operations and maintenance based on organic and particulate waste load and flow. Long-term discharge agreements may require a capital contribution for the plant works and interceptors. It is currently assumed that usage charges will be primarily on a flow basis as the cost recovery system for the proposed plant expansion has not been developed to date. The sewer use charge in force for the existing plant is approximately $1.14 per 1,000 gallons discharged of municipal wastewater.

Capital, operation and maintenance and present worth costs are presented in Table 6-8.

OFFSITE TREATMENT AT AN RCRA FACILITY

The main components of treatment offsite at an RCRA permitted facility include onsite facilities for storage and tanker truck loading and transport of contaminated groundwater to the facility, followed by treatment. Several facilities within a 200-mile radius of the site were used during surface cleanup activities and these are assumed to be available for treatment of the groundwater. Facilities onsite would include a 100,000-gallon above-ground storage tank and the necessary pumps and piping for filling the tank and tanker trucks. Trucks would transport the groundwater to the RCRA permitted facility.

Table 6-8
GROUNDWATER TREATMENT AT A POTW
COST SUMMARY

	Construction Cost	Annual Operation & Maintenance
Pipeline to POTW	$368,000	
Holding Tank at POTW	15,000	
Pump Station	45,000	
POTW User Charge		50,000[b]
Pumping Cost		10,000[b]
CONSTRUCTION SUBTOTAL	$428,000	
Mobilization/Demobilization (1%)	4,000	
Health and Safety (1%)	4,000	
Bid Contingency (15%)	64,000	
Scope Contingency (20%)	86,000	
CONSTRUCTION TOTAL	$590,000	
Permitting (3%)	20,000	
Services During Construction	80,000	
TOTAL IMPLEMENTATION COST	$690,000	
Engineering Design Cost	80,000	
TOTAL CAPITAL COST	$770,000	
ANNUAL OPERATION AND MAINTENANCE		60,000
TOTAL PRESENT WORTH[a]		$1,040,000

[a]Present worth at 10 percent interest over 30 years.
[b]Operation of extraction well system for 4 years only.

GLT533/60

Technical Evaluation

The performance of offsite treatment is assumed to be effective since it would be regularly monitored as an RCRA facility. Treatment or transport would be reliable and could be implemented quickly. There are no unusual safety concerns for the system.

Public Health and Welfare, Environment and Institutional Evaluation

Impacts from noise and dust generated by trucking the contaminated groundwater are the only substantial public health and welfare impacts of offsite treatment at an RCRA facility, assuming the facility performs according to its permit. No other substantial environmental or institutional impacts were identified.

Cost

Costs of offsite treatment at an RCRA facility are shown in Table 6-9.

SELECTION OF A GROUNDWATER TREATMENT TECHNOLOGY

It is recommended that GAC treatment be the selected groundwater treatment technology for the following reasons:

- GAC is more effective than air stripping or POTW treatment in meeting effluent water quality criteria. Though air stripping could be sized to meet all criteria, present worth costs would far exceed GAC costs.
- POTW treatment, in addition to being more costly than GAC, may be difficult to implement due to permitting requirements.
- Though GAC and offsite treatment at an RCRA facility are both effective, GAC is considerably less costly.
- GAC could be implemented quickly with no problems foreseen for discharge permitting.

ASSEMBLY OF REMEDIAL ACTION ALTERNATIVES

Several remedial action categories have been established by EPA to guide the assembly of remedial action alternatives. These are:

- Alternatives for treatment or disposal at an offsite facility, as appropriate.
- Alternatives that attain applicable or relevant and appropriate Federal public health and environmental requirements.

Table 6-9
GROUNDWATER TREATMENT AT A RCRA FACILITY
COST SUMMARY

	Construction Cost	Annual Operation & Maintenance
Holding Tank 100,000 gal.	$ 100,000	
Transportation to Facility		2,940,000[b]
Treatment		4,420,000[b]
CONSTRUCTION SUBTOTAL	$ 100,000	
Mobilization/Demobilization (1%)	1,000	
Health and Safety (1%)	1,000	
Bid Contingency (15%)	13,000	
Scope Contingency (20%)	17,000	
CONSTRUCTION TOTAL	$132,000	
Permitting (2%)	3,000	
Services During Construction	20,000	
TOTAL IMPLEMENTATION COST	$155,000	
Engineering Design Cost	30,000	
TOTAL CAPITAL COST	$185,000	
ANNUAL OPERATION AND MAINTENANCE		7,360,000
TOTAL PRESENT WORTH[a]		$30,040,000

[a]Present worth at 10 percent interest over 30 years.
[b]Operation of extraction well system for 4 years only.

GLT533/61

- As appropriate, alternatives that exceed applicable or relevant and appropriate Federal public health and environmental requirements.

- As appropriate, alternatives that do not attain applicable or relevant and appropriate Federal public health and environmental requirements but will reduce the likelihood of present or future threat from the hazardous substances and that provide significant protection to the public health and welfare and the environment. This must include an alternative that closely approaches the level of protection provided by the applicable or relevant and appropriate requirements.

- No action

Alternatives falling within each of these categories are assembled here from the remaining remedial technologies shown in Figures 6-4 and 6-5. The assembled remedial action alternatives represent a range of public health and environmental risks as well as costs. They are arranged in order of increasing cost and increasing public health and environmental benefit. They are listed below under each remedial action category and described in the subsequent sections.

NO ACTION

- 1 - No action

ALTERNATIVES THAT DO NOT ATTAIN ALL FEDERAL REQUIREMENTS BUT REDUCE THREAT TO PUBLIC HEALTH, WELFARE, AND ENVIRONMENT

- 2 - Access Restrictions
- 3 - Capping
- 4 - Groundwater Collection and Treatment

ALTERNATIVES THAT ATTAIN FEDERAL PUBLIC HEALTH AND ENVIRONMENTAL REQUIREMENTS

- 5 - Groundwater Collection and Treatment - Soil Vapor Extraction
- 6 - Soil Excavation and Disposal Offsite - Groundwater Collection and Treatment
- 7 - Soil Excavation with Onsite Incineration and Onsite Disposal - Groundwater Collection and Treatment

Alternative 6 also falls within the final category where offsite RCRA facilities are used. An alternative incorporating removal of contaminated soil to background levels would fall within the exceeds standards guidance and advisories

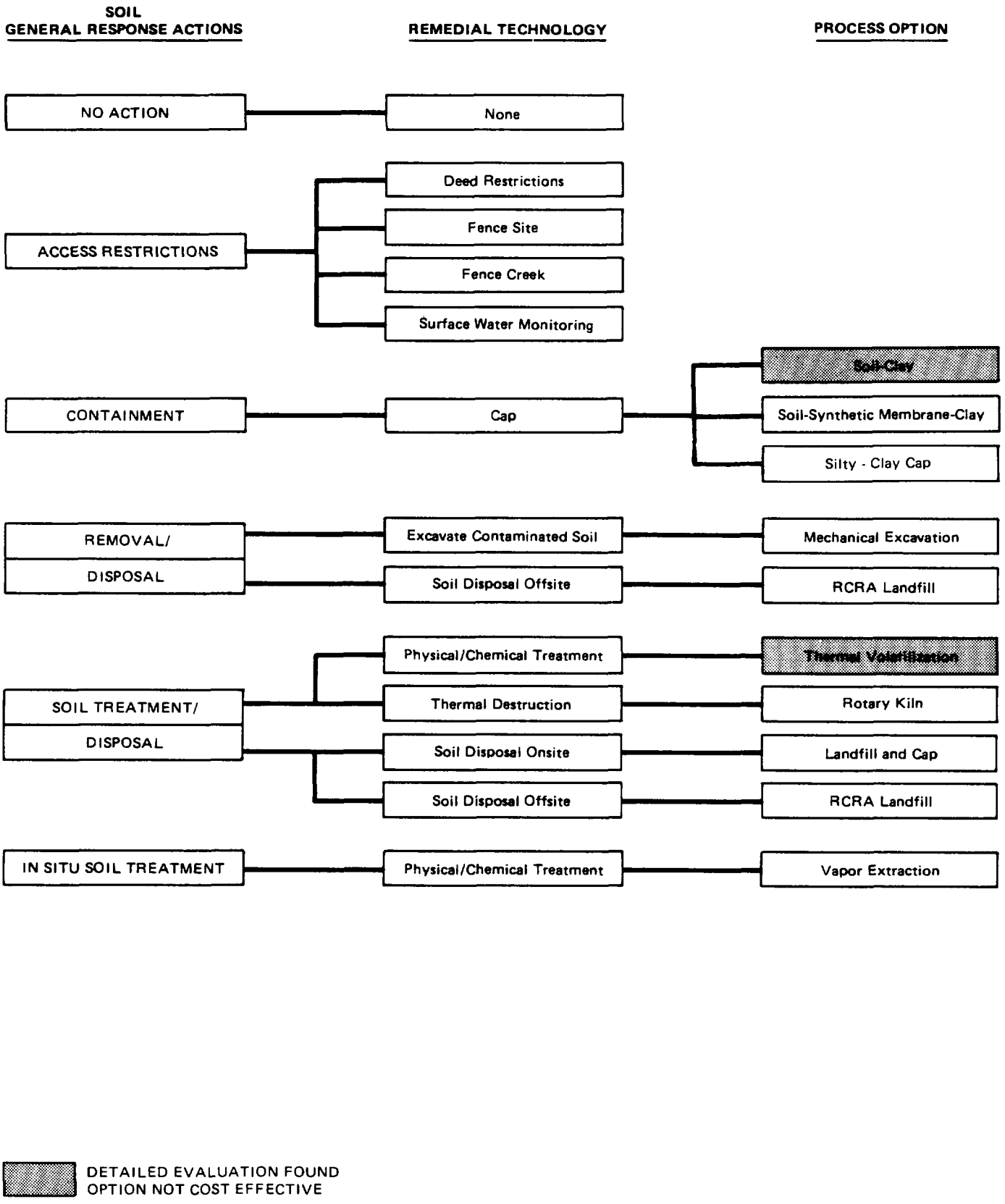


FIGURE 6-4
REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR ASSEMBLY INTO REMEDIAL ACTION ALTERNATIVES - SOIL OPERABLE UNIT
ECC FS

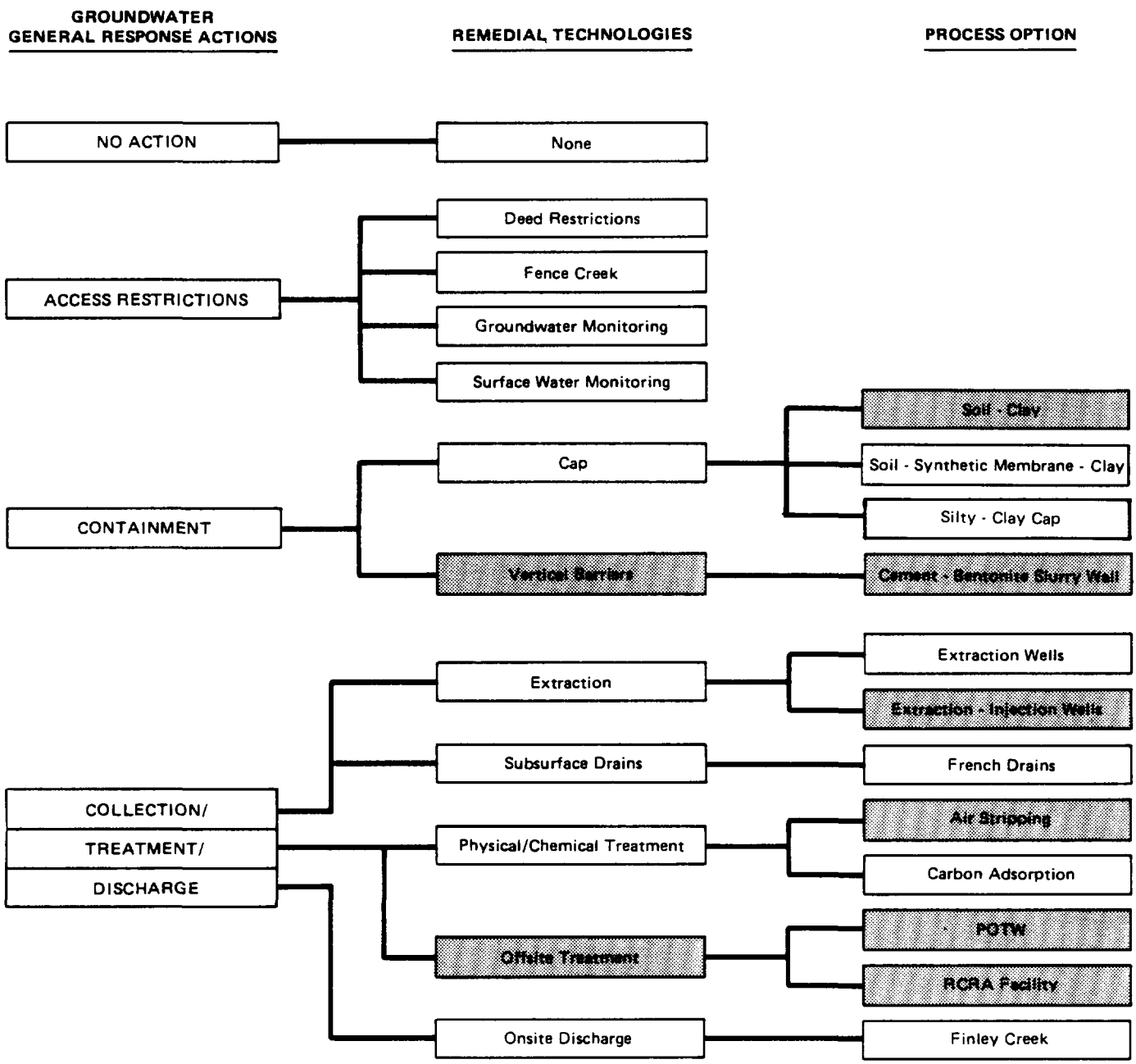


FIGURE 6-5
REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR ASSEMBLY INTO REMEDIAL ACTION ALTERNATIVES - GROUNDWATER OPERABLE UNIT
ECC FS

category. This was considered earlier in the chapter and was not carried forward.

The alternatives presented here demonstrate a reasonable range of overall remediation that may be employed at the ECC site. Additional (or modified) alternatives can be evaluated for selection of the agency's recommended alternative. The selected alternative will undergo further refinement and perhaps be reevaluated during the final design, with the extent determined by modification of the data base and assumptions supporting the alternative.

DESCRIPTION OF ALTERNATIVES

Alternative 1 - No Action

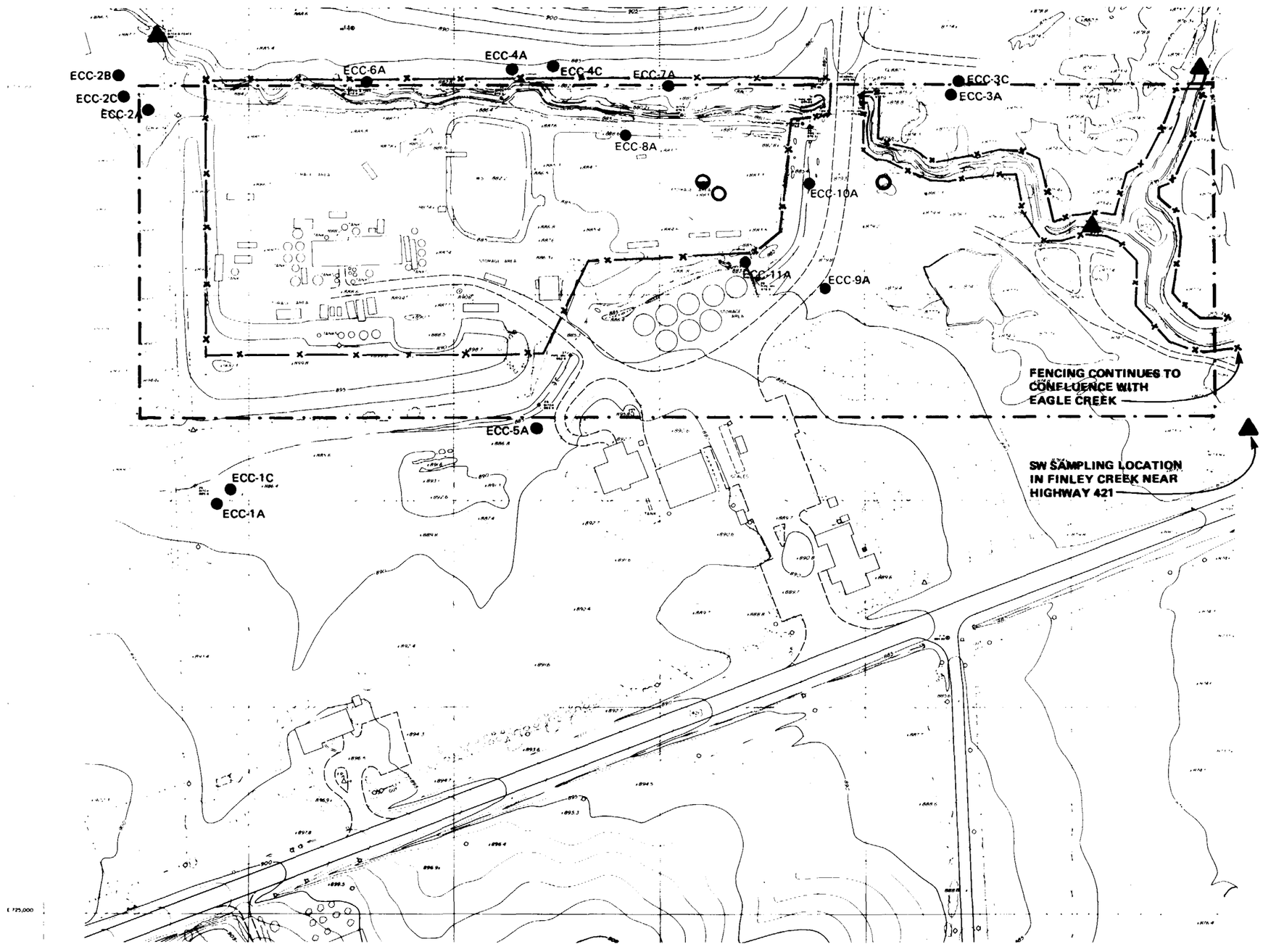
The No Action alternative provides a baseline for comparison of other alternatives. Since remedial actions would not be taken at the site, the public health and environmental risks would be identical to those described in the endangerment assessment. The pathways of most concern are potential future pathways associated with direct contact with excavated soil, ingestion or absorption of contaminated groundwater, absorption of surface water contaminants during wading, or ingestion of contaminated fish. Direct contact with contaminated soil may occur if it is unearthed during potential future construction activities. Ingestion or absorption of contaminated groundwater in the shallow saturated zone or sand and gravel deposit may occur via construction of a potable water well onsite or immediately offsite. Lower public health risks are associated with migration of groundwater contaminants to the unnamed ditch and Finley Creek.

Alternative 2 - Access Restrictions

The Access Restrictions alternative reduces the public health risks associated with the site by controlling access to the contaminants and monitoring the contaminant pathways. The main components of the alternative are shown in Figure 6-6.

Deed restrictions would be placed on the ECC site property, areas immediately surrounding the site and the area south of the site to Finley Creek. The restrictions would prohibit excavation of soil, building construction, or installation of wells (other than monitoring wells). Access to the site or contaminated surface water would be controlled by installation of fencing around the site, the unnamed ditch and a portion of Finley Creek. Portions of the existing site fence would be used where appropriate.

Contaminant migration would be assessed through a regular groundwater and surface water monitoring program. The groundwater monitoring program would include semi-annual sampling and analysis of selected RI monitoring wells and



LEGEND

- ECC-7A — REMEDIAL INVESTIGATION MONITORING WELL
- AREA OF DEED RESTRICTIONS PROHIBITING EXCAVATION OF SOIL, CONSTRUCTION OF BUILDINGS, OR INSTALLATION OF DRINKING WATER OR INDUSTRIAL WELLS
- FENCING
- NEW SHALLOW SAND AND GRAVEL ZONE MONITORING WELL
- NEW SHALLOW SATURATED ZONE MONITORING WELL
- SURFACE WATER MONITORING LOCATIONS

NOTE: Map represents topography and onsite features prior to surface cleanup.

All well locations are approximate.

N

0 100 200
50 150
SCALE IN FEET

FIGURE 6-6
ALTERNATIVE 2
ACCESS RESTRICTIONS
ECC FS

three new shallow monitoring wells. Surface water monitoring would be conducted at four locations semi-annually during high and low stream flow periods in the spring and summer. VOC's would be analyzed for each sample with occasional analysis for other organic fractions. Depending on surface water sample results, fish would be occasionally collected from Finley and Eagle Creeks and their tissues analyzed for bioaccumulation of organic contaminants.

Alternative 3 - Capping

The capping alternative reduces public health risks by greatly reducing leaching of contaminants from onsite soils to the groundwater. Reduction in public health risks associated with ingestion of contaminated groundwater, dermal absorption of surface water contaminants, and ingestion of fish occur for this alternative.

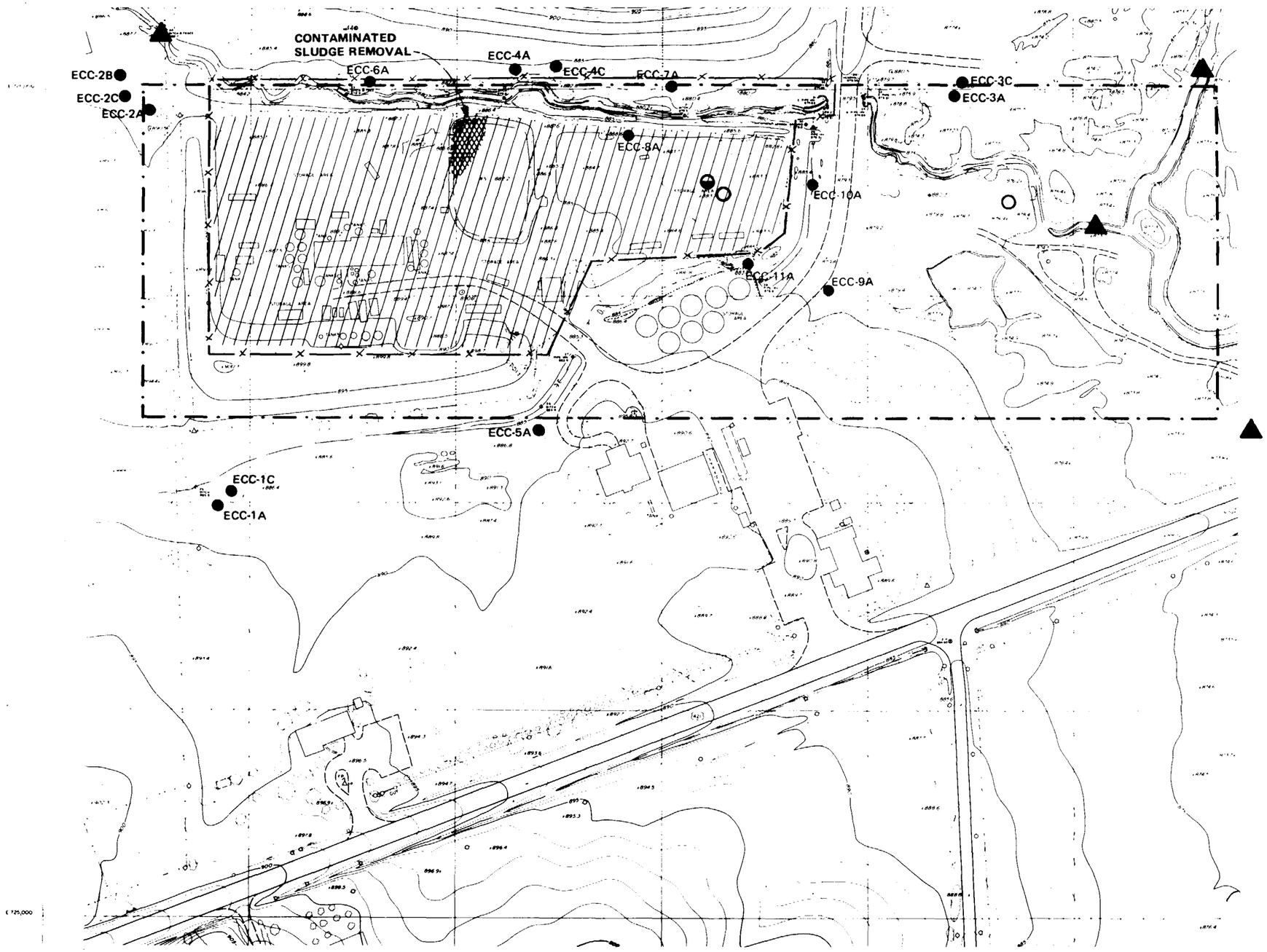
The alternative includes the preceding access restriction alternative along with capping the site with a soil-synthetic membrane-clay cap (Figures 6-7 and 6-8). Before construction of the cap, any contaminated sludge remaining in the cooling pond would be excavated and disposed at a licensed RCRA landfill. Soil samples would be collected from soil borings in the former cooling pond and analyzed to determine excavation locations and volumes. Excavated sludge would be replaced with clean fill. Removal of all remaining contaminated sludge would prevent any further contamination of the sand and gravel deposit. Groundwater removed during sludge excavation would be transported and treated at a licensed RCRA facility.

The cap would be constructed as described previously and would prevent erosion of the existing silty clay cap while decreasing the amount of soil contaminants leaching to groundwater. To ensure the integrity of the cap, the existing process building would be demolished. The concrete floor and foundation would remain and the cap would be placed on top.

Alternative 4 - Groundwater Collection and Treatment

The Groundwater Collection and Treatment alternative further reduces public health risks due to the site by collection and treatment of all contaminated groundwater. This greatly reduces the time period for drinking WQC for groundwater to be met. It also nearly eliminates migration of groundwater contaminants to the surface water.

The cooling pond sludge removal, deed restrictions, and monitoring components of Alternative 3 are included in this alternative. The groundwater collection system includes a system of french drains onsite to collect contaminated groundwater in the shallow saturated zone and convey it to a



LEGEND

- ECC-7A — REMEDIAL INVESTIGATION MONITORING WELL
- AREA OF DEED RESTRICTIONS PROHIBITING EXCAVATION OF SOIL, CONSTRUCTION OF BUILDINGS, OR INSTALLATION OF DRINKING WATER OR INDUSTRIAL WELLS
- FENCING
- NEW SHALLOW SAND AND GRAVEL ZONE MONITORING WELL
- NEW SHALLOW SATURATED ZONE MONITORING WELL
- SURFACE WATER MONITORING LOCATIONS
- CAPPING AREA

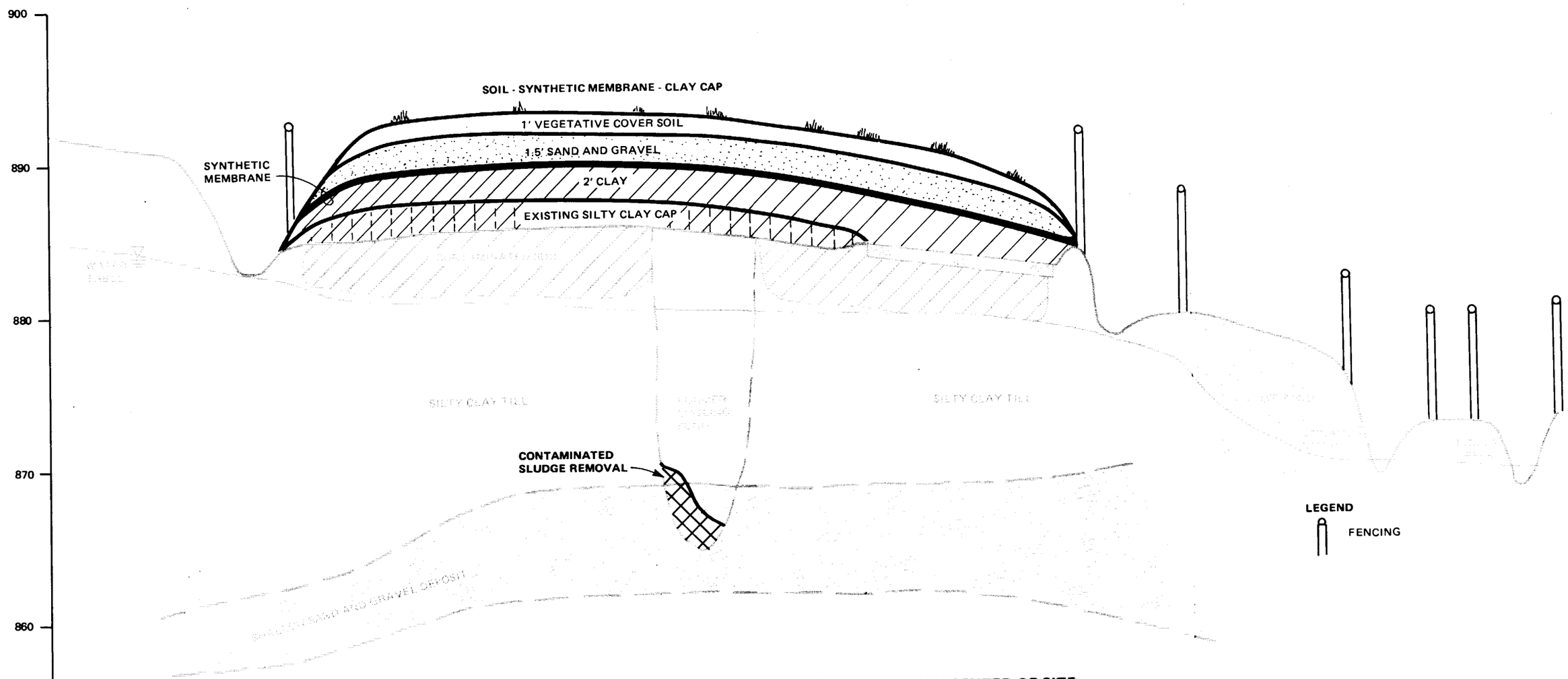
NOTE: Map represents topography and onsite features prior to surface cleanup.

All well locations are approximate.

0 100 200
50 150
SCALE IN FEET

FIGURE 6-7
ALTERNATIVE 3
CAPPING
ECC FS

ALTERNATIVE 3 CAPPING



CONCEPTUAL NORTH - SOUTH CROSS SECTION THROUGH CENTER OF SITE

FIGURE 6-8
ALTERNATIVE 3
CROSS ECTION
ECC FS

holding tank. Before installation, soil borings with continuous split-spoon sampling to the sand and gravel deposit and on a 50-foot grid across the site would be taken to establish the depth of the french drains. Groundwater in the shallow sand and gravel deposit is collected through four extraction wells downgradient of the site (see earlier section on Groundwater Collection System Design.)

A GAC system is used to treat the collected groundwater flow of 8 gpm from the french drains and 48 gpm from the extraction wells before discharge to the unnamed ditch (see Evaluation of Groundwater Treatment Technologies). The system would be in operation for 100 years or more before groundwater contaminant levels are reduced to drinking water criteria. The extraction well portion of the collection system, however, may be in operation for as few as 4 years due to higher soil permeability and the lack of a continuing source of contamination.

As discussed earlier in the section "Comparison of Capping Options" the silty-clay cap is the most advantageous cap for alternatives incorporating groundwater collection and treatment. The existing silty clay cap would remain onsite and would be covered with 1 foot of silty-clay and 6 inches of loam to prevent runoff of contaminants remaining on the cap and to provide a good growth media for vegetation. Fencing of the ditch and creek is eliminated although the existing fence around the site will be maintained. Figure 6-9 and 6-10 present the major components of the alternative.

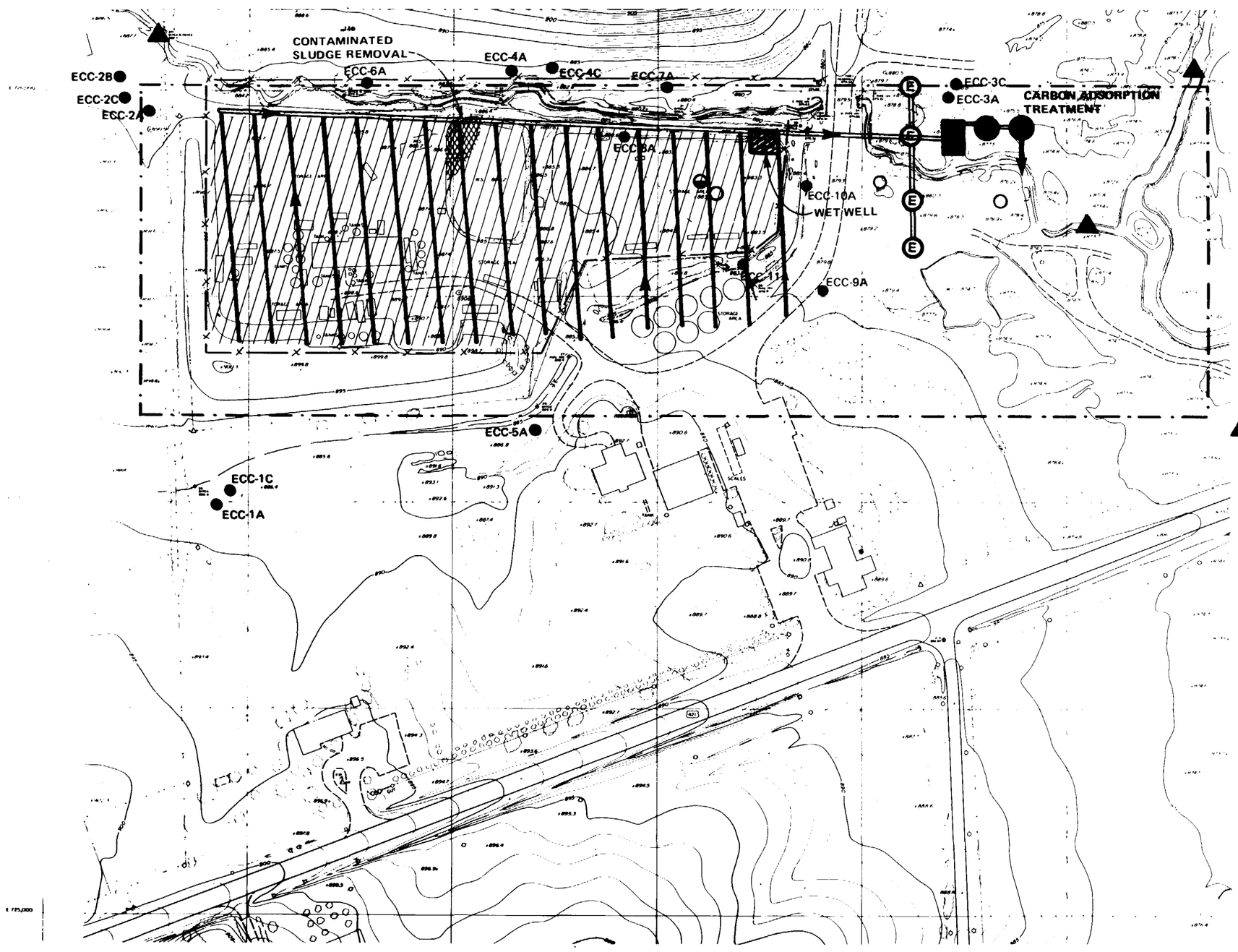
Alternative 5 - Groundwater Collection and Treatment - Soil Vapor Extraction

Alternative 5 provides additional public health benefits over Alternative 4 by reducing soil contaminant levels with vapor extraction. The contaminant levels are reduced to the 10^{-6} cancer risk level for direct contact with soil. The lower soil contaminant levels in turn cause a reduction in the period necessary to meet groundwater drinking WQC.

All components of Alternative 4 are included in Alternative 5. In addition, vapor extraction is used to remove volatile contaminants from the soil. Alternative 5 is shown in Figures 6-11 and 6-12.

Vapor extraction (or enhanced volatilization) would reduce the level of contamination in the unsaturated zone by inducing a flow of air through the soil to evacuate the volatile contaminants. Volatile compounds in the air stream would then be adsorped in a granular activated carbon adsorber system.

Vapor extraction wells are screened in the unsaturated zone to slightly below the water table (2 feet). A vacuum is placed on the well and air extracted from the well. As more air is extracted from the soil, the pressure around the well is lowered. The lower pressure has two effects:



LEGEND

ECC-7A — REMEDIAL INVESTIGATION MONITORING WELL

AREA OF DEED RESTRICTIONS PROHIBITING EXCAVATION OF SOIL, CONSTRUCTION OF BUILDINGS, OR INSTALLATION OF DRINKING WATER OR INDUSTRIAL WELLS

FENCING

NEW SHALLOW SAND AND GRAVEL ZONE MONITORING WELL

NEW SHALLOW SATURATED ZONE MONITORING WELL

SURFACE WATER MONITORING LOCATIONS

CAPPING AREA

FRENCH DRAINS

PIPING

GROUNDWATER EXTRACTION WELLS

NOTE: Map represents topography and onsite features prior to surface cleanup.

All well locations are approximate.

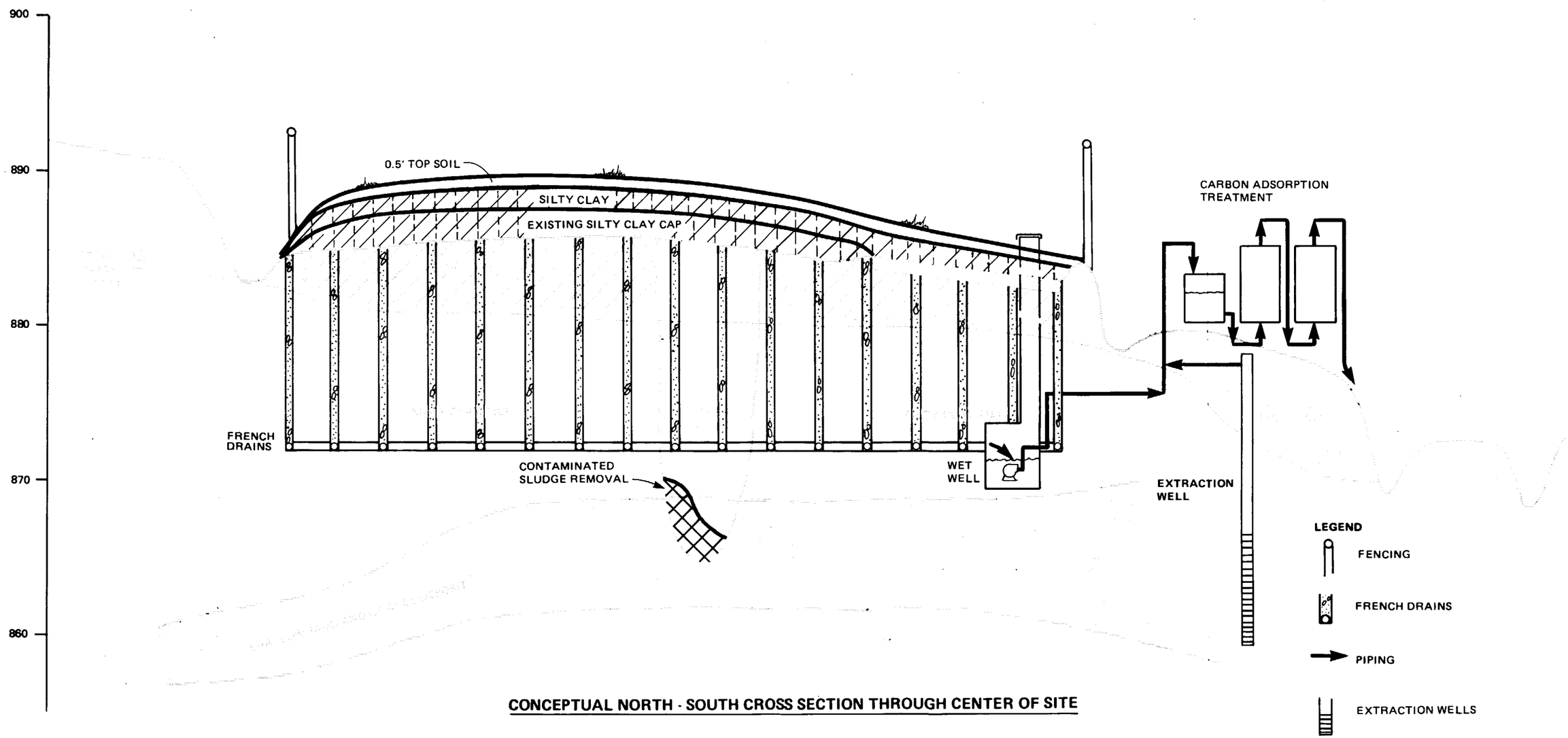
SW SAMPLING LOCATION IN FINLEY CREEK NEAR HIGHWAY 421

N

0 100 200
50 150
SCALE IN FEET

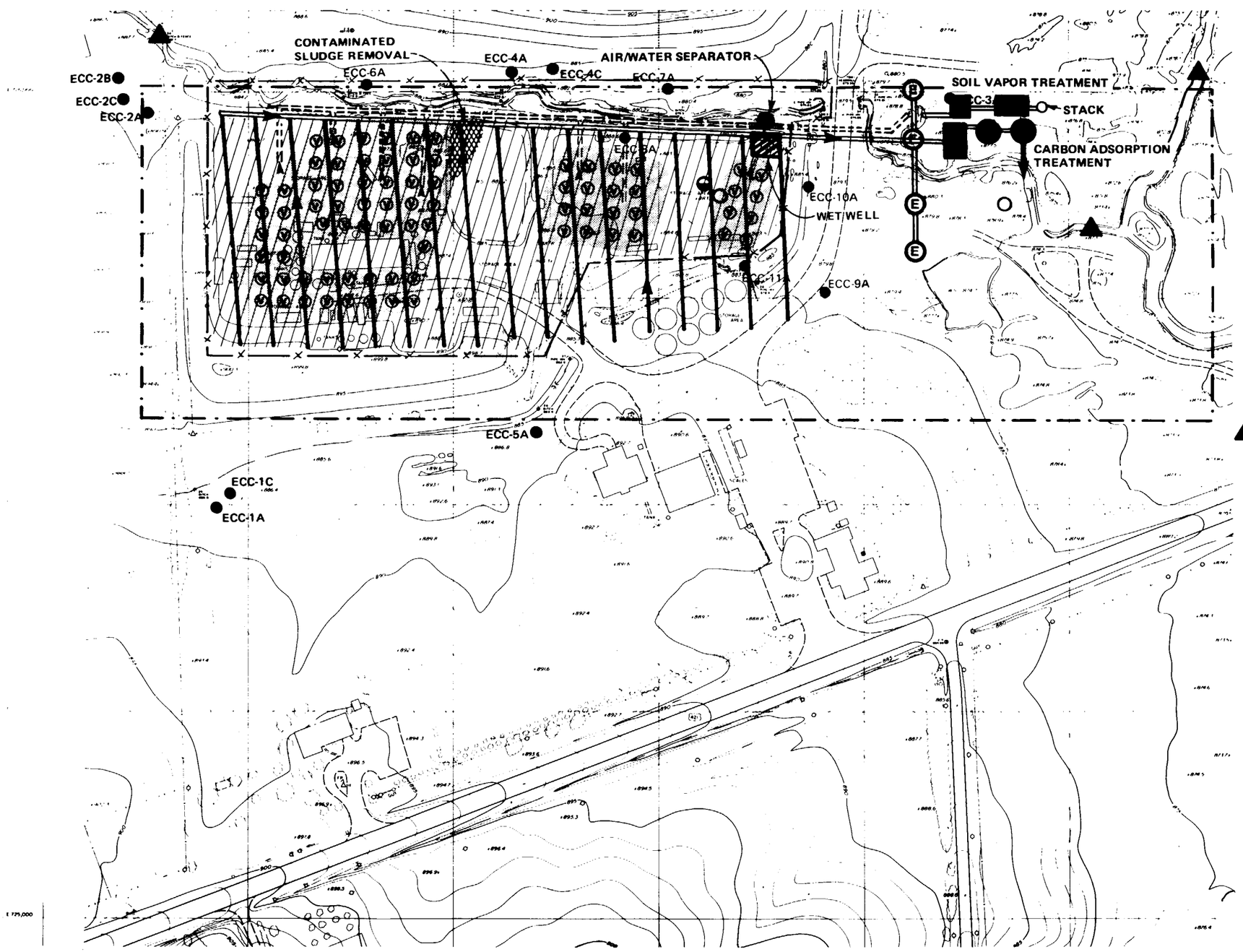
FIGURE 6-9
ALTERNATIVE 4
GROUNDWATER COLLECTION AND TREATMENT
ECC FS

ALTERNATIVE 4 - GROUNDWATER COLLECTION AND TREATMENT



CONCEPTUAL NORTH - SOUTH CROSS SECTION THROUGH CENTER OF SITE

FIGURE 6-10
ALTERNATIVE 4
CROSS SECTION
ECC FS



LEGEND

- ECC-7A — REMEDIAL INVESTIGATION MONITORING WELL
- AREA OF DEED RESTRICTIONS PROHIBITING EXCAVATION OF SOIL, CONSTRUCTION OF BUILDINGS, OR INSTALLATION OF DRINKING WATER OR INDUSTRIAL WELLS
- FENCING
- NEW SHALLOW SAND AND GRAVEL ZONE MONITORING WELL
- NEW SHALLOW SATURATED ZONE MONITORING WELL
- SURFACE WATER MONITORING LOCATIONS
- CAPPING AREA
- FRENCH DRAINS
- PIPING
- SOIL VAPOR PIPING
- GROUNDWATER EXTRACTION WELLS
- SOIL VAPOR EXTRACTION WELLS
- POTENTIAL SOIL VAPOR EXTRACTION AREAS

SW SAMPLING LOCATION IN FINLEY CREEK NEAR HIGHWAY 421

NOTE: Map represents topography and onsite features prior to surface cleanup.

All well locations are approximate.

N

0 100 200
50 150
SCALE IN FEET

FIGURE 6-11
ALTERNATIVE 5
GROUNDWATER COLLECTION AND TREATMENT-SOIL VAPOR EXTRACTION
ECC FS

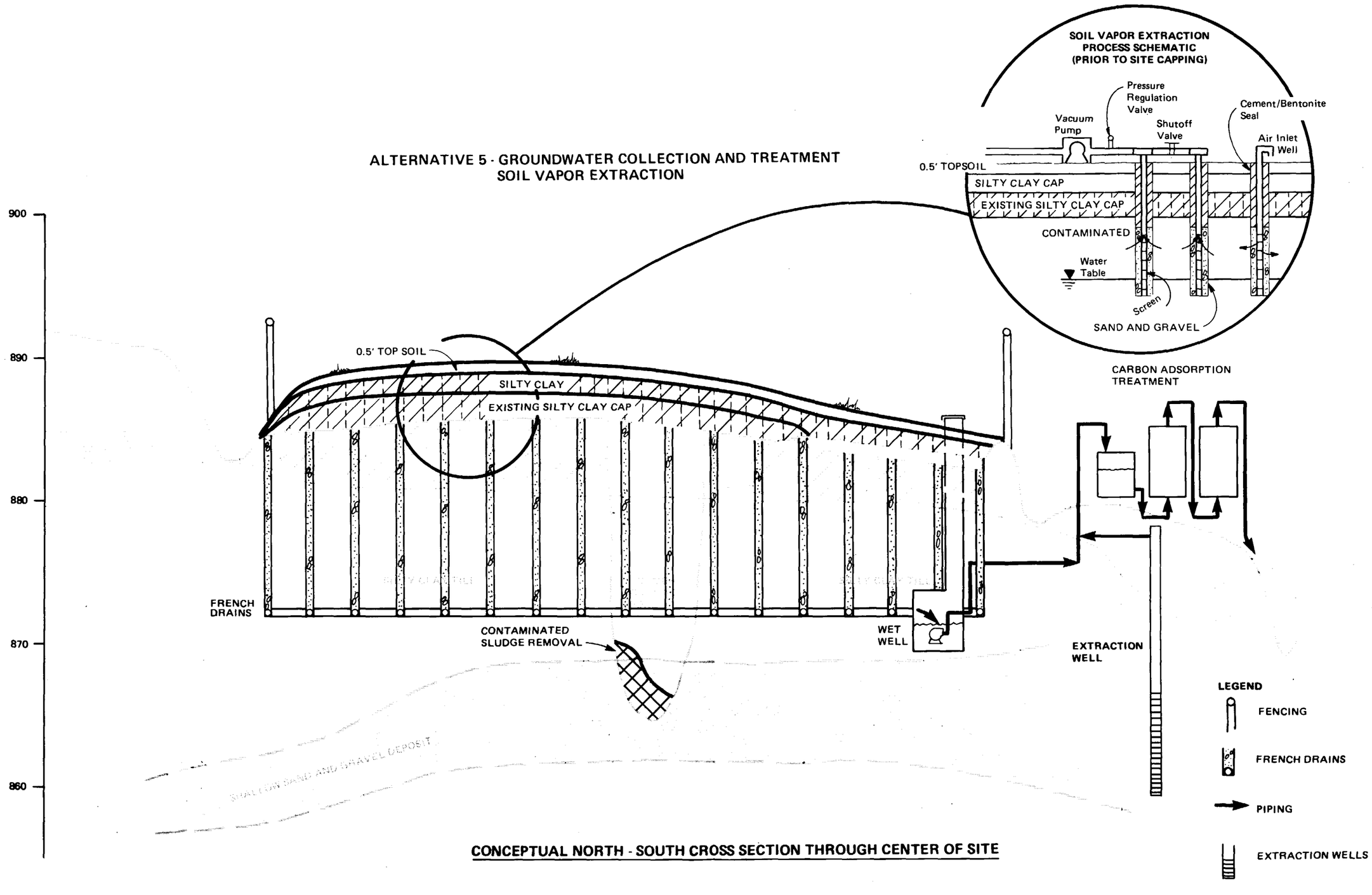


FIGURE 6-12
ALTERNATIVE 5
CROSS SECTION
ECC FS

1) More contaminants are volatilized from the soil moisture into the soil gas.

2) Air is drawn through the inlet wells and through the contaminated soil to the extraction well.

With the clean source of air, and a system of wells with overlapping effects, the contaminants can be extracted from the unsaturated zone.

Vapor Extraction System Description

The system described in this alternative is conceptual in nature. The exact number and placement of wells, withdrawal rate and vacuum applied to each well will be based upon pilot testing before design. Additional soil sampling and analysis in the unsaturated zone would be performed to further delineate volatile distribution in the soil and aid in the optimal placing of wells.

Based on existing data, the system would consist of 10 networks of eight air withdrawal (extraction) wells and eight air inlet wells. They would be placed in areas that account for approximately 99.5 percent of the volatile contaminant mass in the unsaturated zone and include all areas that the volatile compound concentrations exceed the 1×10^{-6} excess lifetime cancer risk level from soil ingestion.

Two inch PVC withdrawal wells would be installed to approximately 2 feet below the water table and would be screened through the water table to 3 feet above the water table. The top of the well would have a vacuum line attached with a shutoff valve and a vacuum gage. The wells are connected to a manifold via transfer lines. The array of extraction wells would be ringed with an equal number of air inlet wells to allow more efficient transfer of air below the existing cap. These are similar in construction to the extraction wells. The inlet wells would be metered to monitor flow into the wells.

The network of extraction wells would be connected to a vacuum pump capable of pulling 200 to 300 cfm and up to 2 inches mercury gage vacuum. Based upon pilot plant results, the number of wells per vacuum pump, the blower size, gage vacuum and flowrate may be adjusted to increase efficiency.

The extracted air would require treatment to remove the organic contaminants. This can be accomplished by using a granular activated carbon system. It is assumed that the air stream would be completely saturated with a relative humidity of 90 to 100 percent. Activated carbon is less efficient in vapor streams above 50 percent relative humidity. It is necessary to increase the temperature of the air stream in order to reduce the relative humidity.

The extracted air would flow from the wells and into an air/water separator to remove any free water from the vapor stream. The air would flow from the air/water separator into a heater, where the temperature would be raised to 90°F, and then into the granular activated carbon adsorbers. Purified air would exit the carbon adsorbers thru a vacuum pump and be discharged to the atmosphere.

The system would be monitored daily to assure that proper vacuums are being maintained. Additional routine maintenance of the pumps would be performed.

In the pilot study stage and the initial stage of full scale operations, daily sampling and analysis of the discharge air stream would be performed. In addition, at least three soil gas monitoring points would be installed at each network to allow monitoring of removal rates. Air samples would be analyzed by GC/MS. After the first week, monitoring could be reduced to weekly for the next 2 months and then biweekly to monthly for the duration of the operation. The initial samples would be analyzed for a complete volatile organic scan. Three or four key compounds can then be chosen and routine monitoring performed for them. Periodic complete volatile scans would be performed to monitor changes in discharge makeup.

Based on the monitoring of both the soil gas composition and the discharge stream, a system termination point can be chosen. It is estimated that the vapor extraction system may take 2 to 4 years to lower VOC concentrations below the 10^{-6} cancer risk level from soil ingestion.

Alternative 6 - Soil Excavation and Disposal Offsite - Groundwater Collection and Treatment

Additional public health benefits are provided by Alternative 6 since nonvolatile contaminants would be removed from the site. Risks associated with these contaminants are unquantifiable but are not believed to be great relative to the risks associated with VOC's in soil.

Alternative 6 includes excavation of an estimated 11,500 cubic yards of contaminated soil as described in the earlier section "Evaluation of Contaminated Soil Removal Volumes." The excavation locations, depth, and total volume would be determined following a soil sampling and analysis program including a grid of 26 soil borings at 50-feet centers across the site. The contaminated soil would be hauled to and disposed of at a licensed RCRA landfill within a radius of 200 miles of the ECC site. Following soil removal, the site would be backfilled with clean fill to the existing grade and capped with the silty clay cap used in Alternatives 4 and 5. Groundwater collection and treatment would be similar to Alternative 4 although the period of collection and treatment for the shallow saturated zone would be shortened to 30 years. Alternative 6 is shown in Figures 6-13 and 6-14.

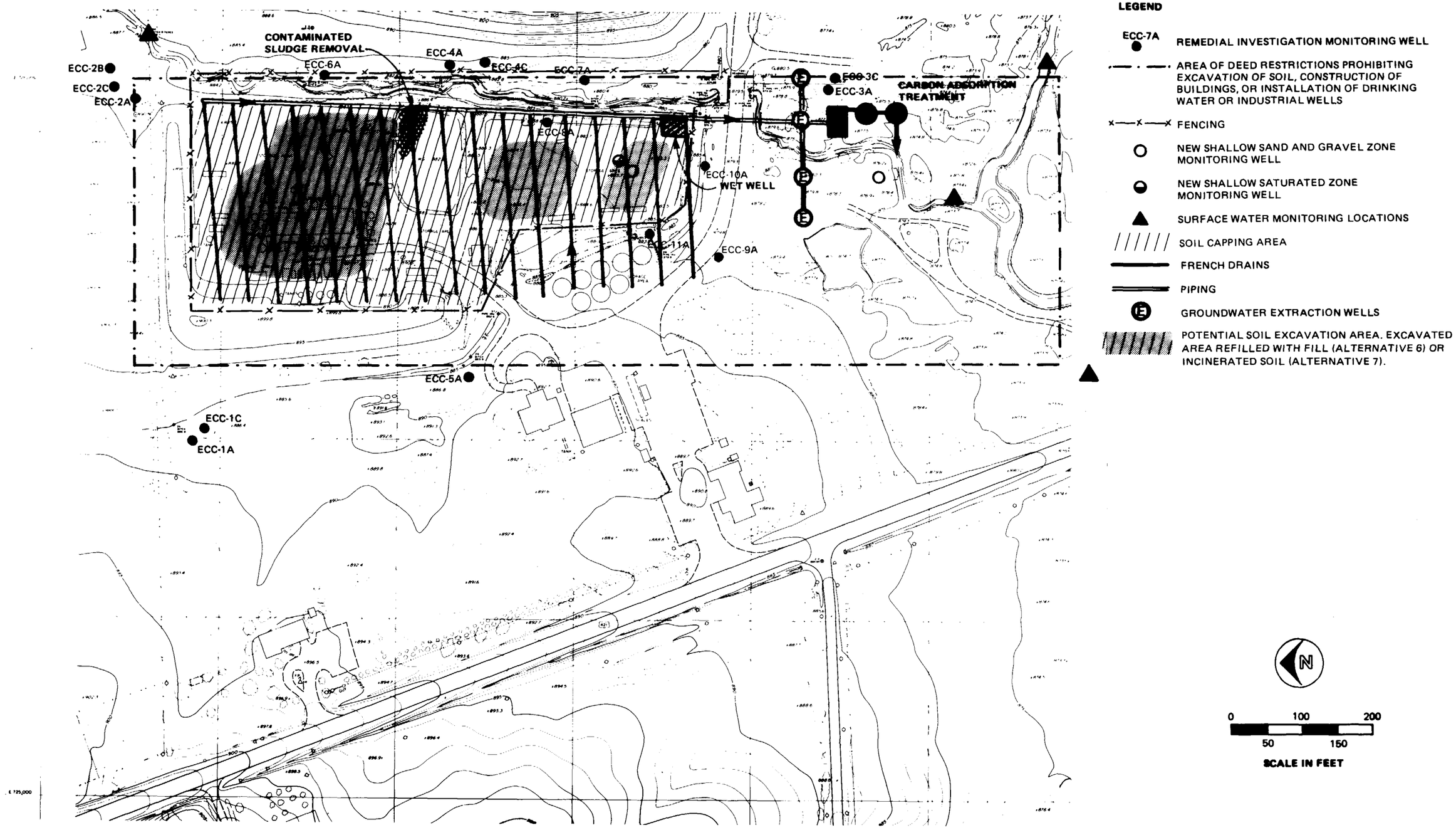
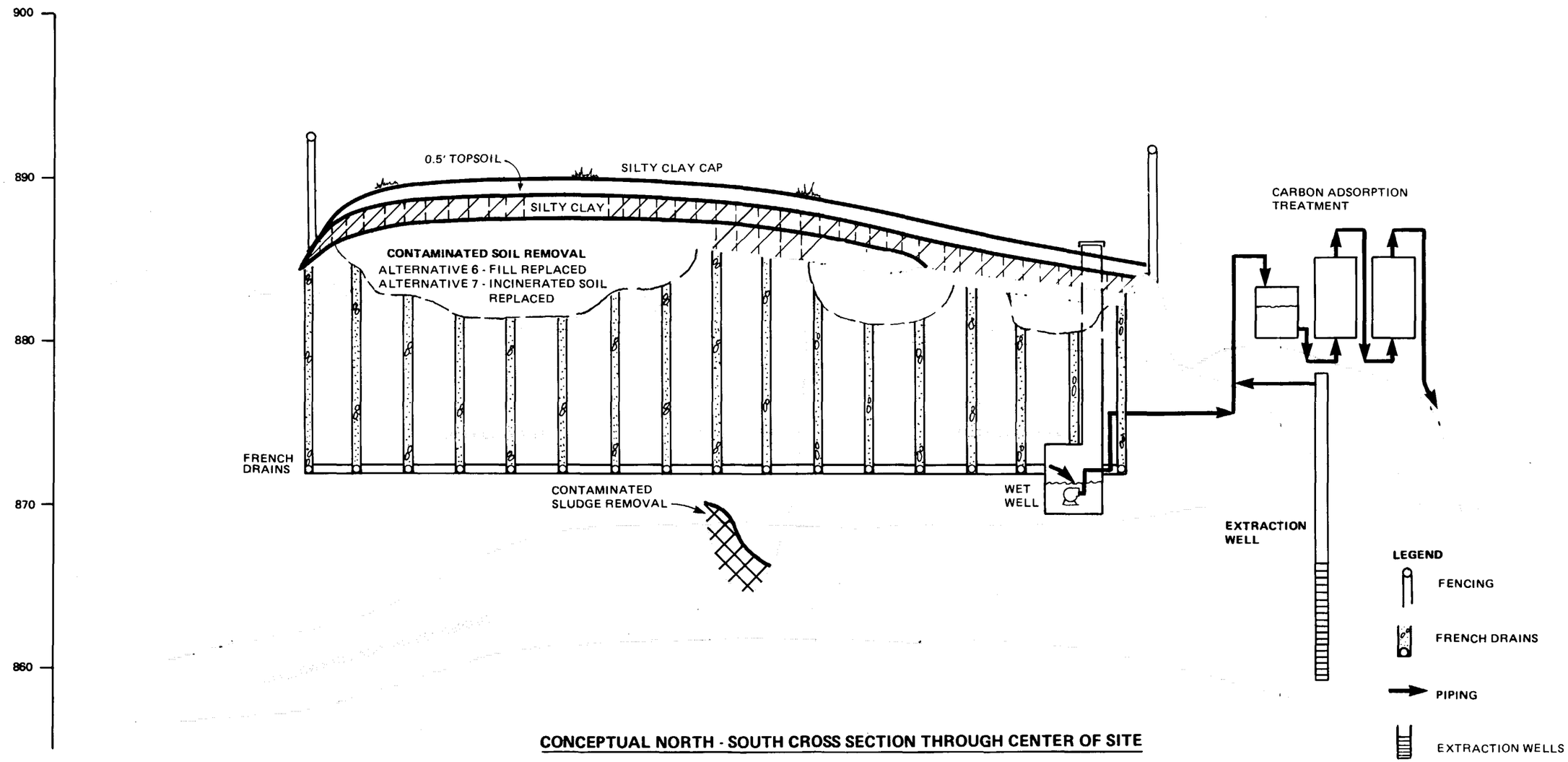


FIGURE 6-13
ALTERNATIVES 6 AND 7
ECC FS

ALTERNATIVE 6 - SOIL EXCAVATION AND DISPOSAL OFFSITE - GROUNDWATER COLLECTION AND TREATMENT

ALTERNATIVE 7 - SOIL EXCAVATION WITH ONSITE INCINERATION AND ONSITE DISPOSAL - GROUNDWATER COLLECTION AND TREATMENT



CONCEPTUAL NORTH - SOUTH CROSS SECTION THROUGH CENTER OF SITE

FIGURE 6-14
ALTERNATIVES 6 AND 7
CROSS SECTION
ECC FS

Site excavation includes removal of the process building, concrete pad, and soil with disposal at an offsite RCRA permitted landfill facility. The process building was steam cleaned and may possibly be salvaged or disposed of in a solid waste landfill, though this is not assumed for costing. Removal of the concrete pad in the southern portion of the site would begin before or simultaneously with soil excavation. The pad, assumed to have an average thickness of 0.7 feet, would require breaking before excavation. Cost effective soil excavation and transport was found to require stockpiling onsite. A backhoe would fill several dump trucks which would stockpile the soil at a loading area onsite. At the loading area, a fleet of 15 trucks per day carrying a maximum of 20 cubic yards of contaminated soil would be lined and filled by a front-end loader. Excavation, loading, and hauling of the contaminated soil and wastes would take approximately 5 months.

Alternative 7 - Soil Excavation with Onsite Incineration and Onsite Disposal - Groundwater Collection and Treatment

The public health benefits provided by Alternative 7 are similar to Alternative 6 with the exception that contaminants contributing to cancer risks are permanently destroyed and do not have the potential for creating exposures in the future.

This alternative is identical to Alternative 6 in all respects except that contaminated soil is incinerated and disposed onsite rather than disposed offsite at an RCRA landfill. It is assumed here that the incinerated soil could be delisted as a hazardous waste and disposed onsite. A silty-clay cap would be placed over the incinerated soil returned to the site. Figures 6-13 and 6-14 present the main alternative components.

The main components of the incineration process are the rotary kiln, afterburner, packed tower, and wet scrubber. The incineration facility would take approximately one year to design and install, and an additional 1 to 3 years for startup and permitting. Incineration of 14,400 cubic yards of soil and 7,500 cubic yards of the existing silty-clay cap (assuming a 15 percent moisture content) would take from 1.5 to 4 years at a throughput of 1 to 2 yards per hour for 300 days per year. Operating the kiln continuously would reduce thermal stress on the refractory, although some down time has been allowed. After the soil has been treated, the incinerator would be dismantled and salvaged or reused on other sites.

The rotary kiln would operate at 2,200°F with a total waste-heat input of 23 million Btu/hour. Residence time of a waste material is a function of temperature, rotational speed, and kiln angle to horizontal. A trial burn conducted

at the startup time will determine these factors along with the residence time. In general, solid wastes can take several hours for combustion. Rotary kiln systems usually have a secondary combustion chamber, or afterburner, following the kiln to ensure complete combustion of the waste and gases from the kiln. This chamber is usually designed to have a gas residence time of a few seconds with temperatures between 2,200 and 3,000°F.

To operate, the kiln would require approximately 225 gallons per hour of supplemental fuel oil because of the low heating value of the soil. Electrical requirements for the complete system would be 130 kW. Water requirements would vary depending on the kiln and scrubber design. At most, approximately 450 gpm would be needed if the system included a venturi scrubber.

The contaminated soil would be ram fed or conveyed through the higher end of the kiln. As the kiln rotates, the incinerated soil moves to the lower end of the kiln where it is discharged. The residual ash would then be replaced onsite.

High levels of nitrogen oxide emissions are expected, especially when a rotary kiln is operated at higher temperatures. Nitrous oxides are formed from thermal fixation of nitrogen in the air used for combustion or from organic nitrogen compounds present in the waste. Emissions of nitrogen oxide and particulate matter are dependent on the waste. Sulfur oxides are formed from sulfur present in the waste material and auxiliary fuel. A wet scrubber is assumed to be necessary for control of emissions of particulate matter and the gaseous products of combustion.

GLT533/27

Chapter 7
DETAILED ANALYSIS OF ALTERNATIVES

In accordance with Section 300.68(h) of the NCP, a detailed analysis of the alternatives assembled and described in Chapter 6 is presented in this chapter. This detailed analysis includes technical, public health and welfare environmental, institutional and cost analyses.

TECHNICAL EVALUATION

The technical feasibility of each alternative is evaluated based on performance, reliability, implementability, and safety. These criteria were described in Chapter 5. Ratings were assigned for each category and are described in Appendix C. The technical evaluation of alternatives is presented in Table 7-1.

PUBLIC HEALTH AND WELFARE AND ENVIRONMENTAL ANALYSIS

In the detailed evaluation and final selection of a remedial action alternative, adequate protection of public health, welfare, and the environment is a major concern. The National Contingency Plan (NCP) requires in 40 CFR 300.68(h)(2)(iv) and (vi):

(iv) An assessment of the extent to which the alternative is expected to effectively prevent, mitigate, or minimize threats to, and provide adequate protection of public health and welfare and the environment.

(vi) An analysis of any adverse environmental impacts, methods for mitigating these impacts, and costs of mitigation.

In this section, each alternative undergoing detailed analysis is evaluated with regard to its impact on environmental and public health and welfare concerns. Short-term (construction-related) activities, the operation of the remedial technologies and the final results of the remedial action alternative are each assessed. Criteria used in evaluating the impact on public health and welfare include: disruption and dislocation of households, businesses, and services; impact on traffic; use of resources; aesthetics; impact on parks and recreation; historic site alterations; odor, noise, air and water pollution impacts; and public health exposure risks.

Criteria used in evaluating the environmental impacts include: wildlife habitat alteration; water pollution; toxic and adverse effects on plants and wildlife; impact on threatened and endangered species; natural resource loss and

TECHNICAL EVALUATION CRITERIA AND EVALUATION RATING[a]	1 NO ACTION	2 ACCESS RESTRICTIONS	3 CAPPING (see Alternative 2 for evaluation of access restrictions and monitoring components)	4 GROUNDWATER COLLECTION AND TREATMENT (see Alternative 3 for evaluation of mutual components)
PERFORMANCE	−− Allows release of hazardous constituents that cause public health risks in excess of the 10^{-6} risk level for direct contact with soil, ingestion or dermal absorption of groundwater, or ingestion of fish from contaminated surface water.	− Limits exposure to contaminants by controlling access. Effectiveness depends on fence maintenance, regular monitoring and enforcement of deed restrictions for possibly hundreds of years. Possibility of lax controls in future may lead to exposures. Fencing requires regular replacement.	o Capping reduces potential for direct exposure to contaminants and greatly reduces leaching of contaminants from soil but may extend duration of contaminant release to groundwater at concentrations above drinking WQC. Excavation of cooling pond sludge prevents further contamination of the sand and gravel aquifer.	+ Collection and treatment of contaminated groundwater in both the shallow saturated zone and the shallow sand and gravel aquifer reduces potential future exposure to groundwater while also reducing migration of groundwater contaminants to surface water. System operation is necessary for 4 years for the shallow sand and gravel aquifer and more than 100 years for the shallow saturated zone.
RELIABILITY	Not applicable.	− Minimal maintenance requirements. Enforcement of deed restrictions for hundreds of years has not been demonstrated.	+ Cap has proven performance. Double lining gives additional safety factor. Periodic maintenance required.	o GAC treatment has proven performance. Requires regular monitoring and trained operation personnel. Extraction wells and french drains have low maintenance requirements and proven performance.
IMPLEMENTABILITY	No implementation is necessary.	++ All actions are quickly and easily implementable.	+ Installation of synthetic membrane in cap requires rigid quality control. Implementation time is less than 1 year for the cap. Cap installation requires process building demolition. Excavation of cooling pond sludge will require pumping and containment of groundwater.	− Construction of extraction wells, piping, and GAC treatment system is routine. Attaining discharge permit for treated groundwater will require performance testing and will add to implementation time. Groundwater in shallow sand and gravel aquifer does not attain water quality criteria for 4 years and in shallow saturated zone for over 100 years.
SAFETY	− No remedial action to fail.	o No substantial safety concerns. Failure of deed restriction enforcement may result in exposures. Failure of fencing for periods less than several years not likely to result in substantial exposure.	+ Installation of cap and sludge excavation requires proper site safety procedures for workers. Presence of existing clay cap will reduce risk. Demolition of the process building introduces safety concerns normal to demolition activities.	o System failure is not expected to introduce substantial health risks due to long-term nature of risks. Construction of extraction wells and french drains introduce safety concerns due to possible contact with contaminated soil and potential unearthing of buried tanks or drums.

[a]Evaluation ratings are described in Appendix C.

TABLE 7-1 (Page 1 of 2)
TECHNICAL EVALUATION OF ALTERNATIVES
ECC FS

TECHNICAL EVALUATION CRITERIA AND EVALUATION RATING[a]	5 GROUNDWATER COLLECTION AND TREATMENT - SOIL VAPOR EXTRACTION (see Alternative 4 for evaluation of mutual components)	6 SOIL EXCAVATION AND DISPOSAL OFFSITE - GROUNDWATER COLLECTION AND TREATMENT (see Alternative 4 for evaluation of mutual components)	7 SOIL EXCAVATION WITH ONSITE INCINERATION AND ONSITE DISPOSAL - GROUNDWATER COLLECTION AND TREATMENT (see Alternative 6 for evaluation of mutural components)
PERFORMANCE	+ + Soil vapor extraction reduces risks associated with direct contact with VOC contaminants, reduces leaching of these contaminants to groundwater or surface water, and reduces groundwater collection and treatment period.	+ + Soil excavation to the 10^{-6} cancer risk level and disposal offsite greatly reduces risk associated with direct contact with soils. Reduces groundwater collection and treatment period.	+ + Removal of soil organic contaminants with levels above the 10^{-6} cancer risk levels greatly reduces risk associated with future excavation of the site. Reduces groundwater collection and treatment period. Organic contaminant incineration removal efficiencies will meet RCRA requirements of 99.99 percent. Organic contaminants are destroyed.
RELIABILITY	o Vapor extraction has been proven reliable under different site conditions. Pilot testing would be necessary.	+ Soil excavation, transport, and disposal is operationally routine. Performance is demonstrated for soil excavation and transport. Performance of ultimate disposal at a RCRA landfill is considered reliable.	+ Soil incineration has been demonstrated to be effective. Operation is complex and would require full-time trained operating personnel. Partial replacement of refractory lining is common maintenance requirements. Onsite disposal of incinerated soil can be accomplished with standard construction equipment. Demonstrated performance of incineration minimizes potential for leaching of organic contamination in incinerated soil to groundwater or surface water.
IMPLEMENTABILITY	o Construction of system is routine. Obtaining air emission permit will require pilot testing. Vapor extraction system will require 2 to 4 years of operation before VOC's are reduced to 10^{-6} risk levels in soil.	+ Excavation, transport, and disposal can be implemented easily and quickly with conventional construction methods. Results are realized as contaminants are removed from site, time to achieve results is about 6 months. RCRA landfills are presently available for contaminated soil disposal.	– Onsite incineration will require about 1 year for startup. Performance testing and permitting may require 2 additional years. Incineration of contaminated soil will require about 15 months to complete, operating 24 hours per day. Onsite disposal of incinerated soil will require delisting as a hazardous waste and will take several months, though this could be performed during the soil incineration period.
SAFETY	o Air emissions during operation are believed not to pose risk to operator.	– Safety during construction is a concern due to possible contact with contaminated soil and potential unearthing of buried tanks or drums. Transportation of contaminated soil over public highways is a concern, though proper cleanup, in event of a truck accident would mitigate impacts.	o Contact with contaminated soil and high temperatures of the rotary kiln are operational safety concerns. Handling and use of heating fuel requires normal safety precautions. Extensive testing, maintenance and monitoring required to insure VOC emissions do not exceed permitted levela. Onsite disposal does not present safety concerns other than those normally associated with construction operations.

[a]See Appendix C for description of ratings.

TABLE 7-1 (Page 2 of 2)
TECHNICAL EVALUATION OF ALTERNATIVES
ECC FS

diminution; and impacts on wetlands, prime farmland and unique resources.

The impacts of the alternatives are described in Table 7-2.

INSTITUTIONAL ISSUES

This section discusses federal, state, and local environmental and public health laws, regulations, and policies that may affect the implementation of remedial action alternatives. As a general rule, it is EPA's policy that in CERCLA remedial actions, "applicable or relevant and appropriate" Federal public health and environmental requirements must be complied with.

Applicable laws and standards are those that would be specifically triggered when the law or regulation is clearly and indisputably the controlling authority for the planned action for the proposed Superfund remedy except that the proposed action would be undertaken pursuant to the CERCLA Section 104 or 106; e.g., applicable laws and standards are those those would legally apply if the action was not being taken under the authority of CERCLA. Relevant and appropriate laws or standards are those where the intent of the law or standard is to apply to circumstances sufficiently similar to those encountered at CERCLA sites. The term "relevant and appropriate" means that the law or regulation need not be truly applicable or legally required to the proposed action or existing circumstances but that the intent of the law was to control similar situations.

EPA does not require permits for onsite fund-financed or enforcement actions taken under CERCLA. Certain permits are, however, required for offsite actions involving treatment, storage, or disposal beyond the site boundaries. Examples are wastewater discharges and disposal of hazardous wastes.

Federal, state and local laws, regulations, and policies are reviewed for applicability to the remedial action alternatives in this study. Applicable requirements considered important "institutional" issues in comparing remedial action alternatives are reviewed in more detail in the following discussion. These issues include hazardous waste management, wastewater discharges, and contaminant emissions to the atmosphere.

COORDINATION WITH OTHER AGENCIES

The NCP states in 40 CFR300.22 that federal agencies should coordinate their planning and response activities through mechanisms outlined in Subpart C of the NCP. The duty to manage certain aspects of CERCLA responses has been delegated

PUBLIC HEALTH, WELFARE AND ENVIRONMENTAL IMPACTS OF ALTERNATIVES[a]

PUBLIC HEALTH AND WELFARE EVALUATION CRITERIA	1 NO ACTION	2 ACCESS RESTRICTIONS	3 CAPPING
LONG-TERM HEALTH RISKS			
SOIL - Direct Contact via Ingestion			
Excess Lifetime Cancer Risk/ADI	4×10^{-3} / Exceedance of Xylene, Lead, and Cadmium ADI's	4×10^{-3} /Exceedance of Xylene, Lead, and Cadmium ADI's	4×10^{-3} / Exceedance of Xylene, Lead, and Cadmium ADI's
Exposure Potential	Requires Development of Site	Exposure prevention requires successful enforcement of restrictions and maintenance of fencing for over 100 years.	Exposure prevention requries successful enforcement of restrictions and maintenance of fencing for over 100 years.
Duration of Potential Exposure	> 100 Years	> 100 Years	> 100 Years
GW - Shallow Saturated Zone via Ingestion			
VOC Peak Concentrations[b]/Drinking WQC	1,200,000 ug/L / WQC is exceeded	1,2000,000 ug/L / WQC's exceeded	45,000 ug/L / WQC's exceeded.
Exposure Potential	Unlikely due to low hydraulic conductivity of zone	Unlikely due to low hydraulic conductivity of zone and deed restrictions	Unlikely due to low hydraulic conductivity of zone and deed restrictions.
Duration of WQC Exceedance	> 200 Years	> 200 Years	> 200 Years
GW - Shallow Sand and Gravel Zone via Ingestion or Dermal Absorption			
Excess Lifetime Cancer Risk/Drinking WQC	7×10^{-5} / WQC's exceeded	7×10^{-5} /WQC's exceeded	2×10^{-5} / WQC's exceeded.
Exposure Potential	Requires well installation in contamination area	Requires successful enforcement of deed restrictions for over 200 years.	Requires successful enforcement of deed restrictions for 24 years.
Duration of WQC Exceedance	Not estimated due to unknown contaminant levels remaining in cooling pond sludge	Not estimated due to unknown contaminant levels remaining in cooling pond sludge.	24 Years.
SW - Migration From Shallow Saturated Zone & via Dermal Absorption			
Excess Lifetime Cancer Risk	6×10^{-7}	6×10^{-7}	2×10^{-8}
Exposure Potential	2,000 ft stream reach affected. Future population unknown	Requires successful maintenance of fencing for over 200 years.	Requires successful enforcement of deed restrictions for over 200 years.
Duration of Potential Exposure	> 200 Years	> 200 Years	> 200 Years.
SW - Migration From Shallow Saturated Zone & via Ingestion of Fish			
Excess Lifetime Cancer Risk	3×10^{-6}	3×10^{-6}	1×10^{-7}
Exposure Potential	700 ft stream reach affected. Future population unknown	Requires successful maintenance of fencing for over 100 years.	Requires successful enforcement of deed restriction for over 100 years.
Duration of Potential Exposure	> 200 Years	> 200 Years	> 200 Years
SUMMARY OF LONG TERM HEALTH RISKS	Public health risks exist for direct contact with excavated soil, ingestion or dermal absorption of GW contaminants, dermal absorption of SW contaminants, and ingestion of fish. Exposure limited to local population. Duration of potential exposure exceeds 100 years for soil contact and 200 years for other risks.	Lifetime cancer risks the same as No Action if exposure occurs. Exposure prevention depends on successful enforcement of deed restrictions and maintenance and replacement of fencing for over 200 years.	Capping decreases peak VOC concentrations in GW but period where WQC's are exceeded remain > 200 years. Cancer risks reduced for GW ingestion or dermal absorption, SW dermal absorption and ingestion of fish.
OPERATION RELATED IMPACTS	None.	None.	None.
CONSTRUCTION RELATED IMPACTS	None.	None considered substantial.	None considered substantial.
ENVIRONMENTAL IMPACTS	Local vegetation and burrowing animals may be affected through uptake or direct contact with onsite soil. Food chain bioconcentration may affect other local terrestrial or aquatic animals.	Local vegetation and burrowing animals may be affected through uptake or direct contact with onsite soil. Food chain bioconcentration may affect other local terrestrial or aquatic animals. Fencing may limit exposure of some terrestrial animals.	Cap will reduce exposure potential of terrestrial animals.

[a] Excess lifetime cancer risks and durations of potential exposures were estimated based on available data and involved many simplifying assumptions. As a result, considerable uncertainty is associated with these estimates. They are intended primarily for comparative purposes.

[b] Summation of TCE, PCE, 1, 1, 1 TCA, methylene chloride and ethyl benzene.

TABLE 7-2 (Page 1 of 3)
PUBLIC HEALTH, WELFARE, AND ENVIRONMENTAL IMPACTS OF ALTERNATIVES
ECC FS

PUBLIC HEALTH, WELFARE AND ENVIRONMENTAL IMPACTS OF ALTERNATIVES[a]			
PUBLIC HEALTH AND WELFARE EVALUATION CRITERIA	4 GROUNDWATER COLLECTION AND TREATMENT	5 CAPPING-GROUNDWATER COLLECTION AND TREATMENT -SOIL VAPOR EXTRACTION	6 SOIL EXCAVATION WITH DISPOSAL OFFSITE-GROUNDWATER COLLECTION AND TREATMENT
LONG-TERM HEALTH RISKS			
SOIL - Direct Contact via Ingestion			
Excess Lifetime Cancer Risk/ADI	4×10^{-3} / Exceedance of Xylene, Lead, & Cadmium ADI's.	$<10^{-6}$ / ADI's exceedance unchanged for Lead and Cadmium.	$<10^{-6}$ onsite, 4×10^{-3} @ RCRA facility/ ADI's not exceeded onsite.
Exposure Potential	Exposure prevention requires successful enforcement of restrictions and maintenance of fencing for over 100 years.	Exposure prevention requires successful enforcement of restrictions and maintenance of fencing for over 100 years.	--Exposure prevention at RCRA facility requires successfull enforcement of deed restrictions and maintenance of fencing for over 100 years.
Duration of Potential Exposure	>100 Years.	>100 Years for ADI's.	--, >100 Years at RCRA facility.
GW - Shallow Saturated Zone via Ingestion			
VOC Peak Concentrations[b]/Drinking WQC	WQC met.	WQC met.	WQC met.
Exposure Potential	--	--	--
Duration of WQC Exceedance	130 Years required before WQC met.	30 years required before WQC met.	30 years required before WQC met.
GW - Shallow Sand and Gravel Zone via Ingestion or Dermal Absorption			
Excess Lifetime Cancer Risk/Drinking WQC	$<10^{-6}$ / WQC met.	$<10^{-6}$ / WQC met.	$<10^{-6}$ / WQC met.
Exposure Potential	--	--	--
Duration of WQC Exceedance	4 Years	4 Years	4 Years
SW - Migration From Shallow Saturated Zone & via Dermal Absorption			
Excess Lifetime Cancer Risk	--	--	--
Exposure Potential	--	--	--
Duration of Potential Exposure	--	--	--
SW - Migration From Shallow Saturated Zone & via Ingestion of Fish			
Excess Lifetime Cancer Risk	--	--	--
Exposure Potential	--	--	--
Duration of Potential Exposure	--	--	--
SUMMARY OF LONG TERM HEALTH RISKS	WQC for GW in the saturated zone are met in 130 years. GW sand and gravel deposit health risks reduced to 10^{-6} after 1 year operation period. SW health risks greatly reduced since all contaminated groundwater is intercepted before discharge. Deed restrictions and fencing needed during operation. Risks from soil exposure unchanged.	Cancer risks from soil reduced to $<10^{-6}$. ADI exceedance for Lead and Cadimum unchanged. WQC for GW in the shallow saturated zone met in 30 years. All other health risks same as Alternative 4.	Cancer risks from soil reduced to $<10^{-6}$ onsite. No exceedance of ADI's. Health risks from soil direct contact *remain at RCRA landfill though exposure potential is lower.* All other health risks same as Alternative 4.
OPERATION RELATED IMPACTS	None.	None.	None.
CONSTRUCTION RELATED IMPACTS	Minor soil release during french drain construction.	Minor soil release during french drain and extraction well construction.	Excavation may result in localized exposure from dust release. Can be mitigated with dust control measures. Public welfare impacts from truck traffic and noise along route to RCRA landfill.
ENVIRONMENTAL IMPACTS	Local vegetation and burrowing animals may be affected through uptake or direct contact with onsite soil. Food chain bioconcentration may affect other local terrestrial or aquatic animals. Fencing may limit exposure of some terrestrial animals.	Soil exposure risk reduced for terrestrial animals.	Soil exposure risk reduced for terrestrial animals.

[a] Excess lifetime cancer risks and durations of potential exposures were estimated based on available data and involved many simplifying assumptions. As a result, considerable uncertainty is associated with these estimates. They are intended primarily for comparative purposes.

[b] Summation of TCE, PCE, 1, 1, 1 TCA, methylene chloride and ethyl benzene.

TABLE 7-2 (Page 2 of 3)
PUBLIC HEALTH, WELFARE, AND ENVIRONMENTAL IMPACTS OF ALTERNATIVES
ECC FS

PUBLIC HEALTH, WELFARE AND ENVIRONMENTAL IMPACTS OF ALTERNATIVES[a]			
PUBLIC HEALTH AND WELFARE EVALUATION CRITERIA	7 SOIL EXCAVATION WITH ONSITE INCINERATION AND ONSITE DISPOSAL-GROUNDWATER COLLECTION AND TREATMENT		
LONG-TERM HEALTH RISKS SOIL - Direct Contact via Ingestion Excess Lifetime Cancer Risk/ADI Exposure Potential Duration of Potential Exposure	 $<10^{-6}$ / Exceedance of Lead and Cadmium ADI's. -- --		
GW - Shallow Saturated Zone via Ingestion VOC Peak Concentrations[b]/Drinking WQC Exposure Potential Duration of WQC Exceedance	 WQC met. -- 30 years required before WQC met.		
GW - Shallow Sand and Gravel Zone via Ingestion or Dermal Absorption Excess Lifetime Cancer Risk/Drinking WQC Exposure Potential Duration of WQC Exceedance	 $<10^{-6}$ / WQC met. -- 4 Years		
SW - Migration From Shallow Saturated Zone & via Dermal Absorption Excess Lifetime Cancer Risk Exposure Potential Duration of Potential Exposure	 -- -- --		
SW - Migration From Shallow Saturated Zone & via Ingestion of Fish Excess Lifetime Cancer Risk Exposure Potential Duration of Potential Exposure	 -- -- --		
SUMMARY OF LONG TERM HEALTH RISKS	All cancer health risks reduced to $<10^{-6}$. ADI's for Lead and Cadmium exceeded. All other health risks same as Alternative 4.		
OPERATION RELATED IMPACTS	Potential for impacts from air emissions if incineration system is run improperly.		
CONSTRUCTION RELATED IMPACTS	Excavation may result in localized exposure risk from dust release. Can be mitigated with dust control measures.		
ENVIRONMENTAL IMPACTS	Soil exposure risk reduced for terrestrial animals.		

[a] Excess lifetime cancer risks and durations of potential exposures were estimated based on available data and involved many simplifying assumptions. As a result, considerable uncertainty is associated with these estimates. They are intended primarily for comparative purposes.

[b] Summation of TCE, PCE, 1, 1, 1 TCA, methylene chloride and ethyl benzene.

TABLE 7-2 (Page 3 of 3)
PUBLIC HEALTH, WELFARE, AND ENVIRONMENTAL IMPACTS OF ALTERNATIVES
ECC FS

to several federal agencies. Those federal agencies that may have responsibilities in the CERCLA response to the ECC site are listed in Table 7-3.

COMPLIANCE WITH ENVIRONMENTAL STATUTES

Not all federal environmental laws and regulations are applicable to each CERCLA response action. For the assembled alternatives developed for the ECC site, several federal environmental laws and regulations are not applicable. These laws and regulations, along with the reasons for their nonapplicability, are set out in Table 7-4. Alternatives and relevant laws are shown in Table 7-5.

SUMMARY OF INSTITUTIONAL ISSUES

This analysis addresses the impacts of each alternative on the basis of interplay between implementation of the alternative and institutional constraints. Criteria used in evaluating the institutional impacts include: political jurisdictions; relevant and applicable federal and state standards; need for land acquisition; changes in land use and zoning; local/state/federal laws or policies; and need for permits and permit-like restrictions. These impacts are summarized in Table 7-6.

COST ANALYSIS

Costs were developed as described in Chapter 6. They are order-of-magnitude level estimates, i.e., the cost estimates have an accuracy of +50 and -30 percent. Further refinement of cost estimates occurs during the design process. The estimated present worth of all remedial alternatives was based on a 30-year period and 10-percent interest rate. Inflation was not considered in preparing present worth estimates.

Estimated construction costs, capital costs, annual operation and maintenance costs, and present worth for each assembled alternative, except no action, are presented in Tables 7-7 through 7-12.

The feasibility level cost estimates presented have been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. Final costs of the alternatives will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope, the firm selected for final engineering design, and other variable factors. As a result, the final alternative costs will vary from the estimates presented in this report. Because of these factors, funding needs must be carefully reviewed

Table 7-3
FEDERAL AGENCY COORDINATION

Agency	Comments
Federal Emergency Management Agency[a] (FEMA)	No alternative requires relocation of a business operation.
Dept. of Health & Human Services (HHS)	All alternatives that involve action will be preceded by a contact with HHS to request the appropriate support.
U.S. Army Corps of Engineers (COE)	All alternatives that involve action will be managed by the COE. COE will be contacted when EPA has selected a remedial action and is prepared to proceed.
Dept. of Labor Occupational Safety and Health Administration (OSHA)	All alternatives that involve onsite action may require OSHA contact before action to provide input and assistance if necessary.
Department of Transportation (DOT)	All alternatives that require offsite transportation of contaminated media will comply with DOT regulations regarding the transportation of hazardous materials.
U.S. Fish and Wildlife Service (USFWS)	Some game species and fish maybe affected if the access restriction or no action alternative is implemented.
Bureau of Land Management (BLM)[a]	No federal lands are involved in the implementation of alternatives.
Advisory Council on Historic Preservation[a]	No landmarks, historic sites, or areas of historic, scientific, or cultural interest will be affected by the implementation of alternatives.
U.S. Forest Service (USFS)[a]	No wild and scenic rivers will be affected by implementation of alternatives.
Department of Housing and Urban Development (HUD)[a]	The site does not lie in a flood plain; therefore, HUD flood plain maps are not required for the site.

[a] Coordination with this agency not anticipated to be needed at this site.

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Table 7-4 (Page 1 of 2)
FEDERAL LAWS, REGULATIONS, POLICIES, AND STANDARDS REVIEWED
AND FOUND NOT APPLICABLE TO ALTERNATIVES

Law, Regulation or Policy	Applicability
Safe Drinking Water Act, Underground Injection Control (UIC) Program: Criteria and Standards (40 CFR Part 146)	None of the alternatives include the underground injection of any materials.
Marine Protection, Research and Sanctuaries Act (40 CFR Part 220-229) Ocean Dumping Requirements	Implementation of the alternatives does not include the dumping of any materials in the ocean or incineration at sea.
Radioactive Waste Rule--High and Low Level	Existing records do not indicate that the site does not contain high- or low-level radioactive waste.
National Register of Historic Places	Implementation of the alternatives will not affect sites on the register.
Wild and Scenic Rivers Act (40 CFR Part 6.302)	Rivers on the national inventory will not be affected by alternatives.
Endangered Species Act Protection of Threatened or Endangered Species and Their Habitats (50 CFR Part 402)	Implementation of the alternatives will not affect threatened or endangered species and their habitat.
Fish and Wildlife Act Conservation of Wildlife Resources	Implementation of the alternatives will not affect areas of important wildlife resources.
Coastal Zone Management Act (15 CFR 920-926)	Implementation of the alternatives will not affect a coastal zone.
Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1979 (40 CFR 4)	Implementation of the alternatives should not require relocation of residences or businesses or acquisition of property.
Executive Orders for Flood Plain (EO11988)	Implementation of this alternative will not occur in a flood plain.
Executive Orders for Wetlands (EO11990)	Implementation of this alternative will not occur in a wetland.

GLT360/87-1

Table 7-4 (Page 2 of 2)

Law, Regulation or Policy	Applicability
National Environmental Policy Act (NEPA)	CERCLA actions are exempted from the NEPA requirement because EPA's decision-making process in selecting a remedial action alternative is the functional equivalent of the NEPA analysis.
Archaeological and Historic Preservation Act of 1974	No such resources are expected to be affected by the alternatives.

GLT360/87-2

Table 7-5 (Page 1 of 4)

ASSEMBLED ALTERNATIVES COMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS

Law or Regulation	Analysis	Alternative 1	2	3	4	5	6	7
FEDERAL								
Resource Conservation and Recovery (RCRA) - Subtitle C								
40 CFR 262 Standard for Generators	This alternative will involve offsite treatment/disposal of hazardous waste. RCRA generator regulations apply.			X	X	X	X	X
40 CFR 264-265 Standards for owners and operators of hazardous waste treatment, storage and disposal facilities.	This alternative will not be consistent with current RCRA regulations.	X	X					
	This alternative will require use of an RCRA-permitted facility in compliance with current RCRA regulations.			X	X	X	X	X
DOT Hazardous Materials Transport Rules (49 CFR Subchapter C) and RCRA - Subtitle C Standards for Transporters 40 CFR 263	Implementation of this alternative includes the offsite transport of hazardous materials. The transport of these materials will be in compliance with these rules, including use of properly constructed and marked transport vehicles, use of a licensed transporter, and use of hazardous waste manifests.			X	X	X	X	X
Clean Air Act (CAA)	Implementation of this alternative may result in the emission of pollutants into the air though below regulatory limits. A permit will not be required, but any necessary technical requirements will be met.					X		X
	Onsite excavation will result in the short-term emission of particulates. Onsite personnel will be adequately protected. Efforts to mitigate release will be made.			X	X	X	X	X

Table 7-5 (2 of 4)

Law or Regulation	Analysis	Alternative 1	2	3	4	5	6	7
Clean Water Act (CWA)								
40 CFR Parts 122, 125 and Subpart N National Pollutant Discharge Elimination System (NPDES)	Indiana has authorization to administer NPDES in Indiana. Refer to section on state regulation.							
40 CFR 403 Effluent Guidelines and Standards - Pretreatment Standards	Indiana has authorization to administration pretreatment in Indiana. Refer to section on state regulations.							
Federal Water Quality Criteria (FWQC)	Implementation of this alternative may not result in compliance with FWQC in surface water.	X	X	X				
EPA Groundwater Protection Strategy	This alternative will not attain EPA's groundwater protection strategy goals for a class II aquifer.	X	X	X				
Occupational Safety & Health Act (OSHA) Part 1910 (OSHA Standards)	Implementation of this alternative will require work on the site. Working conditions must assure safety and health of workers.			X	X	X	X	X
Toxic Substances Control Act (TSCA) 40 CFR 761	Alternative may require disposal of PCB-contaminated material; however, PCB levels are not at concentrations triggering disposal requirements. Material cannot be spread along roadways.			X	X	X	X	X
Intergovernmental Review of Federal Programs 40 CFR 29	Alternative requires intergovernmental review of project since project will use federal funds.		X	X	X	X	X	X

Table 7-5 (3 of 4)

Law or Regulation	Analysis	Alternative 1	2	3	4	5	6	7
STATE								
Indiana Hazardous Waste Management Program - Indiana Environmental Management Board Article 4 (320-1AC-4)								
Rules 2, 3, 4, Waste Generation Identification, Standards for Generators	This alternative will involve offsite disposal of hazardous waste and generator regulations apply.			X	X	X	X	X
Rule 5 Standards Applicable	Implementation of this alternative includes the offsite transport of hazardous materials. The transport of these materials will be in compliance with these rules, including use of properly constructed and marked transport vehicles, use of licensed transporters, and use of hazardous waste manifests.			X	X	X	X	X
Rule 6 Standards Applicable to Owners and Operators of Hazardous Waste Facilities	This alternative will not be consistent with current state regulations.	X	X					
Rule 7 Closure/Postclosure	This alternative will be consistent with current state regulations although no permit will be required.			X	X	X	X	X
Rule 8-9 Hazardous Waste Facility Construction and Operating Permit	This alternative will require the use of a state-permitted facility in compliance with current state regulations.			X	X	X	X	X
Indiana Waste Treatment Facilities Regulation - Title 330 - Article 3.1 Facility Construction	This alternative will require construction of a waste treatment facility and will be consistent with the technical requirement of Article 3.1.				X	X	X	X

Table 7-5 (4 of 4)

Law or Regulation	Analysis	Alternative 1	2	3	4	5	6	7
Article 5 Industrial Wastewater Pretreatment and NPDES Programs - Rules 1 - 10	Implementation of this alternative may result in an onsite point source discharge. An NPDES permit will not be required, but the technical requirements will be met.				X	X	X	X
Rules 11-15 Pretreatment Standards	Not applicable. Implementation of this alternative will not result in discharge of a waste stream to a publicly-owned treatment works (POTW).	X	X	X	X	X	X	X
Indiana Water Quality Standards Stream Pollution Control Board 330 (AC Article 1-2, Section 6 Water Quality Standard	Implementation of this alternative may not result in compliance with Indiana Water Quality Standards	X	X	X				
Indiana Air Pollution Control	This alternative will be consistent with the technical requirement of current Indiana regulation although no permit will be required.	X	X	X	X	X	X	X
LOCAL								
Zoning	This alternative will require no zoning change.	X	X	X	X	X	X	X

GLT533/34

Table 7-6
SUMMARY OF INSTITUTIONAL IMPACTS OF ALTERNATIVES

Alternative	Comment
1 No Action	Uncontrolled hazardous waste site does not meet goals of CERCLA. Groundwater in violation of drinking water quality criteria. Surface water exceeds ambient water quality criteria for protection of human health. The public and elected officials in the area around ECC are in opposition to its presence.
2 Access Restrictions	The site is not cleaned up, but isolated. This may not satisfy citizens and elected officials. Water quality criteria still violated. Would need to acquire land and implement deed restrictions. The site is not "cleaned up" so policy goal of CERCLA is not met.
3 Capping	The site is not cleaned up. Contaminant migration greatly reduced but groundwater may continue to exceed water quality criteria far into the future.
4 Groundwater Collection and Treatment	Cleanup is more complete then in Alternative 3 since groundwater treatment is included. The CERCLA cleanup goal is achieved, but over a long time frame.
5 Groundwater Collection and Treatment - Soil Vapor Extraction	Cleanup of soil contaminants to 10^{-6} risk level allows CERCLA cleanup goal to be achieved in shorter time frame than previous alternatives.
6 Soil Excavation with Offsite Disposal-Groundwater Collection and Treatment	All standards will be met. Because waste is removed permanently, public reaction should be positive. CERCLA goals will be met in relatively short time. Because waste is to go offsite, RCRA generator and transporter requirements will require compliance. Waste must go to a RCRA permitted facility.
7 Soil Excavation with Onsite Incineration and Onsite Disposal- Groundwater Collection and Treatment	Same as Alternative 6. CERCLA goals will be met. Requires delisting of residue to dispose of it onsite. No permits required but need to follow technical requirements.

GLT533/35

TABLE 7-7
ALTERNATIVE 2 - ACCESS RESTRICTIONS
COST SUMMARY (a)

		Capital Cost (b)	Average Annual Operation & Maintenance (b)	
Monitoring program		23,000	19,100	
Access restrictions (e)		41,000	2,800	
CONSTRUCTION SUBTOTAL		64,000		
Mobilization/demobilization	5%	3,200		
Health & Safety	5%	3,200		
Bid contingency	10%	6,400		
Scope contingency	10%	6,400		
CONSTRUCTION TOTAL		83,000		
Permitting & Legal	5%	4,200		
Services during construction		5,000		
TOTAL IMPLEMENTATION COST		92,000		
Engineering design cost	0.06	15,000		
TOTAL CAPITAL COST		$107,000		
ANNUAL OPERATION & MAINTENANCE			$22,000	
TOTAL PRESENT WORTH (c)				$293,000

a. Capital and operation and maintenance (O&M) cost estimates are order of magnitude level estimates with an expected accuracy of +50 to -30 percent.
b. Construction costs, subtotals, contingencies, and final capital, O&M and present worth estimates worth estimates are rounded to two significant figures.
c. The estimated present worth is based on 10 percent discount rate, and 30-year alternative life.
e. Present worth is based on replacement at 30 years.

Table 7-8
ALTERNATIVE 3 - CAPPING COST SUMMARY (a)

		Capital Cost (b)	Average Annual Operation & Maintenance (b)	
ECC Site Work		144,000		
Monitoring program		23,000	19,100	
RCRA Cap		365,000	3,600	
Access restrictions (e)		41,000	2,800	
CONSTRUCTION SUBTOTAL		573,000		
Mobilization/demobilization	5%	29,000		
Health & Safety	10%	57,000		
Bid contingency	15%	86,000		
Scope contingency	20%	115,000		
CONSTRUCTION TOTAL		860,000		
Permitting & Legal	5%	43,000		
Services during construction		75,000		
TOTAL IMPLEMENTATION COST		978,000		
Engineering design cost		75,000		
TOTAL CAPITAL COST		$1,053,000		
ANNUAL OPERATION & MAINTENANCE			$26,000	
TOTAL PRESENT WORTH (c)				$1,272,000

a. Capital and operation and maintenance (O&M) cost estimates are order of magnitude level estimates with an expected accuracy of +50 to -30 percent.
b. Construction costs, subtotals, contingencies, and final capital, O&M and present worth estimates worth estimates are rounded to two significant figures.
c. The estimated present worth is based on 10 percent discount rate, and 30-year alternative life.
e. Present worth is based on replacement at 30 years.

Table 7-9
ALTERNATIVE 4 - GROUNDWATER COLLECTION AND TREATMENT COST SUMMARY (a)

		Capital Cost (b)	Average Annual Operation & Maintenance (b)	
ECC site work		251,000		
Monitoring program (e)		23,000	20,000	
Silty clay cap		133,000	5,400	
Groundwater collection		562,000	2,000	
Groundwater treatment		157,000	78,000	
CONSTRUCTION SUBTOTAL		1,126,000		
Mobilization/demobilization	5%	56,000		
Health & Safety	15%	169,000		
Bid contingency	15%	169,000		
Scope contingency	20%	225,000		
CONSTRUCTION TOTAL		1,745,000		
Permitting & Legal	3%	52,000		
Services during construction		200,000		
TOTAL IMPLEMENTATION COST		1,997,000		
Engineering design cost		300,000		
TOTAL CAPITAL COST		2,297,000		
ANNUAL OPERATION & MAINTENANCE			$105,000	
TOTAL PRESENT WORTH (c)				$3,285,000

a. Capital and operation an.. maintenance (O&M) cost estimates are order of magnitude level estimates with an expected accuracy of +50 to -30 percent.
b. Construction costs, subtotals, contingencies, and final capital, O&M and present worth estimates worth estimates are rounded to two significant figures.
c. The estimated present worth is based on 10 percent discount rate, and 30-year alternative life.
e. Present worth is based on replacement at 30 years.

Table 7-10
ALTERNATIVE 5 - SOIL VAPOR EXTRACTION AND GROUNDWATER COLLECTION AND TREATMENT COST SUMMARY (a)

		Capital Cost (b)	Average Annual Operation & Maintenance (b)	
ECC site work		251,000		
Monitoring program (e)		23,000	20,000	
Silty clay cap		133,000	5,400	
Groundwater collection		562,000	2,000	
Groundwater treatment		157,000	78,000	
Soil vapor extraction		500,000	47,000	
CONSTRUCTION SUBTOTAL		1,626,000		
Mobilization/demobilization	5%	81,000		
Health & Safety	15%	244,000		
Bid contingency	15%	244,000		
Scope contingency	25%	407,000		
CONSTRUCTION TOTAL		2,602,000		
Permitting & Legal	3%	78,000		
Services during construction		250,000		
TOTAL IMPLEMENTATION COST		2,930,000		
Engineering design cost		400,000		
TOTAL CAPITAL COST		3,330,000		
ANNUAL OPERATION & MAINTENANCE			$152,000	
TOTAL PRESENT WORTH (c)				$5,442,000

a. Capital and operation and maintenance (O&M) cost estimates are order of magnitude level estimates with an expected accuracy of +50 to -30 percent.
b. Construction costs, subtotals, contingencies, and final capital, O&M and present worth estimates worth estimates are rounded to two significant figures.
c. The estimated present worth is based on 10 percent discount rate, and 30-year alternative life.
e. Present worth is based on replacement at 30 years.

Table 7-11
ALTERNATIVE 6 - SOIL EXCAVATION WITH DISPOSAL OFFSITE, GROUNWATER COLLECTION AND TREATMENT COST SUMMARY (a)

		Capital Cost (b)	Average Annual Operation & Maintenance (b)	
ECC site work		251,000		
Monitoring program (e)		23,000	20,000	
Soil excavation		2,027,000		
Silty clay cap		277,000	5,400	
Groundwater collection		562,000	2,000	
Groundwater treatment		157,000	78,000	
CONSTRUCTION SUBTOTAL		3,297,000		
Mobilization/demobilization	5%	165,000		
Health & Safety	15%	495,000		
Bid contingency	15%	495,000		
Scope contingency	25%	824,000		
CONSTRUCTION TOTAL		5,276,000		
Permitting & Legal	2%	106,000		
Services during construction		300,000		
TOTAL IMPLEMENTATION COST		5,682,000		
Engineering design cost		350,000		
TOTAL CAPITAL COST		$6,032,000		
ANNUAL OPERATION & MAINTENANCE			$105,000	
TOTAL PRESENT WORTH (c)				$7,019,000

a. Capital and operation and maintenance (O&M) cost estimates are order of magnitude level estimates with an expected accuracy of +50 to -30 percent.
b. Construction costs, subtotals, contingencies, and final capital, O&M and present worth estimates worth estimates are rounded to two significant figures.
c. The estimated present worth is based on 10 percent discount rate, and 30-year alternative life.
e. Present worth is based on replacement at 30 years.

Table 7-12
ALTERNATIVE 7 - SOIL EXCAVATION WITH ONSITE INCINERATION AND ONSIT DISPOSAL, GROUNWATER COLLECTION AND TREATMENT COST SUMMARY (a)

		Capital Cost (b)	Average Annual Operation & Maintenance (b)	
ECC site work		408,000		
Monitoring program (e)		23,000	20,000	
Soil excavation		103,000		
Soil incineration		22,000,000		
Silty clay cap		168,000	5,400	
Groundwater collection		562,000	2,000	
Groundwater treatment		157,000	78,000	
CONSTRUCTION SUBTOTAL		23,421,000		
Mobilization/demobilization	1%	234,000		
Health & Safety	3%	703,000		
Bid contingency	15%	3,513,000		
Scope contingency	20%	4,684,000		
CONSTRUCTION TOTAL		32,555,000		
Permitting & Legal	2%	651,000		
Services during construction		700,000		
TOTAL IMPLEMENTATION COST		33,906,000		
Engineering design cost		1,500,000		
TOTAL CAPITAL COST		$35,406,000		
ANNUAL OPERATION & MAINTENANCE			$105,000	
TOTAL PRESENT WORTH (c)				$36,394,000

a. Capital and operation and maintenance (O&M) cost estimates are order of magnitude level estimates with an expected accuracy of +50 to -30 percent.
b. Construction costs, subtotals, contingencies, and final capital, O&M and present worth estimates worth estimates are rounded to two significant figures.
c. The estimated present worth is based on 10 percent discount rate, and 30-year alternative life.
e. Present worth is based on replacement at 30 years.

before making specific financial decisions or establishing final budgets.

DETAILED ANALYSIS SUMMARY

A summary of the detailed analysis of alternatives is presented in Table 7-13.

GLT360/78

	1 No Action	2 Access Restrictions	3 Capping	4 Groundwater Collection and Treatment
TECHNICAL CRITERIA	— — Allows release of hazardous constituents causing unacceptable public health risk.	— Effectiveness and reliability depends on fence maintenance, regular monitoring and enforcement of deed restrictions for 200 years. Possibility of lax maintenance or deed restriction enforcement in future may lead to exposures.	O Reduces leaching of contaminants from soil to groundwater. Excavation of former cooling pond sludge prevents further contamination of sand and gravel aquifer. Cap has proven performance and no substantial implementation problems. Access restriction components have similar technical evaluations as Alternative 2.	+ Reduces exposure risk to groundwater and surface water. GAC treatment has proven performance. Implementation will require performance testing and discharge permitting. Components mutual with Alternative 3 have similar technical evaluation.
PUBLIC HEALTH AND WELFARE CRITERIA	— — Public health risks exist for direct contact with excavated soil, ingestion or dermal absorption of groundwater contaminants, and dermal absorption of surface water contaminants. Exposure limited to local population. Duration of potential exposure exceeds 100 years for excavated soil contact and 200 years for the groundwater and surface water risks.	— Lifetime cancer risks the same as No Action if exposure occurs. Exposure prevention depends on successful enforcement of deed restrictions and maintenance of fencing for over 200 years.	O Capping decreases health risks associated with groundwater and surface water contamination but the period where exceedance of groundwater WQC remains greater than 200 years. Exposure prevention depends on successful enforcement of deed restrictions and maintenance of fencing for over 200 years.	+ WQC for groundwater in the saturated zone are met in 130 years. Groundwater sand and gravel aquifer cancer risks reduced to $< 10^{-6}$ after 4-year operation period. Surface water health risks greatly reduced since all contaminanted groundwater is intercepted before discharge. Deed restrictions and fencing needed during operation. Risks from soil exposure unchanged.
ENVIRONMENTAL CRITERIA	— Local vegetation and burrowing animals may be affected through uptake or direct contact with onsite soil. Food chain bioconcentration may affect other local terrestrial animals.	O Fencing may limit exposure to some terrestrial animals.	+ Cap will reduce exposure of terrestrial animals.	+ Same as Alternative 2.
INSTITUTIONAL CRITERIA	— — Uncontrolled hazardous waste site does not meet goals of CERCLA or RCRA. Groundwater in violation of drinking water standards.for protection of human health. The public and elected officials in area around ECC are in opposition to its presence.	— The site is not "cleaned up" so policy goal of CERCLA is not met. Standards and criteria still violated. Would need to acquire land and implement deed restrictions.	O The site is not cleaned up. Contaminant migration greatly reduced but groundwater may continue to exceed WQC far into future, possibly resulting in public opposition.	+ Same as Alternative 3 except cleanup is more complete since groundwater is included. This CERCLA cleanup goal is achieved, but over a long time frame.
ORDER-OF-MAGNITUDE COST ESTIMATE[a]				
TOTAL CAPITAL[b]	0	$107,000	$1,050,000	$2,300,000
ANNUAL O&M	0	22,000	26,000	105,000
PRESENT WORTH[c]	0	293,000	1,270,000	3,290,000

RATINGS

++ An extremely positive benefit
+ A positive or moderately positive benefit
O Of very little apparent positive or negative effects, but inclusion can be justified for some special reason; or no change from existing conditions.
— Negative effects but not strong enough or certain enough to be the sole justification for eliminating an alternative; or of only moderate significance.
— — Extremely negative effects even with mitigating measures; capable of eliminating an alternative.

NOTES:

[a] The American Association of Costs Engineers define an Order-of-Magnitude Estimate as an approximate estimate made without detailed engineering data. It is normally expected that an estimate of this type is accurate within +50% to -30%. Sources of cost information include the U.S. EPA's "Compendium of Cost of Remedial Technologies at Hazardous Waste Sites," the 1985 Means Site Work Cost Data Guide, Cost Reference Guide for Construction Equipment 1985, and vendor estimates.
[b] Total Capital Cost include indirect cost for engineering services, legal fees, administration costs and contingency (45% of total construction cost.)
[c] Total Present Worth Cost is based on 30-year period of 10% interest. Uniform series present worth factor 9.4269. In some cases, a portion of the annual O&M is for a period less than 30 years. See individual cost tables for details.

TABLE 7-13 (Page 1 of 2)
DETAILED EVALUATION SUMMARY MATRIX
ECC FS

	5 Groundwater Collection and Treatment - Soil Vapor Extraction	6 Soil Excavation and Disposal Offsite - Groundwater Collection and Treatment	7 Soil Excavation with Onsite Incineration and Onsite Disposal - Groundwater Collection and Treatment
TECHNICAL CRITERIA	+ + Reduces risk associated with direct contact with soil or leaching of soil contaminants to groundwater. Vapor extraction proven effective and reliable under different site conditions. Pilot-testing would be necessary. Implementation also requires air discharge permit. Components mutual with Alternative 4 have similar technical evaluation.	+ + Reduces risk associated with direct contact with soil or leaching of contamination to groundwater. Soil excavation and transport is effective, reliable and easily implementable. Disposal at a RCRA landfill does not result in contaminant destruction. Performance of ultimate disposal at a RCRA landfill is considered reliable. Components mutual with Alternative 4 have similar technical evaluation.	+ + Reduces risks associated with direct contact with soil or leaching of contamination to groundwater. Incineration has been proven effective for removal of organic contaminants to 99.99 percent. Operation is complex. Implementation requires performance testing and air discharge permit. Onsite disposal of incinerated soil requires delisting as hazardous waste. Components mutual with Alternative 6 have similar technical evaluation.
PUBLIC HEALTH AND WELFARE CRITERIA	+ + Cancer risk from soil reduced to $< 10^{-6}$. ADI exceedance of lead and cadmium unchanged. WQC for groundwater in the shallow saturated zone met in 30 years. All other health risks same as Alternative 4. Minor soil release during french drain and extraction well construction.	+ + Cancer health risks from soil reduced to $< 10^{-6}$ onsite. No exceedance of ADI's. Health risks from soil direct contact remain at RCRA landfill though expsure potential is lower. WQC for groundwater in the shallow saturated zone met in 30 years. All other health risks the same as Alternative 4. Public welfare impacts from truck traffic and noise along route to RCRA landfill.	+ + All cancer health risk reduced to $< 10^{-6}$. ADI's for lead and cadmium may be exceeded. Potential for impacts from air emissions if incinerated system is run improperly. WQC for groundwater in the shallow saturated zone met in 30 years. All other health impacts same as Alternative 4.
ENVIRONMENTAL CRITERIA	+ Soil exposure risk reduced for terrestrial animals.	+ Same as Alternative 5.	+ Same as Alternative 5.
INSTITUTIONAL CRITERIA	+ CERCLA cleanup goal achieved in shorter time frame than previous alternatives.	+ + All standards will be met. Because waste is removed permanently, the public reaction should be positive. CERCLA goals will be met in relatively short time. Because waste is to go offsite, RCRA generator and transporter requirements will require compliance. Waste must go to a RCRA facility.	+ Same as Alternative 6 except because waste is detoxified onsite there may be some local opposition. CERCLA goals will be met. Requires delisting of residue to dispose onsite. No permits required but need to follow technical requirements.
ORDER-OF-MAGNITUDE COST ESTIMATE[a]			
TOTAL CAPITAL[b]	$3,330,000	$6,030,000	$35,400,000
ANNUAL O&M	152,000	105,000	105,000
PRESENT WORTH[c]	5,440,000	7,020,000	36,400,000

RATINGS

++ An extremely positive benefit
+ A positive or moderately positive benefit
o Of very little apparent positive or negative effects, but inclusion can be justified for some special reason; or no change from existing conditions.
— Negative effects but not strong enough or certain enough to be the sole justification for eliminating an alternative; or of only moderate significance.
—— Extremely negative effects even with mitigating measures; capable of eliminating an alternative.

NOTES:

[a] The American Association of Costs Engineers define an Order-of-Magnitude Estimate as an approximate estimate made without detailed engineering data. It is normally expected that an estimate of this type is accurate within +50% to -30%. Sources of cost information include the U.S. EPA's "Compendium of Cost of Remedial Technologies at Hazardous Waste Sites," the 1985 Means Site Work Cost Data Guide, Cost Reference Guide for Construction Equipment 1985, and vendor estimates.

[b] Total Capital Cost include indirect cost for engineering services, legal fees, administration costs and contingency (45% of total construction cost.)

[c] Total Present Worth Cost is based on 30-year period of 10% interest. Uniform series present worth factor 9.4269. In some cases, a portion of the annual O&M is for a period less than 30 years. See individual cost tables for details.

TABLE 7-13 (Page 2 of 2)
DETAILED EVALUATION SUMMARY MATRIX
ECC FS

Appendix A
SOIL REMOVAL/LEACHATE--GROUNDWATER INTERACTION ANALYSIS

Appendix A
SOIL REMOVAL/LEACHATE - GROUNDWATER INTERACTION ANALYSIS

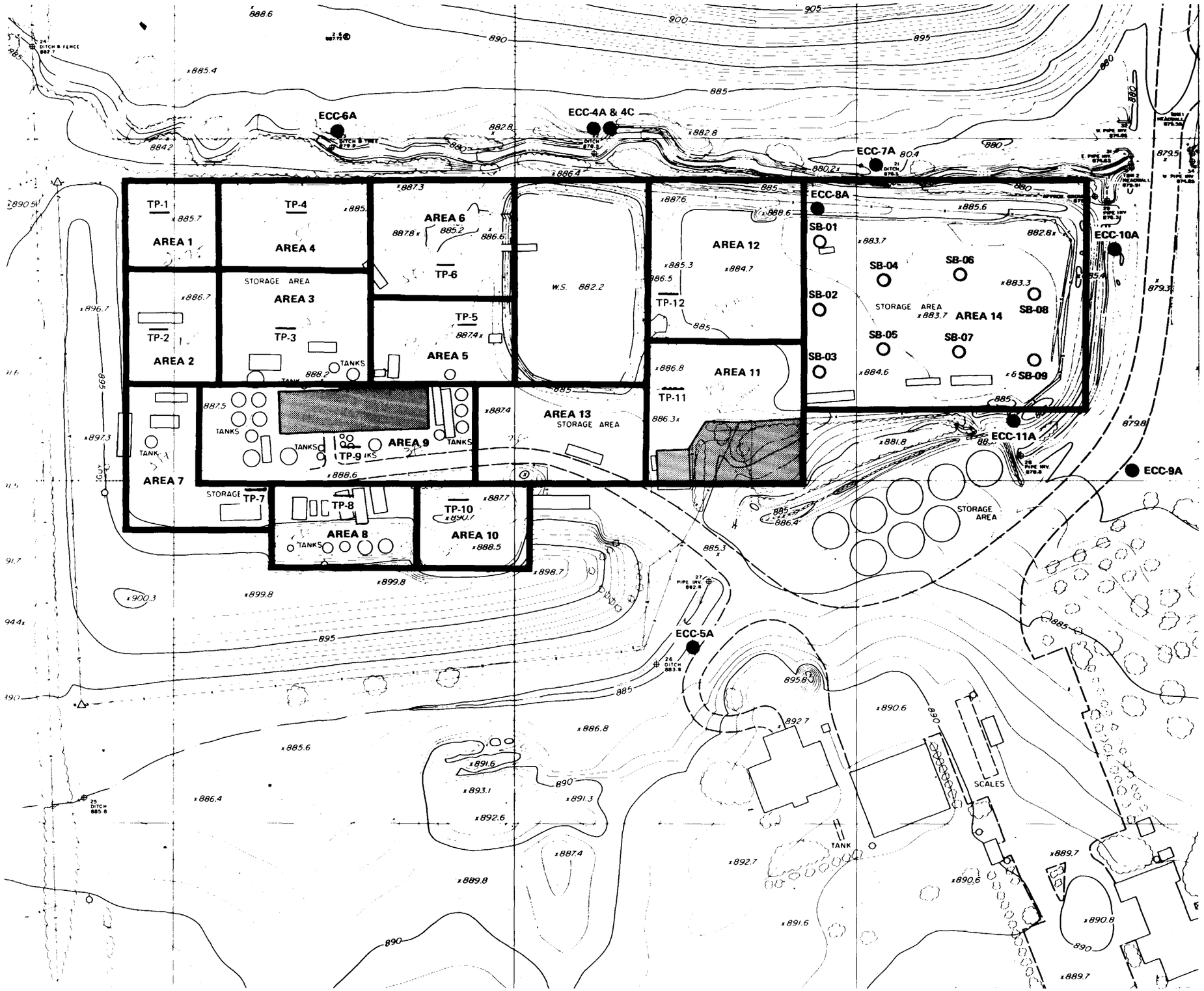
This appendix presents the description of the analysis used to assess the vertical and horizontal distribution of soil contaminants at the site, various soil removal options, and potential groundwater contamination resulting from water percolating downward through contaminated soil and recharging the groundwater system. Detailed description of the analysis methodology and assumptions are presented in Attachments 1 and 2 to this appendix.

ANALYSIS OF SOIL REMOVAL OPTIONS

Removal of contaminated soil from the site serves the dual functions of reducing potential direct contact with contaminated materials and removing the most important contaminant source with regards to leachate generation. The distribution of contaminants within the soil column is described in Attachment 1 of this appendix. Included in this attachment are data relevant to the vertical distribution of contaminants. Figure A-1 shows how the site was divided for this soil analysis.

Three contaminated soil removal options are identified and evaluated: contaminated soil removal to background levels, contaminated soil removal to the 10^{-6} cancer risk level, and no soil removal. Contaminated soil removal to background was estimated considering removal of all unsaturated soil beneath the areas delineated in Figure A-1. The contaminated soil removal to background option involves excavation to a depth of 5-feet, an estimated 24,000 yd^3 of soil, below the existing cap and concrete pad. The contaminated soil removal to the 10^{-6} risk level involves excavation of an estimated 11,500 yd^3 of soil with contaminant concentrations having a calculated excess lifetime cancer risk of 10^{-6} or greater for residents ingesting soil. The no soil removal option consists of leaving the existing contaminated soil in place.

The three identified soil removal options are summarized as follows:



LEGEND

- TEST PIT LOCATION
- SOIL BORING LOCATION
- MONITORING WELL LOCATION
- AREAS EXCLUDED FROM ANALYSIS

NOTE: Map represents topography and onsite features prior to surface cleanup.

All well locations are approximate.

N

0 25 50

SCALE IN FEET

FIGURE A-1
AREAS IDENTIFIED FOR EVALUATION OF CONTAMINATED SOIL REMOVAL
ECC FS

	Estimated Soil Volume Excavated (yd^3)	Maximum Excess Lifetime Cancer Risk
No Soil Removal	0	4×10^{-3}
Contaminated Soil Removal to 10^{-6} Risk Level	11,500	10^{-6}
Contaminated Soil Removal to Background Level	24,000	0

ANALYSIS OF GROUNDWATER -- LEACHATE INTERACTION

To aid in selecting various soil removal options and assessing their relative impacts on groundwater quality with time, five organic priority pollutant compounds are identified for the analysis. This subset of compounds is selected to reduce the variety of total identified compounds to a manageable number. These compounds include the following:

- Volatile Organic Priority Pollutant Compounds
  - trichloroethene
  - tetrachloroethene
  - 1,1,1-trichloroethane
  - methylene chloride
  - ethylbenzene

These organic compounds are selected to represent a range of considerations that affect groundwater quality and duration of extraction. Criteria used for selection of these compounds include:

- Ambient Water Quality Criteria (AWQC) concentrations for carcinogenicity protection. Low AWQC concentrations affect the duration of extraction and possibly type and size of treatment.

- Groundwater concentration and estimated mass in the saturated zone. Both affect extraction during treatment.

- Estimated mass in the unsaturated zone subject to desorption and migration into the saturated zone through leachate. This affects the duration of extraction, if required.

- Partitioning coefficient. The partitioning coefficient affects the duration required for extraction to a specific cleanup level.

Three soil removal options are analyzed to evaluate their effect on reducing contaminants in soil and groundwater at the site. Table A-1 summarizes the relative effect each option has on the estimated average soil concentration for the selected organic compounds. Details regarding the calculation of these average concentrations are presented in Attachments 1 and 2.

In addition, these removal options are assessed considering implementation of either a multimedia (RCRA) cap (assumed permeability of 10^{-9} cm/sec), a clay cap (assumed permeability of 10^{-7} cm/sec), or a more permeable silty clay cap (no infiltration reduction; strictly direct contact control).

LEACHATE -- GROUNDWATER ANALYSIS

This analysis assesses and compares the relative effects of various soil remedial actions (e.g., soil removal, encapsulation, and/or capping) on groundwater quality and groundwater remedial actions. The connection between soil remedial actions and groundwater is leachate generated with percolation of water through contaminated soil. Soil remedial actions influence groundwater quality by affecting the quantity of contaminants available for leaching and the quantity of water percolating through the soil. In turn, groundwater quality directly influences the operation time of groundwater actions such as extraction and treatment.

METHODOLOGY

The basis of this analysis relies on the integration of sorption theory with mass balancing. Adsorption-desorption principles are applied to estimate contaminant concentrations in soil and water. Mass balancing is applied to estimate depletion for contaminants present in both the unsaturated (above the water table) and saturated groundwater zones.

The analysis of leachate effects involves estimation of infiltration rates, the quantity of contaminants available for leaching, concentrations of those contaminants in water percolating through the unsaturated zone, and rates of contaminant contribution to the groundwater or saturated zone. Estimates of this kind are tentative and limited in accuracy because of the uncertainties associated with sample data, site characterization, and the developmental nature of the science; however, they are presented here as a practical tool for assessing the relative impacts associated with various remedial actions.

This analysis can be divided into these major steps:

Table A-1

"AVERAGE" SOIL CONCENTRATIONS (ug/kg) OF SEVERAL PRIORITY POLLUTANT COMPOUNDS RESULTING FROM SPECIFIC SOIL REMOVAL ACTIONS

Removal Option	Removal Volume (yd^3)	Trichloroethene	Tetrachloroethene	1,1,1-trichloroethane	Methylene Chloride	Ethylbenzene
No Soil Removal	0	154,000	25,400	42,800	22,500	103,000
Contaminated Soil Removal to 10^{-6} Risk Level[1]	11,500	154	59	2,290	400	4
Contaminated Soil Removal to Background Level[2]	24,000	0	0	0	0	0

[1] Estimated based on the following soil excavation depths: Area 1 - 2.75 feet; Area 2 - 1.5 feet; Areas 3 - 2.5 feet; Area 4 - 5 feet; Area 5 - no removal; Areas 6, 7, 8 - 5 feet; Areas 9, 10, 13 - 3 feet; Areas 11 and 12 - no removal; Area 14 - removal of 1,500 cubic yards.

[2] Estimates based on excavation of all unsaturated soil beneath areas delineated in Figure A-1.

GLT533/29

- Estimation of leachate parameters: Quantity and contaminant concentrations in leachate versus time.

- Estimation of groundwater parameters: Contaminant quantities present in the saturated zone.

- Estimation of groundwater quality versus time: Combined effects of contaminants present in the unsaturated and saturated zones.

Estimation of Leachate Parameters

To estimate contaminant concentrations in water percolating through the unsaturated zone beneath the site, the quantity and average concentration of each contaminant in the soil are estimated. Total quantities for each contaminant are calculated using the analysis presented in the soil analysis discussion (Attachment 1). An average soil concentration is determined by dividing the calculated total quantity of each contaminant by the volume of the unsaturated zone beneath the site in areas delineated for the soil analysis (Attachment 1).

Contaminant concentrations in the leachate are estimated from the calculated average soil concentrations using the Freundlich equation to describe the adsorption-desorption process. The Freundlich equation relates the equilibrium concentration of adsorbate in solution (C) to the weight of adsorbate per unit weight of adsorbent (x/m) using an expression of the form:

$$x/m = KC^{1/n}$$

where K and n are empirical constants. The constant K is referred to as the distribution or partition coefficient. Several significant assumptions (detailed in Attachment 2) together with the average soil concentrations calculated previously allow an estimate of the concentrations of various contaminants in water passing through the unsaturated zone.

Water percolating through the soil profile over a period of time removes a quantity of contaminants from the unsaturated zone. This removal reduces the average concentration of each contaminant, and thus reduces the concentrations in the next volume of water passing the profile. Continuing this cycle allows an estimation of the changes in contaminant concentration in soil and leachate with time.

Estimation of Groundwater Parameters

To apply a mass balance approach to the groundwater system requires an estimate of the total quantity of contaminants

present in the shallow saturated zone. Using estimated plume configuration equivalent to the shape of the site areas shown in Figure A-1, quantities of each contaminant detected in the groundwater sampled from well 11A are calculated. Quantities of each compound (trichloroethene and trans-1,2-dichloroethene) in the groundwater are calculated from the measured groundwater concentrations and the assumed plume dimensions. The Freundlich equation is applied using groundwater concentrations to estimate the quantity of each contaminant adsorbed onto solids in the saturated zone. The sum of the estimated groundwater and adsorbed contaminant quantities yielded the total quantity of contaminant present in the saturated zone.

A detailed description of the assumptions and methodology used in estimating these contaminant quantities is presented in Attachment 2.

Groundwater Quality Versus Time

Estimation of contaminant concentrations in groundwater with time requires a simulation of the complex processes involved in the mixing zone or interface between the unsaturated and saturated zones. This analysis assumes that leachate from the unsaturated zone enters a cell of aquifer volume equal to the assumed plume volume. The amount of leachate contributed to this cell is determined by the estimated residence time of groundwater in the plume volume (time associated with one pore volume exchange or extraction). For this estimation method, groundwater absent of any contaminants is moved into the cell to fill the remaining pore space.

Sorption equilibrium (as described by the Freundlich equation) is assumed to occur between the aquifer skeleton and the groundwater in the cell. The equilibrium concentrations of the groundwater and aquifer skeleton are determined using the Freundlich equation and the total mass of contaminant available in the cell (sum of contaminant adsorbed on aquifer skeleton and contributed by leachate).

The equilibrium groundwater concentrations generated by this analysis are "average" concentrations within the cell volume. The "equilibrated" groundwater now containing contaminants is removed from the cell and the process repeated. The total mass of contaminants to be partitioned or distributed between the solid and liquid phases changes because of mass balance considerations for the unsaturated and saturated zones. Each removal of leachate from the unsaturated zone or contaminated groundwater from the aquifer cell volume removes contaminants from the respective systems and thus changes the estimated concentrations of leachate and groundwater with time.

Details concerning the assumptions and methodology for this analysis are presented in Attachment 2 of this appendix.

GLT533/28

Attachment 1
SOIL ANALYSIS

This attachment to Appendix A presents the detailed methodology used to estimate the quantity and distribution (both in area and with depth) of priority pollutant compounds at the site. This methodology is also applied to determine the average concentration of each compound in the soil (unsaturated zone) for input into leaching estimates (Attachment 2 to Appendix A).

To estimate the quantity of soil contaminants at the site, the following equation is applied to RI investigation soil samples:

$$Q = \sum_{i=1}^{14} \sum_{j=1}^{n} (C_{ij})\ (T_{ij})\ (A_i)\ \gamma$$

where:

Units are consistent, and

Q = Estimated total quantity (mass) of priority pollutant fraction (volatile organics, base/neutrals, pesticides, or acids),

C_{ij} = Concentration (total for priority pollutant fraction in question) for j^{th} sample in i^{th} area,

T_{ij} = Soil depth interval thickness associated with the jth sample in i^{th} area,

A_i = Area of ith area,

γ = Dry unit weight of soil (assumed to be 120 lb/ft^3 or 54.43 kg/ft^3), and

n = number analyzed samples in i^{th} area.

Compounds reported in samples at concentrations below quantification limits are included in the analysis with values equal to the quantification limits. This assumption biases the analysis results upward only slightly, since these sample values represent a relatively minor component of the analysis. The relative comparison of alternatives is not altered by this assumption.

Fourteen areas inside the fenced area of the site are delineated (Figure A-1). The areas are delineated considering

historical information on handling and storage practices, historical air photographs, site topography, and soil sampling locations. Onsite areas excluded from the analysis include soil beneath existing structures (no data available), soil in the previous berm area (assumed uncontaminated based on previous sampling), soil in the cooling pond area (assume uncontaminated backfill following water and sludge removal).

The soil depth interval (thickness) associated with each soil sample is taken as the distance between the midpoints to the adjacent overlying and underlying soil samples for which analyses are conducted.

Additional assumptions included in the analysis are:

- Only 4 feet of unsaturated soil beneath the concrete pad (1 foot average thickness of concrete pad).
- Concentration of organic compounds below depth of 2.5 feet in Area 3 are assumed equal to 1/10 the concentrations detected in the sample from a depth of 1 foot in TP-3. This assumption is based on observed trends with depth for adjacent areas.
- Area 13 concentrations were assumed equal to the average of adjacent Areas 5, 9, 10, and 11.

GLT533/31

Attachment 2
LEACHATE-GROUNDWATER ANALYSES

This attachment to Appendix A presents detailed methodology used to estimate the interaction of soil contaminant leaching and groundwater extraction for aquifer cleanup. This attachment is subdivided into three sections:

- Soil leachate calculations,
- Aquifer/plume characteristics, and
- Groundwater quality versus time calculations.

A summary of the methodology is presented in Figure A2-1.

SOIL LEACHATE CALCULATIONS

This section presents the methodologies applied in estimating the amounts, rates, and duration of contaminant transport from the soil (unsaturated zone) to the aquifer (saturated zone).

ESTIMATION OF VOLUMETRIC-WEIGHTED AVERAGE SOIL CONCENTRATIONS

For each priority pollutant compound detected in soil samples collected from locations within the delineated areas (Attachment 1), an "average" soil concentration is calculated. The "average" concentration is calculated by dividing the estimated mass of each compound by the mass of an unsaturated zone. The mass of the unsaturated zone is estimated to be 35,110,000 kg (645,000 ft^3 x 54.43 kg/ft^3), representing the soil mass beneath the delineated areas to a depth of 5 feet.

Quantities of each priority pollutant compound are estimated from test pit samples and soil boring samples collected during the RI investigation. Estimated quantities from surface and soil boring samples are calculated using the same procedures outlined in Attachment 1 for estimating total contaminant quantities.

ESTIMATION OF COMPOUND CONCENTRATIONS IN LEACHATE

Compound concentrations in water percolating downward through the unsaturated zone beneath the site are estimated using the Freundlich equation. The Freundlich equation can be written as follows:

$$\frac{M_{sc}}{Ms} = Kd\left(\frac{M_{wc}}{V_w}\right)^n$$

where: M_{sc} = mass of adsorbate on solids (ug),
Ms = mass of solids (kg),

Soil Leachate Calculations

- Estimate average soil concentrations
- Estimate concentrations in leachate using Freundlich equation
- Estimate recharge rate
- Estimate leachate concentrations versus time

Aquifer/Plume Characteristics

- Estimate plume volumes for each contaminant
- Estimate total quantity of contaminants in estimated plume volumes (quantity in groundwater and adsorbed on aquifer solids)

Groundwater Quality Versus Time Calculations

- Establish aquifer volume of cell in which to simulate the interaction between contaminants from the unsaturated and saturated zones.
- Establish time increments for the simulation analyses (based upon estimated residence time of groundwater in the established aquifer volume)
- Add quantity of contaminants in leachate to aquifer volume with adsorbed contaminants
- Assume equilibrium and distribute contaminants between solid and liquid phases according to Freundlich equation
- Assume removal of contaminated groundwater from cell and determine changes in contaminants masses within aquifer volume
- Repeat process of adding leachate and distributing among aquifer phases
- Analysis yields estimate of average groundwater concentrations (in the established plume volume) versus time

FIGURE A2-1
METHODOLOGY FLOW CHART FOR LEACHATE - GROUNDWATER ANALYSIS
ECC FS

M_{wc} = mass of adsorbate in solution (ug),
V_w = volume of solution (l), and
n and K_d = empirical constants (dimensionless and l/kg, respectively).

For the purpose of this analysis, the Freundlich equation is assumed to be linear (n = 1) over the range of compound concentrations present at the site.

K_d values, specific to each compound, are calculated from K_{oc} values obtained from correlations with octonal/water partitioning coefficients and an assumed organic carbon content of the unsaturated zone. The correlation used to obtain values of K_{oc} is:

K_{oc} = 10[(log octonal/water partition coefficient)-0.21] after Karickhoff et al. (1979).

where:

K_{oc} = is the soil solids-soil water distribution coefficient normalized to soil organic carbon content, and

K_d = (organic carbon content) x K_{oc}.

Table A2-1 lists the priority pollutant compounds detected in samples from the delineated areas and their estimated K_d values (assuming an organic carbon content of 0.2 percent).

ESTIMATION OF RECHARGE RATE

Considering the topographic position of the site, permeability of the surface soil, the amount of vegetation, and average precipitation per year for the Zionsville area a recharge rate of 7.8 inches per year is used for the analysis (no cap present).

ESTIMATION OF LEACHATE CONCENTRATIONS VERSUS TIME

Leachate and soil concentration changes over time are estimated using a mass-balance approach. Given the recharge rate, the volume of water passing into the unsaturated zone per year is calculated. The analysis assumes that the "average" soil concentration of each compound remains constant over the period of 1 year. Using the Freundlich equation, a concentration for each compound in the infiltrating volume of water is calculated. In addition, the quantity or mass of each compound in that volume of water is calculated. This quantity represents a mass of contaminant removed from the total mass of that contaminant adsorbed in the unsaturated zone.

Table A2-1
ESTIMATED DISTRIBUTION COEFFICIENTS FOR ORGANIC PRIORITY POLLUTANT COMPOUNDS DETECTED IN SOIL AT THE ECC SITE

Compound	Estimated Distribution Coefficient K_d
1,2-Dichlorobenzene	2.9
1,3-Dichlorobenzene	15
Naphthalene	2.9
Diethyl phthalate	10
Phenanthrene	36
Fluorene	19
Bis(2-ethylhexyl)phhalate	670,000
Di-n-butyl phthalate	200
Di-n-octyl phthalate	2,000,000
Chlorobenzene	0.87
1,1-Dichloroethane	0.076
1,1,1-Trichloroethae	0.18
1,1,2-Trichloroethae	0.18
Chloroform	0.115
Methylene chloride	0.022
Toluene	0.61
Trans-dichloroethen	0.037
Ethylbenzene	1.8
1,1-Dichloroethene	0.037
1,2-Dichloroethane	0.037
Tetrachloroethene	0.95
Trichloroethene	024
Vinyl chloride	0.05
PCB	125
Phenol	0.036

Note: K_d values were calculated assuming an organic carbon content of 0.2 percent.

GLT533/30

The reduced mass of contaminants in the unsaturated zone correspondingly decreases the calculated "average" soil concentration of each compound. To calculate the leachate concentrations during the second time increment (i.e., second year) the Freundlich equation and an adjusted "average" soil concentration are used. This sequence of calculations is continued to generate an estimate of compound concentrations in leachate from the unsaturated zone versus time.

$$C_L = (K_{du})^{-1} C_s = (K_{du})^{-1} \frac{M_{cu}}{M_{su}}$$

where:

C_L = contaminant concentration in leachate,
C_s = average soil concentration,
K_{du} = K_d for unsaturated zone (assumes 0.2 percent organic carbon),
M_{cu} = mass of contaminant in the unsaturated zone,
M_{su} = mass of soil in the unsaturated zone,
M_{Lc} = mass of leached contaminant, and
M_{Lc} = (infiltration rate)(site area)(C_L).

$$M_{Lc} = (0.65\ ft/yr)(135{,}600\ ft^2)\ (K_{du})^{-1}\ (C_s)\ (28.316\ l/ft^3)$$

Leachate concentration variation with time:

at time t_o; $M_{uco} = (M_{su})\ (C_{so})$

at time t_i; $M_{ucl} = M_{uco} - M_{Lco}$

$$C_{sl} = \frac{M_{ucl}}{M_{su}}$$

where:

M_{Lco} = mass of leached contaminant over time t_o through t_i

Continue the process so that at time t_n;

$$M_{ucu} = M_{uco} - \sum_{i=o}^{n} M_{Lc}\ (n-1)$$

$$C_{su} = \frac{M_{ucu}}{M_{su}}$$

AQUIFER/PLUME CHARACTERISTICS CALCULATIONS

This section presents the methodologies used to estimate the aquifer and plume characteristics for estimation of groundwater contamination removal rates.

ESTIMATION OF TOTAL MASS OF CONTAMINANTS IN PLUME VOLUMES

The total mass in the aquifer of each priority pollutant organic compound detected in groundwater samples from well 11A at the site is estimated. The estimated mass includes contaminants in solution and adsorbed on solids of the aquifer skeleton. The mass of each contaminant in solution is estimated by assuming the concentration in the shallow saturated zone beneath the site areas shown in Figure A-1 is equal to the values detected in well 11A and calculating the volume of groundwater (assumed porosity equals 0.10 for the till). Then the mass is estimated by multiplying the concentration and the associated volume of groundwater. The mass of contaminants adsorbed is estimated using the Freundlich equation to describe the partitioning between the groundwater and aquifer skeleton. The values of K_d used are estimated as described previously (the organic carbon content of the saturated zone is assumed to be 0.2 percent).

GROUNDWATER QUALITY VERSUS TIME CALCULATIONS

This section presents the methodologies applied in estimating the change in groundwater quality with time as the groundwater is extracted.

The plume volume previously identified for the compounds detected in well 11A (trichloroethene and trans-1,2-dichloroethene) are used to simulate the interaction between contaminants from the saturated and unsaturated zones. For compounds not detected in groundwater samples from well 11A an aquifer volume equal to the area beneath the delineated areas and 12 feet in thickness is used to simulate the interaction between the saturated and unsaturated zones (the concentration in groundwater is assumed to be zero).

The time increment used for successive calculations in this analysis is 1 year. This time increment is based upon the dimensions of the aquifer volumes used in simulating the interaction of leachate and groundwater together with reasonable estimates of groundwater flow rates considering measurements during the RI and implementation of a groundwater extraction system similar to the French drain system developed in Appendix B.

The following procedure is used to estimate groundwater concentration.

at time T_n:

$$C_{gwn} = \frac{M_{gwn}}{V_{gw}} = \frac{\text{Mass of contaminant in solution}}{\text{Volume of groundwater}}$$

this equation can be written as:

$$C_{gwn} = \frac{\dfrac{M_{tn}}{1 + \dfrac{(K_{ds})\ (1.855)}{0.2}}}{V_{gw}}$$

where:

M_{tn} = total mass of contaminant in aquifer volume during time increment n, and

K_{ds} = partitioning coefficient for saturated zone.

$$M_{tn} = M_{sco} + \sum_{i=0}^{n} M_{Lcn} - \sum_{i=1}^{n} M_{gwn}$$

where:

M_{sco} = initial mass of contaminant adsorbed on aquifer skeleton,

Δt = time increment

M_{Lcn} = mass of contaminant leached from the unsaturated zone during increment n, and

M_{gwn} = mass of contaminant in groundwater at end of the increment.

GLT533/32

Appendix B
GROUNDWATER COLLECTION SYSTEM CONFIGURATION CALCULATIONS

Appendix B
GROUNDWATER COLLECTION SYSTEM
CONFIGURATION CALCULATIONS

FRENCH DRAIN SYSTEM

A system of French drains was designed for the removal of existing contaminants in the shallow saturated zone. The design of the drain system was based on maintaining a specified water table height midway between the drains. The main concern of the analysis was the distance between the drains, the amount of discharge entering the drains, and the time to remove the contaminants.

CALCULATION OF OPTIMAL DRAIN SPACING

The optimal distance between drains, L, is dependent on the drain depth, the amount of available recharge, and the hydraulic conductivity of the media, K. The equation to calculate the optimal drain spacing can be written as:

$$L^2 = \frac{4\ Kh_m}{W_T}(hm + 2d) \qquad (1)$$

where:

L = The distance between drains
K = Hydraulic Conductivity
h_m = Height of the water table above drain centers midway between the drains
d = Depth of the boundary below the drain centers
W_T = Total rate of recharge

and:

$$W_T = W_P + W_V$$

in which:

W_P = Recharge from precipitation
W_V = Recharge from sand and gravel aquifer

The recharge from the sand and gravel aquifer can be calculated for a unit area using Darcy's Law.

$$W_V = Ki$$

where:

i = Gradient due to the head differential in the two aquifers.

ASSUMPTIONS

The solution for the optimal drain spacing was based on the following idealized model:

- The rate of recharge, W_T, was constant with time and invariant over the entire area. The recharge from precipitation, W_P, was 7.8 inches/year as derived from mass balance calculations. The recharge from the sand and gravel deposit, Wv, was calculated using an upward vertical gradient of 0.25 ft/ft. It was assumed that a 3 feet difference in head (observed in the field) occurs over the entire thickness of the saturated zone (12 feet).

- The media was homogeneous and isotropic with respect to the hydraulic conductivity, K. K for the shallow saturated zone was assumed to be 1×10^{-5} cm/s.

- The derivation of equation (1) assumes that there was an impermeable barrier at a depth, d below the drains. This analysis assumed that this depth was the distance from the drain centers and the top of the sand and gravel aquifer (d = 1 foot).

- The drains have a diameter of 2 feet and the drains are parallel with the drain centers, 16 feet below the ground surface.

- The height of the water table above the drain centers at the midpoint between drains, h_m was 10.5 feet.

The calculation of the recharge rate and therefore, the optimal drain spacing was found to be sensitive to changes in the upward vertical gradient. The drain spacing increase was approximately 50 percent with each order-of-magnitude decrease in the gradient. Thus, a careful evaluation of the upward gradients is necessary in the actual design of the drain system.

The design is also a direct function of the hydraulic conductivity used. The value used, 1×10^{-5} cm/s, was derived from grainsize analysis. The hydraulic conductivity for silty clays ranges between 1×10^{-4} and 1×10^{-7} cm/sec (Bear, Zaslausky, and Irmay, 1968). Tests for hydraulic conductivity of the site should be made before the actual design of the drain system:

DISCHARGE CALCULATIONS

The calculation for the amount of water entering the drains was based on a mass balance approach. The discharge into

the drains was equal to the amount of water recharging the aquifer. The discharge per unit for the first drain can be calculated by:

$$Q_1 = Q_{recharge} + Q_{regional} + Q_{induced}$$

or, expanding the terms:

$$Q_1 = W_T A + K_{i\ regional} (h_m l) \frac{h_m}{h_m + d} + Ki_{\ induced} A$$

where:

A = Length of the drain x drain spacing

$i_{regional}$ = Regional gradient = 0.02 ft/ft

l = Length of drain

$i_{induced}$ = Gradient induced due to drains

$$= \frac{10.5}{20.5} = 0.51 \text{ ft/ft}$$

K, W_T, h_m, d as previously defined

For the remainder of the drains, the discharge is equal to the recharge from precipitation and from upward leakage from the sand and gravel aquifer or:

$$Q_n = W_t A$$

CALCULATION OF TIME

The time for a water particle to travel from the midpoint between the drains to the drains (maximum distance of travel = L/2) under the induced gradients was calculated by:

$$t = \frac{L/2}{\frac{Ki_{\ induced}}{n}}$$

where:

t = Time for water particle to travel from midpoint of drains to the drain

n = Effective porosity

L, K, i as previously defined

This represents the time necessary to remove 1 pore volume of water from the saturated zone.

The time calculations for the removal of contaminants is given in Appendix A.

EXTRACTION WELL SYSTEM

An extraction well system was designed for the removal of contaminants from the shallow saturated zone and the sand and gravel deposit. The design of the well system was based on the steady-state flow equations for wells in a regional flow field. The major calculations in this analysis are the drawdown and capture zones for a specific discharge, the optimal spacing between wells and the estimate of time for the removal of contaminants.

CALCULATION OF DRAWDOWN, WELL CAPTURE ZONES AND WELL SPACING

The design of the extraction well system was developed using an iterative approach. A pumping rate, Q was assumed for a well in a regional flow field and the associated drawdown and capture zones were calculated. The process was continued until a desired drawdown was detained. The optimal spacing between wells could then be calculated.

The drawdown, S_w in a fully penetrating well can be calculated by (Kelly and Tsang, 1983).

$$S_W = \frac{Q}{2\pi T} \ln \frac{R}{r_w}$$

where:

S_W = Drawdown at the well

T = Transmissivity of the aquifer

r_w = Radius of the well

= 2 inches (assumed)

Q = Well discharge

R = Distance to the stagnation point

and:

$$R = \frac{Q}{2\pi b V_D}$$

in which:

b = Aquifer thickness

V_D = Darcy velocity

The Darcy velocity can be written as:

$$V_D = Ki$$

where:

K = Hydraulic conductivity

i = Regional gradient

The limit of groundwater entering the well perpendicular to the direction of the regional gradient can be calculated by (Todd, 1980)

$$Y_L = \pm \frac{Q}{2bV_D} = \pm \pi r$$

In a multiple well system, the optimal spacing, y' required for overlapping capture zones can be determined by:

$$y' \leq \frac{Q}{\pi bV_D} \leq 2R$$

ASSUMPTIONS

The solution of the flow equations were based on the following simplifying assumptions:

- The wells were fully penetrating and the flow to the wells were assumed to be steady-state.
- The sand and gravel deposit was confined with an average thickness of 9 feet. The saturated zone was unconfined with a saturated thickness of 12 feet.
- The average regional gradient was 0.02 ft/ft in the northern and central areas and 0.05 ft/ft in the area south of the site.
- The shallow sand and gravel deposit is isotropic and homogenous with respect to the hydraulic conductivity. The hydraulic conductivity for the saturated zone was 1×10^{-5} cm/s and 1×10^{-2} cm/sec for the sand and gravel deposit.

CALCULATION OF TIME FOR CONTAMINANT REMOVAL

The estimate of the time to remove the water with velocities induced by pumping and the regional gradient can be calculated by:

$$t = t_o + r \Big/ \frac{r}{\frac{(r^2 - r_w^2)\ \pi\ bn}{Q}} + \text{regional velocity}$$

where:

t = time for water particle to travel from r to r_w

t_o = initial time to reach steady-state
= 3 months (assumed)

b = Aquifer thickness

n = Effective porosity

= 0.30 for sand and gravel aquifer

Q = pumping rate

r_w = radius of well

r = maximum distance

The time for removal of contaminants t_r can be calculated using:

$$t_r = t\ R_c$$

where:

R_c = retardation coefficient

For the contaminants found at the ECC site the retardation coefficient ranges between 1.2 and 17.4 (see Appendix A).

GLT360/96

Appendix C
TECHNICAL PUBLIC HEALTH AND WELFARE, ENVIRONMENTAL, AND INSTITUTIONAL EVALUATION CRITERIA

Appendix C
TECHNICAL, PUBLIC HEALTH AND WELFARE, ENVIRONMENTAL, AND INSTITUTIONAL EVALUATION CRITERIA

The following criteria scales were used to rate individual alternatives in Chapter 4 with regard to the technical, environmental, health, and institutional criteria. In Chapter 3, only the technical criteria were used to individually screen technologies.

The general rating scale used for these criteria is:

Rating	Definition
++	An extremely positive benefit.
+	A positive or moderately positive benefit.
o	Of very little apparent positive or negative effects, but inclusion can be justified for some special reason; or no change from existing conditions.
-	Negative effects, but not strong enough or certain enough to be sole justification for eliminating a technology; or only of moderate negative effects.
--	Extremely negative effects, even with mitigating measures; technology not worth further consideration in this category.
*	Inappropriate to draw conclusions at this point in evaluation process.

TECHNICAL EVALUATION CRITERIA

PERFORMANCE

Performance is assessed on the basis of effectiveness and useful life. Effectiveness relates to the degree with which the technology or alternative will prevent or minimize release of hazardous substances to current or future public health, welfare, or environmental receptors. Useful life relates to the length of time that the level of effectiveness can be maintained.

Effectiveness

Effectiveness is defined as the ability of the remedial alternative to perform as intended to control release of hazardous materials and to protect the public and the environment.

Effectiveness is evaluated on the following scale:

++ Prevents release of all hazardous materials; provides maximum protection of human health and environment.

+ Minimizes release of hazardous materials; adequately protects human health and environment.

o Controls release of hazardous materials; adequately protects public and environment.

- Reduces release of most hazardous materials; limited protection of public and environment.

-- Allows release of many hazardous materials.

Useful Life

Useful life, which refers to the length of time that the effectiveness of a technique lasts, is evaluated on the following scale:

++ All technologies and all remedial actions permanent without maintenance.

+ Major remedial actions permanent with some remedial actions easily replaceable or repairable through routine maintenance.

o Overall long-term solution requiring only routine maintenance and replaceable or repairable.

- Overall short-term solution requiring significant and unpredictable maintenance; difficult to replace or repair.

-- Overall short-term solution requiring frequent extensive maintenance; repair impractical upon failure.

RELIABILITY

Reliability is assessed on the basis of operation and maintenance and demonstrated performance. Operation and maintenance are evaluated for labor availability, frequency, necessity, and complexity. Demonstrated performance includes proven performance, probability of failure, and pilot testing.

Operation and Maintenance Requirements

This criterion, which is used to evaluate the frequency and/or complexity of service required, is evaluated on the following scale:

++ Never requires operation or maintenance attention after implementation.

+ Requires infrequent attention; capable of functioning unattended with periodic maintenance.

o Capable of functioning with no more than periodic attention.

- Requires dedicated personnel to maintain functions and regular operation and maintenance attention by trained personnel.

-- Requires very frequent or constant attention by full-time trained personnel.

Demonstrated Performance

This criterion is used to evaluate technologies employed at hazardous waste sites in relation to their record of good performance in similar situations and thus favors techniques that have proven to be reliable in full-scale operation, under field conditions. This criterion is evaluated on the following scale:

++ All remedial technologies proven reliable in the field under similar conditions on similar waste materials and mixtures.

+ All remedial technologies proven reliable in the field under similar conditions on similar waste materials.

o Proven reliable but under different conditions and materials.

- Demonstrated only in laboratory- or pilot-scale studies on similar materials; reliability is not demonstrated on full scale.

-- Demonstrated only in laboratory-scale on pure substances or simple mixtures; reliability not demonstrated for practical field conditions.

IMPLEMENTABILITY

Implementability is assessed for ease of installation and time to implement. Ease of installation relates to constructibility, applicability to site conditions, external conditions such as permits and access to offsite disposal facilities, and equipment availability. The time to implement and the time to achieve beneficial results are also evaluated.

EASE OF INSTALLATION AND CONSTRUCTION

This criterion reflects the ability to construct facilities required for the remedial alternative under site conditions. Constraints include physical site conditions, permit and zoning requirements, and availability of offsite facilities. Public acceptability of the remedial alternative is not considered in this evaluation of ease of installation. This criterion is evaluated on the following scale:

++ No unusual impediments to construction.

+ Construction effort routine; most necessary offsite facilities readily available; permits readily obtainable.

o Construction effort required is not excessive; availability of offsite facilities will not adversely affect construction schedule; permits can be obtained with reasonable effort.

- Construction possible but major construction effort required to overcome site conditions; offsite facilities available but at great distance or expected cost; permits difficult to obtain.

-- Magnitude of construction effort exceptional; essential offsite facilities are unavailable; permits very difficult to obtain.

Time to Implement

This criterion represents a measure of the time required to implement a remedial alternative and includes time for treatability studies, design, and construction. This criterion is evaluated on the following scale:

++ Alternative can be implemented immediately.

+ Alternative can be implemented in less than 6 months.

o Alternative can be implemented within 1 year.

- Alternative can be implemented but will require more than 1 year.

-- Alternative requires more than 2 years to implement.

Time to Achieve Beneficial Results

This criterion is a measure of the time required to achieve beneficial results upon implementation. Beneficial results are defined as the reduction of contamination or degree of exposure necessary to attain the remedial action goals as stated in the early section of Chapter 3. It is evaluated on the following scale:

++ Immediate overall results (within implementation period).

+ Rapid overall results (within 1 year after implementation period).

o Timely overall results but requires between 1 and 5 years.

- Obtaining overall results requires between 5 and 20 years.

-- Obtaining overall results requires greater than 20 years.

SAFETY

Safety during construction and operation as well as safety upon failure is also assessed.

Safety During Installation and Operation

Evaluation under this criterion considers threats to the safety of community, environment, and workers during installation and operation of a remedial action. This criterion is evaluated on the following scale:

++ All remedial actions intrinsically safe.

+ All remedial actions very safe; requires no more than normal safety procedures required for workers at hazardous waste sites; no threat to surroundings.

o Safe; requires few safety procedures other than those normally required at a hazardous waste site; little or no threat to surroundings.

- Hazardous; requires stringent safety procedures to ensure worker safety; may possibly require emergency evacuation of homes near the site.

-- Very hazardous, requires remote operation and evacuation of area homes.

Safety Upon Failure

This criterion, which refers to safety in the event that the remedial measure fails to perform, is evaluated on the following scale:

++ Intrinsically safe; redundant components prevent hazardous occurrence.

+ Failure can be quickly detected and results in hazard that is less than that presented by the site prior to remediation.

o Failure can be quickly detected and results in hazard approximately equal to that presented by the site prior to remediation.

- Failure difficult to detect and results in hazard greater than that presented by the site prior to remediation.

-- Failure very difficult to detect and results in catastrophic spread of contamination or loss of life.

PUBLIC HEALTH AND WELFARE EVALUATION CRITERIA

Short-term and long-term exposure risks are considered in relation to the following scale:

++ Alternative superiorly improves the current condition/ or completely eliminates existing problem.

+ Alternative improves the current conditions/or reduces/ mitigates an existing hazard/problem/or improper condition.

o Alternative causes no impact.

- Alternative produces negative impact or does not alter existing adverse conditions.

-- Alternative produces extremely negative impact or worsens existing conditions.

* Does not apply; is inappropriate.

ENVIRONMENTAL EVALUATION CRITERIA

SHORT TERM EFFECTS (CONSTRUCTION-RELATED)

Odor, noise, air pollution, surface water pollution, and groundwater pollution are considered in relation to the following scale:

++ Alternative causes no impact.

+ Alternative causes effects that are contained within the site boundary.

o Alternative causes effects beyond site boundary but generally limited, controllable, and within acceptable limits.

- Alternative causes limited uncontrollable or unacceptable effects beyond site boundary.

-- Alternative causes significant uncontrollable and unacceptable effects beyond site boundary.

Wildlife habitat alteration, historic site alteration, and disruption of households, businesses, and services are considered in relation to the following scale:

++ Alternative causes no effect.

+ Alternative causes brief temporary alterations or disruptions which are returned to normal quickly.

o Alternative causes prolonged temporary alterations or disruptions which are returned to normal.

- Alternative causes slight alterations or disruptions which are not returned to normal.

-- Alternative causes extensive alterations or disruptions which are not returned to normal.

LONG-TERM IMPACTS

Odor, noise, air pollution, surface water pollution, and groundwater pollution are considered in relation to the following scale:

++ Alternative causes no impacts.

+ Alternative causes effects that are contained within the site boundary.

o Alternative causes effects beyond the site boundary but generally limited, controllable, and within acceptable limits.

- Alternative causes limited uncontrollable or unacceptable effects beyond the site boundary.

-- Alternative causes significant uncontrollable and unacceptable effects beyond the site boundary.

Wildlife habitat alteration; threatened and endangered species; use of natural resources, parks, transportation, and urban facilities; historic site alteration; relocation of households, businesses, and services; and aesthetic changes are considered in relation to the following scale:

++ Alternative causes no alterations or disruptions.

+ Alternative causes brief temporary alterations or disruptions.

o Alternative causes prolonged temporary alterations or disruptions which are returned to normal.

- Alternative causes slight alterations or disruptions which are not returned to normal.

-- Alternative causes extensive alterations or disruptions which are not returned to normal.

INSTITUTIONAL EVALUATION CRITERIA

Surface and groundwater standards and criteria; air, odor, and noise standards; and local, state, and federal laws or policies are not considered in the same manner in this evaluation. These standards, criteria, laws, and policies represent the fundamental framework or contexts for developing the assembled remedial alternatives.

INSTITUTIONAL RATING CRITERIA

++ Alternative will exceed existing conditions/standards.

+ Alternative will meet existing conditions/standards; will reduce objectionable aspects of current situation.

o Alternative will not have adverse consequence/will not trigger institutional action.

- Alternative requires institutional action; violates standards or criteria; will meet with public/political resistance or retain objectionable aspects of current situation.

-- Alternative requires expensive or long-term action; strongly violates standards; will be totally objectionable to public.

* Does not apply; is inappropriate.

GLT360/60

Appendix D
DETAILED COST SUMMARY TABLES

GLT533/24

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 2: ACCESS RESTRICTIONS

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST		ASSUMPTIONS
DIRECT CAPITAL COSTS						
1. MONITORING PROGRAM						FOR MONITORING
MOBILIZATION/DEMOBILIZATION	3	EA	4500	13,500		
DRILLING	75	LF	60	4,500		3 WELLS @ 25 FT. DEEP EA.
WELL SCREEN, CASING, LOCKING CAP	3	EA	265	795		
GROUT, BENTONITE, GRAVEL PACK	3	EA	250	750		
WELL DEVELOPMENT	3	LS	1300	3,900		
SUBTOTAL					$23,445	
2. ACCESS RESTRICTIONS						
FENCING	3200	LF	12	38,400		6' CHAIN LINK WITH BARBED WIRE
GATE	1	EA	2000	2,000		
SIGNAGE	9	EA	33	297		1 SIGN EVERY 150 FT. ALONG FENCE
SUBTOTAL					$40,697	
CONSTRUCTION SUBTOTAL					$64,142	
3. CONTINGENCIES						
MOBILIZATION/DEMOBILIZATION (5 %)				3,207		
HEALTH AND SAFETY (5 %)				3,207		
BID CONTINGENCIES (10 %)				6,414		
SCOPE CONTINGENCIES (10 %)				6,414		
CONSTRUCTION TOTAL					$83,385	
4. OTHER						
PERMITTING AND LEGAL (5%)				4,169		
SERVICES DURING CONSTRUCTION				5,000		
TOTAL IMPLEMENTATION COST					$92,554	
5. ENGINEERING						
ENGINEERING DESIGN COST				15,000		
TOTAL CAPITAL COST					$107,554	

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 2: ACCESS RESTRICTIONS

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST	ASSUMPTIONS
DIRECT OPERATION AND MAINTENANCE COSTS					
1. MONITORING ($/YEAR) EVERY YEAR					
					TWO SAMPLES PER YEAR
MONITORING WELLS	5	EA	275	2,750	VOC SCAN
SURFACE WATER	4	EA	275	2,200	VOC SCAN
LABOR FOR SAMPLES	1	LS	2000	4,000	1 E1, 1 TECH, 2.5 DAYS
FIELD BLANKS					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	275	550	
SURFACE WATER	1	EA	275	550	
DUPLICATES					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	275	550	
SURFACE WATER	1	EA	275	550	
SHIPPING CHARGES	1	LS	100	200	FED EX - $100/COOLER
2. MONITORING ($/YEAR) EVERY 3RD YEAR					
MONITORING WELLS	5	EA	1075	5,375	FULL SCAN AND VOC SCAN - $275 + $800
SURFACE WATER	4	EA	1075	4,300	FULL SCAN AND VOC SCAN - $275 + $800
LABOR FOR SAMPLES	1	LS	2000	4,000	1 E1, 1 TECH, 2.5 DAYS
FIELD BLANKS					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	1025	1,025	
SURFACE WATER	1	EA	1025	1,025	
DUPLICATES					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	1025	1,025	
SURFACE WATER	1	EA	1025	1,025	
SHIPPING CHARGES	2	LS	100	400	FED EX - $100/COOLER
3. MONITORING ($/YR) EVERY 5TH YEAR					
FISH SAMPLING	1	LS	15000	15,000	
4. INSPECTION ($/YEAR) SEMI-ANNUALLY					
SITE INSPECTION	1	LS	1200	2,400	1 E1, 1 TECH, 3 DAYS
5. OTHER MAINTENANCE ($/YR)					
FENCE MAINTENANCE	1	LS	1000	1,000	
REFURBISH WELL SCREENS	1	LS	1000	1,000	CLEAN EVERY 10 YRS. - 2 DAYS LABOR, 2 PEOPLE
FENCE REPLACEMENT	4400	LF	12	52,800	REPLACED AT YEAR 30

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 2: ACCESS RESTRICTIONS

TOTAL PRESENT WORTH (BASED ON ANNUAL CAPITAL COST) ANALYSIS

YEAR	ANNUAL CAPITAL COST $	ANNUAL O&M COST $	DISCOUNT RATE 10%	PRESENT WORTH
0	$107,554			$107,554
1		$14,750	0.90909	$13,409
2		$14,750	0.82645	$12,190
3		$21,575	0.75131	$16,210
4		$14,750	0.68301	$10,074
5		$29,750	0.62092	$18,472
6		$21,575	0.56447	$12,178
7		$14,750	0.51316	$7,569
8		$14,750	0.46651	$6,881
9		$21,575	0.4241	$9,150
10		$30,750	0.38554	$11,855
11		$14,750	0.35049	$5,170
12		$21,575	0.31863	$6,874
13		$14,750	0.28966	$4,272
14		$14,750	0.26333	$3,884
15		$36,575	0.23939	$8,756
16		$14,750	0.21763	$3,210
17		$14,750	0.19784	$2,918
18		$21,575	0.17986	$3,880
19		$14,750	0.16351	$2,412
20		$30,750	0.14864	$4,571
21		$21,575	0.13513	$2,915
22		$14,750	0.12285	$1,812
23		$14,750	0.11168	$1,647
24		$21,575	0.10153	$2,191
25		$29,750	0.0923	$2,746
26		$14,750	0.08391	$1,238
27		$21,575	0.07628	$1,646
28		$14,750	0.06934	$1,023
29		$14,750	0.06304	$930
30		$90,375	0.05731	$5,179
TOTAL O&M PRESENT WORTH				$185,264
TOTAL PRESENT WORTH				$292,818

ANNUAL O & M COSTS:

ANNUAL COSTS	
MONITORING ($/SAMPLING ROUND) EVERY YEAR	
MONITORING WELLS	2,750
SURFACE WATER	2,200
LABOR FOR SAMPLES	4,000
FIELD BLANKS	
GROUNDWATER	550
SURFACE WATER	550
DUPLICATES	
GROUNDWATER	550
SURFACE WATER	550
SHIPPING CHARGES	200
MONITORING ($/SAMPLING ROUND) EVERY 3RD YEAR	
MONITORING WELLS	5,375
SURFACE WATER	4,300
LABOR FOR SAMPLES	4,000
FIELD BLANKS	
GROUNDWATER	1,025
SURFACE WATER	1,025
DUPLICATES	
GROUNDWATER	1,025
SURFACE WATER	1,025
SHIPPING CHARGES	400
MONITORING ($/YEAR) EVERY 5TH YEAR	
FISH SAMPLING	15,000
INSPECTION ($/YEAR) SEMI-ANNUALLY	2,400
OTHER MAINTENANCE ($/YEAR)	
GEN. MAINTENANCE ($/YR)	
FENCE MAINTENANCE	1,000
NON-ANNUAL COSTS	
WELL MAINTENANCE ($/ACTIVITY)	
REFURBISH SCREENS (EVERY 10 YRS.)	1,000
REPLACE FENCE (AT YEAR 30)	52,800

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 3: ACCESS RESTRICTIONS WITH CAPPING

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST		ASSUMPTIONS
DIRECT CAPITAL COSTS						
1. ECC SITE WORK						
REMOVE PROCESS BUILDING						
BUILDING REMOVAL	108750	CF	0.2	21,750		SINGLE BLDG, NO SALVAGE
DISPOSAL	225	CY	4.4	990		DEMOLISHED VOLUME
REMOVE CONTAMINATED SLUDGE/SOIL						
TESTING PRIOR TO EXCAVATION	1	LS	14000	14,000		
EXCAVATE	1825	CY	3.4	6,205		BACKHOE EXCAV, & DOUBLED FOR H&S
TRUCK LINERS	37	EA	200	7,400		
HAUL OFFSITE	730	CY	43	31,390		225 MI HAUL, 730 CY
DISPOSAL @ RCRA FACILITY	730	CY	80	58,400		
REMOVE EXTRACTED CONTAMINATED GROUNDWATER						
HAUL OFFSITE	9000	GAL	0.24	2,160		$450/TRUCK, $3.25/MILE, 225 MILES TO FACILITY
TREATMENT @ RCRA FACILITY	9000	GAL	0.24	2,160		TRUCK HANDLING AND TREATMENT
SUBTOTAL					$144,455	
2. MONITORING PROGRAM						FOR MONITORING
MOBILIZATION/DEMOBILIZATION	3	EA	4500	13,500		
DRILLING	75	LF	60	4,500		3 WELLS @ 25 FT. DEEP EA.
WELL SCREEN, CASING, LOCKING CAP	3	EA	265	795		
GROUT, BENTONITE, GRAVEL PACK	3	EA	250	750		
WELL DEVELOPMENT	3	LS	1300	3,900		
SUBTOTAL					$23,445	
3. SOIL-SYNTHETIC MEMBRANE-CLAY CAP						
CLAY LAYER						2 FT. THICK, COMPACTED
EXCAVATE & HAUL	11600	CY	10	116,000		
BACKFILL	11600	CY	3	34,800		
GEOTEXTILE	35000	SY	1.5	52,500		2 LAYERS OF POLYPROPYLENE
SYNTEHTIC MEMBRANE	17500	SY	1.8	31,500		30 MIL. PVC
SAND AND GRAVEL DRAINAGE LAYER						USE ONSITE SOIL (COMMON EARTH) @ 1.5 FT. THICK
EXCAVATE & HAUL	8720	CY	8	69,760		
BACKFILL	8720	CY	3	26,160		
ESTABLISH VEGETATIVE COVER						
SOIL	5820	CY	5	29,100		ONSITE TILL, EXCAVATE, HAUL, BACKFILL @ 1 FT. THICK
HYDROSEED	157000	SF	0.03	4,710		HYDRAULIC SPREADER
SUBTOTAL					$364,530	
4. ACCESS RESTRICTIONS						
FENCING	3200	LF	12	38,400		6' CHAIN LINK WITH BARBED WIRE
GATE	1	EA	2000	2,000		
SIGNAGE	9	EA	33	297		1 SIGN EVERY 150 FT. ALONG FENCE
SUBTOTAL					$40,697	
CONSTRUCTION SUBTOTAL					$573,127	
5. CONTINGENCIES						
MOBILIZATION/DEMOBILIZATION (5 %)				28,656		
HEALTH AND SAFETY (10 %)				57,313		
BID CONTINGENCIES (15 %)				85,969		
SCOPE CONTINGENCIES (20 %)				114,625		
CONSTRUCTION TOTAL					$859,691	
6. OTHER						
PERMITTING (5%)				42,985		
SERVICES DURING CONSTRUCTION				75,000		
TOTAL IMPLEMENTATION COST					$977,675	
7. ENGINEERING						
ENGINEERING DESIGN COST				75,000		

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 3: ACCESS RESTRICTIONS WITH CAPPING

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST	ASSUMPTIONS
DIRECT CAPITAL COSTS					
TOTAL CAPITAL COST				$1,052,675	

TABLE D-5

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 3: ACCESS RESTRICTIONS WITH CAPPING

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST	ASSUMPTIONS
DIRECT OPERATION AND MAINTENANCE COSTS					
1. MONITORING ($/YEAR) EVERY YEAR					
					TWO SAMPLES PER YEAR
MONITORING WELLS	5	EA	275	2,750	VOC SCAN
SURFACE WATER	4	EA	275	2,200	VOC SCAN
LABOR FOR SAMPLES	1	LS	2000	4,000	1 EI, 1 TECH, 2.5 DAYS
FIELD BLANKS					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	275	550	
SURFACE WATER	1	EA	275	550	
DUPLICATES					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	275	550	
SURFACE WATER	1	EA	275	550	
SHIPPING CHARGES	1	LS	100	200	FED EX - $100/COOLER
2. MONITORING ($/YEAR) EVERY 3RD YEAR					
MONITORING WELLS	5	EA	1075	5,375	FULL SCAN AND VOC SCAN - $275 + $800
SURFACE WATER	4	EA	1075	4,300	FULL SCAN AND VOC SCAN - $275 + $800
LABOR FOR SAMPLES	1	LS	2000	4,000	1 EI, 1 TECH, 2.5 DAYS
FIELD BLANKS					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	1025	1,025	
SURFACE WATER	1	EA	1025	1,025	
DUPLICATES					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	1025	1,025	
SURFACE WATER	1	EA	1025	1,025	
SHIPPING CHARGES	2	LS	100	400	FED EX - $100/COOLER
3. MONITORING ($/YR) EVERY 5TH YEAR					
FISH SAMPLING	1	LS	15000	15,000	
4. INSPECTION ($/YEAR) SEMI-ANNUALLY					
SITE INSPECTION	1	LS	1200	2,400	1 EI, 1 TECH, 3 DAYS
5. OTHER MAINTENANCE ($/YR) AS NOTED					
REFURBISH WELL SCREENS	1	LS	1000	1,000	CLEAN EVERY 10 YRS. - 2 DAYS LABOR, 2 PEOPLE
SOIL COVER REPAIRS					EVERY YEAR
EROSION CONTROL	4	AC	225	900	
FENCE MAINTENANCE	1	LS	1000	1,000	EVERY YEAR
FENCE REPLACEMENT	4400	LF	12	52,800	REPLACED AT YEAR 30
MOWING/REVEGETATION	4	AC	670	2,680	EVERY YEAR

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 3: ACCESS RESTRICTIONS WITH CAPPING

TOTAL PRESENT WORTH (BASED ON ANNUAL CAPITAL COST) ANALYSIS

YEAR	ANNUAL CAPITAL COST $	ANNUAL O&M COST $	DISCOUNT RATE 10%	PRESENT WORTH
0	$1,052,675			$1,052,675
1		$18,330	0.90909	$16,664
2		$18,330	0.82645	$15,149
3		$25,155	0.75131	$18,899
4		$18,330	0.68301	$12,520
5		$33,330	0.62092	$20,695
6		$25,155	0.56447	$14,199
7		$18,330	0.51316	$9,406
8		$18,330	0.46651	$8,551
9		$25,155	0.4241	$10,668
10		$34,330	0.38554	$13,236
11		$18,330	0.35049	$6,424
12		$25,155	0.31863	$8,015
13		$18,330	0.28966	$5,309
14		$18,330	0.26333	$4,827
15		$40,155	0.23939	$9,613
16		$18,330	0.21763	$3,989
17		$18,330	0.19784	$3,626
18		$25,155	0.17986	$4,524
19		$18,330	0.16351	$2,997
20		$34,330	0.14864	$5,103
21		$25,155	0.13513	$3,399
22		$18,330	0.12285	$2,252
23		$18,330	0.11168	$2,047
24		$25,155	0.10153	$2,554
25		$33,330	0.0923	$3,076
26		$18,330	0.08391	$1,538
27		$25,155	0.07628	$1,919
28		$18,330	0.06934	$1,271
29		$18,330	0.06304	$1,156
30		$93,955	0.05731	$5,385
TOTAL O&M PRESENT WORTH				$219,012
TOTAL PRESENT WORTH				$1,271,687

ANNUAL O & M COSTS:

ANNUAL COSTS	
MONITORING ($/SAMPLING ROUND) EVERY YEAR	
MONITORING WELLS	2,750
SURFACE WATER	2,200
LABOR FOR SAMPLES	4,000
FIELD BLANKS	
GROUNDWATER	550
SURFACE WATER	550
DUPLICATES	
GROUNDWATER	550
SURFACE WATER	550
SHIPPING CHARGES	200
MONITORING ($/SAMPLING ROUND) EVERY 3RD YEAR	
MONITORING WELLS	5,375
SURFACE WATER	4,300
LABOR FOR SAMPLES	4,000
FIELD BLANKS	
GROUNDWATER	1,025
SURFACE WATER	1,025
DUPLICATES	
GROUNDWATER	1,025
SURFACE WATER	1,025
SHIPPING CHARGES	400
MONITORING ($/YEAR) EVERY 5TH YEAR	
FISH SAMPLING	15,000
INSPECTION ($/YEAR) SEMI-ANNUALLY	2,400
OTHER MAINTENANCE ($/YEAR)	
GEN. MAINTENANCE ($/YR)	
FENCE MAINTENANCE	1,000
SOIL COVER REPAIRS	
EROSION CONTROL	900
MOWING/REVEGETATION	2,680
NON-ANNUAL COSTS	
WELL MAINTENANCE ($/ACTIVITY)	
REFURBISH SCREENS (EVERY 10 YRS)	1,000
REPLACE FENCE (AT YEAR 30)	52,800

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 4: GROUNDWATER COLLECTION AND TREATMENT

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST		ASSUMPTIONS
DIRECT CAPITAL COSTS						
1. ECC SITE WORK						
REMOVE PROCESS BUILDING						
BUILDING REMOVAL	108750	CF	0.2	21,750		SINGLE BLDG, NO SALVAGE
FOUNDATION DEMOLITION	3625	SF	3.3	11,963		CONCRETE SLAB, REINFORCED 1 FOOT THICK
DISPOSAL	360	CY	3.7	1,332		DEMOLISHED BUILDING VOLUME AND FDN. VOLUME
REMOVE CONCRETE PAD						
DEMOLITION	30500	SF	3	91,500		DEMOLISH CONCRETE PAD
DISPOSAL	850	CY	3.7	3,145		ASSUME 0.75 FEET THICK
REMOVE CONTAMINATED SLUDGE/SOIL						
TESTING PRIOR TO EXCAVATION	1	LS	14000	14,000		
EXCAVATE	1825	CY	3.4	6,205		BACKHOE EXCAV, & DOUBLED FOR H&S
TRUCK LINERS	37	EA	200	7,400		
HAUL OFFSITE	730	CY	43	31,390		225 MI HAUL, 730 CY
DISPOSAL @ RCRA FACILITY	730	CY	80	58,400		
REMOVE EXTRACTED CONTAMINATED GROUNDWATER						
HAUL OFFSITE	9000	GAL	0.24	2,160		$450/TRUCK, $3.25/MILE, 225 MILES TO FACILITY
TREATMENT @ RCRA FACILITY	9000	GAL	0.24	2,160		TRUCK HANDLING AND TREATMENT
SUBTOTAL					$251,405	
2. MONITORING PROGRAM						FOR MONITORING
MOBILIZATION/DEMOBILIZATION	3	EA	4500	13,500		
DRILLING	75	LF	60	4,500		3 WELLS @ 25 FT. DEEP EA.
WELL SCREEN, CASING, LOCKING CAP	3	EA	265	795		
GROUT, BENTONITE, GRAVEL PACK	3	EA	250	750		
WELL DEVELOPMENT	3	LS	1300	3,900		
SUBTOTAL					$23,445	
3. SILTY CLAY CAP CONSTRUCTION						
SILTY CLAY LAYER						1.5 FT. THICK, COMPACTED
EXCAVATE & HAUL	8720	CY	10	87,200		
BACKFILL	8720	CY	3	26,160		
ESTABLISH VEGETATIVE COVER						
SOIL	2910	CY	5	14,550		ONSITE TILL, EXCAVATE, HAUL, BACKFILL @ 0.5 FT. THICK
HYDROSEED	157000	SF	0.03	4,710		HYDRAULIC SPREADER
SUBTOTAL					$132,620	
4. GROUNDWATER COLLECTION						
FRENCH DRAINS						
SOIL BORING PRIOR TO EXCAVATION	1	LS	36000	36,000		46 BORINGS ON 50 FOOT CENTERS
SHORING AND BRACING	92000	SF	2	184,000		TRENCH - 17' DEEP, 4' WIDE, 5400' LONG (TOTAL)
DEWATERING	4	EA	440	1,760		WOOD SHEETING, JACKS
EXCAVATE TRENCH	13600	CY	4	54,400		17' DEEP X 4' WIDE
PERVIOUS GEOTEXTILE	205200	SF	0.17	34,884		
PERFORATED PIPE	4700	LF	4	18,800		4 " DIA.
GRAVEL AND BACKFILL	13600	CY	15	204,000		GRAVEL AND BACKFILL, COMPACTED
COLLECTOR & RISER PIPE	1000	LF	4	4,000		4 " DIA.
CONNECTIONS	18	EA	39	702		(TOTAL 8)
WET WELL	1	EA	2300	2,300		PRECAST CONC., MANHOLE, 6' ID, 16' DEEP
SUMP PUMP	1	EA	2100	2,100		
EXTRACTION WELLS						
WELLS	100	LF	60	6,000		8" DIA., ROTARY DRILLING, 4 WELLS
PUMPS	4	EA	265	1,060		
COLLECTION PIPE	400	LF	4	1,600		
CONNECTION, TEES & BENDS	6	EA	325	1,950		
TRENCH FOR PIPE	120	CY	5	600		
WIRING CONDUIT	500	LF	4	2,000		
WIRE	3000	LF	2	6,000		
SUBTOTAL					$562,156	
5. GROUNDWATER TREATMENT						

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 4: GROUNDWATER COLLECTION AND TREATMENT

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST		ASSUMPTIONS
DIRECT CAPITAL COSTS						
GRANULAR ACTIVATED CARBON SYSTEM						DESIGN BASIS: 56 GPM,
ACTIVATED CARBON ADSORBER	1	LS	70000	70,000		
BACKWASH PULSE SYSTEM	1	LS	11000	11,000		15% OF ADSORBER COST
PILOT TESTING	1	LS	10000	10,000		
STARTUP	3	DAY	500	1,500		
CARBON REPLACEMENT	7000	LB	1.5	10,500		
CARBON TRANSFER TANK	1	LS	7000	7,000		
BUILDING	225	SF	40	9,000		
CHLORINE TREATMENT SYSTEM	1	LS	6000	6,000		
PUMPS AND PIPING	1	LS	20000	20,000		
SURGE TANK	1	LS	12000	12,000		10,000 GAL. 3 HR. HOLDING TIME
SUBTOTAL					$157,000	
CONSTRUCTION SUBTOTAL					$1,126,626	
6. CONTINGENCIES						
MOBILIZATION/DEMOBILIZATION (5 %)				56,331		
HEALTH AND SAFETY (15 %)				168,994		
BID CONTINGENCIES (15 %)				168,994		
SCOPE CONTINGENCIES (20 %)				225,325		
CONSTRUCTION TOTAL					$1,746,270	
7. OTHER						
PERMITTING AND LEGAL (3 %)				52,388		
SERVICES DURING CONSTRUCTION				200,000		
TOTAL IMPLEMENTATION COST					$1,998,658	
8. ENGINEERING						
ENGINEERING DESIGN COST				300,000		
TOTAL CAPITAL COST					$2,298,658	

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 4: GROUNDWATER COLLECTION AND TREATMENT

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST	ASSUMPTIONS
DIRECT OPERATION AND MAINTENANCE COSTS					
1. MONITORING ($/YEAR) EVERY YEAR					
					TWO SAMPLES PER YEAR
MONITORING WELLS	5	EA	275	2,750	VOC SCAN
SURFACE WATER	4	EA	275	2,200	VOC SCAN
LABOR FOR SAMPLES	1	LS	2000	4,000	1 E1, 1 TECH, 2.5 DAYS
FIELD BLANKS					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	275	550	
SURFACE WATER	1	EA	275	550	
DUPLICATES					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	275	550	
SURFACE WATER	1	EA	275	550	
SHIPPING CHARGES	1	LS	100	200	FED EX - $100/COOLER
2. MONITORING ($/YEAR) EVERY 3RD YEAR					
MONITORING WELLS	5	EA	1075	5,375	FULL SCAN AND VOC SCAN - $275 + $800
SURFACE WATER	4	EA	1075	4,300	FULL SCAN AND VOC SCAN - $275 + $800
LABOR FOR SAMPLES	1	LS	2000	4,000	1 E1, 1 TECH, 2.5 DAYS
FIELD BLANKS					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	1025	1,025	
SURFACE WATER	1	EA	1025	1,025	
DUPLICATES					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	1025	1,025	
SURFACE WATER	1	EA	1025	1,025	
SHIPPING CHARGES	2	LS	100	400	FED EX - $100/COOLER
3. MONITORING ($/YR) EVERY 5TH YEAR					
FISH SAMPLING	1	LS	15000	15,000	
4. INSPECTION ($/YEAR) SEMI-ANNUALLY					
SITE INSPECTION	1	LS	1800	3,600	1 E1, 1 TECH, 3 DAYS
5. GROUNDWATER COLLECTION SYSTEM					
FRENCH DRAINS					
PIPE REPAIRS	1	LS	500	500	
ELECTRICITY	13100	kw-h	0.05	655	
EXTRACTION WELLS					
ELECTRICITY	43000	kw-h	0.05	2,150	1 PUMP PER WELL, 4 WELLS
6. GRANULAR ACTIVATED CARBON SYSTEM					
CARBON REPLACEMENT	16000	LB	1.5	24,000	
CARBON HAULING	8	TON	45	360	
CARBON DISPOSAL	8	TON	80	640	
ELECTRICITY	23000	kw-h	0.05	1,150	
LAB ANALYSIS	4	EA	275	1,100	1 SAMPLE PER QUARTER
LABOR	1460	HR	30	43,800	4 HOURS PER DAY
SUPERVISION	156	HR	45	7,020	3 HOURS PER WEEK - INCLUDES GW COLLECTION SYSTEM
7. OTHER MAINTENANCE ($/YR) AS NOTED					
FRENCH DRAIN					
CLEAN/FLUSH DRAIN PIPE	4700	LF	0.5	2,350	EVERY 5 YEARS
REPLACE PUMPS	1	EA	400	400	EVERY 5 YEARS
REFURBISH MONITOR WELL SCREENS	1	LS	1000	1,000	EVERY 10 YEARS
SOIL COVER REPAIRS					EVERY YEAR
EROSION CONTROL	4	AC	225	900	
FENCE MAINTENANCE	1	LS	1000	1,000	EVERY YEAR
FENCE REPLACEMENT	2100	LF	12	25,200	REPLACED AT YEAR 30
MOWING/REVEGETATION	4	AC	670	2,680	EVERY YEAR

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 4: GROUNDWATER COLLECTION AND TREATMENT

TOTAL PRESENT WORTH (BASED ON ANNUAL CAPITAL COST) ANALYSIS

YEAR	ANNUAL CAPITAL COST $	ANNUAL O&M COST $	DISCOUNT RATE 10%	PRESENT WORTH
0	$2,298,658			$2,298,658
1		$100,905	0.90909	$91,732
2		$100,905	0.82645	$83,393
3		$107,730	0.75131	$80,939
4		$100,905	0.68301	$68,919
5		$116,505	0.62092	$72,340
6		$105,580	0.56447	$59,597
7		$98,755	0.51316	$50,677
8		$98,755	0.46651	$46,070
9		$105,580	0.4241	$44,776
10		$117,505	0.38554	$45,303
11		$98,755	0.35049	$34,613
12		$105,580	0.31863	$33,641
13		$98,755	0.28966	$28,605
14		$98,755	0.26333	$26,005
15		$123,330	0.23939	$29,524
16		$98,755	0.21763	$21,492
17		$98,755	0.19784	$19,538
18		$105,580	0.17986	$18,990
19		$98,755	0.16351	$16,147
20		$117,505	0.14864	$17,466
21		$105,580	0.13513	$14,267
22		$98,755	0.12285	$12,132
23		$98,755	0.11168	$11,029
24		$105,580	0.10153	$10,720
25		$116,505	0.0923	$10,753
26		$98,755	0.08391	$8,287
27		$105,580	0.07628	$8,054
28		$98,755	0.06934	$6,848
29		$98,755	0.06304	$6,226
30		$149,530	0.05731	$8,570
TOTAL O&M PRESENT WORTH				$986,651
TOTAL PRESENT WORTH				$3,285,309

ANNUAL O & M COSTS:

ANNUAL COSTS	
MONITORING ($/SAMPLING ROUND) EVERY YEAR	
MONITORING WELLS	2,750
SURFACE WATER	2,200
LABOR FOR SAMPLES	4,000
FIELD BLANKS	
GROUNDWATER	550
SURFACE WATER	550
DUPLICATES	
GROUNDWATER	550
SURFACE WATER	550
SHIPPING CHARGES	200
MONITORING ($/SAMPLING ROUND) EVERY 3RD YEAR	
MONITORING WELLS	5,375
SURFACE WATER	4,300
LABOR FOR SAMPLES	4,000
FIELD BLANKS	
GROUNDWATER	1,025
SURFACE WATER	1,025
DUPLICATES	
GROUNDWATER	1,025
SURFACE WATER	1,025
SHIPPING CHARGES	400
MONITORING ($/YEAR) EVERY 5TH YEAR	
FISH SAMPLING	15,000
INSPECTION ($/YEAR) SEMI-ANNUALLY	3,600
OTHER MAINTENANCE ($/YEAR)	
GEN. MAINTENANCE ($/YR)	
FENCE MAINTENANCE	1,000
SOIL COVER REPAIRS	
EROSION CONTROL	900
MOWING/REVEGETATION	2,680
NON-ANNUAL COSTS	
WELL MAINTENANCE ($/ACTIVITY)	
REFURBISH SCREENS (EVERY 10 YRS)	
MONITORING WELLS	1,000
CLEAN DRAIN PIPE (EVERY 5 YEARS)	2,350
REPLACE PUMPS	
FRENCH DRAIN (EVERY 5 YEARS)	400
REPLACE FENCE (AT YEAR 30)	25,200

OPERATING COSTS ($/YEAR)	
GROUNDWATER COLLECTION SYSTEM	
FRENCH DRAINS	
PIPE REPAIRS	500
ELECTRICITY	655
EXTRACTION WELLS	
ELECTRICITY	2,150
GRANULAR ACTIVATED CARBON SYSTEM	
CARBON REPLACEMENT	24,000
CARBON HAULING	360
CARBON DISPOSAL	640
ELECTRICITY	1,150
LAB ANALYSIS	1,100
LABOR	43,800
SUPERVISION	7,020
TOTAL ANNUAL OPERATING COSTS ($/YR) - FIRST 4 YEARS (WITH EXTRACTION WELLS)	$81,375
TOTAL ANNUAL OPERATING COSTS ($/YR) - AFTER 4 YEARS (WITHOUT EXTRACTION WELLS)	$79,225

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 5: SOIL VAPOR EXTRACTION AND GROUNDWATER COLLECTION AND TREATMENT

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST	ASSUMPTIONS
DIRECT CAPITAL COSTS					
1. ECC SITE WORK					
REMOVE PROCESS BUILDING					
BUILDING REMOVAL	108750	CF	0.2	21,750	SINGLE BLDG, NO SALVAGE
FOUNDATION DEMOLITION	3625	SF	3.3	11,963	CONCRETE SLAB, REINFORCED 1 FOOT THICK
DISPOSAL	360	CY	3.7	1,332	DEMOLISHED BUILDING VOLUME AND FDN. VOLUME
REMOVE CONCRETE PAD					
DEMOLITION	30500	SF	3	91,500	DEMOLISH CONCRETE PAD
DISPOSAL	850	CY	3.7	3,145	ASSUME 0.75 FEET THICK
REMOVE CONTAMINATED SLUDGE/SOIL					
TESTING PRIOR TO EXCAVATION	1	LS	14000	14,000	
EXCAVATE	1825	CY	3.4	6,205	BACKHOE EXCAV, & DOUBLED FOR H&S
TRUCK LINERS	37	EA	200	7,400	
HAUL OFFSITE	730	CY	43	31,390	225 MI HAUL, 730 CY
DISPOSAL @ RCRA FACILITY	730	CY	80	58,400	
REMOVE EXTRACTED CONTAMINATED GROUNDWATER					
HAUL OFFSITE	9000	GAL	0.24	2,160	$450/TRUCK, $3.25/MILE, 225 MILES TO FACILITY
TREATMENT @ RCRA FACILITY	9000	GAL	0.24	2,160	TRUCK HANDLING AND TREATMENT
SUBTOTAL				$251,405	
2. MONITORING PROGRAM					FOR MONITORING
MOBILIZATION/DEMOBILIZATION	3	EA	4500	13,500	
DRILLING	75	LF	60	4,500	3 WELLS @ 25 FT. DEEP EA.
WELL SCREEN, CASING, LOCKING CAP	3	EA	265	795	
GROUT, BENTONITE, GRAVEL PACK	3	EA	250	750	
WELL DEVELOPMENT	3	LS	1300	3,900	
SUBTOTAL				$23,445	
3. SILTY CLAY CAP CONSTRUCTION					
SILTY CLAY LAYER					1.5 FT. THICK, COMPACTED
EXCAVATE & HAUL	8720	CY	10	87,200	
BACKFILL	8720	CY	3	26,160	
ESTABLISH VEGETATIVE COVER					
SOIL	2910	CY	5	14,550	ONSITE TILL, EXCAVATE, HAUL, BACKFILL @ 0.5 FT. THICK
HYDROSEED	157000	SF	0.03	4,710	HYDRAULIC SPREADER
SUBTOTAL				$132,620	
4. GROUNDWATER COLLECTION					
FRENCH DRAINS					
SOIL BORING PRIOR TO EXCAVATION	1	LS	36000	36,000	46 BORINGS ON 50 FOOT CENTERS
SHORING AND BRACING	92000	SF	2	184,000	TRENCH - 17' DEEP, 4' WIDE, 5400' LONG (TOTAL)
DEWATERING	4	EA	440	1,760	WOOD SHEETING, JACKS
EXCAVATE TRENCH	13600	CY	4	54,400	17' DEEP X 4' WIDE
PERVIOUS GEOTEXTILE	205200	SF	0.17	34,884	
PERFORATED PIPE	4700	LF	4	18,800	4 " DIA.
GRAVEL AND BACKFILL	13600	CY	15	204,000	GRAVEL AND BACKFILL, COMPACTED
COLLECTOR & RISER PIPE	1000	LF	4	4,000	4 " DIA.
CONNECTIONS	18	EA	39	702	(TOTAL 8)
WET WELL	1	EA	2300	2,300	PRECAST CONC., MANHOLE, 6' ID, 16' DEEP
SUMP PUMP	1	EA	2100	2,100	
EXTRACTION WELLS					
WELLS	100	LF	60	6,000	8" DIA., ROTARY DRILLING, 4 WELLS
PUMPS	4	EA	265	1,060	
COLLECTION PIPE	400	LF	4	1,600	
CONNECTION, TEES & BENDS	6	EA	325	1,950	
TRENCH FOR PIPE	120	CY	5	600	1 TEST @ 48 HR., 1 TEST @ 12 HR.
WIRING CONDUIT	500	LF	4	2,000	
WIRE	3000	LF	2	6,000	
SUBTOTAL				$562,156	
5. GROUNDWATER TREATMENT					

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 5: SOIL VAPOR EXTRACTION AND GROUNDWATER COLLECTION AND TREATMENT

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST		ASSUMPTIONS
DIRECT CAPITAL COSTS						
GRANULAR ACTIVATED CARBON SYSTEM						DESIGN BASIS: 56 GPM,
ACTIVATED CARBON ADSORBER	1	LS	70000	70,000		
BACKWASH PULSE SYSTEM	1	LS	11000	11,000		15% OF ADSORBER COST
PILOT TESTING	1	LS	10000	10,000		
STARTUP	3	DAY	500	1,500		
CARBON REPLACEMENT	7000	LB	1.5	10,500		
CARBON TRANSFER TANK	1	LS	7000	7,000		
BUILDING	225	SF	40	9,000		
CHLORINE TREATMENT SYSTEM	1	LS	6000	6,000		
PUMPS AND PIPING	1	LS	20000	20,000		
SURGE TANK	1	LS	12000	12,000		10,000 GAL. 3 HR. HOLDING TIME
SUBTOTAL					$157,000	
6. SOIL VAPOR EXTRACTION						
PILOT TESTING	1	LS	75000	75,000		
SAMPLING PRIOR TO EXTRACTION						
26 SOIL BORINGS	208	LF	40	8,320		8 FOOT DEEP
SAMPLE COLLECTION	1	LS	8400	8,400		2 MAN CREW @ $40/HR PLUS EXPENSES
VOC AND SEMI-VOLATILES ANALYSIS	52	EA	800	41,600		2 SAMPLES PER BORING
EXTRACTION WELLS	640	LF	32	20,480		8 WELLS PER SET, 10 CLUSTERS
INLET WELLS	640	LF	32	20,480		8 WELLS PER SET, 10 CLUSTERS
CONNECTING PIPE	2000	LF	6	12,000		
BLOWER ASSEMBLY	10	EA	4100	41,000		
GAC SYSTEM FOR VAPOR						
CARBON ADSORBER SYSTEM	1	LS	200000	200,000		4 MODULES @ $50,000 EACH
CARBON TRANSFER TANK	1	LS	20000	20,000		
WATER HEATER	1	LS	9000	9,000		3.5 FEET DIA. X 8 FOOT HIGH
PUMP AND PIPING	1	LS	1000	1,000		
HEAT EXCHANGER	1	LS	13000	13,000		
CHLORINATION SYSTEM	1	LS	5000	5,000		
TRENCH EXCAVATION	340	CY	4.5	1,530		5 FT. DEEP X 2 FOOT WIDE X 900 FEET, DOUBLE FOR H&S
PIPING TO TREATMENT	1	LS	11600	11,600		
AIR MONITORING	1	LS	4000	4,000		INCLUDES EQUIPMENT AND 8 WEEKS SAMPLING, NO LABOR
START-UP	1	LS	8000	8,000		
SUBTOTAL					$500,410	
CONSTRUCTION SUBTOTAL					$1,627,036	
7. CONTINGENCIES						
MOBILIZATION/DEMOBILIZATION (5 %)				81,352		
HEALTH AND SAFETY (15 %)				244,055		
BID CONTINGENCIES (15 %)				244,055		
SCOPE CONTINGENCIES (25 %)				406,759		
CONSTRUCTION TOTAL					$2,603,257	
8. OTHER						
PERMITTING (3 %)				78,098		
SERVICES DURING CONSTRUCTION				250,000		
TOTAL IMPLEMENTATION COST					$2,931,355	
9. ENGINEERING						
ENGINEERING DESIGN COST				400,000		
TOTAL CAPITAL COST					$3,331,355	

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 5: SOIL VAPOR EXTRACTION AND GROUNDWATER COLLECTION AND TREATMENT

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST	ASSUMPTIONS
DIRECT OPERATION AND MAINTENANCE COSTS					
1. MONITORING ($/YEAR) EVERY YEAR					
					TWO SAMPLES PER YEAR
MONITORING WELLS	5	EA	275	2,750	VOC SCAN
SURFACE WATER	4	EA	275	2,200	VOC SCAN
LABOR FOR SAMPLES	1	LS	2000	4,000	1 E1, 1 TECH, 2.5 DAYS
FIELD BLANKS					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	275	550	
SURFACE WATER	1	EA	275	550	
DUPLICATES					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	275	550	
SURFACE WATER	1	EA	275	550	
SHIPPING CHARGES	1	LS	100	200	FED EX - $100/COOLER
2. MONITORING ($/YEAR) EVERY 3RD YEAR					
MONITORING WELLS	5	EA	1075	5,375	FULL SCAN AND VOC SCAN - $275 + $800
SURFACE WATER	4	EA	1075	4,300	FULL SCAN AND VOC SCAN - $275 + $800
LABOR FOR SAMPLES	1	LS	2000	4,000	1 E1, 1 TECH, 2.5 DAYS
FIELD BLANKS					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	1025	1,025	
SURFACE WATER	1	EA	1025	1,025	
DUPLICATES					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	1025	1,025	
SURFACE WATER	1	EA	1025	1,025	
SHIPPING CHARGES	2	LS	100	400	FED EX - $100/COOLER
3. MONITORING ($/YR) EVERY 5TH YEAR					
FISH SAMPLING	1	LS	15000	15,000	
4. INSPECTION ($/YEAR) SEMI-ANNUALLY					
SITE INSPECTION	1	LS	1800	3,600	1 E1, 1 TECH, 3 DAYS
5. GROUNDWATER COLLECTION SYSTEM					
FRENCH DRAINS					
PIPE REPAIRS	1	LS	500	500	
ELECTRICITY	13100	kw-h	0.05	655	
EXTRACTION WELLS					
ELECTRICITY	43000	kw-h	0.05	2,150	1 PUMP PER WELL, 4 WELLS
6. GRANULAR ACTIVATED CARBON SYSTEM					
CARBON REPLACEMENT	16000	LB	1.5	24,000	
CARBON HAULING	8	TON	45	360	
CARBON DISPOSAL	8	TON	80	640	
ELECTRICITY	23000	kw-h	0.05	1,150	
LAB ANALYSIS	4	EA	275	1,100	1 SAMPLE PER QUARTER
LABOR	1460	HR	30	43,800	4 HOURS PER DAY
SUPERVISION	156	HR	45	7,020	3 HOURS PER WEEK - INCLUDES GW COLLECTION SYSTEM
7. SOIL VAPOR EXTRACTION SYSTEM					
BLOWER ELECTRICITY	457000	kw-h	0.05	22,850	10 BLOWERS
AIR MONITORING					
KEY COMPONENT ANALYSIS	120	EA	70	8,400	10 CLUSTER OF WELLS, 1 SAMPLE PER MONTH
VOLATILE SCAN WITH BASE/NEUTRALS	40	EA	800	32,000	10 CLUSTER OF WELLS, 4 SAMPLES PER YEAR
SAMPLING TRIP	36	DAYS	100	3,600	1 SAMPLE PER MONTH, 3 DAYS PER TRIP
GRANULAR ACTIVATED CARBON SYSTEM					
CARBON REPLACEMENT	126000	LB	1.5	189,000	
CARBON HAULING	63	TON	45	2,835	
CARBON DISPOSAL	63	TON	80	5,040	
ELECTRICITY	124000	kw-h	0.05	6,200	
MATERIALS	1	LS	48000	48,000	1 SAMPLE PER QUARTER
LAB ANALYSIS	1	LS	1000	1,000	1 SAMPLE PER QUARTER
LABOR	1040	HR	30	31,200	4 HOURS PER DAY
SUPERVISION	102	HR	45	4,590	3 HOURS PER WEEK - INCLUDES GW COLLECTION SYSTEM
8. OTHER MAINTENANCE ($/YR) AS NOTED					

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 5: SOIL VAPOR EXTRACTION AND GROUNDWATER COLLECTION AND TREATMENT

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST	ASSUMPTIONS
DIRECT OPERATION AND MAINTENANCE COSTS					
FRENCH DRAIN					
CLEAN/FLUSH DRAIN PIPE	4700	LF	0.5	2,350	EVERY 5 YEARS
REPLACE PUMPS	1	EA	400	400	EVERY 5 YEARS
REFURBISH MONITOR WELL SCREENS	1	LS	1000	1,000	EVERY 10 YEARS
SOIL COVER REPAIRS					EVERY YEAR
EROSION CONTROL	4	AC	225	900	
FENCE MAINTENANCE	1	LS	1000	1,000	EVERY YEAR
FENCE REPLACEMENT	2100	LF	12	25,200	REPLACED AT YEAR 30
MOWING/REVEGETATION	4	AC	670	2,680	EVERY YEAR

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 5: SOIL VAPOR EXTRACTION AND GROUNDWATER COLLECTION AND TREATMENT

TOTAL PRESENT WORTH (BASED ON ANNUAL CAPITAL COST) ANALYSIS

YEAR	ANNUAL CAPITAL COST $	ANNUAL O&M COST $	DISCOUNT RATE 10%	PRESENT WORTH
0	$3,331,355			$3,331,355
1		$455,620	0.90909	$414,200
2		$455,620	0.82645	$376,547
3		$462,445	0.75131	$347,440
4		$455,620	0.68301	$311,193
5		$116,505	0.62092	$72,340
6		$105,580	0.56447	$59,597
7		$98,755	0.51316	$50,677
8		$98,755	0.46651	$46,070
9		$105,580	0.4241	$44,776
10		$117,505	0.38554	$45,303
11		$98,755	0.35049	$34,613
12		$105,580	0.31863	$33,641
13		$98,755	0.28966	$28,605
14		$98,755	0.26333	$26,005
15		$123,330	0.23939	$29,524
16		$98,755	0.21763	$21,492
17		$98,755	0.19784	$19,538
18		$105,580	0.17986	$18,990
19		$98,755	0.16351	$16,147
20		$117,505	0.14864	$17,466
21		$105,580	0.13513	$14,267
22		$98,755	0.12285	$12,132
23		$98,755	0.11168	$11,029
24		$105,580	0.10153	$10,720
25		$116,505	0.0923	$10,753
26		$98,755	0.08391	$8,287
27		$105,580	0.07628	$8,054
28		$98,755	0.06934	$6,848
29		$98,755	0.06304	$6,226
30		$149,530	0.05731	$8,570
TOTAL O&M PRESENT WORTH				$2,111,048
TOTAL PRESENT WORTH				$5,442,403

ANNUAL O & M COSTS:

ANNUAL COSTS	
MONITORING ($/SAMPLING ROUND) EVERY YEAR	
MONITORING WELLS	2,750
SURFACE WATER	2,200
LABOR FOR SAMPLES	4,000
FIELD BLANKS	
GROUNDWATER	550
SURFACE WATER	550
DUPLICATES	
GROUNDWATER	550
SURFACE WATER	550
SHIPPING CHARGES	200
MONITORING ($/SAMPLING ROUND) EVERY 3RD YEAR	
MONITORING WELLS	5,375
SURFACE WATER	4,300
LABOR FOR SAMPLES	4,000
FIELD BLANKS	
GROUNDWATER	1,025
SURFACE WATER	1,025
DUPLICATES	
GROUNDWATER	1,025
SURFACE WATER	1,025
SHIPPING CHARGES	400
MONITORING ($/YEAR) EVERY 5TH YEAR	
FISH SAMPLING	15,000
INSPECTION ($/YEAR) SEMI-ANNUALLY	3,600
OTHER MAINTENANCE ($/YEAR)	
GEN. MAINTENANCE ($/YR)	
FENCE MAINTENANCE	1,000
SOIL COVER REPAIRS	
EROSION CONTROL	900
MOWING/REVEGETATION	2,680
NON-ANNUAL COSTS	
WELL MAINTENANCE ($/ACTIVITY)	
REFURBISH SCREENS (EVERY 10 YRS)	
MONITORING WELLS	1,000
CLEAN DRAIN PIPE (EVERY 5 YEARS)	2,350
REPLACE PUMPS	
FRENCH DRAIN (EVERY 5 YEARS)	400
REPLACE FENCE (AT YEAR 30)	25,200

OPERATING COSTS ($/YEAR)	
GROUNDWATER COLLECTION SYSTEM	
FRENCH DRAINS	
PIPE REPAIRS	500
ELECTRICITY	655
EXTRACTION WELLS	
ELECTRICITY	2,150
GRANULAR ACTIVATED CARBON SYSTEM	
CARBON REPLACEMENT	24,000
CARBON HAULING	360
CARBON DISPOSAL	640
ELECTRICITY	1,150
LAB ANALYSIS	1,100
LABOR	43,800
SUPERVISION	7,020
SOIL VAPOR EXTRACTION SYSTEM	
BLOWER ELECTRICITY	22,850
AIR MONITORING	
KEY COMPONENT ANALYSIS	8,400
VOLATILE SCAN WITH BASE/NEUTRALS	32,000
SAMPLING TRIP	3,600
GRANULAR ACTIVATED CARBON SYSTEM	
CARBON REPLACEMENT	189,000
CARBON HAULING	2,835
CARBON DISPOSAL	5,040
ELECTRICITY	6,200
MATERIALS	48,000
LAB ANALYSIS	1,000
LABOR	31,200
SUPERVISION	4,590
TOTAL ANNUAL OPERATING COSTS ($/YR) - FIRST 4 YEARS (WITH EXTRACTION WELLS - AND SOIL VAPOR EXTRACTION)	$436,090
TOTAL ANNUAL OPERATING COSTS ($/YR) - AFTER 4 YEARS (WITHOUT EXTRACTION WELLS - AND SOIL VAPOR EXTRACTION)	$79,225

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 6: SOIL EXCAVATION AND OFFSITE DISPOSAL AND GROUNDWATER COLLECTION AND TREATMENT

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST	ASSUMPTIONS
DIRECT CAPITAL COSTS					
1. ECC SITE WORK					
REMOVE PROCESS BUILDING					
BUILDING REMOVAL	108750	CF	0.2	21,750	SINGLE BLDG, NO SALVAGE
FOUNDATION DEMOLITION	3625	SF	3.3	11,963	CONCRETE SLAB, REINFORCED 1 FOOT THICK
DISPOSAL	360	CY	3.7	1,332	DEMOLISHED BUILDING VOLUME AND FDN. VOLUME
REMOVE CONCRETE PAD					
DEMOLITION	30500	SF	3	91,500	DEMOLISH CONCRETE PAD
DISPOSAL	850	CY	3.7	3,145	ASSUME 0.75 FEET THICK
REMOVE CONTAMINATED SLUDGE/SOIL					
TESTING PRIOR TO EXCAVATION	1	LS	14000	14,000	
EXCAVATE	1825	CY	3.4	6,205	BACKHOE EXCAV, & DOUBLED FOR H&S
TRUCK LINERS	37	EA	200	7,400	
HAUL OFFSITE	730	CY	43	31,390	225 MI HAUL, 730 CY
DISPOSAL @ RCRA FACILITY	730	CY	80	58,400	
REMOVE EXTRACTED CONTAMINATED GROUNDWATER					
HAUL OFFSITE	9000	GAL	0.24	2,160	$450/TRUCK, $3.25/MILE, 225 MILES TO FACILITY
TREATMENT @ RCRA FACILITY	9000	GAL	0.24	2,160	TRUCK HANDLING AND TREATMENT
SUBTOTAL				$251,405	
2. MONITORING PROGRAM					FOR MONITORING
MOBILIZATION/DEMOBILIZATION	3	EA	4500	13,500	
DRILLING	75	LF	60	4,500	3 WELLS @ 25 FT. DEEP EA.
WELL SCREEN, CASING, LOCKING CAP	3	EA	265	795	
GROUT, BENTONITE, GRAVEL PACK	3	EA	250	750	
WELL DEVELOPMENT	3	LS	1300	3,900	
SUBTOTAL				$23,445	
3. SOIL EXCAVATION					
SITE PREPARATION					
SOIL TESTING PRIOR TO EXCAVATION	1	LS	43000	43,000	
SOIL EXCAVATION					11,500 CY EXCAVATED PLUS 25 % FOR VOLUME EXPANSION
SOIL REMOVAL/STOCKPILE	14400	CY	2.6	37,440	150 FT HAUL, COMMON EARTH
DECONTAMINATION OF EQUIPMENT	1	LS	3000	3,000	
DISPOSAL AT RCRA FACILITY					
TRUCK LINING	576	TRK	200	115,200	PVC LINER @ $1.75/SY, TRUCK SIZE 35 X 8 X 5, 25 CY
TRUCK LOADING	14400	CY	2	28,800	185 CY/HR, 5 CY CAP., DOUBLED FOR H&S
SOIL AND WASTE HAULING	14400	CY	45	648,000	225 MILES
DISPOSAL AT LANDFILL	14400	CY	80	1,152,000	
SUBTOTAL				$2,027,440	
4. SILTY CLAY CAP CONSTRUCTION					
FILL FOR EXCAVATED AREA	18000	CY	8	144,000	
SILTY CLAY LAYER					1.5 FT. THICK, COMPACTED
EXCAVATE & HAUL	8720	CY	10	87,200	
BACKFILL	8720	CY	3	26,160	
ESTABLISH VEGETATIVE COVER					
SOIL	2910	CY	5	14,550	ONSITE TILL, EXCAVATE, HAUL, BACKFILL @ 0.5 FT. THICK
HYDROSEED	157000	SF	0.03	4,710	HYDRAULIC SPREADER
SUBTOTAL				$276,620	
5. GROUNDWATER COLLECTION					
FRENCH DRAINS					
SOIL BORING PRIOR TO EXCAVATION	1	LS	36000	36,000	46 BORINGS ON 50 FOOT CENTERS
SHORING AND BRACING	92000	SF	2	184,000	TRENCH - 17' DEEP, 4' WIDE, 5400' LONG (TOTAL)
DEWATERING	4	EA	440	1,760	WOOD SHEETING, JACKS
EXCAVATE TRENCH	13600	CY	4	54,400	17' DEEP X 4' WIDE
PERVIOUS GEOTEXTILE	205200	SF	0.17	34,884	
PERFORATED PIPE	4700	LF	4	18,800	4 " DIA.
GRAVEL AND BACKFILL	13600	CY	15	204,000	GRAVEL AND BACKFILL, COMPACTED
COLLECTOR & RISER PIPE	1000	LF	4	4,000	4 " DIA.
CONNECTIONS	18	EA	39	702	(TOTAL 8)

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 6: SOIL EXCAVATION AND OFFSITE DISPOSAL AND GROUNDWATER COLLECTION AND TREATMENT

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST		ASSUMPTIONS
DIRECT CAPITAL COSTS						
WET WELL	1	EA	2300	2,300		PRECAST CONC., MANHOLE, 6' ID, 16' DEEP
SUMP PUMP	1	EA	2100	2,100		
EXTRACTION WELLS						
WELLS	100	LF	60	6,000		8" DIA., ROTARY DRILLING, 4 WELLS
PUMPS	4	EA	265	1,060		
COLLECTION PIPE	400	LF	4	1,600		
CONNECTION, TEES & BENDS	6	EA	325	1,950		
TRENCH FOR PIPE	120	CY	5	600		1 TEST @ 48 HR., 1 TEST @ 12 HR.
WIRING CONDUIT	500	LF	4	2,000		
WIRE	3000	LF	2	6,000		
SUBTOTAL					$562,156	
6. GROUNDWATER TREATMENT						
GRANULAR ACTIVATED CARBON SYSTEM						DESIGN BASIS: 56 GPM,
ACTIVATED CARBON ADSORBER	1	LS	70000	70,000		
BACKWASH PULSE SYSTEM	1	LS	11000	11,000		15% OF ADSORBER COST
PILOT TESTING	1	LS	10000	10,000		
STARTUP	3	DAY	500	1,500		
CARBON REPLACEMENT	7000	LB	1.5	10,500		
CARBON TRANSFER TANK	1	LS	7000	7,000		
BUILDING	225	SF	40	9,000		
CHLORINE TREATMENT SYSTEM	1	LS	6000	6,000		
PUMPS AND PIPING	1	LS	20000	20,000		
SURGE TANK	1	LS	12000	12,000		10,000 GAL. 3 HR. HOLDING TIME
SUBTOTAL					$157,000	
CONSTRUCTION SUBTOTAL					$3,298,066	
7. CONTINGENCIES						
MOBILIZATION/DEMOBILIZATION (5 %)				164,903		
HEALTH AND SAFETY (15 %)				494,710		
BID CONTINGENCIES (15 %)				494,710		
SCOPE CONTINGENCIES (25 %)				824,516		
CONSTRUCTION TOTAL					$5,276,905	
8. OTHER						
PERMITTING (2 %)				105,538		
SERVICES DURING CONSTRUCTION				300,000		
TOTAL IMPLEMENTATION COST					$5,682,443	
9. ENGINEERING						
ENGINEERING DESIGN COST				350,000		
TOTAL CAPITAL COST					$6,032,443	

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 6: SOIL EXCAVATION AND OFFSITE DISPOSAL AND GROUNDWATER COLLECTION AND TREATMENT

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST	ASSUMPTIONS
DIRECT OPERATION AND MAINTENANCE COSTS					
1. MONITORING ($/YEAR) EVERY YEAR					
					TWO SAMPLES PER YEAR
MONITORING WELLS	5	EA	275	2,750	VOC SCAN
SURFACE WATER	4	EA	275	2,200	VOC SCAN
LABOR FOR SAMPLES	1	LS	2000	4,000	1 E1, 1 TECH, 2.5 DAYS
FIELD BLANKS					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	275	550	
SURFACE WATER	1	EA	275	550	
DUPLICATES					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	275	550	
SURFACE WATER	1	EA	275	550	
SHIPPING CHARGES	1	LS	100	200	FED EX - $100/COOLER
2. MONITORING ($/YEAR) EVERY 3RD YEAR					
MONITORING WELLS	5	EA	1075	5,375	FULL SCAN AND VOC SCAN - $275 + $800
SURFACE WATER	4	EA	1075	4,300	FULL SCAN AND VOC SCAN - $275 + $800
LABOR FOR SAMPLES	1	LS	2000	4,000	1 E1, 1 TECH, 2.5 DAYS
FIELD BLANKS					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	1025	1,025	
SURFACE WATER	1	EA	1025	1,025	
DUPLICATES					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	1025	1,025	
SURFACE WATER	1	EA	1025	1,025	
SHIPPING CHARGES	2	LS	100	400	FED EX - $100/COOLER
3. MONITORING ($/YR) EVERY 5TH YEAR					
FISH SAMPLING	1	LS	15000	15,000	
4. INSPECTION ($/YEAR) SEMI-ANNUALLY					
SITE INSPECTION	1	LS	1800	3,600	1 E1, 1 TECH, 3 DAYS
5. GROUNDWATER COLLECTION SYSTEM					
FRENCH DRAINS					
PIPE REPAIRS	1	LS	500	500	
ELECTRICITY	13100	kw-h	0.05	655	
EXTRACTION WELLS					
ELECTRICITY	43000	kw-h	0.05	2,150	1 PUMP PER WELL, 4 WELLS
6. GRANULAR ACTIVATED CARBON SYSTEM					
CARBON REPLACEMENT	16000	LB	1.5	24,000	
CARBON HAULING	8	TON	45	360	
CARBON DISPOSAL	8	TON	80	640	
ELECTRICITY	23000	kw-h	0.05	1,150	
LAB ANALYSIS	4	EA	275	1,100	1 SAMPLE PER QUARTER
LABOR	1460	HR	30	43,800	4 HOURS PER DAY
SUPERVISION	156	HR	45	7,020	3 HOURS PER WEEK - INCLUDES GW COLLECTION SYSTEM
7. OTHER MAINTENANCE ($/YR) AS NOTED					
FRENCH DRAIN					
CLEAN/FLUSH DRAIN PIPE	4700	LF	0.5	2,350	EVERY 5 YEARS
REPLACE PUMPS	1	EA	400	400	EVERY 5 YEARS
REFURBISH MONITOR WELL SCREENS	1	LS	1000	1,000	EVERY 10 YEARS
SOIL COVER REPAIRS					EVERY YEAR
EROSION CONTROL	4	AC	225	900	
FENCE MAINTENANCE	1	LS	1000	1,000	EVERY YEAR
FENCE REPLACEMENT	2100	LF	12	25,200	REPLACED AT YEAR 30
MOWING/REVEGETATION	4	AC	670	2,680	EVERY YEAR

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 6: SOIL EXCAVATION AND OFFSITE DISPOSAL WITH GROUNDWATER COLLECTION AND TREATMENT

TOTAL PRESENT WORTH (BASED ON ANNUAL CAPITAL COST) ANALYSIS

YEAR	ANNUAL CAPITAL COST $	ANNUAL O&M COST $	DISCOUNT RATE 10%	PRESENT WORTH
0	$6,032,443			$6,032,443
1		$100,905	0.90909	$91,732
2		$100,905	0.82645	$83,393
3		$107,730	0.75131	$80,939
4		$100,905	0.68301	$68,919
5		$116,505	0.62092	$72,340
6		$105,580	0.56447	$59,597
7		$98,755	0.51316	$50,677
8		$98,755	0.46651	$46,070
9		$105,580	0.4241	$44,776
10		$117,505	0.38554	$45,303
11		$98,755	0.35049	$34,613
12		$105,580	0.31863	$33,641
13		$98,755	0.28966	$28,605
14		$98,755	0.26333	$26,005
15		$123,330	0.23939	$29,524
16		$98,755	0.21763	$21,492
17		$98,755	0.19784	$19,538
18		$105,580	0.17986	$18,990
19		$98,755	0.16351	$16,147
20		$117,505	0.14864	$17,466
21		$105,580	0.13513	$14,267
22		$98,755	0.12285	$12,132
23		$98,755	0.11168	$11,029
24		$105,580	0.10153	$10,720
25		$116,505	0.0923	$10,753
26		$98,755	0.08391	$8,287
27		$105,580	0.07628	$8,054
28		$98,755	0.06934	$6,848
29		$98,755	0.06304	$6,226
30		$149,530	0.05731	$8,570
TOTAL O&M PRESENT WORTH				$986,651
TOTAL PRESENT WORTH				$7,019,094

ANNUAL O & M COSTS:

ANNUAL COSTS	
MONITORING ($/SAMPLING ROUND) EVERY YEAR	
MONITORING WELLS	2,750
SURFACE WATER	2,200
LABOR FOR SAMPLES	4,000
FIELD BLANKS	
GROUNDWATER	550
SURFACE WATER	550
DUPLICATES	
GROUNDWATER	550
SURFACE WATER	550
SHIPPING CHARGES	200
MONITORING ($/SAMPLING ROUND) EVERY 3RD YEAR	
MONITORING WELLS	5,375
SURFACE WATER	4,300
LABOR FOR SAMPLES	4,000
FIELD BLANKS	
GROUNDWATER	1,025
SURFACE WATER	1,025
DUPLICATES	
GROUNDWATER	1,025
SURFACE WATER	1,025
SHIPPING CHARGES	400
MONITORING ($/YEAR) EVERY 5TH YEAR	
FISH SAMPLING	15,000
INSPECTION ($/YEAR) SEMI-ANNUALLY	3,600
OTHER MAINTENANCE ($/YEAR)	
GEN. MAINTENANCE ($/YR)	
FENCE MAINTENANCE	1,000
SOIL COVER REPAIRS	
EROSION CONTROL	900
MOWING/REVEGETATION	2,680
NON-ANNUAL COSTS	
WELL MAINTENANCE ($/ACTIVITY)	
REFURBISH SCREENS (EVERY 10 YRS)	
MONITORING WELLS	1,000
CLEAN DRAIN PIPE (EVERY 5 YEARS)	2,350
REPLACE PUMPS	
FRENCH DRAIN (EVERY 5 YEARS)	400
REPLACE FENCE (AT YEAR 30)	25,200

OPERATING COSTS ($/YEAR)	
GROUNDWATER COLLECTION SYSTEM	
FRENCH DRAINS	
PIPE REPAIRS	500
ELECTRICITY	655
EXTRACTION WELLS	
ELECTRICITY	2,150
GRANULAR ACTIVATED CARBON SYSTEM	
CARBON REPLACEMENT	24,000
CARBON HAULING	360
CARBON DISPOSAL	640
ELECTRICITY	1,150
LAB ANALYSIS	1,100
LABOR	43,800
SUPERVISION	7,020
TOTAL ANNUAL OPERATING COSTS ($/YR) - FIRST 4 YEARS (WITH EXTRACTION WELLS)	$81,375
TOTAL ANNUAL OPERATING COSTS ($/YR) AFTER 4 YEARS (WITHOUT EXTRACTION WELLS)	$79,225

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 7: SOIL EXCAVATION AND ONSITE INCINERATION AND DISPOSAL AND GROUNDWATER COLLECTION AND TREATMENT

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST	ASSUMPTIONS
DIRECT CAPITAL COSTS					
1. ECC SITE WORK					
REMOVE PROCESS BUILDING					
BUILDING REMOVAL	108750	CF	0.2	21,750	SINGLE BLDG, NO SALVAGE
FOUNDATION DEMOLITION	3625	SF	3.3	11,963	CONCRETE SLAB, REINFORCED 1 FOOT THICK
TRUCK LINERS	18	EA	200	3,600	
HAUL OFFSITE	360	CY	43	15,480	225 MI HAUL, 730 CY
DISPOSAL AT RCRA FACILITY	360	CY	80	28,800	DEMOLISHED BUILDING VOLUME AND FOUNDATION VOLUME
REMOVE CONCRETE PAD					
DEMOLITION	30500	SF	3	91,500	DEMOLISH CONCRETE PAD
TRUCK LINERS	43	EA	200	8,600	
HAUL OFFSITE	850	CY	43	36,550	225 MI HAUL, 730 CY
DISPOSAL AT RCRA FACILITY	850	CY	80	68,000	DEMOLISHED BUILDING VOLUME AND FOUNDATION VOLUME
REMOVE CONTAMINATED SLUDGE/SOIL					
TESTING PRIOR TO EXCAVATION	1	LS	14000	14,000	
EXCAVATE	1825	CY	3.4	6,205	BACKHOE EXCAV, & DOUBLED FOR H&S
TRUCK LINERS	37	EA	200	7,400	
HAUL OFFSITE	730	CY	43	31,390	225 MI HAUL, 730 CY
DISPOSAL @ RCRA FACILITY	730	CY	80	58,400	
REMOVE EXTRACTED CONTAMINATED GROUNDWATER					
HAUL OFFSITE	9000	GAL	0.24	2,160	$450/TRUCK, $3.25/MILE, 225 MILES TO FACILITY
TREATMENT @ RCRA FACILITY	9000	GAL	0.24	2,160	TRUCK HANDLING AND TREATMENT
SUBTOTAL				$407,958	
2. MONITORING PROGRAM					FOR MONITORING
MOBILIZATION/DEMOBILIZATION	3	EA	4500	13,500	
DRILLING	75	LF	60	4,500	3 WELLS @ 25 FT. DEEP EA.
WELL SCREEN, CASING, LOCKING CAP	3	EA	265	795	
GROUT, BENTONITE, GRAVEL PACK	3	EA	250	750	
WELL DEVELOPMENT	3	LS	1300	3,900	
SUBTOTAL				$23,445	
3. SOIL EXCAVATION					
SITE PREPARATION					
SOIL TESTING PRIOR TO EXCAVATION	1	LS	43000	43,000	
SOIL EXCAVATION					11,500 CY EXCAVATED PLUS 25 % FOR VOLUME EXPANSION
SOIL REMOVAL/STOCKPILE	22000	CY	2.6	57,200	150 FT HAUL,COMMON EARTH
DECONTAMINATION OF EQUIPMENT	1	LS	3000	3,000	
SUBTOTAL				$103,200	
4. SOIL INCINERATION					
EQUIPMENT	1	LS	3550000	3,550,000	
INSTALLATION AND STARTUP	1	LS	3050000	3,050,000	
OPERATION	22000	CY	700	15,400,000	
SUBTOTAL				$22,000,000	
5. SILTY CLAY CAP CONSTRUCTION					
PLACE INCINERATED SOIL ONSITE	22000	CY	1.6	35,200	
SILTY CLAY LAYER					1.5 FT. THICK, COMPACTED
EXCAVATE & HAUL	8720	CY	10	87,200	
BACKFILL	8720	CY	3	26,160	
ESTABLISH VEGETATIVE COVER					
SOIL	2910	CY	5	14,550	ONSITE TILL, EXCAVATE, HAUL, BACKFILL @ 0.5 FT. THICK
HYDROSEED	157000	SF	0.03	4,710	HYDRAULIC SPREADER
SUBTOTAL				$167,820	
6. GROUNDWATER COLLECTION					
FRENCH DRAINS					
SOIL BORING PRIOR TO EXCAVATION	1	LS	36000	36,000	46 BORINGS ON 50 FOOT CENTERS
SHORING AND BRACING	92000	SF	2	184,000	TRENCH - 17' DEEP, 4' WIDE, 5400' LONG (TOTAL)
DEWATERING	4	EA	440	1,760	WOOD SHEETING, JACKS

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 7: SOIL EXCAVATION AND ONSITE INCINERATION AND DISPOSAL AND GROUNDWATER COLLECTION AND TREATMENT

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST		ASSUMPTIONS
DIRECT CAPITAL COSTS						
EXCAVATE TRENCH	13600	CY	4	54,400		17' DEEP X 4' WIDE
PERVIOUS GEOTEXTILE	205200	SF	0.17	34,884		
PERFORATED PIPE	4700	LF	4	18,800		4 " DIA.
GRAVEL AND BACKFILL	13600	CY	15	204,000		GRAVEL AND BACKFILL, COMPACTED
COLLECTOR & RISER PIPE	1000	LF	4	4,000		4 " DIA.
CONNECTIONS	18	EA	39	702		(TOTAL #)
WET WELL	1	EA	2300	2,300		PRECAST CONC., MANHOLE, 6' ID, 16' DEEP
SUMP PUMP	1	EA	2100	2,100		
EXTRACTION WELLS						
WELLS	100	LF	60	6,000		8" DIA., ROTARY DRILLING, 4 WELLS
PUMPS	4	EA	265	1,060		
COLLECTION PIPE	400	LF	4	1,600		
CONNECTION, TEES & BENDS	6	EA	325	1,950		
TRENCH FOR PIPE	120	CY	5	600		1 TEST @ 48 HR., 1 TEST @ 12 HR.
WIRING CONDUIT	500	LF	4	2,000		
WIRE	3000	LF	2	6,000		
SUBTOTAL					$562,156	
7. GROUNDWATER TREATMENT						
GRANULAR ACTIVATED CARBON SYSTEM						DESIGN BASIS: 56 GPM,
ACTIVATED CARBON ADSORBER	1	LS	70000	70,000		
BACKWASH PULSE SYSTEM	1	LS	11000	11,000		15% OF ADSORBER COST
PILOT TESTING	1	LS	10000	10,000		
STARTUP	3	DAY	500	1,500		
CARBON REPLACEMENT	7000	LB	1.5	10,500		
CARBON TRANSFER TANK	1	LS	7000	7,000		
BUILDING	225	SF	40	9,000		
CHLORINE TREATMENT SYSTEM	1	LS	6000	6,000		
PUMPS AND PIPING	1	LS	20000	20,000		
SURGE TANK	1	LS	12000	12,000		10,000 GAL. 3 HR. HOLDING TIME
SUBTOTAL					$157,000	
CONSTRUCTION SUBTOTAL					$23,421,579	
8. CONTINGENCIES						
MOBILIZATION/DEMOBILIZATION (1 %)				234,216		
HEALTH AND SAFETY (3 %)				702,647		
BID CONTINGENCIES (15 %)				3,513,237		
SCOPE CONTINGENCIES (20 %)				4,684,316		
CONSTRUCTION TOTAL					$32,555,994	
9. OTHER						
PERMITTING (2 %)				651,120		
SERVICES DURING CONSTRUCTION				700,000		
TOTAL IMPLEMENTATION COST					$33,907,114	
10. ENGINEERING						
ENGINEERING DESIGN COST				1,500,000		
TOTAL CAPITAL COST					$35,407,114	

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 7: SOIL EXCAVATION WITH ONSITE INCINERATION AND DISPOSAL AND GROUNDWATER COLLECTION AND TREATMENT

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST	ASSUMPTIONS
DIRECT OPERATION AND MAINTENANCE COSTS					
1. MONITORING ($/YEAR) EVERY YEAR					
					TWO SAMPLES PER YEAR
MONITORING WELLS	5	EA	275	2,750	VOC SCAN
SURFACE WATER	4	EA	275	2,200	VOC SCAN
LABOR FOR SAMPLES	1	LS	2000	4,000	1 E1, 1 TECH, 2.5 DAYS
FIELD BLANKS					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	275	550	
SURFACE WATER	1	EA	275	550	
DUPLICATES					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	275	550	
SURFACE WATER	1	EA	275	550	
SHIPPING CHARGES	1	LS	100	200	FED EX - $100/COOLER
2. MONITORING ($/YEAR) EVERY 3RD YEAR					
MONITORING WELLS	5	EA	1075	5,375	FULL SCAN AND VOC SCAN - $275 + $800
SURFACE WATER	4	EA	1075	4,300	FULL SCAN AND VOC SCAN - $275 + $800
LABOR FOR SAMPLES	1	LS	2000	4,000	1 E1, 1 TECH, 2.5 DAYS
FIELD BLANKS					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	1025	1,025	
SURFACE WATER	1	EA	1025	1,025	
DUPLICATES					NO. REQ'D. FROM J. KEISER
GROUNDWATER	1	EA	1025	1,025	
SURFACE WATER	1	EA	1025	1,025	
SHIPPING CHARGES	2	LS	100	400	FED EX - $100/COOLER
3. MONITORING ($/YR) EVERY 5TH YEAR					
FISH SAMPLING	1	LS	15000	15,000	
4. INSPECTION ($/YEAR) SEMI-ANNUALLY					
SITE INSPECTION	1	LS	1800	3,600	1 E1, 1 TECH, 3 DAYS
5. GROUNDWATER COLLECTION SYSTEM					
FRENCH DRAINS					
PIPE REPAIRS	1	LS	500	500	
ELECTRICITY	13100	kw-h	0.05	655	
EXTRACTION WELLS					
ELECTRICITY	43000	kw-h	0.05	2,150	1 PUMP PER WELL, 4 WELLS
6. GRANULAR ACTIVATED CARBON SYSTEM					
CARBON REPLACEMENT	16000	LB	1.5	24,000	
CARBON HAULING	8	TON	45	360	
CARBON DISPOSAL	8	TON	80	640	
ELECTRICITY	23000	kw-h	0.05	1,150	
LAB ANALYSIS	4	EA	275	1,100	1 SAMPLE PER QUARTER
LABOR	1460	HR	30	43,800	4 HOURS PER DAY
SUPERVISION	156	HR	45	7,020	3 HOURS PER WEEK - INCLUDES GW COLLECTION SYSTEM
7. OTHER MAINTENANCE ($/YR) AS NOTED					
FRENCH DRAIN					
CLEAN/FLUSH DRAIN PIPE	4700	LF	0.5	2,350	EVERY 5 YEARS
REPLACE PUMPS	1	EA	400	400	EVERY 5 YEARS
REFURBISH MONITOR WELL SCREENS	1	LS	1000	1,000	EVERY 10 YEARS
SOIL COVER REPAIRS					EVERY YEAR
EROSION CONTROL	4	AC	225	900	
FENCE MAINTENANCE	1	LS	1000	1,000	EVERY YEAR
FENCE REPLACEMENT	2100	LF	12	25,200	REPLACED AT YEAR 30
MOWING/REVEGETATION	4	AC	670	2,680	EVERY YEAR

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION - ALTERNATIVE 7: SOIL EXCAVATION AND ONSITE INCINERATION/DISPOSAL WITH GROUNDWATER COLLECTION AND TREATMENT

TOTAL PRESENT WORTH (BASED ON ANNUAL CAPITAL COST) ANALYSIS

YEAR	ANNUAL CAPITAL COST $	ANNUAL O&M COST $	DISCOUNT RATE 10%	PRESENT WORTH
0	$35,407,114			$35,407,114
1		$100,905	0.90909	$91,732
2		$100,905	0.82645	$83,393
3		$107,730	0.75131	$80,939
4		$100,905	0.68301	$68,919
5		$116,505	0.62092	$72,340
6		$105,580	0.56447	$59,597
7		$98,755	0.51316	$50,677
8		$98,755	0.46651	$46,070
9		$105,580	0.4241	$44,776
10		$117,505	0.38554	$45,303
11		$98,755	0.35049	$34,613
12		$105,580	0.31863	$33,641
13		$98,755	0.28966	$28,605
14		$98,755	0.26333	$26,005
15		$123,330	0.23939	$29,524
16		$98,755	0.21763	$21,492
17		$98,755	0.19784	$19,538
18		$105,580	0.17986	$18,990
19		$98,755	0.16351	$16,147
20		$117,505	0.14864	$17,466
21		$105,580	0.13513	$14,267
22		$98,755	0.12285	$12,132
23		$98,755	0.11168	$11,029
24		$105,580	0.10153	$10,720
25		$116,505	0.0923	$10,753
26		$98,755	0.08391	$8,287
27		$105,580	0.07628	$8,054
28		$98,755	0.06934	$6,848
29		$98,755	0.06304	$6,226
30		$149,530	0.05731	$8,570
TOTAL O&M PRESENT WORTH				$986,651
TOTAL PRESENT WORTH				$36,393,765

ANNUAL O & M COSTS:

ANNUAL COSTS	
MONITORING ($/SAMPLING ROUND) EVERY YEAR	
MONITORING WELLS	2,750
SURFACE WATER	2,200
LABOR FOR SAMPLES	4,000
FIELD BLANKS	
GROUNDWATER	550
SURFACE WATER	550
DUPLICATES	
GROUNDWATER	550
SURFACE WATER	550
SHIPPING CHARGES	200
MONITORING ($/SAMPLING ROUND) EVERY 3RD YEAR	
MONITORING WELLS	5,375
SURFACE WATER	4,300
LABOR FOR SAMPLES	4,000
FIELD BLANKS	
GROUNDWATER	1,025
SURFACE WATER	1,025
DUPLICATES	
GROUNDWATER	1,025
SURFACE WATER	1,025
SHIPPING CHARGES	400
MONITORING ($/YEAR) EVERY 5TH YEAR	
FISH SAMPLING	15,000
INSPECTION ($/YEAR) SEMI-ANNUALLY	3,600
OTHER MAINTENANCE ($/YEAR)	
GEN. MAINTENANCE ($/YR)	
FENCE MAINTENANCE	1,000
SOIL COVER REPAIRS	
EROSION CONTROL	900
MOWING/REVEGETATION	2,680
NON-ANNUAL COSTS	
WELL MAINTENANCE ($/ACTIVITY)	
REFURBISH SCREENS (EVERY 10 YRS)	
MONITORING WELLS	1,000
CLEAN DRAIN PIPE (EVERY 5 YEARS)	2,350
REPLACE PUMPS	
FRENCH DRAIN (EVERY 5 YEARS)	400
REPLACE FENCE (AT YEAR 30)	25,200

OPERATING COSTS ($/YEAR)	
GROUNDWATER COLLECTION SYSTEM	
FRENCH DRAINS	
PIPE REPAIRS	500
ELECTRICITY	655
EXTRACTION WELLS	
ELECTRICITY	2,150
GRANULAR ACTIVATED CARBON SYSTEM	
CARBON REPLACEMENT	24,000
CARBON HAULING	360
CARBON DISPOSAL	640
ELECTRICITY	1,150
LAB ANALYSIS	1,100
LABOR	43,800
SUPERVISION	7,020
TOTAL ANNUAL OPERATING COSTS ($/YR) - FIRST 4 YEARS (WITH EXTRACTION WELLS)	$81,375
TOTAL ANNUAL OPERATING COSTS ($/YR) - AFTER 4 YEARS (WITHOUT EXTRACTION WELLS)	$79,225